



Triband Planar Antenna with Enhanced Directivity for WiMAX and WLAN Application

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Abstract

This paper proposes the improved gain and performance parameters design of Microstrip Triband antenna employing dual edge resonators. The proposed design of antenna is $12 \times 22 \times 1 \text{ mm}^3$ composed of FR4 substrate of relative permittivity of 4.65. The compact design of the proposed antenna was achieved employing ACS feed along with LSER and ECER for two independent desired resonances at 3.5 and 2.4 GHz respectively in addition to beveled monopole resonating at 2.4 GHz. The paper demonstrates one of the key techniques to improve the gain of the antenna in a direction by employing director at an optimum distance of $\lambda/6$ from the radiator. The complete work has been accomplished on 3D full wave FEM based ANSYS simulator. The simulated and experimentally measured parameters reflects close agreement to each other. As a part of the study, the reference antenna [1] was implemented on ANSYS and fabricated to study the performance and characteristics of antenna for triband operation. An exhaustive optometric simulations has resulted in achieving the desired results. The proposed antenna application in addition to WLAN and WiMAX, paves the way for the applications demanding enhanced directivity such as devices with electromagnetic absorbers at relatively low cost.

1. Introduction

Recent advancement in the field of microwave has brought various techniques to improve the design to improve various performance parameters leading to miniaturization of electromagnetic devices. Performance parameters such as return loss, VSWR, radiation pattern, gain, directivity etc. can be improved using advanced techniques resulting in the design of best electromagnetic devices at low cost and size. In designing multiband antenna, keeping the compact size and maintaining the low profile of antenna has always been a challenge for designers. Day by day, modern wireless devices are becoming more and more compact. This has led to the miniaturization of every single component on the device. It is characteristic of an antenna to radiate energy which is then launched into its input end, or the feed. The

design of a matched feed assumes importance for the purpose of completely justifying maximum power transfer from the source to the radiating antenna at the load end. Such feed which transfers maximum energy has important role to play in the design of the antenna especially in case of discussed compact planar antenna. Much importance is given to the radiators by the designers. However, the feed region remains nearly untouched in most compact designs. It is understood from the previous research and study that the overall area of an antenna depends mostly on the size of the radiating element i.e. radiator and the feed, it becomes important to tap into the unutilized potential of the feed. The detailed study in the reference antenna revealed that the ACS feed was best suited for the antenna as it reduces the antenna feed section dimension to greatest extent and more importantly, width of larger strip of the ACS feed is bound to have less effect on the characteristic impedance which allows the greater freedom of selecting the feed dimensions based on circuit requirements. There are various techniques for designing of multiband antenna as discussed in this paper using edge resonators. Use of higher order resonances, resonant traps, combined resonant structures and use of parasitic resonators are some of the basic principles involved to realize multiband antenna of the type discussed here. There are various literature available on the microwave circuit analysis of various structures of the antenna controlling the modes of operation. Multiple resonators have been deployed by the designers to improve the bandwidth of antenna. Employing co-planar coupled patches, vertical stacking, or by using internal slots and apertures are some the ways for achieving greater bandwidth. The reference antenna [1] was implemented for triband operation in WLAN and WiMAX application by incorporating an ECER (E Shaped coupled edge resonator) and LSER (L Shaped Slot Edge Resonator) for achieving resonance at 2.4 and 3.5 GHz respectively. A beveled monopole was designed to have resonance at 5.5 GHz and enabling ACS (Asymmetric Coplanar Strip) feed. For the improvement in the design various comparative study have been attempted during simulation. Gain of antenna is very important parameter which as a whole determines the performance of an antenna in all dimensions. This design extracts the advantage of

directors in order to concentrate the radiation of electromagnetic wave in one direction thereby improving the directivity. Various optimization attempts have been made to achieve best results. Experimental results shows that the proposed antenna design improved the gain of the antenna to a greater extent.

2. Antenna Design

The geometry of the proposed antenna is based on the reference antenna. The reference antenna discussed here is printed on FR4 substrate of thickness 1 mm and lossy relative permittivity of 4.65. The dimension of the proposed antenna is designed at 12 mm × 22 mm. A comparative study of same class of antenna is shown in Table 1. All three papers [2] [3] [4] propose certain promising solutions to multiband antenna. Various advantages and short comings have also been highlighted. One common shortcoming of the monopole type antenna is its omni-directionality, and it affects the solution in all three papers. What is characteristically missing from all three papers is the lack of directivity or maximizing the gain in one direction.

Table 1. Parametric Comparison of the Calculated and Measured Antenna Parameters

Paper Reference	Subject	Size (mm ²)	Average Peak Gain	Application	Shape	Feed	Substrate	
[2]	Comparison of different feeding techniques	13x12x1.6	3.8 dBi	Wideband - 11 GHz	2.4	O	CPW Microstrip ACS	FR-4
[3]	Quad band ACS-fed antenna	21.6x12x0.5	2 dBi	BT/WLAN/ C, X band/ITU-T	Meandered	ACS	FR-4	
[4]	Dual Band ACS-fed antenna	20x12.5x1.6	1 dBi	2.4 GHz BT/WLAN 5 GHz WLAN/WiMAX	0	ACS	FR-4	

It is for this reason that a solution is proposed to enhance the directivity of the proposed antenna studied previously [1]. The design of proposed antenna has been incorporated keeping in view the best solutions to fulfill the proposed design concept. The L shape and polygon shaped are chosen according to their respective resonant frequency. For both, it is $\lambda/4$. But for the case of E- shape it is not straightforward as there also coupling edges. Therefore, its length further reduces to $\lambda/8$. The height of the radiation is chosen according to the Fraunhofer distance i.e. $2D^2/\lambda$ where D is the longest diagonal distance. In the case of stacking, optimizing length parameter comes to be 22 mm. Compared to Radiation boundaries, which create absorbing boundary conditions (ABC), PMLs, in general, make it more difficult for the iterative solver to reach convergence compared to the same model with using ABCs. PMLs also require significantly more RAM. That's why we have used simple radiation boundary conditions. For stacking preferably the same type is used for better results as well as for fabrication simplicity. One of the most prominent feature of the

proposed design was implementation of ACS feed. Against the previously mentioned merits of ACS feed, the characteristic impedance of the ACS fed line can be given as [7]

$$Z_0 = \frac{60 \pi K'(k)}{\sqrt{\epsilon_{re}} K(k')} \quad (1)$$

The gain have been measure for fabricated proposed antenna. The gain were practically measured using Friis Equation. The Friis Equation is used to calculate the gain of the antenna when other parameters are known. The path loss was calculated as per the anechoic chamber conditions. The Friis Equation is given by

$$P_t(dBm) = P_r(dBm) - G_t - G_r + 20 \text{Log} [L_p] \quad (2)$$

Where,

- P_t is Transmitted power in dBm
- G_r is Gain of the receiving antenna
- P_r is received power in dBm
- L_p is Path loss
- G_t is Gain of transmitting antenna

In the first part of study, the proposed antenna design had been simulated in ANSYS and the better results were achieved as desired. During second part of study, the simulated antenna was fabricated and experimental results were analyzed. Figure 1 shows the ANSYS design of the proposed antenna. Use of simple radiation boundaries has assisted in faster and accurate simulation results. The proposed antenna design was implemented on FR-4 substrate which is easily available with low cost and suitable for the antenna design. FR-4 substrate was deliberately chosen in order to implement the improvement in reference base antenna. The design concept was successfully simulated on ANSYS.

3. Experimental Results and Discussions

To validate the simulated design concept, a prototype was fabricated. The fabricated antenna design is depicted in figure 2. The fabricated antenna design was experimentally tested in the microwave laboratory.

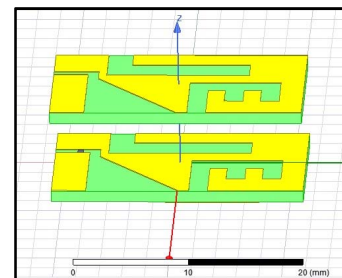


Figure 1. ANSYS Design of Proposed antenna

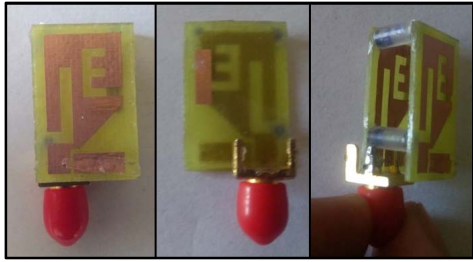


Figure 2. Fabricated Proposed antenna

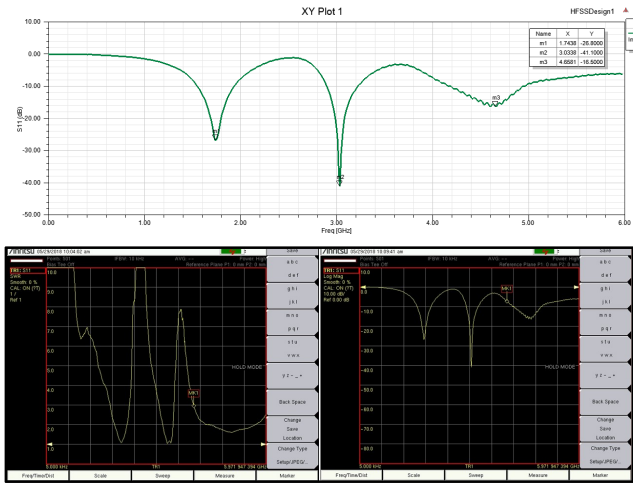


Figure 3. Experimental Results of VSWR and Return Loss of Proposed antenna

VNA Anritsu 2038C was used to measure the basic return loss and VSWR parameters. The experimental results of VSWR and return loss are shown in figure 3. The prototype was tested in anechoic chamber for the gain measurement in far field. The results of the simulated and the experimentally measured values of return loss and VSWR are shown in figure 4. The results clearly illuminates the improvement in the return loss, VSWR and more importantly, the gain. As can be seen that return loss achieved in the design are -26.8, -41 and -16.5 dB at 2.4, 3.5 and 5.5 GHz respectively. Excellent VSWR of 1.1, 1 and 1.4 were achieved at 2.4, 3.5 and 5.5 GHz respectively which is one of the attractive features of the design.

Experimental setup of antenna testing are shown in figure 5 and 6. An overall increase in the area proposed antenna design can be neglected against the achieved impressive gains at all the three bands. Figure 7 and 8 shows the experimentally measured results and comparison of reference antenna with proposed antenna respectively in respect of gain parameter.

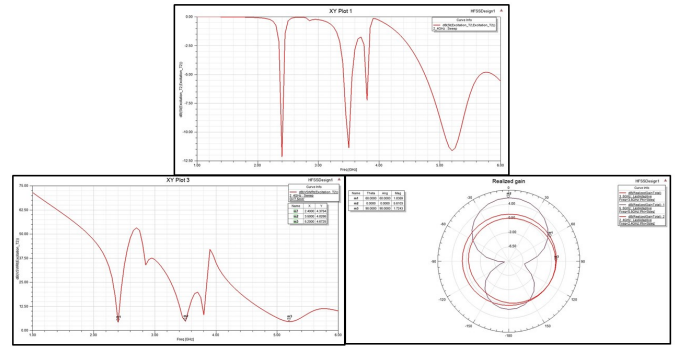


Figure 4. Simulated Results of Return Loss, VSWR and Realized Gain of Proposed antenna

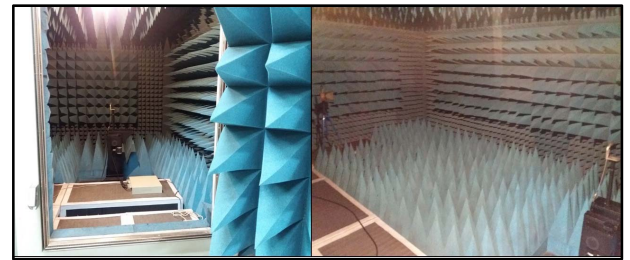


Figure 5. Experimental Setup for Antenna Testing in Anechoic Chamber

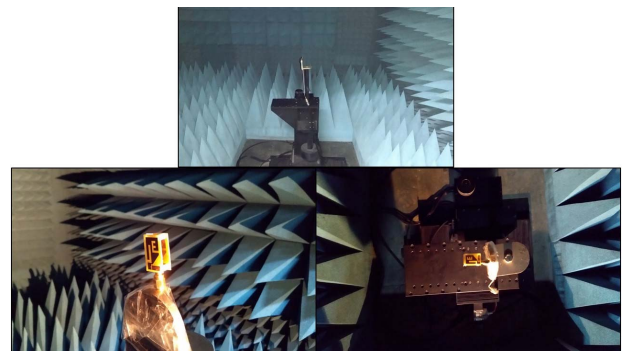


Figure 6. Experimental Setup for Antenna Testing in Anechoic Chamber

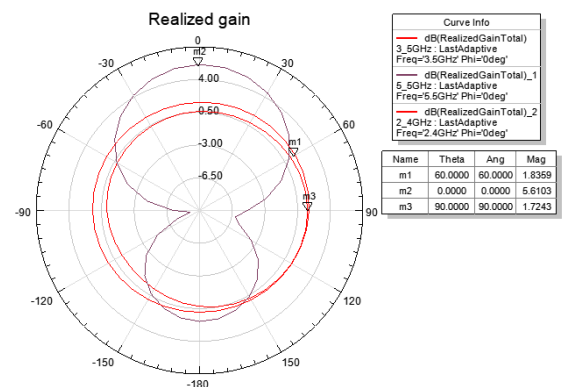


Figure 7. Simulated Realized Gain of the Proposed Antenna

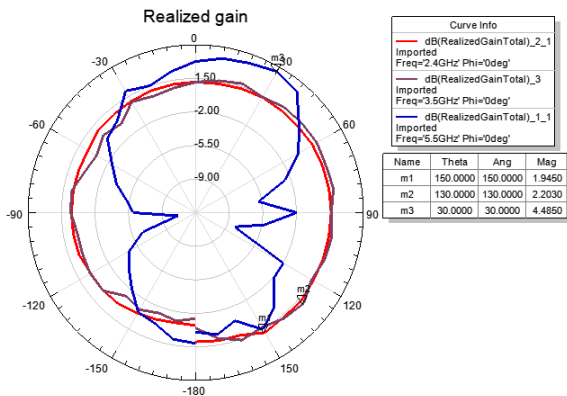


Figure 8. Experimentally Measured Realized Gain of the Proposed Antenna

The most important part of study involves the improvement in gain of the proposed design. An enormous improvement in the gain is measured experimentally. The achieved gains of 1.5, 2.2 and 4.4 dBi for 2.4, 3.5 and 5.5 GHz respectively of proposed antenna design against the gains 0.77, 1.98 and 1.56 dBi for 2.4,3.5 and 5.5 GHz respectively of reference antenna [1] design endorse the phenomenal increase in the gain by 94, 11 and 182 % for 2.4, 3.5 and 5.5 GHz respectively.

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5. References

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