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DESIGN AND IMPLEMENTATION OF TRIPLE-BAND CIRCULARLY POLARISED MICROSTRIP ANTENNA

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Abstract- Design and implementation of triple-band circularly polarized microstrip antenna is presented. In this work, L shaped triple band microstrip antenna was designed on rectangular patch. A rectangular strip is added at the right side corner of the patch. A triple band circularly polarized (CP) radiation consists of a L-shaped radiator on the rectangular patch. The upper CP bandwidth of proposed antenna reaches (8.59~8.70 GHz). The triple band CP antenna for lower and middle bands are (2.83~2.98 GHz), (5.68~5.82 GHz). This project is to design, and test a triple-wide band CP microstrip antenna based on rectangular patch with suitable slot structure for Bluetooth, HiperLAN and X band applications. Designed antenna had been simulated in HFSS (High Frequency Structural Simulator) software.
Keywords- Triple-wideband, triple-sense, circularly polarized, slot antenna

1. INTRODUCTION

Nowadays, wireless communication technologies are in demand of low profile, light weight, and multi band antenna. To fulfill these requirements microstrip patch antennas are used. The modern wireless communication systems often operate at several different frequency bands, such as global positioning system (GPS), global navigation satellite system (GNSS), and wireless local area network (WLAN). Many dual-band circularly polarized (CP) antennas have been designed with stacked patches, cross-dipoles, and square or ring slots. However, the axial ratio bandwidth (ARBW) and impedance bandwidth (IBW) of these antennas are too wide for certain applications. Triple-Wideband Triple-Sense Circularly Polarized Square Slot Antenna [1], A micro strip-fed simple square slot antenna is proposed for triple- wideband triple-sense circularly polarized (CP) radiation. In [2]. Triple-sense circular polarization (CP) is presented for ultra-wideband (UWB). The circular polarization characteristic at the WiMAX band was obtained by an inverted-U-shaped radiator rotated bandwidth enhancement for 2.45/5.8 GHz wireless local area by 45° around the horizontal axis. In [3], the antenna covers the UWB operation from 3.1GHz to 11.8GHz with good CP waves at Worldwide Interoperability for Microwave Access (WiMAX) (3.63-3.77 GHz bands), the wireless local area network band (WLAN) (4.95-5.18 GHz bands). In [4], By adding three L-shaped slit arms to the hexagonal slot, circularly polarized radiation is achieved at three different frequencies. In [5], the antenna operate at the L1 & L2 bands of the Global Positioning System (GPS) and the frequency band of the Compass Navigation Satellite System (CNSS). In [6], antenna operates at the two bands of GPS systems (at 1.2 GHz and 1.575 GHz), and at the UMTS band (at 2.03 GHz). [7], The impedance bandwidths (voltage standing wave ratio (VSWR) < 2.5) for the three frequency bands are 112, 118 and 427 MHz with 3 dB axial-ratio bandwidths of 15, 44 and 36 MHz, respectively. The peak gains across the operating bands are 4.2, 5.5 and 4 dBi respectively.

In this work, a simple triple-band circularly polarised microstrip antenna is proposed. It consists of an L-shaped radiator and a rectangular strip is added at the right side corner of the patch to produce CP waves with different polarization. A rectangular strip is used to reduce the noise bandwidth. It shows that this antenna has a simpler structure, more compact size, and reduces noise bandwidth.

2. ANTENNA DESIGN AND PARAMETER STUDIES

2.1 Antenna Design

The antenna is printed on a FR4 substrate of thickness 2.0 mm and permittivity 4.4 (tan δ= 0.02, size: 50×50 mm2). An L-shaped radiator is printed on the upper surface of substrate, and used to generate three resonance frequency bands. The L-shaped radiator patch composes of x-direction strip and y-direction strip. The lower frame structure ground is printed on the lower surface of substrate. A rectangular strip is added at the right side corner of the patch to produce CP waves with different polarization. Therefore, the lower and middle CP waves are generally achieved by the x-direction strip, and the upper CP wave is produced by y-direction strip. So, the noise bandwidth will be reduced. The upper CP bandwidth of proposed antenna reaches (8.59~8.70 GHz). Furthermore, a triple-band triple-sense CP microstrip antenna is achieved.

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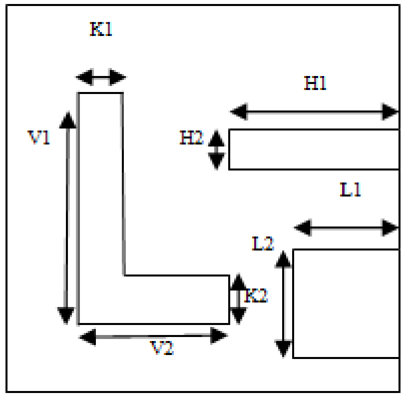

Fig. 1 Geometry of the proposed antenna

V1=30 mm , K1 = 5mm; V1=15mm , K2= 5 mm ; L1= 15 mm, L2= 15mm; h1 = 25mm, h2 = 6mm

Steps to Realize Proposed Antenna

The antenna is printed on a FR4 substrate of thickness 2.0 mm and permittivity 4.4 (tan δ= 0.02, size: 50×50 mm2). An L-shaped radiator is printed on the upper surface of substrate, and used to generate three resonance frequency bands. The L-shaped radiator patch composes of x-direction strip and y-direction strip. The lower frame structure ground is printed on the lower surface of substrate. A rectangular strip is added at the right side corner of the patch to produce CP waves with different polarization. Therefore, the lower and middle CP waves are generally achieved by the x-direction strip, and the upper CP wave is produced by y-direction strip. So, the noise bandwidth will be reduced. The upper CP bandwidth of proposed antenna reaches (8.59~8.70 GHz).

Furthermore, a dual-band dual-sense CP slot antenna is achieved. Front view and bottom view of the proposed design is shown in Fig. 1. This antenna uses an L-shaped radiator along with a rectangular patch structure and a lower frame ground to generate a triple-band CP wave. A rectangular strip found to reduce the noise bandwidth and increase gain. The antenna is simulated using ansoft HFSS with its characteristics parameters and the corresponding responses are obtained. The measured 3 dB bandwidths are (2.83~2.98 GHz), (5.68~5.82 GHz), and (8.59~8.70 GHz). This antenna is very much suitable for Bluetooth, HiperLAN and X band applications. The antenna operates under frequency such as 2.8 GHz, 5.7 GHz and 8.6 GHz. The return loss at these frequencies obtained as -22 dB, -40 dB and -23 dB respectively.

Table 1. Design parameters

Design parameters	Values
Substrate	FR4
Thickness	2 mm
Dielectric Permittivity	4.4
Loss Tangent	0.025
Ground Plane	50 x 50 mm²
Slot 1	15 x 15 mm²
Feeding Method	Microstrip Feedline

SIMULATION RESULT FOR RETURN LOSS

The simulation based analysis of the proposed antenna is done using HFSS software.

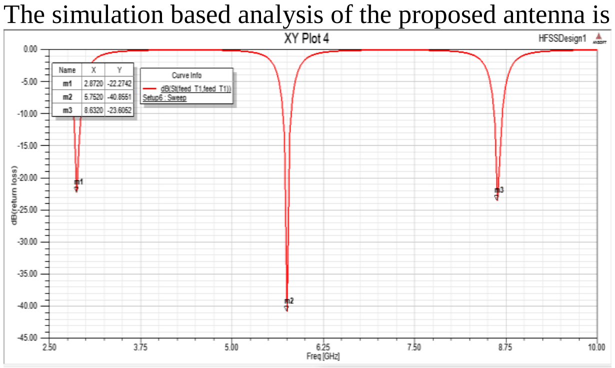

Fig. 2 Simulation result for Return Loss

In this section the return loss, radiation pattern, gains are analyzed for the L-Shaped microstrip patch antenna. Return loss shows the level of the reflected signal with respect to the incident signal in dB. The negative sign is dropped from the return loss value, so a large value for return loss indicates a small reflected signal. The return loss of a load is merely the magnitude of the reflection coefficient expressed in decibels. The Fig. 2, shows the return loss of L-Shape antenna. It illustrates the simulated and measured BWs and antenna gain. The measured 3-dB BWs are (2.40~3.45 GHz), (4.65~7.27 GHz), and (8.13~8.66 GHz). Simulation results shows band selection at three frequencies, 2.8 GHz, 5.7 GHz and 8.6 GHz. The return loss is obtained as -22 dB, -40 dB and -23 dB respectively at these frequencies.

3. SIMULATION RESULT FOR RADIATION PATTERN

The simulated gain and radiation efficiency of the antenna are shown below. The gain of the antenna was measured at far field using HFSS. The antenna gain shows a stable performance over the proposed bands. Radiation pattern along XY, YZ, and XZ planes observed in the HFSS simulation tool. The relationship between azimuth and elevation angles theta and phi and the planes are given in table 2.

Table 2. Angles and Planes in the Radiation Pattern

	Theta (deg)	Phi (deg)
XY	0	All values
YZ	All values	90
XZ	All values	0

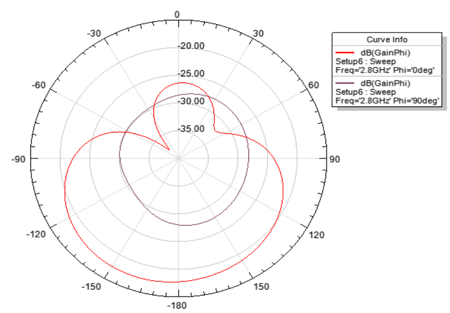

Fig. 3 Radiation Pattern of L-Shape Antenna (2.8 GHZ Gain Phi)

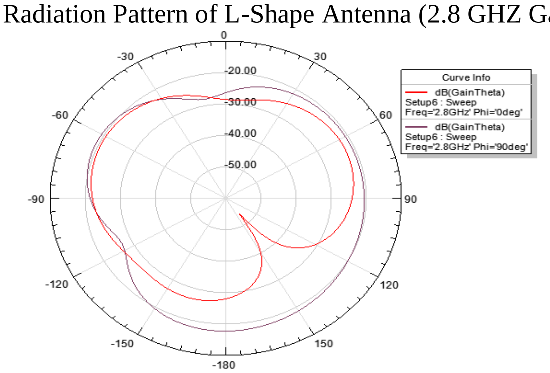

Fig. 4 Radiation Pattern of L-Shape Antenna (2.8 GHZ Gain theta)

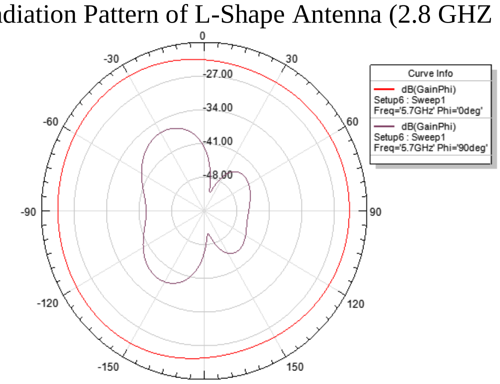

Fig. 5 Radiation Pattern of L-Shape Antenna (5.7 GHZ Gain Phi)

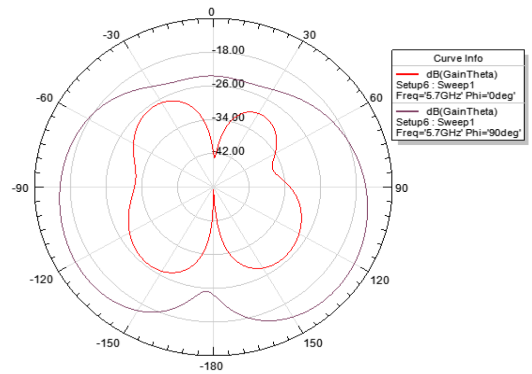

Fig. 6 Radiation Pattern of L-Shape Antenna (5.7 GHZ Gain theta)

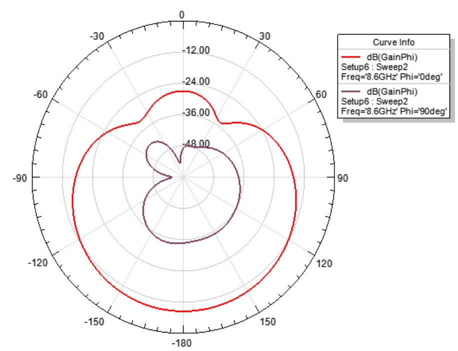

Fig. 7 Radiation Pattern of L-Shape Antenna (8.6 GHZ Gain Phi)

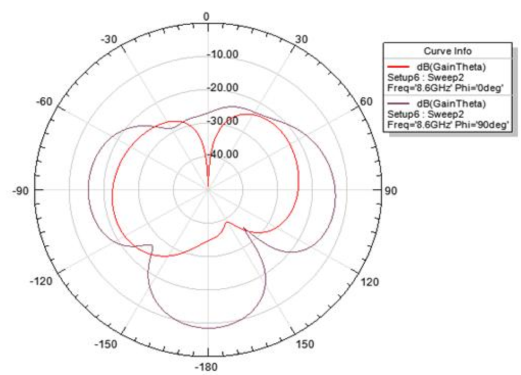

Fig. 8 Radiation Pattern of L-Shape Antenna (8.6 GHZ Gain theta)

The above figs. shows the simulated normalized radiation patterns at 2.8, 5.7 and 8.6 GHz (XZ-Plane and YZ-Plane) respectively. The value on the perimeter of the circle is values for Theta while the values inside the circle are radiation intensity values. This is polar plot of antenna gain versus angle (theta or phi in spherical coordinates).The values inside the circle are gain values in dB.

4. CONCLUSION

Design and implementation of triple-band circularly polarized microstrip antenna is presented in this paper. This antenna uses an L-shaped radiator and a lower frame ground to generate a triple-bands. This antenna uses an L-shaped radiator along with a rectangular patch structure and a lower frame ground to generate a triple-band CP wave. A rectangular strip found to reduce the noise bandwidth and increase gain.

The antenna is simulated using ansoft HFSS with its characteristics parameters and the corresponding responses are obtained. The measured 3 dB bandwidths are (2.83~2.98 GHz), (5.68~5.82 GHz), and (8.59~8.70 GHz). This antenna is very much suitable for Bluetooth, HiperLAN and X band applications. The antenna operates under frequency such as 2.8 GHz, 5.7 GHz and 8.6 GHz. The return loss at these frequencies obtained as -22 dB, -40 dB and -23 dB respectively.

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