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Design of dual-band bandpass filter based on multistub resonator structure at frequency of 900 MHz and 1.85 GHz

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ABSTRACT
In this paper was proposed dual band bandpass filter (DBPF) using multistub resonator structure in frequency of 947.1 MHz and 1.844 GHz with RL of -26.797, IL of -0.532 dB, VSWR of 37.208, and group delay of 8.43.10-10 s and RL-20.932 dB, IL of -1.347 dB, VSWR of 16.076, and group delay of 1.063.10-9 s on simulation of ADS, operate at the frequency of 929.883 MHz wi RL of -28.386 dB, IL of -0.809 dB, group delay of 8.439.10-10, and VSWR of 22.149 and 1.844 GHz with RL of -18.949 dB, IL of -1.62 dB, group delay of 8.873.10-10, and VSWR of 12.112 at the CST simulation, and operate at the frequency of 912.636 MHz with RL of -23.389 dB, IL of -1.163 dB, VSWR of 1.145, and group delay of 3.157.10-9 s and 1.896 GHz with RL of -21.595 dB, IL of -1.843 dB, VSWR of 1.181, and group delay of 3.033.10-9 s in real measurement. Compare to the DBPF specification which operation frequency is at 950 MHz and 1.85 GHz, there was frequency changes in simulation of ADS from 950 MHz to 947.1 MHz and from 1.85 GHz to 1.844 GHz, there was frequency changes in simulation of CST from 950 MHz to 929.883 MHz and from 1.85 GHz menjadi 1.844 GHz, and there was frequency changes in measurement from 950 MHz to 912.636 MHz and from 1.85 GHz to 1.8958 GHz. A good agreement is shown in comparison between simulated and measured.

Key words : Dualband BPF, microstrip, multistub resonator.

1. INTRODUCTION

In wireless mobile telecommunication system, Band pass filter (BPF) is an essential part component, the increase demand of wireless based communication application needs RF transceiver which operate at different frequencies, so that the users can access various service by single multimode handset or terminal [1-3]. Filter has function to reduce noise, to prevent signal change due to intermodulation [4], to prevent aliansing and to reduce signal interference [5]. Multiband-Band-Pass Filter (MBPF) is needed to reduce noise and signal interference at various frequency ribbons simultaneously [6]-[15].

As novelty, a study in a form of " Designing of Mikrostrip Multiband Band-Pass-Filter at the Frequency of 950 MHz, 1.85 GHz, and 2.35 GHz using Multi-Stub Resonator Method". It was expected that it has good performance which consist of width bandwidth, high RL and IL close to 0, Voltage Standing Wave Ratio (VSWR) close to 1, small size, relatively small error compare to Network Analyzer, good group delay, and low production cost. For scale down folded method was used. Microstrip based designing made of FR4 with ε_r = 4.3, δ = 0.025, ground and patch material was copper with electric conductivity as $5.8.10^7$ S/m, height of ground and patch = 0.015 mm, and h = 1.6 mm.

2. DESIGN OF OF DUAL BAND PASS FILTER

To design DBPF the ADS software 2009 was used. In this simulation, DBPF consist of three open stub which form discontinuity microstrip in a form of T-junction. The design of DBPF is presented in figure 1.

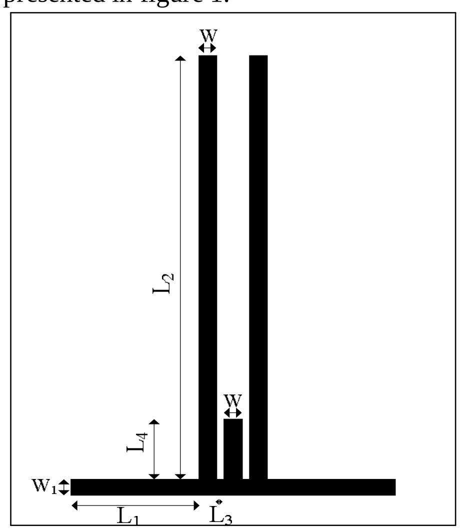


Figure 1: DBPF design

Figure 1. shows that DBPF has three open stub. Two open stub has the same dimension (open stub 1 and open stub 3) and one open stub is in between (o[pen stub 2) with the same distance. The specification of DBPF is presented in table 1.

Table 1:. Specification of DBPF

Parameters	unit (mm)
Transmission unit width (W_1)	3.08
Transmission stream length (L_1)	21.85
Open Stub 1 and 3 length (L_2)	81.04
Open Stub 4 length (L_4)	11.55
Space between *Open Stubs* (L_3)	1.25

being simulated DBPF based on specification ob Table 1, the result is as follow:

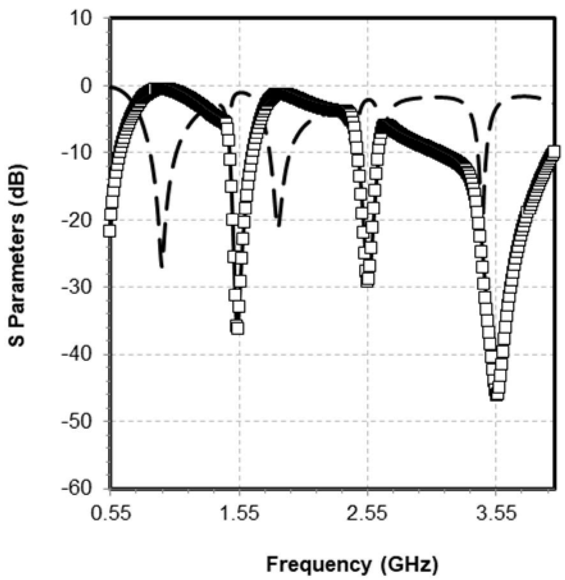


Figure 2: Graph of RL and IL DBPF

Figure 2 is a graph of RL and IL based on specification on Table 3.4. Y axis is the RL and IL from range of -160 to 0, with X axis as frequency at the range of 0.55 GHz up to 4GHz. Resonance frequency of 950 MHz was obtained with RL as -26.927 dB and IL as -0.531 dB and 1.85 GHz with RL -21.342 dB and IL as -1.317 dB. This phenomenon is in accordance with the specification of DBPF. To produce DBPF suitable for the specification, iteration was conducted for open stub 1 and 3(L_2) length, space between open stubs (L_3), and open stub 4 length (L_4). The graph of iteration of open stub 1 and 3(L2) length is presented in figure 3.

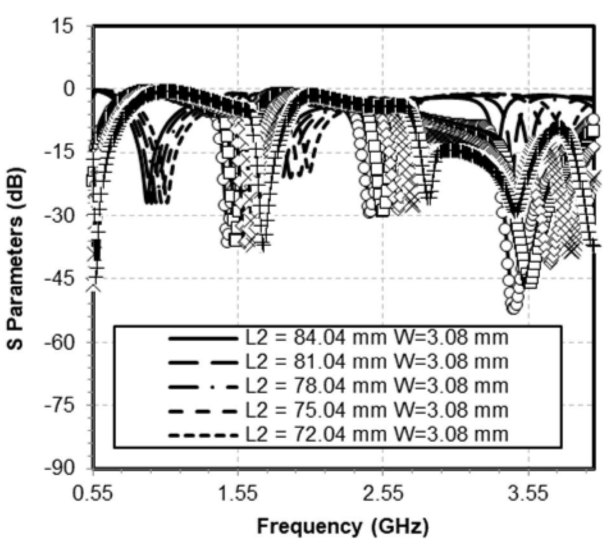


Figure 3 : Graph of RL and IL from result of L2 DBPF Parameter iteration

Figure 3 is a graph of RL and IL as a result of iteration for 5 times on L_2 parameter. Y axis is the RL and IL from range of -90 to 15, with X axis as frequency at the range of 0.55 GHz up to 4GHz. At the first iteration with the value of L_2 of 84.04 mm and W of 3.08 mm it was obtained resonance frequency of 920 MHz it was obtained with RL of -26.837 dB and IL of -0.524 dB and 1.79 GHz with RL of -21.366 dB and IL of -1.284, second iteration with L_2 value of 81.04 mm and W of 3.08 mm it was obtained resonance frequency of 950 MHz with RL of -26.927 dB and IL of -0.531 dB and 1.85 GHz with RL of -21.342 dB and IL of -1.317 dB, third iteration with L_2 of 78.04 mm and W of 3.08 mm it was obtained resonance frequency of 980 MHz with RL of -26.788 dB and IL of -0.54 dB and 1.915 GHz with RL of -20.974 dB and IL of -1.317 dB, forth iteration with L_2 value of 75.04 mm and W of 3.08 mm it was obtained resonance frequency of 1.02 GHz with RL of -26.982 dB and IL of -0.547 dB and 1.97 GHz with RL of -20.518 dB and IL of -1.461dB, and fifth iteration with L_2 value of 72.04 mm and W of 3.08 mm it was obtained resonance frequency of 1.06 GHz with RL of -26.901 dB and IL of -0.557 dB and 2.04 GHz with RL of -19.814 dB and IL of -1.535 dB.

There was a shifting of first frequency from 920 MHz, 950 Mhz, 980 MHz, 1.02 GHz, and 1.06 GHz and the frequency from 1.79 GHz, 1.85 GHz, 1.91 GHz, 1.97 GHz, and 2.04 GHz. At the frequency range of 920 MHz to 980 MHz the frequency shifting was relatively more stable for 30 MHz and there was a shifting of frequencies from 980 MHz to 1.06 GHz for 40 MHz. At the second frequency there was a relatively stable shifting from 1.79 GHz to 1.97 GHz for 60 MHz and increase for 10 MHz at the range of 1.97 GHz to 2.04 GHz. The best RL was in the second iteration at the desired frequency and the best IL at the first iteration but not at the desired resonance frequency. From all five iteration, second iteration was shown with resonance frequency of DBPF of 950 MHz and 1.85 GHz. After being reviewed from resonance frequency, RL, and IL, DBPF it can be considered from the quality of VSWR and group delay.

2a. VSWR DBPF

Figure 4 shows tha graph of VSWR based on specification of DBPF on Table 3.4.

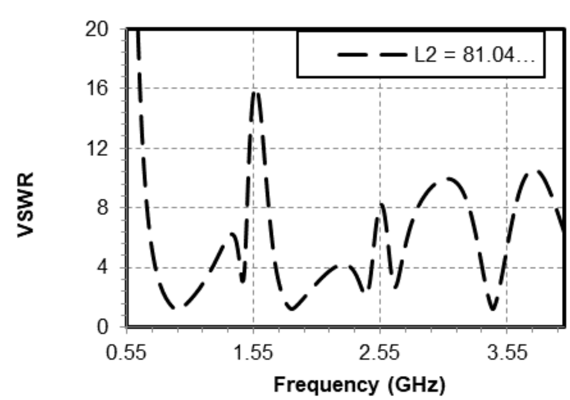


Figure 4: Graph of VSWR DBPF

Figure 4 is a graph of VSWR from DBPF based on DBPF specification on table 3.4. Y axis is VSWR from the range of 0 to 20, while X axis is a frequency of 0.55 GHz up to $ GHz. It was obtained VSWR of 1.094 and 1.187 and this VSWR was in accordance with DBPF specification which was VSWR < 2. To obtained VSWR at the resonance frequency of 950 MHz, five times iteration were conducted. This process of iteration is presented in graph of VSWR iteration in figure 5.

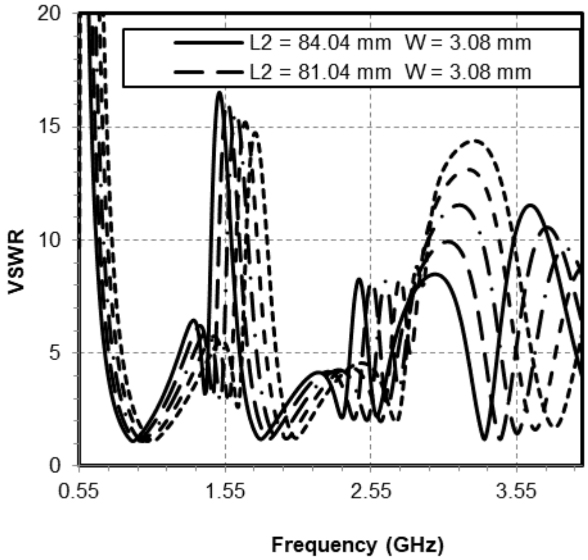
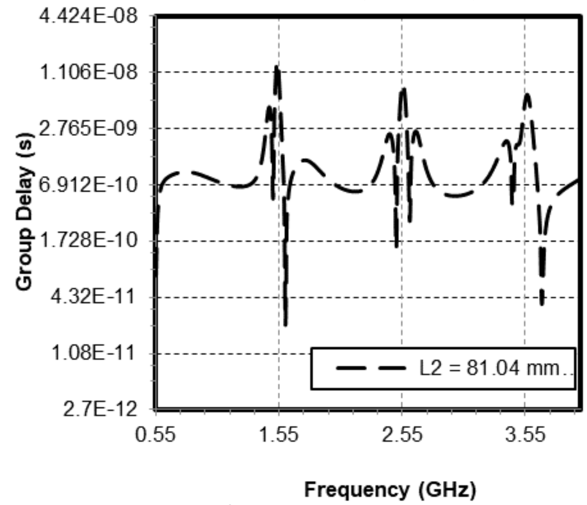


Figure 5: Graph of VSWR of iteration result of L_2 DBPF parameters

Figure 5 is a Graph of VSWR of iteration result of L_2 DBPF parameters for 5 times. Y axis is VSWR with the range of 0 to 20, meanwhile X axis is a frequency from the range of 0.55 GHz to 4 GHz. In the first iteration with L_2 value of 84.04 mm and W of 3.08 mm, it was obtained VSWR of 1.095 and 1.187, second iteration with L2 value of 81.04 mm and W of 3.08 mm, it was obtained VSWR of 1.094 and 1.187, the third iteration with L_2 value of 78.04 mm and W of 3.08 mm, it was obtained VSWR of 1.096 and 1.196, the forth iteration with L_2 value of 75.04 mm and W of 3.08 mm, it was obtained VSWR of 1.094 and 1.208, and the fifth iteration with L_2 value of 72.04 mm and W of 3.08 mm, it was obtained VSWR of 1.095 and 1.228.

There was a shifting of VSWR value of first frequency from 1.095, 1.094, 1.096, 1.094, and 1.095 and at the second frequency VSWR value from first and second iteration was relatively stable; however in second iteration there were VSWR value shifting from 1.187, 1.196, 1.204, and 1.228. At frequency range of 1.41 GHz to 2.04 GHz there was the highest peak of signal, but it decreased at the frequency range of 2.35 GHz to 2.79 GHz and increased at the frequency range of 3.33 GHz to 4 GHz. The best VSWR was obtained in second iteration and forth iteration at first frequency and in first and second iteration at the second frequency. At the expected frequency of 950 MHz in second iteration it was obtained VSWR categorized as the best.

Figure 6 is a graph of group delay of DBPF based on DBPF specification on table 3.4. Y axis is group delay at the range of



$2.7.10^{-12}$ s to $4.424.10^{-8}$ s, while X axis is the frequency from 0.55 GHz to 4 GHz.

Figure 6: Graph of Group Delay DBPF

It was obtained group delay as $8.494.10^{-10}$ s (0.8494 ns) and $1.071.10^{-9}$ s (1.071 ns). This group delay is in accordance with DBPF specification which is group delay< 10 ns. To obtain those group delays at the resonance frequency of 950 MHz, 5 times iteration was conducted. This phenomenon is presented in Graph of iteration group delay in Figure 7.

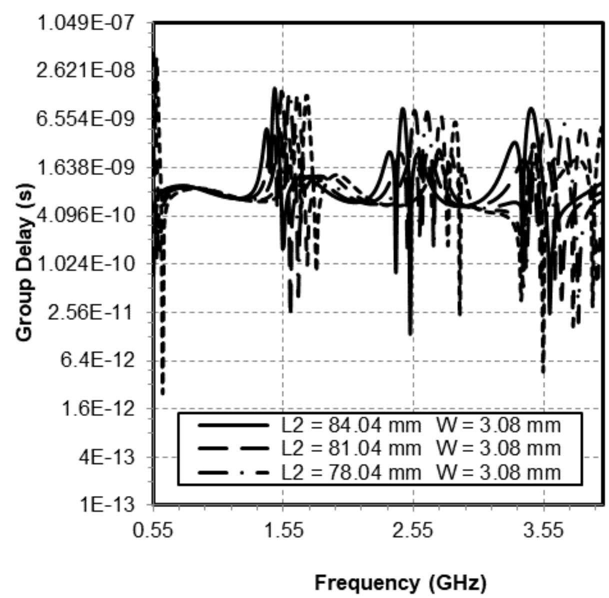


Figure 7: Graph of group delay from L_2 DBPF Parameter iteration result

Figure 7 is graph of group delay from L_2 DBPF Parameter iteration result for five times. Y axis is group delay at the range of 1.10^{-13} s to $1.049.10^{-8}$ s, while X axis is the frequency from 0.55 GHz to 4 GHz. In first iteration with the value of L_2 of 84.04 mm and W of 3.08 mm, it was obtained group delay $8.633.10^{-10}$ s (0.8633 ns) and $1.075.10^{-9}$ s (1.075 ns), in second iteration with the value of L2 of 81.04 mm and W of 3.08 mm, it was obtained group delay of $8.494.10^{-10}$ s (0.8494 ns) and $1.071.10^{-9}$ s (1.071 ns), in third iteration with L_2 of 78.04 mm and W of 3.08, it was obtained group delay of $8.378.10^{-10}$ s (0.8378 ns) and $1.082.10^{-9}$ s (1.082 ns), forth iteration with the value of L_2 of 75.04 mm and W of 3.08 mm it was obtained group delay of $7.98.10^{-10}$ s (0.798 ns) and 8.902.10-10 s (0.8902 ns), fifth iteration with the value of L_2 of 72.04 mm and W of 3.08 mm, it was obtained group delay of $8.031.10^{-10}$ s (0.8031 ns) and $1.126.10^{-9}$s (1.126 ns).

There was a change of group delay of first frequency from 8633 ns, 0.8494 ns, 0.8378 ns, 0.798 ns, and 0.8031 ns and at second frequency from 1.075 ns, 1.071 ns, 1.082 ns, 0.8902 ns, 0.8902 ns, and 1.126 ns. The higher the frequency, the wider the signal waves from group delay and the closer the range between group delays. The best group delay was at the first frequency of 0.798 ns in third iteration, but not at the expected frequency. It was difference at second frequency of 1.071 in second iteration which is in accordance with the group delay at the expected frequency. At the frequency of 950 MHz and 1.85 GHz it was obtained group delay of 0.8494 ns and 1.071 ns which is in accordance with DBPF specification. After iteration was conducted at parameter of L_2, iteration wat the parameter of L3 was carried out from DBPF based on DBPF specification from table 3.4. Graph of simulation is presented in figure 8

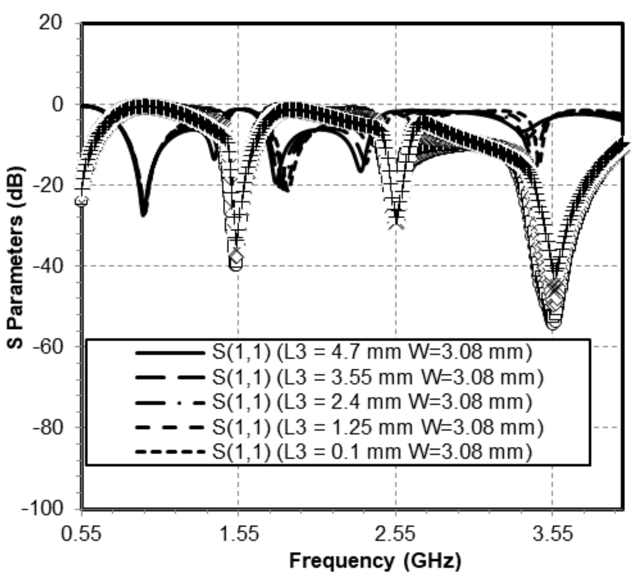


Figure 8: Graph of RL and IL from L_3 DBPF Parameter iteration result

Figure 8 is a graph of RL and IL which had been iterated for five times on parameter of L_3. Y axis is RL and IL at the range of -100 to 20, while X axis is the frequency from 0.55 GHz to 4 GHz. In first iteration with the value of L_3 of 4.7 mm and W of 3.08940 MHz with RL of -27.462 dB and IL of -0.561 dB and 1.79 GHz with RL of -19.387 dB and IL of -1.667, in second iteration with the value of L_3 of 3.55 mm and W of 3.08 mm, it was obtained resonance frequency of 940 MHz with RL of -26.839 dB and IL of -0.553 dB and 1.81 GHz with RL of -20.416 dB and IL of -1.533 dB, in third iteration with L_3 of 2.4 mm and W of 3.08, it was obtained resonance frequency of 950 MHz with RL of -26.938 dB and IL of -0.54 dB and 1.83 GHz with RL of -20.973 dB and IL of -0.54 dB, in forth iteration with the value of L_3 of 1.25 mm and W of 3.08 mm it was obtained resonance frequency of 950 MHz with RL of -26.927 dB and IL of -0.531 dB and 1.85 GHz with RL of -21.342 dB and IL of -1.317 dB, in fifth iteration with the value of L_3 of 0.1 mm and W of 3.08 mm, it was obtained resonance frequency of 950 MHz with RL of -26.764 dB and IL of -0.522 dB and 1.87 GHz with RL of -21.264 dB and IL of -1.233 dB.

In first iteration and second iteration, the first frequency was relatively constant which was 940 MHz and there was a change in third iteration for 10 MHz and relatively constant up to fifth iteration (950 MHz). It was different from first frequency, in second frequency there was a change from 1.79 GHz, 1.81 GHz, 1.83 GHz, 1.85 GHz, and 1.87 GHz. At the second frequency the change was relatively stable which was 20 MHz. the best RL was in first iteration at frequency of 940 MHz and in fifth iteration at frequency of 1.87 GHz, however not at the expected resonance frequency. IL in fifth iteration, but no path the expected resonance frequency as well. At the expected frequency it was obtained RL of -26.938 dB and -21.342 dB and IL of -0.531 dB and -1.317 dB which is in accordance with expected specification. From all five iteration, forth iteration was chosen because its is in accordance with resonance frequency of DBPF which was at 950 MHz and 1.85 GHz. After being considered from the resonance frequency, RL, and IL, DBPF can also be considered from the quality of VSWR and group delay at parameter of L_3.

Figure 9 shows the graph VSWR from iteration of L_3 parameter which was based on specification.

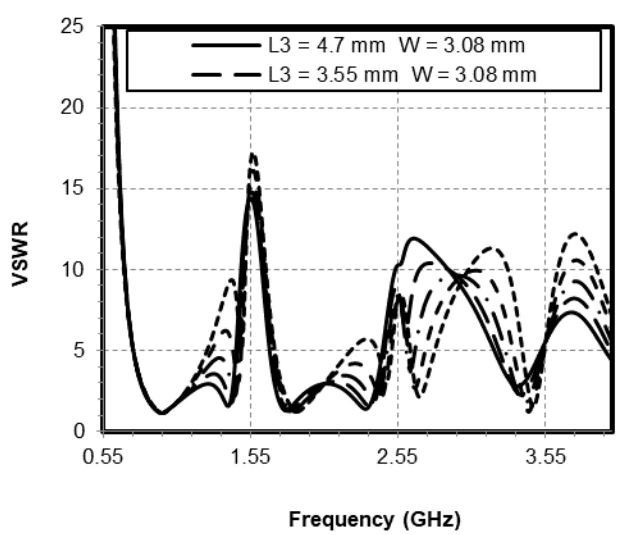


Figure 9: Graph of VSWR from L_3 Parameter iteration of DBPF

Figure 9 is a graph of VSWR of iteration of L_3 parameter of DBPF based on specification of DBPF on table

3.4. Y axis is VSWR at the range of 0 to 25, while X axis is the frequency from 0.55 GHz to 4 GHz. In first iteration with the value of L_3 of 4.7 mm and W of 3.08 mm it was obtained VSWR of 1.088 and 1.24, in second iteration with the value of L_3 of 3.55 mm and W of 3.08 mm, it was obtained VSWR of 1.095 and 1.211. In third iteration with the value of L_2 of 2.4 mm and W of 3.08 mm it was obtained VSWR of 1.094 and 1.196, in forth iteration with the value of L_2 of 1.25 mm and W of 3.08 mm it was obtained VSWR of 1.094 and 1.187 in fifth iteration with the value of L_2 of 0.1 mm and W of 3.08 it was obtained VSWR 1.096 and 1.189.

There was a change of VSWR of first frequency from first iteration to third iteration as 1.088, 1.095, and 1.094. In third and forth iteration the value of VSWR was relatively stable (1.094) and there was a change in fifth iteration. It was difference from the second frequency, the value of VSWR change from 1.24, 1.211, 1.196, 1.187, and 1.189. at the frequency range of 2.55 GHz to 2.98 GHz the value of VSWR in first iteration undergo unstability of signal wave, this phenomenon can be indicated from signal wave which tend to insignificant decrease at the frequency of 2.58 GHz, and then it formed a wide peak up to the frequency of 2.98 GHz. At the expected frequency of 950 MHz and 1.85 GHz in forth iteration t was obtained the best VSWR. Figure 10 shows graph of group delay as the result from iteration of parameter of L_3.

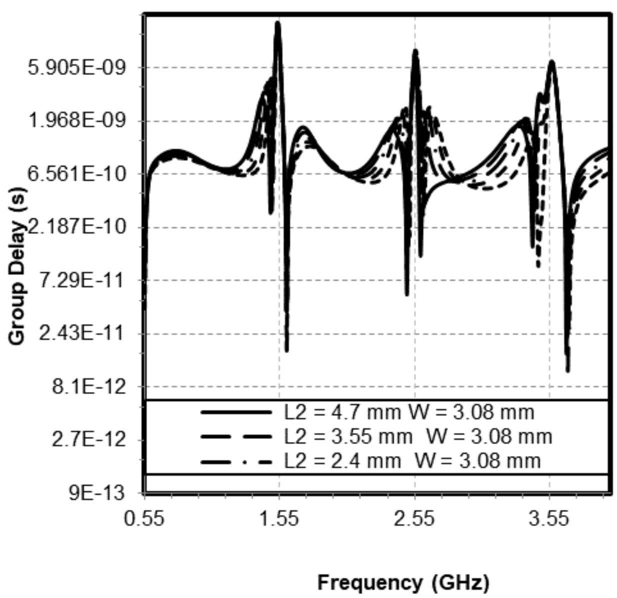


Figure 10: Graph of Group Delay from L_3 Parameter iteration of DBPF

Figure 10 is graph of group delay from L3 Parameter iteration on DBPF for five times. Y axis is group delay at the range of 9.10^{-13} s to $1.771.10^{-8}$ s, while X axis is the frequency from 0.55 GHz to 4 GHz. In first iteration with the value of L_3 of 4.7 mm and W of 3.08, it was obtained group delay of $89.058.10^{-10}$ s (0.9058 ns) and 1.379.10-9 s (1.379 ns), in second iteration with the value of L_3 3.55 mm and W of 3.08 mm, it was obtained group delay of $8.912.10^{-10}$ s (0.8912 ns) and $1.263.10^{-9}$ s (1.263 ns), in third iteration with L_3 of 2.4 mm and W of 3.08, it was obtained group delay of *group delay* of $8.641.10^{-10}$ s (0.8641 ns) and $1.16.10^{-9}$ s (1.16 ns),in forth iteration with the value of L_3 of 1.25 mm and W of 3.08 mm it was obtained group delay of $8.494.10^{-10}$ s (0.8494 ns) and $1.071.10^{-9}$ s (1.071 ns), in fifth iteration with the value of L_3 of 72.04 mm and W of 3.08 mm, it was obtained group delay of $8.343.10^{-10}$ s (0.8343 ns) and $9.957.10^{-10}$ s (0.9957 ns).

There was a change of group delay of first frequency from 0.9058 ns, 0.8912 ns, 0.8641 ns, 0.8494 ns, and 0.8343 ns and at second frequency from 1.379 ns, 1.263 ns, 1.16 ns, 1.071 ns, and 0.9957 ns. The higher the frequency, the lower the group delay signal wave peak and tend to move and separating signal wave between group delays was closer. The best group delay was in fifth iteration, but it was not at the expected frequency. At the frequency of 950 MHz and 1.85 GHz it was obtained group delay of of 0.8641 ns and 1.263 ns which is in accordance with DBPF specification.

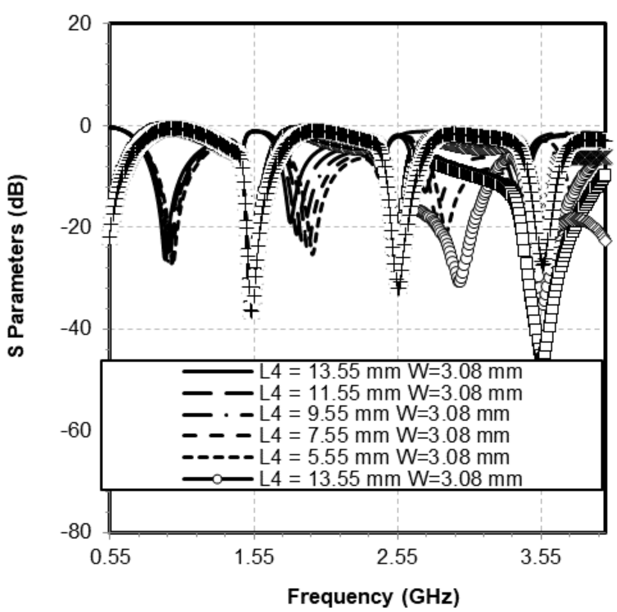


Figure 11: Graph of RL and IL from L_4 Parameter iteration of DBPF

Figure 11 is graph of RL and IL from iteration for five times on element of L_4. Y axis is RL and IL at the range of -80 to 20, while X axis is the frequency from 0.55 GHz to 4 GHz. In first iteration with the value of L_4 of 13.55 mm and W of 3.08mm it was obtained the frequency of 940 MHz with RL of -26.379 dB and IL of -0.537 dB and 1.81 GHz with RL of -19.092dB and IL of -1.527, in second iteration with the value of L_4 of 11.55 mm and W of 3.08 mm, it was obtained resonance frequency of 940 MHz with RL of -26.927 dB and IL of -0.531 dB and 1.81 GHz with RL of -21.342 dB and IL of -1.317 dB, in third iteration with L_4 of 9.55 mm and W of 3.08, it was obtained resonance frequency of 960 MHz with RL of -26.93 dB and IL of -0.528 dB and 1.89 GHz with RL of -23.039 dB and IL of -1.184 dB, in forth iteration with the value of L_4 of 7.55 mm and W of 3.08 mm it was obtained resonance frequency of 980 MHz with RL of -26.972 dB and

IL of -0.524 dB and 1.93 GHz with RL of -24.287 dB and IL of -1.1dB, in fifth iteration with the value of L_4 of 1.96 mm and W of 3.08 mm, it was obtained resonance frequency of 990 MHz with RL of -27.377 dB and IL of -0.523 dB and 1.967 GHz with RL of -25.291 dB and IL of -1.064 dB.

There were changes of first frequency from 940 MHz, 950 Mhz, 960 MHz, 980 GHz, and 990 GHz and second frequency from 1.81 GHz, 1.85 GHz, 1.89 GHz, 1.93 GHz, and 1.96 GHz. At the frequency range of 940 MHz to 960 MHz the frequency change was relatively stable for 10 MHz and there was an increase of frequency change from 960 to 990 GHz for 10 MHz. it was different from the second frequency, there was a relatively stable change at the range of 1.81 GHz to 1.93 GHz for 40 MHz ad the change decrease from 40 MHz to 30 MHz from the forth frequency iteration (1.93 GHz) up to frequency of fifth iteration (1.96 GHz). The best RL and IL were in the fifth iteration but it was not at the expected resonance frequency. From all five iteration the second iteration was chosen because the resonance frequency of DBPF which was at 950 MHz and 1.85 GHz. After being considered from resonance frequency, RL, and IL, DBPF it can be considered from the quality of VSWR and group delay on L_4 parameter.

Figure 12 shows the graph of VSWR from L_4 iteration parameter which based on DBPF specification.

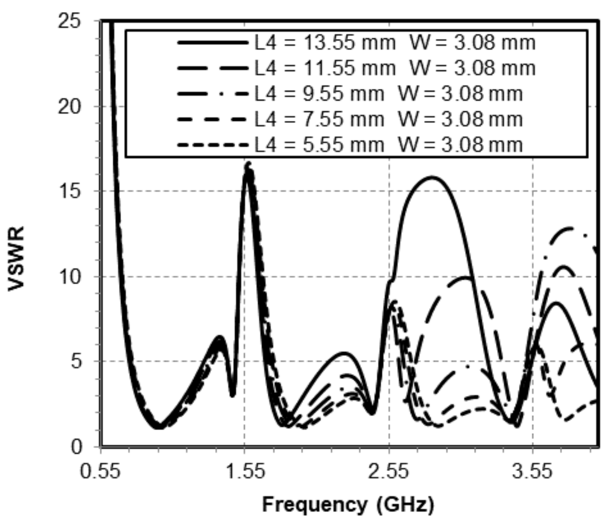


Figure 12 : Graph of VSWR from L_4 parameter iteration of DBPF

Figure 12 is a graph of VSWR from L4 parameter iteration of DBPF based on DBPF specification on table 3.4. Y axis is VSWR from the range of 0 to 25, while X axis is a frequency of 0.55 GHz up to 4 GHz. At first iteration with the value of l4 of 13.55 mm and W of 3.08 mm, it was obtained VSWR of 1.101 and 1.25, in second iteration with the value of L_4 of 11.55 mm and W of 3.08 mm, it was obtained VSWR of 1.094 and 1.187. In third iteration with the value of L4 of 9.55 mm and W of 3.08 mm it was obtained VSWR of 1.094 and 1. 152, in forth iteration with the value of L_4 of 7.55 mm and W of 3.08 mm it was obtained VSWR of 1.094 and 1.13 in fifth iteration with the value of L_4 of 5.55 mm and W of 3.08 it was obtained VSWR 1.089 and 1.115. There was a change of VSWR value of first frequency from in first and second iteration as 11.101 and 1.094, it was relatively stable in second to forth iteration (1.094), and the change was undergone from forth to fifth iteration from 1.094 to 1.089. However in second frequency there were VSWR value change from 1.25, 1.187, 1.152, 1.13, and 1.115. The best VSWR was obtained in second to forth iteration at first frequency and in fifth iteration at the second frequency. At the expected frequency of 950 MHz in second iteration it was obtained VSWR categorized as the best. At the expected frequency of (950 MHz and 1.85 GHz), the value of VSWR fulfilled DBPF specification.

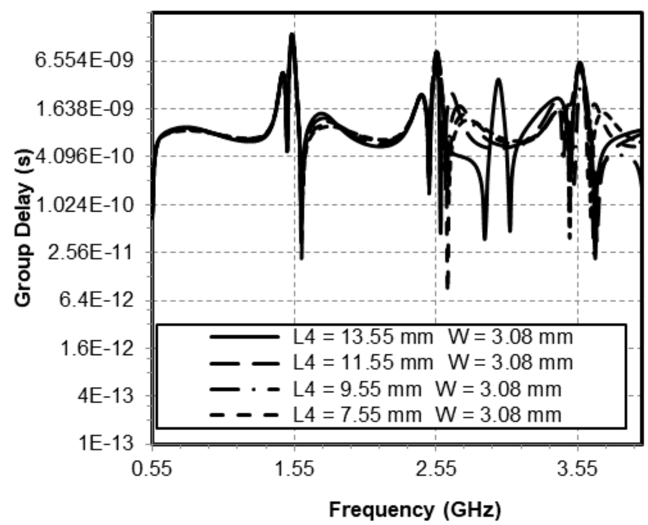


Figure 13: Graph of Group Delay from L_4 iteration of DBPF

Figure 13 is a graph of group delay of L_4 parameter iteration of DBPF for five times. Y axis is group delay at the range of 1.10^{-13} s to $2.621.10^{-8}$ s, while X axis is the frequency from 0.55 GHz to 4 GHz. In first iteration with the value of L_4 of 13.55 mm and W of 3.08, it was obtained group delay of 8.66.10-10 s (0.866 ns) and 1.247.10-9 s (1.247 ns), in second iteration with the value of L_4 of 11.55 mm and W of 3.08 mm, it was obtained group delay of 8.494.10-10 s (0.8494 ns) and 1.071.10-9 s (1.071 ns), in third iteration with L_4 of 9.55 mm and W of 3.08, it was obtained group delay of 8.351.10-10 s (0.8351 ns) and 9.553.10-10 s (0.9553 ns) in forth iteration with the value of L_4 of 7.55 mm and W of 3.08 mm it was obtained group delay of 8.152.10-10 s (0.8152 ns) and 8.775.10-10 s (0.8775 ns), in fifth iteration with the value of L_4 of 5.55 mm and W of 3.08 mm, it was obtained group delay of 8.059.10-10 s (0.8059 ns) and 8.388.10-10 s (0.8388 ns). There was a change of group delay of first frequency from 0. 866 ns, 0.8494 ns, 0.8351 ns, 0.8152 ns, and 0.8059 ns, and at second frequency from 1.247 ns, 1.071 ns, 0.9553 ns, 0.8775 ns, and 0.8388 ns. The signal wave on group delay in first iteration wan unstable, this phenomenon was proven by the emergence of third group delay at frequency range of 2.62 GHz to 3.49 GHz and restabilized by the formation of forth group delay (same as third group delay in second iteration up to fifth iteration) thus the gap between group delays was not exist. The best group delay was in fifth iteration, but it was not at the expected frequency. At the frequency of 950 MHz and 1.85 GHz it was obtained group delay of 0.8494 ns and 1.071ns which is in accordance with DBPF specification.

3. COMPARISON OF SIMULATION AND MEASUREMENT

DBPF in frequency of 947.1 MHz and 1.844 GHz with RL of -26.797, IL of -0.532 dB, VSWR of 37.208, and group delay of 8.43.10-10 s and RL-20.932 dB, IL of -1.347 dB, VSWR of 16.076, and group delay of 1.063.10-9 s on simulation of ADS, operate at the frequency of 929.883 MHz wi RL of -28.386 dB, IL of -0.809 dB, group delay of 8.439.10-10, and VSWR of 22.149 and 1.844 GHz with RL of -18.949 dB, IL of -1.62 dB, group delay of 8.873.10-10, and VSWR of 12.112 at the CST simulation, and operate at the frequency of 912.636 MHz with RL of -23.389 dB, IL of -1.163 dB, VSWR of 1.145, and group delay of 3.157.10-9 s and 1.896 GHz weigh RL of -21.595 dB, IL of -1.843 dB, VSWR of 1.181, and group delay of 3.033.10-9 s in real measurement.

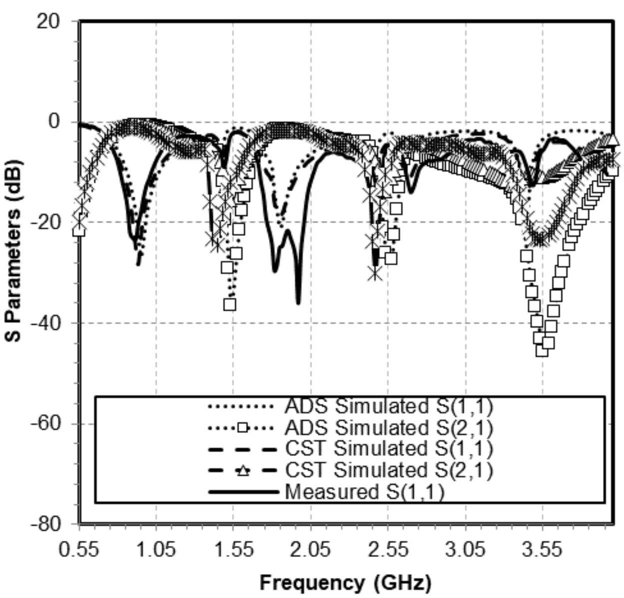


Figure 14: Graph of RL and IL DBPF

From the result of simulation and measurement it was obtained data of RL and IL. Figure 4.7 is RL graph and IL graph from simulation result and DBPF measurement. Y axis is RL and IL at the range of -80 to 20 dB, while X axis is the frequency at the range of 0.55 GHz to 4 GHz. At the simulation of ADS operated at the frequency of 947.1 MHz with RL of -26.797 and IL of -0.532 dB and 1.844 GHz with RL of -20.932 dB and IL of -1.347 dB, simulation of CST operated at the frequency of 929.883 MHz with RL of -28.386 dB, IL of -0.809 dB and 1.844 GHz with RL of -18.949 dB and IL of -1.62 dB, and at real measurement operated at the frequency of 912.636 MHz with RL of -23.389 dB and IL of -1.163 dB and 1.896 GHz with RL of -21.595 dB and IL of 1.843 dB .

Compare to the expected DBPF specification which operation frequency is at 950 MHz and 1.85 GHz, there was frequency changes in simulation of ADS from 950 MHz to 947.1 MHz and from 1.85 GHz to 1.844 GHz, there was frequency changes in simulation of CST from 950 MHz to 929.883 MHz and from 1.85 GHz menjadi 1.844 GHz, and there was frequency changes in measurement from 950 MHz to 912.636 MHz and from 1.85 GHz to 1.8958 GHz. There was a relatively significant change in signal of measurement compare to the simulation of ADS and CST. From simulation of ADS, simulation of CST and real measurement it was obtained the gradual decrease of RL and at the measurement of first frequency and there was an increase at the second frequency. There was an gradual increase of IL from measurement simulation of CST and simulation of ADS at the second frequency. RL and IL is in accordance with specification filter, RL< -10 dB and IL< 2 dB.

From the result of simulation and measurement VSWR was obtained. Figure 15 is a graph of VSWR from simulation and measurement of SBPF. Y axis is VSWR from range of 0 to 45, meanwhile X axis is frequency at the range of 0.55 GHz. In simulation ADS, it was obtained VSWR of 37.208 and 16.076, from simulation of CST it was obtained VSWR of 22.149 and 12.112, in measurement, VSWR of 1.145 and 1.181 was obtained. From those three experiments, the value of VSWR from measurement has much higher quality from the value of VSWR as the result of simulation of ADS and CST eventhough it was not at the expected frequency. Signal of VSWR in measurement has characteristic with signal peak and expected frequency range become the value at first and become peak at the expected frequency, so that it caused the value of VSWR was so high. VSWR from those three experiments, the one which fulfilled the filter specification was only from the measurement which was VSWR < 2.

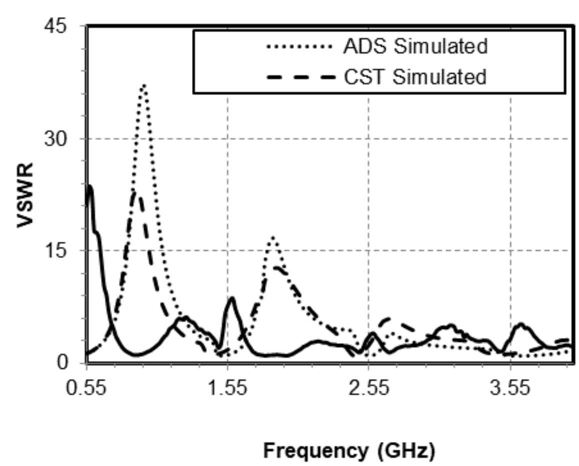


Figure 15: Graph of VSWR DBPF

From the result of simulation and measurement it was obtained the data of group delay. Figure 16 is a graph of group delay from simulation and measurement of SBPF. Y axis is group delay at the range of 9.10-12 s to 2.812.10-8¬ s, meanwhile X axis is frequency at the range of 0.55 GHz to 4 GHz. All group delays fulfilled the specification of group delay <10.10-9 s (10 ns).

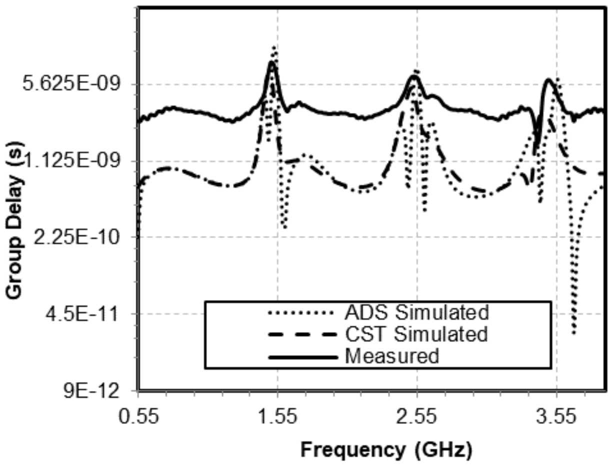


Figure 16: Graph of group delay of DBPF

It was obtained group delay of 8.434.10-10 s and 1.063.10-9 s, in simulation using CST it was obtained group delay of 8.439.10-10 s and 8.873.10-10 s, and in measurement, it was obtained group delay of 3.157.10-9 s and 3.033.10-9 s. there was an increase of group delay gradually, from simulation, in ADS simulation and CST simulation, and measurement at first frequency and second frequency there was decrease from simulation of CST, measurement and simulation of ADS. The best group delay was obtained at the simulation of ADS with the value of 1.35.10-10 s, but it was not at the expected frequency (3.689 GHz).

4. CONCLUSION

In this paper was successfully designed dual band bandpass filter (DBPF) using multistub resonator structure in frequency of 947.1 MHz and 1.844 GHz at the middle frequency (Fc) of 912.636 MHz, *Return Loss* of -23.389 dB, *Insertion Loss* of -1.163 dB, VSWR of 1.145, *Group Delay* of 3.157 ns, and middle frequency (Fc) of 1.896 GHz, *Return Loss* of -21.595 dB, *Insertion Loss* of -1.843 dB, VSWR of 1.181, *Group Delay* of 3.033 ns. *Size* of 57.44 x 124.12 mm. A good agreement is shown in comparison between simulated and measured.

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