WIDEBANDWIDTH IMPATT AND GUNN VOLTAGE TUNED OSCILLATORS

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This paper describes circuit techniques for obtaining wide frequency tuning capability from IMPATT and Gunn devices using varactor tuning. Using the coaxial circuit described here, an IMPATT VTO with a half octave tuning bandwidth (35%) was developed and a Gunn oscillator with a 52% bandwidth was achieved. Similar results have been reported previously by Large[1] for a Gunn device circuit. The circuit described here applies equally well to IMPATT devices.

A coaxial type of circuit was chosen for wideband application because it does not exhibit the dispersion characteristics of a waveguide circuit. An MIC circuit was also considered and tried, however, the coupling of the IMPATT or Gunn device to the MIC line has an undesirable impedance transforming characteristic compared with the coupling to a coax line; consequently, the tuning bandwidth of the MIC circuit was less.

Three basic circuits approaches were studied for varactor tuning the IMPATT or Gunn oscillator. In all circuits the tuning diodes were connected in series with the IMPATT or Gunn device. The circuits differed only in the manner in which the load was coupled to the series diodes. The resonance for the circuits in each case is formed in the series combination of the diodes capacitances and lead inductance. Since operation was designed for X-band, it was not necessary to add additional inductive line length to resonate the devices; the device's package lead inductive had sufficient inductance for this.

The first method for coupling the load was to simply use a multiple section quarter wave transformer in series with the diodes to provide the correct load impedance. This technique proved to be limited in bandwidth and would not oscillate at low frequencies with significant power output. In each case at the lower frequencies the power fell off due to an increase in the tuning diode's resistance with decreasing voltage. The second technique tried, was to couple the output between the tuning diodes. This technique enhanced the lower frequency power but gave a null in the band center. Finally, inductive coupling was used to the series resonant circuit. This proved to be most successful. Doing this, the results shown in Figures 1 and 2 were obtained. In this case a peak power output of 100 mW was obtained and the source could be tuned from 9.3 to 13.1 GHz, although the output power varied substantially over this range of frequencies. The useful tunable bandwidth was from about 11.0 to 13.1 GHz.

The IMPATT diode used here was a 500 mW device from Sylvania and the tuning diodes used were two series connected Ga As devices in a miniature package with a junction capacitance of 1 pf. at 0 volts. The IMPATT operated at 99 volts drawing 100 mA of DC current.

The Gunn device used was a Varian device with a 100 mW output power rating at 8 GHz. The bias current was 400 mA with a voltage of 6.5 volts. Notice that a much flatter output power versus frequency is obtained from the Gunn device as well as a much larger tuning range. This is because the Gunn diode is inherently a lower Q device.

The circuit used is shown schematically in Figure 3. For biasing purposes, a high impedance line (wire) one quarter wavelength long is connected to the circuit. RF bypassing is accomplished using a very low impedance quarter wave section of line. It was found necessary to form a low pass type filter section to adequately inhibit spurious frequency jumping and other undesirable effects. The inductive output coupling loop was made a very low impedance. This increased the amount of output power obtained from the device.

In order to maximize the frequency tuning, two tuning diodes were used in series. This permitted the use of larger capacitance tuning diodes and, consequently, the package shunt capacitance had a smaller effect. Use of just one diode reduced the tuning range almost by a factor of two. Three series connected varactors were also tested which gave a slightly greater tuning bandwidth.

These techniques show that half octave bandwidths or greater are achievable from Gunn or IMPATT devices. Some of the limitations apparent in comparison with a transistor oscillator are (1) the IMPATT and Gunn device tuning curves are more nonlinear, (2) the output power variation is much greater, and (3) the tendency to "jump" frequency in the band is somewhat worse.

[1] D. Large, "Octave Band Varactor-Tuned Gunn Diode Sources," Microwave Journal, Vol. 13, No. 10, pp. 49-51, October 1970.

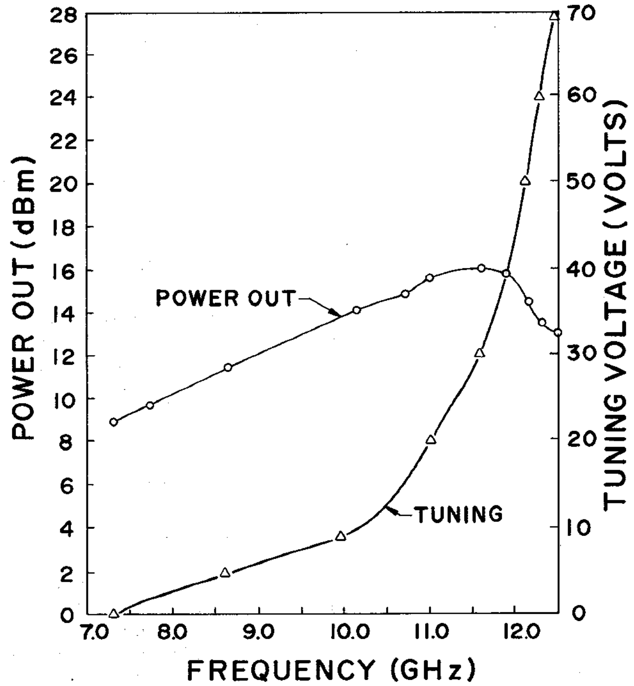

Fig. 1: Varactor Tuned Gunn Oscillator Power Out and Tuning Voltage Versus Frequency.

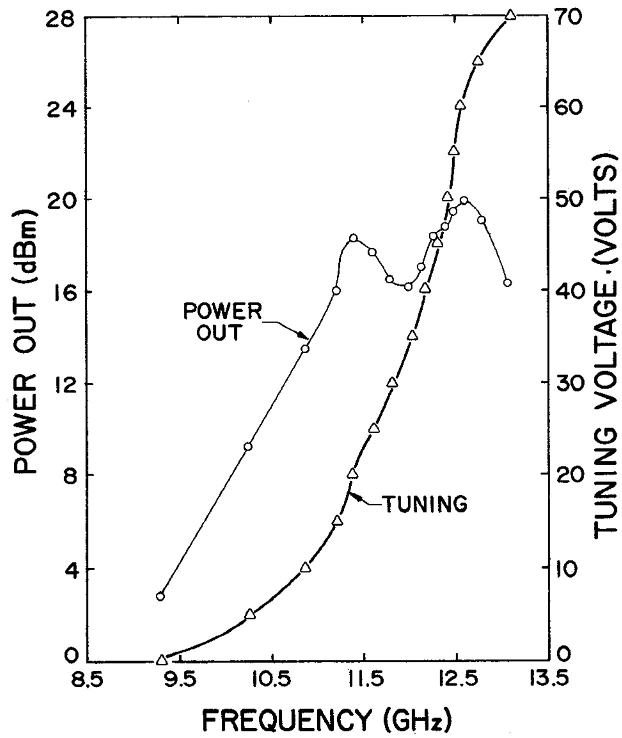

Fig. 2: Varactor Tuned IMPATT Oscillator Power Out and Tuning Voltage Versus Frequency.

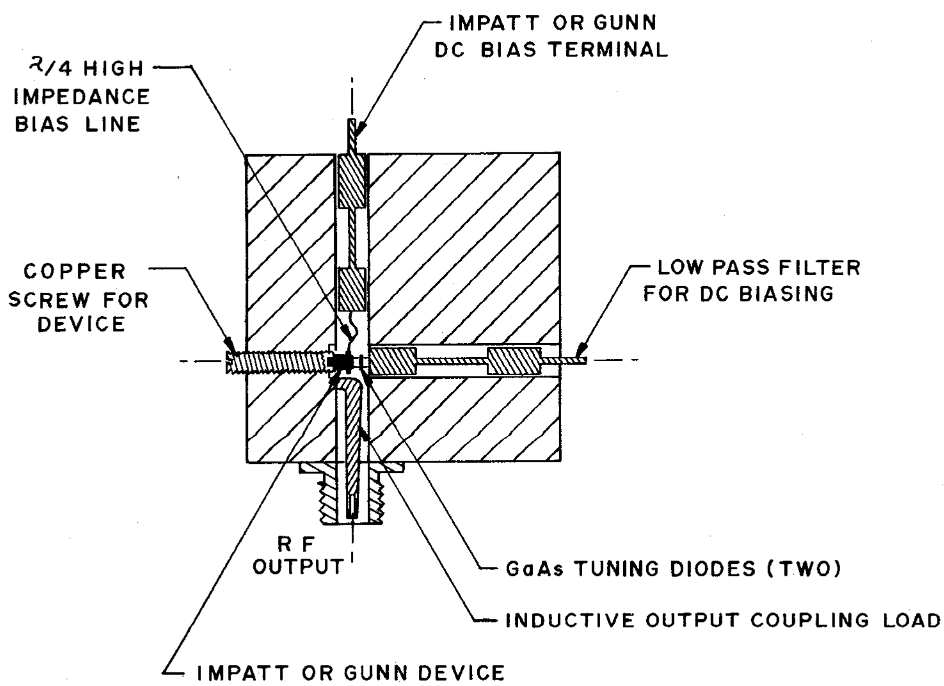

Fig. 3: Internal View of the IMPATT or Gunn Device Voltage Tuned Oscillator.