SMALL-SIZE COMB-LINE MICROSTRIP NARROW BPF

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Abstract

A small-size microstrip BPF is developed by using a high dielectric constant ($\varepsilon r = 92$) substrate, shield-lines between coupled resonators to get smaller coupling coefficient and short microstrip-line resonators of comb-line type. The newly developed three stage BPF is designed and demonstrated at 1.2GHz. This BPF can be produced at low cost and is useful for portable radio equipment.

1. INTRODUCTION

Recently, small-size BPFs using quarter-wavelength coaxial-line resonators made of high dielectric constant material have been developed and used in portable radio equipment. In general, microstrip filters are suitable for mass production than coaxial type, but the size of microstrip filters, especially narrow bandwidth BPFs, using a high dielectric constant material is larger than coaxial type using the same dielectric constant material.

This paper reports on a small-size comb-line microstrip BPF. The new microstrip BPF is developed by using a high dielectric constant substrate (relative dielectric constant $\varepsilon r = 92$) and shield-line between microstrip resonators and demonstrated at 1.2GHz.

The new microstrip BPF can be used for radio equipment such as mobile or portable telephones.

2. LENGTH of MICROSTRIP RESONATORS

The resonator of conventional comb-line BPF that is connected to a capacitor at the open end is shorter than that of inter-digital BPF's working in the same center frequency. In the case of a micro strip-line resonator of comb-line type, the relation between fg, the resonant frequency of quarter-wavelength of the resonator, and fr, the resonant frequency of the same resonator with a loaded capacitor, is expressed as:

$$fr/fg = (2/\pi) \cdot \tan (Zc/Zo) < 1$$
$$\text{with } Zc < \infty$$

where Zc is an impedance of the loaded capacitor and Zo is the characteristic impedance of the microstrip-line.

The ratio of ls, the length of quarter-wave microstrip-line resonator, and lc, the length of quarter-wave coaxial-line resonator, is expressed as:

$$ls/lc = \sqrt{\varepsilon r/\varepsilon eff} > 1.$$

where εr is a relative dielectric constant of the coaxial-line and microstrip substrate and εeff is an effective relative dielectric constant of the microstrip-line.

When the relation

$$(2/\pi) \cdot \tan (Zc/Zo) \geqq \sqrt{\varepsilon eff/\varepsilon r}$$

is hold, the length of comb-line type resonator is equal to or smaller than coaxial type. Fig. 1 shows resonant frequency of a microstrip resonator with a gap at the open end of the resonator working as lorded capacitor.

3. COUPLING COEFFICIENT

To design a narrow BPF, smaller coupling coefficient is necessary. When a high dielectric constant substrate is

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used, the coupling coefficient of microstrip resonators, placed in parallel, has large value. To get smaller coupling coefficient, the distance between the resonators needs to be larger as shown in Fig. 2.

The new microstrip narrow BPF realizes smaller coupling coefficient by using shielded-lines between resonators as shown in Fig. 3. The measured value of coupling coefficient of a coupled micro-strip resonator is shown in Fig. 4. It is obvious from Fig. 4 that the coupling coefficient using shield-line is smaller than that which is not using shield-line.

4. DESIGN EXAMPLE

Small-size microstrip narrow BPF can be achieved by using the above methods. Using the layout shown in Fig. 5, Tchebycheff's three-stage BPF with 0.01dB tipple and 1.2GHz center frequency is fabricated on a substrate 3mm high, 7.4mm wide, 20mm long of which material manufactured by SUMITOMO METAL CERAMICS Co. composed of $BaO\text{-}TiO_2\text{-}Nd_2O_3$ (part no. N-90) with a relative dielectric constant of 92.

The bandwidth of the BPF ΔB is calculated as follows. [1]

$$\Delta B = k_{12} \cdot \sqrt{g_1 \cdot g_2} \cdot fo = 51\text{MHz}$$

where g_1 g_2 are element values of a three stage plot-type low-pass filter of 0.01dB ripple, k_{12} is the coupling coefficient between resonator 1 and 2, 0.055 from Fig. 4, and the center frequency fo = 1.2GHz. The external Q value, Qe, of the output and input side resonator is

$$Qe = g_0 \cdot g_1 \cdot (fo/\Delta B) = 14.$$

The tapped-line coupling method [2] is used for coupling of input and output port as shown in Figure 6. A chip capacitor of 3pF is used as coupling capacitor at each port. The gap at the open side of resonator works as a loaded capacitor. However, this BPF needs a 0.75pF chip capacitor at the open end of the center resonator for frequency tuning.

5. RESULT

The measured result of the new three-stage BPF are shown in Fig. 7 and Fig. 8. The bandwidth in which R.L. is smaller than –25dB (equivalent to 0.0'dB ripple) is about 50MHz and the insertion loss is 1.6dB at the center frequency of 1.185GHz.

The unloaded Q value of the resonators used in the BPF is estimated about 160. By using 2mm thick substrate made of the same dielectric material, a three stage BPF is tested. The measured bandwidth is about 34MHz and I.L. is 2.3dB at the center frequency of 1.2GHz. A two stage BPF using a high dielectric constant substrate is reported in reference [3].

6. CONCLUSION

A small-size microstrip BPF has been developed by using a high dielectric constant substrate, shield-line between coupled resonators to get smaller coupling coefficient and short microstrip-line resonators of comb-line type. The three stage BPFs are fabricated on substrates 20mm long 7.4mm wide 3mm and 2mm high and demonstrated at 1.2GHz. The new microstrip BPF can be produced at low cost and used for radio equipment.

ACKNOWLEDGMENT

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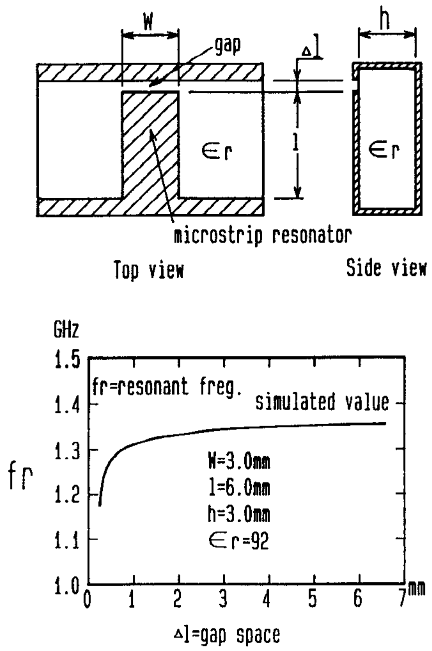
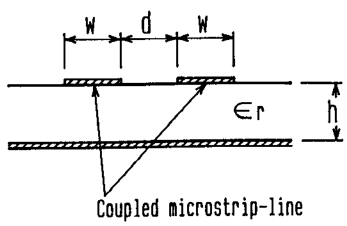


Fig. 1 Resonant frequency of a microstrip resonator



d^{mm}	K^*	
3	0.133	w=3.0mm h=3.0mm ∈r=92
10	0.039	

* simulated value of coupling coefficient without gap

Fig. 2 Effect of the distance between microstrip resonators to the coupling coefficient

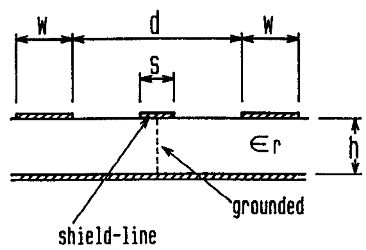
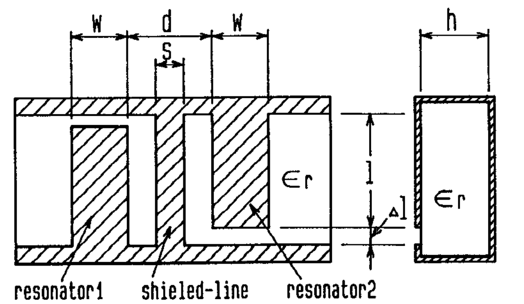
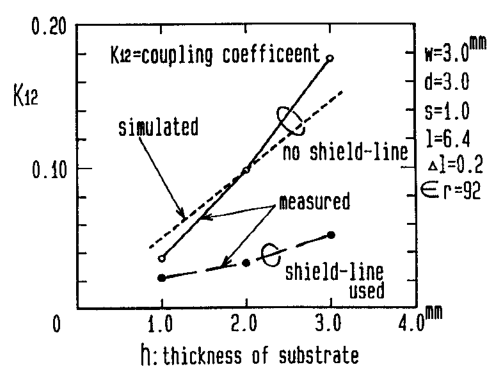


Fig. 3 Coupled microstrip resonators using shield-line



(a) Layout of coupled microstrip resonators using shielded-line



(b) Coupling coefficient of the coupled resonator illustrated in Fig. 4(a)

Fig. 4 Coupling coefficient of coupled microstrip resonators using shield-line

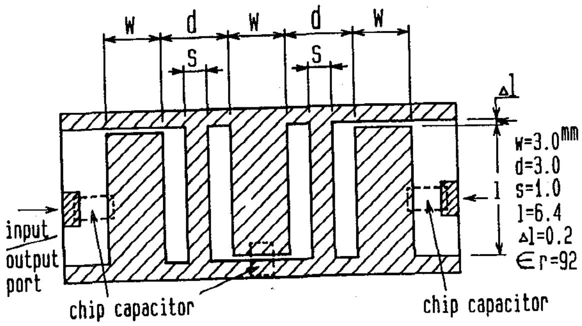


Fig. 5 Layout of a new developed three stage BPF

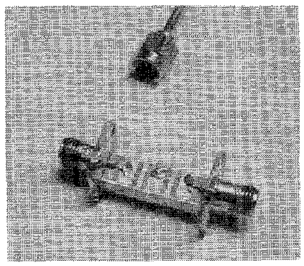


Fig. 6 The developed three stage BPF

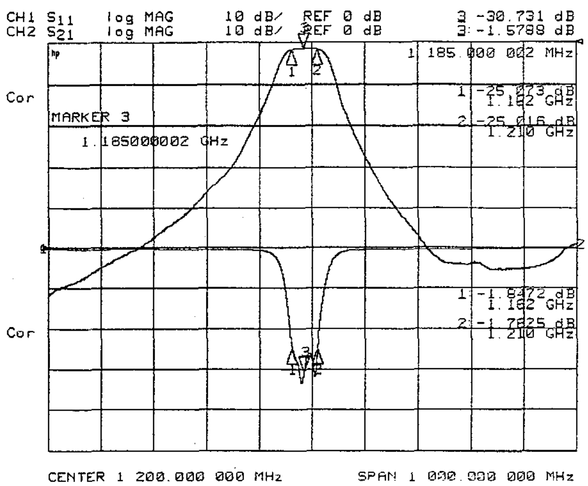


Fig. 7 Measured performance of the developed BPF using 3.0mm thick substrate

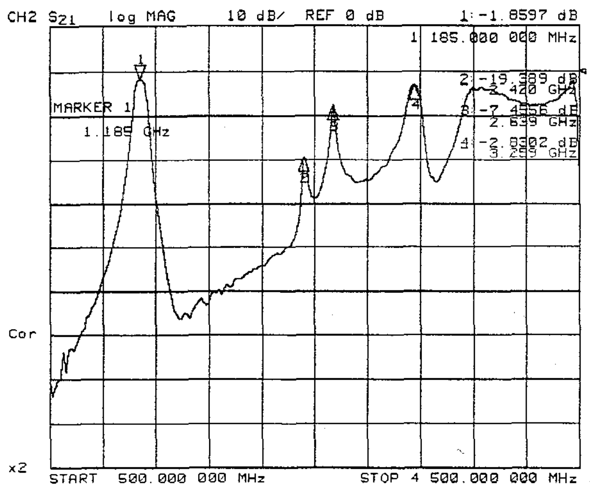


Fig. 8 Measured wideband performance of the developed BPF using 3.0mm thick substrate