



APPLICATION NOTE

# No. 665: Test for Spinwave Line Width

## Introduction

Microwave device engineers have known for some time that ferrimagnetic materials exhibit nonlinear loss characteristics at high levels of peak microwave power. In general, as shown in Figure 1, the high power effects appear as: (1) a saturation of the ferromagnetic resonance line width, and (2) the appearance of a subsidiary absorption peak at values of d.c. magnetic field below that required for the main resonance.

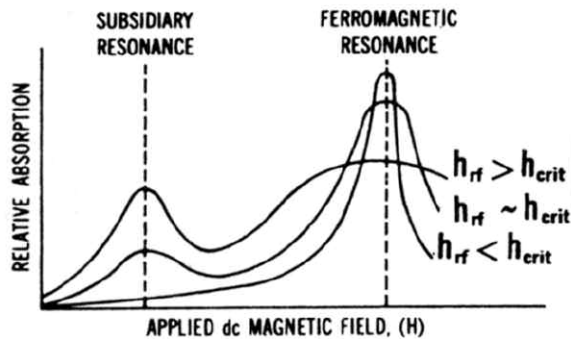


Figure 1

### Subsidiary Absorption and Premature Saturation

Present theory suggests that these high power effects arise from power-dependent coupling between the so-called uniform mode of magnetic precession, which is driven by the applied magnetic microwave field ( $h_{rf}$ ), and certain spin wave modes which become excited if  $h_{rf}$  exceeds the instability threshold ( $h_{crit}$ ). The saturation of the main resonance is caused by spin waves which have the same frequency as that of the  $h_{rf}$  field. Other spin waves having a frequency of one-half the signal frequency are responsible for the subsidiary absorption peak.

In recent years, material scientists have preferred to measure the power handling capacity of ferrimagnets by comparing their nonlinear thresholds, employing the "parallel pump instability."

## Cavity Method

A  $TE_{10n}$  ( $n$  even) 9300 mc transmission cavity of known characteristics is employed. The test sample is a sphere approximately 0.080 inch diameter, and is positioned away from the cavity wall at a point of minimum microwave electric and maximum microwave magnetic field. In parallel pumping, the d.c. magnetic field ( $H$ ) is applied parallel to  $h_{rf}$ . The value of  $H$  field required for the minimum instability threshold is approximately:

$$H = \frac{\omega}{2|\gamma_{eff}|} \quad (1)$$

The magnetic microwave field required for the onset of instability is given by the equation:

$$H_{erit} = \frac{\omega \Delta H_k}{|\gamma_{eff}| 4\pi M_s} \quad (2)$$

where

$\omega$  = operating frequency ( $2\pi f$ )

$\gamma$  = gyromagnetic ratio

$4\pi M_s$  = saturation magnetization

$\Delta H_k$  = spin wave line width

Since there is, at present, no way of calculating  $\Delta H_k$  of a polycrystal ferrimagnet,  $h_{erit}$  must be found experimentally.

The onset of ferrimagnet nonlinearity can be observed quite easily by noting the distortion of the trailing edge of a high power pulse after transmission through the test cavity, as shown in Figure 2. The critical value of  $h_{rf}$  can be determined from a knowledge of the test cavity parameters using the equation (MKS units):

$$(H_{rf})^2 = \frac{P_{diss} Q_u}{\omega_0 \mu_0 \frac{V}{4} \left(\frac{\lambda_g}{\lambda}\right)^2} \quad (3)$$

where

$P_{diss}$  = microwave power dissipated in the cavity without the ferrimagnet.

$Q_u$  = the unloaded Q of the cavity

$V$  = volume of the cavity.

$\lambda_g$  = cavity wave length

$\lambda$  = free space wave length

$\mu_0$  = free space permeability

$\omega_0$  = cavity resonant frequency

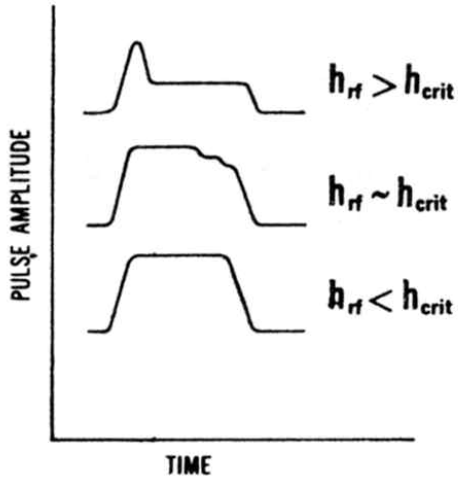


Figure 2  
Pulse Deterioration at Onset of Subsidiary Resonance

### Measurement

Figure 3 indicates typical equipment required. Pulsed power from a tunable magnetron (A) is fed through a ferrite isolator (B) and a power divider (C). The unused power is dissipated in load (D). The average power incident on the test cavity (E) is measured with the decoupled power circuit (F). The transmitted pulse is monitored at the decoupled CRO circuit (G). The d.c. magnetic field is adjusted with the aid of equation (1) to cause pulse deterioration at a minimum value of incident power. The corresponding value of microwave magnetic field ( $H_{rf} \sim h_{crit}$ ) is then calculated from equation (3), which allows  $AH_k$  to be calculated from equation (2).

### Reference

J. F. Ollom and W. H. von Aulock, "Measurement of Microwave Ferrites at High Signal Levels", I.R.E. Transactions on Instrumentation, Vol. 1-9, Sept. 1960, pp 187-193.

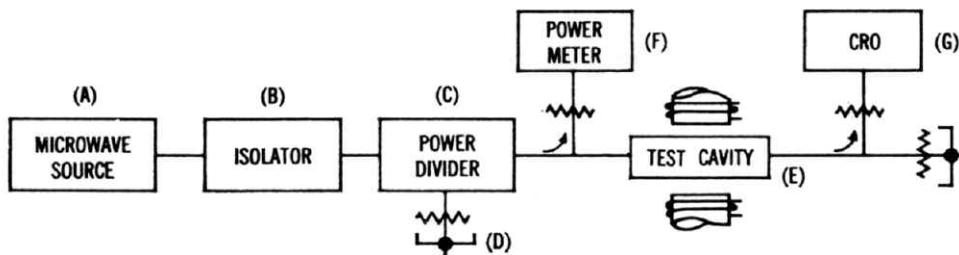


Figure 3  
Diagram of Typical Equipment Set Up

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