AUSTRALIAN JOURNAL OF BASIC AND APPLIED SCIENCES

ISSN:1991-8178 EISSN: 2309-8414
Journal home page: www.ajbasweb.com

Wireless Energy Monitoring in Biped Robot Based on Xbee RF Module

[1]Iman Ahmed, [2]Ishak bin Aris, [3]Mohammad Hamiruce Marhaban and [4]Asnor Juraiza Ishak

[1,a,2,3,4]*Department of Electrical and Electronic Engineering, Faculty of Engineering, University Putra Malaysia, 43400 UPM Serdang, Box.3030. Selangor, Malaysia.*
[1,b]*Department of Mechatronics, Al-Khawarizmi College of Engineering, Baghdad University, Baghdad, Iraq.*

Address For Correspondence:
Iman Ahmed, Department of Electrical and Electronic Engineering, Faculty of Engineering, University Putra Malaysia, 43400 UPM Serdang, Box.3030. Selangor, Malaysia
E-mail: eng.iman79@yahoo.com.

ARTICLE INFO

Article history:
Received 3 March 2016
Accepted 2 May 2016
published 26 May 2016

Keywords:
Biped robot, Wireless, Energy, Monitoring, Zigbee.

ABSTRACT

For mobile and humanoid robots, in the field of analysis, conservation, data monitoring, and management of the energy, the need of real time wireless communication for data to access and control is important. Wireless technology, which is widely used not only in close range but also in long range, is a technique which uses electronic components that can interface to the other devices. In this work, the energy sensors, such as voltage and current analogue sensors are connected to the XBee RF module directly to reduce the power consumption and the complexity. The wireless XBee RF module together with the sensors were utilized in such a way that direct coupling and data processing have been used to send the energy values wirelessly for monitoring or managing station which may be considered as a computer. A significant clear signals for the current and voltage rates were harvested from the developed circuits and to compare with the direct oscilloscope measuring method. The suitable setting up of the components selection and configuration were the main reason for this method to success. The contribution of this proposed method is the utilizing of the XBee built-in microcontroller at the remote and base XBee's modes to dispense about any other microcontroller or extra components.

INTRODUCTION

The aim of this work is to develop a wireless low power; low cost acquisition device to communicate and analyze the data which is accumulated from remote on-board wireless communication node which accesses both, the current and the voltage of the power source(robot battery) throughout utilizing a suitable current and voltage sensors.

Although the first XBee RF module is introduced in 2005 and were based on the 802.15.4-2003 standard designed for point-to-point and star communications at baud rates of 250 kbit/s, not many researches recently focus on the study and analysis of power consumption rate in mobile robot application. Araújo *et al.* (2013) focus on gait analysis hardware using various design their work based on Xbee 802.15.4, their hardware has been designed to improve the accuracy of the gait analysis and based on the attachment unit which consist of sensor, microcontroller, power supply and Xbee transceiver to the shoe. The result highlights the design and realization of the hardware components for the development of shoe integrated instrumentation for human motion measurement system, their components, including the PIC 16F877A microcontroller, Arduino microcontroller, 2.4 GHz IEEE 802.15.4 Transmitter and the power supply unit. Bezzo *et al.* In (2014) using the

To Cite This Article: Iman Ahmed, Ishak bin Aris, Mohammad Hamiruce Marhaban and Asnor Juraiza Ishak., Wireless Energy Monitoring in Biped Robot Based on Xbee RF Module. ***Aust. J. Basic & Appl. Sci.,*** *10(11): 228-235, 2016*

XBee RF in building automation system and produce a radio planning strategy lead to optimal wireless network deployments in terms of capacity, quality of service, and reduced power consumption.

In (2010), Boonsawat presents a platform for developing a Zig bee based low cost, low power Wireless EKG system using the unlicensed 2.4GHz ISM band. Zigbee is based on IEEE 802.15.4 standard for WPANs, that is being used in many research applications today as an attractive solution for low power and low cost applications. They have used the transmitter and receiver pair design in which the receiver is mounted on a SmartRF05EB board which is connected to the computer through the USB port, while the information is transmitted to the computer through SmartRF05EB board. Their designs are proposed a featuring which has a good ranges and potential for " smart fabric " wearable implementations.

In Wireless Sensor Networks application and for temperature monitoring, Mukala *et al*. (2010) uses WSN nodes, each WSN node consists of a microcontroller on the Arduino board and an Xbee wireless communication module based on the IEEE 802.15.4/Zigbee standards to enhance the energy cost and reducing energy consumption. The system provides a web user interface for any user to access the current and past temperature readings in different rooms.

In mobile robot application, HORNFECK (2011) proposes Remote Position Control of Mobile Robot, The system is composed of the mobile robot (controlled object), PC as positioning controller, camera as sensor and ZigBee based wireless communication device. The camera captures images of mobile robot. The experimental results confirm the effectiveness of the proposed control system. In Lutvica *et al*. (2011), an Arduino-based Educational Mobile Robots in the Robotic Operating System has been used together with the Xbee RF module. The authors used of several tools for data analysis, easiness of interaction between multiple robots, sensors and teleoperation devices, thereby targeting engineering education. Micea (2010) , designs a socially interactive robot for use in homes of those who need special care, such as children or the older. He has used ATMEGA328 and the XBee wirelessly transmitted data from a wearable health monitoring device (WHMD). His preliminary tests confirm that both internal and external factors have a noticeable impact on the behavioral responses. Nicola (2014), have used an XBee radios (running Zig-Bee protocol) for networking in their research together with Hokuyo and Sick laser range finders for obstacles avoidance, Garmin GPS, Microstrain IMUs, stereo cameras, Kinect sensors all these sensors and components are used in Heterogeneous Mobile Wireless Mechatronic System.

This research recognized from all the above literature review with its high rate data transmission, a 50 Hz sampling frequency, very low power consumption, 1 m Watt,and 10-bits impeded ADC only, so, without any extra microcontroller to achieve the data processing or wireless remote monitoring system.

Our contribution is that we have used only the XBee capabilities to accomplish our research target which has the objectives; Firstly, based on the concept of component matching to curtailment the system components and consequently, to fulfill more energy saving. Secondly, to achieve optimum performance in terms of energy saving by utilizing all the facilities that could get from the available components. Thirdly, using only single microcontroller which is built in XBee RF Module. Finally, reducing the consumption of the data processing and transmitting unit by adopting initial sufficient study for each selected component in terms of; sampling rate, single supply components, conversion resolution, components matching, system compatibility.

System Design:

The system has been designed based on the mentioned research objectives as shown in Fig.1.using the bioloid premium robot (type A) developed by the Korean company Robotis. With the Xbee RF module, conditioning circuit, and the current sensor.

Methodology:

Overview:

The flow chart for the wireless communication between xbee and the robot of the system is shown in Fig. 2 which is starting with XBee RF nodes configurations to initialize the system parameters to indicate the maximum and the minimum values of the measured signal, the system sampling rate, and threshold limits. The data is acquired and storing stage is tested if the number of samples is covering the duration to transfer to parameters scaling stage and then to draw and analyze the results of the energy.

System Specification:

Referring to the Fig. 1; Hardware Specification: the energy communication node is placed inside the head of the robot, one XBee RF module IEEE 802,15,4, current and voltage sensors. The phases of the assembling the energy communication node are shown in Fig.3

Energy Sensors Conditioning Circuit:

Referring to Fig. 1, one of the most important thing which should be taken in to account when selecting each active component is the single voltage supply and the minimum power consumption. So the design of the signal conditioning circuit would be as shown in Fig. 4.

The full range of the input analogue voltage. We have used XBeeRF Module, 1mW power consumption, a suitable XBee explorer, USB interface card to connect the PC used for configuration and accessing the data.We

have used the software X-CTU, from DIGI International, during installation USB serial port (COM) , the X-CTU software could be used to set parameters directly by connecting the module as shown in Fig. 5. We've configured one XBee as a coordinator, which is connected to the computer and driven by Maltab software, whilst the other one configured as an End device to be connected with the current and voltage sensors through their conditioning circuit as shown in Fig. 4

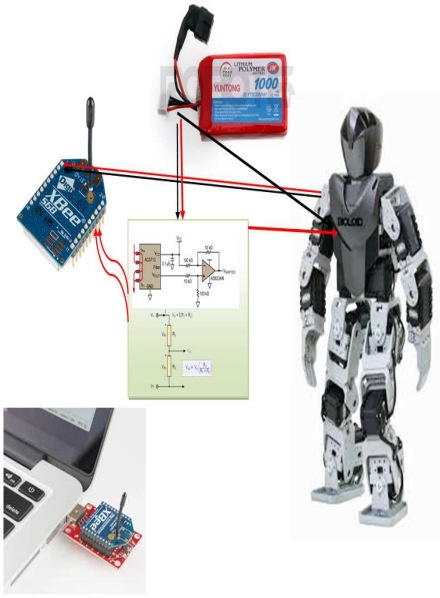

Fig. 1: Diagram represents the wireless communication system design.

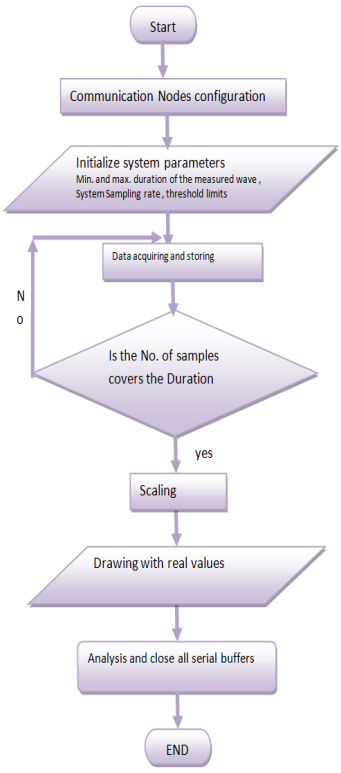

Fig. 2: Flow chart for the wireless communication between xbee and the robot.

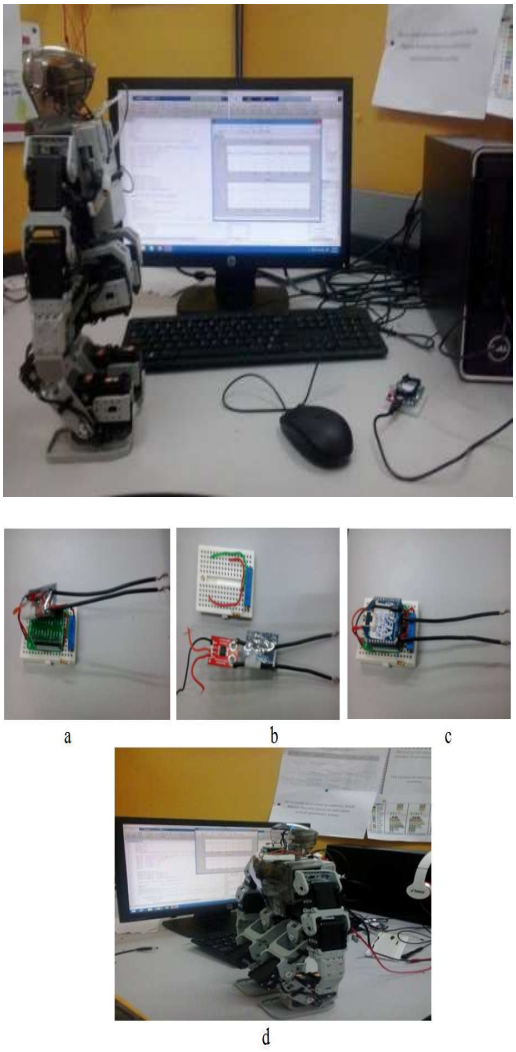

Fig. 3: a. Voltage and Current sensor, b. Voltage & current sensor with xbee, c. The transmitting remote circuit .d. the response of the robot

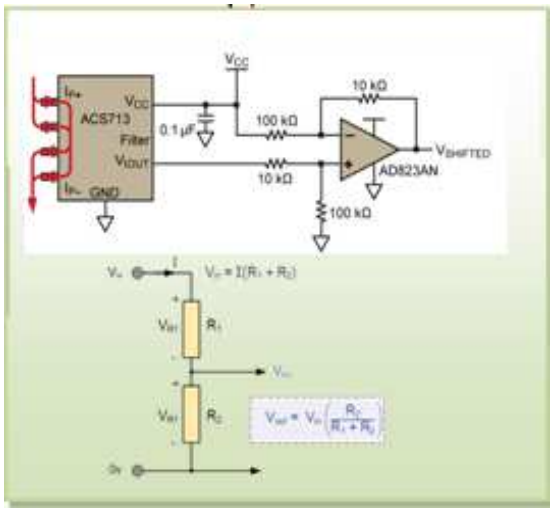

Fig. 4: Energy sensors signal conditioning.

As it is shown in Fig. 4, multi-turn precision resistor has been used to connect it to the sensor as a voltage divider supplied with 3.6V, which is the Lithium Ion Polymer battery standard voltage. The single supply

operation amplifier which is selected in our developed circuit is connected as a voltage follower to overcome the drop due to the impedance mismatching.

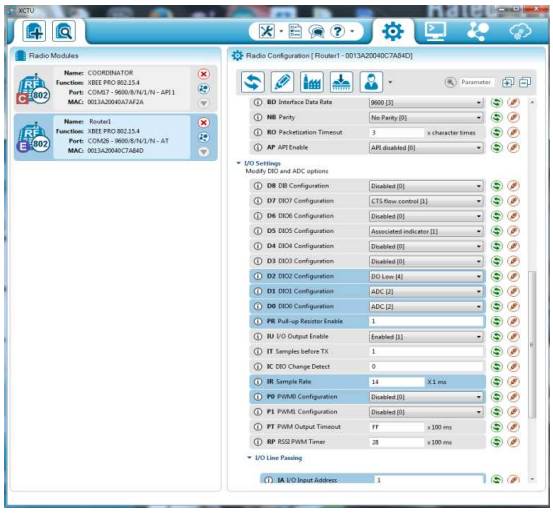

Fig. 5: X-CTU software.

MATLAB User Interface Design:

To communicate with serial of an external device from Matlab, the following steps need to be performed:-

- Serial port object needs to be created to identify the specific serial port of the PC connected to the external device, then we need to specify how this serial port is to be configured (i.e., number of data bits, baud rate, etc.).
- The serial port object created above need to be connected to the external device.
- To send a command signal to the external device and receiving the data from the external device.
- To disconnect the serial communication connection from the external device and close the serial port object. Finally, release control of the serial port.

XBee RF series 1 Module:

The power supply voltage range between 2.8 - 3.7V of the XBee module, sometimes we need to regulate the voltage to 3.3V before we could start the communication through stabilizer with an output of 3.3V in the control circuit. We have used pins 20 and 19 (analogue input pins) with a reference voltage equal to the XBee biasing voltage (3.3V) so as to reduce the components and attain the full range of the input analogue voltage. We have used XBee RF Module, 1mW power consumption, a suitable XBee explorer, USB interface card to connect the PC used for configuration and accessing the data. We have used the software X-CTU, from DIGI International, during installation USB serial port (COM) , the X-CTU software could be used to set parameters directly by connecting the module as shown in Fig. 5. We've configured one XBee as a coordinator, which is connected to the computer and driven by Maltab software, whilst the other one configured as an End device to be connected with the current and voltage sensors through their conditioning circuit as shown in Fig. 4.

Design and components selection:

Power source: since the selection of the power source depends on the application, the most important factor here is the energy density of the power source, which is the amount of energy stored in a given system or region of space per unit volume or mass. For this work , we have found that the on-board robot battery of the bioloid robot satisfies the goal of the proposed system, which is Lithium Ion Polymer battery.

XBee RF module: which consumed 1mW of power and can be functioned on power saving mode when it is switched to sleep mode if configured to operate only on action signal.

As future work, the electronic components and a PCB board would be prepared to re-size the overall circuit, resulting system would be not only smaller in size but also lighter in weight and less power consumption. The selected components can be shown in Fig. 6.

Results:

The response of the base (coordinator) XBee which is connected to the PC is shown in Fig.7.

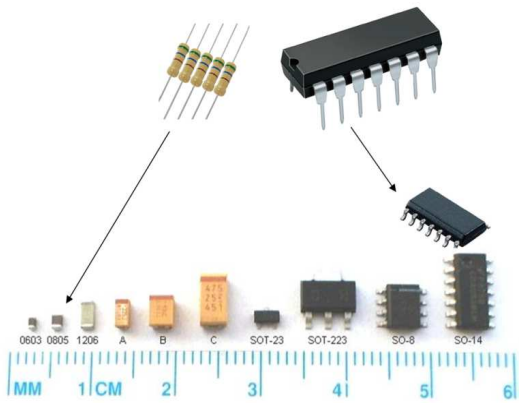

Fig. 6:. Re-sizing of components.

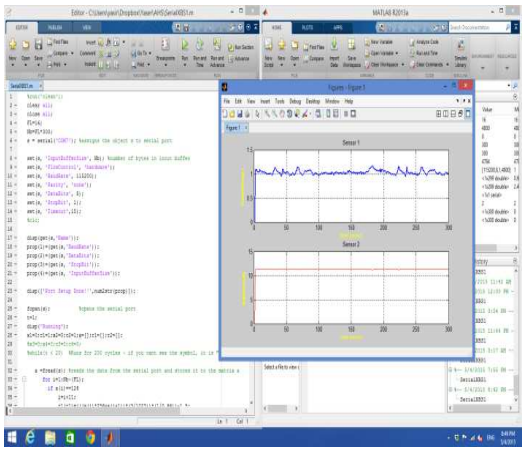

Fig. 7: Matlab program used for the serial communication.

Comparison results:

Fig.8 and 9 show the same motion task (Bow motion), the first graph (Fig. 8) represents the oscilloscope measurements of the battery current signal over the time of the motion. While Fig.9.represents the battery current rate for the same motion, but with the proposed wireless method.

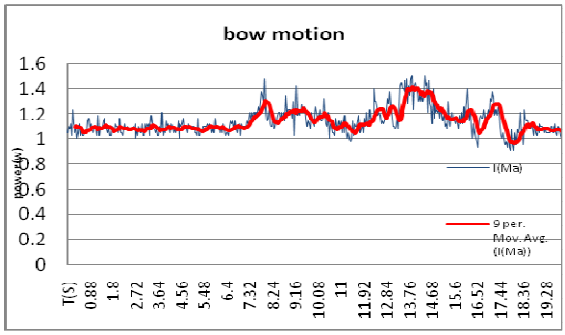

Fig. 8: Oscilloscope measurements (Wired) result.

The result shows a significant comparison points can be listed in the following table, Table 1.

While in terms of values for the power consumption as a comparison with conventional microcontroller card (Arduino Uno), table 2 shows the difference between the two cases.

Conclusion:

In Biped robot power consumption rate analysis application, the need for an accurate, wireless measurement for monitoring and control is important. We have found that The wireless XBee RF module together with the sensors were sufficient when utilized in such a way that direct coupling setting between them has satisfied. A

significant clear signals for the current and voltage rates were harvested as compared with the direct oscilloscope measuring method, the unavoidable noise is appeared only with normal wire results, as shown in Fig. 9, where the red color curve is the 9 points average of the harvested data .Only suitable place and ground shield printed circuit board is enough to block the noise of the robot microcontroller and Bluetooth interferences. Suitable setting up of the components selection and configuration were the main reason for this method to success. The total power consumed by the sending units (remote node) is 1.3 mWatt, which is very low power consumption as compared with the past researches that is used more components, such as arduino microcontroller or other conditioning circuit .The contribution of this proposed method is the utilizing of the XBee built-in microcontroller at the remote and base XBee's modes to dispense about any other microcontroller or extra components.

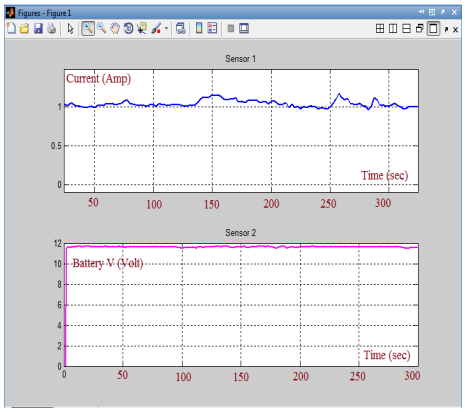

Fig. 9: Proposed Wireless measurements result.

Table 1: Comparison between wire and wireless communication.

Parameter for way of communication	Wireless communication	Wire communication
Losses on the on-board battery	existed	Not-exist
Extra Components	Need extra components like voltage –current sensor and radio communication node	No need only the lab instruments
Distance for robot task	Not limited-long distance	Limited or short distance
Noise	Noise free	An unavoidable noise even with using RC filter

Table 2: Comparison between Conventional and Proposed microcontroller card.

	Microcontroller			Specifications		
	Arduino Uno	Xbee S1			Conventional (Arduino Uno+Xbee)	Proposed
DC Current per I/O Pin	40 mA	TX Peak Current at 3.3V	45 mA	Data Process Power (mW)	400	64
		RX Current: at 3.3V	50 mA	Transmit Power (mW)	1.9	1.3
		Transmit Power	1mW			
Operating Voltage	5V		3.3V	Operating Voltage (V)	5	3.3

ACKNOWLEDGMENTS

This work is supported by University Putra Malaysia under grant ref: (GP-IPS)/(2014-9438720). The main author would like to thank The Ministry of Higher Education and Scientific Researches and Baghdad university, Al-Khawarizmi College of Engineering for providing a scholarship.

REFERENCES

Araújo A., M.S. Couceiro, R.P. Rocha, 2013. Integrating Arduino - based Educational Mobile Robots in ROS, 9–14.

Bezzo, N., S. Member, B. Griffin, P. Cruz, S. Member, J. Donahue, 2014. Mechatronic System, 19(1): 20–31.

Boonsawat, V., 2010. XBee wireless sensor networks for temperature monitoring. Second Conf … [Internet]. 2010; Available from: http://www2.siit.tu.ac.th/somsak/pub/final_XBeeWSN_100328.pdf.Mukala V, Lakafosis V, Traille A, Tentzeris MM, Tech G. system, 1: 624–7.

HORNFECK K.B., 2011. A CUSTOMIZABLE SOCIALLY INTERACTIVE ROBOT WITH WIRELESS HEALTH MONITORING CAPABILITY..

Lutvica, K., N. Kadic, G. Dzampo, H. Muminovic, J. Velagic, N. Osmic, 2011. Remote position control of mobile robot based on visual feedback and ZigBee communication. Proc ELMAR, 169–72.

Micea, M.V., A. Stancovici, D. Chiciudean, C. Filote, 2010. Indoor inter-robot distance measurement in collaborative systems. AdvElectrComput Eng, 10(3): 21–6.

Nicola Bezzo, Student Member, IEEE, Brian Griffin, Patricio Cruz, Student Member, IEEE, John Donahue,Rafael Fierro, Member, IEEE, and John Wood, 2014. Cooperative Heterogeneous Mobile WirelessMechatronic System.IEEE/ASME TRANSACTIONS ON MECHATRONICS, 19-1.