Double Folded Multiband Slot Antenna with Dual E Stub

S. Suganthi[1], S. Iswaryalakshmi[2], D. Sriadhavi[3]
[1]Professor, [2&3]UG Student, Department of ECE, K.Ramakrishnan College of Technology
Trichy, Tamil Nadu, India.

***Abstract*-The communications standards like GPS, WiMAX, and WLAN are designed with multiband slot antenna is presented. This antenna contains rectangular slot with dimension 40*18 and the substrate and ground of dimension 44*44mm. The multiband slot antenna is designed and measured. Antenna is fabricated and it is measured to verify the simulated result. Simulation is done through HFSS (High Frequency Structural Simulator) software. Antenna parameters like radiation pattern, return loss, gain, VSWR, efficiency are presented. This antenna covers frequency bands from 1.5 to 1.6 GHz for GPS, 3.2 to 3.97 GHz for WiMAX systems,5.17 to 5.93 for IEEE802.11a WLAN systems.**

***Index terms*-Global positioning systems(GPS), multiband slot antenna, wireless area networks(WLAN), worldwide interoperability for microwave access(WiMAX)**

I. INTRODUCTION

With the development of many different wireless communication standards, it is desirable to integrate as many standards such as GPS, WLAN, WIMAX standards as possible into a single wireless device. For this reasons different antennas have been studied. For example, differential evolution algorithm (DE) used for optimizing the size and position of parallel open rectangular slot. The resonators are used for realizing multiband performance. The width of the feed line is 2mm to obtain 50 ohm impedance. The resonant frequency is dependent to each other. So it is difficult to tune the other frequency when one frequency is fixed. So IE3D software is used along with DE algorithm [1]. It is only for GPS. It consists of two substrates of thickness 0.8mm and 2mm. The radiation pattern is obtained by using the MATLAB tool [2].The antenna dimension is 65*120*1.56cubic.mm.it is a combination of pin diodes and varactor diodes. The resistors are used to connect any one of the diode to the radiating part of the antenna [3]. The strip has no effect on the antenna performance. A biasing circuit is needed to isolate dc source from electromagnetic structure of the antenna[4].it use meta meterial reactive loaded monopole antenna for WLAN/WiMAX applications.[5].Three pin diode switches are located on the feedline between the two dielectric resonators.[6].probe feed techniques is preferred due to its direct contact mechanism with the antenna. Feed is isolates from the patch [7].There is no connection of inner conductor of an SMA connector was kept in. There is no measurement result was presented. It operates only in 2 bands. [8].There is a design complexity when adjusting the antenna performance of each frequency band. [9].It consists of two mechanical parts-cones and cylindrical blocks.[10].It has Slow speed, reduced reliability, high cost and designed complexity.[11]. A simple dual loop antenna capable of providing Hepta-band WWAN/LTE operation under surrounding of unbroken metal rim in Smartphone application. unbroken metal rim with 5mm in height embrace the system circuit board of 130*70 square mm. two no ground portion of 10*70 squaric mm and 5*70 square mm are set at top and bottom edge of system circuit board [12]. An switchable planar monopole antenna operating in ultra wide band (UWB) and dual band mode ,the antenna operates in dual-band /UWB mode and it covers 2.4GHZ wireless local area network application[13]. An EBIV index was implemented to evaluate the optimization outcomes against a traditional conical monopole antenna achieving optimal improvement but it is difficult .the structure is shaped in solid brass and parts are strategically designed to fit directly on to an SMA pin and flange[14]. The dual notched frequency band operation was originated from the dual band resonance of two pairs of meta resonators which consist of two inner cell slot and two outer cell slot embedded in Unipolar symmetric dipole antenna [15].the fundamental system cavity mode is designed to resonate at 2.4GHZ and it is used in coverage area of 5GHZ WLAN band. The performance of antenna in terms of mutual coupling and envelope correlation have done [16]

II. ANTENNA CONFIGURATION

The proposed multiband slot antenna is shown in Figure.1. This antenna consists of rectangular slot which has the dimension 40*18 on one side of substrate. An inverted T-Shaped Stub is loaded at the upper edge of the rectangular slot. Two E-Shaped stubs are loaded on the left hand and right hand sides of the rectangular slot. The inverted T-Shaped stub is folded on both sides to achieve the compact size. A T-Shaped feed patch is used along with microstip fed on other side of substrate to feed the rectangular slot. The width of the feedline is 1.76mm to achieve an impedance of 50ohm. The antenna is able to generate three frequency bands at about 1.5-1.6GHZ,3.2-3.97GHZ,5.17- 5.93GHZ.These frequency ideas re denoted as bands 1,2,3 respectively which are used for different wireless applications such as GPS,WIMAX,WLAN. The band 1 which is used for GPS applications can be generated using the combination of rectangular slot and the inverted T-Shaped stub. The band 2 which is used for WIMAX application can be generated using the combination of T-Shaped feed patch and inverted T-Shaped stub. The band 3 which is used for WLAN applications can be generated using T-Shaped feed patch in the higher modes.

This antenna is studied and designed on a substrate using the material FR4 (Flame retardant) and a thickness of 0.8mm.The final dimensions of the proposed antenna are given in table.1. The feed line is designed as 90 degree bent which is used to give more space for other components. For the simulation purpose HFSS (High frequency structural simulator) is used as software for antenna design because of its compatibility. It is very easy to study and understand. It is used to draw 3D structures. The HFSS software is based on finite element method. In general, the finite element method divides the full problem space into thousands of smaller region and represents the field in each sub region (element) with a local function. In HFSS, a perfect E boundary represents the perfectly conducting surfaces in a structure. The length of feed line can be varied and produce required bands of frequencies and to obtain the parameters like return loss, radiation pattern, gain, efficiency, VSWR which are all shown in Figures.

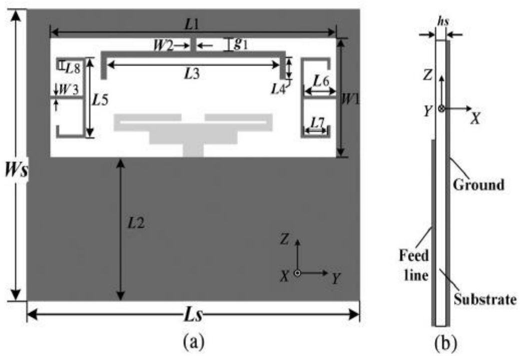


Fig. 1. Geometry of antenna: (a) top view; (b) side view; and (c) bottom view (dark gray—metal in front and light gray—metal in bottom).

Table.1. final dimensions of the proposed antenna

Parameters	Dimensions (mm)	Parameters	Dimensions (mm)
L1	40	G1	2
L2	21.6	G2	4
L3	25	W1	18
L4	3.3	W2	1
L5	12	W3	0.5
L6	2.5	W4	3.6
L7	2	W5	15
L8	1.3	Wf	1.76
L9	2	Ws	44
L10	2	Hs	0.8
L11	2	Ls	44
L12	8.5		

By varying L2 parameter as 19mm or 22 mm or 20.5mm, different return losses are obtained. When we compared these different outputs obtained, we observed that the return loss gets decreased for increasing the L2 parameters. Similarly when we change the parameters L3, G1, G2, the return loss gets decreased by increasing the parameters. The effect of varying feed in patch, we produce different antenna parameter output and it is shown in the figures.

The computer simulation of the proposed antenna is carried out in four conditions namely

1) Only the T-shaped feed patch
2) Only the T-shaped feed patch and the inverted T-shaped stub
3) Only the T-shaped feed patch and the two E-shaped stubs
4) The completed design i.e. the proposed antenna

By varying L2 parameter as 19mm or 22 mm or 20.5mm, different antenna gains are obtained. When we compared these different outputs obtained, we observed that the antenna gain gets decreased for increasing the L2 parameters. Similarly when we change the parameters L3, G1, G2, the antenna gain gets decreased by increasing the parameters. The effect of varying feed in patch, we produce different antenna parameter output and it is shown in the figures.

The parameters L1, L3-L10, W1, W5 and g1 would affect the frequency bands. The design in different applications needs to find the parameters and a method to set frequencies for frequency bands. The parameter L2 determines the ground plane size. This ground plane size helps to achieve better matching. The current is distributed at the edges of the rectangular slot. In condition 1,the T-shaped feed patch is used in the slot so that the antenna generates 1.8GHZ,3.5GHZ and 5.2GHZ respectively. In condition 2, the inverted T-shaped stub is added, so that the band 1 moves slightly from 1.8GHZ to 1.5GHZ.In condition 3,the two

E-shaped stubs are used, so that the antenna generates 1.8GHZ,3.5GHZ,2.5GHZ and 5.2GHZ respectively.

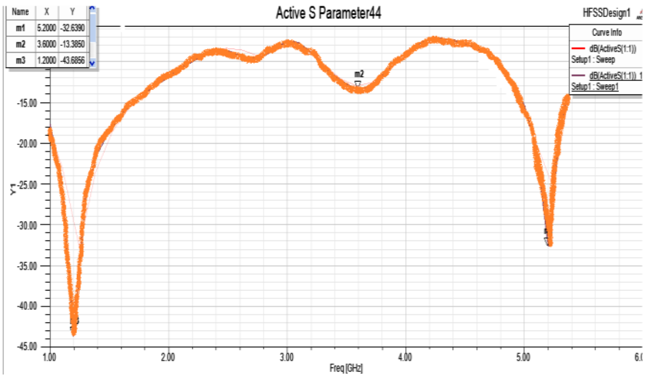
Similarly by varying the parameter values of L1, L2, L3, G1, G2 etc the radiation efficiency of antenna can be simulated and measured. By varying L2 parameter as 19mm or 22 mm or 20.5mm, different radiation efficiency is obtained. When we compared these different outputs obtained, we observed that the radiation efficiency gets decreased for increasing the L2 parameters. Similarly when we change the parameters L3, G1, G2, the radiation efficiency gets decreased by increasing the parameters.

In computer simulation, no feeding cable is used. But in measurement, feeding cable must be used to connect the antenna to antenna equipment. At low frequencies, the ground plane of the antenna becomes electrically small and some currents will flow back from the antenna to the outer surface are of the feeding cable. The radiations patterns for the proposed antennas in the x-y plane are quite in omnidirectional.The radiation pattern of the proposed antenna in the x-z plane are in dumb-bell shape.

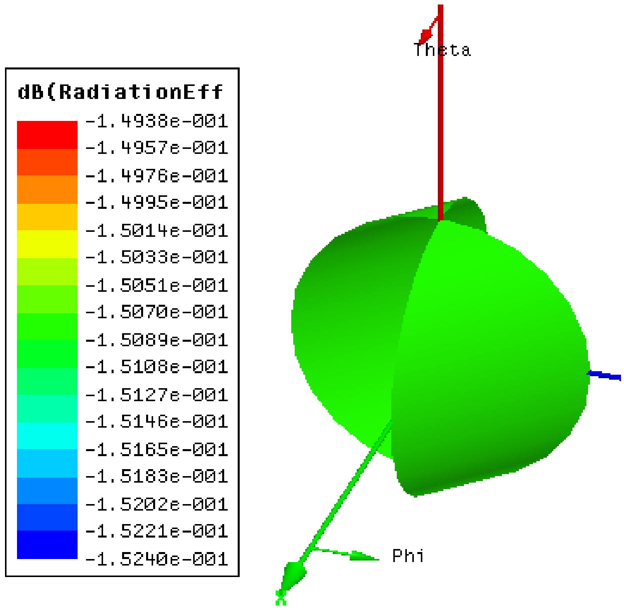
The parameter g1 affects the length of the current path and hence can be used to adjust band 1.The two E-shaped stubs are serve as monopole radiators. The parameter L6 is used to adjust the frequency for band 2.Finally we compare the total size, the size of the radiating portion and the gain of our proposed antenna. The results of the return loss, radiation efficiency, radiation pattern, Voltage Standing Wave Ratio and overall gain are obtained.

III.RESULTS AND EXPLANATIONS

In Fig.2(a), by varying feed 1.7mm, we have obtained three bands of frequency which is 1.23GHZ for GPS with the return loss of -43.68Db and 3.45GHZ for WIMAX with the return loss of -13.68Db AND 5.36 GHz for WIMAX with the return loss of -32.63db.this is output obtained for actual values of parameters given in the mentioned table. By varying the parameter values of L1, L2, L3, G1, G2 etc the return loss of antenna can be simulated and measured.



(a)



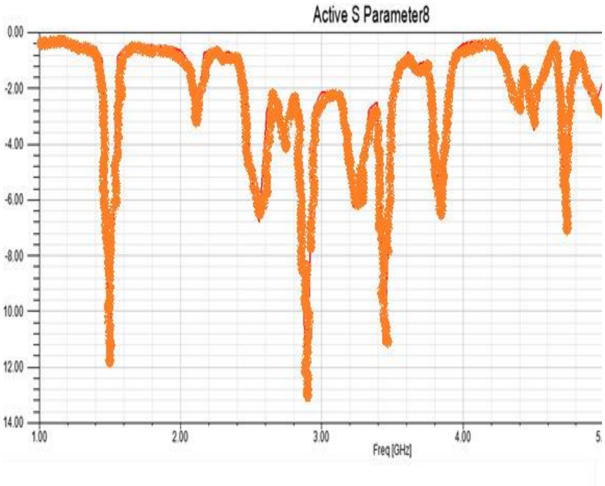
(b)

Fig.2. (a) Simulated return loss of the proposed antenna with optimal dimensions (b) Radiation Efficiency in 3d view

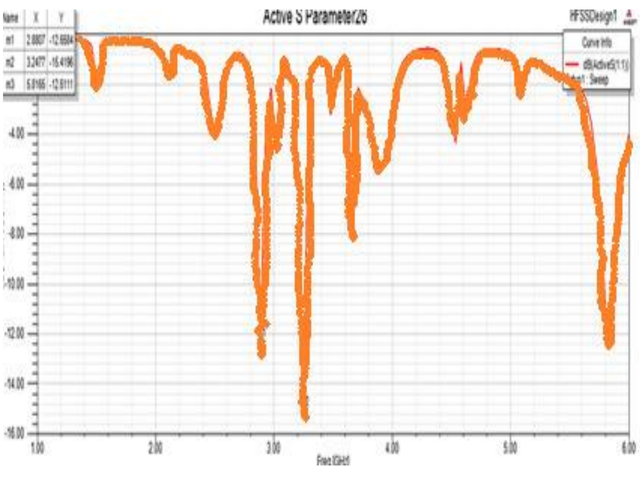
In telecommunications, return loss is the loss of power in the signal returned/reflected by a discontinuity in transmission line or optical fiber. This discontinuity can be a mismatch with the terminating load or with a device inserted in the line. Return loss is related to both standing wave ratio and reflection coefficient. Increasing return loss corresponds to lower SWR. Return loss is a measure of how well devices or lines are matched. A match is good if the return loss is high. 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 resolutions for small values of reflected wave.

By varying L2 parameter as 19mm or 22 mm or 20.5mm, different return losses are obtained. When we compared these different outputs obtained, we observed that the return loss gets decreased for increasing the L2 parameters. Similarly when we change the parameters L3, G1, G2, the return loss gets decreased by increasing the parameters. The effect of varying feed in patch, we produce different antenna parameter output and it is shown in the figures.

From Fig.2 (b), we have obtained maximum radiation efficiency of antenna with feed of 1.7mm and used for the application of GPS, WIMAX, and WLAN. This is output obtained for actual values of parameters given in the mentioned table. In antenna theory, antenna efficiency is a loose term usually meaning radiation efficiency, often abbreviated to efficiency. It is a measure of the efficiency with which in a radio antenna converts the radio frequency power accepted at its terminals into radiated power. Radiation efficiency is defined as the ratio of the total power radiated by an antenna to the net power accepted by the antenna from the connected transmitter. It is sometimes expressed as a percentage and is frequency dependent. It can also be described in decibels.



(a)



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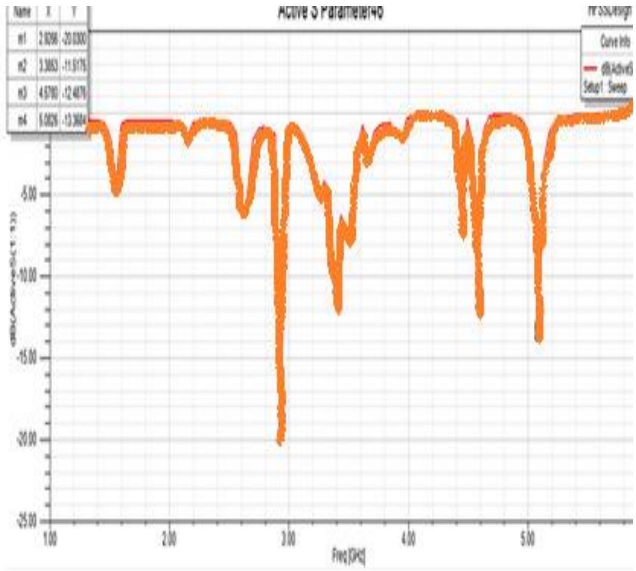


(c)

Fig.3. (a) Simulated return loss of the proposed antenna with optimal dimensions (a) L2=17mm (b) L2=20.5mm (c) L2=22.5mm

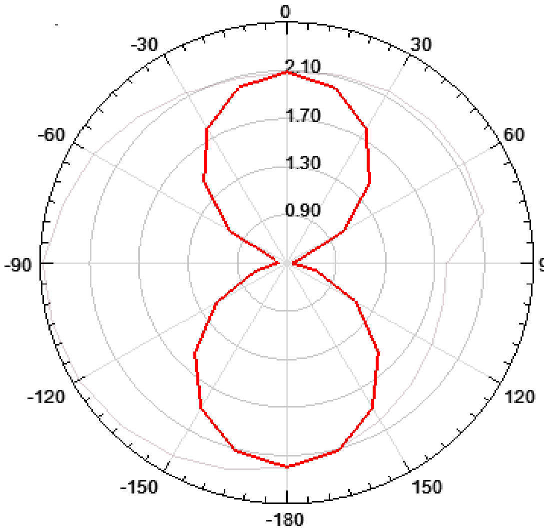
Table.2.Obtained parameters of our proposed antenna

L2	GPS		WLAN		WIMAX	
	FREQUENCY	RETURN LOSS	FREQUENCY	RETURN LOSS	FREQUENCY	RETURN LOSS
19	1.5GHZ	-11.4 dB	2.42GHZ	-12.8 dB	3.38GHZ	-10.7 dB
20.5	1.60GHZ	-11.7 dB	2.46GHZ	-13.1 dB	3.58GHZ	-11.3 dB
22	1.8GHZ	-11.9 dB	2.50GHZ	-13.5 dB	3.72GHZ	-11.1dB

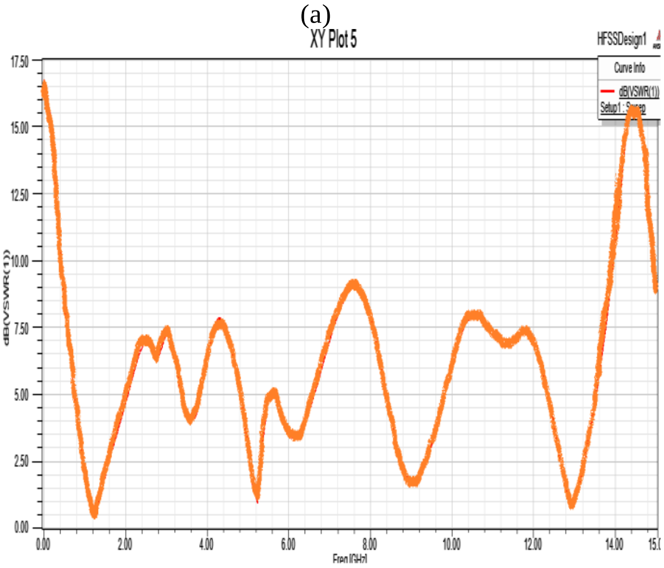
By varying the parameter values of L1, L2, L3, G1, G2 etc the radiation efficiency of antenna can be simulated and measured. By varying L2 parameter as 19mm or 22 mm or 20.5mm, different radiation efficiency is obtained.

When we compared these different outputs obtained, we observed that the radiation efficiency gets decreased for increasing the L2 parameters. Similarly when we change the parameters L3, G1, G2, the radiation efficiency gets decreased by increasing the parameters. In fig 3(a), we have obtained radiation pattern with bidirectional plot, it consist of x and y plane with the bidirectional output by varying the angles from -360 to 360 degrees and obtain the radiation pattern with x plane as electric E plane and Y as magnetic H plane. A radiation pattern defines the variation of the power radiated by an antenna as a function of the direction away from the antenna.

This power variation as a function of the arrival angle is observed in the antennas far-field. In the field of the antenna design the term radiation pattern or antenna pattern or far-field pattern refers to the directional dependence of the strength of the radio waves from the antenna or other source. By varying the parameters such as L2, L3, G1, and G2 from the exact structure value, the different radiation patterns are obtained as outputs.From these different radiation patterns obtained the antennas different directivity can be observed.



(a)



(b)

Fig.4 (a) Radiation pattern of proposed antenna with bidirectional plot (b) Simulated vswr of the proposed antenna

In the Fig.3 (b), we have obtained VSWR by varying the feed in the patch and we obtain the values for the frequencies such as 1.2GHZ for GPS, 3.32GHZ for WIMAX and 5.26GHZ for WLAN applications. By varrying the parameters such as L2, L3, G1, G2 from the exact structure value, the different values of VSWR can be obtained as outputs.From these different values of VSWR, the antennas different outputs can be observed.

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. VSWR is a function of the reflection coefficient, which describes the power reflected from the antenna.

By varying L2 parameter as 19mm or 22 mm or 20.5mm, different VSWR are obtained. When we compared these different outputs obtained, we observed that the VSWR gets decreased for increasing the L2 parameters. Similarly when we change the parameters L3, G1, G2, the VSWR gets decreased by increasing the parameters. The effect of varying feed in patch, we produce different antenna parameter output and it is shown in the figures.

The simulated peak gains against frequency are plotted in Fig.4.The gain is obtained for different frequency bands such as 1.2GHZ, 3.4GHZ, and 5.2GHZ.The frequency band 1.2GHZ is used for GPS and the frequency band 3.4GHZ is used for WIMAX and the frequency band 5.2GHZ is used for WLAN. By varying the parameters such as L2, L3, G1, and G2 from the exact structure value, the different radiation patterns are obtained as outputs. In electromagnetic, an antennas power gain or simply gain is a key performance number which combines the antennas directivity and electrical efficiency. As a transmitting antenna, the gain describes how well the antenna converts the input power into radio waves headed in a specified direction. As a receiving antenna, the gain describes how well the antenna converts the radio waves arriving from a specified direction into electrical power.

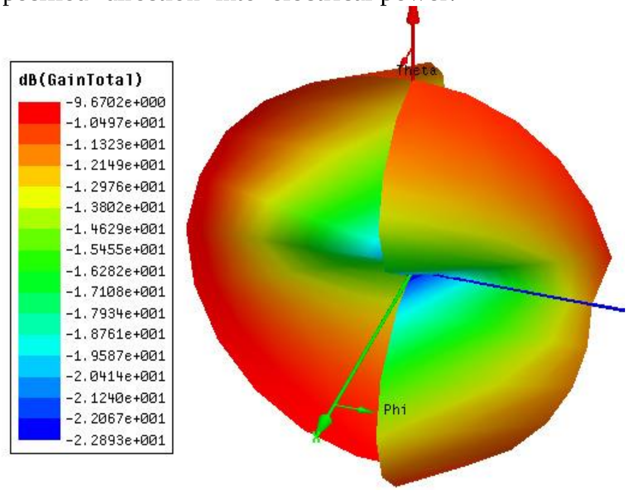


Fig.4.Simulated overall gain of proposed antenna.

By varying L2 parameter as 19mm or 22 mm or 20.5mm, different antenna gains are obtained. When we compared these different outputs obtained, we observed that the antenna gain gets decreased for increasing the L2 parameters. Similarly when we change the parameters L3, G1, G2, the antenna gain gets decreased by increasing the parameters. The effect of varying feed in patch, we produce different antenna parameter output and it is shown in the figures.

When no direction is specified,"gain" is understood to refer to the peak value of the gain. A plot of the gain as a function of direction is called the radiation pattern. Antenna gain is usually defined as the ratio of the power produced by the antenna from a far-field source on the antennas beam axis to the power produced by a hypothetical lossless isotropic antenna, which is equally sensitive to signals from all directions. Usually this ratio is expressed in decibels and these units are referred to as decibels- isotropic (dBi).

An alternative definition compares the antenna to the power received by a lossless half-wave dipole antenna, in which case the units are written as dBi. Since a lossless dipole antenna has a gain of 2.15 dBi, the relation between these units is: gain in dBi, gain in dbi-2.15dBi. By varying the parameters such as L2, L3, G1, and G2 from the exact structure value, the different values of gain can be obtained as outputs.

For a given frequency, the antennas effective area is proportional to the power gain. An antennas effective length is proportional to the square root of the antennas gain for a particular frequency and radiation resistance. Due to reciprocity, the gain of any antenna when receiving is equal to its gain when transmitting.

IV. CONCLUSION

In this paper, Double Folded Multiband Slot Antenna with E- shaped stub is proposed and simulated successfully. The design of a three band slot antenna for GPS, WIMAX, and WLAN has presented. The multiband antenna consist of rectangular slot, an inverted T-shaped stub, a T-shaped feed patch and two E-shaped stubs. The feed line has the width of 1.76mm to achieve 50 ohm impedance. This antenna will be of compact size. The use of HFSS is another advantage in simulation process. In simulation, the results of return loss, radiation pattern, realized peak gain, efficiency and VSWR of the antenna are observed. From these results, it is observed that this antenna has three frequency bands such as 1.5GHZ, 3.5GHZ and 5.2GHZ which are used for GPS, WIMAX, WLAN applications.

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