APPLICATION NOTE

Test for Spinwave Line Width

Introduction

Microwave device engineers know that ferrimagnetic materials exhibit nonlinear loss characteristics at high levels of peak microwave power. As shown in Figure 1, the high power effects generally appear as:

- A saturation of the ferromagnetic resonance line width.
- The appearance of a subsidiary absorption peak at values of the Direct Current (DC) magnetic field below that required for the main resonance.

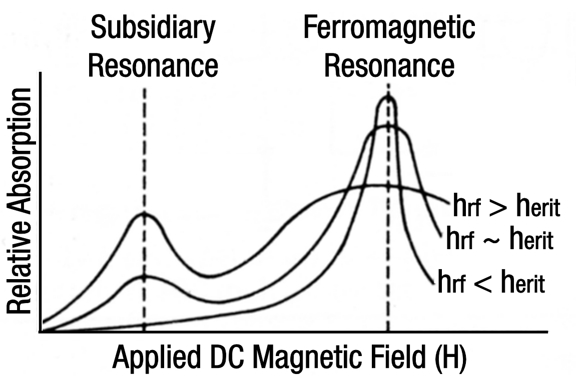

Figure 1. Subsidiary Absorption and Premature Saturation

Theory suggests that these high power effects arise from a power-dependent coupling between the uniform mode of magnetic precession that is driven by the applied magnetic microwave field (h_{rf}), and certain spin wave modes that become excited if h_{rf} exceeds the instability threshold (h_{erit}).

The saturation of the main resonance is caused by spin waves that 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.

Material scientists prefer to measure the power handling capacity of ferrimagnets by comparing their nonlinear thresholds using the parallel pump instability.

Cavity Method

The A TE_{10n} (n even) 9300 Multipoint Controller (MC) transmission cavity of known characteristics is used. The test sample is a sphere of an approximate diameter of 0.080 inches, and is positioned away from the cavity wall at a point of minimum microwave electric and maximum microwave magnetic fields. In parallel pumping, the DC magnetic field (H) is applied parallel to h_{rf}. The value of the H field required for the minimum instability threshold is approximately:

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

Where:

H = Magnetic field.
ω = Operating frequency ($2\pi f$).
γ = Gyromagnetic ratio.

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

$$h_{erit} = \frac{\omega \Delta H_K}{|\gamma_{eff}| 4\pi M_S} \quad \textbf{(2)}$$

Where:

h_{erit} = Magnetic instability threshold.
ω = Operating frequency ($2\pi f$).
ΔH_K = Spin wave line width.
γ = Gyromagnetic ratio.
$4\pi M_S$ = Saturation magnetization.

Because there is no way of calculating the ΔHk of a polycrystal ferrimagnet, h_{erit} must be found experimentally.

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The onset of ferrimagnet nonlinearity can be observed by noting the distortion of the trailing edge of a high power pulse after transmission through the test cavity, as shown in Figure 2.

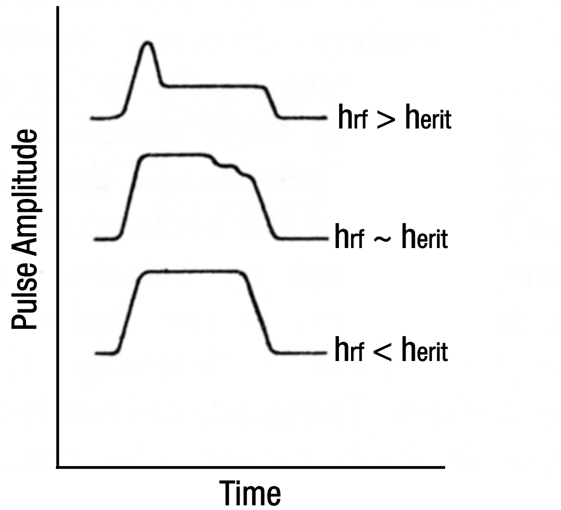

Figure 2. Pulse Deterioration at Onset of Subsidiary Resonance

The critical value of h_{rf} can be determined from knowledge of the test cavity parameters using the following equation in Meter, Kilogram, and/or Second (MKS) units:

$$(h_{rf})^2 = \frac{P_{diss}\,Q_u}{\omega_o \mu_o \frac{V}{4}\left(\frac{\lambda g}{\lambda}\right)^2} \tag{3}$$

Where:

h_{rf} = Magnetic microwave field.
P_{diss} = Microwave power dissipated in the cavity without the ferrimagnet.
Q_u = Unloaded Q of the cavity.
ω_o = Cavity resonant frequency.
μ_o = Free space permeability.
V = Cavity volume.
λg = Cavity wave length.
λ = Free space wave length

Measurement

Figure 3 indicates the required typical equipment. 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 the 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 DC 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 ΔH_K to be calculated from Equation (2).

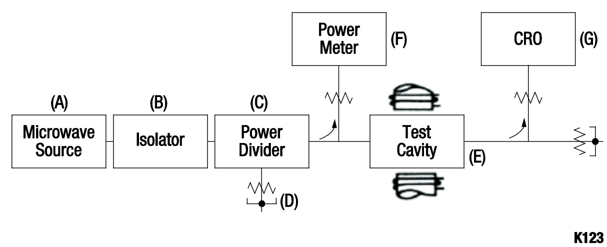

Figure 3. Typical Equipment Set Up Diagram