DESIGNING A MICROSTRIP PATCH ANTENNA - OPERATING AT 1.518GHz.

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ABSTRACT:

In this paper we stimulate a simple microstrip patch antenna consisting of substrate and ground plane, at an operating frequency of 1.518GHz. It is used primarily for military purposes and wireless-lan. The working of antenna is described in terms of VSWR, Radiation pattern, S-parameter magnitude and gain of the antenna using CST microwave studio software.

KEYWORDS: Microstrip-patch antenna, VSWR, S-Parameter magnitude, Polar plot…

INTRODUCTION:

Microstrip patch antennas are becoming more augmenting and useful because they can be easily printed directly on to a circuit board. Microstrip patch antennas are becoming widespread with in mobile communications. For an efficient antenna, it can be epitomized as thick substrates whose dielectric constant is extremely lower because they provide greater efficiency, high bandwidth, loosely bound fields for radiation into space. And thin substrates with higher dielectric constants are suitable for microwave circuits as they require adamant bounded fields to disaugment undesired radiation and coupling, and lead to compact element sizes. Consider a microstrip patch antenna transmission line and ground plane are made of same material that is highly conductive metal (copper annealed). The radiating patch could be square, rectangular, circular, elliptical, triangular, or any other shape which possess higher directivity.

Arrays of microstrip elements, with single or multiple number feeds are used to achieve higher directivities. There are many techniques to feed microstrip antennas. The most faddish techniques are microstrip line, coaxial probe, aperture coupling, and proximity coupling. One of the most swanky or faddy technique used for feeding is coaxial probe. Coupling of power to the patch antenna through a probe is very austere, cheap, and effective way. If the designer adjusts the feed point of impedence of 50Ω, so he just needs to use a 50Ω coaxial cable with N-type coaxial connector. The N-coaxial connector is coupled to the back side of the microstrip antenna (the ground plane) and the center connector of the coaxial probe will be passed through the substrate and will be soldered to the patch.

It is the fringing field that is onus for the radiation. The fringing fields at the surface of the patch antenna that are along the +y direction. Therefore, the fringing E-fields on the edge of the microstrip patch antenna add up in phase and produce the radiation of the microstrip patch antenna. So, as to enhance the performance of antenna having low desired dielectric constant which augments the bandwidth, efficiency and gain of the microstrip antenna. The effective dielectric loading of a microstrip antenna affects both its radiation pattern and impedence bandwidth. As the dielectric constant value of the substrate increases, the antenna bandwidth accordingly decreases and accordingly it increases the Q-factor of the antenna and therefore it decreases the bandwidth.

The patch of length L and width is of W, placing on top of the substrate of thickness h with permittivity ε_r. For a rectangular microstrip patch antenna, the dielectric constant is in the range of $2.2 \leq \varepsilon_r \leq 12$. The height of the dielectric substrate is in the range of $0.003\lambda o \leq h \leq 0.05\lambda o$. The length of the patch is usually $0.3333\lambda o < L < 0.5\lambda o$.

This sort of patch antennas are mainly used in

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[2] RECTENNA applications: It is used to convert microwave energy into DC power.

[3] Medicinal applications of patch: It is used for treatment of malignant tumors, the microwave energy is said to be the most effective way.

[4] Radio Frequency Identification (RFID): RFID is primarily used in mobile communication, manufacturing, transportation and health care.

The electric field intensity E due to theta(θ):

$$E_\theta = \frac{\sin\left(\frac{KW\sin\theta\sin\emptyset}{2}\right)}{\frac{KW\sin\theta\sin\emptyset}{2}}\cos\left(\frac{KL}{2}\sin\theta\cos\emptyset\right)\cos\emptyset$$

The electric field intensity due to phi($\emptyset$):

$$E_\emptyset = -\frac{\sin\left(\frac{KW\sin\theta\sin\emptyset}{2}\right)}{\frac{KW\sin\theta\sin\emptyset}{2}}\cos\left(\frac{KL}{2}\sin\theta\cos\emptyset\right)\cos\theta\sin\emptyset$$

W=width of the substrate.

L=length of the substrate.

The resultant electric field is given by the below equation:

$$f(\theta,\emptyset) = \sqrt{E_\theta^2 + E_\emptyset^2}$$

PROPOSED ANTENNA DESIGN:

For designing a microstrip patch antenna, we have to select the resonant frequency and a dielectric medium. The parameters to be calculated are as below.

Width (W): The width of the patch is calculated using the following equation

$$W = \frac{c\sqrt{2}}{F_r\left(\sqrt{\varepsilon_r+1}\right)}$$

W = Width of the patch.

c = Speed of light.

ε_r= value of the dielectric substrate.

F_r=1.8GHz,$\varepsilon_r = 4.3$ we get the values of length and width L=38mm,W=50.5mm.

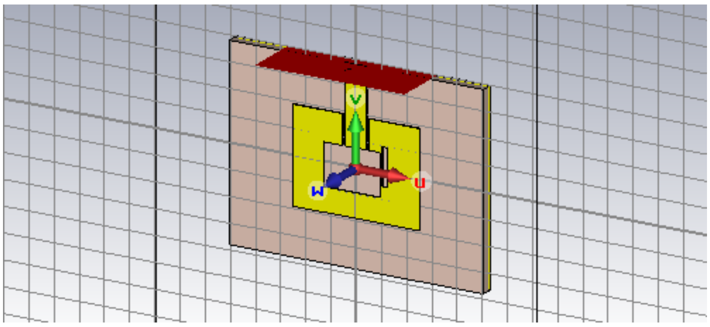

FIGURE 1:

STRUCTURE OF RECTANGULAR MICROSTRIP ANTENNA.

The figure 1 describes the design and delineate of the microstrip patch antenna which is operated at a frequency of 1.518GHz.

The effective refractive index value of a patch is an important parameter in the designing procedure of a microstrip patch antenna. The radiations coming out from the patch passes through the ground plane, air and also through the substrate (known as fringing field line). We know that both air and the substrates have different dielectric values, therefore in order to account this we have to find the value of effective dielectric constant. The value of the effective dielectric constant (ε_{reff}) is calculated by

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(\sqrt{1 + 12\left(\frac{h}{W}\right)}\right)\frac{W}{h} \gg 1$$

LENGTH:

Due to fringing effect, electrically the size of the antenna is increased by an amount of (ΔL). Therefore, the actual increase in length (ΔL) of the patch is to be calculated using the following equation

$$\frac{\Delta L}{h} = \frac{0.412(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} - 0.8\right)}$$

Where 'h'= height of the substrate.

The length (L) of the patch is now to be calculated using the below mentioned equation.

$$L = \frac{c}{(2F_r\sqrt{(\varepsilon_{reff})})} - 2\Delta l$$

Length (L) and width (W) of ground plane: The length and width of a substrate is equal to that of the ground plane. The length(L) and width(W) of a ground plane are calculated using the equations mentioned above. The width (W/2) and length (L/2) of the patch at a resonant frequency of 1.518 GHz are found to be 19mm and 25.25mm. The height of the substrate(h) is 4.5 mm. For ground plane, the length (L) and width (W) are calculated to be 50.5 mm and 38 mm . A rectangular strip is isolated from the patch, of length and width 16.7mm and 22.5mm. Another rectangular strip is isolated from the previously isolated strip with a gap of 1mm, of length and width 15.375mm and 2.125mm. And the length (Lf) and width (Wf) of transmission line is This is done so as to aggrandize the performance of microstrip patch antenna. Thus, this simulation is performed out in CST Microwave Studio software. The resultant radiation patterns and polar plots are given below.

STIMULATION AND RESULTS USING CST MICROWAVE STUDIO SOFTWARE:

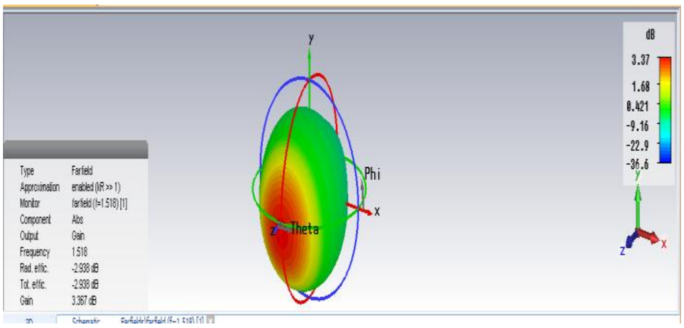

FIGURE 2:

The figure set forth in 3-D view tells us about gain pattern in the farfield radiation. And it resembles the direction of maximum gain of the antenna.

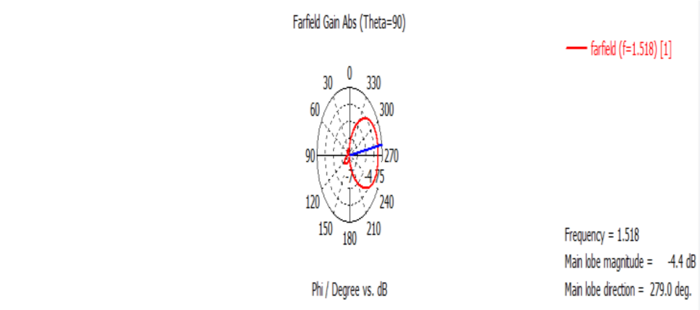

FIGURE 3 POLAR PLOT(θ):

The figure 3 resembles 2-D view and it describes about polar plot of the microstrip patch antenna with respect to the (θ) variation.

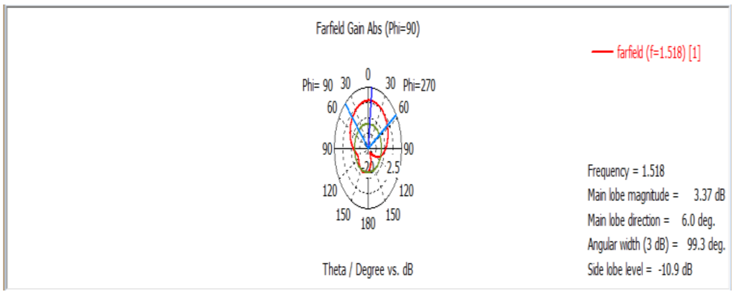

FIGURE 4: POLAR PLOT(∅)

The above figure 4 set forth in 2-D view tells us about the polar plot of the microstrip patach antenna with respect to (∅) variation.

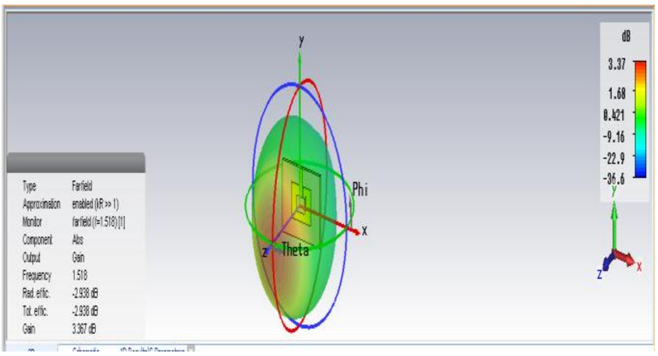

FIGURE 5: FAR FIELD RADIATION

The above figure 5 describes about the farfield radiation pattern of the microstrip patch antenna and total gain of the antenna, when the antenna is operated at a resonant frequency of 1.518GHz.

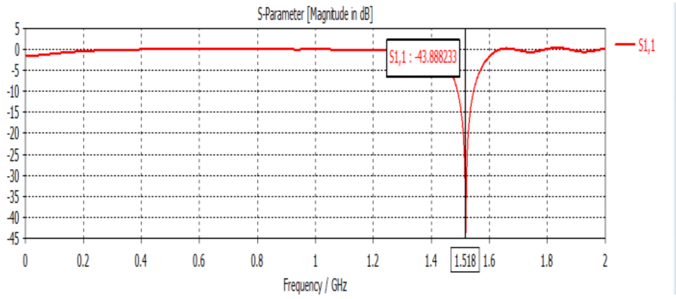

FIGURE 6: S-PARAMETER MAGNITUDE.

The above figure 6 describes about the S-parameter magnitude S11 having a return loss gain of -43.88dB at a resonant frequency of 1.518GHz.

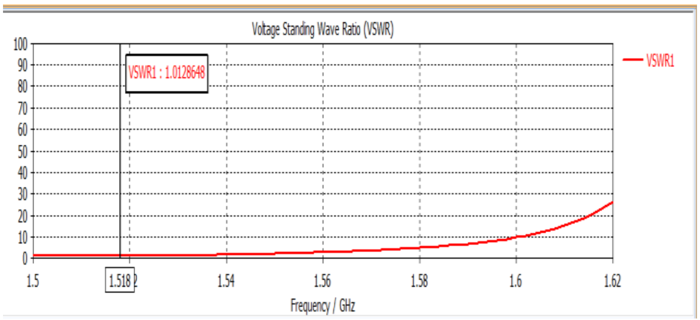

FIGURE 7: Voltage standing wave ratio.

The above figure 7 describes about stimulated VSWR of rectangular microstrip patch antenna at 1.518GHz.

COCLUSION:

In this paper, microstrip patch antenna is successfully designed at an operating frequency of 1.518GHz. The gain obtained at this frequency is 3.367dB, VSWR is 1.012 and S-parameter magnitude is -43.886dB.

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