DYNAMIC DIODE MIXER DAMAGE MEASUREMENTS

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ABSTRACT

An experiemntal setup has been developed which permits the progressive degradation of a mixer to be observed while it is being exposed to high-power-microwave pulses at a low repetition rate.

SUMMARY

Most characterizations of burnout of mixer diodes are at a high repetition rate, in which the physical mechanism of damage is thermal degradition of the junction. For low repetition rates the physical mechanism is different and the burnout level is higher. When diodes are exposed to low repetition rate, high power pulses they have shown anomalous behavior, in that one pulse will degrade conversion loss while the next pulse may partially or totally restore it. Furthermore the damage power level for low repetition rates tends to be an independent function of pulse length rather than a constant energy as with pulses at higher repetition rates.

It is desirable to know the damage level of mixers in general terms in order to know how much protection to provide them when installed in smaller radar systems that may be exposed to the very high power of much larger systems.

The test setup shown in figure 1 has been developed to monitor the progressive degradation of conversion loss of mixers as they are exposed to high power microwave pulses. The signal or local oscillator is slowly swept across the band giving the full display of the spectrum analyzer, taking 10 seconds. The high power pulses are repeated at 10 per second, giving 10 pulses per centimeter on the display. The beginning of the high power pulses is delayed for about one second after the sweep has started in order to give a good reference measure of the conversion loss before damage.

The typical responses of 1N23 mixer diodes is shown in figure 2. The vascillating degradation can be seen at all power levels. It can also be seen that there is a gradual annealing for longer times at medium powers. The data has led to two speculated mechanisms for explaining the degradation pattern observed.

One explanation is that the first pulse heats up the very tiny volume of the junction to a high enough temperature that impurities are moved, degrading the properties of the junction. At the next pulse the volume obsorbing the heat is larger because the damage has caused the active area to be enlarged (as well as degraded). Spreading the energy of the pulse over a larger volume causes a smaller temperature rise which may be amenable to annealing. Consequently the next pulse can cause annealing to take place in the junction. Depending on how much healing has taken place the following pulses can cause even more annealing or revert again to degradation.

The other suggested damage mechanism is based on the physical model that the diode whisker, under spring tension, rests on three points on the semiconductor. When it is damaged, one of these points becomes soft enough to yield, and three new points are defined for the contact. With each new pulse, new points are defined, giving a random but slowly degrading conversion loss, which finally settles into a structure based on the local metallurgy surrounding the whisker point.

The test setup of figure 1 allows the damage of mixer diodes to be measured in a way that reduces the uncertainty in deriving a general characterization of their damage level. Higher or lower repetition rates can be used to meet any low repetition rate application. Our initial observation is that repetition rates below 10 pps agree well with single pulse data. The transition of the damage from peak power (10 pps or lower) to average power (1000 pps or higher) has not been worked out.

The measurement setup described here also addresses another problem in comparing mixer damage data in that different criteria are used for defining the damage level. Some use 3-dB, some 1-dB, and others, a degradation of match. The conversion loss degradation profile is useful to all who use dB. It is even more useful to system engineers, who may be able to tolerate 10 dB of degradation or some number other than the fixed 3- or 1-dB.

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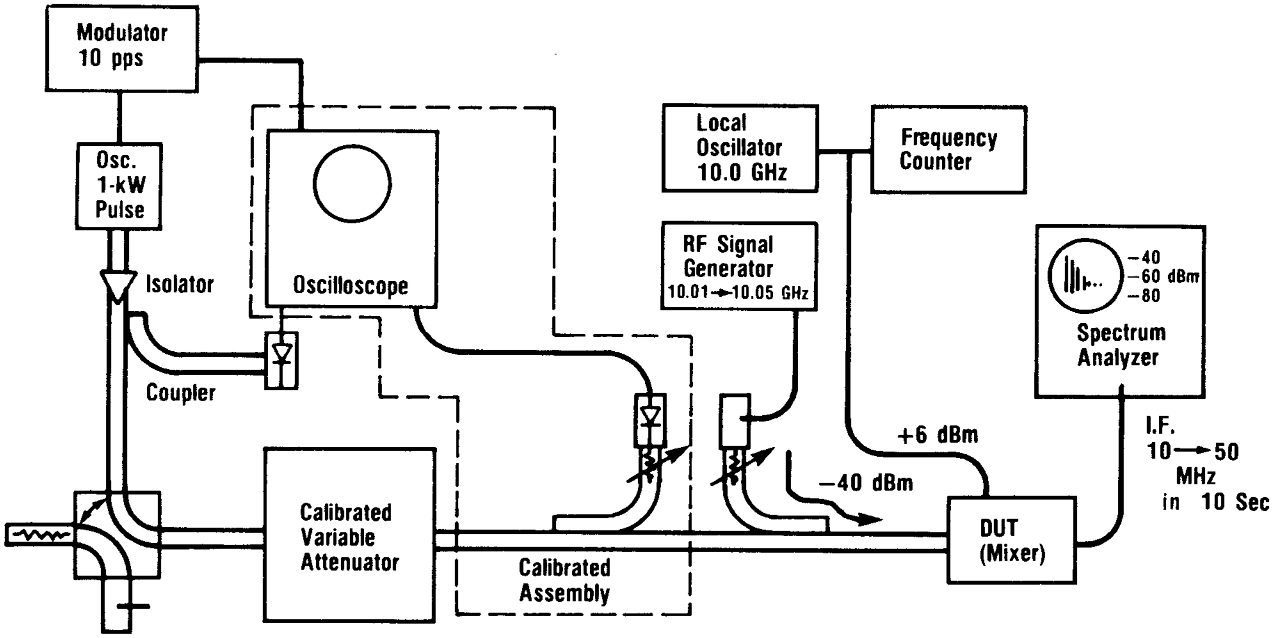

Figure 1. Test circuit for monitoring conversion-loss degradation during high-power pulse damage tests

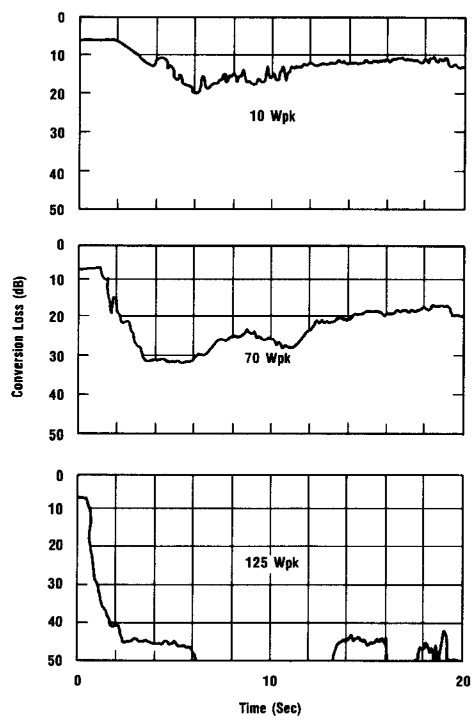

Figure 2. Conversion-loss degradation during high power pulse stress