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Millimicrosecond Magnetization Reversal in Thin Magnetic Films

From ferromagnetic resonance experiments and from calculations based on the modified Landau-Lifschitz equation, switching times for the coherent rotation of the magnetization in thin, permalloy-type films have been predicted to lie in the range of 1 millimicrosecond.[1] First measurements by D. O. Smith et al,[2] utilizing a travelling-wave oscilloscope with a response time of 2 mμsec, indicated switching times of about 3 mμsec. In this communication, first results of advanced millimicrosecond measurements are reported. These were obtained by using special pulse equipment including a sampling oscilloscope,[3,4] with an over-all response time of about 0.5 mμsec. Flux changes as fast as 1.5 mμsec could be observed, for not only the longitudinal flux component,[5] but also, for the first time, the transverse one.

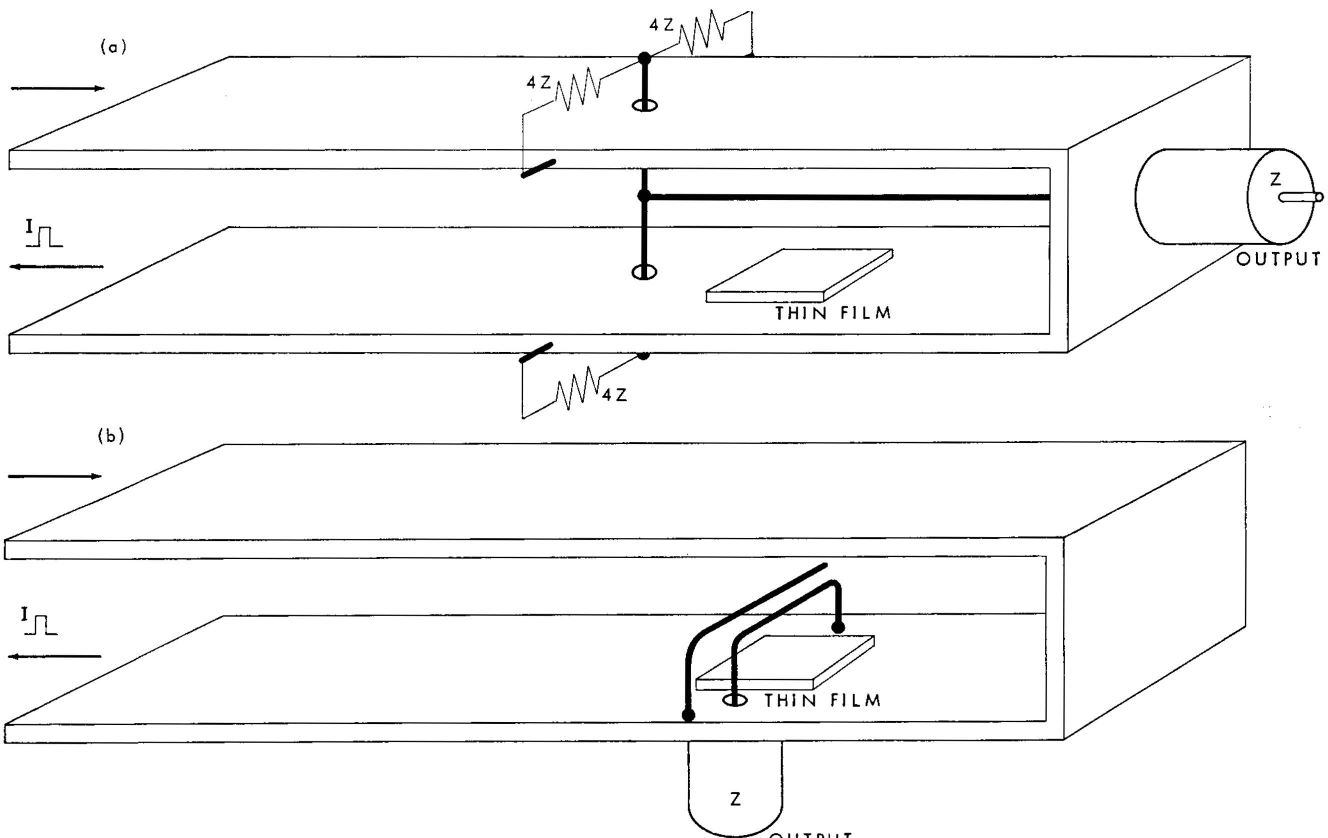
Experimental techniques

A pulsed magnetic field is generated in a 50-Ω short-circuited strip transmission line by discharging a 50-Ω coaxial cable over a coaxial mercury relay. The end of the cable is matched for the reflected wave by diodes and *RC*-compensating networks. Two pairs of Helmholtz coils provide the premagnetization and reset fields in the plane of the film.

The longitudinal magnetic flux change of the magnetic film is picked up by a wire placed in the symmetry axis of the strip line. The end of this wire is matched by four balancing resistors (Fig. 1a). By this means the voltage induced by the air flux is cancelled out.

The transverse flux change of the film is picked up by a wire placed normal to the axis of the strip line (Fig. 1b).

Figure 1 **Strip transmission with longitudinal (a) and transverse (b) pick-ups.**



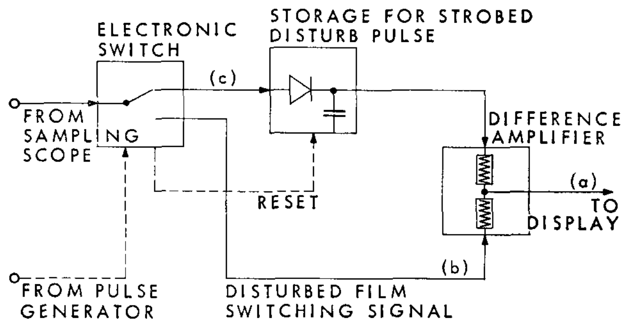


Figure 2a **Block diagram of electronic subtracter.**

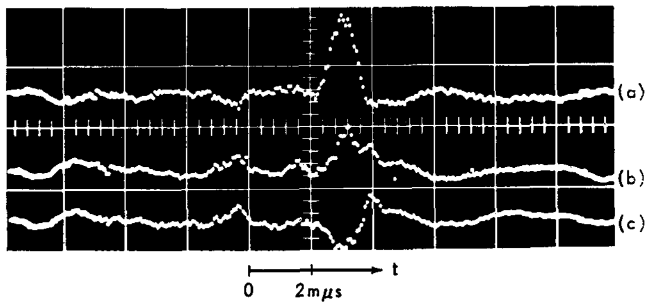
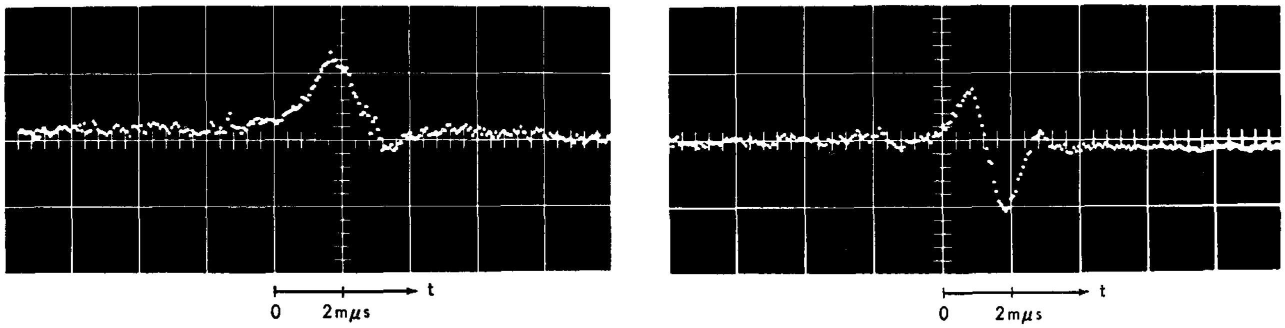


Figure 2b **The disturbed switching signal (b), the disturbing signal (c), and the corrected signal (a) after electronic subtraction.**



a) Longitudinal

b) Transverse

Figure 3 **Picked up signal from irreversible uniform rotation of magnetization in thin film.**

It is disturbed only by the capacitively coupled component of the drive pulse in the strip line. This disturbing signal is minimized by the use of a thin resistive pickup wire. An additional small wire above it has been found useful for capacitive compensation.[6]

It was possible to reduce the remaining picked-up disturbances considerably by making use of the principle of operation of the sampling oscilloscope. The disturbed film-switching signal and the disturbing signal alone are generated and sampled alternatively. The disturbing signal is produced by applying the driving pulse while the film is completely saturated. The difference between the two signals is formed electronically by storing one sampled disturbing pulse and subtracting the succeeding sampled, disturbed switching pulse (Fig. 2a). Fig. 2b shows the disturbed switching signal, the disturbing signal and the corrected signal after electronic subtraction. By this means the disturbances have been reduced in our set-up to about 5 mV (peak to peak) at a pulse field of 6 oe.

Film switching

Uniform rotation of the magnetization is observed when the pulsed magnetic field is applied at a certain angle to the magnetization of a permalloy-type film with induced uniaxial anisotropy. The film thickness is about 1000 A and the surface area 1×1 cm. Each pulsed field is succeeded by a reset field, which brings the magnetization into the original direction. The output signal induced in a longitudinal pickup is displayed in Fig. 3a. Output voltages of about 1.0 v could be observed with a switching time of about 1.5 mμsec. The switching signal picked up in the transverse direction is shown in Fig. 3b for irreversible rotation.

Further results and evaluations will be reported at the Conference on Magnetism and Magnetic Materials, Detroit, November 1959.

References

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