



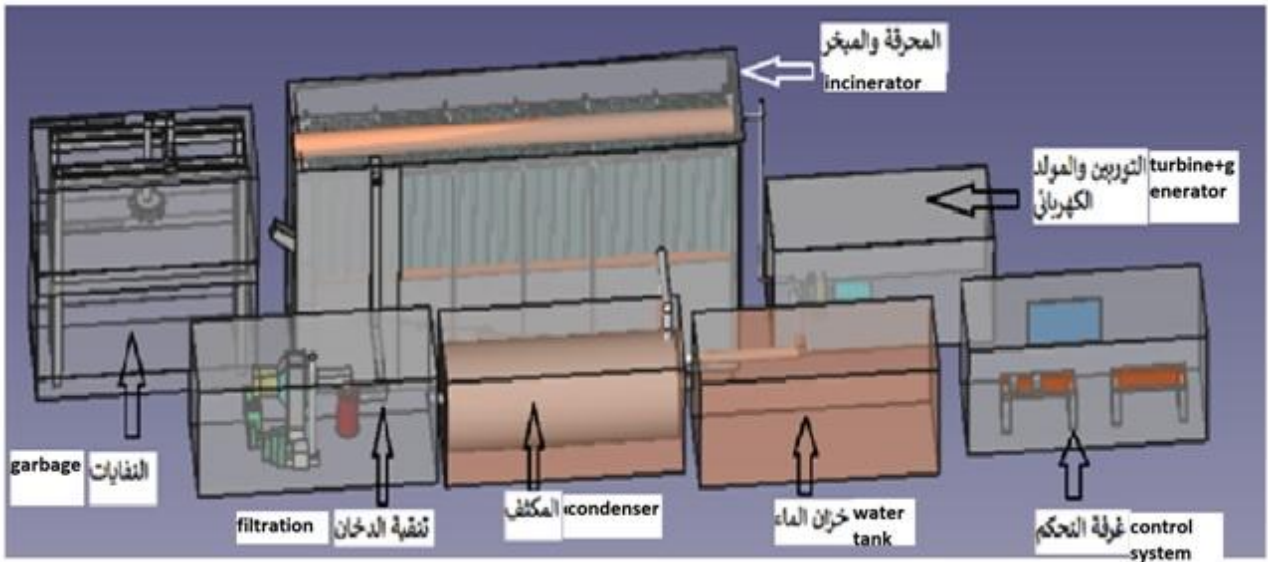
نظام التحكم

-

Process Control System (PCS) for NLAP incineration plant

Platform System

Report 2018



Initial Document: 07.09.2018 (platform)

Last update: 02.02.2019

Authors:

Mourad

6	Abstract / تلخيص	
7	(Project Management) ادارة المشروع	1
7	Prototype for Incineration Air&Waste Supply + Turbine&Generator Control	1.1
8	Project Planning GUI-Integration (Oct-Nov 2017)	1.2
9	Project Planning Update Jan 2018	1.3
10	Project Planning Update Sep 2018	1.4
11	Basics	2
12	System Architecture Design with MODBUS	3
13	(GUI Specification) تحديد وجهة المستخدم	4
13	NLAP-2MW Plant overview page	4.1
13	NLAP-2MW control loops page	4.2
13	NLAP -2MW incineration air/waste supply control & incineration page	4.3
13	NLAP-2MW incinerator power control page	4.4
13	NLAP-2MW turbine generator page	4.5
13	NLAP-2MW feedwater and extraction steam page	4.6
13	NLAP-2MW feedwater and extraction steam page	4.6.1
13	NLAP-2MW MW demand setpoint (SP) and steam generator pressure control (SGPC)	4.7
14	(Communication Concept) تصميم لاتصالات بين الحاسوب اجهزة المقياس والتحكم	5
14	Protocol (MODBUS)	5.1
14	Hardware	5.2
14	Software	5.3
14	protocol.h	5.3.1
15	Turbine Govering System	6
16	RPM Sensor with MODBUS	6.1
16	Hardware & MODBUS-RPM Connecting Software	6.1.1
16	Testrig Program	6.1.2
16	Program Start	6.1.2.1
16	Connecting	6.1.2.2
18	Odometric Measurement (Rotor Speed)	6.1.2.3

19	Main Steam Valve Actuator (تحكم صمامة البخار عند مدخل التوربين)	6.2
22 (Incinerator Regulating System) تحكم عملية الحرق	7
23	IR Camera (Incinerator Temperature Sensor)	7.1
23 Melexis IR Camera	7.1.1.1
24	Air&Waste Supply Actuator	7.2
24	Module Diagram	7.2.1
25 Boiler Pressure Control	8
26	Pressure Sensor (Data Sheet)	8.1
28	Atmospheric Steam Discharge Valve	8.2
28	Condenser Bypass Steam Discharge Valve	8.3
29 Literature / المراجع	
30 Appendix/ ملحق	9
30	RPM.ino	9.1
30	ملحق ب: برنامج واجهة التحكم (GUI)	9.2

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

In the Name of God, the Most Merciful

Inst./Proj.	Working Package	Actual Grade of Fulfilment (25%,50%,75%,100%)	Due Time Line	Respon-sible	Required Time Ressource (men months MM)
NLAP	CAD 40 bar pressure tubes for 40MW plant	0%	Jul		0,5
NLAP	Brochure 2 MW plant (6 pages)	100%	May	Samir	
NLAP	Process Control System for TEMO-IPP: - GUI Specification (incl. simulator)	75%		Samir	0,5
NLAP	Prototype for Incineration Air&Waste Supply + Turbine&Generator Control: Air&Waste Supply page + RP3: 1. Melexis IR Sensor(Camera), 2. waste band motor 3. Air Supply Ventilator Motor Turbine&Generator page + K8061: 1. T/p sensor at turbine inlet, 2. main steam supply valve 3. bypass valve motor 4. odometric sensor of turbine axis			Samir	
NLAP	NLAP-PCS: GUI with 9 pages	0%		A1	0,5
NLAP	NLAP-PCS: Adapting Visual Pressure Sensor to Raspberry	25%		A1	0,5
NLAP	Process Control System for TEMO-IPP: - Messaging: Adapting Sensors/Actuators via wireless to GUI	0%		A1	0,5

1.1 Prototype for Incineration Air&Waste Supply + Turbine&Generator Control

Detailed Working packages:

- Adapting K8061 to RaspberryPi

1.2 Project Planning GUI-Integration (Oct-Nov 2017)

Project managers:	Samir
Dates:	23.10.2017 - 30.11.2017
Complete:	4%
Tasks:	7
People:	2

Tasks

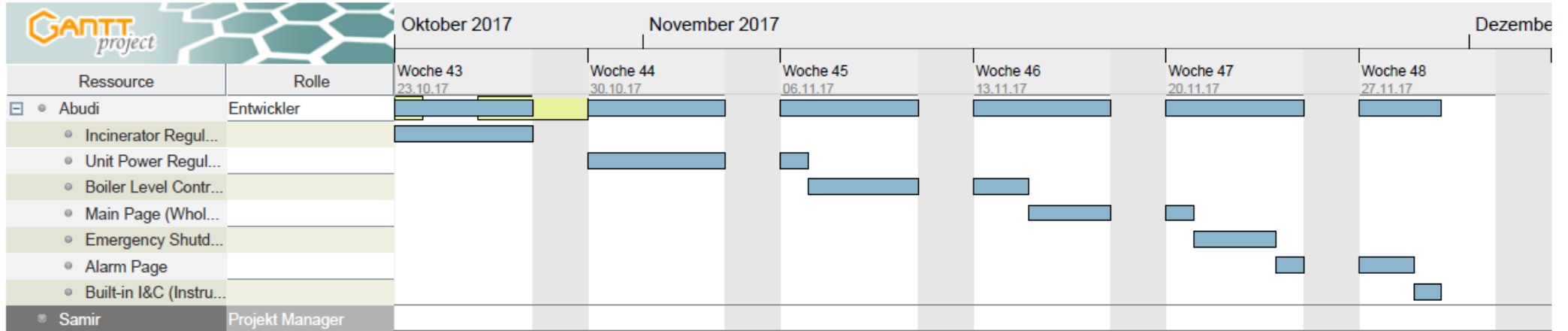
Vorgang	Anfang	Ende
Incinerator Regulation System (IRS) inkl. HW - Kamera + Incinerator Air Supply + Anweisung für Mülleingabe - Controlprogramm auf Raspberry oder MainControlComputer (MCC) - Monitoring auf MCC (Main Page , RRC Page (mit Realtime-IR-Aufnahme))	23.10.17	27.10.17
Unit Power Regulator Page (UPR) inkl. HW - Drehzahlsensor an Raspberry anschliessen - Control und Feedback an MainSteamValve - Monitoring auf UPR Page	30.10.17	06.11.17
Boiler Level Control Page (BLC) inkl. HW - Schaltkasten Levelcontrol an Monitoring anschliessen (- Automatic Valve on Boiler (ausser Safety Valve)) - BLC Page for Monitoring on MainControlComputer (MCC)	07.11.17	14.11.17
Main Page (Whole System)	15.11.17	20.11.17
Emergency Shutdown System inkl. HW bei Notfall (Druck in Boiler zu hoch, Safety Valve >10s oder ...): Massnahmen: - Air aus - Einspritzung von Feuerlöschpulver - Atmospheric Automatic Valve aufmachen	21.11.17	23.11.17
Alarm Page - Overpressure in Boiler - Drehzahl der Turbine zu hoch	24.11.17	28.11.17
Built-in I&C (Instruments&Control) Diagnostics Page	29.11.17	29.11.17

Resources

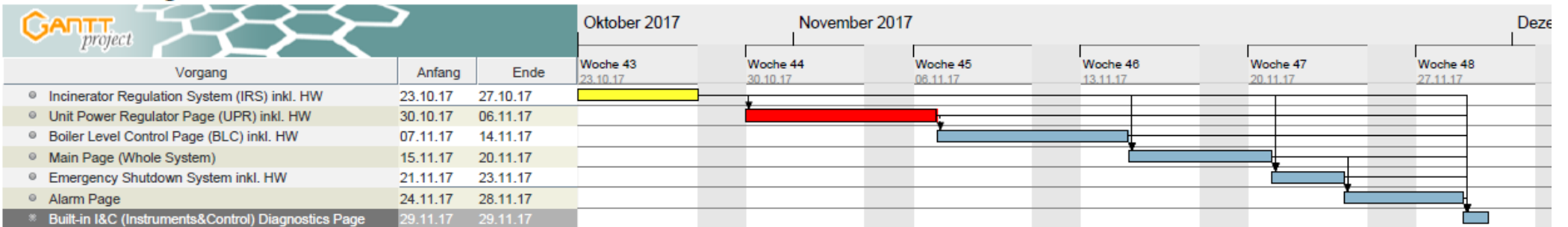
Ressource	Rolle
Abudi	Entwickler
Samir	Projekt Manager

Ressourcendiagramm

5



Gantt-Diagramm



1.3 Project Planning Update Jan 2018

1.4 Project Planning Update Sep 2018

Task	Remarks	Due Date	Responsible
Steam Valve Modbus PCB+Firmware	Turbine Gov. System	10.1.18	CNCLab (Rami)
IR Camera (Modbus Slave) PCB+Firmware	Incinerator Regulating Syst.	10.1.18	CNCLab (Rami)

2 Basics

Please refer to NLAP-PCS Report 2017

3 System Architecture Design with MODBUS

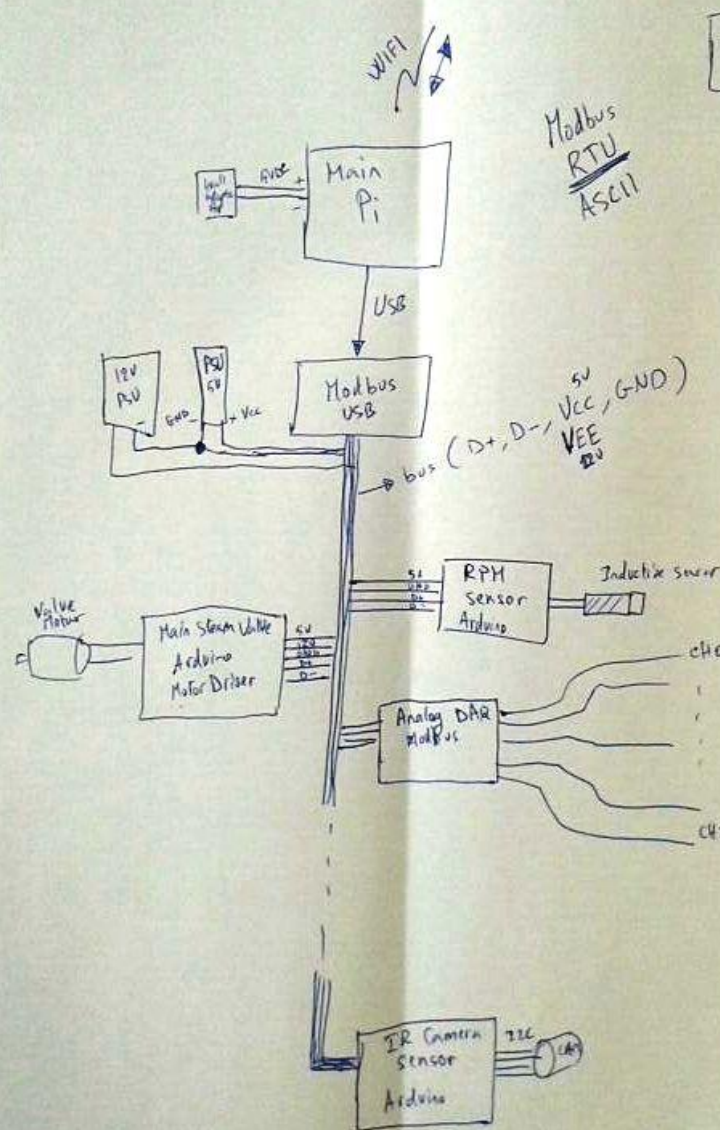
Pi:

Manual Control & Monitor:

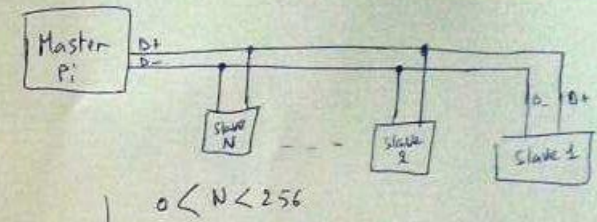
- * Query All Sensors Data from Modbus slaves
- * Control All Actuators on Modbus slaves
- * Control values are variables in Pi

Auto Mode:

- * logic closed loops control
- * logic Automatic Power generation



Modbus RTU ASCII



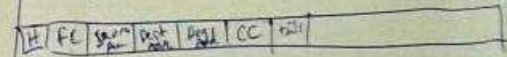
Function Code:

- Read bit
- Set Coil
- Read Input Reg
- Read Continuous Input Reg
- Read Holding Reg
- Read Cont Holding Reg
- Write Holding Reg
- write Conti Holding Reg

Memory Areas

- Digital In/Bit
- Digital Out/coil
- Input Reg (I16)
- Holding Reg (H16)

Syntax Frame



4.1 NLAP-2MW Plant overview page

4.2 NLAP-2MW control loops page

4.3 NLAP -2MW incineration air/waste supply control & incineration page

4.4 NLAP-2MW incinerator power control page

4.5 NLAP-2MW turbine generator page

4.6 NLAP-2MW feedwater and extraction steam page

4.6.1 NLAP-2MW feedwater and extraction steam page

4.7 NLAP-2MW MW demand setpoint (SP) and steam generator pressure control (SGPC)

5.1 Protocol (MODBUS)

5.2 Hardware

5.3 Software

5.3.1 protocol.h

NLAP Messaging Protocol Library

protocol definitions

Message structures defined here follow the binary protocol format. They can be packed and serialized.

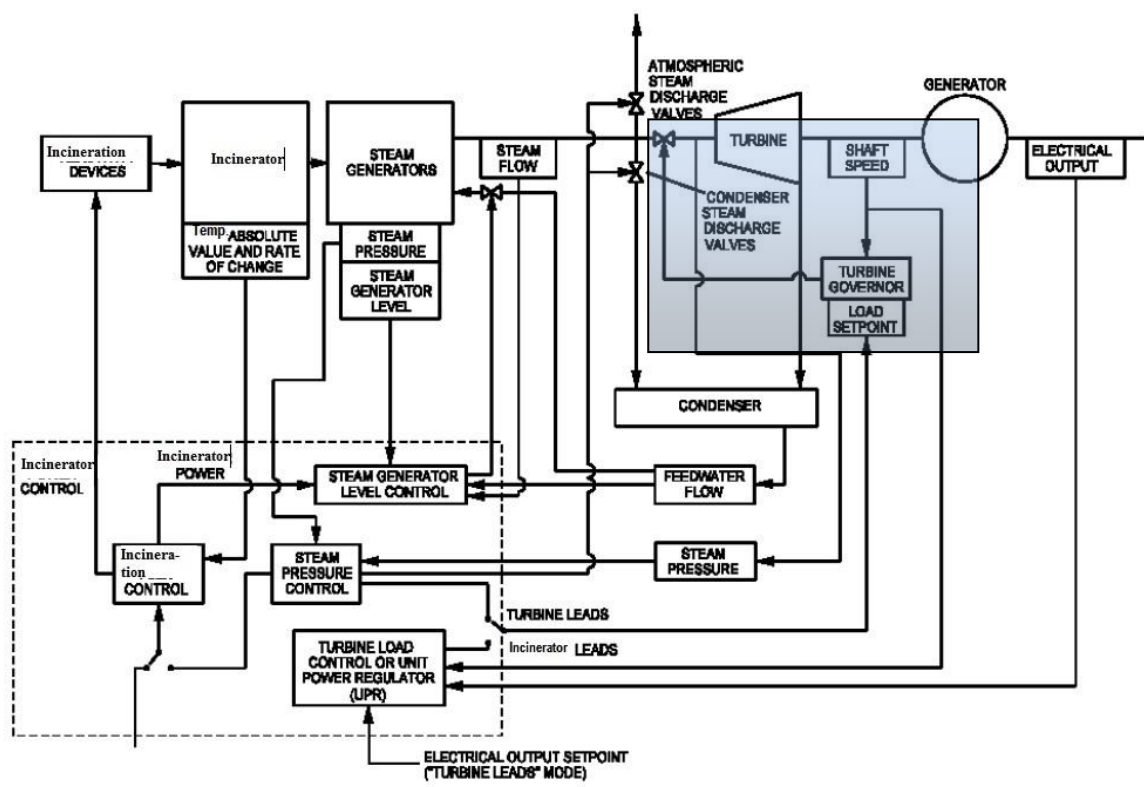
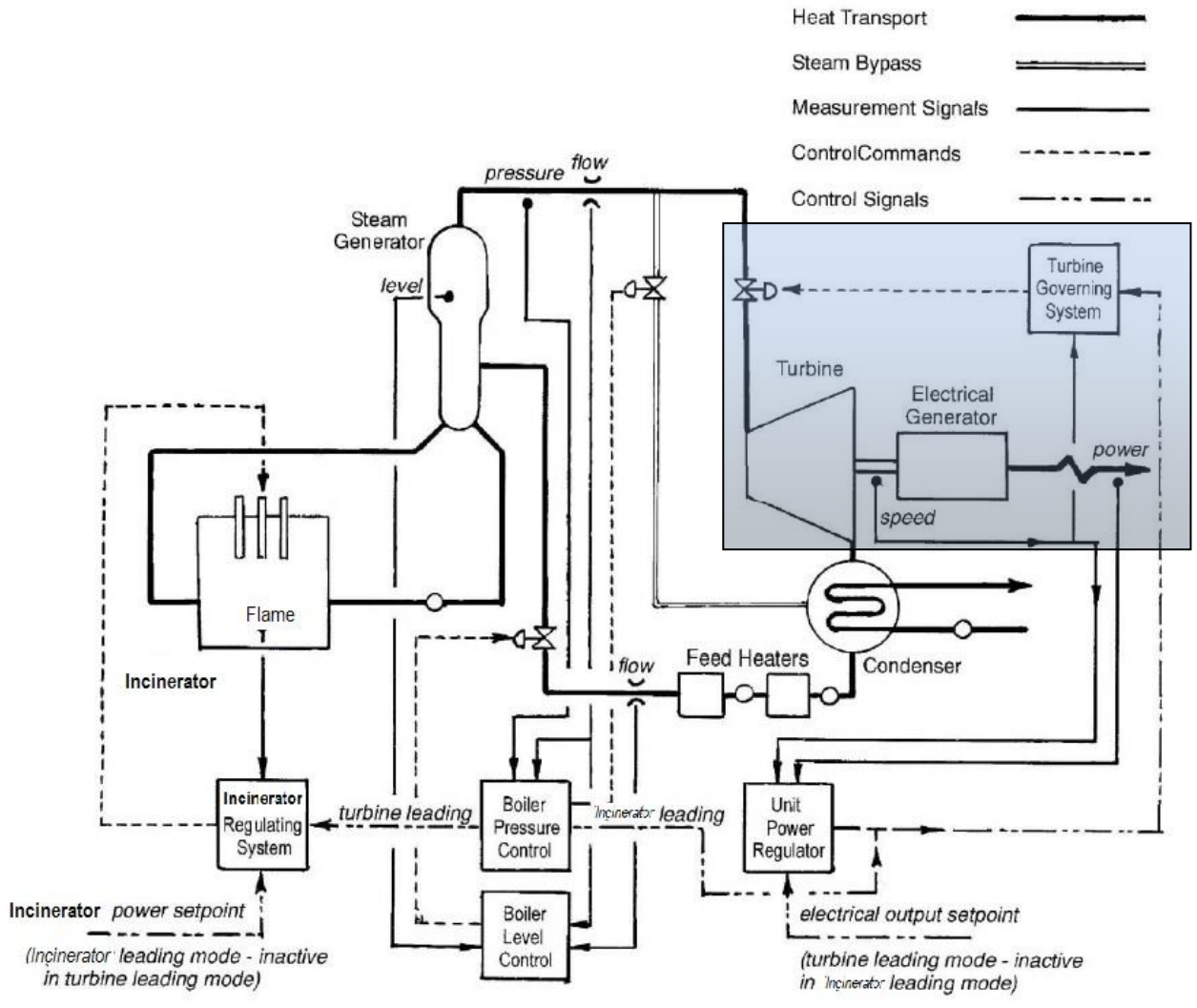
Definitions contained here should be considered opaque to the users of the API.

```
#ifndef PROTOCOL_H
#define PROTOCOL_H

#endif // PROTOCOL_H
```

Service class messages

6 Turbine Governing System



6.1 RPM Sensor with MODBUS

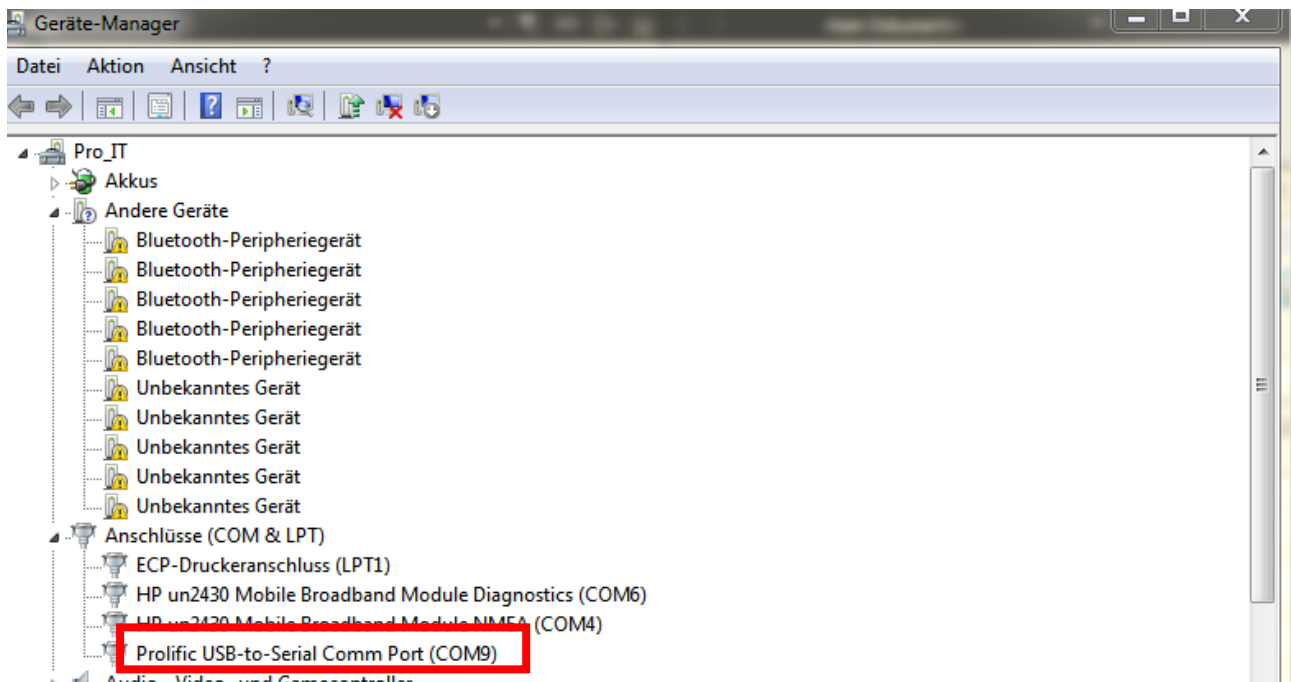
The RPM sensor is mounted at the turbine axe and connected to an Arduino (Modbus slave). The Arduino is connected via the (Mod-)Bus to the Modbus Master (an Raspberry Py or another computer running our control System Software). The source-code (file) running on the Arduino is shown in the Appendix ([RPM.ino](#)).

6.1.1 Hardware & MODBUS-RPM Connecting Software

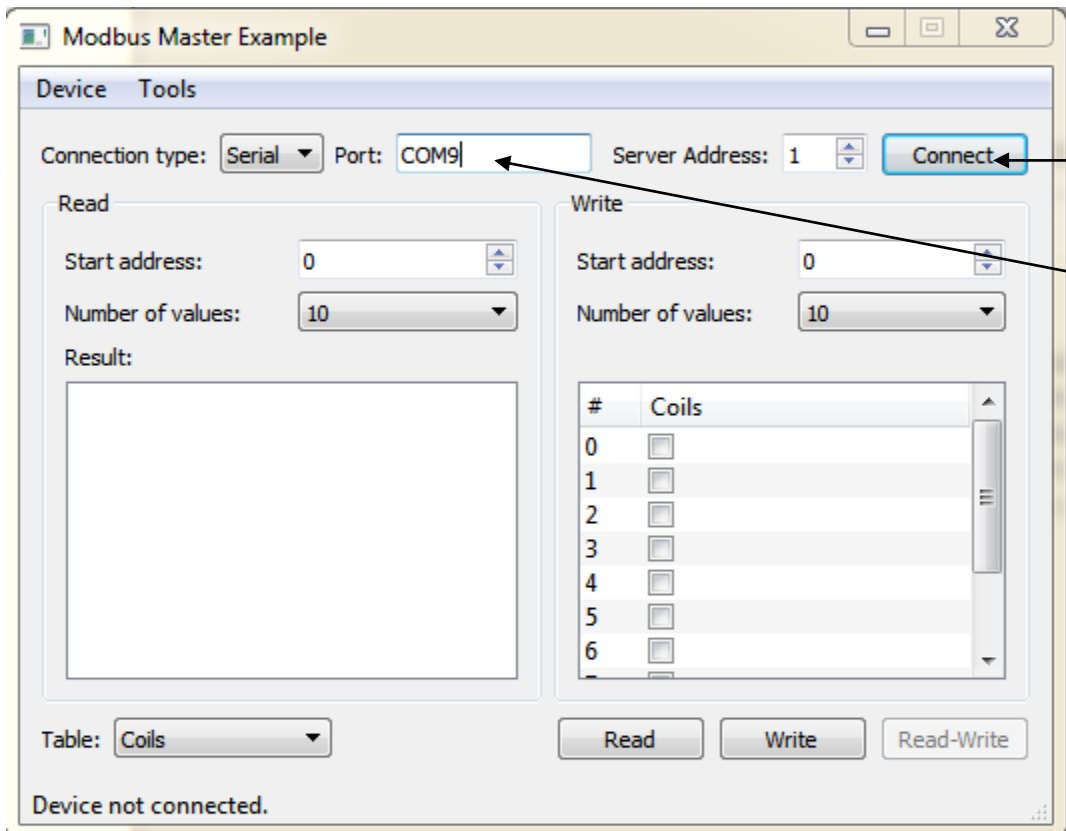
6.1.2 Testrig Program

6.1.2.1 Program Start

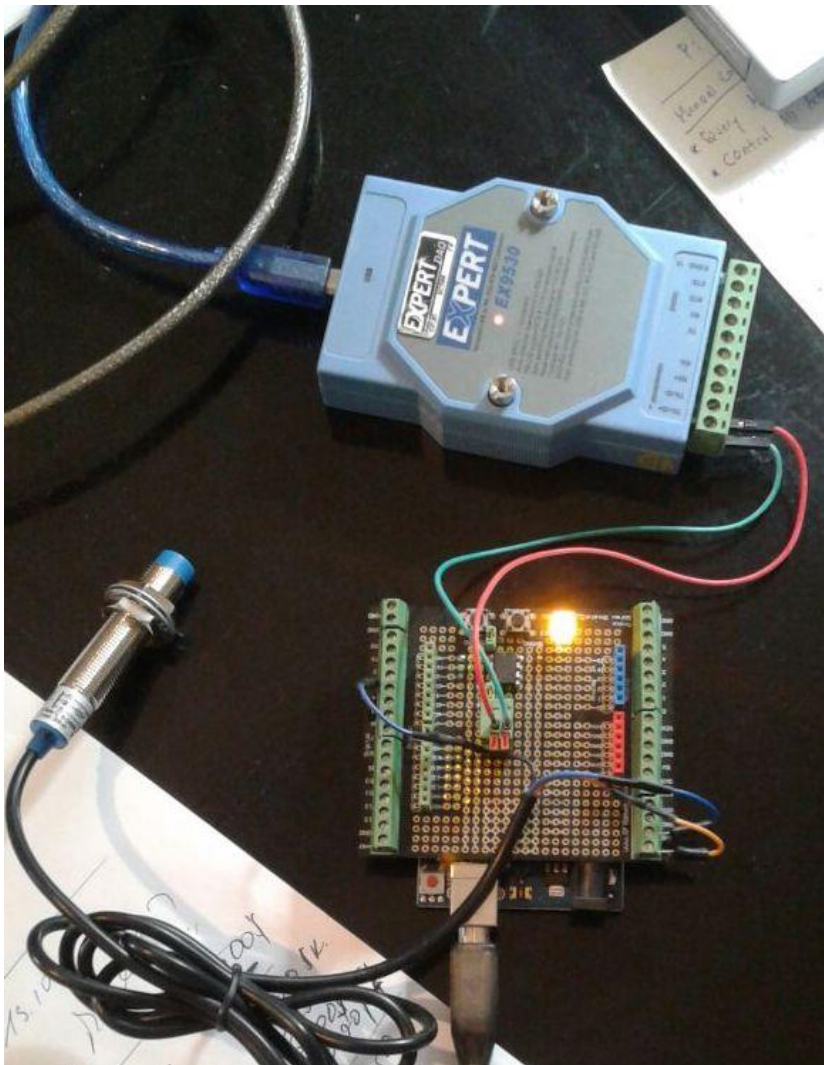
6.1.2.2 Connecting



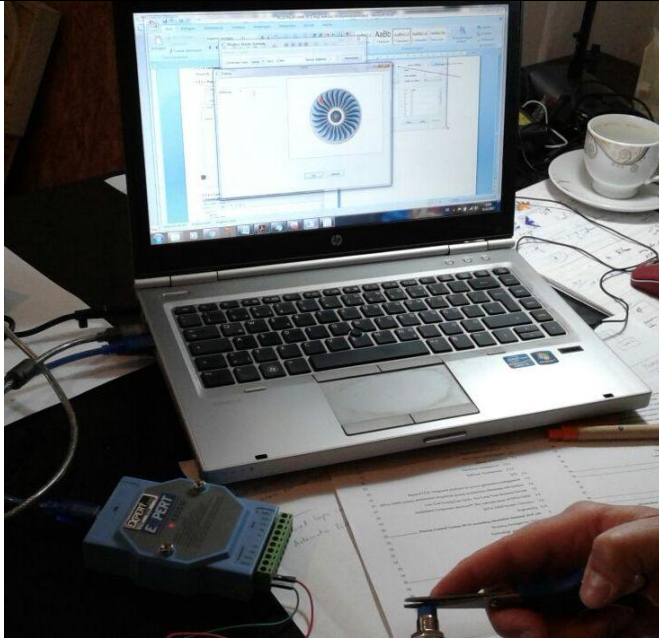
RPM Sensor with MODBUS



Press Connect

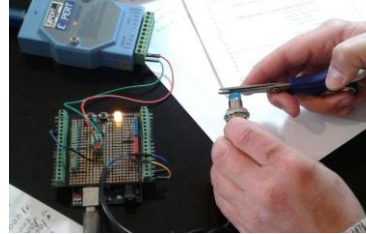


6.1.2.3 Odometric Measurement (Rotor Speed)

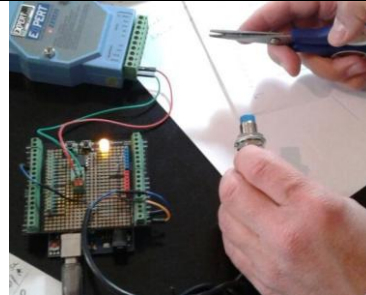


Simulating rotor

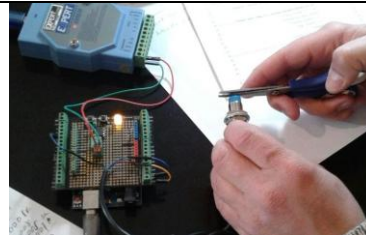
1 ($t=0$)



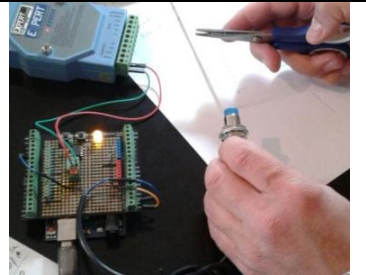
2 ($t=0,2s$)



3 ($t=0,4s$)

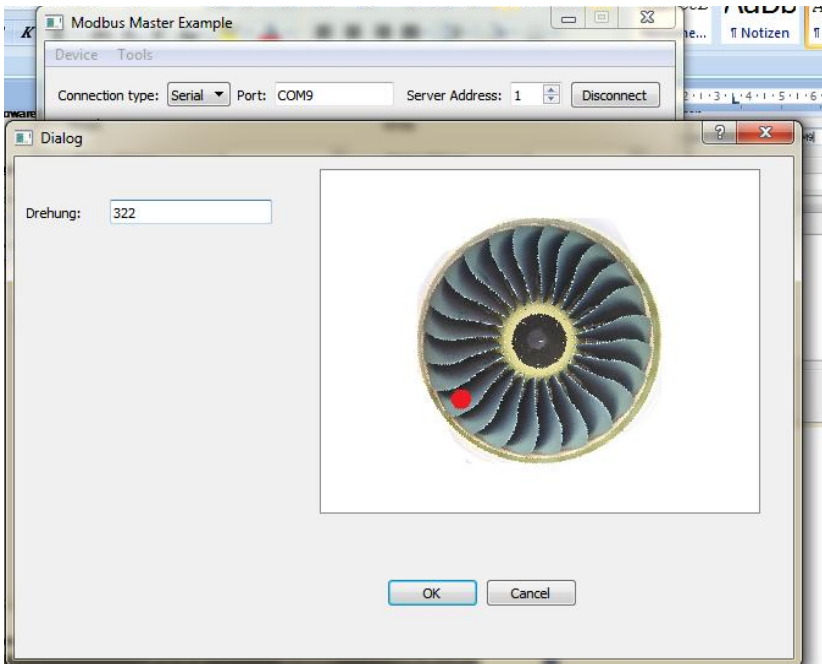


4 ($t=0,6s$)

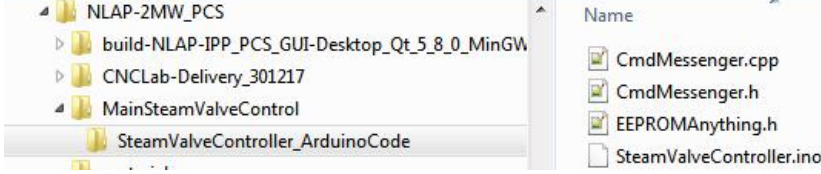

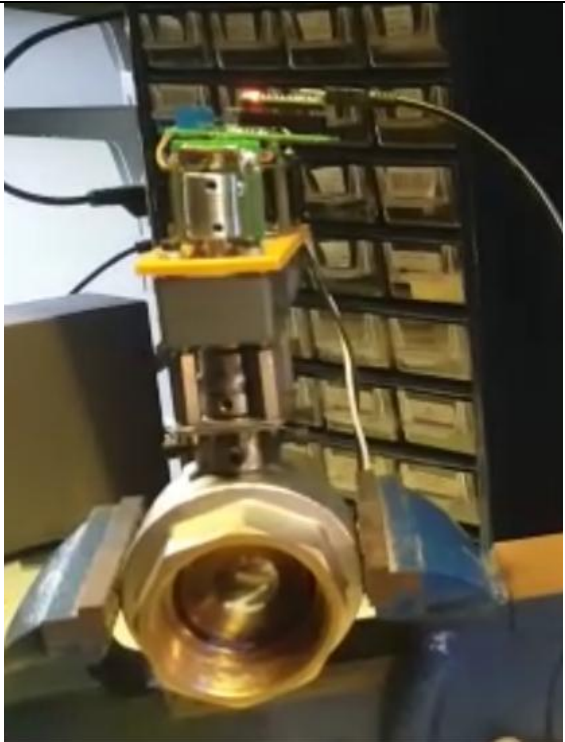
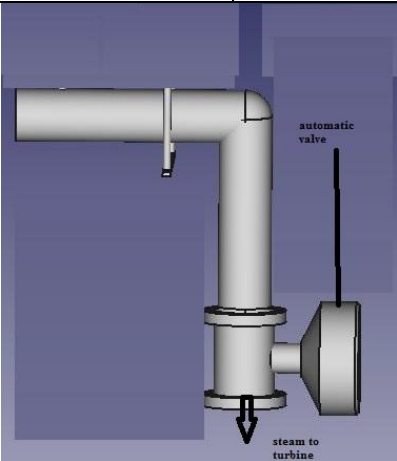


Main Steam Valve Actuator (تحكم صمامة البخار عند مدخل التوربين)

Display: 322 RPM (rotations per minute)



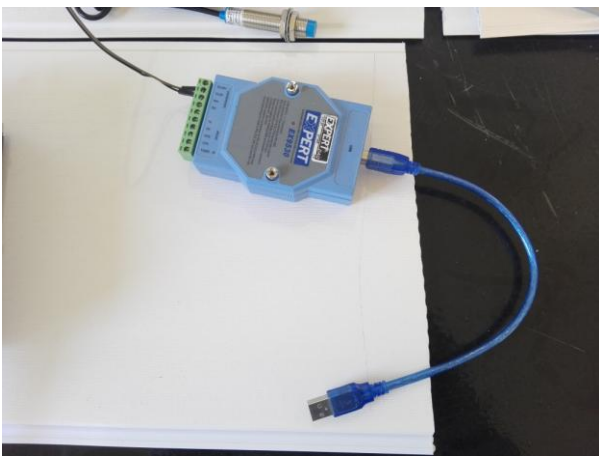
6.2 Main Steam Valve Actuator (تحكم صمامة البخار عند مدخل التوربين)

MainSteamValveControl	
<p>Arduino Code:</p> 	 <p>SteamValveControllerArduinoCode.zip</p>
Testrig-GUI (Raspberry)	
	 <p>The automatic valve is constructed with a 2 inch valve, some steel adapting (with CNC) and a strong step motor able to open and close it under working condition (14 bar steam)</p>

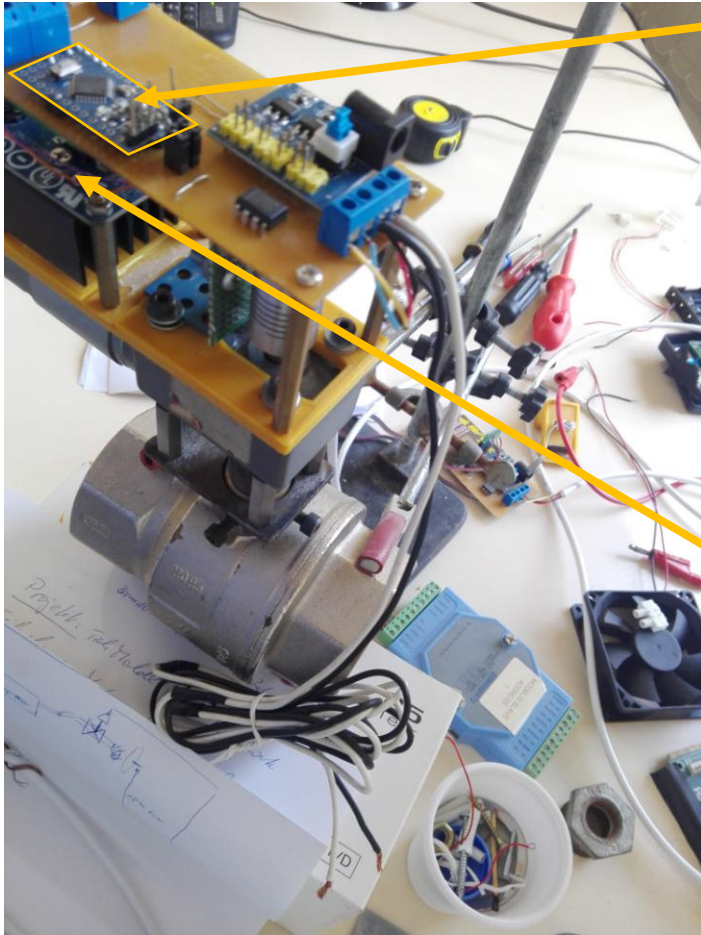
The valve (driven by a 12 Volt motor) is connected to an Arduino (Modbus slave). The Arduino is connected via the (Mod-)Bus to the Modbus Master (an Raspberry Py or another computer running our control System Software). The source-code (file) running on the Arduino is shown in the Appendix (SteamValveControllerMODBUS.ino).

The Modbus Slave have the address 2, this is defined in the Arduino code. This address will be used in the ModbusMaster-Monitoring Software (our control System Software) to connect and communicate with the Valve (Modbus-slave), that is, read the current opening position and set a target opening position.

The valve opening position is in a range of 0 (closed) to 1000 (completely opened).

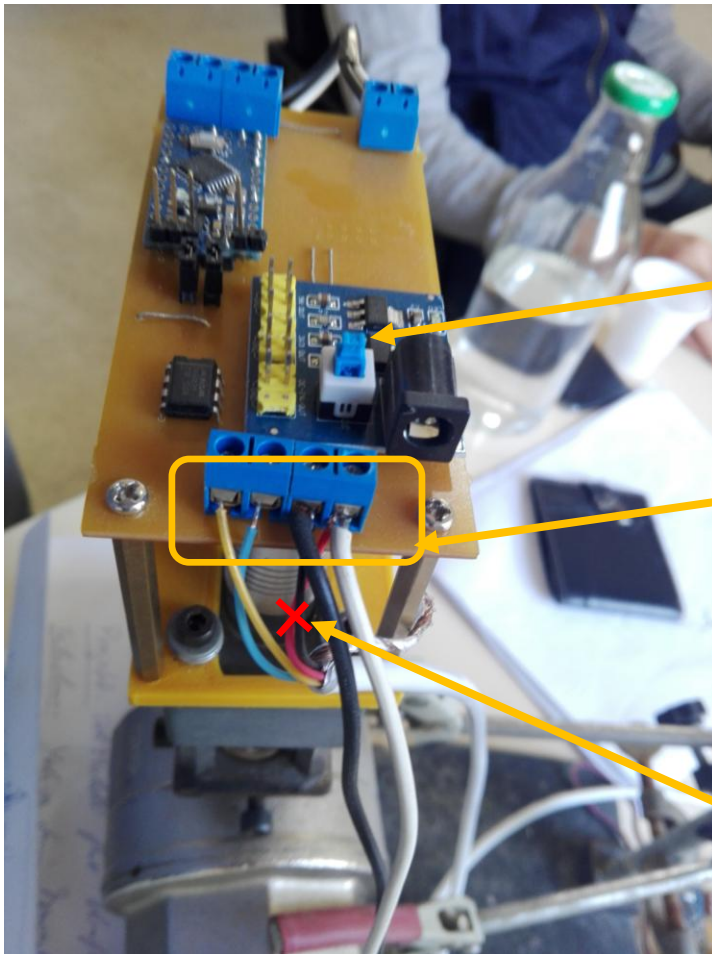


Main Steam Valve Actuator (تحكم صمامة البخار عند مدخل التوربين)



Arduino: Modbus slave
Adresse: 2

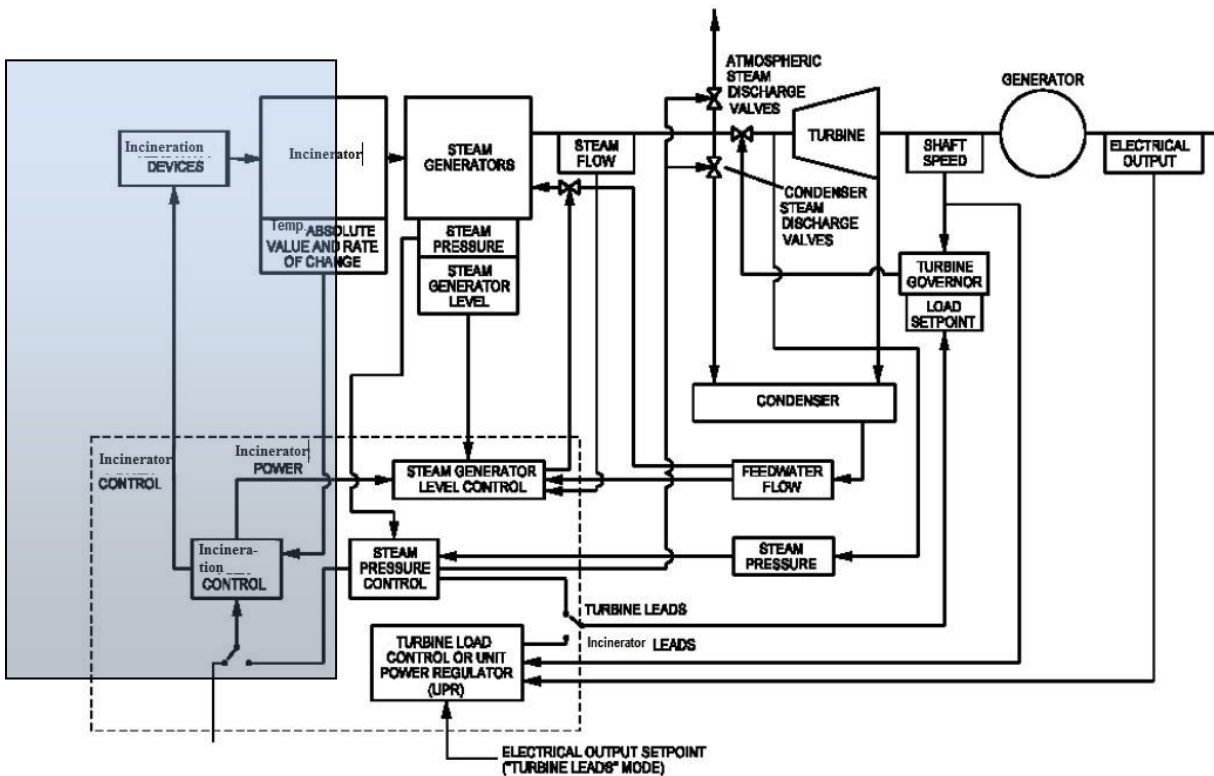
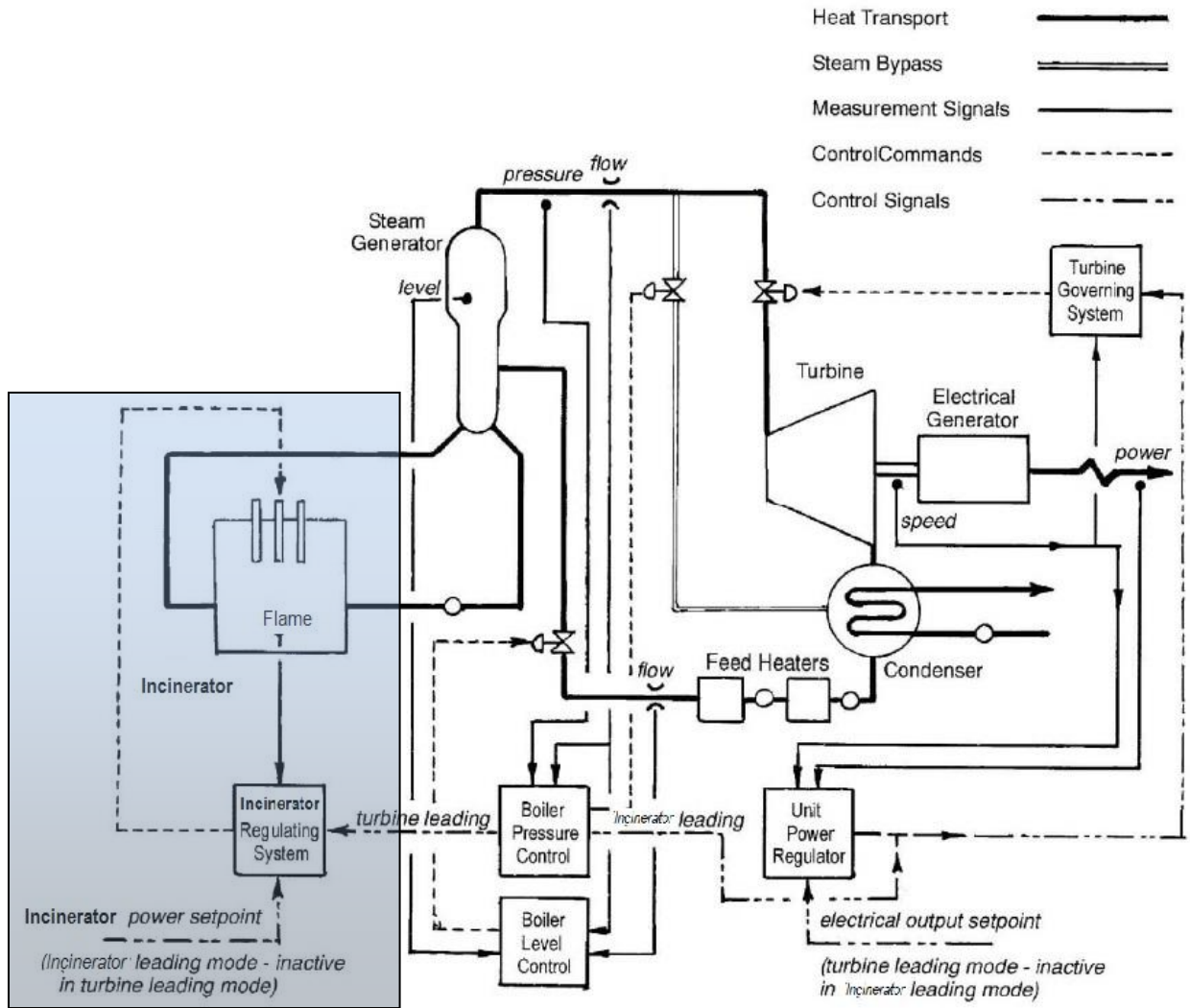
Arduino: Motor driver



On/off

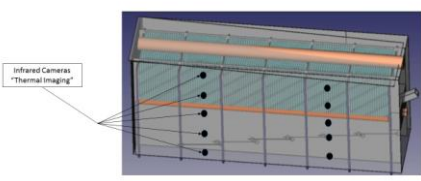
Yellow: Modbus D+
Blue: Modbus D-
White: 12 V + input
Black: 12 V -

not used



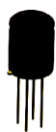
IR Camera (Incinerator Temperature Sensor)

7.1 IR Camera (Incinerator Temperature Sensor)

	<p>Visualization of Temperature distribution in incineration chamber</p>
---	--

7.1.1.1 Melexis IR Camera

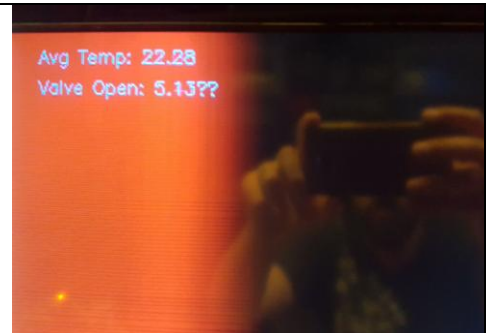
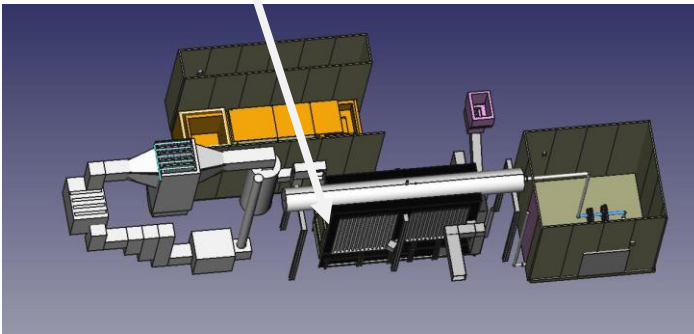
One IR Camera shall take samplings from whole incineration chamber by moving in x-y-directions. Camera is positioned at the windows at the end of the waste band (working package 1 for CNC Lab)



Part No.	Temperature Code	Package Code	Option Code	Standard part	Packing form
MLX90621	E (-40°C to 85°C)	SF (10-39)	- X X X (1) (2) (3)	000	-TU

(1) Supply Voltage: B = 2.6V
 (2) Number of thermopiles: A = 16X4
 (3) Package options: A = 120°x25° FOV, B = 60°x16° FOV, C = reserved, D = 40°x10° FOV

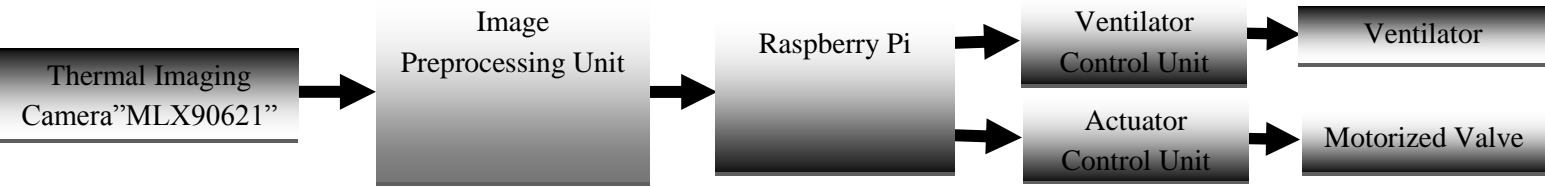
Example: MLX90621ESF-BAB-000-TU



7.2 Air&Waste Supply Actuator

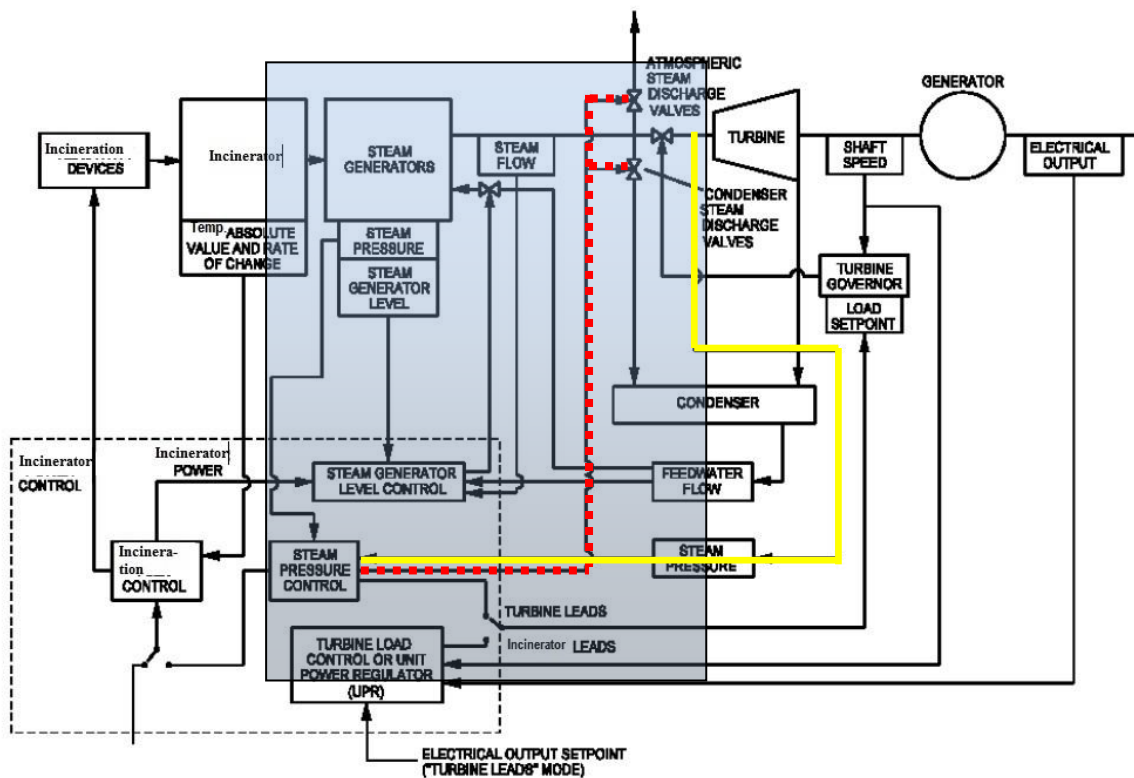
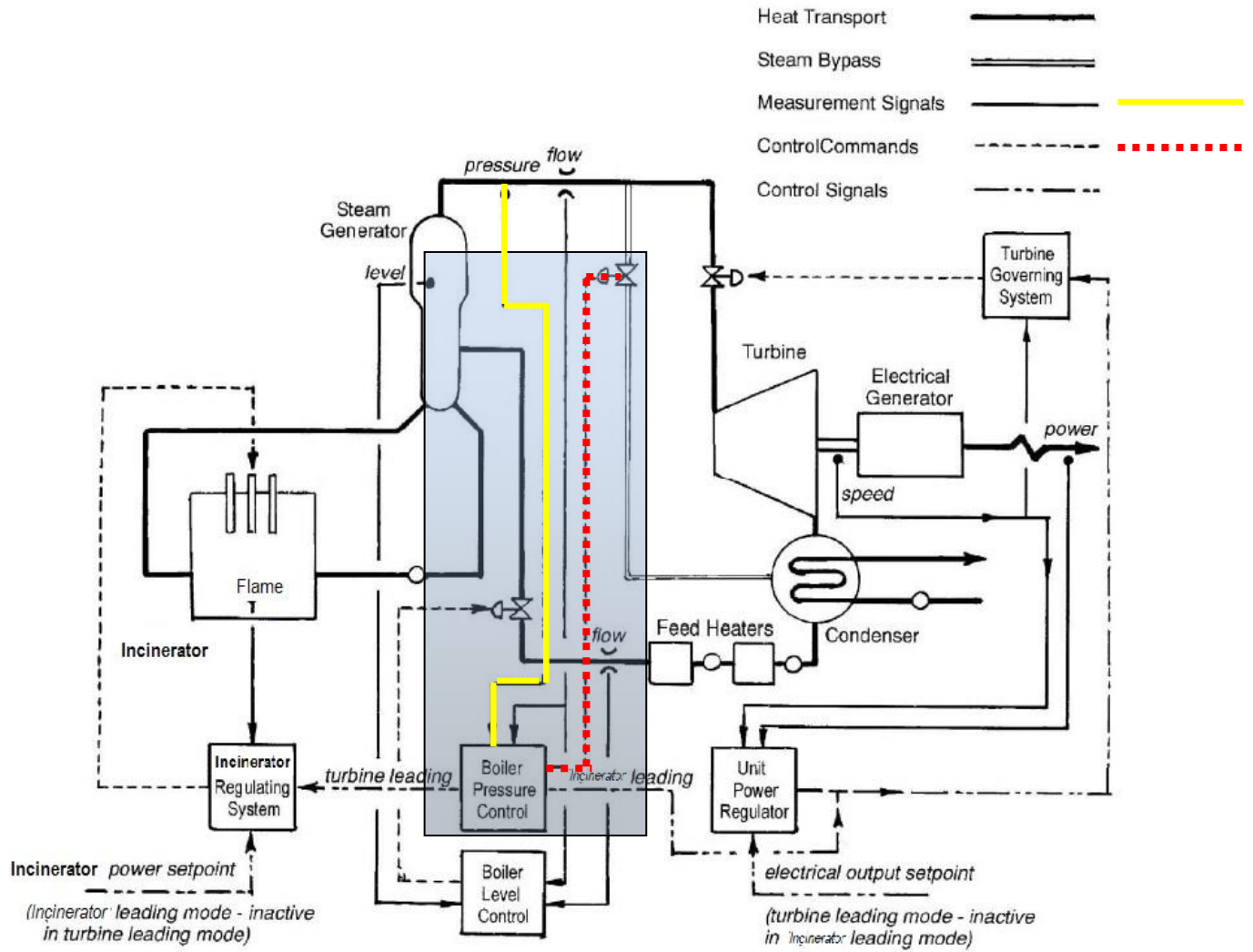
Based on IR Camera data the air& waste supply shall be opened totally or partly.

7.2.1 Module Diagram



tbd.

8 Boiler Pressure Control



8.1 Pressure Sensor (Data Sheet)

DEDICATING FOR EVERY POSSIBILITIES OF SENSING SOLUTION

GAMICOS

High Temperature Type Pressure Transmitter GPT220-B

Description

GPT220 high temperature pressure transmitter uses GS series piezoresistive silicon oil-filled sensors as measuring component. Sensors' output are transformed to standard output signal via integrated amplify circuit. The transmitter is with high reliability&stability. It widely Chemi-industry, process control system, hydrology, etc

Features

- high temperature pressure transmitter
- pressure range: -100kPa~0...0~10kPa...60MPa
- gas or dilute liquid compatible with 316LSS
- high reliability and stability

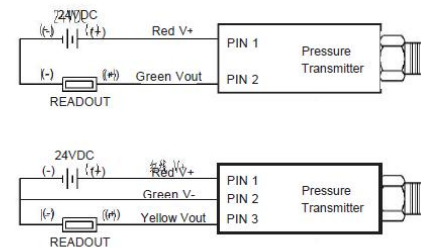
Application

- process control system
- petroleum industry
- chemical industry
- metallurgy industry
- electric power, hydrology etc

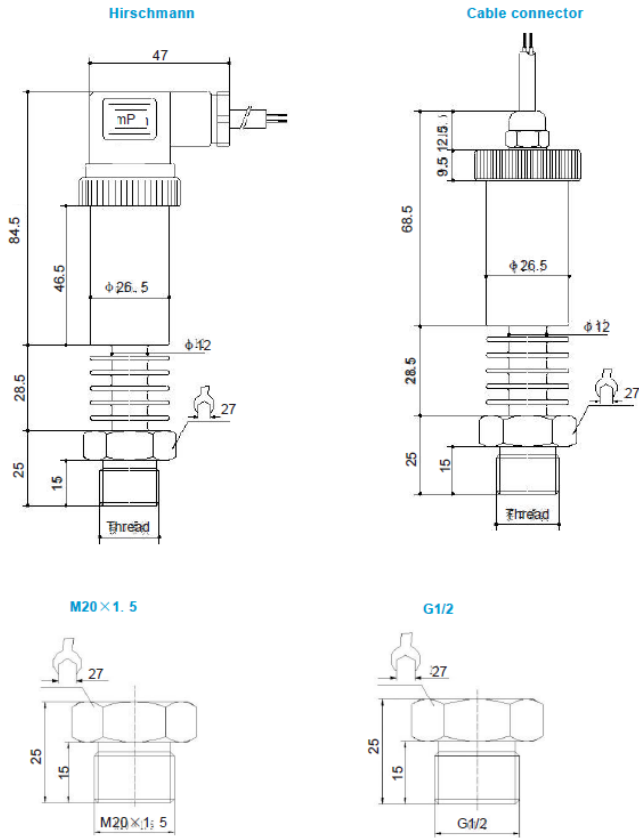


pressure range	-0.1... 0~0. 01... 60MPa	
pressure type	gauge (G), absolute (A), sealed gauge (S)	
overpressure	150%FS	
output signal	4~20mA	0~5Vdc
power supply	12~36Vdc	12~36Vdc
accuracy	0.2%FS(typ.)	
long-term stability temp.coefficient	±0.2%FS/year	
of zero temp.coefficient of span	±1. 5%FS/°C	
compensated temperature range	±1. 5%FS/°C	
operating temperature range	-40~+280 °C	
Environment temperature range	-10~+300 °C	
Explosion-proof	ExiallCT6	
Protection	IP65	
pressure interface	M20x1.5, G1/4, G1/2, 1/4NPT, 1/2NPT (customer request)	
material of pressure membrane	316L stainless steel	
material of housing	stainless steel	
response time(10%~90%)	≤1ms (Rises to 90%FS) 20g(20~5000HZ)	

Wiring



Dimension(mm)

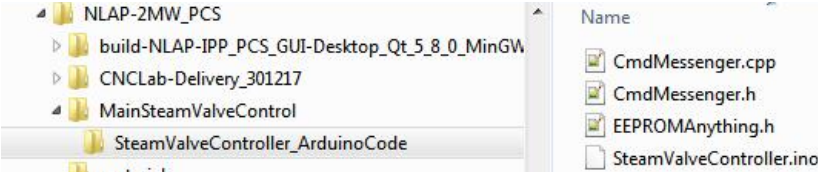

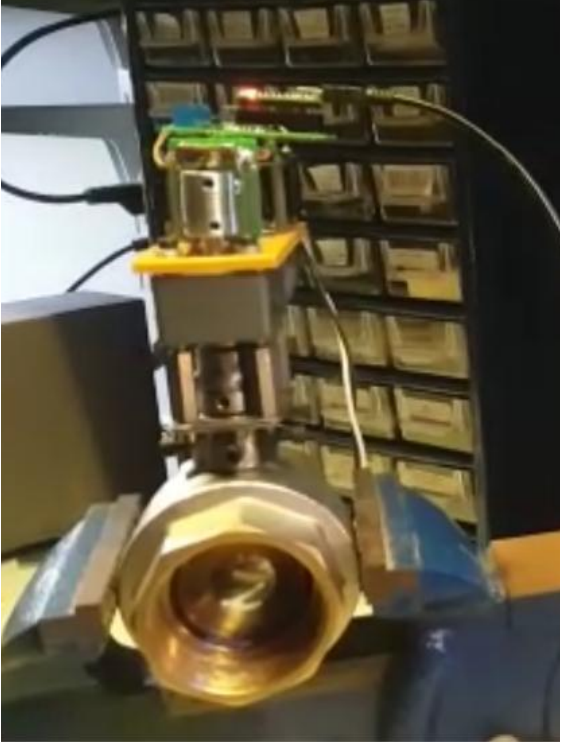
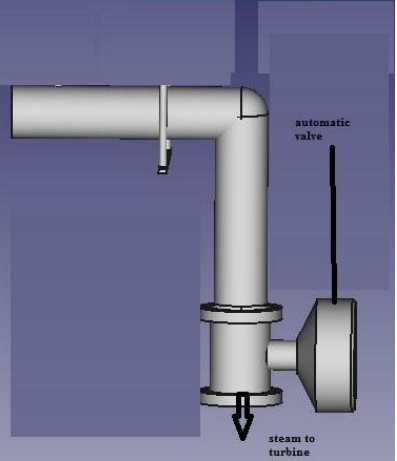


Ordering code

GPT220		Pressure Sensor	
Code	0/x	Pressure range	
		-0.1... 0-0.01... 60MPa	
Code		Unit	
M		MPa	
B		Bar	
P		Psi	
Code		Pressure type	
G		gauge	
S		sealed gauge	
A		absolute	
Code		Output signal	
T1		4-20mA	
T2		0-5Vdc	
T3		1-5Vdc	
T4		0-10Vdc	
T5		0.5-4.5Vdc	
Code		power supply	
V1		12Vdc	
V2		24Vdc	
V3		12-30Vdc	
V4		5V	
Code		accuracy	
A1		0.2%FS	
A2		0.25%FS	
A3		0.5%FS	
Code		Electrical interface	
B1		DIN43650	
B2		cable connection	
B3		plug-in connector	
B4		can be customized	
Code		electrical interface	
K1		cable connection	
K2		2088housing	
K3		2088housing+display	
Code		Housing Material	
S1		304 SS	
S2		316L SS	
Code		Pressure interface	
C1		M20x1.5(male)	
C2		G1/4(male)	
C3		G1/2(male)	
C4		1/4NPT(male)	
Cx		other	
Code		Explosion-proof function	
E		Ex I explosion-proof	
O		non-explosion-proof	
E		Complete specification	

GPT220 1MPa P s T2 V3 A2 B4 K2 S2 C4 E

8.2 Atmospheric Steam Discharge Valve

SteamValveControl	
<p>Arduino Code:</p> 	 SteamValveControllerArduinoCode.zip
Testrig-GUI (Raspbery)	
	 <p>The automatic valve is constructed with a 2 inch valve, some steel adapting (with CNC) and a strong step motor able to open and close it under working condition (14 bar steam)</p>

8.3 Condenser Bypass Steam Discharge Valve

same as Atmospheric Steam Discharge Valve.



Description of most important functions:

void setup():

Setups the input and output pins. Setups and starts the modbusslave.

Binds the RPM-interruption-pin to the function blink().

This function is only executed once when starting the Arduino.

void blink():

counts the interruptions(in variable SC) sent by the RPM sensor through the Arduino pin.

void loop():

slave.poll:

This method checks if there is an incoming query in its serial buffer. If there is, the library will validate the message (check the device address, data length, and CRC) and subsequently perform the correct function.

We must pass it an unsigned 16-bit integer array (here au16data)and its length(12). The array will contain the data that the master device is reading or writing over (here we read only).

If master reads the LED-light is changing state(on/off).

calls updateIO().

Always when the update interval is reached(1000 millsec –defined in P-) the RPM average value is changing(updating). This value is read by the master in .

This function is executed over and over while the Arduino is turned on.

void updateIO():

read/write from/in pins.

SteamValveControllerMODBUS.ino 9.2



9.3 ملحق ب: برنامج واجهة التحكم (GUI)