International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 8, August - 2014

Bandwidth Enhancement of Microstrip Line Inset Fed Patch Antenna

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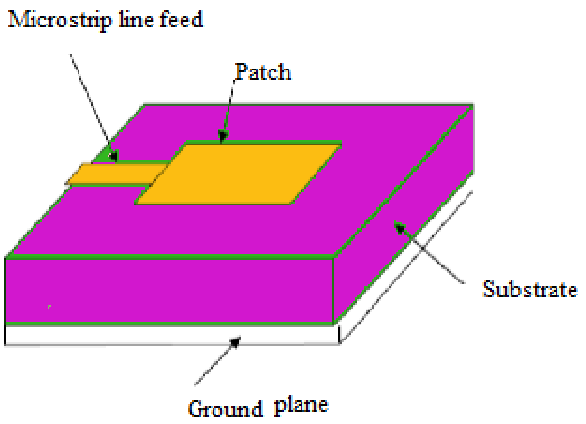
Abstract*-Microstrip patch antennas becomes most popular these day due to its interesting feature such as low cost, light weight, low profile planar configuration which can be easily made conformal to host surface. It has little disadvantages too- like low gain, low efficiency, low directivity and narrow bandwidth. These disadvantages can be overcome by implementation of many patch antennas in array configuration, creating cuts in ground and by increasing the height of patch, increasing the substrate thickness and decreasing the permittivity of substrate the percentage of bandwidth is increased. In this paper line inset feeding technique is use and HFSS 13 Software is used for the simulation and design calculation of microstrip patch antenna. The return loss, vswr curve, radiation pattern and gain are evaluated.

***Keywords*- Microstrip Patch Antenna, HFSS Software, line Inset fed, Bandwidth Enhancement, cost low**

I. INTRODUCTION

Microstrip patch antennas are becoming most useful because they can be printed directly onto a circuit board. Microstrip antennas are becoming more popular within the mobile phone market due to its compact size, low cost, light weight etc. These day microstrip patch antennas have been widely used in satellite communications, aerospace, radars, biomedical applications and reflector feeds because of its inherent characteristics such as light weight, low profile, low cost, mechanically robust, compatibility with integrated circuits and very versatile in terms of resonant frequency. To support these applications microstrip antenna should have good return loss as well as VSWR value and bandwidth. To design microstrip patch antenna there are different feeding technique. In this paper the patch antenna is design with microstrip line inset feeding shown in fig.1. There are four main component of antenna such as substrate, patch, ground plane and line fed. This model uses an inset feeding strategy that does not need any additional matching parts. Feeding a patch antenna from the edge leads to a very high input impedance, causing an undesirable impedance mismatch if a conventional 50 Ω line is directly connected. One solution to this problem is to use a matching network of quarter-wave transformers between the feed point of the 50 Ω line and the patch. However, this approach has two drawbacks. First, the quarter-wave transformers would be realized as microstrip lines that would Have to extend beyond the patch antenna, significantly increasing the overall structure size. Second, these microstrip lines should have a high characteristic impedance and thus would have to be narrower than practical for fabrication. Therefore, a better approach is desired.

The patch antenna model used for the numerical simulation in Ansoft HFSS is shown below. In this paper the patch antenna is designed for 7.0955 GHz operation on a substrate with 2.2 permittivity and substrate height 1.5748mm. To determine the width (W), the microstrip patch antenna calculator was used to provide an initial starting point. The length (L) was chosen to be the same as W to obtain a symmetric radiation pattern. The patch with the line feeding was simulated in Ansoft HFSS to adjust W for resonance at 7.0955 GHz. Next, the input impedance of the patch at the edge was determined by placing a length of 50Ω transmission line at the edge. The microstrip line of 50Ω is Inserted using inset feed technique to excite the antenna. The bandwidth of antenna is increasing by increasing substrate thickness, patch height. In this paper cut are provided in the ground which are the responsible for improving the bandwidth and also help in maintain field pattern. The distance between the patch in each design is maintained so that fields every single patch overlap in constructive manner to reduce the size.



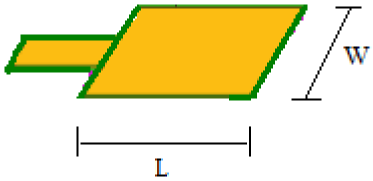


Fig 1:- Line inset Fed Microstrip patch antenna

II. ANTENNA DESIGN

Antenna is designed to operates on 7.0955GHZ frequency and substrate is of Rogers RT/duroid5880(tm)

Resonant frequency (f_o) : 7.0955GHz
Dielectric constant (ε_r) :2.2
Thickness of dielectric (h) : 1.5748 mm

Formulas for the design calculations of physical dimensions of patch are given by

Width: The width of the patch can be calculated from the following equation

$$W = \frac{c}{2f0\sqrt{\frac{\varepsilon r+1}{2}}}$$

Substituting the value of f_o =7.0955GHz, Ɛr=2.2 and $C = 3 \times 10^8$m/s

W =16.71mm

Length: The length of patch can be calculated from the following equation.

$$L = Leff - 2\Delta L$$

L =13.28mm

Where L_{eff} and ΔL are the effective length and extended length due to fringing effects between patch and field. These values are calculated using fallowing formulas as

$$Leff = \frac{c}{2fo\sqrt{\varepsilon reff}}$$

=14.91mm

$$\Delta L = \frac{.412h(\varepsilon reff+.3)(\frac{W}{h}+.264)}{(\varepsilon reff-.258)(\frac{W}{h}+.8)}$$

ΔL =0.815mm

Effective dielectric constant

The effective dielectric constant (*εreff*) is always less than (*εr*) because the fringing field around the periphery of the patch is not confined to the dielectric speared in the air also. Its value is calculated as by formulas:-

$$\varepsilon reff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}[1+12\frac{h}{W}]^{-\frac{1}{2}}$$

=2.01

Return loss

Return Loss is the loss of power in the signal form which returned or reflected by a discontinuity in a transmission line or optical fiber. This discontinuity can be a mismatch with the terminating load or with a device inserted in the line. It is usually expressed as a ratio in decibels (dB).

$$RL(dB) = 10log_{10}\frac{Pi}{Pr}$$

Where *RL* (dB) is the return loss in dB, P_i is the incident power and P_r is the reflected power. Return loss is related to both standing wave ratio (SWR) and reflection coefficient (Γ). Increasing the return loss lower the SWR. Return loss is a measure of how well devices or lines are matched. If the return loss is high mean match is good.A high return loss is desirable and results in a lower insertion loss. Return loss is used in modern practice in preference to SWR because it has better resolution for small values of reflected wave.[2]

RL = -20log |Γ| (dB)

Where |Γ| (dB) is $= \frac{V_0^-}{V_0^+} = \frac{Z_L - Z_O}{Z_L + Z_O}$

|Γ| is the reflection coefficient

V_0^- Is the reflected voltage

V_0^+ Is the incident voltage

Z_L And Z_O are the load and characteristics impedance

We can check the antenna's performance by operating the antenna at a high frequency by observing *VSWR*, when the value of VSWR≤2 and return loss (*RL*≥-9.5dB) the antenna is said to have performed good.

Voltage Standing Wave Ratio (VSWR)

The parameter VSWR is a measure that numerically describes how well the antenna is impedance matched to the radio or transmission line it is connected to.VSWR stands for Voltage Standing Wave Ratio, and is also referred to as Standing Wave Ratio (SWR). VSWR is a function of the reflection coefficient, which describes the power reflected from the antenna [10]. If the reflection coefficient is given by, then the VSWR is defined as:-

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$$

The VSWR is always a real and positive number for antennas. The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. The minimum VSWR is 1.0. In this case, no power is reflected from the antenna, which is ideal. When a transmitter is connected to an antenna by a feed line, the impedance of the antenna and feed line must match exactly for maximum possible energy transfer from the feed line to the antenna. When an antenna and feed line do not have matching impedances, some of the electrical energy cannot be transferred from the feed line to the antenna. Energy not transferred to the antenna is reflected back towards the transmitter. It is the interaction of these reflected waves with forward waves which causes standing wave patterns. Ideally, VSWR must lie in the range of 1-2 [3] Measured VSWR of the frequency range 7.0955GHZ is1.504.

III SIMULATION RESULTS

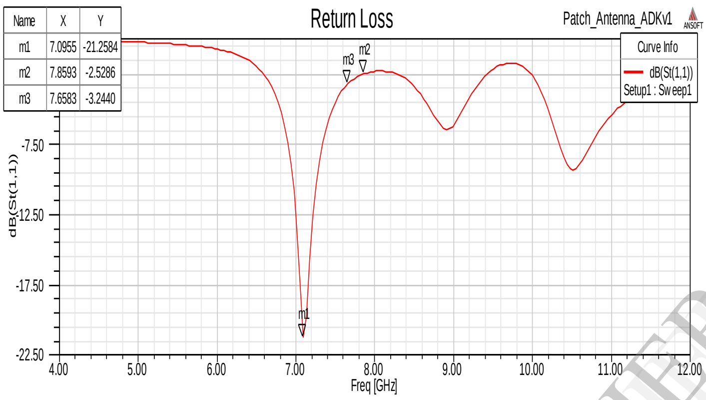


Figure 2:- Return loss curve for designed antenna

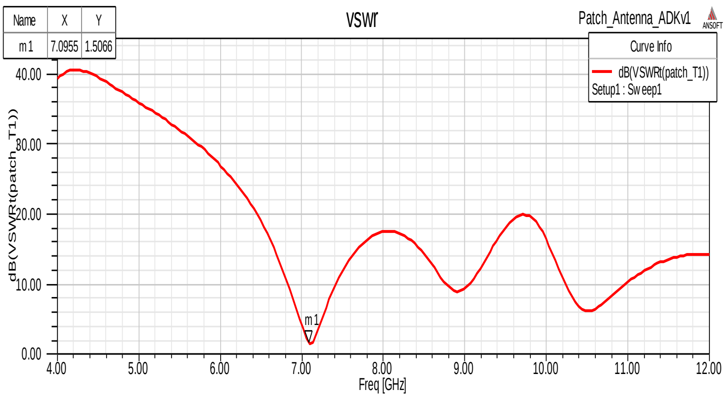


Figure3:- VSWR curve vs Frequency

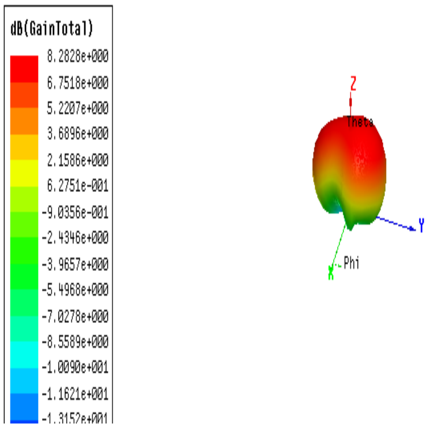


Figure 3:- 3D polar model for the total gain in dB

Finally we check the simulation result and the value of return loss is -21.258 dB at 7.0955GHz, vswr=1.5066 and the total gain=8.28 dB

IV. CONCLUSION

The overall design is cost effective as the cuts are introduced in ground base as well as size is kept as smaller as possible. We can see the simulation result the return loss is minimum which mean design is very efficient and have good impedance matching which mean there is negligible power loss. Antenna is radiating energy to the environment instead of storing it. Moreover this concept we make n×n array and check the overall performance.

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