

ANALYSIS OF SPECIFIC ABSORPTION RATE(SAR)USING MICROSTRIP PATCH ANTENNA FOR MOBILE PHONE, TABLET, SMART WATCH AND WIFI ROUTER.

A Project Report phase - II

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Electronics and Communication Engineering

by

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**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of V.LOGESH (39130260),JHAASWANTH P(39130188) who carried out the project entitled "ANALYSIS OF SPECIFIC ABSORPTION RATE (SAR) USING MICROSTRIP PATCH ANTENNA FOR MOBILE PHONE, TABLET, SMART WATCH AND WIFI ROUTER" under our supervision from November 2022 to April 2023.

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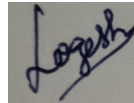
We Logesh V and Jhaashwanth P hereby declare that the Analysis of specific absorption rate (SAR) using microstrip patch antenna for Mobile Phone, Tablet, Smart Watch, Wifi Router . Done by us under the guidance of Dr .I .Rexiline Sheeba.M.E..Ph.D., is submitted in partial fulfilment of the award Bachelor of Engineering degree in Electronics and Communication Engineering.

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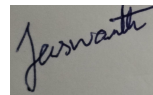
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ABSTRACT

Micro strip antennas are low-profile antennas. A metal patch mounted at a ground level with a di-electric material in-between constitutes a Micro strip or patch antenna. These are very low size antennas having low radiation. It consists of a very thin metallic strip placed on a ground plane with a di-electric material in-between. The radiating element and feed lines are placed by the process of photo-etching on the di-electric material. Usually, the patch or micro-strip is chosen to be square, circular or rectangular with slots to operate at 5.8 GHz ISM band using Rogers Duroid RT5880 respectively. Then the same design was applied over the other fabric substrates like Velcro, Fleece and Polystyrene Foam and by using the scaling technique all the substrates have been made to operate within the 5.725 GHz - 5.875 GHz ISM band. The interaction between the human body and antennas needs to be taken into account, since wearable devices have to be functional, and at the same time, guarantee biological compatibility. The present research analyzed the performance of several antenna with different substrates having slotted ground planes and patch in free space and also in the presence of the human body. Specific absorption rate (SAR) is measure of the rate of RF(radio frequency) energy absorption by the body from the source being measured. The main objective was to compare the antenna parameters (free space and human interaction), and the impact on the measured SAR of such antennas as functions of the slot configuration in the ground plane and patch and the antenna's location. Changing the antenna's location was a good way to achieve a significant SAR reduction. Although all antennas suffered from change in their performance when brought near the head model, SAR is effectively reduced. SAR can be calculated by integrating or averaging over 1 gram or 10 gram.

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CHAPTER 1

INTRODUCTION

1.1 MICROSTRIP PATCH ANTENNA

The microstrip patch antenna is a popular printed resonant antenna for narrow-band microwave wireless links. Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side. The patch is generally made of a conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate.

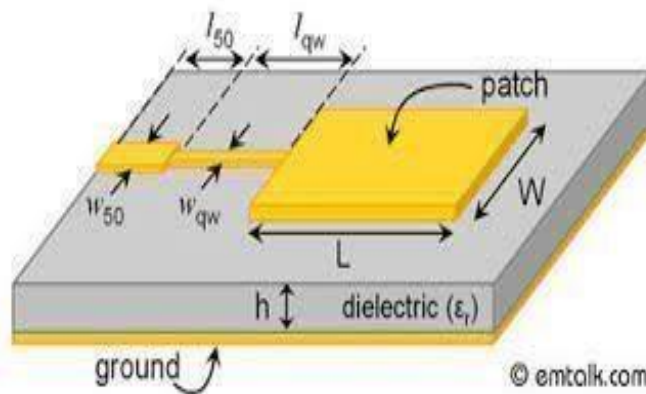


Fig 1.1 Microstrip Patch Antenna

The microstrip antenna was first proposed by G.A. Deschamps in 1953, but didn't become practical until the 1970s when it was developed further by researchers such as Robert E. Munson and others using low-loss soft substrate materials that were just becoming available. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation.

1.1.1 ADVANTAGES AND DISADVANTAGES OF MICROSTRIP ANTENNA

Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore they are extremely compatible for embedded antennas in handheld wireless devices such as cellular phones, pagers etc.. The telemetry and communication antennas on missiles need to be thin and conformal and are

often Microstrip patch antennas. Another area where they have been used successfully is in Satellite communication. Some of their principal advantages are : It is lightweight, low volume and thin profile configuration. These make them to be easily incorporated into any package. It has a low profile planar configuration that can be easily made conformal to host surface which fits the shape design and needs of modern communication equipment. It can be made compact for use in personal mobile communication. The microstrip antenna shape flexibility enables mounting them on a rigid surface which makes them mechanically robust. Using printed-circuit technology leads to a low fabrication cost hence can be manufactured in large quantities. It supports both linear polarization and circular polarization. They accept for dual and triple frequency operations and can be easily integrated with microwave integrated circuits (MICs) on the same substrate. Microstrip patch antennas also have a number of disadvantages as compared to conventional antennas. Some of their major disadvantages discussed are : It operates over narrow bandwidth. Low efficiency and low gain while compared with conventional antennas. radiation efficiency as it radiates only in half-space. It also has low power handling capacity and high loss resulting from surface wave excitation.

1.2 FEEDING TECHNIQUES

Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories- contacting and noncontacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch. The four most popular feed techniques used are Coaxial probe feed, Microstrip transmission line feed comprising both edge feed and inset feed, Aperture coupled feed and Proximity coupled feed.

1.2.1 COAXIAL FEED

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. As the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.

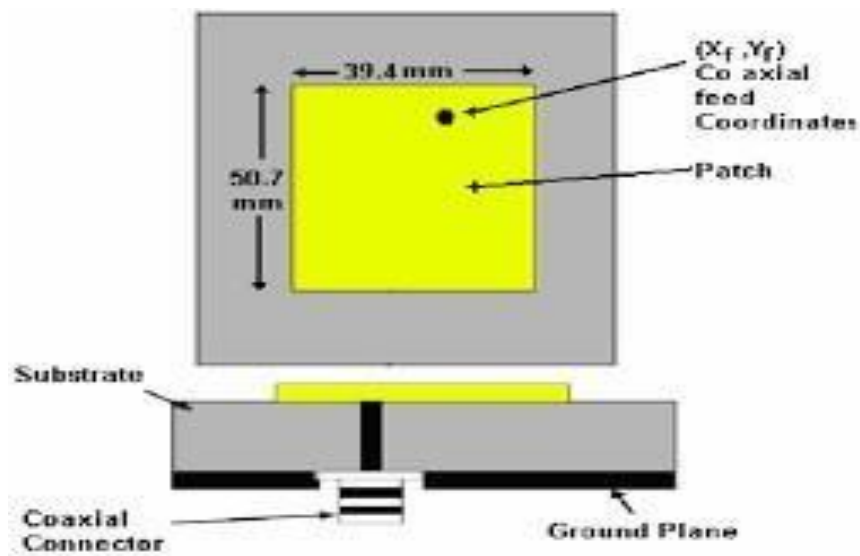


Fig 1.2 Coaxial Feed

The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance.

1.2.2 MICROSTRIP LINE FEED

In this type of feed technique, a conducting strip is connected directly to the edge of the microstrip patch. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure.

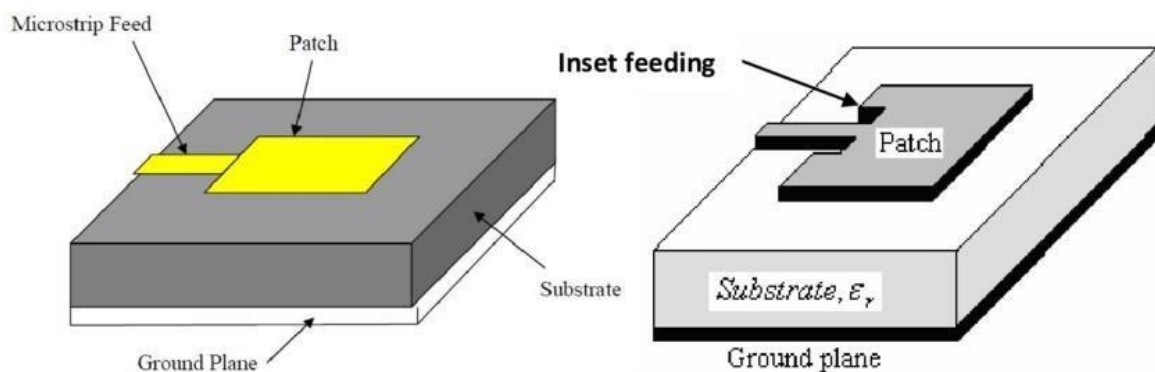


Fig 1.3 Microstrip Line Feed

The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element. This is achieved by properly controlling the inset position. Hence this is an easy feeding scheme, since it provides ease of fabrication and simplicity in modeling as well as impedance matching. However as the thickness of the dielectric substrate being used, increases, surface waves and spurious feed radiation also increases, which hampers the bandwidth of the antenna. The feed radiation also leads to undesired cross polarized radiation. Since the current is low at the ends of a half-wave patch and increases in magnitude toward the center, the input impedance ($Z=V/I$) could be reduced if the patch was fed closer to the center. Method of doing this is by using an inset feed.

1.2.3 APERTURE COUPLED FEED

In this type of feed technique, the radiating patch and the microstrip feed line are separated by the ground plane. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane.

1.2.4 PROXIMITY COUPLED FEED

This type of feed technique is also called as the electromagnetic coupling scheme. two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the upper substrate. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth (as high as 13%) , due to overall increase in the thickness of the microstrip patch antenna. This scheme also provides choices between two different dielectric media, one for the patch and one for the feed line to optimize the individual performances.

1.3 GROUND PLANE

A ground plane is a flat or nearly flat horizontal conducting surface that serves as part of an antenna, to reflect the radio waves from the other antenna elements. Ground plane shape and size play major roles in determining its radiation characteristics including gain. The ground plane should extend beyond the edges of the patch by at least 2 to 3 times the for proper operation. A ground plane that is too small will result in a reduced front to back ratio. Making the ground plane larger also increases the gain but as the ground plane size increases, diffraction near the edges plays less of a role.

1.5 SUBSTRATES

Generally, Substrate or wafer is a solid (usually planar) substance onto which a layer of another substance is applied, and to which that second substance adheres. Substrate is the binding substance present between the radiating patch element and the ground plane. In patch antenna point of view, Substrate is a dielectric material over which patch is etched. There are numerous substrates present such as fr4, rogers duroid, tanonic, fabric etc. In this Project ,Rogers Duroid RT 5880 ,Velcro, Fleece and Polystyrene Foam are used as substrates.

alternative feed methods: further down.

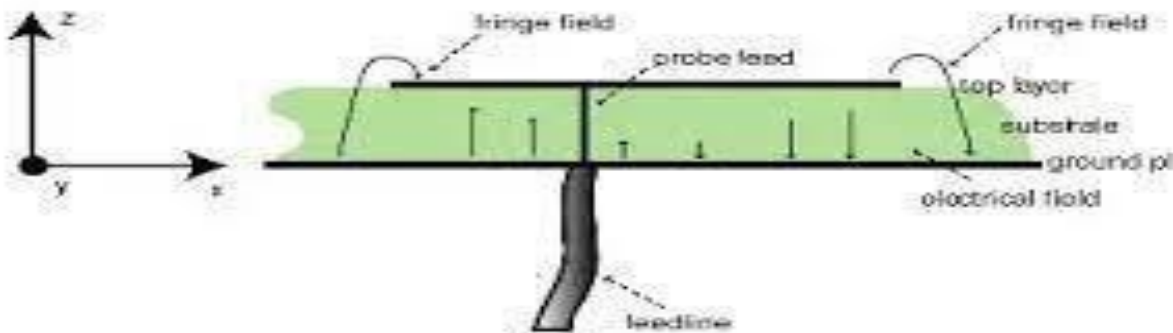


Figure 1: Cross section of a patch antenna in its basic form

Fig 1.4 Substrate

The two main important parameters based on which the substrates is selected are:

- DIELECTRIC CONSTANT
- LOSS TANGENT

1.5.1 DIELECTRIC CONSTANT

The dielectric constant is the ratio of the permittivity of a substance to the permittivity of free space. It is an expression of the extent to which a material concentrates electric flux, and is the electrical equivalent of relative magnetic permeability. Dielectric constant is also commonly known as Relative permittivity. It can be seen from the definitions of permittivity that constants are related according to the following equation: Relative

permittivity can be calculated from the formula $\epsilon_r = \epsilon_s / \epsilon_0 \rightarrow (1.1)$ Where ϵ_r = relative permittivity ϵ_s = permittivity of the substance in Farads per metre ϵ_0 = permittivity of a vacuum in Farads per metre.

1.5.2 LOSS TANGENT

The dielectric loss tangent is defined by the angle between the capacitor's impedance vector and the negative reactive axis, as illustrated in the diagram to the right. It determines the lossiness of the medium. Similar to dielectric constant, low loss tangents result in a "fast" substrate while large loss tangents result in a slow substrate.

1.6 ANTENNA PARAMETERS

The major parameters associated with an antenna are defined in the following sections.

1.6.1 ANTENNA GAIN

Gain is a measure of the ability of the antenna to direct the input power into radiation in a particular direction and is measured at the peak radiation intensity. It is standard practice to use an isotropic radiator as the reference antenna. An isotropic radiator is a hypothetical lossless antenna that radiates its energy equally in all directions. This means that the gain of an isotropic radiator is $G=1$ (or 0 dB). It is customary to use the unit dB.

1.6.2 DIRECTIVITY

Directivity is a parameter of an antenna which measures the degree to which the radiation emitted is concentrated in a single direction.

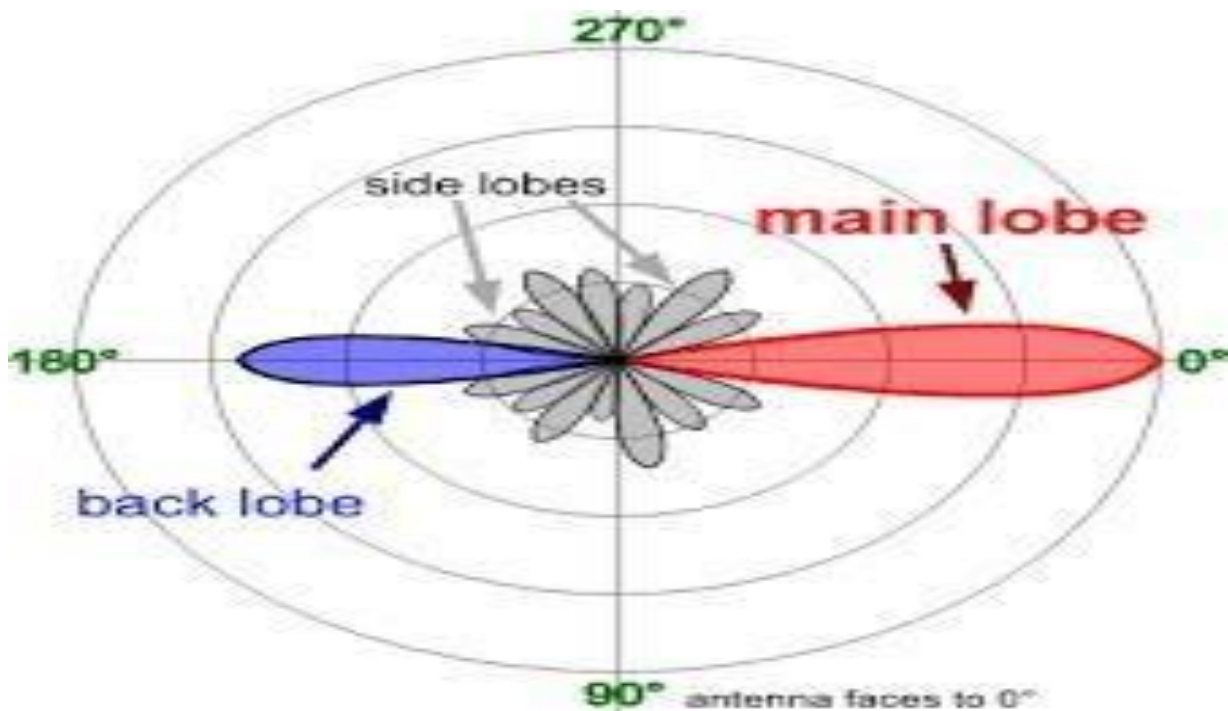


Fig 1.5 Directivity

1.6.3 RESONANT FREQUENCY

Resonant frequency is the frequency where the capacitive and inductive reactances cancel each other out. At this point the antenna appears purely resistive, the resistance being a combination of the loss resistance and the radiation resistance.

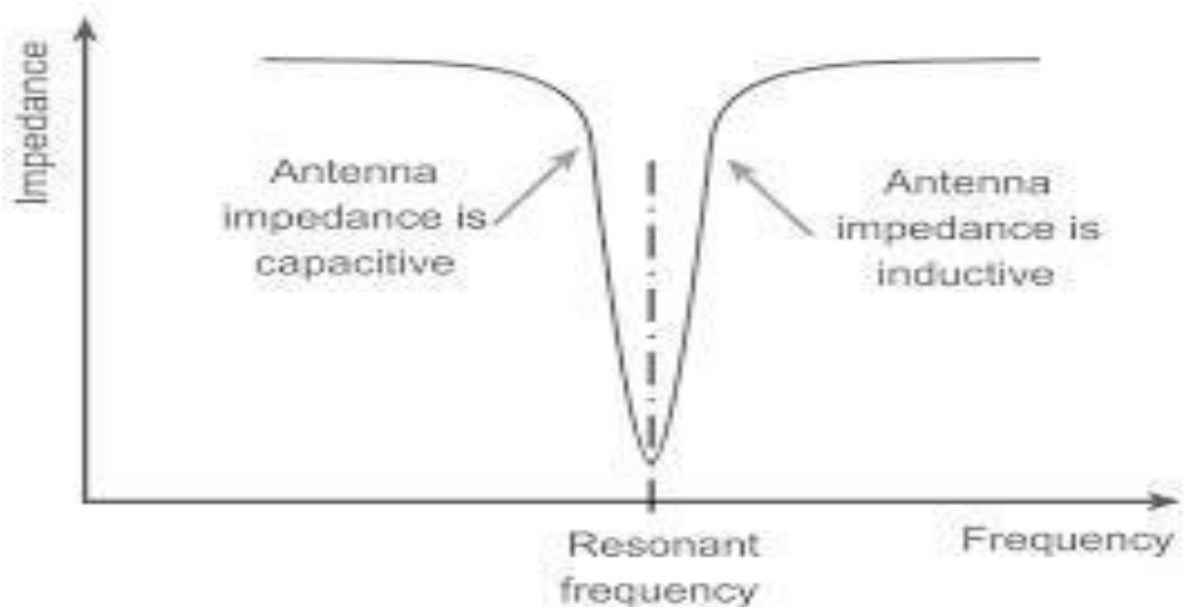


Fig 1.6 Resonant Frequency

1.6.4 RETURN LOSS

Return loss is the loss of power in the signal returned/ reflected by mismatch with the terminating load or with a device inserted in the line. Unit of return loss is decibels (dB). An antenna's Return Loss is a figure that indicates the proportion of radio waves arriving at the antenna input that are rejected as a ratio against those that are accepted. It is specified in decibels (dB) relative to a short circuit.

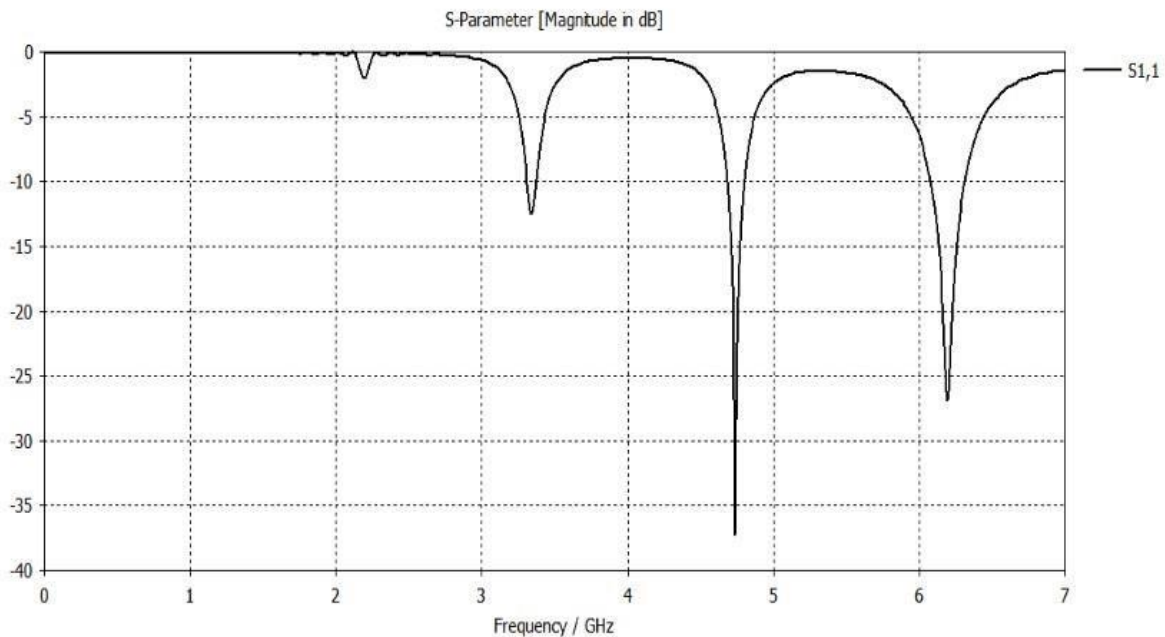


Fig 1.7 Return Loss

1.6.5 RADIATION PATTERN

A radiation pattern defines the variation of the power radiated by an antenna as a function of the direction away from the antenna.

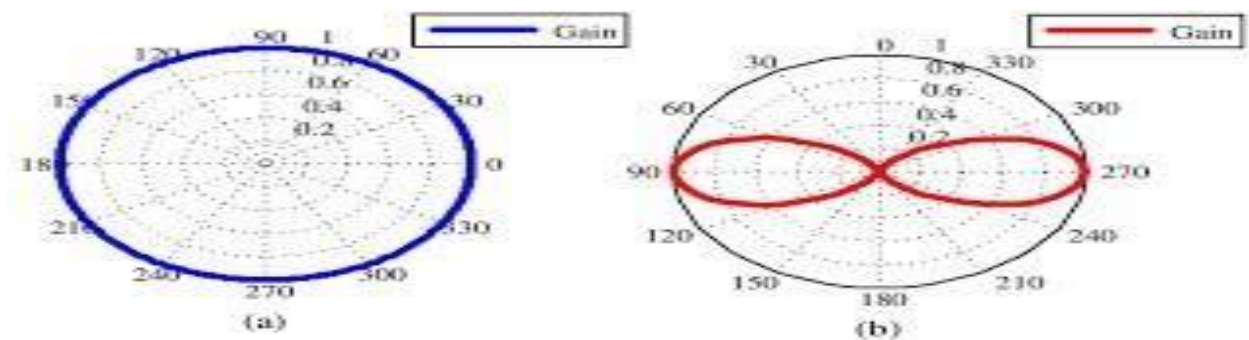


Fig 1.8 Radiation Pattern

1.6.6 VSWR

VSWR is the ratio of the peak amplitude of a standing wave to the minimum amplitude of a standing wave.

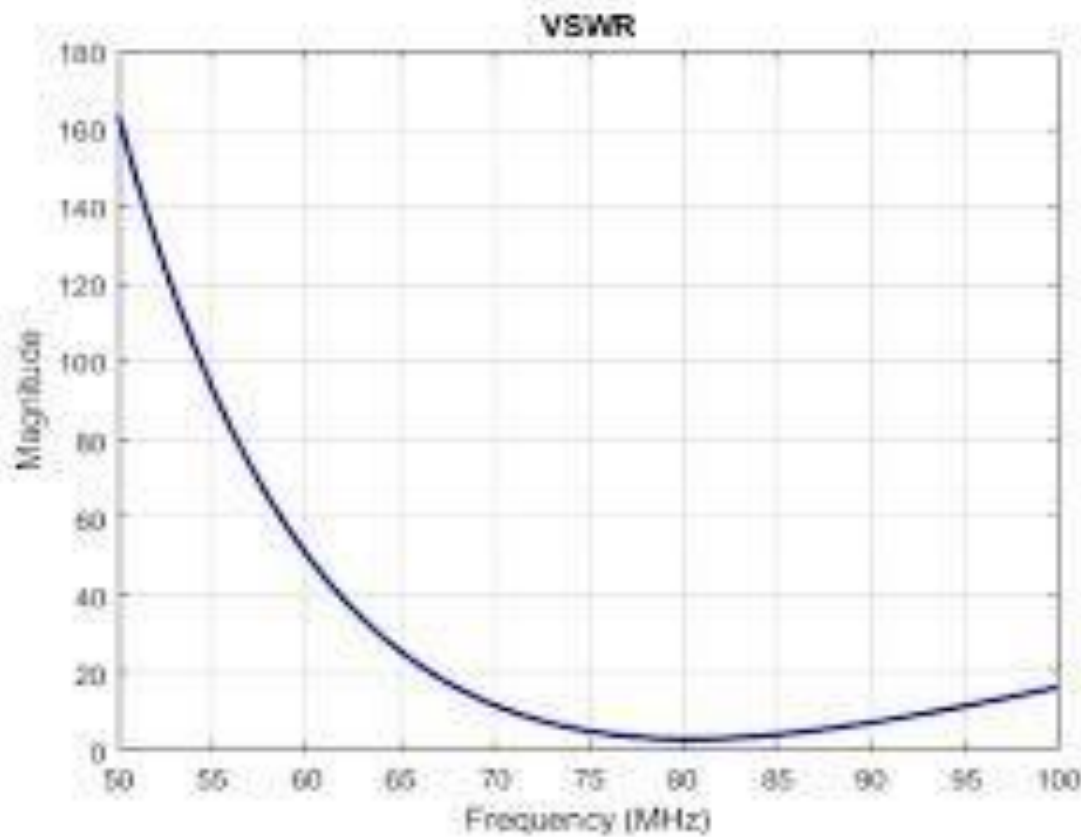


Fig 1.9 VSWR

1.6.7 INPUT IMPEDANCE

The input impedance of an antenna is defined as “the impedance presented by an antenna at its terminals or the ratio of the voltage to the current at the pair of terminals or the ratio of the appropriate components of the electric to magnetic fields at a point. input impedance is defined as the ratio of the voltage and current at the pair of the input antenna terminals $Z_a = R_a + jX_a$, where R_a is the resistance at antenna terminals and X_a is the reactance at antenna terminals. From: Human Interaction with Electromagnetic Fields.

CHAPTER 2

LITERATURE SURVEY

2.1 SAR

Evaluation of specific absorption rate and temperature elevation in a multi layered human head model exposed to radio frequency radiation using the finite difference time domain method(2010), the FDTD method evaluated the specific absorption rate distributions and temperature increase in a multi-layered human head model exposed to the field radiated from cellular phones and wireless local area networks antennas. In addition, the case of using cellular phones in enclosed areas was studied. Moreover, the effect of distance between the source and the head model was investigated. At the same levels of radiated power, SAR levels in the tissues are less than the safety limit recommendations, except in skin and CSF tissues. The effect of age on dielectric properties of tissues, and head size in SAR measurement is studied. The results show a very small difference in temperature elevation because of age. For children, temperature increase is less than adults' temperature increase value by ~2%. This means that the dielectric properties for the child head models do not significantly affect the temperature elevation.

2.1.1 MICROSTRIP PATCH ANTENNA

S. Daya Murali et al (2014) developed a wearable Microstrip rectangular patch antenna used for this application. Cotton Textiles with different dielectric values are used as substrates for this antenna. Here Rectangular patch is used. Due to its larger physical area, it has higher bandwidth and ease of fabrication when compared to other type of patches. Generally for microstrip antennas the values of substrate dielectric constants are in the range of $2.2 \leq \epsilon_r \leq 12$. Jean cotton, wash cotton, polycotton and curtain cotton is used as substrates. The antenna is energized by using co-axial feed. Co-axial feeding is used since it has low spurious radiations and also mitigates the other drawbacks when compared to other type of microstrip antenna feedings. Jean cotton as substrate is more appropriate textile than other cotton textiles for wearable antennas. "Investigation of Flexible Textile Antennas and AMC Reflectors(2012)", M.Mantash et al has proposed two different methods for fabric characterization are presented: a single frequency method and a broadband

method. Felt and denim fabrics are characterized, and patch antennas are designed using these substrates to test both methods.

A new dual-band hexagonal AMC reflector combinable with antennas is also proposed to improve their performance and reduce the backward radiation to the human body. A novel broadband CPW-fed monopole antenna is designed to be combined with the AMC. Two different electro textiles have been selected in this work: "Pure Copper Taffeta Fabric" and "Shieldit Super." "Pure Copper Taffeta Fabric" is made using pure copper and has the advantages of being smooth, flexible, light weight, easy to be cut and sewn. An additional adhesive layer is unfortunately needed to fix the electro textile to the fabric, thus increasing $130^{\circ}\text{C} = 266^{\circ}\text{F}$. Two patch antennas at 2.45GHz using denim and felt fabrics as substrate are designed and characterized. Both use Shieldit Super as electro textile.

"Design and Simulation of a Wearable Textile Monopole Antenna for Body Centric Wireless Communications", I. Adam et al has proposed a lightweight and simple structure of monopole antenna using conductive textile. Pure Copper Polyester Taffeta Fabric (PCPTF) is used as a conductive textile, in comparison with conventional micro strip monopole antenna. The prototype is designed with 40mm * 60mm total dimension and spaced by a 2mm thick felt fabric for Body Centric Wireless Communications (BCWC) operating in the 2.45 GHz Industrial, Scientific and Medical (ISM) band. Two antenna prototypes are investigated in this work; conventional monopole antenna using microstrip and textile monopole antenna. The antennas are designed for operation at the center frequency, f_c , of 2.45 GHz, however, a slight downward frequency shift is observed. The textile antenna showed a shifting at 1.1%, compared to the conventional monopole that produced the shifting at 0.98%. This can conclude that the textile monopole is comparable to the conventional monopole.

The textile monopole produced a satisfactory result for reflection coefficient and gain. The textile antenna is seen to produce about 4 dB higher in reflection coefficient than conventional monopole antenna. It was also found that the bandwidth yielded by textile monopole in free space was twice as the bandwidth of conventional monopole antenna, indicating that a broader bandwidth was achieved by the textile monopole at frequency of 2.45 GHz. However, the textile produced about 0.33 dB lower in gain, when compared to the conventional monopole antenna. A light-weight and simple monopole antenna prototype using conductive textile material suited for BCWC applications. The result demonstrated the wearable textile monopole produced higher reflection coefficient value, with a reasonable gain compared to the conventional monopole antenna.

Besides, variations on the length and width of top radiator affect the resonance frequency of the textile monopole, while the variations on the length of ground plane affects significantly reflection coefficient of the textile monopole. The simulated results exhibited that the textile monopole is able to operate like a conventional monopole antenna in free space.

2.2 MOBILE PHONE

Anu Tharakan et.al (2015) has presented a study of various antennas used in mobile phones in terms of their Specific Absorption Rates (SARs). Conventional antennas such as a half wavelength dipole antenna. Gap (EBG) structure is placed near the dipole antenna. High Impedance Electromagnetic Band Gap Structures (EBG) are typically periodic artificial media, which exhibit properties of preventing electromagnetic wave propagation in specified directions and frequency ranges. This led to an enhancement in maximum gain, giving smooth pattern with side or back lobe. The various plots such as the S-parameter, radiation patterns and SAR values are generated to investigate results. The human head model with six layers having the appropriate material properties is designed to have a realistic approach in the detailed study on the SAR. The dipole antenna when kept above the PEC does not radiate at all but the radiation efficiency of dipole antenna improved upon using the EBG structure for SAR reduction. The return loss has improved from 1.8447 dB to -11.404 dB at resonance.

2.2.1 SOURCES OF RADIATION

Many studies use usual mobile phones to expose the samples or animals, often alternation of standby mode and dial mode is used. It is also obvious that the generation of mobile technology used, e.g., 2G (GSM), 2.5G (GPRS), 3G (LTE), plays a role. Another possibility is a source of radiofrequency radiation, where exact parameters (e.g., frequency) can be set. The above-mentioned parameters are very important, and even slight variations can lead to discrepant results in seemingly similar studies. According to Saliev et al., the most important parameters are the used cell line and the type of radiation (frequency, but also modulation and shape of the waves). Moreover, the conditions in cell culture incubators should be controlled carefully. A study by Mild et al. detected enhanced levels of extremely low-frequency magnetic fields in cell culture incubators, which can have a significant influence on the cell cultures.

A review by Panagopoulos comes to an important conclusion that once the electromagnetic field is polarized, includes extremely low frequencies, and has adequate intensity, then the main parameter is variability. It suggests the extreme and unpredictable variability of the real mobile telephone signals seems to be the main reason for the corresponding bioactivity.

2.2.2 DEVELOPMENT OF MOBILE PHONE TECHNOLOGIES

The parameters of the telecommunication part of the experiments are very important and should be well controlled. Unfortunately, the radiofrequency radiation sources used in the studies are mostly either not well defined and controlled (a usual mobile phone), or do not simulate the unpredictable changes of the real mobile phone radiofrequency radiation (a vector signal generator). In recent years, new generations of mobile network technologies were introduced: 4G, using frequencies up to 8 GHz (mostly up to 2500 MHz) and 5G , using frequencies below 6 GHz and up to 86 GHz (24.25–27.5 GHz for Europe), i.e., new frequency bands and wider spectral bandwidth per frequency channel are assigned]. The future use of these higher frequencies and the need for a denser network of base stations is currently initiating debates about the influence of the 5G mobile infrastructure on organisms and human health. A new review by Karipidis et al. found no confirmed evidence that low-level RF fields above 6 GHz are hazardous for human health. A review by Simkó and Mattsson pointed out there were no consistent relationships between power density, exposure duration or frequency, and exposure effects in studies. Kostoff et al. emphasize 5G technology can have effects other than only surface effects (on skin or eyes). It is obvious the results of older experiments, i.e., mobile phones/networks, do not apply to the new technologies due to new frequency bands, the number of antennas, modulation techniques, access methods, scheduling, etc., collectively called a radio access network.

we emphasize that the dosimetry should always be clearly set and observed in the laboratory tests. This includes using a radiofrequency radiation source where the frequency, time, and intensity of the radiation, including placement of the radiation source, can be precisely set and controlled. To comply with the above-mentioned criteria precisely defined radiofrequency radiation on the one hand, and unpredictable changes of the signal on the other hand we suggest using the Software Defined Radio (SDR) approach available for 2G, 3G , 4G, and 5G instead of a signal vector generator or undefined cell phone. The SDR transceiver enables the generation of high-frequency multichannel/wideband power signals in repeatable scenarios (recorded signal or artificial signal), with respect to timing,

modulation methods, waveform, transmission power, and its time changes, etc., of real mobile phone radio channel parameters and for different xG mobile generations, unlike a standard signal generator. In order to be able to repeat the experiments in a controlled manner, it is necessary to use a standardized antenna adapter for radiating high-frequency power, i.e., an antenna structure for near/far EM field. The SDR enables the creation of a new base transceiver station (2G), Node B (3G), eNode B (4G), or gNode B (5G), which directly communicates with mobile phones, i.e., it can generate a real unpredictable mobile phone signal (i.e., signal changing in an irregular, unpredictable way), as suggested by Panagopoulos . In addition, the SDR also enables the creation of a mobile phone phantom, i.e., specific hardware solution, e.g., OsmocomBB , with a well-defined mobile phone phantom (antenna, controlled radiofrequency signal radiation setup, etc., in standardized measurement environment, i.e., measurement cell), which can facilitate the reproducibility of future experiments. All necessary parameters of individual mobile technologies, including time intervals, frequency, modulation, intensity, etc., can be precisely controlled. Using the SDR and standardized measurement cell could substantially help to avoid problems of the replication of studies. In addition, one of the advantages of this approach is the possibility of sharing a specific scenario between laboratories in order to ensure the repeatability of the radiation source.

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2.2.2 WIRELESS DEVICE RADIATION AND HEALTH

The antennas contained in mobile phones, including smartphones, emit radiofrequency (RF) radiation such as microwaves; the parts of the head or body nearest to the antenna can absorb this energy and convert it to heat. Since at least the 1990s, scientists have researched whether the now-ubiquitous radiation associated with mobile phone antennas or cell phone towers is affecting human health. Mobile phone networks use various bands of RF radiation, some of which overlap with the microwave range. Other digital wireless systems, such as data communication networks, produce similar radiation.

In response to public concern, the (WHO) established the International EMF (Electric and Magnetic Fields) Project in 1996 to assess the scientific evidence of possible health effects of EMF in the frequency range from 0 to 300 GHz. They have stated that although extensive research has been conducted into possible health effects of exposure to many parts of the frequency spectrum, all reviews conducted so far have indicated that, as long as exposures are below the limits recommended in the (1998) EMF guidelines, which cover the full

frequency range from 0–300 GHz, such exposures do not produce any known adverse health effect. In

2011,,an agency of the WHO, classified wireless radiation as possibly . That means that there "could be some risk" of carcinogenicity, so additional research into the long-term, heavy use of wireless devices needs to be conducted. The WHO states that "A large number of studies have been performed over the last two decades to assess whether mobile phones pose a potential health risk. To date, no adverse health effects have been established as being caused by mobile phone use."International guidelines on exposure levels to microwave frequency EMFs such as ICNIRP limit the power levels of wireless devices and it is uncommon for wireless devices to exceed the guidelines. These guidelines only take into account thermal effects, as non-thermal effects have not been conclusively demonstrated. The official stance of the British (HPA) is that "[T]here is no consistent evidence to date that and WLANs adversely affect the health of the general population", but also that "... it is a sensible precautionary approach ... to keep the situation under ongoing review ...". In a 2018 statement, the said that "the current safety limits are set to include a 50-fold safety margin from observed effects of Radio-frequency energy exposure".

2.3 TABLET

Tablets have up to 5 transmitter antennas emitting radiation as a beacon signal that transmits even when the internet is NOT being used. Yes, the radiation intensity is stronger when you are using the internet with a Wi-Fi connection, however, the radiation does not automatically stop when you work offline. The bursts continue because the tablet antennas “check in” with what is called a “digital handshake” to the base network which is usually a Wi-Fi router or hotspot, or a nearby cell tower. If the network signal strength is low then the tablet’s radiation burst is higher. This digital handshake continuously repeats. Doctors Recommend Reducing Exposure to This RadiationThe American Academy of Pediatrics, which is the largest organization of pediatricians in the United States, has repeatedly Warned of children’s greater vulnerability to this wireless radiation and recommends that families reduce exposure. For example, one of their 10 tips to reduce exposure includes, “If you plan to watch a movie on your device, download it first, then switch to airplane mode while you watch in order to avoid unnecessary radiation exposure.” Worldwide many Medical organization are cautioning the public to minimize wireless exposures. The New Jersey

Education Association, and the Maryland State Expert Council on Children's Environmental Health Protection recommends reducing exposure in classrooms.

2.4 SMART WATCH

Wearable smart watches can be considered a boon to healthcare technology. It provides patient monitoring, diagnosis and assistance with treatment. It is capable of monitoring blood pressure, Oxygen saturation, heartbeats, pulse rate, sleep habits, physical activities, etc. It can also be used as an alarm for daily habits like exercises, taking medicines etc. It can track physical activities like daily step counter, location. There is little uncertainty that wearable advancements are entering our lives, particularly among early adopters. Various organizations have put resources into creating wearable with novel functionalities to gain effective access into buyer markets. The wrist is the convenient place to display all vital information as the arm moves several times compared to all other body parts so it is able to trace all the motions of the body and also, the wrist has veins and arteries to measure pulse, and the skin is thin enough for sensors to detect blood pressure. A smart watch can be characterized as a portable electronic gadget worn as an adornment or inconspicuously implanted in the client's clothing . For the most part, wearable gadgets embrace the advances of modern biosensors and remote information correspondence that permit the wearer to get to and send data in all areas of human undertaking. Given the usefulness of scaled down biosensors equipped for remote correspondence, these gadgets are created to be imaginative, non-obtrusive observing innovations for ceaseless and independent transmission of physiological information . As these wearable gadgets multiply in the clinical area, they can possibly give parental figures the data they need to work on the nature of medical care, change and work with clinical work process, oversee and treat patients distantly, gather more prominent wellbeing information, and convey more significant medical care to patients . For functional use, Zhang's examination bunch noticed a few key factors that ought to be created to carry out wearable gadgets, including scaling down, reconciliation, systems administration, digitalization, and normalization . A new appearance to the quickly developing business sector of wearable gadgets is the savvy. With its scaled down structure factor plan and figuring innovation, a savvy can be worn persistently without intruding on the client's everyday movement. Albeit PDAs have turned into a piece of our day-to-day routines and may be viewed as wearable, these gadgets regularly dwell in a pocket or satchel. In contrast to PDAs, keen watches can be genuinely wearable without intruding on our day-today routines and can likewise fill in as a promptly available

augmentation of the advanced mobile phone . With the potential for boundless reception in the medical care area, savvy watches outfitted with biosensors can possibly give significant medical services data to patients and their suppliers.

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augmentation of the advanced mobile phone . With the potential for boundless reception in the medical care area, savvy watches outfitted with biosensors can possibly give significant medical services data to patients and their suppliers

2.5 WIFI ROUTER

Wireless routers are commonly found in homes they're the hardware devices that Internet service providers use to connect you to their cable or xDSL Internet network. A wireless router, also called a Wi-Fi router, combines the networking functions of a wireless access point and a router. A router connects local networks to other local networks or to the Internet. A wireless access point connects devices to the network wirelessly, using radio frequencies in the 900 MHz and 2.4, 3.6, 5, and 60 GHz frequency bands. The latest wireless routers are based on the IEEE 802.11ac Wave 2 standard, often shortened to Wave 2. While EMF emissions from different routers vary, for most home WiFi routers, a distance of 40 feet (ideally, or 10 feet at a minimum) will help the human body and shouldn't impact WiFi connection.

There's a lot of bad "science" floating around about radio frequency and electromagnetic field exposure from Wi-Fi routers and the wireless network that your iPhone accesses. AppleInsider delves into the subject, and the actual science behind it. First and foremost, RF radiation is not the same as ionizing radiation generated by decay of radioactive isotopes, and from the sun itself. This isn't Radiation Physics 101 in 1000 words, so in short, RF lacks the energy that ionizing radiation has to break chemical bonds, ionize atoms, and damage DNA. Sufficiently high levels of RF radiation can heat tissue and could theoretically cause tissue damage. But, these levels aren't reachable by the public, assuming safety standards are maintained, and the only people that need to be worried about them are generally workers in extremely close proximity to a transmitter.

Without delving into a basic physics lesson about time, distance, shielding, and wavelengths, that microwave in your kitchen is probably 700W. It is focused on the area below the emitter, and shielded by the microwave's structure itself. Wi-Fi is just radio waves in the 2.4GHz and 5GHz bands, which are far below the ionizing range. On the electromagnetic spectrum, radio waves make up the lower frequencies, visible light is in the middle, and X-rays and gamma rays make up the extremely high frequencies above ultraviolet light. Electromagnetic waves at or below the frequency of visible light are considered non-ionizing radiation because they don't have the ability break apart molecules into ions.

CHAPTER 3

PROPOSED SYSTEM

3.1 DESIGN CALCULATION

Since the antenna is designed based on rectangular patch antenna, hence the design calculation of rectangular patch is applicable. To obtain the dimensions of patch antenna we need to specify the dielectric constant of substrate (ϵ_r), the resonant frequency (f_r) and the height of the substrate (h). For a patch (w/h) > 1.

For an efficient radiator, a practical width that leads to good radiation efficiency is

$$W = \frac{c}{2f_o \sqrt{\frac{(\epsilon_r + 1)}{2}}} \quad \rightarrow (3.1)$$

Determine the effective dielectric constant of the microstrip antenna.

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-\frac{1}{2}} \quad \rightarrow (3.2)$$

Once W is found determine the extension of the length ΔL using the below equation.

$$\Delta L = 0.412h \frac{(\epsilon_{eff} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{eff} - 0.258) \left(\frac{W}{h} + 0.8 \right)} \quad \rightarrow (3.3)$$

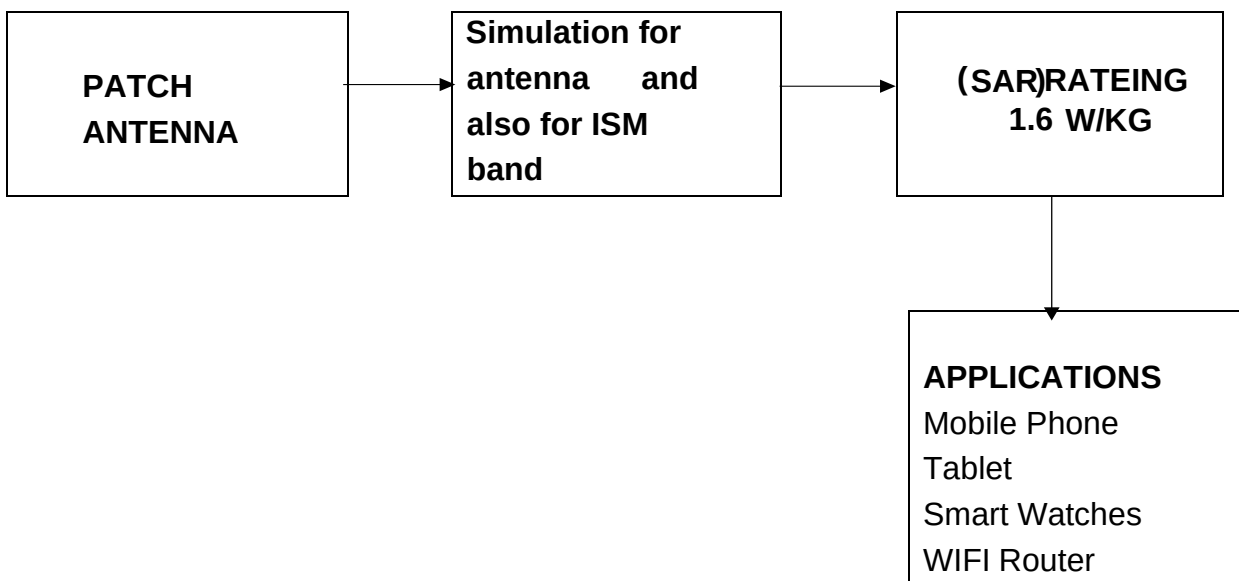
The actual length of the patch can now be determined by solving for L

$$L_{eff} = \frac{c}{2f_0\sqrt{\epsilon_{eff}}} \quad \rightarrow (3.4)$$

$$L = L_{eff} - 2\Delta L \quad \rightarrow (3.5)$$

Where : f_0 is the Resonance Frequency W is the Width of the Patch L is the Length of the Patch h is the thickness ϵ_r is the relative Permittivity of the dielectric substrate c is the Speed of light = 3×10^8 m/s.

3.2 BLOCK DIAGRAM



3.3 TECHNIQUE TO REDUCE (SAR)

Reducing the electrical magnetic field of the antenna will effect to reduce the value of SAR in human head that can be made by using the RF shield. SAR can also be reduced by changing in the antenna surface current distribution, using suitable metamaterial and also

by changing in the antenna physical structure or feeding network. Also by bringing changes in the radiation edges or by introducing geometric changes such as embedding slots, the SAR can be reduced effectively. The important thing to be noted when a slot is being introduced is that there is a significant difference in the antenna performance when the size of the slot differs. When small slots are introduced in the antenna structure it improved the gain and directivity of the antenna but there was also increase in the SAR value which most of the times exceeded the SAR limit of 1.6 W/Kg. When bigger slots are introduced in the antenna structure although there was a slight drop in the peak gain and directivity, there was a significant drop in the SAR value which mostly was under our country's limit.

3.4 THE LIMIT OF SAR IN DIFFERENT COUNTRIES

Table 1.1 SAR limit in Different regions

Region	SAR measurement protocol	SAR limit
Europe	European Specification ES 59005	2.0 W/kg in 10g of tissue
Australia	Australian Communication Authority	1.6 W/kg in 1g of tissue
US	Federal Communications commission	1.6 W/kg in 1g of tissue
India	Trai and Department Of Telecommunications, Government of India.	1.6 W/kg in 1g of tissue

Regarding to the table 1.1, the average limit of European countries is 2.0 W/kg in 10g of tissue is absorbing the most signal, Australia and US has the same limitation 1.6 W/kg in 1g of tissue. India followed the same limitation as Europe until 2012 and then switched over

to follow the same limitation as US, and the test of SAR in India is done by Telecommunication engineering center.

3.5 PROPOSED ANTENNA DESIGN FOR MOBILE PHONE AND TABLET

A mobile phone is a wireless electronic device used for telephone and multimedia communications. The term "mobile phone" does not typically refer to cordless phones, which is ultimately still connected to a land line. Mobile phones are just another word for cell phones, and they receive their service from cell phone towers. A mobile phone may be used anywhere outdoors or indoors, and does not have a base unit that it must be returned to like a cordless phone. Mobile phones may be purchased directly from the manufacturers, or they may be purchased as part of a cell phone service contract from a service provider. It is often more expensive to purchase a mobile phone from the manufacturer, because service providers often offer steep discounts when purchasing a phone with a one- or two-year contract. There are different types of mobile phones to suit different needs.

A basic mobile phone is simply able to make and receive calls, and send and receive text messages. In addition, it may have other basic features such as games, a calendar, or a camera, among others. A smartphone, on the other hand, is a mobile phone that is capable of accessing and browsing the Internet; it may also include computer programs for word processing or spreadsheets, for example. Smartphones are convenient for those who need to frequently check email or access documents.

Other features included on a mobile phone might include a video camera, a GPS device, an MP3 player, among other useful applications. Mobile phones typically get more expensive as more features are added. With every mobile phone, it is necessary to have a calling plan on a network in order for the phone to be used. Mobile phones may be purchased directly from the manufacturers, or they may be purchased as part of a cell phone service contract from a service provider. It is often more expensive to purchase a mobile phone from the manufacturer, because service providers often offer steep discounts when purchasing a phone with a one- or two-year contract. There are different types of mobile phones to suit different needs.

3.5.1 MOBILE PHONE RADIATION CHART

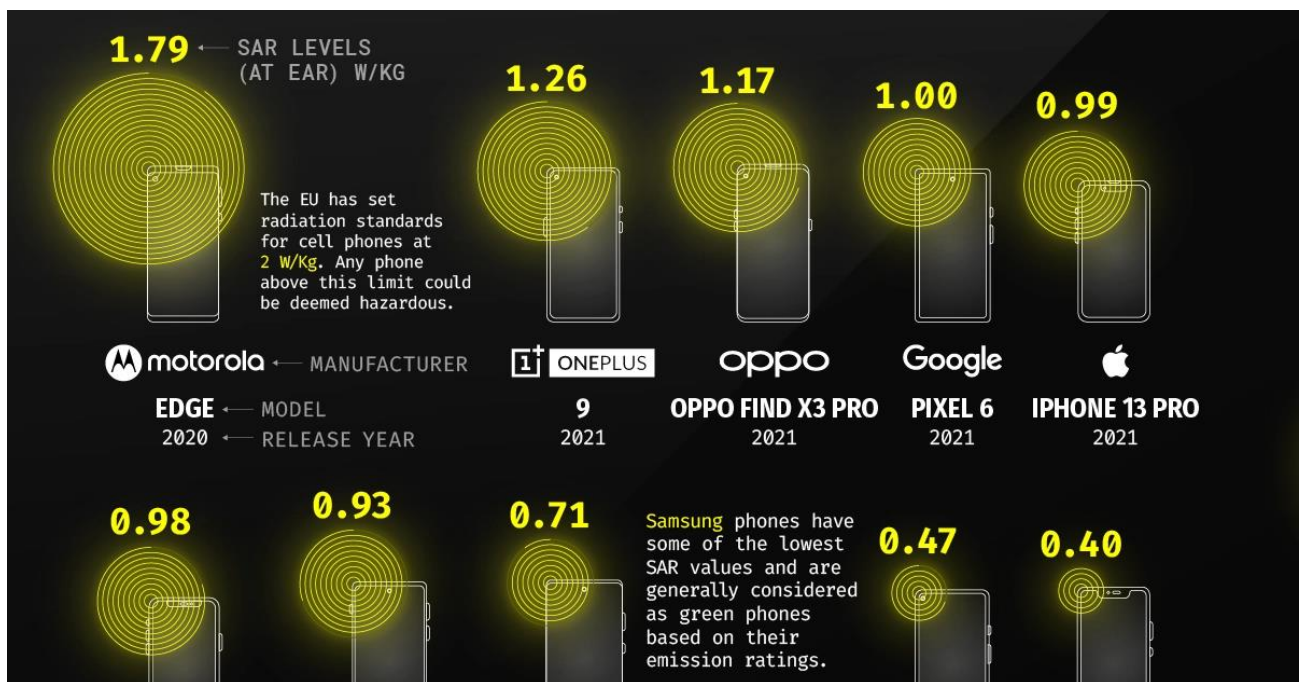


Fig 3.1 Mobile Radiation Chart

There is considerable confusion and misunderstanding about the meaning of the maximum reported Specific Absorption Rate (SAR) values for cell phones (and other wireless devices). SAR is a measure of the rate of RF (radiofrequency) energy absorption by the body from the source being measured – in this case, a cell phone. SAR provides a straightforward means for measuring the RF exposure characteristics of cell phones to ensure that they are within the safety guidelines set by the FCC.

Many people mistakenly assume that using a cell phone with a lower reported SAR value necessarily decreases a user's exposure to RF emissions, or is somehow "safer" than using a cell phone with a high SAR value. While SAR values are an important tool in judging the maximum possible exposure to RF energy from a particular model of cell phone, a single SAR value does not provide sufficient information about the amount of RF exposure under typical usage conditions to reliably compare individual cell phone models. Rather, the SAR values collected by the FCC are intended only to ensure that the cell phone does not exceed the FCC's maximum permissible exposure levels even when operating in conditions which result in the device's highest possible – but not its typical - RF energy absorption for a user.

3.5.2 TABLET AND ITS USES

Most tablets outshine smartphones when it boils down to battery life. In fact, their battery life is far better than laptops, too! While smartphones are facing the heat when it comes to delivering on the battery front, tablets, on the other hand, appear to last forever even when pushed beyond their limits. For instance, when you use a few battery-hogging apps on your smartphone, it seems to dwindle within a few hours.

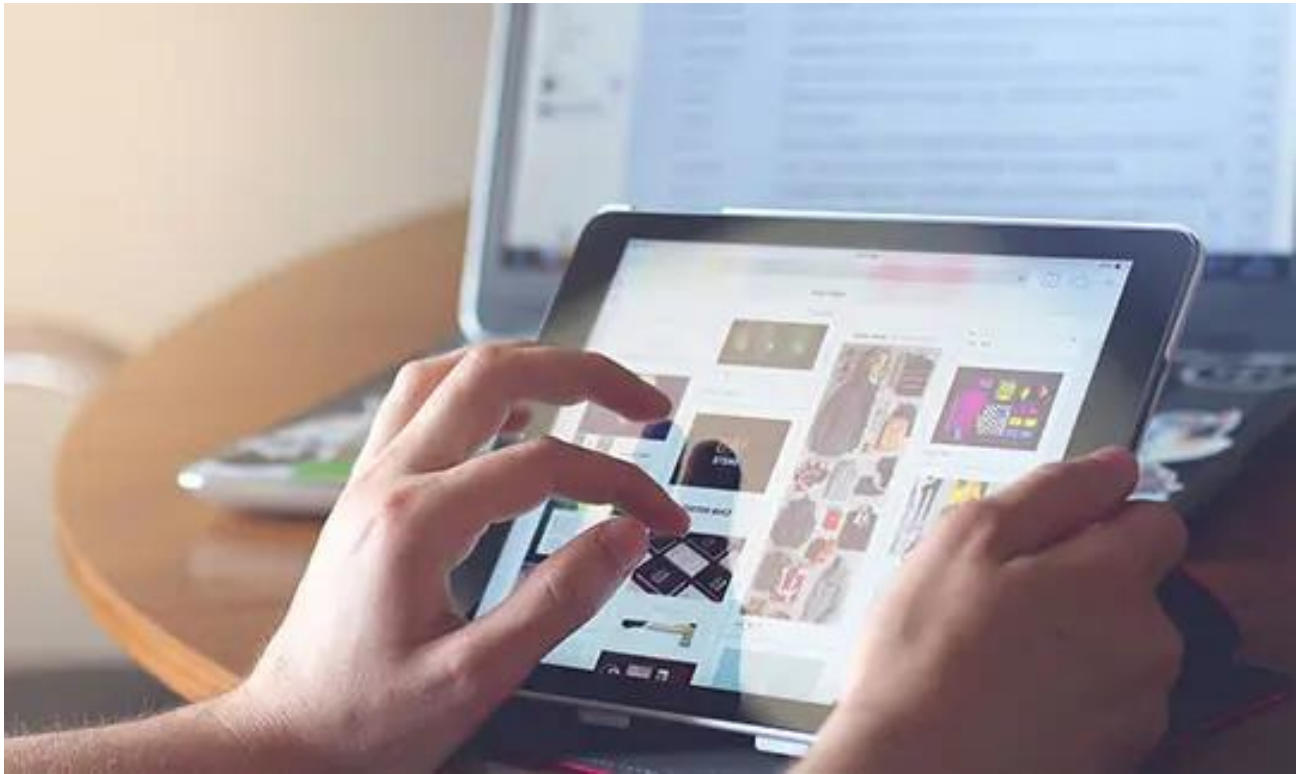


Fig 3.2 Tablet and its Uses

Tablets offer you access to multiple applications which are difficult to run on smartphones. Through tablets, you can read reviews, browse news, compose music, and search for unlimited content. Though smartphones are quite portable, they have limitations when it comes to screen size. So rather than opting for a smartphone having maximum dimensions, you can switch to a tablet to do the reading, enjoy gaming and access some valuable online content. A recent study has revealed that Tablets have a low possibility of getting misplaced when compared with smartphones. As they are big in size and less cumbersome than laptops, you can carry them anywhere without feeling the risk of losing them. They are easy to get noticed which offers them a slight advantage over other portable devices such as Smartphones.

3.6 PROPOSED ANTENNA DESIGN FOR SMART WATCH

A smartwatch is a portable device that's designed to be worn on a wrist. Like smartphones, they use touchscreens, offer apps, and often record your heart rate and other vital signs.



Fig 3.3 Smart Watch

Smartphones display notifications to alert you of important events or activities. The types of notifications differ; devices connected to a smartphone may simply mirror the phone's notifications on your wrist, but other smartwatches display notifications that only a wearable could provide. For example, newer Apple Watches includes a fall sensor. If you fall while wearing the watch, it senses your subsequent movement. If it doesn't detect any movement, it sends a series of escalating notifications. Fail to respond to the notification, and the watch assumes you're injured and alerts authorities on your behalf.

3.6.1 TYPES OF SMART WATCHES

- Apple Watch: Designed and sold by Apple.
- Pixel Watch: Designed and sold by Google, compatible with Android phones but not currently with Apple devices.
- Wear watches: Designed and sold by many vendors, using Google's Wear operating system.
- Tizen watches: Proprietary operating system designed by Samsung for its popular Galaxy line of smartwatches.

- Hiking watches: Intended for remote travel and featuring solid battery life, GPS tracking and navigation, basic vitals, and weather forecasting. Often engineered for advanced durability to protect against bumps, drops, dust, and water. Examples include the Garmin Fenix 5 Plus, the Suunto 9 Baro, and the 2022 Apple Watch Ultra.
- Diving watches: Connect your first-stage regulator to a Bluetooth transmitter to use a diving watch. Garmin's Descent Mk2i and Suunto's DX offer depth, time-remaining, temperature, and other important indicators. And the Apple Watch Ultra can make use of the to calculate dive times, display a number of different stats, and can handle depths of up to 130 feet (40 meters).
- Flying watches: A niche market, but Garmin's MARQ Aviator Gen. 2 offers a jet-lag advisor, GPS-powered moving map, NEXRAD weather reports (using METARs, TAFs and MOS2), flight logging, a barometric altimeter, and more.

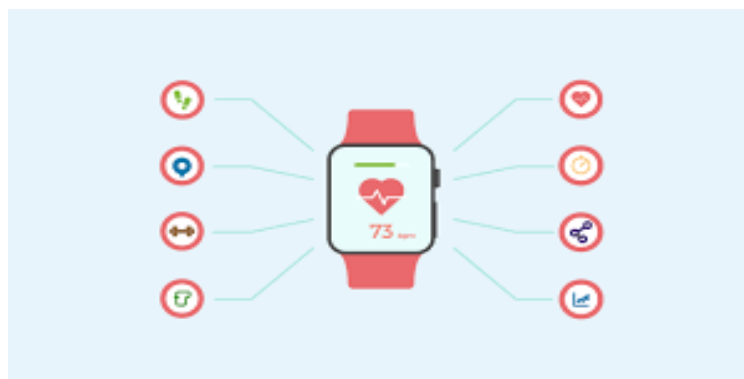


Fig 3.4 Smart Watch Chart

3.7 PROPOSED ANTENNA DESIGN FOR WIFI ROUTER

Wi-Fi is a popular wireless networking technology. Wi-Fi stands for “wireless fidelity”. Wi-Fi was invented by NCR Corporation/AT&T in the Netherlands in 1991. By using this technology we can exchange information between two or more devices. Wi-Fi has been developed for mobile computing devices, such as laptops, but it is now extensively using for mobile applications and consumer electronics like televisions, DVD players, and digital cameras. There should be two possibilities in communicating with the Wi-Fi connection that may be through an access point to the client connection or client to client connection. Wi-Fi is one type of wireless technology. It is commonly called a wireless LAN (local area network). WiFi technology allows local area networks to operate without cable and wiring. It is making

a popular choice for home and business networks. A computer's wireless adaptor transfers the data into a radio signal and transfers the data into an antenna for users.

3.7.1 WiFi Technology Working Principle

Wi-Fi is a high-speed internet connection and network connection without the use of any cables or wires. The wireless network is operating three essential elements that are radio signals, antenna, and router. The radio waves are keys that make Wi-Fi networking possible. The computers and cell phones are ready with Wi-Fi cards. Wi-Fi compatibility has been using a new creation to constituent within the ground connected with community network. The actual broadcast is connected in sequence in fact it is completed by way of stereo system surf as well as the worth of wires with the monitor to classification prone. Wi-Fi allows the person in order to get access to the web any place in the actually provided area. You can now generate a system within Resorts, library, schools, colleges, campus, personal institutes, as well as espresso stores as well as on the open public spot to help to make your company much more lucrative as well as interact with their own customer whenever.



Fig 3.5 WiFi Technology

Wi-Fi compatibility can make surf with stare to the company using their inspiring cable television much a smaller amount force down. The radio signals are transmitted from antennas and routers that signals are picked up by Wi-Fi receivers, such as computers and cell phones that are ready with Wi-Fi cards. Whenever the computer receives the signals within the range of 100-150 feet for the router it connects the device immediately. The range of the Wi-Fi is depended upon the environment, indoor or outdoor ranges. The Wi-Fi cards will read the signals and create an internet connection between the user and the network. The speed of the device using Wi-Fi connection increases as the computer gets closer to the main source and the speed is decreased the computer gets further away. Any new laptops, mobile phones have inbuilt Wi-Fi cards you don't have to do anything which is one of the best things. If it is a free-based type of network connection the user will be prompted with a login id and password. The free base network connections also well in some areas. The Wi-Fi network connection is creating hot spots in the cities. The hot spots are a connection point of the Wi-Fi network. It is a small box that is hardwired into the internet. There are many Wi-Fi hot spots available in public places like restaurants, airports, and hotels offices, universities, etc. The radio waves are keys that make Wi-Fi networking possible. The computers and cell phones are ready with Wi-Fi cards. Wi-Fi compatibility has been using a new creation to constituent within the ground connected with community network. The actual broadcast is connected in sequence in fact it is completed by way of stereo system surf as well as the worth of wires with the monitor to classification prone. Wi-Fi allows the person in order to get access to the web any place in the actually provided area. You can now generate a system within Resorts, library, schools, colleges, campus, personal institutes, as well as espresso stores as well as on the open public spot.

CHAPTER 4

SIMULATED AND RESULTS

4.1 ANTENNA DESIGN (MOBILE PHONE & TABLET)

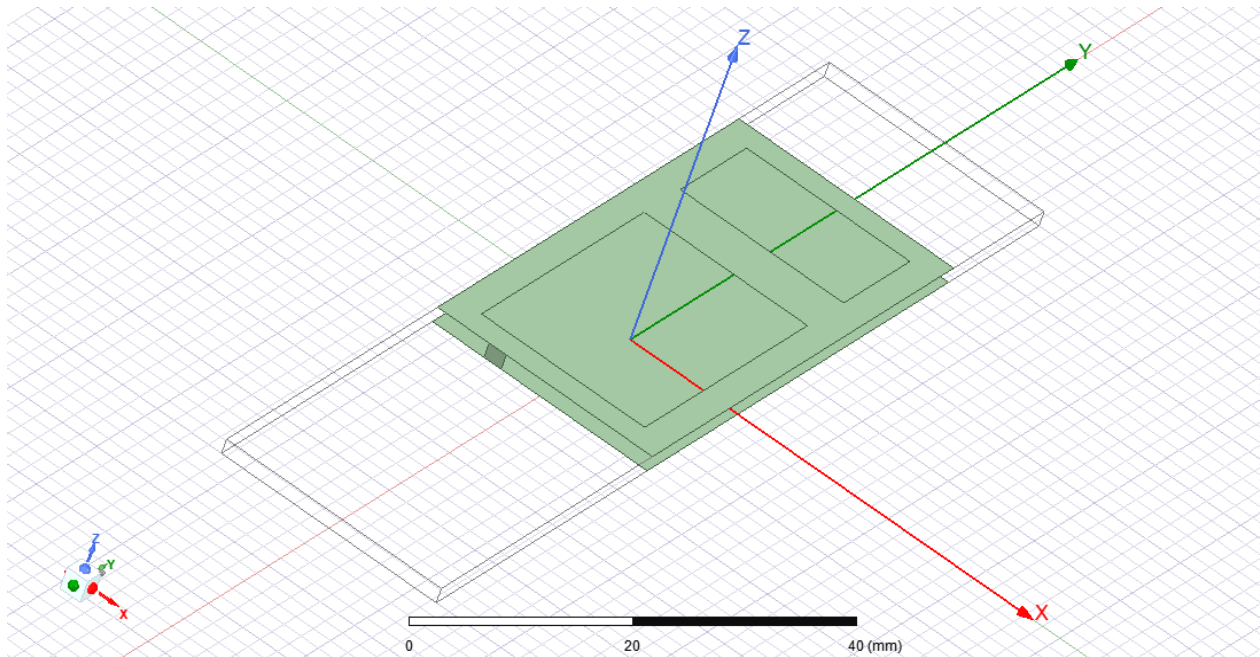


Fig 4.1 (Mobile and Tablet) Design

4.1.1 DESIGN SPECIFICATION

PATCH

Patch size along x axis: 3mm

Patch size along y axis: 50mm

SUBSTRATE

Substrate size along x axis: 25mm

Substrate size along y axis: 100mm

Substrate thickness: 1.6mm

GROUND

Ground size along x axis: 25mm

Ground size along y axis: 50mm.

4.1.2 RADIATION PLOT IN FREE SPACE PROPAGATION

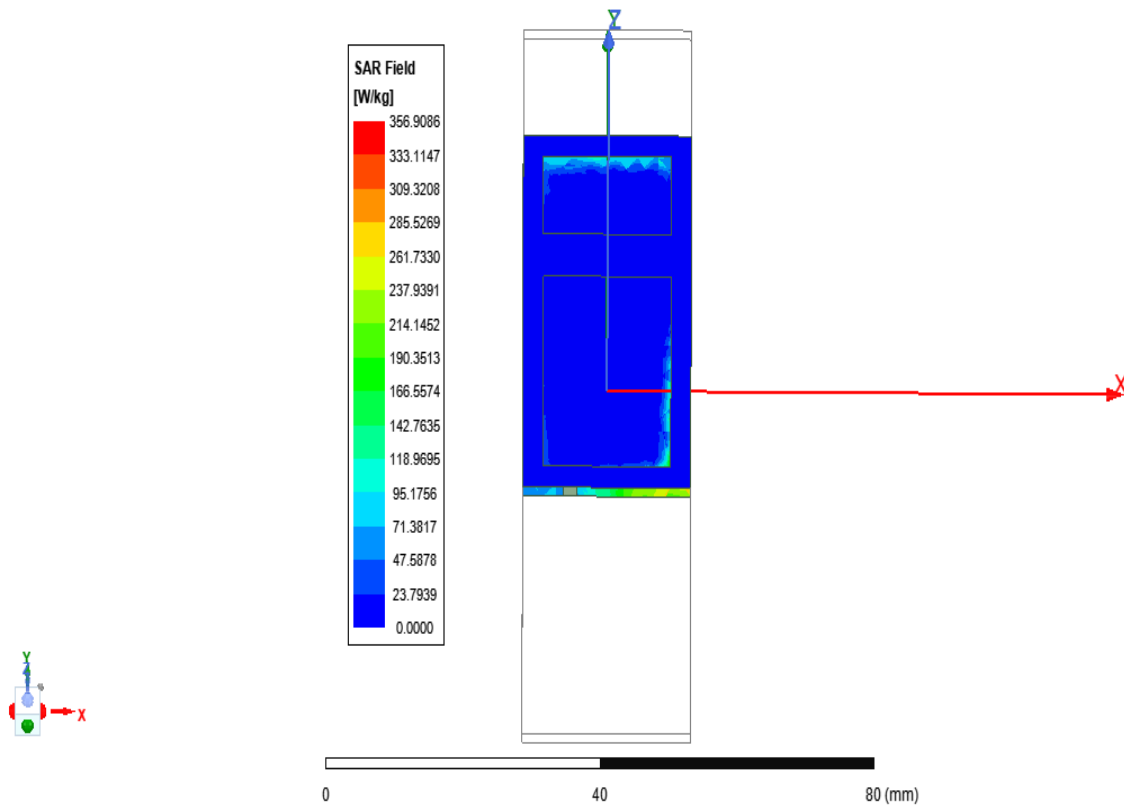


Fig 4.2 Radiation Plot in FSP

Free space propagation, the radiation plot refers to the pattern of electromagnetic waves that are radiated from an antenna in all directions. The radiation pattern can be represented graphically as a plot of the power density (or electric field strength) of the electromagnetic waves in different directions relative to the antenna. A common way to visualize the radiation pattern is by using a polar plot, which shows the power density of the waves in different directions relative to the antenna. The angle is plotted on the horizontal axis, and the power density is plotted on the vertical axis. Thus the radiation plot in Free space propagation of the mobile phone and Tablet is obtained.

IT IS CALCULATED AS

$$23.7939 / 1000$$

$$=0.0237 \text{ W/KG}$$

Where 1000 represents mass of Tissue in W/Kg.

4.1.3 RADIATION PATTERN ON PHANTOM MODEL

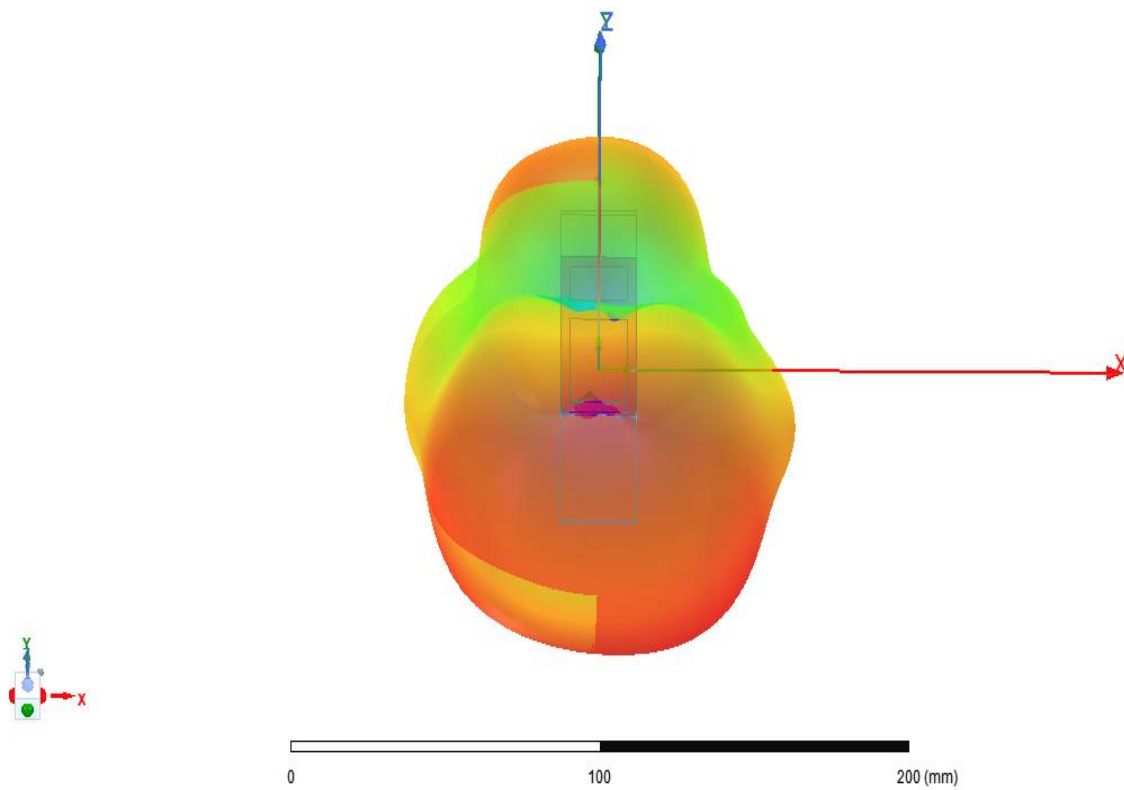


Fig 4.3 Radiation Pattern on phantom model

The radiation pattern of an antenna is a graphical representation of the directional properties of the antenna's radiation. It shows the strength of the electromagnetic radiation emitted by the antenna in different directions. The radiation pattern is typically plotted in two or three dimensions, with the antenna placed at the origin of the coordinate system. The strength of the radiation is usually represented by the color or the length of the lines or curves on the graph. Thus the Radiation Pattern on phantom model of the mobile phone and Tablet is obtained.

IT IS CALCULATED AS

$$\begin{aligned} & 45.9773 / 1000 \\ & = 0.0459\text{W/KG} \end{aligned}$$

Where 1000 represents mass of Tissue in W/Kg.

4.1.4 RESULT

4.1.5 S PARAMETER

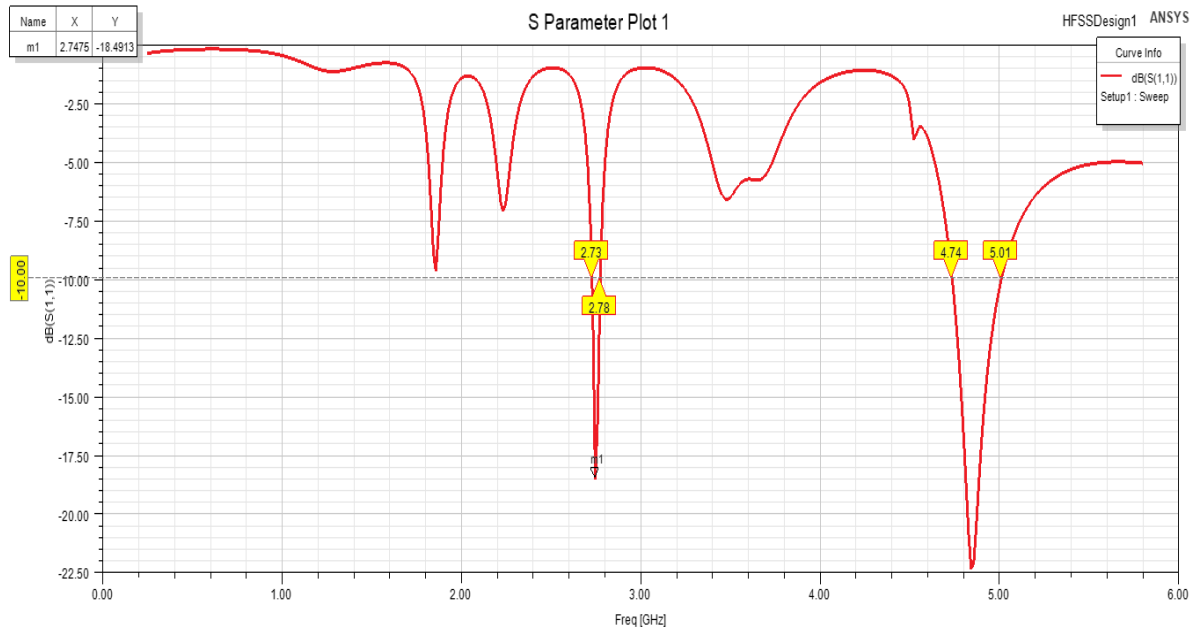


Fig 4.4 S Parameter

S-parameters, or scattering parameters, are a set of parameters used in microwave engineering to describe the behavior of linear electrical networks, such as amplifiers, filters, and antennas, at radio frequencies. S-parameters are complex numbers that relate the amplitudes and phases of input and output signals at different frequencies. S-parameters describe how a device or circuit responds to an incoming signal at a given frequency. They are typically measured using network analyzers, which can measure the amplitude and phase of the signal at the input and output ports of the device. The S-parameters are typically represented in a matrix form, known as the scattering matrix or S-matrix. The S-matrix consists of four S-parameters, labeled S_{11} , S_{12} , S_{21} , and S_{22} , which represent the input reflection coefficient, the forward transmission coefficient, the reverse transmission coefficient, and the output reflection coefficient, respectively.

.db(s(1,1))

X= 2.7475

Y= -18.4913

4.1.6 VSWR

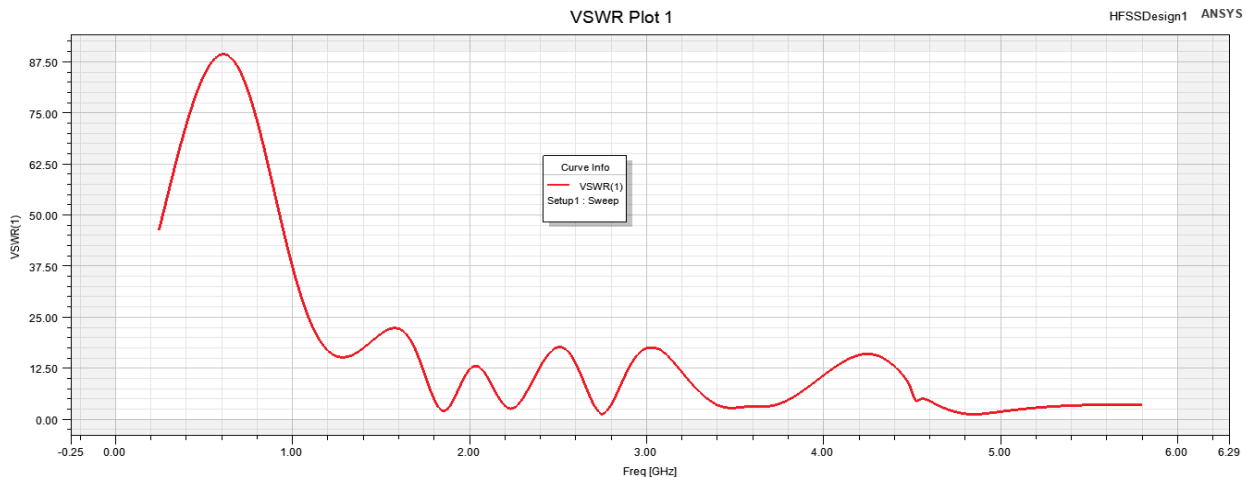


Fig 4.5 VSWR

VSWR stands for Voltage Standing Wave Ratio. It is a measure of the efficiency of power transmission between a radio frequency (RF) source and a load, such as an antenna. VSWR is defined as the ratio of the maximum voltage to the minimum voltage along the transmission line. When there is a mismatch between the impedance of the transmission line and the impedance of the load, some of the power transmitted by the source is reflected back towards the source. This results in a standing wave pattern along the transmission line, with maximum and minimum voltage points. The VSWR is the ratio of the maximum voltage to the minimum voltage along this standing wave. A VSWR of 1:1 means that there is no reflection of power and all the power is transmitted to the load. A VSWR of 2:1 means that the maximum voltage is twice the minimum voltage, indicating that 11% of the power is reflected back towards the source. As the VSWR increases, more power is reflected back, leading to lower efficiency and potentially damaging the RF source. VSWR is an important parameter in RF system design and is used to ensure maximum power transfer from the source to the load. It can be measured using a VSWR meter or by using an RF network analyzer to measure the S-parameters of the transmission line. VSWR is typically specified in antenna specifications and is an important consideration in the design and deployment of antennas for various applications.

4.1.7 ANTENNA GAIN

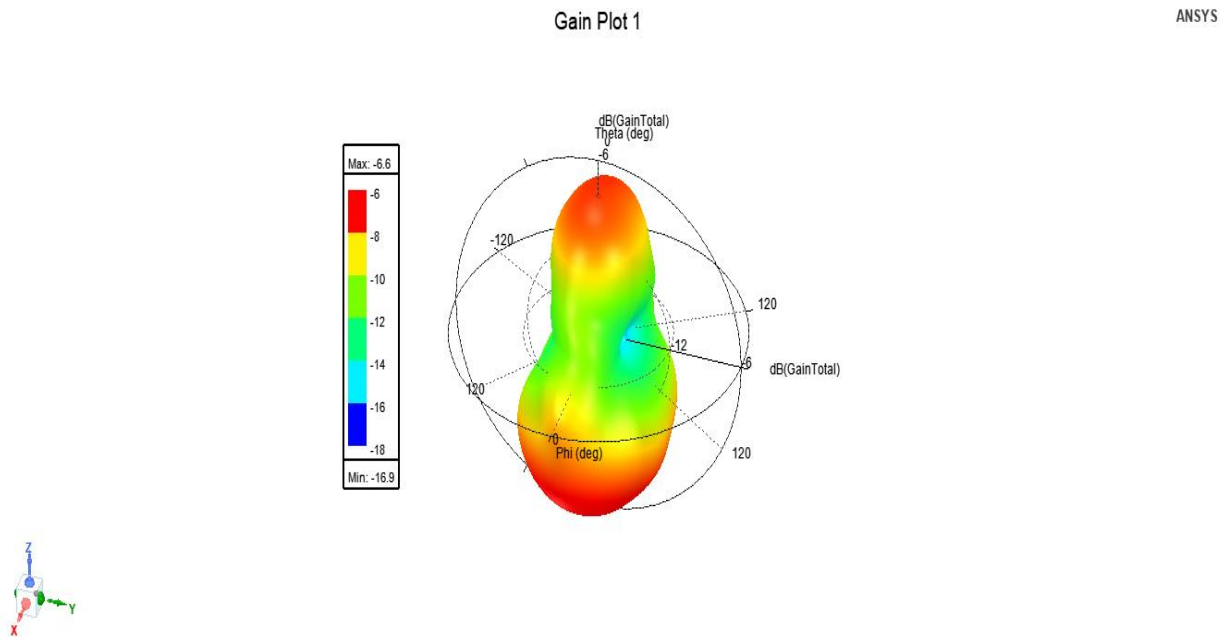


Fig 4.8 Antenna Gain

An antenna gain plot is a graphical representation of the directional properties of an antenna, and it shows how effectively the antenna radiates energy in different directions. The gain plot typically shows the gain of the antenna in decibels (dB) versus angle, frequency, or both. The gain of an antenna is a measure of its ability to radiate energy in a particular direction, and it is usually expressed in dBi (decibels relative to an isotropic radiator). An isotropic radiator is a theoretical antenna that radiates equally in all directions. The gain of a practical antenna is typically higher than that of an isotropic radiator, and it can vary with the direction of radiation. The gain plot of an antenna shows the variation of antenna gain with angle, and it is typically measured in the plane perpendicular to the axis of the antenna. The plot can be in two or three dimensions, and it is usually displayed as a polar plot or a 3D plot.

Maximum gain plot = -6.6

Minimum gain plot = -16.9.

4.2 ANTENNA DESIGN (SMART WATCH)

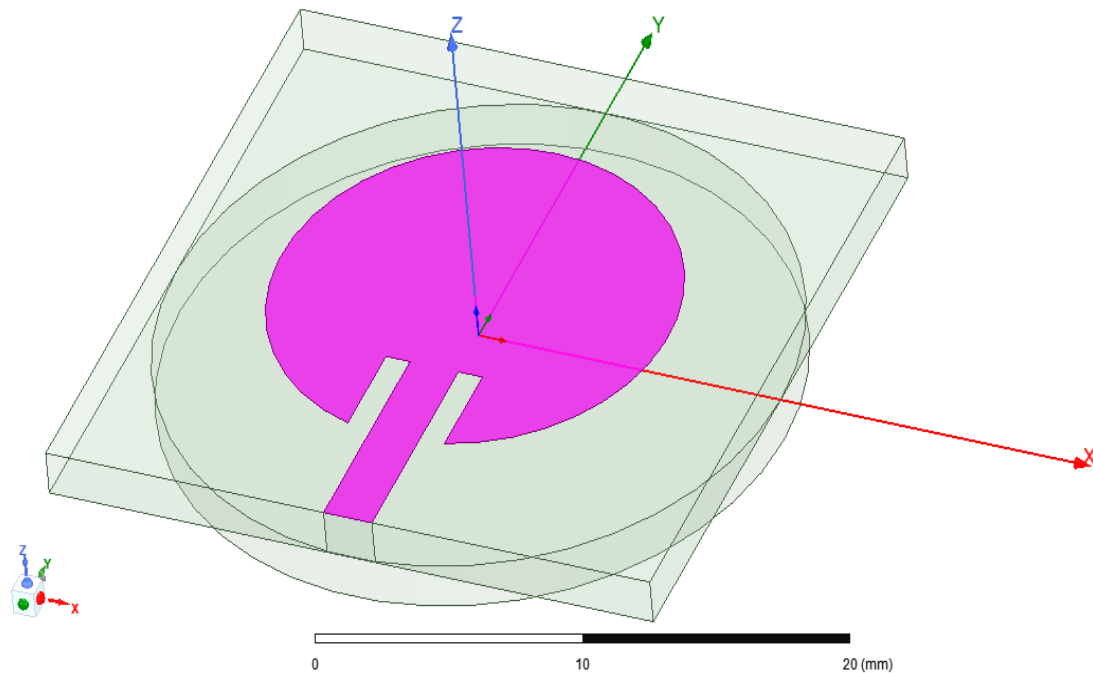


Fig 4.9 Smart Watch Design

4.2.1 DESIGN SPECIFICATION

PATCH

Patch radius along z axis: 8mm

Position = (0,0,1.6)

SUBSTRATE

Substrate size along x axis: 25mm

Substrate size along y axis: 25mm

Substrate thickness: 1.6mm

GROUND

Ground size along x axis: 25mm

Ground size along y axis: 25mm

4.2.2 RADIATION PLOT IN FREE SPACE PROPAGATION

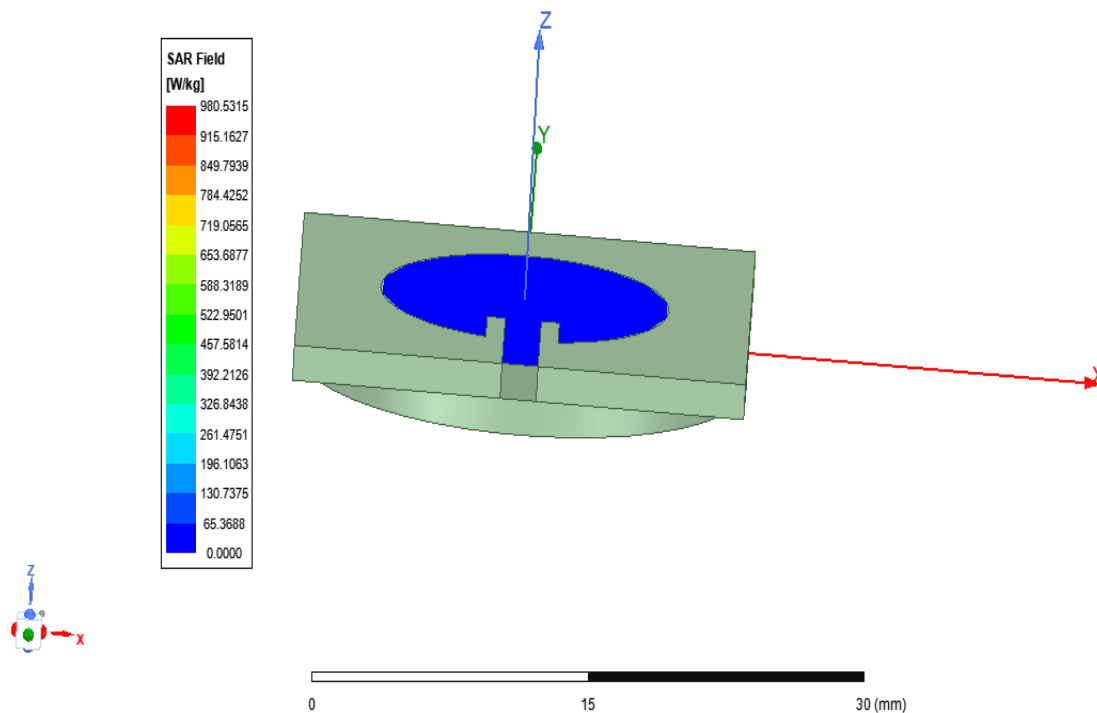


Fig 4.10 Radiation Plot in FSP

Free space propagation, the radiation plot refers to the pattern of electromagnetic waves that are radiated from an antenna in all directions. The radiation pattern can be represented graphically as a plot of the power density (or electric field strength) of the electromagnetic waves in different directions relative to the antenna. A common way to visualize the radiation pattern is by using a polar plot, which shows the power density of the waves in different directions relative to the antenna. The angle is plotted on the horizontal axis, and the power density is plotted on the vertical axis. Thus the radiation plot in Free space propagation of the Smart Watch is obtained.

IT IS CALCULATED AS

$$65.3688 / 1000$$

$$=0.06536 \text{ W/KG}$$

Where 1000 represents mass of Tissue in W/Kg.

4.2.3 RADIATION PATTERN ON PHANTOM MODEL

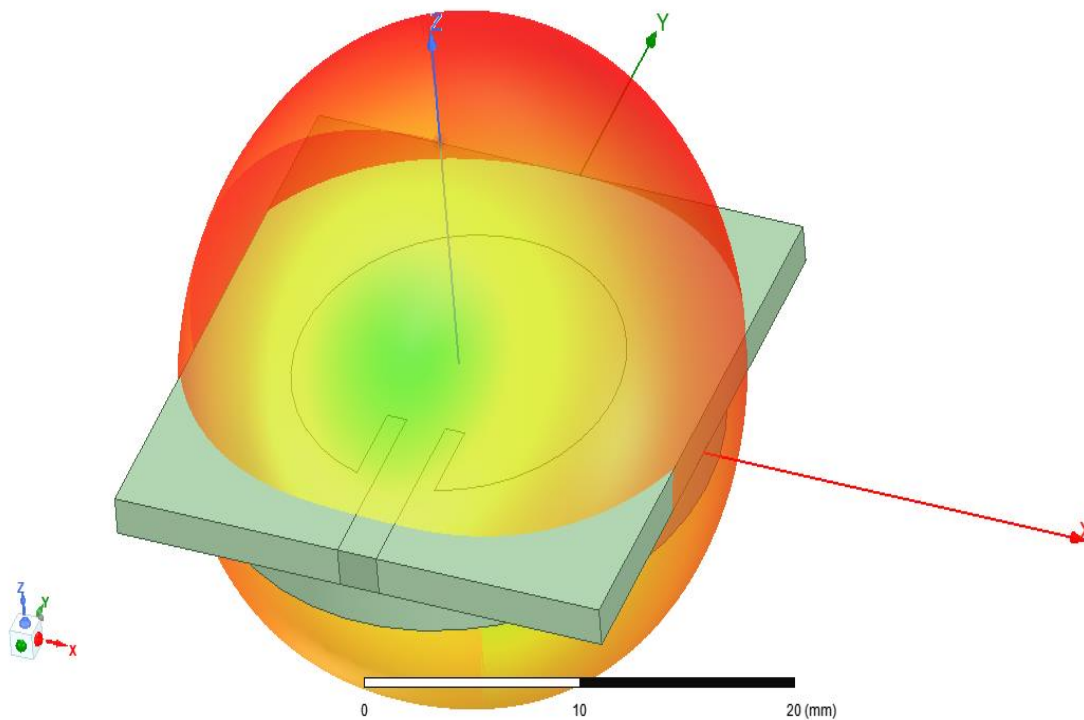


Fig 4.11 Radiation pattern on Phantom model

The radiation pattern of an antenna is a graphical representation of the directional properties of the antenna's radiation. It shows the strength of the electromagnetic radiation emitted by the antenna in different directions. The radiation pattern is typically plotted in two or three dimensions, with the antenna placed at the origin of the coordinate system. The strength of the radiation is usually represented by the color or the length of the lines or curves on the graph. Thus the Radiation pattern on Phantom model of the Smart Watch is obtained.

IT IS CALCULATED AS

$$980.5315 / 1000$$

$$= 0.98053 \text{ W/KG}$$

Where 1000 represents mass of Tissue in W/Kg

4.2.4 RESULT

4.2.5 S PARAMETER

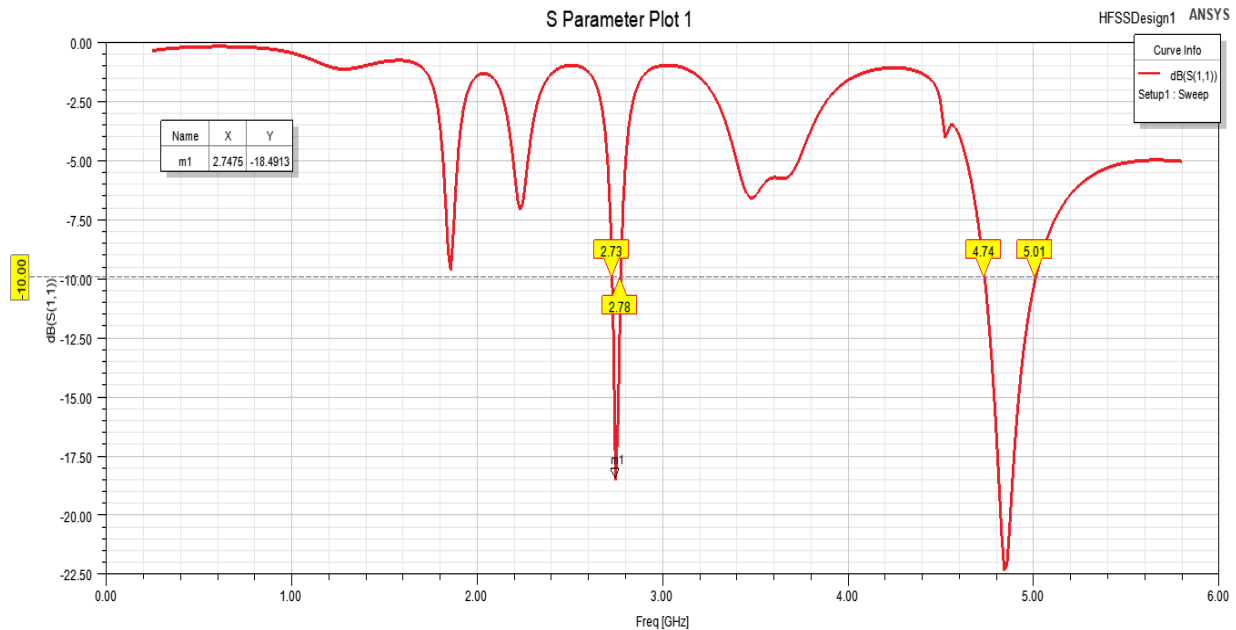


Fig 4.12 S Parameter

S-parameters, or scattering parameters, are a set of parameters used in microwave engineering to describe the behavior of linear electrical networks, such as amplifiers, filters, and antennas, at radio frequencies. S-parameters are complex numbers that relate the amplitudes and phases of input and output signals at different frequencies. S-parameters describe how a device or circuit responds to an incoming signal at a given frequency. They are typically measured using network analyzers, which can measure the amplitude and phase of the signal at the input and output ports of the device. The S-parameters are typically represented in a matrix form, known as the scattering matrix or S-matrix. The S-matrix consists of four S-parameters, labeled S_{11} , S_{12} , S_{21} , and S_{22} , which represent the input reflection coefficient, the forward transmission coefficient, the reverse transmission coefficient, and the output reflection coefficient, respectively.

$\text{db}(s(1,1))$

$X = 2.7475$

$Y = -18.4913$.

4.2.6 VSWR

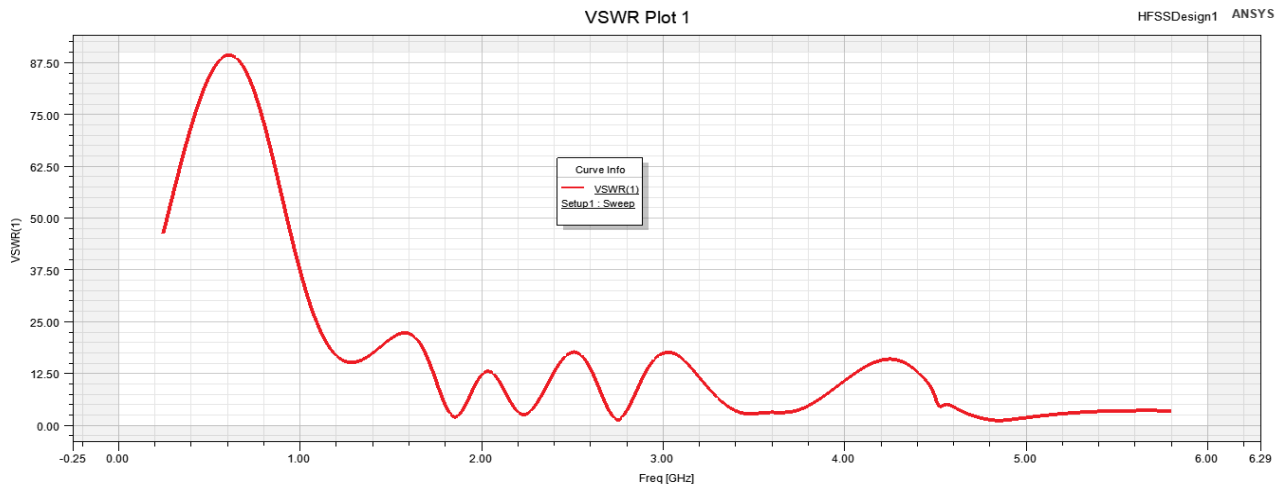


Fig 4.13 VSWR

VSWR stands for Voltage Standing Wave Ratio. It is a measure of the efficiency of power transmission between a radio frequency (RF) source and a load, such as an antenna. VSWR is defined as the ratio of the maximum voltage to the minimum voltage along the transmission line. When there is a mismatch between the impedance of the transmission line and the impedance of the load, some of the power transmitted by the source is reflected back towards the source. This results in a standing wave pattern along the transmission line, with maximum and minimum voltage points. The VSWR is the ratio of the maximum voltage to the minimum voltage along this standing wave. A VSWR of 1:1 means that there is no reflection of power and all the power is transmitted to the load. A VSWR of 2:1 means that the maximum voltage is twice the minimum voltage, indicating that 11% of the power is reflected back towards the source. As the VSWR increases, more power is reflected back, leading to lower efficiency and potentially damaging the RF source. VSWR is an important parameter in RF system design and is used to ensure maximum power transfer from the source to the load. It can be measured using a VSWR meter or by using an RF network analyzer to measure the S-parameters of the transmission line. VSWR is typically specified in antenna specifications and is an important consideration in the design and deployment of antennas for various applications.

4.2.7 GAIN PLOT

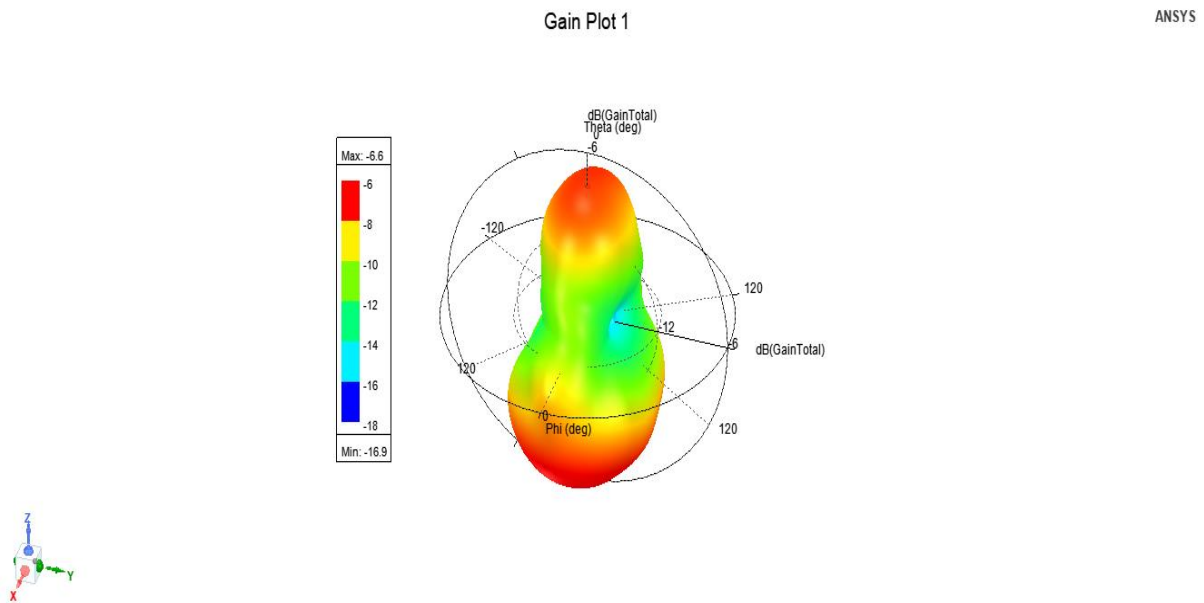


Fig 4.14 Gain Plot

An antenna gain plot is a graphical representation of the directional properties of an antenna, and it shows how effectively the antenna radiates energy in different directions. The gain plot typically shows the gain of the antenna in decibels (dB) versus angle, frequency, or both. The gain of an antenna is a measure of its ability to radiate energy in a particular direction, and it is usually expressed in dBi (decibels relative to an isotropic radiator). An isotropic radiator is a theoretical antenna that radiates equally in all directions. The gain of a practical antenna is typically higher than that of an isotropic radiator, and it can vary with the direction of radiation. The gain plot of an antenna shows the variation of antenna gain with angle, and it is typically measured in the plane perpendicular to the axis of the antenna. The plot can be in two or three dimensions, and it is usually displayed as a polar plot or a 3D plot.

Maximum gain plot = -6.6

Minimum gain plot = -16.9

4.3 ANTENNA DESIGN (WIFI ROUTER)

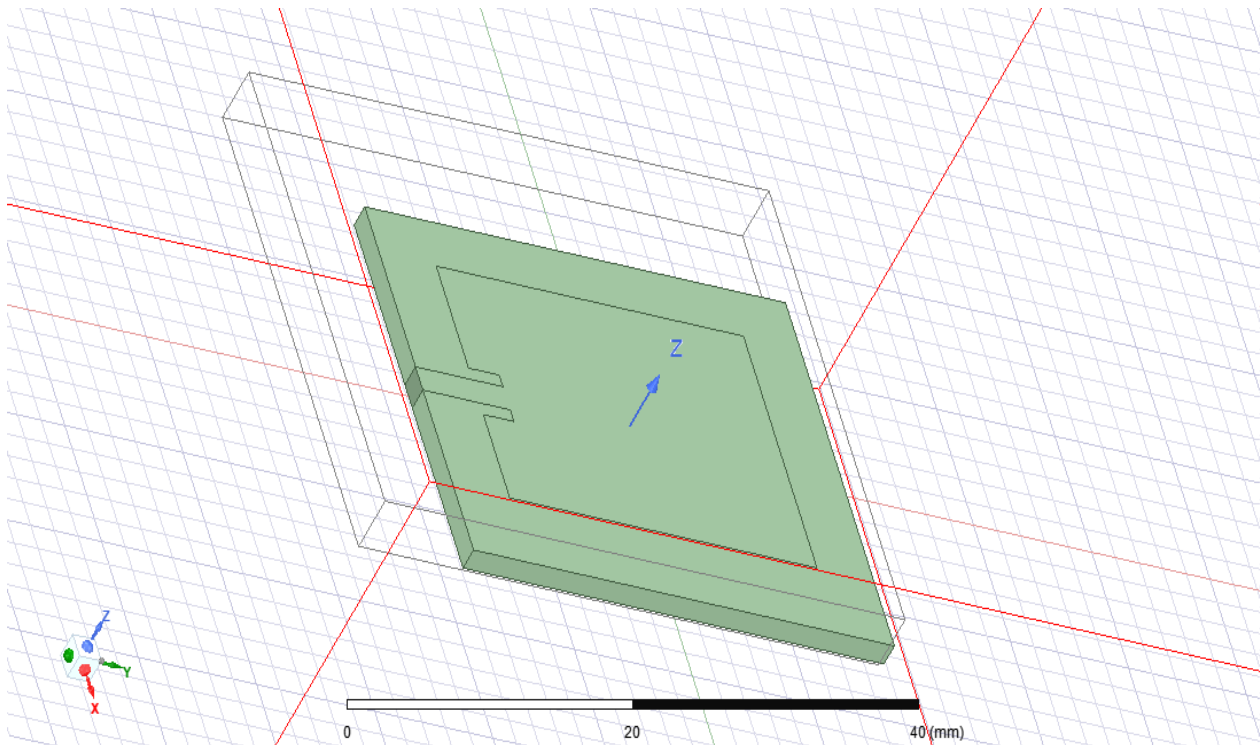


Fig 4.15 Wifi Router Design

4.3.1 DESIGN SPECIFICATION

PATCH

Patch size along x axis: 20mm

Patch size along y axis: 26mm

SUBSTRATE

Substrate size along x axis: 4mm

Substrate size along y axis: 2.6mm

GROUND

Ground size along x axis: 29.6mm

Ground size along y axis: 35.6mm

4.3.2 RADIATION PLOT IN FREE SPACE PROPAGATION

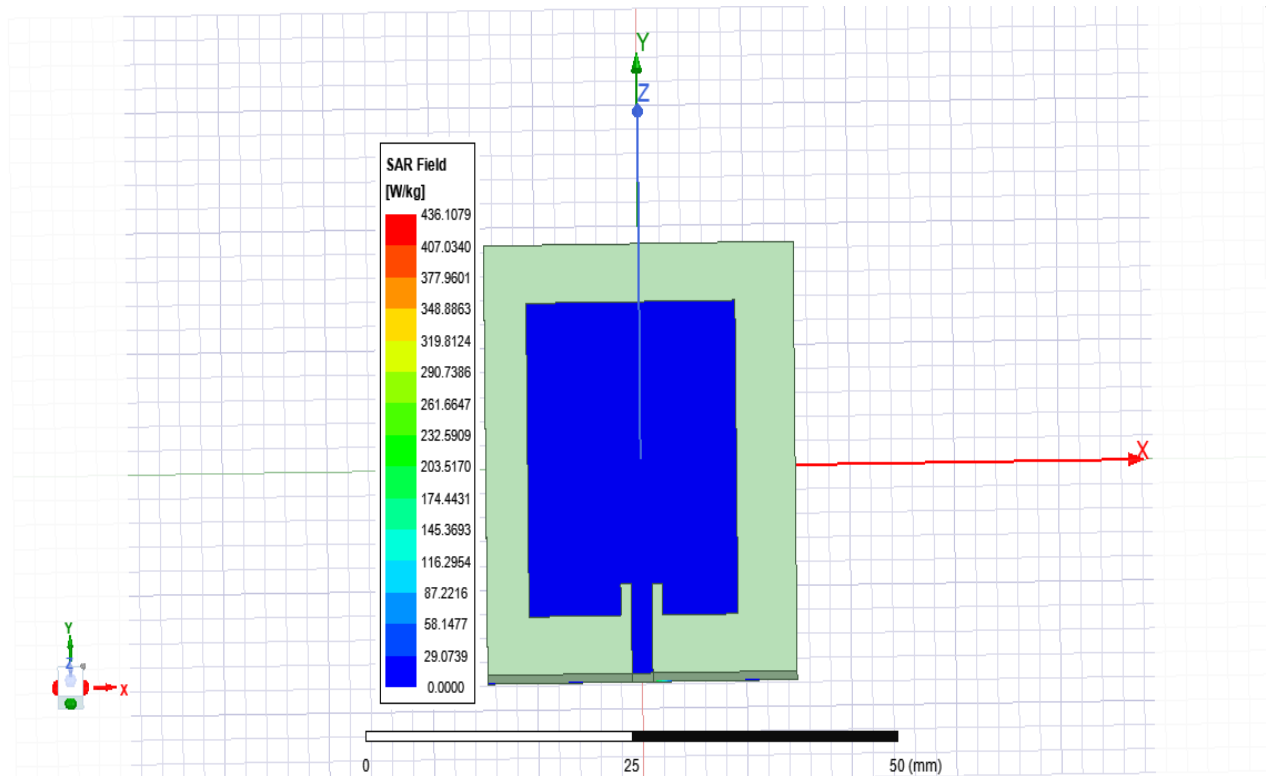


Fig 4.16 Radiation Plot In FSP

Free space propagation, the radiation plot refers to the pattern of electromagnetic waves that are radiated from an antenna in all directions. The radiation pattern can be represented graphically as a plot of the power density (or electric field strength) of the electromagnetic waves in different directions relative to the antenna. A common way to visualize the radiation pattern is by using a polar plot, which shows the power density of the waves in different directions relative to the antenna. The angle is plotted on the horizontal axis, and the power in density is plotted on the vertical axis. Thus the radiation plot in Free space propagation of the WIFI Router is obtained.

IT IS CALCULATED AS

$$29.0739 / 1000$$

$$=0.0290 \text{ W/KG}$$

Where 1000 represents mass of Tissue in W/Kg.

4.3.3 RADIATION PATTERN ON PHANTOM MODEL

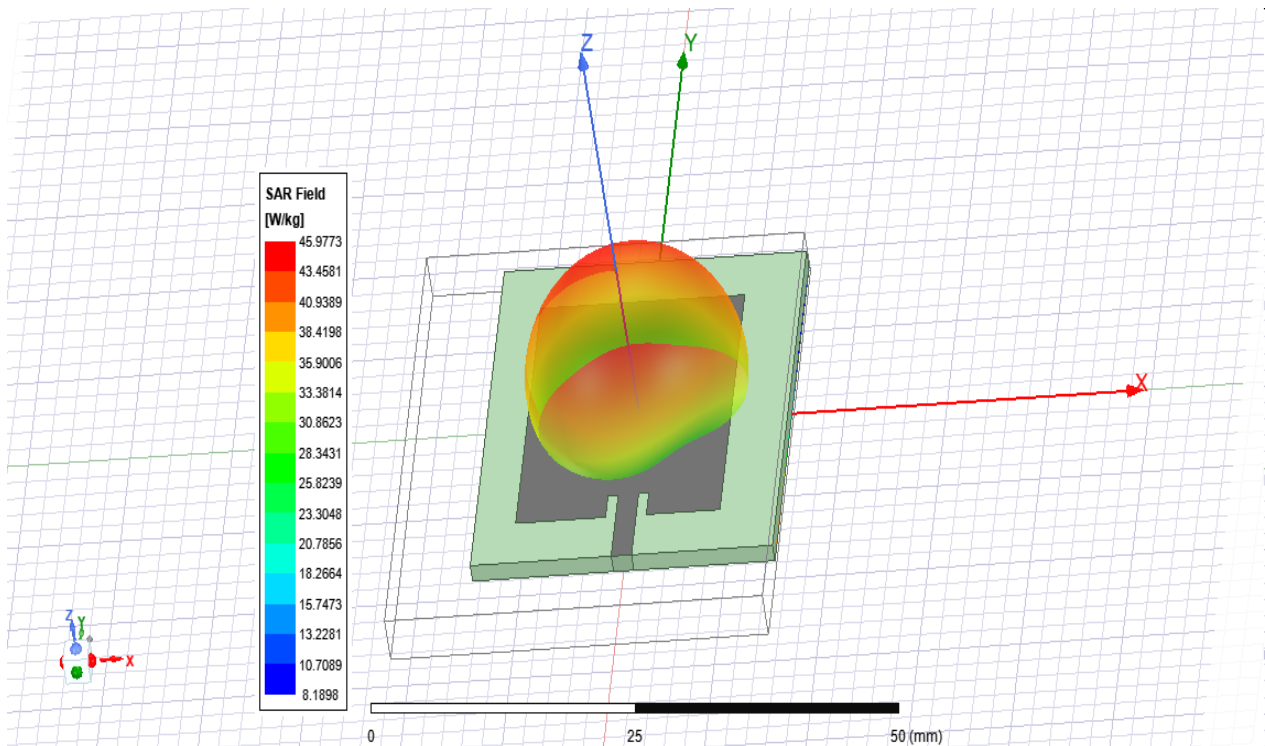


Fig 4.17 Radiation pattern on Phantom Model

The radiation pattern of an antenna is a graphical representation of the directional properties of the antenna's radiation. It shows the strength of the electromagnetic radiation emitted by the antenna in different directions. The radiation pattern is typically plotted in two or three dimensions, with the antenna placed at the origin of the coordinate system. The strength of the radiation is usually represented by the color or the length of the lines or curves on the graph. Thus the Radiation pattern on Phantom model of WIFI Router is obtained.

IT IS CALCULATED AS

$$\begin{aligned} & 45.9773 / 1000 \\ & = 0.0459 \text{ W/KG} \end{aligned}$$

Where 1000 represents mass of Tissue in W/Kg.

4.3.4 RESULT

4.3.5 S PARAMETER

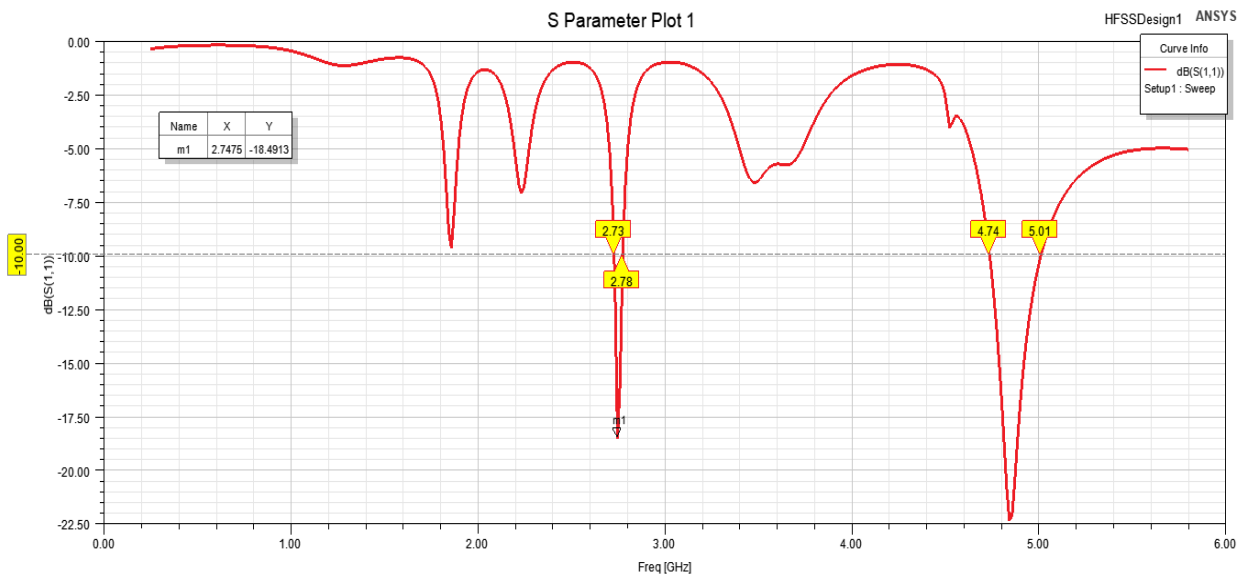


Fig 4.18 S Parameter

S-parameters, or scattering parameters, are a set of parameters used in microwave engineering to describe the behavior of linear electrical networks, such as amplifiers, filters, and antennas, at radio frequencies. S-parameters are complex numbers that relate the amplitudes and phases of input and output signals at different frequencies. S-parameters describe how a device or circuit responds to an incoming signal at a given frequency. They are typically measured using network analyzers, which can measure the amplitude and phase of the signal at the input and output ports of the device. The S-parameters are typically represented in a matrix form, known as the scattering matrix or S-matrix. The S-matrix consists of four S-parameters, labeled S_{11} , S_{12} , S_{21} , and S_{22} , which represent the input reflection coefficient, the forward transmission coefficient, the reverse transmission coefficient, and the output reflection coefficient, respectively.

$\text{db}(s(1,1))$

$X = 2.7475$

$Y = -18.4913$.

4.3.6 VSWR

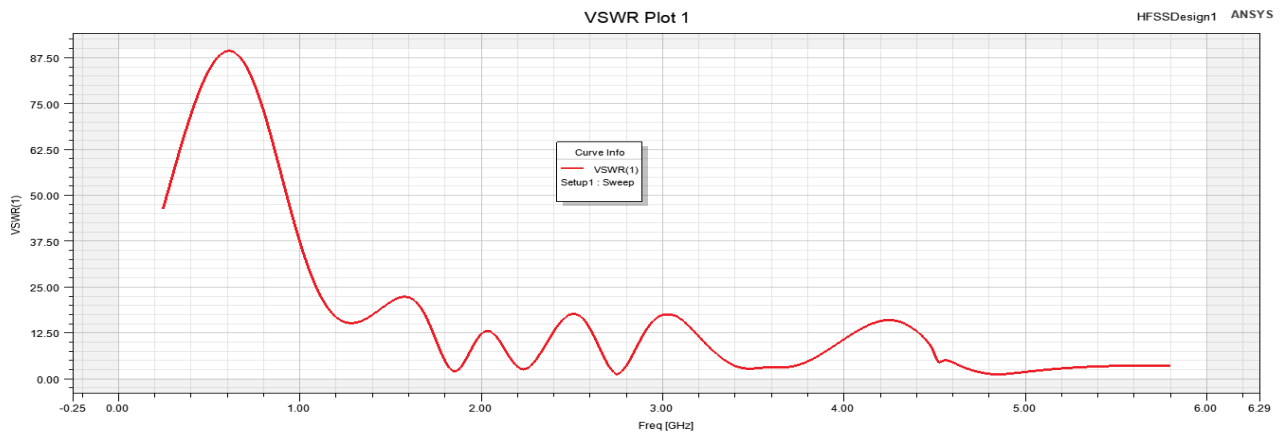


Fig 4.19 VSWR

VSWR stands for Voltage Standing Wave Ratio. It is a measure of the efficiency of power transmission between a radio frequency (RF) source and a load, such as an antenna. VSWR is defined as the ratio of the maximum voltage to the minimum voltage along the transmission line. When there is a mismatch between the impedance of the transmission line and the impedance of the load, some of the power transmitted by the source is reflected back towards the source. This results in a standing wave pattern along the transmission line, with maximum and minimum voltage points. The VSWR is the ratio of the maximum voltage to the minimum voltage along this standing wave. A VSWR of 1:1 means that there is no reflection of power and all the power is transmitted to the load. A VSWR of 2:1 means that the maximum voltage is twice the minimum voltage, indicating that 11% of the power is reflected back towards the source. As the VSWR increases, more power is reflected back, leading to lower efficiency and potentially damaging the RF source. VSWR is an important parameter in RF system design and is used to ensure maximum power transfer from the source to the load. It can be measured using a VSWR meter or by using an RF network analyzer to measure the S-parameters of the transmission line. VSWR is typically specified in antenna specifications and is an important consideration in the design and deployment of antennas for various applications.

4.3.7 GAIN PLOT

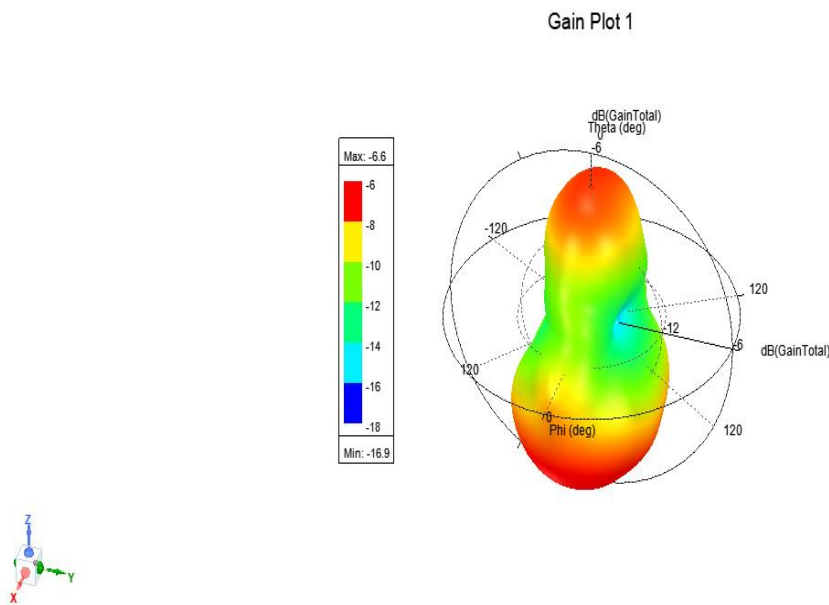


Fig 4.20 Gain Plot

An antenna gain plot is a graphical representation of the directional properties of an antenna, and it shows how effectively the antenna radiates energy in different directions. The gain plot typically shows the gain of the antenna in decibels (dB) versus angle, frequency, or both. The gain of an antenna is a measure of its ability to radiate energy in a particular direction, and it is usually expressed in dBi (decibels relative to an isotropic radiator). An isotropic radiator is a theoretical antenna that radiates equally in all directions. The gain of a practical antenna is typically higher than that of an isotropic radiator, and it can vary with the direction of radiation. The gain plot of an antenna shows the variation of antenna gain with angle, and it is typically measured in the plane perpendicular to the axis of the antenna. The plot can be in two or three dimensions, and it is usually displayed as a polar plot or a 3D plot.

Maximum gain plot = -6.6

Minimum gain plot = -16.9

CHAPTER 5

CONCLUSION

Thus the Microstrip patch antenna for in ISM band using four different applications have been designed and verified. The antenna is suitable for applications like mobile phone, tablet, smart watch and wifi router .. SAR reduction is performed by putting slots and changing the current distribution in patch and ground plane Antenna. The advantage of Polystyrene Foam is that it is available in Low cost and highly flexible & bearable. Also the amount of radiation experienced is compared low SAR rateing in india .Specific Absorption Rate (SAR) is a measure of the amount of radio frequency energy absorbed by the human body when exposed to electromagnetic waves. SAR values are important for assessing the potential health risks of using mobile phones, tablets, smartwatches, and WiFi routers. Microstrip patch antennas are commonly used in mobile phones, tablets, smartwatches, and WiFi routers due to their compact size and efficient radiation pattern. The SAR values of these devices depend on several factors such as the frequency of operation, the distance from the body, and the antenna design.

Studies have shown that the SAR values for mobile phones can vary widely depending on the specific make and model, the position of the antenna, and the distance from the body. Generally, SAR values are highest when the device is held close to the head or body, and decreases as the distance between the device and the body increases. The use of hands-free devices or speakerphone mode can also reduce the SAR values. Tablets and smartwatches typically have lower SAR values than mobile phones due to their larger size and the fact that they are not usually held directly against the body. However, SAR values can still vary depending on the specific device and the location of the antenna. WiFi routers typically have very low SAR values since they are designed to operate at a distance from the body. However, the SAR values can increase if the device is placed in close proximity to the body, such as in a pocket or on a lap. Overall, the SAR values of devices using microstrip patch antennas are influenced by several factors, and it is important for manufacturers to ensure that their devices comply with the SAR limits set by regulatory agencies to minimize potential health risks for users.

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APPENDIX

CERTIFICATE

