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Modeling and Simuiation Of RPC V-I curve (Using Matlab)

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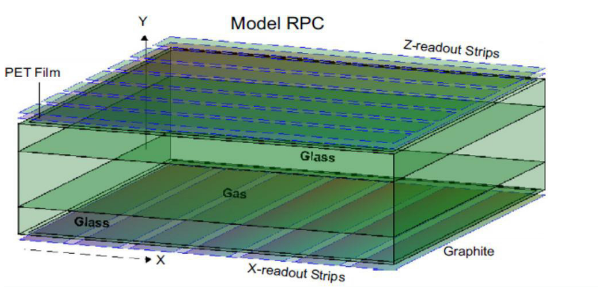
Abstract— In this paper, I have developed a electronically simulated circuit models of RPC (Resistive Plate Chamber) detector which is a gas filled device used for detecting radiation. The aim of developing the circuit models was to represent the electronic characteristics of RPC detector through the model whose results closely matches the experimental results. In order to find the circuit model which best represented the detector, the total current flowing through the circuit in each case was calculated. The simulation was primarily done using MATLAB Simulink. The results obtained from this was compared with the experimental data.

Keywords- RPC, MATLAB,Zener Diode

I. INTRODUCTION [1]

An RPC is a particle detector utilizing a constant and uniform electric field produced by two parallel electrode plates, at least one of which is made of a material with high bulk resistivity (e.g. glass, Bakelite). Since such a detector has very good timing (1-2 ns) and spatial resolution, it is well suited for tracking comic radiation like neutrino, especially muon.



Model RPC

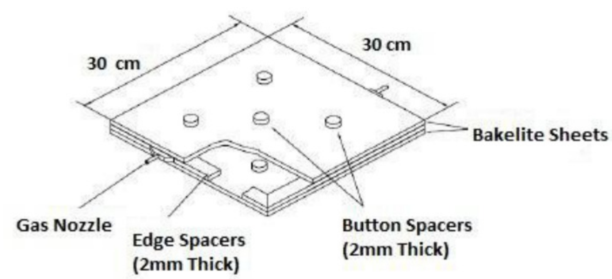
The RPC consists of two plates of Bakelite of area 30cmX30cm and the thickness of the plates is 2mm. The thickness of the gap between the two Bakelite plates is also 2mm which is filled with gas. There is a square frame of thickness 2mm which is placed between the two bakelite plates to enclose the middle gas volume. This frame is made up of polycarbonate. The frame is 1cm wide throughout.

II. MODES OF OPREATION

A. A RPC operates in two modes 1) Avalanche Mode 2)Streamer Mode

Avalanche Mode- When the charged particle passes through the gas
mixture, it will ionize gas molecules (primary ionization), the so produced ions will further ionize neighboring molecules, results in the secondary ionization. As the external applied field opposes the internal field produced by ionization, this avalanche stops. The pulse so produced will be small of the order of few mili volts and hence it require amplifiers to readout its signal.

Streamer Mode- In this mode, continuous ionization of gas mixture will take place until there is a breakdown. The pulse produced in this mode will be of the few hundreds of mili volts, hence can be readout directly without seeking the help of amplifiers. Wireless Development Tool.



Schematic Diagram of different layers of a RPC

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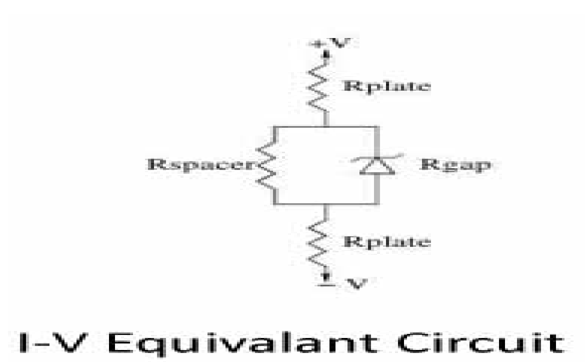
III. PROPOSED MODULE [2]



AT LOW VOLTAGE:

$R_{gap=\infty}$ $R_{spacer} > R_{plate}$

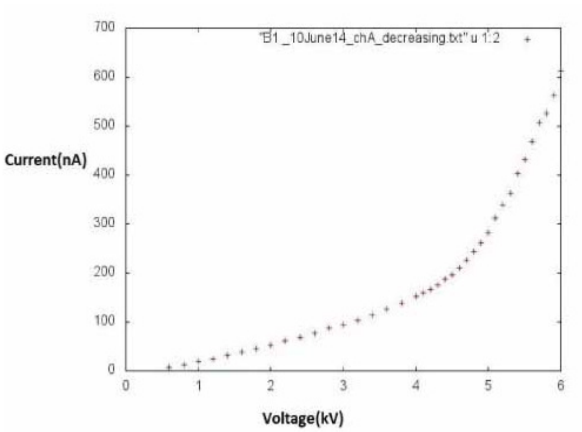
$dV/dI = R_{spacer}$

At High Voltage:

$$R_{gap} = 0$$

$$dV/dI = R_{plate}$$

I-V characterization of the finished RPC was carried out by applying a high and opposite polarity voltage gradually to either of the electrodes by a D.C. power supply system through the copper strips pasted on to the graphite coating. The current noted includes the leakage or dark current that exists even without the application of a bias. After application of the highest voltage of 6kV(on either electrode), the RPC was kept at that particular voltage for at least 30 minutes to enable the electrode parameters to be stabilized. The temperature and humidity in the room were noted and were attempted to be kept constant. Values of current and voltage were noted down during ramp-down.



The plots show a common feature that the current-voltage curves have two distinctly different slopes as it has been shown earlier. The reason is explained by the equivalent circuit of RPC:

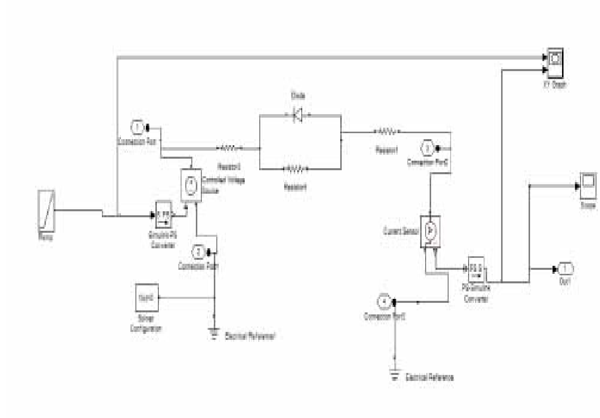
The RPC gas gap is represented by a parallel combination of spacer (Ohmic) resistance and gas ionisation volume of the gap (represented by a Zener diode).

At lower applied voltages, the primary ionisations in the gas gap do not lead to development of avalanches. Therefore, the gas gap offers infinite

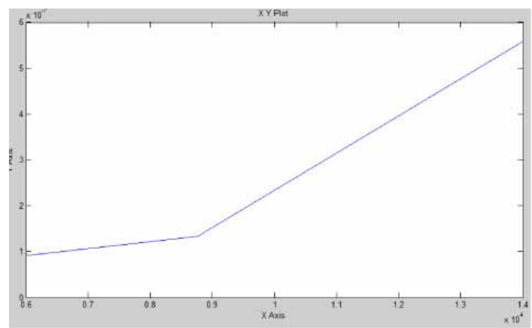
resistance. i.e. the gas gap behaves as an insulator in the lower range of applied voltage and hence the slope over this span scales as the conductance of the polycarbonate spacers.

Starting from the chamber's turn-on point, at a voltage above discharge (high voltage) the slope of the curve changes drastically as the ionisation volume almost seizes to offer any ohmic resistance. The current flowing through the chamber in this case is determined by the Bakelite plate resistance i.e. at the higher range of voltage, the gas behaves as a conducting medium due to the formation of streamers.

IV.Circuit simulation using MatLab

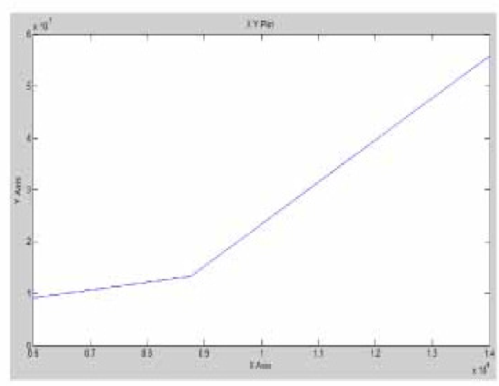


The total current flowing through the circuit was found by attaching a scope to the circuit to measure the amount of current flowing through the internal resistance (resister1)

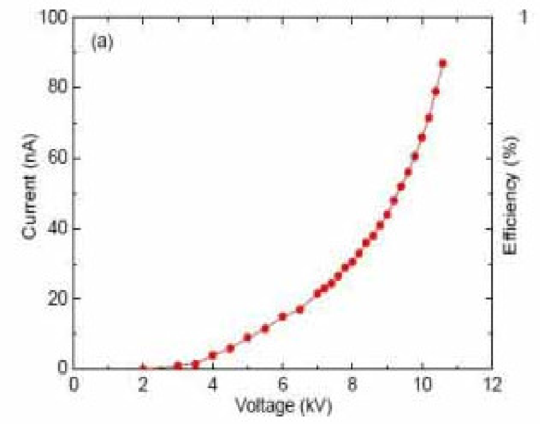


Simulation result

V. *Comparison between experimental data and simulation*



Simmulation result



V. Experimental Data

Both results most closely to each other.The RPC gas gap is represented by a parallel combination of spacer (Ohmic) resistance and gas ionisation volume of the gap (represented by a Zener diode).
The difference between two graph can be solved by design this circuit using MatLab script or by using more electrical componants in simulink circuit.

VI. Conclusion

When we compare the results of the electronic circuit simulations performed using matlab, we find that the total current obtained from model is almost the same in both the cases. Moreover, this current most closely resembles the experimental data.

VII. Future Developments and Improvements

In this project, the RPC has been considered to consist of bakelite plates. The circuit simulation of RPCs having glass plates can be another interesting case for similar investigation.

This project primarily dealt with the charging of the capacitors, however, it can be further developed by considering the electronic avalanche effect to study how it affects the current profile of the RPC. In addition to that, simulation can be carried out incorporating the electrical breakdown characteristics of the materials to reproduce the observed I-V characteristics of the detector. In future, based upon the understanding of the electronic circuit simulation of RPC, similar project can be undertaken for studying other gaseous detectors like GEM, Micromegas.

VIII. References

[1]. The dynamic behaviour of Resistive Plate Chambers- M.Abbrescia, Nuclear Instruments and Methods in Physics Research A 533 (2004) 7-10

[2].Design and Characterization of a 2m x 2m Resistive Plate Chambers (RPCs) –Raveendrababu Karnam, INO Graduate Training Programme, TIFR

