Bandwidth Enhancement Using Figure Eight Shaped Slot Antenna

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Abstract
An eight shaped annular ring slot antenna is presented. A simple 50 ohms microstrip line is used to excite the slot. Two annular slots are linked to achieve wide band width. Parametric Design and Analysis is carried out with permutations of the angle between the line joining the centers of the two rings of eight shaped slot and a vertical reference line and with permutations of the distance between the centers of the two rings of eight shaped slot. Its optimal impedance band width(S_{11}<-10dB) is 2. to 3.5 GHz, more than 1GHz , 55% centered at 2.7GHz.

Keywords Microstrip Antenna, Wideband, Annular Ring Slot

INTRODUCTION

It is well known that annular ring patch antennas [1-5] and annular slot antennas[6-9] have bring interest because of their significant characteristics such as wide bandwidth, small size, light weight and ease of fabrication. Normally the bandwidth for single frequency annular slot is about 10%[6,9]. Several techniques have been reported to achieve broad band for annular slot antennas[9,10]. It has been reported in the subsequent work [11-14], annular slot antenna have 10-20% impedance bandwidth, which is wider than conventional microstrip patch antenna.

However the development of wireless communications experiencing an exponential growth hence increase the need for wideband microstrip antennas. As a result, new antennas have to developed to provide larger bandwidth and this, within small dimensions. challenge which arises is that the gain and bandwidth performances of an antenna are directly related to its dimensions. These applications include WWANs, WLANs and WPANs. Usually, broad band characteristics are tough to achieve, because good impedance matching is difficult.

In this paper an 8- shaped slot antenna is proposed, there by increasing the surface current path and enabling wide bandwidth of the slot antenna. By adjusting the parameters of the antenna parametric analysis is carried out using HFSS software by changing the inclination angle that is angle between the line joining centers of two circles of figure eight and a vertical reference line. The optimized results are found to be impedance bandwidth more than 1GHz. A simple 50 ohms microstrip line is used to excite the slot.

Parametric Analysis is carried out with combinations of the angle between the line joining the centers of the two rings of eight shaped slot and a vertical reference line from 15 to 90 degrees in steps of 15 degrees and with permutations of the distance between the centers of the two rings of eight shaped slot from 7 mm to 9.5 mm in steps of 0.5mm. The Antenna Size is 35mm x 65mm x1.6mm. Its optimal impedance band width(S_{11}<-10dB) is 2.12 to 3.16 GHz, more than 1GHz , 44% centered at 2.3GHz at angle of rotation is 15 degrees and centre to centre distance 17mm.. The simulated and measured results are explained below.

CONFIGURATION AND DESIGN OF EIGHT SHAPED ANNULAR RING SLOT ANTENNA

The configuration of figure eight shaped annular ring slot antenna is illustrated in figure1. It consists of eight shaped annular slot. The slot antenna is excited by a 50 ohms microstrip line to provide impedance matching. Normally the resonant frequencies are mainly found by circumference length of annular slot.

The annular- slot width and the microstrip feed line parameters have significant effect on antenna parameters.

The fundamental resonant frequency of conventional annular circular ring slot antenna comprises in the ground plane of a dielectric substrate fed by a microstrip conductor can be calculated according to the following[12]

$$f_0 = \frac{300}{2\pi R_m \sqrt{\varepsilon_{re}}} \quad \text{-------------} \ 1$$

Where R_m is the average radius of inner ring radius and outer ring radius in mm. f_0 is the resonant frequency in GHz. And ε_{re} is effective dielectric constant of annular ring patch is given by

$$\varepsilon_{re} = \frac{2\varepsilon_r}{1+\varepsilon_r} \quad \text{-------} \ 2$$

To improve the impedance bandwidth one more annular linked slot is introduced. Using below equation width of the microstrip line width for 50 ohms is calculated[15].

$$Z_0(\Omega) = \frac{87}{\sqrt{\varepsilon_r + 1.41}} \ln\left[\frac{5.98h}{(0.8w+t)}\right] \quad \text{-----3}$$

ANALYSIS AND STUDY OF THE PARAMETERS

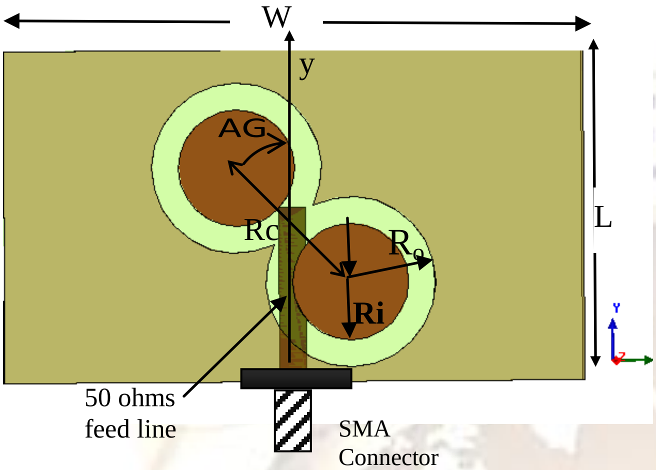


Figure1. Geometry of the Eight shaped antenna

In this paper, the effects of eight shaped slot antenna parameters are discussed and analyzed using HFSS software which is a FEM based simulator.. Annular slot antennas have relatively broad band characteristics compare to conventional patch antennas. Normally , for narrow slot antennas impedance bandwidth is around 10%. However for wide slots high bandwidth can be obtained, because of reduced quality factor.

A single layer with 8 shaped slot is taken out of infinite ground plane. FR4 substrate was selected to reduce the cost, which has a relative permittivity of 4.4, loss tangent of 0.01 and a thickness of 1.56 mm. The ground plane size was 65mmX35mm. Radius of inner ring of the slot is Ri=6.5mm,Radius of the outer ring slot is taken as Ro=9.5mm.

The 50 ohms feed line length is fl= 19.5mm, and width is fw3mm was designed for good impedance matching. Radius of the inner slot ring is R_i=6.5 mm , radius of the outer circle of ring is R_o=9.5 mm, separation distance between the centers of two slots is $2R_c$ and the angle between the line joining the centers of the two rings of eight shaped slot and a vertical reference line is AG. The dimensions Ri,, Ro, optimized to get wider bandwidth.

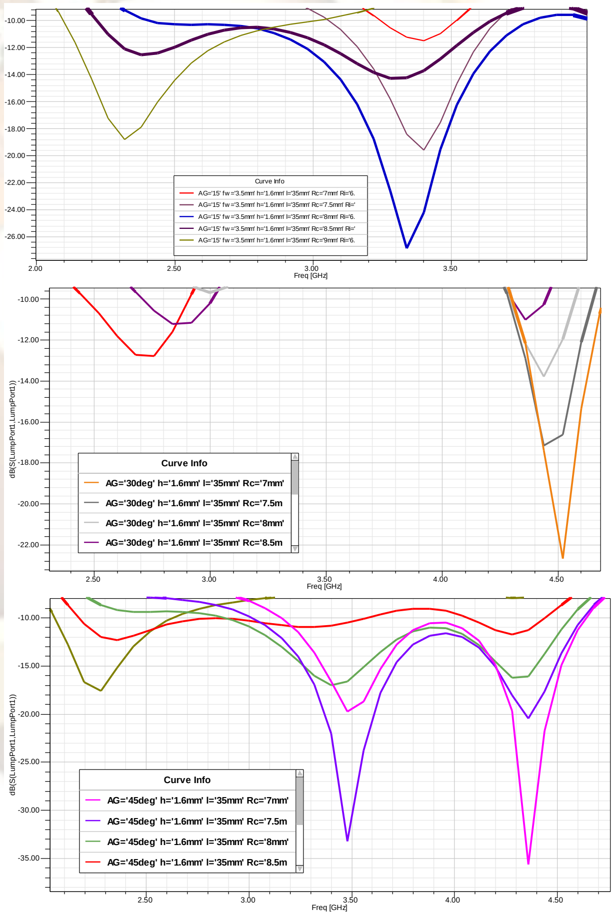
Angle of inclination AG is varied from 15 to 90 degrees insteps of 15degrees. The half of the distance between the centers of two linked annular rings is R_c is varied from 7 to 9.5 mm insteps of 0.5mm. Only one parameter is varied every time in the numerical simulation

RESULTS AND DISCUSSIONS

Based on the simulated results effect of angle of rotation and center to center distance of two annular slots of eight shaped slot are discussed in the following section.

DEPENDENCE ON THE ANGLE OF ROTATION AND CENTER TO CENTER DISTANCE

The Return loss plots by adjusting the rotation angle AG and distance of separation between the centers of rings 2Rc are shown in Figure.2. It is observed in figure.2 that impedance bandwidth for return loss below -10 dB is from 2.28 GHz to 3.64 GHz when angle of rotation AG = 15 degrees and Rc =9mm, which is more than 44 % centered at 2.3GHz. % Bandwidth for different combinations of antenna parameters is shown in figure 3. and in table1. Flatten gain of 4dBi is observed over the optimized band, shown in figure 4. It is also observed that E plane and H plane Radiation patterns at different values of frequencies are relative omni directional shown in figure 5.



% Bandwidth

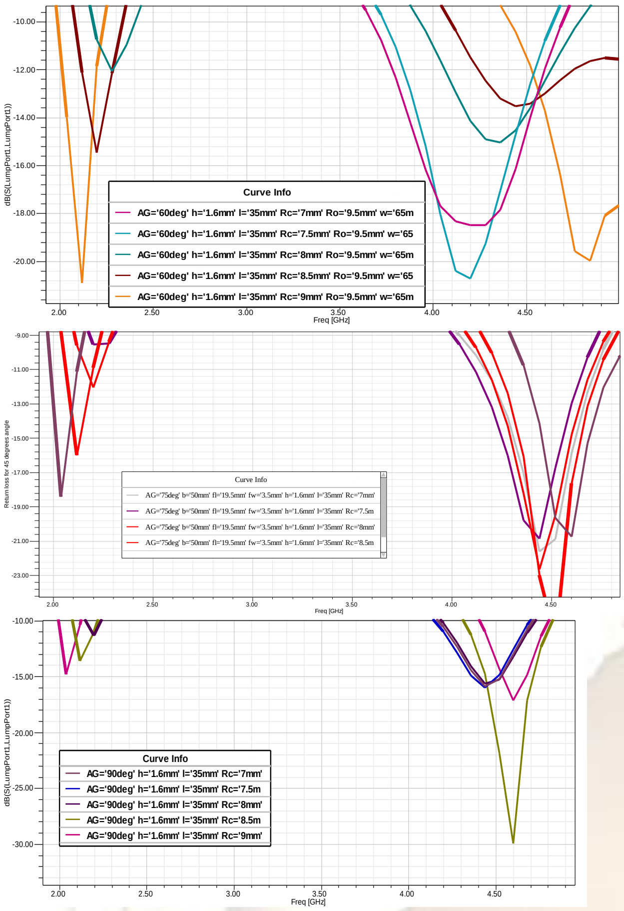


Figure.2 Return loss plots for Angle AG = 15^0 '30^0'45^0,60^0,75^0 for different values of Rc

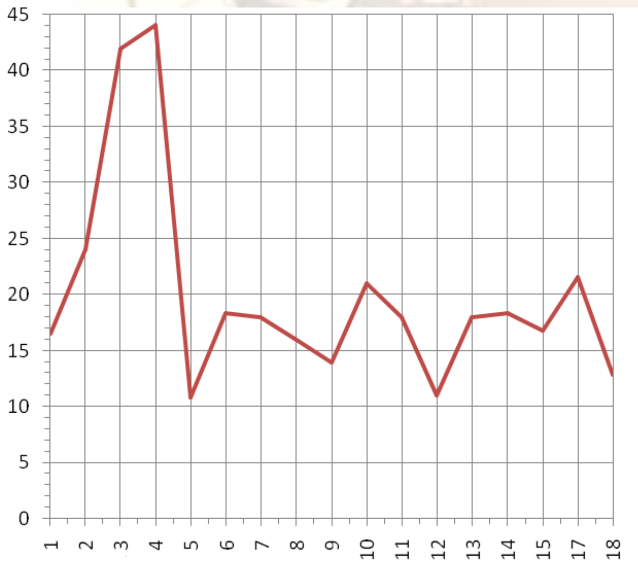


Figure.3 Bandwidth performance of the antenna

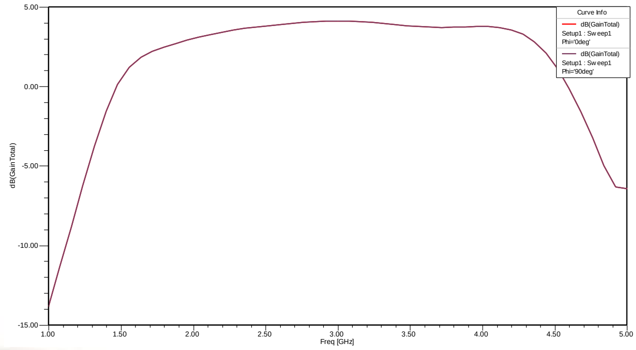


Figure. 4 Gain performance of the antenna

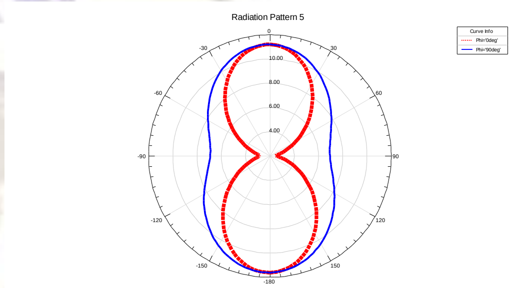


Figure. 5 Radiation pattern of the antenna
Eplane – red, H plane – blue)

Table 1. Band width performance of the antenna			
S.No	Angle of Rotation AG(deg)	Rc distance (mm)	% Band Width
1	15	7.5	16.47
2	15	8	24.09
3	15	8.5	41.97
4	15	9	44.06
5	30	7	10.81
6	30	7.5	18.35
7	30	8	18.02
8	30	8.5	15.93
9	30	9	13.91
10	45	7	21
11	45	7.5	18
12	45	8.25	10.97
13	90	7	18.02
14	90	7.5	18.35
15	90	8	16.82
16	90	8.5	21.6
	90	9	12.8

Experimental Results

Photographs of top view and bottom vies are show in figure 6. Fabricated antenna consists centre to centre distance between two rings is 19mm and angle of rotation is 15 degrees. VSWR vs frequency plot was shown in figure 7. From experimental results it is observed that the impedance band width is from 2 to 3.5 GHZ centered at 2.7 GHZ that is 55%.

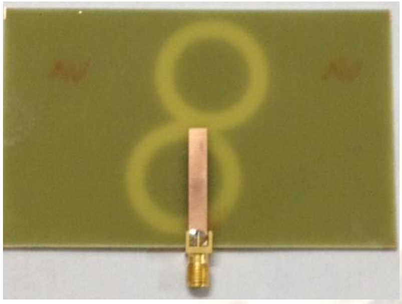


Figure 6. Photograph of the fabricated antenna

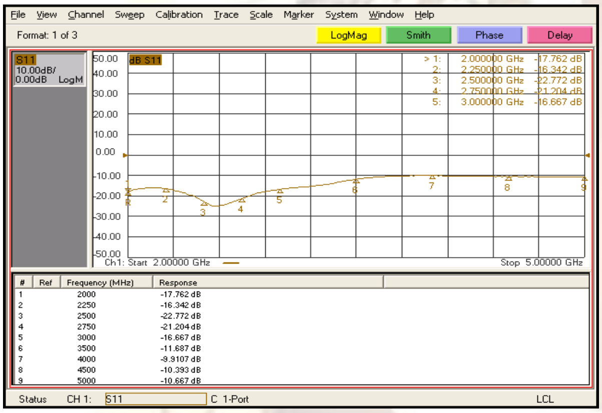


Figure 7. Return loss vs Frequency plot

CONCLUSION

An eight shaped slot is implemented to achieve broadband characteristics of the antenna. Parametric analysis to achieve wide bandwidth is investigated with permutations of the angle between the line joining the centers of the two rings of eight shaped slot and a vertical reference line, and the distance between the centers of the two rings of eight shaped slot. Simulated results of impedance matching and radiation patterns are discussed. Experimental results are discussed. And experimental impedance band width for VSWR<2dB is achieved for the band of 2 to 3.5 GHZ centered at 2.7 GHZ that is 55%. Simulated results are good agreement with the experimental results.

REFERENCES

1) Xiulong Bao, Max Amman,Microstrip-Fed Dual-Frequency Annular-Slot Antenna Loaded by Split-Ring-Slot,IET Microw. Antennas Propag., 2009, Vol. 3, Iss. 5, pp. 757–764
2) BATCHELOR J.C., LANGLEY R.J.: ‘Microstrip ring antennas operating at higher order modes for mobile applications’,IEE Proc. H, Microw., Antennas Propag., 1995, 141, (2),pp. 151–155
3) GUO Y.X., LUK K.M., LEE K.F.: ‘L-probe proximity-fed annular ring microstrip antennas’, IEEE Trans. Antennas Propag., 2001, 49, (1), pp. 19–21
4) BAO X.L., AMMANN M.J.: ‘Comparison of several novel annular-ring microstrip patch antennas for circular polarization’, J. Electromag. Waves Appl., 2006, 20, (11), pp. 1427–1438
5) Parsche, Fracis Eugene, US. Patent No. 6992630, Annular ring Antenna
6) BATCHELOR J.C., LANGLEY R.J.: ‘Microstrip annular ring slot antennas for mobile applicaiotns’, Electron. Lett., 1996, 32, (18), pp. 1635–1636
7) SHARMA S.K., SHAFAI L., JACOB N.: ‘Investigation of wideband microstrip slot antenna’, IEEE Trans. Antennas Propag., 2004, 52, (3), pp. 865–872
8) TEHRANI H., CHANG K.: ‘Multifrequency operation of microstrip-fed slot-ring antennas on thin low-dielectric permittivity substrates’, IEEE Trans. antennas Propag., 2002, 50, (9), pp. 1299–1308
9) YOSHIMURA Y.: ‘A microstripline slot antenna’, IEEE Trans. Microw. Theory Tech., 1972, 20, (11), pp. 760–762
10) HONG C.S.: ‘Large bandwidth circular slot at resonance with directional radiation’, Electron. Lett., 1988, 24, (23), pp. 1449–1450
11) JANG Y.W.: ‘Experimental study of wideband printed annular slot antenna with cross-shaped feedline’, Electron.Lett., 2002, 38, (22), pp. 1305–1307
12) Wong.K.L. and T.W. Chiou, “ Broad band single patch circularly polarized microstrip antenna with dual capacitively coupled feeds”. IEEE Trans. Antennas Prop. Vole 49, 41-47, 2001
13) T.-N. Chang,Wideband circularly polarised antenna using two linked annular slots, ***Electronics letters***, June 2011 Vol. 47 No. 13
14) Chang, T.-N., and Han, Y.-L.: ‘A dual-band circularly polarized antenna using combined C-shaped and L-shaped slots excited by a microstrip, ***Microwave and Optical Technology Letters***,Volume 53, 1041–1044, May 2011
15) Balanis.C.A.Antenna Theory Analysis Design, Second Edition, United states of America, John Wiley &Sons 1997..p73
16) Srilakshmi.A, Koteswararao.N.V, Srinivasarao.D, R***ecent Advances in Intelligent Computational Systems (RAICS),*** 2011 IEEE , 2011 , Page(s): 851 – 855