DESIGN OF BROADBAND MICROSTRIP PATCH ANTENNA FOR PROXIMITY SENSOR OF ARTILLERY SHELLS

[1]JUHI H GODHWANI, [2]MANGALE S.A.

[1,2]Department of Electronics and Telecommunication, Cummins College Engineering for Women, Karvenagar, Pune-411052, M.S India
E-mail: Juhigodhwani01@gmail.com, Supriya.mangale@cumminscollege.in

Abstract- Artillery shells are used by the military to fire explosives, whose path is a projectile. In order to determine at what distance from the ground the shell has to explode, there is a proximity sensor inside the shell. This paper deals with the design of a broadband microstrip patch antenna, for the proximity sensor of artillery shells. Two different types of patch antenna designs are proposed, one having a spiral patch and another having a square patch. Both antennas are designed to meet the given specifications, and simulated using IE3D software. The performance of both these antennas is compared, based on the results which are obtained by using IE3D software simulation.

Keywords- Antenna Feed, Broadband Antennas, Circular Polarization, Dielectric constant, Microstrip Patch Antennas, Spiral Antennas.

I. INTRODUCTION

Microstrip patch antennas have become an attractive choice for antenna engineers due to their numerous advantages. They are light in weight, low in cost, and mechanically robust when mounted on rigid surfaces. [1] In its most fundamental form, a microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate, which has a ground on the other side as shown in figure below.

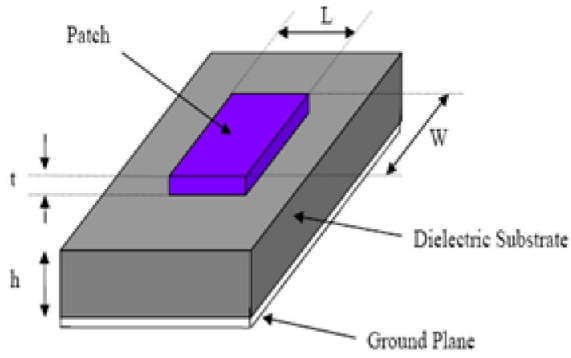


Fig .1: Structure of microstrip Patch Antenna.

Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. The patch is generally square, rectangular, circular, triangular or elliptical. Depending on the application the patch shape can be selected. [2] The spiral patch is selected in this design, as spiral antennas are inherently circularly polarized radiators with relatively constant input impedance, and radiation pattern over wide frequency ranges. [3] Also a microstrip patch antenna with a square patch is designed for the same specifications. Two slots crossing each other in shape of „X" are created at the center of the square patch, to obtain circular polarization. [4] Low dielectric constant substrates are generally preferred for maximum radiation. But this increases the size of the antenna. Therefore a tradeoff has to be realized between the antenna performance and the antenna dimensions. [5]

II. SPECIFICATIONS

The Microstrip patch antenna has to be designed for the following specifications which are given by the DRDO.

1. Operating Frequency Band: S Band (2-4 GHZ).
2. Bandwidth: 125+_ 25 MHZ@ VSWR 1.5
3. Input Impedance: 50+_2 OHMS.
4. Efficiency: > 60%
5. Polarization: Circular.
6. VSWR (within BW) <= 1.5:1.
7. Antenna Gain: > 5 DB
8. Antenna Shape With Radom: Aerodynamic shape
9. Space Available For Antenna: 3CM*3CM
10. Antenna Material: Low Dielectric Constant Material (<=5).
11. Antenna Feed: Coaxial/ Microstrip.
12. Radom Material: Nylon/Teflon.

III. SPIRAL MICROSTRIP PATCH ANTENNA.

For the substrate of the spiral patch, FR 4 Epoxy material having a dielectric constant 4.4, and loss tangent 0.002 is used. The height of the substrate is 1.6 mm and the width*length is 24.4*24.4 mm. Dielectric constant of substrates affects the antenna performance.

The substrate which has a low dielectric constant will give better performance than the substrate which has a high dielectric constant. Loss tangent or dissipation factor also plays a part in antenna performance. The high dielectric material allows for a reduction of space but at the cost of higher moisture absorption level. [5] Patch parameters.

The spiral patch is etched on top off the FR4 Epoxy substrate. The dimensions of this patch are as given below:
Diameter: 21.4 mm
Number of arms: 2
Number of turns: 2
Spiral arm width: 1.5 mm
Spiral arm separation: 3 mm
Start radius: 0.1 mm

Feeding technique.
Coaxial feeding technique is used. Two port feeding, with both ports at same magnitude, and 90 degrees out of phase are used to obtain Circular Polarization.

Feed locations:
- Port1: (x,y)=(3.6,-0.5)
- Port 2: (x,y)=(7.75,0.5)

The designed patch and its 3D geometry view are shown below.

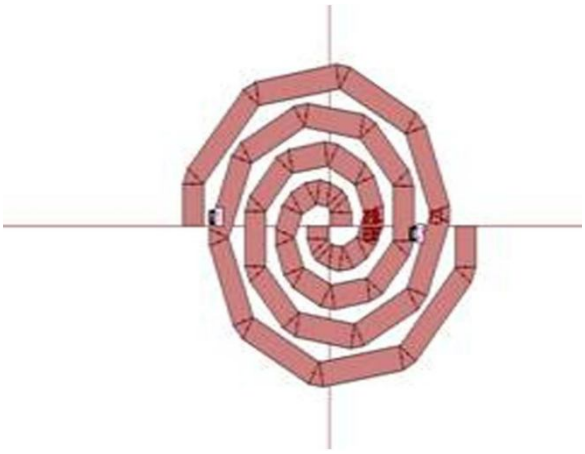


Fig .2: Designed Spiral microstrip Patch Antenna

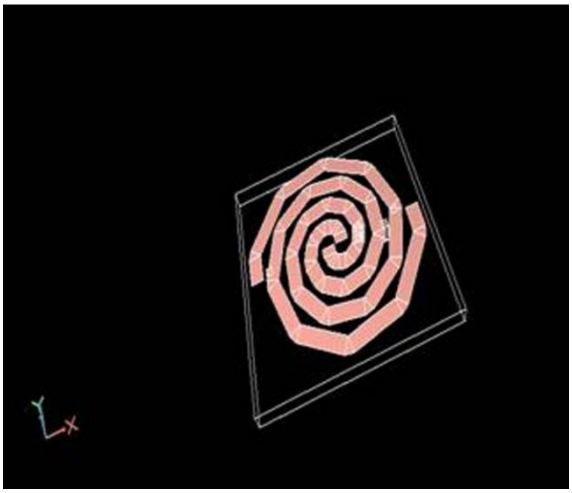


Fig. 3: 3D geometry view of the spiral microstrip patch antenna.

IV. SIMULATION RESULTS.

The designed spiral Microstrip patch antenna is simulated using IE3D software simulator, based on method of moments.

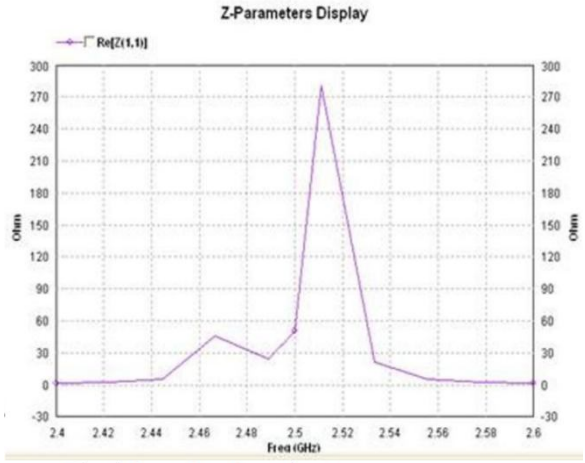


Fig .4: Input Port Impedance.

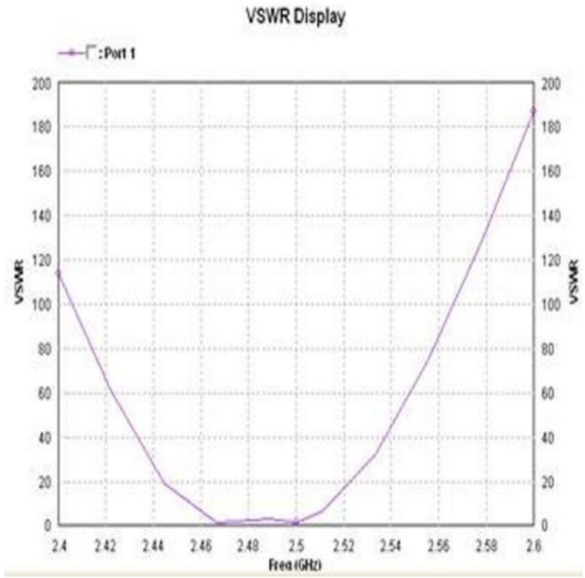


Fig .5: Voltage Standing Wave Ratio

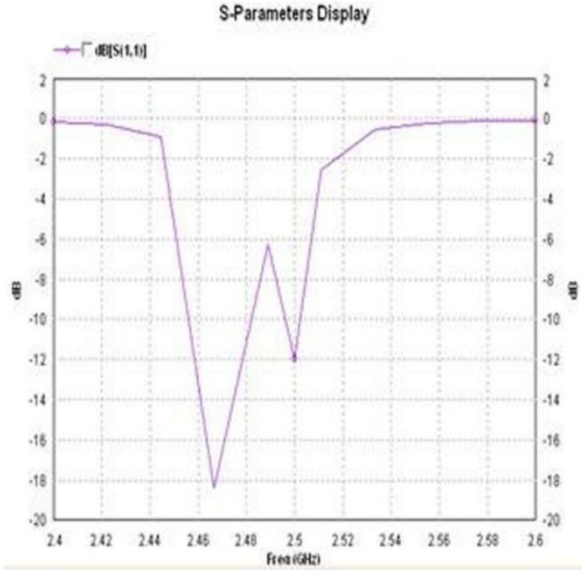


Fig .6: Reflection Coefficient.

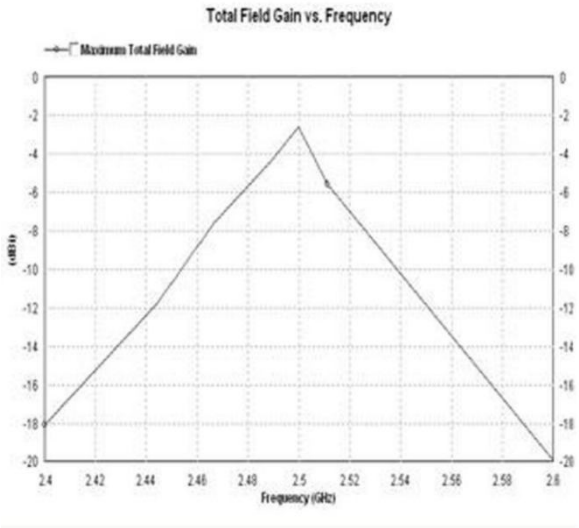


Fig.7: Antenna Gain

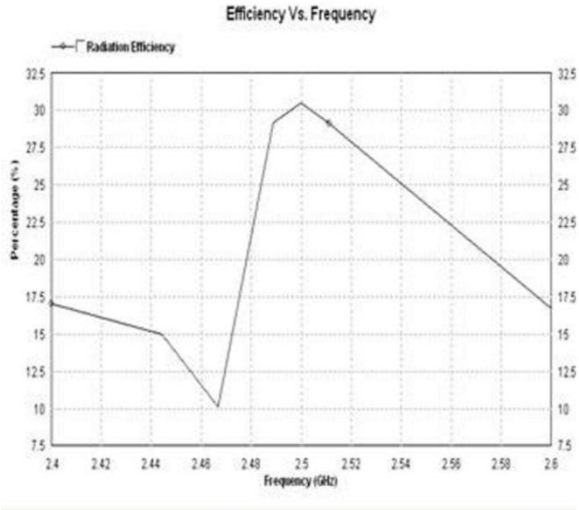


Fig. 8: Antenna Efficiency.

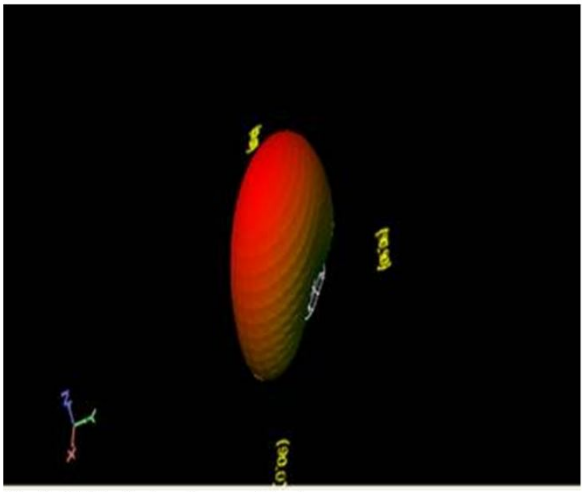


Fig.9:3D Radiation Pattern Display

IV. SQUARE MICROSTRIP PATCH ANTENNA

For the substrate of the Square Microstrip Patch Antenna, RT Duroid material has been used. It has a dielectric constant of 2.2 and loss tangent of 0.004. The height of the substrate is 1.59 mm and width*length is 30*30 mm. The different substrates used in both the designs were selected by trial and error method. Many different substrates were tried for both the designs and the ones giving the best results were selected.

A. Patch Parameters

The square patch is etched on top off the RT Duroid substrate. Two slots crossing each other in shape of „X" are created at centre of the patch antenna, to obtain circular polarization. The dimensions of this patch are as given below:

Length*width: 10*10 mm
X slot length: 4.6 mm
X slot width: 0.46 mm

B. Feeding technique

Microstrip line feed, with both feeds 90 degrees out of phase is used. The designed patch and its 3D geometry view are shown below.

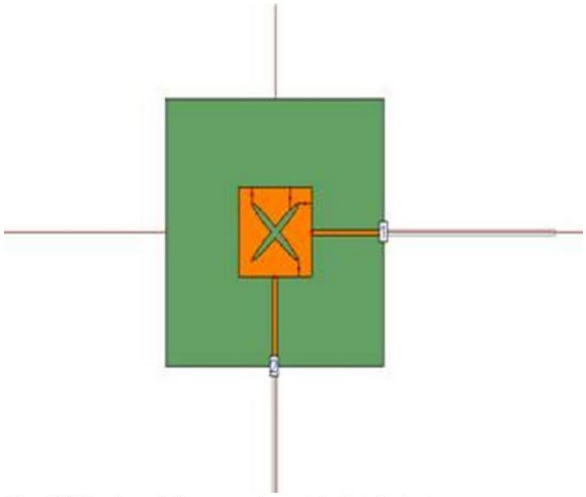


Fig. 10 Designed Square microstrip Patch Antenna

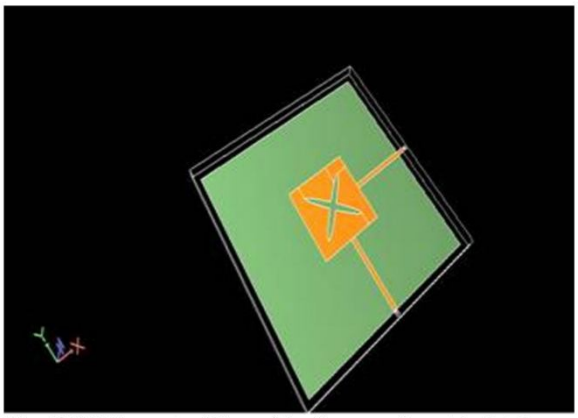


Fig. 11 3D Geometry View of the Square microstrip Patch Antenna

C. Simulation results.

The designed square microstrip patch antenna, with an „X" slot in the center of the patch, is simulated using IE3D software simulator.

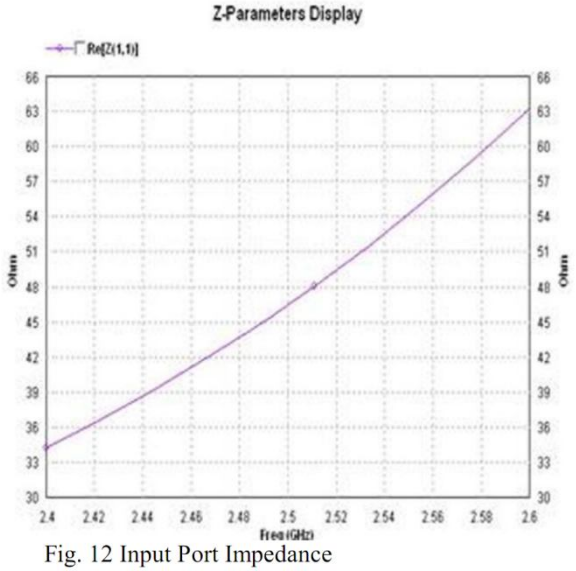


Fig. 12 Input Port Impedance

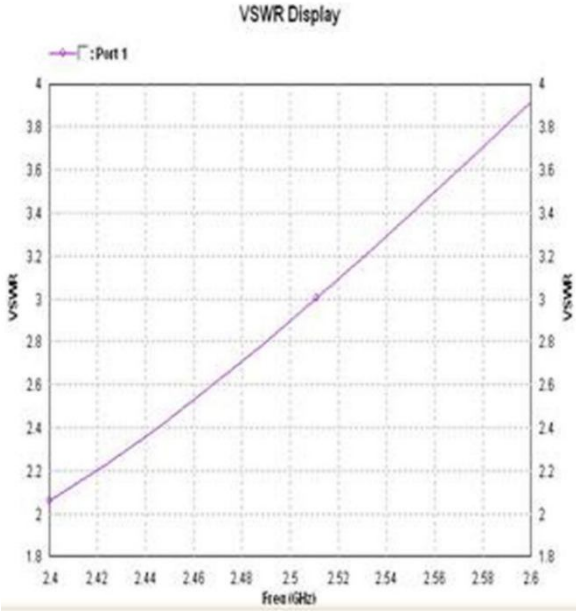


Fig. 13 Voltage Standing Wave Ratio

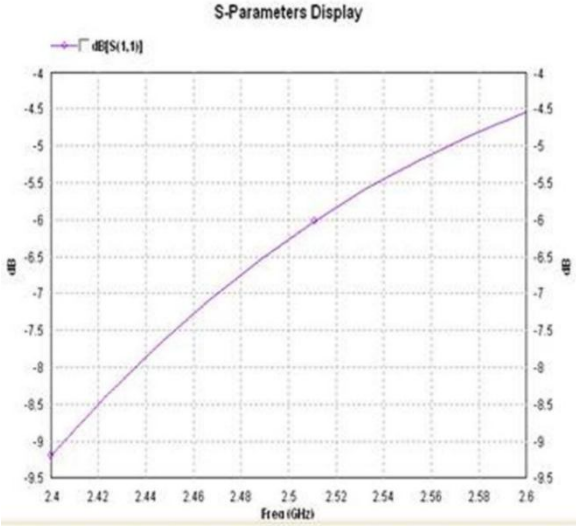


Fig.14 Reflection Coefficient

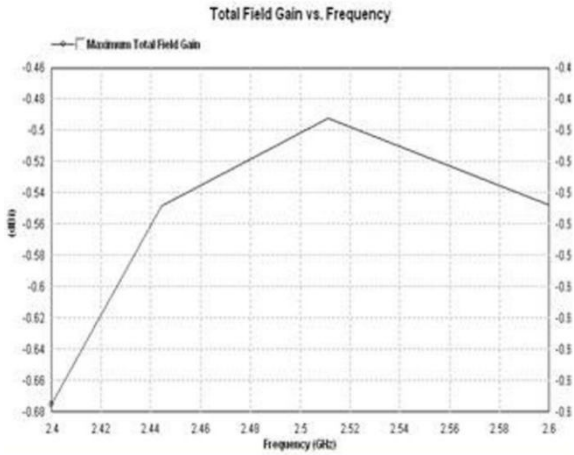


FIG. 15 ANTENNA GAIN

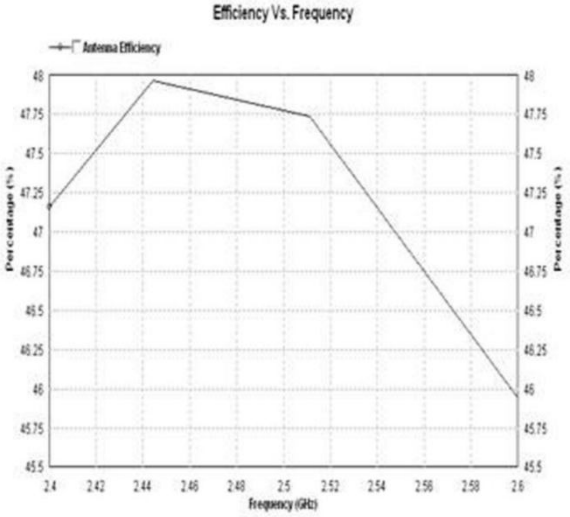


Fig. 16 Antenna Efficiency

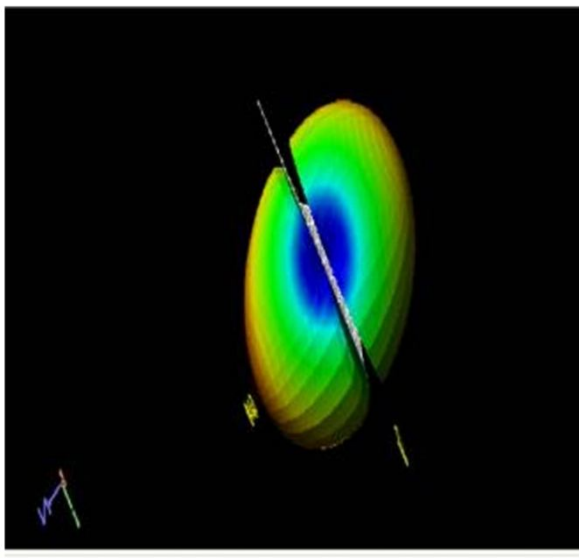


Fig.17:3D Radiation Pattern Display.

As observed, the 3D radiation pattern of the Square Microstrip Patch Antenna is two sided as compared to that of the Spiral Patch. Hence an absorber can be

used on one side of the patch to make this pattern one sided.

V. PERFORMANCE COMPARISON

The table below shows the comparison between the two performances of both patch antennas.

PARAMETER	DESIRED	SPIRAL PATCH	SQUARE PATCH
BANDWIDTH	125+-25 MHZ	40 MHZ	120 MHZ
BEAMWIDTH	110+-10 DEGREES	140 DEGREES	90 DEGREES
INPUT IMPEDANCE	50+- 2 OHMS	50 OHMS	47 OHMS
EFFICIENCY	>=60%	30 %	48 %
POLARIZATION	CIRCULAR	CIRCULAR	CIRCULAR
VSWR	1.5	1.5	2.9
REFLECTION COEFFICIENT	<-10 DB	<-10 DB	<-6 DB
ANTENNA GAIN	>5 DB	1 DB	2.7 DB

Table 1: Performance Comparison

The performances of both antennas are summarized in the table given above. The VSWR of the spiral patch antenna is less (i.e. close to desired) as compared to the VSWR of square patch antenna. But again the bandwidth of Spiral Patch is also less when compared to the Square Patch Antenna .Hence a tradeoff has to be realized between the VSWR and the bandwidth of the antenna. For this application a broadband antenna is required. Hence the square patch antenna would be more suitable as it has a greater bandwidth. This spiral patch antenna can be used in applications where less VSWR is a critical parameter.

CONCLUSION

Two different kinds of microstrip patch antennas, one having a spiral patch and another having square patch were designed and simulated using IE3D software. Their simulation results were compared. The antenna with the square patch was found to be suitable for application in proximity sensor of artillery shells, as it has a greater bandwidth. The spiral microstrip patch antenna can be used in applications were bandwidth is a less critical parameter.

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