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DESIGN OF WIDE BAND CMPA

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Abstract

In this paper we are going to design CMPA (Circular Microstrip Patch antenna), and then tried to enhance its bandwidth and radiation efficiency, and other related antenna parameters. We have enhanced its parameters by changing the dimensions of slot of circular microstrip patch antenna.

Introduction

The MSA is an excellent radiator for many applications such as mobile antenna, aircraft and ship antennas, remote sensing, missiles and satellite communications [1]. It consists of radiating elements (patches) photo etched on the dielectric substrate. Microstrip antennas are low profile conformal configurations. They are lightweight, simple and inexpensive, most suited for aerospace and mobile communication. Their low power handling capability posits these antennas better in low power transmission and receiving applications [2]. The flexibility of the Microstrip antenna to shape it in multiple ways, like square, rectangular, circular, elliptical, triangular shapes etc., is an added property.

Microstrip antennas basically consist of a radiating patch on one side of a dielectric substrate, which has a ground plane on the other side. The patch is generally made of conducting material such as copper and gold. The patch is very thin ($t<<\lambda o$ where λo is free space wavelength) and is placed a small fraction of a wavelength ($h<< \lambda o$ usually $0.003\ \lambda o \leq h \leq 0.05\ \lambda o$) above the ground plane. The microstrip patch is designed so its pattern maximum is normal to the patch (broadside radiator). This is accomplished by properly choosing the mode (field configuration) of excitation beneath the patch. There are numerous substrates that can be used for the design of microstrip patch antennas and their dielectric constants are usually in the range of $2.2 \leq \varepsilon r \leq 12$. Those desirable for antenna performance are thick substrates whose dielectric constant are in the lower end of the range due to better efficiency, larger bandwidth, and loosely bound fields for radiation into space but at the expense of larger element size. Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. The radiation increases with frequency, thicker substrates, lower permittivity, and originates mostly at discontinuities (Lewin, 1960) Since microstrip antennas are often integrated with other microwave circuitry, a compromise has to be reached between good antenna performance and circuit design. The radiating element and the feed lines are usually photo etched on the dielectric substrate. The radiating patch may be square, rectangle, thin strip (dipole), circular, elliptical, triangle or any other configuration. A microstrip antenna is very versatile and made for a wide range of resonant frequencies, polarization patterns and impedances. Due to its operational features viz low efficiency, low power, high quality factor, poor polarization purity, poor scan performance and very narrow frequency bandwidth, it is suitable for mobile and government security systems where narrow bandwidth are priority. They are also used on laptops, microcomputers, mobile phones etc. The basic form of circular microstip patch antenna is shown in fig.1

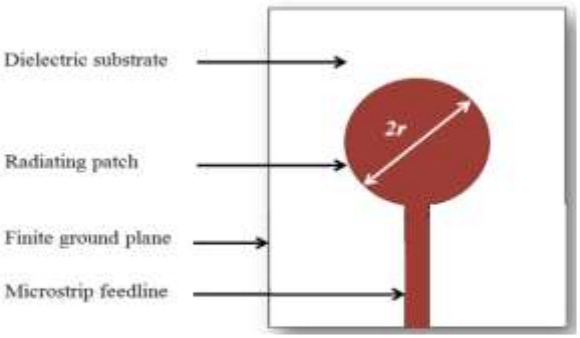


Fig-1. Basic form of CMPA

Methods of analysis

There are three popular models for the analysis of microstrip antennas - viz transmission line model, cavity model, and full wave model. The transmission line model is the simplest. It gives a good physical insight but is less accurate. The cavity model, which is used in this work, is quite complex but gives good physical insight and is more accurate. The full wave model is the most complex. It is very accurate in the design of finite and infinite arrays or stacked structures. The quantity associated with radiated EM wave is the Poynting vector given as: (Balanis, 1982)

$$S = E \times H \qquad (1)$$

where S is instantaneous Poynting vector, E is instantaneous electric field intensity and H is instantaneous magnetic field intensity. The complex fields E and H are related to their instantaneous counterparts by.

$$E(x, y.z.t) = Re[E(x, y, z)e^{jwt} \qquad (2a)$$

$$H(x, y.z.t) = Re[H(x, y, z)e^{jwt} \qquad (2b)$$

Using the identity Re[Xe^{jwt}] = ½[Xe^{jwt} +X^*e^{jwt}] equation (1) can be written as;

$$s = \frac{1}{2}Re[E \times H^*] + \frac{1}{2}Re[E \times He^{jwt}] \qquad (3)$$

Hence, the time average Poynting vector can be written as.

$$s_{av} = \frac{1}{2}Re[E \times H] \quad w/m^2 \qquad (4)$$

The factor ½ appears because the E and H fields are peak values and not rms.

A Closed Form Expression for CMSA Design

The performance of circular microstrip antennas has been studied extensively, both analytically and experimentally. Consider the circular microstrip antenna with radius a, height *h* and permittivity constant *εr* whose resonant frequency in the dominant TM11 mode as explained by Guney [4], is given by

$$a_e = a\sqrt{\left\{1+\frac{2h}{\pi a\epsilon_r}\left[ln\left(\frac{\pi a}{2h}\right)+1.7726\right]\right\}} \qquad (5)$$

$$\varepsilon_{reff} = \frac{\epsilon_r+1}{2}+\frac{\epsilon_r-1}{2}\frac{1}{\sqrt{\left[1+12\frac{h}{a\sqrt{\pi}}\right]}} \qquad (6)$$

where *αnm*- the *m*th zero of the derivatives of the Bessel
function of order *n*
c - the velocity of light.
a - Radius of the circular patch
fr - resonant frequency of circular patch.
h - Height of dielectric substrate
εr - Permittivity of dielectric substrate

Design and fabrication

The software model of antenna is designed using Microwave studio CST 2010 software. After designing the model and optimizing the results, the best possible outcome of design is fabricated.

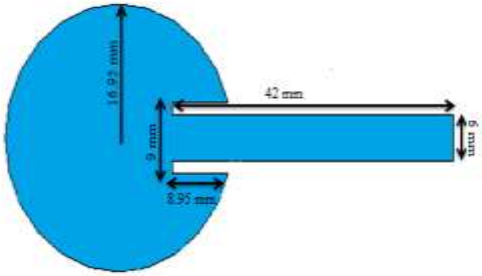


Fig-2. Geometry showing the dimensions of CMPA

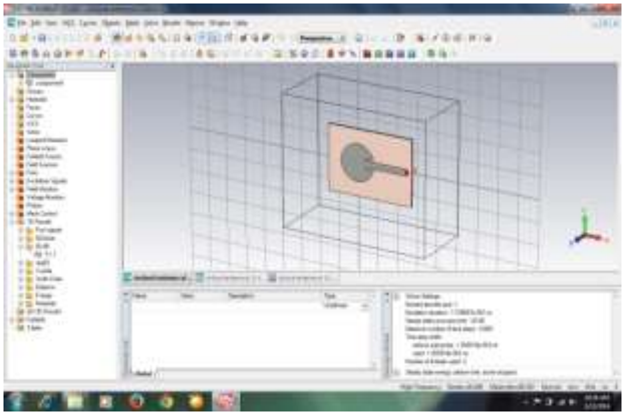


Fig-3. 3D view of CMPA in CST 2010 Softwar

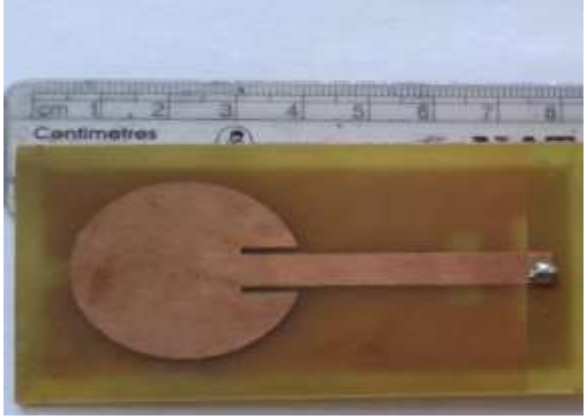


Fig-4. Fabricated view of CMPA

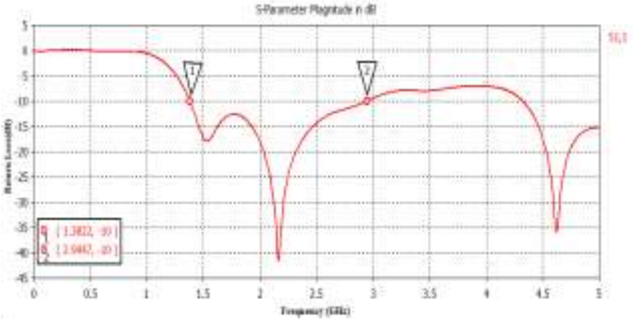
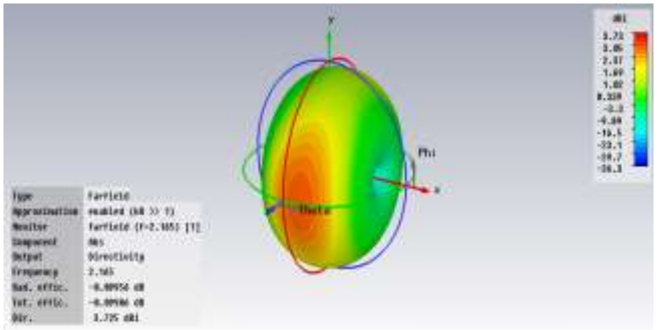
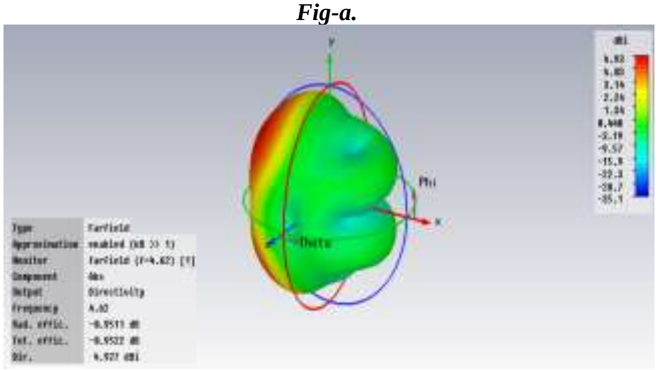


Fig-5.Graph showing the simulated response of CMPA



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=2.165) [1]
Component	Abs
Output	Directivity
Frequency	2.165
Rad. effic.	-0.00956 dB
Tot. effic.	-0.00986 dB
Dir.	3.735 dBi

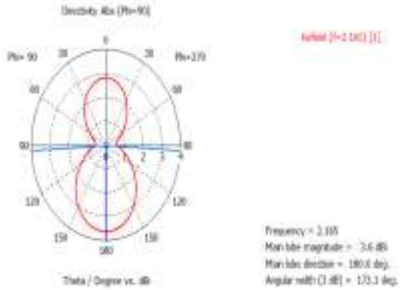
Fig-a.



Type	Farfield
Approximation	enabled (kR >> 1)
Monitor	farfield (f=4.62) [1]
Component	Abs
Output	Directivity
Frequency	4.62
Rad. effic.	-0.9511 dB
Tot. effic.	-0.9522 dB
Dir.	4.927 dBi

Fig-b.

Fig-6. Radiation Pattern (a)at 2.165 GHz ,(b)at 4.62 GHz



Figa

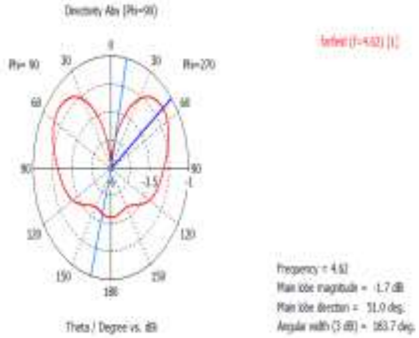


Fig-b

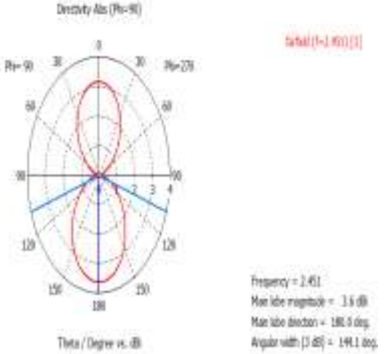


Fig- c

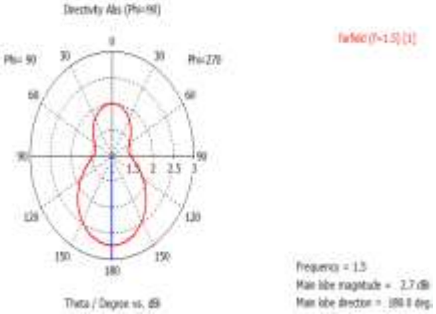


Fig- d

Table-1. Showing the comparison of dimensions of slot and band width

S.No.	Dimensions of Slot(mm)	Series	Return Loss(dB)	Bandwidth obtained(MHz)
1.	6.5 mm	Series-1	-25.6	1552.9
2.	7.2 mm	Series-2	-30.8	1683.8
3.	8.9 mm	Series-3	-42.5	1641.2
4.	9.1 mm	Series-4	-30.1	1626.4
5.	12 mm	Series-5	-25.2	0995.6

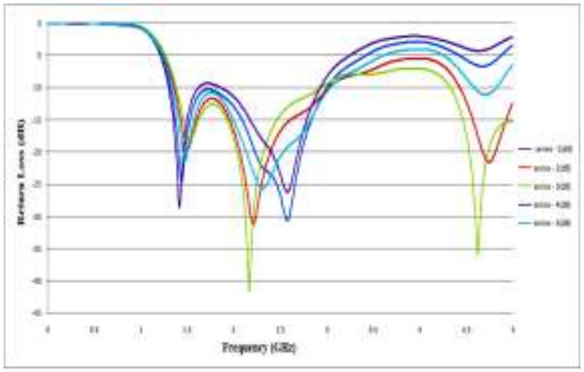


Fig-8. Comparision of Return Loss Vs Frequency with changes in dimension of slot

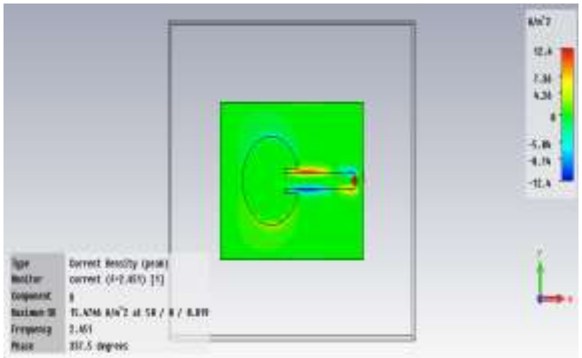


Fig-9. Current distribution on CMPA Surface

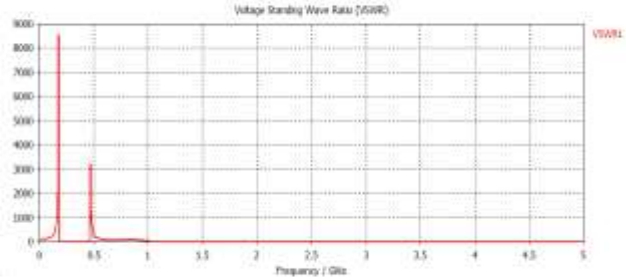


Fig-10. VSWR Graph

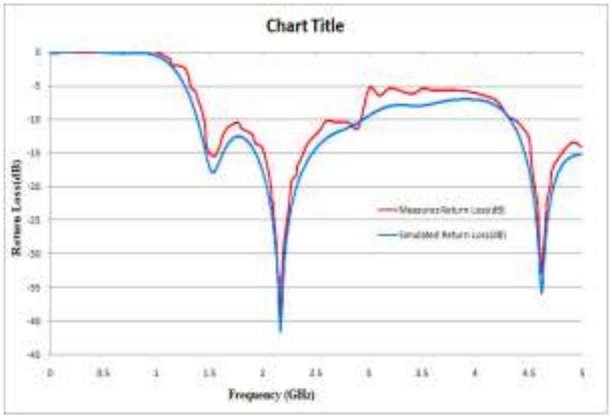


Fig-11. Graph Showing the measured and simulated response of CMPA

Conclusions

After comparing all the results, i.e measured and simulated we concluded that From the table-1. Dimensions of Slot plays an important role in enhancement of parameters of CMPA. The most optimum values of parameters is obtained at 8.9mm dimension depth while keeping the width of slot constant, the return loss obtained is -42.5 dB and bandwidth obtained is 1641.2 MHz

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