Measurement of characteristic impedance of Silicon fiber sheet (Ceramic foam) based read out strips panel

M. K. Singh[1], A. Kumar[1], N. Marimuthu[1, 2], V. S. Subrahmanyam[1], V. Singh[1*]
[1] *High Energy Physics laboratory, Physics Department, Banaras Hindu University, Varanasi-221005, INDIA*
[2]*American College, Madurai-625002, Tamilnadu, INDIA*
Email: venkaz@yahoo.com

1. Introduction

Resistive Plate Chambers are parallel plate fast gaseous detectors built using electrodes of high resistivity (10^{12} ohm-cm) such as glass or Bakelite. Both electrodes are connected to the positive and negative polarities of the high voltage power supply. When a charged particle such as muon passes through the chamber it ionizes the gas and charges move towards opposite electrodes. The electrodes are transparent to the signal, which is finally picked up by external metallic strips after a small but precise time delay. Regarding the electrical properties, it will be ideal to have the characteristic impedance of the strips of readout panel match with the front-end electronics so that signal reflections are minimized. Another important consideration is the attenuation in the pickup strips, which should be minimized as well.

2. Measurement of Characteristic Impedance

We have measured the characteristic impedance of the Polycarbonate based Pickup strips panel of size 50cm × 50cm and also of Silicon fiber sheet of size 50cm × 50cm by pulse method using Scientific 20 MHz Pulse Generator SM 5035, Tektronix Digital Phosphor Oscilloscope 3054 of 500 MHz and a MARS VC97 Digital Multimeter. The experimental arrangement is shown in Fig. 1; the pulser sends a pulse through a 50 ohms coaxial cable and it gets into the terminating circuit where it fed on to a 120 ohms twisted pair flat ribbon cable without being distorted. The 120 ohms cable is about 10 meter long and it is branched to an oscilloscope for study at about 1.5 meter from the impedance matching circuit. The end of the 120 ohms cable is connected to the front-end of pickup strip panel.

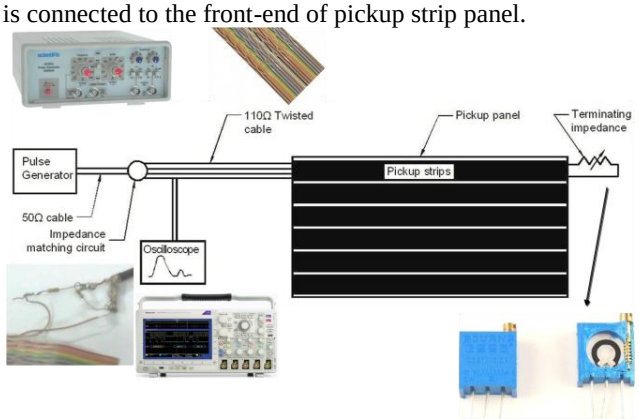

Figure1: Schematic diagram of experimental arrangement for the measurement of characteristic impedance of both materials based pickup panels.

The back-end is connected with variable resistance for which we have used the BOURNS 3296-3/8 Trimpot Trimming Potentiometer (COSTA RICA) along with multi-meter to measure the change in resistance. We have designed and tested many pickup strip panels using various dielectric materials but could not achieve the desired results. We obtained the desired results only with Silicon fiber sheet dielectric material. From this experimental setup we want to optimize the following parameters:-

1) The thickness of dielectric material for which we will get the minimum signal reflection.

2) The value of terminating impedance at the backend of the pickup strip panel.

Figure 2 shows the original pulse and reflected pulse from one of the strip of pickup panel, a similarity observed with each strip. For each strip we have sent a pulse, the pulse reflected back from both ends i.e. front-end and back-end called as front-end reflection and back-end reflection, respectively. The back-end reflection is more probable to interfere with the original signal and therefore it must be removed / minimized. For eliminating the back-end reflection we have to connect a terminating resistor at the back-end of strips of a particular value equal to the characteristic impedance of the strip.

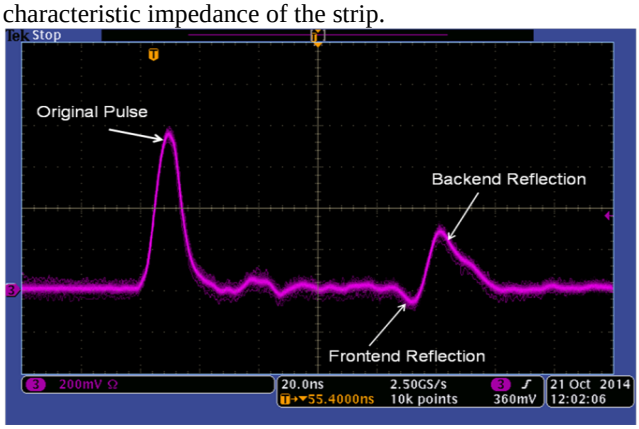

Figure 2: Original pulse (Left) along with reflected pulse is taken from the oscilloscope screen, with open end of pickup panel.

For this purpose we have used a multi-term trimming potentiometer and vary the resistance until the back-end reflection has been minimized. For the Silicon fiber sheet based pickup strip panel of thickness 4.0 mm and honeycomb based pickup strip panel of thickness 4.5 mm, we have repeated the above procedure in the same way. For visual observation and comparison the screen shots of the oscilloscope are shown in figure 3.

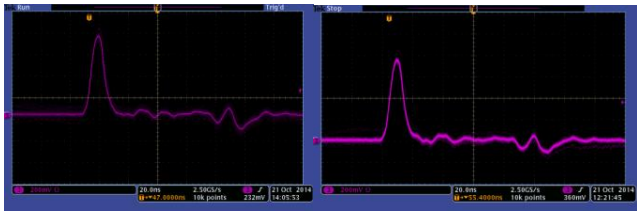

Figure 3: Oscilloscope display for Silicon fiber sheet (left) and honeycomb (right) based readout panels

4. Measurement of characteristic impedance by varying the thickness of readout panel

We have also measured the characteristic impedance by varying the thickness of readout panel. We observed the following oscilloscope display for different thickness at minimum reflection of signal.

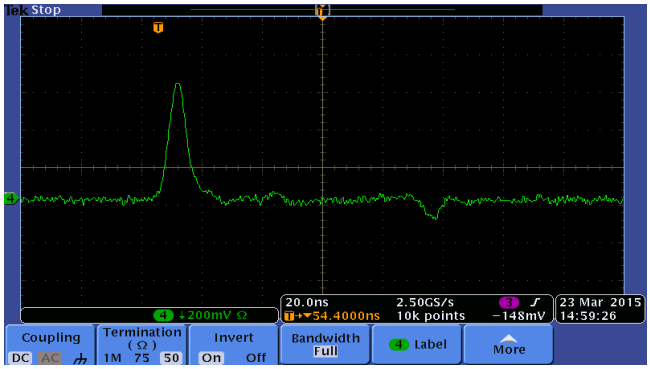

Figure 4: At 50.0 Ohm terminating resistance for Silicon fiber sheet based readout strips panel of thickness 5mm.

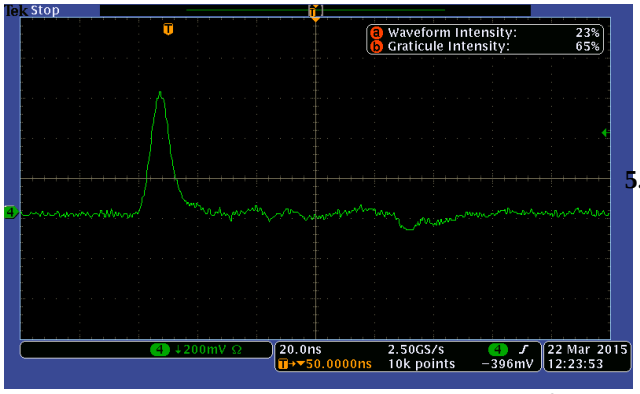

Figure 5: At 48.5 Ohm terminating resistance for honeycomb based pick-up panel of thickness 4.5 mm.

In the above two figures 4 & 5 we have shown the oscilloscope display of minimum reflected signal along with original signal, both for plastic honeycomb and silicon fiber sheet based read out strips panel made by us. In addition we have also varied the thickness of Silicon fiber sheet as 4mm, 3mm, 2mm, 1mm and noted the corresponding termination impedance values. In table 1, we have tabulated the observed results. From these results we have observed that the terminating impedance values have inverse relation with the thickness of the dielectric material as shown in Figure 6.

From this figure we may conclude that at 5 mm thickness of dielectric material desired impedance may be achieved. From this plot one can very easily understand that by decreasing the thickness of readout strips and keeping the pitch of strip constant the terminating impedance value increases correspondingly.

Table 1: Characteristic Impedance and the thickness of Silicon fiber sheet

S. No.	Thickness (mm)	Characteristic Impedance (Ω)	Strip width(28 mm)/Thickness ratio
1.	1	134.0	28.0
2.	2	116.7	14.0
3.	3	93.7	9.3
4.	4	73.0	7.0
5.	5	50.0	5.6

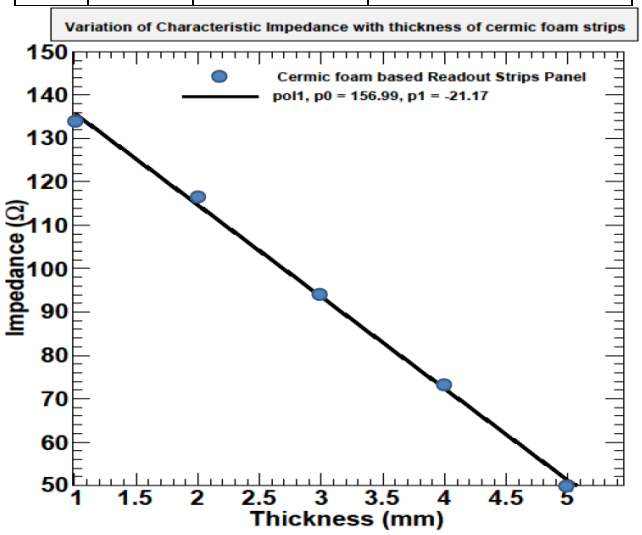

Figure 6: Variation of characteristic impedance with thickness of silicon fiber sheet strips

5. Results and conclusion

On the basis of our study on Silicon fiber sheet based readout strips panel with respect to the plastic honeycomb based read out strips panel we may conclude that Silicon fiber sheet is much more helpful in making readout strips panel for its use in any laboratory especially for the underground lab. The characteristic impedance for 28 mm pitch (keeping it constant), 5mm thickness of Silicon fiber sheet based readout strips panel will be good for the RPC detectors.

6. Acknowledgment

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References

[1] M. K. Singh et. al., Proceedings DAE Symp. Nucl. Phys.59, 976 (2014).