93 GHz SELF-MIXING GUNN OSCILLATOR

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Abstract

Gallium Arsenide Gunn diodes have been used to develop self-mixing oscillators in the 94 GHz region. Experiments have been performed to measure conversion loss, excess noise, minimum detectable signal and IF impedance. The results are compared with balanced mixers and video detectors to place the self-mixing oscillator in proper perspective in terms of performance.

Introduction

Numerous requirements for moderate performance, low cost millimeter-wave mixers in the 94 GHz region have surfaced recently. Some of these requirements can be fulfilled by the self-mixing Gunn oscillator, which offers performance falling between that of a balanced mixer and a detector while having the simplicity and low cost of a single semiconductor device. Experiments have been conducted to characterize the self-mixing Gunn for output power, conversion loss, excess noise, minimum detectable signal, and IF impedance.

Characterization of the Self-Mixing Gunn

Figure 1 shows the equivalent circuit of the oscillator/mixer circuit. A Gallium Arsenide Gunn diode is mounted in a full height W-band waveguide circuit using a radial transmission line resonator to determine the oscillator frequency. The rear tuning short is used to optimize the performance. Figure 2 shows the output power and frequency characteristics as a function of bias voltage. Conversion loss was measured using the circuit shown in Figure 3. An IMPATT used as a signal source was tuned to 300 MHz above or below the Gunn oscillator frequency to produce an IF falling into the filter passband. Conversion loss was measured as a function of bias voltage and is shown in Figure 4.

Excess noise (noise above thermal) from the self-mixing Gunn was also measured using the setup shown in Figure 3. All noise measurements were done in an IF noise bandwidth of 100 MHz. By noting the change in IF output noise power with and without the Gunn bias applied, the excess noise generated by the Gunn was measured as a function of bias voltage. Figure 5 shows the results. To verify that the noise content far from the carrier was indeed white, the filter was removed and the IF output noise spectrum observed on a spectrum analyzer. Figure 6 shows the resulting spectrum.

Probably the most useful parameter of the self-mixing Gunn is minimum detectable signal (MDS) in a given bandpass. By observing the noise power output of the IF with no signal input from the IMPATT, the minimum detectable signal was defined as the input power which caused a 3 dB change in IF output power. Figure 7 shows minimum detectable signal in a 100 MHz bandpass as a function of bias voltage. Note how the MDS remains quite constant. This can be predicted on the basis of conversion loss and excess noise since these parameters have nearly equal and opposite variations with bias voltage.

Finally, IF impedance as a function of IF frequency has been measured at fixed bias voltages. Low frequency (<100 MHz) impedance data was measured with a vector voltmeter while from 100 MHz to 300 MHz the impedance was measured with a network analyzer. The complete impedance measured on the analyzer is shown in Figure 8. Frequency is increasing in a clockwise manner.

Conclusions

By examining the experimental data, the self-mixing Gunn oscillator is clearly put into perspective in terms of performance. A balanced mixer/preamp with an 8 dB noise figure has an MDS of about -86 dBm in a 100 MHz bandpass as compared with -60 dBm for the self-mixing Gunn. However, compared with a video detector with an MDS of -30 dBm to -40 dBm, the self-mix Gunn offers substantially higher performance. This places the self-mixing Gunn oscillator about midway between balanced mixers and video detectors in terms of sensitivity performance, thus making this device a viable component in moderate performance millimeter wave applications with design simplicity and low unit cost.

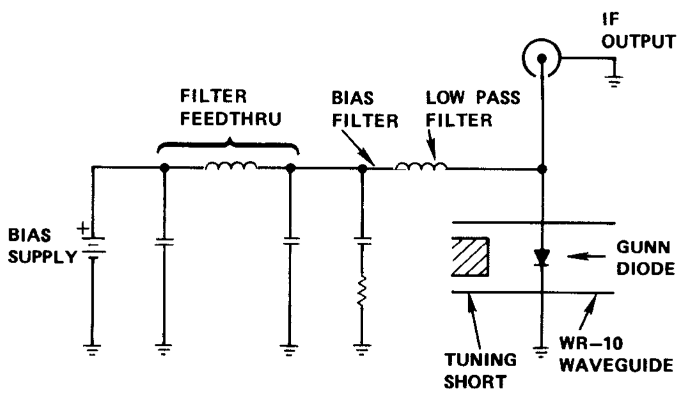

FIGURE 1: OSCILLATOR CIRCUIT SELF-MIXING GUNN.

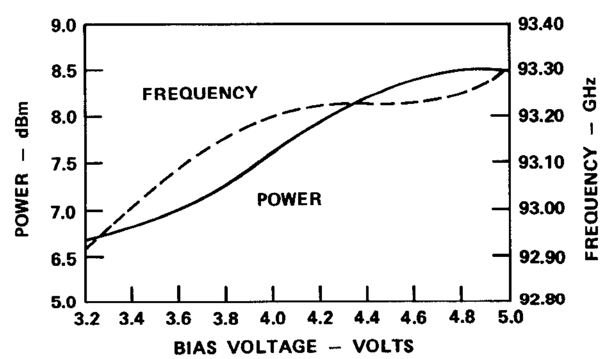

FIGURE 2: POWER/FREQUENCY CHARACTERISTICS OF GUNN OSCILLATOR.

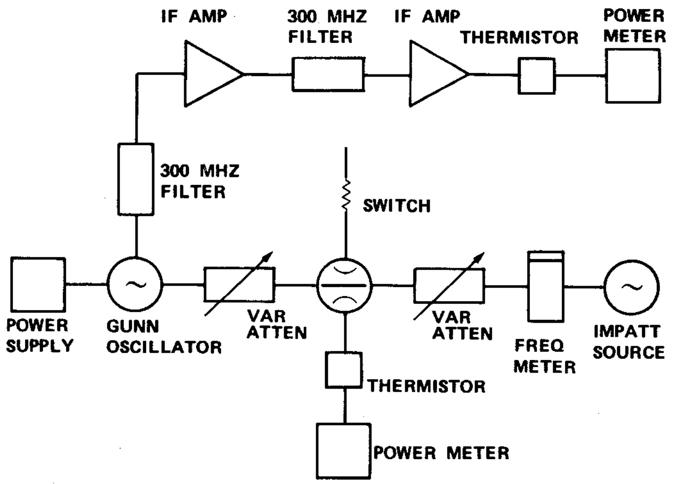

FIGURE 3: EXPERIMENTAL SETUP FOR GUNN CHARACTERIZATION.

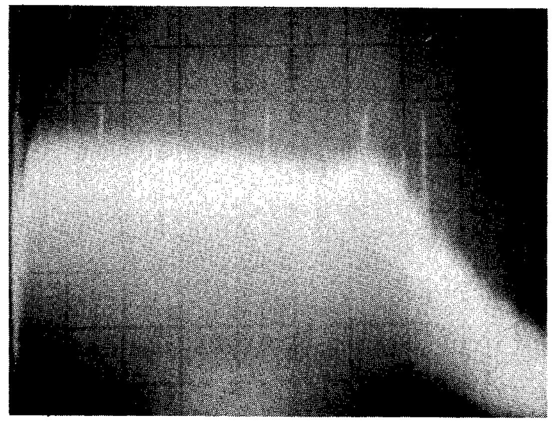

FIGURE 6: WIDEBAND EXCESS NOISE OF SELF-MIXING GUNN
HORIZONTAL: 100 MHz/div VERTICAL: 10 dB/div.

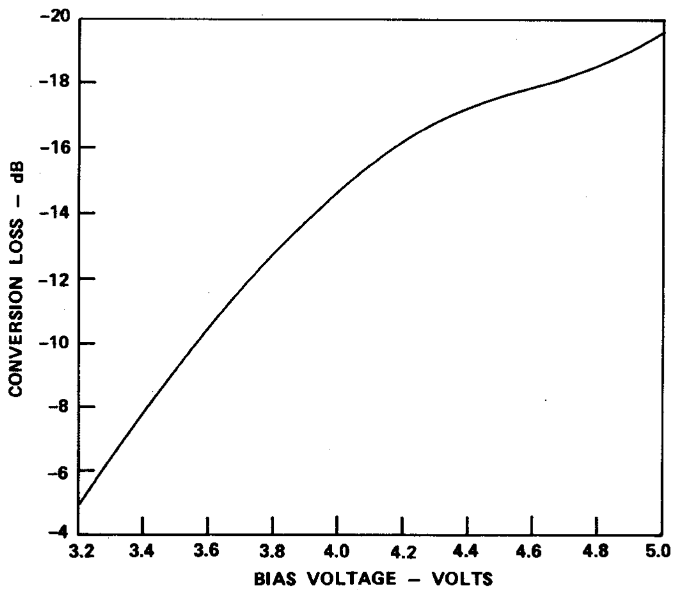

FIGURE 4: SELF-MIXING OSCILLATOR CONVERSION LOSS.

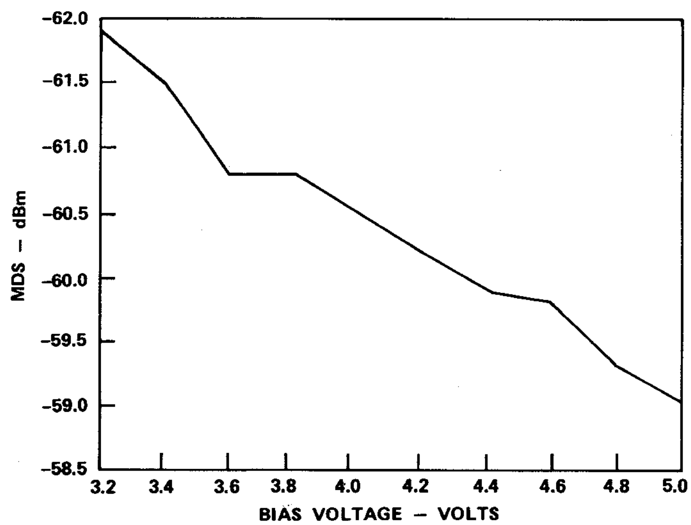

FIGURE 7: MINIMUM DETECTABLE SIGNAL IN 100 MHz BANDPASS.

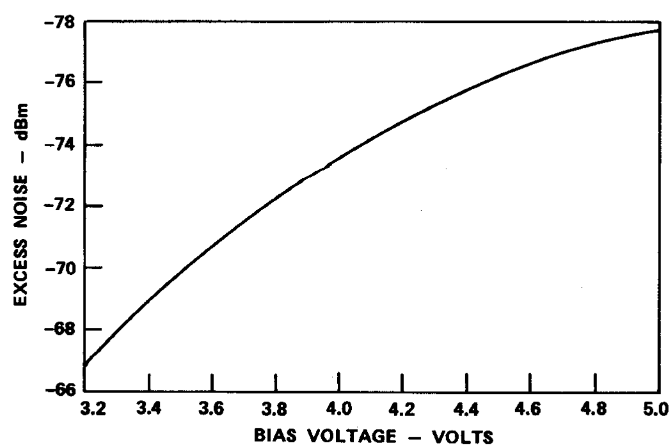

FIGURE 5: SELF-MIXING GUNN EXCESS NOISE IN 100 MHz BANDPASS 300 MHz FROM CARRIER.

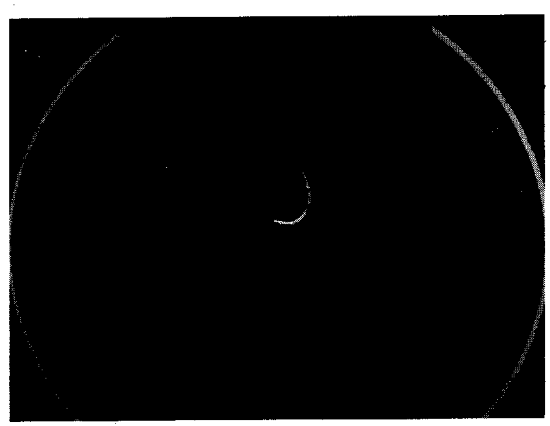

FIGURE 8: COMPLEX IF IMPEDANCE OF SELF-MIXING GUNN FROM 100 MHz TO 300 MHz.