Design of microstrip patch antenna for smart antenna applications

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Abstract - *This Paper portrays the outline and investigation of rectangular& roundabout fix reception apparatus concerning dimensional portrayal. Fix and substrate will assume the fundamental part in the execution of the miniaturized scale strip fix reception apparatus. Measurements and material of the substrate has an impact on the yield parameters of the radio wire. The substrate thickness variety impacts concerning dimensional portrayal are investigated for roundabout fix receiving wire. MATLAB program was produced to reproduce the essential parameters of a microwave rectangular and roundabout fix receiving wire. These parameters are the real range of fix, compelling sweep of fix, conductance because of radiation, conductance because of conduction.*

Key Words*: *circular &rectangular patch antenna, Mat lab, Microstrip antenna. Smart / Adaptive Antenna; Wireless; Beam forming; DSP; Diversity.

1. INTRODUCTION

Keeping in mind the end goal to meet the prerequisites in shuttle or airplane applications where measure, weight, cost, execution and a position of safety receiving wire are required. Radio wire is one of the basic parts in any remote correspondence framework. The word „antenna" is gotten from Latin word „antenna." Since the principal exhibit of remote innovation by Heinrich Hertz and its first application in commonsense radio correspondence by Guglielmo Marconi, the receiving wire has been a key building hinder in the development of each remote correspondence framework. IEEE characterizes a receiving wire as "a piece of a transmitting or getting framework that is intended to emanate or get electromagnetic waves. Miniaturized scale strip Antenna Micro-strip reception apparatus is a standout amongst the most famous kinds of printed receiving wire. It assumes an extremely huge part in today's universe of remote correspondence frameworks. A microstrip reception apparatus in its least difficult shape is a layered structure with two parallel transmitters isolated by a thin dielectric substrate and the channel. The upper segment is named as dielecric substrate fix that is in charge of radiation and lower partition goes about as a ground plane. Smaller scale strip fix radio wire comprises of an emanating patch on one side of a(Cu) on the opposite side as appeared in.

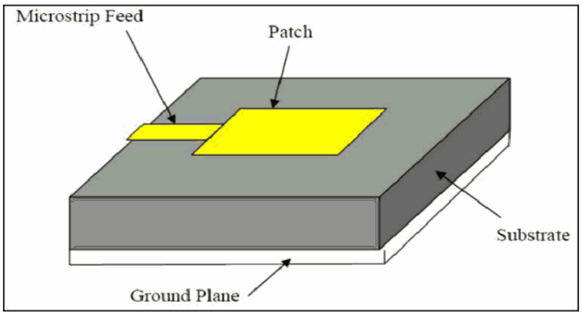

Fig-1: Microstrip patch antenna

A rectangular Microstrip reception apparatus comprises of thin emanating metallic fix set at little stature in one side of dielectric substrate which other plane is grounded. By and large, a Microstrip comprises of rectangular emanating patch component nourished with a coaxial line in which length is most basic measurement and marginally not as much as half wavelength in the dielectric substrate. The emanating patch of Microstrip recieving wire are of various shapes, for example, rectangular, roundabout, circular, square and so forth There are numerous favorable circumstances of Micro-strip fix reception apparatus like minimal effort, reduced size, direct structure and likeness with fused equipment. It has gigantic applications in military, radar frameworks or portable correspondences, worldwide situating framework (GPS), remote identifying et cetera. A microstrip radio wire combined with a single shorting post at honest to goodness position and size is found to give reducing as a rule area with reverence to a conventional fix accepting wire. Furthermore, the negligible indirect entranced fix accepting wires can be refined by space stacking on fix. The store of the spaces or openings in the exuding patch can cause meandering of the invigorated fix surface current Paths besides, realize bringing down of the full repeat of the gathering mechanical assembly, Which identifies with a diminished radio wire measure for such a gathering device, appeared differently in relation to a routine circularly enchanted microstrip radio wire at a similar working repeat. For diagram littler and broadband microstrip fix getting wire here shorting procedure used with conductive vias [1] for proposed and separated. This kind of accepting wire had wide information exchange limit and radiation configuration like a monopole and this getting wire was created on a round fix radio wire [1] that was shorted concentrically with a plan of conductive vias. The accepting wire was analyzed through discouragement show. Here mono-polar fix getting wire was utilizing two modes (TMo1 and TMo2 modes) and the two modes give monopole like radiation area.

2. Antenna Parameters

For design a micro-strip patch antenna following parameters such as dielectric constant (ϵr = 11.9), resonant frequency ($f0$=2 GHz), and height (h=1.6mm) are considered for calculating the width, effective dielectric constant and the length of the patch.

Effective dielectric constant of antenna($\epsilon reff$): $\epsilon reff$ $=\frac{\epsilon r+1}{2}+\frac{\epsilon r-1}{2}\left(1+12\left(\frac{h}{w}\right)\right)$^(−0.5)

Width of patch (w): $w = c/2f0\sqrt{(\epsilon r+1)}$

Effective electric length of antenna:

$Leff = c/\ 2f0\ \sqrt{\epsilon reff}$

The extended length of antenna (ΔL): $\Delta L/h$ $=\frac{0.412(\varepsilon reff+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon reff-0{,}258)(\frac{W}{h}+0.8)}$

The length of the patch is: $L = Leff - 2\Delta L$

The width of ground plane is: Wg= 6h + w

The length of ground plane is: Lg = 6h + L

3. Proposed Work

In this research the bi-polar mechanism is used for increase the efficiency and gain of the micro-strip antenna (MPA). In this mechanism dual polarity is introduced, surface current is induced. More will be the surface current induced, maximize the radiation pattern. For design the antenna we use the MATLAB software. We take the silicon material with 2 GHz frequency, height between ground and patch is 1.6mm and the dielectric constant is taken as 11.9. This mechanism is reducing the losses and improves the efficiency and radiation pattern.

4. Simulation Results

All the results are calculated by MATLAB software by using bi-polar mechanism. Fig. shows the frequency range and antenna bandwidth.

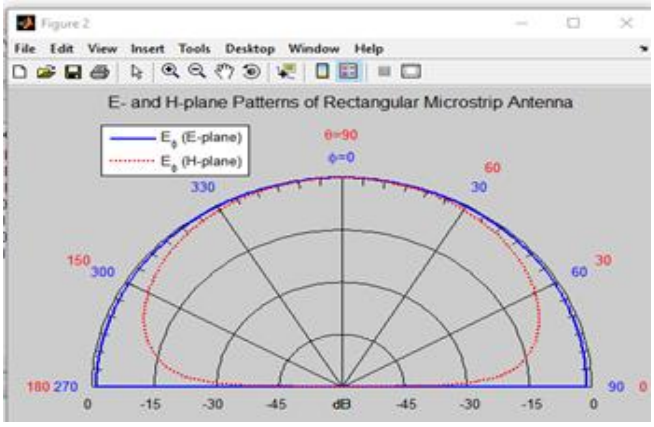

Fig-2:radiation pattren of rectangular patch

5. Circular patch

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 (Wikipedia, 2010). The patch is very thin (t<<λo where λo is free space wavelength) and is placed a small fraction of a wavelength (h<< λo usually 0.003 λo ≤h ≤ 0.05 λo) 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 ≤εr≤ 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.

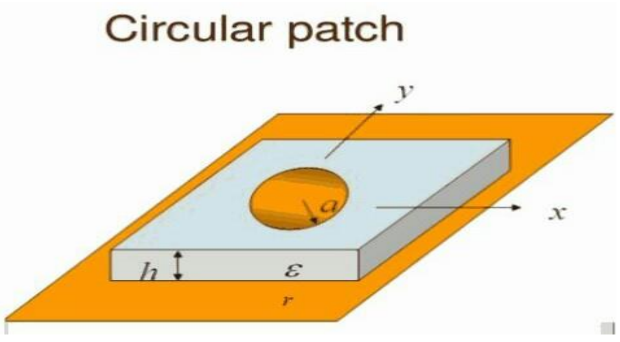

Fig-3:circular patch antenna

5.1.DESIGN ANALYSIS OF CIRCULAR PATCH MICROSTRIP ANTENNA

Circular Patch Radius and Effective Radius Since the dimension of the patch is treated a circular loop, the actual radius of the patch is given by

a=$F/\{1+2h/\pi er F[\ln\left(\frac{\pi F}{2h}\right) 1.7726]\}$^$(-0.5)$

F=$8.791\times10^{9}/fr\sqrt{er}$

Since fringing makes the patch electrically larger, the effective radius of patch is used and is given by

ae=$F/\{1+2h/\pi er a[\ln\left(\frac{\pi F}{2h}\right) 1.7726]\}$^$(-0.5)$

Hence, the resonant frequency for the dominant TMz110 is given by

Fr=1.8412v0/2$\pi ae\sqrt{ee}$

where v0 is the free space speed of light

5.2 simulation results

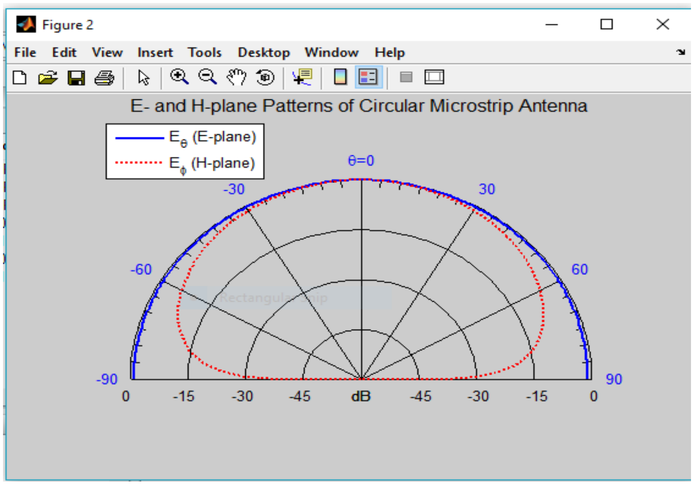

Fig- 4:radiation pattern of circular patch antenna

6. Smart antenna

The adoption of smart / adaptive antenna techniques in future wireless systems is expected to have a significant impact on the efficient use of the spectrum, the minimization of the cost of establishing new wireless networks, the optimization of service quality and realization of transparent operation across multi technology wireless networks [1]. This paper presents brief account on smart antenna (SA) system. SAs can place nulls in the direction of interferers via adaptive updating of weights linked to each antenna element. SAs thus cancel out most of the co-channel interference resulting in better quality of reception and lower dropped calls. SAs can also track the user within a cell via direction of arrival algorithms [2]. This paper explains the architecture, evolution and how the smart / adaptive antenna differs from the basic format of antenna. The paper further explains about the radiation pattern of the antenna and why it is highly preferred in its relative field. The capabilities of smart / adaptive antenna are easily employable to Cognitive Radio and OFDMA system.

6.1 Design procedure for smart antenna:

The array factor for uniform linear array is given in eqn1.

$$AF(\emptyset)=\sum_{m=0}^{M-1} A_m e^{jm(\frac{2\pi}{\lambda})}$$ ……………………(1)

The phase shift between inter element is given in eqn2.

$\alpha=-2\pi d/\lambda 0 cos\emptyset 0$……………………….(2)

Where, $\emptyset 0$ is the desired beam direction. At wave length $\lambda 0$, the phase shift corresponds to a time delay that will steer the beam to$\emptyset 0$.

By using a feedback loop the weigths, $w1 \ldots wN$, are updated by the time sampled error signal is given in eqn3.

e(n)=d(n)-y(n) ……………………………(3)

Where d(n) is training sequence or replica of the desired signal. And y(n) is the output of the adaptive array described in eqn4

y(n)=wHx(n)………………………………(4)

Where x(m) is the input signal.

The adaptive algorithm adjusts the weight vector to minimize the mean square error (MSE) of the error signal,e (n) is given in eqn5

E e(n)= E d(n)-y(n)…………………………(5)

Where E is the expectation operator

Substituting eqn3 &4 in to eqn5 and expanding the augment of the MSE term

E[$e(k)$ 2]=E[{d(n)-y(n)}{d(n)-$y(n)$}*] ....(6)

Solving eq(6) to obtain the MSE term

$$E[|e(k)|^2]=E[|d(k)|^2-r_{xd}^H w-w^H r_{xd}+w^H R_{xx} w] \quad ......(7)$$

E[$X(n) * x(n)^H$]=Rxx is the MXM covariance Matrix of the input data vector (n).

E[x(n)$d*(n)$]=rxd is the Mx1 cross correlation vector between the input data vector ,x(n),and the training sequence,d(n).Taking the gradient operator of the mean square error with respect to the array weights and setting the result equal to zero.

$$\nabla E[|e(k)|^2]=\frac{\partial}{\partial w^*}E[|e(k)|^2]=0 \quad ....(8)$$

Substituting the value of eqn7 in to eqn8 .

$$-2r_{xd}+2R_{xx}w_{opt} = 0 \quad ....(9)$$

The optimum weight eqn is obtain using eqn10.

$$w_{opt}=R_{xx}^{-1}r_{xd} \quad ... .(10)$$

Let nw represent the Mx1 weight vector at time sample n.The weight vector can be updated at time sample n+1 which is given in eqn11.

$$w(n+1)=w(n)+\mu[-\nabla(J(n))] \quad ....(11)$$

Where J(n)= E[$e(n)$ ^2] defines the MSE cost function.

Using eqn9,the value of the error signal at time sample n is given as in eqn12

$$\nabla(J(n))= -2r_{xd}+2R_{XX}w(n) \quad .....(12)$$

Substituting eqn12 in to eqn11 result in eqn13

$$w(n+1)=w(n)+2\mu[r_{xd} - R_{xx}w(n)]] \quad .....(13)$$

Where μ is step size parameter. It is a real valued positive constant generally less than one. The initial weight w(0) is assumed to be zero. The successive corrections of the weight vector eventually leads to the minimum value of the mean squared error. The step size varies from 0 to λmax, whereλ max is the largest Eigen value of the correlation matrix R[8].

Substituting the value of rxd andRxx in to eqn13 result in eqn14.

$$w(n+1)=w(n)+2\mu E[x(n)e^*(n)] \quad ......(14)$$

6.2 Simulation results:

Enter phase angle=30

Interference angle=-20

Number of antennas=5

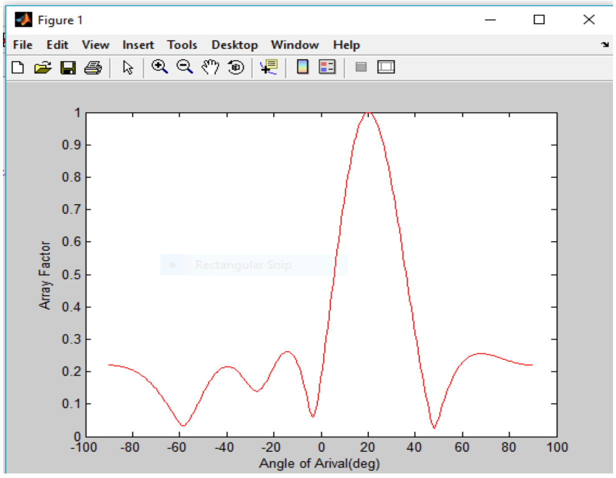

Fig-5:phase graph of smart antenna

Enter phase angle=30

Interference angle=-20

Number of antennas=5

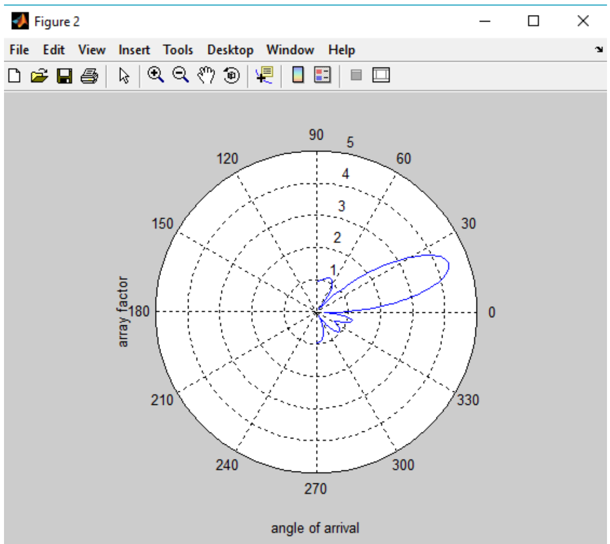

Fig- 6:polar plot of smart antenna

Conclusion

This project was designing and implementing the microstrip patch antenna for smart antenna applications. Also, various parameters like actual and effective patch radius, conductence, directivity, return loss, insertion loss, and quality factor, which describe the performance of antenna are determined by simulation using a program developed in

MATLAB and also by manual computation. the results obtained from both the simulation are in above chapter.

Future scope:

The program developed could be used in the design, analysis and manufacture of more complex micro strip antenna configurations to suit different shapes that can be mounted on spacecraft's and in microwave circuitry. For usagein telecommunication, security, aviation, medicine etc. By using a RF signal source capable of generating different RF signals. It can reduce the complexity and size of the smart antenna.

References:

[1]Shivani Gupta and Saket Kumar, "Design and Analysis of Compact and Broadband High Gain Microstrip Patch Antennas" 2014 IEEE, 978-1-4799-6266-2/14.

[2]Poonam Devi, "design of Micro strip and study of parameters by varying frequency" IJETCAS.

[3]Patch antenna &microstrip antenna Wikipedia.

[4]K.K.Shetty, "A Novel Algorithm for Uplink Interference Suppression using Smart Antennas in Mobile Communications " Master's Thesis, Famu-Fsu College of Engineering, THE Florida state university, February 2004.

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