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A GROOVED MONOBLOCK COMB-LINE FILTER SUPPRESSING THE THIRD HARMONICS

Yoji Isota, Moriyasu Miyazaki, Osami Ishida, Fumio Takeda

Mitsubishi Electric Corporation
5-1-1 Ofuna,Kamakura-City,
Kanagawa Prefecture 247,Japan

ABSTRACT

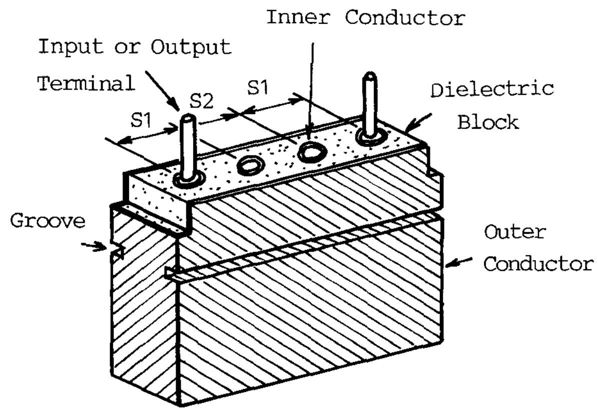
A grooved monoblock comb-line filter has been developed. By putting the grooves on the outer surfaces of dielectric block, the second passband is shifted to the higher frequency than the third harmonics. So this filter is very effective for suppressing the third harmonics, besides these grooves are effective for inter-resonator coupling.

INTRODUCTION

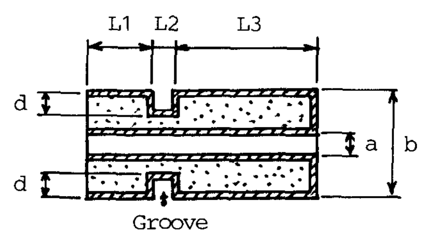
In mobile communications, compact and low cost radio equipments are required. As transmitting and receiving filters at radio frequency occupy a large part in the equipment, so it is significant to reduce filter size.

Conventionally, comb-line type filter with quarter wavelength resonator is used as Tx and Rx filter. But this filter has a second passband at the third harmonics, so the third harmonics generated in nonlinear circuits such as oscillators and amplifiers cause spurious radiation. Moreover, as the quarter wavelength resonators are short-circuited at same sides, enough inter-resonator coupling is not obtained without coupling elements.

In this paper, the grooved monoblock comb-line filter which has solved the above problems is presented. The grooves which are put on the outer surface of dielectric block as shown in Figure 1 make the second passband shift to higher frequency than the third harmonics and suppress the third harmonics to make spurious radiation. Moreover, they provide enough inter-resonator coupling.



(a) Monoblock-Dielectric-Filter



(b) Cross-Section of Filter.

Fig.1 Configuration of filter.

This filter was fabricated at UHF band, and volume of this filter was only 2 cc. Spurious suppression of 45 dB at the third harmonics was obtained. These results show good coincidence with theory.

CONFIGURATION

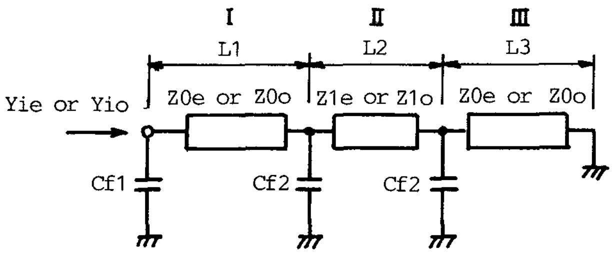
Figure 1 shows the configuration of the grooved monoblock comb-line filter. Holes and a pair of grooves are provided in a dielectric block. Inner surfaces of the holes and outer surfaces of the block except the upper surface are metalized. The metalized holes operate as inner conductors of the filter. The hole length is nearly quarter wavelength of the fundamental wave.

The grooves are provided at the position where the magnetic field of the third harmonics is maximum and the electric field of fundamental wave is fairly large. As a result, the second passband shifts to higher frequency and fundamental passband shifts to lower frequency. So, the third harmonics are suppressed. Moreover as the resonator becomes shorter than a quarter wavelength at fundamental wave, magnetic inter-resonator coupling are obtained.

THEORETICAL CONSIDERATION

Figure 2 shows the equivalent circuit of coupled resonators with the grooves. Zoe and Zoo are the even and odd mode characteristic impedance of the coupled resonator. The resonant frequency fr and the inter-resonator coupling coefficient K are obtained from Figure 2[1]:

$$fr = \frac{fe + fo}{2} \qquad (1)$$



Yie,Yio ; input admittance
Z0e,Z0o ; characteristic impedance of section I and III [2]
Z1e,Z1o ; characteristic impedance of section II
Cf1 ; fringing capacitance[2]
Cf2 ; capacitance of discontinuity[3]

Fig.2 Even and Odd mode equivarent circuit of coupled resonator with groove .

$$K = \frac{2(fo - fe)}{fe + fo} \qquad (2)$$

where fe ,fo are the resonant frequencies of even and odd mode respectively, and obtained from following equations.

$$Yie(fe) = 0$$
$$Yio(fo) = 0 \qquad (3)$$

In Figure 3 and 4, calculated and experimental values of coupling coefficient K and resonant frequencies are shown as function of groove depth. In calculation, the fringing capacitance Cf2 is assumed to be a half of coaxial discontinuity capacitances[2],[3]. From the figures, it is seen coupling coefficient and resonant frequencies can be adjusted by the groove depth.

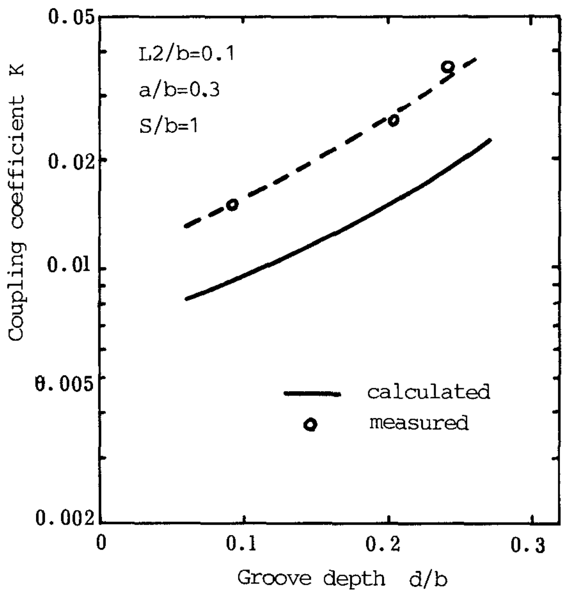


Fig.3 Coupling coefficient vs. groove depth.

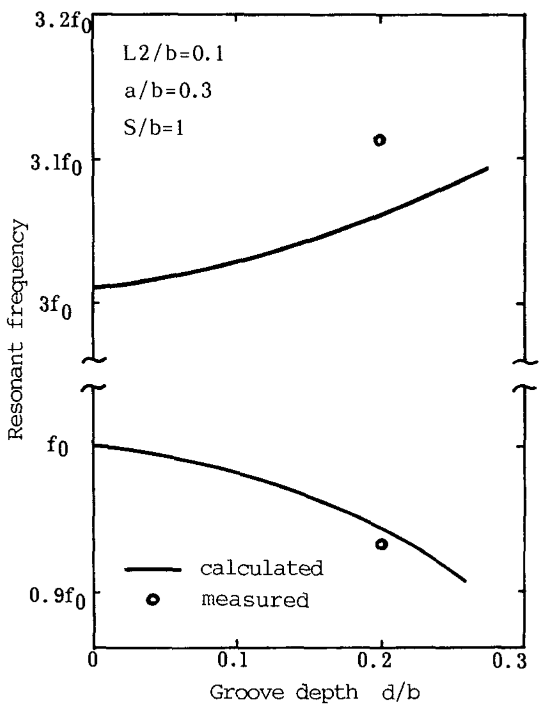


Fig.4 Resonant frequencies vs. groove depth.

EXPERIMENT

A grooved monoblock comb-line bandpass filter with four-stages Tchebyscheff response is fabricated in UHF band.

Figure 5 shows the photograph of the filter. The permittivity of the dielectric block is 81. The inter-resonator couplings required for the Tchebyscheff response are realized by changing the distance between inner conductors and the groove depth.

Figure 6 shows the frequency response of the filter. The insertion loss of the passband is 1.2 dB at the center frequency. Figure 7 shows spurious response. The second passband is shifted to the higher frequencies by 10 % and the attenuation at 3fo is 45 dB.

CONCLUSION

A grooved monoblock comb-line filter with insertion loss 1.2 dB, third harmonics suppre-ssion 45 dB and volume 2 cc has been developed. This filter is usefull for mobile communications.

REFERENCE

[1] Milton Dishal, "Alignment and Adjustment of Synchronously Tuned Multiple-resonant-circuit Filters,"Proc.IRE,pp.1448-1450,Nov. 1951.

[2] Matthaei,G.L.,Young,L.,and Jones,E.M.T., "Microwave Filters, Impedance-Matching Networks and Coupling Structure,"McGraw-Hill (1964).

[3] Cristal,E.G., "Coupled Circular Cylindrical Rods Between Parallel Ground Planes,"IEEE Trans.,MTT-12,July 1964.

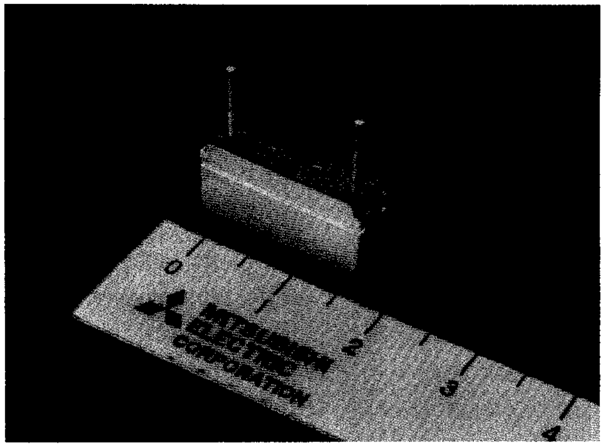


Fig.5 Photograph of the filter.
(without case)

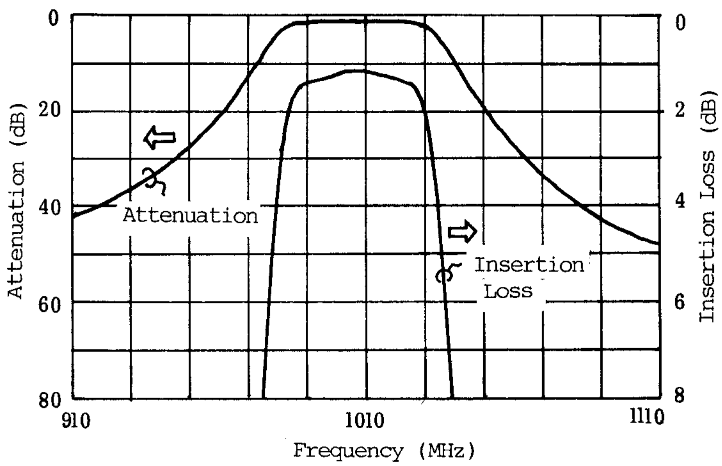


Fig.6 Measured frequency response of the filter.

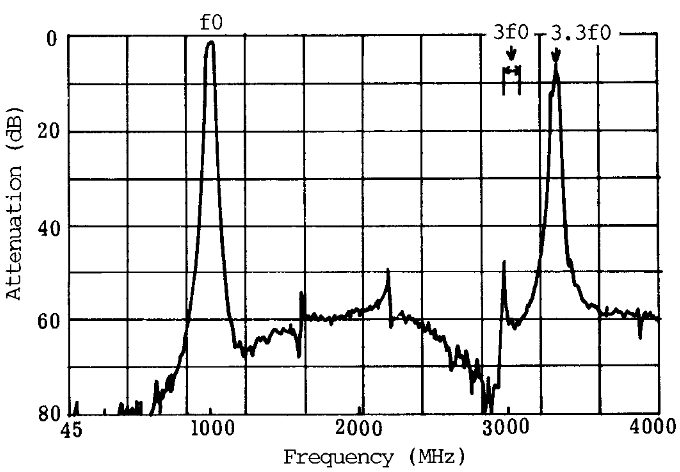


Fig.7 Measured spurious response of the filter.