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ANALYSIS OF MICROSTRIP CIRCULAR PATCH ANTENNA LOADED WITH CENTRE SHORT

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Submitted in partial fulfillment of the Degree of Bachelor of Technology

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CERTIFICATE

This is to certify that the work entitled, "Analysis of Microstrip Circular Patch Antenna Loaded with Centre Short" submitted by Swapnil Saxena in partial fulfillment for the award of degree of Bachelor of Technology in Electronics & Communication Engineering of Jaypee University of Information Technology has been carried out under my supervision. This work has not been submitted partially or wholly to any other University or Institute for the award of this or any other degree or diploma.

Prof. Tapas Chakravarty

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ABSTRACT

This project describes the change in resonant frequency when the electrically thin patch is loaded with centre short. In this project I have done analysis of electric and magnetic fields and applied the boundary condition and thus obtaining the resonant frequency of thin circular patch microstrip antenna and than analyzed the electric and magnetic field equations again by applying boundary condition on these equation when the circular patch is loaded with center short and found its resonant frequency and on analysis of non loaded and loaded patch found the change in resonant frequency. The simulation showed the same change in frequency on loading the patch.

CHAPTER – 1

INTRODUCTION

Microstrip Antennas:

In high performance aircraft, spacecraft and missile applications, where size, weight, cost, performance, ease of installation, and aerodynamic profile are constraints, and low profile antennas may be required. Presently there are many other government and commercial applications, such as mobile radio and wireless communication that have similar specifications. To meet these requirements, microstrip antenna can be used.

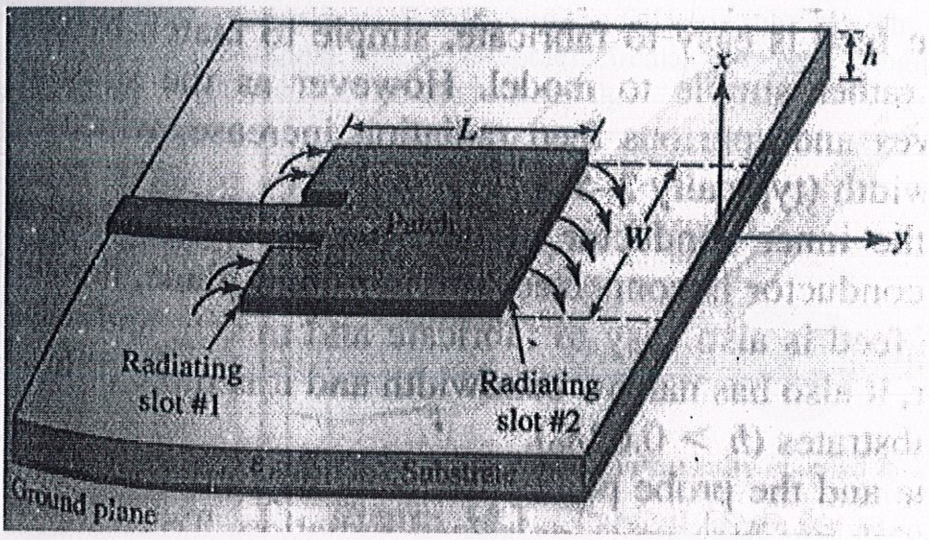


Fig (1): Microstrip Antenna

These antennas are low profile, conformable to planar and non planar surfaces, simple and inexpensive to manufacture and mechanically robust when mounted on rigid surfaces, compatible with MMIC designs, and when the particular patch shape and mode are selected they are very versatile in terms of resonant frequency, polarization, pattern and impedance. In addition by adding the load between the patch and the ground plane such as pins and varactor diodes, adaptive elements with variable resonant frequency, impedance, polarization and patterns can be designed.

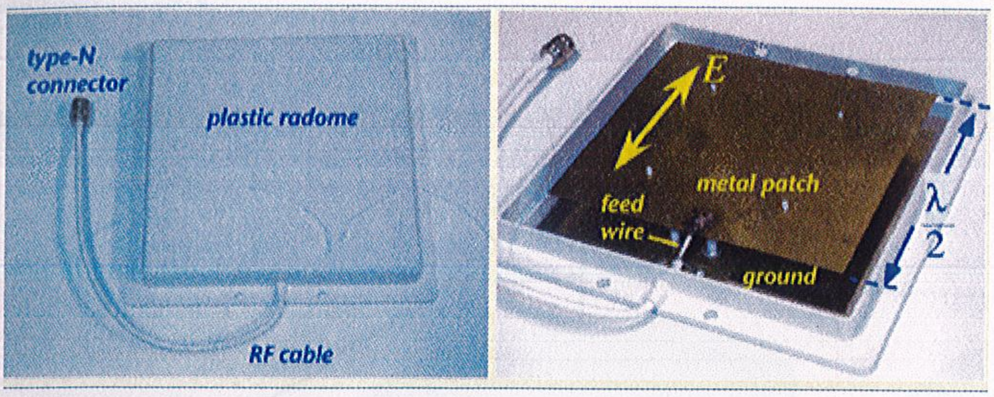


Fig (2): Microstrip Patch Antenna with Feed Lines

Often microstrip antennas are also referred to as patch antennas. The radiating elements and the feed lines are usually photo etched on the dielectric substrate. The radiating patch may be a square, rectangular, thin strip (dipole), circular, elliptical, triangular or any other configuration. These and other are illustrated in fig:

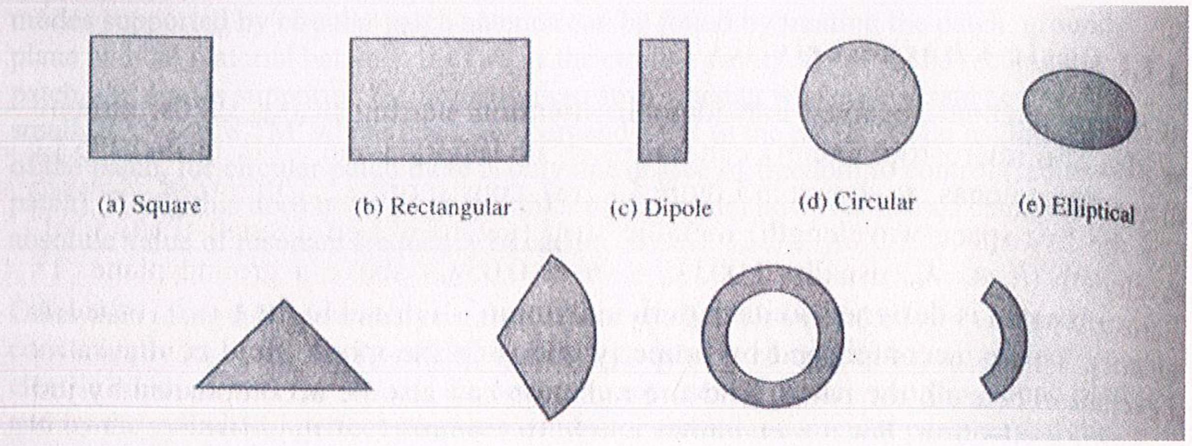


Fig (3): Representative shapes of microstrip patch elements

Circular patch antenna:

One of the most popular configurations is the circular patch or disk, as shown in the fig:-

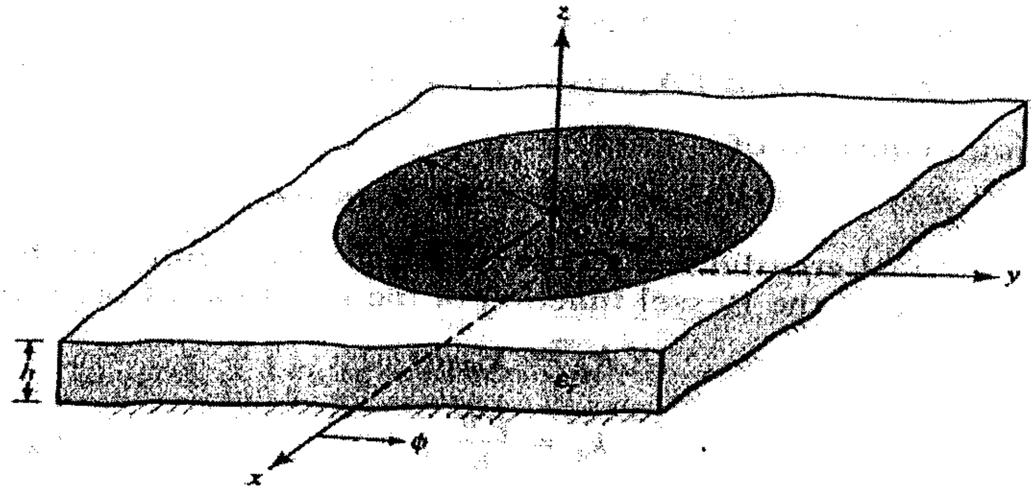


Fig (4): Geometry of circular micro strip patch antenna

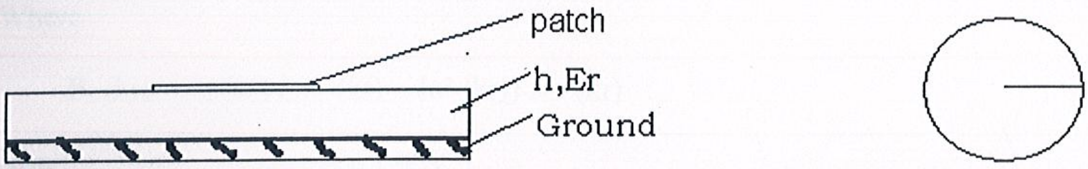
It has also received a lot of attention not only as a single element but also in arrays. The modes supported by circular patch antenna can be found by treating the patch, ground plane and the material between the two as the circular cavity. As with the rectangular patch, the modes supported by circular micro strip antenna whose substrate height is small ($h << \lambda$) are TM^z where z is taken perpendicular to the patch. As far as dimension of the patch, for circular patch there is only one degree of freedom to control (radius of patch). Doing this does not change the order of the mode; however it does changes the absolute value of resonant frequency of each.

Other than using full wave analysis, the circular patch antenna can only be analyzed conveniently using the cavity model. The cavity model is composed of two perfect electric conductors at the top and the bottom to represent the patch and the ground plane, and by the cylindrical perfect magnetic conductor around the circular periphery of the cavity. The dielectric material of the substance is assumed to be truncated beyond the extend of the patch.

CHAPTER – 2

ANALYSIS OF CIRCULAR PATCH

A circular microstrip patch is represented in Fig (5):



The expressions for electric and magnetic field for an electrically thin patch are given as:

$E_z = -j\omega\mu C_1 Jn\ (kr)\ Cosn\varphi$ - (1)

$H_r = -\ (n/r)\ C_1 Jn\ (kr)\ Sinn\varphi$ - (2)

$H_\varphi = -kC_1 Jn'\ (kr)\ Cosn\varphi$ - (3)

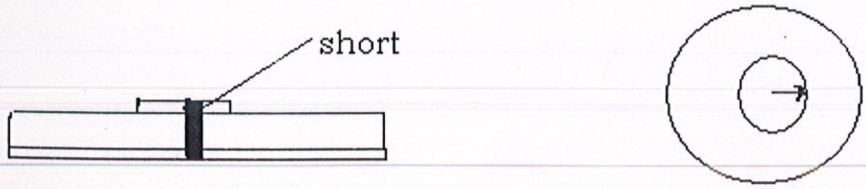
Application of magnetic wall boundary condition at the edge of the patch leads to the following result –

$H_\varphi = 0$ at $r = r_2$ - (4)

Or $Jn'\ (kr_2) = 0$ - (5)

The resonant frequency of the given TMnp mode is obtained by the solution of eq (4). In this case Jn represents Bessel function of 1st kind.

Let us now assume that the patch is loaded by a short of radius r1 at the centre. This is shown in Fig (6).



The field expressions are now:

$E_z = -j\omega\mu\ [C_1 Jn\ (kr) + C_2 Nn\ (kr)]\ Cosn\varphi$ - (6)

And

$$H_\varphi = -k\,[C_1 Jn'(kr) + C_2 Nn'(kr)]\,\text{Cos}n\varphi \qquad -(7)$$

Application of boundary condition given by eq. (4) leads to

$$C_1 Jn'(kr_2) + C_2 Nn(kr_2) = 0$$
$$C_2/C_1 = -Jn'(kr_2)/Nn'(kr_2) \qquad -(8)$$

Using eq (8) we can rewrite thc field expression as

$$E_z = -j\omega\mu CnF_n(kr)\,\text{Cos}n\varphi \qquad -(9)$$
$$H_\varphi = -kCnF_n'(kr)\,\text{Cos}n\varphi \qquad -(10)$$

Where

$$F_n(kr) = Jn(kr)\,Nn'(kr) - Jn'(kr_2)\,Nn(kr)$$

Now $\qquad E_2 = 0$ at $r = r_2$

Therefore

$$Jn(kr_1)\,Nn'(kr_2) - Jn(kr_2)\,Nn(kr_1) = 0 \qquad -(11)$$

The resonant frequency of the short loaded patch is obtained by the solution of eq (11)

It is to be noted that the magnetic wall is imposed at effective radius of the patch. Therefore in eq (11), r_2 is to be replaced by r_{2e}. Where,

$$r_{2e}=r2\sqrt{1+2 * h *(Y_1/3.14 * r_2 * \varepsilon_r)}$$

Results:

$$F_{np} = [300*X_{np}]/[2 * 3.14 * r_{2e} *\sqrt{\varepsilon_r}]$$

We consider a patch of radius of 15mm on dielectric of dielectric constant = 2.2 and height of substrate = 1.59 mm

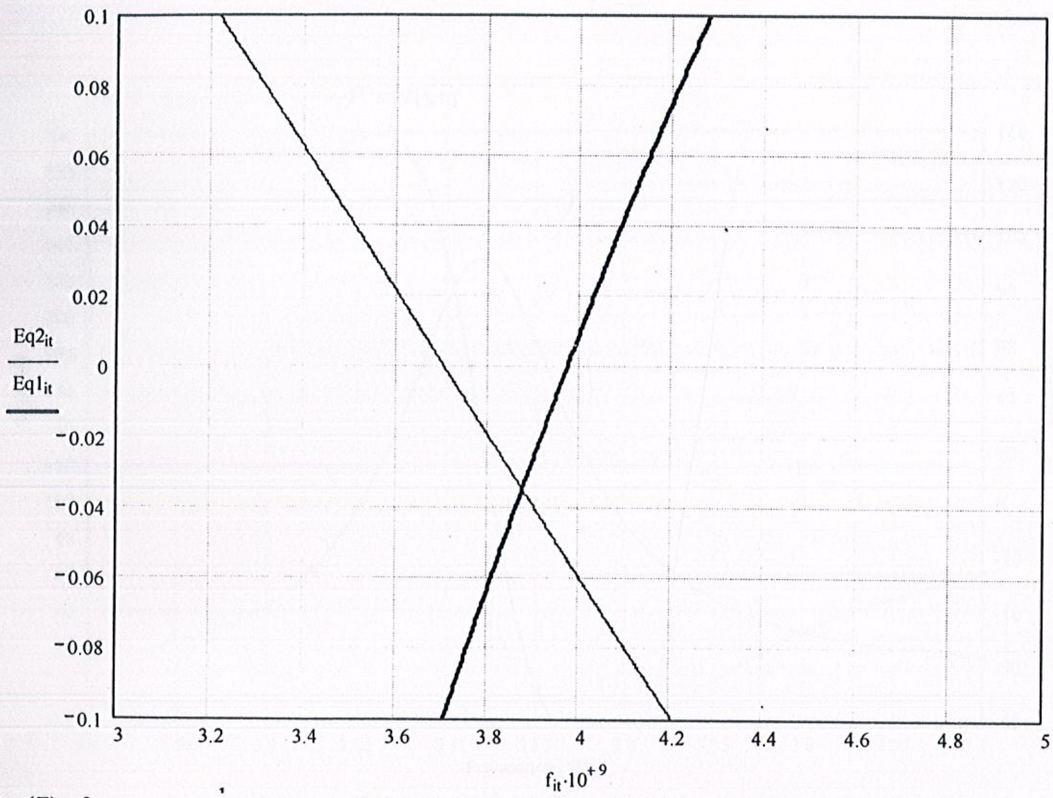


Fig (7): frequency variation of thin patch without load versus patch loaded a short of radius r_1 when r_1=3 (mode 1) (ε_r = 2.2, h = 1.59, r_2 = 15 mm)

This graph shows that frequency changes shifts toward left from 3.68GHz (for unloaded patch) to 4.05GHz when patch is loaded by a short of radius r_1 at the center. The shift in frequency can be verified with formula of frequency obtained in by solving eq. 11. $Eq2_{it}$ shows frequency response of electrically thin patch without load and $Eq1_{it}$ shows the new frequency which bends toward left when patch is loaded with a short of radius r_1.

CHAPTER – 3

GRAPHS: SIMULATION RESULTS

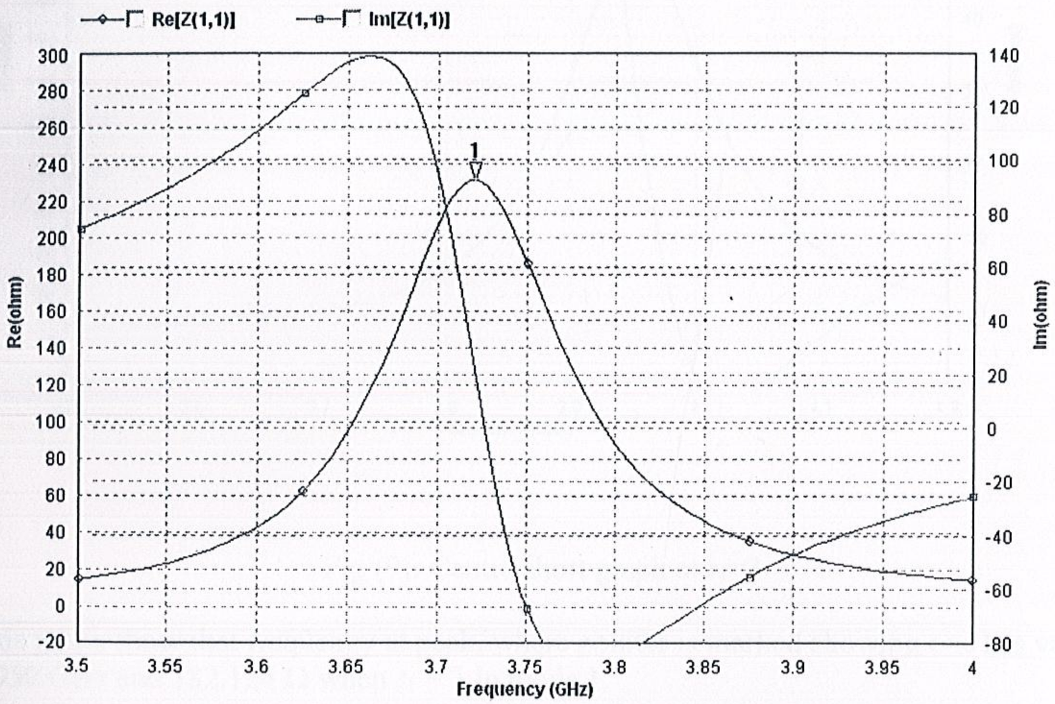


Fig (8): Centre short graph at r_l=1

This graph show that frequency at peak, where pointer is marked showing one has value 3.735 GHz and 230.570 Ω when $r_l = 1$ in mode 1.

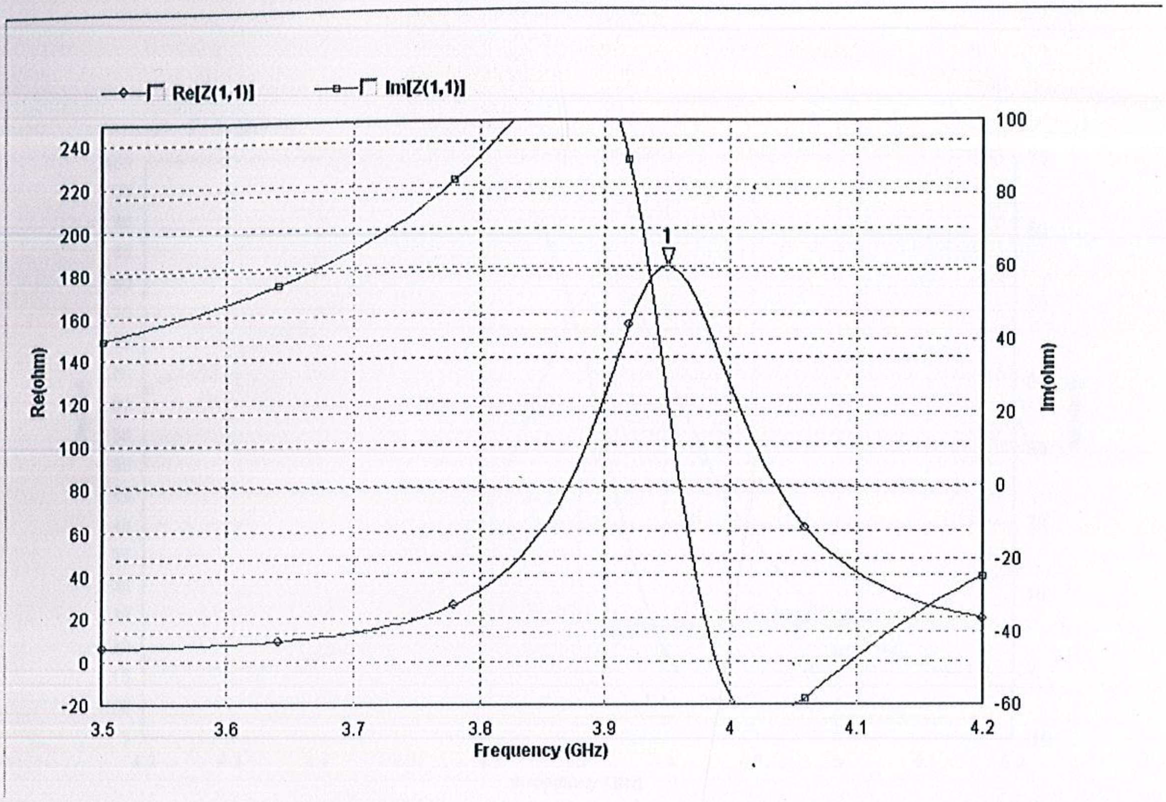


Fig (9): Centre short graph at r_1=3

This graph show that frequency at peak, where pointer is marked showing one has value 3.950 GHz and 182.124 Ω when $r_1 = 3$ in mode 1.

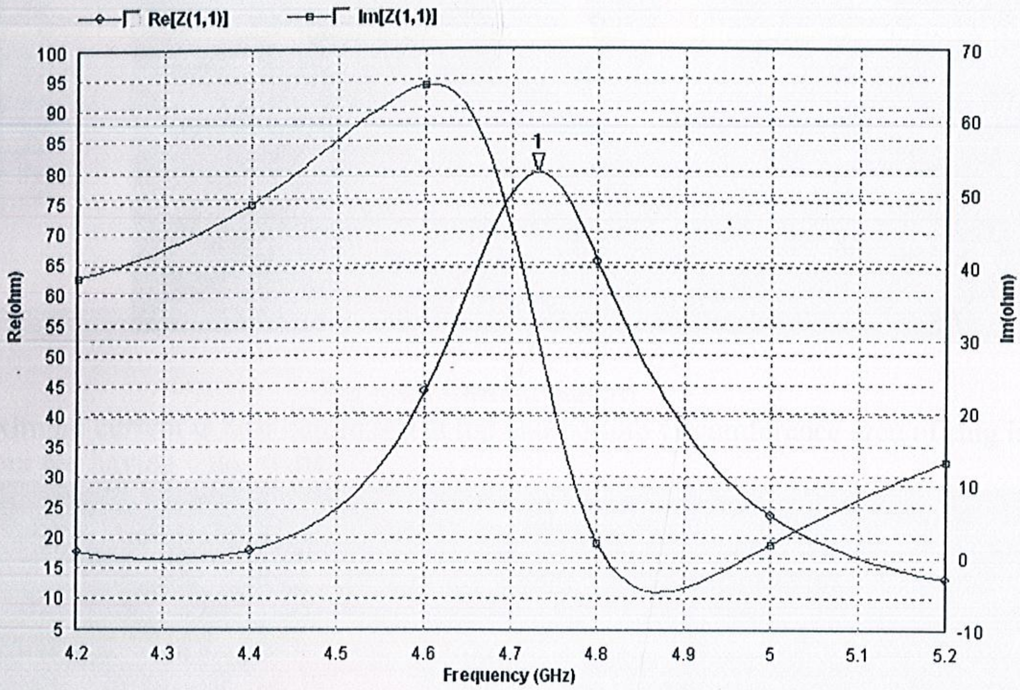


Fig (10): Centre short graph at r_1=6

This graph show that frequency at peak, where pointer is marked showing one has value 4.728 GHz and 79.741 Ω when $r_1 = 6$ in mode 1.

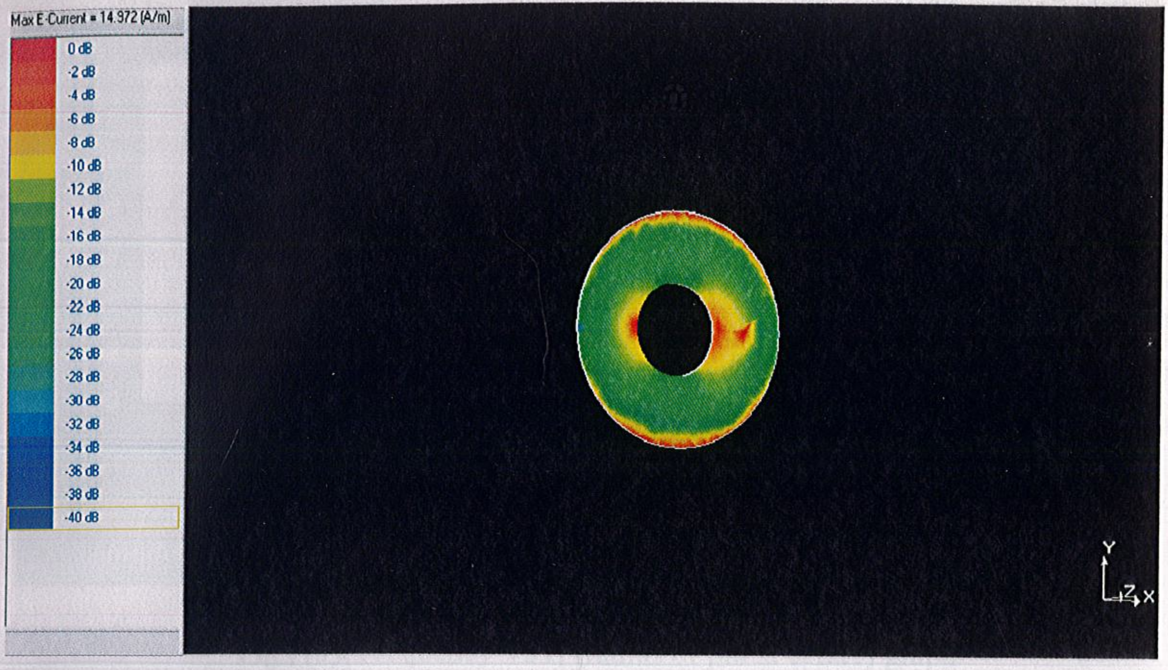


Fig (11): Current pattern

Maximum current is near centre and at top and bottom circumference area of ring in colour red having value 0 dB

Fig (12): Pattern

Showing the maximum value at peak value of pattern on y axis having value 5.593 dBi [Gain]

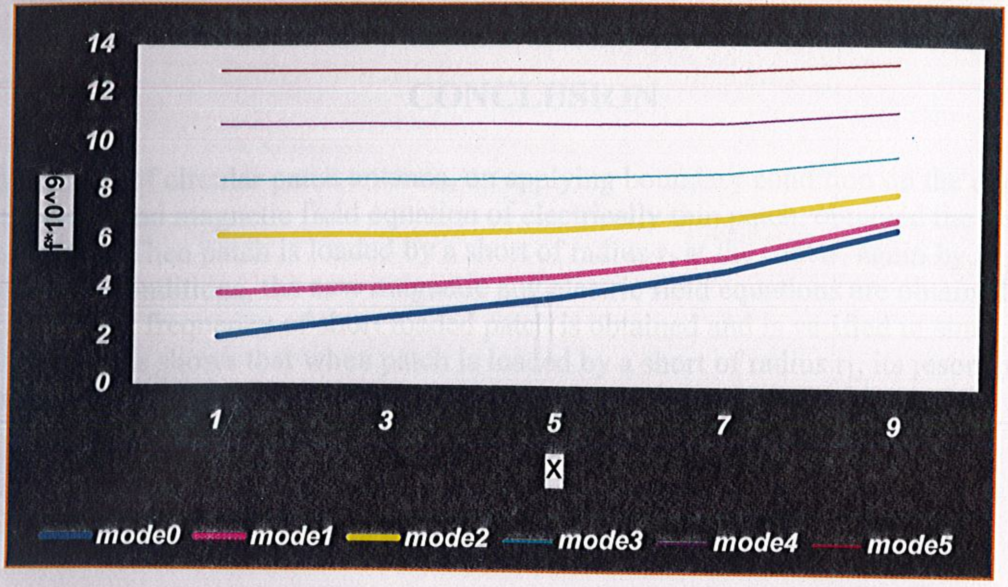


Fig (13): Frequency Vs r_1 (radius of pin at centre) graph

This graph has five lines denoting five different modes in which this graph is plotted. In this graph we see that as the mode increases from 0 to 5 the value of frequency is also increasing at same value of X. We can also say that as we increase the value or X the value of frequency increases. Here frequency is in GHz and X is r_1 with values 1, 3,5,7,9.

CONCLUSION

In analysis of circular patch antenna, on applying boundary condition on the expressions of electric and magnetic field equation of electrically thin patch, obtained the resonant frequency. Then patch is loaded by a short of radius r_1 at the center, again by applying boundary conditions, the new magnetic and electric field equations are obtained and than the resonant frequency of short loaded patch is obtained and is verified in simulation. This analysis shows that when patch is loaded by a short of radius r_1, its resonant frequency increases.

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