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To build a Patch antenna at 435 MHz

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Abstract- It is found that Patch antennas are mostly built and used for frequencies greater than 1 GHz. At such high frequencies the dimensions of the patch would be smaller and hence it would be easy to fabricate it on pcb itself. In the present study patch antenna is analyzed for its performance below 1GHz. The finding of the study revealed that the patch antennas can be used at frequencies which are lower than 1 GHz but dimensions becomes too large. Also radiation pattern, reflection coefficient, HPBW and other parameters of the antenna were tested and results were found to be satisfactory.

Index Terms- Patch antenna at lower frequencies

I. Introduction

Patch antennae are usually constructed for frequencies in GHz ranges hence their size becomes smaller. However, as the frequency for our case is in the MHz range, the Patch will be of considerable size. It is quite unusual and actually difficult to build patch at frequencies lower than 1 GHz. In this study we are designing a patch antenna at 435 MHz

II. Patch Antenna

These antennas are popular for low profile application at frequencies above 1 GHz (λ0 < 0.3m). They commonly consist of rectangular or square metal patch on a thin layer of dielectric (called the substrate) on a ground plane (Kraus 2006). These antennas are conformable to planar and non-planar surfaces, simple and inexpensive to manufacture using modern printed circuit technology; mechanically robust when mounted on rigid surfaces.

The patch of length say L and width say W sits on top of a substrate (some dielectric) of thickness h with permittivity ε. For a rectangular patch, the length L of the element is usually λ0/3 < L < λ0/2 (Balanis 2007). The thickness of the metallic strip t << λ0 (λ0 is the free space wavelength). Typically the height h is much smaller than the wavelength of operation h<<λ0 (Usually 0.003λ0 ≤ h ≤ 0.05 λ0). This substrate ultimately sits on ground plane which is also a metallic plane.

There are numerous substrates that can be used for the design of microstrip antennas, and their dielectric constants are usually in the range 2.2 ≤ εr ≤12. Thick substrates have lower dielectric constant are preferable since it provides better efficiency, larger bandwidth, loosely bound fields for radiation into space but at the expense of larger element size(Balanis 2007).

Like all antennas, patch antennas work because currents in a conductive surface induce electric fields in the surrounding space. Antennas are most commonly compared to dipole antennas because they are the simplest to analyze which is also true for patch antennas. In a patch antenna the edge of the antenna acts like a dipole antenna, inducing an electric field perpendicular to the radiating edge.

III. Calculating Dielectric Constant of the Material

The patch antenna was designed and built using basic equation of the patch antenna dimensions (Balanis 2007)

1. Calculating the wavelength

Wavelength of operation is calculated using the equation:

$c = fr.\lambda$

2. Calculating Width

Width of the antenna is calculated as follows:

$$W = \frac{c}{2fr}\sqrt{\frac{2}{\epsilon r+1}}$$

3. Calculating Effective Dielectric constant.

Effective dielectric constant of the substrate is calculated as

$$\epsilon r(effective) = \frac{\epsilon r+1}{2} + \frac{\epsilon r-1}{2}\{1+12\frac{h}{W}\}^{-1/2}$$

4. Calculating fringing length

Due to fringing effective length of the antenna is shorter than the actual calculated length.

$$\Delta L = h \times 0.412\frac{(\epsilon r(effective)+0.3)(\frac{W}{h}+0.264)}{(\epsilon r(effective)-0.258)(\frac{W}{h}+0.8)}$$

5. Calculating Length.

Length of the antenna is calculated as

$$L = \frac{c}{2fr\sqrt{\epsilon r}}$$

6. Calculating effective length.

Thus the effective length of the antenna is as follows

$$L(effective) = \frac{c}{2fr\sqrt{\epsilon r}} - 2\Delta L$$

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A. Initial design

Using above equations dimensions of the patch antenna were calculated considering frequency 435 MHz and dielectric constant of the material equal to 2. The initial design of patch antenna was as: length = 24, width=28.15, height of the substrate=6 mm and the feed point was 7.75 cm away from one of the edge.

B. Use of Simulation software

PCAAD software was used for the simulation of the patch antenna. Simulations of different antennas were done using values. After simulation was done, results were noted and these results were analysed and were to be matched by the experimental tests.

C. Fabrication

The basic design of the antenna was done. The Engineering drawing for the same was drawn and antenna was constructed in workshop. The ground plane was 3mm thick aluminum plate and the patch was 1.5 mm brass plate with a hole at the distance calculated in the design and verified in simulations. The N-type connector was used as a feed.

D. Testing

During first testing the reflection coefficient was found to be at frequency 404 MHz which was way too offset. As the dimensions were calculated accurately, we conclude that the error is either because of the error during fabrication or due to approximate value of the dielectric constant. As we were not sure, we checked both the things. The dimensions were correct.
We then calculated the dielectric constant for same dimensions with newly obtained frequency. For reaching accurate results we had to do that several times. Finally dielectric constant of the material was found out to be 2.225. So for this dielectric constant, dimensions were calculated for 435 MHz and design was again simulated. The final design is as: Length=22.3, Width= 27, Height of the substrate=6mm, Distance of feed from the edge=7.25. After verification from the simulation, final testing is done for calculating other parameters such as swr, input impedance and all. Results are given in the table1.

Tab -1:Testing of Patch antenna at 435 MHz on spectrum analyzer

Parameters	Values
Return loss	-15.7 dB
Reflection Coefficient	0.163
SWR	1.39
Input Impedance	69.47 Ohm
Bandwidth	1.6%

IV. RADIATION PATTERN MEASUREMENT

The testing of the radiation pattern was done by keeping two antennas apart at a distance of nearly 12 meters. To measure radiation pattern we have to keep any one (Tx or Rx) antenna in fixed position and rotate other antenna. But as we were not interested in back lobes and side lobes; we just rotate receiving antenna around its own vertical axis. Geometrically it functions same as if the antenna is rotated around the transmitting antenna. The response of the receiving antenna is observed on the handheld spectrum analyzer. The testing was open air and there were no antennas at same frequency near the test antenna.
Signal level for the received antenna is plotted against angle. The HPBW is found to be 70 degrees. The radiation pattern is as shown in the figure 1.

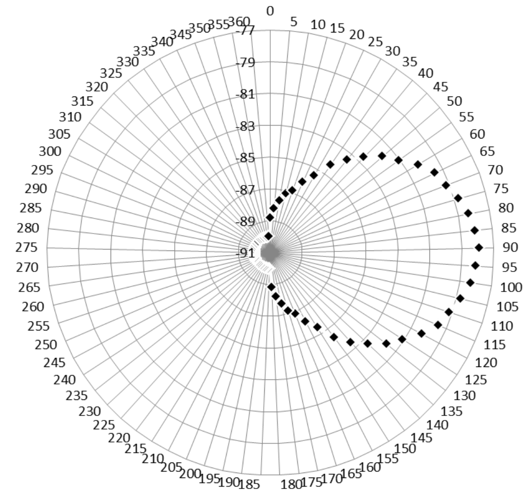

Fig- 1: Test results for the radiation pattern measurement.

V. CONCLUSION

A patch antenna is designed, simulated, fabricated and tested. The dielectric constant of the substrate was accurately found during the design of the antenna. The HPBW of the antenna was found to be 70 degrees and the gain is 3.35. The results are thus as expected.

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REFERENCES

[1] John D Kraus, Ronald J Marhefka, Ahmad S Khan, "Antennas for all application", Third Edition, Tata McGraw Hill Publications, pp. 313–320
[2] Constantine A. Balanis, "Antenna theory : Analysis and design" , Second Edition, Wiley India Edition,pp. 722–736
[3] Girish Kumar, K. P. Ray, "Broadband Microstrip antennae" , First Edition, Artech House antennas and propagation library,pp. 1-21
[4] David M. Pozar,"PCAAD 6.0 manual" Antenna Design Associates, Inc., Leverett, MA 01054

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