Ridged waveguide manifold multiplexers with improved performance.

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High-Q Dielectric Combline Resonator with Wide Spurious Free Performance

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Abstract—**Lower dielectric constant material loaded Combline resonators achieve high-Q and excellent spurious free performance is presented. A design and characteristics are discussed. Simulated responses are presented in this paper.**

Index Terms **— combline resonators, dielectric constant, permittivity.**

I. INTRODUCTION

Combline resonators are widely used in cellular radio base station applications because of their small size and stability performance. The backward of the existence of its inner conductor is high loss, which makes its lower quality factor. A lot of researches are made in order to improve the quality factor of the combline resonators. It is well known that quality factor can be improved by replacing its inner conductor with high dielectric constant material [1]. However, high dielectric constant material loaded resonator has higher cost and very poor spurious performance.

Combline resonator with higher dielectric constant material post loaded has a high Q factor, which is inverse proportion to its loss tangent because its field distribution is confined in the dielectric post. It makes that higher dielectric conststant material loaded combline resonator has smaller size. While pure metallic combline resonator has a Q factor proportion to the space of a cavity. High Q pure metallic resonator implies physically large resonator. Pure metallic combline resonators have low cost and excellent spurious free performance but low Q factor. Higher permittivity dielectric resonators have low loss and smaller size but poor spurious property. For a compromise of these properties, lower permittivity dielectric combline cavity resonator is investigated in this paper.

II. ANALYSIS

Dielectric resonator with high permittivity material loaded can usually be explained as a hypothetical perfect magnetic wall resonator, which is positioned in a cavity.

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The cavity protects its radiation. The electromagnetic field energy is mainly confined in the dielectric resonator.
It is the dual case of a pure metallic combline cavity resonator with a perfect electric wall boundary condition at the side of its inner conductor. Hence, the field distribution and resonator frequencies for these resonators can be calculated analytically.

Dielectric combline resonators loaded with lower permittivity post exist neither perfect magnetic wall nor perfect electric wall boundary conditions at the border of the post. Appling an artificial cylindrical boundary [2] at ρ=R or $x^2 + y^2 = R^2$ of the rectangular cavity resonator shown in figure 1. The cavity can be divided into the cylindrical and rectangular waveguide regions: region I ($\rho \leq a$, $0 \leq z \leq h_1$mm), region 2 ($\rho \leq a$, $h_1 < z \leq h$), region III ($a < \rho \leq R$) and rectangular waveguide region).

The field in each cylindrical region can be expanded by TE_z and TM_z modes [3] in a cylindrical coordinate system (ρ, φ, z), the field in the rectangular regions are expanded into the summations of the TE_z and TM_z modes in the rectangular waveguide in the Cartesian coordinate system (x, y, z). For TM modes, H_z=0 and E_z plays the role of a potential function, for TE modes, E_z=0 and H_z plays the role of a potential function from which the remaining field components may be derived. Here we assume the fields are uniform in the φ direction because of the symmetrical of the system. The electric field and magnetic field satisfies the reduced Helmoholtz equation in their own coordinate system, respectively, as

$$\nabla_t^2 E_z + k E_z = 0$$
or
$$\nabla_t^2 H_z + k H_z = 0 \qquad (1)$$

$$k = \omega \sqrt{\mu \varepsilon} \qquad (2)$$

We express electromagnetic field components in each region and then imposed the tangential E and H fields to be continuous at the interface between the cylindrical regions and cylindrical-rectangular region. Natural frequencies of the dielectric post loaded combline cavity resonator can be found. Field coefficients of the resonant modes can also be obtained. The unloaded Q of the cavity can then be computed analytically by

$$Q_u = \frac{\varpi W}{P_l} = \frac{\varpi W}{P_c + P_d} = \frac{1}{\frac{1}{Q_c} + \frac{1}{Q_d}} \qquad (3)$$

$$Q_c = \frac{\varpi W}{P_c} = \frac{\varpi_0 W_0}{P_c} = \frac{\varpi_0 \mu_0 \int_V |H|^2 dV}{R_s \oint_S |H_t|^2 dS} \qquad (4)$$

$$Q_d = \frac{1}{tg\delta} \qquad (5)$$

where Q_c is quality factor due to conductor loss, Q_d is quality factor due to dielectric loss. H is the magnetic field in the cavity, H_t is the tangential magnetic field at the surface of the conductor and R_s is the surface resistance of the conductor, δ is the loss tangent of the dielectric material.

III. RESONATOR CONFIGURATION

Figure 1 shows the configuration of the proposed resonant structure. Specific design for combline resonator is readily available in literatures [4,5,6].

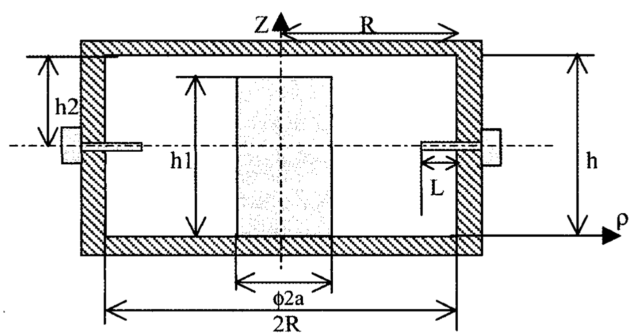

Fig. 1 The Cross Section of combline resonator with dimensions 2b=22mm, h=13.5 mm, h1=12.25 mm, h2=6.75 mm, ϕ2a=6.25 mm, L is tuneable.

IV. SIMULATION RESULTS

Figure 2 shows the frequency difference of dominant mode (with resonant frequency f_0) and lowest higher mode (with resonant frequency f_1) increases while the dielectric constant decreases. Figure 3 shows the response of pure metallic combline resonator. It has wide spurious free range. The difference Δf between f_0 and f_1 is 7.39GHz.

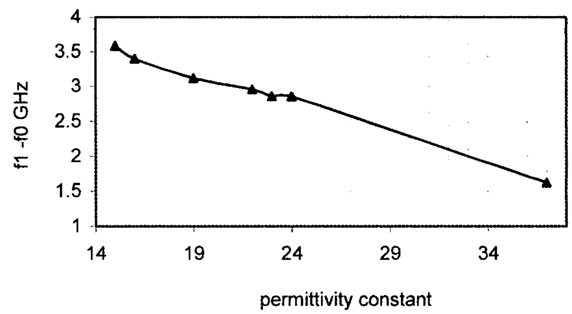

Fig. 2. Δf vs dielectric constant ε_r used in dielectric combline resonators

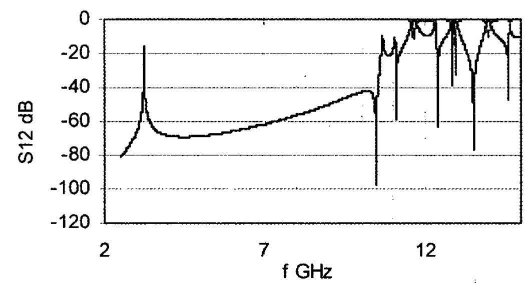

Fig. 3 Response of pure metallic combline resonator

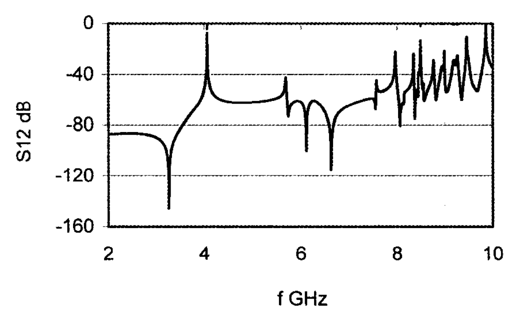

Fig. 4 Response of dielectric combline resonator with ε_r=37

Figure 4 shows the response of the dielectric combline resonator with dielectric constant 37. It has narrow stopband. Its frequency difference $\Delta f = f_l - f_0 =$ 1.62GHz and Q_L=2879. Figure 5 shows the response of the dielectric combline resoantor resonator with ε_r=16. It has wider stopband and higher loaded Q performance. Its frequency difference $\Delta f = f_l - f_0 =$ 3.40GHz and Q_L=4224.

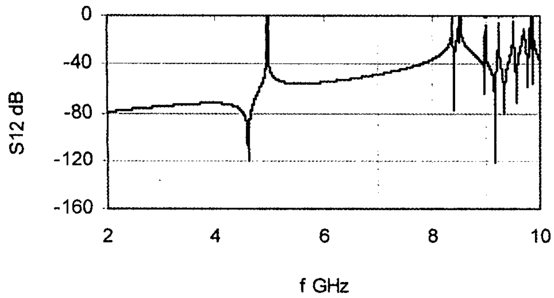

Fig.5. Response of dielectric combline resonator with ε_r=16

VI. CONCLUSION

Lower permittivity combline resoantor with higher Q and wider spurious free performance has been proposed. Preliminary simulation describes well behaviour of the material Gd_2BaCuO_5 with ε_r=16 applied in dielectric combline resonators. Further researches are needed to develop the prospect for lower dielectric constant material applying in dielectric combline resonators in order to obtain excellent performance of this kind of resonators. Ansoft HFSS was used for electromagnetic simulation of the proposed structures.

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