Design of Compact-Size and High-Q Resonator with Composit of Folded Meander-Line and Spiral

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***Abstract*—In this paper, a new compact and high loaded quality factor (Q_L) resonator with composite of folded meander-line and spiral structure on low dielectric substrate is designed and simulated. The proposed resonator is connected directly to feeding line in order to get high Q_L and frequency responses. The resonator is designed to operate at 5.5 GHz and the simulation result shows the Q_L value of 170. The entire size of resonator is 2.60 x 1.61 mm^2.**

Keywords—Compact size;hig loaded quality factor; folded meander-line; spiral; resonator

I. INTRODUCTION

Recently, the mobile communication has rapidly grown with the extension of the wireless local area network (LAN) and intelligent transport system (ITS) service. There have been increasing researches on high loaded quality factor (Q_L) with sharp-skirt, high selectivity characteristics, and small size for the resonator as an ITS mobile communication system.

Also, a high-Q_L resonator is essential for position detection in vehicle mobile communication. Thus, the Q_L is the most important parameter in a position detector because it determines the overall performance of the detective device. The cavity and dielectric resonator (3D) are promising elements because of its high-Q_L characteristic. It is, however, due to its three-dimensional (3D) structure, only limited to the system on chip (SoC) and integrated circuit (IC) realization but also is not adequate for mass production [1].

In order to reduce the size of resonator, high dielectric (ε_r) substrate can be used, but the cost is high [2]. In this paper, the compact-size and high-Q_L resonator with composite of folded meander-line and spiral structure is presented.

II. ANALYSIS OF THE COMPACT-SIZE RESONATOR

A hair-pin resonator consists of $\lambda_g/2$ open-circuited line with folded structure and 50 Ω coupled feeding line as shown in Fig. 1 [3].

This type of U-shaped resonator is the called hair-pin resonator. The conventional hair-pin resonator [3] consists of electrical lengths as shown in Table I. As depicted in the Table , Z_s is the characteristic impedance of the single line, Z_{pe} and Z_{po} are the even-and odd-mode impedances of the capacitance-load parallel coupled lines and θ_s is the electrical length of microstrip-line, θ_{pe} and θ_{po} are the even-and odd-mode electrical lengths of parallel coupled line [4].

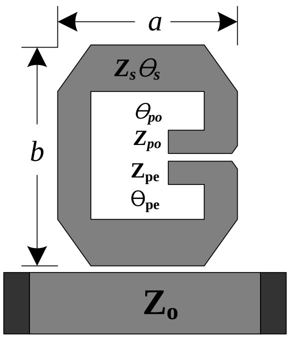

Fig. 1. Schematic of the hair-pin resonator

TABLE I
Dimensions of the hair-pin resonator

length	value [mm]	Parameter	
		Dielectric constant	Frequency [GHz]
a	4.10	2.52	10.0
b	3.45		

TABLE II
Experimental results of the loaded quality factor

Ref [#]	Q_L	Parameter		
		ε_r	Freq. [GHz]	Size [mm^2]
[3]	82	2.52	10.0	1.35X1.96
[5]	59	2.54	9.20	3.38X3.24

The resonance conditions of hair-pin resonators can be obtained by the ABCD matrix, which expresses a transmission line and a capacitor [4]. Table II shows the experimental results for the Q_L and size.

In the table, the exhibition of resonators has low Q_L and the size is larger than proposed resonator at 10 GHz.

III. PROPOSED RESONATOR

The proposed resonator is composed of outer folded meander line and inner spiral structure as shown in Fig. 2. From the Figure, the Z_1 is characteristic impedance of resonator and the Z_0 is characteristic impedance of feeding line.

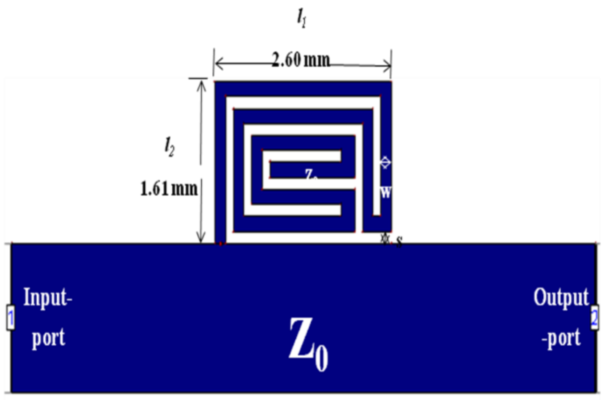

Fig. 2. Structure of the proposed resonator

The Z_0 is 50 Ω and the Z_1 is 120 Ω. Also, the *w* and *s* are the width of microstrip line in the resonator and a gap between microstrip lines respectively. In the same way, l_1 and l_2 are lengths of the resonator. Then, the wavelength of a resonator is $\lambda_g/2$. In this characteristic, the proposed resonator is coupled to directly connection with feeding line. In this way, the spiral meander line is built by folding to make the size small. Figure 3 shows the equivalent circuit of the proposed resonator.

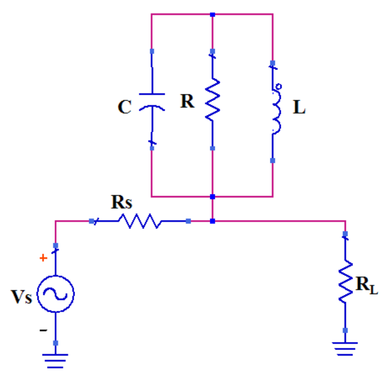

Fig. 3. Equivalent circuit of the proposed resonator

From the Figure, the L is inductance corresponding to the length of the resonator and the C is capacitance corresponding to the gap size in resonator. R is conductance in microstrip line. Also, the Vs and Rs are voltage source and source resistance in feeding line and the R_L is the load resistance. In the equivalent circuit, the circuit is like a spiral resonator circuit.

IV. EXPERIMENTAL RESULT

The simulation has been carried out by EM simulator tool, IE3D and the simulation result for Q_L of the proposed resonator is 170 at the resonant frequency of 5.5 GHz as shown in Fig. 4. Since the Q_L is higher, we can have a good input reflection coefficient characteristics.

The loaded quality factor can be calculated from the equivalent circuit shown in Fig. 2 using the equation (1) as follows [6]:

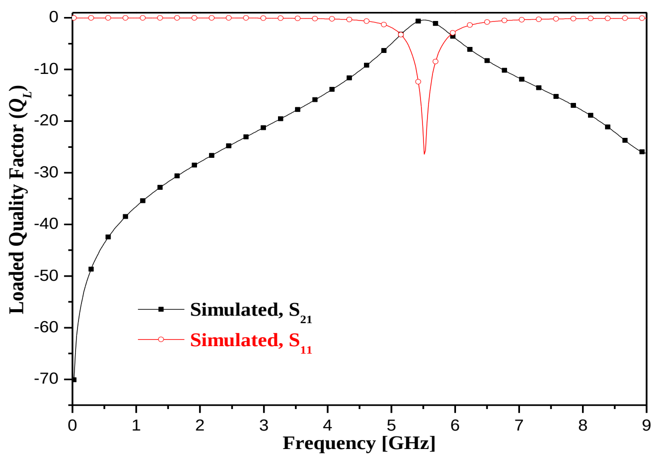

Fig. 4. Simulation result of the proposed resonator

$$Q_L = \omega_o \frac{R \cdot 2Z_o}{R + 2Z_o} C \quad (1)$$

It can also be computed from the measured reflection coefficient, S_{11} as depicted in Fig. 5.

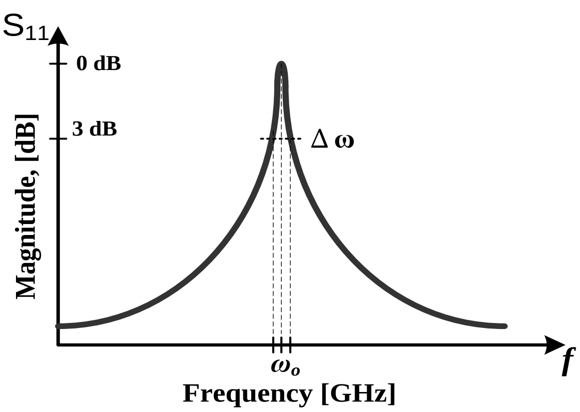

Fig. 5. Definition of the loaded quality factor measurement

The loaded quality factor corresponds to the 3 dB bandwidth of S_{11} given by the equation (2).

$$Q_L = \frac{\omega_o}{\Delta\omega}. \quad (2)$$

The entire size of the proposed resonator is 2.60 X 1.61 mm^2.

V. CONCLUSION

In this paper, a new reduced size with high-Q_L resonator and with composite folded meander-line and spiral structure. In this case, the proposed resonator is connected directly to couple the feeding line. The proposed resonator has used a low dielectric substrate and the size is decreased due to folded structure. The resonator is designed to operate at 5.5 GHz and the simulation result shows the Q_L value of 170. The total size of the resonator is 2.6 X 1.61 mm^2. The resonator can be possible to fabricate with integrated passive device (IPD) in semiconductor technique due to its entirely planar structure. Also, it can be applied to wireless local area network (LAN) system and intelligent transport system (ITS).

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