C BAND FERRITE MICROSTRIP LIMITER

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ABSTRACT

A microstrip line on a polycrystalline yttrium iron garnet substrate was measured as a function of incident microwave power level to determine power limiting. Properties acceptable to system designers were found for the low level insertion loss, recovery time, temperature performance and response to a frequency modulated pulse.

INTRODUCTION

Soon after Sulh (1956) showed theoretically that the parametric excitation of spin waves was responsible for the high power effects earlier observed in ferrites it was recognized that these effects could be used for power limiting. The first devices used ferrite loaded waveguide. They were bulky and began limiting at power levels of several watts. It has been recognized that microstrip lines currently in widespread use are compact and because of the field concentration under the center conductor should give limiting at power levels significantly lower than the earlier waveguide devices. To decide whether a ferrite microstrip limiter would be useful to system designers we have looked at four specific properties: (1) The low power insertion loss; (2) The recovery time; (3) The change in performance at elevated temperatures; (4) The change in performance with frequency modulation, a chirped pulse.

EXPERIMENTAL RESULTS

Fifty ohm microstrip lines were fabricated on polycrystalline yttrium iron garnet (YIG) substrates of 6, 10 and 20 mil thickness. High power measurements of insertion and return loss were made primarily at room temperature at frequencies centered at 5.5 GHz up to peak power levels of 1000 watts. To minimize the low power magnetic loss the static magnetic biasing field was applied in the plane of the substrate normal to the direction of propagation along the microstrip line. In this configuration the static magnetic field and the rf magnetic field are parallel so that limiting results from the parallel pump spin wave instability. The limiting absorption was mapped out as a function of biasing field and at temperatures up to 100°C.

A biasing field which gave the maximum absorption at elevated power levels was chosen for device evaluation. This field was approximately 200 oe. less than the biasing field that exhibited the lowest power for the onset of limiting and was the order of several hundred oe. A low power insertion loss of less than .25 db per cm. was found for the lines on the 20 mil substrates. Approximately 75% of this loss comes from the microstrip conductors and the remainder from the dielectric and magnetic loss of the YIG substrate. The low power insertion loss was considerably higher for the units made with the thinner substrates which made them relatively unattractive for use in receiver protection.

On a 20 mil substrate unit, 2cm long, an increase of insertion loss (limiting) began at .1 watt incident power and reached a value of 13 db at 300 watts incident. The 13 db increase declined to about 10 db when the substrate temperature was raised to 100°C.

In contrast to devices which perform limiting by reflecting power the microstrip ferrite limiter absorbes power. Furthermore when the ferrite microstrip was terminated by a short the 300 watts of incident power experienced another 13 db of attenuation after reflection from the short so that the actual power emerging from the input to the ferrite microstrip was 26 db down from that entering.

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It was possible to obtain a relatively good match into these microstrip units below the limiting threshold. The return loss (S_{11} and S_{22} in db), after the connector S-parameters were accounted for, was better than -30 db. This return loss changed only slightly as the incident power increased and limiting occurred.

The recovery time defined as the time required after the secession of a high power pulse for the limiter to return to a low power level insertion loss state was found to be less than .2 μsec.

Measurements were also made when the frequency of the incident high power pulse was linearly varied up to rates of 20 MHz per μsec. Since the parametrically excited spin waves responsible for the limiting absorption satisfy the criteria that their natural frequency be equal to one half of the frequency of the incident microwave energy new spinwaves must assume the limiting role as the frequency of the incident energy is varied. If the frequency is varied fast enough the required readjustment by the spinwaves cannot keep up and a decline in limiting is to be expected. A slight decline in the magnitude of the limiting was observed at the maximum modulation rates. The magnitude of the decline depended on whether the frequency change of the incident energy was positive or negative.

Because of the half frequency requirement on the parametrically pumped spinwaves responsible for the limiting it is possible to have frequency selective limiting. It was possible to observe a low power signal in the presence of another signal that was 45 db larger and was offset by 150 MHz. The large signal was being limited but there was no effect upon the low power signal. With a detector filter that has a steeper roll off then the one we had available it should be possible to significantly decrease this offset and still observe frequency selective limiting .

CONCLUSIONS

A three stage diode limiter is frequently used to protect a sensitive low noise receiver. The high power stage in such a limiter is susceptible to burn out. The properties we have observed in these ferrite microstrip limiters are adequate to allow replacement of such a stage with a ferrite limiter that is not susceptible to burn out without degrading the performance of the low noise receiver. Furthermore in such a three stage combination the absorbing properties of the ferrite and fact that the ferrite microstrip can be very closely matched to the input line will result in a very low reflected power in a high power limiting situation. In additon the planar geometry of the ferrite microstrip is convenitnt to heat sink making it attractive for use in limiting applications that involve substantial average power. If this power were not absorbed in the limiter then the system designer would have to deal with it elsewhere.