Rectangular Grooving with Comb-shaped Tuning Stub Antenna for Dual BandApplication

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Abstract

This paper presents a rectangular grooving with comb-shaped tuning stub antenna. This antenna was fabricated by grooving technique and be analyzed by CST software. The proposed antenna was designed to 30 x 30 mm^2 using FR4 PCB with ε_r = 4.3 and its thickness (h) = 0.764 mm for dualbands application i.e. first band was 2.37-2.57 GHz with low resonance frequency of 2.45 GHz and second band was 5.01-6.34 GHz with high resonance frequency of 5.79 GHz. These frequency bands entirely cover IEEE 802.11b/g 2.4 GHz (2.40 - 2.4835 GHz), IEEE 802.16a 5.2 GHz (5.13-5.35 GHz) and 5.8.GHz (5.7-5.9 GHz) as required.

Keywords:PCBComb-shapeWireless communication networkDouble frequency range

1. Introduction

Nowadays, most of communication system in Thailand and other countries have use wireless communication to facilitate short and long distance transmission. Nevertheless, huge volume in communication system may affect to slower traffic and the related provider needs to increase more communication channels for faster response and more selective frequency band. So the IEEE has extend the existing IEEE standard i.e. first band IEEE.802.11b/g 2.45 GHz (2.4-2.4835 GHz) and shifting to higher frequency band IEEE.802.16a 5.2 GHz (5.13-5.35 GHz) and 5.8 GHz (5.7-5.9 GHz) from WAN wireless communication system. However, the necessary element need to be developed is the antennae which can response mentioned frequency bands and it is require some research [1-5] regarding the antenna responding dual frequency bands but those antenna still was bully size [1-4] and some smaller size antenna has a bandwidth impedance that cannot response over the required frequency band [5]. The simulation of prototype antenna used the teeth and groove tuning [6-7] to find out the optimized parameters for obtaining the optimized antenna by experimental method and CST software.

2. Antenna Design and Simulation

2.1 Antenna Structure

Microstrip antenna is a rectangular grooving on PCB with comb-shapedtuning stub as shown in Fig. 1. This antenna was designed on single-sided circuit board and FR4 substrate with dielectric constant (ε_r) = 4.3 and thickness (h) = 0.764 mm and its dimension was 30 x 30 mm^2. The signal was fed at the bottom of prototype antenna and its parameters are shown as Table 1.

2.2 Simulation Results

The proposed antenna was simulated with CST software for studying the frequency responding, for example, return loss, radiation, and bandwidth to optimize the antenna structure covering wireless communication according to IEEE 802.11 b/g and IEEE 802.16a/d. The result showed that when adjusting both width and length of prototype antenna by cutting as scalene-triangle to reduce the return loss (S_{11}) for low frequency and high frequency. To obtain the optimized parameters with required frequency band, four steps was conducted. Firstly, to groove the antenna using tuning technique with comb-shaped stub [6-8] to obtain parameter W_2 by adding lines W_2 as 2, 3, 4, and 5 lines and found that 5 lines is an optimized value. The simulation output showed that this modified antenna can responses dual frequency bands i.e. point a with the return loss at low frequency of 2.61 GHz is -17.76 dB and point b with return loss at high frequency is -18-27 GHz. So now this antenna can responses dual frequency bands as required.

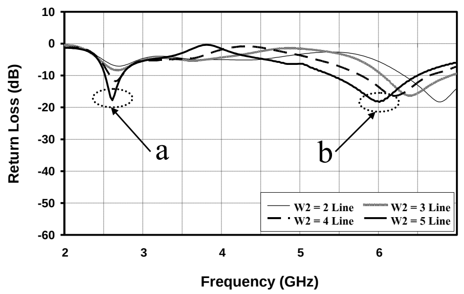


Fig. 2 return loss (S_{11}) when adding W_2

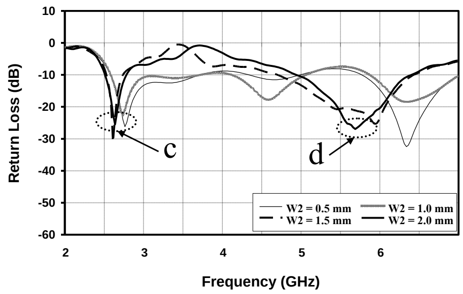
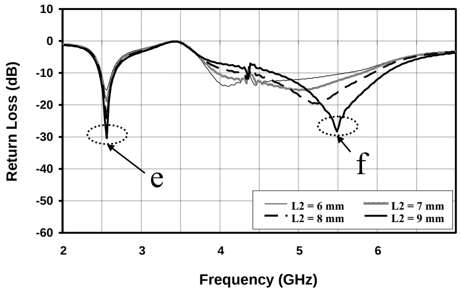


Fig. 3 return loss (S_{11}) when adjusting W_2

The second steps was to adjust the line width (W_2) to the optimized value and found that when adjusting, the return loss is lower point a and point b for low frequency and high frequency bands. W_2 value was adjusted from 0.5, 1.0, 1.5, and 2.0 mm and found that the optimized value is 2 mm. This value will result in point c with return loss is -25.49 dB at low frequency of 2.62 GHz and point d with return loss is 26.56 dB at high frequency of 5.69 dB as shown in Fig. 3.

The third step was to adjust the line length (L_2) to optimized value and found that when adjusting, the return loss is lowerby adjusting from 6, 7, 8, and 9 mm. The optimized value of L_2 is 9 mm, at point e the return loss is -30.40 dB at low frequency of 2.55 GHz and point f with return loss of -28.32 dB at high frequency of 5.49 GHz. We found that at these points the return loss is lower point c and d as shown in Fig. 2 but it cannot cover low and high frequency band as required, illustrated in Fig. 4.



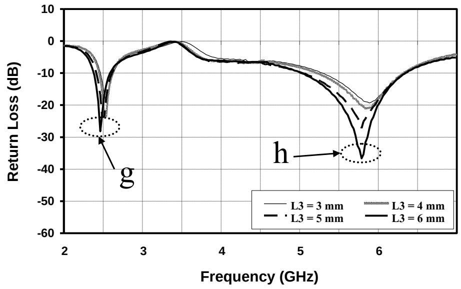


Fig. 4 return loss (S_{11}) when adjusting L_2 Fig. 5 return loss (S_{11}) when adjusting L_2

The final step was to groove between comb-shaped stub and upper signal feeder to obtain the resonance frequency of low and high band as standard required. This groove induces the length parameter of strip (L_3) as shown in Fig. 5. The L_3 value was adjusted to obtain the optimized value for reducing the return loss. The adjustable values are 3, 4, 5, and 6 mm and found that the optimized value is 6 mm. at point g the return loss is -28.17 with low frequency of 2.45 GHz anand point h with return loss of-36.63 dB at high frequency of 5.79 GHz. We found that at these points the return loss (S_{11}) can cover IEEE 802.11 b/g 2.4 GHz (2.40 - 2.4835 GHz), IEEE 802.16a 5.2 GHz (5.15 - 5.35 GHz), and 5.8 GHz (5.7 - 5.9 GHz) as shown in Fig. 4.

3. Fabrication and Measurement

From the simulation result we obtain the optimized parameter of antenna and it was fabricated to prototype antenna. The interesting parameter were return value, bandwidth, and gain of antenna was measured by E8363B network analyzer. The measurement and simulation values were compared and obtaining the return loss and gain we found that both values are consistent as shown in Fig. 7 and Table 2.

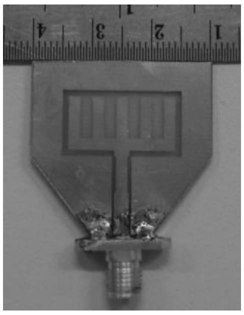


Fig. 6 physical antenna

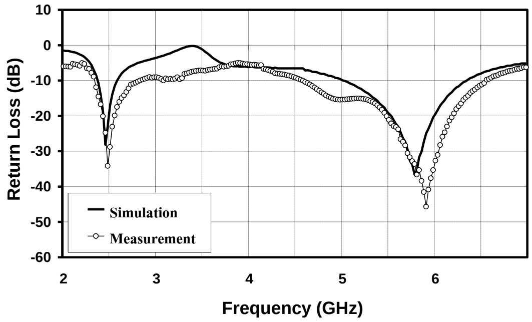


Fig. 7 measurement and simulation comparison of return loss (S_{11}) for prototype antenna

In addition, simulated and physical antennas were compared the radiation parameters and found that at 2.48 GHz and 5.81 GHz the radiation is bidirectional on x-z plane as shown in Fig 8-9 and y-z plane as shown in Fig. 9-10.

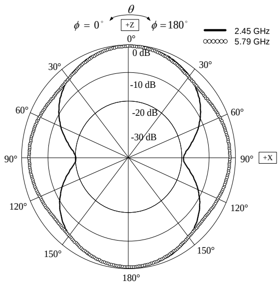


Fig. 8 radiation simulation at resonance frequency of 2.45 GHz and 5.79 GHz on x-z plane

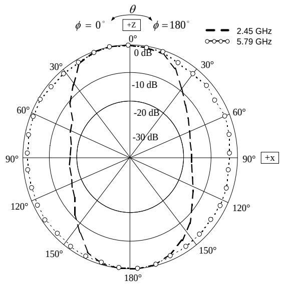


Fig. 9 radiation simulation at resonance frequency of 2.45 GHz and 5.79 GHz on y-z plane

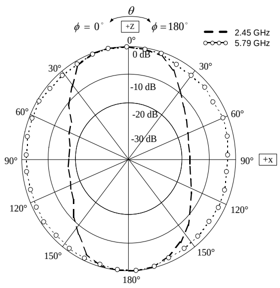


Fig. 10 radiation simulation at resonance frequency of 2.45 GHz and 5.79 GHz on x-y plane

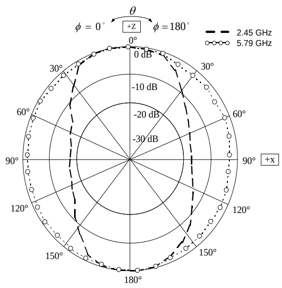


Fig. 11 radiation simulation at resonance frequency of 2.45 GHz and 5.79 GHz on y-z plane

4. Conclusion

The rectangulargrooving with comb-shaped tuning stubantenna was fabricated and measured found that length tuning of groove was to add more line to 5 lines and reducing its length W_2 = 1.0 mm, to increase its length L_2 = 9mm, and final step was to create grooves between comb-shaped stub and upper signal feeder with length L_3 = 6 mm together with rectangular groove tuning and cutting the antenna as scalene-triangle of both sides. The bandwidth of low frequency range is 0.45 GHz (2.35-2.80 GHz) and high frequency range is 1.91 GHz (4.61-6.52 GHz) covering IEEE 802.11b/g and IEEE 802.16a/d as well. The gain of prototype antenna are 4.76 and 5.21 dBi for low and high frequency ranges, respectively.

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