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INTELLIGENT COMMUNICATION BETWEEN MULTIPLE ROBOTS

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Abstract*:*

This paper focuses on intelligent communication between different robots. In multiple robot systems, follower robot obeys the order form a leader robot to complete a task. This task coordination is done by using Zigbee signals for interaction between the robots. This idea was tested using a leader robot and follower robots with a gas sensor. The leader robot consists of a PIC microcontroller to control the activities of I/O system and Zigbee is used for the communication between the robots. Serial communication is done through MAX 232. The follower robots have a sensor system, senses the gas leakage and the movement of the follower robot is as the same as the leader robot. The leader robot stops at the point of gas leakage and do the service.

Keywords*:* Multi Robot Communication, Zigbee, PIC Microcontroller, L293 Driver & Gas Sensor

1. Introduction:

Wireless technology has been developing very rapidly due to highly efficient wireless communications [1]. One of the wireless communication technologies in great demand is Wireless Local Area Network (WLAN). WLANs are based on IEEE 802.11 standards that use has some advantageous, such as high capacity, wide coverage and able to broadcast directly [2]. If the area used in wireless is not too widely, a kind of wireless technology applied are Wireless Personal Area Network known as WPAN. WPAN is a network communication among devices over wireless technologies. The reach of a WPAN varies from a few centimetres to a few meters. WPANs are widely used for communication between sensors and electronic devices. There are some technologies used in WPAN such as IrDA, Wireless Universal Serial Bus, Bluetooth, Z-Wave and ZigBee.

Nowadays, ZigBee is applied in many applications. Zigbee has a defined rate of 250 Kbit/s, best suited for periodic or intermittent data or a single signal transmission from a sensor or input device [3]. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that requires short-range wireless transfer of data at relatively low rates [4]. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth or Wi-Fi.

The technology and application of robotic grow rapidly, in terms of reliability, coverage ability and field applications. There are several research themes were also developing, such as sensor technology, motor technology, power supply technology, telecommunications technology, control technology and artificial intelligence technology. The development of these technologies supports each other's to robotic technology [5].

In this decade, there has been an important variation in robotic research focus. Researchers are beginning to modify the direction of robotic research, from investigation of a single robot system to exploration of coordination of multi-robot systems [6]. Multi-robot system is a system of a robot entities that work together to

complete a specific task [7]. There are several advantageous of the application of multi-robot systems. Generally, the application of multi-robot system is to produce a better system in order to solve the problems of the system. The tracking of multiple robots by field navigation method is complex [8]. Sensors are used to co-ordinate the communication of multiple robots. [9].Fuzzy system is used to control the motion of multiple robots [10].With the multi-robot system, the existing complex and difficult system can be performed using the robot with a cheap and simple.

Therefore, this paper seeks to address multiple robot communication system design. A communication system design attempted a possible compared to the existing ones. The focus of the design is intended for communication between the leader and the follower so that the follower can follow the movement leaders. The transmission medium used among the robots is a wireless system using the XBee, PIC microcontroller where the mobile robot is able to perform bi-directional communication and recognize the controller.

2. Methodology:

The leader robot consists of a PIC microcontroller as the center of all the systems, and manages all activities of the input/output system. Sensor system which uses gas sensors functions as sensors gas leakage in order that the robot can signal the other robot. Motion system using a DC motor driven with L293D. Communication systems use ZigBee Module with MAX232 as connections between ZigBee and the PIC microcontroller. This communication function for communication between leader robot and follower robots. As for the follower robots have a sensor system, the movement of the follower robot just follows the leader robot by receiving commands via ZigBee modules and stops at the point of gas leakage.

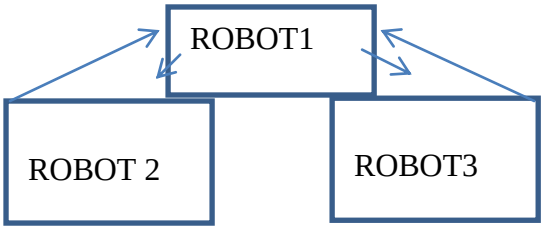

Figure (1): Block Diagram

3. ZigBee:

The CC2500 is a low-cost 2.4 GHz transceiver designed for very low-power wireless applications. The circuit is intended for the 2400-2483.5 MHz ISM (Industrial, Scientific and Medical) and SRD (Short Range Device) frequency band. The RF transceiver is integrated with a highly configurable baseband modem. The modem supports various modulation formats and has a configurable data rate up to 500 Kilo baud. CC2500 provides extensive hardware support for packet handling, data buffering, burst transmissions, clear channel assessment, link quality indication, and wake-on-radio. The main operating parameters and the 64- byte transmit/receive FIFOs of CC2500 can be controlled via an SPI interface. In a typical system, the CC2500 will be used together with a microcontroller and a few additional passive components.

CC2500 features a low-IF receiver. The received RF signal is amplified by the low noise amplifier (LNA) and down-converted in quadrature (I and Q) to the intermediate frequency (IF). At IF, the I/Q signals are digitized by the ADCs. Automatic gain control (AGC), fine channel filtering, demodulation bit/packet synchronization are performed digitally. The transmitter part of CC2500 is based on direct synthesis of the RF frequency. The frequency synthesizer includes a completely on-chip LC VCO and a 90

degrees phase shifter for generating the I and Q LO signals to the down-conversion mixers in receive mode.

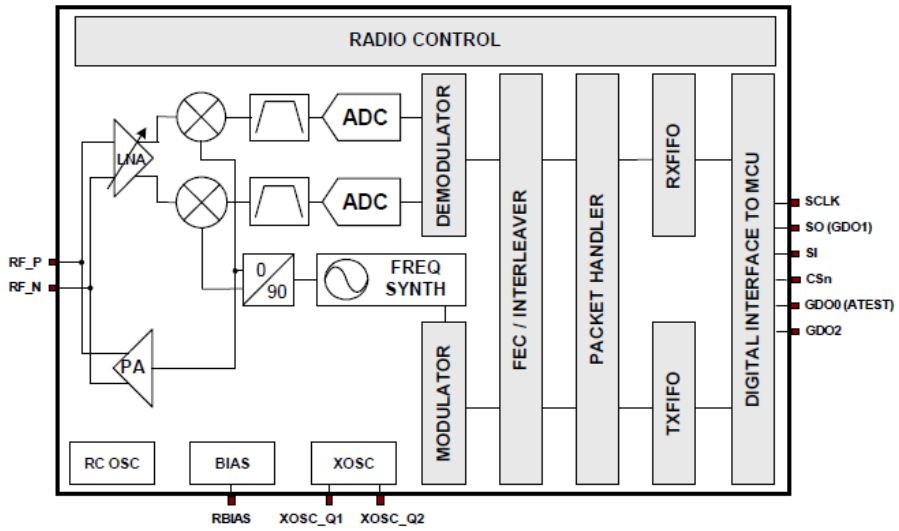

Figure (2): CC2500 Zigbee Module

A crystal is to be connected to XOSC_Q1 and XOSC_Q2. The crystal oscillator generates the reference frequency for the synthesizer, as well as clocks for the ADC and the digital part. A 4-wire SPI serial interface is used for configuration and data buffer access. The digital baseband includes support for channel configuration, packet handling, and data buffering.

Fig. 3 shows how to interface the Zigbee with microcontroller. The Xbee modules work at the 2.4 GHz frequency which means smaller board and antenna size. Xbee modules have the ability to transmit Digital, PWM, Analog or Serial RS232 signals wirelessly. To communicate over UART or USART, we just need three basic signals which are namely, RXD (receive), TXD (transmit), GND (common ground). So to interface UART with LPC2148, we just need the basic signals.

Interfacing Zigbee module with PIC Board for used for controlling application through UART0. The data communication is done by using the Zigbee module through MAX232 into the SBUF register of PIC microcontroller.

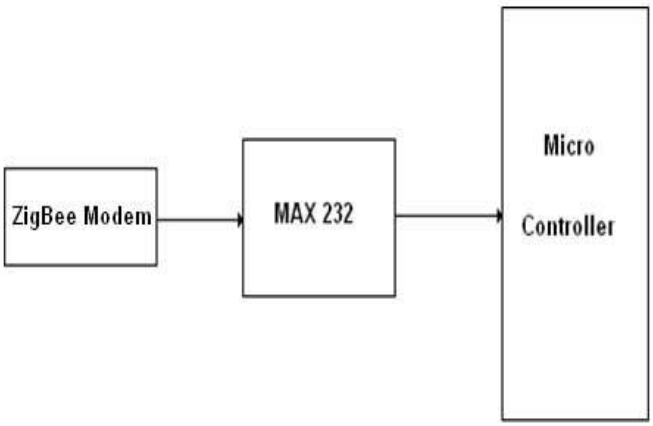

Figure (3): Interfacing ZigBee to Micro-Controller

The serial data from the Zigbee receiver is taken by using the Serial Interrupt of the controller. +5V and ground is connected to provide power to the module. While TX and RX pin is connected for communication.

4. 293 Motor Driver:

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC. The L293D can drive small and quiet big motors as well. Motor Driver ICs are primarily used in autonomous robotics only. Also most microprocessors operate at low voltages and require a small amount of current to operate while the motors require a relatively higher voltages and current. Thus current cannot be supplied to the motors from the microprocessor. This is the primary need for the motor driver IC.

The 4 input pins for this l293d, pin 2,7 on the left and pin 15 ,10 on the right as shown on the pin diagram. Left input pins will regulate the rotation of motor connected across left side and right input for motor on the right hand side. The motors are rotated on the basis of the inputs provided across the input pins as LOGIC 0 or LOGIC 1.In simple you need to provide Logic 0 or 1 across the input pins for rotating the motor.

The L293D IC receives signals from the microprocessor and transmits the relative signal to the motors. It has two voltage pins, one of which is used to draw current for the working of the L293D and the other is used to apply voltage to the motors. The L293D switches it output signal according to the input received from the microprocessor.

If the microprocessor sends a 1(digital high) to the Input Pin of L293D, then the L293D transmits a 1(digital high) to the motor from its Output Pin. An important thing to note is that the L293D simply transmits the signal it receives. It does not change the signal in any case.

The L293D is a 16 pin IC, with eight pins, on each side, dedicated to the controlling of a motor. There are 2 INPUT pins, 2 OUTPUT pins and 1 ENABLE pin for each motor. L293D consist of two H-bridge. H-bridge is the simplest circuit for controlling a low current rated motor.

Fig.4 shows the circuit diagram for l293d motor driver IC controller:

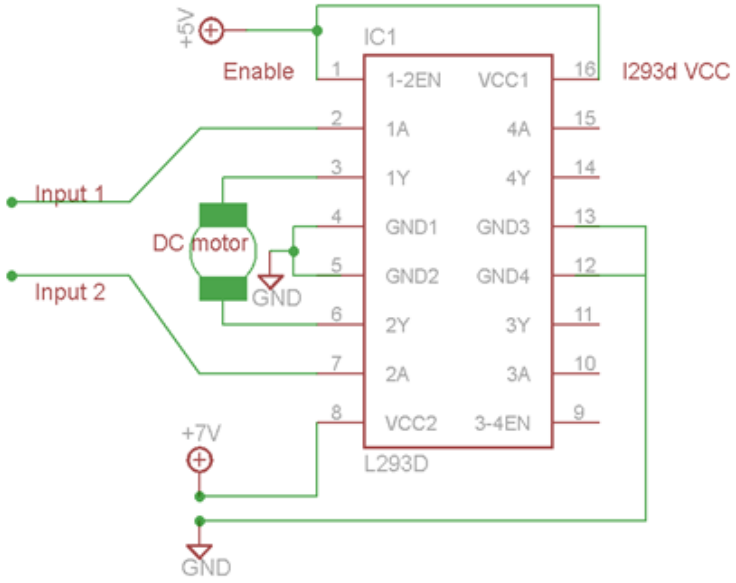

Figure (4): Pin Connection with DC Motor

5. Gas Sensor:

The MQ 6 Gas sensor composed by micro AL2O3 ceramic tube, Tin Dioxide (SnO2) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-6 have 6 pin, 4 of them are used to fetch signals, and other 2 are used for providing heating current. They are used in gas leakage detecting equipment's in family and industry, are suitable for detecting of LPG, iso-butane, propane, LNG, avoid the noise of alcohol and cooking fumes and cigarette smoke. The features of this gas sensor are High sensitivity to LPG, iso-butane, propane, Small sensitivity to alcohol, smoke. Fast response, Stable and long life.

Resistance value of MQ-6 is difference to various kinds and various concentration gases. So, when using this component, sensitivity adjustment is very necessary. we recommend that you calibrate the detector for 1000ppm of LPG concentration in air and use value of Load resistance (RL) about 20KΩ(10KΩ to 47Ω). When accurately measuring, the proper alarm point for the gas detector should be determined after considering the temperature and humidity influence. Fig.5 shows the gas sensor used in this paper.

Figure (5): Pin Configuration of Gas Sensor

6. Results:

Overall system is made with zigbee according to function. PIC is located at the very bottom and the motor driver L293D is on PIC after the Zigbee modules are on the top right. The compilers of a series or robot are obtained. Fig. 6 is the overall picture of the system

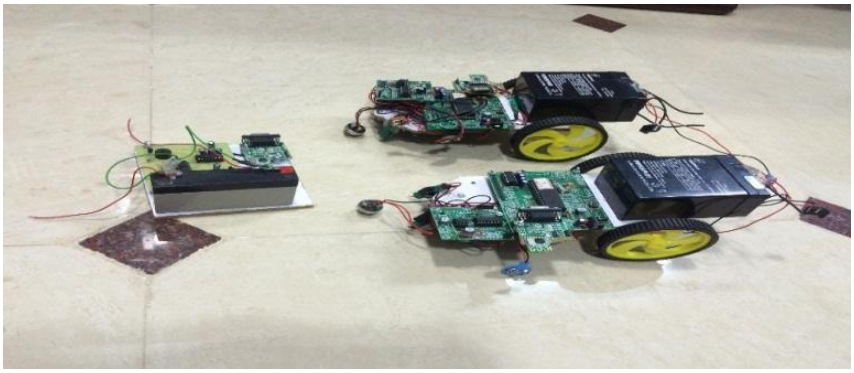

Figure (6): Overall Picture of the System

At this signal measurement spectrum analyzer are set according to the specifications of the XBee signal with a frequency range of 2.4 GHz marker around 2419.25 GHz and a frequency range between 2400 and 2440 MHz spectrum and level of -100 dBm. Transmitter signal form the leader is shown in Fig.7.

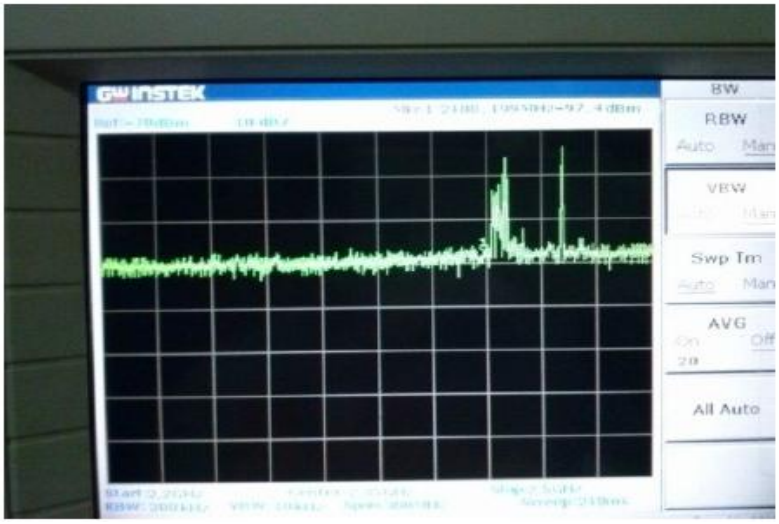

Figure (7): Transmitter Signal form the Leader

From the results of measurements of the spectrum analyzer are shown in transmitter signal power level leader, it is Maximum -81 dBM and -97.4 dBM. The interaction between the leader and the follower is shown in the Fig.8

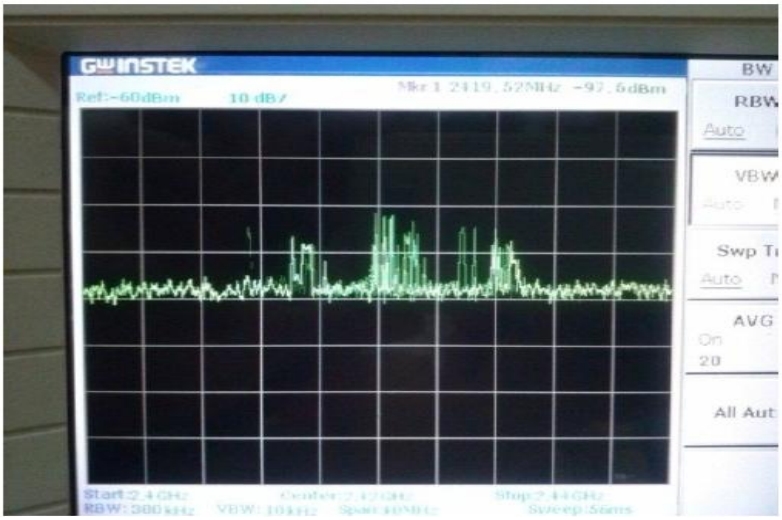

Figure (8): Interaction between the Leader and the Follower

From the results of measuring the power level can be displayed in graphical form as shown in Fig. 9 Based on the graph it can be concluded that the further the distance, the smaller the power level. It means that the distance also affects the communication between the robots so it will affect system performance. Based on some experiments it can be said that the leader and the follower robots can communicate with a maximum distance of 11 meters. Robots are not the connected at a distance of 12 meters because of the low power level that is -99.1 dBM. Based on the specifications XBee is shows the minimum receiver sensitivity -92 dBM so that if the price is less than -92 dBM, the signal cannot be captured by the XBee receiver on the follower. Another experiments measuring time required to make communication between the leader and the follower so that everything started to move. It aims to determine the speed of the robot performance in receiving orders and execute it. The experiments were conducted to determine the performance of signal XBee outdoor and environmental influences on the robot XBee signal.

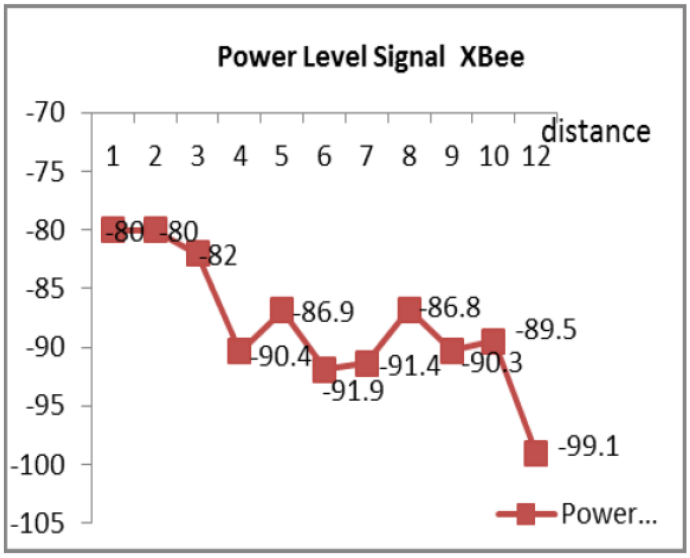

Figure (9): Power Level of ZigBee Signal

7. Conclusion:

Robot communication system designed able to work well in indoor and outdoor as well. Based on experiments results it can be concluded that the experimental signal indoors can be connected properly to a distance of 12 meters. The average power level of the signal up to a distance of 12 meters is -88.02 dBM. The average time need to make communications between leader and follower robot is 12.5 seconds. Unfortunately, in outdoor experiments transmitter receiver can catch the signal well only up to 5 meters.

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