

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:

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

where  $\gamma_{\text{eff}}$  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 ( $\Delta H$ ) 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 ( $\lambda$ ) of the microwave radiation within it:

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

where  $f$  is in megacycles and  $\epsilon'$  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

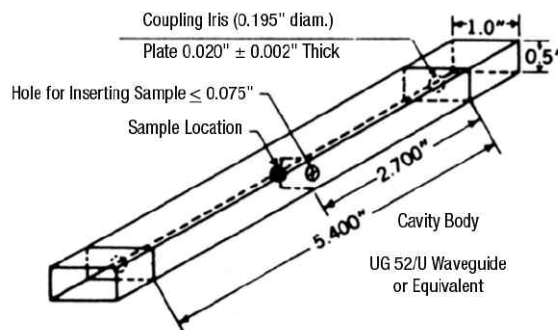


Figure 1. Typical  $TE_{106}$  Cavity Resonant at 9300 me

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  $\alpha_0$  is this attenuator reading in decibels with no sample present, and  $\alpha_r$  is this reading for maximum specimen absorption, then the reading corresponding to a specimen absorption of half the resonance value is given by the equation:

$$\alpha^{1/2} = \alpha_0 + 20 \log 2 - 20 \log(10^{(\alpha_0 - \alpha_r/20)} + 1) \quad (3)$$

### 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  $\alpha_0$  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,  $\alpha_r$ , 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,  $\Delta H$ .

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

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

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.

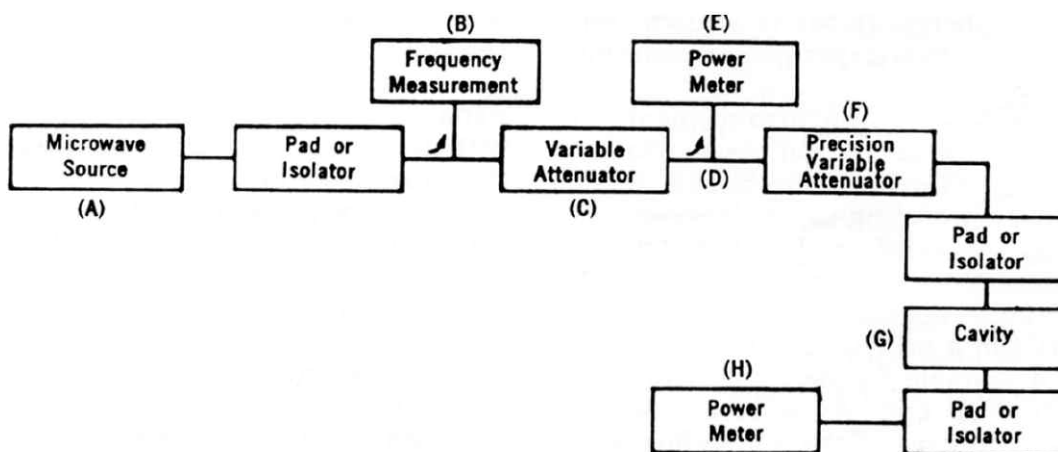


Figure 2. Diagram of Typical Equipment Set up

Copyright © 2006, 2007, Trans-Tech Inc., Inc. All Rights Reserved.

Information in this document is provided in connection with Trans-Tech, Inc. ("Trans-Tech"), a wholly-owned subsidiary of Skyworks Solutions, Inc. These materials, including the information contained herein, are provided by Trans-Tech as a service to its customers and may be used for informational purposes only by the customer. Trans-Tech assumes no responsibility for errors or omissions in these materials or the information contained herein. Trans-Tech may change its documentation, products, services, specifications or product descriptions at any time, without notice. Trans-Tech makes no commitment to update the materials or information and shall have no responsibility whatsoever for conflicts, incompatibilities, or other difficulties arising from any future changes.

No license, whether express, implied, by estoppel or otherwise, is granted to any intellectual property rights by this document. Trans-Tech assumes no liability for any materials, products or information provided hereunder, including the sale, distribution, reproduction or use of Trans-Tech products, information or materials, except as may be provided in Trans-Tech Terms and Conditions of Sale.

THE MATERIALS, PRODUCTS AND INFORMATION ARE PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND, WHETHER EXPRESS, IMPLIED, STATUTORY, OR OTHERWISE, INCLUDING FITNESS FOR A PARTICULAR PURPOSE OR USE, MERCHANTABILITY, PERFORMANCE, QUALITY OR NON-INFRINGEMENT OF ANY INTELLECTUAL PROPERTY RIGHT; ALL SUCH WARRANTIES ARE HEREBY EXPRESSLY DISCLAIMED. TRANS-TECH DOES NOT WARRANT THE ACCURACY OR COMPLETENESS OF THE INFORMATION, TEXT, GRAPHICS OR OTHER ITEMS CONTAINED WITHIN THESE MATERIALS. TRANS-TECH SHALL NOT BE LIABLE FOR ANY DAMAGES, INCLUDING BUT NOT LIMITED TO ANY SPECIAL, INDIRECT, INCIDENTAL, STATUTORY, OR CONSEQUENTIAL DAMAGES, INCLUDING WITHOUT LIMITATION, LOST REVENUES OR LOST PROFITS THAT MAY RESULT FROM THE USE OF THE MATERIALS OR INFORMATION, WHETHER OR NOT THE RECIPIENT OF MATERIALS HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Trans-Tech products are not intended for use in medical, lifesaving or life-sustaining applications, or other equipment in which the failure of the Trans-Tech products could lead to personal injury, death, physical or environmental damage. Trans-Tech customers using or selling Trans-Tech products for use in such applications do so at their own risk and agree to fully indemnify Trans-Tech for any damages resulting from such improper use or sale.

Customers are responsible for their products and applications using Trans-Tech products, which may deviate from published specifications as a result of design defects, errors, or operation of products outside of published parameters or design specifications. Customers should include design and operating safeguards to minimize these and other risks. Trans-Tech assumes no liability for applications assistance, customer product design, or damage to any equipment resulting from the use of Trans-Tech products outside of stated published specifications or parameters.