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U-shaped Monopole Antenna design with Defected Ground Structures for UWB Applications

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Abstract

Here, a plain fork shaped monopole antenna with compact printed dual-band fork – shaped antenna designed with low cost for ultra wideband (UWB) applications is proposed. It uses a fork-shaped patch and also a rectangular ground patch having a defected structure to work in the 3.1–10.6 GHz (UWB) frequency band. A 50-microstrip line feeds this antenna, which is fabricated on a low-cost FR4 substrate with dimensions of 42 x 24 x 1.6mm. Fabrication and testing of the antenna structure has been completed. Over 3.2–11.8 GHz, S11 is estimated to be 10 dB. Over the UWB band, the antenna exhibits suitable flatness in gain and has an omnidirectional radiations.

Index Terms **─** Omni directional antenna, Defected ground plane, Ultra-Wide Band (UWB) antenna.

I .INTRODUCTION

After the FCC has published a 10-dB bandwidth of the range of 7.5 GHz (3.1 to 10.6 GHz) that produces an effective isotropic radiated power (EIRP) spectral density of 41.3 dBm / MHz used for communication applications, this ultra wideband (UWB) technology has gained importance and attracted the academicians and industrialist in the wireless world. A quite lot of research and developments started emerging in short-range wireless communications, imaging radar, remote sensing and various other fields. The impedance bandwidth of monopole antennas that are fabricated on a substrate is sufficient to cover UWB. UWB monopole antennas with various other shapes as circular disk, rectangular, elliptical and binomial curved shapes have been introduced. Here, printed fork-shaped monopole antenna is designed concentrating in the UWB applications.

II. DESIGN AND FABRICATION

Fabrication is done for the design on a 1.6-mm thick FR4 substrate with a 42 x 24 mm surface area and is fed by a 50-microstrip line. The substrate's relative permittivity and loss tangent are 4.4 and 0.02, respectively. A circular monopole antenna is used as the antenna structure. The circular monopole's radius R is calculated using the following equation:

$$f_{\mathrm{L}} = \frac{7.2}{2.25R + g}\,\mathrm{GHz}$$

Over the frequency range of 2.44 to 10.3 GHz, measured S11 is less than or equal to -10 dB. Over the UWB band, the antenna exhibits acceptable gain flatness and nearly Omni-directional radiation patterns. Mobile applications, imaging radar, remote sensing, and a variety of other applications benefit from the circular structure. As a consequence, the semicircle is useful in a number of sensing applications. The Ultra large bandwidth from 3.1 to 10.6 GHz is the focus of the U-shaped monopole. Additionally, optimizations may be made by changing the ground structures for a better return loss

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level. The use of defected ground structures aids in the reduction of S11 return loss as well as the development of an Omni-directional radiation pattern with good gain characteristics.

There are various factors affecting the performance of the design. They are:

i) the width (w) and length (l) of the symmetrical phase slot in the ground plane
ii) The distance (g) of the radiating patch from the ground plane,
iii) the dimension of the symmetrical phase slot in the ground plane,
iv) the dimension of the central rectangular monopole,
v) the dimension of the rectangular strip over the semicircular annular ring, and
vi) the inner (r) and outer radius (R) of the semicircular annular ring.
vii) defected ground plane size and shape variation.

MATERIAL USED:

FR4 substrate, 1.6mm thickness, 4.4 permittivity, 0.02 loss tangent Because of its flammability and use as a mobile device antenna, the FR4 substrate is used as a substrate. Since FR4 is used as the PCB board substrate in mobile devices. Copper plate is used as a ground plane radiating element because of its high conductivity. Copper plate is often used as a radiating and conducting arm for grounding purposes.

III. SIMULATION AND RESULTS

Simulation is done in CST. This software helps in reading the S parameters, E-H fields and resonant frequency. CST is a full-wave electromagnetic simulator that uses the moments Process.

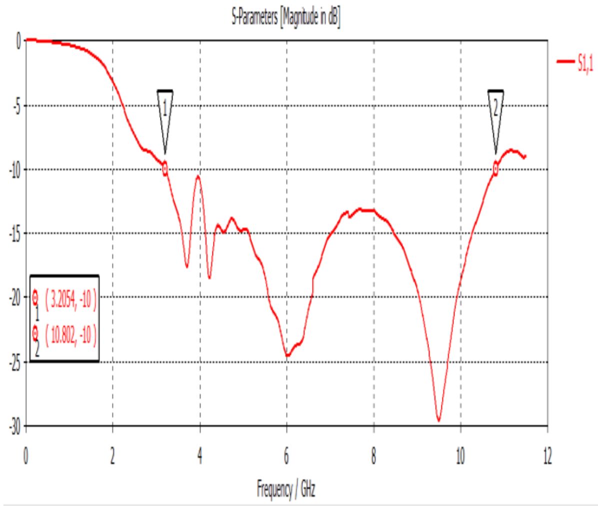

Fig 1: |S11| parameter

DESIGN EQUATION:

$$h + r = 0.24(c/f)$$

where h and r are length and width of patch,

c = speed of light,

f = frequency of operation.

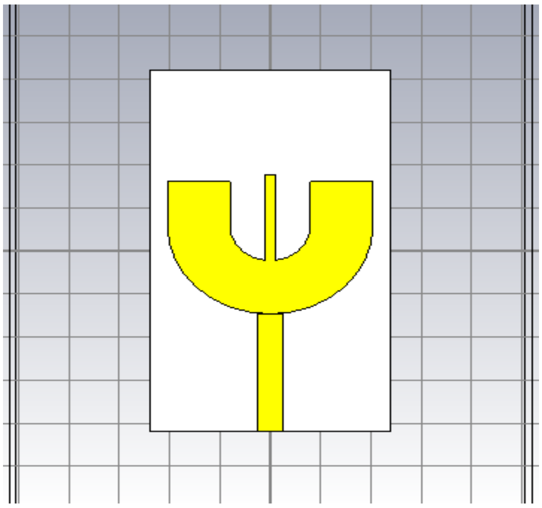

Fig 2: Design layout in CST software (Front view)

The resonant frequency gets affected by the length parameter of the rectangular strip on either sides of this structure. rectangular monopole antenna –RMA resonates at 2.5GHz over the lower cut-off frequency level because of the defected ground patch at the center of the U-shaped radiation. The central resonating frequency is defined by the length (LB) of the RMA, the width (WB) of the RMA affects the impedance bandwidth. With a decrease in LB, the central resonating frequency rises. With an increase in WB, the impedance bandwidth expands. The RMA is found to be shorter than the measured because of the coupling between two radiation elements that resonates in the UWB bands. Over the UWB range, the return loss in simulation for various strip width and length indicates various variations in the return loss. There is a discussion of the parameters that have a major impact on UWB band efficiency. The impedance bandwidth is influenced by the distance between the patch and the ground plane, which functions as a matching network. With g = 0.5 mm, the best impedance bandwidth is obtained. A capacitance is formed by the spacing between the ground plane and the radiating patch. This balances its inductance at g = 0.5 mm. The radius determines the first resonant frequency. Impedance bandwidth is also affected by r. (inner radius). When the inner radius r = 4 mm, impedance bandwidth is obtained. Only when the value of r exceeds 4 mm does the S11 degrade.

$$L_{\mathrm{B}} = \frac{c}{4f_{\mathrm{B}}}.$$

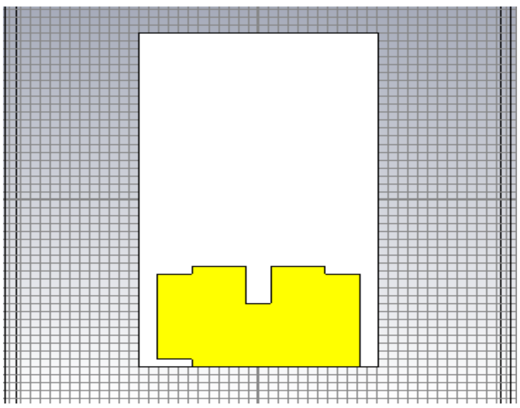

Fig 3: Defected ground structures.

The U-shaped monopole is found to be resonating over UWB, the rectangular defected ground structure monopole aids in obtaining the ultra wideband standard. In comparison to other UWB antennas, the proposed design is compact. Over the frequency range of 2.44 to 10.3 GHz, measured S11 is less than or equal to -10 dB. Over the UWB band, it exhibits normal gain flatness and nearly Omni-directional radiations.

RADIATION PATTERNS:

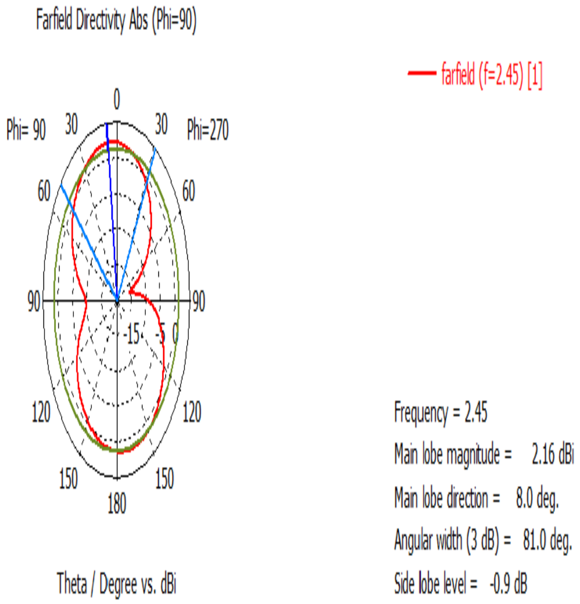

Fig 4(a): Far field plot at 2.45 GHz

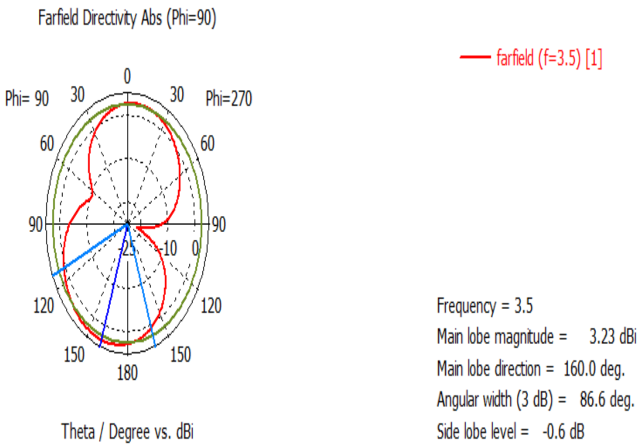

Fig 4(b): Far field plot at 3.5 GHz

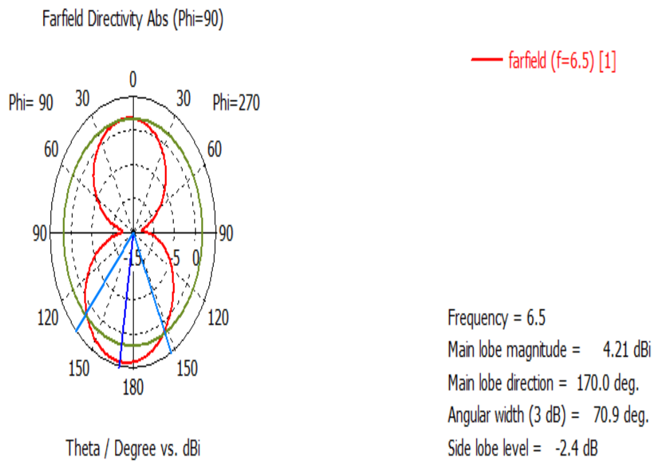

Fig 4(c): Far field plot at 6.5 GHz

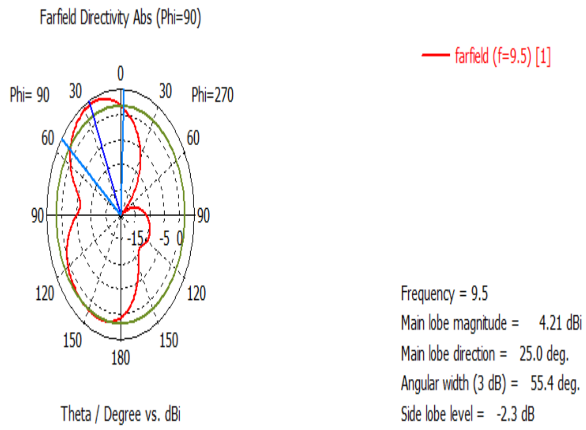

Fig 4(d): Far field plot at 9.5 GHz

EFFICIENCY:

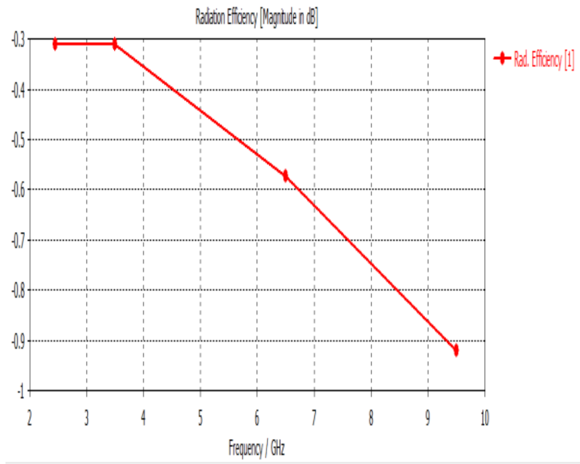

Fig 5: Radiation efficiency

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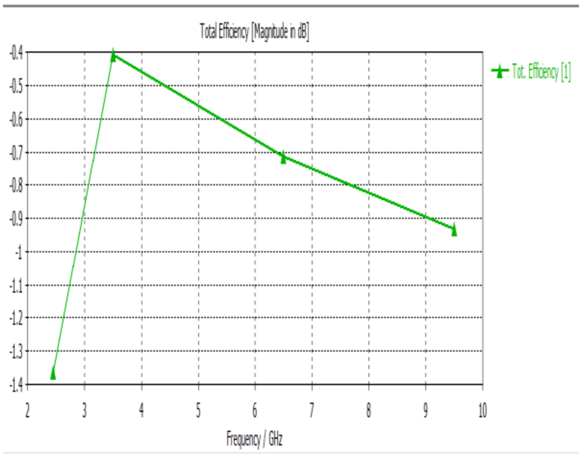

Fig 6: Total efficiency

IV. CONCLUSION

A printed fork-shaped antenna that is simple, low-cost, and compact is declared. Also a micro strip-line-feed can also be easily inserted into various systems' printed circuit boards (PCBs). Lower frequency levels are governed by the central arm's dimensions, while the U-shaped dimensions rule the UWB band at 3.1 to 10.6 GHz. As a result, the proposed antenna will effectively control two operating bands. The antenna has an antenna efficiency of more than 80% and a gain range is found to be 2–5 dB over these two bands. The proposed antenna has a omnidirectional radiations, suggesting that it is acceptable for UWB applications.

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