An Efficient and Low - Cost Technique for Charging Nodes in Wireless Sensor Network

Ayesha Feroz [1] and Mohammed Rashid [2]

Department of Electrical Engineering,
University of Engineering and Technology, Peshawar, Pakistan

***Abstract*— Wireless Sensor Network (WSN) is a network of nodes (containing sensors) that are deployed to collect the data from the environment and send it to the base station. Energy of the nodes is the major constraint in the successful implementation of different protocols in WSN. This paper proposes a technique to keep continue successful operation of nodes in WSN by charging them without using any wired connection. It can be made possible by the use of wireless mediums that could be infrared, Bluetooth, radio-waves, or microwaves. In this paper, Microwaves is used because it enables us to transfer energy wirelessly at both low power and high power to large distances; one can achieve distance up to kilometres. Power transfer through microwave provides long range, less path losses and high efficiency when compared with others. Microwave frequency is generally very high frequency generated from a very high input power microwave generator. A pyramidal horn-shaped wave guide antenna is used to guide the microwaves carrying electric power on its selected path to sink. A good design and angle of antenna along with a perfect microwave generator may increase the efficiency and range of power transmission.**

For the monitoring of power transmission, a thermistor is interfaced with the AT89C52 Microcontroller, which is connected with the computer via Max 232 IC. The user can see the status of the energy transfer to nodes in WSN through microwave source in the hyper-terminal software on personal computer (PC).

***Keywords*—Microwave, Transformer, Waveguide, Hyper-terminal, Micro-controller, Microwave generator.**

I. INTRODUCTION

Wireless sensor network (WSN) consists of nodes that are connected together to collect data from the environment and send it to the base station. Each node in WSN consists of memory unit, computational unit and a limited energy source [1]. The major constraint in developing routing protocols for WSN is that it should be energy efficient; because due to loss of power, it is possible that the sensor node may die and all the valuable data gathered by it is lost. Therefore, energy is the major constraint in the successful operation of WSN. This paper proposes an efficient technique for re-charging nodes in WSN. Our re-charging system provides the transmission of electrical energy from source to sink by using an unguided medium. It is advantageous when interlaced wires are inconvenient, impossible, or hazardous. Efficiency is the most important consideration for wireless power transmission. A receiver must receive all the energy generated by the transmitting power plant. There are mostly three methods for wireless power transmission; it can be transmitted by using infrared, radio-waves, or microwaves. But Microwave provides the greatest efficiency in transferring electric power from source to sink because of long range and less path loss. This paper proposes a low-cost hardware for power transmission by microwave which can also be used as a charging system for charging of electric vehicles. The proposed system is also interfaced with the personal computer that displays the status of energy transfer through microwave to sensor nodes. The objective of our project was to develop a reliable and low-cost wireless power transmission system; therefore, all low-cost components were utilized in it. Inexpensive microwave generator for $14 USD was used in this project which not only reduces the cost of the overall hardware but also maintains the reliability of the system.

Following are the objectives of this project:

1. Selecting proper hardware component for power transmission using Microwave such that the over-all cost of the hardware does not exceed $44 USD while maintaining the reliability of the system. These components

include microwave generator, transformer, capacitor, MAX-232 chip, waveguide, and micro-controller.
2. Interfacing the power transmitting system with PC for monitoring purpose.
3. Finding the software to communicate with the microcontroller using serial port of the PC.

The rest of the paper is organized as such: related work is discussed in section II, the proposed system model is discussed in section III, section IV contains Components of wireless power transmission system, Section V is discussion on the Experiment and Results, and Section VI concludes the work and provides ideas for future work.

II. Related Work

In 1864 Maxwell proposed the theory and equations of electromagnetic field. That work was published in 1873 in his book "A Treatise on Electricity and Magnetism" [2]. Those formulas are nowadays applied in different scenarios of wireless communication.

Then in 1880s, Nikola Tesla started to work on wireless energy transfer. In 1891, he proposed Tesla Coil [3]. Tesla coil is a transformer which has primary and secondary circuits; it can produce electricity of high voltage and high frequency. In 1893, Tesla transmitted power wirelessly and illuminated vacuum bulbs. He designed the Wardenclyffe tower [4] for wireless power transmission.

After Tesla's experiments and inventions, Noble made another attempt to transmit energy wirelessly [5]. He was able to transmit hundreds of watts over 25 ft. However, the design was not efficient--the energy was lost and was not measured as transferred, because the energy was not focused on a particular point. The lack of knowledge for point-to-point communication was the primary reason for inefficient system design.

In [6], a motor of 0.1 hp was driven by transmitting power to it wirelessly, in 1904, from a distance of approximately 100 feet. For the first time in 1964, Brown published his work and proposed Microwave energy for transmitting power from source to sink. Then, in 1964, he flew a helicopter which received all the power wirelessly from a microwave source [7].

A remarkable concept was introduced in 1968 by Glaser. He proposed the solar power satellite (SPS) which beams sun light to the earth where it is converted into energy [8]. In 1987, the world first airplane that was powered by a microwave source from ground was reported, called SHARP [9]. In 2003, NASA proposed an airplane powered by Laser for indoors. Similarly, Powercast Company proposed wireless power transfer using radio-waves in 2007.

III. PROPOSED WIRELESS POWER TRANSMISSION SYSTEM

The design of the proposed system for transmitting and monitoring energy transfer through microwave is shown in Figure 1. The components of the proposed system have the following objectives:

1. Modern resonant cavity Magnetron is used to produce microwave oscillations when a constant voltage is applied.
2. A high voltage transformer is used to step up the voltage from 220 volt to 2100 volts for microwave generator.
3. A waveguide is used to guide the microwave towards the load.
4. A high voltage capacitor i-e CH85 (2100 volts) is used to store energy in an electric field and eliminate the ripple effect from the input voltage of the microwave generator.
5. Regulator is used for stable operation and thermistor is used as sensor to sense the power transmission through microwave.
6. A micro-controller is used which is used to show results on PC through hyper-terminal.

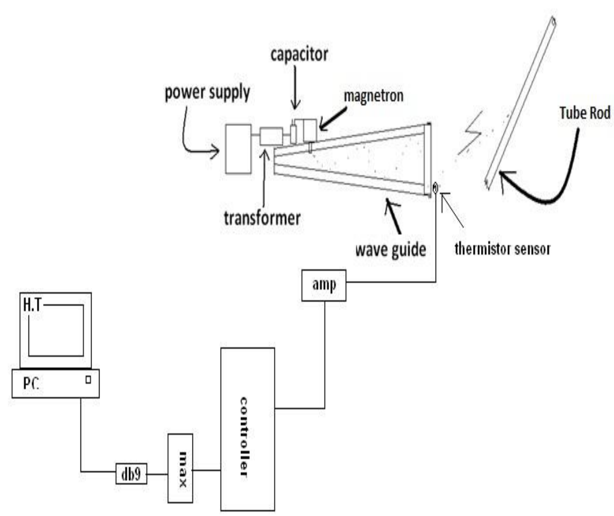

Figure 1: Wireless power transmission system

IV. COMPONENTS OF PROPOSED WIRELESS POWER TRANSMISSION SYSTEM

The important components of our Microwave based wireless power transmission system include Transformer, waveguide, microwave generator, Hyper-terminal, and microcontroller. These are described below in detail.

a) Transformer :

The transformer that is shown in Figure 2 transfers energy by inductive coupling between its winding circuits. A varying current in the primary winding creates a varying magnetic flux in the transformer's core; and thus, a varying magnetic flux through the secondary winding. This varying magnetic flux induces a varying electromotive force (emf) or voltage in the secondary winding. Step up transformer used in this project stepped up 220V to 2100V.

Figure 2: High voltage Step-up transformer

b) Pyramidal horn-shaped Waveguide:

A waveguide that is shown in Figure 3 is a linear structure that directs microwaves to the destination.The waveguide is use for transmission of microwave signal. The parabolic dish antenna and slotted wave-guide antenna are the most favourable antennas for transmitting microwave signals to the receiver. However, slotted wave-guide antenna can achieve high aperture efficiency of approximately 95% and can handle high power easily. This waveguide construction cost $3.8 USD only.

Figure 3: Pyramidal horn-shaped waveguide antenna

c) Microwave generator:

The device that is often used for transmiting microwave is semiconductor based microwave transmitter. Many semiconductor microwave transmitter are available like GaAs, SiC MESFET, and InGaAs, etc. Usually, microwave transmitter uses 2.4 GHZ of ISM band which can achieve the best efficiency of 90% than for other frequencies [10].The microwave generator used in this project is a modern resonant cavity magnetron that generates high power pulses of shorter wavelength. Galanz M24FB-210A is used in this project.

d) Hyper-terminal:

It is the name of the computer program that allows your PC to communicate through serial port with other machines/systems. The serial port of our PC in this project is connected to the micro-controller through MAX232 IC. Hyper-terminal is used to display that whether the power transmission through microwave source is on or off as shown in Figure 4.

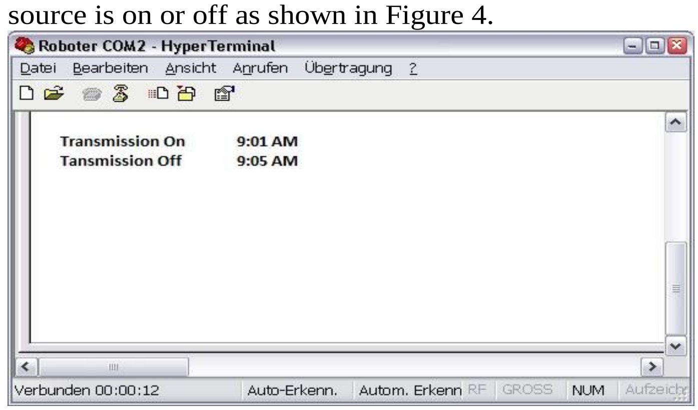

Figure 4: Software for displaying the status of power transmission

e) Microcontroller:

The AT89C52 microcontroller used for this project has 8Kilobytes of programmable Flash memory, 256 bytes of RAM and 32 I/O lines. It is a 16 bit low power and high performance micro-controller with a full duplex serial port, on-chip oscillator, and clock circuitry. The block diagram of it is shown in Figure 5 below.

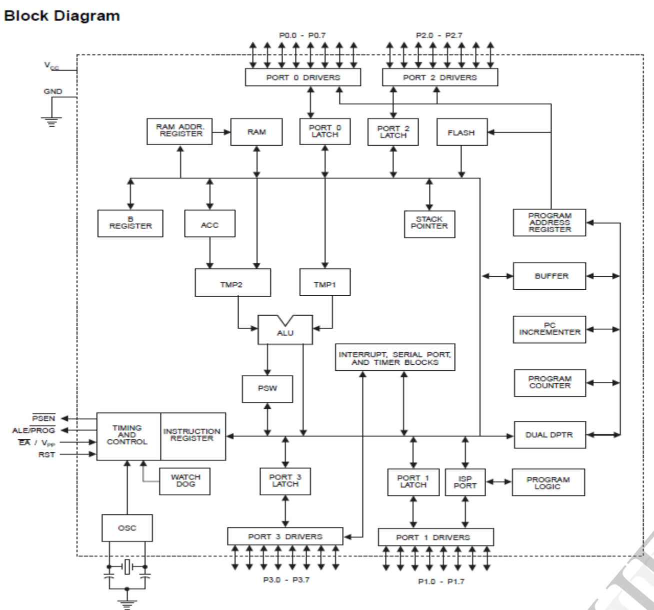

Figure 5: Block-diagram of Micro-Controller AT89C52

Thermistor and MAX232 are interfaced with the AT89C52 micro-controller. Thermistor converts the heat energy into voltage signal. This voltage signal is read by the microcontroller which forwards the appropriate signal to the PC through MAX232 IC. The AT89C52 is used for this project because it only costs $1 USD and works on low power. Figure 6 shows the flow chart that describes the functioning of microcontroller in this project.

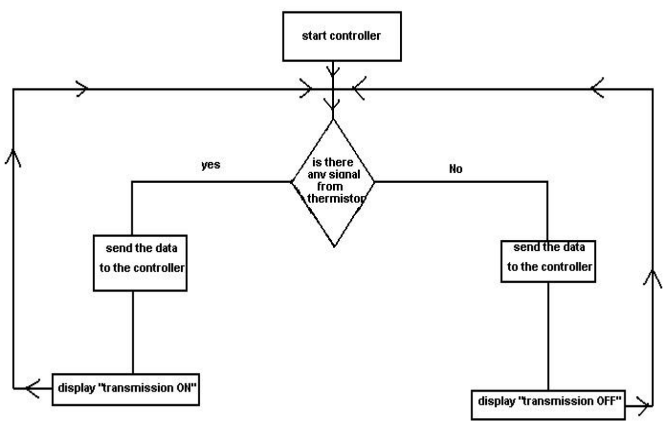

Figure 6 Flow-chart for microcontroller's program

V. EXPERIMENT AND RESULT

We performed the experiment by turning on the voltage supply to the microwave generator; and, connecting the thermistor via microcontroller and max232 IC to the PC. This helped to see the power transmission status on the hyper-terminal software on the PC. Different loads like electronic fluorescent tube, energy saver bulbs, etc, were brought closer to the microwave transmitter at different distances. This helped to note the range of power transmission by microwave—and, also see the working of hyper-terminal software. Figure 4 shows the time and status when the power transmission through microwave is turned on and off.

We have achieved an impressive range of 1.5 meters (5 ft) in just $44 USD. However, we can increase the range of microwave power transfer which depends on design of antenna, angle of load and microwave generator. The cost can be reduced further by mass production.

VI. CONCLUSION

From the above experiment it is observed that power can be transmitted wirelessly through microwave by using a high voltage step-up transformer, microwave generator, and a waveguide antenna. But there is some distance limit for power transmission, i.e. if the load is continued to move away from the waveguide antenna—a point will come when no power would be received by the load. This zone is called dead zone. This can be extended by using good antenna, proper angle of load, and efficient microwave generator However, with our system, we achieved an impressive range of 5ft with 35% efficiency.

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