A 25 KV/10A PULSER FOR DRIVING A HIGH-POWER PIERCE ELECTRON GUN

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Abstract **—This paper describes the design and operation of a hard-tube pulser to drive a high-power electron gun. The tube includes a 2.0μF/100kV capacitor bank whose discharge is controlled by a tetrode tube connected to the gun cathode. Typical measured operating parameters are 3.0 A current and 10.0 kV beam voltage.**

***Key words* — hard-tube pulser, Pierce electron gun, microwave tube, monotron**

I. INTRODUCTION

Consisting of a cylindrical cavity driven by a rectilinear electron beam, the monotron is the simplest microwave generator, whose principle of operation relies on transit-time effects experienced by the electron beam propagating across the cavity. Here we describe a hard-tube pulser used to accelerate and inject a hollow electron into a cylindrical cavity to generate high-power microwaves at 6.7 GHz, a frequency suitable for communications, medical and industrial applications. Currently under development at our laboratory, this monotron [1] operates with beam currents of about 4.0 A at 10 kV as discussed throughout the paper in connection with the design characteristics of the pulser

II. THE PULSER GENERATOR

A schematic diagram of the pulsed power supply used for driving the monotron electron gun is shown in Fig. 1. The circuit consists basically of capacitor bank C (2.0 μF/ 100 kV) which discharges through a tetrode tube TH5188 in series with the beam impedance [2]. A DC high voltage power supply (100 kV/50 mA) is used to charge the capacitor bank where the resistor R_1 of 60 kΩ limits the transient charging current. The tetrode operates as a fast on-off switch, with the screen grid (g2) held at the potential of +1000 V thus assuring that the tube remains in the cutoff state for cathode-anode voltages up to 25 kV on condition that control grid (g1) is biased at –300 V according to the tube characteristics displayed in Fig.2. The TTL pulse generator located on ground at panel rack controls the pulse length with the tube remained switched on as long as the TTL pulse is active. Whenever this external triggering occurs, the potential on the tetrode control grid is increased from -300 V (cut off condition) to a few volts above the tetrode cathode potential leading the tube into saturation. As the tube and its driver amplifier are located on the high voltage floating deck an optical fibre transmits the TTL signal via optical interface units. A second resistor of 2.5 kΩ in series with the tetrode and the beam load protects the system against the risk of short-circuits. Since the current capability of the tetrode is of the order of 10 A in the case of a short-circuit, the limit of the charging voltage is up to a maximum of 25 kV. The pulsed system has a maximum capability of operating at a repetition frequency of about 1 kHz with a duty cycle of the order of 5 %. This means a maximum pulse duration of about 50 μs for the operation condition described above.

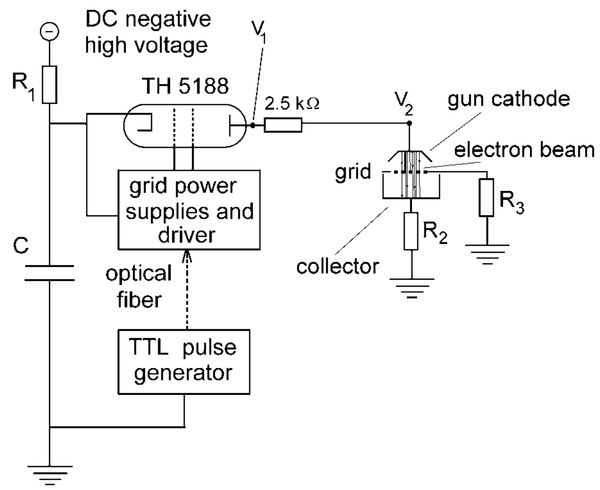

Fig. 1 Schematic of the tube pulser power supply connected to the monotron gun

III. ELECTRON GUN OPERATION

The gun is a parallel plane diode in the Pierce configuration [3], with the cathode consisting of a nickel disk coated with a barium oxide film heated at the typical temperature of 900 C. The gun cathode voltage is fixed at the nominal value of 10 kV, while the current supplied by the emitter is freely adjusted by varying the cathode temperature. The pulser is connected to the gun cathode as illustrated in Fig.1, where the current drawn by the cathode is inferred by the voltage drop V_2-V_1 across the 2.5 kΩ ballast resistor and then compared with the grid and collector currents (directly determined from voltage measurements on resistors

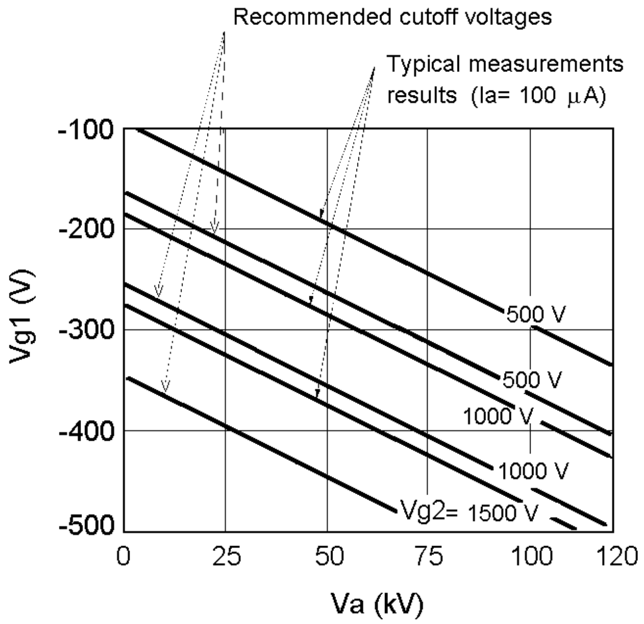

Fig. 2 Typical measurements and recommended values for the cutoff voltages of the TH5188 tetrode.

R_2=1.1 Ω and R_3=10.0 Ω) to certify whether the beam is properly focused upon entering the cavity.

A set of such measurements are given in Fig. 3. Indicative of proper functioning of the gun, the pulses are well time correlated; with no occurrence of either pulse shortening or delay effects, the current pulses follow the leading and trailing edges of the voltage pulses. In fact, we see the voltage difference V_1-V_2 (Fig. 1) gives the total current of 4.0 A, which is consistent with the sum of the current components, namely, the grid (~0.9 A) and collector (3.1~A) currents.

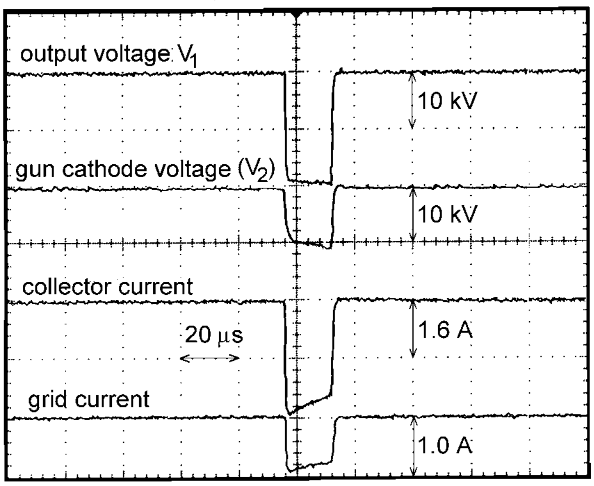

Fig. 3 Measured voltage and current waveforms

IV. CONCLUSION

The 25 kV/10A pulse generator described here has proven to be well suited for driving a high-power electron gun, which is a critical component in all microwave tubes. Concerning the beam optics, the tests have indicated that a substantial fraction of the injected current is intercepted by the cavity's input grid, made up of a slotted circular plate that acts as a short circuit at the RF operating frequency, thus totally reflecting back to the cavity the incident electromagnetic energy. This is an issue to be addressed in future experiments as full utilization of the beam current translates into higher RF power generated by the monotron. Reliability of the system has been demonstrated through well correlated and voltage and current pulses. We remark in addition that the pulses are regularly shaped by approximate rectangles such that this desired characteristic defines unambiguously the corresponding pulsed beam power.

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