Effect of Wideband Microstrip BPF Design for Bandwidth Enhancement and Its Equivalent Circuit

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Abstract: Characteristic of microstrip filter can be analyzed with equivalent circuit. In this paper, wideband microstrip bandpass filter was analyzed by means of its equivalent circuit with lumped element of capacitor and inductor. Meanwhile, bandwidth enhancement is done by adding strip and DGS slot. Simulation results show that design changes can enhance the bandwidth up to 0.95 GHz for microstrip simulation and 1.25 GHz for equivalent circuit.

1 INTRODUCTION

Filter is one of the important devices in communication system used to pass the desired signal and reject undesired signals (Misra, 2004). Many researches have been done in filter development to get a good performance [2-6]. One of the filter implementations is by using a microstrip with multiple design like Defected Ground Structure (DGS), multi-layered microstrip, L and T shaped resonator, and Substrate Integrated waveguide (SIW). On a research, L and T shaped resonator produces two transmission zeros in the stopband as well as three reflection zeros in the passband, other than that between simulation and measurement produces good performance (Esmaeili and Bornemann, 2015). Meanwhile in another research, the measurement result with simulation are satisfactory with the fractional bandwidth of 13.5 % (Chen et all, 2015).

Characteristic of microstrip filter can be analyzed with equivalent circuit of lumped element capasitor and inductor. There has been a lot of research on equivalent circuit. On a research, equivalent circuit of square-loop-resonator bandpass filter has been analyzed and compared with 3D simulation result. The reflection coefficient of equivalent circuit has a better response than the 3D simulation, but it has a bandwidth of 50 MHz narrower than the 3D simulation (Edwar and Munir, 2017). And in another research, microstrip bandpass filter with DGS have been analyzed using equivalent circuit of capasitor and inductor. The scattering parameter has almost the same result as the simulation microstrip with a bandwidth of about 1 GHz (Zheng and Wang, 2019).

In this paper, wideband microstrip bandpass filter was analyzed by means of its equivalent circuit with lumped element of capacitor and inductor. Bandwidth enhancement is done by changing the filter design that is by adding more strip and DGS slot. To show the feasibility of equivalent circuit analysis, the simulation of equivalent circuit is compared with microstrip simulation.

2 OVERVIEW OF EQUIVALENT CIRCUIT

Generally, microstrip filters are designed with microstrip elements. To get the perfect frequency response, microstrip filter can be analyzed with equivalent circuit. To analyze this equivalent circuit can use lumped element of capacitor and inductor. For instance, the distance between strip in microstrip elements can be illustrated as a divider between strips. The equivalent circuit of the distance between strip in microstrip is represented by capacitor with phi shape and strip in microstrip elements can be represented by inductor with shunt capacitor. Its equivalent circuit is shown in Figure 1. From that explanation, an analysis of wideband microstrip bandpass filter with defected ground structure using equivalent circuit for the proposed design shown in Figure 2.

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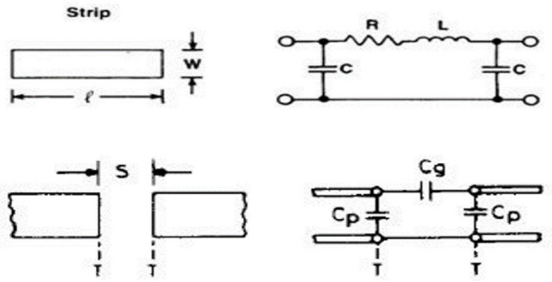

Figure 1: Equivalent circuit of microstrip element (Gupta, 1996).

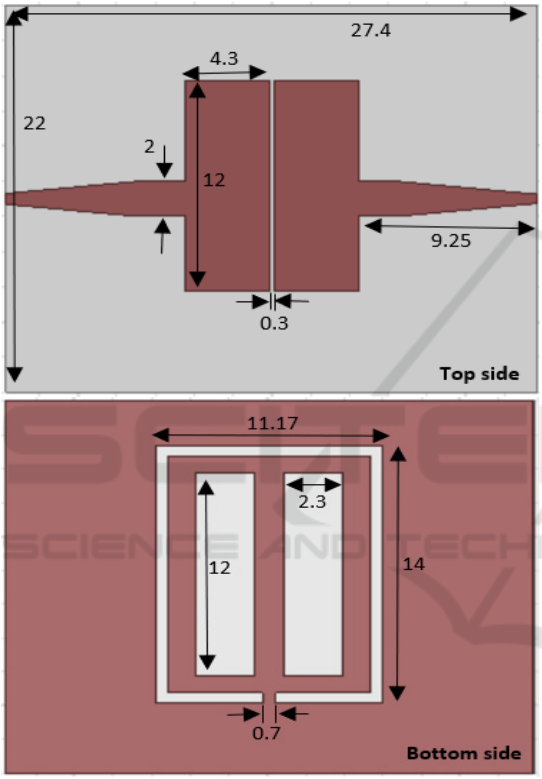

Figure 2: Proposed wideband microstrip BPF applying DGS (unit in mm).

The proposed design of wideband microstrip BPF applying DGS is 27.4 x 22 mm consist of two strips on the top side and two slots mixed with a ring slot on the bottom.

The equivalent circuit of microstrip BPF shown in Figure 3 and Figure 4. On the top side, two strips and feedline configured with lumped element inductor and gap between strips represented by capacitor. The dielectric substrate between top and bottom side is represented by capacitors mounted in parallel on each inductor.

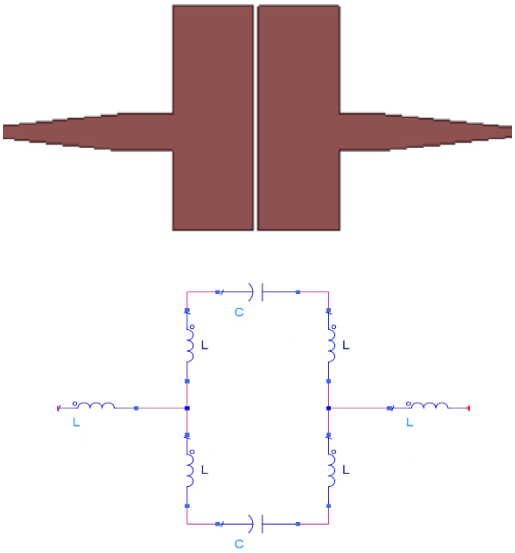

Figure 3: Equivalent circuit of two strips on top side.

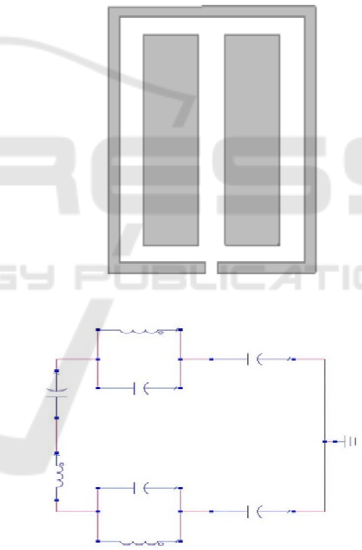

Figure 4: Equivalent circuit of two slots combined with a ring slot on the bottom.

And representation of ground plane is done by adding a capacitor at each element connected to ground. On the bottom side, DGS slots is represented by inductor and capacitor. For ring slots, capacitors mounted in series on inductor of DGS slots and capacitors in parallel with inductor mounted in series on capacitor of DGS slots. So, the whole of equivalent circuit of wideband microstrip BPF applying DGS shown in Figure 5.

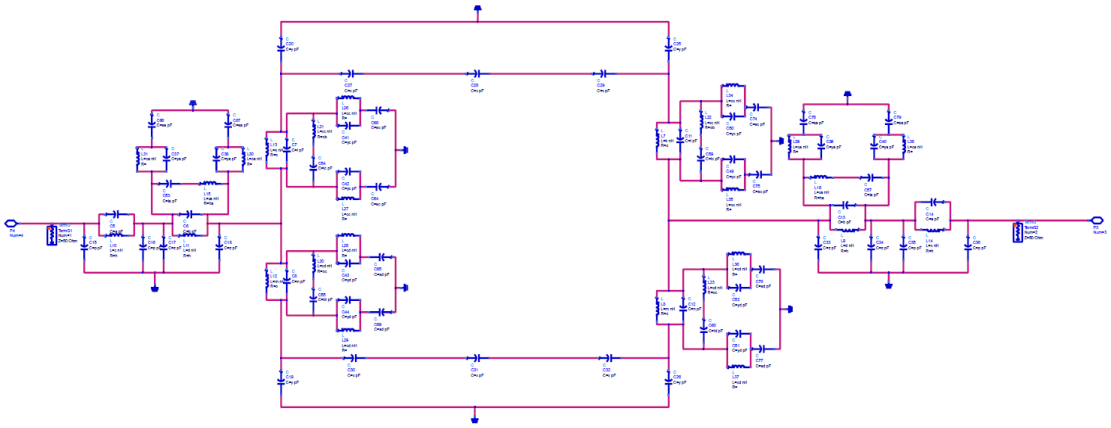

Figure 5: Equivalent circuit of wideband microstrip BPF.

3 SIMULATION RESULT

The simulation result of proposed wideband microstrip BPF and its equivalent circuit shown in Figure 6. between the two has a small difference in bandwidth of 0.05 GHz. The proposed wideband microstrip BPF applying DGS can pass frequencies in the range of 1.5 GHz to 4.6 GHz with bandwidth of 3.1 GHz. And the equivalent circuit can pass frequencies in the range of 1.55 GHz to 4.6 GHz with bandwidth of 3.05 GHz. At a certain frequency, the value of equivalent circuit return loss is greater than the microstrip simulation, this is because the structure of DGS ring slot has an effect on patch, especially for lumped element capacitors that have dominant effect for return loss.

Based on characterization result above, change in the number of strips and DGS slot is carried out to see the effect of bandwidth. Change of slots and strip by adding to be 3 strips and DGS slots. The simulation result shown in Figure 7.

From the simulation result, change in the number of strips and DGS slot can affect the bandwidth. Additional of strip and DGS slot can enhances the bandwidth up to 0.95 GHz for microstrip simulation and 1.25 GHz for equivalent circuit, it shown in Tabel 1. The proposed wideband microstrip BPF applying DGS that changed of strip and slot can pass frequencies in the range of 1.4 GHz to 5.45 GHz with bandwidth of 4.05 GHz. And the equivalent circuit can pass frequencies in the range of 1.3 GHz to 5.6 GHz with bandwidth of 4.3 GHz. From figure 7, equivalent circuit has better insertion loss than microstrip simulation because of the equivalent circuit is considered ideal and there is no attenuation.

The comparison of equivalent circuit shown in Figure 8. When the number of strip and DGS slot is added, the frequency response shifts to low frequency region for low frequency and shifts to high frequency region for high frequency with good response in return loss and insertion loss. Meanwhile, change in the number of strips and DGS slots results in a better return loss value.

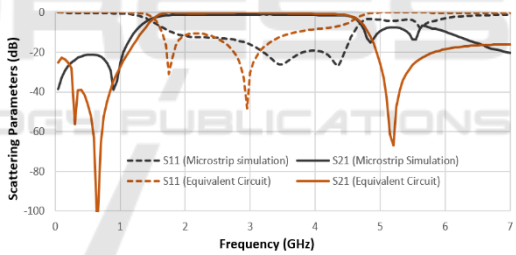

Figure 6: Simulation result of proposed microstrip BPF and its equivalent.

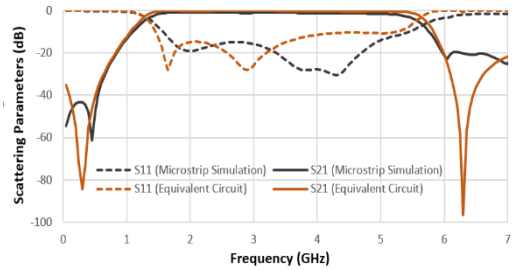

Figure 7: Simulation result of 3 strips and DGS slots.

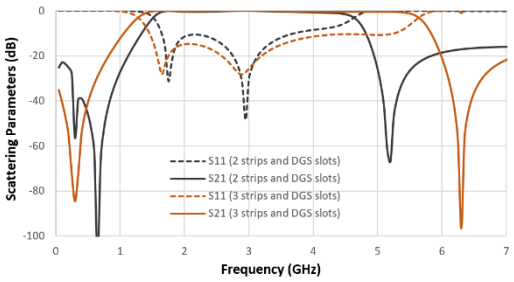

Figure 8: Results comparison of equivalent cirrcuit.

Table 1: Simulation Result

Design	Bandwidth
2 strips and DGS slots	3.05 GHz
3 strips and DGS slots	4.3 GHz

4 CONCLUSIONS

Study of wideband microstrip BPF design and its equivalent circuit using lumped element of capacitor and inductor have been done. Bandwidth enhancement is done by adding strips and DGS slots. Additional of strips and DGS slots can enhances the bandwidth up to 0.95 GHz for microstrip simulation and 1.25 GHz for equivalent circuit. Lumped element of capacitor and inductor in equivalent circuit for DGS slot has an effect on return loss. The bandwidth response value of the equivalent circuit is 3.05 GHz for 2 strips and DGS slots. While for 3 strips and DGS slots, the bandwidth response value of the equivalent circuit is 4.3 GHz.

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