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Comparitive Study On Radio Frequency Power Harvesting Technique

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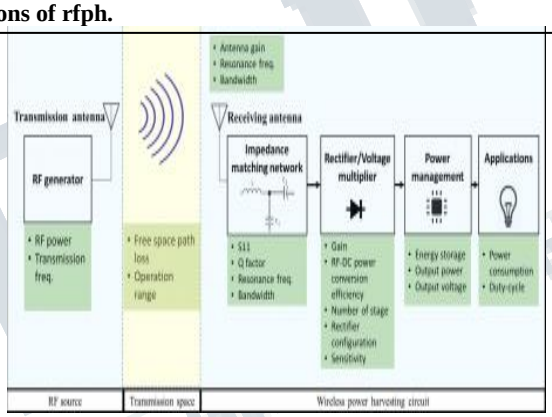
Abstract- **In recent years, the use of wireless devices is increasing tremendously in many applications such as mobile phones, remote sensing and many more. This has resulted in an increased demand on the use of batteries. Compared to other methods of energy scavenging,rf deals with low energy density and poses big challenges. With semiconductor and many other technologies continually struggling towards the low operating powers, batteries can be replaced by alternative sources that employ energy harvesting techniques. In this paper we present a comparative study on rfph also referred to as rf energy scavenging that includes background, system design, advantages and disadvantages and applications of rfph.**

I. INTRODUCTION

The idea of rf power harvesting was emerged in late 1950's which used microwave powered helicopter system. Use of portable devices in today's world creates the technology that largely relies upon the battery power. This leads to the problem of charging the battery continuously. Therefore, the rf power scavenging technique mainly concentrates on providing solutions to these problems. The rf energy is omnipresent. Many of the electronic devices such as TV, radio emit rf power continuously to the atmosphere. Hence, the rf energy is available abundantly at any location. The sources for rf power harvesting are available in many other forms such as thermal energy, kinetic energy, electromagnetic energy, wind energy, solar energy. Among these sources, electromagnetic energy is widely available in space and can be restored without any limits. The major problem in today's world is processing of batteries. A majority of batteries end up in landfills, leading to the contamination of water and air underneath. Therefore, in order to reduce the battery wastes more effectively, the best way is to avoid using them. Applying this rf power harvesting technology will help to reduce the use of batteries which will finally have a positive blow on the environment. The design of the system is based on simple concepts, increased received voltage and to use gained energy in order to charge a device. The key units of rf energy harvesting includes antenna and a rectifier circuit which allows to convert rf power or ac to dc energy.



As we know that electromagnetic waves are abundant in nature, we can consider this as an important factor to design an rf system. According to frequency, distance and conducting environment the behavior of electromagnetic waves varies. During propagation in free space the loss of power in space can be assigned by free space path loss, which is the loss of signal power.Usually the behaviour of electromagnetic waves rely upon the distance from the transmitting antenna. These attributes are divided into three segments: far field, radiated near field and near field. The near field region is a space that lies within the fraunhofer's distance. Outside the fraunhofer's distance the far field region is present. Therefore the fraunhofer's distance is given by the formula

$$d_f = \frac{2D^2}{\lambda}$$

Where D is the measurement of the radiator or diameter of the antenna, λ is the wavelength of the EM waves, d_f is the fraunhofer's distance. In rf energy scavenging systems frequency selection is considered as an important point. The transition between the regions is not distinct although the fraunhofer creates a border region. In the far- field free

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space for a transmitter and receiver antenna, the power propagation at the receiver antenna is given by

$$P_R = \frac{P_T G_T G_R \lambda^2}{(4\pi R)^2}$$

Where λ is wavelength of the EM signal,GR is the receiver antenna gain, then PR is the power at the receiver antenna. We know that λ is given by $\lambda = c/f$ and $k = 2\pi/f$ where k is the wave number. From the above two equations, the free space path loss,PL for fraunhofer's field can be inferredas

$$P_L = \frac{P_T}{P_R} = \frac{(4\lambda R)^2}{G_T G_R \lambda^2} = \frac{(4\pi f R)^2}{G_T G_R c^2} = \frac{4}{G_T G_R}(kR)^2$$

the above equation in terms of dB is given by

$$P_L(dB) = 20\log_{10}(f) + 20\log_{10}(R) + 20\log_{10}\left(\frac{4\pi}{c}\right) - G_T - G_R$$

.If gain GT and GR are measured in dB, in case if the distance R is measured km and f measured in MHz then the above equation is given by (eq5).The disadvantages of rf power are low density and efficiency is inversely proportional to distance. The relationship between the magnetic and electric waves in the Fresnel field varies with respect to space and time and is very difficult to predict therefore all these regions makes a power density a big problem. The typical design of the system consists of antenna, tuning circuit, storage capacitor, impedence matching network and rectifier or voltage multiplier circuit. Let us define antenna and compare the designs with different types of antennas.

ANTENNA: The metallic structure that are designed for transmitting and receiving the EM energy. In this paper we have included several translation of antenna's which include monopole antenna, micro strip patch antenna, loop antenna and grid antenna.

DESIGN WITH MONOPOLE ANTENNA: Usage of monopole antenna was not so efficient. The radiation pattern of monopole antenna is as shown below.

Disadvantages are as follows:

Because you are radiating equally in all directions, you have equally poor radiation in all directions.

The "torus" shape doesn't extend to the top of the antenna because the voltage increases as it travels up the antenna. In reality, the signal is sent from the bottom two thirds of the antenna.

Metal objects and the ground itself can cause signal reflections, so you may get a signal that is both horizontally and vertically polarized.

Inside a shielded chamber, monopole antennas can have impedances vary by orders of magnitude, making it difficult to calibrate. Take measurements too close to the tip of the antenna or ground plane, and they will likely be wrong.

Fig1: Mono pole antenna

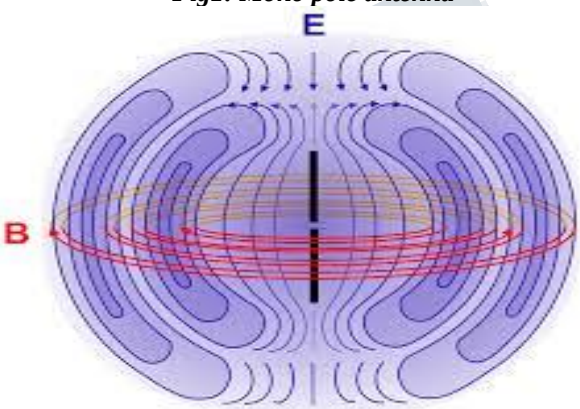

Fig2: radiation pattern of monopole antenna

DESIGN WITH MICROSTRIP PATCH ANTENNA: The design of the micro strip patch antenna requires three essential parameters namely height of dielectric substrate(h),frequency of the operation (f),dielectric constant of the substrate. The radiation pattern of rectangular micro strip antenna is as shown below and also the view of micro strip antenna is as shown in figure 2.

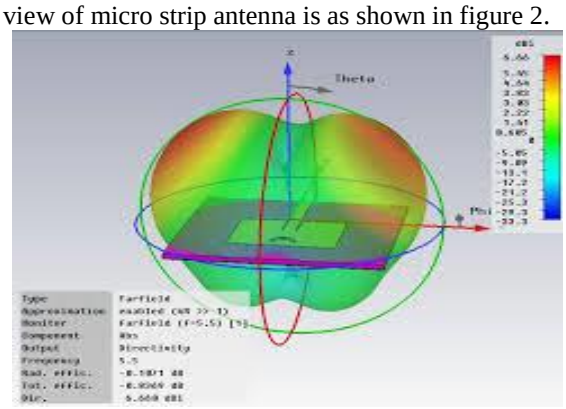

Fig1: radiation pattern of rectangular micro strip patch antenna

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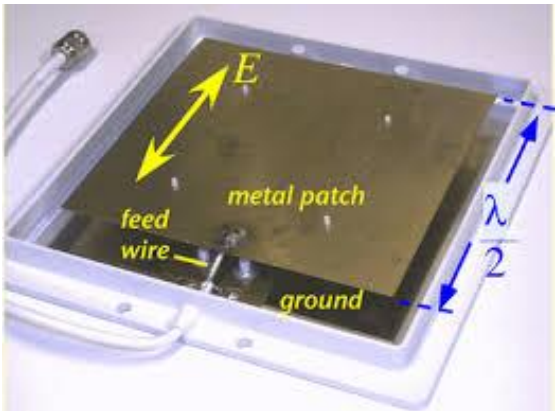

Fig(2): micro strip patch antenna

Disadvantages of micro strip antenna:

The spurious radiation exists in various micro strip based antennas such as micro strip patch antenna, micro strip slot antenna and printed dipole antenna.

It offers low efficiency due to dielectric losses and conductorlosses.

It offers lower gain. It has higher level of cross polarization radiation. It has lower power handling capability. It has inherently lower impedance bandwidth. The micro strip antenna structure radiates from feeds and other junction points.

DESIGN WITH LOOP ANTENNA: By the use of loop antenna was found to be most efficient.

Generally loop antennas are widely used in direction finding application in radar. It is also used in aircraft receivers and some radio receivers . It is also used in UHF transmitters and RFID applications.

The loop antenna view is as shown in the fig1. And the radiation pattern for the same is as shown in fig2.

Fig1: loop antenna

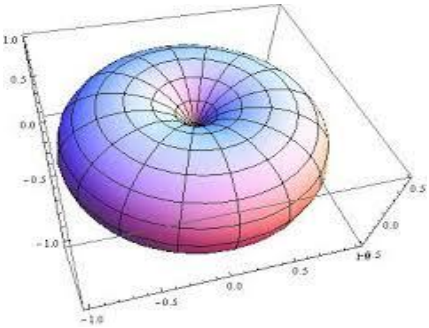

Fig2: radiation pattern of loop antenna

Advantages:

It is light in weight.

It is simple and compact in structure.

It is suitable for portable applications such as direction finding etc.

It is available in large varieties viz. adcock antenna, alford loop, cloverleaf antenna, Bellini-Tosi antenna etc.

Disadvantages:

Small loops have poor efficiency and hence are mainly used as receiving antenna at lower frequencies.

Small loop antennas have very low value of radiation resistance. This results into power loss as heat due to flow of current with high levels. Hence large loop antennas are preferred over smaller ones.

DESIGN WITH GRID ANTENNA: The usage of grid antenna lead to decrease in the power density which ruled out the disadvantages of rf power scavenging. Parasitic strips are used in order to enhance the gain.

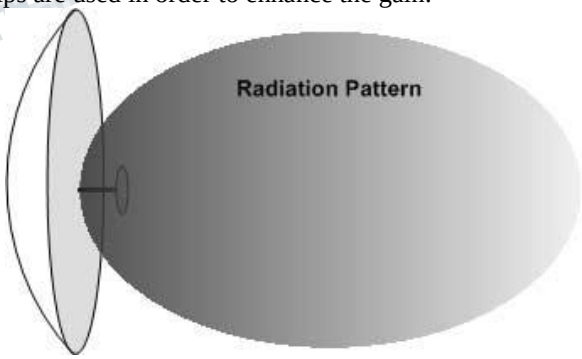

Fig 1:radiation pattern of grid antenna.

Advantages:

It can be used both as transmitting antenna and receiving antenna due to principle of reciprocity. The feed can be used in various modes with parabolic reflector viz. centre feed, cassegrain feed or offset feed. Each of these configurations have their respective benefits and applications. Smaller size and low cost.

Disadvantages:
Feed antenna and reflector disc block certain amount of radiation from the main parabolic reflector antenna. This is about 1 to2%.

The design of parabolic reflector is a complexprocess. Inspite of feed horn at focus and uniform illumination, certain amount of power from feed is bound to slop over the edges of parabolic reflector. This power is responsible to form side lobes in the radiationpattern. Surface distortions can occur in very large dish. This is reduced by using wide mesh instead of continuous surface. In order to achieve best performance results, feed should be placed exactly at the focus of the parabolic reflector antenna. This is difficult to achieve practically.

ADVANTAGES AND DISADVANTAGES OF RFPH TECHNIQUE:

Advantages:

- The operating cost is minimized-in order to maintain power to wireless sensor networks through batteries lead to enormous cost to supply.
- The disposal of batteries and handling becomes easier.
- Controllable and reliable- the power source can be controlled and is available on demand.
- Simple scalability – it has the capability to be changed in scale or size.
- Durability is improved and the failure of product is reduced.

Disadvantages:

- Low power density
- Efficiency is inversely proportional to the distance.

APPLICATIONS

The rf power scavenging technique will play a major role in batteries replacement in the near future. Some of the applications of rf power harvesting have been realized practically. Due to the availability of electromagnetic waves abundantly in space, this technique can be implemented widely in today's world. In medical and health care field the rf power harvesting is highly recommended. Particularly the rf power harvesting supports low health care and medical devices. It also facilitates the development of MEMES technology, wireless sensor networks and IOT's by providing mobility of use. The development of the MEMES technology and WSN'S has achieved wide popularity in recent years. Rf energy scavenging techniques are also used in radio frequency identification. Additionally, the advancement in integrating rf energy harvesting circuits into cmos technology creates a completely wireless SoC'S.

II. CONCLUSION

This paper summarizes the development of rf power harvesting technology in recent years, Nowadays the processing of battery wastes a major problem. Therefore by applying rfph technology, dependency on batteries can be reduced which ultimately leads to appositive impact on environment. Since these energy harvesting circuits are designed in order to operate with small voltages and currents and they depend on state of the art.Art electrical technology in order to obtain high efficiency Therefore the process of utilising electromagnetic energy will never generate waste as it is a clean source of energy.
And also there are wide range of application in the field of medical and health care devices. The Trend of Energy Harvesting Methods for Portable Medical Devices are used extensively now a days. The need to extend the availability of various energy devices is vital. However, the portable and low power medical devices field, either to monitor various vital parameters or to perform a particular therapy represents a promising sector for the use of these technologies.

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