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RF Energy Harvesting Antenna

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ABSTRACT

Nowadays energy harvesting is essential because of the future scarcity of the natural mineral resources. Energy harvesting is done from those natural resources which are inexhaustible. So that it is more convenient than wall plugs and batteries which are costly and need replacements. Now, with ubiquitous computing requirements in the fields of embedded systems, wireless sensor networks and low power electronics such as MEMS devices, an alternative source of energy is required. Also with the limited capacity of finite power sources and the need for supplying energy for a lifetime of a system, there is a requirement for self-powered devices. The process of extracting energy from the surrounding environment is termed as energy harvesting. Energy harvesting, which originated from the windmill and water wheel, is widely being considered as a low maintenance solution for a wide variety of applications. There are various forms of energy that can be scavenged, like thermal, mechanical, solar, acoustic, wind, and wave. The Energy Harvesting is generating electrical energy from solar, thermal or kinetic energy present within or around the system. This paper serves as a survey for identifying the sources of energy harvesting based on various technical papers available in the public domain.

Keywords: Harvesting,

I. INTRODUCTION

Energy harvesting is an active field of research aimed at powering low power wireless systems, self-powered sensors and micro-systems and recharging existing batteries.. Solar cells are excellent energy harvester under direct sunlight, but are limited in application under dim day light condition, in the night and where light has no access, such as in embedded systems. Thermal energy can be converted into electrical energy using seeback effect, but this approach produces energy in the range of a few µW only. Kinetic energy harvester converts kinetic energy present in the environment into electrical energy. It has already been demonstrated by several groups that the ambient kinetic energy can be easily converted into electrical energy in the µW range. Kinetic energy is typically present in the form of vibration, random displacement of forces and is typically converted into electrical energy using electromagnetic, electrostatic and piezoelectric energy transduction method. There has been a significant increase in research on energy harvesting techniques. It is the process whereby ambient energy is captured and converted to usable electrical energy and then stored for later use. Ambient energy is natural, non-electrical in nature, and is self-regenerating or renewable. Micro harvesting is the system which can produce electricity in scale of micro or mill watt. This is intended for ultra-low power solution. Some of the Promising sources are discussed below [5].

	Advantages	Disadvantages	Application area
photonic	Cost effective. Size effective. Durable. DC power.	Does not work well indoors. Prone to failure by debris. Requires secondary storage for 24/7 uptime	Agriculture. Shipping yards. Outdoor security. Transportation.
Thermal	Works where batteries cannot. Adaptable. Active whenever the object to be measured is active.	Requires large thermal gradients Requires bulky sinks	Monitoring industrial exhaust. Furnaces. Engine/power train.
Vibrational	Has the potential to work anywhere there is machinery, regardless of temperature or illumination. Frequency can be tuned for a specific application.	Highly frequency dependent. Requires excellent mechanical coupling. Requires rectification. Currently expensive.	Machine tool monitoring. Pump monitoring. Engine monitoring.

Figure 1.Various Techniques for Energy harvesting

II. TECHNIQUE OF ENERGY HARVESTING

2.1 Electromagnetic Harvester

In this process, magnetic field is used to produce electric energy. A mass wrapped within a coil can be allowed to oscillate in a magnetic field or a magnet can be used to oscillate inside a coil. In general the coil travels through a varying amount of magnetic flux so it inducing voltage according to Faraday's law. This produces a voltage which is very small (~0.1V) and varying, thus an amplifier circuit has to be used. To do this, many factors can be changed, the magnet strength, number of turns in the coil (more turns means it will cut with the magnetic field lines more), changing the mass or even changing the diameter of the wire which makes the coil. However, each of these parameters is limited by the size. Another important factor is that, it needs no external voltage source to start generating. Typical sources are wind vibration and mechanical vibration (using a cantilever).

2.2 Piezoelectric Energy Harvester

This method alters mechanical energy into electrical energy by straining or deformation of a piezoelectric material. Deformation of a piezoelectric material causes charge separation across the material, producing an electric field and consequently a voltage drop across it. This voltage drop is almost proportional to the stress applied. The oscillating system is typically a cantilever beam structure with a mass (piezoelectric) at one end of the lever. The voltage produced varies with time and strain, producing an irregular current. Piezoelectric materials can also be used in systems where it is subjected to stress or compression, producing a voltage of around 2~10V. Piezoelectric energy conversion produces relatively higher voltage and power compared to the electromagnetic system. Piezoelectric materials can separate the electric charges from the crystal lattice which flows through the system. If the piezoelectric material is not short circuited, the applied vibration induces a voltage across the material. This induced voltage is relatively high and the system requires no external voltage source for excitation. It is easy to maintain. However, the material itself is not so very available yet and it depolarizes easily causing less production of voltage at times, leakage voltage is high and it has high output impedance. It is used for harvesting vibration energy where stress or compression is available, for example human body movement, it can be easily placed inside a shoe which will provide enough deformation of the material to produce voltage, as a person walks. It is extensively used in Instrumentation Engineering where the displacement is to be transported to the system whose output depends on feedback in form of this voltage

2.3 Electrostatic (capacitive) energy harvesting

This type of harvesting is based on the changing capacitance of vibration-dependent variable capacitors. Vibrations separate the plates of an initially charged variable capacitor (varactor), therefore to start generating the system requires an external voltage source, and mechanical energy is converted into electrical energy as both the plates move up and down (mechanical constrains are needed). The produced voltage is relatively high (2-10V). It can be easily worked with MEMS. The system can be placed in a car near to the shock absorber, where the vibration is maximum. The disadvantage associated with this technique is the fragility of Electronic components employed.

Figure 2 The Capacitors of different Farads and Wattage

III. The Wireless Era

The Era of Wireless is here, and advancing towards Wireless electricity has already been initiated but with slow and silent steps. Electricity has been the agent of technology revolution and leading the way for every other revolution, from the Economic circumstances (Digitized Stock Markets) to Farming (e-Mandi).Every step of Human Beings are now Tech-friendly, but not just our energy resource, which is still majorly dependent on Fossil fuels. The performance of a Fossil fuel depends on its Calorific Value (The amount of heat a unit mass of Fossil fuel emits). But, where on one hand Calorific value, an important attribute for a fossil fuel, Pollution could be the biggest problem which could not go unnoticed anymore.

Pollution is the headache of every Developed nation and a bottleneck for further development in developing economies, but the stakeholders are not just these two worlds, but a third world as well, which without any exploitation of natural resources are paying the price by the unfavorable conditions prevailing geographically and other far reaching effects of the Pollution.

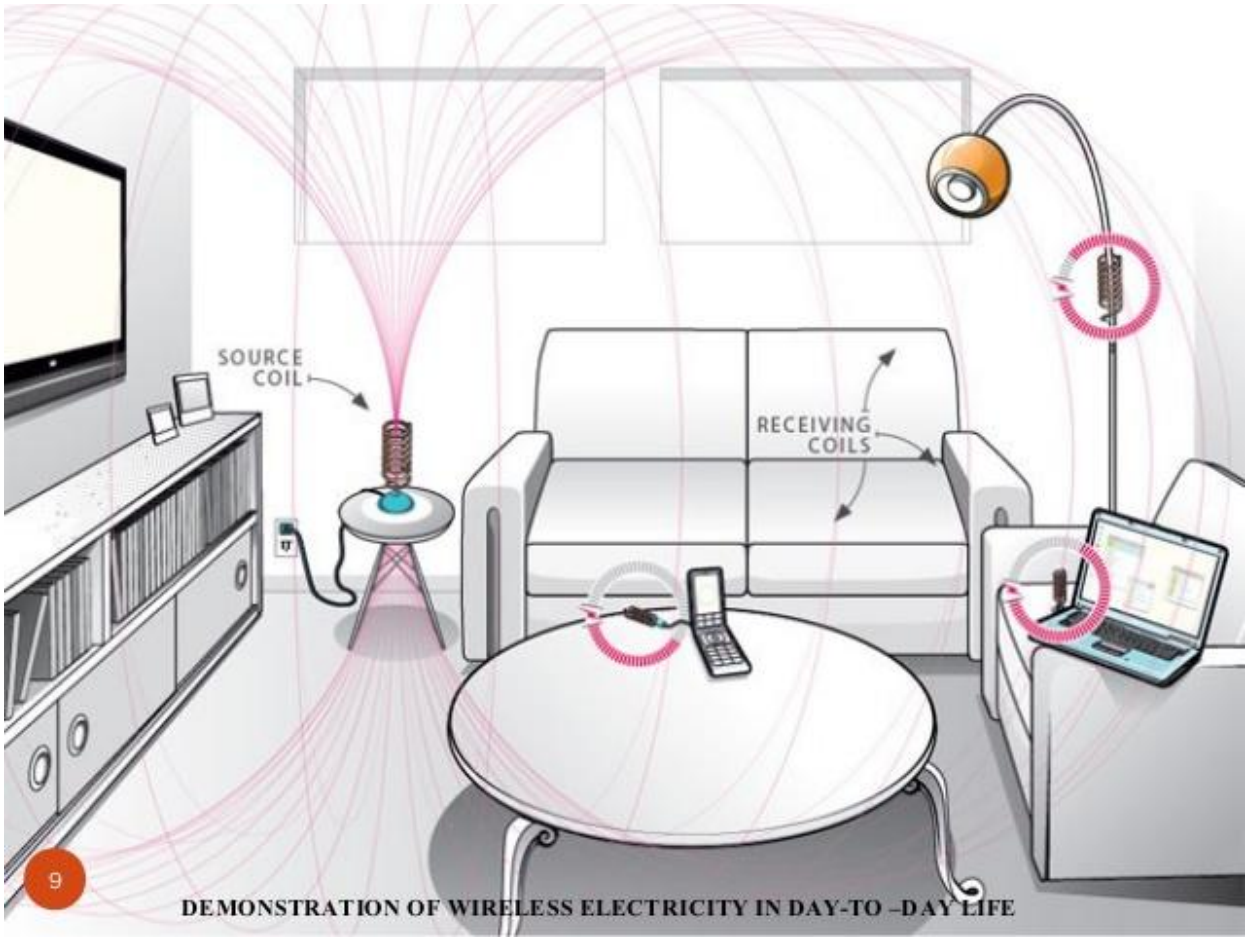

Figure 3. The penetration of Wireless technology in our daily lives

IV. TECHNIQUE PROPOSED

Most of this research has been focused on technology specific solution. The sources of ambient energy, depends on the applications. The most familiar ambient energy source is solar power. Thermal energy is another ambient

energy source. With ever increasing demand for energy and ever depleting Natural Resources, the Overall sustainability of Homosapiens and our Planet is in dark. But, maybe Sir Nikola Tesla didn't knew that his experiments could be the savior of the entire humanity economically and biologically.

Figure 4. Tesla Tower

Tesla Tower as it is popularly known to the Sci-friendly masses could be the answer for all our energy related problems. Renewable energyresources such as Wind Energy and Solar Energy have their own limitations, such as wind energy require comparatively large areas for Installation and operation. Solar Energy require the "threshold Lumens" which could be a limiting factor within our country itself or even some states, in that case. In Countries where the Economy is not as strong as that of the Developed world, Renewable resources have the "costly" Bottleneck.

But, if we can just exploit the Height dimension of a longitude object, it might cost you negligible as compared to the conventional renewable resources. The Tesla tower is a renewable mechanism as it uses the Charge present in the atmosphere by the virtue of distance above the sea level. The abundance of the Charge Particles increases with increase in Height.

4.1 The Proposed Design

From Ancient Pyramids to Present day Eiffel Tower, Tesla Tower could be anything but not the mentioned examples (they lack a thing or two). Factually, Lightning occurs 100 times in a minute on an average day but just not enough magnitude for us to be noticed. This gives us an idea about the probable charge distribution in the space around us.

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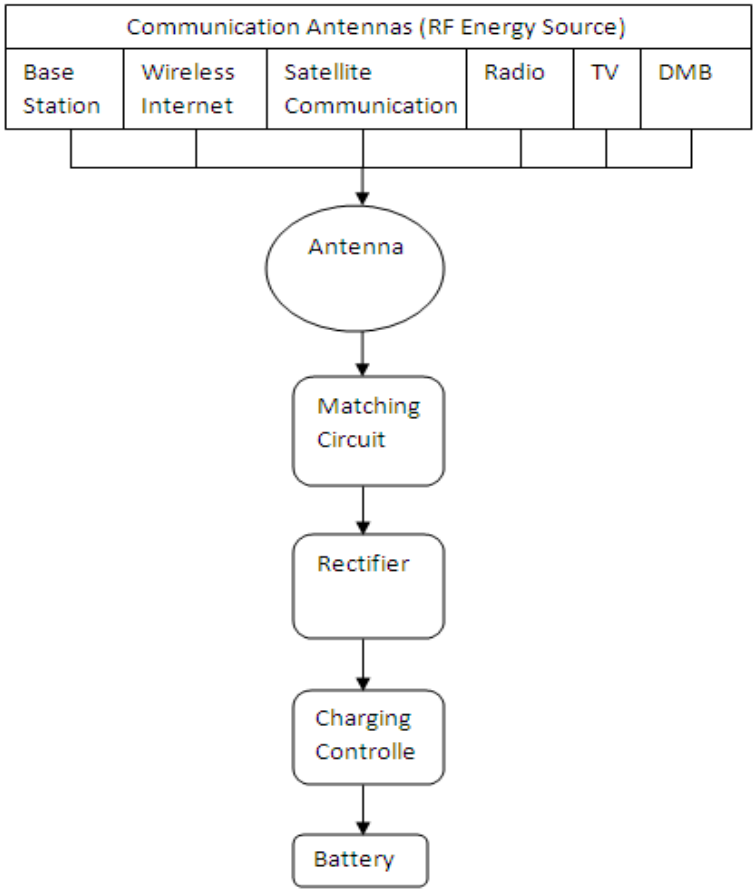

Figure 5. Flow chart for Energy Harvester

To utilize this charge as a Potential difference to drive our circuits. There is about a 300 000 volt (V) potential difference between the Earth's surface and the electrosphere, which gives average electric field strength of about 6 V/metre (m) throughout the atmosphere. Near the surface, the fine-weather electric field strength is about 100 V/m.

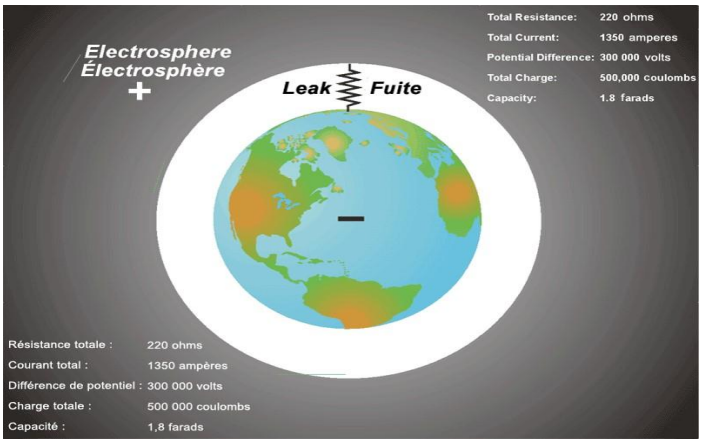

Figure 6. The Electrosphere

Average height of a man is 6 feet or 2 meters so 100 V/m x 2 meters = 200 Volts 6 feet off the ground. That is the reason why Earth is at Zero Potential, which is used in Earthing of Electronic and Electrical Devices.The

tesla tower could reduce various forms of Pollution, but not all. It could reduce the pollution in dividends. Optimization of e-waste would still have a scope for great development.

V. Conclusion

Harvesting energy from the environment is being considered as a viable option to replace the current power supplies for energy constrained embedded systems. The desire to use self-powered devices drives to achieve enormous growth in the field of energy harvesting. With the few limitations such as low amount of power generated using the power harvesters, the researchers are working towards generating new methods. These methods would help in placing the energy harvesters as one of the best

sources to power portable devices in the field of wireless technology.

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