B-6

Mechanically tunable MSW bandpass filter with combined magnetic units

Y. Ishikawa, T. Nishikawa, T. Okada, S. Shinmura,
Y. Kamado, F. Kanaya and K. Wakino

Murata Manufacturing Company Limited
Nagaokakyo, Kyoto, Japan

Abstract

An MSW bandpass filter with combined magnetic units composed of main and sub magnetic units has been developed. Its volume is reduced to one-fifth compared to conventional YIG-sphere filters. The filter can be tuned mechanically and keep the same shape of transmission response in 2.5～2.75 GHz. The insertion loss can be kept less than 3dB within 20MHz bandwidth by adjusting the magnetic field distribution.

1. Introduction

MSW filters are greatly promising as the key component to increase the performance of microwave telecommunications. We have previously reported(1) that the insertion loss of the MSW YIG-film filter can be lowered by parallel strip transducers in an electromagnet. The size of a conventional YIG-sphere filter is mostly more than 35×35×35mm, and the component used for microwave circuits is required to be still smaller-sized.

We have developed a small-sized MSW filter, which has the construction added a complimental magnetic unit(sub magnetic unit) to a main magnetic unit. We call it combined magnetic units. The construction of the units contribute to lower the insertion loss and to suppress the higher-order mode.

The volume of this filter is one-fifth of the conventional YIG-sphere filter. Its tuning frequency range is 2.5～2.75GHz and its bandwidth is 20 MHz.

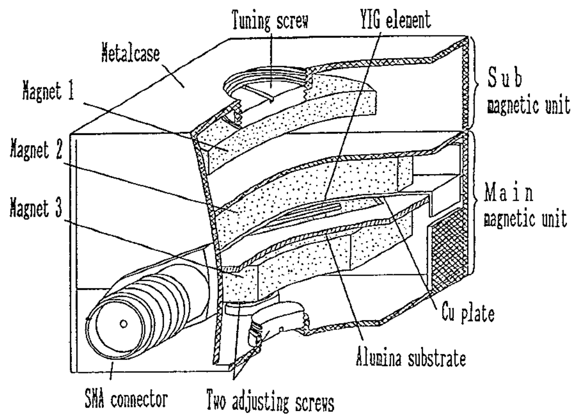
The insertion loss and the magnetic field distribution of the units are discussed, and the device characteristics is described.

2. Construction

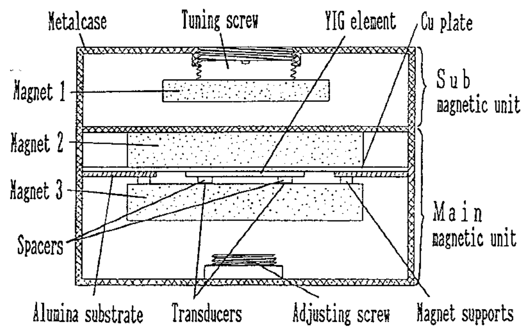
The construction of the filter is shown in Fig.1(a). The combined magnetic units are composed of a main magnetic unit and a sub magnetic unit. The main magnetic unit consists of two square ferrite magnets and two adjusting screws, which is placed on diagonal of a metal case. These screws contribute to lower the insertion loss and to suppress the higher-order mode. The YIG element is placed on a copper plate with an alumina substrate. The YIG element and two adjusting screws meet at right angle with each other. The sub magnetic unit consists of a metal case and a tuning screw with a ferrite permanent-magnet. The sub magnetic unit changes the magnetic field between magnets in the main magnetic unit.

A cross section of the MSW filter is shown in

Fig.1(b). The magnetic field is applied perpendicular to the YIG element to excite MSFVW. A 50μm-thick transducers are connected with SMA connectors through an alumina substrate.
The size of this filter is 20×20×20mm.



(a) Interior of an MSW filter



(b) Cross section of an MSW filter

Fig.1 Construction of an MSW filter

3. Magnetic-field distribution calculated by FEM

The distribution of the magnetic field applied to the YIG element is calculated by a numerical analysis using Finite Element Method, which is a method to solve Poisson equation numerically. The uniformity of the magnetic field is evaluated by calculating the degree of field degradation at point A (the edge of YIG), as shown in Fig.2 and Fig.3. Fig.2 shows the magnetic field distribution of a conventional magnetic unit. The degree of field degradation at g=1.3mm and g=2.3mm are 1% and 3%, respectively. Where g is the air gap between magnets. Fig.3 shows the magnetic field distribution of the combined magnetic units. The degree of field degradation at s=0.5mm and s=2.0mm are both 0%. Where s is the distance between magnet 1 and magnet 2 at g=1.3mm.

These values suggest that the combined magnetic units are effective to obtain a uniform distribution of the magnetic field. Even if the field strength is changed, this uniformity is maintained.

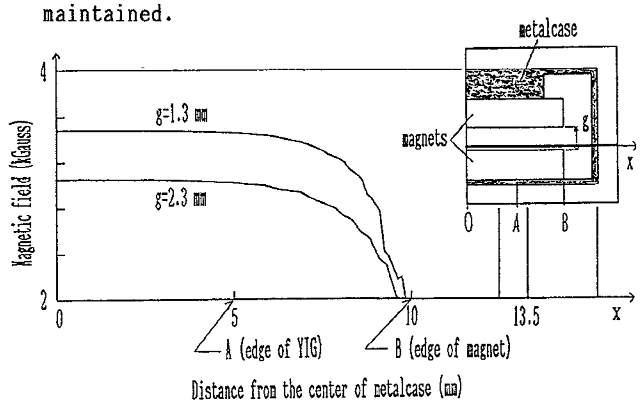


Fig. 2 Magnetic field distribution of a conventional magnetic unit

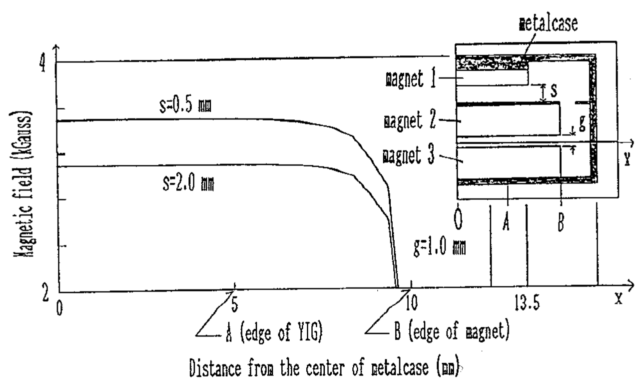


Fig. 3 Magnetic field distribution of a new magnetic unit

4. Device characteristics

The characteristics of the filter is shown in

Fig.4. The field distribution of magnetic-field was adjusted to an optimum condition by two adjusting screws. The insertion loss was 3dB within 20MHz bandwidth and the suppression ratio of higher-order mode was 40dB.

The group delay characteristics is shown in Fig.5. The delay time was 32±5nsec within 20MHz bandwidth. The time domain response (Fig.6) shows the first signal pulse at 26nsec, the third traveling echo (TTE) pulse at 78nsec, and no reflection echo pulse from the edge of the YIG element. Suppression ratio of TTE

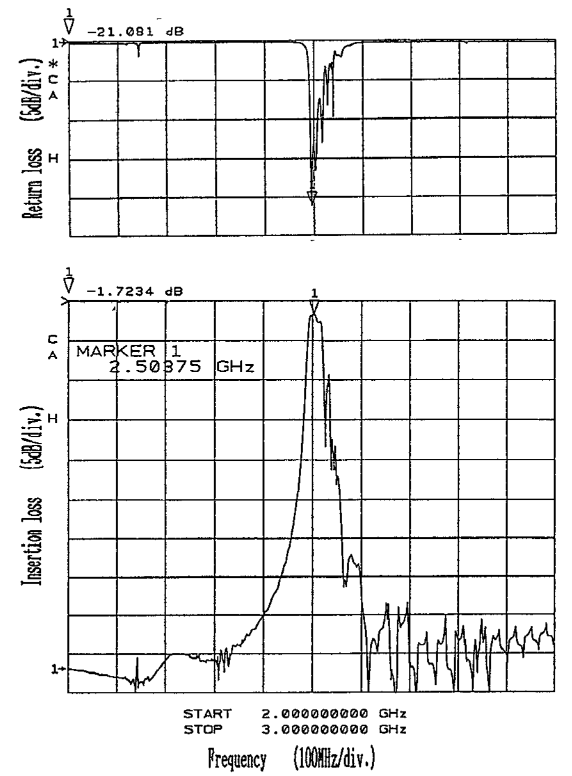


Fig.4 Transmission and reflection responses characteristics

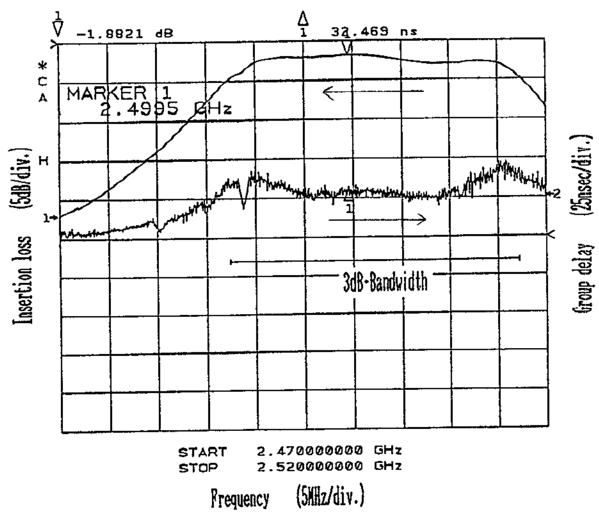


Fig.5 Group delay vs.frequency

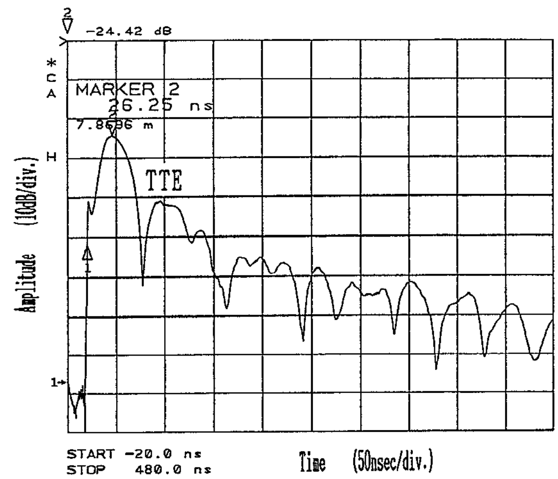


Fig.6 Time domain response

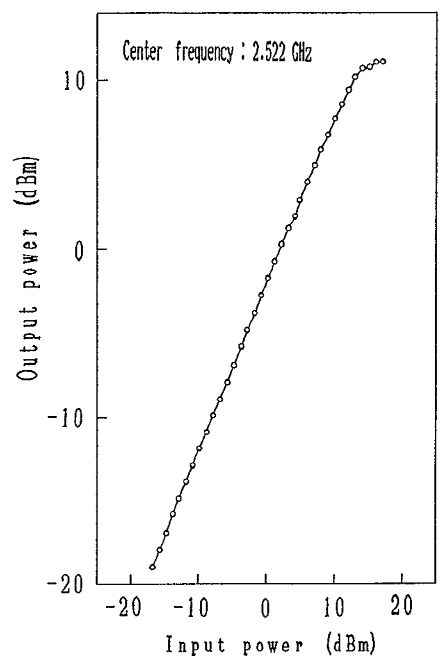


Fig.7 Input-Output power characteristics

pulse was -18dB. TTE caused passband ripples. The input-output power characteristics is shown in Fig.7. 1 dB compression happened for an input power of +9dBm, and limiting level was input power greater than +11dBm.

Fig.8 shows the transmission responses in the range between 2.5 and 2.75GHz. Three different magnetic bias fields were applied by adjusting the tuning screw. Fig.9 shows the appearance of the MSW filter.

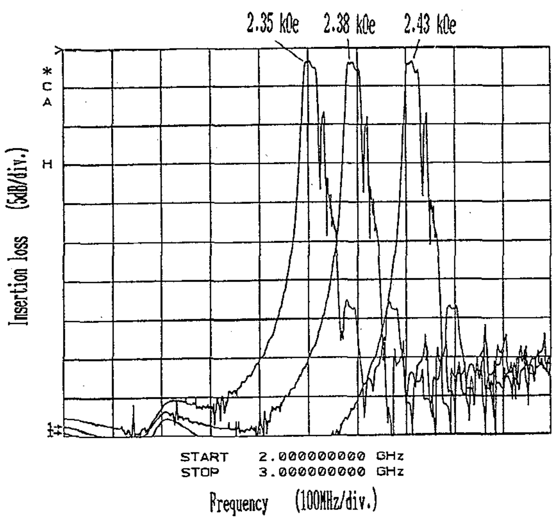


Fig.8 Transmission responses of the MSW filter at 3 different bias fields

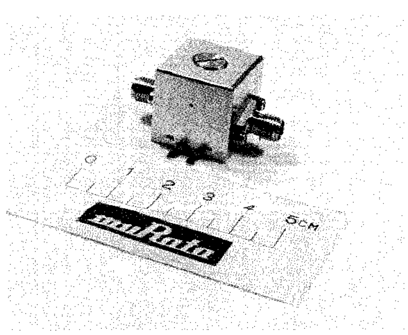


Fig.9 Appearance of the MSW filter

5. Conclusions

We have developed the 20×20×20mm MSW band-pass filter with the permanent magnets to apply magnetic field to the YIG element. The combined magnetic units were effective to obtain the uniform magnetic field. This uniformity was maintained even if the field strength was changed. For this reason, the filter could maintain the same shape of transmission response even if the center frequency was changed by a tuning screw. The insertion loss was 3dB within 20MHz bandwidth and the suppression ratio of higher order mode was 40dB when the field distribution was optimized by two adjusting screws.

This filter is useful for signal processing in microwave circuits because of its compactness and excellent filter characteristics.

Acknowledgement

The authors wish to thank Professor M. Tsutsumi of Kyoto Institute of Technology for his valuable comments and cotinual encouragement throughout the development of this filter.

Reference

(1) T. Nishikawa, H. Tanaka, S. Shinmura and Y. Ishikawa, "A low-loss magnetostatic wave filter using parallel strip transducer.", 1989 IEEE MTT-S Digest,p.p.153～156.