Chapter 10
Energy Harvesting for Wireless Sensor Nodes Using Rectenna

Sanjeev Kumar
Ambedkar Institute of Advanced Communication Technologies and Research, India

Jyotsna Sharma
Ambedkar Institute of Advanced Communication Technologies and Research, India

Arvind Kumar
Ambedkar Institute of Advanced Communication Technologies and Research, India

ABSTRACT
Wireless sensor nodes generally operate using energy from source line batteries, which need to be replaced or recharge from time to time. The connection of electromagnetic energy to DC energy, which is called radiofrequency (RF) energy harvesting, is one of the best techniques to act as an energy source for this equipment. An ambient amount of RF energy is present in our environment radiated from numerous sources so that it can act as a much predictable source of energy as compared to other techniques of energy harvesting. This system eliminates the periodic replacement of energy batteries for these sensor nodes. Despite the enormous RF energy present in the environment, the power per unit area is quite low. Hence, the major barrier is to increase the output of the rectifier circuit, even though the power density is low.

INTRODUCTION
Wireless sensor nodes generally operate using energy from source line batteries which needs to be replaced or recharge from time to time. Connection of electromagnetic energy to DC energy which is called Radio frequency (RF) energy harvesting is one of the best techniques to act as energy source to these equipments. Ambient amount of RF energy is present in our environment radiated from numerous sources so it can act as much predictable source of energy as compared to other techniques of energy harvesting. This system eliminates the periodic replacement of energy batteries for these sensor nodes.
Despite the enormous RF energy present in environment, the power per unit area is quite low. Hence, the major barrier is to increase the output of rectifier circuit even though the power density is low. Different antenna designs are placed forward for higher efficiencies, line dipole, wide band and so on. Circular patch antenna provides higher gain for a given size of an antenna. Though wideband antennas provide higher efficiency by reception of larger amount of RF energy but impedance mismatching and lower output voltage may occur as compared to single band antenna. Diode in the rectifier circuit operates on the basis of frequency and input power levels, hence the rectifying effect of diode have impedance mismatch and lower output voltage in wide band antennas. Hence, to harvest more and more energy from environment, an array antenna is employed in this paper based on superposition of energy from each antenna in the form of exponentials.

The gain of antenna is ratio of intensity of given antenna in given direction to radiation intensity of isotropic antenna.

$$G = \frac{\hat{E}(\theta, \phi)}{\omega_r / 4\pi}$$  \[1\]

Where $\psi (\theta, \phi)$ is intensity of given antenna and $\omega_r$ is the power radiated by isotropic antenna.

1. Related work

"Wireless ambient radio power”. TV, radio, cellular and Wi-Fi transmitters in our environment provides with huge energy. It is possible to harvest and store the energy signals to be used in various applications. It is four step procedure i.e. electromagnetic wave incident on antenna providing excitation current, rectification of resulting power, optimal voltage and current conversion with last stage of energy storage with use of capacitors for sensors (Sample, 2013).

For IoT thing environment, wireless sensor nodes are required to be constructed but we need to replace batteries which make its economic prospective weak. Power harvested from environment is very low to be used for exciting the sensor nodes. They provide power of range from 0- 80 nw which depends upon frequency of antenna in case of loop and spiral antennas. So the need of system is to increase the power output. This power can be increased by use of antenna array system. When antenna are arranged in array, mutual coupling exist between them. Mutual coupling effects the distribution of current on antennas. Impedance is governed by this current which eventually affects the power of system. The mutual coupling phenomena affects the power in two ways i.e. one positive and the other negative which depends on the nature of equivalent impedance of circuit when coupling is considered. Spacing of antenna with range equal to $d/\lambda<1$ increase the mutual coupling effect whereas the range of $d/\lambda>1$ decreases the mutual coupling Mutual coupling provides an advantage of increasing the power of system when the equivalent impedance of system consist of capacitive reactance .Around 0.55$\lambda$ spacing provides 1.5 times more power as compared to uncoupled power (Kim, 2016).

Due to long distance between the transmitter and the receiving antenna there are chances of power loss in harvesting system so the objective of this paper was to minimize the loss due to distance. Therefore, antenna array was employed to increase the power gain of the system. The bandwidth of the system increased up to 11% (Keyrouz, 2012).