Parametric Study on the Compact G-Shaped Monopole Antenna for 2.4 GHz and 5.2 GHz Application

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***Abstract*—This paper describes the design of a compact printed microstrip G-shaped monopole antenna for wireless local area network (WLAN application). The antenna has G-shaped resonating element which is designed for the two resonance frequencies at 2.4GHz and 5.2GHz respectively, which are the operating bands for WLAN application. The antenna is constructed by a non-conductor backed G-shaped strip with a mircostrip feed line. The dual band performance can be easily achieved by fine-tuning the length of the resonant path. The antenna is designed and simulated by using Computer Simulation Technology (CST) Studio simulation software. The parametric study with five different ground lengths had been done using parametric sweep. The the measurement results will be compared and analyzed with the simulated antenna.**

Keyword-monopole antenna, wireless LAN, return loss, radiation pattern, antenna gain

I. INTRODUCTION

Nowadays, wireless local area network (WLAN) has played an important role in human living especially in the telecommunication area. WLAN are providing the high speed connectivity with easy access in a wireless communications system. WLAN antennas, in particular, have become important and play a crucial role in achieving optimum system performance [1-7]. A compact printed monopole antenna was proposed as for (WLAN) applications. To support high data rate wireless communication, besides being along with compact size, the antenna is preferred to be light weight, low cost, less fragile, and low profile [8-9]. This can make the fabrication done much easier and simpler [10-13].

Previously, there are many designs that focus on this monopole technique. Hasliza had been fabricated a textile monopole using wearable textile for body-centric wireless communications (BCWC) at 2.45 GHz [15]. Kashihara had been proposed J-shaped monopole antenna array for terrestrial digital broadcasting at UHF Band. His measurement work had been confirmed that the antenna successfully operates in the frequency ranges from 440 MHz to 770 MHz [16]. Ramlee in 2011 had been introduced compact ring monopole antenna for wireless implantable body area network (WiBAN) application. The antenna operates in frequency range of 2.4 GHz to 2.9 GHz with 2.4 dB of gain at 2.5 GHz [17]. Jamlos had been fabricated a dual frequency of the half-monopole antenna for WiMAX and Wi-Fi application. His antenna had been achieved 4.18 dB and 4.32 dB of gain at the 2.3 GHz and 2.45 GHz of frequency range. The return loss of this antenna is - 26.98 dB and - 11.67 dB respectively [18]. Panda in 2010 had been fabricated printed 9-shaped dual-band monopole antenna for WLAN and RFID application [19]. This antenna operates at resonant frequencies of 2.595 GHz and 5.18 GHz [20].

With the increasing demands of wireless high data rate transmission and different wireless protocols and modulation techniques, the compact printed monopole antenna will be one of the best antennas to be used [21]. Since many compact printed monopole antennas were fabricated for the wireless applications, the antenna is providing the broadband impedance matching and has appropriate gain characteristics for WLAN applications.

There are many techniques that can be applied to make a dual band planar in monopole antenna. Nurul in 2007 had been introduced a dual band planar monopole antenna with inverted-M parasitic plane. The resonant frequencies for this antenna are in the 2.03 GHz and 2.465 GHz [22]. Zhu in 2010 had been designed a novel dual-band monopole antenna that consists U-shaped and T-shaped antenna. This antenna operates at two frequency band of 2.46 GHz and 5.30 GHz [23]. In this paper, a new compact printed G-shaped monopole antenna is presented using WLAN applications of 2.4 GHz and 5.2 GHz. The antenna is constructed with microstrip feedline and have non-conductor backed G-shaped strips. By tuning the length of the resonant path, the dual-band antenna performance can easily achieve. Three parametric studies had been done to compare the antenna performance of return loss, gain, radiation pattern and bandwidth.

II. ANTENNA DESIGN

Figure 1 shows the geometry of the designed printed G-shaped monopole antenna. The substrate of G-shaped monopole antenna is a FR-4 substrate where it has permittivity, εr = 4.4 and the copper thickness, t =1.6 mm. The shape of the antenna element is like a G-shaped without a conductor backed ground plane. A 50 ohm microstrip line is used for excitation. The dimensions (width x length) of the substrate are 30 mm and 38 mm respectively. Table 1 shows the dimension of the G-shaped monopole antenna.

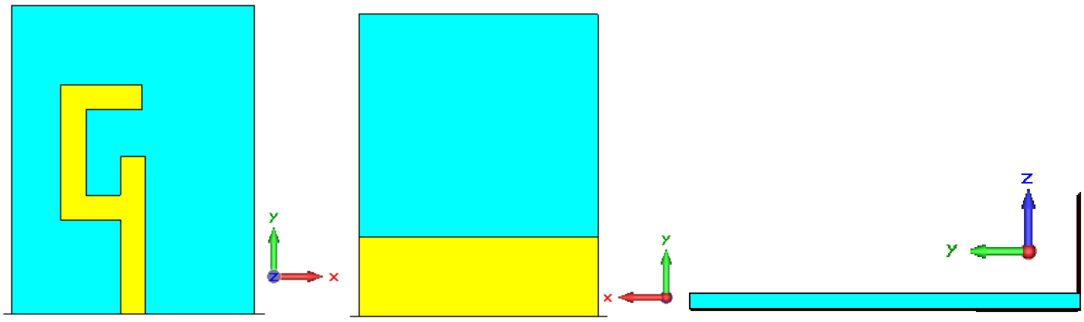


Figure 1: Geometry of the printed microstrip G-shaped monopole antenna (a) side view, (b) plan view

Table 1: Dimension of the G-shaped monopole antenna

Part	Dimension (mm)
W	30
L	38
L_1	1.00
L_2	5.40
L_3	16.66
L_4	6.90
W_e	3.06
L_k	11.5
L_{gnd}	9.5

III. RESULT

Figure 2(a) shown the return loss of the compact printed G-shaped monopole antenna in the range between 1.0 GHz and 6.0 GHz. It response at two frequency points that is at 2.4 GHz with a return loss of -16.38 dB and 5.2 GHz with return loss -19.19 dB. Figure 2(b) and Table 2 represents the parametric study on the different length of the antenna ground. Five different lengths had been simulated that is 8.5 mm, 9.0 mm, 9.5 mm, 10.0 mm and 10.5 mm. The adjustment of the ground length will shift the resonant frequency. For example, the reduction of the normal length from 9.5 mm to 8.5 mm will shift the resonant frequency from 2.40 GHz to 2.35 GHz.The best point is achieved by L_{gnd} = 8.5 mm with a return loss of -24.80 dB at 4.77 GHz. Figure 4 shows the 2D radiation pattern of the antenna for 2.4 GHz and 5.2 GHz. Figure 5 shows the 3D radiation pattern of the antenna for 2.4 GHz and 5.2 GHz.

Table 2: Parametric study on different ground length

	L_{gnd} (mm)									
	8.5		9.0		9.5		10.0		10.5	
Frequency (GHz)	2.35	4.77	2.38	4.97	2.40	5.20	2.47	5.70	2.44	5.51
Return loss (dB)	-14.62	-24.80	-15.50	-22.35	-16.38	-19.19	-21.73	-15.00	-17.99	-17.10

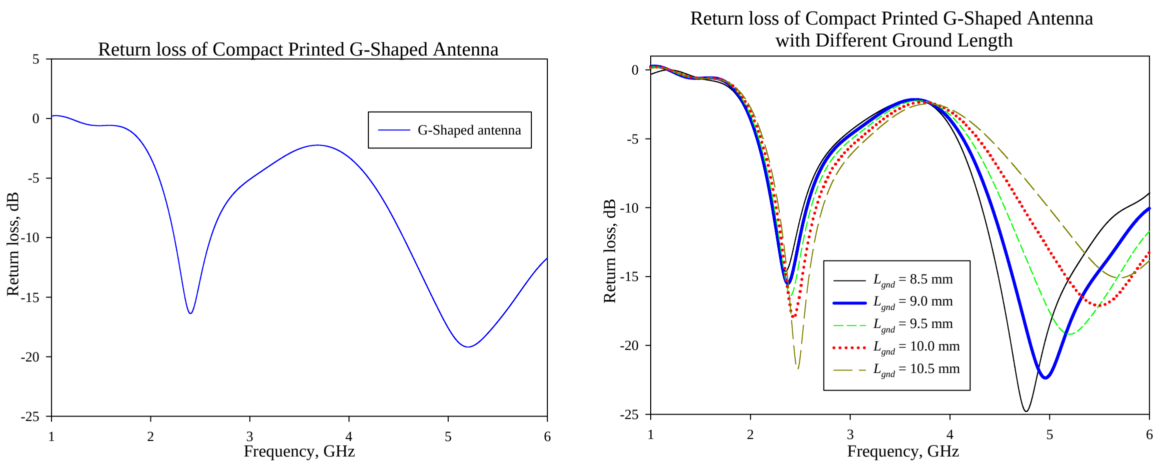


Figure 1: (a) Return loss of compact printed G-shaped monopole antenna, (b) Return loss of compact printed G-shaped monopole antenna with different ground length

Figure 3(a) and Table 3 shows the return loss of the printed G-shaped monopole antenna with three different L_4 dimensions – 4.9 mm, 6.9 mm and 8.9 mm. From the simulation result, it shows that L_4 = 6.9 mm operates in the 2.4 GHz and 5.2 GHz with a return loss of – 16.38 dB and – 19.19. The reducing of dimension into L_4 = 6.9 mm had been shifted the return loss from 2.4 GHz to 2.615 GHz and 5.2 GHz to 4.960 GHz. The return loss at this design is – 21.693 dB and – 15.13 dB.

Figure 3(b) and Table 4 represent the return loss performance of the printed G-shaped monopole antenna with five different L_x dimension – 3.36 mm, 3.81 mm, 4.26 mm, 4.81 mm and 5.16 mm. For L_x = 4.26 mm, its response at two frequency points that is at 2.4 GHz with a return loss of - 16.38 dB and 5.2 GHz with return loss - 19.19 dB.

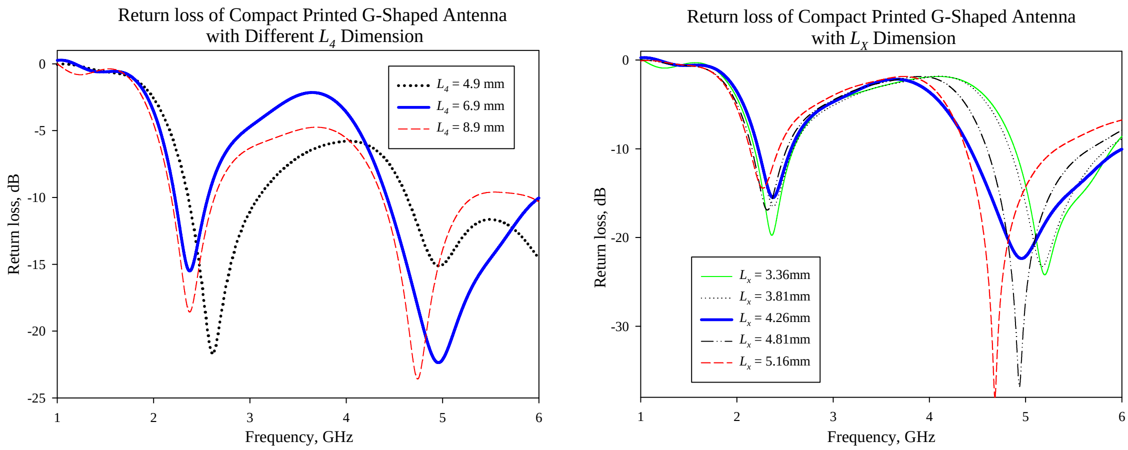


Figure 3: (a) Parametric study on different L_4 dimension, (b) Parametric study on different L_4 dimension

Table 3: Parametric study on different L_4 dimension

	Different L_4 (mm) Dimension					
	4.9		6.9		8.9	
Frequency (GHz)	2.615	4.960	2.400	5.200	2.375	4.745
Return loss (dB)	- 21.69	- 15.13	- 16.38	- 19.19	- 18.57	- 23.57

Table 4: Parametric study on different L_x dimension

	Different L_x (mm) Dimension									
	3.36		3.81		4.26		4.81		5.16	
Frequency (GHz)	2.365	5.200	2.380	5.175	2.400	5.200	2.315	4.935	2.27	4.68
Return loss (dB)	-19.74	-24.20	-16.46	-23.25	-16.38	-19.19	-16.91	-36.85	-14.44	-38.08

The best return loss is shown in L_x = 5.16 mm with – 38.08 dB at 4.68 GHz of resonant frequency. The increasing of the L_x will reduce the resonant frequency. For example, the reducing of the length from L_x = 5.16 mm to L_x = 3.36 mm will shift the resonant frequency from 4.68 GHz to 5.20 GHz.

Figure 4(a) and Table 5 shows the parametric study on different Y_k dimension. Three dimensions that consider in this graph are 10.3 mm, 11.5 mm and 12.7 mm with – 16.21 dB, - 16.38 dB, and 16.06 dB of return loss at 2.725 GHz, 2.400 GHz and 2.335 GHz of frequency. Figure 4(b) and Table 6 represent the effect on the change of the Y_3 dimension on the G-shape antenna performance.It shows that the resonant frequency for Y_3 = 15.66 mm is 2.52 GHz with – 16.91 dB and 5.24GHz with – 35.89 dB.

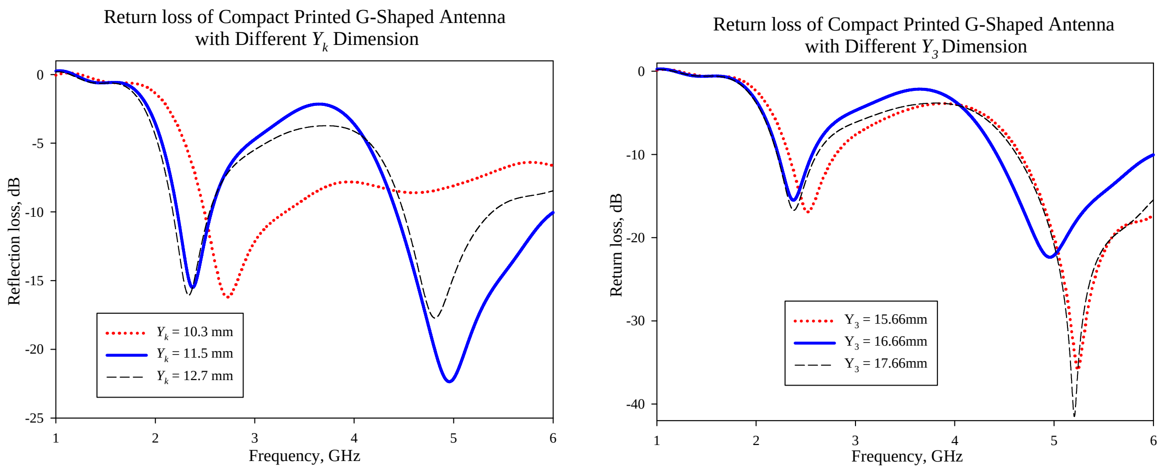


Figure 4: (a) Parametric study on different Y_k dimension, (b) Parametric study on different Y_3 dimension

Table 5: Parametric study on different Y_k dimension

	Different Y_k (mm) dimension					
	10.3		11.5		12.7	
Frequency (GHz)	2.725	4.605	2.400	5.200	2.335	4.812
Return loss (dB)	-16.21	-8.61	-16.38	-19.19	-16.06	-17.72

Table 6: Parametric study on different Y_3 dimension

	Different Y_3(mm) dimension					
	15.66		16.66		17.66	
Frequency (GHz)	2.52	5.24	2.400	5.200	2.380	5.205
Return loss (dB)	-16.91	-35.89	-16.38	-19.19	-16.72	-41.49

Figure 5 and Table 7 shows the compared return loss result of simulation and measurement result for compact printed G-shaped monopole antenna at 2.4 GHz and 5.2 GHz (in the range between 1.0 GHz and 6.0 GHz). From the graph it shows that the measured result of the antenna are - 14.51 dB at 2.4 GHz and – 11.30 dB at 5.2 GHz. The bandwidth of this antenna is 1264.3 MHz and >1165.4 dB for measured compared with simulation result are 367.45 MHz and >1451.2 MHz. Figure 6 shows the fabricated compact printed G-shaped monopole antenna.

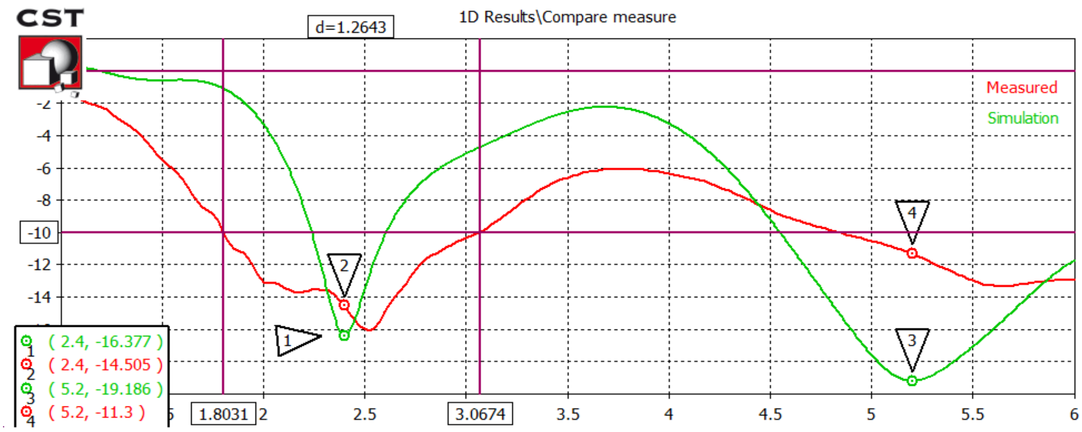


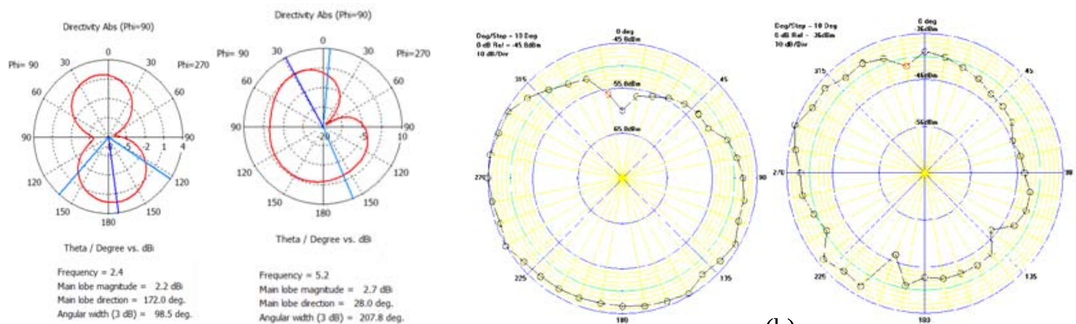
Figure 5: Compared return loss result between simulation and measurement

Table 7: Compared return loss result between simulation and measurement

	Simulation vs Measurment			
	Simulation		Measurment	
Frequency (GHz)	2.4	5.2	2.4	5.2
Return loss (dB)	- 16.38	- 19.19	- 14.51	- 11.30
Bandwidth (MHz)	367.45	>1451.2	1264.3	>1165.4

Figure 6: Fabricated printed G-shaped monopole antenna

Figure 7 shows the simulated and measured 2D radiation pattern of the compact printed G-shaped monopole antenna. The gain for the simulation of compact printed G-shaped monopole antenna at 2.4 GHz is 1.597 dB and at 5.2 GHz is 1.581 dB.



(a) (b)

Figure 7: (a) 2D radiation pattern of the antenna for 2.4 GHz and 5.2 GHz (simulation), (b) 2D radiation pattern of the antenna for 2.4 GHz and 5.2 GHz (measurement)

The proposed antenna design can be potentially integrated with RF transmitter [24-26] and RF receiver [27-31] to form a complete WLAN front-end system. The gain of the antenna can improve by adding the split ring resonator into the patch of the antenna [32-40].

IV. CONCLUSION

A compact printed G-shaped monopole antenna for WLAN application has been fabricated and presented. The antenna has been simulated by using Computer Simulation Technology (CST) Studio simulation software. After that, the comparison results have been analyzed between the fabricated prototype and the simulated antenna. Besides, the fabricated antenna has been performed successfully with functional test by connecting the antenna to the WiFi router. From the functional test, it can be shown that dual-band operation for WLAN application has been achieved by the G-shaped configuration of the radiating element. The experimental lower and upper cutoff frequencies are quite matching with the simulated lower and upper cutoff frequencies and shows that there is a good fabrication quality of the fabricated prototype. Thus, the proposed antenna can be a suitable design for the dual-band operation for WLAN application.

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