WIDEBAND RECTANGULAR MICROSTRIP ANTENNA WITH DIRECTLY COUPLED AND TWO GAP COUPLED PARASITIC PATCHES

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Abstract:

In this paper, the conventional microstrip antenna is replaced by a configuration which consists of a rectangular microstrip antenna with a directly coupled patch and two gap coupled parasitic patches to achieve a wide bandwidth. The impedance BW determined is 15.8 % of the center frequency at 4.12 GHz. The microstrip antenna is fed by a coaxial cable to achieve linear polarization. The proposed geometry provides a band of 640 MHz (3.8 GHz to 4.44 GHz) that is suitable for certain frequencies of S band as well as of C band applications. Other important parameters directivity, gain, axial ratio, aperture efficiency and radiation efficiency are also simulated. All the simulations are carried out using Zeland IE3D simulation software.

Keywords: Directly coupled patch;Gap coupled patch;Parasitic patch;MSA.

1. Introduction

In high – performance aircraft, spacecraft, satellite, missile, mobile and wireless applications, where size, weight, cost, performance, ease of installation and aerodynamic profile are constraints, low - profile antennas may be required. To meet these requirements, microstrip antennas [2] – [7] can be used. These antennas are low profile, conformable to planar and nonplanar surfaces, simple and inexpensive to manufacture using modern printed circuit technology, mechanically robust when mounted on rigid surfaces, and compatible with MMIC designs.

An MSA in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side as shown in figure 1.1. There are different shapes of the microstrip antenna, such as the square, circular,triangular, semicircular, sectoral, annular ring, but the most common is rectangular. A major drawback of the MSAs is that they have a narrow bandwidth, typically 1 – 5% which is the major limiting factor for the widespread application of these antennas.

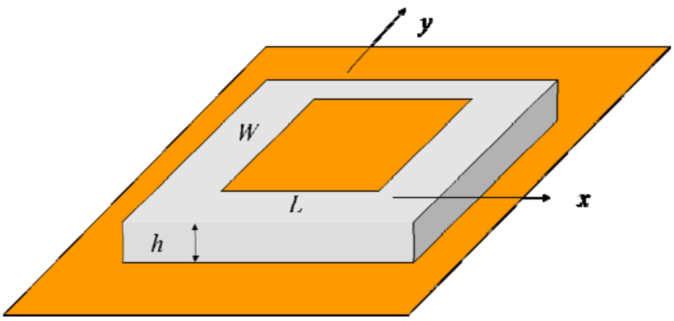

Fig. 1.1 Rectangular microstrip antenna

The BW of the MSAs can be increased by using the modified shape patches, planar multiresonator configurations, multilayer configurations, stacked multiresonator configurations[8,13].

In this paper, the conventional microstrip antenna of dimensions L × W is replaced by a multiresonator configuration to achieve a wide bandwidth. This multiresonator configuration consists of a rectangular microstrip antenna with a directly coupled patch and two gap coupled parasitic patches. A rectangular microstrip antenna having dimensions L1 × W1 (Patch 1) has additional resonators of a directly coupled patch of dimensions L2 × W2 (Patch 2) and two gap – coupled parasitic patches of dimensions L3 × W3 (Patch 3) and L4 × W4 (Patch 4), respectively. Patch 2 is connected to the radiating edge of patch 1 through a narrow conducting strip of length l and width w. Patches 3 and 4 are gap coupled, with a gap spacing of S,to the nonradiating edges of patch 1.

2. Proposed antenna geometry and design

A typical design of rectangular microstrip antenna has been presented here and results are discussed at centre frequency of 2.0 GHz. The width and length of the patch are given by [1, 5, 7]:--

$$w = \frac{c}{2f\sqrt{(\varepsilon r+1)/2}} \quad (1)$$

$$L = L_{eff} - 2\Delta L \quad (2)$$

$$\Delta L = \frac{0.412h\left[\varepsilon_{eff}+0.300\right]\left[\left(\frac{w}{h}\right)+0.264\right]}{\left[\varepsilon_{eff}-0.285\right]\left[\left(\frac{w}{h}\right)+0.8\right]} \quad (3)$$

$$\varepsilon_{eff} = (\varepsilon_r+1)/2+[(\varepsilon_r-1)/2](1+12h/W)^{-1/2} \quad (4)$$

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon eff}} \quad (5)$$

Where ,

C = velocity of light,

ε_r = dielectric constant of substrate,

f = operating frequency

ε_{eff} = effective dielectric constant,

L_{eff} = effective length,

ΔL = edge extension

3. Designing parameters

For designing the proposed antennas the following parameters are used :--

Design frequency	=	2.0 GHz
Dielectric constant	=	4.4
Loss tangent	=	0.02
Thickness of substrate	=	1.6 mm
Length of the conventional patch L	=	36 mm
Width of the conventional patch W	=	46 mm
Dimensions of patch1 (L1 × W1)	=	18 mm × 18 mm
Dimensions of patch2 (L2 × W2)	=	16 mm × 46 mm
Dimensions of patch3 (L3 × W3)	=	19 mm × 13 mm
Dimensions of patch4 (L4 × W4)	=	19 mm × 13 mm
Dimensions of conducting strip (l × w)	=	2 mm × 1 mm
Gap spacing s	=	1 mm

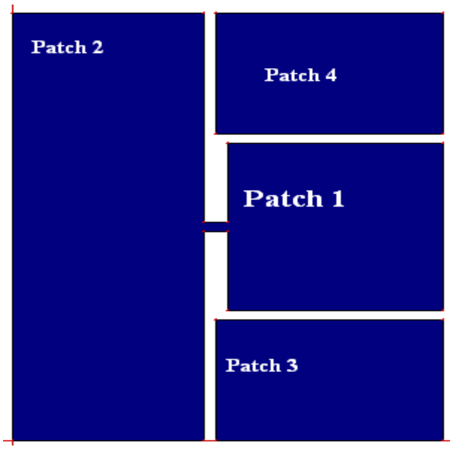

Fig. 1.2 Proposed geometry of microstrip antenna

4. Results and Discussion

The conventional patch having dimensions L × W resonates at different frequencies such as 1.54GHz, 1.94 GHz, 2.53 GHz, 3.82 GHz, 4.56 GHz with maximum impedance BW = 2 % at center frequency 3.82 GHz. Now patch 1, which is directly coupled to patch 2, is simulated and it resonates at 4.28 GHz with maximum impedance BW = 4.2 % (4.19 GHz to 4.37 GHz) at center frequency 4.28 GHz. Now patch 1, which is directly coupled to patch 2 and parasitically gap coupled to patch 3, is simulated and it resonates at 3.88 GHz, 4.25 GHz with maximum impedance BW = 6.3 % (4.12 GHz to 4.39 GHz) at center frequency 4.26 GHz. Now the patch 1, which is directly coupled to patch 2 and parasitically gap coupled to patch 3 and patch 4, is simulated and it resonates at 3.87 GHz and 4.34 GHz . The impedance bandwidth, determined from the -9.5dB return loss, is 650 MHz (3.8 GHz to 4.44 GHz), which is 15.6 % at the center frequency of 4125 MHz. Since the impedance bandwidth is 70 MHz or about 2 % at the center frequency of 3815 MHz for the conventional microstrip antenna without directly coupled and parasitically gap coupled patches. The impedance bandwidth for the constructed prototype is 7.8 times that of the conventional antenna.

In the research paper [10], the impedance bandwidth determined was 12.7 % whereas the present geometry provides the impedance bandwidth of 15.6 % with a peak directivity 8.172 dBi, gain 4.62 dBi, axial ratio 51.5 dB, aperture efficiency 47.7 %, and radiation efficiency 50 % in the given band.

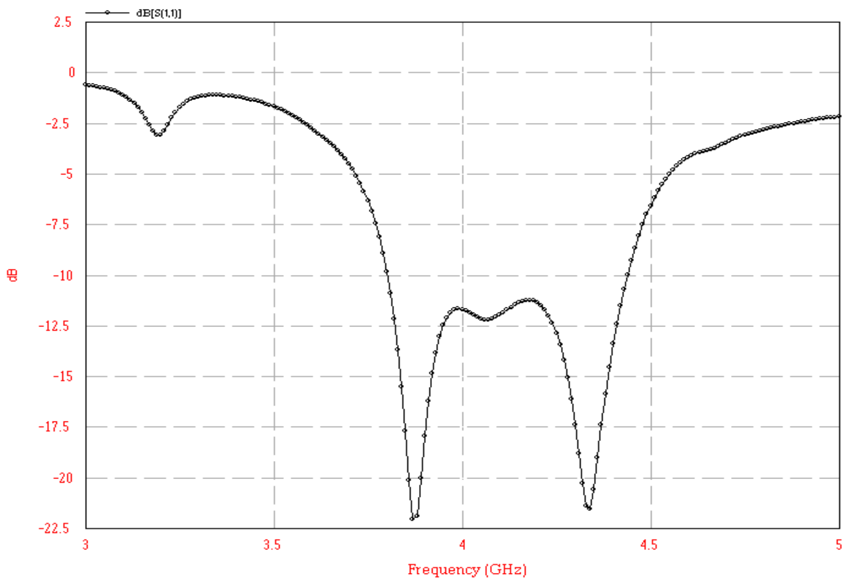

Fig. 1.3 Return Loss Vs Frequency

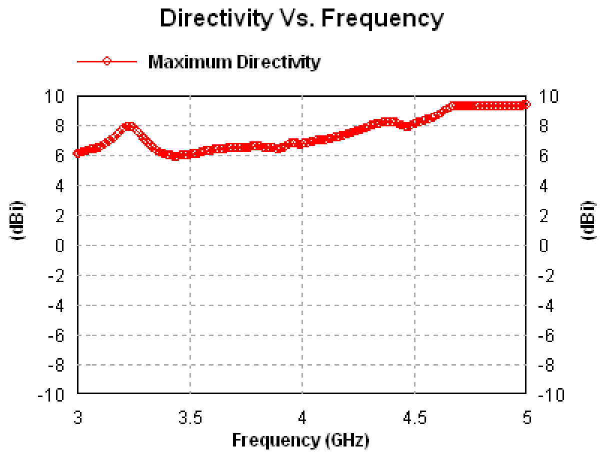

Fig. 1.4 Directivity Vs Frequency

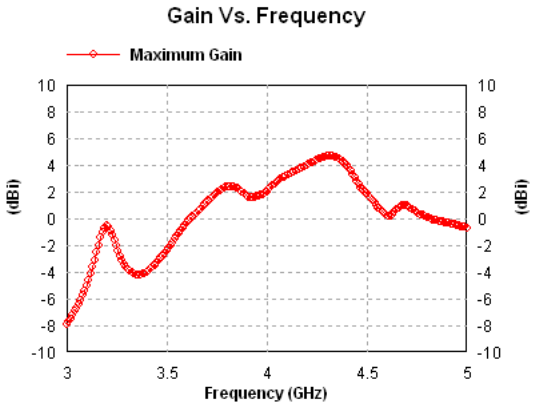

Fig. 1.5 Gain Vs Frequency

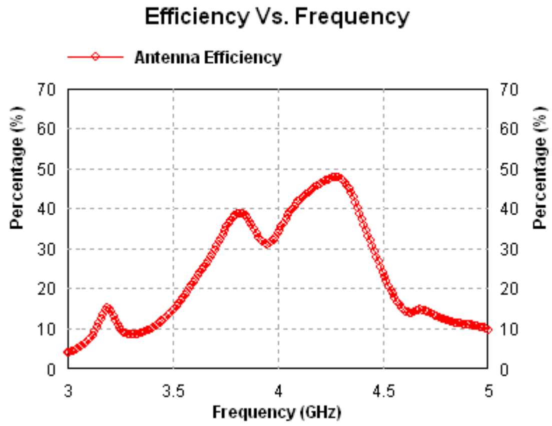

Fig. 1.6 Aperture Efficiency Vs Frequency

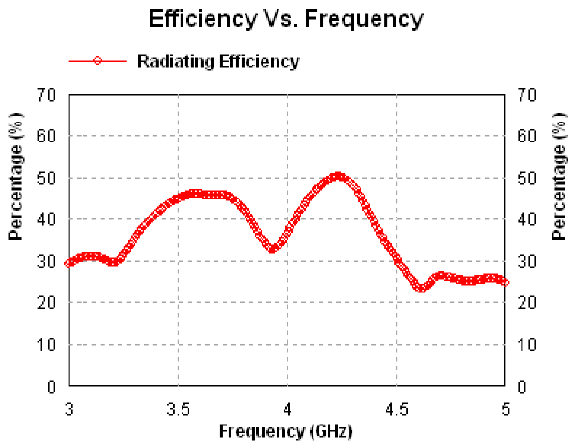

Fig. 1.7 Radiation efficiency Vs Frequency

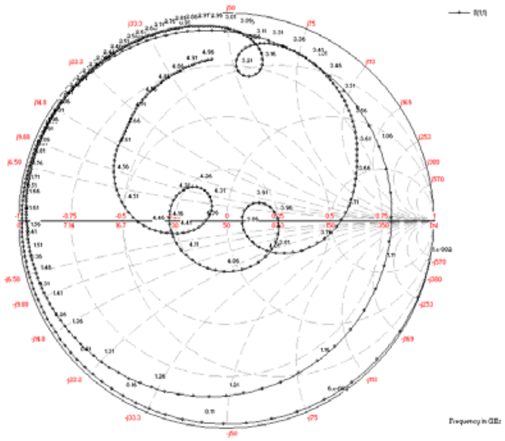

Fig 1.8 Smith Chart

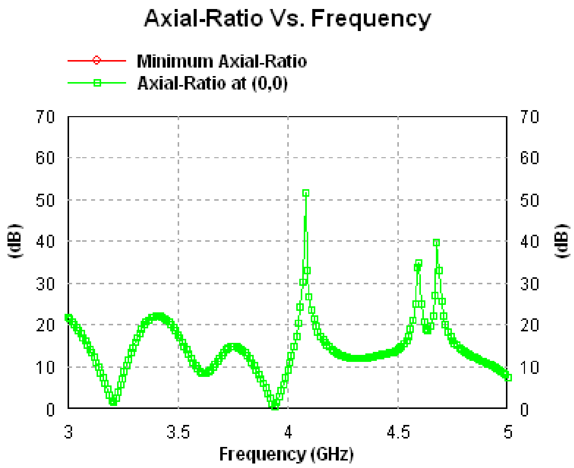

Fig. 1.8 Axial Ratio Vs Frequency

Conclusion

A coaxially fed wideband rectangular microstrip antenna with a directly coupled and two gap coupled parasitic patches is studied , designed and simulated and compared with a conventional rectangular microstrip antenna. This configuration provides the impedance bandwidth of 15.6 % with a peak directivity 8.172 dBi, gain 4.62 dBi, axial ratio 51.5 dB, aperture efficiency 47.7 % , radiation efficiency 50 % for a band (3.8 GHz to 4.44GHz) which is suitable for higher frequencies of S band and lower frequencies of C band applications.

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References

[1] Anandan, C. K., P. K. Mohanan, and K. G. Nair, ‘‘Broadband Gap-Coupled Microstrip Antenna,’’ IEEE Trans. Antennas Propagation, Vol. AP-38, pp. 1581–1586, 1990.
[2] Balanis C. A., “Antenna Theory: A Review,” Proc. IEEE, Vol. 80, No. 1, pp. 7–23, January 1992.
[3] Bahl I. J. and P. Bhartia, Microstrip Antennas, Artech House, Norwood, MA, 1980.
[4] Collin R. E., Antennas and Radiowave Propagation, McGraw-Hill, New York, 1985.
[5] James J. R. and P. S. Hall (Eds.), Handbook of Microstrip Antennas, Vols. I and II, Peter Peregrinus, 1989.
[6] Jordan E. and K. Balmain, Electromagnetic Waves and Radiating Systems, Prentice-Hall,New York, 1968.
[7] Kraus J. D., Antennas, McGraw-Hill, New York, 1988.
[8] Kumar G. and K. P. Ray,Broadband Microstrip Antennas, Artech House, 2002.
[9] Kumar G. and K. C. Gupta, “Directly coupled multiple resonator wide-band microstrip antennas,” IEEE Trans. Antennas Propagat. 33, 588–593, June 1985.
[10] Kumar G. and K. C. Gupta, “Nonradiating edges and four edges gap-coupled multiple resonator broad- band microstrip antenna,” IEEE Trans. Antennas Propagat. 33, 173–178,Feb. 1985.
[11] Nile, M. B., A. A. Rasheed, and G. Kumar, ‘‘Broadband Gap-Coupled Semicircular and Triangular Microstrip Antennas,’’ IEEE AP-S Int. Symp. Digest, pp. 1202–1205, July 1994.
[12] Wu C. K. and K. L. Wong, “Broadband microstrip antenna with directly coupled and gap-coupled parasitic patches,” Microwave Opt. Technol. Lett. 22, 348–349, Sep. 5, 1999.
[13] Wong Kin-Lu-, Compact and Broadband Microstrip Antenas, Joh Wiley & Sons,INC.