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Wireless Communication for Mobile Robots Using Commercial System

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***Abstract*—Commercial mobile robots provide good platform for the study and development of algorithms for wireless mobile communication of devices. E-Puck is a good example, with wireless communication utilising Bluetooth among others. However, the limitations of Bluetooth communications lead to the investigation of using X-Bee module as an alternative. This is to allow the E-Puck to communicate with a computer and other mobile robots using specified Zigbee protocol. This paper presents X-Bee module as wireless communication method between computer and E-Pucks and the way they exchange data.**

***Keywords*— E-Puck, wireless communication, X-Bee.**

I. INTRODUCTION

There are several types of mobile robots platform has been developed nowadays and many of them have been commercialized to be used especially in research field to other universities. E-puck, Jasmine, Alice and Khepera are some of those well-known existing mobile robots [1]. The use of these mobile robots will help researchers to be more innovative in designing their prototypes to make it more functional and meet the needed requirements.

Mobile robots usually were equipped with wireless module, such as Bluetooth, Global Positioning System (GPS), X-Bee or sensors to exchanged data from robot to computer, or communicate among each other. In this project, X-Bee RF module has been mounted on the E-Puck to allow communication between E-Puck and computer and also E-Puck to E-puck in order to transfers data from sensors to computer and transmit data to the other E-Puck members.

The features of X-Bee which transmits and receives in both directions, unique addressing and have in build data packet and error checking make it being chosen to be used in this project [2].

II. BACKGROUND

With rapid development in technologies these years, our quality of lives had become better from time to time. In robotics field, the use of these intelligent machines to reduce the use of manpower and saves time on certain works that hardly been accomplish by human kind had made the researchers to become more creative in designing robots in order to improve the quality of life for humans.

One of the most important criteria in designing robots was the method it used to communicate to the user or the other robots. Wireless communication has been chosen nowadays as it is more reliable and not cumbersome to be applied to the robots, especially for mobile robots as they are moving and not static at certain place.

In this project, X-Bee module is chosen as communication method for E-Puck, using Zigbee 802.15.4 protocol. Zigbee is defined as a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard for wireless personal area networks (WPANs), such as wireless headphones connecting with cell phones via short-range radio [3].

III. DESIGN

There are five major methods have been used in order to develop wireless communication system for mobile robots. Each part has its own role to build the system.

A. E-Puck

E-Puck robot, developed by Ecole Polytechnique Federale de Lausanne has been used as the main component in this project. E-Puck used DSPic30F6014A as its processor and is equipped with eight infrared proximity sensors, three microphones, Bluetooth as wireless communication module, a camera, eight LEDs and a speaker to enhance their ability [4].

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Fig. 1 E-Puck

B. SKXBEE and X-Bee RF Module

The experiment used XBee Starter Kit (SKXBEE) from Cytron as a communication method to PC with USB plug and play for more reliable and easier functionality test. It uses 3.3V DC supply thus make the battery of mobile robots lasts longer. SKXBEE is used to communicate between mobile robot and the computer [5].

Fig. 2 SKXBee

In order for these E-Pucks to communicate to each other, an X-Bee module, developed by Digi International has been mounted at the top of the E-Pucks. There are two version of wireless module, which is X-Bee and X-Bee Pro. There is not much different between these two modules, but X-Bee Pro offers a longer wireless range about 100 meters compared to 30 meters for regular X-Bee [6]. For this project, X-Bee is selected as communication module because it does not need a longer range as the experiment is tested for indoor environment.

To interface X-Bee with E-Puck, four pins from X-Bee module which is GND, VCC, TX and RX is connected to JE1 and JE2 connector of E-Puck. The connection is as illustrated in the figure below.

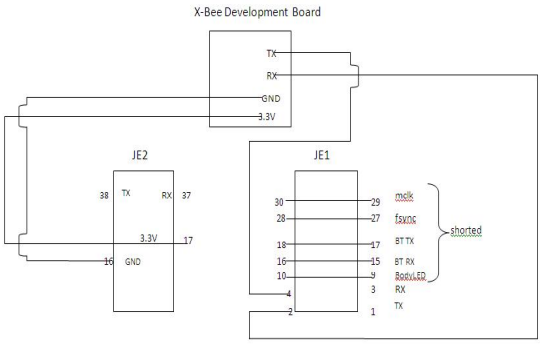

Fig. 3 Connection of X-Bee to JE1 and JE2 of E-Puck

C. Programming with MPLAB IDE

MPLAB IDE v8.10 (Student version) is used to develop a program in C language for DSPIC30F family, which is a microcontroller used by E-Puck robots. The software can be downloaded for free at Microchip website [7]. The program needs to be compiled before it is loaded into the E-Puck's microcontroller. The features of the MPLAB make it easier for user to use; moreover it comes with useful libraries that make the user no need to configure the microcontroller's registers manually.

D. X-CTU Software

X-CTU (Configuration & Test Utility Software) is free software provided by Digi International to easily interact with RF products by Digi. It has four major tabs, which is PC Settings tab, Range Test, Terminal and Modem Configuration. The software has a function where we can access the module's firmware to be in AT command or API command, as well as setting the desired command mode and sequence. The range test tab is used to check the RSSI (Received Signal Strength Indicator) of each X-Bee in the network. The terminal tab is where we can send and receive data in Hex or ASCII formats, and modem configuration tab is for reading and writing modem's firmware to radio's microcontroller according to the needed settings.

IV. RESULTS

In this project, Application Programming Interface (API) communication mode was used to allow communication between mobile robot and control centre (PC) and between the mobile robots. In API mode, the data sent and received is contained in frames which define the operation of the module [8].

A. Point to Point Communication

In point-to-point topologies, two X-Bees are communicating with each other only and no other x-Bees involved. An E-Puck is connected to X-Bee module and SKXBEE is plugged into computer USB. To set the X-Bee to talk to each other, the Channel (C) and Personal Area Network Identifier (PAN ID) of each X-Bee must be identical to both modules. Destination Address Low (DL) and 16-bit Source Address (MY) of the module must be vice versa to each other.

TABLE I
TRANSMIT STATUS FOR 16 BIT ADDRESS

Byte	Value (Hex)	Description
01	0x7E	Start Delimiter
02-03		Datalength
04	0x89(transmit status)	Indicates which API type messages will be contained in identifier-specific data.
05	The value is based on frame ID for Transmit Request.	Frame ID
06	0x00(success)/0x01(no ACK received)/0x02 (CCA failure)/0x03(purged)	Status
07	0xFF-(API Identifier+Frame ID+Status)	Checksum

The data from must be in data frames format which has been standardized by Zigbee protocol. All these settings is set using X-CTU software. Table below shows the data frames format for 16 bit address X-Bee transmits status [8].

Figure below is the transmit status received by SKXBEE terminal between SKXBEE module and E-Puck for point to point communication. The blue one is data frame sent by E-Puck and the red one is data received by SKXBEE at computer. The sixth byte of red data which is '00' in the figure below indicates that the data has been successfully transmitted or not. If the status is '00' it means that the data is successfully transmitted.

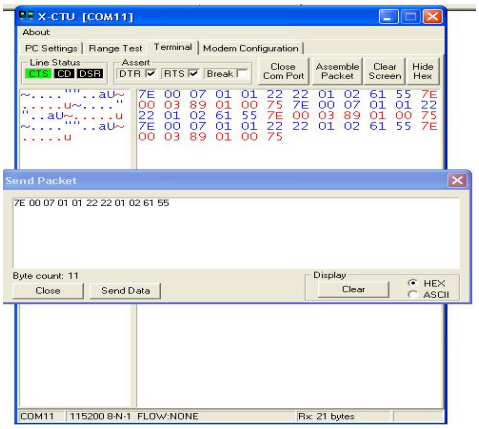

Fig. 4 Transmit Status Received by SKXBEE from X-Bee E-Puck

B. *Point to Multipoint Communication*

Point to multipoint communication is another way of communication that is capable to be implemented using X-Bees. Point to multipoint communication involved more than two X-Bees at a certain time. In this project, three X-Bees were used. Two X-Bees connected to E-Pucks will transmit data to SKXBEE plugged into computer.

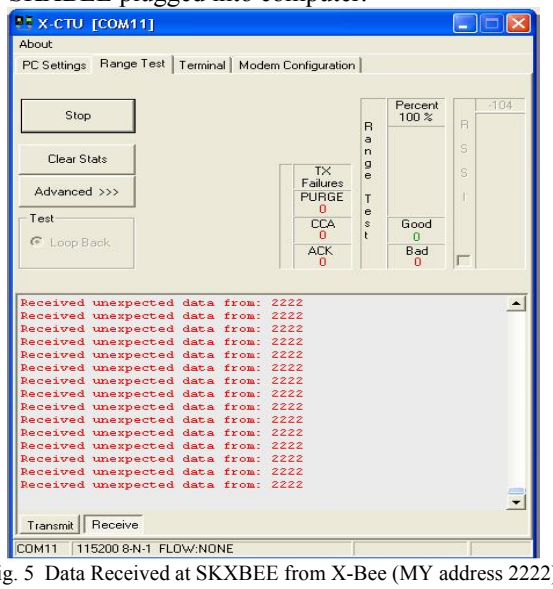

Fig. 5 Data Received at SKXBEE from X-Bee (MY address 2222)

To set the X-Bees to send data to SKXBEE, the Channel (C) and Personal Area Network Identifier (ID) of the X-Bee must be identical to both modules. 16-bit Source Address (MY) of each module must be different from each other as MY will act as an address of each X-Bee and will indicate which one had transmit data to the SKXBEE. SKXBEE will act as a centre where it will receive all X-Bee's transmitted data and classified which X-Bee's data is from MY address. Figure below shows that some data had been received by SKXBEE from X-Bee with MY address 2222.

V. Conclusions

The wireless communication using Zigbee protocol for E-Puck robot has been proved to be practical for low cost monitoring and controlling devices. The results showed that the X-Bee module can successfully being used as an alternative to wireless communication method for mobile robots.

Mobile robots can be used to speed up many works that are quite difficult to be done by human, such as doing inspection in a narrow space or hazardous environment. Therefore, this project can be further improved to be applied in real life.

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