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Dual Band Slot Antenna for 3.5 WiMAX and 5.8 WLAN

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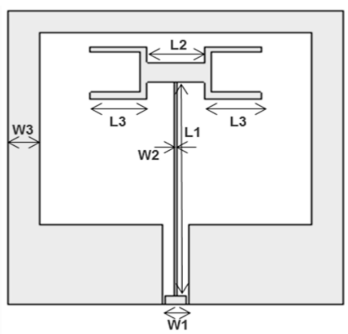
Graphical abstract



Abstract

This paper presents a single layer planar slot antenna for dual band operation. The antenna is fed by a coplanar waveguide (CPW) with two inverted C-shaped resonators to achieve the dual band operation. The impedance bandwidth for $|S_{11}| < -10$dB is 14% in lower band and 7% in higher band. The antenna prototype's electromagnetic performance, impedance bandwidth, radiation pattern, and antenna gain were measured. The proposed configuration offers a relatively compact, easy to fabricate and dual band performance providing gain between 2 and 4 dBi. The designed antenna has good dual bandwidth covering 3.5 WiMAX and 5.8 WLAN tasks. Experimental and numerical results also showed good agreement after comparison.

Keywords: Slot antenna; dual-band; WiMAX and WLAN

Abstrak

Kertas kajian ini membentangkan antena slot satah untuk operasi dwi frekuensi. Antena ini disuap oleh pandu gelombang sesatah (CPW) dengan dua resonator berbentuk C terbalik untuk mencapai operasi dwi frekuensi. Lebar jalur impedans bagi operasi frekuensi jalur rendah,| S11 | <-10dB adalah 14% dan 7% bagi operasi frekuensi jalur tinggi. Prestasi elektromagnet prototaip antena termasuk impedans lebar jalur, corak sinaran, dan gandaan antena telah diukur. Konfigurasi yang dicadangkan ini memberi saiz yang agak padat, mudah untuk fabrikasi dan dua operasi jalur yang menyediakan gandaan antara 2 dan 4 dBi. Antena yang direka mempunyai dwi lebar jalur yang baik meliputi 3.5 GHz WiMAX dan 5.8 GHz WLAN. Perbandingan keputusan eksperimen dan keputusan berangka juga menunjukkan perjanjian yang baik.

Kata kunci: Antena slot; dwi frekuensi; WiMAX dan WLAN

■1.0 INTRODUCTION

Slot antenna is commonly is preferred due to its high efficiency, low profile, and ease of fabrication [1-3]; these characteristics are largely required in satellite communications. On top of that, in wireless communication system, slot antenna is used because it gives good radiation efficiency [3-6].

Dual band operation is activated by exciting the first and second resonant modes simultaneously [7-9]. In this regard, slot and tunable antennas are preferred because of their wide impedance bandwidth and size, but the disadvantage is that they have a complex structure. Nonetheless, schemed slot antennas can efficiently improve multi and dual band for wireless communication operations. An example of this is the coplanar waveguide (CPW) fed rectangular slot with different types of tuning stubs built to improve antenna bandwidth [1]. CPW fed antennas have advanced much since its inception in wireless communication due to their promising potential to provide single layer structure features, good dual or multi impedance matching, ease for integration with system circuits, suitable radiation pattern, etc.

The aim of this paper presents a new design of slot antenna with CPW feeding structure. Resonance position and impedance matching status of the proposed antenna are mainly provided by the dual slots at the radiating patch. By properly selecting dimensions of slots, the designed antenna is able to produce adequate impedance bandwidth to cover the WiMAX system at 3.5 GHz and even Wireless Local Area Networking (WLAN) system at 5.8 GHz operations. The antenna was manufactured and empirically examined for radiation performance. It was designed using computer simulation technology (CST-2012) [13]. Structured measurements were performed to reach a rational agreement between simulation and measurement. Theoretical and empirical results of the acquired antenna shall be shown, compared, and discussed accordingly.

2.0 ANTENNA CONFIGURATION

The advancements in slot antenna designs has significantly increased in recent years [6-9] where some designs combine slot antenna with resonant elements such as thin wire, patch, and dielectric resonator. Figure 1 shows the proposed antenna configuration in this study.

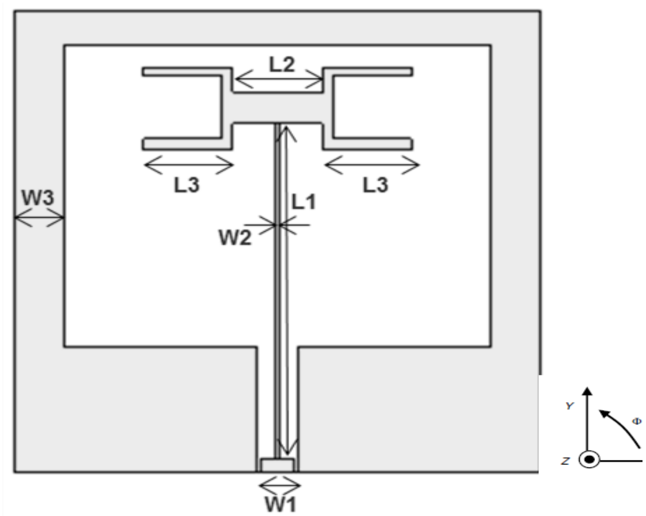


Figure 1 The geometry of dual band slot antenna

This antenna was designed on the FR4 substrate with relative dielectric constant, ε_r, of 4.3, tanδ at 0.022, and thickness, *h* of 1.6 mm. The proposed structure antenna has a substrate dimension of 47mm × 45mm for its fundamental slot antenna. As shown in Figure 1, CPW feed line is used for exciting the antenna that consists of W_1 and W_2 as well as a gap of 3mm, 0.5 mm, and 0.38 mm. The CPW-fed line width is 3 mm and the input impedance is 50 ohms. The operational range is between 3.14 GHz and 6.13 GHz which covers both 3.5 GHz-WiMAX and 5.8 GHz-WLAN applications. The bandwidth and resonance frequency of the C-shaped resonator at right hand is 5.8 GHz and provide the bandwidth of 23% while by adding the left C-shaped resonator, a bandwidth of 3.5 GHz with 14% is achieved. Essentially, the resonance frequencies of the two radiating slots are independent to obtain dual band antenna.

The symmetry of the proposed slot antenna demonstrates the dual band operation. The improved dimensions of the proposed antenna are shown in Table 1.

Table 1 The optimized dimensions of proposed antenna

W1	W2	W3	L1	L2	L3
3mm	0.5mm	4.5mm	32.7mm	8mm	7mm

3.0 PARAMETRIC STUDY AND DISCUSSION

In order to analyze the characteristics of the proposed antenna, variation in geometric parameters of the designed slot antenna was addressed. The CST Microwave Studio software 2012 [10] which functioned based on the finite integral technique was used for the parametric analysis. Through a parallel process, the effect of L_1, L_2 and L_3 (see Figure 1) on the proposed antenna impedance bandwidth and the optimum values of other parameters were scrutinized. The simulated S_{11} of the antenna at different values of L_1 and L_2 are shown in Figure 2 and Figure 3 respectively.

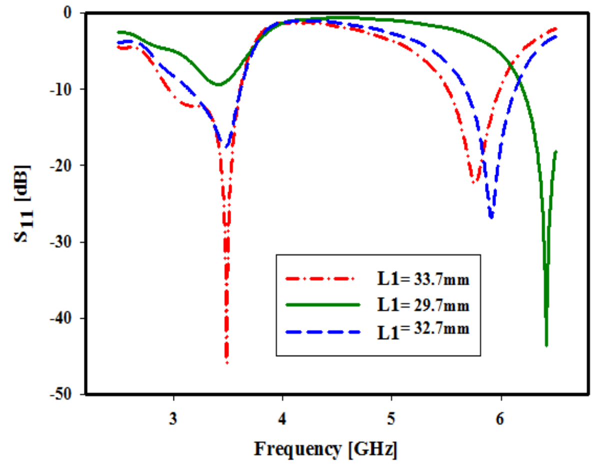


Figure 2 Effects of changing the L1

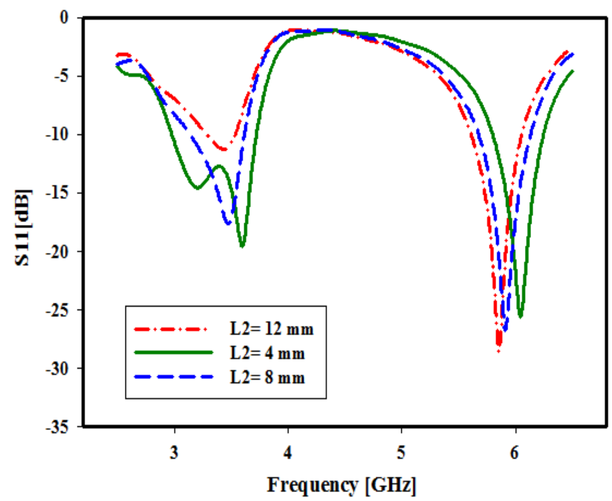


Figure 3 Effects of changing the L2

The effect of varying L_1 on impedance bandwidth is shown in Figure 2. It can be seen that increase in L_1 have reduced the resonant frequency at high band, but the resonant frequency at low band remained unaffected. Therefore, it proves that high band resonant frequency is dependent on L_1.

The effect of changing L_2 on resonant frequency is shown in Figure 2. The graph showed that resonant frequency at low band has increased when L_2 is reduced. This is evident of the resonant frequency's dependency on L_2 at lower band where it failed to reach the resonance frequency of WiMAX and WLAN. Nevertheless, this variation rate is very slow.

It was found that, after tuning these values, the best value of L_3 was 7 mm. As shown in Figure 4, the impedance matching is dependent on the length (L_1 and L_2), especially at higher frequencies.

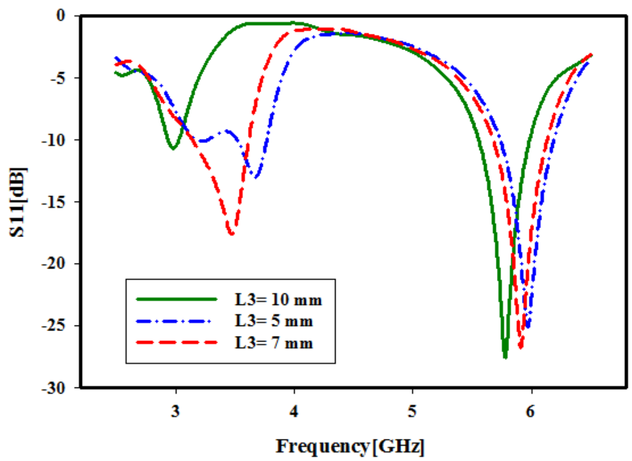


Figure 4 Effects of changing the L3

4.0 MEASURED RESULTS

In the final step, a prototype using the optimal parameters, was fabricated and measured. The photograph of the realized dual band slot antenna is shown in Figure 5.

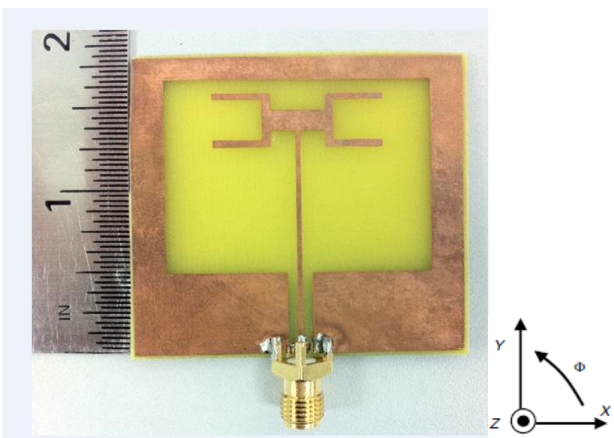


Figure 5 Photograph of the fabricated antenna

Also, the simulation and measurement of S_{11} of the antenna are shown in Figure 6.

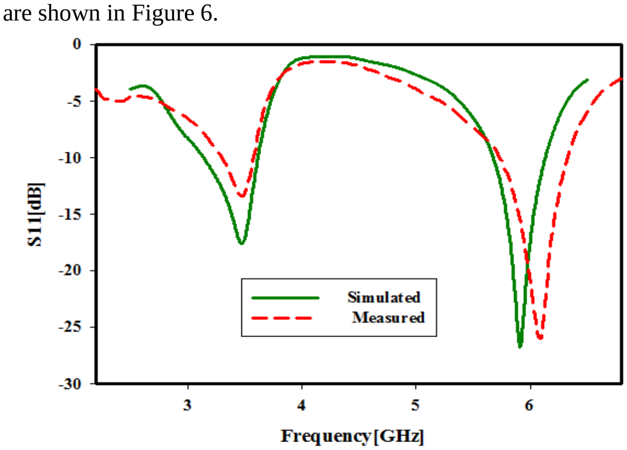
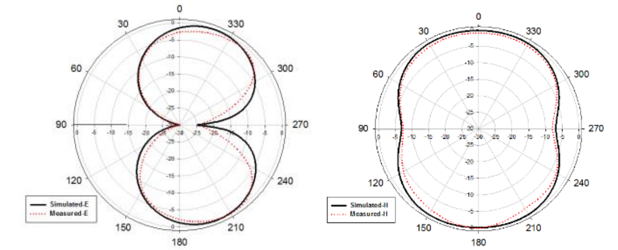


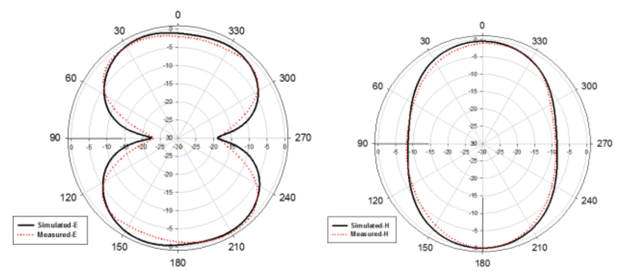
Figure 6 Simulation and measurement results for proposed antenna

The simulated results illustrates that the lower band's covered frequency range was between 3.1425 and 3.617GHz (14%). The measured bandwidth of the proposed antenna covered 14% (3.1-3.6GHz) at the lower band for the 3.5 GHz Mobile-WiMAX system and 7% (5.6788-6.1334GHz) at the higher band for 5.8 GHz WLAN system.

The simulated and measured radiation patterns of the proposed antenna are shown in Figure 7. The radiation patterns were measured in an anechoic chamber.



(a)



(b)

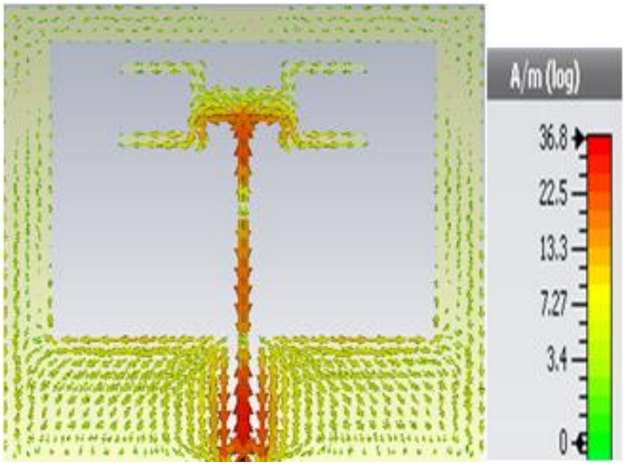
Figure 7 Simulated and Measured Radiation Patterns at a) 3.5 GHz b) 5.8 GHz

The radiation pattern is nearly omni-directional. The simulated current distributions for two sub band frequencies at 3.5 GHz and 5.8 GHz are shown. It has been observed that the current at 3.5 GHz concentrated at the nearly corner of the topology and through the L_2 and L_3, but at 5.8 GHz, it concentrated only at L_2. The simulated antenna gain for the proposed antenna is illustrated in Figure 8.

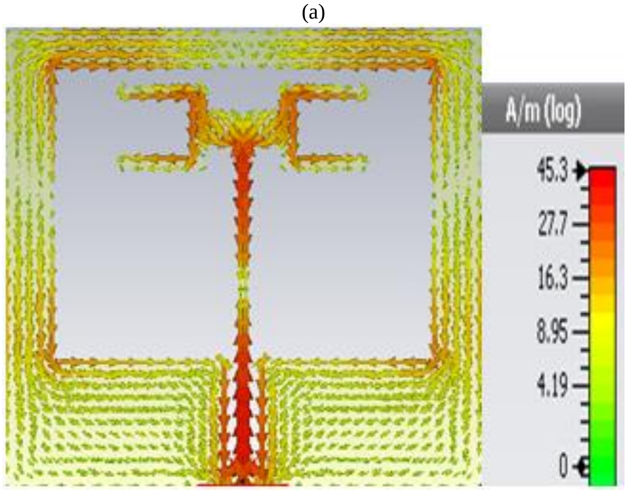
The simulated antenna gain in lower band and higher band was roughly 3.2 dBi. The measured gain was 2.41dBi at 3.5 GHz and 2.67 dBi at 5.8 GHz. The antenna efficiencies at 3.5 and 5.8 are 59%, 93% respectively. Generally, the presented antenna has demonstrated practical usage possible for various wireless communication systems.

5.0 CONCLUSION

A new dual band slot antenna for 3.5GHz WiMAX and 5.8GHz WLAN applications was proposed in this paper. Dual band characteristics were achieved at 3.5 and 5.8 GHz bands. The simulated and measured results of S_{11}, gain, and radiation patterns were presented. The gain and radiation patterns over the covered frequency range were archived. The proposed antenna had a bandwidth of 14% in lower band covering from 3.1425GHz to 3.617 GHz and also 7% in higher band covering from 5.6788 GHz to 6.1334 GHz. Since the measured and simulated results has good agreement, it proves that the proposed slot antenna has promising potential to be practically used in 3.5GHz WiMAX and 5.8GHz WLAN.



(a)



(b)

Figure 8 Current distribution for proposed antenna at a) 3.5 GHz b) 5.8 GHz

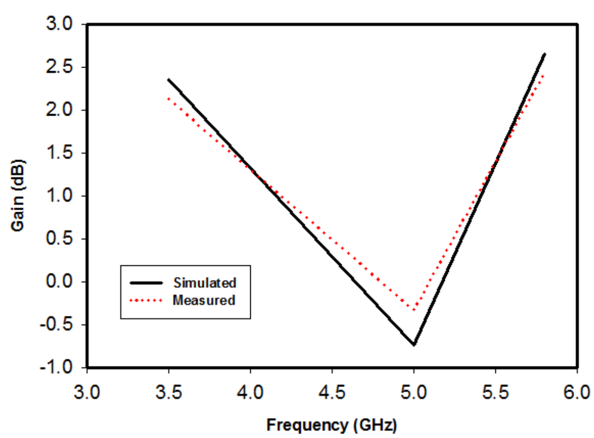


Figure 9 Simulated and measured gain of the proposed antenna

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References

[1] N. Behdad and K. Sarabandi. 2004. Bandwidth Enhancement and Further Size Reduction of a Class of Miniaturized Slot Antennas. *IEEE Transactions on Antennas and Propagation.* 52: 1928–1935.

[2] C. Wen-Shan and K. Kuang-Yuan. 2008. Band-Rejected Design of the Printed Open Slot Antenna for WLAN/WiMAX Operation. *Antennas and Propagation, IEEE Transactions on*. 56: 1163–1169.

[3] S. Rhee and G. Yun. 2006. CPW Fed Slot Antenna for Triple-Frequency Band Operation. *Electronics Letters.* 42: 952–953.

[4] W. REN. 2008. Compact dual-band slot antenna for 2.4/5 GHz WLAN applications. *Progress In Electromagnetics Research B*. 8: 319–327.

[5] C. J. Wang and S. W. Chang, 2008. Studies on Dual-Band Multi-Slot Antennas. *Progress in Electromagnetics Research*. 83: 293–306.

[6] S. Natarajamani, S. K. Behera, and S. K. Patra. 2010. Compact Slot Antenna for UWB Application and Band-Notch Designs. In Computational Intelligence and Communication Networks (CICN), 2010 International Conference on. 11–15.

[7] M.Khalily, M. K. A. Rahim, N. A. Murad, N. A. Samsuri, A. A. Kishk. 2013. Rectangular Ring-Shaped Dielectric Resonator Antenna for Dual And Wideband Frequency. *Microwave and Optical Technology Letters.* 55: 1077–1081.

[8] M. Khalily, Mohamad Kamal Abd Rahim. 2010. A Novel Hybrid Design of Printed Hemi-Cylindrical Dielectric ResonatorMonopole Antenna with Multibands Operation. *Progress In Electromagnetics Research C.* 15: 175–186.

[9] M. Khalily, M. K. A. Rahim, A. A. Kishk, Sh. Danesh. 2013. Wideband P-Shaped Dielectric Resonator Antenna. *Radioengineering*. 22.

[10] Eldek, A. Z. Elsherbeni, and C. E. Smith. 2004. Characteristics of Bow-Tie Slot Antenna with Tapered Tuning Stubs for Wideband Operation. *Progress In Electromagnetics Research PIER*. 49: 53–69.

[11] R. Chair, A. A. Kishk, K. F. Lee, C. E. Smith, and D. Kajfez. 2006. Microstrip Line and CPW Fed UltraWideband Slot Antennas With U-Shaped Tuning Stub and Reflector. *Progress In Electromagnetics Research, PIER*. 56: 163–182.

[12] C. M. Li and L. H. Ye. 2011. Improved Dual Band-Notched UWB Slot Antenna with Controllable Notched Band-Widths. Progress In Electromagnetics Research. 115: 477–493.

[13] CST. 2012. Microwave Studio based on the Finite Integration Technique.