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# An Overview about Microstrip Antenna for Energy Harvesting in Agriculture

**Ban M. Alameri, Shahad Khalid Khaleel & Mustafa Mahmood Abd**

## Abstract
Interest in implementing wireless sensor networks across a variety of industries has been on the rise in recent years. Ecological monitoring, inventory tracking, healthcare, animal tracking and control are just few of the many uses for network systems made up of spatially distributed sensor nodes. One promising use for WSNs is in the agricultural industry, where they are placed in fields to track environmental factors including soil moisture, mineral concentration, and temperature. It is possible that the information gathered by these sensors might be utilized to optimize water and fertilizer usage, forecast agricultural yield, and enhance crop quality. Battery life is a major issue for agricultural wireless sensors. The batteries that power these sensors often have a finite energy capacity and a short service life. This necessitates their eventual replacement. Because the sensor devices must be dug up, the expense of replacing their dead batteries is also prohibitive. Additionally, there is the problem of where to put all those old batteries. Heavy elements found in batteries, such as mercury, lead, and cadmium, can cause health and environmental risks if disposed of incorrectly in landfills. Energy harvesting, which is the process of collecting energy from the environment around the sensors and converting it into electrical energy that can be used, has the potential to be a long-term solution to the problems that have been identified. Wireless energy transfer is currently advised above collecting energy from radio frequencies (RF) due to concerns about its impact on the environment. It is possible to use RF energy harvesting to not only resupply the power that is required to operate the soil sensors, but also to provide a more regulated and predictable power source. This is an advantage over other potential methods of gathering energy, as it is possible to use RF energy harvesting to resupply the power that is required to operate the soil sensors. The revolutionary practice of RF energy harvesting has the capacity to supply power to thousands of wireless sensors despite the great distances that separate them, all while retaining the scalability that allows the user to maintain control. The devices that make use of this wireless technology can be completely sealed, incorporated into structures, or made mobile without the requirement of the usage of batteries in any of these scenarios.

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## Introduction

The invention of a wireless soil sensor network that allows for continuous monitoring of insect activity in croplands is the most significant finding. This system is made up of a network of sensor nodes that are dispersed all over the yard in various locations. Due to the fact that the soil sensor nodes are stationary, it is possible to conceal them in the ground, behind a tree, or even by covering them with rotten leaves or dirt. Wireless energy transfer is currently advised above collecting energy from radio frequencies (RF) due to concerns about its impact on the environment. It is possible to use RF energy harvesting to not only resupply the power that is required to operate the soil sensors, but also to provide a more regulated and predictable power source. This is an advantage over other potential methods of gathering energy, as it is possible to use RF energy harvesting to resupply the power that is required to operate the soil sensors (Lai, Redfern, & Wright, 2005; Guha, 2011; Brown,1984; Kawahara, et al., 2009; Miskam, et al., 2009). An antenna at the sensor node picks up radio frequency (RF) energy transmitted by a remote controller and converts it into usable direct current (DC) using a rectifier and a voltage regulator. This sensor is powered by a DC output that is first stored in a battery ( Miskam, et al., 2009; Lu, et al., 2014; Taha, et al., 2018; Nintanavongsa, et al., 2012).

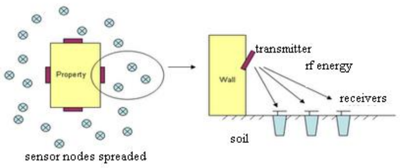


Figure 1. Transmission of radio frequency energy from a transmitter mounted on a building's exterior to indoor receivers

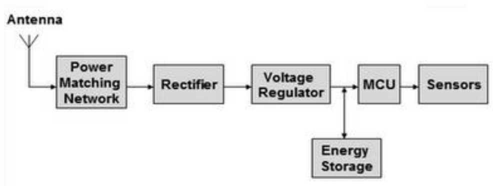


Figure 2. The system for harvesting RF energy, shown as a block diagram

Solar, vibration, thermal, and radio frequency (RF) energy are all examples of micro power that can be harvested by a growing business. Each energy harvesting method has its advantages and disadvantages, and the best one will depend on the environment and the specifics of the installation, but they may all generate the micropower required for wireless sensor applications. To harness radio frequency energy, a DC power converter is used. An antenna is used to pick up radio waves, and the signal is converted and the output power is conditioned.
Because of the power restrictions of commercially available transmitters or the distance from sources such as radio and television transmitters, the amount of power that can be utilized via RF energy harvesting is typically in the milliwatt to microwatt range. There are several military and industrial applications that require higher amounts of transmission power, and these applications can benefit from increased useful power or range. It is standard practice to evaluate the power density of various energy harvesting devices in terms of W/cm3, which stands for watts per cubic millimeter. Because different forms of energy harvesting offer a variety of advantages, comparing them based on their power density is not the most effective way. RF energy harvesting has many advantages, including the ability to provide power that is

both adjustable and ambient over a distance, the ability to distribute power wirelessly from one location to multiple locations, portability, in-built harvesting technology, and immunity to external influences such as temperature and lighting. RF energy harvesters can be as simple or complex as is required, depending on performance and functionality requirements. Even the most basic harvester can use external power management circuitry for tasks like rectification when using an AC source. Advanced harvesters may incorporate a unified module that handles power management in addition to other functions. If you want your commercial RF energy harvester to function well, provide you design leeway, and adapt to a wide range of use cases, it's important to look for these key aspects. The harvester needs to be sensitive enough to pick up RF energy at its lowest levels. In order to be practical, it must convert as much of the energy into usable power as possible. Various input and output powers, as well as loads of different resistances and voltages, necessitate a broad efficiency range. Maximum system efficiency requires that a microcontroller can either command or make use of the harvester's intelligent power management features. It should be simple to put together, with features such as a 50-ohm input impedance that is compatible with a wide range of commercially available antennas and packaging that is amenable to standard PCB manufacturing techniques. This should be the last thing to be mentioned, but it is still important (Kawahara, et al., 2009; Shi, et al., 2009).

**Importance of energy Harvesting**

The revolutionary practice of RF energy harvesting has the capacity to supply power to thousands of wireless sensors despite the great distances that separate them, all while retaining the scalability that allows the user to maintain control. Because it eliminates the requirement for batteries, wireless power makes it possible for electronic devices to be totally enclosed, incorporated into structures, or made portable. Engineers can now use this technology in conjunction with commercially available components for collecting RF energy to supply low-power wireless devices with embedded wireless power. Energy can be successfully obtained from ambient sources on either a regular or intermittent basis; however, it is not possible to properly predict when these sources will produce energy. A mobile phone density indicator can assist you know how many people will be in a specific spot, such a bus stop or a popular sidewalk. By 2012, the anticipated 3.5 billion present GSM subscribers could expand to 4 billion. When transmitting, a cluster of mobile devices may consume many milliwatts of electricity. Such transmitters are prevalent in today's culture and have been examined extensively; for instance, radio and television transmitting infrastructure and mobile phone base stations. Radio frequency (RF) energy is still supplied either constantly or intermittently by uncontrolled and unknown environmental sources such as microwave radio links and mobile radios used by police forces. This is the case whether the energy is delivered continuously or sporadically. Because of the power restrictions of commercially available transmitters or the distance from sources such as radio and television transmitters, the amount of power that can be utilized via RF energy harvesting is typically in the milliwatt to microwatt range. There are several military and industrial applications that require higher amounts of transmission power, and these applications can benefit from increased useful power or range. It is standard practice to evaluate the power density of various energy harvesting devices in terms of W/cm3, which stands for watts per cubic millimeter. Because different forms of energy harvesting offer a variety of advantages, comparing them based on their power density is not the most effective way. RF energy harvesting has many advantages, including the ability to provide power that is both adjustable and ambient over a distance, the ability to distribute power wirelessly from one location to multiple locations, portability, in-built harvesting technology, and immunity to external influences such as temperature and lighting (Kawahara, et al., 2009; Shi, et al., 2009).

### Microstrip Patch Antenna

As they may be easily printed on a circuit board, microstrip patch antennas are a symbol of critical components. Microstrip antennas have been widely used in the mobile phone industry. Patch antennas are inexpensive, discrete, and simple to produce. Figure 3 shows the fundamental construction of a conservative microstrip patch antenna using an inset feed. Copper, a high conductivity metal, is used for the patch antenna, microstrip transmission line, and ground plane. With the studies (Miskam, et al., 2009; Lu, et al., 2014; Taha, et al., 2018; Nintanavongsa, et al., 2012), we may determine that the patch has dimensions of length (L) and width (W), and that it rests on a substrate (a dielectric circuit board) with dielectric height (h).

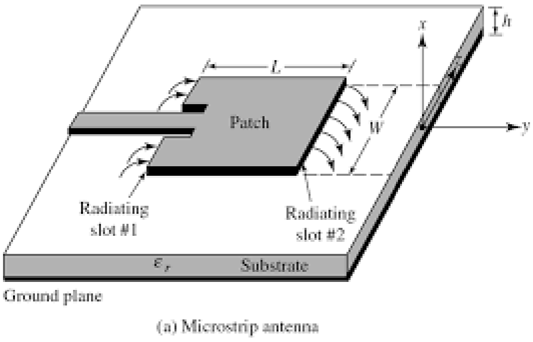


Figure 3. Elementary structure of microstrip antenna

### Harvesting Circuit using Rectenna

The ever-present problem of dead batteries that need to be recharged or replaced is drawing growing attention as a possible problem that could be solved by the practice of energy harvesting. Given the extremely low power consumption of digital systems and sensor nodes that are currently accessible, the development of low power harvesting systems is within the realm of possibility. Electromagnetic energy harvesters often operate at the more common frequency range of 2-18 GHz or inside the unlicensed ISM band operating at 2.4 GHz. Due to the fact that the majority of frequencies are fairly high, the RF transmitter and the harvesting equipment only need to be separated by a very short distance. The power level of transmissions that take place in the ISM band is normally quite modest. The low power factor of the harvesting unit is taken into account throughout the entire design process, beginning with the antenna and continuing through the impedance matching network, rectifier circuit, low pass filter, storage element, and control unit. This ensures that the unit will function properly. This component is more commonly referred to as a rectenna. When designing antennas and matching components, it is common practice to take high bandwidth into consideration (Taha, et al., 2018; Singh, et al., 2018; Hashim et al.,2018).

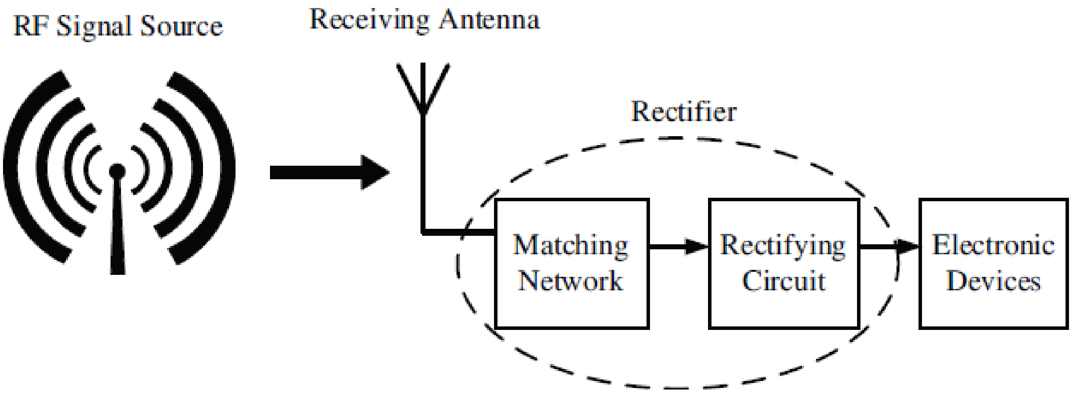


Figure 4. RF energy harvesting system

Rectennas use rectifier circuitry to reverse the alternating current (AC) that microwaves induce in the antenna. Rectifying circuits, which use nonlinear components like diodes, generate harmonics of the fundamental frequency. These unwelcome harmonics cause inefficiency through harmonic radiation, as well as electromagnetic interference with nearby circuits and antennas. The DC voltage can be multiplied by two with a voltage doubler circuit. Low power gadgets are targeted for charging using the voltage doubler's output power (Zbitou, et al., 2006). There are 3 primary types of rectifier (basical rectifier, voltage doubler, and voltage multiplier), often called charge pumps.

Intended for rectenna application, a rectifier must have high RF to DC conversion efficiency. Characteristically applied through one or more diodes, the choice of diode is of primary importance as it can be a foremost source of power loss and its performance determines total efficiency of the system (Shinohara, et al., 2013).

The wireless sensor nodes can be easily powered by the unused power generated by commercial RF broadcasting stations like radio and television, as well as mobile base stations. As a result, this way of powering may prove to be particularly useful for sensor nodes that are situated in distant places, where it can be challenging to put solar or wind panels. Because of the relatively low amount of electricity that is produced, this technology is efficient and has the potential to complement other types of power generation. Because the antenna is coupled to a tuner stage, it is only able to receive one specific commercial broadcast when it is tuned in. Due to the fact that the sensor node will be installed at a location where the selected channel is the only one that has more strength, that channel will be the only choice that is viable. A charge pump is one of the components that makes up a rectifier circuit that is connected to the tuner stage. Due to its low input impedance at microwave frequencies, the two-cell Dickson charge pump voltage doubler rectifier circuit is widely employed for 50-ohm matching. This is because the circuit can double the voltage. When diodes are linked in parallel in a radio frequency (RF) circuit, but in series in a direct current (DC) circuit, the voltage across each diode is increased by a factor of two (Brown,1984; Kawahara, et al., 2009; Thakur, et al., 2019; Chen, et al.,2017).

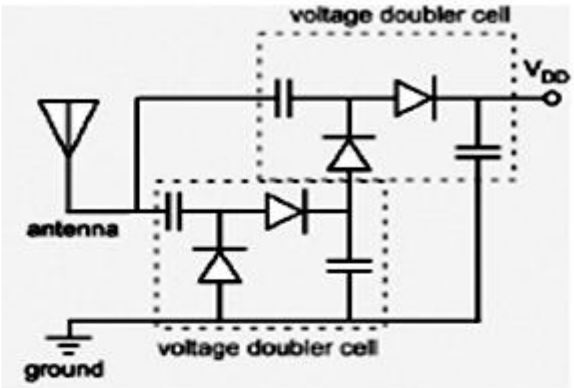


Figure 4. Sample Circuit of RF energy harvesting

As an antenna, it makes use of a microstrip patch that is both lightweight and thin. By incorporating fractal geometry into the design of antennas, it is possible to reduce the size of traditional antennas while simultaneously increasing their electrical length (as opposed to their actual length). It is possible that the final design of the antenna will have a characteristic impedance of 50 ohms if sophisticated computational methods are utilized. Effective results can be achieved when the impedance matching circuit is constructed by connecting transmission lines in series and using shorted stubs.

## Conclusion

This study provides a clear and comprehensive explanation of the processes involved in RF energy harvesting in agriculture, as well as a discussion of the significance of this topic. The usage of arrays of patch antennas that have wider bands and smaller diameters, in addition to low power CMOS transistors in place of diodes for low power applications, is one way that harvesting circuits could be improved even further. In the not-too-distant future, harvesting devices might benefit from the addition of a planar, low-profile rectenna. The majority of applications for collecting RF energy being used today will require the usage of artificial power supplies. An optimal level of performance can be attained in a wireless power distribution system by connecting and controlling the power transmitters through the utilization of wireless networking. As a result of repurposing the power sources, a comprehensive infrastructure for wireless power and data may be developed, and the need to replace the batteries will be eliminated. The ambient RF power level will increase in tandem with the number of transmitting devices that are utilized in a given environment. The development of technologies that consume less and less power will pave the way for the gathering of RF energy derived from the surrounding environment. Because of the decreased requirement for energy, more locations are now appropriate for harvesting radio frequency energy from the surrounding environment. If widespread ambient collection is going to become a reality in the coming years, then it is imperative that effective multiband or wideband RF energy harvesters be developed. The revolutionary practice of RF energy harvesting has the capacity to supply power to thousands of wireless sensors despite the great distances that separate them, all while retaining the scalability that allows the user to maintain control. Because it eliminates the requirement for batteries, wireless power makes it possible for electronic devices to be totally enclosed, incorporated into structures, or made portable. Engineers can now use this technology in conjunction with commercially available components for collecting RF energy to supply low-power wireless devices with embedded wireless power. The next generation of low power electronic products and systems will be able to be commercialized with the assistance of energy harvesting integrated circuits as well as power management integrated circuits (ICs). The widespread use of low-power devices has the potential to benefit a wide variety of wireless and wired systems, including mesh networks, sensor and control systems, and micro-electromechanical systems, amongst others (MEMS). These devices have a wide variety of applications, some of which include but are not limited to radio frequency identification (RFID), automotive tire pressure sensors, home automation, industrial process/automated meter reading, medicine, the military, and even home automation. Other applications include home automation.

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