Wide Band Printed Ring Circular Slot Radiator

K. Sneha and N. N. Sastry

***Abstract*—For wideband phased arrays, ridged waveguides, spirals, log periodics, tapered slot antennas and ridged gap waveguides have been used. In the printed circuit antenna category, tapered slot antenna has become a natural choice for wideband operation. However, this antenna is a 3D antenna and not a planar one. The antenna which is reported here is a planar antenna and is eminently suited to phased array applications. A printed ring radiator is simulated and implemented which operates over 6-18GHz with a VSWR of less than 2.5. Two cases have been dealt with, namely, bi-directional and unidirectional antennas. Typical radiation patterns are given.**

***Index Terms*—Broadband antenna, EW antennas, Printed antenna**

I. Introduction

THERE has been a need for planar wide band antennas covering 6-18GHz. The Vivaldi radiator has been extensively used for wideband applications [1]. Similarly, spiral antennas covering 1-40GHz have been developed and are being marketed. Log Periodic antennas easily cover 6-18GHz but with fabrication complexity. The ridged tapered slot antennas have been reported for use over 6-18GHz [2]. All the above antennas are prominently 3D antennas. For phased array applications there is a crying need to develop truly planar antennas which lend themselves to easy integration with array power distribution and phasing network. Further, the planar antennas are eminently suited to conformal phased array airborne and ship board applications. In this class of truly planar antennas is the class of wideband planar antennas which are the printed UWB antennas. These antennas have been extensively used over the communication band of 3.1-10GHz. Since 2001, the ITU has relaxed its rules so that this band could be utilized for commercial communications. Since then there has been an explosion of activity in UWB antennas covering 3.1-10GHz [3-9]. However, for EW applications, 6-18GHz is a tactical band of frequencies and there is a need to develop a planar antenna to cover the tactical band. In this paper, efforts have been made to realize an antenna covering 6-18GHz. The UWB design methodology has been extended to realize the above antenna. However, the UWB antennas are bi-directional in nature with regard to radiation patterns and are therefore not suitable for phased array applications. Wide slot loading to enhance bandwidth has been reported earlier and several slot shapes have been tried such as circular, elliptical, rectangular, rotated square, arc shape etc. [10-13]. Of these, the wide slot antenna (WSA) approach has yielded bandwidths of more than 172% [14].

Specifically, mention should be made of the circular patch UWB printed antenna which has been taken as reference and loaded with an annular slot and an electromagnetically coupled rectangular strip with an extended and shaped ground plane to achieve the frequency coverage of 6-18GHz.

The UWB antenna reported earlier [15] has a frequency coverage of 3.1-10.6GHz. The reported antenna is a bidirectional antenna. An attempt has been made in this paper to obtain the frequency coverage of 6-18GHz. Extensive simulations have been made. Two versions of this antenna have been designed and results reported namely, the bidirectional and the unidirectional ones.

II. The Bidirectional Antenna

A circular patch (inner radius r_1 = 4.5mm and outer radius r_2 = 9mm') with a microstrip feed is designed and analyzed. The substrate dimensions are of length L=42mm and width W=50mm and ground plane height H=9mm as shown in Fig.1. What is described in this paper is the circular patch loaded with a circular slot.

To obtain a VSWR of less than 2.5 over the band, the annular patch is loaded with an electromagnetically coupled strip 'S' printed on the backside of the substrate. Nulls in radiation patterns at higher frequencies posed a serious problem and they have been substantially reduced with a shaped ground plane which has been optimized. Specifically, the angle 'α' has been varied and the behavior of nulls has been studied.

A. Parametric Studies

There are a number of dimensional parameters that affect the bandwidth. Parametric studies have been conducted by varying the following parameters.

i. Annular patch - radii r_1 and r_2
ii. Strip 'S' - L_1 and W_1
iii. Ground plane - α

The variation of r_1 and r_2 affects the bandwidth and the low frequency limit. Variation of L_1 and W_1 (Optimized L_1 =10mm and W_1 =2mm) of the strip has got effect on the VSWR bandwidth. Then variation of 'α' has significant effect on appearance of nulls in the radiation patterns. α=45° is optimum for good patterns. The dimension of AB=20mm.

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III. Unidirectional Antenna

In the case of unidirectional antenna, a ground plane (gp) with an absorber(abs) is incorporated as shown in Fig.1. A VSWR of less than 2.5 has been obtained over 6-18GHz. The unidirectional planar printed ring radiator is shown in Fig.2. .

IV. Results

Based on HFSS simulations, optimum dimensions of the antenna have been arrived at, as given above.

Both bidirectional and unidirectional antennas have been fabricated with a substrate having ε_r = 2.2 and thickness = 1.6mm. For the unidirectional antenna an absorber backed by a ground plane is added as shown in Fig.2. The thickness of the absorber is 20mm. Various dimensions are optimized through simulations. The input is given through an SMA connector and is matched to 50Ω. The measured VSWR of bidirectional and unidirectional antennas are shown in Fig.3. The measured radiation patterns of bidirectional and unidirectional antennas are shown in Figs. 4 and 5. It can be Seen that the VSWR is less than 2.5 over a frequency range of 6-18GHz for both the bidirectional and unidirectional cases. For the bidirectional antenna, gain varies from 1.3 to 3.6 and for the unidirectional antenna gain varies from -2.5 to 1.5 over 6-18GHz. In both the cases, H-plane (omnidirectional) pattern is represented by chain line and E-plane pattern is represented by solid line.

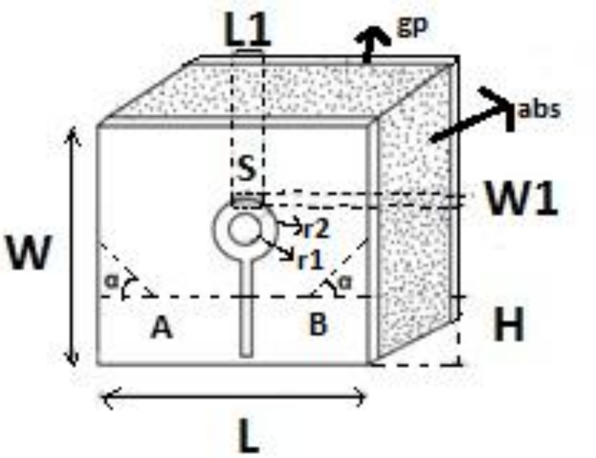


Fig. 1. Sketch of unidirectional antenna

Fig. 2. Fabricated Unidirectional Planar Printed Ring Radiator

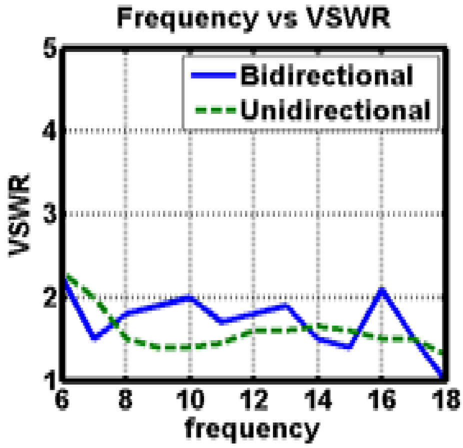
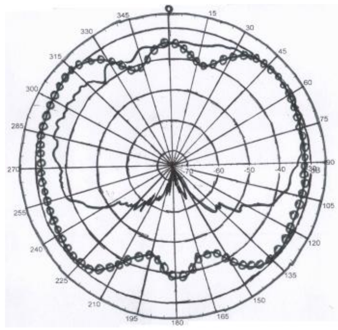


Fig. 3. VSWR of fabricated Bidirectional and Unidirectional antenna



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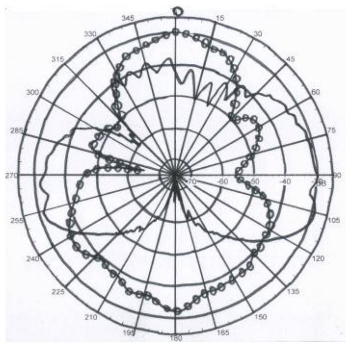

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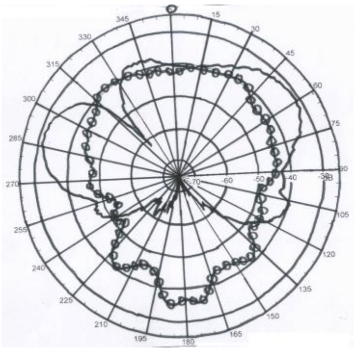

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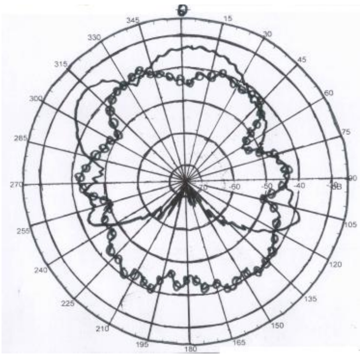

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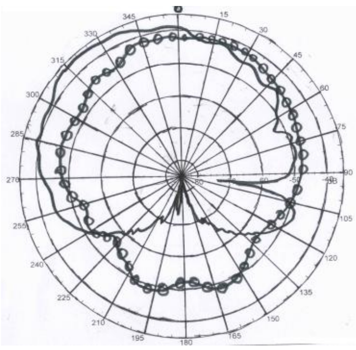
Fig. 4. Radiation Patterns (Bidirectional)
(a) 6GHz (b) 10GHz (c) 14GHz (d) 18GHz



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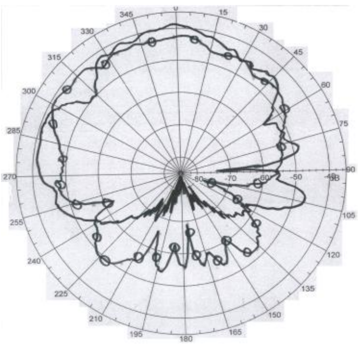

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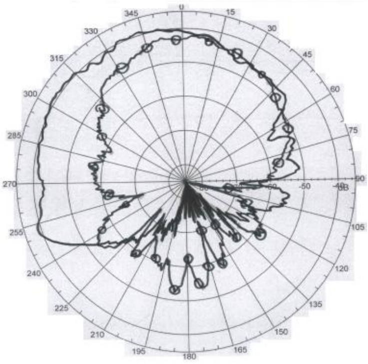

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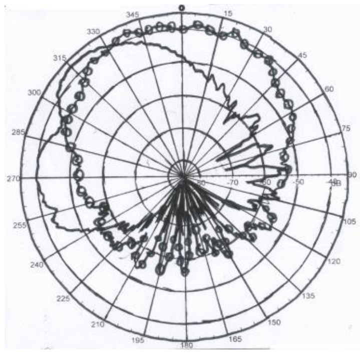

(d)

Fig. 5. Radiation Patterns (Unidirectional)
(a) 6GHz (b) 10GHz (c) 14GHz (d) 18GHz

V. Conclusion

There has been a need for a truly planar antenna for phased array applications. The UWB technology is quite mature and this has been adopted to some extent to design an antenna operating over 6-18GHz using HFSS software. The novelty in this design is the shaped ground plane and the parasitic strip at the back of the substrate as shown. The same has been fabricated with a substrate of ε_r = 2.2 and thickness of 1.6mm. Two cases have been studied namely the bidirectional and the unidirectional antennas. Both the antennas have yielded a VSWR of less than 2.5 over 6-18GHz. Satisfactory radiation patterns have been obtained over the band. The unidirectional antenna has a VSWR of less than 2.5 over 6-18GHz. This antenna finds applications in Communications and EW antenna arrays.

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