# V-10. UHF MAGNETOACOUSTIC DELAY LINE

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The feasibility of exploiting the relatively slow velocity of propagation of acoustic waves in order to delay an electromagnetic signal in the microwave frequency range has been clearly established. Several different approaches in the conversion of the electromagnetic energy to acoustic energy have been shown to be practical. One of these involves the use of a rod of single crystal yttrium iron garnet (YIG) which serves both as the delay medium and also as the transducer to convert the electromagnetic energy to acoustic energy, and vice-versa. A basic advantage of this type of delay line is the ability to vary delay time continuously over a large range by means of a magnetic biasing field. Though considerable progress has been reported in the field of magnetoacoustic delay lines of this type (References 1, 2, and 3) further advances are required in the reduction of insertion loss, increase in the delay time, and a more precise understanding of the phenomena involved. In pursuance of these objectives, experiments have been performed on a magnetoacoustic delay line intended for operation over the range of 200 to 1000 mc. Comprehensive data on insertion loss and VSWR is presented and analyzed. Also, results of bonding two single crystal YIG rods to achieve a longer delay are given.

A schematic of the delay line used is shown in Figure 1. The dimensions of the single crystal rod are 0.62 cm diameter by 1.20 cm, and the cross section of the coupling wire is 0.01 cm by 0.25 cm. Detailed plots of insertion loss versus biasing field were obtained at nine frequencies over the range of 200 to 1000 mc. Plots at two of the frequencies are shown in Figures 2 and 3. This data was obtained with the input and output of the delay line tuned. The delay time at various biasing fields is also indicated on the graphs. This ranged from 5.0 microseconds at low fields to 3.5 at high fields.

The insertion loss fluctuated very rapidly with small changes in biasing field, making it impractical to show each fluctuation separately. Hence, only the upper and lower limits of the fluctuations are shown on the graphs.

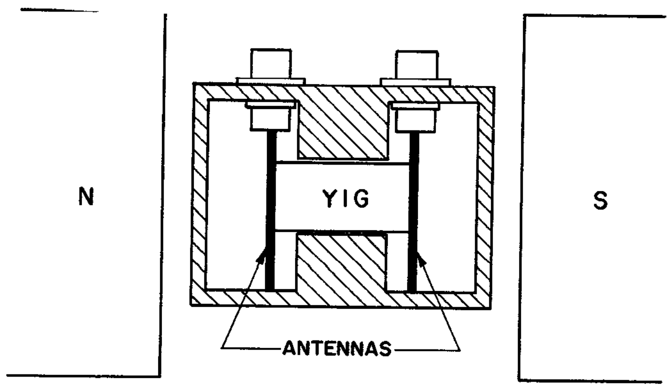


Figure 1. Sectional View of YIG Delay Line

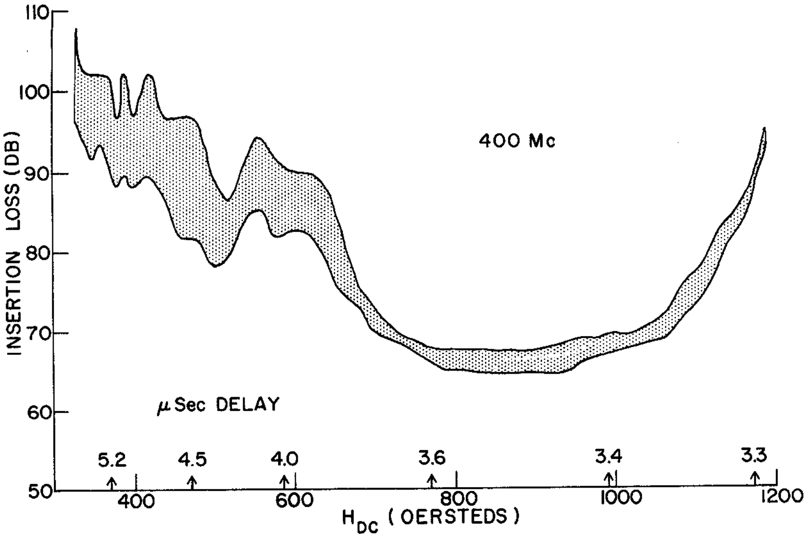


Figure 2. Insertion Loss versus Applied Magnetic Field for Tuned YIG Delay Line at 400 mc

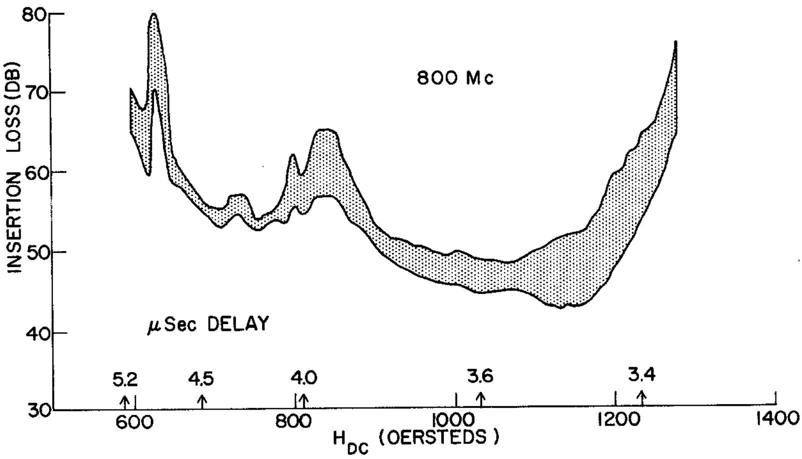


Figure 3. Insertion Loss versus Applied Magnetic Field for Tuned YIG Delay Line at 800 mc

A plot of the separation in biasing field between adjacent insertion loss peaks of the "fast" variation as a function of biasing field is shown in Figure 4 for a frequency of 740 mc. Also included in the figure is the theoretical separation predicted by Schlömann (References 4 and 5) to a first order approximation. Though the experimental data is off by a factor of approximately 2.5, the trend with respect to biasing field follows that predicted by theory.

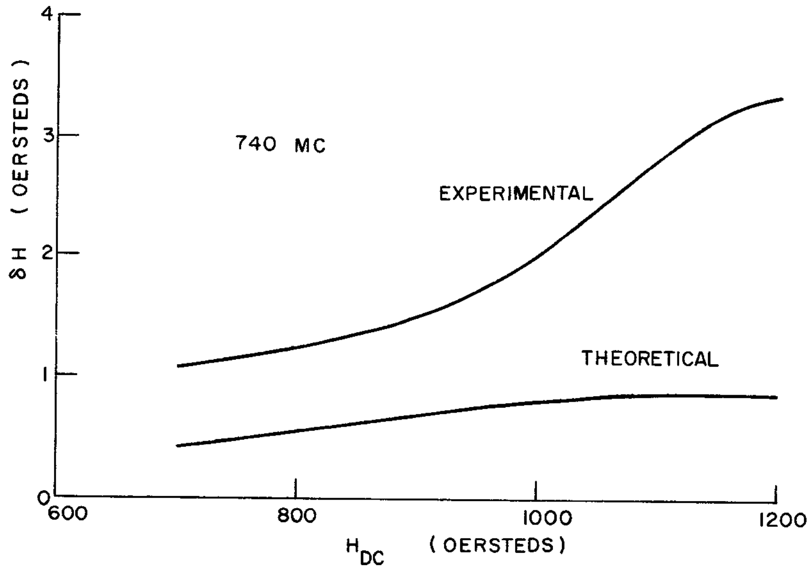


Figure 4. Separation δH of Adjacent Peaks in Insertion Loss at 740 mc versus Applied Magnetic Field

In addition to the rapid fluctuation of the insertion loss with bias field discussed above, a slow variation of insertion loss as a function of bias field is also noted in Figures 2 and 3. Consider the average of the two limit lines. The minimum value of this average decreases as frequency is increased from 200 mc to 600 mc. From 600 to 1000 mc, the minimum value is relatively constant. Also, the average value is relatively flat over the range of bias field from 900 to 1100 oersteds for all frequencies from 200 to 1000 mc. This is desirable for broadband operation.

The VSWR of the untuned delay line was measured at a number of frequencies to determine what fraction of the incident energy was actually absorbed by the ferrite. The results at two frequencies are plotted in Figure 5. It is noted that VSWR varies very slowly with biasing field, and the rapid fluctuation found in the plot of insertion loss is absent here. Comparison of the data in Figure 5 with that in Figures 2 and 3, shows that the loss in getting electromagnetic energy in and out of the YIG rod in untuned lines is considerably lower than the loss in the conversion of the electromagnetic energy that gets in the rod to acoustic energy.

A basic limitation to the delay time possible from a single crystal YIG rod is the length of rod available. At present, it is difficult and costly to produce suitable rods greater than one centimeter in length. Hence, the successful bonding of two single crystal YIG rods with only a moderate increase in insertion loss due to the bond is a significant accomplishment. The bonded YIG rods were 1.2 centimeter and 0.62 centimeter in length, respectively. The increase of the insertion loss of the delay line using the bonded rods over that using the 1.20 centimeter rod is less than 14 db over most of the frequency range. A detailed plot of the insertion loss at 700 mc, as a function of biasing field, is shown in Figure 6. Delay time as a function of field is also shown.

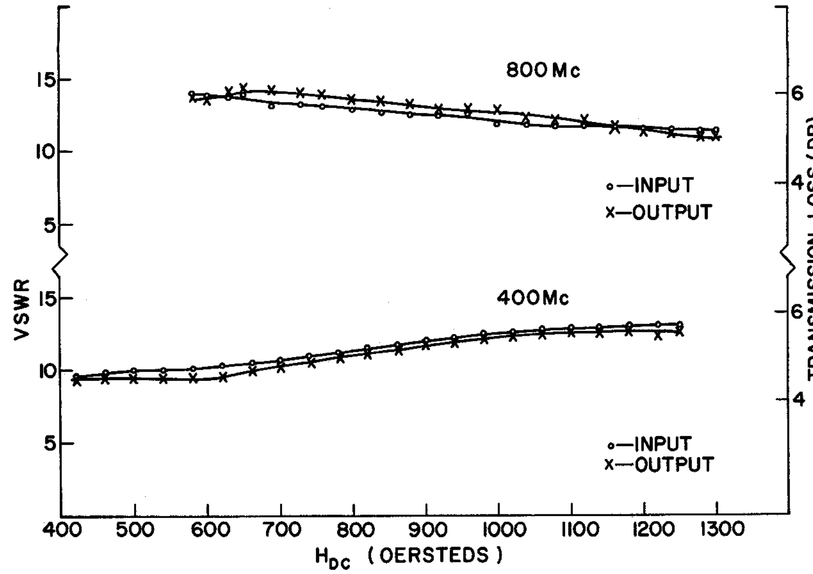


Figure 5. VSWR and Transmission Loss versus Applied Magnetic Field of Untuned YIG Delay Line at 400 and 800 mc

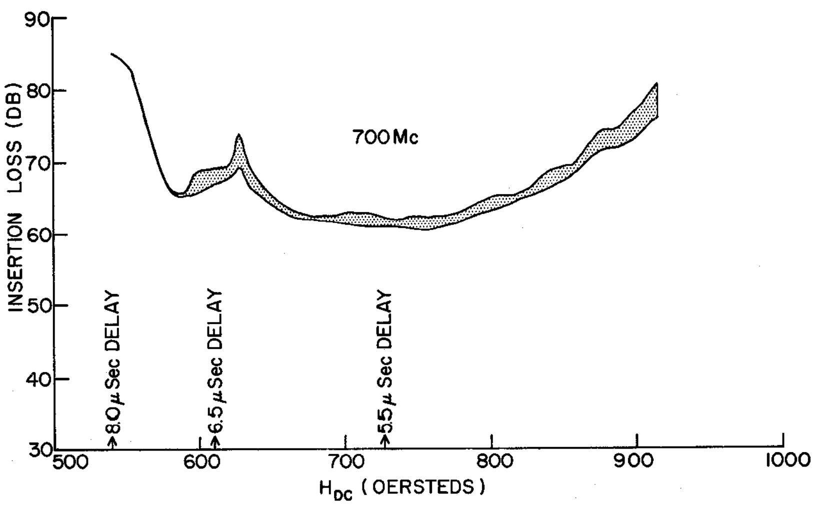


Figure 6. Insertion Loss versus Applied Magnetic Field for Tuned Delay Line Consisting of Two Bonded Single Crystal YIG Rods at 700 mc

## REFERENCES

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