4.1 SPURIOUS OUTPUTS FROM HIGH POWER MICROWAVE TUBES AND THEIR CONTROL

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The emission of spurious outputs from microwave tubes has been known for a long time. With steady increase in transmitter power level, receiver sensitivity and number of radiating equipment, the problem of spurious outputs has taken on greater significance in terms of radiation interference. As the power levels of high power tubes have increased so have the spurious output power levels, and in a microwave system the presence of the spurious power may have deleterious effects such as arcing in chokes, arcing at flanges and signal transmission through ionized duplexers. In addition, if large amounts of spurious power are generated, the microwave tube may suffer in its own performance by decreased efficiency and by introducing an objectionable amount of amplitude and phase instability of the fundamental frequency output.

Under the general category of spurious output is included the following:

a. harmonics
b. anharmonic
c. moding
d. diode oscillation[1,2]
e. parasitic oscillations
f. band-edge oscillation[3]

The normal modulation sideband components are excluded. Among high power microwave tubes such as magnetrons, klystrons and traveling wave tubes, some of the spurious outputs are common but others are not (Figs. 1–5). The spurious output characteristics differ depending on the following:

a. self-excited oscillator or amplifier
b. pulsed or CW
c. pulse length
d. frequency within band
e. tuning adjustments
f. magnetic field
g. input r-f drive power level
h. saturated power output
i. beam voltage
j. rise and fall time of beam voltage
k. modulator impedance
l. impedance of load at spurious frequencies.

Among the spurious outputs, the harmonic frequencies cannot be eliminated from an efficient high power tube without affecting its performance. By using filters external to the tube, harmonics and high frequency spurious outputs can be attenuated to sufficiently low levels to meet interference requirements. Some of the anharmonic and moding outputs can be reduced by redesigning the modulator circuit. The remainder of the spurious outputs are affected by tube design and operation. Since the latter outputs are frequently erratic, their analyses are difficult to undertake. Definitive experiments are not easy to specify because of the numerous interdependent effects possible arising from the multitude of design and manufacturing parameters involved. The amount of time and costs required for these experiments are usually very large so that their analyses often are prohibitive on tube development and production programs.

In a limited experimental effort, two diode oscillation modes in a high voltage klystron gun were found to be localized in the annular space between cathode focus cup and anode housing. The TE_{41} and TE_{61} coaxial-line modes were near cutoff and their Q were about 1000. Altering the gun geometry had a profound effect on these modes.

The presence of spurious frequencies can usually be detected at the output of the tube. The frequencies can be easily determined by using conventional instruments but the power levels are much more difficult to ascertain. Harmonic frequency signals in waveguide may propagate simultaneously in many modes and this multimodal behavior greatly complicates the power measurement problem. Besides the cumbersome but accurate multiple probe technique, a special harmonic power calorimeter has certain appeal.

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[1] F. B. Llewellyn and A. E. Bowen, "The Production of Ultra-High Frequency Oscillations by Means of Diodes," B. S. T. J., Vol. 18, pp. 280–291; April 1939.

[2] K. Tomiyasu and Max P. Forrer, "Diode Oscillations in High-Voltage Klystrons," submitted for publication.

[3] Daniel G. Dow, "Behavior of Traveling-Wave Tubes near Circuit Cutoff," IRE Transactions on Electron Devices, Vol. ED-7, pp. 123–131, July 1960.

	KLYSTRON		TRAVELING WAVE TUBE		PULSED MAGNETRON
	PULSED	CW	PULSED	CW	
HARMONICS	YES	YES	YES	YES	YES
ANHARMONICS					POSSIBLE
MODING					POSSIBLE
DIODE OSCILLATION	POSSIBLE	POSSIBLE	POSSIBLE	POSSIBLE	
PARASITIC OSCILLATION	POSSIBLE	POSSIBLE	POSSIBLE	POSSIBLE	
BAND-EDGE OSCILLATION			POSSIBLE	NO	

Figure 1 - Spurious Outputs from High Power Microwave Tubes.

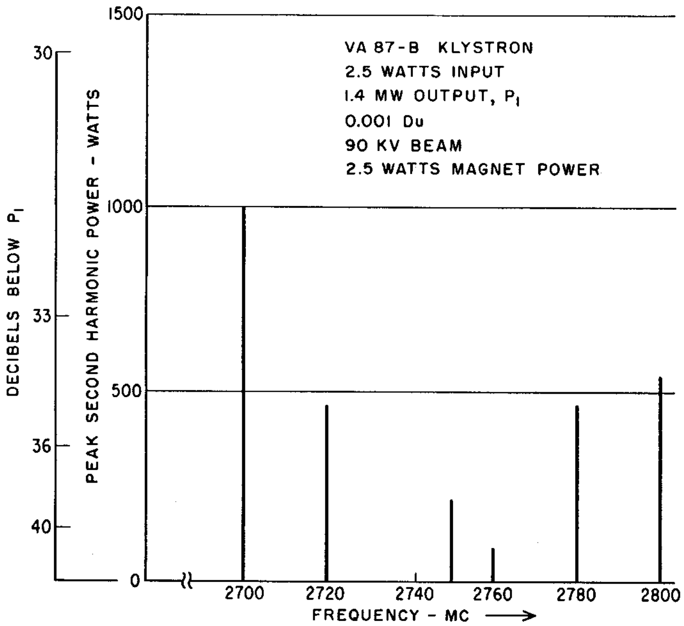

Figure 2 - VA87-B Klystron Harmonic Output as a Function of Frequency.

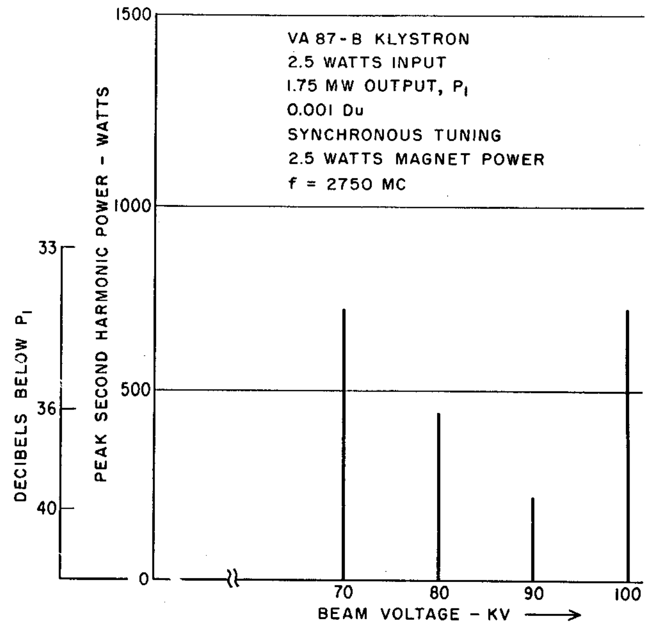

Figure 3 - VA87-B Klystron Harmonic Output as a Function of Beam Voltage.

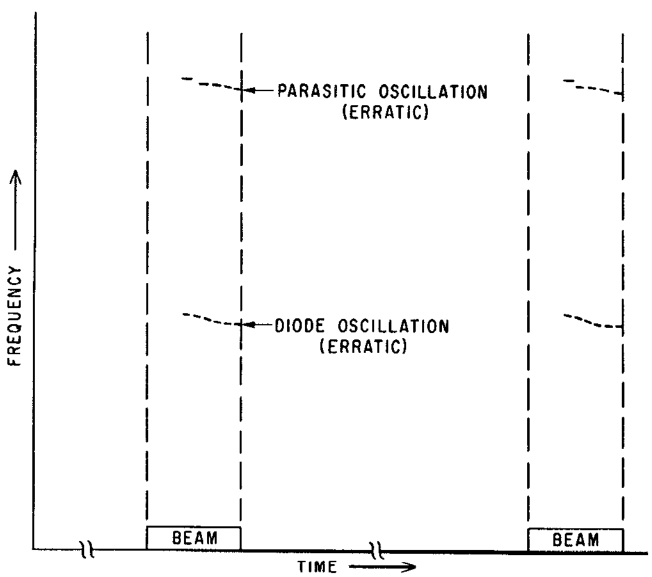

Figure 4 - Spurious Output from High Voltage Klystron Without Input Drive Signal.

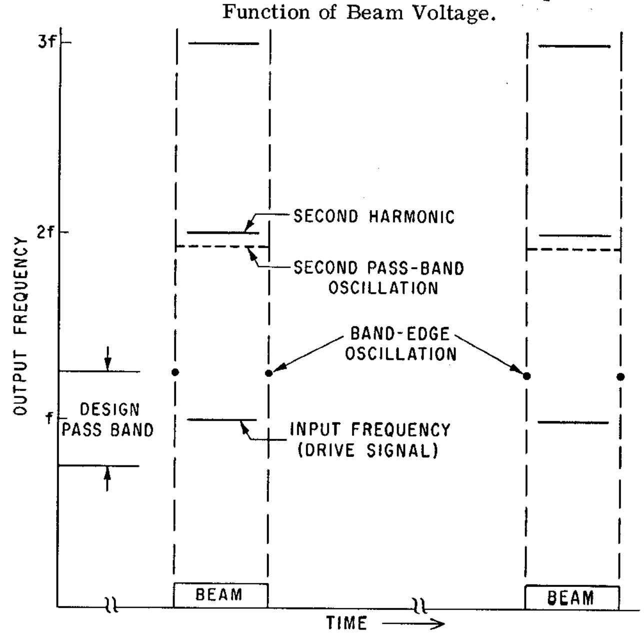

Figure 5 - Spurious Output from Traveling Wave Tube.