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# DESIGN AND ANALYZE WEARABLE MICROSTRIP PATCH ANTENNA WITH DIFFERENT FLEXIBLE SUBSTRATES FOR HEALTH MONITORING SYSTEM

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***ABSTRACT:***
In this paper, Design and analyze of wearable U- slot rectangular microstrip patch antenna (RMSA) using high frequency structure simulator (HFSS) and analyze their performance with different flexible substrate. The RMSA is designed using other flexible materials is such as Epoxy, Teflon, Polyethylene, Polyamide to manage operation frequency of 1.3-1.6GHz. The parameter like Return loss (S11), Bandwidth, Radiation pattern, gain and cost of antenna are analysed by keeping all substrates of same height(3.6mm).
***Keywords:*** *Wearable antenna, Flexible substrate, RMSA, U-slot rectangle microstrip patch antenna, HFSS software*

## I. INTRODUCTION

Health care is considered as inviolable human right and have given the most essential part of our daily routine which is taking some part of our expenditure. It is also affecting the public in many sectors because one needs to run hospital which affect time, traffic, finance and work. Not only the public sector it also affects the elderly person in most situations. So, to avoid such type of problems, one efficient and low cost technical solution is health monitoring system. This technology helps the patient to avail than a costly nursing home. So, in this regard, health monitoring system is considered as the key strategies for comfortable, good quality and low cost of health care. Wireless technology is the key factor health monitoring system. At the state of art, many solutions are there which identify different parameter and extract information looking to change in habitat behaviour. In the proposed system, it was presented that, a system consists of microwave radar sensor and a wirelessly connected base station for data processing which detects the change in indoor environment. Recently, research on wireless body area networks (WBANs) has been developed for both medical and non-medical field applications. Wearable antenna has drawn the attention as it is a center point for wireless sensor in biomedical application. The challenges behind antenna designing for health monitoring system and biomedical applications are to be planar, light weight, flexible, non-toxic and low cost. Wearable medical devices are used to measure the body signals like

- Electrocardiogram (ECG)
- Electroencephalogram (EEG) and
- Body temperature

There are many diseases such as hormonal imbalance, diabetes, tuberculosis, thyroid; patients suffer from unexpected weight gain or loss. In order to avoid such problems, patients need to take concern from doctor every time. When patient will use a weighing machine having wide band antenna with wireless sensor network facility, it is not required to go to hospital regularly as the status of health can be effortlessly observed at home. Biomedical devices in which antenna are used should be stretchable as it is used on wrist, near heart, on foot etc. Wearable antennas are mounted on patients' bodies (inside/outside on the clothes) for transmitting the patients' body parameters (such as body temperate, heart rate, etc.) and measured using various sensors/transducers. There are many challenges in designing and implementing wearable antenna on human body such as size and shape of antenna, flexibility, right placement of wearable antenna on body/cloth, good radiation patterns and impedance matching. In U-shaped slot patch antenna, band width and data rate are higher hence transmitting and receiving signal is faster. So it is suitable in wearable patch antenna. The factors which improve the performance of antenna depend upon the design and materials of the devices.

### 1.1 ANTENNA:

Antenna is an electrical device which convert electrical power into radio waves and vice versa without an efficient antenna, EMF (electromagnetic energy) would not be radiation and wireless communication over the long distance would be impossible. Antenna can be design to transmit and receive radio waves in all horizontal direction equally (omni directional or antennas), or preferentially in particular direction called directional or high gain antennas. Radio waves are electromagnetic waves are electromagnetic waves which carry signals through the space or air at the speed of light with almost no transmission loss. Radio transmitters and receivers are used to convey signals (information) in systems.

### 1.2 ANTENNA PARAMETER:

#### 1.2.1 Radiation pattern:

Radiation pattern is a mathematical function or a graphical representation of the radiation properties of the antennas as a function of space coordinates. The radiation properties include properties power flux density, radiation intensity, field strength, directivity, phase or polarization. Various parts of a radiation pattern are referred to as lobes.
Major lobe-it is defined as the radiation lobe containing the direction of maximum radiation.
Minor lobe - all lobes except the major lobe are called as minor lobe.
Side lobe - it is adjacent to the main lobe and occupies the hemisphere in the direction of main lobe.
Back lobe – it occupies the hemisphere in a direction opposite to that of major lobe

#### 1.2.2 Gain:

Gain is the ability of the antenna to concentrate the radiation power in a given direction or conversely to absorb effectively then incident power from that direction. **G=(power radiation by an antenna)/(power radiation by reference antenna)**.Gain denotes the concentration of energy; the high values of gain are association with narrow beam width

#### 1.2.3 Directivity and Bandwidth:

The directivity of an antenna is defined as the measure concentrated power radiation in a particular direction. It may consider as the capability of an antenna to direct radiation power in a given direction.

$$D = \max\left(\frac{U}{P_{tot}/(4\pi)}\right) \quad (1.1)$$

$$= \frac{U(\theta,\emptyset)|max}{\frac{1}{4\pi}U(\theta,\emptyset)sin\theta d\theta d\emptyset} \quad (1.2)$$

It can also note as the ratio of the radiation intensity in a given direction to the average radiation intensity. Bandwidth is one of the desired parameters to choose an antenna. It can be defined as the range of frequencies over which an antenna can properly radiates energy and receives energy.

#### 1.2.4 S-Parameter:

Linear two port networks are characterized by a number of equivalent circuit parameter, such as their transfer matrix, impendence matrix, admittance matrix, scattering matrix. The matrix elements S11, S12, S21 and S22 are the S-parameter. The parameter S11, S22 have the meaning of reflection coefficient, and S11, S21 have the meaning of reflection coefficient, and S12, S21 the meaning of transmission coefficient

## II. PROPOSED SYSTEM:

The different flexible substrate like Epoxy, RT Duroid, Polyamide, Teflon and Polyethylene are used for designing for RMSA with HFSS SOFTWARE to operate in 1.3GHz resonant frequency and their performance are analysed and compared for health monitoring system. In the proposed system, Rectangular Microstrip Antennas **(RMSA)** various application in different medical and non-medical fields. Generally RMSA antennas has its narrow bandwidth which can be resolved by using U-shaped slot on radiating patch and it is best suitable structure for patch antenna. Designing the RMSA antennas with different substrate in same height with help of the simulation we can find which substrate is more suitable for biomedical application. Calculating the parameter such as S11, Gain, Radiation pattern and Bandwidth

### 2.1 Properties of different substrate:

The different flexible substrate like Epoxy, Polyethylene, Polyamide, RT Duroid, Telfon are used in designing the RMSA and their properties are represented in table.

TABLE 1 PROPERTIES OF DIFFERENT SUBSTRATE

| Substrate | Dielectric constant ($\varepsilon_r$) | Loss tangent ($tan\delta$) | Operating frequency (GHz) | Height (mm) |
|---|---|---|---|---|
| Epoxy | 4.2 | 0.02 | 1.35 | 3.6 |
| Polyamide | 2.25 | 0.001 | 1.35 | 3.6 |
| Polyethylene | 4.3 | 0.004 | 1.35 | 3.6 |
| RT Duroid | 2.2 | 0.0009 | 1.35 | 3.6 |
| Teflon | 2.1 | 0.001 | 1.35 | 3.6 |

Table 1 displayed the dielectric constant (), loss tangent () and height(3.6mm) with in the operating frequency of 1.35GHz

### 2.2 Design and Dimensions:

In this paper, a rectangular microstrip patch antennas having resonant frequency at 1.35GHz are designed on flexible substrate using HFSS software. In our work, a simple patch antenna with **U-shaped** slot is designed by taking different types of flexible substrates and various antenna parameters are analyzed. By using transmission line model, the length (L) and width (W) of the patch, effective dielectric constant ($\varepsilon_{reff}$)and the substrate dimensions etc. are calculated. Width and length of the patch can be calculated by using following parameters

#### 2.2.1 width of patch(wp):

$$W = \frac{C}{2f_0\sqrt{\frac{(\varepsilon_r+1)}{2}}} \qquad (2.1)$$

Where, C is presenting speed of the light in free space and $f_0$ is the operating frequency.

#### 2.2.2 Effective dielectric constant ($\varepsilon_{reff}$):

Fringing field has importance to obtain the effective dielectric constant($\varepsilon_{reff}$) As the fringing field in the region of the radiating patch is not restricted within the substrate so value of dielectric constant ($\varepsilon_r$) is more than the effective constant ($\varepsilon_{reff}$).To calculate the effective dielectric constant the following equation is given.

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}[1 + 10h/w]^{-\frac{1}{2}} \qquad (2.2)$$

where, w (mm), h (mm) and ($\varepsilon_r$) are width, height and dielectric constant of the substrate respectively.

#### 2.2.3 Length of patch(lp):

The length of the radiating patch determines the operating frequency so it is an important factor to design the antenna. Length of the patch(lp) is calculated as

$$l_{eff} = \frac{C}{2f_0\sqrt{\varepsilon_{reff}}} - 2dl \qquad (2.3)$$

Where, dl is the extended length and the extension is due to the fringing field and expressed as

$$(dl)=0.421h\frac{(\varepsilon_{reff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{reff}-0.258)(\frac{w}{h}+0.8)} \qquad (2.4)$$

#### 2.2.4 Substrate dimensions (ls and ws):

Dimensions like length and width ($l_g$ and $w_g$) of both the substrate and ground plane depends upon the dimension of patch and height of the substrate which can be calculated from the next equation

$$Ls=l+6h \text{ and } Ws=w+6h \qquad (2.5)$$

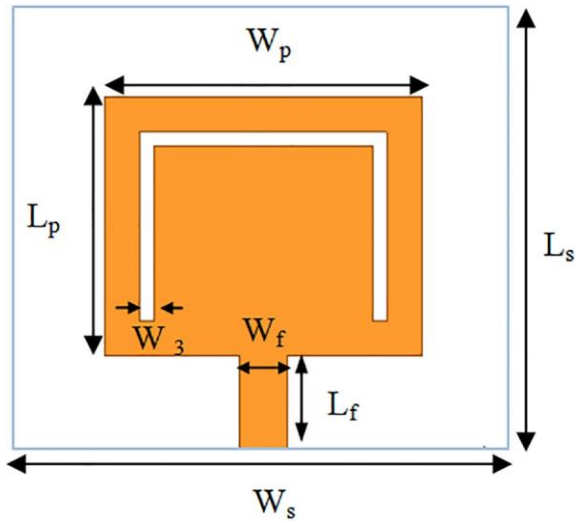
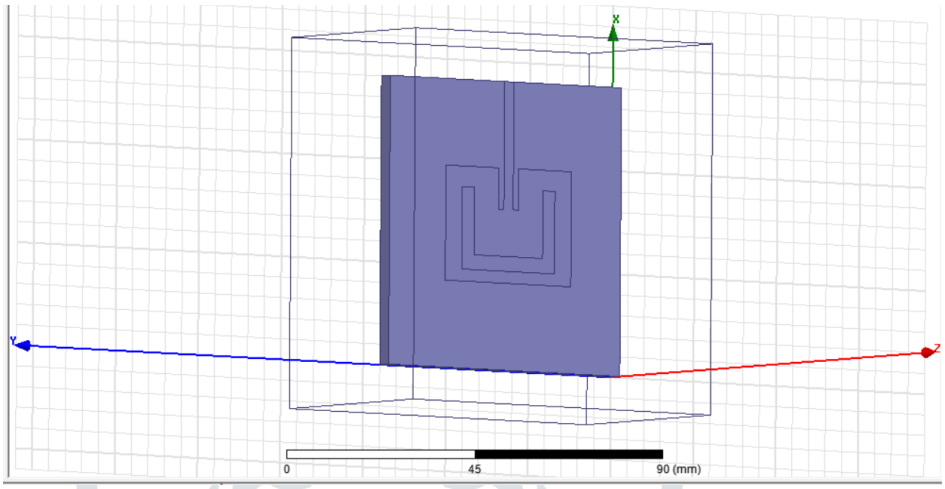



**Fig 1** Geometrical View of Proposed Antenna

TABLE 2 DIMENSION OF SUBSTRATE

| PARAMETER | DESCRIPTION | PHYSICAL SIZE(mm) |
|---|---|---|
| *Ws* | Width of substrate | 70 |
| *Ls* | Length of substrate | 70 |
| *Wp* | Width of patch | 28 |
| *Lp* | Length of patch | 38 |
| *Wf* | Width of feedline | 2.8 |
| *Lf* | Length of feedline | 33 |
| *W3* | Width of the U-slot | 3.6 |

### 2.2.5 Designed Microstrip Antenna




## III. SIMULATION RESULTS AND DISCUSSION

The rectangular microstrip patch antenna (RMSA) with U- shaped slot has been designed, simulated and optimized by HFSS software and the results are analyzed. The design of antenna generated by HFSS software having all the dimensions has shown in. Reflection coefficient ($S11 \leq -10db$), radiation pattern (for phi =0° *and* 90°), gain and bandwidth have analyzed and discussed for each antenna with different flexible substrates. The proposed flexible antennas are chosen to operate at 1.3 GHz operating frequency. Here the intention is to analyze the simulation-based results.

### 3.1 Return loss:

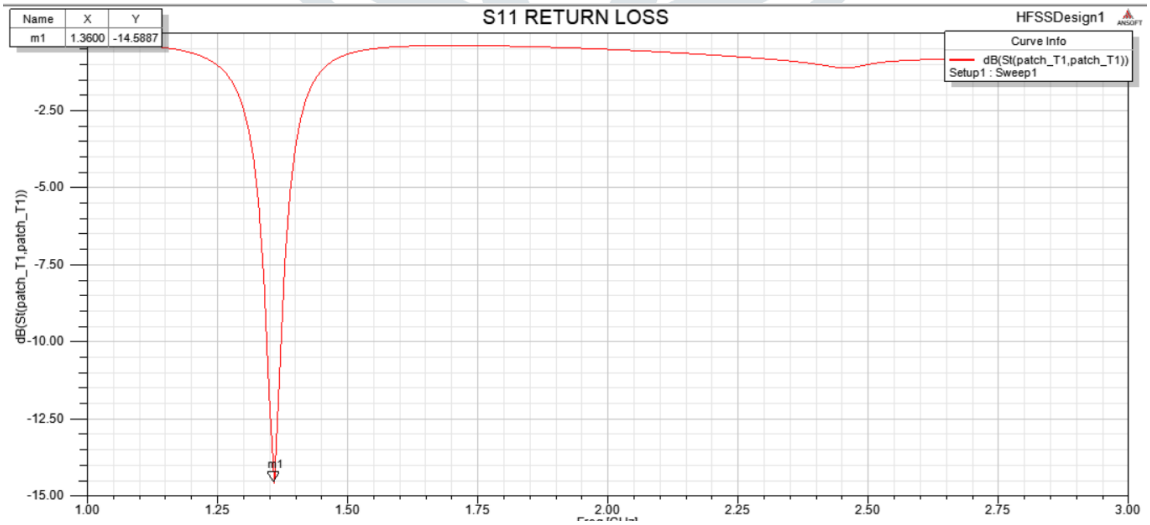



**Fig 2** Return loss of Epoxy

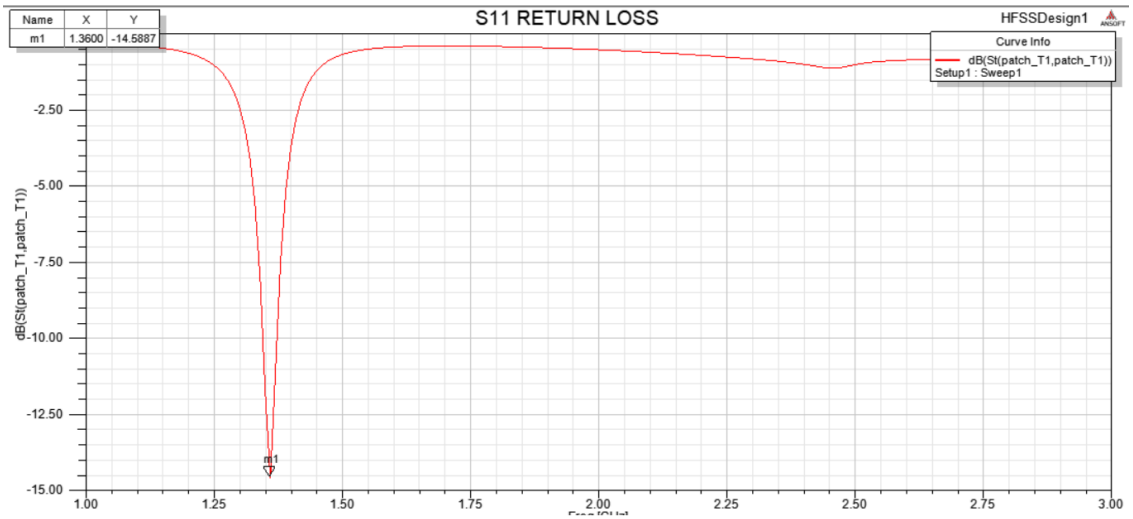



**Fig 3** Return loss of polyamide

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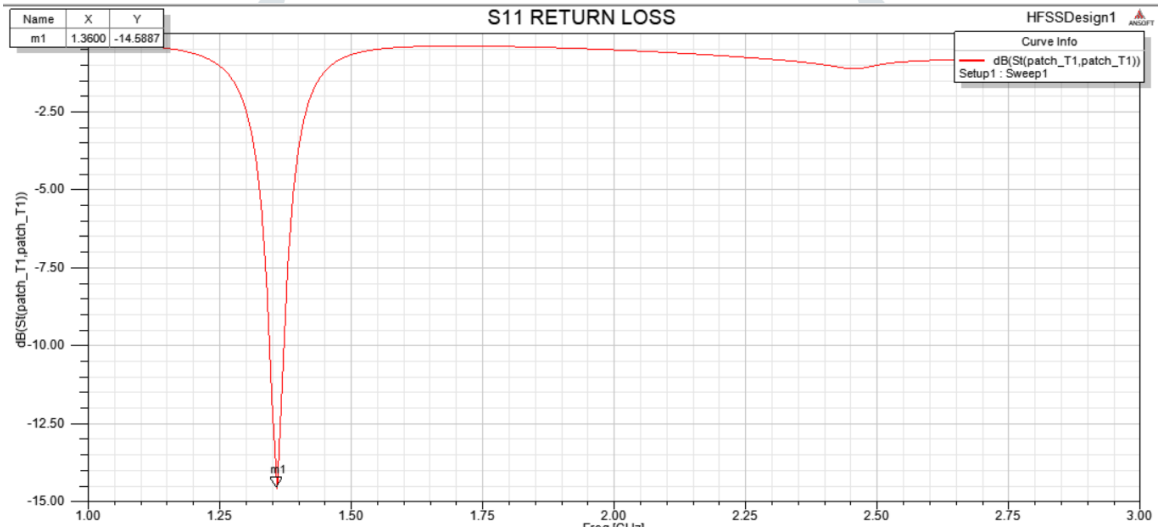



**Fig 4** Return loss of polyethylene

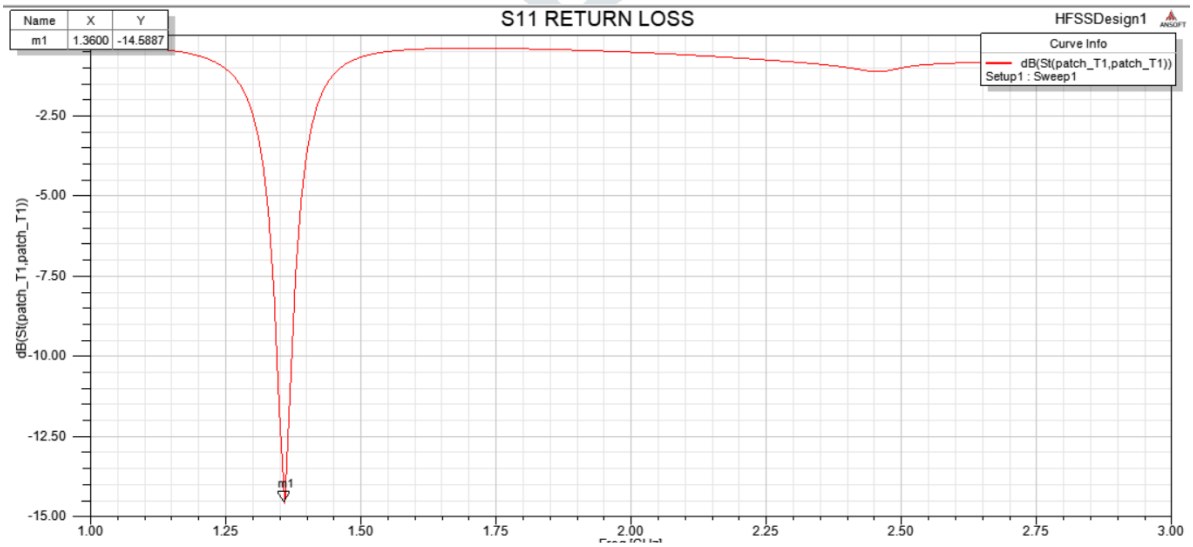



**Fig 5** Return loss of RT Duroid

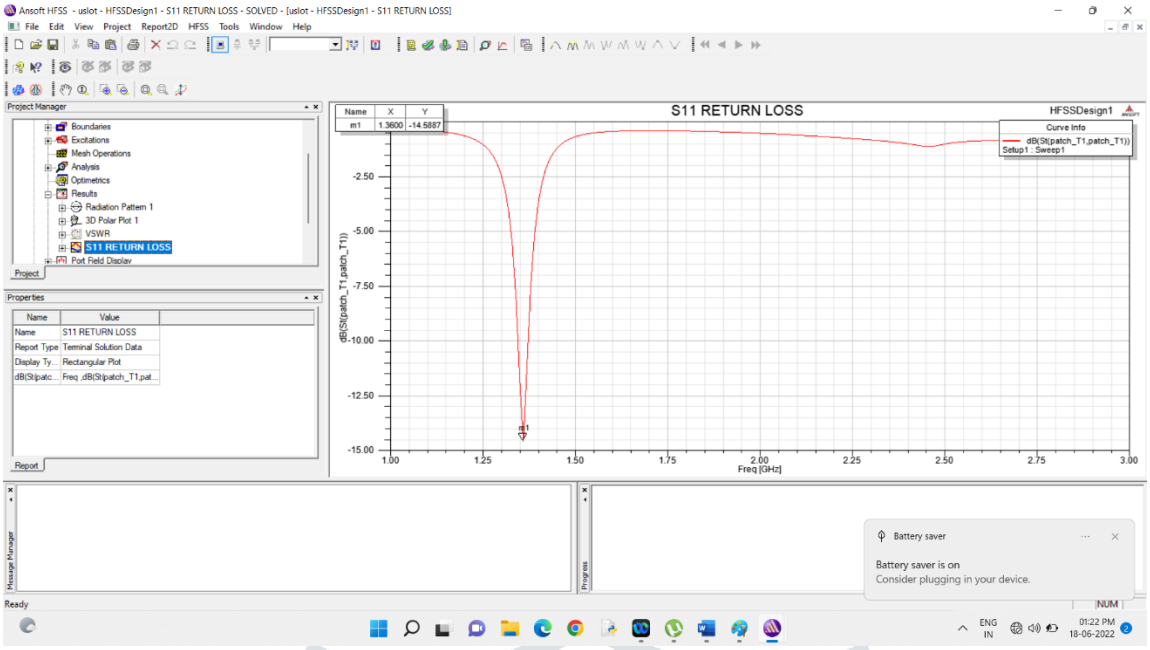



**Fig 6** Return loss of Teflon

### 3.2 Radiation pattern

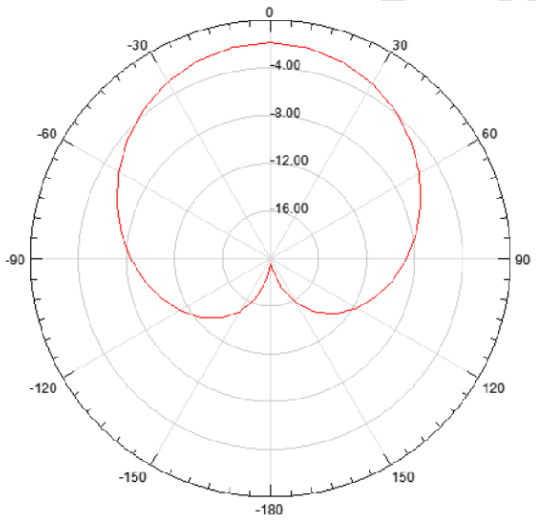



**Fig 7** Radiation pattern of Epoxy

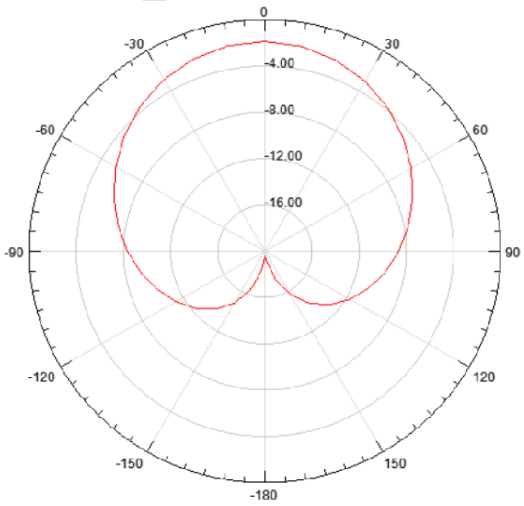



**Fig 8** Radiation pattern of Polyamide

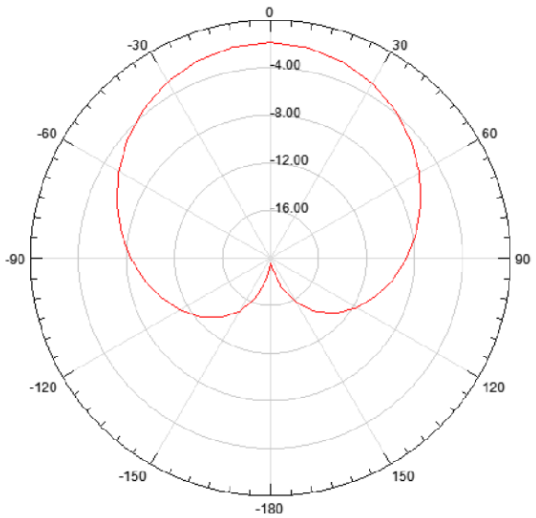



**Fig 9** Radiation pattern of Polyethylene

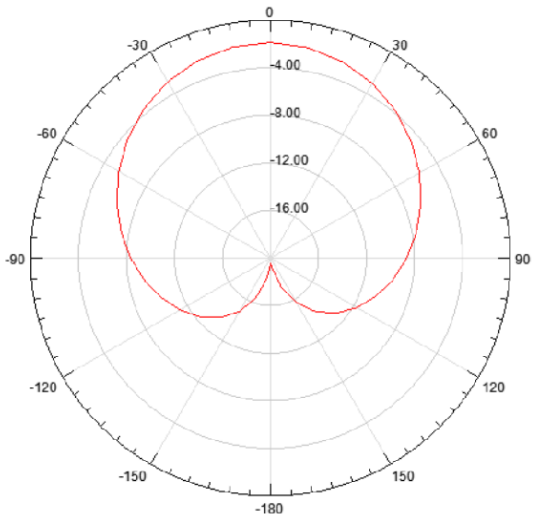



Fig 10 Radiation pattern of RT Duroid

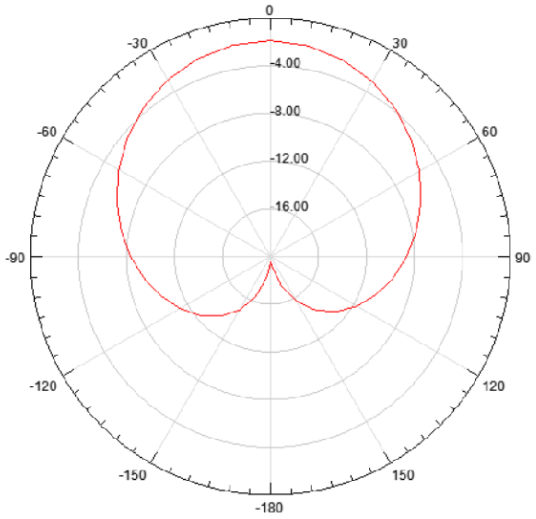



**Fig 11** Radiation pattern of Teflon

TABLE 3 PEFORMANCE COMPARSION OF DIFFERENT SUBSTRATE

| SUBSTRATE | OPERATING FREQUENCY(GHZ) | BANDWIDTH(MHz) | RETURN LOSS (dB) |
|---|---|---|---|
| Epoxy | 1.36 | 90 | -14.36 |
| Polyamide | 1.36 | 53 | -10.06 |
| Polyethylene | 1.36 | 56 | -15.63 |
| RT Duroid | 1.36 | 38 | -15.97 |
| Teflon | 1.36 | 45 | -18.65 |

## IV. CONCLUSION

Epoxy material is used as substrate for microstrip patch antenna using high frequency structure simulator (HFSS). Substrate has main role in MSA as it gives support to the patch and maximum antenna parameters depend upon the substrate type. In flexible and stretchable antennas, the quality of flexibility depends on the type of substrates used in designing antenna which can be enabled by approaching new materials with structural designs. By the process of doping, dielectric constant value of the dielectric materials can be changed as per application. In this paper Epoxy found as the most suitable substrate for biomedical application because of its physiological inertness, good blood compatibility, low toxicity, good thermal, chemical and oxidative stability properties. Due to wide bandwidth features of the antenna with Epoxy substrate, it can be used for remote health monitoring system. As the loss tangent value of Epoxy is more resulting low gain. From the simulations it is observed that the antenna is matched with the transmission line and more power is delivered. Hence Epoxy materials can be used as advanced electronics materials in devices. Flexible MSA are mostly used in case of biomedical applications like remote health monitoring, glucose monitoring, self monitoring and digestive monitoring.

## V. FUTURE SCOPE

The Designed antennas can be used as Wearable antenna. The importance of wearable antennas has gained importance for healthcare and monitoring purpose application. Utilization of flexible materials for the development of microstrip antennas segment has been rapid due to the recent miniaturization of wireless devices. The wearable antennas are special class of antennas that are partially or entirely made out of flexible in contrast to conventional antennas. The use of wearable antennas is increasing rapidly in wireless application

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