Design of Compact Multiband Slot Antenna for Wideband Applications

S. Priya*, Student, S. Radhika, Assistant Professor,
*Department of Electronics and Communication,
Sri Venkateswara College of Engineering,
Sriperumbudur,

***Abstract*— A compact multiband slot MIMO antenna is presented with three frequency bands for Ultra wideband (UWB) applications using defected ground structure (DGS). The overall dimension of the antenna is 27.1x30.8x1.6mm^3. The simulated return loss, isolation, radiation pattern, gain, directivity are presented using advanced design software (ADS).**

Keywords*— Multiple Input Multiple Output (MIMO), Ultra wideband (UWB) , isolation, advanced design software (ADS).

I. INTRODUCTION

Multiple-input-multiple output (MIMO) antenna systems plays a key role, enabling technology to achieve high data rates for the future scope of wireless communication systems. Therefore, all new wireless standards go for MIMO antenna system [1]. One of the main advantages of MIMO systems over traditional Single-input-single-output (SISO) systems are their improved capacity and reliability, without increasing transmitted power or bandwidth over the system [2]. A compact dual band two element MIMO array covering the 2.4GHz and 5.2GHz bands for the mobile WLAN applications**.** The MIMO array is then incorporated with two tree-type monopoles and a simple narrow band isolator to achieve high isolation is presented in [3].

A multiple-input multiple-output (MIMO) antenna with a compact size of 40×26 mm^2 is presented for portable ultra wideband (UWB) applications. Here, microstrip feed is used as the elements of the MIMO antenna and are placed perpendicularly to each other to obtain pattern diversity is discussed in [4] this MIMO antenna can cover the entire UWB band from 3.1-10.6 GHz with an isolation S21>-16dB throughout the frequency band. A novel dual-broadband multiple-input–multiple-output (MIMO) antenna system is developed. This antenna consists of two dual-broadband antenna elements, each of which comprises two opened loops, an outer loop and an inner loop. Two U-shaped slots are etched to reduce the coupling between the two dual-broadband antenna elements. The isolation achieved is greater than 15 dB in the lower band and greater than 20 dB in the upper band, with an envelope correlation coefficient (ECC) of less than 0.01<0.5 is presented in [5].

The MIMO antenna system with two parallel folded branch monopoles with an edge-to-edge separation of 0.2 mm dual bands MIMO antenna is proposed for WLAN 2.4/5.2/5.8 GHz bands. Introducing a round off-set structure at the end of the coupled feeding-line helps to achieve high isolation is discussed in [6]. In paper [7], MIMO configuration is obtained by employing L-shaped antenna. Here, isolation of the MIMO antenna is enhanced by diversity technique. In [8] the radiating patch is connected through a via with the strip placed under the patch. This strip not only provides coupling path, but also serves as the impedance transformer, resulting in good isolation of -15dB. High isolation between the antenna elements requires diversity properties, which is achieved by using a decoupling technique that utilizes a lumped capacitance between the antenna elements is discussed in [9]. Slot antenna with enhanced bandwidth is presented in [10] with a stub-loaded dual-mode radiator.

II. MIMO ANTENNA CONFIGURATION

Fig. 1 shows the geometry and dimensions of the proposed MIMO anenna for ultra wideband applications. It consists of two radiating antenna elements with a microstrip feed. The feed width is minimum near the ports and is gradually increasing towards the patch for better return loss or reflection coefficient. The resonance frequency of the microstrip patch antenna is computed from (1)

$$f_r = \frac{C}{2L_{eff}\sqrt{\epsilon_{reff}}} \quad (1)$$

$$\epsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left(1+\frac{12h}{W}\right)^{-1/2} \quad (2)$$

Where C is the velocity of light in free space,

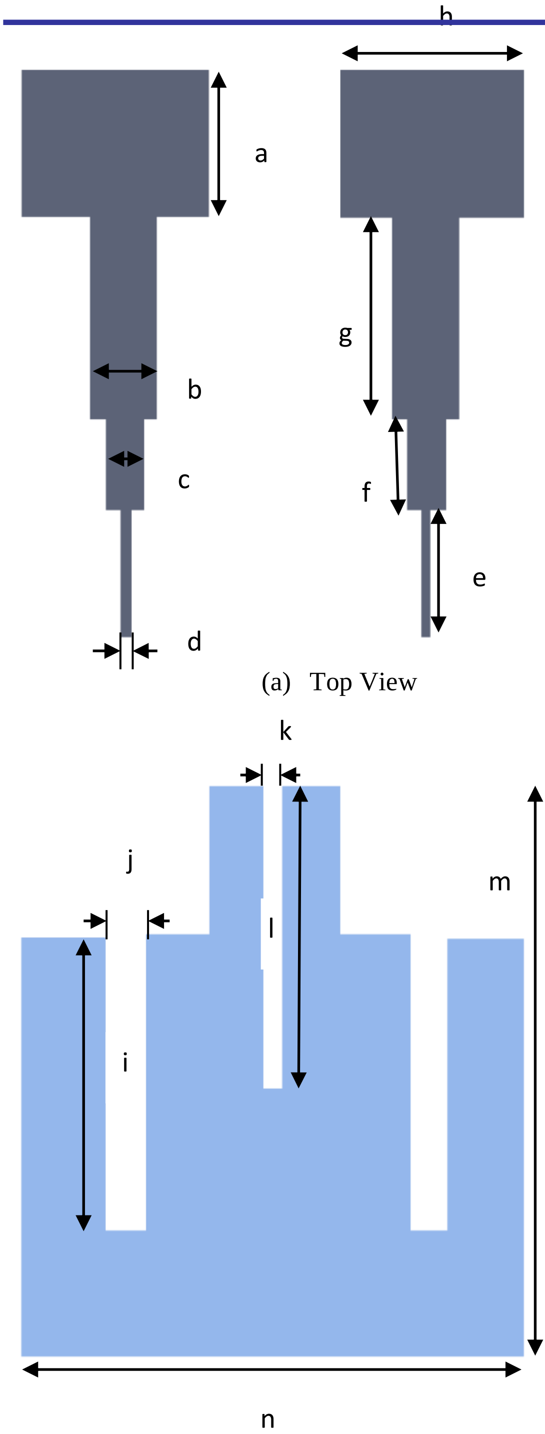
ε_{reff} is the effective relative permittivity,

$$\frac{\Delta L}{h} = 0.412\frac{(\epsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\epsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \quad (3)$$

$$L_{eff} = L + 2\Delta L \quad (4)$$

L is the patch length, L_{eff} is the effective length.
Effective relative permittivity is calculated from equation (2) as shown. Efective length of the patch is computed from equation (4).

ISSN: 2278-0181
NCSPC - 2016 Conference Proceedings



(a) Top View

(b) Bottom View

Fig.1 .Geometry of the proposed multiband slot MIMO antenna.

The dimension of the proposed MIMO antenna is given in TABLE 1. The proposed antenna is designed and simulated using advanced design software (ADS).

TABLE I
DIMENSION OF THE PROPOSED ANTENNA

Parameters	**Value (mm)**	**Parameters**	**Value (mm)**
a	8	h	10.13
b	3.39	i	15.96
c	1.98	j	1.9
d	0.5	k	0.9
e	6.8	l	16.25
f	4.8	m	30.8
g	10.9	n	27.1

The proposed antenna is configured with two antenna element placed closely with eachother. Microstrip feed is used to excite the ports. The isolation between the antenna elements is due to flow of large amount of surface current from the excited port to the other port. The antenna is designed with FR4 substrate of real 4.6 and loss tangent 4.6 of thickness 1.6mm. Defected ground structure involves etching of slots of dimension as shown in TABLE 1 along the microstrip feed over the ground plane. Defected ground structure technique employs etching of slots of various pattern thereby disturbing the surface current distribution over the ground plane.

Here, isolation is obtained by incorporating an additional slot over the ground plane inbetween the two antenna elements.

III. RESULTS AND DISCUSSION

The proposed multiband antenna is found to be operating at three frequency bands,5.64GHz-5.96GHz, 7.24GHz-7.58GHz, and 8.24GHz-8.75GHz with a minimal return loss of -22.76dB at 5.8GHz, -12.93dB at 7.4GHz and -42.18dB at 8.5GHz respectively. Generally, for an MIMO antenna the mutual coupling effect between the antenna elements needs to be reduced so that the antenna will perform better for wireless communications.

For an MIMO antenna, isolation is considered to be an important factor. In common, isolation should be less than -10dB for practical applications. Here, isolation of -12.58dB at 5.8GHz, -16.35dB at 7.4GHz and -14.31dB at 8.5GHz respectively. The antenna was designed and simulated using advanced design software (ADS). The simulated return loss against frequency is shown in the Fig.2. The comparison of return loss (S11 in dB) and isolation (S21 in dB) is shown in the Fig.3.

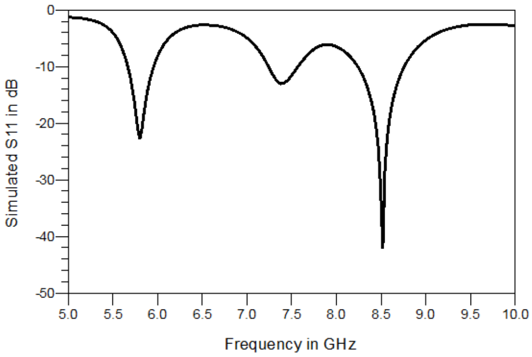


Fig.2 Simulated S_{11} return loss versus frequency.

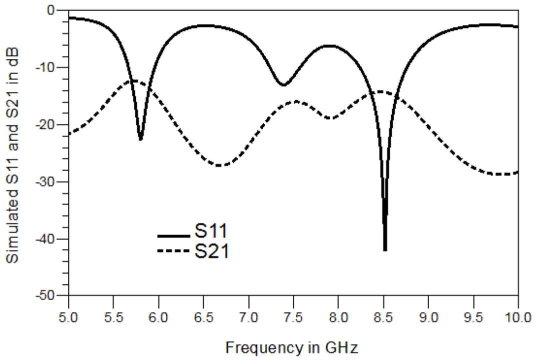


Fig.3 Comparison of simulated S11 and S21 versus frequency.

TABLE II

Parameters	5.8GHz	7.4GHz	8.5GHz
Gain (dBi)	1.94	2.33	1.34
Directivity (dBi)	6.28	5.45	5.24
Bandwidth (MHz)	315	352	506

TABLE II shows the gain, directivity and bandwidth of the proposed multiband MIMO antenna for all the three resonating frequencies. Fig.4 represents the three dimensional (3D) view of the antenna, which is done using the advanced design software (ADS). The 3D view represents clearly about the design of the antenna, where the radiating patch is placed over the FR4 substrate and the ground plane is designed below the substrate. Otherwise, FR4 substrate is sandwiched between the patch and the ground plane.

The radiation pattern of the proposed MIMO antenna is omni-directional. Fig.5 shows the 3D omni-directional view of the proposed antenna for all the three resonating frequencies.

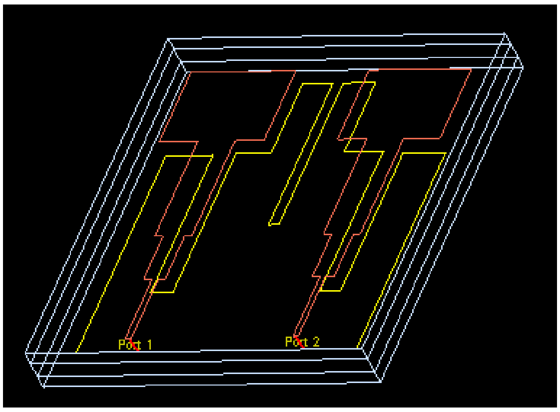
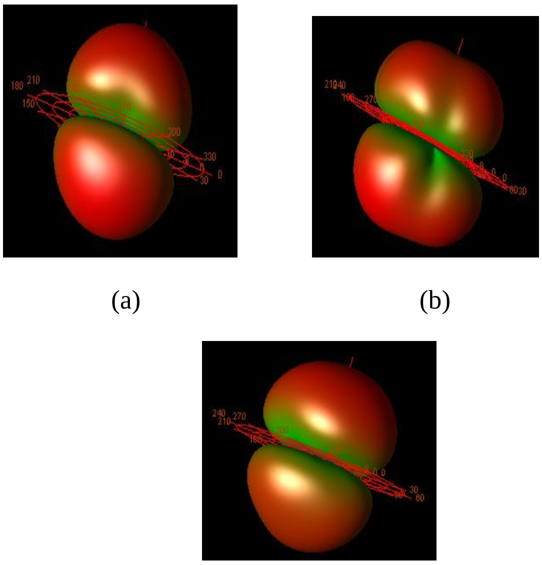


Fig.4 3D view of the proposed antenna.



(a) (b)

(c)

Fig.5 3D radiation pattern of the proposed antenna. (a) at 5.8GHz (b) at 7.4GHz (c) at 8.5GHz.

IV. CONCLUSION

A compact multiband MIMO antenna using defected ground structure is proposed. The design and simulation of the antenna is done using advanced design software (ADS). This antenna is featured with minimal return loss and isolation of average of -12dB is achieved at all the resonating frequencies. The simulated gain, directivity and bandwidth is also represented. The proposed antenna can be used for WLAN, RADAR ,satellite communications.

REFERENCES

[1] Muhammad U. Khan and Mohammad S. Sharawi, "A Compact 8-Element MIMO Antenna System for 802.11ac WLAN Applications", *Int. Workshop on Antenna Technology*,2013.

[2] Haili Zhang, Zhihong Wang, Jiawei Yu, and Jia Huang, "A compact MIMO Antenna for Wireless Communication", *IEEE Antennas and Propagation MagaZine, Vol. 50, No.6*, December 2008

[3] Ching-Song Chuang , Wu-Tung Hsu,Lin Ming Chun, "A Compact multi band MIMO antenna" .

[4] L. Liu, S. W. Cheung, T. I. Yuk and D. Wu, "A Compact Ultrawideband MIMO Antenna", *7th European conference on Antennas and Propagation*,2013.

[5] Xiang Zhou, XuLin Quan, and RongLin Li, *Senior Member, IEEE*, *"*A Dual-Broadband MIMO Antenna System for GSM/UMTS/LTE and WLAN Handsets", IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, VOL. 11, 2012.

[6] Cho-Jung Lee, Lih-Tyng Hwang, T.-S. Jason Horng, Shun-Min Wang, Yi-Chieh Lin, and Kun-Hui Lin," A MIMO Antenna with Built-in Isolation for WLAN USB Dongle Applications", Asia-Pacific Microwave Conference Proceedings, 2013.

[7] Sachin S.Khade, Dr.S.L.Badjate, "A Spatial Diversity MIMO Antenna for Wi-max Application", Annual IEEE India Conference (INDICON), 2013.

[8] Tzu-Chun Tang, *Student Member*, *IEEE*, and Ken-Huang Lin, *Member, IEEE, "*An Ultrawideband MIMO Antenna With Dual Band-Notched Function", *IEEE Antennas and Wireless Propagation Letters*, vol. 13, 2014.

[9] V.Ssorin, A.Artemenko, A. Sevastyanov, R. Maslennikov, "Compact 2.5-2.7 GHz Two Element MIMO Antenna System for Modern USB Dongle", *6th European Conference on Antennas and Propagation (EUCAP)*.

[10] Qing-Xin Chu, Yu-Ting Wu, Xing-Xing Xia," Compact Broadband Slot MIMO Antenna with A Stub-Loaded Radiator", 978-1-4799-3678-6/14/$31.00©2014 IEEE.