X-Band 250-kW Klystron

R. H. Smith
R.F. Systems Development Section

An X-band radar with an output of 400 kW is needed for future spacecraft mission planning. It will be used for planetary ranging of Saturn's rings, Mercury, Mars, the Jovian moons, and asteroids and to prepare for future spacecraft X-band uplink. To obtain this power level, two 250-kW klystrons will be combined for an output of 400 kW. The first 250-kW klystron has been tested by the contractor. Tests will shortly be conducted at the Goldstone High-Power Test Facility to determine the design of components for the 400-kW system.

I. Introduction

There is a need for improved (better-resolution) planetary radar mapping of Saturn's rings, Mercury, Mars, the Jovian moons, and asteroids. To fulfill this need an X-band radar is being developed. An X-band transmitter is being developed to deliver 400 kW of RF power at 8495 MHz. This transmitter will be used to demonstrate X-band operational capability for future spacecraft X-band uplink. The wider bandwidth at X-band allows improved ranging and altitude resolution. The transmitter power level is being produced by combining the output of two klystrons to produce an output power of 400 kW.

The first klystron has been tested by the contractor. An output power of 250 kW was achieved with an overall efficiency of 42% and, at 200 kW, an efficiency of 39%. This report covers the initial development stages of a 250-kW X-band klystron.

II. Description and Development

The klystron is a five-cavity beam modulated tube. It is being developed by Varian Associates of Palo Alto, California. Table 1 lists the requirements for the klystron performance. The output of each tube will be 250 kW, at a maximum voltage of 55 kV, operating at 8495 ±25 MHz and a minimum saturated gain of 47 dB. The 50-MHz bandpass is required for the ranging modulation and to demonstrate operational capability of a klystron at this frequency with a 50-MHz bandpass that could be used at X-band DSN frequency.

III. Test Results

Tests were conducted on the first klystron at the contractor's facility. Table 2 lists the test results for 250-kW output saturated power. Table 3 lists the test results for

200-kW output at saturated power. At 53 kV the output power of 250 kW was achieved with a gain of 47 dB and an efficiency of 42%. At 50 kV, 200 kW was achieved with a gain of 46 dB and an efficiency of 39%. Figure 1 shows a group of output power curves vs frequency for varying beam voltages and constant drive. Figure 2 is a group of saturated power output curves vs beam voltage. The klystron was phase-modulated for 100% carrier suppression from 500 kHz to 1 MHz at 250- and 200-kW power levels with a body current increase of approximately 4 mA. Some other types of klystrons, when phase-modulated, had a 50% increase in body current. This increased body current exceeds the maximum limit (power dissipation in the klystron body).

IV. Future Plans

Three more klystrons are to be made and tested. The output power of two klystrons will be combined to produce an output power of 400 kW. Waveguide components will be tested at this level, the klystrons will be mounted in a cone, and the cone will be placed on the 64-m-diam antenna. Radar mapping of Saturn's rings and other experiments will be demonstrated.

Table 1. Klystron requirements

RF output power	250 kW CW
Operating voltage	55 kV maximum
Input frequency	8495
Bandwidth	±25 MHz at −1 dB Po
Efficiency at saturation	40% minimum
Saturated gain	47 dB minimum at 250 kW
Mounting	Any position
Coolant	Distilled water
Maximum VSWR	1.2:1

Table 2. Klystron performance (250 kW)

Frequency	8495 MHz
Beam voltage	53 kV
Beam current	11.2 A
Power output	250 kW
Gain	47 dB
Efficiency	42%
RF drive	5 W
Body current	25 mA
Bandwidth (−1 dB)	56 MHz

Table 3. Klystron performance (200 kW)

Frequency	8495 MHz
Beam voltage	50 kV
Beam current	10.3 A
Power output	200 kW
Gain	46 dB
Efficiency	39%
RF drive	5 W
Body current	25 mA
Bandwidth (−1 dB)	54 MHz

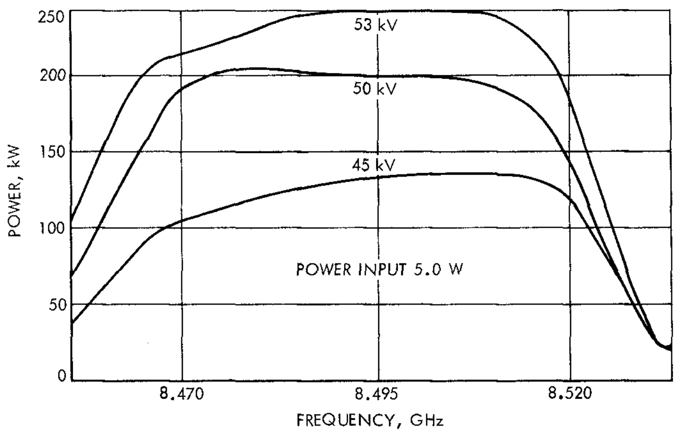

Fig. 1. Power output vs beam voltage

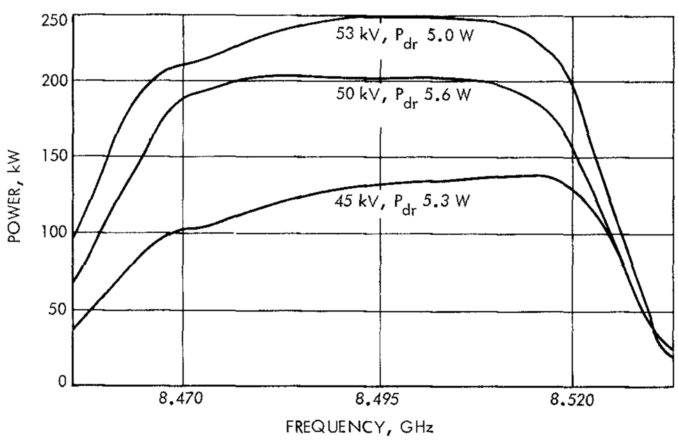

Fig. 2. Power output saturated vs beam voltage