A Miniaturerized Ceramic Bandpass Filter For Cordless Phone Systems

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ABSTRACT

Miniaturized band–pass filter, which size is 3.0mm x 2.0mm x 1.5mm, was developed by two different dielectric ceramics with low and high permittivities. The filter was constructed by putting strip line made by high permittivity ceramics(ε_r=75) between micro strip line made by low permittivity ceramics(ε_r=15). As its filter characteristics, two attenuation poles were observed at the lower frequency and higher frequency than the pass band. The reason for two attenuation poles' appearances was discussed using by the theoretical equivalent circuit.

INTRODUCTION

Recent advance in mobile communication systems, such as cellular phone system, cordless phone system and global positioning system, has dramatically increased in mobile communication users. In cellular phone system, more reduction of the size and weight for the users' handset is expected. Therefore, it is necessary to be miniaturized for electronic devices in handset. In particular, filters are one of the most critical components for size and weight efficiency. To satisfy this demands, we have developed a miniaturized ceramic bandpass filter(BPF), which size is 3.0mm x 2.0mm x 1.5mm as shown in Fig.1, constructed by two different ceramics with low and high permittivities. The volume of the developed BPF is only 30% of conventional BPFs. The filter was constructed by putting strip line made by high permittivity ceramics(ε_r=75) between micro strip line made by low permittivity ceramics(ε_r=15). In this paper, the performance of this miniaturized BPF was described and the reason for two attenuation poles' appearances was discussed using by the theoretical equivalent circuit.

DESIGN

An ideal 2–pole Chebyshev BPF was analyzed on the basis of a lumped equivalent circuit which consists of L element and coupled C element as shown in Fig.2(a). Distributed equivalent circuit of this filter is shown as Fig.2(b), which was constructed by coupling capacitor part and electromagnetic coupling part. Coupling capacitor part was strip line with high permittivity ceramics and electromagnetic coupling part was microstrip line with low permittivity ceramics. The filter was constructed by putting strip line structure between microstrip line structure as shown in Fig.3. The reasons for using high permittivity ceramics in coupling capacitor part and using low permittivity ceramics in electromagnetic coupling part were as follows. To miniaturize the filter in the distributed equivalent circuit as shown in Fig.2(b), characteristic impedance of coupling capacitor part will be decreased and its electromagnetic coupling part will be increased with decreasing unit line length. Table 1 shows the analytical results for the needed characteristic impedance of each element Z_0, when the electrical

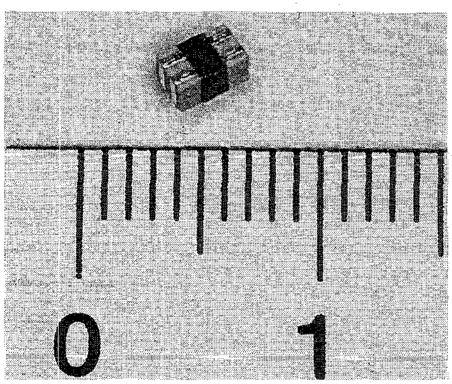

Fig.1 Outside view of the miniaturized filter

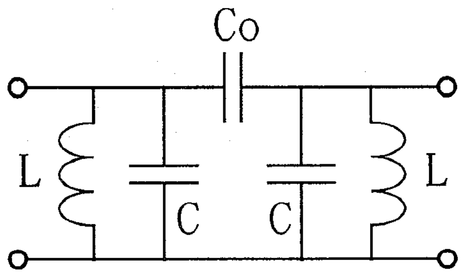

Fig.2 (a)Lumped equivalent circuit

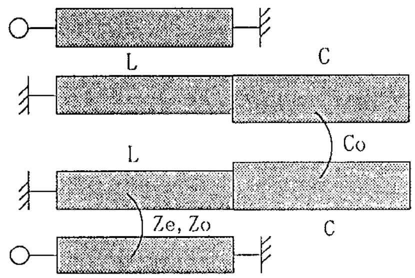

Fig.2 (b)Distributed equivalent circuit

length of each element is chosen to be λ /20. If the same permittivity ceramics were used for both of coupling capacitor part and electromagnetic coupling part, each electrode's widths were greatly different and the filter characteristics was worse. Different permittivity ceramics were used to uniform the electrode's widths and to get a better filter characteristics.

Table.1 Specifications of the miniaturized filter

the electrical length	characteristic impedance	
	L element	coupled C element
λ/20	52.71Ω	1.87Ω

EXPERIMENT

The L elements were formed as microstrip lines on Mg–Ti–O ceramics with ε_r of 15[1], while coupled C elements are realized as broadside coupled strip lines in Ba–Nd–Ti–O ceramic with ε_r of 75[2]. Both parts of strip line and microstrip line were formed separately and each part was connected to the ground electrodes. The frequency characteristics of this filter was measured by setting this filter on the microstrip line with 50 ohm which was constructed on the glass–epoxy substrate. The measured performance is shown in Fig.4. The insertion loss was less than 3.0dB at 1.9GHz. Two attenuation poles were observed at both higher and lower than the pass band in mesured performance but they were not

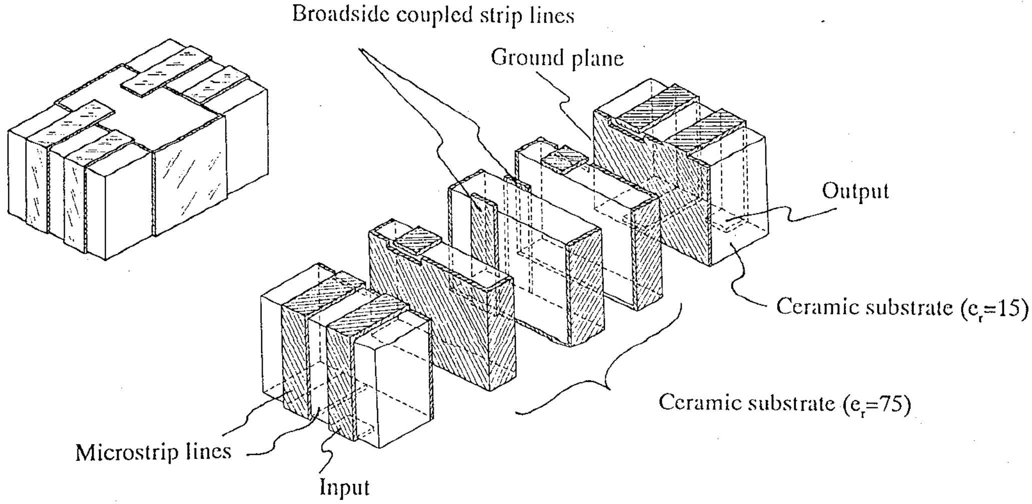

Fig.3 Structure of a miniaturized filter

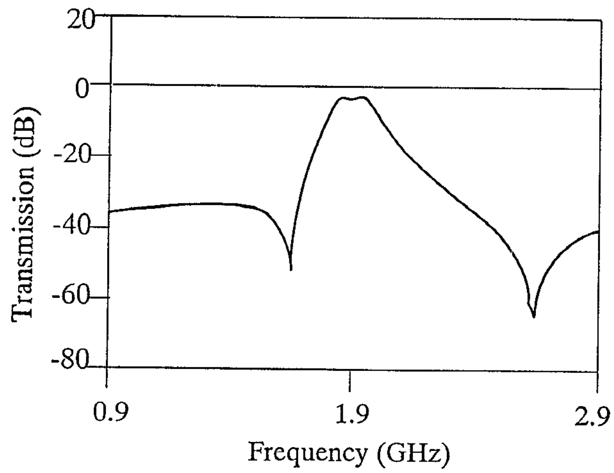

Fig.4 Measured performance

observed by the simulation as shown in Fig.5. The band width of mesured performance was wider than its simulated performance. No ripples such as harmonics was observed at between 0.1GHz and 10GHz.

DISCUSSION

The reasons for two poles' appearances at the out of the pass band in Fig.4 were studied by the calculation of equivalent circuit as shown in Fig.2(a). Ideal of the lumped equivalent circuit did not include the L or C that was effected by the structure of the filter and the electrode. The performance of the lumped circuits considering with L and C for the structure was calculated. As shown in Fig.6, L component, Lx, was connected sequentially to C. Lx

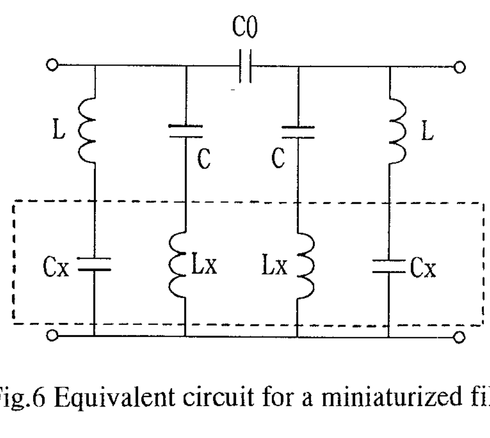

Fig.6 Equivalent circuit for a miniaturized filter

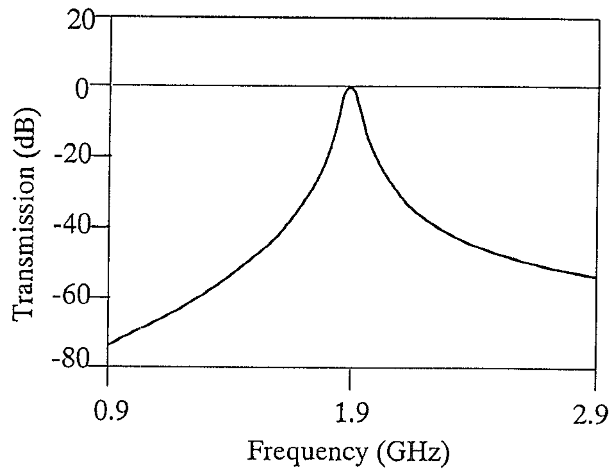

Fig.5 Simulated performance by the lumped equivalent circuit

corresponds to the length effect of the broadside coupled strip line in the coupling capacitor. C component, Cx, was connected sequentially to L. Cx corresponds to the capacitance at the corner of the filter due to the folding structure of the electrode as shown in Fig.3. Simulated performance for a miniaturized filter is shown in Fig.7. Two attenuation poles at higher and lower than the pass band were observed and the band width was wider than its simulation in Fig.5. These results were in good agreement with there measured performance in Fig.4.

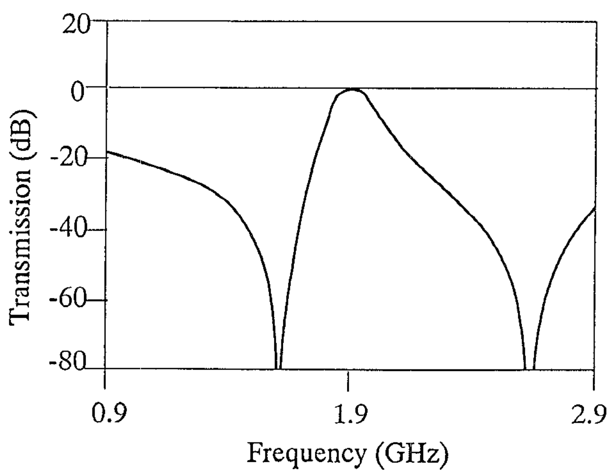

Fig.7 Simulated performance by the equivalent circuit for a miniaturized filter

This study showed that two poles at the higher and lower frequency than the pass band were respectively due to L and C components, which were based on the actual structure of our developed filter.

CONCLUSION

Miniaturized band–pass filter was developed by two different dielectric ceramics with low and high permittivities. No ripples such as harmonics were observed but two poles both outsides of the band pass of the filter were observed. These results suggested that the observed poles at the higher and lower frequency than the pass band frequency were originated from the actual structure of our developed filter.

REFERENCES

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[2] T.Okawa, H.Utaki, "The Development of a Multilayer Dielectric Filter Using Low Temperature Fired Microwave ceramic", The Sumitomo Search, No.47, pp117–121, October 1991