A Survey - RF Energy Harvesting

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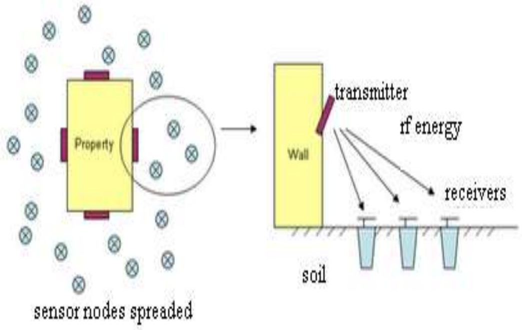
Abstract: **In recent years, there has been a growing interest in the deployment of wireless sensor networks within many sectors. These network systems, consisting of spatially distributed sensor nodes are used extensively in various applications such as environmental monitoring, animal tracking and control, agriculture, habitat monitoring, inventory tracking, and healthcare system. one emerging Wireless Sensor Node application is in agriculture sector, where the sensor nodes are deployed in outdoor fields to monitor soil conditions, such as moisture, mineral content, and temperature. Data collected from these sensors could be used to manage irrigation and fertilization, to predict crop yield, as well as to improve crop quality. Energy supply has been a limiting factor to the lifetime of agricultural wireless sensors. These sensors are typically powered by onboard batteries which have fixed energy rating and limited lifespan. Hence, they need to be replaced in due time. Moreover, the cost is prohibitive when replacing the exhausted batteries since the sensor devices need to be unearthed. Apart from that, disposal of used batteries poses another major issue. Batteries containing heavy metals such as mercury, lead, or cadmium could be hazardous to human and environment if they are improperly disposed in the landfills. A possible long-term solution to overcoming these problems is by using energy harvesting in which ambient energy can be extracted and converted into usable electrical energy to power the sensors. Based on the given environmental conditions, Radio Frequency (RF) energy harvesting, which relates the concept of wireless energy transmission, is preferred. RF energy harvesting can not only be used to replenish the power required to operate the soil sensors, but it can also provide a more controllable and predictable power supply compared to other possible energy harvesting methods. RF energy harvesting is a unique technology that can enable controllable, wireless power over distance, and scale to provide power to thousands of wireless sensors. Devices built with this wireless power technology can be sealed, embedded within structures, or made mobile, and battery replacement can be eliminated.**

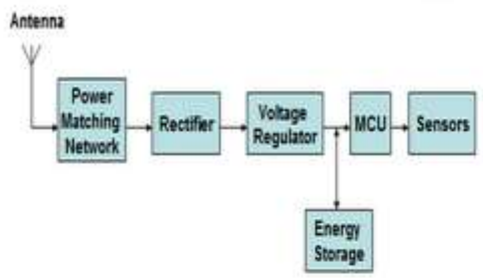
Key Words: **RF Energy Harvesting, Rectenna, Microstrip Patch Antenna, Voltage Doubler.**

RF Energy Harvesting Scheme: The main application of this research is a wireless soil sensor network used for in-field pest detection and monitoring. This network comprises of several sensor nodes which are distributed across an outdoor field surrounding a property. The soil sensor nodes are non-moving and could be located in an open area, in the shades of trees, or even covered by dried leaves or mud. Based on the given environmental conditions, Radio Frequency (RF) energy harvesting, which relates the concept of wireless energy transmission, is preferred. RF energy harvesting can not only be used to replenish the power required to operate the soil sensors, but it can also provide a more controllable and predictable power supply compared to other possible energy harvesting methods.

Through this approach, RF energy radiated from a controlled transmitter is captured by a receiving antenna attached to the sensor node and converted into usable DC voltage via a combination of rectifier and voltage regulator circuit. This DC output is then stored in an energy storage system before being used to power the sensor.



RF energy transfer mechanism between a transmitter, attached to the wall of a property, and the receivers



The energy harvesting industry is developing technologies to take advantage of varied sources of micro power (power measured in milliwatts) including solar, vibration, thermal, and RF energy. For any specific installation, there will likely be a clear choice of the optimal energy harvesting technology to be used, but—depending on the application—all are capable of providing the micro power needed for wireless sensor applications. RF energy harvesting converts radio waves into DC power. This is accomplished by receiving radio waves with an antenna, converting the signal, and conditioning the output power.

Usable power from RF energy harvesting will typically be in the milliwatt and microwatt range based on the power limits from commercially available transmitters or the distance from sources such as radio and TV transmitters. The usable power or range can be greater for specialized military or industrial applications that use higher levels of transmission power. Comparisons are often made regarding the power density (i.e., W/cm3) of various energy harvesting technologies. While power density is a valid metric of comparison, it is also incomplete because each type of energy harvesting presents unique benefits. In the case of RF energy harvesting, for example, these are controllable and ambient power over distance, one-to-many wireless power distribution, mobility, embedded harvesting technology, and independence of weather conditions or time of day.

RF energy harvesters (such as those in the sidebar, "RF Energy Harvesting Modules") can be simple or complex,

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depending on the performance and functionality required. A simple harvester, for example, may provide basic signal rectification and require external power management circuitry. A more complex harvester may combine the power management and other functionality within a single component. For maximum performance, design flexibility, and application flexibility, there are several important characteristics that a commercial RF energy harvester should provide. The harvester should have high sensitivity to enable it to harvest from ultralow levels of RF energy. It should have high efficiency to convert as much of that energy as possible into usable power. The efficiency range should be sufficiently broad to support a wide range of operating conditions such as input power, load resistance, and output voltage. The harvester should have intelligent power management capabilities that can be controlled or used by a microcontroller to optimize system-level power. And lastly, it should be easy to implement, such as having an input impedance of 50 ohms to be compatible with a wide selection of commercially available antennas, and packaged to participate in standard PCB manufacturing processes.

Why RF energy Harvesting? RF energy harvesting is a unique technology that can enable controllable, wireless power over distance, and scale to provide power to thousands of wireless sensors. Devices built with this wireless power technology can be sealed, embedded within structures, or made mobile, and battery replacement can be eliminated. With commercial RF energy harvesting components currently available, engineers can integrate this technology to provide embedded wireless power for their low-power wireless devices.

Anticipated ambient sources are sources where, although there is no control, they can be relied on to act as sources of power on a regular or intermittent basis. An example of this is the concentration of mobile phones (i.e. people) expected at a given location such as bus stops or crowded sidewalks. There are estimated to be 3.5 billion GSM subscriptions globally and predicted to grow to 4 billion by 2012. Depending on transmit power, multiple phones in close proximity can provide several milliwatts of power. Additional examples of these sources include known radio, television, and mobile base station transmitters. Unknown ambient sources are sources of RF energy of which there is no control and no knowledge (e.g., microwave radio links and mobile radios such as those used by police forces), but which still provide a continual or intermittent source of power.

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Harvesting Circuit using Rectenna: To remove the problem of battery replacing or recharging a researching area is undertaken in which people is getting interest on the harvesting energy. At the present time there are digital systems and sensor nodes with ultra low power consumption which makes feasible the development of low power harvesting systems. There are electromagnetic energy scavenging on high frequencies from 2 GHz to 18 GHz or the unlicensed 2.4 GHz ISM band. Moreover, most of the frequencies are high and therefore, the distance between the RF transmitter and the harvesting unit is relatively short. The transmitted power in the ISM band is pretty low. On depending upon the low power factor the harvesting unit is designed which comprises of an antenna, an impedance matching network, a rectifier circuit, a low pass filter, a storage element and a control unit. This kind of device is called “rectenna”.

Most of rectennas and matching devices are designed for having a large bandwidth.

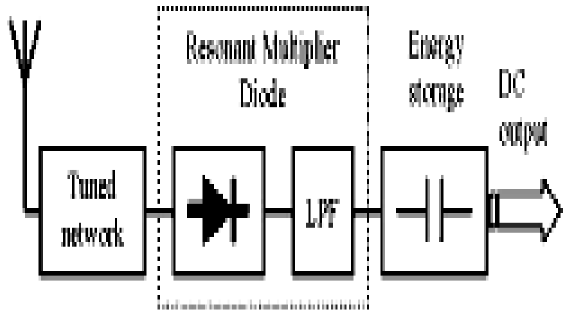

Fig. 2. Rectenna block diagram.

The convenient way to use the energy from commercial RF broadcasting stations like radio or TV and from mobile base stations to supply energy to wireless sensor nodes. Therefore this powering method can be specially interesting for sensor nodes located in remote places, where other energy sources like solar radiation or wind energy are not feasible. This kind of energy transfer is, although small amount of energy is uninterrupted and could serve as the energy support for other energy sources. The antenna is connected to a tuner stage, since we want to use a only channel of all the possible commercial transmissions. The selected channel is the only one that is more powerful where the sensor node is located. The tuner stage is connected to a rectifier circuit which is composed by a charge pump. Generally two cell Dickson charge pump voltage doubler rectifier circuit is used because it posses the advantage of low input impedance at microwave frequencies, thus making matching to 50 ohm easier. The diodes appear in parallel to RF signals but are in series for DC circuit; as such the voltage output is doubled.

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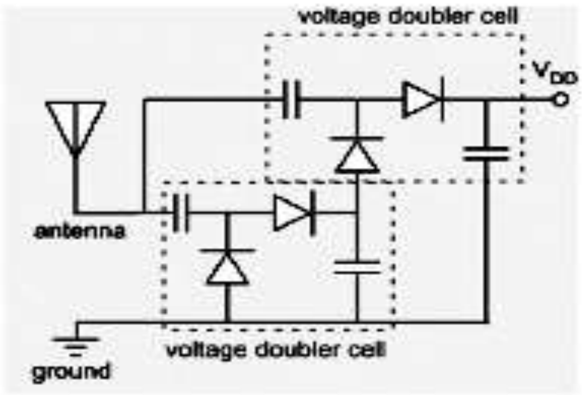

(b) Circuit layout of the rectenna.

A planar low profile and light weight microstrip patch antenna is used. The application of fractal geometry to conventional antenna structures optimizes the shape of the antennas in order to increase the electrical length not physical length, thus reducing the overall size. The characteristic impedance of the feedline may be designed to be 50 ohm and the final antenna design will be optimized using efficient computational tools. The impedance matching circuit may be realized by series transmission lines and shorted stubs for good result.

Conclusion: In this paper the RF energy harvesting mechanism in agriculture and the importance of RF energy harvesting is described shortly. A planar low profile rectenna may be designed for harvesting device and additional improvements in harvesting circuits can be still achieved using array of patch antenna with wider band and reduced size and low power CMOS transistor instead of diodes for low power application in future generation.

Future scope of research: Today, the most practical implementations of RF energy harvesting will require intentional sources to provide the energy. Wirelessly networking the transmitting sources to control how they operate can maximize the overall performance of a wireless power distribution system. Turning the power sources into access points completes the functionality to create a complete infrastructure for wireless power and data while also eliminating the need for battery replacement. Ambient RF power levels will increase as more transmitting devices are put into use. A more significant factor in enabling pure ambient RF energy harvesting will be the introduction of devices that operate at lower and lower power levels. As device power consumption decreases, ambient RF energy harvesting will become more practical and available in more areas. The development of efficient multiband or wideband RF energy harvesters will also play an important role in the realization of widespread ambient harvesting over the next several years. RF energy harvesting is a unique technology that can enable controllable, wireless power over distance, and scale to provide power to thousands of wireless sensors. Devices built with this wireless power technology can be sealed, embedded within structures, or made mobile, and battery replacement can be eliminated. With commercial RF energy harvesting components currently available, engineers can integrate this technology to provide embedded wireless power for their low-power wireless devices. Energy harvesting and power management integrated circuits (ICs) are in a position to enable the commercial rollout of the next generation of low power electronic devices and systems. Low power devices will be deployed for wireless as well as wired systems, such as mesh networks, sensor and control systems, and micro-electromechanical systems (MEMS). Applications include home automation, building automation, industrial process/automated meter reading, medical, military, automotive tire pressure sensors, radio frequency identification (RFID) and others.

References

[1] E.Lai, A.Redfern, and P.Wright, " Vibration powered battery assisted passive RFID tag," Embedded and Ubiquitous Computing, pp. 1058-1068, 2005.

[2] Gianfranco Andia Vera, Apostolos Georgiadis, Anna Collado, and Selva Via, " Design of a 2.45 GHz Recetenna for Electromagnetic (EM) Energy Scavenging," IEEE, 2010

[3] W. C. Brown, " The History of Power Transmission by Radio Waves," IEEE Tranc. on Microwave Theory and Techniques, Vol. 32 No. 9 pp. 1230-1242. Sept. 1984.

[4] Y. Kawahara, K. Tsukada, and T. Asami, " Feasibility and Potential Application of Power Scavenging from Environmental RF Signals," Proc. IEEE Intl. Conf. On Antennas and Propag, Charleston, pp. 1-4, June, 2009.

[5] Muhammad Azman Miskam, Azwan bin Nasiruddin and Inzarulfaisham Abd. Rahim, "Preliminary Design of Wireless Sensor Network for Paddy Rice Cropping Monitoring Application in Malaysia," ISSN 1450-216X Vol. 37 No. 4 . European Journal of Scientific Research pp. 649-657, 2009.

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