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Design and Simulation of Ultra Wide Band Planar Inverted –F Antenna at 10.8ghz Application

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Abstract: *The demand for high data rate in modern day wireless communication is on the increase and requires a miniature device. Ultra wide band is one of the techniques for high frequency band. Microstrip patch antenna has gain popularity in the design of UWB. In this study, a coaxial fed Planar inverted –F Antenna with one slot for Ultra wide band resonating at 10.8GHz was designed with a reduced height and with a better performance of antenna parameters. The High Frequency Software Structure (HFSS) was used. The substrate used is FR4 with dimensions 62.5mm x56mm having a height of 0.8mm dielectric constant of 2.2. A patch with dimension of length 23.5mm and width 15mm was considered. The result shows antenna operating on an UWB frequency range of 8.5GHz to 10.8GHz having a return loss less than -10dB, directivity of 5.77dBi, gain of 4.60dB, a bandwidth of 9.1% axial polarization of* 0^0 *and efficiency of 80%. The research has met up with standard as compared to conventional antennas and it is therefore recommended to carry out more research using other simulator package, the change against the non-correlation of simulated and calculated value. There is need for fabrication of the designed antenna.*

Key Words: Ultra wide band, Planar Inverted –F Antenna(PIFA),Substrate

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I. Introduction

Antenna plays a crucial and vital role in telecommunication field such as satellite communication, security, mobile phone, sending signals, and for military use (Li *et al.,* 2010).Ultra Wide Band (UWB) is a radio technology that can be used for transmitting and receiving a large amount of data over an ultra-wide band frequency with very low power and for short distances (Breed, 2005). It has some advantages like high data rate, low equipment cost, multipath immunity and finally ranging and communication at the same time is possible. In all wireless communication systems, the antenna has an essential role since it is the means by which the signals are converted from electrical to electromagnetic wave form and vice versa. The design of an UWB antenna is subject to numerous challenges such as achieving a wide impedance bandwidth and keeping high radiation efficiency. This has been the subject of many studies (Vaderas*et al.*, 2010).Recently, design for novel planar antenna are used in fulfilling specifications for specific bandwidth especially in systems used in mobile communication. Devices used in wireless communication uses planar antenna due it is miniaturization. The planar inverted-F antenna is dominating the digital world of design of antenna today not only because of its miniaturization but also due to it is low profile and omnidirectional pattern.

The PIFA antenna is fed at the base of the feed wire at the point where the wire connects to the plane. It also has a shorting plates that provides good impedance matching for effective radiation which is a prerequisite for outstanding antenna. Anoop Varghese and Kazi Aslam (2015),fabricated an antenna using the FR4 substrate at a low cost which occupies a small space the work was design for Global System Mobile, digital system communication and personal communication system band. The voltage standing wave ratio (VSWR) with respect to frequency which was observed to be with an antenna impedance bandwidth that extends from 0.83-0.91GHz and 1.72-2.10GHz with VSWR less than 2.

The bandwidth of 84MHz was obtained for a resonance frequency of 0.87GHz and a bandwidth of 382MHz was obtained from a resonant frequency of 1.89GHz reading a directivity with a peak value of 3.90dB. The characteristics parametric performance of their work is not as expected.

Joseph and Ali (2016) develop an UWB for MIMO antenna of frequency band of 3.1GHz to 10.6GHz adopting the PIFA with a circular monopole disc printed in a block of FR-4 dielectric substrate with a relative permittivity of 4.6. The design met the main requirements but the radiation pattern and radiation efficiency of 70% is not too encouraging.

However, meeting the equipment physical constraints like size and portability is another challenge which led to the purpose of this research is

1. To model and design microstrip patch antenna that can operate at 10.8GHz
2. To design and simulate PIFA antenna operating at 10.8GHz.
3. To ensure that the reduced height attained the good functional properties of a smart antenna

II. Method of Design

The width and length of the rectangular microstrip antenna operating at 10.8GHz was calculated using equations (3.1) and (3.2c) for the actual length and (3.2b) for the extended length of the patch. It was calculated to be 15.37mm and 23.202mm respectively. The substrate used is (RT/droid) with a height of 0.8mm and a dielectric constant $\boldsymbol{\varepsilon_r}$ of 2.2.

Waves travels in substrate and some in air to be sure of proper wave propagation and fringing an effective dielectric constant is calculated (Balanis,2005)

$$e_{ff}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}(1+12\frac{h}{w})^{-1/2} \qquad 3.2a$$

The extension of the patch length ΔL as stated by (Balanis,2005)

$$\frac{\Delta L}{h}= 0.412\frac{\varepsilon_{ff}+0.3(\frac{W}{h}+0.24)}{\varepsilon_{ff}-0.258(\frac{W}{h}+0.8)} \qquad 3.2b$$

The actual length L will be determined (Balanis,2005)

$$L=\frac{\lambda}{2}-2\Delta L \qquad 3.2c$$

For dominant TM_{010} the Resonant frequency of the microstrip antenna is a function of the length given by (Balanis,2005).

III. Results

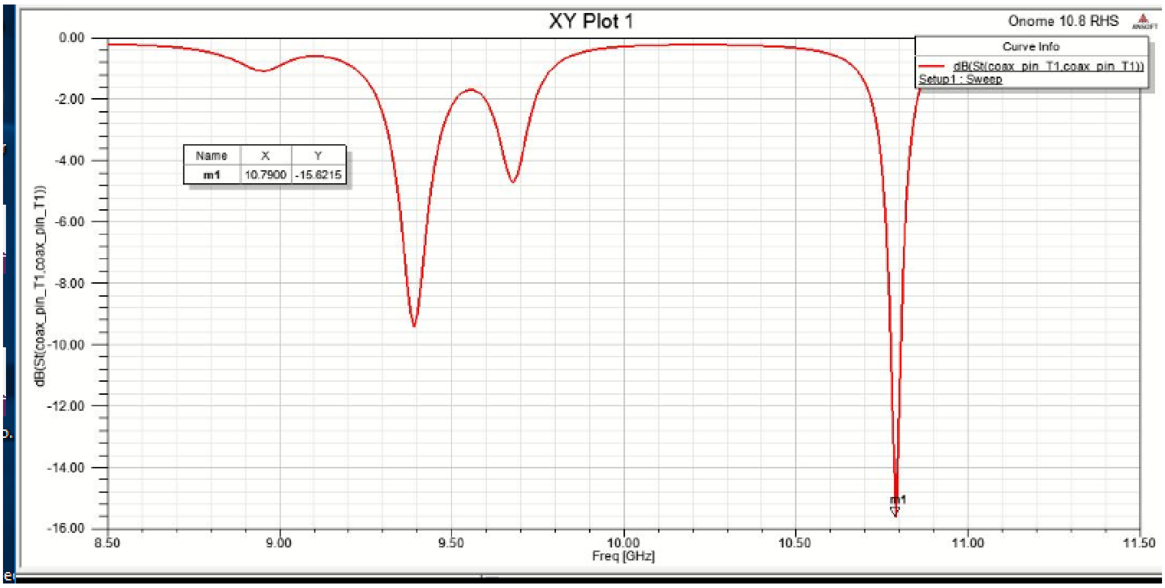

Plate: 1Return Loss of 10.8GHz

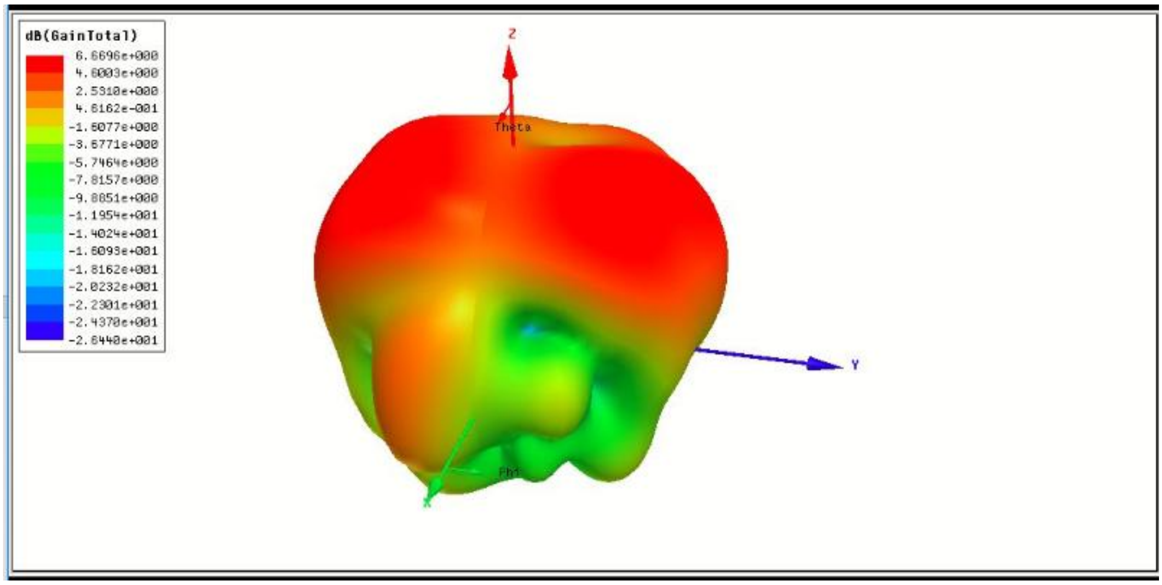

Plate:2Antenna Gain

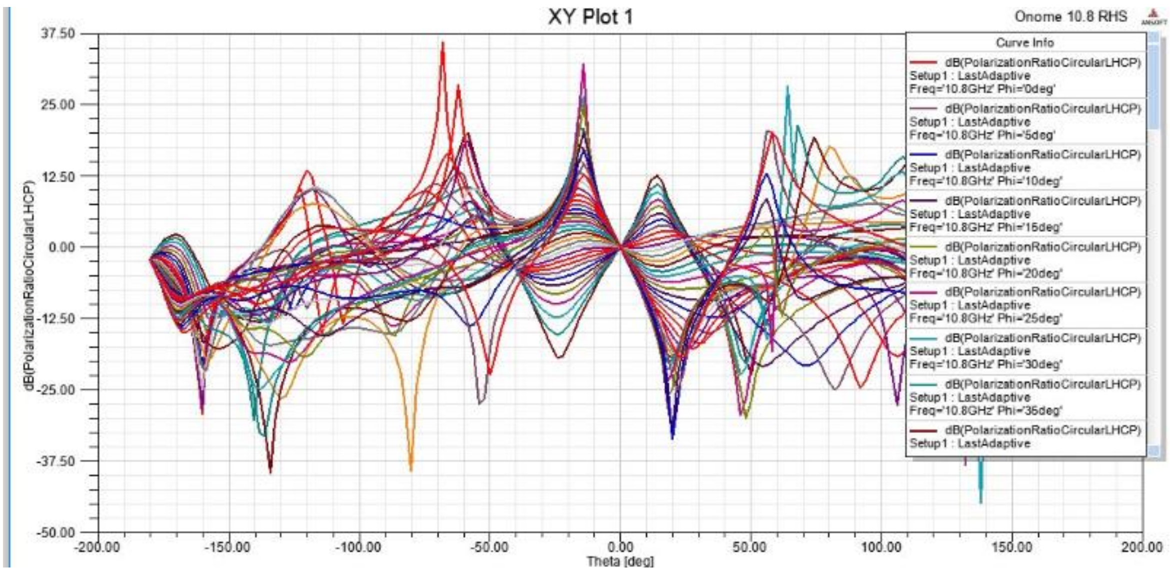

Plate:3 Polarization Ratio

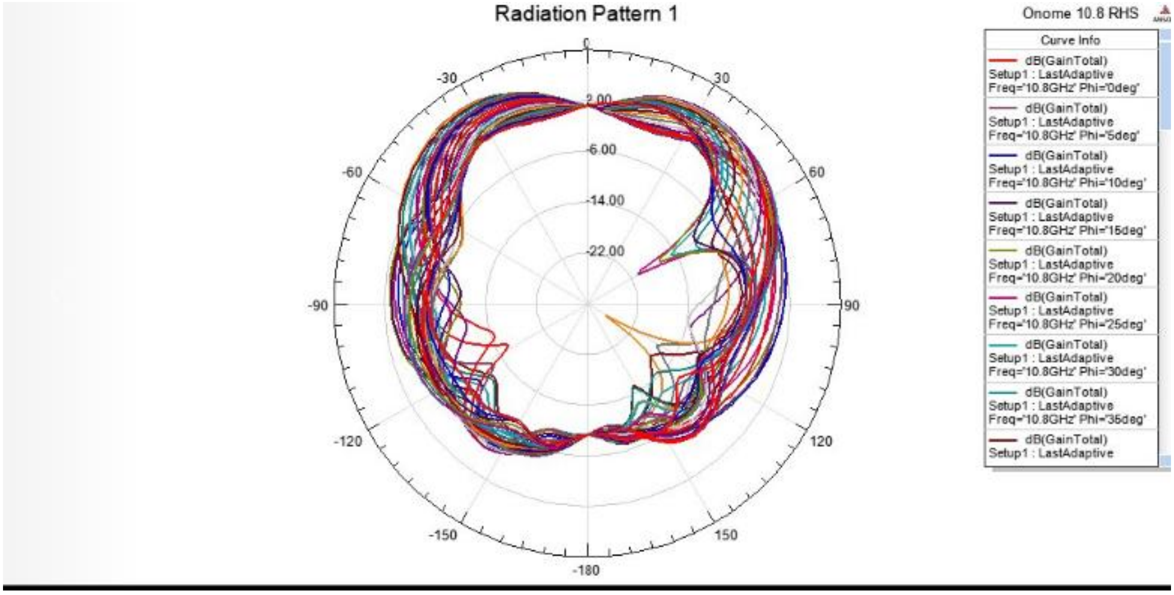

Plate:4 Radiation pattern

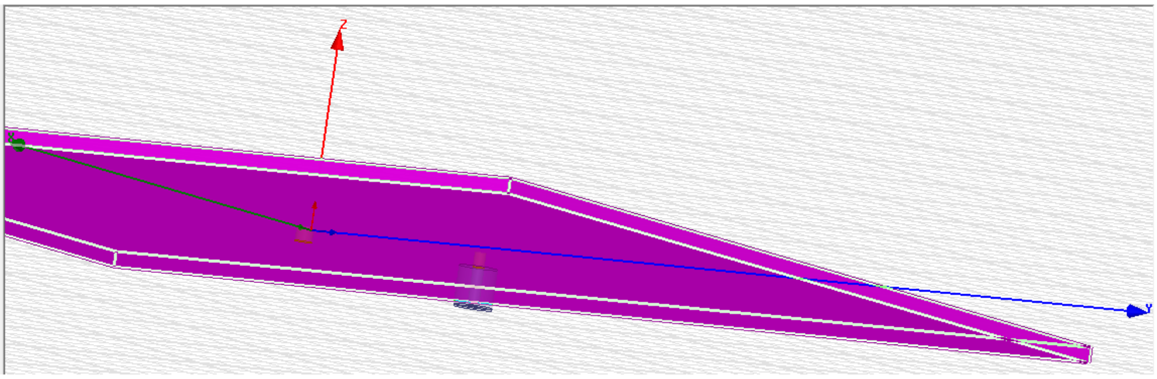

Plate:5The Designed Antenna resonating at 10.8GHz

IV. Discussion

Deductions and Comparison of Results

The antenna operating at 10.8GHz has been designed and simulated successfully. From Plates1 the frequency operates from a range of 8.5GHz to 10.8GHz having a return loss of -15dB with a good diversity gain. The microstrip patch antenna is known for its usual characteristics of narrow bandwidth low cost, easy fabrication and high efficiency. The high frequency band antenna has a performance parameters which can be used for UWB in digital wireless network. The quest for faster connectivity and high data necessitated for this design. From plates 2 it is obvious the 3D polar plot has a good a radiation pattern with one slot feed from the patch and matched with 50Ω.It is quite clear that the radiation pattern having a directivity of 5.7738dBi and is omnidirectional, antenna indicates a good polarization and pattern diversity for UWB which could be applied in MIMO antenna.

Planar Inverted –F Antenna rectangular for UWB in 3D shape in Plates 3, reading a gain of 4.0 dB which shows the energy accepted by the antenna been directed to particular direction was obtained. The value correlates for a good characteristics performance and mutual coupling between the elements was low, the radiation efficiency was 80% which is good and acceptable. A circular polarization was obtain at 0dB for which makes the antenna highly polarized. It isVoltageStand Wave Ratioresonate at less than 3dB having a VSWR of 2.78. However the frequency is seen resonating at the desired frequency of 10.8GHz with a narrow bandwidth of 10.49-11.48GHz.

Anoop and Aslam (2015) with FR-4 of low substrate obtained a narrow band of 84MHz and a peak directivity of 3.90dB, compared to this research the parametric performance is not as expected compared to this research.

Also comparing the result obtain to Joseph and Ali (2016) who arrived at 3.1GHz to 10.6GHz adopting a circular monopole FR-4 with relative permittivity of 4.6 and average efficiency of 65%, an envelope correlation of -60dB which was too low, which was not too encouraging compared to this research work that had envelope correlation of -22dB peak gain of 4.6448dB and peak directivity of 5.7738dBi.

Plate 5 it is seen clearly the structure of the designed antenna on the X,Y, and Z ground plane was successfully designed. From the parameter studied it is observer that the gain remain unchanged and the rotating arms considerably, the antenna experiences an impartial current distribution from the patch to the rotating arms. The antenna could be rotated, it is omnidirectional and a good matching was obtained.

V. Conclusion

The aim of this research work is to design a rectangular microstrip patch antenna used in wireless network suitable for mobile handset, laptops and tabs. It is simulated using the HFSS software to obtain the radiated power, peak gain incident power accepted power and the radiation efficiency. The result got was satisfactory. The ground plane was 62.5mm by 57mm with a patch length of 23.5mm and 15mm the antenna was rightly placed, a gain of 4.6448dB, directivity of 5.7738dB and efficiency of 80.4% was obtained. The bandwidth obtained was 300MHz and percentage bandwidth of 2.7%.

The emphasis was on developing MIMO antennas with low correlation between element and with low profile easy fabrication light weight. The design antenna can be miniaturized into smaller shapes for biomedical system, range of microwave system of radar of telemetry system navigation, satellite communication.

5.3 Recommendations

The research work has successfully been carried and antenna resonated at the expected value and there was some observation encountered during the research work.

i Further work can be done to improve the efficiency of the antenna by altering some parameters and by the use of other substrate materials.

iiIt was observed that the simulated and calculated parameters were not closely related; which is also an area that can be improved upon.

iiiMore research work can also be done using different field solvers and simulators like ZELAND IE3D, Microwave Studio CST, FEKO and Antenna Magus, since Ansoft HFSS was used in this research work.

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