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Bevel microstrip printed antenna for satellite communication

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A single feed, single layer compact bevel cut rectangular patch antenna is proposed. The bevels are cut at the left-top corner and the right-bottom corner. The 1st resonant frequency (4.25 GHz) is applicable for short band radio wave communication and the other resonant frequency (6.93 GHz) is applicable for radar communication. All the results are simulated by using IE3D, a MoM based software and the results are verified by the VNA network analyzer. This paper includes the bandwidth, return loss, vswr range and radiation pattern.

Keywords: Bevel, Feed, Layer, Patch, Resonant frequency, Antenna

1 Introduction

For new era of communication, design of compact microstrip antenna creates a lot of interest among the young engineers especially for microwaves engineer[1]. For the portability of microwave devices, we need small, light weight and compact antenna and on this ground Compact Microstrip Antenna is the most suitable device. For microwave communication as well as also for the wireless communication, now-a-days more than one operating frequency is required due to many reasons. The two operating frequencies are required mainly because most of the microwaves and wireless engineers use different communication bands and for uses of different bands different frequencies are used by the engineers. Therefore, recently the engineers design antennas which have multiband characteristics. Another criteria needed to design the antenna is size reduction which is the new technique and in this method the size of the antenna is the same for conventional as well as proposed antenna. For size reduction the most useful technique is to cut different structures in the proper position on the conventional microstrip antenna[2-5]. Reducing the size of the antenna means the resonant frequency of slotted antenna is drastically reduced as compared to conventional antenna[6-8]. There are so many antennas are used to reduce the size of proposed antenna like DRA (Dielectric Resonator Antenna), fractal antenna[15-20] etc. But the above mentioned antennas are very difficult to design as compared to microstrip patch antenna. Now the structure of fractal antennas are just like a euclidean geometry structure and it is a combination of triangle, square and circles etc. So fractal antennas are very much difficult to design and DRA requires high dielectric constant substrates (more than 20) which are not readily available. Now-a-days the size of the compact microstrip antenna is very small and miniaturization is possible so these antennas are increasing the demand of their application in various communications especially microwave and mobile communication[9-10]. In the present paper, two bevels are cut at the left-top corner and the right-bottom corner to increase the return loss and gain bandwidth performance. It also gives the increased frequency ratio for the proposed compact microstrip printed antenna. For size reduction of the antenna, we need dielectric constant with high values[11-14]. Our aim is to design the antenna with multiband operation and increased frequency ratio as well as increase the operating bandwidth. The simulation has been carried out by IE3D[21] software which uses the MOM method and verified by measurements. This is applicable to C-band microwave frequency in the band range 4-8 GHz

The C band is a name given to certain portions of the electromagnetic spectrum, including wavelengths of microwaves that are used for long-distance radio telecommunications. The IEEE C-band (4 GHz to 8 GHz)-and its slight variations-contain frequency ranges that are used for many satellite communications transmissions, some Wi-Fi devices, some cordless telephones, and some weather radar systems. For satellite communications, the microwave frequencies of the C-band perform better under adverse weather conditions

2 Antenna Design

Different values of dielectric constant are possible for PTFE substrate. Basically, the values of dielectric constant for PTFE substrate are 2.2 and 4.4 which are readily available. There are numerous substrates that can be used for the design of microstrip antennas, and their dielectric constants are usually in the range of $2.2 \leq \varepsilon_r \leq 35$. The ones that are most desirable for good antenna performance are thick substrates whose dielectric constant is in the lower end of the range because they provide better efficiency, larger bandwidth, loosely bound fields for radiation into space, but at the expense of larger element size. Thin substrates with higher dielectric constants are desirable for microwave circuitry because they require tightly bound fields to minimize undesired radiation and coupling, and lead to smaller element sizes, however, because of their greater losses; they are less efficient and have relatively smaller bandwidths. PTFE (polytetrafluoroethylene) based substrates are used to provide a laminate with a dielectric constant that is relatively low. While PTFE has very good electrical properties, other properties need to be well understood for several considerations. The design and fabrication of microstrip patch antennas are easily possible on PTFE substrate. For MoM based transmission line analysis, we can choose any dimensions for width (W) and length (L). Now in the present paper, we chose a rectangular substrate to design the proposed antenna whose width and length are different. A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane.

Designed proposed antenna configuration shows in Fig. 1 with similar PTFE substrate. Two bevels are cut at the left-top and right bottom corner whose dimensions and the location of coaxial probe-feed (radius=0.8 mm) are shown in Fig. 1.

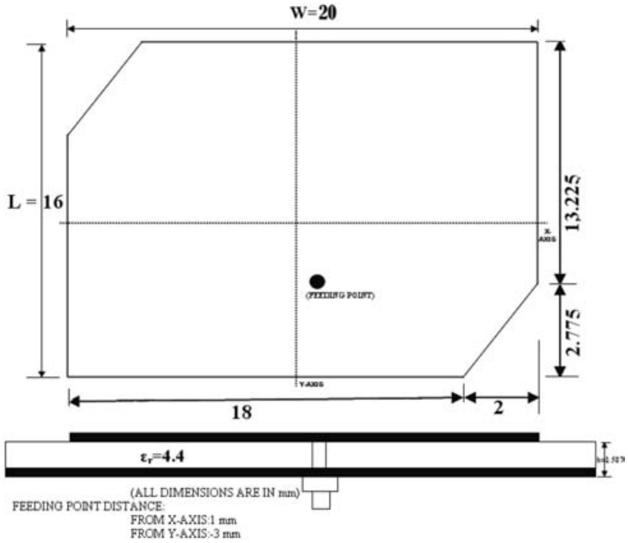

Fig. 1 — Proposed antenna configuration

3 Results and Discussion

Figure 2 shows the simulated (using IE3D[21]) results of return loss for slotted antenna structure. A significant improvement of return loss is achieved in the proposed antenna with this very simple antenna structure which is described in this paper by cutting two bevels at the left top and right bottom corner.

Due to the cutting of two bevels at the left top and right bottom corner in proposed antenna, resonant frequency operation is obtained with large values of frequency ratio along with the significant return loss. The first resonant frequency is obtained for proposed antenna at f_1 = 4.25 GHz with return loss of about-31.32 dB. The second resonant frequency is obtained at f_2 = 6.93 GHz with return losses –28.79 dB. Corresponding 10 dB bandwidth obtained for proposed antenna at f_1, f_2 are 95.63 MHz and 165.37 MHz, respectively. The simulated E plane and H-plane radiation patterns for proposed antenna are shown in Figs 3-10.

The simulated VSWR versus frequency plot of proposed antenna is shown in Fig. 12. The VSWR value for the 1st resonant frequency (4.25 GHz) is 1.06. The second resonant frequency is obtained at f_2 = 6.93 GHz with VSWR value 1.08. All these values are within 2:1 range. With the help of Tables 1 and 2 all the simulated results are summarized as follows:

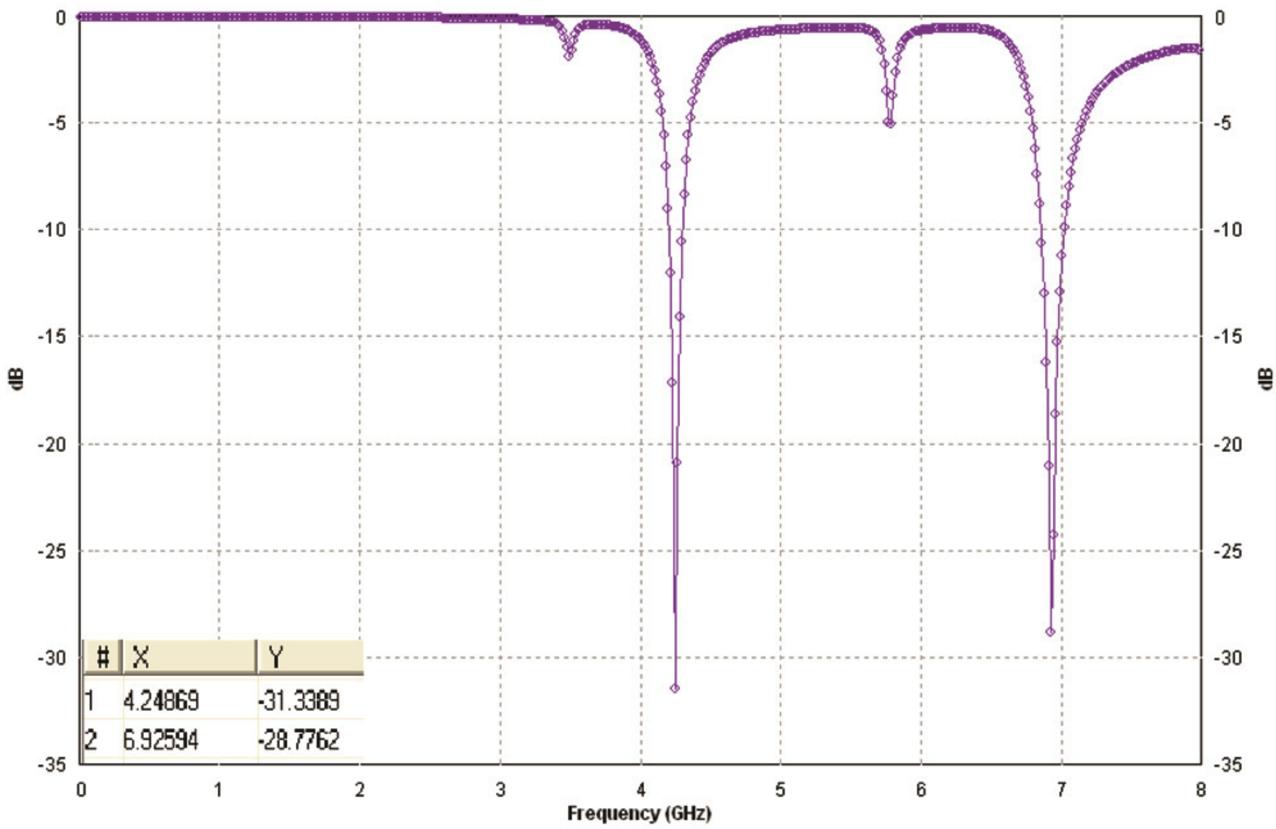

Fig. 2 — Proposed antenna (return loss versus frequency)

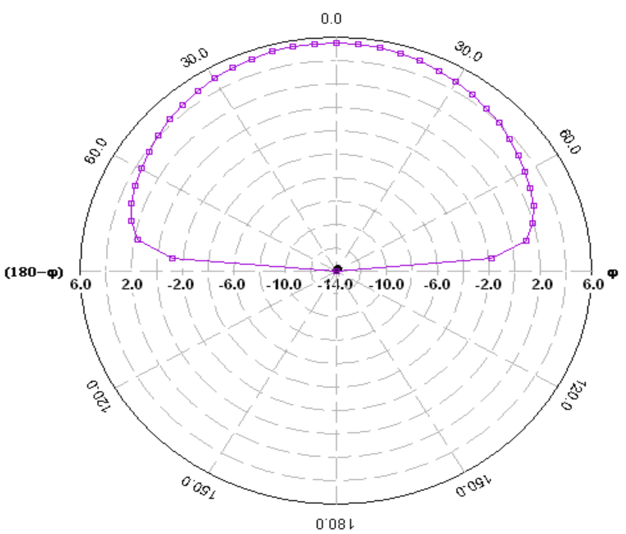

Fig. 3 — Simulated E-plane radiation pattern for proposed antenna at 4.25 GHz

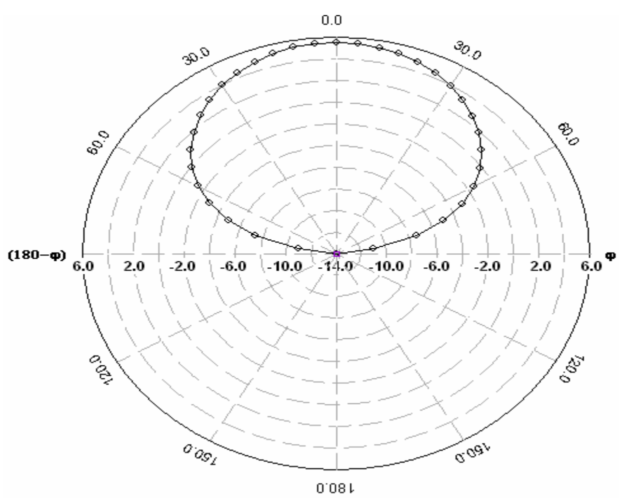

Fig. 4 — Simulated H-Plane radiation pattern for proposed antenna at 4.25 GHz

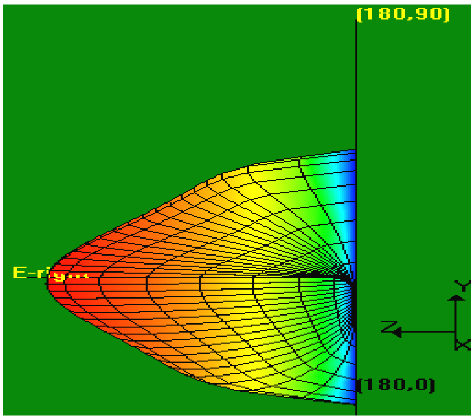

Fig. 5 — Simulated E-plane radiation pattern (3D View) for proposed antenna at 4.25 GHz

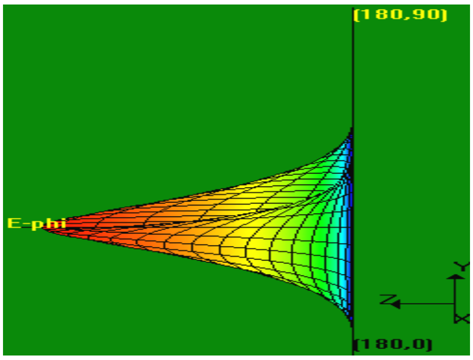

Fig. 6 — Simulated H-plane radiation pattern (3D view) for proposed antenna at 4.25 GHz

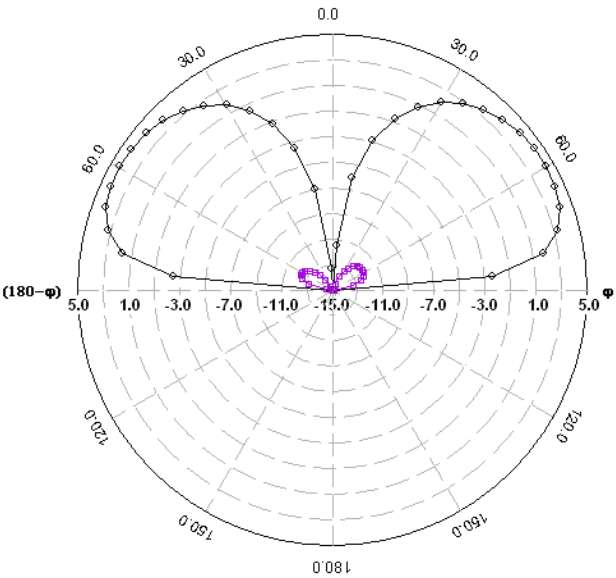

Fig. 7 — Simulated E-plane radiation pattern for proposed antenna at 6.93 GHz

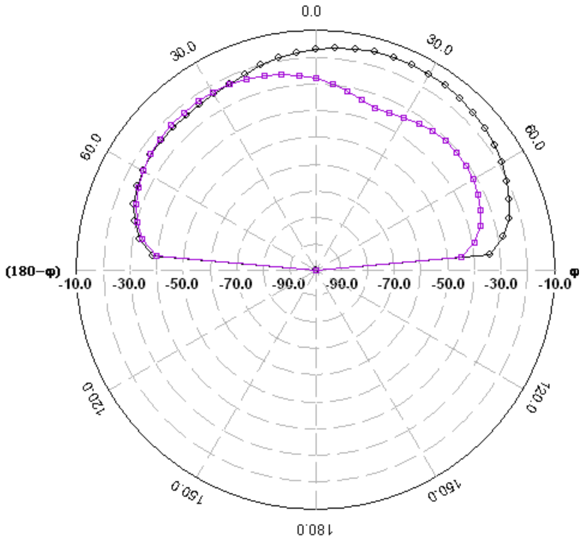

Fig. 8 — Simulated H-plane radiation pattern for proposed antenna at 6.93 GHz

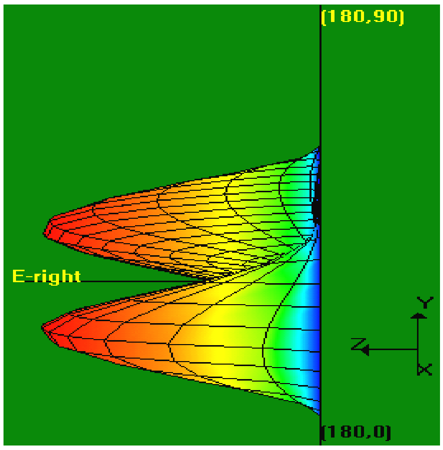

Fig. 9 — Simulated E-Plane Radiation Pattern (3D View) for proposed antenna at 6.93 GHz

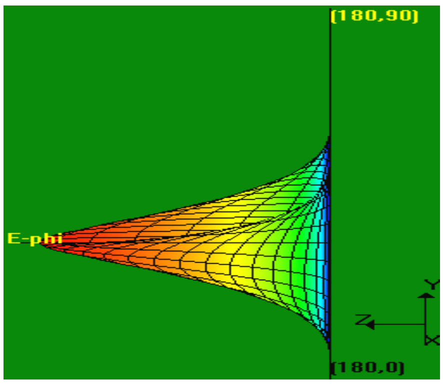

Fig. 10 — Simulated H-plane radiation pattern (3D view) for proposed antenna at 6.93 GHz

Figures 13 and 14 show the prototype of proposed antenna. It was also fabricated and tested, which is shown in Fig. 15. All the measurements were carried out using Vector Network Analyzer (VNA) Agilent N5 230A.

The comparisons of the measured return loss with the simulated ones are shown in Fig. 15 for the proposed antenna which is described in the present paper. The discrepancy between the measured and simulated results is due to the effect of improper soldering of SMA connector or fabrication tolerance.

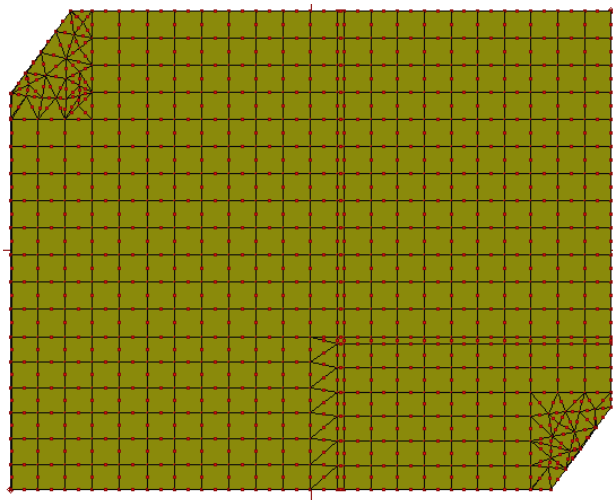

Fig. 11 — Total current distribution pattern for proposed antenna

Table 1 — Simulated results for proposed antenna with respect to radiation pattern

Antenna structure	Resonant freq.(GHZ)	Freq. ratio	3 DB Beam width (°)	Absolute gain (DBI)
1	$f_1 = 4.25$		170.92[Rf]	5.51
	$f_2 = 6.93$	f_2/f_1=1.631	170.62[Rf]	4.29

Table 2 — Simulated results for proposed antenna with respect to return loss

Antenna structure	Resonant frequency (GHz)	Return loss (dB)	10 DB Bandwidth (MHz)
1	$f_1 = 4.25$	-31.32	95.63
	$f_2 = 6.93$	-28.79	165.37

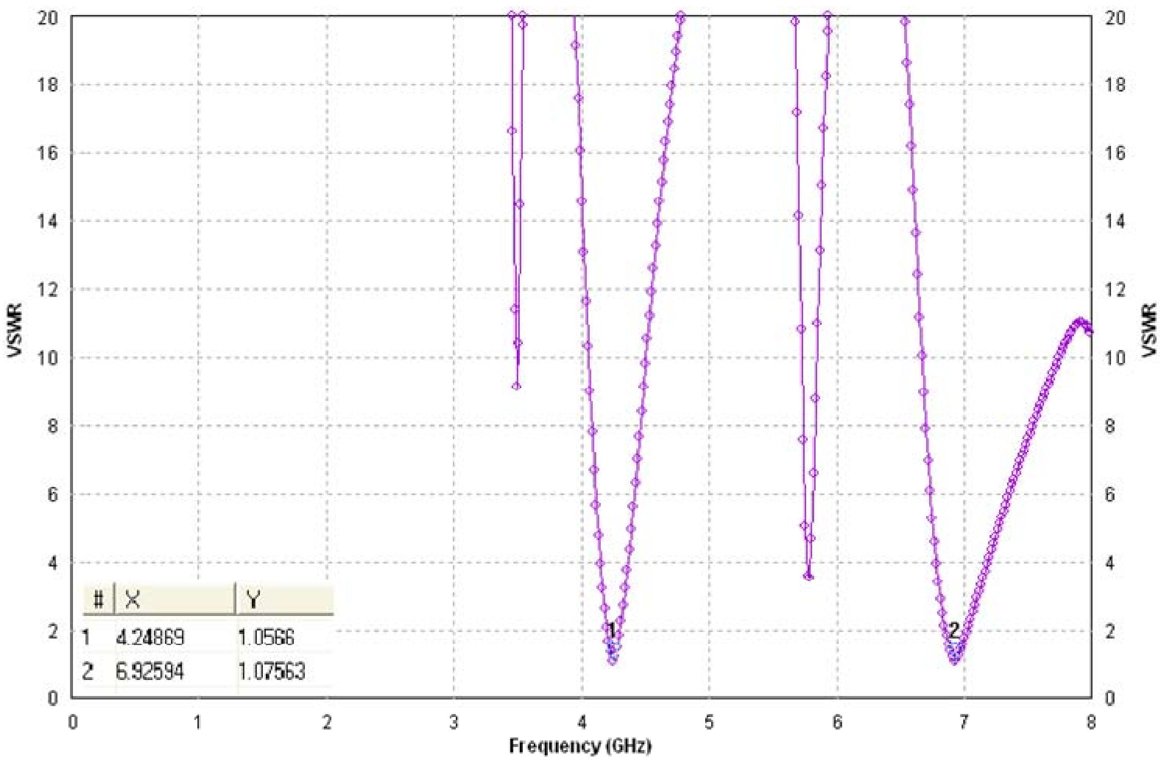

Fig. 12 — VSWR versus frequency plot for proposed antenna

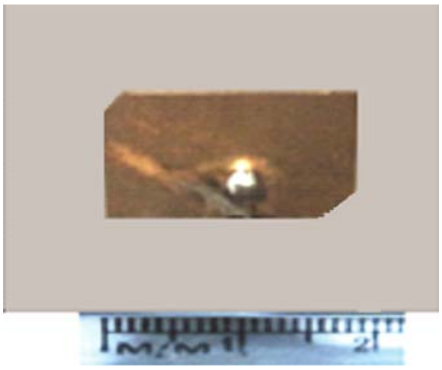

Fig. 13 — Top layer photograph of proposed antenna

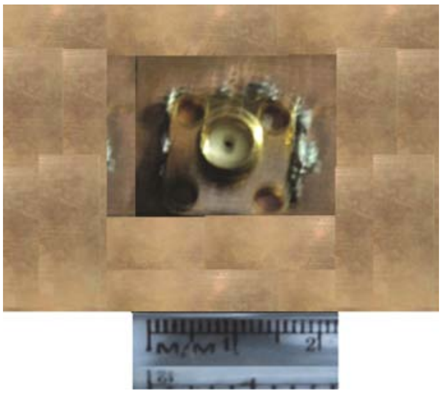

Fig. 14 — Bottom layer photograph of proposed antenna

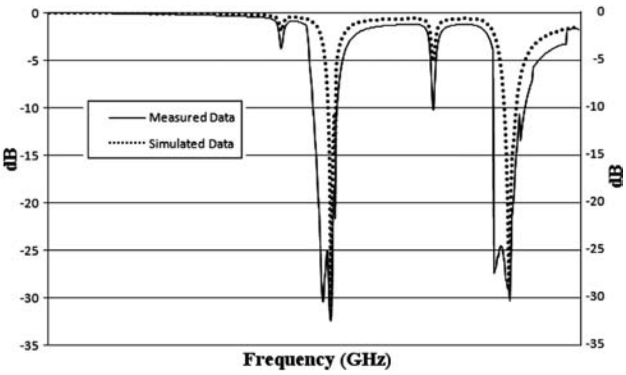

Fig. 15 — Comparison between simulated and measured data for proposed antenna

4 Conclusions

Single layer, single feed compact bevel cut micro strip printed antenna on which theoretical investigations have been carried out using Method of Moment based software IE3D and it was also verified by measurements with the help of VNA (Vector Network Analyzer). Introducing two bevel slots at the left top and right bottom corner at the edge of the patch, a significant improvement is achieved in return loss of about-31.32 dB as well as in VSWR value which was closer to the minimum value of VSWR. Another result is also observed that for the proposed antenna, the-3dB beam-width of the radiation pattern of about 170.92° is achieved which is sufficiently broad beam for the applications for which it is intended. The resonant frequency antenna presented in the paper for a particular location of feed point (1 mm, -3 mm) considering the centre as the origin was quite large as is evident from Table 2. If we change the location of the feed point, then the results give narrower 10 dB bandwidth and less sharp resonances.

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