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Annexure I

1. Project Title: Effect of substrate material and thickness on the performance of Microstrip patch antennas

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1. Abstract & Objective

1.1 Abstract

The rapid growth in the demand for wireless communication and information transfer using handsets and personal communications (PCS) devices has created the need for major advancements of antenna designs as a fundamental part of any wireless system. One type of antennas that fulfills most of the wireless systems requirements is the microstrip antennas. These antennas has many advantages like low profile, conformability, low production cost, etc. and it has one major limitations of narrow bandwidth and low efficiency. For designing this microstrip antenna to achieve desired performance the designer is to select the suitable substrate material and its thickness. So, if the designer has a clear knowledge about the effect of changing substrate material and it's thickness on the performance of the antenna, it will be easier to design an antenna. This project explores that how antenna performance changes when we vary substrate material and it's thickness in terms of return loss (RL in dB), VSWR and impedance bandwidth. The designed probe feed rectangular microstrip patch antenna operates at 5.8 GHz WLAN frequency band.

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1.3 Objective

A microstrip patch antenna is a low profile antenna that has a number of advantages over other antennas. The aim of this project is to investigate how an antenna performance changes when we vary substrate material and it's thickness in terms of return loss (RL in dB), VSWR and impedance bandwidth. The designed probe feed rectangular microstrip patch antenna operates at 5.8 GHz WLAN frequency band.

1.3 METHODOLOGY:

The step by step procedure to design the antenna for the given specifications is as follows.

Step-1: Specify Input Parameters to design the antenna as follows

- Antenna Geometry- rectangular
- Type of Feeding- probe feeding

- Specify ϵ_r, f_r (in GHz) and h. – frequency is 5.8 GHz and then select various substrates with various heights to verify antenna performance.

Step-2: Theoretical Design of Antenna.

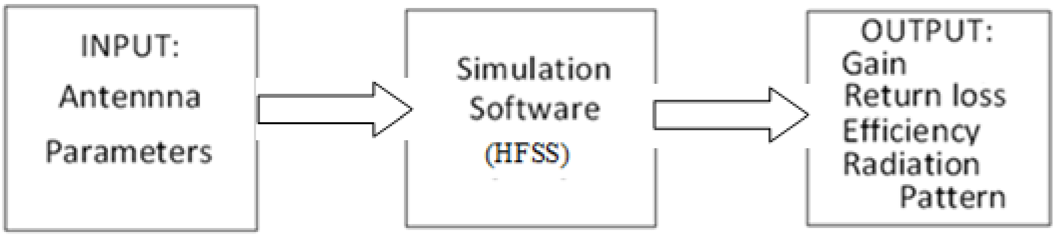
- Design Patch Dimensions
- Design Substrate Dimensions
- Design Feed
- Find Feed Location

Step-3: Design with EM Simulators (HFSS Software).

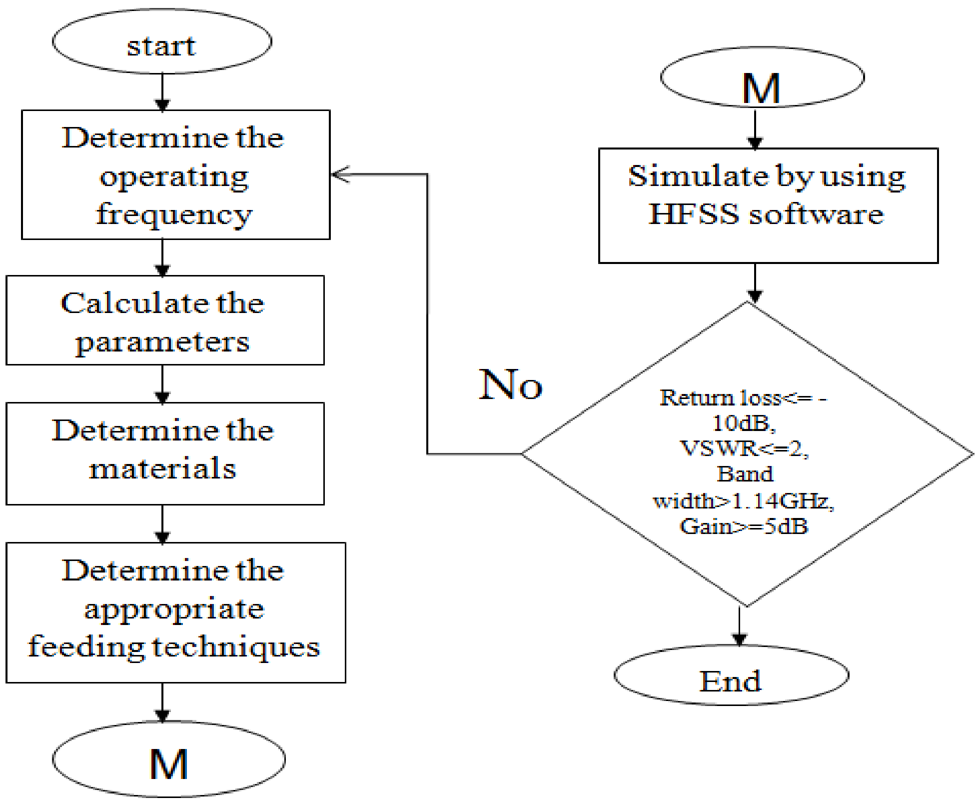
Step-4: Verify Antenna performance in terms of RL (in dB), BW, VSWR, etc.

2. Block Diagram & Technical Specifications

2.1 Block Diagram and Working:



2.1.1 Flow chart



2.1.2. Description:

The summarizations of basic operation for microstrip patch antenna's parameters are discussed as follows. The antenna substrate dielectric constant is given as εr. The εr is primarily affects the bandwidth and radiation efficiency of the antenna. The lower the permittivity will give a wider impedance bandwidth and reduce the surface wave excitation.

The antenna substrate thickness is given as h. The substrate thickness affects bandwidth and coupling level. A thicker substrate results in wider bandwidth, but less coupling for a given aperture size. L is the microstrip patches length. The length of the patch radiator determines the resonant frequency of the antenna. The microstrip patches width is given as w. The width, w of the patch affects the resonant resistance of the antenna, with a wider patch giving a lower resistance.

2.2 Technical specifications:

HFSS is a high performance full wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modelling that takes advantage of the familiar Microsoft Windows graphical user interface. It integrates simulation, visualization, solid modelling, and automation in an easy to learn environment where solutions to your 3D EM problems are quickly and accurate obtained. Ansoft HFSS employs the Finite Element Method (FEM), adaptive meshing, and brilliant graphics to give you unparalleled performance and insight to all of your 3D EM problems. Ansoft HFSS can be used to calculate parameters such as S-Parameters, Resonant Frequency, and Fields. Typical uses include

- Package Modelling – BGA, QFP, Flip-Chip
- PCB Board Modelling – Power/ Ground planes, Mesh Grid Grounds, Backplanes
- Silicon/GaAs-Spiral Inductors, Transformers
- EMC/EMI – Mobile Communications – Patches, Dipoles, Horns, Conformal Cell Phone Antennas, Quadrafilar Helix, Specific Absorption Rate (SAR), Infinite Arrays, Radar Section (RCS), Frequency Selective Surface (FSS)
- Connectors – Coax, SFP/XFP, Backplane, Transitions
- Waveguide – Filters, Resonators, Transitions, Couplers
- Filters – Cavity Filters, Microstrip, Dielectric
- HFSS is an interactive simulation system whose basic mesh element is a tetrahedron. This allows you to solve any arbitrary 3D geometry, especially those with complex curves and shapes, in a fraction of the time it would take using other techniques.
- The name HFSS stands for High Frequency Structure Simulator. An soft pioneered the use of the Finite Element Method (FEM) for EM simulation by developing / implementing technologies such as tangential vector finite elements, adaptive meshing, and Adaptive Lancozos- pade Sweep (ALPS). Today, HFSS continues to lead the industry with

innovations such as Modes to Nodes and Full wave Spice.

- Ansoft HFSS has evolved over a period of years with input from many users and industries. In industry, Ansoft HFSS is the tool of choice for High productivity research, development, and virtual prototyping.
- This chapter includes results regarding the performance of patch antenna and comparison of parameters with U and without U- Shape slot on patch designed at an operating frequency of 3.75 GHz.

3 RESULTS:

The below outputs represents the plots of patch antenna without U- slot and coxial feed.

3.1.1 S-parameters (S11) Vs Frequency plot:

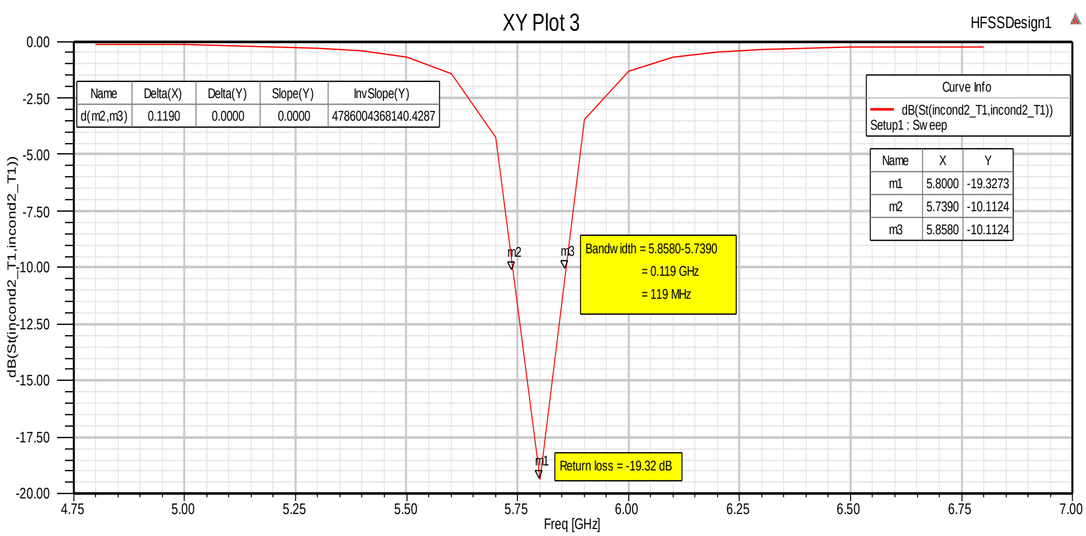


Figure 5.1: Return loss characteristics for FR-4 substrate with thickness 1.6 mm.

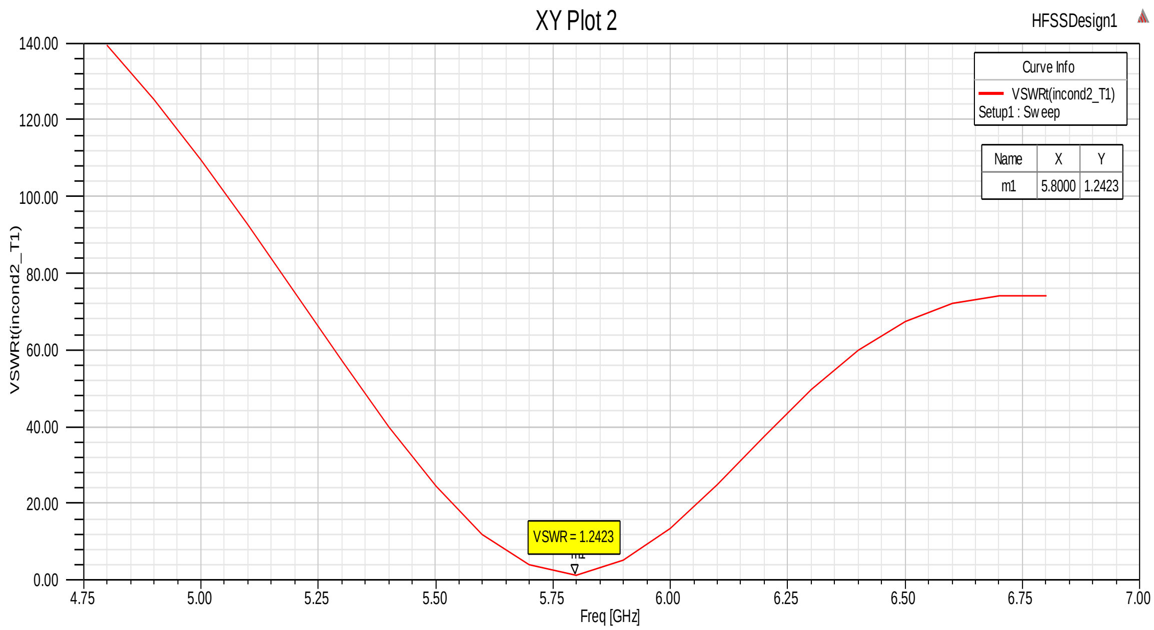


Figure 5.2: VSWR Parameter for FR-4 substrate with thickness 1.6 mm.

Table 5.1: Comparison table for effect of change in thickness of substrate material.

Substrate material/Antenna Parameter	**h = 1.6 mm**	**h = 2.1 mm**	**h = 2.6 mm**
Length of Patch L_p (mm)	11.7	11.5	11.2
Width of Patch W_p (mm)	15.7	15.7	15.7
Return loss (RL in dB)	-19.32	-19.97	-22.51
Bandwidth BW (MHz)	119	123.8	134
VSWR	1.24	1.22	1.16

5.3.4 Comparison table:

Table 5.2: Comparison table for effect due to change in substrate material.

Substrate material/Antenna Parameter	RT Duroid 5880 (ϵ_r=2.2)	GML 1000 (ϵ_r=3.12)	FR-4 (ϵ_r=4.4)
Length of Patch L_p (mm)	16.47	13.92	11.7
Width of Patch W_p (mm)	20.43	18	15.7
Return loss (RL in dB)	-22.51	-19.29	-19.32
Bandwidth BW (MHz)	135	121.3	119
VSWR	1.16	1.24	1.243

5.4 CONCLUSION:

From the results shown above, it is clear that, bandwidth and substrate height are proportional and the bandwidth and relative permittivity of the material are inversely proportional i.e., bandwidth increases as height increases and the bandwidth decreases as the relative permittivity of the substrate increases. Hence the effect of substrate material and its thickness on the performance of microstrip patch antenna is proven experimentally.