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RF Energy Harvesting

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Abstract*: An emerging technology known as RF energy harvesting has the potential to change the way systems and devices are powered. It makes it possible to turn ambient electromagnetic radiation into electrical energy that can be used to power things like wireless sensor networks, IoT devices, and mobile devices. The ability to operate in remote or difficult-to-reach locations and the absence of the need for batteries are just two of the many benefits offered by this technology. The antenna's AC signal is converted into DC power that can be used to power electronic devices by rectification circuits. A variety of topologies, such as voltage doubler, half-wave, and full-wave rectifiers, can be utilized in the design of these circuits. The requirements of the application and the frequency of the incoming RF signal determine which rectifier circuit to use. RF energy reaping has various possible applications, including fuelling, remote sensor organizations, brilliant homes, clinical gadgets, and wearable hardware, among others. It enables the deployment of devices and systems in remote or difficult-to-reach locations and provides an alternative to traditional battery-powered systems that is both sustainable and cost-effective. In conclusion, RF energy harvesting is a fascinating technology that is rapidly developing and has the potential to change the way systems and devices are powered.*

Keywords: RF Energy Harvester, Antenna, Rectifier, Matching circuit, Electromagnetic radiation, radio frequency

I. INTRODUCTION

The Radio frequency energy harvesting (RFEH) is the process of converting energy from the electromagnetic (EM) field into voltages and currents in the electrical domain. Since it makes it conceivable to remotely drive low-power sensors and frameworks in an assortment of use situations, RFEH is particularly engaging for use in body region organizations. Because they are situated at the intersection of electronic circuitry and electromagnetic fields, designers and researchers face a challenging task when attempting to extract energy from RF sources. In this way, to make a superior presentation RF energy gatherer, information from the two regions is required. Here we will present the various strategies of Radio Recurrence Energy. Condition of a workmanship methods for Collecting. Both their benefits and drawbacks are discussed. Application and history is made sense of also.

Radio frequency energy harvesting (RFEH) is the process of converting energy from the electromagnetic (EM) field into voltages and currents in the electrical domain. Basically, RF energy gathering is the method involved with changing over encompassing electromagnetic energy into electrical power that can be utilized. Any sort of radio wave, including those from television/FM stations, Wi-Fi switches, telephone pinnacles, or radar, could be encompassing energy. RFEH is particularly appealing for use in body area networks because it makes it possible to wirelessly power low-power sensors and systems in a variety of application scenarios. Because of this basic understanding, RF energy harvesting is receiving so much attention as a green power solution. Radio waves are wherever today, and it is absolutely impossible to keep away from them. In addition, the particular requirements of IoT devices, which are frequently tiny/macro-sized (even nano-sized) and designed to operate in extremely harsh, remote environments, make RF harvesting an excellent choice. Health monitors and other industrial solutions frequently include sensors that are hard to access for battery replacement or maintenance.

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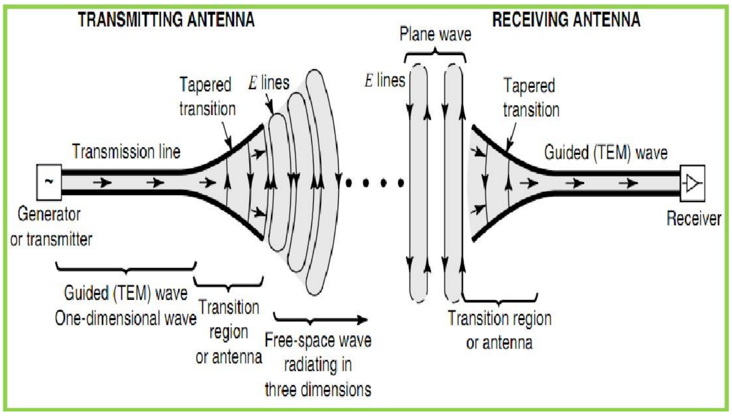
II. SPECIALTY OF ANTENNA:

By acting as a medium between the guiding device and free space, the antenna functions as a transitional structure that transforms one form of energy into others. Electromagnetic waves can travel through free space without the aid of any medium and vice versa thanks to this device, which transforms the energy of an electrical signal into them. "Antenna can be viewed as a device used to radiate or receive electromagnetic waves within a transmitting or receiving system," according to the IEEE, is a definition of the term. Beam area, square degree, Ste radians, and solid angles can be used to measure these three-dimensional structures. It is polarized in three ways: straight, round and curved. The workings of the antenna are depicted in the figure. At the receiver end, the transition from a guided wave to a free-space wave takes place. As a result, the antenna acts as a transducer, a wireless link, or a link between the transmitting and receiving antennas.



Wireless connection showing Transmitting and Receiving Antenna

A receiving wire comprises of a metal channel that conveys radio recurrence (RF) waves between two focuses in space. A signal can be sent or received by this device. Radio signals are produced when a voltage is applied to a transmitting antenna. These radio signals then travel to a receiving antenna, where they are transformed back into electrical energy in the form of information. The radio wave is created by the transmitter's antenna. A voltage at the ideal recurrence is applied to the receiving wire. The voltage across the radio wire components and the flow through them make the electric and attractive waves, separately. A small voltage is produced at the receiver by the electromagnetic wave that travels through the antenna. As a result, the antenna becomes the receiver input signal source.

Antenna parameters like VSWR, Return Loss, Antenna Gain, Directivity, Antenna Efficiency, and Bandwidth are just a few examples.

Gain: Acquire is characterized as concerning the proportion of the force, in a provided guidance, to the radiation force that would be gotten assuming the power acknowledged by the receiving wire were emanatedisotopically.

Radiation pattern: The radiation design is an element of the numerical and graphical portrayal of the radiation properties of the receiving wire as a component of room organizes.

Antenna efficiency: It is characterized as the proportion of all-out power transmitted by a radio wire to the info force of a receiving wire.

VSWR: It is defined as the ratio of

$$VSWR=V_{max}/V_{min}.$$

It ought to be one in the ideal situation, and the VSWR value ought to be for improved antenna performance. VSWR= maximum voltage on the line/minimum voltage

Antennas have to be classified to understand their physical structure and functionality more clearly. There are many types of antennas depending upon the applications. The most popular Antennas are:

High Gain antenna: An antenna with a narrow radio beam called a high-gain antenna (HGA) is used to boost signal strength. High-gain receiving wires give a more exact approach to focusing on radio transmissions and are consequently extremely fundamental for long-range remote organizations. They can even strengthen weak signals. A directional antenna is another name for a high-gain antenna. A stronger signal is received by the receiver when a high-gain antenna transmits more power to it. When used as a receiving antenna, high-gain antennas can also make transmitted signals

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100 times stronger by capturing more energy. Directional antennas transmit fewer signals from directions other than the main beam because of their directivity.

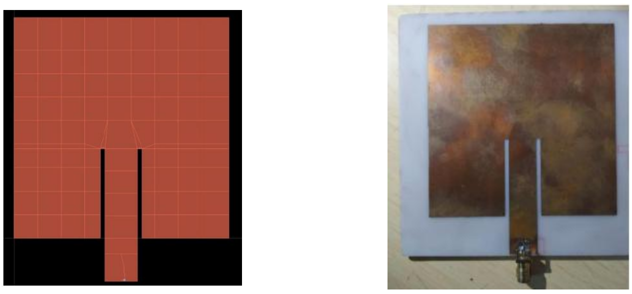
Dual Band Antenna: For both worldwide interoperability for Microwave Access (WiMAX) applications and wireless local area network (WLAN) applications, a dual-band design of a finite ground coplanar waveguide (CPW) fed antenna is presented. This kind of receiving wire has two different reverberating frequencies. Utilization of the Double band receiving wires in the RF energy reaping prompts an assortment of conceivable recurrence.

Compact and multiband Antenna: The fundamental objective is to plan radio wires for remote correspondence applications where the space worth of the radio wire is very restricted while it holds the attributes of multiband, lightweight, minimal expense, strength, variety, bundling capacities and capacity for RF PIN switches/MEMS incorporation for shrewd recieving wire frameworks.

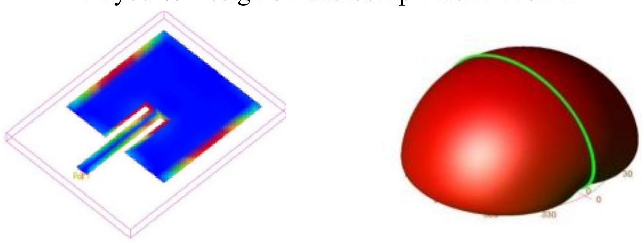
Microstrip Antenna: A microstrip antenna, also known as a printed antenna, is typically used in telecommunications to refer to an antenna that is printed on a printed circuit board (PCB) using photolithographic processes. A kind of internal antenna, it is. They are for the most part utilized at microwave correspondence, Air-make, Rockets, Cell Phones. The following are examples of microstrip antennas: Round formed, Rectangular molded metallic fix over the ground plane.

III. DISCUSSION OF MPA

Microstrip Patch Antennas can be printed directly onto a circuit board, they are becoming more and more beneficial. The use of microstrip antennas in daily life is expanding rapidly. Patch antennas are inexpensive, have a small profile, and are simple to make. The patch antenna, microstrip transmission line, and ground plane are all constructed of high-conductivity metal (usually copper), and the microstrip antenna is fed by a microstrip transmission line. The patch has the following dimensions: L, W, and it is supported by a substrate (some dielectric circuit board) with a permittivity of h.



Layout& Design of Microstrip Patch Antenna



3D View of Antenna Radiation Pattern&3D View of Microstrip Patch Antenna

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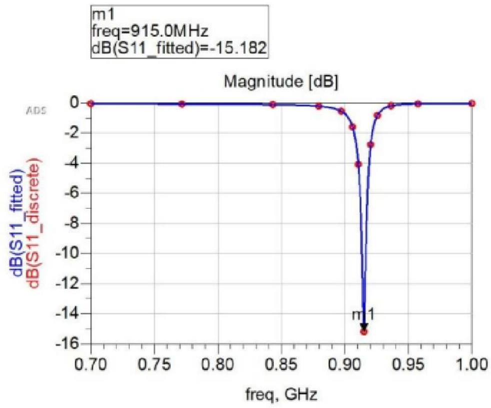

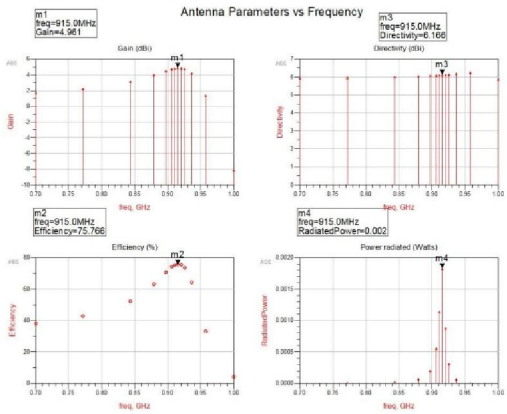

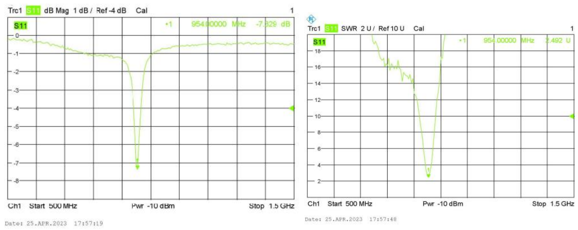

(a) S11 Testing result of (b) SWR Testing Result of Microstrip Patch Antenna Microstrip Patch Antenna

IV. SPECIALITY OF RECTIFIER

The radio recurrence signal caught by the recieving wire is an exchanging current (AC) signal. To get a DC signal out of AC signal and work on the proficiency of the RF-DC power transformation framework, a rectifier circuit is utilized. The decision of amendment circuits relies upon the radio recurrence transmission and power got since various upsides of DC voltage could be acquired with a similar circuit and different radio recurrence sources.

TOPOLOGIES:

The configuration of the diodes used for rectification determines which topologies the microwave rectifier can take. The sequential and shunt geographies are the most utilized in the writing. Additionally, the voltage doubler or voltage multiplier topology can be utilized to enhance the output DC voltage. These customary rectifier circuit geographies are shown in fig. below.

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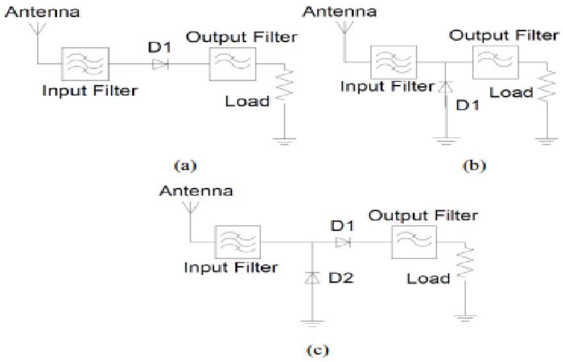

The conventional rectenna topologies: (a) series; (b) shunt; (c) single stage voltage doubler

DIODE:

In planning a rectifier circuit with high RF-to-DC change productivity, the decision of a legitimate diode is one of the main variables since the diode is the primary wellspring of misfortune and its exhibition and trademark decide the general presentation of the circuit. Due to their higher switching capacity, lower barrier (high saturation current), lower junction capacitance, and lower voltage threshold than standard PN diodes, zero bias Schottky diodes are typically utilized in high frequency rectifiers.

HALF WAVE RECTIFIER:

The most fundamental rectifier topology is the half-wave rectifier. As shown in Fig. 4.2.1, the half-wave rectifier consists of a series diode followed by a shunt capacitor. The load of the rectifier is placed in parallel with the capacitor.

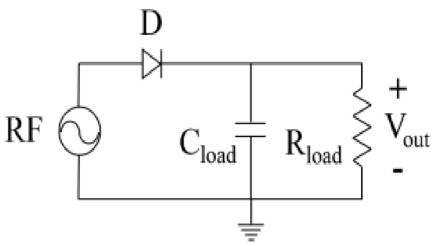

Fig. Half-wave rectifier

MATCHING NETWORK:

An impedance matching circuit expands the power move from the getting recieving wire to the rectifier and a multi-stage rectifier changes over the approaching RF transmissions to a result DC voltage. In a RF Energy collector circuit or some other AC circuit, there is a most extreme exchange of force from the source to the heap, when the heap impedance (ZL) is equivalent to the source impedance (ZS). Fixed LC impedance matching circuits are utilized to match the information impedance of the rectifier to the result impedance of the radio wire. To fine-tune the impedance match between the antenna and the rectifier, a printed circuit board (PCB) is outfitted with a fixed impedance matching circuit.

Fig. Typical Impedance Matching Network

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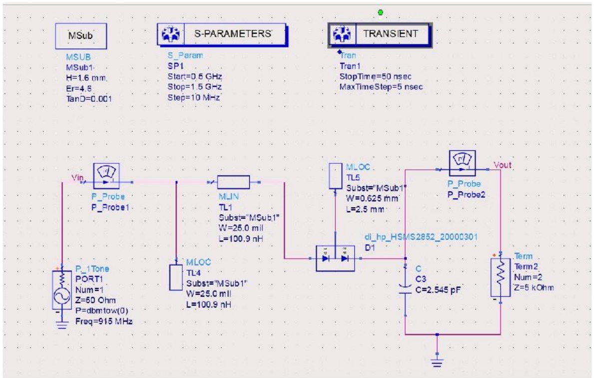

Fig. Schematic of matched single band rectifier circuit

RF ENERGY HARVESTING CIRCUIT:

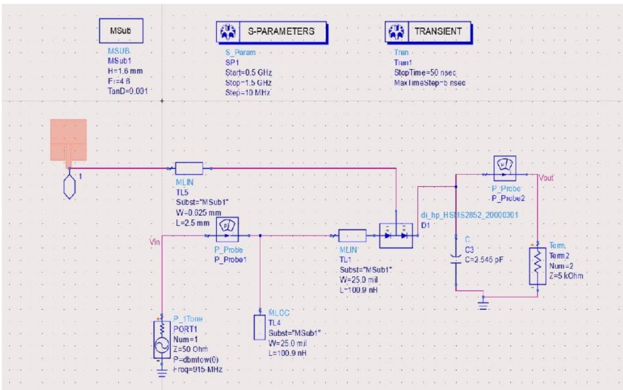

Fig.Schematic of RF Energy Harvesting Circuit

V. FUTURE SCOPE

Wireless energy harvesting has a lot of potential for projects like home automation and the Internet of Things. Devices with advanced embedded technology that typically operate at a microwatt input power can be produced using smart sensor technology. The automotive, industrial, and home automation sectors all make use of wireless temperature, humidity, and proximity sensors. Without wire charging of any gadgets gadget would be conceivable with headways in remote energy reaping innovation. Wireless charging technology will be available for use as an alternative power source in our upcoming mobile devices. Wireless energy will be used to power wearable devices and medical sensors. Wireless energy harvesting is a method by which power can be used by enhanced security devices that incorporate smart sensor technology. It has advantages due to its small size, wire-free wireless transmission, and ease of implementation.

VI. CONCLUSION

This paper has presented an exhaustive review ofthe design and fabrication of antennas for RF energy harvesting at a frequency of 915 MHz, along with the implementation of rectifiers and matching circuits using ADS (Advanced Design System) software.

Using ADS, the antennas were designed to resonate at the desired frequency of 915 MHz, ensuring efficient energy capture. The design process involved considering factors such as antenna size, impedance matching, and radiation pattern to optimize energy harvesting efficiency.

Rectifiers and matching circuits were also designed and implemented using ADS to convert the captured RF energy into usable electrical power. These components are crucial in maximizing power transfer and minimizing losses during the energy harvesting process.

Overall, the paper aimed to harness RF energy at a frequency of 915 MHz through the design, simulation, fabrication, and testing of antennas, rectifiers, and matching circuits. By efficiently capturing and converting RF energy into usable electrical power, such technology holds the potential for various applications, including powering low-power devices, wireless sensors, and IoT (Internet of Things) devices, thereby contributing to energy efficiency and sustainability.

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