A Design of Microwave Resonator

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Abstract: - A microwave resonator has been designed with the aid of GENESYS software and the circuit was fabricated on Roger microstrip with dielectric constant of 3.48. A combination of two congruent coupled line sections was used to resonate at 1.8 GHz. The discrepancies between measure and simulated result of half-power bandwidth was due to the size of the gap between the two conductors. Such structure has advantage to design ultra-narrowband filter. Some simulation and experimental results have been compared and presented in this paper.

Key-Words: - Microwave resonator, ultra-narrowband filter and bandwidth.

1 Introduction

Resonator is an important device in designing a filter network. It is also used in controlling or stabilizing the frequency of oscillator, wave meter, antennas and measurement equipment. Each of resonators may resonate at different frequencies. Hence, to achieve an accurate or first-passed filter design it is essential to characterize couplings of coupled resonators whose self-resonant frequencies are different. In general two frequencies in association with the coupling between a pair of coupled resonators can be observed despite whether the coupled resonators are synchronously or asynchronously tuned. If the coupled resonators are synchronously tuned, the coupling coefficient can be extracted from these two frequencies that easily identified either in experiments or in full-wave EM simulations. However, if the coupled resonators are asynchronously tuned, a wrong result will occur if one attempts to extract the coupling coefficient by using the same formula derived for the synchronously tuned resonators. Therefore, other appropriate formulas than those presented in [1-2] should be sought.

An open cavity resonator with suspending a spherical reflector above a microstrip line can supports fewer modes than a conventional closed cavity of similar dimensions. The modes sustained within the resonator can be used for reasonable cavity dimensions. When a microstrip line is coupled to such an open resonator mode, the energy stored in the resonator volume becomes accessible to the microstrip circuit, theoretically leads to simple lumped equivalent circuits coupling mechanisms between the open resonator and microstrip.

At millimetre wavelengths, the geometric-optics assumption that the wavelength is negligibly small compared to the cavity dimensions is no longer valid and diffraction effects become increasingly significant. Cullen [3] has summarized the best current theoretical models for fields inside a millimetre wave open resonator of practical dimensions. For the purposes of analysis, a scalar-field approach gives satisfactory precision. Some of problems have been solve by the model.

Hybrid circuits were another approach that can perform in all microwave applications with resisted efforts at integration of the intrinsic limitations in planar transmission-line media [1]. Although the use of dielectric resonators can alleviate this problem at the millimetre wavelengths, these devices become very small and difficult to mount.

The space between two coupled conductors is inversely proportional to the coupling factor of two conductors. The half-power bandwidth (BW) of resonator can be calculated in term of the difference between odd-mode and even-mode characteristic impedances that was inversely proportional to the space...
between two couple conductors. From that, the design of resonators for half-power bandwidth can be realized [4-5].

2 Design Methodology

The cross-sectional view of coupled microstrip lines shown in the Fig. 1 can be approximately modelled by the equivalent circuit as shown in Fig. 2. The width $w$ of the microstrip line, the spacing $s$ between two couple conductors, the thickness $h$ and the relative permittivity $\varepsilon_r$ of the substrate are shown in the figure.

In a microstrip line model, a pair of couple lines with two ports open ended may be specified by even- and odd-mode impedances and coupling length as illustrated in Fig. 2.

The coupled lines are equivalent with line lengths, $\phi$. The characteristic impedance $Z_0$ of the input and output is according to the strip conductor when the coupled line is operated in the even- and odd-modes respectively.

The coupled line sections were assumed $\lambda/4$ long, this was corresponding to the resonant frequency of the device [6].

A transmission line $\lambda/2$ long of characteristic impedance $Z_0$ in the vicinity of the central frequency of the resonator has an approximate equivalent circuit that composes of a shunt parallel RLC resonator as shown in Fig. 3. The components of parallel RLC resonator were computed using standard equation in [6].

Fig. 3: The $\lambda/2$ equivalence circuit.

Fig. 4: The microstrip layout

Fig. 4 shows couples lines that have $\lambda/4$ long according to the center frequency. It is such as $\lambda/2$ open-circuit terminated resonators that are parallel coupled to the input and output lines. Each couple was represented by its admittance and line that were $\lambda/4$ long. Adjacent $\lambda/4$ lines form a $\lambda/2$ resonators.

3 Result and Discussion

The bandwidth, BW is inversely proportional to space, $s$ between the two microstrip lines. This proposed resonator could be used to design ultra-narrowband filters with low cost. Quality factor of dielectric cavity resonator is high but there has been growing in planar structures in order to reduce size of those filters.

The disadvantage of high conductor loss of the planar filters using conventional thin film conductor can be overcome by replacing them with high-temperature superconductor (HTS) thin films [7]. However, this will be costly in order to design the filters.

The resonator has been simulated by GENESYS software. Then the design was fabricated. Fig. 5 shows the complete parallel-coupled resonator. The circuit then was measured using vector network analyzer (VNA).
The exact dimensions of the space between the two coupled conductors were 0.56 mm and 2.63 mm. When the space between the two coupled conductors was increased, the bandwidth will decrease but the attenuation at the centre frequency will increase. Such result was obtained experimentally from the simulation.

Table 1: Insertion loss from the simulation

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>Insertion Loss (S21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.721</td>
<td>-2.807 dB</td>
</tr>
<tr>
<td>3.457</td>
<td>-4.028 dB</td>
</tr>
</tbody>
</table>

From Table 1, the second resonant frequency was at 3.457 GHz with the insertion loss of –4.028 dB.

Table 2: Insertion loss from the fabricated circuit

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>Insertion Loss (S21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.675</td>
<td>-6.593 dB</td>
</tr>
<tr>
<td>3.34</td>
<td>-5.386 dB</td>
</tr>
</tbody>
</table>

Table 2 shows the second resonant frequency from the measurement result was at 3.34 GHz with insertion loss of -5.386 dB.

Fig. 7 shows the simulation result of standing wave ratio, SWR. The SWR is a measure of circuit matching. The value of SWR was 1.823 at 1.707 GHz from the simulation, while the measurement shows in Fig. 8 was 3.728 at 1.675 GHz.
The SWR for the first and second resonant frequencies were shown in the Table 3 and Table 4 for simulation and measurement respectively.

Table 3: Simulation result of SWR

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>SWR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.707</td>
<td>1.823</td>
</tr>
<tr>
<td>3.457</td>
<td>1.933</td>
</tr>
</tbody>
</table>

Table 3 shows that the SWR was 1.933 at 3.457 GHz while in Table 4, at 3.34 GHz the SWR was 1.261. The lowest SWR was obtained from the second resonant point of measurement.

Table 4: Measurement result of SWR

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>SWR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.675</td>
<td>3.728</td>
</tr>
<tr>
<td>3.34</td>
<td>1.261</td>
</tr>
</tbody>
</table>

The result shows that the simulation was small in both critical points. However, the lowest value was come from the measurement. The small value of SWR is considered a good matching level while the high SWR means the port was not properly matched [8-9].

4 Conclusion

This paper has presented a design of microstrip resonator from simulation and experimental measurement. The resonator work well with bandwidth that respect to the centre frequency < 8% and attenuation of –2.087 dB in the pass band region. Since the material loss was quite high, the attenuation in pass band region of the filter also larger than the result that obtained from simulation and calculation. The losses that cause the difference between simulation and measurement were due to imperfection of the dielectric and manual fabrication process. However, the similarity in shape of the responses shows that the design objective has been achieved. Based on the bandwidth percentage shows that an ultra narrowband filter can be designed using the proposed resonator.

References: