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Design and Analysis of Omega Shaped Slotted Multiband Antenna

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Abstract*: An omega shaped slotted multiband antenna is designed to operate over different frequencies. It is designed with FR4 substrate having thickness 1.6mm. In the first design a simple omega shaped slot is formed in the rectangular patch antenna. In the second design, L shaped slot is inserted in the ground plane and width is increased. Third design focused on introducing a circle in the middle of the patch and C shaped slot inside omega to increase multiband operation. A smaller circle is made in the corner of the patch in the fourth design to slightly improve the gain of the antenna. This antenna resonates to four different frequencies with three stop band frequencies. The multiband antenna resonates for the frequencies 4.125, 5.093, 7.042 and 9.031 GHz and notch frequencies at 2.734, 4.888, 7.8 to 8.5 GHz. The efficiency is reaching 100% for few frequencies. The antenna is suitable for WiFi and Wimax and X band applications. ADS software is used for designing the antenna.

***Index Terms*: Multiband antenna, wireless application, Slots, Notch frequency.**

I. INTRODUCTION

Now a day due to rapid growth in mobile and cellular communications, novel antenna should be designed to meet the requirements of the future trends and user requirements in the field of wireless and mobile communication. In this paper multiband antenna is designed to operate with different frequencies which enable the antenna to be used for different applications. Compatibility, low power consumption, high gain, high speed, low cost are the major challenges in designing an antenna for mobile applications. These parameters are taken into considerations in the proposed antenna design.

Joseph Costan tine et al (2007) proposed a multi wide bandwidth antenna for wireless communications. Rectangular and triangle shaped patches are merged together to enhance the area of the radiation spread. Rectangular and triangle slots are introduced in the patch to operate the antenna in the multiband of frequencies. Antenna is designed with probe feed which enhance the impedance matching characteristics of the antenna. It can be used for Bluetooth, GSM and wi-Fi applications. Chebyshev distribution of order 10 is used in the design for inserting slots in the patch.

Wen et al (2010) suggested multiband antenna for WLAN and WiMAX operations. FR-4 substrate with 4.6 of thickness 0.8mm, relative permittivity with the total size of 30mm × 30mm. A Semicircular structure with L shaped slots is introduced in the patch. Another semicircle with double L shaped slot is is attached the ground.

Cheng-yuan Liu et al (2011) proposed UWB antenna with dual stop band frequencies. U shaped slots are introduced in the patch and a rectangular slot in the ground plane. Omni directional radiation pattern is obtained. Ansoft HFSS 10 tool is used for simulation.

Osama M. Haraz et al (2011) designed an antenna to operate with four different frequencies which enable the antenna to be used for different applications. It can be used for mobile applications such as GSM, DCS and WLAN, Bluetooth. Operate frequency range of the antenna is between 2 to 5 GHz. For antenna design RT-Duroid substrate with dielectric constant of 2.2 and microstrip line feed is used.

Cao et al (2012) designed a monopole antenna resonates to triple bands suitable for WLAN/WIMAX applications. An L shaped slot is made and an U shaped stripline is introduced to the rectangular patch. Dielectric constant of the substrate material used is 2.65 and thickness1.5 mm

El Misilmani et al (2012) proposed a multiband antenna tuned to triple band of frequencies and appropriate for WLAN and WiMAX applications. The substrate material used is FR4 with 1.6 mm thickness. A split ring slot and U shaped slot is made in the patch and ground plane makes the antenna tuned to triple band of frequencies.

D.G. Yang et al (2012) Multiband antenna is designed to in LTE700, UMTS, WLAN, Wi-MAX, WCDMA etc., L shaped ground plane structure and slotted rectangular meandered patch is used in this paper. FR4 substrate with dielectric constant of 4.5 is used for antenna design. VSWR, return loss, peak gain parameters produce better results to operate with the different frequencies.

DebdeepSarkar et al (2013) designed a microstrip dual band rectangular patch antenna uses two CSRR with defected ground plane works for WLAN and WiMAX frequencies. The coaxial feeding is employed. FR4 substrate with dielectric constant 4.4 and 1.6mm thickness is used. Simulations are carried out using HFSS software.

Ashish Pande et al (2016) designed a monopole antenna which is operated with dual band of frequencies from 2 to 5 GHz. It can be used for the applications such as RFID and WLAN. It results omni directional radiation pattern provides better return loss and peak gain. The design is of 9 shape and it is very compact which proves that the antenna can be used inside the handheld device.

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Praveen V. Naidu and Akshay Malhotra (2017) designed triple band monopole antenna for PCS, WLAN and WiMAX applications.

Prashant Ranjan et al (2017) Flower shaped antenna is used with circular patch antenna. Square shaped slots are introduced in the circular shaped patch to enhance the antenna performance of the antenna. UWB filter is used in the antenna design which acts as BPF.

Praveen V. Naidu (2017) recommended asymmetric coplanar strip fed multiband antenna for Bluetooth, LTE, WLAN and WiMAX applications. FR-4 substrate with thickness of 1.6 mm with the total size of the antenna is 14.75 × 26. Dual band operation is achieved by combining V shaped strip with rectangular shaped strip. The proposed antenna has omnidirectional radiation pattern and good gain characteristics.

I. Methodology and Proposed System

ADS tool is used for the design and implementation of the antenna. Four omega designs are made by introducing slots at different positions in the patch and ground plane.

Table 1. Dimensions of Omega Antenna

Parameters	Dimensions (mm)	Parameters	Dimensions (mm)
Lp	14	Or	4.8
Wp	14	Ir	4.3
L	31	Oc	3.8
W	27.5	Ic	3.3
Lf	13.5	Rb	2
Wf	2	Rs	1
Wg	30	Ws	3.1
Lg	12.5	Ls	5

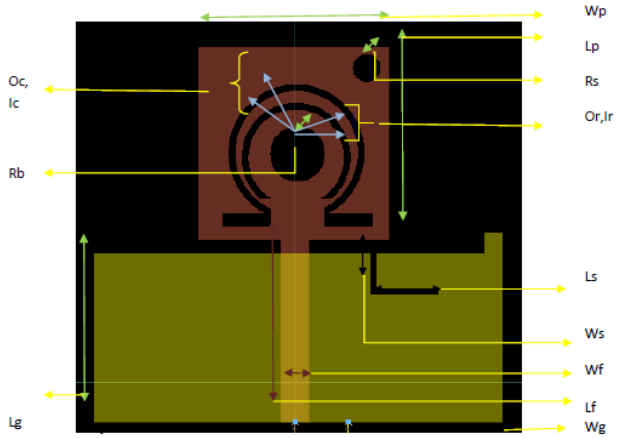

Fig. 1 Proposed omega antenna

In Fig. 1 the proposed antenna design is shown after 4 modifications. The step by step antenna design is illustrated in design (i), (ii), (iii) and (iv).

Design (i)

The omega shaped slot is created in the rectangular patch antenna is shown in Fig 2a and the current distribution is shown in Fig 2b. The return loss characteristic is depicted in Fig 2c. The dimensions of the antenna are specified in Table 1. The overall size of the antenna is 31x27.5x1.6 mm.

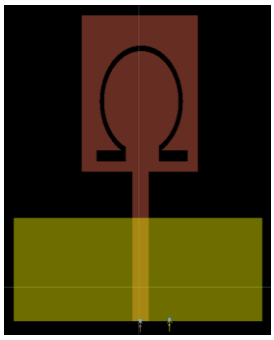

Fig 2a: Omega Antenna

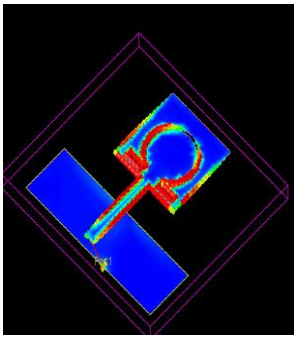

Fig 2b: Current Distribution

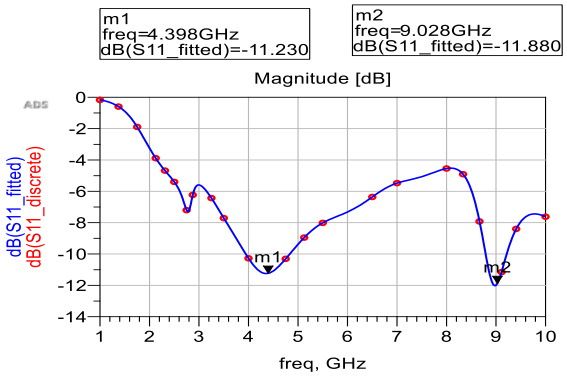

Fig 2c: Return Loss Graph

Design (ii)

L shaped slot is introduced and width of the ground plane is increased and is shown in Fig 3a and the current distribution is shown in Fig 3b. The return loss characteristic is depicted in Fig 3c. This configuration leads to five different frequencies with increased return loss and three notch frequencies.

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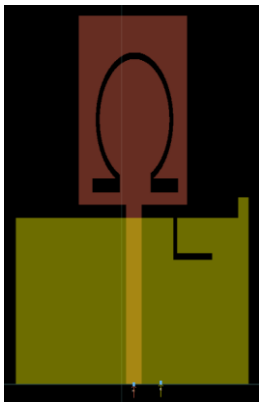


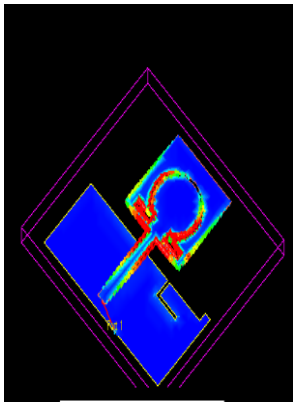


Fig 3a: Omega Antenna **Fig 3b: Current Distribution**

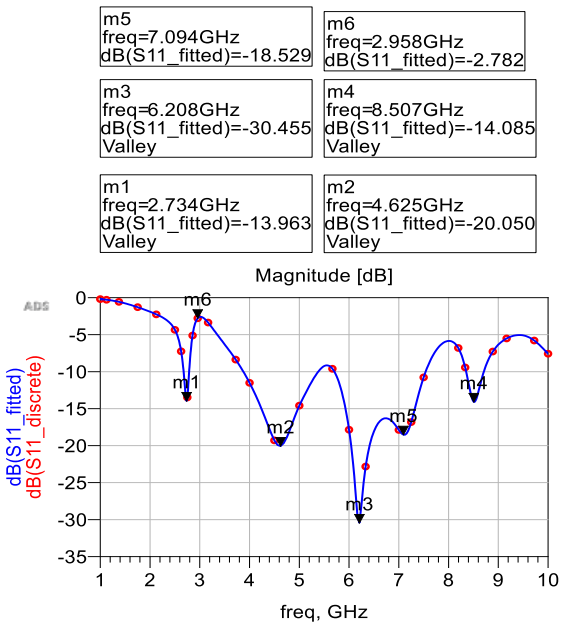
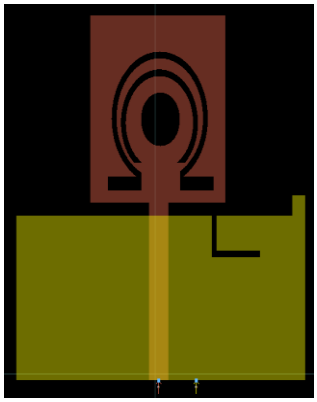


Fig 3c: Return Loss Graph

Design (iii)

A semicircular ring is created inside the omega shaped slot and a small circle of radius 2 mm is made in center of the patch and is shown in Fig 4a and the current distribution is shown in Fig 4b. The return loss characteristic is depicted in Fig 4c. This design tuned to four different frequencies and three notch frequencies.



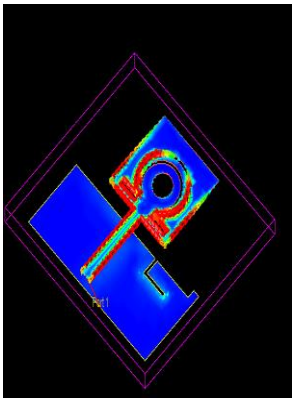


Fig 4a: Omega Antenna **Fig 4b: Current Distribution**

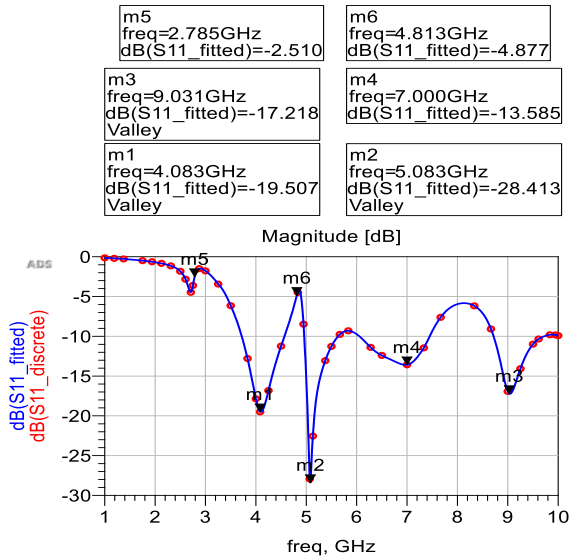
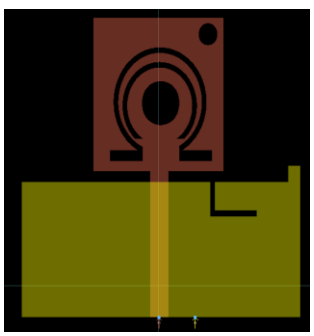


Fig 4c: Return Loss Graph

Design (iv)

A circle of radius 1mm is made at the right most corner of the patch and is shown in Fig 5a and the current distribution is shown in Fig 5b. The return loss characteristic is depicted in Fig 5c.



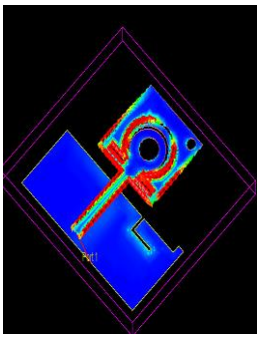


Fig 5a: Omega Antenna **Fig 5b: Current Distribution**

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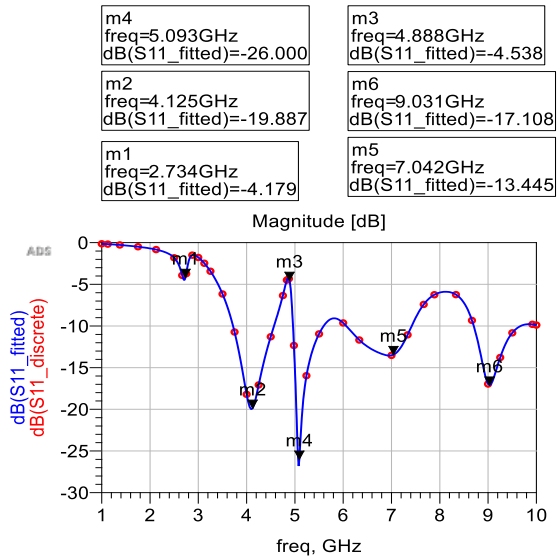

Fig 5c: Return Loss Graph

II. SIMULATION RESULTS

For the design (i) the return loss graph is shown in Fig.2a. The antenna tuned to two frequencies 4.398 and 9.028 GHz with the return loss of -11.23 and -11.88 dB respectively. To improve the performance of the antenna, the other designs are proposed. In design (ii), the resonating frequencies are at 2.734, 4.625, 6.208, 7.094, 8.507 GHz and the notch frequencies are at 2.958, 8, 9-9.8 GHz. Gain at the resonating frequencies are less. To improve that third design is considered. Third design tuned to four different frequencies and three notch frequencies. The resonating frequencies are at 4.083, 5.083, 7, 9.031 and the notch frequencies are at 2.785, 4.813, 8.5 GHz. Gain at the resonating frequencies are comparatively higher to the previous design. Design (iv) enables tuning to the resonate frequencies at 4.125, 5.093, 7.042 and 9.031 GHz and notch frequencies at 2.734, 4.888, 7.8-8.5 GHz. The return loss graph for the design (iv) is shown in Fig 5c.

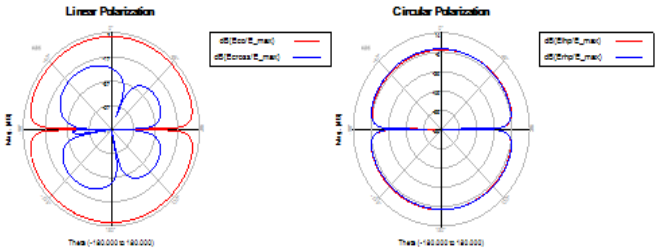

Fig. 6 Linear and circular polarization at 5 GHz

Fig. 6 shows the radiation pattern for co and cross polarization for the frequency 5 GHz. From the plot it is observed that the antenna design produces omnidirectional radiation pattern.

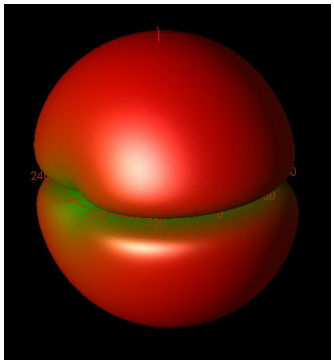

Fig. 7 Far field radiation pattern of Omega Antenna Design (iv)

The simulated far field radiation patterns of the omega antenna Design (iv) is illustrated in Fig.7. It is observed from the graph that the proposed design results in omnidirectional radiation pattern.

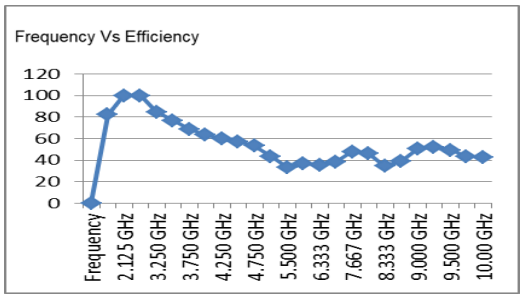

Fig.8 (a) Frequency Vs Efficiency

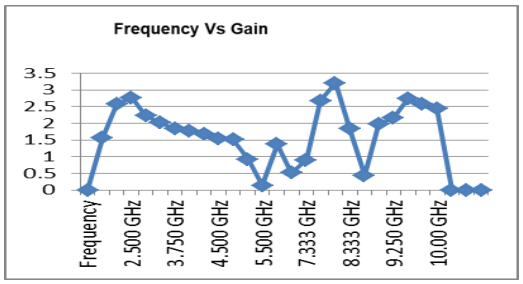

Fig.8 (b) Frequency Vs Gain

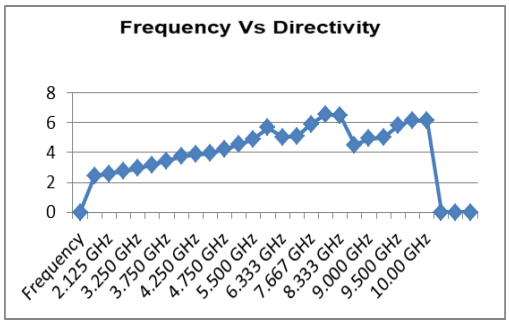

Fig.9 Frequency Vs Directivity plot

The simulated Frequency Vs Efficiency, Frequency Vs Gain and Frequency Vs Directivity of omega antenna are shown in Fig. 8(a), 8(b) and 9 respectively.

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Comparative Result analysis

The comparison among the four omega designs are given in Table.2.

Table.2 Frequency Vs Return loss for four different rectangular Omega designs

Patch design	Resonating frequencies	Notch frequencies	Frequency(GHz)	Return loss (dB)
(i)	2	2	4.398 GHz, 9.028 GHz	-11.23dB, -11.88 dB
(ii)	5	3	2.734 GHz, 4.625 GHz, 6.208 GHz, 7.094 GHz, 8.507 GHz	-13dB, -20dB, -30dB, -18dB,-14dB
(iii)	4	3	4.083 GHz, 5.083 GHz, 7 GHz, 9.031 GHz	-19 dB, -28 dB, -13 dB, -17 dB
(iv)	4	3	4.125 GHz, 5.093 GHz, 7.042 GHz and 9.031 GHz	-19 dB, -26 dB, -13.5 dB, -17 dB

III. CONCLUSION

The monopole omega shaped multiband antenna is designed to operate over four different frequencies and shows notch characteristics at three different frequencies. Four different designs of omega antenna are proposed. The suggested antenna is suitable for WLAN, WiMAX and X-band applications. The simulation results shows that the modified omega antenna has multiband tuning, improved gain, directivity and better radiation efficiency which confirms that it is suitable for present wireless communication systems.

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