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A NOVEL UWB ANTENNA WITH TWO BAND-NOTCHES

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ABSTRACT: A novel design of microstripline feed rectangular monopole microstrip antenna for ultra-wideband with dual band-notched operation is proposed. Hexagonal shaped slot with circular parasitic strip is etched on the rectangular radiating patch to obtain dual band notched function in the frequency range of 7.51-8.41 and 10.08-10.62 GHz. By varying the radius of circular parasitic strip the notch-band frequency range may be controlled. The proposed antennas are simple in their structure and they use low cost substrate material. The antenna operates between 7 to 16 GHz and gives ominidirectional radiation characteristics and peak gain of 11.86 dB. The proposed antennas may find applications in microwave communication systems.

Keywords: Microstrip Antenna, Monopole, Slot, Ominidirectional, Parasitic Strip

I.INTRODUCTION

Microstrip antennas are popular because of compact size, simple in design, low cost and capable of operating more than one band of frequencies. Owing to its thin profile, light weight, low cost, planar configuration and easy fabrication, the microstrip antenna is the better choice for these requirements. Design and development of microstrip antenna operating for desired frequency bands and rejecting unused band is the better choice for specific applications in microwave communication. Number of investigations has been reported in the literature for the design and development of notch-band operation [3-9]. Further most of the antennas presented in the literature are either complex in their structure or bigger in size and hence require carful manufacturing procedure than that of the regular microstrip antenna for practical applications. In this study we have demonstrated a simple technique to achieve dual notch-band operation and their control by varying the radius of circular parasitic strip of rectangular monopole microstrip antenna.

II. DESIGN OF ANTENNA GEOMETRY

The art work of the proposed antenna is sketched by using computer software Auto-CAD to achieve better accuracy and is fabricated on low cost FR4-epoxy substrate material of thickness of h = 0.16 cm and permittivity $\varepsilon_r = 4.4$.

Figure 1 shows the top view geometry of hexagonal shaped slot with circular parasitic strip rectangular monopole microstrip antenna (HCRMA). In Fig.1 the area of the substrate is $L \times W$ cm. On the top surface of the substrate a ground plane of height which is equal to the length of microstripline feed L_f is used on either sides of the microstripline with a gap of 0.1 cm. On the bottom of the substrate a continuous ground copper layer of height L_f is used below the microstripline. The HCRMA is designed for 3 GHz of frequency using the equations available for the design of conventional rectangular microstrip antenna in the literature [2]. The length and width of the rectangular patch are L_p and W_p respectively. The feed arrangement consists of quarter wave transformer of length L_t and width W_t which is connected as a matching network between the patch and the microstripline feed of length L_f and width W_f. A semi miniature-A (SMA) connector is used at the tip of the microstripline feed for feeding the microwave power. In Fig.1 a hexagonal slot with circular parasitic strip is loaded on the radiating patch of vertices X and radius of circular parasitic strip R respectively.

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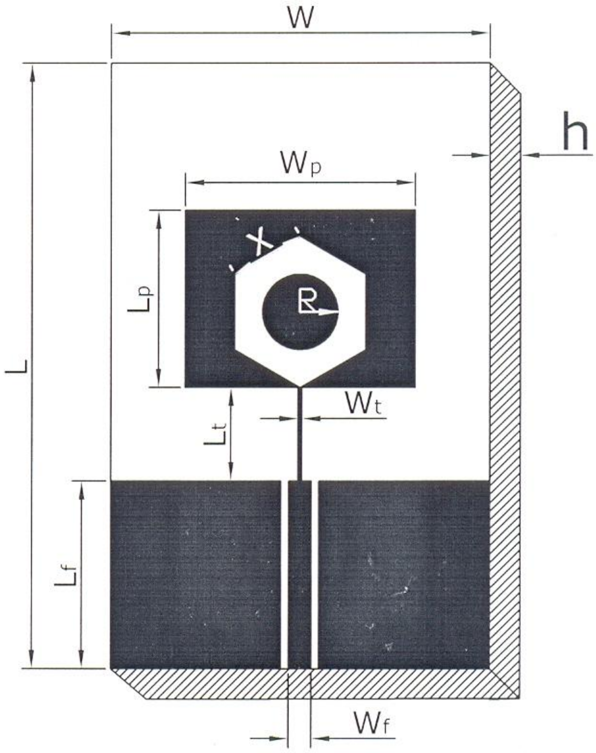

Fig. 1 Top view geometry of HCRMA

Figure 2 shows the geometry of modified hexagonal shaped slot with circular parasitic strip rectangular monopole microstrip antenna (MHCRMA). In this figure radius of circular parasitic strip is changed to 0.4 cm. The other geometry of Fig. 2 remains same as that of Fig.1. The design parameters of the proposed antenna is shown in Table 1

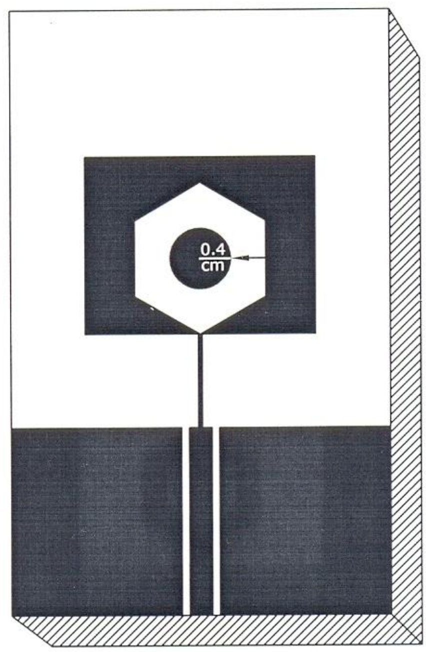

Fig. 2 Top view geometry of MHCRMA

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TABLE 1

DESIGN PARAMETERS OF PROPOSED ANTENNA

Antenna parameter	L	W	L_p	W_p	L_f	W_f	L_t	W_t	X	R
Dimensions in cm	8.0	5.0	2.34	3.04	2.48	0.3	1.24	0.05	1	0.5

III. EXPERIMENTAL RESULTS

The antenna bandwidth over return loss less than -10 dB is tested experimentally on Vector Network Analyzer (Rohde & Schwarz, Germany make ZVK model 1127.8651). The variation of return loss verses frequency of HCRMA is as shown in Fig. 4. From this graph the experimental bandwidth (BW) is calculated using the equations,

$$\mathrm{BW} = \left[\frac{f_2 - f_1}{f_c}\right] \times 100\ \% \qquad (1)$$

were, f_1 and f_2 are the lower and upper cut of frequencies of the band respectively when its return loss reaches – 10 dB and f_c is the center frequency of the operating band. From this figure, it is found that, the antenna operates between 7 to 16 GHz and gives three resonant modes at f_1 to f_3, i.e. at 7.37, 8.71, and 15.51 GHz respectively and two notch-bands from 7.51 - 8.41 and 10.08 - 10.62 GHz. The magnitude of experimental -10 dB bandwidth measured for BW_1 to BW_3 by using the equation (1) is found to be 330 MHz (4.49 %), 1.67 GHz (18.06 %), and 5.38 GHz (40.42%) respectively.

The multi mode response of is due to the different surface currents on the patch. The fundamental resonant frequency mode shifts from 3 GHz designed frequency to 7.37 GHz due to the coupling effect of microstripline feed and top ground plane of HCRMA.

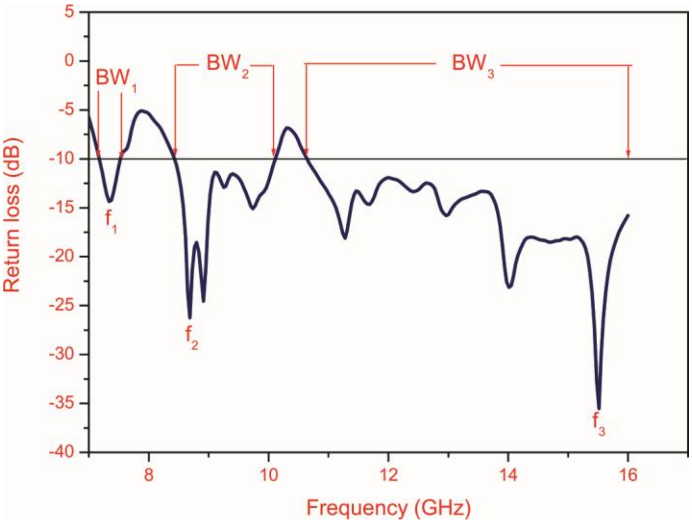

Fig. 3 Variation of return loss versus frequency of HCRMA

Figure 4 shows the variation of return loss verses frequency of MHCRMA. It is seen from this figure that, the antenna operates for three bands of frequencies BW_4 to BW_6. The magnitude of these operating bands measured at BW_4 to BW_6 is found to be 640 MHz (8.59 %), 1.80 GHz (19.56 %) and 5.51 GHz (41.60 %) respectively. Further from Fig.4 it is clear that, the MHCRMA is capable of widening each operating band when compared to the operating bands BW_1 to BW_2 of HCRMA. The antenna also retains two notch-bands but the notch-bands between BW_4 to BW_5 and BW_5 to BW_6 have been reduced to 6.59 and 3.78 % when compared to the notch-band between BW_1 to BW_2 and BW_2 to BW_3. Hence by changing the radius of circular parasitic strip on the patch is effective in controlling the notch-band operation of the antenna.

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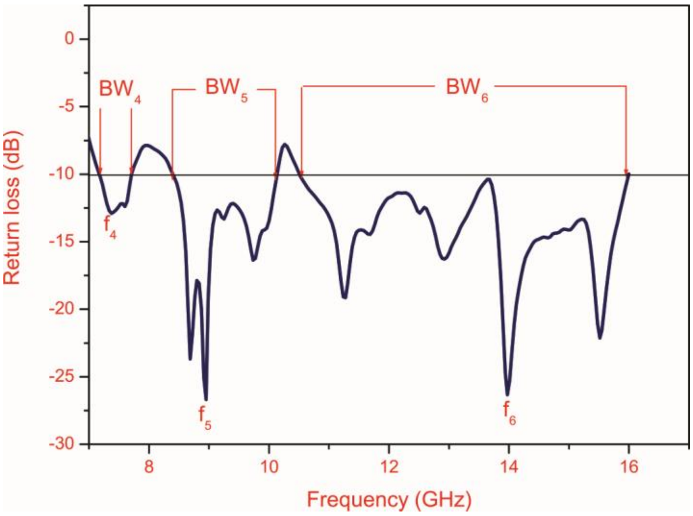

Fig. 4 Variation of return loss versus frequency of MHCRMA

The gain of the proposed antennas is measured by absolute gain method. The power transmitted 'P_t' by pyramidal horn antenna and power received 'P_r' by antenna under test (AUT) are measured independently. With the help of these experimental data, the gain (G) dB of AUT is calculated by using the formula,

$$(G)\ \text{dB} = 10\log\left(\frac{P_r}{P_t}\right) - (G_t)\ \text{dB} - 20\log\left(\frac{\lambda_0}{4\pi R}\right)\text{dB} \qquad (2)$$

where, G_t is the gain of the pyramidal horn antenna and R is the distance between the transmitting antenna and the AUT. Using equation (2), the maximum gain of HCRMA and MHCRMA measured in their operating bands is found to be 9.70 dB and 11.86 dB respectively. Hence the decease of radius of circular parasitic strip also enhances gain of the antenna.

The co-polar and cross-polar radiation pattern of HCRMA and MHCRMA is measured at 8.45 and 7.41 GHz. The typical radiation patterns measured at 8.45 and 7.41 GHz are shown in Fig 5 to 6 respectively. The obtained patterns are ominidirectional in nature.

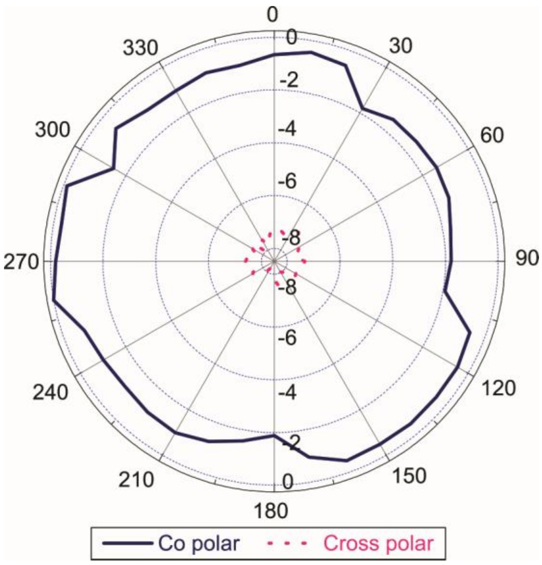

Fig. 5 Typical radiation pattern of HCRMA measured at 7.45 GHz

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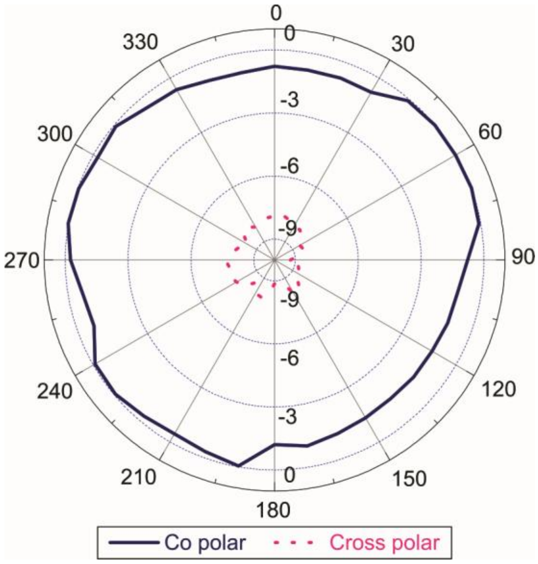

Fig. 6 Typical radiation pattern MHCRMA measured at 7.41 GHz

IV.CONCLUSION

From the detailed experimental study, it is concluded that, the HCRMA with microstripline feed have been designed for dual notch-band operation. The antenna operates for two bands of frequencies in the range of 7 to 16 GHz. If the radius of circular parasitic strip is changed to 0.4 cm, the antenna operates again for three bands but reduces the magnitude of each notch-band frequency range which causes enhancement in the operating bands. The proposed antennas are simple in their structure and they use low cost substrate material FR4. Both antennas give ominidirectional radiation characteristics inspite of reduction in the notch-bands and enhancement in the gain. With these features the proposed antennas may find applications in microwave communication systems operating in the frequency range of 7 to 16 GHz.

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