IJETAE
EXPLORING RESEARCH AND INNOVATIONS

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 2, February 2013)

Radiation Pattern of OMNIDIRECTIONAL Conformal Microstrip Patch Antenna On Cylindrical Surface

Vinay kumar, Scientist

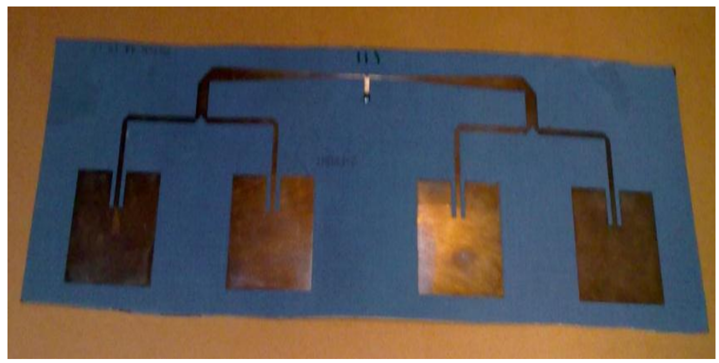
Armament R&D Establishment, DRDO, Pune, India

***Abstract*- Omnidirectional antennas are required to maintain a ease (proper) communication link. Conformal antennas follow the shape of the surface on which they are mounted and generally exhibit a very low profile. When these types of antenna are mounted on aircraft, missiles and instrumented artillery shells, they reduce turbulence effects in flight, because of their low profile. Conformal Microstrip antennas have been printed on low loss dielectrical material like Polytetrafluoroethylene (PTFE). These materials being very flexible, a significant portion of these can be wrapped around easily, for altering the radiation pattern. First we design a single patch on the PTFE material, with help of Powerful Computed Aided Design(PCAD) software. After analysis of the simulated result of this single patch antenna, we finalize the patch position and number of patches for achieving the omnidirectional pattern on the cylindrical surface. For achieving the omnidirectional pattern after wrapping antenna on the cylindrical body, choose the proper equidistance (in perimeter) of patches on the cylindrical surface. We will see the effect of the antenna parameters like VSWR, IMPEDANCE, REFLECTION COFFICIENT, CENTER FREQUENCY, before wrapping antenna on cylindrical surface and after wrapping antenna on cylindrical surface with cylinder radii less than one guided wavelength.**

I. INTRODUCTION

The concept of microstrip radiators was given by 'Deschamp' first time in 1953.Development and fabrication of this type of antenna nearly started during 1970's after availability of good substrate with low tangent loss, attractive thermal and mechanical properties and improved photolithographic techniques .Ideally the dielectric constant(ε_r)of the substrate should be low(ε_r<2.5)to enhance the fringe field that accounts for radiation. Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Figure 1.The patch is generally made of conducting material such as copper and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. These are low profile, light weight antennas, most suitable for aerospace, missile, and mobile applications. Because of their low power handling capability, these antennas can be used in low power transmitting and receiving applications.

Microstrip patch antenna(4-Array type)on Flat surface:



Conformal microstrip antenna is a new class of antenna using microstrips to form the feed networks and radiators. High velocity aircraft, missiles and rockets require conformal, thin antennas. Ideally an antenna **paper thin** would best suit for aerodynamically and mechanically nature wise. This antenna would neither disturb the aerodynamic flow, nor it would protrude inwardly to disturb the mechanical structure. The wraparound microstrip antenna that wraps around missiles, rockets and satellites to provide omnidirectional coverage in its simple form, is a low bandwidth structure .Bandwidth depends on thickness of the dielectric substrate and and dielectric constant. For L band and S band the bandwidth vary from 30 MHz to 100 MHz (2% to 3% of the center frequency) and gain G_{dB}= 4.5 to 7 dBi ,when VSWR less than 2:1.

The conformal microstrip antenna consists of two parts i) microstrip feed network ii) microstrip radiator

Microstrip feed network : The microstrip feed network is a parallel (corporate) feed network where two- way power splits and equal line lengths result in equal power and equal phase to all of the feed points.the number of power divisions can be 2,4,8,16 etc.the number of feeds ,power divisions ,required is dictated by microstrip radiator. The number of individual antenna required (number of feeds) N_a depends upon the electrical size of the projectile. A rule of thumb sets the spacing between two Consecutive antennas to be a half wavelength.

$$N_a = \frac{\text{Circumference of projectile}}{halfwavelength}$$

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 2, February 2013)

$$N_a = \frac{4\pi R}{\lambda}$$

where R=radius of the projectile and λ= wavelength of carrier signal

Two types of feed network are used to accomplish a 2, 4,8,16 etc. Power split:

i) Most often tapered lined used to transfer a 50 Ω impedance to 100Ω, so that it can be combined in parallel with another 100 Ω line.

ii) Sometimes quarter wave transformer technique is used to realize the desired impedance transformation.

Here i am using taper line for impedance transformation purpose in our experiments.

Microstrip Radiator: Generally two types of radiator are used, the long microstrip radiator and the microstrip patch radiator. In the long microstrip radiator, the radiating edge extends the entire length of both sides. In case of patch radiator the radiating edges are also lengthwise. Microstrip antenna can be designed to have many geometrical shape and dimensions. All microstrip antenna can be divided into four basic categories: microstrip patch antenna, microstrip dipole, printed slot antenna, microstrip travelling wave antennas. In this paper i have selected rectangular type **microstrip patch antenna** according to our application.

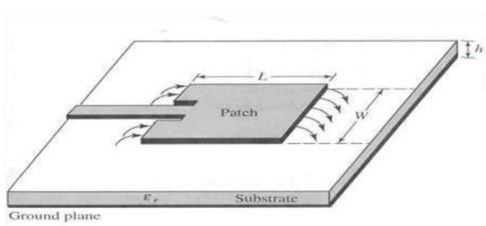


Figure 1: Structure of a Microstrip Patch Antenna

Design of antenna:

1) Effective dielectric constant (ε_{eff})

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+\frac{10h}{w}\right]^{-1/2} - (\varepsilon_r-1)\left[\frac{\frac{t}{h}}{4.6\sqrt{\frac{w}{h}}}\right],$$

Where ε_r- dielectric constant of the substrate

h- Substrate thickness

t- Copper thickness

w- Patch width of antenna

2) Patch width has minor effect on resonant frequency and radiation pattern of the antenna. It affects to the input resistance and bandwidth to the larger extent. A larger patch width increases the power radiated and thus decreased resonance resistance, increased bandwidth and increased radiation efficiency. With proper excitation one may choose a patch width W greater than patch length L without exciting undesired mode. A constraint against larger patch width is the generation of grating lobes in antenna arrays and small patch size might be preferred to reduce the real estate requirements. The patch width also affects the cross polarization characteristics .the patch width should be selected to obtain good radiation efficiency if real estate requirements OR grating lobe are not overriding factors. Its range should be $1<\frac{W}{L}<2$, where W – patch width and L – patch length. Patch length (L) determine the resonant frequency (f_r) and is a critical parameter in the design because of the inherent narrow bandwidth of the patch.

Patch length **(L)** = $\frac{C}{2f_r\sqrt{\varepsilon_r}}$, where C= velocity of light in free space ($3\text{x}10^8$ m/sec)

The factor $\sqrt{\varepsilon_r}$ is due to loading of subtract. In practice fields are not confined to the patch, a fraction of fields lie outside of the physical dimension L x W. This is called fringing field. The effect of the fringing field along the edges y=0 to y =W can be included through the effective dielectric constant (ε_{eff}) for the microstrip line of width W on the given substrate. With the replacement of ε_r by ε_{eff}, the patch length(L) becomes

Effective patch length **(L_{eff})** = $\frac{C}{2f_r\sqrt{\varepsilon_{eff}}}$

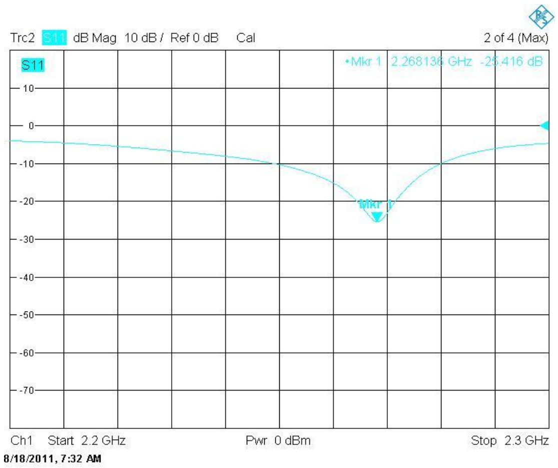
Practical results and conclusion of designed conformal microstrip patch antenna:

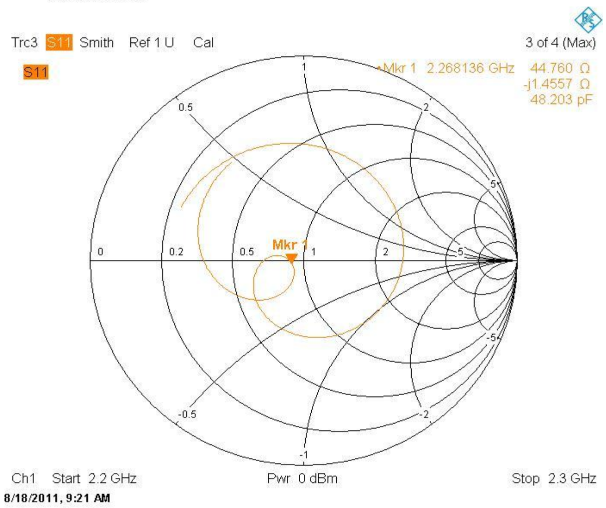
We have taken patch length (L) =44.15 mm, patch width (W) =44.15 mm, dielectric constant(ε_r) =2.2, substrate thickness= 0.7874 mm, copper thickness=0.035 mm, probe distance from radiating edge=144 mm. Using these value PCAD software gives the ε_{eff}=2.154, resonant frequency (f_r)= 2.26979 GHz, impedance(Z_o)=46.2 Ω . After fabrication the result shows resonant frequency = 2.268138 GHz, reflection coefficient=25.416dB, impedance=44.67 Ω, VSWR=1.11 on flat surface. When this fabricated antenna wrapped on the cylindrical surface, there is not much difference in antenna parameters as before wrapped on cylindrical surface. For achieving the Omnidirectional radiation pattern calculate the no. of individual patch required for this projectile (N_a=5.704), by taking radius of the projectile (R)=60mm .From this calculation we have taken four patch for achieving the Omnidirectional radiation pattern.

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 2, February 2013)

The practical result from ANECHOIC chamber shows the omnidirectinal radiation pattern in roll plane.

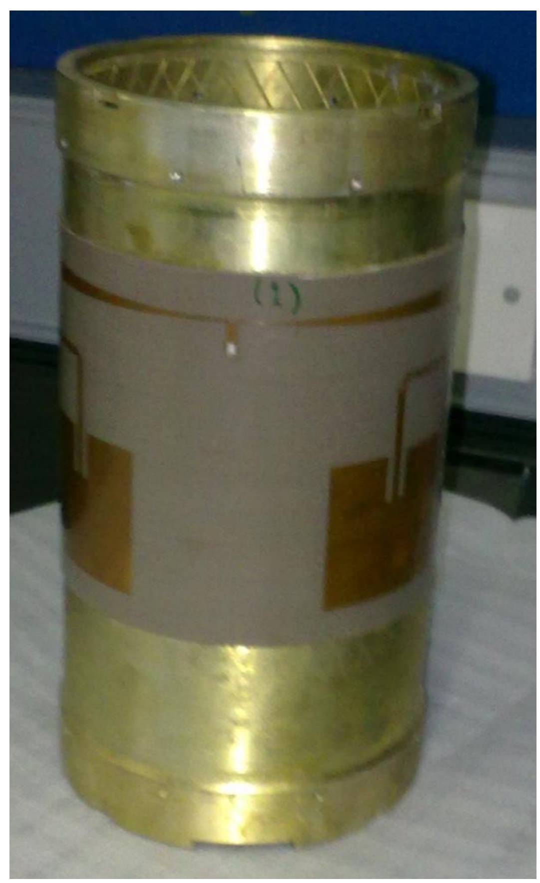
Practical Results:





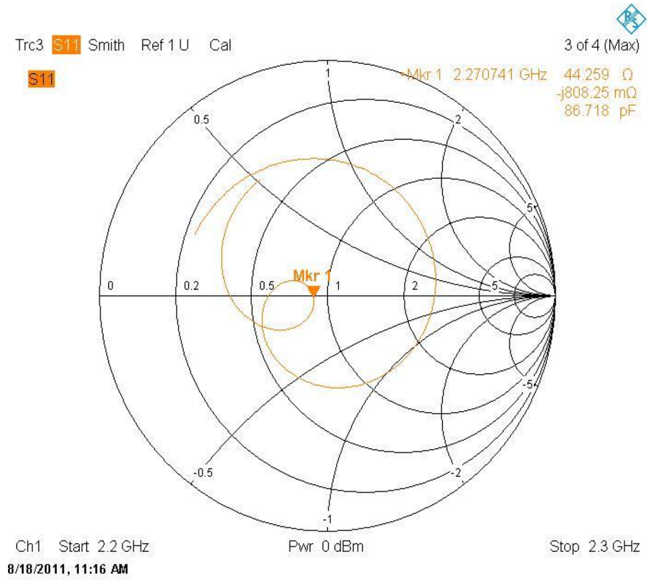
VSWR after Antenna wrapped on cylinder

Microstrip Patch Antenna(4-Array type)on cylindrical surface:

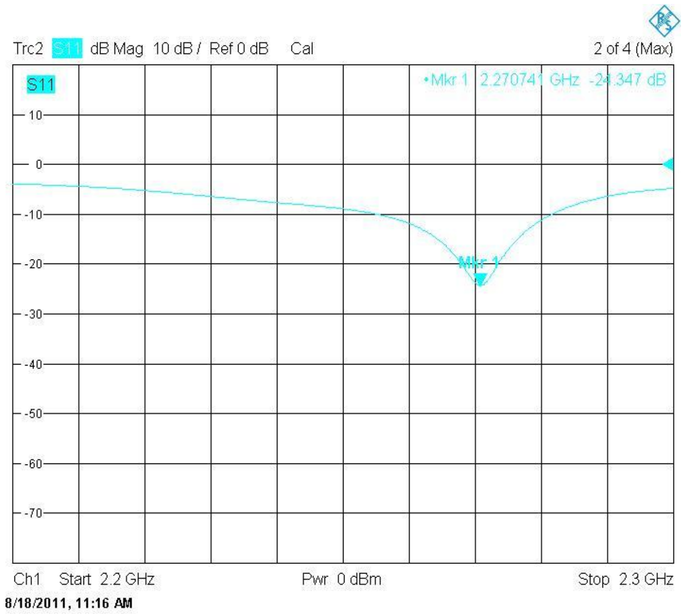


IJETAE
EXPLORING RESEARCH AND INNOVATIONS

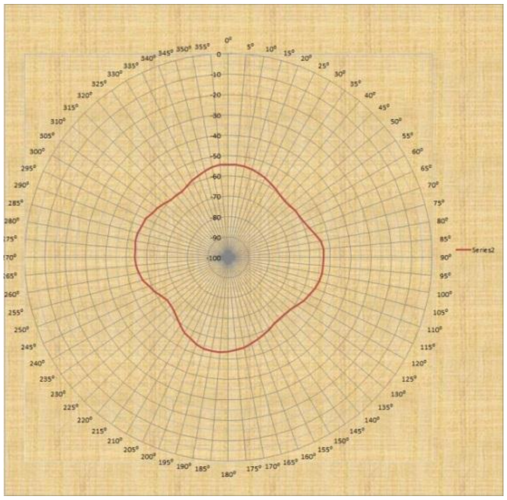
International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 2, February 2013)



VSWR before Antenna wrapped on cylinder



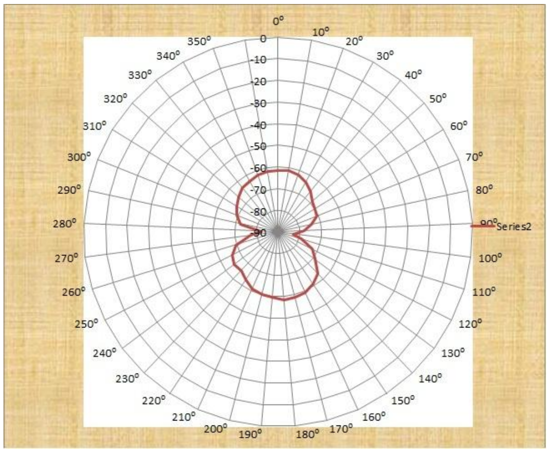
Radiation pattern of Microstrip antenna in Roll plane
(Result from ANECHOIC chamber)



International Journal of Emerging Technology and Advanced Engineering

Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, Issue 2, February 2013)

Radiation pattern of Microstrip antenna in Elevation plane
(Result from ANECHOIC chamber)



REFERENCES:

[1] Microstrip Antenna Design Handbook by Ramesh Garg,Prakash Bhartia, Inder Bahl, Apisak Ittipiboon

[2] Telemetry System Engineering by Frank Carden, Russell Jedlicka, Robert Henry

[3] Phased Array Antenna by R.C Hansen

[4] Modern antenna design by Thomas A Milligan

[5] Antenna theory analysis and design by Constantine A. Balanis