Enhanced Performance Of CPW-Fed Circularly Polarized MIMO Antenna

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Abstract. The circularly polarized MIMO(multiple input multiple output) antenna is used to improve the bandwidth.The antenna is based on coplanar waveguide (CPW)-fed monopole extension of an microstrip line. The orthogonal field components required by circular polarization are induced by using a modified left/right side ground plane. In specific, a stub extending from the ground plane along with the length of the microstrip line is vertical component and the current along the width of the ground plane is horizontal component. A coplanar waveguide feeding is used with asymmetrical ground planes along the longitudinal axis of the microstrip line. One side of the ground plane is etched to create a loop-like path for the current flow. The proposed MIMO antenna features $|S_{11}| \leq 10$ dB and $|S_{21}| \leq 22$ dB from 5.1 GHz to 6.4 GHz. The antenna can operate in either uni-directional or bi-directional characteristics. It also includes multiple commerical application band like WLAN,ISM higher bands and U-NII bands.

Keywords. CircularPolarization-CP**,** Coplanar wave guide –CPW.

1. Introduction

MIMO is the multiple input multiple output antenna technology for wireless communications ,where multiple antennas are used in both source and the destination to receive and transmit electromagnetic waves. CP is a electromagnetic field wave in which a polarisation state at a point have a constant magnitude but it rotates in a direction at a constant rate for a perpendicular direction of planar wave. Microstrip is the transmission line which consists of a conductor with the dielectric substrate fabricated on a grounded plane. Coplanar waveguide is a planar transmission line fabricated by PCB board technology. CPW-fed antenna has important features like wide bandwidth ,easy integration and improving impedance with active devices. In this paper the antenna was designed to improve the bandwidth . The antenna is based on a simple coplanar waveguide (CPW)-fed monopole extension of the microstrip line. A stub extending groundplane called vertical component and the current along extending groundplane called vertical component and the current along Ws × Ls is 36.48×13.77 mm. The FR4 substrate is used to design antenna . The dielectric constant of FR-4

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substrate is 1.6 with thickness 0.035 mm. The software used here CST STUDIO SUITE Software. Two different designs are simulated and compared in this paper with circular polarization MIMO antenna to improve bandwidth .

2. Related Works

The multiple-input-multiple-output (MIMO) technology is the wireless communication which has more improvement in the effciency and spectral communication links [1] [2]. The MIMO will send and receive more number of streams and data over multiple channels and improves the data rates ,link reliability and the channel capacity which limits bandwidth and power[3]. The MIMO systems will have a capacity to demonstrate in increasing the overall capacity system in a high multipath environment[4][5]. The MIMO wireless communications technology will be inferred in the state of current trending communication systems. The major factor will be increasing in industry demands. The system capacity in overall current 4G standard as well as the future 5G standards[6].The design of modern and improving MIMO systems will be in wireless industry. In specific, the performance of the MIMO it can be further more improved by parallel channels provided in data transmitter and receiver are uncorrelated [7][8]. The antenna can be correlated by implementing various isolation techniques for reducing the mutual coupling inbetween radiators. The upcomings of these techniques includes complexity and high cost of circuit [9][10]. Spatial diversity is an effective in improving isolation of an antenna and thus it reduces the correlation inbetween the MIMO antennas[11]. In this method, the antennas are basically separated from each other in the minimum allowance of edge-to-edge distance in half a wavelength [12].The disadvantage of this technique is mainly electrically large antenna, which Increase the physical size of the undesired structure [14][15].

3. Antenna Design And Analysis

Antenna is designed to improve the bandwidth. The stub extending from the ground plane along with the length of the microstrip line is vertical component and the current along the width of the ground plane is horizontal component. One side of the ground plane is

etched to create a loop-like path for the current flow and same design is mirrored in right side with distance d.The substrate used here is FR4 The patch designs are calculated by below formulas (1-5). The proposed MIMO antenna results $|S_{11}| \leq 10$ dB and $|S_{21}| \leq 22$ dB from 5.1 GHz to 6.4 GHz.

Width (W) - $w = \dfrac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}}$ --(1)

Effective Dielectric Constant $\varepsilon_{eff} = \dfrac{\varepsilon_r+1}{2} + \dfrac{\varepsilon_{r-1}}{2}\left[1 + 12\dfrac{h}{w}\right]^{\frac{1}{2}}$----------(2)

Effective length $L_{eff} = \dfrac{c}{2f_0\sqrt{\varepsilon_{eff}}}$ ---------------------------------------(3)

length extension $\Delta L = 0.412h\,\dfrac{(\varepsilon_{eff}+0.3)\,(\frac{w}{h}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{w}{h}+0.8)}$ -----------------(4)

length of the patch $L = L\varepsilon_{eff} - 2\Delta L$ --------------------------------(5)

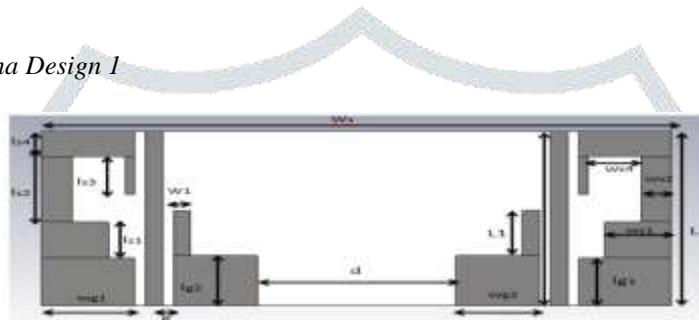### 3.1. Layout Of Proposed Antenna Design 1

Figure 1. Layout Antenna Design1

Fig.1 represents the layout of antenna design 1 and the measurement values are given in the table 1. The antenna is designed by using CST software .The dimension of Ws × Ls is 36.48 × 13.77 mm. The FR4 substrate is used to design antenna . The dielectric constant of FR-4 substrate is 1.6 with thickness 0.035 mm The left side of the design is mirrored in the right side with distance 10.5 mm distance d. Stub is placed in between ground plane .

Table 1: Proposed Values Of Antenna Design1

Parameters	Value in mm	parameters	Value in mm
Ls	13.77	W1	1
Ls1	2 .85	L1	3.5399
Ws1	3.8625	Lg2	3.95
D	10.5	Wg2	4.8625
Ls2	5.17	Ls3	3
Ws2	1.75	Ws3	0.5
Lg1	3.75	G	0.6325
Wg1	5.3625	Ls4	2
Ws	36.48	Ws4	5.3625

3.2. Layout Of Proposed Antenna Design 2

Fig.4 represents the layout of antenna design 2 and the measurement values are given in the table 2. The dimension of Ws × Ls is 36.48 × 13.77 mm. The FR4 substrate is used to design antenna . The dielectric constant of FR-4 substrate is 1.6 with thickness 0.035 mm The left side of the design is mirrored in the right side with distance 10.5 mm distance d. Stub is placed in between ground plane.
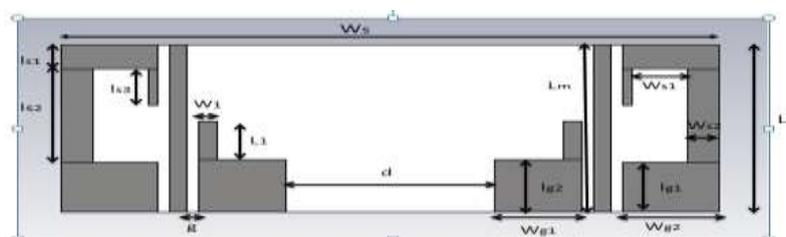

Figure 4.Layout Antenna Design 2

Table 1. Proposed Values Of Antenna Design1

parameters	Value in mm	Parameters	Value in mm
Ls	13.77	W1	1
Ls1	2	L1	3.169
Ws1	5.3625	Lg2	4.3
d	10.5	Wg2	4.8625
Ls2	7.67	Ls3	3
Ws2	1.75	Ws3	0.5
Lg1	4.1	g	0.6325

3. Simulated Results

Fig.7 shows the simulation of reflection coefficient S_{11} is -34.367dB at operating frequency 5.6 GHz and bandwidth 1.27 GHz and Fig.8 shows the simulation of S_{21} is -37.704 dB at operating frequency 5.6GHz and bandwidth 1.27GHz for proposed design1.
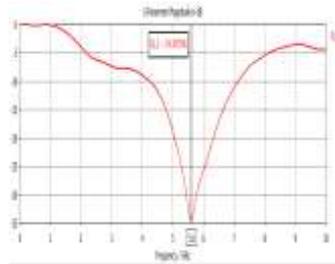

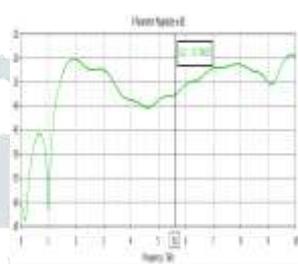**Figure 7.** S_{11} simulation for 2.5GHz   **Figure 8.** S_{21} simulation for 2.5GHz

Fig.9 shows the simulation of reflection coefficient S_{11} is -27.696 dB at operating frequency 5.6 GHz and bandwidth 1 GHz and Fig.10 shows the simulation of reflection coefficient of S_{21} is -38.315 dB at operating frequency 5.6 GHz and bandwidth 1 GHz for proposed design 2.
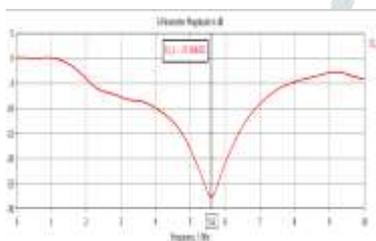

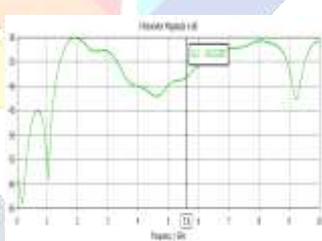**Figure 9.** S_{11} simulation for 2.5GHz   **Figure 10.** S_{21} simulation for 2.5GHz

Table 3. Comparison Of Proposed Antenna Designs 1 & 2

Parameters	Proposed design 1	Proposed design 2
Dimensions in mm	36.48×13.77	36.48×13.77
Frequency	5.6 GHz	5.6 GHz
S_{11} in dB	-34.367	-27.696
S_{21} in dB	-37.704	-38.315
Bandwidth	1.27 GHz	1 GHz

Table.3 represents the Comparison of proposed antenna designs 1 & 2 in which design 1 obtain the reflection coefficient S_{11} as -34.367 dB and S_{21} as -37.704 dB and results bandwidth of 1.27 Ghz and design 2 obtain the reflection coefficient S_{11} as -27.696 dB and S_{21} as -38.315 dB and results bandwidth of 1 Ghz.

5. Conclusion

In this paper, the proposed MIMO antenna is designed by CST software. Two antenna design is designed and simulated .The dimension of the antenna Ws × Ls is 36.48 ×13.77 mm. The first design obtain 1.25 GHz bandwidth and the second design obtain 1GHz bandwidth.Thus the required output is achieved for wideband antenna and it results $|S_{11}| \leq 10$ dB, average isolation $|S_{21}| \leq 22$ dB from 5.1 GHz to 6.4 GHz. Bandwidth is improved by the design using circularly polarized MIMO antenna. The advantage of this project is high efficency with low cost and improves bandwidth for high range of communication purpose.The antenna can be operated with either bi-directional or uni-directional characteristics and covering multiple commercial application bands including WLAN, U-NII band and ISM higher bands.

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