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Wireless Colour Sensing Arm Robot

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Abstract - **This paper presents the implementation of wireless arm robot using Programmable System on Chip (PSoC) and virtual Instruments programming using LabVIEW graphical language. The wireless control has been implemented with Zigbee protocol. Some of the main features of Zigbee protocol are to establish wireless communication medium between the arm robot and the PC controller. The hardware system is based on the PSoC microcontroller interfaced wirelessly with LabVIEW via a Zigbee module. The user can send the control instructions to the robot from the PC by using the Zigbee Protocol. As soon as the instruction is received by another Zigbee at the receiver end, PSoC microcontroller will come into action and will start the motor drivers so that the Robot starts moving as per the instructions sent by the user/ operator from PC. In addition to the above qualities of the arm robot, its intelligence is further upgraded in this design by making use of a color sensor to identify and handle the required color objects.**

Keywords— **Arm Robots, PSoC, Virtual Instrument, LabVIEW, Zigbee, Color sensing.**

I. INTRODUCTION

For the last few decades, unmanned robots-vehicles are becoming very popular and common in R&D, Industries home and military organizations. There are many advantages of these robots as compared to human contributing to those application areas. One of the most important things about these robots is that they have the capability to perform their action remotely in the field, where human cannot enter and do the activity without any risks to human lives [1]. This shows a great impact on robots. These robots are expected to be great successful intelligent machines in the risky as well as unmanned critical environment. Zigbee protocol is widely used in embedded applications such as unmanned multi-functional robot for defense applications [1, 2]. Several leading radio system manufacturers have implemented solutions based on the IEEE detailed Zigbee protocol as described in literature [3]. RF controlled terrorist fighting Robot, structural monitoring to track building and bridge integrity [4].Use of arm robots in medical field for surgery as well as for taking medical tests such as colonoscopy[5]. These applications generally require numerous low-cost nodes communicating over multiple hops to cover a large geographical area, and they must operate unattended for years on modest batteries. Such requirements target a very different set of applications than do Wireless Personal Area Network (WPAN) technologies such as Bluetooth, which eliminate wiring for headsets, game controllers, and personal devices. Accordingly, Zigbee's capabilities are more limited than other WPANs and WLANs – they have small frame sizes, low bandwidth, and low transmit power.

II. BACKGROUND

With the rapid development in robotic technology around the world, many robotic applications were developed to improve our quality of lives [5-7]. The International Organization for Standardization gives definition of robot is "an automatically controlled, reprogrammable, multipurpose, manipulator programmable in three or more axes, which may be either fixed in place or mobile for use in automation applications". In this design, Zigbee wireless technology is used together with robotic application to demonstrate the effectiveness of unmanned arm robots. Zigbee is one of the new technologies designed to enable WPAN based around the new and emerging IEEE 802.15.4 standard.

A. ZIGBEE

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 standard for WPANs, such as wireless headphones connecting with cell phones via short-range radio. The technology defined by the Zigbee specification is intended to be simpler and less expensive than other WPANs. Zigbee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking. For these reasons, Zigbee is chosen as the communication medium for the controlling unmanned vehicle. Successful implementation of wireless autonomous arm robot using Zigbee protocol will lead to basis for building actual search and rescue mobile units capable of performing unmanned and almost impossible missions for human.

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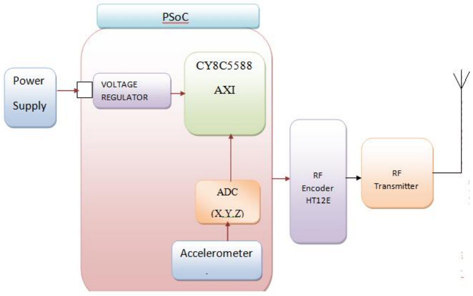
Transmitter:



Receiver:

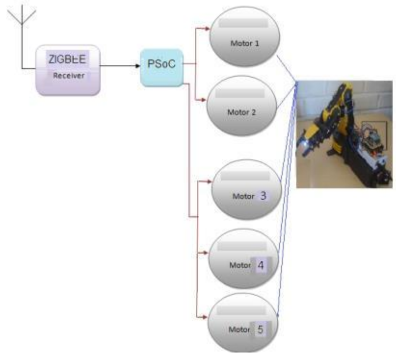


Fig.1 Block diagram of Robot controller with its (a) Transmitter and (b) Receiver module using PSoC microcontroller

III. SYSTEM DESIGN

The hardware and software details of the embedded controlled arm robot having color sensing intelligence are summarized as shown in Fig. 1.

A. Programmable System on Chip (PSoC)

The microcontroller acts like the brain of the wireless mobile robot system. The microcontroller chip that has been used in this design is CY8C55, manufactured by Cypress semiconductors. This chip has been opted based on the following technological innovative features:

i. Programmable system on chip (PSoC 3) is a true system-level solution providing micro controller unit (MCU), memory, analog, and digital peripheral functions built-in a single chip.
ii. The flexible and programmable analog and digital subsystems.
iii. It has built-in PWM which allow us to programmatically control the duty cycle of DC motor drive.
iv. It is a very simple but powerful micro controller.
v. The new architectures also support a wide range of communications interfaces, including Full-Speed USB, I2C, SPI, UART, CAN, LIN, and I2S

B. Features:

32-bit ARM Cortex-M3 CPU Core, Low voltage operation, Versatile I/O system, Digital and analog peripherals, Programming, debugging and tracing operations.

IV. PSoC IMPLEMENTATION

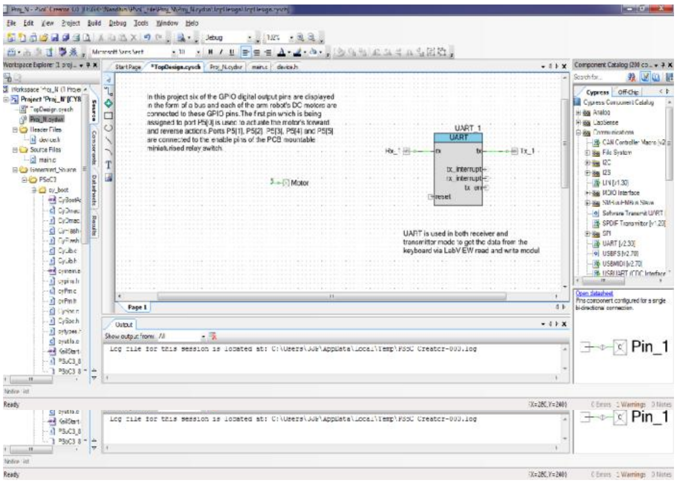


Fig.2.PSoC implementation using GPIO pins and an UART module (Both TX and RX mode).

Figure.2 shows the PSoC implementation where six GPIO pins are used in the form of a six pin bus and an UART module is also configured to operate in both transmission and reception modes.

Port P5 [5:0] is assigned for the six GPIO digital output pins as shown in the above fig.2. Among these pins, port P5[0] is used to facilitate the forward and reverse actions in the arm robot and the remaining pins are used as enable for each of the five DC motors which is achieved via a PCB mountable miniaturized relay switch.

V. LabVIEW

LabVIEW (Laboratory Virtual Instruments Engineering Workbench) is a graphical user interface (GUI). Using LabVIEW tool a menu driven module is developed on its front panel such that both motor selection and color selection are done simultaneously and this in turn enables the PSoC microcontroller to drive the selected motor of the arm robot and pick the required color ball.
Some of the following unique features of LabVIEW virtual instruments have led to its use as a user interface in this project.

- Extensive support for accessing instrumentation hardware.
- Drivers and abstraction layers present themselves as graphical nodes for many different types of instruments and buses.
- Abstraction layers offer standard software interfaces to communicate with hardware devices.
- Driver interfaces help in minimizing program development time.

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- Visualization of the program flow decreases the code development time and thereby increases the number of executions.

A. LabVIEW Implementation:

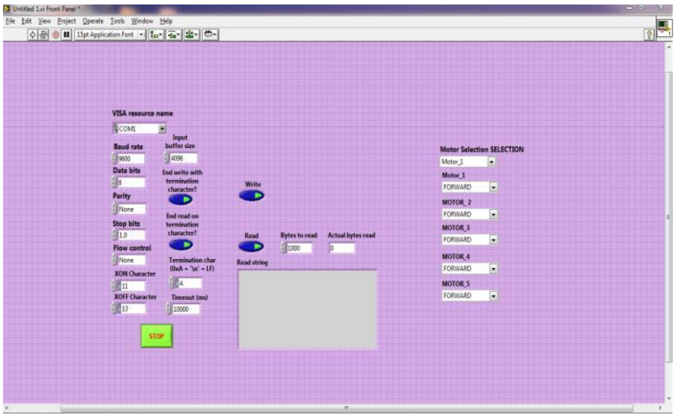

Fig.3.LabVIEW read and write front panel with motor controls.

VI. ZIGBEE MODULE

This project requires two XBee-PRO modules in order to establish wireless communication between the PC controller and the OWI arm robot. The XBee-PRO Zigbee module is slightly different from other typical PCB circuits. It has an operating voltage of the order 3.0-3.4 V (DC supply). This low dc supply voltage can be obtained by feeding the output of 5V to the voltage regulator LM317. This low voltage input is one of the advantages of using Zigbee in autonomous robot because the battery life time will be retained much longer. The XBee-PRO used 7 pins to interface with microcontroller circuit which are Data In, Data out, RTS, CTS, VCC, GND and reset. In Zigbee transmit power output is rated at 50mW with an operating frequency of 2.4GHz with operating current around 295mA and RF data rate of 250k bps. The XBee-Pro edition runs at a 10mW output power, enabling it to transmit much further antenna options are Integrated Whip, Chip, RPSMA, or U.FL Connector. The Zigbee module is low power, small, and easy to integrate into any project with short-range wireless communication.

A. UART

In this paper UART is initially used to test the entire working of the proposed system in a wired communication medium. Later the same system is demonstrated with Zigbee protocol. Some of the basic details of UART module are as follows. A UART (Universal Asynchronous Receiver/Transmitter), is a type of "asynchronous receiver/transmitter", a piece of computer hardware that translates data between parallel and serial forms. UARTs are commonly used in conjunction with communication standards such as EIA, RS-232, RS-422 or RS-485. UARTs are now commonly included in almost all microcontrollers. A UART usually contains the following components:

A clock generator usually allows the sampling to occur at every multiple of the bit rate in the middle of a bit period.

- A clock generator usually a multiple of the bit rate to allow sampling in the middle of a bit period.
- input and output shift registers
- transmit/receive control
- read/write control logic
- transmit/receive buffers(optional)
- parallel data bus buffers(optional)
- First-In-First-Out (FIFO) buffer memory (optional)

VII. DC MOTORS

This design uses DC motors for the movement of arm robot. The arm robot directional control is as shown in Table 1 below. The default speed of DC motor used is 200 rpm. The higher the speed the more the power required and the quicker the battery discharged.

In this arm robot five DC motors are available to correspondingly drive the gripper, wrist, elbow, shoulder and base. The fig.2 shows the arm robot that was designed using Zigbee module.

Table.1 shows the movement sequences of the arm robot.

Table.1 Directions of Motors.

S.No	Arm Robot Parts	Possible Movements
1.	GRIPPER	Open/Close
2.	WRIST	Forward/Reverse
3.	ELBOW	Forward/Reverse
4.	SHOULDER	Forward/Reverse
5.	BASE	Right/Left

VIII. SOFTWARE PROGRAMMING

The intelligence of the arm robot totally depends on its menu driven software. To move the arm robot, it needs to be programmed. Virtual instrument menu driven programming in Graphical language has been carried out efficiently with LabVIEW for sensing and controlling the arm robot through a programmable intelligent PSoC controller.

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IX. FLOWCHART

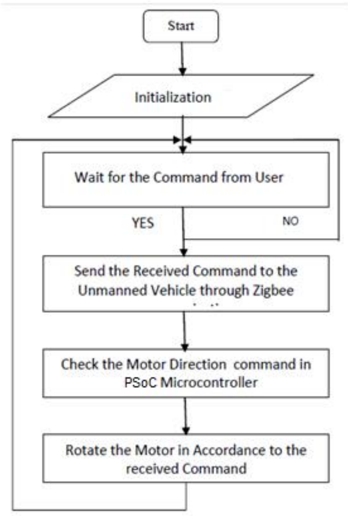

Fig.4 .Flow Chart

The data flow from the PC controller to the robots hardware is shown in the flow chart (Fig.4).

X. HARDWARE

A. Color Sensor

As an innovative idea, in this project the intelligence of the arm robot is further enhanced by exploiting a commercial color sensor IC TCS230, which is capable of providing the frequency information corresponding to the object's color that is being sensed. This sensor is mounted onto the gripper of the arm robot and through PSoC interface and a menu-driven LabVIEW program; the arm actions of the robot is enabled. Upon receiving the instructions from LabVIEW, PSoC embedded interface design enables the robot to pick the opted color objects. This is achieved by comparing the acquired color frequency with a user selected color related frequency in PSoC Programming. The one which matches with a particular color frequency is being selected via LabVIEW using a menu-driven module and this in turn is then used to actuate the base and gripper motors and the arm robot is moved to the particular location in order to pick the selected color object.

The following figure illustrates the functioning of the color sensor TCS230.

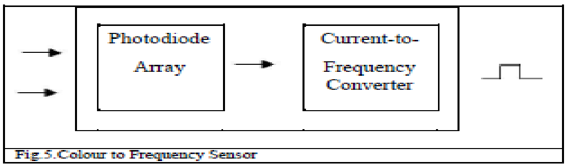

Fig 5.Colour to Frequency Sensor

In fig.5, light rays are made to pass through a photodiode array which consists of four diodes connected in parallel, with each diode capable of sensing red, green and blue colors respectively. These photodiodes are 110µm x 110µm in size and are on 134-µm centers. Later this output is fed into a current to frequency converter and in turn provides the corresponding frequencies as output.

Hence this sensor doesn't require any ADC to convert the sensed data. The major advantage of this color sensor is that: PSoC microcontroller directly receives the digital data of the sensor. The following section explains about the interfacing of DC motors with PSoC controller using PCB mountable miniaturized relay in order to enable / actuate the motor's forward and reverse actions.

B. PCB Mountable Relay Interface with PSoC

The main purpose for the implementation of PCB mountable miniaturized relays is to actuate the five motors accordingly in the preferred directions. Motor's forward and reverse movements are facilitated by a menu-driven module built in LabVIEW 7.1 version. Any choice selected from the LabVIEW front panel will be sent in the form of instructions via wireless Zigbee communication medium. The data received at the receiving end is then processed by PSoC microcontroller and the required part of the arm robot is rotated either in the forward or reverse direction. Fig.6 shows the pin configuration of PCB mountable miniaturized relay module, its pin configuration and its driver using BC547 NPN Transistor.

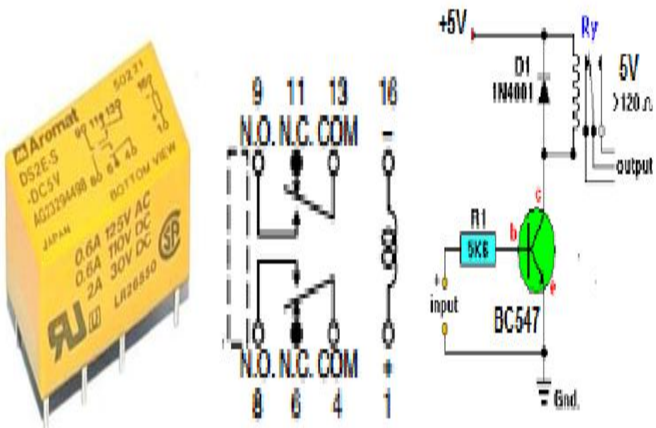

Fig.6 PCB Mountable Miniaturized Relay, Pin Configuration and its transistor driver circuit.

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Five PCB mount relays are used to control 5 motors in the arm robot for its forward and reverse movements. In the miniaturized relay pins 1 and 16 are the inputs to which the five GPIO pins of PSoC are connected through NPN driver transistor externally to enable/ disable 5 motors in the arm robot. The pins NO pins of 5 relays are the outputs to which the five DC motors are connected. In PSoC Creator five General purpose Input Output (GPIO) pins are used to enable the five DC motors for stimulating the robot's arm actions. PCB mount relays are then used to control the motors forward and reverse actions by connecting the control signal input of the switch to

PSoC's 5V supply with the help of connecting wires. In this project we are making use of ports P5(0) , P5(1) , P5(2) , P5(3) , P5(4) and P5(5) as inputs to the switch as well as to the five DC motors.

C. Wireless Color Sensing Arm Robot

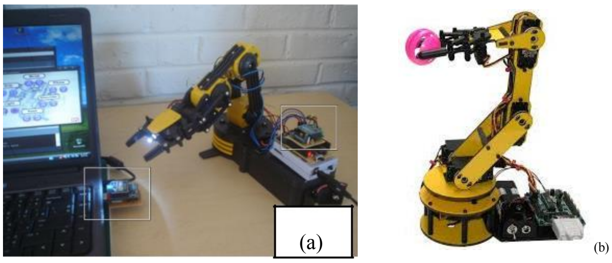

Fig.7 (a) PSoC Embedded design Controlled Wireless Color Sensing Robot and (b) Arm Robot with its colored ball sensing and picking up.

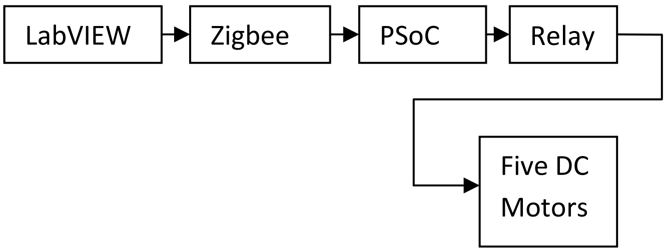

Fig.8. Flow of firmware source code

The fig.7 shows the designed color sensing wireless arm robot controlled with PSoC embedded design and Zigbee wireless module. The menu driven software written in graphical language, LabVIEW, resides in PC memory has the graphical user friendly menu driven control software to enable/ activate the unmanned color sensing arm robot in a remote area.

The fig.8 describes the flow of firmware source code from LabVIEW and PSoC Creator to the five DC motors. In this project data flow between LabVIEW and PSoC 3 is facilitated by the use of a ZIGBEE wireless module which comprises of both transmitter and receiver.

D. PSoC implementation for color sensing arm robot

Figure.9 shows the PSoC implementation for color sensing module of the robot. The workspace shown in fig.9.includes both the motor interface as well as the interface for the color sensor. Counter module is mainly used in here in order to count the frequency obtained as output from the color sensor which is connected to the count input of the counter. The Vcc supply connection as well as the ground connection for the color sensor is given directly to the respective supply and ground pins available on the PSoC board.

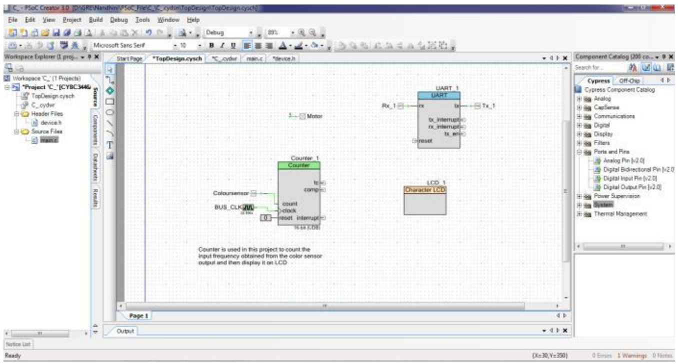

Fig.9.PSoC implementation using color sensor and DC motors

E. LabVIEW implementation for color sensing arm Robot

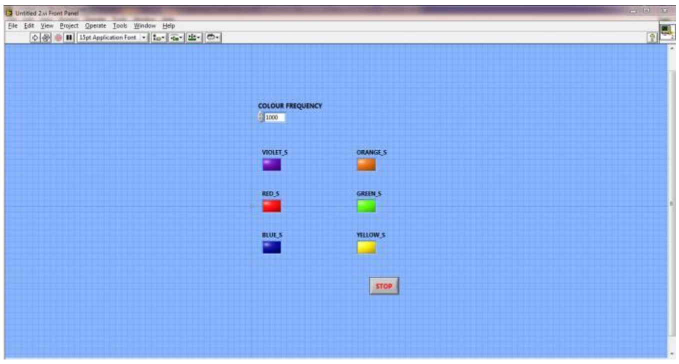

Fig.10.LabVIEW color sensor front panel implementation

LabVIEW block diagram implementation for color sensing module of the arm robot:

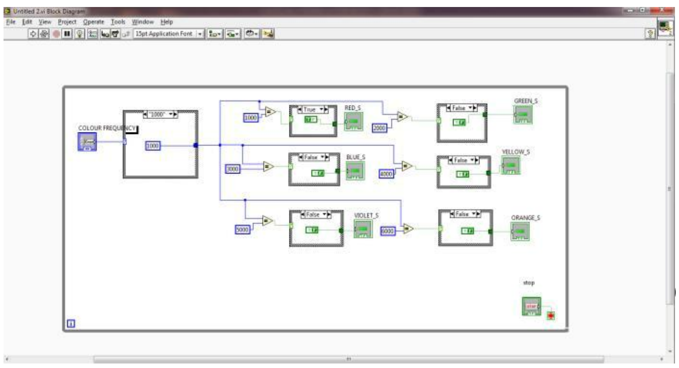

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Fig.11.LabVIEW block diagram for color sensing module of the arm robot.

XI. APPLICATIONS

- As a recovery vehicle robot during rescue operation of any collapsed buildings with wheels attached to it.
- In industries for material movements.
- Effective arm robot in civil constructions
- Provides security
- Military applications.

XII. CONCLUSIONS

An intelligent arm robot has been designed with its wireless sense and control operations making use of PSoC embedded design, Zigbee module and its menu driven virtual instrument program that is designed along with LabVIEW. This arm robot design has an enhanced intelligence of color sensing in comparison with the existing commercially available robots. This designed arm robot can give an exposure about how a simple, cost effective robot with excellent intelligence can be used to do multifunction in home, industry, medical, R&D and defense etc. This design supports user-friendly control of the arm robot from the control room which is located far away from the border area. The system uses commercially available Zigbee module for wireless communication. This project design is aimed towards the Zigbee technology up to 300 meters line of sight and with obstruction 150 meter distance for wireless control. In future we can increase the distance by using high gain antennas. This system has also upgraded the basic intelligence of arm robot by using color sensors and it is also possible to further increase its intelligence by implementing the same system with strain, pressure, current and force sensors. Thus, the designed arm robot is focusing on the possible application area to a greater extent.

REFERENCES

[1]. Unmanned Multi-Functional Robot Using Zigbee Adopter Network for Defense Application. International Journal Of Advanced Research In Computer Engineering & Technology (IJARCET) Volume 2, Issue 1, January 2013.

[2]. Design and Implementation of Zigbee sensor With PSOC for Wireless Robot. Sathisha B M, Sandeep S, Suresh H N http://www.sharepdf.com /65a19ddac41540f5bc2adadab0e0b0 ee/IEEE_ZIGBEE.htm.

[3]. “RF Controlled Terrorist Fighting Robot” International Journal of Computer science & Communication Vol. 1, No. 1, January-June 2010.

[4]. Remote Monitoring And Controlling System Based On Zigbee Network International Journal Of Software Engineering And Its Applications Vol. 6, No. 3, July, 2012.

[5]. A Micro robotic Arm for a self-propelling colonoscopy, June 1998, Proc. Actuator 98.

[6]. Internet Controlled Robotic Arm, Kader Ibrahim. Engineering Procedia, (2012), 1072-1078.

[7]. Wireless Mobile Robotic Arm. Procedia engineering 41(2012), 1065-

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