بسم الله الرحمن الرحيم

NLAP-WEDC Final Report (2012 - 2020)

Waste Incineration Electrical Power Plant Technology

- Part 2 -

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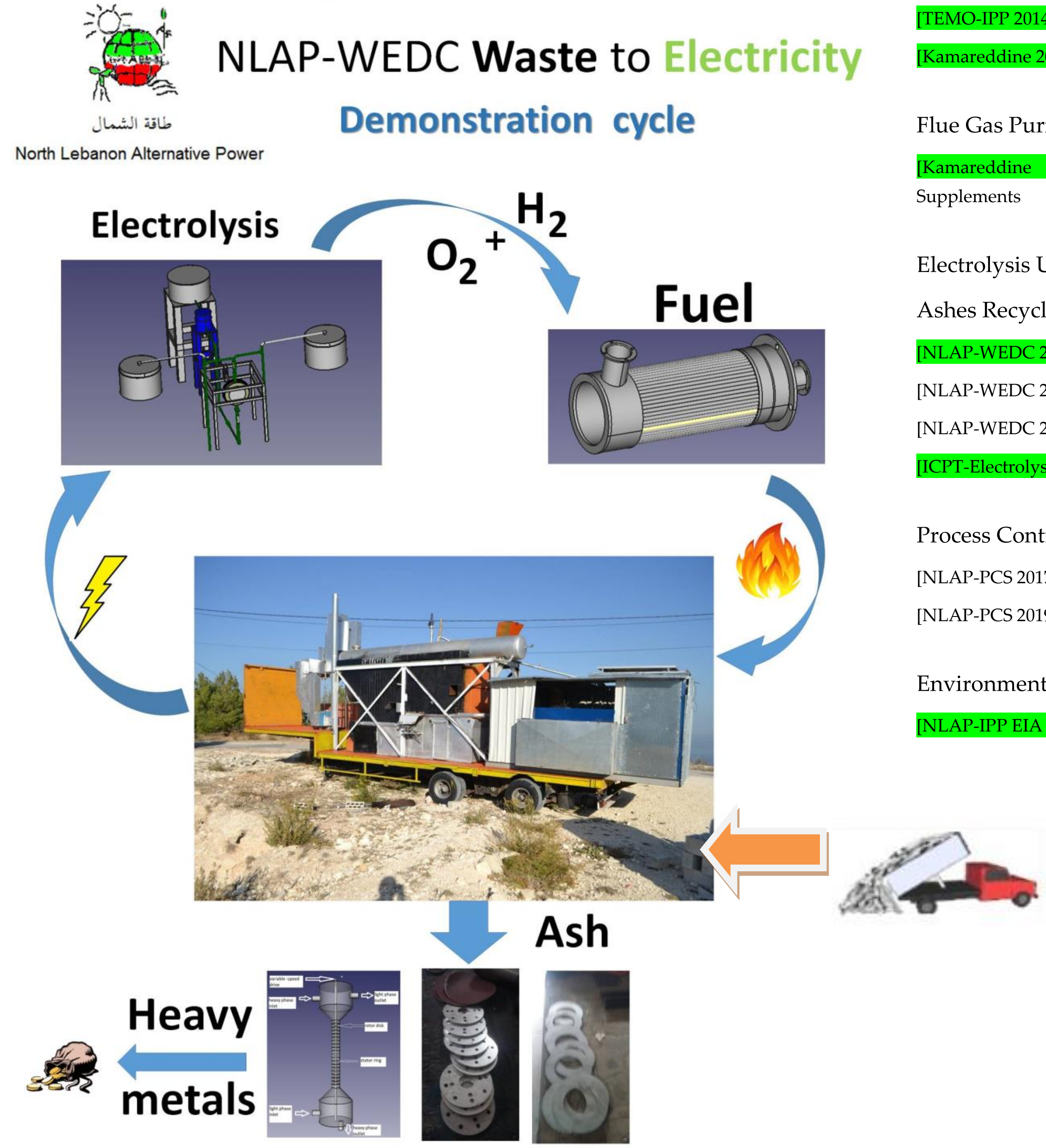

<u>Based on the following research reports:</u>

Demonstration Incineration Power Plant NLAP-IPP

[TEMO-STPP/IPP 2012]

[TEMO-IPP 2013]

[TEMO-IPP 2014]

[Kamareddine 2016]

Flue Gas Purification

[Kamareddine 2016] and Supplements

Electrolysis Unit,

Ashes Recycling Unit

[NLAP-WEDC 2017]

[NLAP-WEDC 2018]

[NLAP-WEDC 2019]

[ICPT-ElectrolysisFuelBurner 2020]

Process Control System

[NLAP-PCS 2017]

[NLAP-PCS 2019]

Environment Impact Assessment

[NLAP-IPP EIA Rayhaniyye 2018]

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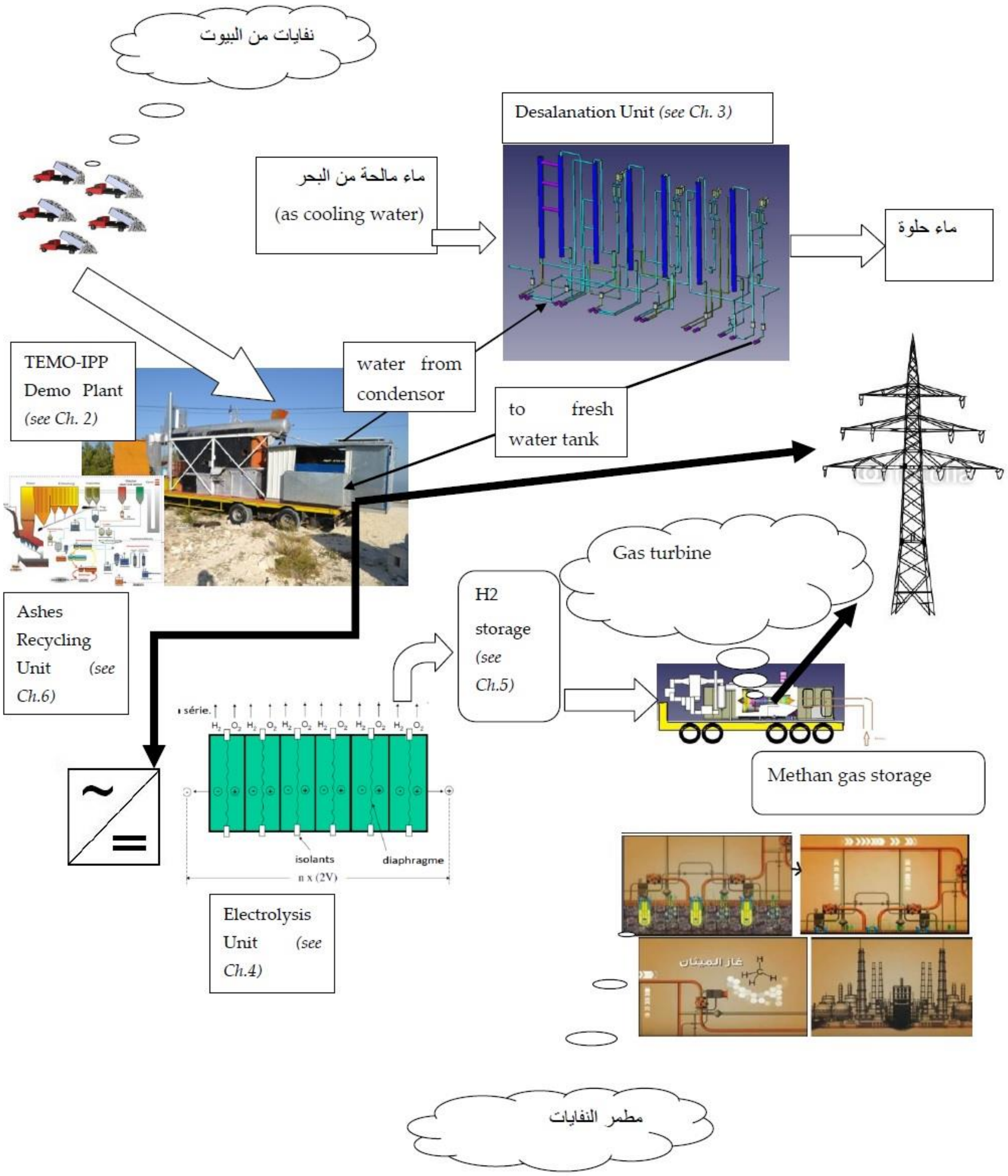
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Gas turbine
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AECENAR
Association for Economical and Technological Cooperation in the Euro-Asian and North-African Region
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Institute of NanoTechnology

Laser Based Flue Gas Detection

Laser Based Measurement of Flue Gases (CO, NO, SO2, HF, HCl) for a municipality waste incinerator

Master Thesis

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Last Update: 28.09.2020 12:15

Submitted in fulfilment of the requirements for the degree of

Master of **Physics of the Radiation-Matter Interaction**

Department of Physics-Faculty of Science

Lebanese University

2020

1 Contents

Acknowledgement

The concept for the measurement environment, which is the base of this work, was done by Siham Aisha und Mariam Abdelkarim. I would like to thank them very much for this.

Abstract

TODO

2 Introduction

2.1 Task of master thesis

The master thesis has the following tasks:

- For that, a partly completed laser system has to be completed and measurements with the TDLAS have to be undertaken. The Laser diode, the current and temperature controller are ready. The remaining parts have to be identified and procured.
- Every detail of the mechanism and the theoretic part of the measurement have to be described.
- The measurements for four of the flue gases have to be undertaken and documented.

3 Basics[1]

3.1 Introduction

Tunable diode laser absorption spectroscopy (TDLAS) is a technique for measuring the concentration of certain species such as methane, water vapor and many more, in a gaseous mixture using tunable diode lasers and laser absorption spectrometry. The advantage of TDLAS over other techniques for concentration measurement is its ability to achieve very low detection limits (of the order of ppb). Apart from concentration, it is also possible to determine the temperature, pressure, velocity and mass flux of the gas under observation.[1][2] TDLAS is by far the most common laser based absorption technique for quantitative assessments of species in gas phase.

A number of spectroscopic techniques have been developed for trace gas measurements. The traditional technique has been non-dispersive infrared (NDIR) where the transmission has been measured at two wavelength regions, one at absorbing and the other at non-absorbing wavelengths. This technique is suited for gases with broad absorption bands. In recent years new techniques has emerged such as Fourier transform infrared (FTIR), differential optical absorption spectroscopy (DOAS), laser-induced fluorescence (LIF) and tuneable diode laser absorption spectroscopy (TDLAS).

An overview of these techniques is given in [2]. There are several optical instruments commercially available for continuous emission monitoring based on these techniques. Some are extractive, where the gas has to be preconditioned before measurement in an internal cell, and others are insitu systems. These are broad-band spectroscopic instruments working in the infrared or ultraviolet. The middle infrared (MIR, 3–15 μm is a very rich spectral region where most of the interesting trace gases absorb on their fundamental rotational=vibrational modes. The absorption is so strong, particularly from H_2O and CO_2 molecules, that a very high spectral resolution is required to avoid interference between species. Tuneable diode lasers (TDL) have line widths of only a few MHz or less and are therefore well suited for highresolution spectroscopy. Lead-salt-based lasers are available in the middle infrared but both the TDLs and the detectors require cooling to around liquid nitrogen temperatures. In the near infrared (NIR, 0:8–3 mm we have the first and second overtones of the rotational=vibrationalmodes of the trace gases, and there are commercial III-V semiconductor lasers available up to approximately 2 mm that operate at room temperature. The absorption typically drops by an order of magnitude for every higher overtone, however, and a higher absorption sensitivity is required to obtain sufficiently low detection limits for many of the important gases. [1]

[1] Mostly from [Abdel-Karim, Aisha 2020]

3.1.1 Working

Basic TDLAS setup consists of tunable diode laser light source, transmitting (i.e. beam shaping) optics, optically accessible absorbing medium, receiving optics and detector/s. The emission wavelength of the tunable diode laser, viz. VCSEL, DFB, etc., is tuned over the characteristic absorption lines of a species in the gas in the path of the laser beam. This causes a reduction of the measured signal intensity, which can be detected by a photodiode, and then used to determine the gas concentration and other properties as described later.[3]

Different diode lasers are used based on the application and the range over which tuning is to be performed. Typical examples are InGaAsP/InP (tunable over 900 nm to 1.6 μm), InGaAsP/InAsP (tunable over 1.6 μm to 2.2 μm), etc. These lasers can be tuned by either adjusting their temperature or by changing injection current density into the gain medium. While temperature changes allow tuning over 100 cm−1, it is limited by slow tuning rates (a few hertz), due to the thermal inertia of the system. On the other hand, adjusting the injection current can provide tuning at rates as high as ~10 GHz, but it is restricted to a smaller range (about 1 to 2 cm−1) over which the tuning can be performed. The typical laser linewidth is of the order of 10−3 cm−1 or smaller. Additional tuning, and linewidth narrowing, methods include the use of extracavity dispersive optics.[4]

3.1.2 Basic principle[2]

Concentration measurement

The basic principle behind the TDLAS technique is simple. The focus here is on a single absorption line in the absorption spectrum of a particular species of interest. To start with the wavelength of a diode laser is tuned over a particular absorption line of interest and the intensity of the transmitted radiation is measured. The transmitted intensity can be related to the concentration of the species present by the Beer-Lambert law, which states that when a radiation of wavenumber ($\tilde{\upsilon}$) passes through an absorbing medium, the intensity variation along the path of the beam is given by,[5]

$$I(\tilde{\nu}) = I_0(\tilde{\nu}) \exp(-\alpha(\tilde{\nu})L) = I_0(\tilde{\nu}) \exp(-\sigma(\tilde{\nu})NL)$$

Where,

$I(\tilde{\upsilon})$ is the transmitted intensity of the radiation after it has traversed a distance L through the medium,

$I_0(\tilde{\upsilon})$ is the initial intensity of the radiation,

$\alpha(\tilde{\upsilon}) = \sigma(\tilde{\upsilon})N = S(T)\phi(\tilde{\upsilon} - \tilde{\upsilon}_0)$ is the absorbance of the medium,

$\sigma(\tilde{\upsilon})$ is the absorption cross-section of the absorbing species,

[2] https://en.wikipedia.org/wiki/Tunable_diode_laser_absorption_spectroscopy

N is the number density of the absorbing species,

S(T) is the line strength (i.e. the total absorption per molecule) of the absorbing species at temperature T,

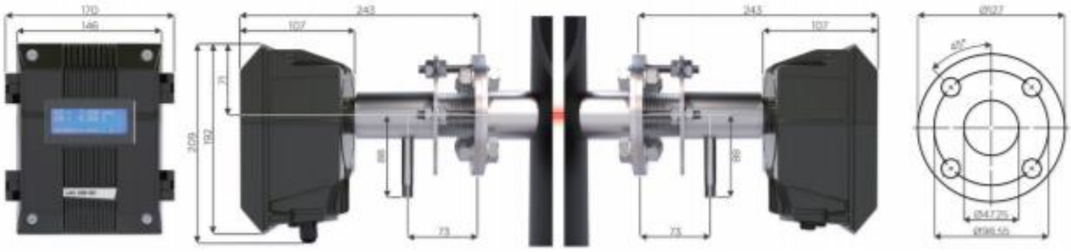
$\Phi(\tilde{\upsilon} - \tilde{\upsilon}_0)$ is the lineshape function for the particular absorption line. Sometimes also represented by $g(\tilde{\upsilon} - \tilde{\upsilon}_0)$,

$\tilde{\upsilon}_0$ is the center frequency of the spectrum.

3.2 Product LAS 300 XD[3]

[3] http://www.environnement-sa.com/products-page/en/las-300-xd-cross-duct-tdlas-laser-absorption-gas-analyzer/

Tunable Diode Laser Spectroscopy **LAS 300 XD**



Measurement ranges:	
$NH_3 + H_2O$	0 - 15 ppm / 0 - 500 ppm + 0 - 5% / 0 - 50%
$HCl + H_2O$	0 - 10 ppm / 0 - 3000 ppm + 0 - 5% / 0 - 50%
HF	0 - 100 ppm
CO (low)	0 - 500 ppm
CO (high)	0 - 100%
O_2	0 - 10% / 0 - 100%
Accuracy:	≤ ±2% of full scale
Response time (0-90%):	1s
Linearity:	≤ ±1% of full scale
Process gas (°C max):	
$NH_3 + H_2O$ / $HCl + H_2O$ / HF	+400°C
CO (low) / CO (high) / O_2	+1200°C
Process gas pressure:	Typical max. 2 bar absolute
Display:	4 x 20 alphanumeric LED backlit LCD
Input signals:	Optional temperature and pressure inputs (4-20 mA)
Communication:	Modbus RTU
Output signals:	x2 analog outputs (4-20 mA), x2 relays
Power supply:	+ 24 V DC, ripple and noise 50 mV
Power:	15 W when starting-up the LAS 300 XD < 15 W in normal operation
Ambient operating (°C):	-10°C to +55°C
Enclosure rating:	IP65
Enclosure material:	Die-cast aluminium (polyester powder coated)
Mounting flange size:	DN40 PN20 or 1.5" 150lb ANSI
Mounting flange material:	SS 316 L
Air purge consumption:	10-50 L/min (depends on application conditions)
Stack temperature:	0-450°C (other temperatures upon request)
Stack diameter:	0.5 to 6 m

MAIN OPTIONS:

- IP67 Junction box (for power and signal)
- Purge air unit (blower, filters, flow meters, pressure regulator)
- Connecting cable (usb) RS485 or RS232
- In-line span check cell ①
- Weather protection covers
- Specific flanges (length / material / C°)
- Remote interface
- Audit cell (with tripod) ②
- Optical alignment tool ③

THE STANDARD LAS 300 XD IS SUPPLIED WITH:

- 1 signal cable, between the Transmitter and Receiver (10 m standard and 25 m optional)
- 2 cables for power supply and signal outputs (each 3 m long)
- 2 alignment bellows (type: ASME B16.6 class 150)
- LaserTool® software

Distributed by:

3.2.1 Exclusive features

The Tunable Diode Laser Spectroscopy (TDLS) is the perfect technology to use when you are looking for a selective measurement and a fast response time on some gas components as NH3, HCL, HF, low or high CO, or even O_2 when conditions are too rough for standard O_2 Zirconia In-Situ analysers. It uses a solid-state laser source with a wavelength that can be adjusted to the gas component unique spectrum, also called gas component “fingerprint”. TDLS method is a non-contact optical technology and therefore the emitter (laser source) as the sensor stays protected from any contamination or corrosion and so the maintenance operation and the cost of operation are very low compared to other technologies.

The LAS 300 XD uses a semiconductor laser light source that is rapidly tuned over the absorption peak of the gas being measured.

The LAS 300 XD uses fast, advanced signal processing electronics and Direct Absorption Spectroscopy (DAS). This combination leads to very low noise DAS measurements that are comparable or often better than those made using wavelength modulation spectroscopy (WMS).

Main advantages of LAS 300 XD technology:

Sensitive. With a large dynamic range

Accurate. The laser absorption relates directly to the quantity of gas being measured at a molecular level. This leads to extremely accurate measurements using fundamental and proven signal-processing algorithms in both single gas and multi-gas applications.

Linear. No complex calibration curves required. Unaffected by changes in background species.

Fast. Rapid laser tuning ensures an accurate measurement even with fast changing process conditions.

3.2.2 Specifications

LAS 300 XD gas analyzers are very easy to install. The two main parts are arranged on opposite sides of the duct. The Transmitter is on one side and the Receiver is on the opposite side.

The Transmitter contains the laser along with the signal processing and communication electronics. The Receiver contains a photodetector and is connected to the Transmitter unit by a cable.

Alignment of the two units is simple thanks to the alignment bellows supplied with the LAS 300 XD. For additional help with alignment, an alignment tool is available.

The LAS 300 XD includes a window purge system as standard. Options are available to help with the installation and arrangement of the purging system. For example: a complete purge system that includes blower/filter and regulator, when there is no instrument air available at the installation point.

Measurement ranges:

NH_3 + H_2O: 0 – 15 ppm / 0 – 500 ppm + 0 – 5% / 0 – 50%

HCl + H_2O: 0 – 10 ppm / 0 – 3000 ppm + 0 – 5% / 0 – 50%

HF: 0 – 100 ppm

CO (low): 0 – 500 ppm

CO (high): 0 – 100%

O_2: 0 – 10% / 0 – 100%

3.3 Sensor design

The developed sensor follows the classical in situ TDLAS design and consists of transmitter and receiver units. The transmitter unit contains a diode laser, collimating optics, a microprocessor board, and all input–output electronics. The transmitter unit also has a built in cell for H_2 validation. The receiver unit incorporates a photodetector, focusing optics, and signal detection electronics (amplifier, mixer, etc.). The sensor is based on the wavelength modulation spectroscopy (WMS) technique, which is well described in the literature [18–20]. This technique has been proven to be very useful in trace gas sensing due to its ability to perform very sensitive interference-free measurements directly in the process or across stacks without sample extraction and preconditioning. Since WMS provides nominally baseline-free absorption signals, it is especially suited for measuring weak absorbance. Recently published comparisons of WMS and direct absorption spectroscopy (DAS) techniques revealed that WMS is approximately one order of magnitude more sensitive [21–23]. Figure 1a shows a photograph of the LaserGas II sensor mounted on the demo pipe using DN50 flanges, and Figure 1b depicts a schematic diagram and the basic principle of the sensor operation.

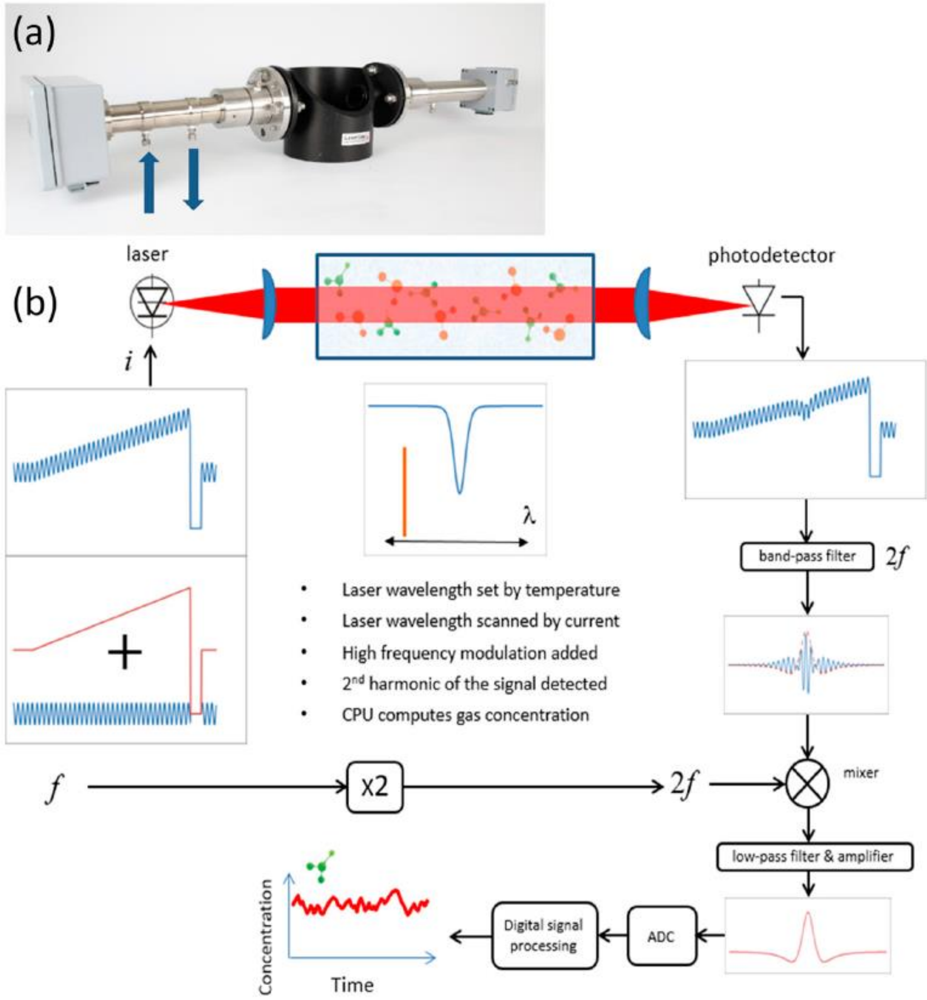


Figure 1. (a) Tunable diode laser absorption spectroscopy (TDLAS) H2 sensor mounted on a demo pipe. Transmitter unit is on the left and receiver unit on the right. Gas inlet and outlet of the built-in validation gas cell are indicated. (b) Schematic overview of the principles of sensor operation. A sinusoidally modulated current ramp is applied to the laser, which is swept in frequency across the transition of interest. After interacting with the sample, the absorption information is encoded in the transmitted intensity, which is measured using a photodetector. The photodetector signal is amplified, filtered, mixed, and digitized. Finally, digital signal processing is used to retrieve the concentration (and possibly other relevant parameters).

3.4 Diode lasers for spectroscopic applications [1][4]

The development of semiconductor diode lasers in the near infrared has been spurred by the development of CD players (0:78 μm) and fibre optic communication (1:3 μm, 1:55 μm). As technology has improved, lasers have been developed for new applications such as pumping of solid-state (0:808 μm) and fibre (0:98 μm) lasers. In addition to wavelength, other important laser parameters are mode stability, in order to obtain single-frequency operation, current tuneability,

[4] https://link.springer.com/article/10.1007%2Fs003400050509

and frequency drift. The Fabry–PKerot (FP) type lasers are unreliable with respect to mode jumping, therefore other types of lasers such as distributed feedback (DFB), distributed Bragg reflector (DBR) and vertical cavity surface emitting lasers (VCSEL) have been developed. Low current tuneability has to be compensated by higher current modulation which generally increase the RAM noise. It is beyond the scope of this paper to describe lasers in detail and we refer the reader to the literature (e.g. [14, 15]).

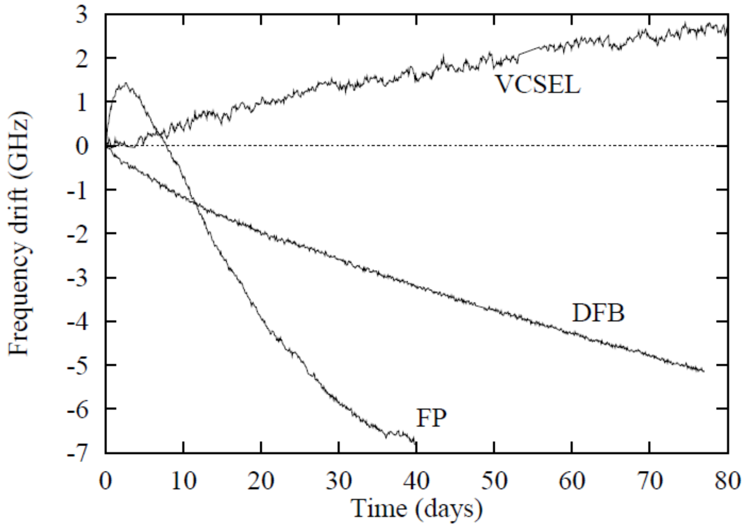


Fig. 6. Long-term frequency drift of some lasers at 760 nm. The lasers have passed "burn-in" tests prior to these measurements

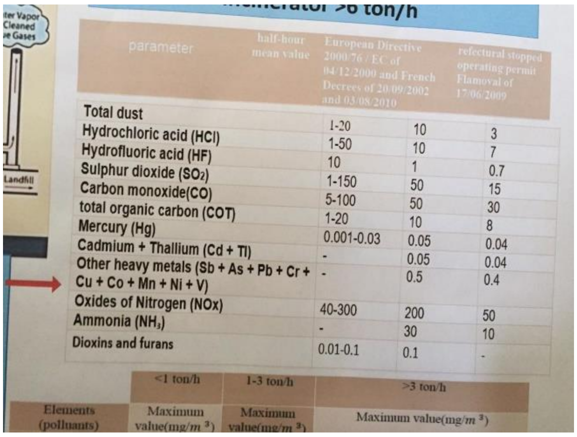
Long-term frequency stability is one of the most important parameters for diode lasers used in industrial gas monitors. Most lasers have some frequency drift and Fig. 6 shows some long-term measurements for three lasers at 760 nm. We have observed a large spread in drift, both for lasers of the same kind, and for different types of lasers, but it is generally smaller in lasers at longer wavelengths. The drift is usually smaller after several months of operation, but a drift as shown in Fig. 6 may cause instrument failure during such a period. The drift can be overcome by adjusting the laser temperature such that the absorption line is always in the centre of the frequency scan. However, some applications normally have zero concentration and therefore no line to track (e.g. measurement of O_2 for explosion safety). In such cases one can introduce a gas cell temporarily or permanently in the measurement path, or in a split-off beam with a separate detector. However, such solutions will increase the optical noise and=or mechanical=electronical complexity. The monitors described in this paper use lasers which have been selected for low drift, but the testing is a costly and time consuming process. It is difficult to specify a maximum acceptable drift since this is coupled to the actual mechanical=optical solution. A large, persistent frequency drift is often accompanied by drift in other parameters such as output power and to some extent current tuneability. Such effects may result in drift in the measured gas concentration and short life time of the laser.

Most of the diode lasers mentioned above are used in high-volume products. Diode lasers for gas monitors are expected to be required in low volumes only [16], and until recently only gases with strong absorption lines near the above-mentionedwavelengths have been possible to measure.

However, the advances in the manufacturing of diode lasers in recent years have made it possible to make lasers at other wavelengths, and several of the lasers used in the monitors described in this paper have been specially designed for the purpose of gas monitoring.

Table 1. Typical wavelengths and detection limits for some gases measured with the technique described in this paper. The detection limit for O_2 is not limited by electronic or optical noise, but by uncertainty due to air in the receiver and transmitter

Gas	Laser type	Wavelength /µm	Detection limit /ppm·m
O_2	FP, DFB, VCSEL	0.764, 0.760	1000
HF	DFB	1.28, 1.30	0.03
NH_3	DFB, DBR	1.51	0.2
CO	DFB	1.56	20
H_2S	DFB	1.57	5
HCl	DFB	1.74	0.1
NO	DFB	1.81	5



parameter	half-hour mean value European Directive 2000/76/EC of 04/12/2000 and French Decrees of 20/09/2002 and 03/08/2010		refectural stopped operating permit Flamoval of 17/06/2009
Total dust	1-20	10	3
Hydrochloric acid (HCl)	1-50	10	7
Hydrofluoric acid (HF)	10	1	0.7
Sulphur dioxide (SO_2)	1-150	50	15
Carbon monoxide(CO)	5-100	50	30
total organic carbon (COT)	1-20	10	8
Mercury (Hg)	0.001-0.03	0.05	0.04
Cadmium + Thallium (Cd + Tl)	-	0.05	0.04
Other heavy metals (Sb + As + Pb + Cr + Cu + Co + Mn + Ni + V)	-	0.5	0.4
Oxides of Nitrogen (NOx)	40-300	200	50
Ammonia (NH_3)	-	30	10
Dioxins and furans	0.01-0.1	0.1	-

Elements (polluants)	<1 ton/h Maximum value(mg/m^3)	1-3 ton/h Maximum value(mg/m^3)	>3 ton/h Maximum value(mg/m^3)

Table 1 lists some of the types of lasers and wavelengths we have used for some gases, and the corresponding detection limits obtained. Note that the detection limit for O_2 comes not from electronic or optical noise, but from uncertainty due to air in the receiver and transmitter. More extensive lists of suggested wavelengths for several gases can be found in [4, 17].

Standard wavelengths for hydrogen chloride detection HCl

nanoplus offers various wavelengths to target the vibrational-rotational bands of hydrogen chloride. Literature recommends the following wavelengths for hydrogen chloride detection:

- 1742 nm
- 3395 nm

Standard wavelengths for sulfur dioxide detection (SO2)

nanoplus offers various wavelengths to target the vibrational-rotational bands of sulfur dioxide. Literature recommends the following wavelengths for sulfur dioxide detection:

- 2460 nm
- 4020 nm

Standard wavelengths for carbon monoxide detection (CO)

nanoplus offers various wavelengths to target the vibrational-rotational bands of carbon monoxide. Literature recommends the following wavelengths for carbon monoxide detection:

- 1568 nm
- 2330 nm
- 4610 nm

Standard wavelengths for nitrogen oxide detection (NOx)

nanoplus offers various wavelengths to target the vibrational-rotational bands of nitrogen oxides. Literature recommends the following wavelengths for nitrogen oxides detection:

- 1814 nm
- 2270 nm
- 2670 nm
- 2860 nm
- 3420 nm
- 4470 nm
- 5255 nm

3.5 Industrial applications of TDLAS[5]

Due to the short response time, industrial TDLAS monitors are ideal as process control tools in processes requiring a fast response, and they are also well suited for continuous emission monitoring of gases such as HCl and HF where the maximum permissible emission levels are in the low ppm range. Some typical examples are presented below, followed by measurements from real installations.

3.5.1 Process control

O2 measurement. The use of TDLAS offers for the first time a reliable and accurate method for measurement of oxygen by using spectroscopic techniques.While the O2 monitor can be used in most of the traditional applications for O2 measurements in combustion processes, the most challenging applications are found in process control and safety systems in chemical and petrochemical plants (i.e. flare gas explosion control), as well as safety systems in hazardous waste and solvents destruction plants.

The gas temperature is typically in the range 150 to 300 °C and the pressure can vary from a few millibar to 3–5 bar. For these processes the gas matrix mainly consists of hydrocarbons (25%–80%) with the rest being H_2O, CO and CO2 plus a low concentration of O2 (typically from 1% to 2%).

Another process control application which has now become feasible is the use of the O2 monitor to improve combustion control in high-temperature furnaces, such as steel and cement ovens. Performing high-temperature CO measurements at the same location will improve the combustion control even further. The temperature is typically 900–1200 °C and the gas matrix will in this case consist of O2, CO, CO2, N2, NO and H2O.

NH3 measuerement. At the moment there are no environmental emission standards for ammonia emissions from industrial processes. Ammonia is, however, widely used in power plants and incinerators to reduce NOx emissions. Two frequently used techniques are selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) in which NH3 is added to the flue gas. For such installations, monitoring NH3 is valuable for optimising the consumption of the gas, as well as reducing corrosion and environmental impact from excessive use. The NH3 slippage level should preferably be well below 5 ppm and should be measured as close as possible to the injection point. Typical conditions at this stage in the process are gas temperatures of 250–350 μC, dust levels of 10–20 g=m3 and a gas mix of 10%–20% CO2 , 10%–30% H2O, 3%–5% O2, with the rest being N2 and ppm levels of SOx , NOx and NH3.

CO measurement. Accurate and fast measurements of CO as close as possible to the process may be used for effective combustion control in high-temperature processes used in steel and cement ovens. The use of TDLAS offers for the first time a reliable and accurate method for this type of process control, by measuring the CO level at temperatures above 1000 °C.

H2S measurement. H_2S is a hazardous gas normally present in refineries and other petrochemical plants, which have facilities for reduction=destruction of it. The gas mix typically includes H_2, O_2, N_2, CH_4, CO_2 and H_2O, and monitoring H_2S on a continuous basis is an efficient tool for process optimisation.

3.5.2 Emission monitoring

The most important emission gases believed to have an impact on the environment are related to combustion processes. In an industrial context, emissions usually come from boilers (power plants), chemical industry, waste incinerators and furnaces such as aluminium smelters and steel and glass furnaces. Other significant sources of emission are cars, buses and other motor vehicles.

Continuous monitoring of gas emissions from industrial processes has traditionally been limited to measurement of carbon monoxide (CO) nitrogen oxides (NO and NO2) and sulphur dioxide (SO2), and the techniques for continuous measurements are well established. Limitations in performance=detection levels of the equipment available for continuous measurements of gases such as HF, HCl and NH3 has in practice prevented continuous monitoring for reporting of emissions. Standard practice has been sampling tests mentioned several spectroscopic methods which can be used for a large number of gases. However, for the gases that are particularly difficult to measure, TDLAS offers a new and unique method. Some examples are presented below.

HCl measurement. HCl is an emission depending mostly on the content of chlorine in the fuel. Experience from domestic waste incinerators [18] has shown that approximately 90% of the Cl in the fuel will end up as HCl in the flue gas. The maximum permissible emission level of HCl from industrial and domestic waste incinerators in Europe is now specified to not exceed 10 mg/m^3 (daily mean values). Only a few types of instrumentation can meet this requirement, the TDLAS being one of these, with a detection limit of approximately 0:1 ppm-m for the monitors described in this paper.

HF measurement. HF emissions come primarily from aluminium plants, glass works, tile manufacturers, incinerators and alkylation plants. For incinerators, typically 10% of the fluorine in the fuel will end up as HF in the flue gas [18]. The maximum permissible level is typically 1 to 10 mg/m^3, depending on the process and application. Until recently HF has been a gas which has been considered impossible to measure on a continuous basis at these low levels due to the lack of suitable instrumentation. The use of TDLAS has now changed this as HF proves to be one of the most suitable gases for the TDLAS technique with a detection limit of 30 ppb for a 1-m optical path length.

3.5.3 Measurement of O2, CO and HCl from a waste incinerator

In Fig. 7 we show some simultaneous time-series measurements from the stack of a 27-MW circulating fluidized bed (CFB) combined boiler and incinerator at a paper mill. The boiler produces a maximum of 40 tons of steam per hour at 210 °C and 20 bar. The steam is used in the paper mill production and may vary rapidly from 20% to 100% capacity. The boiler is designed to burn municipal waste, plastic, wood, paper, waste oil and coal. These fuels have greatly different calorific values and this puts high demands on both the process control and the abatement system.

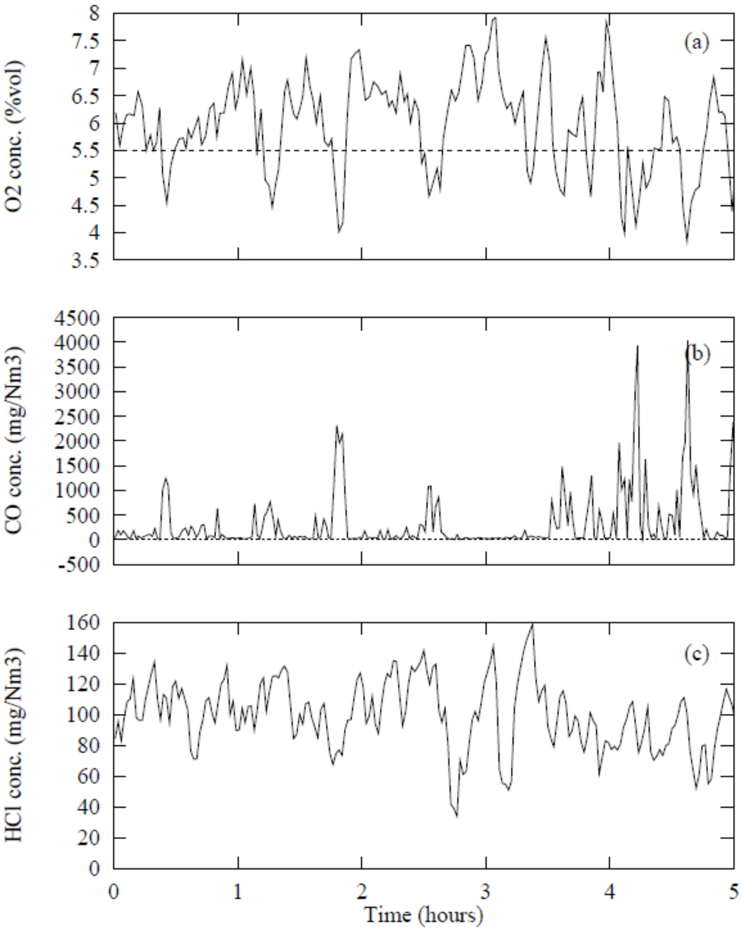


Fig. 7. Concentrations in flue gas from a waste incinerator measured over a period of 5 hours, where each sample is averaged over 60 seconds. The CO concentration peaks abruptly when the O_2 concentration drops below approximately 5.5 vol. % The HCl concentrations do not show a similar correlation

After the combustion in the CFB reactor the flue gas passes through two cyclones and the boiler before it is cleaned in a multi-cyclone and an electro-scrubber. The flue gas is then let out through a 40-m-high stack, where the gas monitors are located.

O2 and CO concentrations in the flue gas are the most importan gases for monitoring combustion efficiency. Complete oxidation can in practice be obtained only with an excessive amount of air Too much air, however, can cool down the combustion and increase the amount of CO in the flue gas. There exists an optimal amount of air. Figure 7a,b shows the O2 and CO concentrations for varying efficiency of the combustion. When the O2 concentration drops below approximately 5:5 vol:% the CO concentration peaks sharply to values as high as 4000 mg/Nm^3, and when the O2 concentration is approximately 6 vol:% to 7 vol:% the CO concentration is close to 50 mg/Nm^3. The fluctuations in CO concentrations are extremely fast and large. In Fig. 7 the concentrations have been averaged over 1min and we see changes from 50 to 2300 mg/Nm3 from one sample to the next. The fastest response of the CO monitor is 15 s, and we have seen cases where the concentration has changed from 100 to 9000 to 100 mg/Nm^3 in three successive samples at this sampling rate. It is difficult to understand how conditions can change this fast in such a large furnace, but considering a gas flow of up to 20 m^3/s, we realise that all the gas in the furnace has been replaced in less than 15 s. Such fast response measurements can therefore give valuable information that may be used in the process control of the furnace.

HCl was also measured in the flue gas from this waste incinerator. The concentration of HCl depends mostly on the content of chlorine in the fuel and is not expected to show much correlation with process-control-related parameters. This is consistent with the measurements shown in Fig. 7 where there is no correlation between the concentration of HCl and the other two gases. The content of chlorine in municipal waste can vary greatly, which is also seen in this figure. At the time of measurement the incinerator had no abatement system for removing HCl.

HF was also measured in the stack of the waste incinerator. In the analysed period the concentrations were generally very low and rarely above the detection limit, which was approximately 0:05 mg/Nm^3.

3.6 Gas Properties

3.6.1 CO

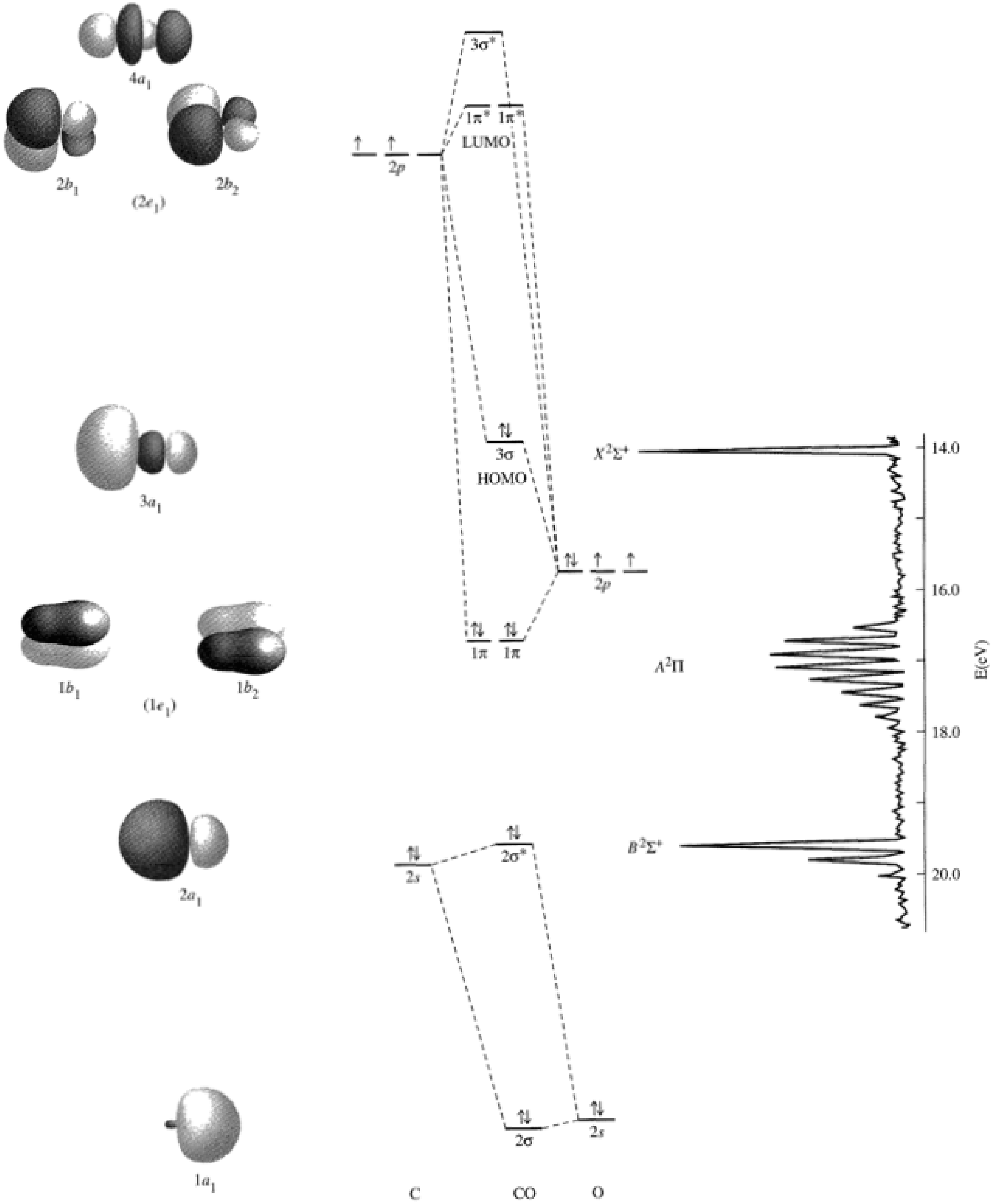


FIGURE 5-14 Molecular Orbitals and Photoelectron Spectrum of CO. Molecular orbitals 1σ and $1\sigma^*$ are from the $1s$ orbitals and are not shown, The e_1 and e_2 labels in the left-hand column are for the Cinfinityv symmetry labels; the b_1 and b_2 labels are for C_2v symmetry. (Photoelectron spectrum reproduced with permission from J. L. Gardner and J. A. R. Samson, *J. Chem. Phys.*, **1975**, *62*, 1447.)

3.6.2 NO

3.6.3 SO2

3.6.4 HCl

3.7 Gas analysis spectroscopy

3.8 Shematic

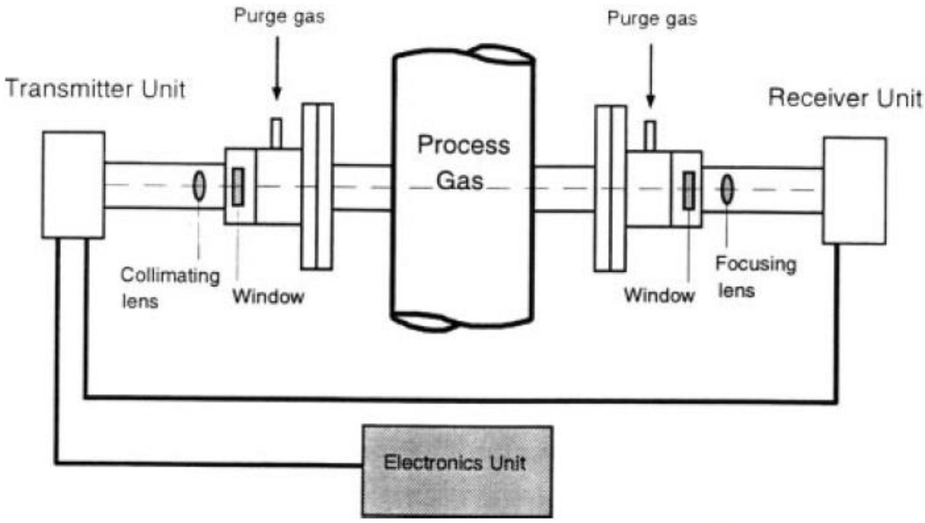
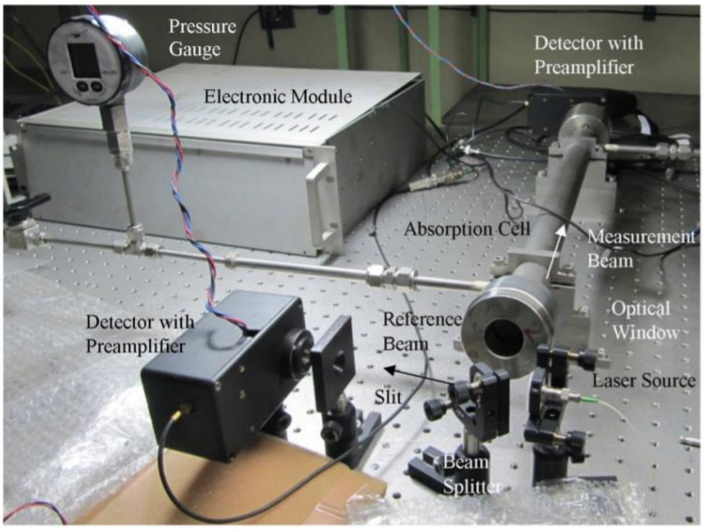


Fig. 2. Schematic drawing of the TDLAS gas monitors described in this paper

The mechanical layout of a monitor installed on a stack is shown in Fig. 2. The laser and detector are located in the transmitter and receiver units, respectively. Both units are mounted on the stack by using standard flanges purged with dry air to keep the optical windows clean. The detected signal is transmitted through a cable to the electronics unit, which contains signal-processing electronics. The measured concen- tration is displayed on an LCD display, and for data recording and logging it is sent through an RS232 digital output and a standard 4–20 mA analogue output.



[6]

3.9 Experimental setup[7]

3.9.1 Care of diode laser

Diode lasers are extremely sensitive to static electricity and surges in voltage. There are several concerns that must be kept in mind when dealing with diode lasers:

1. Never handle the diode laser with a tool (including fingers) that are not grounded. Static electricity may cause the diode laser to fail.
2. Take care never to drive the diode laser at voltages and currents beyond its capacity. The diode laser controller should be configured to restrict voltage, current, and case temperature.
3. Be sure to connect all equipment to a common ground to protect against ground loops.
4. Always configure the diode laser mounts to keep the diode voltage floating. Grounding the diode laser to earth ground will increase susceptibility to line power fluctuations and surges.

3.9.2 Alignment of Optics

There is no substitute for practice in learning to align optics. However, a few suggestions might be helpful.

When aligning an optical setup for the first time, or if the optics have become badly out of alignment, place a visible He-Ne laser in place of the detector. Align the optics so that the visible laser shines directly on the head of the IR laser. Then, turn the IR laser on and adjust the IR laser so that the beam follows the same path as the visible laser.

In my experience, it is best to always work the laser to the detector when aligning optics. For the TDLAS setup,

1. Align the aspheric lens to achieve a well – collimated and symmetric beam.
2. Align the nearest mirror to direct the beam across the flame.
3. Adjust the mirror on the opposite side of the flame to direct the beam back across the flame.

[6] https://aip.scitation.org/doi/abs/10.1063/1.5113968?journalCode=rsi

[7] https://vtechworks.lib.vt.edu/bitstream/handle/10919/36293/MS_F_TDLASmanual.pdf?sequence=14

4. Adjust the far mirror to direct the beam onto the detector.
5. Once the lasers are aligned on the correct path, small adjustments can be made to maximize the detector output.
6. The detector gain can then be adjusted to the desired output voltage.

The detector signal may begin to oscillate due to etalon effects (reflections) in the optical path. If this occurs, make small adjustments to the optical path until the oscillations are no longer observed.

3.10 Measurement procedure

3.10.1 Theoretical Lineshapes.

Theoretical lineshapes are calculated to identify attractive transitions and to determine physical parameters. The HITRAN database contains spectroscopic parameters for many important molecules. The HITEMP database includes parameters for high-temperature transitions. Many of the parameters are theoretical, although some have been experimentally verified. Using these parameters, theoretical lineshapes can be computed to compare with measured lineshapes. Also, the theoretical properties are used to calculate the temperature dependence of transitions (see Section 3.1.1). The Matlab program "spectra.m" calculates theoretical lineshapes based on the parameters in HITRAN and HITEMP.

3.10.2 Lineshape Data.

When a high-bandwidth measurement is not required, the wavelength of the laser is scanned over the entire absorption feature. The temperature and injection current is set through the laser controller to maintain the laser at the linecenter. A function generator is used to send a sawtooth waveform to the external modulation connection on the laser controller. Observing the lineshape on an oscilloscope, the case temperature and mean current can be adjusted to position the linecenter of the transition at the center of the waveform. The amplitude of the sawtooth wave should be adjusted so that at least 30% of the waveform is outside of the transition. For the setup at the VACCG, analog output channel 0 was connected to the modulation input on the diode laser controller. The Labview program "fungen.vi" was used to create a 50 Hz sawtooth waveform with amplitude of 0.2 Volts. Diode lasers can be modulated at up to 10 kHz. However, your data acquisition system must be able to record at atleast three times the modulation frequency. The Labview program "diagnostic_main.vi" was used to record the lineshape data. The data was processed by the Matlab program "v_scan.m". This program fit baselines to the data to solve for the reference intensity (see Appendix B2) and plotted the resulting lineshape. The program also calculates the peak absorbance which is used in the temperature calculation.

By fitting theoretical lineshapes, using the data from the HITRAN database, to the measured lineshapes, species concentration, pressure, and broadening coefficients can be determined. The program "tst_voigtfit.m" was used to fit theoretical lineshapes to measured lineshapes.

MS_F_TDLASmanual.pdf

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3.10.3 Beam splitter (To do.√..)

Beamsplitters are optical components used to split incident light at a designated ratio into two separate beams. Additionally, beamsplitters can be used in reverse to combine two different beams into a single one. Beamsplitters are often classified according to their construction: cube or plate (Table 1).

Table 1: Comparison of Cube and Plate Beamsplitters

Cube Beamsplitters	Plate Beamsplitters

Table 1: Comparison of Cube and Plate Beamsplitters

Cube Beamsplitters

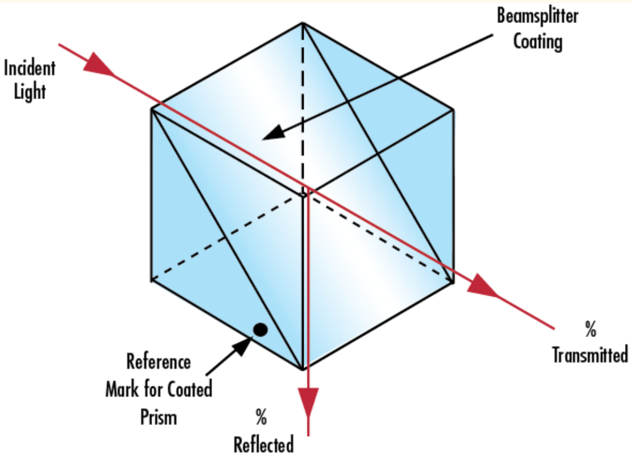


Figure 1: Cube Beamsplitter

Cube beamsplitters are constructed using two typically right angle prisms (Figure 1). The hypotenuse surface of one prism is coated, and the two prisms are cemented together so that they form a cubic shape. To avoid damaging the cement, it is recommended that the light be transmitted into the coated prism, which often features a reference mark on the ground surface.

Plate Beamsplitters

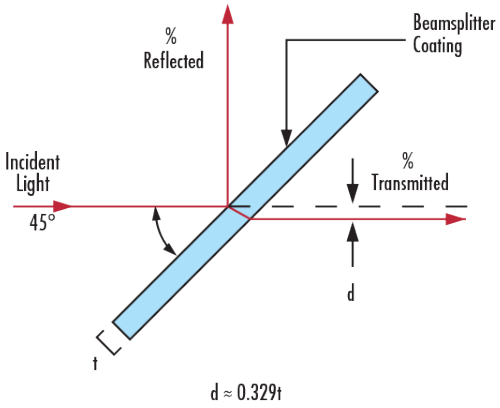
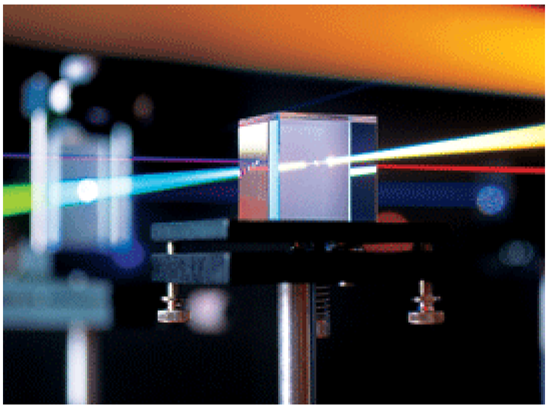


Figure 2: Plate Beamsplitter

Plate beamsplitters consist of a thin, flat glass plate that has been coated on the first surface of the substrate (Figure 2). Most plate beamsplitters feature an anti-reflection coating on the second surface to remove unwanted Fresnel reflections. Plate beamsplitters are often designed for a 45° AOI. For substrates with a 1.5 index of refraction and a 45° AOI, beam shift distance (d) can be approximated using the equation in Figure 2.

Table 2: Beamsplitter Construction

	Advantages	Disadvantages
Cube Beamsplitters	• Easy Integration with 0° AOI • No Beam Shift • Equal Reflected and Transmitted Optical Path Lengths • Shorten the Optical Path of a System	• Heavy, Solid Glass Construction • Difficult, and more Expensive to Make in Large Sizes
Plate Beamsplitters	• Lightweight • Relatively Inexpensive • Easy to Manufacture in Larger Sizes	• Reflected and Transmitted Optical Paths are Different Lengths • Beam Shift of Transmitted Light (see Figure 2) • The 45° AOI may Require Additional Alignment Time



3.11 Types of Beamsplitters

Standard Beamsplitters are commonly used with unpolarized light sources, such as natural or polychromatic, in applications where polarization state is not important. They are designed to split unpolarized light at a specific Reflection/Transmission (R/T) ratio with unspecified polarization tendencies.

Polarizing beamsplitters are designed to split light into reflected S-polarized and transmitted P-polarized beams. They can be used to split unpolarized light at a 50/50 ratio, or for polarization separation applications such as optical isolation (Figure 3).

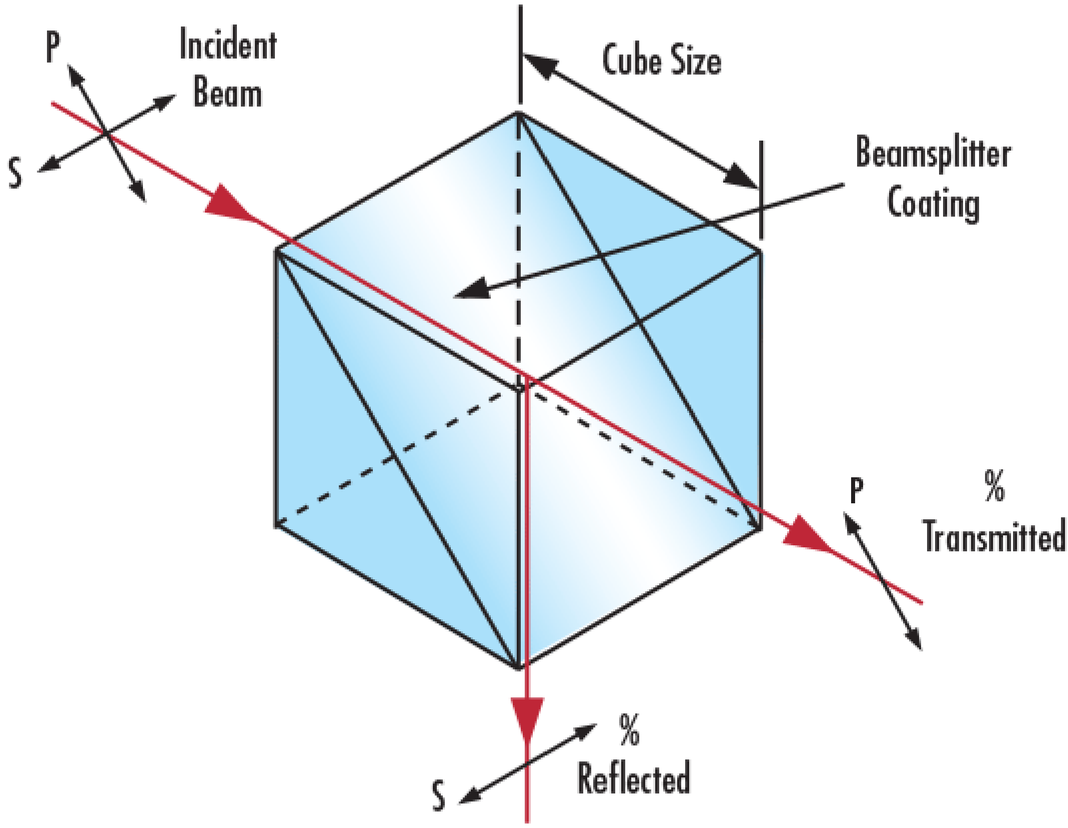


Figure 3: Polarizing Beamsplitter

Non-polarizing beamsplitters split light into a specific R/T ratio while maintaining the incident light’s original polarization state. For example, in the case of a 50/50 non-polarizing beamsplitter, the transmitted P and S polarization states and the reflected P and S polarization states are split at the design ratio. These beamsplitters are ideal for maintaining polarization in applications utilizing polarized light (Figure 4).

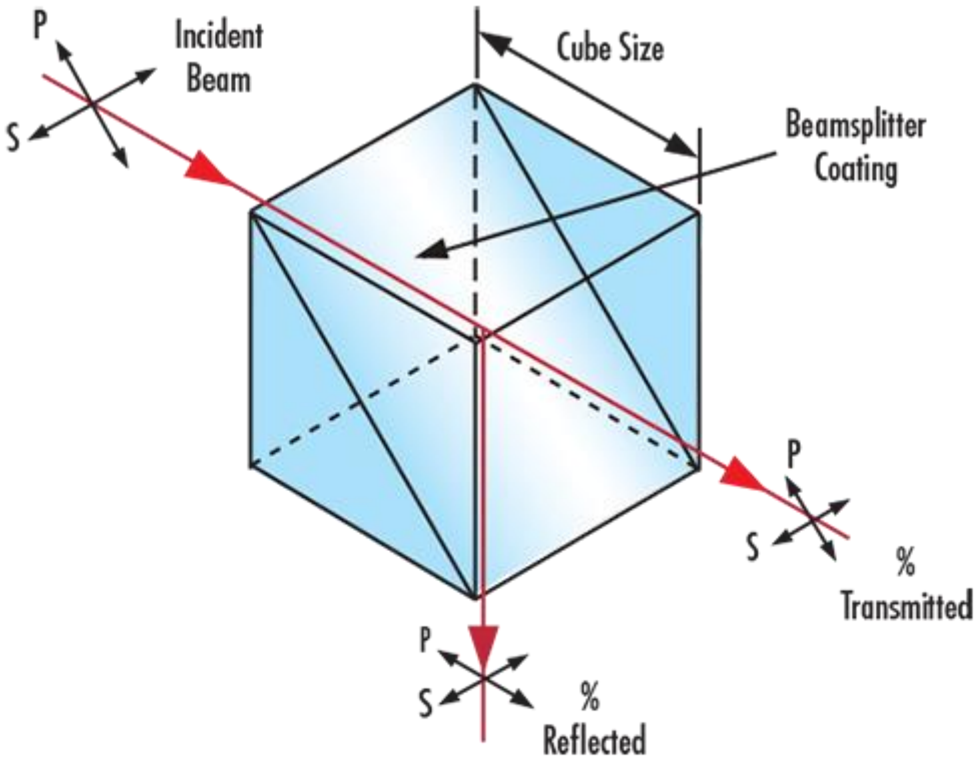
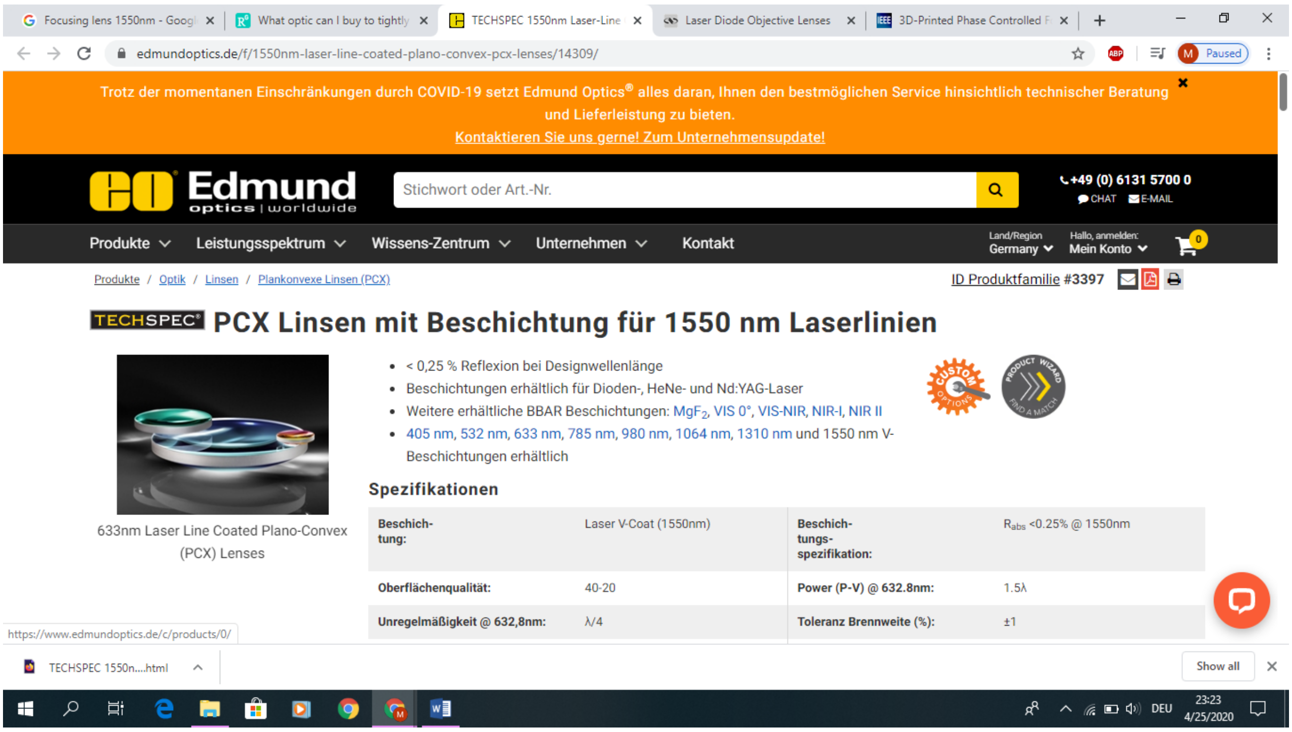


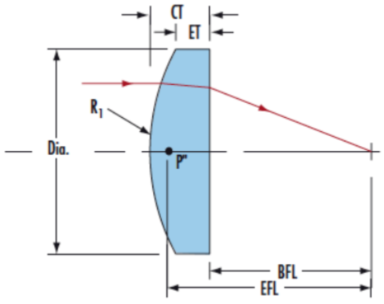
Figure 4: Non-Polarizing Beamsplitter

Dichroic Beamsplitters split light by wavelength. Options range from laser beam combiners designed for specific laser wavelengths to broadband hot and cold mirrors for splitting visible and infrared light. This type of beamsplitter is commonly used in fluorescence applications.

3.11.1 Focusing lens (To do.√..)



Our standard TECHSPEC® plano-convex lenses are also with a V-AR coating rating. These lenses are ideal for applications where HeNe, diode or Nd: YAG lasers are used with high power and have been developed to be used for central transmission. The lenses demand above all in the use of the individual optical components, which ensure very good transmission, since max. 0.25% of the design wavelength is reflected.



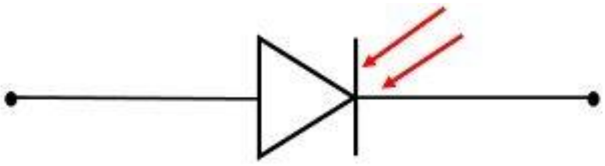
3.12 Detector (To do.√..)

3.12.1 PHOTODIODE

3.12.1.1 Definition:

A special type of PN junction device that generates current when exposed to light is known as Photodiode. It is also known as photodetector or photosensor. It operates in reverse biased mode and **converts light energy into electrical energy**.

The figure below shows the symbolic representation of a photodiode:



Symbolic representation of Photodiode

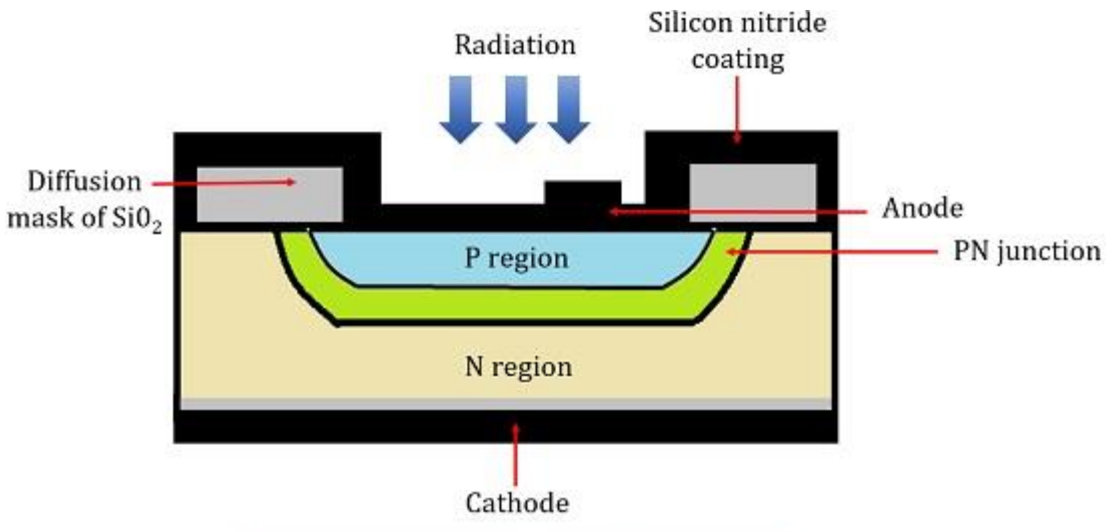
3.12.1.2 PRINCIPLE OF PHOTODIODE

It works on the principle of **Photoelectric effect**.

The operating principle of the photodiode is such that when the junction of this two-terminal semiconductor device is illuminated then the electric current starts flowing through it. Only minority current flows through the device when the certain reverse potential is applied to it.

3.12.1.3 CONSTRUCTION OF PHOTODIODE

The figure below shows the constructional detail of a photodiode:



Structure of Photodiode

The PN junction of the device placed inside a glass material. This is done to order to allow the light energy to pass through it. As only the junction is exposed to radiation, thus, the other portion of the glass material is painted black or is metallised.

The overall unit is of very small dimension nearly about **2.5 mm**.

It is noteworthy that the current flowing through the device is in **micro-ampere** and is measured through an ammeter.

3.12.1.4 OPERATIONAL MODES OF PHOTODIODE

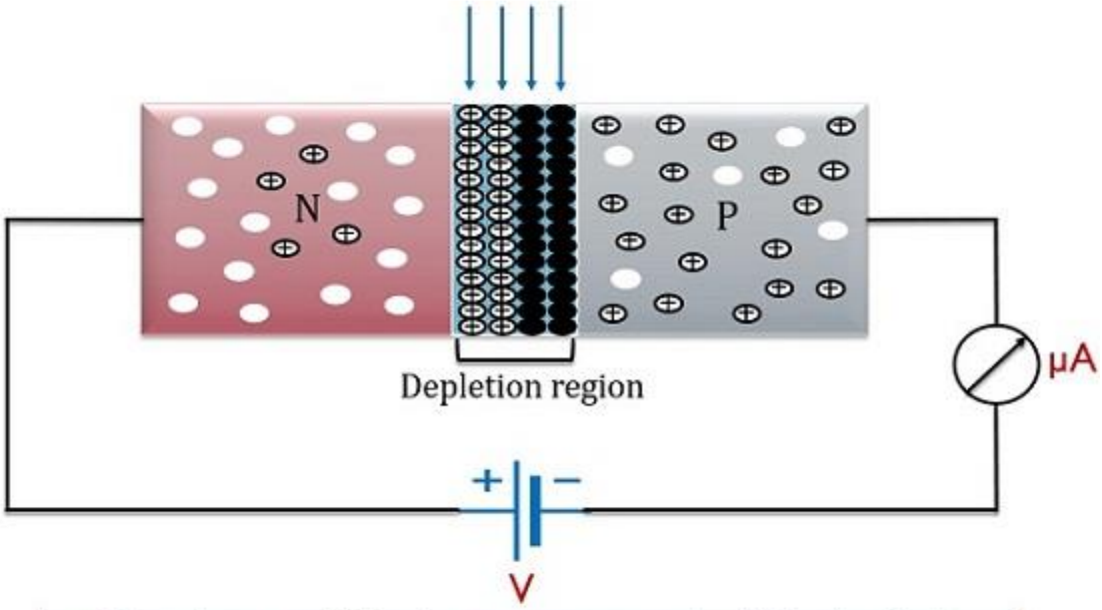
Photodiode basically operates in two modes:

- **Photovoltaic mode**: It is also known as zero-bias mode because no external reverse potential is provided to the device. However, the flow of minority carrier will take place when the device is exposed to light.
- **Photoconductive mode**: When a certain reverse potential is applied to the device then it behaves as a photoconductive device. Here, an increase in depletion width is seen with the corresponding change in reverse voltage.

Let us now understand the detailed circuit arrangement and working of the photodiode.

3.12.1.5 WORKING OF PHOTODIODE

In the photodiode, a very small reverse current flows through the device that is termed as **dark current**. It is called so because this current is totally the result of the flow of minority carriers and is thus flows when the device is not exposed to radiation.



Structure and biasing arrangement of Photodiode

The electrons present in the p side and holes present in n side are the minority carriers. When a certain reverse-biased voltage is applied then minority carrier, holes from n-side experiences repulsive force from the positive potential of the battery.

Similarly, the electrons present in the p side experience repulsion from the negative potential of the battery. Due to this movement electron and hole recombine at the junction resultantly generating depletion region at the junction.

Due to this movement, a very small reverse current flows through the device known as dark current.

The combination of electron and hole at the junction generates neutral atom at the depletion. Due to which any further flow of current is restricted.

Now, the junction of the device is illuminated with light. As the light falls on the surface of the junction, then the temperature of the junction gets increased. This causes the electron and hole to get separated from each other.

At the two gets separated then electrons from n side gets attracted towards the positive potential of the battery. Similarly, holes present in the p side get attracted to the negative potential of the battery.

This movement then generates high reverse current through the device.

With the rise in the light intensity, more charge carriers are generated and flow through the device. Thereby, producing a large electric current through the device.

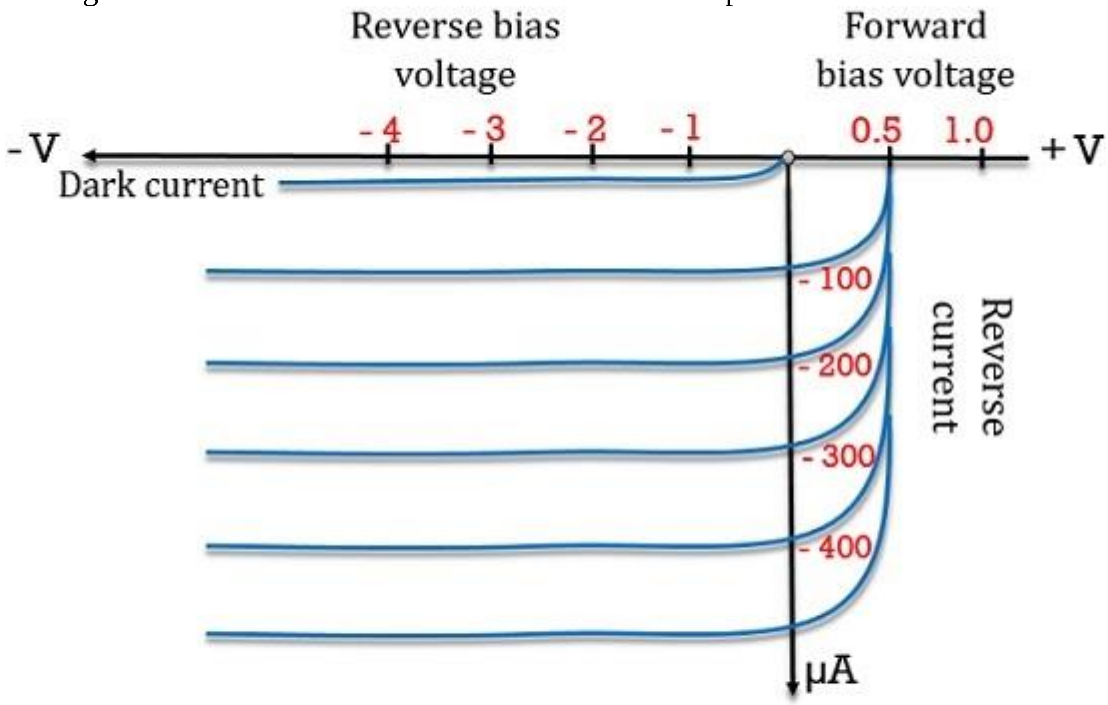
This current is then used to drive other circuits of the system.

So, we can say the intensity of light energy is directly proportional to the current through the device.

Only positive biased potential can put the device in no current condition in case of the photodiode.

3.12.1.6 CHARACTERISTICS OF PHOTODIODE

The figure below shows the VI characteristic curve of a photodiode:



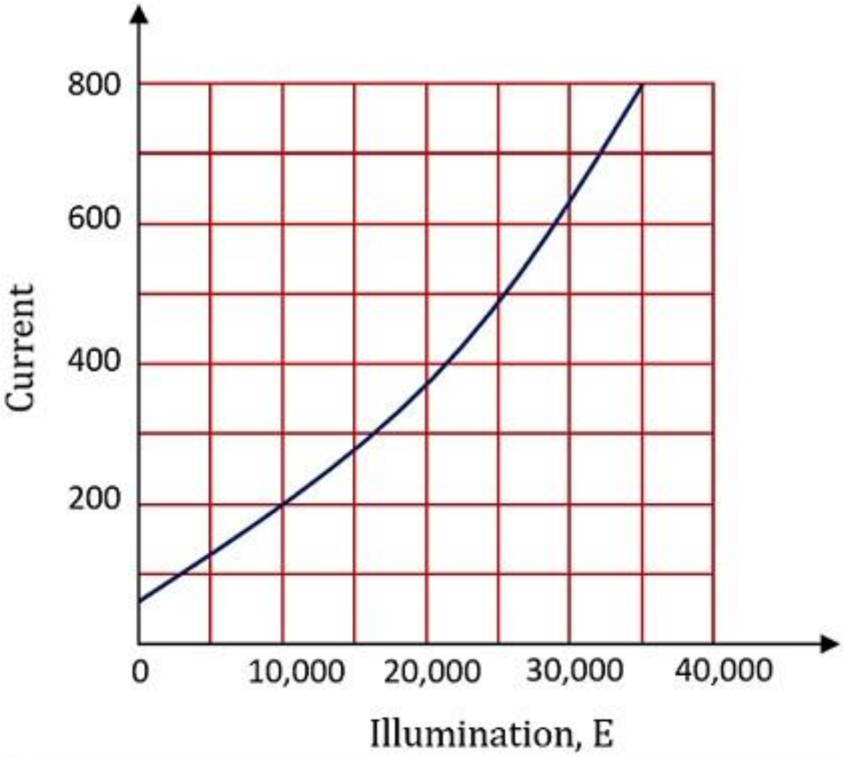
Characteristics curve of Photodiode

Here, the vertical line represents the reverse current flowing through the device and the horizontal line represents the reverse-biased potential.

The first curve represents the dark current that generates due to minority carriers in the absence of light.

As we can see in the above figure that all the curve shows almost equal spacing in between them. This is so because current proportionally increases with the luminous flux.

The figure below shows the curve for current versus illumination:



Illumination versus current curve

It is noteworthy here that, the reverse current does not show a significant increase with the increase in the reverse potential.

3.12.1.7 ADVANTAGES OF PHOTODIODE

- It shows a quick response when exposed to light.
- Photodiode offers high operational speed.
- It provides a linear response.
- It is a low-cost device.

3.12.1.8 DISADVANTAGES OF PHOTODIODE

- It is a temperature-dependent device. And shows poor temperature stability.
- When low illumination is provided, then amplification is necessary.

3.12.1.9 APPLICATIONS OF PHOTODIODE

1. Photodiodes majorly find its use in counters and switching circuits.
2. Photodiodes are extensively used in an optical communication system.
3. Logic circuits and encoders also make use of photodiode.
4. It is widely used in burglar alarm systems. In such alarm systems, until exposure to radiation is not interrupted, the current flows. As the light energy fails to fall on the device, it sounds the alarm.

In case of a typical photodiode, the normal reverse current is in tens of microampere range.

3.12.2 Alternative

3.12.2.1 Scintillator

3.12.2.2 IR Sensors

PIR Passiv Infrarot Sensoren

Hier handelt es sich um Passiv-Infrarot-Bewegungsmelder. Bewegungsmelder regieren beim Eintritt einer Person (Tier) in das Erfassungsfeld des Sensors. Die Anwendungsmöglichkeiten sind nahezu unbegrenzt, man kennt die Technik ja von vielen Terrassenlampen, welche sich beim vorbeigehen automatisch einschalten. Reagiert wird also auf die Körperwärme einer sich im Erfassungsfeld bewegenden Person.

Zum Prinzip: Wärmestrahlen, die einen Erfassungsvorgang auslösen, liegen im Infrarot-Bereich des Wellenspektrums. In diesem Bereich gibt der menschliche Körper seine Wärmestrahlung ab. Leuchtmittel wie Glüh- , Halogen- und Entladungslampen, die für eine Strahlung im sichtbaren Bereich um 0,555 µm entwickelt wurden, geben jedoch auch einen erheblichen Teil an Wärmestrahlung im Infrarot-Bereich ab. Im Spektrum oberhalb des sichtbaren Licht, ab 0,780 µm, beginnt der Infrarot-Bereich. Die Wellenlänge dieser IR-Strahlung ist abhängig von der Temperatur eines Körpers. Die Wärmestrahlung des Menschen hat ihr Maximum zwischen 9 und 10 µm im Infrarot-Bereich. Diese Tatsache nutzt der PIR Sensor mittels sogenannter pyroelektrischer IRDetektoren, welche eine hohe Empfindlichkeit im langwelligen Infrarot-Bereich aufweisen. Die Infrarot- Strahlung verhält sich ähnlich wie sichtbares Licht. Sie kann reflektiert und durch Linsen gebündelt werden. Basis eines solchen IR-Detektors (Sensors) sind Lithium-Tantalatkristalle. Diese Kristalle erzeugen, bei Wärmeänderung (positive oder negative Temperaturänderung), eine elektrische Spannung. Die von den Kristallen abgegebene Spannung liegt im Bereich von einigen µV (µV = millionstel Volt) und ist von folgenden Bedingungen abhängig:

- Der Intensität der Wärmequelle (Temperatur und Größe)
- Dem Umgebungsmedium (Temperatur, unterschiedliche Luftfeuchtigkeit)
- Der Entfernung zwischen Wärmequelle und IR-Sensor
- Der Bewegungsgeschwindigkeit und Bewegungsrichtung der Wärmequelle
- Der Empfindlichkeit des PIR-Elementes (frequenzabhängiges Bandpaßverhalten mit Maximum bei ca. 0,1 Hz)

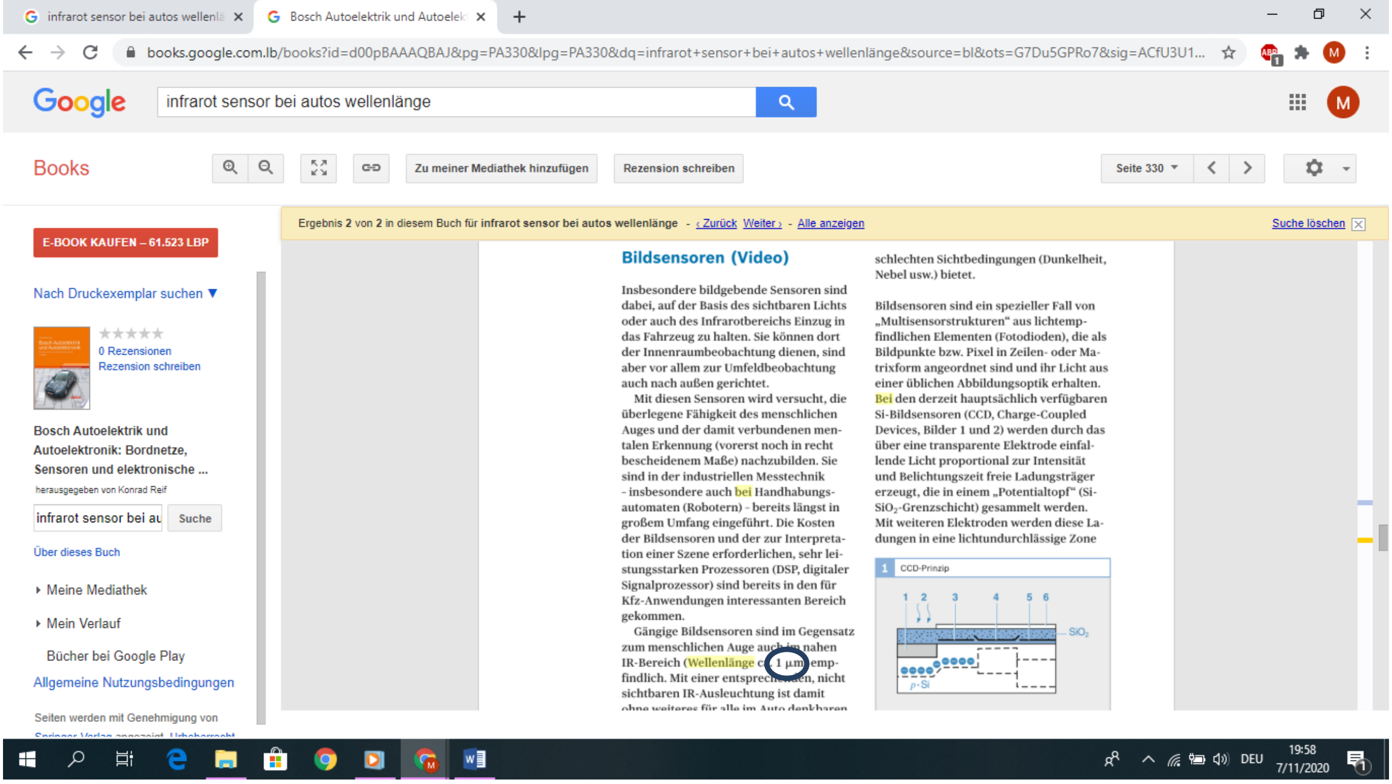
Zur Unterdrückung von Einflüssen aus der Umgebung (übliche wetterbedingte Temperaturänderungen), sind in jedem Sensor 2 Kristalle antiparallel geschaltet. Einer der Kristalle gibt, bei Auftreffen von Wärmestrahlung einen positiven, der andere einen negativen Spannungsimpuls ab. Wärmeänderungen die gleichzeitig und mit gleicher Intensität auf beide Kristalle einwirken lösen so keinen Erfassungsvorgang aus, denn die beiden Impulse heben sich gegenseitig auf. Dadurch ist ein Auslösen bei Wärmeänderungen der Umgebung weitgehend ausgeschlossen. Anders verhält es sich bei schnellen Bewegungen. Die Lithiumtantalat-Kristalle geben, entsprechend der Bewegung und der dadurch hervorgerufenen Wärmeänderung im Erfassungsfeld, ihre Impulse zeitversetzt ab. Die beiden Impulse addieren sich zu einer Wechselgröße mit höherer Signalamplitude. Dieses elektrische Ausgangssignal ist proportional der Wärmeänderung und führt zur Meldung einer Bewegung.

Infrarot Thermopiles

Bei den Infrarotsensoren gibt es neben den oben beschrieben PIR Sensoren aus Bewegungsmeldern auch solche auf Basis von Thermopiles. Diese können nicht nur auf Änderungen reagieren, sondern auch eine konstante Strahlung messen. Beispiele ist der TPS334. Der Sensor gibt eine relativ kleine Spannung (oft < 0,1 mV) aus, die in der Regel erst verstärkt werden muss. Neben dem eigentlichen Strahlungssensor gibt es noch eine Möglichkeit die Temperatur des Sensors selbst zu messen, um die Abstrahlung des Sensor zu kompensieren.

Zu finden sind solche Sensoren z.B. in Infrarotthermometern.

https://rn-wissen.de/wiki/index.php/Sensorarten#PIR_Passiv_Infrarot_Sensoren



Bildsensoren (Video)

Insbesondere bildgebende Sensoren sind dabei, auf der Basis des sichtbaren Lichts oder auch des Infrarotbereichs Einzug in das Fahrzeug zu halten. Sie können dort der Innenraumbeobachtung dienen, sind aber vor allem zur Umfeldbeobachtung auch nach außen gerichtet.

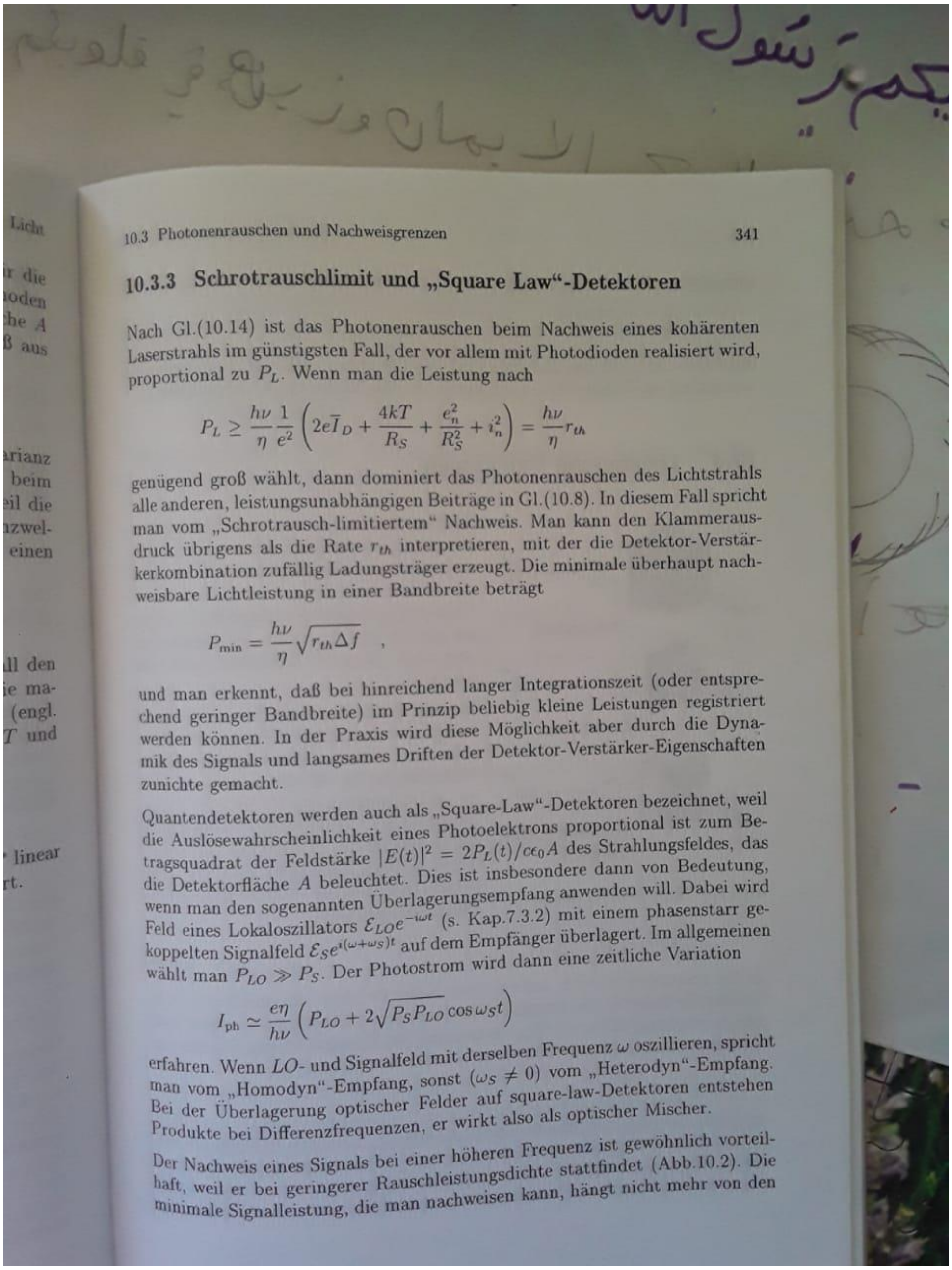
Mit diesen Sensoren wird versucht, die überlegene Fähigkeit des menschlichen Auges und der damit verbundenen mentalen Erkennung (vorerst noch in recht bescheidenem Maße) nachzubilden. Sie sind in der industriellen Messtechnik – insbesondere auch bei Handhabungsautomaten (Robotern) – bereits längst in großem Umfang eingeführt. Die Kosten der Bildsensoren und der zur Interpretation einer Szene erforderlichen, sehr leistungsstarken Prozessoren (DSP, digitaler Signalprozessor) sind bereits in den für Kfz-Anwendungen interessanten Bereich gekommen.

Gängige Bildsensoren sind im Gegensatz zum menschlichen Auge auch im nahen IR-Bereich (Wellenlänge ca. 1 µm) empfindlich. Mit einer entsprechenden, nicht sichtbaren IR-Ausleuchtung ist damit ohne weiteres für alle im Auto denkbaren

schlechten Sichtbedingungen (Dunkelheit, Nebel usw.) bietet.

Bildsensoren sind ein spezieller Fall von „Multisensorstrukturen" aus lichtempfindlichen Elementen (Fotodioden), die als Bildpunkte bzw. Pixel in Zeilen- oder Matrixform angeordnet sind und ihr Licht aus einer üblichen Abbildungsoptik erhalten. Bei den derzeit hauptsächlich verfügbaren Si-Bildsensoren (CCD, Charge-Coupled Devices, Bilder 1 und 2) werden durch das über eine transparente Elektrode einfallende Licht proportional zur Intensität und Belichtungszeit freie Ladungsträger erzeugt, die in einem „Potentialtopf" (Si-SiO_2-Grenzschicht) gesammelt werden. Mit weiteren Elektroden werden diese Ladungen in eine lichtundurchlässige Zone

1 CCD-Prinzip



10.3 Photonenrauschen und Nachweisgrenzen 341

10.3.3 Schrotrauschlimit und „Square Law“-Detektoren

Nach Gl.(10.14) ist das Photonenrauschen beim Nachweis eines kohärenten Laserstrahls im günstigsten Fall, der vor allem mit Photodioden realisiert wird, proportional zu P_L. Wenn man die Leistung nach

$$P_L \geq \frac{h\nu}{\eta}\frac{1}{e^2}\left(2e\overline{I}_D + \frac{4kT}{R_S} + \frac{e_n^2}{R_S^2} + i_n^2\right) = \frac{h\nu}{\eta} r_{th}$$

genügend groß wählt, dann dominiert das Photonenrauschen des Lichtstrahls alle anderen, leistungsunabhängigen Beiträge in Gl.(10.8). In diesem Fall spricht man vom „Schrotrausch-limitiertem“ Nachweis. Man kann den Klammerausdruck übrigens als die Rate r_{th} interpretieren, mit der die Detektor-Verstärkerkombination zufällig Ladungsträger erzeugt. Die minimale überhaupt nachweisbare Lichtleistung in einer Bandbreite beträgt

$$P_{\min} = \frac{h\nu}{\eta}\sqrt{r_{th}\Delta f} \quad ,$$

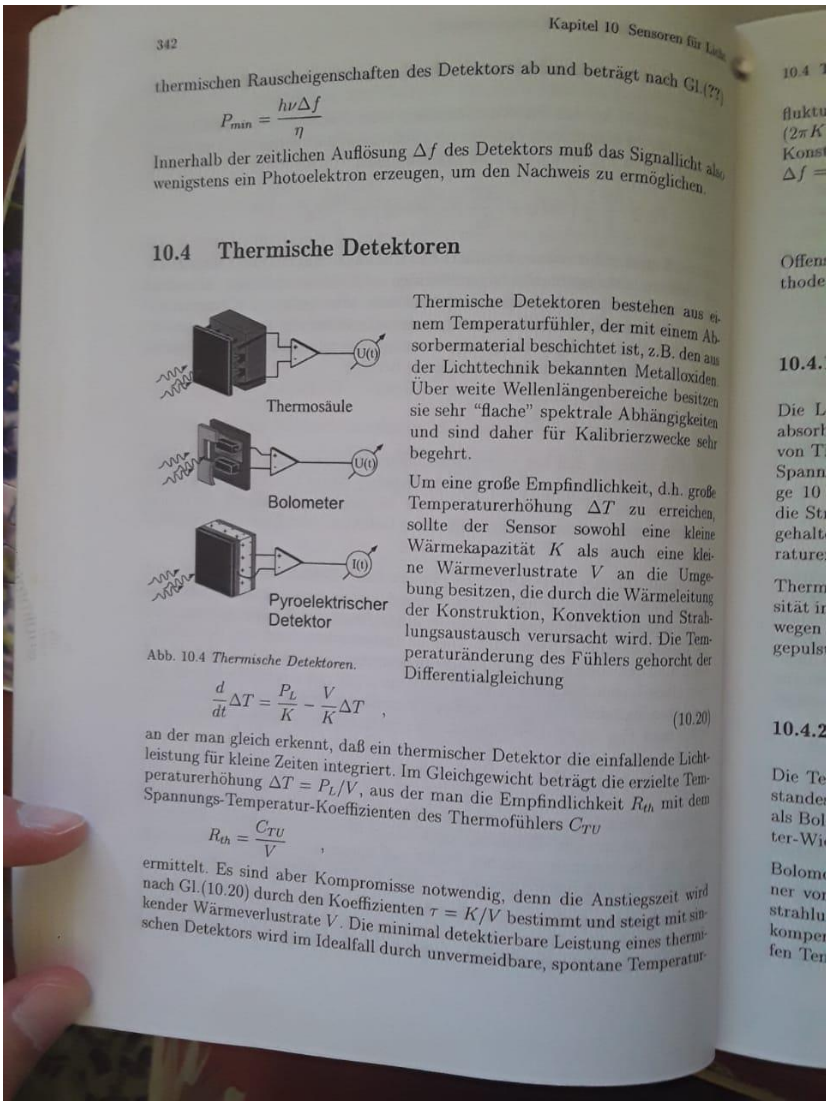
und man erkennt, daß bei hinreichend langer Integrationszeit (oder entsprechend geringer Bandbreite) im Prinzip beliebig kleine Leistungen registriert werden können. In der Praxis wird diese Möglichkeit aber durch die Dynamik des Signals und langsames Driften der Detektor-Verstärker-Eigenschaften zunichte gemacht.

Quantendetektoren werden auch als „Square-Law“-Detektoren bezeichnet, weil
die Auslösewahrscheinlichkeit eines Photoelektrons proportional ist zum Be-
tragsquadrat der Feldstärke $|E(t)|^2 = 2P_L(t)/c\epsilon_0 A$ des Strahlungsfeldes, das
die Detektorfläche A beleuchtet. Dies ist insbesondere dann von Bedeutung,
wenn man den sogenannten Überlagerungsempfang anwenden will. Dabei wird
Feld eines Lokaloszillators $\mathcal{E}_{LO}e^{-i\omega t}$ (s. Kap.7.3.2) mit einem phasenstarr ge-
koppelten Signalfeld $\mathcal{E}_S e^{i(\omega+\omega_S)t}$ auf dem Empfänger überlagert. Im allgemeinen
wählt man $P_{LO} \gg P_S$. Der Photostrom wird dann eine zeitliche Variation

$$I_{\text{ph}} \simeq \frac{e\eta}{h\nu}\left(P_{LO} + 2\sqrt{P_S P_{LO}}\cos\omega_S t\right)$$

erfahren. Wenn LO- und Signalfeld mit derselben Frequenz ω oszillieren, spricht
man vom „Homodyn“-Empfang, sonst ($\omega_S \neq 0$) vom „Heterodyn“-Empfang.
Bei der Überlagerung optischer Felder auf square-law-Detektoren entstehen
Produkte bei Differenzfrequenzen, er wirkt also als optischer Mischer.

Der Nachweis eines Signals bei einer höheren Frequenz ist gewöhnlich vorteil-
haft, weil er bei geringerer Rauschleistungsdichte stattfindet (Abb.10.2). Die
minimale Signalleistung, die man nachweisen kann, hängt nicht mehr von den



thermischen Rauscheigenschaften des Detektors ab und beträgt nach Gl.(??)

$$P_{min} = \frac{h\nu\Delta f}{\eta}$$

Innerhalb der zeitlichen Auflösung Δf des Detektors muß das Signallicht also wenigstens ein Photoelektron erzeugen, um den Nachweis zu ermöglichen.

10.4 Thermische Detektoren

Abb. 10.4 *Thermische Detektoren.*

Thermische Detektoren bestehen aus einem Temperaturfühler, der mit einem Absorbermaterial beschichtet ist, z.B. den aus der Lichttechnik bekannten Metalloxiden. Über weite Wellenlängenbereiche besitzen sie sehr "flache" spektrale Abhängigkeiten und sind daher für Kalibrierzwecke sehr begehrt.

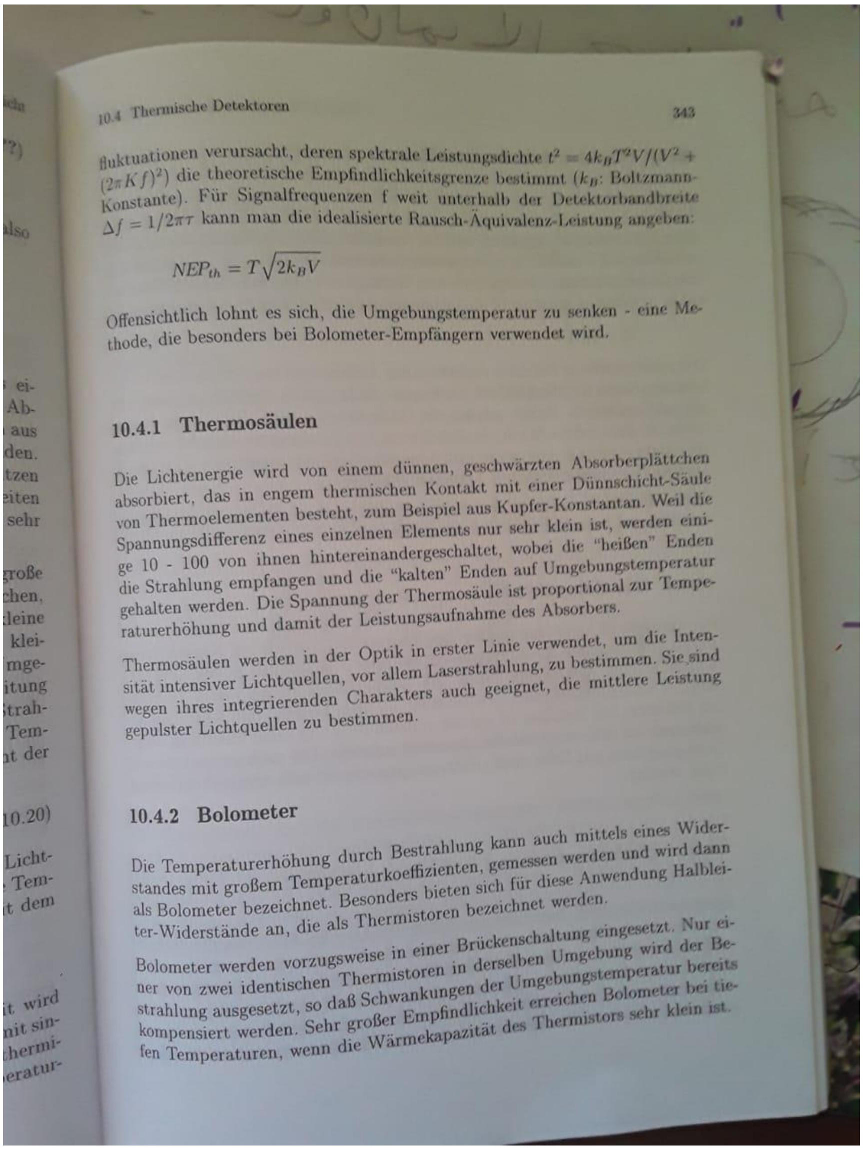
Um eine große Empfindlichkeit, d.h. große Temperaturerhöhung ΔT zu erreichen, sollte der Sensor sowohl eine kleine Wärmekapazität K als auch eine kleine Wärmeverlustrate V an die Umgebung besitzen, die durch die Wärmeleitung der Konstruktion, Konvektion und Strahlungsaustausch verursacht wird. Die Temperaturänderung des Fühlers gehorcht der Differentialgleichung

$$\frac{d}{dt}\Delta T = \frac{P_L}{K} - \frac{V}{K}\Delta T \quad , \tag{10.20}$$

an der man gleich erkennt, daß ein thermischer Detektor die einfallende Lichtleistung für kleine Zeiten integriert. Im Gleichgewicht beträgt die erzielte Temperaturerhöhung $\Delta T = P_L/V$, aus der man die Empfindlichkeit R_{th} mit dem Spannungs-Temperatur-Koeffizienten des Thermofühlers C_{TU}

$$R_{th} = \frac{C_{TU}}{V} \quad ,$$

ermittelt. Es sind aber Kompromisse notwendig, denn die Anstiegszeit wird nach Gl.(10.20) durch den Koeffizienten $\tau = K/V$ bestimmt und steigt mit sinkender Wärmeverlustrate V. Die minimal detektierbare Leistung eines thermischen Detektors wird im Idealfall durch unvermeidbare, spontane Temperatur-



10.4 Thermische Detektoren 343

fluktuationen verursacht, deren spektrale Leistungsdichte $t^2 = 4k_BT^2V/(V^2 + (2\pi Kf)^2)$ die theoretische Empfindlichkeitsgrenze bestimmt (k_B: Boltzmann-Konstante). Für Signalfrequenzen f weit unterhalb der Detektorbandbreite $\Delta f = 1/2\pi\tau$ kann man die idealisierte Rausch-Äquivalenz-Leistung angeben:

$$NEP_{th} = T\sqrt{2k_BV}$$

Offensichtlich lohnt es sich, die Umgebungstemperatur zu senken - eine Methode, die besonders bei Bolometer-Empfängern verwendet wird.

10.4.1 Thermosäulen

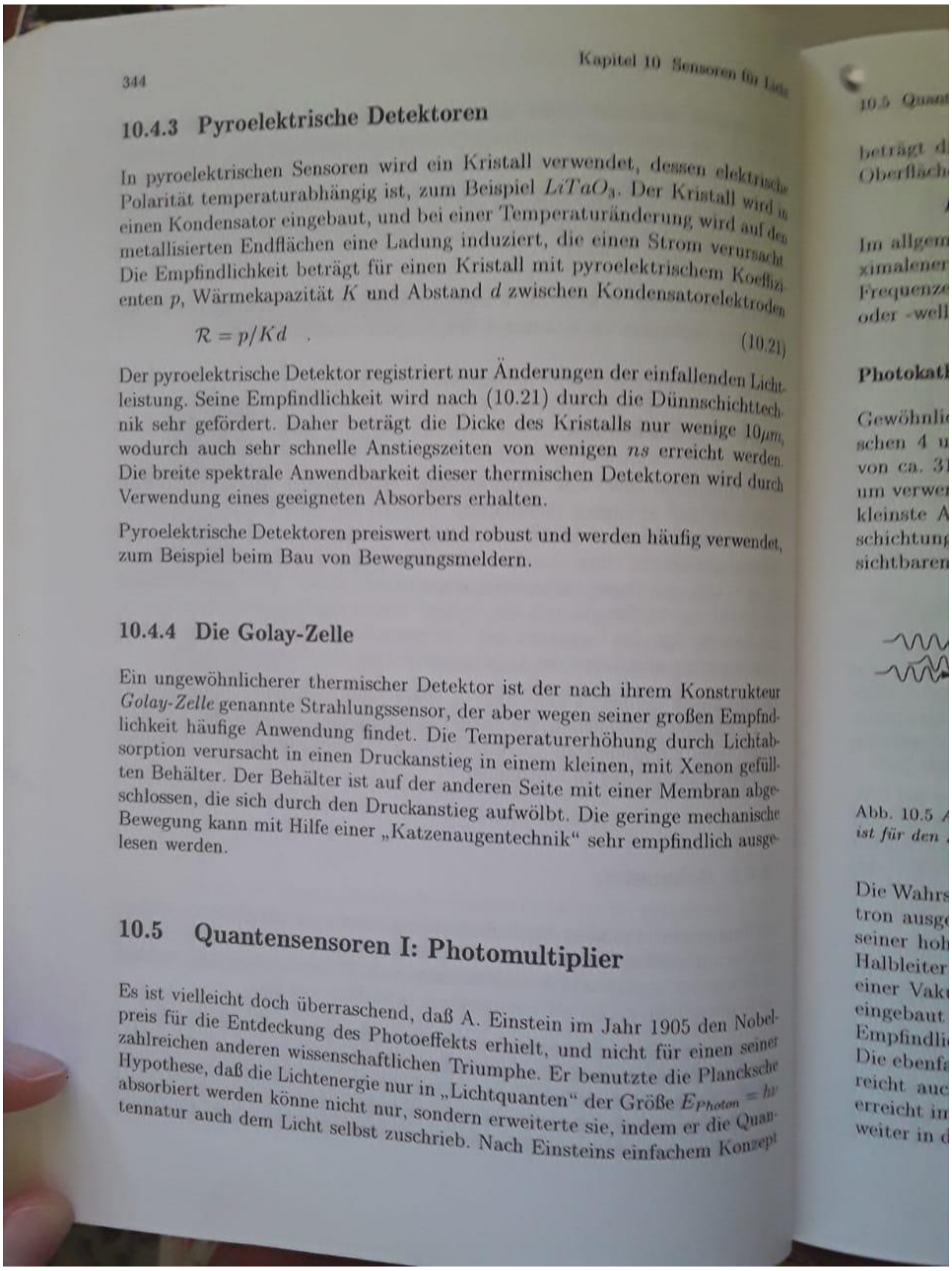
Die Lichtenergie wird von einem dünnen, geschwärzten Absorberplättchen absorbiert, das in engem thermischen Kontakt mit einer Dünnschicht-Säule von Thermoelementen besteht, zum Beispiel aus Kupfer-Konstantan. Weil die Spannungsdifferenz eines einzelnen Elements nur sehr klein ist, werden einige 10 - 100 von ihnen hintereinandergeschaltet, wobei die "heißen" Enden die Strahlung empfangen und die "kalten" Enden auf Umgebungstemperatur gehalten werden. Die Spannung der Thermosäule ist proportional zur Tempe-raturerhöhung und damit der Leistungsaufnahme des Absorbers.

Thermosäulen werden in der Optik in erster Linie verwendet, um die Intensität intensiver Lichtquellen, vor allem Laserstrahlung, zu bestimmen. Sie sind wegen ihres integrierenden Charakters auch geeignet, die mittlere Leistung gepulster Lichtquellen zu bestimmen.

10.4.2 Bolometer

Die Temperaturerhöhung durch Bestrahlung kann auch mittels eines Wider-standes mit großem Temperaturkoeffizienten, gemessen werden und wird dann als Bolometer bezeichnet. Besonders bieten sich für diese Anwendung Halblei-ter-Widerstände an, die als Thermistoren bezeichnet werden.

Bolometer werden vorzugsweise in einer Brückenschaltung eingesetzt. Nur ei-ner von zwei identischen Thermistoren in derselben Umgebung wird der Be-strahlung ausgesetzt, so daß Schwankungen der Umgebungstemperatur bereits kompensiert werden. Sehr großer Empfindlichkeit erreichen Bolometer bei tie-fen Temperaturen, wenn die Wärmekapazität des Thermistors sehr klein ist.



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10.4.3 Pyroelektrische Detektoren

In pyroelektrischen Sensoren wird ein Kristall verwendet, dessen elektrische Polarität temperaturabhängig ist, zum Beispiel $LiTaO_3$. Der Kristall wird in einen Kondensator eingebaut, und bei einer Temperaturänderung wird auf den metallisierten Endflächen eine Ladung induziert, die einen Strom verursacht. Die Empfindlichkeit beträgt für einen Kristall mit pyroelektrischem Koeffizienten p, Wärmekapazität K und Abstand d zwischen Kondensatorelektroden

$$\mathcal{R} = p/Kd \quad . \tag{10.21}$$

Der pyroelektrische Detektor registriert nur Änderungen der einfallenden Lichtleistung. Seine Empfindlichkeit wird nach (10.21) durch die Dünnschichttechnik sehr gefördert. Daher beträgt die Dicke des Kristalls nur wenige $10\mu m$, wodurch auch sehr schnelle Anstiegszeiten von wenigen ns erreicht werden. Die breite spektrale Anwendbarkeit dieser thermischen Detektoren wird durch Verwendung eines geeigneten Absorbers erhalten.

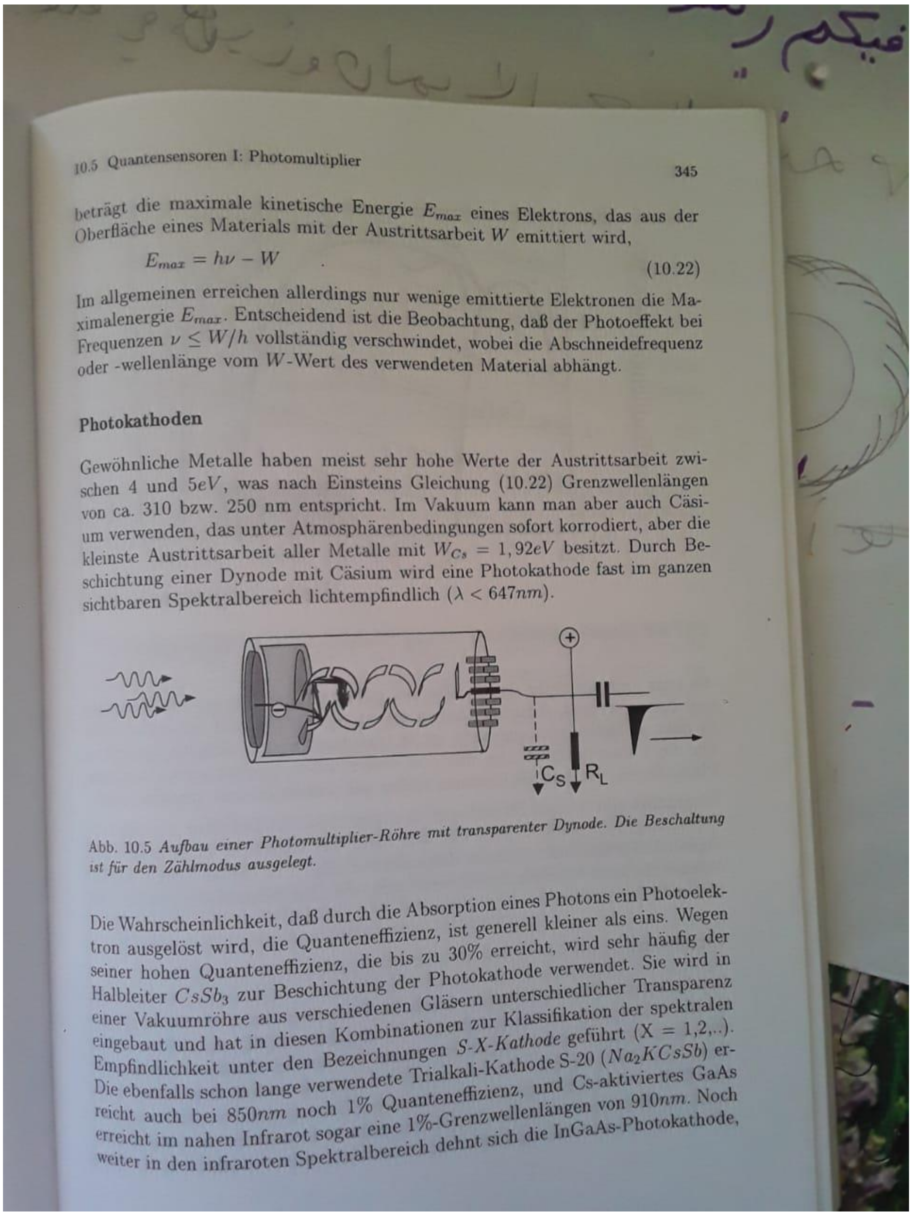
Pyroelektrische Detektoren preiswert und robust und werden häufig verwendet, zum Beispiel beim Bau von Bewegungsmeldern.

10.4.4 Die Golay-Zelle

Ein ungewöhnlicherer thermischer Detektor ist der nach ihrem Konstrukteur *Golay-Zelle* genannte Strahlungssensor, der aber wegen seiner großen Empfindlichkeit häufige Anwendung findet. Die Temperaturerhöhung durch Lichtabsorption verursacht in einen Druckanstieg in einem kleinen, mit Xenon gefüllten Behälter. Der Behälter ist auf der anderen Seite mit einer Membran abgeschlossen, die sich durch den Druckanstieg aufwölbt. Die geringe mechanische Bewegung kann mit Hilfe einer „Katzenaugentechnik" sehr empfindlich ausgelesen werden.

10.5 Quantensensoren I: Photomultiplier

Es ist vielleicht doch überraschend, daß A. Einstein im Jahr 1905 den Nobelpreis für die Entdeckung des Photoeffekts erhielt, und nicht für einen seiner zahlreichen anderen wissenschaftlichen Triumphe. Er benutzte die Plancksche Hypothese, daß die Lichtenergie nur in „Lichtquanten" der Größe $E_{Photon} = h\nu$ absorbiert werden könne nicht nur, sondern erweiterte sie, indem er die Quantennatur auch dem Licht selbst zuschrieb. Nach Einsteins einfachem Konzept



beträgt die maximale kinetische Energie E_{max} eines Elektrons, das aus der Oberfläche eines Materials mit der Austrittsarbeit W emittiert wird,

$$E_{max} = h\nu - W \tag{10.22}$$

Im allgemeinen erreichen allerdings nur wenige emittierte Elektronen die Maximalenergie E_{max}. Entscheidend ist die Beobachtung, daß der Photoeffekt bei Frequenzen $\nu \leq W/h$ vollständig verschwindet, wobei die Abschneidefrequenz oder -wellenlänge vom W-Wert des verwendeten Material abhängt.

Photokathoden

Gewöhnliche Metalle haben meist sehr hohe Werte der Austrittsarbeit zwischen 4 und $5eV$, was nach Einsteins Gleichung (10.22) Grenzwellenlängen von ca. 310 bzw. 250 nm entspricht. Im Vakuum kann man aber auch Cäsium verwenden, das unter Atmosphärenbedingungen sofort korrodiert, aber die kleinste Austrittsarbeit aller Metalle mit $W_{Cs} = 1,92eV$ besitzt. Durch Beschichtung einer Dynode mit Cäsium wird eine Photokathode fast im ganzen sichtbaren Spektralbereich lichtempfindlich ($\lambda < 647nm$).

Abb. 10.5 *Aufbau einer Photomultiplier-Röhre mit transparenter Dynode. Die Beschaltung ist für den Zählmodus ausgelegt.*

Die Wahrscheinlichkeit, daß durch die Absorption eines Photons ein Photoelektron ausgelöst wird, die Quanteneffizienz, ist generell kleiner als eins. Wegen seiner hohen Quanteneffizienz, die bis zu 30% erreicht, wird sehr häufig der Halbleiter $CsSb_3$ zur Beschichtung der Photokathode verwendet. Sie wird in einer Vakuumröhre aus verschiedenen Gläsern unterschiedlicher Transparenz eingebaut und hat in diesen Kombinationen zur Klassifikation der spektralen Empfindlichkeit unter den Bezeichnungen *S-X-Kathode* geführt (X = 1,2,..). Die ebenfalls schon lange verwendete Trialkali-Kathode S-20 (Na_2KCsSb) erreicht auch bei $850nm$ noch 1% Quanteneffizienz, und Cs-aktiviertes GaAs erreicht im nahen Infrarot sogar eine 1%-Grenzwellenlängen von $910nm$. Noch weiter in den infraroten Spektralbereich dehnt sich die InGaAs-Photokathode, wenn nicht nur die Anstiegszeit, sondern auch die durch Laufzeiten im Detektor bedingte Verzögerungszeit eine Rolle spielt.

Mikrokanalplatten und Channeltrons

Bei den „Mikrokanalplatten“ (MCP, von engl. *micro channel plate*) handelt es sich eigentlich um eine Variante des Sekundärelektronenvervielfacher: Ein einzelner Mikrokanal besteht aus einer Glaskapillarröhre von 6 -20 μm Durchmesser. Die Wand ist mit einem Halbleitermaterial (z.B. Ni-Cr) beschichtet, das eine verhältnismäßig geringe Leitfähigkeit besitzt. Die Enden des Röhrchens werden metallisiert und dienen als Photokathode bzw. Anode; eine Hochspannung fällt entlang der Wandung ab und erzeugt eine „kontinuierliche Dynode“. Diese Sekundärelektronenvervielfacher sind auch unter dem Namen *Channeltron* bekannt. Sie können durch geeignete Beschichtung der Eingangsfläche in sehr kompakte Photomultiplier verwandelt werden. Ihr Nachteil ist das Sättigungsverhalten, das wegen des hohen Wandwiderstandes im allgemeinen früher als bei Photomultiplier-Röhren einsetzt.

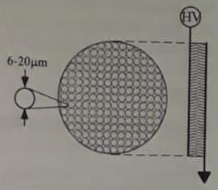
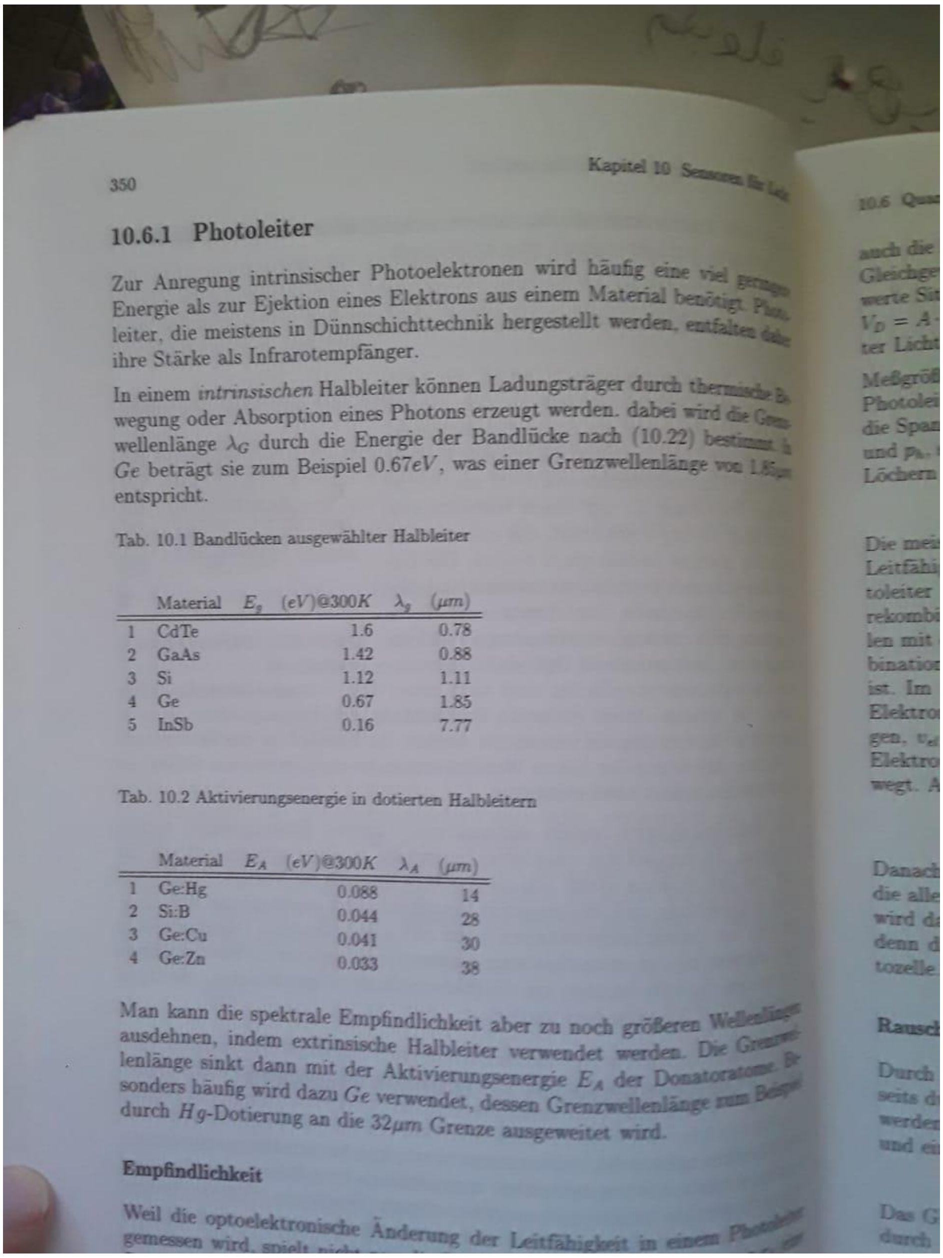


Abb. 10.7 *Mikrokanalplatten, schematisch.*

Eine Mikrokanalplatte besteht aus mehreren Tausend dichtgepackten Kapillarröhren, die parallel von einer Spannungsquelle versorgt werden und wie ein Feld von *SEV*-Röhren wirkt. Als *MCP-PMT*s besitzen sie Vorteile durch ihre hohe Zeitauflösung und ihre geringere Empfindlichkeit gegen magnetische Felder (die das Verstärkungsverhalten jeden *SEV*s beeinflussen). Darüberhinaus aber erlauben sie den ortsaufgelösten Nachweis sehr geringer Lichtintensitäten und werden deshalb benutzt, um die Bildverstärker zu konstruieren, die unter Abschnitt 10.7.3 besprochen werden.

10.6 Quantensensoren II: Halbleitersensoren

In Halbleitern müssen die Elektronen nicht aus dem Material herausgeschlagen werden, sondern können dort selbst bewegliche Ladungsträger erzeugen. Der innere Photoeffekt wird in zwei unterschiedlichen Typen von Photodetektoren genutzt, den *Photoleitern* und den *Photodioden*. In Photoleitern wird die photoelektrische Veränderung der Leitfähigkeit gemessen, während Photodioden Quellen eines Photostromes sind.



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10.6.1 Photoleiter

Zur Anregung intrinsischer Photoelektronen wird häufig eine viel geringere Energie als zur Ejektion eines Elektrons aus einem Material benötigt. Photoleiter, die meistens in Dünnschichttechnik hergestellt werden, entfalten daher ihre Stärke als Infrarotempfänger.

In einem *intrinsischen* Halbleiter können Ladungsträger durch thermische Bewegung oder Absorption eines Photons erzeugt werden. dabei wird die Grenzwellenlänge λ_G durch die Energie der Bandlücke nach (10.22) bestimmt. In Ge beträgt sie zum Beispiel $0.67eV$, was einer Grenzwellenlänge von $1.85\mu m$ entspricht.

Tab. 10.1 Bandlücken ausgewählter Halbleiter

	Material	E_g (eV)@$300K$	λ_g (μm)
1	CdTe	1.6	0.78
2	GaAs	1.42	0.88
3	Si	1.12	1.11
4	Ge	0.67	1.85
5	InSb	0.16	7.77

Tab. 10.2 Aktivierungsenergie in dotierten Halbleitern

	Material	E_A (eV)@$300K$	λ_A (μm)
1	Ge:Hg	0.088	14
2	Si:B	0.044	28
3	Ge:Cu	0.041	30
4	Ge:Zn	0.033	38

Man kann die spektrale Empfindlichkeit aber zu noch größeren Wellenlängen ausdehnen, indem extrinsische Halbleiter verwendet werden. Die Grenzwellenlänge sinkt dann mit der Aktivierungsenergie E_A der Donatoratome. Besonders häufig wird dazu Ge verwendet, dessen Grenzwellenlänge zum Beispiel durch Hg-Dotierung an die $32\mu m$ Grenze ausgeweitet wird.

Empfindlichkeit

Weil die optoelektronische Änderung der Leitfähigkeit in einem Photoleiter gemessen wird, spielt nicht ...

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rate bestimmt, die wiederum ein Zufallsmechanismus ist. Das Schrotrauschen eines Photoleiters wird als *Generations-Rekombinations-Rauschen* bezeichnet und ist um den Faktor 2 größer als im Photomultiplier oder in der Photodiode.

$$\overline{i_{GR}^2} = 4e\bar{I}\frac{\tau_{rec}}{\tau_d} \quad .$$

Die Detektivität ist bei Wellenlängen um $10\mu m$ und darüber im allgemeinen durch den thermischen Strahlungsuntergrund limitiert. Reale Detektoren erreichen diese Grenze weitgehend.

10.6.2 Photodioden oder Photovoltaische Detektoren

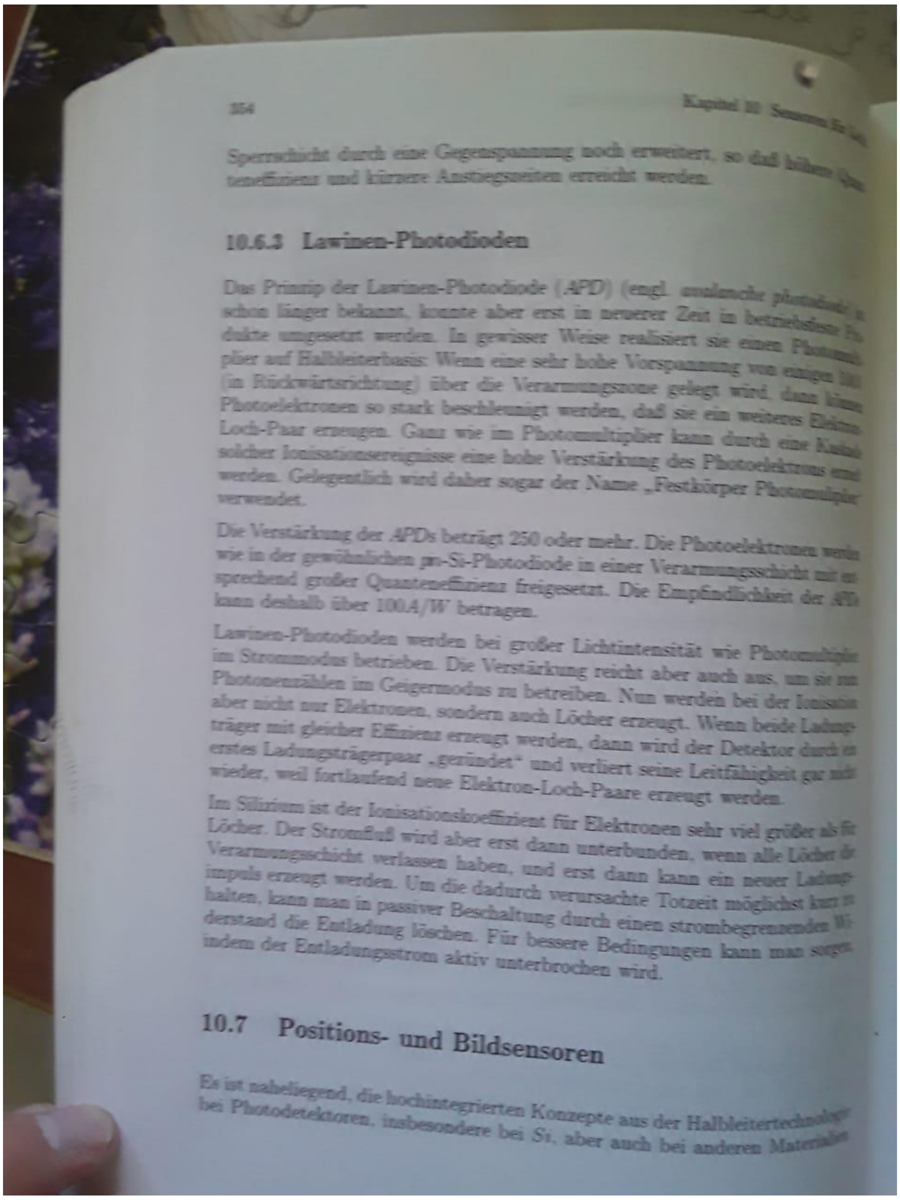
Halbleiter-Photodioden gehören zu den verbreitetsten optischen Detektoren überhaupt, weil sie kompakte Komponenten sind und über viele wünschenswerte physikalische Eigenschaften verfügen, zu denen hohe Empfindlichkeit, schnelle Anstiegszeit und großer dynamischer Bereich zählen. Außerdem werden sie in ungezählten Bauformen hergestellt und passen nahtlos zur elektronischen Halbleitertechnologie.

Ihre Wirkung beruht auf einer *pn*-Grenzschicht, in der Elektron-Loch-Paare, die durch Absorption von Licht in der Grenzschicht erzeugt werden, von einem inneren elektrischen Feld beschleunigt werden und dadurch einen Stromfluß im Meßkreis verursachen. Die Grenzschicht wirkt als Stromquelle mit hohem Innenwiderstand.

pn- und pin-Dioden

Die Entstehung der Verarmungsschicht in der Nähe des pn-Übergangs ist in Abb.10.8 dargestellt. Löcher des p-dotierten bzw. Elektronen des n-dotierten Materials diffundieren auf die jeweils andere Seite und rekombinieren dort. Die Löcher verursachen eine positive Raumladungszone auf der n-Seite; die Elektronen, die im allgemeinen beweglicher sind als Löcher, die entsprechende negative, weiter ausgedehnte Zone auf der p-Seite. Der Vorgang endet, wenn das durch die Raumladung verursachte elektrische Feld die Diffusion der Elektronen bzw. Löcher verhindert. Eine Si-Diode erzeugt in der Verarmungsschicht den bekannten Spannungsabfall von $0,7V$.

Die Konstruktion einer effizienten Photodiode muß zum Ziel haben, möglichst viel Licht in der Randschicht zu absorbieren, so daß das elektrische Feld, das noch durch eine äußere Gegenspannung verstärkt werden kann, die Elektron-Loch-Paare schnell trennt und einen Stromfluß verursacht. Anders als in einem Photoleiter kann dann keine



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Sperrschicht durch eine Gegenspannung noch erweitert, so daß höhere Quantenefﬁzienz und kürzere Anstiegszeiten erreicht werden.

10.6.3 Lawinen-Photodioden

Das Prinzip der Lawinen-Photodiode (*APD*) (engl. *avalanche photodiode*) ist schon länger bekannt, konnte aber erst in neuerer Zeit in betriebsfeste Produkte umgesetzt werden. In gewisser Weise realisiert sie einen Photomultiplier auf Halbleiterbasis: Wenn eine sehr hohe Vorspannung von einigen 100 (in Rückwärtsrichtung) über die Verarmungszone gelegt wird, dann können Photoelektronen so stark beschleunigt werden, daß sie ein weiteres Elektron-Loch-Paar erzeugen. Ganz wie im Photomultiplier kann durch eine Kaskade solcher Ionisationsereignisse eine hohe Verstärkung des Photoelektrons erzielt werden. Gelegentlich wird daher sogar der Name „Festkörper Photomultiplier" verwendet.

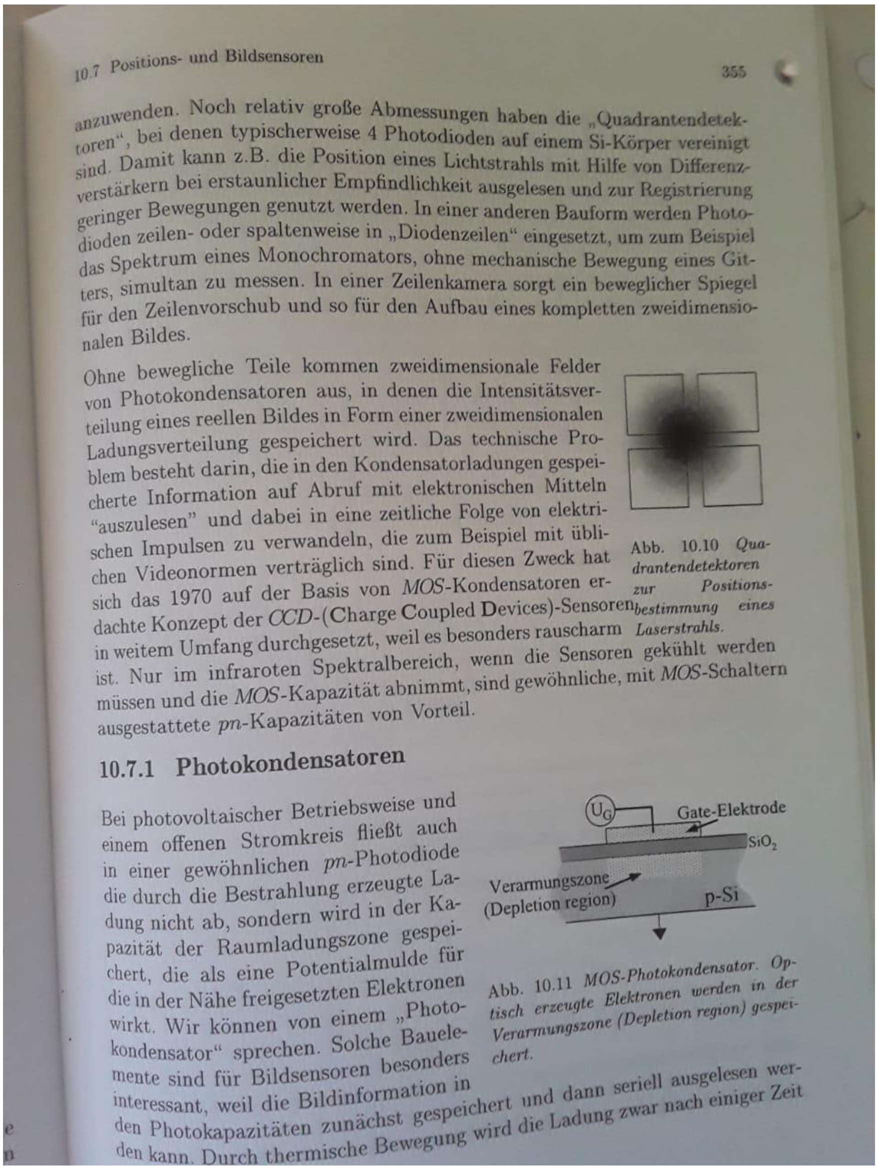
Die Verstärkung der *APDs* beträgt 250 oder mehr. Die Photoelektronen werden wie in der gewöhnlichen *pn*-Si-Photodiode in einer Verarmungsschicht mit entsprechend großer Quantenefﬁzienz freigesetzt. Die Empﬁndlichkeit der *APDs* kann deshalb über $100 A/W$ betragen.

Lawinen-Photodioden werden bei großer Lichtintensität wie Photomultiplier im Strommodus betrieben. Die Verstärkung reicht aber auch aus, um sie zum Photonenzählen im Geigermodus zu betreiben. Nun werden bei der Ionisation aber nicht nur Elektronen, sondern auch Löcher erzeugt. Wenn beide Ladungsträger mit gleicher Efﬁzienz erzeugt werden, dann wird der Detektor durch ein erstes Ladungsträgerpaar „gezündet" und verliert seine Leitfähigkeit gar nicht wieder, weil fortlaufend neue Elektron-Loch-Paare erzeugt werden.

Im Silizium ist der Ionisationskoefﬁzient für Elektronen sehr viel größer als für Löcher. Der Stromﬂuß wird aber erst dann unterbunden, wenn alle Löcher die Verarmungsschicht verlassen haben, und erst dann kann ein neuer Ladungsimpuls erzeugt werden. Um die dadurch verursachte Totzeit möglichst kurz zu halten, kann man in passiver Beschaltung durch einen strombegrenzenden Widerstand die Entladung löschen. Für bessere Bedingungen kann man sorgen, indem der Entladungsstrom aktiv unterbrochen wird.

10.7 Positions- und Bildsensoren

Es ist naheliegend, die hochintegrierten Konzepte aus der Halbleitertechnologie bei Photodetektoren, insbesondere bei *Si*, aber auch bei anderen Materialien



anzuwenden. Noch relativ große Abmessungen haben die „Quadrantendetektoren“, bei denen typischerweise 4 Photodioden auf einem Si-Körper vereinigt sind. Damit kann z.B. die Position eines Lichtstrahls mit Hilfe von Differenzverstärkern bei erstaunlicher Empfindlichkeit ausgelesen und zur Registrierung geringer Bewegungen genutzt werden. In einer anderen Bauform werden Photodioden zeilen- oder spaltenweise in „Diodenzeilen“ eingesetzt, um zum Beispiel das Spektrum eines Monochromators, ohne mechanische Bewegung eines Gitters, simultan zu messen. In einer Zeilenkamera sorgt ein beweglicher Spiegel für den Zeilenvorschub und so für den Aufbau eines kompletten zweidimensionalen Bildes.

Ohne bewegliche Teile kommen zweidimensionale Felder von Photokondensatoren aus, in denen die Intensitätsverteilung eines reellen Bildes in Form einer zweidimensionalen Ladungsverteilung gespeichert wird. Das technische Problem besteht darin, die in den Kondensatorladungen gespeicherte Information auf Abruf mit elektronischen Mitteln "auszulesen" und dabei in eine zeitliche Folge von elektrischen Impulsen zu verwandeln, die zum Beispiel mit üblichen Videonormen verträglich sind. Für diesen Zweck hat sich das 1970 auf der Basis von *MOS*-Kondensatoren erdachte Konzept der *CCD*-(**C**harge **C**oupled **D**evices)-Sensoren in weitem Umfang durchgesetzt, weil es besonders rauscharm ist. Nur im infraroten Spektralbereich, wenn die Sensoren gekühlt werden müssen und die *MOS*-Kapazität abnimmt, sind gewöhnliche, mit *MOS*-Schaltern ausgestattete *pn*-Kapazitäten von Vorteil.

Abb. 10.10 *Quadrantendetektoren zur Positionsbestimmung eines Laserstrahls.*

10.7.1 Photokondensatoren

Bei photovoltaischer Betriebsweise und einem offenen Stromkreis fließt auch in einer gewöhnlichen *pn*-Photodiode die durch die Bestrahlung erzeugte Ladung nicht ab, sondern wird in der Kapazität der Raumladungszone gespeichert, die als eine Potentialmulde für die in der Nähe freigesetzten Elektronen wirkt. Wir können von einem „Photokondensator“ sprechen. Solche Bauelemente sind für Bildsensoren besonders interessant, weil die Bildinformation in den Photokapazitäten zunächst gespeichert und dann seriell ausgelesen werden kann. Durch thermische Bewegung wird die Ladung zwar nach einiger Zeit

Abb. 10.11 *MOS-Photokondensator. Optisch erzeugte Elektronen werden in der Verarmungszone (Depletion region) gespeichert.*

Schottky-Kontakt genannt wird, entsteht ein Potential verursacht, welches als Speicher für Elektronen dient.

Die MOS-Kondensatoren erreichen große Kapazitäten und verhindern dadurch, daß der Potentialtopf durch die gespeicherte Ladung reduziert wird und der Kondensator schon mit wenigen Photoelektronen oder -löchern sättigt. Ein Modell eines *MOS*-Kondensators, der aus einem metallischen oder polykristallinen Silizium-Gate, einer SiO_2-Oxidschicht und p-Si besteht, ist in Abb.10.11 gezeigt. Daran ist insbesondere zu erkennen, daß bei positiver Gatespannung U_G ein Potentialtopf für Elektronen in unmittelbarer Nachbarschaft der Oxid-Halbleiter-Grenzschicht entsteht. In der Raumladungszone freigesetzte Elektronen können befreit werden, indem die Gatespannung wieder herabgesetzt wird. Die Speicherzeit der Photokondensatoren ist begrenzt durch thermische Relaxation und variiert bei Raumtemperatur von s bis zu mehreren min.

10.7.2 CCD-Sensoren

Das Herz digitaler Kameras ist der CCD-Chip, der eine zur Intensität der einfallenden Strahlung proportionale Ladung erzeugt und in Photokondensatoren speichert, bis sie durch eine Steuerelektronik abgerufen werden [15]. Gegenüber der Photoplatte hat die CCD-Kamera die Vorteile eines großen linearen Bereiches, hoher Quanteneffizienz von 50-80% und die direkte Erzeugung eines Spannungssignals, das digitalisiert und im Computer verarbeitet werden kann.

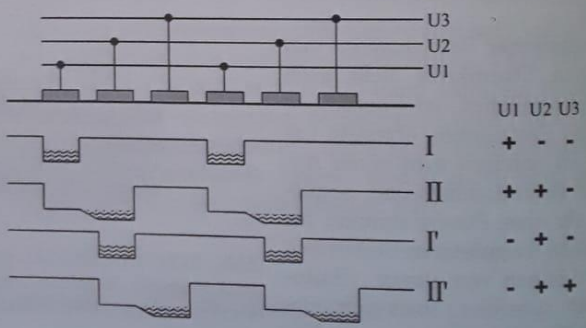


Abb. 10.12 *Drei-Phasen-Betrieb einer CCD-Zeile.*

Der Schlüssel für den Erfolg der *CCD*-Sensoren ist die Auslesemethodik, die geringer als 10 ... gelangen selbst bei vielen hundert Taktschritten im ... übertragung ist im Mittel Allgemeinen mehr als 99,99% des Ladungsinhaltes eines Pixels an zum Ausleseverstärker. Bei einer digitalen Auflösung von 12 Bit wird damit noch nicht einmal der Digitalisierungsfehler erreicht!

Ein Bildsensor muß zeilenweise ausgelesen werden. Um aber zu verhindern, daß dadurch eine lange Totzeit entsteht und außerdem noch weiter Ladungen akkumuliert werden, bestehen die *CCD*-Sensoren aus einer beleuchteten „Bild-zone" und einer unbeleuchteten „Speicherzone". Die Aufnahme eines Bilde wird beendet, indem alle Spalten der beleuchteten Hälfte parallel und inner halb $1ms$ in die angrenzende Speicherzone verschoben werden. Während si von dort zeilenweise über ein Ausleseregister sukzessive zum Ausleseverstärke befördert werden, kann in der beleuchteten Hälfte schon das nächste Bild r gistriert werden.

Die Empfindlichkeit eines CCD-Sensors wird durch die Rauscheigenschaft jedes einzelnen Pixels bestimmt, die einerseits von der Schwankung der the misch erzeugten Elektronen abhängen, andererseits aber meistens durch d sogenannte „Ausleserauschen" dominiert werden, das dem Ladungsinhalt ei Pixels durch den Ausleseverstärker hinzugefügt wird. Weil dieser Rauschb trag nur einmal pro Auslesevorgang auftritt, ist es häufig günstig, solange möglich photoelektronisch erzeugte Ladungen auf dem Sensor zu akkumul ren. dabei sind allerdings nur langsame Bildfolgen zu erzielen. Die Rauscheig schaften eines CCD-Sensors werden häufig in der Einheit „Elektronen/Pix angegeben, wodurch die rms-Breite des Dunkelstroms gemeint ist.

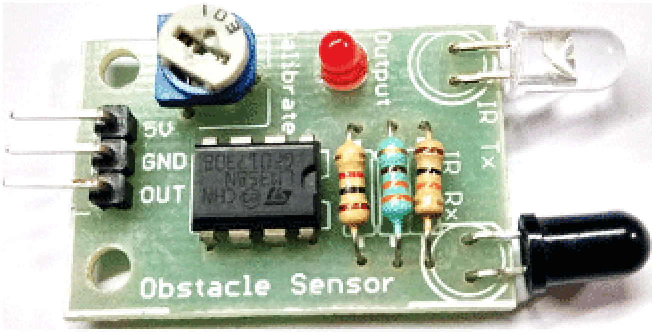
Die räumliche Auflösung eines *CCD*-Sensors wird durch die Größe der Pixel stimmt, deren Kantenlänge heute einige μm bis 25 μm beträgt. Selbstverstä lich kann die Auflösung aber nicht besser sein als das optische Abbildung stem, das Kameraobjektiv.

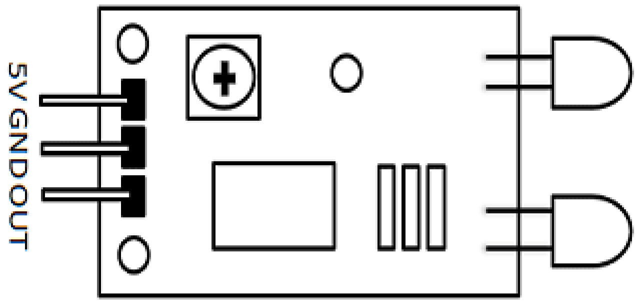
10.7.3 Bildverstärker

Bei Bildverstärkern werden die extrem empfindlichen Eigenschaften eines tomultipliers, die auf der Konversion von Licht in Elektronen beruht, in ortsauflösenden Detektoren eingesetzt. Das Anwendungspotential der verstärkerröhren und ihrer Varianten ist hoch, weil sie es nicht nur erla von extrem lichtschwachen Objekten Bilder anzufertigen, sondern weil sic

4 IR Sensor Module

30 August 2018 - 0 Comments





IR Sensor Module

IR Sensor Module Pinout

[Click the image to enlarge it]

4.1.1 Pin Configuration

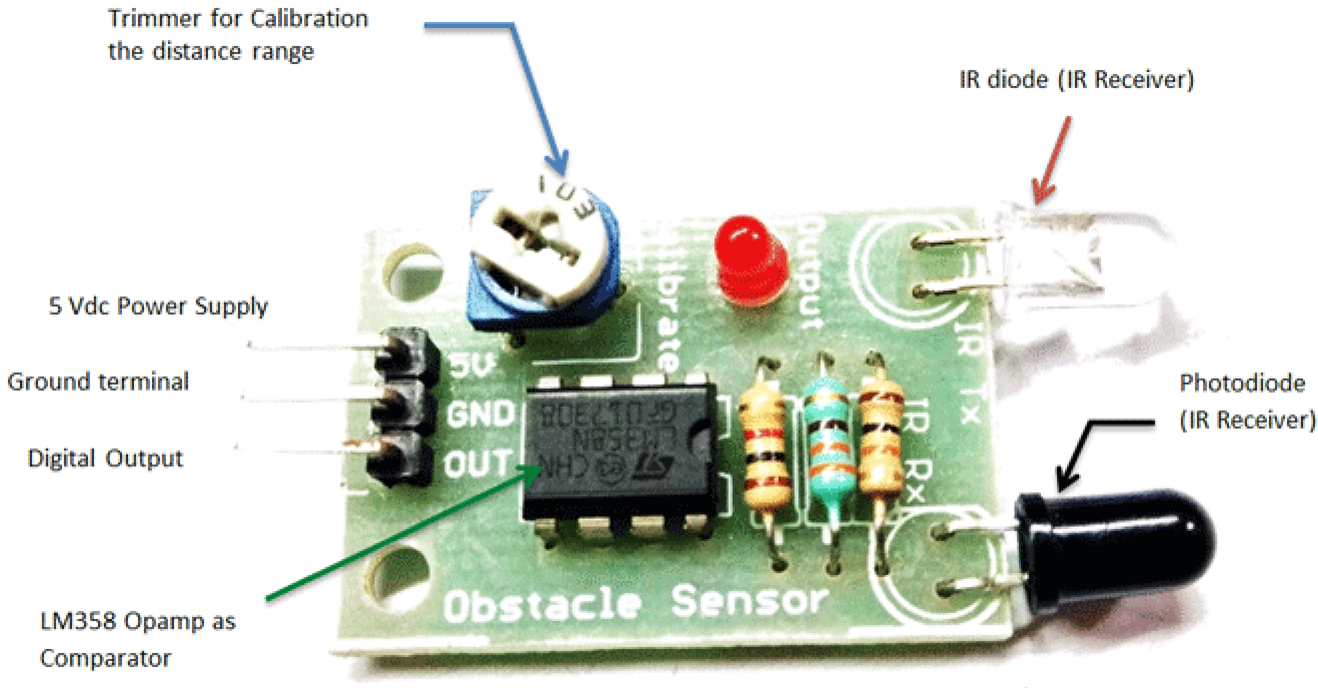
Pin Name	Description
VCC	Power Supply Input
GND	Power Supply Ground
OUT	Active High Output

4.1.2 IR Sensor Module Features

- 5VDC Operating voltage
- I/O pins are 5V and 3.3V compliant
- Range: Up to 20cm
- Adjustable Sensing range
- Built-in Ambient Light Sensor
- 20mA supply current

- Mounting hole

4.1.3 Brief about IR Sensor Module



The IR sensor module consists mainly of the IR Transmitter and Receiver, Opamp, Variable Resistor (Trimmer pot), output LED in brief.

IR LED Transmitter

IR LED emits light, in the range of Infrared frequency. IR light is invisible to us as its wavelength (700nm – 1mm) is much higher than the visible light range. IR LEDs have light emitting angle of approx. 20-60 degree and range of approx. few centimeters to several feets, it depends upon the type of IR transmitter and the manufacturer. Some transmitters have the range in kilometers. IR LED white or transparent in colour, so it can give out amount of maximum light.

Photodiode Receiver

Photodiode acts as the IR receiver as its conducts when light falls on it. Photodiode is a semiconductor which has a P-N junction, operated in Reverse Bias, means it start conducting the current in reverse direction when Light falls on it, and the amount of current flow is proportional to the amount of Light. This property makes it useful for IR detection. Photodiode looks like a LED, with a black colour coating on its outer side, Black colour absorbs the highest amount of light.

LM358 Opamp

LM358 is an Operational Amplifier (Op-Amp) is used as voltage comparator in the IR sensor. the comparator will compare the threshold voltage set using the preset (pin2) and the photodiode's series resistor voltage (pin3).

Photodiode's series resistor voltage drop > Threshold voltage = Opamp output is High

Photodiode's series resistor voltage drop < Threshold voltage = Opamp output is Low

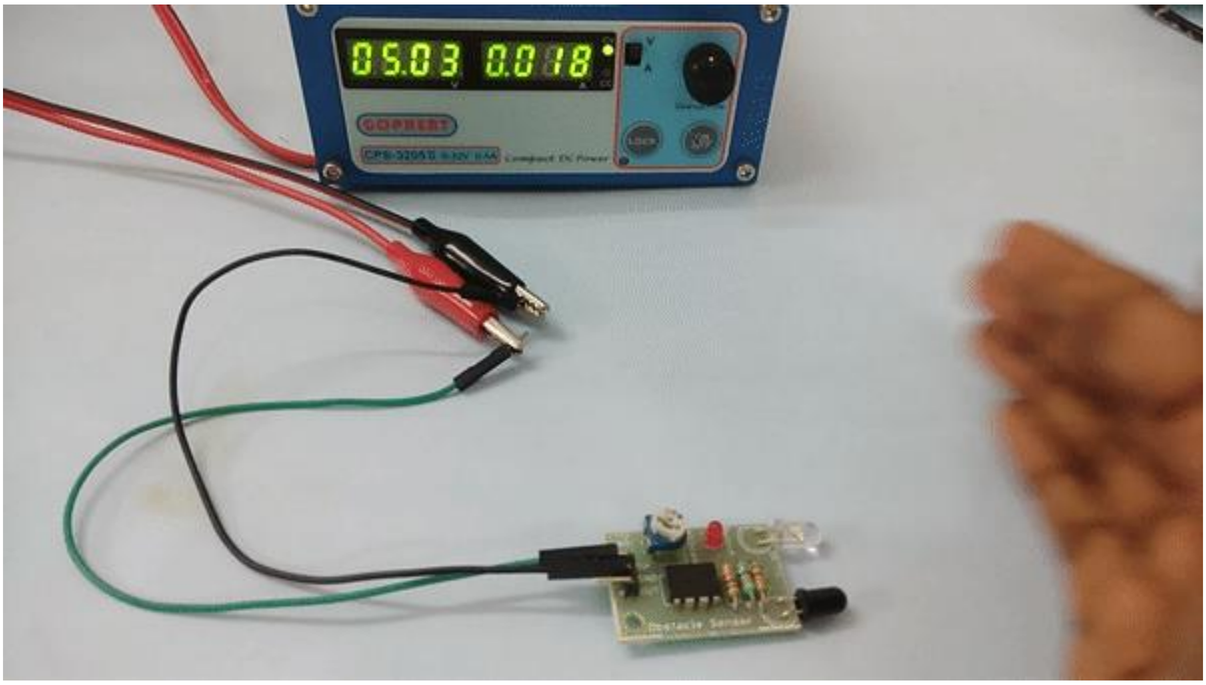
When Opamp's output is **high** the LED at the Opamp output terminal **turns ON** (Indicating the detection of Object).

Variable Resistor

The variable resistor used here is a preset. It is used to calibrate the distance range at which object should be detected.

4.1.4 How to Use IR Sensor Module?

The 5 VDC supply input is given to the VCC pin and the supply negative is connected to the GND terminal of the module. When no object is detected within the range of the IR receiver, the output LED remains off.



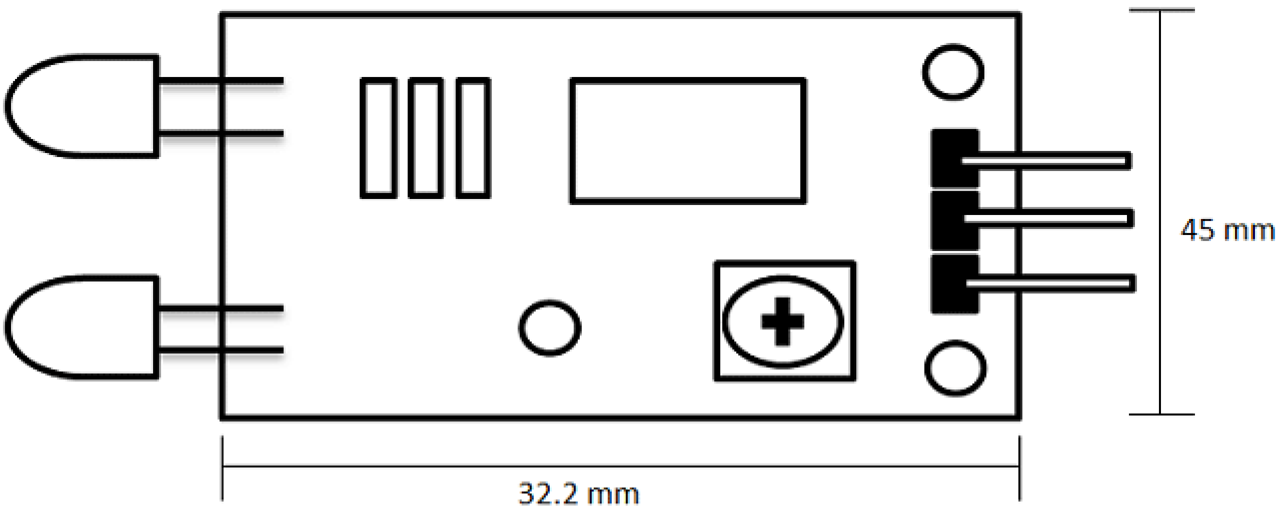
When a **object is detected** within the range of the IR sensor the LED glows.

4.1.5 Applications

- Obstacle Detection
- Industrial safety devices
- Wheel encoder

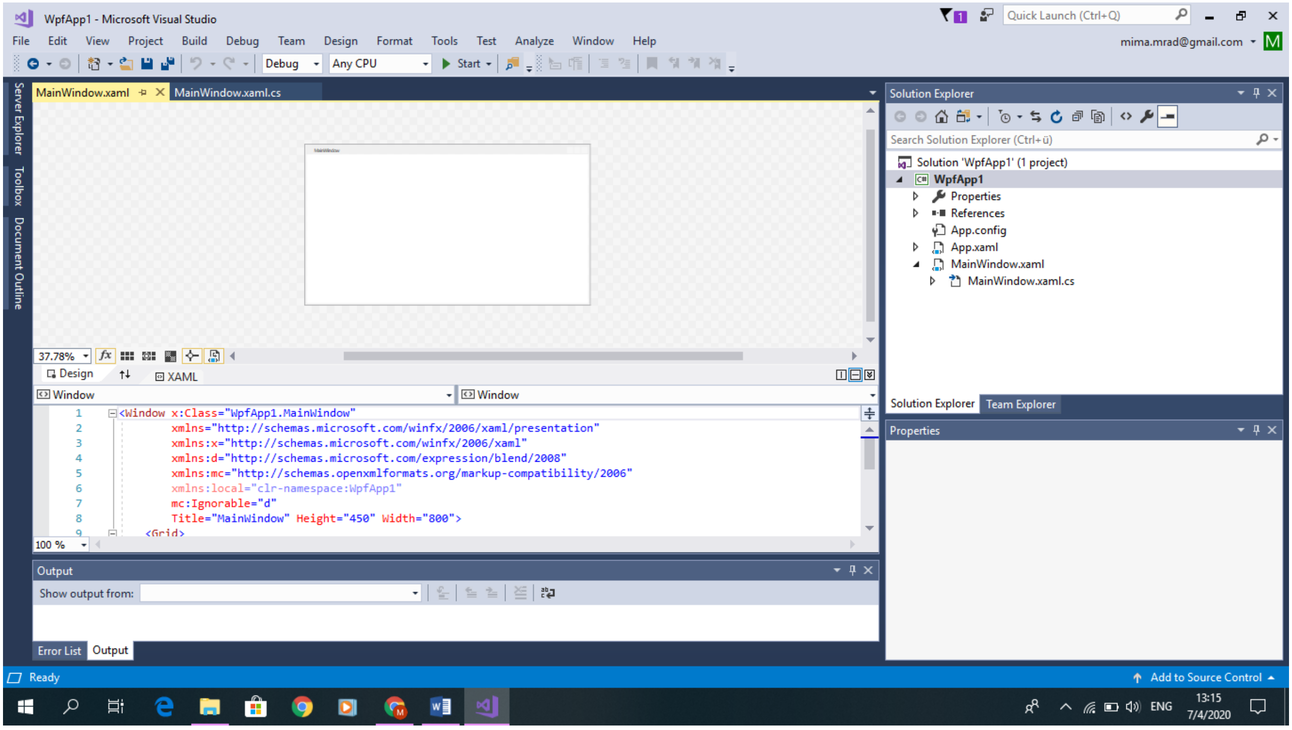
4.1.6

4.1.7 2D-Model



4.2 Interface

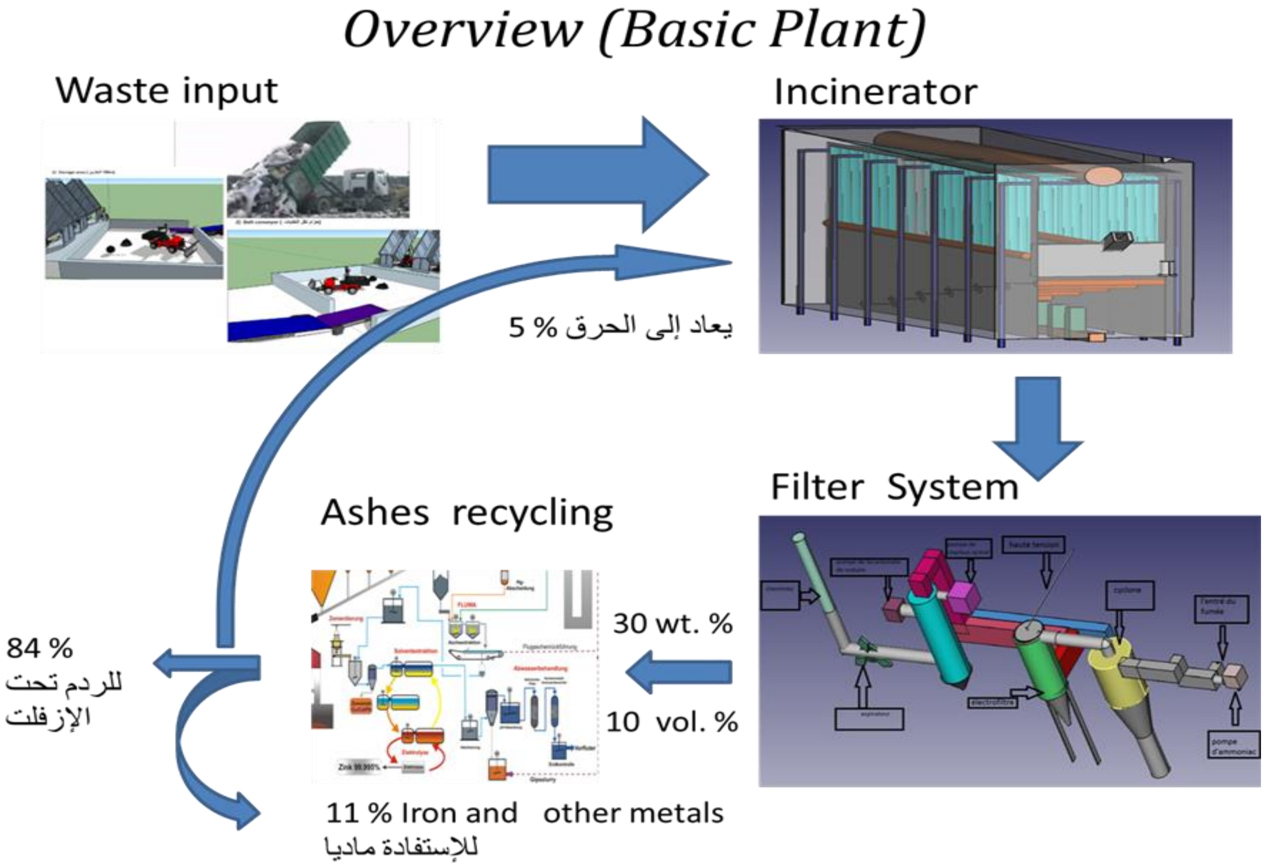
The interface will be done with C# and WPF or Windows form in Visual Studio

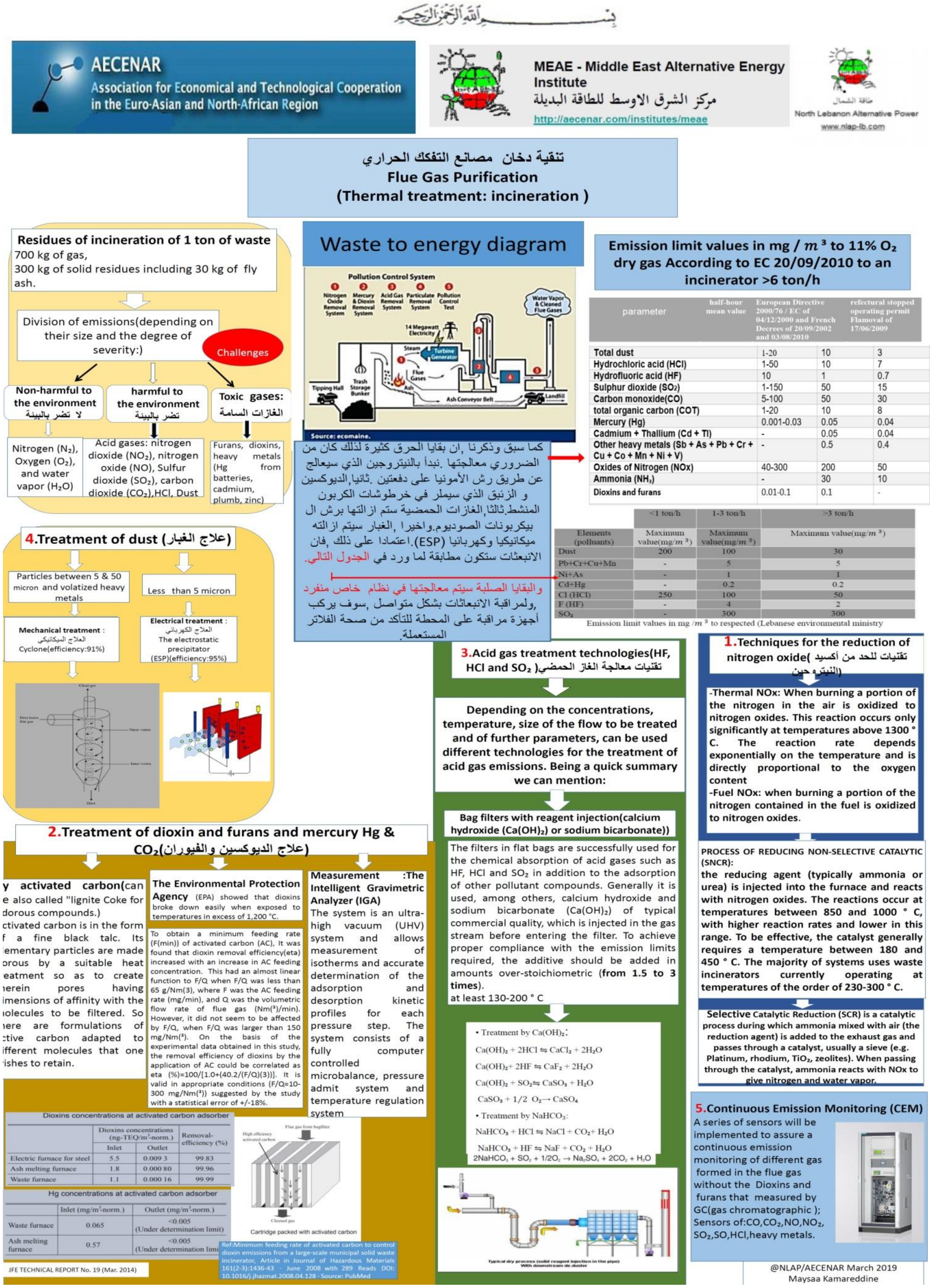


5 Building of the measurement environment

5.1 Project Enviroment

AECENAR has built an incinerator and a filter system for it.





Now it has to be proved that the flue gas is under the norms, i.e. environmentally friendly.

The content of the flue gas coming from the incinerator has to be measured.

It was decided to use Laser based flue gas measurement technology.

بســـــــــــــــم الله الرحمن الرحيم

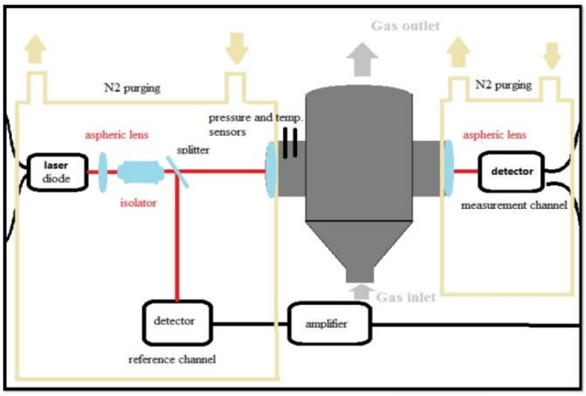
AECENAR
Association for Economical and Technological Cooperation in the Euro-Asian and North-African Region

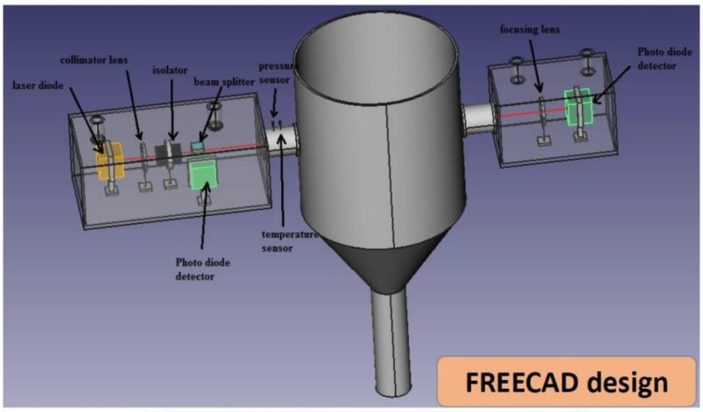
INT Institute of NanoTechnology

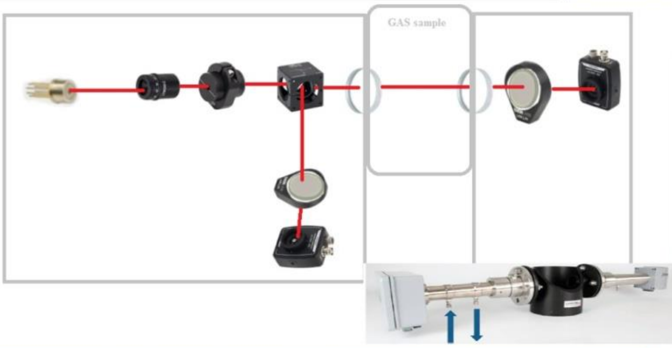
Gas Detecting Spectroscopy

Objective: Design of Spectroscopy application to detect waste incineration exhaust (HF, NH3, CO, NO, NO2, SO2, HCl)

schematic







Principals

The setup consists of tunable diode laser light source, transmitting (i.e. beam shaping) optics, optically accessible absorbing medium, receiving optics and detector/s. The emission wavelength of the tunable diode laser is tuned over the characteristic absorption lines of a species in the gas in the path of the laser beam. This causes a reduction of the measured signal intensity, which can be detected by a photodiode, and then used to determine the gas concentration and other properties. The spectrometer is placed directly on the exhaust tube.

The beam laser passes through a collimator to keep the beam shaped, then it passes through an isolator which allows the transmission of light in only one direction. The beam splitter (10:90 (R:T)) split the laser beam in two directions, one of them will pass to a photodetector by a focusing lens (Reference channel), the other one will continue to the absorbing medium (gas exhaust) to be collected by the other photodetector (measuring channel). All the optical component are exposed to a N2 purging to keep them clean. We are interested in our application about the gases mentioned in the table below.

Table 1. Typical wavelengths and detection limits for some gases measured with the technique described in this paper. The detection limit for O_2 is not limited by electronic or optical noise, but by uncertainty due to air in the receiver and transmitter

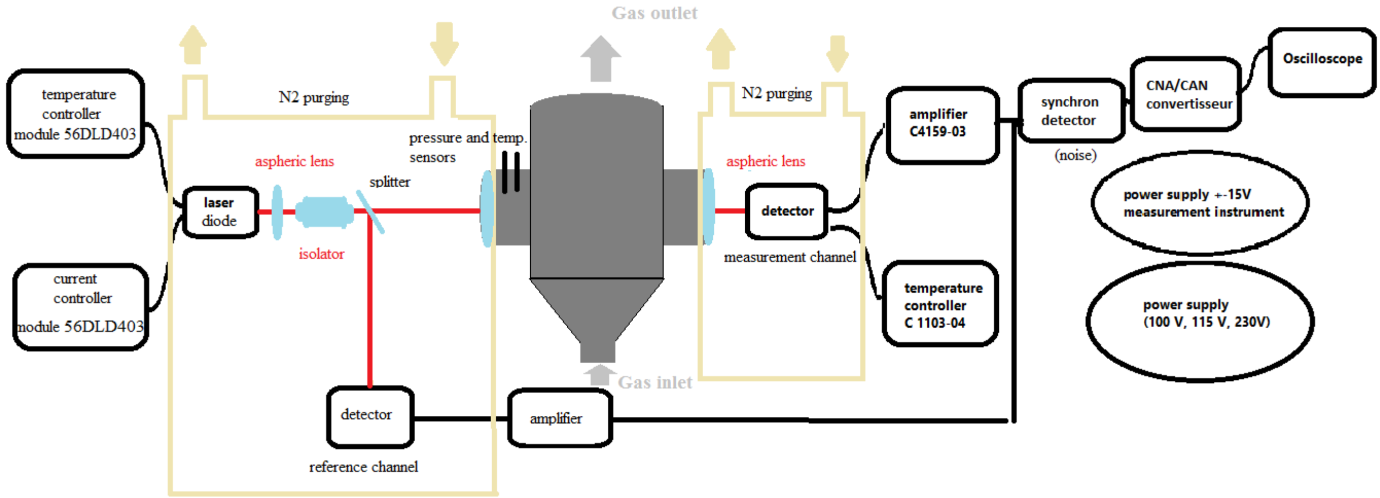
Gas	Laser type	Wavelength /µm	Detection limit /ppm · m
O_2	FP, DFB, VCSEL	0.764, 0.760	1000
HF	DFB	1.28, 1.30	0.03
NH_3	DFB, DBR	1.51	0.2
CO	DFB	1.56	20
H_2S	DFB	1.57	5
HCl	DFB	1.74	0.1
NO	DFB	1.81	5

List of Components for CO gas analysis

Item	Image	Part Number	Ship Date	Qty	Price	Subtotal	Remove
2		L1575G1 - (WEIGHT (Total)):0.02 Kgs 1575 nm, 1.7 W, Ø9 mm, G Pin Code, MM Laser Diode * NOTE: * L1575G1 is export controlled. To comply with US export laws, an End User Statement will be requested as part of the checkout process.	Today	1	295,10 €	295,10 €	
3		LTN330-C - (WEIGHT (Total)):0.04 Kgs Adjustable Collimation Tube with Optic for Ø5.6 and Ø9 mm Laser Diodes, f = 3.1 mm, NA = 0.68, AR Coated: 1050 - 1700 nm	Today	1	229,19 €	229,19 €	
4		SR9F - (WEIGHT (Total)):0.04 Kgs ESD Protection and Strain Relief Cable, Pin Codes F and G, 3.3 V	Today	1	49,19 €	49,19 €	
5		AD15NT - (WEIGHT (Total)):0.01 Kgs Ø1" Unthreaded Adapter for Ø15 mm Cylindrical Components	Today	1	22,13 €	22,13 €	
6		CP36 - (WEIGHT (Total)):0.03 Kgs 30 mm Cage Plate, Ø1.2" Double Bore for SM1 and C-Mount Lens Tubes	3-5 Days	1	~~20,06 €~~* 20,06 €	20,06 €	
7		IOT-4-1550-VLP - (WEIGHT (Total)):0.17 Kgs Free-Space Tandem Isolator, 1550 nm, Ø3.6 mm Max Beam, 2.4 W Max	Today	1	1.418,42 €	1.418,42 €	
8		PDA10D2 - (WEIGHT (Total)):1.98 Kgs InGaAs Fixed Gain Amplified Detector, 900 - 2600 nm, 25 MHz BW, 0.8 mm², Universal 8-32 / M4 Mounting Holes	Today	2	516,42 €	1.032,84 €	
9		CM1-BP108 - (WEIGHT (Total)):0.09 Kgs Cube-Mounted Pellicle Beamsplitter, 8:92 (R:T), Uncoated, 400 - 2400 nm	Today	1	232,14 €	232,14 €	
10		LBF254-200-C - (WEIGHT (Total)):0.05 Kgs N-BK7 Best Form Lens, Ø1", f = 200 mm, ARC: 1050-1700 nm	Today	2	55,08 €	110,16 €	
11		LMR1/M - (WEIGHT (Total)):0.02 Kgs Lens Mount with Retaining Ring for Ø1" Optics, M4 Tap	Today	2	14,26 €	28,52 €	
12		WW31050 - (WEIGHT (Total)):0.05 Kgs Ø1" Wedged Sapphire Window, Uncoated	Today	2	100,33 €	200,66 €	
13		BA2E - (WEIGHT (Total)):0.80 Kgs Flexure Clamping Base / Post Mount, Ø1/2" Double Bore, 2.00" x 3.00" x 0.48"	3-5 Days	8	30,54 €	244,32 €	
14		PH3-P5 - (WEIGHT (Total)):0.48 Kgs Ø1/2" Post Holder, Spring-Loaded Hex-Locking Thumbscrew, L = 3", 5 Pack	Today	1	38,71 €	38,71 €	
15		TR30/M - (WEIGHT (Total)):0.08 Kgs Ø12.7 mm Optical Post, SS, M4 Setscrew, M6 Tap, L = 30 mm	Today	3	4,44 €	13,32 €	
16		PH3 - (WEIGHT (Total)):0.25 Kgs Ø1/2" Post Holder, Spring-Loaded Hex-Locking Thumbscrew, L = 3"	Today	3	7,74 €	23,22 €	
17		TR30/M-P5 - (WEIGHT (Total)):0.13 Kgs Ø12.7 mm Optical Post, SS, M4 Setscrew, M6 Tap, L = 30 mm, 5 Pack	Today	1	19,97 €	19,97 €	
* For Thorlabs Price and Discount Policy please see Thorlabs Price Policy. WEIGHT (Total): 4.22 Kgs					TOTAL:	3.977,95 €	

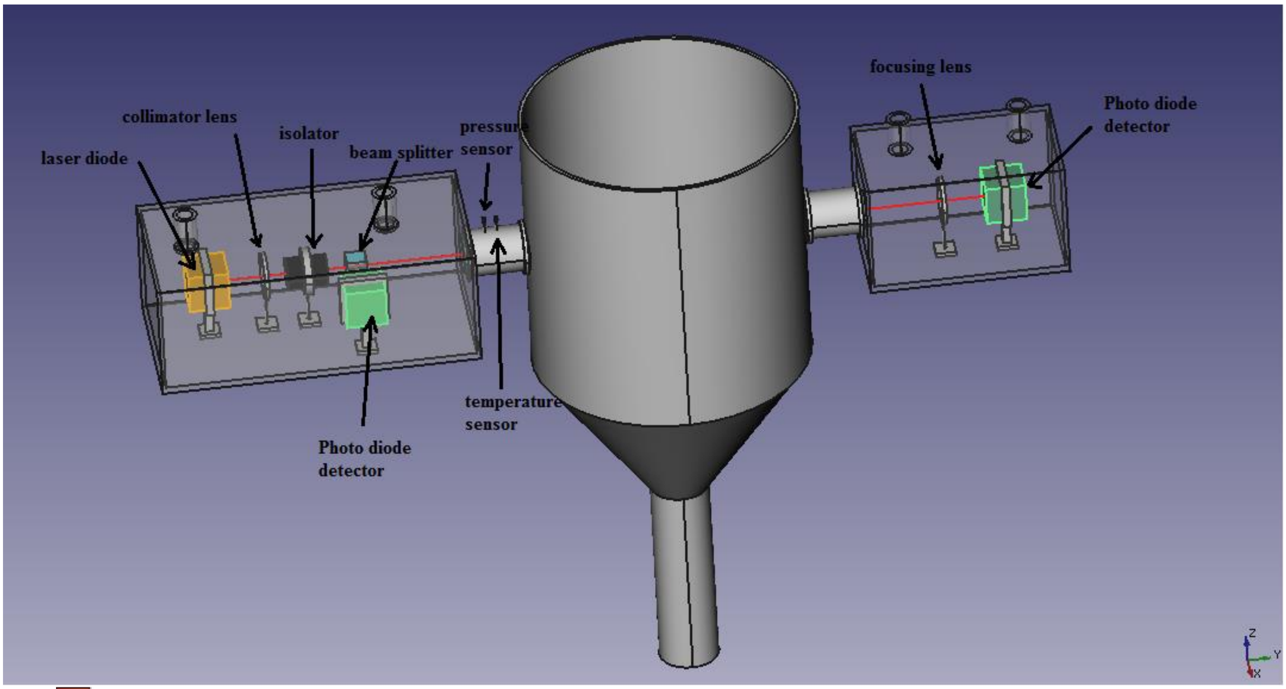
Maryam Abdel-karim
Siham Aisha @AECENAR /

5.2 Concept and Design[8]



Optical path. The output from the laser diode is collimated by an aspheric lens before passing through an optical isolator. The isolator prevents reflected radiation from damaging the diode. After the optical isolator, the light enters a beam splitter with a typical transmission: reflection ratio of 90:10. The weaker reflected signal from the beam splitter is incident on a photodetector whose signal compared with the received photodetector signal.

[8] From [Abdel-Karim, Aisha 2020] and https://espace.library.uq.edu.au/data/UQ_690617/s4111331_final_thesis.pdf?Expires=1578991666&Key-Pair-Id=APKAJKNBJ4MJBJNC6NLQ&Signature=IiK5vmsYt-GtLAfQynJTXcqGPrEgHmIDtGkVusuGTvSjr-AFU-6fP9HXXDe9KYya8xpM6Eo5lKMfKVw3~4KLhMVtvmEHC9yLxOH6IlfLLeIfl0g4D-a2S6aX3Ovfmc36eTYbESfhGqwtzBZlC5GPo-zwwCUo4nU2-ZxN8rIDP0DTynribbjF8ZpzMb96qOH-hekmrvx0PuvyrYxZ2IM-IxMBkuGLNB2JQAhkAze-C~PRedPTpbBtlR22PcGLUTmGs6SvATzIKWq9avUZhMIgFkskAjywiBGAcNJ84VlPRmz-IK3Ys2qiptwtOvCJ5rJ7YpFEo6WEU8pA5~QS-YcTuA__



collimator lens
laser diode
isolator
beam splitter
pressure sensor
focusing lens
Photo diode detector
temperature sensor
Photo diode detector

TDLAS.FCStd

5.3 List of components for CO measurement[9]

Thorlabs GmbH
Münchner Weg 1
85232 Bergkirchen
85232 Bergkirchen

Phone ...: +49 (0) 8131-5956-0
Fax .....: +49 (0) 8131-5956-99

Quotation

Number: **WEB N27W977793**
Purchase Order: **N27W977793**

Item Number	Description	Quantity	Price Each	Amount
L1575G1	1575 nm, 1.7 W, Ø9 mm, G Pin Code, MM Laser Diode	1	€ 295,10	€ 295,10 EUR
LTN330-C	Adjustable Collimation Tube with Optic for Ø5.6 and Ø9 mm Laser Diodes, f = 3.1 mm, NA = 0.68, AR Coated: 1050 - 1700 nm	1	€ 229,19	€ 229,19 EUR
SR9F	ESD Protection and Strain Relief Cable, Pin Codes F and G, 3.3 V	1	€ 49,19	€ 49,19 EUR
AD15NT	Ø1" Unthreaded Adapter for Ø15 mm Cylindrical Components	1	€ 22,13	€ 22,13 EUR
CP36	30 mm Cage Plate, Ø1.2" Double Bore for SM1 and C-Mount Lens Tubes	1	€ 20,06	€ 20,06 EUR
IOT-4-1550-VLP	Free-Space Tandem Isolator, 1550 nm, Ø3.6 mm Max Beam, 2.4 W Max	1	€ 1.418,42	€ 1.418,42 EUR
PDA10D2	InGaAs Fixed Gain Amplified Detector, 900 - 2600 nm, 25 MHz BW, 0.8 mm^2, Universal 8-32 / M4 Mounting Holes	2	€ 516,42	€ 1.032,84 EUR
POWER CORD EUROPE	PDA10D2:POWER CORD EUROPE : No Cost Accessory	2	€ 0,00	€ 0,00 EUR
CM1-BP108	Cube-Mounted Pellicle Beamsplitter, 8:92 (R:T), Uncoated, 400 - 2400 nm	1	€ 232,14	€ 232,14 EUR
LBF254-200-C	N-BK7 Best Form Lens, Ø1", f = 200 mm, ARC: 1050-1700 nm	2	€ 55,08	€ 110,16 EUR
LMR1/M	Lens Mount with Retaining Ring for Ø1" Optics, M4 Tap	2	€ 14,26	€ 28,52 EUR
WW31050	Ø1" Wedged Sapphire Window, Uncoated	2	€ 100,33	€ 200,66 EUR
BA2E	Flexure Clamping Base / Post Mount, Ø1/2" Double Bore, 2.00" x 3.00" x 0.48"	8	€ 30,54	€ 244,32 EUR
PH3-P5	Ø1/2" Post Holder, Spring-Loaded Hex-Locking Thumbscrew, L = 3", 5 Pack	1	€ 38,71	€ 38,71 EUR
TR30/M	Ø12.7 mm Optical Post, SS, M4 Setscrew, M6 Tap, L = 30 mm	3	€ 4,44	€ 13,32 EUR
PH3	Ø1/2" Post Holder, Spring-Loaded Hex-Locking Thumbscrew, L = 3"	3	€ 7,74	€ 23,22 EUR
TR30/M-P5	Ø12.7 mm Optical Post, SS, M4 Setscrew, M6 Tap, L = 30 mm, 5 Pack	1	€ 19,97	€ 19,97 EUR

General Manager: Dr. Bruno Gross
Email: europe@thorlabs.com - Web: www.thorlabs.com
HRB: 85345/Munich VAT-No.: DE 129 442 088
Please note our standard terms and conditions incl. WEEE
EAR: DE97581288

** NOTE ** : **Please note that the customs and duties charges are the responsibility of the customer.**

Subtotal: € 3.977,95
Shipping and Handling: 9.24
VAT: € 757,57
Grand Total: € 4.744,76 EUR

Component	Type	quantity	Price/supplier
Laser diode	L1575G1	1	**324.64$** https://www.thorlabs.com/thorproduct.cfm?partnumber=L1575G1
Collimator	LTN330-C	1	**252.13$** https://www.thorlabs.com/thorproduct.cfm?partnumber=LTN330-C
Isolator	IOT-4-1550-VLP	1	**1560.42 $** https://www.thorlabs.com/thorproduct.cfm?partnumber=IOT-4-1550-VLP
Beam splitter	CM1-BP108	1	**255.38$** https://www.thorlabs.com/thorproduct.cfm?partnumber=CM1-BP108
Focusing	LBF254-	2	**60.59$/piece**

[9] From [Abdel-Karim, Aisha 2020]

lens + Holder	200-C LMR1/M		https://www.thorlabs.com/thorproduct.cfm?partnumber=LBF254-200-C **15.69$/piece** https://www.thorlabs.com/thorproduct.cfm?partnumber=LMR1/M#ad-image-0
Photodiode	PDA10D2-InGaAs	2	**568.12 $ / piece** https://www.thorlabs.com/thorproduct.cfm?partnumber=PDA10D2
Window	WW31050-ϕ1“	2	**110.37$ / piece** https://www.thorlabs.com/thorproduct.cfm?partnumber=WW31050
Holder	TR30/M TR30/M-P5	Pachage 1 Piece 3	**4.88$/piece** https://www.thorlabs.com/thorproduct.cfm?partnumber=TR30/M **21.97$/package**
Cable (diode)	SR9F	1	**54.11$** https://www.thorlabs.com/thorproduct.cfm?partnumber=SR9F
Adapter (collimator)	AD15NT CP36		**24.35$** https://www.thorlabs.com/thorproduct.cfm?partnumber=AD15NT **22.07$** https://www.thorlabs.com/thorproduct.cfm?partnumber=CP36
Base	BA2E	8	**33.60$** https://www.thorlabs.com/thorproduct.cfm?partnumber=BA2E#ad-image-0
Post holder	PH3 PH3-P5	Pieces 3 Package 1	**8.52$/piece** https://www.thorlabs.com/thorproduct.cfm?partnumber=PH3-P5#ad-image-0 **42.59$/package**
Total price			**3,359.43$**

Item	Image	Part Number	Ship Date	Qty	Price	Subtotal	Remove
2		L1575G1- (WEIGHT (Total)):0.02 Kgs 1575 nm, 1.7 W, Ø9 mm, G Pin Code, MM Laser Diode * NOTE: * L1575G1 is export controlled. To comply with US export laws, an End User Statement will be requested as part of the checkout process.	Today	1	295,10 €	295,10 €	
3		LTN330-C- (WEIGHT (Total)):0.04 Kgs Adjustable Collimation Tube with Optic for Ø5.6 and Ø9 mm Laser Diodes, f = 3.1 mm, NA = 0.68, AR Coated: 1050 - 1700 nm	Today	1	229,19 €	229,19 €	
4		SR9F- (WEIGHT (Total)):0.04 Kgs ESD Protection and Strain Relief Cable, Pin Codes F and G, 3.3 V	Today	1	49,19 €	49,19 €	
5		AD15NT- (WEIGHT (Total)):0.01 Kgs Ø1" Unthreaded Adapter for Ø15 mm Cylindrical Components	Today	1	22,13 €	22,13 €	
6		CP36- (WEIGHT (Total)):0.03 Kgs 30 mm Cage Plate, Ø1.2" Double Bore for SM1 and C-Mount Lens Tubes	3-5 Days	1	~~20,06 €~~* 20,06 €	20,06 €	
7		IOT-4-1550-VLP- (WEIGHT (Total)):0.17 Kgs Free-Space Tandem Isolator, 1550 nm, Ø3.6 mm Max Beam, 2.4 W Max	Today	1	1.418,42 €	1.418,42 €	
8		PDA10D2- (WEIGHT (Total)):1.98 Kgs InGaAs Fixed Gain Amplified Detector, 900 - 2600 nm, 25 MHz BW, 0.8 mm^2, Universal 8-32 / M4 Mounting Holes	Today	2	516,42 €	1.032,84 €	
9		CM1-BP108- (WEIGHT (Total)):0.09 Kgs Cube-Mounted Pellicle Beamsplitter, 8:92 (R:T), Uncoated, 400 - 2400 nm	Today	1	232,14 €	232,14 €	
10		LBF254-200-C- (WEIGHT (Total)):0.05 Kgs N-BK7 Best Form Lens, Ø1", f = 200 mm, ARC: 1050-1700 nm	Today	2	55,08 €	110,16 €	
11		LMR1/M- (WEIGHT (Total)):0.02 Kgs Lens Mount with Retaining Ring for Ø1" Optics, M4 Tap	Today	2	14,26 €	28,52 €	
12		WW31050- (WEIGHT (Total)):0.05 Kgs Ø1" Wedged Sapphire Window, Uncoated	Today	2	100,33 €	200,66 €	
13		BA2E- (WEIGHT (Total)):0.80 Kgs Flexure Clamping Base / Post Mount, Ø1/2" Double Bore, 2.00" x 3.00" x 0.48"	3-5 Days	8	30,54 €	244,32 €	
14		PH3-P5- (WEIGHT (Total)):0.48 Kgs Ø1/2" Post Holder, Spring-Loaded Hex-Locking Thumbscrew, L = 3", 5 Pack	Today	1	38,71 €	38,71 €	
15		TR30/M- (WEIGHT (Total)):0.08 Kgs Ø12.7 mm Optical Post, SS, M4 Setscrew, M6 Tap, L = 30 mm	Today	3	4,44 €	13,32 €	
16		PH3- (WEIGHT (Total)):0.25 Kgs Ø1/2" Post Holder, Spring-Loaded Hex-Locking Thumbscrew, L = 3"	Today	3	7,74 €	23,22 €	
17		TR30/M-P5- (WEIGHT (Total)):0.13 Kgs Ø12.7 mm Optical Post, SS, M4 Setscrew, M6 Tap, L = 30 mm, 5 Pack	Today	1	19,97 €	19,97 €	
* For Thorlabs Price and Discount Policy please see Thorlabs Price Policy . WEIGHT (Total): 4.22 Kgs					TOTAL:	3.977,95 €	

5.3.1 Laser diode

planned

L1575G1 - 1575 nm, 1.7 W, Ø9 mm, G Pin Code, MM Laser Diode

Zoom

Complete Product Details

Part Number:	L1575G1 -Ask a technical question
Package Weight:	0.03 lbs / Each
Available:	Today
RoHS:	RoHS
Price:	$324.64
Add To Cart:	Qty :1 Add To Cart
Release Date:	Jul 6, 2018

Drawings and Documents:

Auto CAD PDF

Auto CAD DXF

Solidworks

eDrawing

Step

Spec Sheet

RoHS

REACH

Download all support documents

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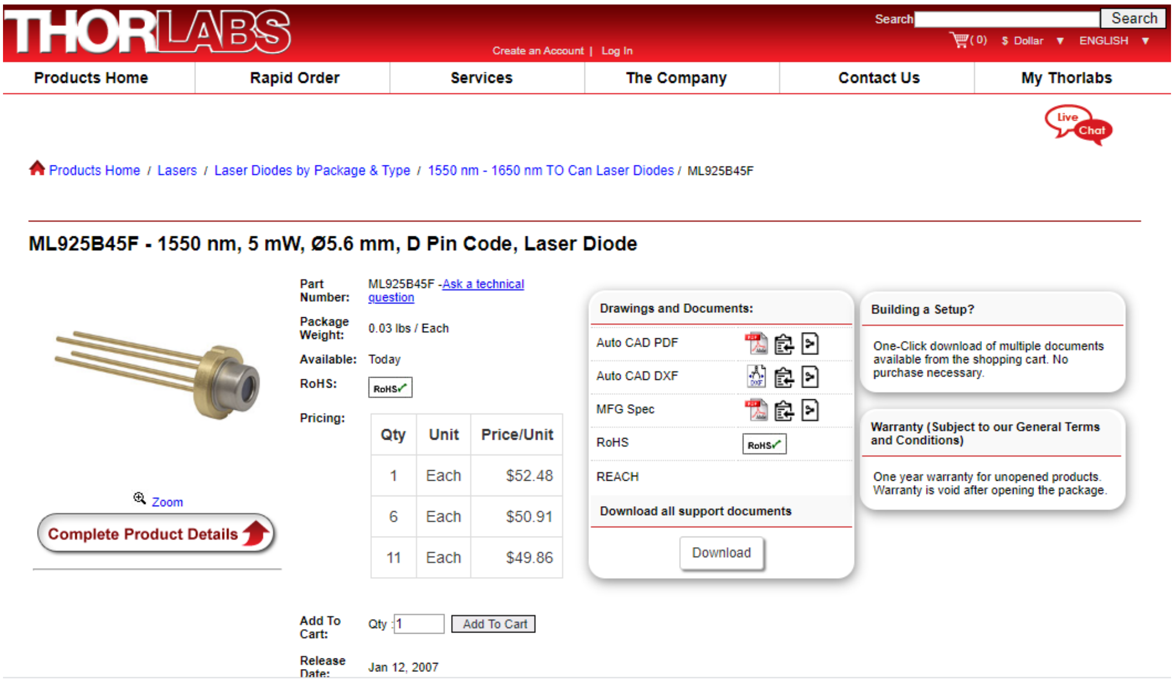
buyed



ELECTRICAL/OPTICAL CHARACTERISTICS(Tc=25°C)

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
Ith	Threshold current	CW		3	10	20	mA
Iop	Operation current	CW, Po=5mW[3mW]		10	30	50	mA
Vop	Operating voltage	CW, Po=5mW[3mW]		---	1.1	1.5	V
η	Slope efficiency	CW, Po=5mW[3mW]		0.15[0.1]	0.25[0.2]	0.5	mW/mA
λc	Center wavelength	CW, Po=5mW[3mW]	-01spec	1520	1550	1580	nm
			-02spec	1495	1520	1544	
Δλ	Spectral Width	CW, Po=5mW, [3mW]RMS(-20dB)		---	1.5	3	nm
θ ‖	Beam divergence angle(parallel)	CW, Po=5mW[3mW]		---	25[11]	---	deg.
θ ⊥	Beam divergence angle (perpendicular)	CW, Po=5mW[3mW]		---	30[11]	---	deg.
tr,tf	Rise and Fall time (10%-90%)	Ib=Ith,Po=5mW [3mW],10-90%		---	0.3	0.7	nsec
Im	Monitor Current (PD)	CW, Po=5mW[3mW], VRD=1V,		0.1	0.5	1.0	mA
Id	Dark Current (PD)	VRD=10V		---	---	0.1	μA
Ct	Capacitance (PD)	VRD=10V, f=1MHz		---	10	20	pF
Pf(Note2)	Fiber Coupling characteristics at peak coupling<3>	CW, PL=3mW,SI10/125		0.2	0.5	---	mW
Df(Note2)		CW, PL=3mW SI10/125	ML920K45S ML925C45F	5.0	5.8	6.2	mm
			ML920Y45S	6.0	6.5	7.0	

The wavelength of CO is 1568 nm. So continued in the interval 1520-1580. Interval length 60nm.

SR9F - ESD Protection and Strain Relief Cable, Pin Codes F and G, 3.3 V

Zoom

Complete Product Details

Part Number:	SR9F -Ask a technical question
Package Weight:	0.08 lbs / Each
Available:	Today
RoHS:	RoHS✓
Price:	$54.11
Add To Cart:	Qty : 1
	Add To Cart
Release Date:	May 28, 2015

Drawings and Documents:

Auto CAD PDF	
Auto CAD DXF	
Solidworks	
eDrawing	
Step	
RoHS	RoHS✓
REACH	

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AD15NT - Ø1" Unthreaded Adapter for Ø15 mm Cylindrical Components

Zoom

Complete Product Details

Part Number:	AD15NT -Ask a technical question
Package Weight:	0.03 lbs / Each
Available:	Today
RoHS:	RoHS✓
Price:	$24.35
Add To Cart:	Qty 1 / Add To Cart
Release Date:	Oct 7, 2009

Drawings and Documents:

- Auto CAD PDF
- Auto CAD DXF
- Solidworks
- eDrawing
- Step
- RoHS — RoHS✓
- REACH

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CP36 - 30 mm Cage Plate, Ø1.2" Double Bore for SM1 and C-Mount Lens Tubes

Zoom

Complete Product Details

Part Number:	CP36 -Ask a technical question
Package Weight:	0.06 lbs / Each
Available:	Today
RoHS:	RoHS✓
Price:	$22.07
Add To Cart:	Qty 1 / Add To Cart
Release Date:	Nov 11, 2019

Drawings and Documents:

- Auto CAD PDF
- Auto CAD DXF
- Solidworks
- eDrawing
- Step
- RoHS — RoHS✓
- REACH

Download all support documents

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5.3.2 Collimator

LTN330-C - Adjustable Collimation Tube with Optic for Ø5.6 and Ø9 mm Laser Diodes, f = 3.1 mm, NA = 0.68, AR Coated: 1050 - 1700 nm

Zoom

Complete Product Details

Part Number:	LTN330-C -Ask a technical question
Package Weight:	0.08 lbs / Each
Available:	Today
RoHS:	RoHS✓
Price:	$252.13
Add To Cart:	Qty 1 / Add To Cart
Release Date:	Jan 22, 2015

Drawings and Documents:

- Auto CAD PDF
- Auto CAD DXF
- Solidworks
- eDrawing
- Step
- RoHS — RoHS✓
- REACH

Download all support documents

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Building a Setup?

One-Click download of multiple documents available from the shopping cart. No purchase necessary.

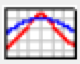
Warranty (Subject to our General Terms and Conditions)

Two year warranty. Incorporated light sources are warranted for the lesser of one year or (to the extent applicable) the number of hours stated in the specifications.

Adjustable Lens Mount with Collimating Optic for our LD Sockets with Strain Relief Cables (Sold Below)

- 13/32"-40 Threaded Retaining Ring Secures Ø5.6 mm or Ø9 mm Laser Diode
- Aspheric Collimation Optic with One of Three Broadband AR Coatings:
    - A Coating: 350 - 700 nm
    - B Coating: 600 - 1050 nm
    - C Coating: 1050 - 1700 nm
- Rotating Cap with Locking Ring Provides 2.5 mm (0.1") of Lens Travel for an Adjustable Focus
- Includes Main Tube with Mounted Optic, Retaining Ring, and Adapter Kit for Ø5.6 mm Diode Packages
- Ø15 mm (Ø0.58") Tube Can be Mounted Using a Ø1" AD15NT Adapter or SM1-Threaded AD15F Adapter
- Laser Diode Retaining Ring Compatible with SPW301 and SPW801 Spanner Wrenches

5.3.3 Isolator

Click Image for Details	
Item #	IOT-4-1550-VLP
Type	Tandem Fixed Narrowband
Center Wavelength	1550 nm
Tuning Range	N/A
Operating Range	1500 - 1600 nm
Transmission[e]	85%
Isolation[e]	60 dB (Min)
Performance Graph (Click for Details)	
Max Beam Diameter[f]	3.6 mm
Max Power[g]	2.4 W
Max Power Density	Blocking: 50 W/cm^2

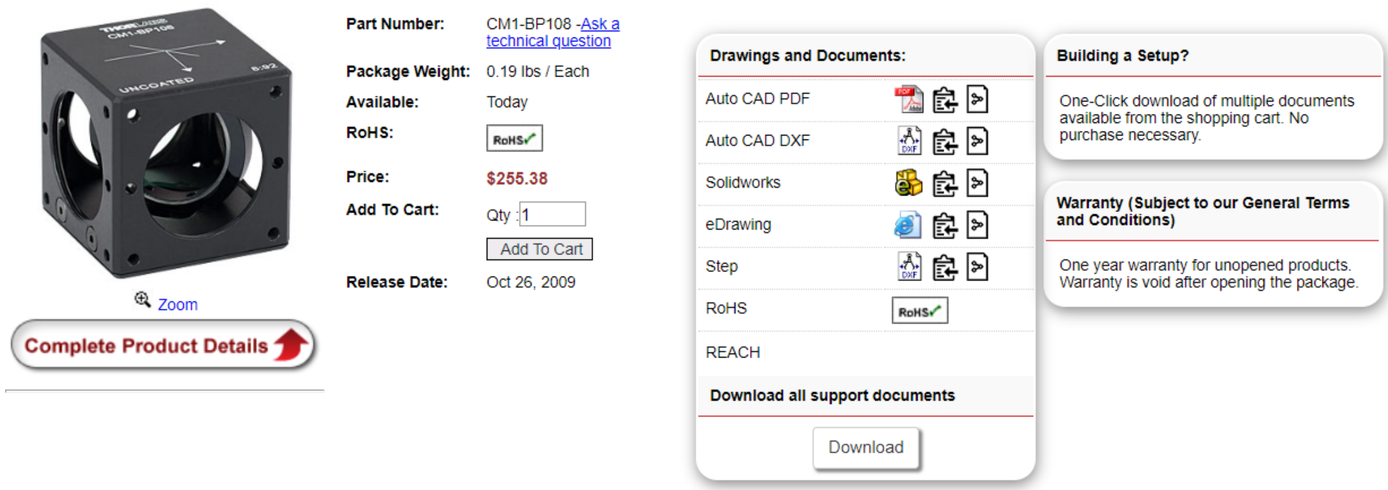
Optical isolators, also known as Faraday isolators, are magneto-optic devices that preferentially transmit light along a single direction, shielding upstream optics from back reflections. Back reflections can create a number of instabilities in light sources, including intensity noise, frequency shifts, mode hopping, and loss of mode lock. In addition, intense back-reflected light can permanently damage optics.

a. The input aperture is in the black end of the cylinder, while the output aperture is in the gold end of the cylinder.

b. This isolator can be supplied in an optic mount with twin steel dowel pins for our FiberBench systems by contacting Tech Support prior to ordering.
c. The mounting saddle contains an 8-32 tap. For an M4-threaded saddle, please contact Tech Support prior to ordering.
d. This isolator has two exit ports for rejected beams. Adequate beam traps should be selected and positioned to ensure safety.
e. Specified at center wavelength. See Performance Graph for wavelength dependence.
f. Defined as containing 100% of the beam energy.
g. The maximum power specification represents the maximum power for the combined forward and reverse directions. Therefore, the sum of the powers in the forward and reverse directions cannot exceed the maximum power specification.
h. The blocking power density corresponds to light polarized perpendicular to the transmission axis, while the transmission power density corresponds to light polarized parallel to the transmission axis.
i. Please see below for further details.
j. One SM087RC with an 8-32 tap is included with each of these isolators. For an isolator that includes an SM087RC/M with an M4 tap.
k. One SM1RC with an 8-32 tap is included with this isolator. For an SM1RC/M with an M4 tap.

5.3.4 Beam splitter

CM1-BP108 - Cube-Mounted Pellicle Beamsplitter, 8:92 (R:T), Uncoated, 400 - 2400 nm



- Eliminates Ghosting
- No Chromatic Aberration with Focused Beams
- Minimal Change in Optical Path Length
- SM1-Threaded Entrance and Exit Ports
- 30 mm Cage System Compatible

These beamsplitters virtually eliminate ghosting since the second surface reflection is superimposed on the first one. However, they are extremely fragile due to the nitrocellulose membrane being microns thick, which exhibits less than 1/2 wave of variation at 635 nm across its 25 mm diameter. To provide maximum protection from damage, these beamsplitters are housed inside a 30 mm cage-system-compatible cube. The cubes are post-mountable and have SM1-threaded access ports, making them compatible with our entire line of Ø1" lens tubes and accessories. The cubes are M6 x 0.5 threaded, but include 8-32 and M4 mounting adapters. These

Beamsplitter cubes can also be connected to other cage cubes with cage rods and our ERSCB adapters.

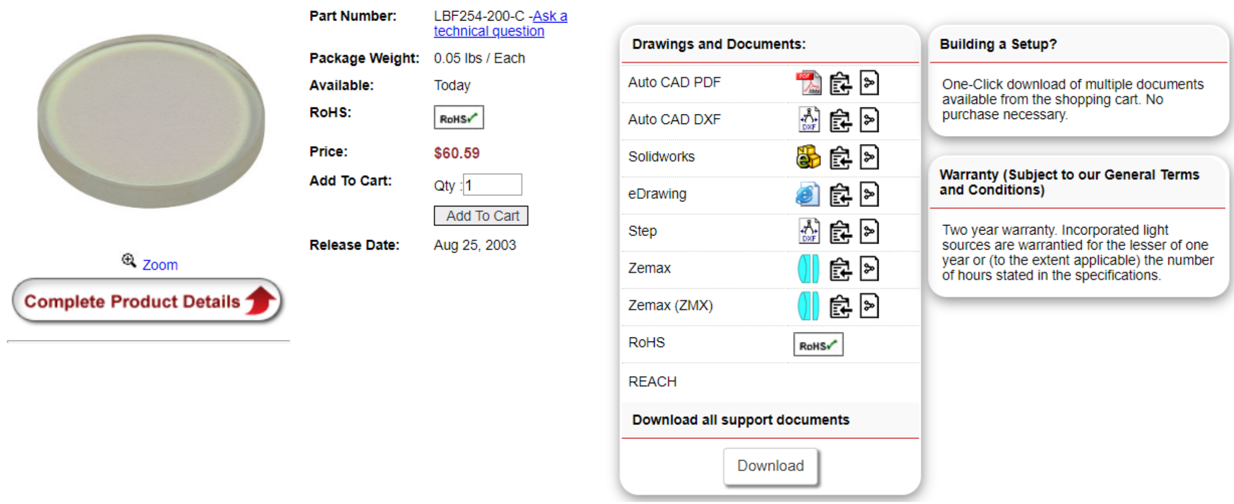
Handling Precautions

Our pellicle beamsplitters are manufactured from an extremely thin and fragile membrane. Please do not touch the membrane under any circumstances. Compressed or canned air can be used to clean these beamsplitters, but please exercise caution as the force of the air may be large enough to damage the membrane. Aim the stream of air such that it makes a small angle with the surface, and hold the can sufficiently far away to avoid damaging the membrane. If the pellicle becomes damaged, please contact tech support for information about replacement of the beamsplitter; in these cases, we only charge for the cost of the pellicle.

5.3.5 Focusing lens + holder

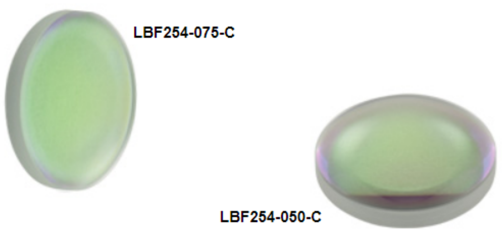
5.3.5.1 Focusing lens

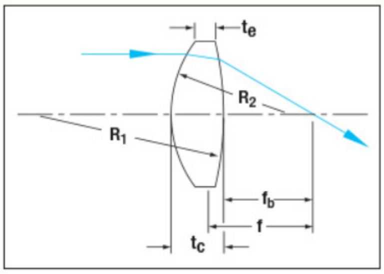
LBF254-200-C - N-BK7 Best Form Lens, Ø1", f = 200 mm, ARC: 1050-1700 nm



Ø1" N-BK7 Best Form Spherical Lenses, AR Coating: 1050-1700 nm

- Best Possible Performance from a Spherical Singlet
- Optimized for Infinite Conjugates
- Diffraction-Limited Performance at Small Input Diameters
- AR Coated for 1050 - 1700 nm





Features

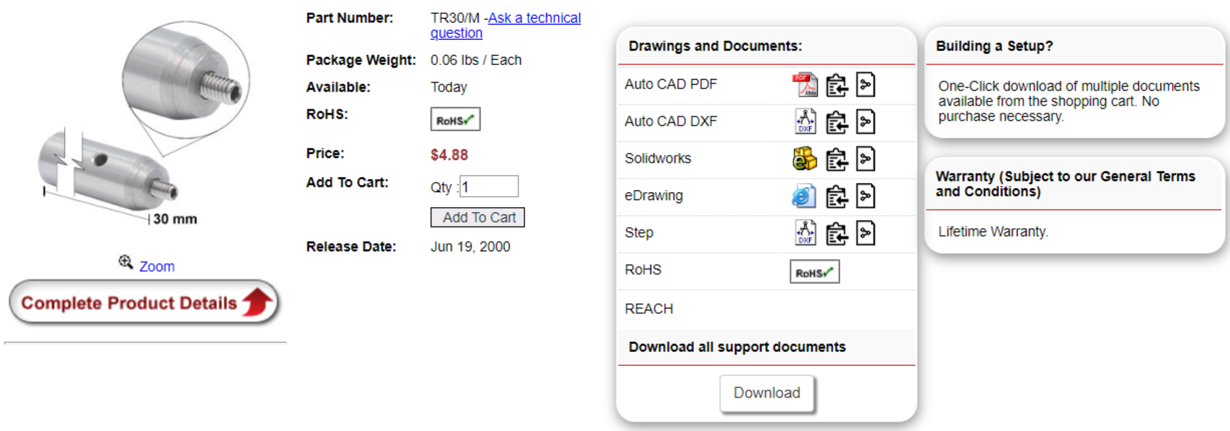
- Best Possible Performance from a Spherical Singlet
- 1050 - 1700 nm AR Coating Range
- Ideal for High-Power Applications
- Diffraction-Limited Performance at Small Input Diameters

Best Form lenses are designed to minimize spherical aberration while still using spherical surfaces to form the lens. Best form lenses are available with an AR coating for 1050 - 1700 nm to reduce the light reflected from each surface of the lens. Best Form Lenses are ideally suited for use at infinite conjugates in high-power applications where doublets are not an option.

Each side of the lens is polished so that it has a different radius of curvature, optimizing it for use at infinite conjugates. This process makes these lenses more expensive than plano-convex or bi-convex lenses. Since the lenses are optimized for minimum spot size, they can theoretically reach diffraction-limited performance for small input beam diameters

5.3.5.2 Holder

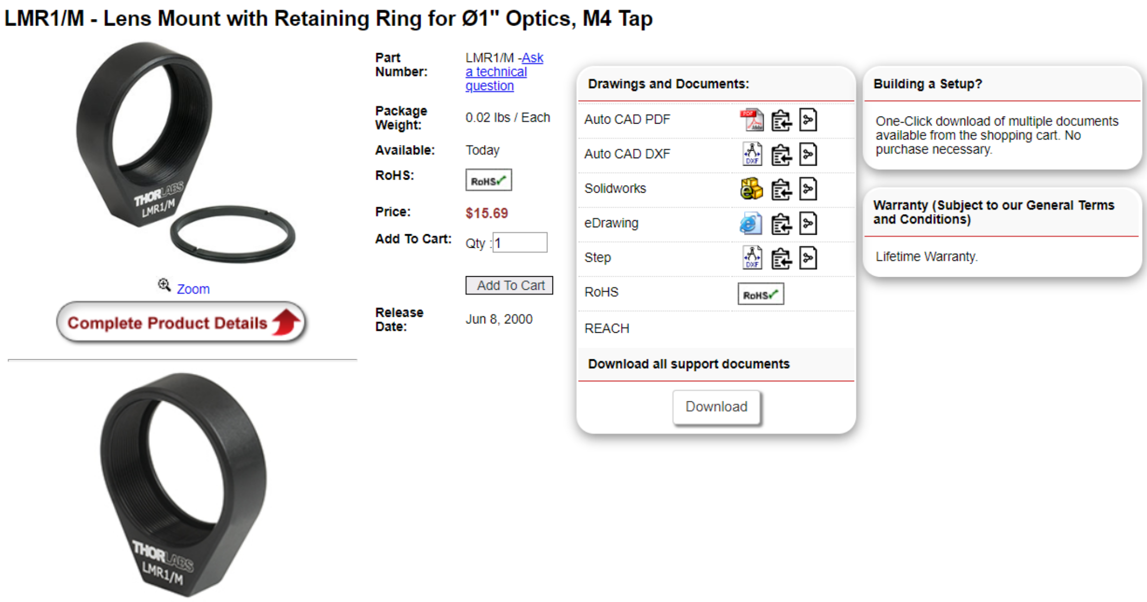
TR30/M - Ø12.7 mm Optical Post, SS, M4 Setscrew, M6 Tap, L = 30 mm



Features

- Precision-Ground Posts with 1/2" (12.7 mm) or 12 mm Diameters
  - Ø1/2" Imperial Posts: Bottom-Located 1/4"-20 Tapped Hole and Top-Located 8-32 Removable Setscrew

  - Ø12.7 mm Metric Posts: Bottom-Located M6 Tapped Hole and Top-Located M4 Removable Setscrew
  - Ø12 mm Metric Posts for Japanese Optomechanics: Bottom-Located M6 Tapped Hole and Top-Located M4 Removable Setscrew.
- Three Material Options Available
  - Standard Posts (303 Stainless Steel)
  - Vacuum-Compatible Posts (304L Stainless Steel)
  - Non-Magnetic, Low-Reflectivity Posts (Aluminum with Anodized Hard Coat)
- Available in a Variety of Lengths Ranging from 0.60" to 12" (15 mm to 300 mm for Metric Posts)
- Posts Available with Hex Tops Instead of Side-Located Bores
- Graduated Posts Available to Aid in Optic Alignment
- Post Spacers (Shims) to Achieve Intermediate Post Heights
- All Included Setscrews are Double-Ended (Except with Vacuum-Compatible Posts)



- ➢ Accommodates Various Optic Diameters from Ø5 mm to Ø4"
- ➢ Internally Threaded
- ➢ 8-32 (M4) Tapped Hole Allows for Mounting to Ø1/2" Posts
- ➢ Includes Compatible Retaining Ring for Mounting Optics
- ➢ Ø1/2", Ø1", and Ø2" Optic Mounts Available in 5 Packs

These Fixed Optic Mounts are our standard mounts for 20 distinct optic diameters ranging from Ø5 mm to Ø4". Each mount features internal threading, and ships with a retaining ring for securing the optic into place. The internal threading is deep enough to hold most unmounted optics or externally threaded components. The base of each mount features an 8-32 (M4) tapped hole, which allows for easy mounting to Ø1/2" Posts, as shown to the right. Additional retaining rings are sold separately below.

5.3.6 Detector: Photodiode

PDA10D2 - InGaAs Fixed Gain Amplified Detector, 900 - 2600 nm, 25 MHz BW, 0.8 mm^2, Universal 8-32 / M4 Mounting Holes

Zoom

Complete Product Details

Part Number:	PDA10D2 -Ask a technical question
Package Weight:	2.18 lbs / Each
Available:	Today
RoHS:	RoHS
Price:	$568.12
Add To Cart:	Qty 1 Add To Cart
Release Date:	Apr 20, 2018

Drawings and Documents:

Auto CAD PDF	
Auto CAD DXF	
Solidworks	
eDrawing	
Step	
Manual	
RoHS	RoHS
REACH	

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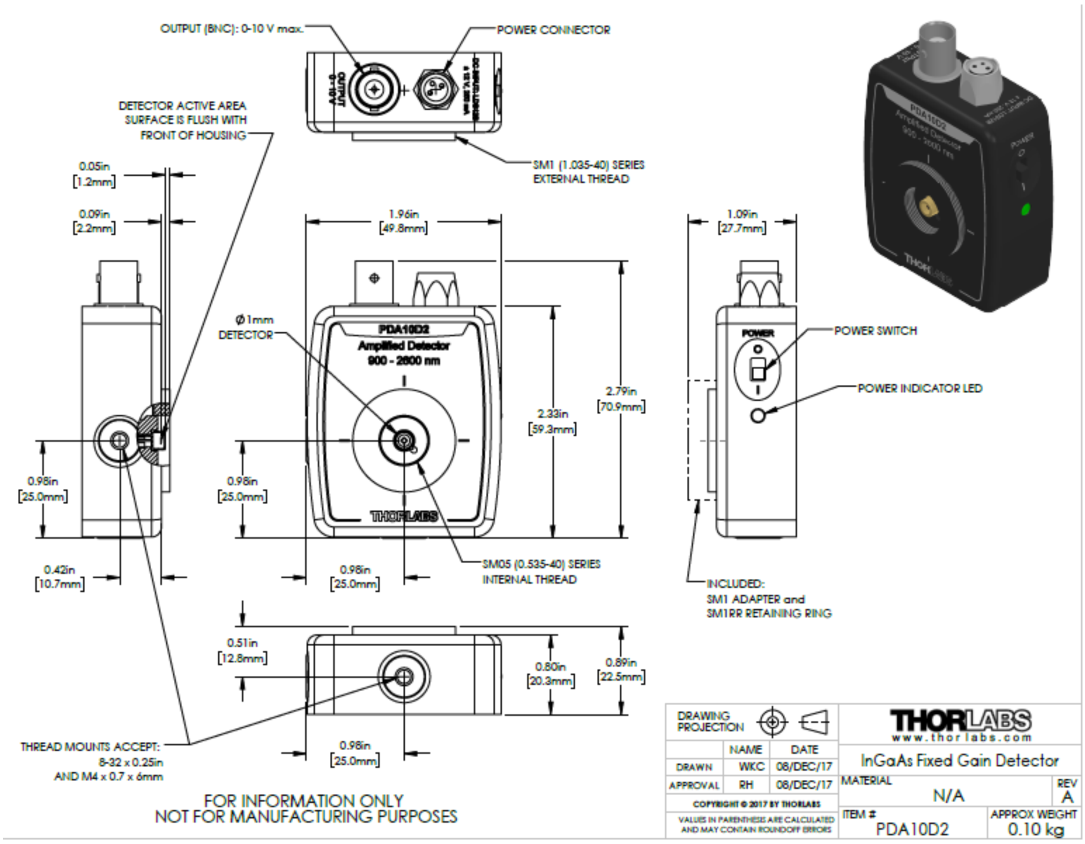
Warranty (Subject to our General Terms and Conditions)

Two year warranty. Incorporated light sources are warranted for the lesser of one year or (to the extent applicable) the number of hours stated in the specifications.

Share this Product Print Friendly Add favorite Watch for updates



Electrical Specifications[2]		
Detector	-	InGaAs
Active Area	-	Ø1.0 mm (0.8 mm^2)
Wavelength Range	λ	900 to 2600 nm
Peak Wavelength	λ_p	2300 nm (Typ.)
Peak Response	$\Re(\lambda_p)$	1.35 A/W (Typ.)
Small Signal Bandwidth	-	25 MHz
NEP (λ_p)	W/√Hz	1.01 x 10^{-11}
Noise (RMS)	-	2.5 mVrms
Max Ouput Current	I_{OUT}	100 mA
Dark Offset	-	±75 mV (Typ.) ±375 mV (Max)
Load Impedance	-	50 Ω to Hi-Z
Transimpedance Gain	-	5 x 10^3 V/A (50 Ω) 1 x 10^4 V/A (Hi-Z)
Output Voltage	V_{OUT}	0 to 5 V (50 Ω) 0 to 10 V (Hi-Z)

General	
On/Off Switch	Slide
Output	BNC (DC Coupled)
Package Size	2.79" x 1.96" x 0.89" (70.9 mm x 49.8 mm x 22.5 mm)
PD Surface Depth[3]	0.09" (2.2 mm)
Weight, Detector Only	0.10 kg
Accessories	SM1T1 Coupler SM1RR Retainer Ring
Operating Temp	10 to 50 °C
Storage Temp	-25 to 70 °C
AC Power Supply	AC – DC Converter
Input Power[4]	6 W 100 V / 120 V / 230 V, 50 – 60 Hz

Features

- Wavelength Ranges within 800 to 2600 nm
- Low-Noise Amplification with Fixed or Switchable Gain
- Load Impedances 50 Ω and Higher for ≥3 kHz Bandwidth Versions
- Free-Space Optical Coupling

A selection of Indium Gallium Arsenide (InGaAs) Free-Space Amplified Photodetectors that are sensitive to light in the NIR wavelength range. Thorlabs' amplified photodetectors feature a built-in, low-noise transimpedance amplifier (TIA) which, for select detectors, is followed by a voltage amplifier. Menlo Systems' FPD series amplified photodetectors have a built-in radio frequency (RF) or transimpedance amplifier. We offer fixed-gain versions that possess a fixed maximum bandwidth and total transimpedance gain, as well as switchable-gain versions with two or eight gain settings.

Thorlabs' photodetectors are designed to meet a range of requirements, with offerings that include the 380 MHz PDA015C with an impulse response of 1 ns, the high-sensitivity PDF10C with a noise equivalent power (NEP) of 7.5 fW/Hz1/2, and the switchable-gain PDA20CS2 with eight switchable maximum gain (bandwidth) combinations from 1.51 kV/A (11 MHz) to 4.75 MV/A (3 kHz). The PDF10C with femtowatt sensitivity is a low-frequency device that should only be terminated into high impedance (Hi-Z) loads, while all other of our InGaAs PDA amplified photodetectors are capable of driving loads from 50 Ω to Hi- Z.

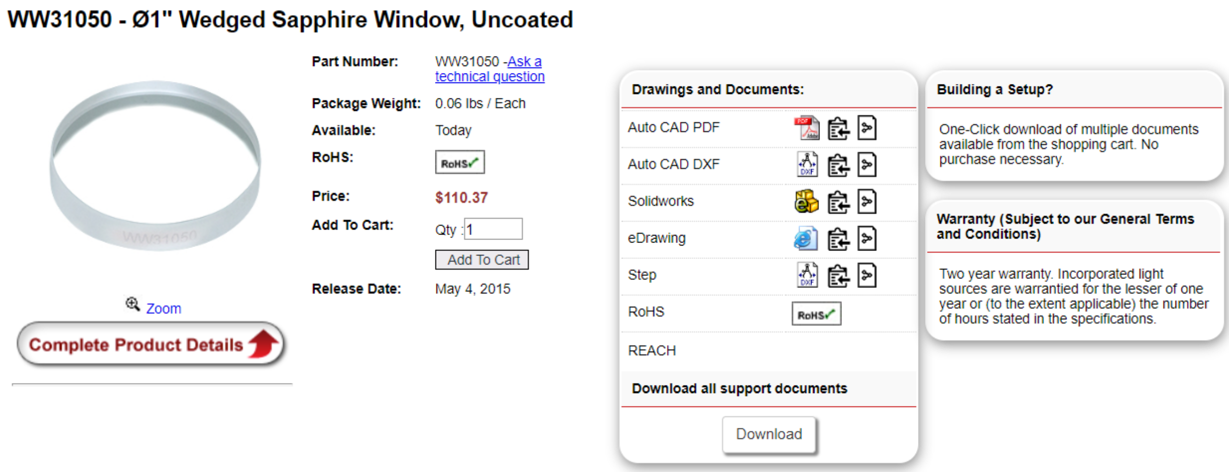
Every PDA and PDF detector has internal SM05 (0.535"-40) threading and external SM1 (1.035"-40) threading. Except for some select detectors, each unit's housing features 8-32 tapped holes (M4 for -EC and /M models). The PDA05CF2, PDA20C2, PDA10D2, PDA10CS2, and PDA20CS2 feature a new housing with two universal mounting holes that accept both 8-32 and M4 threads. For more information about the location of these mounting points and mounting these units

Menlo Systems' FPD series photodetectors are easy-to-use InGaAs-PIN photodiode packages with an integrated high-gain, low-noise RF (FPD310-FS-NIR) or transimpedance (FPD510-FS-NIR and FPD610-FS-NIR) amplifier. The FPD310-FS-NIR is recommended, in particular, for applications like pulse shape and low-noise radio frequency extraction. This photodetector is optimized for high gain, high bandwidths, extremely short rise times, and high signal-to-noise ratio. It has a 0.5 ns rise time and a switchable gain between two settings, allowing for an optimal performance for the user's application. The FPD510-FS-NIR and FPD610-FS-NIR have a fixed gain and are optimized for highest signal-to-noise-ratio for detection of low level optical beat signals at frequencies up to 250 MHz and 600 MHz, respectively. The FPD510-FS-NIR has a rise time of 2 ns, while the FPD610-FS-NIR has a 1 ns rise time. The 3 dB bandwidth of these DC-coupled devices is 200 MHz for the FPD510-FS-NIR and 500 MHz for the FPD610-FS-NIR. The compact design of the FPD detectors allows for easy OEM integration. The housing of each Menlo detector features one M4 tapped hole for post mounting.

<u>Power Supply</u>

A ±12 V linear power supply that supports input voltages of 100, 120, and 230 VAC is included with each amplified photodetector. Replacement power supplies are available separately below. Before connecting the power supply to the mains, ensure that the line voltage switch on the power supply module is set to the proper voltage range. The power supplies should always be powered up using the power switch on the power supply itself. Hot plugging the unit is not recommended.

5.3.7 Optical window



Features

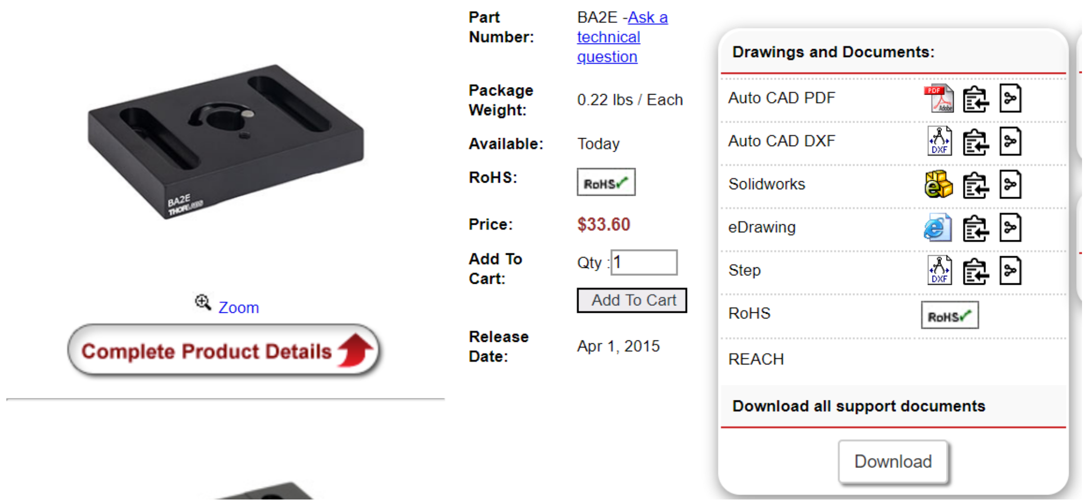
- 30 arcmin Wedged Windows
- Available Uncoated (150 nm - 4.5 µm) or with One of Two Broadband AR Coatings
- 1.65 - 3.0 µm (-D Coating Designation)
- 2.0 - 5.0 µm (-E1 Coating Designation)
- Ø1/2" and Ø1" Window

Sapphire is the material of choice for very demanding applications that benefit from reliability, strength, a broad transmission range, or low transmitted wavefront distortion at both high and low operating temperatures. Sapphire is transparent from the UV to the IR and can be scratched by only a few substances other than itself. It is chemically inert and insoluble in water, common acids, and alkalis at temperatures up to ~1,000 °C. Our sapphire windows are cut so that the c-axis of the crystal is parallel to the optical axis.

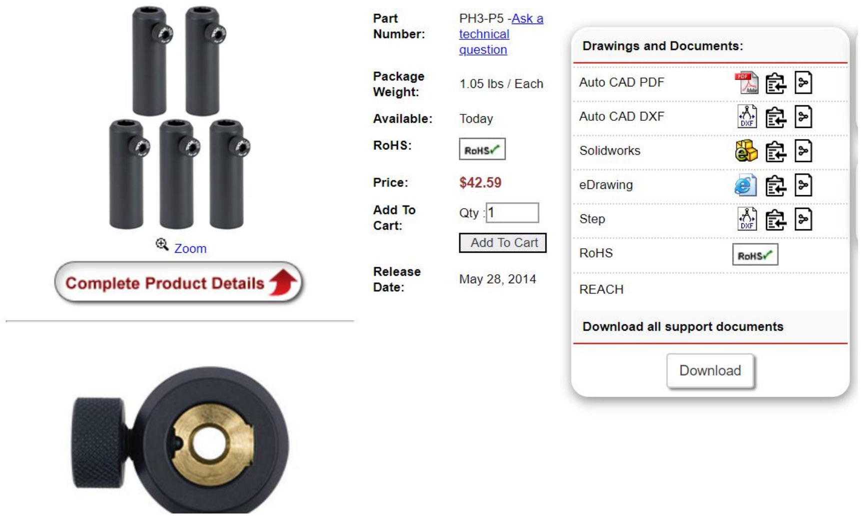
In addition to the sapphire wedged windows offered here, Thorlabs also offers wedged windows with other substrate materials (see the selection guide to the right). Wedged Laser Windows with AR coatings centered around common lasing wavelengths and wedged Beam Samplers with broadband AR coatings on only one face are also available

5.3.8 Component holders

BA2E - Flexure Clamping Base / Post Mount, Ø1/2" Double Bore, 2.00" x 3.00" x 0.48"



PH3-P5 - Ø1/2" Post Holder, Spring-Loaded Hex-Locking Thumbscrew, L = 3", 5 Pack

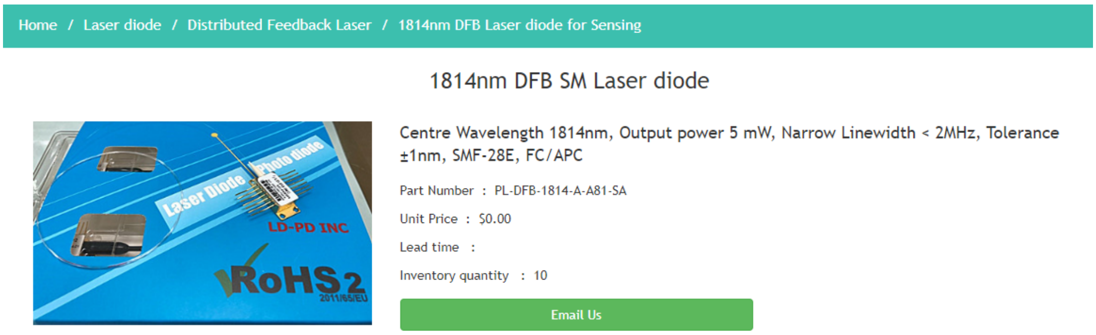


5.4 List of components for NO measurement[10]

1814 nm

5.4.1 Laser diode (To do √...)

or



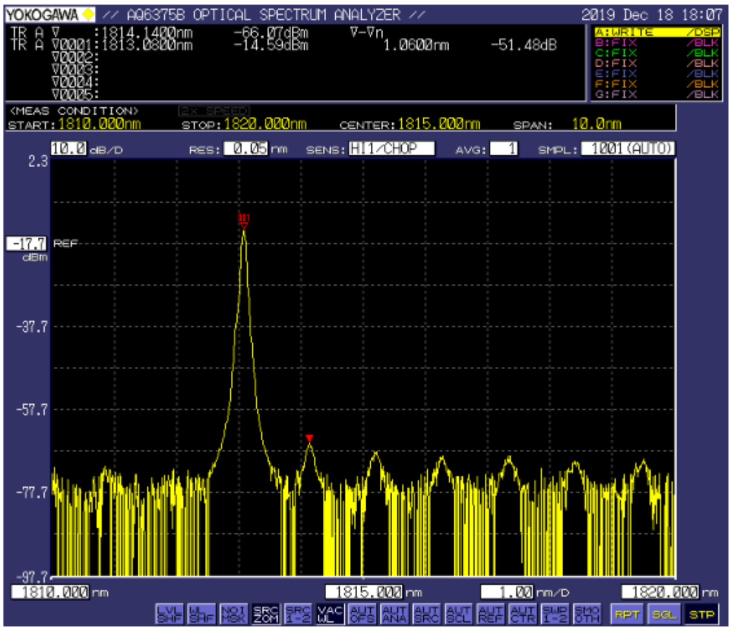
[10] From [Abdel-Karim, Aisha 2020]

Laser Specifications

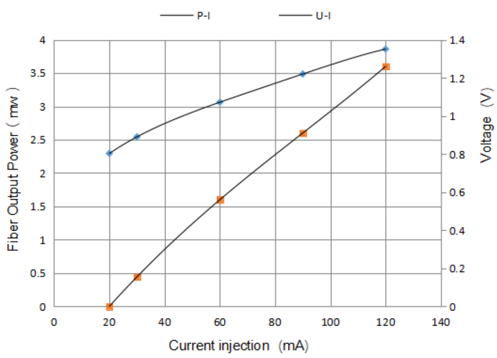
Electrical/Optical Characteristics (Tsub=25°C, CW bias unless stated otherwise)

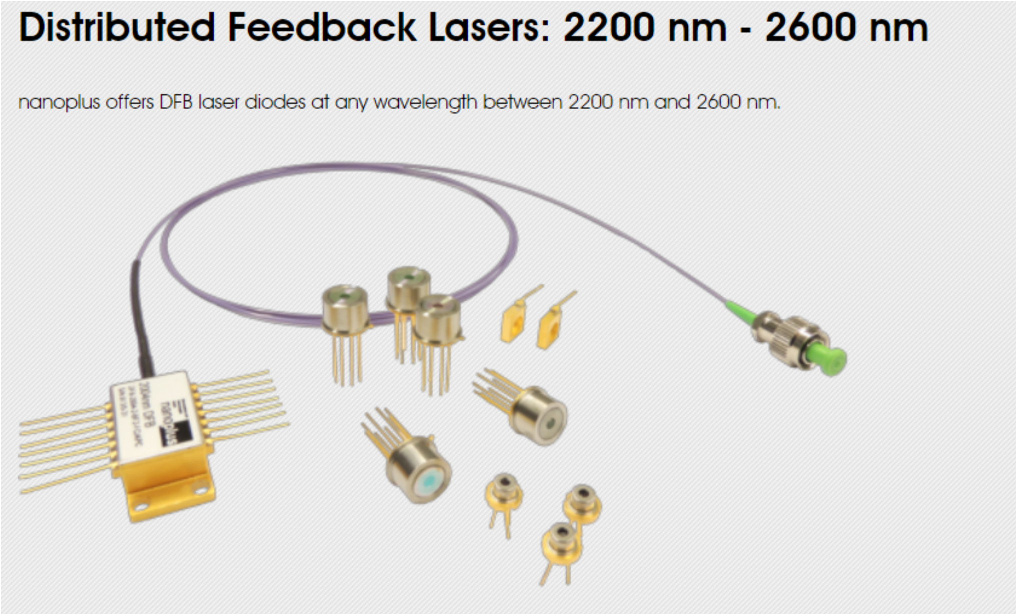
Parameter	Symbol	Min	Typ	Max	Unit
Centre Wavelength	λ	1813	1814	1815	nm
Side Mode Suppression Ratio	SMSR	30	40		dB
Threshold Current	Ith		20	30	mA
Operating Current	Iop		80	120	mA
Chip output Power	3		5	8	mW
Quantum Efficiency	η	0.08	0.12		mW/mA
Current Tuning Coefficient	Δλ/ΔI		0.015		nm/mA
Temperature Tuning Coefficient	Δλ/ΔT		0.12		nm/K
Forward Voltage	Vf		1.3	2	V
Thermistor Resistance	RT	9.5	10	10.5	KΩ
Thermistor Temp. Coefficient			-4.4		%/°C
Connector	FC/APC				

Spectrum



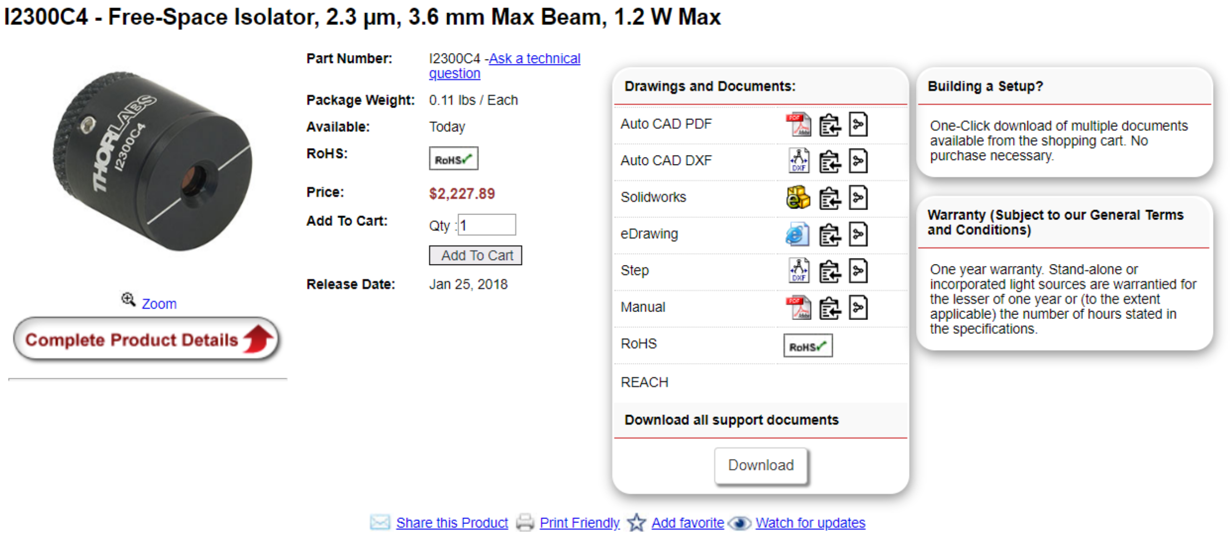
L-I Curve



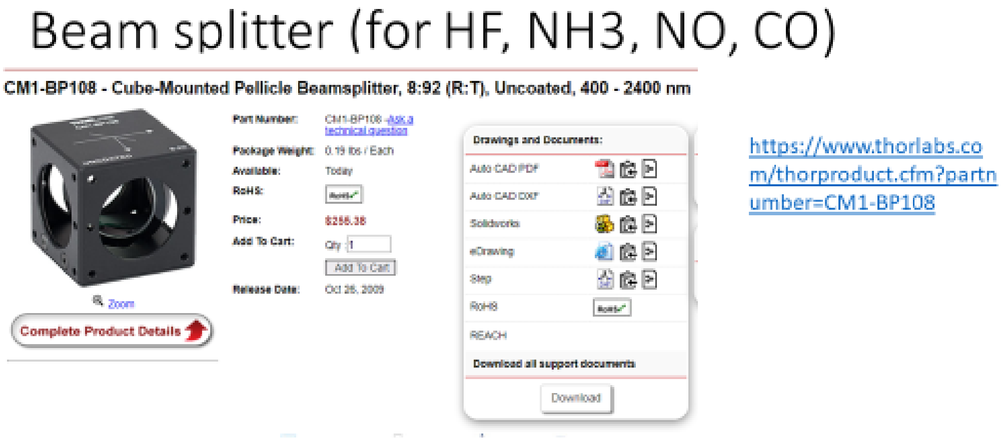


5.4.2 Collimator (To do...)

5.4.3 Isolator

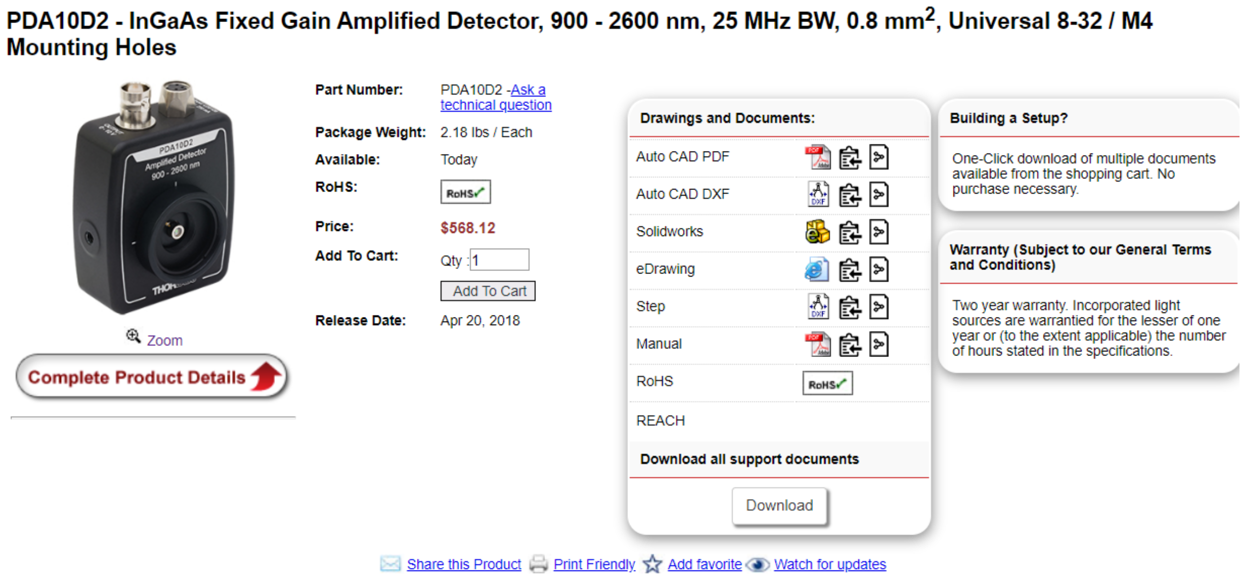


5.4.4 Beam splitter



5.4.5 Focusing lens (To do.√..)

5.4.6 Photodiode

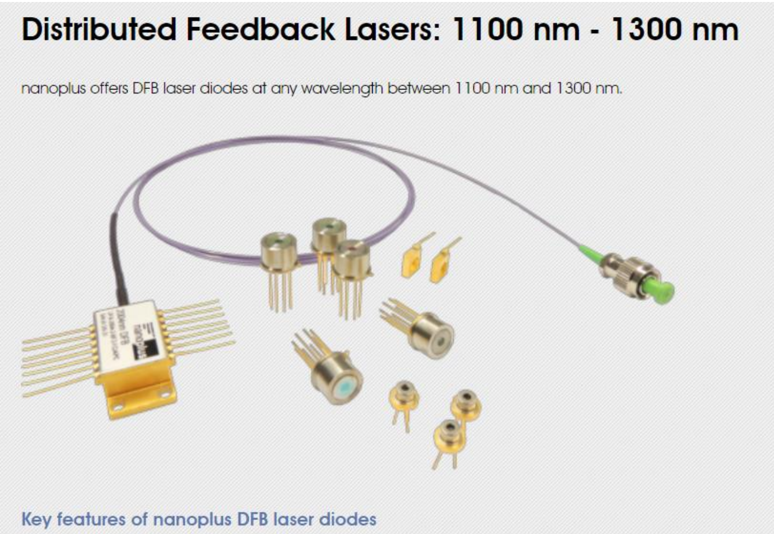


Same detector as for CO measurement

5.5 List of components for HF measurement[11]

1280nm 1300nm

5.5.1 Laser diode (To do.√..)



[11] From [Abdel-Karim, Aisha 2020]

5.5.2 Collimator

LTN330-C - Adjustable Collimation Tube with Optic for Ø5.6 and Ø9 mm Laser Diodes, f = 3.1 mm, NA = 0.68, AR Coated: 1050 - 1700 nm

Zoom

Complete Product Details

Part Number:	LTN330-C -Ask a technical question
Package Weight:	0.08 lbs / Each
Available:	Today
RoHS:	RoHS✓
Price:	$252.13
Add To Cart:	Qty 1 Add To Cart
Release Date:	Jan 22, 2015

Drawings and Documents:

- Auto CAD PDF
- Auto CAD DXF
- Solidworks
- eDrawing
- Step
- RoHS
- REACH

Download all support documents

Download

Building a Setup?

One-Click download of multiple documents available from the shopping cart. No purchase necessary.

Warranty (Subject to our General Terms and Conditions)

Two year warranty. Incorporated light sources are warranted for the lesser of one year or (to the extent applicable) the number of hours stated in the specifications.

Share this Product Print Friendly Add favorite Watch for updates

5.5.3 Isolator

IO-4-1310-VLP - Free-Space Isolator, 1310 nm, Ø3.6 mm Max Beam, 1.2 W Max

Zoom

Complete Product Details

Part Number:	IO-4-1310-VLP -Ask a technical question
Package Weight:	0.18 lbs / Each
Available:	Today
RoHS:	RoHS✓
Price:	$947.94
Add To Cart:	Qty 1 Add To Cart
Release Date:	Oct 24, 2007

Drawings and Documents:

- Auto CAD PDF
- Auto CAD DXF
- Solidworks
- eDrawing
- Step
- Manual
- RoHS
- REACH

Download all support documents

Download

Building a Setup?

One-Click download of multiple documents available from the shopping cart. No purchase necessary.

Warranty (Subject to our General Terms and Conditions)

One year warranty. Stand-alone or incorporated light sources are warranted for the lesser of one year or (to the extent applicable) the number of hours stated in the specifications.

Share this Product Print Friendly Add favorite Watch for updates

5.5.4 Beam splitter

CM1-BP108 - Cube-Mounted Pellicle Beamsplitter, 8:92 (R:T), Uncoated, 400 - 2400 nm

Zoom

Complete Product Details

Part Number:	CM1-BP108 -Ask a technical question
Package Weight:	0.19 lbs / Each
Available:	Today
RoHS:	RoHS✓
Price:	$255.38
Add To Cart:	Qty :1 Add To Cart
Release Date:	Oct 26, 2009

Drawings and Documents:

Auto CAD PDF	
Auto CAD DXF	
Solidworks	
eDrawing	
Step	
RoHS	RoHS✓
REACH	

Download all support documents

Download

5.5.5 Focusing lens

LBF254-200-C - N-BK7 Best Form Lens, Ø1", f = 200 mm, ARC: 1050-1700 nm

Zoom

Complete Product Details

Part Number:	LBF254-200-C -Ask a technical question
Package Weight:	0.05 lbs / Each
Available:	Today
RoHS:	RoHS✓
Price:	$60.59
Add To Cart:	Qty :1 Add To Cart
Release Date:	Aug 25, 2003

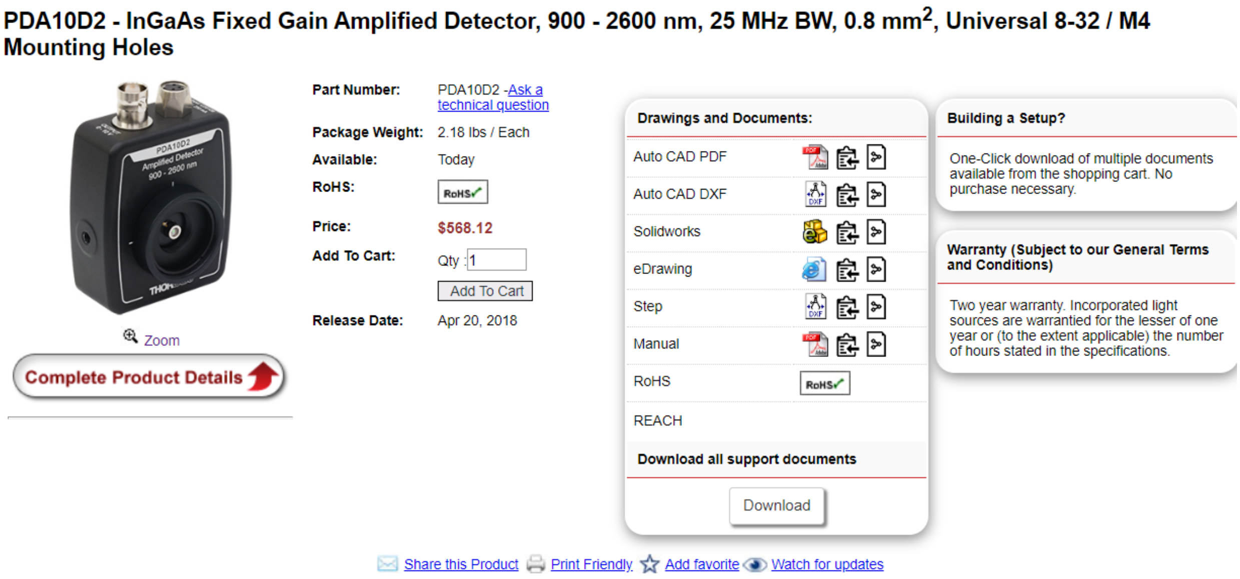
Drawings and Documents:

Auto CAD PDF	
Auto CAD DXF	
Solidworks	
eDrawing	
Step	
Zemax	
Zemax (ZMX)	
RoHS	RoHS✓
REACH	

Download all support documents

Download

5.5.6 Photodiode

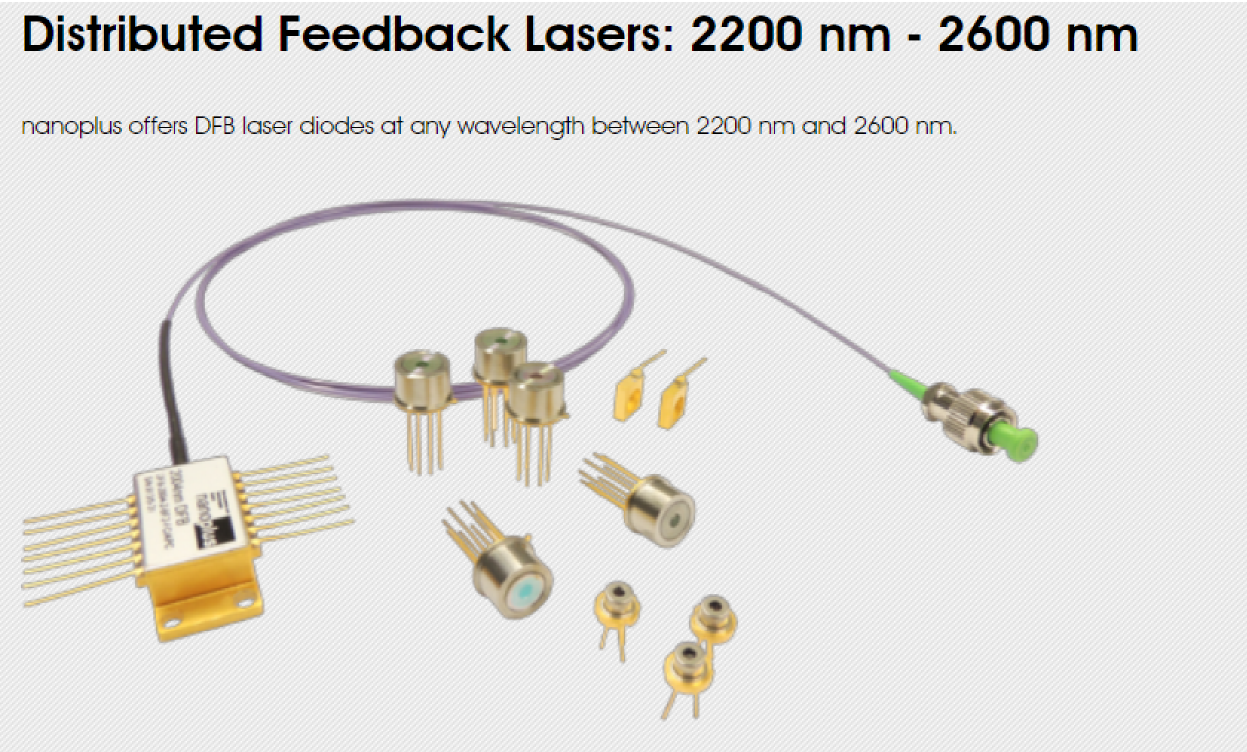


Same detector as for CO measurement

5.6 List of components for SO2 measurement[12]

2460 nm and 4020 nm

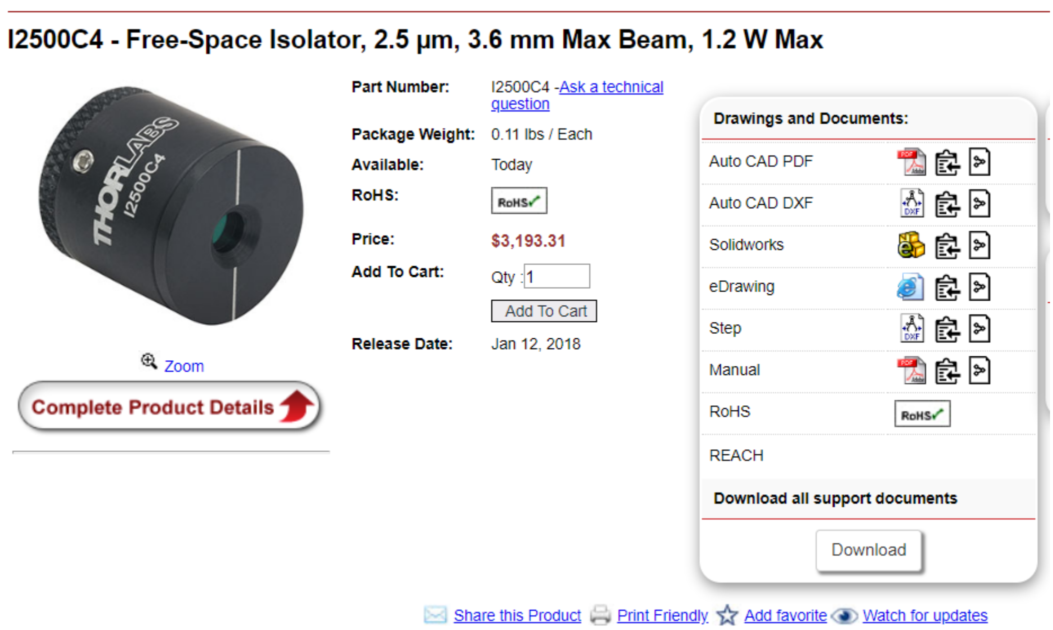
5.6.1 Laser diode (To do..√.)



12 From [Abdel-Karim, Aisha 2020]

5.6.2 Collimator (To do...)

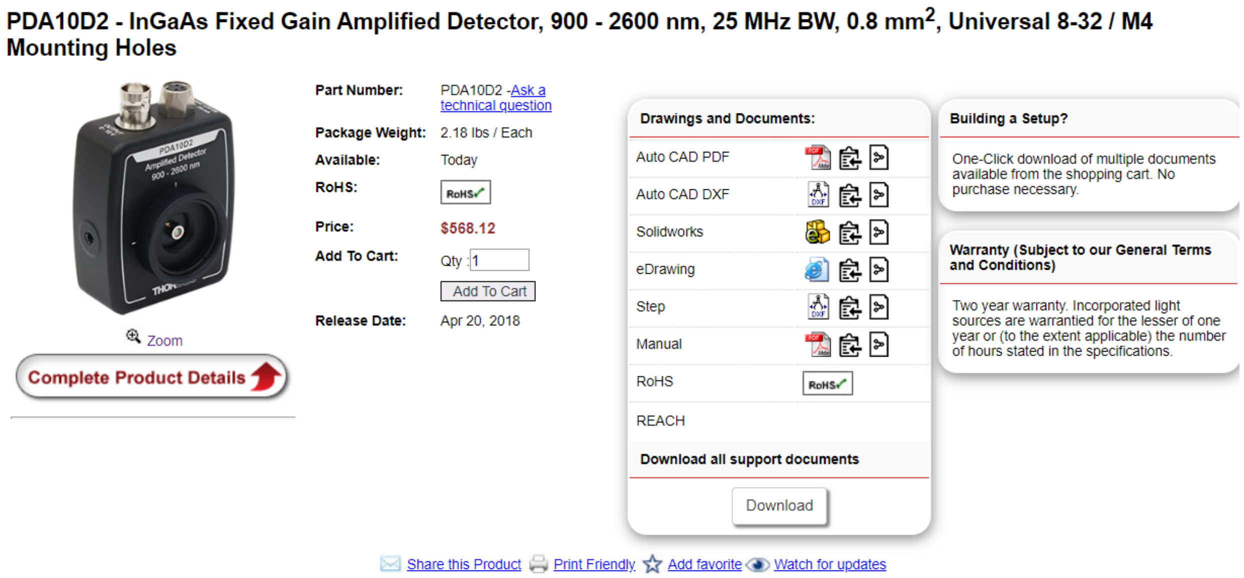
5.6.3 Isolator



5.6.4 Beam splitter (To do...)

5.6.5 Focusing lens (To do...)

5.6.6 Photodiode

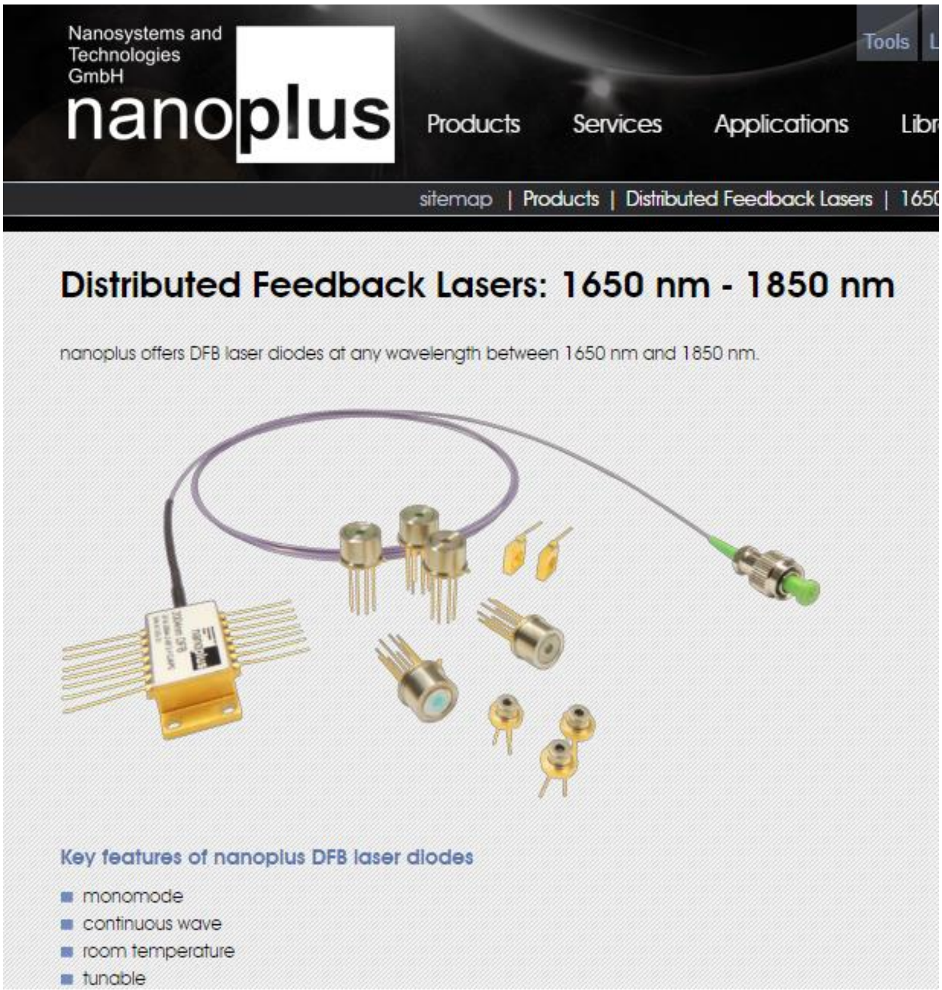


Same detector as for CO measurement

5.7 List of components for HCl measurement[13]

1742nm 3395nm

5.7.1 Laser diode (To do.√..)



[13] From [Abdel-Karim, Aisha 2020]

5.7.1.1 Key features of nanoplus DFB laser diodes

- monomode
- continuous wave
- room temperature
- tunable
- custom wavelengths

5.7.1.2 Why choose nanoplus DFB laser diodes

- stable longitudinal and transversal single mode emission
- precise selection of target wavelength
- narrow laser linewidth
- mode-hop-free wavelength tunability
- fast wavelength tuning
- typically > 5 mW output power
- small size
- easy usability
- high efficiency
- long-term stability

For more than 15 years nanoplus has been the technology leader for lasers in gas sensing. We produce lasers at large scale at our own fabrication sites in Gerbrunn and Meiningen. nanoplus cooperates with the leading system integrators in the TDLAS based analyzer industry. More than 20,000 installations worldwide prove the reliability of nanoplus lasers.

5.7.1.3 Quick description of nanoplus DFB laser technology

Nanoplus uses a unique and patented technology for DFB laser manufacturing. We apply a lateral metal grating along the ridge waveguide, which is independent of the material system. Read more about our patented distributed feedback technology.

5.7.1.4 Related information for nanoplus DFB laser diodes between 1650 nm and 1850 nm

Specifications

The following table summarizes the typical DFB laser specifications in the 1650 nm to 1850 nm range:

parameters (T = 25 °C)	symbol	unit	minimum	typical	maximum
wavelength precision	δ	nm		0.1	
optical output power	P_{out}	mW		5	
forward current	I_f	mA		70	
threshold current	I_{th}	mA	20	35	65
current tuning coefficient	C_I	nm / mA	0.008	0.02	0.03
temperature tuning coefficient	C_T	nm / K	0.07	0.10	0.14
typical maximum operating voltage	V_{op}	V		2	
side mode suppression ratio	SMSR	dB		> 35	
slow axis (FWHM)		degrees	20	30	40

parameters (T = 25 °C)	symbol	unit	minimum	typical	maximum
fast axis (FWHM)		degrees	40	50	60
emitting area	W x H	μm x μm	2.0 x 1.0	3.0 x 1.5	5.0 x 2.0
storage temperature	T_S	°C	-40	+20	+80
operational temperature at case	T_C	°C	-20	+25	+50

Nanoplus DFB lasers show outstanding spectral, tuning and electrical properties. They are demonstrated in figures 1 - 3. Click on the graphics to enlarge.

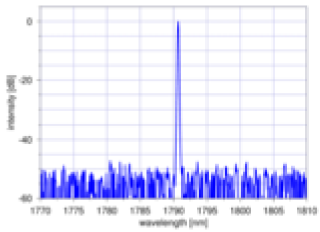


Figure 1: Spectrum of nanoplus 1780 nm DFB laser diode

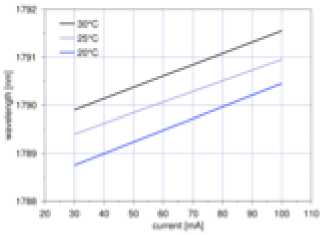


Figure 2: Mode hop free tuning of nanoplus 1780 nm DFB laser diode

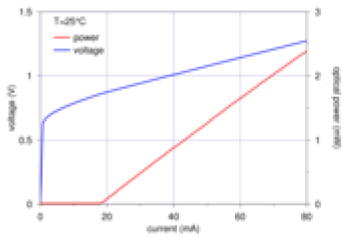


Figure 3: Typical power, voltage and current characteristics of nanoplus 1780 nm DFB laser diode

Distributed Feedback Lasers: 3000 nm - 6000 nm

nanoplus DFB interband cascade laser facilitates new TDLAS applications in mid-infrared

nanoplus offers a DFB interband cascade laser (ICL) at any target wavelength in the mid-infrared (MIR) between 3 µm and 6 µm. The device operates in continuous wave (cw) mode around room temperature. Specifications and behavior are very comparable to a nanoplus laser at lower wavelengths. When you set up an ICL-based analyzer, you can, hence, transfer the engineering knowledge you have gained from building short-wavelength gas sensors.

Why?

Because:

1742 nm

3395 nm

5.7.2 Collimator (To do...)

5.7.3 Isolator

5.8 Realization

Because of the Corona crises, we just managed to order the laser kit of CO.

In July, we found that we perhaps could use the IR camera as detector.

The MELEXIS IR camera was used bevor for the safety valve of the incinerator.

Either we found that we ordered for another project with fiber optics a collimator.

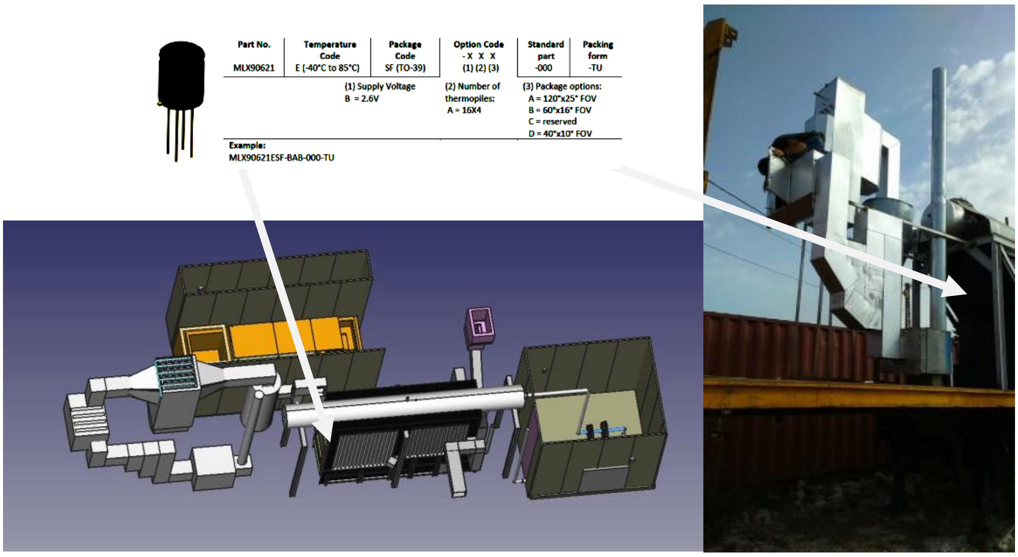
This replacement of materials probably release the error of our experiment. Nevertheless, it is better than to do nothing.

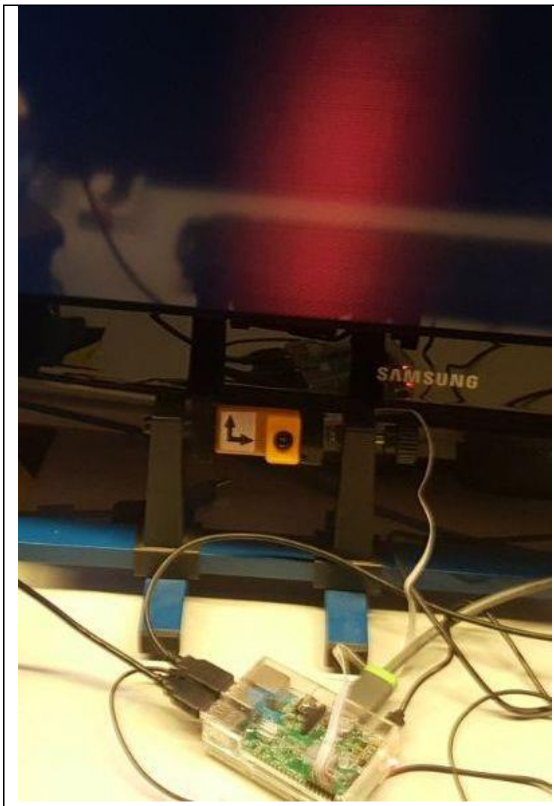
We have also to change parts of the experiment.

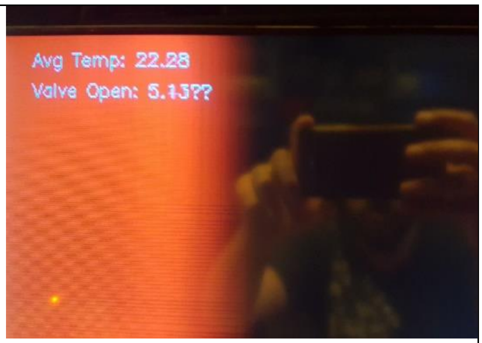
With just one detector, I propose to compare the cases: “with” and “without” gas between laser and gas. Instead of the results of two detectors: one bevor and one after the gas. Therefore, we do not need a splitter nor an isolator.

5.8.1 Melexis IR Camera

One IR Camera shall take samplings from whole incineration chamber by moving in x-y-directions. Camera is positioned at the windows at the end of the waste band (working package 1 for CNC Lab)







SteamValveControllerArduinoCode.zip

Bevor we found the Melexis IR camera we study the opportunity of using a parking sensor as detector. There are different types. Parking sensors which use IR waves and others which use sonor waves.

5.8.2 Camera Laptop connection

arduino.cc/en/Guide/ArduinoUno

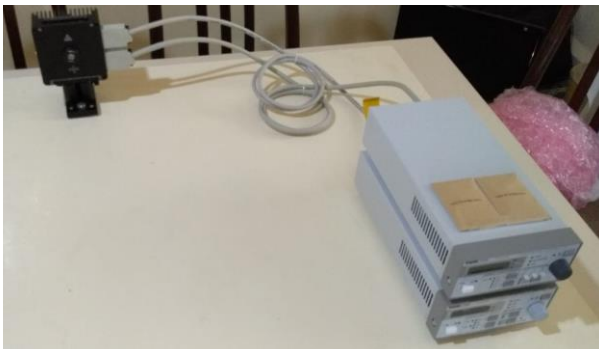
STORE SOFTWARE EDU PRO RESOURCES COMMUNITY HELP SIGN IN

If you used the Installer, Windows - from XP up to 10 - will install drivers automatically as soon as you connect your board.

If you downloaded and expanded the Zip package or, for some reason, the board wasn't properly recognized, please follow the procedure below.

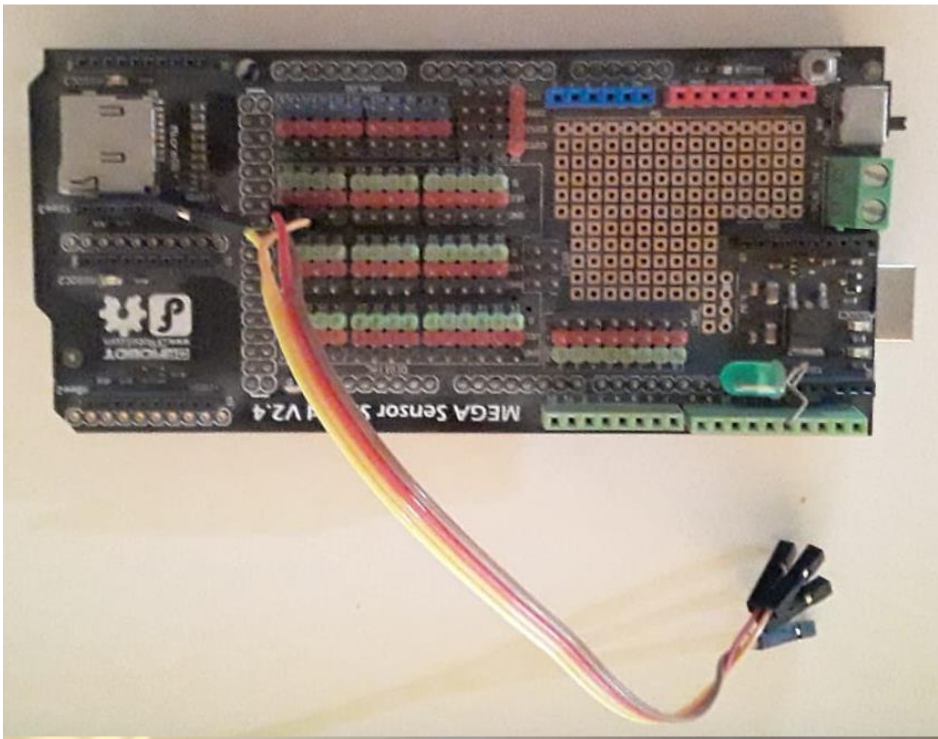
- Click on the Start Menu, and open up the Control Panel.
- While in the Control Panel, navigate to System and Security. Next, click on System. Once the System window is up, open the Device Manager.
- Look under Ports (COM & LPT). You should see an open port named "Arduino UNO (COMxx)". If there is no COM & LPT section, look under "Other Devices" for "Unknown Device".
- Right click on the "Arduino UNO (COmxx)" port and choose the "Update Driver Software" option.
- Next, choose the "Browse my computer for Driver software" option.
- Finally, navigate to and select the driver file named **"arduino.inf"**, located in the "Drivers" folder of the Arduino Software download (not the "FTDI USB Drivers" sub-directory). If you are using an old version of the IDE (1.0.3 or older), choose the Uno driver file named **"Arduino UNO.inf"**
- Windows will finish up the driver installation from there.

See also: step-by-step screenshots for installing the Uno under Windows XP.




MODBUS SLAVE
ADDRESS
1


مواليد 30/10/2001
توفي 21 رمضان 1441
الموافق 14/05/2020




يا أيتها النفس المطمئنة
ارجعي الى ربك راضية مرضية
فادخلي في عبادي وادخلي جنتي
الشاب ابراهيم رامي مراد رحمه الله
مواليد 30/10/2001
توفي 21 رمضان 1441
الموافق 14/05/2020

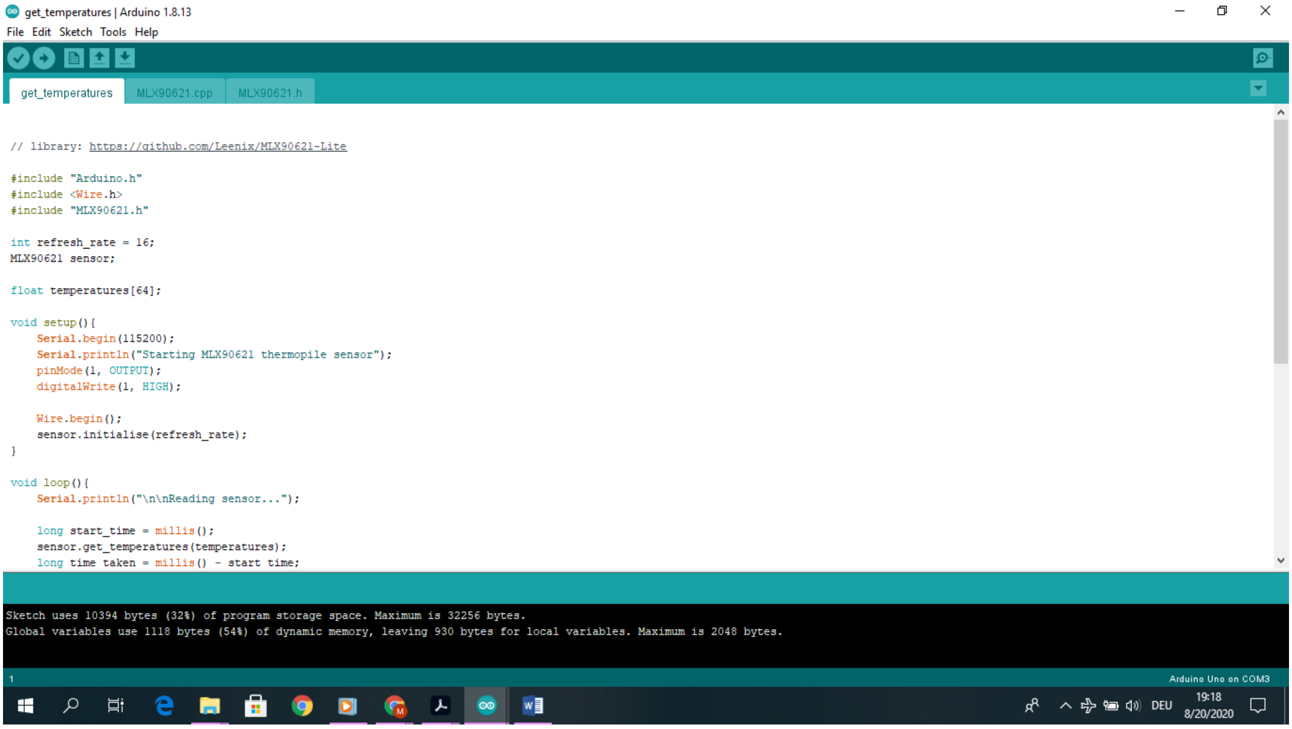

T controller
Melexis IR camera
Detector
LD mount
Arduino
LD controller

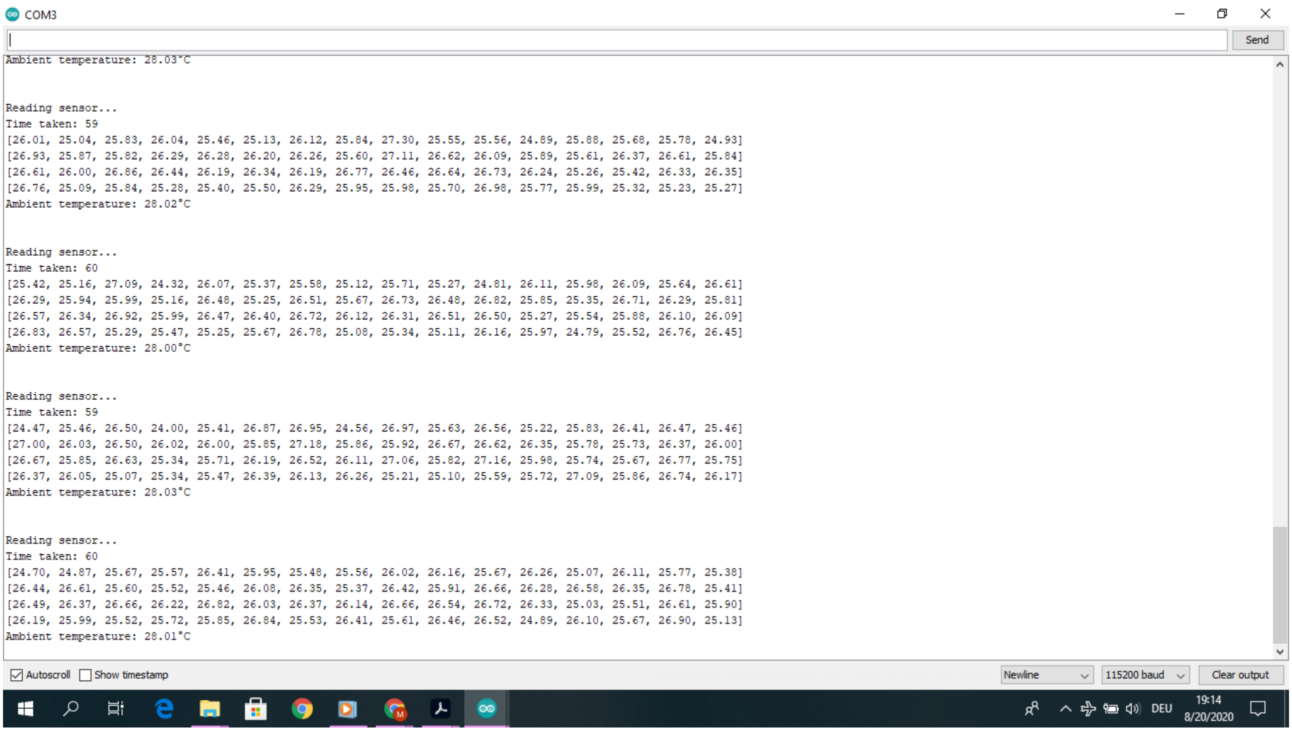

THOR
LDM56/M
LD
collimator

6 Results

First Exp 20 .8.20.

Laser off:





Laser on:

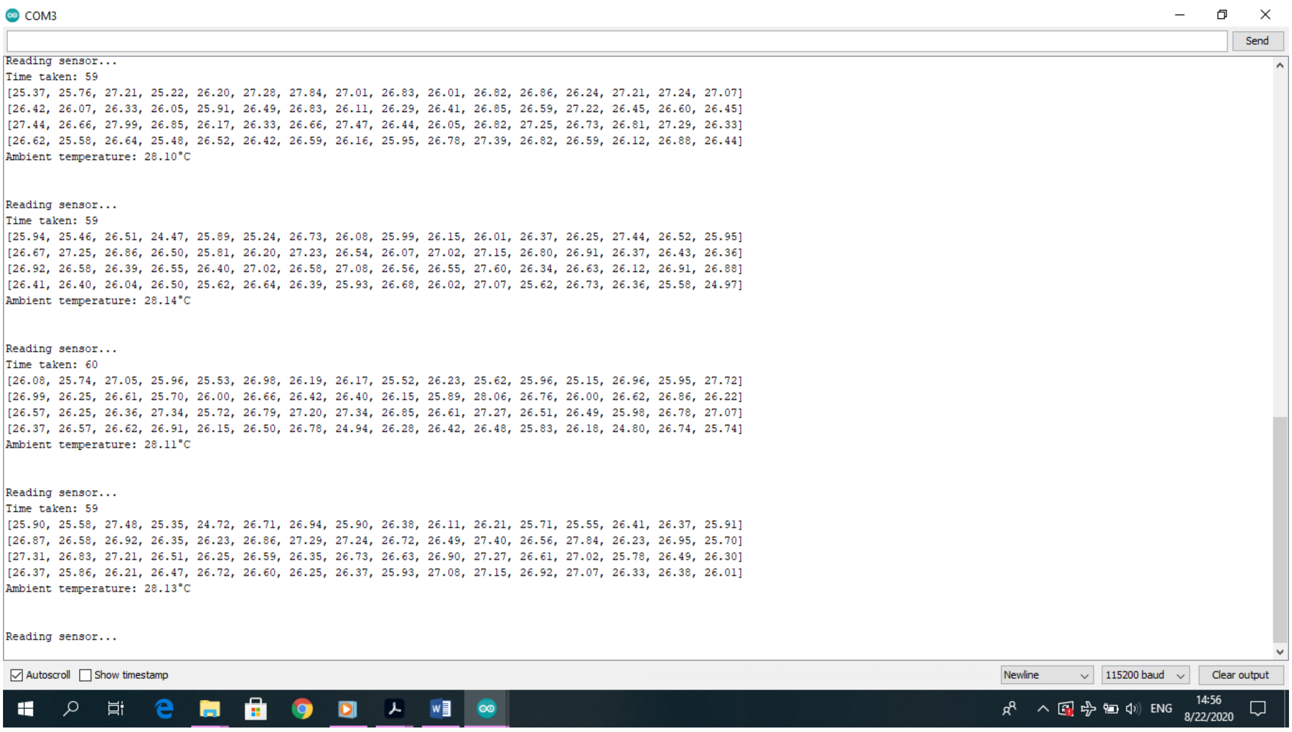
We have to ground it first.

22.8.20

Grounding completed.

Second Exp:

Without Laser:



```
Reading sensor...
Time taken: 59
[25.37, 25.76, 27.21, 25.22, 26.20, 27.28, 27.84, 27.01, 26.83, 26.01, 26.82, 26.86, 26.24, 27.21, 27.24, 27.07]
[26.42, 26.07, 26.33, 26.05, 25.91, 26.49, 26.83, 26.11, 26.29, 26.41, 26.85, 26.59, 27.22, 26.45, 26.60, 26.45]
[27.44, 26.66, 27.99, 26.85, 26.17, 26.33, 26.66, 27.47, 26.44, 26.05, 26.82, 27.25, 26.73, 26.81, 27.29, 26.33]
[26.62, 25.58, 26.64, 25.48, 26.52, 26.42, 26.59, 26.16, 25.95, 26.78, 27.39, 26.82, 26.59, 26.12, 26.88, 26.44]
Ambient temperature: 28.10°C


Reading sensor...
Time taken: 59
[25.94, 25.46, 26.51, 24.47, 25.89, 25.24, 26.73, 26.08, 25.99, 26.15, 26.01, 26.37, 26.25, 27.44, 26.52, 25.95]
[26.67, 27.25, 26.86, 26.50, 25.81, 26.20, 27.23, 26.54, 26.07, 27.02, 27.15, 26.80, 26.91, 26.37, 26.43, 26.36]
[26.92, 26.58, 26.39, 26.55, 26.40, 27.02, 26.58, 27.08, 26.56, 26.55, 27.60, 26.34, 26.63, 26.12, 26.91, 26.88]
[26.41, 26.40, 26.04, 26.50, 25.62, 26.64, 26.39, 25.93, 26.68, 26.02, 27.07, 25.62, 26.73, 26.36, 25.58, 24.97]
Ambient temperature: 28.14°C


Reading sensor...
Time taken: 60
[26.08, 25.74, 27.05, 25.96, 25.53, 26.98, 26.19, 26.17, 25.52, 26.23, 25.62, 25.96, 25.15, 26.96, 25.95, 27.72]
[26.99, 26.25, 26.61, 25.70, 26.00, 26.66, 26.42, 26.40, 26.15, 25.89, 28.06, 26.76, 26.00, 26.62, 26.86, 26.22]
[26.57, 26.25, 26.36, 27.34, 25.72, 26.79, 27.20, 27.34, 26.85, 26.61, 27.27, 26.51, 26.49, 25.98, 26.78, 27.07]
[26.37, 26.57, 26.62, 26.91, 26.15, 26.50, 26.78, 24.94, 26.28, 26.42, 26.48, 25.83, 26.18, 24.80, 26.74, 25.74]
Ambient temperature: 28.11°C


Reading sensor...
Time taken: 59
[25.90, 25.58, 27.48, 25.35, 24.72, 26.71, 26.94, 25.90, 26.38, 26.11, 26.21, 25.71, 25.55, 26.41, 26.37, 25.91]
[26.87, 26.58, 26.92, 26.35, 26.23, 26.86, 27.29, 27.24, 26.72, 26.49, 27.40, 26.56, 27.84, 26.23, 26.95, 25.70]
[27.31, 26.83, 27.21, 26.51, 26.25, 26.59, 26.35, 26.73, 26.63, 26.90, 27.27, 26.61, 27.02, 25.78, 26.49, 26.30]
[26.37, 25.86, 26.21, 26.47, 26.72, 26.60, 26.25, 26.37, 25.93, 27.08, 27.15, 26.92, 27.07, 26.33, 26.38, 26.01]
Ambient temperature: 28.13°C


Reading sensor...
```

Laser on:

Problem: PLD reach only 0.2mW.

Chat with Thorlabs.

Note:

I chat with them as Samir Mourad, because he is their official costumer.

Tech Support
-Applications
-Specification
-Customization

Sale Support
-Catalog Products
-Order Status
-Delivery
-Pricing

Info

at 17:39, Aug 24:

Thank you for choosing to chat with us. An agent will be with you shortly.

Info

at 17:40, Aug 24:

You are now chatting with Victor.

Samir Mourad

at 17:40, Aug 24:

Hello

Victor

at 17:40, Aug 24:

Hello Samir, How can I help you?

Samir Mourad

at 17:40, Aug 24:

I have problems with the calibration of LDC205C

Samir Mourad

at 17:41, Aug 24:

it reach 0.2mW and stops

Victor

at 17:45, Aug 24:

I see, are any current limit set?

Samir Mourad

at 17:46, Aug 24:

yes

Victor

at 17:52, Aug 24:

What is the current limit?

Samir Mourad

at 17:52, Aug 24:

40 mA

Victor

at 17:57, Aug 24:

I see, when you adjust the current does it reaches 40 mA?

Samir Mourad

at 17:57, Aug 24:

yes

Victor

at 18:00, Aug 24:

The 2 mW is read on the LDC205C or measured at the output of the laser?

Samir Mourad

at 18:00, Aug 24:

0.2 mW

Samir Mourad

at 18:01, Aug 24:

are displayed on the LDC205C

Victor

at 18:02, Aug 24:

Are you using an Thorlabs laser diode?

Samir Mourad

at 18:03, Aug 24:

yes

Samir Mourad

at 18:03, Aug 24:

l1550P5DFB

Samir Mourad

at 18:04, Aug 24:

and ML925B45F before

Victor

at 18:07, Aug 24:

I see, was the LDC205C working properly with the l1550P5DFB? Or did it stop working when you change from the ML925B45F to the l1550P5DFB?

Samir Mourad

at 18:09, Aug 24:

at both the PLD reach only 0.2mW

Victor

at 18:10, Aug 24:

Was it working properly before and suddenly stopped or has it never reached above 0.2 mW?

Samir Mourad

at 18:10, Aug 24:

never ..

Victor

at 18:10, Aug 24:

I see, which mount at you using?

Samir Mourad

at 18:11, Aug 24:

LDM56/M

Victor

at 18:14, Aug 24:

What is the I_PD set to on the LDC205C?

Samir Mourad

at 18:18, Aug 24:

0

Victor

at 18:18, Aug 24:

I see, so the I_PD should be set to 25 uA

Samir Mourad

at 18:20, Aug 24:

it's a laser diode

Samir Mourad

at 18:20, Aug 24:

I can't set I-PD

Victor

at 18:21, Aug 24:

Actually, I apologize for the confusion the I_PD should be set between 3 mA and 10 mA. This will ensure that the photodiode can used to monitor the current suplied to the laser diode to acheive constant power. I would recommend reading over section 3.4 of the manual

Victor

at 18:21, Aug 24:

https://www.thorlabs.com/drawings/918fc56944d49410-45F29080-DEB9-0FDC-E856FAC13DD12DC0/LDC205C-Manual.pdf

Victor

at 18:22, Aug 24:

If you would like to run in constant current mode then I would recommend measuring the output of the laser diode as you increase the current on the LDC205C.

Samir Mourad

at 18:23, Aug 24:

OK I will try

Samir Mourad

at 18:23, Aug 24:

thank you

Victor

at 18:25, Aug 24:

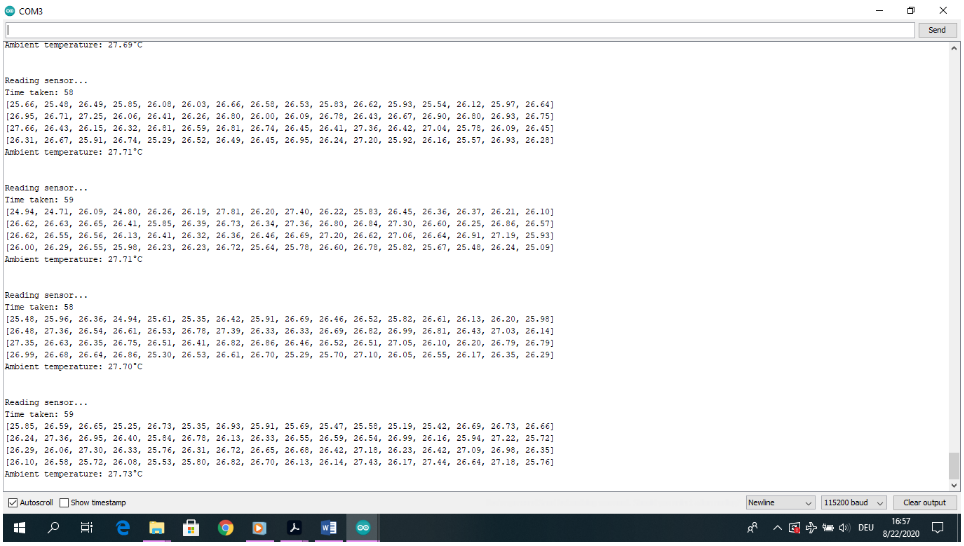
You are welcome. What might be happening is that the current supplied to the laser diode is correct and the laser diode is correctly working but the monitor photodiode is not showing the correct power.

Samir Mourad

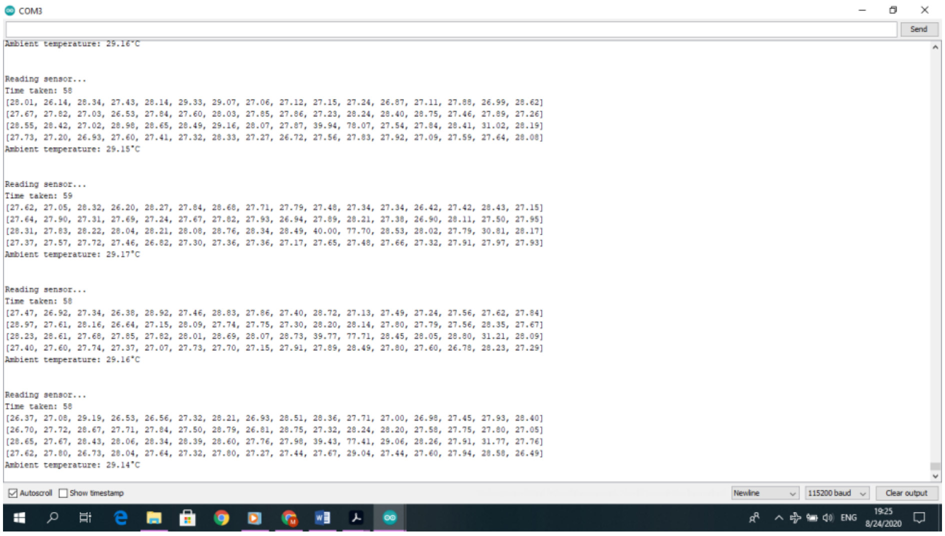
at 18:26, Aug 24:

ok

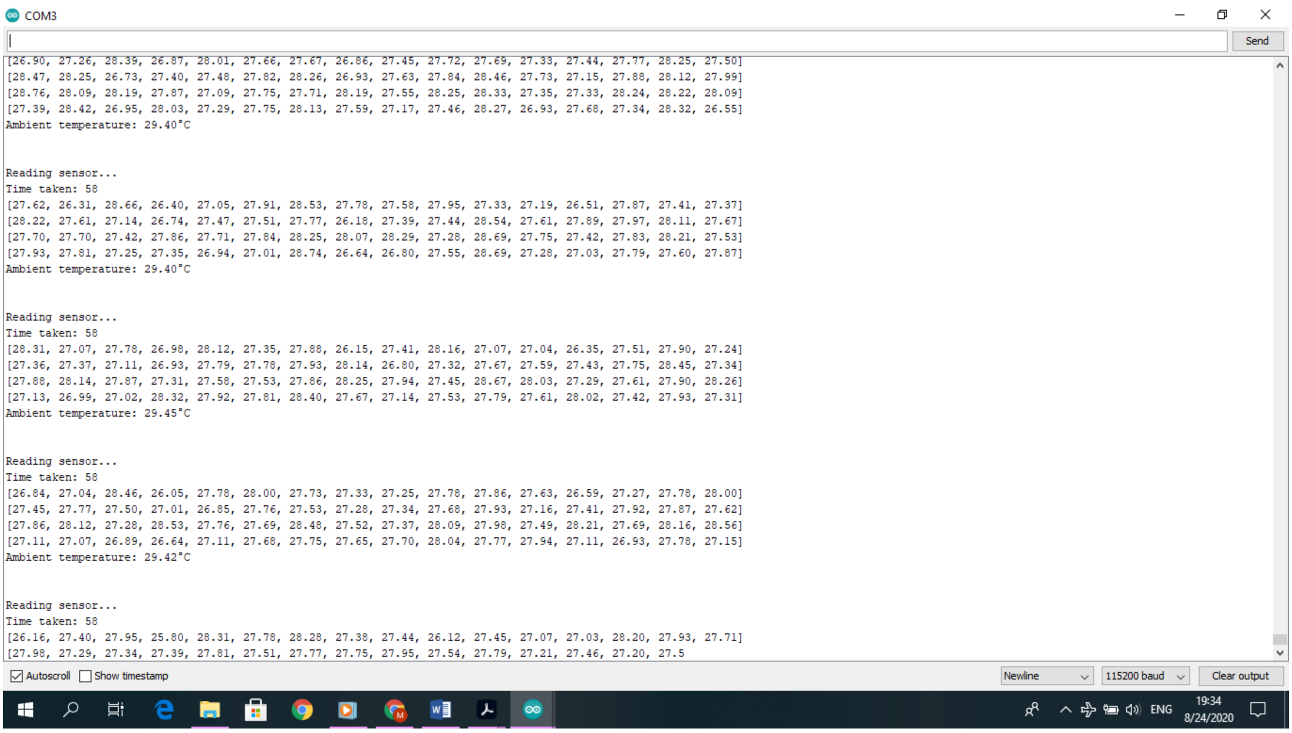
laser off

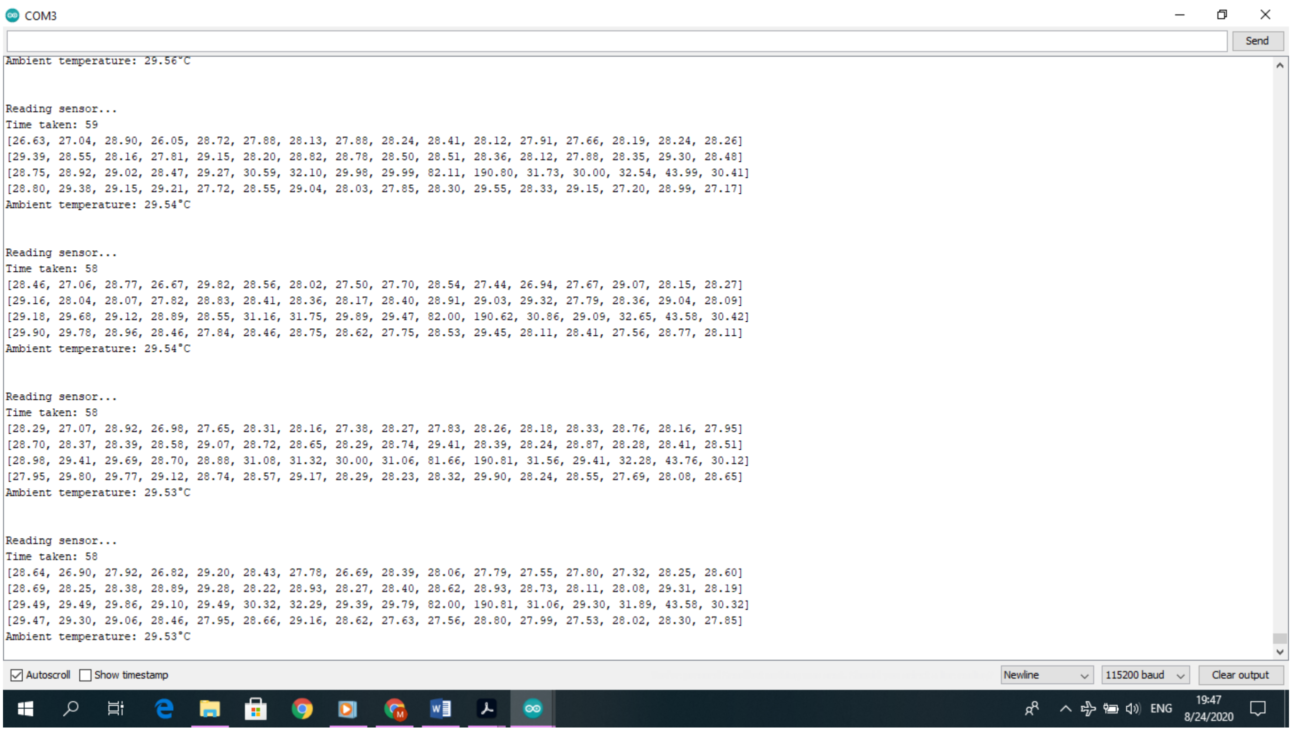


Laser on in CP mode



Laser on CC mode





We see in the middle of each temperature image a very high one, here 190 °C and 81/82 °C.

This is the Lasers consequence.

For the indoor Experiment with CO, we can use chemically produced CO.

$$HCOOH \longrightarrow H_2O + CO$$

We revoke the water from the formic acid by adding sulfuric acid to it.

We will obtain CO. without an increase of temperature. Which would be a grand error.

Formic acid will cost 75 000 LL / l

It costs 25 000 LL powder.

Text

Table for the planed experiments

EXP	**LD type**			**CO**				
Nr.	ML925B45F	l1550P5DFB		x/√	quantity	d_{LD}	d_C	
1								
2								
3								
4								
5								
6								
	LD controller							
					const		LD POL	
Nr.	I_{LIM}	I_{LD}	P_{LD}	I_{PD}	I	P	AG	CG
1								
2								
3								
4								
5								
6								
	T controller							
Nr.	I_{LIM}	T_{SET}	T_{ACT}	I_{TEC}	PID cal x/√	Sensor		
1								
2								
3								
4								
5								
6								
	LD Mount							
	LD		PD		1		2	
Nr.	CG	AG	CG	AG	up	down	up	Down
1								
2								
3								
4								
5								
6								
	Results							
	Camera	arduino						
Nr.	D	T_{max}	T_{av}					
1								
2								
3								
4								
5								
6								

9.1.20

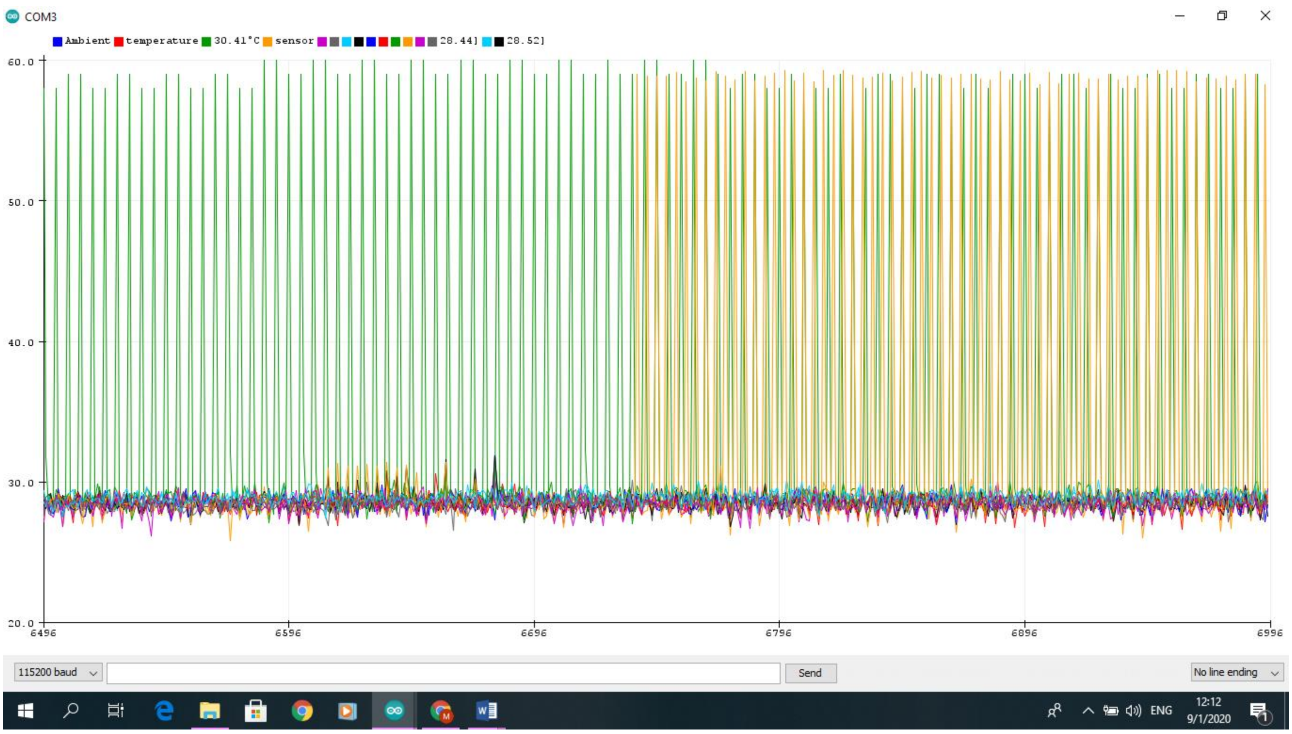
EXP: Arduino ->Tools-> Serial Plotter

Work?

Yes.

With laser?

Dlc=10cm



7 Conclusion

Text

8 Annex

8.1 List of figures

8.2 List of Tabels

8.3 List of Abbreviations

OEM	Original Equipment Manufacturer
OP-AMP	
RAM	Residual amplitude modulation
TDLAS	Tunable diode laser absorption spectroscopy
VCSEL	vertical cavity surface emitting laser
WMS	wavelength modulation spectroscopy
TTL	**Transistor–transistor logic**

8.4 Manuals

THORLABS

Laser Diode Controller

LDC200C Series Operation Manual

2018

Version: 6.5
Date: 10-Jul-2018

Contents

Operational Incineration Tests with municipality waste

9 Cooperation with Greentrack (فرز من المصدر)

9.1 Meeting 25.9.2019

خضر عيد من جبل محسن

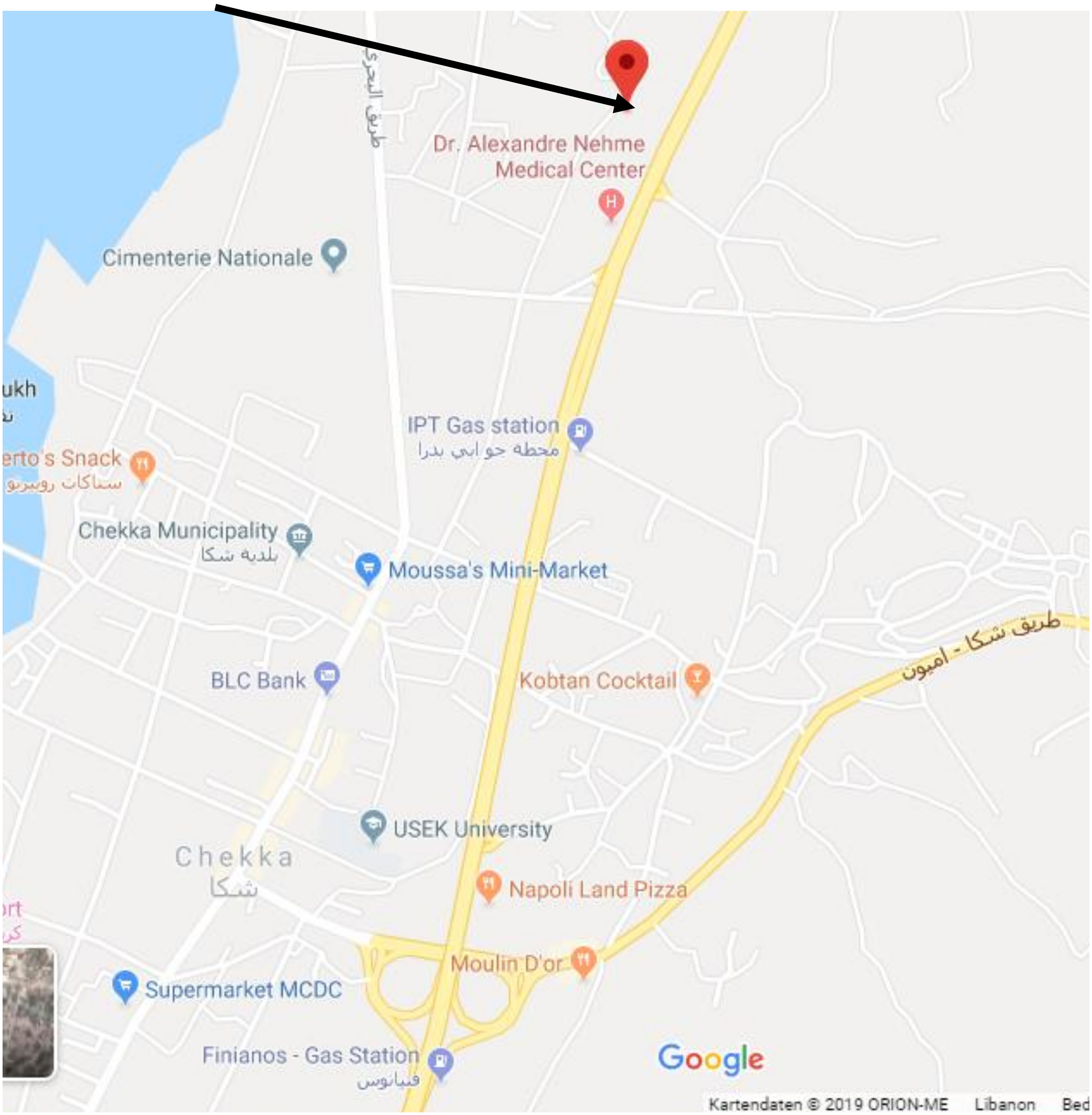
9.2 Suitable for Recycling

Sorting facility (at Tripoli - Jabal Muhsin)

9.3 Refused Waste Jabal Muhsin (for incineration)

9.4 Planned Waste Incineration at Chekka

9.4.1 Hangar of refused waste



10 TEMO-IPP Operational Test at Ras Maska[14]

10.1 Preparations 26.8.-28.9.2019

10.1.1 Official Permission from Ras Masqa Municipality

Request

[00:07, 28.8.2019] Samir Mourad: صباح الخير سيدة ليال. ارسل لكم الطلب والمستندات تحضيرا لموعدنا قبل ظهر اليوم.

[00:10, 28.8.2019] Samir Mourad:

1. Request for long enduring test (about 3 days)

2. Documentation of former tests in Ras Nhache:

http://aecenar.com/index.php/downloads/send/3-meae-institute/359-281016masterthesismayssakamareddine-temo-ipp (see pages 94-101). All emmission were according to the limits of emissions in Lebanon:

<pictures from test in Ras Nhache 2016>

[00:10, 28.8.2019] Samir Mourad: 👆our filter system

[00:10, 28.8.2019] Samir Mourad: monitoring system for emmisions (actually we got an offer from a German company):

<document from Gasmet emissions measurement>

next morning: answer by whatsApp, that Major Simon Nakhoul has subscribed the request (see below the substcribed request)

[14] from [NLAP-WEDC 2019], Ch. 14

North Lebanon Alternative Power
www.nlap-lb.com

LSA Lebanese Scientific Association الجمعية العلمية اللبنانية

AECENAR
Association for Economical and Technological Cooperation in the Euro-Asian and North-African Region
www.aecenar.com

راسمسقا في 27.08.2019

جانب رئيس بلدية راسمسقا السيد سيمون نخول المحترم

الموضوع: طلب تشغيل ماكينة التفكك الحراري على سبيل التجربة.

المستدعي: الجمعية العلمية اللبنانية LSA، الجمعية العلمية الألمانية AECENAR ومؤسسة طاقة الشمال NLAP

تحية طيبة، وبعد

1. إلحاقاً بالطلب المقدم سابقاً من قبل الجهات المذكورة أعلاه

2. وإستناداً إلى التجارب الناجحة المنجزة في بلدة راسنحاش قضاء البترون، التي أثبتت أن مستوى الإنبعاثات الضارة الناجمة عن عملية الحرق ما تزال تحت المستوى المشار إليه من قبل وزارة البيئة اللبنانية.

3. وبعد مناقشة ملف هذه الماكينة فيما يتعلق بالتقنية المعتمدة في الفلاتر المستخدمة فيها، وذلك في وزارة البيئة مع المستشار البيئي السيد المهندس شاكر نون بحضور الأستاذ غسان براس في تاريخ 21 .05 .2019

4. ونظراً لما يتطلبه البحث العلمي من إعادة متكررة للتجارب العلمية، نتقدم من حضرتكم بالسماح بتشغيل الماكينة لمدة تتراوح من 3 إلى 7 أيام، بغرض إثبات فعالية الماكينة أمام المعنيين بهذا الشأن

5. تتعهد الشركة المشغلة للماكينة بعدم صدور أي إزعاج أو إضرار بالسكان المقيمين في نطاق الماكينة.

بلدية راسمسقا
تاريخ الورود
رقم ٦٩٤

وتفضلوا بقبول فائق الاحترام.

د. سمير مراد
AECENAR, LSA ومدير مؤسسة طاقة الشمال

مع الموافقة دون أي مسؤولية مترتبة على البلدية

10.1.2 Mechanical Issues

10.1.2.1 Installing Fuel Burner and Tank for Fuel Burner, Fuel Spray

- Tank on terasse at Ras Maska
- location: tbd.
- connections/valves
- Spray System for Fuel (Solenoid Valve)

10.1.2.2 Primary Water Tank

- Checking connecting with Condensor, pump, outlet

10.1.2.3 Cooling Cycle

- Water Tank (from Ras Nhache)
- connecting pipes
- pump (Ras Nhache)

10.1.2.4 Filter System

- Transformator 30kV (optional) (W ?)
- Spray System for Sodium Carbonate (Solenoid Valve, Kompressor)
- Heat Exchanger (optional)
- Installing 2. Exhaust Fan

10.1.2.5 Steam inlet to turbine and condensor

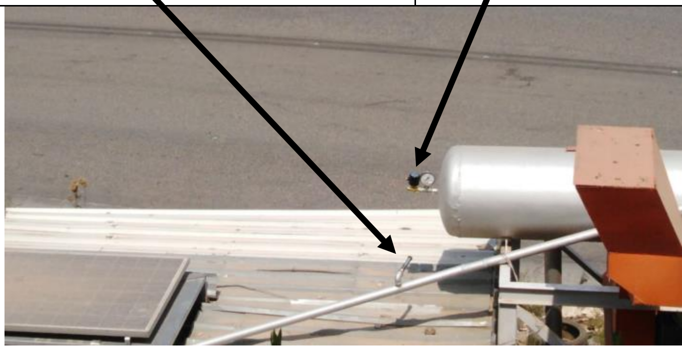
<table>
<tr><td>Before</td><td>During Work 30.08.19</td><td>After</td></tr>
<tr><td></td><td>
</td><td></td></tr>
</table>

10.1.2.6 Waste Inlet

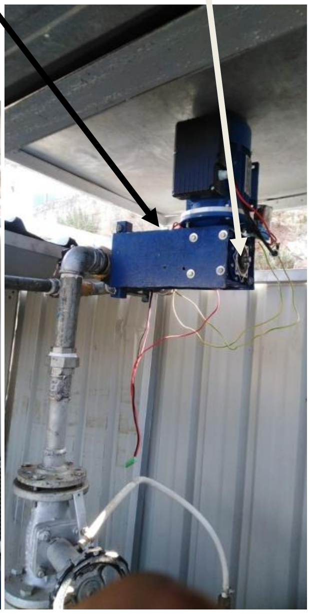
<table>
<tr><td>Putting Waste from Container into Waste Inlet
</td><td></td></tr>
</table>

10.1.3 Automation System

10.1.3.1 Periphery Instruments for Boiler Pressure Control (BPC)

Mechanical Safety Valve	pressure sensor	Atmospheric discharge valve	Condenser Discharge Valve
			

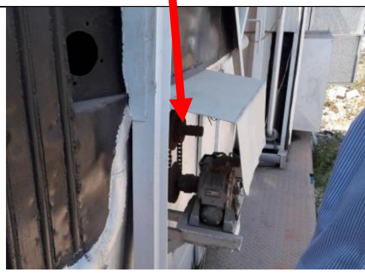
10.1.3.2 Periphery Instruments for Turbine Govering System (TGS)

Turbine Govering Valve	RPM Sensor
تثبيت للgear  	

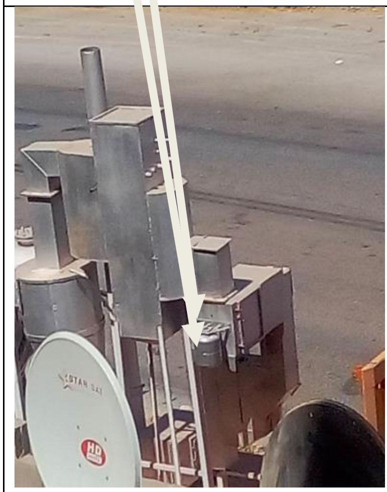
10.1.3.3 Periphery Instruments for Boiler Level Control (BLC)

Level Sensor	Primary Pump (3 phase power supply) (ON/OFF Interactive Control)
	 

10.1.3.4 Periphery Instruments for Incinerator Control System (INC)

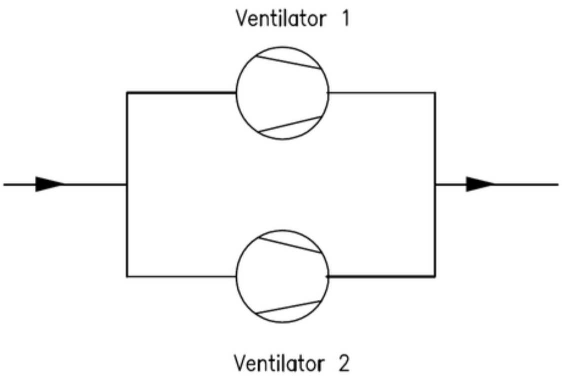
Primary Air Supply Fan to Incineration Chamber (Interactive ON/OFF Control)	Secondary Air Supply Fan to Incineration Chamber (Interactive ON/OFF Control) Tbd	Fuel Burner To be purchased? سامر يسأل (Interactive ON/OFF Control)	Incinerator Camera (Glass Window) القطر 12.3 سنتم (Human Operator supervises)	تشغيل محرك لتحريك النفايات Waste Band Motor (ON/OFF Control)
		Manual ON, after max. 1 minute automatic OFF مكان Tbd.	  	

10.1.3.5 Filter Control System

Control Valve (ON/OFF) for sodium hydrogen carbonate spray valve تشغيل رش للفلتر (Pressurized tank with sodium hydrogen carbonate, compressor)	Electric Filter 30 kV Power Supply (Interactive ON/OFF Control)	Control Valve (ON/OFF) Exhaust Fan 2 (شفاط بعد غرفة الحرق مباشرة و الى cyclotrone) Operator sets to ON	Control Valve (ON/OFF) Exhaust Fan 1 (بعد baghouse فلترات) Operator sets to ON
			

Parallel- und Reihenschaltung

In lufttechnischen Anlagen können betriebsbedingt oder aus sicherheitstechnischen Gründen mehr als ein Lüfter zum Einsatz kommen. Beim **Parallelbetrieb** zweier baugleicher Lüfter erreicht man eine **Verdoppelung des Fördervolumens**.



Beim **Reihenbetrieb** wird eine Druckerhöhung erreicht.

10.1.3.6 Cooling Cycle

<table>
<tr><td>pump, Control Valve (ON/OFF)</td><td>Condensor Cooling Cycle Connections</td><td>Water tank for cooling cycle</td></tr>
<tr><td>

</td><td></td><td></td></tr>
</table>

10.1.3.7 Cabinet for PLC

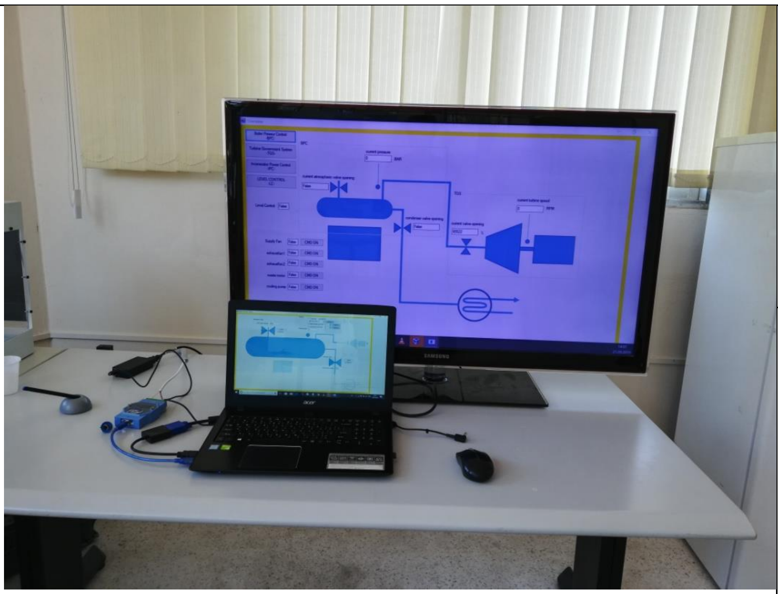
PLC

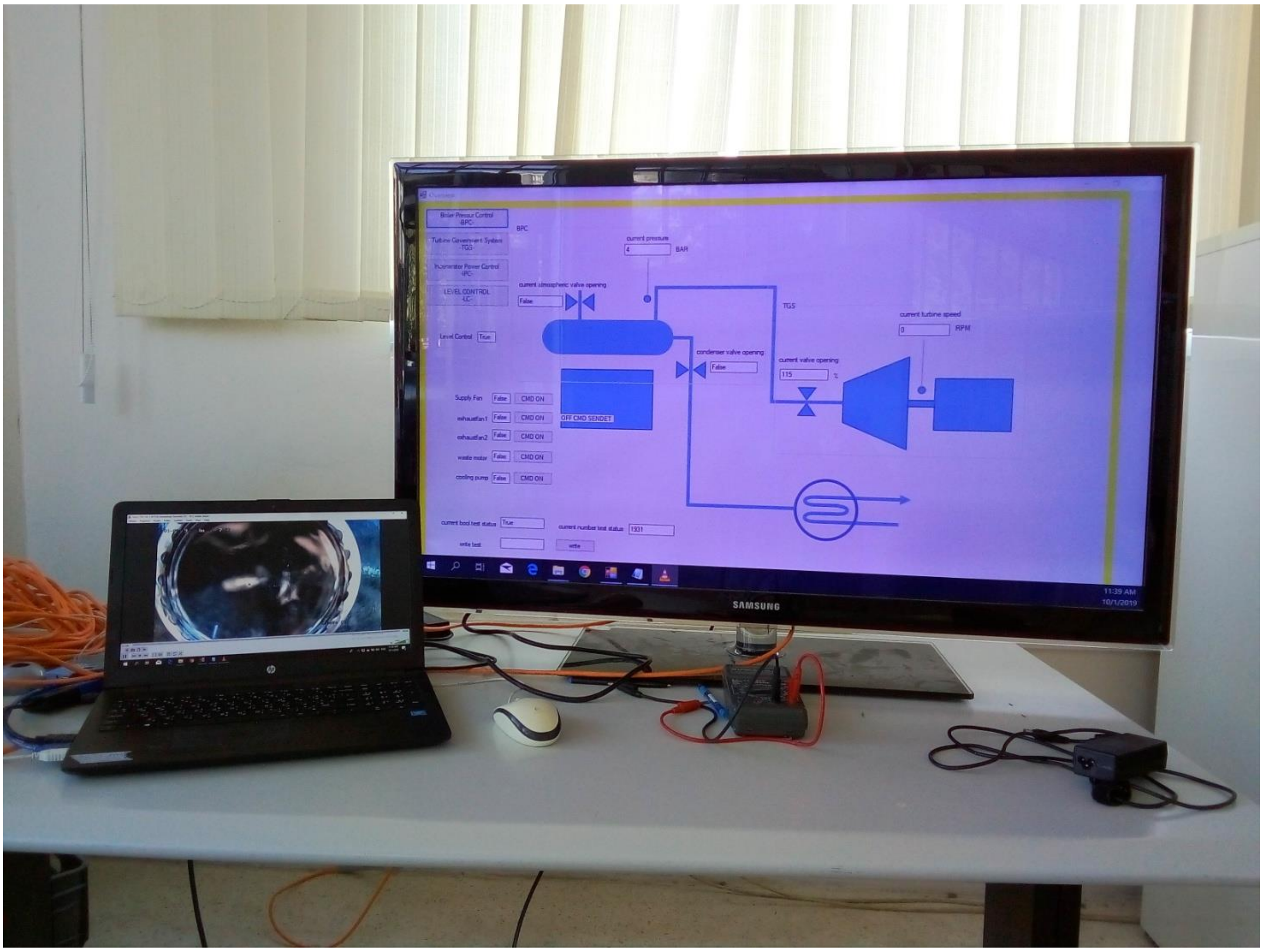
Modbus Cable

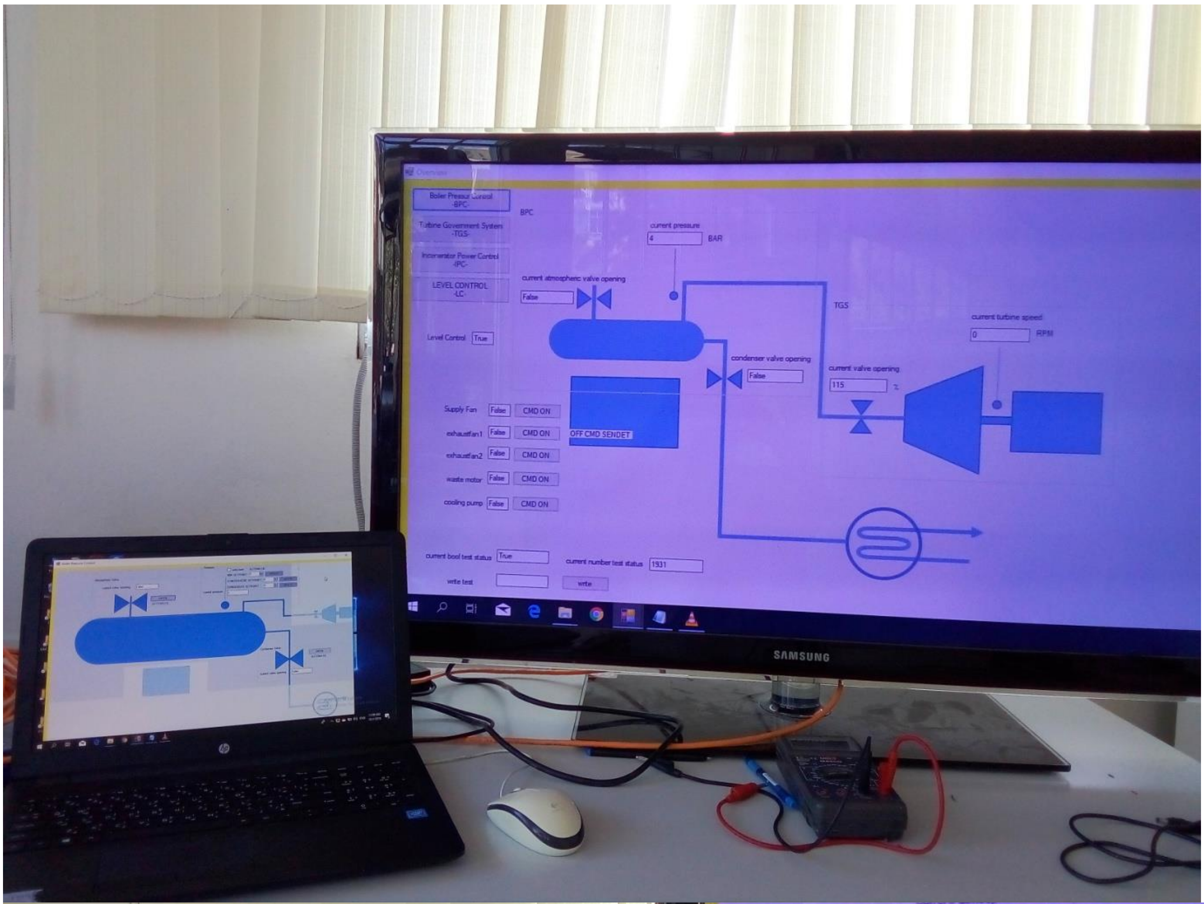
IP Cable for Camera

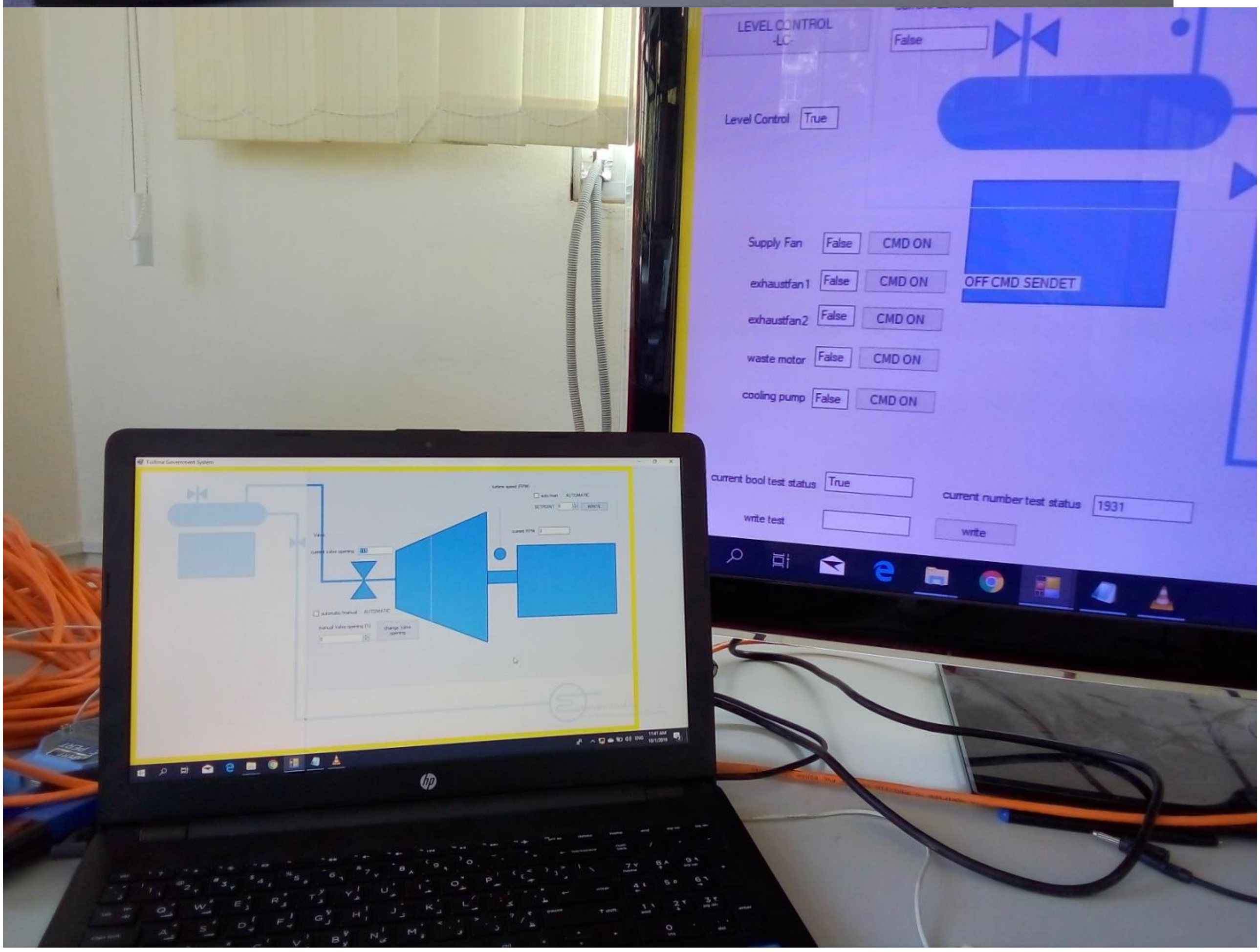
10.1.3.8 Graphical User Interface (GUI)

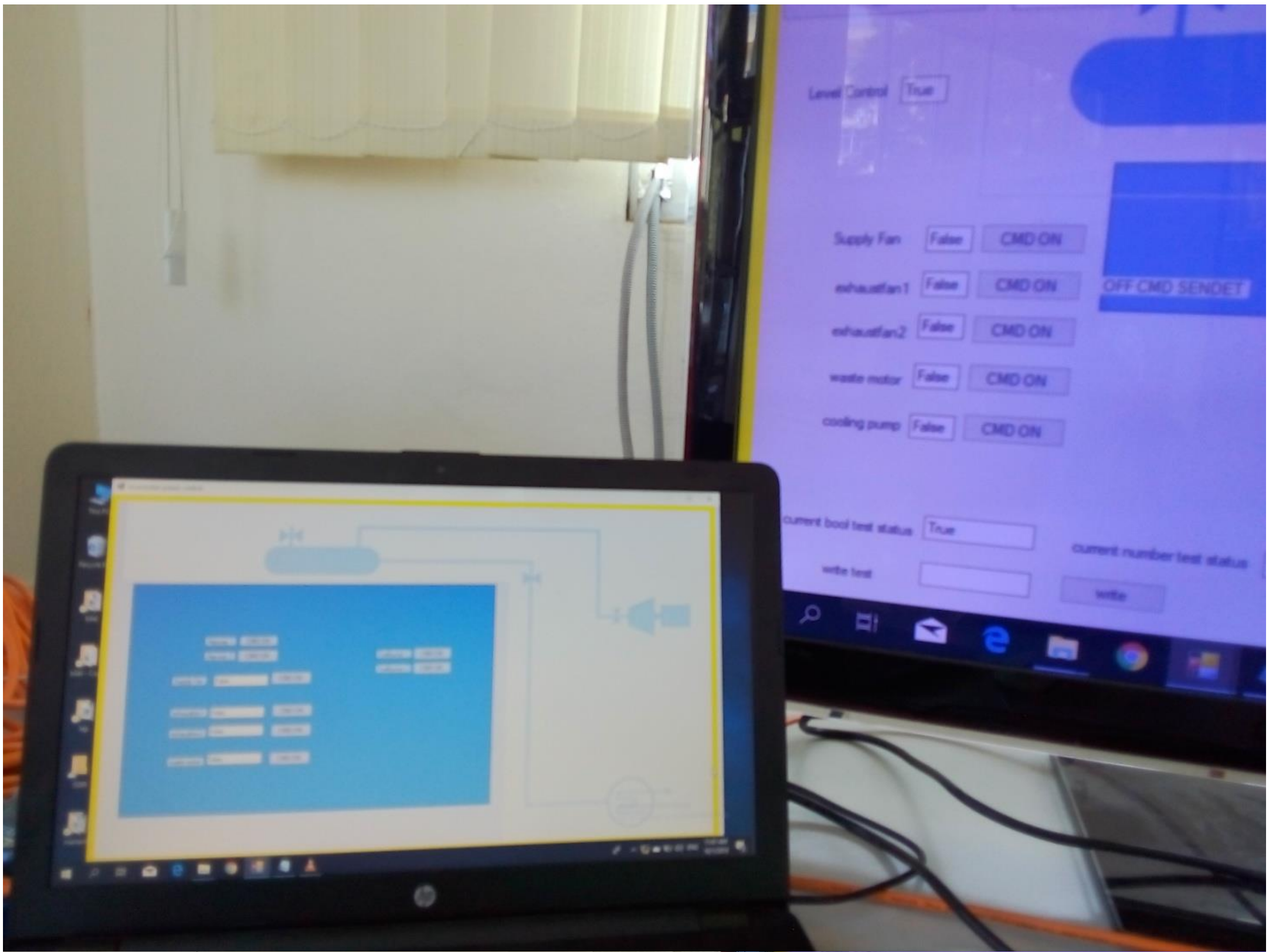
MEAE Laptop, Large Monitor, modbus cable (see PLC Cabinet)

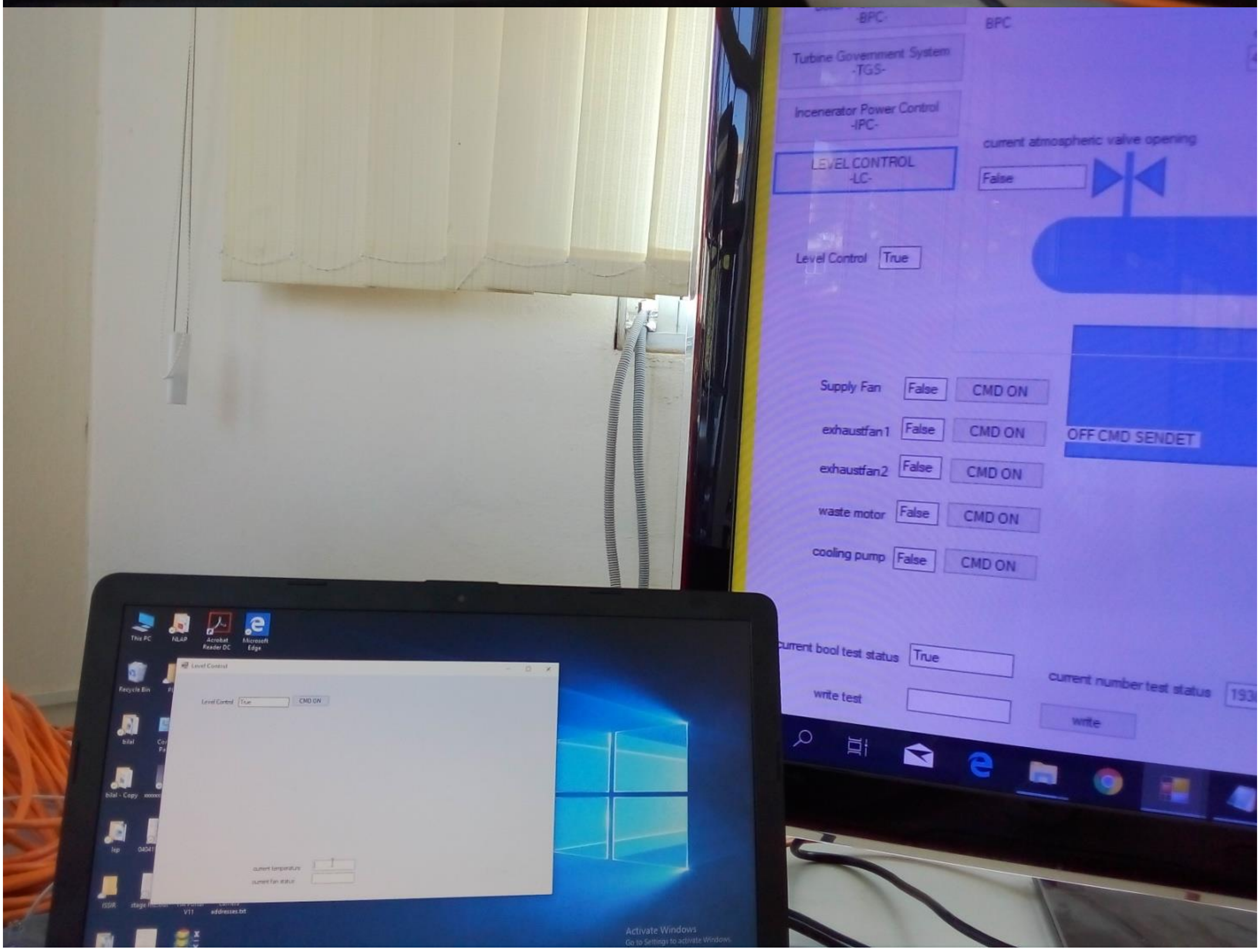





SAMSUNG
Level Control
True
OFF CMD SENDET


LEVEL CONTROL
-LC-
False
Level Control
True
Supply Fan
False
CMD ON
exhaustfan1
False
CMD ON
OFF CMD SENDET
exhaustfan2
False
CMD ON
waste motor
False
CMD ON
cooling pump
False
CMD ON
current bool test status
True
current number test status
1931
write test
write


Level Control
True
Supply Fan
False
CMD ON
exhaustfan1
False
CMD ON
exhaustfan2
False
CMD ON
waste motor
False
CMD ON
cooling pump
False
CMD ON
OFF CMD SENDET
current bool test status
True
write test
current number test status
write


BPC
Turbine Government System
-TGS-
Incenerator Power Control
-IPC-
LEVEL CONTROL
-LC-
current atmospheric valve opening
False
Level Control
True
Supply Fan
False
CMD ON
exhaustfan1
False
CMD ON
exhaustfan2
False
CMD ON
waste motor
False
CMD ON
cooling pump
False
CMD ON
OFF CMD SENDET
current bool test status
True
write test
current number test status
write
Activate Windows

10.1.4 Preparing/Cleaning Ground

- لَمّ النفايات
- وضع سياج او اواني حمر توضع فيها الماء (من البلدية) من ناحية الشارع

10.1.5 Waste Management

نفايات مفروزة. من دار عمار (زياد ملك يسأل ر. خالد زعبي)

10.1.6 Costs

Mechanical Issues		
Automation System	2.9.2019 100$ given to A. Kassem to buy cables and extra PLC Extension Module (8 IN, 8 OUT) 3.9.2019 25.000 LL given to A. Kassem for cables	

10.1.7 Summary Parts for Incinerator (Check List)

اللوازم لتشغيل المحرقة دون توليد الطاقة الكهربائية

		الوضع الحالي	المسؤول
~~Fuel Burner~~	~~Fuel Burner~~	~~--------~~	
-	~~Installing Fuel Burner~~	~~--------~~	
-	~~Tank for Fuel Burner~~	~~--------~~	
-	~~Spray System for Fuel (Solenoid Valve)~~	~~--------~~	
-	~~Installing Tank, pipes for Fuel Burner~~	~~--------~~	
		~~--------~~	
Filter	~~Transformator 30kV (optional) (W ?)~~	~~--------~~	
	~~Spray System for Sodium Carbonate (Solenoid Valve, Kompressor)~~	~~--------~~	
	~~Heat Exchanger (optional)~~	~~--------~~	
	~~Second Exhaust Fan (قبل الداخون)~~	~~------~~	~~عبد الله و ايهاب~~
	~~Check Baghouse Filter~~	At place	
	~~3 Trays (Cyclotrone, E-Filter, 3.Filter)~~ ~~تسكير وقتي لفتحات الفلترات حتى يسحب الشفاط فقط من غرفة الاحتراق~~		
Waste Inlet	Putting Waste from Container into Waste Inlet (سكة لإدخال النفايات)	TOT, aluminium	سمير

Incineration Chamber	~~Primary Air Supply Fan to Incineration Chamber (Interactive ON/OFF Control)~~	~~في محلها. يجب ان تربط بالPLC~~	
	~~Secondary Air Supply Fan to Incineration Chamber (Interactive ON/OFF Control)~~	~~--------~~	
	Incinerator Camera + Cable Network	To be installed	عبد الرحمن و ابو عمر
	Waste Band Motor (ON/OFF Control)	To be tested	

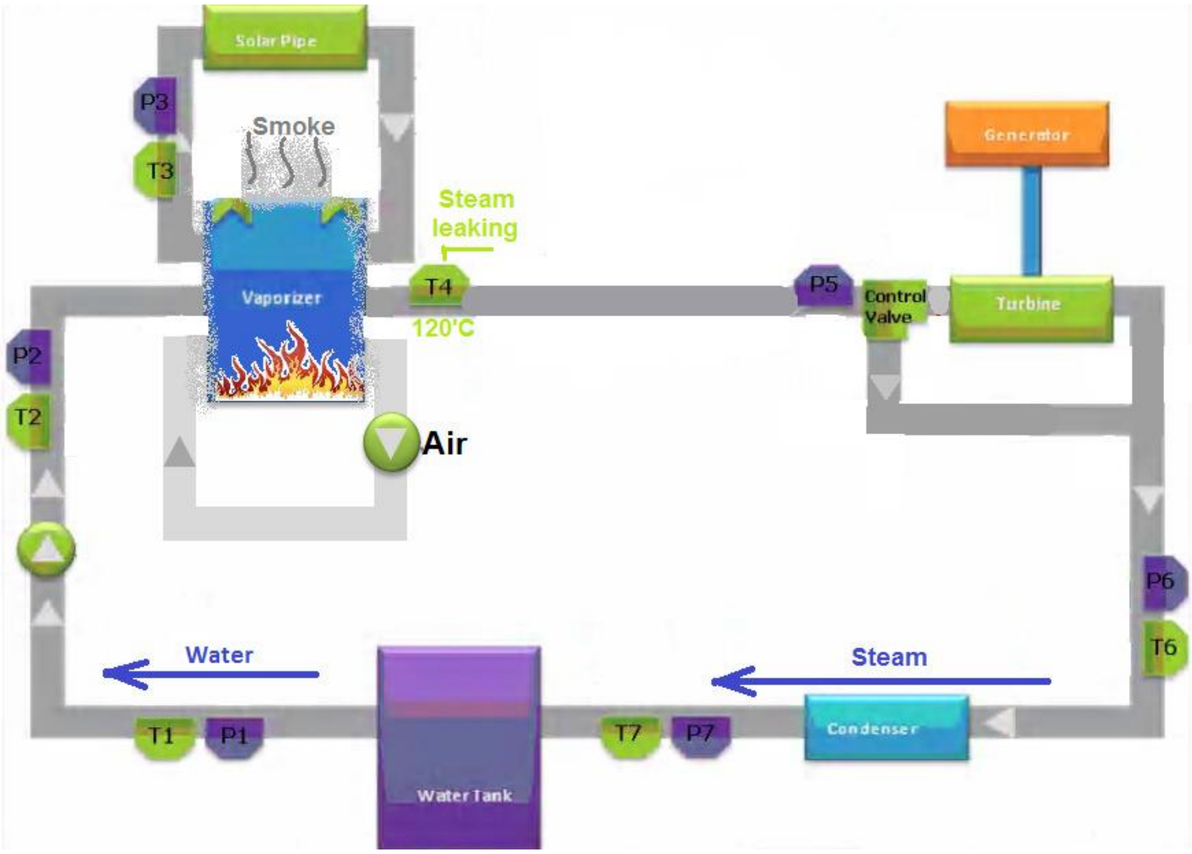
10.1.7.1 Still Open Issues at 24.9.2019

		الوضع الحالي	المسؤول
Mechanical	~~تجهيز نقطة تشغيل النفايات (الفتحة من قبل الشارع لغرفة الحرق)~~		~~عبد الله و ايهاب~~
	تلحيم الفتحات-		
	~~تفقد الفلترات-~~		
	~~سكة تدخيل النفايات مع طبقة يلي بتسكر~~		
Facility	تنظيف حول الماكينا		سمير
	وضع حد للامان من قبل الشارع		سمير
تشغيل محطة توليد الكهرباء	اشتراك كهربا 3 phase	ممكن بالاجار 3 phases	سمير
	اشتراك كهربا 20 A	ممكن بالاجار 3 phases	سمير
	كابلات 3phase	ممكن بالاجار 3 phases	سمير
	توفير مياه للتبريد		ابو عمر
	فحص ال valve الكبيرة مع حساس السرعة		ابو عمر و عبد الرحمن

10.2 System Test Specification / Plan (for electricity generation)

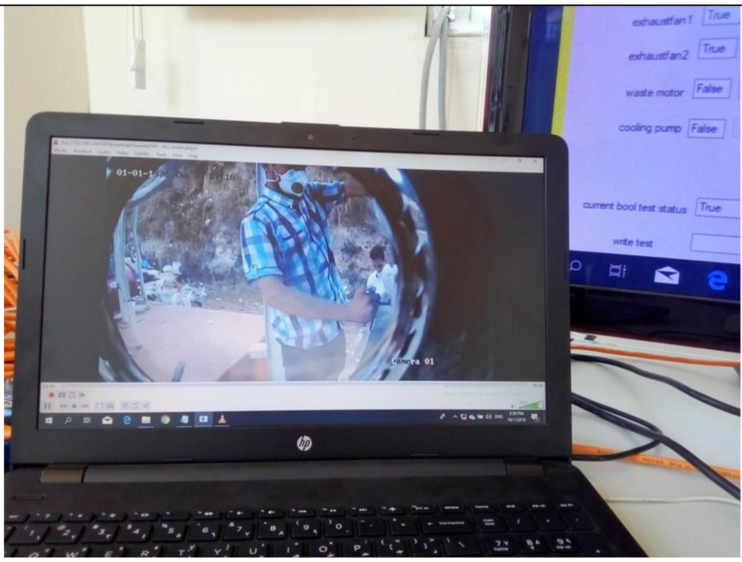
Unit	Test Activity	Expected Post condition	Post condition	Result
Control system	Read Temperature values from Temperature sensors: T1, T2, T3, T4	T1: Linear Value		
		T2: Linear Value		
		T3: Linear value		
		T4: Linear Value		
	Read Pressure values from the pressure sensors: P1, P2, P3, P4	P1: Linear Value		
		P2: Linear Value		
		P3: Linear Value		
		P4: Linear Value		
	RPM Sensor	Linear Value		
	IR Sensor	Clear Reading		
	Open & Close Valves	Full Open		
		Full Close		
		Step Open\Close		
Vaporizer	Ignite fire on the vaporizer for a half of hours without water	No leaking smoke		
		Stable Temperature value		
		Emergency Fire extinguishing		
	Ignite fire on the vaporizer for a half of hours with water	Valve controlled via PLC OPEN\CLOSE		
		No leaking water		
		No leaking steam		
Condenser	Full by water	No leaking water		
	Enter steam	No leaking steam		
		Steam should be transfer to water		
Pipes	Pipes between vaporizer and turbine	No leaking steam		
	Pipes between turbine and condenser	No leaking steam		
	Pipes between condenser and water tank	No leaking water		
	Pipes between water tank and vaporizer	No leaking water		

Turbine	Turbine mechanical	Flexible turn		
	Turbine oil	On the Right levels		
Generator	Connection to turbine	Well connected		
	Power output	Well connected		



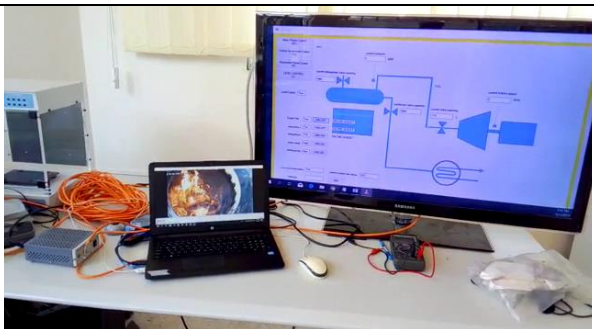
10.3 Test 01.10.2019, 15.30-16 (30min) incineration

10.3.1 Testteam



10.3.2 Before Incineration (Ignition)

10.3.3 At Begin of Incineration



No smoke

10.3.4 About 20 min. after ignition




Grey smoke

10.3.5 After incineration

about 80% of original volume (after 30 min.)

10.3.6 Results

10.3.6.1 capacity of incinerator

material: 25 packs x 50kg = 1 ton 125 kg;

in incineration chamber could be put 2-4 packs (=100-200 kg). To be incinerated in 1 hour => about 1ton in 8 hours.

10.3.6.2 To be improved:

- additional baghouse filter -> less smell/less color of smoke
- additional fan/mounting green fan more effectively
- closing gaps: at incineration chamber
- better closing for door of incineration chamber

10.3.7 Ashes Analysis

Leaching with citric acid, Liquid-Liquid


24/29
VWR


24/29
VWR


G 20
SCHOTT
MAINZ
VWR
Household


AL JOUDA
CITRIC ACID


VWR
VICON
ZERO
PRINT
ENTER
CAL
ACCULAB
Sartorius group

10.4 Reparations after Test on 1.10.19

- Closing of leaks in incineration chamber

- putting second exhaust fan parallel to first exhaust fan immediately before chimney

- direct exhaust way between last filter (baghouse filter) and fans.

10.5 Test 4 (27.12.2019): Leaks, Suction and Filtering

Unit	Test Activity	Expected Post condition	Post condition	Result
Control System	Open & Close Fans	Open\Close main fan (Big fan)	Opened and closed normally	Success
		Open\Close secondary fan (small fan)	Opened and closed normally	Success
		Open the two fan together	Opened and closed normally	Success
	Connect to burning room camera	Clean and clear live video	Image not too much clear	Done with remarks
Burning room	Ignite fire on the Burning room for 10 minutes	No leaking smoke in the room	There are leaking smoke, check below for details	Leaks should be fixed
		Stable Temperature value	normal	Normal
Suction System	Keep fire burning and turn on Main Fan for 10 minutes	Smoke coming out from the funnel	Yes it is, funnel smoke density: about 4/10	Nothing to do till the next test
	Keep fire burning and turn off main fan wait a minute then turn on the secondary fan for 10 minutes	Smoke coming out from the funnel	Yes it is, funnel smoke density: about 2/10	Nothing to do till the next test
	Keep fire burning and turn on the two fans together for 5 minutes	Smoke coming out from the funnel strongly	Yes it is, funnel smoke density: about 5/10	Nothing to do till the next test
Filtering System	Keep fire burning with two fans and check the smoke color and smell	Smoke with no or transparent color	Transparent from the funnel and white from the leaks	Good result
		Smoke with no smell	There is smell but it may be caused by leaks	Nothing to do till the next test

Test date and time:

The test take place in Tripoli, Haikaliyeh on Friday 27-12-2019 at 2:00 PM and it takes about 42 minutes.

Test participators:

Supervise this test Eng. Mahmoud Zohby,

And Mr. Abdul Rahman Mourad on the control system

With Mr. Bilal and Ibrahim Mourad on the burning and test tasks.

Test record:

All the test procedure was video recorded using a 4K camera

Videos are available on company server on:

Detailed info:

In the beginning of the test after burning the garbage, the smoke start to leaks from the burning room and the smoke path.

Below are the most important leaks places with images:

Place 1: burning room

Place 2: garbage entrance

Image 3: the beginning of the smoke path

Place 4: electro-filter circles Place 5: burning room main door

Next Tasks:

1. Fix leaking places, with checking of fixes result by immediate test
2. Reinstall the compressor and the powder valve instead of the stolen one
3. Install fuel burner
4. Find a way to get rid of the mesh
5. Install a fire extinguisher to safely extinguish the fire in emergency cases
6. Enhance the garbage entrance way or install a garbage shredder
7. Install pollution sensors or make a contract for regular checks during works
8. Install temperature sensors all around the steam path
9. Complete working on the Electro-Filter
10. Revise the control system with its control interface

This report is prepared by Eng. Mahmoud Zohby
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Test team


CH7


NOUVO PANO

Electrolysis Unit & Fuel Burner Unit

Based on the follwing reports

[NLAP-WEDC 2017]

[NLAP-WEDC 2018]

[NLAP-WEDC 2019]

Detailed Design & Construction for:

- Electrolysis System
- Fuel burner

<u>With contributions of:</u>

Siham Aisha

Othman Dhaibe

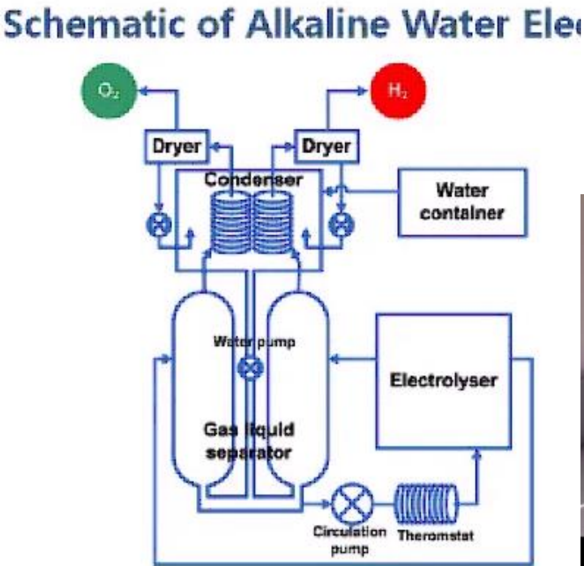
Samer Youssef

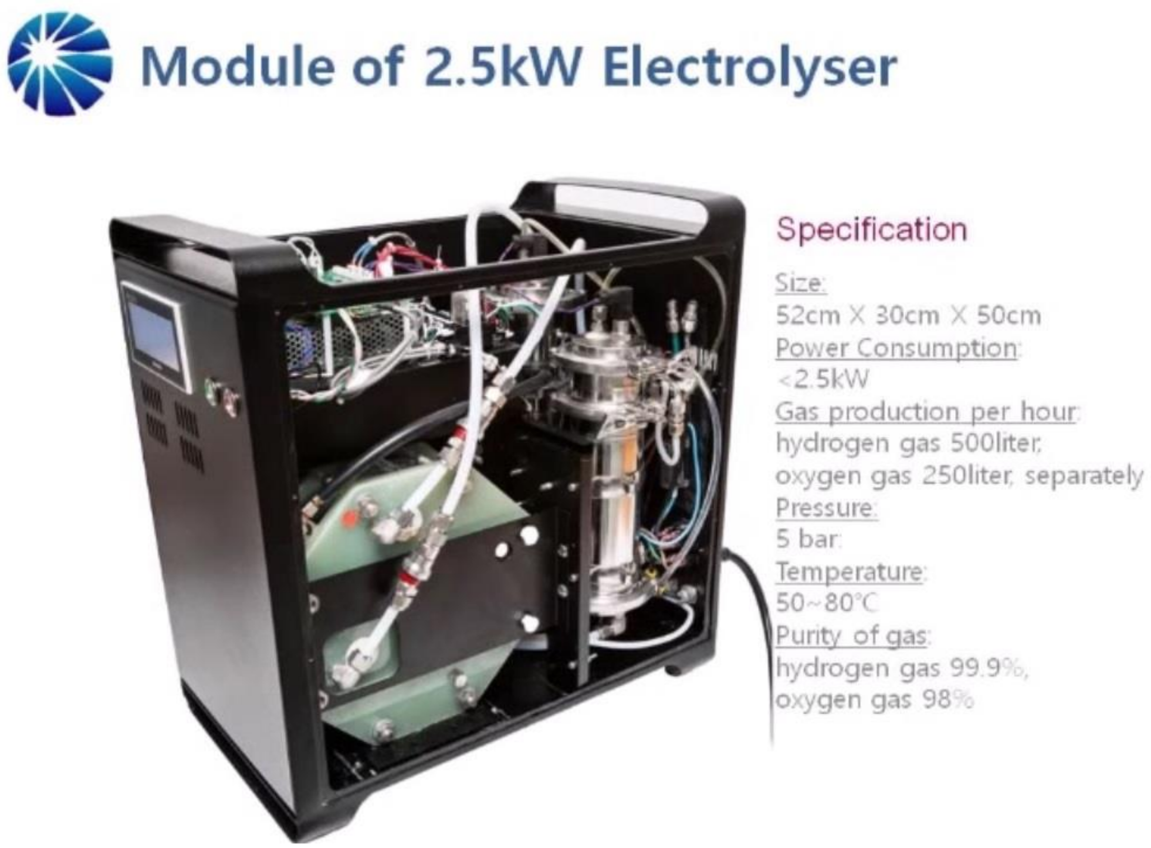
Last update: 28. Sep. 2020 / الإثنين، 11 صفر، 1442

D:\AECENAR\ICPT\Electrolysis_sinceSep2019\18052020_ICPT-EFB_Report1_2020.docx

11 Conception and Predevelopment for Electrolysis Unit&Hydrogen Burner Unit[15]

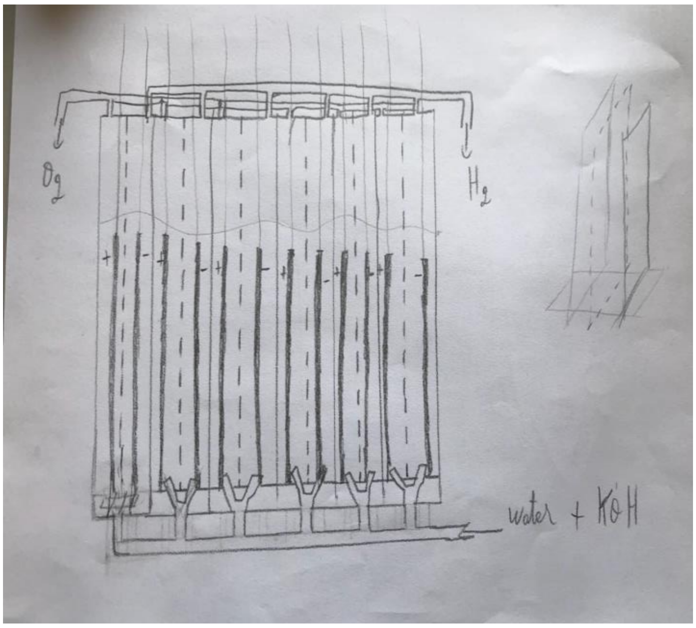
11.1 Alkaline Electrolysis System Design from lightbridge.sales@gmail.com





[15] from [NLAP-WEDC 2018]

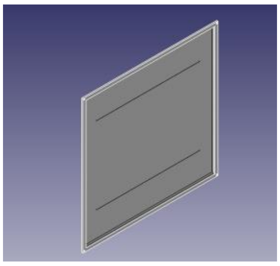
11.2 Concept



11.3 Design 1 (April 2018)

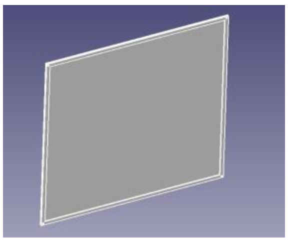
Electrolyse_cadre.FCStd   21042018_assemblage_electrolysis(color).F(

Base plate for anode and cathode



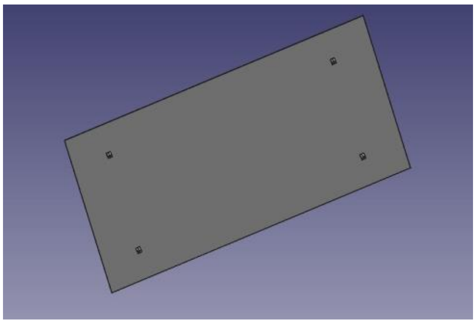
17042018_Prototype electrolysis.FCStd

Diaphragm



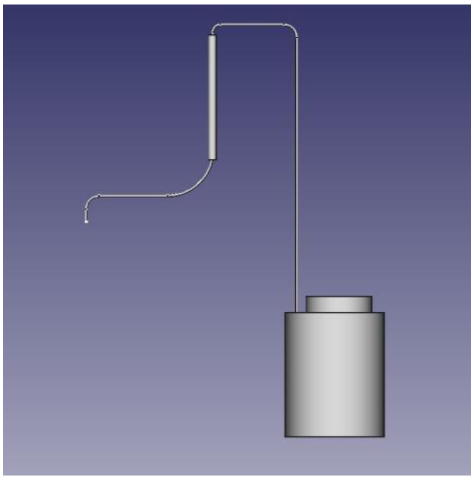
19042018_diaphragm.FCStd

Electrode



19042018_electrode.FCStd

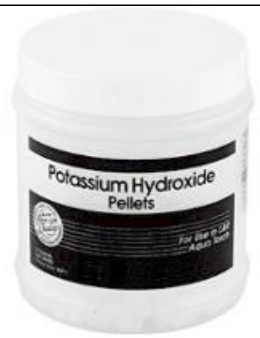
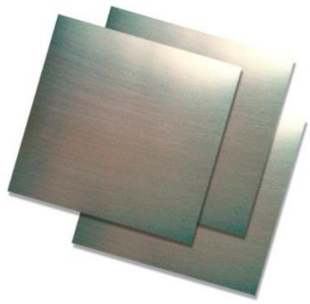
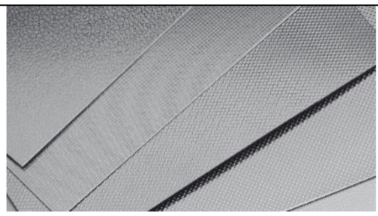
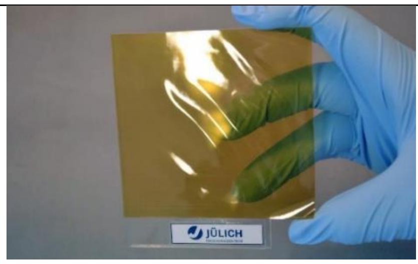
Pipe



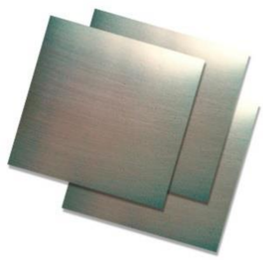
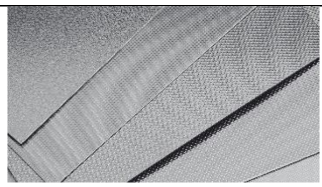
28042018_pipe.FCStd

11.3.1 Materials

2 plates plastic	1m * 1m
8 plates plastic	1.1 cm * 1m
4 plates caoutchouc	1m * 1m * 0.5 cm
1 plate Stainless	95 cm * 90 cm
1 plate Nickel	95 cm * 90 cm
2 tubes Nickel	Φ 1cm L:10 cm
2 tubes Stainless	Φ 1cm L:10 cm
6 tubes plastic	Φ 2cm L:10 cm
7 tubes plastic	Φ 2cm L:20 cm
7 elbows plastic	Φ 2cm ╓
2 tubes plastic	Φ 2cm L: 1m
2 T plastic	Φ 2cm ╢
2 condenser	
2 faucet	
2 tank plastic	
2 fixes bolt	

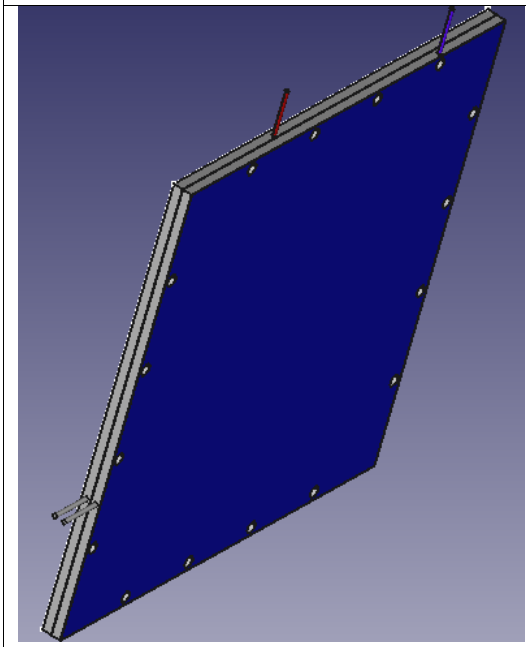
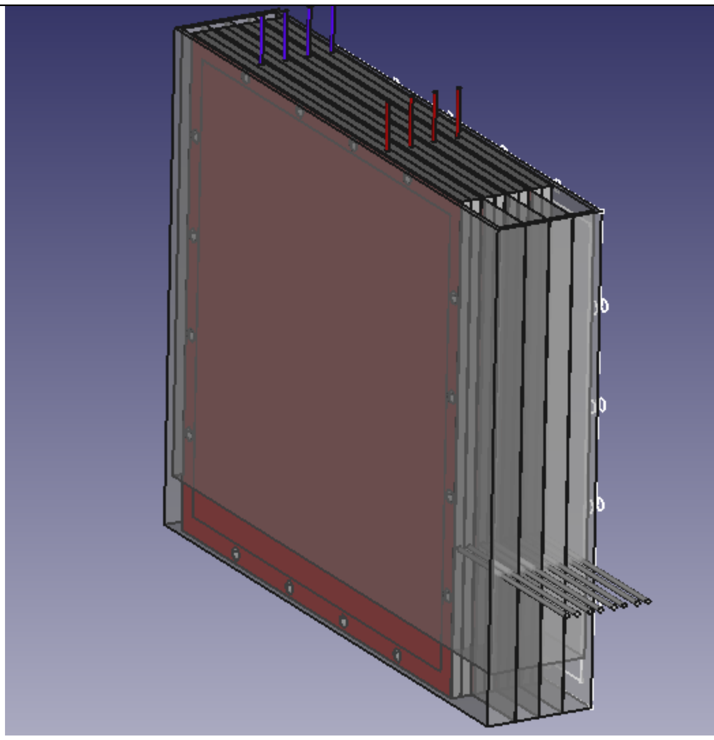
Electrolyte (KOH)	
Anode (Nickel)	
Cathode (Stainless)	
Diaphragm	

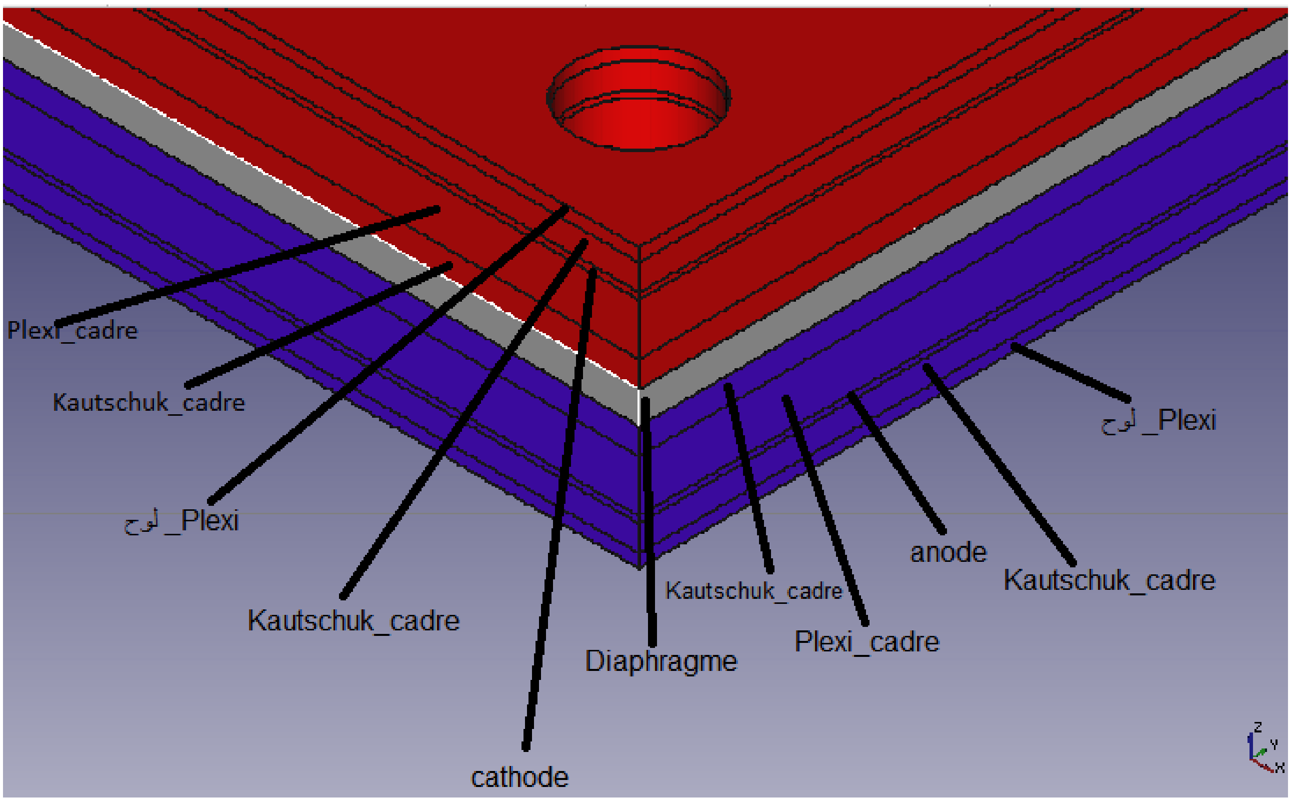
11.3.2 Cost of materials

Material	**Suppliers**	**Prices**	**Pictures**
Nickel	نوفل	1 kg = 2.5 $	
	Alibaba	1kg = [15$ - 40$]	
Stainless	نوفل	1kg = 4.5$	
	Alibaba	1 kg = 2.3$	

Diaphragm	Alibaba	Piece = [20$ - 500$]	

11.4 Design 2 (May 2018)

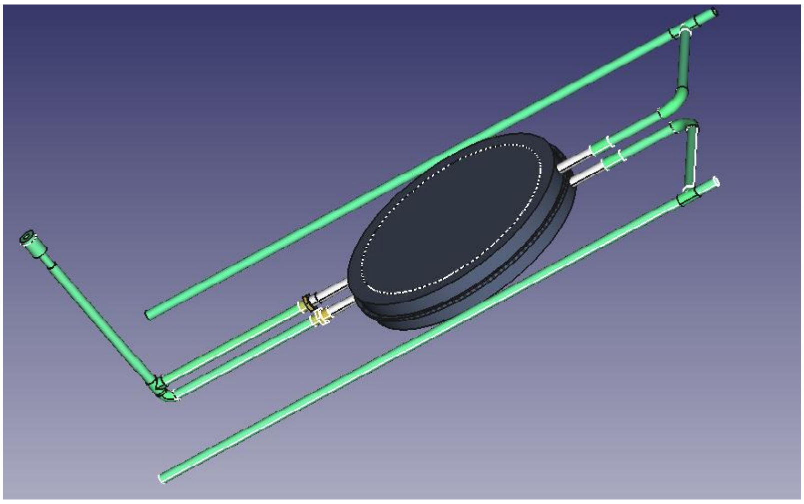
03052018_one_cell.FCStd	03052018_Stack_electr.FCStd
	



11.4.1 Result:

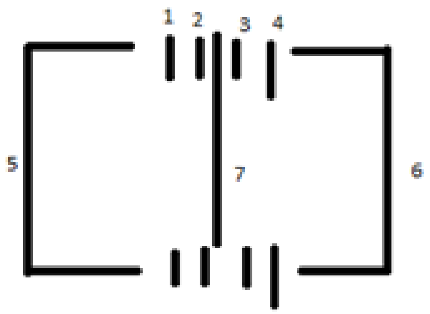
Plexi breaks, when two plates are pressed together such that the water can't flow out.

11.5 Design 3 (Aug 2018)

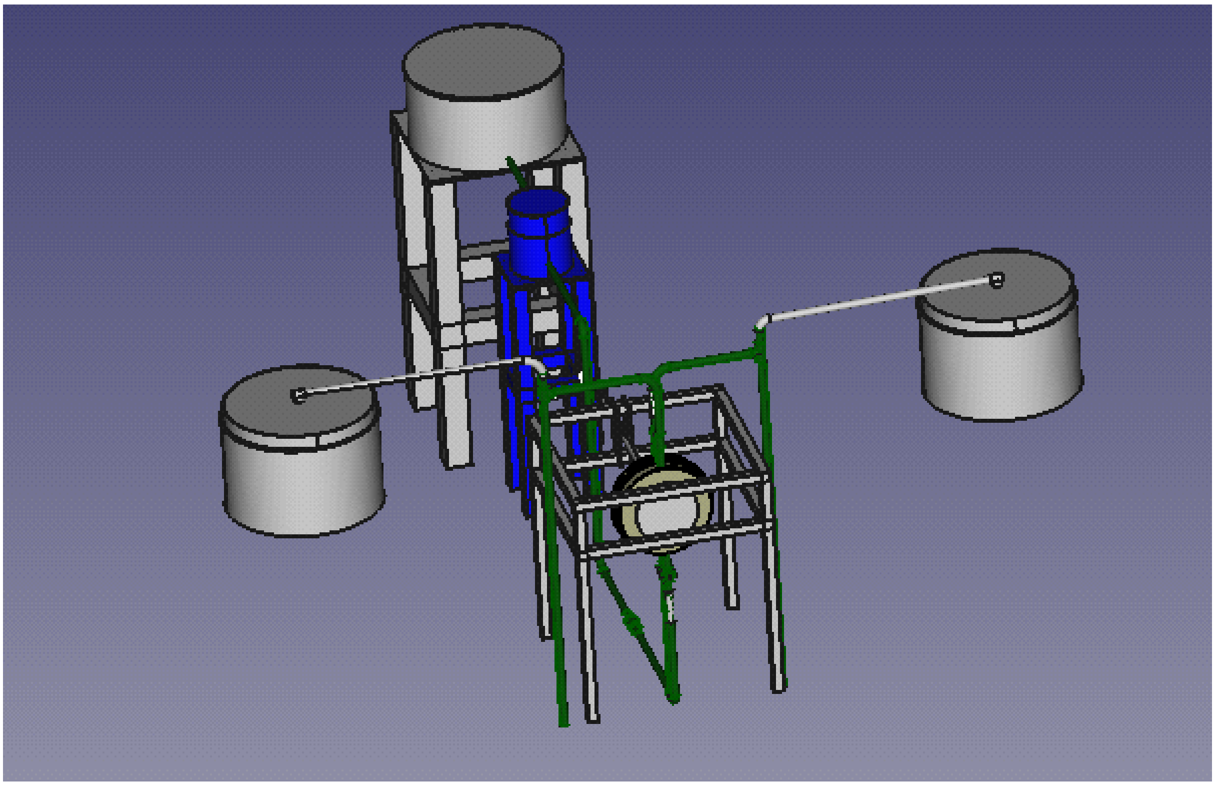


electrolyser 210818.FCStd

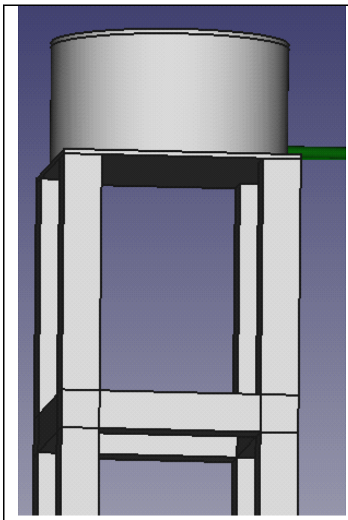
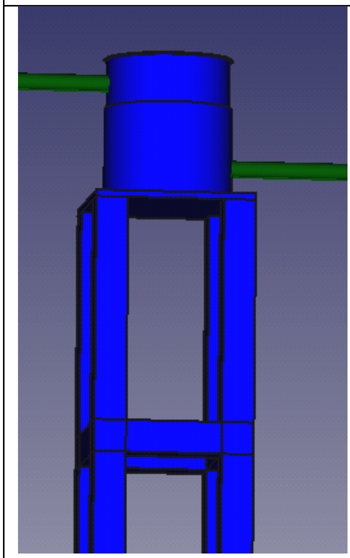
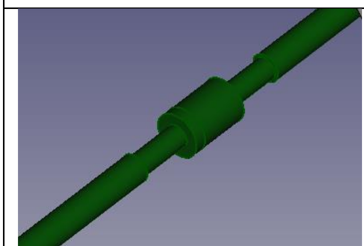
	STEPS: 1-2 stainless plates tied up tightly 2- ppr pipes allowing the gas to flow freely 3- a plastic headed bound to prevent electrical contact between the 2 plates 4-retatchebel iron link to separate the 2 basic compounds [pipes,plates] (قطع وصل).

	a check valve (NON-REVERSE LINK) to prevent the water from turning back once it has been pumped .
	The motor has initially the basic role to pump the water threw the device starting the mechanicsm witch whom it is meant for.
	1-industriel rolls 2-جلدة 3-جلدة 4-industriel rolls 5- stainless cathode 6-stainless anode 7- nafion membrain
	We have replaced the motor with a more accurate full-mechanic system , using a relatively small volume tank decreasing the water pressure in the pipes making a more efficient and accurate mechanicsm

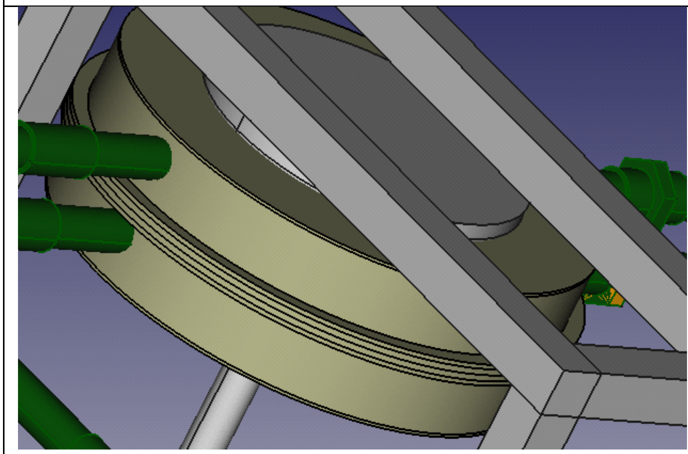
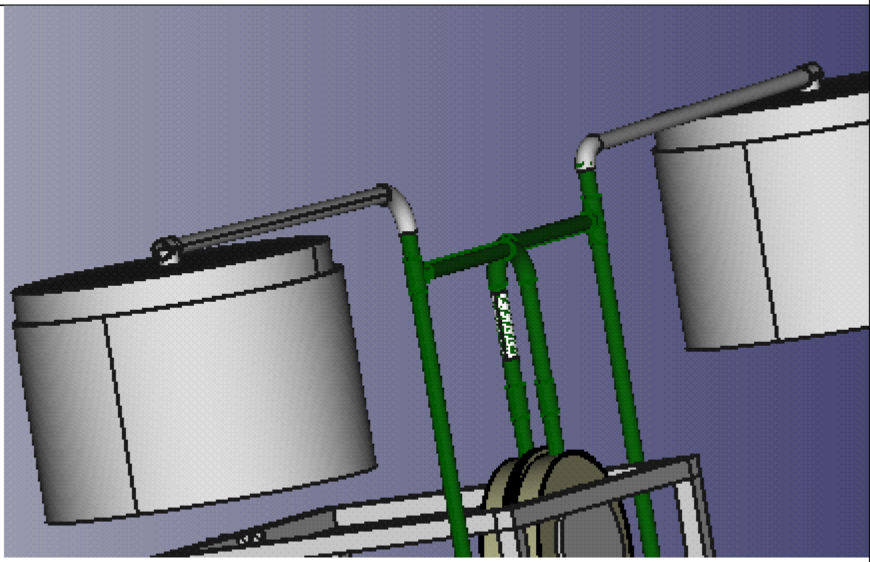
11.5.1 From report 10 Nov 2018 (Samer Youcef)



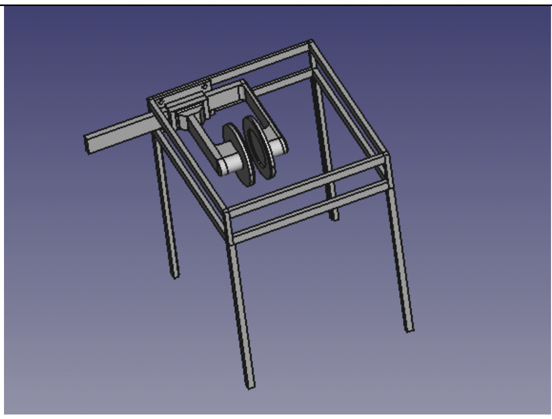
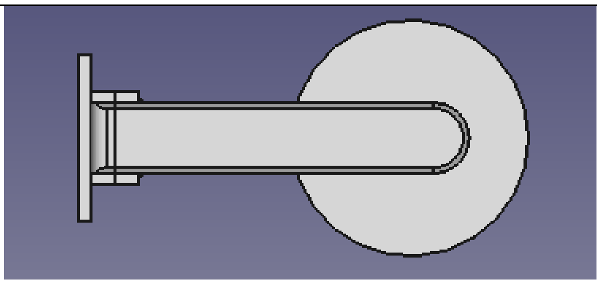
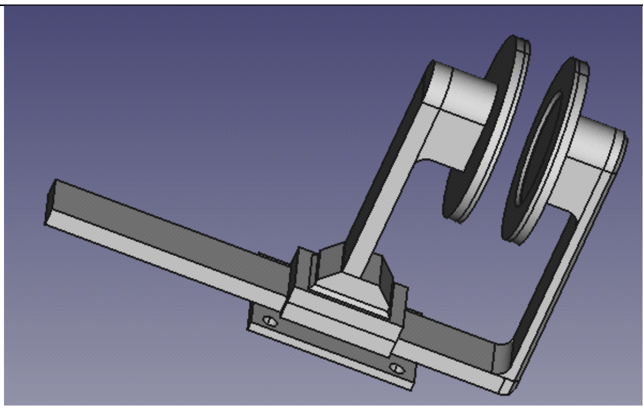
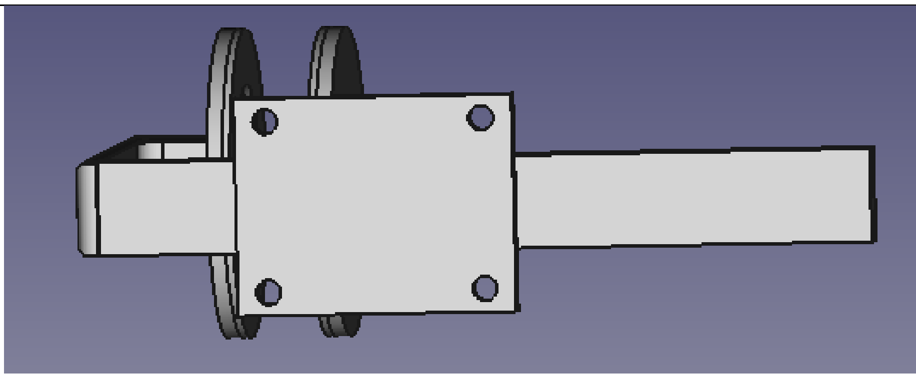
electrolyser 201018 - Copy (16).FCStd

	big tank.FCStd A WATER TANK AT 50 cm OF DIAMETRE , STANDING ON A 90cm HEIGHT TABLE , WE ATTACHED A WATER TAP TO IT , CONTROLING THE WATER QUANTITY IN THE SYSTEME
 small tank (2).FCStd	A REALTIVELY SMALLER TANK, THIS TANK HAS NO WATER TAP, IT'S MAIN ROLE IS CONTROLING WATER LEVEL WITHIN THE SYSTEME , THREW A SPECIFIC WATER LEVELING INTRUMENT(FAWAYSHA); IT HAS LESS THEN 20cm IN DIAMETER, AND STANDING AT A TABLE HEIGHT OF 70cm .
 	stop check valve.FCStd A STOP CHECK VALVE, PREVENTING WATEER FROM TURNING BACK TO THE DIRECTION OF IT'S SOURCE, PLAYING A KEY ROLE IN THE STABILITY OF THE WATER IN THE SYSTEME, INCREASING LEVEL CONTROLING PRESICION; AND TO THE RIGHT WE HAVE A WATER TAP, WICH REPRESENTS THE SOUL EXIST OF THE WATER FROM THE SYSTEME, WHEN WANTED

.

 	stainless steal plates.FCStd THE MAIN PART OF THE SYSTEME, 2 STAINLESS STEAL PLATES(D=30cm,edge:L,l=4mm,h=4 cm) PRESSED TOGETHER , LAYS IN BETWEEN THEM 2 RUBBER JOINTS TO ENDURE THE MASSIVE PRESSURE , AND THESE JOINTS ARE IDEAL IN PREVENTING ANY PENETRATION, BETWEEN THE PALTES
	pressure table.FCStd AFTER THE DECOMPOSASTION PROCESS, GAS WILL START FLOATING INSIDE THE PLAKSI PIPES , WICH WILL EVENTUALLY BE STOCKED IN THE PRESSURE CHAMPER BY A SPECIFIC WATER METHODE, EACH ONE OF THIS 2 CHAMPERS CONTAINS DIFERENT GASES ($H2,O2$).

Electrolyser base :180918

	ارتفاع الاقدام :60 سنتمتر الطول والعرض :55 سنتمتر
	قطر الدائرة :20 سنتمتر السماكة: 10 ملمتر
	قطر الدائرة الداخلية : 12 سنتمتر السماكة :5 ملمتر ارتفاع الدائرة : 25 سنتمتر تبعد الدائرة الاولى عن الثانية كحد اقصى : 50 سنتمتر
	طول : 14 سنتمتر عرض :18 سنتمتر

11.6 Hydrogenics electrolyzer

Technical specifications

MODEL	HySTAT™-10-10	HySTAT™-15-10	HySTAT™-10-25
Operating Pressure	10 barg		25 barg
Max. Nominal Hydrogen Flow	10 Nm^3/h	15 Nm^3/h	10 Nm^3/h
Hydrogen Flow range	40 - 100% (25 -100% as an option)		
Hydrogen Purity (before HPS)	99,9%; H2O saturated, O2 < 1,000 ppm		
Hydrogen Purity (after HPS)	99,998% (99,999% as an option); O2 < 2ppm; N2 < 12ppm; Atm. Dew point: -60°C or -76°F (-75°C or -103°F as an option)		
Nr. of cell stacks	1		
Estimated AC power consumption (all included)	4,9 kWh/Nm^3 at full load		
Voltage	3 x 400 VAC ± 3% (3 x 480 or 575 VAC ± 3% as an option)		
Frequency	50 Hz ± 3% (60 Hz ± 3% as an option)		
Installed power	100 KVA	120 KVA	100 KVA
Max. cooling water t° (electrolyte)	40°C	40°C	30°C
Design flow cooling water (electrolyte)	2 m^3/h		
Max. cooling water t° (gas cooling)	15°C		
Design flow cooling water (gas cooling)	0,15 m^3/h		
Demineralized water consumption	< 1 liter/Nm^3 H2		
Electrolyte	H2O + 30% wt. KOH		
Approx. Electrolyte Quantity	300 L		
Installation Area	Indoor, in dedicated building		
Ambient Temperature Range	+5°C to +40°C		
Dimensions Process Part (LxWxH)**	1,7m x 1,85m x 2,6m		
Dimensions Power Rack (LxWxH)	0,9m x 0,9m x 2,3m		
Dimensions Control Panel (LxWxH)	1,0m x 0,5m x 2,1m		
Approx. empty Weight Process Part	1.350 kg	1.500 kg	1.400 kg
Weight Power Rack	750 kg		
Weight Control Panel	400 kg		

(*) HPS = hydrogen purification system
(**) including 'ATEX' enclosure

HYDROGENICS
Advanced Hydrogen Solutions

12 Cascaded Design and Calculation for Alkaline Electrolysis Unit

12.1 Overview

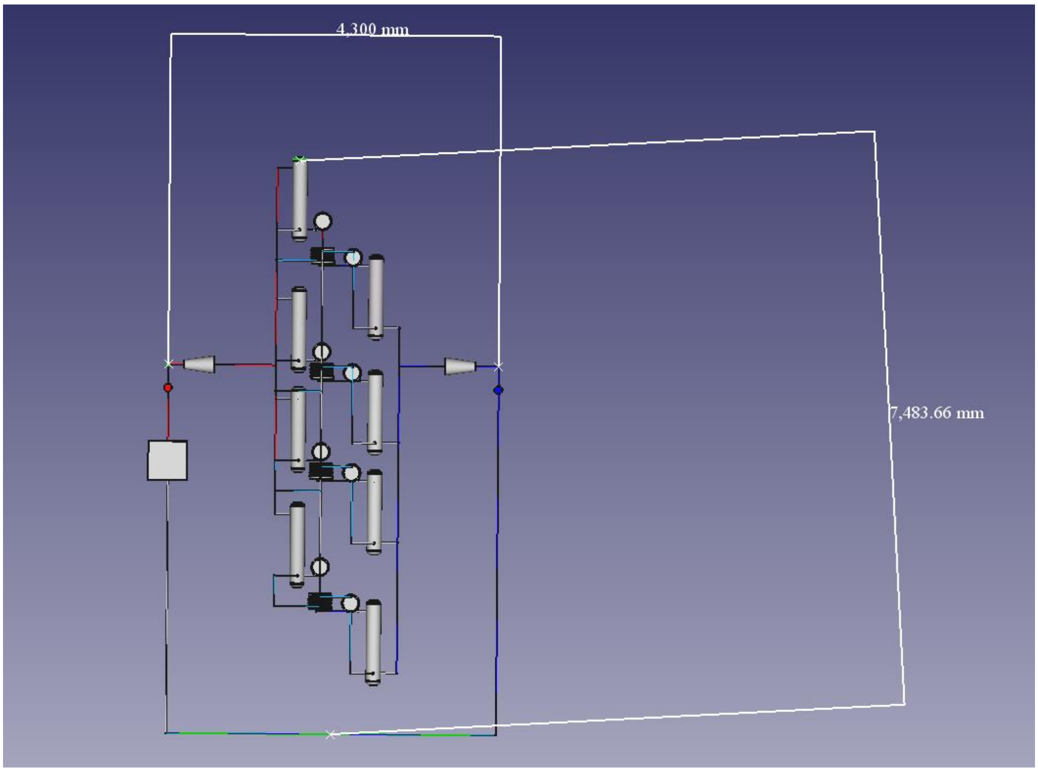


Figure 1: Plant of electrolysis (FreeCAD)

Specification	
Voltage	8 volt
Current	300 Ampere
Power	2.4 KW
KOH	5.7 Kg
Gas flow rate Hydrogen all stacks	2.27 $L.min^{-1}$
Gas flow rate Oxygen all stacks	1.13 $L.min^{-1}$
Dimensions	Electrode (Radius: 15 cm / thickness: 2cm) Stainless 304 Stack (Radius: 15 cm/ Thickness: 16 cm)

Table 1: Specification of electrolysis

8 Volt/ 300 Ampere

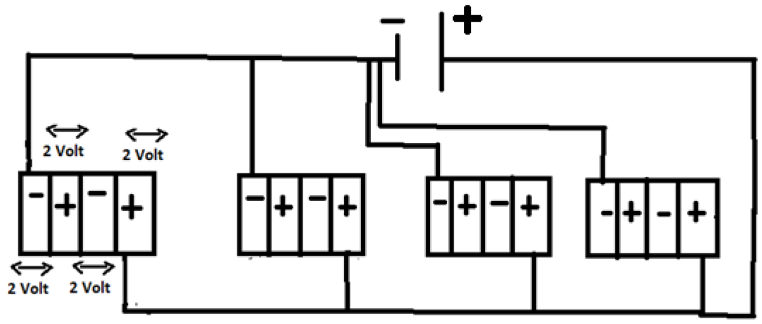


Figure 2:Multistack Amperage/Voltage

Each stack has 4 serial cells (2+2+2+2 = 8 Volt / 75 Ampere)

4 stack parallel (8 Volt/ 75 Ampere*4 = 300 Ampere)

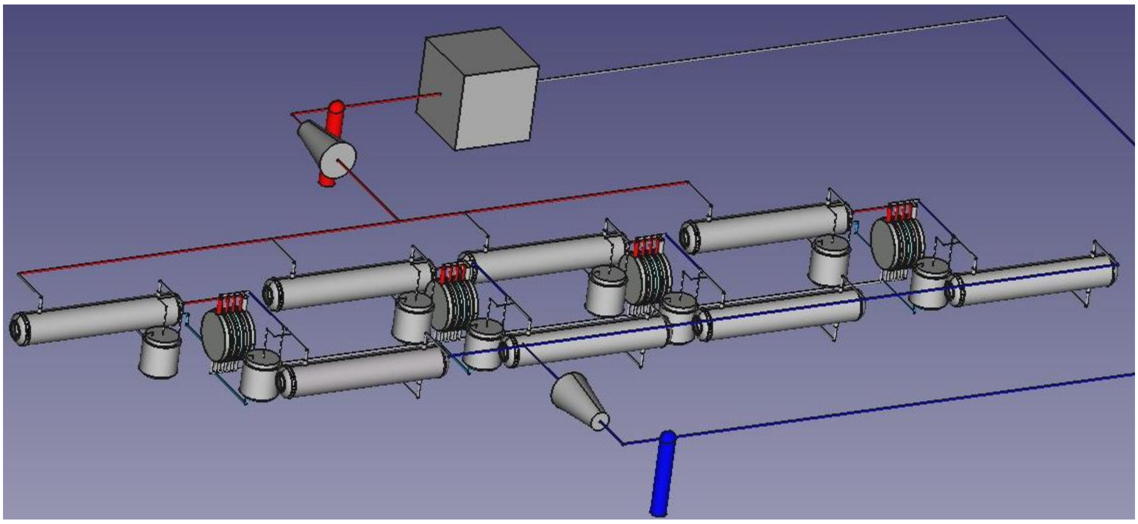
- Each electrode has thickness 2 cm: 166.6 g (KOH)

We have 30 electrodes (2 cm) => 30 * 166.6 = 5000 g (KOH)

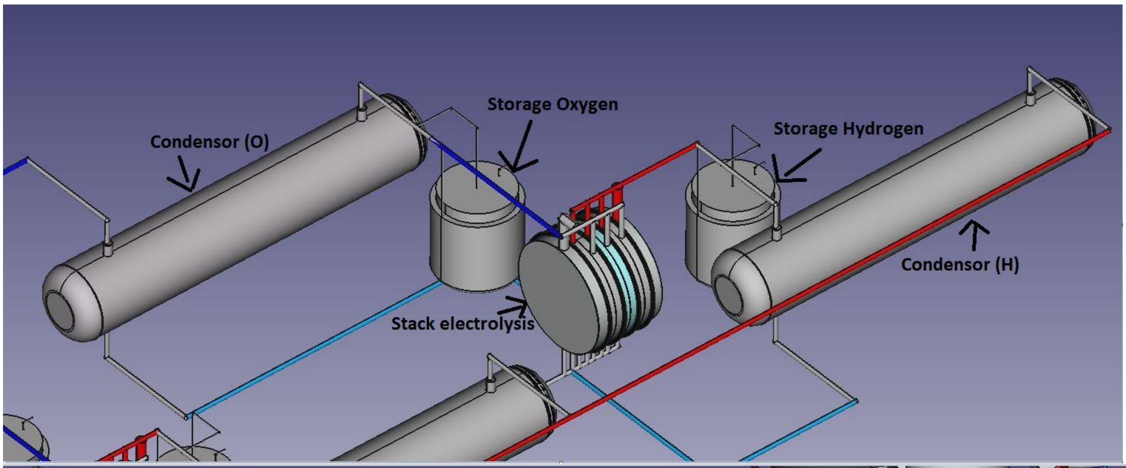
- Electrode has thickness 4 cm: 333.3 g (KOH)

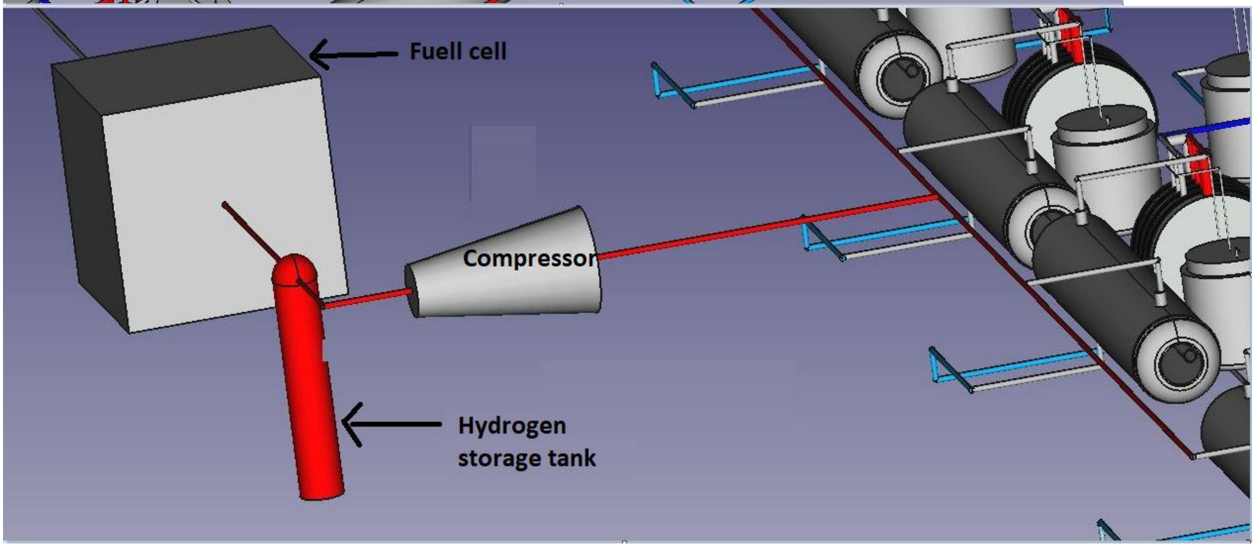
We have 2 electrodes (4 cm) => 2 * 333.33 = 666.6 g (KOH)

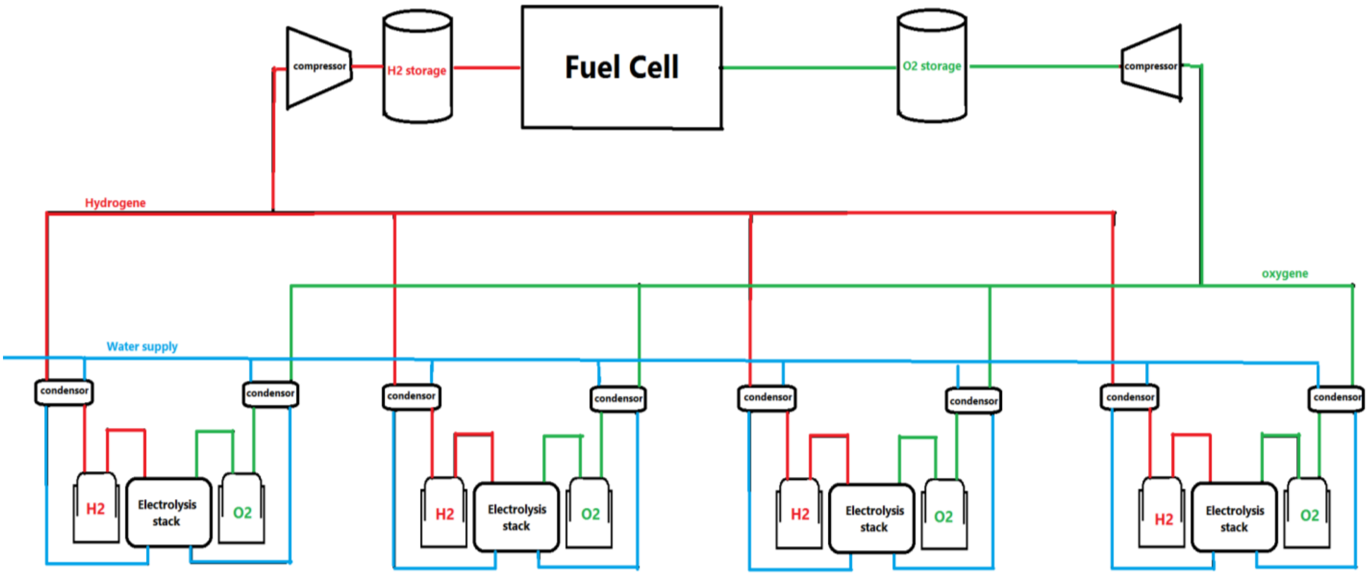
12.2 Design FreeCad



160319_electrolysis_
multistack.FCStd


Condensor (O)
Storage Oxygen
Storage Hydrogen
Condensor (H)
Stack electrolysis


Fuell cell
Compressor
Hydrogen
storage tank


compressor
H2 storage
Fuel Cell
O2 storage
compressor
Hydrogene
oxygene
Water supply
condensor
condensor
H2
Electrolysis stack
O2
condensor
condensor
H2
Electrolysis stack
O2
condensor
condensor
H2
Electrolysis stack
O2
condensor
condensor
H2
Electrolysis stack
O2

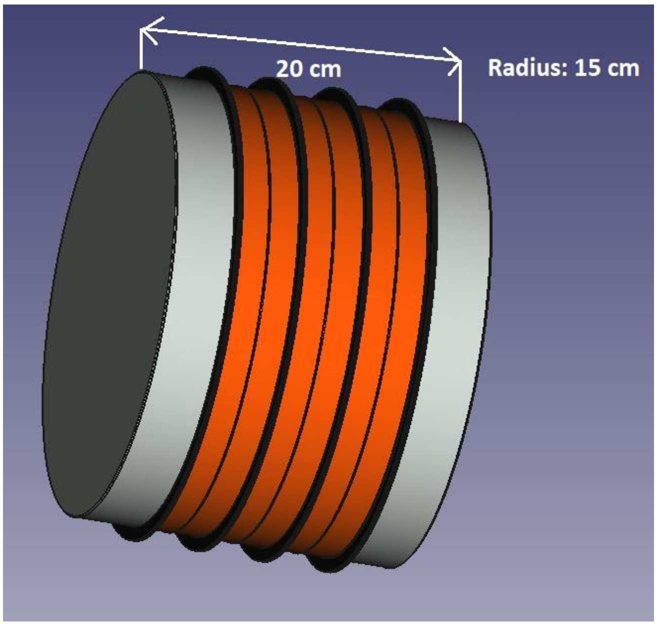
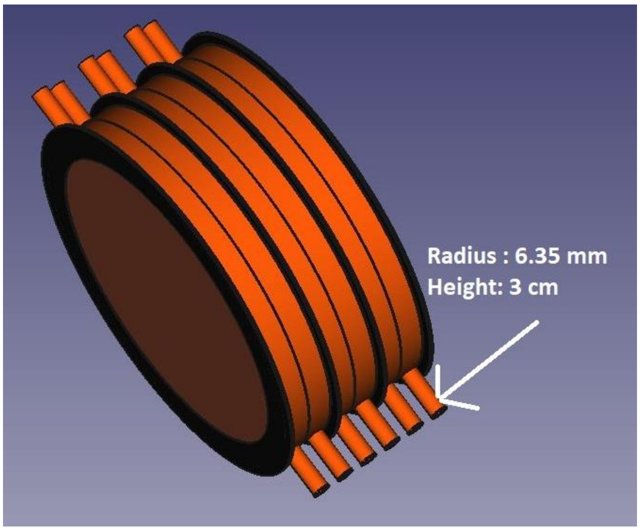


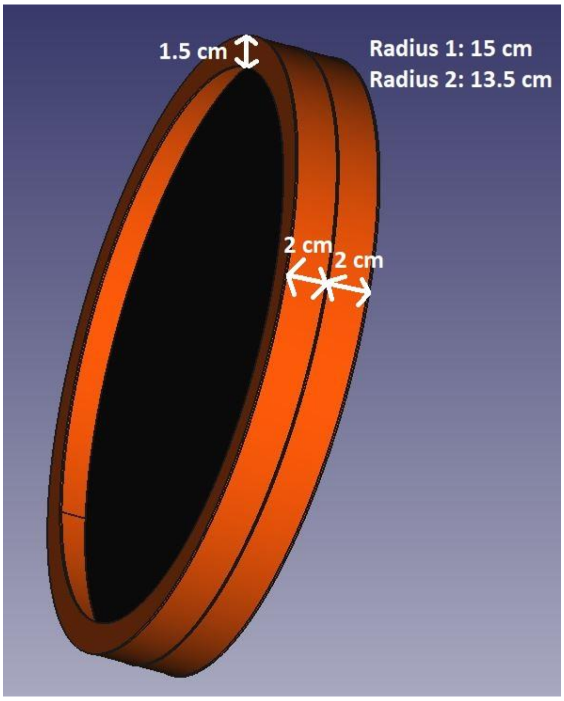
Figure 3: Serial stack

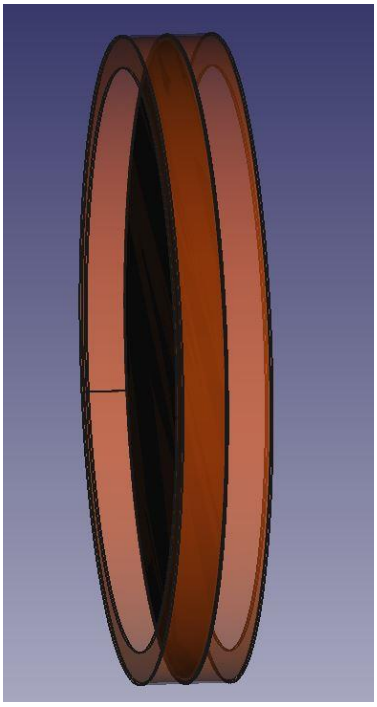
180319_Stack_electrol
ysis.FCStd

Stack

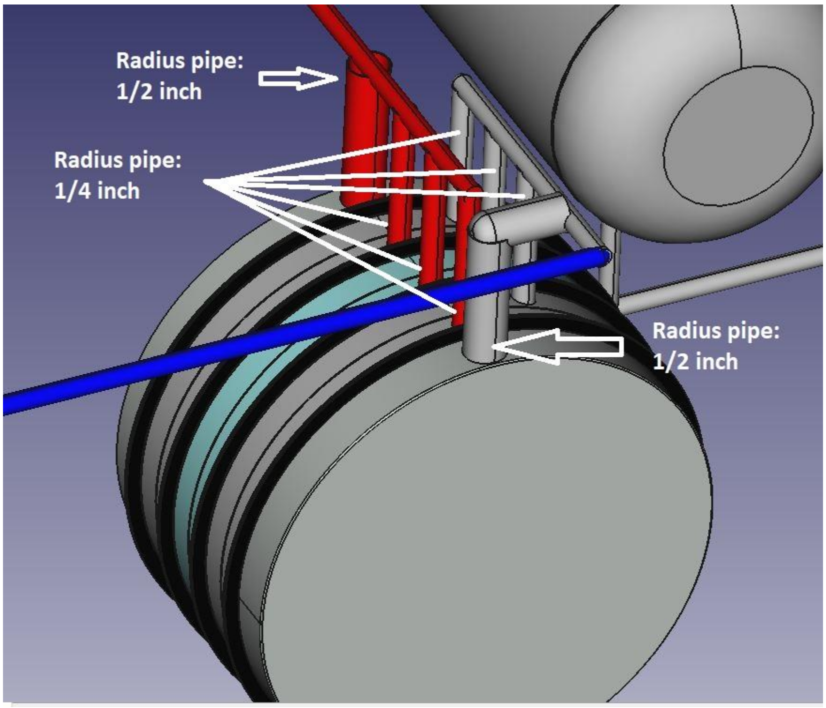


180319_baseplate_ele
ctrolysis.FCStd

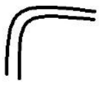
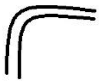


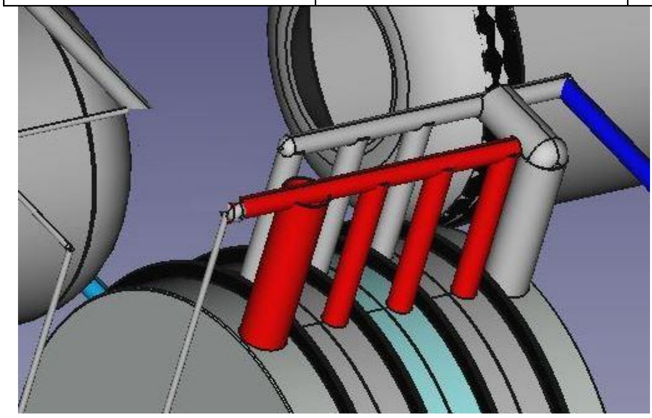


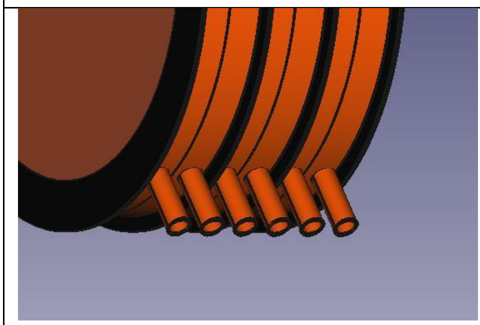
Base plate

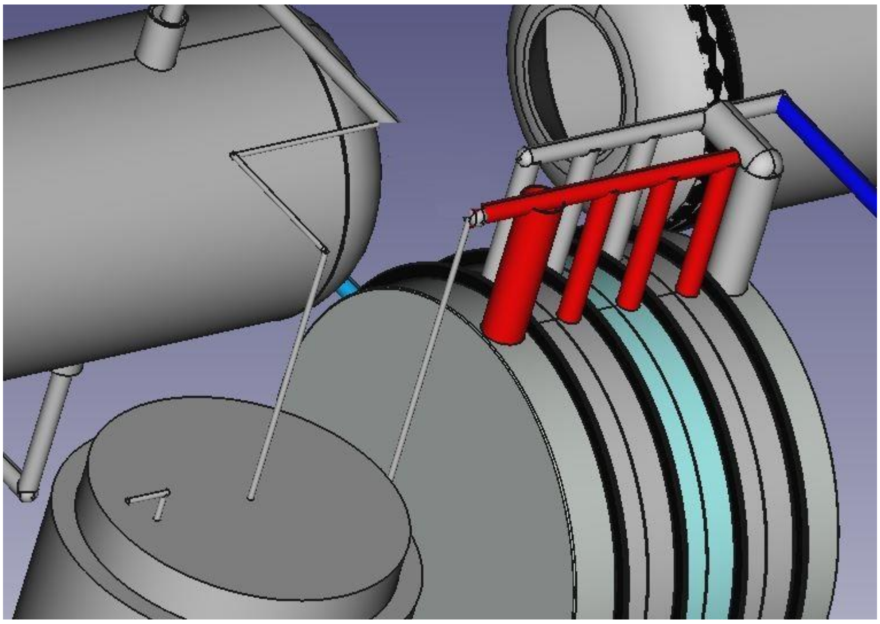


الشكل	المقاس	عدد	مواد
	¼ انش طول 10 سنتمتر	6	قسطل
	من ½ الى ¼	2	محول

كوع	1	½ انش	
كوع	4	¼ انش	
	4	¼ انش	



مواد	عدد	المقاس	الشكل
قسطل	6	¼ انش طول 10 سنتمتر	
	5	¼ انش	



12.3 Calculation of the amount of water and KOH

$V=\prod.R^2.h$

Radius: 15 cm

H_1 : 4 cm H_2 = 2 cm

$V_1=\prod.R^2.h_1$

$= \prod. 0.15^2 . 0.04$

$= 2.82* 10^{-3}$ m³

$= 2.82* 10^{-3}.10^6$ cm³

$=2.82*10^3$ cm³

=2.82 liter

$V2 =\prod.R^2.h_2$

$= \prod. 0.15^2 . 0.02$

$= 1.41* 10^{-3}$ m³

$= 1.41* 10^{-3}.10^6$ cm³

$=1.41*10^3$ cm³

=1.41 liter

The cell can contain 2.82 liter and 1.41 liter but in reality we want fell cell a)1 liter and b) 0.5 liter respectively

<u>KOH</u>

A. *The electrolysis need 25 % KOH in 1000 ml so 75 % is water*

250 g → 750 ml

?? <--1000 ml

Amount of KOH in one cell end plate electrode $= \frac{1000\ ml*250\ g}{750\ ml} = 333.33\ g$

We have 2 electrodes end plate: 2*333.3 g = 666.6 g

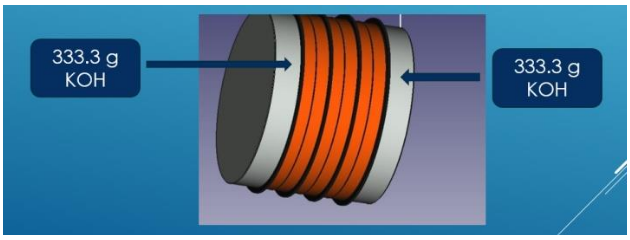


Figure 4: Amount of KOH

B. *The electrolysis need 25 % KOH in 500 ml so 75 % is water*

125 g → 375 ml

?? <--500 ml

Amount of KOH in one cell base plate $= \frac{500\ ml*125\ g}{375\ ml} = 166.66\ g$

We have 30 electrodes base plate: 30 * 166.66 g= 5000 g

12.4 Calculate gas flow rate

The maximum cell current value of 75 A is selected for the calculation. Faraday constant (F= 96485 C.mol^{-1} or C: coulomb (1C = 1A.s)). Moreover, Eq. 1 is used to calculate the number of hydrogen moles as follows.

$$n_{(H_2)} = \frac{I * t}{2F} = \frac{75\ (A) * 60(s)}{2(electrons) * 96485\ C.mol^{-1}} = 0.0233\ mol/min$$

Considering Eq. 2, assuming the pressure of 1 atm and the operating temperature of 25°C, the theoretical $V_{H2(g)}$ can be determined as,

$$V_{H_{2(g)}} = \frac{n_{H_2}RT}{P} = \frac{0.0233\ mol/\min * 0.082\ Latm\ K^{-1}mol^{-1} * 298\ K}{1\ atm}$$

$$V_{H_2} = 0.569\ L.\ min^{-1}$$

Each stack produce 0.569 L.min^{-1} => 4 stack produce = 0.569 L.min^{-1} * 4 (stack) = 2.279 L.min^{-1}

<u>For oxygen:</u>

The amount of substance for O_2 (g) can be determined by using either Eq. 5.1 or the electrochemical reaction of the alkaline electrolysis cell. According to the electro chemical reaction, the number of O_2(g) moles should be half of H_2(g) moles. Hence, the number of O_2(g) moles can be easily determined as in Eq.

$$n_{O_2} = \frac{n_{H_2}}{2}$$

$$n_{O_2} = 0.0116\, mol/min$$

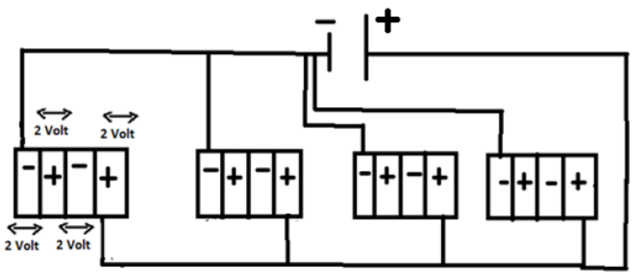
$$V_{O_{2(g)}} = \frac{n_{O_2}RT}{P} = \frac{0.0116\, mol/\min * 0.082\, Latm\, K^{-1}mol^{-1} * 298\, K}{1\, atm}$$

$$V_{O_2} = 0.284\, L.min^{-1}$$

Each stack produce 0.284 L.min^{-1} => 4 stacks produce = 0.284 $L.min^{-1}$ * 4 (stacks)= 1.138 L.min^{-1}

Other https://www.editions-petiteelisabeth.fr/calculs_electrolyse_3.php

12.5 Power supply



- Density current for electrolysis: 0.2 – 0.4 A/cm^2
- Our cell contains 0.5 liter = 250 cm^2
- Current apply for each cell $= \frac{250\, cm^2 * 0.3\, A/cm^2}{1 cm^2} = 75\, A$
- Voltage apply for each cell is 2V
- Each stack has 4 serial cell => voltage = 4*2 = 8 V

  Current = 75A

- The total is 4 parallel stack => voltage = 8 V

  Current = 4 * 75 = 300 A

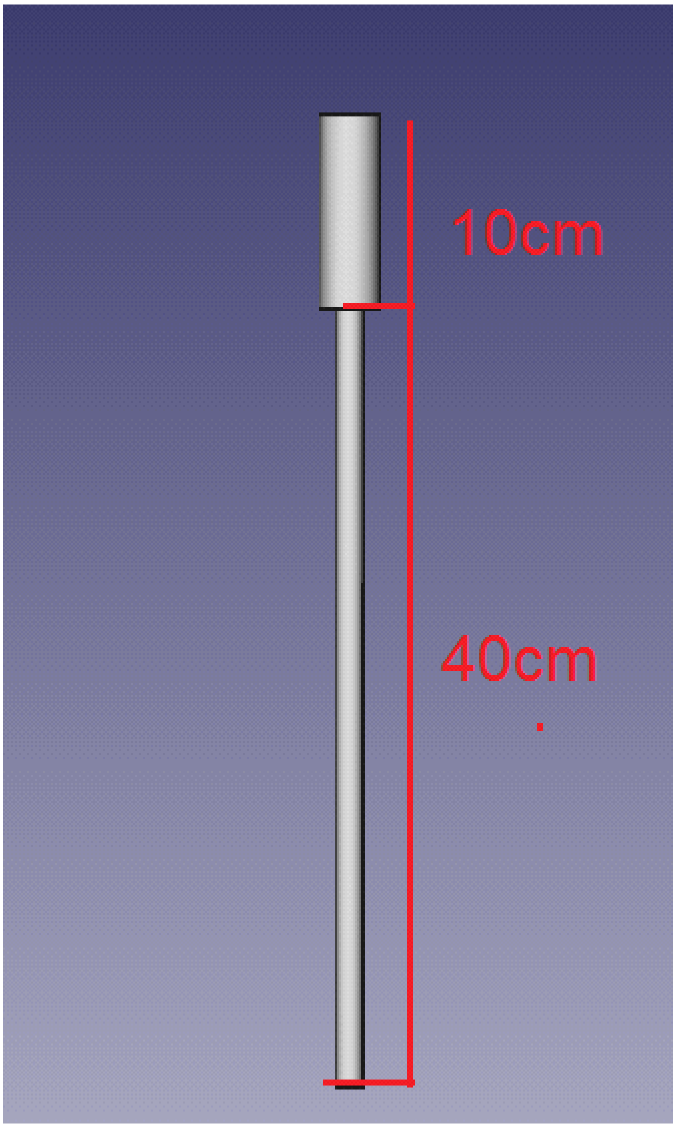
- Power apply: Power = voltage x Current = 8 Volt x 300 Ampere = 2.4 KW

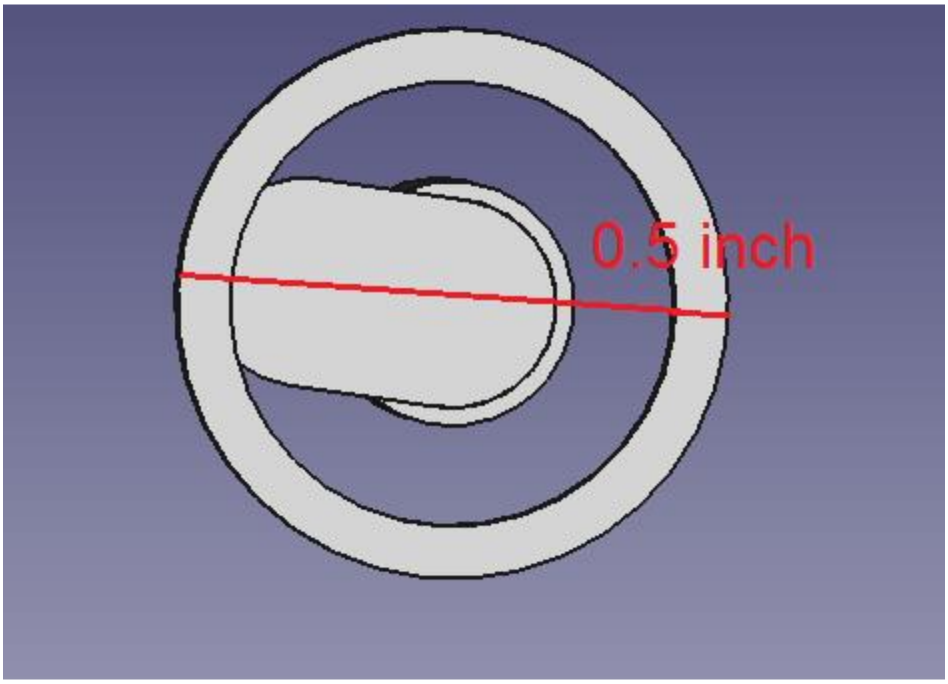
12.6 Simplified Design[16]

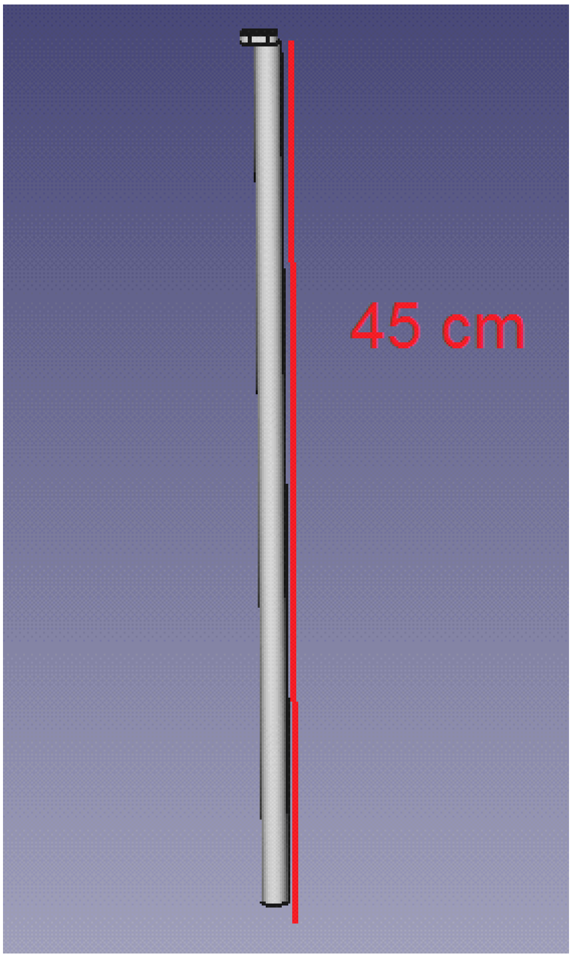
12.6.1 Level Control System

tubes=12.5mm,6mm

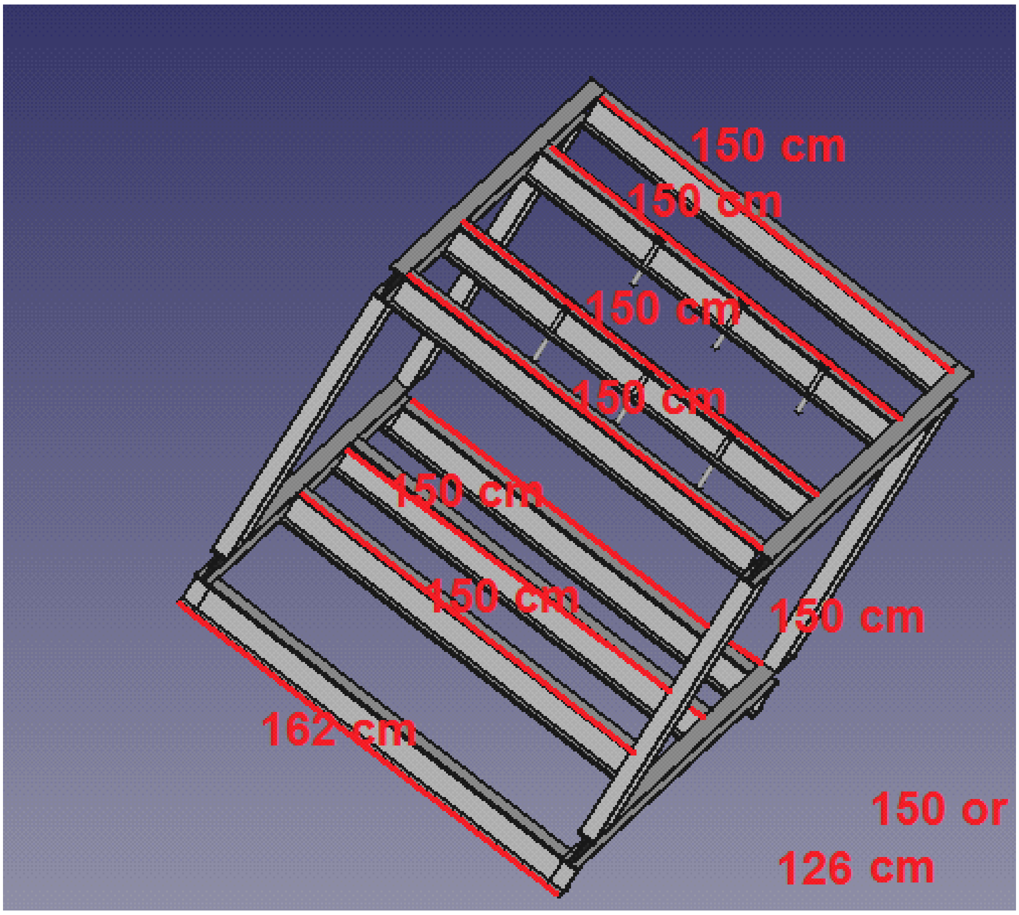
[16] Samer Youssef, July/Aug 2019

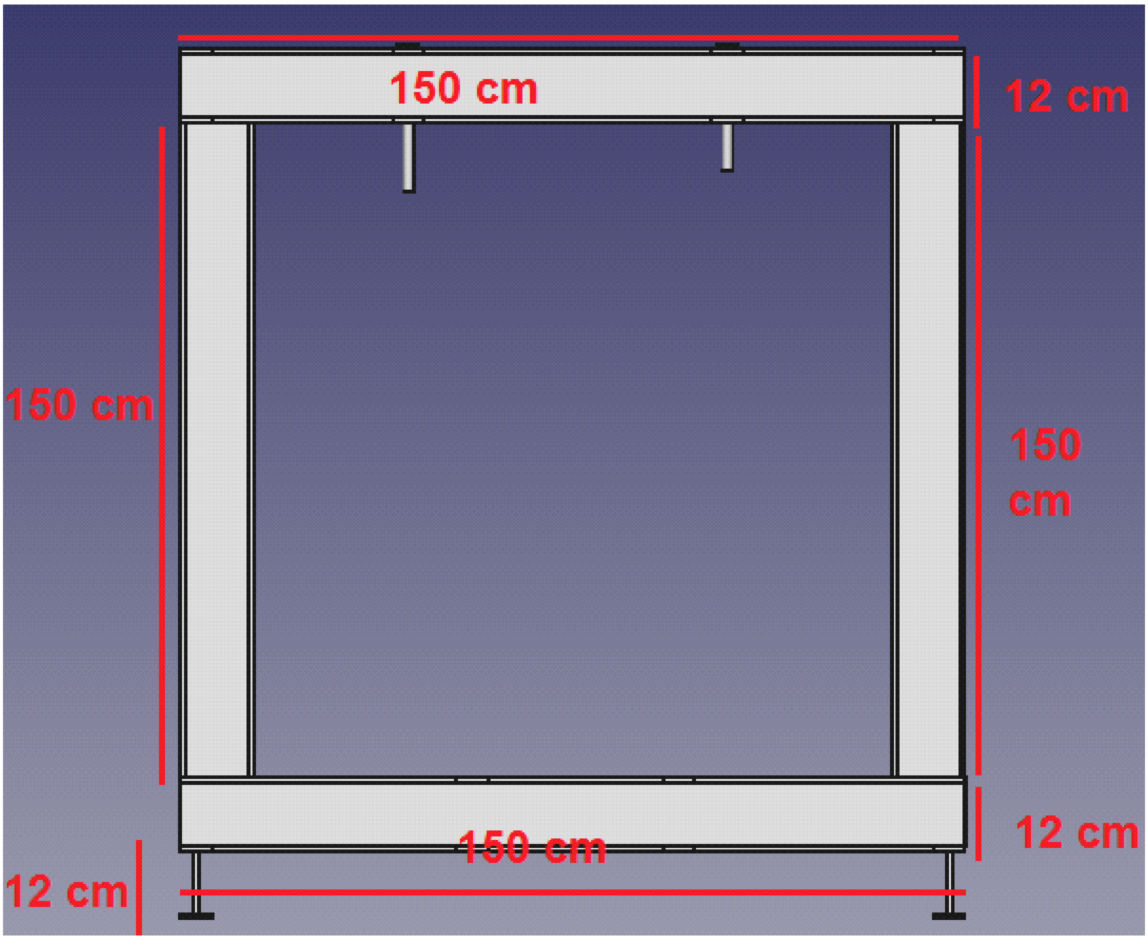

10cm
40cm


0.5 inch


45 cm

12.6.2 Electrolyser Container



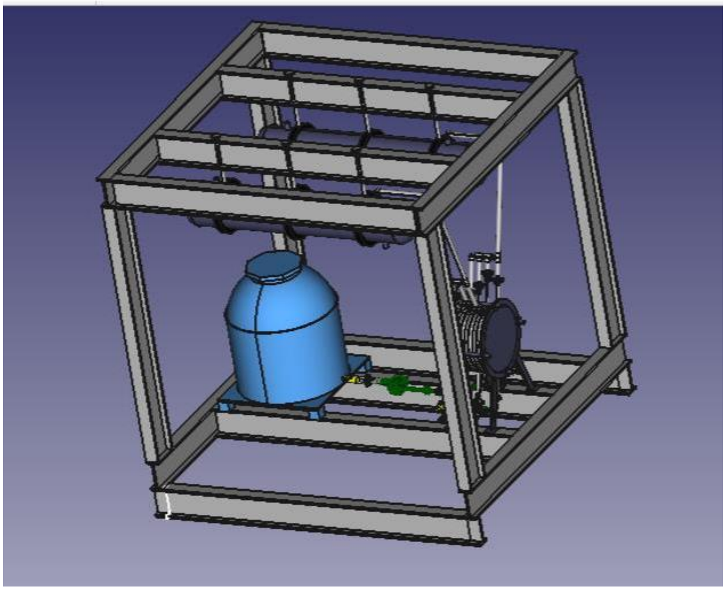


numbers of columns : 2-(162)cm

14-(150)cm.. or.. 12(126)cm

2(150)cm.

12.6.3 Integration

	110619NLAP-WEDC_ElectrolysisUnit.FCStd

13 Alkaline Electrolysis of Water Unit including Fuel Burner

13.1 Overview

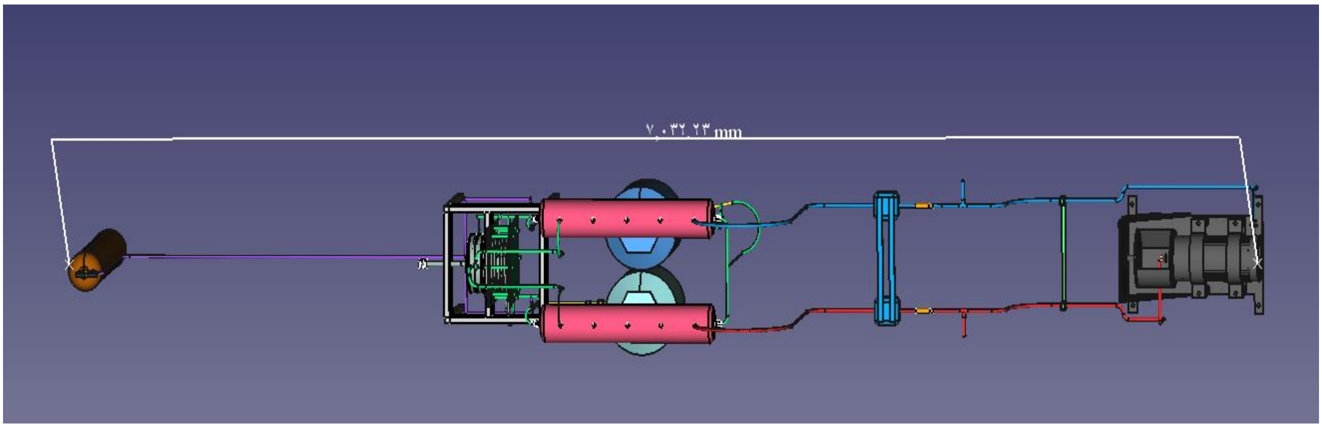


Figure 5 : Plant of electrolysis (FreeCAD

Specification	
Voltage	4 volt
Current	150 Ampere
Power	0.6 KW
KOH	1.33 Kg
Gas flow rate Hydrogen all stacks	2.27 $L.min^{-1}$
Gas flow rate Oxygen all stacks	1.13 $L.min^{-1}$
Dimensions	Electrode (Radius: 15 cm / thickness: 2cm) Stainless 304 Stack (Radius: 15 cm/ Thickness: 16 cm)

Table 2: Specification of electrolysis

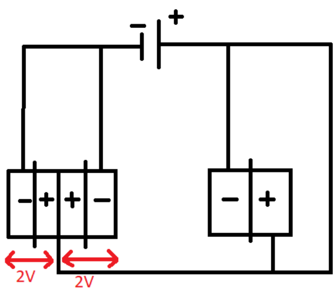


Figure 6 :Multistack Amperage/Voltage

Each stack has 2 serial cells (2+2 = 4 Volt / 75 Ampere)

2 stack parallel (4 Volt/ 75 Ampere * 2 = 150 Ampere)

- Each electrode has thickness 2 cm: 166.6 g (KOH)

We have 6 electrodes (2 cm) => 4 * 166.6 = 666.6 g (KOH)

- Electrode has thickness 4 cm: 333.3 g (KOH)

We have 2 electrodes (4 cm) => 2 * 333.33 = 666.6 g (KOH)

13.2 FreeCad Design

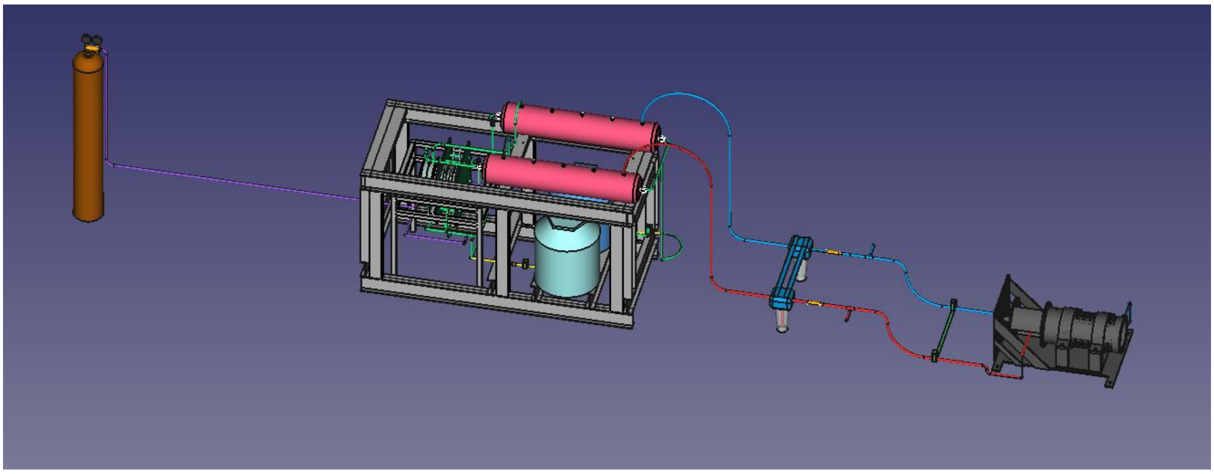


Figure 7

electrolyser+fuel burnner 010120.FCStd

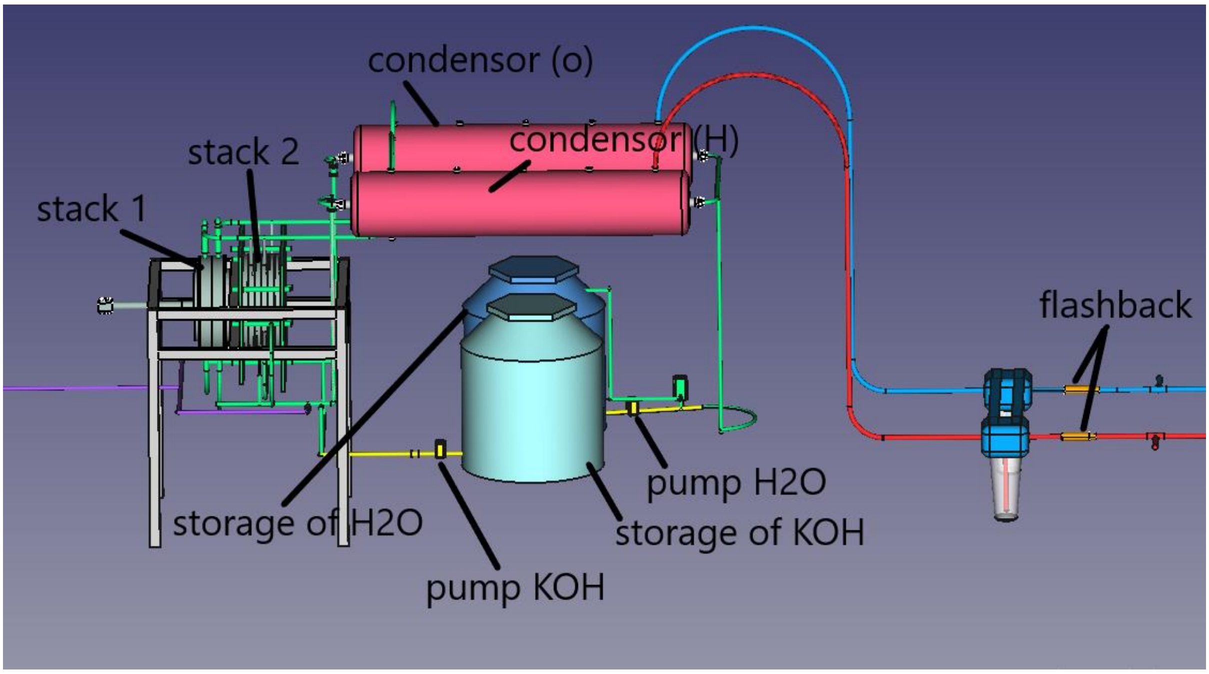


Figure 8

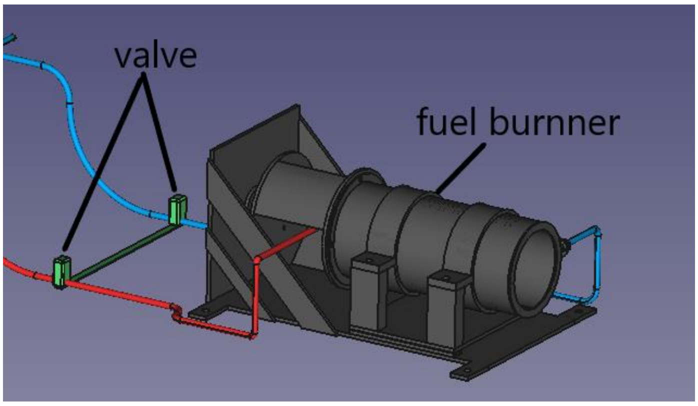


Figure 9

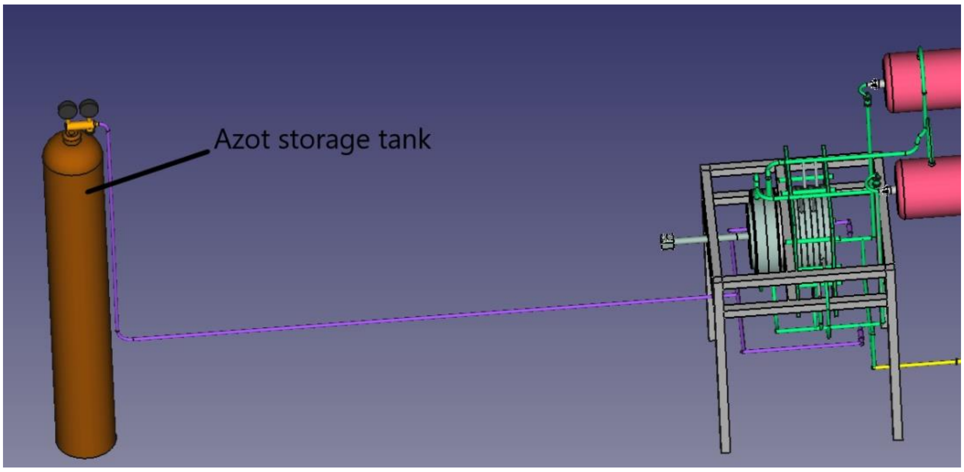


Figure 10

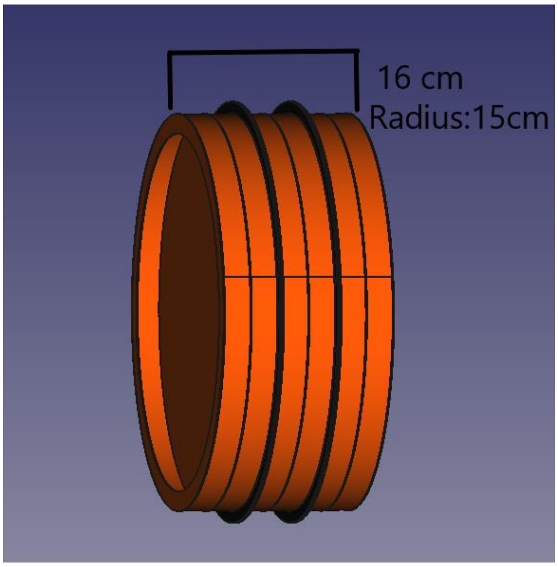


Figure 11: Serial stack

180319_Stack_electrol
ysis.FCStd

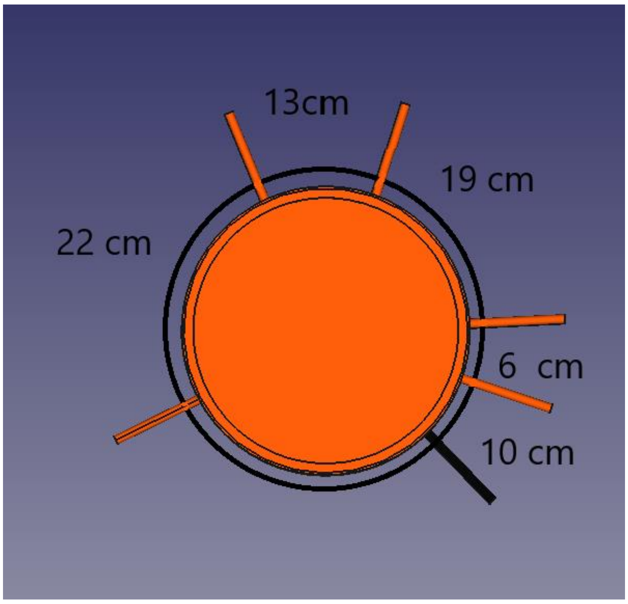


Figure 12

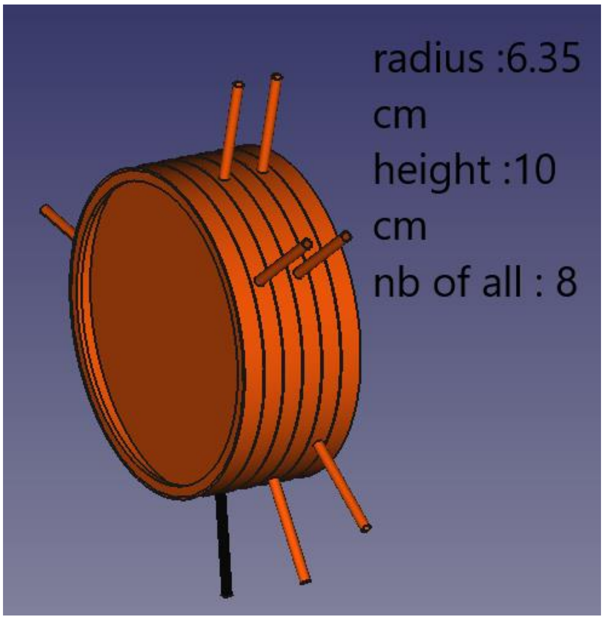


Figure 13

original electroluser.FCStd

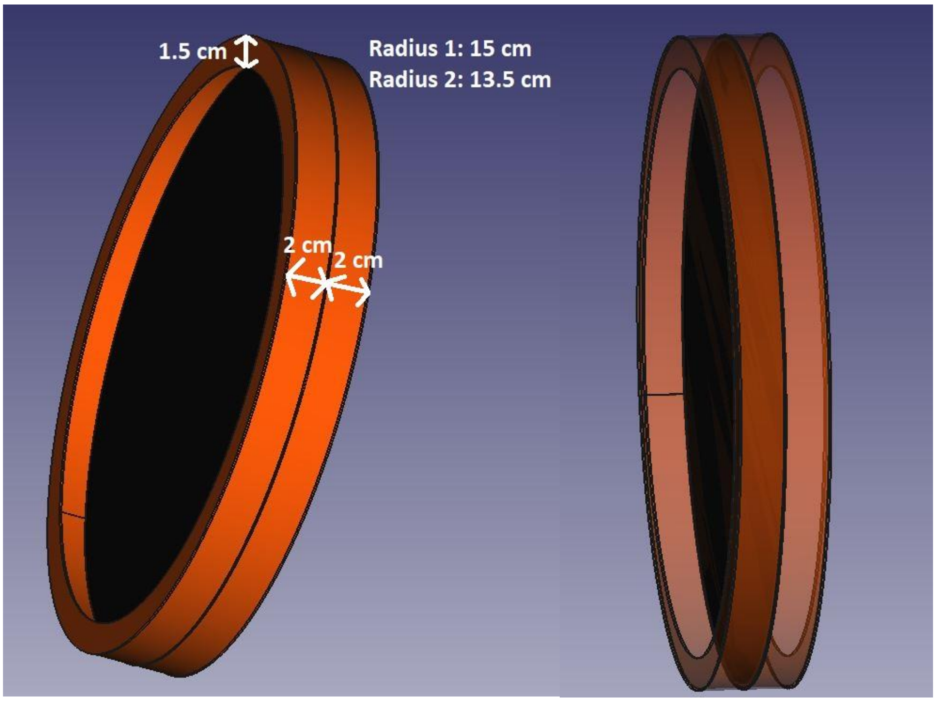


Figure 14

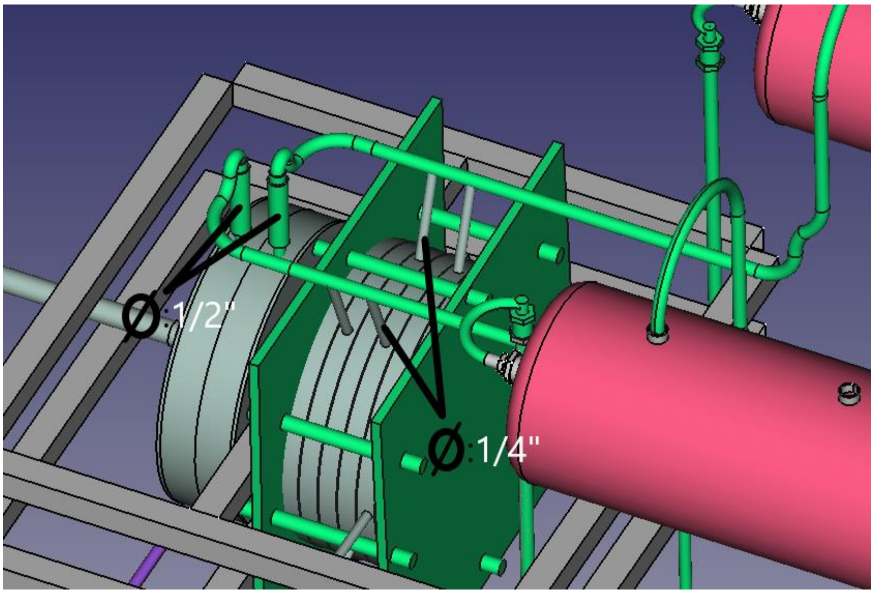
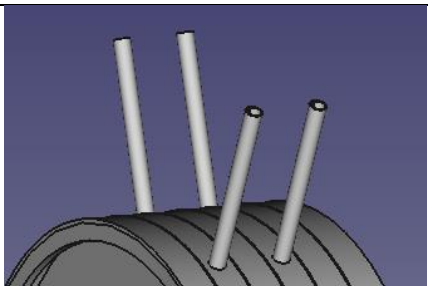


Figure 15

الشكل	المقاس	عدد	مواد
	قطر: " 1/4 طول 10سنتمتر	8	قسطل

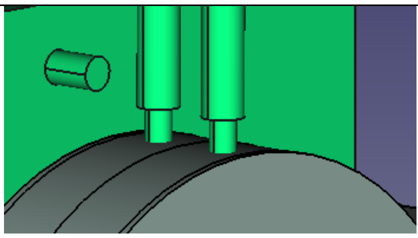
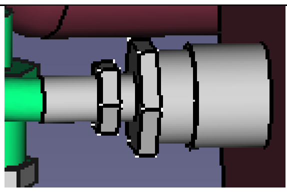
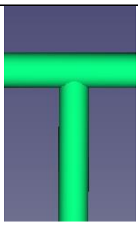
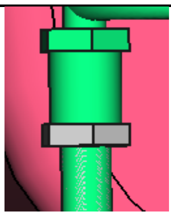
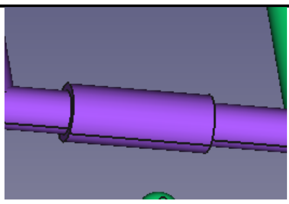
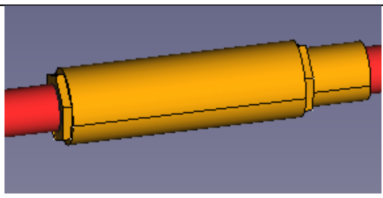
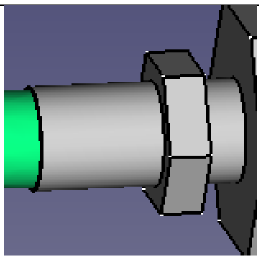
	قطر: "1/2 طول10سنتمتر	4	قسطل
	من "1 الى "1/2	4	محول
	1/4"	16	T(بلاستك)
	1/2"	3	صباب عدم رجوع(ماء)
	Ø:16 mm	2	صباب عدم رجوع (azot)
	Ø:16 mm	2	صباب عدم رجوع(Hyd,Oxy)
	1/2"	8	شريط بعزقة
	20 mm	43	حبسة حجم صغير
	40 mm	35	حبسة حجم كبير

Table 3

13.3 Calculation of the amount of water and KOH

$V = \prod . R^2 . h$

Radius: 15 cm

H_1 : 4 cm H_2 = 2 cm

$V_1 = \prod . R^2 . h_1$

$= \prod . 0.15^2 . 0.04$

$= 2.82 * 10^{-3}\ m^3$

$= 2.82 * 10^{-3} . 10^6\ cm^3$

$= 2.82 * 10^3\ cm^3$

=2.82 liter

$V2 = \prod . R^2 . h_2$

$= \prod . 0.15^2 . 0.02$

$= 1.41 * 10^{-3}\ m^3$

$= 1.41 * 10^{-3} . 10^6\ cm^3$

$= 1.41 * 10^3\ cm^3$

=1.41 liter

The cell can contain 2.82 liter and 1.41 liter but in reality we want fell cell a)1 liter and b) 0.5 liter respectively

KOH

B. *The electrolysis need 25 % KOH in 1000 ml so 75 % is water*

250 g → 750 ml

?? <--1000 ml

Amount of KOH in one cell end plate electrode $= \frac{1000\ ml * 250\ g}{750\ ml} = 333.33\ g$

We have 2 electrodes end plate: 2*333.3 g = 666.6 g

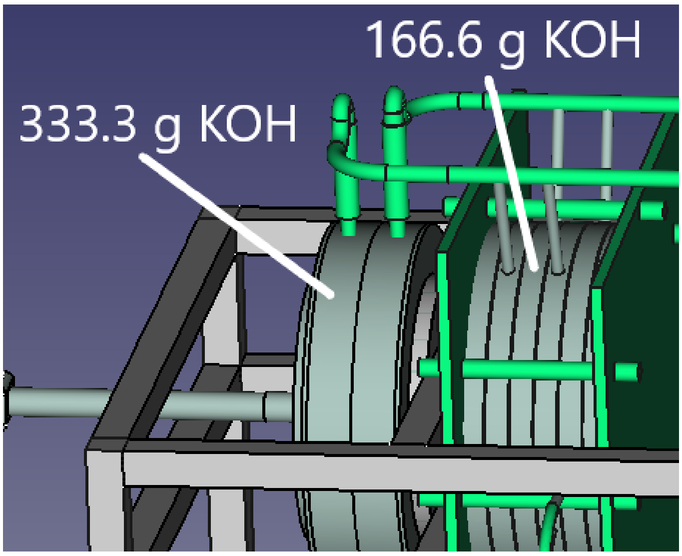


Figure 16: Amount of KOH

C. *The electrolysis need 25 % KOH in 500 ml so 75 % is water*

125 g → 375 ml

?? <--500 ml

Amount of KOH in one cell base plate $= \frac{500\ ml * 125\ g}{375\ ml} = 166.66\ g$

We have 4 electrodes base plate: 4 * 166.66 g= 666.6 g

13.4 Calculation of gas flow rate

The maximum cell current value of 75 A is selected for the calculation. Faraday constant (F= 96485 C.mol^{-1} or C: coulomb (1C = 1A.s)). Moreover, Eq. 1 is used to calculate the number of hydrogen moles as follows.

$$n_{(H_2)} = \frac{I * t}{2F} = \frac{75\ (A) * 60(s)}{2(electrons) * 96485\ C.mol^{-1}} = 0.0233\ mol/min$$

Considering Eq. 2, assuming the pressure of 1 atm and the operating temperature of 25°C, the theoretical $V_{H2(g)}$ can be determined as,

$$V_{H_{2(g)}} = \frac{n_{H_2}RT}{P} = \frac{0.0233\ mol/\min * 0.082\ Latm\ K^{-1}mol^{-1} * 298\ K}{1\ atm}$$

$$V_{H_2} = 0.569\ L.\ min^{-1}$$

Each stack produce 0.569 L.min^{-1} => 4 stack produce = 0.569 L.min^{-1} * 2 (stack) = 1.138 L.min^{-1}

For oxygen:

The amount of substance for O_2 (g) can be determined by using either Eq. 5.1 or the electrochemical reaction of the alkaline electrolysis cell. According to the electro chemical reaction, the number of O_2(g) moles should be half of H_2(g) moles. Hence, the number of O_2(g) moles can be easily determined as in Eq.

$$n_{O_2} = \frac{n_{H_2}}{2}$$

$$n_{O_2} = 0.0116\, mol/min$$

$$V_{O_{2(g)}} = \frac{n_{O_2}RT}{P} = \frac{0.0116\, mol/\min * 0.082\, Latm\, K^{-1}mol^{-1} * 298\, K}{1\, atm}$$

$$V_{O_2} = 0.284\, L.min^{-1}$$

Each stack produce 0.284 L.min^{-1} => 2 stacks produce = 0.284 $L.min^{-1}$ * 2 (stacks)= 0.568 L.min^{-1}

Other https://www.editions-petiteelisabeth.fr/calculs_electrolyse_3.php

13.5 Power supply

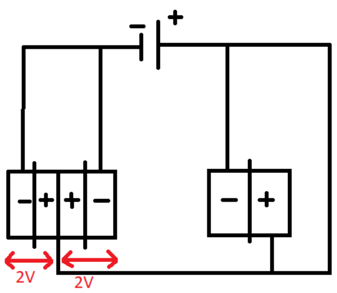


Figure 17

- Density current for electrolysis: 0.2 – 0.4 A/cm^2
- Our cell contains 0.5 liter = 250 cm^2
- Current apply for each cell = $\frac{250\, cm^2 * 0.3\, A/cm^2}{1 cm^2} = 75\, A$
- Voltage apply for each cell is 2V
- Each stack has 2 serial cell => voltage = 2*2 = 4 V
  Current = 75A
- The total is 2 parallel stack => voltage = 8 V
  Current = 2 * 75 = 150 A
- Power apply: Power = voltage x Current = 4 Volt x 150 Ampere = 0.6 KW

13.6 Compact Design[17]

13.6.1 Level Control System

tubes=12.5mm,6mm

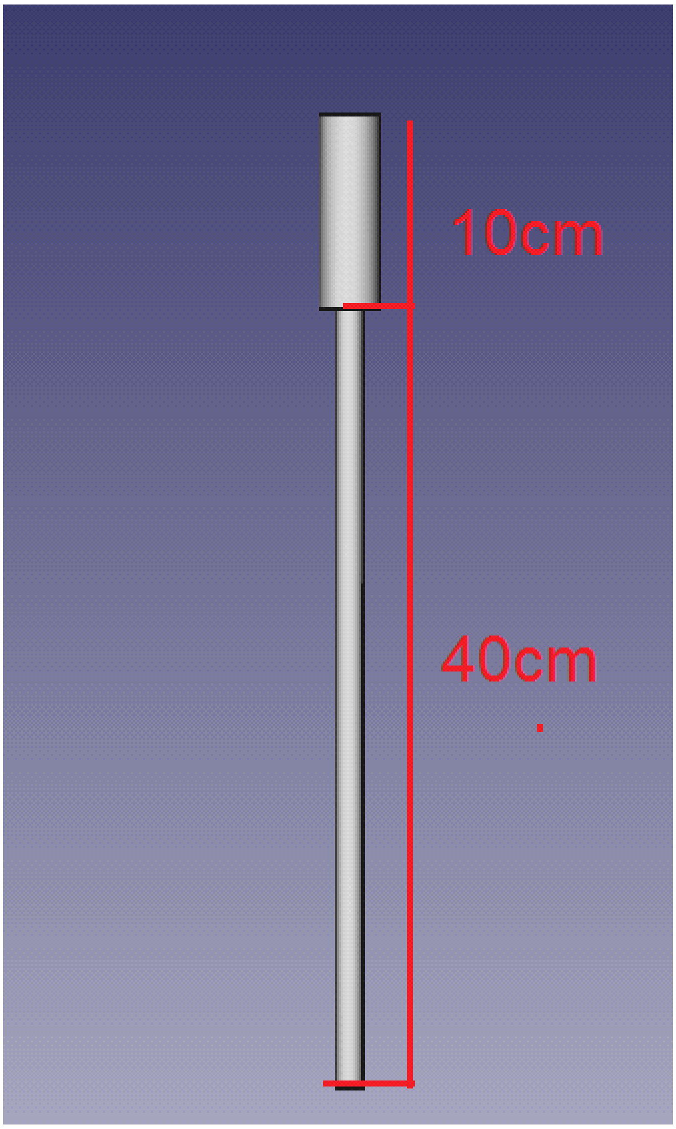


Figure 18

[17] Samer Youssef, July/Aug 2019

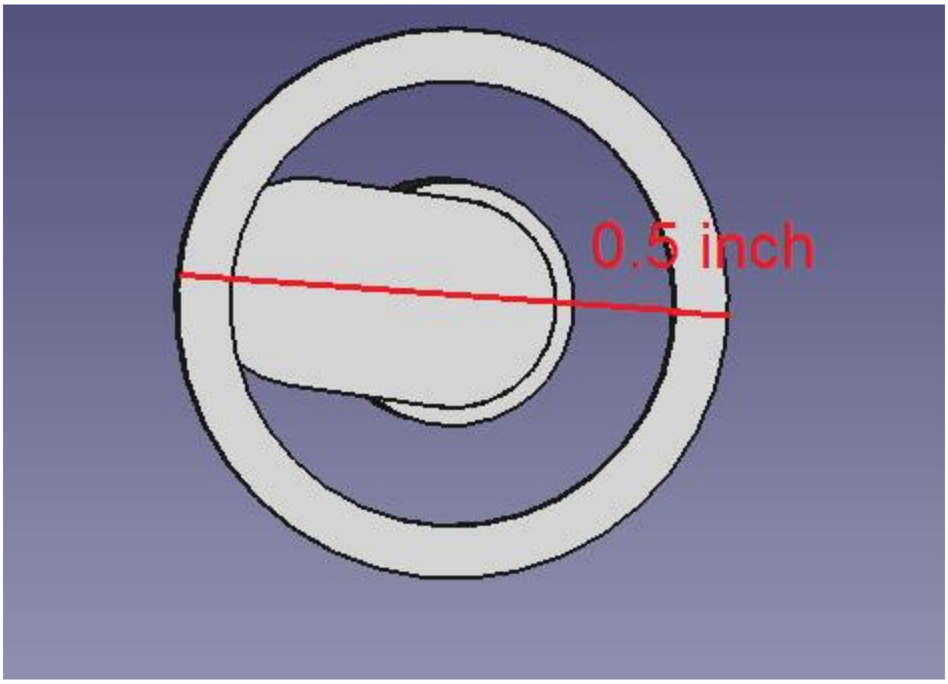


Figure 19

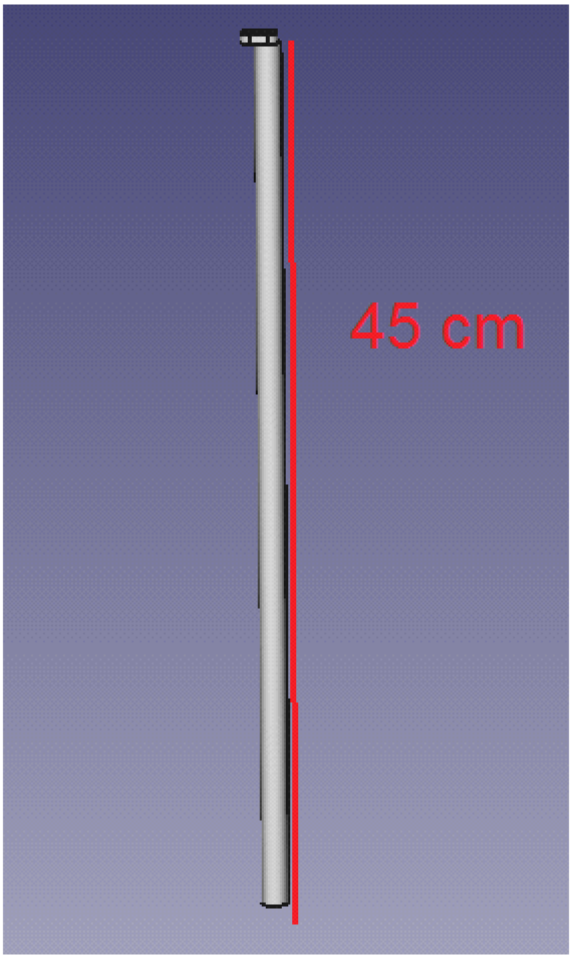


Figure 20

13.6.2 Electrolyser Container

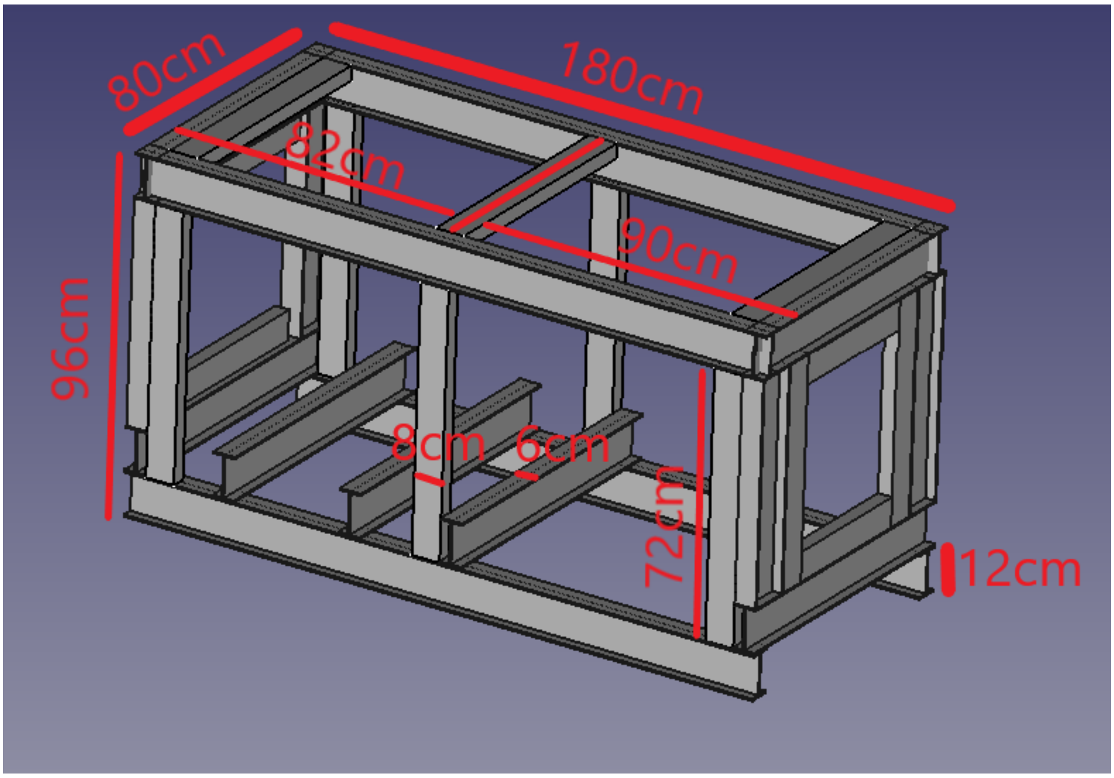


Figure 21

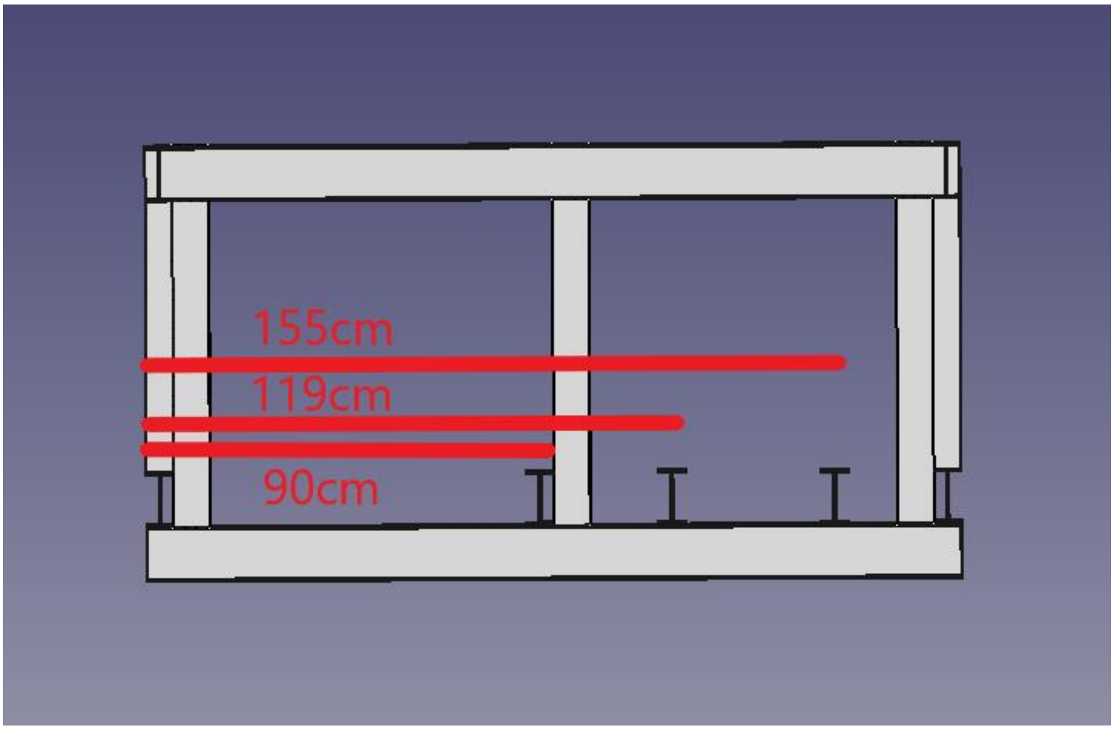
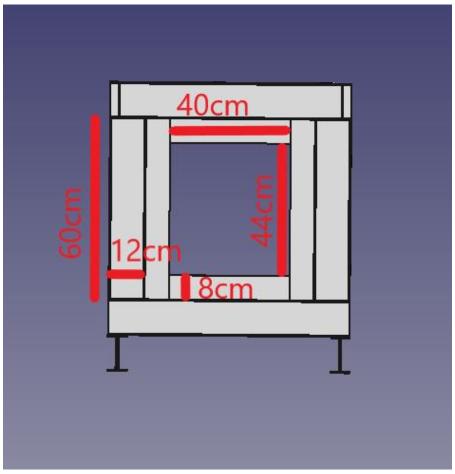


Figure 22



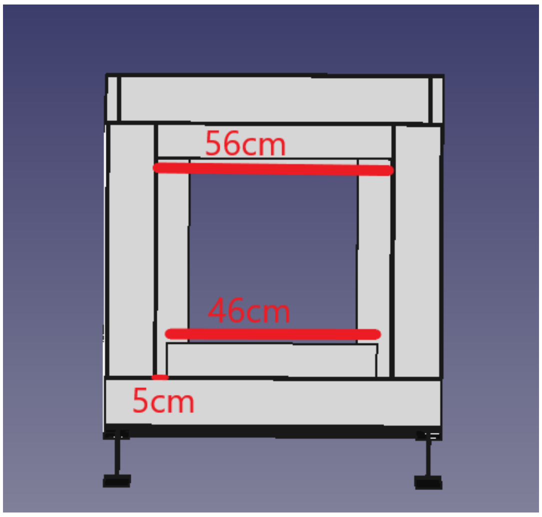


Figure 23 Figure 24

numbers of columns : 4-(180)cm

6-(72) cm

5-(80) cm

5-(68) cm

6-(60) cm

2-(40) cm

1-(56) cm

1-(46) cm.

13.6.3 Integration

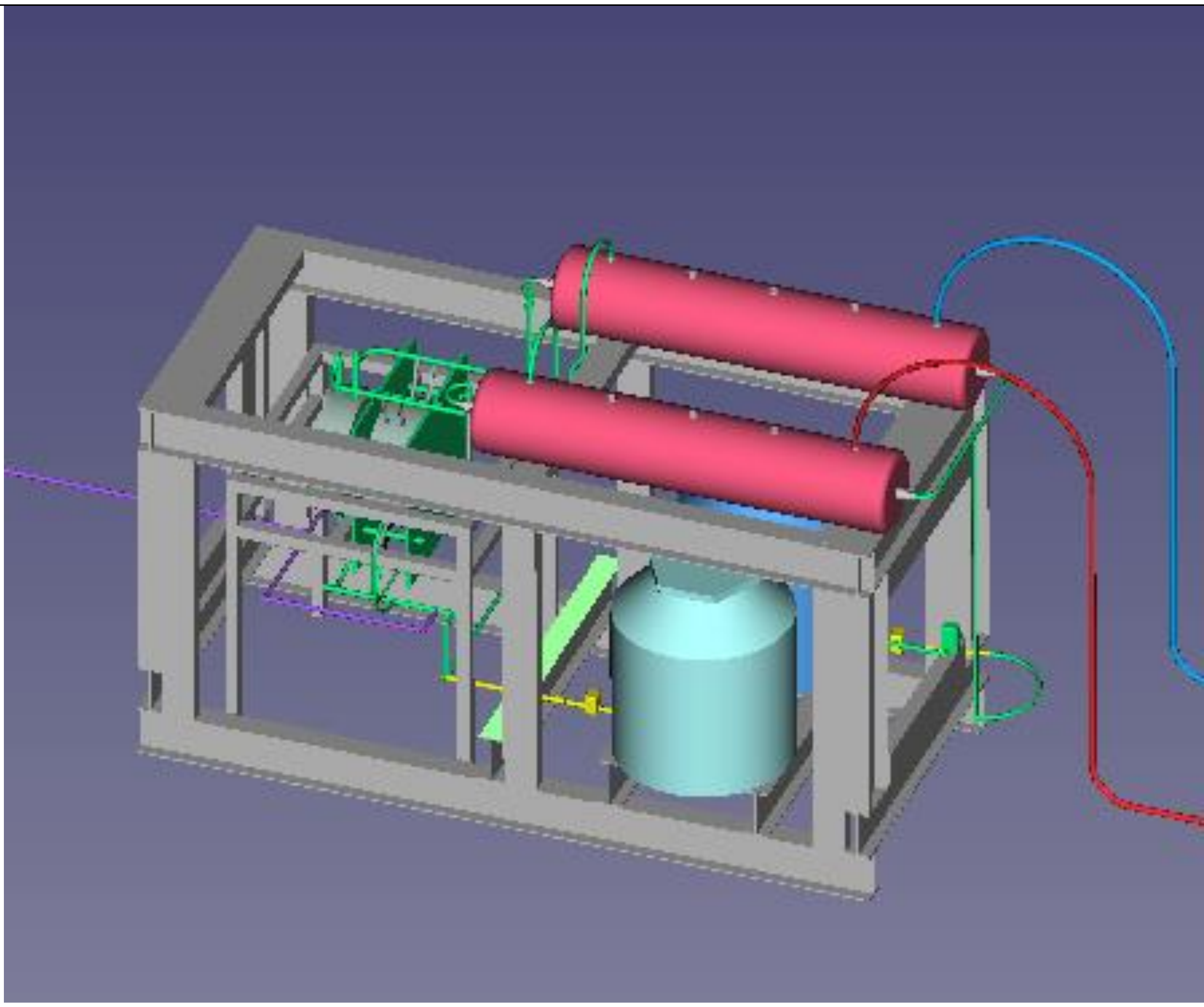
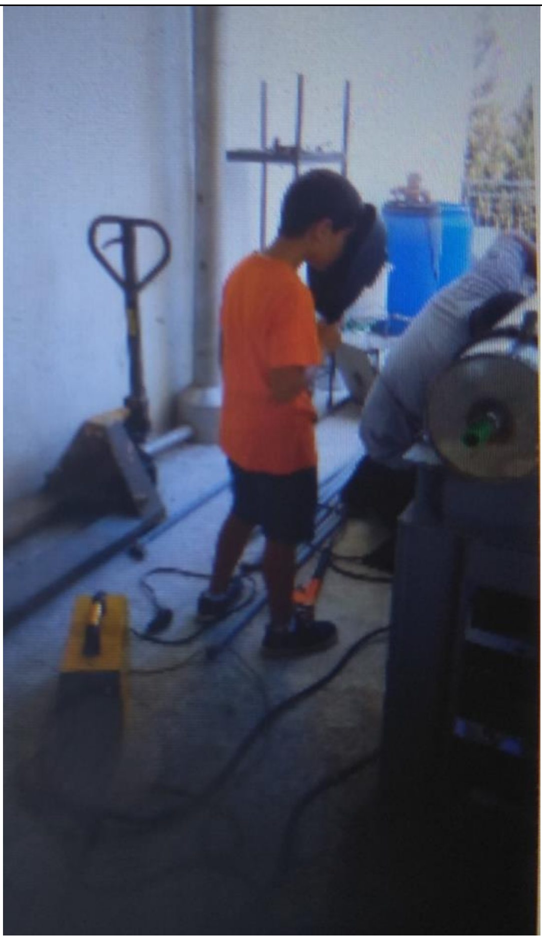
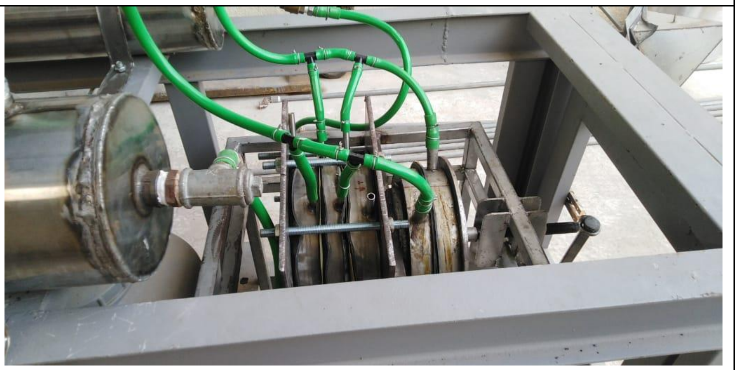


Figure 25

electrolyser+fuel burnner 010120.FCStd

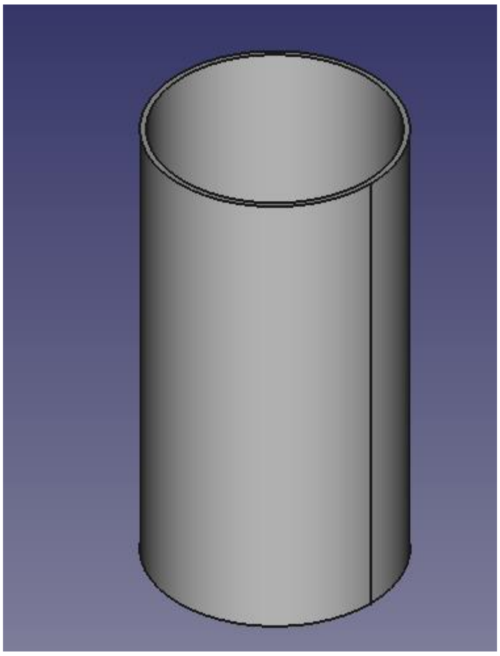
14 Fuel burner unit

14.1 Fuel burner

14.1.1 FreeCAD Design

fuel_burner_261218.FCStd

Figure 26



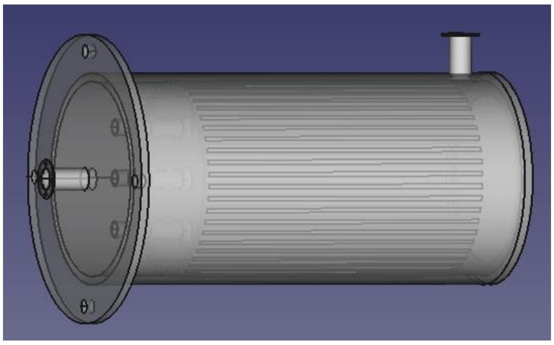


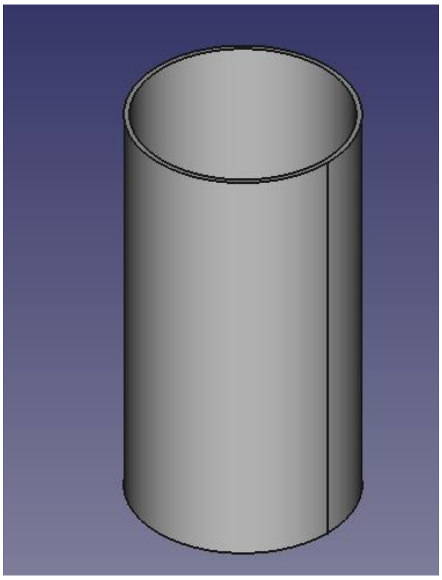
Figure 27

Int diameter: 23 cm ,

Ext diameter: 25cm ,

Length: 50 cm .

Figure 28



Int diameter : 17 cm,

Ext diameter: 20 cm,

Length : 40 cm .

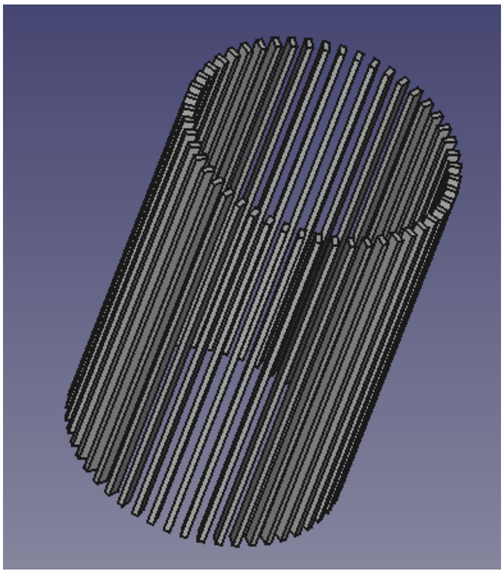


Figure 29

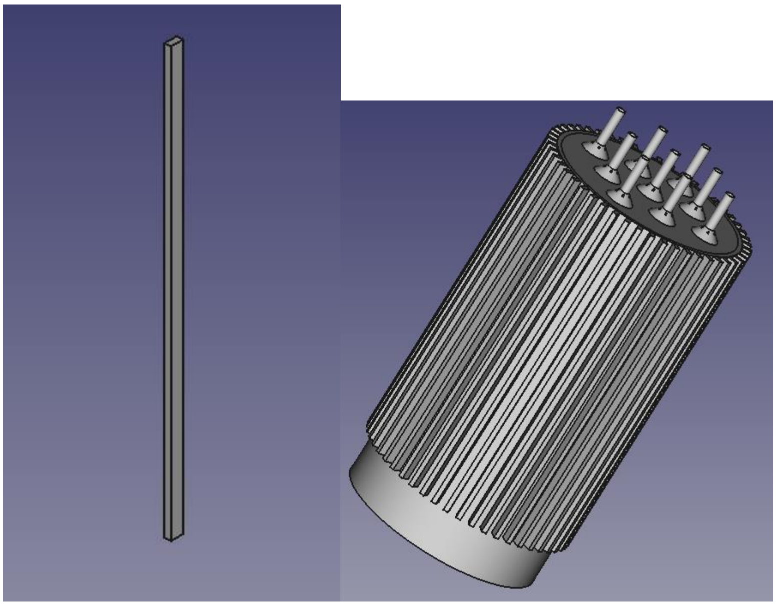


Figure 30

length: 1 cm

width : 5mm

height : 35 cm

Nb of bars: 50

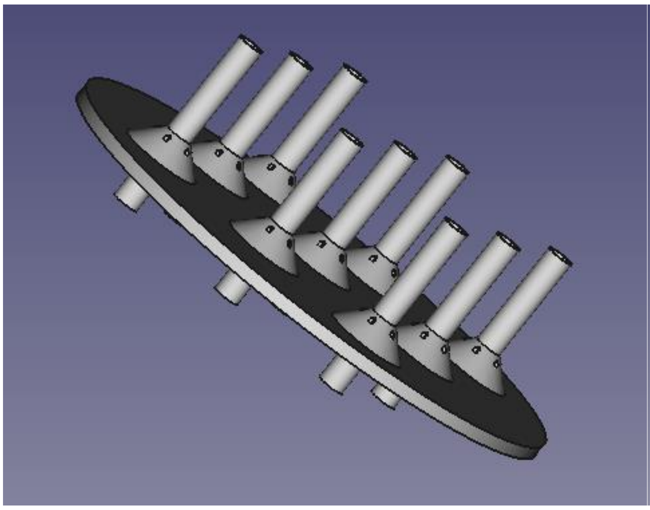


Figure 31

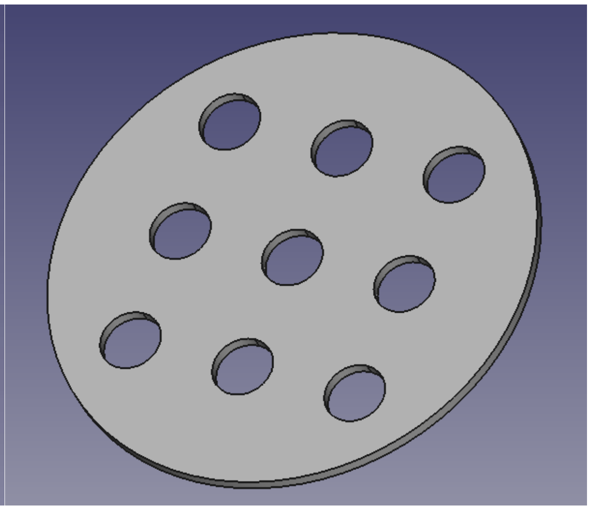


Figure 32

Dimetre of plate : 17 cm

Thickness : 5mm

Diameter of holes : 25 mm

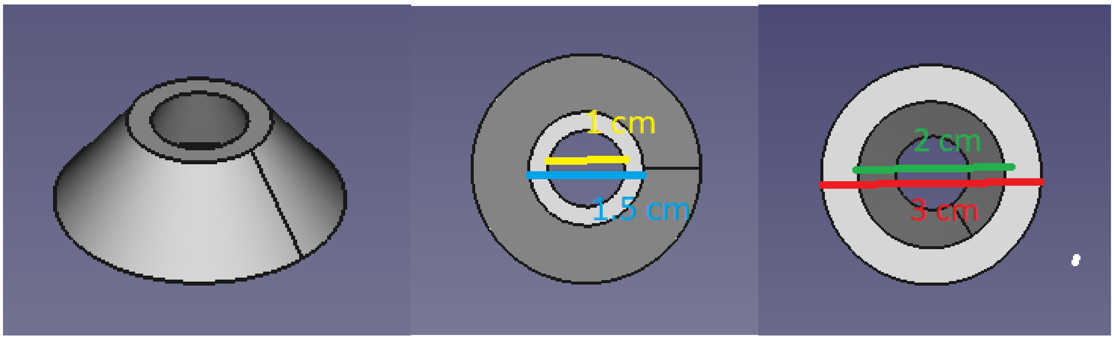


Figure 33

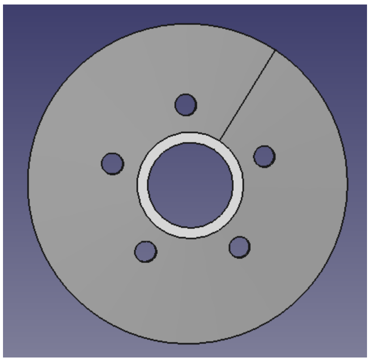
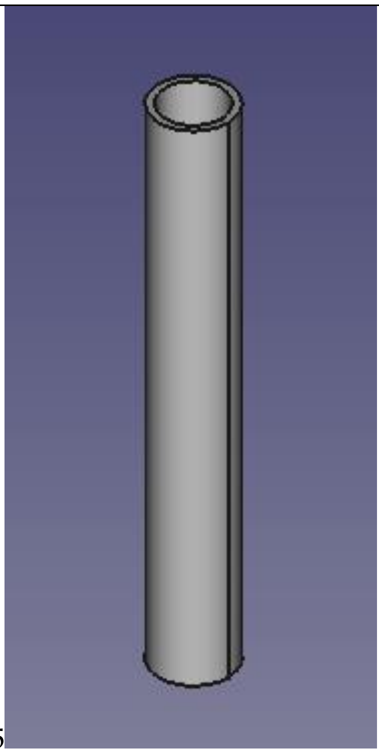


Figure 34

Height of cone:1cm

Diametre of holes : 2 mm

 Figure 35	Height: 7 cm Int diameter: 8 mm Ext diameter: 10 mm

14.1.2 Manufactoring

Table 4

Table 5

Table 6

Table 8

Table 7

14.2 Holder of fuel burner

14.2.1 Free Cad Design

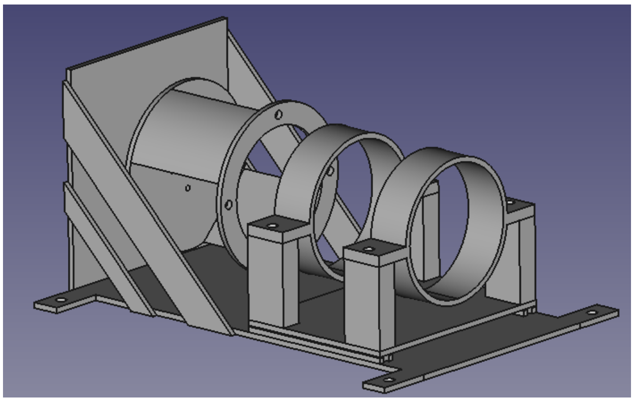


Figure 36: FreeCad holder of fuel burner Figure

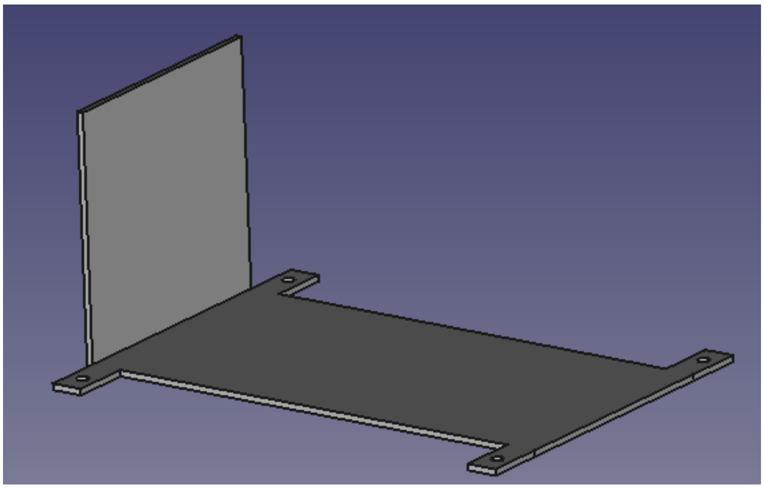


Figure 37

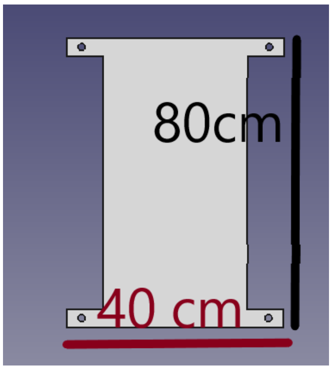


Figure 38

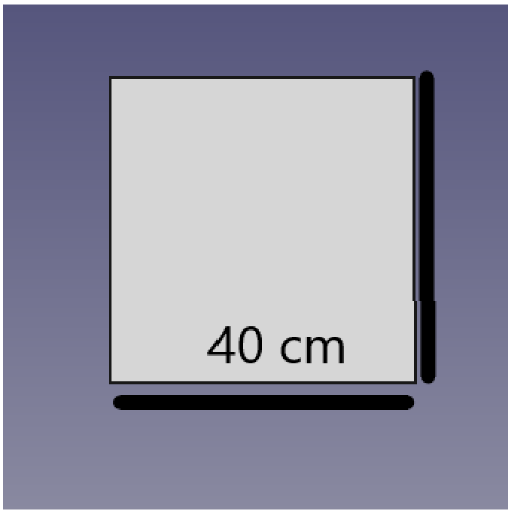


Figure 39

Thickness: 10 mm

Diameter of holes: 20 mm

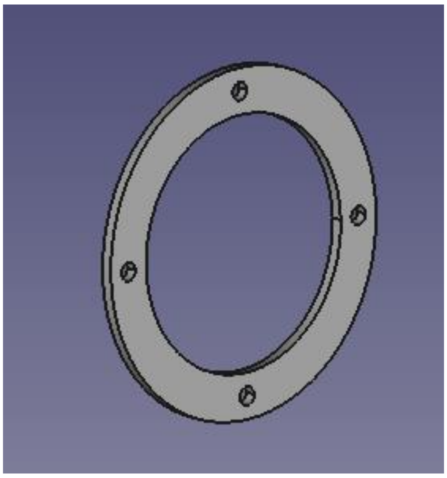


Figure 40

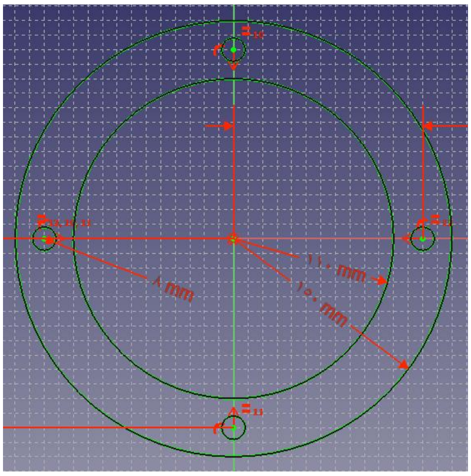


Figure 41

Int diameter: 22 cm

Ext diameter: 30 cm

Diameter of holes: 16 mm

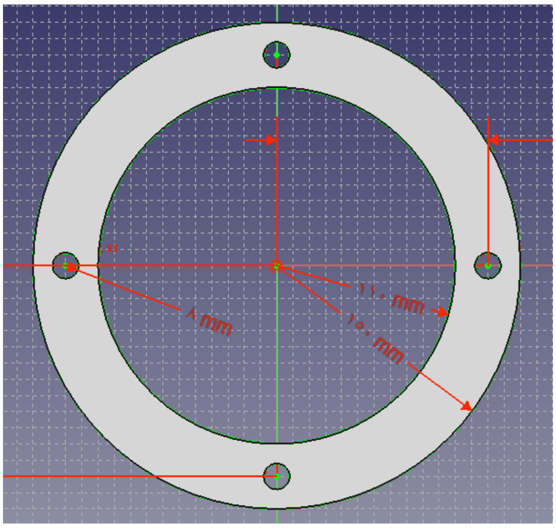


Figure 42

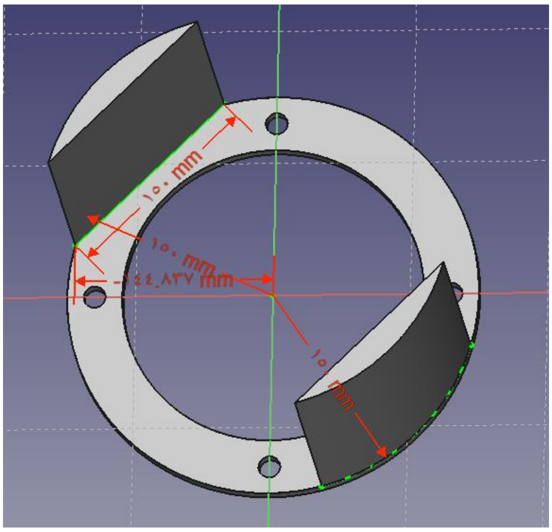


Figure 43

Thibkness : 10 mm

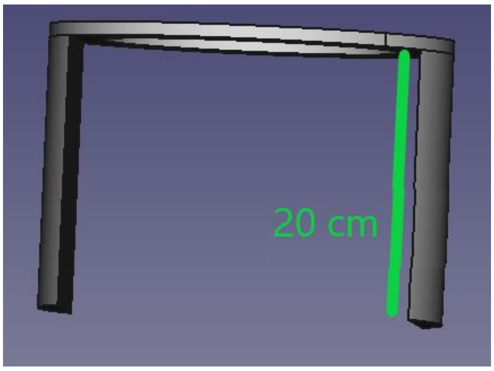
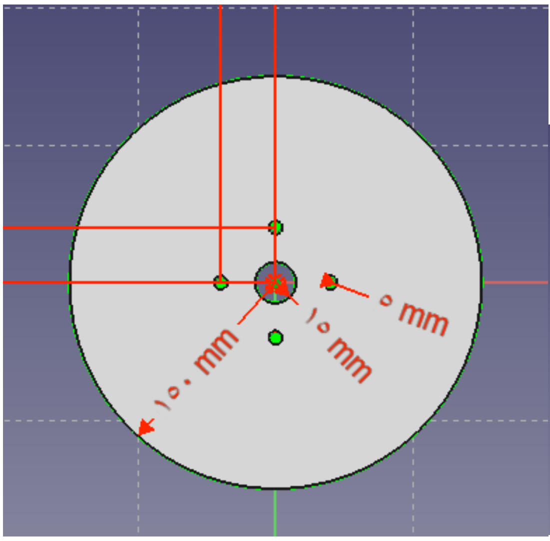


Figure 44



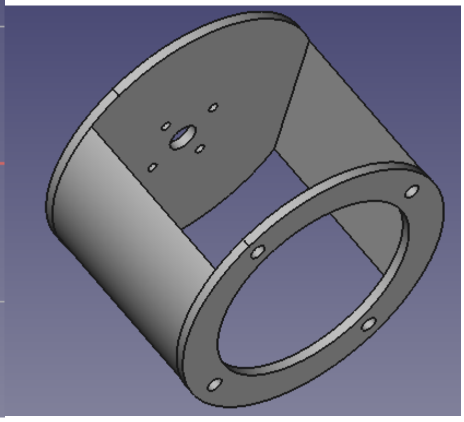
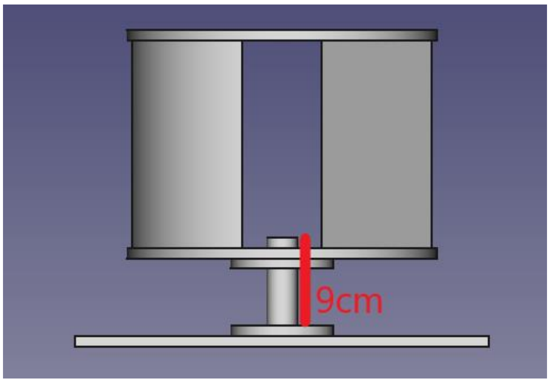


Figure 45

Figure 46



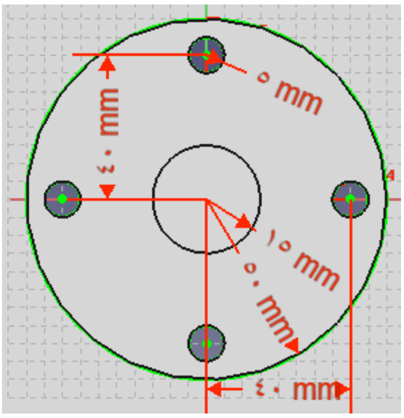
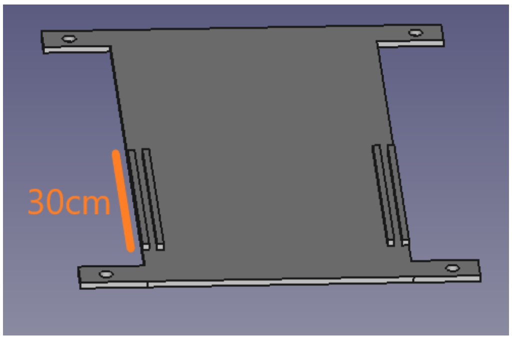


Figure 47

Figure 48



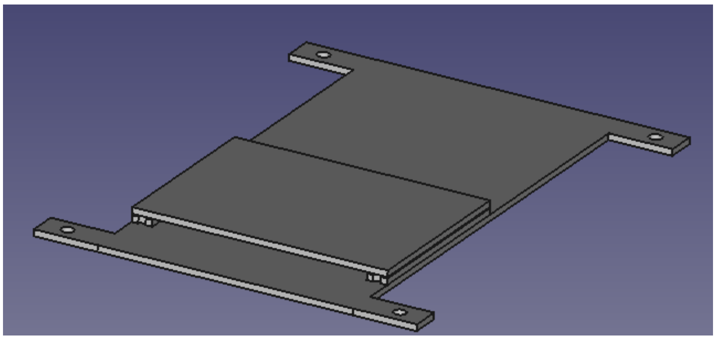


Figure 49

Figure 50

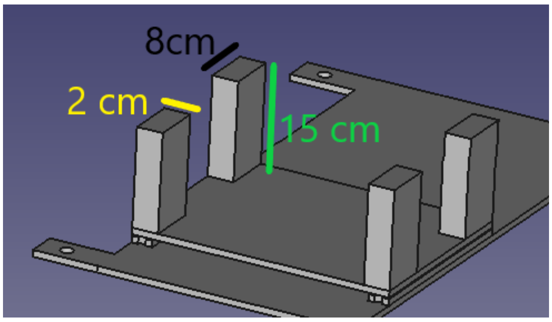


Figure 51

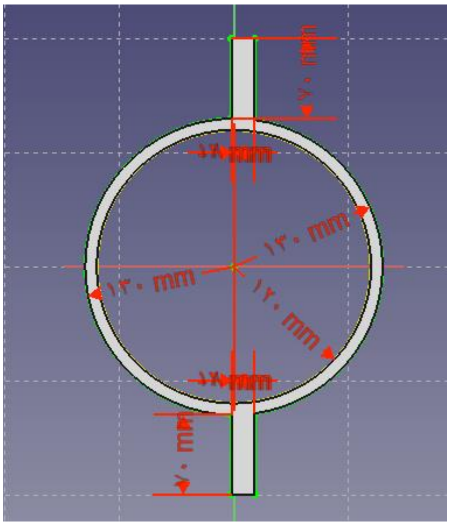


Figure 52

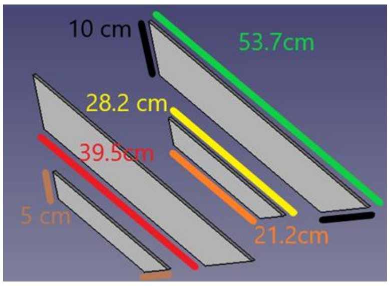


Figure 53

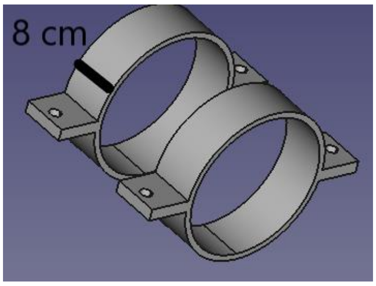


Figure 54

14.2.2 Manufactoring



Table 10



Table 10

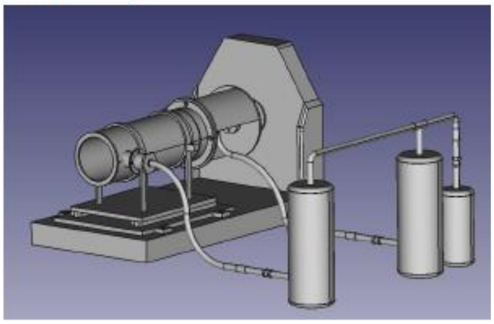
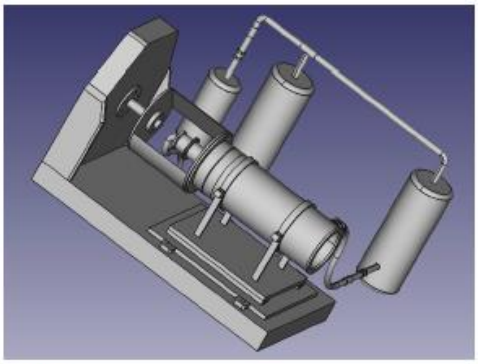
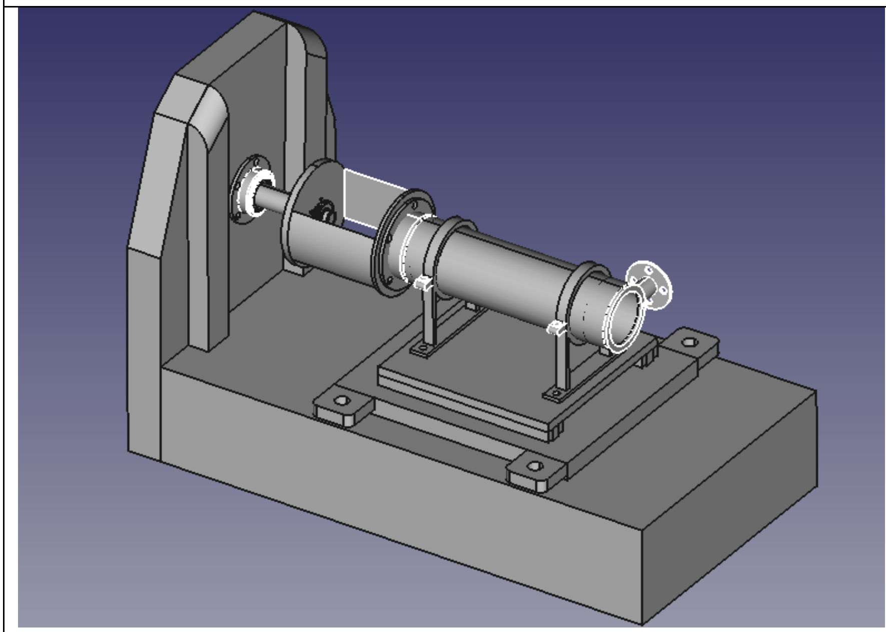
Table 11

Table 12

14.3 Integration

Table 13

14.4 Test Fuel with Propan Gas and Air / Propan Gas and Oxzgene

Holder & fuel burner   holder+fuleburner_05 1118.FCStd	holder+fuleburner_05 1118.FCStd
	fuel_burner_04_08_18.FCStd
Fuel burner test rig	

<table>
<tr><td>With air:</td><td>With oxygene</td></tr>
<tr><td></td><td>
For ignition a sparc from a 10 kV tranformator was used</td></tr>
</table>

14.5 Summary Fuel Burner

The Fuel Burner:

I. Introduction:

A burner is the mechanical element that ensures the production of heat by mixing a fuel (gaseous, liquid or solid) with an oxidant (usually air, naturally containing oxygen), thus producing a combustion . The mixture requires the best adjustment so that the combustion efficiency is maximum and the combustion is the best possible, that is to say, generating the least possible unburnts and pollutants.

The fuel supplying a burner may be gaseous, liquid or solid, alone or as a mixture, for example:
hydrogen
methane (natural gas);
butane;
propane ;
oil;
oil (fossil, plant, animal);
pulverized coal;
wood pellets and crushed biomass waste;
waste (in cement burners for example).

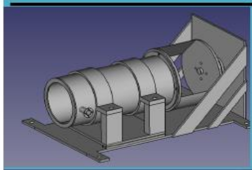
Natural gas burner equipping an industrial cooking oven

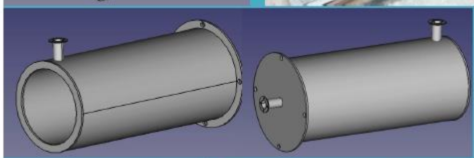
Combustion fan with frequency variator for gas / oil burners

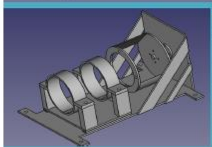
Properties of the inlet of fuel	
number	9
diameter(cm)	1
length (cm)	7
volume of 1 tube (cm2)	5.495
volume of 9 tubes	49.455
Properties of the inlet of air	
diameter of pores(cm)	0.2
number of pores around each tube	6
total number	54
surface of pore	0.0314
total volume	1.6956
chamber of air	
length (cm)	5
diameter (cm)	23
volume (cm2)	2076.325
chamber of fuel	
length (cm)	5
diameter	23
volume	2076.325
dimension of the tube related flask to burner	
diameter(cm)	1
surface of section	0.785
length (cm)	400
combustion value of butane (MJ/m^3)	120
flow rate of fuel (g/s)	556
flow rate of oxygen (g/s)	30442
velocity of fuel (m/s)	0.948
velocity of oxygen(m/s)	17.12

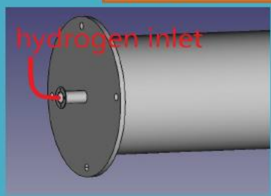
II. burner functionality :

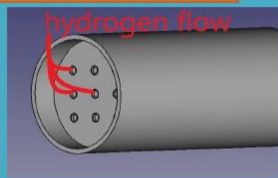
This burner is powered by oxygen and hydrogen

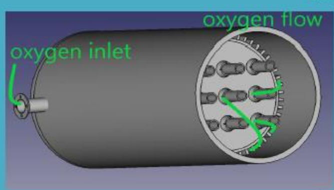




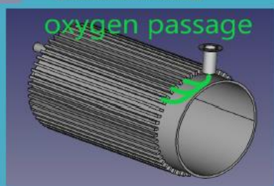








the flow of oxygen on the wall leads to its cooling



15 Fuel / Oxidizer Mixing Test Rig[18]

15.1 Some basics concerning working with Raspberry and flow sensor

15.1.1 Step 1 reading book about Raspberry and C++

Reading a book about raspberry pi and how to write code in C ++

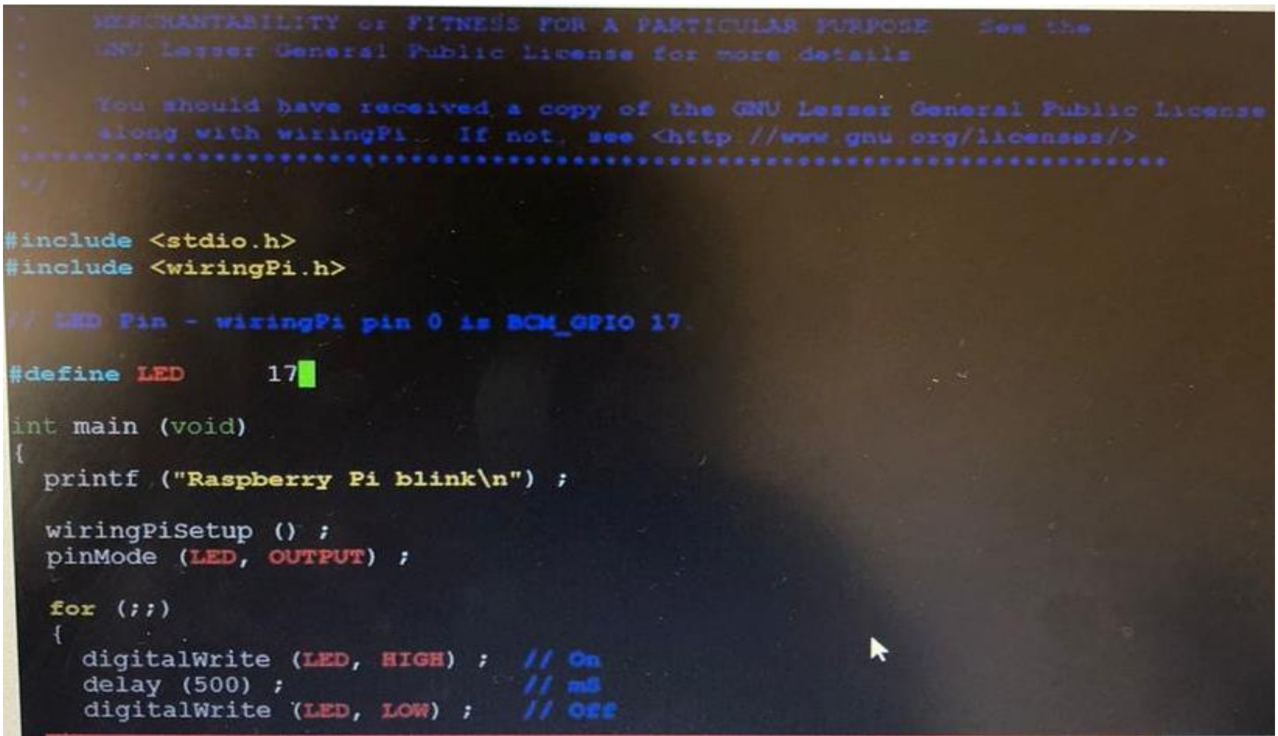
The link of this book:

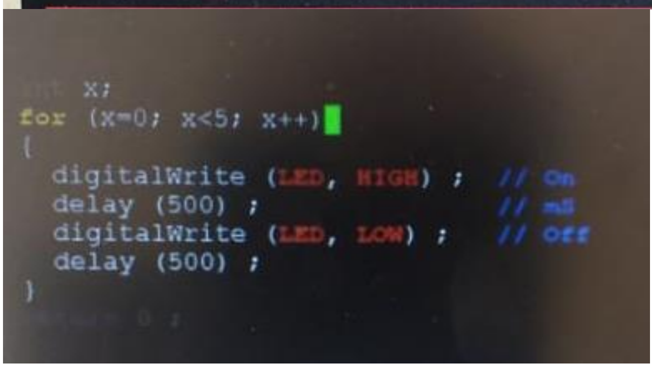
https://bbooks.info/b/w/8873f497932991f0a46529d6b98eea3373f9ad81/exploring-the-raspberry-pi-2-with-c.pdf

15.1.2 Step 2 Watch on YouTube a video related to LED control

The title of this video: writing to GPIO pins in C using wiringPi on the raspberry Pi

15.1.3 Step 3 Writing C++ code on Raspberry pi





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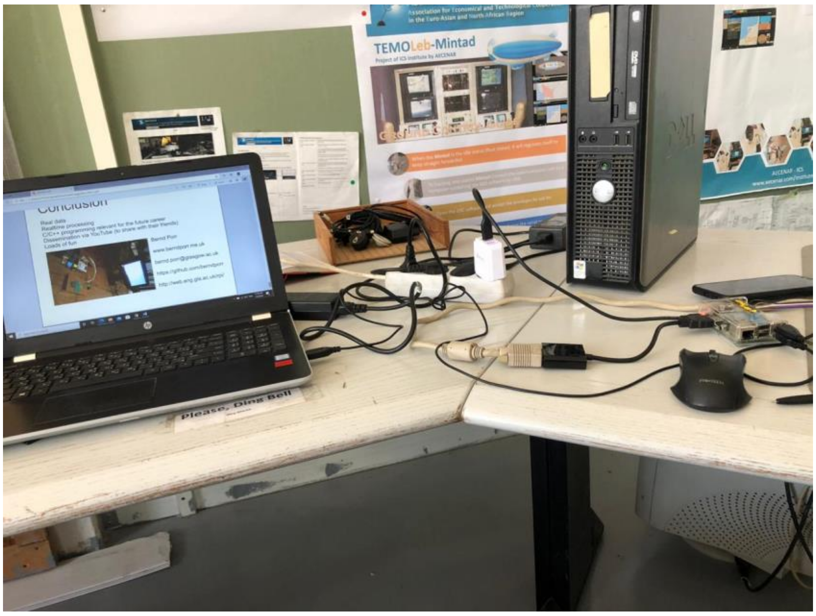
[18] Based on Trainee Report of Ali Ibrahim and Ali Awad, August 2020

15.1.4 Step 4 Hardware integration

We installed a resistor with LED on breadboard and connected it on Raspberry PI

15.1.5 Step 5 Running

Some pictures while working and controlling the LED:



15.1.6 Flowmeter buyed from CNCLab

5.3.1 Flowmeter[16]

Quantity: 2

Price per unit: 15,775 L.L (11% VAT excluded)

Specification:

The lowest rated working voltage: DC4.5 5V-24V

Maximum operating current: 15 mA (DC 5V)

Working voltage range: DC 5~18 v

Load capacity: = 10 mA (DC 5V)

Use temperature: = 80°C

Operating humidity range: 35%~90%RH (no frost)

Allowing pressure: pressure 2.0Mpa

Temperature: -25~+80 °C

External threads: 1/2"

Outer diameter: 20mm

Intake diameter: 9mm

Outlet diameter: 12mm

Application:

Water heaters, credit card machines, water vending machine, flow measurement device!

15.1.7 Raspberry GPIO pins

Pin #	Name	Beschreibung
3	GPIO2	Input/Output. Oder I2C-Kabel SDA (I2C1_SDA).
5	GPIO3	Input/Output. Oder I2C-Kabel SCL (I2C1_SCL).
7	GPIO4	Input/Output. Oder liefert Ausgang für Grundtakt (GPCLK0) an externe Schaltkreise.
8	GPIO14	Input/Output. Oder UART Sendepin (UART_TXD).
10	GPIO15	Input/Output. Oder UART (UART_RXD).
11	GPIO17	Input/Output.
12	GPIO18	Input/Output.
13	GPIO27	Input/Output.
15	GPIO22	Input/Output.
16	GPIO23	Input/Output.
18	GPIO24	Input/Output.

175

19	GPIO10	Input/Output. Oder SPI Masterkabel Eingang (SPI_MOSI).
21	GPIO09	Input/Output. Oder SPI Masterkabel Ausgang (SPI_MISO).
22	GPIO25	Input/Output.
23	GPIO11	Input/Output. Oder SPI Clock Kabel (SPI_SCLK).
24	GPIO8	Input/Output. Oder SPI Device Select 0 (SPI_CE0).
26	GPIO7	Input/Output. Oder SPI Device Select 1 (SPI_CE0).
27	ID_SC	Reserviert.
28	ID_SC	Reserviert.
29	GPIO5	Input/Output.
31	GPIO6	Input/Output.
32	GPIO12	Input/Output.
33	GPIO13	Input/Output.
35	GPIO19	Input/Output.
36	GPIO16	Input/Output.
37	GPIO26	Input/Output.
38	GPIO20	Input/Output.
40	GPIO21	Input/Output

Sie akzeptieren keine 5V und

15.2 Some basics connerning Python programming with Raspberry

15.2.1 Step 1: write code in new script to control led

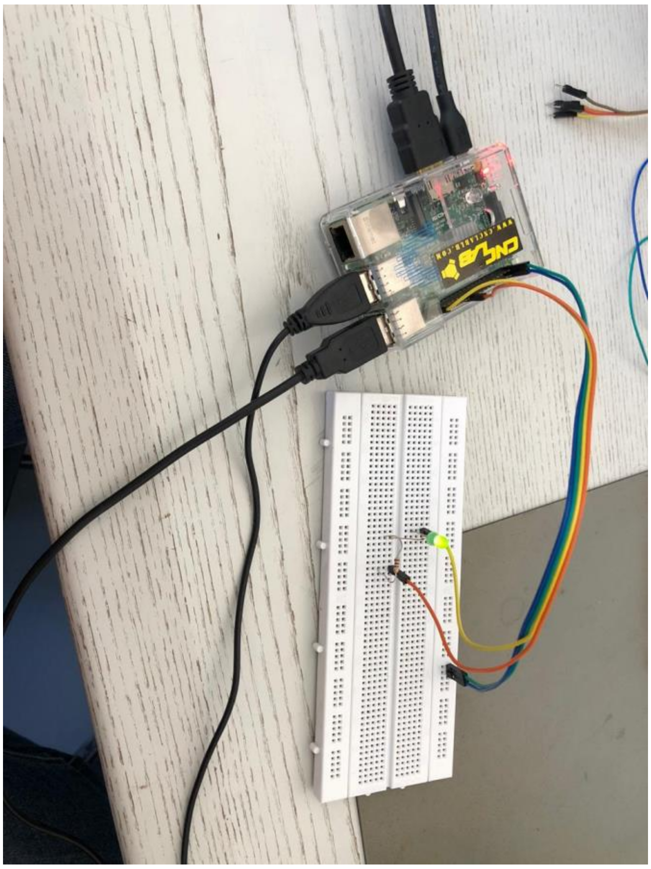
Python قمنا باختبار LED لأنه الكود الاسهل ولقد تم نجاح هذا الاختبار والكود موجود بالأسفل

كوننا جدد على code

Attention: using this raspberry pi you must focus to GPIO.setmode(GPIO.BCM) NOT .BOARD

```
import RPi.GPIO as GPIO
import time
from time import sleep

GPIO.setwarnings(False)
GPIO.setmode(GPIO.BCM)
GPIO.setup(8, GPIO.OUT,initial=GPIO.LOW)

GPIO.output(8, GPIO.HIGH)
sleep(1)
GPIO.output(8, GPIO.LOW)
sleep(1)

GPIO.output(8, GPIO.HIGH)
sleep(1)
GPIO.output(8, GPIO.LOW)
sleep(1)

```

15.2.2 Step 2: Hardware



15.2.3 Testing code for flow meter

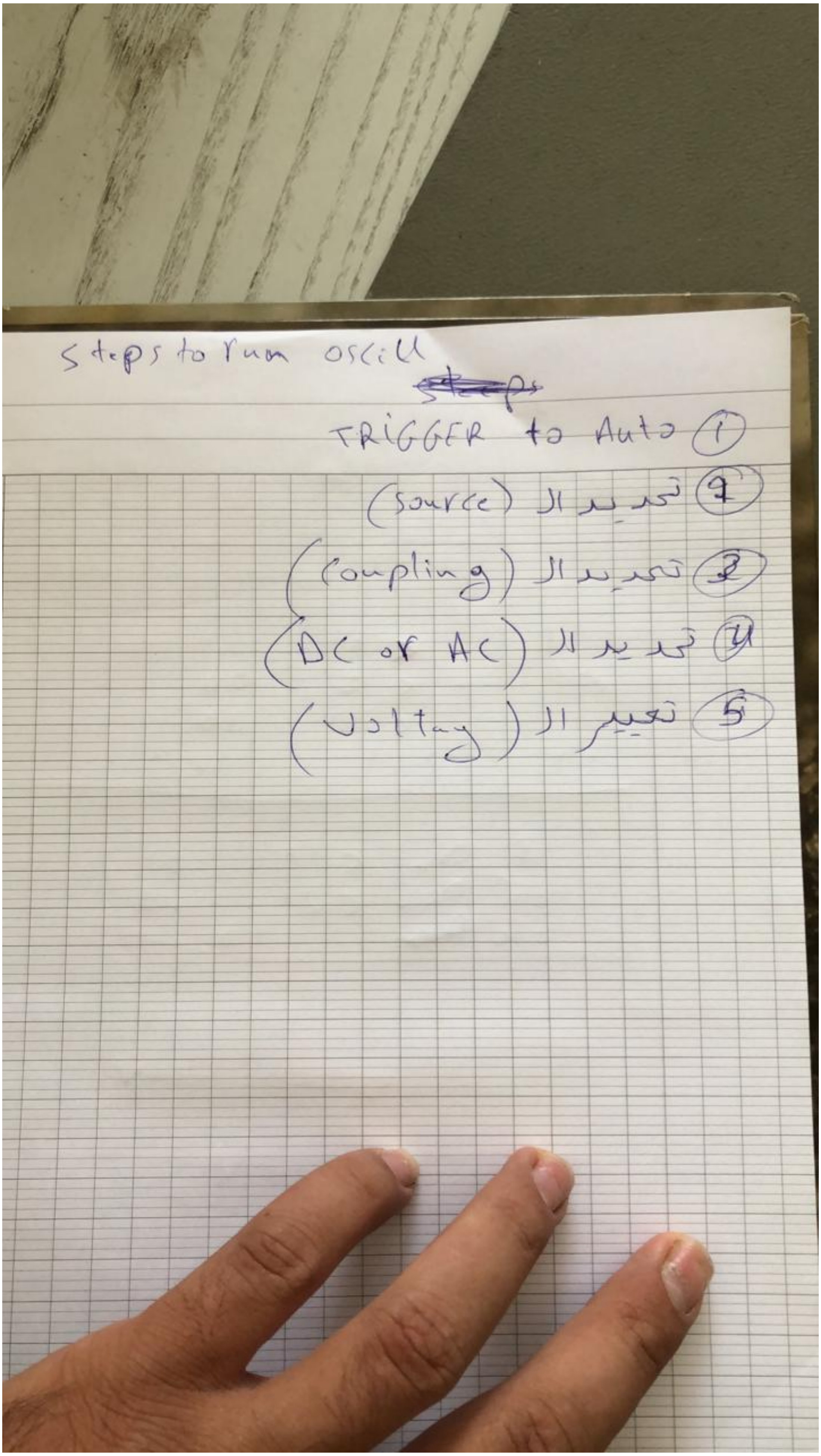
اليوم كتبنا كود لنقوم بتشغيل The flow sensor

```
#!/usr/bin/env python
#flowsensor.py
import RPi.GPIO as GPIO
import time, sys

FLOW_SENSOR = 23

GPIO.setmode(GPIO.BCM)
GPIO.setup(FLOW_SENSOR, GPIO.IN, pull_up_down = GPIO.PUD_UP)

#global count

#count = 0



def countpulse(channel,start_counter):
       print ("Bismillah")
       print (channel)
#        global count
       start_counter = 1
       count = 0
       if start_counter == 1:
        count += 1
#print count
#flow = count / (60 * 7.5)
```

```
#print(flow)
        channel= GPIO.add_event_detect(FLOW_SENSOR, GPIO.FALLING,
callback=countpulse)

        while True:
         try:
           start=count - 1
           time.sleep(1)
           start=count - 1
           flow = (count * 60 * 2.25 / 1000)
           print ("The flow is:" , flow)
           #%.3f Liter/min' % (flow)
           count = 0
           time.sleep(5)

         except KeyboardInterrupt:
           print ('\ncaught keyboard interrupt!, bye')
           print ("No flow")
           GPIO.cleanup()
           sys.exit()

countpulse (1,2)
New test of flow meter sensor
import RPi.GPIO as GPIO
import time, sys
pulse_pin = 25
GPIO.setmode(GPIO.BCM)
GPIO.setup(pulse_pin, GPIO.IN,pull_up_down = GPIO.PUD_UP)

def countPulse1(channel1):
    count+=1
    print("Number of revolution of wheel of flow sensor:")
    print(count)

GPIO.add_event_detect(pulse_pin, GPIO.RISING, callback=countPulse1)



try:
     while True:
         print("Inside while starting")
         time.sleep(10)
         print("Inside while ending")
         time.sleep(10)
except keyboardInterrupt:
    print ('\ncaught keyboard interrupt!, bye')
    GPIO.cleanup()
    sys.exit()
```

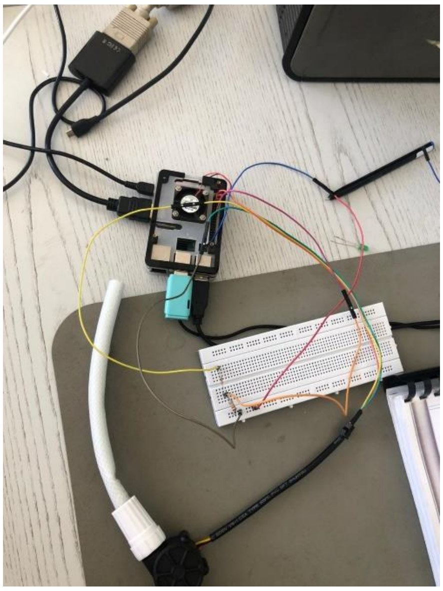
- Today, we're going to modify the code to suit our work with a flow meter sensor
- We will also connect the sensor to the raspberry pi and we will try to reach a result
- We'll also connect the valve to the raspberry pi and we'll control it
- We will write all the writing work on the word

15.3 Working with oscilloscope


steps to run oscill
TRIGGER to Auto 1
(source) تحديد ال 2
(coupling) تحديد ال 3
(DC or AC) تحديد ال 4
(Voltay) تغيير ال 5

15.4 Python program for flow sensor

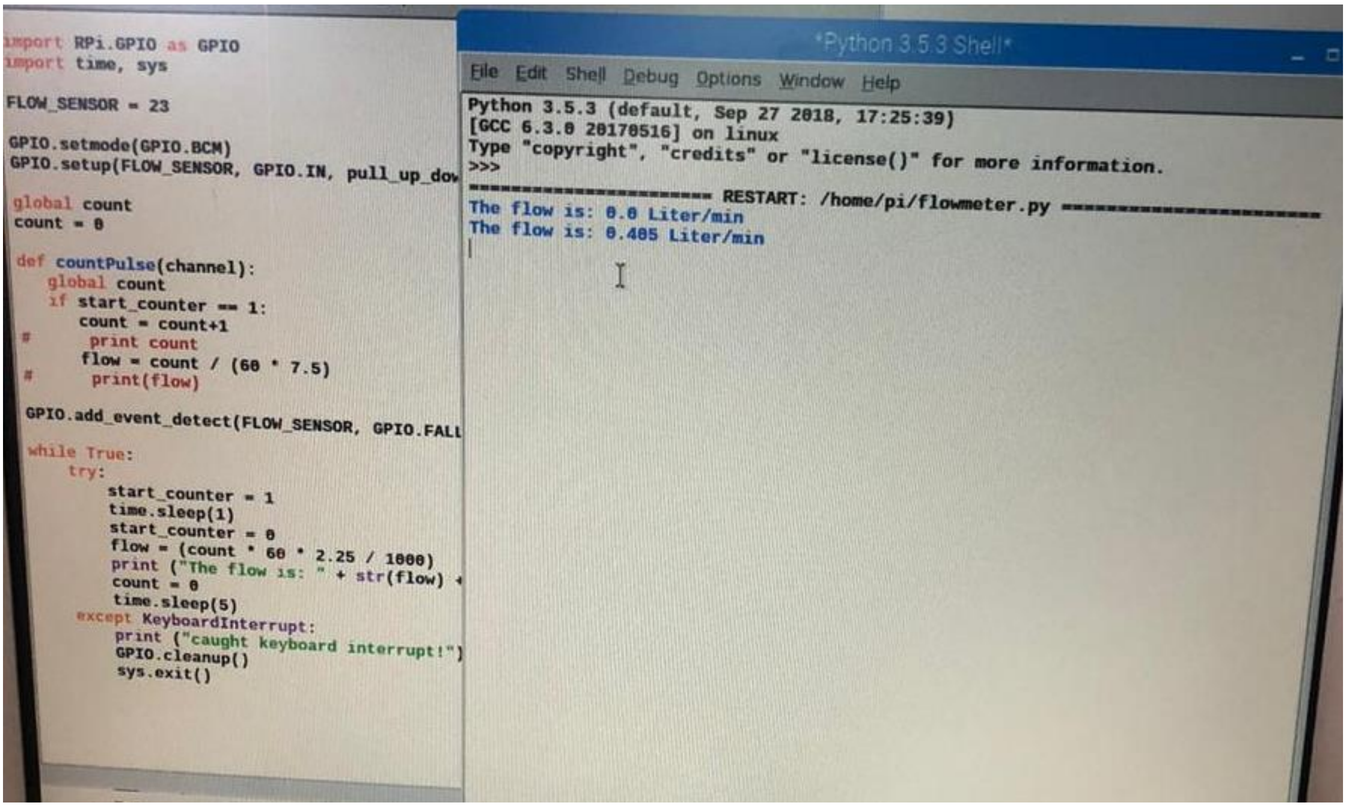
15.4.1 Hardware for flowmeter sensor:



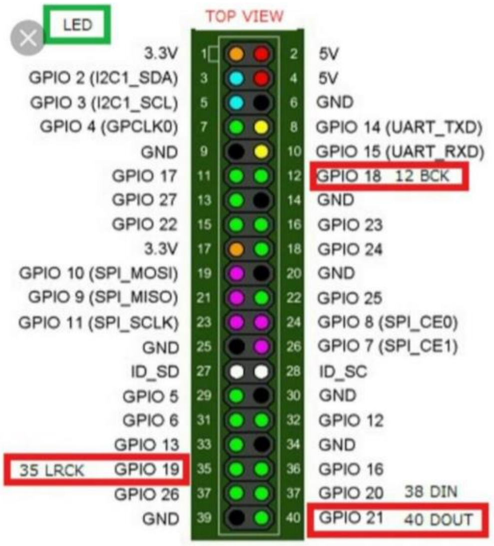
15.4.2 The code of flow meter sensor:

```
import RPi.GPIO as GPIO
import time, sys

FLOW_SENSOR = 23

GPIO.setmode(GPIO.BCM)
GPIO.setup(FLOW_SENSOR, GPIO.IN, pull_up_down = GPIO.PUD_UP)

global count
count = 0

def countPulse(channel):
   global count
   if start_counter == 1:
      count = count+1
#      print count
#      flow = count / (60 * 7.5)
#      print(flow)

GPIO.add_event_detect(FLOW_SENSOR, GPIO.FALLING, callback=countPulse)

while True:
    try:
        start_counter = 1
        time.sleep(1)
        start_counter = 0
        flow = (count * 60 * 2.25 / 1000)
        print "The flow is: %.3f Liter/min" % (flow)
        count = 0
        time.sleep(5)
    except KeyboardInterrupt:
        print '\ncaught keyboard interrupt!, bye'
        GPIO.cleanup()
        sys.exit()
```

15.4.3 Running test result



15.4.4 Pins of raspberry pi 3



15.5 Python code for servo motor (automatic valve, variant 1)

15.5.1 The code for servor motor

```
# Import libraries
import RPi.GPIO as GPIO
import time

# Set GPIO numbering mode
GPIO.setmode(GPIO.BOARD)

# Set pin 11 as an output, and set servo1 as pin 11 as PWM
```

```
GPIO.setup(11,GPIO.OUT)
servo1 = GPIO.PWM(11,50) # Note 11 is pin, 50 = 50Hz pulse

#start PWM running, but with value of 0 (pulse off)
servo1.start(0)
print ("Waiting for 2 seconds")
time.sleep(2)

#Let's move the servo!
print ("Rotating 180 degrees in 10 steps")

# Define variable duty
duty = 2

# Loop for duty values from 2 to 12 (0 to 180 degrees)
while duty <= 12:
    servo1.ChangeDutyCycle(duty)
    time.sleep(1)
    duty = duty + 1

# Wait a couple of seconds
time.sleep(2)

# Turn back to 90 degrees
print ("Turning back to 90 degrees for 2 seconds")
servo1.ChangeDutyCycle(7)
time.sleep(2)

#turn back to 0 degrees
print ("Turning back to 0 degrees")
servo1.ChangeDutyCycle(2)
time.sleep(0.5)
servo1.ChangeDutyCycle(0)

#Clean things up at the end
servo1.stop()
GPIO.cleanup()
print ("Goodbye")
```

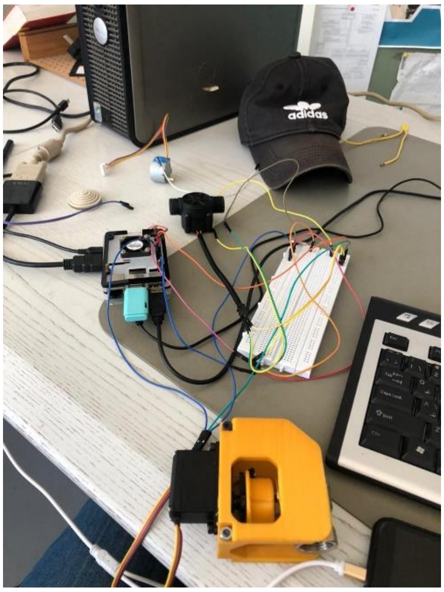
15.5.2 Hardware

15.6 The code for the servo motor and flow sensor:

```
# Import libraries
import RPi.GPIO as GPIO
import time, sys

FLOW_SENSOR = 23
SERVO = 11

# Set GPIO numbering mode
GPIO.setmode(GPIO.BCM)

# Set pin 23 as input for the flow sensor
# Set pin 11 as an output, and set servo1 as pin 11 as PWM
GPIO.setup(FLOW_SENSOR, GPIO.IN, pull_up_down = GPIO.PUD_UP)
GPIO.setup(SERVO, GPIO.OUT)

global count
count = 0
start_counter = 0

def countPulse(channel):
   global count
   if start_counter == 1:
      count = count+1
#      print count
      flow = count / (60 * 7.5)
#      print(flow)
```

```
servo1 = GPIO.PWM(11,50) # Note 11 is pin, 50 = 50Hz pulse

GPIO.add_event_detect(FLOW_SENSOR, GPIO.FALLING, callback=countPulse)

#start PWM running, but with value of 0 (pulse off)
servo1.start(0)
print ("Waiting for 2 seconds")
time.sleep(2)

#Let's move the servo!
print ("Rotating 180 degrees in 10 steps")

# Define variable duty
duty = 2

# Loop for duty values from 2 to 12 (0 to 180 degrees)
while duty <= 12:
    servo1.ChangeDutyCycle(duty)
    time.sleep(1)
    duty = duty + 1

# Wait a couple of seconds
time.sleep(2)

# Turn back to 90 degrees
print ("Turning back to 90 degrees for 2 seconds")
servo1.ChangeDutyCycle(7)
time.sleep(2)

#turn back to 0 degrees
print ("Turning back to 0 degrees")
servo1.ChangeDutyCycle(2)
time.sleep(0.5)
servo1.ChangeDutyCycle(0)
time.sleep(2)

while True:
    try:
        start_counter = 1
        time.sleep(1)
        start_counter = 0
        flow = (count * 60 * 2.25 / 1000)
        print ("The flow is: " + str(flow) + " Liter/min" )
        count = 0
        time.sleep(2)
    except KeyboardInterrupt:
        servo1.stop()
        print ("caught keyboard interrupt!")
        GPIO.cleanup()
        print ("Goodbye")
        sys.exit()
```

15.6.1 Hardware of servo motor and flow sensor:

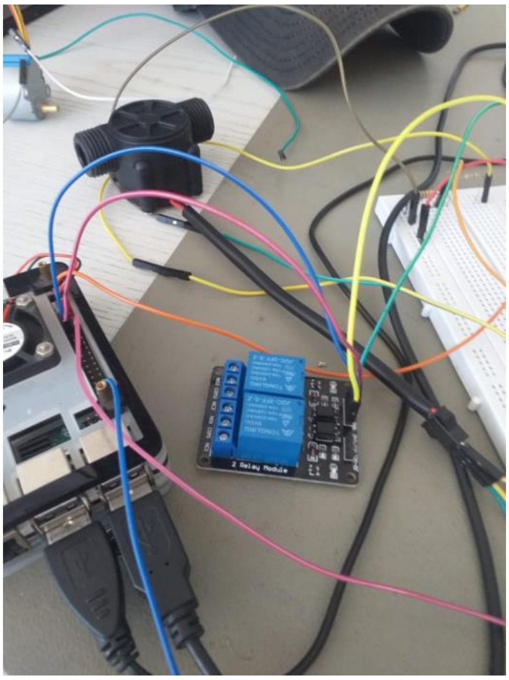


15.6.2 DC motor for automatic valve (on-off of a relay) (automatic valve, variant 2)

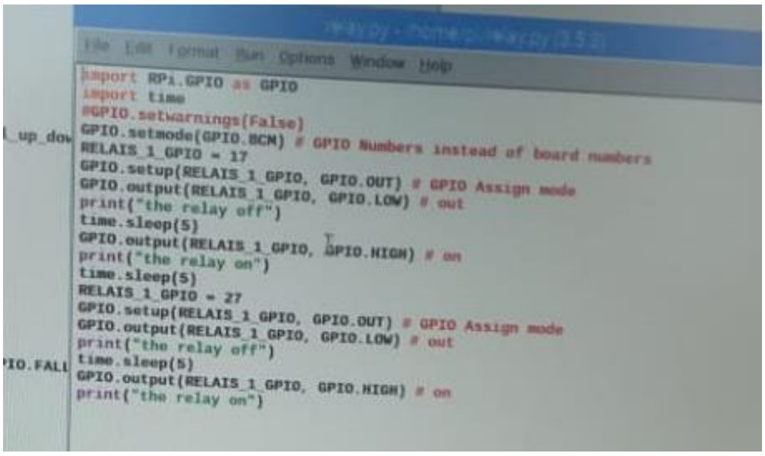
15.6.3 References of control DC motor:

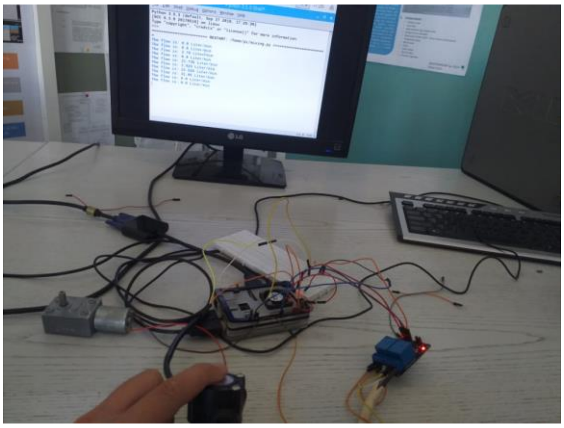
https://www.aranacorp.com/en/control-a-dc-motor-with-raspberry-pi/

15.6.4 Hardware

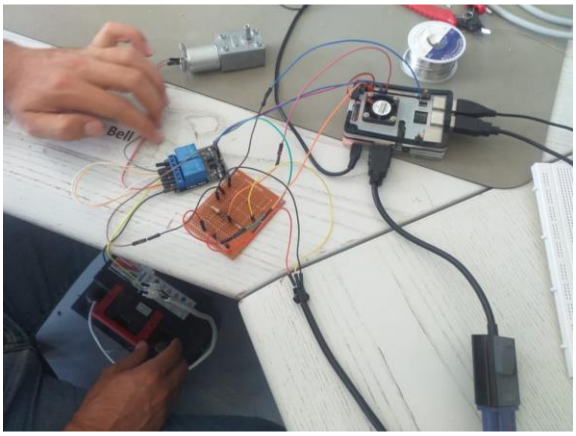
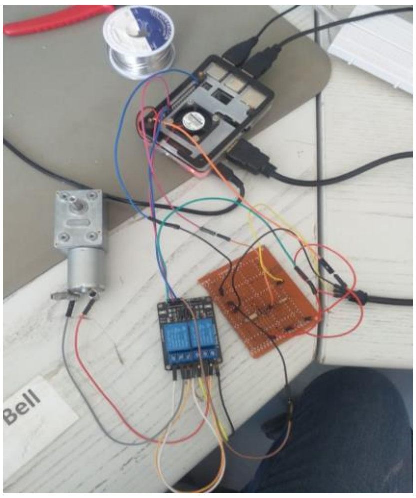


15.6.5 The code

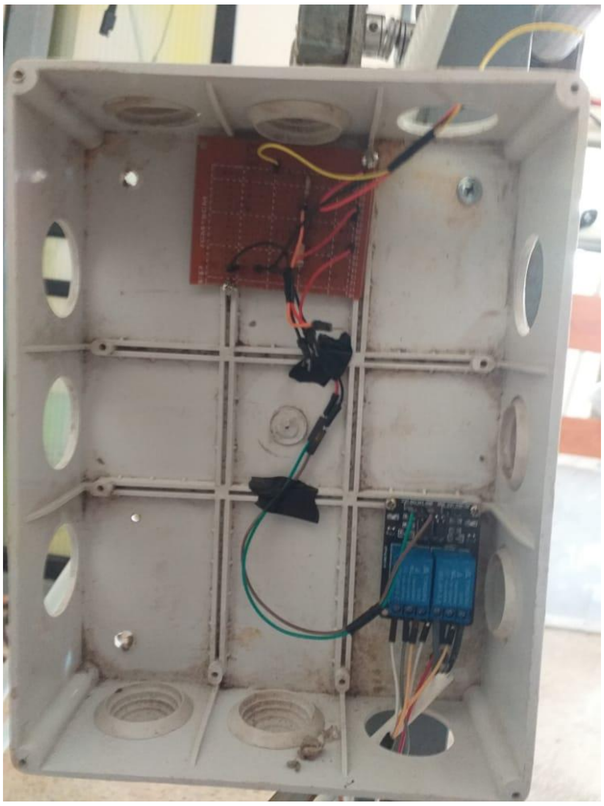




15.6.6 Testing

15.7 System integration Mixing Control (Mechanical, Hardware & Software)

15.7.1 Code

```
import RPi.GPIO as GPIO
import time, sys
RELAY_2_GPIO = 27
FLOW_SENSOR = 23
RELAY_1_GPIO = 17
GPIO.setmode(GPIO.BCM)
GPIO.setup(FLOW_SENSOR, GPIO.IN, pull_up_down = GPIO.PUD_UP)
GPIO.setup(RELAY_1_GPIO, GPIO.OUT) # GPIO Assign mode
GPIO.setup(RELAY_2_GPIO, GPIO.OUT)
GPIO.output(RELAY_1_GPIO, GPIO.LOW)
GPIO.output(RELAY_2_GPIO, GPIO.LOW)

global count
count = 0

def countPulse(channel):
   global count
   if start_counter == 1:
      count = count+1
#       print count
      flow = count / (60 * 7.5)
#       print(flow)

GPIO.add_event_detect(FLOW_SENSOR, GPIO.FALLING, callback=countPulse)

while True:
    try:
        start_counter = 1
        time.sleep(1)
```

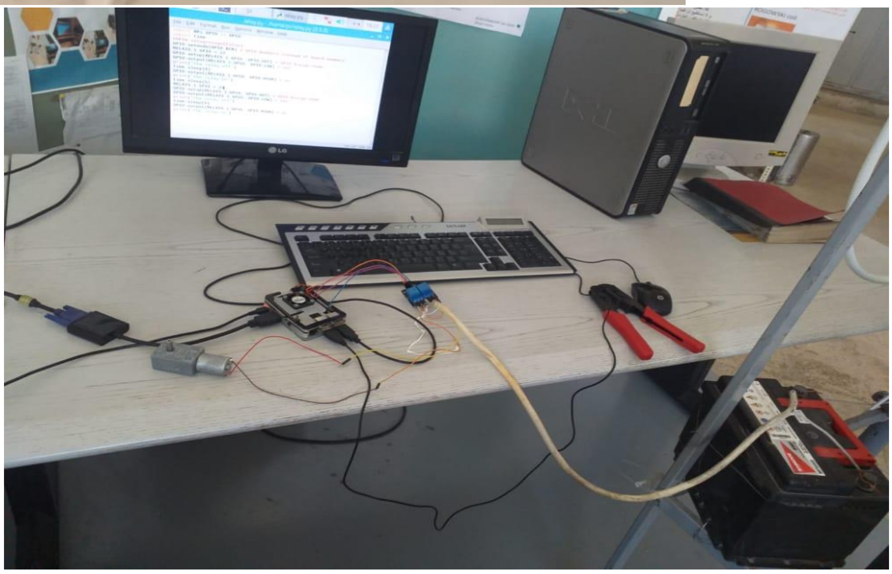
```
        start_counter = 0
        flow = (count * 60 * 2.25 / 1000)
        print ("The flow is: " + str(flow) + " Liter/min" )
        if flow == 0: # 0.0
            GPIO.output(RELAY_1_GPIO, GPIO.LOW)
            GPIO.output(RELAY_2_GPIO, GPIO.LOW)
        elif flow < 15:  # 1.9
            GPIO.output(RELAY_1_GPIO, GPIO.LOW)
            GPIO.output(RELAY_2_GPIO, GPIO.HIGH)
        elif flow < 20: # 2.1
            GPIO.output(RELAY_1_GPIO, GPIO.LOW)
            GPIO.output(RELAY_2_GPIO, GPIO.LOW)
        else:
            GPIO.output(RELAY_1_GPIO, GPIO.HIGH)
            GPIO.output(RELAY_2_GPIO, GPIO.LOW)
        count = 0
        time.sleep(5)
    except KeyboardInterrupt:
        print ("caught keyboard interrupt!")
        GPIO.cleanup()
        sys.exit()
```

15.8 Mixing control

نحن نريد التحكم بنوعين من السوائل لذلك هذه الخطوة ستكون مشابهة للخطوة الأولى فهي عبارة عن تحكم بكمية السائل الذي نحتاجه

سنحتاج بهذا العمل الى

- 2 relays for DC motors (automatic valves, variant 2)
- Raspberry pi
- Battery 12v
- Wires
- Flow sensor

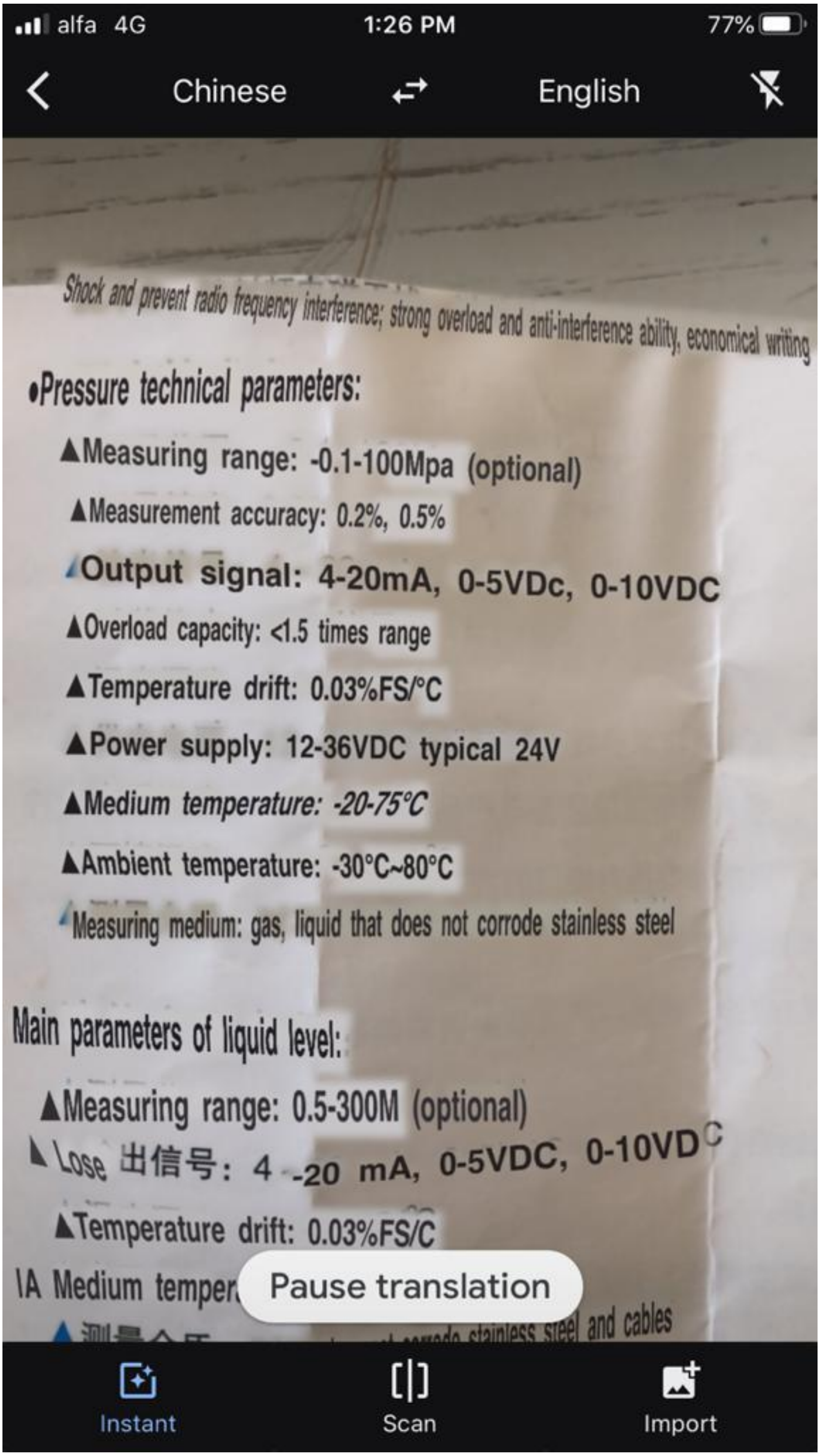
- 

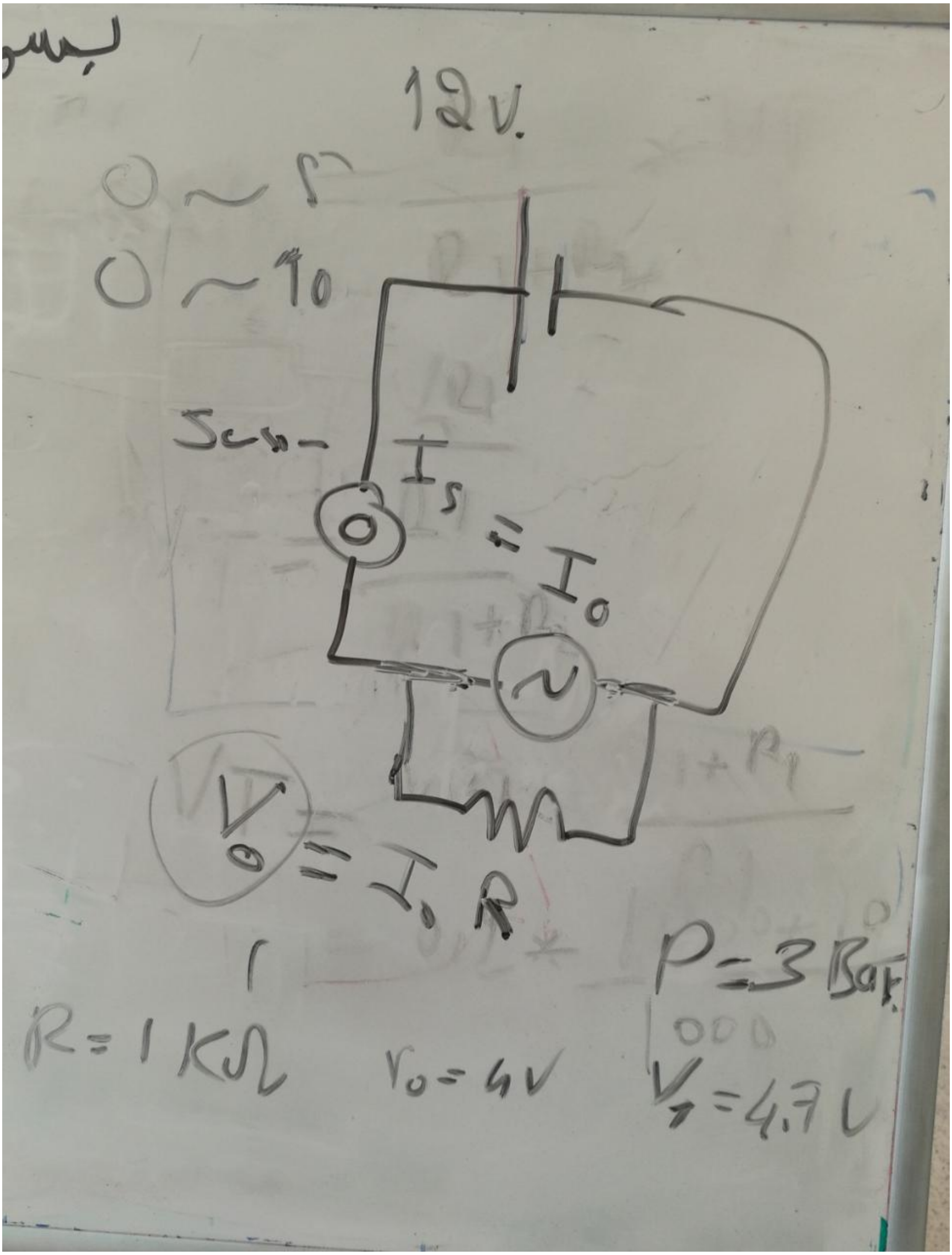
15.8.1 The code

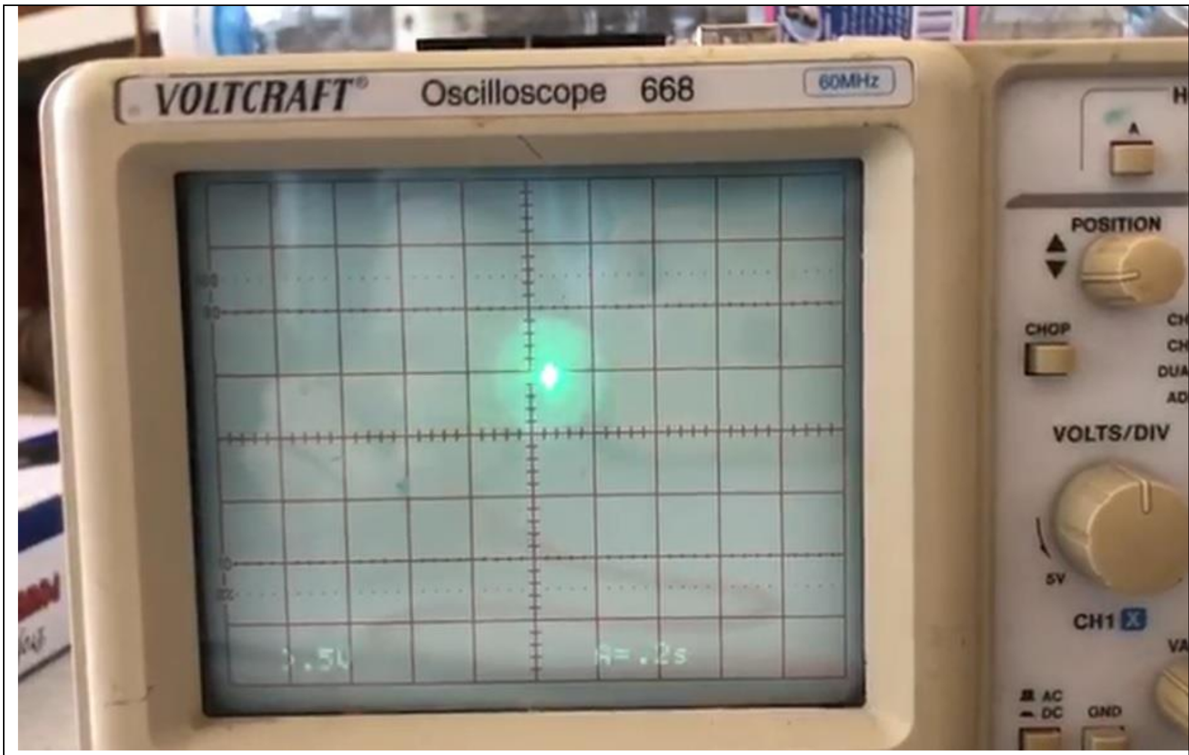
```
import RPi.GPIO as GPIO
import time, sys
RELAY_2_GPIO = 27
FLOW_SENSOR = 23
RELAY_1_GPIO = 17
GPIO.setmode(GPIO.BCM)
GPIO.setup(FLOW_SENSOR, GPIO.IN, pull_up_down = GPIO.PUD_UP)
GPIO.setup(RELAY_1_GPIO, GPIO.OUT) # GPIO Assign mode
```

```
GPIO.setup(RELAY_2_GPIO, GPIO.OUT)
GPIO.output(RELAY_1_GPIO, GPIO.LOW)
GPIO.output(RELAY_2_GPIO, GPIO.LOW)

global count
count = 0

def countPulse(channel):
   global count
   if start_counter == 1:
      count = count+1
#      print count
      flow = count / (60 * 7.5)
#      print(flow)

GPIO.add_event_detect(FLOW_SENSOR, GPIO.FALLING, callback=countPulse)

while True:
    try:
        start_counter = 1
        time.sleep(1)
        start_counter = 0
        flow = (count * 60 * 2.25 / 1000)
        print ("The flow is: " + str(flow) + " Liter/min" )
        if flow == 0: # 0.0
            GPIO.output(RELAY_1_GPIO, GPIO.LOW)
            GPIO.output(RELAY_2_GPIO, GPIO.LOW)
        elif flow < 15:  # 1.9
            GPIO.output(RELAY_1_GPIO, GPIO.LOW)
            GPIO.output(RELAY_2_GPIO, GPIO.HIGH)
        elif flow < 20: # 2.1
            GPIO.output(RELAY_1_GPIO, GPIO.LOW)
            GPIO.output(RELAY_2_GPIO, GPIO.LOW)
        else:
            GPIO.output(RELAY_1_GPIO, GPIO.HIGH)
            GPIO.output(RELAY_2_GPIO, GPIO.LOW)
        count = 0
        time.sleep(5)
    except KeyboardInterrupt:
        print ("caught keyboard interrupt!")
        GPIO.cleanup()
        sys.exit()
```

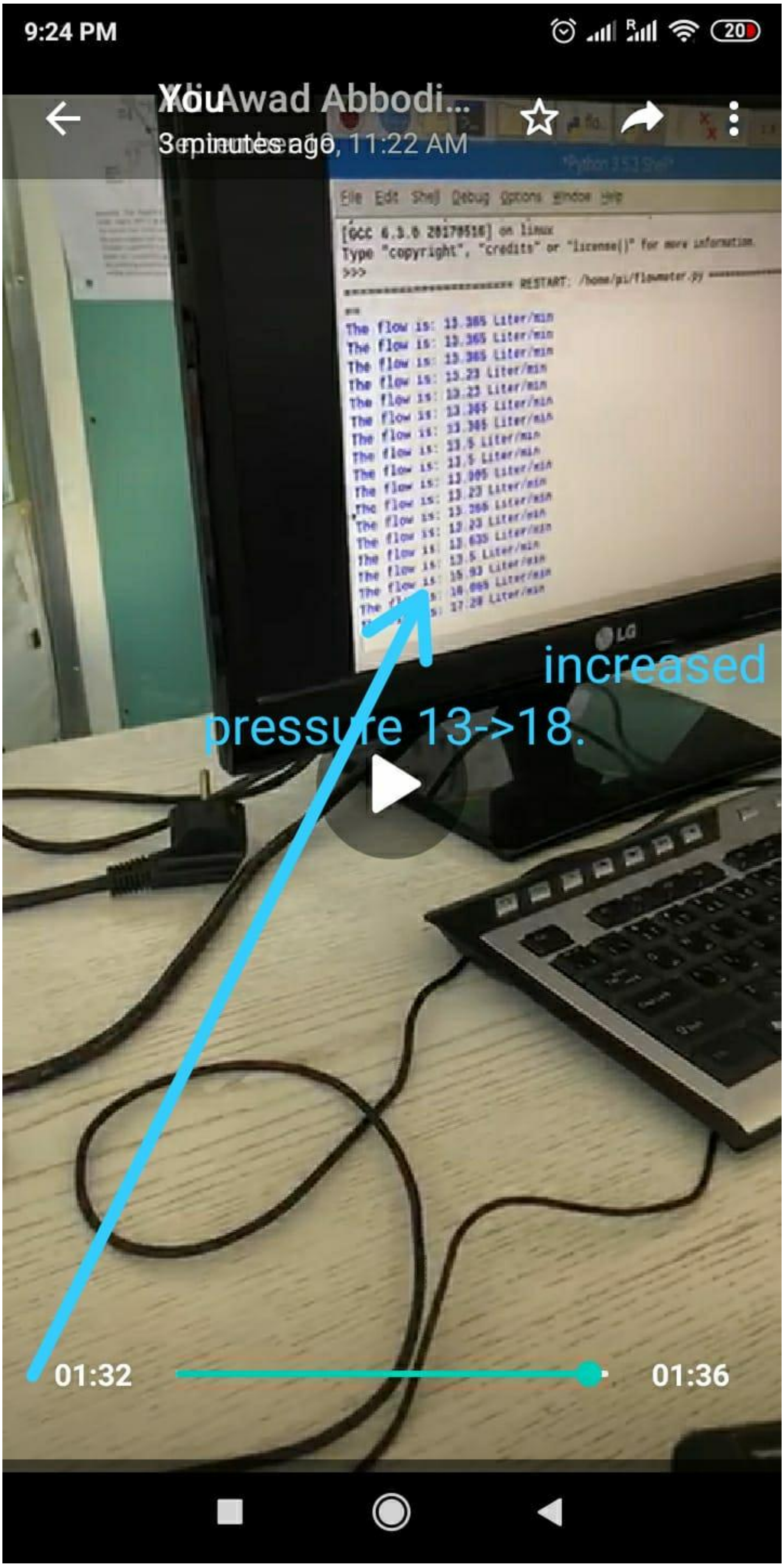
15.1 Pressure Sensor


alfa 4G
1:26 PM
77%
Chinese
English
Shock and prevent radio frequency interference; strong overload and anti-interference ability, economical writing
•Pressure technical parameters:
▲Measuring range: -0.1-100Mpa (optional)
▲Measurement accuracy: 0.2%, 0.5%
Output signal: 4-20mA, 0-5VDc, 0-10VDC
▲Overload capacity: <1.5 times range
▲Temperature drift: 0.03%FS/°C
▲Power supply: 12-36VDC typical 24V
▲Medium temperature: -20-75℃
▲Ambient temperature: -30°C~80°C
Measuring medium: gas, liquid that does not corrode stainless steel
Main parameters of liquid level:
▲Measuring range: 0.5-300M (optional)
Lose 出信号: 4 -20 mA, 0-5VDC, 0-10VDC
▲Temperature drift: 0.03%FS/C
\A Medium temper
Pause translation
stainless steel and cables
Instant
Scan
Import


12V.
Sen-
$I_s = I_0$
$V_0 = I_0 R$
$R = 1 K\Omega$
$V_0 = 4V$
P=3 Bar
$V_1 = 4.7V$

	High pressure
	Low pressure


9:31 PM
You
Today, 12:55 PM
dSPACE
pressure
sensor


9:24 PM
increased
pressure 13->18.
01:32
01:36

15.1.1 Code for pressure sensor

MixingTestrig_src.zip

15.1.1.1 Pressure

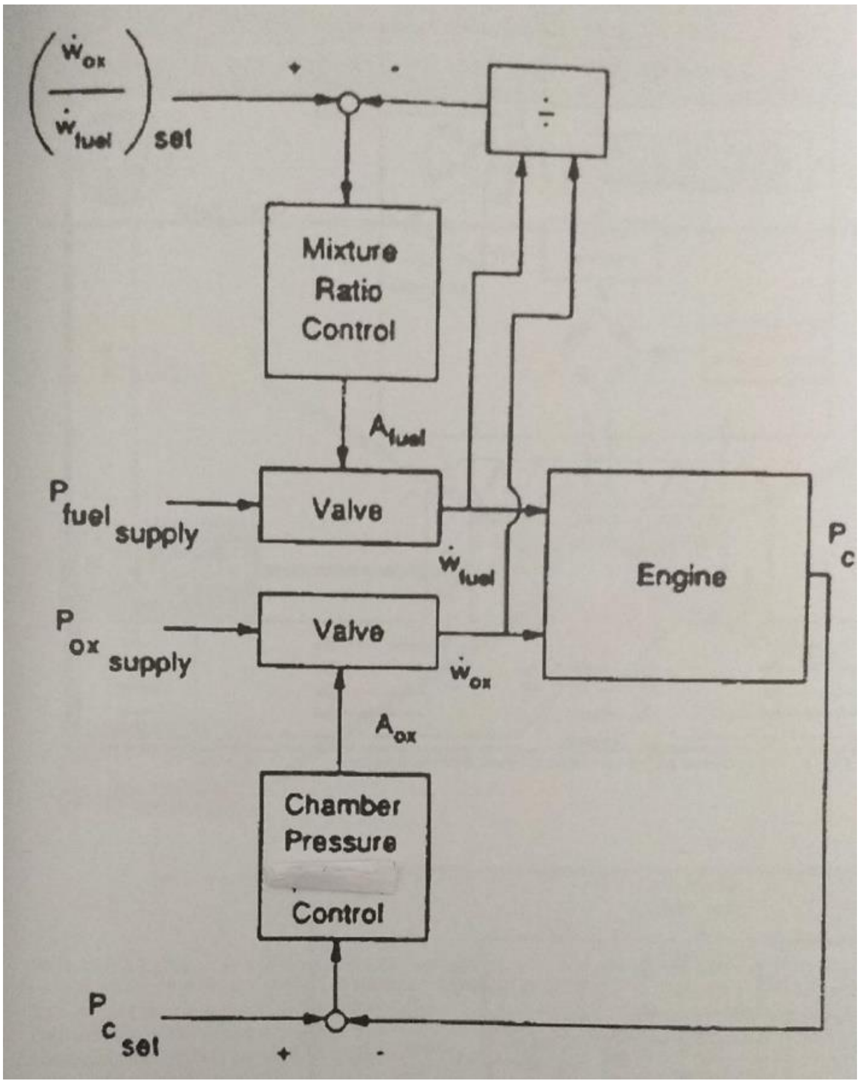
```
import RPi.GPIO as GPIO
import time, sys

FLOW_SENSOR = 26
lps = adafruit_lps35hw.LPS35HW(i2c)
GPIO.setmode(GPIO.BCM)
GPIO.setup(FLOW_SENSOR, GPIO.IN, pull_up_down = GPIO.PUD_UP)

while True:
    print("Pressure: %.2f hPa" % lps.pressure)
    print("Temperature: %.2f C" % lps.temperature)
    print("")
    time.sleep(1)
```

15.1.1.2 Pressure sensor

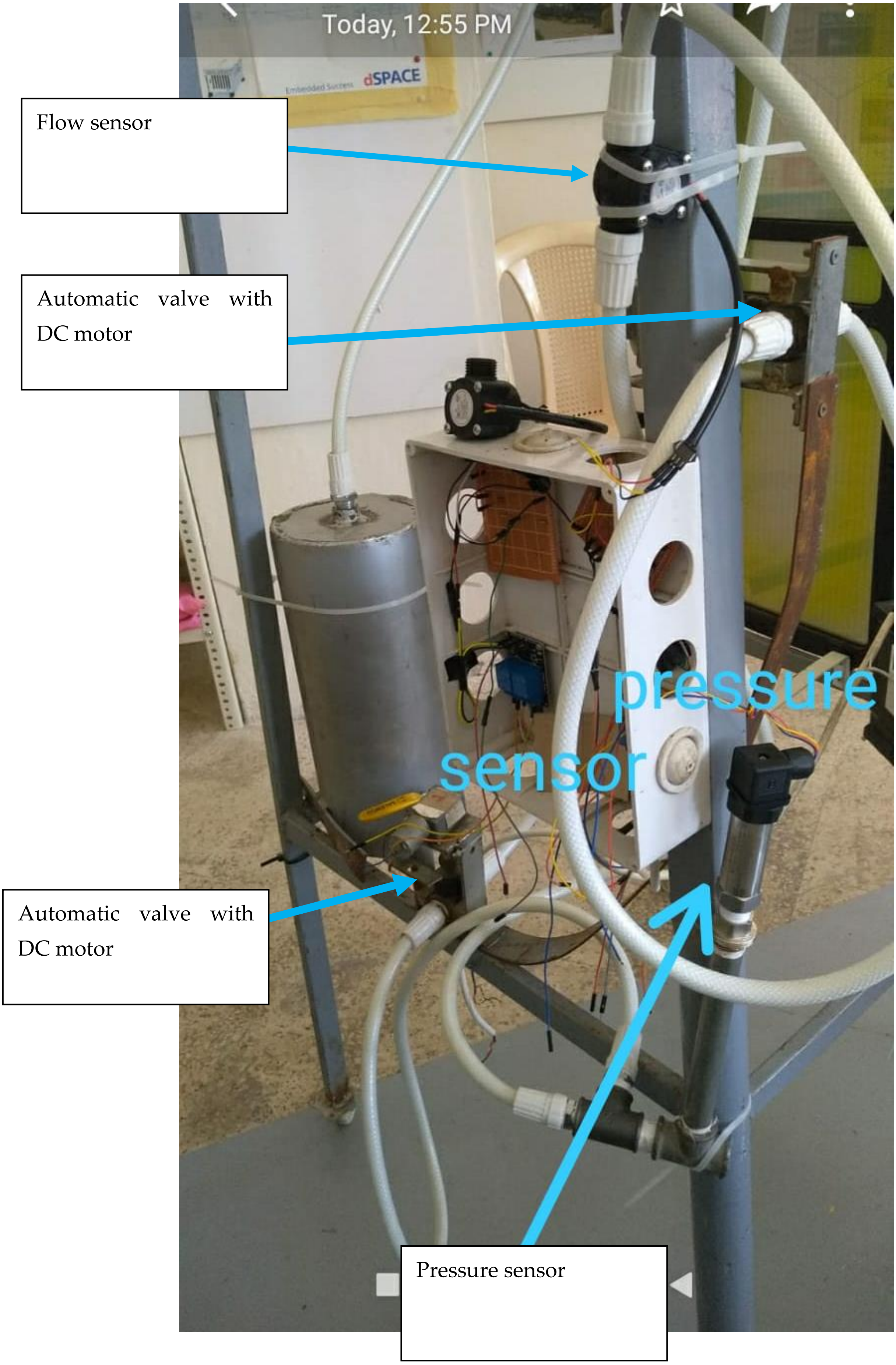
```
import RPi.GPIO as GPIO
import time, sys
FLOW_SENSOR = 26
GPIO.setmode(GPIO.BCM)
GPIO.setup(FLOW_SENSOR, GPIO.IN, pull_up_down = GPIO.PUD_UP)
global count
count = 0

global pressure
pressure = 0.0001
if pressure >= 0.0001:
   print(0.0001)
```

15.2 Combustion Control

الهدف القادم هو إضافة Pressure sensor ودمجه مع ال 2 flowsensor



لقد قمنا اليوم تقريبا بنفس العمل السابق لأننا بحاجة الى تحكمين للوصول الى هدفنا و قد قمنا بتجربة ناجة و الهدف الان تركيب جمبع القطع


Today, 12:55 PM
dSPACE
Flow sensor
Automatic valve with DC motor
pressure sensor
Automatic valve with DC motor
Pressure sensor

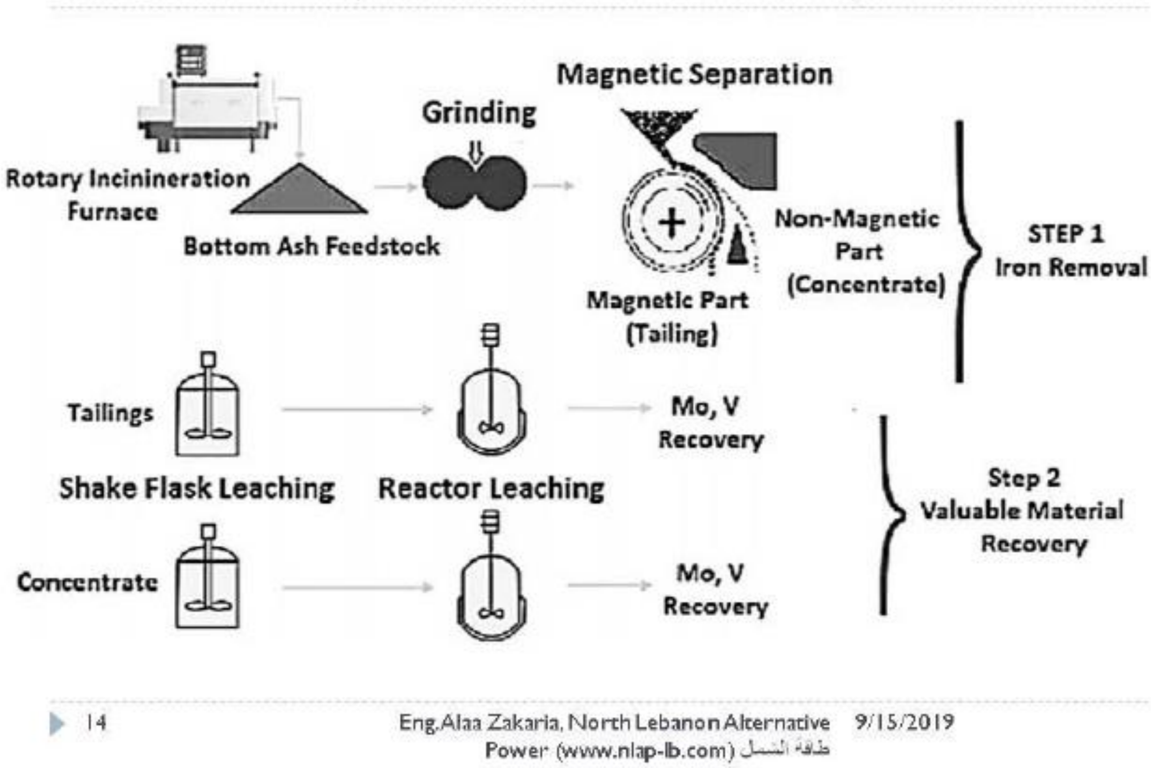
Ashes Recyling and Heavy Metals Recovery

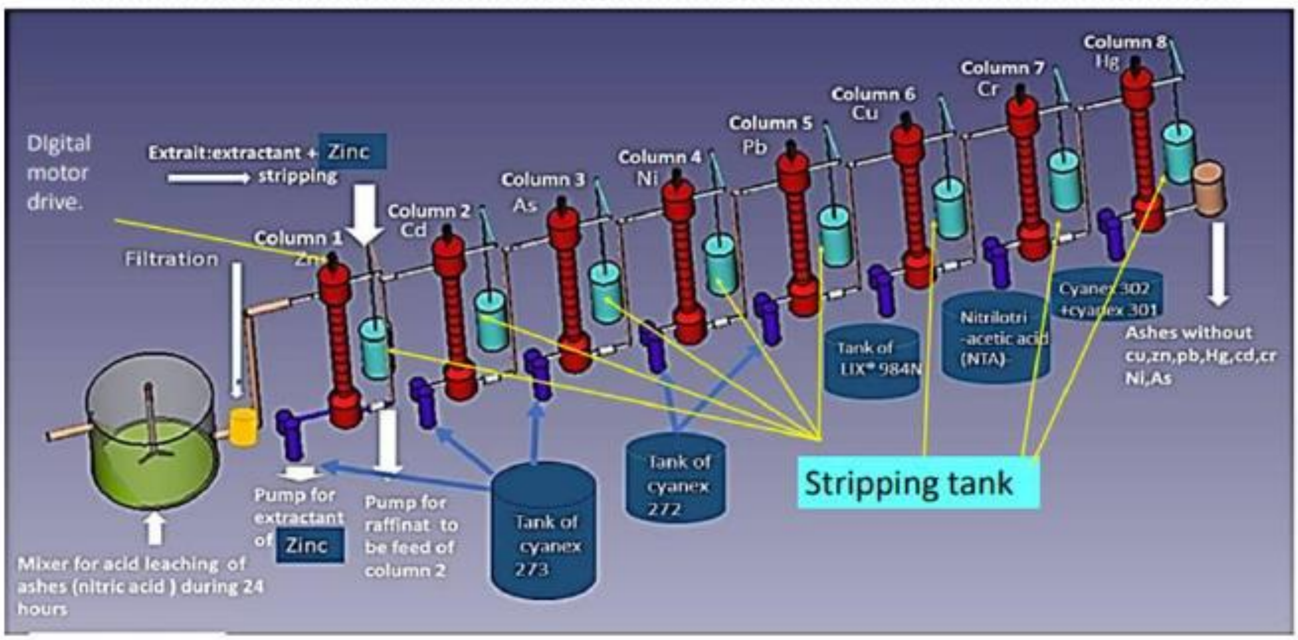
Based on the following reports

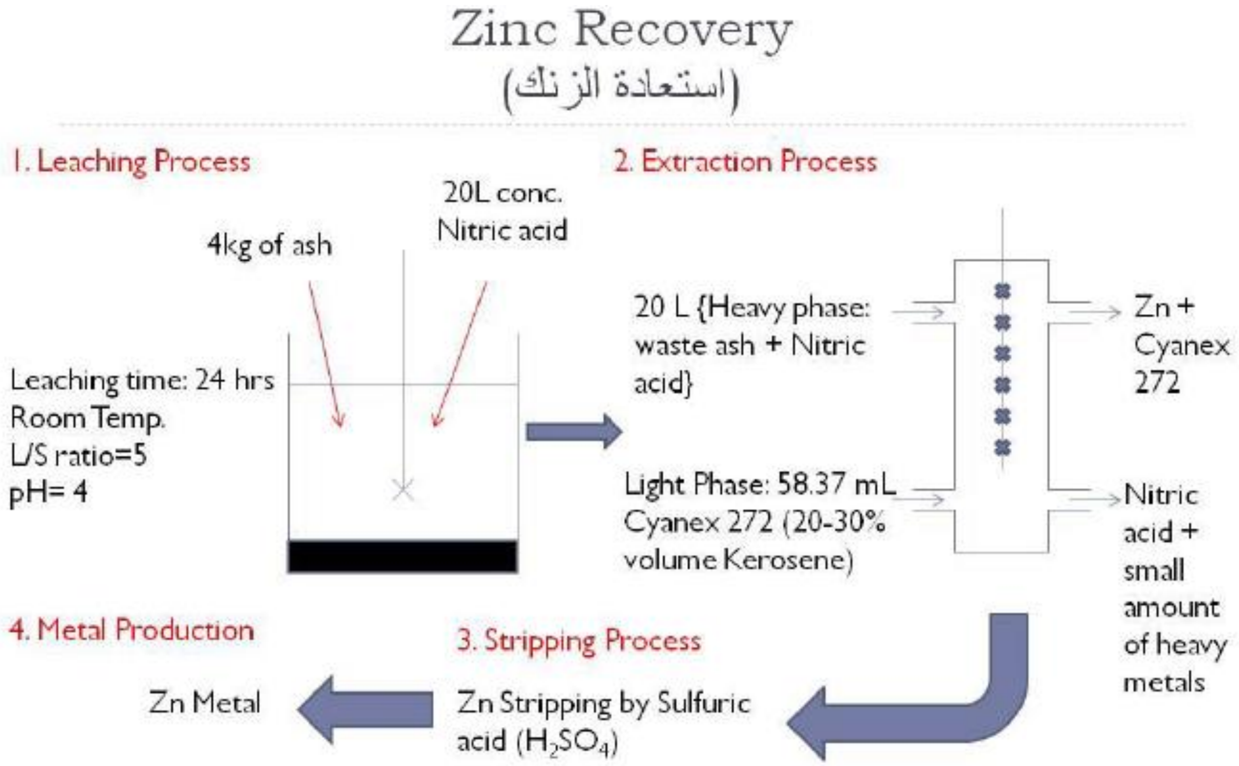
[NLAP-PCS 2018] Chapter 8

[NLAP-PCS 2019] Chapter 6,7,8,9

Trainee Report Concept for Automation for Ashes Reycling Test Rig (6 July 2020)

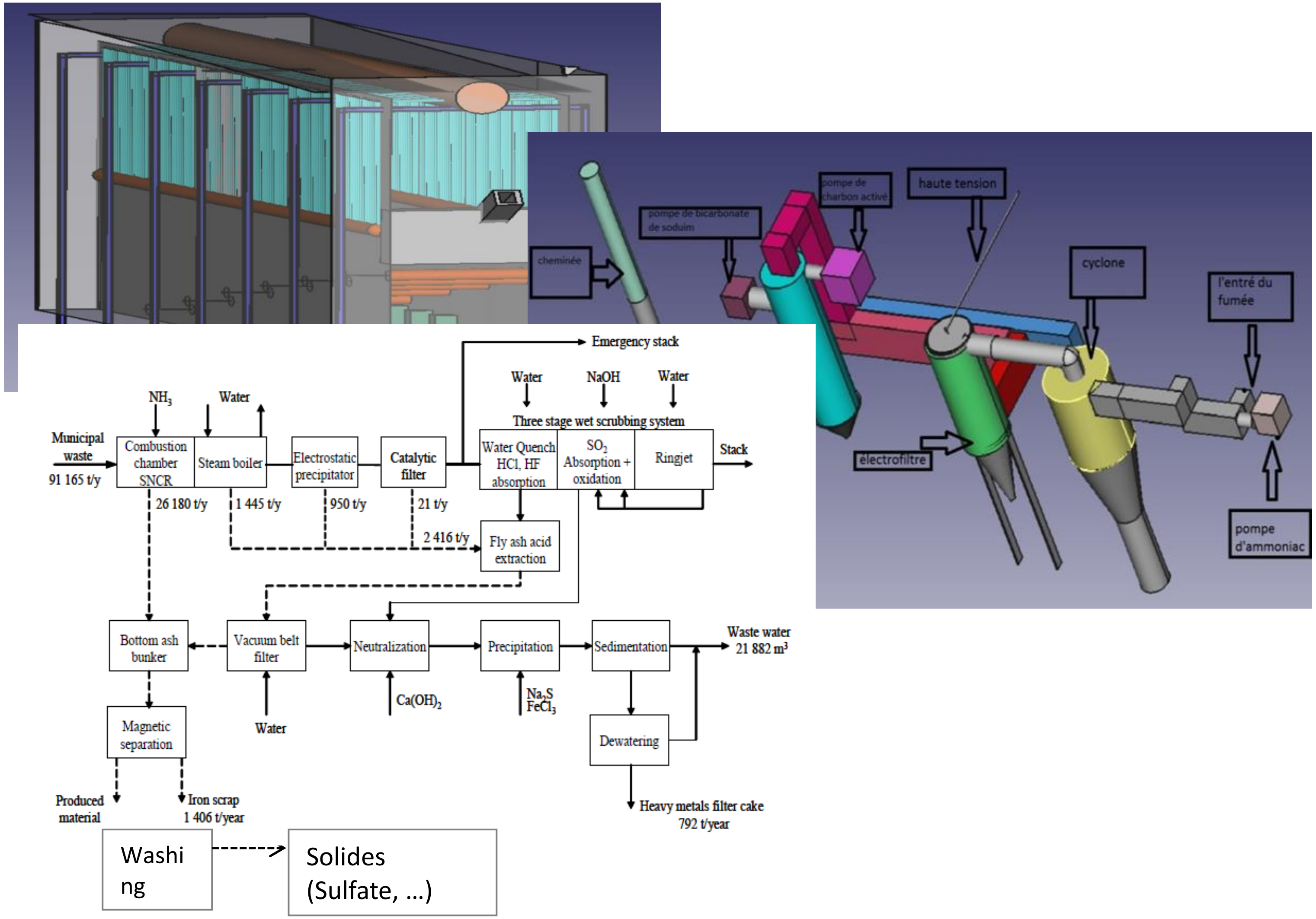

Magnetic Separation
Grinding
Rotary Incinineration Furnace
Bottom Ash Feedstock
Non-Magnetic Part (Concentrate)
Magnetic Part (Tailing)
STEP 1
Iron Removal
Tailings
Mo, V Recovery
Shake Flask Leaching
Reactor Leaching
Step 2
Valuable Material Recovery
Concentrate
Mo, V Recovery
14
Eng.Alaa Zakaria, North Lebanon Alternative Power (www.nlap-lb.com) طاقة الشمال
9/15/2019


Digital motor drive.
Extrait:extractant + Zinc stripping
Filtration
Column 1 Zn
Column 2 Cd
Column 3 As
Column 4 Ni
Column 5 Pb
Column 6 Cu
Column 7 Cr
Column 8 Hg
Tank of LIX® 984N
Nitrilotri -acetic acid (NTA)
Cyanex 302 +cyanex 301
Ashes without cu,zn,pb,Hg,cd,cr Ni,As
Tank of cyanex 272
Stripping tank
Pump for extractant of Zinc
Pump for raffinat to be feed of column 2
Tank of cyanex 273
Mixer for acid leaching of ashes (nitric acid) during 24 hours


Zinc Recovery
(استعادة الزنك)
1. Leaching Process
4kg of ash
20L conc. Nitric acid
Leaching time: 24 hrs
Room Temp.
L/S ratio=5
pH= 4
2. Extraction Process
20 L {Heavy phase: waste ash + Nitric acid}
Light Phase: 58.37 mL Cyanex 272 (20-30% volume Kerosene)
Zn + Cyanex 272
Nitric acid + small amount of heavy metals
3. Stripping Process
Zn Stripping by Sulfuric acid (H_2SO_4)
4. Metal Production
Zn Metal

17 Ashes Recycling Unit (From [NLAP-WEDC 2018])

17.1 First Conception Dec 2017



17.2 Heavy Metals extraction unit[19]

17.2.1 COPPER EXTRACTION[20]

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[19] Maysaa Kamareddine, Concept for Ashes Recycling Unit, May 2018

[20] Murdoch Mackenzie, Henkel Australia Pty ltd , THE SOLVENT EXTRACTION OF SOME MAJOR METALS - AN OVERVIEW (thesolve.pdf) (about 1998)

REFERENCES

(1) R.B. Sudderth and G.A. Kordosky, "Some Practical Considerations in the Evalaution and Selection of Solvent Extraction Reagents" Chemical Reagents in the Mineral Processing Industry. Ed. Malhotra and Riggs. SME 1987

(2) J.M.W. Mackenzie, "Uranium Solvent Extraction Using Tertiary Amines" ALTA 1997 Uranium Ore to Yellow Cake Seminar. ALTA Metallurgical Services, Melbourne Australia.

(3) K. Soldenhoff, N. Hayward and D. Wilkins, "Direct Solvent Extraction of Cobalt and Nickel from Laterite Acid-Pressure Leach Liquors" EPD Congress 1998. Ed. B.Mishra (The Minerals, Metals and Materials Society, AIME) 1998 p153-165

(4) G.M. Ritcey, "Commercial Processes for Nickel and Cobalt" In Handbook of Solvent Extraction. Ed Lo, Baird, and Hansen. John Wiley and Sons 1983. P 673

(5) J.M.W. Mackenzie and M.J.Virnig, "Recovery of Nickel from Ammoniacal Solutions Using LIX® 84-I" Proceedings of ALTA Nickel /Cobalt Pressure Leaching and Hydrometallurgy Forum, May 1996. Perth West Australia. ALTA Metallurgical Services Melbourne.

(6) J.M.W. Mackenzie and M.J.Virnig, "Extraction of Nickel from Ammoniacal Leach Solutions: Extractant and Solution Chemistry Issues" Proceedings of ALTA 1998 Nickel/Cobalt Pressure Leaching and Hydrometallurgy Forum. May 1998. Perth West Australia. ALTA Metallurgical Services Melbourne

(7) M.J.Price and J.G.Reid, "Separation and Recovery of Nickel and Cobalt in Ammoniacal Systems: Process Development" Proceedings ISEC 93 , SCI London 1993 p159.

(8) M.J.Virnig, J.M.W.Mackenzie, and C.Adamson. " The Use of Guanidine – Based Reagents for the Recovery of Gold" Hidden Wealth. South African Institute of Mining and Metallurgy. 1996 p151

(9) R.L.Movsowitz, R.Kleinberger, and E.M.Buchalter, "Application of Pulsed Colums for Uranium SX From Pilot to Industrial Columns" ALTA 1997 Uranium Ore to Yellowcake Seminar. ALTA Metallurgical Services, Melbourne 1997

(10) T.A.Post, M.A.Giralico, M.C.Greaves, and G.M.Frazer, "Operational Results from Optimised Lightnin SX Pumper and Auxilliary Mixer Designs" ALTA 1996 Copper Hydrometallurgy Forum. Brisbane 1996. ALTA Metallurgical Services Melbourne.

(11) B.Nyman, R.Kuusisto, P.Taipale and J. Lyyra, "Emphaisi on Feed End Settling in Outokumpu's VSF Mixer-Settler" Ibid.

Copper extractants for acid leach solutions are exclusively oximes. For extraction from ammoniacal solutions beta diketones may be used. The chemistry of oxime extraction of copper is relatively simple:

$$2RH_{(org)} + Cu^{+2} + SO_4^{-2} \rightleftharpoons R2Cu_{(org)} + 2H^{+} + SO_4^{-2}$$

Note the following points about this equation:

When M(2+) is extracted two hydrogen atoms are released.

Extraction of 1.0 gpl Cu produces 1.5 gpl H_2SO_4. There are other reactions which take place in copper extraction which can influence extraction and stripping.

17.2.1.1 • Buffering of the aqueous

Dissociation of H_2SO_4:

$$H_2SO_4 \rightleftharpoons H^{+} + HSO_4^{-}$$

$$HSO_4^{-} \rightleftharpoons H^{+} + SO_4^{-2}$$

This dissociation depends on the SO4.

17.2.1.2 Concentration and salts such as aluminium

Sulphate or magnesium sulphate can drive this reaction to the left and reduce the H+ concentration which enhances copper extraction. For this reason highly buffered solutions will yield better copper extraction than non buffered solutions.

17.2.1.3 Dimerisation of the oxime

Oximes can form dimers in the organic phase and this can influence the extraction.

17.2.1.4 Equilibrium Modifiers

These are used in all commercial extractants based on aldoximes and play a most significant role in the extraction of copper influencing not only the equilibrium but also the physical properties of the organic.

17.2.1.5 Extractant Types

Oxime based extractants for copper are largely based on salicyaldoximes which have been modified with one of three modifier types. Examples of the three main extractant types currently in use are:

1. LIX® 984N

A mixture of 2-hydroxy-5-nonylacetophenone oxime and 5-nonylsalicylaldoxime in a

high flash diluent. The acetophenone oxime modifies the aldoxime and also performs as an extractant in its own right.

2. Acorga® M5640

5-Nonylsalicylaldoxime modified with an ester, 2,2,4-Trimethyl-1,3-pentanediol Diisobutyrate (TXIB) in a high flash diluent.

3. LIX® 622N

5-Nonylsalicylaldoxime modified with tridecyl alcohol in a high flash diluent. Each of the extractants marketed by the major chemical suppliers has been designed for a specific type of PLS with regard to pH and copper tenor. Used under the conditions for which they were designed they all deliver very similar copper net transfer values. The physical properties of the various types of extractant do show some differences with the aldoxime/ketoxime mixtures such as LIX984N showing lower entrainments and greater tolerance to crud than the other reagents when treating some types of PLS. The vol% concentration of the commercially available extractants is limited by organic viscosity constraints to about 30-33% and this means that the maximum net transfer of copper will be about 10g/l. For leach solutions containing significantly higher copper tenors than this the throughput O/A ratio will have to be increased above 1.0. Typical copper and acid concentrations for an SX plant treating a dump leach solution of 3.0g/l and pH1.8 are shown in Figure 4.

17.2.1.6 Copper solvent extraction plant configurations

A variety of circuit configurations are used.

- **2E X 1S**

The usual circuit for heap leach plants

- **2E X 2S**

Used where the copper tenor is above about 7-10 g/l or the PLS pH is less than about 1.2. The decision to use a second strip stage is influenced by the life of the project and the sensitivity of the circuit to the copper tenor of the raffinate. Agitation leach plants for example are sensitive to the loss of copper in a raffinate bleed or in the wash liquor used in the solid liquid separation stages.

- **3E X 2S**

These can be justified when the PLS has a very high copper tenor, say above 20- 25g/l and a high 93% plus copper recovery is desired. It is possible to use a 2EX2S circuit under these conditions but the throughput O/A ratios will be high, in excess of 2.5:1 and the capital cost of the 2EX2S plant may be higher than that of the 3EX2S plant. The 3EX2S plant will also be much more flexible in operation.

- **2E X 1W X 1S**

The wash stage is used to remove entrained impurities, usually chloride, and entrained and chemically loaded iron.

- **2E X 1P X 1S**

Series parallel circuits are used to treat high volumes of low tenor leach solutions. The parallel stage is often retrofitted to maintain copper production when the copper tenor of the PLS falls below project design and there is also the possibility to increase the volume of the PLS flow. Extractant concentrations are higher and copper recoveries are lower in series parallel circuits than in series circuits. Examples of these circuit configurations are shown in Figure 5.

17.2.1.7 Computer modeling of copper extraction circuits

Copper SX circuits have been modeled using a number of techniques. One such model is Henkel's IsocalcTM TM programme which applies the stability constants for the equilibrium reactions involved in copper extraction to calculate the extraction isotherm for a given leach solution and circuit organic and then applies the McCabe Thiele construction to predict circuit operation. A typical Isocalc print out is shown in Figure 6.

Isocalc can be used in many ways by both project design and plant operating personnel.

• Copper recovery may be predicted for a given PLS, circuit configuration and vol% extractant concentration.

• The reagent inventory cost and copper recovery may be predicted for a variety of circuit configurations.

• A wide range of "what if?" situations may be examined, eg. what if the PLS pH changes from 1.8 to 1.5?

• Operating circuit profiles may be compared with Isocalc predictions. This comparison may indicate the presence of errors in the assumed or measured parameters of the plant, eg. the vol % extractant analysis may be in error.

17.2.1.8 Extractant stability

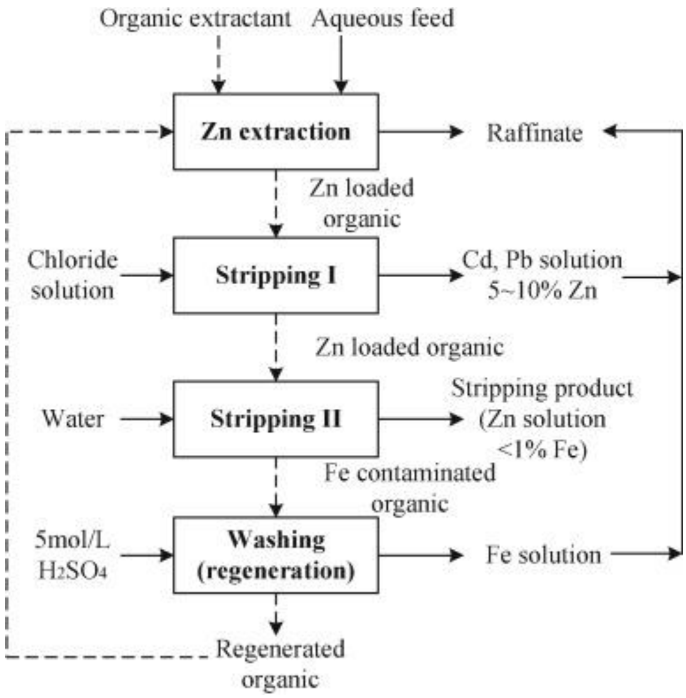
The oxime based extractants used to recover copper exhibit high chemical stability under normal operating conditions. Chemical attack can take place in the high acid concentrations in strip. Under normal operating temperatures this is not excessive however the degradation rate doubles for every 10oC increase in temperature. At 30oC the half-life of most copper extractants exceeds 150 days and it is only above 50oC that chemical degradation may become an issue. Manganese contamination of the tankhouse may, if the iron level of the tankhouse electrolyte is low, result in permanganate formation and this species can severely degrade both the extractant and the diluent. Bacterial oxidation of the diluent to form carboxylates is relatively common and these ay have a negative effect on the physical and iron transfer characteristics of the organic.

17.2.2 Nickel extractants

Unlike U/copper extraction where one type of extractant and circuit predominates there is a number of potential nickel extractants and circuit configurations. Sulphide nickel is usually treated using pyrometallurgical routes but in recent years there has been intensive activity in the development of hydrometallurgical routes for both sulphide concentrates and laterites. Nickel deposits can contain valuable quantities of cobalt and copper and these must also be recovered by SX if they are present in sufficient quantity.

Direct solvent extraction of copper, cobalt and nickel from acid leach solutions using oximes, phosphinic acids and versatic acids to extract copper, cobalt and nickel in sequence. While this circuit may function on leach solutions derived from sulphide concentrates, laterite leach solutions contain significant manganese and magnesium, both of which are extracted by phosphinic acid extractants. In addition the aqueous solubility of versatic acid at the pH used for extraction necessitates the inclusion of a versatic acid recovery stage.

17.2.3 ZINC, CADMIUM, LEAD EXTRACTION



17.2.4 SOLVENT EXTRACTION- SOME OPERATIONAL AND EQUIPMENT ISSUES

17.2.4.1 Contactor Design

For the major metals recovered by solvent extraction the mixer-settler contactor design predominates. However there is a range of mixer settler designs available and in recent years there has been some attention refocused on the use of pulsed columns for plants using the kinetically fast ion- exchange extractants. For the chelating extractants which require a minimum of two minutes' mixer residence time in a well-stirred incinerator, columns have not yet become commercially acceptable. Kvaerner have marketed a variety of the mixer – settler called the combined mixer- settler. As with columns, this unit has only found acceptance for ion-pair extractant systems. Some features of mixer-settlers and columns are given below.

Mixer Settlers

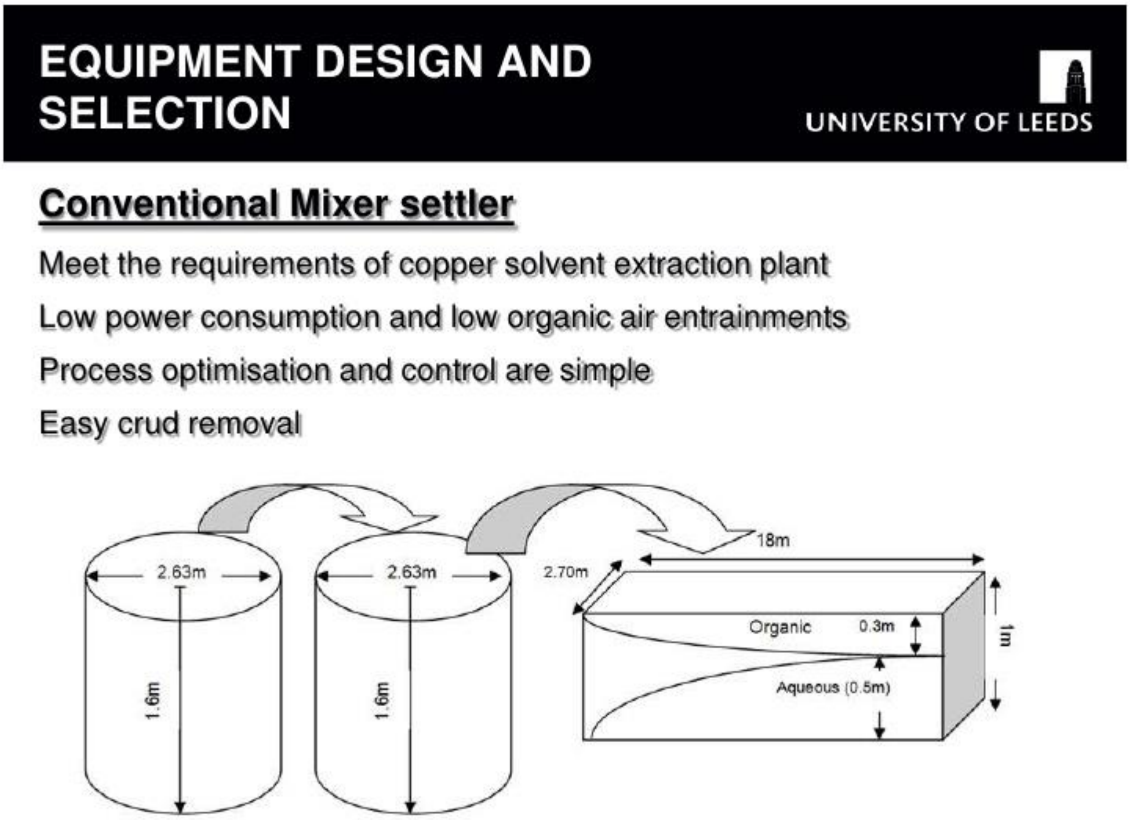
- Well established with literally hundreds of operating units.
- Design parameters are well established and very large units treating over 1000 cubic metres per hour of PLS can be designed from bench scale tests.

• Excellent mixing characteristics with control of the optimum droplet size claimed to be possible with modern turbine designs.

• Prediction of capital and operating costs is accurate.

• The phases are readily accessible for sampling and examination in situ.

• Several design varieties are available such as the Bateman Reverse Flow Settler, the Krebs unit and the Outokumpu VSF mixer settler. The Bateman and Krebs units offer the advantage of installing all of the mixers in a row avoiding the extra piping, walkways and civils involved in the typical head to toe mixer arrangement for conventional mixer settlers. The Outokumpu unit uses a special design of mixer, the vertical smooth flow spiral mixer and pumps the phases from adjacent stages using a dispersion overflow pump. Low power requirements and low entrainments are claimed for the Outokumpu unit.



EQUIPMENT DESIGN AND SELECTION

UNIVERSITY OF LEEDS

Mixer settler designs

Four units designs: krebs, outokumpu vf, reverse flow and conventional mixer settler.

Mixer

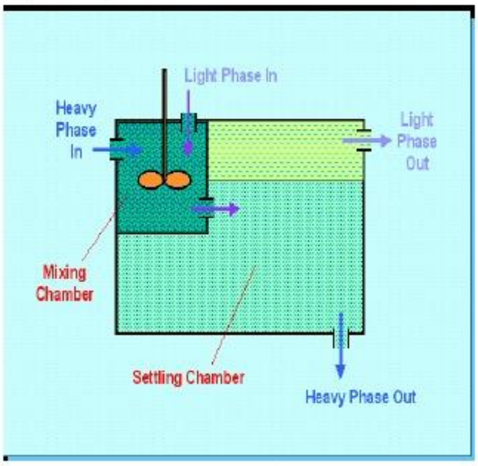
2 cylindrical mixing tanks per stage

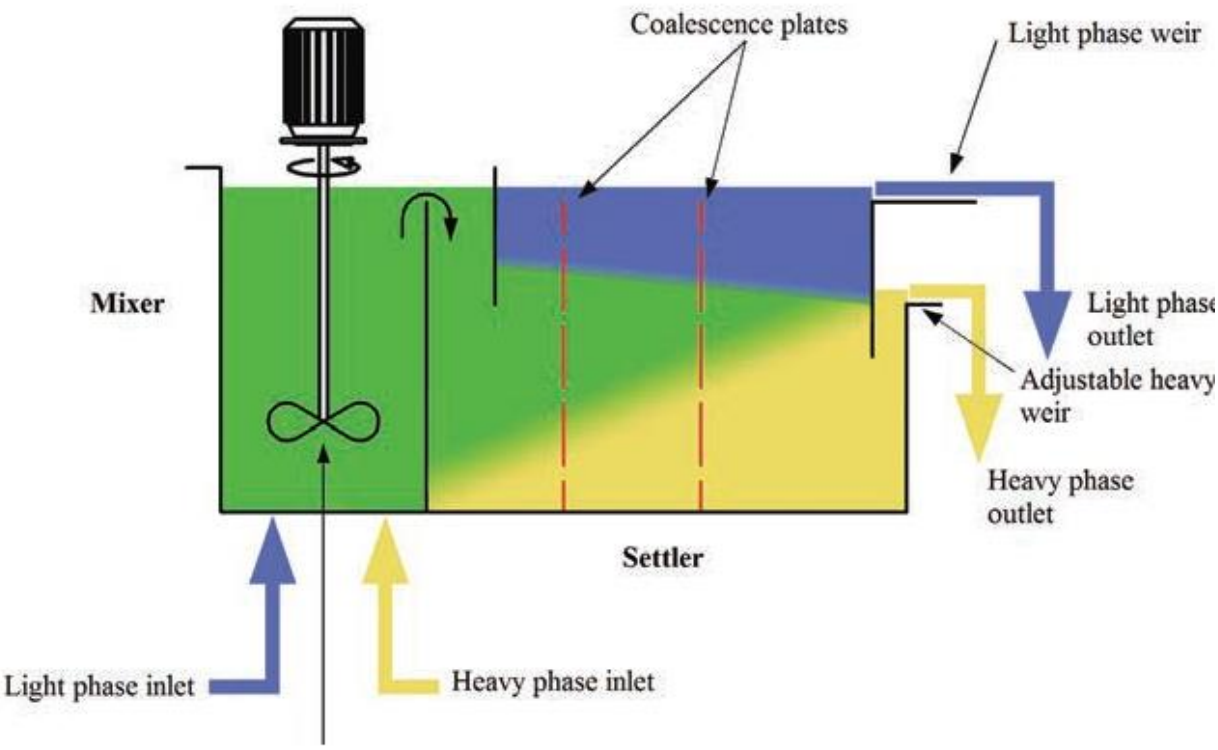
Residence time : 3 minutes.

Tank volume = (solution flow rate x residence time)/effective volume

Tank volume: 6.62m^3

Diameter=: 2.63m





Column Contactors

Advantages claimed for the column contactor include:

- Low area requirements
- Multiple stages within one unit
- Few moving parts
- Low entrainment
- Good vapor conservation

Column installations require piloting for each installation and the flooding conditions for the column must be determined. Recently Olympic Dam Corporation in South Australia has installed a large column plant for uranium extraction. The long residence times in a column compared to a mixer settler can influence the selectivity of the extraction if contaminants have slow extraction kinetics. The main features of conventional mixer – settlers and pulsed columns are shown in Figures 12 and 13.

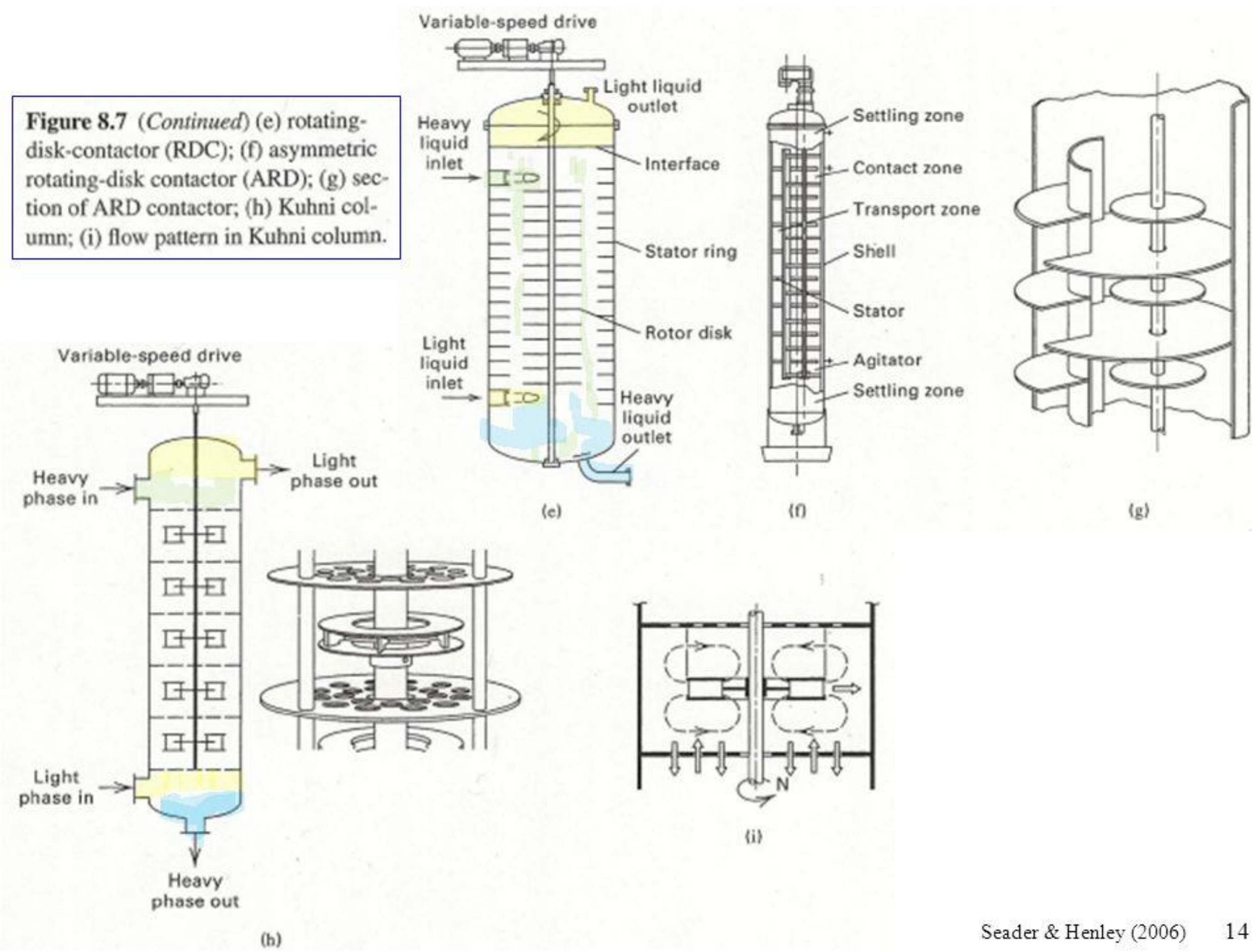
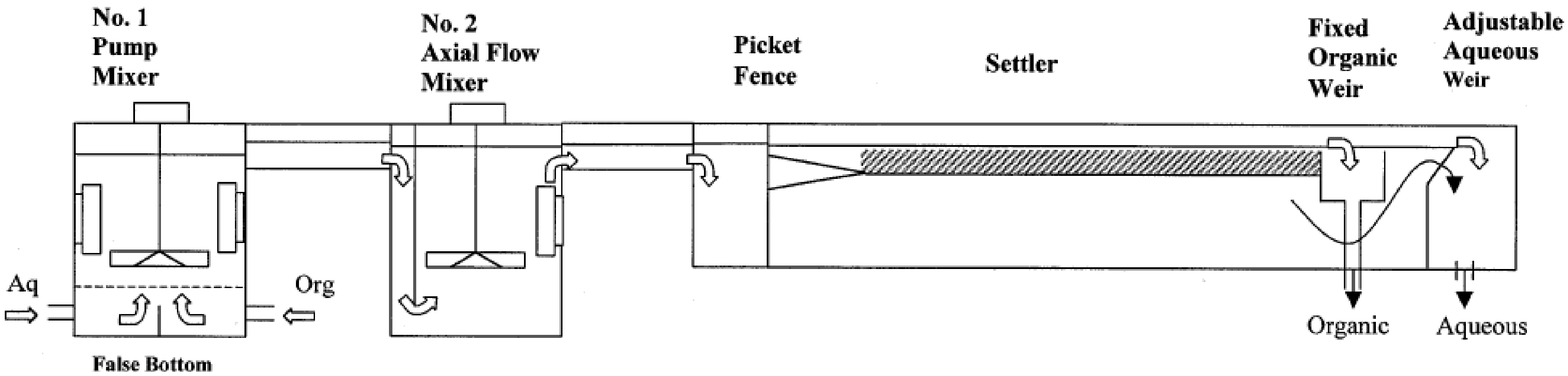


Figure 55 : OVERVIEW OF KIND OF COLUMNS

CONVENTIONAL MIXER SETTLER



MIXER DESIGN CRITERIA

Mixer O/A (use recycles if needed)	1.1
Mixer Residence Time	
Copper	2 mins 3 mins if cold
Tip Speed	250 – 300 metre/min
N^3D^2	< 20
N =	rps
D =	diameter in feet

SETTLER DESIGN CRITERIA

SPECIFIC FLOW RATE	4.0 – 5.0 $m^3/m^2/hr$ (Total flow)
If cold	3.0 – 3.5 $m^3/m^2/hr$
ORGANIC SPACE VELOCITY	3 – 6 cm/sec.
ORGANIC DEPTH	200 – 250 mm

From total organic flow calculate settler width from organic space velocity and organic depth.

From specific flow rate calculate settler area and settler length.

Figure 12

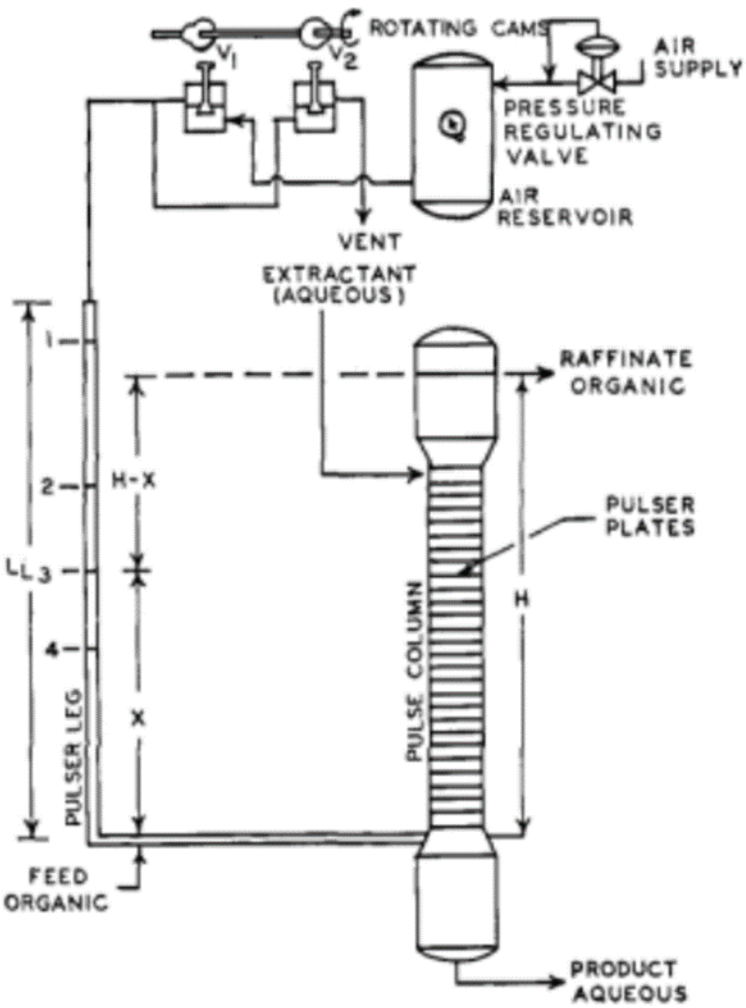
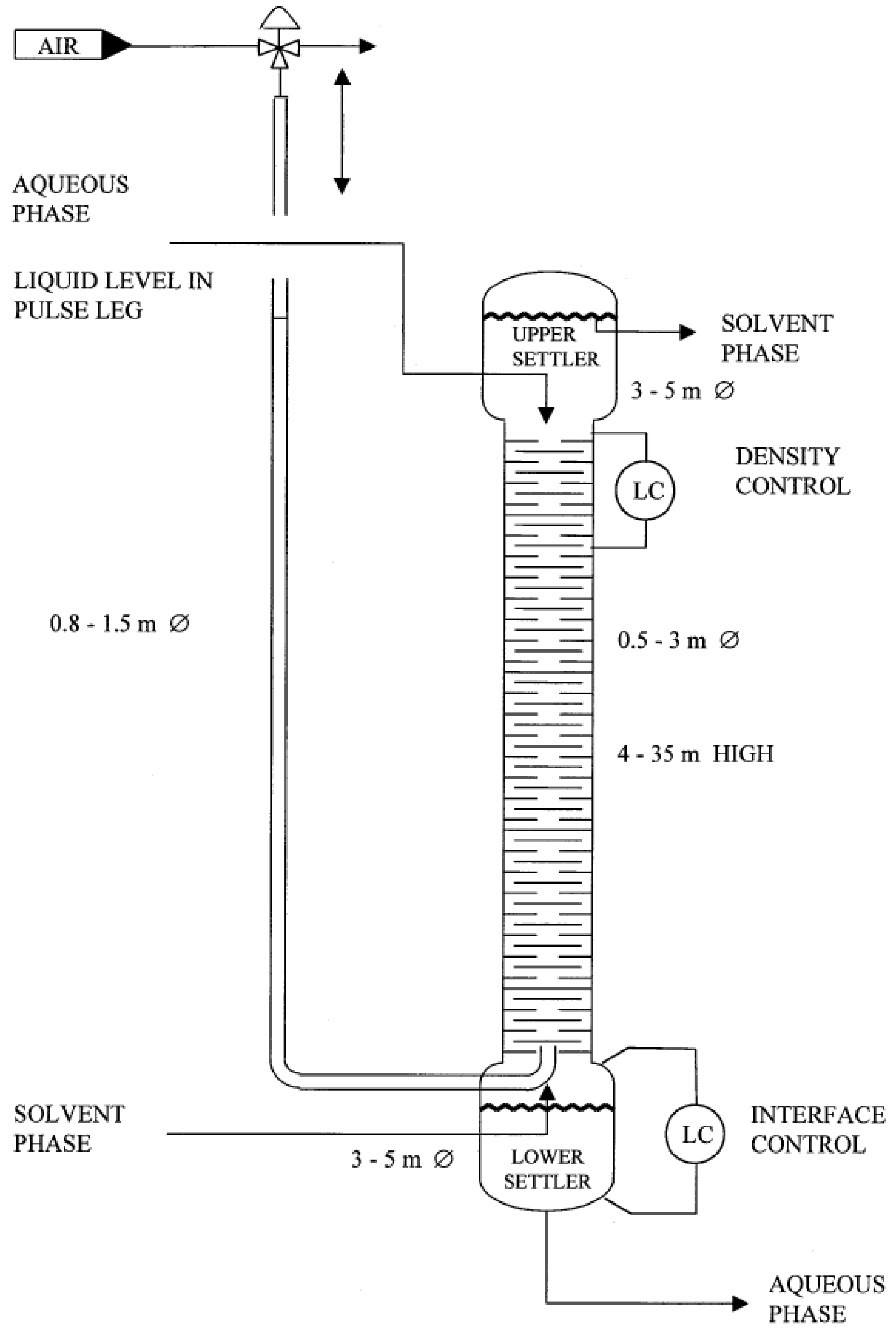


Figure 56 :pulsed column

if the fluid in the column and pulse leg are permitted to reach hydraulic equilibrium (valve 2 open), the fluid level will have reached position 1 in the leg with the fluid level maintained at the overflow point in the column. air pressure is now set and the cam started rotating. When v1 is open, v2 is closed which alternately admits and released air into and from the pulse leg. After equilibrium is reached in the system, the fluid in the leg will reach an average position 3 and will oscillate between points 2 and 4. air pressure forces the fluid down from 2 to 4 while the hydraulic head differences between the column overflow and fluid in the leg force the fluid in the leg back from 4 to 2.This interchange of fluid between the pulse leg and column provides the pulse action required in the column .Operating ranges usually encountered in amplitude area from 0.4 to 1.25 inches in the plate section of the column at frequencies from 40 to 100 cycles in minute . the poppet valve and motor are arranged with flange disconnects and electrical plugs-in for ease in replacement of unit needing maintenance. This pulsers are fitted with rotary and liquid sensing devices which close a safety in the event either sensor signals.



BATEMAN PULSED COLUMN

Figure 13

Diagram supplied with permission from Alta Metallurgical Services Pty Ltd and Bateman

Comparison between Bateman column and mixer settler[21]

Bateman column: Flux rates of 30 to 50 m3/m2*h, resulting in very small footprint requirements;

• no evaporation losses or air ingress as the units are sealed;

• improved safety of operation and lower fire risk;

• replacement of several mixer settlers by a single column for the equivalent performance;

• operation in either aqueous- or organic-phase continuity (including the possibility of dispersing the major phase in the minor phase);

• inclusion of washing or scrubbing operations in the extraction or stripping columns;

• improved phase separation in the settlers, lower entrainment losses, and reduced crud formation since mixing and mass transfer occur in a very low-shear environment;

• high tolerance of solids or crud in suspension;

• lower maintenance downtime due to few moving parts;

• reduced reagent losses, maintenance costs, and operating costs.

Since columns are particularly appropriate for systems that have rapid kinetics and do not require interstage pH control, the extraction of zinc by di(2-ethyl-hexyl) phosphoric acid (D2EHPA) is ideally suited to this application. The objectives of this study were (i) to determine whether data comparable to the previously optimised results for this system obtained using mixer settlers could be achieved for similar process conditions using a column configuration, and (ii) to validate the claimed advantages of BPCs.

17.2.5 Freecad design

17.2.5.1 TYPE OF METAL TO CONSTRUCTION

the construction of the column requires a metal that is resistant to corrosion and consequently the destruction. We can have mentioned some metals such as stainless steel that is the best un this case

[21] Pilot-plant comparison of Bateman pulsed. (PDF Download Available). Available from: https://www.researchgate.net/publication/292139827_Pilot-plant_comparison_of_Bateman_pulsed_columns_and_mixer_settlers_for_the_extraction_and_stripping_of_zinc_in_the_di2-ethylhexylphosphoric_acid_system [accessed Apr 27 2018].

17.2.5.2 dimension of the extraction column (with rotating discs RDC)

The amount of feed solution that considered as aqueous solution at 90°C (3h) is about 300L(waste +nitric acid ,volume of nitric acid=150 l).

A column of 40 cm radius is suitable in this case.

in most cases found limited to operations where:

• the density differences between the carriers is higher than 50 kg/m^3

• the volumetric phase ratio between dispersed drop phase and continuous

phase is in the magnitude of 0.5 < < 5

• the number of theoretical stages NTS 10

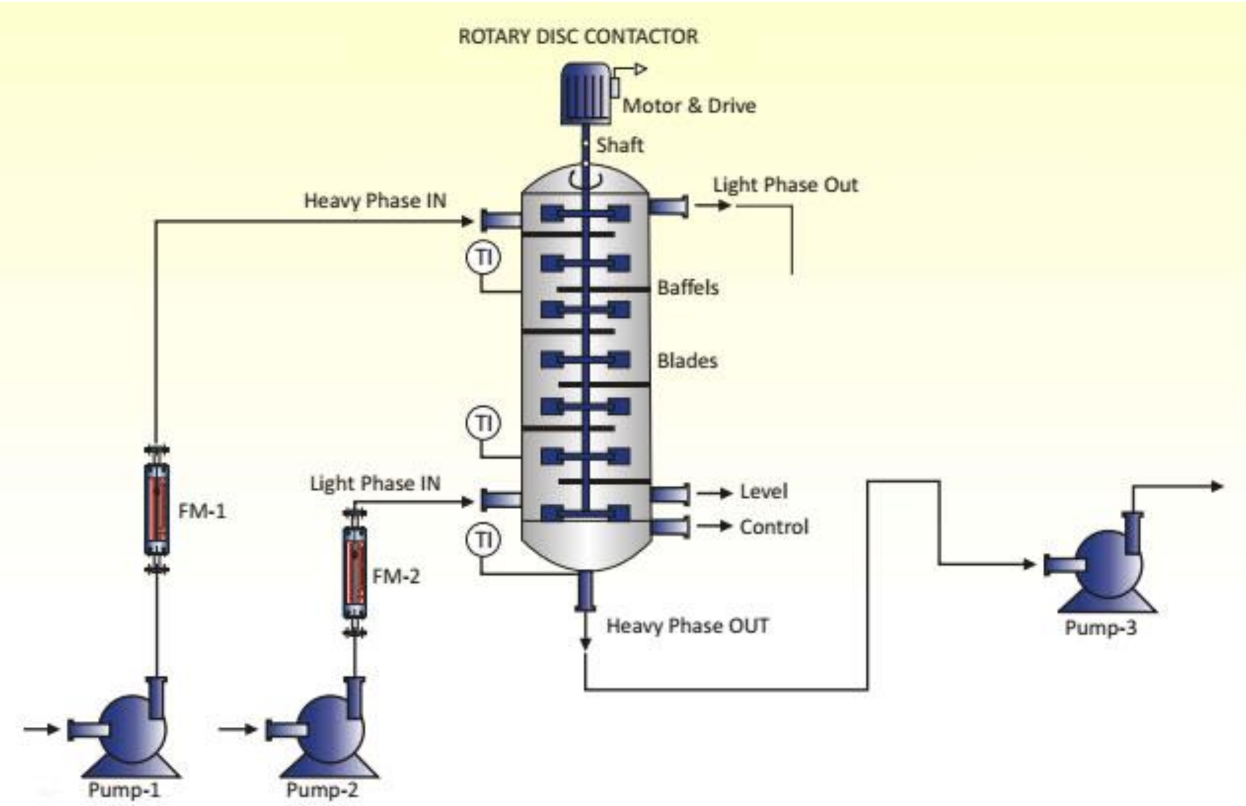


Figure 57 : rotating disc contactor

Equilibrium condition on extraction step is in the range of 8-32%extractant volume percent.

Column	Length (cm)
Height	250
Radius	40
Sheet of stainless steel	2500×125

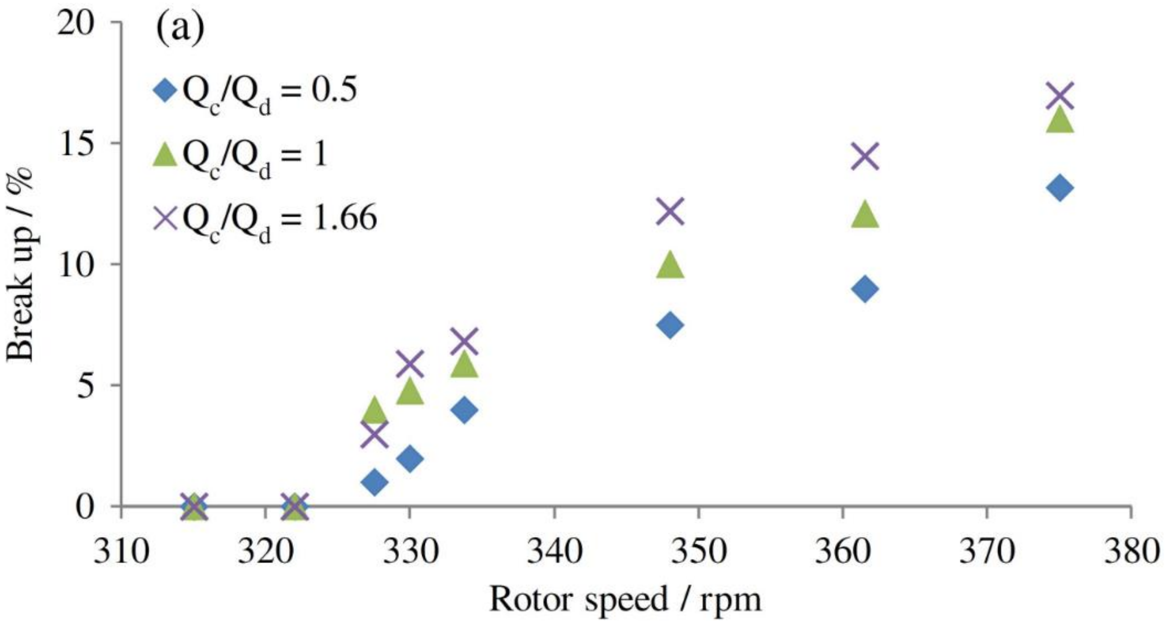
Column height / cm	Column active height / cm	Inner column diameter / cm	Inner stator diameter / cm	Outer rotor diameter / cm	Compartment height / cm	Number of compartment in active region
150	60	9.1	6.1	4.55	3.2	21

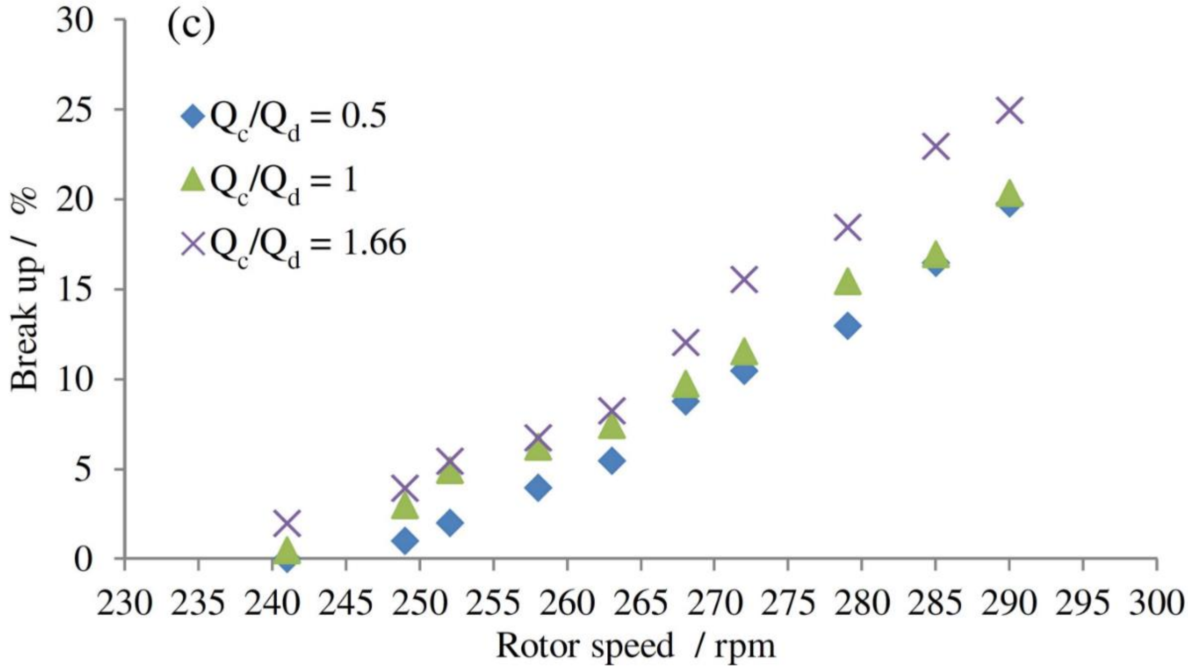
Table 14: Characteristics of the RDC column

17.2.5.3 identification of rotor speed

The first and second critical rotor speeds could also be defined based on breakage probability: the first critical rotor speed for a drop with particular size defines as the rotor speed at which the drop breakage starts. In fact, before the first critical rotor speed, the probability of break up for a drop with specific size is zero. Moreover, the second critical rotor speed (for a drop with a particular size) is a rotor speed at which the probability of breaking that drop is equal to 1

The breakage probabilities versus rotor speed for mentioned chemical systems using glassy nozzles with different inner diameters (1.2 and 2.5 mm) to form various drop sizes by adjusting the Q_c/Q_d ratios and continuous phase heights are presented in next figure regarding to these graphs, the drop breakage increases by increasing the volumetric phase ratio that leads to decrease of the first critical rotor speed. It could be justified with increasing this ratio, the drag forces between the continuous phase and dispersed drops increase results to enhance the probability of drop break up due to collision with the rotors. Mother drop diameter is effective on first critical rotor speed such that the nozzle with larger internal diameter produces larger mother drops with an increase in the probability of break up results to decrement of first critical rotor speed. Increasing the height of continuous phase led to increase of resistance against to upward motion of drops thereupon increment of the break up probability and decrement of the first critical rotor speed. Based on experimental results, the first critical rotor speed for considered chemical system should be 230 rpm.


(a)
Q_c/Q_d = 0.5
Q_c/Q_d = 1
Q_c/Q_d = 1.66
Break up / %
0
5
10
15
20
310
320
330
340
350
360
370
380
Rotor speed / rpm


(c)
Q_c/Q_d = 0.5
Q_c/Q_d = 1
Q_c/Q_d = 1.66
Break up / %
0
5
10
15
20
25
30
230 235 240 245 250 255 260 265 270 275 280 285 290 295 300
Rotor speed / rpm

17.2.5.4 Characteristics of LIX® 984N

Typical properties Physical and performance specifications

Specific gravity	(25 °/25 °C) 0.935 – 0.955 g/cm³
Flash point	Greater than 170 °F=76 °C
Copper complex solubility	> 30 g/l Cu at 25 °
Maximum copper loading	≥ 5.1 g/l Cu
Extraction isotherm point	≥ 4.40 g/l Cu
Extraction kinetics	≥ 95 % (30 seconds)
Extraction Cu/Fe selectivity	≥ 2000
Extraction phase separation	≤ 70 seconds
Strip isotherm point	≤ 1.8 g/l Cu
Net copper transfer	≥ 2.70 g/l Cu
Strip kinetics	≥ 95 % (30 seconds)
Strip phase separation	≤ 80 seconds

Table 15: Typical properties physical and performance specifications

materials	Density (kg/m³)
Copper	999
Nitric acid	1510
Oxime LIX	806

Table 16 :Density of solutions

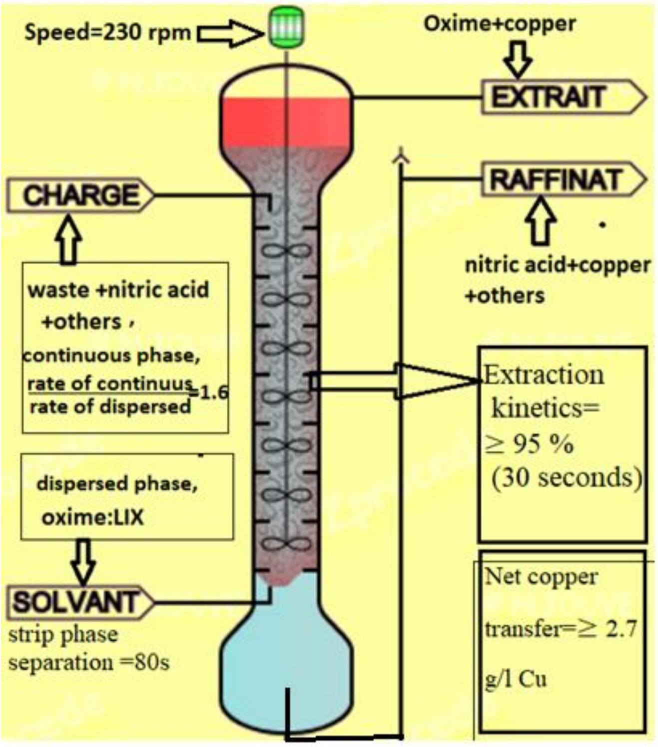


Figure 58 :input and output of column;

Solvent = light phase (feed at bottom), Solvent = dispersed phase (top interface)

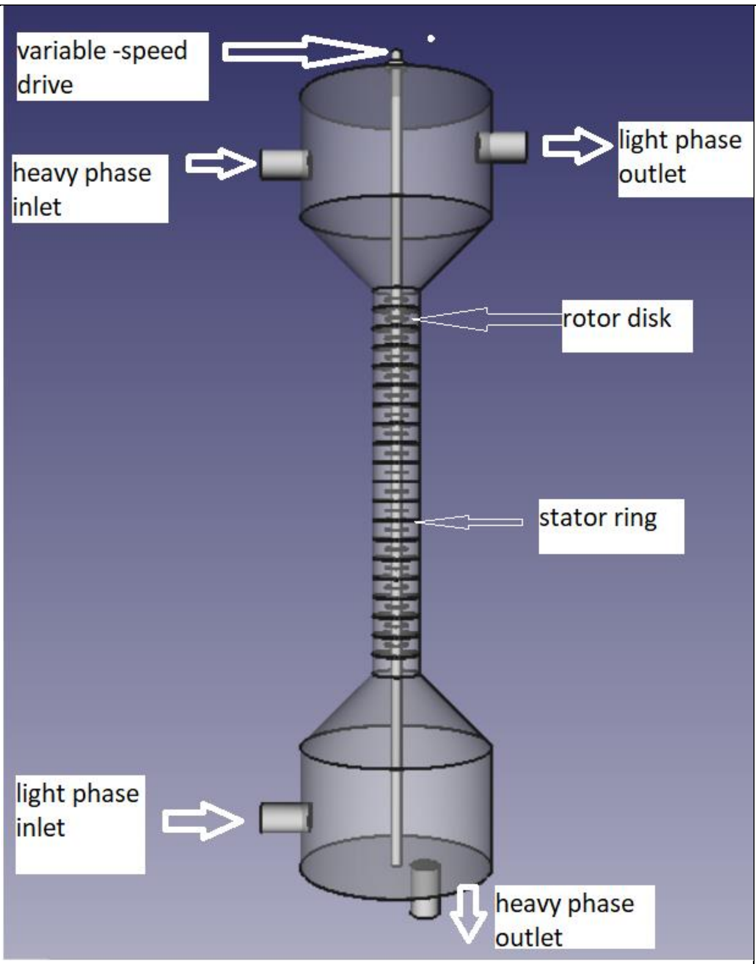
To complete 95% of the extraction process ,it takes 30 seconds ,in others words of the solute (copper) passes from solution A(waste + nitric acid) to solvent . the stripping of copper takes 80 seconds.

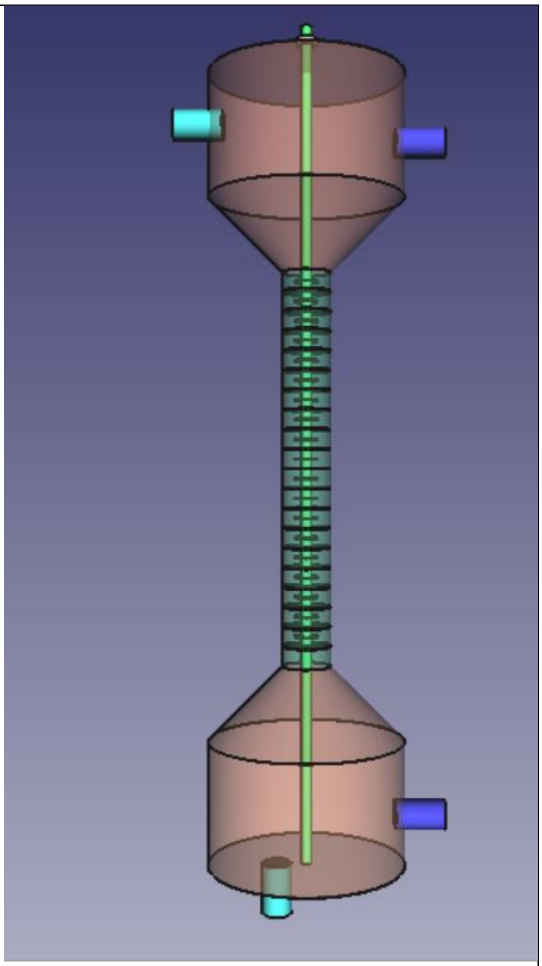
Parts	Dimension
Covering column	Internal diameter:212 mm Outside diameter:220mm
Columns that carry stators	Number:3 Diameter:4 mm Height 2500 mm
Stator	Number:10 Internal diameter:120 mm outside diameter:204 mm Height:15 mm Spaced:150 mm

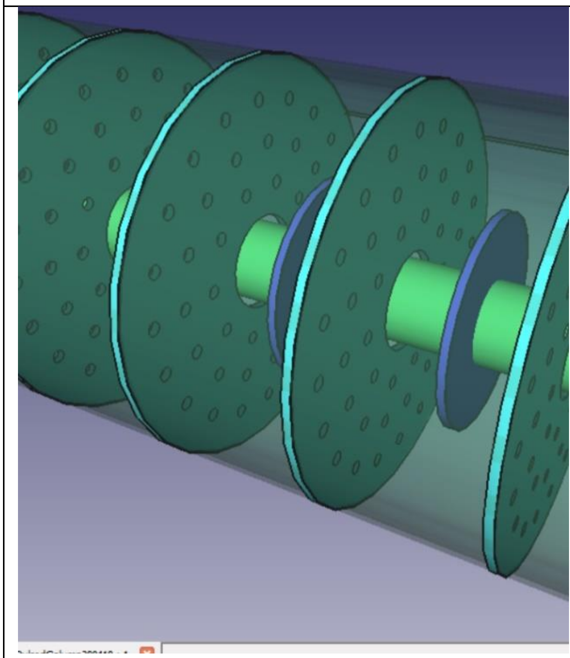
Decanter (cylinder+cone)	Number :2 Radius 1:110 mm Radius 2:200 mm Height: 100 mm -Cylinder: Height :300 mm Diameter:400 mm
Rotation axis	Diameter :40 mm, height:3500 mm
Rotor perforated(20 punch ,D=8 mm)	Number :10 Internal diameter:40 mm Outside diameter:100 mm Height:15 mm Spaced :150 mm

Table 17: dimensions of parts of columns

17.2.5.5 Bateman pulsed column







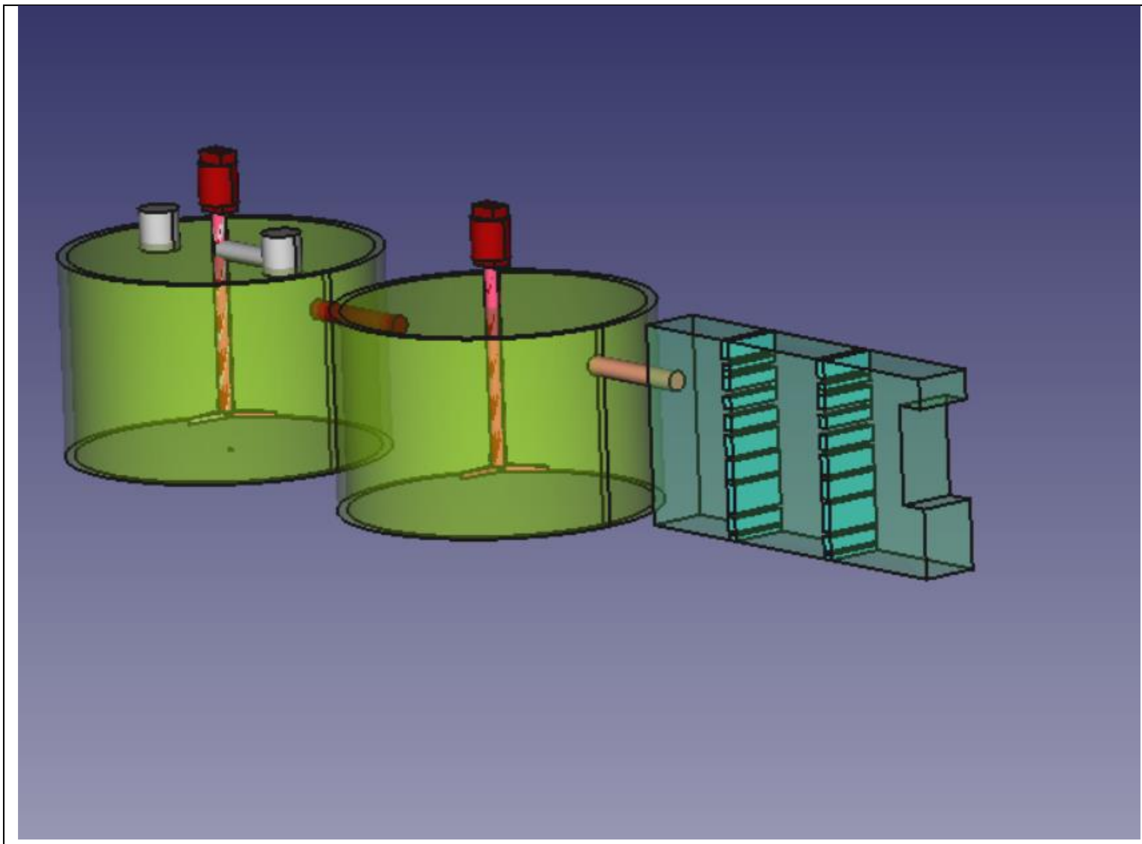
BatemanPulsedColumn100518.FCStd

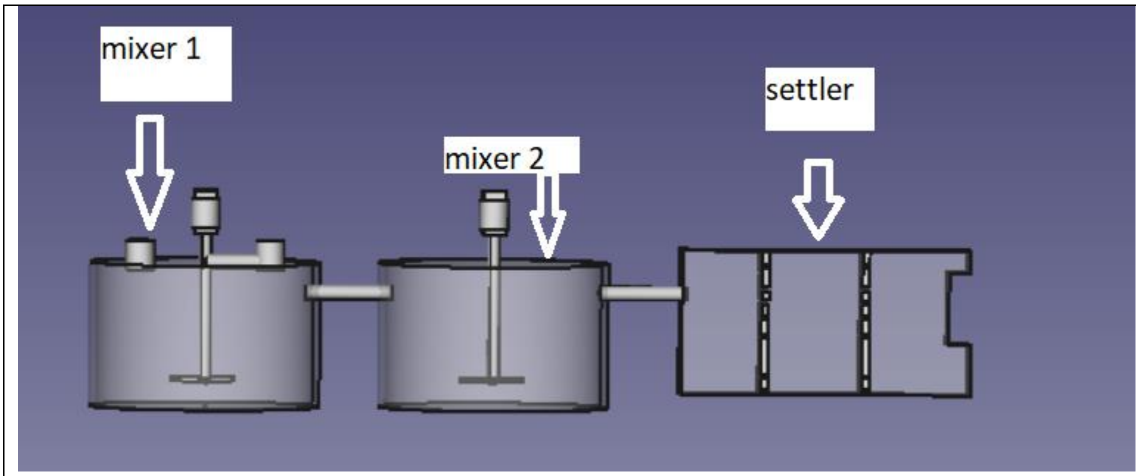
Dimensions of Bateman pulsed column

materials	radius (m)	Height (m)	number
Stator ring	0.245	0.01	19
rotor disk	0.125	0.02	19
Main tube	0.25	4	1
Tube (driver)	0.05	8.5	1
Inlet & outlet	0.15	0.5	2

Total surface needed to bateman pulsed column =20.4 m^2 (11 sheets 1×2 m)

17.2.5.6 Mixer settler





Mixer-settler_schema-030518.FCStd

Dimensions of Mixer –settler

Component	Height(m)	Radius (m)
Mixer 1	1	0.75
Inlet 1	0.2	0.1
inlet 2	0.2	0.1
Outlet 1	0.6	0.05
Mixer 2	1	0.75
Inlet 1	0.2	0.1
inlet 2	0.2	0.1
Outlet 1	0.6	0.05

Component	Length (m)	width (m)	Height (m)
settler	2	0.3	1
Barrier to scroll	2	0.3	2

Total surface needed to mixer=21.2 m^2

Total surface needed to settler=6.3 m^2

Total surface = 27.45 m^2 (13 sheet 1m×2 m)

17.2.5.7 RDC column

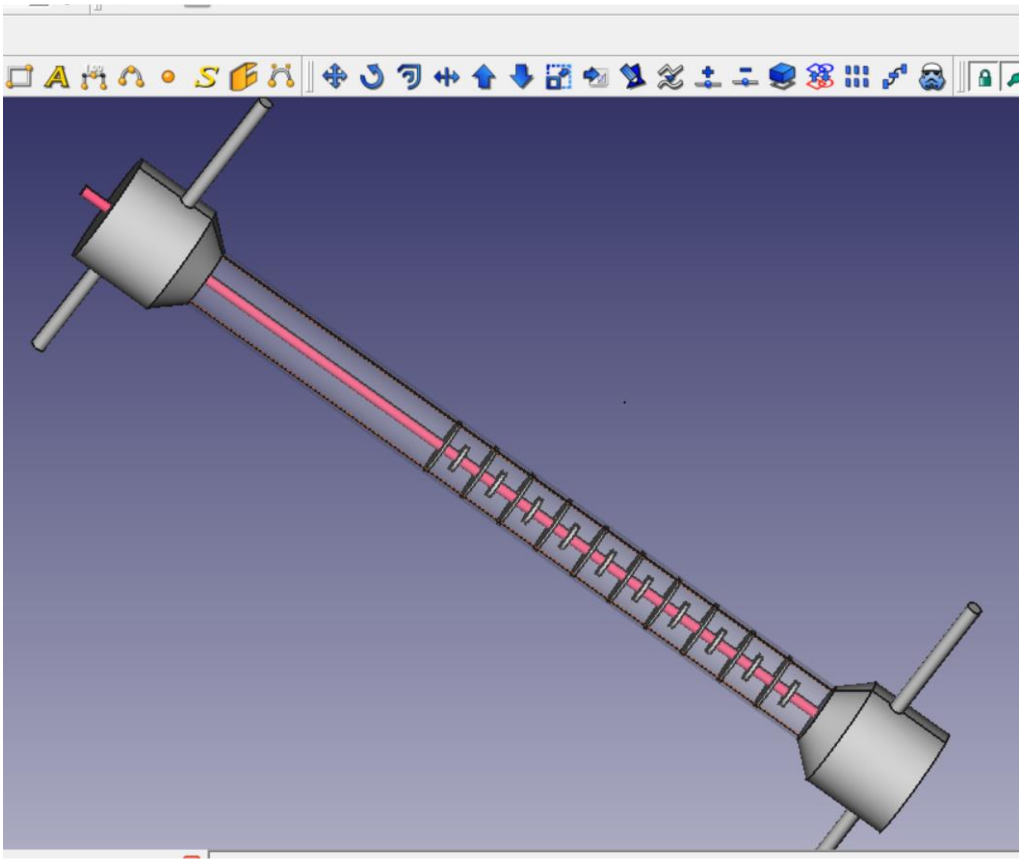


Figure 59 : overview of RDC column

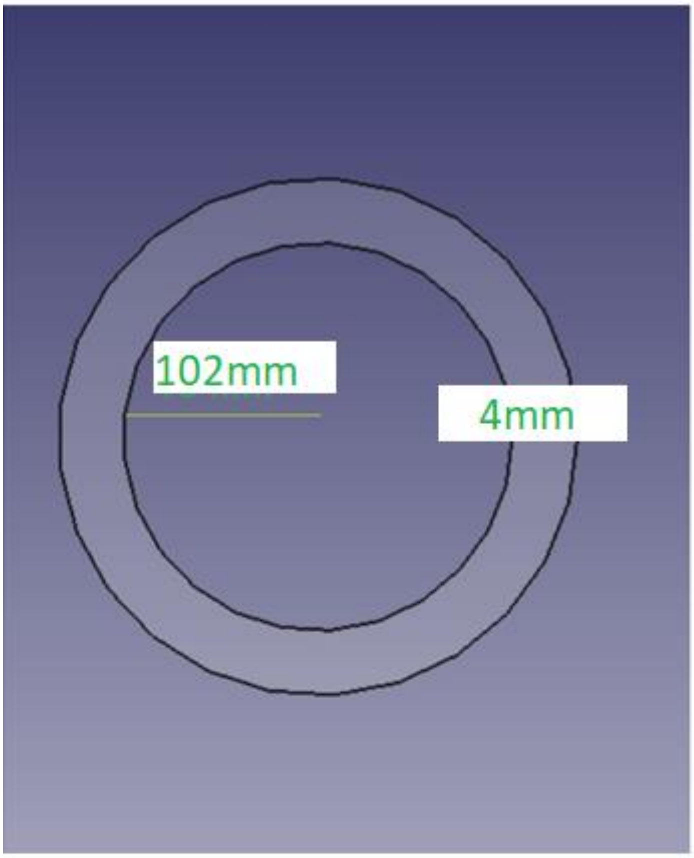


Figure 60 : top and side face of column

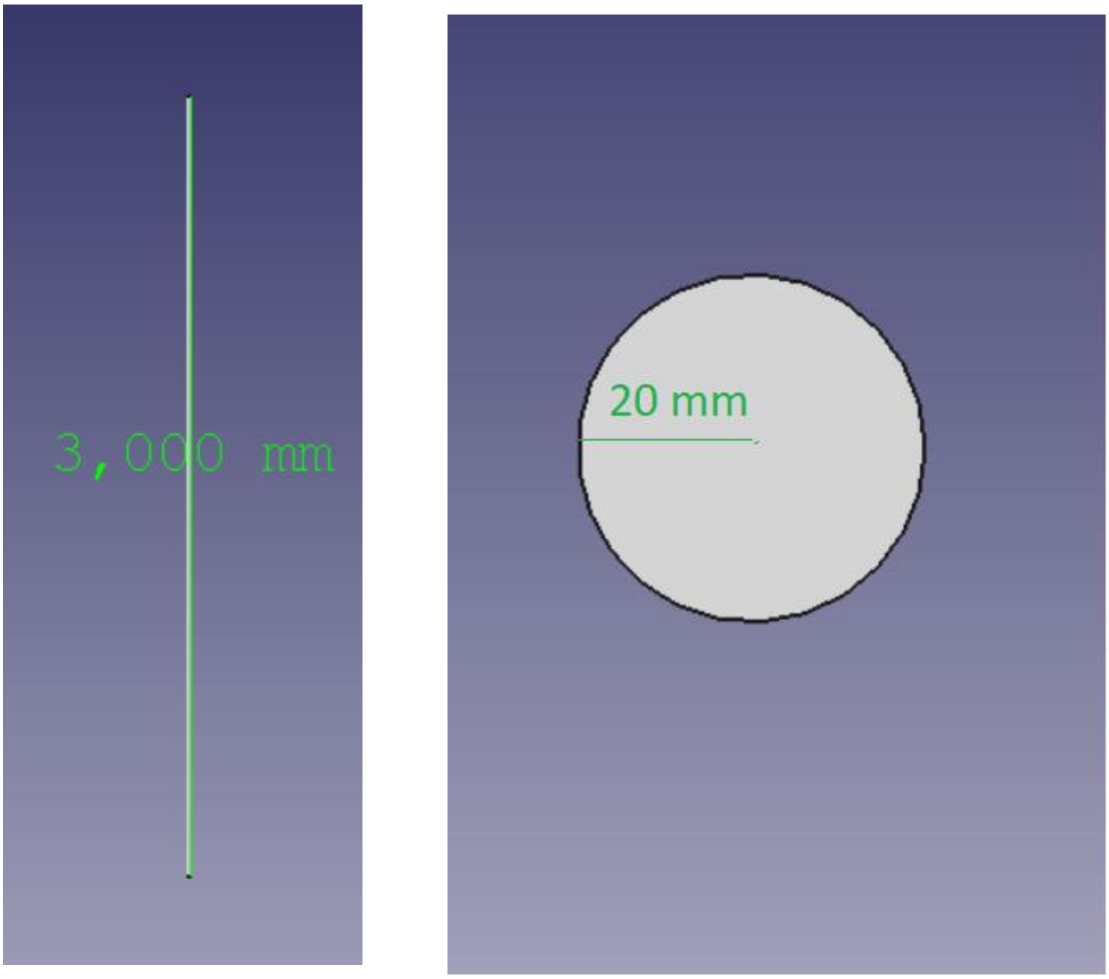


Figure 61 : rotation axis

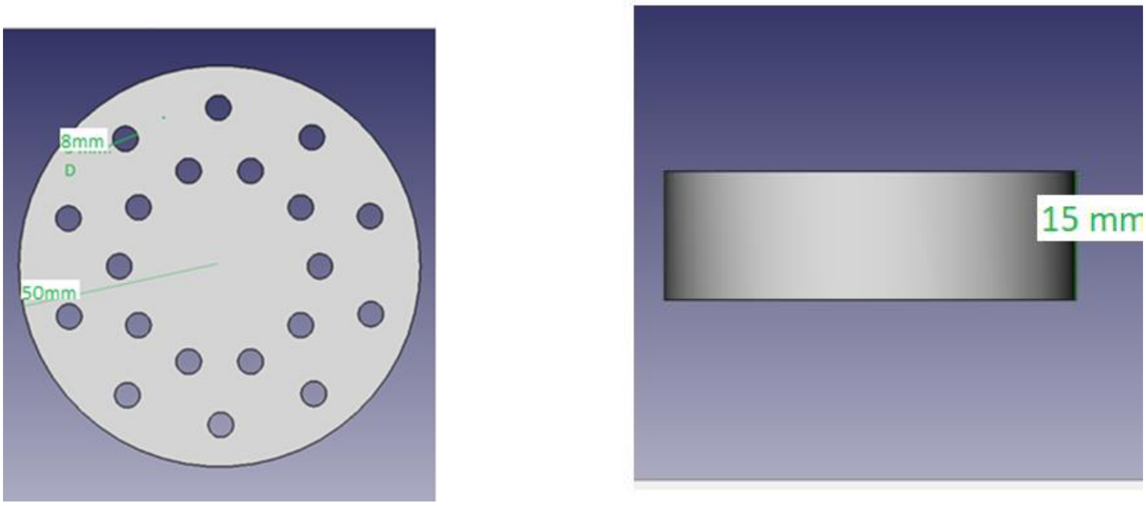


Figure 62 : rotor perforted (20 perforation,)

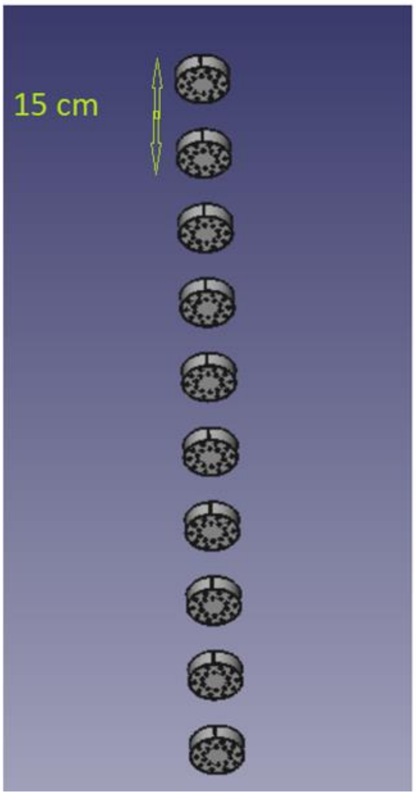


Figure 63 : 10 rotor spaced 15 cm

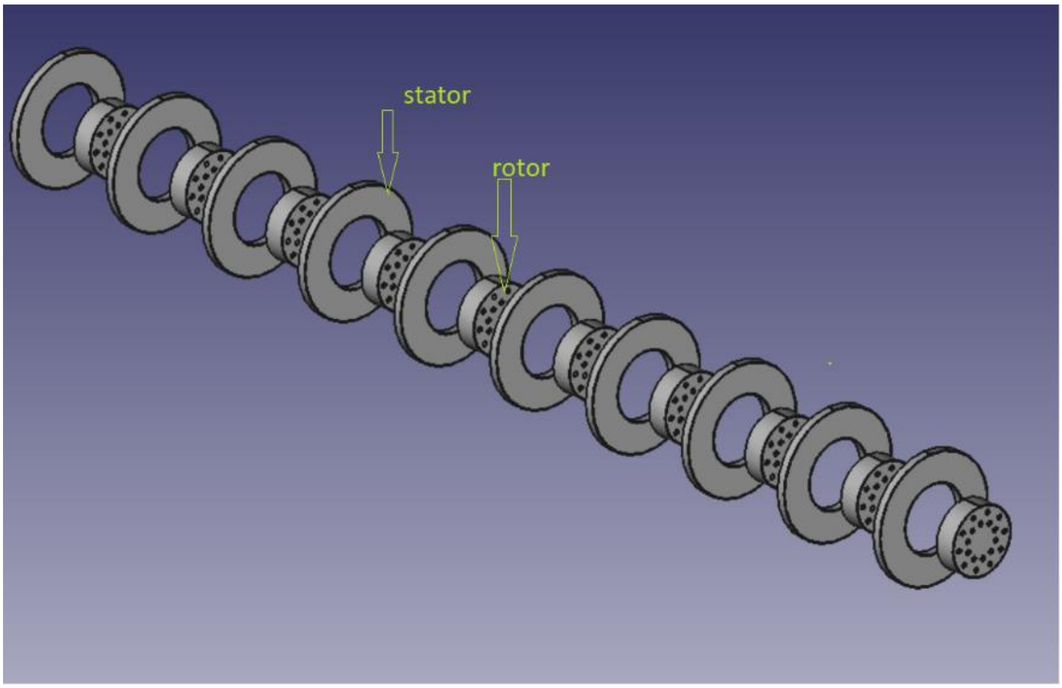


Figure 64 : stator (10 pieces) with rotor

Figure 65 :Distribution of rotors and stators

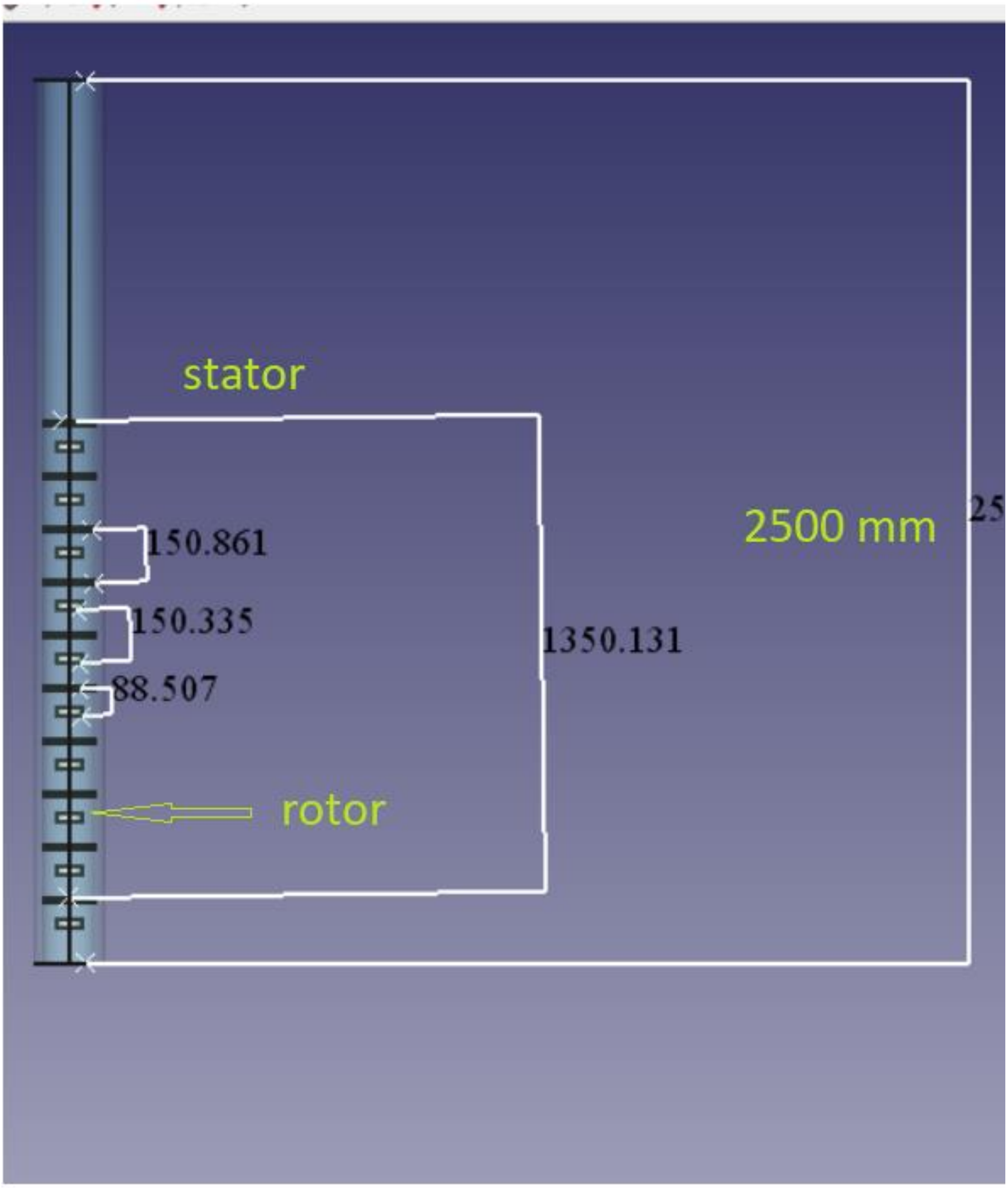
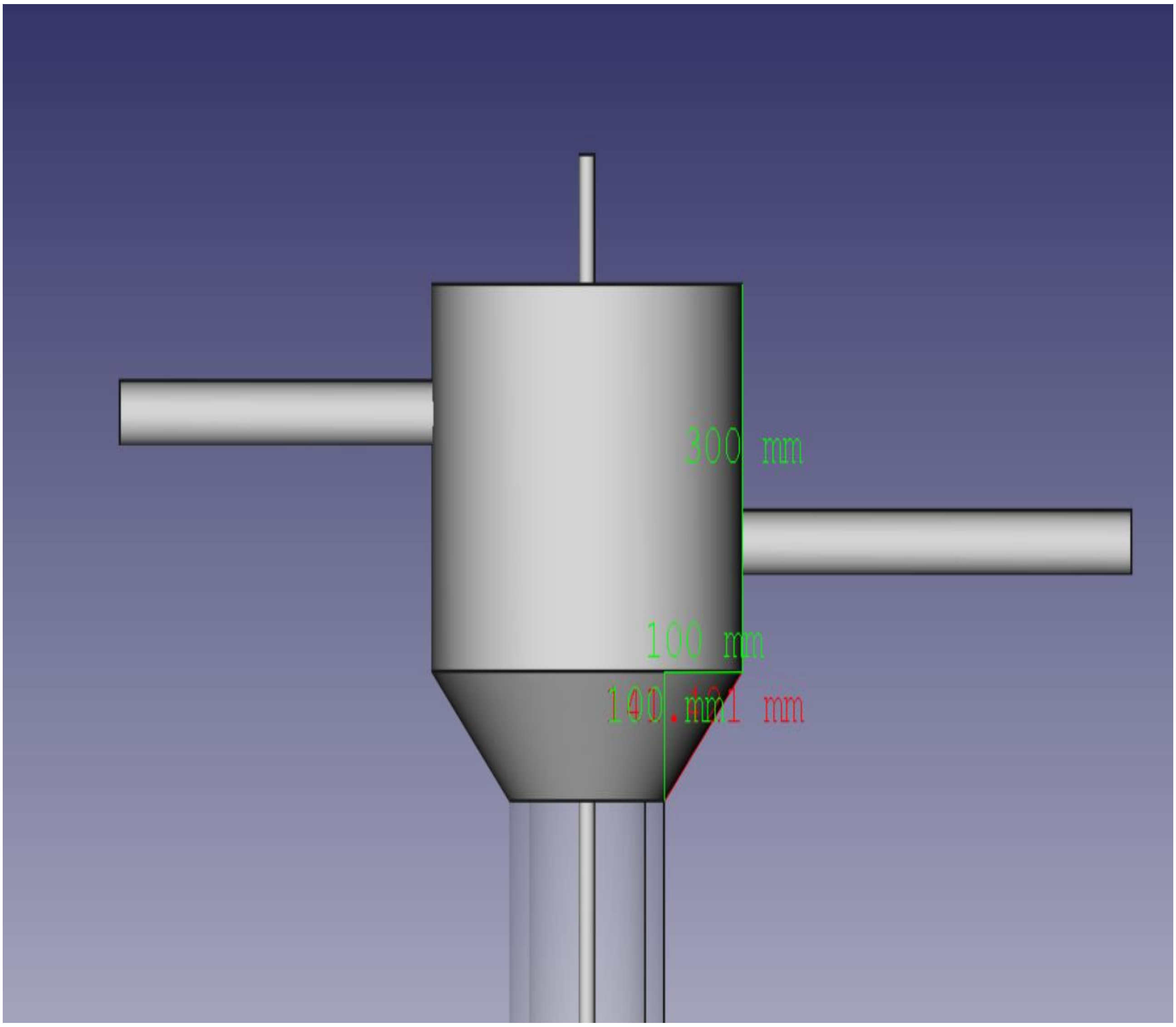


Figure 66 :Distribution of rotors and stators


300 mm
100 mm

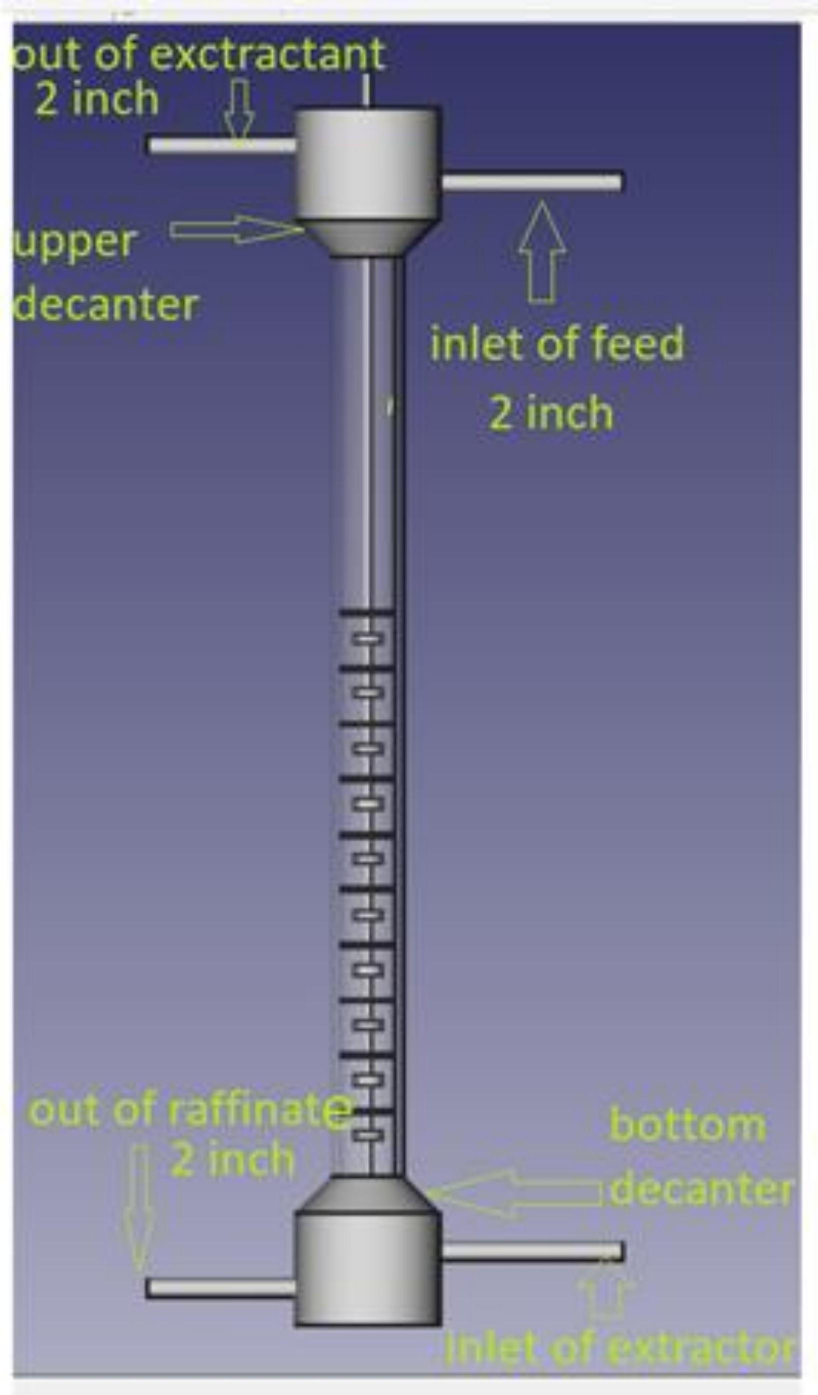


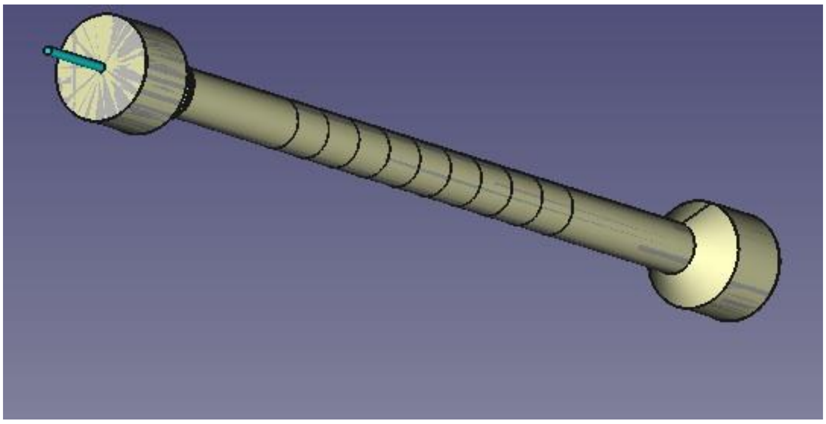
Figure 67 :upper and bottom decanter (200 mm of radius, height 300 mm

Cone r1=200mm, height 100 mm)

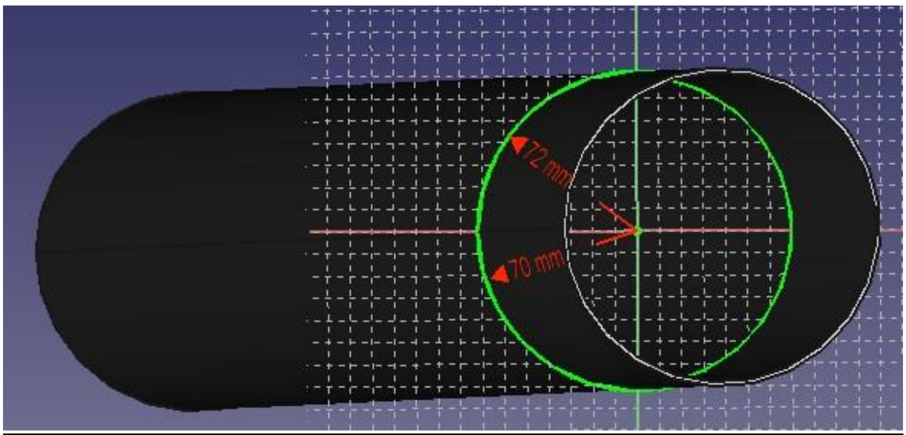
parts	Freecad files
Column	column06082018.FCStd
Rotation axis	column wih rotation axis140818.FCStd
Stator	stator 06082018.FCStd
rotor	rotor 06082018.FCStd
System	FINAL DESIGN OF COLUMN140818.FCStd

Table 18 :list of parts that formed a system of extraction

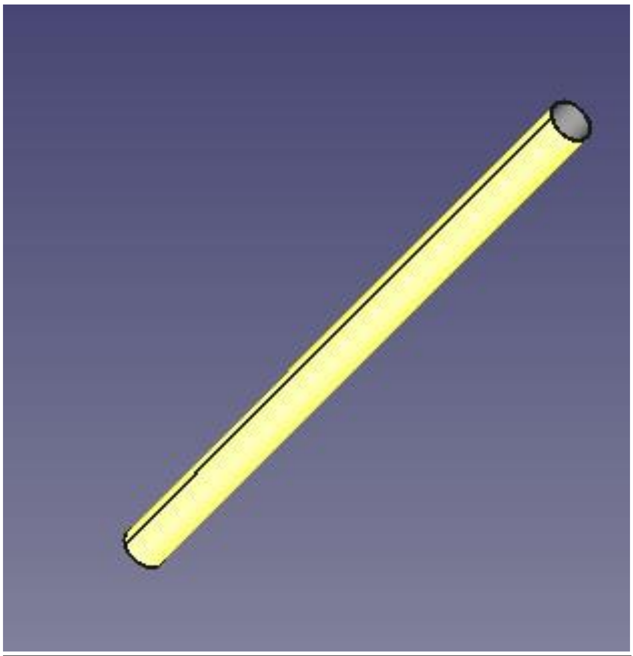
17.2.5.8 The Coulumn:



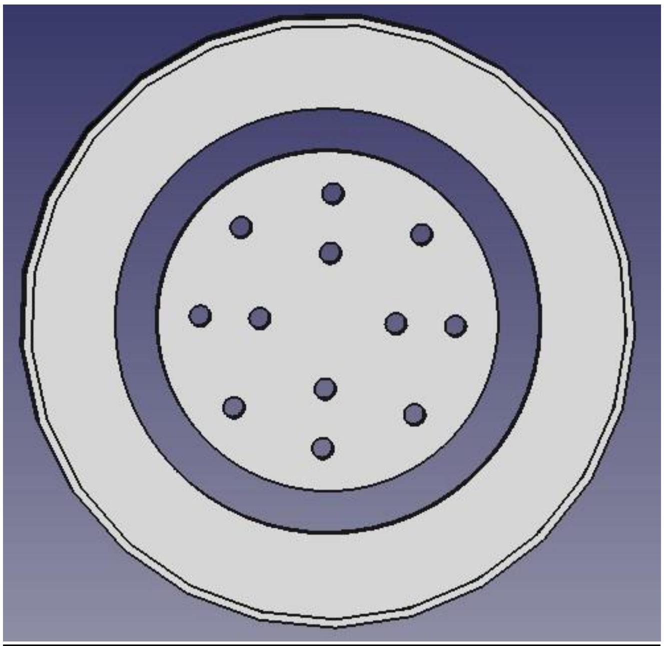
total height: 310 cm

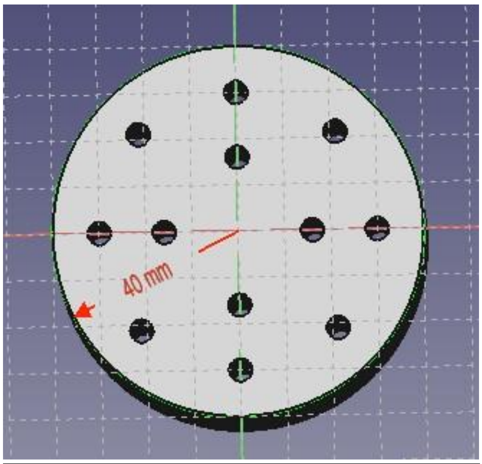


Diameter: 14 cm

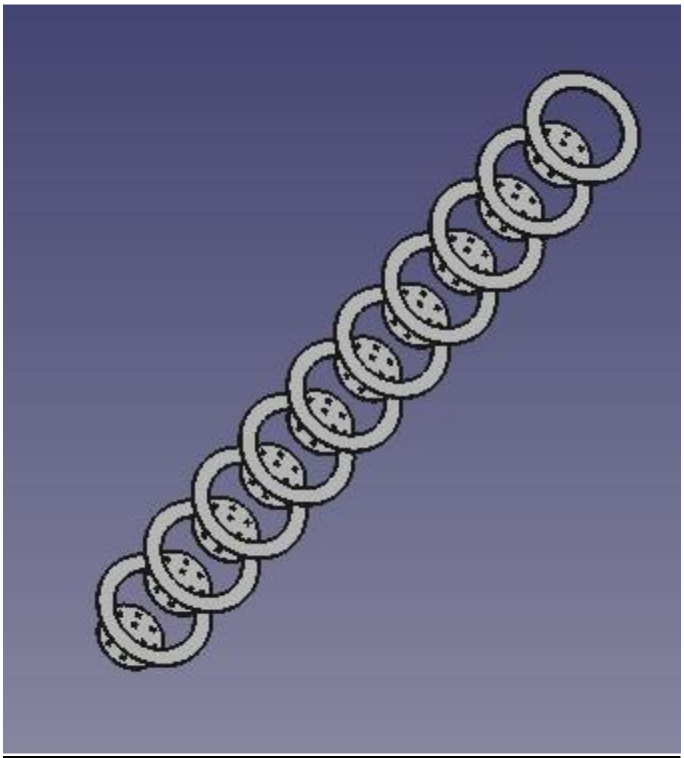


height: 250 cm



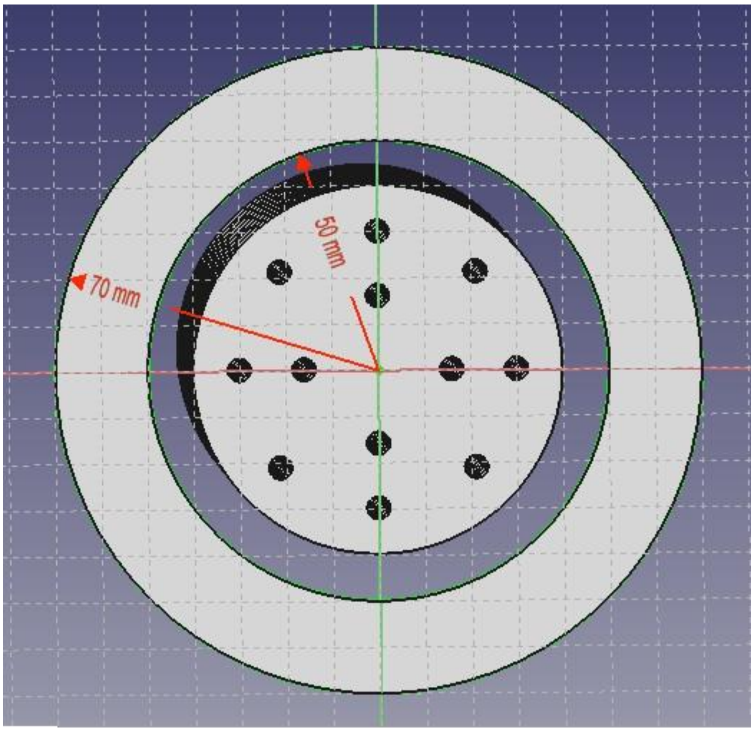


Diameter: 8 cm



thickness: 2 mm

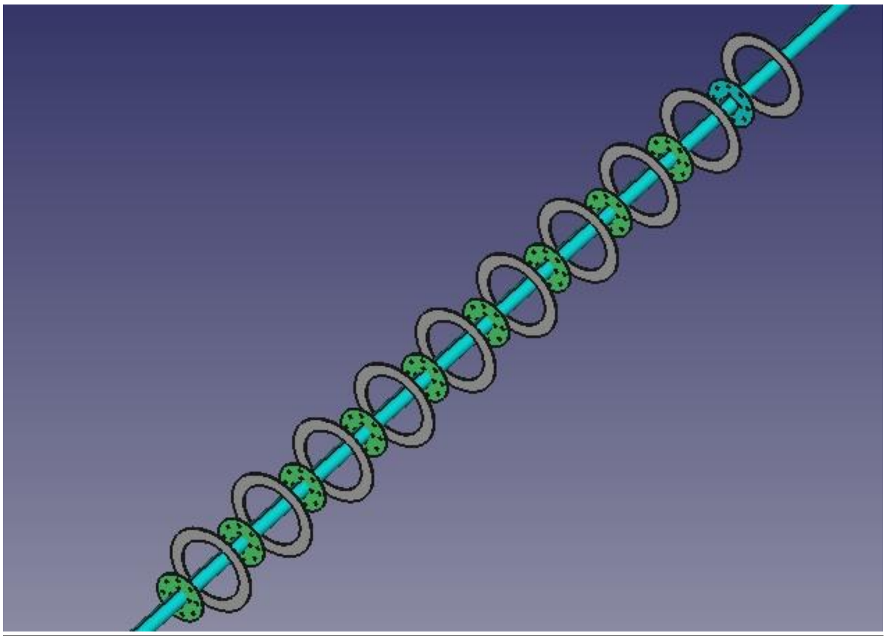
number of disques: 10

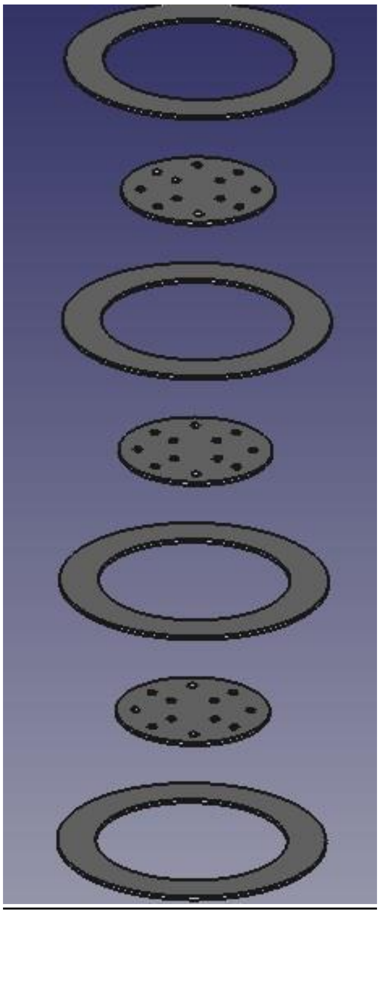


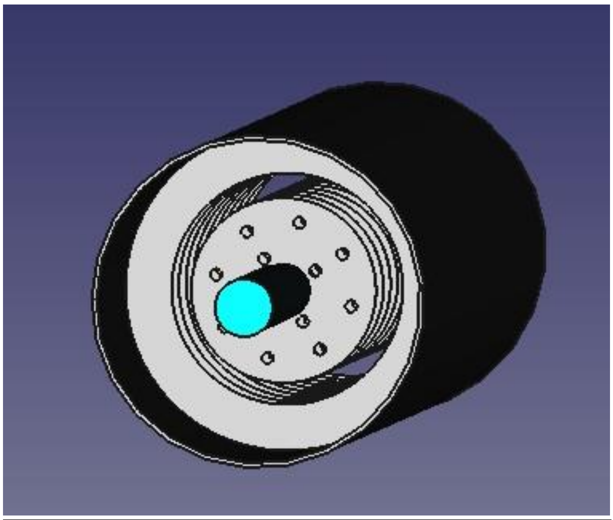
diameter 1 : 10 cm

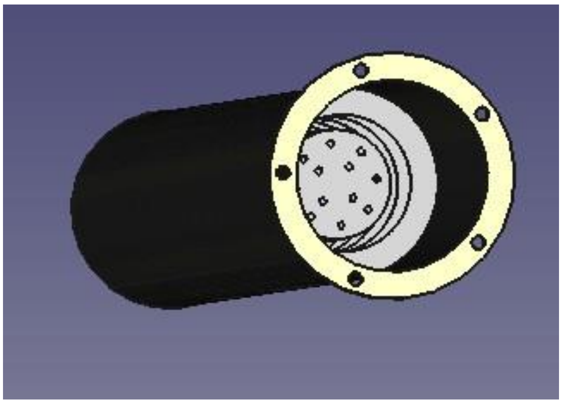
diameter 2 : 14 cm

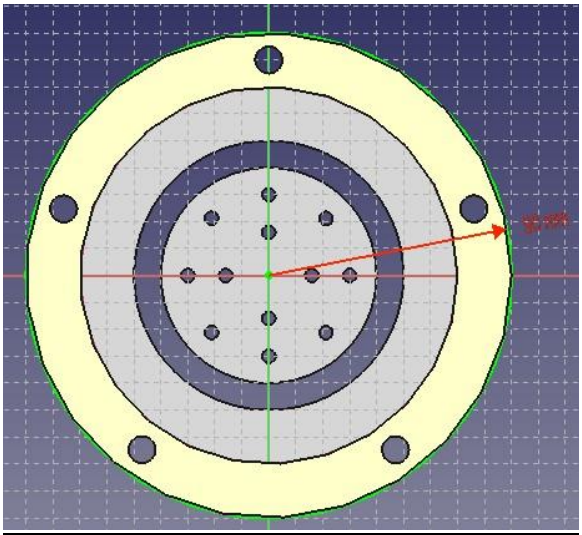
axe: height: 350 cm



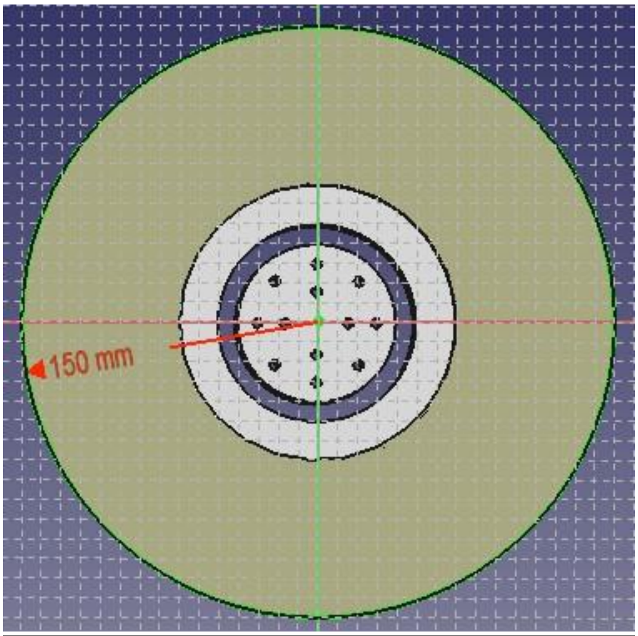


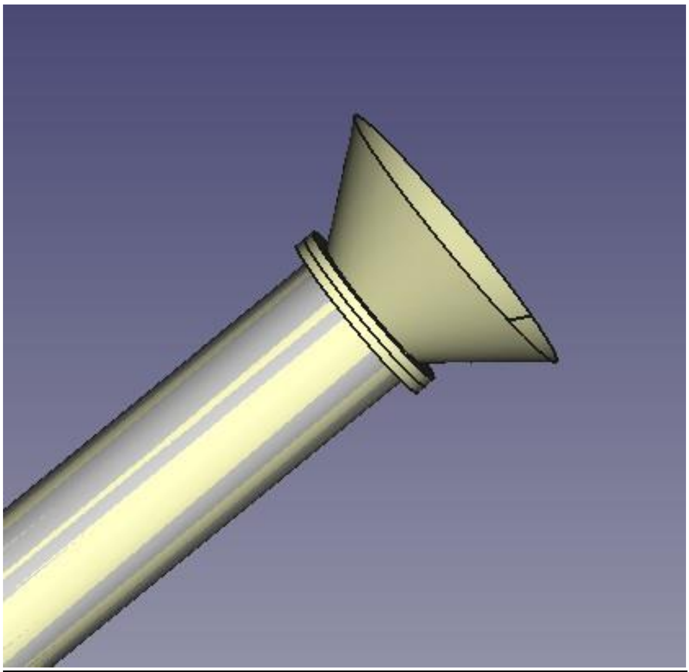






diameter: 18 cm

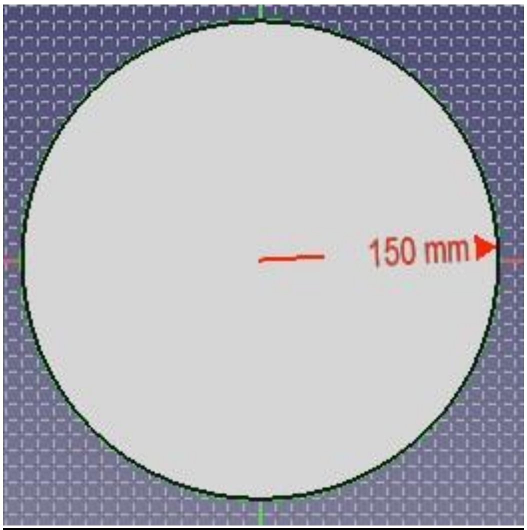




diameter 1 ; 14 cm

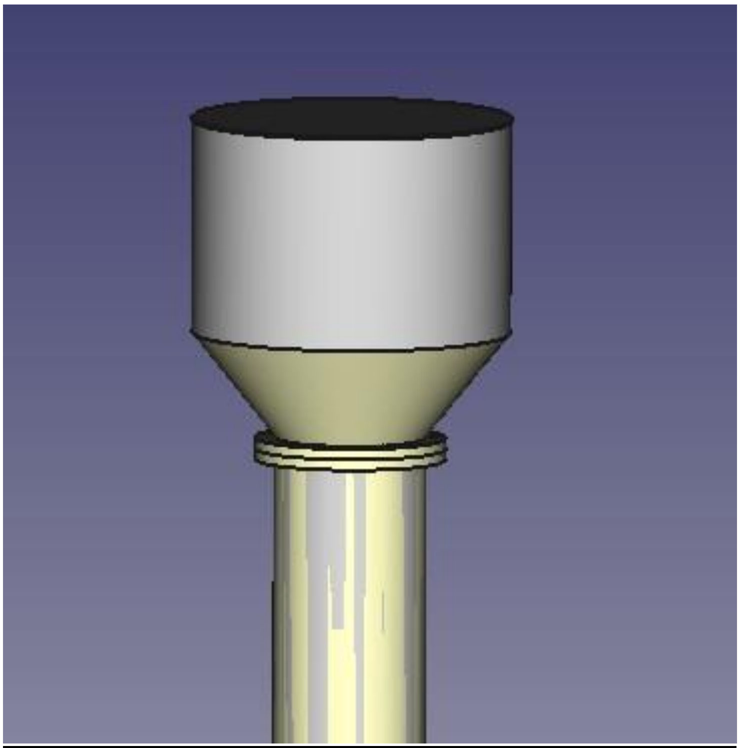
diameter 2 : 30 cm

height: 10 c m



diameter: 30 cm

height : 20 cm



thickness:2mm

Manufacturing


P204

18 Heavy Metals Recycling Unit (for Cu, Zn, As, Hg, Cd, Cr, Ni, Pb) for 0,8 tons of waste per hour (for 2 MW incineration power plant)

Table of figures

In order to built a complete system of heavy metals recovery , we deliver this document to indicate the process used ,operation,instruments and their cost.

18.1 Introduction

Waste-to-energy is an environmentally sound method for reducing the mass and volume of non-recyclable refuse that would otherwise require landfilling. Combustion typically reduces the volume of the refuse by 90% and reduces the solid mass by 70-80%. The resulting ash, while largely inert, can contain concentrations of heavy metals that require treatment in order to comply with regulations, meet standards for producing a usable product, and to provide for long-term stability of the metals when the ash is exposed in the environment. Heavy metals such as lead and cadmium can be toxic to biological systems when present in high enough concentrations.

The bottom ashes, produced by the industrial incinerators, are an essential secondary raw material resource which has been drawing attention to recover economically important metals.

18.1.1 Overview of the system of recycling

Fresh bottom ash samples from the burning incineratorswere collected and dried at 25°C. The unburnt parts such as the screw, wire, plastics were separated manually. Prior to leaching tests (discussed in the next section), the sample was reduced to a size of 500 microns with a roll crusher in order to remove the magnetic content (iron removal). the bottom ash samples (tailings and concentrates) were subjected to leaching tests in order to notice the amenability of the samples for metal recovery along with optimization ofnparameters. The step wise experimental procedure adopted is shown in Figure 1 and the following sections details the methodology. It is important to reduced the size to 500 microns with a roll crusher in order to remove the magnetic contents. the solution is leached and enteres in a series of column when the liquid mixes with a suitable liquid extractants to separate the metals from the solution.

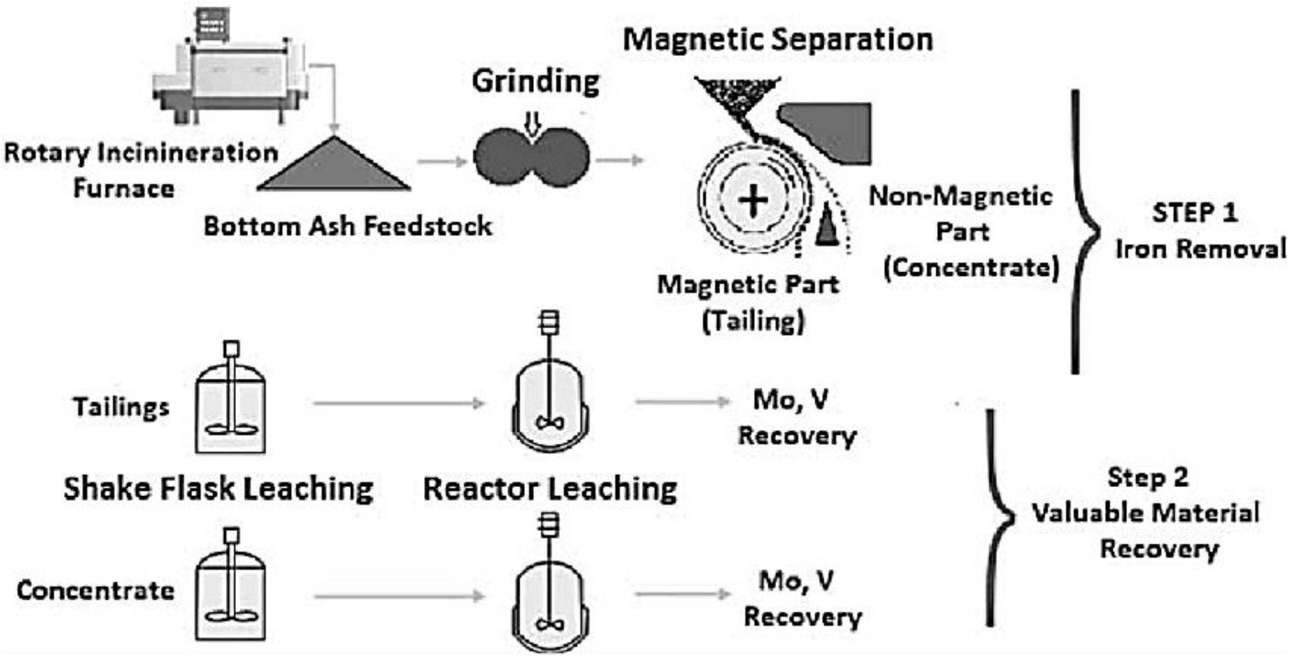


Figure 68: Stepwise experimental procedure adopted for leaching of bottom ash.

18.2 Technology of separation

18.2.1 Principle

Solvent extraction, or liquid-liquid extraction is a separation technique isothermal in a heterogeneous liquid medium.

The method is based on the existence of a difference in the solubility of a substance in two immiscible liquids. The process has three steps, as shown in Figure 1:

- Mixture of the two immiscible liquids, one of them containing the solute,

- Obtaining physico-chemical equilibrium, leading to demixing,

- Separation of the two new liquid phases obtained based on the difference of

densities.

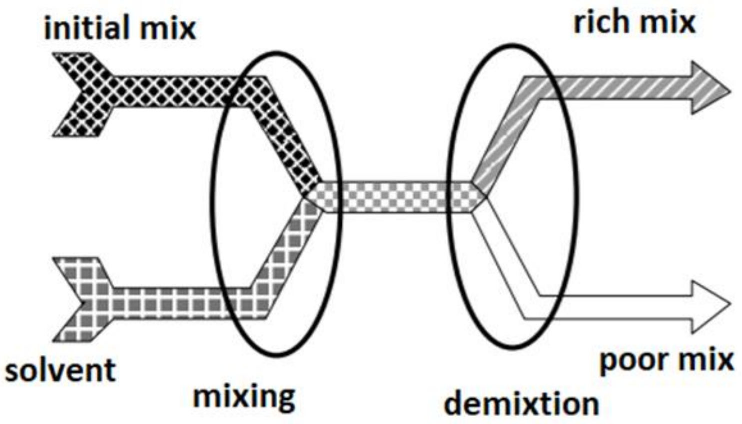


Figure 69: principle of a separation stage by obtaining a balance

Practically, the feed solution F containing solute B dissolved in the diluent A is contacted with the solvent S. The solute B, generally more soluble in the solvent than in the diluent, passes from the solution in the solvent, the solvent enriched in solute is the extract E while the diluent depleted solute is the residue (or raffinate) R.

The passage of solute B from diluent A in solvent S takes place as long as the equilibrium physico-chemical is not reached.

So that the driving force of transfer remains almost constant, the two liquids feeding the column flow against the current.

In order to transport the material as quickly as possible, the area of the transfer surface is increased by various artifices. These objectives can be obtained in a column.

18.2.1.1 The phase equilibrium of ternary mixtures

The partition coefficient

A substance B placed in contact with two partially miscible solvents or immiscible S and A is distributed unequally between the two phases that are formed when the physicochemical balance is reached. The ratio of B concentrations in these two phases is the partition coefficient m.

The ternary diagram

At equilibrium, these biphasic systems are trivariant. At pressure and temperature constants, they can be represented in a system of triangular axes. The equilateral triangle has the advantage of allowing an equivalent representation for all the constituents. The right triangle has the advantage of being able to expand the scale of one of the axes. It is often interesting to limit the plot to the "useful" part. Each vertex of the triangle represents a pure component. The solute content B, in solvent S and diluent A is expressed in mol%, mass, volume, etc ... and is obtained by a suitable projection on the axis chosen as shown in Figure 3.

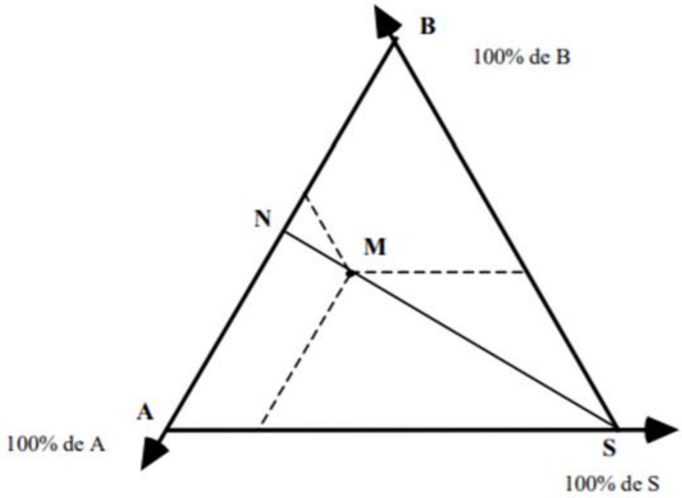


Figure 70:ternary diagram

It is easy to demonstrate that the quantity of S and the quantity of the mixture N are in a ratio of the lengths of the MN and MS segments (rule of the lever arm) and that the quantities of two components are in the ratio of projections of the segments on the binary axis corresponding.

Conversely, if the mixture N is added a mass of solvent S, the ternary mixture result is represented by the point M on the line NS such that:

(mass of N)/(mass of S)=MS/MN

The demixtion

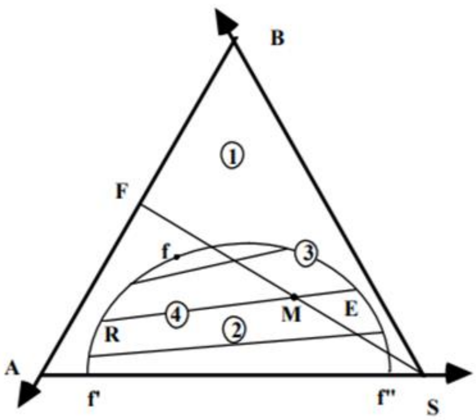


Figure 71:Isothermal and isobaric demixing curve.

In a ternary system with limited mutual solubility zone (1) stable states,

characterized by a complete miscibility, is separated from the zone (2) unstable states constituting the miscibility gap or diphasic zone, by the solubility isotherm (3) or line "Critical" or demixing curve or equilibrium curve or saturation curve.

Within the miscibility gap, no mixture can exist indefinitely:

any system whose overall composition is represented by point M is divided into two composition phases R and E, points at the intersection of the equilibrium line (4) or conodal RME and the demixing curve f'ff ". At the critical point f the two phases in balance have the same composition.

Solvent separation

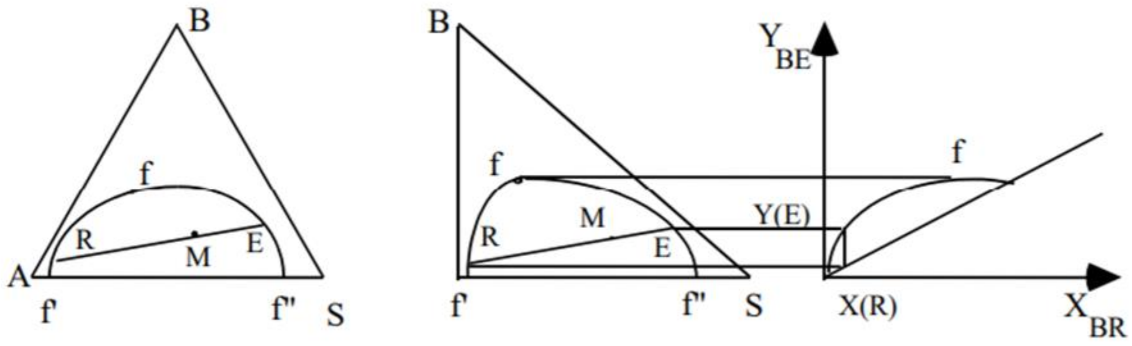


Figure 72:Representation of a ternary system with limited miscibility

In the zone of total miscibility no separation can take place. However, if starting from an initial mixture F, by the addition of the solvent S, a system whose composition is global M lies within the miscibility gap, which separates into two phases R and E. Phase R, rich in diluent A is the raffinate, while phase E, rich in solvent S, constitutes the extract.

In general, the concentration of solute B in the raffinate is designated by x and in the extract by y. It is then possible to draw the distribution curve or equilibrium curve which represents y in terms of x.

18.2.2 Rotating discs column (RDC)

In a rotating discs column (RDC-column) the central shaft equipped with fixed discs is rotating. In addition to that annular rings, so called stators are placed on the inside of the column always in the middle of the distance between two discs. These stators can either be made of metal and inserted into the column or can be integrated in column made of borosilicate glass. The discs have a smaller diameter than inner diameter of the stators so that the shaft can be easily dismantled. Diameters and distances have to be adapted to the process. During operation only the rotating speed can be altered beside the throughput.(https://www.dedietrich.com/en/solutions-and-products/extraction/liquid/liquid-extraction/extraction-columns

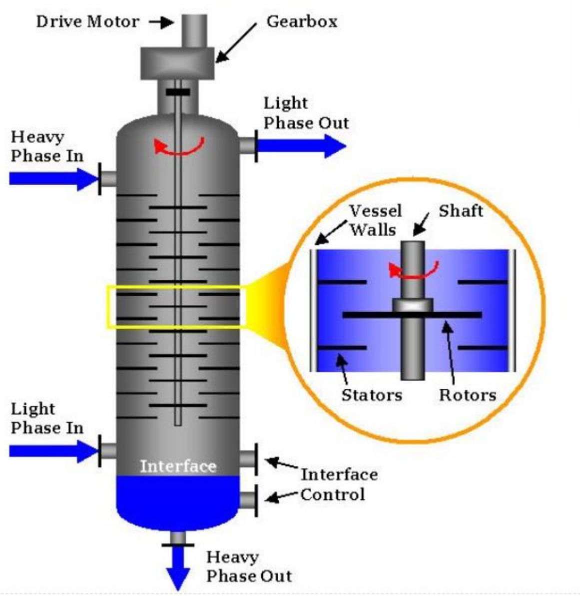


Figure 73: RDC column (https://kochmodular.com/liquid-liquid-extraction/extraction-column-types/rdc/)

18.2.3 Quantities of heavy metals in ashes from different plants

18.2.3.1 Fly ash

Authors Type	[10] FA	[33] FA	[34] FA	[35] FA	[36] FA
Ag	31–95	ND–700	N/A	N/A	N/A
As	31–95	15–751	N/A	93	N/A
Ba	920–1,800	88–9,001	N/A	4,300	539
Cd	250–450	5–2211	25.5	470	95
Co	29–69	2.3–1,671	N/A	N/A	14
Cr	140–530	21–1,901	118	863	72
Cu	860–1,400	187–2,381	313	1,300	570
Hg	0.8–7	0.9–73	52	N/A	N/A
Mn	0.8–1.7	171–8,500	N/A	1,600	309
Ni	95–240	10–1,970	60.8	124	22
Pb	7,400–19,000	200–2,600	1496	10,900	2,000
Se	6.1–31	0.48–16	N/A	41	N/A
Zn	19,000–41,000	2,800–152,000	4,386	25,800	6,288
Sn	1,400–1,900	N/A	N/A	N/A	N/A
Sr	80–250	N/A	N/A	433	151
V	32–150	N/A	N/A	37	N/A

18.2.3.2 Bottom ash

Authors	[37]	[33]	[38]	[31]	[39]
Type	BA	BA	BA	BA	BA
Ag	4.1–14	2–38	8.5–10.7	N/A	N/A
As	19–80	1.3–45	209–227	160	13
Ba	900–2,700	47–2,000	1,104–1,166	N/A	N/A
Cd	1.4–40	0.3–61	6.8–7.8	110	3
Co	<10–40	22–706	49.6–53.1	N/A	N/A
Cr	230–600	13–1,400	323–439	260	900
Cu	900–4,800	80–10,700	4,139–4,474	N/A	500
Hg	<0.01–3	0.003–2	N/A	N/A	2.6
Mn	<0.7–1.7	50–3,100	869–894	N/A	280
Ni	60–190	9–430	216–242	N/A	180
Pb	1,300–5,400	98–6,500	2,474–2,807	N/A	2,700
Se	0.6–8	ND–3.4	230–265	130	N/A
Zn	1,800–6,200	200–12,400	4,261–4,535	N/A	600
Sn	<100–1,300	N/A	N/A	840	960
Sr	170–350	N/A	N/A	N/A	N/A
V	36–90	N/A	N/A	N/A	N/A

Figure 75: Heavy metals found in MSWI bottom ash (BA) (mg/kg).

18.2.4 Extractants (light phase)

Many heavy metlas are essentil trac elements for humans,animals and plamt in small amounts.

In larger amounts cause acute and chronic toxicity. There are Linked to learning disabilities,cancers and even death .Some of this metals are :**As, Cd, Cr, Hg, Ni, Pb, Zn, Cu.** At low pH, i.e. below 3 there is high release of Cu, Mn, Zn, Al, Fe but as the pH is increased the major metals Al, Fe and Si are usually less soluble.

Metals	**Extractants**
As	Phosphoric Acid (cyanex273)
Cd	Chloride solution - cyanex273
Cr	nitrilotriacetic acid (NTA)- Sulfuric acid, Hydrochloric acid, Nitric acid were at 500^{0}C and the range of extraction is from 263 to 222 mg/L. All of them were of industrial grades.
Ni	Versatic acid - cyanex 923 and cyanex 272 (Bis(2,4,4-trimethylpentyl)phosphinic acid)

Pb	Chloride solution- Cyanex 272(Bis(2,4,4-trimethylpentyl)phosphinic acid)
Zn (Nitric acid 0.6-3M)/ pH= 4	Phosphonic acid (cyanex273 is the best) – tri octyl phosphine oxide (cyanex 921) and Tributyl phosphate (TBP) dissolved in kerosene. - EDTA
Cu	- LIX® 984N (mixture of 2-hydroxy-5-nonylacetophenone oxime and 5-nonylsalicylaldoxime in a high flash diluent), - Acorga® M5640, - LIX® 622N) – - **Cupromex-3302** the maximum net transfer of copper will be about 10g/l,ph=1.2. - ethylendiaminetetraacetate (EDTA), or diethylenetriaminepentaacetate (DTPA) with concentration 3.0% at the pH range 3-9.
Hg (liquid at ordinary temperature)	- Chloroform (OAP,Ph=9.5) - By Cyanex 301 (Bis(2,4,4-trimethylpentyl)dithiophosphinic acid) and cyanex 302(Bis(2,4,4-trimethylpentyl)thiophosphinic acid) from hydrochloric acid media

18.2.4.1 Leaching tests

The prewashed sample was vacuum dried at 75°C over-night and subjected to acid leaching tests. Typically,1.00 g of the prewashed sample of fly ash was mixed with different weights of solid citric acid in 50 ml deionized water while the pH was kept constant at a selected value by adjusting with concentrated HNO_3 or NaOH solution.The effect of citric acid concentration was examined in the concentration range from 0.01 to 0.40 M (=mol/L),and the effect of liquid/solid ratio was examined at 10:1,20:1, and 50:1 (ml:g). After stirring for 1 h, the suspension was filtered and the clear solution was sent for heavy metal content analysis by means of ICP/AES. The leaching time was varied from 5 to 250 min, and the temperature was also varied from 25°C to 60°C for examination of the temperature effect. Nitric acid, sulfuric acid, hydrochloric acid, DL-malic acid, oxalic acid, and acetic acid were also examined to compare their leaching performance.

Table 6 Comparison of extraction of elements by different acids (%) (liquid/solid ratio 40:1 ml/g, concentration of organic acid 0.1 M, temperature 25°C, leaching time 60 min)

Leaching reagent	Final pH	Al	Ca	Fe	Cu	Zn	Pb
Citric acid	3.13	100	93.1	67.0	100	100	96.9
Malic acid	3.07	99.7	100	80.2	100	100	97.0
Acetic acid	3.02	88.4	100	23.2	100	100	70.1
Lactic acid	3.06	92.2	100	40.7	100	100	62.0
Oxalic acid	3.09	43.3	0.41	46.5	45.8	44.9	2.7
Tartaric acid	2.98	30.3	6.7	24.4	32.7	35.7	4.0
Sulfuric acid	3.03	44.2	100	5.8	52.4	57.9	28.3
Hydrochloric acid	3.10	42.5	100	2.9	50.2	54.3	14.8
Nitric acid	3.01	41.6	100	2.2	52.8	56.9	25.3

Experimental conditions of leaching (preliminary and main)

Sample	Bottom Ash Concentrate Bottom Ash Tailings
Parameters	**Experimental Conditions**
Acidic/Basic Concentration	1M HCl 3M H_2SO_4 6M NaOH
Sample Ratio (S/L) (Constant)	1:5
Mixing Rate (Constant)	170 rpm
Leaching Time (Constant)	24 h
Temperature (Constant)	25°C

Figure 76: Experimental conditions of preliminary leaching tests.

Sample	Bottom Ash Concentrate Bottom Ash Tailings
Parameters	**Experimental Conditions**
Reagent Concentration	H_2SO_4 1M, 2M, 3M, 4M HCl 1M, 2M, 3M NaOH 3M, 6M, 9M
Sample Ratio (S/L)	1:50/1:25/1:10/1:5
Temperature (°C)	25
Leaching Time (h)	2, 4

Figure 77: Experimental conditions of main leaching test

Note :6 M = 6mol/L

18.2.5 Fly ash

A portion of the fly ash was prewashed with distilled water.A 10-g sample of dried fly ash as-received was mixed together with distilled water at varying liquid/solid ratios[5–50:1 (ml:g)] in a beaker and stirred at room temperature of around 25°C. The suspension was sampled at different time intervals up to 16 h. After vacuum filtration, the metallic elements in the leachate were analyzed by using the ICP/AES spectrometre.

Table 1 Concentration of metal ions (mg/L) and pH in water after varying times of water washing (liquid/solid ratio 5:1 ml/g)

	5 min	10 min	30 min	1 h	2 h	16 h
pH	12.25	12.26	12.23	12.23	12.22	12.26
Na	7.99×10^3	8.09×10^3	6.77×10^3	5.68×10^3	5.05×10^3	4.81×10^3
K	1.92×10^3	1.44×10^3	1.77×10^3	1.46×10^3	1.13×10^3	1.33×10^3
Ca	5.23×10^3	5.23×10^3	4.72×10^3	4.29×10^3	3.87×10^3	2.79×10^3
Mg	0	0	0	0	0	0
Al	3.58	3.41	2.86	2.53	2.58	2.34
Zn	2.31	1.87	0.98	0.33	0	0
Pb	37.91	44.22	25.32	14.19	4.51	0.40
P	1.29	1.31	1.29	1.09	1.09	0.92
Cu	0	0.043	0.017	0	0	0
Fe	0	0.11	0	0	0	0

Table 2 Concentration of metal ions (mg/L) and pH in water after varying times of water washing (liquid/solid ratio 10:1 ml/g)

	5 min	10 min	30 min	1 h	2 h	16 h
pH	12.27	12.29	12.31	12.29	12.27	12.33
Na	3.93×10^3	3.86×10^3	3.69×10^3	3.50×10^3	3.36×10^3	3.31×10^3
K	0.85×10^3	0.54×10^3	0.73×10^3	0.81×10^3	0.48×10^3	0.42×10^3
Ca	3.37×10^3	3.39×10^3	3.27×10^3	3.20×10^3	3.03×10^3	2.58×10^3
Mg	0	0	0	0	0	0
Al	2.28	2.29	2.67	2.27	1.98	1.32
Zn	1.76	0.68	0.23	0.29	0	0
Pb	12.00	8.14	5.74	11.44	4.00	2.77
P	1.29	0.92	0.93	0.91	0.89	0.83
Cu	0	0	0	0	0	0
Fe	0	0	1.77	1.45	0	0

Table 3 Concentration of metal ions (mg/L) and pH in water after varying times of water washing (liquid/solid ratio 20:1 ml/g)

	5 min	10 min	30 min	1 h	2 h	16 h
pH	12.37	12.41	12.42	12.39	12.35	12.39
Na	1.95×10^3	1.96×10^3	1.90×10^3	1.89×10^3	1.87×10^3	1.91×10^3
K	0.66×10^3	0.63×10^3	0.54×10^3	0.68×10^3	0.56×10^3	0.67×10^3
Ca	2.29×10^3	2.22×10^3	2.20×10^3	2.23×10^3	2.15×10^3	2.10×10^3
Mg	0	0	0	0	0	0
Al	2.47	1.43	1.39	1.62	1.55	1.29
Zn	2.13	0.34	0	0	0	0
Pb	5.77	3.12	0.84	0.88	0.91	0.78
P	0.76	0.74	0.77	0.76	0.74	0.70
Cu	0	0	0	0	0	0
Fe	0	0	0	0	0	0

18.2.6 Recovery of Copper (Cu)

Copper is widely used because it has several essential properties for different technological applications, such as applications in electrical materials and construction, transportation and industrial machinery parts, petroleum refining and brass manufacture.

In view of the industrial and economic importance of this metal, there is a great need to separate and recover copper ions using cost effective commercial extractants. Literature review indicates that **hydroxyoximes** are now used widely as extractants for copper . The extraction of copper from aqueous sulfate solution with new extractant Cupromex-3302 (active substance is the 5-nonylsalicylaldoxime) using a rotating disc contactor (RDC) was investigated. It was observed from batch experiments that the best results were obtained with the initial aqueous pH and concentration of Cupromex-3302 of 1.9 and 10% (v/v) respectively.

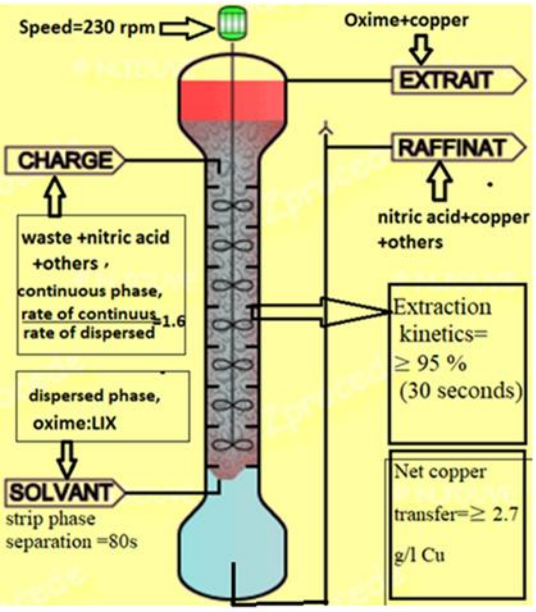


Figure 78:process of separation of copper

The maximum extraction efficiency was equal to 87.44% when the values of rotor speed, Qc and Qd were 375 rpm, 1.83×10^{-6} m³/ *s* and 2.33×10^{-6} m³ /s respectively. With

- Qc: continuous phase flow rate,
- Qd:dispersed phase flow rate.

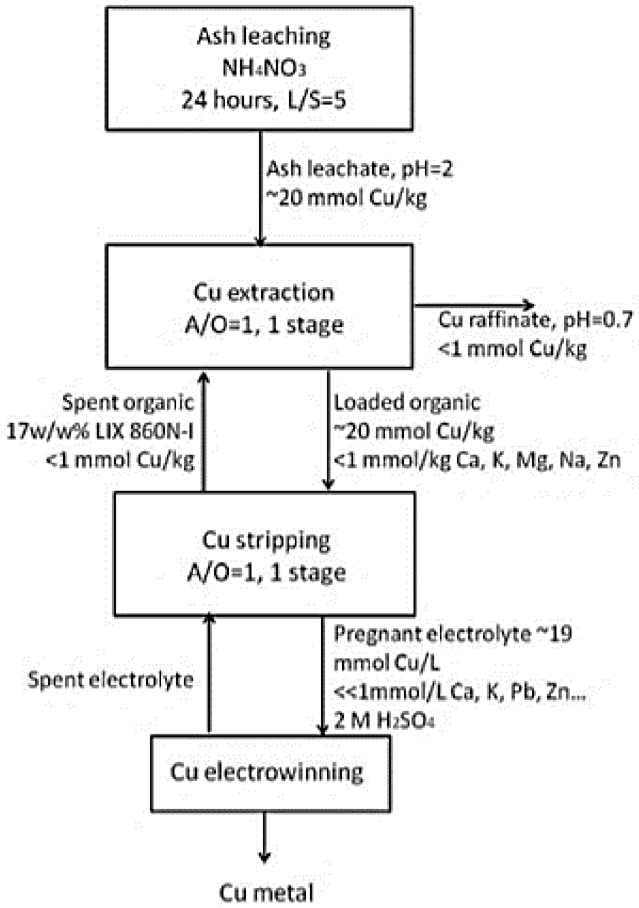


Figure 79: Flow sheet of the proposed recovery method developed for Cu from fly ash

18.2.7 Recovery of zinc

Nitric acid 0.6-3M was used for the ash leaching. The solvent extraction of Zn(II) from acid leachates was carried out using three extraction ligands that have been reported in the literature to be effective in separation of Zn from other metal ions in acid solutions. The ligands used were di-(2,4,4- tri methylpentyl) phosphinic acid (CYANEX 272), tri octyl phosphine oxide (CYANEX 921) and Tributyl phosphate (TBP) dissolved in kerosene and the extractions were carried out at initial pH 2, 3, 4 and 5. A special problem in these extractions is the separation between Zn(II) and Fe(III) from ash leachates. Leaching at pH 4 gives the lowest levels of iron in the leachate and may thus be a good starting point for the solvent extraction step since all tested ligands bind Fe(III) as well as Zn(II). CYANEX 272 gave the best results extracting about 90% of the Zn(II) in the ash leachates to the organic phase. For the fly ash leachate a ligand concentration of 30 vol% in kerosene was needed and for the bottom ash leachate the corresponding concentration was 20 vol%. The other two ligands gave significantly lower extraction results. Literature data indicate that their performance can be much better in a chloride rich media. Thus, they can be interesting to test if ash is leached with hydro chloric acid instead of nitric acid. Based on the results CYANEX 272 is indicated as a suitable extractant for the recovery of zinc from MSWI plant ashes.

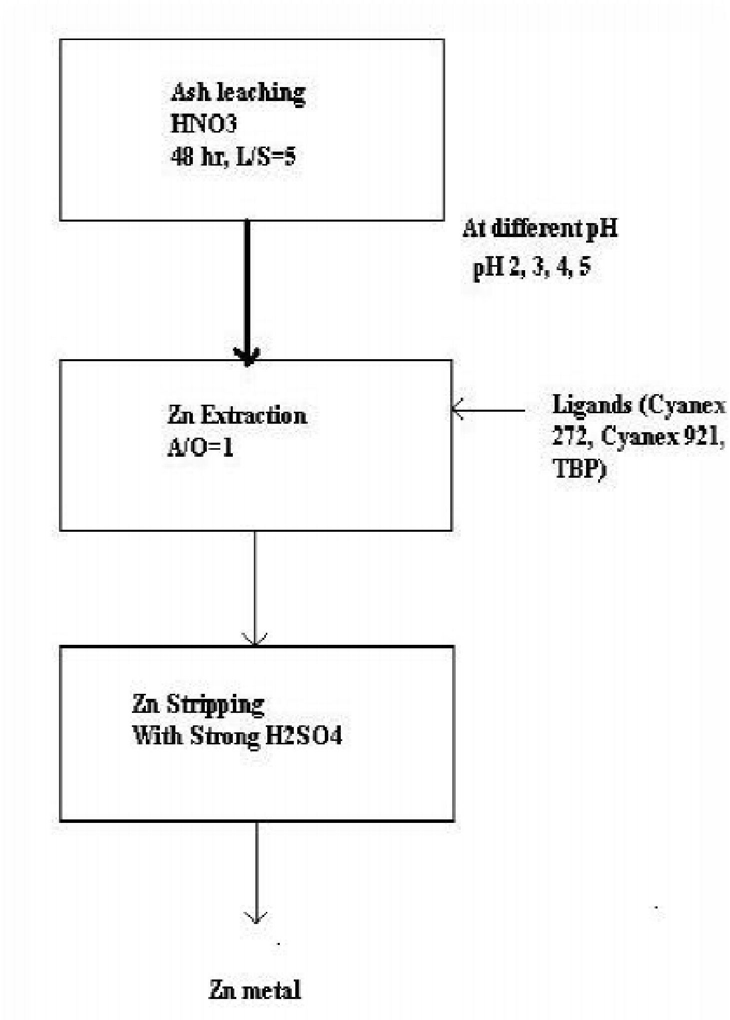


Figure 80:process flow chart

18.2.8 Zinc and copper recovery by Cyanex 272

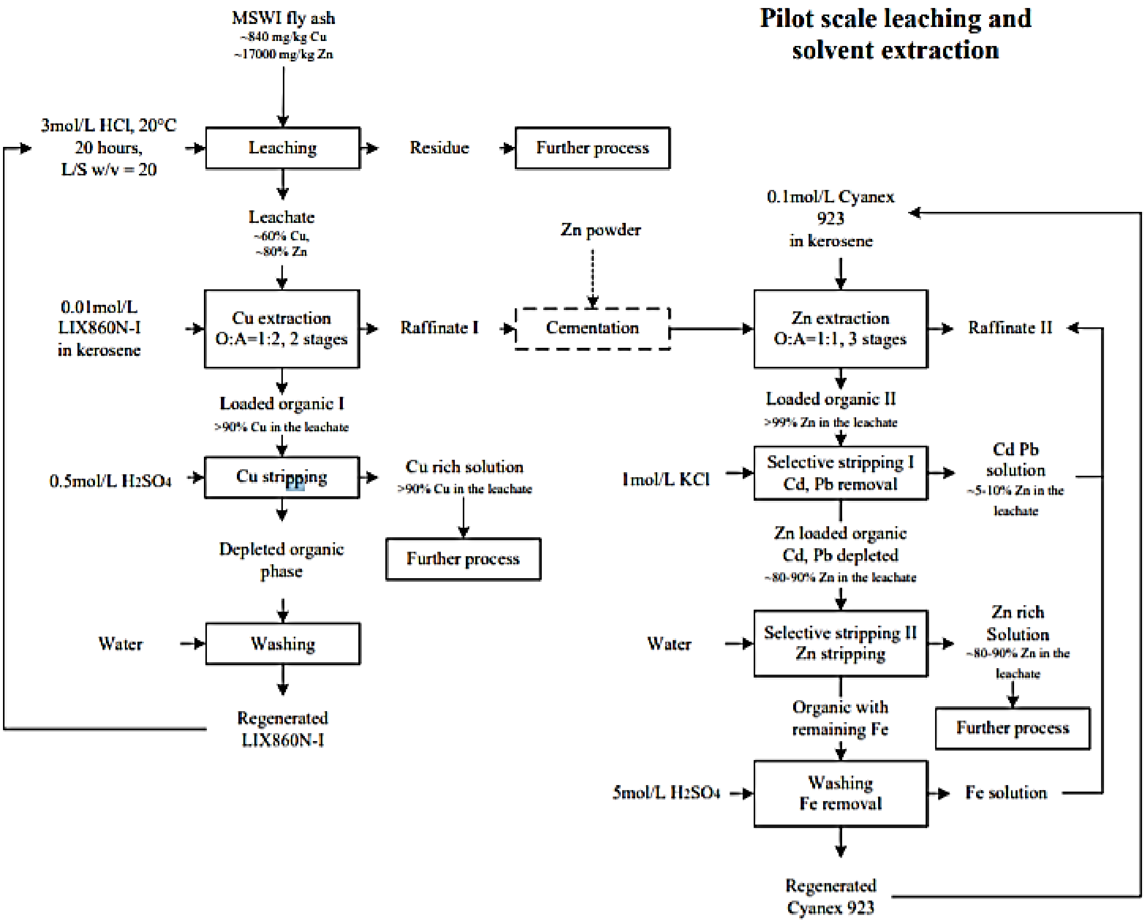


Figure 81: . Mass flowscheme of the leaching-extraction process

18.2.9 Efficiency of leaching

Element	Solution type and metal concentration (mg/L)				
	Leachate	Raffinate I (Cu extraction)	Stripping product I (Cu extraction)	Raffinate II (Zn extraction)	Stripping product II (Zn extraction)
Al	1,089.3	1,090 ± 12.9	nd	1,093 ± 4.2	nd
Ca	4,570	4,582 ± 23	nd	4,582 ± 14	nd
Cd	1.9	1.9 ± 0.0	nd	1.4 ± 0.0	nd
Cr	3.5	3.5 ± 0.0	nd	3.5 ± 0.0	nd
Cu	24.3	1.9 ± 0.1	43.6 ± 0.3	1.9 ± 0.0	nd
Fe	83.2	82.5 ± 1.0	nd	8.1 ± 0.2	0.1 ± 0.0
K	1,030	1,036.3 ± 16.0	nd	1,037.1 ± 5.7	nd
Mg	686.5	687.5 ± 9.2	nd	688.0 ± 6.4	nd
Mn	27.2	27.3 ± 0.9	nd	27.5 ± 0.1	nd
Na	1,290	1,300 ± 7.7	nd	1,300.2 ± 9.3	nd
Pb	45.2	45.2 ± 0.9	nd	19.6 ± 0.7	nd
Ti	nd	nd	nd	nd	nd
Zn	680.3	679 ± 8.1	nd	3.7 ± 0.1	613.9 ± 3.3

Figure 82: Concentration of metals at each stage: after leaching, in the raffinates after copper and zinc extraction, as well as in the stripping products. nd = not detected.

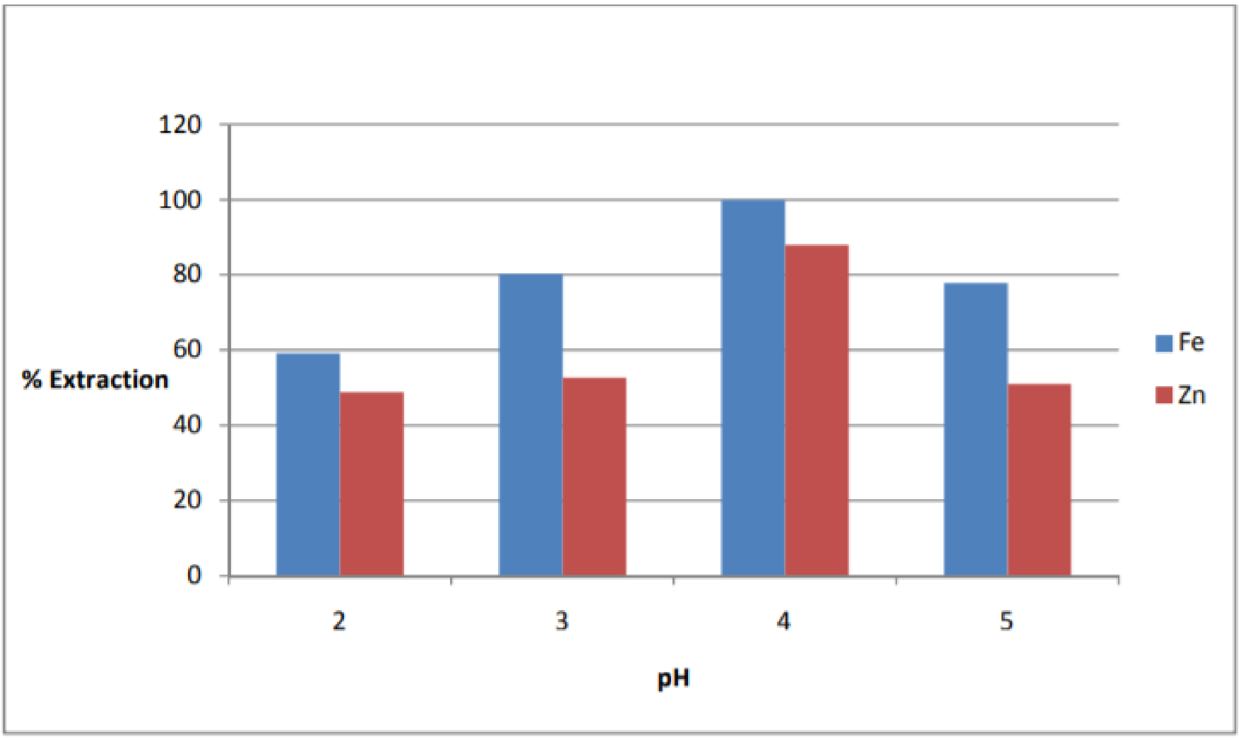


Figure 83: Percentage Extraction of Zn and Fe with 30 vol % Cyanex 272 from bottom ash leachates

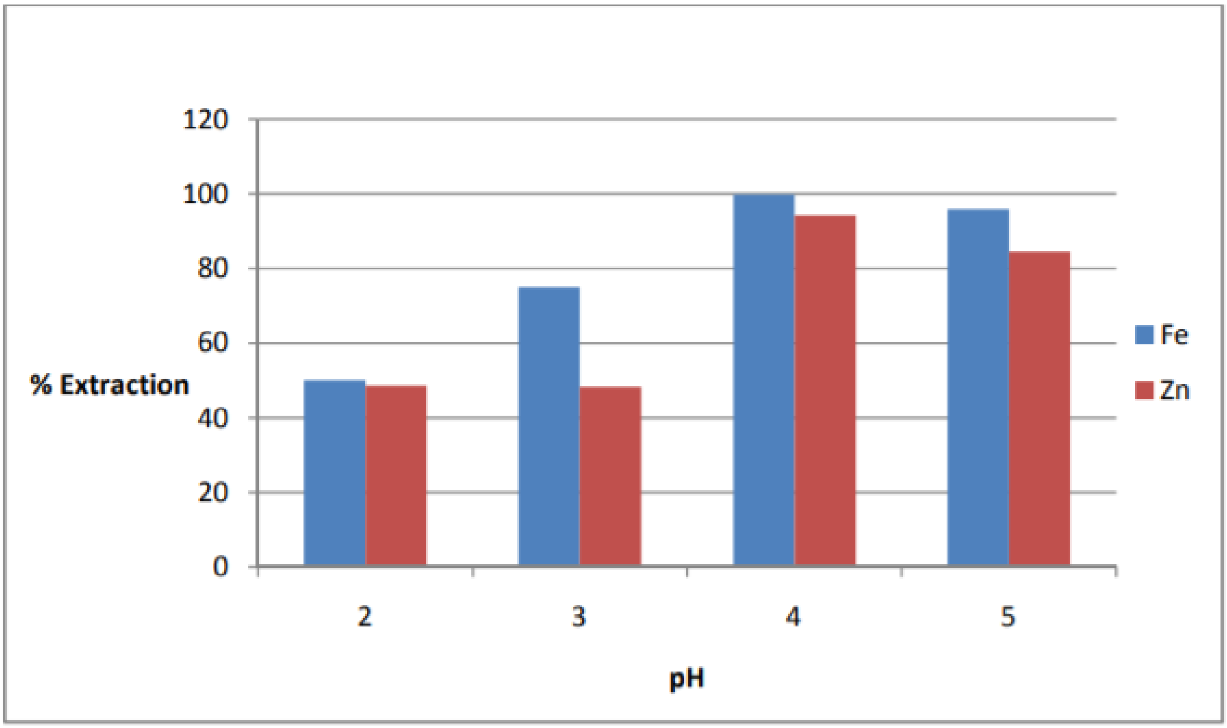


Figure 84: : Percentage extraction of Zn and Fe with 20 vol % Cyanex 272 from bottom ash leachates

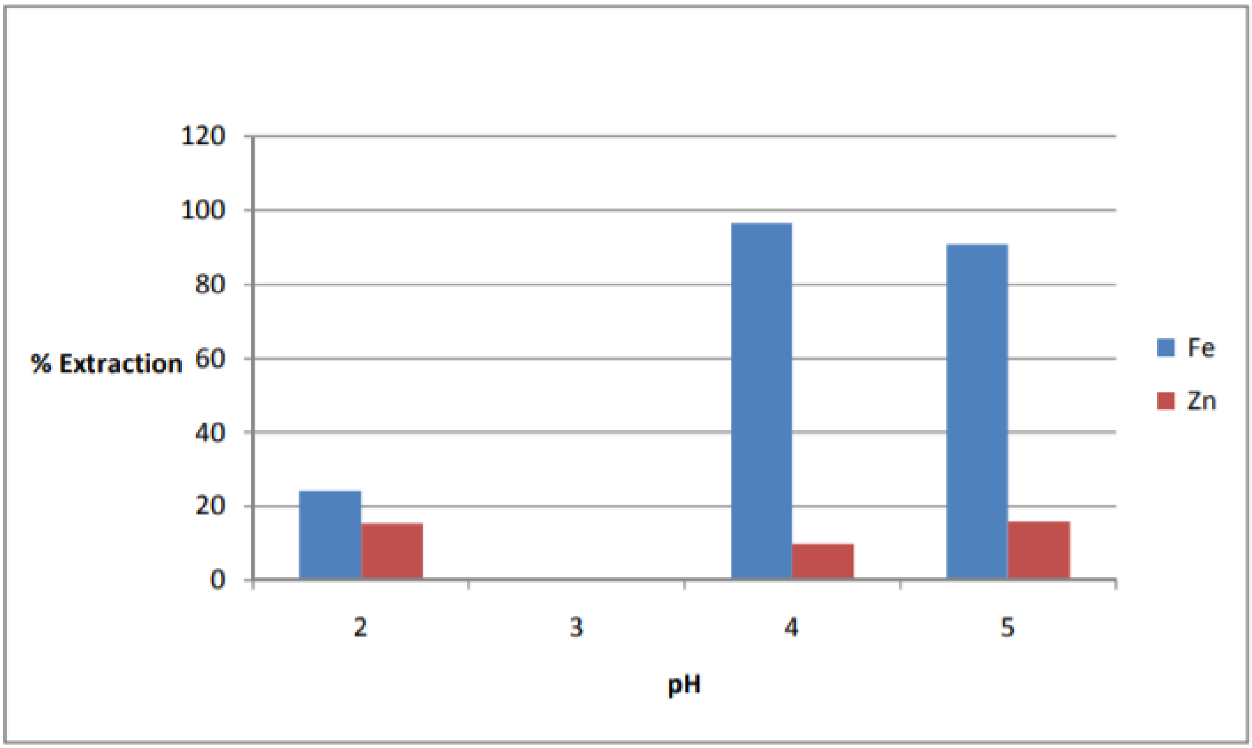


Figure 85: Percentage extraction of Zn and Fe with Cyanex 921 from fly ash leachates

18.3 Contribution

18.3.1 Flow rate of ashes

The the percentage of the residues of incineration change from 20 to 30 %.Then,to calculate the mass of nitric acid that will be used in leaching the ashes ,we should determine the flow rate of ashes.the total mass of residues is **338kg** after incineration of 800 kg of waste **during 1 hour .**

Metals	Quantity in ash(mg/kg)
Cu	2678
Zn	7378
Pb	7760
Ni	1906
Cd	56.6
Cr	1512
As	253.35
Hg	6.67

The ash was extracted at a liquid-to-solid ratio (L/S)=5 correspond to 5L of nitric acid to leach 1 kg of ash .

18.3.2 Nitric acid for leaching

As we mentionned that the nitric acid is a suitable acid for our case .It is important to be concentrated (15.8 mol/L-1.42 g/cm^3) to avoid the leaching of Fe that will be extracted mechanically . Metals such as nickel Ni, cobalt Co, copper Cu, mercury Hg, zinc Zn and cadmium Cd dissolve in nitric acid..See below some physical and chemical properties of HNO_3 - H_2O at 20 °C & 1,013 bar :

Gew % HNO_3	**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
volumetric mass (g/cm³)	1,00	1,05	1,12	1,18	1,25	1,31	1,37	1,42	1,46	1,48	1,513
Viscosity (mPa·s)	1,00	1,04	1,14	1,32	1,55	1,82	2,02	2,02	1,84	1,47	0,88
T_{fus} (°C)	0	–7	–17	–36	–30	–20	–22	–41	–39	–60	–42
$T_{éb}$ (°C)	100,0	101,2	103,4	107,0	112,0	116,4	120,4	121,6	116,6	102,0	86,0

$p(HNO_3)$ (mbar)	0,0	0,0	0,0	0,0	0,0	0,3	1,2	3,9	14,0	36,0	60,0
$p(H_2O)$ (mbar)	23,3	22,6	20,2	17,6	14,4	10,5	6,5	3,5	1,2	0,3	0,0
Molarity (mol/l)	0	1,7	3,6	5,6	7,9	10,4	13,0	15,8	18,5	21	24,01

Considerring that each hour 800 kg of waste will be incinerate which forms 338 kg of ashes (bottom ash and fly ash), this quantity needs :

- Each hour, 1690 L of acid,
- During 10 hours of incineration , the quantity of ash becomes: 338*10=3380 kg,
- In 10 hour, the amount of acid that we need is 16900 L.

18.3.3 Preparation of solution

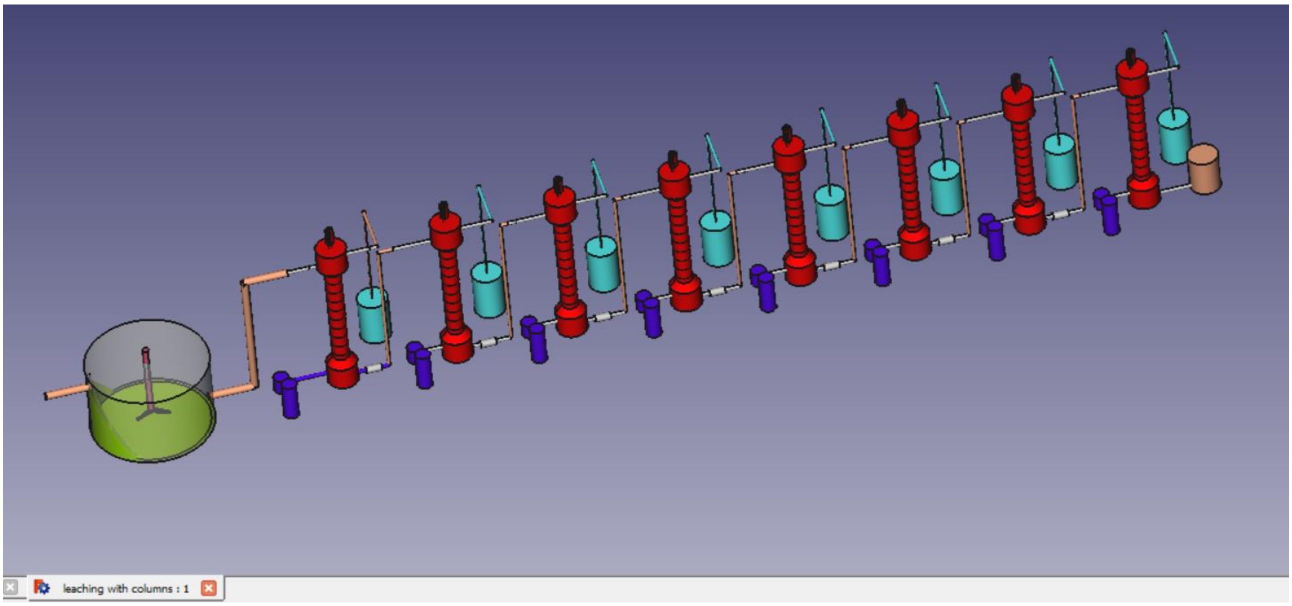
Eash 1 kg of ash needs 5 L of nitric acid .In the mixer then 338 kg grinded of waste is added to 1690 L of acid of 15.8 mol/l of concentration .

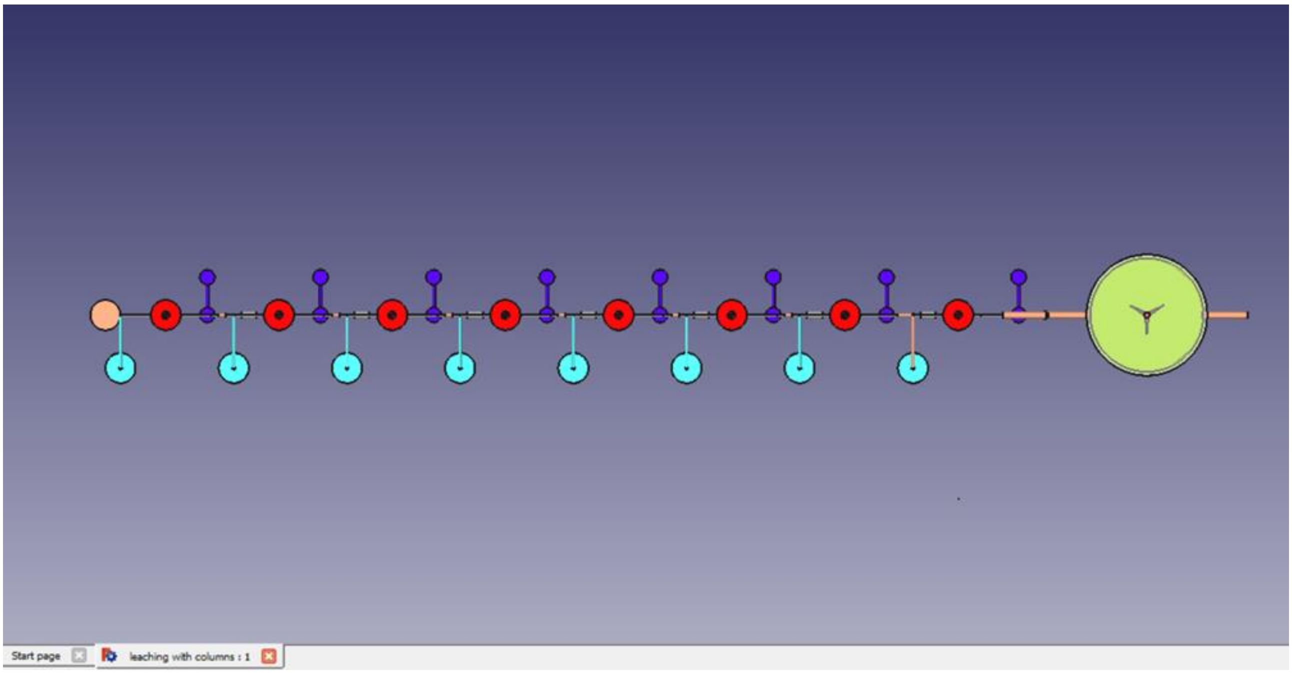
The input of the column 1 is 70.432 l of this mixture leached .

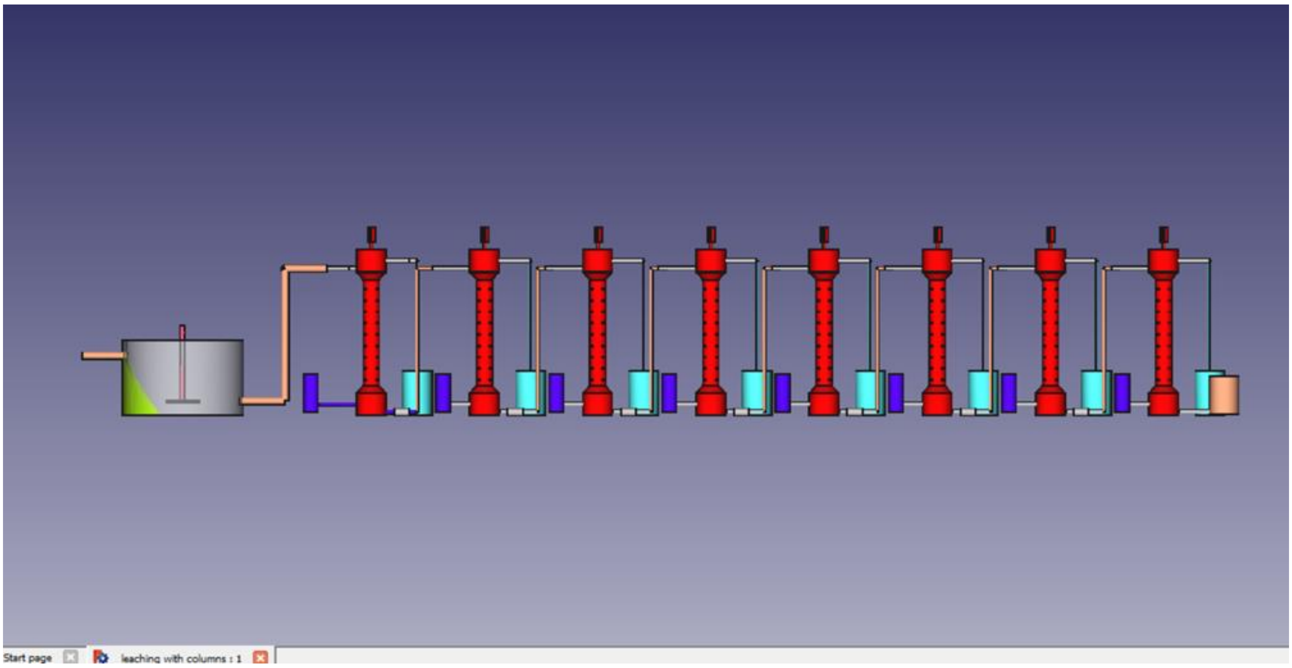
metals	g/kg of ash	338 kg of ashes	metals in 338 of ash(g)	Percentage of metals in 70 L of mixed =4.414, the amount of metals(g)	NOUNS OF extractants	The amount of extractant (ml)
Cu	2.678	338	905.164	37.4737896	LIX® 984N (mixture of 2-hydroxy-5-nonylacetophenone oxime and 5-nonylsalicylaldoxime in a high flash diluent),	74.9475792
Zn	7.3	338	2467.4	102.15036	Cyanex273(Phosphonic acid)	204.30072
Pb	7.76	338	2622.88	108.587232	Cyanex 272(Bis(2,4,4-trimethylpentyl)phosphinic acid)	217.174464
Ni	1.9	338	642.2	26.58708	Cyanex 272(Bis(2,4,4-	53.17416

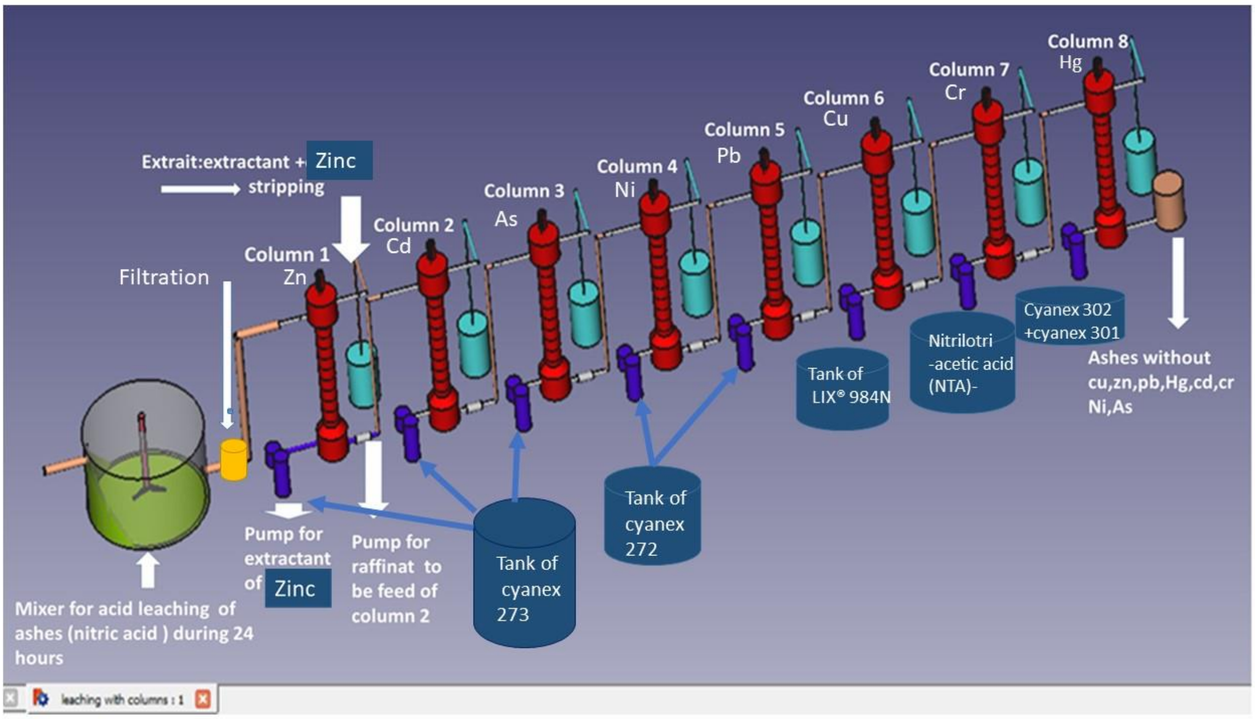
					trimethylpentyl)phosphinic acid)	
Cd	0.056	338	18.928	0.7836192	Cyanex273(Phosphonic acid)	1.5672384
Cr	1.51	338	510.38	21.129732	nitrilotriacetic acid (NTA)-	42.259464
As	0.253	338	85.514	3.5402796	Cyanex273(Phosphonic acid)	7.0805592
Hg	0.00676	338	2.28488	0.094594032	By Cyanex 301 (Bis(2,4,4-trimethylpentyl)dithiophosphinic acid) and cyanex 302(Bis(2,4,4-trimethylpentyl)thiophosphinic acid	0.189188064

18.3.4 Freecad design

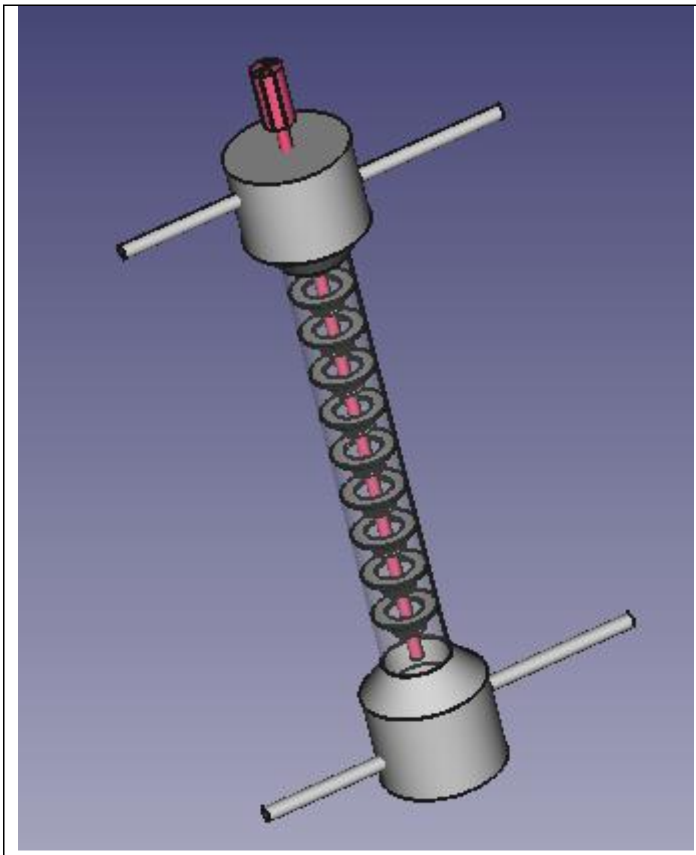
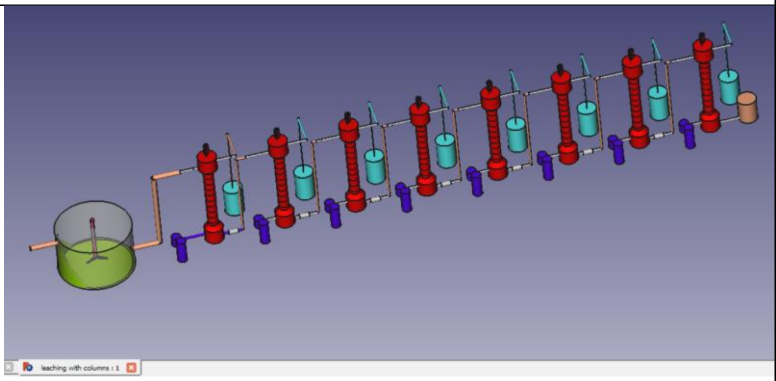



Start page
leaching with columns : 1


Start page
leaching with columns : 1



amount of extractant (ml)	extractant	metals
74.9475792	LIX® 984N (mixture of 2-hydroxy-5-nonylacetophenone oxime and 5-nonylsalicylaldoxime in a high flash diluent),	Cu
204.30072	Cyanex273(Phosphonic acid)	Zn
217.174464	Cyanex 272(Bis(2,4,4-trimethylpentyl)phosphinic acid)	pb
53.17416	Cyanex 272 (Bis(2,4,4-trimethylpentyl)phosphinic acid)	Ni
1.5672384	Cyanex273(Phosphonic acid)	Cd
42.259464	nitrilotriacetic acid (NTA)-	Cr
7.0805592	Cyanex273(Phosphonic acid)	As
0.189188064	By Cyanex 301 (Bis(2,4,4-trimethylpentyl)dithiophosphinic acid) and cyanex 302(Bis(2,4,4-trimethylpentyl)thiophosphinic acid)	Hg

	column of hevy metals recycling100419.FCStd
	leaching with columns100419.FCStd

18.3.5 Operating the Column

- Open the pump and reach the column with 44 l of ash mixed with nitric acid
- When the liquid level in the column reaches the top right nozzle (turn the feed flowrate down to the desired set point.
- Turn on and set the extractant flowrate to the desired set point by adjusting the pump speed.
- Close the extrait out rotameter when the liquid level reaches the top left (extrait out) nozzle.
- Allow the interface to form between the top mesh and the top left nozzle (extrait out). The interface appears as an immiscible layer between acid and extractant with droplets
- Once the interface is formed in the desired location, open the extrait out rotameter slowly until there are flowrates out of the column.
- Adjusting this rotameter is used to control the interface level. Opening the rotameter causes the interface to rise, while closing it causes the interface to drop.

- The optimum setting of this rotameter will allow for a semi-stable interface and give a minimal amount of drift in the interface level.
- Small adjustments should be made in order to keep the interface constant.
- Set the stirrer speed to a setting of 5 using the dial on the top right of the lab equipment panel. Make sure the motor is powered with the top center switch on the right power panel.
- Allow the column to run until steady state is achieved (about hour).

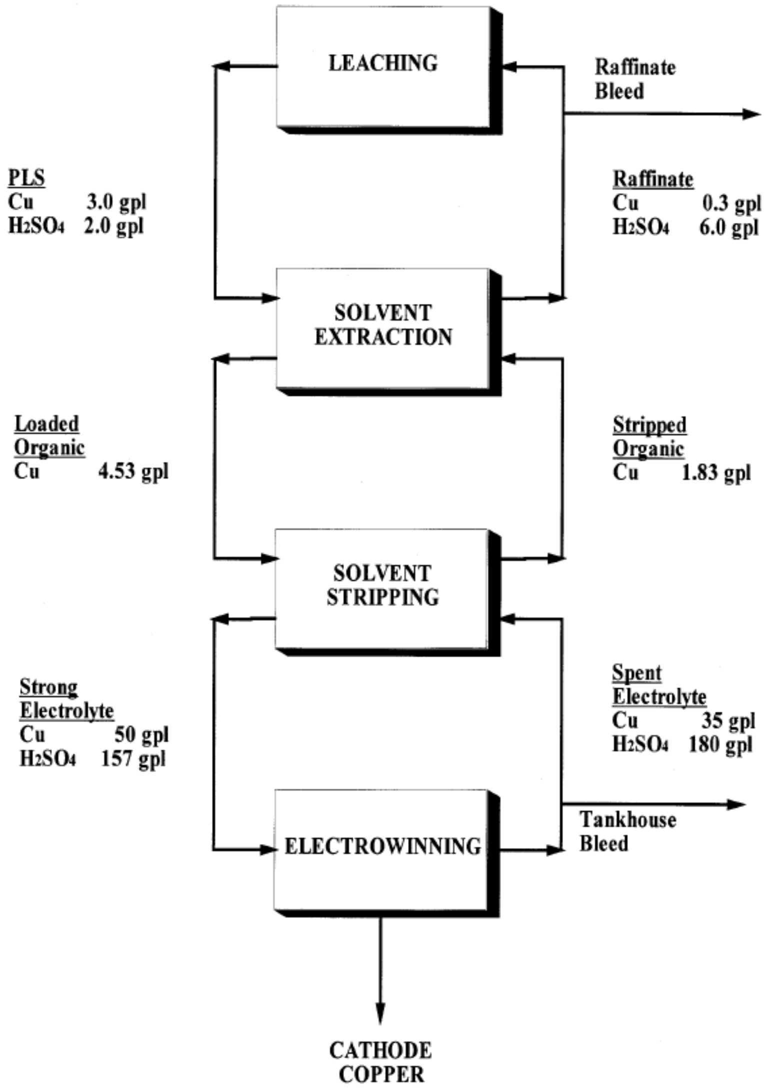
To feed the column in our case with extractant,we need 9890 cm^3 (9.89 Liter extractant per batch load). Wotking time about 1 hour.

18.3.5.1 Shutdown Procedure

1. Once the experiments are complete, turn off the agitator and main power switch.
2. Close the feed and solvent ball valves, leaving the raffinate and extract ball valves open.

18.3.5.2 Stripping

The liquid rich in metals sorted from the sovent extraction column should be the input to the stripping tank where it is mixed with acid in ordr to wash the metals formed in the column . After each column ,a tank of stripping is implemented .



19 Zinc recycling

19.1 Fly Ash Handling

1. Pre-Washing:

- Take a 10 grams sample of dried fly ash

- Mix the sample with distilled water for 5-10mins under the following conditions (solid/liquid ratio 10:1 (ml/g), number of washing twice) - Under these conditions, the prewash can remove 86% Na, 70% K, 12% Ca, 1.2% Al, and 0.5% Pb from the fly ash.

- Perform vacuum filtration.

- Analyze the metallic elements in the leachate using ICP/AES spectrometer.

2. Leaching Tests:

    1. Vacuum dry the pre-washed sample at 75ºC overnight

    2. Mix 1 gram of the prewashed sample with 40mL (0.1M) citric acid, for a contact time of 20mins, at pH=3 (adjust the pH using concentrated HNO_3 and NaOH) and at room temperature.

    3. Filter the suspension and send the clear solution for heavy metal content analysis by means of ICP/AES spectrometer.

    Optimum metal removal was achieved under the following conditions: liquid/solid ratio 40 (ml:g), citric acid concentration 0.1 M, contact time 20 min, and pH 3.0 at room temperature.

1. Required tests: XRD for fly ash powder sample as received and the fly ash residues after water washing and acid leaching

19.2 Bottom Ash Handling (200-250 kg/t)

1. Collect fresh bottom ash samples from the burning incinerators and dry them at 25°C.

2. Manually separate the un-burnt parts such as the screw, wire, plastics.

3. Prior to leaching, reduce the size of the samples to 500microns with a roll crusher in order to remove the magnetic content (Iron Removal).

4. Subject the bottom ash samples (Tailings and concentrates) to leaching tests **(24hours)** in order to notice the amenability of the samples for metal recovery along with optimization of parameters.

- To calculate the mass of nitric acid to use in leaching the ashes, we should determine the flow rate of ashes.

- In example, liquid to solid (L/S) ratio = 5:1 ➔ for every 1kg of ashes, add 5L of Nitric acid.

- It is important to be concentrated (15.8 mol/L-1.42 g/cm^3) to avoid the leaching of Fe that will be extracted mechanically.

- Considering that each hour 800 kg of waste will be incinerated, which forms 338 kg of ashes (bottom ash and fly ash), this quantity needs:

  - Each hour, 1690 L of acid
  - During 10 hours of incineration, the quantity of ash becomes 338*10=3380 kg
  - In 10 hour, the amount of acid that we need is 16900 L

5. Liquid-Liquid Extraction Column:

1. Add the nitric acid solution (including heavy metals) to the column from the upper left vessel, and keep adding until the nitric acid reaches the level of this vessel.

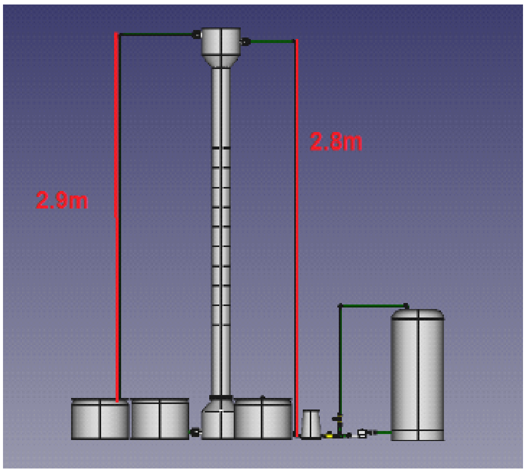
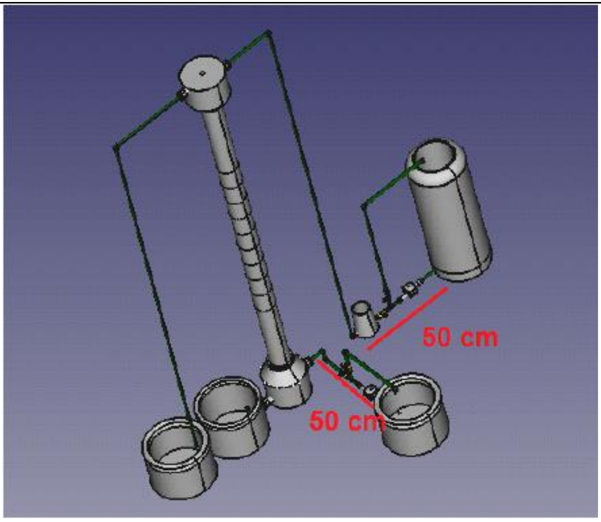
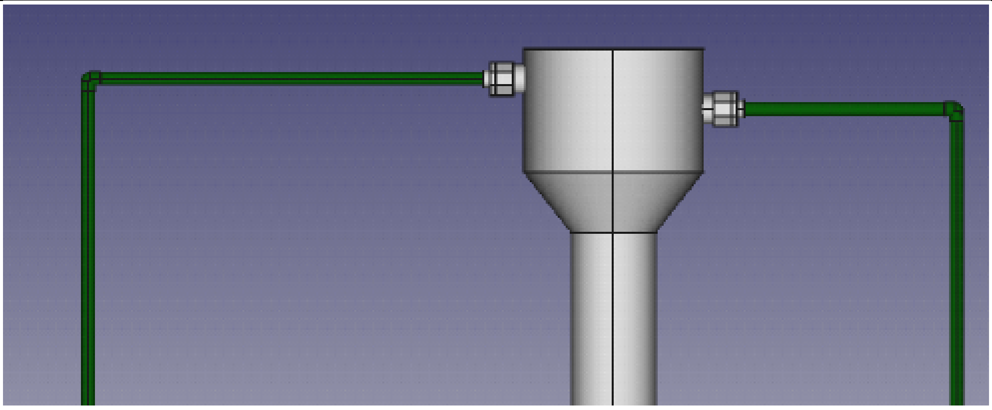
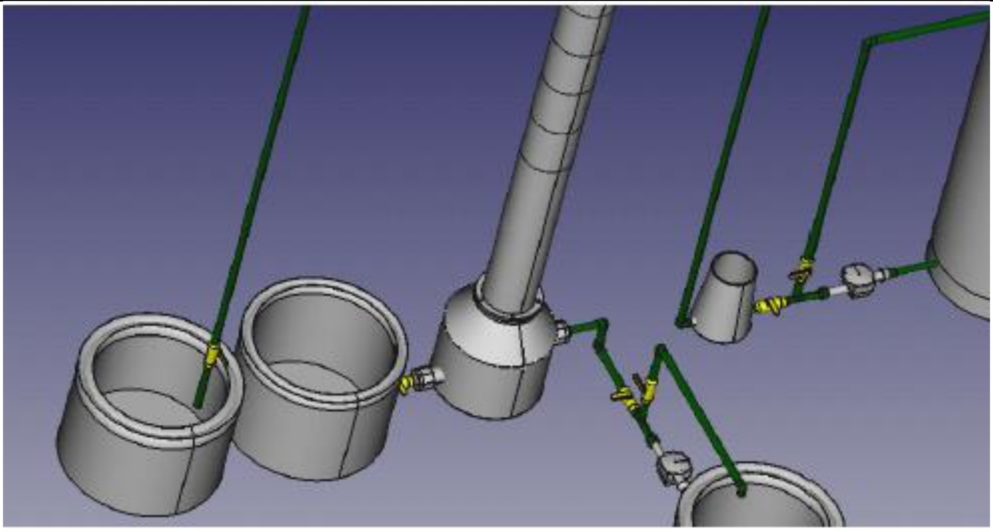
2. Add phosphonic acid from the lower left vessel (3mL phosphonic acid/1L of nitric acid solution)

3. Turn on the mixer for a certain time (ex: 1hr), stop a while to see if two separate phases appear.

4. If yes, remove the upper layer through the upper right vessel and then remove the lower layer through the lower right vessel.

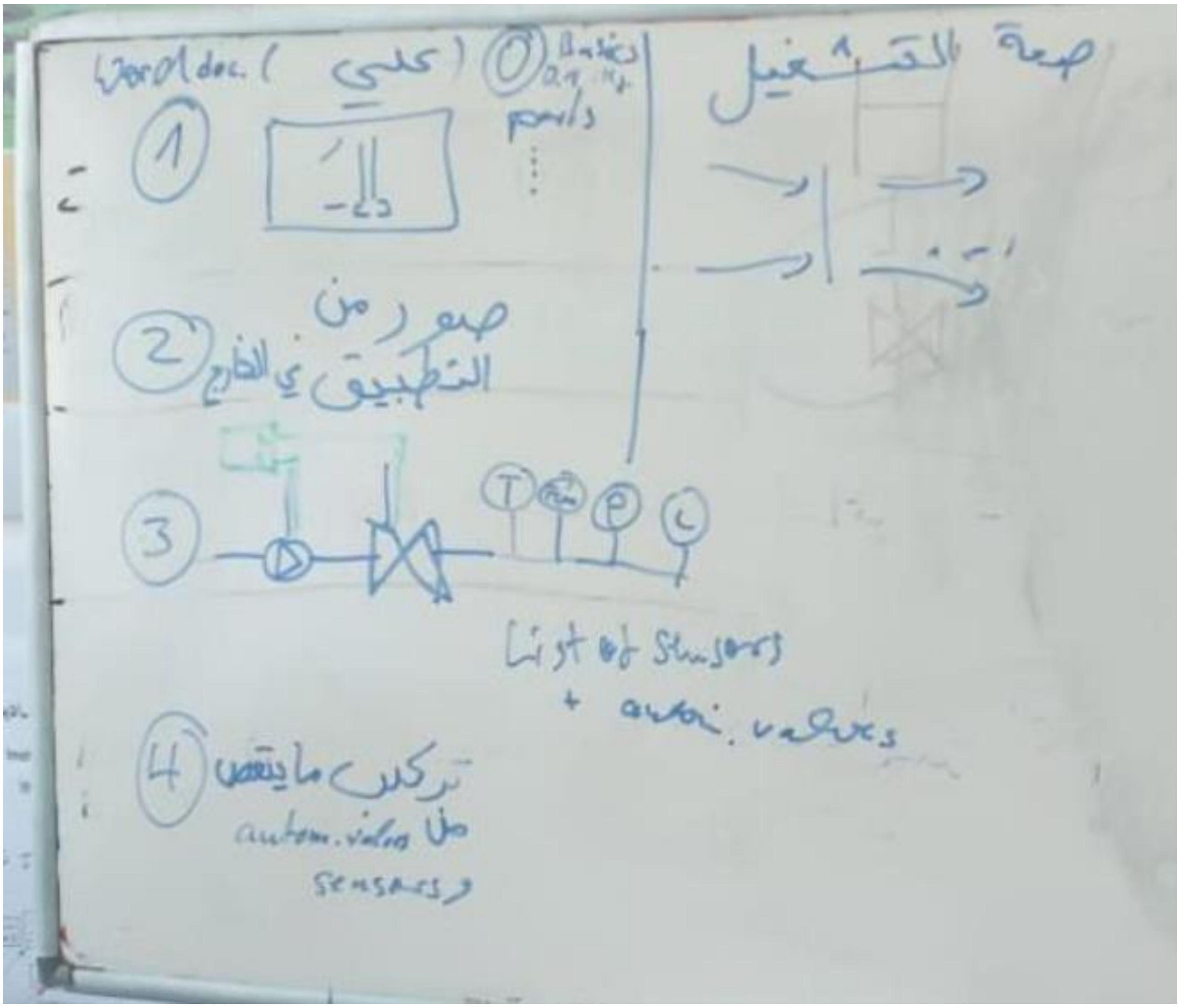
20 Heavy Metals Recycling Test Rig

20.1 Mechanical integration

<table>
<tr><td></td><td>heavymetalrecoverypipes150619.FCStd</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td></td><td rowspan="2">parts needed :
-4 valve
- 4 pipes (4m each)
- 3 medium sized tanks
- 2 electrical pumps (>1hp)
- 4 moukhalef + wasel zira3e
- 9 turnes 90 ppr
- 2 tees ppr
initial cost : ~ 200 $</td></tr>
<tr><td></td></tr>
</table>

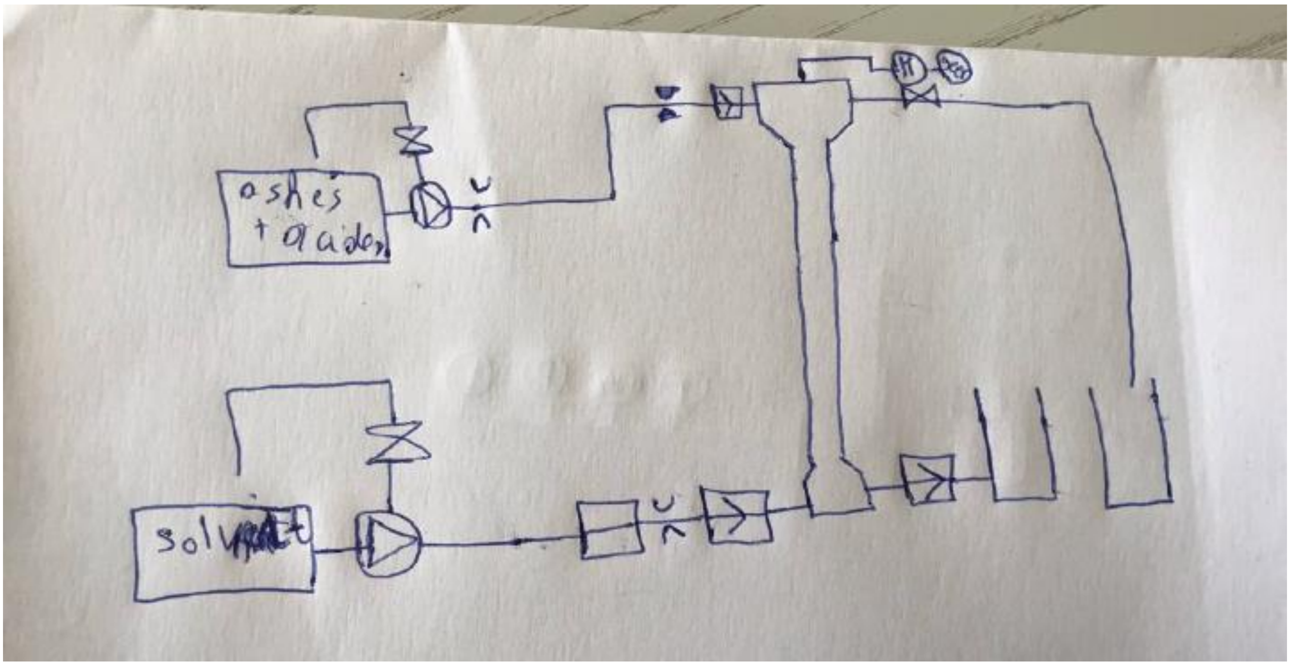
20.2 Concept for automation

20.2.1 Task for Trainees July 2020[22]



[22] Ali Ibrahim, Ali Awad, Walid Naous, Wasim Al Haj

20.2.2 Concept



Requirements:
3 valves
Motor
Geer
2 Flow sensors
3 Check valve

20.2.3 Automation Algorithm

needed for automation: only 2 solonoid valves (for exits)

algorithm

- Open the pump and reach the column with 44 L of ash mixed with nitric acid
- When the liquid level in the column reaches the top right nozzle (turn the feed flowrate down to the desired set point
- Turn on and set the extractant flowrate to the desired set point by adjusting the pump speed
- Close the extrait out rotameter when the liquid level reaches the top left (extrait out) nozzle.

- Allow the interface to form between the top mesh and the top left nozzle (extrait out). The interface appears as an immiscible layer between acid and extractant with droplets.
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- The optimum setting of this rotameter will allow for a semi-stable interface and give a minimal amount of drift in the interface level.
- Small adjustments should be made in order to keep the interface constant.
- Set the stirrer speed to a setting of 5 using the dial on the top right of the lab equipment panel. Make sure the motor is powered with the top center switch on the right power panel.
- Allow the column to run until steady state is achieved (about hour).

Process Control System

Based on the following reports

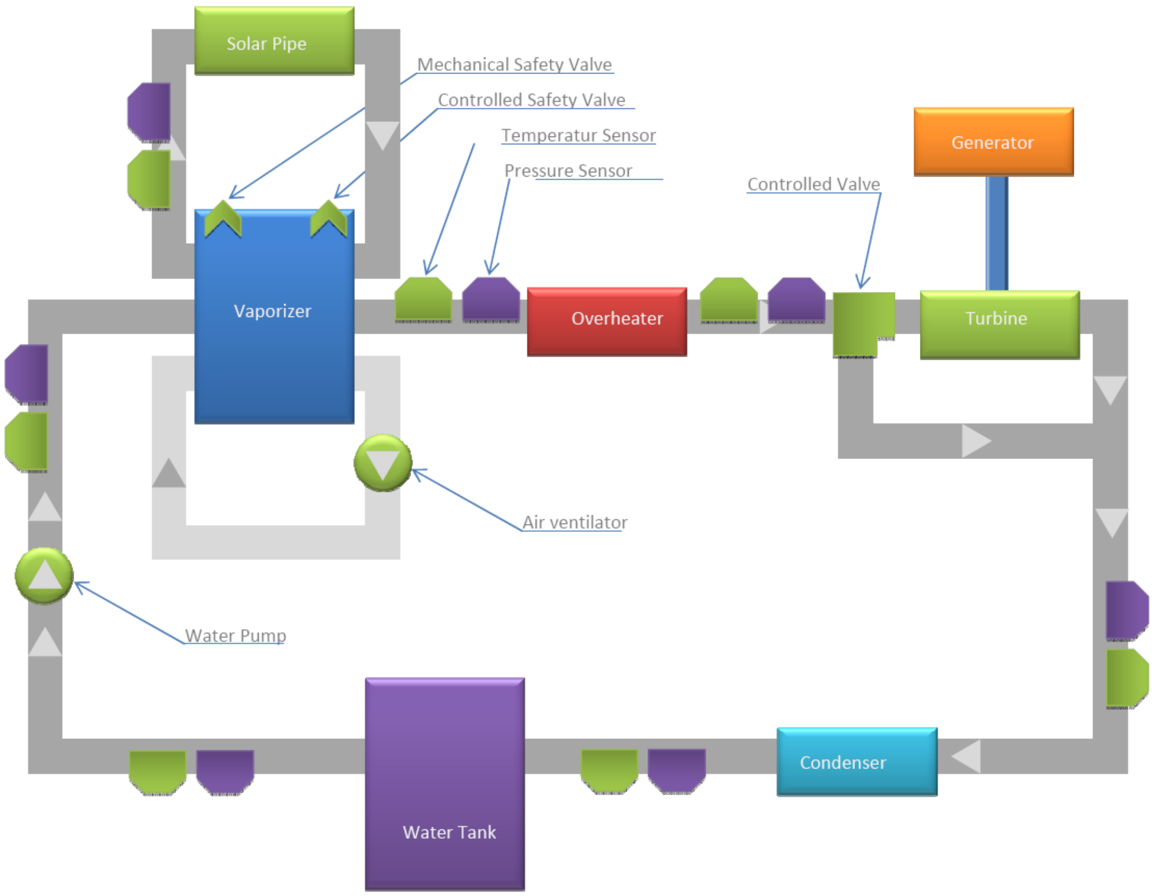
[TEMO-IPP 2013]

[NLAP-PCS 2017]

[NLAP-PCS 2019]

21 التحكمProcess Control System (PCS) 2013

21.1 Test Plant Process Control System - Part 2 (February 2012) - System Design



21.2 Introduction: Installation and putting into operation of a S7 system

A S7-300 SEIMENS PLC was used to control and monitor the plant. The S7-300 is used among the world to control any big industries machine system. The PLC is programed by **STEP7** computer software, and then you can do an interaction between the PLC and the PC using **WinCC** software or any other GUI developed software.

In this part we will programed our PLC using STEP7 and then we will use two ways to interact with PLC and plant system. Part steps:

- Implement S7-300
- Program PLC using STEP7
- Develop WinCC GUI user interface
- System – PLC – Computer Communication
- Develop of second GUI interface choice (using velleman board)

21.3 PLC S7-300

tbd

21.4 Step7 WorkFlow

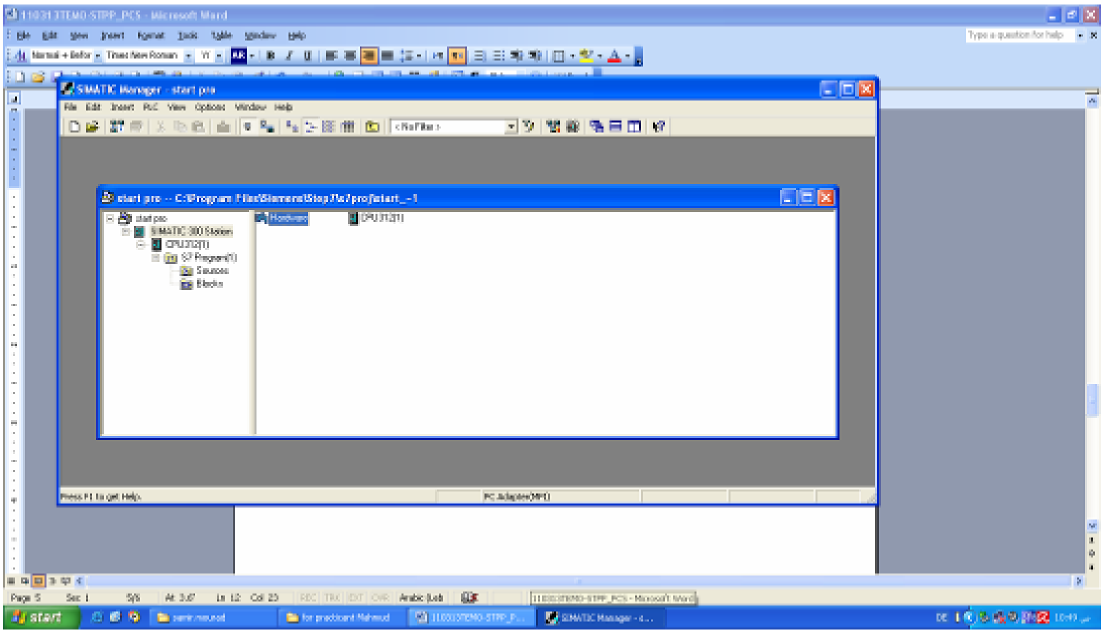
21.4.1 برمجة الـ PLC و تطبيق برنامج تعليمي عليها:

بعد توصيل قطع الـ PLC ببعضها حسب الحاجة (يمكنك النظر في أي ملف تعليمي لمعرفة طريقة توصيلها) لا بد أن تعرّف للـ CPU الشكل الذي قمت بجمع الـ PLC به و ذلك من خلال برنامج SIMATIC Manager على الشكل التالي:

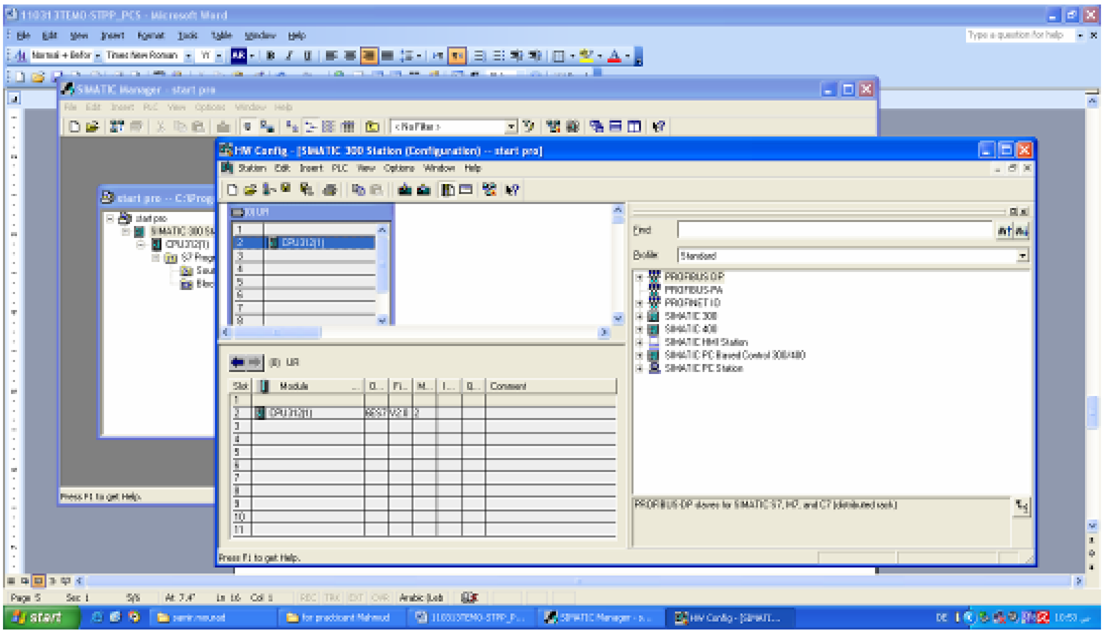
1. أولاً علينا فتح مشروع جديد ('New Project' Wizard) و يتم خلاله إختيار الـ CPU المستخدمة

2. ثانيا بالضغط على SIMATIC 300 station الموجود على يسار الشاشة سيظهر لك خيار الـ Hardware الذي نحتاجه لتعرفت أجزاء الـ PLC للـ CPU

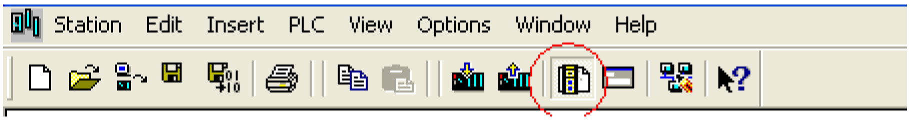
صورة توضح طريقة الدخول على بناء Hardware:



3. بالضغط على خيار Hardware ستظهر لك الشاشة التالية و فيها الـ CPU الذي قمت بأختياره:



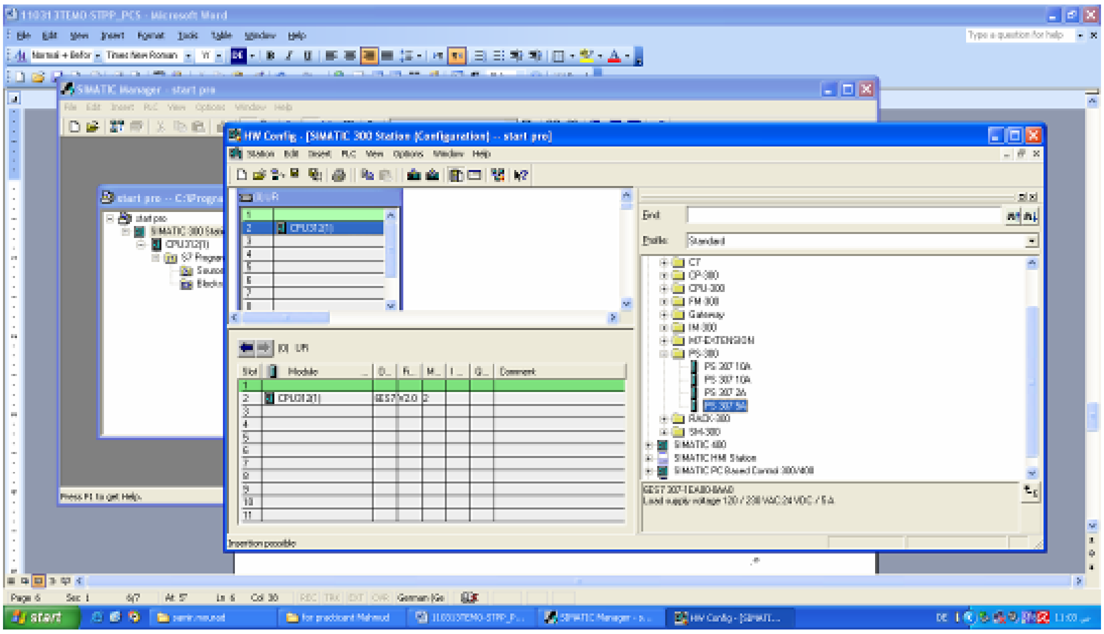
4. الآن علينا أكمال عملية بناء Hadrware الـ PLC من خلال حمل القطع من التسلسل يمين الشاشة و إسقاطها في مكانها يسار الشاشة, في حال لم تجد التسلسل يمكنك عرضه من خلال الضغط على المفتاح التالي:



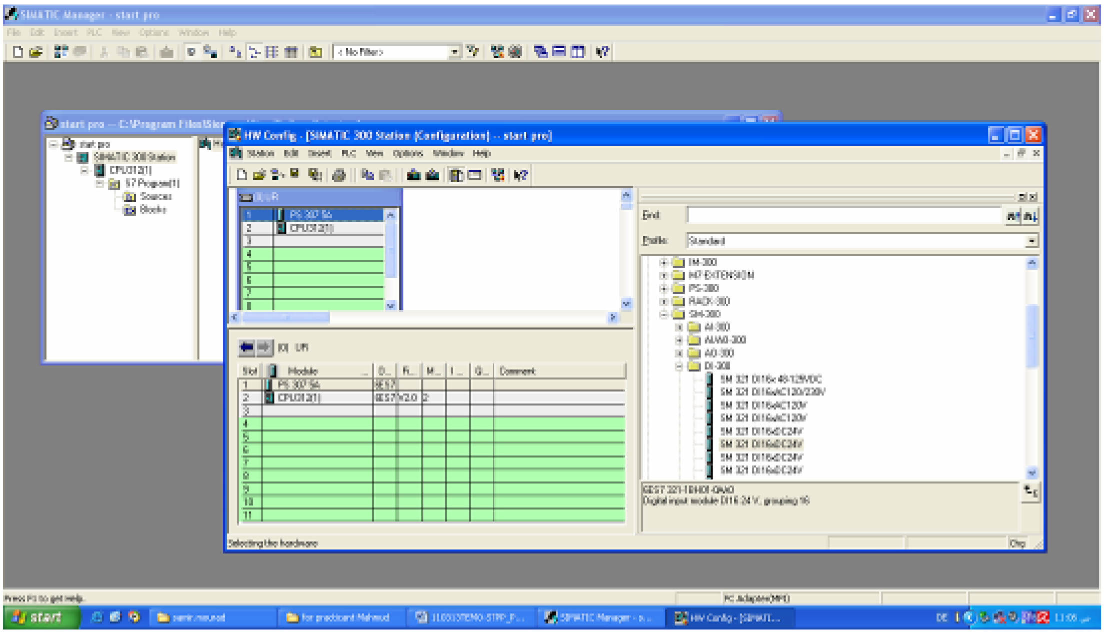
سيظهر لك المكان المناسب القطعة بمجرد الوقوف عليها.

القطع التي سنحتاجها موجودة في قسم SIMATIC 300 من التسلسل على يمين الشاشة

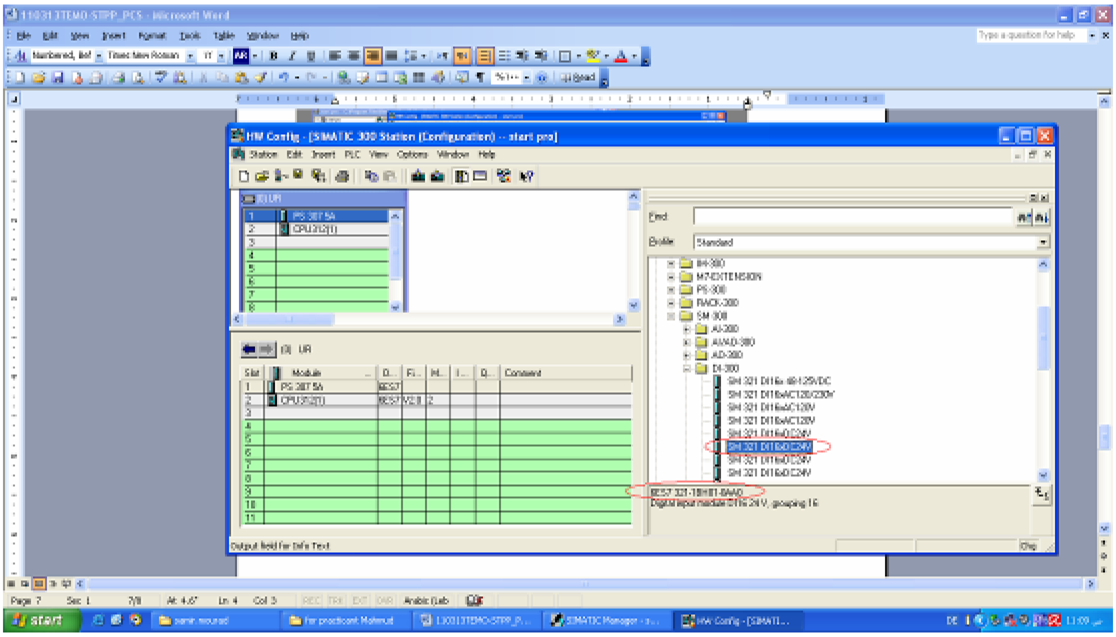
الـ PowerSupply موجودة في قسم PS-300 على الشكل التالي:



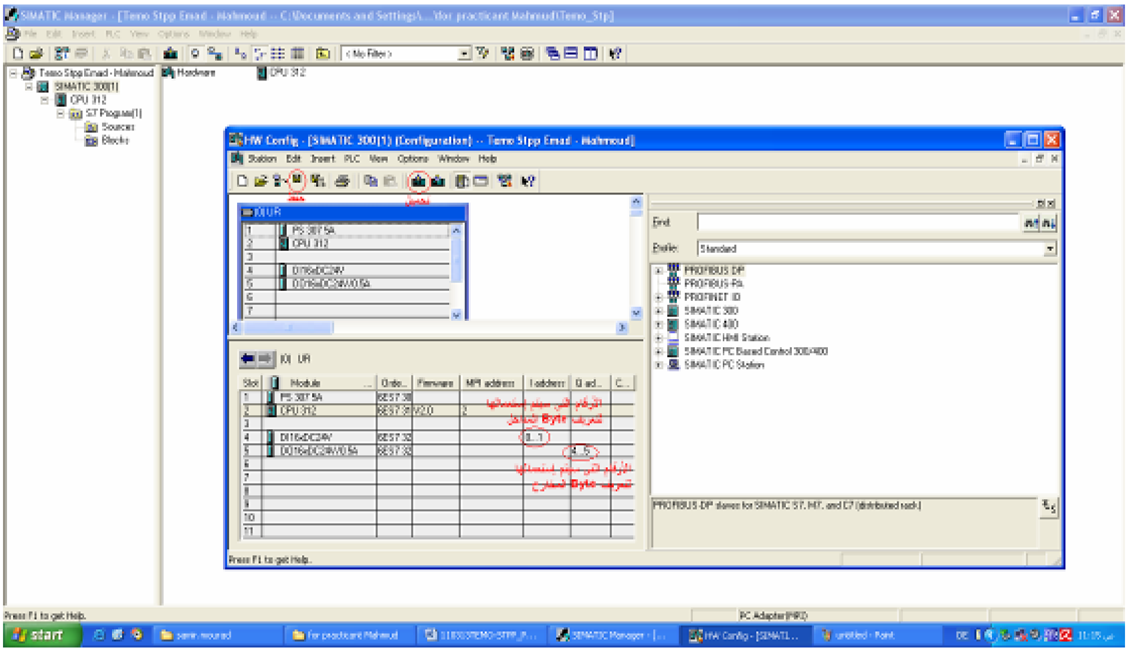
ال input-output devices موجودة في قسم SM-300 على الشكل التالي:



5. قم بإختيار القطع المناسبة بالتأكد من أسمها و رمزها التسلسلي (أي إختلاف سيمنع البرنامج من العمل) صورة توضيحية

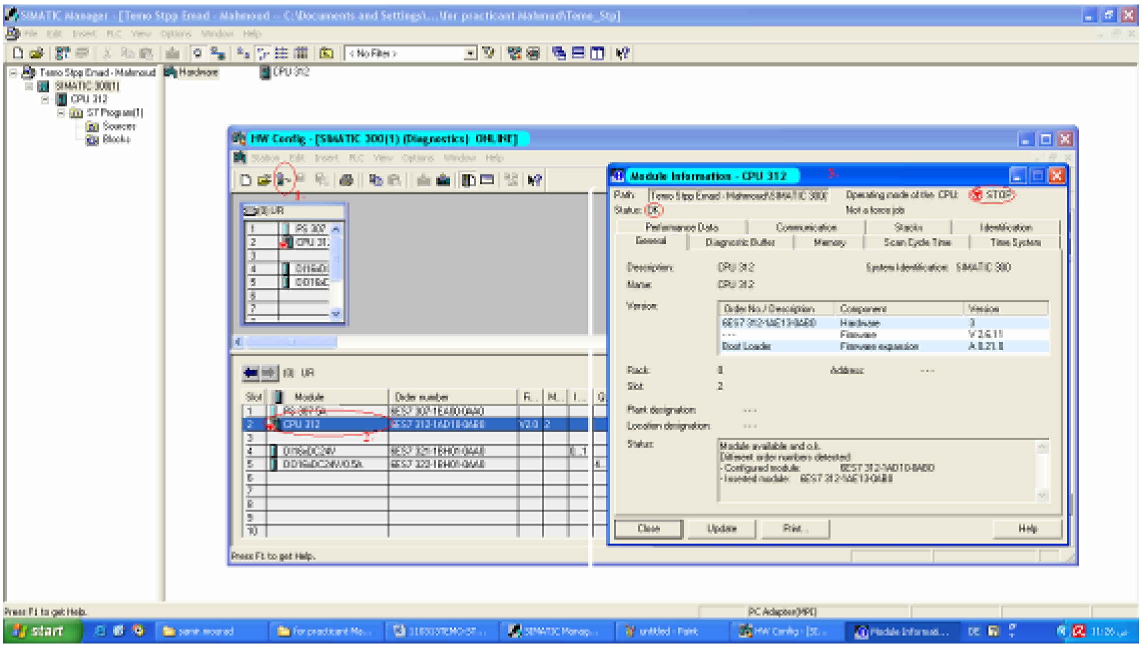


6. بعد إنهاء بناء ال PLC يتم حفظ العمل ليتم تحميله إلى CPU ال PLC



7. يجب أن تكون ال PLC في وضع STOP لتستطيع تحميل البناء عليها

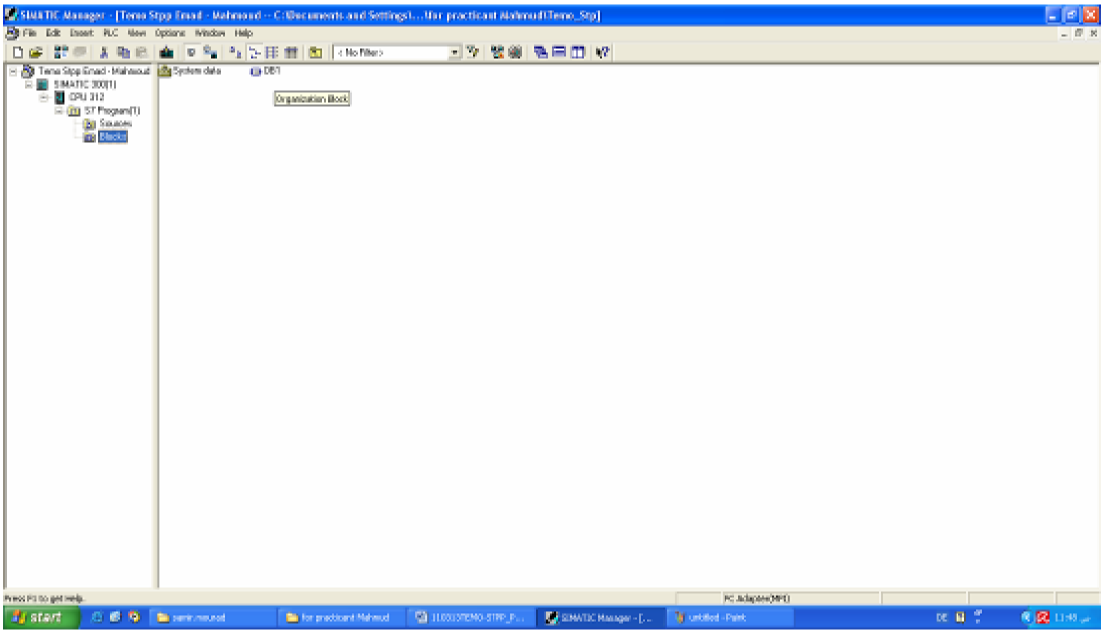
8. للتأكد من توافق البناء من ناحية الـ Software و الـ Hardware قم بنقل حالة الأتصال من Offline إلى Online من خلال المفتاح المشار إليه بالرقم 1 في الصورة. بعدها تستطيع الضغط على أي قطعة للتأكد من حالتها



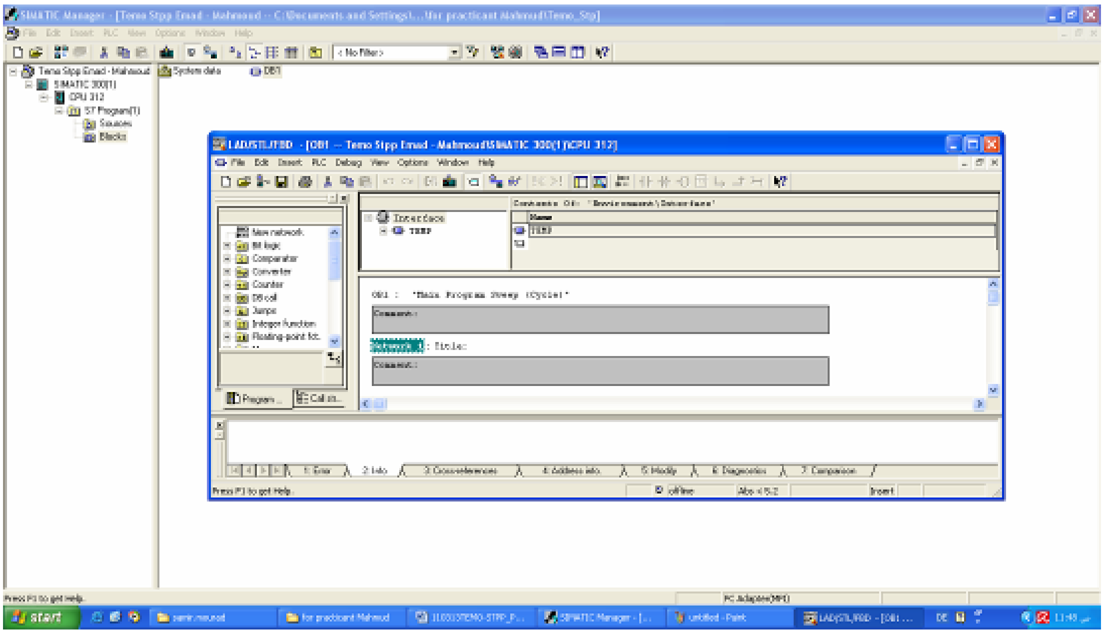
الآن أتممنا عملية تعريف أجزاء الـ PLC للـ CPU . ننتقل الآن إلى برمجتها.

1. أولاً, نفتح ملف OB1 المتحكم (Organization Block) بالـ PLC حيث ستتم برمجتها هنا

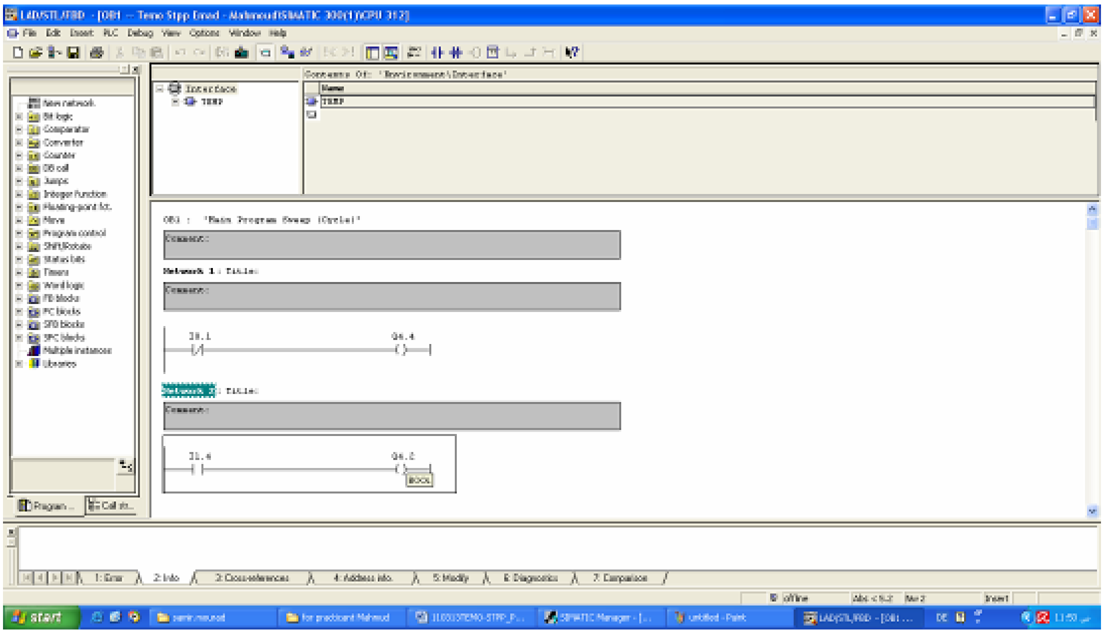
طريقة الولوج للمتحكم(OB1):



شاشة عرض المتحكم(OB1):



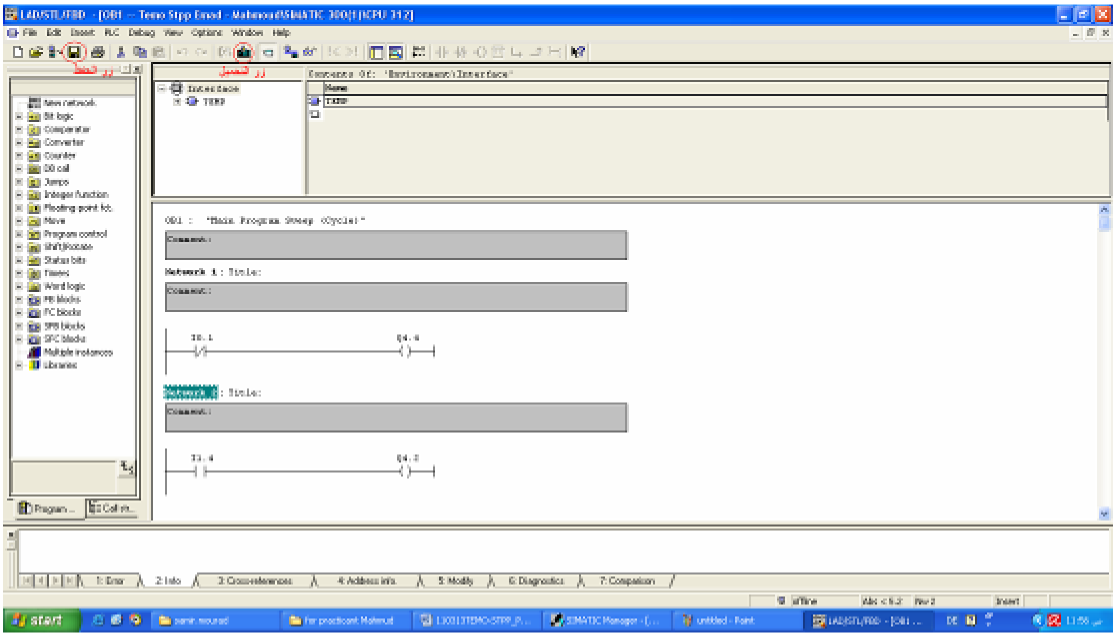
2. و نقوم بكتابة البرنامج البسيط التالي:



ترجمة البرنامج: - زر المخرج رقم 4.4 يعمل في حال كان مدخل 0.1 حر (v0)

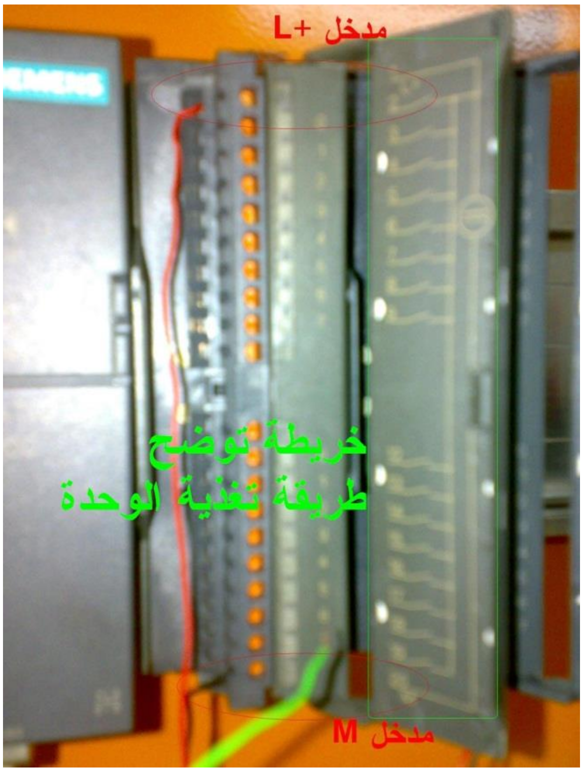
- زر المخرج رقم 4.2 يعمل في حال كان مدخل 1.4 مفتوح (v24)

3. أيضاً يتم حفظ البرنامج و تحميله إلى الـ PLC , بالطبع يجب أن تكون الـ PLC في وضع STOP



4. الآن ننتقل إلى جهاز الـ PLC لتغذية مداخل و مخارج الجهاز لتصبح فاعلة و يتم ذلك حسب الخريطة الخاصة بالقطعة

صورة توضح طريقة تغذية قطعة المداخل DI:

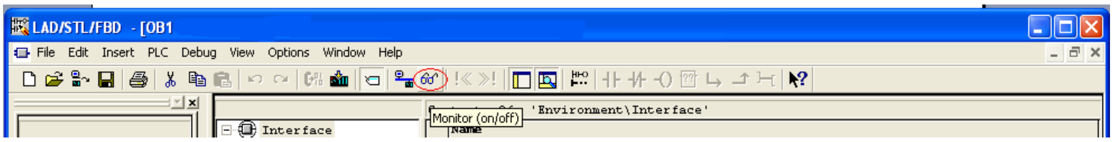


5. إذا و بحسب خريطة التغذية سنحتاج لتغذية المدخل الأول بـ **+L** و المدخل الأخير بـ **M** وسنقوم بتغذيتهم من المغذي الأساسي للـ PLC (PowerSupply) على هذا الشكل:

6. الآن أصبح بأمكاننا تشغيل الـ PLC و تجربت العمل, يبدأ التشغيل بمجرد تغير حالة الـ CPU من STOP إلى **RUN**.

بالنتيجة سيعمل زر المخرج **4.4** كما في الصورة التالية و يمكننا تجربت المداخل و التأكد من المخارج ليكون بذلك تم تنفيذ المشروع الأولي التعليمي على الـ PLC.

7. كما يمكن إجراء محاكاة لما يحدث على الـ PLC من خلال برنامج الـ SIMATIC manager و ذلك بتشغيل زر **Monitor** كما في الصورة التالية:



بعد أن أنهينا هذا المشروع التدريبي أصبح بإمكاننا الأنتقال إلى مشارع أكثر تعقيد, أي أصبح بأمكاني تنفيذ مشروعي الذي يخص TEMO-STPP على الـ PLC S7-300

21.4.2 طريقة توصيل profibus

يستخدم الـ profibus لفصل اجزاء الـ PLC إلى جزئين منفصلين بالمكان متصلين بالعمل. يمكّنك الـ Profibus من فصل أجزاء الـ PLC إلى جزئين: الاول متحكم ليوضع في غرفة المراقبة و التحكم و الثاني خاص بالمداخل و المخارج و يكون قريب من الأجزاء التي ستقوم الـ PLC من قراءة و التحكم بأجزائها.

في مشروع TEMO-Stpp تم تقسيم أجزاء الـ Profibus على الشكل المبين في الصورة التالية:

Figure 4.1: S7-300 PROFIBUS NET

الأجزاء المستعملة هي:

Other description	Order Number	Module
Power Supply	6ES7 307-1EA00-0AA0	PS 307 5A
SIMATIC S7-300 V2.6.11 X1 MPI	6ES7 312-1AE13-0AB0	CPU 312
Communication Profibus module SIMATIC NET V5.7	6GK7 342-5DA02-0XE0	CP 342-5

Bus interface module SIMATIC ET 200M Profibus-DP	6ES7 153-1AA03-0XB0	IM 153-1
Digital Input module, grouping 16	6ES7 321-1BH01-0AA0	SM321 DI 16xDC24V
Digital Output module, grouping 8	6ES7 322-1BH01-0AA0	SM322 DO 16Xdc24V/0.5A
Analog input module, 12Bit	6ES7 331-7KB02-0AB0	SM331 AI 2x12BIT

و كالعادة يجب تعريف الـ PLC بالشكل الذي تم توصيل القطع به من خلال الدخول على قسم Hardware, و سنقوم حاليا بتوصيلها حسب الصيغة التي اعتمدناها في جمع الـ PLC المبينة في الصورة 1. من خلال ترجمة صيغة الترتيب المبينة في الصورة 1 إلى HW Config. ستحصل إلى الصورة التالية:

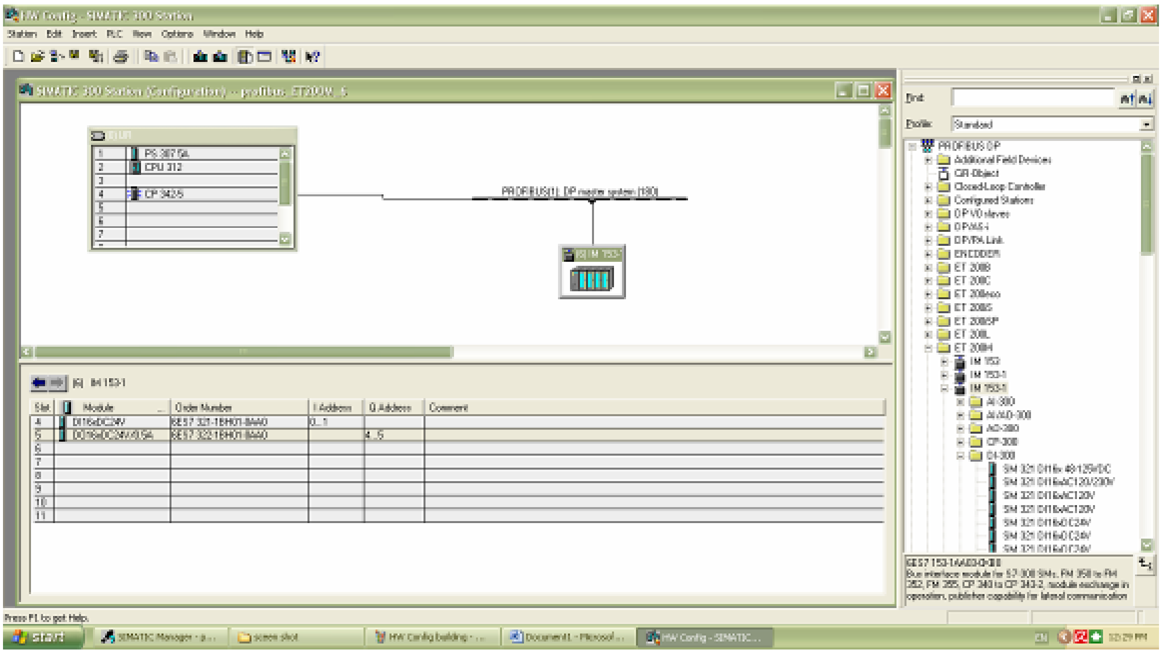


Figure 4.2: HW Config building

تجد الـ CP 342-5 module في هذا العنوان:

SIMATIC 300 > CP 300 > PROFIBUS > CP 342-5

لإضافة الـ DP Slave أي الـ IM 153-1 يجب أولاً إضافة POFIBUS master system و ذلك من خلال الضغط بالزرالايمن للفأرة اثناء الوقوف على module CP 342-5 و إختيارِ Add Master System كما في الصورة التالية:

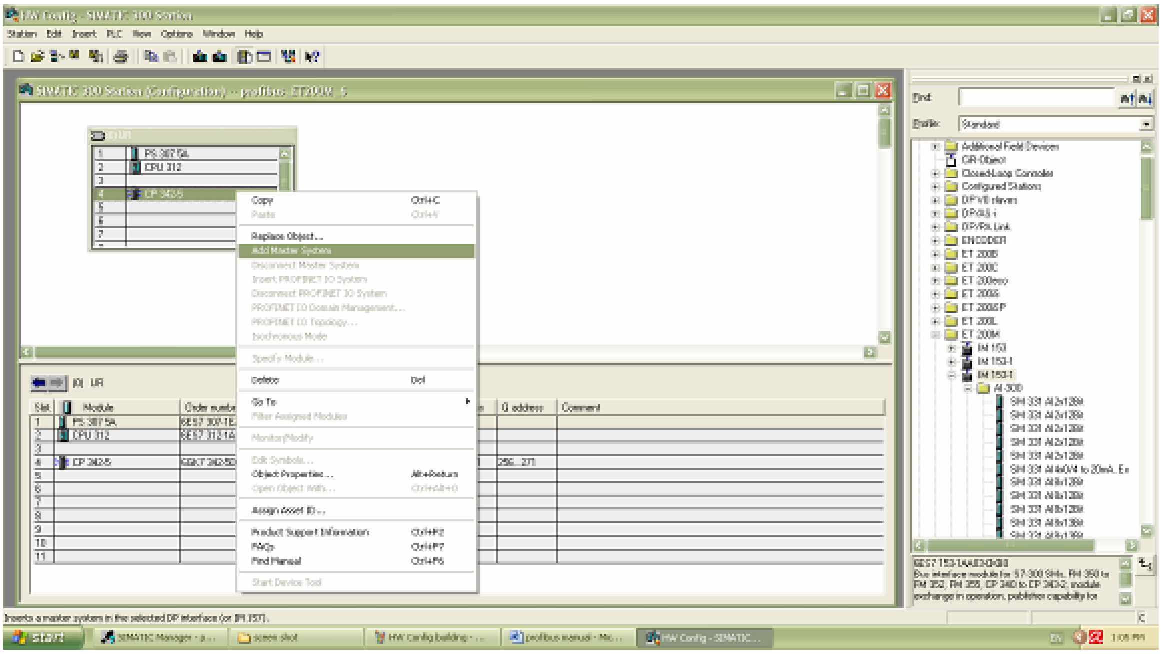


Figure 4.3: HW Config Add Master System

سيطلب منك أن تصله بـ Profibus Network ستقوم بذلك من خلال أتباع الطريقة المبينة في الصورة التالية (انظر الصورة 4) و من ثم تحدد Address للـ master Profibus يفضل أختيار Address = 5 و ما فوق:

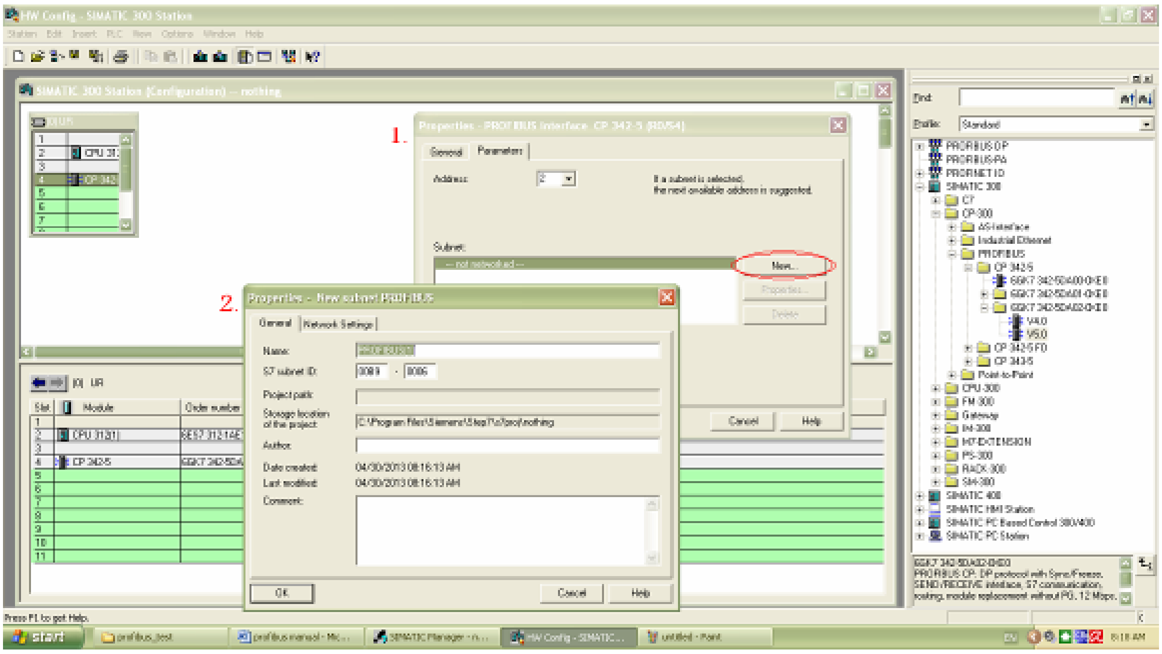


Figure 4.4: HW Config Add Profibus network

ستظهر لك رسالة تبلغك بوجوب نداء الملفين FC1 و FC2 لتستطيع إضافة Profibus system تختار Ok. الآن أصبح بالإمكان إضافة الـ IM 153-1 على الـ Profibus master system من التسلسل التالي:

تختار المناسب منها ثم تقوم بالضغط عليه PROFIBUS DP > ET 200M > IM 153-1

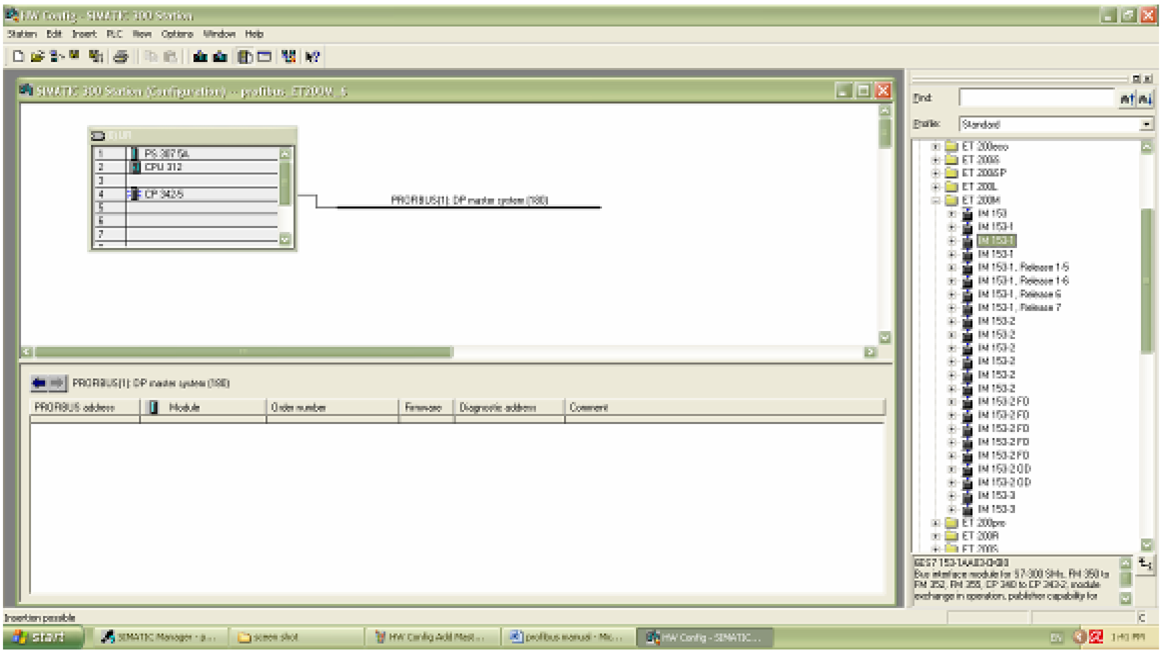
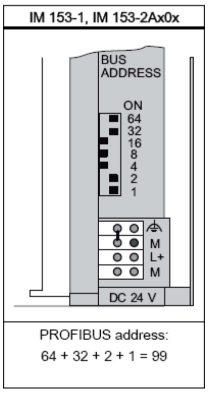


Figure 4.5: HW Config Add IM153-1

و من ثم إختيار address له و موافقته مع ال Address المضبوط على قطعة ال IM 153-1 و يكون بالشكل التالي:



بعد ذلك يتم إضافة الأجزاء الموصولة بال SIAMTIC NET من القائمة الخاصة بال Module IM 153-1 كما في الصورة التالية:

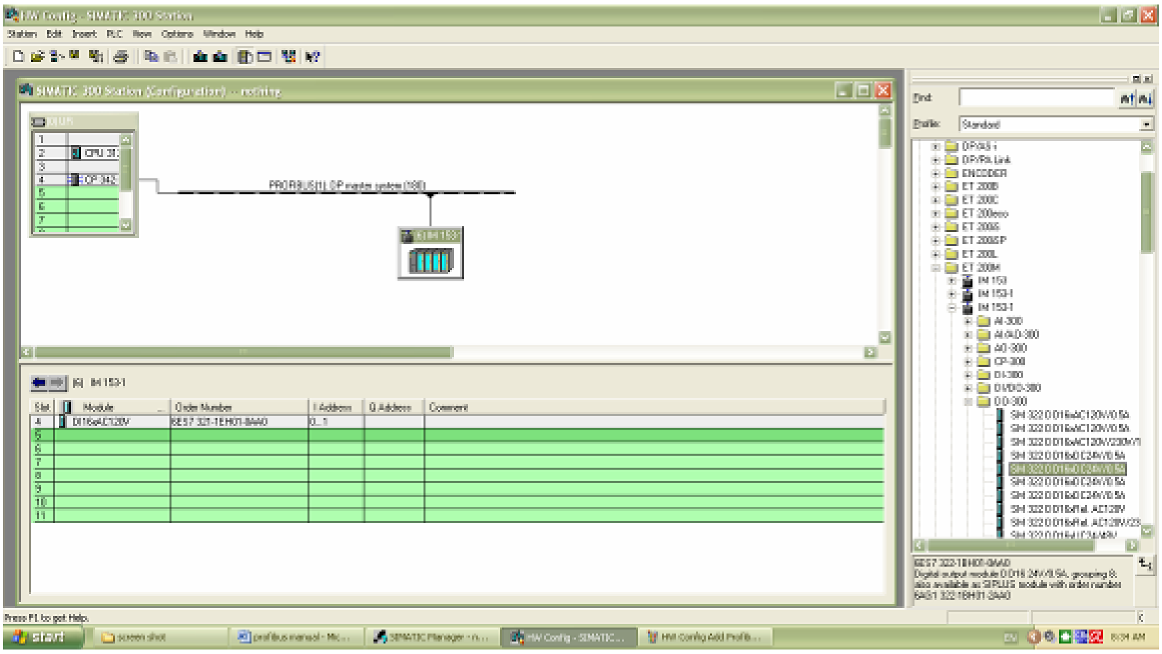


Figure 4.6: HW Config Add Net module

الآن أنهينا العمل على برمجة و تعريف الـ Hardware من خلال برنامج HW config نقوم بحفظ العمل و تحميله على الـ CPU. بعد ذلك أن قمت بالضغط على زر Configure Network (انظر الصورة 7) ستظهر لك التوصيلة بهذا الشكل المبين في الصورة 8:

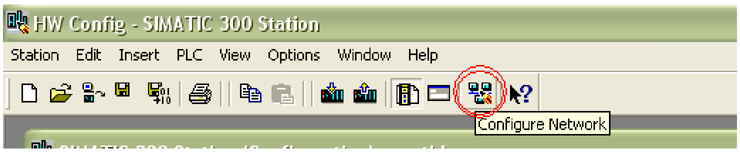


Figure 4.7: Configure Network bottom

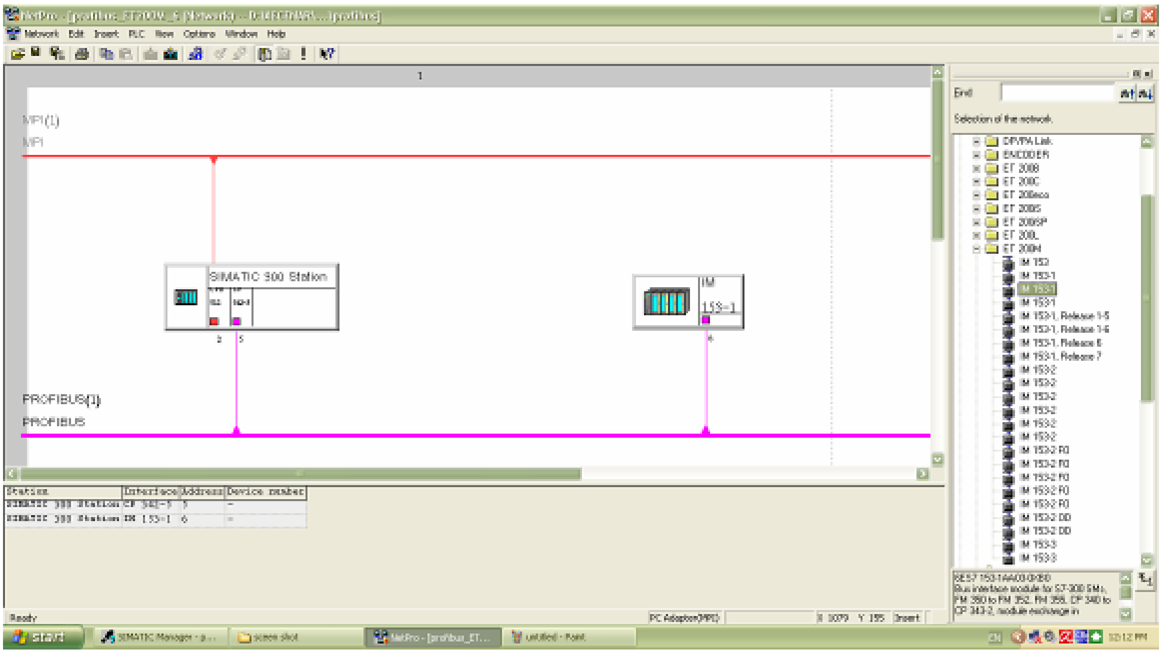


Figure 4.8: NetPro connection

هذه هي طريقة توصيل PROFIBUS الآن أصبح بأمكانك كتابة برنامجك الخاص بمشروعك كالشكل المعتاد. يمكنك مراقبة عمل الـ CPU أو الـ CP 342-5 من خلال أختيار Object properties من قائمة زر الموس اليميني و من ثم Diagnostics و من ثم Run (انظر الصورة 9):

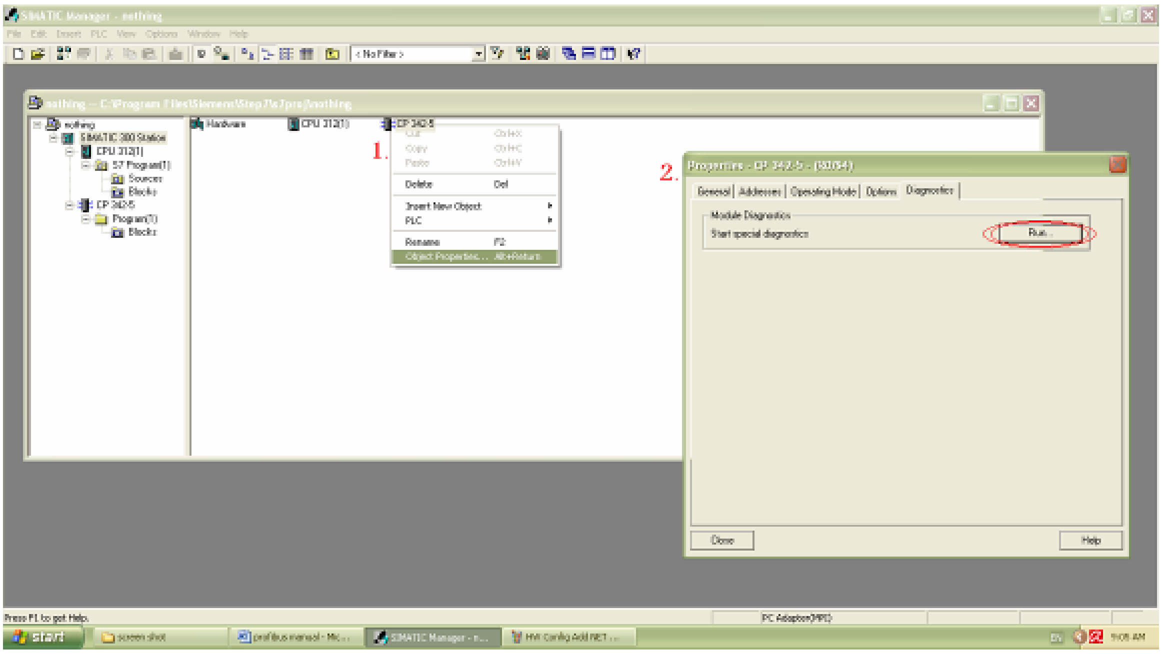


Figure 4.9: open Diagnostics screen

يمكنك مراقبة و معرفت أي معلومات تحتاجها من هنا (انظر الصورة 10):

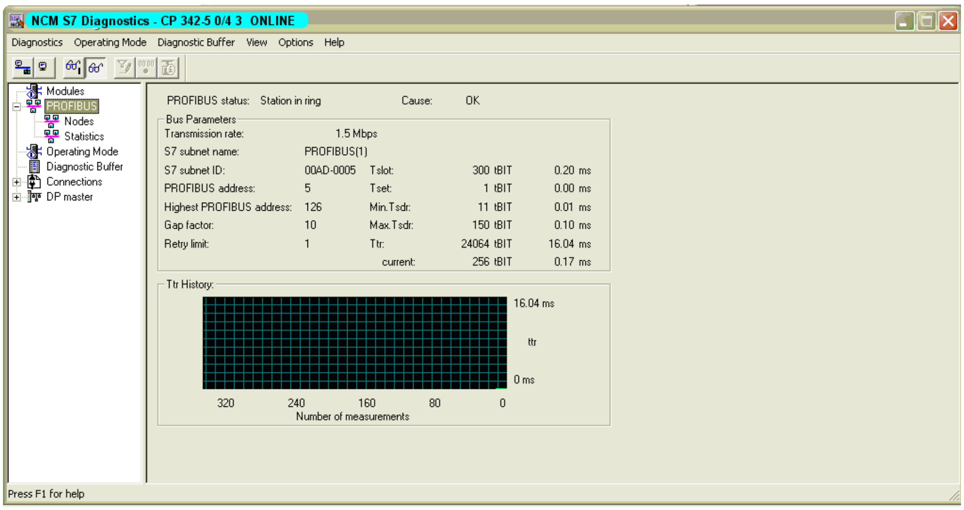


Figure 4.10: Diagnostics screen

21.4.3 Analog input Reading

21.4.3.1 تعريف الـ Analog input module:

تتيح الـ PLC S7-300 امكانية قراءة مداخل متغيرة Analog من خلال إضافة أحدى القطع الخاصة المتوفرةSM 331 AI بعدة أشكال, إخترنا منها AI 2x12Bit لاستعمالها في مشروعنا هذا.

نلاحظ من أسم الـ Module انها تحتوي مدخلين متغيرين Analog يتألف كل منهما من 12Bit أي أن دقة القراءة هي 2"12=4096. من هنا نلاحظ أننا لقراءة المدخل خلال البرمجة لا نقوم باستعماله كـ Bit كما في المداخل العادية Digital input حيث كنا نستعمل المداخل بهذا الشكل I 0.1 أما هنا فلا, لان كل مدخل هو 12Bit اي سنحتاج 2 Byte كون كل Byte=8Bit, و 2 Byte في لغة البرمجة تعني 1Word لذلك يتم تعريف مدخل الـ Analog خلال البرمجة كـ IWxxx مع الإشارة إلى أن الـ xxx هي الرقم المعرف للمداخل.

تظهر الصورة التالية أن Analog module قد حجزت المداخل بين الرقمين 64 و 67 أي أنه سيكون لدينا مدخلين متغيرين هما IW64 و IW66. نلاحظ أننا تجاوزنا الـ 65 و ذلك بسبب أن الـ Word=2Byte لذلك حجز المدخل الأول الـ 64 و الـ 65 و كذالك الامر نفسه بالنسبة لـ 67 حجزت مع الـ 66 (انظر الصورة 1):

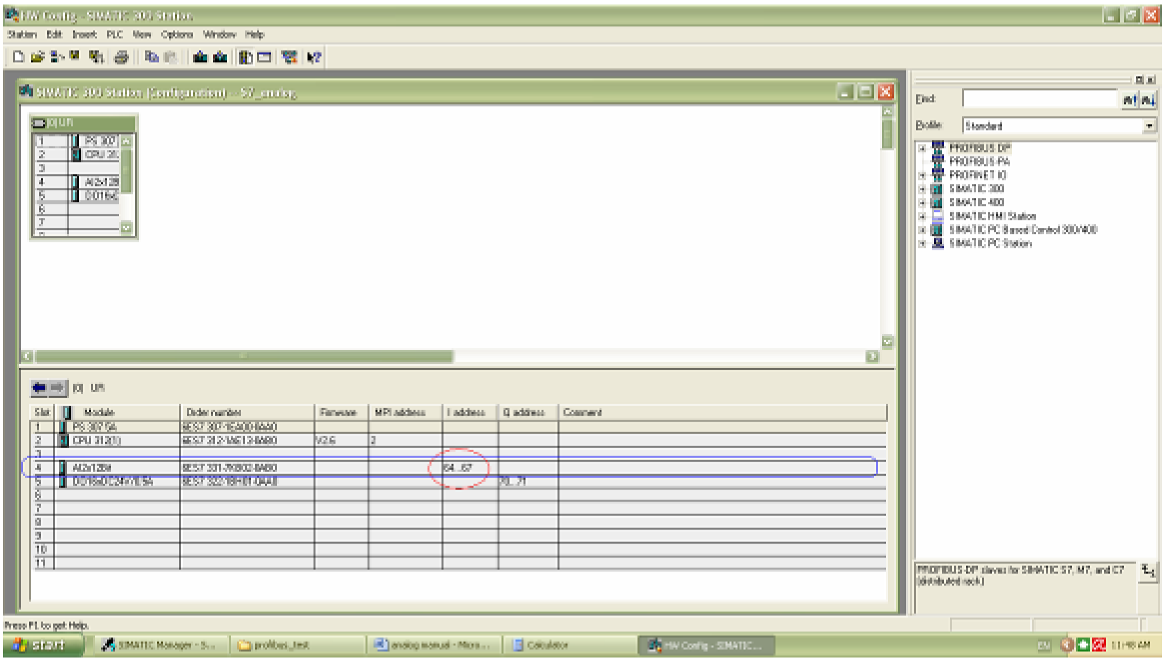


Figure 4.11: I / 0 number specification

بعد أن تم بناء بنية الـ PLC كما في الصورة أعلاه نتحول إلى بدء كتابة برنامج الـ LAD الخاص بقراءة المداخل الـ Analog.

21.4.3.2 كتابة برنامج قراءة الـAnalog :

بداية أود التنويه إلا أن برنامج الـ SIMATIC Manager يوفر إمكانية إضافة بلوكات مبرجة و جاهزة للأستخدام يمكن الإستفادة منها أثناء كتابة البرامج (انظر الصورة 2). سنستخدم بعضها في برنامجنا.

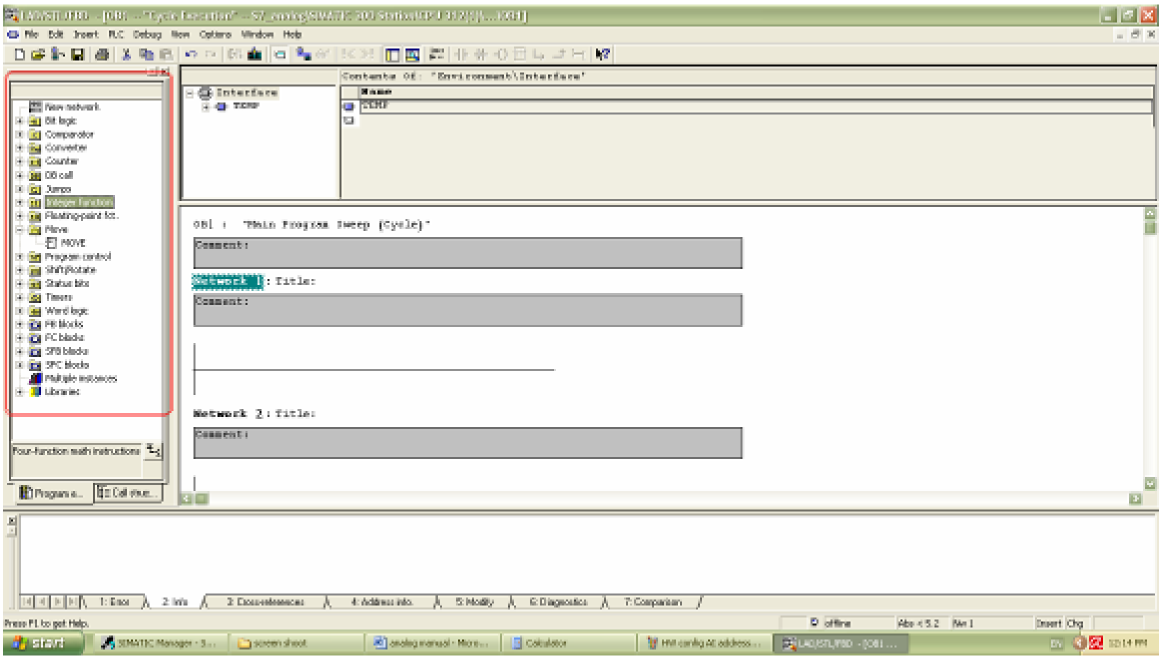


Figure 4.12: order librery

البلوكات المستخدمة (Blocks used) :

- **MOVE:**

تقوم بنقل بيانات من موقع إلى آخر, يتم أستدراجها من قسم <u>Move</u>.

- **DI_R (Digital to Real converter):**

تقوم يتحويل البيانات إلى أرقا م حقيقية, أي من Hexadecimal إلى Decimal, يتم إستدراجها من قسم Converter.

- DIV_R (Real Division):

تقوم بقسمة الدخل الأول على الثاني, يتم أستدراجها من قسم Floating-point function.

- LT_R (CMP < R compare real number, true if less than):

تقوم بفحص أن كان الدخل الاول أصغر من الدخل الثاني أو لا, تستدرج من قسم Comparator.

- GE_R (CMP >= R compare real number, true if greater than or equal):

تقوم بفحص إن كان الدخل الاول أكبر أو يساوي الدخل الثاني أو لا, تستدرج أيضاً من قسم Comparator.

نقاط حفظ البيانات في الـ CPU الـ PLC:

تحتوي ال CPU على عدد من نقاط حفظ البيانات التي يمكن إستخدامها لحفظ البيانات المؤقته خلال البرنامج, يشار إليها بحرف M مصحوباً مع حرف ثاناً يدل على نوع هذه الذاكرة مع رقم يدل على العنوان أو فقط مصحوباً مع رقم في حال كان المراد أستخدامها لحفظ Bit واحدة فقط.

- M: تشير إلى ذاكرة لـ Bit واحدة فقط. تستخدم: **M x.y** (x و y تدلنا على عنوان الذاكرة).
- MB: تشير إلى ذاكرة لـ Byte. تستخدم بهذا الشكل: **MB x** (x يدل على عنوان الذاكرة).
- MW: يشير إلى ذاكرة لـ Word. تستخدم: **MW x** (x يدل على عنوان الذاكرة).
- MD: يشير إلى ذاكرة لـ Double Word. تستخدم: **MD x** (x يدل على عنوان الذاكرة).

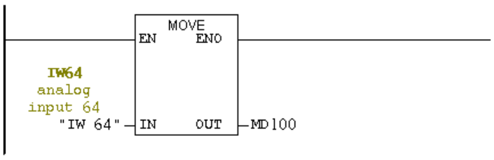
بنية البرنامج:

OB1 : "Main program: analog input reading (Cycle)"

Comment:

Network 1: analog read move from the input pin to the memorry double MD100

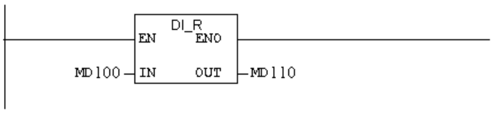
Comment:



هذه الشبكة تقوم بنقل الرقم المقروء من IW64 إلى الذاكرة MD100

Network 2: digital to real converter

Comment:



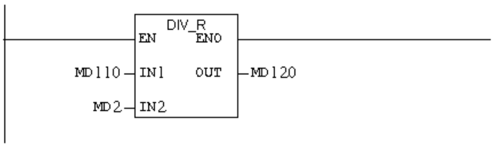
هذه الشبكة تقوم بتحويل محتوى الذاكرة من Digital إلى Real

Network 3: divisor set (MD1)

هذه الشبكة تقوم بجعل MD1=100 و MD2=Real100

Network 4 : division network to minimize the real number

Comment:



هذه الشبكة تقوم بقسمة الـ IN1 على الـ IN2 و تحفظ في MD120

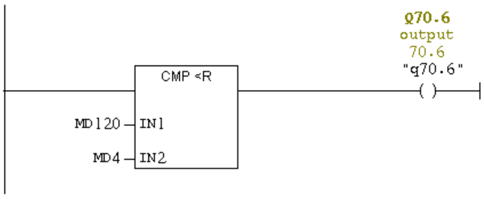
Network 5 : comperator set MD3

Comment:

هذه الشبكة تقوم بجعل MD3=50 و MD4=Real50

Network 6 : comparision network 1

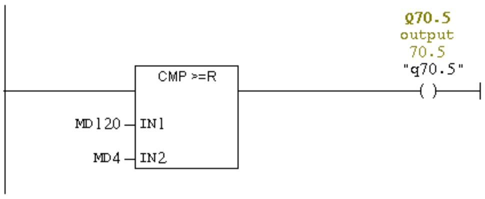
Comment:



هذه الشبكة تقوم بمقارنة, إذا نجحت تشغل Q70.6

Network 7 : comparision network 2

Comment:



هذه الشبكة تقوم بمقارنة, إذا نجحت تشغل Q70.5

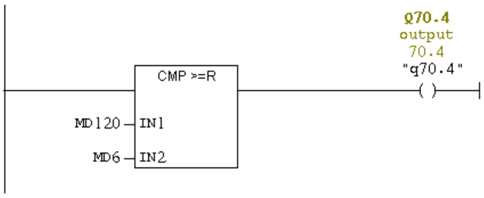
Network 8 : comperator set MD5

Comment:

هذه الشبكة تقوم بجعل MD5=100 و MD6=Real100

Network 9 : comparision network 3

Comment:



هذه الشبكة تقوم بمقارنة, إذا نجحت تشغل Q70.4

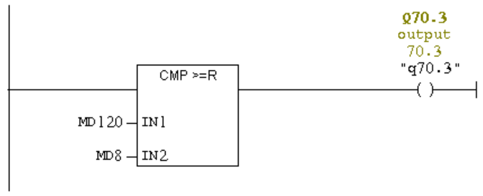
Network 10 : comperator set MD7

Comment:

هذه الشبكة تقوم بجعل MD7=150 و MD8=Real150

Network 11 : comparision network 4

Comment:



هذه الشبكة تقوم بمقارنة, إذا نجحت تشغل Q70.3

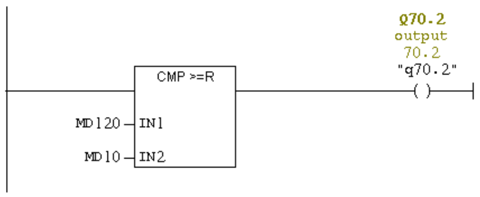
Network 12 : Title:

Comment:

هذه الشبكة تقوم بجعل MD9=200 و MD10=Real200

Network 13 : Title:

Comment:



هذه الشبكة تقوم بمقارنة, إذا نجحت تشغل Q70.2

بعد الإنتهاء من هذا البرنامج نقوم بتحميله على الـ CPU لتجربته. لتجربة البرنامج نحتاج إلى مصدر طاقة كهربائية متغيرة من 0 إلى 10 Volt.

يتم توصيل الـ PLC و تغذيتها مع مدخل الـ Analog كما في الصورة التالية :

Figure 4.13: PLC Analog input connection

ستجد على باب الـ Module من الخلف طريقة تغذيتها بالطاقة و مكان المداخل أو المخارج المجهزة (انظر الصورة 14).

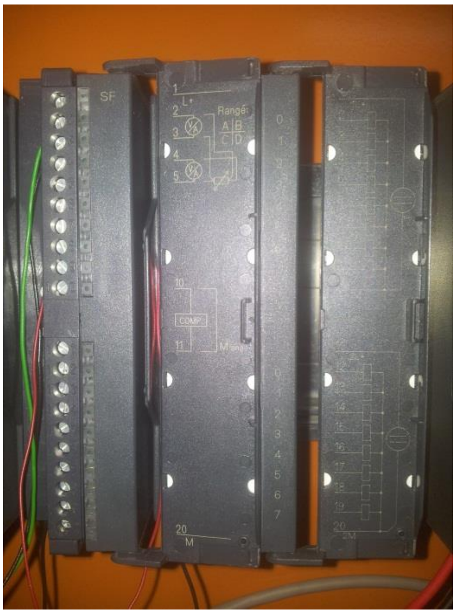


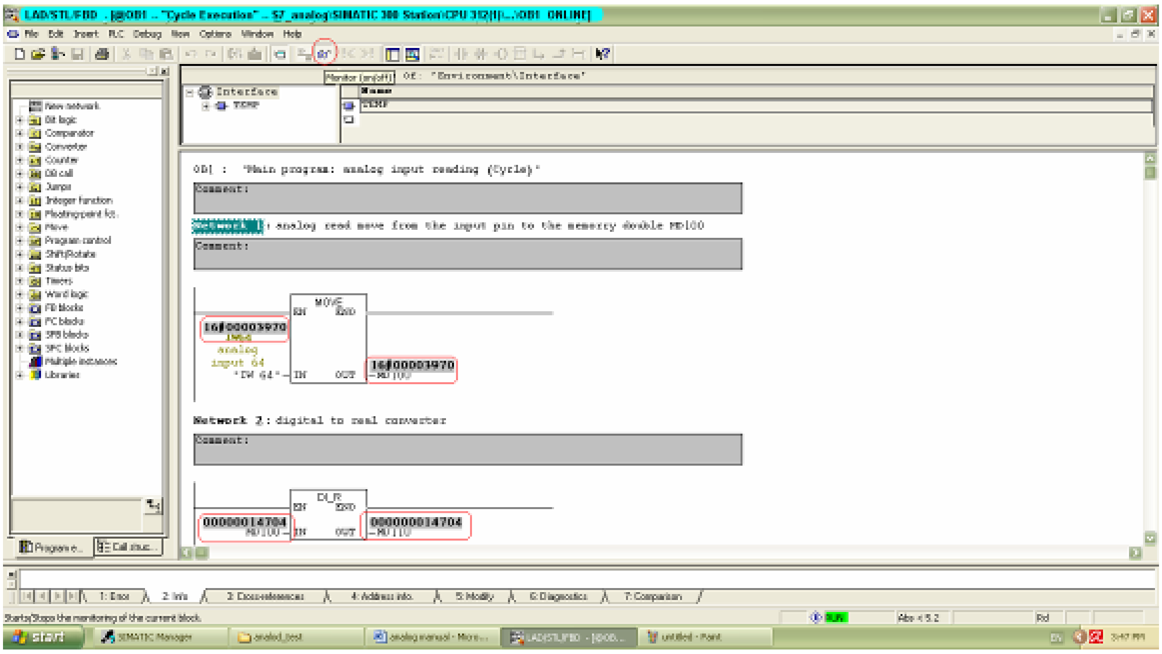
Figure 4.14: module connection MAP

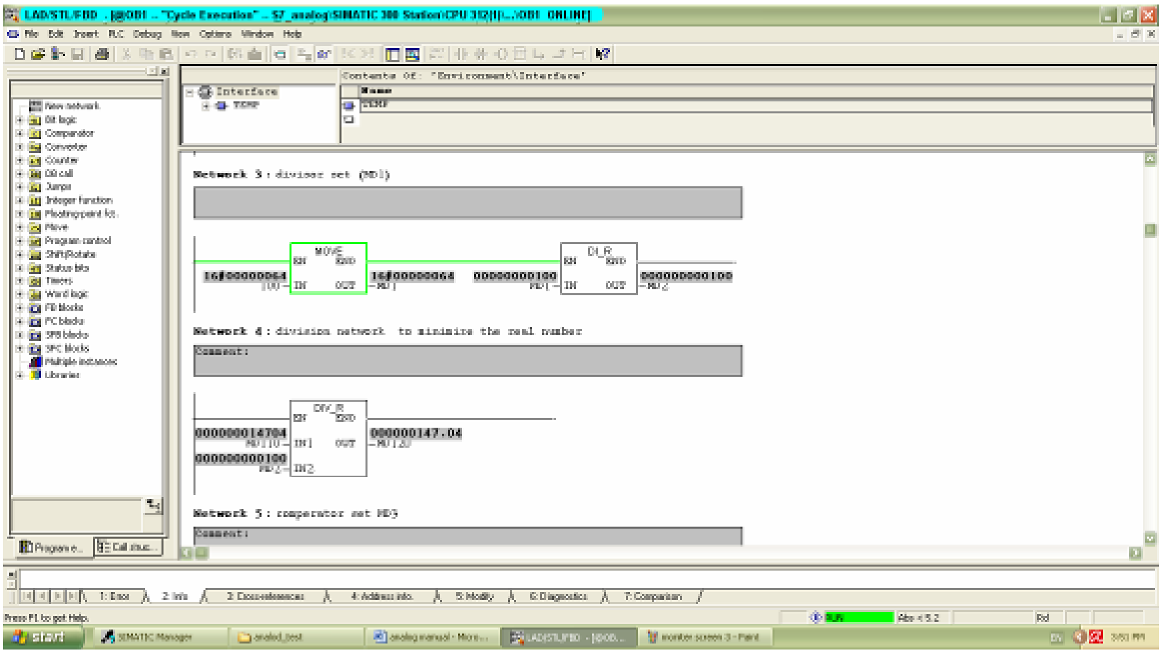
أن كنت قد نجحت في توصيل و تعريف و برمجة الـ PLC كما يجب, إذا تكون قد نجحت في تمثيل حجم الطاقة الموجودة على مدخل الـ Analog على أزرار مخارج الـ Output كما في الصور التالية:

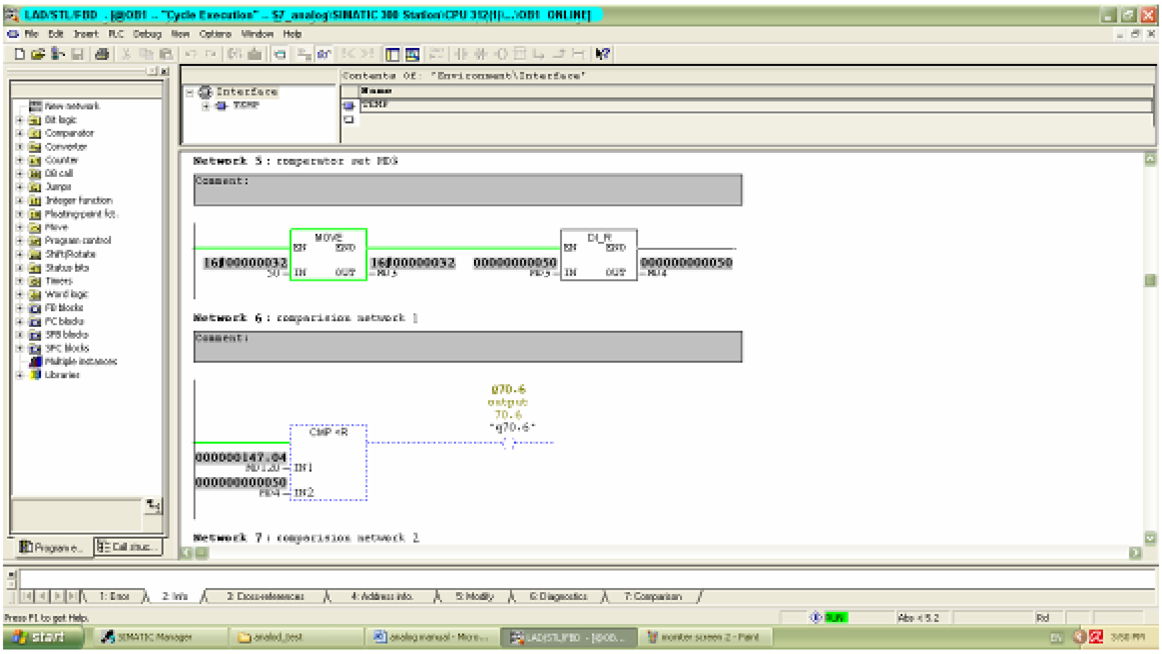
Figure 4.15: analog voltage on output PIN

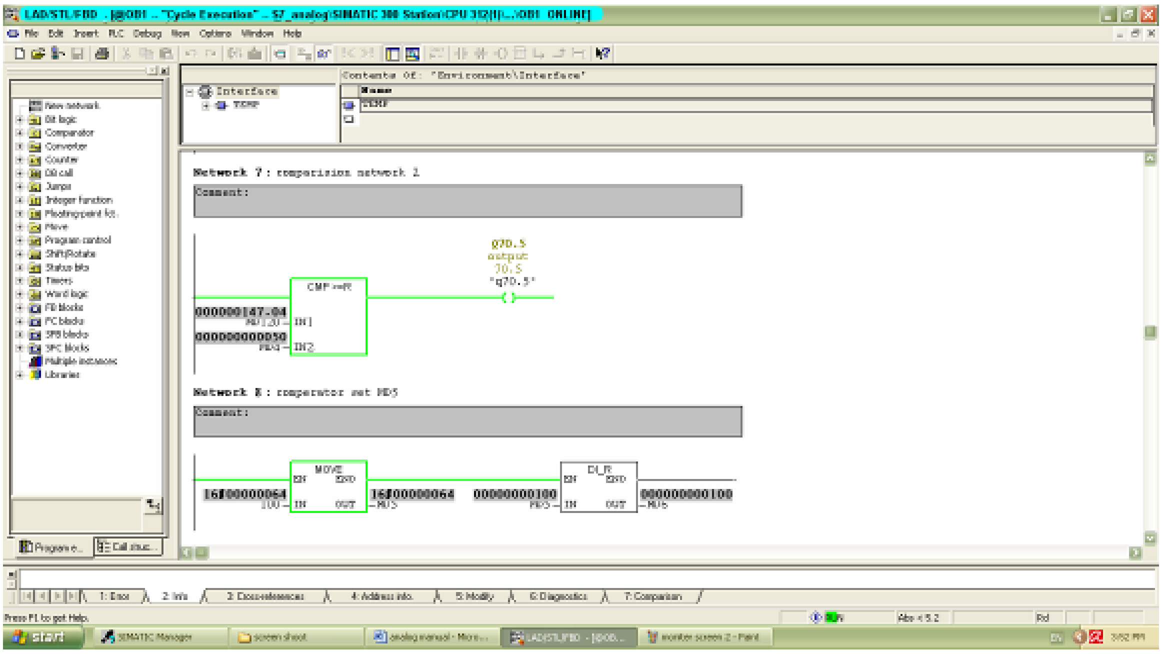
كما يمكنك إجراء محاكاة لما يجري على الـ PLC من برنامج الـ SIMATIC و ذلك من خلال الضغط على زر Monitor من برنامج مبرمج الـ OB1, في ما يلي صور لمحاكاة تجربة حقيقية على الـ PLC:

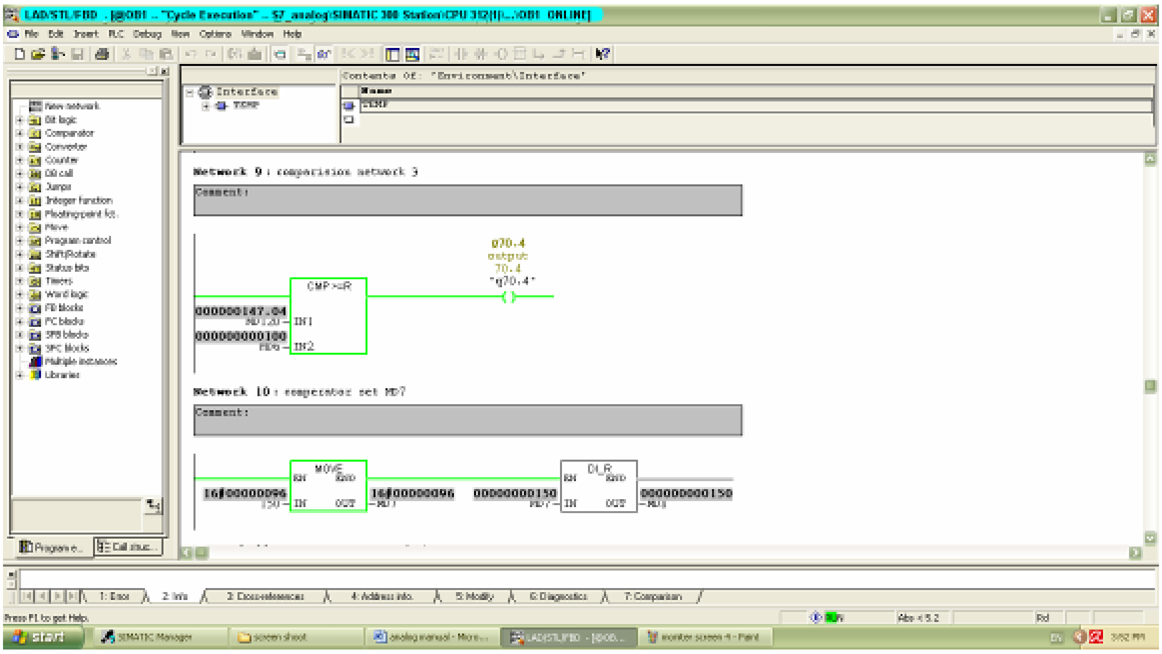
(جميع اللقطات التالية أخذة للحظة إدخال قيمة كهربائية تساوي 5.3 فولت عند مدخل الـ Analog)

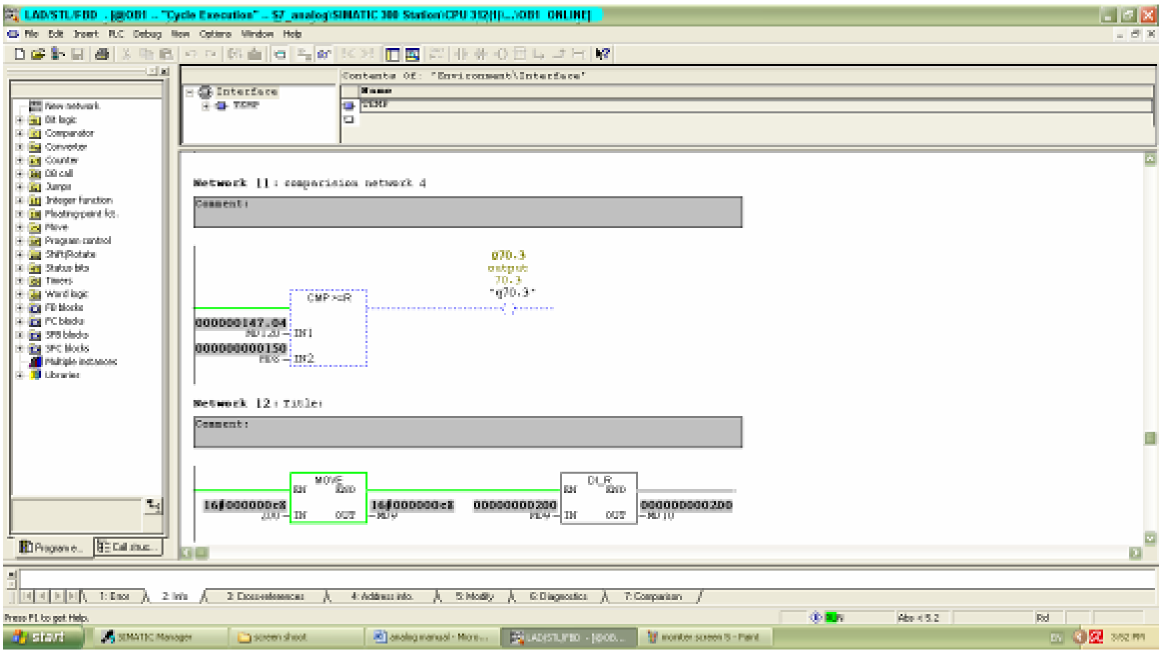


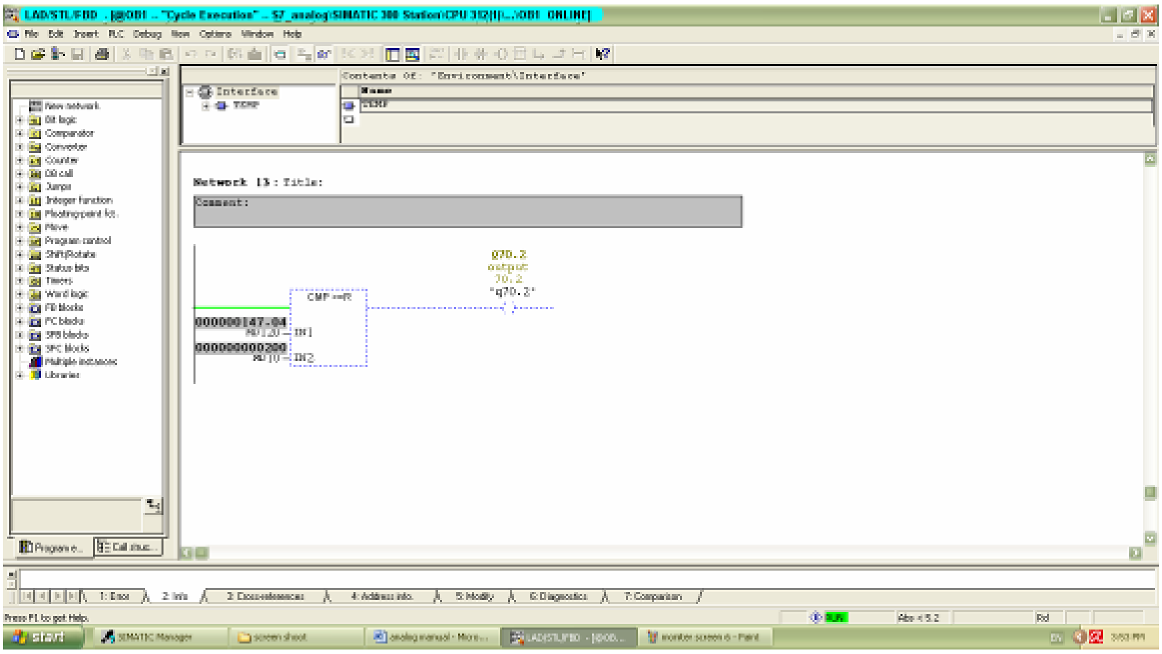








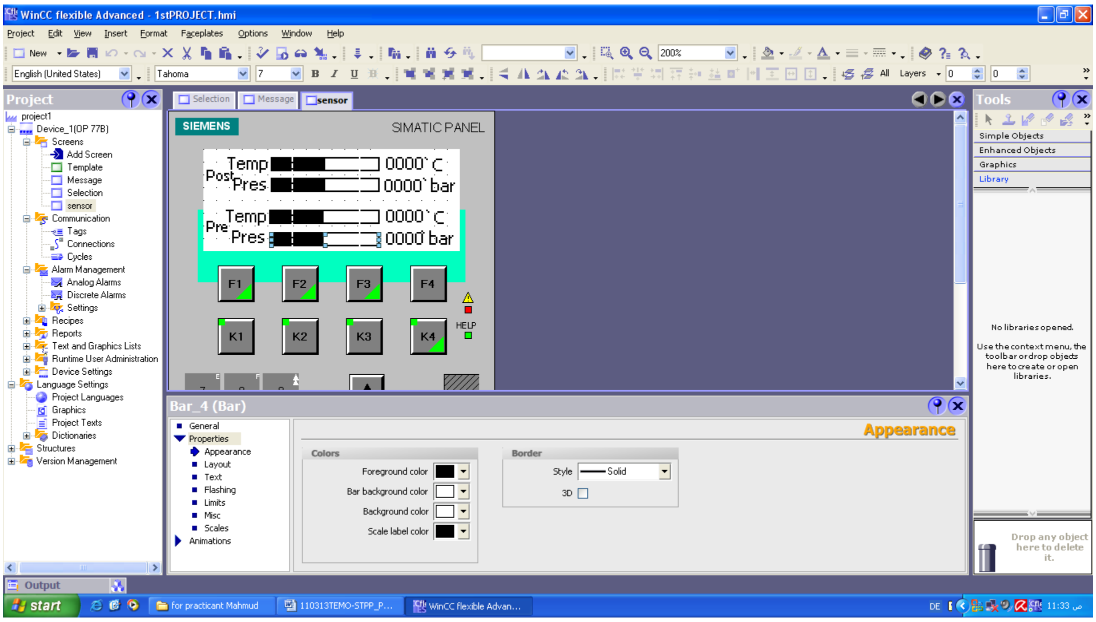




21.5 WinCC WorkFlow:

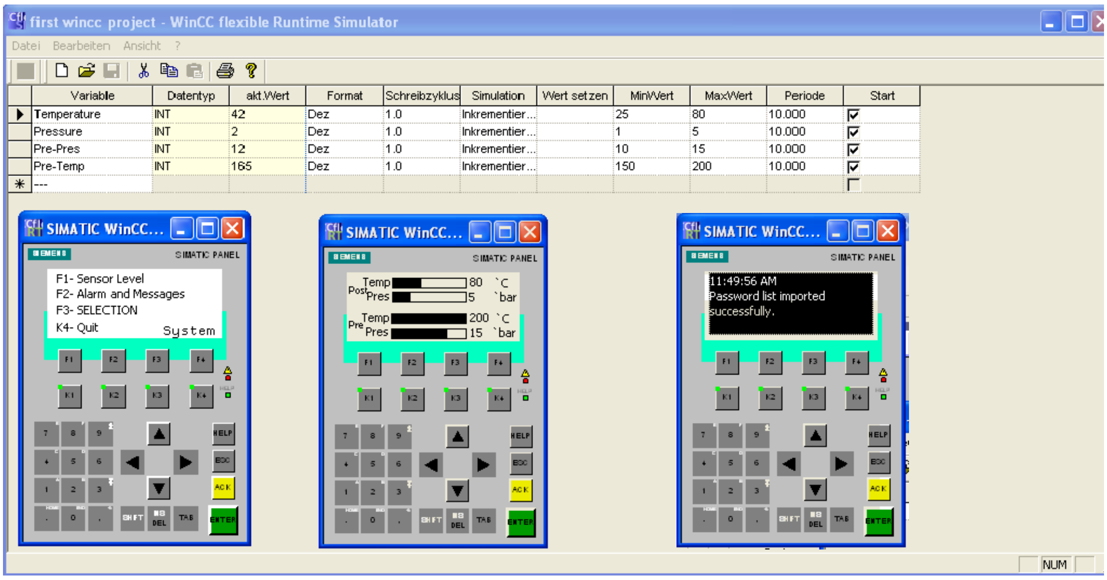
21.5.1 المشروع الأول (التعليمي) على الـ WinCC

بداية للتدرب على برنامج الـ WinCC قمنا بتطبيق الـ Tutorial الموجود في الملف -WinCCflexible GettingStarted-FirstTimeUser مع بعض التعديلات ليتناسب مع مشروع TEMO-STPP



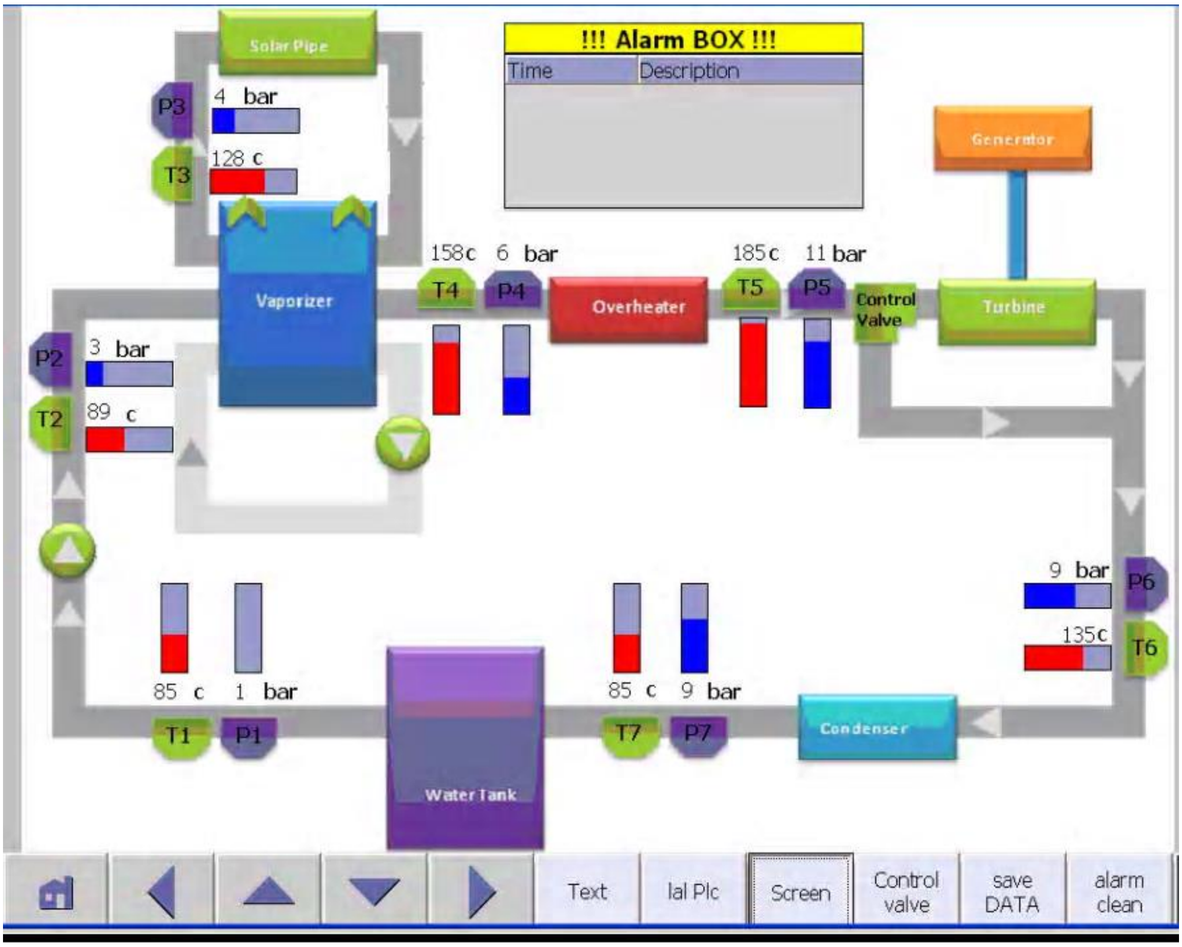
و قمنا بعد ذلك بتشغيل وهمي للبرنامج من خلال برنامج (flexible Runtime Simulator) و ذلك من خلال الضغط على المفتاح الظاهر في اللوحة التالية:

و ستظهر اللوحة التالية مع لوحة البداية (start screen) التي قمنا بتحديدها لتكون الشاشة (selection) لوحة البداية هي اللوحة الأولى من اليسار و من ثم (sensor) في المنطصف و لوحة (alarm) التي على اليمين



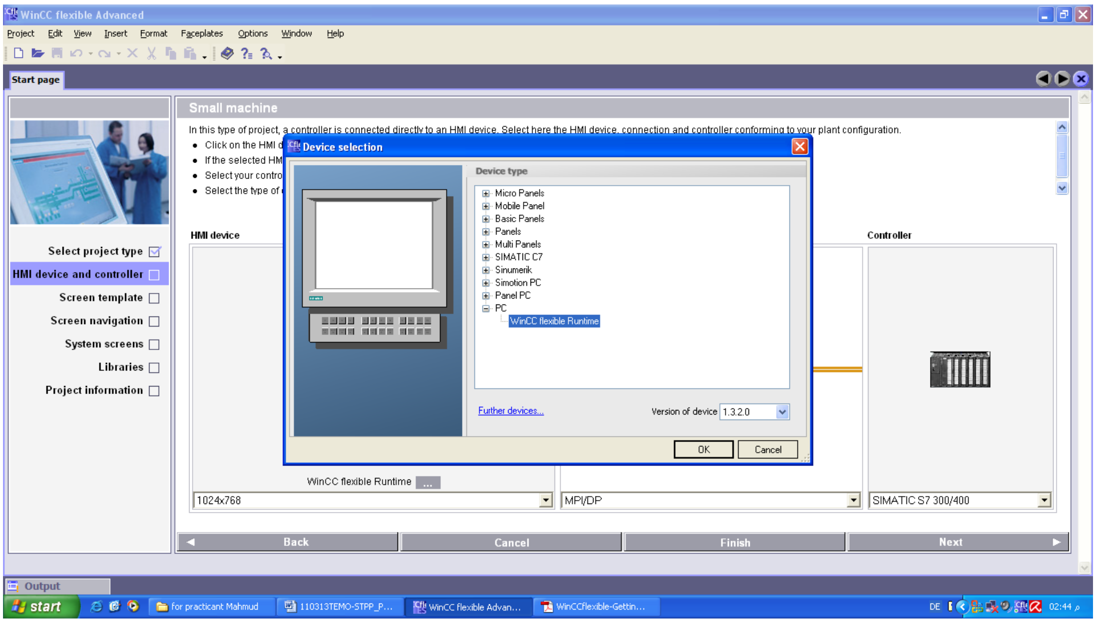
21.5.2 بداية تنفيذ المشروع على الـ WinCC

و بعد هذا التمرين الأولي قمنا بتطوير العمل إلى لوحة أكثر ملائمة لمشروع (TEMO-STPP) لتكون بهذا الشكل:



و تم تنفيذ ذلك من خلال و ضع المأشرات القياسية على صورة المشروع الرئيسية مع إضافة شاشة عرض المنبهات (Alarm BOX) مع بعض أزرار المساعدة التي في الاسفل

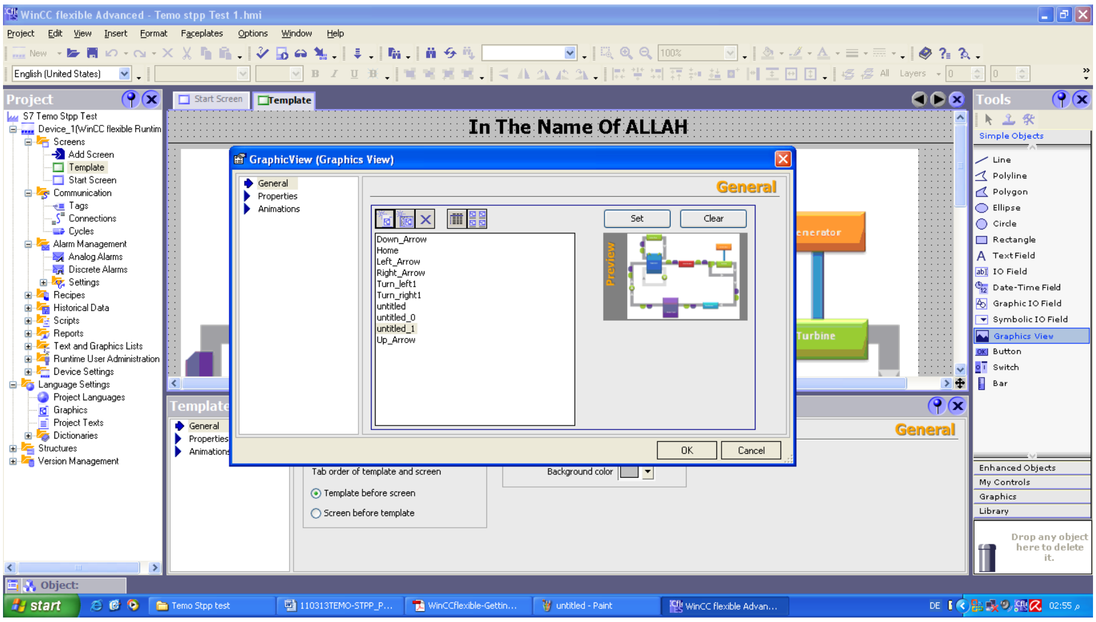
تختلف الشاشة التي هنا عن التي في الكتاب التعليمي (المشروع الأول) كون هذه الشاشة هي كاملة التحكم لا تلتزم بحدود جهاز التحكم (MobileControl) في المشروع الأول و معدة للكمبيوتر و ليس لجهاز الـ HMI كما في الملف التعليمي الاول. يتم تحديد هذا الخيار أثناء بداية مشروع جديد في الخطوة التي تختار بها أنظمة التحكم () و تختار حينها الـ PC و WinCC flexible Runtime على الشكل التالي:



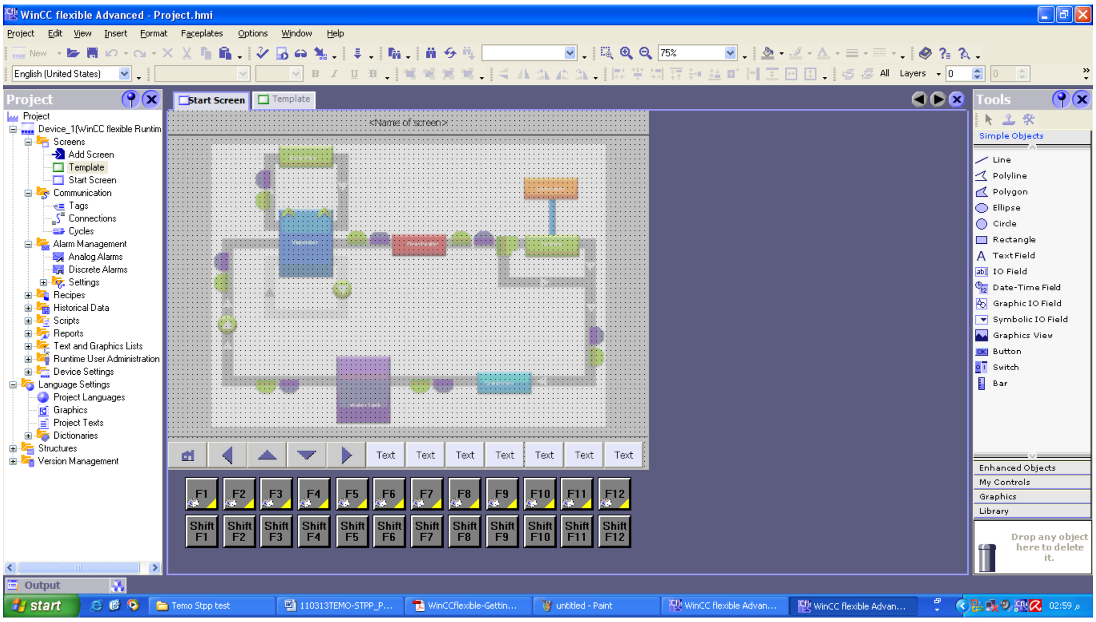
و تستطيع التحكم بباقي الخيارات حسب الحاجة كما يمكنك في حال عدم وجود خيار محدد, الإبقاء على الخيارات الأساسية للوحة.

لوضع صورة الخلفية أو أي شيء أساسي في برنامج التحكم تقوم بوضعه في اللوحة الأساسية (Template Screen) و سيظهر في جميع لوحات البرنامج و أي تخصيص يكون باللوحة الخاصة فقط و ليس في اللوحة الأساسية (Template Screen).

صورة لكيفية وضع صورة خلفية:

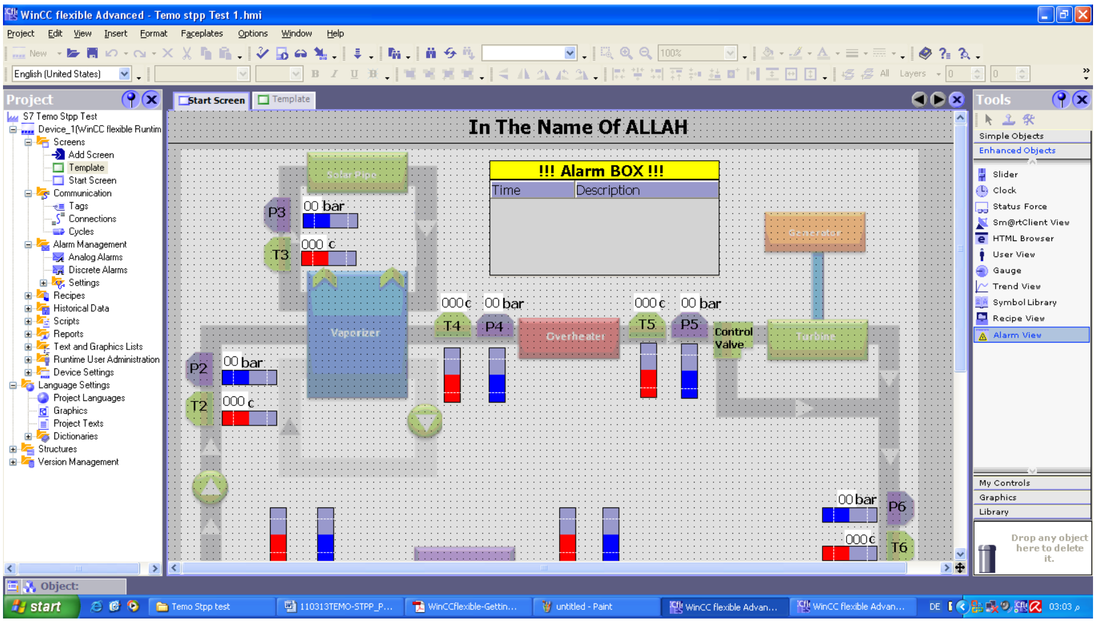


صورة توضح كيفية ظهورها في اللوحات الأخرى مثلا (Start Screen):



و بعد إضافة التخصيصات عليها حسب حاجتك و بنفس الطريقة التي تم بها تنفيذ المشروع الأول

صورة للوحة البداية بعد إضافة التعديلات عليها:



بعد ذلك يتم حفظ المشروع و أقلاعه كما في المشروع الأول ليتم الأنتقال إلى العمل على برمجة الـ PLC S7-300 من خلال برنامج SIMATIC Manager ليتم توصيل برنامج الـ WinCC المنفذ به.

لكن ما زال علي أن أعرف كيفية توصيل برنامج الـ Step 7 SIMATIC manager ببرنامج الـ WinCC لأستطيع التحكم و مراقبة الـ PLC من خلال أي كمبيوتر يحتوي برنامج الـ WinCC الذي أقوم بإعداده.

21.6 WinCC/step7 Integration

21.6.1 أساسيات التوصيل:

سيتم التوصيل عبر وصلة MPI . . .

تم إقاف العمل على هذا القسم بسبب انتهاء الترخيص الخاص بـ WinCC

21.7 Monitoring software

في مشروعنا TEMO-STPP قمنا بأستخدام Velleman P8061 board لنقوم من خلال وصلها على جهاز كمبيوتر بمراقبة و التحكم بالمشروع كطريقة ثانية تعمل بالتوازي مع الـ PCL لتستمر واحدة في حال تعطل الأخرى أو إيقافها للصيانة.

تبرمج الـ Velleman VK8061 CPU بطرق متعددة, إخترنا منها طريقة Python. و Python هي لغة برمجة سهلة و قريبة جدا من لغات البرمجة السائدة و المعروفة بين المبرجين و المهندسين.

21.7.1 Velleman P8061 board

Velleman Board هي لوحة تحكم بمداخل و مخارج متعددة مع ودخل USB يتيح لك أمكانية توصيلها بالكمبيوتر لأجراء محاكاة و تحكم و مراقبة مداخلها و مخارجها المتعددة

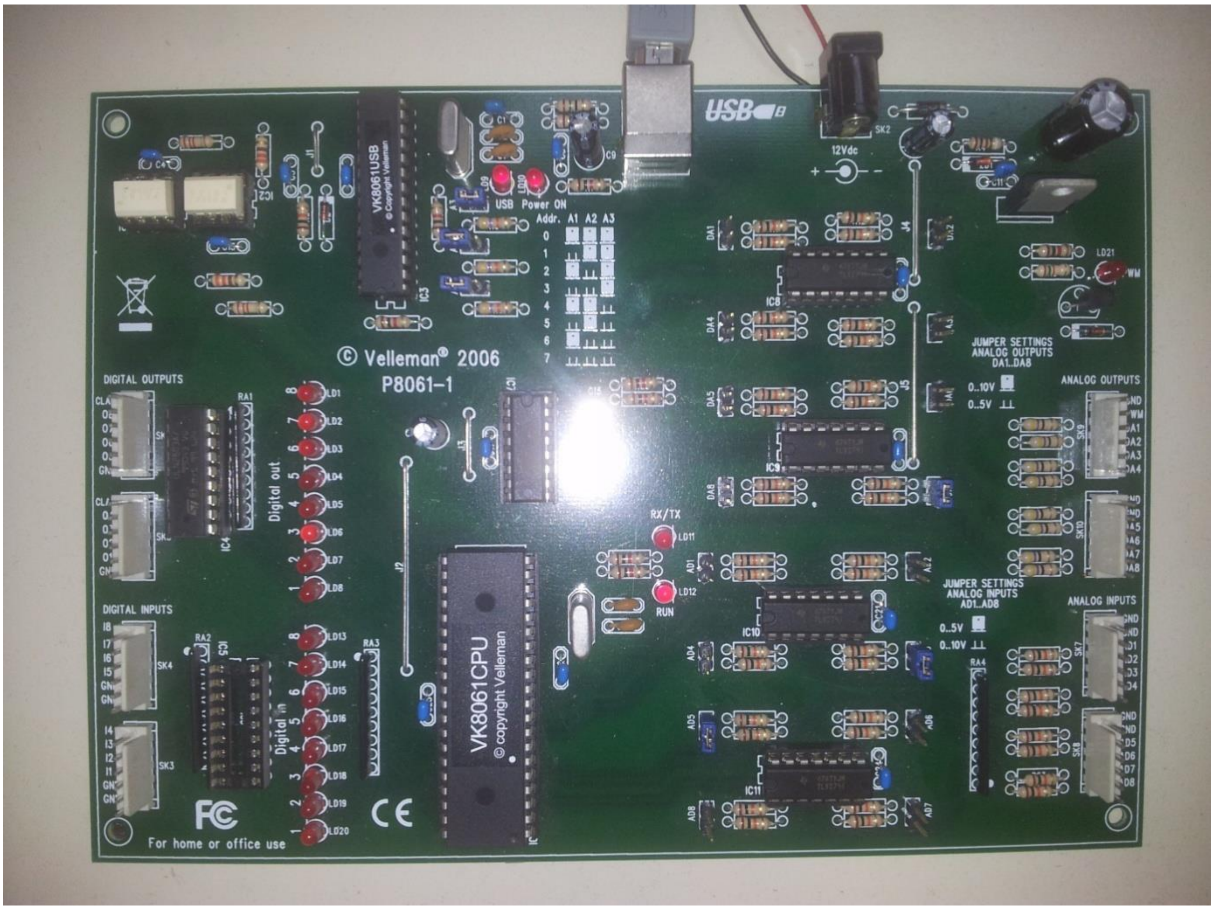


Figure 4.7.1: Velleman Board

يمكنك توصيل من 1 إلى 8 لوحات Velleman board إلى جهاز الكمبيوتر , ذلك كون الـ Velleman board لديها عنوان Board address يحدد من خلال الـ A1, A2 and A3 Jumpers (انظر الصورة 2) و يكون من 0 لـ 7 بما مجموعه ثمانية عناوين أي ثمانية لوحات.

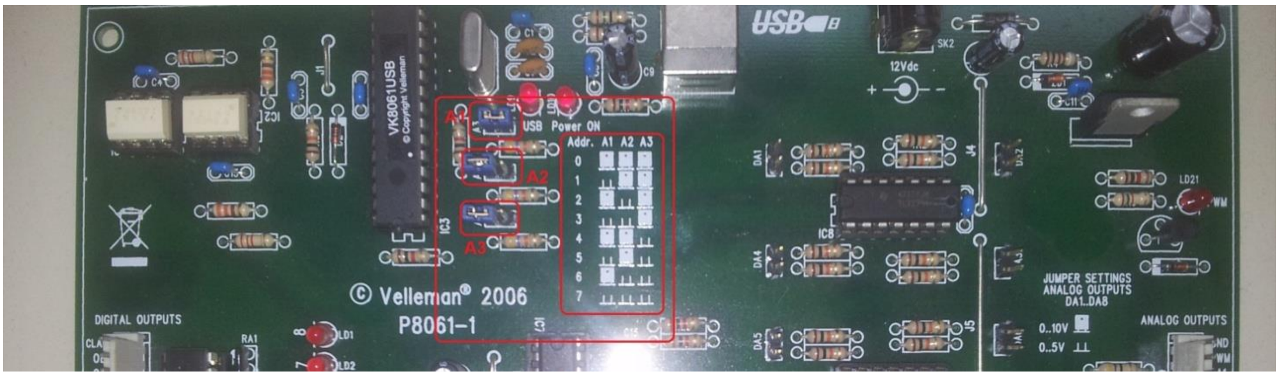


Figure 4.7.2: Velleman Board address setting

21.7.1.1 مواصفات و خصائص الـ Board

إن k8061 board تحتوي على ما مجموعه 33 مدخل و مخرج: ضمنه متغير و ثابت و مخرج إشارة PWM :

- 8 مدخل متغيرة Analog 10 bit: من 0 لـ 5V أو من 0 لـ 10V
- 8 مخارج متغيرة Analog 8 bit: من 0 لـ 5V أو من 0 لـ 10V
- 8 مداخل ثابتة Digital بحالة open collector
- 8 مخارج ثابتة Digital بحالة open collector و يتحمل تغدية خارجية 50V كحد أقصى
- مخرج PWM 10 bit بحالة open collector و يتحمل تغدية خارجية 40V كحد أقصى
- سرعة التنفيذ: 4 مل-ثانية للأمر الواحد 4ms per command
- تغذية خارجية = 12 V DC بقوة 300 mA

21.7.1.2 توصيل الـ board بجهاز الكمبيوتر

كما سبق و ذكرنا تتيح Velleman board إمكانية التوصيل بالكمبيوتر من خلال وصلة USB بطريقة آمنه من تأثير خارجي مضر.

كأي وصلة كمبيوتر خارجية يجب توفر ملف التعرفة Driver الخاص بهذه القطعة ليستطيع الكمبيوتر التفاعل معها, الملف الذي نحتاجه الـ Velleman board هو (mchpusb.sys) المتوفرعلى الأنترنت أو في القرص الصلب المرفق مع الـ Board. تقوم بإضافته من قسم Add new hardware من جهاز كمبيوترك.

كذلك يحتاج الكمبيوتر ملفات الوصلات الديناميكية DLL (Dynamic Link Library) للـ Board ليستطيع التفاعل معها و تضاف إلى نفس الملف الذي يحتوي البرنامج, و هي متوفرة أيضاً إما على الانترنت أو في القرص الصلب المرفق مع الـ board. جميع برامج و صيغ التوصيل متوفرة على DLL files عليك أن توفر هذه الملفات لتقوم بتفعيل التواصل و التفاعل بين الكمبيوتر و الـ Board. الملف الذي ستحتاجه لهذه الـ Board هو (K8061.dll) و ملف (mpusbapi.dll) يوجد أيضا على القرص المرفق أو يمكنك تحميله من الانترنت برنامجين لتجربة (Demo) و لتشخيص (Diagnosis) الـ board مع الكمبيوتر, و هذه بعد التجارب المنجزة:

برنامج الـ Demo :

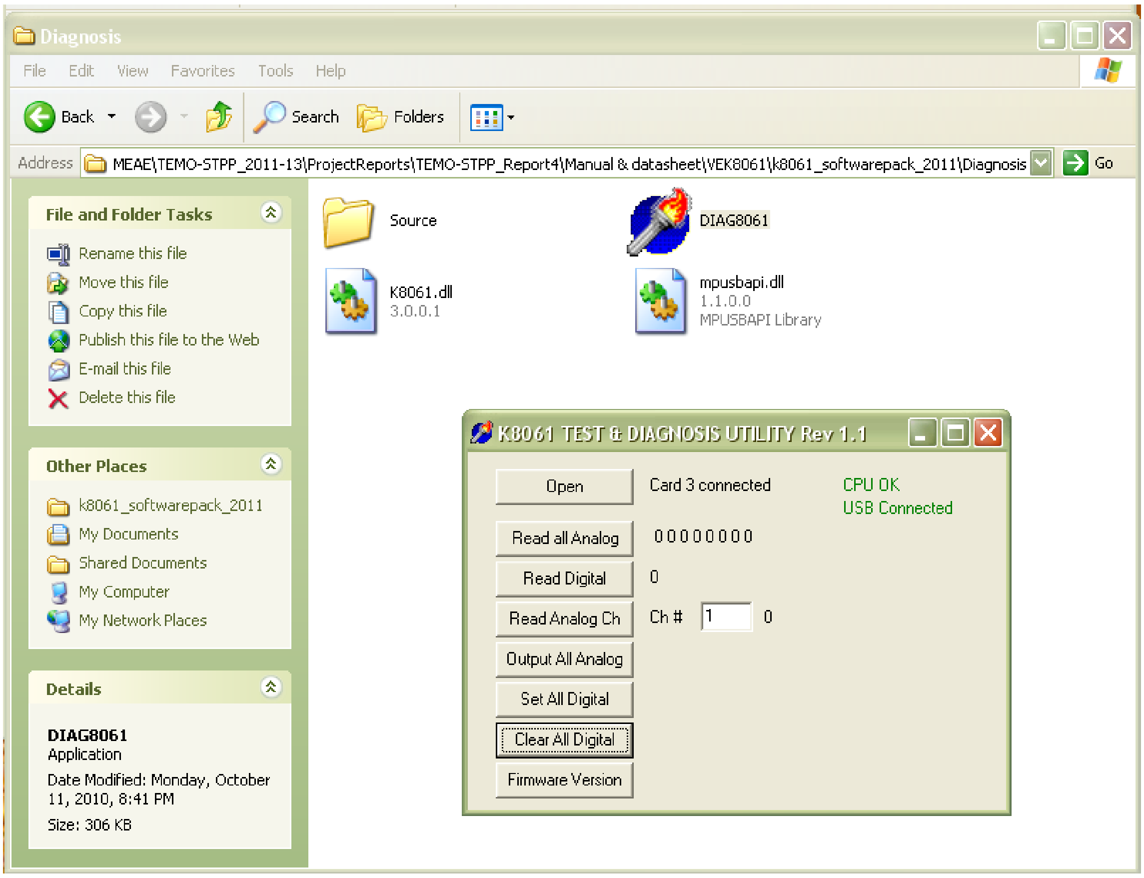


Figure 4.7.3: Demo screen shot on PC

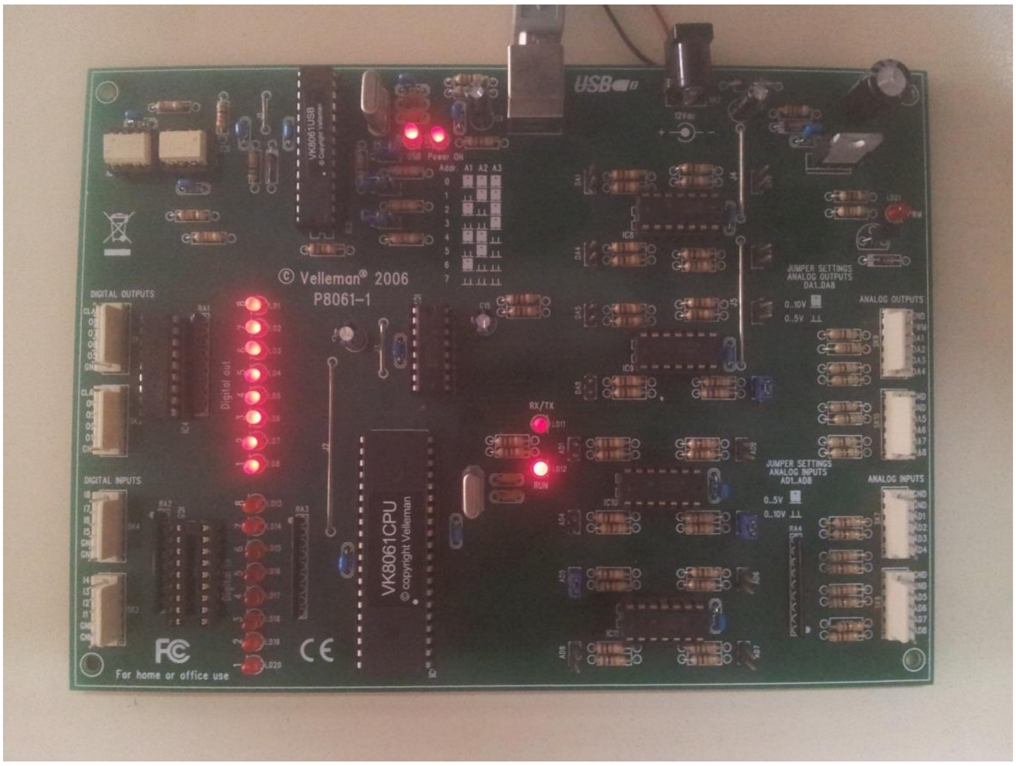


Figure 4.7.4: Velleman board interaction with Demo

برنامج الـ Diagnosis تجربة أولى:

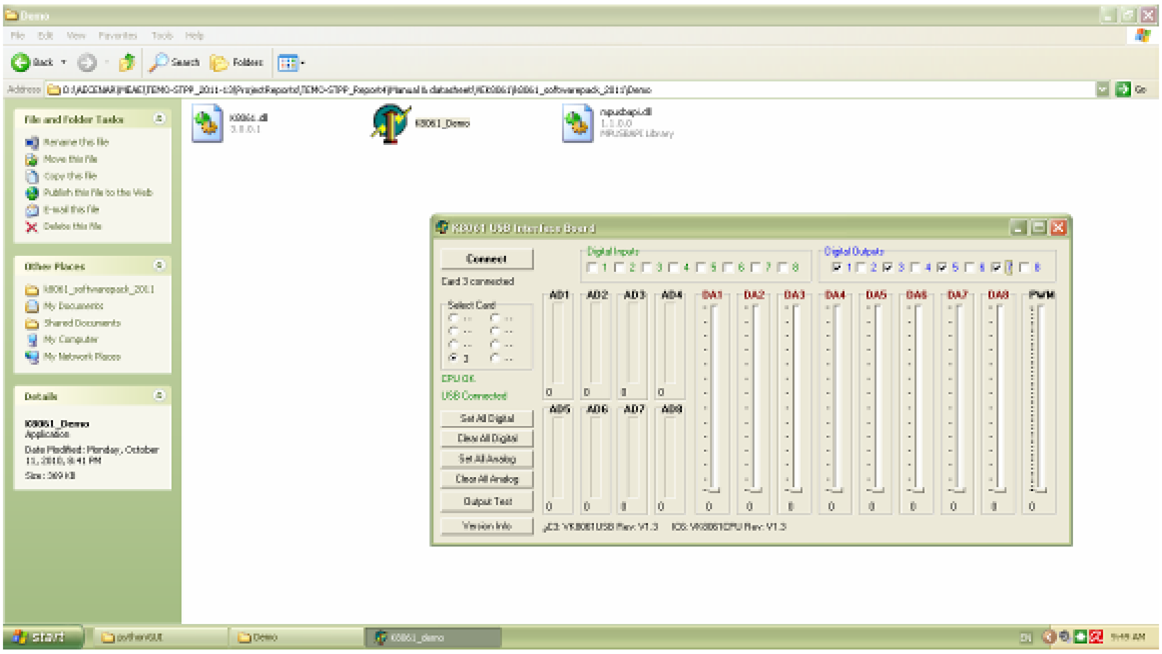


Figure 4.7.5: Diagnosis screen shot on PC

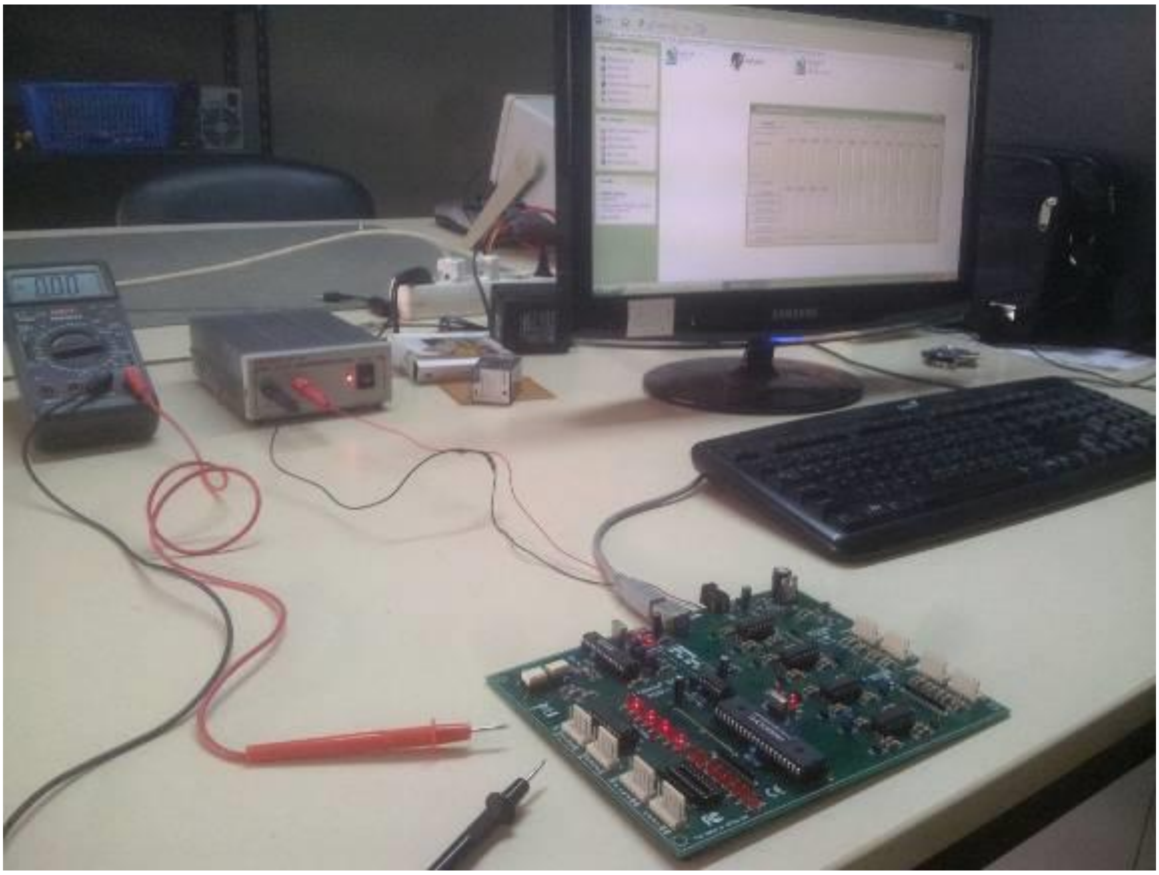


Figure 4.7.6: Velleman board interaction with Diagnosis

برنامج الـ Diagnosis تجربة ثانية:

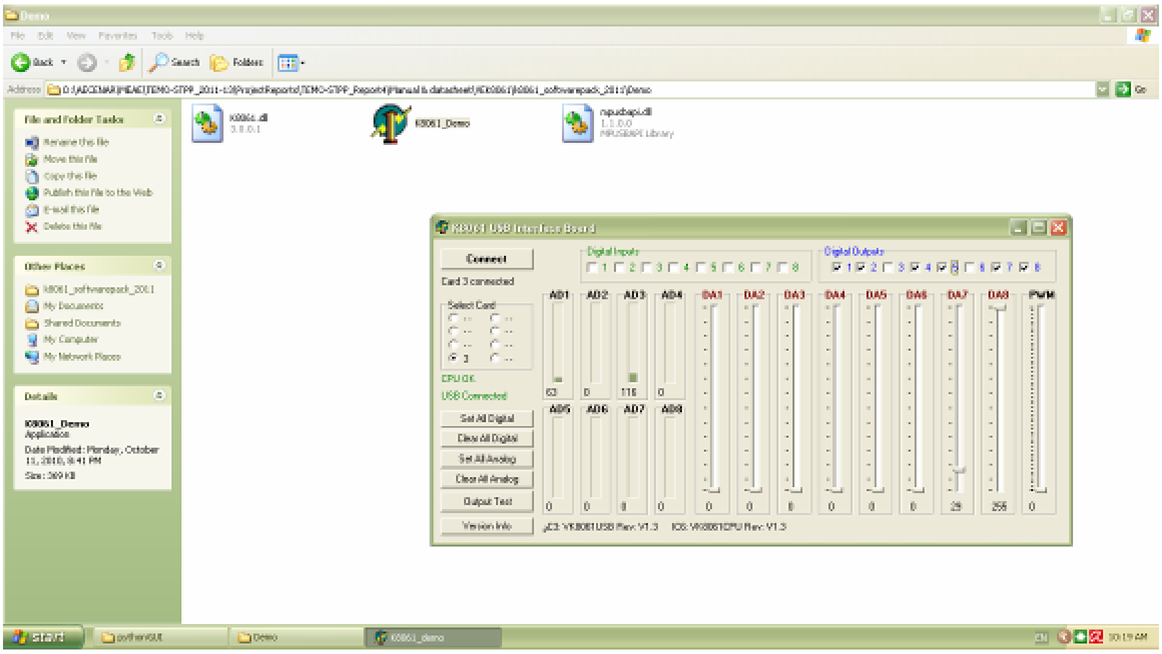


Figure 4.7.7: Diagnosis screen shot on PC

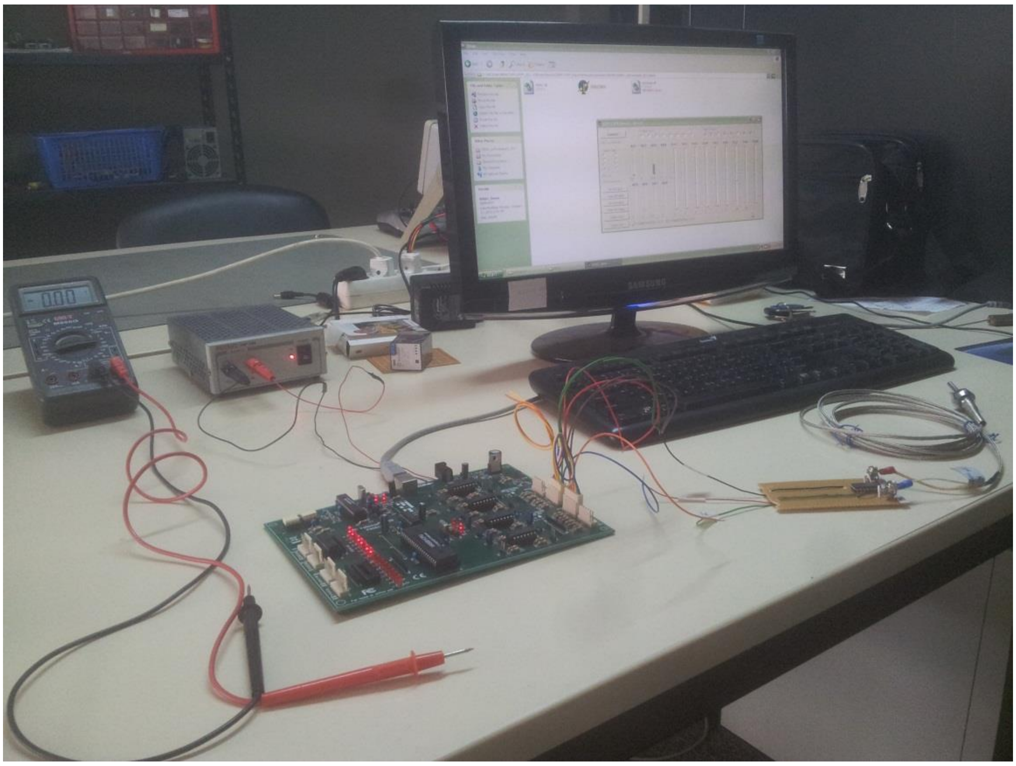
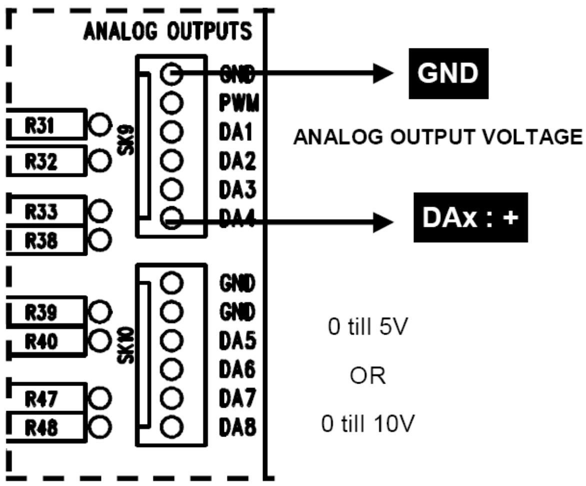


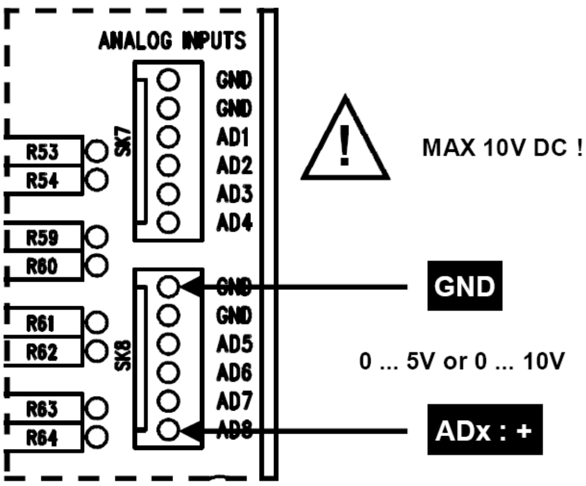
Figure 4.7.8: Velleman board interaction with Diagnosis

21.7.1.3 توصيل مداخل و مخارج الـ Board

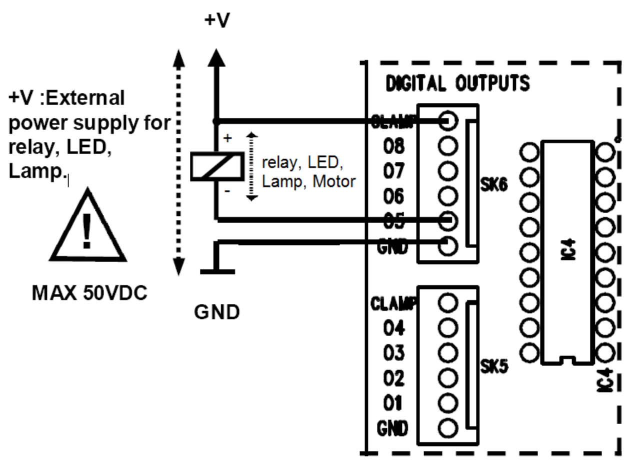
1. Analog output :



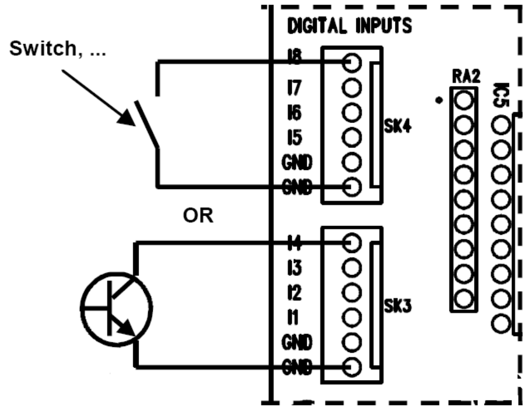
2. Analog input :



3. Digital output :



4. Digital input :



21.7.2 Python Software:

Python هى لغة برمجة عامة لمعظم المجالت ان لم تكن جميعها، وهى High Level Programming اى انها قريبة جدا من لغة الإنسان "الإنجليزية" بدأت فى عام 1989 على يد Guido Van Rossum Language وهو عالم هولندى

تتميز Python بـ:

- سهولة التعلم
- وضوح الكود وسهولة صيانته
- Open source: فيقوم على تطويرها ألاف المطورين

ملفات Python بيكون امتداها py. او pyc. او pyo.

py. => ملف بايثون

pyc. => ملف بايثون مترجم

pyo. => ملف كائن لبايثون

لمعرفة المزيد عن لغة البرمجة Python يمكنك الإطلاع على عدة كتب و مصادر تحدثت بتفصيل عن Python. ولكن سنكتفي هنا بهذا القدر من الحديث عنه لنبدأ فورا ببرنامجنا الخاص.

هدف البرنامج الذي ننوي كتابته هو التحكم و محاكاة محطة الطاقة لمشروع TEMO-STPP من خلال برنامج User interface (GUI) على هذا الشكل كبرنامج أولي:

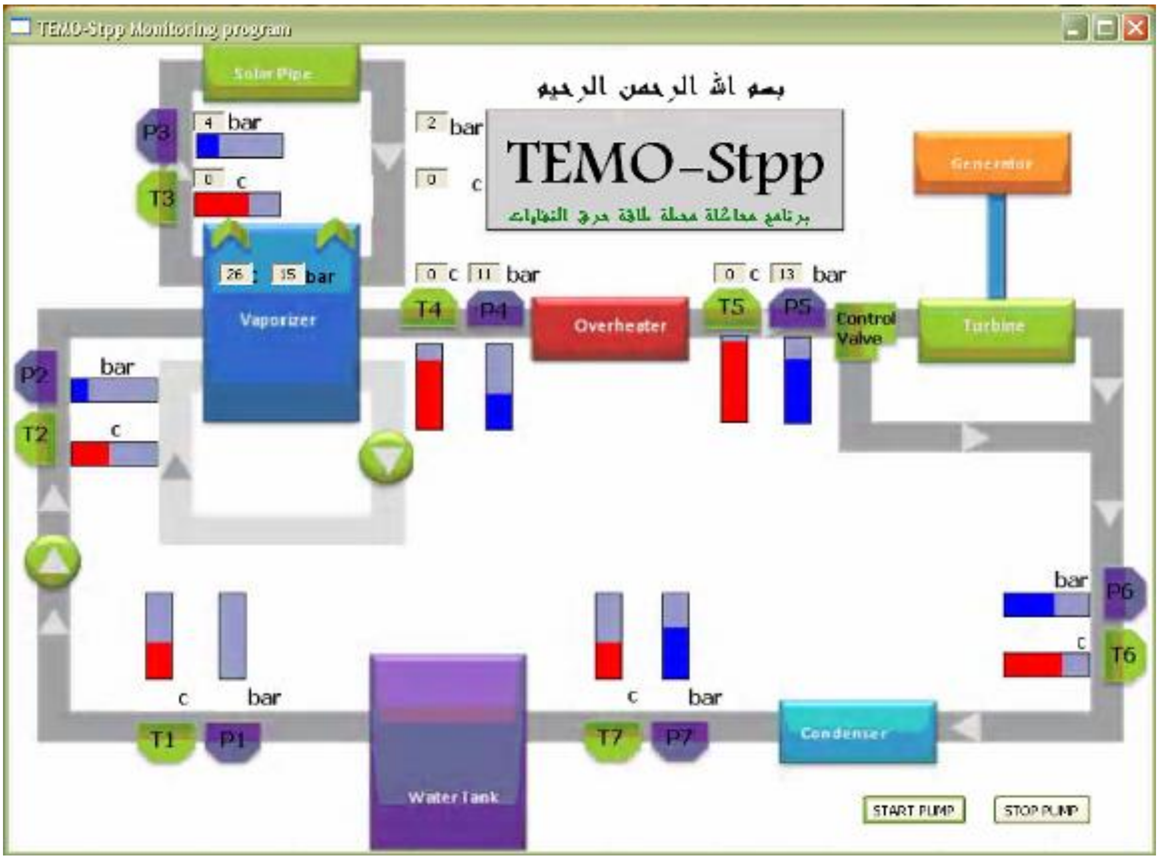


Figure 4.7.9: python monitoring software

نحتاج لتنفيذ و تشغيل هذا العمل إلى Python compiler و إلى مكتبة إضافية لا يحتويها ال compiler العادي و هي wxPython,تجدها في القرص المرفق أو يمكنك لحصول عليها عبر الانترنت.

بعدها سيصبح بإمكاننا بدء كتابة البرنامج. و هو كما يلي مع توضيحات :

```
#**********************
******************************************************************************************
*****
import wx
import random
import sys

import time

from ctypes import *
import thread

#********************** panel frame
**********************************************************************************
```

```
wx.SetDefaultPyEncoding("iso-8859-15")
BACKGROUND_IMAGENAME = "TEMO-STPPscreenshot.bmp"

class MyBackgroundPanel(wx.Panel):
	def __init__(self, parent):
		wx.Panel.__init__(self, parent)
		self.bmp = wx.Bitmap(BACKGROUND_IMAGENAME)
		self.SetSize(self.bmp.GetSize())
		self.Bind(wx.EVT_PAINT, self.on_paint)

	def on_paint(self, event = None):
		dc = wx.BufferedPaintDC(self, self.bmp)

class MyFrame(wx.Frame):
	def __init__(self, parent = None, title = "TEMO-Stpp Monitoring program"):
		self.testUSB = True
		self.dll = None
		self.USBAdr0 = 0
		self.USBAdr1 = 1
		self.USBAdr2 = 2
		self.USBOpened = False
		self.counterUSBBoards = 3
		wx.Frame.__init__(self, parent, -1, title)
		panel = MyBackgroundPanel(self)
		LABELSTYLE = wx.BORDER_SUNKEN | wx.ST_NO_AUTORESIZE |
		wx.ALIGN_CENTER_HORIZONTAL

		#Start of pump
		self.button_Start_Flow_Read = wx.Button(panel, -1, "START PUMP",
		pos=(650,570))
		self.Bind(wx.EVT_BUTTON, self.OpenPumpANDStartRead,
		self.button_Start_Flow_Read)
		#Stop of pump
		self.button_Stop_Read_pump = wx.Button(panel, -1, "STOP PUMP",
		pos=(750,570))
		self.Bind(wx.EVT_BUTTON, self.StopReadButton, self.button_Stop_Read_pump)

		# Vaporizer out
		self.temp_Vaporizer_out = wx.StaticText(
		panel, size = (26, -1), pos = (160, 165), style = LABELSTYLE
		)
		self.pressure_Vaporizer_out = wx.StaticText(
		panel, size = (26, -1), pos = (200, 165), style = LABELSTYLE
		)
```

بنفس الطريقة يتم كتابة الـ LabelStyle الخاص بـ:

```
		# Overheater in
		# Overheater out
		# SolarPipe in
		# SolarPipe out
```

```
            # Layout
            self.Fit()

    def on_timer(self, event = None):
            division = 2

    # Vaporizer out
            answer = (self.dll.ReadAnalogChannel(3,1))/division
            new_value = str(answer)
            self.temp_Vaporizer_out.SetLabel(new_value)
            self.temp_Vaporizer_out.Refresh()
            new_value = str(random.randint(12, 16))
            self.pressure_Vaporizer_out.SetLabel(new_value)
            self.pressure_Vaporizer_out.Refresh()
```

بنفس الطريقة يتم ضبط الـ Label الخاص بكل من:

```
    # Overheater in
    # Overheater out
    # SolarPipe in
    # SolarPipe out
```

مع تغيير الـ Analog PIN Channel number

```
#********************** Run USB System
*********************** ****************************************************************
    def OpenUSBBoardThread(self):
            self.dll = windll.K8061
            i = self.counterUSBBoards
            for doit in range(0,i+1):
                    try:
                            self.dll.OpenDevice()
                            self.USBOpened = True
# debug info
                            print 'USB Board is now connected!'
#end debug info
                    except:
                            txt = 'Please Check USB Board connection'
                            print txt
                            return

            self.dll.OutputAnalogChannel(3,8,255)

#********************** STOP Button
******************** *******************************************************************
    def StopReadButton(self, event):
            self.dll.ClearDigitalChannel(3,1)
            print 'Digital Channel Cleared, pump turn off'
```

```
#********************** START Button
******************** ************************************************************
	def OpenPumpANDStartRead(self, event):
		wx.MessageBox("Do you want to open pump and start monitoring?", "start
		monitoring", wx.OK|wx.ICON_INFORMATION)

	# open the USB board
		self.OpenUSBBoardThread()
		time.sleep(0.5)
		self.dll.SetDigitalChannel(3,1)
		self.timer = wx.Timer()
		self.timer.Bind(wx.EVT_TIMER, self.on_timer)
		self.timer.Start(1000)

#********************* main definition and loop
******************** *************************************************
	def main():
		"""Testing"""
		app = wx.PySimpleApp()
		f = MyFrame()
		f.Center()
		f.Show()
		app.MainLoop()
	if __name__ == "__main__":
		main()

#*********************
*************************************************************************************
*****
```

بعد إتمام كتابة البرنامج يمكن تشغيله من خلال الضغط على Run و ستظهر لك الشاشة التفاعلية المنفذة.

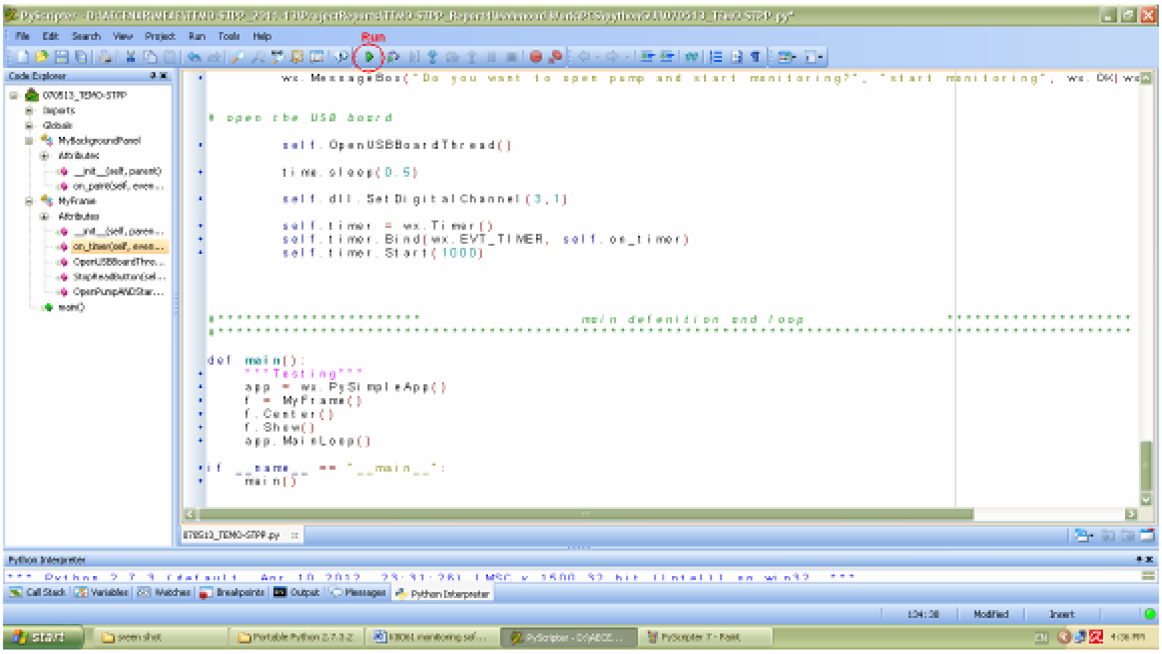


Figure 4.7.10: PyScripter software

أما أن كنت لا تملك برنامج PyScripter فيمكن كتابة البرنامج ك text file عادي من خلال ال NotePad و لكن عند الحفظ يحفظ بصيغة .py مثال (TEMO-STPP.py) بعدها يمكن تشغيلها من خلال ال **(Python command line)** .

نتيجة العمل برنامج تفاعلي بين المستخدم و المحطة كما تظهر الصورة التالية (انظر الصورة 11) في المثال هذا كما نلاحظ تم تفعيل حساس حراري واحد وهو الموجود على ال Vaporizer.

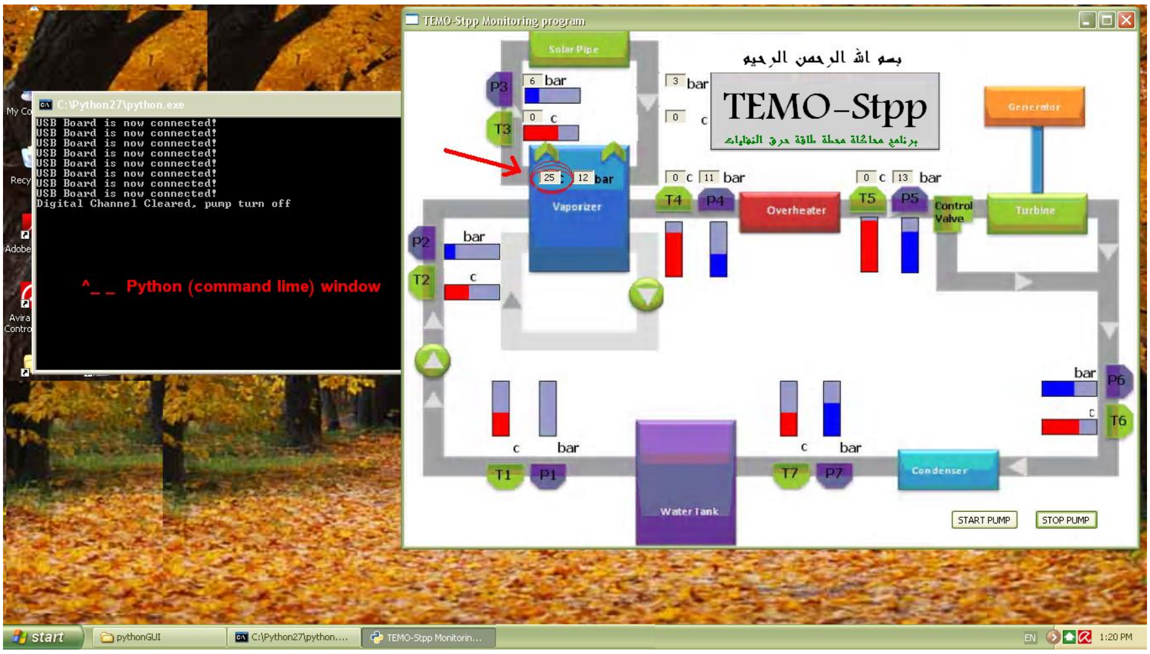


Figure 4.7.11: GUI software

يمكنك أيجاد برنامج الـ Python كاملاً في الـ Appendix D

22 Sensors implementation and design

22.1 Temperature sensor:

In TEMO-STPP project We use 8 thermocouple sensors distribute as shown in **figure 1**. The thermocouple sensor we use it, is the PTFE Exposed Welded Tip Thermocouples ' type K ' which conform the project's need. The 'K' PTFE thermocouple have a temperature range between 0°C and 200°C with cable length 3 or 5 meter (the datasheet of this sensor can find it in Appendix A).

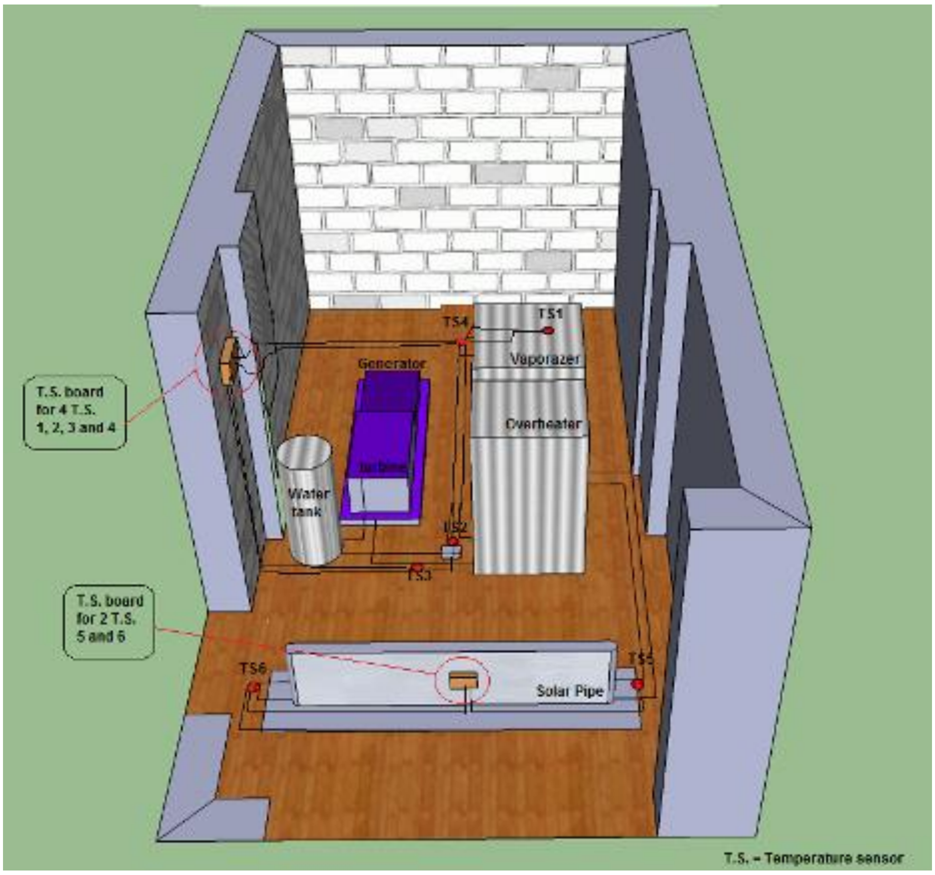


Figure 5.1.1: Temperature sensors distribution for TEMO-Stpp project

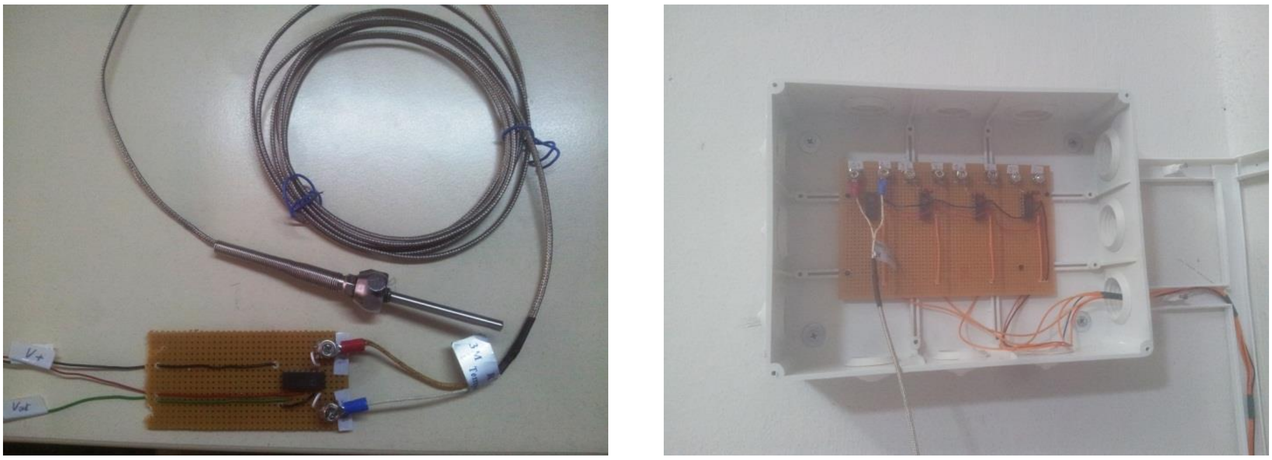


Figure 5.1.2: Temperature sensor boards

The thermocouple output voltage is nonlinear with respect to temperature, for this reason we use a Monolithic Thermocouple Amplifiers **AD595** (the datasheet of this sensor you can find it in **Appendix B**) which linearly amplifies the compensated signal.

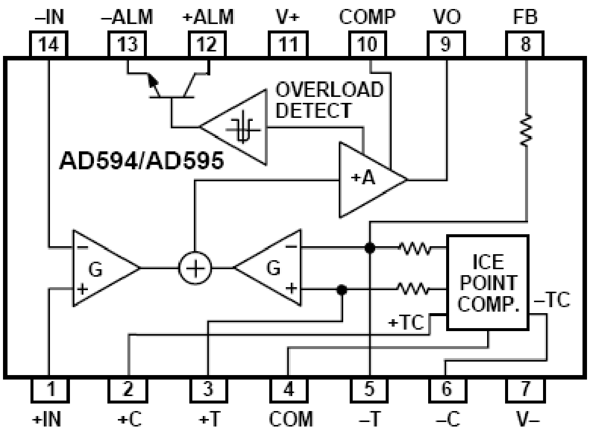


Figure 5.1.3: AD595 design

To achieve a temperature proportional output of 10 mV/°C and accurately compensate for the reference junction over the rated operating range of the circuit, the AD595 is gain trimmed to match the transfer characteristic of K type thermocouples at 25°C. For a type K output in this temperature range the TC is 40.44 mV/°C. The resulting gain for the AD595 is 247.3 (10 mV/°C divided by 40.44 mV/°C). In addition, an absolute accuracy trim induces an input offset to the output amplifier characteristic of 11 mV. This offset arises because the AD595 is trimmed for a 250 mV output while applying a 25°C thermocouple input.

The thermocouple sensor should be connecting to the AD595 amplifier as figure 3.

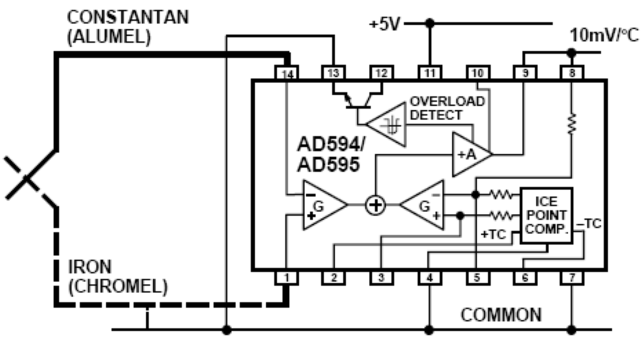


Figure 5.1.4: sensor-Amplifier connection

The output pin give you a linear voltage (AD595 output) with respect to the input voltage (Type K voltage) is shown by the following equition:

$$AD595\ output = (Type\ K\ Voltage + 11\ \mu V) \times 247.3$$

$$Type\ K\ voltage = (AD595\ output/247.3) - 11\ \mu V$$

When the connection is done well you can do a testing for the sensor. For example, If you use an input voltage V_{in}=5V in a 25°C the output voltage should be as the table bellow:

Table 1: V_{out} with respect to the temperature for 25°C

Thermocouple Temperature °C	Type K Voltage mV	AD595 Output mV	Thermocouple Temperature °C	Type K Voltage mV	AD595 Output mV
–200	–5.891	–1454	100	4.095	1015
–180	–5.550	–1370	120	4.919	1219
–160	–5.141	–1269	140	5.733	1420
–140	–4.669	–1152	160	6.539	1620
–120	–4.138	–1021	180	7.338	1817
–100	–3.553	–876	200	8.137	2015
–80	–2.920	–719	220	8.938	2213
–60	–2.243	–552	240	9.745	2413
–40	–1.527	–375	260	10.560	2614
–20	–.777	–189	280	11.381	2817
–10	–.392	–94	300	12.207	3022
0	0	2.7	320	13.039	3227
10	.397	101	340	13.874	3434
20	.798	200	360	14.712	3641
25	1.000	250	380	15.552	3849
30	1.203	300	400	16.395	4057
40	1.611	401	420	17.241	4266
50	2.022	503	440	18.088	4476
60	2.436	605	460	18.938	4686
80	3.266	810	480	19.788	4896

Temperature sensor board design:

The amplifier board may design manually or may be print on PCB. The layout design of the PCB circuit is designed using ARES Proteus PCB Layout Design. The figure bellow show the layout design.

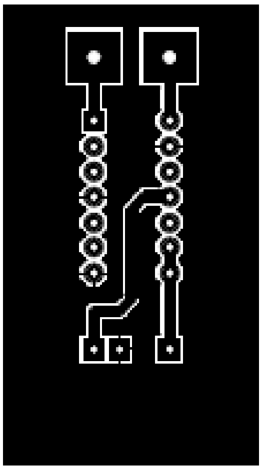


Figure 5.1.5: Layout

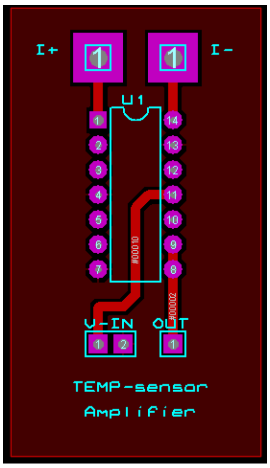


Figure 5.1.6: ARES Design

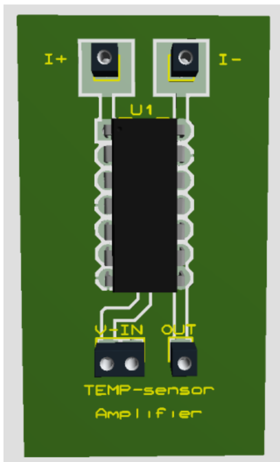


Figure 5.1.7: 3D view

23 ملحق Appendix

Appendix A: Programming with STEP7[23] / STEP7البرمجة بِ23.1

بالتفصيل باللغة العربية انظر

Gourche et. al., Siemens S7-300 مدخل الى , Karlsruhe/Ras Nhache, July 2010 (http://www.aecenar.com/download/doc_download/25-siemens-s7-300--)

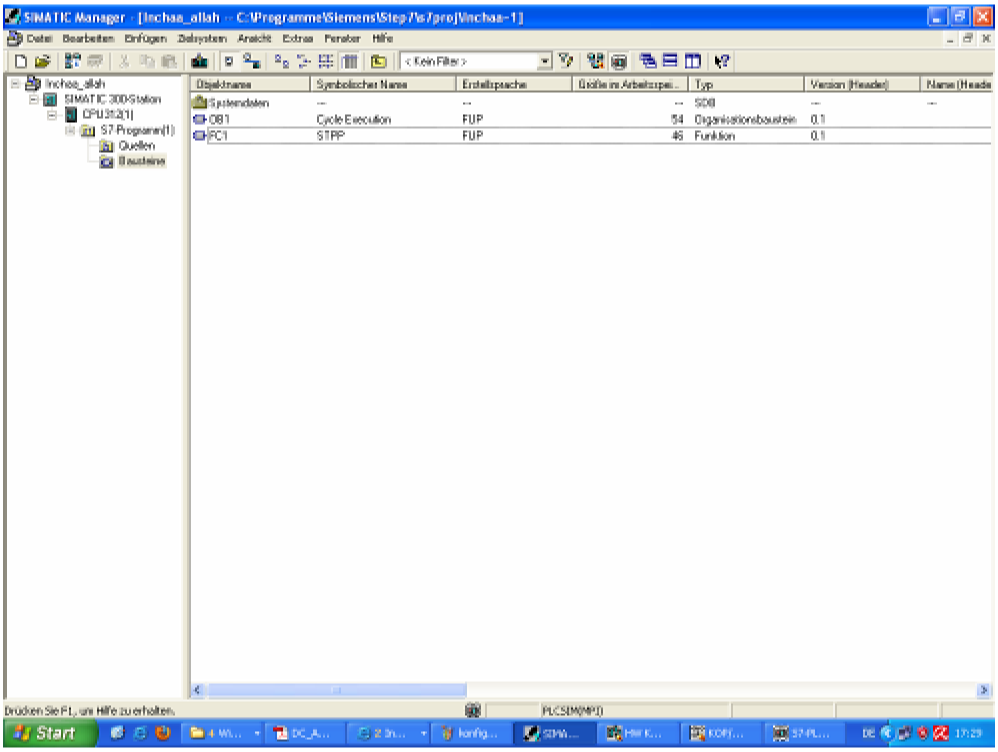
Pieces of the automation system

The Siemens S7 S300 for the TEMO-STPP test rig

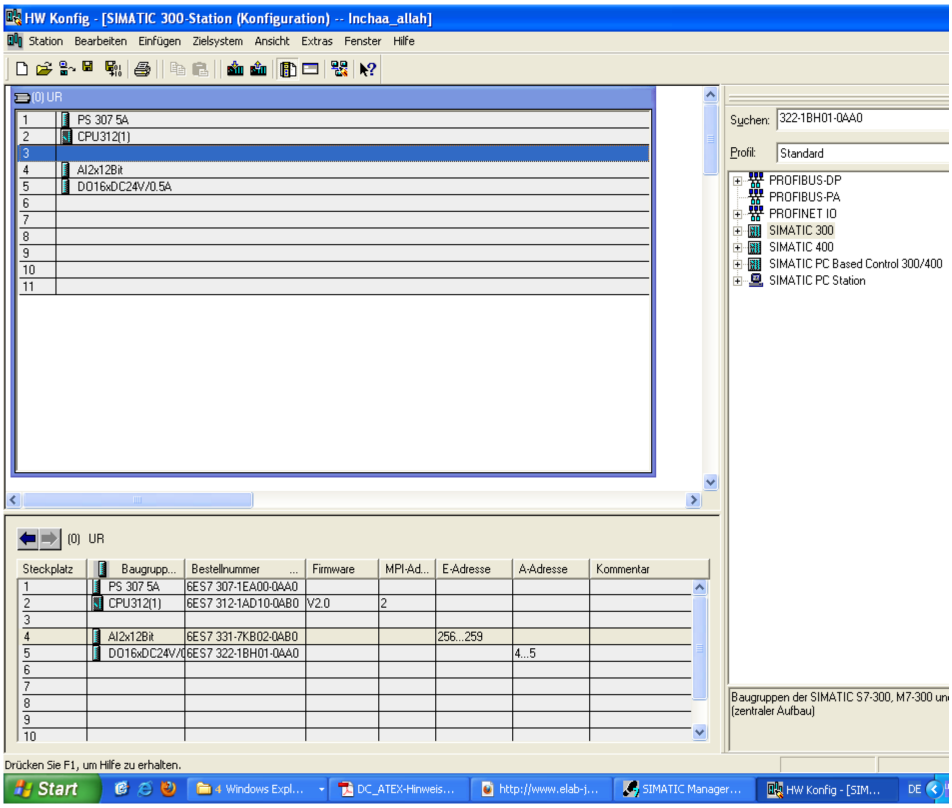
[23] From Mohamed Gourche, Development environment and elements of the Process Control System for the TEMO-STPP test rig Development of a Process Control System for a STPP Test Stand, www.aecenar.com

بالتفصيل باللغة العربية انظر

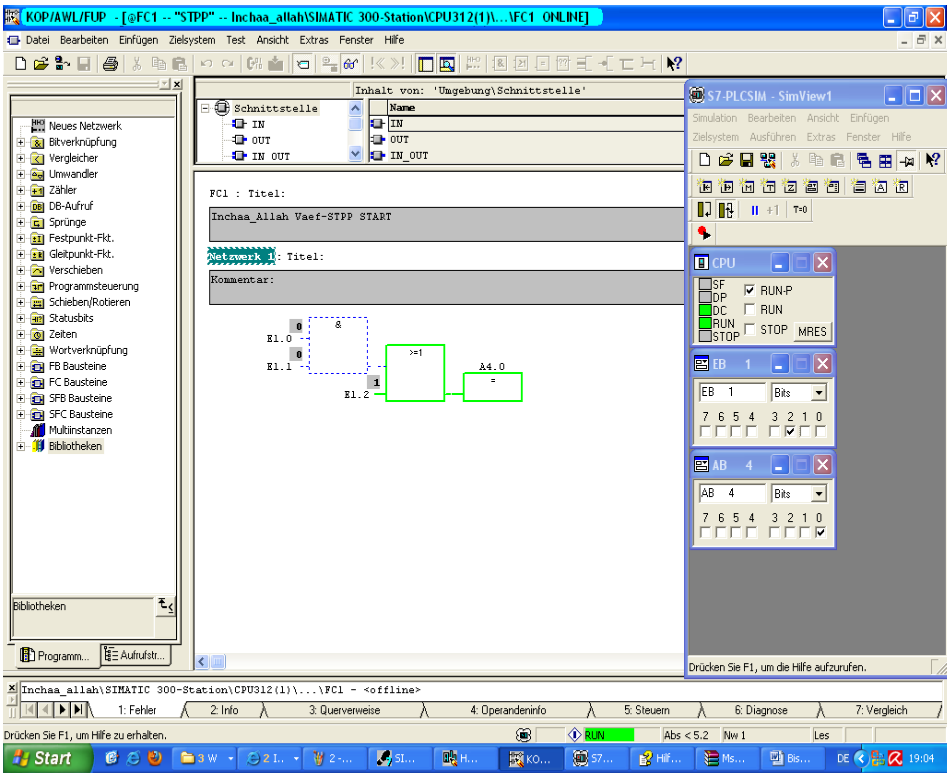
Gourche et. al., Siemens S7-300 مدخل الى , Karlsruhe/Ras Nhache, July 2010 (http://www.aecenar.com/download/doc_download/25-siemens-s7-300--)



Creating a project with the Siemens program STEP 7



Hardware configuration



A Small test program

23.1.1 The communication interface

MPI-USB- interface for S7-300

The multipoint interface (MPI) is a proprietary interface of SIMATIC S7 controller from Siemens and is used for the connection of programming devices (PGs) to the automation device. The PC-MPI adapter converts the data from the RS232 or USB Schnittstelledes PC to the MPI bus (RS485 level). The transmission speed of seriellenSchnittstelle is 19.6 kbaud. The MPI interface operates with 187.5 Kbit / s The MPI adapter has a connection cable that is plugged directly into the CPU connector of the PLC. The power supply receives the MPI adapter from the CPU via the MPI cable. The configuration of the MPI interface of the program supplied with STEP 7.

Setting the PG-PC interface. This is the COM port (USB) set the serial port, registered transfer speeds and defines the MPI address of the PC. The PC is assigned the MPI address 0.

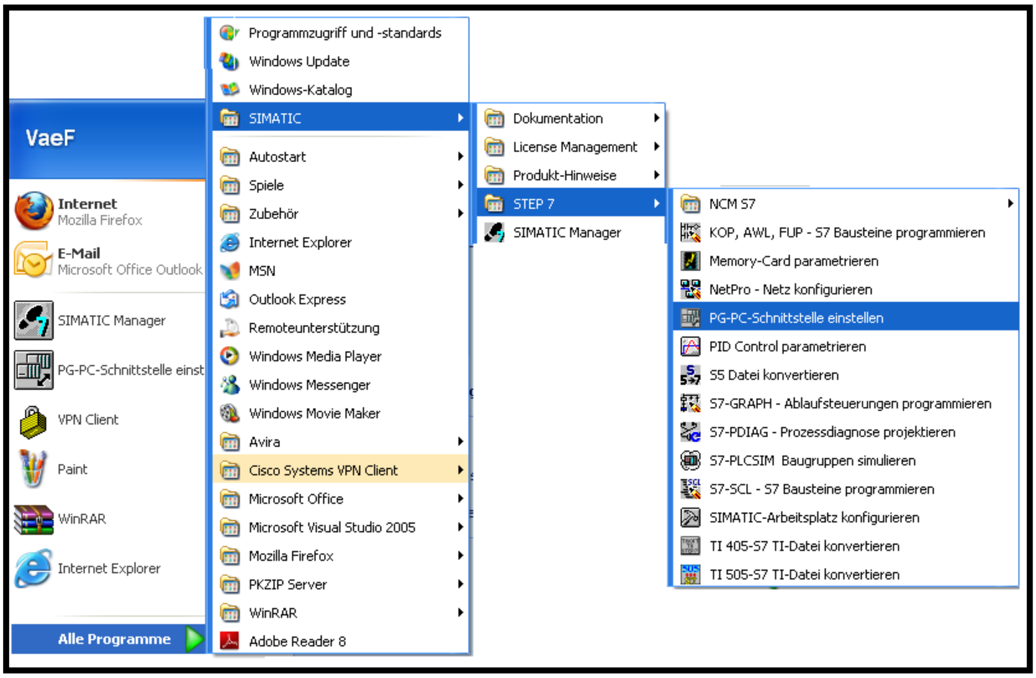
	MPI-USB BUS for S7-300/400

With "real" PLC (no simulator): Setting the PG / PC interface

A started simulator makes working with a real PLC impossible. He has to be stopped in communication priority and must if you want to work with a PLC. An AG is always addressed over that interface, which has been so well set for a project in the Simatic Manager globally for the entire program package, globally. - If the status bar is displayed in the SIMATIC Manager, the interface is displayed permanently.

Is selected on the interface:

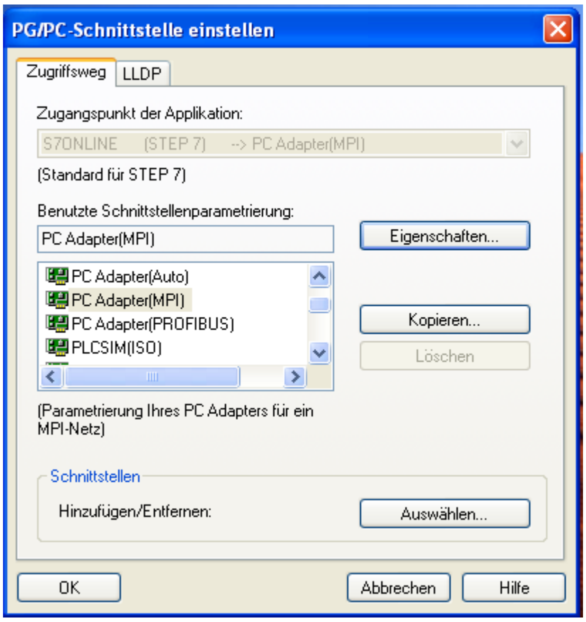
- **Simatic Manager --> Extras --> PG/PC-Schnittstelle einstellen... (Step1)**



Step1

The mark in this dialog is only very weakly visible. If the desired interface is not found in the list, the button must be "Interfaces -> Add / Remove -> Select ..." be pressed to open a dialog that can be installed in the interfaces (Step2).

Here is chosen as an example of the "PC Adapter" in the variant "MPI". This is when one does not have a PG, which has built an RS-485 interface, be the first path that one chooses for a communication with a PLC.

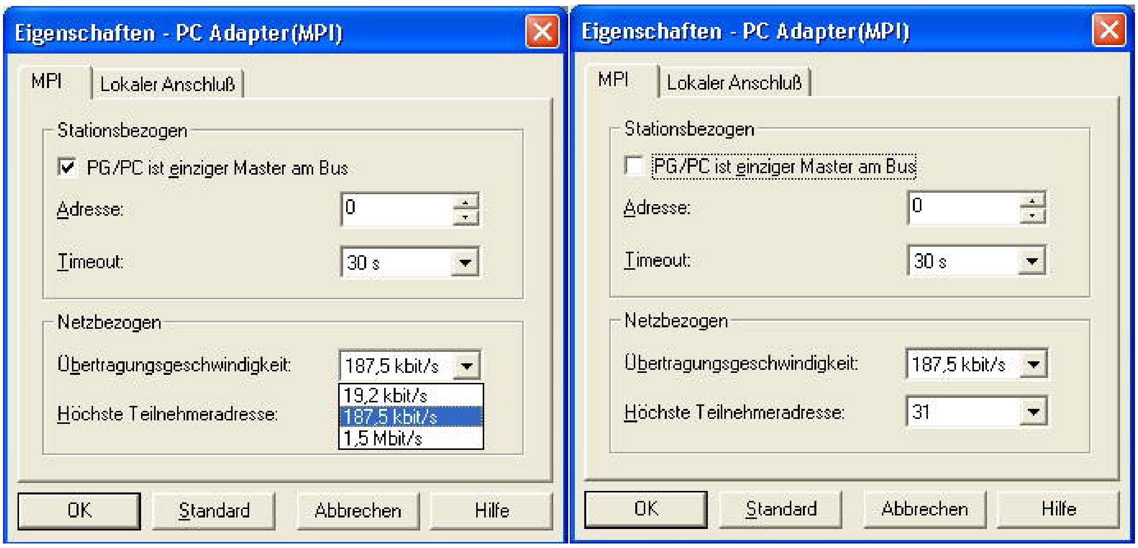


Step2

Step3

A PC adapter has two sides, so to speak, the PC side and the PLC side. On the PC side, it is possible the RS-232C interface to use (in this case must be taken on the data rate!) Or to use the more modern adapter's USB port, as shown here.

On the PLC side is through the pre-selection in the first dialog the MPI interface has been defined (there are also "auto" for communication via Profibus). This generally works at a data rate of 187.5 kbit / s This setting should be checked for safety's sake, just because modern CPUs support a higher data rate. - And especially do not let them impress the serial adapter that also has a data rate must be set on the PC side! These have nothing to do with each other and each refer to only one side of communcation. Between these pages (Step4) provides the adapter, both in terms of level adaptation as well as in terms of data rate.



Step4

23.2 Appendix B: thermocouples sensor datasheet:

Farnell

element14

temperature and process technology

LABFACILITY

TEMPERATURE & PROCESS TECHNOLOGY

About Labfacility

Formed in 1971, Labfacility specialize in the field of Temperature and Process Measurement.

We are the largest UK manufacturer of both temperature sensors and thermocouple connectors.

Quality & Service

Quality and Service are key elements in the continued growth of Labfacility.

Technical support is always freely available from our experienced technical sales teams and the company has ISO9001 accreditation.

Contact Details

Email
sales@labfacility.com

Website
www.labfacility.com

PTFE Exposed Welded Tip Thermocouples

Available in type K & T

- Thermocouple types K & T
- Fast response, welded exposed junction
- 1, 2 , 3 & 5 metre long PTFE twin twisted cable
- 1/0.2mm conductors
- Temperature range –75°C to +250°C
- Tolerance to IEC 584 Class 1
- Colour code to IEC 584-3
- Good mechanical strength and flexibility, resistant to oils, acids and other adverse fluids
- Ideal for test & development applications

T/C Type	Length	Manufacturing Part Number	+Positive tail wire	-Negative tail wire	Farnell Order Code
'K'	1 metres	Z2-K-PTFE-TT-1/0.2-1.0-T	Green	White	707-6150
'K'	2 metres	Z2-K-PTFE-TT-1/0.2-2.0-T	Green	White	707-6162
'K'	3 metres	Z2-K-PTFE-TT-1/0.2-3.0-T	Green	White	163-3481
'K'	5 metres	Z2-K-PTFE-TT-1/0.2-5.0-T	Green	White	163-3482
'T'	1 metres	Z2-T-PTFE-TT-1/0.2-1.0-T	Brown	White	707-6174
'T'	2 metres	Z2-T-PTFE-TT-1/0.2-2.0-T	Brown	White	707-6186
'T'	3 metres	Z2-T-PTFE-TT-1/0.2-3.0-T	Brown	White	163-3483
'T'	5 metres	Z2-T-PTFE-TT-1/0.2-5.0-T	Brown	White	163-3484
'K'	1 metres	Z2-K-PTFE-TT-1/0.2-1.0-Tx5	Green	White	859-8223 (pack of 5)
'K'	2 metres	Z2-K-PTFE-TT-1/0.2-2.0-Tx5	Green	White	859-8150 (pack of 5)
'T'	1 metres	Z2-T-PTFE-TT-1/0.2-1.0-Tx5	Brown	White	859-8231 (pack of 5)
'T'	2 metres	Z2-T-PTFE-TT-1/0.2-2.0-Tx5	Brown	White	859-8169 (pack of 5)

FAR003/0313. PTFE Exposed Welded Tip Thermocouples

LABFACILITY

23.3 Appendix C: thermocouple Amplifier AD595 datasheet:

ANALOG DEVICES

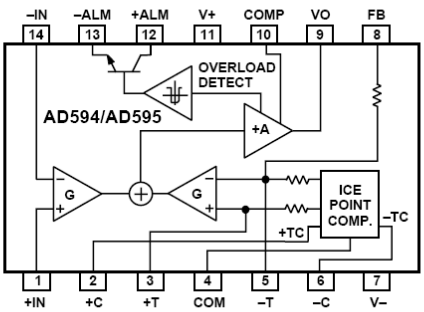
Monolithic Thermocouple Amplifiers with Cold Junction Compensation

AD594/AD595

FEATURES

Pretrimmed for Type J (AD594) or Type K (AD595) Thermocouples
Can Be Used with Type T Thermocouple Inputs
Low Impedance Voltage Output: 10 mV/°C
Built-In Ice Point Compensation
Wide Power Supply Range: +5 V to ±15 V
Low Power: <1 mW typical
Thermocouple Failure Alarm
Laser Wafer Trimmed to 1°C Calibration Accuracy
Setpoint Mode Operation
Self-Contained Celsius Thermometer Operation
High Impedance Differential Input
Side-Brazed DIP or Low Cost Cerdip

FUNCTIONAL BLOCK DIAGRAM



PRODUCT DESCRIPTION

The AD594/AD595 is a complete instrumentation amplifier and thermocouple cold junction compensator on a monolithic chip. It combines an ice point reference with a precalibrated amplifier to produce a high level (10 mV/°C) output directly from a thermocouple signal. Pin-strapping options allow it to be used as a linear amplifier-compensator or as a switched output setpoint controller using either fixed or remote setpoint control. It can be used to amplify its compensation voltage directly, thereby converting it to a stand-alone Celsius transducer with a low impedance voltage output.

The AD594/AD595 includes a thermocouple failure alarm that indicates if one or both thermocouple leads become open. The alarm output has a flexible format which includes TTL drive capability.

The AD594/AD595 can be powered from a single ended supply (including +5 V) and by including a negative supply, temperatures below 0°C can be measured. To minimize self-heating, an unloaded AD594/AD595 will typically operate with a total supply current 160 μA, but is also capable of delivering in excess of ±5 mA to a load.

The AD594 is precalibrated by laser wafer trimming to match the characteristic of type J (iron-constantan) thermocouples and the AD595 is laser trimmed for type K (chromel-alumel) inputs. The temperature transducer voltages and gain control resistors are available at the package pins so that the circuit can be recalibrated for the thermocouple types by the addition of two or three resistors. These terminals also allow more precise calibration for both thermocouple and thermometer applications.

The AD594/AD595 is available in two performance grades. The C and the A versions have calibration accuracies of ±1°C and ±3°C, respectively. Both are designed to be used from 0°C to +50°C, and are available in 14-pin, hermetically sealed, side-brazed ceramic DIPs as well as low cost cerdip packages.

PRODUCT HIGHLIGHTS

1. The AD594/AD595 provides cold junction compensation, amplification, and an output buffer in a single IC package.
2. Compensation, zero, and scale factor are all precalibrated by laser wafer trimming (LWT) of each IC chip.
3. Flexible pinout provides for operation as a setpoint controller or a stand-alone temperature transducer calibrated in degrees Celsius.
4. Operation at remote application sites is facilitated by low quiescent current and a wide supply voltage range +5 V to dual supplies spanning 30 V.
5. Differential input rejects common-mode noise voltage on the thermocouple leads.

REV. C

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781/329-4700 World Wide Web Site: http://www.analog.com
Fax: 781/326-8703

AD594/AD595–SPECIFICATIONS (@ +25°C and V_S = 5 V, Type J (AD594), Type K (AD595) Thermocouple, unless otherwise noted)

Model	AD594A			AD594C			AD595A			AD595C			
	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Units
ABSOLUTE MAXIMUM RATING													
$+V_S$ to $-V_S$			36			36			36			36	Volts
Common-Mode Input Voltage	$-V_S - 0.15$		$+V_S$	$-V_S - 0.15$		$+V_S$	$-V_S - 0.15$		$+V_S$	$-V_S - 0.15$		$+V_S$	Volts
Differential Input Voltage	$-V_S$		$+V_S$	$-V_S$		$+V_S$	$-V_S$		$+V_S$	$-V_S$		$+V_S$	Volts
Alarm Voltages													
+ALM	$-V_S$		$-V_S + 36$	$-V_S$		$-V_S + 36$	$-V_S$		$-V_S + 36$	$-V_S$		$-V_S + 36$	Volts
–ALM	$-V_S$		$+V_S$	$-V_S$		$+V_S$	$-V_S$		$+V_S$	$-V_S$		$+V_S$	Volts
Operating Temperature Range	–55		+125	–55		+125	–55		+125	–55		+125	°C
Output Short Circuit to Common	Indefinite			Indefinite			Indefinite			Indefinite			
TEMPERATURE MEASUREMENT													
(Specified Temperature Range 0°C to +50°C)													
Calibration Error at +25°C[1]			±3			±1			±3			±1	°C
Stability vs. Temperature[2]			±0.05			±0.025			±0.05			±0.025	°C/°C
Gain Error			±1.5			±0.75			±1.5			±0.75	%
Nominal Transfer Function			10			10			10			10	mV/°C
AMPLIFIER CHARACTERISTICS													
Closed Loop Gain[3]		193.4				193.4			247.3			247.3	
Input Offset Voltage	(Temperature in °C) × 51.70 μV/°C			(Temperature in °C) × 51.70 μV/°C			(Temperature in °C) × 40.44 μV/°C			(Temperature in °C) × 40.44 μV/°C			μV
Input Bias Current		0.1			0.1			0.1			0.1		μA
Differential Input Range	–10		+50				–10		+50	–10		+50	mV
Common-Mode Range	$-V_S - 0.15$		$-V_S - 4$	$-V_S - 0.15$		$-V_S - 4$	$-V_S - 0.15$		$-V_S - 4$	$-V_S - 0.15$		$-V_S - 4$	Volts
Common-Mode Sensitivity – RTO			10			10			10			10	mV/V
Power Supply Sensitivity – RTO			10			10			10			10	mV/V
Output Voltage Range													
Dual Supply	$-V_S + 2.5$		$+V_S - 2$	$-V_S + 2.5$		$+V_S - 2$	$-V_S + 2.5$		$+V_S - 2$	$-V_S + 2.5$		$+V_S - 2$	Volts
Single Supply	0		$+V_S - 2$	0		$-V_S - 2$	0		$+V_S + 2$	0		$+V_S - 2$	Volts
Usable Output Current[4]		±5			±5			±5			±5		mA
3 dB Bandwidth		15			15			15			15		kHz
ALARM CHARACTERISTICS													
$V_{CE(SAT)}$ at 2 mA		0.3			0.3			0.3			0.3		Volts
Leakage Current			±1			±1			±1			±1	μA max
Operating Voltage at – ALM			$+V_S - 4$			$+V_S - 4$			$+V_S - 4$			$+V_S - 4$	Volts
Short Circuit Current		20			20			20			20		mA
POWER REQUIREMENTS													
Specified Performance		$+V_S = 5, -V_S = 0$			$+V_S = 5, -V_S = 0$			$+V_S = 5, -V_S = 0$			$+V_S = 5, -V_S = 0$		Volts
Operating[5]		$+V_S$ to $-V_S \le 30$			$+V_S$ to $-V_S \le 30$			$+V_S$ to $-V_S \le 30$			$+V_S$ to $-V_S \le 30$		Volts
Quiescent Current (No Load)													
$+V_S$		160	300		160	300		160	300		160	300	μA
$-V_S$		100			100			100			100		μA
PACKAGE OPTION													
TO-116 (D-14)		AD594AD			AD594CD			AD595AD			AD595CD		
Cerdip (Q-14)		AD594AQ			AD594CQ			AD595AQ			AD595CQ		

NOTES

[1] Calibrated for minimum error at +25°C using a thermocouple sensitivity of 51.7 μV/°C. Since a J type thermocouple deviates from this straight line approximation, the AD594 will normally read 3.1 mV when the measuring junction is at 0°C. The AD595 will similarly read 2.7 mV at 0°C.

[2] Defined as the slope of the line connecting the AD594/AD595 errors measured at 0°C and 50°C ambient temperature.

[3] Pin 8 shorted to Pin 9.

[4] Current Sink Capability in single supply configuration is limited to current drawn to ground through a 50 kΩ resistor at output voltages below 2.5 V.

[5] $-V_S$ must not exceed –16.5 V.

Specifications shown in **boldface** are tested on all production units at final electrical test. Results from those tests are used to calculate outgoing quality levels. All min and max specifications are guaranteed, although only those shown in **boldface** are tested on all production units.

Specifications subject to change without notice.

INTERPRETING AD594/AD595 OUTPUT VOLTAGES

To achieve a temperature proportional output of 10 mV/°C and accurately compensate for the reference junction over the rated operating range of the circuit, the AD594/AD595 is gain trimmed to match the transfer characteristic of J and K type thermocouples at 25°C. For a type J output in this temperature range the TC is 51.70 μV/°C, while for a type K it is 40.44 μV/°C. The resulting gain for the AD594 is 193.4 (10 mV/°C divided by 51.7 μV/°C) and for the AD595 is 247.3 (10 mV/°C divided by 40.44 μV/°C). In addition, an absolute accuracy trim induces an input offset to the output amplifier characteristic of 16 μV for the AD594 and 11 μV for the AD595. This offset arises because the AD594/AD595 is trimmed for a 250 mV output while applying a 25°C thermocouple input.

Because a thermocouple output voltage is nonlinear with respect to temperature, and the AD594/AD595 linearly amplifies the compensated signal, the following transfer functions should be used to determine the actual output voltages:

AD594 output = (Type J Voltage + 16 μV) × 193.4

AD595 output = (Type K Voltage + 11 μV) × 247.3 or conversely:

Type J voltage = (AD594 output/193.4) – 16 μV

Type K voltage = (AD595 output/247.3) – 11 μV

Table I lists the ideal AD594/AD595 output voltages as a function of Celsius temperature for type J and K ANSI standard thermocouples, with the package and reference junction at 25°C. As is normally the case, these outputs are subject to calibration, gain and temperature sensitivity errors. Output values for intermediate temperatures can be interpolated, or calculated using the output equations and ANSI thermocouple voltage tables referred to zero degrees Celsius. Due to a slight variation in alloy content between ANSI type J and DIN FE-CUNI

Table I. Output Voltage vs. Thermocouple Temperature (Ambient +25°C, V_S = –5 V, +15 V)

Thermocouple Temperature °C	Type J Voltage mV	AD594 Output mV	Type K Voltage mV	AD595 Output mV
–200	–7.890	–1523	–5.891	–1454
–180	–7.402	–1428	–5.550	–1370
–160	–6.821	–1316	–5.141	–1269
–140	–6.159	–1188	–4.669	–1152
–120	–5.426	–1046	–4.138	–1021
–100	–4.632	–893	–3.553	–876
–80	–3.785	–729	–2.920	–719
–60	–2.892	–556	–2.243	–552
–40	–1.960	–376	–1.527	–375
–20	–.995	–189	–.777	–189
–10	–.501	–94	–.392	–94
0	0	3.1	0	2.7
10	.507	101	.397	101
20	1.019	200	.798	200
25	1.277	250	1.000	250
30	1.536	300	1.203	300
40	2.058	401	1.611	401
50	2.585	503	2.022	503
60	3.115	606	2.436	605
80	4.186	813	3.266	810
100	5.268	1022	4.095	1015
120	6.359	1233	4.919	1219
140	7.457	1445	5.733	1420
160	8.560	1659	6.539	1620
180	9.667	1873	7.338	1817
200	10.777	2087	8.137	2015
220	11.887	2302	8.938	2213
240	12.998	2517	9.745	2413
260	14.108	2732	10.560	2614
280	15.217	2946	11.381	2817
300	16.325	3160	12.207	3022
320	17.432	3374	13.039	3227
340	18.537	3588	13.874	3434
360	19.640	3801	14.712	3641
380	20.743	4015	15.552	3849
400	21.846	4228	16.395	4057
420	22.949	4441	17.241	4266
440	24.054	4655	18.088	4476
460	25.161	4869	18.938	4686
480	26.272	5084	19.788	4896

Thermocouple Temperature °C	Type J Voltage mV	AD594 Output mV	Type K Voltage mV	AD595 Output mV
500	27.388	5300	20.640	5107
520	28.511	5517	21.493	5318
540	29.642	5736	22.346	5529
560	30.782	5956	23.198	5740
580	31.933	6179	24.050	5950
600	33.096	6404	24.902	6161
620	34.273	6632	25.751	6371
640	35.464	6862	26.599	6581
660	36.671	7095	27.445	6790
680	37.893	7332	28.288	6998
700	39.130	7571	29.128	7206
720	40.382	7813	29.965	7413
740	41.647	8058	30.799	7619
750	42.283	8181	31.214	7722
760	–	–	31.629	7825
780	–	–	32.455	8029
800	–	–	33.277	8232
820	–	–	34.095	8434
840	–	–	34.909	8636
860	–	–	35.718	8836
880	–	–	36.524	9035
900	–	–	37.325	9233
920	–	–	38.122	9430
940	–	–	38.915	9626
960	–	–	39.703	9821
980	–	–	40.488	10015
1000	–	–	41.269	10209
1020	–	–	42.045	10400
1040	–	–	42.817	10591
1060	–	–	43.585	10781
1080	–	–	44.439	10970
1100	–	–	45.108	11158
1120	–	–	45.863	11345
1140	–	–	46.612	11530
1160	–	–	47.356	11714
1180	–	–	48.095	11897
1200	–	–	48.828	12078
1220	–	–	49.555	12258
1240	–	–	50.276	12436
1250	–	–	50.633	12524

thermocouples Table I should not be used in conjunction with European standard thermocouples. Instead the transfer function given previously and a DIN thermocouple table should be used. ANSI type K and DIN NICR-NI thermocouples are composed

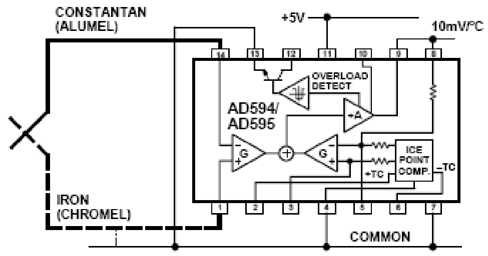


Figure 1. Basic Connection, Single Supply Operation

of identical alloys and exhibit similar behavior. The upper temperature limits in Table I are those recommended for type J and type K thermocouples by the majority of vendors.

SINGLE AND DUAL SUPPLY CONNECTIONS

The AD594/AD595 is a completely self-contained thermocouple conditioner. Using a single +5 V supply the interconnections shown in Figure 1 will provide a direct output from a type J thermocouple (AD594) or type K thermocouple (AD595) measuring from 0°C to +300°C.

Any convenient supply voltage from +5 V to +30 V may be used, with self-heating errors being minimized at lower supply levels. In the single supply configuration the +5 V supply connects to Pin 11 with the V– connection at Pin 7 strapped to power and signal common at Pin 4. The thermocouple wire inputs connect to Pins 1 and 14 either directly from the measuring point or through intervening connections of similar thermocouple wire type. When the alarm output at Pin 13 is not used it should be connected to common or –V. The precalibrated feedback network at Pin 8 is tied to the output at Pin 9 to provide a 10 mV/°C nominal temperature transfer characteristic.

By using a wider ranging dual supply, as shown in Figure 2, the AD594/AD595 can be interfaced to thermocouples measuring both negative and extended positive temperatures.

AD594/AD595

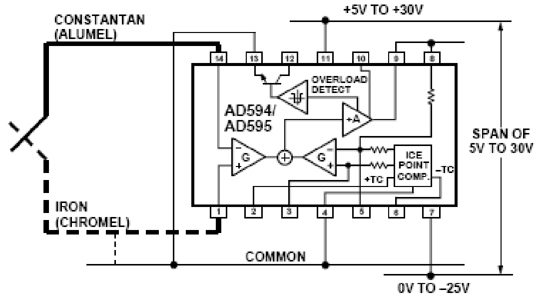


Figure 2. Dual Supply Operation

With a negative supply the output can indicate negative temperatures and drive grounded loads or loads returned to positive voltages. Increasing the positive supply from 5 V to 15 V extends the output voltage range well beyond the 750°C temperature limit recommended for type J thermocouples (AD594) and the 1250°C for type K thermocouples (AD595).

Common-mode voltages on the thermocouple inputs must remain within the common-mode range of the AD594/AD595, with a return path provided for the bias currents. If the thermocouple is not remotely grounded, then the dotted line connections in Figures 1 and 2 are recommended. A resistor may be needed in this connection to assure that common-mode voltages induced in the thermocouple loop are not converted to normal mode.

THERMOCOUPLE CONNECTIONS

The isothermal terminating connections of a pair of thermocouple wires forms an effective reference junction. This junction must be kept at the same temperature as the AD594/AD595 for the internal cold junction compensation to be effective.

A method that provides for thermal equilibrium is the printed circuit board connection layout illustrated in Figure 3.

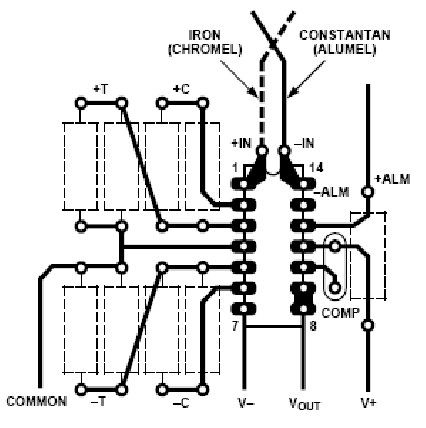


Figure 3. PCB Connections

Here the AD594/AD595 package temperature and circuit board are thermally contacted in the copper printed circuit board tracks under Pins 1 and 14. The reference junction is now composed of a copper-constantan (or copper-alumel) connection and copper-iron (or copper-chromel) connection, both of which are at the same temperature as the AD594/AD595.

The printed circuit board layout shown also provides for placement of optional alarm load resistors, recalibration resistors and a compensation capacitor to limit bandwidth.

To ensure secure bonding the thermocouple wire should be cleaned to remove oxidation prior to soldering. Noncorrosive rosin flux is effective with iron, constantan, chromel and alumel and the following solders: 95% tin-5% antimony, 95% tin-5% silver or 90% tin-10% lead.

FUNCTIONAL DESCRIPTION

The AD594 behaves like two differential amplifiers. The outputs are summed and used to control a high gain amplifier, as shown in Figure 4.

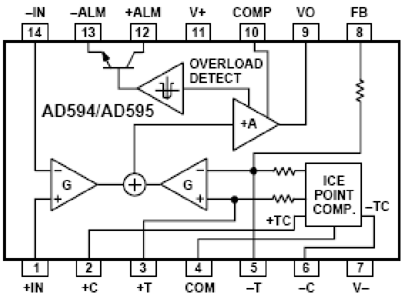


Figure 4. AD594/AD595 Block Diagram

In normal operation the main amplifier output, at Pin 9, is connected to the feedback network, at Pin 8. Thermocouple signals applied to the floating input stage, at Pins 1 and 14, are amplified by gain G of the differential amplifier and are then further amplified by gain A in the main amplifier. The output of the main amplifier is fed back to a second differential stage in an inverting connection. The feedback signal is amplified by this stage and is also applied to the main amplifier input through a summing circuit. Because of the inversion, the amplifier causes the feedback to be driven to reduce this difference signal to a small value. The two differential amplifiers are made to match and have identical gains, G. As a result, the feedback signal that must be applied to the right-hand differential amplifier will precisely match the thermocouple input signal when the difference signal has been reduced to zero. The feedback network is trimmed so that the effective gain to the output, at Pins 8 and 9, results in a voltage of 10 mV/°C of thermocouple excitation.

In addition to the feedback signal, a cold junction compensation voltage is applied to the right-hand differential amplifier. The compensation is a differential voltage proportional to the Celsius temperature of the AD594/AD595. This signal disturbs the differential input so that the amplifier output must adjust to restore the input to equal the applied thermocouple voltage.

The compensation is applied through the gain scaling resistors so that its effect on the main output is also 10 mV/°C. As a result, the compensation voltage adds to the effect of the thermocouple voltage a signal directly proportional to the difference between 0°C and the AD594/AD595 temperature. If the thermocouple reference junction is maintained at the AD594/AD595 temperature, the output of the AD594/AD595 will correspond to the reading that would have been obtained from amplification of a signal from a thermocouple referenced to an ice bath.

The AD594/AD595 also includes an input open circuit detector that switches on an alarm transistor. This transistor is actually a current-limited output buffer, but can be used up to the limit as a switch transistor for either pull-up or pull-down operation of external alarms.

The ice point compensation network has voltages available with positive and negative temperature coefficients. These voltages may be used with external resistors to modify the ice point compensation and recalibrate the AD594/AD595 as described in the next column.

The feedback resistor is separately pinned out so that its value can be padded with a series resistor, or replaced with an external resistor between Pins 5 and 9. External availability of the feedback resistor allows gain to be adjusted, and also permits the AD594/AD595 to operate in a switching mode for setpoint operation.

CAUTIONS:

The temperature compensation terminals (+C and –C) at Pins 2 and 6 are provided to supply small calibration currents only. The AD594/AD595 may be permanently damaged if they are grounded or connected to a low impedance.

The AD594/AD595 is internally frequency compensated for feedback ratios (corresponding to normal signal gain) of 75 or more. If a lower gain is desired, additional frequency compensation should be added in the form of a 300 pF capacitor from Pin 10 to the output at Pin 9. As shown in Figure 5 an additional 0.01 µF capacitor between Pins 10 and 11 is recommended.

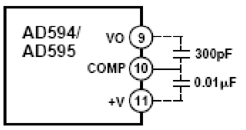


Figure 5. Low Gain Frequency Compensation

RECALIBRATION PRINCIPLES AND LIMITATIONS

The ice point compensation network of the AD594/AD595 produces a differential signal which is zero at 0°C and corresponds to the output of an ice referenced thermocouple at the temperature of the chip. The positive TC output of the circuit is proportional to Kelvin temperature and appears as a voltage at +T. It is possible to decrease this signal by loading it with a resistor from +T to COM, or increase it with a pull-up resistor from +T to the larger positive TC voltage at +C. Note that adjustments to +T should be made by measuring the voltage which tracks it at –T. To avoid destabilizing the feedback amplifier the measuring instrument should be isolated by a few thousand ohms in series with the lead connected to –T.

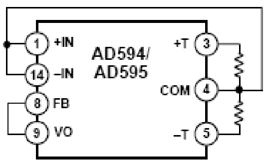


Figure 6. Decreased Sensitivity Adjustment

Changing the positive TC half of the differential output of the compensation scheme shifts the zero point away from 0°C. The zero can be restored by adjusting the current flow into the negative input of the feedback amplifier, the –T pin. A current into this terminal can be produced with a resistor between –C and –T to balance an increase in +T, or a resistor from –T to COM to offset a decrease in +T.

If the compensation is adjusted substantially to accommodate a different thermocouple type, its effect on the final output voltage will increase or decrease in proportion. To restore the nominal output to 10 mV/°C the gain may be adjusted to match the new compensation and thermocouple input characteristics. When reducing the compensation the resistance between –T and COM automatically increases the gain to within 0.5% of the correct value. If a smaller gain is required, however, the nominal 47 kΩ internal feedback resistor can be paralleled or replaced with an external resistor.

Fine calibration adjustments will require temperature response measurements of individual devices to assure accuracy. Major reconfigurations for other thermocouple types can be achieved without seriously compromising initial calibration accuracy, so long as the procedure is done at a fixed temperature using the factory calibration as a reference. It should be noted that intermediate recalibration conditions may require the use of a negative supply.

EXAMPLE: TYPE E RECALIBRATION—AD594/AD595

Both the AD594 and AD595 can be configured to condition the output of a type E (chromel-constantan) thermocouple. Temperature characteristics of type E thermocouples differ less from type J, than from type K, therefore the AD594 is preferred for recalibration.

While maintaining the device at a constant temperature follow the recalibration steps given here. First, measure the device temperature by tying both inputs to common (or a selected common-mode potential) and connecting FB to VO. The AD594 is now in the stand alone Celsius thermometer mode. For this example assume the ambient is 24°C and the initial output VO is 240 mV. Check the output at VO to verify that it corresponds to the temperature of the device.

Next, measure the voltage –T at Pin 5 with a high impedance DVM (capacitance should be isolated by a few thousand ohms of resistance at the measured terminals). At 24°C the –T voltage will be about 8.3 mV. To adjust the compensation of an AD594 to a type E thermocouple a resistor, R1, should be connected between +T and +C, Pins 2 and 3, to raise the voltage at –T by the ratio of thermocouple sensitivities. The ratio for converting a type J device to a type E characteristic is:

$$r\ (AD594) = (60.9\ \mu V/°C)/(51.7\ \mu V/°C) = 1.18$$

Thus, multiply the initial voltage measured at –T by r and experimentally determine the R1 value required to raise –T to that level. For the example the new –T voltage should be about 9.8 mV. The resistance value should be approximately 1.8 kΩ.

The zero differential point must now be shifted back to 0°C. This is accomplished by multiplying the original output voltage VO by r and adjusting the measured output voltage to this value by experimentally adding a resistor, R2, between –C and –T, Pins 5 and 6. The target output value in this case should be about 283 mV. The resistance value of R2 should be approximately 240 kΩ.

Finally, the gain must be recalibrated such that the output VO indicates the device's temperature once again. Do this by adding a third resistor, R3, between FB and –T, Pins 8 and 5. VO should now be back to the initial 240 mV reading. The resistance value

AD594/AD595

of R3 should be approximately 280 kΩ. The final connection diagram is shown in Figure 7. An approximate verification of the effectiveness of recalibration is to measure the differential gain to the output. For type E it should be 164.2.

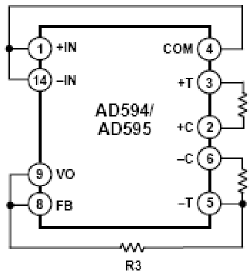


Figure 7. Type E Recalibration

When implementing a similar recalibration procedure for the AD595 the values for R1, R2, R3 and r will be approximately 650 Ω, 84 kΩ, 93 kΩ and 1.51, respectively. Power consumption will increase by about 50% when using the AD595 with type E inputs.

Note that during this procedure it is crucial to maintain the AD594/AD595 at a stable temperature because it is used as the temperature reference. Contact with fingers or any tools not at ambient temperature will quickly produce errors. Radiational heating from a change in lighting or approach of a soldering iron must also be guarded against.

USING TYPE T THERMOCOUPLES WITH THE AD595

Because of the similarity of thermal EMFs in the 0°C to +50°C range between type K and type T thermocouples, the AD595 can be directly used with both types of inputs. Within this ambient temperature range the AD595 should exhibit no more than an additional 0.2°C output calibration error when used with type T inputs. The error arises because the ice point compensator is trimmed to type K characteristics at 25°C. To calculate the AD595 output values over the recommended –200°C to +350°C range for type T thermocouples, simply use the ANSI thermocouple voltages referred to 0°C and the output equation given on page 2 for the AD595. Because of the relatively large nonlinearities associated with type T thermocouples the output will deviate widely from the nominal 10 mV/°C. However, cold junction compensation over the rated 0°C to +50°C ambient will remain accurate.

STABILITY OVER TEMPERATURE

Each AD594/AD595 is tested for error over temperature with the measuring thermocouple at 0°C. The combined effects of cold junction compensation error, amplifier offset drift and gain error determine the stability of the AD594/AD595 output over the rated ambient temperature range. Figure 8 shows an AD594/AD595 drift error envelope. The slope of this figure has units of °C/°C.

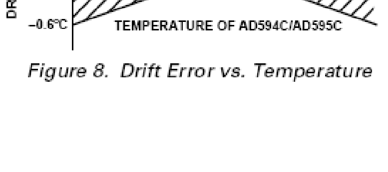


Figure 8. Drift Error vs. Temperature

THERMAL ENVIRONMENT EFFECTS

The inherent low power dissipation of the AD594/AD595 and the low thermal resistance of the package make self-heating errors almost negligible. For example, in still air the chip to ambient thermal resistance is about 80°C/watt (for the D package). At the nominal dissipation of 800 μW the self-heating in free air is less than 0.065°C. Submerged in fluorinert liquid (unstirred) the thermal resistance is about 40°C/watt, resulting in a self-heating error of about 0.032°C.

SETPOINT CONTROLLER

The AD594/AD595 can readily be connected as a setpoint controller as shown in Figure 9.

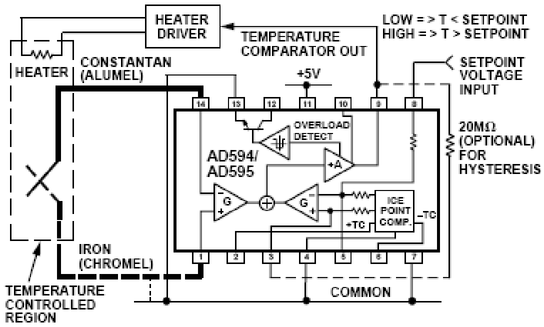


Figure 9. Setpoint Controller

The thermocouple is used to sense the unknown temperature and provide a thermal EMF to the input of the AD594/AD595. The signal is cold junction compensated, amplified to 10 mV/°C and compared to an external setpoint voltage applied by the user to the feedback at Pin 8. Table I lists the correspondence between setpoint voltage and temperature, accounting for the nonlinearity of the measurement thermocouple. If the setpoint temperature range is within the operating range (–55°C to +125°C) of the AD594/AD595, the chip can be used as the transducer for the circuit by shorting the inputs together and utilizing the nominal calibration of 10 mV/°C. This is the centigrade thermometer configuration as shown in Figure 13.

In operation if the setpoint voltage is above the voltage corresponding to the temperature being measured the output swings low to approximately zero volts. Conversely, when the temperature rises above the setpoint voltage the output switches to the positive limit of about 4 volts with a +5 V supply. Figure 9 shows the setpoint comparator configuration complete with a heater element driver circuit being controlled by the AD594/AD595 toggled output. Hysteresis can be introduced by injecting a current into the positive input of the feedback amplifier when the output is toggled high. With an AD594 about 200 nA into the +T terminal provides 1°C of hysteresis. When using a single 5 V supply with an AD594, a 20 MΩ resistor from V_O to +T will supply the 200 nA of current when the output is forced high (about 4 V). To widen the hysteresis band decrease the resistance connected from VO to +T.

ALARM CIRCUIT

In all applications of the AD594/AD595 the –ALM connection, Pin 13, should be constrained so that it is not more positive than (V+) – 4 V. This can be most easily achieved by connecting Pin 13 to either common at Pin 4 or V– at Pin 7. For most applications that use the alarm signal, Pin 13 will be grounded and the signal will be taken from +ALM on Pin 12. A typical application is shown in Figure 10.

In this configuration the alarm transistor will be off in normal operation and the 20 k pull up will cause the +ALM output on Pin 12 to go high. If one or both of the thermocouple leads are interrupted, the +ALM pin will be driven low. As shown in Figure 10 this signal is compatible with the input of a TTL gate which can be used as a buffer and/or inverter.

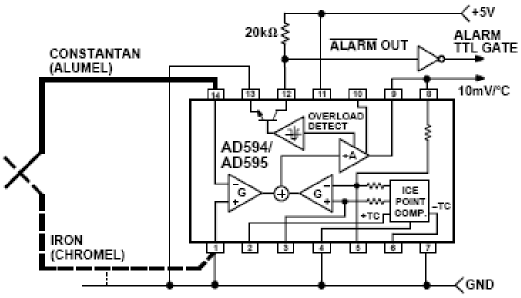


Figure 10. Using the Alarm to Drive a TTL Gate ("Grounded" Emitter Configuration)

Since the alarm is a high level output it may be used to directly drive an LED or other indicator as shown in Figure 11.

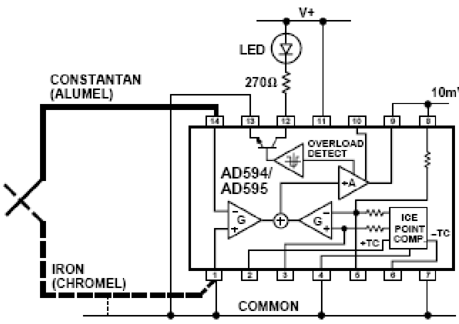


Figure 11. Alarm Directly Drives LED

A 270 Ω series resistor will limit current in the LED to 10 mA, but may be omitted since the alarm output transistor is current limited at about 20 mA. The transistor, however, will operate in a high dissipation mode and the temperature of the circuit will rise well above ambient. Note that the cold junction compensation will be affected whenever the alarm circuit is activated. The time required for the chip to return to ambient temperature will depend on the power dissipation of the alarm circuit, the nature of the thermal path to the environment and the alarm duration.

The alarm can be used with both single and dual supplies. It can be operated above or below ground. The collector and emitter of the output transistor can be used in any normal switch configuration. As an example a negative referenced load can be driven from –ALM as shown in Figure 12.

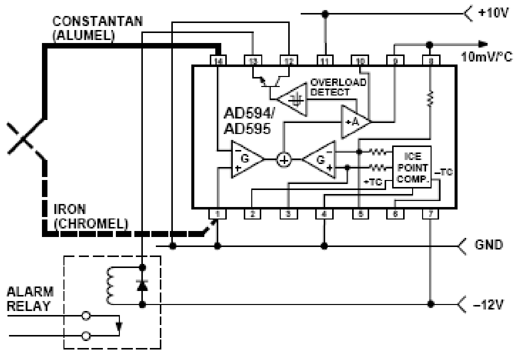


Figure 12. –ALM Driving A Negative Referenced Load

The collector (+ALM) should not be allowed to become more positive than (V–) +36 V, however, it may be permitted to be more positive than V+. The emitter voltage (–ALM) should be constrained so that it does not become more positive than 4 volts below the V+ applied to the circuit.

Additionally, the AD594/AD595 can be configured to produce an extreme upscale or downscale output in applications where an extra signal line for an alarm is inappropriate. By tying either of the thermocouple inputs to common most runaway control conditions can be automatically avoided. A +IN to common connection creates a downscale output if the thermocouple opens, while connecting –IN to common provides an upscale output.

CELSIUS THERMOMETER

The AD594/AD595 may be configured as a stand-alone Celsius thermometer as shown in Figure 13.

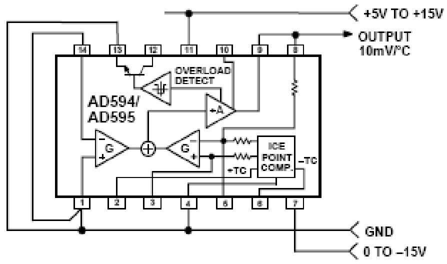


Figure 13. AD594/AD595 as a Stand-Alone Celsius Thermometer

Simply omit the thermocouple and connect the inputs (Pins 1 and 14) to common. The output now will reflect the compensation voltage and hence will indicate the AD594/AD595 temperature with a scale factor of 10 mV/°C. In this three terminal, voltage output, temperature sensing mode, the AD594/AD595 will operate over the full military –55°C to +125°C temperature range.

AD594/AD595

THERMOCOUPLE BASICS

Thermocouples are economical and rugged; they have reasonably good long-term stability. Because of their small size, they respond quickly and are good choices where fast response is important. They function over temperature ranges from cryogenics to jet-engine exhaust and have reasonable linearity and accuracy.

Because the number of free electrons in a piece of metal depends on both temperature and composition of the metal, two pieces of dissimilar metal in isothermal and contact will exhibit a potential difference that is a repeatable function of temperature, as shown in Figure 14. The resulting voltage depends on the temperatures, T1 and T2, in a repeatable way.

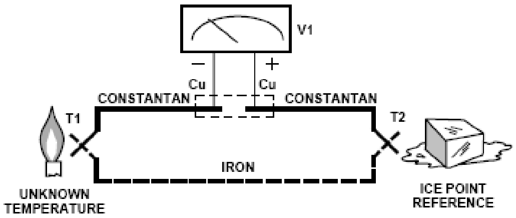


Figure 14. Thermocouple Voltage with 0°C Reference

Since the thermocouple is basically a differential rather than absolute measuring device, a know reference temperature is required for one of the junctions if the temperature of the other is to be inferred from the output voltage. Thermocouples made of specially selected materials have been exhaustively characterized in terms of voltage versus temperature compared to primary temperature standards. Most notably the water-ice point of 0°C is used for tables of standard thermocouple performance.

An alternative measurement technique, illustrated in Figure 15, is used in most practical applications where accuracy requirements do not warrant maintenance of primary standards. The reference junction temperature is allowed to change with the environment of the measurement system, but it is carefully measured by some type of absolute thermometer. A measurement of the thermocouple voltage combined with a knowledge of the reference temperature can be used to calculate the measurement junction temperature. Usual practice, however, is to use a convenient thermoelectric method to measure the reference temperature and to arrange its output voltage so that it corresponds to a thermocouple referred to 0°C. This voltage is simply added to the thermocouple voltage and the sum then corresponds to the standard voltage tabulated for an ice-point referenced thermocouple.

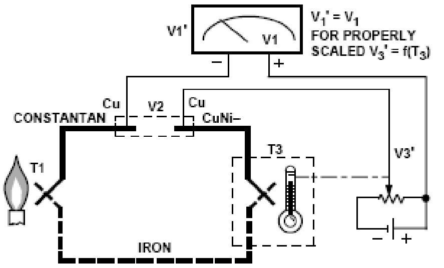


Figure 15. Substitution of Measured Reference Temperature for Ice Point Reference

The temperature sensitivity of silicon integrated circuit transistors is quite predictable and repeatable. This sensitivity is exploited in the AD594/AD595 to produce a temperature related voltage to compensate the reference of "cold" junction of a thermocouple as shown in Figure 16.

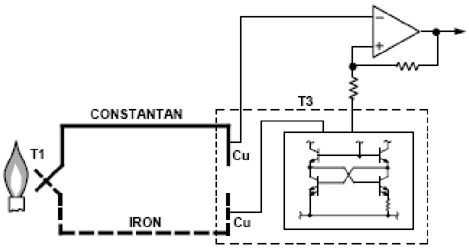


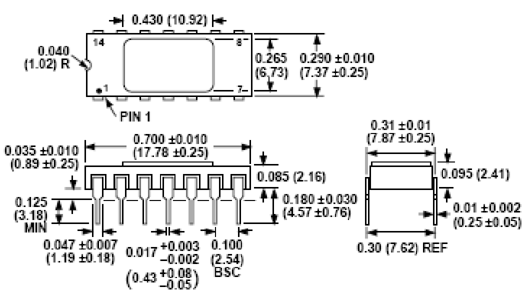
Figure 16. Connecting Isothermal Junctions

Since the compensation is at the reference junction temperature, it is often convenient to form the reference "junction" by connecting directly to the circuit wiring. So long as these connections and the compensation are at the same temperature no error will result.

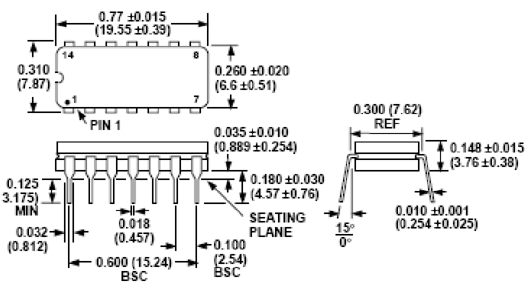
OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

TO-116 (D) Package



Cerdip (Q) Package



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23.4 Appendix D: Python program for the GUI software:

Python program for the monitoring and controlling (GUI) user interface program:

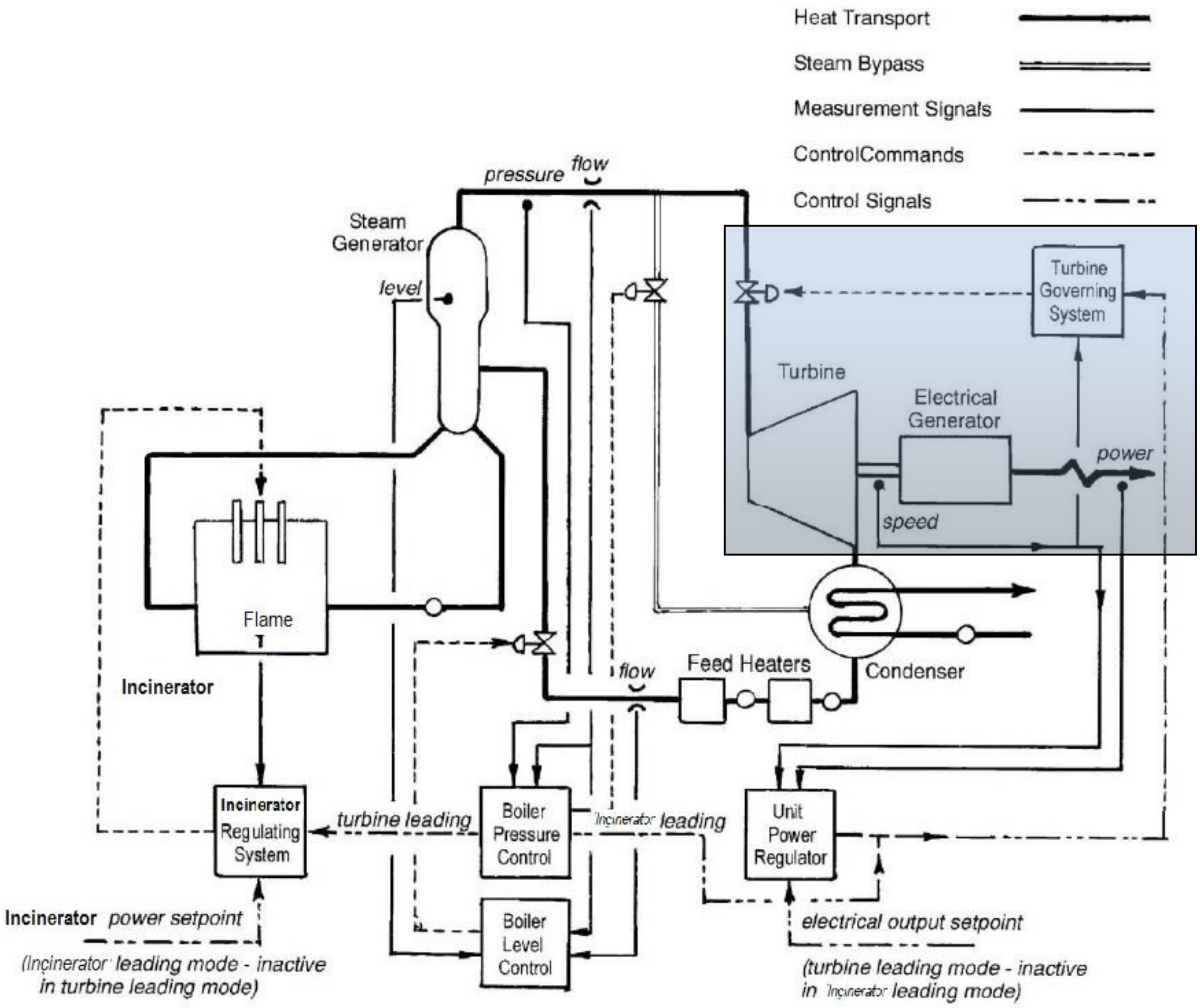
```
#********************
*****************************************************************************************
*****
import wx
import random
import sys

import time

#import ctypes
from ctypes import *
import thread

#********************* panel frame
********************* ***********************************************************
wx.SetDefaultPyEncoding("iso-8859-15")
BACKGROUND_IMAGENAME = "TEMO-STPPscreenshot.bmp"

class MyBackgroundPanel(wx.Panel):
      def __init__(self, parent):
            wx.Panel.__init__(self, parent)
            self.bmp = wx.Bitmap(BACKGROUND_IMAGENAME)
            self.SetSize(self.bmp.GetSize())
            self.Bind(wx.EVT_PAINT, self.on_paint)


      def on_paint(self, event = None):
            dc = wx.BufferedPaintDC(self, self.bmp)

class MyFrame(wx.Frame):
      def __init__(self, parent = None, title = "TEMO-Stpp Monitoring program"):
            self.testUSB = True
            self.dll = None
            self.USBAdr0 = 0
            self.USBAdr1 = 1
            self.USBAdr2 = 2
            self.USBOpened = False
            self.counterUSBBoards = 3
            wx.Frame.__init__(self, parent, -1, title)
            panel = MyBackgroundPanel(self)
            LABELSTYLE = wx.BORDER_SUNKEN | wx.ST_NO_AUTORESIZE |
            wx.ALIGN_CENTER_HORIZONTAL

            #Start of pump
            self.button_Start_Flow_Read = wx.Button(panel, -1, "START PUMP",
            pos=(650,570))
            self.Bind(wx.EVT_BUTTON, self.OpenPumpANDStartRead,
            self.button_Start_Flow_Read)
            #Stop of pump
```

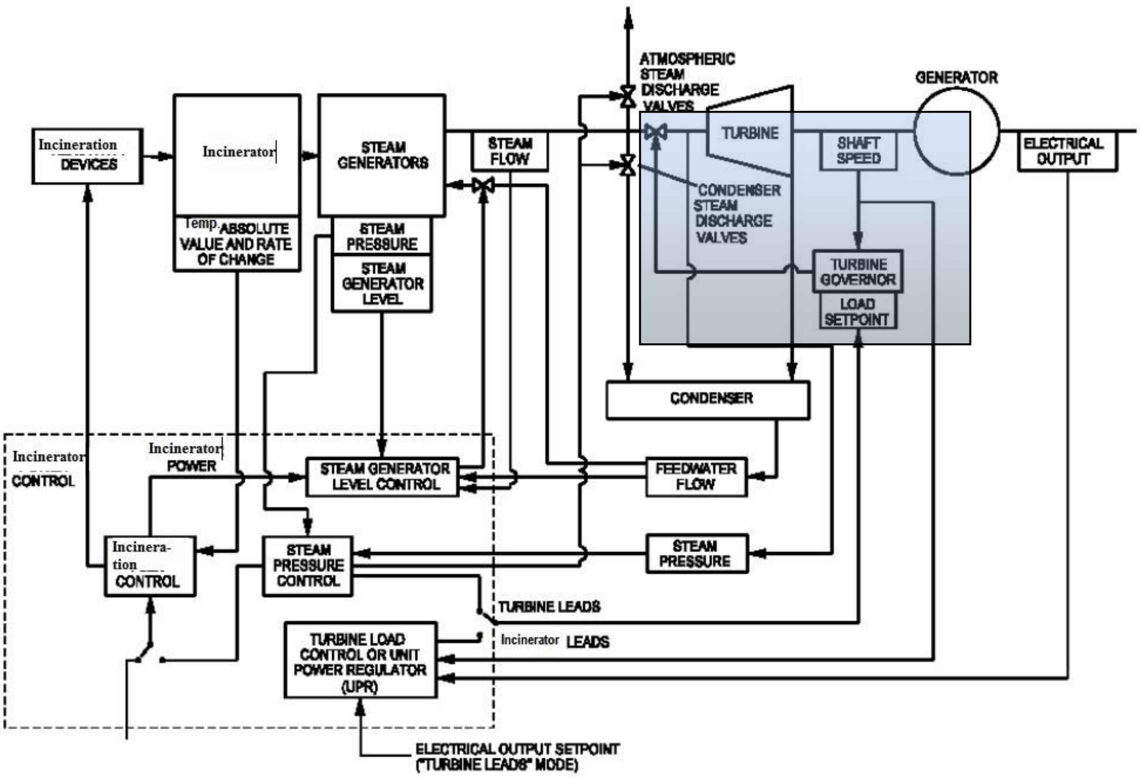
```
        self.button_Stop_Read_pump = wx.Button(panel, -1, "STOP PUMP",
        pos=(750,570))
        self.Bind(wx.EVT_BUTTON, self.StopReadButton, self.button_Stop_Read_pump)

        # Vaporizer out
        self.temp_Vaporizer_out = wx.StaticText(
        panel, size = (26, -1), pos = (160, 165), style = LABELSTYLE
        )
        self.pressure_Vaporizer_out = wx.StaticText(
        panel, size = (26, -1), pos = (200, 165), style = LABELSTYLE
        )

        # Overheater in
        self.temp_Overheater_in = wx.StaticText(
        panel, size = (26, -1), pos = (310, 165), style = LABELSTYLE
        )
        self.pressure_Overheater_in = wx.StaticText(
        panel, size = (26, -1), pos = (350, 165), style = LABELSTYLE
        )

        # Overheater out
        self.temp_Overheater_out = wx.StaticText(
        panel, size = (26, -1), pos = (537, 165), style = LABELSTYLE
        )
        self.pressure_Overheater_out = wx.StaticText(
        panel, size = (26, -1), pos = (580, 165), style = LABELSTYLE
        )

        # SolarPipe in
        self.pressure_SolarPipe_in = wx.StaticText(
        panel, size = (26, -1), pos = (140, 50), style = LABELSTYLE
        )
        self.temp_SolarPipe_in = wx.StaticText(
        panel, size = (26, -1), pos = (140, 93), style = LABELSTYLE
        )

        # SolarPipe out
        self.pressure_SolarPipe_out = wx.StaticText(
        panel, size = (26, -1), pos = (310, 50), style = LABELSTYLE
        )
        self.temp_SolarPipe_out = wx.StaticText(
        panel, size = (26, -1), pos = (310, 93), style = LABELSTYLE
        )

        # Layout
        self.Fit()

    def on_timer(self, event = None):
        division = 2

    # Vaporizer out
        answer = (self.dll.ReadAnalogChannel(3,1))/division
        new_value = str(answer)
```

```
            self.temp_Vaporizer_out.SetLabel(new_value)
            self.temp_Vaporizer_out.Refresh()
            new_value = str(random.randint(12, 16))
            self.pressure_Vaporizer_out.SetLabel(new_value)
            self.pressure_Vaporizer_out.Refresh()

        # Overheater in
            answer = (self.dll.ReadAnalogChannel(3,2))/division
            new_value = str(answer)
            self.temp_Overheater_in.SetLabel(new_value)
            self.temp_Overheater_in.Refresh()
            new_value = str(random.randint(11, 15))
            self.pressure_Overheater_in.SetLabel(new_value)
            self.pressure_Overheater_in.Refresh()

        # Overheater out
            answer = (self.dll.ReadAnalogChannel(3,3))/division
            new_value = str(answer)
            self.temp_Overheater_out.SetLabel(new_value)
            self.temp_Overheater_out.Refresh()
            new_value = str(random.randint(10, 14))
            self.pressure_Overheater_out.SetLabel(new_value)
            self.pressure_Overheater_out.Refresh()

        # SolarPipe in
            answer = (self.dll.ReadAnalogChannel(3,4))/division
            new_value = str(answer)
            self.temp_SolarPipe_in.SetLabel(new_value)
            self.temp_SolarPipe_in.Refresh()
            new_value = str(random.randint(3, 6))
            self.pressure_SolarPipe_in.SetLabel(new_value)
            self.pressure_SolarPipe_in.Refresh()

        # SolarPipe out
            answer = (self.dll.ReadAnalogChannel(3,5))/division
            new_value = str(answer)
            self.temp_SolarPipe_out.SetLabel(new_value)
            self.temp_SolarPipe_out.Refresh()
            new_value = str(random.randint(2, 4))
            self.pressure_SolarPipe_out.SetLabel(new_value)
            self.pressure_SolarPipe_out.Refresh()

#********************** Run USB System
********************** **************************************************************

    def OpenUSBBoardThread(self):
            self.dll = windll.K8061
            i = self.counterUSBBoards
            for doit in range(0,i+1):
                    try:
                            self.dll.OpenDevice()
                            self.USBOpened = True
            # debug info
```

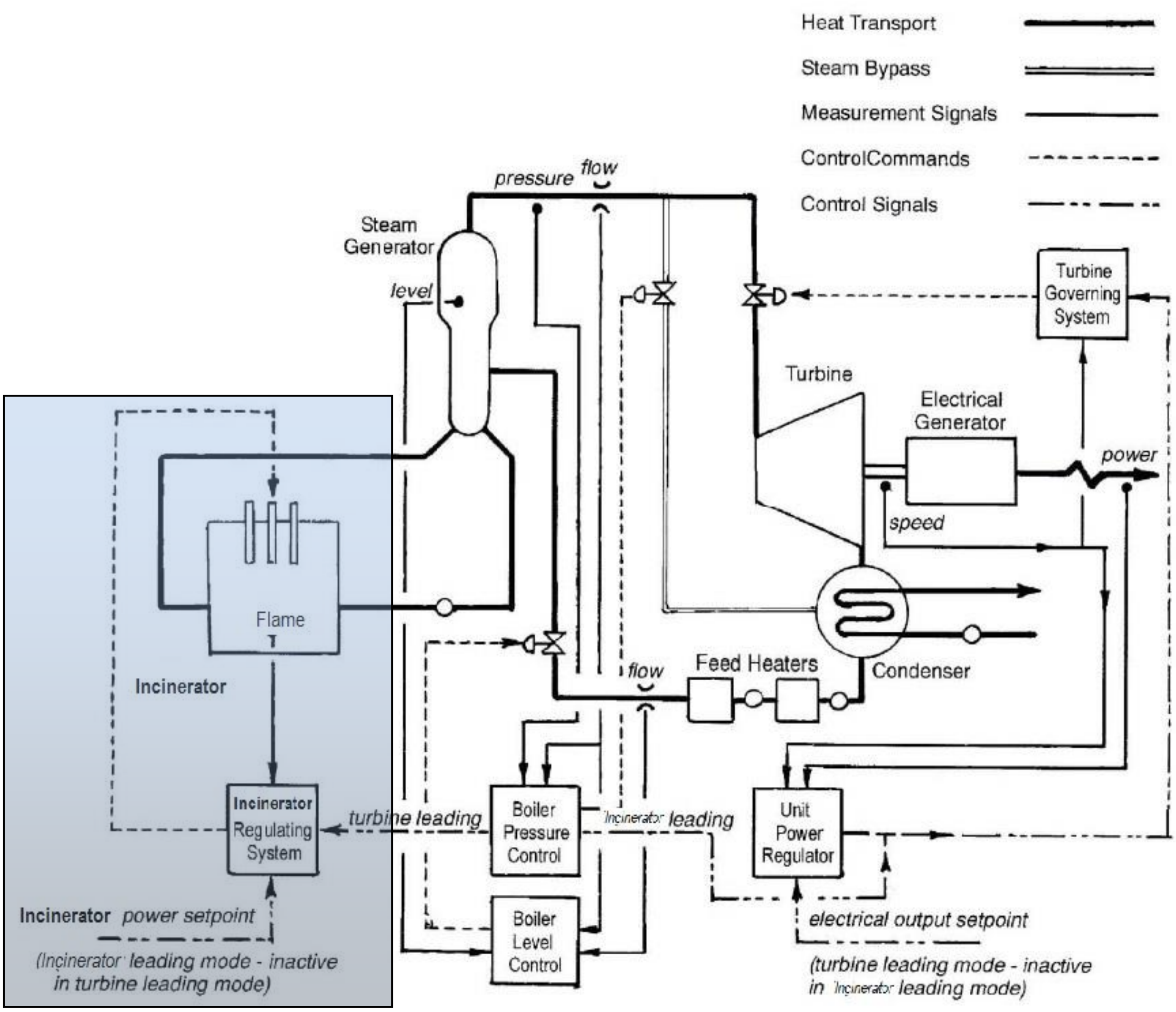
```
                        print 'USB Board is now connected!'
        #end debug info
                    except:
                        txt = 'Please Check USB Board connection'
                        print txt
                        return
                self.dll.OutputAnalogChannel(3,8,255)

#********************** STOP Button
*******************************************************************************
        def StopReadButton(self, event):
                self.dll.ClearDigitalChannel(3,1)
                print 'Digital Channel Cleared, pump turn off'

#********************** START Button
******************************************************************************
        def OpenPumpANDStartRead(self, event):
                wx.MessageBox("Do you want to open pump and start monitoring?", "start
                monitoring", wx.OK|wx.ICON_INFORMATION)

        # open the USB board
                self.OpenUSBBoardThread()
                time.sleep(0.5)
                self.dll.SetDigitalChannel(3,1)
                self.timer = wx.Timer()
                self.timer.Bind(wx.EVT_TIMER, self.on_timer)
                self.timer.Start(1000)

#********************** main definition and loop
*******************************************************************
        def main():
                """Testing"""
                app = wx.PySimpleApp()
                f = MyFrame()
                f.Center()
                f.Show()
                app.MainLoop()
        if __name__ == "__main__":
                main()

#*********************
*************************************************************************************
*****
```

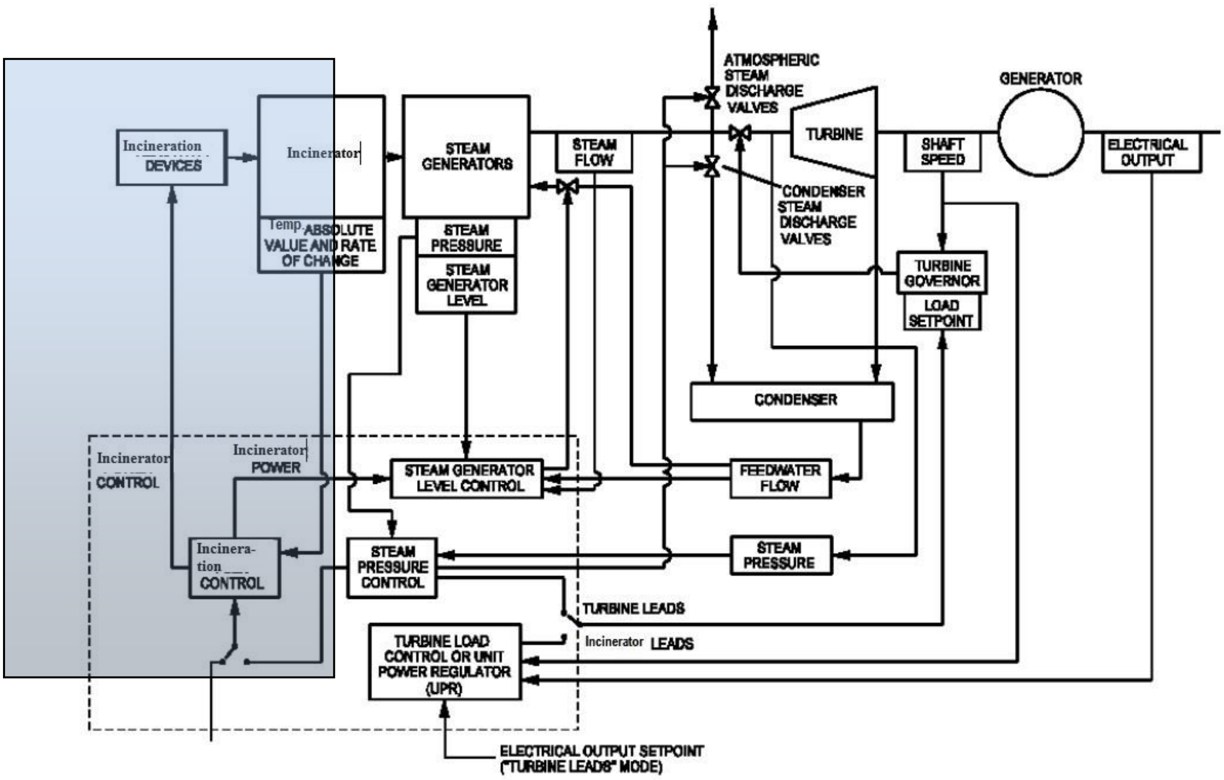
24 Turbine Govering System



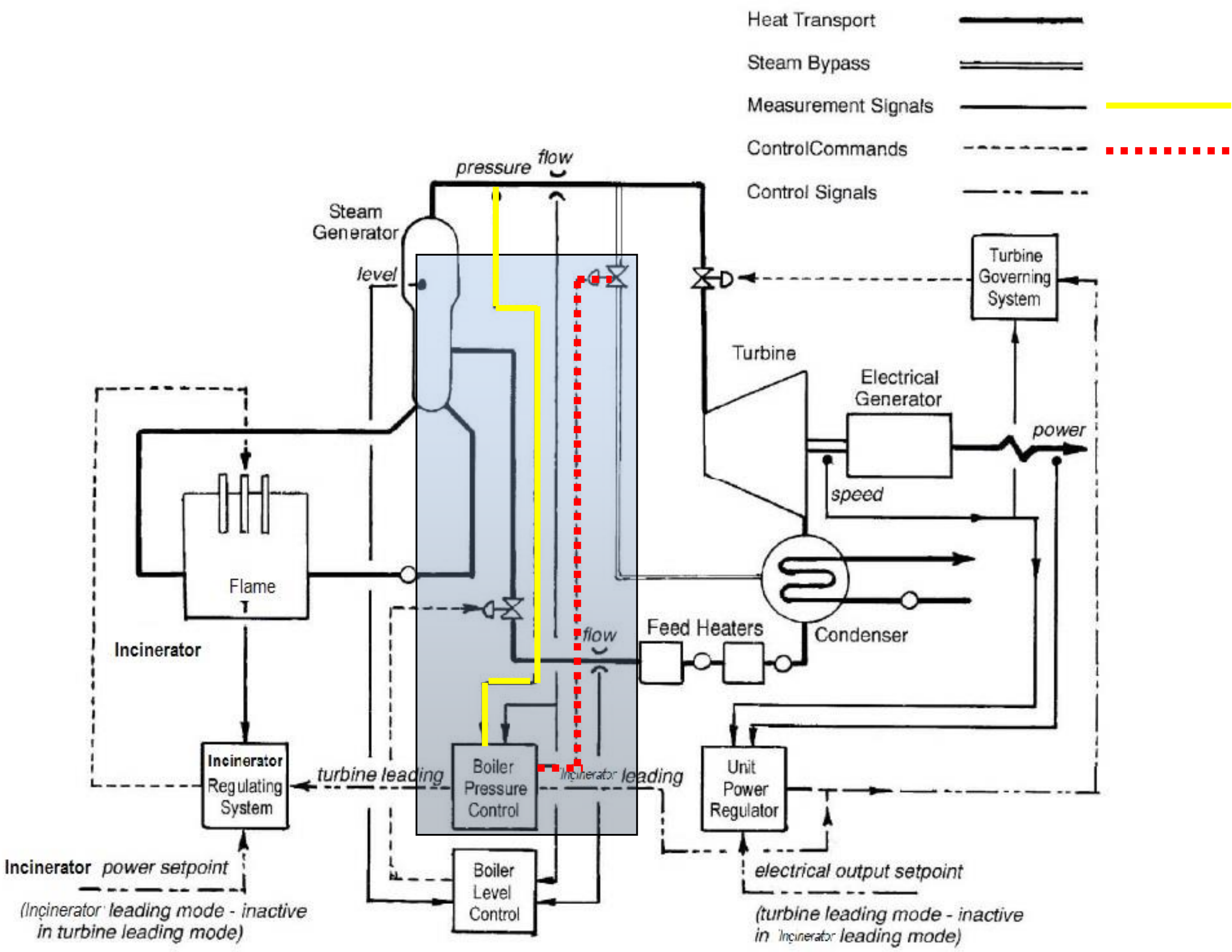


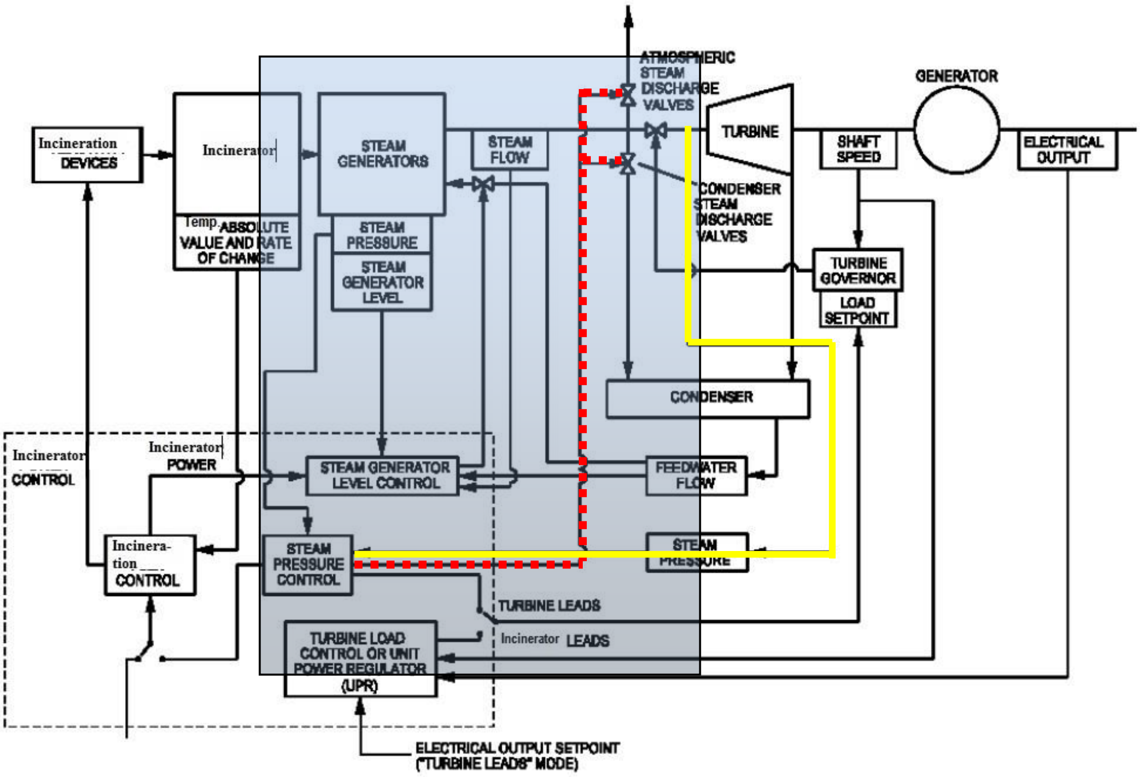
25) تحكم عملية الحرق Incinerator Regulating System(





26 Boiler Pressure Control




ATMOSPHERIC STEAM DISCHARGE VALVES
GENERATOR
Incineration DEVICES
Incinerator
STEAM GENERATORS
STEAM FLOW
TURBINE
SHAFT SPEED
ELECTRICAL OUTPUT
Temp. ABSOLUTE VALUE AND RATE OF CHANGE
STEAM PRESSURE
STEAM GENERATOR LEVEL
CONDENSER STEAM DISCHARGE VALVES
TURBINE GOVERNOR
LOAD SETPOINT
CONDENSER
Incinerator CONTROL
Incinerator POWER
STEAM GENERATOR LEVEL CONTROL
FEEDWATER FLOW
Incineration CONTROL
STEAM PRESSURE CONTROL
STEAM PRESSURE
TURBINE LEADS
Incinerator LEADS
TURBINE LOAD CONTROL OR UNIT POWER REGULATOR (UPR)
ELECTRICAL OUTPUT SETPOINT ("TURBINE LEADS" MODE)

PCS Platform 2019

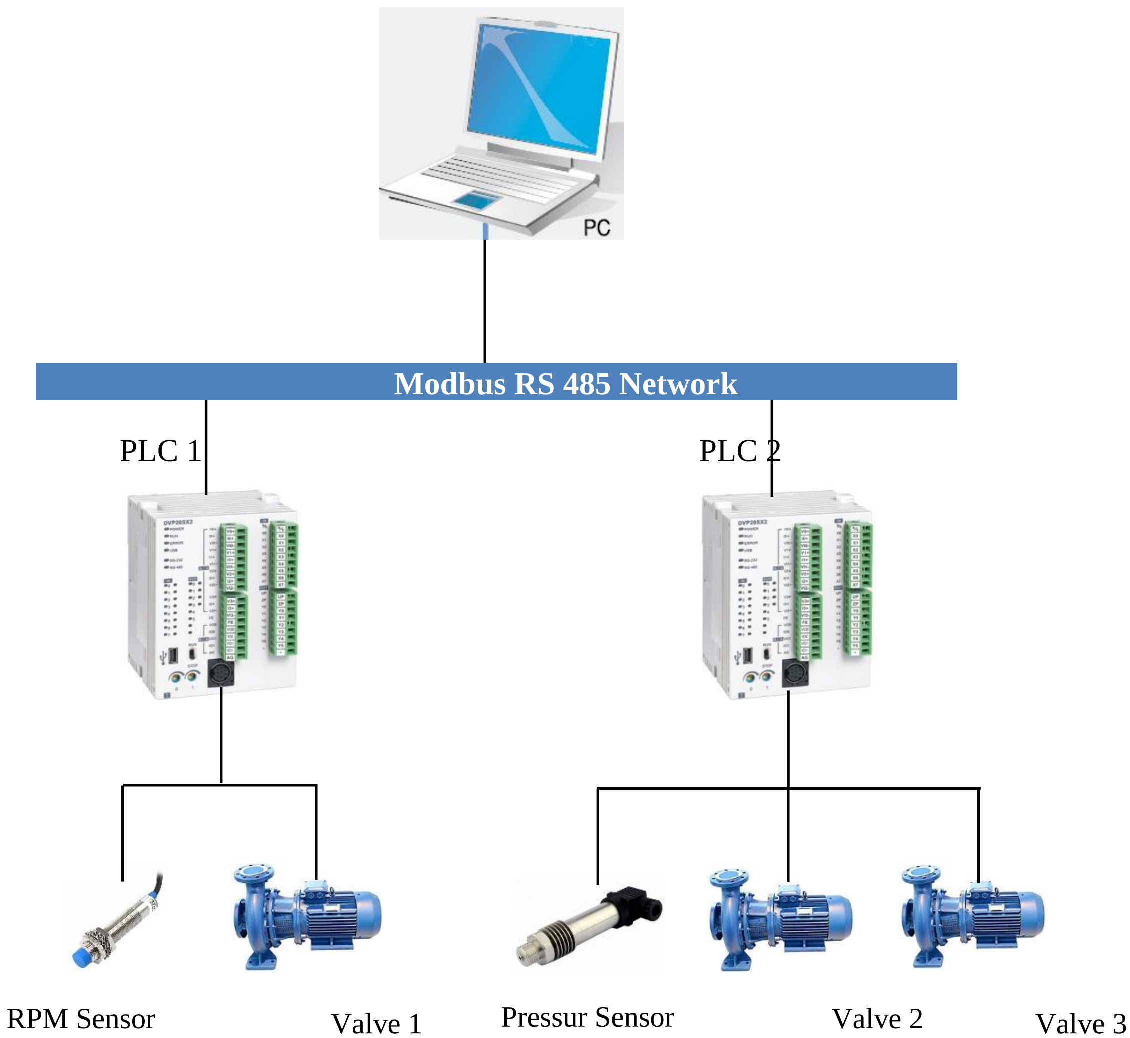
نظام التحكم

Document 1: PLC

Document 2: GUI

المشروع : التحكم بمحطة توليد الكهرباء بواسطة الحاسوب من خلال ال PLC

(control system of alternative power by PLC & PC)



Turbine governing system

Boiler Pressure control

Chapter 1

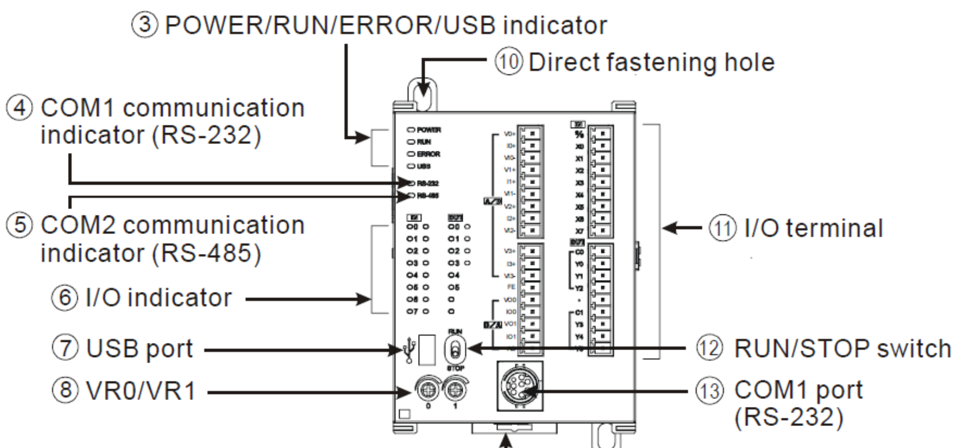
PLC DELTA DVP20SX211R

1. Specifications

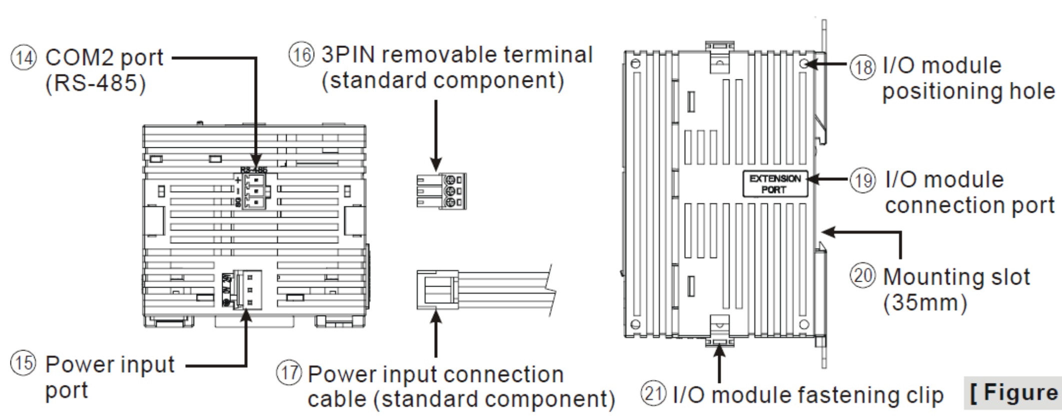
_ Program capacity: 16k steps/Data register: 10k words
_ Higher execution speed compared to the competition: LD: 0.35μs, MOV: 3.4μs
_ Built-in mini USB, RS-232 and RS-485 ports (Master/Slave) Supports standard MODBUS ASCII/RTU protocol and PLC Link function
_ Supports real time clocl for version 2.0 and above (no battery required) It operates for at least one week after power off.
_Built-in 4 analog inputs / 2 analog outputs / 8 Digital Inputs & 6 Digital Outputs (Relay)
_ Supports DVP-S series left-side and right-side modules
_Power supply voltage : 24V DC

Built-in Analog I/O			
Analog Input		**Analog Output**	
Channels	4	**Channels**	2
Resolution	12-bit	**Resolution**	12-bit
Spec.	-20~20mA or -10~10V or 4~20mA	**Spec.**	0~20mA or -10V~10V or 4~20mA

2. Product Profile



[Figure 1]



[Figure 2]

3. Point Specifications

3.1-Input point Specifications

Items \ Spec.		Input Point		
		24VDC (-15% ~ 20%) single common port input		
Input No.		X0, X2	X1, X3	X4 ~ X7
Input type		DC (SINK or SOURCE)		
Input Current (± 10%)		24VDC, 5mA		
Input impedance		4.7K Ohm		
Action level	Off→On	> 15VDC		
	On→Off	< 5VDC		
Response time	Off→On	< 2.5μs	< 10μs	< 20us
	On→Off	< 5μs	< 20μs	< 50us
Filter time		Adjustable within 0 ~ 20ms by D1020 (Default: 10ms)		

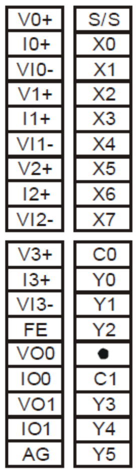
3.2-Output point Specifications

Items \ Spec.		Output Point
		Relay
Output No.		Y0 ~ Y5
Max. frequency		1Hz
Working voltage		250VAC, < 30VDC
Max. load	Resistive	1.5A/1 point (5A/COM)
	Inductive	#2
	Lamp	20WDC/100WAC
Response time	Off→On	Approx. 10 ms
	On→Off	

3.3- Analog input & Analog output Specifications

Items	Analog Input (A/D)			Analog Output (D/A)		
	Voltage	Current		Voltage	Current	
Analog I/O range	±10V	±20mA	4 ~ 20mA[#1]	±10V	0 ~ 20mA	4 ~ 20mA[#1]
Digital conversion range	±2,000	±2,000	0 ~ +2,000	±2,000	0 ~ +4,000	0 ~ +4,000
Resolution [#2]	12-bit					

4. Point Wiring

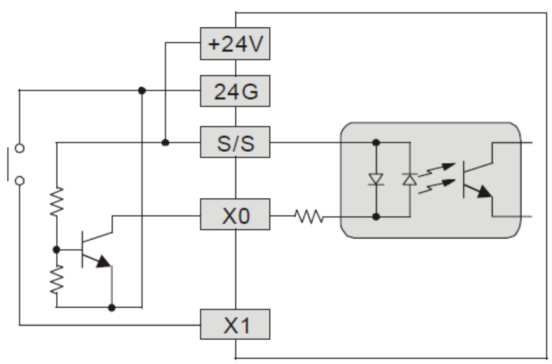


4.1-Input Point Wiring

There are 2 types of DC inputs, SINK and SOURCE. (See the example below. For detailed point configuration, please refer to the specification of each model.)

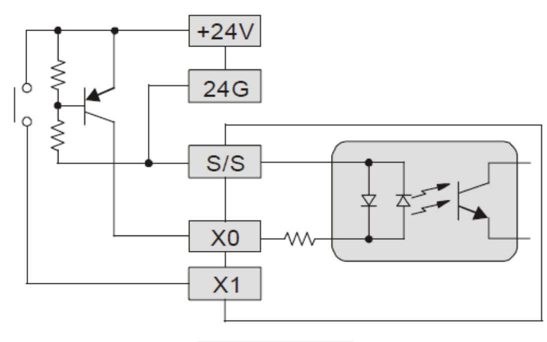
- DC Signal IN – SINK mode

Input point loop equivalent circuit



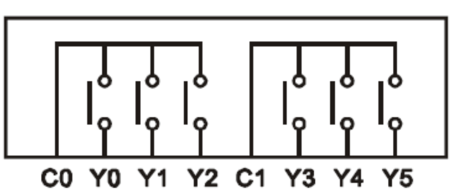
- DC Signal IN – SOURCE mode

Input point loop equivalent circuit

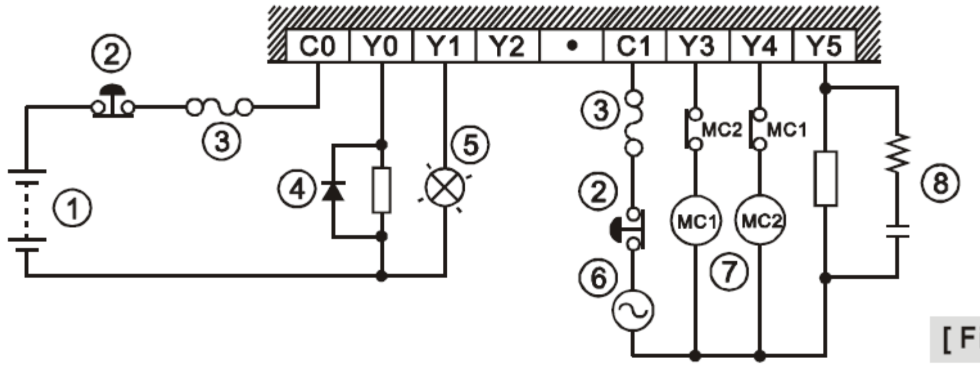


4.2- Output Point Wiring

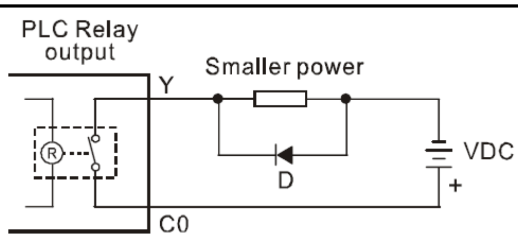
Output terminals, Y0, Y1, and Y2, of relay models use C0 common port; Y3, Y4, and Y5 use C1 common port; as shown in the Figure . When output points are enabled, their corresponding indicators on the front panel will be on.



Relay (R) output circuit wiring

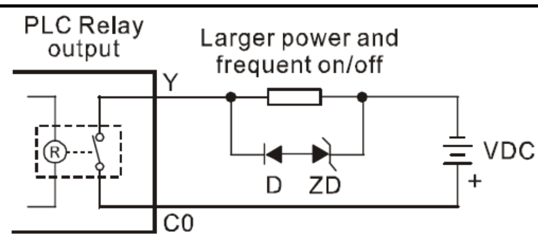


[Figure 11]



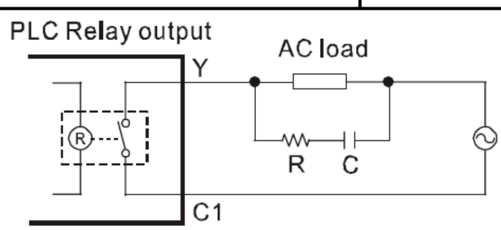
D: 1N4001 diode or equivalent component

[Figure 12a]



D: 1N4001 diode or equivalent component
ZD: 9V Zener, 5W

[Figure 12b]

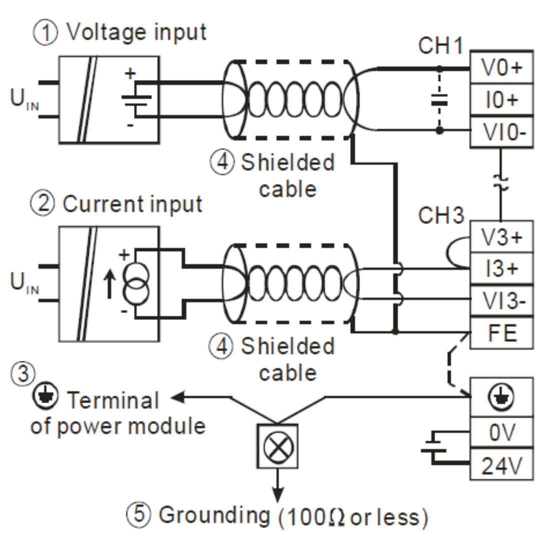


R: 100~120Ω
C: 0.1~0.24uF

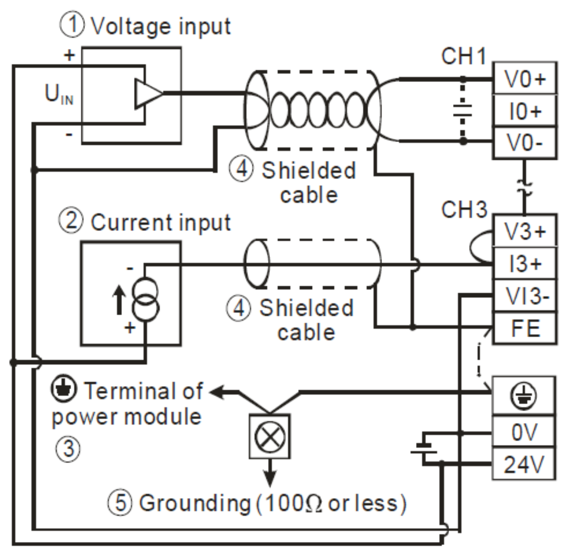
[Figure 13]

4.3- Analog input A/D & Analog output D/A External Wiring

- A/D: Active
- A/D: Passive

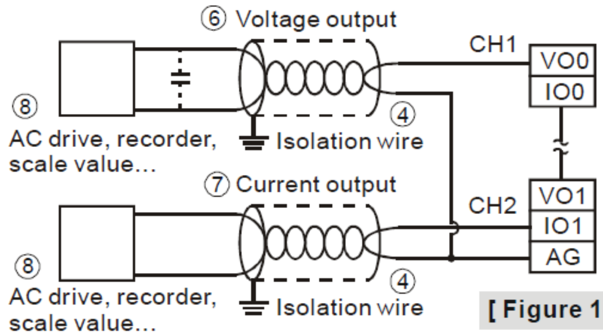


[Figure 16]



[Figure 17]

- D/A



[Figure 18]

5. DVP20SX2 Memory Map

<table>
<tr><th colspan="6">Specifications</th></tr>
<tr><td colspan="4">Control Method</td><td colspan="2">Stored program, cyclic scan system</td></tr>
<tr><td colspan="4">I/O Processing Method</td><td colspan="2">Batch processing method (when END instruction is executed)</td></tr>
<tr><td colspan="4">Execution Speed</td><td colspan="2">LD instructions – 0.54μs, MOV instructions – 3.4μs</td></tr>
<tr><td colspan="4">Program language</td><td colspan="2">Instruction List + Ladder + SFC</td></tr>
<tr><td colspan="4">Program Capacity</td><td colspan="2">15872 steps</td></tr>
<tr><td rowspan="11">Bit Contacts</td><td>X</td><td colspan="2">External inputs</td><td>X0~X377, octal number system, 256 points max.</td><td rowspan="2">Total 480+32 I/O(*4)</td></tr>
<tr><td>Y</td><td colspan="2">External outputs</td><td>Y0~Y377, octal number system, 256 points max.</td></tr>
<tr><td rowspan="3">M</td><td rowspan="3">Auxiliary relay</td><td>General</td><td>M0~M511, 512 points, (*1)
M768~M999, 232 points, (*1)
M2000~M2047, 48 points, (*1)</td><td rowspan="3">Total 4096 points</td></tr>
<tr><td>Latched</td><td>M512~M767, 256 points, (*2)
M2048~M4095, 2048 points, (*2)</td></tr>
<tr><td>Special</td><td>M1000~M1999, 1000 points, some are latched</td></tr>
<tr><td rowspan="6">T</td><td rowspan="6">Timer</td><td rowspan="3">100ms (M1028=ON, T64~T126: 10ms)</td><td>T0~T126, 127 points, (*1)
T128~T183, 56 points, (*1)</td><td rowspan="6">Total 256 points</td></tr>
<tr><td>T184~T199 for Subroutines, 16 points (*1)</td></tr>
<tr><td>T250~T255(accumulative), 6 points (*1)</td></tr>
<tr><td rowspan="2">10ms (M1038=ON, T200~T245: 1ms)</td><td>T200~T239, 40 points, (*1)</td></tr>
<tr><td>T240~T245(accumulative), 6 points, (*1)</td></tr>
<tr><td>1ms</td><td>T127, 1 points, (*1)
T246~T249(accumulative), 4 points, (*1)</td></tr>
</table>

	C	Counter	16-bit count up		C0~C111, 112 points, (*1) C128~C199, 72 points, (*1)	Total 233 points
					C112~C127, 16 points, (*2)	
			32-bit count up/down		C200~C223, 24 points, (*1)	
					C224~C232, 9 points, (*2)	
			32bit high-speed count up/down	Soft-ware	C235~C242, 1 phase 1 input, 8 points, (*2)	Total 22 points
					C233~C234, 2 phase 2 input, 2 points, (*2)	
				Hard-ware	C243~C244, 1 phase 1 input, 2 points, (*2)	
					C245~C250, 1 phase 2 input, 6 points, (*2)	
					C251~C254 2 phase 2 input, 4 points, (*2)	
	S	Step point	Initial step point		S0~S9, 10 points, (*2)	Total 1024 points
			Zero point return		S10~S19, 10 points (use with IST instruction), (*2)	
			Latched		S20~S127, 108 points, (*2)	
			General		S128~S911, 784 points, (*1)	
			Alarm		S912~S1023, 112 points, (*2)	

Specifications					
Word Register	T	Current value		T0~T255, 256 words	
	C	Current value		C0~C199, 16-bit counter, 200 words	
				C200~C254, 32-bit counter, 55 words	
	D	Data register	General	D0~D407, 408 words, (*1) D600~D999, 400 words, (*1) D3920~D9799, 5880 words, (*1)	Total 10000 points
			Latched	D408~D599, 192 words, (*2) D2000~D3919, 1920 words, (*2)	
			Special	D1000~D1999, 1000 words, some are latched	
			Righ-side special module	D9900~D9999, 100 words (*1) (*6)	
			Left-side special module	D9800~D9899, 100 words (*1) (*7)	
			Index	E0~E7, F0~F7, 16 words, (*1)	
Pointer	N	Master control loop		N0~N7, 8 points	
	P	Pointer		P0~P255, 256 points	
	I	Interrupt Service	External interrupt	I000/I001(X0), I100/I101(X1), I200/I201(X2), I300/I301(X3), I400/I401(X4), I500/I501(X5), I600/I601(X6), I700/I701(X7), 8 points (01: rising-edge trigger, 00: falling-edge trigger)	
			Timer interrupt	I602~I699, I702~I799, 2 points (Timer resolution = 1ms) I805~I899, 1 point (Timer resolution = 0.1ms) (Supported by V2.00 and above)	
			High-speed counter interrupt	I010, I020, I030, I040, I050, I060, I070, I080, 8 points	
			Communication interrupt	I140(COM1), I150(COM2), I160(COM3), 3 points, (*3)	

Constant	K	Decimal	K-32,768 ~ K32,767 (16-bit operation), K-2,147,483,648 ~ K2,147,483,647 (32-bit operation)
	H	Hexadecimal	H0000 ~ HFFFF (16-bit operation), H00000000 ~HFFFFFFFF (32-bit operation)
Serial Ports		SA2	COM1: built-in RS-232 ((Master/Slave) COM2: built-in RS-485 (Master/Slave) COM3: built-in RS-485 (Master/Slave) COM1 is typically the programming port.
		SX2	COM1: built-in RS-232 ((Master/Slave) COM2: built-in RS-485 (Master/Slave) COM3: built-in USB (Slave) COM1 is typically the programming port.
Real Time Clock			Year, Month, Day, Week, Hours, Minutes, Seconds
Special I/O Modules			Right side: Up to 8 I/O modules can be connected Left side: Up to 8 high-speed I/O module can be connected
File Register (*5)			K0~K4999, 5000 points (*2)

6. PLC Device Address

Device	Range	Effective Range			MODBUS Address	Address
		ES2/EX2	SS2	SA2/SE SX2		
S	000~255	000~1023	000~1023		000001~000256	0000~00FF
S	256~511				000257~000512	0100~01FF
S	512~767				000513~000768	0200~02FF
S	768~1023				000769~001024	0300~03FF
X	000~377 (Octal)	000~377	000~377		101025~101280	0400~04FF
Y	000~377 (Octal)	000~377	000~377		001281~001536	0500~05FF
T	000~255 bit	000~255	000~255		001537~001792	0600~06FF
	000~255 word	000~255	000~255		401537~401792	0600~06FF
M	000~255	0000 ~ 4095	0000~4095		002049~003584	0800~08FF
M	256~511					0900~09FF
M	512~767					0A00~0AFF
M	768~1023					0B00~0BFF
M	1024~1279					0C00~0CFF
M	1280~1535					0D00~0DFF

Device	Range	Effective Range			MODBUS Address	Address
		ES2/EX2	SS2	SA2/SE SX2		
M	1536~1791	0000 ~ 4095	0000~4095		045057~047616	B000~B0FF
M	1792~2047					B100~B1FF
M	2048~2303					B200~B2FF
M	2304~2559					B300~B3FF
M	2560~2815					B400~B4FF
M	2816~3071					B500~B5FF
M	3072~3327					B600~B6FF
M	3328~3583					B700~B7FF
M	3584~3839					B800~B8FF
M	3840~4095					B900~B9FF
C	000~199 (16-bit)	000~199	000~199		003585~003784	0E00~0EC7
		000~199	000~199		403585~403784	0E00~0EC7
C	200~255 (32-bit)	200~255	200~255		003785~003840	0EC8~0EFF
		200~255	200~255		401793~401903 (Odd address valid)	0700~076F

D	000~255	0000 ~ 9999	0000 ~ 4999	0000 ~ 9999	404097~405376	1000~10FF
D	256~511					1100~11FF
D	512~767					1200~12FF
D	768~1023					1300~13FF
D	1024~1279					1400~14FF
D	1280~1535				405377~408192	1500~15FF
D	1536~1791					1600~16FF
D	1792~2047					1700~17FF
D	2048~2303					1800~18FF
D	2304~2559					1900~19FF
D	2560~2815					1A00~1AFF
D	2816~3071					1B00~1BFF
D	3072~3327					1C00~1CFF
D	3328~3583					1D00~1DFF
D	3584~3839					1E00~1EFF
D	3840~4095					1F00~1FFF
D	4096~4351				436865~440960	9000~90FF
D	4352~4999					9100~91FF
D	4608~4863					9200~92FF
D	4864~5119					9300~93FF
D	5120~5375		N/A			9400~94FF
D	5376~5631					9500~95FF
D	5632~5887					9600~96FF
D	5888~6143					9700~97FF

D	6144~6399	0000 ~ 9999	N/A	0000 ~ 9999	436865~440960	9800~98FF
D	6400~6655					9900~99FF
D	6656~6911					9A00~9AFF
D	6912~7167					9B00~9BFF
D	7168~7423					9C00~9CFF
D	7424~7679					9D00~9DFF
D	7680~7935					9E00~9EFF
D	7936~8191					9F00~9FFF
D	8192~8447				440961~442768	A000~A0FF
D	8448~8703					A100~A1FF
D	8704~8959					A200~A2FF
D	8960~9215					A300~A3FF
D	9216~9471					A400~A4FF
D	9472~9727					A500~A5FF
D	9728~9983					A600~A6FF
D	9984~9999					A700~A70F
D	10000~11999	Applicable to DVP-SE			442769~444768	A710~AEDF

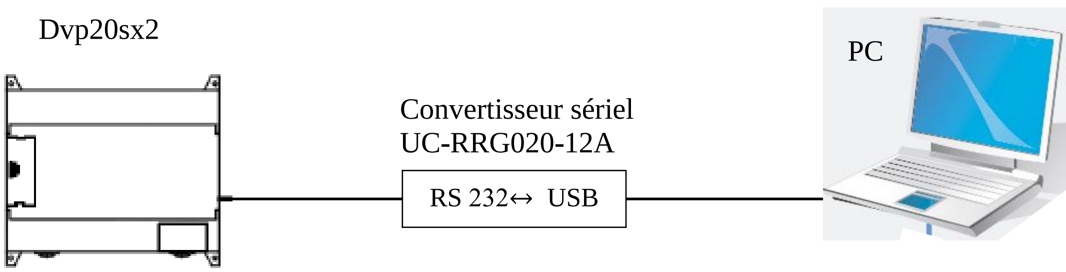
7. Instructions

Instruction	Function	Operand	Execution speed (us)		Steps
			ES2/EX2/SS2 SA2/SX2	SE	
LD	Load NO contact	X, Y, M, S, T, C	0.76	0.64	1~3
LDI	Load NC contact	X, Y, M, S, T, C	0.78	0.68	1~3
AND	Connect NO contact in series	X, Y, M, S, T, C	0.54	0.58	1~3
ANI	Connect NC contact in series	X, Y, M, S, T, C	0.56	0.62	1~3
OR	Connect NO contact in parallel	X, Y, M, S, T, C	0.54	0.62	1~3
ORI	Connect NC contact in parallel	X, Y, M, S, T, C	0.56	0.64	1~3
ANB	Connect a block in series	N/A	0.68	0.68	1
ORB	Connect a block in parallel	N/A	0.76	0.76	1
MPS	Start of branches. Stores current result of program evaluation	N/A	0.74	0.68	1
MRD	Reads the stored current result from previous MPS	N/A	0.64	0.54	1
MPP	End of branches. Pops (reads and resets) the stored result in previous MPS	N/A	0.64	0.54	1
OUT	Output coil	Y, S, M	0.88	0.68	1~3
SET	Latches the ON status	Y, S, M	0.76	0.68	1~3
RST	Resets contacts, registers or coils	Y, M, S, T, C, D, E, F	2.2	1.04	3
MC	Master control Start	N0~N7	1	0.8	3
MCR	Master control Reset	N0~N7	1	0.8	3
END	Program End	N/A	1	0.8	1
NOP	No operation	N/A	0.4	0.5	1
P	Pointer	P0~P255	0.4	0.5	1
I	Interrupt program pointer	I□□□	0.4	0.5	1
STL	Step ladder start instruction	S	2.2	2	1
RET	Step ladder return instruction	N/A	1.6	1.4	1
NP	Negative contact to Positive contact	N/A	1.66	0.72	1
PN	Positive contact to Negative contact	N/A	1.62	0.72	1

Chapter 2 : WPL Soft

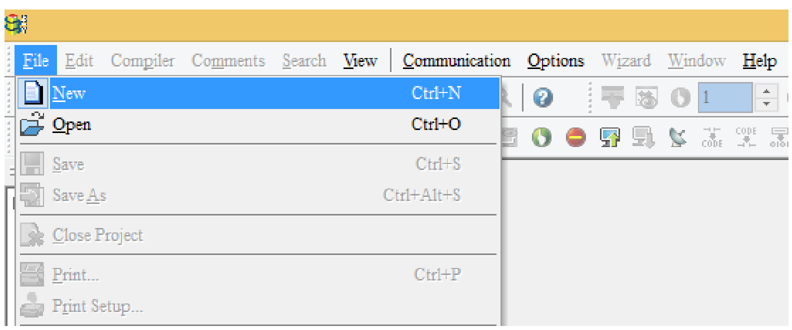
1- البرنامج المخصص لبرمجة ال PLC هو "WPL Soft"

2- لبرمجة ال PLC نحتاج لوصلة UC-RRG020-12A مع التعريف من اجل ربط الحاسوب بال PLC

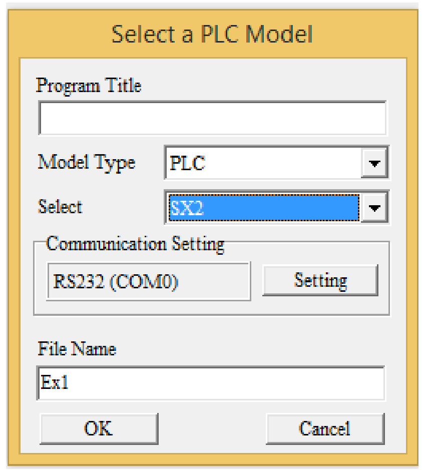


3- انشاء برنامج لل PLC

نضغط على File – New

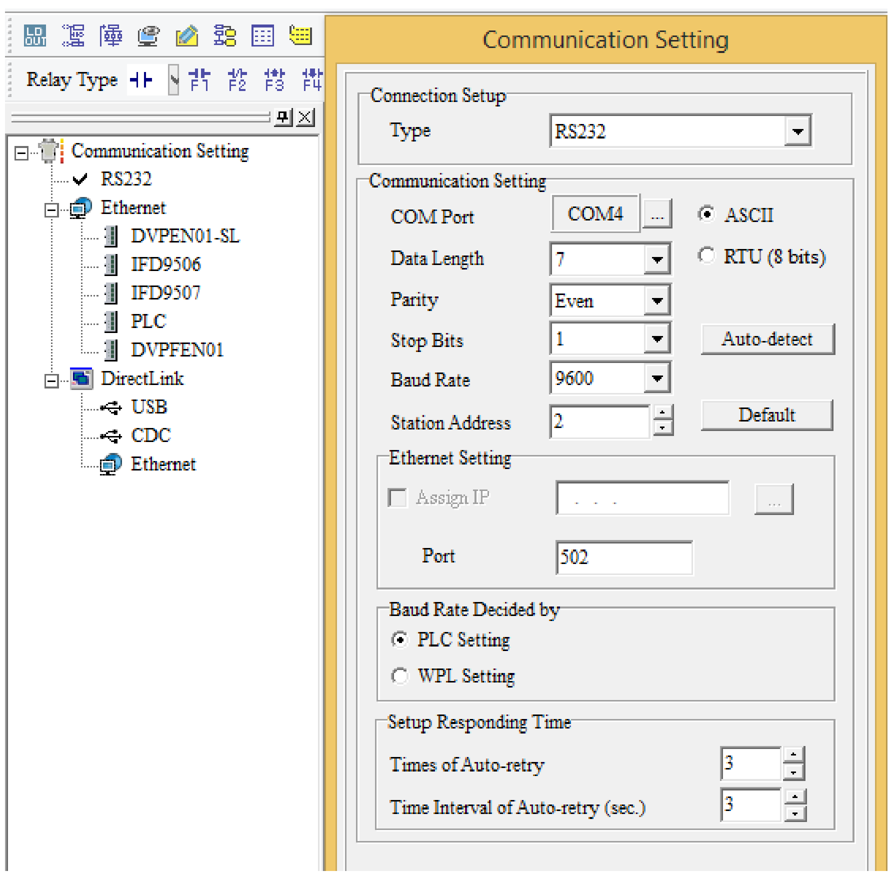


نختار نوع ال PLC (SX2) ونضع اسم للمشروع في File Name ثم نضغط OK .



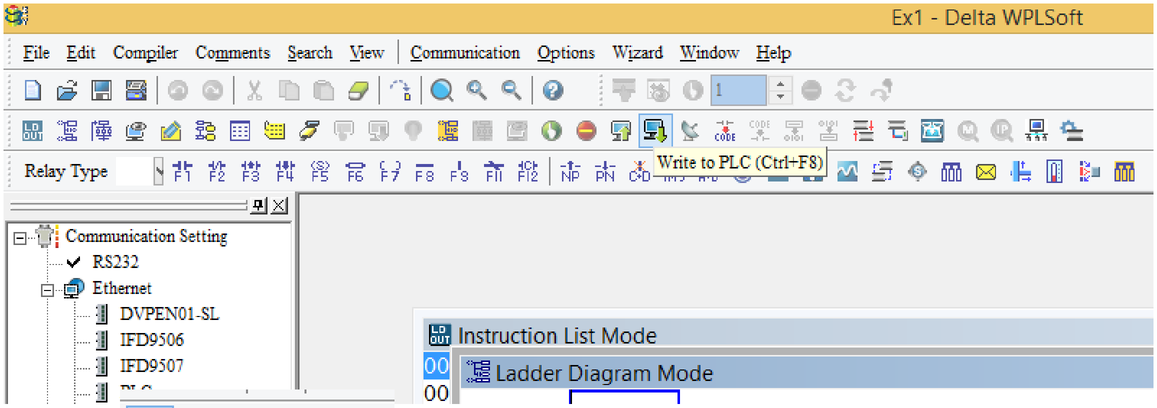
4- خصائص لتنزيل البرنامج على ال PLC

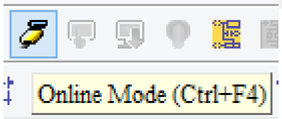
- بعد ربط الحاسوب بال PLC نضغط على RS232 في Communication setting على يسار البرنامج لتفقد وجود ال Port (COM4) لكي تتمكن من تنزيل البرنامج.
- يجب اختيار ال station address الخاص بال PLC (قبل استعمال ال PLC يكون ال address 1 ويمكن تغيره من خلال البرمجة كما سنراه لاحقا) .
- يمكنا اختيار برمجة ال PLC اما ASCII او RTU .



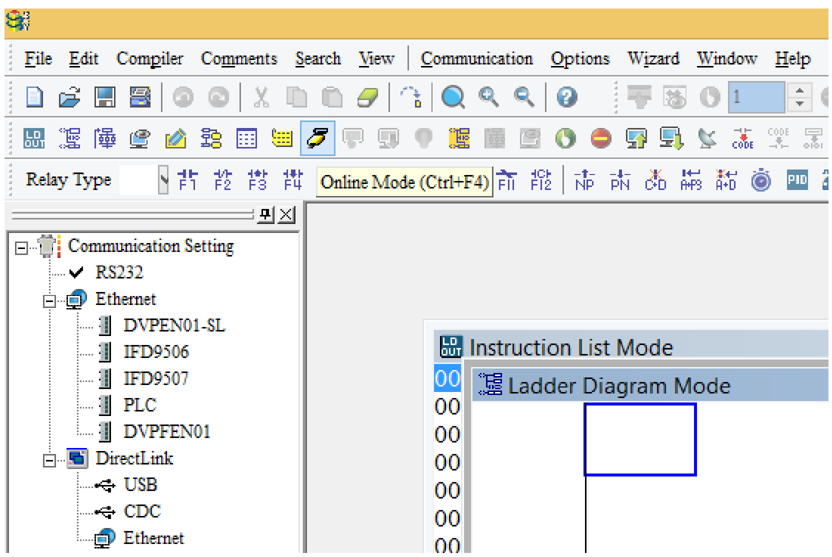
5- تنزيل البرنامج عل ال PLC

لتنزيل البرنامج نضغط الزر التالي 





6- لمراقبة عمل البرنامج بشكل مباش في ال PLC نضغط على الزر التالي



Chapter 2 : Vijeo designer

Vijeo Designer software

Vijeo Designer is a state-of-the-art software application with which you can create operator panels and configure operating parameters for human machine interface (HMI) devices. It provides all the tools needed to design an HMI project, from the data acquisition to the creation and display of animated drawings.

Realization of an application

The procedures to follow to implement an application are:

1- Create a new project,

2- Selection of the communication protocol.

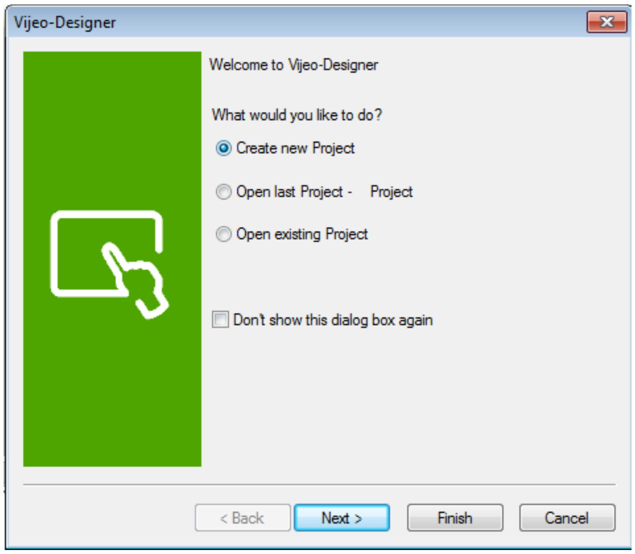
3- Creating Variables

4- Create a Command Button

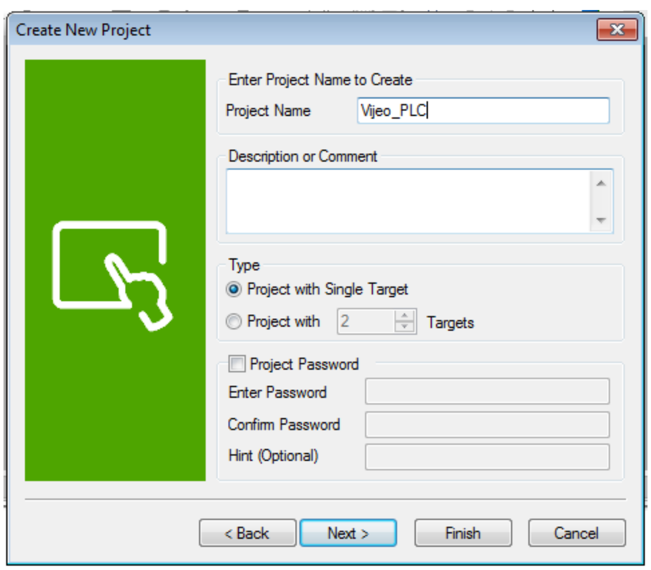
5- Create an alarm lamp.

6- Create a Numeric Indicator

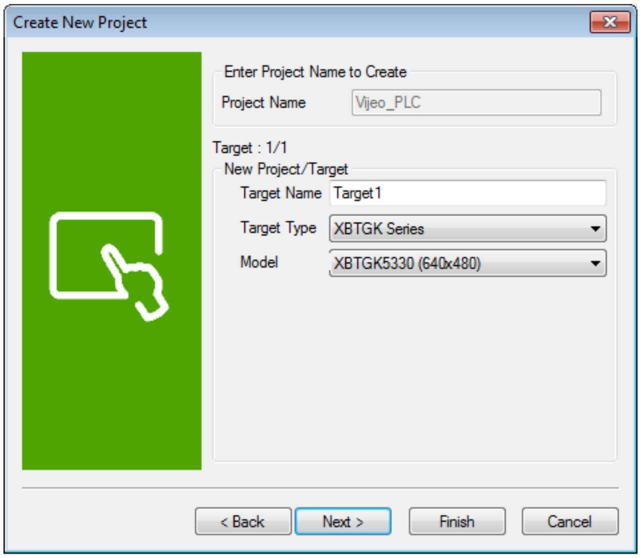
1- Create a new project,This dialog box appears when you start Vijeo Designer. Make sure **Create new project** is selected and click "**Next**" to continue.



Enter the name of your project and click **Next**. In our case, type "**Manual**".

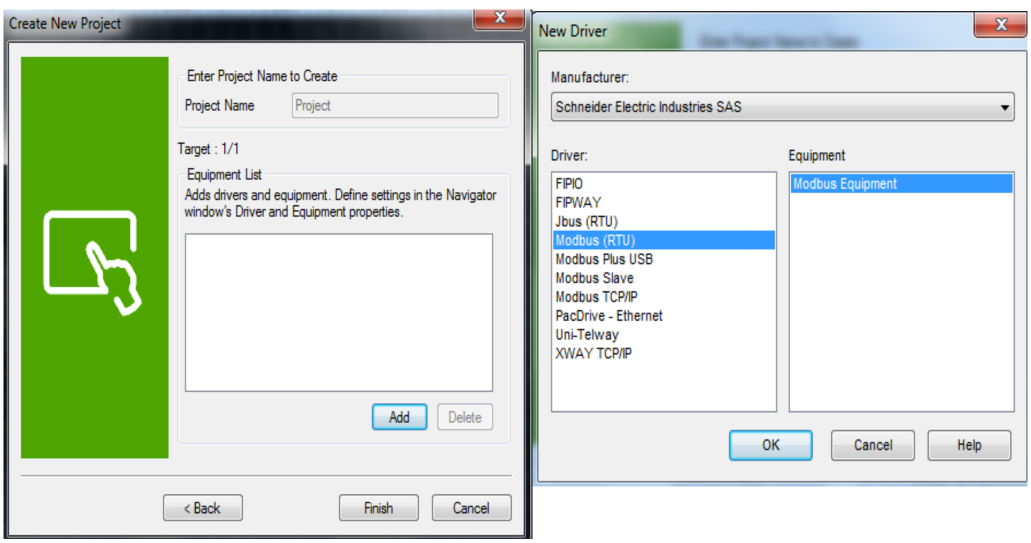


Select the target type …, and the model ..., Click **Next, Next.**



2- Selection of the communication protocol.

Select the relevant driver for the device type using the **Add** button. Select "**Schneider Electric Industrie SAS"** as the **Manufacturer**, " **Modbus_(RTU)"** as the **driver**, and "**Modbus Equipment"** as the **Equipment**. Then click on **Finish**.



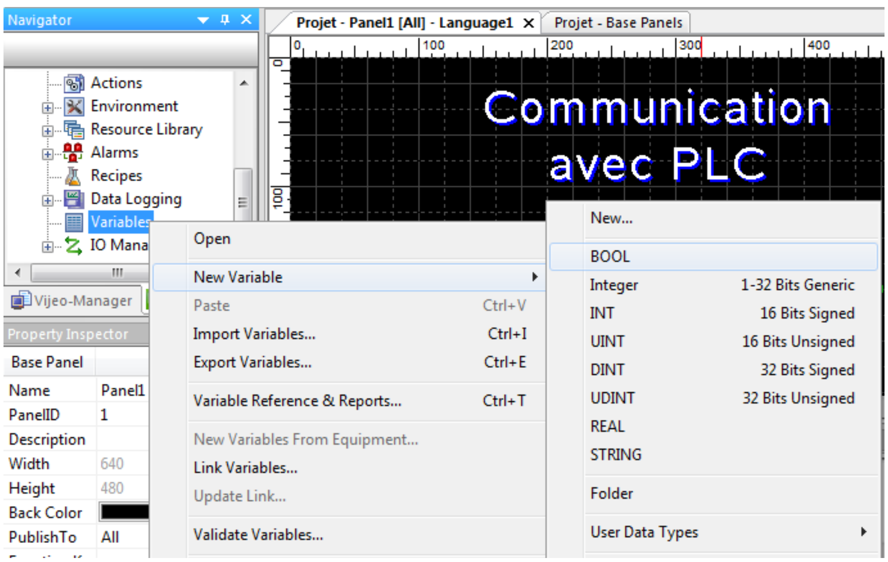
3- **Creating Variables**

A variable is a memory address indicated by a name. Vijeo Designer handles the following types of variables:

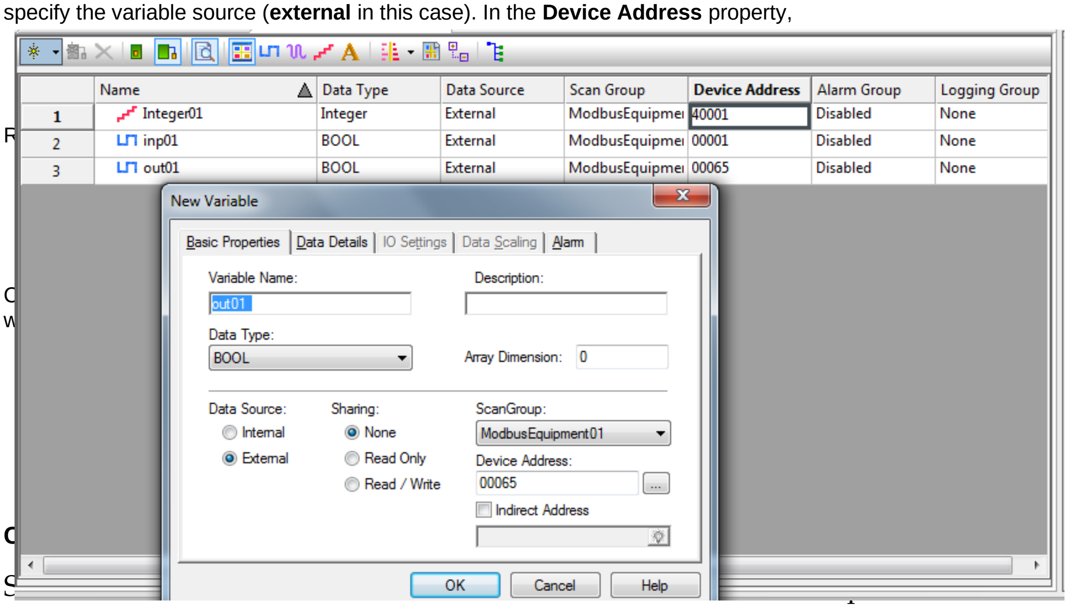
- BOOL
- INT (16 bit signed integer)
- UINT (16 bit unsigned integer)
- DINT (32 bit signed integer)
- UDINT (32 bit unsigned integer)
- Integer (1-32 bit generic integer)
- REAL

 STRING
 User Data Type (Array or Structure)
 Folder
 Block INT (16 bit signed block integer)
 Block UINT (16 bit unsigned block integer)
 Block DINT (32 bit signed block integer)
 Block Integer (1-32 bit generic block integer)
 Block REAL
Vijeo Designer uses the variables to communicate with devices. You can also define internal variables that will only be used by Vijeo Designer.

Right-click the "**Variables**" node in the "**Navigator**" window, select "**New Variable**" and click "**BOOL**".



Change the name of the Boolean-type "**BOOL01**" variable. In this window, specify the variable source (**external** in this case). In the **Device Address** property,



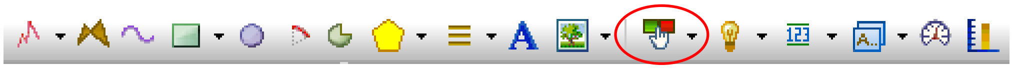
R

C
w

C

S button will be placed.

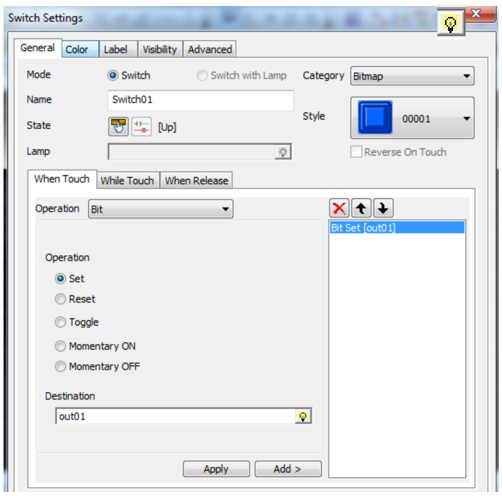
Select the "**Switch**" icon in the toolbar and use it to draw a **rectangle**, defining an area on the screen where it will be placed.



The **Switch Settings** window is displayed. Configure the properties as shown in the screen below:

In the **General** window:
- select **00001** as the switch style.

Under the "**When Touch**" tab, click the icon and:
- select the "**BOOL**" "Emptying" variable,
- select "**Set"** which will switch ON the Emptying bit when the button is pressed
- click **Add** to confirm the selection.

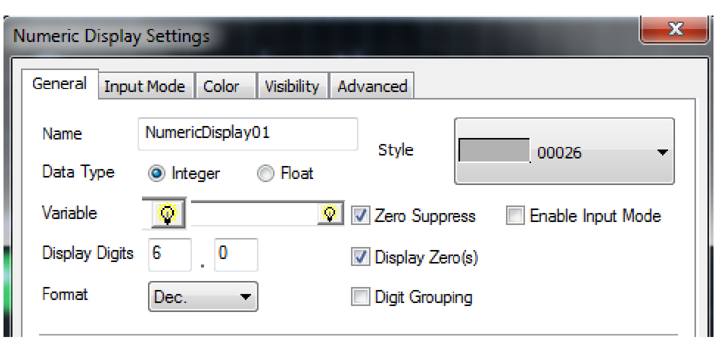


Under the "**When Release**" tab, click the icon and:
- select the "**BOOL**" "Emptying" variable,
- select "Re**set"** which will switch OFF the Emptying bit when the button is released
- click **Add** to confirm the selection.

Create a Numeric Indicator

Select the "Data Display" icon in the toolbar and draw an area on the screen where the numeric window will be placed.

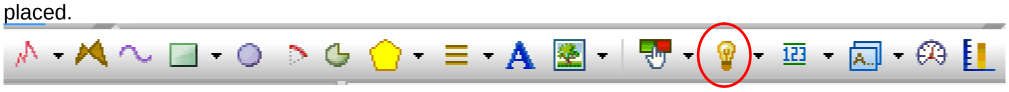
The **Numeric Display Settings** window is displayed. Configure the properties as shown in the screen below:



To write in this indicator, Select the **« Enable Input Mode »** In the "**Input mode**" tab:

Create an alarm lamp.

The lamp animates depending on the state of the variable: red if it is active and green if it is inactive.
Select the "**Lamp**" icon in the toolbar and use it to draw a **Lamp**, defining an area on the screen where the lamp will be placed.



In this window, from the "**General**" tab:
Click the icon  then:

- ➢ Select the "**BOOL**" variable,
- ➢ Retain the lamp style **10001**.

7- **Basic Instructions**

Instruction	Function	Operand	Execution speed (us)		Steps
			ES2/EX2/SS2 SA2/SX2	SE	
LD	Load NO contact	X, Y, M, S, T, C	0.76	0.64	1~3
LDI	Load NC contact	X, Y, M, S, T, C	0.78	0.68	1~3
AND	Connect NO contact in series	X, Y, M, S, T, C	0.54	0.58	1~3
ANI	Connect NC contact in series	X, Y, M, S, T, C	0.56	0.62	1~3
OR	Connect NO contact in parallel	X, Y, M, S, T, C	0.54	0.62	1~3
ORI	Connect NC contact in parallel	X, Y, M, S, T, C	0.56	0.64	1~3
ANB	Connect a block in series	N/A	0.68	0.68	1
ORB	Connect a block in parallel	N/A	0.76	0.76	1
MPS	Start of branches. Stores current result of program evaluation	N/A	0.74	0.68	1
MRD	Reads the stored current result from previous MPS	N/A	0.64	0.54	1
MPP	End of branches. Pops (reads and resets) the stored result in previous MPS	N/A	0.64	0.54	1
OUT	Output coil	Y, S, M	0.88	0.68	1~3
SET	Latches the ON status	Y, S, M	0.76	0.68	1~3
RST	Resets contacts, registers or coils	Y, M, S, T, C, D, E, F	2.2	1.04	3
MC	Master control Start	N0~N7	1	0.8	3
MCR	Master control Reset	N0~N7	1	0.8	3
END	Program End	N/A	1	0.8	1
NOP	No operation	N/A	0.4	0.5	1
P	Pointer	P0~P255	0.4	0.5	1
I	Interrupt program pointer	I□□□	0.4	0.5	1
STL	Step ladder start instruction	S	2.2	2	1
RET	Step ladder return instruction	N/A	1.6	1.4	1
NP	Negative contact to Positive contact	N/A	1.66	0.72	1
PN	Positive contact to Negative contact	N/A	1.62	0.72	1

Chapter 3

1-تصميم برنامج للPLC لتفعيل Modbus RTU slave مع RS485

Function Group COM Port Function

Number

Item \ Port	COM1	COM2	COM3
Communication format	D1036	D1120	D1109
Communication setting holding	M1138	M1120	M1136
ASCII/RTU mode	M1139	M1143	M1320
Slave communication address	D1121		D1255

Contents:
COM ports (COM1: RS-232, COM2: RS-485, COM3: RS-485) support communication format of MODBUS ASCII/RTU modes. When RTU format is selected, the data length should be set as 8. COM2 and COM3 support transmission speed up to 921kbps. COM1, COM2 and COM3 can be used at the same time.

COM1:
Can be used in master or slave mode. Supports ASCII/RTU communication format, baudrate (115200bps max), and modification on data length (data bits, parity bits, stop bits). **D1036:** COM1 (RS-232) communication protocol of master/slave PLC. (b8 - b15 are not used) Please refer to table below for setting.

COM2:
Can be used in master or slave mode. Supports ASCII/RTU communication format, baudrate (921kbps max), and modification on data length (data bits, parity bits, stop bits). **D1120:** COM2 (RS-485) communication protocol of master/slave PLC. Please refer to table below for setting.

COM3:
Can be used in master or slave mode. Supports ASCII/RTU communication format, baudrate (921kbps max), and modification on data length (data bits, parity bits, stop bits). **D1109:** COM3 (RS-485) communication protocol of master/slave PLC. (b8 - b15 are not used) Please refer to table below for setting.

M1002 : Enable single positive pulse at the moment when RUN is activate (Normally OFF)
H81: Set up communication protocol as 9600,8,N,1
D1120 : COM2 (RS-485) communication protocol

MOV H81 D1120 : Set up communication protocol as 9600, 8, N, 1

SET M1143 : For COM2(RS-485), ASCII/RTU mode selection (OFF: ASCII; ON: RTU)

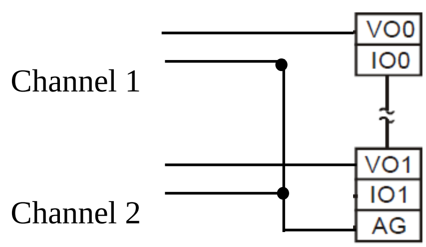
Mov K2 D1121 : COM1(RS-232) and COM2(RS-485) PLC communication address 2 (k2= address 2)

Mov K100 D1129 : COM2 (RS-485) Communication time-out setting (ms) (time k100=100ms)

SET M1120: Retaining the communication setting of COM2 (RS-485), modifying D1120 will be invalid when M1120 is set.

2- تصميم برنامج للتحكم ب analog output (0-10v) او actuator

طريقى توصيل ال actuator مع ال PLC



MOV K2000 D0 : MOVE 2000 in D0

D1116 : Analog output channel DA0 (VO0)

D1116 : Analog output channel DA1 (VO1)

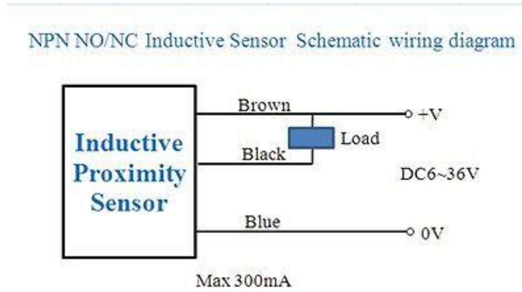
MOV D0 D1116 : MOVE 2000 in DA0 (2000 =10V)

MOV D1 D1117 MOVE 1000 in DA1 (1000 =5V)

3- تصميم برنامج لقراءة السرعة من (Proximity Sensor) من خلال (digital input)

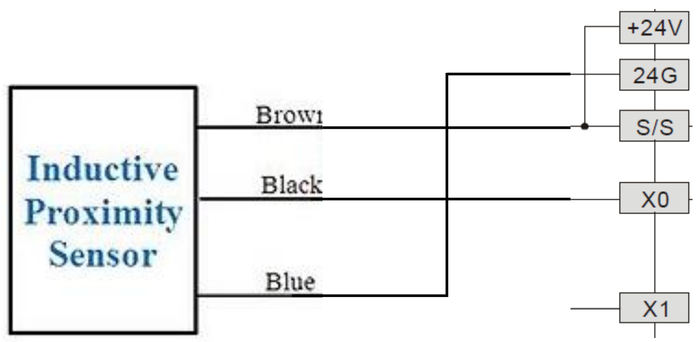
نوع الحساس وطريقة عمله

Proximity Sensor LJ12A3-4-Z/BX



قبل عمل الحساس تكون النقطة مفتوحة Normally opened وعند اقتراب مادة معدنية من الحساس تتغير الى مغلقة.

طريقة توصيل ال Sensor مع ال PLC



Sensor PLC

طريقة احتساب السرعة تكون عل الشكل التالي : في كل دورة يقترب المعدن مرة واحدة من الحساس فيعمل الحساس ويتلقى X0 هذه الاشار ويضاف 1 في ال D0 ثم تتكرر العملية لمدة

ثانية (1s) وخلال هذه المدة يتم تسجيل عدد الدورات في الثانية ونحصل عل السرعة التي يتم حفظها في D2

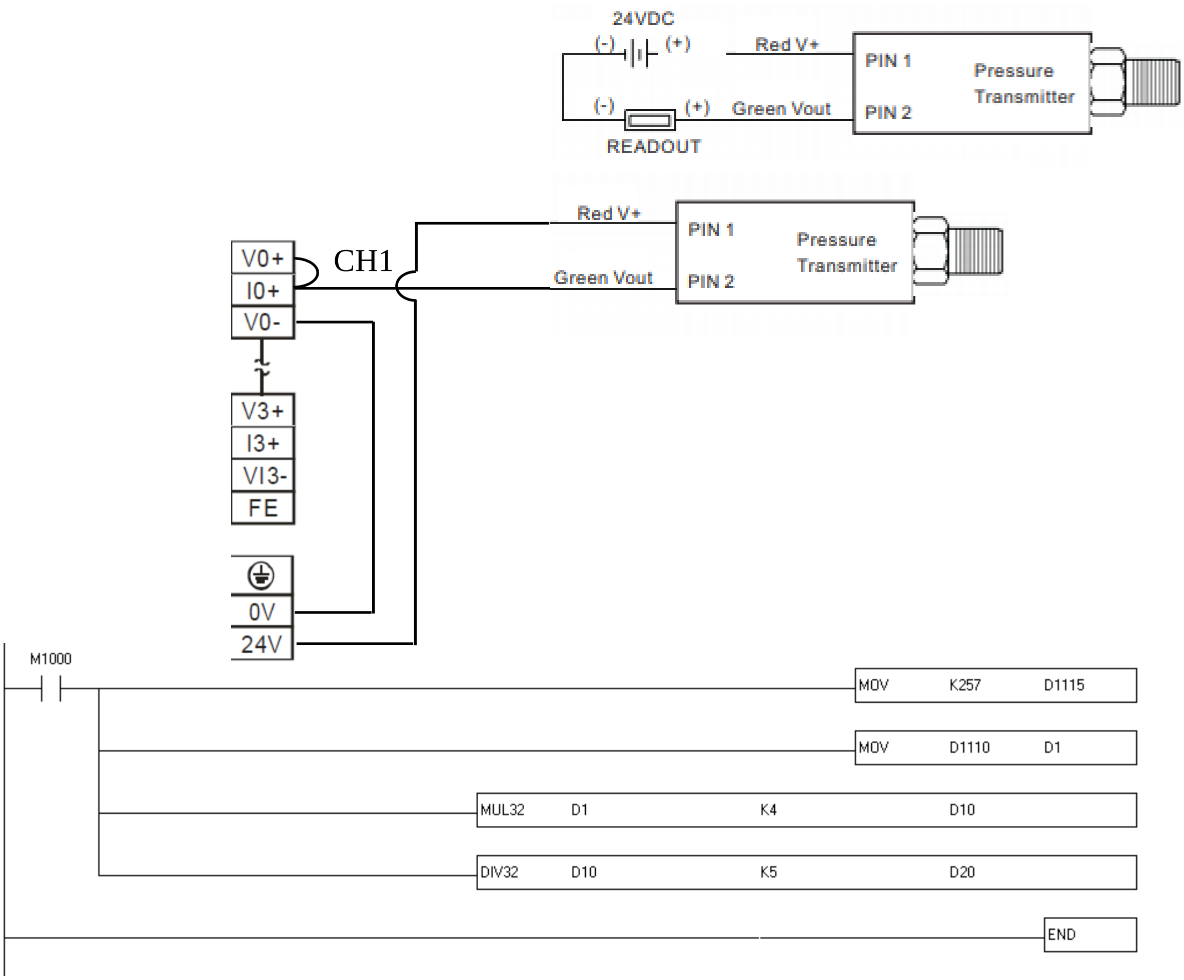
-INCP D0: When X0 is triggered, the content of D0 will be incremented by 1.
-TMR T1 K10 : M1000 is ON, T1 is activated After 1 seconds (K10 × 0.1 sec = 1 sec), NC contact T1 is ON,
-When T1 is OFF move D0 in D1
-When T1 is ON : DO is cleared, move D1 in D2 & Reset T1
-When Reset T1 then the operation is repeated.

4- تصميم برنامج لقراءة الضغط من Pressure transmitter من خلال analog input (4 - 20 mA)

مواصفات ال Pressure transmitter

COMPANY : GAMICOS
MODEL : GPT220
Range : 0-16bar
Output : 4-20 mA
Power : 12- 36V
Temperature : 220^0 C

طريقة توصيل ال Sensor مع ال PLC



M1000 : normal on

D1115 : analog input/output mode setting

Device number	Function
D1115	20EX2/SX2 analog input/output mode setting (Default=H'0) bit0~bit5: Selection between the voltage/current mode (0: Voltage; 1: Current; Default: Voltage) bit0~bit3: Analog inputs (AD0~AD3) bit4~bit5: Analog outputs (DA0~DA1) bit8~bit 13: Current mode bit8~bit11: AD0~AD3 (0: -20 mA~20 mA; 1: 4~20 mA) bit12~bit13: DA0~DA1 (0: 0~20 mA; 1: 4~20 mA)

MOV K257 D1115 :

(257 decimal = 0000 0001 0000 0001 Binary) ,

bit 0 = 1 : analog input mode of AD0 is the current mode

bit 8 =1 : current 4-20 mA.

D1110 : analog input channel 0 (AD 0)
Mov D1110 D1 : move D1110 in D1

طريقة قراءة الضغط تكون عل الشكل التالي :

ال PLC تقرأ من الحساس (0 bar = 0 in PLC , 16bar =2000 in PLC)

لتحويل قراءة ال PLC الى قراءة شبيهة بالحساس نعمل ما يلي ($\frac{4}{5} \times x$ مثلا

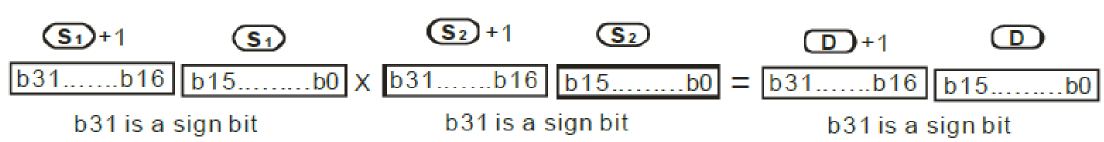
$1600 = \frac{4}{5} \times 2000$) نقرا قيمة الحساس من D1110 ونضرب 4 وتحفظ في D11 D10

ثم نقسم على 4 وتحفظ في D21 D20 على شكل شبيه بقيمة الحساس.

MUL32 D1 K4 D10:

(D2,D1) ×(4) = (D11,D10)

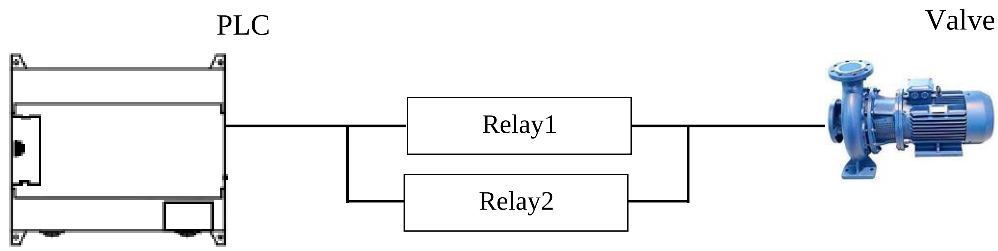
6. 32-bit binary multiplication



DIV32 D10 K5 D20 :

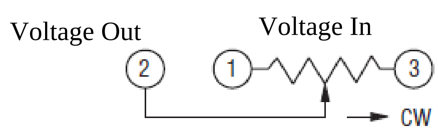
(D11,D10) / (5) = (D21,D20)

5-تصميم برنامج للتحكم ب Valve بواسطة محرك 1 ~ (single-phase motor)



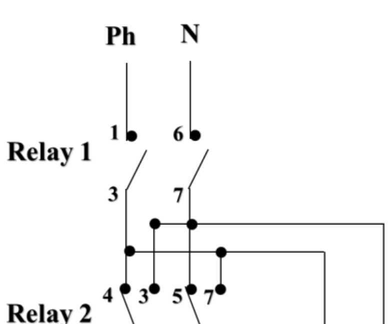
Relay 1 لتشغيل المحرك وال Relay 2 لتغير الاتجاه (عند تشغيل Relay 2 فهذا يعني أن المحرك جاهز لاغلاق ال Valve وعند توقيف Relay 2 يعني ان المحرك مستعد لفتح ال Valve) نقرأ نسبة الفتح اوالاغلاق التي نفذت من خلال وجود ال Potentiometer (نحصل عل نسبة voltage من potentiometer عل حسب نسبة فتح ال valve).

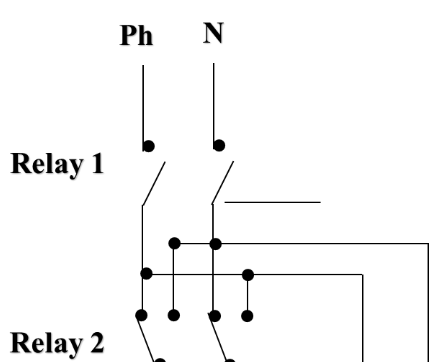
Potentiometer



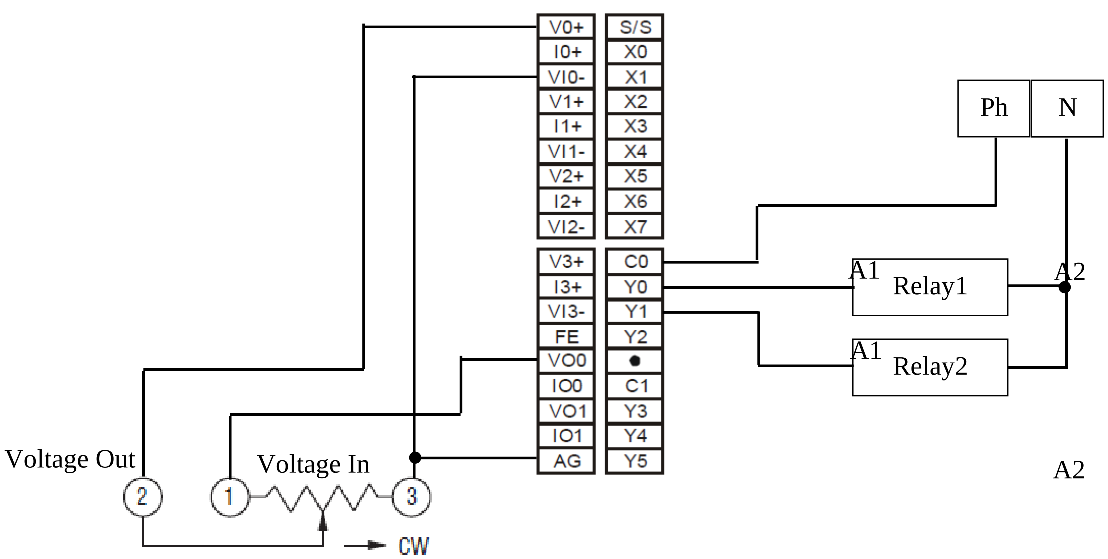
A potentiometer is a manually adjustable, variable resistor with three terminals. Two terminals are connected to a resistive element, the third terminal is connected to an adjustable wiper. The position of the wiper determines the output voltage.

طريقة توصيل المحرك مع Relay من اجل تغير الاتجاه





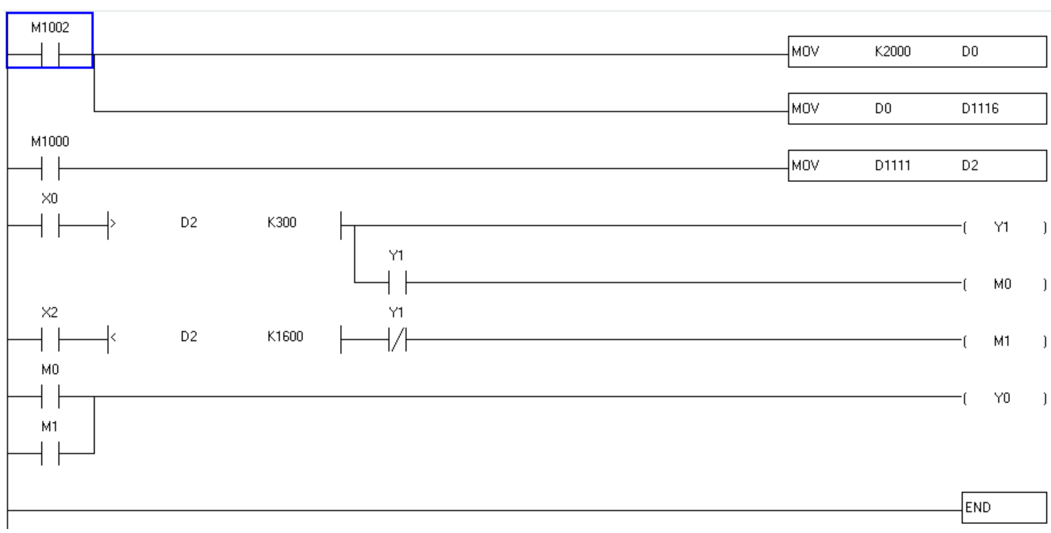
طريقة توصيل ال Relay و ال potentiometer مع ال PLC



Potentiometer

طريقة عمل البرنامج : نغزي ال potentiometer ب10V من خلال DA0 (VO0) ونقرأ من ال potentiometer نسبة فتح ال valve من خلال AD1 (V1+) (حسب تصميم مشروعنا عندما يكون ال valve مغلق يعطينا ال potentiometer 1V وعند الاغلاق بشكل كامل يعطينا 8.5V)

يمكن فتح ال valve بواسطة Y0 بشرط ان يكون ال potentiometer اقل من 8V مع تشغيل X2 ويمكن اغلاق ال Valve بواسطة Y0 و Y1 بشرط أن يكون ال Potentiometer اكثر من 1V مع تشغيل X0.

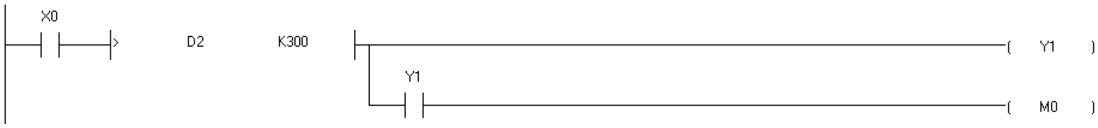


MOV K2000 D0

MOV D0 D1116 — Move 10V in DA0 (VO_0) for potentiometer

MOV D1111 D2 — D1111: AD1 read voltage from potentiometer, Move AD1 in D2

> D2 K300 : if D2 > K300 (Voltage from potentiometer>1.5 V)



If x0=ON & Voltage from potentiometer>1.5 V , Y1=ON

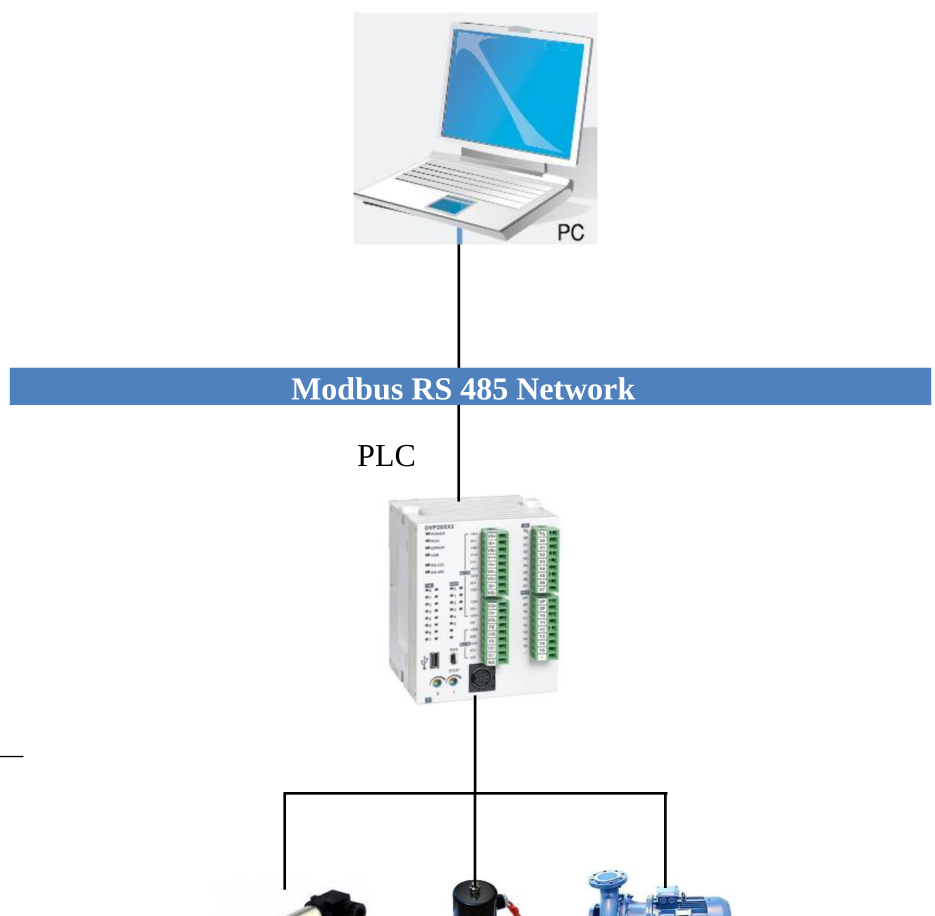
If x0=ON & Voltage from potentiometer>1.5 V &Y1=ON, M0=ON (Y0=M0=ON)

if D2 < K1600 (Voltage from potentiometer<8 V)

If x2=ON & Voltage from potentiometer < 8 V &Y1=OFF, M1=ON (Y0=M1=ON **)**

6- تصميم برنامج للمراقبة والتحكم بال "Boiler pressure control" من خلال الحاسوب عن طريق ال modbus. (باستعمال برنامج Vijeo Designer على الحاسوب)

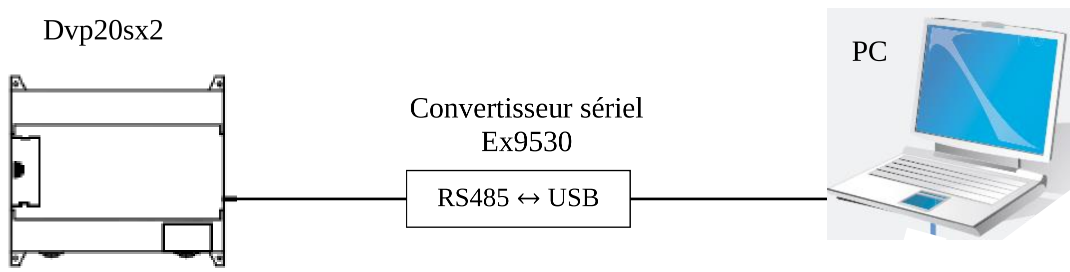
Boiler pressure control system



طريقة عمل البرنامج

يكون التحكم في ال valves اما بشكل اوتوماتيكي بواسطة ال PLC (عندما يرتفع الضغط الى 15 bar يفتح Condenser valve وعندما ينخفض الضغط الى 14.1 bar يغلق valve . اما عندما يصل الضغط الى 15.5 bar فيفتح atmospheric valve وعندما ينخفض الضغط الى 14.1 bar فيغلق ال Valve .

Communication between Vijeo software and the PLC



لربط ال PLC مع برنامج ال Vijeo نحتاج لوصلة Ex9530 مع التعريف

2-configure the communication settings

The communication parameters are given in the following table:

26.1 Item	26.2 Specification
26.3 Protocol	26.4 **Modbus (RTU)**
26.5 Port	26.6 **COM2**
26.7 Slave address	26.8 **2**
26.9 Baud Rate	26.10 **9600**
26.11 Data bits	26.12 **8**
26.13 Parity	26.14 **None**
26.15 Stop bit	26.16 **1**

Application development

In this application, the Vijeo software ：

Read the status of atmospheric valve

Read the status of condenser valve

Manual Control of atmospheric valve

Manual Control of condenser valve

Monitoring the pressure

Write in the PLC default pressure for test

The Application Settings are given in the following table:

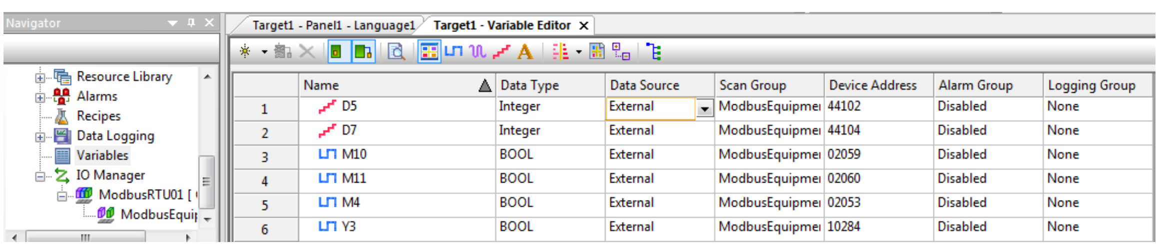
parameter

26.17 Device in PLC	**26.18** The address in decimal	**26.19** Fonction	**26.20** Action
26.21 M4	**26.22 02053**	**26.23 Read**	**26.24 Status of atmospheric valve**
26.25 M10	**26.26 02059**	**26.27 write**	Control of atmospheric valve
26.28 M11	**26.29 2060**	**26.30 write**	**26.31 Control of condenser valve**
26.32 Y3	**26.33 01284**	**26.34 Read**	**26.35 Status of condenser valve**
26.36 D5	**26.37 44102**	**26.38 Read**	Monitoring the pressure **26.39**
26.40 D7	**26.41 44104**	**26.42 write**	Write the default pressure for test **26.43**

In the Vijeo software we did:

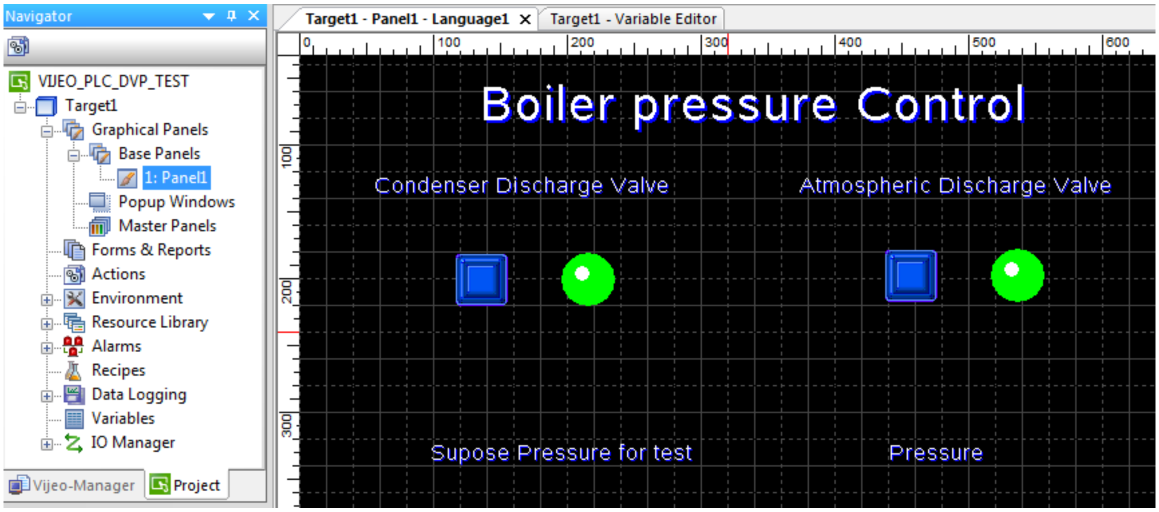
1) Creation of a new project and one chooses Modbus RTU Protocol

2) Creating variables

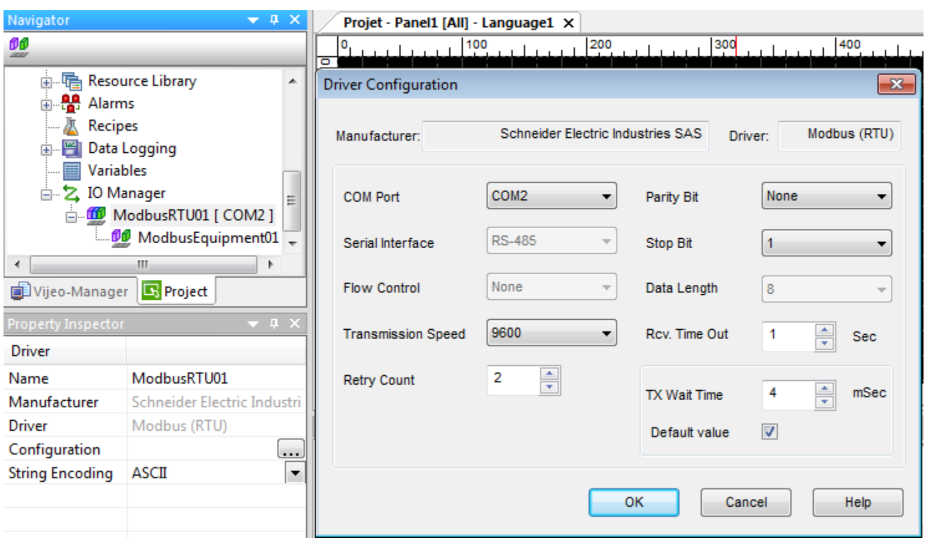


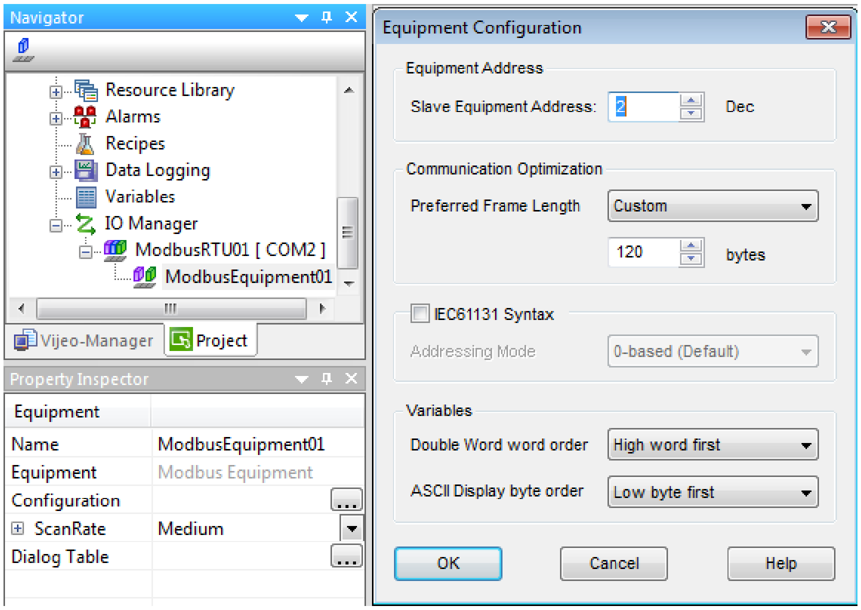
	Name	Data Type	Data Source	Scan Group	Device Address	Alarm Group	Logging Group
1	D5	Integer	External	ModbusEquipmei	44102	Disabled	None
2	D7	Integer	External	ModbusEquipmei	44104	Disabled	None
3	M10	BOOL	External	ModbusEquipmei	02059	Disabled	None
4	M11	BOOL	External	ModbusEquipmei	02060	Disabled	None
5	M4	BOOL	External	ModbusEquipmei	02053	Disabled	None
6	Y3	BOOL	External	ModbusEquipmei	10284	Disabled	None

3) Creation of the supervision page.

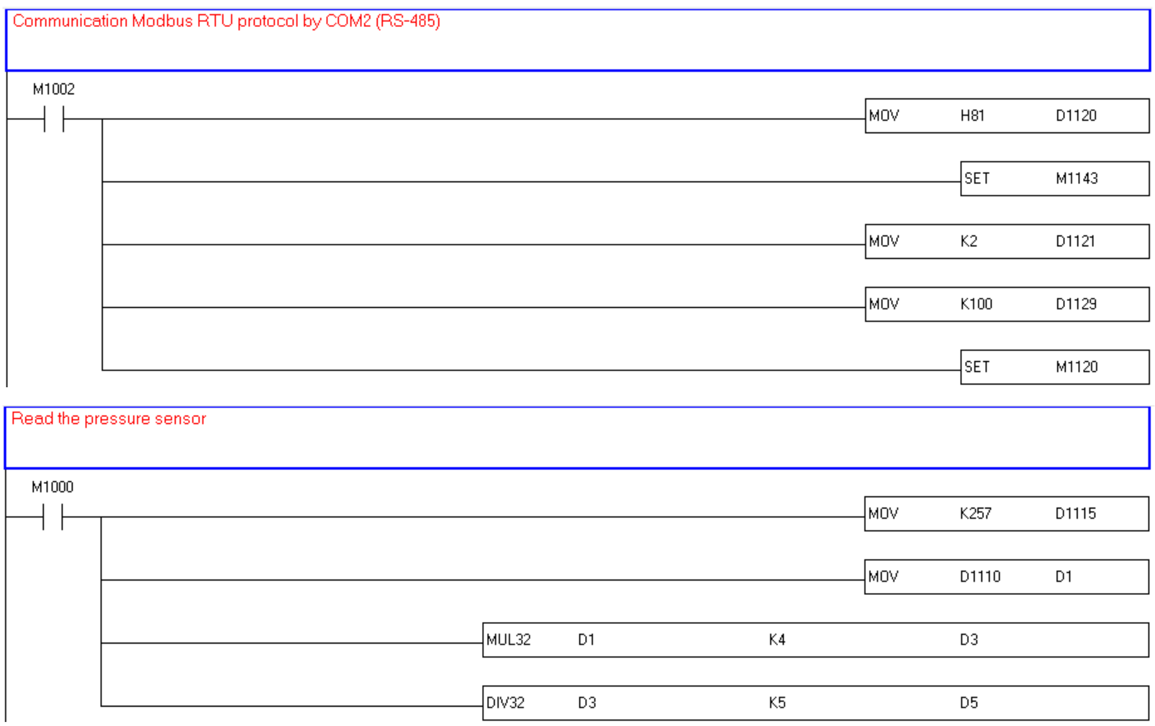


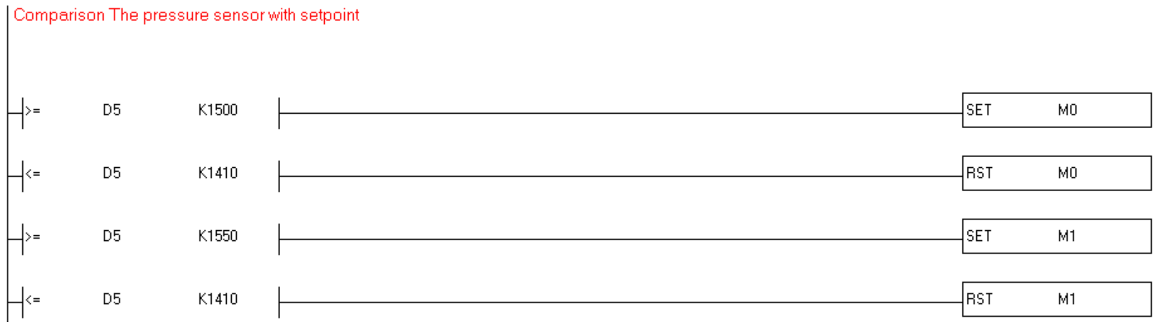
4) Definition of the communication parameters in the "Driver configuration" and "Equipment Configuration" windows ((the communication parameters in the "**IO Manager**" node from the "**Navigator**" window).





In the WPL soft we did:

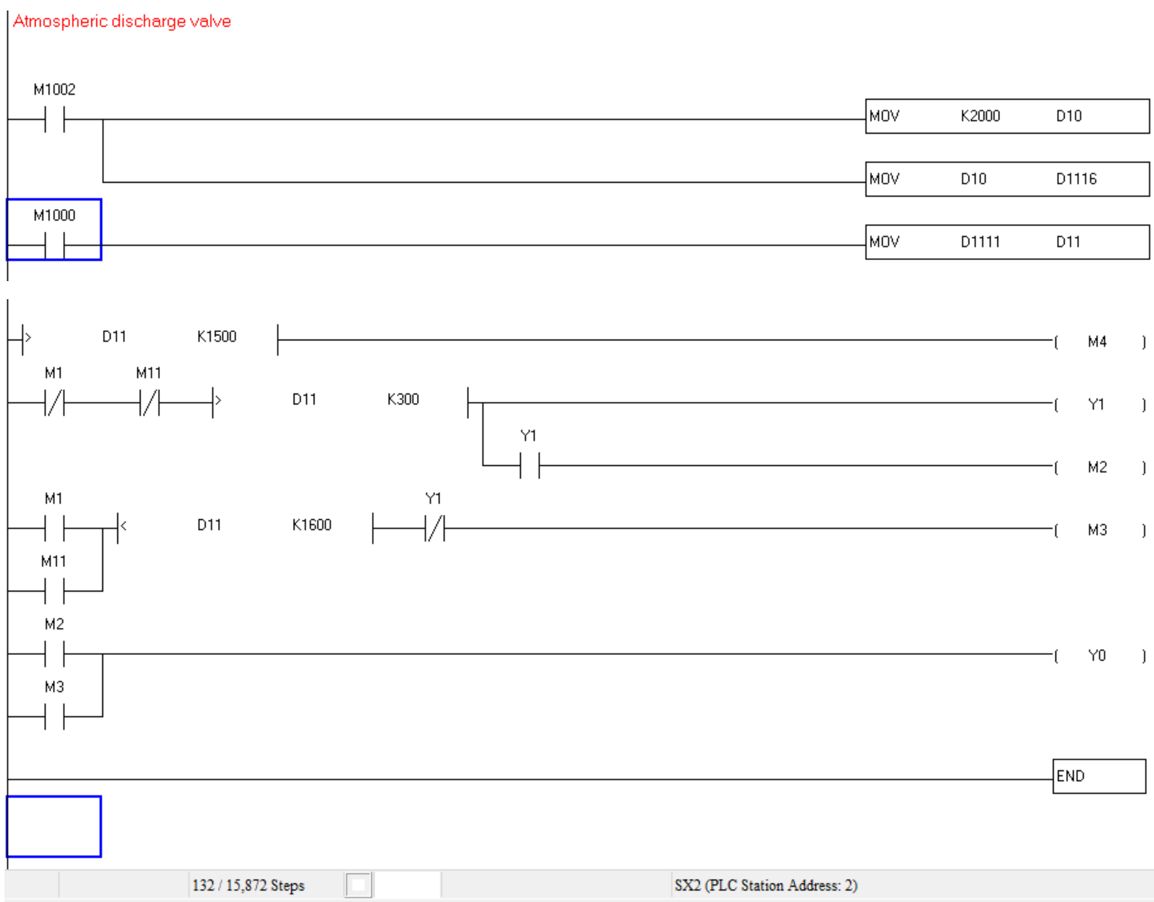




If the pressure >= 15 bar, M0 ON & if the pressure <=14.1 bar, M0 OFF

If the pressure >= 15,5 bar, M1 ON & if the pressure <=14.1 bar, M1 OFF

If M0 ON or M10 ON from User interface, Solenoid valve Open by Y3

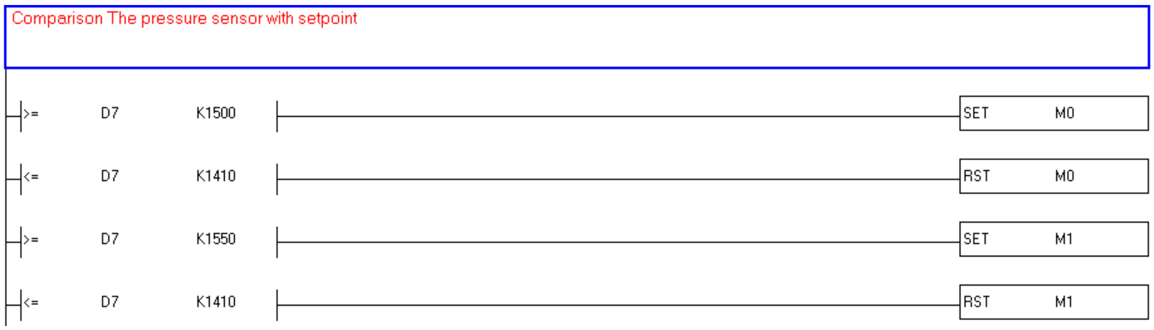


If D11> 1500 (the PLC Read from potentiometer > 7.5V), M4 ON (status of valve is open).

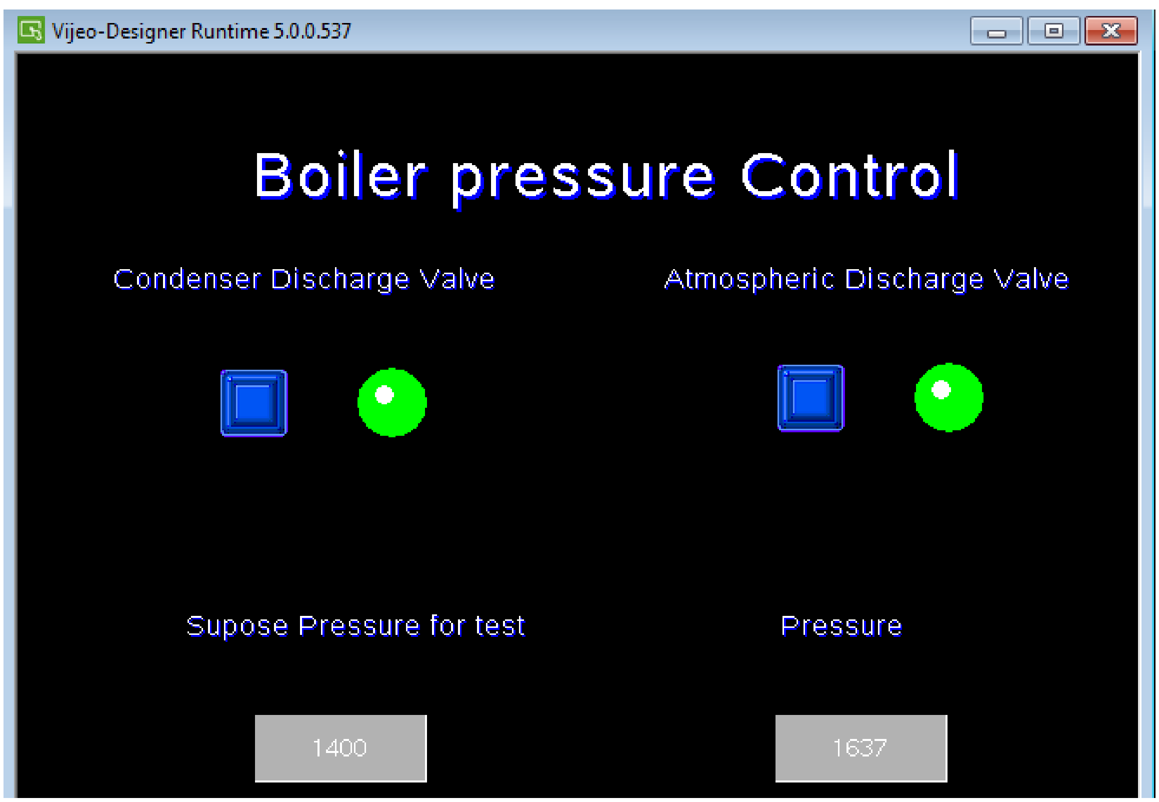
If M1 ON (the pressure >= 15.5 bar) or M11 ON from User interface & D11<1600 (if the valve is incomplete opening) & Y1 OFF, M3 ON (the valve is open by Y0)

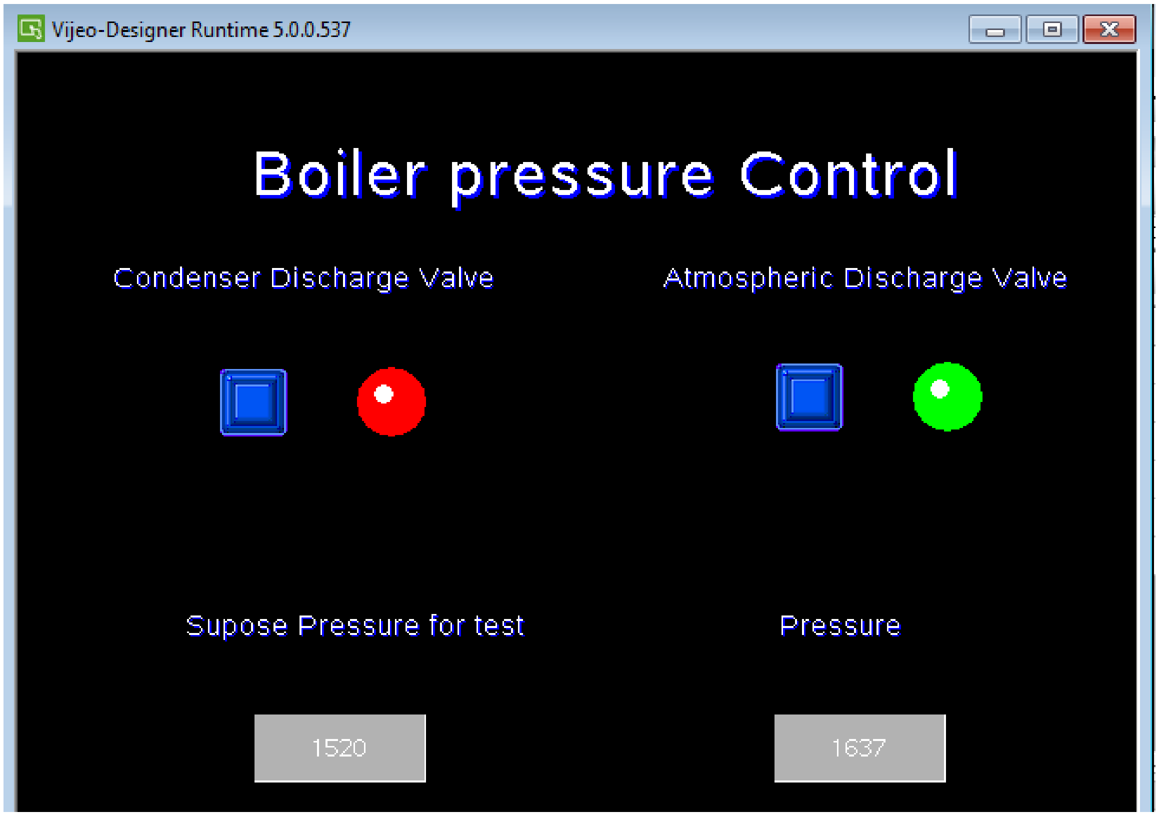
If M1 OFF (the pressure <=14.1 bar) & M11 OFF from User interface & D11>300 (if the valve is incomplete closure) , Y1 ON & M2 ON (the valve is close by Y0 & Y1)

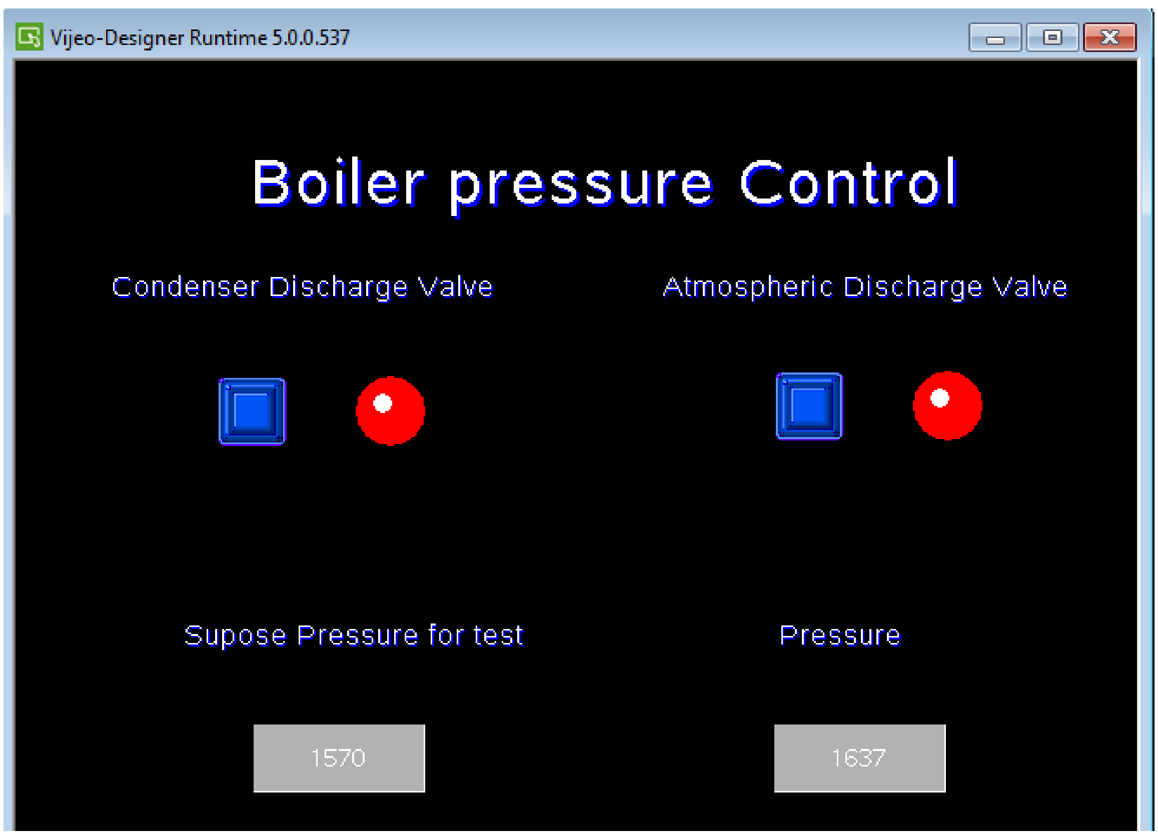
Note : For test We replaced D5 (real pressure) by D7 (default Pressure from user)



Simulation




Vijeo-Designer Runtime 5.0.0.537
Boiler pressure Control
Condenser Discharge Valve
Atmospheric Discharge Valve
Supose Pressure for test
Pressure
1520
1637


Vijeo-Designer Runtime 5.0.0.537
Boiler pressure Control
Condenser Discharge Valve
Atmospheric Discharge Valve
Supose Pressure for test
Pressure
1570
1637

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نظام التحكم

-

Process Control System (PCS) for NLAP incineration plant

Platform System

Graphical User Interface (GUI)

Report 2019

Authors:

Mourad

27 Contents

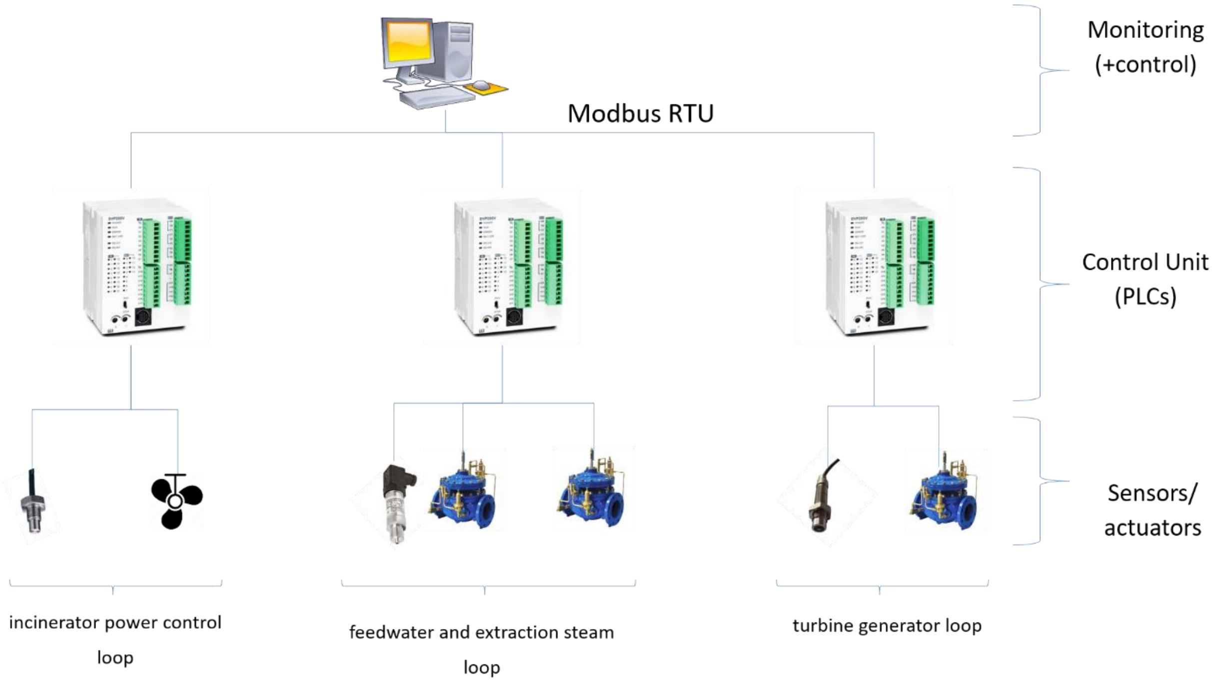
28 Introduction

The graphical user interface (GUI) is used to monitor and control the power plant.

It is developed in C# using visual studio 2017.

The main task of the GUI is to initiate and monitor the plants, intervening from time to time. The main control has the control unit with their PLCs.

The PC running the GUI is connected with the Control Unit via Modbus RTU (see figure below) using a USB to Serial adapter (see figure below). To establish a working connection drivers are necessary. For driver installation instructions and more informations see Modbus-connection in the Appendix.

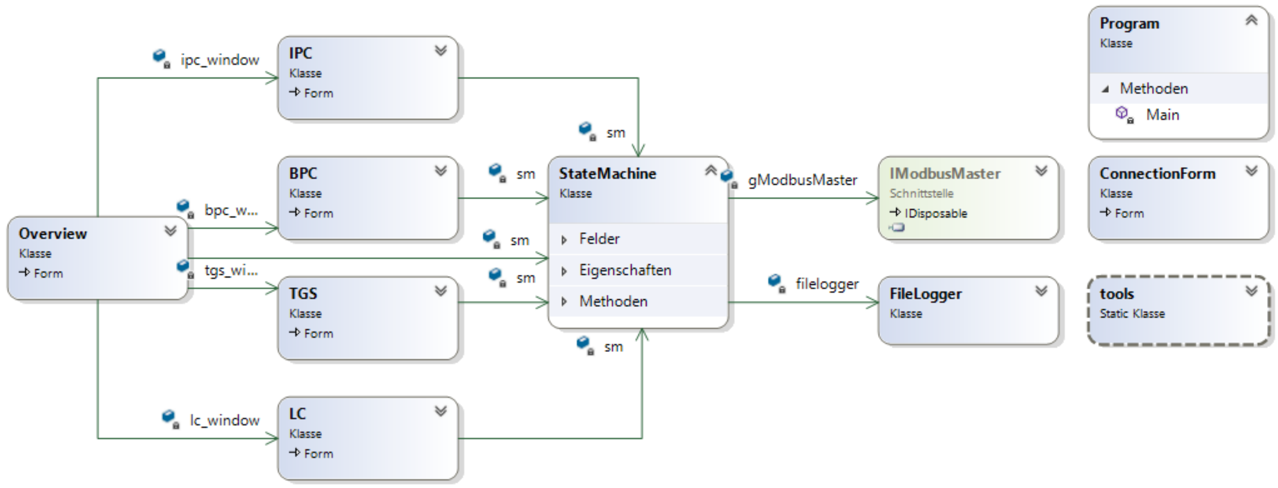


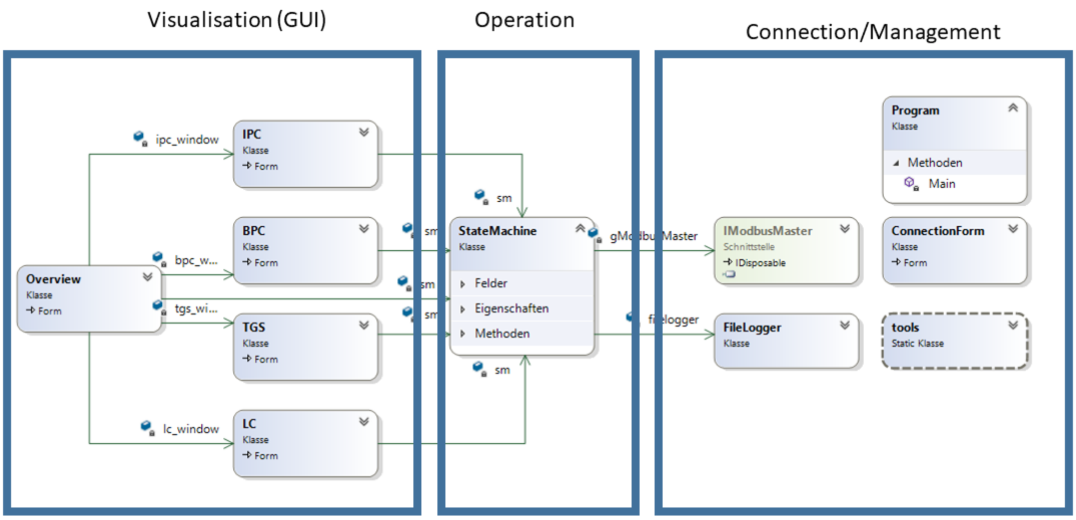
Most of the power plant is directly connected to the Control Unit and thus visible in the GUI and possibly also controllable. But a few things are not. Below the camera, which monitors the combustion chamber. More in the chapter camera.

In this document we will see how the GUI-Software is structured, what it can do, and how it's started and used. In addition, the source code is included in the appendix, as well as other instructions that are helpful in the further development.

29 Software Structure

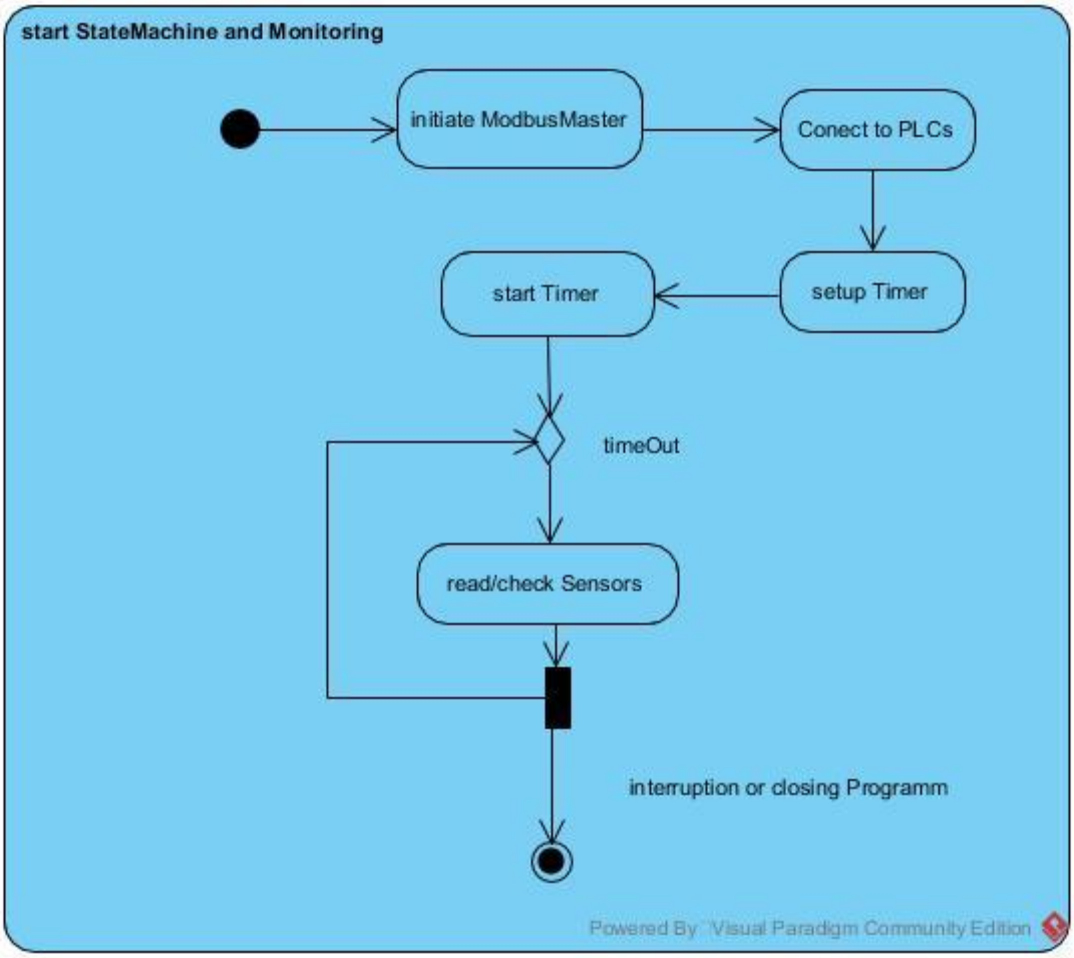
29.1 Class diagram



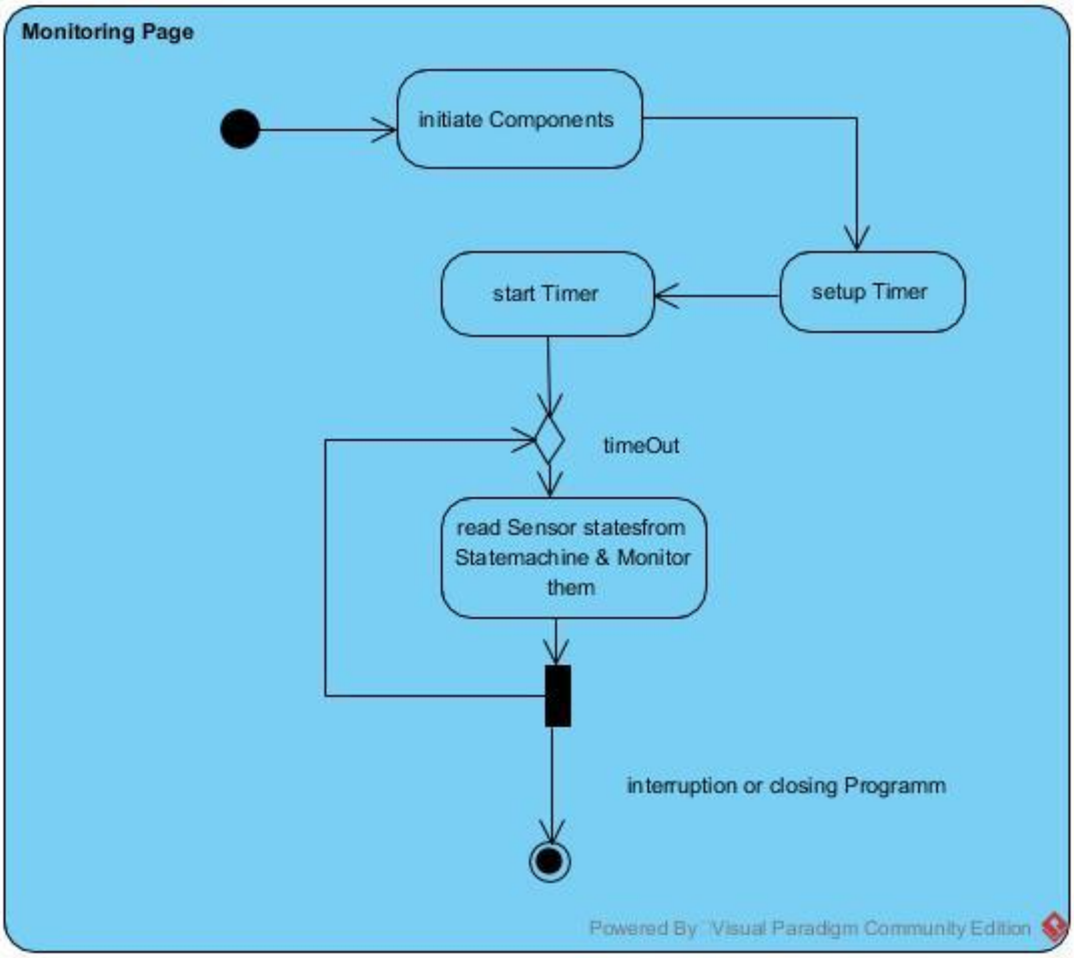


29.2 Activity diagrams

The following diagram shows a simplified view of how the statemachine works

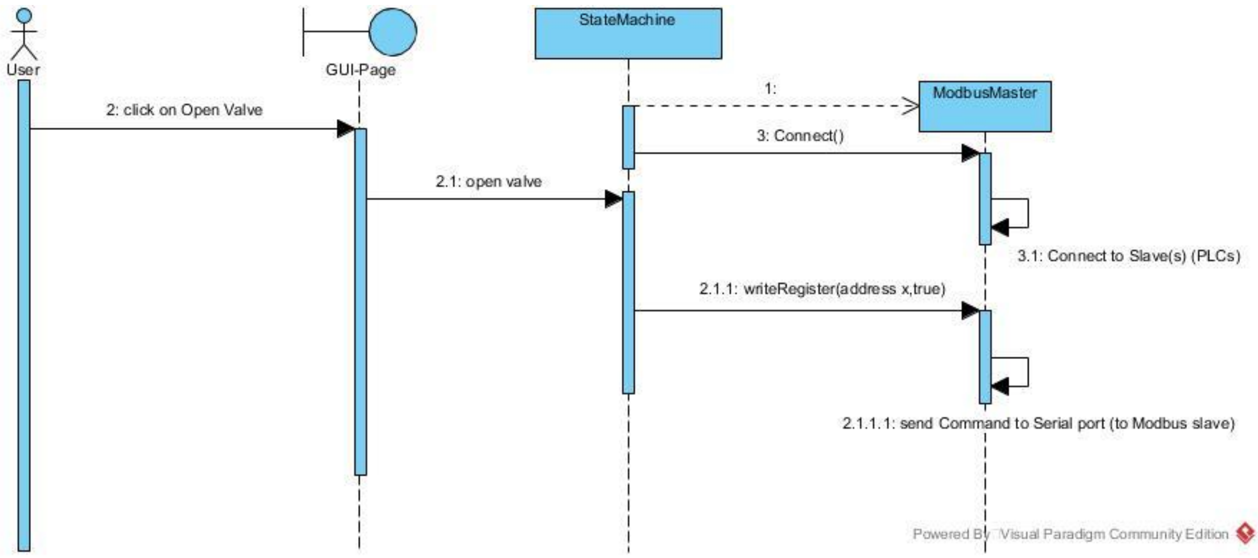


The following diagram shows how an GUI page works



29.3 Sequence diagrams

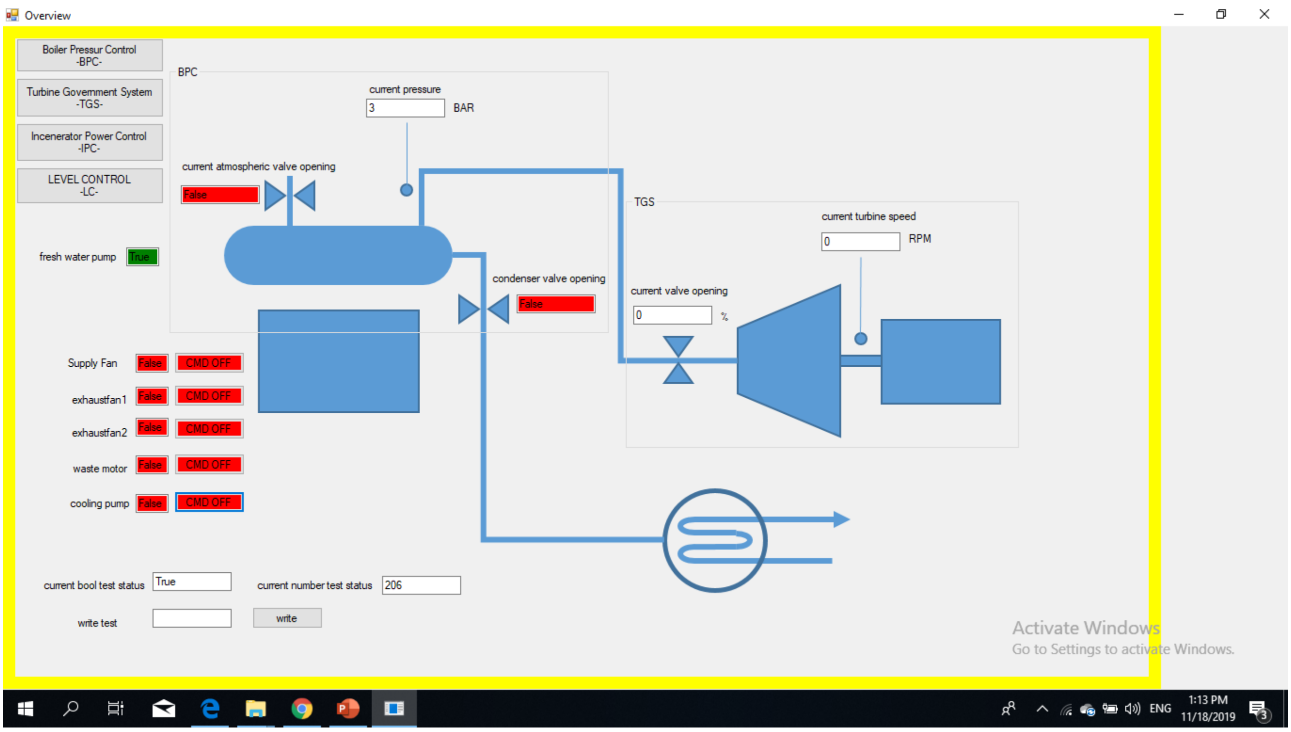
The following diagram shows an controlling interaction example (names may differ from code):



30 Pages

30.1 Overview

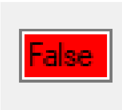
In the overview the most values/states of sensors and actuators are monitored. The control of some actuators is also possible (supplyfan, exhaustfans, waste motor, cooling pump, fresh water pump).



Color indication for states (Text fields):

For supplyfan, exhaustfans, waste motor, cooling pump, fresh water pump:

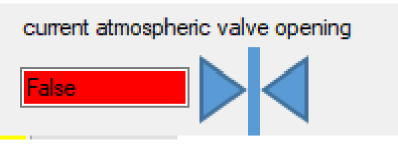
-Red→False/OFF

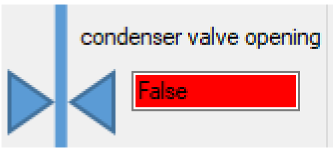


-Green→True/ON

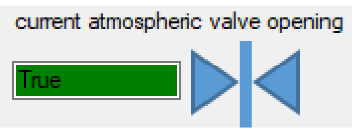
For atmospheric and condenser valves:

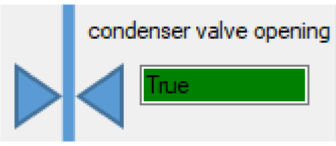
-Red→False/CLOSED





-Green→ True/OPEN





Color indication for control commands (Buttons):

For supplyfan, exhaustfans, waste motor, cooling pump, fresh water pump:

-Red→False/OFF Command is send (the state field should also be red (OFF))

-Green→True/ON Command is send (the state field should also be green (ON))

IMPORTANT NOTE:

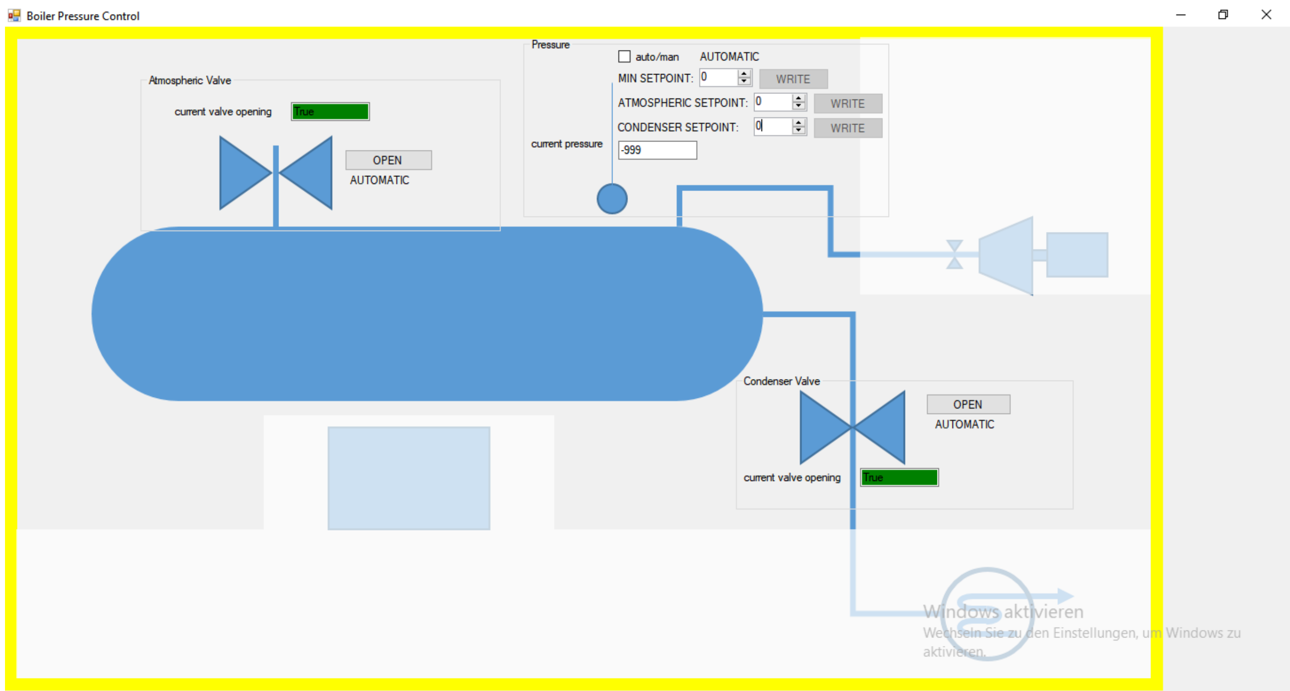
- If the buttons have a different color than the statefields, that means something is wrong with the sensor or the actuator.
- If the buttons don’t change the color by clicking, that means something is wrong with the connection.

From the overview you can reach the other pages by clicking on the respective buttons (left upper side).

30.2 Other pages

30.2.1 Boiler pressure Control (BPC)

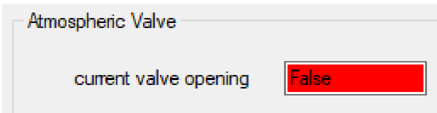
On this page its possible to view states of and control the atmospheric valve, condenser valve, and pressure. It is also possible to set different pressure setpoints (which affects the automatic opening and closing of the valves).

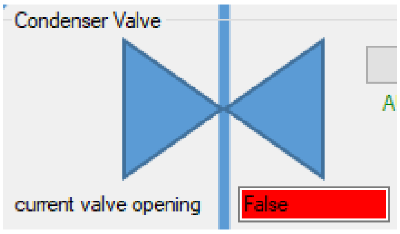


30.2.1.1 Valves

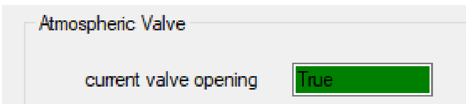
<u>Color indication for states (Text fields):</u>

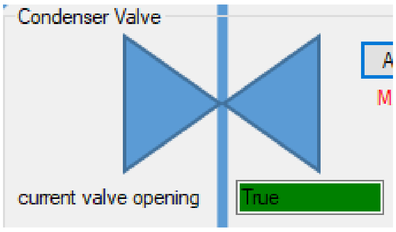
For atmospheric and condenser valves:





-Red→False/CLOSED



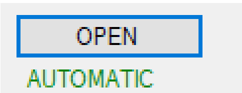


-Green→ True/OPEN

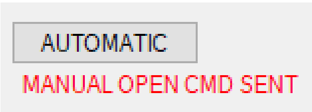
<u>Control indications (Buttons):</u>

By clicking the Buttons its possible to open the valves manually.

There can be 2 situations:

- 

Thant means the valve is in AUTOMATIC mode. Clicking the button will open the valve manually and turn into MANUAL mode.

- 

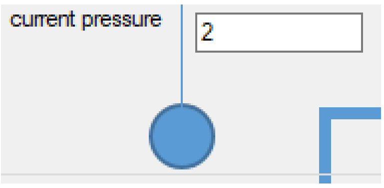
Thant means the valve is in MANUAL mode (and OPEN). The valve will never close until returning into AUTOMATIC mode. Clicking the button will return into AUTOMATIC mode.

IMPORTANT NOTE:

- If the label under the button indicates the MANUAL (OPEN) mode and the valve state (textbox) is not green (TRUE/OPEN), that means something is wrong with the sensor or the actuator.
- If the buttons and the labels among them don't change by clicking, that means something is wrong with the connection.

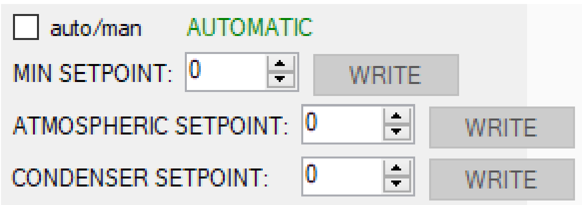
30.2.1.2 Pressure

The current pressure is monitored in bar:

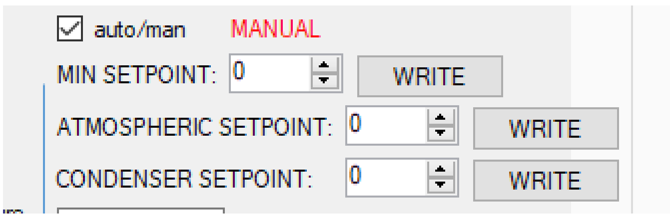


Considering the setpoints there are 2 modes:

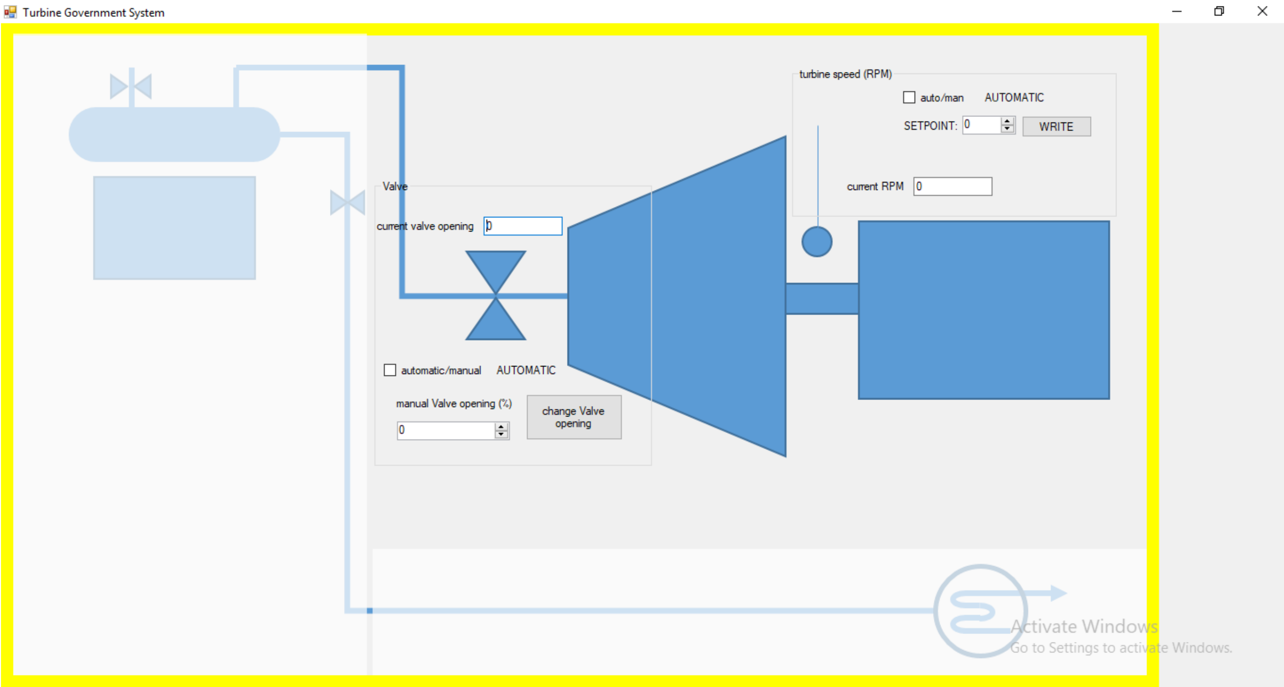
- AUTOMATIC: the auto/man checkbox is not checked and label indicates *AUTOMATIC*. In this mode its not possible to set any setpoint manually. The valves (if they are in automatic-mode) will be controlled depending on the default pressure-setpoints saved in the PLC. For more details, see the PLC documentation.



- MANUAL: the auto/man checkbox is checked and label indicates *MANUAL*. In this mode its possible to set the setpoints manually. By writing a setpoint, the valves (if they are in automatic-mode) will be controlled depending on the written setpoints. For more details, see the PLC documentation.

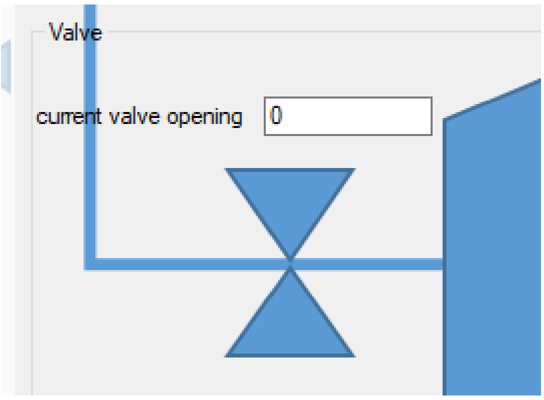


30.2.2 Turbine govering system (TGS)



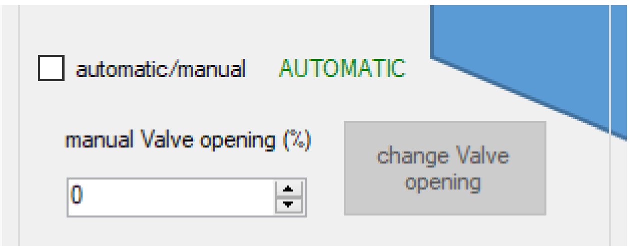
30.2.2.1 Valve

The current valve opening is monitored in %:

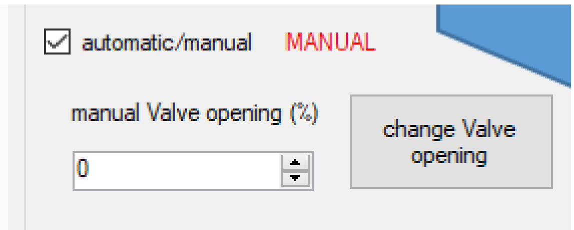


For the valve control there are 2 modes:

- AUTOMATIC: the auto/man checkbox is not checked and the label indicates *AUTOMATIC*. In this mode its not possible to set the valve opening manually. The valve will be controlled automaticly depending on the turbine-speed-setpoint saved in the PLC (the setpoint can be either the default value or a manually written value. See 3.2.2.2-Turbine speed). For more details, see the PLC documentation.

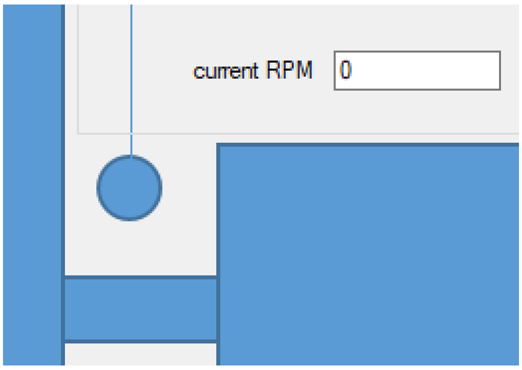


- MANUAL: the auto/man checkbox is checked and the label indicates *MANUAL*. In this mode its possible to controle the valve manually by writing an opening % to the PLC. For more details, see the PLC documentation.



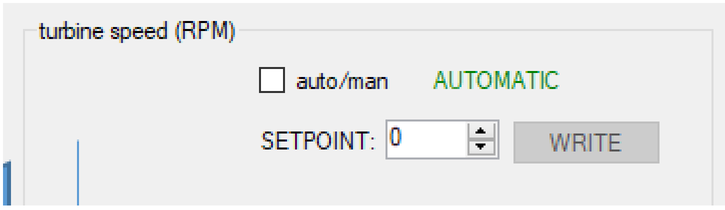
30.2.2.2 Turbine speed

The current turbine speed is monitored in rpm:

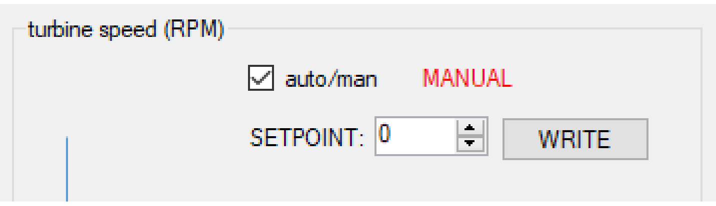


Considering the setpoint there are 2 modes:

- AUTOMATIC: the auto/man checkbox is not checked and the label indicates *AUTOMATIC*. In this mode its not possible to set the setpoint manually. The valve (if in automatic-mode) will be controlled depending on the default turbine-speed-setpoint saved in the PLC. For more details, see the PLC documentation.



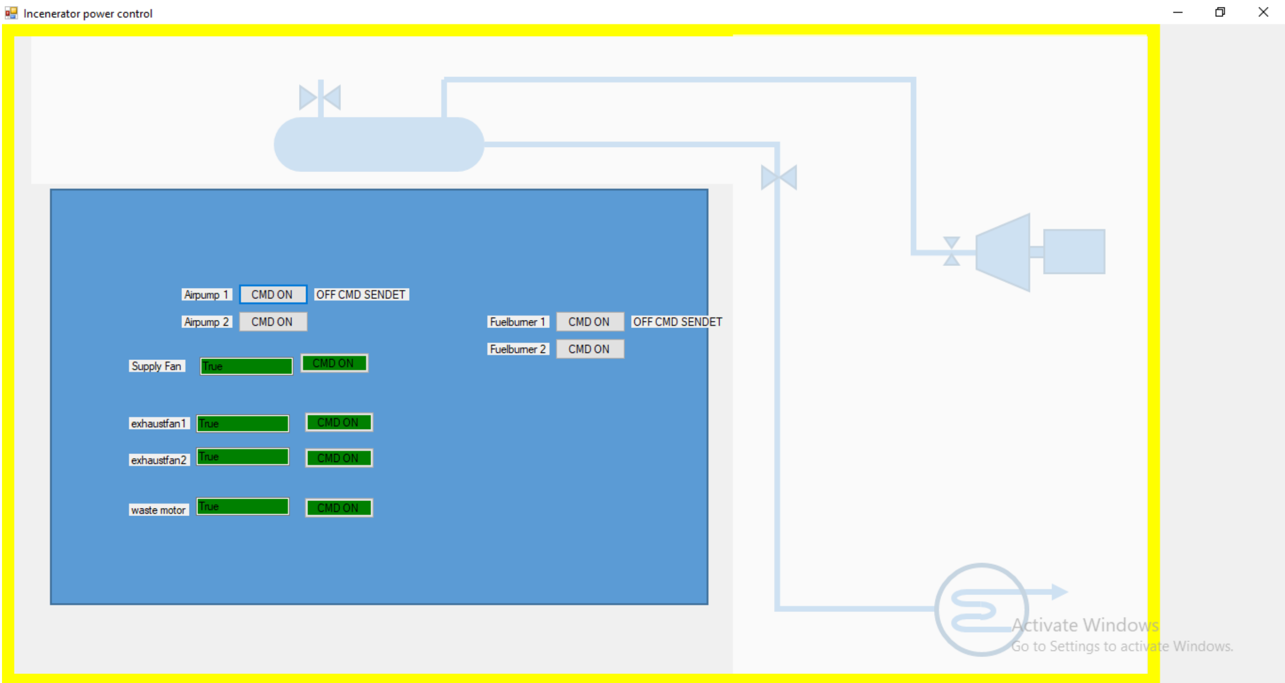
- MANUAL: the auto/man checkbox is checked and the label indicates *MANUAL*. In this mode its possible to set the setpoint manually. By writing a setpoint, the valve (if in automatic-mode) will be controlled depending on the written setpoint. For more details, see the PLC documentation.



30.2.3 Incenerator power control (IPC)

On this page its possible to view the state of and control:

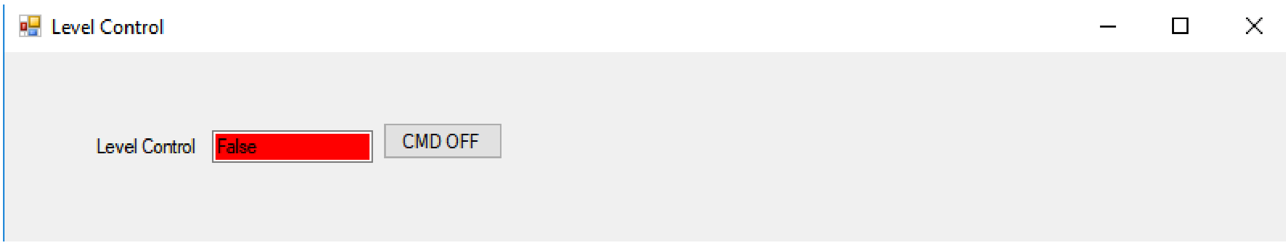
Supplyfan, exhaust fans, waste motor.



All works like in the overview. For more indications how to control or what the color indicate, see overview.

30.2.4 Level control (LC)

On this page its possible to view the state of and control the level control.



All works like in the ipc. For more indications how to control or what the color indicate, see IPC.

When LC is on, that means that the fresh water pump is controlled by the level control sensors in the boiler.

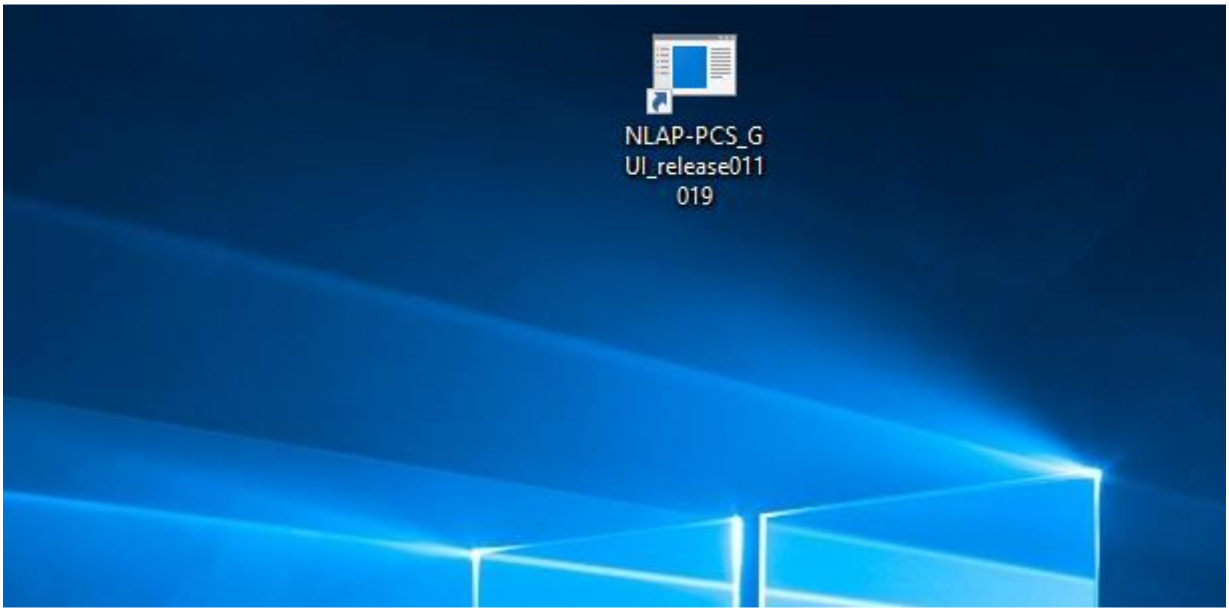
30.3 Settings window

This window appears after starting the GUI-programm. Here some settings can be set.

Until the current version there is no settings.

31 Use Instructions

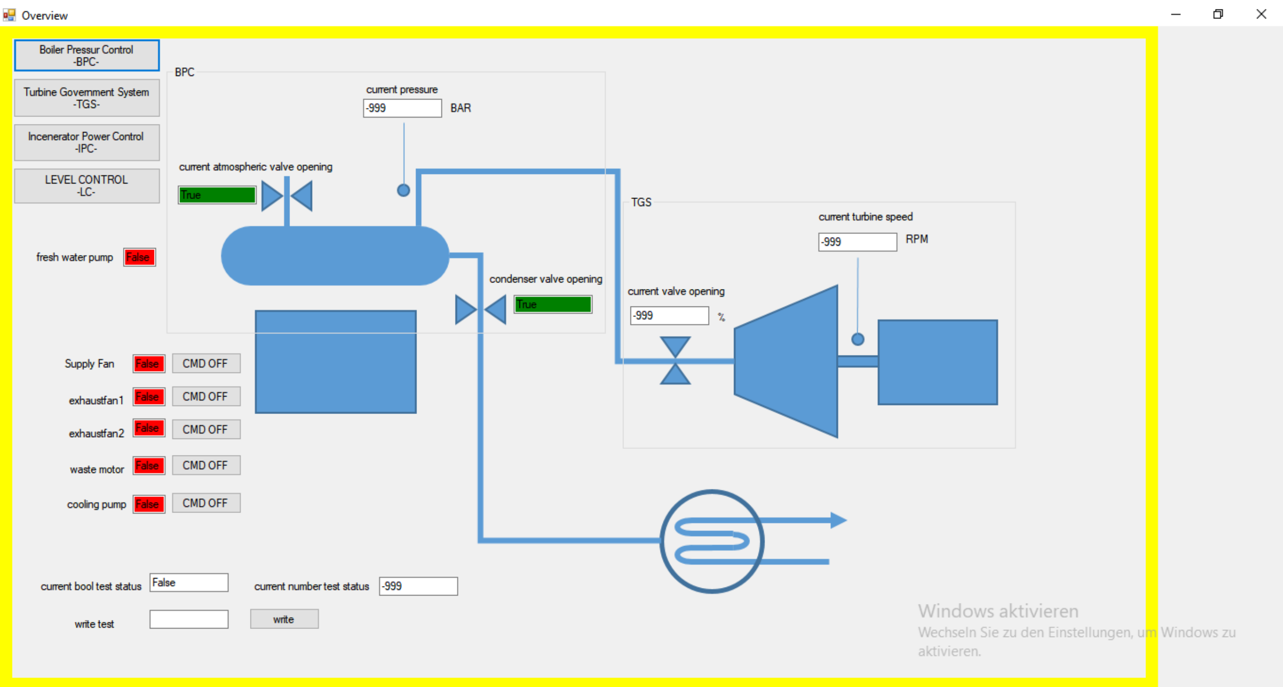
To start the GUI double click on the binary executable 'ContSys.exe' in the release folder named 'release', or 'current release', or '<date>release', or 'release<date>'. Anyway there must be a shortcut of the executable on the desktop (on the operation laptop).



Once runned, the he settings window must appear.

For informations how to set settings and what they mean see Settings window.

After closing this window, you must be directed to the overview window.



From there, to operate see Overview in Pages.

32 Logger

The logger records the read values of sensors and states. It writes them in a text file named *CS_log.txt* (may change) located in *C:/ControlSystemData* (may change). The file and directory are created automatically in case they do not exist.

Recording periode: always when the values are read. (may change, see source code)

Current Version saves file at plain-text-file, so for further processing and analysis or visualization, the file content should be taked manually from the text-file.

Time format: DD.MM.YYYY HH:MM:SS.mS

Line format (maybe needed for parsing): time<tab><variable-name>:<tab><value><tab><next-variable-name>………

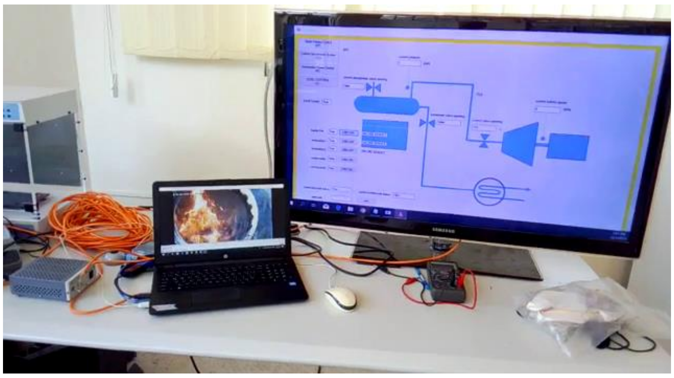
Recording example: (in real one record is listed in one single line)

```
25.9.2019 14:50:59.622
bpc_Current_pressure: 1
bpc_Current_atmospheric_valve_opening:     False
bpc_Current_condenser_valve_opening:       False
tgs_Current_turbine_speed:    60
tgs_Current_valve_opening:    65522
Current_exhaustfan1_status:   False
Current_exhaustfan2_status:   False
ipc_Current_wastemotor_status:        False
ipc_Current_supplyfan_status: False
Current_coolingpump_status:   False
lc_Current_levelControl_status:       False
```

For more details, look in the source-code in the Appendix.

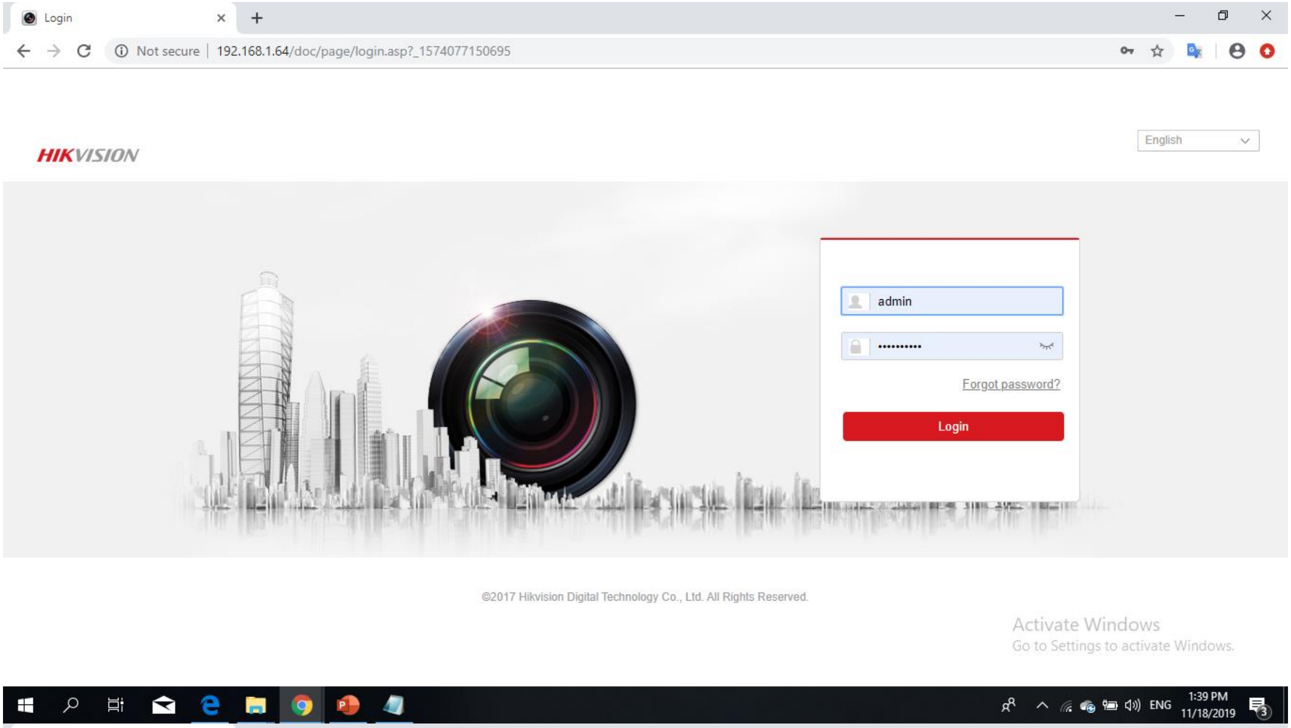
33 Camera

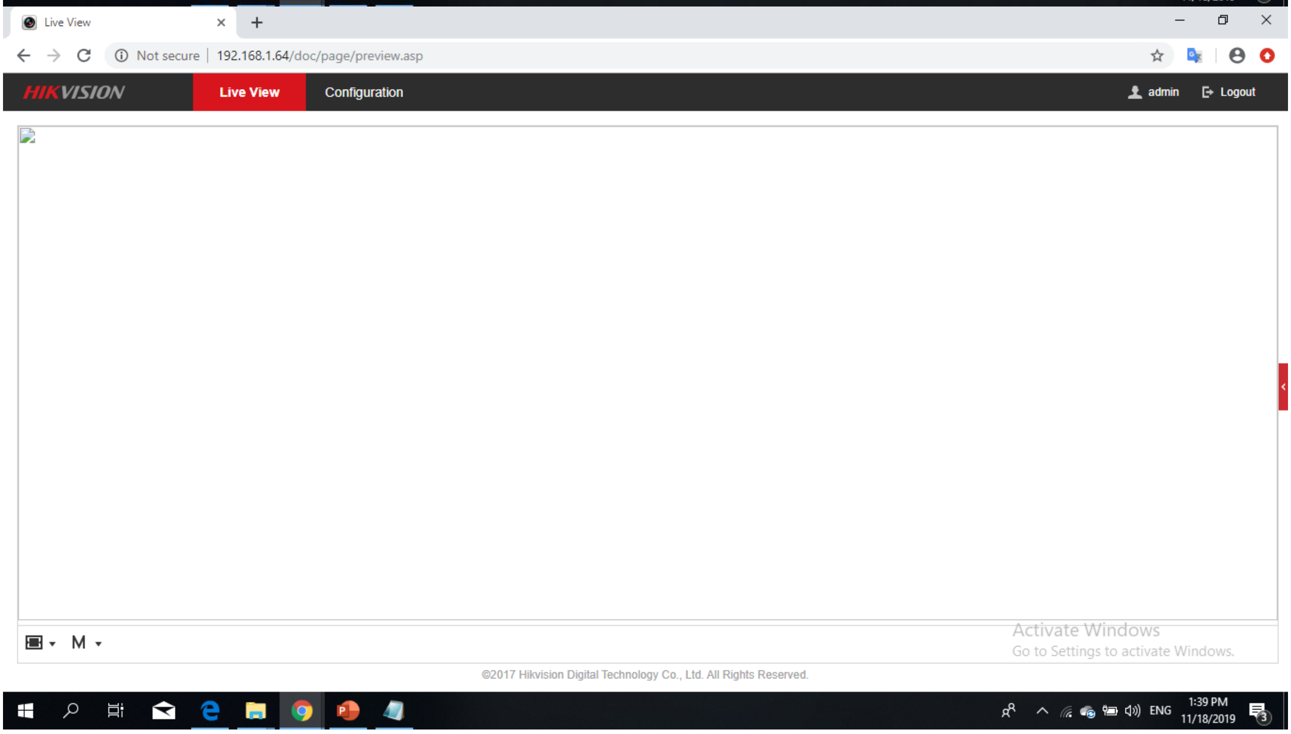
To keep the inside of the incinerator in look, an IP camera is put in front from the outside.

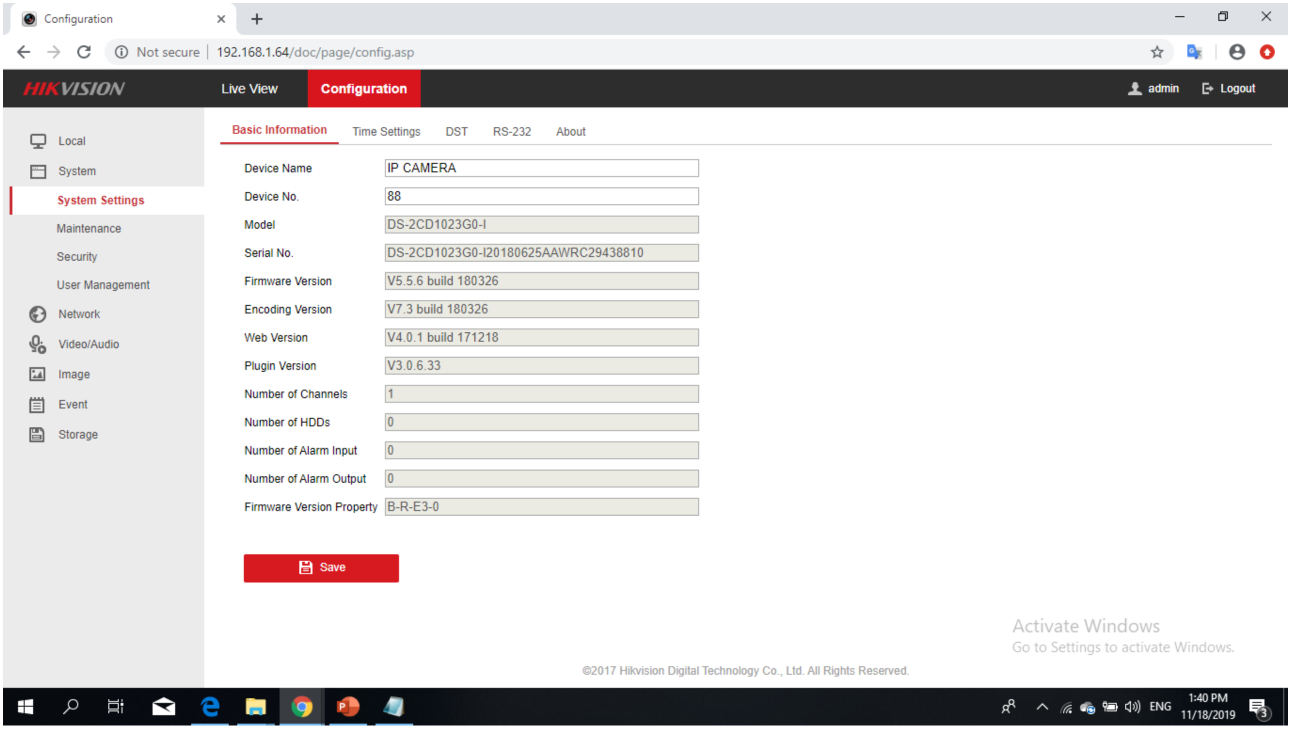


The camera is not integrated in the gui-programm. The camera is independently accessed per the local network.

For configurations enter the camera-ip address in the browser (ip: 192.168.1.64 username: admin pass: admin12345). There you can also view the stream.


Login
Not secure | 192.168.1.64/doc/page/login.asp?_1574077150695
HIKVISION
English
admin
Forgot password?
Login
©2017 Hikvision Digital Technology Co., Ltd. All Rights Reserved.
Activate Windows
Go to Settings to activate Windows.
ENG
1:39 PM
11/18/2019


Live View
Not secure | 192.168.1.64/doc/page/preview.asp
HIKVISION
Live View
Configuration
admin
Logout
Activate Windows
Go to Settings to activate Windows.
©2017 Hikvision Digital Technology Co., Ltd. All Rights Reserved.
ENG
1:39 PM
11/18/2019



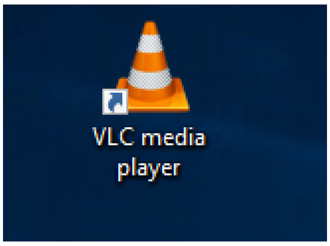
Another and better way to stream is through the direct streaming address using a streaming software like VLC.

There are 2 ways:

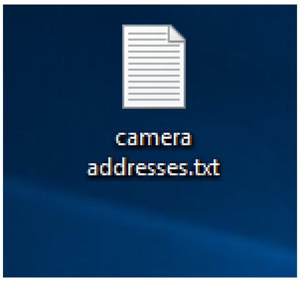
1- manually enter the address in VLC:

Steps:

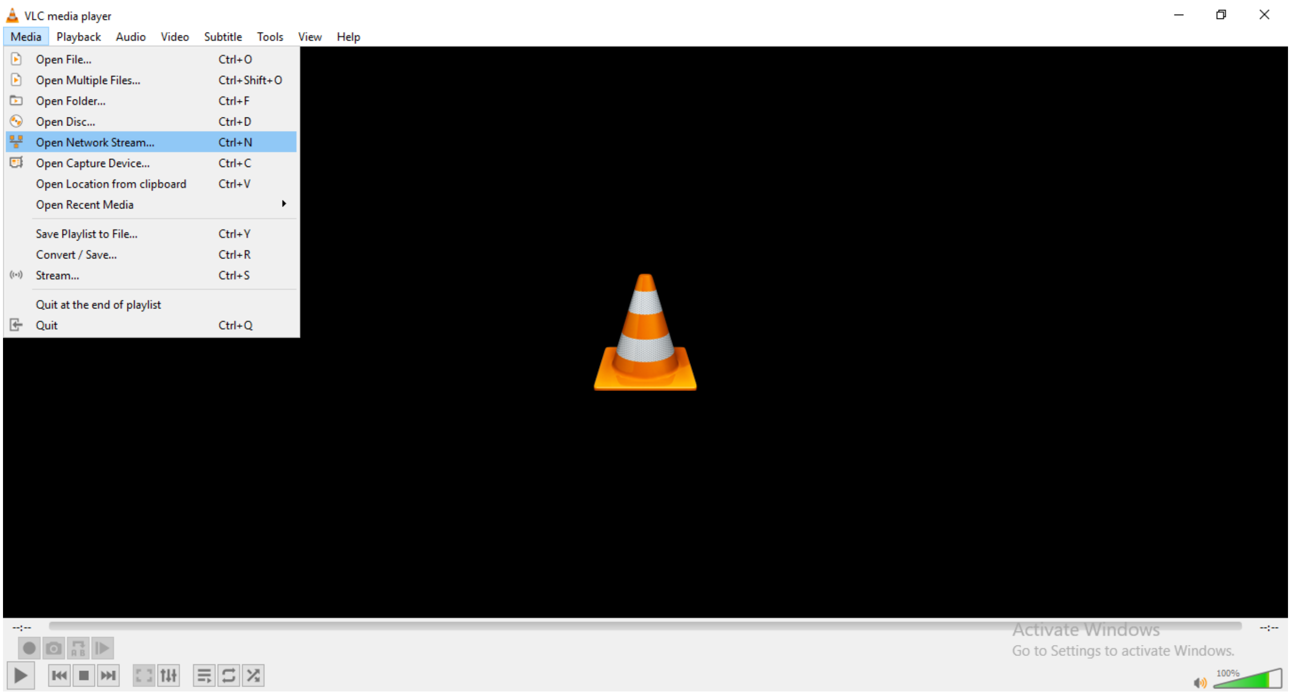
1- open VLC media player

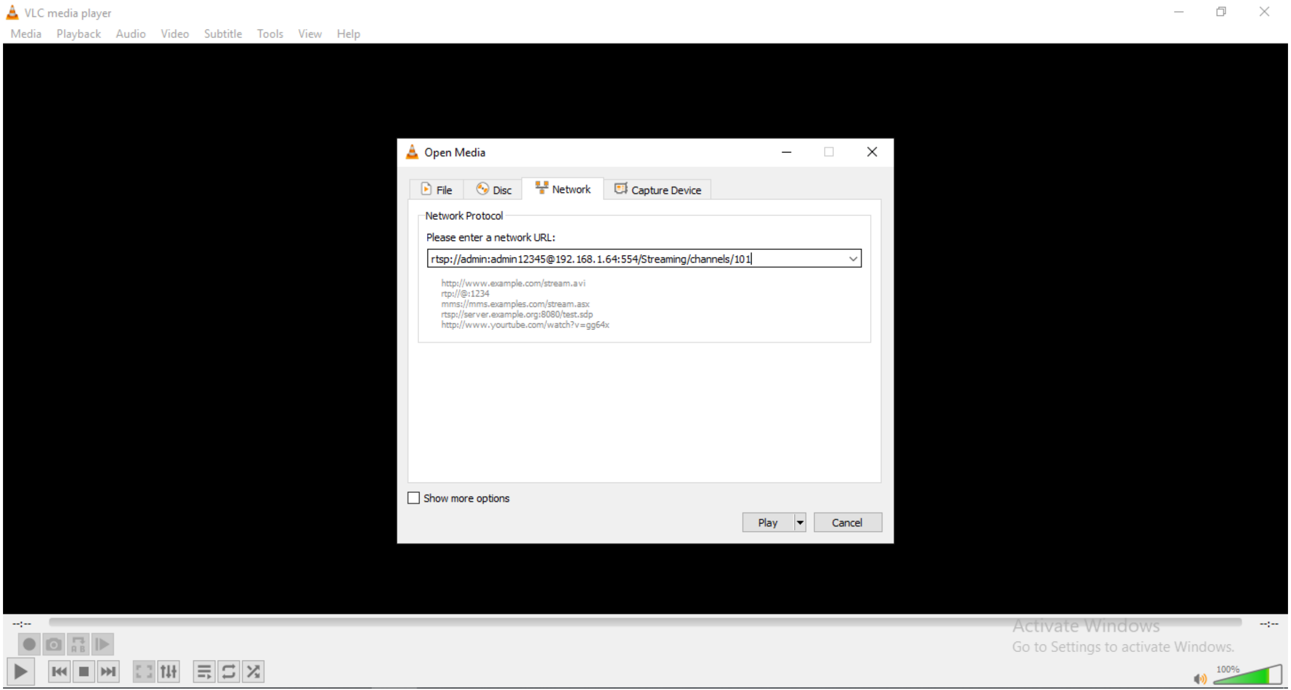


2- copy the address: rtsp://admin:admin12345@192.168.1.64:554/Streaming/channels/101 (possible addresses are in the textfile “camera addresses.txt” on the Desktop)



3- paste it into VLC (Ctr+V) and press Enter (otherwise you can click on Media->open nwtwork stream and paste the link there)

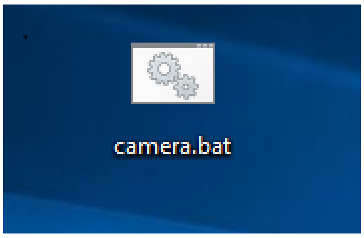


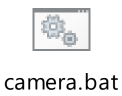


2- use the script:

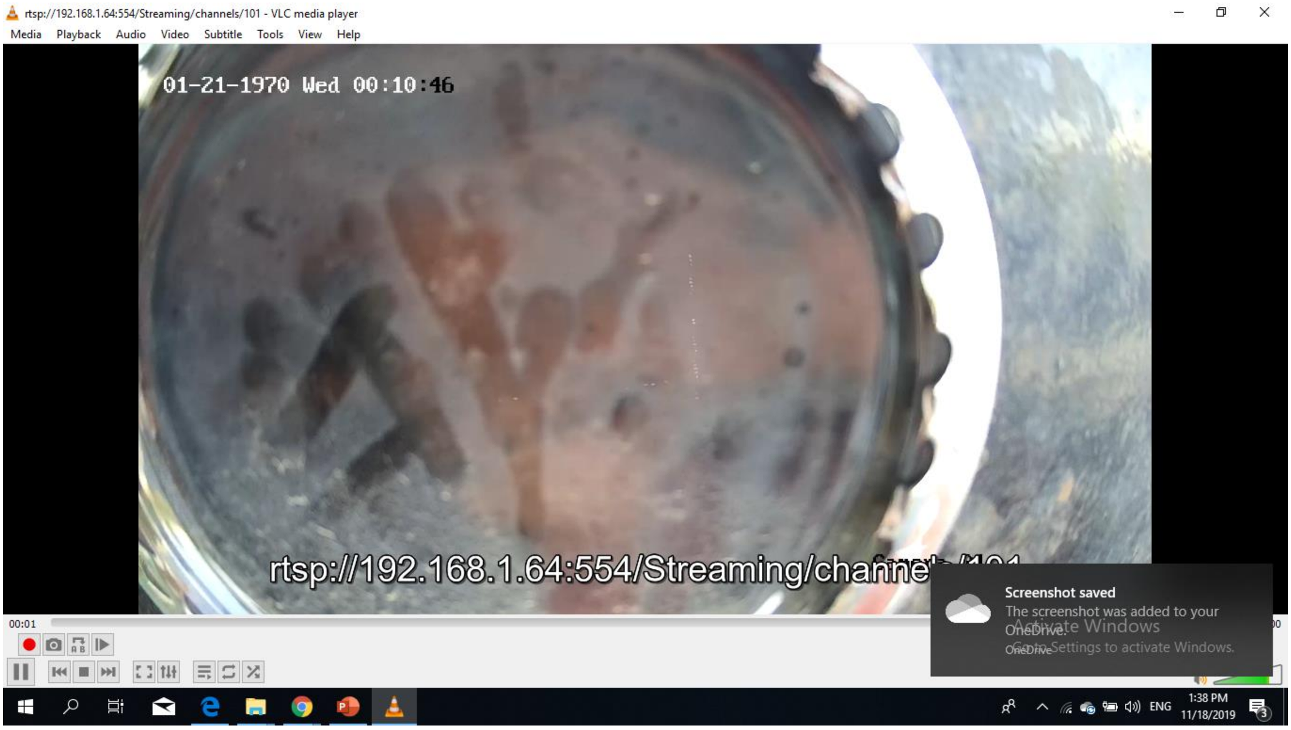
Steps:

1- doubleclick the script “camera.bat” on the Desktop





2- VLC will open….



For more possibilities and configurations see the camera manual.

34 Appendix

34.1 Source code

nlap_pcs_platform_
GUI_sourceCode201

34.2 Modbus connection

For a good introduction and understanding of the Modbus protocol and addressing, the following webpage is useful:

Modbus-explained.
rar

34.2.1 Rtu/Asci

The Modbus protocol can be used in asci or in rtu mode. Which one is used depends on the PLC programming. Currently used in code: rtu.

To change that, change the variable '`rtu_or_asci`' in StateMachine.cs.

34.2.2 Modbus driver

On Windows 7(like our nlap-laptop), this adapter(Ex9530)  needs a manual installation of the driver.

Driver name: Prolific USB-to-serial comm Port

Driver file:

pl2303.zip

Installation:

1- Install the driver from the zip file
2- Check in device manager and check connection in GUI. If all ok you are done
3- Open device manager
4- Right click on the new device (adapter must be connected) either in Ports(COM & LPT) or in unknown devices. -> update driver
5- Choose the second field(choose from computer…)
6- Choose the second field(pick from a list…)

7- Duble-click on the new-installed driver.

8- Done(no more problem mark if there was one)

Com port must be set to “COM 2” (important because of the plc-programmation):

1- In device manager on the device:
2- Right-click->properties
3- In “Port settings” tap:
4- Click on “advanced”
5- Choose “COM2” from droplist in Com Port number.
6- Ok->you are done

34.2.3 Modbus addresses

A List of all Modbus-addresses used are listen in the following excel List:

ADDRESSES_201219
.xlsx

34.3 Development instructions

To make the further development easier some checklists or protocols list the steps for adding/removing sensors/actuators and changing the GUI background.

howto-protocols_2
01219.rar

34.4 Camera manual

Search here for the current manual(model: -):

https://www.hikvision.com/en/support/document-center/user-manual/

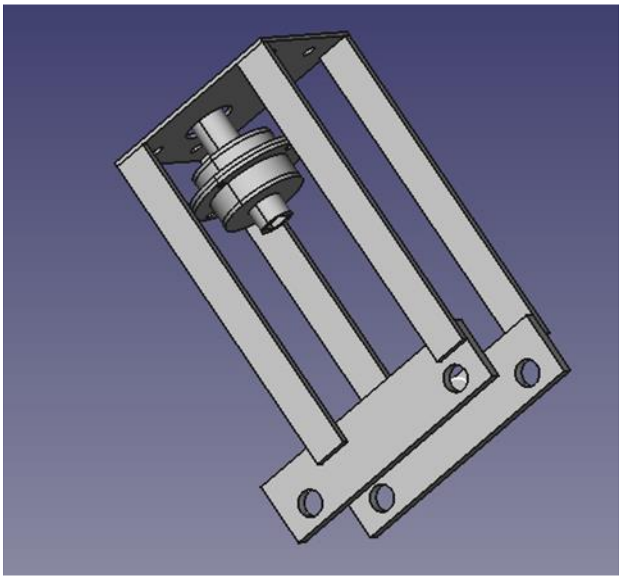
34.5 References and helpful documents

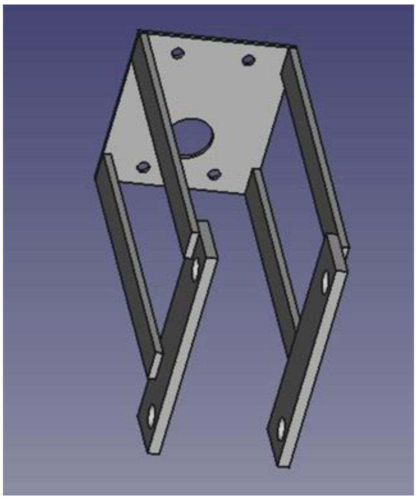
35 Electric valve motor healder

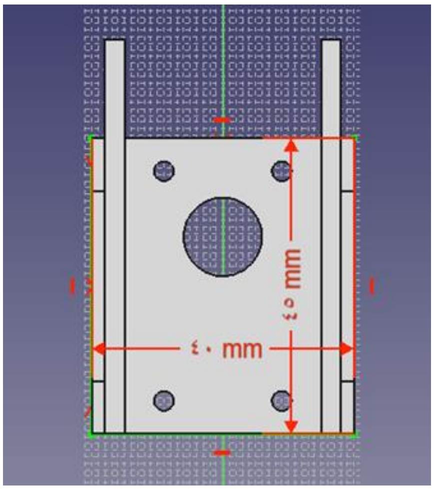
Electric valve 12V DC

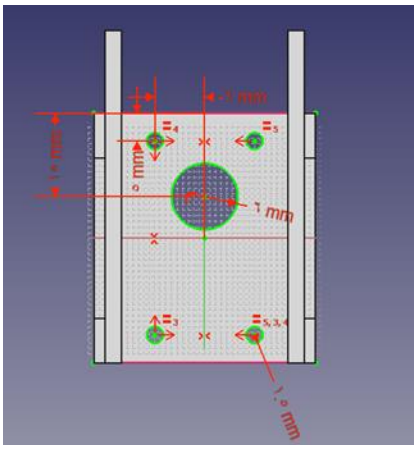
35.1 Design system

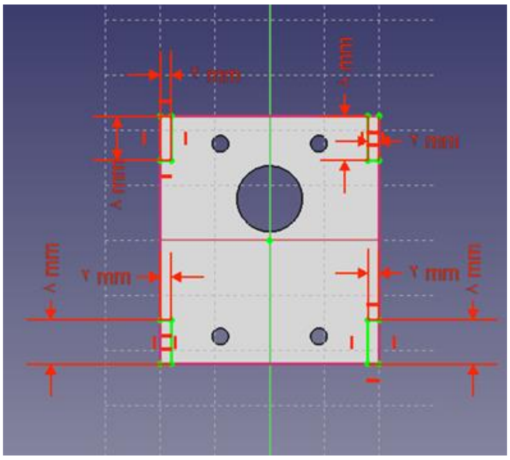
Design 1:

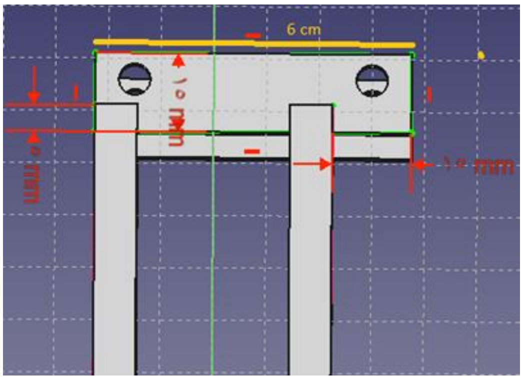


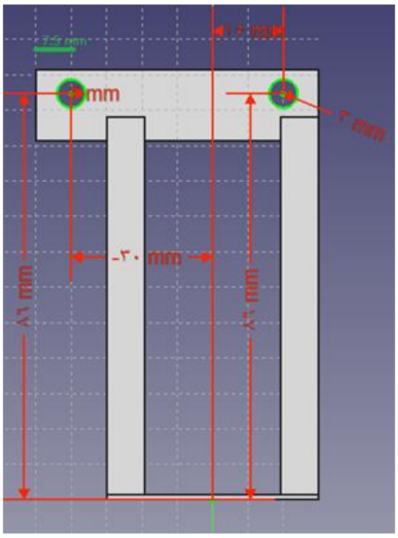


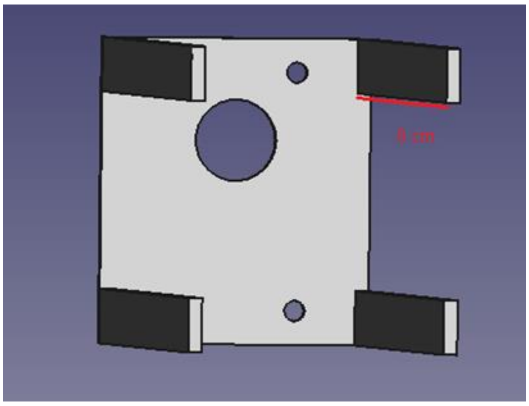


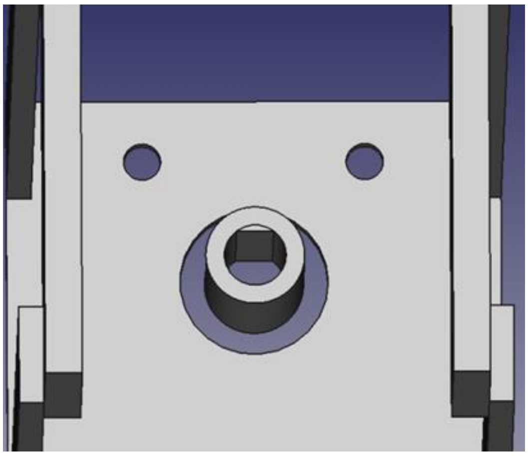


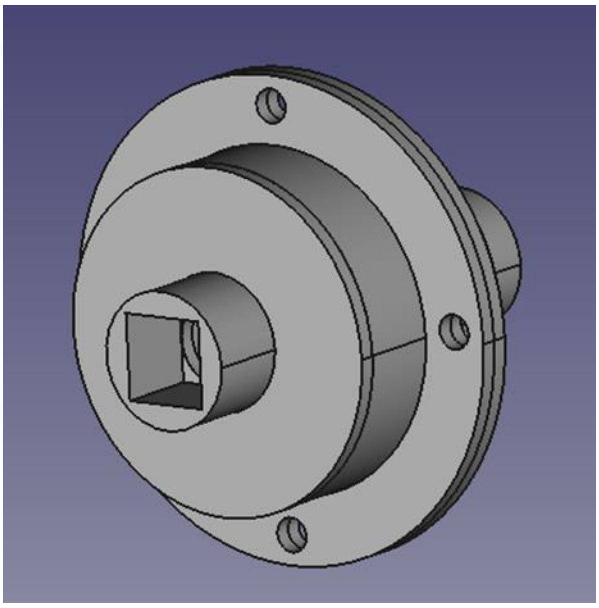


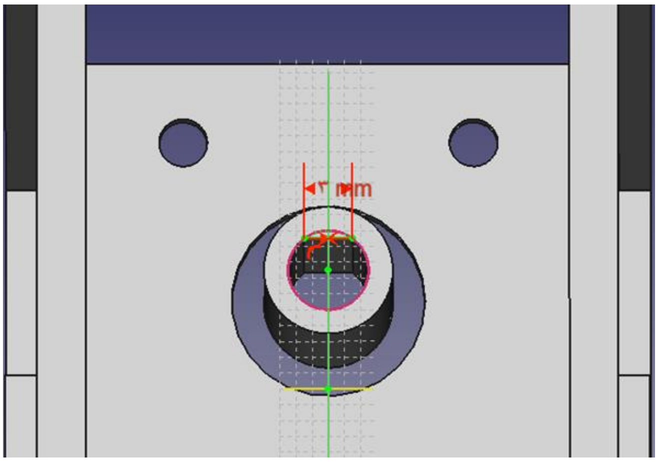


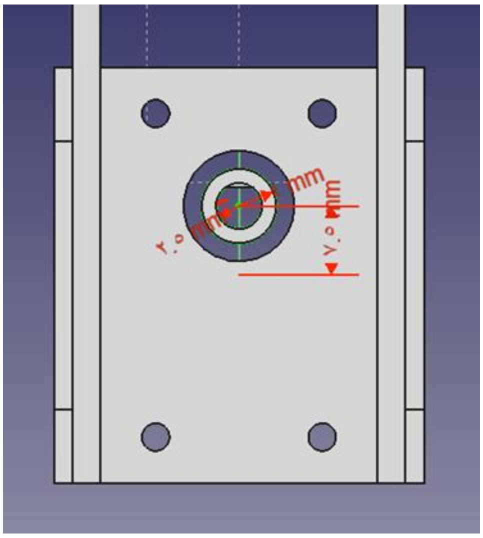


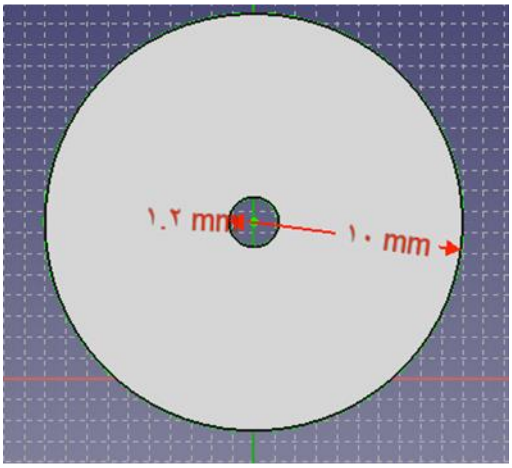


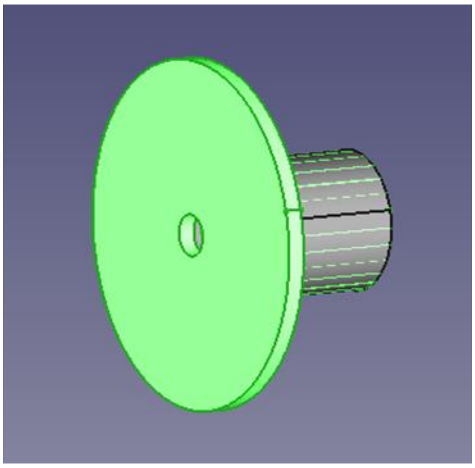


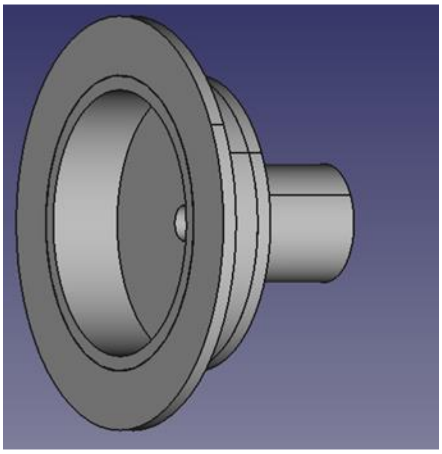


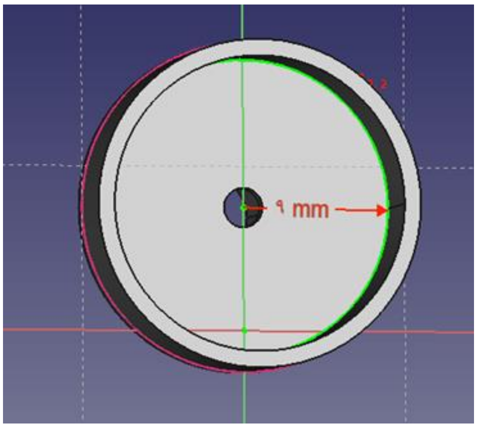


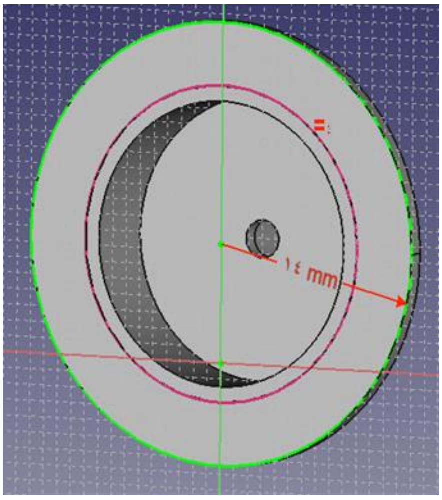


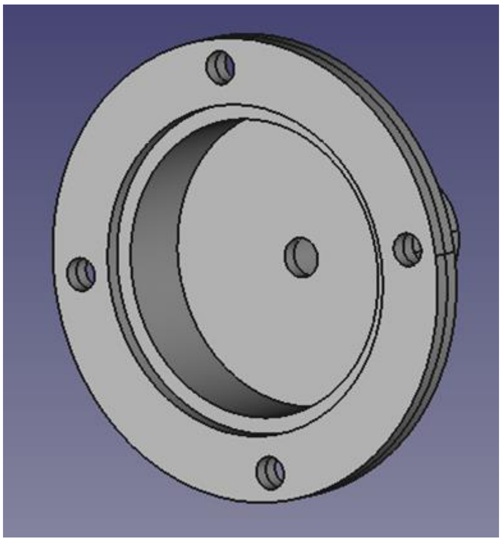

١.٢ mm
١٠ mm

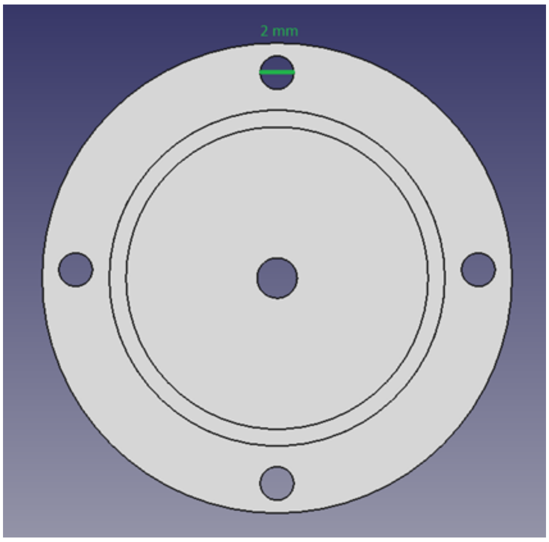


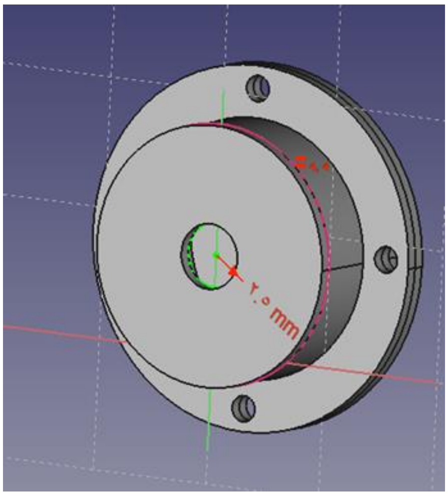


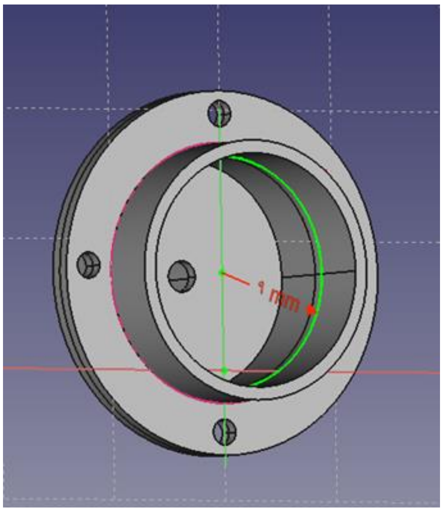

٩ mm


١٤ mm

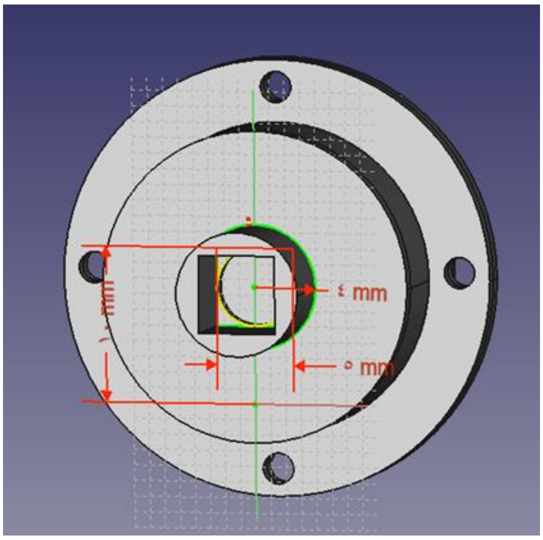




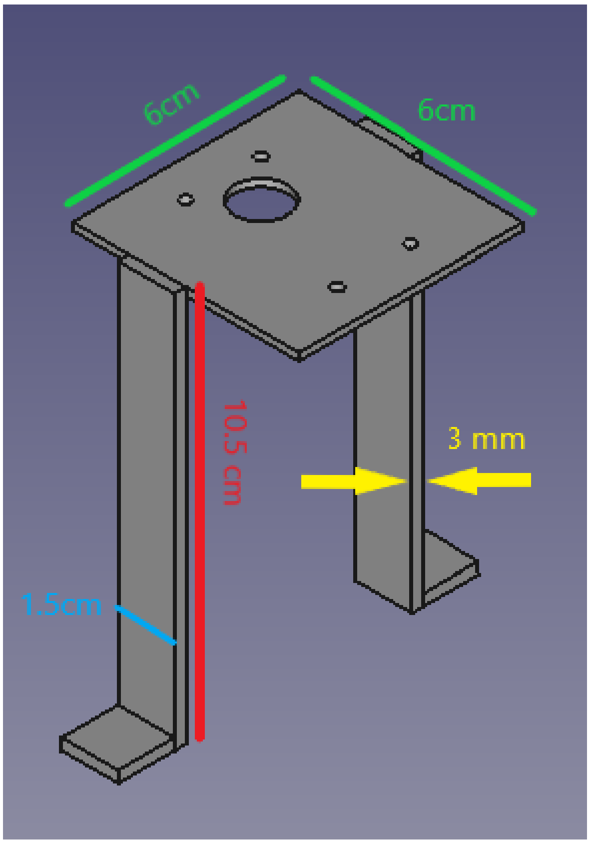


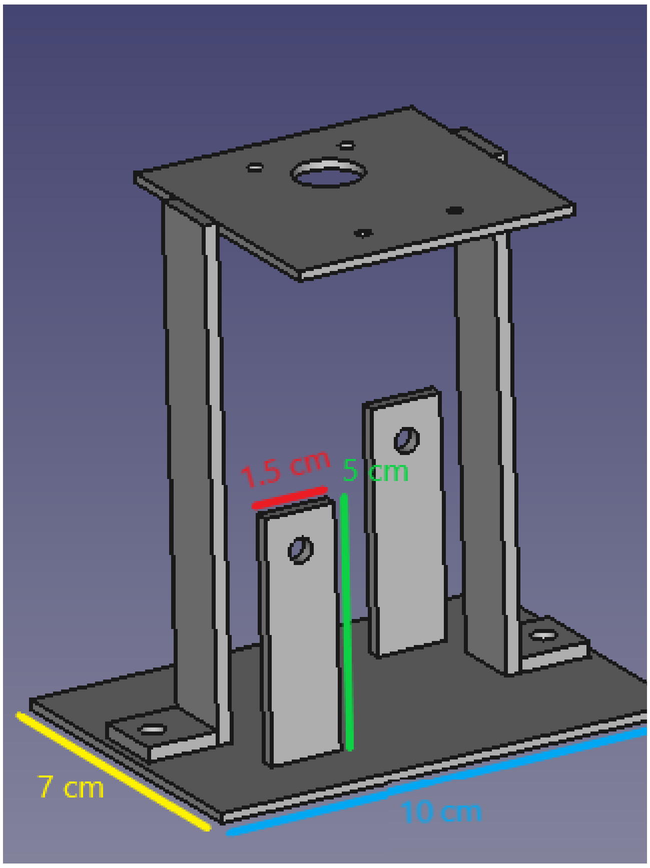


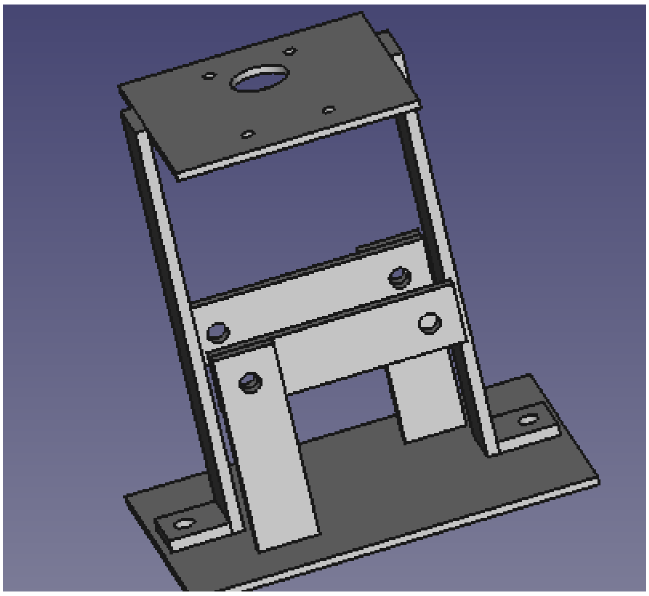
moto_holder.FCStd

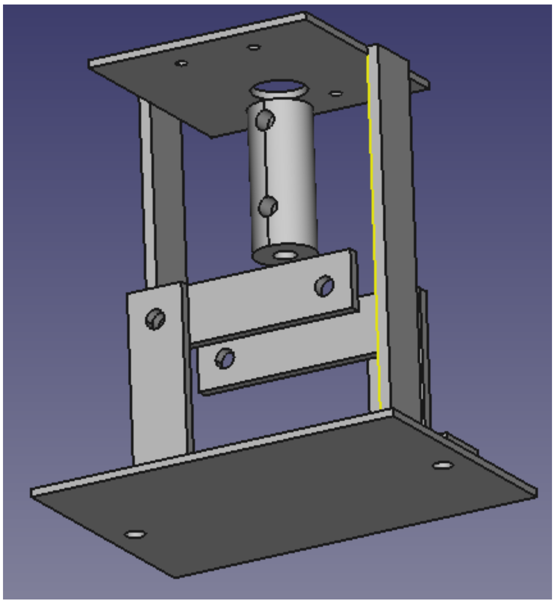


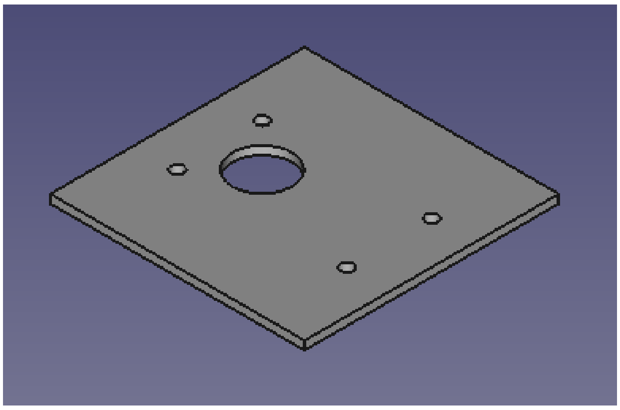
Design 2:

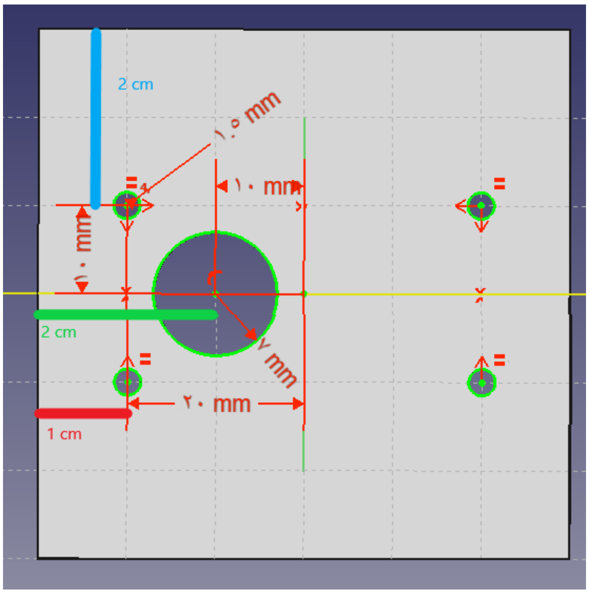


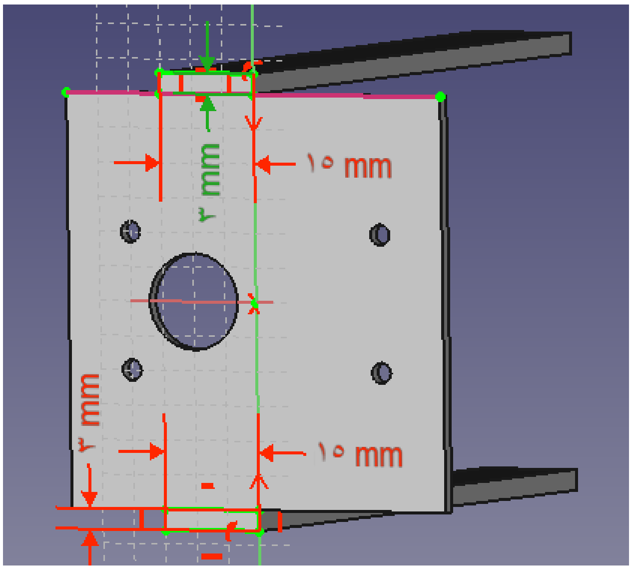


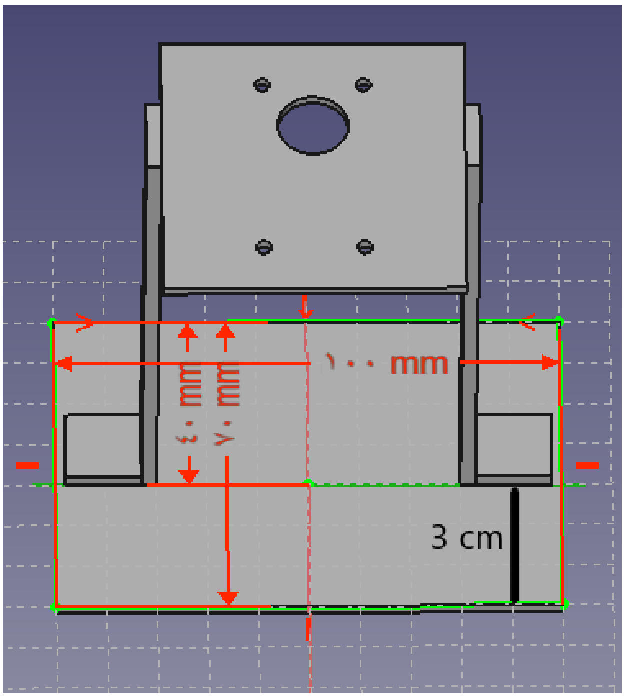


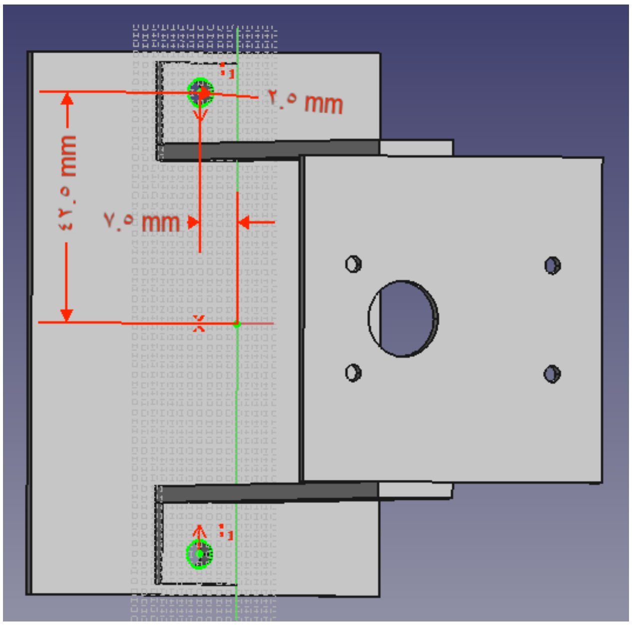


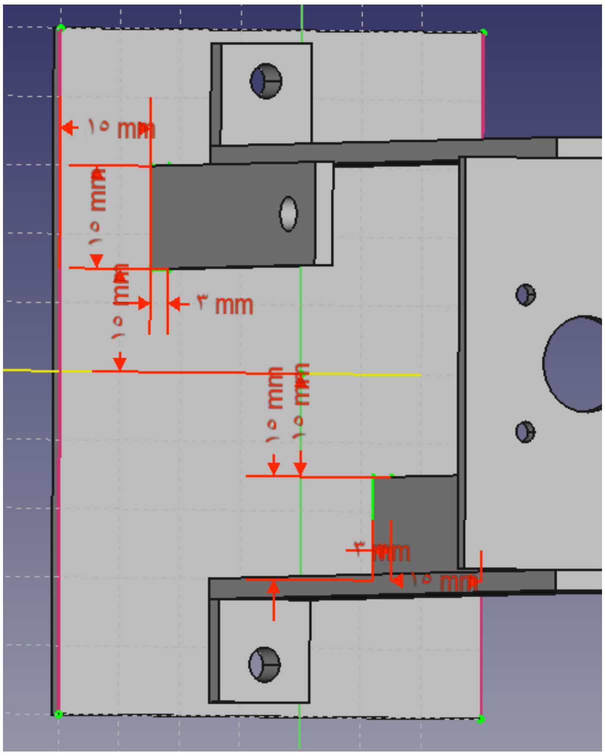


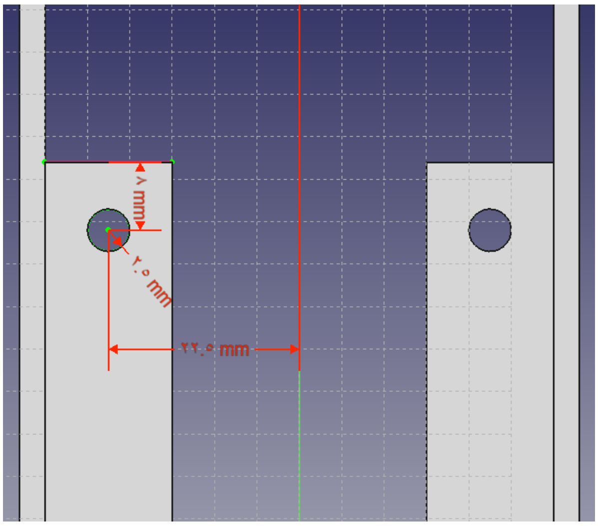

2 cm
١٥ mm
١٠ mm
١٠ mm
٧ mm
2 cm
٢٠ mm
1 cm

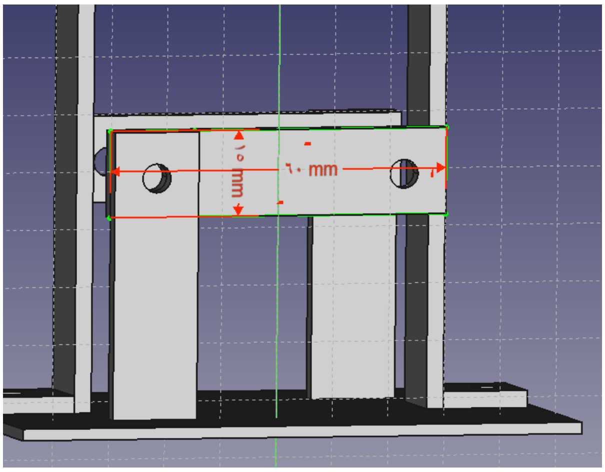

١٥ mm
٣ mm
٣ mm
١٥ mm

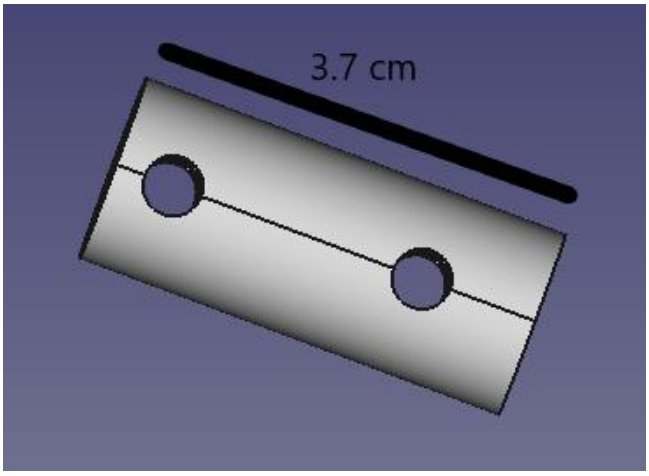

١٠٠ mm
٤٠ mm
٧٠ mm
3 cm

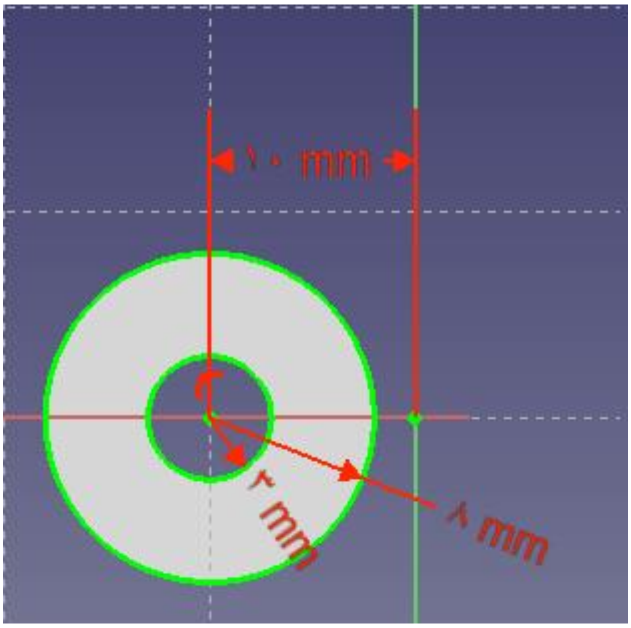

٢.٥ mm
٤٢.٥ mm
٧.٥ mm

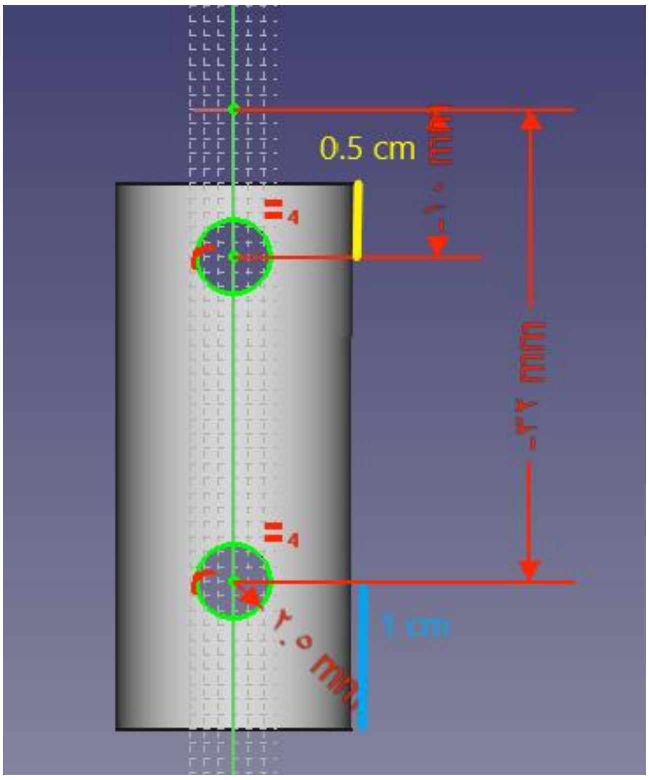

١٥ mm
١٥ mm
١٥ mm
٣ mm
١٥ mm
١٥ mm
٣ mm
١٥ mm


٨ mm
٢.٥ mm
٢٢.٥ mm


١٥ mm
٦٠ mm

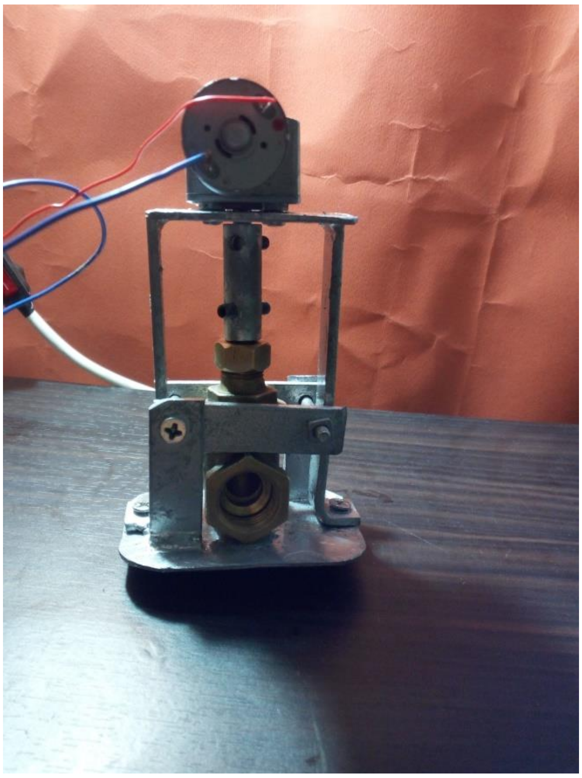

3.7 cm

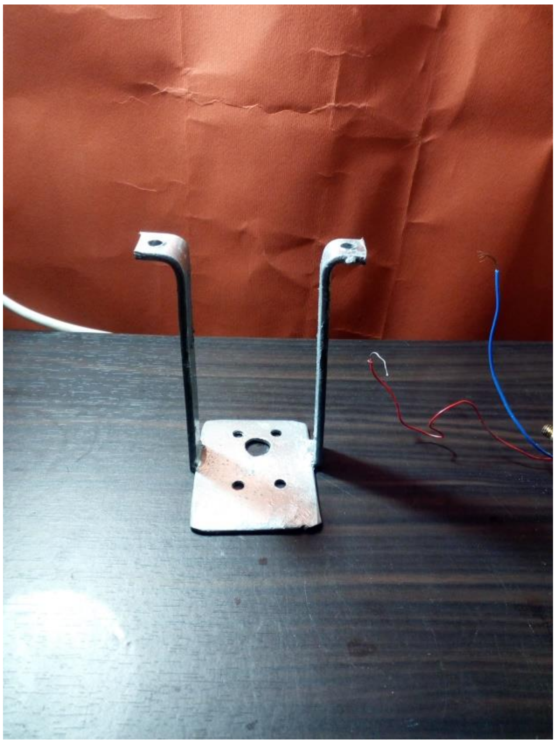

٢٠ mm
٣ mm
٨ mm

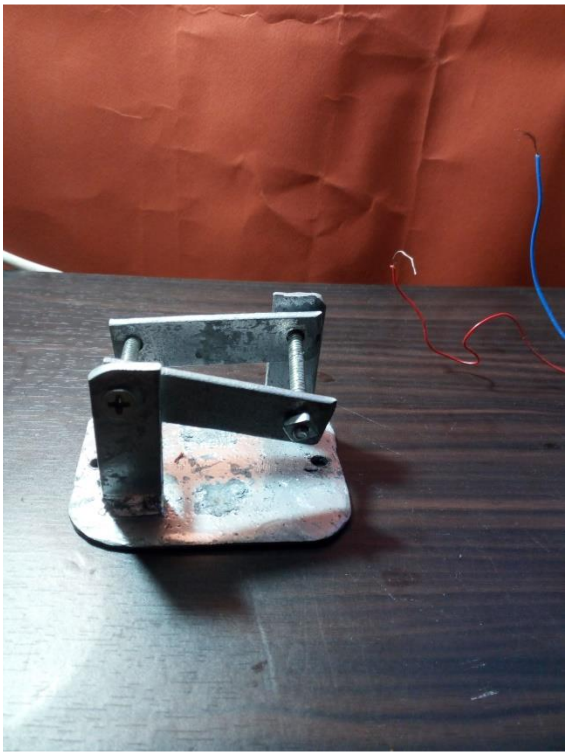


moto_holder
261218.FCStd

Manufacturing design 2 :








6 cm
1.5 cm


3.7 cm

4 electric valve

Environment Impact Assessment for Rayhaniyye Camp

Based on the follwing reports

Environment Impact Assessment

[NLAP-IPP EIA Rayhaniyye 2018]

بسم الله الرحمن الرحيم

AECENAR
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North Lebanon Alternative Power
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Operational Commisioning of Waste to Incineration Demonstration Plant NLAP-IPP in Rihaniye Camp

Waste incinerator 1 ton/day, 25 kW electricity (NLAP-IPP Demo Plant)

الخطوات الاولى في تقييم الاثر البيئي

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Last update: 07.11.2018

Content

36 Introduction

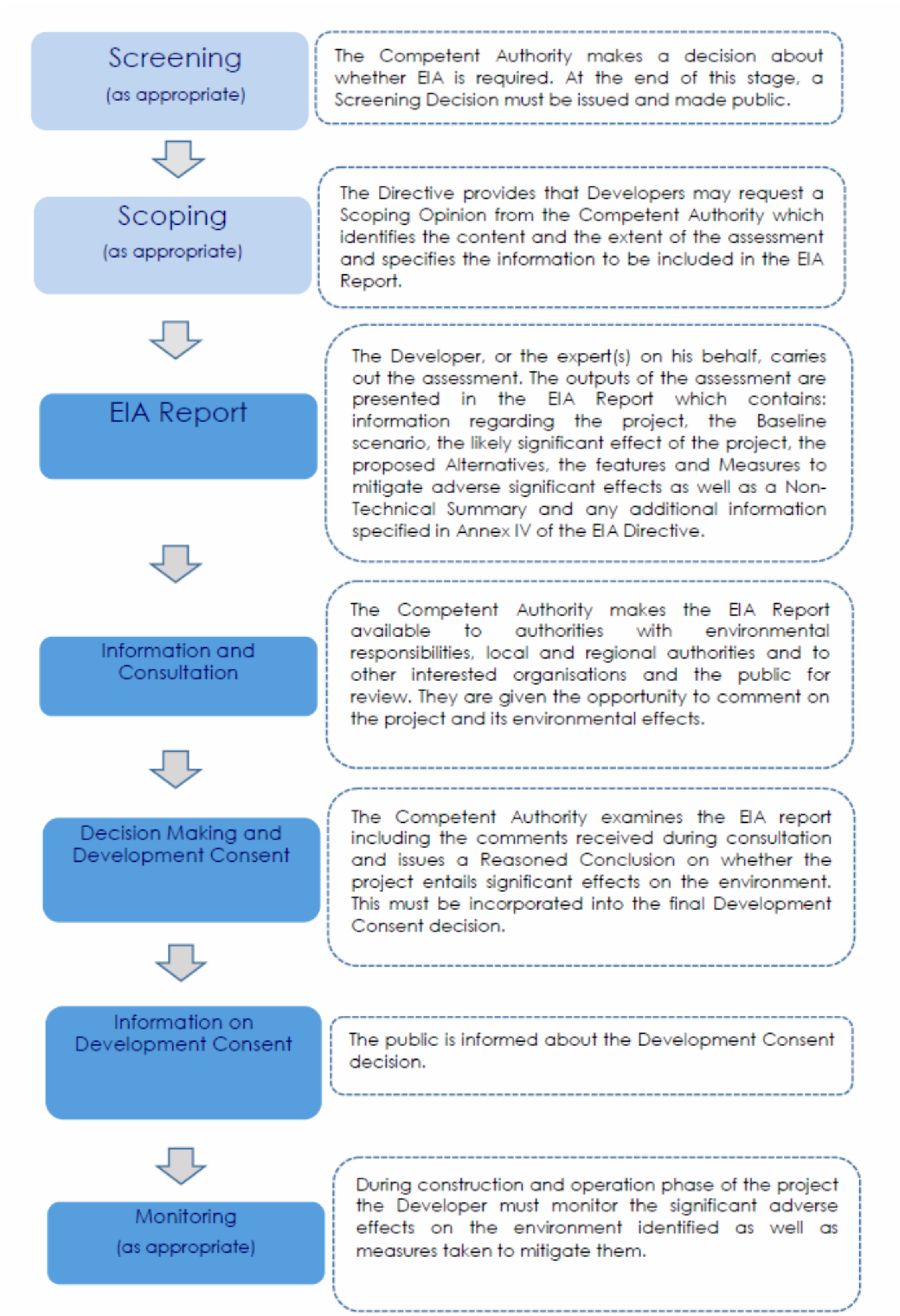
This document is the first document concerning the process to get permission from Lebanese Government to operate NLAP-IPP.

37 Laws

37.1 Description to write an Environment Impact Assessment

http://ec.europa.eu/environment/eia/eia-support.htm

37.1.1 Steps of EIA



37.1.2 THE REVIEW CHECKLIST

SECTION 1	DESCRIPTION OF THE PROJECT			
No.	**Review Question**	**Relevant?**	**Adequately Addressed?**	**What further information is needed?**
The Objectives and Physical Characteristics of the Project				
1.1	Are the Project's objectives and the need for the Project explained?			
1.2	Is the programme for the Project's implementation described, detailing the estimated length of time (e.g. expected start and finish dates) for construction, operation, and decommissioning? (this should include any phases of different activity within the main phases of the Project, extraction phases for mining operations for example)			
1.3	Have all of the Project's main characteristics been described? (for assistance, see the Checklist in Part C of the Scoping Guidance Document in this series)			
1.4	Has the location of each Project component been identified, using maps, plans, and diagrams as necessary?			
1.5	Is the layout of the site (or sites) occupied by the Project described? (including ground levels, buildings, other physical structures, underground works, coastal works, storage facilities, water features, planting, access corridors, boundaries)			
1.6	For linear Projects, have the route corridor, the vertical, and horizontal alignment and any tunnelling and earthworks been described?			
1.7	Have the activities involved in the construction of the Project (including land-use requirements) all been described?			
1.8	Have the activities involved in the Project's operation (including land-use requirements and demolition works) all been described?			
1.9	Have the activities involved in decommissioning the Project all been described? (e.g. closure, dismantling, demolition, clearance, site restoration, site re-use, etc.)			
1.10	Have any additional services, required for the Project, been described? (e.g. transport access, water, sewerage, waste disposal, electricity, telecoms)			
1.11	Are any developments likely to occur as a consequence of the Project identified? (e.g. new housing, roads, water or sewerage infrastructure, aggregate extraction)			
1.12	Have any existing activities that will alter or cease as a consequence of the Project been identified?			

SECTION 1 DESCRIPTION OF THE PROJECT				
No.	**Review Question**	**Relevant?**	**Adequately Addressed?**	**What further information is needed?**
1.13	Have any other existing or planned developments, with which the Project could have cumulative effects, been identified?			
1.14	Has the 'whole Project' been described, e.g. including all associated/ancillary works?			
1.15	Are any activities described as part of the 'whole Project' excluded from the assessment? Are such exclusions justified? (e.g. associated/ancillary activities can be included either because they fall under the scope of the Directive (Annex I or II) or because they can be considered as an integral part of the main infrastructure works using the 'centre of gravity test'. Guidance on associated and ancillary works has been published by the European Commission in an Interpretation Line available at: http://ec.europa.eu/environment/eia/pdf/Note%20-%20Interpretation%20of%20Directive%2085-337-EEC.pdf)			
The Size of the Project				
1.16	Is the area of land occupied by each of the permanent Project components quantified and shown on a scaled map? (including any associated access arrangements, landscaping, and ancillary facilities)			
1.17	Has the area of land required temporarily for construction been quantified and mapped?			
1.18	Is the reinstatement and after-use of the land occupied temporarily for the operation of the Project described? (e.g. land used for mining or quarrying)			
1.19	Has the size of any structures or other works developed as part of the Project been identified? (e.g. the floor area and height of buildings, the size of excavations, the area or height of planting, the height of structures such as embankments, bridges or chimneys, the flow or depth of water)			
1.20	Has the form and appearance of any structures or other works developed as part of the Project been described? (e.g. the type, finish, and colour of materials, the architectural design of buildings and structures, plant species, ground surfaces, etc.)			
1.21	For urban or similar development Projects, have the numbers and other characteristics of new populations or business communities been described?			
1.22	For Projects involving the displacement of people or businesses, have the numbers and other characteristics of those displaced been described?			

SECTION 1 DESCRIPTION OF THE PROJECT				
No.	Review Question	Relevant?	Adequately Addressed?	What further information is needed?
1.23	For new transport infrastructure or Projects that generate substantial traffic flows, has the type, volume, temporal pattern, and geographical distribution of new traffic generated or diverted as a consequence of the Project been described?			
Production Processes and Resources Used				
1.24	Have all of the processes involved in operating the Project been described? (e.g. manufacturing or engineering processes, primary raw material production, agricultural or forestry production methods, extraction processes)			
1.25	Have the types and quantities of outputs produced by the Project been described? (these could be primary or manufactured products, goods such as power or water or services such as homes, transport, retailing, recreation, education, municipal services (water, waste, etc.)			
1.26	Have the types and quantities of resources, e.g. natural resources (including water, land, soil, and biodiversity), raw materials, and energy needed for construction and operation been discussed?			
1.27	Have the environmental implications of the sourcing of resources, e.g. natural resources (including water, land, soil and biodiversity), raw materials, and energy been discussed?			
1.28	Have efficiency and sustainability in use of resources, e.g. natural resources (including water, land, soil and biodiversity), raw materials, and energy been discussed?			
1.29	Have any hazardous materials used, stored, handled or produced by the Project been identified and quantified? • during construction; • during operation; • during decommissioning.			
1.30	Has the transportation of resources, including natural resources (including water, land, soil, and biodiversity) and raw materials to the Project site, and the number of traffic movements involved, been discussed? (including road, rail and sea transport) • during construction; • during operation; • during decommissioning.			

SECTION 1	DESCRIPTION OF THE PROJECT			
No.	**Review Question**	**Relevant?**	**Adequately Addressed?**	**What further information is needed?**
1.31	Have the Project's environmentally relevant social and socio-economic implications been discussed? Will employment be created or lost as a result of the Project, for instance? • during construction; • during operation; • during decommissioning.			
1.32	Have the access arrangements and the number of traffic movements involved in bringing workers and visitors to the Project been estimated? • during construction; • during operation; • during decommissioning.			
1.33	Has the housing and provision of services for any temporary or permanent employees for the Project been discussed? (this is relevant for Projects that require the migration of a substantial, new workforce into the area, either for construction or in the long term)			
Residues and Emissions				
1.34	Have the types and quantities of solid waste generated by the Project been identified? (including the construction or demolition of wastes, surplus spoil, process wastes, by-products, surplus or reject products, hazardous wastes, household or commercial wastes, agricultural or forestry wastes, site clean-up wastes, mining wastes, decommissioning wastes) • during construction; • during operation; • during decommissioning.			
1.35	Have the composition and toxicity, or other hazards from all solid wastes produced by the Project, been discussed?			
1.36	Have the methods for collecting, storing, treating, transporting, and finally disposing of these solid wastes been described?			
1.37	Have the locations for the final disposal of all solid wastes been discussed, in consideration with the Waste Management Plan(s) concerned?			
1.38	Have the types and quantities of liquid effluents generated by the Project been identified? (including site drainage and run-off, process wastes, cooling water, treated effluents, sewage) • during construction; • during operation; • during decommissioning.			

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SECTION 2 DESCRIPTION OF ENVIRONMENTAL FACTORS LIKELY TO BE AFFECTED BY THE PROJECT				
No.	**Review Question**	**Relevant?**	**Adequately Addressed?**	**What further information is needed?**
Baseline: Aspects of the Environment				
2.1	Have the existing land uses on the land to be occupied by the Project and the surrounding area described and are any people living on or using the land been identified? (including residential, commercial, industrial, agricultural, recreational, and amenity land uses and any buildings, structures or other property)			
2.2	Have the topography, geology and soils of the land to be occupied by the Project and the surrounding area been described?			
2.3	Have any significant features of the topography or geology of the area described and are the conditions and use of soils been described? (including soil quality stability and erosion, agricultural use and agricultural land quality)			
2.4	Has the biodiversity of the land/sea to be affected by the Project and the surrounding area been described and illustrated on appropriate maps?			
2.5	Have the species (including their populations and habitats), and the habitat types that may be affected by the Project been described? (Particular attention should be paid to any species and habitats protected under the Habitats and Birds Directives (Directives 92/43/EEC and 2009/147/EC).			
2.6	Have the Natura 2000 sites that may be affected by the Project been described?			
2.7	Has the water environment of the area been described? (including reference to any River Basin Management Plans/Programme of Measures under the WFD, running and static surface waters, groundwaters, estuaries, coastal waters and the sea and including run off and drainage. N.B. not relevant if water environment will not be affected by the Project)			
2.8	Have the hydrology, water quality, and use of any water resources that may be affected by the Project been described? (including any River Basin Management Plans/Programme of Measures under the WFD, use for water supply, fisheries, angling, bathing, amenity, navigation, effluent disposal)			
2.9	Have local climatic and meteorological conditions in the area been described? (N.B. not relevant if the atmospheric environment will not be affected by the Project)			
2.10	Has existing air quality in the area been described, including, where relevant, limit values set out by Directives 2008/50/EC and 2004/107/EC as well as relevant Programmes adopted under this legislation? (N.B. not relevant if the ambient air will not be affected by the Project)			

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SECTION 3 DESCRIPTION OF THE LIKELY SIGNFICANT EFFECTS OF THE PROJECT				
No.	**Review Question**	**Relevant?**	**Adequately Addressed?**	**What further information is needed?**
Scoping of Effects				
3.1	Has the process by which the scope of the information for the EIA Report defined been described? (for assistance, see the Scoping Guidance Document in this series)			
3.2	Is it evident that a systematic approach to Scoping has been adopted?			
3.3	Was consultation carried out during Scoping?			
3.4	Have the comments and views of consultees been presented?			
Prediction of Direct Effects				
3.5	Have the direct, primary effects on land uses, people, and property been described and, where appropriate, quantified?			
3.6	Have the direct, primary effects on geological features and characteristics of soils been described and, where appropriate, quantified?			
3.7	Have the direct, primary effects on biodiversity been described and, where appropriate, quantified? (if relevant, are references made to Natura 2000 sites? (Directive 2009/147/EC and Directive 92/43/EEC))			
3.8	Have the direct, primary effects on the hydrology and water quality of water features been described and, where appropriate, quantified?			
3.9	Have the direct, primary effects on uses of the water environment been described and, where appropriate, quantified? (if relevant, are references made for River Basin Management Plans/Programmes of Measures under the WFD (2000/60/EC))			
3.10	Have the direct, primary effects on air quality been described and, where appropriate, quantified? (if relevant, are references made to Air Quality Plans under Directives 2008/50/EC and 2004/107/EC))			
3.11	Have the direct, primary effects on climate change been described and, where appropriate, quantified?			
3.12	Have the direct, primary effects on the acoustic environment (noise or vibration) been described and, where appropriate, quantified? (if relevant, are references made to Action Plans/Programme under the Environmental Noise Directive (2002/49/EU))			
3.13	Have the direct, primary effects on heat, light or electromagnetic radiation been described and, where appropriate, quantified?			

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SECTION 4	CONSIDERATION OF ALTERNATIVES			
No.	**Review Question**	**Relevant?**	**Adequately Addressed?**	**What further information is needed?**
4.1	Have the different Alternatives suggested during Scoping been considered and assessed, and if not has justification been provided?			
4.2	Have the Developer and practitioners, who are preparing the EIA Report, identified and assessed additional Alternatives (to the ones suggested during Scoping)?			
4.3	Have the process by which the Project was developed been described and are the Alternatives to the design of the Project considered during this process been described? (for assistance, see also the guidance on types of Alternatives which may be relevant in the Scoping Guidance Document in this series)			
4.4	Have the Alternatives to the design considered during this process been described? (for assistance, see also the guidance on types of alternatives which may be relevant in the Scoping Guidance Document in this series)			
4.5	Have the Alternatives to technology been considered during this process? (for assistance, see also the guidance on types of Alternatives which may be relevant in the Scoping Guidance Document in this series)			
4.6	Have the Alternatives to the location considered during this process been described? (for assistance, see also the guidance on types of alternatives which may be relevant in the Scoping Guidance Document in this series)			
4.7	Have the Alternatives to the size considered during this process been described (for assistance, see also the guidance on types of alternatives which may be relevant in the Scoping Guidance Document in this series)			
4.8	Have the Alternatives to the scale considered during this process been described? (for assistance, see also the guidance on types of alternatives which may be relevant in the Scoping Guidance Document in this series)			
4.9	Has the Baseline situation in the 'do-nothing' scenario been described?			
4.10	Are the Alternatives realistic and genuine Alternatives to the Project? (i.e. feasible Project options that meet the objectives)			

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SECTION 5 DESCRIPTION OF MITIGATION				
No.	**Review Question**	**Relevant?**	**Adequately Addressed?**	**What further information is needed?**
5.1	Where there are significant adverse effects on any aspect of the environment, has the potential for the mitigation of these effects been discussed?			
5.2	Have the measures that the Developer has proposed to implement, in order to mitigate effects, been clearly described and is their effect on the magnitude and significance of impacts clearly explained?			
5.3	Have any proposed mitigation strategy's negative effects been described?			
5.4	If the effect of Mitigation Measures on the magnitude and significance of impacts is uncertain, has this been explained?			
5.5	Is it clear if the Developer has made a binding commitment to implement the mitigation proposed or acknowledged that the Mitigation Measures are just suggestions or recommendations?			
5.6	Do the Mitigation Measures cover both the construction and operational phases of the Project?			
5.7	Have the Developer's reasons for choosing the proposed mitigation been explained?			
5.8	Have the responsibilities for the implementation of mitigation including roles, responsibilities, and resources been clearly defined?			
5.9	Where the mitigation of significant adverse effects is not practicable, or where the Developer has chosen not to propose any mitigation, have the reasons for this been clearly explained?			
5.10	Is it evident that the practitioners developing the EIA Report and the Developer have considered the full range of possible approaches to mitigation, including measures to avoid, prevent or reduce and, where possible, offset impacts by alternative strategies or locations, changes to the Project design and layout, changes to methods and processes, 'end of pipe' treatment, changes to implementation plans and management practices, measures to repair or remedy impacts and measures to compensate impacts?			
Other Questions on Mitigation				

SECTION 6 DESCRIPTION OF MONITORING MEASURES				
No.	Review Question	Relevant?	Adequately Addressed?	What further information is needed?
6.1	Where adverse effects on any aspect of the environment are expected, has the potential for the monitoring of these effects been discussed?			
6.2	Are the measures, which the Developer proposes implementing to monitor effects, clearly described and has their objective been clearly explained?			
6.3	Is it clear whether the Developer has made a binding commitment to implement the proposed monitoring programme or that the Monitoring Measures are just suggestions or recommendations?			
6.4	Have the Developer's reasons for choosing the monitoring programme proposed been explained?			
6.5	Have the responsibilities for the implementation of monitoring, including roles, responsibilities, and resources been clearly defined?			
6.6	Where monitoring of adverse effects is not practicable, or the Developer has chosen not to propose any Monitoring Measures, have the reasons for this been clearly explained?			
6.7	Is it evident that the practitioners developing the EIA Report and the Developer have considered the full range of possible approaches to monitoring, including Monitoring Measures covering all existing environmental legal requirements, Monitoring Measures stemming from other legislation to avoid duplication, monitoring of Mitigation Measures (ensuring expected significant effects are mitigated as planned), Monitoring Measures capable of identifying important unforeseen effects?			
6.8	Have arrangements been proposed to monitor and manage residual impacts?			
Other Questions on Monitoring Measures				

SECTION 7 QUALITY				
No.	Review Question	Relevant?	Adequately Addressed?	What further information is needed?
Quality of presentation				
7.1	Is the EIA Report available in one or more clearly defined documents?			
7.2	Is the document(s) logically organised and clearly structured, so that the reader can locate information easily?			
7.3	Is there a table of contents at the beginning of the document(s)?			
7.4	Is there a clear description of the process that has been followed?			
7.5	Is the presentation comprehensive but concise, avoiding irrelevant data and information?			
7.6	Does the presentation make effective use of tables, figures, maps, photographs, and other graphics?			
7.7	Does the presentation make effective use of annexes or appendices to present detailed data that is not essential to understanding the main text?			
7.8	Are all analyses and conclusions adequately supported with data and evidence?			
7.9	Have all sources of data been properly referenced?			
7.10	Has terminology been used consistently throughout the document(s)?			
7.11	Does it read as a single document, with cross referencing between sections used to help the reader navigate through the document(s)?			
7.12	Is the presentation demonstrably fair and, as far as possible, impartial and objective?			
Non-Technical Summary				
7.13	Does the EIA Report include a Non-Technical Summary?			
7.14	Does the Summary provide a concise but comprehensive description of the Project, its environment, the effects of the Project on the environment, the proposed Mitigation Measures, and proposed monitoring arrangements?			
7.15	Does the Summary highlight any significant uncertainties about the Project and its environmental effects?			
7.16	Does the Summary explain the Development Consent process for the Project and the EIA's role in this process?			
7.17	Does the Summary provide an overview of the approach to the assessment?			

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37.1.3 Example section: Waste Framework Directive

Name used	Formal name
WasteFD	■ Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain directives
Relevant EU guidance:	■ Application of EIA Directive to the rehabilitation of landfills.

The WasteFD establishes a legal framework for the management and treatment of most waste types. The Directive sets out a waste hierarchy that ranges from prevention to disposal. Waste management under the Directive must be implemented without endangering human health and without harming the environment (e.g. without risk to water, air, biodiversity, and without causing nuisance). It also sets out rules for extended producer responsibility, effectively adding to the burdens of manufacturers to manage products returned after use.

Opportunities for synergy
The WasteFD requires the adoption and implementation of Waste Management Plans and Waste Prevention Programmes at the national and local levels. These plans and programmes should analyse the current situation with regards to waste treatment, as well as identify the measures needed to carry out waste management in the context of the WasteFD's objectives. This includes existing and planned waste management installations, which are likely to constitute Projects subject to the EIA Directive. As waste installations should be provided for under Waste Management Plans, they are also subject to the requirements of the SEA Directive (see above).

The EIA Directive may also bear relevance for any Project with regard to the waste produced not only during the construction and operation of the Project, but also, in particular, with regard to the decommissioning and/or rehabilitation of the site.

During the preparation of the EIA Report, the waste produced and returned to the Project location must be taken into consideration in assessing the Project's significant effects on the environment, and would be relevant for the establishment of Alternatives and Mitigation as well as Compensation Measures.

37.2 Incineration of Waste Directive 2000/76/EC[24]

37.2.1 Summary of Directive 2000/76/EC on the incineration of waste (the WI Directive)

The WI Directive entered into force on 28 December 2000. It repealed former directives on the incineration of hazardous waste (Directive 94/67/EC) and household waste (Directives 89/369/EEC and 89/429/EEC) and replaced them with a single text. The aim of the WI Directive is to prevent or to reduce as far as possible negative effects on the environment caused by the incineration and co-incineration of waste. In particular, it should reduce pollution caused by emissions into the air, soil, surface water and groundwater, and thus lessen the risks which these pose to human health.

This is to be achieved through the application of operational conditions, technical requirements, and emission limit values for incineration and co-incineration plants within the EU.

The WI Directive sets emission limit values and monitoring requirements for pollutants to air such as dust, nitrogen oxides (NOx), sulphur dioxide (SO2), hydrogen chloride (HCl), hydrogen

[24] http://ec.europa.eu/environment/archives/air/stationary/wid/legislation.htm

fluoride (HF), heavy metals and dioxins and furans. The Directive also sets controls on releases to water resulting from the treatment of the waste gases. Most types of waste incineration plants fall within the scope of the WI Directive, with some exceptions, such as those treating only biomass (e.g. vegetable waste from agriculture and forestry). Experimental plants with a limited capacity used for research and development of improved incineration processes are also excluded.

The WI Directive makes a distinction between:

a) incineration plants (which are dedicated to the thermal treatment of waste and may or may not recover heat generated by combustion) and

b) co-incineration plants (such as cement or lime kilns, steel plants or power plants whose main purpose is energy generation or the production of material products and in which waste is used as a fuel or is thermally treated for the purpose of disposal).

The WI Directive provides for public consultation, access to information and participation in the permitting procedure.

Transposition into national legislation was necessary by 28 December 2002. From this date on new incinerators have had to comply with the provisions of the WI Directive. The deadline to bring existing plants into compliance was 28 December 2005.

37.2.2 Legislation Summary - Waste incineration [25]:

The European Union (EU) has introduced measures to prevent or reduce air, water and soil pollution caused by the incineration or co-incineration of waste, as well as the resulting risk to human health. These measures specifically require a permit be obtained for incineration and co-incineration plants, and emission limits for certain pollutants released to air or to water.

37.2.2.1 ACT

Directive **2000/76/EC** of the European Parliament and of the Council of 4 December 2000 on the incineration of waste [**See amending act(s)**].

37.2.2.2 SUMMARY

Incineration of both hazardous and harmless wastes may cause emissions of substances which pollute the air, water and soil and have harmful effects on human health. In order to limit these risks, the European Union (EU) shall impose strict operating conditions and technical requirements on waste incineration plants * and waste co-incineration plants *.

37.2.2.3 Plants

This Directive not only applies to solid or liquid waste incineration plants, but also to co-incineration plants.

[25] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM:l28072

Experimental plants which aim to improve the incineration process and which treat less than 50 tonnes of waste are excluded from the scope of the Directive, as are plants which only treat:

- vegetable waste from agriculture and forestry;
- vegetable waste from food processing, if the heat generated is recovered;
- certain fibrous vegetable waste from pulp paper or paper production if it is co-incinerated at the place of production and the heat generated is recovered;
- certain wood waste;
- cork waste;
- radioactive waste;
- animal carcasses;
- waste resulting from the exploration of oil and gas and incinerated on board off-shore installations.

37.2.2.4 Permits

All incineration or co-incineration plants must have a permit to carry out their activities. The permit will be issued by the competent authority on the condition that the requirements defined in this Directive are complied with. The permit specifies the categories and quantities of waste which may be treated, the plant's incineration or co-incineration capacity and the procedures for sampling and measuring air and water pollutants to be used.

37.2.2.5 Delivery and reception of waste

During delivery and reception of waste, the operator of the incineration plant or co-incineration plant shall take all necessary precautions to prevent or limit negative effects on the environment and risks to people.

Furthermore, prior to accepting hazardous waste at the incineration plant or co-incineration plant, the operator of the plant must have at their disposal the administrative information on the generating process, the physical and chemical composition of the waste, as well as on the hazardous characteristics of the waste.

37.2.2.6 The operating conditions

In order to guarantee complete waste combustion, the Directive requires all plants to keep the incineration or co-incineration gases at a temperature of at least 850°C for at least two seconds. If hazardous waste with a content of more than 1 % of halogenated organic substances, expressed as chlorine, is incinerated, the temperature has to be raised to 1 100 °C for at least two seconds.

The heat generated by the incineration process has to be put to good use as far as possible.

37.2.2.7 Air emissions limit values

The limit values for **incineration plant** emissions to air are set out in Annex V to the Directive. They concern heavy metals, dioxins and furans, carbon monoxide (CO), dust, total organic carbon (TOC), hydrogen chloride (HCl), hydrogen fluoride (HF), sulphur dioxide (SO2) and the nitrogen oxides (NO and NO2).

The determining of limit values for **co-incineration plant** emissions to air is set out in Annex II. In addition, special provisions are laid down relating to cement kilns and combustion plants which co-incinerate waste.

37.2.2.8 Water discharges from the cleaning of exhaust gases

Incineration and co-incineration plants must have a permit which authorises them to discharge used water caused by exhaust-gas clean-up. This permit will ensure that the emission limit values set out in Annex IV to the Directive are complied with.

37.2.2.9 Residues

Incineration or co-incineration residues must be reduced to a minimum and, as far as possible, recycled. When dry residues are transported, precautions must be taken to prevent their dispersal in the environment. Tests must be carried out to establish the physical and chemical characteristics, and polluting potential, of residues.

37.2.2.10 Monitoring and surveillance

The Directive requires the installation of measurement systems to monitor the parameters of an installation and relevant emissions. Emissions to air and to water must be measured continuously or periodically in accordance with Article 11 and Annex III of the Directive.

37.2.2.11 Access to information and public participation

Applications for new permits must be made accessible to the public so that the latter may comment before the competent authority reaches a decision.

For plants with a nominal capacity of two tonnes or more per hour, the operator must provide the competent authority with an annual report on the functioning and monitoring of the plant, to be made available to the public. A list of plants with a nominal capacity of less than two tonnes per hour must be drawn up by the competent authority and made available to the public.

37.2.2.12 Implementation reports

By 31 December 2008, the Commission must report to Parliament and the Council on the application of the Directive, progress achieved in emission control techniques and experience with waste management. This report has been included in the Communication COM(2007) 843 final.

Other reports on the implementation of the Directive will also be produced.

37.2.2.13 Penalties

The Member States must determine the penalties applicable to breaches of the Directive.

37.2.2.14 Context

This Directive aims to integrate into existing legislation technical progress in terms of monitoring emissions from incineration processes and to ensure compliance with the international commitments made by the Community with regard to reducing pollution, specifically concerning the setting of emissions limit values for dioxides, mercury and dust produced by waste incineration. The Directive is based on an integrated approach: limits relating to water discharges have been introduced alongside value limits set for emissions into air.

37.2.2.15 Key terms of the Act

- Incineration plant: any stationary or mobile technical unit and equipment dedicated to the thermal treatment of wastes with or without recovery of the combustion heat generated. This includes the incineration by oxidation of waste as well as other thermal treatment processes such as pyrolysis, gasification or plasma processes in so far as the substances resulting from the treatment are subsequently incinerated.
- Co-incineration plant: any stationary or mobile plant whose main purpose is the generation of energy or production of material products and:

References

Act	Entry into force	Deadline for transposition in the Member States	Official Journal
Directive 2000/76/EC	28.12.2000	28.12.2002	OJ L 332 of 28.12.2000

Amending act	Entry into force	Deadline for transposition in the Member States	Official Journal
Regulation (EC) No 1137/2008	11.12.2008	-	OJ L 311 of 21.11.2008

The successive amendments and corrections to Directive 2000/76/EC have been incorporated in the original text. This consolidated version is of documentary value only.

37.2.2.16 RELATED ACTS

Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) [Official Journal L 334 of 17.12.2010].

Commission Decision **2006/329/EC** of 20 February 2006 laying down a questionnaire to be used for reporting on the implementation of Directive **2000/76/EC** on the incineration of waste [Official Journal L 121 of 06.05.2006].

See also

- Integrated pollution prevention and control (IPPC Directive)
- Framework Directive on Waste

37.2.3 Legislation Summary - Incinération des déchets[26]

L'Union européenne (UE) fixe des mesures visant à prévenir ou réduire la pollution de l'air, de l'eau et du sol résultant de l'incinération et de la coïncinération des déchets, ainsi que les risques pour la santé humaine qui en résultent. Ces mesures imposent notamment l'obtention d'un permis pour les installations d'incinération ou de coïncinération et des limites d'émission pour certaines substances polluantes rejetées dans l'atmosphère et dans les eaux.

ACTE

Directive 2000/76/CE du Parlement européen et du Conseil du 4 décembre 2000 relative à l'incinération des déchets [Voir acte(s) modificatif(s)].

SYNTHÈSE

L'incinération des déchets dangereux et non dangereux peut donner lieu à des émissions de substances polluant l'air, l'eau et le sol et ayant des effets nocifs sur la santé humaine. Pour limiter ces risques, l'Union européenne (UE) impose des conditions d'exploitation et des exigences techniques strictes aux installations d'incinération * et de coïncinération * de déchets.

Les installations

La présente directive s'applique non seulement aux installations destinées à l'incinération des déchets solides ou liquides mais aussi aux installations de coïncinération.

Sont exclues du champ d'application de la directive les installations expérimentales visant à améliorer le processus d'incinération et traitant moins de 50 tonnes de déchets par an, ainsi que les installations traitant seulement:

- des déchets végétaux agricoles et forestiers;

[26] https://eur-lex.europa.eu/legal-content/FR/TXT/HTML/?uri=LEGISSUM:l28072&from=EN

- des déchets végétaux provenant de la transformation alimentaire si la chaleur produite est valorisée;
- certains déchets végétaux fibreux issus de la production de la pâte à papier ou du papier s'ils sont coïncinérés sur le lieu de production et si la chaleur produite est valorisée;
- certains déchets de bois;
- des déchets de liège;
- des déchets radioactifs;
- des carcasses d'animaux;
- des déchets provenant de l'exploitation de pétrole et gaz et incinérés dans des installations offshore.

Les permis

Toutes les installations d'incinération ou de coïncinération doivent posséder un permis pour exercer leurs activités. Ce permis est délivré par une autorité compétente sous réserve du respect des conditions définies dans la présente directive. Le permis spécifie les catégories et les quantités de déchets qui peuvent être traités, la capacité d'incinération ou de coïncinération de l'installation et les procédures d'échantillonnage et de mesure des polluants de l'air et de l'eau qui vont être utilisées.

La livraison et la réception des déchets

Lors de la livraison et de la réception des déchets, l'exploitant de l'installation d'incinération ou de coïncinération prend les précautions nécessaires afin de prévenir ou limiter les effets négatifs sur l'environnement et les risques pour les personnes.

Par ailleurs, avant que des déchets dangereux puissent être acceptés dans une installation d'incinération ou de coïncinération, l'exploitant de l'installation doit avoir à sa disposition des informations administratives sur le processus de production, sur la composition physique et chimique des déchets, ainsi que sur les risques inhérents à ces déchets.

Les conditions d'exploitation

Afin de garantir l'accomplissement total de la combustion des déchets, la directive prévoit une obligation pour toutes les installations de maintenir les gaz résultant de l'incinération et de la coïncinération à une température minimale de 850 °C pendant au moins 2 secondes. S'il s'agit de déchets dangereux avec une teneur en substances organiques halogénées, exprimée en chlore, supérieure à 1 %, la température doit être amenée à 1 100 °C pendant au moins deux secondes.

La chaleur résultant du processus d'incinération devra être valorisée autant que possible.

Les valeurs limites des émissions dans l'air

Les valeurs limites des émissions atmosphériques pour les **installations d'incinération** sont indiquées à l'annexe V de la directive. Elles portent sur les métaux lourds, les dioxines et furannes, le monoxyde de carbone (CO), les poussières, le carbone organique total (COT), le chlorure d'hydrogène (HCl), le fluorure d'hydrogène (HF), le dioxyde de soufre (SO2) et les oxydes d'azote (NO et NO2).

La détermination des valeurs limites d'émissions atmosphériques pour les **installations de coïncinération** est indiquée à l'annexe II. Des dispositions spéciales relatives aux fours de ciment et aux installations de combustion coïncinérant des déchets y sont aussi indiquées.

Rejets d'eaux usées provenant de l'épuration des gaz d'échappement

Les installations d'incinération ou de coïncinération doivent posséder un permis qui les autorise à rejeter les eaux usées résultant de l'épuration des gaz d'échappement. Ce permis doit garantir que les valeurs limites d'émission indiquées dans l'annexe IV de la directive sont respectées.

Les résidus

Les résidus du processus d'incinération ou de coïncinération doivent être réduits au minimum et recyclés dans la mesure du possible. Au moment du transport des résidus secs, des précautions doivent être prises pour éviter leur dispersion dans l'environnement. Des essais doivent être faits pour connaître les caractéristiques physiques et chimiques des résidus, ainsi que leur potentiel de pollution.

Le contrôle et la surveillance

La directive prévoit l'installation obligatoire des systèmes de mesure permettant de surveiller les paramètres d'exploitation et les émissions pertinentes. Les émissions dans l'air et dans l'eau sont mesurées en continu ou périodiquement conformément à l'article 11 et à l'annexe III de la directive.

L'accès à l'information et la participation du public

Les demandes de permis pour des nouvelles installations seront mises à disposition du public pour que celui-ci puisse émettre des observations avant que l'autorité compétente ne prenne une décision.

Les installations avec une capacité nominale égale ou supérieure à deux tonnes par heure doivent mettre à disposition de l'autorité compétente et du public un rapport annuel concernant leur fonctionnement et leur surveillance. La liste des installations qui n'atteignent pas les deux tonnes est établie et rendue publique par l'autorité compétente.

Les rapports d'application

Avant le 31 décembre 2008, la Commission doit présenter un rapport au Parlement européen et au Conseil concernant l'application de la directive, les progrès réalisés dans le contrôle des émissions et l'expérience dans la gestion des déchets. Ce rapport a été inclus dans la communication COM(2007) 843 final.

D'autres rapports sur la mise en œuvre de la directive seront aussi établis.

Les sanctions

Les États membres déterminent les sanctions applicables aux violations des dispositions établies par la directive.

Contexte

La présente directive vise à intégrer dans la législation existante les progrès techniques en matière de contrôle des émissions des procédés d'incinération et à assurer le respect des engagements internationaux pris par la Communauté en matière de réduction de la pollution, notamment ceux concernant la fixation de valeurs limites pour les émissions de dioxines, de mercure et de poussières occasionnées par l'incinération de déchets. La directive se fonde sur une approche intégrée: aux valeurs limites mises à jour pour les émissions atmosphériques s'ajoutent des limites relatives aux rejets dans l'eau.

Termes-clés de l'acte

- Installation d'incinération: tout équipement ou unité technique fixe ou mobile destiné spécifiquement au traitement thermique de déchets, avec ou sans récupération de la chaleur produite par la combustion. Le traitement thermique comprend l'incinération par oxydation ou tout autre procédé de traitement thermique, tel que la pyrolyse, la gazéification ou le traitement plasmatique, dans la mesure où les substances qui en résultent sont ensuite incinérées.
- Installation de coïncinération: une installation fixe ou mobile dont l'objectif essentiel est de produire de l'énergie ou des produits matériels et:

Références

Acte	Entrée en vigueur	Délai de transposition dans les États membres	Journal officiel
Directive 2000/76/CE	28.12.2000	28.12.2002	JO L 332 du 28.12.2000

Acte(s) modificatif(s)	Entrée en vigueur	Délai de transposition dans les États membres	Journal officiel
Règlement (CE) n° 1137/2008	11.12.2008	-	JO L 311 du 21.11.2008

Les modifications et corrections successives à la directive 2000/76/CE ont été intégrées au texte de base. Cette version consolidée n’a qu’une valeur documentaire.

ACTES LIÉS

Directive 2010/75/UE du Parlement européen et du Conseil du 24 novembre 2010 relative aux émissions industrielles (prévention et réduction intégrées de la pollution) [Journal officiel L 334 du 17.12.2010].

Décision 2006/329/CE de la Commission du 20 février 2006 établissant un questionnaire à utiliser pour rendre compte de la mise en œuvre de la directive 2000/76/CE sur l'incinération des déchets [Journal officiel L 121 du 6.5.2006].

37.2.3.1 See also

- Prévention et réduction intégrées de la pollution (directive IPPC)
- Directive-cadre sur les déchets

38 Description of the Environmental

38.1 Introduction

38.2 Description of the Area

Coordinates: 34.4924855,35.9840801,178m

38.3 Environmental Components in Akkar

38.3.1 Physical Resources

28 Description of Existing Environment

A. Physical Environment

Components/ Parameters	☐ Yes	☐ No	Remarks
1. What is the general elevation of the proposed *gasoline station project site*? <100 m 100-300 301-500 501-1,000 1,000-1,500 >1,500 (To determine elevation, refer to the topographic map where the elevation per contour line is indicated)	178m		
2. Slope and Topography of the area *(within 50 meter radius from center of site)* ☐ Terrain is flat or level (0-3% slope) ☐ Gently sloping to undulating (3-8% slope) ☐ Undulating to rolling (8-18% slope) ☐ Rolling to moderately steep (18-30% slope) ☐ Steeply rolling (30-50% slope) ☐ Very steep to mountainous (>50% slope)	☐ Terrain is flat or level (0-3% slope)		
3. Are there areas in the site where indications of soil erosion are occurring? If yes, what activities are causing erosion?			

Causes of erosion:	☐ Heavy Rains	☐ Unstable Slopes	☐ Others, pls. specify

Do you know of any land sliding occurring or that has occurred in the site? NO Cause of Landslide:

☐ Earthquake	☐ Unstable slopes	☐ Earthmoving	☐ Others, pls. specify

Has the area experienced any flooding during the wet season?	
If yes, when was the last time the area was flooded? Period(s) of flooding:	

Causes of flooding:		☐ low area	☐ poor drainage	☐ water logged areas
Soil type of the area	☐ Clayey soil	☐ Sandy loam soil	☐ Sandy soil	☐ Other soil types:

Is there an access road going to the project site?	Type of access road:

If yes, what is its distance to the site _______km.	public road
Does the site conform to the approved land use of the municipality? Yes	
Are there existing structures or developments around the project site? If yes, please list them	Electricity Water

Project Activities Affecting the Physical Environment	☐ **Yes**	☐ **No**
Cooling water cycle Waste inputmanegement Aches manegemengt Waste water manegement Are there any structures on the proposed site? Will there be demolition of existing structures? If yes, what types of structures will be demolished? Types of Structures:		
11. Is there a need to construct an access road going to the site? NO If Yes, what type of access road: [ ] all weathered road, length _____(m) width ____, [ ] concrete, [ ] asphalt		

B. Biological Environment	☐ **Yes**	☐ **No**
Are there any trees and other types of vegetation in the *project site*? If yes, please *identify*.	Yes	
Are there birds and other forms of wildlife found in the area? Please *identify*.	Yes	
Are there fishery resources in the water bodies found near or within the site? Please *identify*.		
Is the site near or within a watershed or forest reservation area? If near, only, how near? ___________ m or km If within, indicate name of the watershed or forest reservation area		
Are there any reserved forests or protected area within 1,000 m of the proposed site?		
What is the present land use in the vicinity (roughly a radius of 500m) of the proposed site?		

Coastal/ Marine	Residential	Forest	Mangrove	Grassland	Agriculture

Project Activities Affecting the Biological Environment	**Yes**	**No**
Type of vegetation on site		
1. Will there be vegetation clearing?		
2. Will clearing activities affect any critical wildlife habitats?		
3. Will clearing activities affect any rare, threatened or endangered plant and animal species?		

4. Will there be trees to be affected (e.g. cut down; remove) during clearing? If yes, how many and what are these species of trees?		
Will the project cause an increase in traffic or disrupt traffic in major routes due to the entry and exit of construction equipment?	NO	
Is the available domestic water supply enough to meet the maximum projected water consumption of the petrol station?		

For any agricultural farmland on the proposed site and/or a radius of 500m around it, provide the following information:

Main crop(s) and average yield---

Source of irrigation water--

Area attached by salinity or water logging---

C. Socio-Economic Environment

1. Are there existing settlements in the proposed station? If yes, indicate the number of: (within 50m radius) Yes

Households/Families:___, Legitimate landowners: ____; Tenants:______; Squatters:____________

Are there existing social or cultural infrastructures within 1000m of the proposed site or in the area?

Type	Names and number if more than 1	Size (No. of students or beds)	Location (village, road, district, etc.)	Distance from Site
Schools/College				
Hospitals				
Health centers/clinics				
Communications library				
Churches/Mosques				
Archeological site				
Others				

Project Activities Affecting the Socio-Cultural and Economic Environment	**Yes**	**No**
Will the project cause or increase traffic in the areas?	Yes	
Are there existing transport services/facilities routing the areas?		
Will the project cause an increase in traffic or disrupt traffic in major routes due to the entry and exit of construction equipment?		

Is there a prevailing water shortage or water supply problem in the area?		No
Are there already existing commercial establishments within the vicinity of the project area?		

38.3.2 Ecological Resources

38.3.3 Socio-Cultural and Economic Activities

38.3.4 Education and Literacy

38.3.5 Environment, Archaeological Sites and Cultural Heritage 40

38.3.6 Cultural Facilities

39 Description of the Project

39.1 Location of the Project

Coordinates: 34.4924855,35.9840801,178m

39.2 Type of Project (Size and Magnitude of the Project)

The project is the commisioning of a pilot plant (waste incineration power plant). It is a mobile plant on a standard truck trailer (with overhangs 14mx3m). The generated power is 25 kW (optional 40kW).

39.3 Need of the Project & Project Oblective

To convince Lebanese authorities that a waste incineration power plant with the appropriate waste remnats traetment is one of suitable solutions for the Lebanese waste problem this pilot project shall be undergone.

39.4 Data Collection and Preparation of Maps

During commisioning and operation emissions data shall be measured and collected.

39.5 Methodology

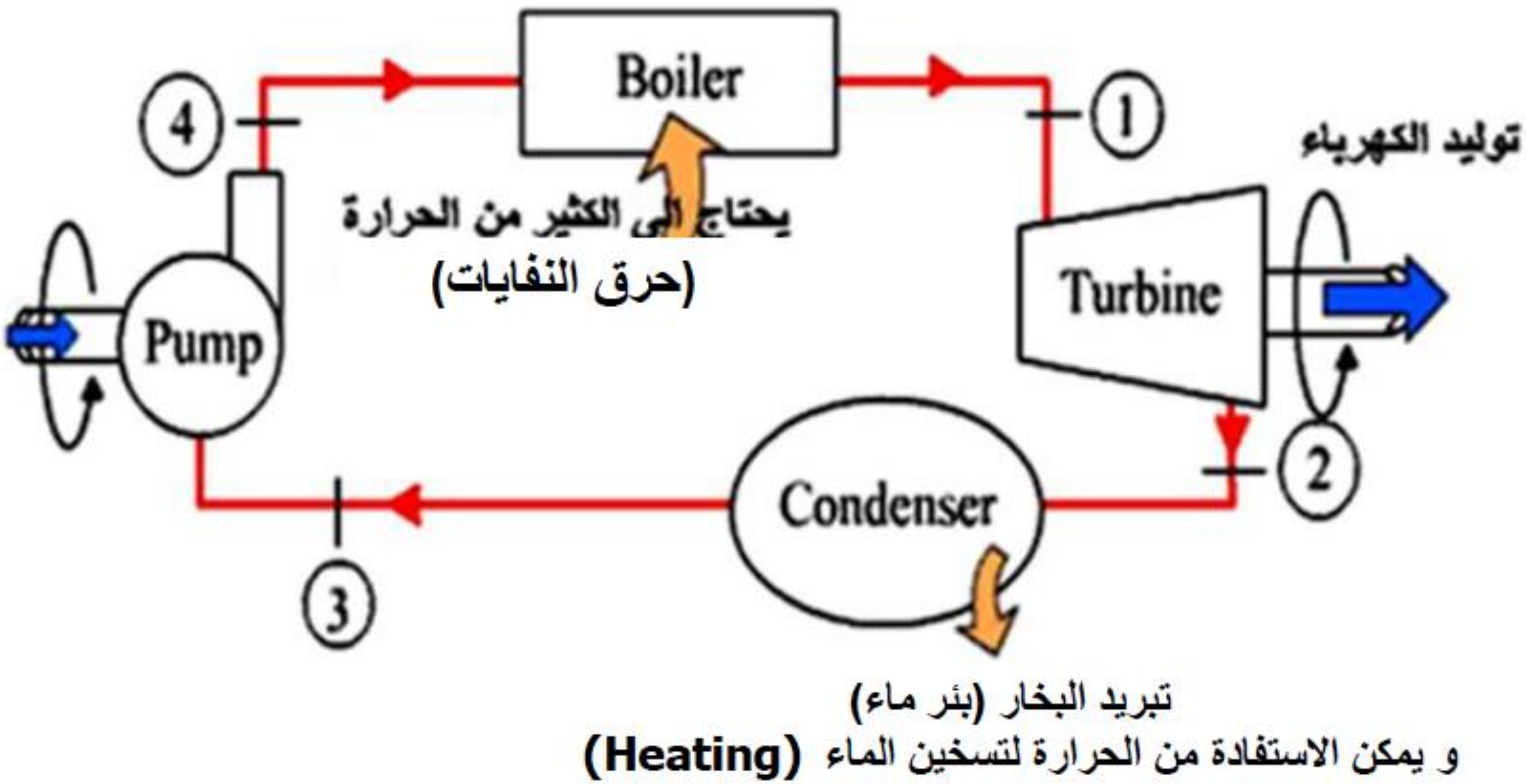
After commisioning the plant shall be oprated for 8 hours a day. During operation the exact waste volume per day needed to generate the power the will be known insha Allah.

39.6 Description of the Project

An already built waste-to-electricity small scale mobile pilot plant shall be commisioned. The operation is planned for 8 hours a day and for 1 year in a refugees camp. All waste of the refugees camp shall be treated and the generated electricity shall be offered for free to the refugees camp.

- The plant eliminates about **1 (tons/day)** of camp waste (depending on their type).
- The plant includes a **filtration system** to fulfill the Lebanese and International requirements and norms concerning smoke emissions.
- Incineration remnant (**Smoke and Ashes**) are **recycled**. Wate water is treated.

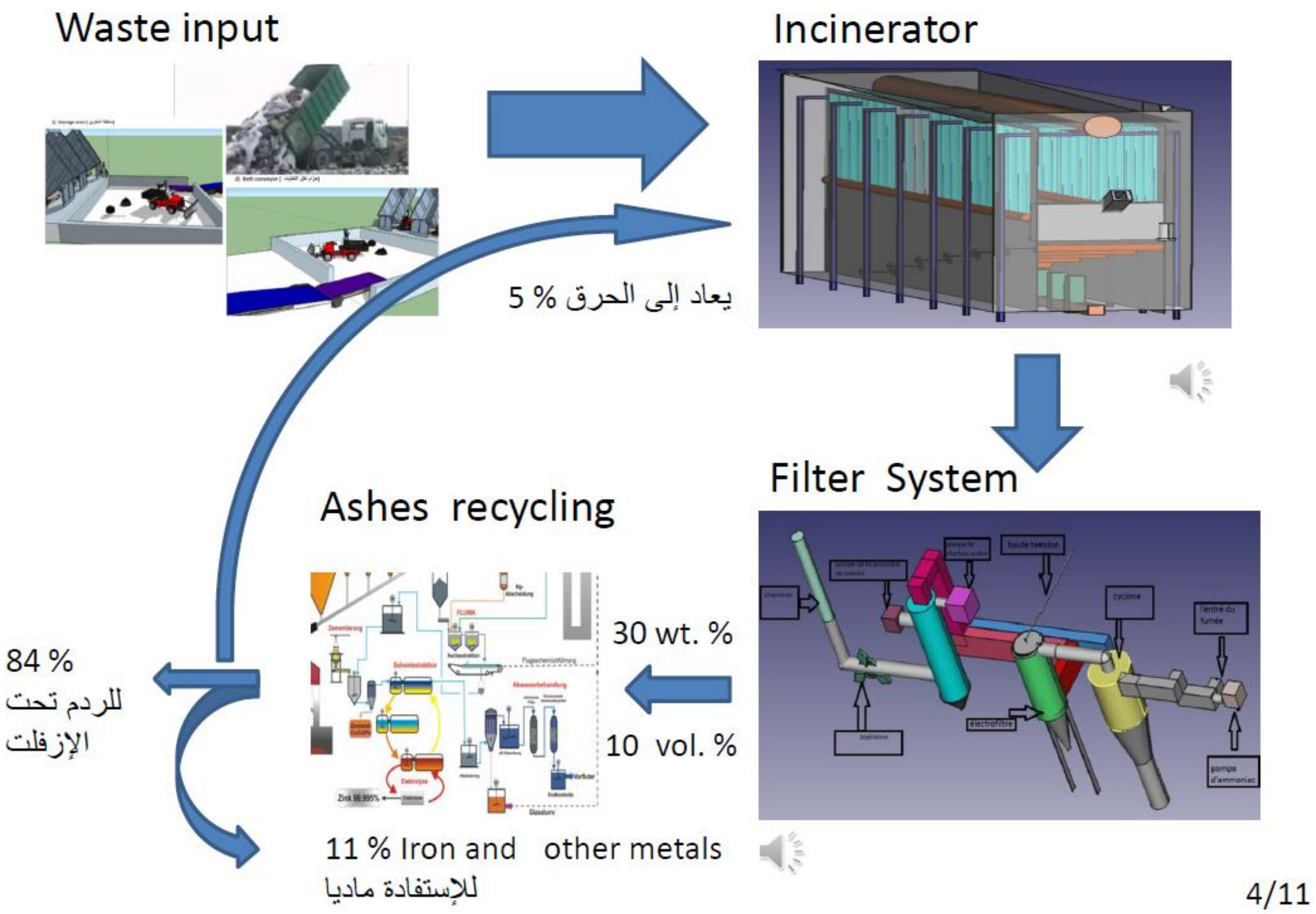
39.6.1 Schema of kernel power plant (without waste input treatment and waste material output treatment)



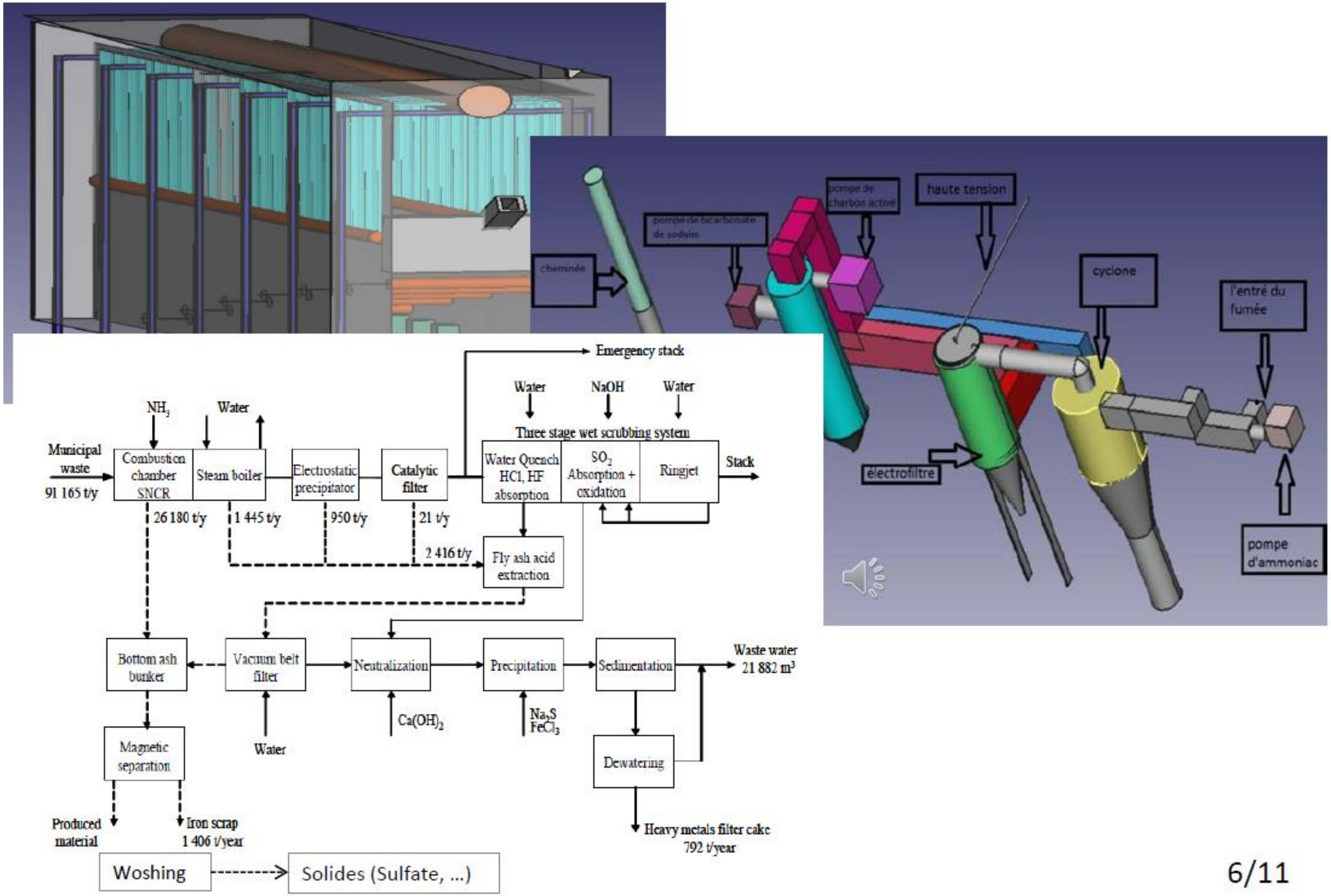
39.6.2 The already built kernel power plant (mobile plant NLAP-IPP)

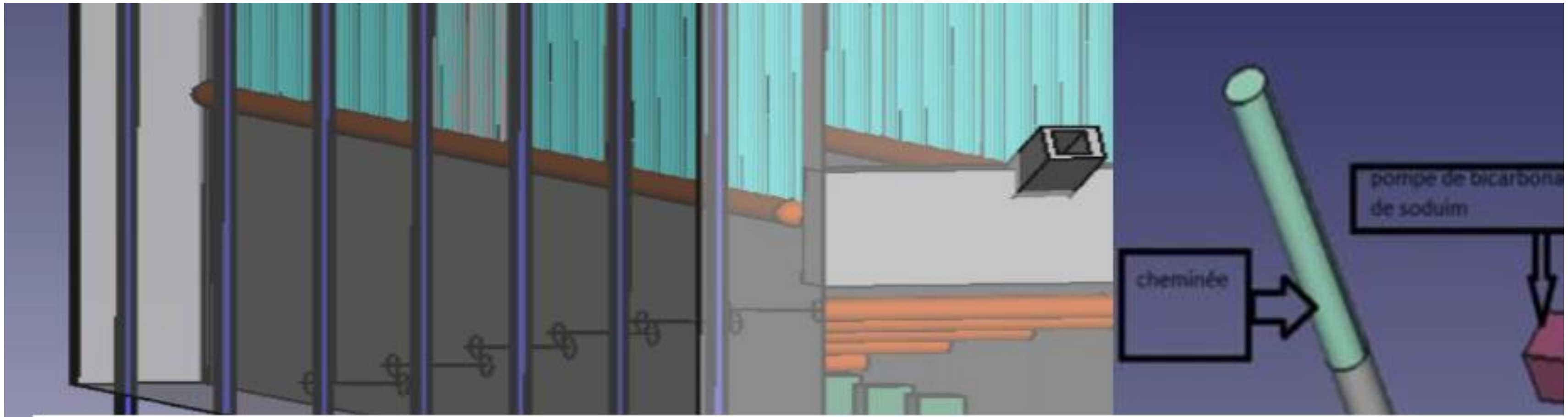
IN		OUT	
Type	Quantity	Type	Quantity
Waste	1 ton/day	Electricity	25 kW
Cooling Water	10 m³/day	Smoke (Dust)	< 170 mg/m³
Electricity	2 kW	Ashes	300 kg/day (30% M, 10% V)
		Hot Water	10 m³/day

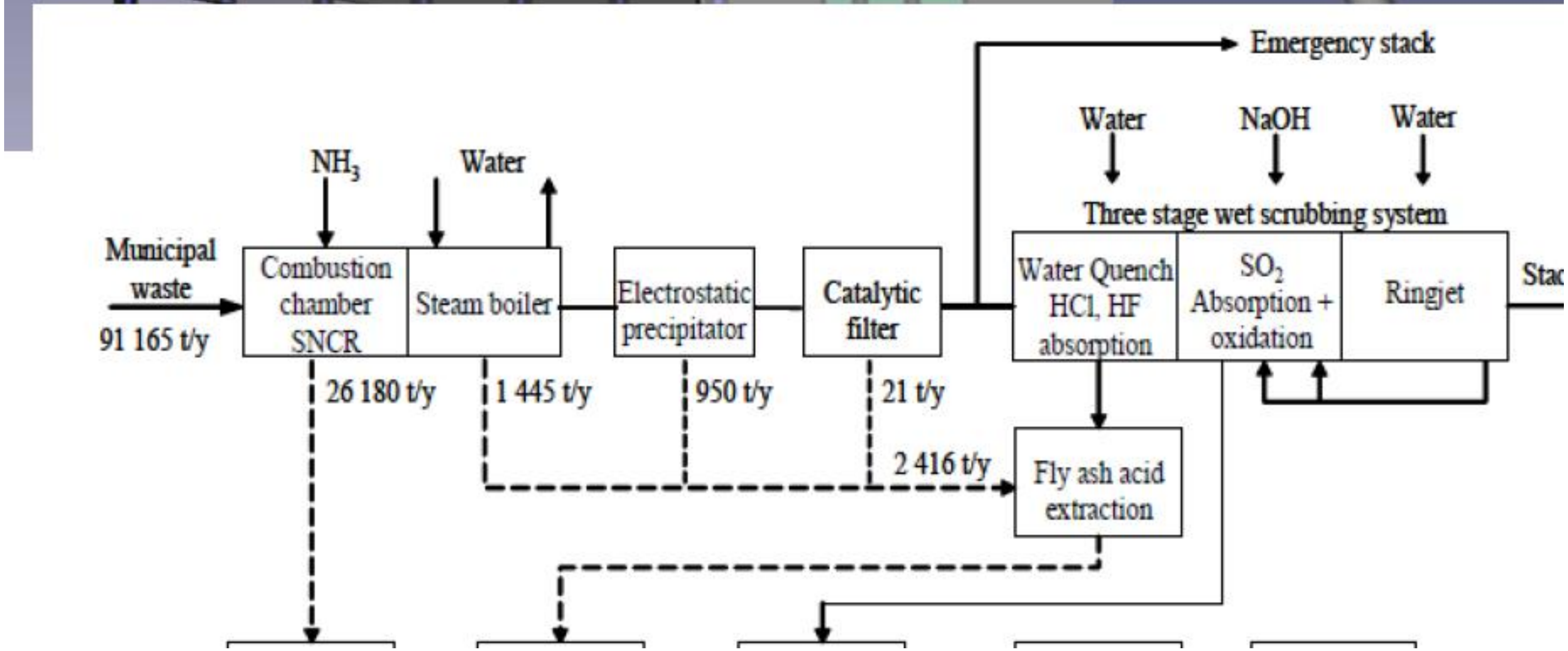
39.6.3 Waste material cycle



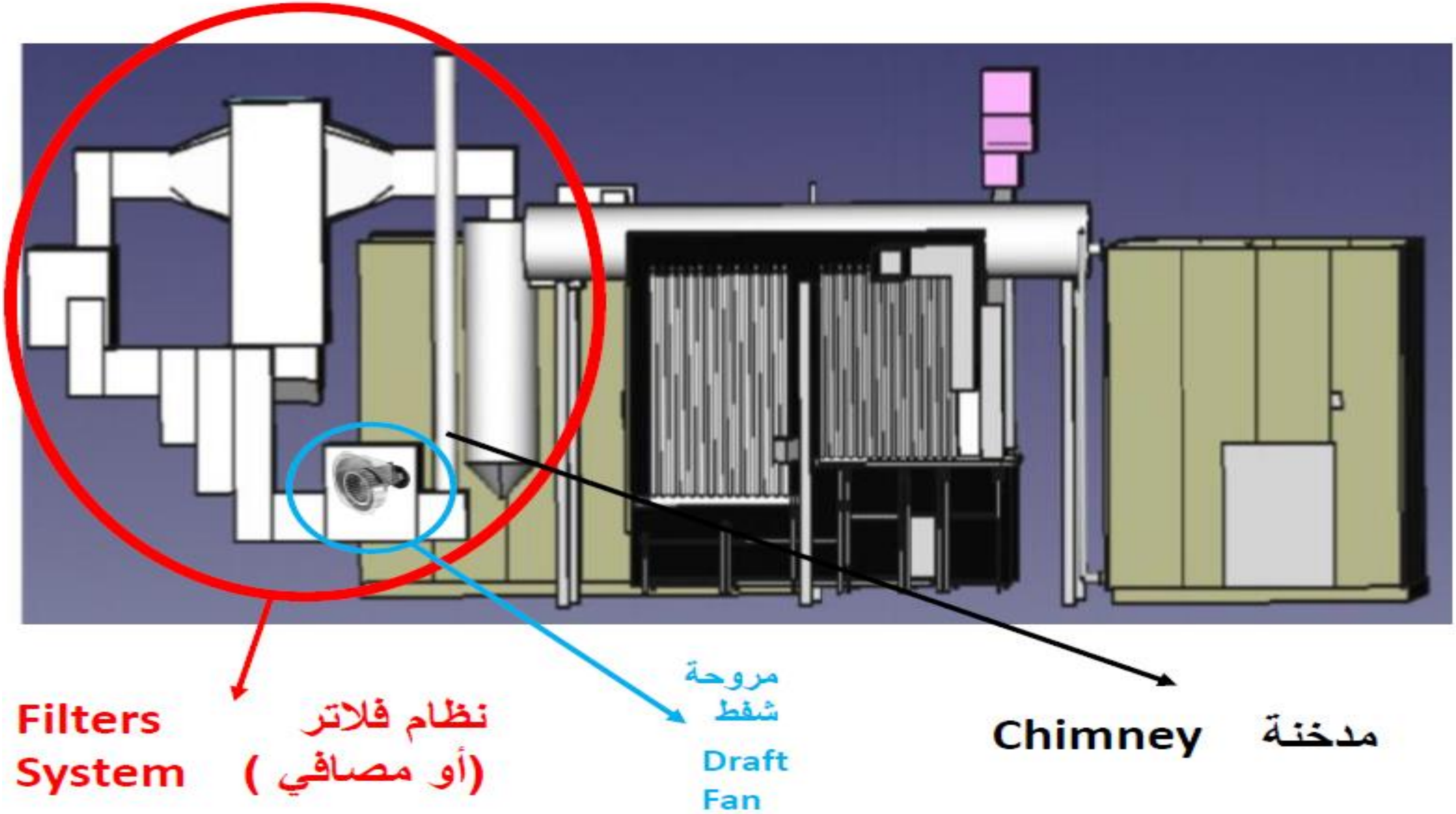
39.6.4 Incinerator (Burning chamber) and filters







above mass flow data for a **250t**/day incinerator


Filters System
نظام فلاتر
(أو مصافي)
مروحة شفط
Draft Fan
Chimney
مدخنة

Evacuations system (Chimney, Filters & Ducts)

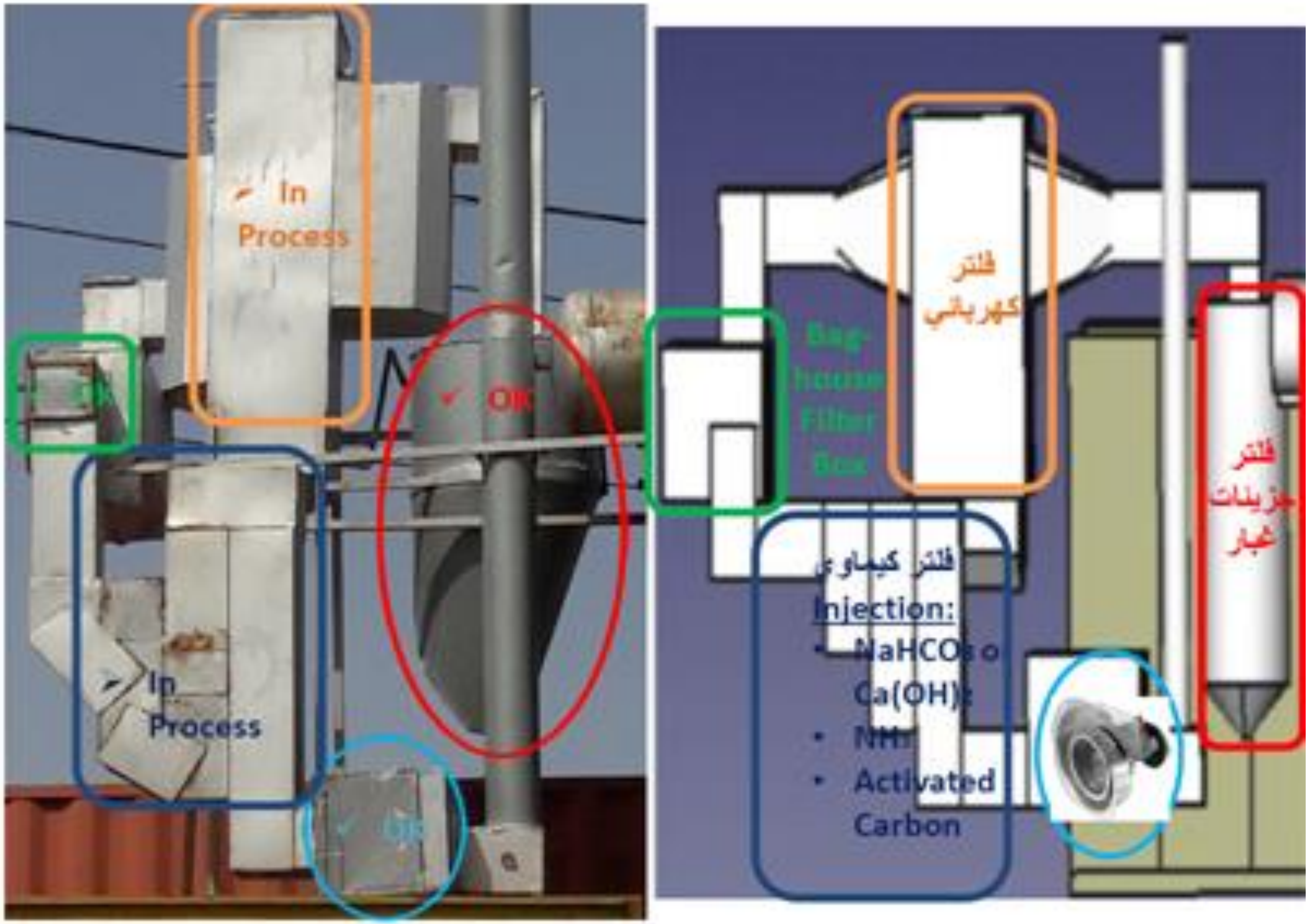
نظام سحب الدخان (مدخنة، فلاتر و أنابيب)

- نظام فلاتر
- Filters System

- مدخنة
- Chimney

- Burning Chamber
- Evaporator

- Turbine
- Electrical-Generator
- Condenser


In Process
OK
In Process
فلتر كهربائي
Bag-house Filter Box
فلتر كيماوى
Injection:
• NaHCO3 o Ca(OH)2
• NH3
• Activated Carbon
فلتر جزيئات غبار


فلتر
كهرباني
Bag-house
Filter
Box
فلتر
جزيئات
غبار
فلتر كيماوي
4 Feet (Electrical Filter)


Bag-house
Filter

39.7 Layout Specifications

مساحة الأرض المطلوبة (حوالي 500 متر مربع)

- الارتفاع = 620 cm
- الطول = 1400cm
- العرض = 280 cm

ألان لننظر إلى :

محطة نظام حرق النفايات المتحركة

mobile NLAP-IPP unit

39.7.1 Construction Material

Mostly steel/stainless steel

39.7.2 Construction Equipment

Equipment is available at site.

39.7.3 Construction of the sewage collection network

tbd

39.8 Financial Plan (Project Cost)

The overall budget was originally 30,000$, then updated to 67,000$.

39.8.1 Original Funding utilization and milestones

39.8.1.1 For installation

Date	Milestone		Funding need
20 March 2018	**Ground** preparation	Infrastructure	2000 $
26 March	**Transportation**, **Training** waste separation	Logistic, Education	700 $
2 April 2018	**Installation** (assembly, welding parts, Components controls…)	Incinerator plant project	500 $
9 April	**Insulation** (Incineration Ch., Evaporator, Condenser, Chimney…)	Incinerator plant project	1200 $
16 April	**Water** supply & Accessories (Tank, Pump, Pipes, Filtration & Demineralization RO)	Incinerator plant project	2000 $
23 April	**Process Control System** (Valve, Sensor, Display, Electronic devices & software) installation	Incinerator plant project	600 $
30 April	Smoke **filtration** System & Tests	Incinerator plant project	1500 $
May –June 2018	**Operating** the System (see **Staff Costs**)	Incinerator plant project	

Total			8500 $

39.8.1.2 For commisioning and operation

* Staff Costs / month			
Task	**Number**	**Qualification**	**Salary/month**
Project manager	**1**	**Eng. expert**	**NLAP internal**
Developers	**2**	**Master Physics, Eng.**	**NLAP internal**
Waste Separation employees	**1**	**Unlearned worker**	**300 $**
Machine Operators	**4**	**Unlearned worker**	**4x300$= 1200 $**
Maintenance		**Technicians: (Plumbing, Welding, Electricians…)**	**300 $**
Total Man Salary/Project	**8**		**1800$ + NLAP internal staff cost**

39.8.2 Updated Funding utilization and milestones (last update 8.10.18)

Mar- June 2018		
Prepraration of plant in Rayhaniyya Camp Mar-June/2018	$9.500	material + external suppliers cost + project management
	$7.000	technical project leader cost (Dr Khaled Maulaoui) AECENAR كتب المبلغ كأسهملصالح ->

June - Nov 2018		
Getting permission from Environmental Ministry in Lebanon for Operational Test Phase Sep-Dec 2018	$1.800	متابعة
	$800	متابعة
	$1.200	اعداد الاوراق، متابعة
		تقييم اثر بيئي (من شركة معتمدة لدى وزارة البيئة) م.
	$7.000	جرجيس، د. مرفت الهوز

Completing Preparation of Plant		
	$2.000	Cooling Cycle, sewage collection network
	$2.000	Insulation
	$3.000	Waste Separation
	$1.500	Waste Inlet and Oulet

Installing Process Control System at Plant		
	$1.200	Turbine Control Cycle
	$1.200	Boiler Pressure Control
	$1.200	Incineration Control

Waste Separation & Inlet Preparation, Sewage Network		
	$1.500	Waste Separation

Sep-Dec 18		$1.500	Waste Inlet and Oulet

Commisioning and Operating of Plant			
Jan-Jun 19	**Project manager (1)**	$12.000	
	Developers waste recyling (1,5)	$3.000	
	Waste Separation employees (2)	$7.200	
	Machine Operator & Monitoring Process Control (1)	$3.600	
	Maintenance	$3.000	

costs Mar-June 18	$16.500
costs Jul-Dec 18	$22.100
costs Jan-Jun 19	$28.800
Total	**$67.400**

Still open (last update: 8.10.18) $50.900

39.9 Site Visit

In Rayhaniyya Camp 10.6.2018

وقد تم زيارة المخيم في 1 تشترين الاول. وكانت في مكان تمركز المحطة اوساخ وروائح كريهة ناتجة عن المكب النفايات هناك. وكانت كثير من الحشرات (flies) على الارض.

فأزالة النفايات في الحرق سيكون حل لهذه المشكلة ان شاء الله.

39.10 Processing Techniques and Unit Operations (Size and Magnitude of the Project) & Human Resource

Please refer to 4.8.2 " Updated **Funding utilization and milestones** (last update 8.10.18)", Section " Commisioning and Operating of Plant"

For preparing&installation:

2 engineers, 3 workers

For operation:

about 2 engineers, 4 workers

39.11 Infrastructure Services (Proposed Infrastructure/Utilities and layout)

39.11.1 Environmental Aspects

Not relevant because of filters and internal heavy metal recovery plant.

39.11.2 Power Supply

No external power supply needed

39.11.3 Water Supply

5 t/ day cooling water, to be taken from local water supply pipe.

39.11.4 Sewerage Services

1 time per week about 2 tons solid waste remnant has to be taken to final destination.

39.11.5 Solid and Liquid Waste Management

Heavy Metals recovering plant under development and construction

39.11.6 Proposed Wastewater Treatment Plant

tbd

40 Correspondance with Ministry of Environment

40.1 Screening application for the installation of a prototype waste to energy unit in Rayhaniyi Camp in Lebanon

13. August 2018 15:46 48 KB
Von: Daniah Turjman

An: samir.mourad@aecenar.com

Cc: Diane Derjani, Samar Malek (1 weitere)

Dear Mr. Mourad,

I hope this email finds you well.

Following our telephone conversation regarding the installation of a prototype waste to energy unit in Rayhaniyi Camp in Lebanon; kindly find attached the screening application (Annex 4 of Decree 8633/2012 for Environmental Impact Assessment).

You will need to fill in the application and submit it, along with all the supporting documents, to the Ministry of Environment.

Accordingly you will receive an official reply stating what type of study your project requires before getting the Ministry and Governor's approval on commencing your project.

For any other queries do not hesitate to contact me on the below details.

Best Regards,

Daniah

Daniah Turjman
Environmental Specialist
Department of Integrated Environmental Systems
Service of Environmental Technology

Address | Ministry of Environment, Lazarieh Center, 7th Floor, Block A-4, Room 7-50 A. P.O. Box: 11/2727- Beirut, Lebanon
Telephone | +961 1 976555- Ext: 554

40.1.1 ملحق رقم 4: نموذج التصنيف لتقييم الأثر البيئي

1. اسم المشروع:

2. صاحب المشروع:
   - ❑ الاسم:
   - ❑ العنوان:

❑ رقم الهاتف: ❑ رقم الفاكس:

❑ البريد الإلكتروني:

3. صنف المشروع:

❑عام ❑زراعي:

❑خاص ❑صناعي (مع تحديد رقم ISIC):

❑ ❑سياحي (مع التحديد):

❑خدماتي (مع التحديد):

❑غيره:

4. طبيعة المشروع:

❑مشروع جديد ❑مشروع قائم أو حائز على ترخيص أو موافق عليه

- ❑ تعديل
- ❑ إضافة
- ❑ توسيع
- ❑ إعادة تأهيل
- ❑ إقفال

5. أهداف المشروع:

6. الكلفة المقدرة للمشروع:

❑إنشاء:

❑تجهيز:

7. البرنامج الزمني للمشروع:

	البداية	النهاية
التخطيط والتصميم		
الإنشاء		

		التشغيل

8. خريطة تبين موقع المشروع – مقياس 20,000/1 (مرفقة)

خريطة مساحة مع إفادة عقارية

إفادة ارتفاق وتخطيط والشروط الخاصة للمنطقة

الاحداثيات الجغرافية للعقار (GPS coordinates)

9. مستندات أخرى مرفقة (تصميم المشروع ووصف المشروع وتفاصيل أكثر عنه)

ملاحظة: يجوز لوزارة البيئة أن تطلب مستندات أخرى تتلاءم مع طبيعة المشروع.

40.2 RE: Screening application for the installation of a prototype waste to energy unit in Rayhaniyi Camp in Lebanon

27. August 2018 12:55 1,3 MB

Von:

Daniah Turjman <D.Turjman@moe.gov.lb>

An:

samir.mourad@aecenar.com

Cc:

Diane Derjani <D.Derjani@moe.gov.lb>, Samar Malek <S.Malek@moe.gov.lb>, Jeryes Berbari <J.Berbari@moe.gov.lb>

Dear Mr. Mourad,

Thank you for your email.

Whilst I appreciate sending me the attached documents via email, unfortunately the email is not considered as an official mode for registering your screening application at the Ministry of Environment.

Therefore I should kindly ask you to send a printed copy of the screening application with the necessary documents mentioned in point 8 of the application.

Only then, we will be able to reply to you through a letter from the H.E. the Minister with what your project requires.

In case your project requires an Environmental impact Assessment study or an Initial Environmental Examination, I have attached the list of approved environmental consultants who can help you prepare this study.

Kindly note that as a preliminary assessment your screening application shows that your project being a ISIC 3720 classified, will need a full Environmental Impact Assessment study. However I should still ask you to submit the screening application as this email shall not be considered as an official classification.

In case you have any further queries do not hesitate to contact me.

Best Regards,

Daniah

Daniah Turjman
Environmental Specialist
Department of Integrated Environmental Systems
Service of Environmental Technology

Tel | +9611976555 - Ext: 554
Web | http://www.moe.gov.lb/
Ministry of Environment, Lazarieh Center, 7th Floor, Block A-4, Room 7-50 A. P.O. Box: 11/2727- Beirut, Lebanon

From: Samir Mourad [mailto:samir.mourad@aecenar.com]
Sent: Tuesday, August 14, 2018 12:09 PM
To: Daniah Turjman
Cc: Diane Derjani; Samar Malek; Jeryes Berbari
Subject: Re: Screening application for the installation of a prototype waste to energy unit in Rayhaniyi Camp in Lebanon

Dear Mrs. Turjman,

thank you very much for the kind telephone call yesterday.
Please find attached the filled file and an attachement concerning the project.
Also please find the following video describing the former phases of the project:
https://www.youtube.com/watch?v=FhQp8ZP52Dg
(Interview with Lebanese MTV and kataeb.org on 5 August 2015)

For more information please refer to this site: http://aecenar.com/institute-projects/nlap-wedc

Best regards,
Samir Mourad

Dr. Eng. Samir Mourad, Director

Phone (Mobile Lebanon) +961 76 341 526
(Mobile Germany) +49 (0)178 72 855 78
Email: samir.mourad@aecenar.com
Association for Technological and Economical Cooperation in the Euro-Asian and North-African Region (AECENAR)
Haykaliyeh Str. Harba Bldg. Ground Floor
Ras Maska
Tripoli, Lebanon

www.aecenar.com

40.2.1 Attachments

مجلس الإنماء والإعمار

بيروت - لبنان

الرقم : ١/١٩٧٨

بيروت في ٢٠١٨/٥/٣

معالي وزير البيئة المحترم

الموضوع: لائحة بالمكاتب الهندسية الاستشارية اللبنانية المؤهلة لدى مجلس الإنماء والإعمار ضمن خانة الدراسات البيئية

المرجع: - كتابكم رقم ٤٣٦٧/ب تاريخ ٢٠١٤/١٠/١٨ المسجل لدى المجلس تحت الرقم ١٠٢٢٥/م.ر. تاريخ ٢٠١٤/١٠/٢٠
- كتابنا رقم ١/١٢٤ تاريخ ٢٠١٨/١/٩

بالإشارة إلى الموضوع والمرجع المبينين أعلاه،

وعطفا على كتابكم المشار اليه في المرجع أعلاه، المتضمن طلبكم تزويدكم بلائحة المكاتب الهندسية الاستشارية اللبنانية المؤهلة لدى مجلس الإنماء والإعمار لدراسة أو الإشراف على تنفيذ مشاريع في فئة الأعمال الأخرى المختلفة – خانة الدراسات البيئية، على أن يصار الى تزويدكم تباعا بأي تحديث يطرأ على هذه اللائحة، نبين أدناه اللائحة المطلوبة، وذلك بدلا من تلك الواردة في كتابنا رقم ١/٥١٨٥ تاريخ ٢٠١٧/١١/١٧:

- ACE - Associated Consulting Engineers
- Al Mouhit Consulting Engineers (MCE)
- Beirut Business Management Consultant (BBMC) S.A.R.L.
- BTD - Bureau Technique pour le Développement
- BTUTP - Bureau Technique d'Urbanisme & des Travaux Publics
- Dar Al Handassah (Nazih Taleb & Partners)
- Dar Al Handassah Consultants (Shair & Partners)
- Delta Engineering Studies
- Earth Link & Advanced Resources Development SAL - ELARD
- Ecocentra S.A.R.L.
- Ecodit Liban S.A.R.L.
- El Bacha L.L.C.
- Engico Consulting Engineers
- Engineer Roger Georges Khalil
- Engineering & Environmental Consultants S.A.R.L.
- Engineering, Design & Environmental Services - Edessa
- Envirotech Ltd.
- Geoflint S.A.R.L.

PQListsCsElAMOfEnv10225PO2010BD356-26-4-2018
2/5/18

مجلس الإنماء والإعمار

- Geti
- Gicome - Antoine Salamé & Associés
- Information International Ltd.
- Issa Consulting
- Jouzy & Partners CEB
- Kabbara & Associates
- Kassia Environmental Consultancy SARL
- Khatib & Alami, Consolidated Engineering Co.
- Kredo s.a.l.
- Lebanese Arab Co.For Eng. & Consultancy "Laceco"
- Libanconsult AGM
- Matrix Engineers
- Maurice Bonfils Architecte (MBA)
- Mazen Ramadan - Consulting Engineers
- Middle East Engineers and Architects s.a.r.l.
- Mores S.A.R.L.
- Nicolas Gerges & Sons (Scte N.Gerges & Fils)
- Rafik El-Khoury & Partners Consulting Engineers
- S.E.S. Sustainable Environmental Solutions S.A.L
- Santec
- Services Design Technology Lebanon SARL (SDT)
- Spectrum Engineering Consultants S.A.R.L.
- Touma Engineering SARL-Engineering & Research
- Team International
- TURBA Ltd
- United Management Bureau Quality Management Institute

علما بأن هذه اللائحة هي عرضة للتعديل وفق المعطيات التي ترد الى المجلس من قبل المكاتب الهندسية المعنية.

وتفضلوا بقبول فائق الاحترام.

رئيس مجلس الإنماء والإعمار

نبيل عدنان الجسر

PQListsCsEIAMOfEnv10225PO2010BD356-26-4-2018
2/5/18

2/2

	Firm	Contact person	Email	Phone number	Fax
1	ACE - Associated Consulting Engineers	Jimmy Hakim	ace@ace-intl.com	01-497250/ 1/2/3/4/5/6/7/8	01-497550
2	Al Mouhit Consulting Engineers (MCE)	Nada Soboh	mohitfawaz@live.com	01-835 449	
3	Beirut Business Management Consultants (BBMC) S.A.R.L.				
4	BTD- Bureau Technique pour le Developpement	Mr. Michel-Abboud N Majdalani (Chairman & General Manager) Mr. Jean M Hajal (Member of the Board) Mr. Jean-Pierre A Seoud (Member of the Board)	btd@btd-lb.com	04-712157	
5	BTUTP- Bureau Technique d'Urbanisme & des Travaux Publics		btutp@btutp.com btutp@cyberia.net.lb	01-820 472 01-821 046 01-826 051 01-381281 01-312548	
6	Dar Al Handassah (Nazih Taleb & Partners)	Karim Yammine	info@daralhandasah.com	01-866665	01-863434
7	Dar Al Handassah Consultants (Shair & Partners)	Fouad El Khoury	beirut@dar.com fouad.khoury@dar.com	01-790002	01-869011
8	Delta Engineering Studies	Youssef Hamze	yhamze@ul.edu.lb	03-828612	07-760612
9	Earth Link & Advanced Resources Development SARL - ELARD		info@elard-group.com; rkhoury@elard-group.com	01-896793 01-888305	ext: 146
10	Ecocentra S.A.R.L		info@ecocentra.me	01-746799	01- 746799
11	Ecodit Liban S.A.R.L.		liban@ecodit.com; kjisr@ecodit.com; cchabarekh@ecodit.com	05-458 012	05-458 013
12	El Bacha L.L.C		info@bachaconsulting.com	01-900632	03-075551
13	Engico Consulting Engineers		info@pixelinvention.com	01-575753	
14	Engineer Roger Georges Khalil		rogerkhalil@yahoo.com	03- 116603	01-893830
15	Engineering and Environmental Consultants S.A.R.L				
16	Engineering, Design & Environmental Services-Edessa	Jaque Chahine	beirut@edessagroup.com jchahine@edessagroup.com	01-615 140 03-330 268	01-615 140/2

17	Envirotech Ltd.			01-390170 76-334848	01-390170
18	Geoflint S.A.R.L.	Khalil Zein	info@geoflint.com; kzein@geoflint.com	03-219059	05-955886
19	Geti		najla@e1holding.com	03-416668 Najla 03-309355 Christian 01-397291 01-397027 01-203094	01-203136
20	Gicome S.A.R.L.	Michel Khayata	michel.khayata@gmail.com; info@gicome.com	03-902040 Mr. Michel Khyata 01-333 997/8	
21	Information International Ltd.		infointl@information-international.com	01-983008/9	01-980 630
22	Issa Consulting				
23	Jouzy & Partners CEB			01-785948	
24	Kabbara & Associates		info@KabbaraAssociates.com	01-803112	01-803 112 – Ext. 104
25	Kassia Environmental Consultancy SARL		inquiries@kassia-env.com	03-727 230 01-342 093	01-342 093
26	Khatib & Alami, Consolidated Engineering Co.	Maher Habanjar	beirut@khatibalami.com maher.habanjar@khatibalami.com	01-843843	01-844400
27	Kredo s.a.l.		kredo@kredo.net	01-204957/8/9	01-336 399
28	Lebanese Arab Co.For Eng & Consultancy "Laceco"		laceco@laceco.net	01-340304	01-736 454
29	Libanconsult AGM		libanconsult@libanconsult.com; naji.abouassaly@libanconsult.com	01-613 863 03-320678	01-427 530
30	Matrix Engineers			05-457488	
31	Maurice Bonfils Architecte (MBA)				
32	Mazen Ramadan - Consulting Engineers		mazenramadan@hotmail.com	01-808540 03-753159	
33	Middle East Engineers and Architects s.a.r.l.		rhaddad@afedonline.org	01-321800	01-321 900
34	Mores S.A.R.L.		mores@mores.com.lb; raji.maasri@mores.com.lb; Helen.mounzer@mores.com.lb	05-953 927 71-747 161	05-953 268
35	Nicolas Gerges & Sons (Scte N.Gerges & Fils)		najibgerges@yahoo.com	03-340 776 03-345867	06-204 529
36	Rafik El-Khoury & Partners Consulting Engineers	Mazen Makki	contact@rafikelkhoury.com; Mazen.makki@rafikelkhoury.com	01-493150 03-370426	01-493 151
37	S.E.S Sustainable Environmental Solutions S.A.L		info@ses-lb.com; nchamieh@ses-lb.com	01-374287/8	01-371 864
38	Santec	Azzam Sankari	a.sankari@santec.com.lb	01-203730	
39	Services Design Technology Lebanon SARL (SDT)		branch.lebanon@sdtconsultant.com	01-250835	
40	Spectrum Engineering Consultants S.A.R.L	Hisham Mneimneh	hisham.mneimneh@spectrumlb.com	01-309416	01-817035
41	Team International		teambeirut@team-international.com	01-353458 01-353477	
42	Touma Engineering SARL-Engineering & Research	Bassam Touma	btouma@touma-engineering.com	04-715401/2/3 03-885288	04-712 478
43	TURBA Ltd		info@turbasolutions.com	01-385081	01-385 082
44	United Management Bureau Quality Management Institute		info@qmiaw.com		01-455 512/3/4

40.3 Meetings with Dr Mirvet House

د. مرفت الهوز تتعامل مع المكتب الوحيد المرخص في الشمال (Najib Gerges 06 204 529)

ونشكر الدكتورة على مساعدتنا.

وقد بعثت لنا هذه الاستمارة لتقوم بتقويم الاثر البيئي:

40.3.1 Project Information

1. Project Name: n
2. Project Owner:
3. Land Ownership:
4. Full Address:
5. Phone:
6. Fax:
7. Email address:
8. Lot number:
9. Petroleum brand: usual
10. Project Cost:
11. Operation:
12. One shift per day?
13. Any days for maintenance:
14. Working days:
15. Man power operating the process:

Position	**No. Required**
Manager	
Total	

16. The number of vehicles arriving the site: 2 / week
17. Type of equipment
18. Population size of village: ca
19. Proximity to Waste Generation Center
20. Proximity to Energy Distribution Networks

21. Project Category:

☐

22. General Land Classification

☐ Agricultural	☐ Residential	☐ Tourism
☐ Industrial	☐ Forest Land	☐ Institutional
☐ Commercial	☐ Open Spaces	☐ Others, Pls. Specify:

23. Project Components

Services			
Facility	**No. of Unit**	**Area (m^2)**	**Capacity**
Access? Originating from? To?			
Area of the incineration			
Total area of the site			
Shape of the site (Length, width)			
Maximum height of infrastructure			
Type of incineration			
Furnace			
Type of Byproducts			
Ash and clinker removal system			
Energy recovery system			
Air pollution control (APC) system			
Stack height			
Any produced Leachate?			
Source and Composition of municipal wastes to be incinerated			
Fuel Storage Area			
Parking Area			
Office Bldg.			
Public Toilets			
Others, Pls. Specify			
Logistics and Principles of Sampling and Analysis of Waste Data			

Design and Layout of the Mass Burning Incineration System

24. Water Resources and Infrastructure

Water Supply Source			Remarks
Existing Public Water			
Estimated daily water requirements of the proposed incineration?			

Deep Well (Underground tanks)

Water Source	No. Wells/Hand Pump/Tanks	Location	Depth (m)	Discharge (liter / sec)
Deep Well w/ Manual Hand Pump				
Deep Well w/ Electric or Motor Pump				

Stormwater Management System (collector pipe, where to?, site drain) Drainage System

☐ Rainwater will be collected in storage tank
☐ Rainwater will be collected in Reservoir
☐ Rainwater will be collected in collector pipe, where to?
☐ Rainwater will be connected to public drainage system
☐ Rainwater will be connected to natural outfall / water body

Drainage System

Type of drainage:

a) Major Road:
b) Other road (street):

Is there any surface water body (river, canal, stream, lake, wetland) within 1,000m of the proposed site?

☐ Yes **☐ No**

If yes, describe each surface water body close to site

Water Source	Name of Water Body	Location	Distance
1. Creek			
2. Spring			
3. Stream			
4. River			
5. Others			

25. Power Supply (Source of Power)

☐ Local Electric
☐ Own Generator:
☐ Others, pls. specify

26. Wastewater (Sewage) Disposal System

Sewage System:

☐ Individual Septic Tank	☐ Communal Septic Tank

Sewage Design:

☐ 2 chamber septic tank with leaching	☐ 2 chamber septic tank without leaching
☐ 3 chamber septic tank w/ leaching **X**	☐ 3-chamber septic tank w/o leaching
☐ On site wastewater treatment plant, pls. specify	

Sewage Disposal

discharge to an existing public sewerage system

Treatment in individual septic tanks with disposal by absorption field or leaching pit

Others: (Specify)___________________________________

Wastewater Treatment Facility:

Attach Flowchart on liquid waste management

Attach lay-out / detailed plan

Liquid waste facility-main component

Wastewater treatment facilities (which one? Name is needed)

27. Solid Waste Disposal System

Bottom ash

Bly ash

Others, (specify):

Will there be a waste sorting/segregation system to be employed prior to incineration?

YES NO

Disposal System

Burning at open dumpsite in the project site

Open dumpsite outside of the project site (where?)

Others, specify:_________________________

Location of the waste disposal site:

28. Description of Existing Environment

A. Physical Environment

Components/ Parameters	☐ Yes	☐ No	Remarks
1. What is the general elevation of the			

proposed *incineration power plant project site*? <100 m 100-300 301-500 501-1,000 1,000-1,500 >1,500 (To determine elevation, refer to the topographic map where the elevation per contour line is indicated)			
2. Slope and Topography of the area *(within 50 meter radius from center of site)* ☐ Terrain is flat or level (0-3% slope) ☐ Gently sloping to undulating (3-8% slope) ☐ Undulating to rolling (8-18% slope) ☐ Rolling to moderately steep (18-30% slope) ☐ Steeply rolling (30-50% slope) ☐ Very steep to mountainous (>50% slope)			
3. Are there areas in the site where indications of soil erosion are occurring? If yes, what activities are causing erosion?			
Causes of erosion: ☐ Heavy Rains	☐ Unstable Slopes	☐ Others, pls. specify	

Do you know of any land sliding occurring or that has occurred in the site? Cause of Landslide:			
☐ Earthquake	☐ Unstable slopes	☐ Earthmoving	☐ Others, pls. specify
Has the area experienced any flooding during the wet season?			
If yes, when was the last time the area was flooded? Period(s) of flooding:			
Causes of flooding:	☐ low area	☐ poor drainage	☐ water logged areas

Soil type of the area	☐ Clayey soil	☐ Sandy loam soil	☐ Sandy soil	☐ Other soil types:

Is there an access road going to the project site? If yes, what is its distance to the site ________km.	Type of access road:
Does the site conform to the approved land use of the municipality? Yes	
Are there existing structures or developments around the project site? If yes, please list them	

Project Activities Affecting the Physical Environment	☐ **Yes**	☐ **No**

Are there any structures on the proposed site? Will there be demolition of existing structures? If yes, what types of structures will be demolished? Types of Structures:		
11. Is there a need to construct an access road going to the site? If Yes, what type of access road: [ ] all weathered road, length _____(m) width ____, [ ] concrete, [ ] asphalt		
B. Biological Environment	☐ **Yes**	☐ **No**
Are there any trees and other types of vegetation in the *project site*? If yes, please *identify*.		
Are there birds and other forms of wildlife found in the area? Please *identify*.		
Are there fishery resources in the water bodies found near or within the site? Please *identify*.		
Is the site near or within a watershed or forest reservation area? If near, only, how near? ___________ m or km If within, indicate name of the watershed or forest reservation area		
Are there any reserved forests or protected area within 1,000 m of the proposed site?		
What is the present land use in the vicinity (roughly a radius of 500m) of the proposed site?		

Coastal/ Marine	Residential	Forest	Mangrove	Grassland	Agriculture

Project Activities Affecting the Biological Environment	**Yes**	**No**
Type of vegetation on site		
1. Will there be vegetation clearing?		
2. Will clearing activities affect any critical wildlife habitats?		
3. Will clearing activities affect any rare, threatened or endangered plant and animal species?		
4. Will there be trees to be affected (e.g. cut down; remove) during clearing? If yes, how many and what are these species of trees?		
Will the project cause an increase in traffic or disrupt traffic in major routes due to the entry and exit of construction equipment?		
Is the available domestic water supply enough to meet the maximum projected water consumption of the petrol station?		
For any agricultural farmland on the proposed site and/or a radius of 500m around it, provide the following information: Main crop(s) and average yield--- Source of irrigation water-- Area attached by salinity or water logging---		

C. Socio-Economic Environment				
1. Are there existing settlements in the proposed station? If yes, indicate the number of: (within 50m radius) Households/Families:___, Legitimate landowners: ____; Tenants:______; Squatters:_____________				
Are there existing social or cultural infrastructures within 1000m of the proposed site or in the area?				
Type	Names and number if more than 1	Size (No. of students or beds)	Location (village, road, district, etc.)	Distance from Site
Schools/College				
Hospitals				
Health centers/clinics				
Communications library				
Churches/Mosques				
Archeological site				
Others				

Project Activities Affecting the Socio-Cultural and Economic Environment	**Yes**	**No**
Will the project cause or increase traffic in the areas?		
Are there existing transport services/facilities routing the areas?		
Will the project cause an increase in traffic or disrupt traffic in major routes due to the entry and exit of construction equipment?		
Is there a prevailing water shortage or water supply problem in the area?		
Are there already existing commercial establishments within the vicinity of the project area?		

40.3.2 Content of Evirnment Impact Assessment Ch3+4

وقد اطتنا د. مرفت هذا:

40.4 Aecenar incinerator in rayhaniyya camp

16. Oktober 2018 11:08 16,7 MB
Von: Samir_ayoubi Samir_ayoub

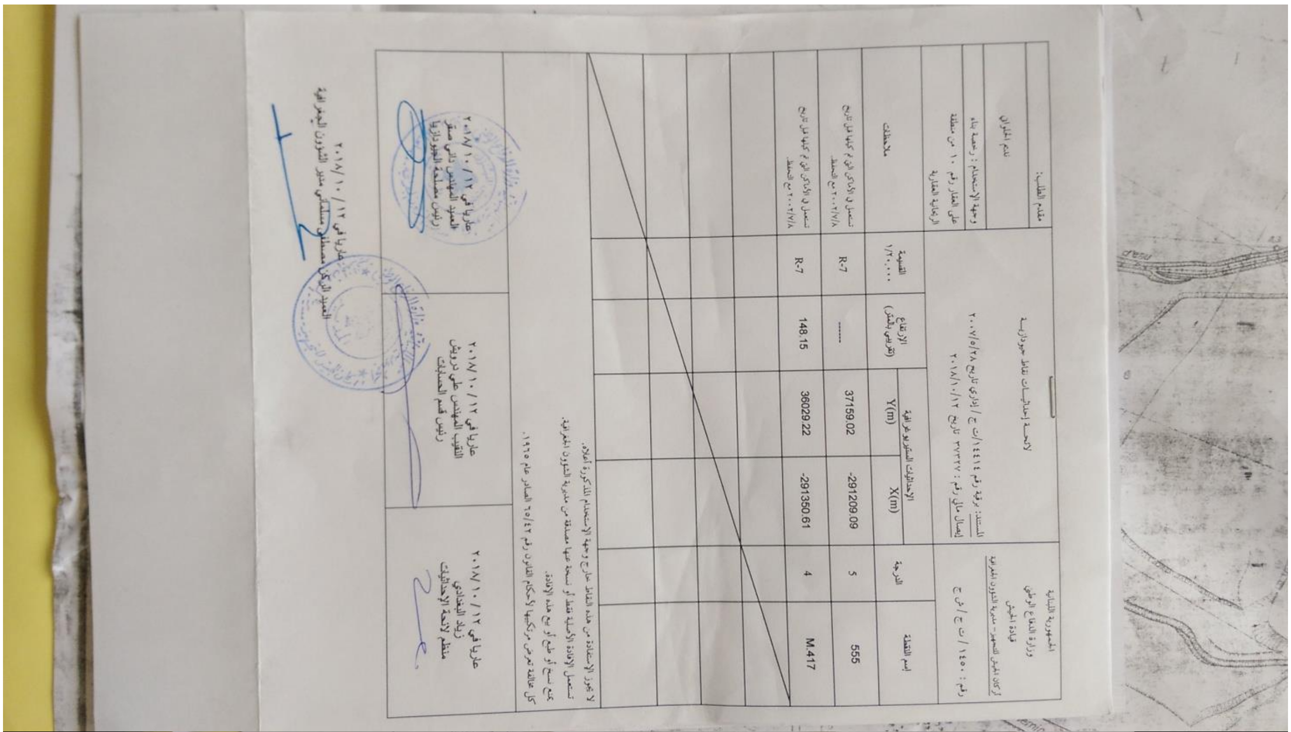
An: D.Turjman@moe.gov.lb

Cc: samir.mourad@aecenar.com

السلام عليكم

. كيف حالكم سيدة دانيا . يرجى اضافة هذه الصور الى الملف المرسل اليكم سابقا من قبل جمعية Aecenar بعد ان اتممناها وهي : افادة عقارية + افادة تخطيط وتصنيف+ لائحة احداثيات نقاط جيودازية +خريطة للمنطقة الواقع فيها العقار . للاستفسار يرجى التواصل معنا على الرقم 70104442 (سمير الايوبي.)

40.4.1 ملحقات



الجمهورية اللبنانية
وزارة الدفاع الوطني
قيادة الجيش
أركان الجيش للتجهيز – مديرية الشؤون الجغرافية

رقم : ١٤٥٠ / ت ج / ش ج

لائحــة إحداثيــات نقاط جيودازيــة

المستند: برقية رقم ١٤٤١٤/ت ج / إداري تاريخ ٢٠٠٧/٥/٢٨
إيصال مالي رقم : ٣٧٣٢٧ تاريخ ٢٠١٨/١٠/١٢

مقدم الطلب:
نديم الحلواني
وجهة الإستخدام : رخصة بناء
على العقار رقم ١٠ من منطقة الريحانية العقارية

إسم النقطة	الدرجة	الإحداثيات الستيريوغرافية X(m)	الإحداثيات الستيريوغرافية Y(m)	الإرتفاع (تقريبي بالمتر)	القسيمة ١/٢٠,٠٠٠	ملاحظات
555	5	-291209.09	37159.02	------	R-7	تستعمل في الأماكن التي تم كيلها قبل تاريخ ٢٠٠٢/٧/٨ مع التحفظ.
M.417	4	-291350.61	36029.22	148.15	R-7	تستعمل في الأماكن التي تم كيلها قبل تاريخ ٢٠٠٢/٧/٨ مع التحفظ.

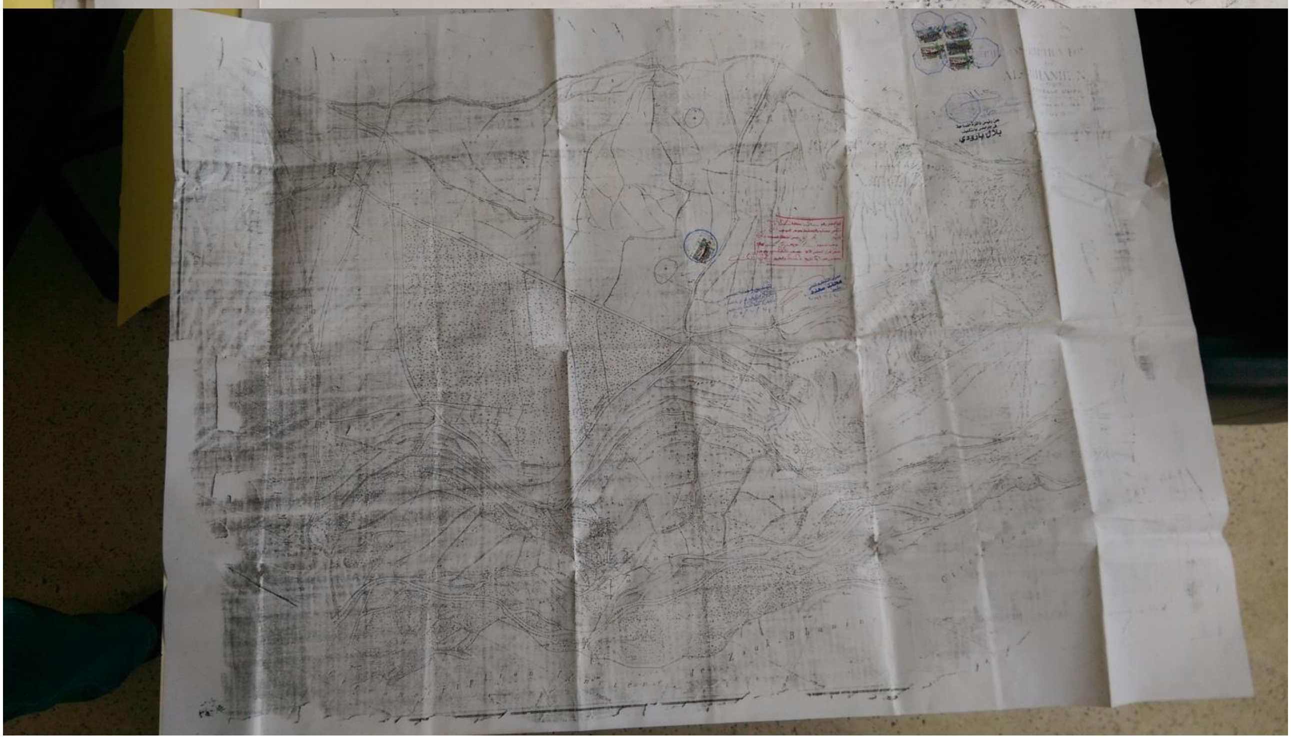
لا يجوز الإستفادة من هذه النقاط خارج وجهة الإستخدام المذكورة أعلاه.
تستعمل الإفادة الأصلية فقط أو نسخة عنها مصدقة من مديرية الشؤون الجغرافية.
يمنع نسخ أو طبع أو بيع هذه الإفادة.
كل مخالفة تعرض مرتكبيها لأحكام القانون رقم ٦٥/٤٢ الصادر عام ١٩٦٥.

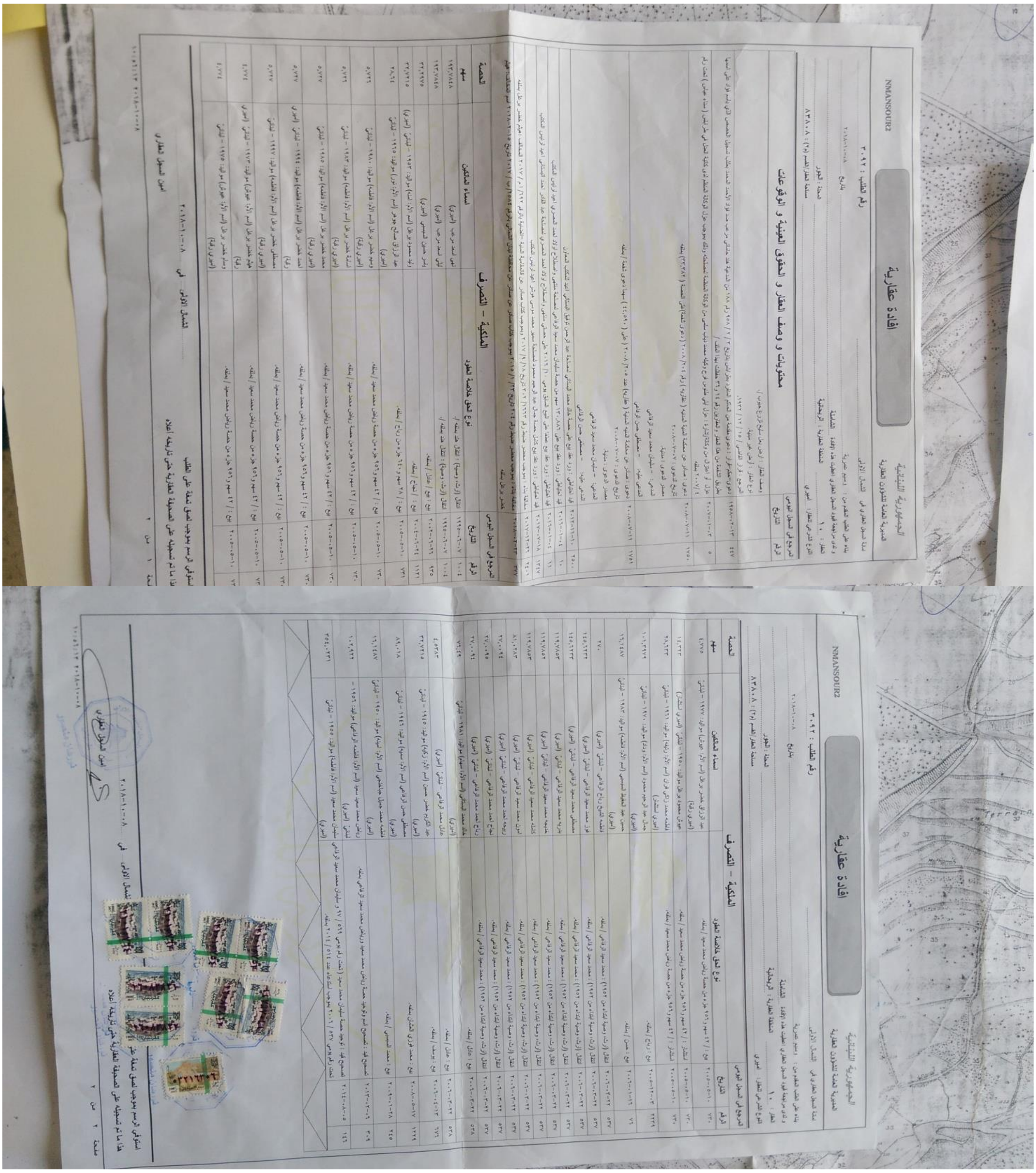
عاريا في ١٢ / ١٠ /٢٠١٨
زياد البغدادي
منظم لائحة الإحداثيات

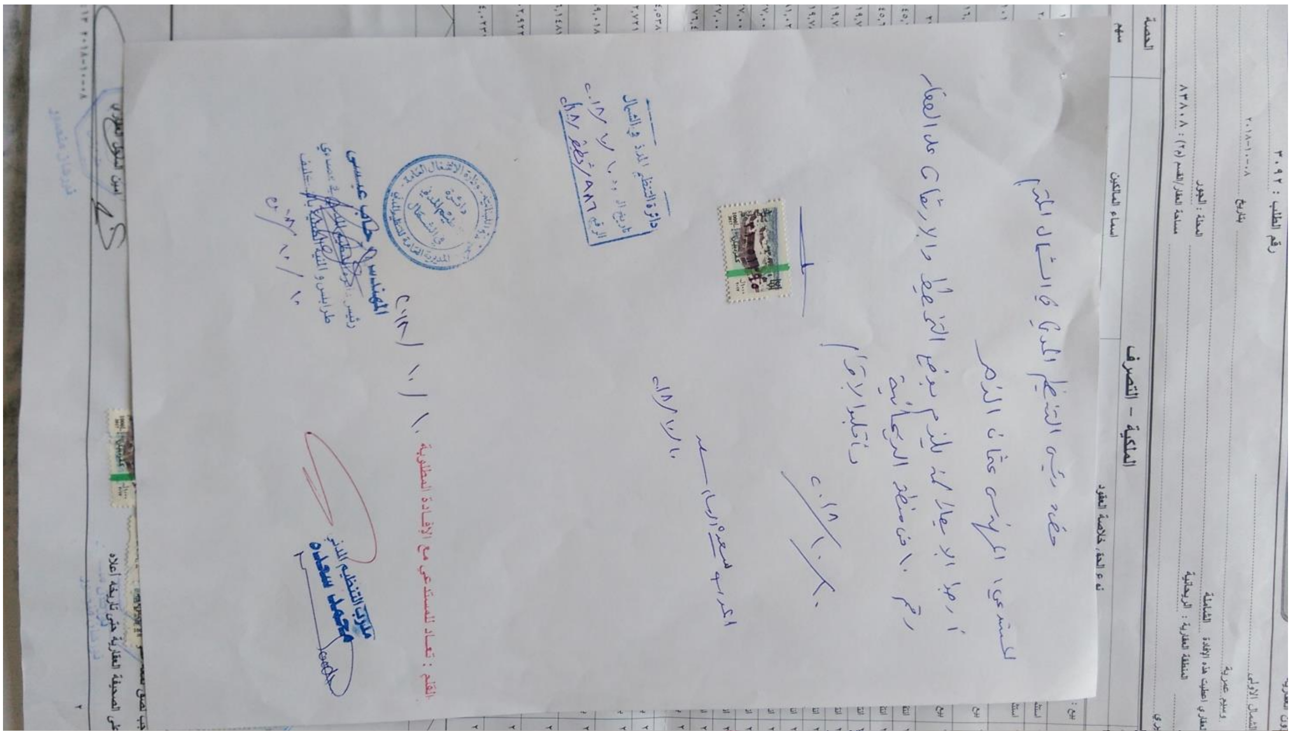
عاريا في ١٢ / ١٠ /٢٠١٨
النقيب المهندس علي درويش
رئيس قسم الحسابات

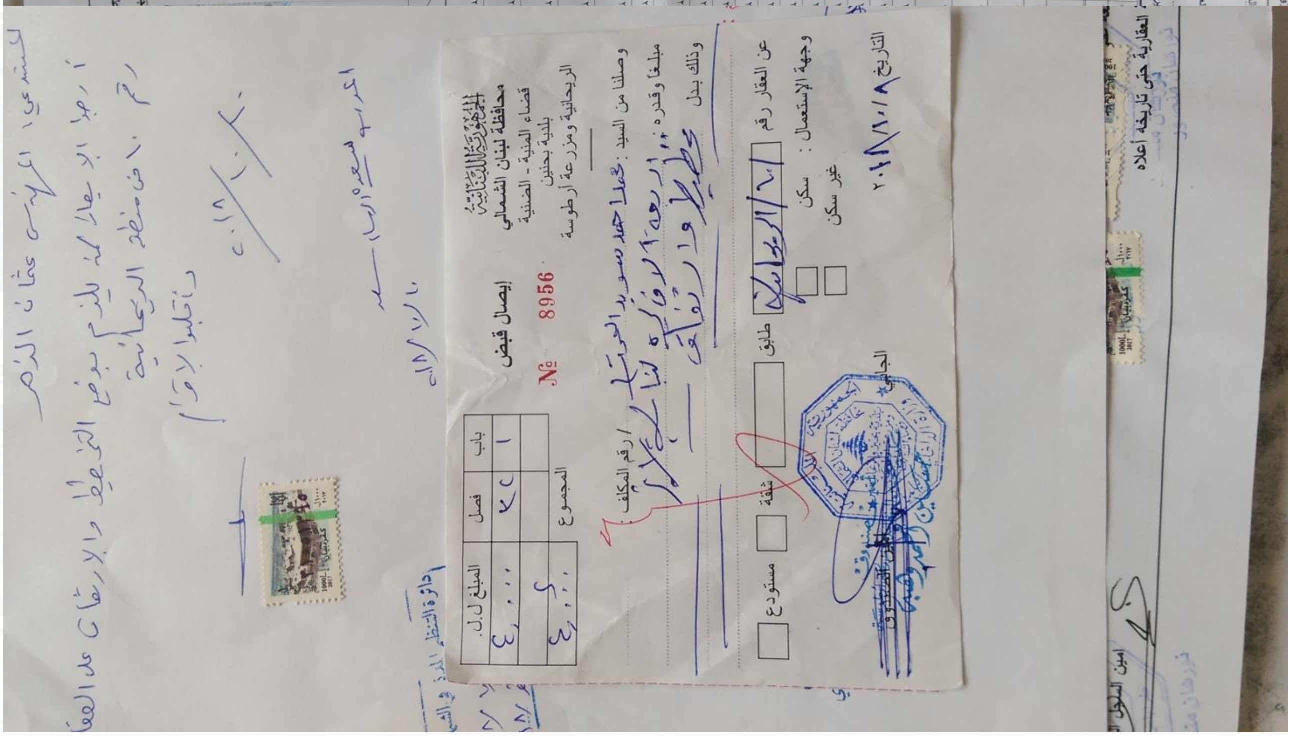
عاريا في ١٢ / ١٠ /٢٠١٨
العميد المهندس داني صقر
رئيس مصلحة الجيودازيا

عاريا في ١٢ / ١٠ /٢٠١٨
العميد الركن مصطفى مسلماني مدير الشؤون الجغرافية









الجمهورية اللبنانية
المديرية العامة للتنظيم المدني
دائرة التنظيم المدني في طرابلس والمنية- الضنية

المنطقة العقارية: الريحانية
القضاء: المنية - الضنية
رقم العقار: ......١٠......
المنطقة الارتفاقية: ....AG.......

رقم التسجيل: ..٢٠١٨/٥/٩٨٦..
التاريخ: ....٢٠١٨/١١/١....

افادة تخطيط وتصنيف

افادة تخطيط

العقار غير مصاب بأي تخطيط والطرقات الموجودة مصنفة على الكشف
وفقاً لما هو مبين على خريطة المساحة المرفقة

العقار مصاب بتخطيط مصدق وفقاً لما هو مبين على خريطة المساحة المرفقة (١)
بموجب المرسوم رقم ..../...... تاريخ ..../...... والطريق مصنف ..../...... انظر المصور رقم ......
بموجب المرسوم رقم ..../...... تاريخ ..../...... والطريق مصنف ..../...... انظر المصور رقم ......
بموجب المرسوم رقم ..../...... تاريخ ..../...... والطريق مصنف ..../...... انظر المصور رقم ......
والطرقات الموجودة مصنفة : ..../.......

العقار مصاب بتخطيط ملحوظ والطريق مصنف : ..../.......
والطرقات الموجودة مصنفة : ..../.......

افادة تصنيف

العقار يقع خارج أي منطقة مصنفة (١) ....
المنطقة الموضوعة تحت الدرس بموجب المرسوم رقم ....../........ تاريخ ....../........
والعقار يقع ضمن المنطقة المصنفة ..AG.. بموجب قرار المجلس الأعلى للتنظيم المدني رقم 21 تاريخ 2016

العقار يقع ضمن المنطقة المصنفة (١) ..../...... بموجب المرسوم رقم ..../...... تاريخ ..../......
العقار يقع ضمن المنطقة المصنفة (١) ..../...... بموجب المرسوم رقم ..../...... تاريخ ..../......
العقار يقع ضمن المنطقة المصنفة (١) ..../...... بموجب المرسوم رقم ..../...... تاريخ ..../......

المنطقة هي منطقة اصطياف بموجب المرسوم رقم (١) ..../...... تاريخ ..../......
على ظهره نظام المنطقة التي يقع ضمنها عقار.
ارتفاقات أخرى <u>يتوجب ضم نقاط التثليث من الشؤون الجغرافية</u>

<u>ملاحظات إضافية:</u>

*** ضرورة مراجعة مؤسسة كهرباء لبنان إذا كانت مساحة الترخيص بالبناء ستزيد عن ٤٠٠ م²**

يعمل بهذه الإفادة لمدة أربعة أشهر من تاريخ ....٢٠١٨/١١/١....

المدرب/الرسام — المهندس — رئيس الدائرة

مدرب التنظيم المدني
محمد سعده

المهندس رحاب عيسى
رئيس دائرة التنظيم المدني في قضاء طرابلس والمنية الضنية التكليف
٢٠١٨/١٠/١

التراجع المفروض بموجب رقم ١٥٢٩٩ تاريخ ١٩٦٤/٢/٥
طريق دولي : ستة عشر متراً عن المحور على أن لا يقل عن خمسة أمتار من حدود الاستملاك
طريق رئيس ثانوي : اثني عشر متراً عن المحور على أن لا يقل عن أربعة أمتار ونصف من حدود الاستملاك
طريق محلي : عشرة أمتار عن المحور على أن لا يقل عن أربعة أمتار من حدود الاستملاك
(١) شطب ما لا يلزم

40.5 رفض من اجل عدم مناسبة المكان

يجب ان لا يكون في بعد 1 كم من المحرقة بيت او مسجد او ما شابه

40.6 Request for appointment for a meeting regarding a research experiment prototype for waste incineration

25. Oktober 2018 15:06 24 KB
Von:

Daniah Turjman
An:

Bassam Sabbagh, Samar Malek
Cc:

Samir_ayoubi Samir_ayoub, Samir Mourad

Dear Mrs. Malek and Mr. Sabbagh,

I have received a request from Dr. Samir Mourad and Dr. Samir Ayoubi to meet with you in order to discuss their potential project.

Mr. Mourad and Mr. Ayoubi plan to test a technology that treats municipal waste using WtE in order to solve the SW issues in Al Rayhaniyi Refugee Camp on Minieh-Dannieh North Governorate.

They submitted a screening application which was refused due to unsuitability of the land.

If you could kindly reply to this email providing them an appointment so they can come meet you in person at the MoE and discuss our conditions for conducting such a project.

Best Regards,

Daniah

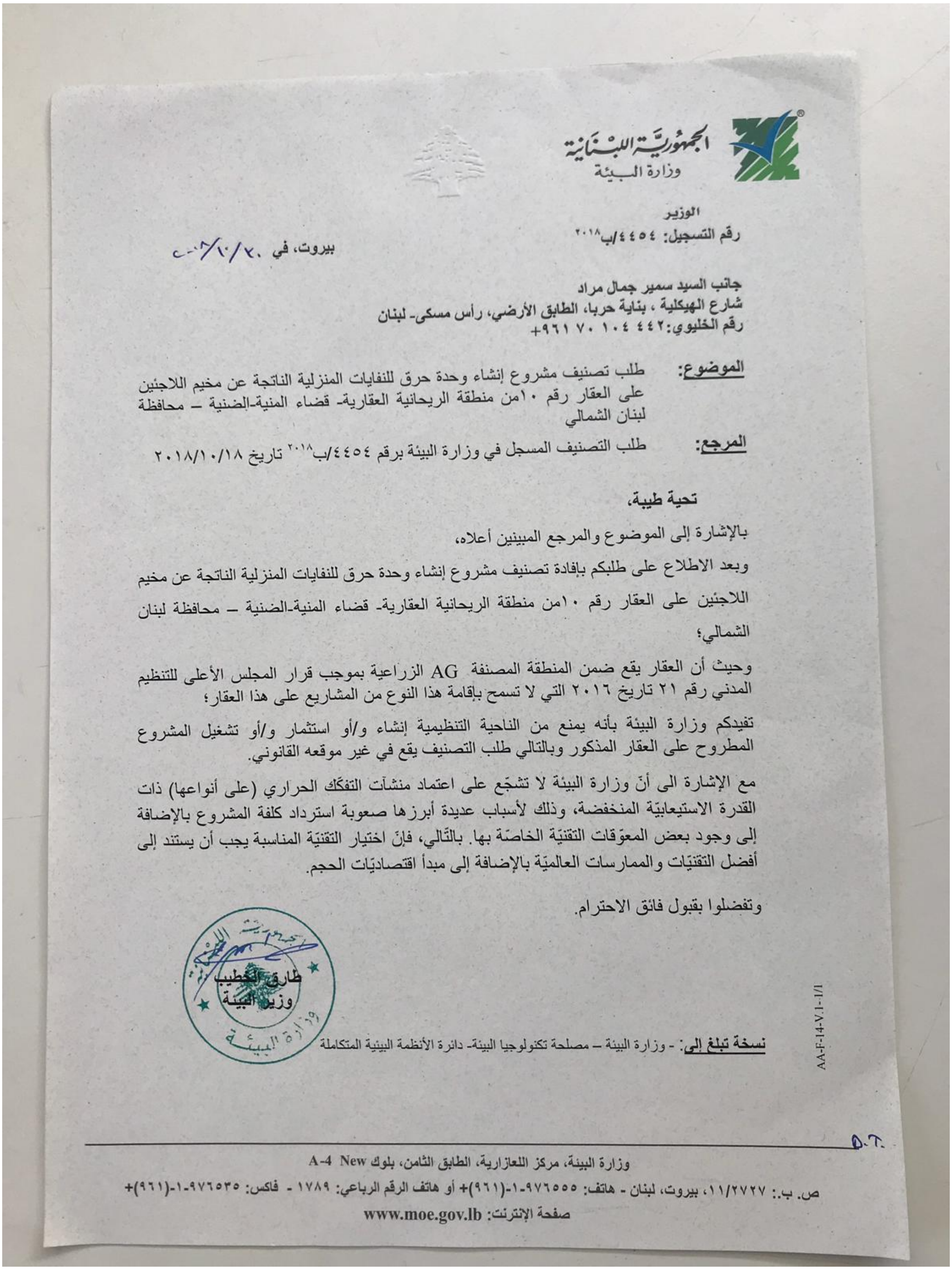
Daniah Turjman
Environmental Specialist
Department of Integrated Environmental Systems
Service of Environmental Technology

Tel | +9611976555 - Ext: 554
Web | http://www.moe.gov.lb/
Ministry of Environment, Lazarieh Center,
7th Floor, Block A-4, Room 7-50A
P.O. Box: 11/2727- Beirut, Lebanon

P ***Protect our planet: do not print this email unless necessary.***

40.7 Decision of the environmental ministry

In 13 November 2018, the Lebanese environmental ministry replied to our request in those images



الجمهورية اللبنانية
وزارة البيئة

الوزير
رقم التسجيل: ٤٤٥٤/ب٢٠١٨

بيروت، في ٢٠/١٠/٢٠١٨

جانب السيد سمير جمال مراد
شارع الهيكلية ، بناية حربا، الطابق الأرضي، رأس مسكى- لبنان
رقم الخليوي:٢ ٤٤ ١٠٤ ٧٠ ٩٦١+

الموضوع: طلب تصنيف مشروع إنشاء وحدة حرق للنفايات المنزلية الناتجة عن مخيم اللاجئين على العقار رقم ١٠من منطقة الريحانية العقارية- قضاء المنية-الضنية – محافظة لبنان الشمالي

المرجع: طلب التصنيف المسجل في وزارة البيئة برقم ٤٤٥٤/ب٢٠١٨ تاريخ ٢٠١٨/١٠/١٨

تحية طيبة،

بالإشارة إلى الموضوع والمرجع المبينين أعلاه،

وبعد الاطلاع على طلبكم بإفادة تصنيف مشروع إنشاء وحدة حرق للنفايات المنزلية الناتجة عن مخيم اللاجئين على العقار رقم ١٠من منطقة الريحانية العقارية- قضاء المنية-الضنية – محافظة لبنان الشمالي؛

وحيث أن العقار يقع ضمن المنطقة المصنفة AG الزراعية بموجب قرار المجلس الأعلى للتنظيم المدني رقم ٢١ تاريخ ٢٠١٦ التي لا تسمح بإقامة هذا النوع من المشاريع على هذا العقار؛

تفيدكم وزارة البيئة بأنه يمنع من الناحية التنظيمية إنشاء و/أو استثمار و/أو تشغيل المشروع المطروح على العقار المذكور وبالتالي طلب التصنيف يقع في غير موقعه القانوني.

مع الإشارة الى أنّ وزارة البيئة لا تشجّع على اعتماد منشآت التفكّك الحراري (على أنواعها) ذات القدرة الاستيعابيّة المنخفضة، وذلك لأسباب عديدة أبرزها صعوبة استرداد كلفة المشروع بالإضافة إلى وجود بعض المعوّقات التقنيّة الخاصّة بها. بالتّالي، فإنّ اختيار التقنيّة المناسبة يجب أن يستند إلى أفضل التقنيّات والممارسات العالميّة بالإضافة إلى مبدأ اقتصاديّات الحجم.

وتفضلوا بقبول فائق الاحترام.

طارق الخطيب
وزير البيئة

نسخة تبلغ إلى: - وزارة البيئة – مصلحة تكنولوجيا البيئة- دائرة الأنظمة البيئية المتكاملة

AA-F-14-V.1-1/1

وزارة البيئة، مركز اللعازارية، الطابق الثامن، بلوك A-4 New
ص. ب.: ١١/٢٧٢٧، بيروت، لبنان - هاتف: ٩٧٦٥٥٥-١-(٩٦١)+ أو هاتف الرقم الرباعي: ١٧٨٩ - فاكس: ٩٧٦٥٣٥-١-(٩٦١)+
صفحة الإنترنت: www.moe.gov.lb

حضرة رئيس التنظيم المدني في الشمال المحترم

المستدعي: المهندس عثمان الذهر

أرجو الإيضاح لمن يلتزم بوضع التخطيط والارتفاقات على العقار رقم ١٠ في منطقة الريحانية

وتقبلوا الاحترام

١٠/١٠/٢٠١٨

المدرب سعده ارسال سعد

١٠/١٠/٢٠١٨

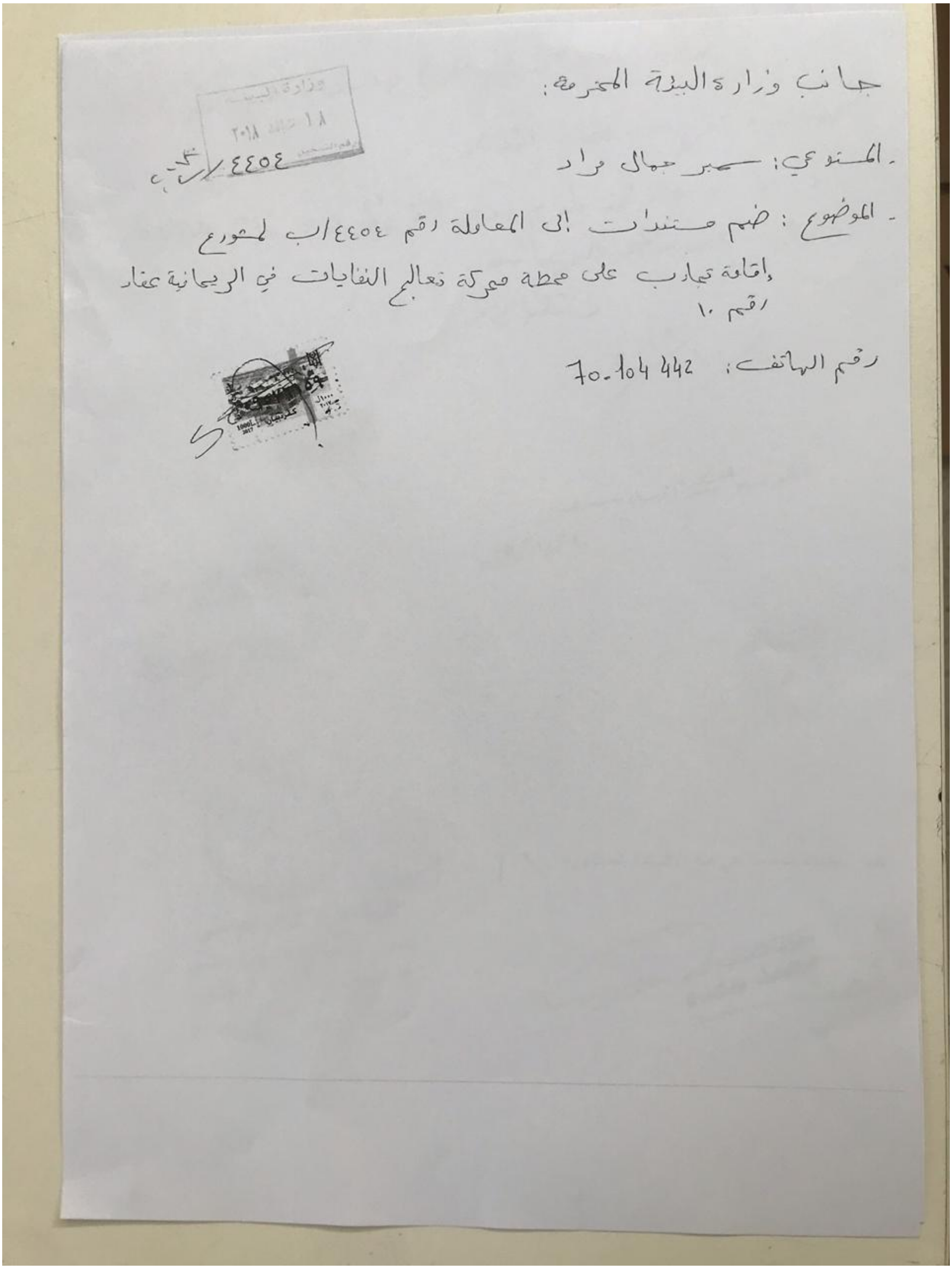
دائرة التنظيم المدني في الشمال
تاريخ الورود ١٠/١٠/٢٠١٨
الرقم ٩٨٦/ تخطيط ٢٠١٨

الجمهورية اللبنانية - وزارة الأشغال العامة - المديرية العامة للتنظيم المدني - دائرة التنظيم المدني في الشمال

القلم : تعاد للمستدعي مع الإفادة المطلوبة ١٠/١٠/٢٠١٨

المهندس رحاب عيسى
رئيس دائرة التنظيم المدني في قضاء طرابلس و المنية الضنية بالتكليف
١٠/١٠/٢٠١٨

مدرب التنظيم المدني
محمد سعده



وزارة البيئة
١٨ ٢٠١٨
٤٤٥٤/ر.ت.ب

جانب وزارة البيئة المحترمة:

- المستدعي: سمير جمال مراد

- الموضوع: ضم مستندات إلى المعاملة رقم ٤٤٥٤/ب لمشروع إقامة تجارب على محطة محركة تعالج النفايات في الريحانية عقار رقم ١٠

رقم الهاتف: 70-104 442

الجمهورية اللبنانية
المديرية العامة للتنظيم المدني
دائرة التنظيم المدني في طرابلس والمنية- الضنية

المنطقة العقارية: الريحانية
القضاء: المنية - الضنية
رقم العقار: ١٠
المنطقة الارتفاقية: AG

رقم التسجيل: ٩٨٦/١٠/٢٠١٨
التاريخ: ١/١٠/٢٠١٨

افادة تخطيط وتصنيف

العقار غير مصاب بأي تخطيط والطرقات الموجودة مصنفة محلي للكشف وفقاً لما هو مبين على خريطة المساحة المرفقة	**افادة تخطيط**
العقار مصاب بتخطيط مصدق وفقاً لما هو مبين على خريطة المساحة المرفقة (١) بموجب المرسوم رقم .... تاريخ .... والطريق مصنف .... انظر المصور رقم ...... بموجب المرسوم رقم .... تاريخ .... والطريق مصنف .... انظر المصور رقم ...... بموجب المرسوم رقم .... تاريخ .... والطريق مصنف .... انظر المصور رقم ...... والطرقات الموجودة مصنفة :	
العقار مصاب بتخطيط ملحوظ والطريق مصنف : .... والطرقات الموجودة مصنفة :	
العقار يقع خارج أي منطقة مصنفة (١) .... المنطقة الموضوعة تحت الدرس بموجب المرسوم رقم .... تاريخ .... والعقار يقع ضمن المنطقة المصنفة AG بموجب قرار المجلس الأعلى للتنظيم المدني رقم **21** تاريخ **2016**	**افادة تصنيف**
العقار يقع ضمن المنطقة المصنفة (١) .... بموجب المرسوم رقم .... تاريخ .... العقار يقع ضمن المنطقة المصنفة (١) .... بموجب المرسوم رقم .... تاريخ .... العقار يقع ضمن المنطقة المصنفة (١) .... بموجب المرسوم رقم .... تاريخ	
المنطقة هي منطقة اصطياف بموجب المرسوم رقم (١) .... تاريخ .... على ظهره نظام المنطقة التي يقع ضمنها عقار. ارتفاقات أخرى **يتوجب ضم نقاط التثليث من الشؤون الجغرافية**	

ملاحظات إضافية:

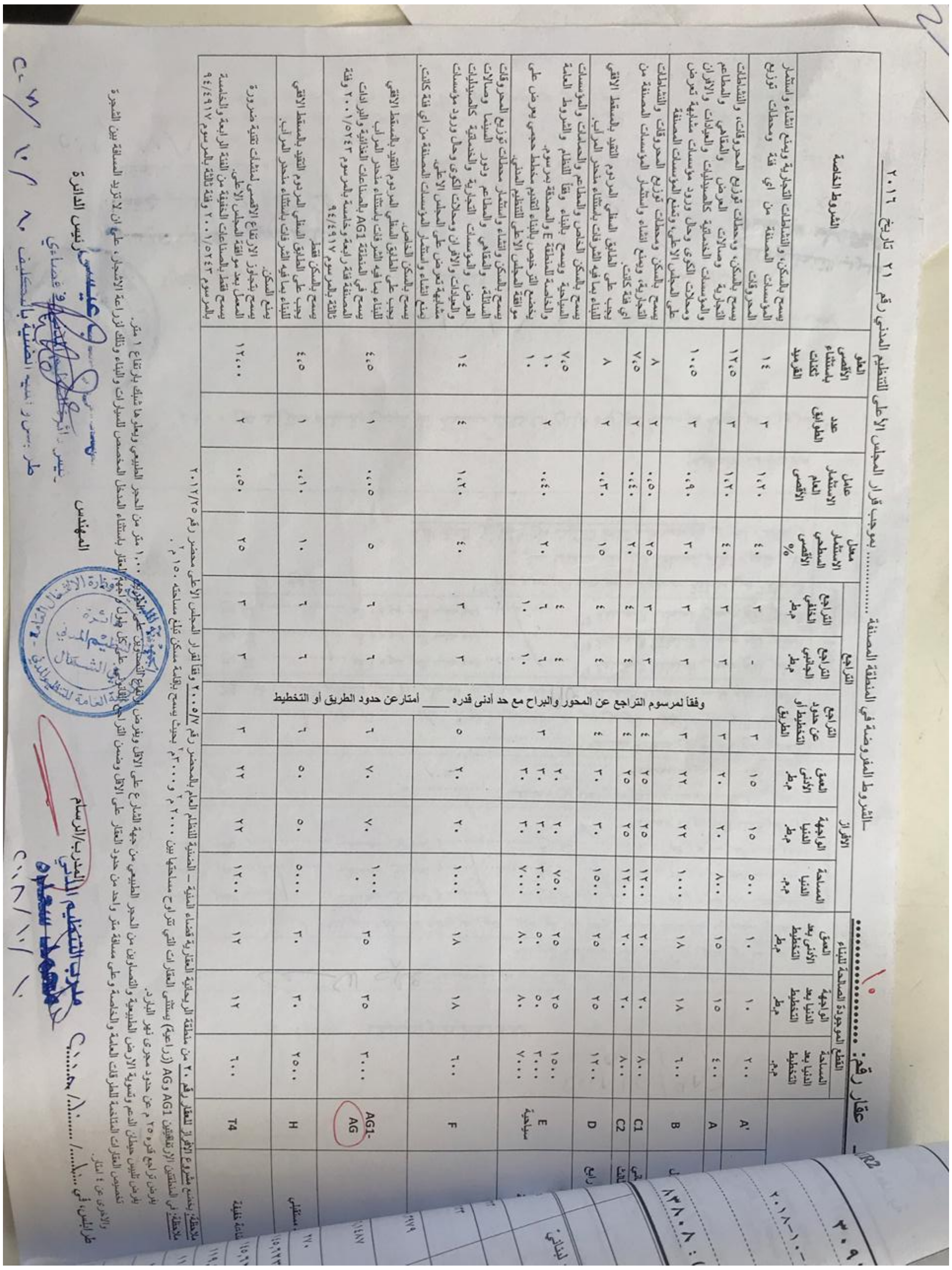
*** ضرورة مراجعة مؤسسة كهرباء لبنان إذا كانت مساحة الترخيص بالبناء ستزيد عن ٤٠٠ م٢**

يعمل بهذه الإفادة لمدة أربعة أشهر من تاريخ ١/١٠/٢٠١٨

المدرب/الرسام	المهندس	رئيس الدائرة
مدرب التنظيم المدني محمد سعده		المهندس رحاب عيسى رئيس دائرة التنظيم المدني في قضاء طرابلس و المنية الضنية بالتكليف ١/١٠/٢٠١٨

التراجع المفروض بموجب رقم ١٥٢٩٩ تاريخ ١٩٦٤/٢/٥
طريق دولي : ستة عشر متراً عن المحور على أن لا يقل عن خمسة أمتار من حدود الاستملاك
طريق رئيس ثانوي : اثني عشر متراً عن المحور على أن لا يقل عن أربعة أمتار ونصف من حدود الاستملاك
طريق محلي : عشرة أمتار عن المحور على أن لا يقل عن أربعة أمتار من حدود الاستملاك
(١) شطب ما لا يلزم

٥٣٨ ٢٠٠٦-٠٣-٢٢ بيع : عادل / بملفه.


الشروط المفروضة في المنطقة الصناعية .... بموجب قرار المجلس الأعلى للتنظيم المدني رقم ٢١ تاريخ ٢٠١٦
عقار رقم:
الشروط الخاصة

الجمهورية اللبنانية
وزارة الدفاع الوطني
قيادة الجيش
أركان الجيش للتجهيز – مديرية الشؤون الجغرافية

رقم : ١٤٥٠ / ت ج / ش ج

لائحـــة إحداثيـــات نقاط جيودازيـــة

المستند: برقية رقم ١٤٤١٤/ت ج / إداري تاريخ ٢٠٠٧/٥/٢٨
إيصال مالي رقم : ٣٧٣٢٧ تاريخ ٢٠١٨/١٠/١٢

مقدم الطلب:
نديم الحلواني
وجهة الإستخدام : رخصة بناء
على العقار رقم ١٠ من منطقة الريحانية العقارية

إسم النقطة	الدرجة	الإحداثيات الستيريوغرافية X(m)	الإحداثيات الستيريوغرافية Y(m)	الإرتفاع (تقريبي بالمتر)	القسيمة ١/٢٠,٠٠٠	ملاحظات
555	5	-291209.09	37159.02	------	R-7	تستعمل في الأماكن التي تم كيلها قبل تاريخ ٢٠٠٢/٧/٨ مع التحفظ.
M.417	4	-291350.61	36029.22	148.15	R-7	تستعمل في الأماكن التي تم كيلها قبل تاريخ ٢٠٠٢/٧/٨ مع التحفظ.

لا يجوز الإستفادة من هذه النقاط خارج وجهة الإستخدام المذكورة أعلاه.
تستعمل الإفادة الأصلية فقط أو نسخة عنها مصدقة من مديرية الشؤون الجغرافية.
يمنع نسخ أو طبع أو بيع هذه الإفادة.
كل مخالفة تعرض مرتكبيها لأحكام القانون رقم ٦٥/٤٢ الصادر عام ١٩٦٥.

عاريا في ١٢ / ١٠ /٢٠١٨
زياد البغدادي
منظم لائحة الإحداثيات

عاريا في ١٢ / ١٠ /٢٠١٨
النقيب المهندس علي درويش
رئيس قسم الحسابات

عاريا في ١٢ / ١٠ /٢٠١٨
العميد المهندس داني صقر
رئيس مصلحة الجيودازيا

عاريا في ١٢ / ١٠ /٢٠١٨
العميد الركن مصطفى مسلماني مدير الشؤون الجغرافية

الجمهورية اللبنانية
وزارة الدفاع الوطني
قيادة الجيش
الجيش للتجهيز – مديرية الشؤون الجغرافية

١٤٥٠ / ت ج / ش ج

لائحـــة إحداثيـــات نقاط جيودازيـــة

المستند: برقية رقم ١٤٤١٤/ت ج / إداري تاريخ ٢٠٠٧/٥/٢٨
إيصال مالي رقم : ٣٧٣٢٧ تاريخ ٢٠١٨/١٠/١٢

مقدم الطلب:
نديم الحلواني

وجهة الإستخدام : رخصة بناء
على العقار رقم ١٠ من منطقة الريحانية العقارية

إسم النقطة	الدرجة	الإحداثيات الستيريوغرافية X(m)	Y(m)	الإرتفاع (تقريبي بالمتر)	القسيمة ١/٢٠,٠٠٠	ملاحظات
555	5	-291209.09	37159.02	------	R-7	تستعمل في الأماكن التي تم كيلها قبل تاريخ ٢٠٠٢/٧/٨ مع التحفظ.
M.417	4	-291350.61	36029.22	148.15	R-7	تستعمل في الأماكن التي تم كيلها قبل تاريخ ٢٠٠٢/٧/٨ مع التحفظ.

لا يجوز الإستفادة من هذه النقاط خارج وجهة الإستخدام المذكورة أعلاه.
تستعمل الإفادة الأصلية فقط أو نسخة عنها مصدقة من مديرية الشؤون الجغرافية.
يمنع نسخ أو طبع أو بيع هذه الإفادة.
كل مخالفة تعرض مرتكبيها لأحكام القانون رقم ٦٥/٤٢ الصادر عام ١٩٦٥.

عاريا في ١٢ / ١٠ / ٢٠١٨
زياد البغدادي
منظم لائحة الإحداثيات

عاريا في ١٢ / ١٠ / ٢٠١٨
النقيب المهندس علي درويش
رئيس قسم الحسابات

عاريا في ١٢ / ١٠ / ٢٠١٨
العميد المهندس داني صقر
رئيس مصلحة الجيودازيا

عاريا في ١٢ / ١٠ / ٢٠١٨
العميد الركن مصطفى مسلماني مدير الشؤون الجغرافية

الاستاذ حسان يعمل مع الامم المتحدة و وزارة البيئة

هيتف 71155653


الجمهورية اللبنانية
محافظة لبنان الشمالي
قضاء المنية - الضنية
بلدية بحنين
الريحانية ومزرعة أرطوسة

إيصال قبض

№ 8956

باب	فصل	المبلغ ل.ل.
١	٢٢	٤,٠٠٠
	المجموع	٤,٠٠٠

وصلنا من السيد : محمد احمد سويد الحوت / رقم المكلف :

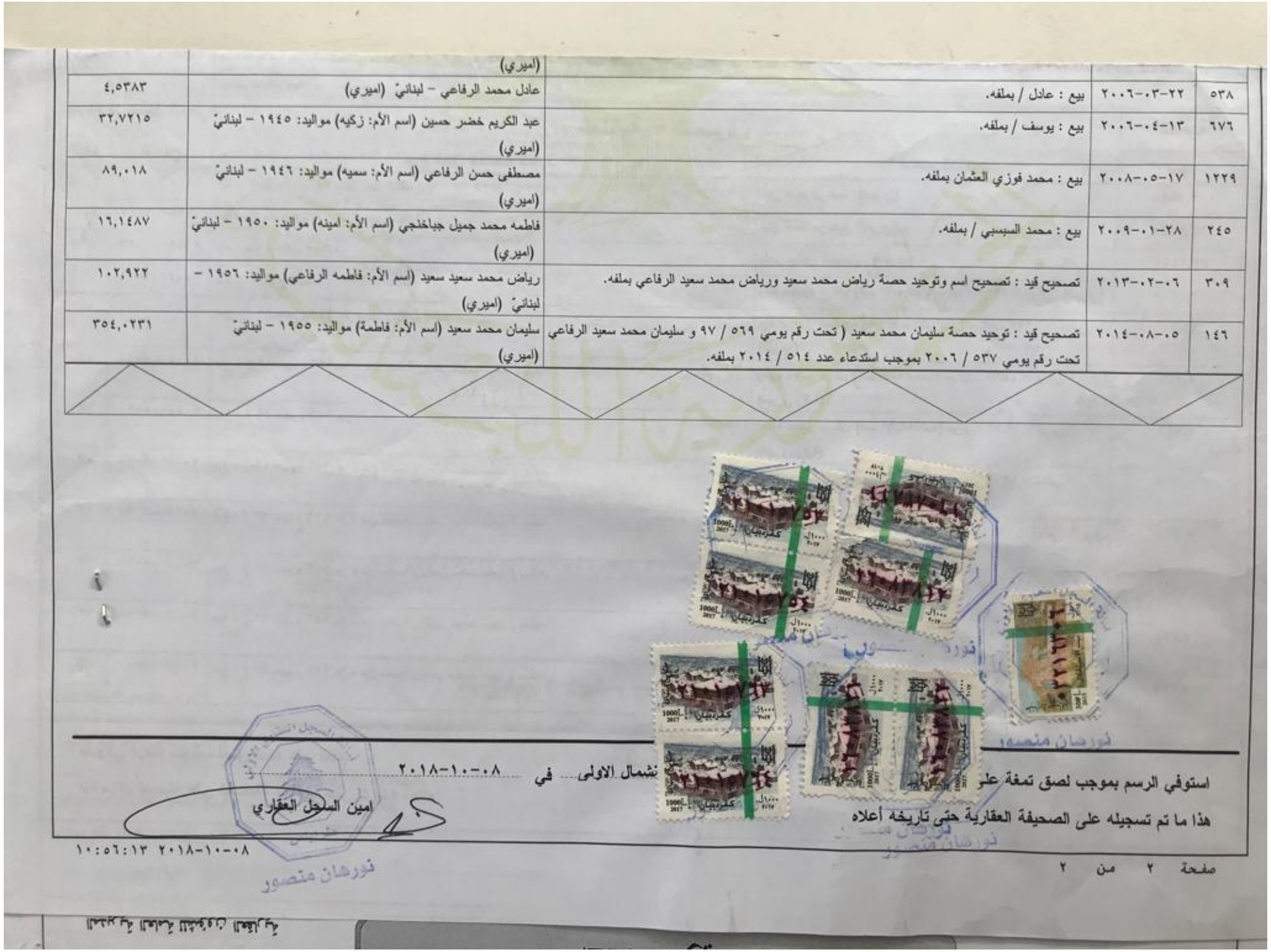
مبلغاً وقدره : اربعة الاف ليرة لبنانية لا غير

وذلك بدل : مخطط وارتفاع

عن العقار رقم ٦/١ الريحانية طابق شقة مستودع

وجهة الإستعمال : سكن
غير سكن

التاريخ ٢٠١٨/١٠/٨ الجابي أمين الصندوق



			(اميري)	
٥٣٨	٢٠٠٦-٠٣-٢٢	بيع : عادل / بملفه.	عادل محمد الرفاعي – لبنانيّ (اميري)	٤,٥٣٨٣
٦٧٦	٢٠٠٦-٠٤-١٣	بيع : يوسف / بملفه.	عبد الكريم خضر حسين (اسم الأم: زكيه) مواليد: ١٩٤٥ – لبنانيّ (اميري)	٣٢,٧٢١٥
١٢٢٩	٢٠٠٨-٠٥-١٧	بيع : محمد فوزي العثمان بملفه.	مصطفى حسن الرفاعي (اسم الأم: سميه) مواليد: ١٩٤٦ – لبنانيّ (اميري)	٨٩,٠١٨
٢٤٥	٢٠٠٩-٠١-٢٨	بيع : محمد السبسبي / بملفه.	فاطمه محمد جميل جباخنجي (اسم الأم: امينه) مواليد: ١٩٥٠ – لبنانيّ (اميري)	١٦,١٤٨٧
٣٠٩	٢٠١٣-٠٢-٠٦	تصحيح قيد : تصحيح اسم وتوحيد حصة رياض محمد سعيد ورياض محمد سعيد الرفاعي بملفه.	رياض محمد سعيد سعيد (اسم الأم: فاطمه الرفاعي) مواليد: ١٩٥٦ – لبنانيّ (اميري)	١٠٢,٩٢٢
١٤٦	٢٠١٤-٠٨-٠٥	تصحيح قيد : توحيد حصة سليمان محمد سعيد (تحت رقم يومي ٥٦٩ / ٩٧ و سليمان محمد سعيد الرفاعي تحت رقم يومي ٥٣٧ / ٢٠٠٦ بموجب استدعاء عدد ٥١٤ / ٢٠١٤ بملفه.	سليمان محمد سعيد (اسم الأم: فاطمة) مواليد: ١٩٥٥ – لبنانيّ (اميري)	٣٥٤,٠٢٣١

استوفي الرسم بموجب لصق تمغة علو

هذا ما تم تسجيله على الصحيفة العقارية حتى تاريخه أعلاه

نشمال الاولى في ٢٠١٨-١٠-٠٨

امين السجل العقاري

نورهان منصور

١٠:٥٦:١٣ ٢٠١٨-١٠-٠٨

صفحة ٢ من ٢

41 Cooperation with Greentrack (فرز من المصدر)

41.1 Meeting 25.9.2019

خضر عيد من جبل محسن

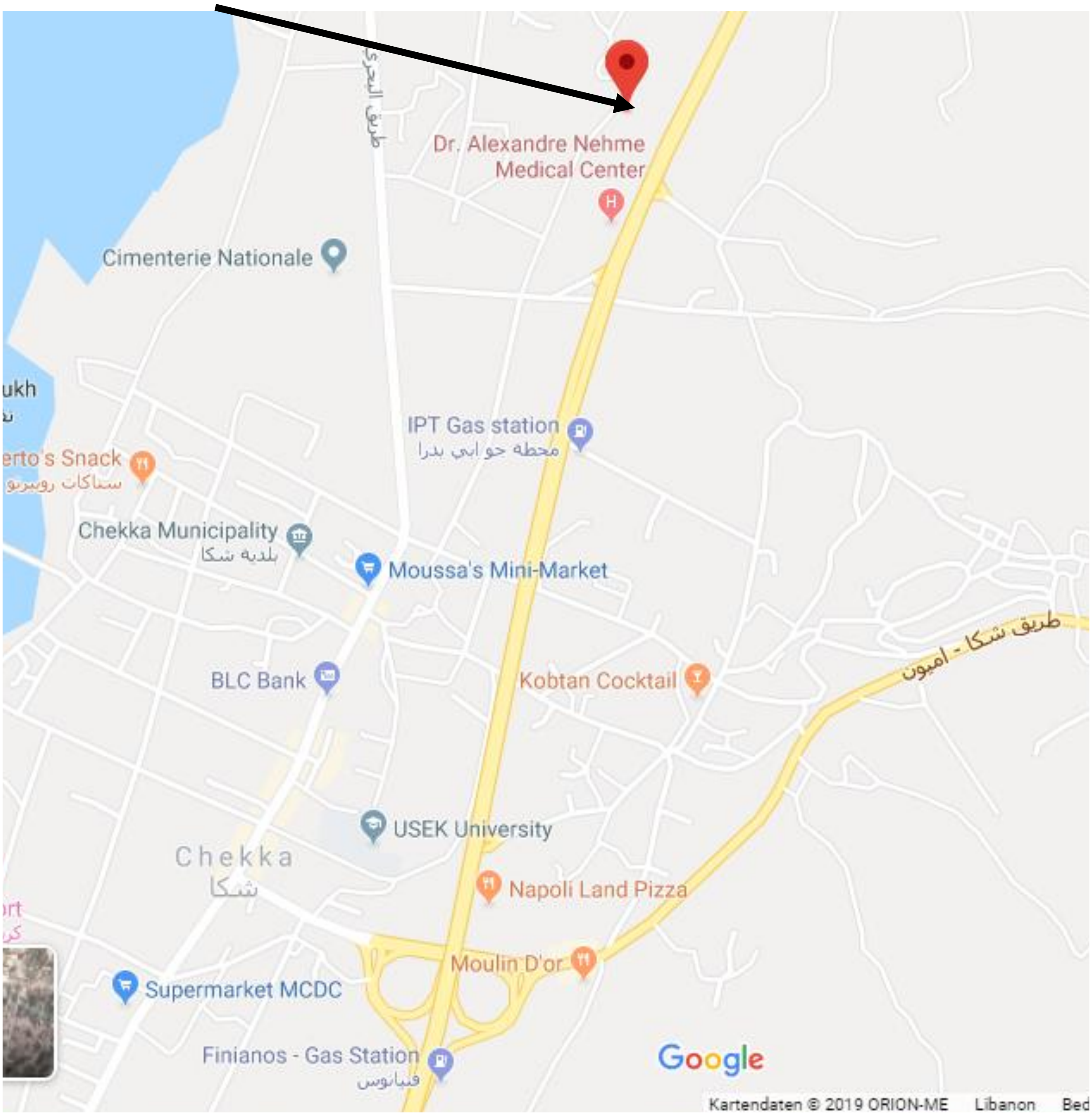
41.2 Suitable for Recycling

Sorting facility (at Tripoli - Jabal Muhsin)

41.3 Refused Waste Jabal Muhsin (for incineration)

41.4 Planned Waste Incineration at Chekka

41.4.1 Hangar of refused waste



Other planned elements: Desalting Unit, Wind Energy, Methan Liquefication, Purification of water

Based on the following reports

DW from [NLAP-WEDC 2017]

[NLAP-WEDC 2018]

[NLAP-WEDC 2019]

42 Bioethanol/Distillated water (DW) production Unit[27]

The concept is to produce pure distillated water (e.g. for medical laboratories) using the outlet steam at the turbine exit. Instead of simply going to the condensor, the outlet steam of TEMO-IPP 40kW plant (110°C, 1,1 bar) and the condensor is used to distillate water from the cooling cycle.

The input to the process is the bioEthanol/water mixture from processed organic waste and sugar beet.

42.1 The series -cascade distillation train

This is a continuous distillation carried out in a train of six columns. This distillation train comprises a rectifying section wherein the concentration of salt is reduced from feed composition (3% bioEthanol) to overhead composition (about 1 %) and a stripping section wherein the concentration is increased from feed to tails composition (about 50% Ethanol). This still train operates at reduced pressures to take advantage of the higher volatility of water at low pressure.

These 6 columns are arranged in a series cascade of 4 stages, 2 columns each comprising the first and second stage, and single smaller columns in the third and fourth stages.

All stages are in series, with transfer of Ethanol/water mixture from stage to stage accomplished by returning all condensate from a higher stage to a plate near the bottom of the next lower stage. A stream of liquid from the base of the lower stage equal to the amount of this condensate plus the product draw-off is sent forward to the higher stage. Several feed points are provided in the first stage so that the feed concentration can be matched to the operating column concentration.

42.2 Equipment description

Stage No.	#columns in the stage	Diameter	Height	Number of plates[28]	Nominal holdup[29] gallons (تنكة)	Reboiler area	Condenser area
1	2	0.32m (12 inch) 0.24m (10 inch)	2.47m 2.74m	7 8	5.8 4.5	0.6967 m²	5.574 m²
2	2	0.32m (12 inch) 0.24m (10 inch)	2.47m 2.74m	7 8	5.2 4.5	0.6967 m²	5.574 m²
3	1	0.17 m (6 inch)	2.35m	7	1.6	0.1858 m²	1.4864m²
4	1	0.08 m (3 inch)	2.35m	7	0.35	0.4645 m²	0.3716m²

27 from [NLAP-WEDC 2017] and [NLAP-WEDC 2018]

28 plate spacing in all columns is 12 inches

29 holdup includes associated calandria and /or condenser

Table 5: Equipment Description 1:10 length, 1:100 areas, volumes 1:1000

In addition to this equipment, each stage is equipped with two stage steam jet eductors which operate off the condenser head space to maintain system vacuum. All gases reaching the jets first pass through ammonia refrigeration units which recover essentially all of the water vapor.

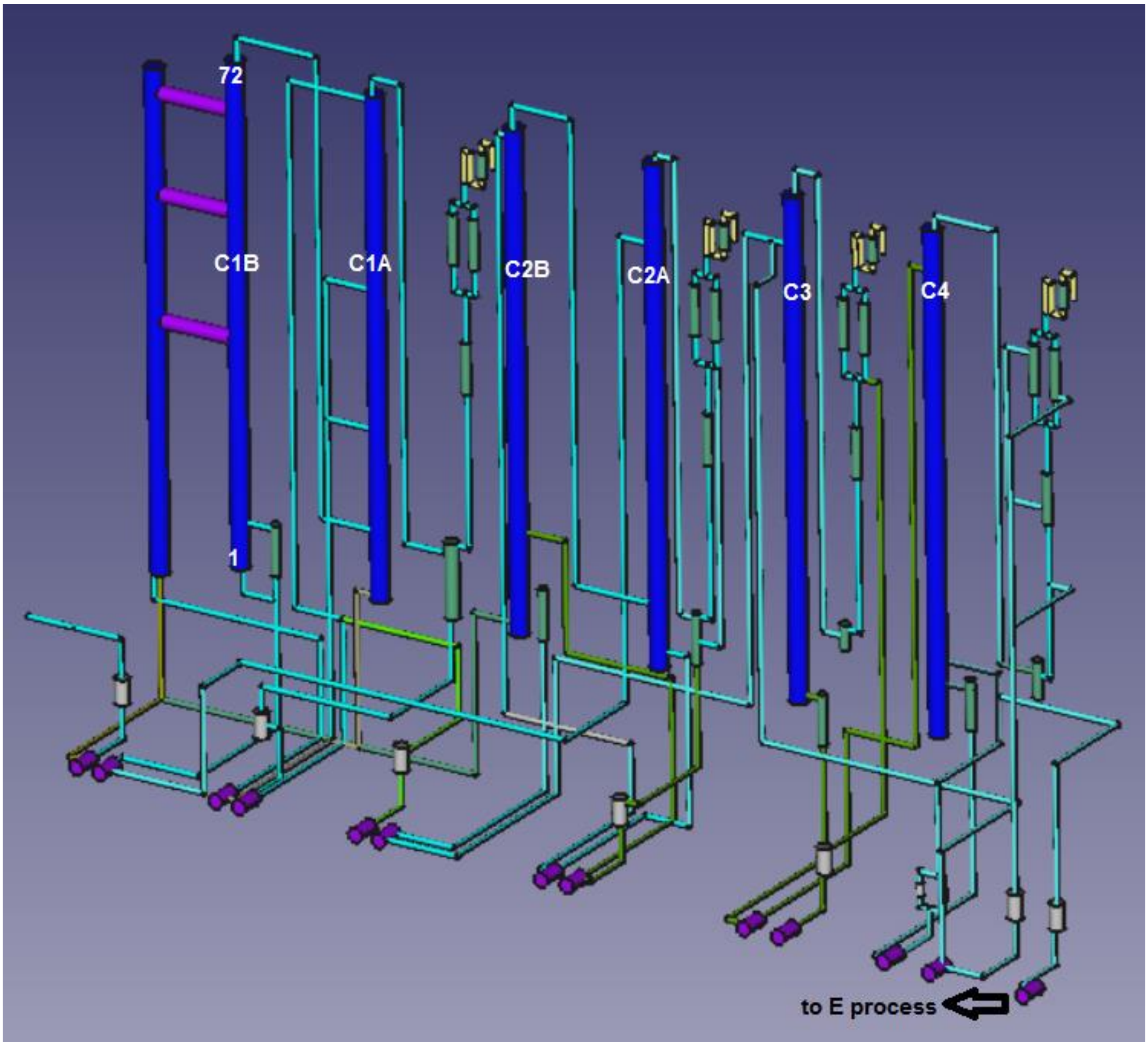
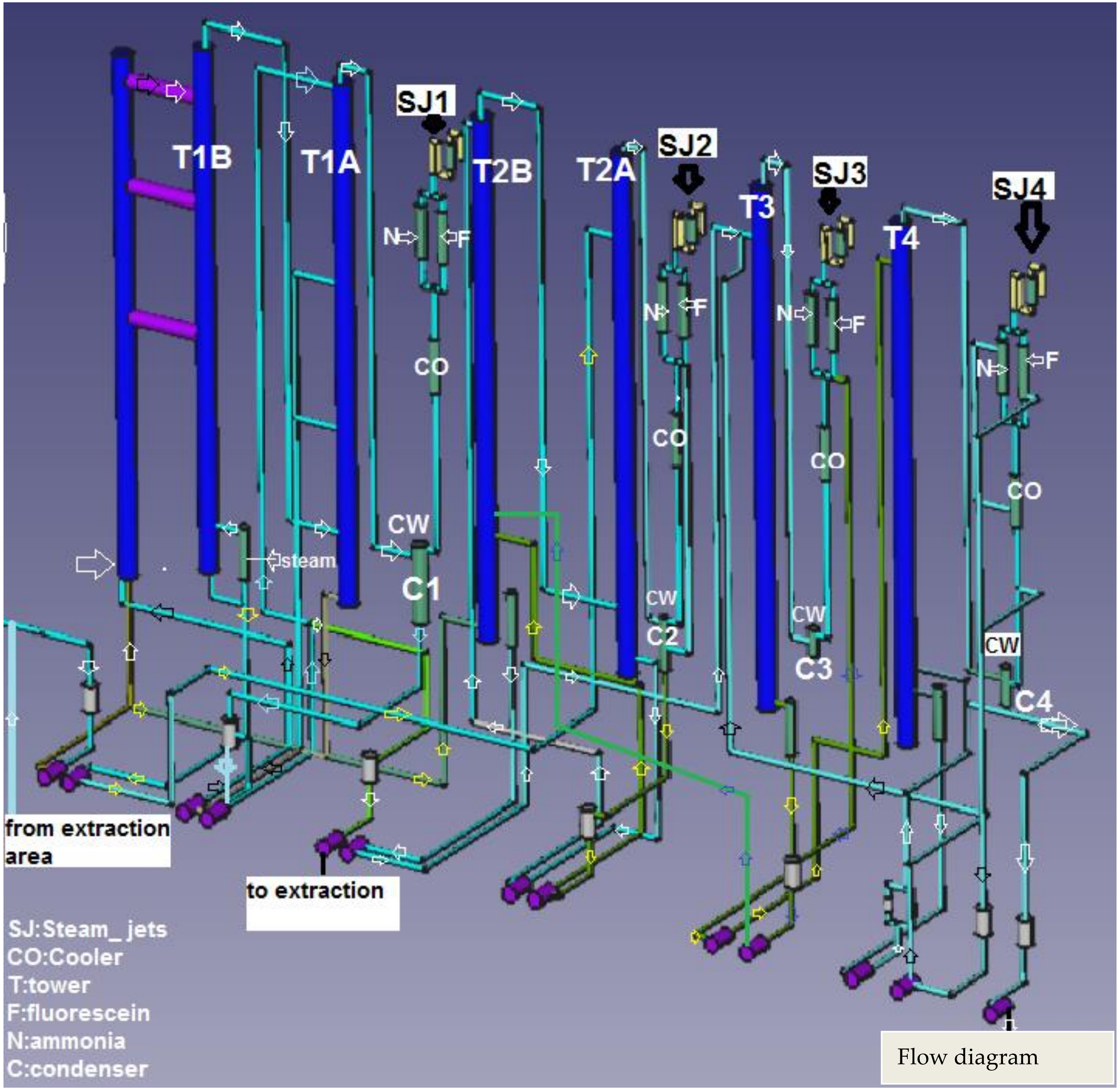


figure 86: capture of DW unit

nlap-Desalination_dd-12-12-016.FCStd



Flow diagram

42.3 Fundamental principles of DW plant design

42.3.1 Relative volatility

The relative volatility of the water and Ethanol varies with temperature, and with the pressure prevailing in the distillation equipment.

42.3.2 Operating pressure

The lower the pressure at which the distillation process is operated, the greater is the relative volatility, and consequently the smaller is the quantity of heat or the fewer the plates required for a given separation.

The preferred operation pressure for a DW column is 0,113 - 0,126 bar.

Pressure units

V·T·E	Pascal (Pa)	Bar (bar)	Technical atmosphere (at)	Standard atmosphere (atm)	Torr (Torr)	Pounds per square inch (psi)
1 Pa	≡ 1 N/m^2	10^{-5}	1.0197×10^{-5}	9.8692×10^{-6}	7.5006×10^{-3}	$1.450\,377 \times 10^{-4}$
1 bar	10^5	≡ 100 kPa ≡ 10^6 dyn/cm^2	1.0197	0.986 92	750.06	14.503 77
1 at	$9.806\,65 \times 10^4$	0.980 665	≡ 1 kp/cm^2	0.967 8411	735.5592	14.223 34
1 atm	$1.013\,25 \times 10^5$	1.013 25	1.0332	1	≡ 760	14.695 95
1 Torr	133.3224	$1.333\,224 \times 10^{-3}$	$1.359\,551 \times 10^{-3}$	≡ 1/760 ≈ $1.315\,789 \times 10^{-3}$	≡ 1 Torr ≈ 1 mmHg	$1.933\,678 \times 10^{-2}$
1 psi	6.8948×10^3	6.8948×10^{-2}	$7.030\,69 \times 10^{-2}$	6.8046×10^{-2}	51.714 93	≡ 1 lbf /in^2

Practical consideration of this equipment, preclude the use of pressures much below 130 mbar, at the top plate of column. the more important are the pressure drop in the condenser system and the pressure drop across each plate of the column itself.

* a pressure drop of 3.5 mm Hg per plate at the vapor rate given in next point

** a vapor _carrying capacity of 122.47 kg/hr*ft*ft of column cross sectional area at 100 mm Hg absolute pressure.

42.3.3 Flexibility of the DW process

An important characteristic of the DW is the fact that as the throughput of Ethanol is reduced, the train is able to handle a lower feed concentration. Since the E process can also handle lower feed compositions at lower throughput rates, this weaker than design material was taken into the E plant and concentrated to full strength. This flexibility is important for two reasons:

1. It is not necessary to achieve design concentrations in pre-dw unit in order to obtain some production of Ethanol.

2. by holding low concentrations in the DW train at reduced throughput the amount of Ethanol held up in the train is lower.

42.4 Process control

42.4.1 General principles

The DW plant is relatively simple to operate. As is the case with any continuous distillation process, flow control is of primary importance, and the more uniformly the various critical flows are maintained the better will be the performance of the still train. The critical flows are

1- steam to each reboiler

2- flow of liquid pumped from base of each tower to next tower in series

3- pre-DW product fed to still training

4- overhead product withdrawn from still train for return to pre-DW

The problem of operating the DW train is essentially one of balancing flows to and from each tower so that the liquid level in each stays within permissible limits. Because of the characteristics of the system it has proved simpler to do this by flow controllers rather than by level controllers. This means flows are held constant and levels are allowed to drift slightly to compensate for minor deviations from perfect balance. Slight corrections to flow settings are made as necessary to fold levels within bounds.

A discussion of still train operation logically starts with steam flow. Each column is capable of carrying a certain vapor load and to bring about this vaporization there is required a definite quantity of steam at the reboiler. The first flows shall be fixed, therefore are the steam flows.

42.4.2 Process

> The first stage consists of 2 towers connected to operate as a single column. All liquid which flows down one tower is pumped from the base of that tower to the top of the second tower, and all vapor leaving the top of the second passes to the base of the first tower.

> to start the first stage, sufficient feed is admitted to fill the plates and the reboiler, cooling water flow is established through the condenser, steam is turned on and established at the standard flow for this stage, and all of the condensate from the condenser is allowed to return to the top plate(total reflux).

>feed is then started at an appropriate rate. The same time a flow of overhead draw-off is started from the condenser in amount equal to the feed.

> to determine whether overhead draw-off rate is exactly equal to the feed rate, it is only necessary to observe the trend of liquid level in the base of the column adjacent to the reboiler. The draw-off rate is then adjusted slightly to correct any drift observed in this liquid level. Thus the technique of operation consists in setting flows of steam and feed at predetermined values, setting flow of overhead draw-off equal to flow of feed, then making minor adjustments in the flow of overhead draw-off in order to make this flow balance exactly with the feed.

> the stage is now operating to concentrate Ethanol, and the Ethanol content of the material at the reboiler end of the stage will gradually increase.

> Now the second stage has been put into operation on total reflux in a manner similar to that described for the first stage. The two stages are then connected together by introducing the total flow of liquid from the second stage condenser into the second plate (counting from base) of the first stage, and at the same time pumping liquid at an equal rate from the base of the first stage to the top of the second stage. These two flows are balanced by observing the level in the base of the second stage and making minor adjustments in the flow of liquid entering the top of that stage. In a similar manner the remaining stages are successively placed in operation.

> in normal operation the total withdrawal of liquid from the train (first stage overhead plus final stage tails) must on the average equal the feed of liquid. The rate of draw-off from the base of the final stage however, is so small compared to the amount of liquid in the train that variations in this rate of draw-off do not affect, the problem of controlling the other stages. The withdrawal of product from the final stage can therefore be varied at the operators discretion, the base of the column acting, in effect, as a small, internal, holdup tank for product.

> if no product is withdrawn from the final stage, the concentration of Ethanol at the base of that stage will gradually increase toward a steady stage value. After withdrawal of product is started the Ethanol concentration will level out some lower value. The composition of the material withdrawn as product from the base of the final stage can be varied over a considerable range simply by varying the total amount withdrawn. As the rate is increased, the Ethanol. content falls, as the rate is reduced, the Ethanol content rises.

42.4.3 Operating pressure

The preferred range of operating pressure for a DW column is 85 to 95 mm Hg absolute, measured in the condenser vent line. The pressure drop through the vapor line and condenser is about 10 mm Hg so that the pressure above the top plate will be about 95 to 105 mm Hg. As previously noted, operation at a higher pressure will increase the productivity of the still train. This is so because the vapor carrying capacity of the still columns is directly proportional to the square root of the operating pressure. As the pressure is raised, the relative volatility decreases, and the steam consumption increases at a greater rate than does the productivity.

42.4.4 Boil-up rates

Column capacity is related to vapor density and vapor velocity by the following formula which has been developed as a design index of capacity has been found that operation at *F* factors much above 1 results in marked increases in plate to plate entrainment with consequent loss of plate efficiency.

$$F = \mu \sqrt{\rho}$$

where μ = vapor velocity, ft/sec (average velocity over column cross section)

ρ = vapor density, lb/ft^3

F = index of column capacity

at the design condition of 0,136 bar pressure the density of saturated water vapor is 0.1 g/m^3 by solving for u in the above equation, there is obtained a value of 4 m/s the vapor rate per square meter of area is then 1350 g per hour.

V=1:1000, A=1:100

42.4.5 Process losses

Only the bottom of the second column in the first stage, the process pumps and pump discharge lines operates at pressure above atmospheric.

Column head pressure	range	Normal
First stage		75 mbar
Second stage		75 mbar
Third stage		75 mbar
Third stage		75 mbar

Boilup rates	Maximum g/hr	Normal
First stage	15000	
Second stage	15000	
Third stage	4000	
Third stage	850	

Table 6: DW process standard operation conditions

Therefore there is very little hazard of product loss in the DW process. However, product dilution can occur through calandria or condenser tube leaks or through air in-leakage carrying with it natural concentration water vapor. Product dilution is controlled by periodic fluorescein dye injection on the calandria steam chests and condenser cooling water. Any dye concentration showing up in the process steam is indicative of a leak. Air in-leakage is detectable by the closing of a pressure controlling air bleed which is located in the steam suction. Closing of this valve and overload of the ammonia coolers both indicate that there is an air leak in the column which the jet and cooler are associated.

All tanks or equipment in the atmosphere pressure parts of the feed, tails or overhead systems where water vapor escape are protected bz passing all of the vents for such equipment through ammonia cooler or desiccant traps.

42.5 Construction Materials

Stage No.	#columns in the stage	Diameter	Height	Number of plates[30]	Nominal holdup[31] gallons (تنكة)	Reboiler area	Condenser area
1	2	0.32m (12 inch) 0.24m (10 inch)	2.47m 2.74m	7 8	5.8 4.5	0.6967 m²	5.574 m²
2	2	0.32m (12 inch) 0.24m (10 inch)	2.47m 2.74m	7 8	5.2 4.5	0.6967 m²	5.574 m²
3	1	0.17 m (6 inch)	2.35m	7	1.6	0.1858 m²	1.4864m²
4	1	0.08 m (3 inch)	2.35m	7	0.35	0.4645 m²	0.3716m²

Table 5: Equipment Description 1:10 length, 1:100 areas, volumes 1:1000

Stage	Numbers of columns	Column Manteau Surface [m²]	Number of plates
1	2	2,8	7
		2,2	8
2	2	2,8	7
		2,2	8
3	1	1,30	7
4	1	0,57	7
Total		11,87	44

The columns are made of stainless steel type 304

42.5.1 Distillation Bubble caps plate

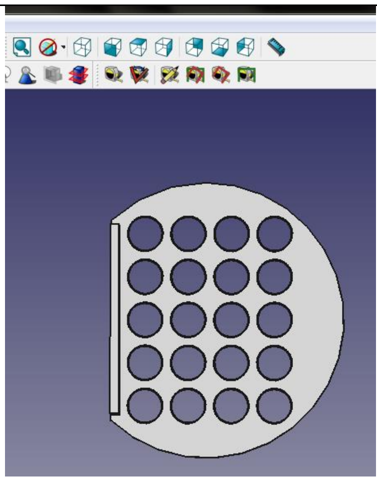
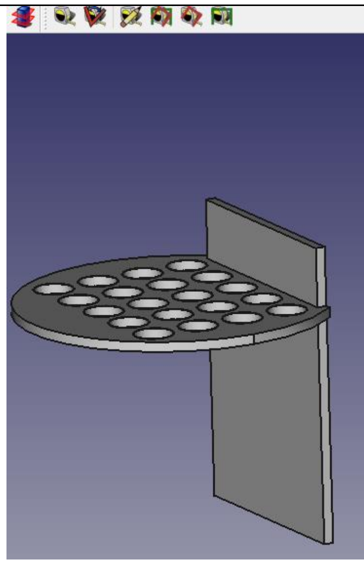
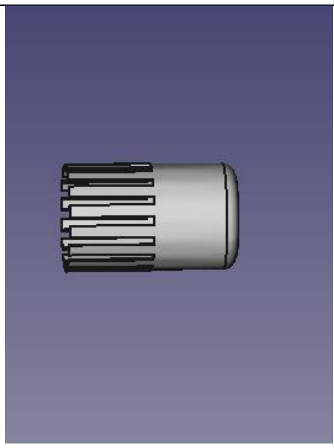
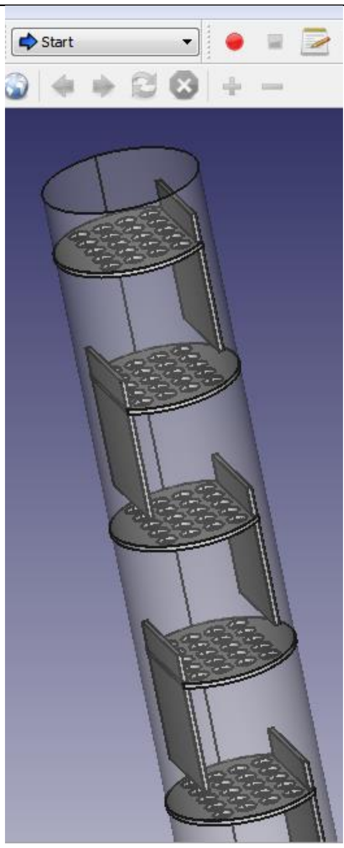
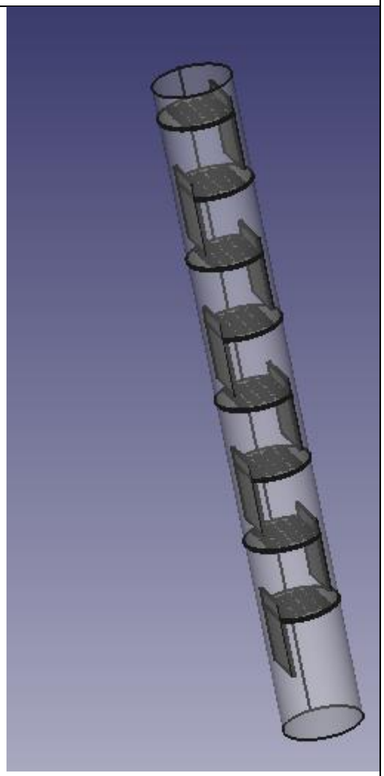
This the details of construction of such bubble cap plate

Metal Casting (صب المعادن): Ahmad +961 76361241 (Miniye)

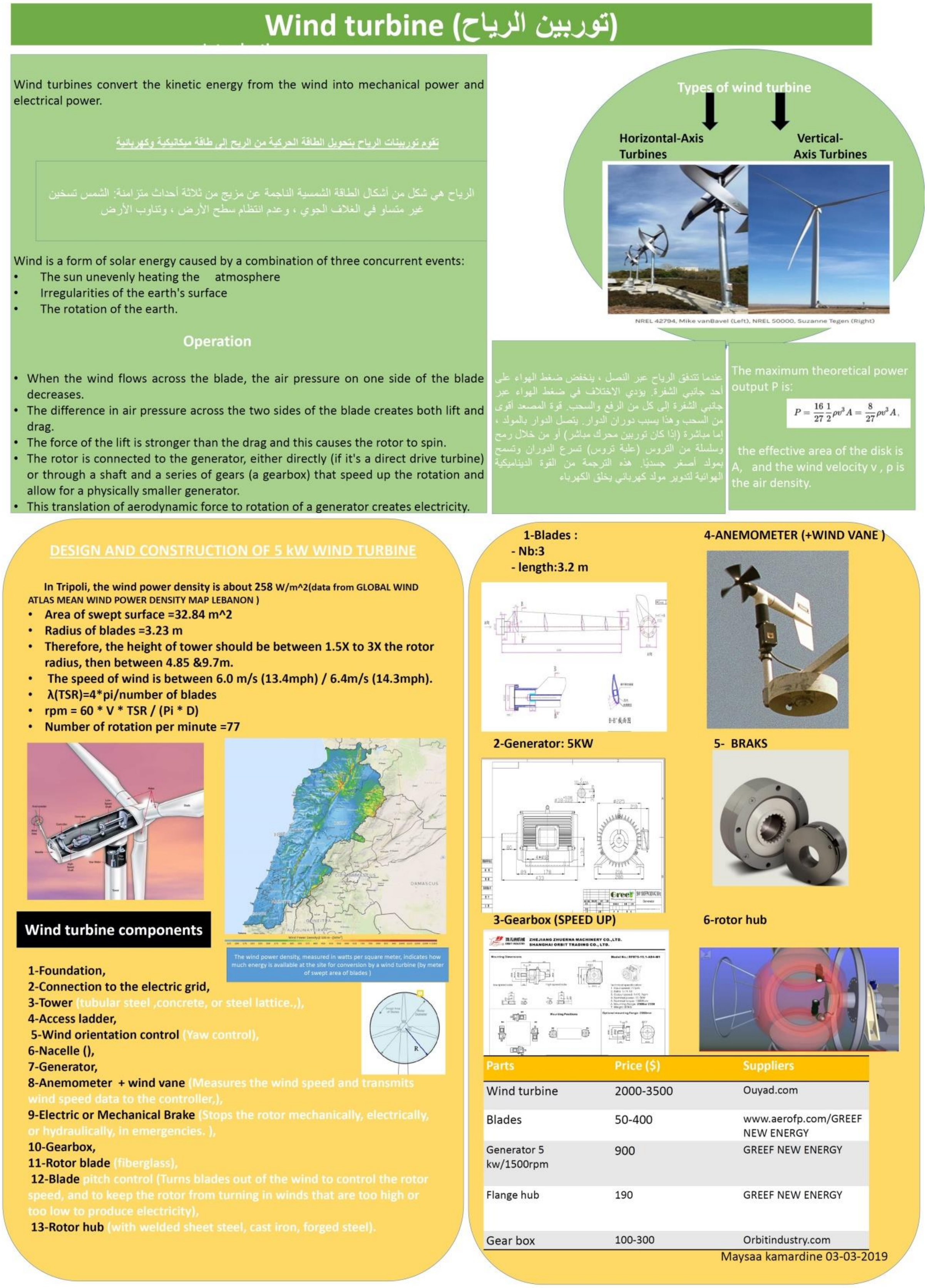
[30] plate spacing in all columns is 12 inches

[31] holdup includes associated calandria and /or condenser

Other planned elements: Desalting Unit, Wind Energy, Methan Liquefication, Purification of water

OneBubble plate distillation040118.FCStd		
cap040118.FCStd		
bubble plate distillation040118.FCStd		

43 5kW Wind Turbine[32]

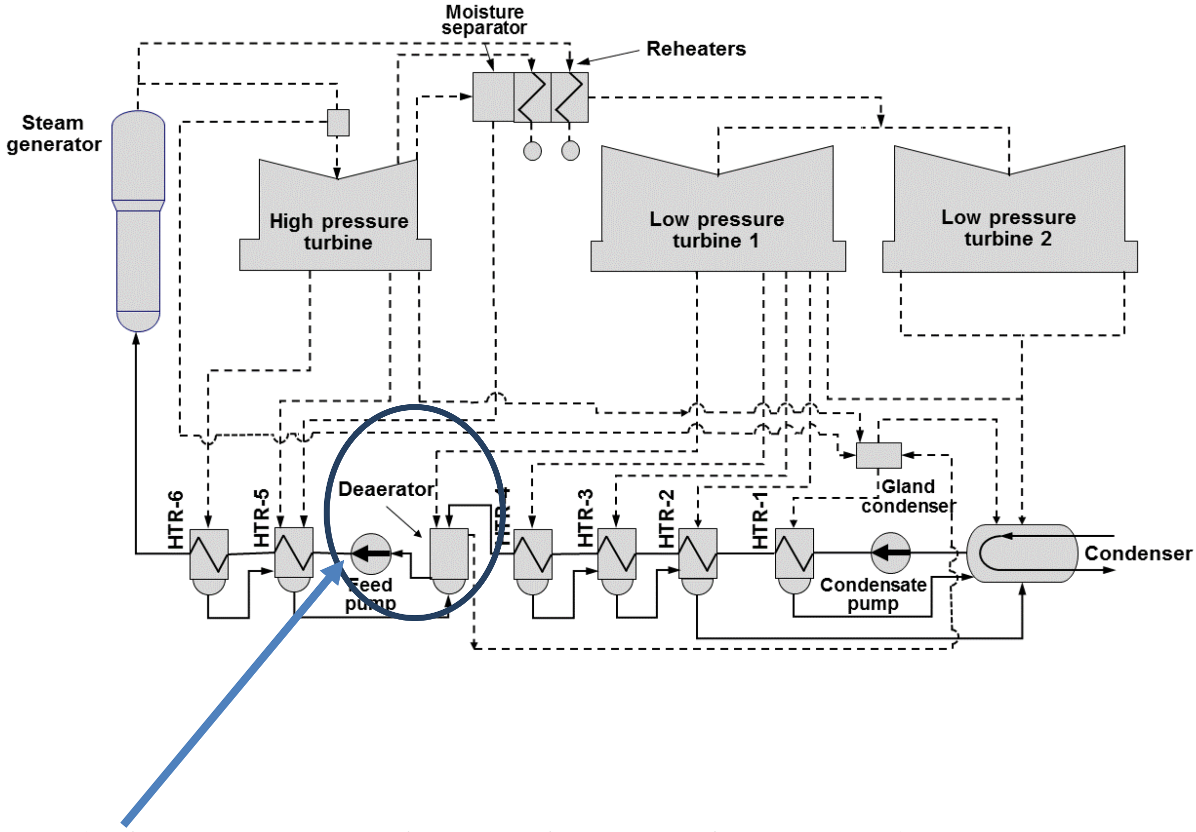


32 http://aecenar.com/index.php/downloads/send/3-meae-institute/469-5-kw-wind-turbine-concept-pdf

44 PURIFICATION OF WATER AND DE-OXIDATION (Deaerator)[33]

Maysaa Kamareddine, Last update: 3.12.18

44.1 Deaerator Basics



This is the first process to purify water after sorting from the condenser "Deaerator".

The *deaerator* is part of the feedwater heating system and receives extraction steam from the

turbine. The condensate to be heated and the extraction steam are intimately mixed in the

deaerator by a system of spray nozzles and cascading trays between which the steam percolates as shown in next Figure. The condensate is heated to saturated conditions and the steam condensed in the process. Any dissolved gases in the condensate are released in this process and removed from the deaerator by venting to the atmosphere or to the main condenser. This ensures removal of oxygen from the system particularly during turbine start-up and minimizes the risk of corrosion within the system. Venting to the atmosphere reduces the load on the condenser vacuum pumps, but results in some steam loss unless

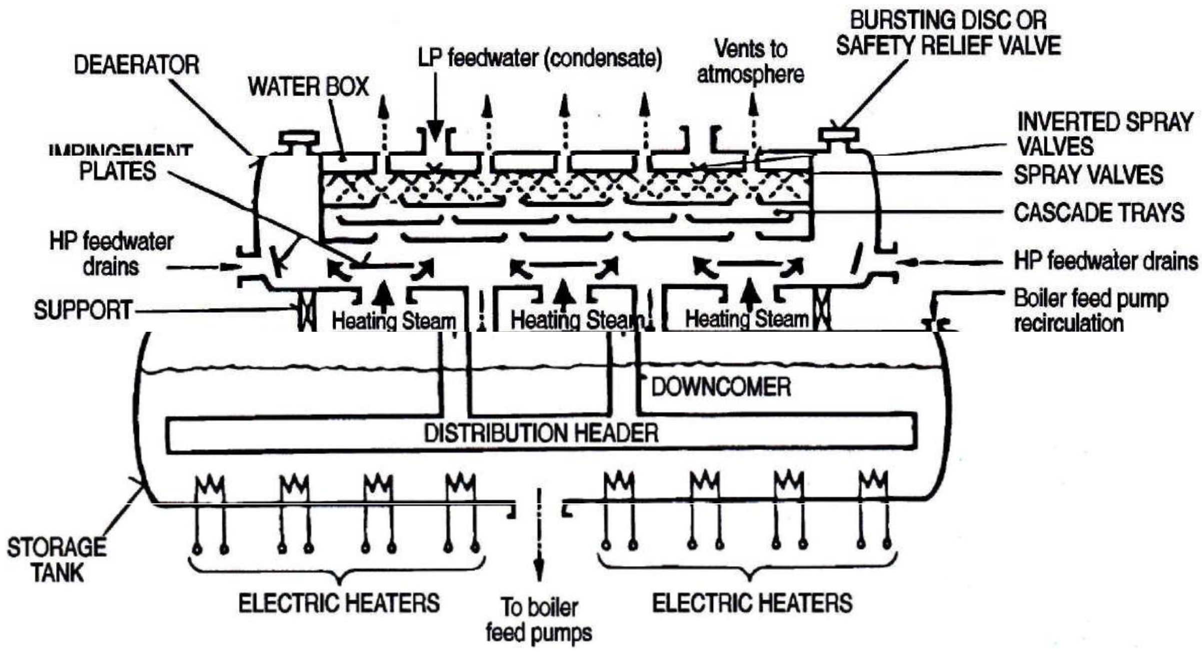
[33] from [NLAP-WEDC 2019]

provision is made to condense it and return it to the condensate system. Venting to atmosphere is only possible if the deaerator pressure is above atmospheric as it is at higher loads.

جهاز التنشيط هو جزء من نظام تسخين الماء المغذي ويستقبل بخار الاستخراج من
التوربينات. يتم خلط المكثف المراد تسخينه و بخار الاستخلاص بشكل وثيق في
تنفيس بواسطة نظام من فوهات الرش والصواني المتتالية التي يتسلل منها البخار
كما هو مبين في الشكل التالي   يتم تسخين المكثفات إلى ظروف مشبعة والبخار مكثف
في العمليه. يتم تحرير أي غازات مذابة في المكثف في هذه العملية و
إزالة من deaerator عن طريق تنفيس في الغلاف الجوي أو إلى المكثف الرئيسي. هذه
يضمن إزالة الأوكسجين من النظام خاصة أثناء بدء التوربين ويقلل
خطر التآكل داخل النظام. التنفيس في الغلاف الجوي يقلل من الحمل على
المضخات الفراغية للمكثف ، ولكن ينتج عنها بعض ضياع البخار ما لم يتم التضمين
ذلك وإعادته إلى نظام المكثفات. التنفيس إلى الغلاف الجوي ممكن فقط إذا كان الماسك
الضغط فوق الغلاف الجوي كما هو الحال في الأحمال العالية. في نظام محطة الطاقة ، مساعدة
يتم توفير (البخار) بأحمال منخفضة للحفاظ على درجات حرارة مرتفعة في خزان جهاز التنشيط.

44.2 The deaerating principle

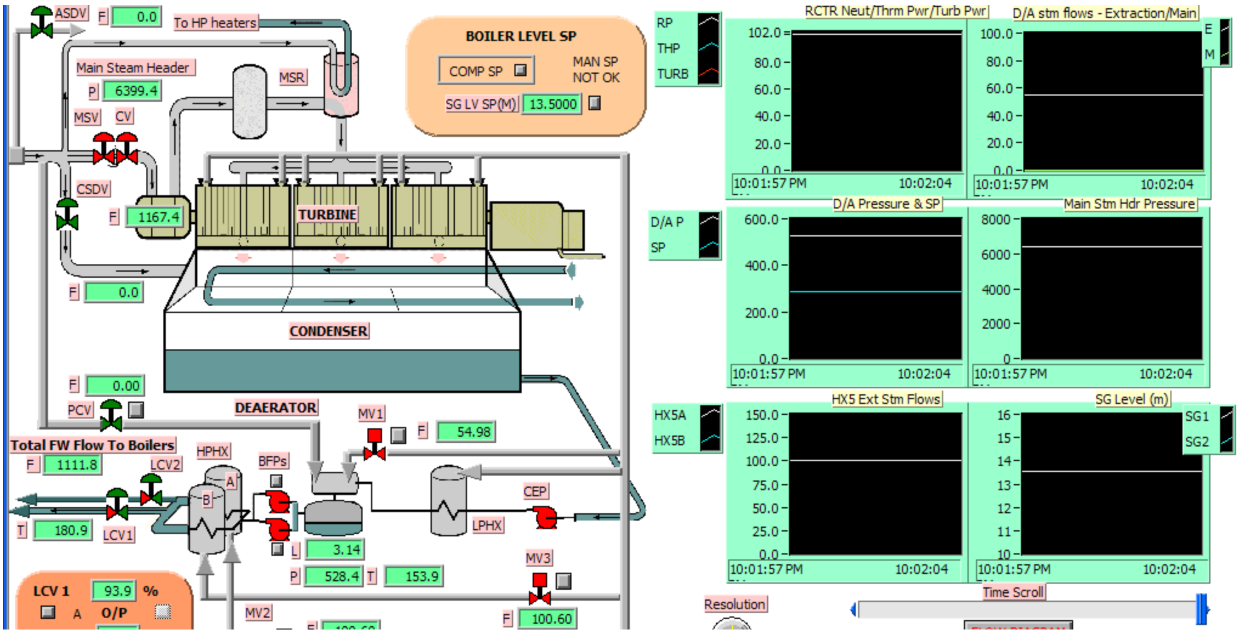
Deaeration is based on two scientific principles. The first principle can be described by Henry’s Law. Henry’s Law asserts that gas solubility in a solution decreases as the gas partial pressure above the solution decreases. The second scientific principle that governs deaeration is the relationship between gas solubility and temperature. Easily explained, gas solubility in a solution decreases as the temperature of the solution rises and approaches saturation temperature. A deaerator utilizes both of these natural processes to remove dissolved oxygen, carbon dioxide and other non-condensible gases from boiler feedwater. The feedwater is sprayed in thin films into a steam atmosphere allowing it to become quickly heated to saturation. Spraying feedwater in thin films increases the surface area of the liquid in contact with the steam, which results in more rapid oxygen removal and lower gas concentrations. This process reduces the solubility of all dissolved gases and removes them from the feedwater. The liberated gases are then vented from the deaerator.



Immediately below the deaerator is the *deaerator storage tank*, where a large quantity of feed water is stored at near saturation conditions. In the event of a turbine trip, the steam generator will require an assured supply of feed water to maintain the required water inventory during subsequent stabilizing conditions, during which residual heat must be removed. During suchconditions, the loss of extraction steam to the high pressure feedwater heaters renders them ineffective, and water from the deaerator storage tank is pumped into the boiler or steam generator without further heating. If deaerator pressure is maintained between 0.5 MPa and 1.0 MPa, then the corresponding temperature of this stored feed water will be between 150 and 180 degree Celsius. With an adequate supply of water at this temperature in the deaerator storage tank, damaging thermal shock to the steam generator can be avoided.

The deaerator storage tank is usually located at a high elevation between the reactor containment and the turbine hall to ensure an adequate net positive suction head at the inlet to the feedwater pumps, thus minimizing the risk of pump cavitation.

Other planned elements: Desalting Unit, Wind Energy, Methan Liquefication, Purification of water



This screen shows the portion of the feedwater system that includes the condenser, low pressure heater, deaerator, the boiler feed pumps, the high pressure heaters and associated valves, with the feedwater going to the steam generator level control valves, after leaving the

HP heaters.

The following display parameters and pop-up controls are provided:

• Main steam header pressure (KPa), steam flow through the turbine governor valve and the bypass valve (Kg/s).

• Deaerator level (m) and deaerator pressure (KPa); extraction steam motorized valve status and controls from turbine extraction, as well pressure controller controls for main steam extraction to deaerator. The extraction steam flows (Kg/s) are shown respectively for turbine extraction as well as for main steam extraction to the deaerator.

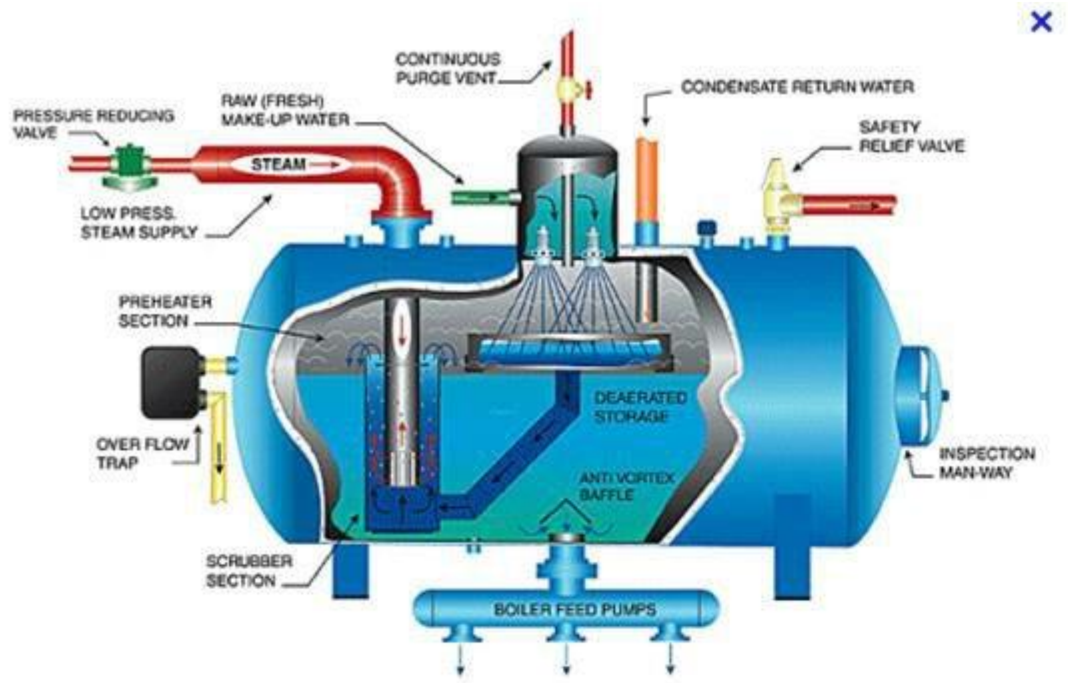
• Main feedwater pump and auxiliary feedwater pump status with associated pop-up menus for 'ON/OFF' controls.

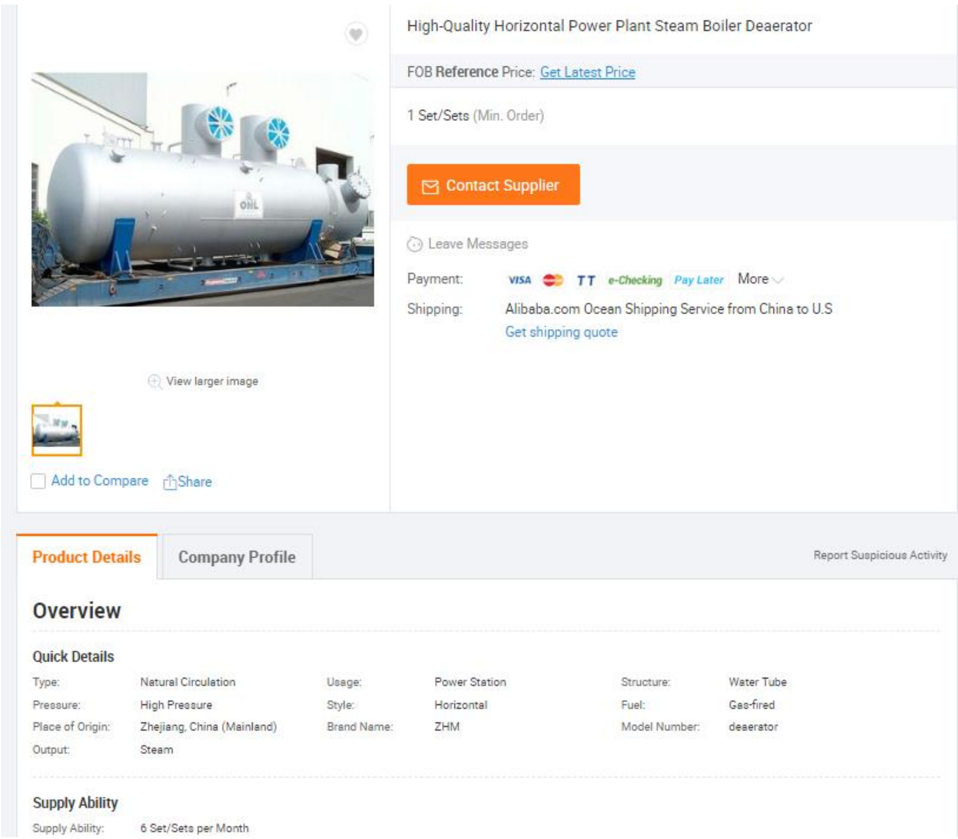
• HP heater motorized valves MV2 and MV3 and pop-up menus for open and close controls for controlling extraction steam flow to the HP heaters.

• Feedwater flow rate (Kg/s) at boiler level control valve (LCV1 & LCV2) outlet and feedwater temperature (°C).

• Pop-up controls for "auto/manual" for boiler level control valves LCV1 & LCV2.

44.3 DEAERATOR FROM alibaba





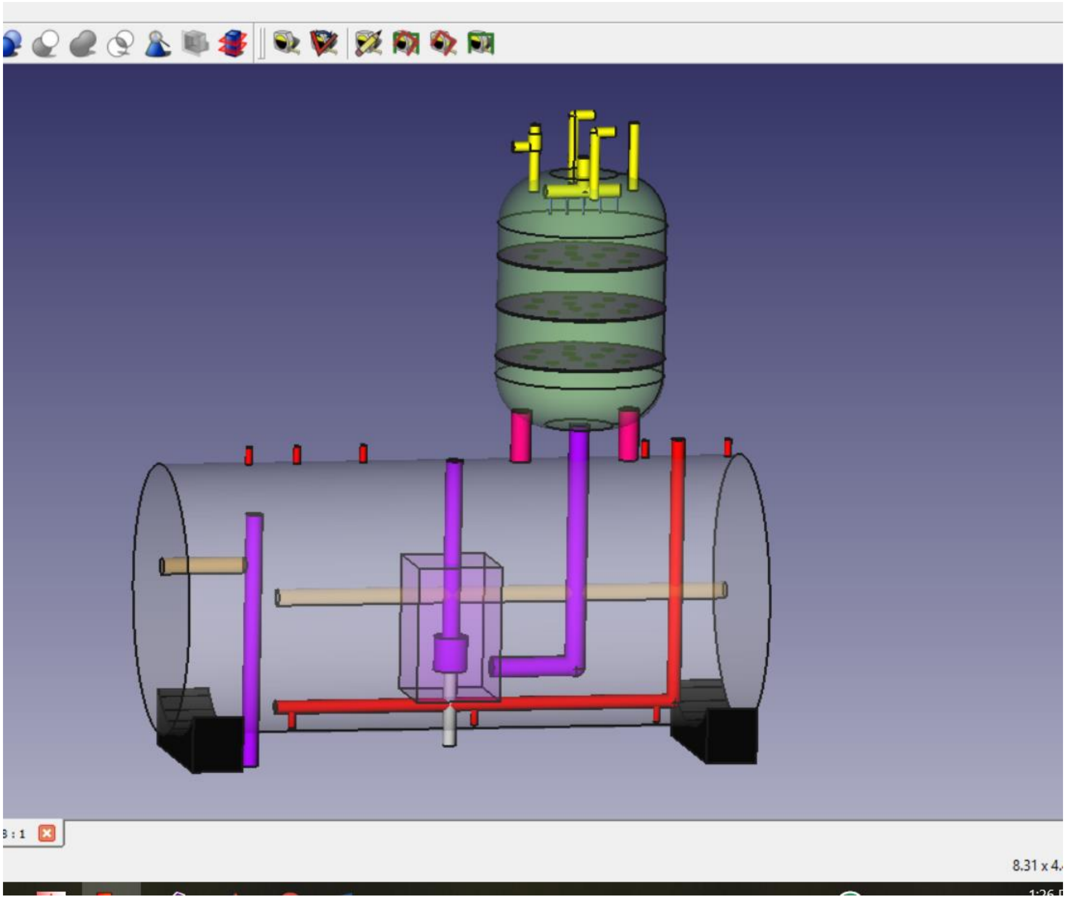
Other planned elements: Desalting Unit, Wind Energy, Methan Liquefication, Purification of water

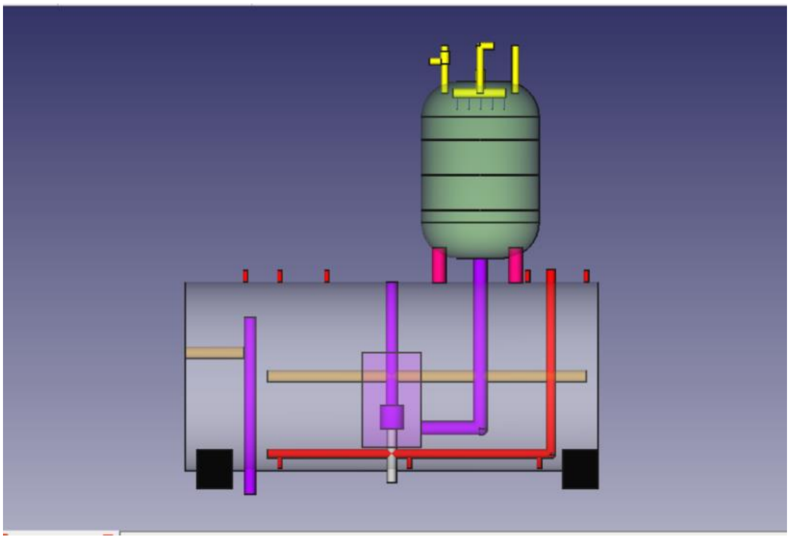
Product name	Thermal de-aerator with Water Tank
Product information	
Unit price	USD 25000/Sets
Min. order quality	1 Sets
Payment terms	T/T
Quotation valid time	2018-12-28
Product description	Place of Origin:China Type:Tanks Brand Name:LSBiotech Working Pressure:0.2MPa Working Temperature:104 degree Cel. Water Tank:Include. 25 CMB Water Flowrate: 50 ton per hour Arrangment:Horizontal tank Valves & Instruments: without
Supplier background	
Business type	✓ Trading Company
Main products	BOILER,BOILER PARTS,BOILER ISLAND
Product certification	

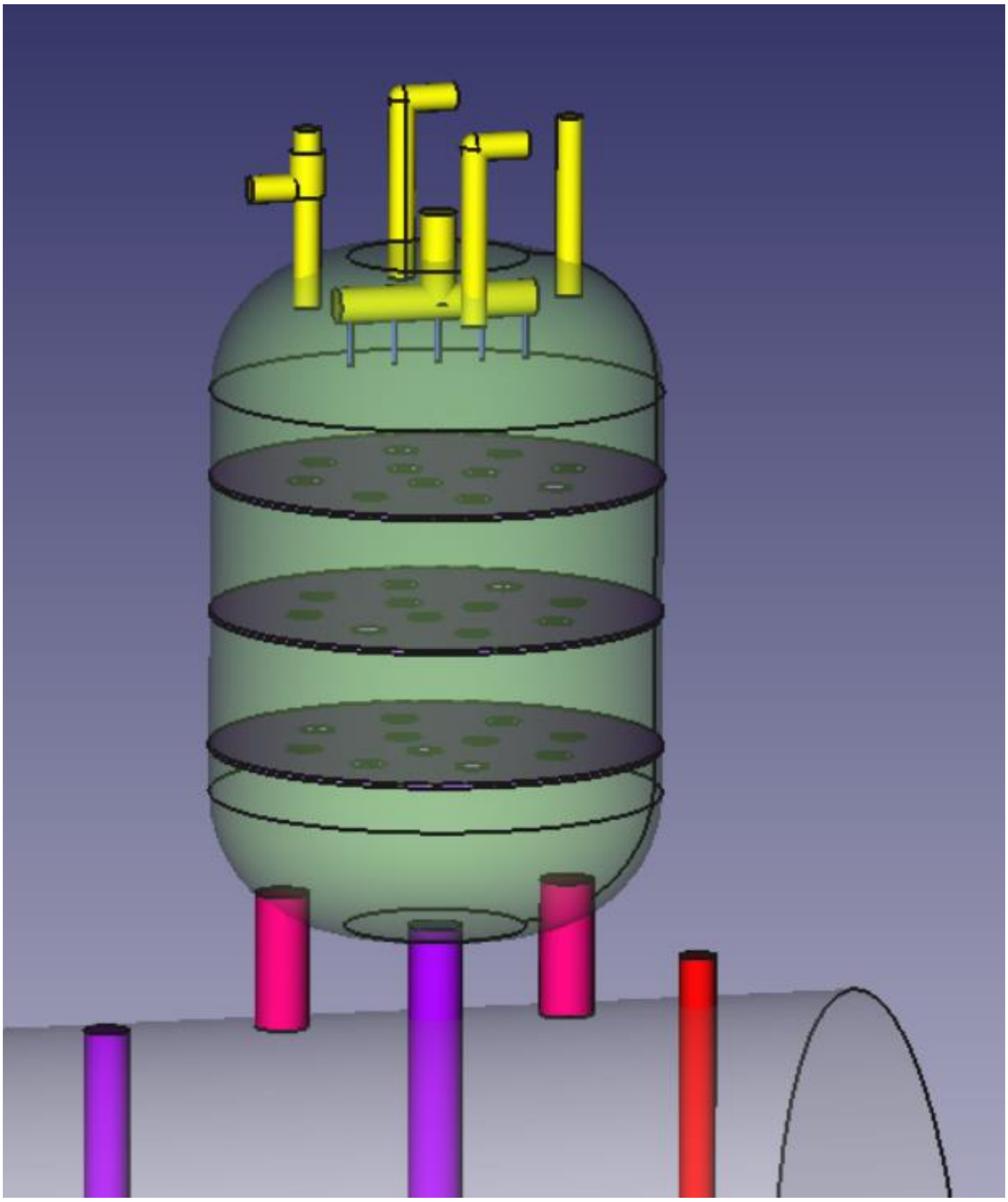
the flowrate is 50 t/hour. It should be 2500 t/h approximately

44.4 freecad design

dearator031218.FCStd

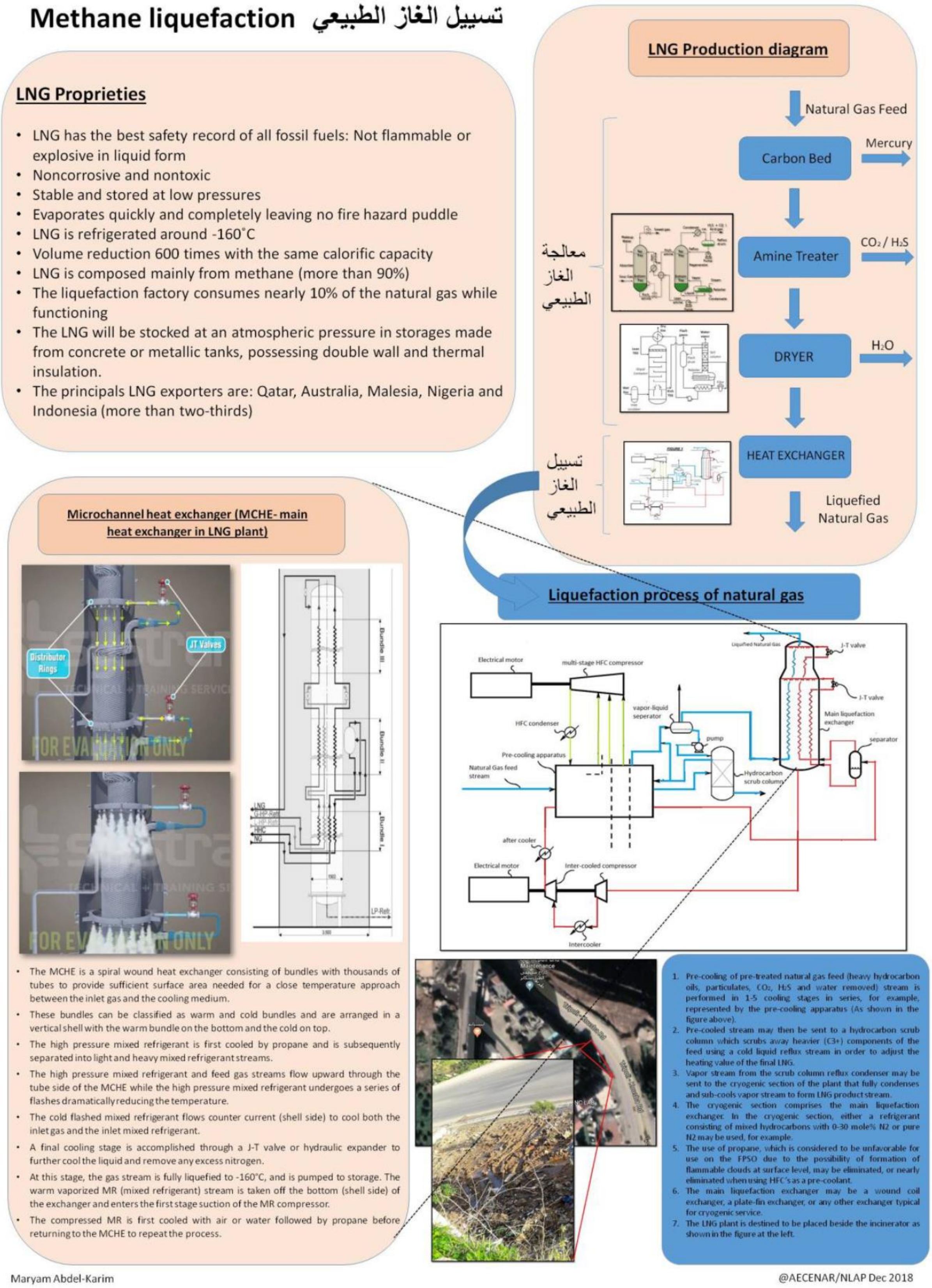






44.5 Deaerator Systems from Zmerly, Tripoli

45 Methan Liquefication[34]



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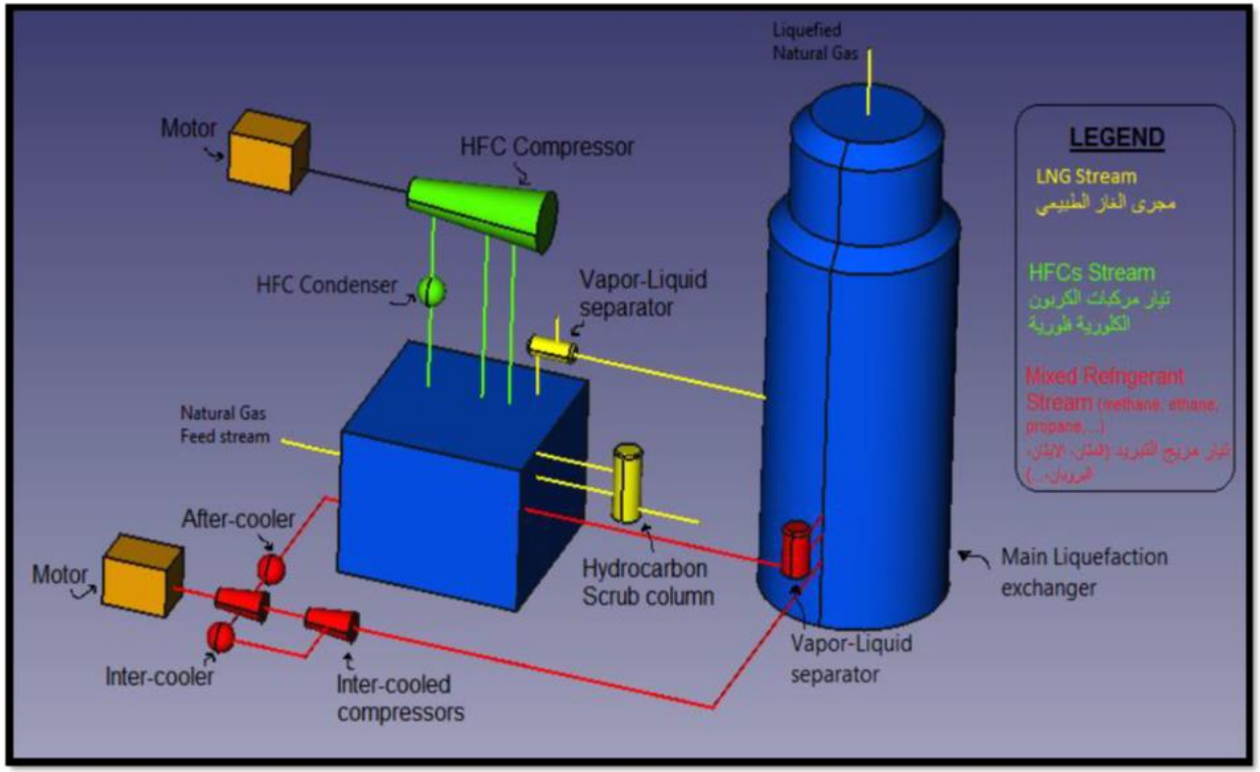
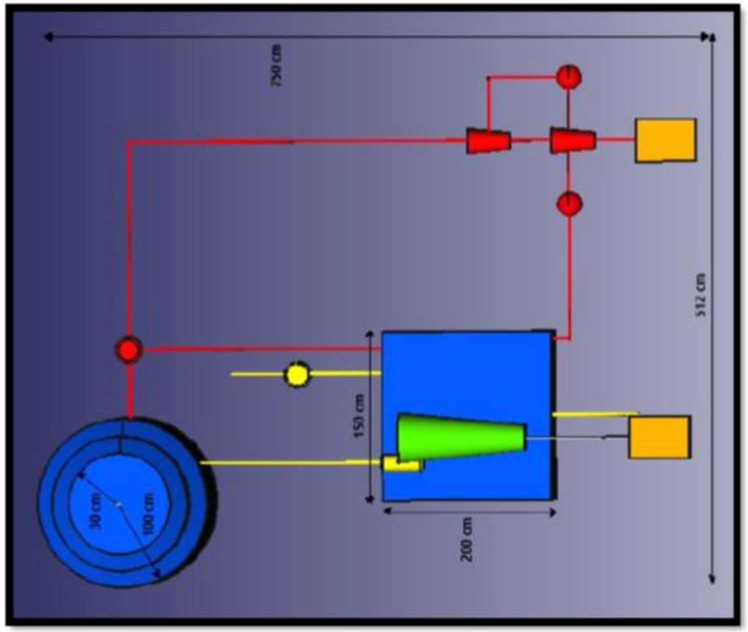
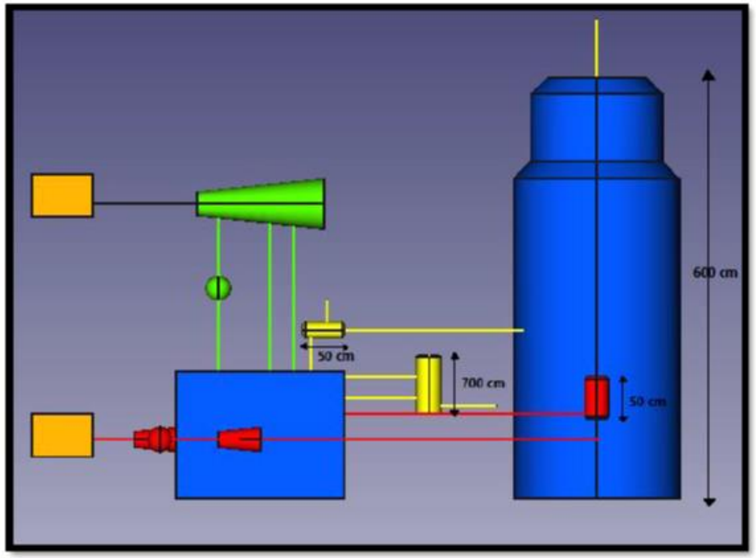
[34] from [NLAP-WEDC 2019]

Methane Liquefaction
تسييل الغاز الطبيعي



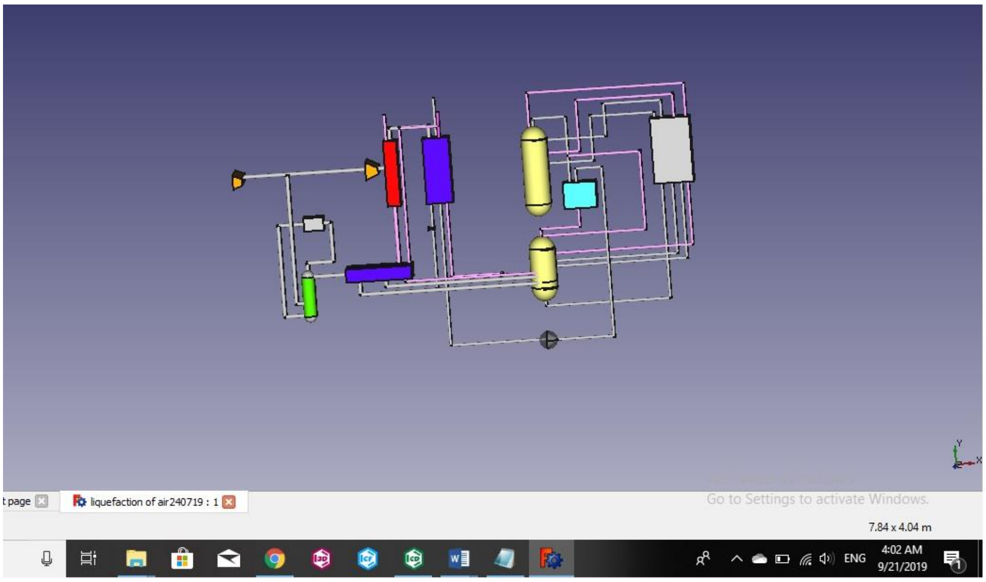


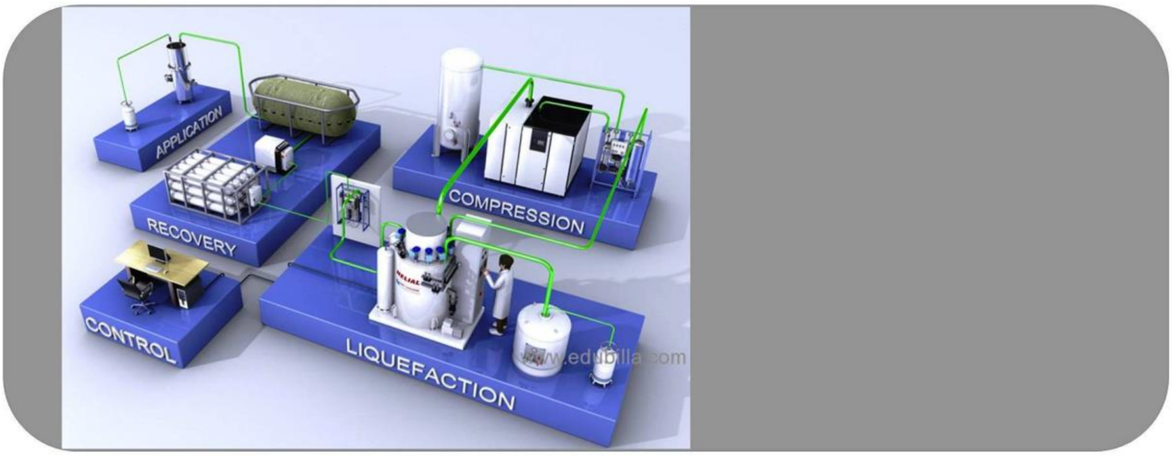


Maryam Abdel-Karim

*الأرقام الموجودة ارقام تقريبية

46 Liquefication of air / oxygene





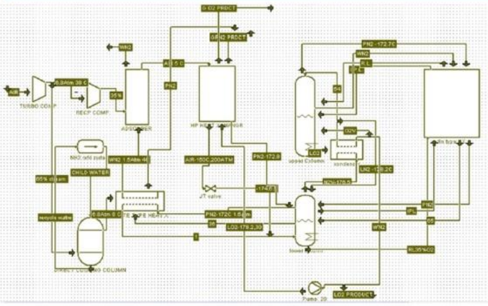
بســــــــــــــــــم الله الرحمن الرحيم

AECENAR
Association for Economical and Technological Cooperation in the Euro-Asian and North-African Region

طاقة الشمال
North Lebanon Alternative Power
www.nlap-lb.com

Liquefaction of air(oxygen)

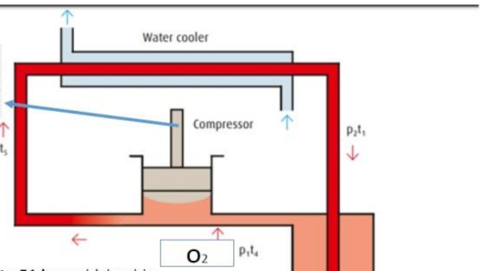
Process of purification and liquefaction of air :

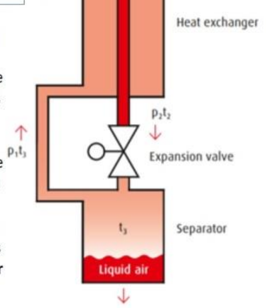


In this process at first air is **filtered & compressed to 6.8 atm** in turbo compressor. During the compression cooling is done to maintain the temp to **35 - 40°C.**
After compression the air is divided into two streams. One is **65% stream** & the other **is 35%,** now the larger stream is then passed through after cooler and heat exchanger where it is cooled to **-150°C to -170°C** by the incoming pure nitrogen & waste nitrogen streams produced from rectification columns.
The smaller stream is passed through **reciprocating compressor** to increase the pressure to about **200atm.**Here the air temp is maintained at **4-8°C** by intermediate cooling between stages using **cold water obtained by ammonia refrigeration.**
Then the air goes through **high pressure heat exchanger** where the temp of air is brought down to about **-120 -140°C.** Now the air undergoes expansion to about **6.5 atm in the expansion engine**.
The temperature of air is brought down from **-170 to -174°C by joule Thompson effect.**
Now the air will be in liquid state & mixes with the larger stream & changes the whole air stream into saturated liquid state.
This saturation liquid is fed to **Linde rectification column**. This column may be **single, double** or compound depending on requirement. the liquid product coming out will have a purity of about **99.4 -99.99%.**
This liquid is partially vaporized in condenser, to **liquefy the nitrogen vapor** &the rest may be taken as liquid product or it may be obtained in gaseous state if it is used for cooling of incoming air, the other products that obtained are pure **nitrogen of purity above 98% &** waste nitrogen product of purity of about 92-96%.

Process of liquefaction of oxygen

Stage 1		Stage 2	Stage 3	Total
1.12E-03	mass flow rate, kg/s	1.12E-03	1.12E-03	
3	Pressure ratio	4	3.6	43.5
0.6	Pump Efficiency	0.6	0.6	
118.8	Input pressure, kPa	356.4	1425.6	
356.4	Outlet Pressure, kPa	1425.6	5167.5	5167.5
1.7	Inlet Density, kg/m3	5.0	20.4	
265	Pump Input Power, W	397	344	1006





- The gas is **compressed to 51 bar,** which adds external energy **(300 k)** into the gas, to give it what is needed for running through the cycle.
The high pressure gas is then cooled by immersing the gas in **a cooler environment;** the gas loses some of its energy (heat).
- The high pressure gas is further cooled with a **countercurrent heat exchanger to arrive to 150 k**; the cooler gas leaving the last stage cools the gas going to the last stage .
- The gas is further cooled by passing the gas through a **Joule–Thomson orifice (expansion valve);** the gas is now **at the lower when it is forced through a valve or porous plug while keeping it insulated so that no heat is exchanged with the environment.**

- The low pressure gas is now at its coolest in the current cycle.
Some of the gas may condense and become output product.
The low pressure gas is directed back to the countercurrent heat exchanger to cool the warmer, incoming, high-pressure gas.
After leaving the countercurrent heat exchanger, the gas is warmer than it was at its coldest, but cooler than it started out at step 1.
The gas is sent back to the compressor to make another trip through the cycle (and become still colder).

Oxygen properties

OXYGEN IN SOLID STATE: It is a hard, pale blue, doubly refracting crystalline solid.

Melting point: -218.81°C

Density at -252.5°C: 1.4256 gm/cc

Specific heat at -256°C: 0.078 cal

Heat of fusion at -219°C: 313 cal/gm

OXYGEN IN LIQUID STATE: It is a pale steel blue, transparent and very mobile liquid

Boiling point: -182.02°C

Density at boiling point: 1.14gm/cc

Surface tension at B.P.: 13074 dynes/cm

It is a non-conductor of electricity and strongly magnetic when compared to iron.

OXYGEN IN GASEOUS STATE: It is a colourless, odourless, tasteless, diatomic gas, a volume of it slightly heavier than equal volume of air. One Litre of oxygen under standard condition weighs 1.42901gm and the corresponding weight of air is 1.2929gm. The oxygen is only slightly soluble in water at ordinary temperature and pressures

Table 12 Work Required to Liquefy Selected Gases[a]

	Work			Thermal Energy	Electricity	
Substance	cal/mole	J/mole	Btu/lb	(Btu/lb)	kWh/lb	kWh/kg
Air	5,000	20,900	310	930	0.091	0.20
Oxygen	4,800	20,300	273	819	0.080	0.18
Nitrogen	5,100	21,400	328	984	0.096	0.21
Helium	6,500	27,200	2,935	8,805	0.86	1.89
Hydrogen	5,700	23,800	5,119	15,357	1.50	3.30

[a]Using ideal (thermodynamically reversible) process: $W_{rev} = T_a \Delta S - \Delta H$, where T_a = 298 K (25°C), and P_a = 1 atm.

Note: The values given for each gas are equivalent amounts of energy (or work) expressed in several units of measure.

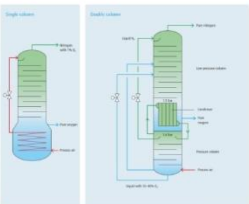


TABLE 5.6a: Specification sheet for Compressor

Power of Compressor	364.355KW
Rotational Speed	2300.0698rpm
Inlet absolute velocity from Imp	50.45m/s
Outlet absolute velocity from Imp	74.726m/s
Radius of Impeller 1 tip	0.0755m
Radius of Impeller 2 tip	0.151m
Number of impeller blades	20
Width of diffuser 1	0.033m
Width of diffuser 2	0.00938

TABLE 5.6c: Specification sheet for the main heat exchanger

fin thickness(t)	30mm
fin frequency (f)	0.7425 fin per meter
fin length (l)	250mm
fin height (h)	50mm
fin spacing (s)	110mm
plate thickness (b)	80mm
free flow area (Aff)	4000mm^2
frontal area (A)	11200mm^2
heat transfer area (As)	83000mm^2
fin area (Af)	28000mm^2
equilibrium diameter (Dh)	48.19mm
fin area/total surface area	0.3373
frontal area ratio (ζ)	0.3571
height-spacing ratio (α)	0.45453
length- spacing ratio (δ)	2.7272
thickness-spacing (ν)	0.27273

HIGH PRESSURE COLUMN, P = 5.0 atm			
COMPONENT	FEED, F1	DISTILLATE, D1	BOTTOM, B1
OXYGEN	0.21	0.005	0.4
NITROGEN	0.79	0.995	0.6
FLOWRATES (Kmol/h)			
F1 = 145.379	D1 = 69.92	B1 = 75.459	
Vn1 = 209.76	Ln1 = 139.84	Vm1 = 209.76	Lm1 = 285.219
FEED TEMPERATURE : -200°C			
FEED POINT : 2			
NUMBER OF STAGES, N = 7			
MINIMUM REFLUX RATIO, Rm = 0.5			
REFLUX RATIO, R = 2			
MINIMUM NUMBER OF STAGES, Nm = 4			
LOW PRESSURE COLUMN, P = 1.4 atm			
COMPONENT	FEED, F2	DISTILLATE, D2	BOTTOM, B2
OXYGEN	0.6	0.005	0.01
NITROGEN	0.4	0.995	0.99
FLOWRATES (Kmol/h)	D2 = 45.20	B2 = 30.26	
F2 = 75.459	Ln2 = 0	Vm2 = 185.039	Lm2 = 215.299
Vn1 = 209.76			
FEED POINT : 5			

NUMBER OF STAGES, N = 7			
PLATE SIZING	PLATE SPACING: 500mm	PLATE THICKNESS: 5mm	
PLATE EFFIENCY : 50%			
HOLE SIZING	HOLE PITCH, LP : 15mm	AREA OF PITCH, : 218.2mm²	
HOLE SIZE, dh : 5mm			
COLUMN SIZING	COLUMN EFFICIENCY : 70%		
COLUMN DIAMETER, Dc : 4700mm			
WEIR/DOWNCOMER SIZING	WEIR LIQUID CREST, how : 50mm liquid	LENGTH OF WEIR, Lw :3619mm	
HEIGHT OF WEIR, hw : 50.0mm			
DOWNCOMER CLEARANCE, hcl : 13mm			
VAPOUR LIQUID FLOW RATE, FLV : 0.62			
FLOOD VELOCITY, Uf : 7.366mm/s			
NUMBER OF REAL STAGES, N : 19			

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