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Compact Triple and Dual Band Antenna for L-S-C Band Wireless Communication

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Abstract: - compact triple band antenna for L-S-C Band wireless communication is presented, folded type U-Slot and via hole technique is used. In this paper design antenna-1 and antenna-2. From Antenna-1 achieving appropriate results for dual band S-Band and C-Band. The Antenna-2 demonstrates appropriate results for Triple band La-Band, S-Band and C-Band. The Antenna-1 is optimized in Antenna-2 by the optimization of dimensions folded U-Slot. Simulation and validation done in IE3D Simulator. Via hole technique is used to optimize the inductance of both geometry. Return loss, axial ratio, Efficiency are studied of proposed antennas. Circular polarization of antenna validated by axial-ratio (AR) curve. By loading a via hole to the patch in orthogonal pattern, the minimum point of lower frequency moves to higher frequency, and broad AR band is obtained consequently. The Antenna-1 is used for dual band application S-C Band and Antenna-2 is appropriate in triple band application L-S-C Band.

Keywords- Folded U-Slot, orthogonal via hole technique, circular polarization, dual and triple band,

I. INTRODUCTION

Polarization reconfigurable antennas have received increasing attention in the last decade. They are sometimes called “polarization agile antennas”, because they can alter their polarization characteristics in real time. This is a desirable feature for wireless applications as it doubles the system capacity through a frequency reuse, provides a powerful modulation scheme for microwave tagging systems [1], and becomes a candidate for multiple-input multiple-output (MIMO) systems [2]. Therefore, they are useful for the compactness and light weight of wireless devices. Polarization switching can be established with the aid of switching devices such as PIN diodes and RF-MEMs [3], [4]. Examples of efforts toward the realization of polarization agile antennas using different methods have been reported in [5]–[12]. However, several challenging problems still exist in these designs, particularly the antenna bandwidth, gain, design complexity, and performance Symmetry upon switching. In [5]–[9], the achieved bandwidth is less Than 2.8% which is not satisfactory for some wireless applications such As WLAN IEEE 802.11 b/g (4%). In [10] and [11], slot antenna designs are used to achieve wider bandwidth 4.2% and 11%, respectively. However, the realized gain is found to be smaller compared to that attained by the micro-strip patch designs. Moreover, in the former design, the biasing circuit for the diodes is relatively complicated. In [12], the antenna geometry is sophisticated and impedance matching at each polarization mode requires a reconfigurable matching network. This antenna configuration imposes design complexity and fabrication inconvenience that limit its practical application. In addition, the antenna performance varies through its switching states because of its asymmetrical geometry, which narrows the overlapped bandwidth along the antenna polarization modes to 2.24%. To overcome these difficulties a circularly polarized microstrip patch antenna with inherent wide bandwidth and simple symmetrical shape is required.

II. ANTENNA DESIGN AND ANALYSIS

In this paper design antenna 1 and antenna 2. The antenna 2 has more width and length of folded U-Slot.

A. *Proposed Antenna-1*
B. *Proposed Antenna –2*

Both antenna design using folded U-Slot structure with via hole technique.

A. *Proposed Antenna-1*

In fig1, shown proposed Antenna-1, the dimension of proposed antenna is calculated using transmission line theory Dimensions are

- Length and width of patch are
  L = 17.77mm, W=22mm
- Length and width of ground plan are
  L_R = 26.77mm, W_R=31mm

$L_R = L+6h$, $W_R=W+6h$

- Feeding points calculated as
  X_f =-4mm, Y_f = -11mm

Length of folded U-Slot is shown in figure 1. All dimension of designs calculated from the theory of transmission line model. All mathematical calculation steps are shown from step 1 to step 5

Step 1: Calculation of the Width (W):

$$W = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}}$$

Step 2: Calculation of Effective dielectric constant (εeff):

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}[1+12\frac{h}{w}]^{\frac{1}{2}}$$

Step 3: Calculation of the length extension (ΔL):

$$\Delta L = \frac{0.412h(\varepsilon_{reff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{w}{h}+0.8)}$$

Step 4: Calculation of the Effective length (Leff):

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}}$$

Substituting c = 3.00e+008 m/s and f = 5.5 GHz,

Step 5: Calculation of actual length of patch (L):

$$L = L_{eff} - 2\Delta L$$

Figure 1 represents antenna -1 Geometry. The Folded U-Slot is design using impedance stub matching techniques, the dimension of folded U-Slot is shown in fig 2.

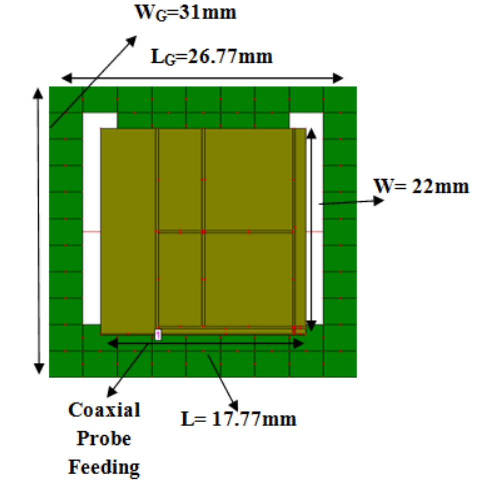

Fig 1 Proposed Antenna-1

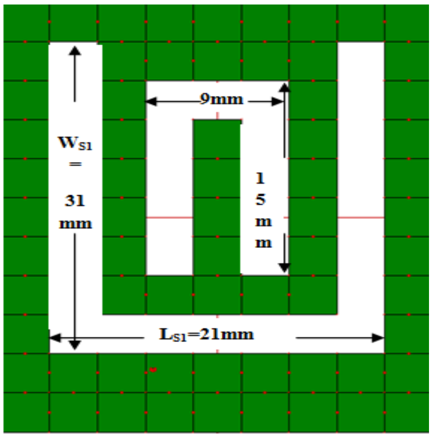

Fig 2 Proposed Folded Configuration of Antenna-1

B. Proposed Antenna –2

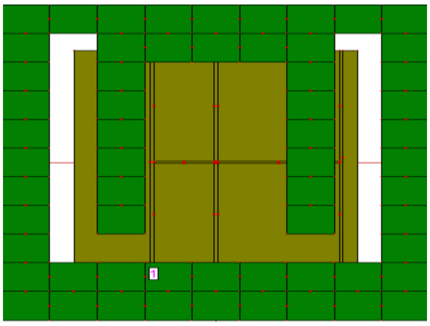

Fig 3 Proposed Antenna-1

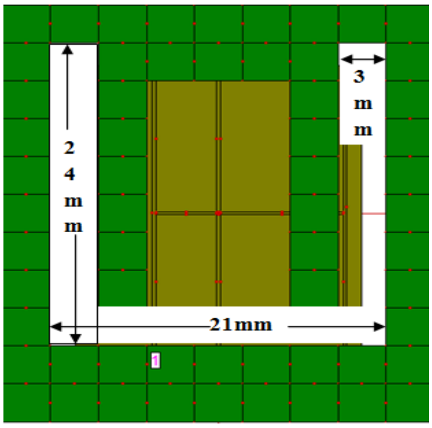

Fig 4 Proposed Folded Configuration of Antenna-2

III. RESULT AND DISCUSSION

Dual band and triple band circularly and Linear Polarized antenna is discuss in this paper. For designing of proposed antenna firstly study and design then loading orthogonal via hole for optimization of inductance of design antenna. Via hole technique improve the conductivity of ground plan and patch so that reduction in reflection of patch and ground plan. Via hole technique enhance surface current of antenna-1 and antenna-2, Orthogonal configuration of via hole, reduce cross polarization and improve efficiency of proposed antenna, due to improvement in surface current obtain shift in higher edge of frequencies towards lower edge of frequency and sustain compactness at 3GHz antenna is 40% in antenna-1 and obtain 65% compactness at 1.5GHz in antenna-2, compare to theoretical antenna. Compactness and multiband are achieved by appropriate choosing the dimension of folded U-Slot Ground plan. Optimization shown in Antenna -1 and Antenna-2. Folded U-Slot is design by theory of impedance stub matching technique.

Proposed antenna design in IE3D Simulator and all results validated in IE3D Simulator. Return losses, VSWR, axial ratio, antenna and radiating efficiency, directivity and radiation pattern discuss in below section.

A. Proposed Antenna-1

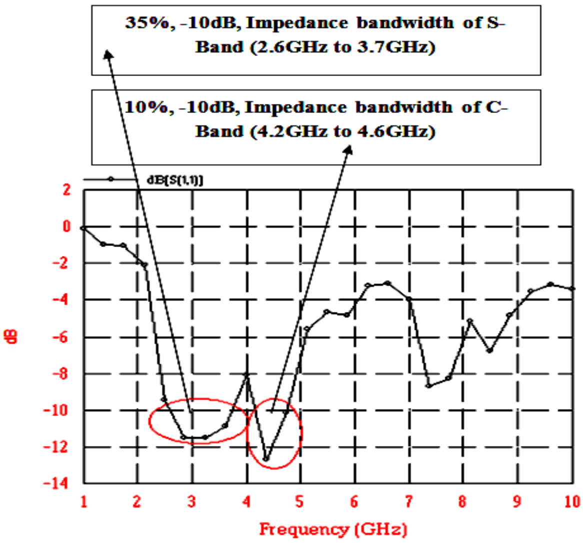

Figure 5 Return Loss Vs Frequency

Fig 5 depicts return loss vs. frequency, this paper reported dual band at 3 GHz, and 4.5GHz shown in return loss. From return losses graph antenna-1 achieved ≤ -10dB, for S-Band and C-Band with -10 dB, impedance bandwidth 35% of S-Band and 10% of C-Band.

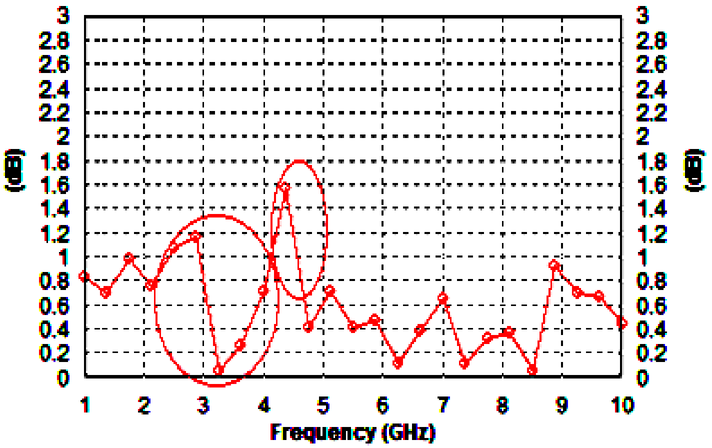

Fig 6 Axial Ratio Vs Frequency

Fig 5 depicts axial ratio result of proposed antenna From 1GHz to 6 GHz achieved axial ratio less than equal to 3dB, Axial ratio represents polarization of antenna if axial ratio less than 1, then antenna is circular polarized and if axial greater than 1,then antenna towards linear polarization.

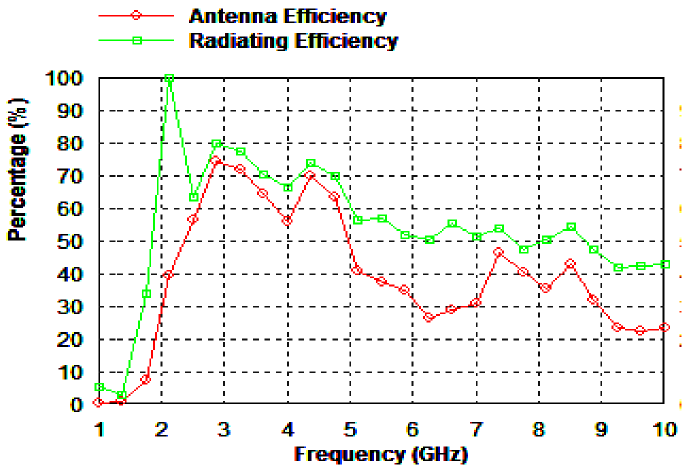

Figure 7 Efficiency Vs Frequency

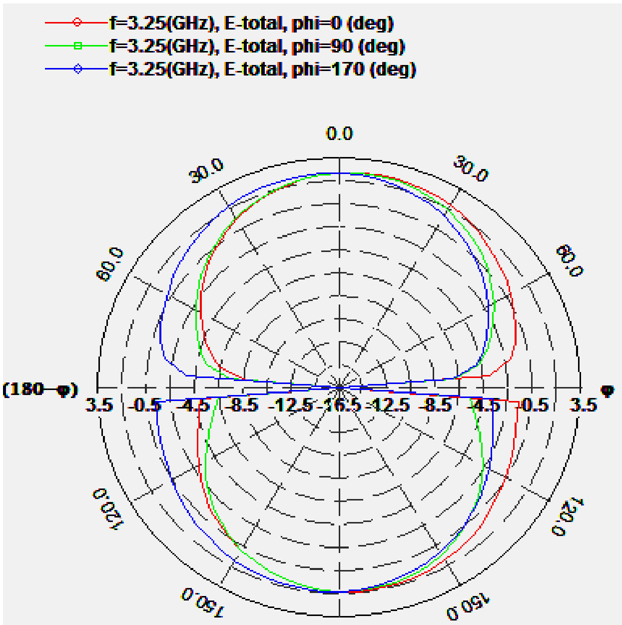

Figure 8 elevation pattern at 3.2GHz

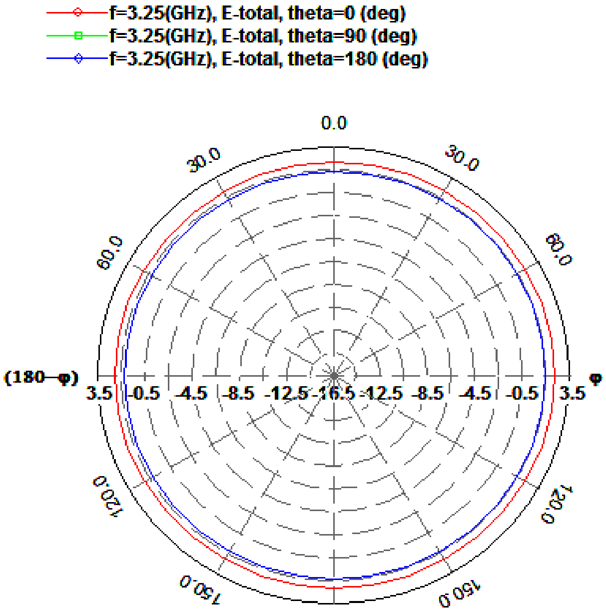

Figure 9 Azimuth pattern at 3.2GHz

Linear Directivity obtain Linear Maximum from radiation pattern is 3.71906 dBi at (10, 20) deg. 3dB Beam Width (58.0957, 133.256) deg . Achieved Circular Gain 1.88493 dBi and Circular Directivity 3.33571 dBi, Circular Maximum at (10, 40) deg , for achieving circular directivity 3dB Beam Width (54.5787, 112.803) deg.

B. Proposed Antenna-2

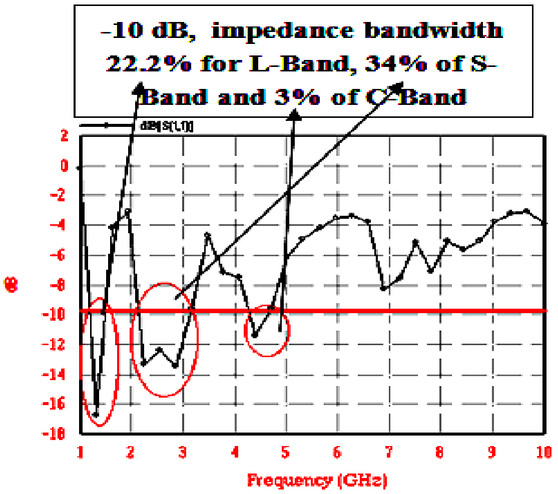

Figure 10 Return Loss Vs Frequency

From return losses graph antenna 2 achieved ≤ -10dB, for L-Band, S-Band and C-Band with -10 dB, impedance bandwidth 22.2% for L-Band, 34% of S-Band and 3% of C-Band.

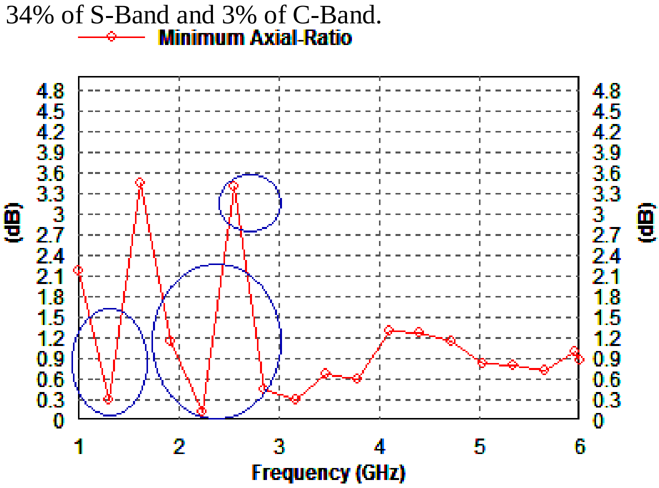

Fig 11 Axial Ratio Vs Frequency

Table-II Results summary of proposed antenna at 3GHz

Parameters	Proposed Design
Frequency	3.25 (GHz)
Incident Power	0.01 (W)
Input Power	0.00929577 (W)
Radiated Power	0.00716014 (W)
Average Radiated Power	0.000569786 (W/s)
Radiation Efficiency	77.0258%
Antenna Efficiency	71.6014%
Linear Gain	2.26828 dBi
Linear Directivity	3.71906 dBi
Linear Maximum	at (10, 20) deg.
3dB Beam Width	(58.0957, 133.256) deg.
Circular Gain	1.88493 dBi
Circular Directivity	3.33571 dBi
Circular Maximum	at (10, 40) deg.
3dB Beam Width	(54.5787, 112.803) deg.

Parameters	Proposed Design
Frequency	4.375 (GHz)
Incident Power	0.01 (W)
Input Power	0.0094671 (W)
Radiated Power	0.00697131 (W)
Average Radiated Power	0.000554759 (W/s)
Radiation Efficiency	73.6372%
Antenna Efficiency	69.7131%
Linear Properties	
Linear Gain	3.18259 dBi
Linear Directivity	4.74945 dBi
Linear Maximum	at (50, 80) deg.
3dB Beam Width	(63.6651, 120.767) deg.
Circular Gain	1.61256 dBi
Circular Directivity	3.17942 dBi
Circular Maximum	at (45, 70) deg.
3dB Beam Width	(69.9017, 102.538) deg.

Table-III Validation of Proposed Antenna-1 and Antenna-2

Parameters	Antenna-1	Antenna-2
-10 dB, impedance bandwidth	Impedance bandwidth 35% of S-Band and 10% of C-Band.	22.2% for L-Band, 34% of S-Band and 3% of C-Band.

IV. CONCLUSION

Compact triple band and dual band antenna for L-S-C Band wireless communication is successfully investigated in this paper , folded type U-Slot and via hole technique is used for designing. In this paper antenna-1 and antenna-2 have designed. From Antenna-1 achieving dual band $\leq$ -10dB, for S-Band and C-Band with -10 dB, impedance bandwidth 35% of S-Band and 10% of C-Band.. The Antenna-2 demonstrates appropriate results for Triple band L-Band, S-Band and C-Band. Achieved $\leq$ -10dB, for L-Band, S-Band and C-Band with -10 dB, impedance bandwidth 22.2% for L-Band, 34% of S-Band and 3% of C-Band. The Antenna-1 is optimized in Antenna-2 by the optimization of dimensions folded U-Slot. Simulation and validation done in IE3D Simulator. Via hole technique is used to optimize the inductance of both geometry. Return loss, axial ratio, Efficiency are studied of proposed antennas. Circular polarization of antenna validated by axial-ratio (AR) curve .By loading a via hole to the patch in orthogonal pattern, the minimum point of lower frequency moves to higher frequency sustain compactness at 3GHz antenna is 40% in antenna-1 and obtain 65% compactness at 1.5GHz in antenna-2, compare to theoretical antenna., broad AR$\leq$3dB, band is obtained consequently. The Antenna-1 is used for dual band application S-C Band and Antenna-2 is appropriate in triple band application L-S-C Band.. IE3D^{TM} Simulator used for validation of proposed antenna. Validation of antenna-1 and antenna-2 shown in Table-III.

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