Compact Ultra-Wideband Antenna Using Coplanar Stripline (CPS)-Fed

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***Abstract*—Today's wireless communication systems should be capable to fulfill various insatiable demands for higher data rate and resolutions requirement. In order to satisfy those requirements in UWB system, a lot of antennas that can provide wide bandwidth have been proposed. In this paper, a coplanar stripline (CPS)-fed antenna for ultra-wideband (UWB) application was proposed. This antenna was designed using FR4 board with dielectric constant, □r = 4.4, tangent loss, tan = 0.02 and substrate's thickness, h = 1.6mm. The simulation was done using Computer Technology (CST) software. The simulation result shows that the modified coplanar stripline (CPS)-fed antenna significantly improved the fractional bandwidth by 200 % at frequency range 3.386 GHz -12.943 GHz. The optimal results of this coplanar ultra-wideband antenna were 5.100 GHz, 9.836 GHz and 12.155 GHz with a gain of 2.598 dB, 4.452 dB and 5.383 dB and the return loss of – 46.845 dB, - 23.428 dB and – 13.595 dB.**

***Index Terms*—CPS Antenna; Patch Antenna; CST; Ultra-Wideband; Returns Loss.**

I. Introduction

Microstrip patch antenna is the easiest and most economical types that can be designed using flat surface printed circuit board (PCB) of FR-4. Depending on its resonant frequency, this antenna can be applied in many applications, for examples the Global System for Mobile Communications for 1.80 GHz, Wireless Local Area Network (WLAN) applications at 2.4 GHz and 5.2 GHz [1], Worldwide Interoperability for Microwave Access (WiMAX) applications at 3.5 GHz or Long-Term Evolution (LTE) applications at 2.6 GHz [2-3].

Ultra-wideband (UWB) communication system involves in the transfer speed of more than 20% of the recurring concentration (> 500 MHz). The recurrent, which has been allowed by the Federal Communications Commission (FCC) in 2002 [4] is used from 3.1 to 10.6 GHz for UWB.

One of the essential issues that receive attention is the wide impedance data transmission for a down to earth UWB application. The use of UWB communication device shall be contained within the frequency band of 3.1 GHz to 10.6 GHz. The devices using UWB technology involve the intentional generation and transmission of radio-frequency energy that spreads over a very large frequency range, which may overlap with several frequency bands allocated to radio communication services [5].

Lately, the advance of UWB antenna inclines to give emphasis on small planar antennas. A compact, low cost and simple CPW-fed monopole antenna is proposed for good pattern performance over the UWB frequency range application. It contains of sunken ground planes, narrow feeding-strip and slot notched on the center of radiator [6].

The need for high data rates wireless communication has become more and more urgent. Commonly, UWB techniques have received the most responsiveness due to their many advantages. The benefits of printed UWB antennas are the high data rates, immunity to multi-path cancellation, increase of communication operational security, low interference to legacy system, low profile, light weight, wide bandwidth, low cost and good omnidirectional radiation pattern [7]. One of the major compensations of UWB is its resistance against fading effects [8].

There are several existing antenna configurations to enhance the bandwidth. In [9], a new coplanar waveguide CPW fed to modify circular patch antenna (MCPA) is proposed with satisfactory radiation patterns over UWB frequency band.

In this paper, a coplanar stripline (CPS)-fed antenna is presented. The staircase-shaped radiator and the shortened strip, running through the bottom of the antenna, are responsible for the realization of UWB frequency band. Another shortened strip of dimension L3 ×W8 was positioned at the far end of the radiators to improve the impedance matching of the proposed antenna. The wide bandwidth was obtained based on the combination of multiple resonances, predominantly due to the three resonances, which are 5.100 GHz, 9.836 GHz and 12.155 GHz with bandwidth from 3.386-12.943 GHz as well as the return loss which is below -10dB. Figure 1 shows the proposed antenna design in CST Microwave Studio.

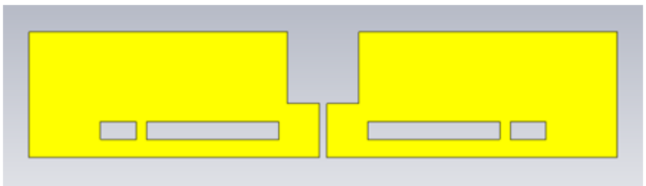


Figure 1: Proposed antenna design in CST Microwave Studio simulation software

II. Design Methodology

This section shows the design of the compact ultra-wideband antenna using coplanar stripline-fed antenna. The target frequency is between of 3 GHz and 10 GHz of ultra-wideband range.

A. Antenna Concept

Figure 2 and 3 shows the structure of coplanar stripline (CPS)-fed antenna in terms of simulated and fabricated UWB application. Figure 2 shows the geometry of ultra-wideband antenna using coplanar stripline-fed antenna. It consists of a square slot and several rectangular slots at the right and left of the patch.

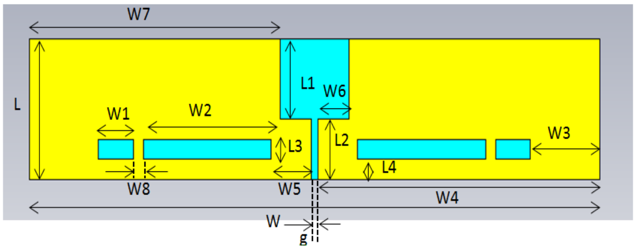


Figure 2: Geometry of UWB antenna

Figure 3 shows the fabricated version of the ultra-wideband antenna using coplanar stripline-fed antenna. This UWB antenna consists of staircase-shaped radiator and the shortened strip, running through the bottom of the antenna. The antenna was fabricated on the FR4 substrate with a thickness (h) of 1.6 mm, relative permittivity (εr) of 4.4, and loss tangent of 0.02. The material of radiating element and ground plane is copper with the thickness of 0.035 mm. Table 1 shows the parameters for every element in the antenna design. All dimensions are in millimeters (mm) unit.

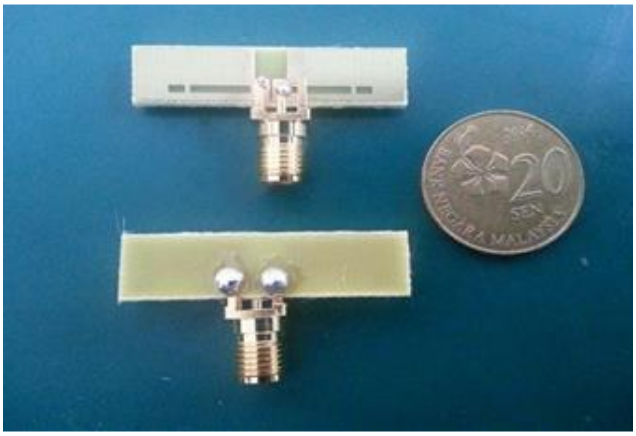


Figure 3: Front views (above) and back view (bottom) photograph of the fabricated UWB antenna (compare with coin)

Table 1
the parameter for every element in the ultra-wideband antenna design. All dimensions are in millimeters (mm) unit

Parameters	L	L1	L2	L3	L4	
Values (mm)	7	4	3	1	1	
Parameters	W	W1	W2	W3	W4	
Values (mm)	33	2	7.4	4	16.3	
Parameters	W5	W6	W7	W8	h	g
Values (mm)	2	1.8	14.5	0.6	1.6	0.4

Figure 4 shows the original design of the antenna that is based on the design in this paper [5]. Figure 5 shows the modified designs that were changed at the square slots.

B. Parametric study

The next step is the drawing process using the CST Microwave Studio software. The design as shown in Figure 5 is the UWB antenna with some modifications at the value of the antenna's dimension. The parametric study was conducted to get the optimized result for the modified antenna. Then, the modified antenna result was compared to the original design to show the improvement of the designated antenna. The parametric study was conducted by varying the L, L1, W7, and W4.

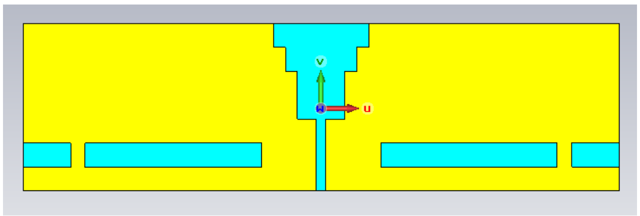


Figure 4: Original design [5]

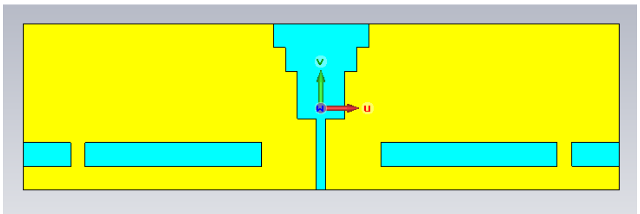


Figure 5: Modified design

III. Results and Discussion

This section shows the results and discussion of the compact ultra-wideband antenna using coplanar stripline-fed design. The simulation was executed before the fabrication of the antenna can be done. By simulating the design in the CST software, the design shows that smaller bandwidths were obtained for each frequency needed. Adding the slot to the antenna to increase the bandwidth was made to obtain the required bandwidth.

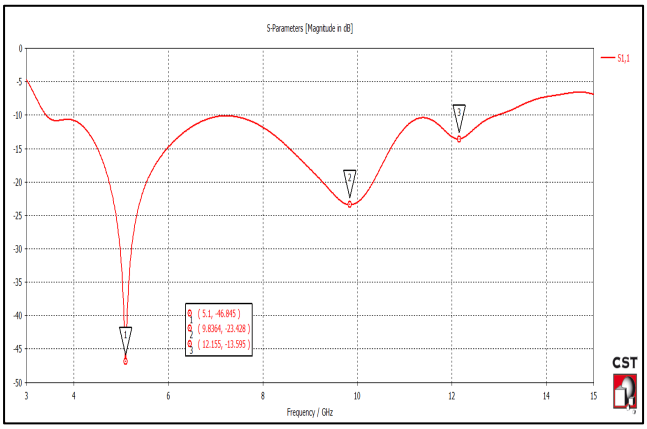


Figure 6: Simulated return loss result against frequency for the UWB antenna

One of the parameters that can be observed in this work is return loss. Figure 6 shows the simulated return loss result against the frequency for the ultra-wideband antenna using coplanar stripline-fed antenna design. The return loss was obtained in the range between 3.38 GHz and 12.94 GHz for original antenna.

The comparison of measurement results and the simulation results are shown in Figure 7. The measurement result and the simulation result were almost the same. The red line is the measurement result, while the green line is the simulation results.

By completing the simulation of the design, the actual dimension of the antenna can be obtained in order to have the optimum performance for the design application. The fabrication process can be done and the results of measurement can be compared with the simulation results. Table 2 shows the performance and specification of antenna. The three target resonant frequencies were 5.1 GHz, 9.8 GHz and 12.1 GHz.

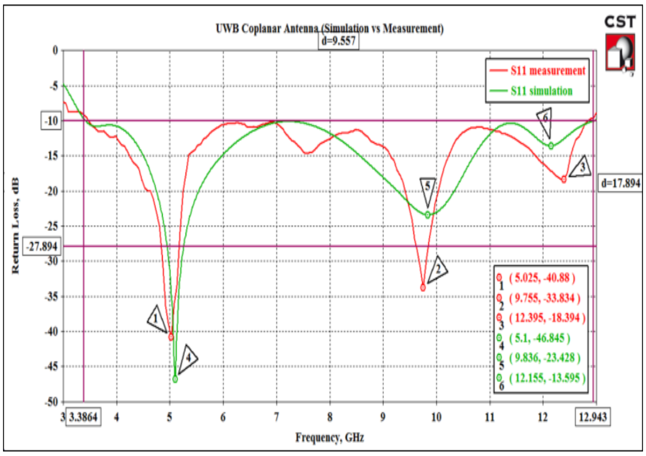


Figure 7: Comparison of the return loss and bandwidth between measurement and simulation result

Table 2
Performance and specification of compact ultra-wideband antenna using coplanar stripline-fed design

Specification	Performance
Resonant frequency	5.1 GHz, 9.8 GHZ and 12.1 GHz
Return loss	>-10 dB
Gain	>2 dB

Table 3 shows the performance result of the return loss and the gain of the compact ultra-wideband antenna using coplanar stripline-fed design. It shows that the return losses of the proposed antenna were at 5.1 GHz, 9.836 GHz and the 12.155 GHz were – 46.845 dB, - 23.428 dB and - 13.595 dB, respectively. In comparison to the measured results, it shows that the return loss results shifted to the 5.025 GHz, 9.755 GHz and 12.395 GHz with - 40.880 dB, - 33.834 dB and - 18.394 dB respectively.

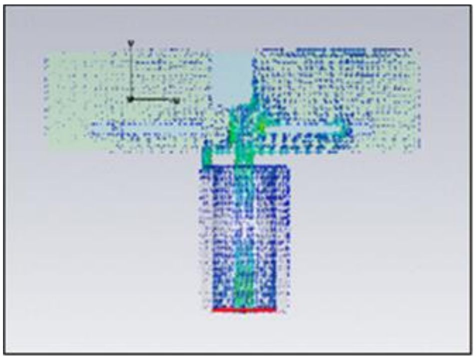
Table 3
Performance result of the antenna and the gain of the compact ultra-wideband antenna using coplanar stripline-fed design

Antenna	Resonant frequency (GHz)	Return loss (dB)	Gain (dB)
Simulation	5.100	- 46.845	2.59
	9.836	- 23.428	4.45
	12.155	- 13.595	5.38
Measurement	5.025	-40.880	2.05
	9.755	-33.834	4.12
	12.395	-18.394	5.61

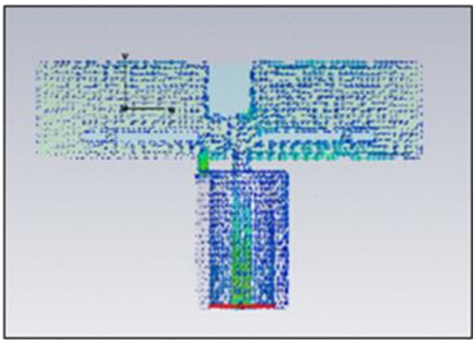
Figure 8 shows the surface current of compact ultra-wideband antenna using coplanar stripline-fed design at resonant frequencies of 5.1 GHz, 9.8 GHz and 12.1 GHz.

At the resonant frequency of 5.1 GHz, it shows that the current flows distribution was concentrating at the left of the patch antenna. It also shows the same situation at the 9.8 GHz with concentrating current flows at both side of the patch antenna. For resonant frequency of 12.1 GHz, it shows a few current flows compared with the resonant frequency at 5.1 GHz and also 9.8 GHz.

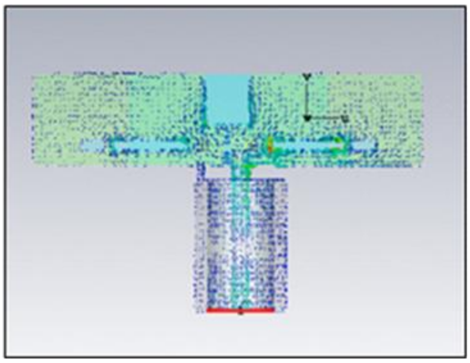
Table 4 shows the E-Field radiation pattern in polar and 3D radiation pattern compact ultra-wideband antenna using coplanar stripline-fed design at resonant frequencies of 5.1 GHz, 9.8 GHz and 12.1 GHz. The polar pattern of 5.1 GHz, 9.8 GHz and 12.1 GHz were in the 8-liked shaped, tooth-liked shaped, and jellyfish-liked shaped.



(a)



(b)



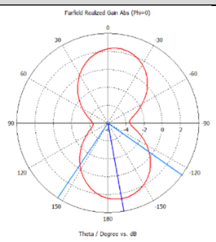
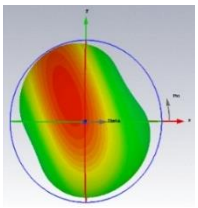
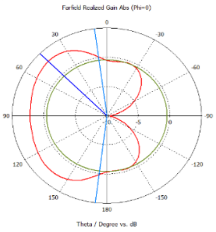
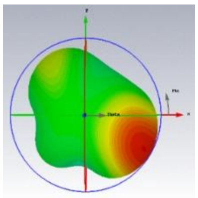
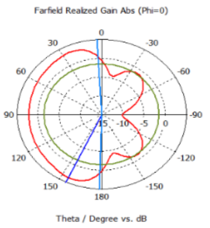
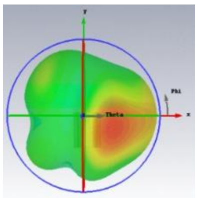
(c)

Figure 8: Performance result of surface current for compact ultra-wideband antenna using coplanar stripline-fed design at resonant frequencies of (a) 5.1 GHz, (b) 9.8 GHz and (c) 12.1 GHz

IV. CONCLUSION

In this paper, a coplanar stripline (CPS)-fed antenna for UWB application was designed. The simulation results show that the antenna covered the frequencies range from 3.386 GHz - 12.943 GHz. The wide bandwidth was obtained by the combination of multiple resonances, predominantly due to the three resonances at 5.1 GHz, 9.8 GHz and 12.1 GHz. Hence, this antenna is very suitable for the UWB application system. Although it has small size, the proposed UWB antenna encounters the necessities of the antenna for UWB radio systems. The antenna is well suited for various portable devices also. The simulated return loss and the measured return loss were below -10 dB as well as the average gain was above 2 dB. Therefore, the Ultra-wideband antenna meets the requirements of the antenna for UWB application.

Table 4
E-Field radiation pattern in polar pattern and 3D radiation pattern compact ultra-wideband antenna using coplanar stripline-fed design at resonant frequencies of 5.1 GHz, 9.8 GHz and 12.1 GHz

Frequency (GHz)	Polar pattern	3D pattern
5.1		
9.8		
12.1		

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