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A simple regulated power supply for characteristics studies of klystron oscillators

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Abstract. A simple and inexpensive power supply suitable for characteristics studies of a klystron is described. The circuit is a modified form of the high voltage adjustable power supply based on LM 317. This provides the necessary cavity and repeller voltages over a wide range, with good regulation. The system is protected against short circuits and is ideally suitable for laboratory experiments with reflex klystrons.

1. Introduction

For the characteristic study of electronic devices such as klystron oscillators, power supplies giving variable high voltages of both polarities are required. A fully solid state and cost effective power supply that meets this requirement is presented in this paper.

The design of the power supply is based on an IC LM 317, a complete 1.5 A adjustable three-terminal voltage regulator manufactured by National Semiconductors. The floating mode operation of this three-terminal regulator is ideal for high voltage operation [1]. The regulator has no ground pin; instead, all the quiescent current flows to the output terminal. Since the regulator sees only the input-output differential, its voltage rating will not be exceeded for outputs of hundreds of volts. However, the IC may break down when the output is shorted unless special design approaches are used to protect it. For this, current-limiting and short-circuiting protection circuits are incorporated.

2. Circuit description

A schematic diagram of the power supply and the output connections is shown in figure 1. The isolated secondaries of the power supply transformer provide different AC voltages. 6.3 V AC/5 A is used as the filament supply wherever required.

The 260 V AC/100 mA secondary is rectified using a bridge rectifier consisting of four 1N 4007 diodes and filtered with a 220 μ F capacitor. This DC voltage is fed to a pre-regulator constructed around two Darlington

triplets (transistors T11–T16) in series, along with Zener diode Z1 (12 V). This Zener diode ensures that the input to the IC LM 317 sees only a 10 V input-output differential over the entire range of output voltage from 1.2 V to 300 V. Since high voltage transistors, of necessity, have a low β , Darlington triplets are used in series to stand off the high voltage and power. Potentiometer Vr1 in series with R16 and Pr1 derives the Vref voltage for the regulator IC. For the LM 317 the voltage difference between the reference and output is 1.2 V. By varying the potentiometer Vr1 the output can be varied from 1.2 V to 300 V. The output voltage in terms of resistor values Vr1, Pr1 and R16 is given by

$$V_{out} = 1.2 \left(\frac{Vr1}{Pr1 + R16} + 1 \right) \quad (V)$$

An output voltage of 300 V is set by keeping Vr1 at its maximum position and adjusting the preset Pr1. In this circuit, the load current is limited to 200 mA, i.e. for an output short-circuit the diode D1 keeps the reference nearly to the output voltage and the input to the regulator is around 10 V (the Zener voltage minus base emitter drops). This voltage is dropped across the resistor R15. In this case $10 \text{ V}/47\Omega = 200 \text{ mA}$ and the power dissipation in R15 is around 2 W. So R15 and D1 protect the system against short circuit and the maximum power dissipation across each series power transistor is nearly 35 W (heat sinks are necessary for the power transistors). Any variation or noise at the reference is reflected in the output. The capacitor C3, connected across the high resistance potentiometer Vr1, improves the ripple rejection. The load regulation of the regulator is 0.1% and the ripple rejection is 80 dB. R17 and C4 improve the transient response.

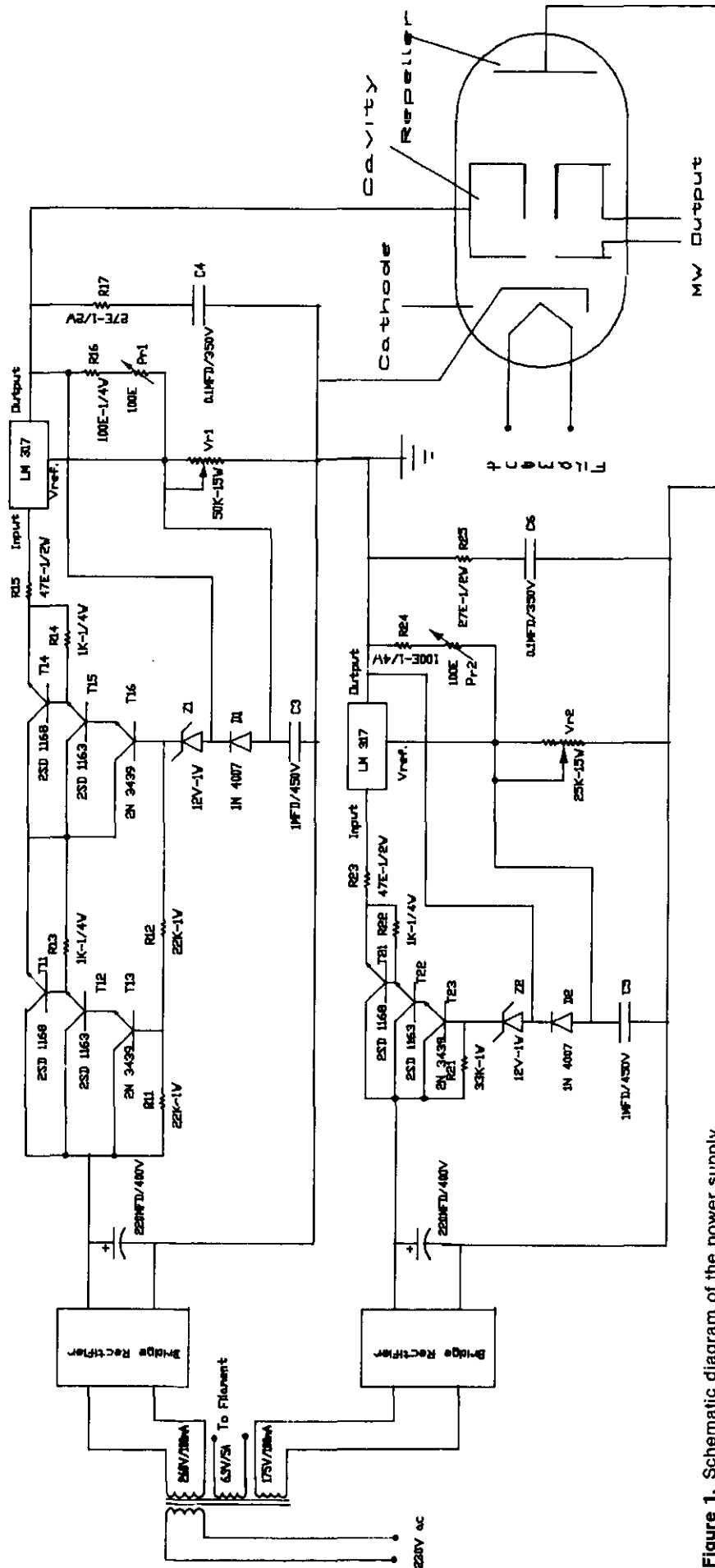


Figure 1. Schematic diagram of the power supply.

The 175 V/100 mA secondary is also rectified using four IN4007 diodes (bridge rectifier) and filtered with a 220 μ F capacitor. This DC is then fed to a pre-regulator constructed around transistors T21, T22 and T23 along with the Zener diode Z2. The rest of the circuit is similar to that in the above case. Here the output is set to a maximum of 200 V. This voltage can be varied between 1.2 V and 200 V with the help of potentiometer Vr2.

The Klystron connections are also shown in the diagram. By adjusting the potentiometers Vr1 and Vr2 the cavity voltage and repeller voltage (negative with respect to the cathode) can be changed respectively.

3. Performance of the power supply

As an application of the power supply, the Klystron characteristics [2] studied using this power supply are shown in figure 2. Klystron 2K25 was used for the experiment. The curves are in good agreement with those plotted using conventional power supplies. These studies reveal the excellent performance of this power supply when put into use within a system. This power supply can be used for all klystrons working with a repeller voltage of 200 V. The power output can also be varied by changing the cavity voltage. This can be used as a general purpose power supply for a maximum current of 200 mA. High voltage power MOSFETS, if available, can substitute transistors T11-T16 and T21-T23 which simplifies the circuit.

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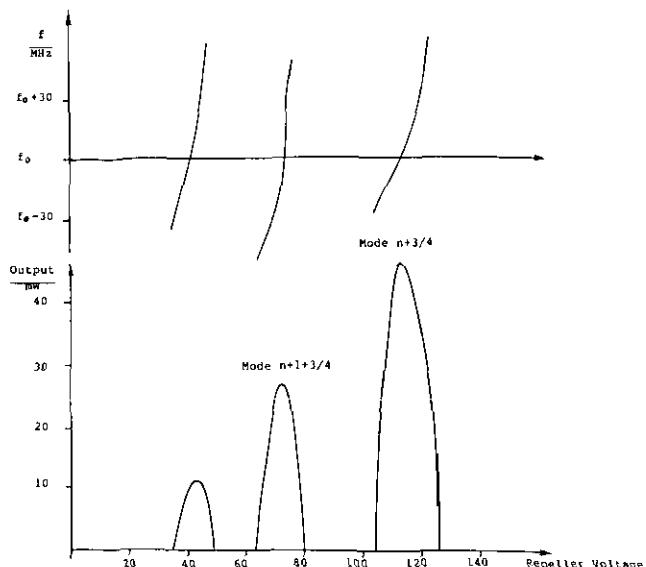


Figure 2. Frequency versus repeller voltage for klystron 2K25 (top), variation of output power versus repeller voltage (bottom). The curves are in good agreement with those plotted using conventional power supplies.

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References

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- [2] Gardiol F 1984 *Introduction to Microwaves* (Boston, MA: Artech House Inc)