Chapter 7
Rectennas for Microwave–Based Wireless Power Transfer (WPT)

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ABSTRACT
Electromagnetics has an important role in power and energy industry. In this chapter, the concept of rectenna is reviewed. The history of rectenna for wireless energy harvesting and transmission is discussed. Finally, examples are employed to illustrate some rectenna design and measurement issues such as rectenna impedance matching and its conversion efficiency. It is also shown that rectennas can harvest wireless energy efficiently under certain conditions and have the potential to become a power supplier for some special applications.

INTRODUCTION
According to current scenario, there are lots of wireless systems which are used for wireless communication like GSM, WiFi, BLE, Bluetooth etc. If one is willing to transmit the power from one point to another point wirelessly, it is still a current research challenging area for all researchers. Wired systems are usually used for power transmission from one point to another point but everyone is looking for Wireless Power Transmission (WPT) system on the account of comfortability. Number of commercial and non-commercial sectors are there where WPT systems are required including WSN networking, Remote Location based industries etc. Currently these applications are using battery system or direct wired system mostly. But the major problem associated with battery-operated-system is the life of battery.

Wireless Power Transfer (WPT) is the process of transferring the power from one circuit (place) to another circuit (place) without using any physical medium or interconnecting elements. Several approaches are there for wireless power transfer including Inductive WPT, Capacitive WPT, Laser, Microwave etc. Inductive Power Transfer (IPT) is the most popular technology among all the available WPT technologies and is being extensively studied particularly from the last two decades. The area of wireless power transmission is very interesting and it is in demand now-a-days in developing countries as most of the developing nations (i.e. China, India, Pakistan etc) are rapidly improving their standards of living. The
technology is in its infancy but the overall benefits from its maturation could be significant to society as a whole. These trends point to an energy demand that will grow at even a larger rate. Wireless power transmission could one day allow us to generate solar power on a satellite and beam it down to Earth, transmit power to a water treatment plant for a disaster relief operation or power a flying communication relay station from a terrestrial station.

In current stage, there are lots of researchers who are working in the field of power transmission and have developed several techniques for transmitting the electricity (power) over the long distances without wires.

Rectennas are used now-a-days for transmitting the power wirelessly over a distance. Rectenna is nothing but a combination of Rectifier and antenna (Rectifier + Antenna = Rectenna) supported by a low pass filter. Antenna is a device which used to transmit and receive the signals (Electromagnetic waves). Antenna works as a transducer which convert the electrical signal to Electromagnetic (EM) signal while using at transmitting end and EM signal to electrical signal in the case of reception. In the case of rectenna, power is transmitted through an EM radiator (antenna) and at receiving end an antenna is there to receive the EM signals. These received EM signal is converted into electrical signal which is further passed through a Low Pass Filter (LPF) to avoid the noise and unwanted signals then pass through the rectifier circuit which works as a voltage multiplier. The combination of receiving antenna, LPF, and rectifier is referred as Rectenna. Different types of load can be connected in further network. By this method, we can transmit power wirelessly which would not be harmful for human being or living things.

This chapter is organized in seven sections. Introduction and background information is given in first part of this chapter and referred as Introduction. Then, classification of power transmission is provided in second section. In next section, power transmission through microwaves and requirement of antennas are discussed followed by a discussion on energy harvesting and use of microwave for energy harvesting. Further, key parameters associated with rectennas are presented and in successive section different type of rectennas are discussed. In last section, conclusion of this chapter is presented.

CLASSIFICATION OF POWER TRANSMISSION

As we know there are lots of approaches for power transmission and we can divide them in following two major parts:

1. Wired Power Transmission
2. Wireless Power Transmission (WPT): In Wired Power Transmission System, both point (transmitting and receiving points) are physically connected via conducting media whereas in WPT power is transmitted from one point to another point wirelessly. WPT systems may further divided in following three subsections:
   a. Electromagnetic
   b. Induction
   c. Magnetic. Each subsection is further divided in following sub-parts:
      i. Microwave
      ii. Laser
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