Amplification Circuit of The Faraday's cup

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Introduction:

The Faraday's cup is a mass spectrometer detector that uses the principle of electrochemistry and the conservation of electric charge, which simply means that it detects the presence of charged particles by colliding on its electrodes which induces current due to the potential difference created between the electrodes and the ground by this process.
The electric charge is a property that is constant for all electrons and protons. In the mass spectrometer currently being worked on, the particles of interest are ionized so that all molecules become ions with one less electron which makes them positively charged thus for large ion currents, 1 ion (+1) has: 1.6 x 10^{-19} Coulombs and that means 1 ion/second is 1.6 x 10^{-19} A or 1.6 x 10^{-4} fA.

Objective:

To amplify the current input of Faraday's cups so it can be measured and recorded.

Equipment and roles:

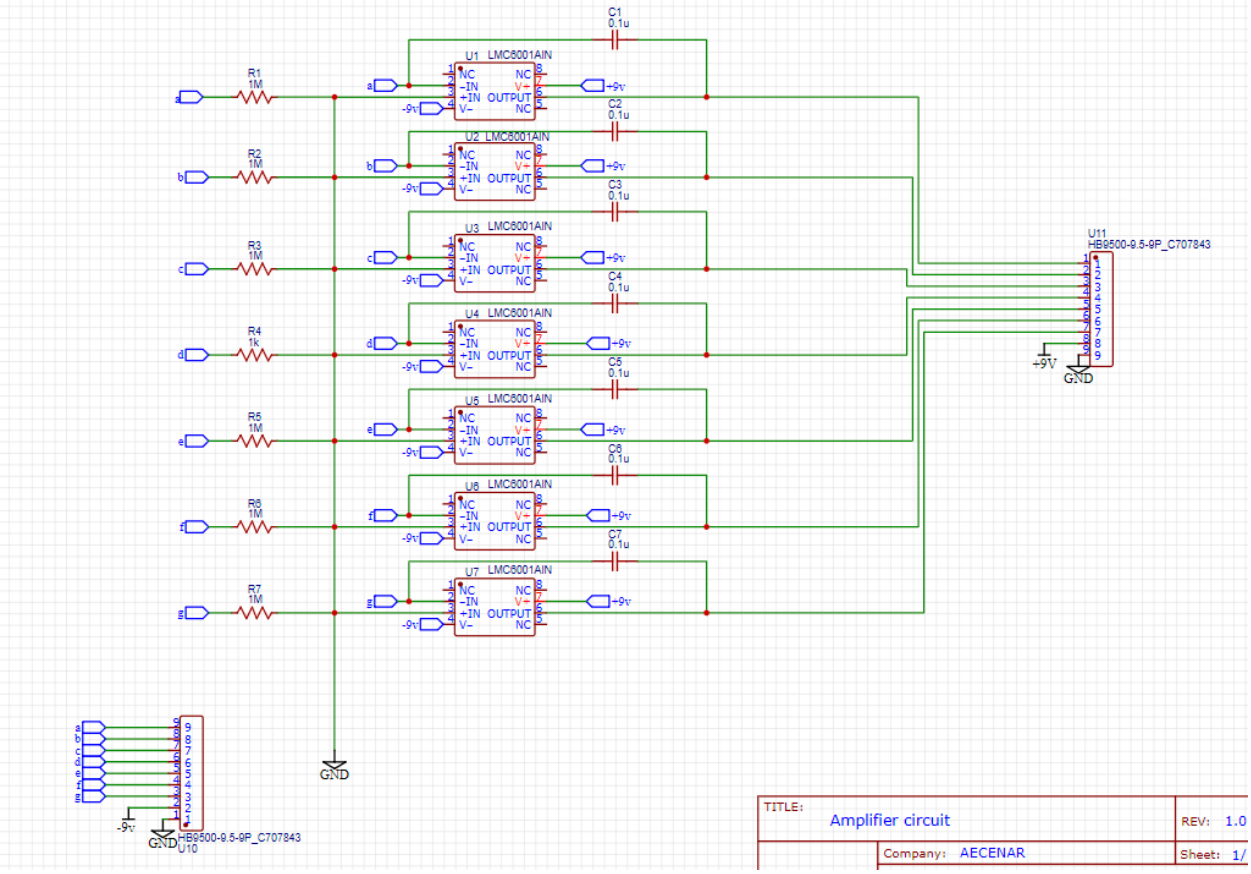

Fig 1: Schematic of the amplifier circuit for faraday's cup

PCB design:

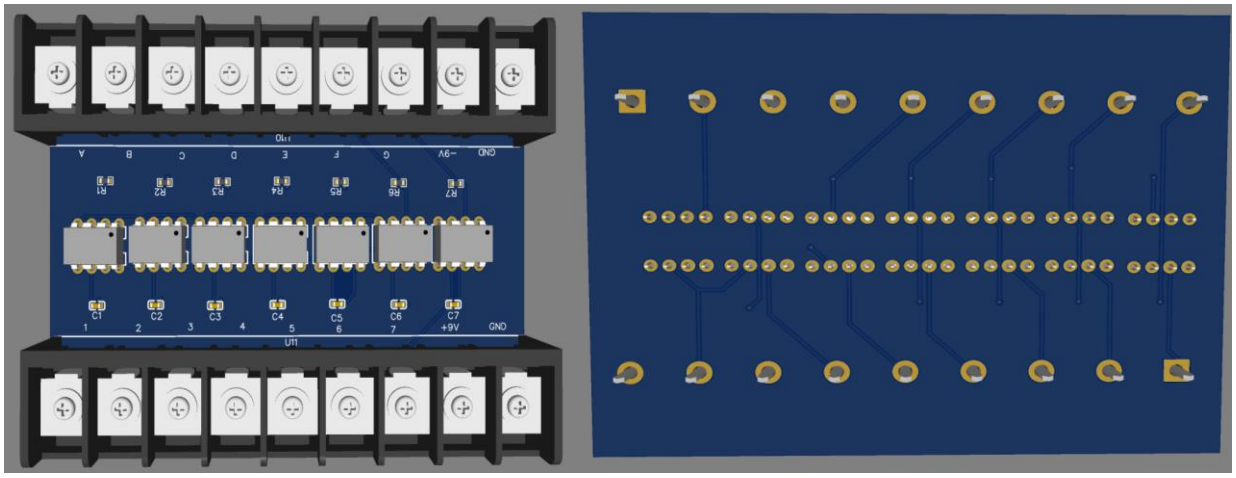

Fig.2: The front -back image of the amplifier circuit (3D)

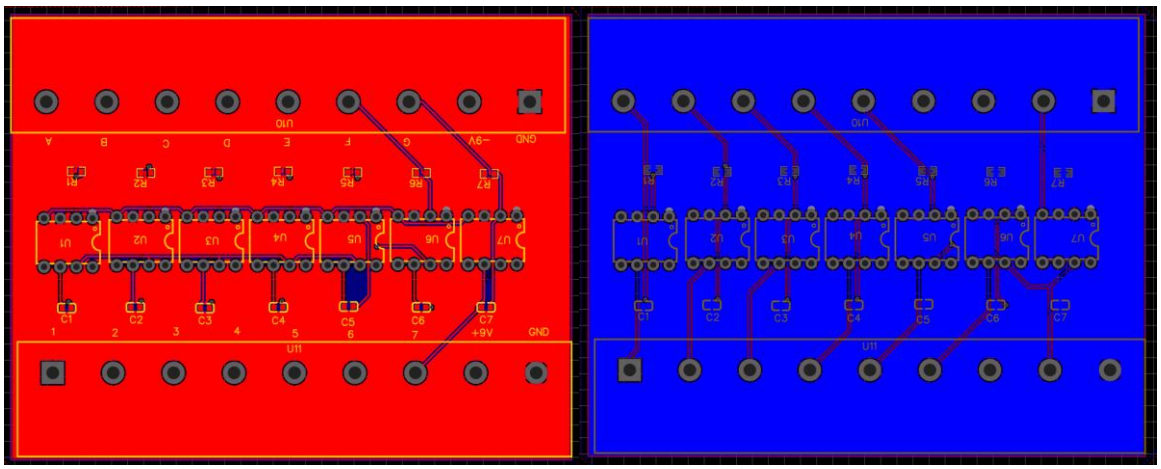

Fig.3: The front -back image of the amplifier circuit with the copper layers

Amplifier circuit:

Operational amplifiers $U_{1\text{-}7}$: the operational amplifiers or Op-Amps are circuit elements that can be used for several tasks, in here they are amplifying the voltage signals coming from the faraday's cups so it can be recorded and saved.

Resistors $R_{1\text{-}7}$: The current created by the faraday's cups will induce a potential difference across these resistors that are going to be amplified by the Op-Amps.

Capacitors $C_{1\text{-}7}$: The capacitors are used to reduce the effect of the outside noise on the signal coming from the Cups.

Port $U_{10\text{-}11}$: Input/Output port of the amplification circuit.

Calculations and numbers:

About the LMC 6001 Op-Amp:

Input bias current (max) = 25 fA
Vos (offset voltage at 25°C) (max) = 0.35 mV
Total supply voltage (+5 V = 5, ±5 V = 10) (max) = 15.5 V
Total supply voltage (+5 V = 5, ±5 V = 10) (min) = 4.5 V
Large signal voltage gain (A) = 1400V/mV or 1400000 times the input.
So, if the input is 1nV the output will be 1.4 mV.

The LMC 6001 A1 Op-Amp was chosen for this application due to its high sensitivity and it low noise amplification process, since its Common-Mode Rejection Ratio (CMRR) is 83 dB, it means that the op-amp can effectively reject common-mode signals (inside noise).
This is a desirable value for precision and sensitive applications. It means that the op-amp can amplify differential signals (signals that are in anti-phase on the inputs) while attenuating common-mode signals (signals that are in phase on the inputs).