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EDGE SLOT SPIRAL MULTIBAND ANTENNA

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ABSTRACT

In this paper we designed single fed edge slot spiral multiband antenna for wireless communication applications. The multiband is achieved by cutting the planar patch on its four sides of edges and spiral shape on the center of the patch. The current antenna is resonating at three different frequencies with high gain and moderate input impedance bandwidth. The antenna was designed using commercial Ansoft HFSS and simulated results of return loss, input impedance smith chart, gain, radiation patterns and field distributions are presented in this current paper

Keywords: Edge slot, Spiral, Multiband, Input impedance bandwidth.

INTRODUCTION

In recent years, many works have been done to design and develop small-sized, simple-fabricated, highly integrated multi-band antennas in terms of multisystem application for mobile or wireless terminals. Multiband Antennas are very desirable for current wireless applications as they can cover multiple frequencies using a single antenna. Moreover, modern wireless communication systems relying on multiband reconfigurable antennas are becoming more popular for their ability to serve multiple standards and applications using a single compact antenna allowing a reduction in the dimensions of the wireless device and more space to integrate other electronic components [1-4].

Reconfigurable antennas can be classified into three different categories. The first category is based on frequency reconfigurability. The aim is to tune the operating frequency of the antenna and to have a single multifunctional antenna in a small terminal for many applications. The second category is based on pattern reconfigurability, where the frequency band remains unchanged while the radiation pattern changes based on system requirements. The third category is based on polarization reconfigurability, where the polarization is switched from linear to circular and from left hand (LHCP) to right hand (RHCP) circular [5-6].

Figure 1 shows the antenna model generated using HFSS. Log spiral and log periodic antennas generally resonate at multiple frequencies and in this case we designed one spiral model with slot edges on the four sides of the patch. Coaxial feeding is chosen for the current case and perfect impedance matching is obtained. The total dimension of the antenna is about 50x50x2mm.

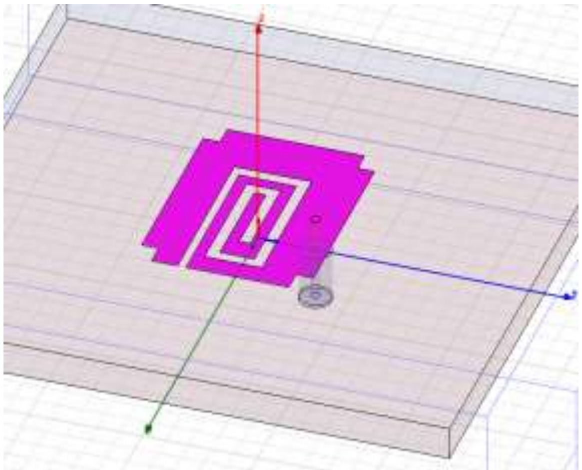

Figure 1. Edge slot spiral antenna

ANTENNA GEOMETRY:

Antenna is designed on RT-Duroid substrate with relative permittivity of 2.2 and loss tangent of 0.009. Patch dimension along x-axis is 19.8mm and along y-axis it is 15 mm. substrate thicknesses of 2mm, substrate dimension along x-axis and y-axis of 50mm. feed position along y-axis is of 5mm distance from centre. On four sides of the patch the slot length and width of 1.5mm. The inner distance between spiral slot faces are of 2mm. coaxial inner radius of 0.4mm and feed length of 4.2mm.

RESULTS AND ANALYSIS

Figure 2 Return loss Vs Frequency

The voltage at the input port location is computed from the Ez field components at the feed point over the entire simulation time interval. The current at the feed point is calculated from the H field values around the feed point using Ampere's circuital law. The input impedance of the antenna is computed as

$$Z_{in}(w) = FFT(V^n, P)/FFT(I^{n-1}, P)$$

Since microstrip line is modeled using Leubber's staircase approach, the internal impedance of source resistance Rs is taken as the characteristic impedance (Z0) of microstrip line.

Return loss in dB, $S_{11} = 20 \log_{10}\Gamma(\omega)$

The return loss computed in the above process is processed for extracting the fundamental resonant frequency and 2:1 VSWR bandwidth corresponding to the -10 dB return loss. The return loss obtained for three cases are presented in the figure (2). The antenna is resonating at three different frequencies with moderate return loss of -16.6, -19.7 and -27.29dB respectively at 4.3, 6.9 and 8.8GHz.

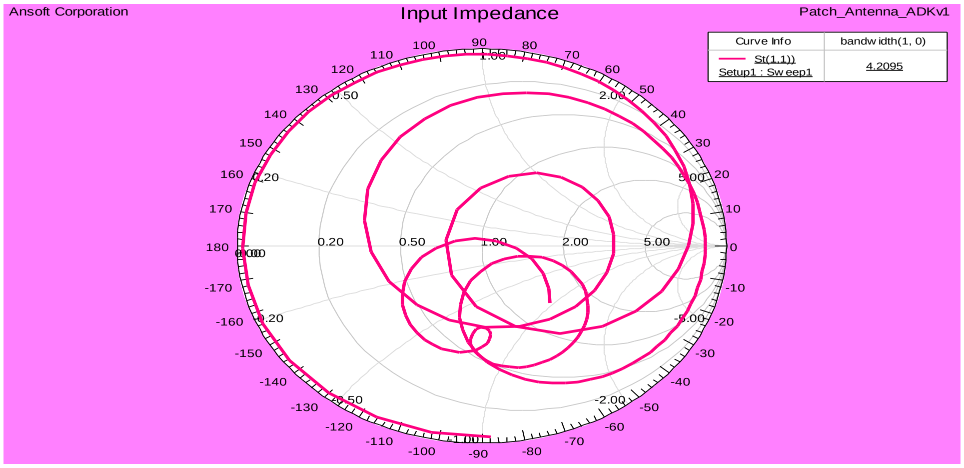

Figure 3 Input impedance smith chart

Figure (3) shows the input impedance smith chart for all the three models of serrated triangular toothed antennas. The input impedance at the feed of the antenna is

$$Z = R+jX = \frac{V}{I} = \frac{-E_{avt}}{I}$$

where Eav is the average value of the electric field at the feed point and I is the total current.

The input impedance is complex and involves a resistive and reactive part. The resistive and reactive components vary as a function of frequency and are symmetric around the resonant frequency.

For a probe fed circular patch, the input impedance with near resonance can be represented as a function of frequency and feed location as,

$$Z_{in}(f, P) = R_{in}(f, P)+jX_{in}(f, P)$$

The input resistance at resonance varies with radial distance P from the centre of the patch as,

$$R_{in}(f = f_r, nm, P) = R_r(P) = \frac{R_{edge} J_n^2 (kP_o \frac{a}{a_{eff}})}{J_n^2(ka)}$$

The input impedance of a rectangular patch and feed location expressed as the functions of frequency and feed location (x_o, y_o) as,

$$Z_{in}(f, x_o) = R_{in}(f, x_o)+jX_{in}(f, x_o)$$

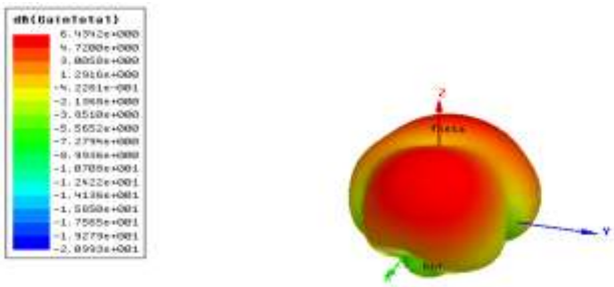

Figure 4 Gain in 3D

Figure 4 shows the gain of the antenna in three dimensional view. Figure 5 shows the antenna co-polarization and cross polarization radiation pattern in polar coordinates. The radiation pattern at 6.9 and 8.8 GHz are slightly Omni directional, but radiation pattern for 4.3 GHz is quasi Omni directional for co-polarization. In the case of cross polarization at 6.9 and 8.8 GHz, the radiation pattern is somewhat better compared with 4.3 GHz. Figure 6 shows the antenna E-field, H-field and current distribution plots in three dimensional view. Table 1 shows the antenna additional parameters and maximum field data at all the resonating frequencies. Peak gain, peak directivity, radiated power, incident power, accepted power and radiation efficiency values are presented.

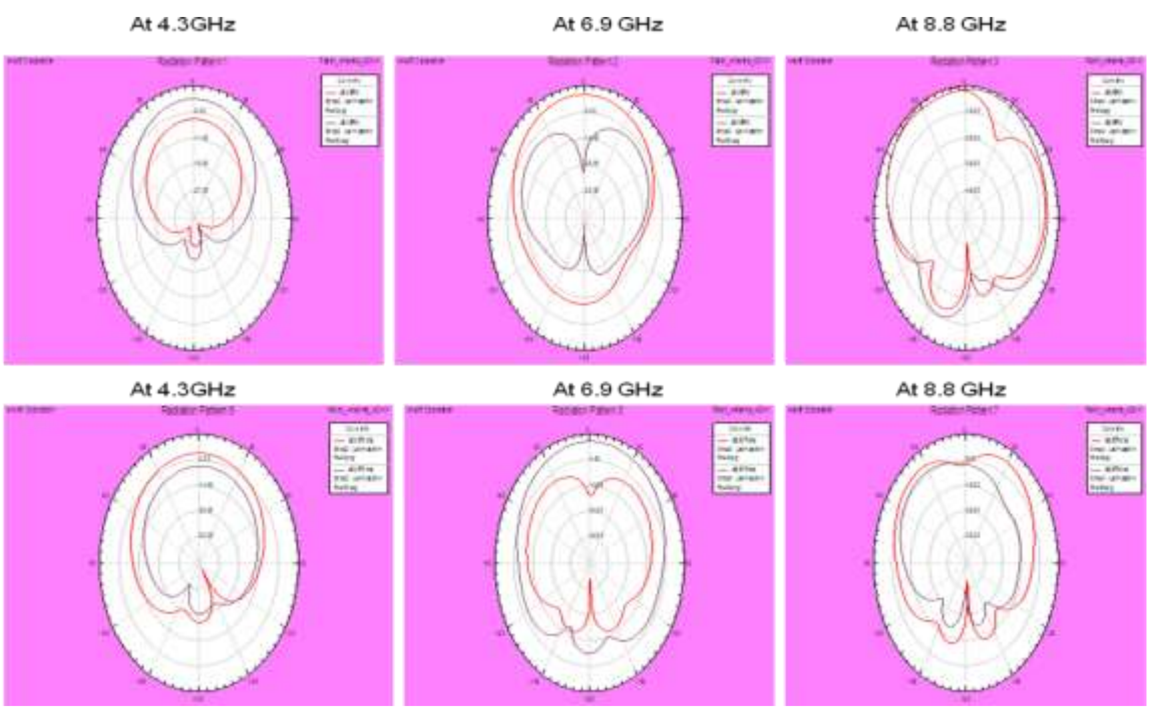

Figure 5. Co-Polarization and Cross-Polarization radiation pattern of antenna at resonating frequencies

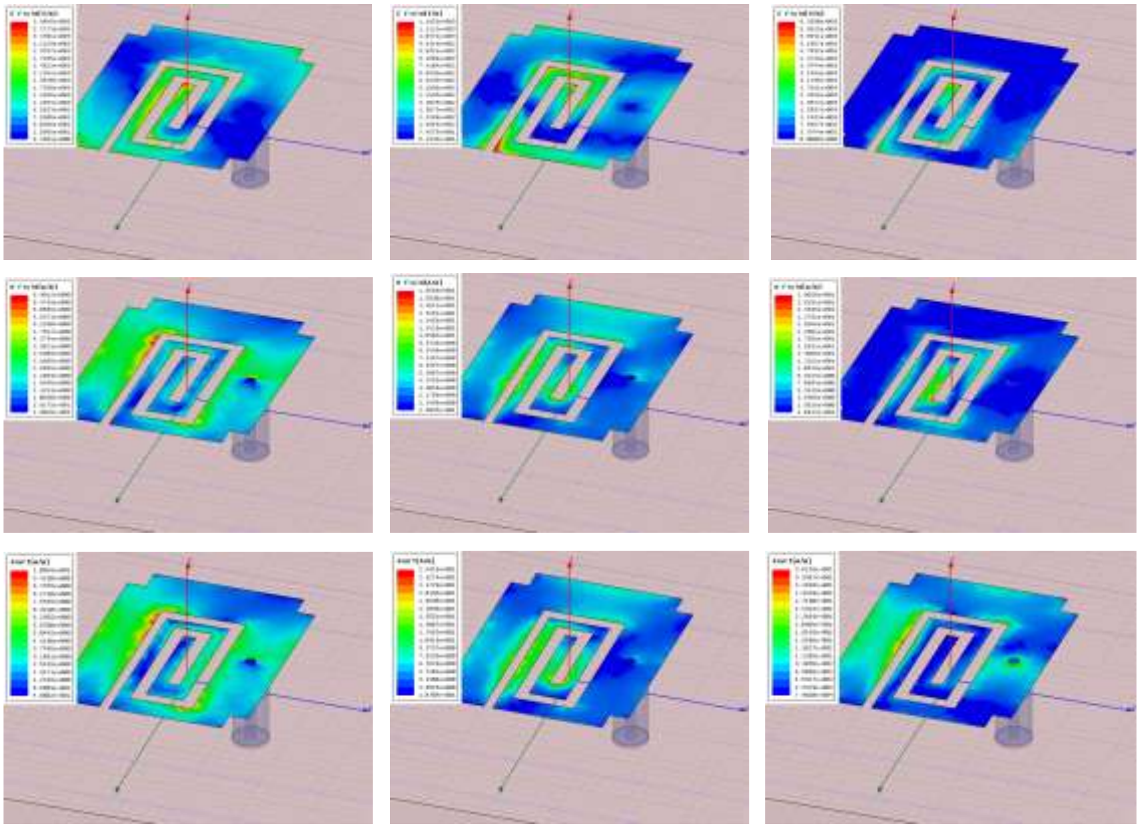

Figure 6. E-field, H-field and current distribution of antenna at three resonating frequencies

Antenna Parameters

Inputs

	4.3 GHz	6.9 GHz	8.8 GHz
Setup Name:	infSphere	infSphere	infSphere
Intrinsic Variation:	Freq='4.3GHz'	Freq='6.9GHz'	Freq='8.8GHz'
Solution:	LastAdaptive	LastAdaptive	LastAdaptive
Design Variation:	Airbox_dist='1.6655cm'	Airbox_dist='1.6655cm'	Airbox_dist='1.6655cm'
Array Setup:	None	None	None

Antenna Parameters:

Quantity	Value (4.3 GHz)	Value (6.9 GHz)	Value (8.8 GHz)	Units
Max U	0.0021228	0.0053317	0.0051961	W/sr
Peak Directivity	5.7644	5.9045	5.0231	
Peak Gain	5.613	5.8632	4.9868	
Peak Realized Gain	4.2376	5.3134	4.8941	
Radiated Power	0.0046278	0.011348	0.012989	W
Accepted Power	0.0047526	0.011428	0.013094	W
Incident Power	0.0062951	0.01261	0.013342	W
Radiation Efficiency	0.97374	0.993	0.99279	

Maximum Field Data (4.3 GHz):

rE Field	Value	Units	At Phi	At Theta
Total	1.2651	V	5deg	-2deg
X	1.1337	V	40deg	-2deg
Y	0.5627	V	50deg	4deg
Z	0.55811	V	160deg	44deg
Phi	1.2526	V	65deg	0deg
Theta	1.2526	V	155deg	2deg
LHCP	0.76682	V	45deg	-8deg
RHCP	1.0113	V	95deg	2deg
Ludwig3/X dominant	1.134	V	20deg	-2deg
Ludwig3/Y dominant	0.56276	V	80deg	2deg

Maximum Field Data (6.9 GHz):

rE Field	Value	Units	At Phi	At Theta
Total	2.005	V	135deg	4deg
X	0.60465	V	105deg	40deg
Y	1.9991	V	150deg	2deg
Z	1.0467	V	115deg	48deg
Phi	1.9981	V	180deg	2deg
Theta	1.9964	V	90deg	2deg
LHCP	1.613	V	95deg	18deg
RHCP	1.4877	V	95deg	-16deg
Ludwig3/X dominant	0.7426	V	120deg	48deg
Ludwig3/Y dominant	2	V	145deg	4deg

Maximum Field Data (8.8 GHz):

rE Field	Value	Units	At Phi	At Theta
Total	1.9794	V	150deg	-36deg
X	1.7377	V	150deg	-38deg
Y	1.1581	V	60deg	-32deg
Z	1.3224	V	160deg	-52deg
Phi	1.5754	V	130deg	-32deg
Theta	1.8664	V	165deg	-36deg
LHCP	1.714	V	55deg	-40deg
RHCP	1.3308	V	150deg	-40deg
Ludwig3/X dominant	1.9745	V	155deg	-36deg
Ludwig3/Y dominant	1.3549	V	70deg	-42deg

Table 1 Antenna Additional parameters at 4.3, 6.9 and 8.8 GHz

CONCLUSION

Edge slot spiral multiband antenna was designed and simulated results are presented in this paper. The current antenna is resonating at 4.3, 6.9 and 8.8 GHz respectively with considerable gain and bandwidth. The radiation efficiency is showing 0.99 at all three resonating frequencies of the antenna. The radiation pattern shows the Omni directional patterns in its entire range. The field distributions presented in this paper is showing the applicability of this antenna at appropriate frequency range of applications.

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