

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.

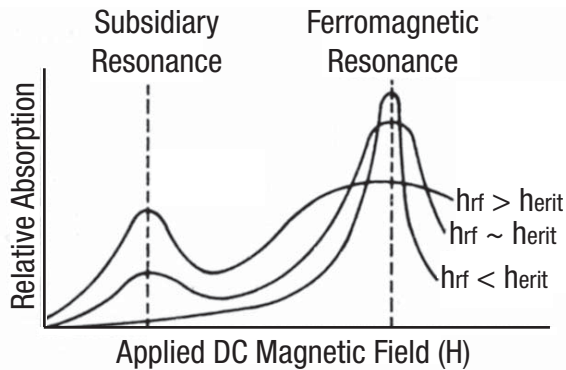


Figure 1. Subsidiary Absorption and Premature Saturation

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_{rit}).

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:

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

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:

$$h_{rit} = \frac{\omega \Delta H_k}{\gamma_{effl} 4\pi M_s} \quad (2)$$

Where:

h_{rit} = 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 ΔH_k of a polycrystal ferrimagnet, h_{rit} must be found experimentally.

APPLICATION NOTE • TEST FOR SPINWAVE LINE WIDTH

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.

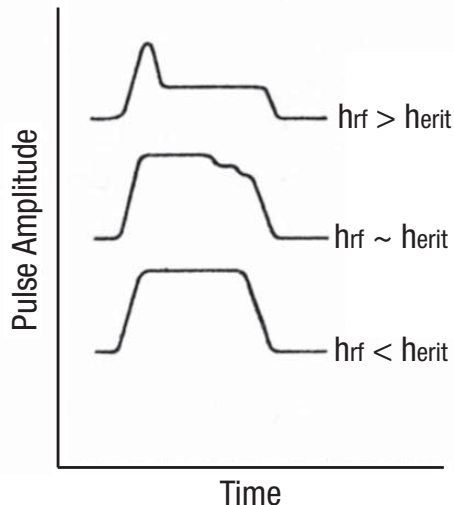


Figure 2. Pulse Deterioration at Onset of Subsidiary Resonance

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:

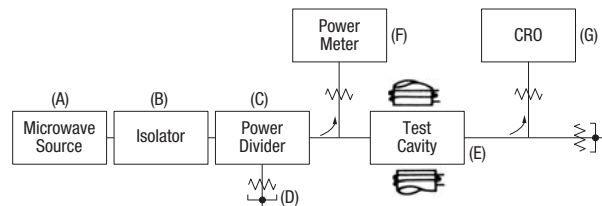
$$(h_{rf})^2 = \frac{P_{diss} Q_u}{\omega_0 \mu_0 V \left(\frac{\lambda_g}{\lambda}\right)^2} \tag{3}$$

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_0 = Cavity resonant frequency.
- μ_0 = Free space permeability.
- V = Cavity volume.
- λ_g = 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).



K123

Figure 3. Typical Equipment Set Up Diagram

Copyright © 2013, 2017 Trans-Tech 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, or 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.

Skyworks and the Skyworks symbol are trademarks or registered trademarks of Skyworks Solutions, Inc., in the United States and other countries. Third-party brands and names are for identification purposes only, and are the property of their respective owners.