An Efficient Design of Planar Inverted F-Antenna

Mr. B. M. S. Sreenivasa Rao[1] Mr. R. Arun Sekar[2]
[1,2]Assistant Professor
[1,2]Department of Electronics & Communication Engineering
[1,2]GMR Institute of Technology, Rajam, Andhra Pradesh, India

Abstract— In broadcast communications and radar, a planar exhibit is a receiving wire in which the majority of the components, both dynamic and parasitic, are in one plane. A planar cluster gives a substantial gap and might be utilized for directional pillar control by shifting the overall period of every component. The Planar Inverted-F antenna (PIFA) is progressively utilized in the cell phone advertise. The reception apparatus is full at a quarter-wavelength, and furthermore normally has great SAR properties. PIFA with a little shape factor, feasible with low manufacture cost strategies is to be structured. As this is a rearranged F receiving wire it has a limit of transmitting and accepting the information adequately. Basic execution parameters of reception apparatuses, for example, Voltage Standing Wave Ratio, Return Loss and radiation design are examined and the outcomes are ended up being essential when contrasted and the current plan strategies.

Key words: Voltage Standing Wave Ratio (VSWR), Return Loss (RL), Planar Inverted F-Antenna (PIFA), Antenna Efficiency, Bandwidth

I. INTRODUCTION

Antennas [1] are metallic structures intended for emanating and accepting electromagnetic vitality. A reception apparatus goes about as a transitional structure between the managing gadget and the free space. The meaning of a receiving wire is additionally given as "The piece of a transmitting or getting framework that is intended to emanate or get electromagnetic waves". The execution of a receiving wire [2,3] can be measured from various parameters. Certain basic parameters [4] are Radiation Pattern, Directivity, Input Impedance, Voltage Standing Wave Ratio, Return Loss, Antenna Efficiency, Antenna Gain, Polarization, Bandwidth.

II. EXISTING ANTENNAS

Antennas come in various shapes and sizes to suit diverse kinds of remote applications [5]. The attributes of a receiving wire are especially dictated by its shape, estimate and the sort of material that it is made of.

A. *Half Wave Dipole*

The length of this radio wire is equivalent to half of its wavelength as the name itself recommends. Dipoles can be shorter or longer than a large portion of the wavelength, yet tradeoffs exist in the execution and consequently the half wavelength dipole is generally utilized.

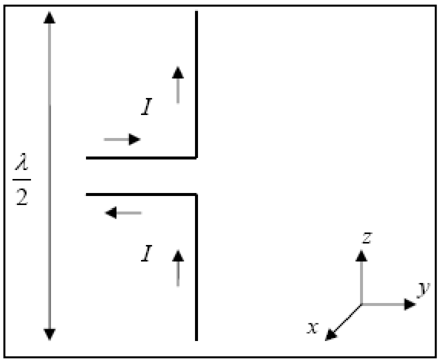


Fig. 2.1: Half-Wave Dipole

The dipole receiving wire is bolstered by a two wire transmission line, where the two flows in the conveyors are of sinusoidal appropriation and equivalent in sufficiency, yet inverse in heading. Thus, due to dropping impacts, no radiation happens from the transmission line. As appeared in Fig. 2.1, the flows in the arms of the dipole are a similar way and they deliver radiation the even way. In this way, for a vertical introduction, the dipole emanates the even way. The normal gain of the dipole is 2dB and it has a data transfer capacity of about 10%. The half power shaft width is around 78 degrees in the E plane and its directivity is 1.64 (2.15dB) with a radiation opposition of 73 Ω.

B. *Monopole Antenna*

The monopole radio wire, appeared in Fig. 2.2, comes about because of applying the picture hypothesis to the dipole. As per this hypothesis, if a leading plane is set beneath a solitary component of length L/2 conveying a current, at that point the mix of the component and its picture demonstrations indistinguishably to a dipole of length L aside from that the radiation happens just in the space over the plane as talked about by Saunders.

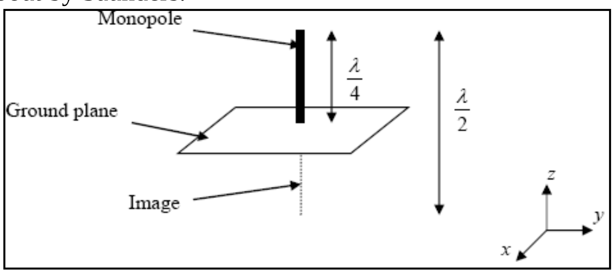


Fig. 2.2: Monopole Antenna

For this kind of radio wire, the directivity is multiplied and the radiation obstruction is divided when contrasted with the dipole. Along these lines, a half wave dipole can be approximated by a quarter wave monopole ($4/2/\lambda = L$). The monopole is helpful in portable radio wires where the leading plane can be the vehicle body or the handset case. The normal gain for the quarter wavelength monopole is 2-6 dB and it has a transfer speed of about 10%. Its radiation opposition is 36.5 Ω and its directivity is 3.28 (5.16dB).

C. Loop Antennas

The circle receiving wire is a channel twisted into the state of a shut bend, for example, a circle or a square with a hole in the conveyor to frame the terminals as appeared in Fig. 3.5. There are two sorts of circle receiving wires electrically little circle radio wires and electrically extensive circle reception apparatuses. In the event that the absolute circle perimeter is little when contrasted with the wavelength (L<<<λ), at that point the circle reception apparatus is said to be electrically little. An electrically substantial circle radio wire regularly has its periphery near a wavelength. The far-field radiation examples of the little circle reception apparatus are uncaring to shape.

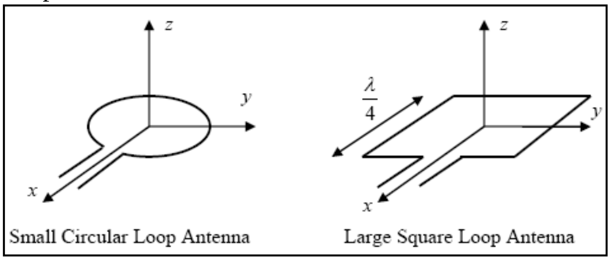


Fig. 2.3: Loop Antenna

D. Helical Antennas

A helical reception apparatus or helix is one in which a conductor associated with a ground plane, is twisted into a helical shape. Fig. 2.4 delineates a helix reception apparatus. The radio wire can work in various modes, anyway the two important modes are the ordinary mode (broadside radiation) and the hub mode (end fire radiation). At the point when the helix distance across is extremely little when contrasted with the wavelength, at that point the receiving wire works in the ordinary mode. In any case, when the boundary of the helix is of the request of a wavelength, at that point the helical radio wire is said to work in the pivotal mode.

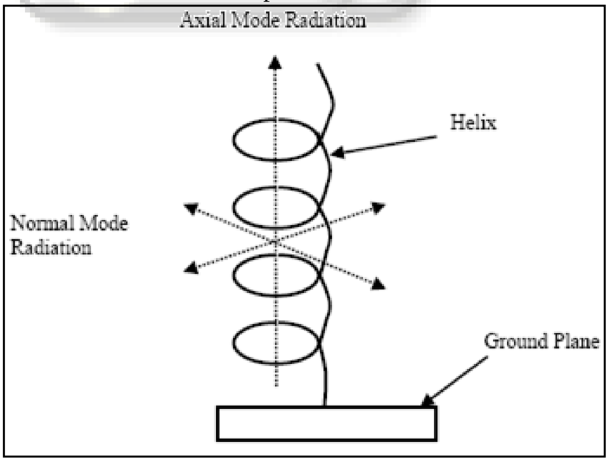


Fig. 2.4: Helix Antenna

In the ordinary method of activity, the reception apparatus field is most extreme in a plane typical to the helical hub and least along its pivot. This mode gives low transmission capacity and is commonly utilized for hand-compact portable applications

E. Horn Antennas

Horn receiving wires are utilized ordinarily in the microwave district (gigahertz run) where waveguides are the standard feed technique, since horn radio wires basically comprise of a waveguide whose end dividers are flared outwards to frame a bull horn like structure.

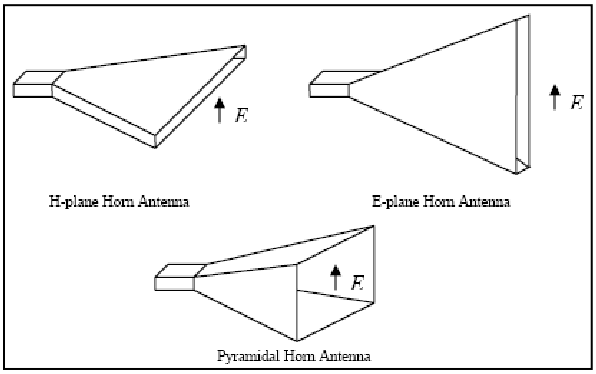


Fig. 2.5: Types of Horn Antenna

Horns give high increase, low VSWR, moderately wide data transmission, low weight, and are anything but difficult to develop. The gap of the horn can be rectangular, roundabout or curved. Nonetheless, rectangular horns are broadly utilized. The three essential kinds of horn reception apparatuses that use a rectangular geometry are appeared in Fig. 2.5. These horns are bolstered by a rectangular waveguide which have an expansive flat well as appeared in the Fig.. For predominant waveguide mode excitation, the E-plane is vertical and H-plane flat. In the event that the expansive divider measurement of the horn is flared with the restricted mass of the waveguide being left for what it's worth, at that point it is called a H-plane sectoral horn receiving wire as appeared in the Fig.. In the event that the flaring happens just in the E-plane measurement, it is called an E-plane sectoral horn reception apparatus. A pyramidal horn reception apparatus is gotten while flaring happens along both the measurements.

F. Microstrip Antenna

Microstrip reception apparatus is printed sort of radio wire comprising of a dielectric substrate sandwiched in the middle of a ground plane and a fix. The idea of Micro strip reception apparatus was first proposed in 1953, twenty years previously the useful receiving wires were delivered. Since the primary commonsense receiving wires were created in mid1970's, enthusiasm for this sort of reception apparatuses was held in New Mexico. The miniaturized scale strip reception apparatus is physically straightforward and level, these are two of the explanations behind the incredible enthusiasm for this sort of receiving wire.

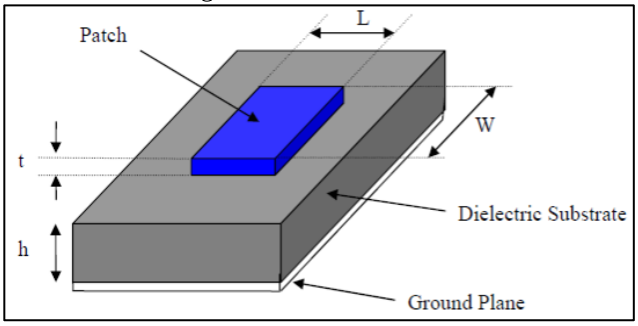


Fig. 2.6: Rectangular Microstrip Antenna

In its least difficult frame, miniaturized scale strip radio wire is a dielectric substrate board sandwiched in the middle of two channels. The lower conductor is called ground plane and the upper conductor is known as fix. Microstrip reception apparatus is generally utilized at frequencies from 1 to 100 GHz and at frequencies beneath ultra-high recurrence, UHF smaller scale strip fix turn out to be extraordinarily substantial. The emanating patch can be structured in different formed by the ideal qualities. Shown in Fig. 2.6 is the least difficult structure of a rectangular smaller scale strip fix receiving wire.

III. PROPOSED MODEL OF PLANAR INVERTED F-ANTENNA (PIFA)

This receiving wire looks like a rearranged F, which clarifies the PIFA name. The Planar Inverted-F Antenna is prominent on the grounds that it has a position of safety and an omni directional example. The PIFA is full at a quarter-wavelength because of the shorting pin toward the end. We'll perceive how the full length is characterized precisely in a moment. The feed is set between the open and shorted end, and the position controls the info impedance.

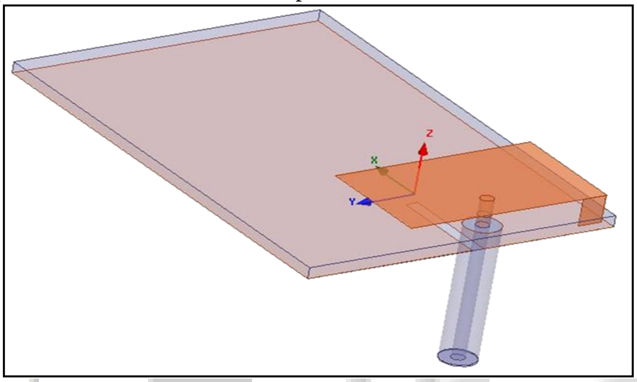


Fig. 3.1: Proposed Antenna

The initial phase in structuring PIFA is to pick the reasonable substrate. There are different kinds of substrate accessible in market that gives extensive adaptability in the decision of a substrate for specific application.

Much of the time, contemplations in substrate qualities included the dielectric steady and lost digression and their variety with temperature and recurrence, dimensional solidness with handling, homogeneity and is otropicity. So as to offer help and generation for the fix components, the dielectric substrate must be solid and ready to persevere through high temperature amid welding process and has high safe towards synthetic compounds that are utilized in manufacture process.

The outside of the substrate must be smooth to lessen misfortunes and stick well to the metal utilized substrate thickness and permittivity decides the electrical qualities of the reception apparatus. Thicker substrate will build the data transmission however it will make the surface waves engender and false coupling will occur. This issue be that as it may, can be diminished or kept away from by utilizing an appropriately low permittivity substrate. The following are two classifications of dielectric ma terial that are utilized for substrates

A. *Roger's Material (ε_r=3, tanδ=0.0013)*

RO3003™ high recurrence circuit materials are fired filled PTFE composites planned for use in business microwave and RF applications. This group of items was intended to offer remarkable electrical and mechanical dependability at focused costs

B. *FR-4 eproxy(ε_r=4.4, tanδ=0.02)*

FR-4 (or FR4) is a review assignment doled out to glass-fortified epoxy overlay sheets, cylinders, bars and printed circuit sheets (PCB). FR-4 is a composite material made out of woven fiberglass fabric with an epoxy tar fastener that is fire safe (self-stifling). FR-4 epoxy gum frameworks ordinarily utilize bromine, a halogen, to encourage fire safe properties in FR-4 glass epoxy covers

There are numerous strategies for investigation for PIFA recieving wires. The most prevalent models are the Transmission line show, Cavity model, and full wave display (Moment of Method/MOM).The transmission-line demonstrate is the least demanding of all, it gives great physical knowledge, however it is less exact.

C. *Transmission Line Model*

This model speaks to the smaller scale strip reception apparatus by two openings of width W and Height h, isolated by a transmission line of length L. The small scale strip is basically a non-homogeneous line of two dielectrics commonly the substrate and air.

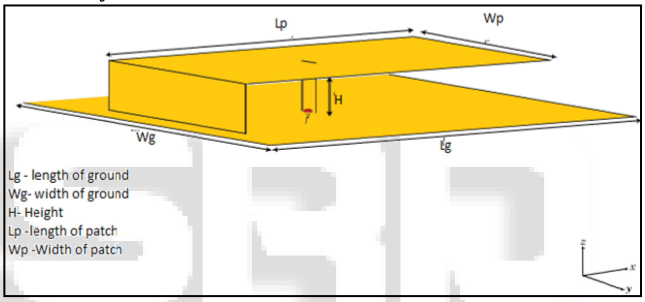


Fig. 3.1: Description of the Parameters

The components of the fix are limited along length and width, the fields at the edges of the fix experience bordering. The measure of bordering is an element of the elements of the fix and the tallness of the substrate. For the essential E-plane bordering is an element of the proportion of the length of the fix L to the stature h of the substrate (L/h) and the dielectric consistent εr of the substrate. Since for miniaturized scale strip recieving wires L/h>>1, bordering is decreased. The equivalent applies for the width.

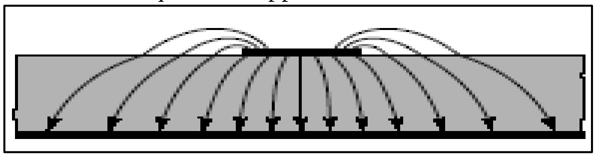


Fig. 3.2: Electric Field Lines

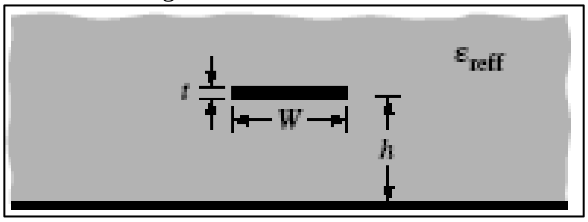


Fig. 3.3: Effective Dielectric Constant

The above Fig. demonstrates the non-homogeneous line of two dielectrics, ordinarily the air and the substrate. A large portion of the electric field lines dwell in the substrate and parts of a few lines exist in air. As W/h >>1 and εr>>1 the electric field lines pack generally in the substrate. Bordering makes the small scale strip line look more extensive electrically contrasted with its physical measurements. A portion of the waves make a trip in to the substrate and some in air, a powerful dielectric steady εreff is acquainted with record for bordering and the wave engendering in the line. The viable dielectric steady has values in the scope of 1<εreff<εr. The powerful dielectric consistent is likewise capacity of recurrence'; as the recurrence of activity builds the greater part of the electric field lines gather in the substrate.

Choosing the consideration of $w/h > 1$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-1/2} \qquad (3.1)$$

D. *Effects of Substrates Parameters*

Impedance data transfer capacity of PIFA is conversely corresponding to the quality factor Q that is characterized for a resonator: Q = Energy Stored/Power Lost .Substrates with high dielectric consistent (Er) will in general store vitality more than transmit it. This is equal by demonstrating the PIFA as a lossy capacitor with high Er, along these lines prompting high Q esteem and clearly diminishing the transfer speed. Thus when the substrate thickness is expanded the opposite proportionality of thickness to the capacitance diminishes the vitality put away in the PIFA and the Q factor too. In rundown, the expansion in stature and decline of Er can be utilized to build the data transmission of the PIFA.

IV. DESIGN USING HFSS SOFTWARE

The system for planning a small scale strip nourished triple band indented reception apparatus is clarified. Next, a miniaturized scale strip sustained triple band scored receiving wire is intended for microwave applications. At last the outcomes acquired from the reproductions are illustrated.

A. *Design Specifications (Single Reference Element)*

The specifications required for the single element is given below.

Notch frequencies	2.4GHz,3.55GHz, 5.75GHz, 8.27GHz
Polarization	Linear
Impedance	50Ω

Table 4.1: Design specifications

B. *Reference Antenna Design*

The essential parameters for the design are

- Band width= 9.50GHz(2.21GHz-7.71GH z)
- Dielectric constant=4.4
- Loss tangent tan δ =0.02
- Height of the substrate=1.6 mm

The reference antenna is simulated by finite element method based commercial electromagnetic simulator HFSS. The values of various parameters are given below:

Parameter	W_p	L_p	W_g	L_g	W_f	H
Value	35	19	35	16	2	1.6

Table 4.2: Reference Antenna Parameters in mm

V. SIMULATION AND RESULTS

A. *Proposed model-1(Single Band)*

parameter	Wp	Lp	Wg	Lg	R	H
Value	11	12	100	90	0.7	10

Table 5.1: Only with Patch Dimensions in mm

The results which are mentioned here are for a frequency of 2.4GHz. Initially a ground plane of length Lg and width Wg is drawn, then a substrate with a thickness of 1 mm is placed on it with same dimensions on itand is made of a material rogers RO3003. After this, a patch with length Lp, width Wp and thickness of 1 mm is drawn and it is made of a material called FR-4 eproxy. Now a feed with radius R is kept at the centre of the patch and a lumped port is defined through the short.

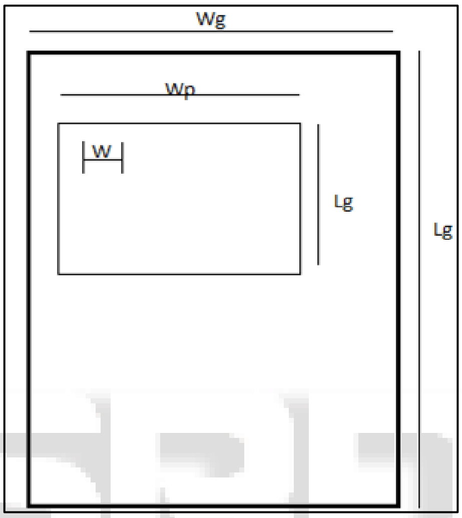


Fig. 5.1: Proposed Model of 2.4GHz Single Band Antenna

B. *VSWR Vs Frequency*

The value of VSWR at 2.4GHz is 1.05 in the output that is achieved. It is nearly equal to one so the observation makes clear that the power that is transmitted haven't been reflected.

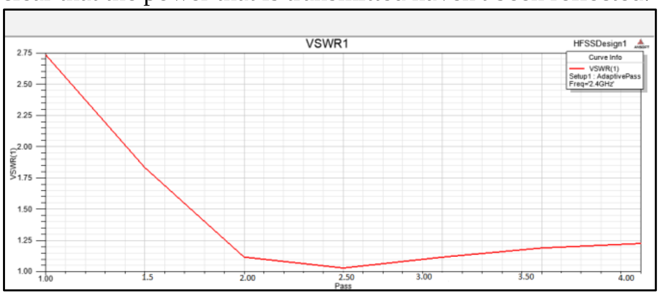


Fig. 5.2: VSWR Vs Frequency

In general for theoritical cases if the value of VSWR is 1 then it is said that total power is transmitted and no power is reflected back. The value of VSWR should always lie between 0 and 1 If the value is equal to 0 then it is said that no power is transmitted everything has been reflected. In the fig 5.2 it is clearly shown that at the designed frequency that is 2.4GHz the antenna value is nearly equal to 1. So the total power is transmitted.

C. *Return Loss Vs Frequency*

The value of RL is similar result as VSWR but it describes about loss in power transmitted this is generally given as a S parameter. In the designed model the value of RL is -29dB at

2.4GHz. In general for practical cases if it's value is less than -9dB then it is said to the device is resonating properly.

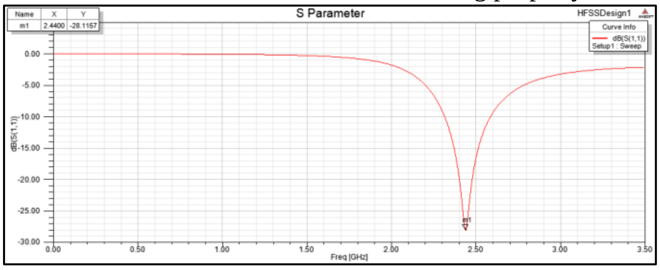


Fig. 5.3: Return Loss Vs Frequency

D. Radiation pattern

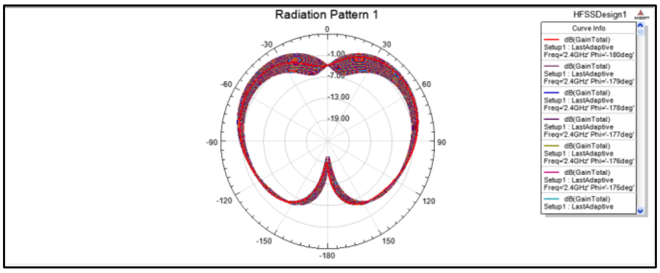


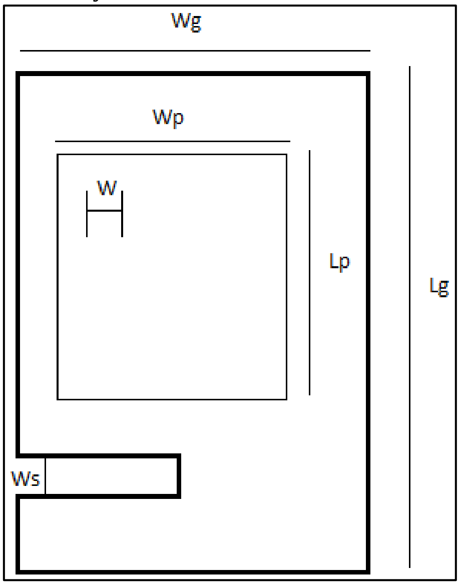
Fig. 5.4: Radiation Pattern of Proposed Model 1

E. Proposed model-2(model band):

The design of a slot antenna for different set of frequencies 2.6GHz, 4.8GHz, 5.8GHz, 7.2GHz.The results which are mentioned here are for a frequency of 2.4GHz. Initially a ground plane of length Lg and width Wg is drawn, then a substrate with a thickness of 1 mm is placed on it with same dimensions on it and is made of a material rogers RO3003. After this, a patch with length Lp, width Wp and thickness of 1 mm is drawn and it is made of a material called FR-4 eproxy. Now a feed with radius R is kept at the centre of the patch and a lumped port is defined through the short.

Parameter	Wg	Lg	Wp	Lp	R	H
Value	100	90	74.2	70	0.7	10

Table 5.2: Only with Patch and slot dimensions in mm



Fig/ 5.5: Design of proposed model 2

F. VSWR Vs Frequency

The value of VSWR at 2.6GHz, 4.2GHz, 5.2GHz, 6.4GHz, 4.2GHz are nearly equal to one so the observation makes clear that the power that is transmitted haven't been reflected at all of these cases.

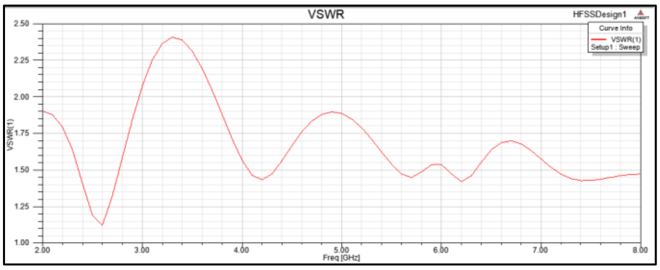


Fig. 5.6: VSWR Vs Frequency

In general for theoritical cases if the value of VSWR is 1 then it is said that total power is transmitted and no power is reflected back. The value of VSWR should always lie between 0 and 1. If the value is equal to 0 then it is said that no power is transmitted everything has been reflected. In the fig 7.3 it is clearly shown that at the multi bands those are created the antenna value is nearly equal to 1. So the total power is transmitted.

G. Return Loss Vs Frequency

The value of RL is similar result as VSWR but it describes about loss in power transmitted this is generally given as a S parameter. In the designed model the value of RL is -24dB, 15.1dB, 14.7dB, 14.9dB respectively at 2.6GHz, 4.2GHz, 5.2GHz, 6.4GHz. In general for practical cases if it's value is less than -9dB then it is said to the device is resonating properly.

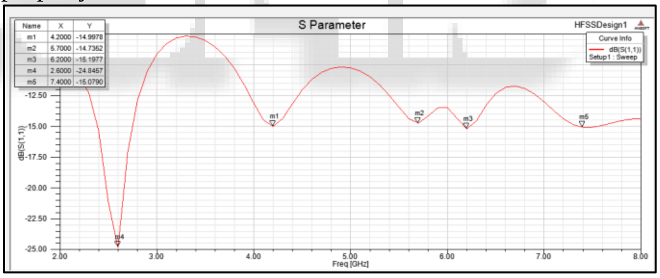


Fig. 5.7: Return Loss Vs Frequency

H. Radiation Pattern

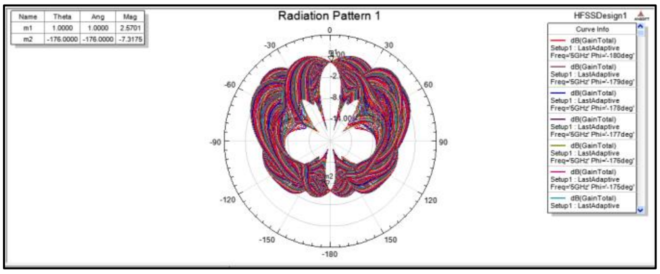


Fig. 5.8: Radiation pattern

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