3.3 SOLID STATE X-BAND POWER LIMITER*

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An X-band solid-state power limiter has been designed which completely protects receiver crystals from high power microwave pulses in the kilowatt region. This passive and reliable crystal protection has been achieved by utilizing the nonlinear properties of both ferrites and varactor diodes.

The recent work on limiters has resulted in good crystal protection at frequencies below C-band.[1,2] At X-band ferrite limiters have shown the most promise although they exhibit a large leakage spike.[3] However, by following the ferrite limiter with a fast response diode limiter the spike can be suppressed and effective crystal protection obtained.

Ferrite Limiter. A new ferrite power limiter has been constructed with a threshold power an order of magnitude lower than that of Uebele's limiter. When the ferrite slab of Fig. 1 is biased to subsidiary resonance a low power insertion loss less than 0.9 db and a threshold power under 10 watts is observed. The effect of the taper of the ferrite slab is two fold: First, the taper provides a good match and secondly, the rf magnetic field intensity is increased in the thick portion of the slab. The typical power response of such a limiter configuration is shown in Fig. 2.

Since the large leakage spike present on the limiter output pulse is the most serious deterrent for the use of the ferrite limiter as a crystal protector, the spike behavior has been analyzed. Using the transient analysis given by Suhl, equations can be derived relating the limiter spike amplitude to the ferrite parameters, microwave circuit geometry, and the signal pulse rise time. Figure 3 shows the close agreement between the theory and experiment. The important conclusion derived from the analysis is that the limiter spike cannot be appreciably reduced by an improved circuit or ferrite.

Diode Limiter. Because of its extremely fast response time, use of the microwave diode appeared feasible as a secondary spike limiter following the ferrite limiter. Early experiments with 1N263 point contact mixer diodes showed that limiting was possible, but such a diode could not withstand ferrite limiter spikes greater than 100 watts. More recent experiments using MA450F varactor diodes have led to a huskier diode limiter. A reflection type limiter was constructed using two diode mounts in conjunction with a 3 db hybrid.[4] Incident power undergoes a 3 db split and is reflected from the varactor diodes placed across the waveguide. At low power levels the reflected power recombines in the hybrid and emerges from the output port with only 0.4 db insertion loss over an 800 Mc band. At high power levels the diode admittance changes and most of the power is absorbed in matched loads terminating the diode mounts. A typical response curve for a 1 usec microwave pulse is shown in Fig. 4.

Solid State Limiter. Due to the husky mesa-type construction the MA450F diode limiter has effectively limited spike amplitudes of up to 1000 watts. Thus, by suitably combining ferrite and diode limiter stages, complete crystal protection has been obtained for input powers of at least 5000 watts. Figure 5 shows the response of this solid state limiter, consisting of two ferrite limiter stages and two diode limiter stages. The total insertion loss was 2.0 db and the bandwidth was approximately 300 Mc. Thus, the feasibility of building an all solid state crystal protector has been demonstrated.

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[1] M. Grace, F. R. Arams, and S. Okwit, "Low-Level Garnet Limiters," 1961 Solid State Conference Digest, February 15, 1961, pp. 86–87.

[2] R. Damon and L. Gould, (private communication).

[3] G. S. Uebele, "Characteristic of Ferrite Microwave Limiters," IRE Trans. on Microwave Theory and Techniques, Vol. MTT-7 No. 1, January 1959, pp. 18–23.

[4] R. V. Garver and D. Y. Tseng, "X-Band Diode Limiter," (to be published).

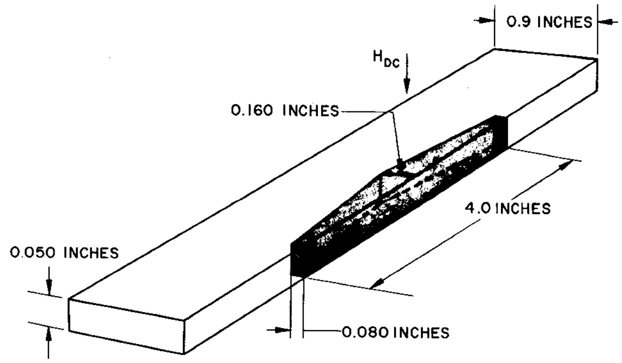

Figure 1 - Ferrite Power Limiter Configuration Using General Ceramic R-4 Ferrite.

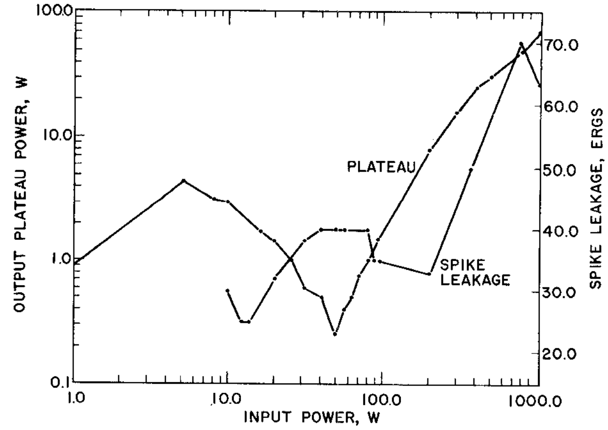

Figure 2 - Power Response of Ferrite Power Limiter.

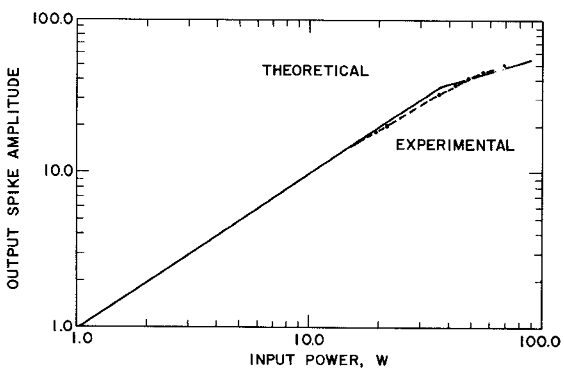

Figure 3 - Comparison of Theoretical and Experimental Variations of Spike Amplitude with Input Power.

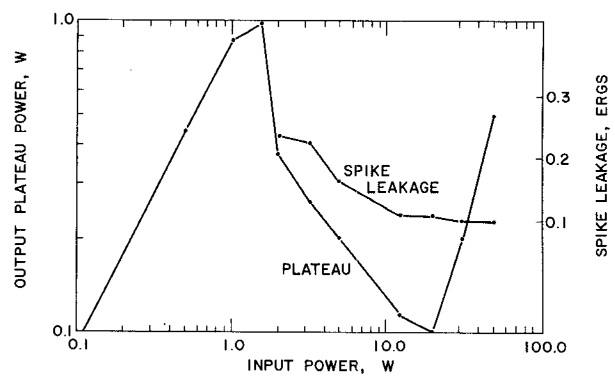

Figure 4 - Power Response Typical of Diode Hybrid Limiter Using Four 450F Diodes.

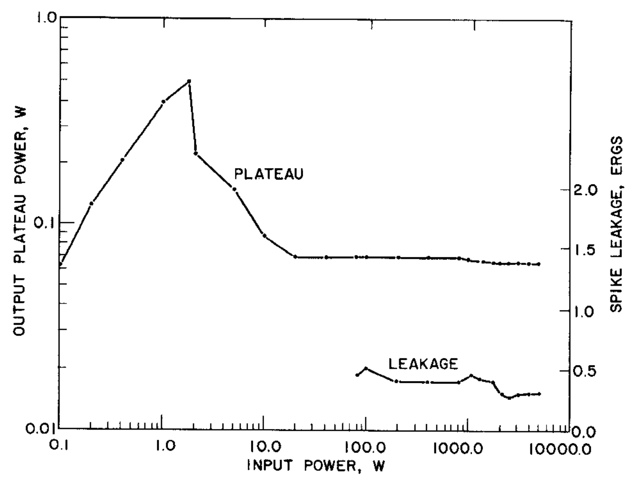

Figure 5 - Power Response of Solid State Limiter.