

A Novel Design of Rectangular Microstrip Antenna by Multiple Slot Loading

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Abstract: A novel design of conventional rectangular microstrip antenna with a modification in the patch by adding three and four vertical slots is presented. Without slot loading there is only one frequency band with antenna resonating at 4.125 GHz and bandwidth of 1.56% with a return loss of -23.0191 dB. With four slots three bands occur with a maximum bandwidth of 6.9%. When one of the slots is removed the antenna resonates with four bands and maximum percentage bandwidth of 18.4%.

Keywords: Slot Loading, Bandwidth, Ground plane, Return loss, Resonates

1. Introduction

Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate and ground plane on the other side. They show the unique characteristics of linear as well as circular polarization, can be easily integrated with microwave integrated circuits (MICs), capable of multiband operations, low profile planar configuration making it easily conformal to host surface, light weight, low volume, low fabrication cost etc [1]. They come in various shapes like rectangular, square, circular, triangular and elliptical and can be housed easily on moving vehicles. But these antennas exhibit narrow bandwidth, low efficiency, low gain, extraneous radiation from feeds and junctions.

The conventional microstrip antenna has very low gain of the order of 2 to 3dB and narrow bandwidth of around 1%. But for some of the critical systems like military communications, SAR (synthetic aperture radar), printed circuit design, MMIC technology, WLAN and GPS [2] there have been continuous efforts to increase the bandwidth, reduce the return loss and reduce the size of the antenna. The most prominent is modification of the patch by introducing slots in the patch or ground plane or both. The dimensions and shapes of the slots can improvised within limits set by the tools used for simulation and fabrication methods available. For obtaining multiple bands many techniques are available like gap-coupling, complementary symmetry, stubs or spur lines [3-5] etc. Antennas that can operate in more than one band can avoid the use of multiple antennas. A study is conducted to compare the number of bands with a change in the number of slots on the patch while observing the corresponding resonant frequencies and bandwidths. This method also increases the gain of the antenna without changing the broadside characteristics.

2. Antenna Configuration

The schematics of the proposed antenna have been made using the design software called Auto-CAD. Any version of the software can be employed. The simulation is performed on Ansoft HFSS (High frequency structure simulator 13.0).

The thickness is taken as $h = 0.16$ cm and relative permittivity of the substrate as $\epsilon_r = 4.2$.

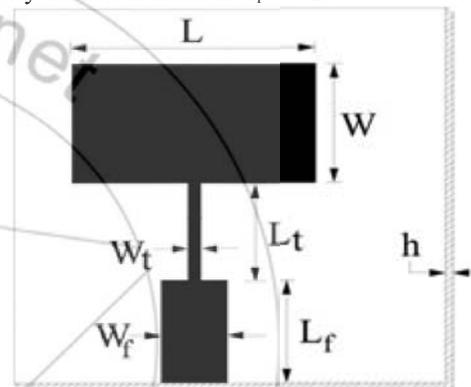


Figure 1: Geometry of CRMA

Above Figure 1 shows the geometry of conventional rectangular microstrip antenna (CRMA). This antenna is designed for the resonant frequency of 4 GHz [4]. The length and width of rectangular patch is L and W respectively. The patch is fed by using microstripline feeding. This feed arrangement consists of a quarter wave matching transformer of length L_t and width W_t which is connected between microstripline feed and patch. The length and width of microstripline feed are L_f and W_f respectively. The study is extended by placing four vertical slots in the CRMA and the antenna is named as four vertical slots rectangular microstrip antenna (FVRMA) as it is shown in the Figure 2.

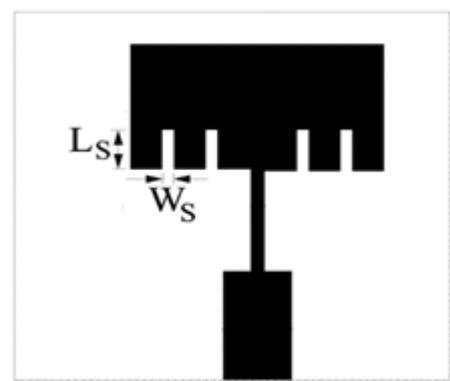


Figure 2: Geometry of FVRMA

The length (L_s) and width (W_s) of vertical of slots are taken in terms of λ_0 where λ_0 is the free space wavelength in cm.

Figure 3 shows the geometry of three vertical slots rectangular microstrip antenna (TVRMA) is also design from Fig. 2 by removing the fourth slot from the right side edge on the patch of FVRMA. The design parameters of proposed antennas are given in Table 1.

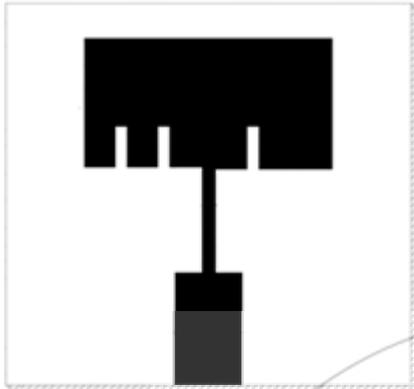


Figure 3: Geometry of TVRMA.

3. Results and Discussion

The results of simulation, made by means of software HFSS of the CRMSA is as shown in figure 4. From this figure it is seen that the antenna is resonating with one band BW_1 at 4.12 GHz which is almost close to the design frequency 4 GHz. The percentage bandwidth is 1.56% which is determined by using the formula as given below, where, f_1 and f_2 are the lower and upper cut-off frequencies of the band respectively, when its return loss become -10dB and f_r is the centre frequency between f_1 and f_2 . Bandwidth

$$(\%) = \left[\frac{f_2 - f_1}{f_r} \right] \times 100$$

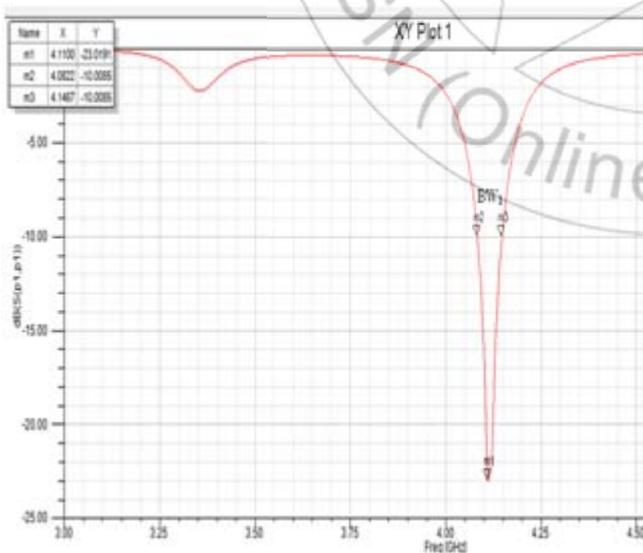


Figure 4: Variation of Frequency Vs Return Loss of CRMA

The Fig. 5 shows the variation of Return loss vs Frequency of FVRMA, from this figure it is seen that the antenna resonates for three bands of frequencies i.e BW_2 , BW_3 and BW_4 with a percentage of bandwidth 3.4%, 6.9% and 4.1% respectively. The three bands are due to the combined effect of slots and the patch resonance [6].

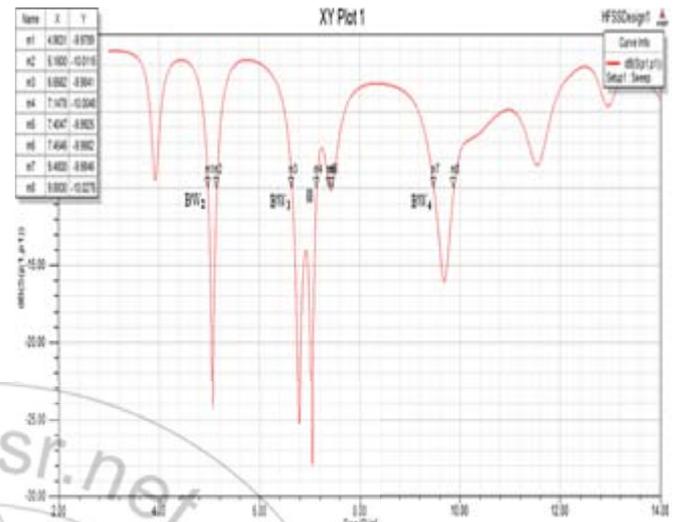


Figure 5: Variation of Frequency Vs Return Loss of FVRMA

Further it is seen that, when the fourth slot from the right side edge on the patch of FVRMA is removed, the antenna resonates with four bands of frequencies i.e. BW_5 , BW_6 , BW_7 and BW_8 with the percentage bandwidths of 2.05%, 1.58%, 18.4% and 4.4%, respectively, the variation of return loss versus frequency is as shown in Fig. 6. It is also seen from this figure that, BW_3 shown in Fig. 5 is splitting into two bands BW_6 and BW_7 and there is a much enhancement in the bandwidth i.e 6.9% to 18.4% [7-8].

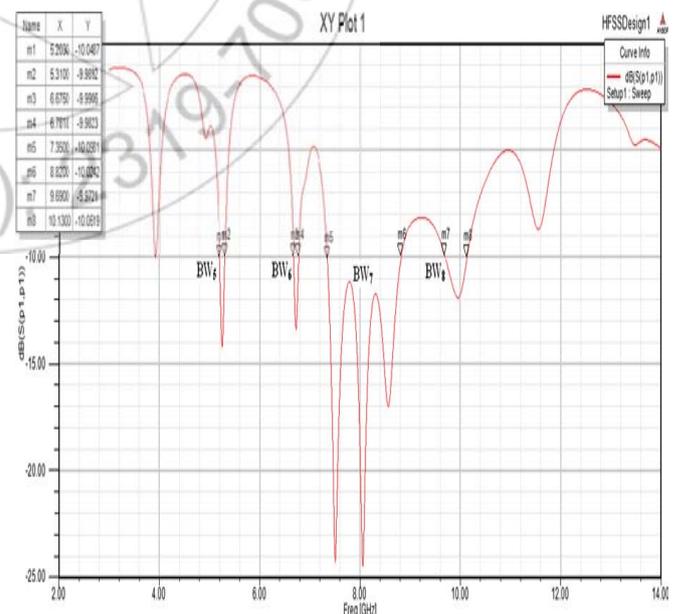


Figure 6: Variation of Frequency Vs Return Loss of TVRMA

Figures 7 and 8 show the co-polar and cross-polar radiation patterns of FVRMA and TVRMA respectively. From these figures it is seen that the patterns are broad sided and linearly polarized. The maximum gain of FVRMA and TVRMA are found to be 3.53 dB and 3.45 dB.

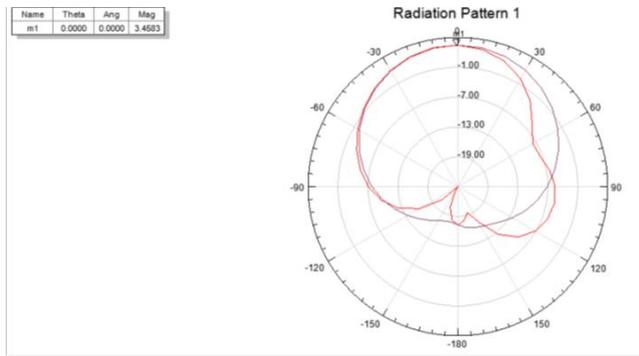


Figure 7: Radiation pattern of FVRMA

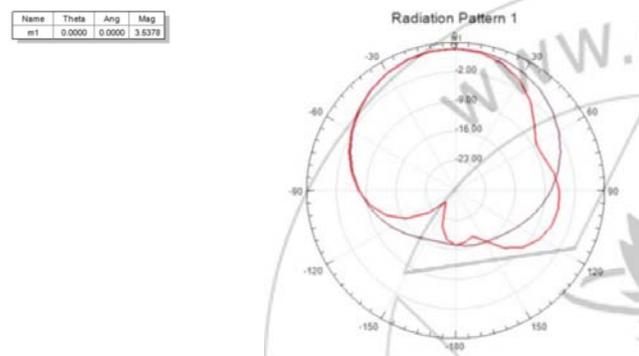


Figure 8: Radiation pattern of TVRMA

Table 1: Design parameters of proposed antennas

Antenna Parameters	Dimension in cm
h	0.16
L	1.78
W	2.32
Wf	0.31
Lf	0.96
Wt	0.20
Lt	0.96
WS	0.20
LS	0.80

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4. Conclusions

From the detailed simulated results it is concluded that, the novel design of CRMA is more effective in producing the three and four band operations. With the four slots three bands occur with a maximum bandwidth of 6.9%. When one of the slots is removed i. e the antenna TVRMA the antenna resonates with four bands and maximum percentage bandwidth is 18.4%. These antennas may find applications in microwave communication systems.

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