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Compact high impedance surface antenna for IEEE S band communication

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ABSTRACT

Wireless communication is one of the widely used fields for research. In wireless communication, micro strip antenna is the promising candidate for its small size, light weight and easy fabrication process. The authors have analysed, simulated and presented compact high impedance surface antenna for IEEE S band communication. The proposed antenna is of 30.8 X 27.6 mm^2 size which has been excited by a 50Ω micro strip line. The FR4 has been utilised as a substrate using standard etching technology for easy and cost effective fabrication. Antenna has partial ground plane to improve the bandwidth. The claimed geometry has been simulated using High Frequency Structural Simulator (HFSS) software.

KEYWORDS High impedance substrate, rectangular, antenna.

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INTRODUCTION

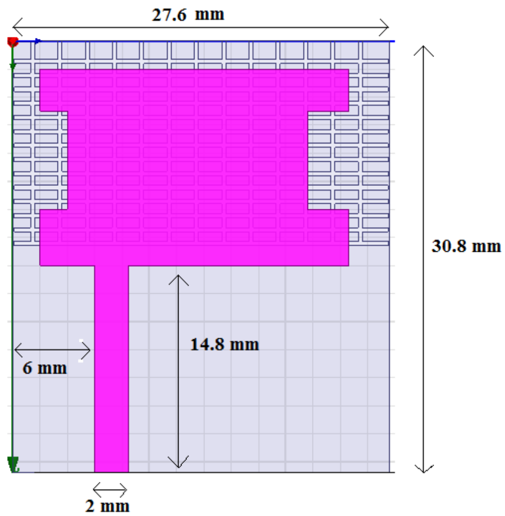
In the past decade, there has been enormous progress in the field of antenna design. The market and wireless communication systems demand compact size, low cost, easy fabrication antennas because of the fast growing technology[8]. Daniel Sieve Piper introduced High Impedance Surface (HIS) structure for the first time as an appropriate alternative to achieve low profile and improved gain antenna[1]. The geometry of high impedance ground plane gives important properties like reflecting filed with phase shift having zero degree. It is also applicable when there is a short distance between radiating element and the reflector. The geometry offers stop band characteristics for surface wave propagation. Because of the aforesaid structure, antenna radiation pattern could be improved which even helps to reduce the multipath and smoothen radiation pattern[2]. To fulfil the desired frequency applications, operational bandwidth should be improved. Partial ground plane could be effectively utilised for the said improvement. Also, impedance matching could be the crucial factor to transfer the maximum power from the feed structure to the other geometry of an antenna[3,15]. Negative refraction, defected ground plane and fractal geometry are the effective techniques which helps the designer to achieve compact size antenna but it is also true that miniaturised micro strip patch antenna has very low bandwidth, typically 1% - 2%[6].

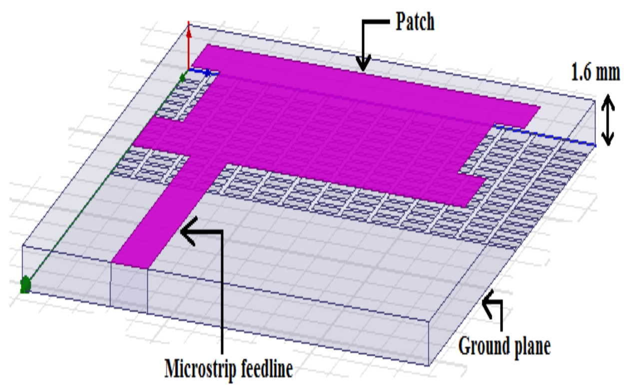
Here, the challenging issue is to cover the demands from wireless communication market with compact size, cost effective, high performance antenna structure [4,14]. The recent developments in antenna field says that stacking different antenna elements, increasing the height of the substrate , using the low permittivity substrate the bandwidth could be significantly improved[5-7]. There are some special designs where high impedance surface could be achieved using plane conducting surface[9].The high impedance structure consists of metal patches on one side, connected by metal vias to a solid conducting sheet. The said structure forms the parallel LC filter which can control the centre frequency. If the applied voltage is parallel to the surface, it causes charges to build up on the metallic end plates[10]. An extraordinary radiation examples are achieved by energizing distinctive modes. A variation of feed system is one of the most desired advantage of micro strip patch antenna. It has also other important advantages like wide bandwidth, low dissipation at high frequency and higher radiation efficiency due to negligible conduction loss [11-15]. Introduction of slot in the patch geometry is one of the techniques for multiband antenna design . Due to electromagnetic, micro strip patch antenna suffers along with its benefits.

Specifically, the surface wave could induce the minor lobes and the EM wave to radiate in directions different from the radiation source. There are many applications in today's world where micro strip antenna could be utilised[13]. The aforesaid antenna is used in medical equipments due to its compact size, low cost and easy fabrication process[12]. The micro strip antenna could be projected as a sensor antenna which deals with health monitoring system. The micro strip patch antennas also have other military and civil applications. The wearable printed micro strip patch antenna could be the appropriate candidate for military applications.

ANTENNA DESIGN

Figure 1 (a) depicts the top view of the proposed antenna geometry. Here, the patch has been structured on the substrate made from FR4 material which has dielectric constant 4.4. Two slots have been effectively introduced in the patch geometry to increase the periphery of current movement. A new design of ground plane is implemented by developing high impedance surface to overcome the effect of surface wave. Figure 1 (b) shows the bird eye view of an antenna. Here, partial ground plane structure has been utilised effectively.





(a) **(b)**

Fig. 1. (a)Top view (b) bird eye view of proposed Antenna.

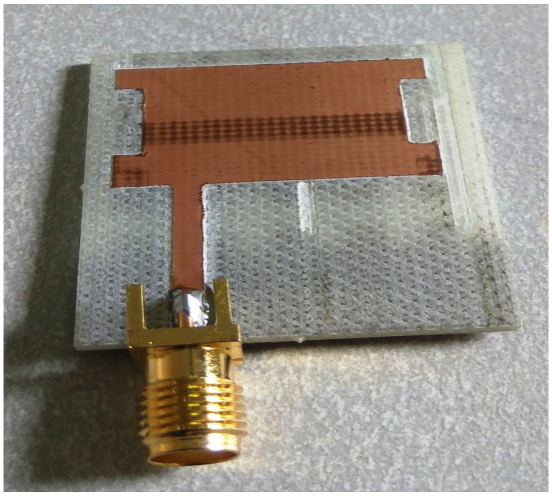
The table 1 shows the detail dimensions of the proposed antenna. Here, dimensions of all parameters are finalized in order to achieve the compact size antenna.

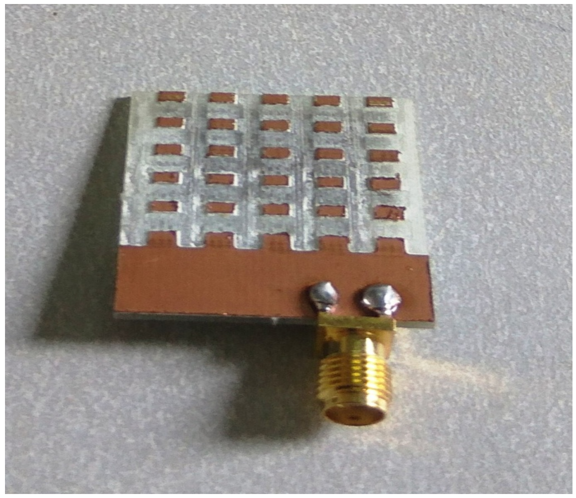
Table 1. Parameters of proposed antenna

S.N.	Parameters	Value
1	Design resonance frequency	2.41GHz
2	Dielectric constant	4.4
3	Substrate height	1.6mm
4	Ground plane length	30.8mm
5	Ground plane width	27.6mm

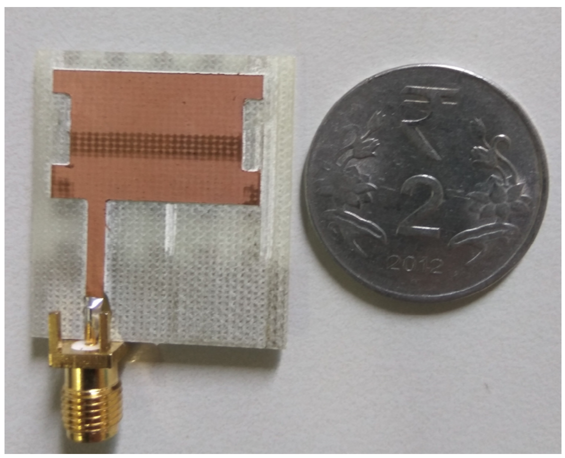
FABRICATED ANTENNA STRUCTURE

Once the desired return loss had been observed in HFSS software, the authors have fabricated the similar antenna with almost similar dimensions in antenna laboratories. FR4 material sheet having 1.6 mm thickness has been used to fabricate the proposed antenna. Fabrication process has been successfully completed using PCB design machine within the laboratories. The fabricated structure has been shown in figure 2. Figure 2 (a) depicts the top view and figure 2 (b) shows back view of an antenna. Here, systematically SMA connector has been shouldered with micro strip feed line of antenna for excitation. It was the gentle approach from the author to fabricate the aforesaid antenna with maximum accuracy. Figure 3 depicts the physical antenna connection with network analyser N9912A.





(a) Top view of physical antenna **(b) Back view of physical antenna**



(c|) Compact size antenna

Fig. 2. Fabricated physical antenna

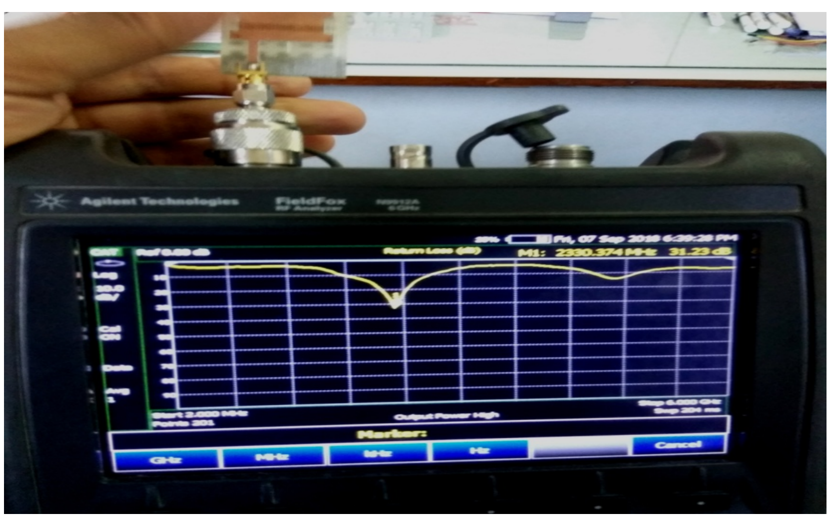


Fig .3. Fabricated antenna mounted on network analyzer

RESULT AND DISCUSSION

The proposed dielectric resonator antenna has been simulated in High Frequency Structure Simulator (HFSS) software. Figure 4 shows the return loss for the proposed DRA. The return loss shows the part of an electromagnetic waves which is reflected back. It is very clear that return loss should be as minimum as possible because it is related with the radiation.

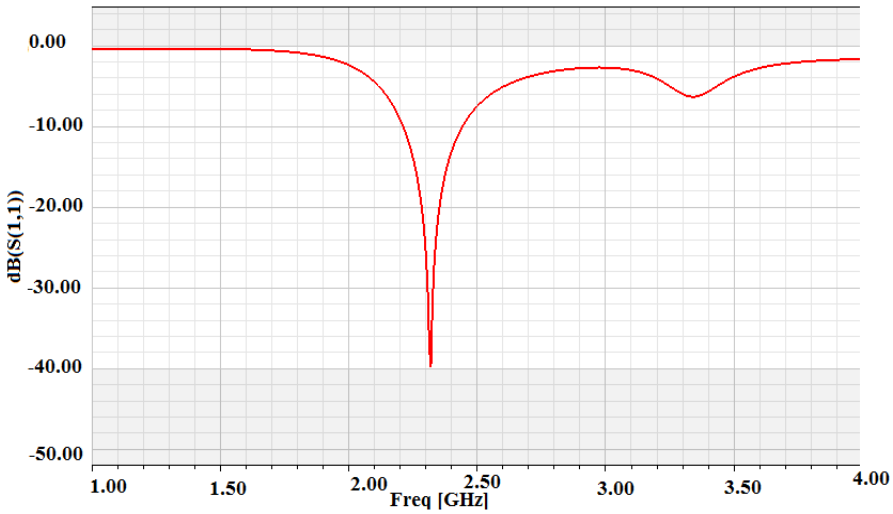


Fig. 4. Simulated S_{11} of a HIS antenna

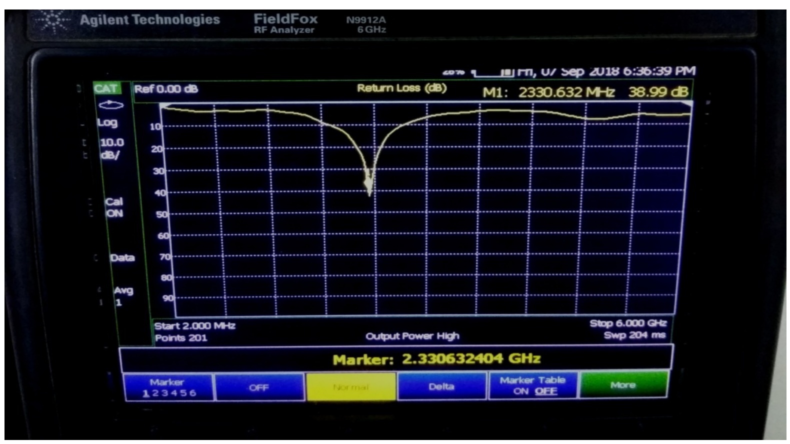


Fig .5. Practical S_{11} parameter response in network analyzer

The simulated reflection coefficient of the proposed antenna is illustrated in figure .4 (red colour line) which claims that stable impedance resonance is between 2.3 GHz to 2.48 GHz with centre frequency of 2.33 GHz. This gives impedance bandwidth of 19.20% which covers IEEE S band frequency spectrum.. The fabricated antenna has been tested and analysed using portable network analyser in the laboratories. The dotted line (in fig 4) represents the actual reflection coefficient. The actual return loss behaviour measured in the said device is very close to the ideal response. The actual response is shown by fig. 5.

An antenna gain is a key parameters which combines the antenna directivity and radiation losses. Higher gain implies higher transmission power of radio waves or low loss. Figure 6 demonstrates simulated gain of a ring dielectric antenna as 2.06 dBi. To build the return loss, one of the early recommendations was to expand the electrical thickness of the substrate. It had two noteworthy inconveniences: expanding the surface waves and Ohmic loss and along these lines lessening radiation efficiency. The simulated gain is illustrated in Figure .

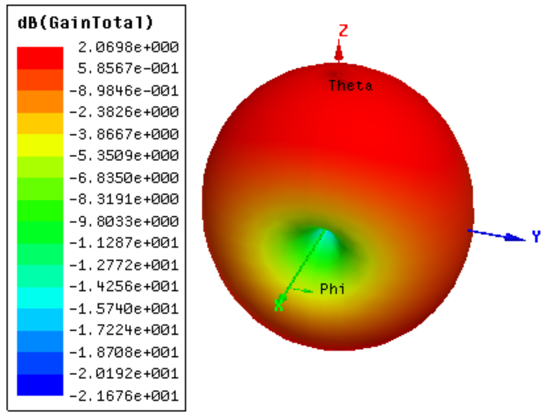


Fig .6. 3-D gain of a HIS antenna

CONCLUSION

A micro strip feed line excited high impedance surface antenna is presented for IEEE S band communication. The proposed antenna illustrate resonance at 2.33 GHz frequency with gain of 2.06 dBi. The fabricated antenna has shown expected results. This antenna is viable option for wireless communication. The claimed antenna meets the industry requirements like small size, light weight and easy fabrication process. The antenna response could be further improved by selecting the proper dimensions of partial ground.

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