

# **DESIGN OF A RF ENERGY HARVESTING ANTENNA FOR WOMEN SAFETY APPLICATIONS**

*Dissertation submitted in partial fulfilment of the requirements for the Degree  
of*

## **MASTERS OF TECHNOLOGY**

By

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UNDER THE GUIDANCE OF

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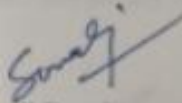
# TABLE OF CONTENTS

INNER FIRST PAGE	i
DECLARATION BY THE SCHOLAR	iv
SUPERVISOR'S CERTIFICATE	v
LIST OF FIGURES	vi
LIST OF TABLES	vii
LIST OF ACRONYMS AND ABBREVIATIONS	viii
ACKNOWLEDGEMENT	ix
ABSTRACT	x
CHAPTER- 1	
INTRODUCTION	1
1.1 PRINTING TECHNOLOGIES	4
1.1.1 3D PRINTING	5
1.1.2 INKJET PRINTING	5
1.1.3 EMBROIDERED ANTENNAS	6
1.1.4 THIN AND UNIFORM METALLIZATION	7
CONDUCTIVE SECTION	
1.2 AMBIENT ENERGY SOURCES	9
1.2.1 SOLAR POWER	9
1.2.2 THERMAL POWER	9
1.2.3 MECHANICAL POWER	10
1.2.4 AMBIENT RF ENERGY	10
1.3 ANTENNA TYPES	11
1.3.1 HALF WAVE DIPOLE ANTENNA	11
1.3.2 PIFA	12
1.3.3 INVERTED F ANTENNA	13
1.3.4 M SLOT FOLDED ANTENNA	13
CHAPTER- 2	
LITERATURE REVIEW	15

2.1 WOMEN's SECURITY	15
2.2 WEARABLE ANTENNA	15
2.3 ENERGY HARVESTING TECHNOLOGY	16
2.4 FABRICATION TECHNOLOGY	18
CHAPTER-3	
METHODOLOGY	19
3.1 MATLAB	19
3.2 CST MWS	22
CHAPTER- 4	
RESULT AND DISCUSSION	23
4.1 MATLAB RESULT	24
4.2 CST RESULT	26
CHAPTER-5	
CONCLUSION AND FUTURE SCOPE	28
CHAPTER-6	
REFERENCES	29

## DECLARATION BY THE SCHOLAR

I hereby declare that the work reported in the M-Tech thesis entitled "**DESIGN OF A RF ENERGY HARVESTING ANTENNA FOR WOMEN SAFETY APPLICATIONS**" submitted at **Jaypee University of Information Technology, Waznaghat India**, is an authentic record of my work carried out under the supervision of **Dr. Ashwani Sharma** I have not submitted this work elsewhere for any other degree or diploma.



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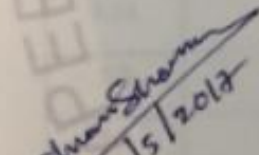
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### CERTIFICATE

This is to certify that the work reported in the M.Tech project report entitled "DESIGN OF ARF ENERGY HARVESTING ANTENNA FOR WOMEN SAFETY APPLICATIONS" which is being submitted by **Sonali Rana** in fulfillment for the award of Masters of Technology in Electronics and Communication Engineering by the Jaypee University of Information Technology, is the record of candidate's own work carried out by her under my supervision. This work is original and has not been submitted partially or fully anywhere else for any other degree or diploma.

  
11/5/2017

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विद्या तत्व ज्योतिसमः

## LIST OF FIGURES

<b>Figure Number</b>	<b>Caption</b>	<b>Page Number</b>
1.1	Stun gun with flashlight	2
1.2	Pepper spray	2
1.3	Wireless body centric communication	4
1.4	Slot antenna made from 3D textile material	5
1.5	Patch antenna fabrication through ink-jet printing	6
1.6	Embroided antenna patch	7
1.7	Wearable antenna, self-adhesive copper tape	8
1.8	Half wave diploe antenna	12
1.9	PIFA	12
1.10	Inverted f antenna	13
1.11	M slot antenna	14
3.1	Flow chart of differential optimization in MATLAB	20
3.2	Belt dimension	21
4.1	Width of antenna after optimization	24
4.2	Length of antenna after optimization	25
4.3	Antenna design in CST	26
4.4	S11 parameter for antenna design	27

## LIST OF TABLES

<b>Table Number</b>	<b>Caption</b>	<b>Page Number</b>
1.1	Comparison of various power sources and harvested power	8-9

## **LIST OF ACRONYMS & ABBREVIATIONS**

BW	Bandwidth
CST MWS	Computer Simulation Technology Microwave Studio
DC	Direct Current
dBm	Decibel-mill watts
EM	Electromagnetic
GPS	Global Positioning System
GSM	Global System for Mobile communications
HF	High Frequency
MATLAB	Matrix Laboratory
PIFA	Planar inverted F antenna
RL	Return Loss
RF	Radio Frequency
RFID	Radio Frequency Identification
SAR	Specific Absorption Rate
UMTS	Universal Mobile Telecommunications System
UWB	Ultra-wideband
WBAN	Wireless Body Area Networks
WSN	Wireless sensor networks



## **ACKNOWLEDGEMENT**

In the following lines, I would like to thank those people, who I consider more important at this stage, without their emotional support this project would not have been possible. First to thank my parents and my brother, for their support and total confidence, for being a motivation and example for me, for encouraging me to do things that I can feel proud of. I would also like to thank my supervisor Dr. Ashwani Sharma and Dr. Pradeep Chauhan who helped me throughout. To all the friends I have known over the course of this project, thank you for helping me selflessly and of course the almighty for always being there.

Thank you so much.

## **ABSTRACT**

The main objective of this project is to design an antenna at 900MHz frequency band and see the S11 parameter after optimization of the dimensions of the antenna in MATLAB using differential optimization method. This antenna can be further fabricated on a leather belt of known dimensions using copper tape for the patch and ground plane and FR4 lossy material as a substrate. We tried to use leather as a substrate but the losses were far bigger. Once this antenna is designed it can be further made manually and then connected to a rectifier for conversion of the AC into DC and possibly an antenna array of the designed antenna can be used to harvest the required power to drive any small device such as a portable GPS.

# CHAPTER 1

## INTRODUCTION

Empowerment of women is empowering women to take their own choices for their individual dependent. Women empowerment is to make them self-governing in all aspects from mind, believed, rights, and choices by leaving all the communal and family limitations. This is done in order to bring impartiality in the society for both male and female in every area. Women empowerment is very essential to make positive future of the family, culture and country. Women need new and a more accomplished atmosphere so they can take their own correct choices in all walks of life whether for themselves, family, civilisation or country. To make nation developed empowerment of women is a vital way to approach development. Status of women in India has gone through several changes through many years. From alike standing with men in olden times to promotion of equivalent rights by many protestors, history of women in India has been momentous. Today's India, women have adorned high offices including that of the President, Prime Minister, Leader of the Opposition and Speaker of the Lok Sabha but still women continue to face several challenges and often are fatalities of abuse and vicious crimes. According to a global poll conducted by Thomson Reuters, our country is "fourth most dangerous country" in the world for women, and most horrible country for women among the G20 [group of developing industrial Nations] countries. Every day more than 30 women are killed and many are suffering serious emotional and physical suffering.

So we need to ensure safety of women by self-defence. In today's world appreciatively quantity of safety and security devices and equipment's are available such as safety rod, stun gun, pepper spray etc. Besides these equipment's there are also other devices which work on the principle of wearable technology and are much more efficient in providing security for women. These devices are also not very popular these days as they are considered to be outdated and new and better technologies have taken over which are far more efficient in providing security to women without being detected. Although these technologies are costly but their failure rate is very less and security provided is more. Several technologies uses antennas as a base for the development of these devices and as they are were able different fabrication schemes are used.



Fig1.1: Stun gun with flashlight [<http://www.hobbr.com/self-defense-products-for-women/>]



Fig1.2: Pepper spray [<http://www.hobbr.com/self-defense-products-for-women/>]

The Clothing and fixtures including computer and innovative electronic technology, known as wearable technology has seen growth in leaps and bounds over the past decade. The wearable gadgets is a group of devices that can be used by a user and include tracing statistics related to health and fitness. Other wearable gadgets include small motion sensors to take photos and synchronise with mobile devices. These Wearable device are not only providing physiological monitoring information but are also being implemented for personal safety. Progress in wireless wearable technology is being slowly directed towards recording and tracking personal safety information. While mobile technology has been developing systems to alert loved ones and the law enforcement. In any wearable technology the antenna is one of the most important part especially in women safety devices.

Wearable Antennas are antenna that are precisely intended to work while being worn. Which include smart watches, glasses. These body worn antennas are becoming common in user electronics. WBAN applications have sustained an intense development starting from the early years of the millennium, with a marked increase in the last three-four years due to the emergence of wearable mobile gadgets. In on- and off-body communication links for security, medical, sports or entertainment applications are required. Depending on the application, very different requirements exist for the communication link: for military and security applications for instance a large

Communication range and a high reliability are of paramount importance whereas for entertainment the range might be short or very short but the data rate has to be high. All these requirements have however one thing in common: They ask for an antenna having the highest possible radiation by taking in account of the losses in the environment.

Wireless communication by body in PAN, BAN can be categorised as off-body, on-body, in-body as shown in Fig. 1.3. In this class of communication from off-body to an on-body device or to the system. Second discussion leads to the wireless communication relation within the on-body networks and the wearable systems. The third class is communication to medical implants and sensor network wirelessly.

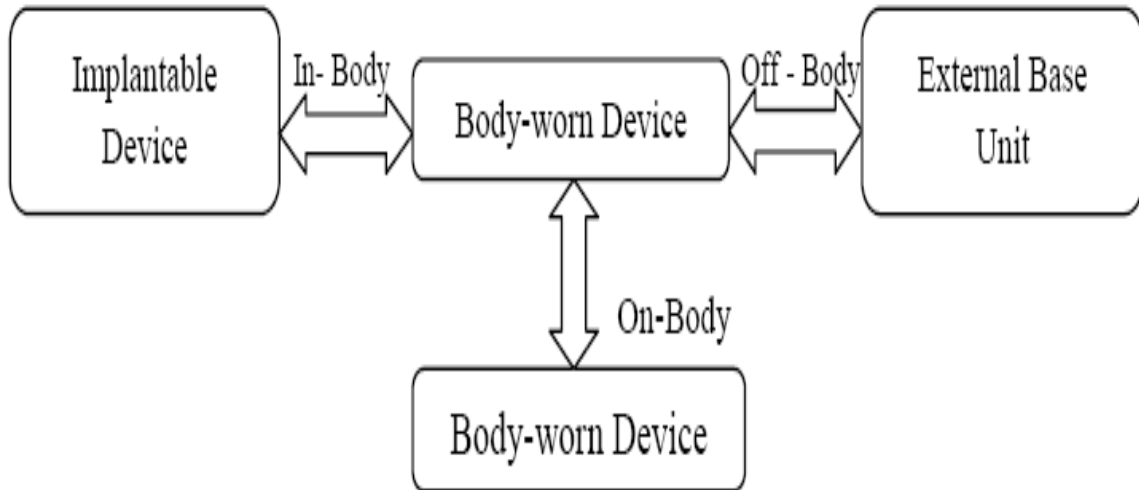


Fig1.3: Wireless body-centric communication[//www.hindawi.com/journals/js/2016/5725836/]

Following design rules can be derived for the design of wearable antennas:

- In theory, it would be better to use antennas orthogonal to the body than antennas parallel to them. As a low profile is usually desired, this is often unpractical.
- Use a ground plane to shield the phantom from the radiated fields. This is the most efficient measure that can be taken, but is not always possible (in the case of UWB antennas for instance, or if space is limited).
- If the ground plane is small with respect to the wavelength as in electrically small antennas, there will be radiating currents on the ground plane. These should be controlled in order to avoid not only radiation into the phantom, but also and more importantly near field coupling into the lossy tissues of the phantom.
- Special care should be taken to the feed design, which is often a location where strong near fields occur. Again, coupling to the lossy phantom tissues should be avoided.

In the case of implantable antennas, we can add the following design rule:

- For implanted antennas, where possible, one should use lossless enclosure for the antenna, designed to contain as much as possible of the near-field.

**1.1 PRINTING TECHNOLOGIES-** Unlike other non-wearable antennas the manufacturing process involved in these antennas are different. The antennas are fabricated

onto a substrate using the following fabrication technology. The main technologies are given below:

**1.1.1 3D PRINTING-** 3D printing, is a stirring technology that is very useful in many fields. 3D printing allows many shapes to be shaped with geometries which are impossible using predictable methods. Additionally, by changing the inner construction, we can also change dielectric properties. 3D Printing has a speedily increasing palette of ingredients. They have been designed for their physical properties and are highly flexible. It is assembly quite a large interest in terms of its impending in case of electromagnetic applications. Other materials have low loss tangents at microwave frequencies. Fresh improvements have allowed complex materials with enhanced permittivity and permeability and printed. 3D Printing permits the shape to get changed so that the designers of antenna are not any longer forced to flat out the substrates. Beneath the antenna patch electric fields are not even so there is a possibility for extra grades of liberty by altering the geometry.

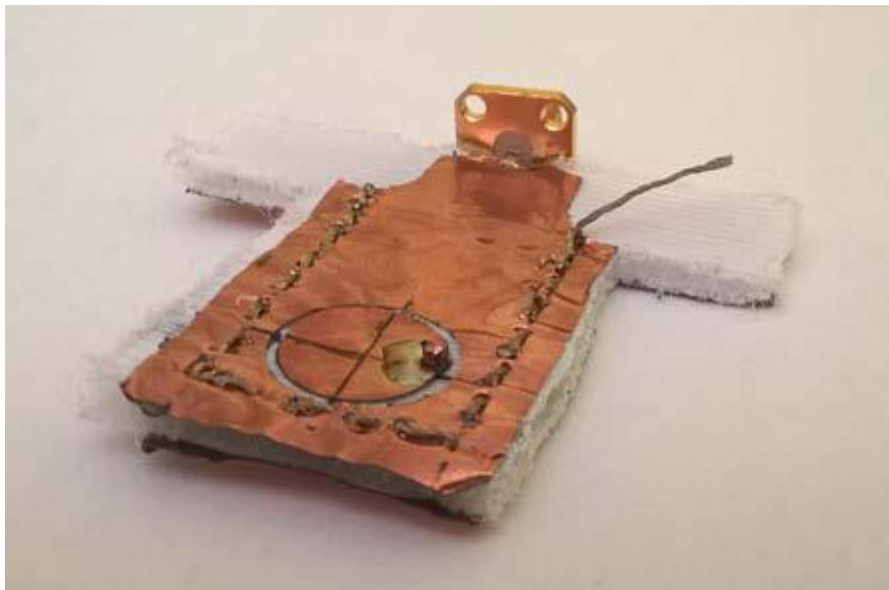


Fig1. 4: slot antenna made from 3D textile material [Wearable Antennas: Comparison of Different Concepts]

**1.1.2 INKJET-PRINTING** - Inkjet printing is another technique. It has the benefits that it does not need a mask and has high resolution. But the width of the conductor is constrained to approx. 1 micron. It means that it is very hard to print it on textile material that are absorbent in nature and a high degree surface unevenness as compared to metallization width.

Conductivity of ink is around one MS/m. So it is difficult to do inkjet printing at lower frequency and attain practical efficiency. One method of avoiding surface roughness is to first screen print boundary on top of fabric. It will provide even surface to the inkjet printer antennas.

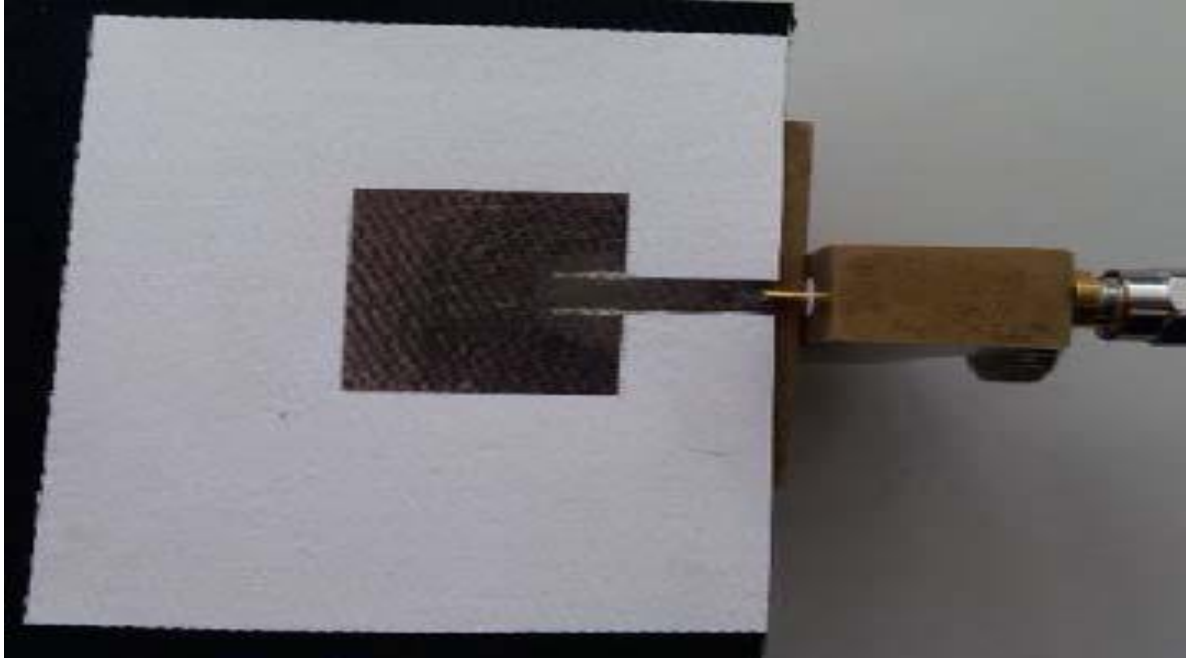


Fig1. 5: Patch antenna fabrication through ink-jet printing [Wearable Antennas: Comparison of Different Concepts]

**1.1.3 EMBROIDED ANTENNAS** – Embroider antenna is a striking technique for wearable technology. Special conducting threads are used that include a core of polymer and also a silver / nickel outer coatings present. These are made for the purpose of their conductivity and should be held with care. Benefits of using embroidery are not needing glue, single work process and appropriateness for large scale manufacturing. The thread is quite expensive but the cost is likely to decrease. Resolution of the embroidery technology is about 0.5 mm which means limitation in terms of frequency maxima. The coat of metal is quite thinner than thread diameter. It is also somewhat made of nickel to get adhesion and that is why conductivity is less than copper. So frequency range is restricted by skin depth at the lesser frequency and attainable resolution at larger frequency. The direction in which stitching is done is important. The current likes to travel along the thread other than than jumping from thread to thread. So, the direction of stitch should be parallel to the direction of flow of current to get largest efficiency. The Patch antennas are two dimensional structures and current supports on surface in two direction. That is why patch antenna are not good



forembroidery. Linear antennas like spiral, fractal antennas are somewhat good applicants for embroidery for the optimization and reducing the length of thread.

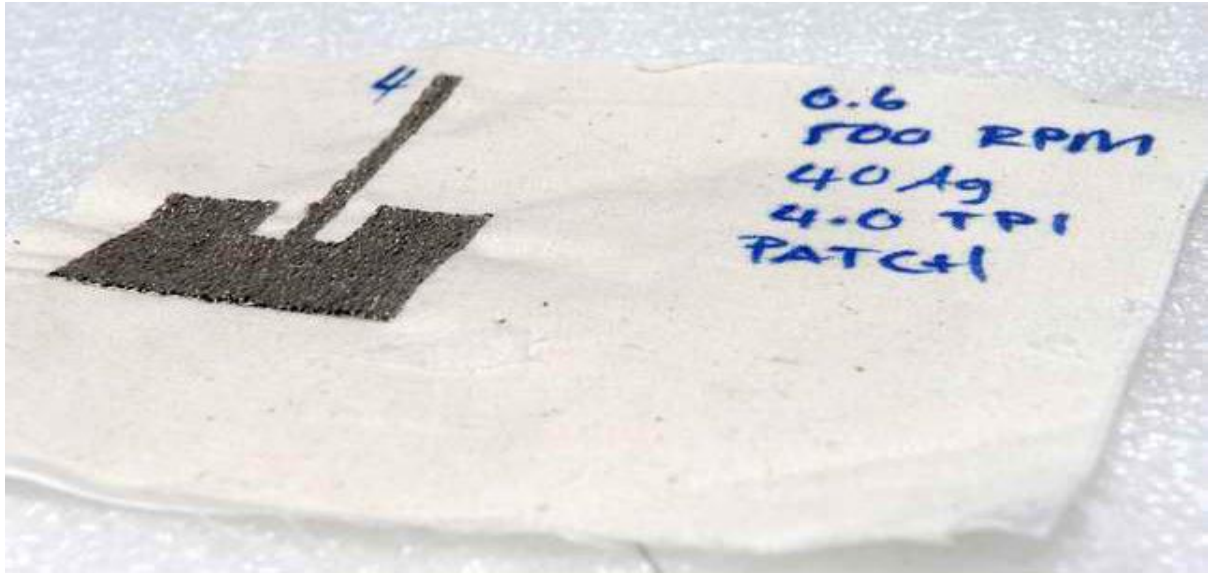


Fig1.6: Embroidered antenna patch [Electronics 2014, 3,314-338; doi: 10.3390/electronics3020314]

**1.1.4 THIN AND UNIFORM METALLIZATION CONDUCTIVE SECTION-** This is a method which is fastest for the manufacture of one or small number of antennas but in case of mass production of antennas it is perhaps slower than rest of the techniques for its manual work which is required and consumes more time. Usually, the method is sensible for untried antennas prototype but it may not be appropriate for long term answers. It is very easy to stick a copper tape or foil on substrate but it is also likely that the copper tape may get separate while bending or due to the environment conditions such as heat or humidity .A solution to circumvent is having the antenna permanently to be stick on the clothing is to use Velcro connectors.



Fig1.7:Wearable antenna, self-adhesive copper tape [Wearable Antennas: Comparison of Different Concepts]

Using these fabrication technique we can implement the antenna design for wearable technology. Most of the wearable women safety devices available in the market use a non-rechargeable battery which is not desirable most of the times. One solution to overcome this problem is use energy harvesting and develop energy harvesting antennas.

The use of renewable energies to power electronics devices is not a new concept. The process of extracting energy from the ambient environment to generate electricity is termed as energy harvesting or energy scavenging. This energy can be harvested from various sources available in the ambient environment such as thermal energy, mechanical energy, and radiant energy.

	Solar Energy	Thermal Energy	Ambient RF Energy	Piezoelectric Energy	
				Vibration	Push Button
Power Density	100Mw/cm <sup>2</sup>	60uW/cm <sup>2</sup>	0.0002-1uW/cm <sup>2</sup>	200uW/cm <sup>2</sup>	50uJ/N
Output	0.5V	-	3-4V	10-25V	100-10000V

Available Time	4-8Hrs	Continuous	Continuous	Activity Dependent	Activity Dependent
Pros	Large amount of energy	Always available	Antenna can be integrated onto frame and Widely available	Light weight and Well developed	Light weight and Small volume
Cons	Need large area	Low power	Distance dependent	Need large area	Low conversion efficiency

Table1.1: comparison of various power sources and harvested power

## 1.2 AMBIENT ENERGY SOURCES-

Numerous available renewable ambient energy sources exist in nature:

**1.2.1 SOLAR POWER-**It is the most frequently used source for high power. Solar power has highest power density of hundred mW/cm<sup>2</sup>. Photovoltaic technique has seen quiet large development over sixty years after 1<sup>st</sup> silicon based solar cell was verified and its physical and electrical properties keep on refining. The power calculated is resolute by the dimension of the solar panel and a number of values of the voltage and current can be made by regulating the size. But, a solar panel needs a comparatively large area to gather adequate amounts of ambient solar power because of its low adaptation efficiency 0%–40%, and the alignment is perilous for collecting solar power.

### 1.2.2 THERMAL POWER-

Electrical power is made through manipulating temperature difference in the thermoelectric devices by making use of thermoelectric effects. In the opposite manner, thermoelectric material makes the temperature change if voltage applied. A thermoelectric phenomenon also is used for temperature sensor in addition for its Energy-harvesting uses. The thermoelectric

generator harvests a energy density of order  $20\text{--}60 \text{ } \mu\text{W}/\text{cm}^2$  as it uses human body for the heat source at a room temperature given as  $18 \text{ } ^\circ\text{C}\text{--}25 \text{ } ^\circ\text{C}$ . The Thermoelectric devices function uninterruptedly as long as there exist temperature difference among them, they are typically inflexible and weighty as equated to rest of the energy-harvesting devices, like the solar cell. In case of the thermoelectric energy-harvesting devices characteristically they need comparatively huge form factor when comes to the volume to create valuable quantities of the power.

**1.2.3 MECHANICAL POWER**-In this case piezoelectric phenomenon creates voltage or current due to the mechanical strain due to the quivering or distortion. The piezoelectric related energy harvesting devices keep on making power as long as there is non-stop motion which is mechanical which include acoustic noise, wind or periodically create power for the irregular straining like in case of human motion. Characteristic production power density value is of the range of piezoelectric materials about  $250 \text{ } \mu\text{W}/\text{cm}^3$  but they can produce large power also if the motion or deformation is strong. In case of piezoelectric energy harvesting or transducers which are piezoelectric is a well-built technique and also many energy-harvesting units related to this type has been described.

In this technique capacity of piezoelectric power producers are comparatively minor as equated to the rest of energy harvesting device because due to the reason that a minor structure cannot be able to create power in these conformations. But yield power of the piezoelectric effect related power producers has a great forceful assortment if asymmetrical signals like human motion are employed as the motivating force. Power generated commonly involves a great voltage, less current causing a little adaptation productivity values.

#### **1.2.4 AMBIENT RF ENERGY-**

RF energy available in the environment is comparatively less energy density of the value of  $0.2 \text{ nW}/\text{cm}^2\text{--}1 \text{ } \mu\text{W}/\text{cm}^2$  equated to the other available energy source. Though the larger quantity of obtainable power could get gathered by making use of a large gain antenna. Ambient energy present today of ambient RF, wireless bases keep on growing because of the growing wireless communication, propagation set-up for example analogue or the digital Television, FM radio, Wi-Fi lastly the cellular networks. Available RF power density typically greater in urban areas and near immediacy of power source such as tower. This RF energy reaping technique can be greatly used in charging the battery running all

electronic devices in situations where it's difficult substituting batteries. The Radio frequency energy harvesting devices could get simply combined with diverse antenna as well as with other harvesting techniques like the solar cell. This one is more thought-provoking because of precise low power density value and low RF to the dc adaptation competence to exploit ambient RF power when the power gatherers are not near from the power sources but the reaped power could be exploited using fittingly improving duty cycle of system. In this case conversion efficacy from RF to DC conversion circuit like a charge pump or more appropriately a rectifier may be about 10%–30% due to less input power levels but the reaped power which is rf could produce about 1.8–4.0 V. Power level of this amount sufficient enough to function sensors sporadically for long time that is for more than five year. The harvested power becomes greater when antenna gain and the energy density of environment upsurge as RF to the DC adaptation efficacy improved due to amplified input.

This type of fabrication technique and the ambient energy source donate to the development of necessary antenna which can easily body worn. There are several types of antenna available some of them are briefly described below:

### 1.3 ANTENNA TYPES-

#### 1.3.1 HALF WAVE DIPOLE ANTENNA –

An antenna is said to be half wave when it has half wavelength at output. In half-wave dipole antenna two conductors installed in line and leave a small gap between both conductors. The voltage is attached to the centre of both conductors. In this case length of dipole should be half of wavelength when there is rise in case of existence of half wave dipole but it is measured to be 0.45 time of wavelength practically. There are two poles of half-wave dipole antenna in which current flow. The flow of current and the voltages in the proposed antenna cause production of radio signal.

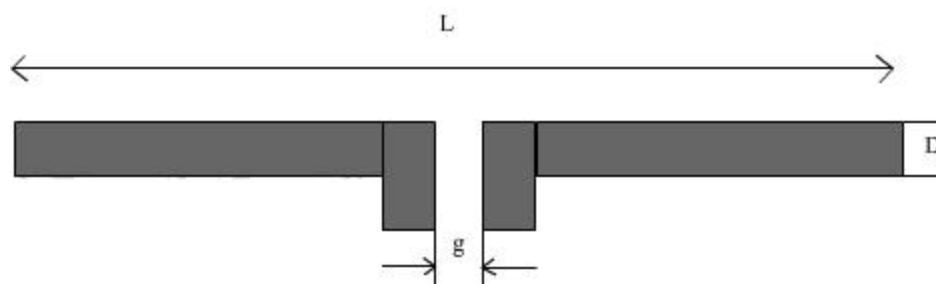


Fig1. 8: Half wave dipole antenna [Various Types of Antenna with Respect to their Applications: A Review]

**1.3.2 (PIFA) PLANER INVERTED F ANTENNAS**– These planer inverted F antennas are very efficient and low profile antennas useful in hand held device systems. These are used in many devices due to their characteristic. The devices working characteristics is better if the making is easy, emission of the signal is high, less covered area, impedance matching is less. The planer inverted F antennas (PIFA) are shaped as inverted F has been adjusted to the parallel part from a wire to plate. On frequency of operation these antenna make them resonate structure with unconditionally resistive weight impedance. The electrical performance of antenna is influenced by height of radiator, separation and area of the feed and variability of length and so on . Fig. 1.9 demonstrates the construction of planar inverted F antennas.

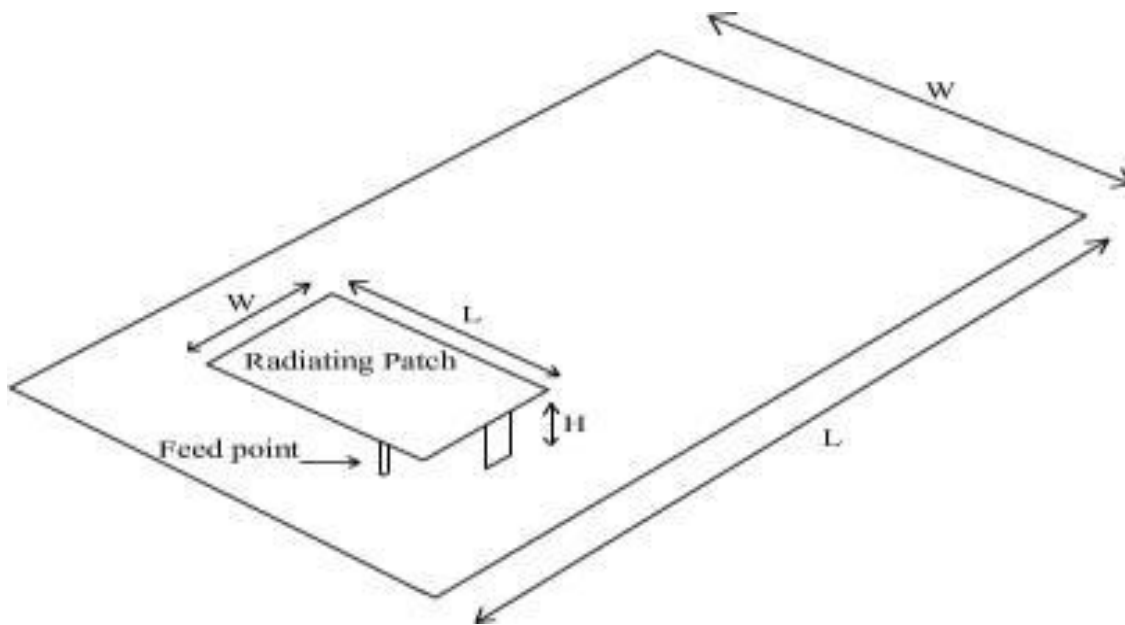


Fig1. 9: Planar type antenna [Various Types in Antenna with Respect to their Applications: A Review]

**1.3.3 INVERTED F ANTENNA –**

The normal for inverted-f-antenna is to give adaptability in impedance coordinatng and it makes both evenly and vertically electric field. The proposed antenna is useful for indoor

communication and is very popular these days. These antennas are used for making compact devices and are efficient but not as efficient as other large scale antennas such as horn antenna, Yagi uda, dish antennas etc.

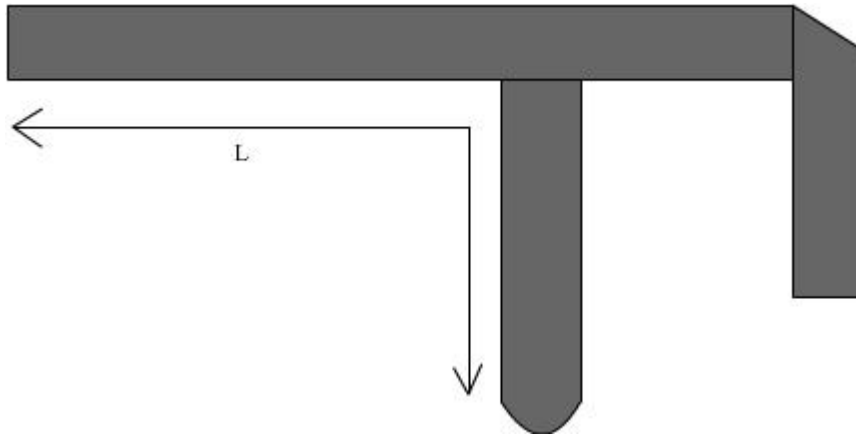


Fig1.10: Inverted f antenna [Various Types of Antenna with Respect to their Applications: A Review]

### 1.3.4 M SLOT FOLDED ANTENNAS –

In comparison to predictable patch antenna and other altered structure the M slot folded antenna are smaller. To get the small size of the antenna there is made a folded patch which is shorted to the ground and then electromagnetically attached to parasitic shorted patch.

The outline of antenna relies on space driving a patch receiving wire. The air substrate is utilized to lessen the general size of the antenna which is related between main patch and mainly the grounds. In this case ground plane size can be taken as 9\*9mmsquare and launching width of shorting divider can be 2.8mm. The principle patch can be loaded through means of an M slot. The better data transmission capacity along superior impedance organising level can be given by M slot. Fig. 1.11 displays construction of a M slot antenna.

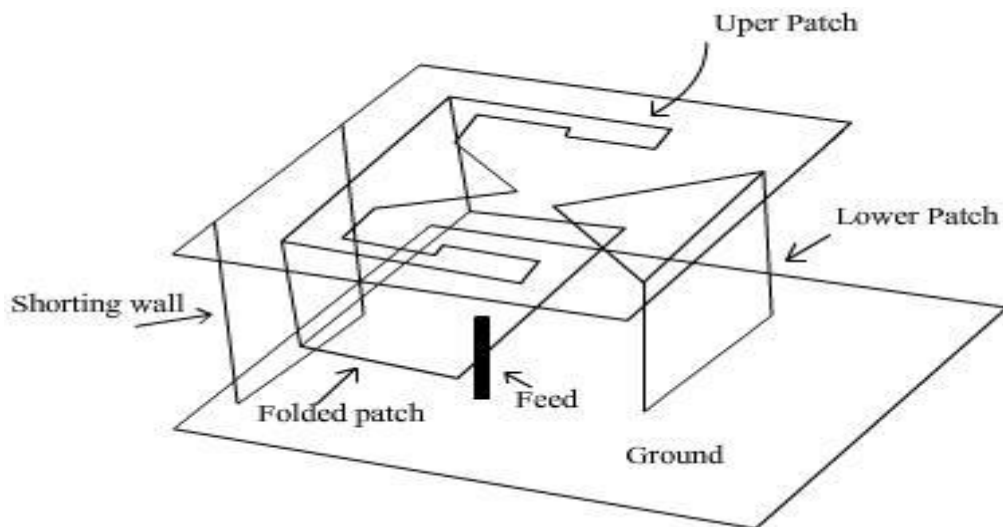


Fig 1.11: M slot antenna [Various Types of Antenna with Respect to their Applications: A Review]

These antennas whether they are compact or large play a very important role in forming the backbone of any technology. Similarly these antennas fabricated on various materials can be used for providing energy to any device by connecting them to energy storage components. So in order to provide renewable energy to any safety device we need to design an antenna that can work at desirable frequency and further can be connected to rectifier and storage devices to store energy. Thus in this project we aim at designing an antenna which is able to work at a particular ambient energy frequency and analyse the output power of the antenna.



## **CHAPTER 2**

### **LITERATURE REVIEW**

This chapter presents the researched journals that were reviewed about antenna designs mostly at frequencies of GSM900 and GSM1800 with a high gain. In addition, this chapter covers a detailed theory about an antenna and its parameters that determine its performance.

#### **2.1 WOMEN SECURITY-**

Women security is a primary concern in today's world for this many wearable technologies are present. Antennas are the essential part in these devices. The design considerations for wearable antennas are defined in [1]. In this contribution, theoretical analysis of different canonical sources placed on biological tissues. Based on the insight gained, several simple design rules will be proposed and illustrated on a practical antenna design. From this certain design rules are derived for wearable antenna. It has been shown that the level of coupling of the antenna near field to the lossy medium is the one of the key parameters to control in order to achieve low SAR and high radiation efficiency levels.

#### **2.2 WEARABLE ANTENNA-**

For wearable purpose the antenna needs to be small in size as done in [2]. This paper includes innovative wearable antennas which radiate at 5 GHz for the communication through body has been presented. This type of antenna contains a conservative micro strip patch antenna which is fixed on top of a gold base which could be used in a finger like a finger ring. The enactment of this antenna is studied using the numerical analysis. Their computer-generated results show that the antenna made this large value of peak gain. Its small size and the good radiation features make this type of antenna suitable candidate for body centric communications which are wireless and the body mounted sensor. For energy harvesting the antenna sometimes needs to be dual band or multiband as observed in [3]. In this paper one single band and the two multiband antennas are described. The Antenna 1 is a single band antenna. We use a first order koch fractal curve in snowflake to get a multiband manoeuvre. The antenna 2 is calculated with cotton as a substrate and a polycot material is used in case for antenna 3. The measurements of both antennas are made equal. First order koch

snowflake fractal curve in shape of a triangle provide four diverse resonant structures and resonate at four dissimilar frequency.

### **2.3 ENERGY HARVESTING TECHNOLOGY-**

For energy harvesting antennas we need to find the spectrum which is most suitable for our purpose. One such spectrum analysis for RF energy harvesting is done in [4]. This paper offers the spectrum prospects for the RF energy harvesting through the power density calculations from the range 350 MHz to 3 GHz. The main purpose of their publication is to design devices converting RF to DC providing substitute source to the power supply WSN products. They then accomplish that this set of frequency band with more obtainable energy harvesting are given as below:

- 750 to 759 MHz
- 934 to 960 MHz
- 1763 to 1 773 MHz
- 1854 to 1 892 MHz
- 2115 to 2 160 MHz
- 2404 to 2 468 MHz.

They also designed a single band antenna to work at GSM900 band. Their frequency bands ranging from 934 to 960 MHz are the most regularly present frequencies in terms power and bandwidth. In [5] there is a scope for spectrum opportunities for the RF energy harvesting done by power density calculations from the range of 350 MHz to 3 GHz have been identified. Based on these credentials we conclude that the most hopeful opportunities are a dual band printed antenna operating at a frequency range of GSM band 900/1800 is projected. If once a spectrum analysis is done on this then we need to design a good RF energy harvesting antenna and for this to make possible many scientists have established number of ideas such as given in [6]. This paper grants an energy harvesting device for the body centric sensor system. The projected device includes the spiral textile antenna combined with simple rectifier circuit usually simple. This antenna is designed and contrived by embroidery conductive thread in the denim material given. The efficiency of energy harvested device need to be as great as possible due to its limitation of limited hypothetically composed power. To improve amount of voltage obtained they have afterwards turned their attention to other circuit topologies and they settled to use a three stage Cockcroft Walton cascaded rectifier circuit. The principal problem that ascends in the implementation of

this planned harvesting circuit is that of its minor conversion efficiency which occurs as a result of the nonlinearity of diodes and low available power at the input of the antenna given.

In the [7] a relative study of the antenna design for RF energy harvesting is proposed. In this paper several antenna designs of rectenna is discussed and associated with mainly the emphasis on antenna size lessening and harmonic rejection also the re configurability in terms of frequencies and also the polarization. Among a large number of various antennas used in rectenna the micro strip patch antenna is selected for the assessment and judgement because due to the simplicity and the ease of fabrication. Various other arrangements of the micro strip patch antenna which is different from the predictable shapes are also examined with description of the alteration made in the design to get a reduced size also a harmonic rejection functional and a re configurable antenna in the polarization and of a frequency. This paper is co-operative in realising behaviour of the patch antenna in diverse situations. In paper number [8] dual band antenna for a energy harvesting system in the wireless sensor network is suggested. The harvesting RF energy which is ambient and then changing the harvested power to a more useful dc power requires a very vigilant design. With the general objective of the RF energy harvesting, emphasis on development and fabrication and classification of the dual band antenna designed as for serving as receiving antenna is done in this. It is also experiential that antenna is resonating at 2.47GHz along with 4.93GHz and also 5.69GHz range. These patches are particularly appropriate for the slender bandwidth presentations. Consequently the test for this is to enlarge the bandwidth so as to make the antenna appropriate for wideband and energy harvesting atmosphere.

As discussed earlier GSM900 and GSM1800 are the most suitable band for energy harvesting for the proposed project. We see that there is a textile antenna used for EM energy harvesting at the range of GSM900 and also DCS1800 is debated in [9]. This paper grants the design of 2 textile antennas which are appropriate for harvesting energy in the given GSM900 and DCS 1800 band range. Mathematical limitations of this projected antenna is made from which we perceived that these type of antenna they give an operating frequency range which is capable of entirely casing 880-960 MHz and 1710-1880 MHz range and future work could be proposed to appraise human body occurrence in the presentation of the given antenna and generate a more malleable and a wearable antenna with the defined classification.

In paper number [10] there is a textile antenna for the purpose of RF energy harvesting fully implanted in some clothing. This paper shows a smart coat with a dual band textile antenna for the application of the Radio Frequency energy harvesting system functioning at the range

of GSM 900 and DCS1800 bands, which is completely fixed in the garment or the coat. For this results are attained before and after incorporation of the antenna system inside the garment and are equated and there is a similarity between the computer-generated and measured results. Other than clothing the energy harvesting system could be employed on the jewellery and this is discussed as in paper no. [11]. In this paper we present a wearable energy harvesting antenna in the form of a necklace which is appropriate for driving smart jewellery. The design comprises of a U-shaped dipole antenna along with a matching network an RF to DC converter and a DC to DC converter. This antenna system changes a 915 MHz RF signal to a relentless 3.1 V DC output which provides an output power up to the value of 106.5  $\mu$ W. We see that beyond distance of 3.7m this input power is not sufficient to uphold a 3.1V. Future work could be done for order of reducing the RF to DC converted volume and improve the complete arrangement efficiency.

## **2.4 FABRICATION TECHNIQUE-**

Many fabrication techniques were discussed earlier for wearable antennas one amongst them all which is very appealing is inkjet technology. A wearable antenna realised on textile using inkjet printing is discussed in the [12]. There is a screen printed boundary layer which was used to decrease the roughness of the surface of the given polyester or the cotton material that enabled the printing of unceasing conducting surface. The conducting ink that was used to generate 3 inkjet printed micro strip antennas was silver. The inkjet printed antenna could be produced straight from the final design without even having the urgency or need to screen print first and that is why this technique allows speedy manufacture for the low dimensions with the suppleness for all the tailored design. In order to evaluate the presentation of this inkjet printed antenna we compared three antenna to one on an etched patch on a small loss substrate. The output or the behaviour of these antenna was calculated inside an anechoic chamber. The results were that only when one layer of ink is used the output is good but is significantly improved by a second layer of silver. This could be advantageous at higher frequencies where the skin depth is of a smaller amount.

## **CHAPTER 3**

### **METHODOLOGY**

In an effort to improve the quality of our lives we aim at designing a micro strip patch antenna which would contribute mainly in providing renewable energy to safety devices and the following measures were made to achieve so:

- A lot of research was made on the availability of a renewable energy source for the devices available in the market but none was found to use a renewable energy source.
- Out of the numerous available renewable energy sources such as thermal ,RF energy etc. we decided to use the ambient RF energy available in the environment
- The frequency of operation of the patch antenna will be 900MHz
- The antenna is a wearable antenna and it will be attached to a leather belt whose dimensions will be defined later in the results
- For wearable purpose the antenna designed is a micro strip patch antenna
- Micro strip patch is an ideal choice for integrated into clothes or accessories using fabric substrate materials which suitable for human on body application.
- The characteristics of the project will be low manufacturing cost, small design, and desirable output power and easy to use
- For antenna designing purpose two software's are used namely MATLAB and CST MWS.

#### **3.1 MATLAB-**

The MATLAB is called high performance language because of its technical computing. This incorporates calculation, conception, also programming in a very easy environment where all the problems and their solutions can be articulated in a similar mathematical representation, typical uses of MATLAB comprise:

1. Computation and maths
2. Improvement of algo
3. Demonstrating, recreation, also prototyping

4. Analysis of the data, investigation, visualization
5. Development of application which include Graphic user Interface building up

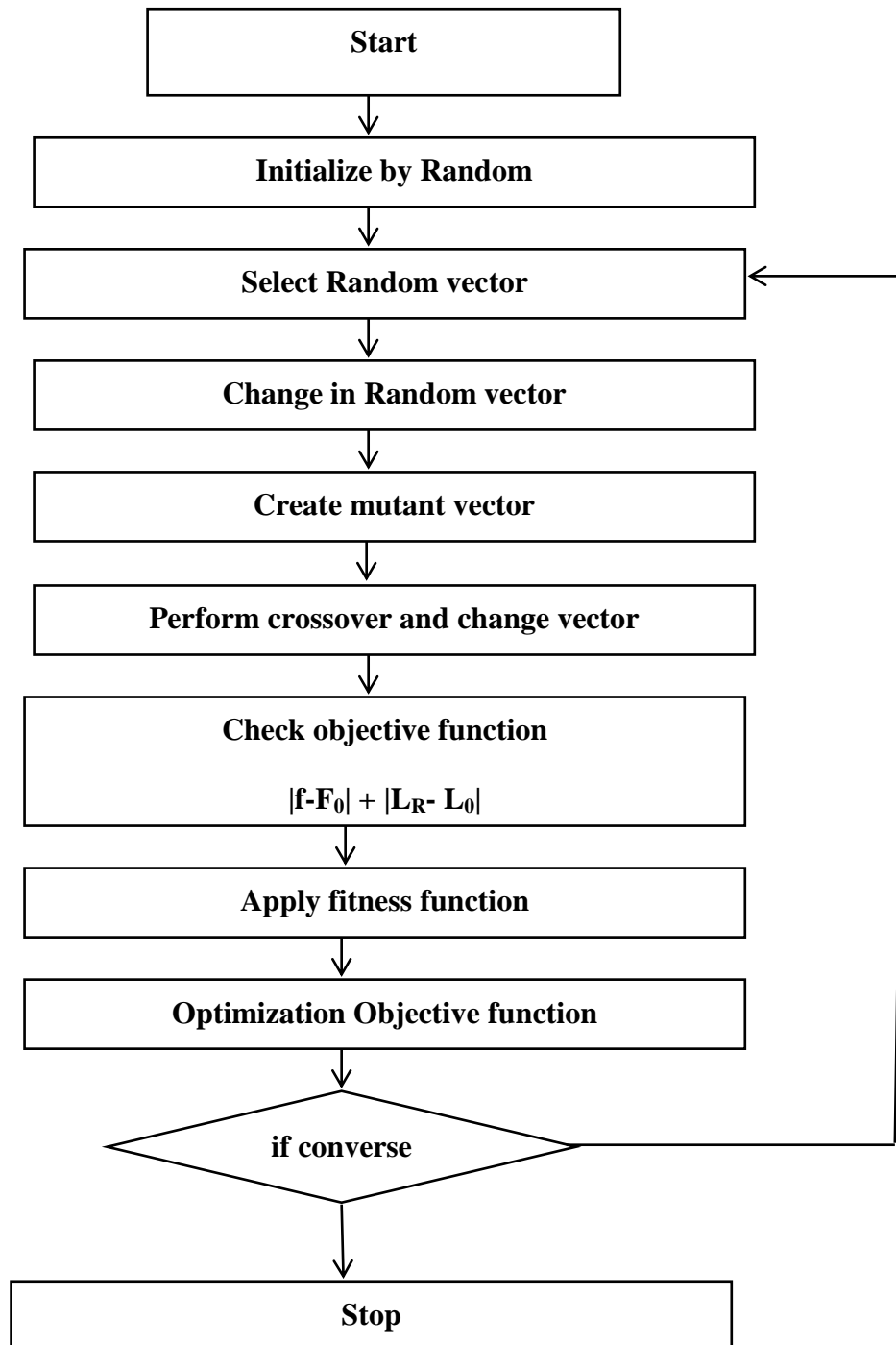


Fig 3.1: Flow chart of differential optimization in MATLAB

The antenna used is optimised to get the appropriate length and width of the micro strip antenna to fit on the leather belt. The appropriate length for all women body types chosen can be 39.5". The thickness of leather belt is 3.3mm and the dielectric constant is 2.95.

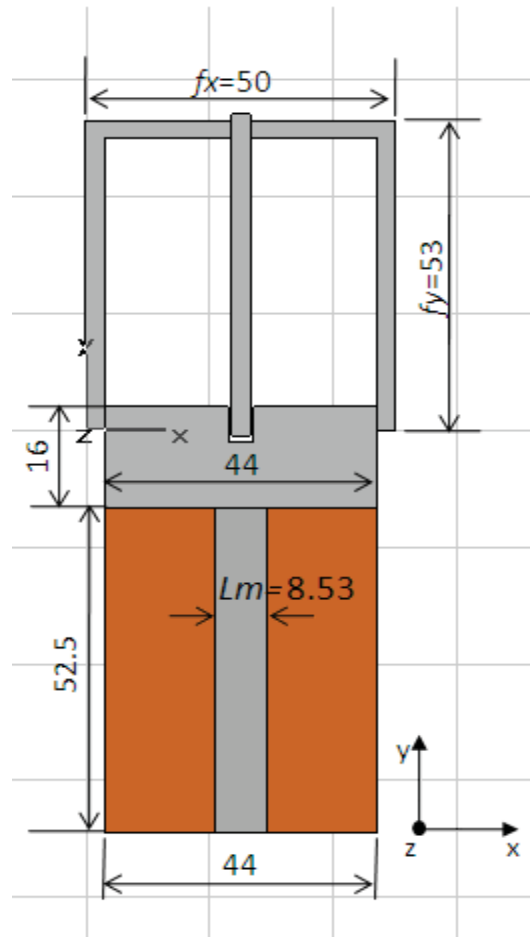


Fig3.2: Belt dimension [STUDY OF A BELT ANTENNA]

This method is used for optimization of the antenna parameters is called differential optimization and is usually practiced in the MATLAB. This type of input offers function for calculating the optimum parameters making use of the evolutionary procedure. If simply speaking suppose you have a complex function for which you are incapable of computing the derivative and you want to find its parameters by reducing output of the given function using this type of platform is one of many possible ways. The fundamental of this optimization is Evolution of Differential algorithm.

### 3.2 CST MWS-

CST microwave studio is a simulation software used to design high frequency components. We designed the antenna and used the transient solver. All solvers are based on solving Maxwell's equation in differential form. Time element solver is fast and takes less memory. The Fourier analysis converts differential equation to algebraic equation. The parameters obtained after optimization in MATLAB were used to design the antenna in CST. The material used for the patch and the ground is copper as copper tapes are easily available in the market and are less pricey. The substrate initially used was leather on which the antenna would be fabricated but the S11 due to losses the substrate used was altered and leather is not used. The frequency of operation is 900MHz coming from the mobile towers.

These two software's are mainly used in designing the antenna and the results obtained will be shown in the upcoming chapters. These methodologies were adopted to design the antenna and analyse the power output and the various losses.



## **CHAPTER 4**

### **RESULTS AND DISCUSSION**

In this thesis work the antenna was designed using MATLAB software and CST microwave studio. The length and width of the antenna was found out to be inappropriate for its future fabrication on belt so and differential technique was applied on MATLAB to obtain the dimension of the micro strip patch antenna and using these dimensions the antenna was designed and simulated in CST MWS version 2016 and the various parameters such as S11, power, losses, radiation pattern were observed. The results are shown below

## 4.1 MATLAB-

- The width of the antenna was optimised as below

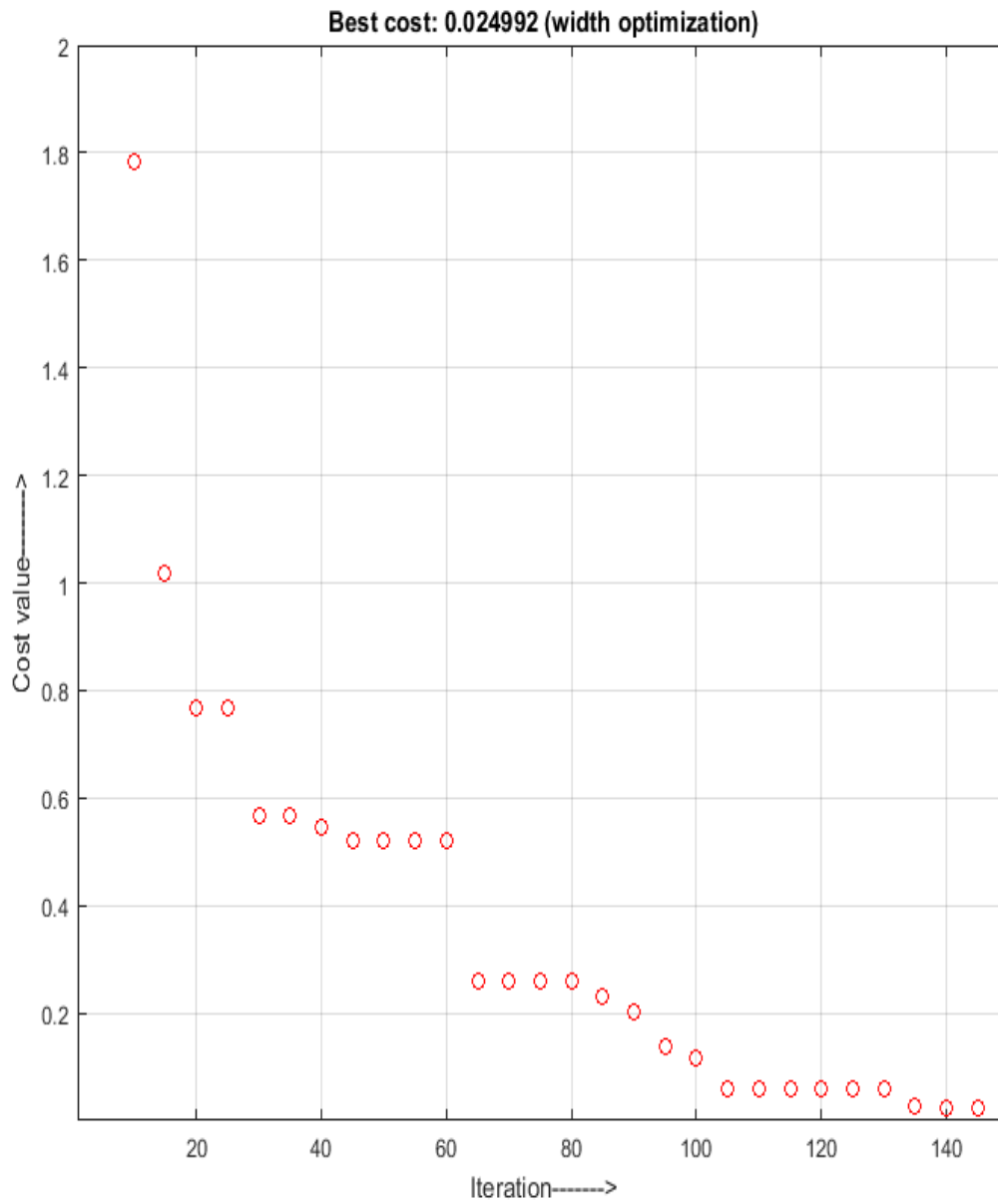


Fig4.1: width of antenna after optimization in MATLAB

- Length of antenna after optimization

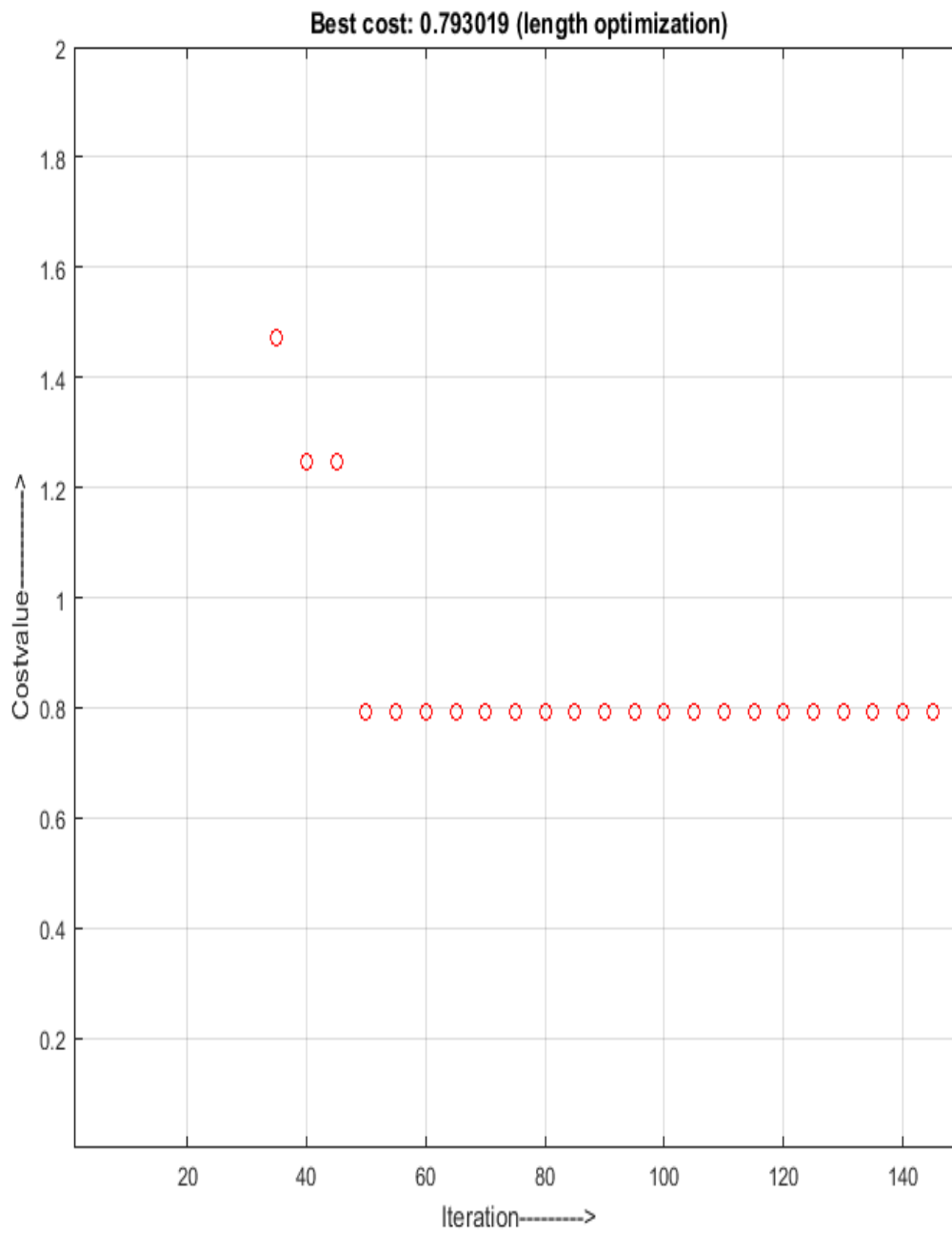


Fig4.2: Length of antenna using differential optimization

## 4.2 CST MWS-

- The design of the antenna is shown below

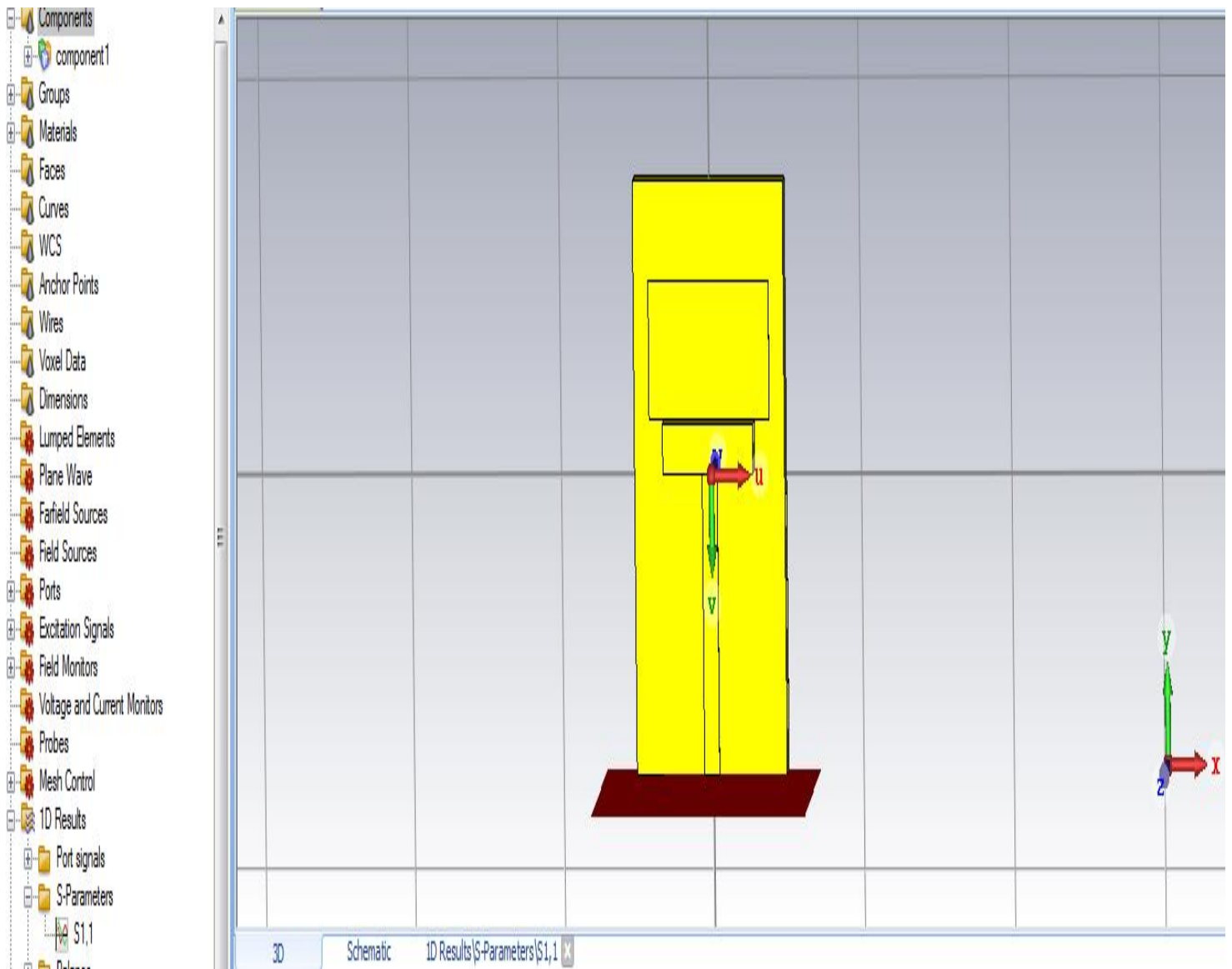


Fig4.3: Antenna design in CST

- The S11 parameter of the antenna is shown

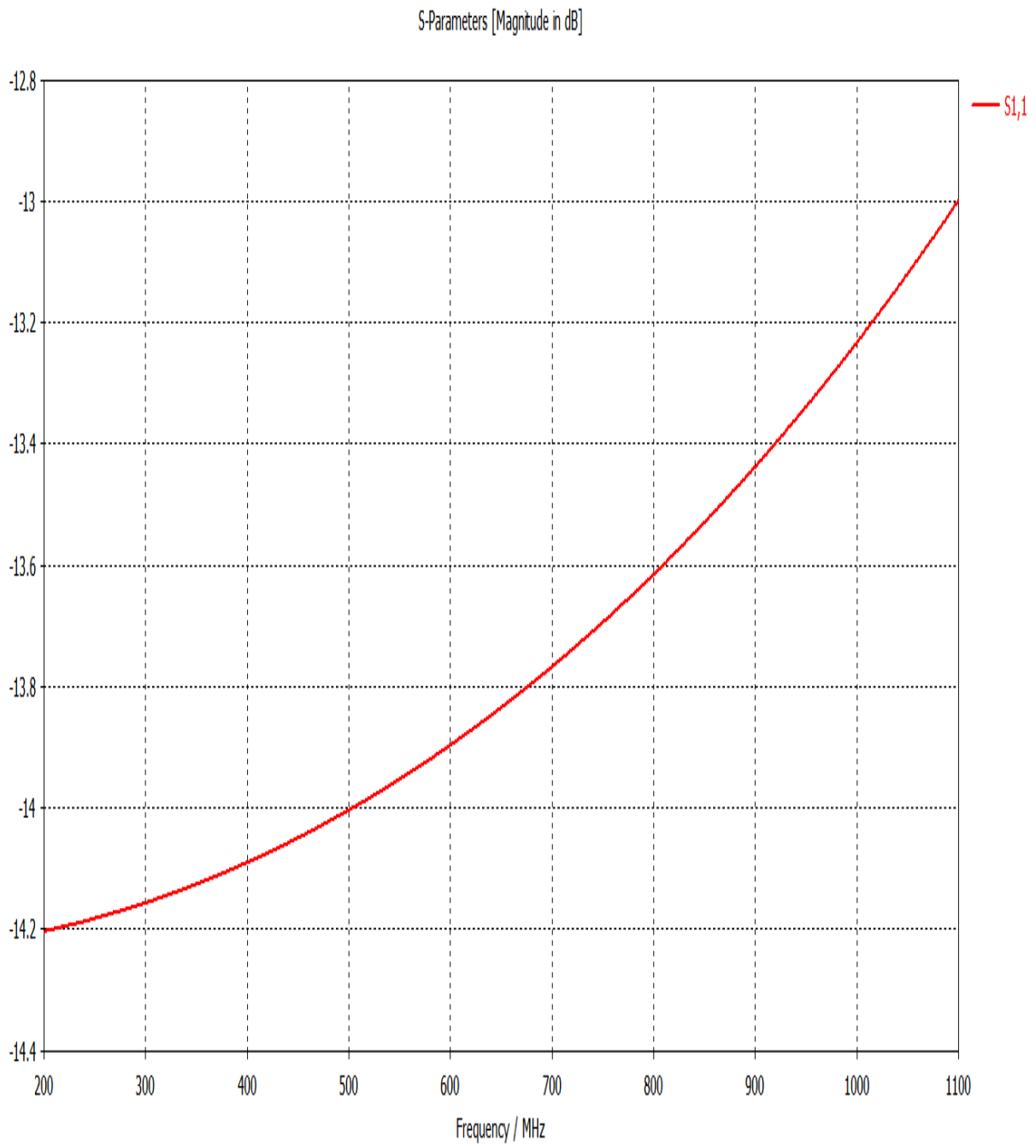


Fig4.4: S11 parameter for the antenna design

## **CHAPTER 5**

### **CONCLUSION AND FUTURE SCOPE**

We can affirm that the low power energy harvesting is a very unique and useful technology in today's world. This is a very useful technology in powering devices such as GPS etc. and the backbone for this technology is the antenna which forms the basic building block of the energy harvesting system. The antenna has been designed and simulated at the operating frequency of 900MHz. It can be made using copper tape on a leather belt and antenna array can be used to provide sufficient power to the devices by connecting the output of antenna to a rectifier to convert AC in DC and store the energy in a storage device. Thus as a future scope the hardware of this antenna can be designed and connect to rectifier for DC output which will power a small device such as portable GPS for various applications.

## **CHAPTER 6**

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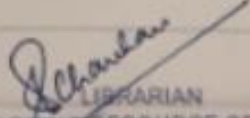
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