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Procedia Computer Science 105 (2017) 111 – 118

Procedia Computer Science

2016 IEEE International Symposium on Robotics and Intelligent Sensors, IRIS 2016, 17-20 December 2016, Tokyo, Japan

Solar Energy Harvester for Industrial Wireless Sensor Nodes

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Abstract

Advancement in recent wireless technology has triggered the need for devices to run on independent power sources. This is evident especially with the wireless sensor network (WSN). This can be accomplished via harvesting energy from the surrounding environment such as solar, wind etc. These enery harvesting devices can power the wireless sensor nodes either directly of in conjunction with a battery. This paper presents the development of a solar energy harvesting mechanism for WirelessHART sensor node using photovoltaic (PV) cell array. Experimental results on the WirelessHART nodes proved that the developed harvester is capable of powering the nodes.

Peer-review under responsibility of organizing committee of the 2016 IEEE International Symposium on Robotics and Intelligent Sensors(IRIS 2016).

Keywords: Wireless Sensor network; Solar energy harvester; photovoltaic array; WirelessHART

1. Introduction

An essential part of Internet of Things (IoTs) is the wireless sensor network (WSN)[1]. These networks have been widely used in various applications such as rescuing in military, emergency recovery, patient health monitoring, air quality monitoring etc.,[2,3,4]. At the moment, the important function of the WSN is for monitoring physical conditions such as temperature, pressure, level, etc. Typically, in the network, the data are transmitted wirelessly[2]. A typical industrial WSN is shown in Fig. 1(a)[5].

The available standards for WSN are ZigBee, Wi-Fi, Bluetooth, Z-wave, etc. Two more industrial wireless standards namely WirelessHART and ISA100 Wireless were introduced recently specifically targeting industrial applications[6]. In this work, the Linear Technology Evaluation Kit based on WirelessHART standard is used. WirelessHART offers mesh network topology, self-healing, self-organizing capabilities, and operates on the traditional industrial, scientific, and medical (ISM) band of 2.4 GHz[7]. This provides maximum interoperability since it is based on HART standard, the most widely used standard in industry[7]. With the mesh topology, the WSN is highly reliable.

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Peer-review under responsibility of organizing committee of the 2016 IEEE International Symposium on Robotics and Intelligent Sensors(IRIS 2016).
doi:10.1016/j.procs.2017.01.184

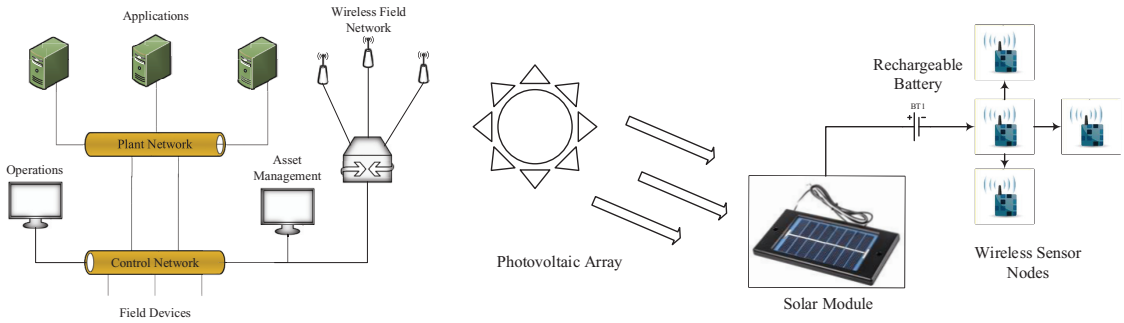

Fig. 1. (a) Wireless sensor network system in a typical industrial setting; (b) Solar energy harvester for WirelessHART mote.

Presently, there are various energy harversting techniques available for WSN. Usually, the main task for energy harvesting in WSN is to transform other forms of energy to electrical energy which can be used to supply the power for wireless sensor nodes. In order to measure the wind speed and to sense the local wildfire, a WSN was deployed at ground level[8]. Here, the wind turbine generator is used to harvest wind energy to power up the wireless sensor node which measures the wind speed. In another energy harvesting approach, mechanical energy of a rail wagon's suspension was harvested to supply power to a sensor mounted on the device for monitoring the railway's condition[9]. Harvested energy distribution was studied with object to distribute concurrent multiple transmitters' energies to recharge wireless sensor nodes in both 2D and 3D environments[10].

Wireless sensors are characterized by their small size, autonomous power supply, and ability to sense environmental phenomena and transmit data. Due to the sensing and transmitting components continue to be scaled down, the size of the nodes in WSNs is mainly determined by the size of the battery. Most of the commercial nodes use two AA batteries as their power sources. Therefore, the life time of each node relies on its duty cycle and the amount of sensed and transmitted data. When the lifetime of the battery comes to an end, the battery need to be replaced or recharged.

Therefore, for using renewable energy effectively many factors to be considered such as energy source characteristics, storage device type, wireless nodes' power management functionality, wireless communication protocol, and detail application's requirements[2]. This project focused on the utilizing solar energy to power WirelessHART nodes as it is located in the open area. For example, at the top of buildings or industrials areas. Although harvesting electricity through vibrational energy is also a good idea. However, there are few consequences that need to be considered before implemented the source energy as the vibration will produce noise. Noise is harmful when taking the data because, the noise will affect the information gathering. Thus, additional circuit need to be added to filter the information before transferring through the entire network. Fig. 1(b) shows a PV array serving as a secondary energy module for WirelessHART nodes.

The rest of this paper is organized as follows. Section 2 describes the methodology for developing the energy harvester for WirelessHART sensor nodes. Section 3 presents the results and discussion of this work. Finally, conclusion is drawn in Section 4.

2. Methodology

This section focuses on the detail work flow for the development of renewable energy for WirelessHART mote. This project development is divided into two parts. The first part solar energy harvesting system and the second part describe the project tools.

2.1. Sun hour daytime

During sunrise and sunset, the sunlight is weak and the incidence angle (θ) is less direct. Since θ, is low, the power generated is also less. At high noon, sun rays have close to right angle with the earth's surface, thus resulting in peak