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Interconnected Robots – A Real Life Military and Commercial Application based on Embedded System Technology

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***Abstract*-Embedded system generally could be defined as a control system which requires incorporation of hardware as well as software technology in order to create a specific application based system. Embedded system devices are being used vitally in various fields of modern life from home devices to high grade military applications. Communication devices could be controlled by the microcontrollers which enable them to send data to connected devices. Specific wireless cluster technology called star topology is used in this project which incorporates a complete embedded system.**

Keywords- Embedded systems, Zigbee, microcontroller, intercommunication, star topology.

I. INTRODUCTION

Embedded systems are widely deployed and are being used in application areas such as home automation, health, commercial, military and so on. For designing a complete embedded system we need feasibility, efficiency, security, robustness, low-cost and reusability. Incorporation of embedded system with adequate wireless technology provides greater applications in various areas. Interconnection generally refers to the connection paired between groups of robots in order to share mutual information through a medium of communication.

A. Application of this project-

In this a compact embedded based group of robots or autonomous vehicles is designed. Robots which are dependable on each other and can share the same data which is transmitted over the communication channel are classified as swarm robots or interconnected robots.

This paper will generally highlight two robots communicating with each other that are robot1 and robot2. Robot1 is the main intelligence head whereas robot2 is dumb (follower) and follows robot1 in the same desired path using Zigbee as mode of communication. Multiple robots can be connected with the robot1 using STAR topology of which star head is robot1 and all the end devices are the interconnected robots to robot1. Robot1 is programmed using password based system which provides authentication for use of robots to driver or the end user. In case of sudden attack only authorized person is able to use robot1 with correct password entry. Different paths are fed into the microcontroller memory which runs the motors accordingly on the desired path.

II. CIRCUIT DESCRIPTION -

A. Microcontroller module-

89c51 by atmel provides more reliable benefits because of its high researched history, easy programming and troubleshooting capability. This controller has all the necessary features required to run the project and has been very successfully tested. As per official datasheet released by the atmel, this controller is working on 8-bit mode containing 4k flash memory to store the program inside it by technology of PEROM called programmable and erasable read only memory. This controller uses 128x8 bit internal RAM and have static operation between 0 to 24Mhz with this project using 11.0592Mhz mode of operation.

Microcontroller module in this project is interfaced with wireless device Zigbee, 16*2 LCD display for display of information, motor module and password based hex-keyboard designed using switches.

B. Wireless module-

Communication device used for wireless module is Zigbee. Under standard 802.15.4 this device is appropriate for testing this project prototype at small scale. Range of this is average of 70m and operates at 20- 250Kbps at 2.40GHz band. Batteries could withstand for years for Zigbee due to its low-battery consumption, hence feasible for continuous testing in prototypes. Zigbee is used in Star cluster hierarchy in which a router Zigbee is configured using AT commands and placed at the centre of star cluster. Each end nodes represents attached following robots which are acting as receivers of serial information from the head robot. Password system in head robot provides security to all the interconnected robots as these robots rely on the head robot for information. If head robot is password protected and hence offers authentication to the system and also to the information transmitted to the connected robots.

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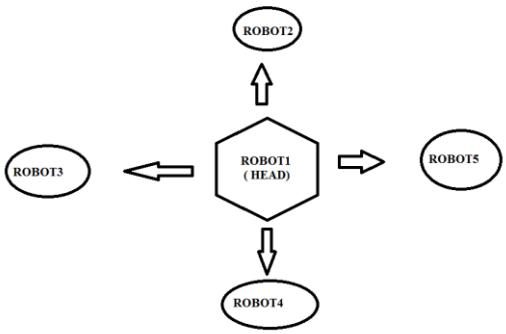


Fig1. Star cluster hierarchy for wireless communication

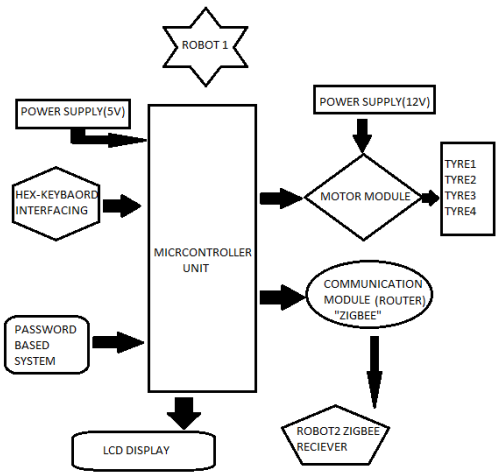
C. Motor module-

Motor module is made using 12V-300rpm DC motors. Each robot has four motors attached to four wheels. This module represents a land transport based robot system. For air transport quad copter can be designed with rotors attached in place of wheels and adjusting it accordingly for the flight trajectory. Microcontroller module controls the motor module according to the path set by the user during programming and then feds it into the system using the hex keyboard.

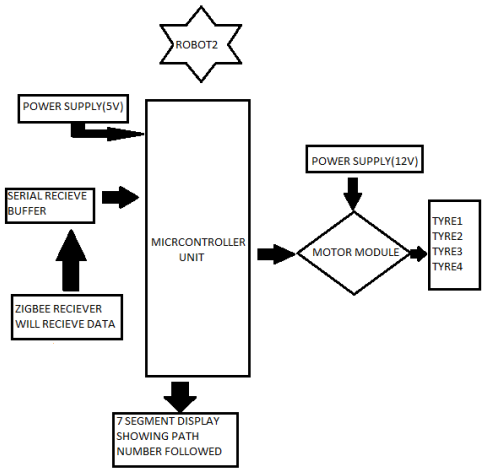
D. Block diagrams of robots-

These block diagram represents the components that are used in making this embedded system. Block diagram for two robots – robot1 (head) and robot2 (follower) are represented.

1) Robot1 block diagram: -

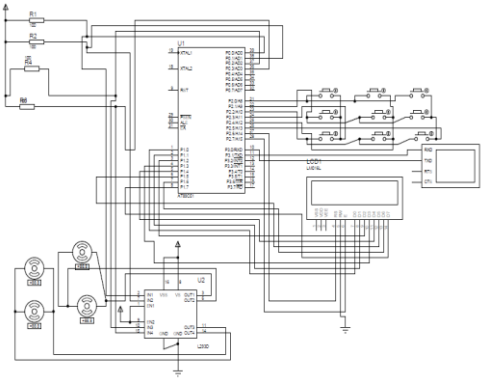


2) *Robot2 block diagram:*

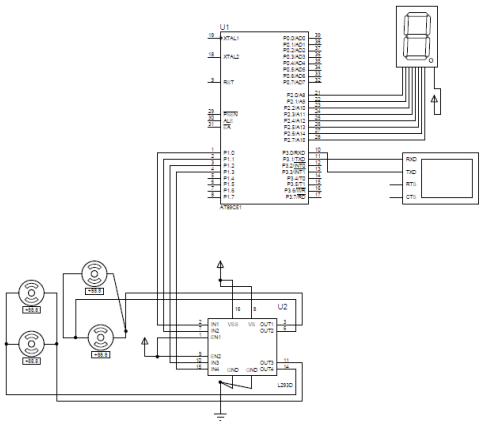


E. Circuit diagrams –

1) Robot1 circuit diagram depicting actual hardware constituents-



2) Robot2 circuit diagram depicting actual hardware constituents-



Above two circuits diagram represents the hardware circuit of the embedded system. Virtual terminal (as shown) is connected to microcontroller serial Rx (receive) and Tx (transfer) pin and represents Zigbee module pin connection with the same.

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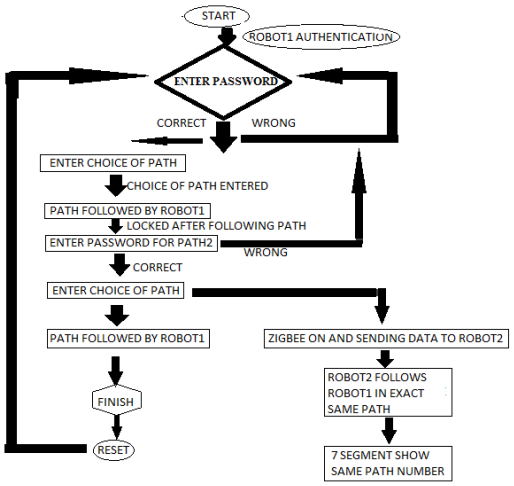
III. DESIGN ALGORITHM-



Above algorithm gives the complete working of the system. "Start" refers to the first triggering voltage given to the complete circuit using battery or the power supply.

Next step is the authentication step in which the user is required to enter the password in order to access the complete system. Correct password will enter the user whereas wrong password will display "wrong" and move user back to screen where it says enter password.

On correct password it will ask for the type of path the robot1 has to follow. This path could be predefined like one in my project or could have real time data feeding using real vehicles where it will store the complete movement of wheels along a particular path. Then the robot1 will follow the path as chosen.

If user need to further use the system he again has to enter the password. Similar password steps as discussed before are followed here. Again there is choice whether it wants robot1 to carry on another path or send the data through Zigbee into the following robots. In my case only one dumb robot is used which is robot2, but it could be swarm of n number of robots.

On pressing defined keypad for Zigbee serial (in my case key 5) it will send data serially to all adjacent connected Zigbee receivers. Adjacent robots are going to follow robot1 in exactly the same pattern of path, as these robots will receive data from robot1 using technology of Zigbee. Robot1 will again continue in its working unless the role reaches to "finish" of the job. In this if "reset" robot1 will again start from the initial step of entering password.

Above algorithm provides a strategic approach to the working of the given embedded system. Above algorithm has been based upon real-time test simulation of the prototypes. Any additional alteration in project may lead to change in algorithm with respect to the working of the circuit.

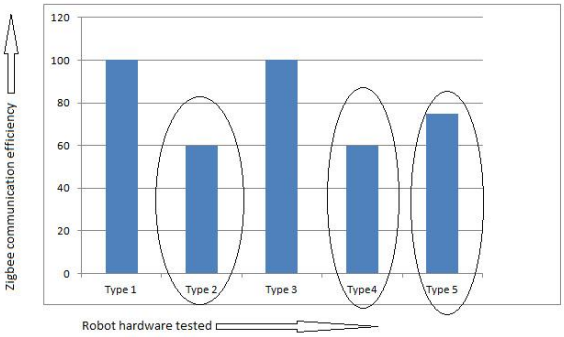
IV. RESULT

A. *Charts and information-*

1) *Chart 1-*

Chart 1 depicts the efficiency of using Zigbee as a mode of communication device. Efficiency of Zigbee is carried with respect to the number of bits of signal received to the distance amongst interconnected robots. It is being calculated in terms of percentage. At small scale Zigbee performed well and communication worked perfectly but moving to larger prospective which required increasing distance amongst devices lead to decrease in overall information transfer and hence reduced efficiency.

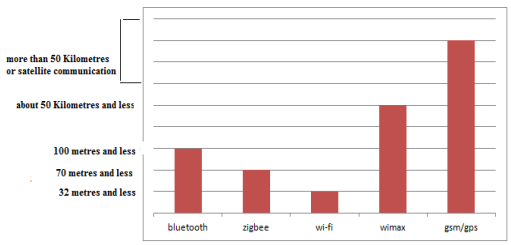
Hence this chart shows that Zigbee works perfectly efficient for small prototypes but as the distance increases it shows a drop in efficiency of communication.



TYPE	Description
Type1	Robot module using 300rpm DC motors with 12V battery in order to run at adequate terrain.
Type2	Quad-copter module simulation using 100rpm Servo motors and multiple 5V-7V batteries in order to reduce the flight weight.
Type3	Circular rearranging tiny bots using 50rpm battery in order to rotate all in synchronous pattern and to generate a constant phase of motion.
Type4	Water interconnection robot boats using 500rpm motor rotor to push water
Type5	Large rover modules for mass survey utility

2) *Chart2-*

Chart 2 represents communication devices that could be used in place of Zigbee in order to carry out this project at defined level of scale.Since application of the project communication could be from few metres to many kilometres, therefore it is represented to use desired device only for maximum efficiency.



Above chart labelled as-
X-axis: Communication technology
Y-axis: Range of communication

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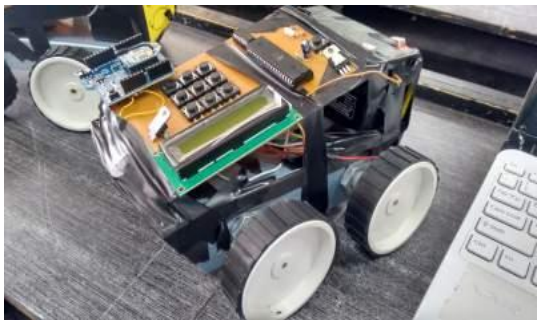
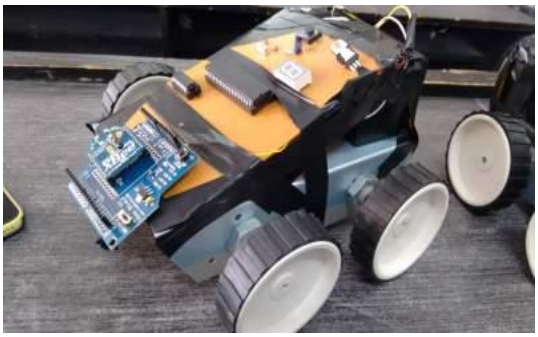
B. Project prototypes-

1) Robot1 prototype with lcd display, hex keyboard for password system and Zigbee-



2) Robot2 prototype with seven-segment display for path number representation which is being followed and the Zigbee module-



V. CONCLUSIONS

Advanced embedded system technology application-specific approach created idea of this project. This project emphasizes upon use of embedded technology in an innovative way to improve human lifestyle. This area provides lot of options to research and apply modern trends in science and technology.

More advancement could be convoluted in this topic related to artificial intelligent robots, self-clustering robots, application specific bots and automation industry application devices.

Result has been evaluated and testing concluded with maximum efficiency using Zigbee based embedded system of interconnected robots.

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