Design of a corporate-series feed array antenna and comparing the performance with single element rectangular patch antenna

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Abstract. The design of corporate series feed array antenna and analysis of its performance are presented here and finally a comparison is made with the single element rectangular patch antenna in respect of performance. The analysis of this design is made in 11GHz frequency band. Microstrip arrays are used to achieve higher gain. Finally a comparison has made in respect of different parameters among the corporate-series feed array and single element antenna.

Keywords: Array antenna, corporate-series feed, Microstrip array, Array comparison.

1 INTRODUCTION

A Microstrip patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane.

An antenna array is a group of isotropic or non-isotropic, identical or non-identical, similar or dissimilar radiators such that the currents running through them are of different amplitudes and phases to enhance the radiative properties in desired direction rather than in non-desired direction through electro-magnetic wave interference phenomenon.

Microstrip antennas are more popular because of their size, weight, cost, ease of installation, performance and so on. Moreover microstrip antennas are relatively inexpensive to manufacture and design because of the simple 2-dimensional physical geometry. For this reason research is running to make these antennas more flexible. Antenna plays a vital role in the field of communication. Antenna has the key roles in transmitting and receiving signals to/from the free space. A precisely designed antenna can improve the overall performance of the system.

Microstrip antennas are popular for their low profile applications over 100MHz frequencies. Microstrip antennas are used in wireless communication, satellite communication, and radar. The major disadvantages of this type of antennas are their inefficiency and narrow frequency BW. The number of antenna element and feeding matching networks are employed to overcome the BW limitation for a specific application. Here 8×1 corporate series feed antenna is designed and analyzed in comparing with single element antenna.

2 DESIGN OF MICROSTRIP ANTENNA

The microstrip patch antenna is feed by a transmission line and placed on a ground plate. The patch, transmission line and made of high conductivity metal usually copper. The patch is of length *L*, width *W*, and sitting on top of a substrate (some dielectric circuit board) of thickness h with permittivity ε_r. The height h must be smaller than operating wavelength but not much smaller than 0.05 of the wavelength. The frequency of operation can be defined by-

$$f_c = \frac{C}{2L\sqrt{\varepsilon r}}$$

This paper mainly includes the design and comparing the performance of two popular Microstrip antennas.
They are-

- Single element rectangular patch
- Corporate feed array network

2.1 Single element patch

For an efficient radiation a practical width of the rectangular patch element becomes.

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}} \times \sqrt{\frac{2}{\varepsilon_r+1}}$$

And the length of the antenna becomes [5, 6, 7].

$$L = \frac{1}{2f_r\sqrt{\varepsilon_{eff}\sqrt{\varepsilon_0\mu_0}}} - 2\Delta L$$

Where,

$$\Delta L = 0.41h\,\frac{\varepsilon_{eff}+0.3}{\varepsilon_{eff}-0.258} \times \frac{{}^{w}/_{h}+0.246}{{}^{w}/_{h}+0.8}$$

And,

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2\sqrt{1+12\frac{h}{w}}}$$

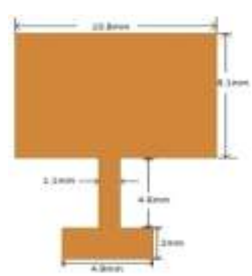

Fig 1: Rectangular Microstrip antenna

Where, λ is the wave length, f_r (in Hz) is the resonant frequency, L and W are the length and width of the patch element in mm, respectively and ε_r is the relative dielectric constant.

In the following Fig. 1, the antenna has been designed to cover specific 11 GHz operating frequency where the antenna dimension is in mm range and the quarter wavelength transformer method is used to match the impedance of the patch element with the transmission line. A probe is also used in the rectangular patch antenna. Fig. 1 is a rectangular patch without slot.

2.2 Corporate-series feed network

In this design, all antenna parameters like patch wide, length, relative dielectric constant, frequency of operation etc. are same as we have designed rectangular patch antenna. Here, 8×1corporate- series network is designed shown in figure 2.

The corporate-feed network is used to provide power splits of 2n (i.e. n = 2; 4; 8; 16; etc.). This is accomplished by using either tapered lines or using quarter wavelength impedance transformers. In this paper the patch elements are connected by using the quarter wavelength impedance transformer method.

In this paper the comparison in respect of performance is analyzed among the single element patch and corporate-series feed antenna.

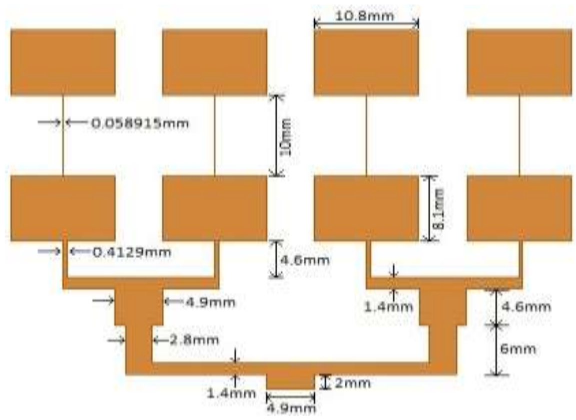

Fig 2: Corporate-series feed array antenna (8×1)

3 SIMULATION RESULT AND DISCUSSION

For each antenna, design parameter is considered that substrate permittivity is 2.2 (Taconic TLY-5), height is 1.588mm and designed frequency is 11GHz and using this consideration simulation and result is taken for each network.

3.1 Single element patch

The simulated return loss is shown in Fig. 3.The return loss at 11GHz is -7.03dB, but maximum return loss is obtained at 10.52GH is -16.61dB. Theta cut (θ=0) directivity at 11GHz is 7.49dB and graph is shown in Fig. 4. Accepted power and radiated power at 11GHz is 79.07mW and 115.5mW respectively. Gain at 11GHz is 9.155dBi and the polar plot of 2D radiation patter is shown in Fig. 5.

3.2 Corporate-series feed array network

The simulated return loss is shown in Fig.3 The return loss at 11GHz is -0.7905dB, but maximum return loss is obtained at 11.67GH is -30.39dB. Theta cut (θ=0) directivity at 11GHz is 15.54dB and graph is shown in Fig.4. Accepted power and radiated power at 11GHz is 4096mW and 18470mW. Gain at 11GHz is 22.08dBi and the polar plot of 2D radiation patter is shown in Fig. 5.

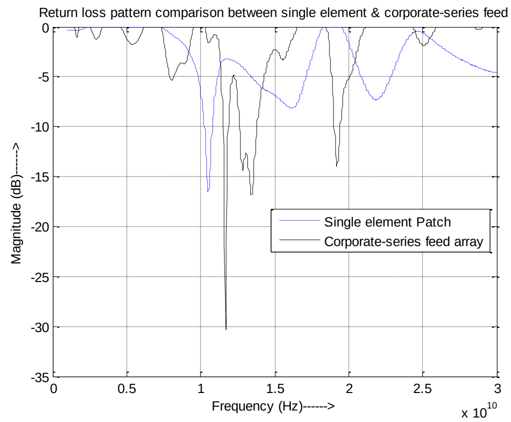

Fig.3: Simulated return loss of corporate-series feed array network.

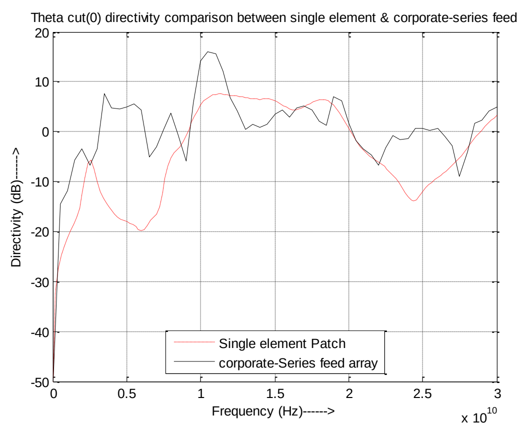

Fig.4: Theta cut (0) directivity comparison between single element patch and corporate-series feed array network.

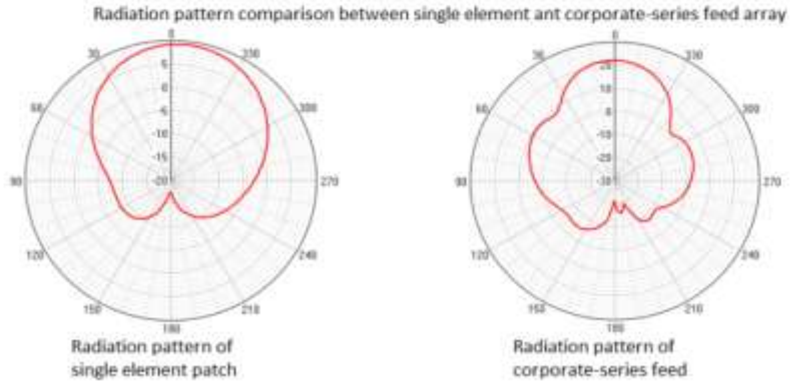

Fig.5: Radiation pattern comparison between single element patch and corporate-series feed array network.

3.3 Comparison between single element and corporate-series feed network

The simulated result of single element patch and corporate-series feed array are tabulated below for making a comparison between them. The operating frequency for both of them is 11GHz. All simulation takes place for substrate with relative permittivity 2.2 and height 1.588mm.

Table 1: Comparison between single element patch and corporate-series feed array network

Performance parameter	Unit	Single element patch	Corporate-Series feed array network
Obtained simulated frequency	GHz	10.52	11.67
Return loss at obtained frequency	dB	-16.61	-30.38
Return loss at designed (11GHz) frequency	dB	-7.3	-0.7905
Theta cut (θ=0) directivity at 11GHz	dB	7.49	15.54
-3dB bandwidth	GHz	2.33	3.38
-9dB bandwidth	GHz	0.73	0.393
Gain at 11GHz	dBi	9.115	22.08
Radiated power at 11GHz	mW	115.5	4096
Accepted power at 11GHz	mW	79.07	18470

We have designed both of the antennas to operate in 11GHz frequency, but simulated result slightly differs from the expected value. The value of return loss highly fluctuating between actual (11GHz) frequency and obtained frequency for both type of antenna. The corporate-series feed array provides higher response value than single element antenna in theta cut directivity, and 3 & 9 dB Bandwidth. The corporate-series feed gives the better gain than single element antenna. The noticeable result found in radiated and accepted power. The directivity of the antenna is defined as the ratio of the maximum power density in the main beam to the average radiated power density. The corporate-series feed network provides very favorable high value in these fields than single element antenna.

4 Conclusion

From above comparison it is seen that two antenna differs more in gain, radiated or accepted power etc. We can't neglect one in any sense. Where high gain is required corporate-series element may play well and where low gain is acceptable, the single element can be better. This philosophy can apply in respect of other parameters.

5 Future works

Our future work is to design a corporate series feed array with multiband application with reduced attenuation.

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