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Design and Study of a Low Cost High Voltage Power Supply

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Abstract: The method of developing a low cost high voltage power supply has been described in this study. The high voltage power supply consists of an oscillator, step-up transformer, voltage multiplier and feedback loop for stabilizing the output. The oscillator is spilt into IC timers suitable for astable and monostable mode using with high frequency that leads to ferrite core small X-former. This type of HVPS can be used in the nuclear field for very low current biasing semiconductor detectors and gas-field detectors to higher currents working with photo multiplier tubes.

INTRODUCTION

A power supply must provide stable and ripple-free DC output voltage independent of line and load variations[1]. Variable high voltage power supply with over-current alarm and time delay that gives 0-300 V and 100 mA based on a simple circuit employing zener diodes and series pass transistor for its regulation[2]. A variable high voltage power supply using phase angle control has been presented by Islam and Quamruzzaman.

The high voltage output is adjustable from 100-1000 V and the current rating is 10 mA. A variable high voltage power supply with astable and monostable multivibrator based on IC timers has been proposed in this study (Fig. 1). The output voltage is ranging from 300-600 V and 12.5 mA. The following blocks comprise the designed high voltage power supply as: Astable, circuit, monostable circuit, driver circuit, voltage multiplier circuit and sampling and feedback circuit.

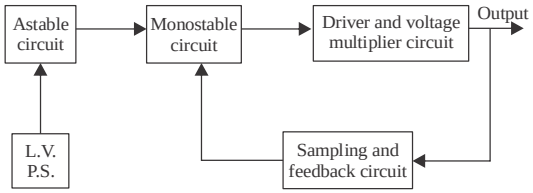

Fig. 1: Block diagram of the designed high voltage power supply

TIMING FORMULAE AND SPECIFICATIONS

Astable operation:

$$T_1 = 0.1(R_a + Rb) \times C \text{ sec} \quad (1)$$

C in F; R_a and R_b in:

$$T_2 = 0.7\ R_b \times C \text{ sec} \quad (2)$$

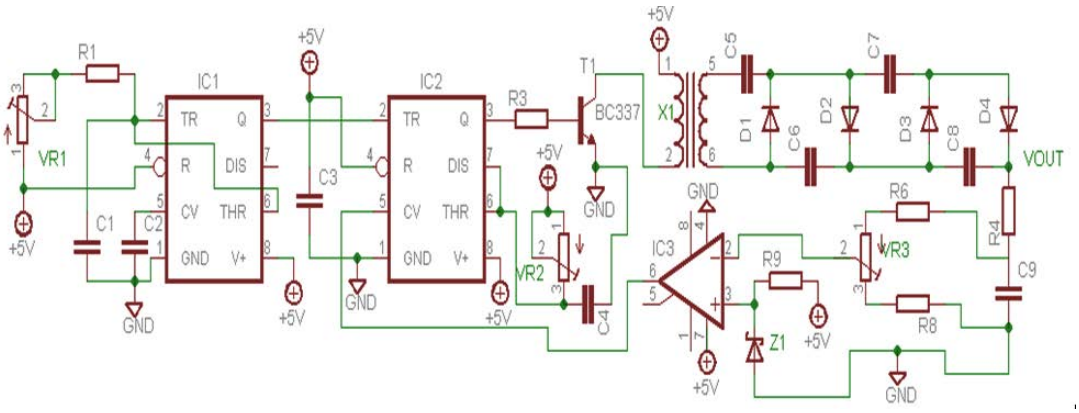

Fig. 2: Complete circuit diagram of the high voltage power supply

$$f = \frac{1}{T_1+T_2} = \frac{1.44}{(R_a+2R_b)C}\ Hz \quad (3)$$

Monostable operation:

$$T = 1.1R_a \times C\ sec \quad (4)$$

C in F; R_a in:

Supply voltage	= 4.8-6.0 V
Supply current	= 12.5 mA
Output voltage	= 555-575 V
Output current	= 12.5 mA
Time period	= 180 µsec
Frequency	= 9.36 KHz
Range of output variation	= 20 V

Functional description: The astable or free running circuit is used for generation of clock pulses or uniform pulse chains. These pulses then applied to monostable circuit which was used to form variable-width pulses for gating action in the driver circuit[3]. For both circuit, the reset has been connected to Vcc which avoids false reset occurring.

In astable circuit, the control voltage terminal has been decoupled to ground line by a 10nF capacitor while in the monostable circuit, this pin has been tied to feedback circuit[4]. The output of this circuit thereafter multiplied by using the the voltage multiplier circuit. The feedback circuit was used to improve and stabilize the output.

Circuit description: Figure 2 shows the complete circuit diagram of the designed high voltage power supply.

Astable circuit: The astable circuit consists of the variable potentiometer, VR1, resistor R1, capacitor C1, C2 and timer IC1.

Monostable circuit: The monostable circuit comprises of the C3, VR2, C4 and timer IC2.

Driver circuit: The driver circuit has resistor R3, transistor T1 and ferrite core step-up transformer X1.

Voltage multiplier circuit: The voltage multiplier circuit includes of the C5, D1, C6, D2, C7, D3, C8 and D4.

Feedback circuit: The feedback circuit consists of the R4, C9, R6, VR3, R8, R9, zener diode Z1 and operational amplifier, IC3.

CONCLUSION

The designed high voltage power supply has been tested repeatedly and its performance was found satisfactory. The output voltage is linearly variable, stable and ripple-free. The unit can be used for biasing different types of detectors in the nuclear and educational research institutions successfully. The device is low cost and it needs US$ 50 for its fabrication whereas the price of the similar instrument in the international market is not less than US$ 400.

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