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Design and Optimization of Multiple slots Microstrip Patch Antenna for WIMAX and WLAN Applications

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Abstract: **In this paper, we present multiple L slots antenna for WIMAX and WLAN applications. wideband microstrip patch antenna for wireless applications. The coplanar waveguide fed microstrip patch antenna comprises of four rectangular patch array each embedded on three L slots and a Plus slot either on the patch or on the ground plane or on both the patch and the ground plane. The design results in reduction in weight, size and allow easily integration in hand held device. Proposed antenna is designed using IE3D and results are analysed by comparing the gain, return loss, directivity, bandwidth and VSWR with the designed antenna.**

I. INTRODUCTION

In the present scenario of wireless communication, there is need of compact and communication system so multiband antennas are essential. Generally small antennas capable of resonating at multiple bands are in countless demand. One of procedure to reduce area is to make use of fractal geometry. Fractal geometries have been executed in several antennas and resonators. There are several advantages of fractal Microstrip antennas. With the rapid development of wireless communication, reconfigurable antennas are attaining huge demand. They are lighter in weight, smaller in size and of low cost. Point to point communication transports a fundamental responsibility to antennas since they are expected to provide the wireless transmission between those devices, moreover being able to indicate good signal to noise ratio and resistance to noise, the antennas in microwave links will have portray compact structures and ease of construction to be mounted on several devices. In high performance point to point communications where size, weight, cost, performance and ease of installation are very much necessary, microstrip antennas are favoured. They are currently one of the fastest growing segments in the telecommunications trade. Microstrip antenna consists of 3 layers which are patch, ground and substrate. Microstrip antenna consists of metallic portion patch on one side of dielectric substrate and ground on the other side. There are different feeding techniques like Microstrip line feed, Coaxial Feed, Aperture Coupled Feed and CPW (Coplanar Waveguide). In this Microstrip Line feed has been used. The patch antennas have been used in many fields such as mobile, radar, GPS system, Bluetooth, aircraft, military hardware, satellite broadcasting communication etc. Narrow bandwidth and low gain are two major drawbacks that limit the applications of microstrip antennas. Thus, the size reduction with gain and bandwidth enhancement has become a major consideration in the microstrip patch antennas. Microstrip antennas are less bulky and capable of resonating at different bands but they suffers from disadvantages like low bandwidth, low gain, poor polarization, high Q and small efficiency. There are number of techniques for improving characteristics of patch antenna which include making use of fractal geometry, defected ground structure and cutting slots in patch. Fractal means broken or uneven fragments. Further antenna may resonate at multiple bands as current has to travel long way path due to application of fractal geometry. In this antennaby using fractal geometry algorithm multiple slots microstrip patch antenna has been proposed. Results have been attained in IE3D software.

II. ANTENNA DESIGN

The schematic configuration of Microstrip patch antenna embedded with multiple L Slots and a Plus Slot. By applying fractal geometry on the patch, area of patch decreases and resonant length increases. This algorithm has been applied to square as shown in figure 1. Using a square of length 20 mm and by cutting 3 L slots and a Plus Slot using rectangular patch array. Wideband Microstrip patch antenna is shown in figure 2 has been formed. The table I mentioned below shows the dimensions of proposed microstrip patch antenna. The substrate materialFR4 epoxy substrate with dielectric constant of 4.4 and loss tangent of 0.02 has been used. A Microstrip Line feed with feed point coordinates (0, 13.75, 0) are selected in such way that impedance matching takes place.

Table I. Antenna Dimensions

Parameter	Value
Length of patch	20 mm
Width of patch	20 mm
Dielectric constantof substrate	4.4
Loss tangentof substrate	0.02
Feed to Patch	Microstrip Line

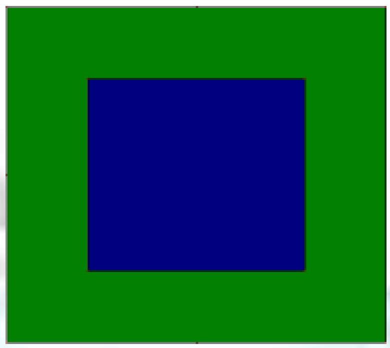

Figure 1. Basic Square Geometry

The Radiation pattern is fed by coplanar waveguide transmission line. The dimension of slots is adjusted to emit in resonant frequency range. The dimensions of slots are carefully chosen in such a way that it produces wider bandwidth.

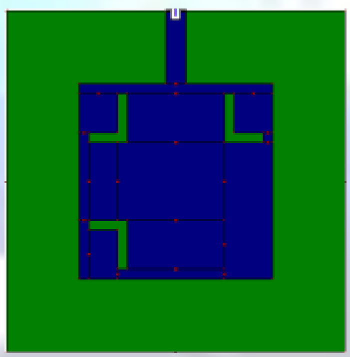

Figure 2. Microstrip antenna with 3L slots

The design with 3L slots is shown in figure 2.Furthur this antenna is redesigned and results of the antenna are compared with the antenna and best results are considered.

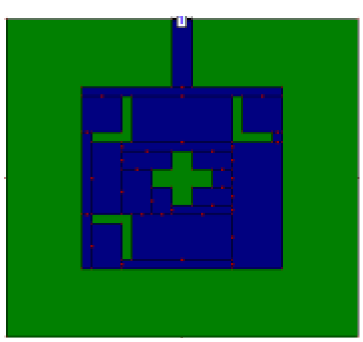

Figure 3. Wideband Microstrip Antenna with 3L slots and Plus slot on patch

Figure 3 shows the antenna with 3L slots and a plus slot on the patch.

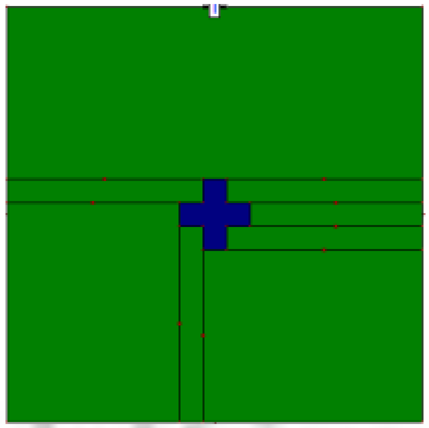

Figure 4. Microstrip antenna with 3L slots and a Plus slot on Ground

Figure 4 shows the Microstrip antenna with 3L slots and a Plus slot on the Ground.

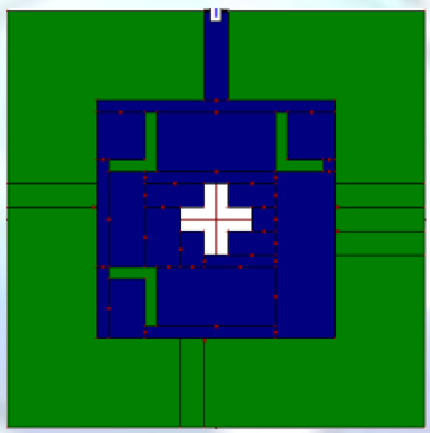

Figure 5. Microstrip antenna with 3L slots and a Plus slot on both the Patch and Ground

Figure 5 shows a Microstrip antenna with 3L slots and a Plus slot on both the Patch and Ground. The results of all the four antenna are calculated and compared.

Microstrip patch antenna is capable of producing omnidirectional radiation pattern. The consequence of ground location on this type of antenna is very important. The proposed antenna is designed with FR4 epoxy substrate with dielectric constant 4.4 and loss tangent 0.02. The gap between ground and the patch is 3 mm. The length of patch is 20mm.

Initially a square of 20 X 20 mm is used. The double L slot antenna is further redesigned to produce antenna with 3L slots and Plus slot either on ground or on patch or on both the ground and the patch. To meet the design requirement i.e. operating frequency, bandwidth, radiation pattern and some other approximations are considered. The dielectric constant of substrate is given as:

$$\epsilon_{r_{eff}} = \left(\frac{\epsilon r+1}{2}\right) + \left(\frac{\epsilon r-1}{2}\right)\sqrt{\left[1+12\left(\frac{h}{w}\right)\right]} (1)$$

Where ϵr is dielectric constant of substrate

The normalised length of patch is calculated as:

$$\Delta L = 0.412h\frac{(\epsilon_{r_{eff}}+0.3)(\frac{w}{h}+0.264)}{(\epsilon_{r_{eff}}-0.258)(\frac{w}{h}+0.8)} \quad (2)$$

Where, w is width of Patch and h is the height of substrate.

The actual length of patch is expressed as:

$$L_{eff} = L + 2\Delta L \quad (3)$$

The width and effective length of microstrip patch antenna are calculated by

$$w = c/2\sqrt{(\epsilon r + 1)} \quad (4)$$

$$L_{eff} = \frac{c}{2f_o\sqrt{\epsilon_{reff}}} \quad (5)$$

Where fo is resonant frequency.

Using above calculations the dimensions of antenna are calculated.

III. Results And Discussions

After making multiple 3L slots and a Plus shaped slot geometry on square patch of length 20 mm using FR4 epoxy substrate of thickness 2.6 mm wide band microstrip patch geometry has been formed. Antenna as shown in figure 2 resonates at 3.5 GHz, with a return loss of -12.54 dB, 2.72dBi of gain and at 9.0 GHz, with a return loss of -17.67 dB, 5.32 dBi of gain. Antenna as shown in figure 3 resonates at 3.4 GHz, with a return loss of -13.65 dB, 2.65336dBi of gain and at 9.0 GHz, with a return loss of -19.45 dB, 5.34171dBi of gain. Antenna as shown in figure 4 resonates at 3.4 GHz, with a return loss of -11.93 dB, 2.63549 dBi of gain and at 8.9 GHz, with a return loss of -24.98 dB, 5.21681dBi of gain. Antenna as shown in figure 5 resonates at 3.4 GHz, with a return loss of -13.41 dB, 2.21795dBi of gain and at 8.9 GHz, with a return loss of -24.24 dB, 5.4142dBi of gain. Figure 6 shows return loss vs. frequency graph for wideband microstrip antenna.

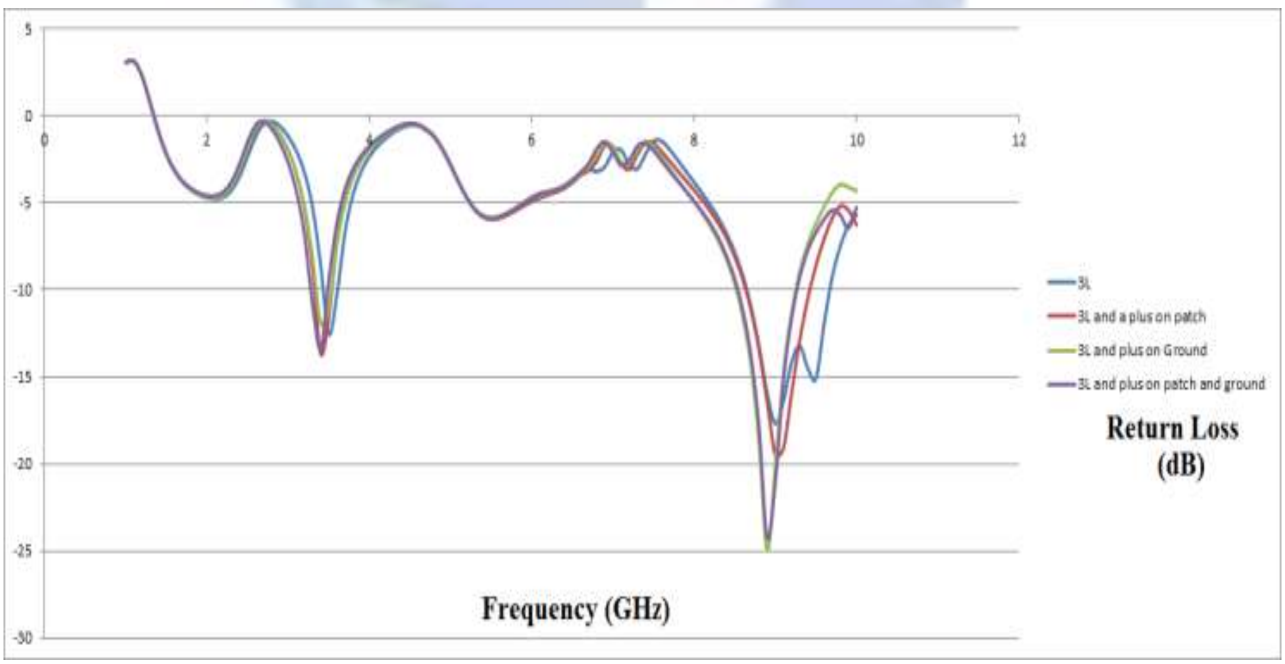

Figure 6. Return Loss vs. Frequency for Multi Slot Microstrip Antenna

The return loss below -10 dB is sufficient for radiations.

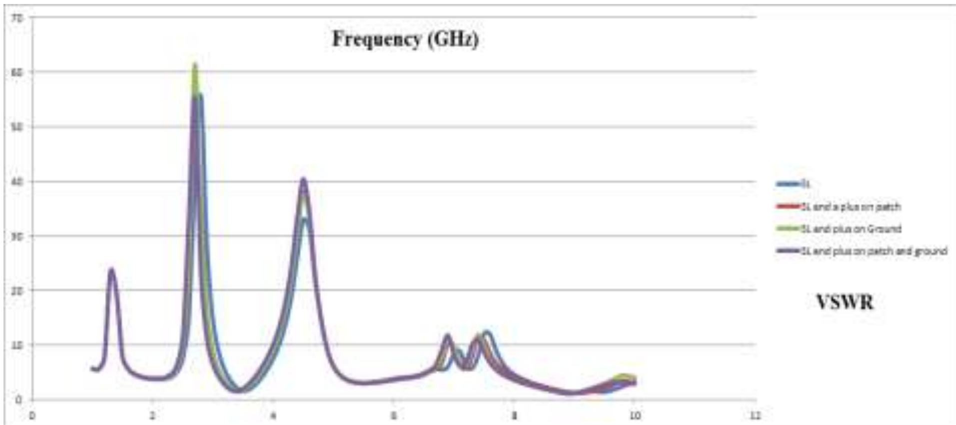

Figure 7. VSWR vs. Frequency

Figure 7 shows VSWR vs. Frequency of Wideband Microstrip Patch Antenna. VSWR describes how well antenna impedance matched to transmission line to which antenna is connected. Value of VSWR is greater than or equal to one

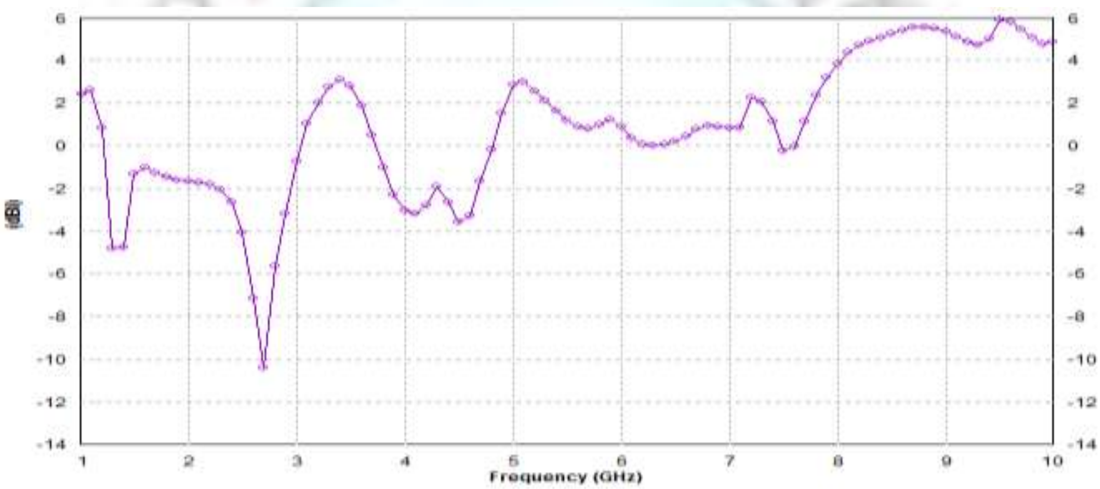

Figure 8. Gain vs. Frequency for Wideband Microstrip antenna with 3L slot

The Gain vs. Frequency of Wideband Microstrip Patch Antenna is shown in figure 8.

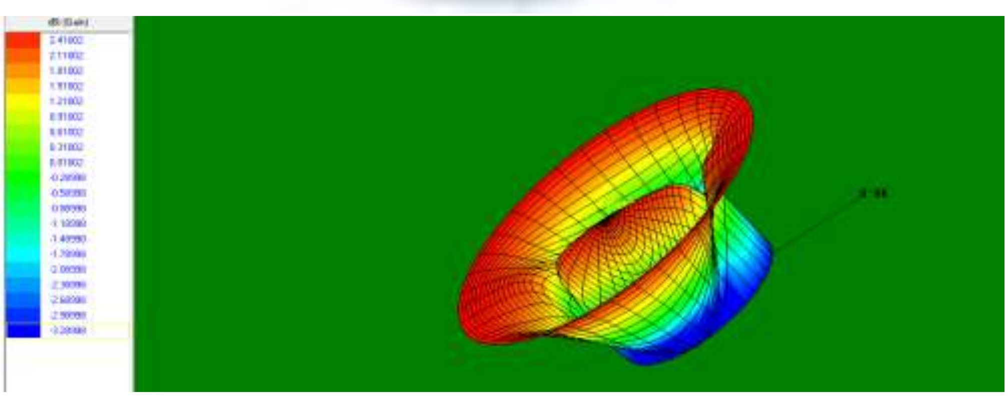

Figure 9. 3D Radiation Pattern

The 3 Dimensional radiation pattern for the Wideband Microstrip patch antenna with multiple slots is shown in figure 9.

CONCLUSION

The design of Wideband Microstrip Patch Antenna with CPW feed technology has been presented, discussed and compared with the each other. We Conclude that by employing three L shaped slots and a plus shaped slot on Ground, a good bandwidth is obtained. Further, the design result in smaller size antenna with good omnidirectional radiation characteristics for all operating frequencies. The measured result of return loss and VSWR has been presented and discussed.

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