APPLICATION NOTE

No. 666: Test for Switching Coefficients

Introduction

The rectangular loop property exhibited by certain microwave ferrimagnets is utilized in the design of a number of digital or “latching” ferrite phase shifters. Tech Brief No. 664 described 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. Current 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 below.

Oscilloscope Method

A typical measuring circuit is shown in Figure 1. Three separate coils are placed around a thin-wall toroidal specimen. They comprise: (1) a block winding through which a 10 µsec duration current pulse (i_b) of constant amplitude, equal to about ten times the specimen coercive force, is passed; (2) a read winding for a 10 µsec duration current pulse (i_r), controllable in amplitude from about one to ten times the specimen coercive force; and (3) a readout winding to obtain the output voltage waveform on a 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. A preferred method has not been established; therefore the technique of measurement should always be specified.

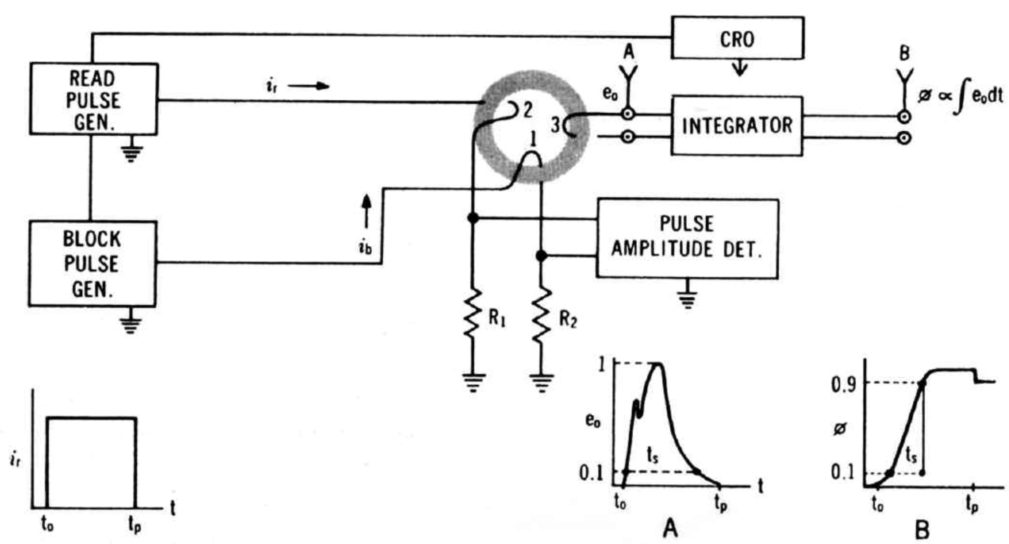

Figure 1
Diagram of Typical Equipment Set Up

Measurement

The dependence of the switching time on the magnetizing field ($H = Ni_r/lm$, where lm is the mean toroid circumference) is most clearly presented by plotting l/t_s, 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 equation:

$$S_W = t_S (H–H_0) \qquad (1)$$

H_r, and S_W are constants for a given ferrimagnet. The threshold field strength (H_0) 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_0 decrease with increasing temperature. Typical values of S_W for rectangular loop ferrimagnets, obtained from the output voltage waveform, range between 0.5 and 1.5 oe • µsec. The switching coefficient (S_W) can be considered as the additional field strength in excess of H_0 required to switch the magnetic flux between $–B_r$ and $+B_r$ in one microsecond. Thus, a small value of S_W denotes a ferrimagnet with a rapid pulse response. For materials with the same H_0 (or same coercive force) a decrease in S_W will result 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. H_0 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.

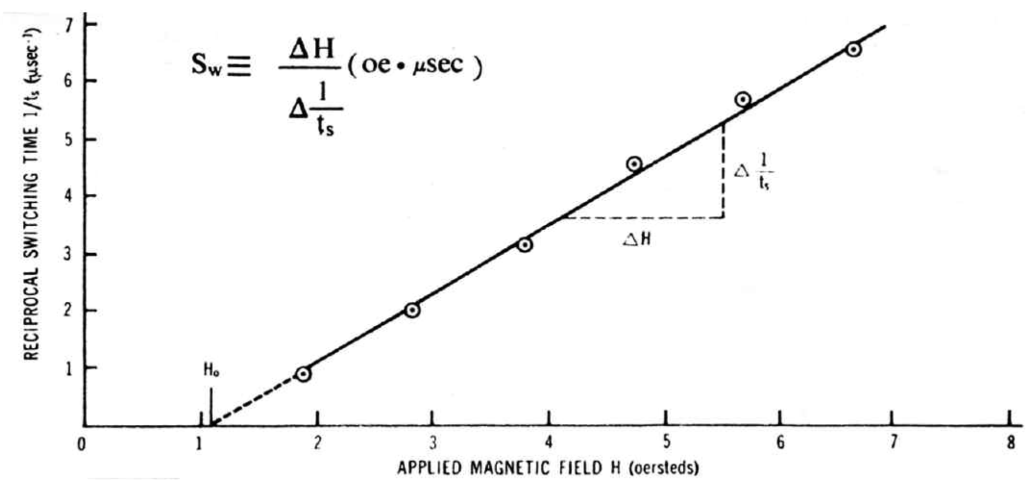

Figure 2

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