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DESIGN AND PARAMETRIC ANALYSIS OF UWBBEVELED TRIPLE BAND REJECTION ANTENNA

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ABSTRACT:

In this paper, a triple band rejection UWB monopole radiator is presented. The UWB antenna incorporate a beveled radiator and partial ground structure for achieving UWB bandwidth from to 3.28 to 13.28 GHz for rejecting 3.78-4.36, 5.18-5.82 and 7.27-7.87 GHz for C, WLAN, and down link of X-band applications, The antenna is designed on FR-4 substrate with 20 x 22 mm², Here the UWB Tri band notch antenna designed by using upper inverted u slot (for rejection of C band), lowerinverted u slot (For rejection of WLAN) and via (for rejection of downlink of x band),via is nothing but a band notch element and it is an advanced technique.

1. INTRODUCTION:

Antennas are the basic components of any wireless communication system and are connecting the transmitter and receiver through space as the communicating medium. They play a vital role in wireless communications. An antenna is an electrical device which converts electrical waves into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver. In transmission a radio transmitter applies an oscillating radio frequency electrical current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic wave in order to produce a tiny voltage as their terminal that is applied in a receiverto be amplified. An antenna can be used for both transmitting and receiving.

The antenna, like eye, is transformation device that converts electromagnetic photons into circuit current; but, unlike, the antenna can convert energy from circuit into photons radiated into the space‖.

An antenna is an electrical device which converts electrical currents into radio waves, and vice versa. Antenna are essential components of all equipment that uses radio. They are used in system such as radio broadcasting, broadcast television, two-way radio communication receivers, radar, cell phone, and satellite communication, as well as other devices such as garage door openers, wireless microphones and Bluetooth enabled devices.

Antennas were used for the first time in 1889, by Henrich hertz (1857-1894) to prove existence of electromagnetic waves predicted by the theory of James clerk maxwells.

The important properties of an antenna are the radiation pattern, radiation intensity polarization, gain, directivity, power gain, efficiency, effective aperture or area, self and mutual inductance, return loss, etc.

2. MICROSTRIP PATCH ANTENNA:

Microstrip antennas received considerable attention in the 1970's, although the first design and theoretical models appeared in the 1950's, they are suitable in many applications like handheld devices, aircrafts, satellite communications, missile, etc. The Microstrip antennas are low profile, mechanically robust, conformable to planar and nonplanar surfaces, inexpensive to manufacture, and can be manufactured with printed circuit technology.

Some of the limitations and operational disadvantages are low efficiency (due to dielectric and conductor losses), low power, spurious feed radiation narrow frequency bandwidth, poor polarization purity, and poor scan performance.

Microstrip antennas are applicable in the GHz range (f>0.5GHz), for lower frequencies their dimensions become too large.

Linear polarization and circular polarization can be obtained with microstrip antennas. Circularly polarization microstrip antenna have been used in many applications such as mobile, satellite communications, radars and global positioning systems (GPS), RFID applications, wireless LAN. Circular polarization provides greater mobility and freedom in the orientation angle between a transmitter and receiver in comparison with a linearly polarized microstrip antenna.

ISSN NO: 9726-001X
Volume 10 Issue 01 Jan 2022

2.1 CONSTRUCTION AND GEOMETRY:

Generally, the MSA are thin metallic patches of various shapes etched on dielectric substrate of thickness h, which usually is from $0.003\lambda o$ to $0.05\lambda o$ The substrate is usually grounded at the opposite side. the dimensions of the patch are usually in the range from $\lambda_0/3$ to $\lambda_0/2$.The dielectric constant of the substrate $\epsilon r$is usually from 2.2 to 12.

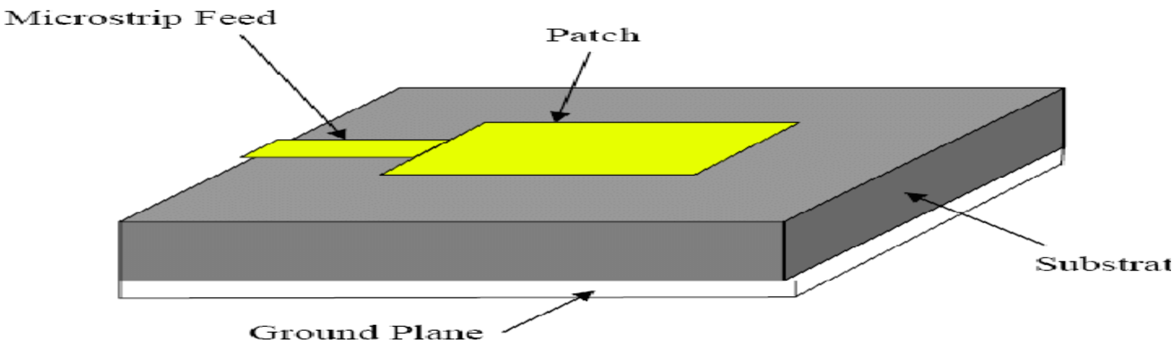

Figure 2.1: Geometry of the microstrip patch antenna

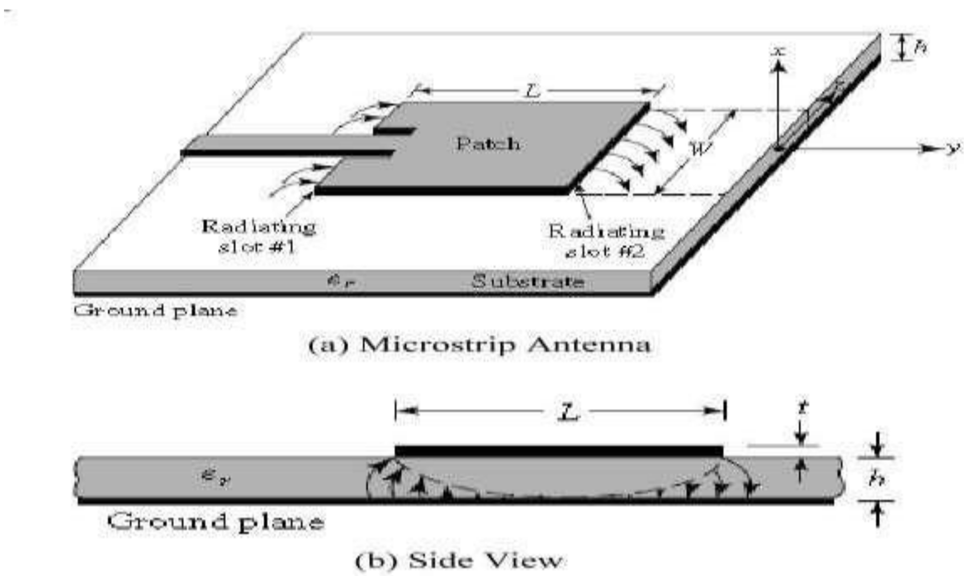

Figure 2.2: Top and side view of microstrip patch antenna

The most common designs use relatively thick substrate with lower ϵr because they provide better efficiency and larger band width,loosely bound fields for radiation into space. on the other hand , this implies larger dimensins of the antennas.The choice of the substrate is limited by RF or microwave circuit coupled to theantenna, which has to be built on the same board.

The microwave circuit together with the antenna is usually manufactured by photo-etching technology.

The substrate with higher dielectric constants are desirable for miceowave circuitry because they require tightly bound fields to minimize undesired radiation coupling , and lead to smaller element size , but with greater losses and less efficient and have relatively smaller band widths.

3. UWB TECHNOLOGY:

The development of UWB technology started by the US military in the year of 1962. Traditionally networks had been characterised according to the parameters such as amplitude and phase with respect to frequency. Then the concept of Ultrawideband had risen. But the equipment's were not available at that time to makeall the possible equipment were not available at that time to make an antenna of such large bandwidth. Then and then the research has started to make all the possible equipment to produce such antenna.

After the microwave networks to impulses, the next major step forward occurred when the techniques were applied to radiating systems. Since in the year of 1968 it become obvious that for the communication purpose applying of UWBtechnology will be advantageous.

The rate of producing equipment was increased after that year and during this period it was termed carrier free or impulse technology. Through the technology had been produced in a larger rate but was only limited to military use.

In the years following 2000, commercial wireless communications became established. Technologies such as 802.11 (Wi-Fi), Bluetooth and others were established. Development of such technologies made are volitionary change in the world of digital technologies. The rate of uses of digital technologies increased in a larger way. One of the major limitations to the speed at which UWB Could enter the commercial market place was legislation.

A certain frequency has been assigned by (FCC) for the UWB antenna is from 3.1 to 10.6GHz for commercial communication applications in February 2002. A feasible UWB antenna should passes a good performance in both the time and frequency domain and small, compact appearance is also necessary. So undoubtedly designing of UWB antenna is a kind of challenge.

Ultra- Wide band is a technology for transmitting information spread over a large bandwidth(>500MHz); such that it can be able to share spectrum with other users.

Regulatory settings by the Federal Communications Commission (FCC) in the United States intend to provide an efficient use of radio bandwidth while enabling high data rate personal network (PAN) wireless connectivity; longer range, low-data rata applications; and radar and imaging systems etc.

3.1 IMPORTANCE OF UWB ANTENNA:

Importance of UWB antenna as follows:

1) Large Bandwidth –The bandwidth allotted more than 500MHz to 7.5GHz which is from 20% to 110% fractional of canter frequency

2) Very Short Duration Pulses—UWB pulses are of typically mono second or nanosecond order

3) High Data Rates with Fast Speed—One of those advantages of UWB transmission for communications is the ability of UWB systems to achieve high data rates in future wireless communication system. Another advantage of UWB systems is the ability to effectively reduce fading and interference problems in different wireless propagation channel environments because of the limited power transmitted power of UWB systems.

4) Low power Consumption—When signals are sent over Ultrawideband antennas, a low level of signal over a wide frequency band, less power is needed because it suffers from less interference. That means UWB antennas need less energy to provide internet access, digital voice services and video telephony. UWB antennas also don't interfere with carrier wave transmissions and narrowband signals. The lower power output reduces the risk of weaves dropping, and when communications are key, the fact that UWB is very hard to Jam is attractive.

Due to spreading the energy of the UWB signals over a large frequency band, the maximum power available to the antenna – as part of UWB system— will be as small as in order of 0.5mW according to the FCC Spectral mask.

5) Small size and low cost – The main arguments for the small size of UWB

transmitters and receivers are due to the reduction of passive components. Antenna size and shape is always an important factor. Low system complexity and low cost are the important parameters of designing antenna. Another valuable aspect of UWB technology is the ability for a UWB radio system to determine the ―time of flight‖ of the transmission at various frequencies. This helps overcome multipath propagation. Ultrawide band has reduced fading from multipath but can suffer from inter symbol interference.

3.2 APPLICATIONS OF UWB ANTENNAS:

Ultra –wideband characteristics are well—suited to short – distance applications, such as PC peripherals. Due to low emission levels permitted by regulatory agencies, UWB systems tend to be short—range indoor applications. Due to the short duration of UWB pulses, it is easier to engineer high data rates; data rate may be exchanged for range by aggregating pulse energy per data bit (with integration or coding techniques). Conventional orthogonal frequency – divisionmultiplexing (OFDM) technology may also be used, subject to minimum bandwidth requirements.

High data rate UWB may enable wireless monitors, the efficient transfer of data from digital camcorders, wireless printing of digital pictures from a camera without the need for a personal computer and file transfers between cell--phone handsets and handheld devices such as portable media players. UWB is used for real—time location systems; its precision capabilities and low power make it well – suited for radio frequency sensitive environments, such as hospitals. Another feature of UWB is its short broadcast time.

Ultra-Wideband is also used in ―see- through – the – wall‖ precision radar-imaging technology, precision locating and tracking (using distance measurements between radius), and precision time-of-arrival-based localization approaches. It is efficient with its spatial capacity of approximately 1013 bits/s/m². UWB radar has been proposed as active sensor component in automatic target recognition application, designed to detect humans or objects that have fallen onto subway tracks. UWB has been proposed technology for use in personal area networks and appeared in the IEEE 802.15.3a draft PAN standard. However, after several years deadlock, the IEEE 802.15.3a task group was dissolved in 2006.

3.3 UWB AND NARROW BAND SYSTEMS:

1. WiMAX
2. Upper C- Band
3. ARN Band
4. Lower and Upper WLAN Bands
5. IEEE INSAT C-Band
6. Down Link Of X-Band
7. ITU 8-Band

4. SIMULATION METHODOLOGY

A well-designed antenna can improve communication links and device performance, but designing an antenna is not a trivial task CST Microwave Studio offers a complete design solution for antenna engineers, to be as a efficient aspossible at every stage of the antenna design process, sum initial concepts exploration to final antenna integration. But the Integration of the antenna and the CubeSat together is not an easy task to be modelled only with CST, so we provide CST with a 3D model file from external software but using the import command. The advanced modelling interface allows we to not only create fully parametric antenna models, but also to integrate them with geometries from a wide range of imported CAD formats. This enables us to create any shape of the antenna by using modelling software and integrate them with CST simulation, note: just by assigning the materials the software can apply the electrical and mechanical properties of that part to the model.

4.1 INTRODUCTION TO CST MICROWAVE STUDIO:

CST Microwave Studio is a tool used for simulating 3D structures at high frequency devices such as antennas, filters, couplers, planar and multilayer structures and we can choose the most appropriate method for designing and optimization of devices operating in a wide range of frequencies. Antennas are used in a vast variety of applications, and thus they come in a vast variety of form factors and radiation mechanisms. They are wide range of simulation methods available in CST MWS which can be determined depending upon the application.

Microwave, RF& Optical is the templates used for antenna simulation,

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wherein there is specific template for patch antennas. It is important to define the preliminary settings before defining the model; in general, the units are length in mm frequency in GHz and time in nano- seconds. Other units such as Resistance (Ohm), Voltage(V), Conductance(S) etc., are predefined by the software.

The frequency of study and the motors can be provided before starting the simulation they can also be redefined subsequently. The frequency is S-Band(0-5GHz), background material properties is typically be vacuum for antenna analysis also important when simulating the antenna in space environment.

In order to simulate in realistic environment, the boundary conditions have to be defined carefully. They are two types of port to provide feed to the patch antenna,

a) Discrete Port

b) Waveguide Port

Discrete port is similar to plane waves, as they do not require a real physical boundary for structure to support the feed if the required parameters such as polarization, frequency and direction are given to the software, it will create port at desired point in space.

On the other hand, a waveguide port is a real port constructed with boundaries. The electromagnetic distribution and the EM waves transmitted from the port are determined by the boundaries and the dimensions of waveguide port. From the view of experimental measurements, the boundaries of the waveguide port correspond to the cross of real physical structure of excitation source. Figure 4.1 provides an illustration of the cross section of the structure.

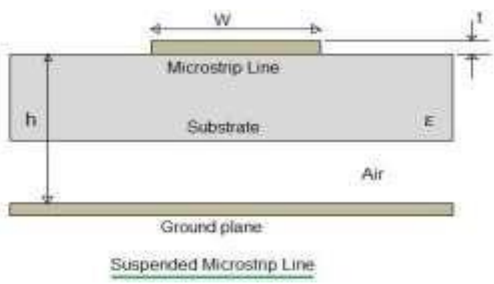

Figure 4.1- port dimension calculation – cross section view

Once we have set the boundaries and choose the waveguide port item, the electromagnetic field distribution on the port will be automatically calculated by the software and calculated EM Field will work as the source of the simulation.

5. DESIGN METHODOLOGY

There are a variety of different microstrip patch antenna designs, most common once are rectangular, triangular and square patch antennas and other available designs such as dipole, circular, elliptical, disk sector, circular ring and ring sector; these designs are valid for different bands like X-band, S-band and K-bands.

They have an edge over the other types of antennas due to their low profile, low cost and low weight. Also, there are easy to manufacture and compatible to devices and space systems where size and weight is very important. these specific attractive features, compel researches and space scientist to pay a significant attention to microstrip antennas.

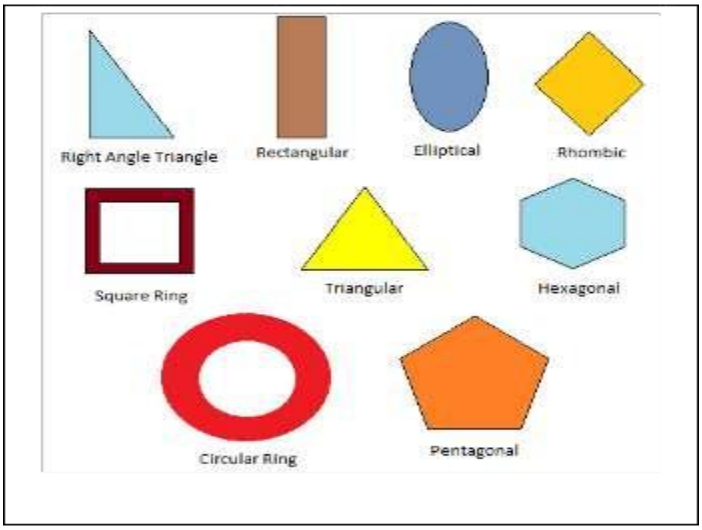

Figure 5.1: various shapes of patch design

Although the main limitations of such patch antennas are their low gain and narrow bandwidth, to overcome these inherent disadvantages many different solutions such as probe fed antennas, stacked patches or patch with thick substrate and slotted patch have been investigated.

This project is focused completely on determining a method to overcome this limitation using a monopole in a scale at which antenna can resonant at a specific frequency of 3.28 to 13.28 GHz with an efficiency gain and radiation efficiency.

However, it must be taken into account that very high directivity could be detrimental for small satellite applications, as this would require a very accurate pointing capability that most of the times escapes the capability of such class of satellites.

Although there are various types of feeding techniques, the four most common feed techniques currently used are the microstrip line, coaxal probe, aperture coupling and proximity coupling. The microstrip line has two different types of feed commonly known as Edge feed and insert feed. In this project we are using the microstrip edge line feed mainly because it is easy to construct and provides with a good input impedance.

In a microstrip edge feed technique, conducting strip is connected directly to the edge of the microstrip patch. The microstrip is smaller in width as compared tothe patch antenna width. When compared with a coaxial feed this kind of feed arrangements has the advantage that it can be fabricated on the same substrate to provide a planar structure. This is quite useful in the case of PCB boards.

5.1 ANTENNA GEOMETRY:

The proposed UWB tri band notch antenna is fabricated on a low-cost FR-4 substrate (with $\varepsilon r = 4.3$ $\tan\delta = 0.02$) fed by a microstrip line is shown in figure 5.2 which is printed on the FR-4 substrate with a size of substrate width 20mm and substrate length 22mm (i.e, Ws*Ls=20 x 22 mm^2), the thickness of 1.5 mm and relative di electric constant of 4.3 and length of the feed line 14.1 mm, and width of the feed line 3mm.

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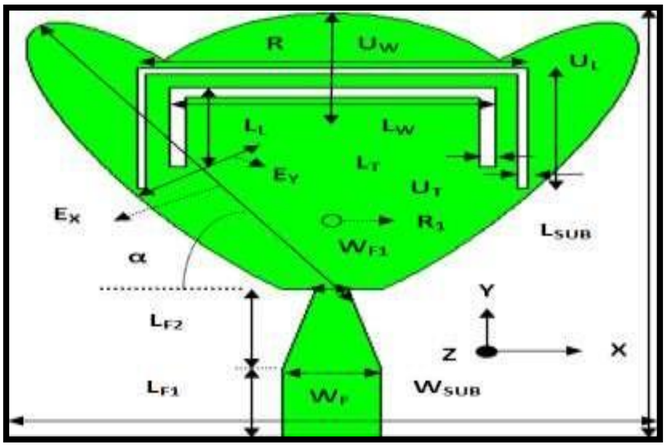

Figure 5.2: Top view

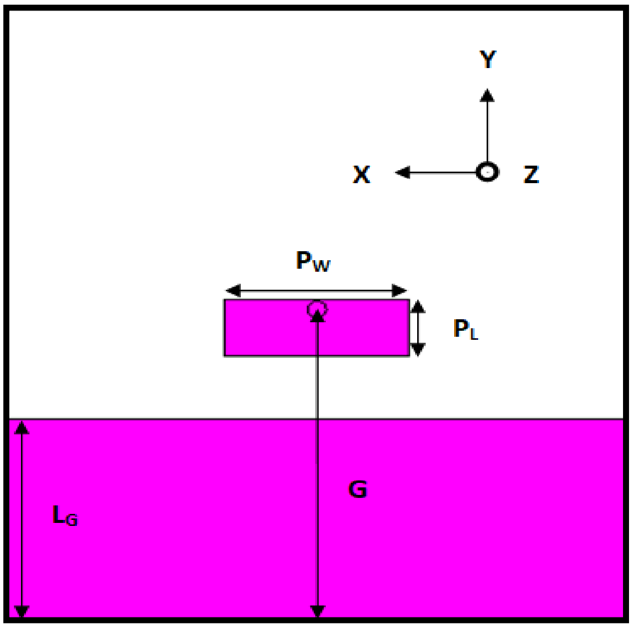

Figure 5.3: Bottom view

5.2 DESIGN MODEL OF THE PROPOSED ANTENNA

This the schematic view of proposed UWB tri band notch antenna was designed based upon the optimized parameters, this antenna was incorporated in beveled radiator and partial ground structure for achieving UWB band width 3.28 to 13.28 GHz, in this design we have upper inverted U slot, lower inverted U slot and via techniques for notch the C, WLAN, and down link of x band

All the optimized design parameters and corresponding values for the proposed

Table 5.1: design parameters of proposed antenna

parameter	Value(mm)	parameter	Value(mm)	parameter	Value(mm)
Wsub	20	LG	14.8	UL	16.7
Lsub	22	G	11.5	LL	13.5
Wf	3	R1	0.3	UT	0.02
Lf	14.4	R	6.5	LT	0.2
Pw	6	Uw	12	Ex	2.6
Pl	2	Lw	10	Ey	8.75

6. RESULTS AND DISCUSSIONS

The simulated return loss (dB) of the proposed antenna is about -14.8 dB for C-band in the range of 2 to 4 GHz, -17dB for WLAN in the range of 4 to 6 GHz and -24.8 dB for downlink of X-band in the range of 6 to 8 GHz and the simulated S-parameter graph shown in the below figure 6.1

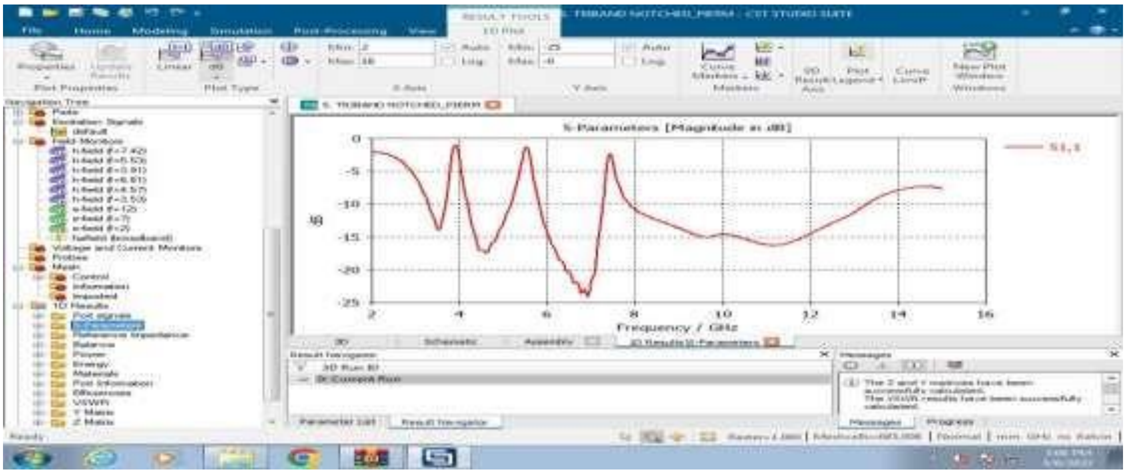

Figure 6.1: S11 – parameter plot of the proposed antenna

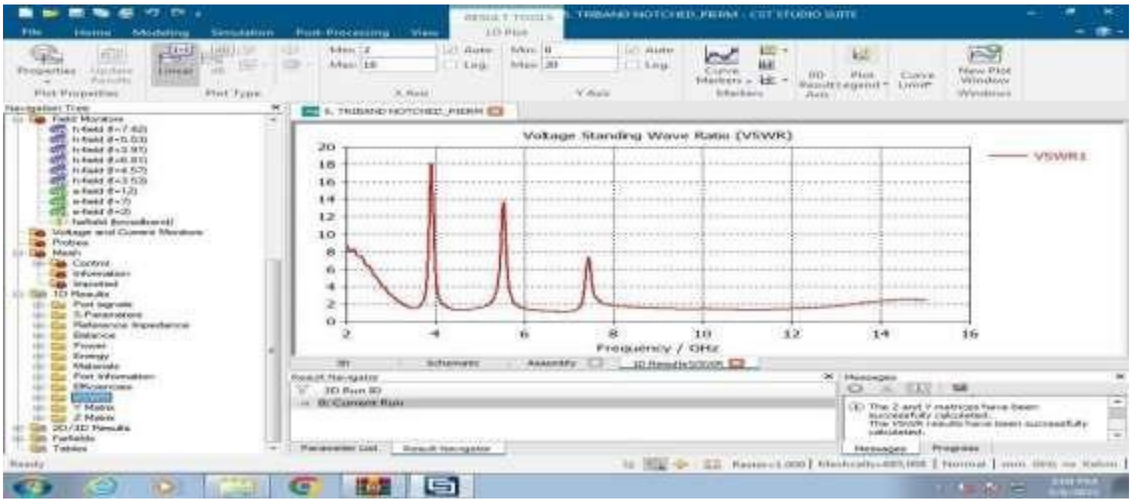

Figure 6.2: VSWR Simulated result:

Ideal value of VSWR is 1 and practical value of VSWR IS 1-2. If the value of VSWR>2 it can reduces the operating range of radio signals, because the transmitted signal to saturate the receiver section. the prosed antenna VSWR values are 17.27 for C- band in the range of 2 to 4 GHz,13.8 for WLAN in the range 4 to 6 GHz and 7.5 for downlink of X- band in the range 6 to 8 GHz. By seeing this VSWR values wecan say that our proposed antenna perfectly notches the 3 bands.

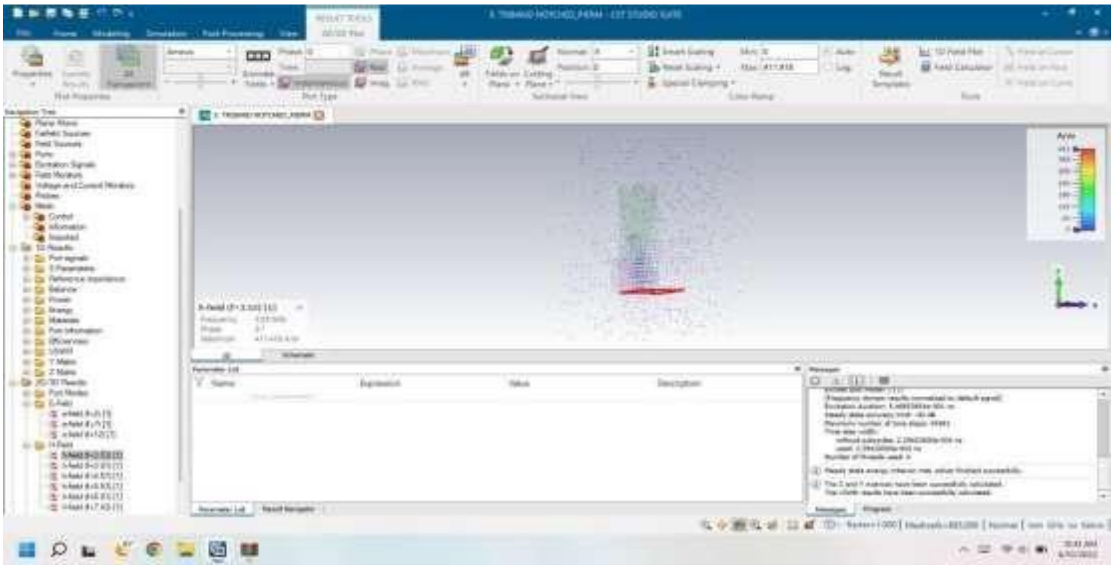

Figure 6.3: Magnetic field of proposed antenna

Figure 6.4: Electric field of the proposed antenna

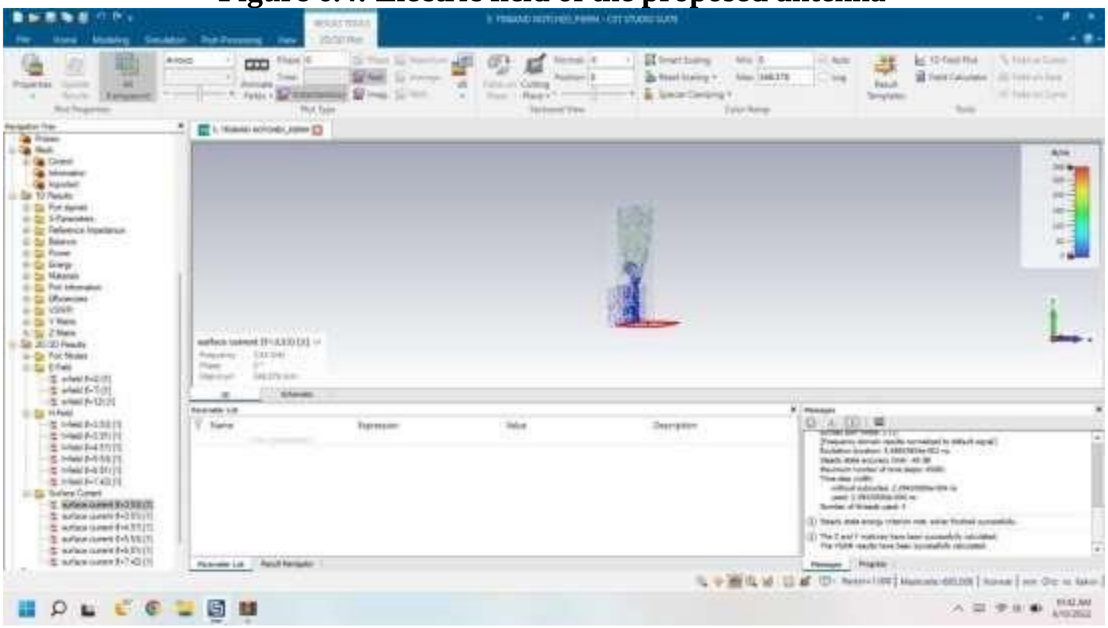

Figure 6.5: surface current of the proposed antenna

Table 6.1: Comparison Between Existing and Proposed Antenna

Antenna	size(mm²)	Area(mm²)	Notch Bands (GHz)	Operating Frequency (GHz)	VSWR at notch frequency

Existing antenna	27.5 × 16.5	473.75	2.2–3.9,5.1-6	1.75-10.3	10, 7.2
Proposed antenna	20 x 22	400	3.68- 4.19, 5.18- 5.8, 7.27- 7.87	3.28- 13.28	17.27, 13.72, 7.50

This is the comparison table between existing and proposed antenna, by seeing this comparison table we can say that proposed antenna size and area is small when compared to existing antenna and by seeing the VSWR values proposed antenna can perfectly notch the three bands

ADVANTAGES OF DESIGNED ANTENNA:

The main advantage is three band rejections in single antenna

1. Low cost
2. Small size
3. stability
4. superior performance

APPLICATIONS OF PROPOSED ANTENNA:

1. Tracking and position location
2. Bio- medical imaging systems.
3. Wireless body area network (WBAN).

7. CONCLUSION

A UWB monopole radiator with triband rejection antenna is designed. The impedance bandwidth of antenna is from 3.28 to 13.28 GHz. Triple band notch characteristics are generated for C Band (3.78–4.36 GHz), WLAN-band (5.18–5.8255GHz), and X-band (7.27–7.87 GHz). It is observed that the triple band notch functionalities are controlled independently by variation in dimensions of parameters of band notched elements. The simulated parameters shows that the antenna is suitable for portable UWB applications.

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