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A Star Shape Wideband Antenna for Microwave Energy Harvesting

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Abstract
The paper proposes a Wideband star shape Microstrip Antenna, with particularly intended to wide bandwidth, small size for utilizing in microwave energy harvesting system. The antenna simulated with half ground is having a lower VSWR (Voltage Standing Wave Ratio) of 1.1 at a design frequency of 3.55 GHz, and a 2:1 VSWR bandwidth of 3.267GHz achieved. The structure of antenna is finally decided after analyzing various dimensional effects on bandwidth, return loss and frequency of operation. The simulations are performed using CST microwave studio and results of the simulation study have been discussed in the paper.

Keywords: *Micro-Strip antenna, wideband antenna, small size antenna.*

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INTRODUCTION

Increasing research and application interests are received by wireless multimedia systems. But developments are still obligatory to deliver higher data-rate links, for example the transmission of video signals. Hence, ultra-wideband (UWB) communication systems are presently under examination and the design of a compressed wideband antenna is very necessary. Various techniques have been developed to cover the entire UWB bandwidth in order to overcome the intrinsically narrow bandwidth of Micro-strip antennas, such as L-/F-shaped probe to feed the patch, triangular patch, U-/V-slot monopoles, among others[1]. We can also use the similar antenna for collection of the energy which is being radiated at various frequencies. Obviously it is more operative to produce the energy of numerous services at the similar time than collecting only one service energy and because of this reason the idea of an UWB antenna for harvesting energy is completely viable. The meaning of Energy Harvesting (also called energy scavenging or power harvesting), is the process by which energy from different sources is captured and stored. Generally, this definition applies when we talk about autonomous devices that require a low amount of energy to function[2-3].

Energy harvesting is done with the help of rectenna. Rectenna is a rectified antenna. It means it is a combination of antenna and rectifying circuit. They harvest microwave power from space and then convert alternating current power to direct current power[4]. For an efficient rectenna, Antenna is an important element. Antenna is main part of microwave energy harvesting system. To harvest maximum power from ambience by a rectenna, antenna should be high gain wideband small in size. The efficiency and Bandwidth of Micro-Strip antenna depends on size of patch, shape, substrate thickness, substrate’s dielectric constant, feed point type and feed location etc. To good antenna performance, dielectric substrate of good thickness which has a low dielectric constant is required for wideband, better radiation and better efficiency, leading to a bigger antenna size. Compact antenna design requires higher dielectric constant, leading to narrower bandwidth, lesser efficiency and higher loss tangents[5]. Alternative operative technique to make antenna small in size is to insert shorting post which would not be used in the proposed antenna. Hence final design requires a trade-off amid antenna dimensions and antenna performance, depending on the microwave energy harvesting system requirement. The upper conducting layer, i.e., patch of the Micro-strip antenna is the source of radiation and it emits mainly because of the fringing fields between the patch edge and the ground plane. The perfectly reflecting ground plane is achieved by lower conducting layer, bouncing energy back through the substrate and into the free space.

Circulating polarized antennas will essentially help to obtain the same DC voltage irrespective of the rotation of the antenna circulating polarized Micro-strip antenna is propositioned in this paper which also found efficient for rectenna design[6].Micro-strip rectangular patch antenna with DGS (Defected Ground Surface) is proposed in this paper and antenna used in this paper having the property at high harmonic rejection because of DGS. The proposed star shape antenna is very small in size and compact. Proposed antenna is giving very high bandwidth which is suitable for microwave energy harvesting.

MICROSTRIP ANTENNA DESIGN

Designing an antenna in the High Frequency or lower UHF (lower Ultra High Frequency) band means that the antenna dimensions could be outsized and antenna could be gigantic which is not acceptable. Keeping this on focus, with the objective to design a very small in size, light wright wideband Micro-Strip antenna, the design approach was taken from broadband antennas to make the antenna work in a large band of frequencies from the many broadband antennas; Micro-strip antenna was chosen. Hence, the chosen shape of the patch was that of the shape of a 2D (Two-Dimensional) Micro-Strip antenna, with an aim to combine the advantage of both the Micro-strip antenna. It was, thus, possible to reduce the size of patch thereby reducing the size of Micro-strip antenna with increased bandwidth and to make antenna light weight. To induce excitation, probe feed or co-axial technique was used as its main advantage was that the feed can be placed at any place in the patch to match with its input impedance (50 ohm).

Figure 1 shows the proposed star shape Micro-strip antenna with it dimensions are mentioned in the table 1. The star shape co axial probe-fed Micro-Strip antenna, with half ground is the proposed antenna. Each dimension of antenna, i.e., L (length), B (breadth), W (width), D (outer diameter), d (inner diameter) was varied in accordance with the other dimensions of the antenna, observing the changes in frequency of operation, bandwidth, and lobe radiation. But the results of the proposed antenna dimensions as mentioned in the table 1 were found to be better in comparison to the results of other antenna dimensions of the similar structure.

***Table 1**: Dimension of Proposed Antenna.*

Total length of antenna	50 mm
Total Width of antenna	30 mm
Height of ground PEC layer	0.038 mm
Height of dielectric substrate	1.6 mm
Height of path PEC0.	0.38 mm
Radius star patch	12 mm

Antenna design is carried out by CST software in the given design parameters. Flame retardant-4 substrate is used to design antenna. Its dielectric constant loss tangent and height are respectively are 4.4, 0.02 and 1.6 mm. This substrate is also known as FR4 (lossy) can be loaded from CST software material library[7-9].

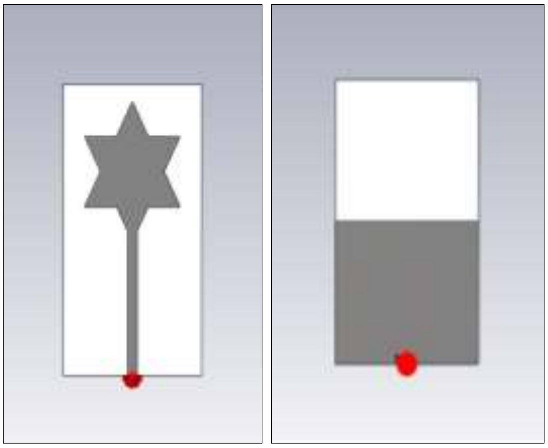

Fig. 1: *Top View and Bottom View of Proposed Micro-Strip Antenna.*

RESULTS

This simulation is carried out by using Transient solver method, CST MSW. For small antenna design, the size of the ground plane is a very important parameter to be considered. For this simulation, the size of the ground plane is equal to the substrate size. The square-shaped half ground plane of size square 30 mm 20 mm is investigated. The simulation of wideband patch antenna with dielectric constant 4.4 and height of substrate 1.6 mm are used in design. The results obtain after the simulation of Patch Antenna are shown in Figure 2 to 5. Figure 2 represents the return loss response for the antenna with DGS.

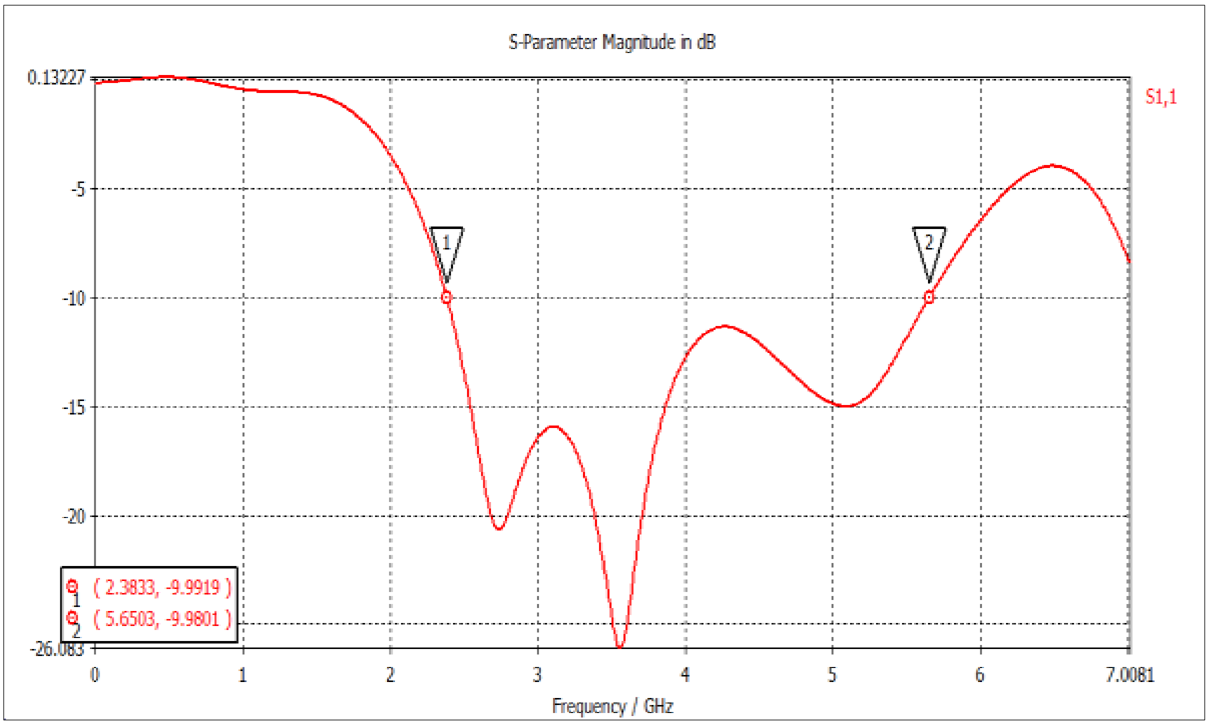

Fig. 2: *Reflection Coefficient of Proposed Antenna.*

Simulated reflection coefficient plot of proposed Micro-Strip antenna is shown in Figure 2.The maximum value of reflection coefficient is –26 db at center frequency 3.5 GHz. From Figure 2, it is clear that the band width of proposed antenna is from 2.38 to 5.65 GHz is achieved. Hence, proposed antenna is a wide band antenna.

Simulated VSWR of proposed Micro-Strip patch antenna are shown in Figure 3. VSWR of proposed antenna is less than 2 from 2.5 to 5.48 GHz. This is under the tolerable VSWR. At resonant frequency 3.45 GHz, VSWR is 1.1. Hence, antenna is perfectly matched. Figure 4 shows the gain plot of proposed antenna.

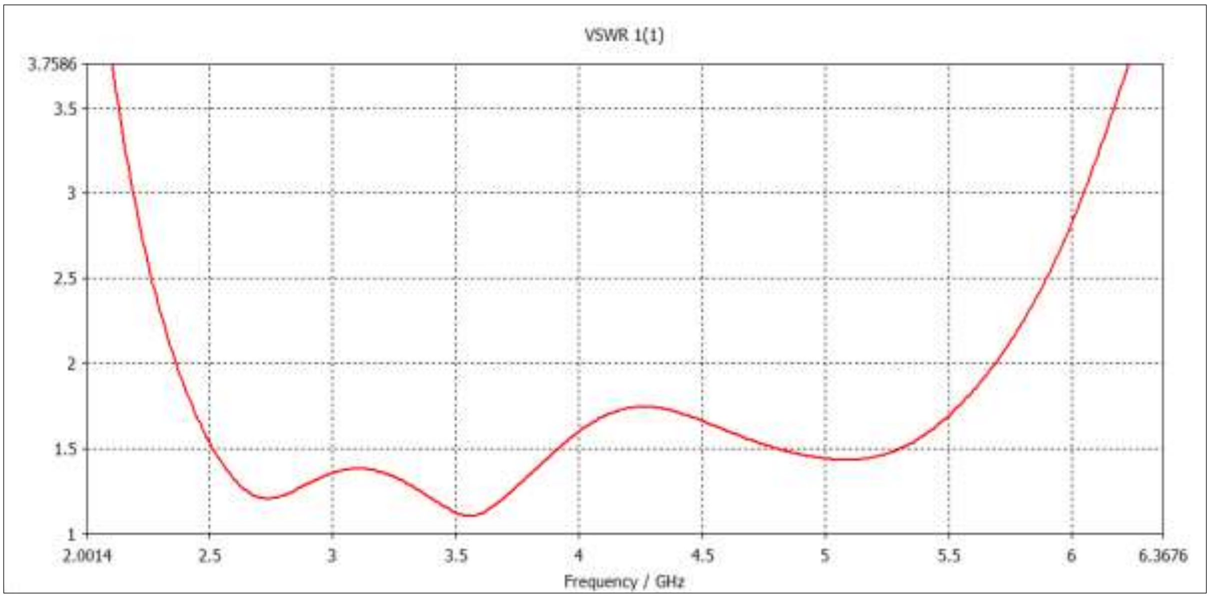

***Fig. 3**: VSWR of Proposed Antenna.*

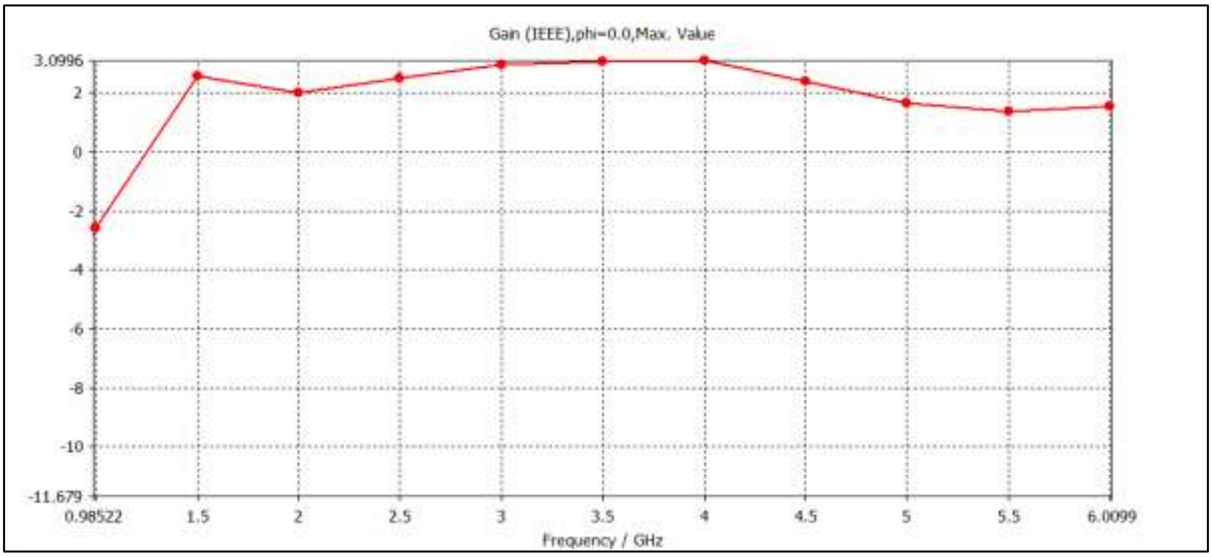

***Fig. 4**: Gain Plot of Proposed Antenna.*

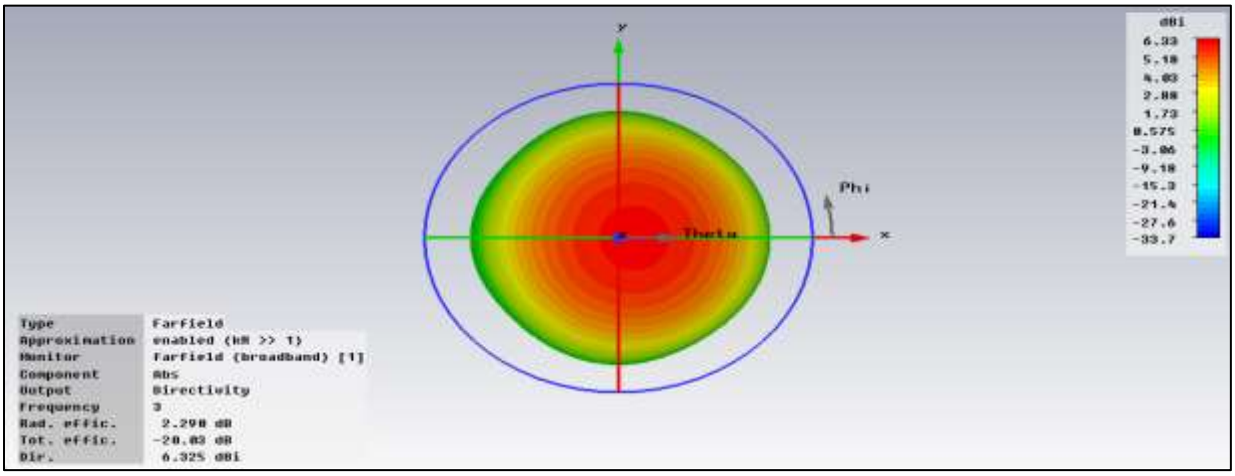

***Fig. 5:** Radiation Pattern of Proposed Antenna.*

CONCLUSION

There is every possibility that the overall performance of the proposed antenna can be utilize for microwave energy harvesting. The performance of antenna can be improved in terms of shape, size, type of substrate, thickness of substrate, bandwidth, power loss, etc. Some of the techniques have been proposed for further improvement in the antenna performance, stacked elements, like the use of parasitic elements, better impedance matching techniques, micro-machining technology, electromagnetic-coupling, photonic crystals, cavity-backed antennas etc.

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