A Miniaturized Low-Spurious 1.9 GHz MSW Band-Pass Filter using YIG Resonators with Multi Metal Rings

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Abstract

A new simple technique of forming multi metal rings on both sides of YIG element have been developed to suppress the spurious responses of YIG resonators effectively. By using this resonator, a 10×5×4 mm³ two-stage MSW band-pass filter has been developed. The insertion loss is about 2 dB at 1.9 GHz, and the suppression of spurious response is 25 dB.

1. Introduction

MSW filter is greatly promising as a key component to improve the performance of microwave telecommunication systems.

So far, MSW band-pass filters(BPF) using a delay line or resonators have been reported.[(1)-(3)] We have previously reported a low-loss(less than 3 dB) and high-attenuation(more than 40 dB) delay line type MSW BPF.[(4)] Its size was large(20×20×20 mm³), because a longitudinal of YIG element(1×10 mm²) was required to suppress the pass band ripple caused by TTE(triple transit echoes) of MSW. Its size was hardly small enough for the trend of small size microwave telecommunication sets.

On the other hand, a resonator-type MSW which had great advantage of reducing the size of YIG element, because it was possible to design pass band ripple which was independent of the size of YIG element. However, a serious disadvantage to this type was the high-level of spurious response generated by MSW higher-order modes.

As it was the most important to reduce a dimension of MSW filter, we have researched effective and simple technique to suppress the spurious response of resonator type MSW. As a result, a new technique of forming multi metal rings on the surface of YIG elements have been developed. And using these YIG elements, we have developed a miniaturized low spurious MSW BPF which has a dimension of 10x5x4 mm³.

Firstly, the effect of multi metal rings for suppressing spurious response generated by the higher-order modes will be discussed. Secondly, the construction and the performance of two-stage BPF using these resonators will be described.

2. Construction of the YIG resonator and the effects of multi metal rings (MMR)

Fig.1 shows the characteristics and constructions of four kinds of YIG resonators. The resonator consists

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of a YIG element and input and output transducers. Two transducers crossed each other are located 100 μm above YIG element with MMR or a metal disk on a surface. The MMR are fabricated by vacuum evaporation and are concentrically located on the center of the YIG elements. An insulator is put between transducers. The size of the YIG element is 2×2 mm^2. The thickness of the YIG is 100 μm. The material used in this experiment is a single crystal yttrium iron garnet (YIG) film that are grown by liquid-phase-epitaxy (LPE) on a single crystal gadolinium gallium garnet (GGG) substrate. Magnetic bias field (Hex) is applied normally to the YIG element to excite magnetostatic forward volume wave (MSFVW). The strength of Hex is tuned to obtain the resonant frequency of 1.9 GHz.

The resonant characteristics of with and without a metal disk and MMR on YIG element are compared so that the effect of MMR will be made evident. Figs.1(a)-(d) show resonant characteristics of following four conditions respectively. Fig.1(a) is an example using a YIG element without MMR. Many spurious responses are excited, and the suppression ratio is only 3 dB. Fig.1(b) shows an example of a metal disk formed on YIG proposed by Tsutsumi[2]. The suppression ratio of spurious is 8 dB. Fig.1(c) shows the resonant characteristics of a YIG element with MMR on surface. Fig.1(d) shows an example of a YIG element with MMRs on surface of both sides(one of MMR is formed on the GGG surface with thickness of 50 μm). As shown in Figs.1(c) and(d), the suppression ratios of spurious response are 13 dB and 20 dB

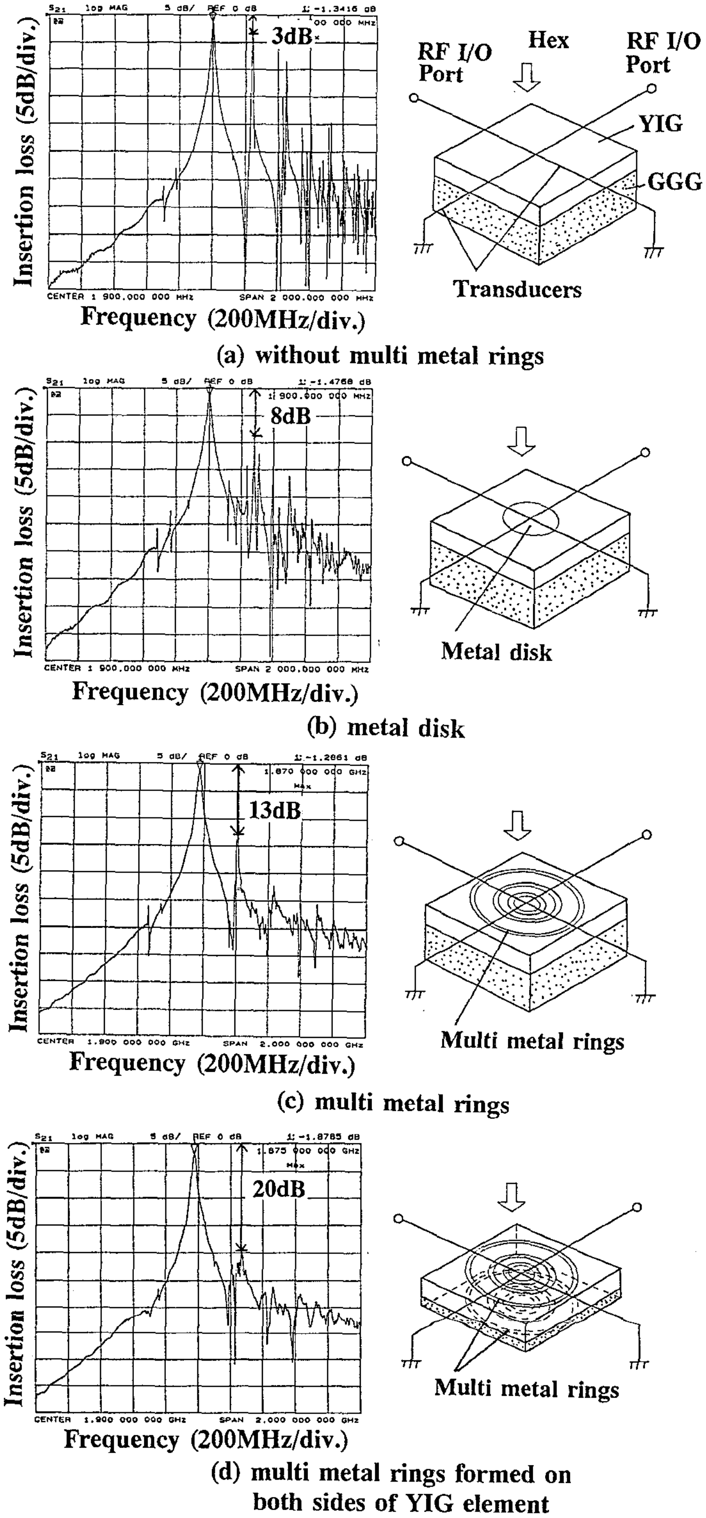

Fig.1 YIG resonator characteristics and constructions

respectively. Even if the thickness of GGG is 50 μm, the effect of MMRs is strong because it is considered that the MSW energy leaked from the surface of YIG element exit. Insertion loss in all cases is less than 2 dB.

Taking above into account, the energy of the higher-order standing modes is consumed only by MMRs, and the frequency and the level of return loss (S_{11}) of the spurious does not change even if MMRs are formed on YIG element. Therefore, the insertion loss of principal mode does not increase.

As described above, it is concluded that a resonator with MMRs formed on both surfaces of YIG element is most suitable for constructing BPF.

3. Construction and characteristics of MSW band-pass filter

Fig.2 shows the construction of MSW band-pass filter using two YIG resonators with MMRs on both surfaces.

The yoke is made of iron. Two rare-earth magnets are located on top and bottom of interior walls of the iron yoke. A resonator holder is located between the magnets. In this holder, two resonators are located. The coupling between resonators is controlled by a copper wire.

The transmission characteristics of two-stage BPF is shown in Fig.3. Insertion loss is about 2 dB at 1.9 GHz, and the suppression ratio of higher-order modes is 25 dB. This suppression ratio is achieved by two resonators with triple metal rings on both sides of the YIG elements. The group delay characteristics is shown in Fig.4. The delay time is 10±5 ns within 34 MHz band-width.

Fig.5 shows input-output power characteristics.

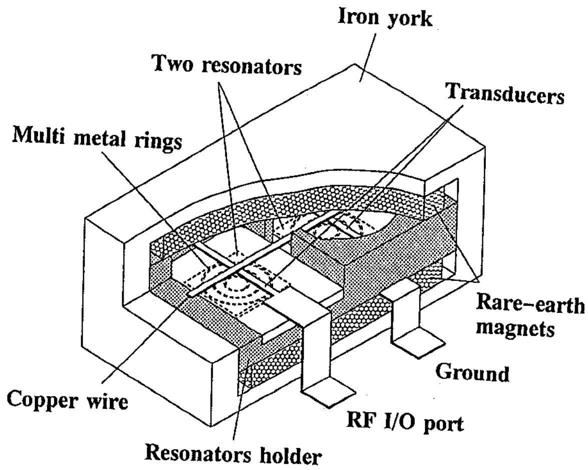

Fig.2 Construction of the MSW filter

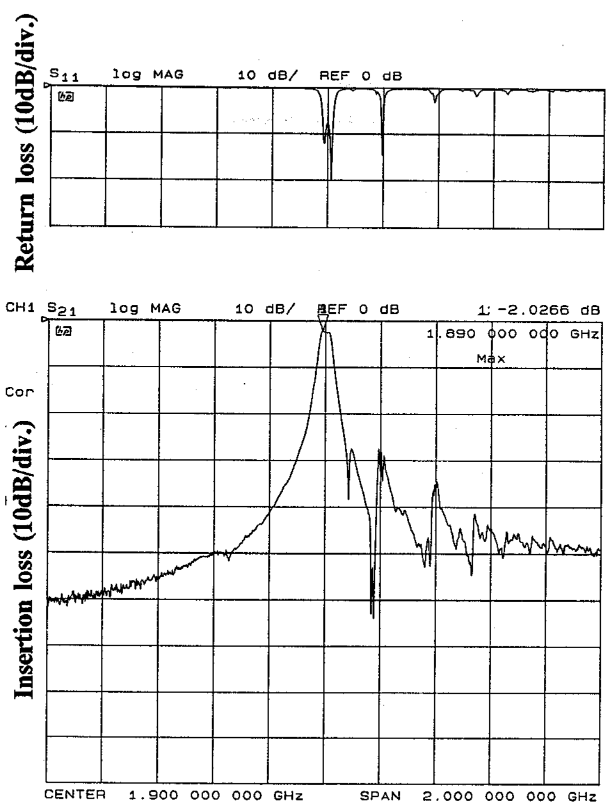

Fig.3 Transmission and reflection responses characteristics

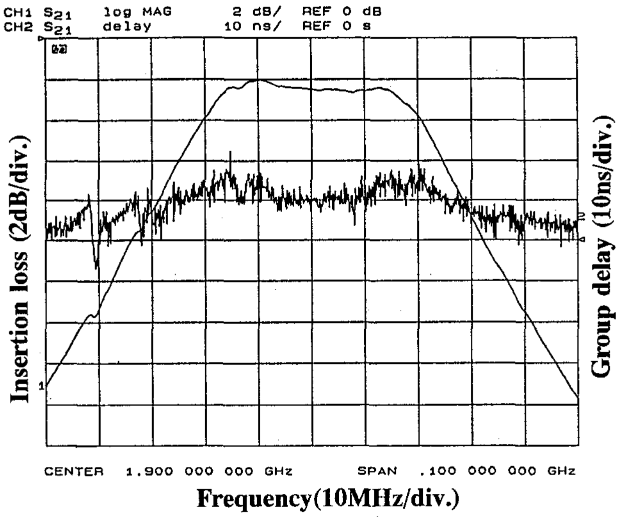

Fig.4 Group delay vs. frequency

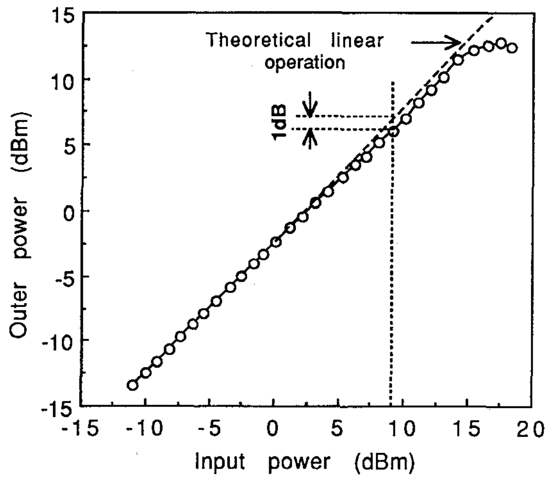

Fig.5 Input-output power characteristics

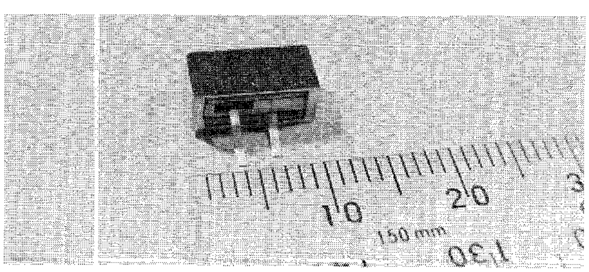

Fig.6 Appearance of the MSW filter

1 dB compression happened for an input power of +9 dBm, and limiting is observed for input power levels greater than +15 dBm. Fig.6 shows the appearance of the MSW filter.

4. Conclusion

We have developed a 10×5×4 mm^3 two-stage MSW band-pass filter. The insertion loss was about 2 dB at 1.9 GHz, the suppression ratio of spurious response was 25 dB. To achieve this suppression ratio, a new technique of forming MMR on both sides of the YIG element have been developed. Evaluating a single YIG resonator, the suppression ratio of the spurious response was 3 dB without MMRs on YIG element, but it was 20 dB with MMRs on both surfaces of YIG element.

This filter is useful for signal processing in the circuit of portable microwave telecommunication sets because of its compact dimensions and excellent filter characteristics.

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Reference

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