Four Element Modified Rectangular Slotted Antenna for Wireless Application

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Abstract

The creation of low-cost, low-profile, light-weight antennas that can sustain good performance across a broad spectrum of frequencies is now necessary due to the advancement of communication systems. A four-element, slotted, modified, compact MIMO antenna is suggested. The suggested patch antenna is created using the optimal Envelop correlation coefficient and tested using the CST microwave studio software. Quarter wave feed line and slot lessen the impact of mutual coupling between radiating elements. The size of single antenna is 24 x 27 mm^2. The obtained isolation is more than 20 dB in proposed band. The bandwidth of proposed antenna is 3.7 GHz which is ranges from 10.0 to 13.8 GHz. The proposed antenna has a directivity of 6.12 dBi, a gain of 4.23 dBi, and an ECC.

Keywords: MIMO, Antenna Design, Bandwidth, directivity, surface current distribution

1.INTRODUCTION

In recent years, there has been an increase in demand for additional services and features for mobile equipment. [1-3]. A larger data rate is required for these new functions and services to operate effectively. GPS, Wi-Fi, Bluetooth, infrared, and other features are now commonplace in mobile devices. To transmit and receive signals, all of these applications require an antenna. The antenna's isotropic radiation, improved radiation efficiency, compact design, efficient impedance matching to receive and transmit paths, and ease of construction are required for optimum antenna system performance. A correct antenna design should be taken into account because a change in any physical parameter [4-7] may have an effect on the antenna's effectiveness and bandwidth.

The utilization of multiple antenna systems using MIMO [8-12] technology to transmit the same power utilizing. The interest in antennas at the transmitter and receiver has increased recently because it increases channel capacity without consuming more bandwidth or power. The MIMO technology has some challenges like isolation amongst ports [13-16]. The good isolation is achieved by some techniques like parasitic elements between the radiators, metamaterials, isolating networks, SSR resonators, orthogonal polarization techniques etc. [17-22].One can find several applications wherein proposed research work [23-29] may be implemented. In the present work, we propose a multi-input multi-output (MIMO) antenna operating at 12.1 GHz..The antenna system's component antennas are placed close to one another [30-37].

2.ANTENNA DESIGN

Design Parameters- A single patch's design parameter is calculated. On a FR-4 substrate, a patch antenna operating at 12.1 GHz is currently being developed. The FR-4 substrate is 1.524 mm tall with a dielectric constant of 4.3. Width and length of patch antenna can be calculated by the equations 1 to equation 4.

For Width B

From equation (1),

$$\mathbf{B} = \frac{c}{2f_r\sqrt{\frac{\epsilon_r+1}{2}}} \quad \text{..................(1)}$$

For Length,

Effective dielectric constant from equation (2),

$$\boldsymbol{\epsilon_{reff}} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\left[1 + 12\frac{h}{B}\right]^{-\frac{1}{2}} \quad \text{..............(2)}$$

The additional length derived from equation (3)

$$\Delta\mathbf{L} = 0.412\frac{(\epsilon_{reff}+.3)(\frac{B}{h}+0.264)}{(\epsilon_{reff}-.258)(\frac{B}{h}+0.8)} \quad \text{... ... ...(3)}$$

Now, the equation (4) can be used to determine the patch antenna's effective length.

$$\mathbf{L_{eff}} = \frac{\mathbf{c}}{\mathbf{2f_r\sqrt{\epsilon_r}}} - \mathbf{2} \times \Delta L \text{……….(4)}$$

The geometry of the suggested MIMO antenna system is shown in Figure 1(a) and (b).The antenna system is made up of four radiating elements that are printed on a shared FR4 substrate that is 1.524 mm thick and 24 x 27 mm^2 in size. The substrate has a dielectric constant of 4.3. The radiator is a rectangular patch, and A 50 micro strip line separately feeds each radiator. The antenna is 96 x 27 mm^2 in total. Table 1 listed the optimized data of antenna.

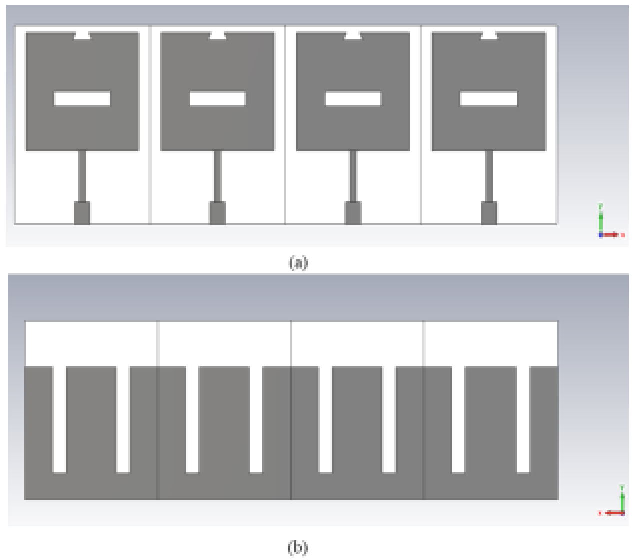

Figure 1. (a) Front view of antenna (b) Back view of antenna

Table 1: Optimized dimensions of suggested MIMO antenna

Parameter	**Description**	**Size in mm**	**Material**
Sw	Substrate width	24	FR-4 (Dielectric cont. 4.3)
Sl	Substrate Length	27	FR-4 (Dielectric cont. 4.3)
Sh	Substrate height	1.524	FR-4 (Dielectric cont. 4.3)
Gw	Ground Width	24	PEC (Copper)
Gl	Ground Length	20	PEC (Copper)
Gh	Ground Height	0.07	PEC (Copper)
Pw	Patch Width	20	PEC (Copper)
Pl	Patch Length	16	PEC (Copper)
Ph	Patch height	0.07	PEC (Copper)
Slot width	-pw/4 to pw/4	10	Nickle
Slot height	----	2	Nickle
Fw1	Upper Feed width	1.1	PEC (Copper)
Fl1	Upper Feed length	7	PEC (Copper)
Fw	Bottom Feed width	2.3	PEC (Copper)
Fl	Bottom Feed length	3	PEC (Copper)

3.RESULT AND DISCUSSION

Software called CST MICROWAVE STUDIO is used to simulate a four-element MIMO antenna. At resonance frequency 12.1 GHz, the simulated values of S-parameters and bandwidth are got and isolated. The results of simple rectangular patch antenna shows in figure 2 which resonate at 12.1 GHz and return loss of -49 dB and In the whole frequency range, isolation The result of same antenna with only S11 parameter and isolation coefficient is discussed separately.

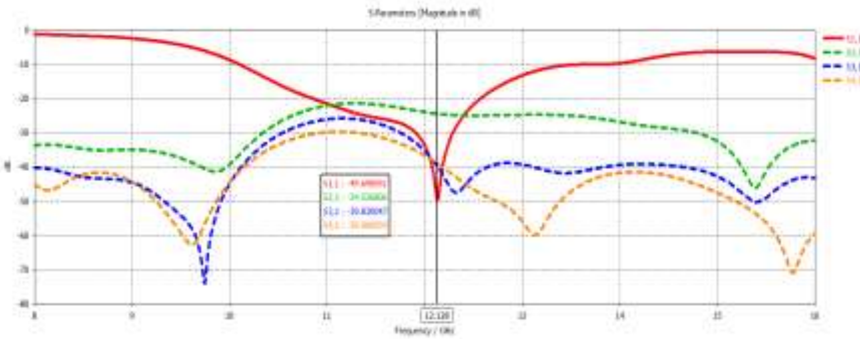

Figure 2: S-parameter MIMO antenna

The suggested basic rectangular microstrip patch antenna's bandwidth graph is shown in figure 3, along with antennas with parasitic and slotted ground. The proposed simple antenna is obtained bandwidth of 3.7 GHz.

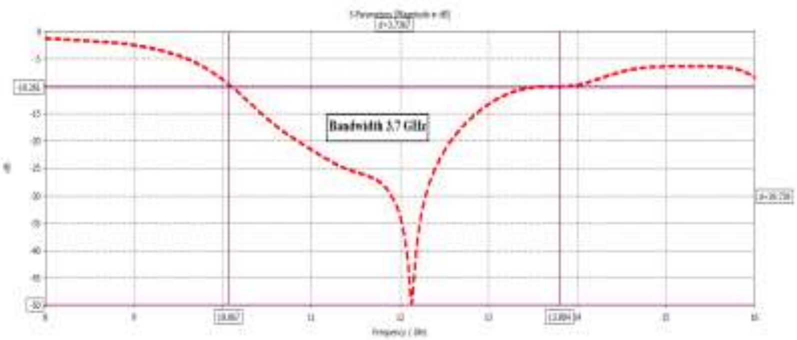

Figure 3: Bandwidth of proposed MIMO antenna

At 12.1 GHz resonant frequency, the far-field radiation patterns of a 4-port MIMO antenna are measured. E- and H-modules can be used to define the effects of a simulated distant field on four-element MIMO E- and H-planes. According to figures 4 to 7, the proposed antenna's directivity is 6.12 dBi and its gain is 4.23 dBi. The envelope correlation coefficient "" in a MIMO antenna system illustrates the impact of various radio frequency signal propagation channels that disperse the antenna components. The envelope correlation coefficient calculates the correlation between the radiation patterns of MIMO receiving antenna pairs (ECC). Its values vary from 0 to 1, with 0 signifying no connection and 1 signifying complete correlation of the radiation patterns. The graphic clearly shows that the suggested structure's ECC is below 0.008. Here, the dispersal of surface current at the antenna system patch is predetermined. An analytical picture of the amount and direction of current flow in the antenna is provided by surface current. Additionally, it is the current direction of current flow. One port is activated, while the remaining ports are turned off by 50, to detect the impact of surface current distribution on the antenna.

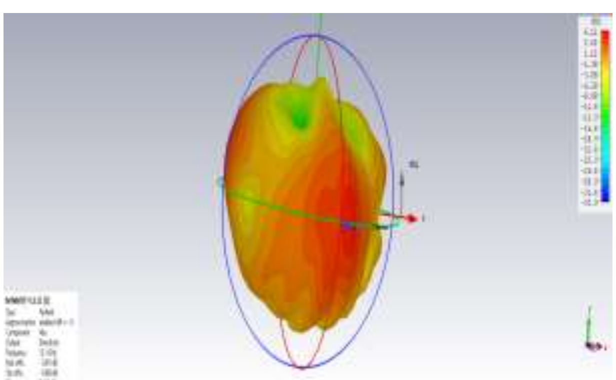

Figure 4: Directivity of antenna

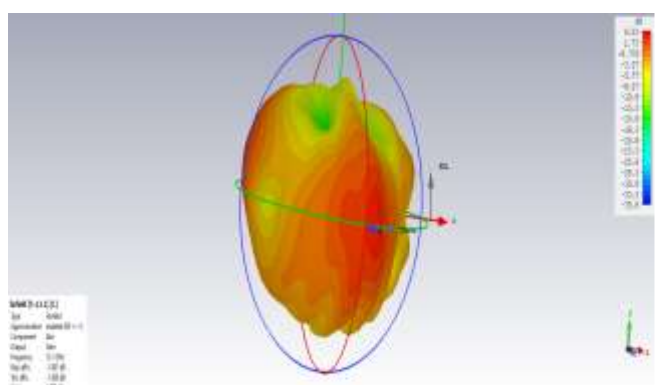

Figure 5: Gain of antenna

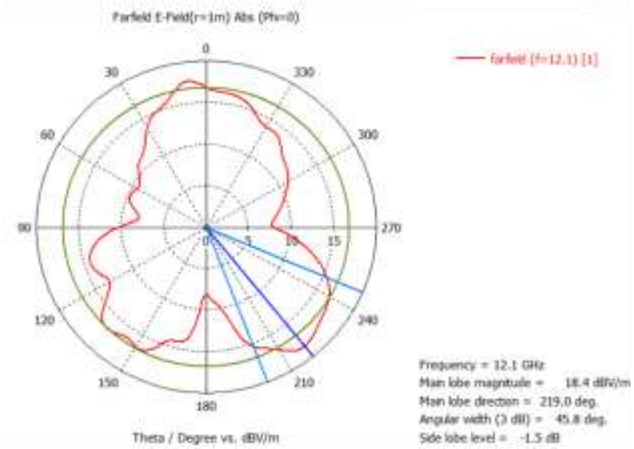

Figure 6: E-field

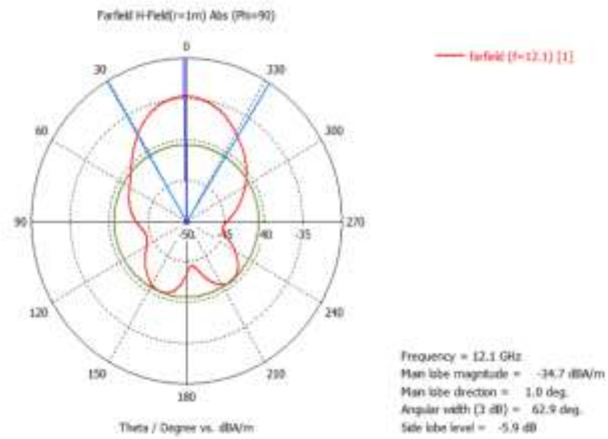

Figure 7: H-field

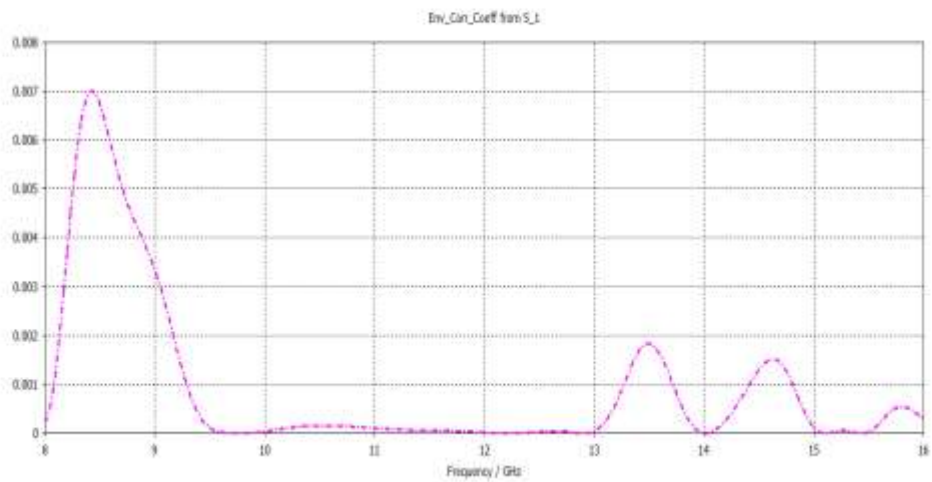

Figure 8: ECC structure

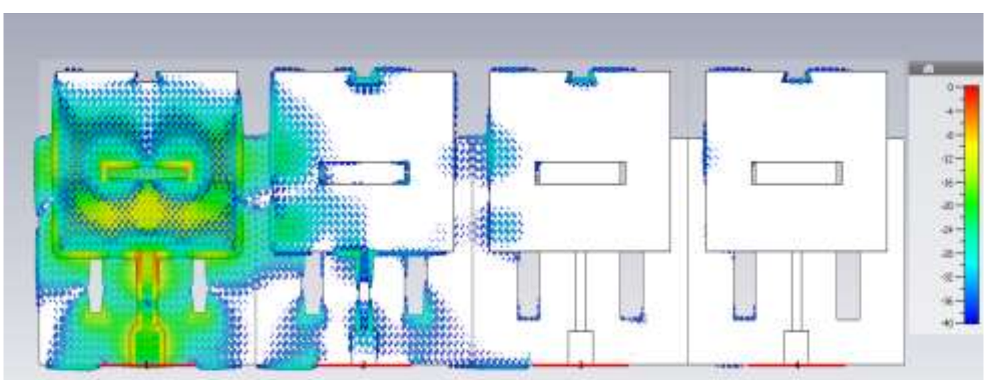

Figure 9: Surface current distribution of antenna when port 1 excited.

4.CONCLUSIONS

For wireless communication at 12.1 GHz, a small four-element single-band MIMO antenna with modified rectangular geometry is presented. Through the use of slotted arrangements and modified ground, the influence of conjoint coupling between radiating elements is lessened. The frequency bands have minimal ECC and encompass the range of 10–13.7 GHz. The suggested antenna is 96 x 27 mm2 in total. The results also showed that this antenna operates efficiently over its whole operational bandwidth. The obtained isolation between radiating elements is greater than 20 dB At 12.1 GHz, the obtained gains were more than 4 dBi for each antenna. ECC is measured at very low resonance frequencies. This design strategy offers a wideband antenna solution with good antenna properties. The isolation between ports is increased by the slots in patches.

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