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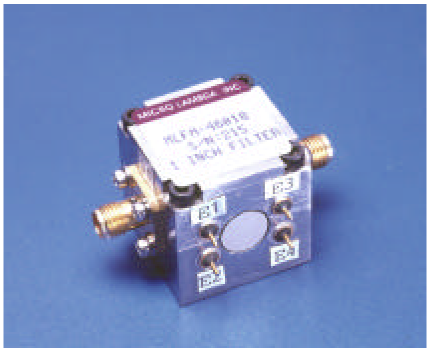

YIG-tuned Filters Shrink Size to 1" Cubes

Yttrium-iron-garnet (YIG) filters are widely used in microwave receivers, test instrumentation and various military applications because of their wide tuning ranges. While YIG filters traditionally use electromagnetic tuning coils, their size has remained relatively large in comparison to the latest YIG oscillator trends. Three- and four-stage YIG filters in 1.2" and 1.4" cubes have been available for some time. Newly developed YIG filter designs yield filter sizes in 1" cubes compatible with currently available 1" cube oscillators.

While the size of these filters has been reduced, the performance has not been compromised. With main coil sensitivities of 18 to 20 MHz/mA and coil resistance of 8 Ohms, the MLFM series of 1" cube filters are compatible with industry-standard, larger designs.

YIG Filters

A simplified cross section of a typical YIG filter is shown in Figure 1. The RF input and output are isolated from one another. All of the RF energy at the resonant frequency must be coupled through the YIG resonators. Off-resonant frequencies are rejected. The frequency of operation is controlled by the density of magnetic flux generated by the electromagnetic coils placed on both sides of the YIG resonators. The electromagnet is constructed utilizing self-shielding outer shells with a magnetic return path to increase its efficiency and reduce effects of external magnetic fields.

Tuning Characteristics

The tuning sensitivity of the filter's electromagnetic coil current is typically set at 18 to 20 MHz/mA. The electromagnet is designed using high permeability iron core to provide a linear increase of magnetic flux at the pole piece gap with a linearly increasing current in the electromagnetic coil. The magnetic structure is designed to provide low hysteresis and a low change of permeability with temperature. The design of the magnetic structure must take into consideration any change in the gap dimension that might occur with a change in the operating temperature. The design of a typical filter utilizes a two-piece magnetic structure where an upper magnet is bolted to the bottom magnet, clamping the inner magnetic pole structure in place (see Fig. 1). This 1" cube filter design uses a one-piece top magnetic structure, which eliminates the number of mechanical parts in the filter, making it a more ruggedized design.

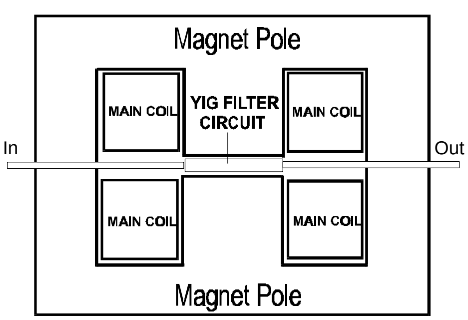

Fig. 1: A typical YIG filter with two piece magnetic structure

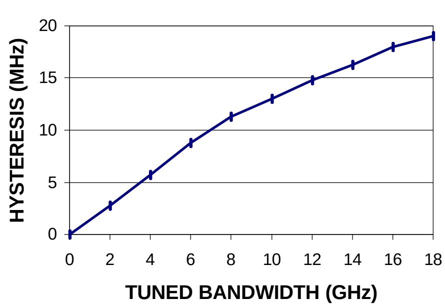

Fig. 2: Hysteresis .vs. Tuning Range

Hysteresis

The effects of hysteresis are shown in Figure 2. Bi-directional tuning to the ends of the frequency range will yield the frequency error shown at the center of the frequency range. The worst condition is tuning from one band end to the other. Smaller tuning steps will produce smaller hysteresis and nonlinearity frequency errors.

Linearity

YIG filters are designed to assure that the high permeability shell of the electromagnet is never magnetically saturated in the tuning range to be covered. This condition eliminates nonlinearities in tuning that might develop.

Temperature Drift

The effects of magnetic shell permeability changes and magnetic gap variations are eliminated as temperature dependent elements in a well designed filter structure. Temperature performance is obtained by orienting the YIG spheres in the magnetic field so that the temperature variations of the internal magnetic field do not affect the filter frequency. Typical YIG filters utilize self-regulating heating elements attached to each of the YIG sphere dielectric mounting rods to control the temperature of the resonator. The heaters are thermally isolated so that only the rod and the sphere are -->>>

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heated. This temperature control prevents changes in the limiting characteristics and bandwidth of the filter as the saturation frequency of the YIG resonator increases with reduced temperatures. The temperature of the heater is adjusted to keep the YIG sphere at a temperature above the highest operating temperature expected. The 1" cube filters utilize fewer heater elements to maintain the same temperature conditions with less heater current required.

Bandwidth and Insertion Loss

The minimum 3 dB bandwidth is controlled by the loss characteristic (unloaded Q) of the YIG resonator. Maximum 3 dB bandwidth is limited by how tightly the RF circuit can be coupled to the YIG resonators. Tight coupling increases the insertion loss substantially. Figure 3 shows the 3 dB bandwidth and insertion loss characteristics of a 1" cube 6 to 18 GHz filter at 12 GHz.

Skirt Selectivity

Figure 4 shows the difference in rejection with the increase in the number of YIG resonator filter stages. Increased rejection increases the insertion loss but provides enhanced off-resonance isolation. These specifications are sufficiently accurate to use in preliminary systems design. Currently, the 1" cube filter design is limited to a maximum of four stages due to the mechanical size constraints.

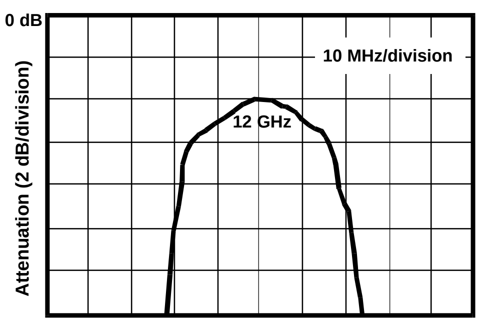

Fig. 3: Typical 3 dB bandwidth and insertion loss at 12 GHz.

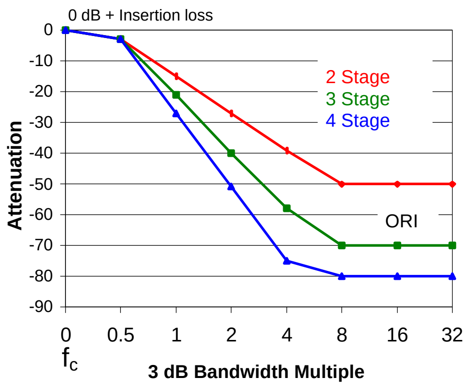

Fig. 4: Filter skirt selectivity and off-resonance isolation (ORI) for 2, 3 & 4 stage filters.

MLFM Series Performance

The MLFM series YIG filters operate over the 500 MHz to 18 GHz frequency range and are available with 3 dB bandwidths of 15 to 25 MHz. They provide linearity of ±4 MHz (max) for the 0.5 to 2 GHz frequency band and ±15 MHz (max) for the 6 to 18 GHz band. The filters have low insertion losses of 6 to 7 dB (max), flat responses of 1.5 to 2 dB over the frequency range and off-resonance isolations of 50 to 80 dB (min).

Conclusion

These filters can reduce the size of the current system designs, as well as the next generation system designs. This miniature line of filters is ideal for use in portable test sets, miniature receivers and small microwave test equipment applications. Filters are available at customer specified frequencies in 30 to 45 days.

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