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A Novel Design of Rectangular Microstrip Array Antenna for Wide Band Operation

Santosh Yadav[1], Dr. Kishan Singh[2]

[1]Research Scholar, Department of EEE, Mewar University, Rajasthan, India

[2]Department of E&CE, Guru Nanak Dev Engineering College, Bidar, India

Abstract: ***A novel design of two element rectangular microstrip array antenna (TERMA) is presented for triple band operation with a percentage bandwidth of 7.44%, 16.41% and 5.3%. If another antenna is connected with the TERMA i.e., the antenna named by three element rectangular microstrip array antenna (THERMA), again the antenna resonates for triple band operation but it is seen that there is a much enhancement in all three bands i.e., the bandwidth are 10.6%, 20.8% and 23%. Further when three vertical slots are placed on each THERMA three bands merge into single band and the antenna gives highest bandwidth of 127%. The proposed antennas may find application in radar communication system.***

Keywords: Two element, three elements, rectangular, bandwidth, radar

1. Introduction

Antenna is a device used to feed or receive the maximum power in the required direction. Antennas are used only for wireless communication like mobile communication, broadcast systems, satellite linking, cellular phones, microwave linking, etc. The signal operation between transmitter and receiver is in the form of electromagnetic waves. There are various types of antennas in day today life like microstrip antenna, yagi-uda antenna, horn antenna, wire antenna, lens antenna parabolic antennas etc. Depend upon different application these antennas are operated. Antennas are basically used as transactional devices that are connecting links between the transmitter and free space or free space and the receiver [1]. Thus antennas play very important role in any communication system i. e. without antenna there is no communication. Among all microstrip antennas is very special because it has so many advantage like simple in design, low cost, easy handle, planar configuration etc but it has some limitation like low bandwidth, gain and some undesirable radiation characteristics. So to overcome these many researchers are working on microstrip antenna by using many techniques. Some of the techniques are slot loading, truncations, parasitic, coupling technique, array elements etc [2]. So in this paper two and three elements rectangular microstrip array antennas are designed and simulated to see the radiation characteristics of the antennas. An array is a combination of more than one antenna; arrays can be designed by using similar or dissimilar antennas. Array can be used to increase the bandwidth gain or directivity in the required direction. Any required power pattern can be obtained using an array of available antennas

2. Antenna Design

The artwork of the proposed antennas is sketched by using software Auto-CAD. These antennas constructed by using substrate material of thickness h = 3.2 mm and dielectric constant e_r = 4.2.

Figure.1 shows the geometry of TERMA. The length (L) and width (W) of the rectangular patch is designed for the resonant frequency of 4 GHz, using the available equation [1]. This antenna is fed with corporate feed arrangement that consist of consists of a 50 Ω microstrip feedline of length L_{50} and width W_{50} which is connected to a 100 Ω microstripline of length L_{100} and width W_{100} to form a two way power divider. A matching quarter wave transformer of length Lt and width Wt is connected between 100 Ω feedline and midpoint of the radiating elements to ensure perfect impedance matching.

Figure 2 shows the geometry of THERMA. In this antenna another element with the same geometry is connected at the center of 100 Ω fedline along the length side, becoming three element rectangular microstrip array antenna.

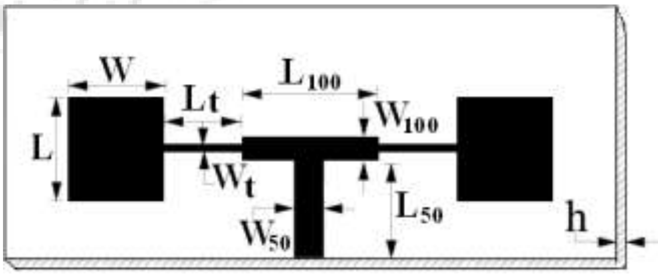

Figure 1: Geometry of TERMA

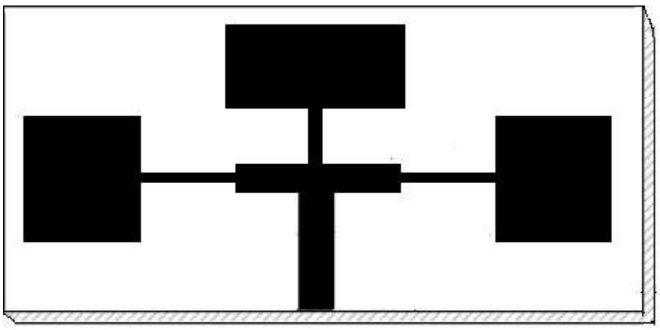
Figure 2: Geometry of THERMA

Figure 3 shows the geometry of three elements slot loaded rectangular microstrip array antenna (THESRMA). In this figure, three identical vertical slots are placed in all three respective elements with the length and width Ls and Ws. The dimension of slots is taken in terms of λo, where λo is the free space wavelength in cm corresponding to the designed **frequency of 4 GHz.**

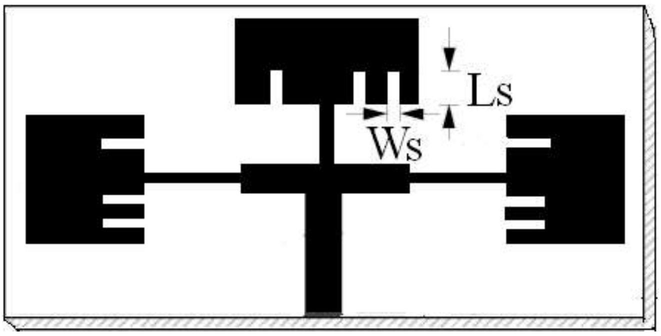

Figure 3: Geometry of THESRMA

3. Result and Discussion

The results of simulation, made by means of software HFSS of the TERMA is as shown in figure 4. From this figure it is seen that the antenna is resonating for three bands of frequencies BW_1, BW_2 and BW_3. The percentage of bandwidth of each operating bands are found to be 7.44%, 16.41% and 5.3% respectively. The percentage of bandwidth is calculated by using the equation as mention below, where, f_1 and f_2 are the lower and upper cut-off frequencies of the band respectively, when its return loss becomes -10dB and f_r is the centre frequency between f_1 and f_2.

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

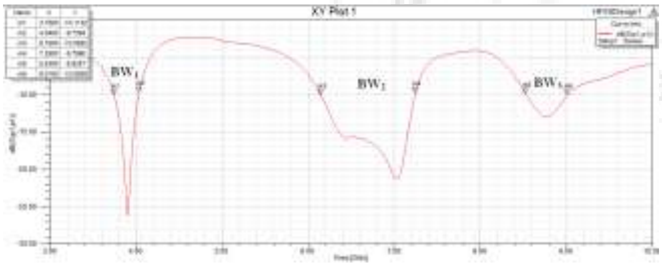

Figure 4: Variation of Return Loss Vs Frequency of TERMA

The variation of return loss versus frequency of THERMA is as shown in Fig. 5. From this figure it is clear, the antenna again resonates for three bands of frequencies BW_4, BW_5 and BW_6. The percentage bandwidth of each operating bands are found to be 10.6% 20.8% and 23% respectively. It is seen that, there is a much enchantment in the three operating bands, in the upper operating band the percentage of bandwidth is increase from 5.3% to 23%when compared with figure 4[3].

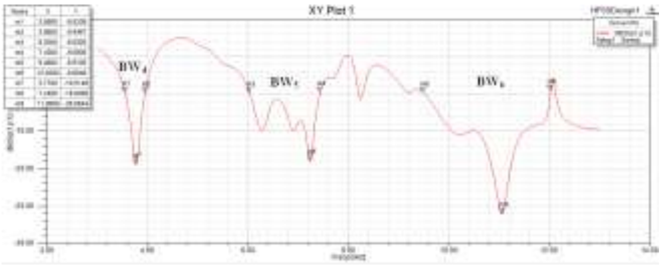

Figure 5: Variation of Return Loss Vs Frequency of THERMA

Figure. 6 shows the variation of return loss versus frequency of THESRMA. It is clearly seen from this figure that, the antenna resonates for single band of frequency BW_7. The three bands obtained in THERMA are merged into a single band and antenna gives highest percentage of bandwidth of 127%. The merging of bands is due to the current flowing along the radiating edges of rectangular patch elements and the slots on the patches which introduces an additional resonance [5], results in the enhancement of bandwidth.

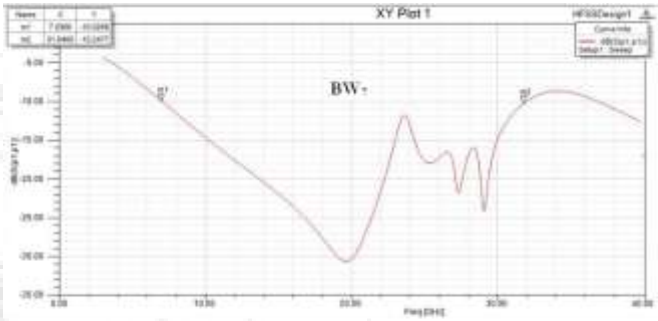

Figure 6: Variation of Return Loss Vs Frequency of THESRMA

Figure 7-8 shows the co-polar and cross-polar radiation patterns of THERMA and TIERSAA measured at 10.5 GHz and 19.77 GHz respectively. From these figures, it is clear that, the patterns are broad sided and linearly polarized.

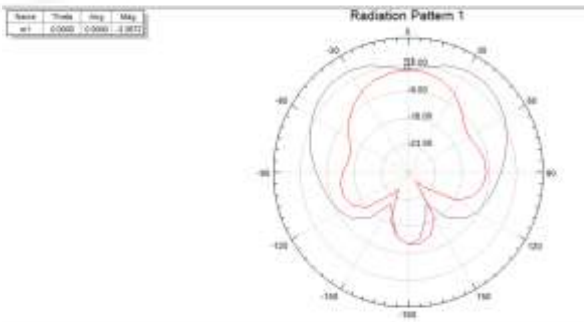

Figure 7: Co-Polar and Cross Polar radiation patterns of THERMA

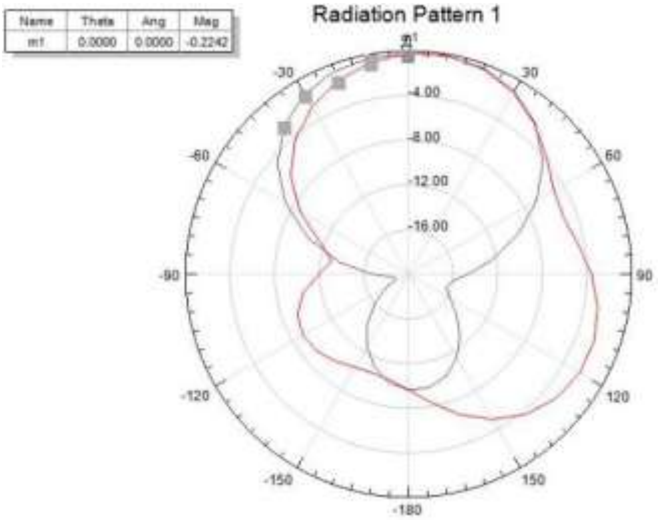

Figure 8: Co-Polar and Cross Polar radiation patterns of TIERSAA

4. Conclusion

From detailed study it is concluded that, the three band operation obtained from the novel design of TERMA can be enhanced by way of an increase in the bandwidths of all three bands. This is achieved by placing another element in the array. These three bands can be further converted into single band by placing the vertical slots on the patches of array elements. The maximum percentage bandwidth obtained is 127%. These antennas may find applications in radar communication systems.

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Author Profile

Santosh Yadav received B. E. in EEE Dept. from NIT Suratkal Mangalore and M. Tech in Power Electronics from VTU Belgaum. He is pursuing Ph.D from Mewar University Rajasthan. He is currently working as Assistant Professor in Guru Nanak Dev Engineering College Bidar since 2008. His areas of interest are Microwave Waves, Antennas, Power Electronics and Signal Processing, Network Analysis.

Kishan Singh, received Ph.D in Microwave and Communication from Applied Electronics Dept. Gulbarga University Gulbarga, India in 2012. He is currently working as Assosiate Professor in Guru Nanak Dev Engineering College, Bidar, India, since 2006. He has also been awarded as a young scientist for research by VGST, Govt. of Karnataka. His fields of interests are Microwaves, antennas, wireless and digital communications.