APPLICATION NOTE

Test for Switching Coefficients

Introduction

The rectangular loop property that is exhibited by certain microwave ferrimagnets is used in the design of a number of digital or latching ferrite phase shifters. The *Test for Hysteresis Loop Properties Application Note* (Document Number 202870) describes a measurement technique to obtain the coercive force (H_e), remanent flux density (B_r), and squareness ratio (R_S) of rectangular loop ferrimagnets. Another useful parameter of these materials, obtained experimentally as a constant of proportionality between magnetizing force and speed of magnetic flux reversal, is known as the switching coefficient (S_W).

The time required for the magnetic flux to switch from $-B_r$ to $+B_r$ in a toroidal core is inversely proportional to the magnetizing field (H), for amplitudes of H greater than approximately twice the coercive force. Theory suggests that the magnetic dipoles are reversed or switched in this region by a non-uniform rotation mechanism. A convenient method of measuring the switching coefficient is described in “Measurement” on page 2.

Oscilloscope Method

Figure 1 shows a typical measuring circuit. Three separate coils are placed around a thin-walled toroidal specimen and comprise of a:

- Block winding through which a 10 μs duration current pulse (i_b) of constant amplitude, equal to about 10 times the specimen coercive force, is passed.
- Read winding for a 10 μs duration current pulse (i_r), controllable in amplitude from about 1-to-10 times the specimen coercive force.
- Readout winding to obtain the output voltage waveform on a Cathode Ray Oscilloscope (CRO) screen at point A; or if followed by an integrating network, to obtain the magnetic flux waveform at point B.

Alternate block and read pulses are applied approximately 100 times per second. As the read pulse magnitude is varied, the switching time (t_S) is measured as the 10% points of the output voltage waveform at A; or as the 10% to 90% points of the magnetic flux waveform at B.

Values of S_W obtained from output voltage are about 1.5 times greater than those obtained from magnetic flux measurements. Because a preferred method has not been established, the technique of measurement should always be specified.

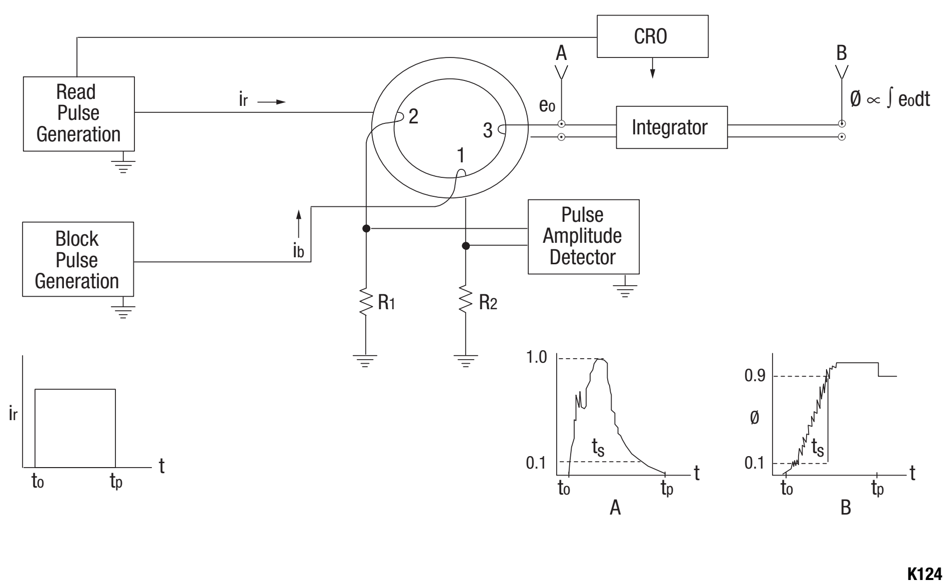

Figure 1. Typical Equipment Setup Diagram

Measurement

The dependence of the switching time on the magnetizing field ($H = NI_r/I_m$, where Im is the mean toroid circumference) is most clearly presented by plotting I/ts, as a function of H. When this is done, a linear curve is obtained, as shown in Figure 2. The experimental relationship may be adequately represented by the following equation:

$$S_W = t_S (H - H_O) \quad \textbf{(1)}$$

Where:

S_W = Constant for a given ferrimagnet.
t_S = Switching time.
H = Magnetizing field.
H_O = Threshold field strength.

The threshold field strength (H_O) is slightly larger than the coercive force of the ferrimagnet and may be termed the threshold for non-uniform rotation flux reversal.

In general, both S_W and H_O decrease with increasing temperature. Typical values of S_W for rectangular loop ferrimagnets, obtained from the output voltage waveform, range between 0.5 oe and 1.5 oe × µs. The switching coefficient (S_W) can be considered as the additional field strength in excess of the H_O required to switch the magnetic flux between $-B_r$ and $+B_r$ in 1 µs. Because of this, a small value of S_W denotes a ferrimagnet with a rapid pulse response. For materials with the same H_O (or same coercive force), a decrease in S_W results in a faster switching time at a given H field.

Application

In the design of latching ferrite phase shifters, the digital bit geometry and speed are dictated by system requirements. The H_O and S_W are of use to the microwave device engineer because they enter into the calculation of switching power needed to meet the system specifications.

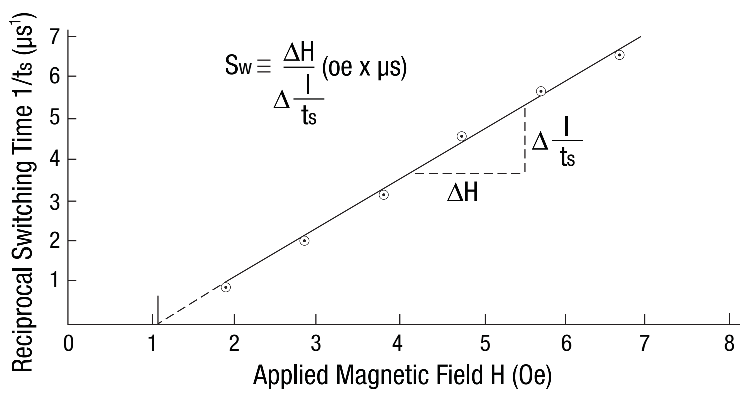

Figure 2. Typical Plot of Switching Time for a Microwave Ferrimagnet Used in Digital Phase Shifters