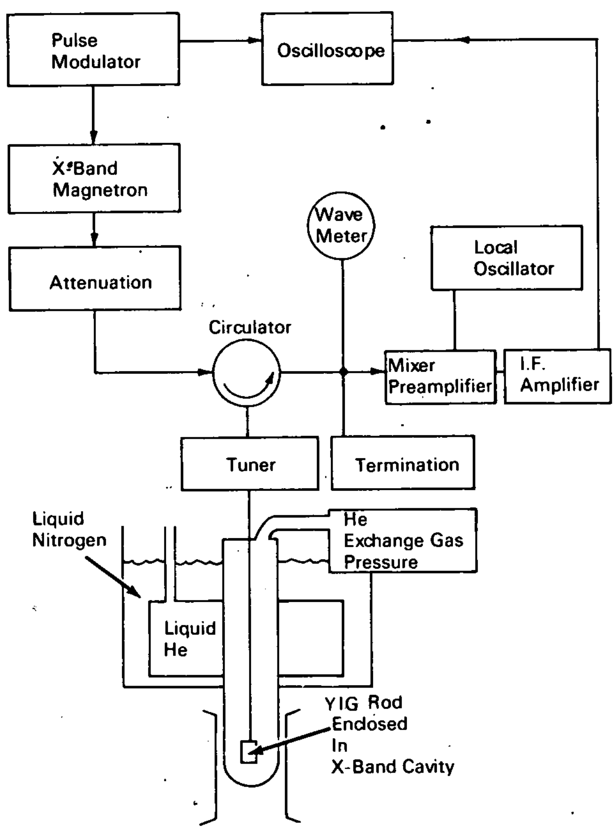
NASA TECH BRIEF

Study of Yttrium Iron Garnet Rods Reveals New Magnetostatic Echo Mode



The problem:

To investigate the effect of magnetic field variation on magnetostatic echo modes in Yttrium Iron Garnet (YIG) rods. Previously reported magnetostatic echo modes in YIG rods experienced nonlinear time delays in their transit times as the magnetic field was varied.

The solution:

Research studies conducted on echo modes in YIG rods revealed an echo mode which differed in its behavior in magnetic fields from those previously reported. This mode, discovered at 8.5 gigahertz, experiences a linear variation of transit time with magnetic field variation. The time delay exhibited is a linear function of the applied magnetic field and the input pulse frequency.

How it's done:

The YIG rod is enclosed as shown in a microwave cavity resonating in the TE_{101} mode and experiments

(continued overleaf)

were conducted in a temperature range of liquid helium (1.8°K) to room temperature (300°K). For studies at cryogenic temperatures, the microwave cavity is immersed in a liquid helium bath. The microwave cavity is contained between the two poles of a magnet, the source of the applied magnetic field.

The single YIG crystal is oriented such that its (100) cylinder axis is perpendicular to the radiofrequency field in the X-band cavity. The external applied magnetic field is either parallel or perpendicular to the rod axis, with the rod placed in the area of maximum radiofrequency magnetic field.

The cavity is coupled to the electronic system by a waveguide. Microwave pulses of 1 μsec duration are produced by the pulse modulator and trigger the X-band magnetron, which is the power amplifier for the microwave pulse. The pulse is then passed through an attenuator, which reduces the pulse to the desired amplitude. The pulse is then transmitted through a circulator and tuner into the cavity, where it is reflected back up the cavity into the circulator. The circulator isolates the input and output portions of the system, and the tuner adjusts the waveguide-cavity system to resonate in the TE_{101} mode.

The receiver portion of the electronic system consists of a mixer amplifier, a local oscillator, and an intermediate frequency amplifier. The local oscillator reproduces the signal and phase of the magnetron, when the YIG rod is not included in the system. The mixer preamplifier mixes the local oscillator signal with the output of the microwave cavity. The time delay properties of the YIG rod cause the output signal to be out of phase with the input signal. Wave beats are produced as a result of the net addition or subtraction of the two waves. The intermediate frequency amplifier amplifies the beat of the difference of the two waves and the resulting pulse is displayed on the oscilloscope.

The longest delay time for the magnetostatic pulse occurs at lower magnetic fields. At 80°K the slope of the delay time versus applied field plot is $dt/dH_0 = -0.24$ sec/gauss, when the applied field is parallel to the rod axis, and $dt/dH_0 = -0.21$sec/gauss, when the applied field is perpendicular to the rod axis. In general these pulse compression delay times may be obtained in two ways: (1) frequency swept input pulses are applied to the YIG rod and the magnetic field is held constant; (2) the input pulses are fixed in frequency, but the magnetic field is varied.

The new magnetostatic echo mode was observed in YIG rods of various diameters and lengths at an applied magnetic field of 100–200 gauss, slightly higher than required for the previously reported echoes. The generation and detection do not depend upon the presence of polished end faces on the rods. Furthermore, the insertion loss for these echoes has a lower limit of 30 db.

Notes:

1. The new techniques should be applicable to chirp-type radars, laboratory testing apparatus, and computer buffer storage units.
2. The radar implications may lead to higher power radars with longer range capabilities.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Electronic Research Center
   575 Technology Square
   Cambridge, Massachusetts 02139
   Reference: B67-10153

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Dr. Robert W. Kedzie
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