APPLICATION NOTE

No. 662: Test for Line Width and Gyromagnetic Ratio

At a constant microwave frequency ($\omega = 2\pi f$), ferrimagnets exhibit electromagnetic energy absorption that is a function of the internal static magnetic field (H_i). Maximum absorption occurs when the precession frequency and direction of the elementary magnetic dipoles equals that of the incident microwave magnetic field. The magnitude of H_i (H_r) required to obtain maximum absorption—the ferromagnetic resonance condition—can be computed from the equation:

$$\omega = \gamma_{eff} H_r \qquad (1)$$

where γ_{eff} is the effective gyromagnetic ratio. For a spherical test specimen H_i is independent of the material magnetization and may be taken as equal to the applied DC magnetic field.

The ferrimagnetic resonance line width (ΔH) is defined as the separation of the two H_i values at which the power absorbed by the ferrimagnet is equal to 1/2 the maximum absorption.

Cavity Method

A TE_{10n} (n even) cavity resonant in the X-band region is employed. The loaded Q (Q_0) of the empty cavity should be 2000 or greater. The test sample is a sphere approximately 0.040 inch diameter. The cavity technique requires that the sample be small compared to 1/4 of the wave length (λ) of the microwave radiation within it:

$$\lambda = 3 \times 10^4/f(\varepsilon')^{1/2} \text{ [cm]} \qquad (2)$$

where f is in megacycles and ε' is the dielectric constant.

The sample, mounted on a fused silica or equivalent rod, is positioned away from the cavity wall at a point of minimum microwave electric and maximum microwave magnetic field. A typical TE_{106} cavity is shown in Figure 1.

The absorption in the specimen is measured by determining the changes of power incident on the cavity required to keep the output power from the cavity at a fixed reference level. It is necessary that the microwave frequency be adjusted to cavity resonance for all measurements. The variations in input power

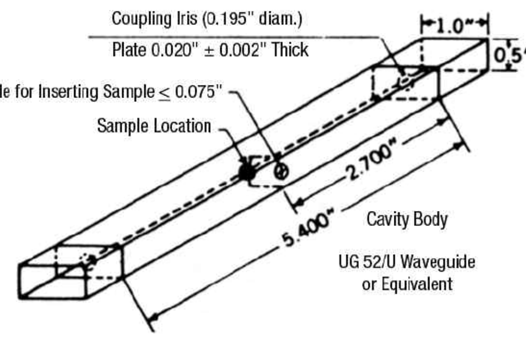

Figure 1. Typical TE_{106} Cavity Resonant at 9300 me

may be characterized by the variations of the attenuation inserted between a monitored source and the cavity in order to maintain the reference output level. If α_0 is this attenuator reading in decibels with no sample present, and α_r is this reading for maximum specimen absorption, then the readir.g corresponding to a specimen absorption of half the resonance value is given by the equation:

$$\alpha^{1/2} = \alpha_0 + 20\log 2 - 20\log(10^{(\alpha o - \alpha r/20)} + 1) \qquad (3)$$

Measurement

Figure 2 indicates typical equipment required. Power from a suitable microwave source (A) unmodulated or with amplitude modulation, but free of frequency modulation, is fed through a precision variable attenuator (F) to the cavity (G) and the output power is detected and indicated on a suitable meter (H). The power incident on (F) is monitored at (E) by directional coupler (D) and a crystal detector. This incident power is kept constant throughout the measurement by variable attenuator (C). The microwave frequency must be adjusted to cavity resonance for all measurements, as indicated by maximum power output with respect to frequency variation. A homogenous adjustable DC magnetic field is applied across the sample region perpendicular to the microwave magnetic field.

The test procedure is: (1) with no specimen present establish an input level α_0 measured at (E) on the precision attenuator, and an output level measured at (H). Take this output level as a reference for the remaining measurements. Insert specimen into cavity and vary external magnetic field until the point of maximum specimen absorption is found, as indicated by minimum transmission. Now determine the microwave frequency f, and magnetic field H_r. Thus, f may be measured with a wave meter at (B), and H_r by a rotating coil fluxmeter, etc. The gyromagnetic ratio may be computed by means of Eq. 1. This characteristic may also be given in terms of $g_{eff} = \gamma_{eff} \bullet 2mc/e$, (MKS units).

(2) Determine the attenuation, α_r, required to obtain the reference output level at resonance. Compute the attenuation, $\alpha 1/2$ required to obtain the reference output level at the half-power points of specimen absorption from Eq. 3. Insert this amount of attenuation with the precision attenuator, and determine the magnetic field at the two points at which the output reaches the reference value. The difference in the magnetic fields at these two points is the ferrimagnetic resonance line width, ΔH.

(3) The value of ΔH and H_r obtained from these measurements must, in addition to Eq. 2, satisfy the equation:

$$\alpha_0 - \alpha_r \leq 20\log\,(1 + 0.06\, Q_0\, \Delta H/H_r) \qquad (4)$$

If Eq. 4 is not satisfied, then the sphere diameter must be reduced until the loss difference meets the above requirement.

Reference

American Society for Testing and Materials (ASTM) tentative standard C524-63T.

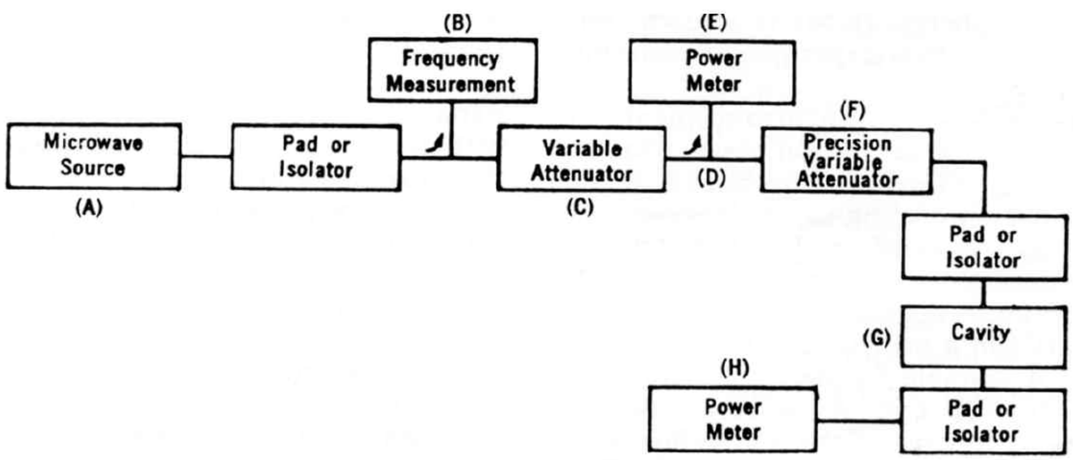

Figure 2. Diagram of Typical Equipment Set up