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Designing of Simulink Model for Low Power Devices using Different Sources: A Survey

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ABSTRACT

In these day's various electronics gadgets are available in market which can be driven from low power. In absence of conventional power in particular area EH technique permits electronics devices to perform. By doing this various cost can be saved like no requirement of wire or batteries replacement. EH systems consists a circuitry which charge cell and the help in coordination power management. The concept of power harvesting works towards developing low powered devices that do not require replaceable power supplies. This paper discuss energy scavenging as an proficient technique to cater to energy requirements of moveable electronics, review recent advancement in the field of power harvesting & present the current state of power harvesting in its drive to create completely self-powered devices. Our main motive is to develop a robust system having more than one energy resource in such a way that round the clock low power devices can be used in emergency circumstances.

Keywords: Fuzzy Logic, PV, Energy, MPPT, Wind Turbine, Piezoelectric, Thermoelectric

1. INTRODUCTION

Owing to the recent advances made in wireless technology and low power electronics, wireless sensors to be used in diverse scenario are being developed. The wireless nature of these systems makes it necessary to have a provision for self –powered devices. The devices are generally powered by a battery offering finite power supply. But batteries increase the size, and sometimes the cost of the devices in question and pose an additional burden of replacement or recharging. Thus there is an increasing effort to develop new sources of long-lasting and regenerative power to meet the energy needs of these wireless systems. Energy Harvesting (EH); also known as Power Harvesting or Energy Scavenging, is the process in which energy is captured from a variety of ambient energy sources and converted into usable electric power. Energy harvesters provide a very small amount of power for low-energy electronics.

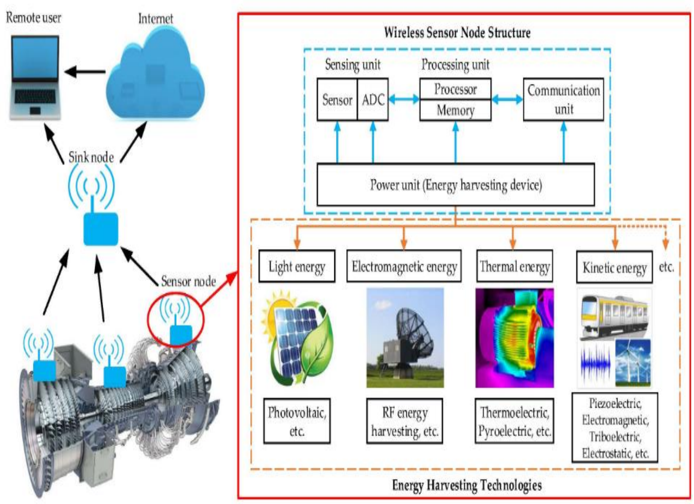

Figure 1: Hierarchy of main energy harvesting technologies

EH allows electronics to operate where there's no conventional power source, eliminating the need for wires or replacement of batteries. EH systems generally include circuitry to charge an energy storage cell, and manage the power, providing regulation and protection. EH-powered systems need reliable energy generation, storage and delivery. Must have energy storage as EH transducer energy source is not always available for example solar at night, motor vibration at rest, air-flow. EH can provide "endless energy" for the electronics lifespan. In many cases, energy harvesting can eliminate batteries from wireless devices and ideal for substituting for batteries that are impractical, costly, or dangerous to replace.

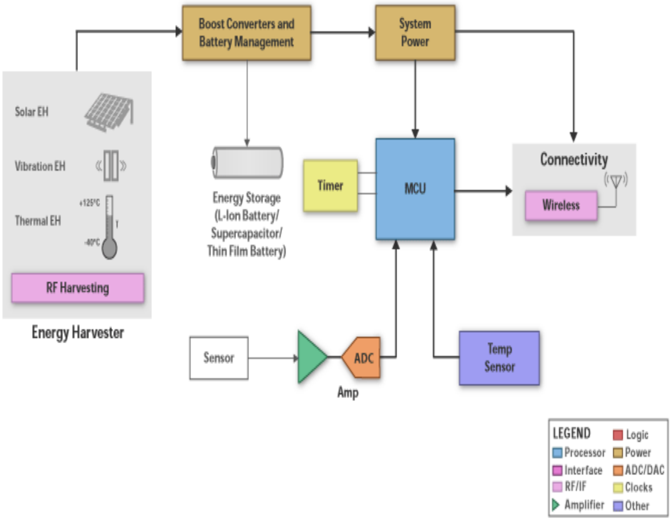

Figure 2: Energy Harvesting Block Diagram

EH uses of ambient energy to provide electrical power for small electronic and electrical devices. Energy Harvesting Module captures milli-watts of energy from light, vibration, thermal or biological sources. A possible source of energy also comes from RF such as emitted from cell phone towers. The power is then conditioned and stored within a battery, an efficient quick charging capacitor or one of the newly developed thin film batteries. The system is then triggered at the required intervals to take a sensor reading, through a low power system. This data is then processed and transmitted to the base station. This kind of EH System eliminates the dependency of the system on battery power and reduces the need to service the system.

2. SOURCE OF ENERGY

Energy harvesting uses unconventional sources to power circuitry. There are various sources of renewable energy are available excluding fossil fuel. For example light energy, natural energy, mechanical energy, thermal energy and many more.

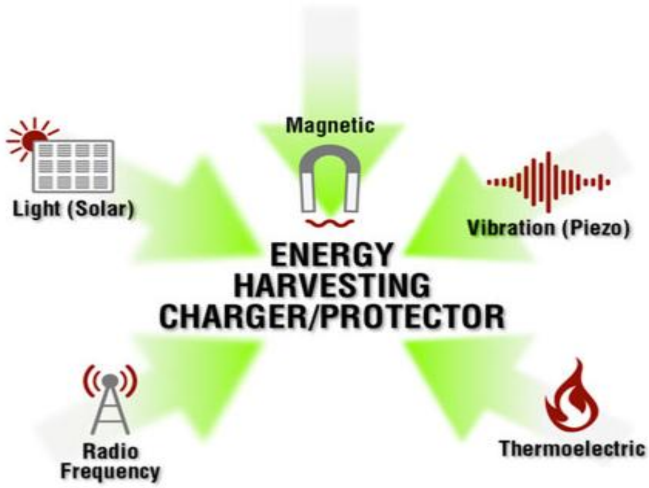

Figure 3: Sources of energy

Thermal energy

Waste heat energy variations from furnaces, heaters, and friction sources. Thermal energy can be obtained from heat present in the ambience or from heat generated during some process. Either thermoelectric or pyroelectric effects can be used to harvest energy. Thermoelectric effects like Peltier effect, Seeback effect & Thomson effects [1] can generate power as long as a heat source is present. Extraction of energy from a thermal source requires a thermal gradient & conversion efficiency mainly depends on the temperature difference between the heat source & the environment (i.e. the cold & the hot side). A greater temperature difference leads to a better output.

Mechanical energy

Mechanical sources provide a promising alternative to harvest energy where vibration source is the best. Vibrations in some situations can be very large, like in case of the vibrations of civil structures like tall buildings, railroads, ocean waves, & even human motions & can give a better output power. Sources for conversion of vibration energy into electrical energy include electrostatic, magnetic field, or strain on a piezoelectric material [2]. Vibrations from machines, mechanical stress, and strain from high-pressure motors, manufacturing machines, and waste rotations can be captured and used as ambient mechanical energy sources

Sound energy

Sound energy is another form of unused energy which can be harvested. Sound energy is almost present continuously & at a considerable level in the environment for e.g. on the railway track, runway, ship yard, or on the road (engine noise of vehicles & horns), loud music played in clubs or parties, at construction sites & other such sources etc. give sufficient sound pressure levels that can be used for EH [3].

Wind energy

Wind energy is another method of harvesting energy. This wind flow, or motion energy, when harvested using huge wind turbines, can be used to generate electricity on a large scale [4].

Light Energy: This source can be divided into two categories of energy: indoor room light and outdoor sunlight energy. Light energy can be captured via photo sensors, photo diodes, and solar photovoltaic (PV) panels.

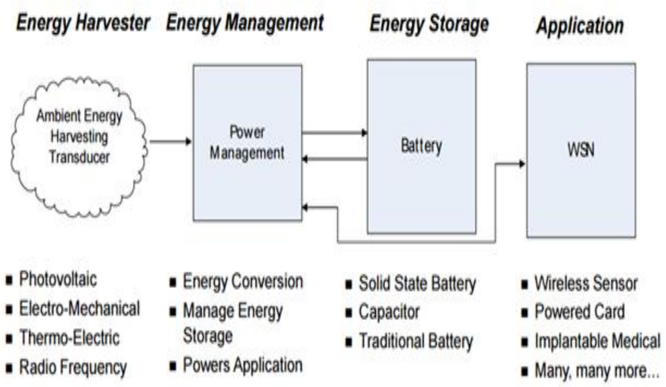

Figure 4: Layout of EH from generation to end requirement

Table 1: Characteristics of Typical Energy Harvester

Energy Source	Characteristics	Efficiency	Harvested Power
Light	Outdoor Indoor	10-25 %	100mW/cm^2 100uW/cm^2
Thermal	Human Industrial	0.1 %	70uW/cm^2 10mW/cm^2
Vibration	Hz Human KHz machines	3 %	4uW/cm^2 850uW/cm^2
Radio Frequency	GSM 900MHz	25-50 %	0.1uW/cm^2 0.01uW/cm^2

3. APPLICATION OF ENERGY HARVESTING

Energy harvesting concept has found a variety of applications in wireless communication & networks. Some adhoc sensor networks follow minimum energy path to optimize energy usage at a node such that the limited resources at sensor nodes can be used more effectively. Photo of a Wireless Sensor Network is shown in Figure 2 [8]. At the same time, if a low energy path is used frequently, it may lead to reduction in the node energy along that path & may even cause network partition. Hence occasionally sub-optimal paths based on energy aware routing protocols may be used to improve the performance with the help of EH. Use of energy harvesting helps to eliminate the need of battery replacement & maintenance & to prolong the lifetime of sensor nodes [8].

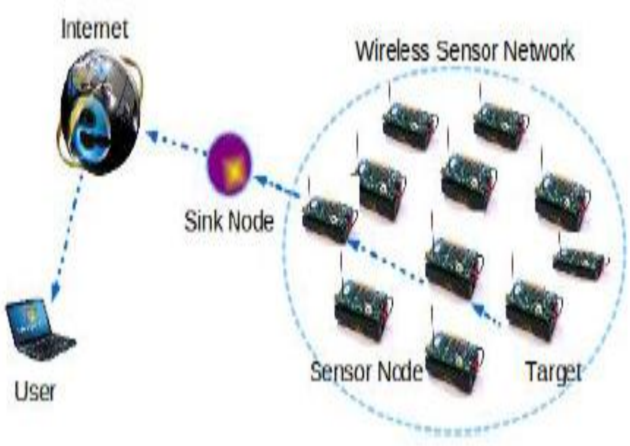

Figure 5: wireless sensor networks

Biomedical Application: The extension of the energy harvesting concept is used for portable medical devices. The portable medical devices are expected to be smaller in size, lightweight& most of the times either wearable (for e.g. the sphygmomanometer) or implanted inside the body (for e.g. the pacemaker). As these devices are smaller in size, their energy consumption is also less. Batteries of smaller size are enough to meet these requirements but the operational time & performance of the portable devices as these batteries need to be replaced or recharged periodically. A person with lithium battery pacemaker will require battery replacement surgery every 8 years.

Table 2: Medical Device and their Power Requirements

Medical Equipment	Power requirement (W)
Pacemaker	5.6 W
Arterial Pressure Monitor	3 W
Glucose Level Monitor	0.5 W
Insulin Infusion Pumps	12 W
Blood Coagulation Monitor	0.5 W

Photo of a Pacemaker with battery is shown in Figure 6 [7]. Likewise, implantable neurostimulator & infusion pumps have a reduced lifespan of 3 to 5 years. Thus dependence on batteries needs to be reduced in this field giving rise to energy harvesting as an alternative solution. Piezoelectricity, thermal energy & electromagnetic energy w. r. t to human body are mainly considered for biomedical EH. Thermoelectric devices are an attractive source of energy as it directly converts temperature gradients in to power. Though thermoelectric generators (TEG) were available for quite some time, it is only recently that low power medical implants have been researched & developed [7].

Figure 6: Pacemaker with battery

Besides these some of domains of application are listed below:

- Remote patient monitoring
- Efficient office energy control
- Surveillance and security

- Agricultural management
- Home automation
- Long range asset tracking
- Implantable sensors
- Structural monitoring
- Machinery/equipment monitoring

4. ENERGY STORAGE DEVICES

There are several simulation tools available for almost all energy-harvesting scenarios require some sort of energy storage element or buffer. Even if the voltage and current requirements of an embedded application were so low as to be run directly on power captured or scavenged from the environment, such power would not flow in a constant way. Storage elements or buffers are implemented in the form of a capacitor, standard rechargeable lithium battery, or a new technology like thin-film batteries. What kind of energy storage is needed depends greatly on the application. Some applications require power for only a very short period of time, as short as the RC time constant discharge rate of a capacitor. Other applications require relatively large amounts of power for an extended duration, which dictates the use of a traditional AA or a rechargeable lithium battery

Table 3: Various Storage Devices Specification

Parameters	Li-Ion Battery	Thin Film Battery	Super Cap
Recharge cycles	Hundreds	Thousands	Millions
Self-discharge	Moderate	Negligible	High
Charge Time	Hours	Minutes	Sec-minutes
Physical Size	Large	Small	Medium
Capacity	0.3-2500 mAH	12-1000 µAH	10-100 µAH
Environmental Impact	High	Minimal	Minimal

CONCLUSION

Harvesting energy from the renewable resources gives many benefits in various domains like for IoT, low power networks and indoor applications which demand greater power. In our proposed work, we came up with experimented solution of producing power from various renewable resources for example solar PV array, wind turbines and piezoelectric sensors and thermo electric system. Energy harvesting can be viewed as a maintenance-free alternative to battery technology. This paper has mainly concentrated on reviewing the various sources that can be used to harvest energy and some potential applications to WSN, biomedical and other areas were discussed. It was observed that out of the many sources available, only a few sources have contributed to the development of good harvesting architectures. Some applications have also combined two sources of energy like human and vibration energy. In future it would be an interesting idea to combine multiple sources using a feedback mechanism from the load to meet its power requirements.

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