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DESIGN OF WIDE BAND ANTENNAS WITH CPW FEED FOR WIRELESS COMMUNICATION APPLICATIONS

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Abstract - An Antenna is a metallic structure that transmits and receives radio waves. Antennas come in all shapes and sizes from tiny microstrip antenna for biomedical applications to very big parabolic reflector antennas for satellite communications.

A Super Wideband Square Monopole Antenna is designed on Arlon AD260A and FR4 Epoxy with CPW-feed structure. Notched bands are obtained by embedding inverted E-shaped stub, using C-shaped parasitic element above radiating patch and etching rotated U- shaped slot in the ground plane. Proposed Antenna has the capability of operating in Ultra Wide band frequency range of (2.534-3.244)GHz with a minimum S_{11} value of -14.9846dB, (4.414-6.300)GHz with S_{11} value of -31.9643dB, (6.728-7.150)GHz with S_{11} value of -12.3336dB and (13.481-15.870)GHz with S_{11} value of -21.9915dB. The maximum gain obtained is 5.86dB in 3-D Omni directional pattern. The minimum VSWR obtained is 1.05.

***Key Words*:** Super Wideband, Ultra Wideband, CPW, X-Band, Ku-Band.

1.INTRODUCTION

Technology evolves each day by pioneers of engineering expeditiously. Every aspect of life is greatly affected by it. Human lives get easier step by step due to new advancements done by the people of science. Ultra Wide Band is a radio technology that can use a very low energy level for short range, high-bandwidth communications over a large portion of the radio spectrum. Similar to Bluetooth and Wi-Fi, Ultra Wide Band (UWB) is a short-range, wireless communication protocol, which operates over radio waves.

An antenna is a transducer for transmission and reception of electromagnetic waves from a transceiver employed in any wireless communication system. This is the basic and the most essential component of any wireless communication system. There are many performance parameters such as antenna gain, aperture, effective length, bandwidth, polarization, etc. There are several types of antennas that include wire, reflector, microstrip patch.

Monopole antennas are widely used in Wireless Communication systems for both transmitting and receiving signals. Such antennas can also used for selective transmit safety critical information in traffic. Monopole antennas have high Radiation efficiency and a wider impedance band. It presents microstrip antenna for microwave imaging and used in radar, civil, military, weather forecasting, Satellite communications, Mobiles and in Wireless applications.

HFSS is a commercial finite element method solver for electromagnetic structures from Ansys. It is one of several commercial tools used for antenna design, and the design of complex RF electronic circuit elements including filters, transmission lines, and packaging. HFSS is a high-performance full-wave electromagnetic (EM) field simulator for arbitrary 3D volumetric passive device modeling that takes advantage of the familiar Microsoft Windows graphical user interface.

This communication reports Super Wideband Monopole triple notched band antenna for wireless applications. Antenna is characterized on Arlon AD260A and FR4 Epoxy substrate with compact dimensions of 24×32×1 mm^3.

SYSTEM REQUIREMENTS

SOFTWARE : High Frequency Structure Simulator (HFSS)
Ansys 2022/R2
Electronic Desktop.

Operating System: Windows 7/8/9/10/11

HARDWARE : Arlon AD 260A, FR4 Epoxy (Substrate Materials)

2.DESIGN METHODOLOGY:

The following steps are proposed to be used while designing and developing a microstrip patch antenna.

STEP 1: Calculate the effective dielectric constant of the substrate is ε_{eff}.

$$\varepsilon_{eff} = \frac{\varepsilon_r - 1}{2}\sqrt{\frac{12h+w}{w}} + \frac{\varepsilon_r + 1}{2} \quad (1)$$

STEP 2: Calculation of the width(W) of the microstrip patch.

$$w = \frac{C}{2fo\sqrt{\frac{\varepsilon_r+1}{2}}} \quad (2)$$

Where h is the height of the substrate, ε_r is the dielectric constant of the substrate, C is the velocity of light in free space and fo is the center frequency of the band.

STEP 3: Length of the patch can be obtained from

$$L = L_{eff} - 2\Delta L \quad (3)$$

Where the effective length and ΔL of the patch can be obtained from,

$$L_{eff} = \frac{c}{2fo\sqrt{\varepsilon_{\text{eff}}}} \quad (4)$$

ΔL is the change in length between L_{eff} and L.

STEP 4: Calculation of Change in length ΔL

$$\Delta L = \frac{\left(\frac{w}{h}+0.264\right)(\varepsilon_{\text{eff}}+0.3)}{\left(\frac{w}{h}+0.8\right)(\varepsilon_{\text{eff}}-0.258)}\, 0.412h \quad (5)$$

STEP 5: Ground plane length L_g, width w_g are calculated from,

$$L_g \geq 6h + L \quad (6)$$

$$w_g \geq 6h + L \quad (7)$$

STEP 6: Inset feed gap, R is calculated from,

$$Z_{in}(R) = Cos^2\left(\frac{\pi R}{L}\right) Z_{in} \quad (8)$$

$Z_{in}(R)$ - input impedance at inset feed 'R' distance from patch edge

Z_{in} - input impedance of patch

3. MODELING AND ANALYSIS

A Microstrip antenna is used in this model. A Microstrip antenna is also called a patch antenna. A patch antenna is one of the most useful antennas at microwave frequencies and it usually consists of a metal patch on top of a grounded dielectric substrate. The patch antenna may be in a variety of shapes, but rectangular and circular are the most common ones.

DESIGN CONFIGURATION

There are two substrate materials used in this design on top of each other. The first substrate is designed by using Arlon AD 260A material (ε_r = 2.6) with a length of 32mm and width of 24mm and the second substrate is designed using FR4 Epoxy material (ε_r =4.4). The ground is designed using copper. The length and width of the ground are 32mm and 24mm respectively. The thickness of the substrate is 1.0mm. Notched bands are obtained by embedding inverted E-shaped stub, using C-shaped parasitic element above radiating patch and etching rotated U-shaped slot in the ground plane.

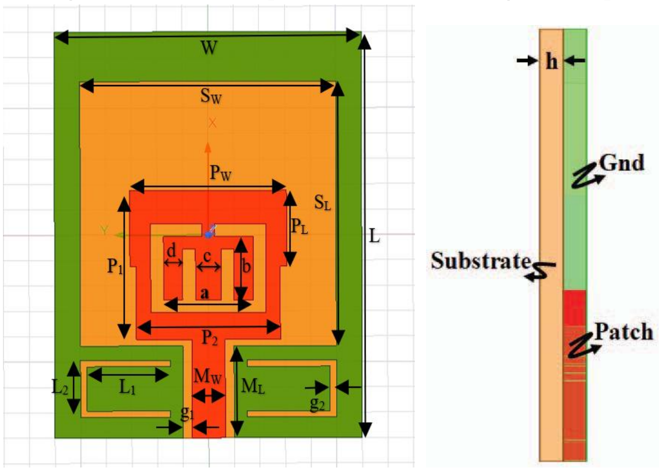


Figure (a) : Design Parameters Figure (b) : side view of proposed antenna

In above Fig.1, shows square monopole triple notches band Super Wideband antenna with CPW feed. Fig.1 illustrates antenna which is printed on Arlon AD 260A and FR4 Epoxy Substrate with dimensions W×L×h mm^3. Antenna consists of radiating patch with dimension $P_L \times P_W$ mm^2. Also, on the same plane, slotted ground is printed. Radiating patch is connected with matched microstrip line of dimension $M_W \times M_L$ mm^2. Above shown parameters are optimized by using EM simulator HFSS and are tabulated in Table 1 given below.

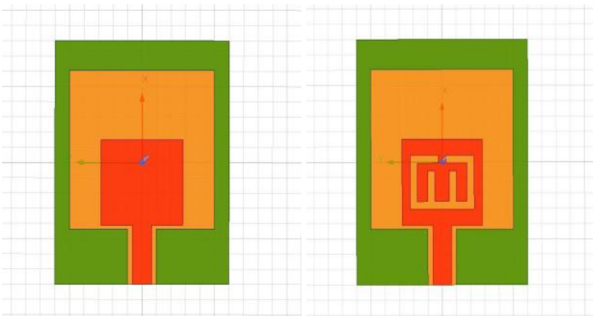
Table 1 : Optimized Parameters

Table shows the tabulated values for antenna development at various stages.

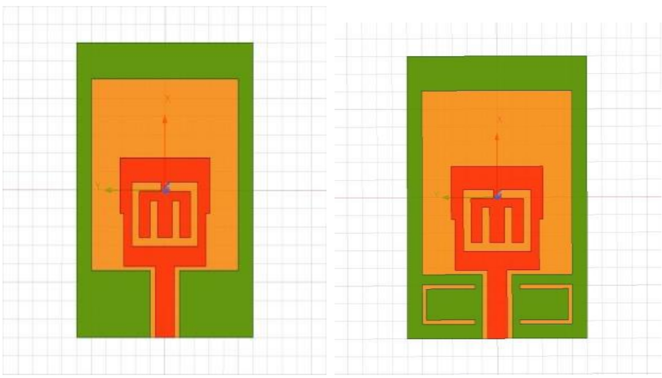
Parameter	mm	Parameter	mm
W	24	A	7.0
L	32	B	5.0
H	1.0	C	2.0
S_W	20	D	1.5
S_L	20.85	M_W	2.6
P_W	12.5	M_L	7.75
P_L	7.0	g_1	0.2
$P_1=P_2$	11.25	g_2	0.5
L_1	7.0	L_2	5.0

Various rectangular patch antennas are designed on Arlon AD260A and FR4 Epoxy Substrates. The design includes inverted E-shaped stub, C-shape, U-shape and radiating patch are designed with rectangular shape. Patches of rectangular shape are used in this design. The antennas are designed using un-uniform Microstrip Feed-line technique. Slots of different shapes are created to enhance antenna parameters like Gain, VSWR, Return loss, Bandwidth. On comparing with Arlon AD 260A and FR4 Epoxy Substrate materials, Arlon AD 260A obtained better antenna parameters. Even Though FR4 Epoxy is cheaper, but results of Arlon AD 260A made high accuracy and better Gain.

INTIATOR PATCH DESIGN STAGES



(a) (b)



(c) (d)

Figure 1: Microstrip Patch antenna design (a) patch & feed (b) Inverted E –Stub & C – Shape (c) Radiating patch (d) U - Shapes

COMPARISON OF ARLON AD260A AND FR4 EPOXY

Arlon's AD260A is a woven fiberglass reinforced PTFE composite material designed as a low cost laminate with excellent low loss characteristics whereas FR4 Epoxy has high Electric Strength and perform well in environmental conditions. Arlon AD260A shows better antenna parameters like gain, frequency, VSWR and return loss compared to FR4 Epoxy with the proposed antenna as shown in table 2.

MATERIAL	FREQUENCIES (GHz)	RETURN LOSS (dB)	VSWR	GAIN (dB)
ARLON AD260A	2.7064 4.6498 6.1666 14.7934	-14.9856 -31.9643 -26.1652 -21.9915	1.4335 1.0517 1.1034 1.1728	5.86
FR4 EPOXY	2.6590 5.1238 6.0244 10.7170	-28.3448 -28.5049 -10.8550 -13.5665	1.0796 1.0781 1.8034 1.5308	2.76

Table 2: Comparison of Arlon AD 260A & FR4 Epoxy

4. RESULTS & ANALYSIS

WIDEBAND ANTENNA (ARLON AD260A)

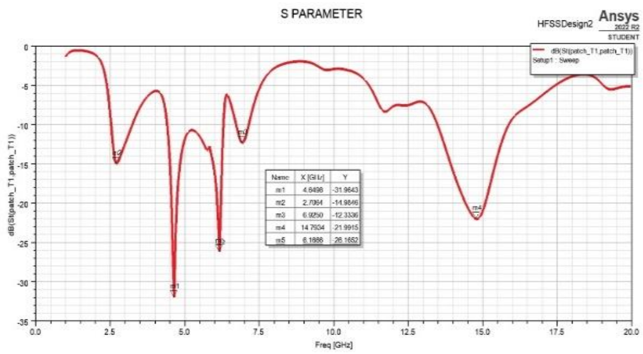


Fig.(i) Return Loss of proposed antenna

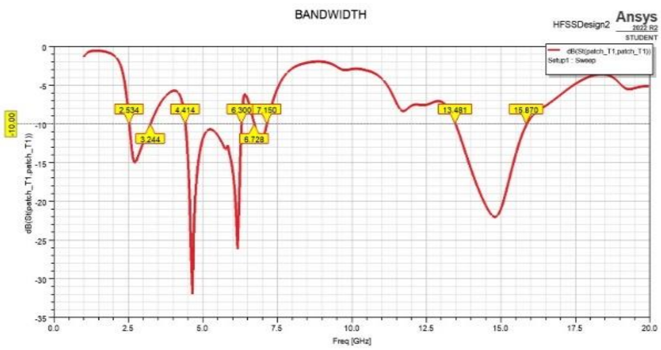


Fig.(ii) Bandwidth of proposed antenna

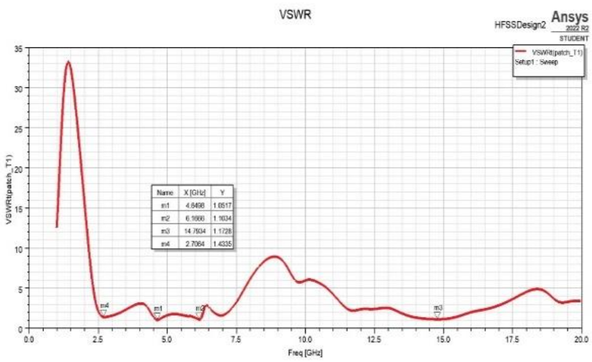


Fig.(iii) VSWR of proposed antenna

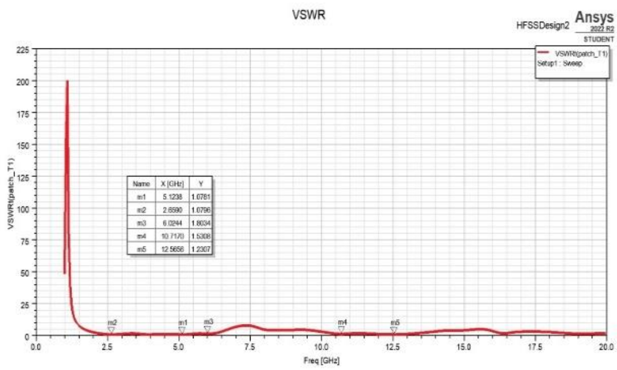


Fig.(iii) VSWR of proposed antenna

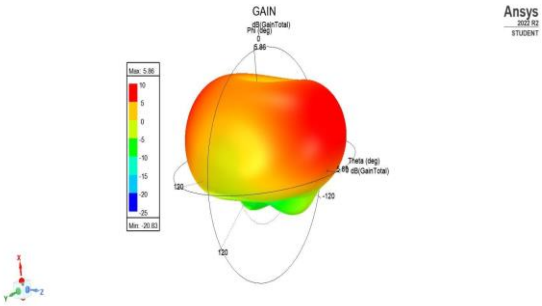


Fig.(iv) Gain of proposed antenna

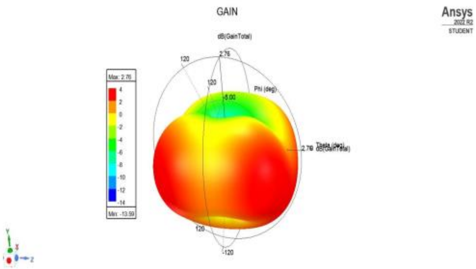


Fig.(iv) Gain of proposed antenna

WIDEBAND ANTENNA (FR4 EPOXY)

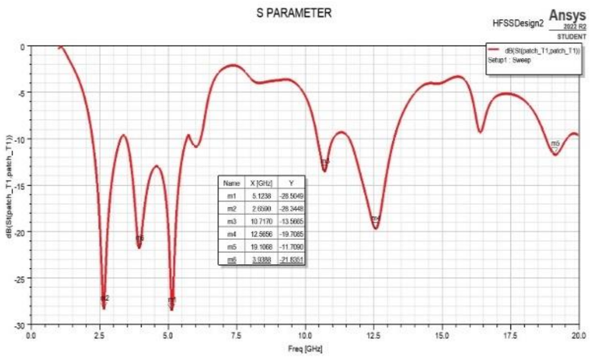


Fig.(i) Return Loss of proposed antenna

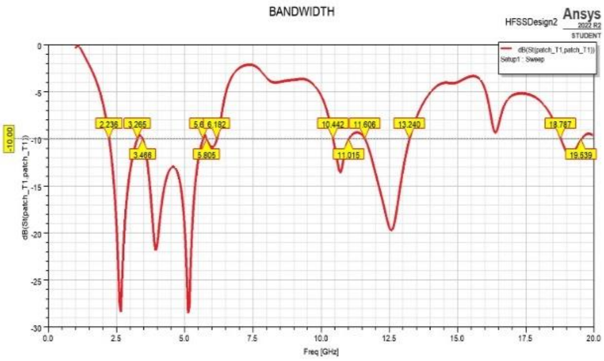


Fig.(ii) Bandwidth of proposed antenna

5. CONCLUSIONS

Comparative approach of material like Arlon AD260A and FR4 Epoxy with rectangular patch antennas are simulated using inverted E-shape, C- shape and U-shaped slots using HFSS. Proposed Antenna has the capability of operating in Ultra Wideband frequency range of (2.534-3.244)GHz with a minimum S11 value of -14.9846dB, (4.414-6.300)GHz with S11 value of -31.9643dB, (6.728-7.150)GHz with S11 value of -12.3336dB and (13.481-15.870)GHz with S11 value of -21.9915dB. The minimum VSWR obtained is 1.05.

Antenna offers maximum gain of 5.86dB in 3D Omnidirectional pattern operating band with stable radiation patterns. Proposed Antenna is widely used in Ultra Wideband ranges (1.0-19.96GHz). With the feature of Ultra Wideband range can generate different bands like UWB(3.1-10.6GHz), X(8-12GHz) and Ku(12-18GHz) bands. It is used in civil, military, radar, satellite communications, weather monitoring and in Mobile applications.

6. ACKNOWLEDGEMENT

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