IMPLEMENTATION OF A 35 GHz MICROSTRIP ANTENNA SYSTEM

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RESEARCH REPORT

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ABSTRACT

Millimeter waves, corresponding to the frequency range 30 to 300 GHz, have characteristics which make them ideal for many applications. Antennas at these frequencies have the advantage of reduced size and weight and can be fabricated as an integral part of the system they are used in.

Millimeter wave microstrip antennas have been extensively researched over the past decade. The purpose of this report was to build and test 35 GHz microstrip antennas as well as put into operation a high voltage klystron power supply, Micro-Now Model 756. The antennas were fabricated and tested in the lab and the results obtained are reported. The operation of the Model 756 power supply is also outlined in detail.

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CHAPTER 1

KLYSTRON POWER SUPPLY

The millimeter wave antennas constructed and tested were powered and driven by an advanced power supply system. This system was composed of a high voltage klystron power supply and a millimeter wave signal generator, the reflex klystron. The description and operation of the component parts of this power supply system will be addressed in this chapter.

1.1 Reflex Klystron

Reflex klystrons are used quite frequently as laboratory signal generators, low power transmitters, or local oscillators. An overview of the reflex klystron and its operation will be presented.

A schematic diagram of a reflex klystron and the voltages required for operation is shown in Figure 1.1. The components composing the tube are the cathode, a focusing electrode at cathode potential, a reflector which is at a negative potential with respect to the cathode, and an anode which operates as a cavity resonator. The teamwork of the cathode, the focusing electrode, and the anode produces an electron beam that travels through the resonator gap toward the reflector. The reflector, being at a negative potential with respect to the anode, repels the electrons back toward the anode. This reverse path of the electrons sends them back through the gap a second time [1].

The operation of the klystron is based on the principle of velocity modulation. An RF signal is

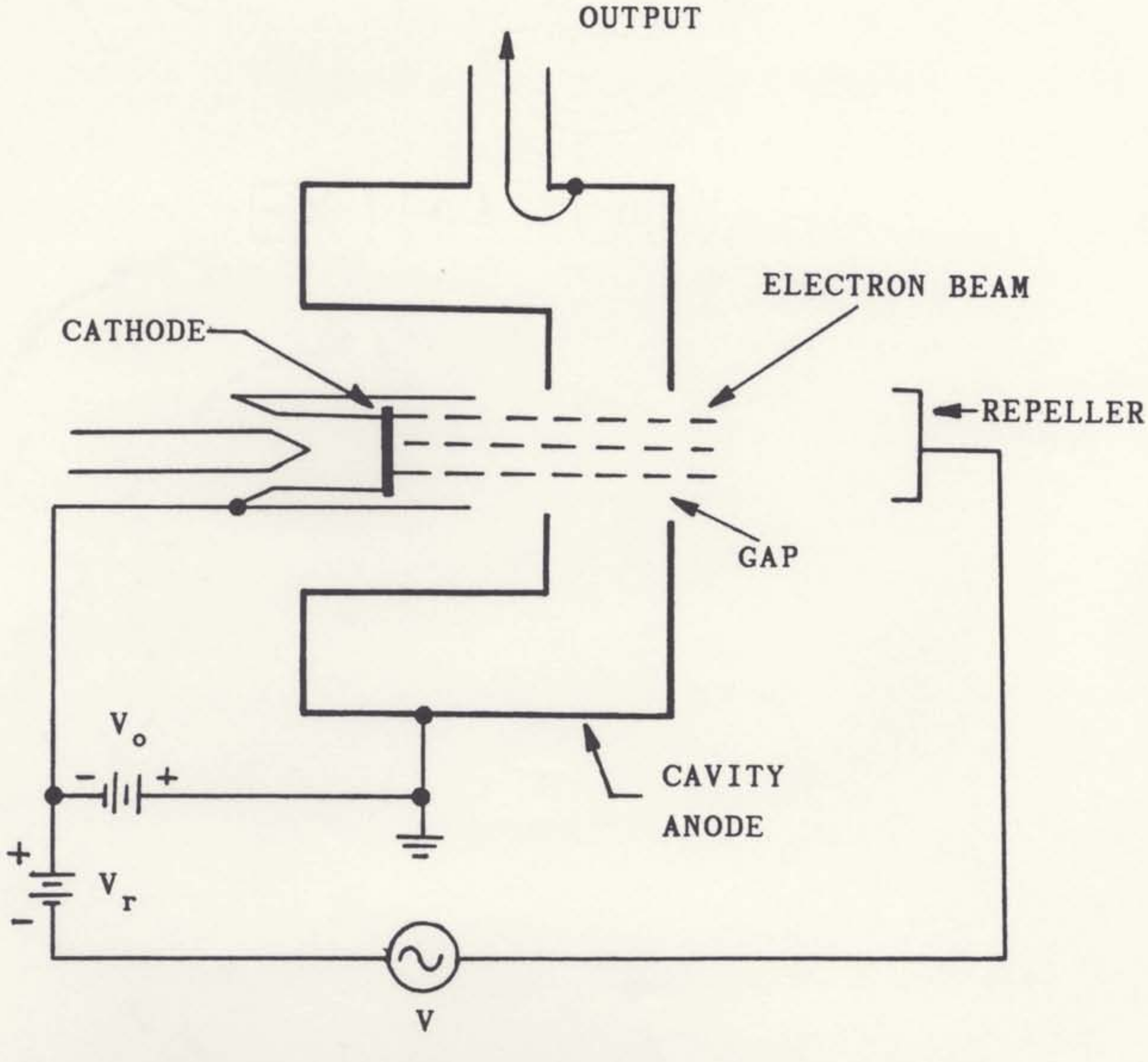

Figure 1.1. The Reflex Klystron.

applied across the gap in the resonator. Electrons passing through the gap are accelerated or decelerated according to the voltage they experience from the gap. Once they leave the gap they then travel through the drift space toward the reflector at different speeds. This difference in velocities causes the electrons to bunch in the drift space as they approach the reflector and are repelled. These bunches of electrons are turned back toward the cavity by the negative repeller voltage. Figure 1.2 shows the distance-time plot of the electrons or Applegate diagram [2].

In order to maintain oscillations and obtain amplification in the cavity, the returning electron

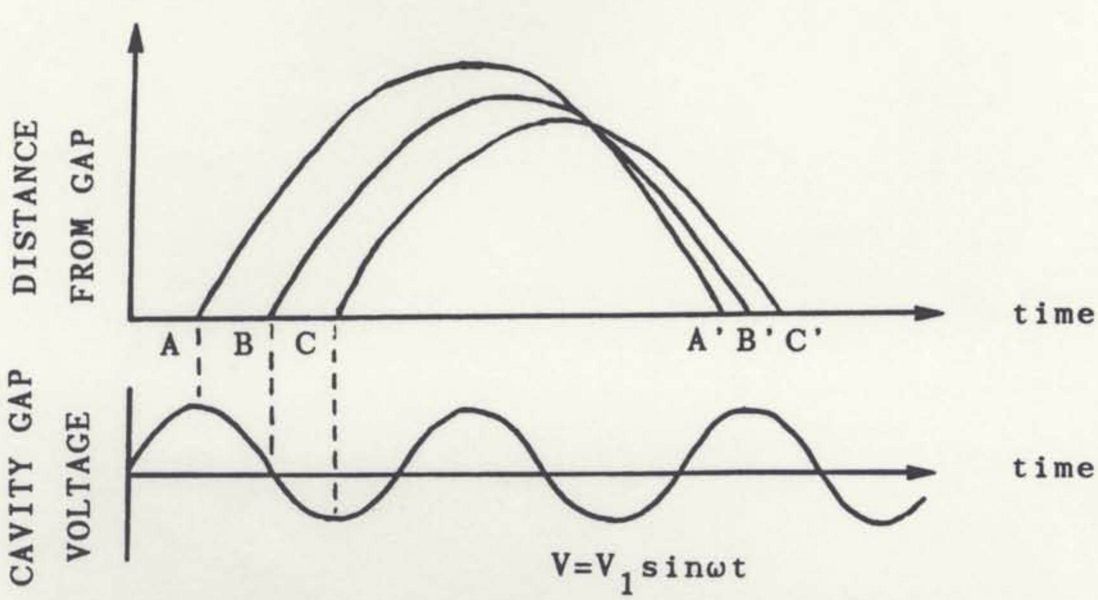

Figure 1.2. Applegate Diagram.

bunches should arrive at the gap when the RF voltage is decreasing so that the electron bunch is slowed down. These electrons will then give up energy to the resonant cavity. The frequency of the cavity oscillation is the frequency of the output produced by the klystron.

The electron transit time can be tuned by adjusting the reflector voltage. The more negative the reflector voltage with respect to the cathode, the shorter the transit time. The oscillation of the klystron produces a signal at the frequency of oscillation. This signal is coupled out of the cavity by either a loop, a coaxial line, or slots. The latter is used for the reflex klystron used in the lab [3].

With the resonant cavity tuned to one frequency, different repeller voltages will produce the same frequency oscillation. The resulting repeller modes are shown in Figure 1.3. The power output and frequency variation versus repeller voltage is shown. As mentioned above, different transit times of the electron bunches produce slightly different frequencies. This provides a fine control of the reflex klystron. The plot shows that the highest power output within a mode is obtained at the center of the mode. Therefore, this technique of frequency variation is used only for slight variations.