Compact Transmitting Dielectric Resonator Filter Using Capacitive Loaded Dual Mode Method For PCS Microcellular Base Station

Jun HATTORI, Hiroyuki KUBO, Shin ABE
Taiyo NISHIYAMA and Youhei ISHIKAWA

Murata Manufacturing Company, Ltd., Kyoto, Japan

ABSTRACT

This paper describes a compact transmitting bandpass filter using dielectric resonators for PCS microcellular base station. We propose new size reduced capacitive loaded TM dual mode resonators that consist of monoblock high K ceramics. The electrical performance of the filter constructed by these resonators is designed by using dual mode dielectric transmission line method. A six pole bandpass filter at 1.9GHz band is manufactured. It has center frequency of 1.87GHz, low insertion loss of 1.1dB and small dimensions of 20x20x60 mm.

1. INTRODUCTION

Recently digital wireless mobile communication systems are experiencing widely covered growth, and in North America PCS system is going to start. In this system, the filter used in microcell base stations have been more critical. The serious demands need the filters must have miniaturized size, high performance (low insertion loss and high attenuation), and low cost. To satisfy these demands we have previously developed high power dielectric filters at 800MHz [1][2] and 1.5GHz band, in which monoblock cubic type TM_{110} dual mode dielectric resonators are used. But now further size reduction, and more precise and quick design method are requested strongly.

To solve this problem, we have newly developed a capacitive loaded TM_{110} dual mode dielectric resonator technique. It has the volume of about 1/3 of conventional TM_{110} dual mode resonator. By using this resonator we have manufactured a new compact six pole bandpass filter at 1.9GHz band. For filter design the dual mode dielectric transmission line method we proposed[3] is adopted, precise and quick design procedure is established. The manufactured filter has the smallest size comparing with conventional filters, and sufficient electrical performances.

In this paper the construction and performance of a concave dual mode dielectric resonator, the bandpass filter design method, and the filter performances are discussed.

2. CAPACITIVE LOADED TM_{110} DUAL MODE DIELECTRIC RESONATOR

We have developed a new size reduced capacitive loaded TM_{110} dual mode resonator. The basic construction is shown in Figure 1. It consists of monoblock type ceramic material, of which K is 38 and tan δ is $5.5x10^{-5}$, and fired silver electrode is constructed on the outer surface. Crossed dielectric posts are arrayed at the center of cavity, and by groove portion at cross point electromagnetic coupling between two modes is caused. By four concavities constructed at side walls, additional capacitance between ground planes is loaded and resonant frequencies of dual mode are reduced.

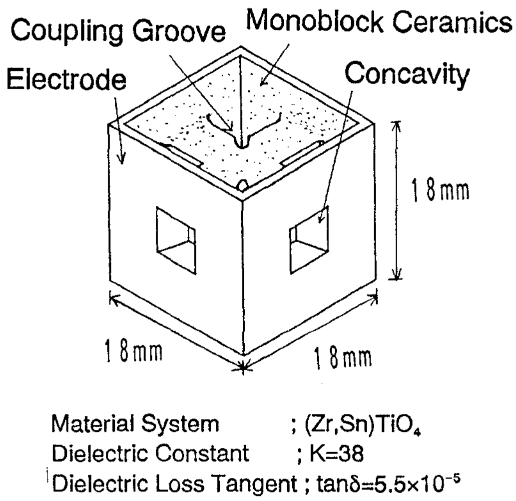

Fig.1 Basic Construction of Concave Type Dual Mode Dielectric Resonator

0-7803-3246-6/96/$5.00 © IEEE

TH 3F

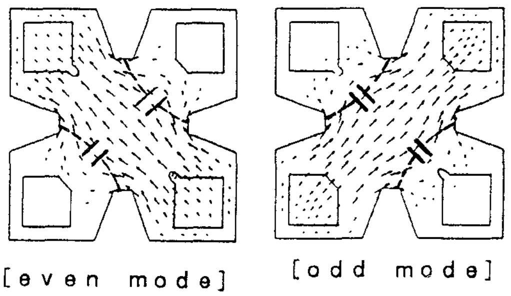

Fig.2 Electric Field Distribution of Dual Mode Resonance

Figure 2 shows electric field distribution of even and odd resonant mode in the cross section of the resonator. Physical dimensions are 18x18x18mm, volume is about 5.8cc. Unloaded Q is about 2200 at 1.9 GHz band, and degradation of unloaded Q caused by coupling is less than 5%. Weight is about 12g. At temperature range of -20 to 60 ℃, frequency deviation is less than 2%. Figure 3 shows the graph of relationship between unloaded Q, resonant frequency and concave depth of the resonator. As the depth becomes deeper, inloaded Q and resonant frequency become lower. In this time, we have selected the point of 4mm depth. Figure 4 shows the relationship between unloaded Q and volume for conventional resonant modes. This type resonator is found to be the smallest one in three type resonators (cavity reentrant, dielectric coaxial, dielectric TM dual). Figure 5 shows a photograph of the external view of the resonator.

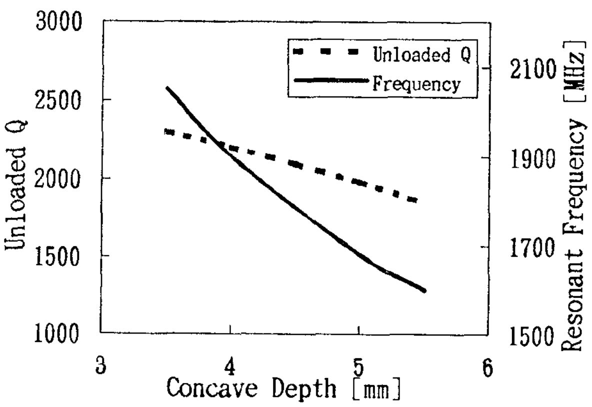

Fig.3 Unloaded Q and Resonant Frequency versus Concave Depth

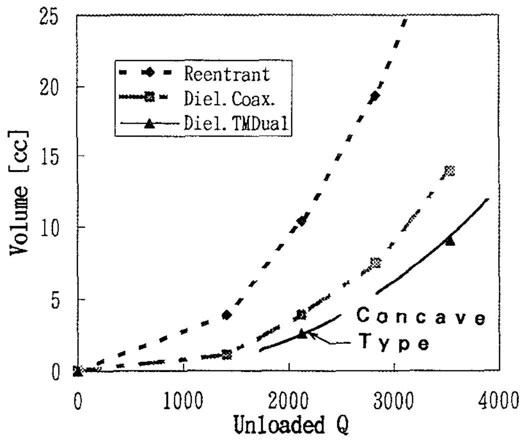

Fig.4 Relationship between Unloaded Q and Volume for Three Type Resonators

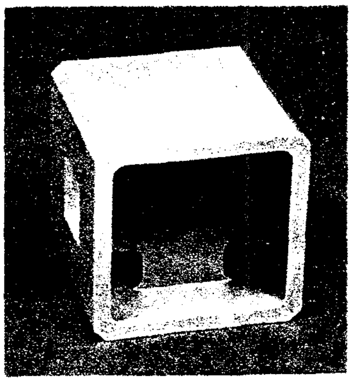

Fig.5 External View of Dual Mode Resonator

3. FILTER DESIGN USING DUAL MODE DIELECTRIC TRANSMISSION LINE METHOD

The dielectric bandpass filter is organized by arraying capacitive loaded TM_{110} dual mode dielectric resonators in a line. Figure 6 shows model construction of six pole bandpass filter. Between adjacent dual mode resonators thin metal plates with partially slitted electrode patterns are set, and control selective electromagnetic coupling of x and y directions. For coupling between a resonator and external load short ended metal loop is used, external Q is controlled according to loop size and angle. At the case of conventional filter design, values of design parameters (resonant frequency, coupling coefficient, etc.) are determined by individual measuring. But simulation accuracy and generality are insufficient.

To solve this problem we have proposed a new equivalent circuit for this construction shown in Figure 7 (a) and (b). The whole circuit is constructed as a series of some kinds of coupled dual mode transmission lines to z direction. A resonator part is divided to three kinds of parts, one is in propagation region of coupled modes and two are in cut off regions. Coupling parts of thin plates with slitted electrodes are represented by using large capacitances and inductances approximately. External coupling parts are represented by mutual coupling inductances approximately. Every parameters are related to three dimensional physical parameters and material parameters. By simulator analyzing of this circuit we can simulate electric performance.

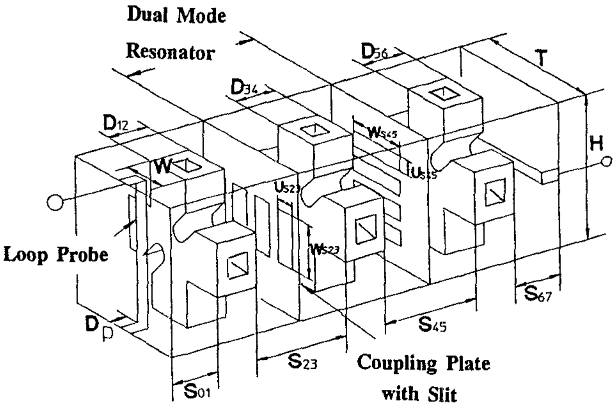

Fig. 6 Model Construction of Bandpass Filter

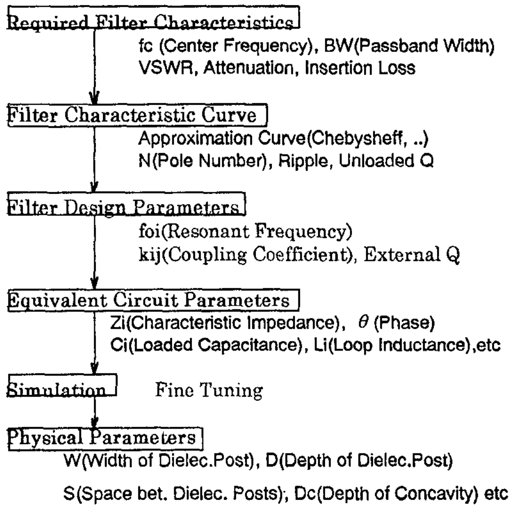

Fig.8 Design Procedure

For filter design, we transform this equivalent circuit to the basic filter circuit shown in Figure 7(a), and represent relations between two kinds of circuit parameters as functions. The basic filter circuit parameter values are calculated from required filter characteristics by using conventional Chebysheff design method[4], and according to these values equivalent circuit parameter values and furthermore physical parameter values can be determined. Figure 8 shows the design procedure. By this design technique more precise and quick design procedure has been confirmed.

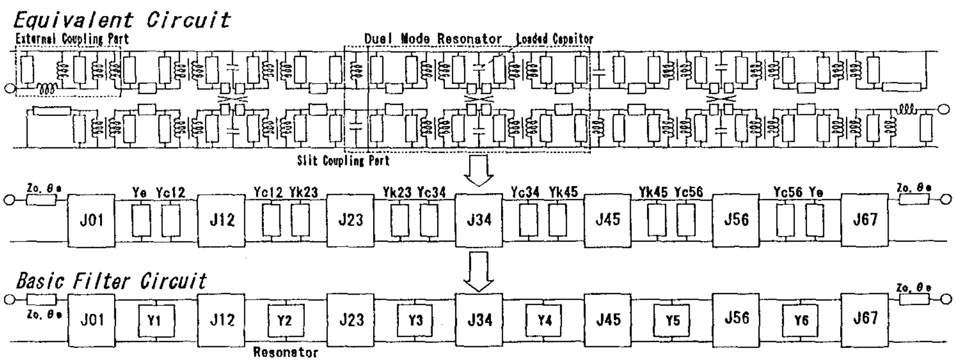

Fig.7 (a) Equivalent Circuit and Basic Filter Circuit

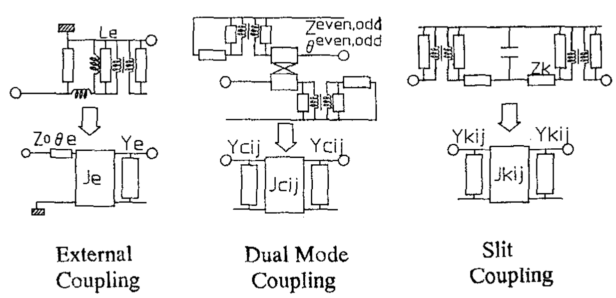

Fig.7 (b) Ciruict Transformation

4. BANDPASS FILTER CONSTRUCTION AND PERFORMANCES

Figure 9 shows the basic construction of the manufactured 6-pole transmitting bandpass filter. Three dual mode resonators are arrayed in a line, and fixed in the metal case. Thin plates with slitted electrodes are formed by silver metalized ceramic plates. Fine frequency tuning is performed by high K ceramic tuning rod. External coupling is realized by metal loop shape proves. Outer electrodes of resonators are grounded by soldering.

Figure 10 and Table 1 show the filter performances. The center frequency is 1870MHz, the band width is 45MHz, the insertion loss is 1.1dB, and return loss is 20dB. Attenuation at 1935MHz is 53dB. Measured response characteristics agree with the simulated data so much. The external dimensions are 20×20×60mm, volume is 24cc, and that is less than 30% comparing with conventional cavity resonator filters. Weight is about 50g. Maximum input power is over 20W, and intermodulation distortion power is sufficiently small Operating temperature range is -20 to 60℃ and humidity range is 20% to 95%. Figure 11 shows the external view of this filter.

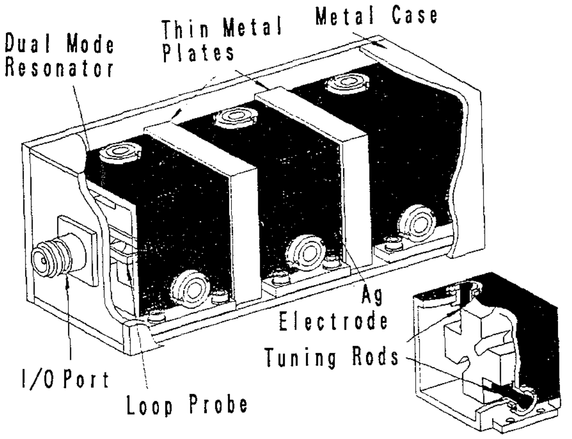

Fig.9 Basic Construction of Bandpass Filter

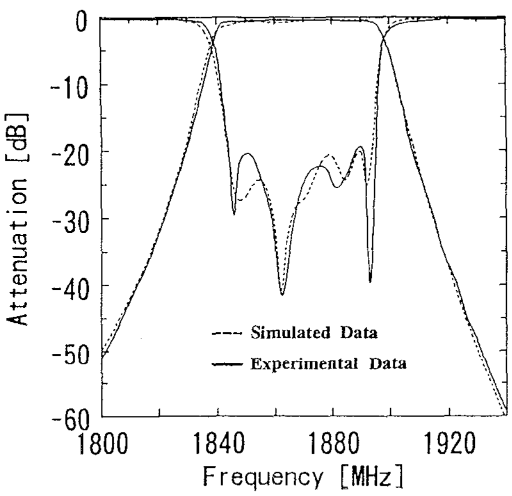

Fig.10 Electrical Filter Characteristics

Pole Number	6
Center Frequency	1870 Mhz
Passband Width	45 MHz
Insertion Loss	1.1 dB
Return Loss	20 dB
Attenuation	at 1935 MHz 52 dB at 1800 MHz 51 dB
Max. Input Power	20 W
Physical Dimensions	20x20x60 mm
Weight	50 g

Table 1 Filter Performance

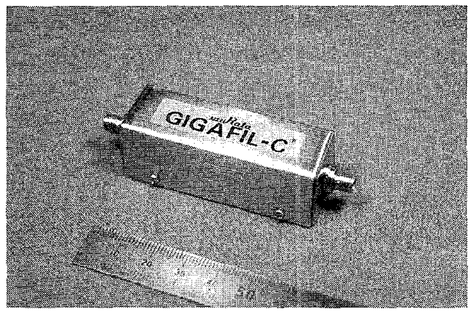

Fig.11 External View of Bandpass Filter

5. CONCLUSION

A new 1.9GHz band compact tranmitting bandpass dielectric filter has been developed. Dielectric resonators are monoblock capacitive loaded TM_{110} dual mode type, and have small volume of 5.8cc and high unloaded Q of about 2200. For filter design and simulation, we proposed a precise design method using dual mode dielectric transmission line technique. We manufactured a six pole bandpass filter, which has small volume of 24cc and low insertion loss of 1.1dB. This filter is sufficiently useful for PCS digital communication system.

REFERENCES

[1] T.Nishikawa,et al.,"800MHz High Power Bandpass Filter Using TM Dual Mode Dielectric Resonators" Proc. 21st EuMC pp.1047,1991.
[2] Y.Ishikawa,et al.,"800MHz High Power Duplexer Using TM Dual Mode Dielectric Resonators" 1992 IEEE MTT-S Digest, pp.1617-1620
[3] Y.Ishikawa,et al.,"1.9GHz Compact Low Loss Dielectric Duplexer Designed By Dual Mode Waveguide Transmission Line Method" Proc. 24th EuMC, pp.1179-1184, 1994.
[4] G.L.Matthaei. et al., "Microwave filters, impedance-matching networks, and coupling structures", MaGraw-Hill Book Company, 1964.
[5] Y.Ishikawa,et al, "Disign Method of Dual Mode Dielectric Filter using Coupled Transmission Line Theory ", IEICE Tech.Rep. MW-24,Japan,1995.