ISSN: 0971-1260
Vol-22-Issue-16-August-2019

Annular-Shaped Compact Monopole Antenna For UWB Applications

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Abstract

This article witness a UWB monopole antenna with a compact annular-shape desired to be useful for oil pipeline imagingsystem. This antenna composed of a circular based monopole radiator where the ground plane is modified to meet the requirement. Here we simply etched a square shaped from the ground plane with a semicircle embedded on the top whose radius is half of the size of the square. Two circular studs are used to enhance the bandwidth at lower frequency band. The antenna is developed on a FR4 substrate whose thickness is assumed to be 1.6 mm with a lateral and longitudinal dimension of 15 mm×15 mm. The proposed design is simulated and the result obtained ensures an UWB band from 3.1 GHz-17 GHz. Thus, designed antenna can be easily integrated within the portable devices.

I. INTRODUCTION

Recent communication systems are in need of antenna and filter design of compact structure with versatile performancesuch as stable radiation patterns, constant gain and high efficiency. Though all these parameters are quite essential forwireless application but it is important to cover the band allocated by FCC [1] to have more practical applicability. Thoughmany designs are available but microstrip design is preferred due to its attractive features like low spectral power density, low cost, high data resolution and high data rates this is the reason why researcher are more attracted towards it. At the same time, this design sometime fail to produce ultra-wide band but this problem can be eliminated with inculcation suitable designs. In the literature, numerous geometries for UWB Microstrip antenna for UWB applications have been proposed some of them are listed as M-shaped [2],octagonal-shaped and U-shaped [3]. C-shaped radiators [4] have been proposed for bandwidth enhancement and the effect of coupling is generally used for impedance matching. In [5] feeding techniques was implemented just to improve bandwidth. Two L-shaped slot with narrow width is added in the design on the ground plane to meet UWB requirements [6], In [7], two long ground stubs and a short ground strip to form a common ground are used to enhance isolation and bandwidth of MIMO antenna. In [8] [9 a planar monopole antenna and rectangular patch with slotted structure for Ultra-wide band application is used. In [10], a hexagonal shaped radiator is used to enhance bandwidth and the ground plane is extended symmetrically on either sides of the radiator in order to utilize the area efficiently. In [11] M-shaped and T-shape ground are etched in the bottom for improvement. This design includes an annular radiating patch along with a modified ground plane, successfully implemented through simulation for its practicable usability.

II. DESIGN ANALYSIS OF THE PROPOSED STRUCTURE

Generally, conventional microstrip antenna is a narrowband antenna. But with proper implementation of new techniques in the design process we are capable of generating multiple bands and this overlapping of multiple bands leads to UWB. Though many methods do exist to

ISSN: 0971-1260
Vol-22-Issue-16-August-2019

generate multiple resonance but we in this design included annular pattern monopole radiator with a modified ground plane to obtain an ultra-wide bandwidth.

TABLE I
DIMENSIONS SHOWN IN FIG. 1

Parameters	L	W	L_{g1}	W_{g1}	W_{g3}	W_{g4}
Unit(mm)	15	15	9	14	10.4	2
Parameters	W_f	L_f	W_{g5}	W_{g6}	W_{g7}	r_1
Unit (mm)	1.8	4.5	1.9	0.5	1.9	1.25
Parameters	r_2	r_3				
Unit (mm)	2.75	1.5				

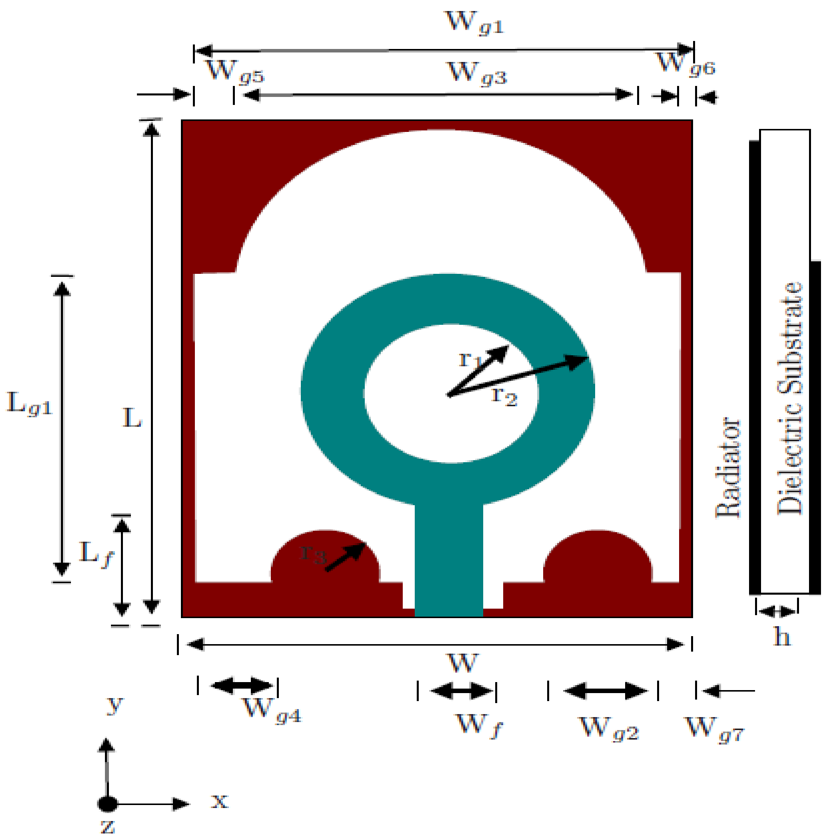


Fig. 1.Schematic of the proposed antenna.

Fig.1 shows the structure of the designed antenna. This annular-pattern is attached to the microstrip line of length L_f and width W_f. Ground plane initially has a square which is further modified by etching a semicircle on its top. Two circular stubs are attached at the lower portion of the ground plane that shifts the bandwidth in lower bands. The monopole radiator consists of an annular ring of radius r_1, r_2 fed with a microstrip line of length and width L_f and W_f. The modified ground plane consist of two semi-circular stub at the bottom of radius r_3, the rectangular slot is etched in theground plane of length L_{g1} and width W_g with a semi-circular stub on top of width Wg_2. Further to enhance the bandwidth arectangular slot at the bottom of ground plane is etched (see Fig. 1).

The whole design process and its optimizations are donethrough Ansoft HFSS [12] and all the parameters related to the design are listed in TableI. The simulation output confirms anultra-wide band from 3.0-18 GHz (15 GHz) which is quite suitable for oil pipeline imaging system, to have a better understanding and analysis we investigated few more parameter like current distribution,

ISSN: 0971-1260
Vol-22-Issue-16-August-2019

radiation patternand Return Loss. The results related to simulated current distribution is shown in Fig. 2 which is clear indication of UWBnature.

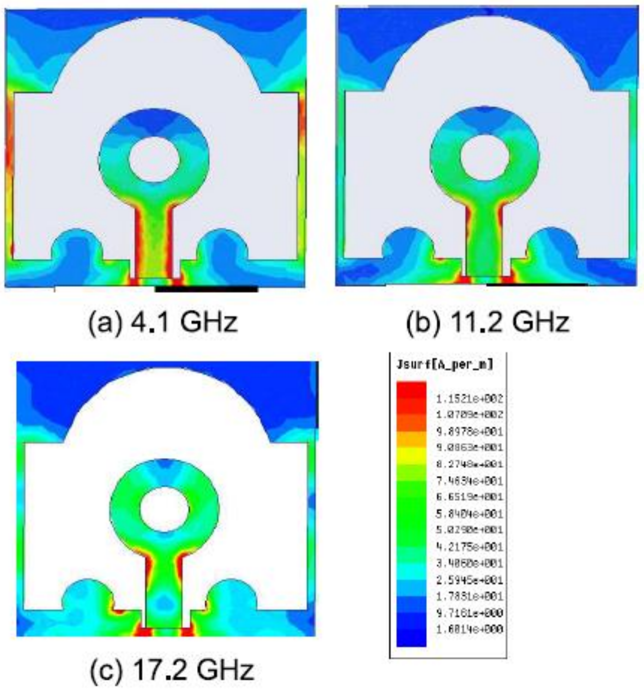
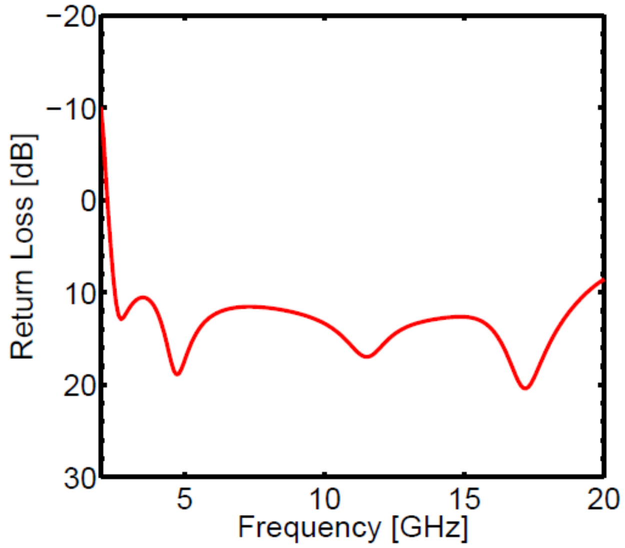


Fig. 2.Current distribution of the proposed UWB antenna.

Fig.2 (a) which is all about surface current information mainly concentrated around feed-line along with the rectangular slotin the ground plane. The purpose of this rectangular slot and the strips on the ground plane excites the lower frequency band.At middle frequency, surface currents mainly focussed on central parts of patch and ground [see Fig. 2(b)]. Finally, in Fig.2(c),the current concentration is around the feed-line and over the entire radiator for 17.2 GHz.

III. RESULT AND DISCUSSION

Fig. 3 talks about frequency response of the proposed UWB antenna where x-axis represents frequency in GHz and Y-axisrepresents the return loss in dB. This result clearly indicating UWB response from 3-18 GHz where the value is seems to be less than 10 dB as it satisfies the band given by FCC [1].



ISSN: 0971-1260
Vol-22-Issue-16-August-2019

Fig.3Frequency response plot (S_{11})

Fig.4 reflects about the 2-D radiation patterns at (a) 4.1 GHz (b) 11.5 GHz, (c) 17.1 GHz frequencies for yz-, xz- and xyplanesrespectively. It is observed that the radiation pattern shows monopole like antenna patterns at lower frequency. At higherorder mode with high frequency normally the radiation lobe splits.

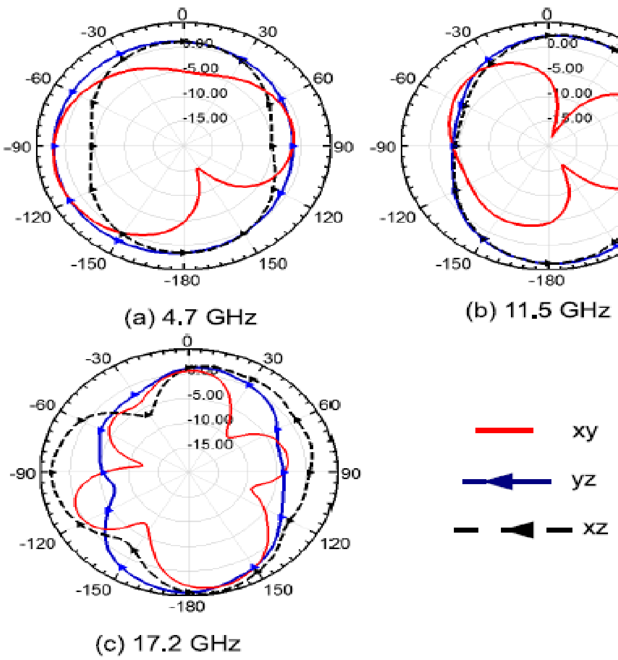


Fig. 42-D radiation pattern obtained from simulation

IV. CONCLUSION

This article mostly deals with oil pipeline imaging system where it can identify problems associated such as blockage system, flow rate. This design is suitable for ultra-wide band applications which are explicitly applicable to the above said environment. To justify the desired application various parameters are investigated in terms of return loss (less than 10 dB for the frequency range of 3.0-18 GHz), current distribution and radiation patterns at certain frequencies. In future this idea can be extended forindustrial applications.

ISSN: 0971-1260
Vol-22-Issue-16-August-2019

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