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Metamaterial Microstrip Patch Antenna Promising Future of Communication

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ABSTRACT:-
Microstrip patch antenna is a antenna with the properties like high gain, planar & directivity & increased bandwidth when integrated with **"so called metamaterials".** This antenna provides conformable antenna structures which is suitable for integration with monolithic microwave integrated circuits (MMIC). Due to their attracted properties, these can be used in various wireless applications including various defense applications.

Till now, we have achieved high "**directivity and gain"** with the patch antenna including a "**metamaterial cover".** Conventional antenna was showing the directivity of 7.9dB but the simulation results showing that the present antenna with **metamaterial** covering results the directivity to 11.92 dB. On the other hand, Gain is also improving considerably by using metamaterial cover on patch antenna. Our main goal is to increase directivity of the microstrip patch antenna keeping the return loss same as in conventional antenna.

KEYWORDS:-
. EM:-Electro Magnetic, MIC:-Microwave Integrated Circuit, MMICs:-Monolithic Microwave Integrated Circuits, MMs:- Metamaterial, MTMs:-Metamaterial, RF: Radio Frequency, RL:-Return Loss, SWR:-Standing Wave Ratio, VSWR:-Voltage Standing Wave Ratio, WLAN:-Wireless Local Area Network, ZIM:- Zero Index Material, SRRs:-Split Ring Resonators

INTRODUCTION:-

In present scenario, Micro strip patch antenna has solved many requirements of low-profile, simple structure, Multi directional radiation patterns. As the improvement in technology now we need to enhance the flaws such as narrow B.W., limited directivity, low efficiency and gain.

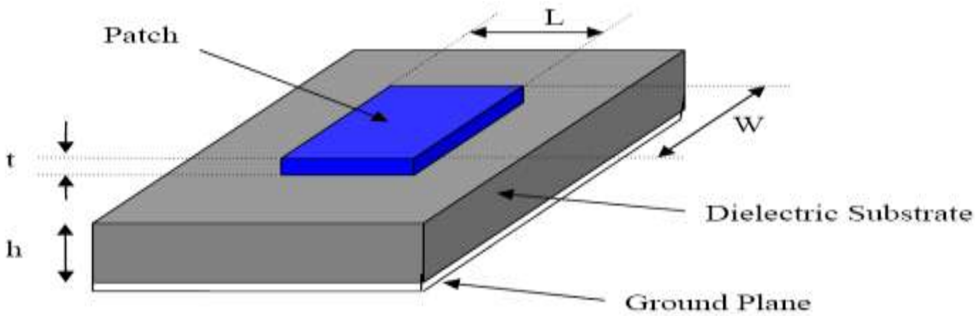
Using different aspects we can overcome on some difficulties. In our project antenna we have tried to eliminate these problems. An antenna with metamaterial cover and quarter wave transformer feed results high directivity with a high efficiency and high gain, bandwidth is also increase with reduced size.

OBJECTIVE:

The main objective of this thesis is to design a highly directive patch antenna with a metamaterial cover and quarter wave transformer feed for wireless application at operating frequency of 10 GHz. Our main target is to enhance directivity of antenna.

STRUCTURE AND OPERATION:

Conventional Microstrip antennas consist of a pair of parallel conducting layers which is separated by a dielectric medium, known as substrate. The upper patch is the radiation source and electromagnetic energy fringes off the edges of the patch and also into the substrate. The lower patch act as a perfectly reflecting ground plane, bouncing energy back through the substrate and into free space. The patch is a thin conductor that has resonant behaviour which is responsible to achieve adequate bandwidth. Mostly it is rectangular or circular in shape; however, in general any geometry is



possible.

Patch antenna may be feed by coaxial cables, micro strip feed lines and by aperture coupled feed lines.

ANTENNA PARAMETERS:

To describe the performance of an antenna, definitions of various parameters are necessary.

a.GAIN AND DIRECTIVITY:

The gain of an antenna is the radiation intensity in a given direction. An isotropic antenna, however, is just a concept. Nevertheless, the isotropic antenna is very important as a reference. It has a gain of unity (G = 1 or G = 0 dB) in all directions, since all of the power delivered to it is radiated equally well in all directions.

The gain of an antenna is usually expressed in decibels (dB). When the gain is referenced to the isotropic radiator, the units are expressed as dBi; but when referenced to the half-wave dipole, the units are expressed as dB. The relationship between these units is

$$G_{dBd}G_{dBd} = G_{dBi}G_{dBi} - 2.15dBi$$

Directivity is the same as gain, but with one difference. It does not include the effects of power lost (inefficiency) in the antenna.

b.ANTENNA POLARIZATION:

Polarization is the orientation of the electric field vector E at some point in space. The polarization is linear if the E-field retains its orientation.

c.INPUT IMPEDANCE:

According to complex form of Ohm's law impedance can be defined as the ratio of voltage across a device to the current flowing through it. Input impedance of patch antenna may be viewed in general complex and it includes resonant and non-resonant part.

d.VOLTAGE STANDING WAVE RATIO:

The standing wave ratio (SWR) can also be termed as VSWR. It is the measure of matching capacity of characteristics impedance to terminal lines. The VSWR is the ratio of the maximum to the minimum RF voltage along the transmission line.

e.BANDWIDTH:

Bandwidth of an antenna is the range of frequency within the performance of the antenna.

For broadband antennas, the bandwidth is usually expressed as the ratio of the upper to lower frequencies of acceptable operation. However, for narrowband antennas, the bandwidth is expressed as a percentage of the bandwidth.

f.QUALITY FACTOR:

The quality factor is a figure-of-merit that representative of the antenna losses.

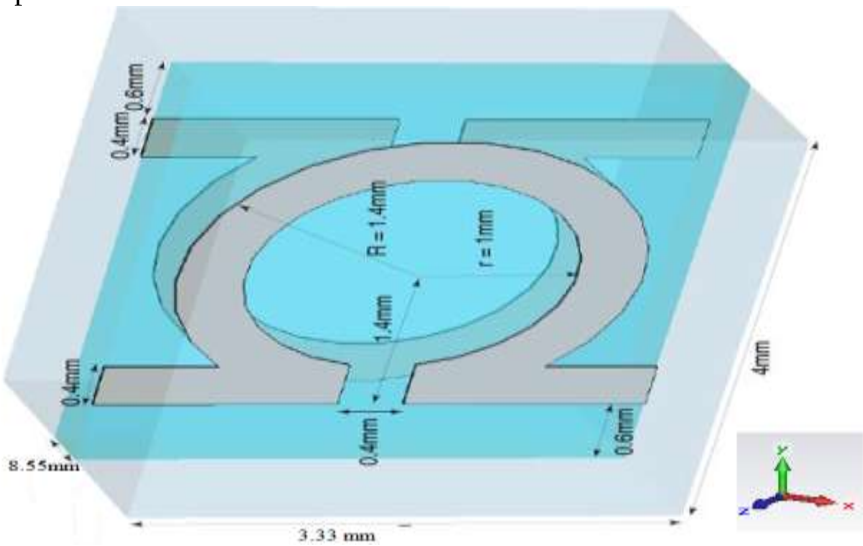
$$\frac{1}{Q_t} = \frac{1}{Q_{rad}} + \frac{1}{Q_c} + \frac{1}{Q_d} + \frac{1}{Q_{sc}}$$

Q_t: Total quality of factor
Q_{rad} : Quality factor due to radiation losses
Q_c: Quality factor due to conduction losses
Q_{dm}: Quality factor due to dielectric losses

METHODOLOGY AND DESIGN PARAMETERS OF PROPOSED ANTENNA:

a.Omega Unit Cell:

Fig. shows a single unit cell of an omega structure, which consist of two parts: the substrate and the omega Perfect Electric Conductor (PEC) structure. Two waveguide ports were set at the top and bottom of the Y-axis, where the wave penetrates into the metamaterial. PEC boundary conditions were implemented on the left and the right of the X-axis, and perfect magnetic conductor (PMC) boundary conditions were placed in front and back of the Z-axis.



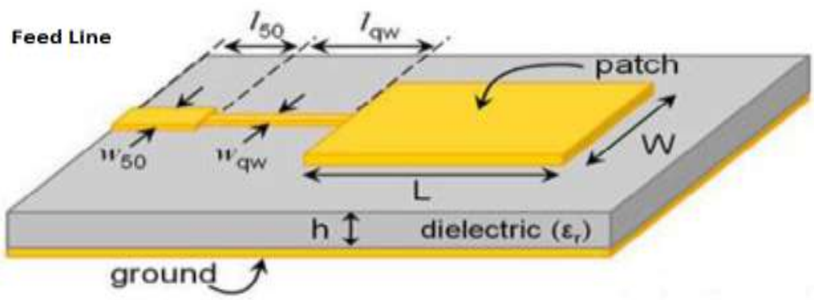
b.GEOMETRY OF UNIT CELL:

Geometry Parameters of Omega Unit Cell is given below in following

Height of Substrate	4 mm
Width of Substrate	3.33 mm
Thickness of Substrate	8.5 mm
Radius of Inner Circle	1 mm
Radius of Outer Circle	1.4 mm

c.QUARTER WAVE MICROSTRIP ANTENNA:

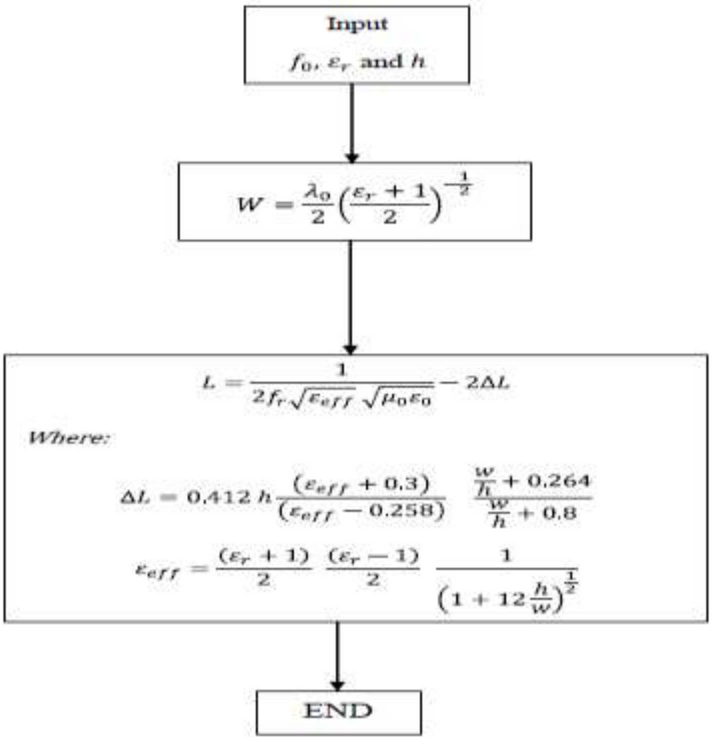
A single element of rectangular patch antenna, as shown in Figure, can be designed for the 10



GHz resonant frequency

Measuring steps required for width (W) and Length (L) calculation of microstrip antenna

Step 1. Initially, select the desired resonant frequency, thickness and dielectric constant of the substrate.
Step 2. Obtain Width (W) of the patch by inserting ε_r *and* λ_0 .
Step 3. Obtain Length (L) of the patch after determining ΔL *and* ε_r.



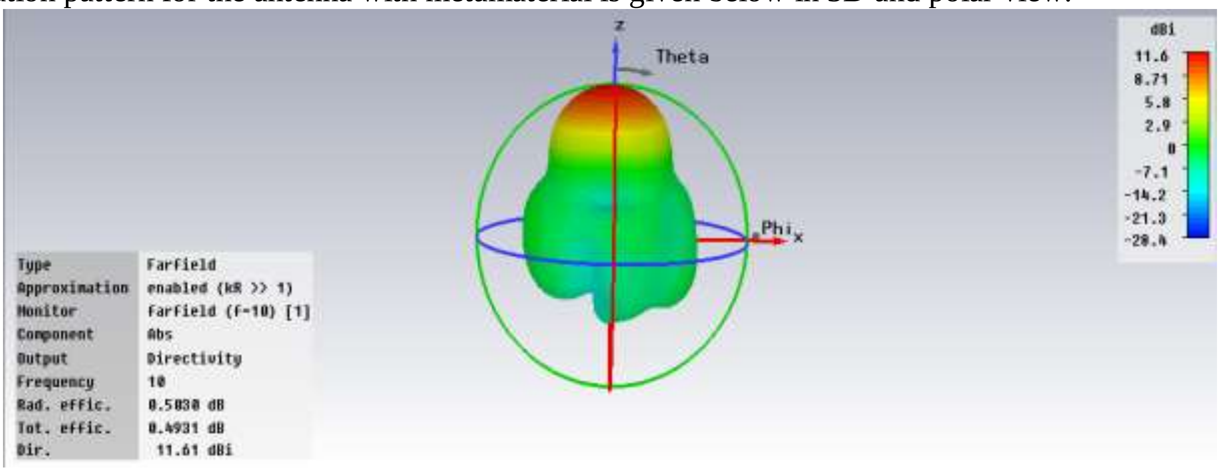
RESULTS AND DISCUSSION FOR QUARTER WAVE TRANSFORMER MICROSTRIP ANTENNA:

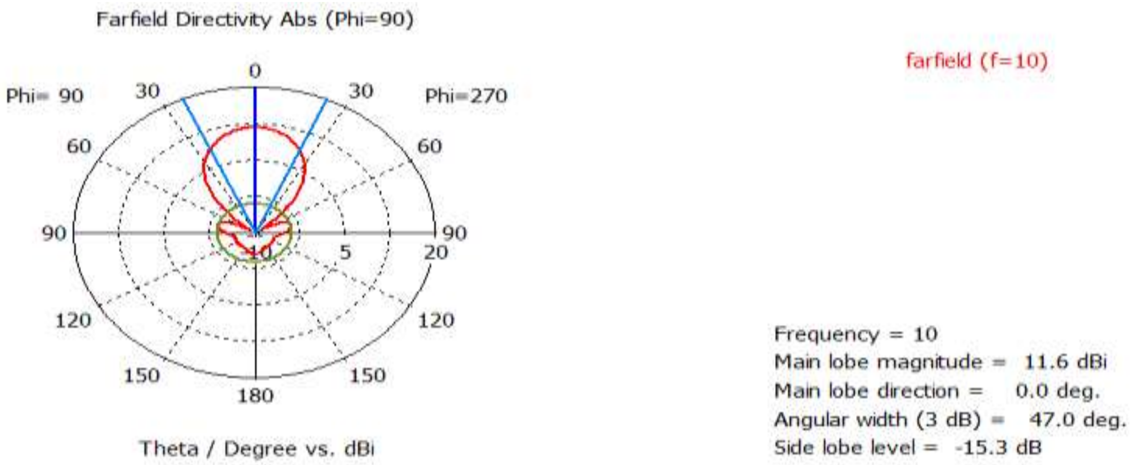
A calculated result for quarter wave transformer micro strip patch antenna is shown in table 5.1 below:

Frequency	10 GHz
Radiation Efficiency	0.5403 dB
Total Efficiency	0.4959 dB
Directivity	7.931 dBi
Beam Width	82.2 deg
Bandwidth	405.7 MHz
Return Loss	-19.92 dB

Directivity of Antenna with Metamaterial

Radiation pattern for the antenna with metamaterial is given below in 3D and polar view.





CONCLUSION:

Due to the appreciable conformable properties as well as its planar structures, Microstrip patch Antenna is widely used in defence applications. On the other side, because of certain limitation like poor less directivity and poor efficiency, it is still the area for many science scholars. But we studied that by the advent of quarter Lambda transformer properties are improving.

In this thesis two aspects of Microstrip antennas have been studied. The first approach is to design the typical rectangular Microstrip antenna and the second is to design the Microstrip antenna with metamaterial cover. To improve impedance matching property of antenna ,an efficient technique is used which is known as quarter wave transformer method. Initially, a rectangular Microstrip antenna is designed to operate at frequency 10 GHz having directivity of 7.92 dBi. After that a microstrip antenna with covering of metamaterial is designed to work at same frequency.The antenna with metamaterial covering shows the highly directive responses.

Our designed Antenna operates at 10 GHz & the performance parameters are compared in tables shows that directivity is improving almost 50 percent.

FUTURE SCOPE:

It has been found that there is an infinite scope of advancement in this property of metamaterial integration. We are looking forward for future improvement in this direction.

- Further, a circular Microstrip antenna with metamaterial covering may also developed, using this concept.
- Using a different dimension or design for metamaterial unit cell, different antenna parameters can be achieved.

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