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FABRICATION OF LOW FREQUENCY PATCH ANTENNA WITH ADHESIVE COPPER TAPE

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ABSTRACT:

In this paper a very easy process of designing & fabricating Microstrip antenna with adhesive copper tape is presented. The rectangular structure is designed for 700MHz and it is modelled with High Frequency Structure Simulator (HFSS). The prototype is fabricated with FR4 material and 70 micron thick copper tape. The fabricated antenna is tested on Antenna Trainer Kit to observe radiation pattern.

KEYWORDS: Patch, MATLAB, FR4, Adhesive conductor.

I. INTRODUCTION:

Modern wireless communication systems are being requiredto operate in almost all environments. Because of thewireless nature of these systems, the antenna is a major part of the design. Conformal antennas have the potential to overcome some of the aforementioned difficulties. However, one drawback of using a traditional conformal antenna can be the copper conductor. This is because of the weight and the potential for copper failure due to repetitive bending and deformations, which was noticed in the work reported in [4]. So before going for fabrication of wearable antenna one need to think about the deposition of conductive layer on substrate material. The most common conductive material used in patch antenna is copper. Deposition of copper on substrate material is such a lengthy and complex method. The alternative solution is to have a copper foil and adhesive. Copper foil can be attached to substrate material using a good adhesive. Now the wearable antenna requires substrate material like cotton or may be jeans (Textile materials). The antenna is then referred as Textile Antenna.

In this paper, the prior experiment is done by using FR4 substrate material. This experimentation is done to conclude that the copper foil with adhesive material can also shows patch properties.

As a start, it is difficult to search any adhesive which has very less effect on antenna properties or parameters. The copper tape is good solution to that. Copper tape seems like a sticker where one can remove the back paper of it and can attach it anywhere.Figure below shows the sample copper tape.

Figure.1 Sample Copper Adhesive Tape.

II. BASICSTURCTURE:

In its most basic form, a Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which also has a ground plane on the other side as shown in Figure 2. The patch is generally made of conducting materials such as copper or gold [2] and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate.

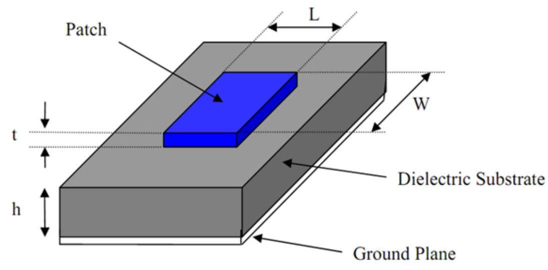

Figure 2. Structure of Microstrip Antenna

ANTENNA DESIGN:

In order to identify and verify the improvement for rectangular structure in microstrip antenna, the conventional Microstrip antenna design method is used [1].

DESIGN STEPS:

Designing the patch antenna is to employ the following formulas as an outline for the design procedures.

i. Width (W):

$$\mathbf{W} = \frac{c}{2f_r\sqrt{(\frac{\varepsilon_r+1}{2})}} \ldots (1)$$

Where;

c - free space velocity of light, 3 x 10^8 m/s

f_r - frequency of operation

ε_r - dielectric constant

ii. Effective Dielectric constant (ε_{reff}):

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}}$$

…(2)

Where;

ε_r- dielectric constant

h - Height of dielectric substrate

W - Width of the patch

iii. Effective Length (L_{eff}):

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} \ldots (3)$$

Where;

c - free space velocity of light, 3 x 10^8 m/s

f_r - frequency of operation

ε_{reff} - effective dielectric constant

iv. Patch length extension (ΔL):

$$\Delta L = 0.412h\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{W}{h}+0.8)} \ldots (4)$$

v. Actual length of patch (L):

$$L = L_{eff} - 2\Delta L \ldots (5)$$

III. FABRICATION OF ANTENNA:

The conventional Fabrication of Microstrip antenna is the process of photolithography. The process is same as PCB (Printed Circuit Board) etching.

In this experimental work, theconventional fabrication process is bypassed. The basic process of etching is completely avoided. In this case, one does not require a conductive layer deposition on both sides of substrate. Here the unwanted conductive layer is not removed by etching process but the desired conductive layer is pasted on substrate material. The copper foil with adhesive paper is shown figure 3.

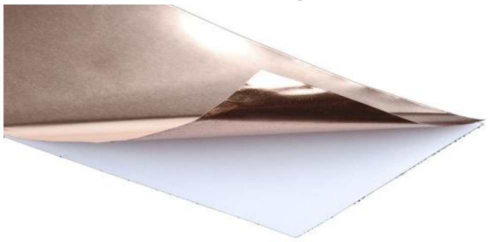

Figure.3. Copper tape with adhesive paper.

Initially the copper tape is pasted on both the sides of FR4 substrate. Copper tape has adhesive paper at the back side of it and the copper foil is at the upper side as shown in Figure.3. The thickness of copper available is the range of 50 to [illegible] microns. The width and length of patch antenna is already calculated using the design equations as explained earlier. Now by taking pencil or marker the rectangular patch and feed (microstrip feed) is made on any one of the side of substrate. This rectangle is a patch which will radiate when a feed is provided. After completing the small drawing the unwanted copper foil around the rectangle is removed by using a paper cutter. By the same way feed is made on the same side of patch and the Rectangular patch antenna is ready to test.

The feed connector is needed to test the antenna. Generally for Microstrip antenna, PCB mount SMA connectors are preferred. SMA connectors are ultimately useful when antenna has to test on Vector Network Analyser (VNA). But here we are going to test this antenna on "Trainer Kit" where provision of BNC connectors is available. So instead of SMA, BNC connector is soldered to our antenna and Radiation pattern is observed.

Figure.4. Fabricated patch antenna.

Fabricated patch antenna for 700MHz is as shown in figure 4. The BNC connector is not soldered directly to the patch coz it may damage the adhesive of copper tape. A small wire is used to connect BNC and patch.

EXPERIMENTAL RESULTS:

The fabricated antenna is tested on Antenna Trainer Kit which has Transmitter and Receiver system. The transmitter has frequency range up to 800MHz. It is suitable for this experiment as the designed frequency of our antenna is 700MHz only.

Figure.5. Experimental setup

The main aim of testing is to obtain radiation pattern of the fabricated antenna. For this purpose, test antenna is connected to transmitter end and a detector is connected at the receiver end as shown in figure.5. The transmitter section is rotated in clockwise direction in azimuth plane and readings are observed on receiver screen. Detector detects the signal and receiver converts the detected field into the dBμV. The display of receiver directly shows readings with unit of dBμV. The measurements that we have obtained are the position (angle in degree) of transmitter and dBμV at the receiver. To observe radiation characteristics, polar plot has to be plotted. The polar plot of angle (radians) v/s dBμV is plotted with the help of MATLAB.

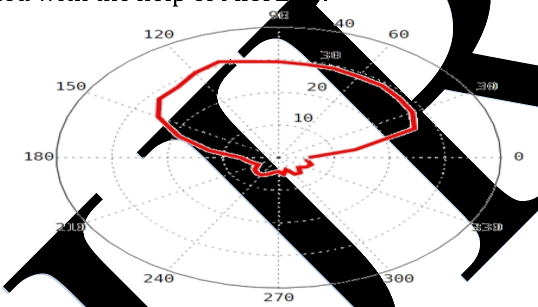

Figure.6 Radiation Pattern

The above figure.6 shows the radiation pattern of the patch antenna which is fabricated using a copper tape. This pattern is almost similar to the ideal radiation pattern of rectangular patch antenna. The same antenna can be further tested using VNA(Vector Network Analysis) to obtain other parameters like S11 and Bandwidth etc.

IV. CONCLUSION:

The radiation characteristics of the antenna with adhesive copper tape are similar to that of conventional OR ideal radiation pattern of patch antennas. The adhesive copper tape is a good solution to the conventional etching process for fabrication of a patch antenna.

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