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Design and Development of High Voltage Power Supply and its Application in RPC

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ABSTRACT: This paper describes the design and construction of a suitable high voltage power supply to operate Resistive Plate counter (RPC). RPC is a gaseous detector in the domain of nuclear physics, two types of multiplication occurs, avalanche and streamer mode in its operation. The induced charges generated is captured from the pickup strips as a pulse with the help of front end electronics and sophisticated instruments.High voltage power supply is important to operate RPC. There are various methods to generate high voltage power supply circuit. Flyback converter is found as an optimum method which can improve the design of the circuit to make it smaller in size, simpler, cost effective and gives good results in RPC experiment. In this paper, the hardware of the HV power supply circuit and its use in measuring the detector cathode current and efficiency is explained.

KEY WORDS: High Voltage, Power Supply, Detector cathode current, Efficiency

I. INTRODUCTION

It is evident that high voltage with low power supply is needed in communication, biomedical equipment,nuclear instrumentation, high voltage testing and any other field are in high demand .The aims of this paper is to design a high voltage low power supply circuit that can produce high voltage up to 7.5 KV with lowest current and power values. This Power supply circuit is designed using flyback converter topology and high frequency transformer which is small in size, simple, low cost and locally available materials.Generated high DC voltages is applied in research work in the domain of pure and applied physics detector like RPC[1,2]. Sometimes, high direct voltages are required for insulation tests on cables, Capacitors and in impulsegenerator charging units. Many methods are found to generate high voltage dc source, while Flybackconverter is found to be suitable for proper operation of RPC due to small size and low cost.

II. FLYBACK CONVERTER

Flyback topology is the most attractive topology on account of its relative simplicity and low cost when compared with other topologies used in high voltage circuit design. It is used in both AC/DC and DC/DC conversion with galvanic isolation between input and output. PWM switching technique has been utilized for its high power capability, fast transient response and in switch mode power supply used in industry [3]. Using this approach, PWM DC-DC power converter has been used to increase the power density and actual efficiency. The advantage of Fly-back power converter is to isolate the switching control section and the output section.

III. METHODOLOGY

The design of the complete circuit is investigated in details and accumulate all the components before combine all the parts together which gives a complete working design.Initially, with the help of rectifier circuit 12V DC is generated which is applied to the driver. The driver which is the 555 timer chip will generate square wave pulse or also known as PWM to increase the frequency until thousands of Hertz. Next the PWM produced will be amplified and controlled the switching on and off by using transistor. The on and off mechanism is applied to input of the Flyback transformer [4]. Flyback transformer increases the voltage to produce the desired output high voltage according to the input frequency applied. The design of the complete circuit assembly is depicted in the following block diagram.

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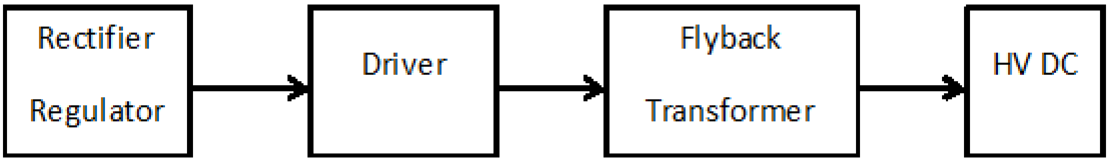

Fig. 1 Overall circuit block diagram

A. Design Details

To implement the hardware of the circuit it can be divided into four important parts, rectifier circuit, switching circuit, Flyback converter and DC high voltage. In the first stage a full wave rectifier with voltage regulator circuit was designed to provide the necessary low voltage to transistors and ICs in the circuit. For designing switching circuit IC 555 timer is used inastable mode. The output of the timer gives a signal to the transistor. After building the switching circuit, the output of the signal from pin 3 of the timer IC is connected to pin no 3 of IC CD4090 and pin no 2 of the same IC is connected to the base of the transistor Q1.The signal generated from Q1 is applied to transistor Q2 via a step-down transformer. The transformer is designed for impedance matching purposes to match the high output impedance of Q1 into the low impedance base circuit of Q2. The connections of T1 are arranged in such a way that the turning on of Q1 causes Q2 to turn off and conversely.

In this circuit.Q1 and Q2 are driver and output transistors respectively. The output transistor operated as an electronic switch. When forward bias, it saturates to close and on reverse biasing cuts off to cause an open circuit. When in saturated mode, it to deliver power to the secondary coil of Flyback transformer[5]. Therefore, it is of great importance that the controlling voltage waveform fed to the base of Q2 shall always be large enough to turn it on and sufficiently negative to reverse bias when it required to cut off. The Q1 is also operated as an electronic switch and triggered into conduction by positive pulse applied to the base. The transistor Q2 can withstand base current (I_B) upto 2A, while the collector current (I_C) resist until 4A and can provide dc current gain 375. Moreover transistor Q1 can withstand (I_B) upto 100mA, collector current (I_C) resist until 1A and can provide maximum dc current gain up to 375.

In this design, the transistor Q1 is saturated its collector is nearly earthed and when turned-off, the collector voltage rises to about the supply voltage Vs. Hence, the waveform appearing at the collector of Q1 takes the form of a series square wave pulse nearly equal to Vs. Thus the waveform appearing at the collector of Q1 takes the form of a series of square wave of amplitude almost equal to Vs. In essence, the amplifier is operating like a switch , at a frequency from 1KHz to several KHz [6]. It operates either saturation or cut off mode. The duty cycle can be derived from 0% to 90% . Fig. 2shows the overall hardware of high voltage power supply circuit.

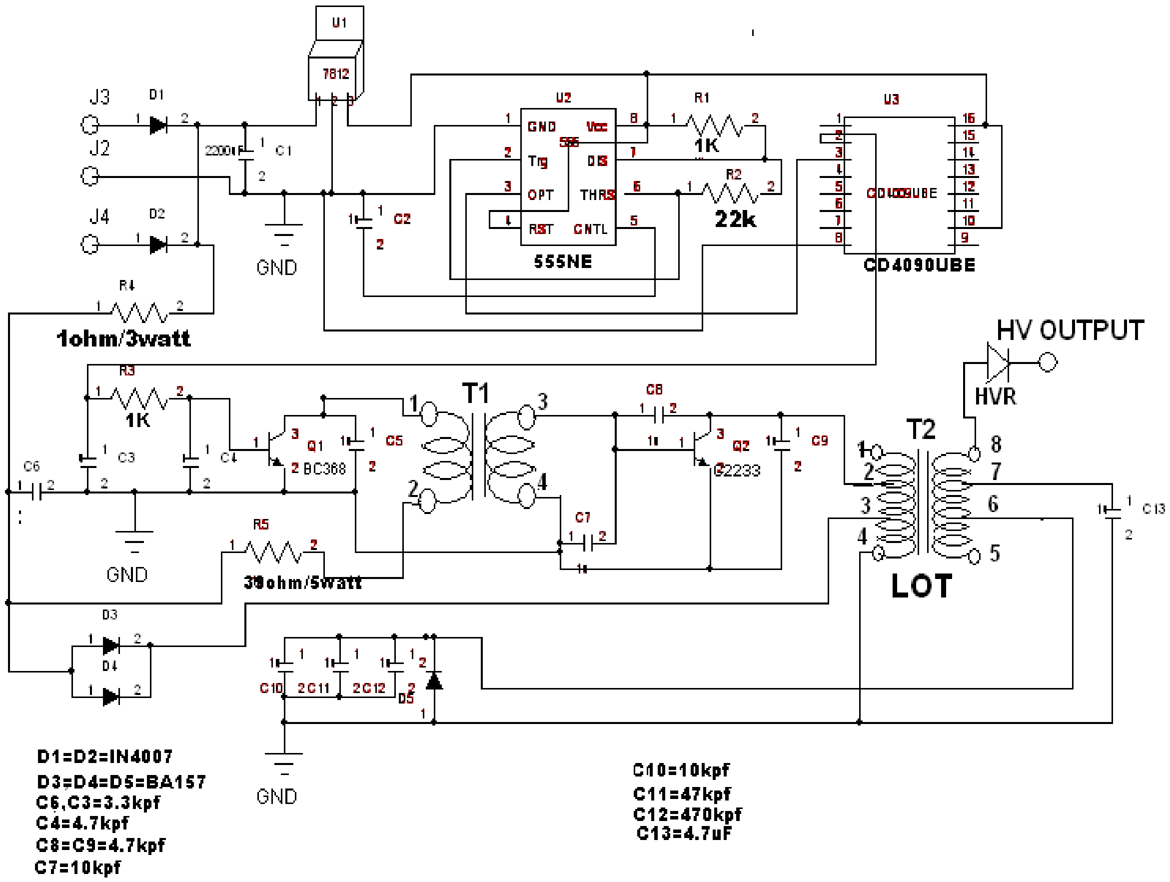

Fig. 2 High Voltage Power Supply Circuit Schematic

IV. RESULT AND DISCUSSION

A standard 7.5KV, high voltage power supply is designed applying fly back converter topology in the laboratory with the help of locally available electronic components . The positive terminal of the high voltage power supply is applied to the anode of the RPC and cathode of the RPC is connected to the negative terminal of the HV supply[7]. The output pulses from the RPC are recorded by Digital storage oscilloscope (Tektronix, TDs-520A) with a GPIB (IEEE 488) interfacing. For counting the pulses the signal is fed to an ultra fast discriminator with a bias of 60 mV and counting is done by one conventional ECIL, (EC 5104) counter.

A. Detector Cathode current measurements

For an operational RPC we measure the detector cathode current to study about the stability. The multiple graphs show the detector behaviors in Fig 3. It is observed that the current takes an initial period to stabilize which is known as warm up period of the detector. The detector warm up time is about 25 minutes for 30 cm x 30 cm size paper phenolic during which the current falls and reaches a stable condition. At stable condition the average cathode current is found 137 µA at bias voltage 5.6 kV of 30 cm x 30 cm RPC.

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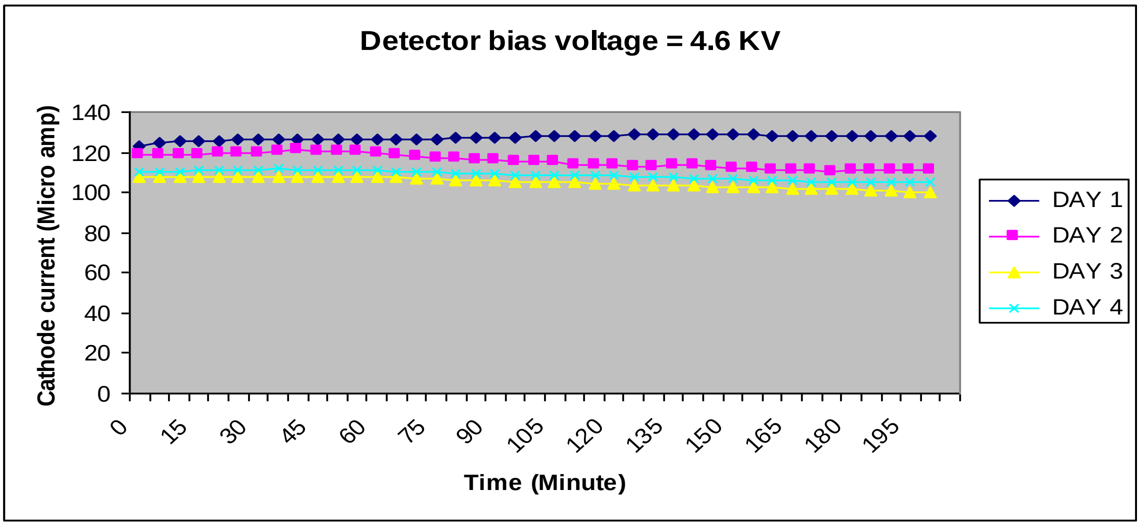

Fig. 3Detector (30 cm x 30 cm, size) cathode current variation as a function of time in minute

B. Detector efficiency test

The efficiency of the detectors (RPC) are measured at different gaseous environment at detector bias voltages from 3.6 KV to 5.6KV in case of 30 cm x 30cm paper phenolic. Here counting is taken for a period of 3.25 hours. The variation of efficiency with applied high voltage for different gas ratios is shown in figure 5 which is more than 92%.

The schematic representation of the experimental setup for measuring detector efficiency is shown in figure 4. RPC module is sandwiched between the two scintillators (SC1 and SC2) each of dimension 50cm x 50cm x 5cm. To obtain the RPC efficiency in a region within one pickup strip, the trigger setup is further zoomed into a region of Finger scintillator (SCF) of dimension 5cm x 5cm x 5cm and placed above RPC pickup strip. The trigger signal is obtained as SC1 AND SC2 AND SCF indicating passage of a cosmic ray muon. Therefore the efficiency is obtained in a region of 3cm x 5cm within a pickup strip. Coincidence between RPC count and the trigger count is taken as final count. Therefore, the efficiency is obtained from the following formulae.

$$\%\ Efficiency = \frac{RPC\ count\ with\ the\ signal\ in\ coincidence\ with\ trigger}{Trigger\ Count} \times 100$$

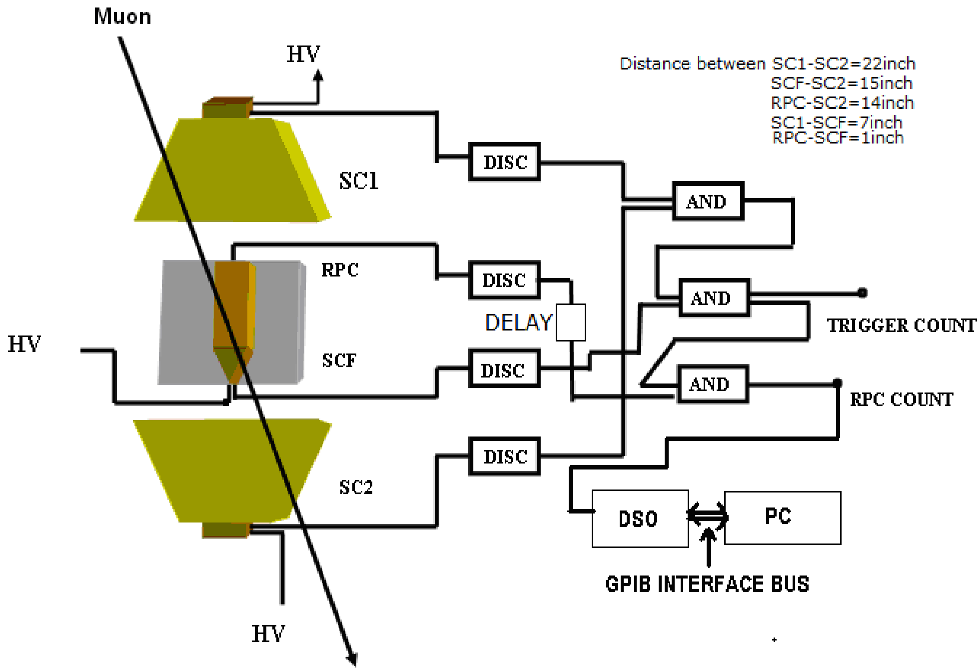

Fig. 4 Experimental setup for efficiency test for RPC

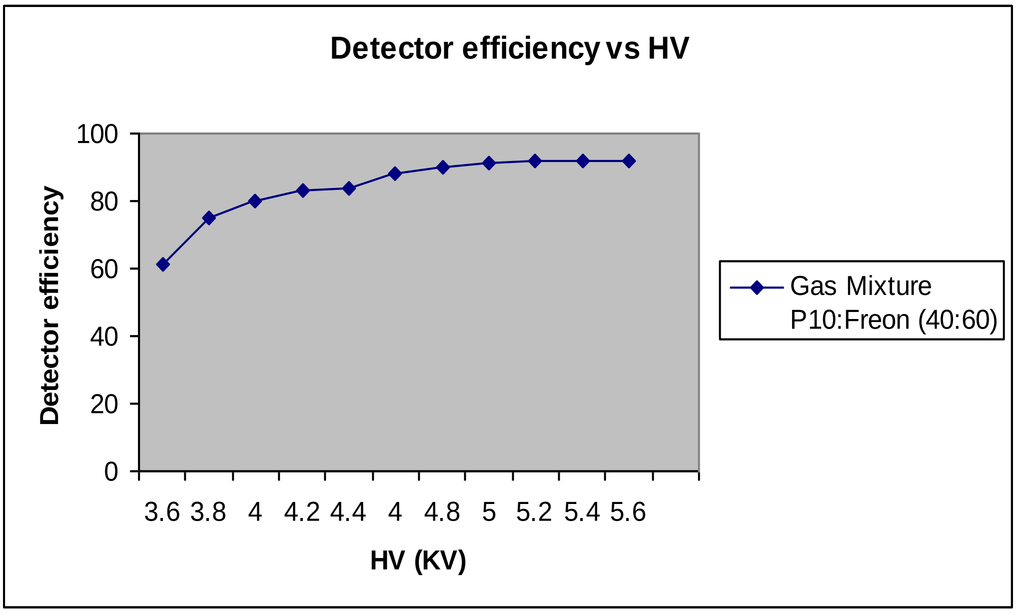

Fig. 5 Detector (30 cm x 30 cm, size) efficiency vs HV (RPC material phenolic, gas gap=1mm)

V. CONCLUSIONS

There are five different ways to build the high voltage power supply circuit which are voltage Doubler and Cockcroft – Walton's Voltage Multiplier , Marx generator , Tesla Coil, and Flyback topology. The most suitable topology is the Flyback, which is used to operate RPC . This power supply is found stable to determine efficiency of the detector as well as detector cathode current.

The detector cathode current is found 137µA at bias voltage 4.6KV, variation as a function of time to find the stability of the detector . Finally the efficiency of detector is obtained, which is varied from 60% to 92% in case of 30 cm x 30 cm at bias voltage 5.6KV.

REFERENCES

[1] P. Fonte, N. Carolino, L. Costa, Rui Ferreira-Marques, S. Mendiratta, V. Peskov, A. Policarpo, A spark-protected high-rate detector,Nuclear Instrumentation and Method, vol. A431, pp. 154-159, 1999.

[2]R. Cardarelli, V. Makeev, R. Santonico, 1996.Avalanche and streamer mode operation of resistive plate chambers, A Nucl. Instr.And Meth.in Phys. Res. A382 (1996) 470.

[3] Nader Barsoum, Glenn Isaiah Stanley, 2015. Design of High Voltage Low Power supply Device, Universal Journal of Electrical and Electronics Engineering 3(1):6-12, DOI:10.13189/ujeee.2015,030102.

[4] K. Ravichandrudu, P. SumanPramod Kumar, 2017, Importance of Flyback Converter for Electric Vehicles, IEEE Internal conference on power control, signals and Instrumentation Engineering.

[5]SC Rajbongshi, HC Medhi , PK Boruah and K.Boruah , 2010. Simulation of Resistive plate counter (RPC) Pulse Height spectrum, IJPAP, Vol 6,NO.1. 2010.pp 9—14.

[6]HC Medhi , SC Rajbongshi, PK Boruah and K.Boruah, 2010. A new pulse strertcher circuit suitable for nanosecond pulses and simulated using VHDL,IJAER, Vol. 5, N0. 10 (2010) pp. 1689-1692

[7] EhsanNajafi, Abdul Halim Mohamed Yatim, 2012. Design and Implementation of a New Multilevel Inverter Topology, IEEE Transactions on Industrial Electronics, Vol.59.No.11,PP.4148-4154 November 2012