# PREMATURE DECLINE LIMITING IN X-BAND YIG FILTERS

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## ABSTRACT

More than ten years have elapsed since the basic experiments on high power effects in ferrites were completed. During the interim period the electronically tunable YIG filter has been developed and its performance characteristics refined for utilization in many diverse system and instrumentation applications. The data presented in this paper are believed to be the first reported measurements of the premature decline limiting characteristics of X-band YIG filters up to input power levels of 2 KW peak. The minimal spike and flat leakage transmission levels are shown to offer significant system receiver front end protection in a typical contemporary electromagnetic environment.

## SUMMARY

More than ten years have elapsed since the significant high power effects[1] in ferrite materials were demonstrated and explained theoretically. Many different devices[2] have been developed that utilize these nonlinear phenomena which are dependent on the type of material used, the frequency of operation, sample shape and circuit geometry considerations.

In this paper important application results are presented on the high power performance of X-band YIG filters that have not been reported previously. An excellent tutorial on the subject of YIG filter-limiters may be found in reference 3. The experimental results reported there, however, did not exceed input power levels greater than +25 dbm.

YIG filters have been widely used in a number of system applications which normally operate at low signal levels (< 10 dbm) that exploit their primary features of narrow band electronically tunable preselection. The high signal level (premature decline) limiting that occurs at X-band in these devices is shown to offer added system benefits while preserving the low level performance features. The transmission response of filters has been measured at average power levels up to 5 watts and peak power levels up to 2 kilowatts.

## EXPERIMENTAL RESULTS

Several two-section X-band YIG filters were selected for conducting peak and average power limiting experiments. Typical filter design specifications for the units tested are summarized in Table I. Preselector performance data measured over the operating temperature range indicated no deviations from the specifications.

In order to evaluate the effects of high average power limiting a set of experiments were performed that included CW and square wave testing of the filters up to the 5 watt level at 10.0 GHz. Available laboratory oscillator, PIN diode modulator and r-f amplifier equipment was used for these tests shown by simple block diagram in Figure 1. The composite results obtained for CW, 1 KHz and 10 KHz square wave modulation are summarized in Figure 2 over nearly a 40 db dynamic range of incident r-f power. The 1 db compression point occurs at an input level slightly greater than +12 dbm and saturates with a maximum output of +11 dbm. At the half-watt input level the output power was observed to drop sharply by more than 10 db and remained below 0 dbm up to the 5 watt input level. The mechanism responsible for this sudden increase in loss is currently being investigated. Note the reflected power indicated by the heavily dashed curve over the full range of incident r-f levels.

A second set of experiments were carried out to investigate peak power limiting effects using a magnetron test station at a frequency of 9.5 GHz. Peak input levels from +10 to +63 dbm were applied to the YIG preselector terminals. The results of several runs under these conditions are summarized in Figure 3.

Separate curves are shown for the leading edge spike leakage level and the subsequent flat leakage level. The amplitude and duration of the spike are of particular concern in systems applications where the preselector is followed by mixer diodes that are susceptible to noise figure degradation or burn-out due to voltage breakdown[4].

The data indicate that spike leakage levels never exceed 150 mw peak for input levels up to +50 dbm. Beyond 100 watts input drive the direct r-f leakage appears to contribute noticably to the net output level which increases monotonically up to about 350 mw peak at 2 KW incident power. Flat leakage levels vary between 2 and 10 db below the spike levels over the hard limiting range of the devices. The curve in the lower righthand corner of Figure 3 is the filter input to output isolation with the magnetic bias field removed. Thus, the tunable X-band YIG preselector offers an added dimension of receiver front end protection for both on and off conditions of operation. This performance has been confirmed under both laboratory and field conditions. Typical oscilloscope photographs of the video detected transmission amplitude response are shown in Figure 4 at several input power levels. A broadband, calibrated detector and preamplifier is essential in order to obtain accurate measurements of the spike leakage levels.

## CONCLUSIONS

The observed leakage levels and pulse shape compare very closely to those reported by Brown,[5] and Clark and Brown[6] for gyromagnetic coupling limiters at C-band over a similar input power range. Important functional differences should be noted, however, in the design intent of these two devices i.e. the YIG limiter and the YIG preselector. The latter device has found much wider application in current systems and instrumentation largely as a result of its spectrum filtering properties. YIG limiters in these frequency ranges, on the other hand, have been sparsely employed principally because other devices such as TR tubes and more recently TR-limiters have demonstrated superior performance features. The major emphasis of this paper is to demonstrate the significant r-f power limiting features of commercially available YIG preselectors in a contemporary electromagnetic environment. Also, the general theoretical predictions of the nonlinear behaviour of YIG resonators at X-band have been confirmed.

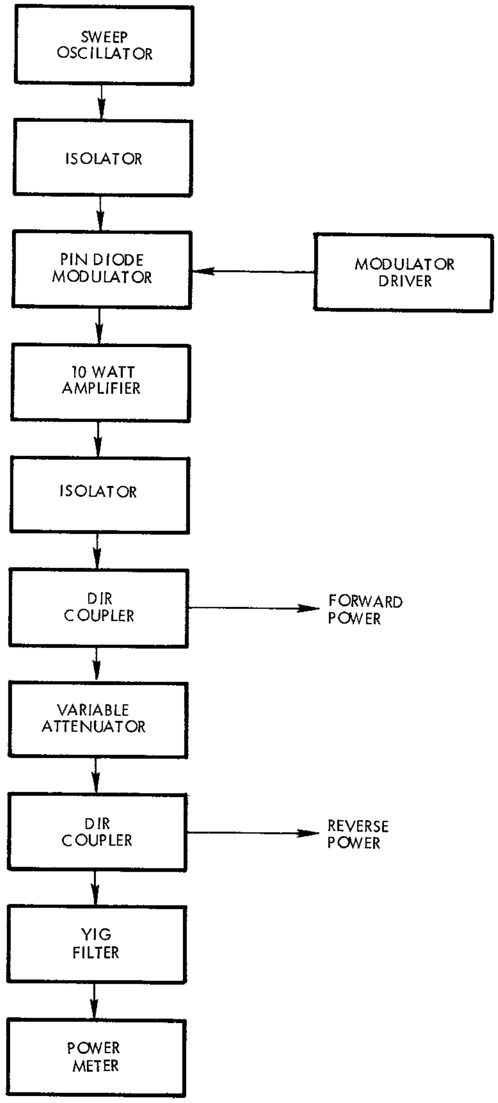


Figure 1 Simple Block Diagram of Instrumentation for Average Power Limiting Tests

## REFERENCES

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3. Watkins-Johnson Company, "YIG Limiters" Advanced Product Technical Description Brochure No. 100261; September 1968.

4. Y. Anand and C. Howell, "The Real Culprit in Diode Failure", Microwaves, pp. 36-38; August 1970.

5. J. Brown, "Ferrimagnetic Limiters", Microwave Journal, pp. 74-79; November 1961.

6. J. Clark and J. Brown, "The Gyromagnetic Coupling Limiter at C-Band", IRE Trans. on Microwave Theory and Techniques, pp. 84-85; January 1962.

## TABLE I

YIG FILTER DESIGN SPECIFICATIONS

| | |
|---|---|
| Tuning Range | 10% @ X-Band |
| 3 db Bandwidth | 20 MHz max. |
| Insertion Loss | 2.5 db max. |
| Limiting Level | +10 dbm min. |
| Off-Resonance Isolation | 50 db min. |
| VSWR | 1.5:1 |
| Passband Ripple | 0.5 db max. |
| Operating Temperature Range | -37° to +75°C |

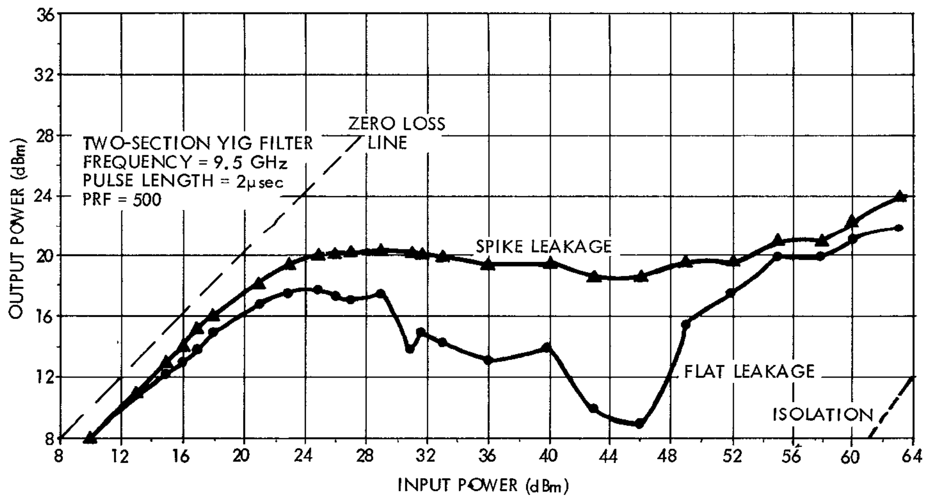


Figure 3 Peak Power Limiting Response of X-Band YIG Filter

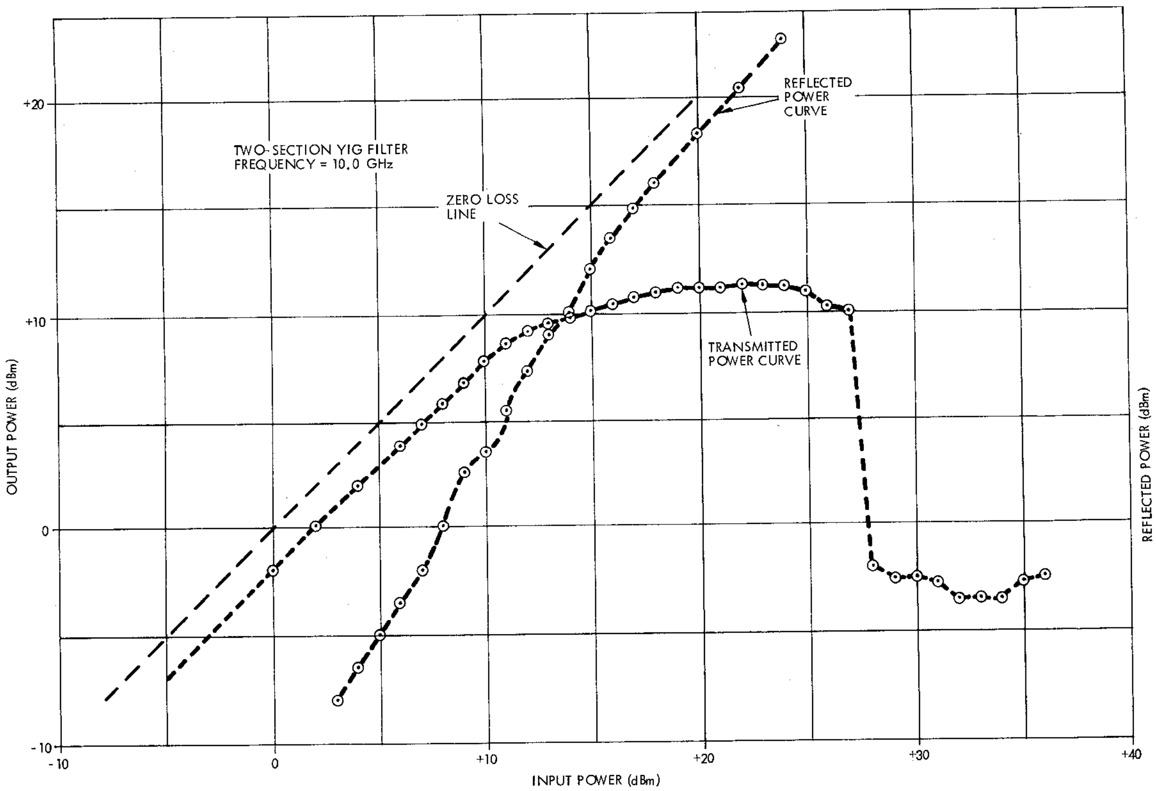


Figure 2 Average Power Limiting Response of X-Band YIG Filter

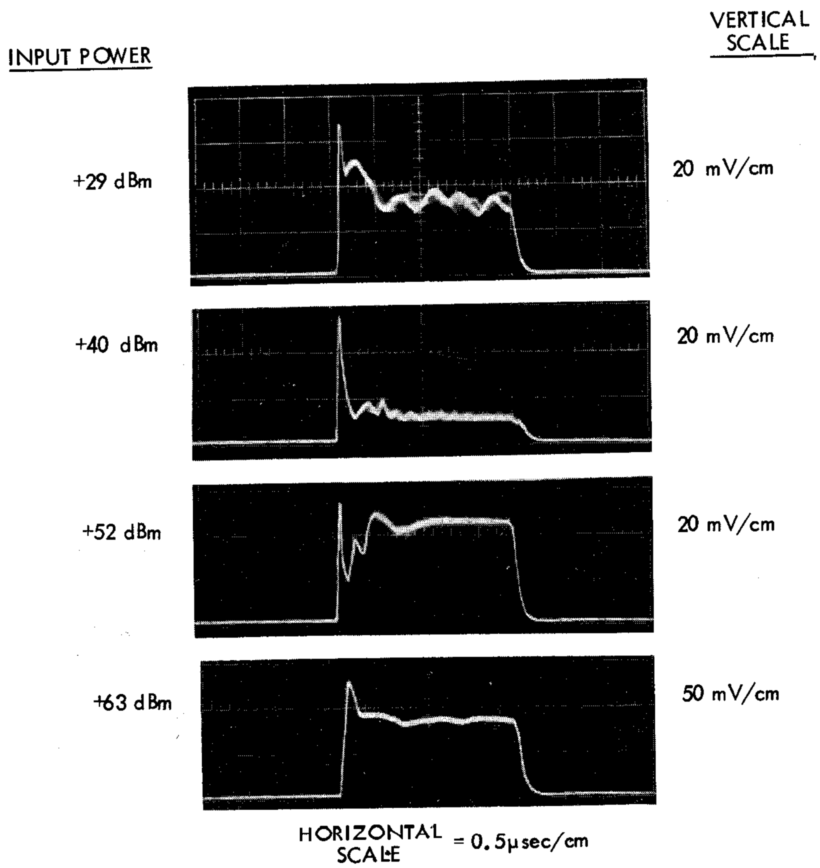


Figure 4 Pulse Amplitude Limiting in X-Band YIG Filter