MICROSTRIP HIGH-POWER L-BAND AVALANCHE-DIODE OSCILLATOR*

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A simple microstrip oscillator circuit has been designed for use with the high-power high-efficiency avalanche diodes recently reported.[1,2] Power outputs of the order of 100 W at L-band with efficiencies between 20 and 30% compare reasonably with that from the coaxial line circuit. This result demonstrates the capability of integration of such high-efficiency diodes for system applications.

The diode chips used for the microstrip circuit are punch-through PNN^+ silicon mesa diodes with junctions formed by diffusion of boron into N-type silicon epitaxial wafers. The resistivity of the epitaxial layer is 5 to 7 ohm-cms, and the width of the N-region is about 6 μm. Mesa diameters range from 0.018 in. to 0.023 in., and the breakdown voltages of the diodes are between 120 and 160 volts.

Figure 1 shows the simple circuit configuration that consists mainly of a 50-ohm microstrip line with a short-circuit and a tuning section. Diode chips are mounted directly onto the line with top of diodes connected respectively to pulsed bias and by-pass capacitor to ground. The position of the short and the tuning section determine the frequency at which maximum power is obtained. The circuit matches the diode impedance at the fundamental L-band frequency while simultaneously being capable of supporting higher frequencies including the transit-time frequency which is believed[2,3] to be essential to the starting of the high-efficiency mode of oscillation.

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NOTES

The tuning sections are essentially a low-pass filter consisting of either two shunt low-impedance line-segments (Figure 1a) or a series high-impedance section together with a low-impedance line segment (Figure 1b). The circuits are in principle analogous to the coaxial-line circuit reported elsewhere.[4] The low-pass-filter type tuning section appears reactive at high frequencies such that the circuit is capable of supporting harmonic frequencies while delivering power to the load only at the fundamental frequency.

Experimental circuits have been constructed where the position of short can be adjusted in steps, and the position of the shunt tuning segments are movable. With this arrangement, oscillation frequencies of over a range of about 30% has been demonstrated. A small line-segment is sometimes added for fine frequency tuning and optimizing power output.

A number of diode chips were tested in the circuits and worked successfully. There were little or no readjustments required from diode to diode. Figure 2 shows a plot of power output and efficiency versus bias current level of a typical diode. The pulsed power output was 95 W at 1.06 GHz with an efficiency of 26.5%. The pulse width was 1 μs and the repetition rate, 300 cps. Waveforms of detected rf envelope, average current and voltage pulses at the diode are shown in Figure 3. The abrupt decrease in average voltage at the diode during oscillation characterizes the high-efficiency mode of oscillation. It is feasible to combine the power output from multiple diode chips on the present microstrip circuit. Successful multiple-unit operation of anomalous-mode diode oscillators has been reported[5] using coaxial circuitry.

One of the advantages of having the microstrip configuration is that fields along the circuit can be easily probed without seriously perturbing the oscillation. It has been found that associated with the high-power output at the fundamental frequency are strong second harmonics (Figure 4) within the circuit which could be important for the high-efficiency mode of operation.

In conclusion, a simple microstrip oscillator circuit for high-power high-efficiency diodes has been developed which indicates the usefulness of such diodes in systems using integrated circuits.

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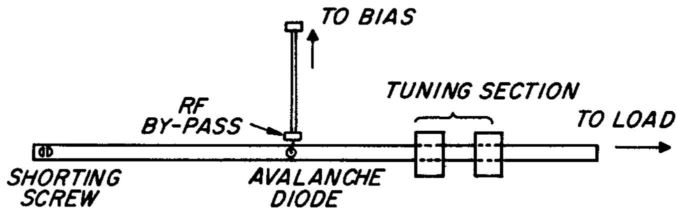

FIG. 1a

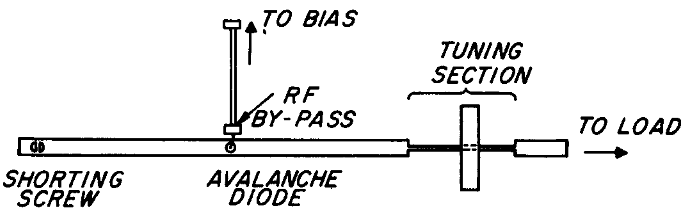

FIG. 1b

Figure 1 - Microstrip circuits for high-power high-efficiency avalanche-diode oscillators.

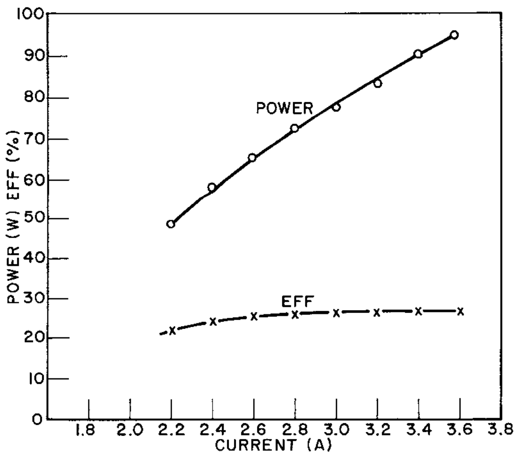

Figure 2 - Power output and efficiency versus bias current of an avalanche-diode oscillator operating at 1.06 GHz.

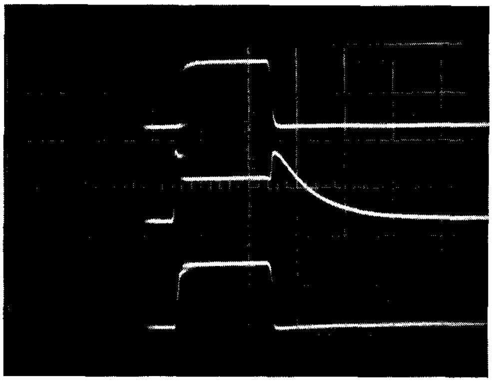

Figure 3 – Waveforms of detected rf envelope at 1.01 GHz (top), average voltage (middle) and current (bottom) pulses at the diode. Scale: top – 70 W, middle – 100 V/cm, bottom – 2 a/cm, time – 0.5 μs/cm.

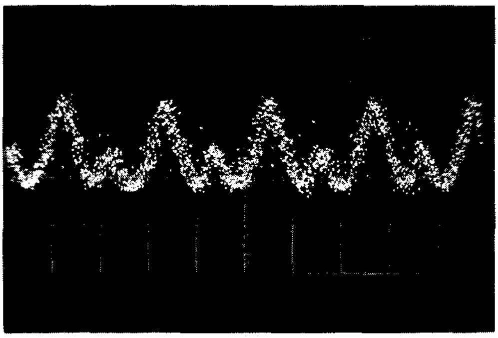

Figure 4 – Probed rf waveform inside the oscillator circuit showing strong second-harmonic components. Horizontal scale: 0.5 ns/cm.