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Modified Rectangular Patch Antenna Loaded With Multiple C Slots for Multiple Applications

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Abstract

A new multiple C- slotted microstrip patch antenna is proposed. A patch antenna is a wide-beam narrowband antenna. Microstrip patch antenna consist of a very thin metallic strip (patch) placed a small fraction of a wavelength above a ground plane. The patch can be designed in any possible shape and normally made by conducting material copper or gold. This paper presents design of a C- Slotted microstrip patch antenna for multiple applications. The proposed antenna has low cost, easy fabrication and good isolation. The antenna has Quad different frequency bands, centered at 1.60 GHz, 2.50 GHz, 4.70 GHz and 5.50 GHz for parameter S_{11}. The antenna is designed, simulated and optimized for Quad band performance using IE3D software. With C - slotted shapes patch antenna is designed on a FR4 substrate of thickness 1.59 mm and relative permittivity of 4.4. The proposed patch dimension is 16*16 mm and it utilizes microstrip line feed. By the simulated results parameter S_{11} and S_{12}, shows that the antenna can cover the bands of several applications including GPS (1.2-1.6 GHz), GSM (1.8-1.9 GHz), WiMAX (2.3-5.8 GHz). Simulation results are presented in terms of Resonant Frequency, Return Loss, Voltage Standing Wave Ratio (VSWR) and Radiation Pattern.

Keywords: Microstrip antenna, Slotted patch, GPS, GSM, WiMAX

1. Introduction

A microstrip patch antenna configuration consists of two sides: one side of dielectric and other side on ground plane. The conductors of patch are usually made of copper and sometimes in gold which can be of any shape. However, regular shapes are normally used for simplification of analysis and performance prediction. On the dielectric substrate, the radiating elements and the feed lines are photo etched. [1] Square, circular, rectangular elliptical or other irregular shapes are some of the radiating patch. But most commonly used shapes are square, rectangular and circular due to its fabrication and ease of analysis. Microstrip patch antennas have numerous advantages such as,

- Low profile, low Volume
- Fabrication cost is low
- Mass production
- Simple feed can provide easy linear and circular polarization
- Integration of MIC is easy

Patch antennas can be used in variety applications from military to commercial, because of their ease of design and fabrication. [2]

Due to the rapid developments in wireless communication, the WLAN plays a vital role for short distance communication and also users can access internet in their portable devices by using 3G/4G through the WLAN. Antenna is inherently a narrow band structure. However bandwidth enhancements usually demanded for practical applications. Application's in present day mobile communication systems usually require smaller antenna size in order to meet the miniaturization requirements of mobile unit. Thus size reduction and bandwidth enhancement are becoming major design considerations for practical applications of microstrip antennas. There are numerous methods to increase the bandwidth of antennas, including increase of the substrate thickness, the use of a low dielectric substrate, the use of multiple resonators, edge coupled parasitic patches, fractal patch and the use of slot antenna geometry. However, the bandwidth and the size of an antenna are generally mutually conflicting properties, that is, improvement of one of the characteristics normally results in degradation of the other [3-5].

Patch antennas are receiving interest in various Mobile communication systems since they can provide advantages over traditional antennas in terms of high efficiency, low EM coupling to the human head and increased mechanical reliability. In many applications the requirements on both bandwidth and physical size are quite stringent. In some applications it is desired to have a dual band or multiband characteristics [6]. These characteristics can be obtained by coupling multiple radiating elements or by using tuning devices. However these methods make antenna more complicated. A simple method to achieve the dual band characteristics in a microstrip antenna is embedding slot in the patch as the structure proposed in which the radiating patch includes a pair of step slots. Inserting a slot on the patch can reduce the resonating frequency while reducing the dimensions of the antenna. Antenna dimensions can be reduced by creating appropriate slots making antenna useful for wideband and multiband frequency application [7-9].

The proposed antenna is simulated using virtual platform IE3D [12]. This paper consists of IV sections. Brief introduction is discussed in section I. Section II describes proposed antenna design. Result analysis and performance comparison with conventional patch antenna and the modify patch antenna loaded with one, two and three slots of C is discussed in section III. Section IV concludes the paper.

2. ANTENNA DESIGN

The proposed antenna is designed on FR4 substrate with relative permittivity of 4.4 and plane at a height of 1.59. The patch antenna is modified into multiple steps to achieve proposed antenna geometry, they are as follows-

2.1 Antenna Geometry

The configuration of the proposed antenna is shown in Fig. 1 with L= W=16mm. Micro strip line fed is placed at appropriate place to match its input impedance 50 ohm. The feed line of the antenna is X=6mm, Y= 3mm. Feed point remains same for all geometries.

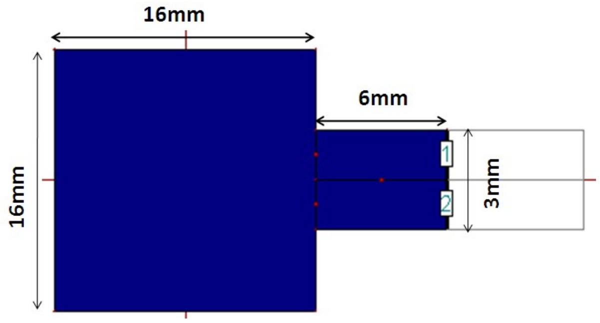

Fig. 1. Geometry of proposed microstrip patch Antenna

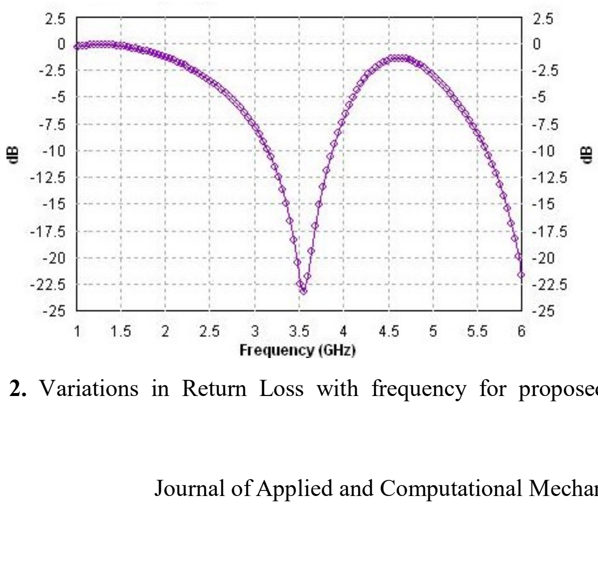

Fig. 2. Variations in Return Loss with frequency for proposed antenna

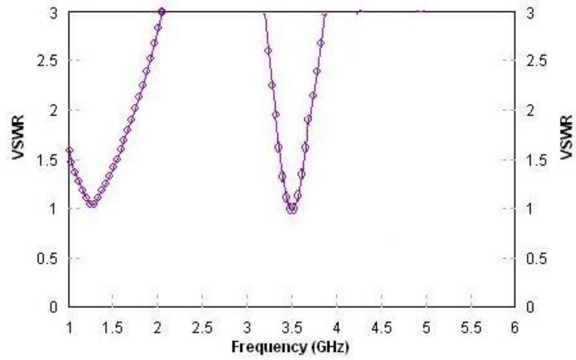

Fig. 3. Variations in VSWR with frequency for proposed antenna

Simulation results obtained for proposed square patch antenna have return loss=-22.93dB, VSWR= 1.01, input impedance = 46.41-j3.44 at resonating frequency 3.54GHz as shown in Fig. 2, 3, 4 respectively.

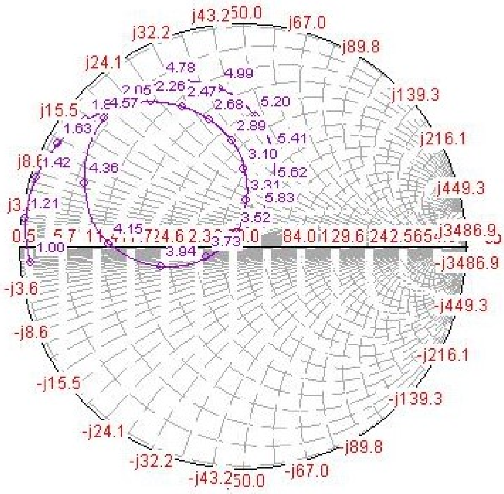

Fig. 4. Variations in input impedance with frequency for proposed antenna

Step-II Modified Microstrip patch antenna loaded with one slit of C Shape

Modified antenna consists a C shape slits with mentioned dimension etched on conventional microstrip patch antenna to increase the return loss and bandwidth as shown in figure 5.

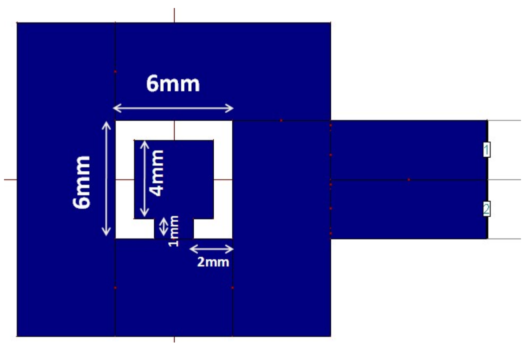

Fig. 5. Geometry of modified microstrip patch Antenna loaded with one slit of C shape

Fig.6 shows the simulated graph of return loss of modified patch antenna. As obtained from the graph the value of return loss -23.46dB at resonating frequency 3.31GHz.

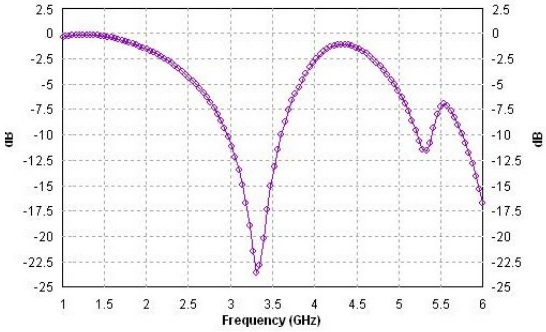

Fig. 6. Variations in Return Loss with frequency for modified microstrip patch Antenna loaded with one slit of C shape

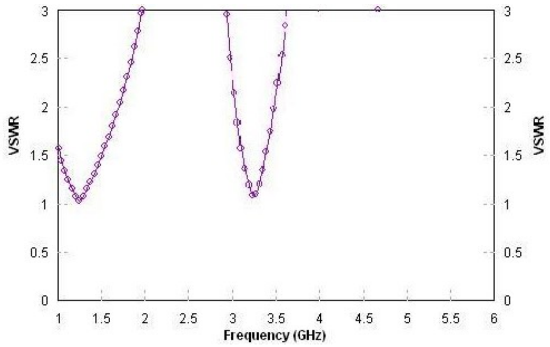

Fig. 7. Variations in VSWR with frequency for modified microstrip patch Antenna loaded with one slit of C shape

From Fig.7 the measured value of VSWR at resonant frequency is 1.06. Fig.8 depicts the simulated variation of input impedance of antenna as a function of frequency. At resonant frequency 3.31 GHz the simulated input impedance of antenna is 46.07-j3.87ohms which is in good agreement with the 50 ohms impedance of feeding network.

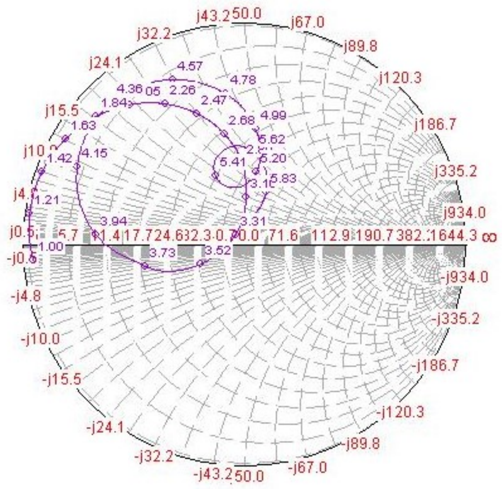

Fig. 8. Variations in input impedance with frequency for modified microstrip patch Antenna loaded with one slit of C shape

Step III Modified microstrip patch antenna loaded with two slits of C Shape

Modified antenna consists of two slits of C shape with the same slit width. The dimensions of the patch as shown in Fig.9

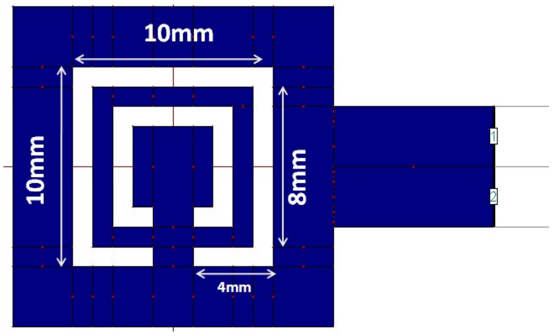

Fig. 9. Geometry of Modified microstrip patch antenna loaded with two slits of C Shape

Simulation results of modified proposed microstrip patch antenna have return loss= (-16.33dB,-23.38dB) at resonating frequency 2.30GHz & 2.9GHz as shown in Fig.10.

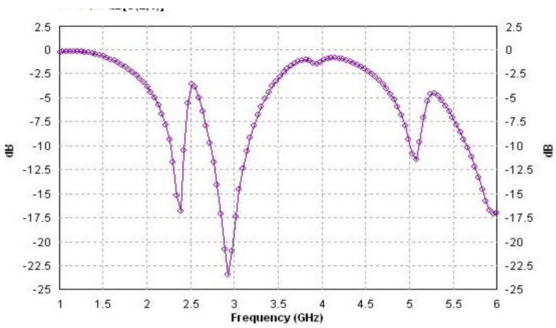

Fig. 10. Variations in Return loss with frequency for modified microstrip patch Antenna loaded with two pair of slits

The simulated variation of VSWR and input impedance with frequency is shown in Fig.11, 12 respectively. From the simulated figure the value of VSWR& input impedance is 1.09 & 44.24-j6.85 ohms respectively.

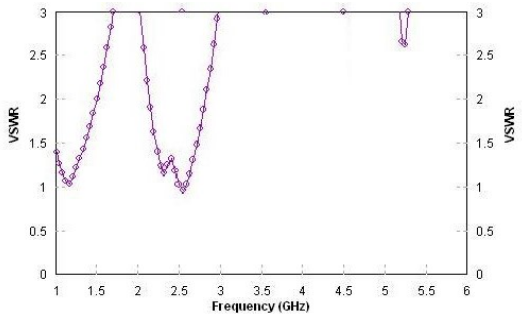

Fig. 11. Variations in VSWR with frequency for modified microstrip patch Antenna loaded with two pair of slits

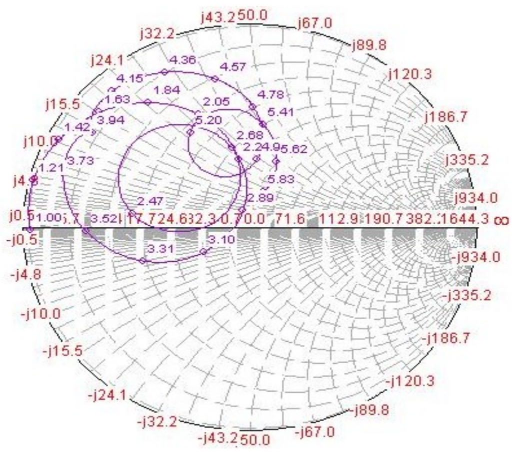

Fig. 12. Variations in input impedance with frequency for modified microstrip patch Antenna loaded with two pair of slits

Step IV Modified microstrip patch antenna loaded with three slits of C Shape

Modified antenna consists of three slits of C Shape etched on conventional microstrip patch antenna as shown in Fig.13.

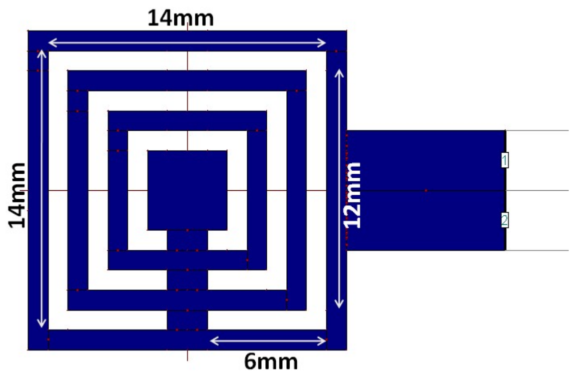

Fig. 13. Geometry of Modified microstrip patch Antenna loaded with three pair of horizontal and vertical slits

Simulation results of modified proposed microstrip patch antenna have return loss=(-33.85dB, -23.69dB, -17.90dB & -18.78dB) at resonating frequency 1.60 GHz , 2.50 GHz, 4.70 GHz & 5.50 GHz as shown in Fig.14 respectively.

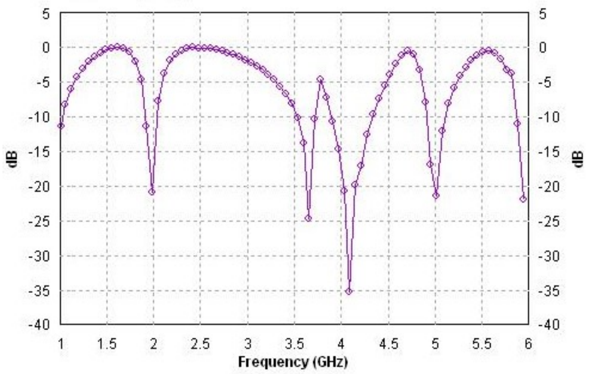

Fig. 14. Variations in Return loss with frequency for modified microstrip patch Antenna loaded with three pair of slits

The variation of VSWR with frequency as shown in Fig.15 indicates that VSWR is close to 1 at resonant frequency which indicates an excellent matching between the antenna and the feed network. The input impedance variation with frequency is shown in Fig.16 with a value of 49.28-j5.84 ohms.

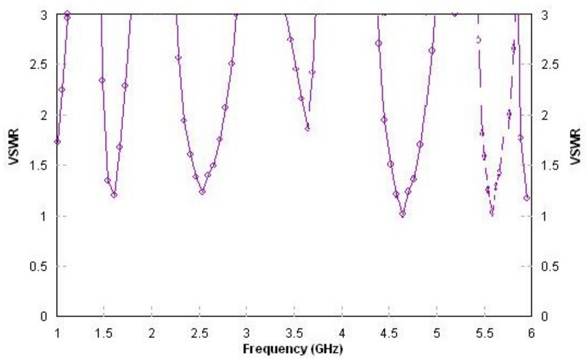

Fig. 15. Variations in VSWR with frequency for modified microstrip patch Antenna loaded with three pair of slits

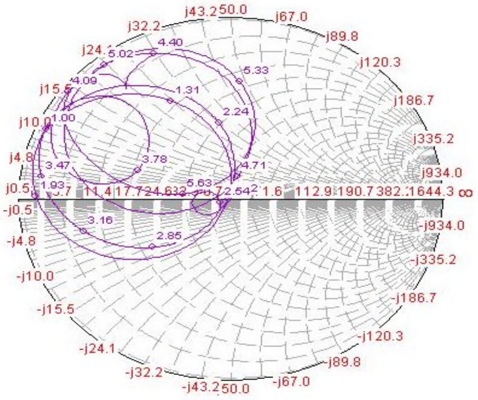

Fig. 16. Variations in input impedance with frequency for modified microstrip patch Antenna loaded with three pair of slits

Comparative study and analysis of the simulated results of the four antenna geometries is shown in Table 1 and in Fig. 17 respectively.

Table 1. Comparative Study of Simulated Results for the four Antenna geometries

Antenna	Antenna Geometry 1	Antenna Geometry 2	Antenna Geometry 3	Antenna Geometry 4
Return Loss (dB)	-22.93	-23.46	-16.33, -23.38	-33.85, -23.69, -17.90, -18.78
Total Resonant Points	01	01	02	04
Best Resonant Frequency(GHz)	3.54	3.31	2.30	1.6
Impedance Bandwidth (%)	20	10	6	16
VSWR	1.01	1.06	1.09	1.2
Input Impedance (Ω)	46.41-j3.44	46.07-j3.87	44.24-j6.85	49.28-j3.184
Material reduction (%)	0	7	13	20

3. RESULTS & DISCUSSION

Result obtained for all steps of modified antenna is presented in Fig.17. It can be seen that resonant frequency decreases as the number of slits increases. Fig.17 shows the variation of return loss (-33.85dB, -23.69dB, -17.90dB & -18.78dB) at resonating frequency 1.60 GHz , 2.50 GHz, 4.70 GHz & 5.50 GHz respectively. The input impedance of antenna is near to 49Ω which shows perfect matching between antenna feed. These antennas show a good matching between antenna and feed network as the value of VSWR is close to unity.

4. CONCLUSIONS

Simulation and measured results of proposed antenna design with three pair of vertical and horizontal slits shows four resonant frequencies -33.85dB, -23.69dB, -17.90dB & -18.78dB. The bandwidth obtained is remarkable as far as the simplicity is concerned and may be useful for multi band operation. The improvement in efficiency along with appreciable bandwidth is the major achievement. Simulation results further justify that proposed designed antenna can be utilized for WiMAX, GPS and GSM applications.

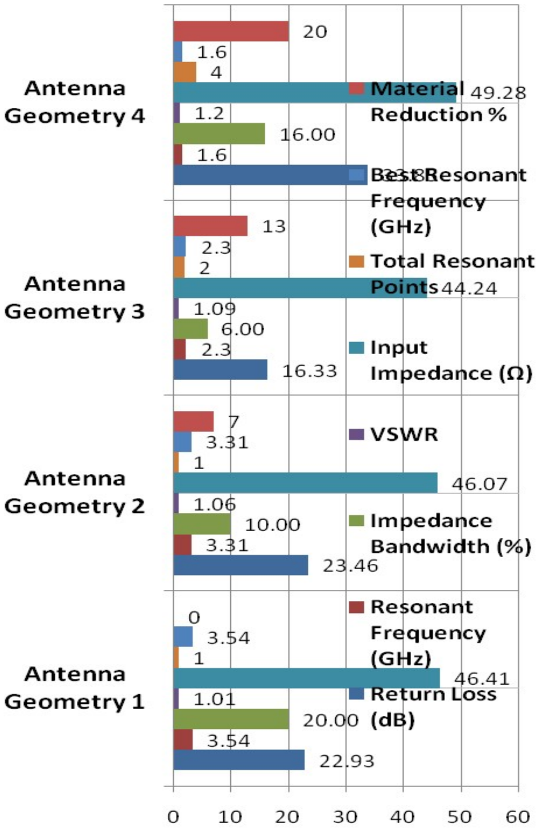

Fig. 17. Comparative Analysis of Simulated Results for the four Antenna geometries

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