VII-5 HIGH POWER PIN DIODE LIMITING

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Conventional high power diode limiters use a multiplicity of varactor diodes in various microwave circuit configurations. The higher power handling PIN diode is normally unsuitable as a passive limiter due to its slow speed of response. The I region thickness of this PIN ranges between one and five mils with a voltage breakdown range of 200 to 1000 volts. By reducing the I region thickness to less than 0.5 mils, a junction is achieved which will respond rapidly enough to limit effectively at frequencies up to the UHF range. The resulting reduction in junction breakdown voltage is not detrimental as the diode is in a low impedance state during application of high power.

When a thin-base PIN diode, as this diode is called, is placed in shunt with a 50 ohm transmission line, and is subjected to various levels of r-f energy, its series resistance will behave as illustrated in Figure 1. With increasing power, R_s drops rapidly at first and levels off to a minimum value of 0.7 ohms. This is about the same resistance measured when a DC bias of 100 ma is applied to the diode.

It is possible to determine the power handling capability of diodes under forward conduction in two ways; one is by monitoring changes in the junction voltage then relating this to temperature; the other is by an observation of the recovery characteristics to the small signal or low loss state. In limiters where no bias is externally applied to the diode, the latter method is more convenient. It is possible to relate the temperature rise in the diode, as determined by the first method, with the recovery time slope as a function of power. Figure 2 shows a plot of recovery time to 50% of full recovery against incident peak power for one diode. Up to a power level A, the slope of the recovery curve is linear. The corresponding junction temperature rise is also linear. Above point A, an upward slope of both the recovery and temperature curves is noted. This is believed to be caused by an increase of the diode resistance, resulting in destruction of the diode if the power level signified by B in Figure 2 is exceeded. At A, the peak temperature rise is about 75° C; this can be considered as a maximum safe operating level.

Figure 2 also shows a direct dependence of the recovery time on pulse width. Such a relationship holds true for pulse widths substantially narrower than the thermal time constant of the diode element which is estimated to be several hundred microseconds.

It can be shown that when a number of diodes are mounted in a plane normal to the r-f propagation, the power handling capability, over a single diode is increased by the square of the number of diodes. A mount was designed incorporating 31 diodes radially arranged in a manner allowing simple replacement. A photograph of this limiter is reproduced in Figure 3.

Tuning of the limiter mount is accomplished by placing a small inductance in parallel with the diodes. By proper choice of this inductance, the resonant frequency can be varied from 50 to 400 MHz. The insertion loss at resonance against frequency is plotted in Figure 4. In this figure, the instantaneous bandwidth of a limiter tuned at 55 MHz is also shown in dotted lines. Utilizing cavity power multiplication techniques, tests were conducted up to power levels of one megawatt peak, 1500 watts average. The flat leakage power characteristics are plotted in Figure 5. Due to a diode response time, the order of 10 nsec, compared to a RF rise time of 30 to 50 nsec, the spike leakage was negligible. Based on individual diode tests, a capability was demonstrated of handling over 10 megawatts peak power with a one microsecond pulse width.

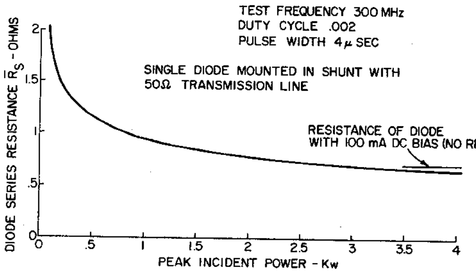

FIG. 1 - Diode Series Resistance is Peak Incident Power

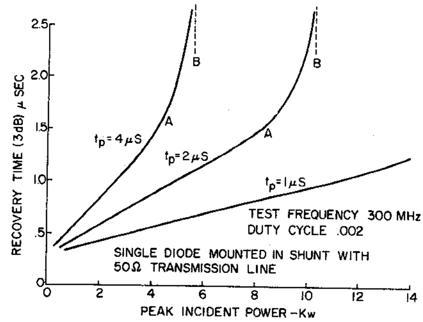

FIG. 2 - Recovery Time vs Peak Incident Power

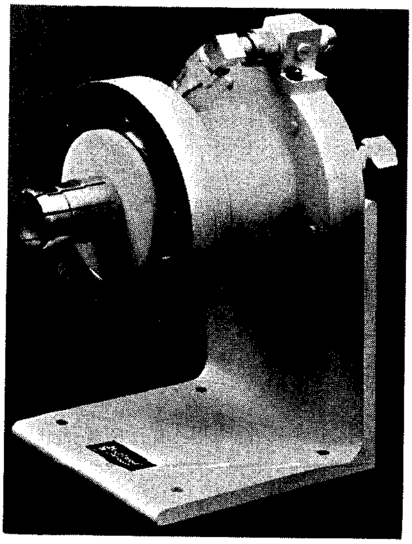

FIG. 3 - UHF Diode Limiter

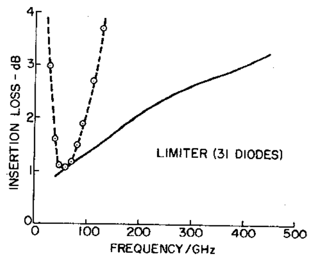

FIG. 4 - Low Level Insulation Loss vs Frequency

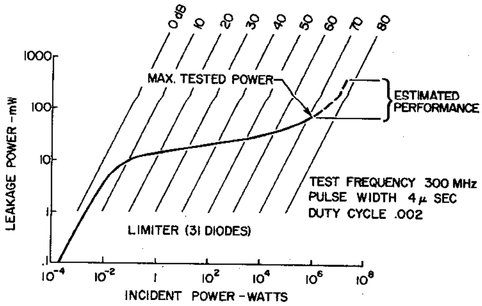

FIG. 5 - Leakage Power vs Incident Power