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A LOW-COST CUSTOMIZABLE PROTOTYPE FOR REMOTE INDUSTRIAL AUTOMATION-AN EXPERIMENTAL STUDY

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Abstract

Microcontroller-based embedded system play important role in Remote industrial automation. In Most of the modern manufacturing and processing industries like plastic, Textile, chemical, Pharmaceutical, Mixing-factory need Remote/manually industrial automation for safety and fast production process through combination of hardware and software. This paper presents a way to build a low-cost customizable prototype for remote industrial automation based on Microcontroller and RF Receiver-Transmitter module with multiple features like multiple mode of operation keypad/remote control, single/repeated process, set on/off time of a particular selected process, increase/decrease performance time of a selected process. And we can also control the speed, direction, mode of motion of an industry appliances like AC/DC, stepper, servo motor (depend on the applications) and also include emergency stop feature and an indication of current process display through LED(Light emitting diode) and LCD(Liquid crystal display).

Keywords: Microcontroller; RF Receiver-Transmitter model; Timer; Digital ICs; LCD; DC –Motor; Relay; Decoder; Encoder; Remote control; keypad control, single and repeated process

Introduction

Control the motion of an appliances depend on AC/DC motor, Servo motor, Stepper motor and other machine plays a vital role in the industrial automation. Manufacturing plants in industries like plastic, textile, chemical, pharmaceutical, Mixing-factory all are required the control of motors at a particular speed, angle and direction for different-different processto performing the meaningful work and less number of wastage, fast production. Because it is impossible work for an employee to control and care the different section like stop one process and start other process on same time. And many dangerous steps comein processes so we need to control the industrial machine by remote.

This paper presents our design and implementation of a low-cost customizable prototype for Remote industrial

automation for control the motion of more than one appliance depend on a motor and other machine at same time. We use NXP P89V51RD2 Microcontroller and 434MHz ASK Transmitter-Receiver as the main component of the system. LCD (Liquid crystal display) and the LED (Light emitting diode) are use in this system for display the current performance message like speed and time of motor, on/off time of an appliances, number of performance etc. We use RF-Receiver and transmitter for control the industrial appliances in remote mode and internal work of a RF Receiver-Transmitter is modulation and demodulation of a key (push button)messages and transfer to microcontroller through Encoder and Decoder driver. We use relay for energized and de-energized of an appliances like motor, heater, cooler, AC and other machine for limited time. We use SPDT(single pole double throw) and SPST(single pole single throw) switch for setting the operation of industries machines. Timer NE555 is use for mono-stable operation at desired time. And digital IC is use send the signal to microcontroller and timer.

The remainder of this paper is organized as follows. In Section 2, we provide a short background on microcontroller, specifically the NXP P89V51RD2 microcontroller and also RF 434MHz ASK Transmitter Receiver module. The design and implementation of the system is described in Section 4. Section 5 provides the results of our experiments and discussion. Finally, Section 6 concludes the paper.

Background

Microcontroller is a single-chip special-purpose computer use to execute a specific application. As in general-purpose computer, microcontroller consists of memory (RAM, ROM, and Flash) I/O peripherals, and processor core. However, in a microcontroller, the processor core is not as fast as in general purpose-computer, the memory size is also smaller. Microcontroller has been widely used in embedded systems such as, home appliances, vehicles, and toys etc. There are several microcontroller products available in the market, for example, Atmel ATmega8051 family, Microchip PIC, and NXP, Intel, Advanced RISC Architecture (AVR). We discuss NXP-P89V51RD2 and RF Receiver-Transmitter in this section.

A. NXP-P89V51RD2 Microcontroller

P89V51RD2 is an 8-bit 80C51 5V low power microcontroller. It has 5V operating voltage from 0 to 40MHz with 80C51 CPU. 64 KB on-chip Flash Memory with ISP(In-System Programming) and IAP(In-Application Programming), 1KB RAM. The other on-chip peripherals include three 16-bit timers/counters, 32 programmable 8-bit I/O lines, PORT 0 to PORT 3 with Analog and Digital pins and 3 High current Port 1 pins (16mA each), support SPI(serial Peripheral interface) and UART. It has PCA (programmable counter array) with PWM and

capture/compare function and TTL-and CMOS compatible logic level. It supports 12-clock (default) and 6-clock mode selections by software or ISP and Programmable watch dog timer. This microcontroller is available in 40-pin PDIP, 44-pin TQFP/MLF, and 44-pin PLCCpackages. Details of P89V51RD2 microcontroller are described in [1].

B. 434MHz RF RECEIVER-TRANSMITTER

An RF module (Radio frequency module) is a small electronic circuit (combination of Receiver and transmitter) used for transmit/receive radio signals on one of the number of carrier frequencies. The corresponding frequency range varies between 30 KHz & 300GHz. In the RF system digital data is represented as variations in amplitude in carries waves. This kind of modulation is known as Amplitude shift keying. RF module often used with encoder/decoder. The RF module is a combination of two parts.1) Receivermodule. 2) Transmitter module.

Figure 1. RF Receiver Transmitter module

The work of Receiver module is demodulation of digital data before sending to decoder. The work of Transmitter module is receives the digital data from encoder and modulates the digital data before sending to Receiver part. Transmission through RF is better than IR (Infrared) because of many reasons. Firstly signal through RF can travel through larger distances making it suitable for long range application. The transmission occurs at the rate of 1Kbps-10Kbps.

The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter. When attaching an external antenna to an RF module, for superior performance which will resonate at a particular frequency. The antenna length should equal to 1/4 of the wavelength of the frequency required in order to achieve resonance and provide the best performance. The length can be calculated by using the formula $C=f*\lambda$. Where C=speed of Light, f=Required-frequency.λ=Wavelength.Details of RF module are described in [2].

Related Work

This system consist the microcontroller, RF Receiver-transmitter module, LCD Display[3], Encoder, Decoder[4], Relay, Timer and Logic gates, Relay driver[5], Motor Driver[6], Motor .We can operate the industrial device by remote or keypad.

A. Remote Mode

Before operating the device select the remote mode and single process or repeated process mode. After giving the power supply the microcontroller internal device, LCD and other component are enabled. Message come on LCD select your device and set on/off time. Set the on-off time for selected appliances by remote switch. when we increase/decrease the operating time for appliances then address code of each key is send by the encoder of remote to Transmitter, And then Transmitter module modulate this address code and send it to receiver module. After receiving, Receiver first demodulate the address code and send to the decoder and decoder try to match the address of the key code if successfully match then send it to microcontroller and after press start key microcontroller send signal to input pin of the relay driver and energize the particular relay which is related to selected appliances and then start operation on the particular appliances at de-sired time. After expired the time the process is stop if it is in single mode or process is repeated after pre-defined time if it is in repeated mode.

B. Keypad mode

Before operating the device select the keypad mode and single process or repeated process mode. After giving the power supply the microcontroller internal device, LCD and other component are enabled. Message come on LCD select your device and set on/off time. Set the on-off time for selected appliances by keypad switch. when we increase/decrease the operating time for appliances then address code of each key is send to microcontroller and after press start key microcontroller send signal to input pin of the relay driver and energize the particular relay which is related to selected appliances and then start operation at the particular appliances at de-sired time. After expired the time the process is stop if it is in single mode or process is repeated after pre-defined time if it is in repeated mode.

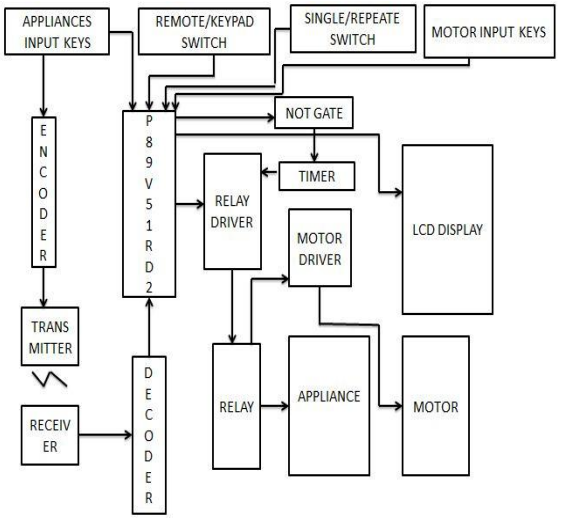

Figure 2. System Block Diagram.

C. Motion Control

By pressing the motor input keys we control the motor by remote and keypad. We select the mode of motion and then press start key input take by the microcontroller and a low-signal generate by the output pin. Low signal convert by the invert gate and sent the high signal to trigger pin of the NE555 [7] timer. (we can increase and decrease the time-period of timer by help of potentiometer).and the output of NE555 is connected the relay which is energies by the invert gate and the input of relay is fix in motor driver and motor start rotating at desired time. And when we press stop key.

Design and Implementation

We define our system to have specification as follows

1) Controlled through microcontroller AT89C51. 2) Message displayed on the LCD module.3) Initiating the process after defined time. 4) Switching on/off the process after predetermined time. 5) Providing delay in between processes (set by input keys). 6) Applying input to on/off type open-loop control system. 7) Repeat (continuous) and single operation 8) fully remote-controlled within 100-metre range (range depend on the frequency of RF-module. 9) User-friendly front-panel controls and display panel with LCD. 10)Emergency stop buttons (on control panel as well as on remote) 11)Provision of potential-free relay contacts for connecting any 230VAC at 10A or 28V DC at 10A device/application.12)Start, stop and change of direction of the motor controlled by push button switches and indicated by LED. 13) Changes the running mode of the motor. 14) Changes the speed of the motor. 15) Time settings are possible for forward and reverse running of the motor.

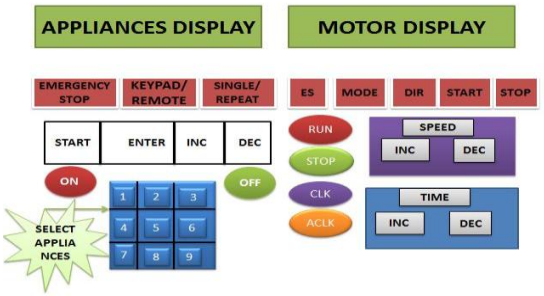

Figure 3. Industrial control panel.

This system consists of Hardware and software part. Simplified block diagram of the system is depicted in figure-2.As shown the microcontroller is connected with RPS (Regulated power supply) for proper power. LCD and LED display are connected with I/O pins of the microcontroller for display the current status of system. Relay driver, Timer NE555 connected to the microcontroller for energize and de-energize the relay and motor. The keypad and input key are connected to microcontroller input pins for selection of appliances and operation setting of system. RF

Receiver model are connected with microcontroller through HT12D decoder, for receiving the RF signal in remote control mode. RF-Transmitter module is connected with Remote input keys through HT12E encoder for selecting and starts operation and sends the signal to RF- Receiver part. The industrial control panel of the system is described in Figure 3.

A. Regulated Power Supply

All TTL/CMOS chip are operated between 3.3V & 5V. So for safety purpose we use the RPS(Regulated power supply). A RPS is used to produce the constant linear voltage. It's generally used with AC/DC power supply. And also it can be used as well as DC to DC voltage converter. RPS contain the step-up transformer for down the Highinput AC voltage (230V) to LOW output AC voltage (12V) by magnetic induction principal. And output AC current is convert into DC by rectifier and this DC voltage sent to voltage converter chip 7805 and 7806 and this IC convert 12V DC input to 5V & 6V DC and give the constant smooth result (by help of capacitor) to TTL/CMOS chip. Detail of RPS is described in [8].

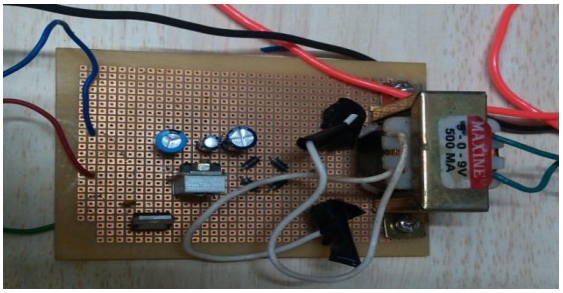

Figure 4. Regulated power supply

B. RF 434MHz ASK TRANSMITTER

The RF Transmitter part is used as a remote. By using RF Transmitter we control the industrial appliances by giving the proper input. RF Transmitter consists the ASK transmitter connected through HT12E Encoder and the Encoder connected with input keys. ASK transmitter take the message from input keys & encoded and modulate the message before sending to ASK Receiver module.

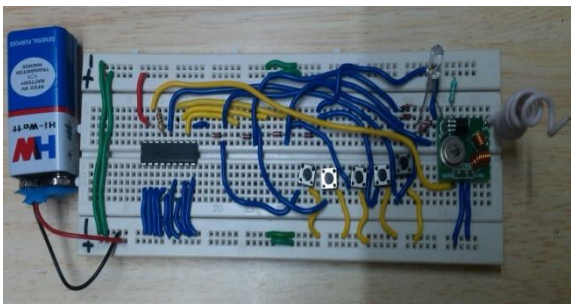

Figure 5. ASK Transmitter.

C. APPLIANCES CONTROLLER AND RF 434MHz ASK RECEIVR

Appliances controller consists the LCD, Microcontroller and input keys for setting the remote mode or keypad mode and for selecting the single/repeated process. In appliances controller have a key for Emergency stop. All this keys are connected with input/out pin of the microcontroller and every message display on LCD like select the appliances and set performing time. The RF Receiver module connected to microcontroller through HT12D decoder. For receiving the Transmitter signal and demodulate the receiving signal and send to the microcontroller through decoder. And after receiving the proper input microcontroller start the process at selecting appliances. In this proposal we give a small prototype for one appliance but we can modify by increasing the no of relay and input to relay driver.

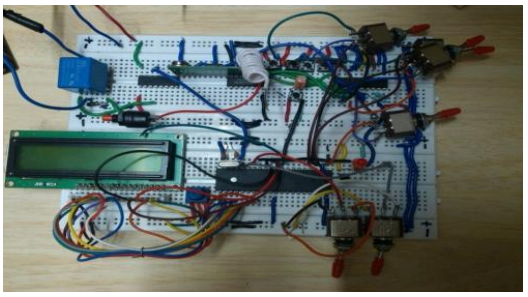

Figure 6. Appliances control section with RF Receiver.

D. Motor Controller

Motor control section consist LCD, Microcontroller, Timer, Invert gate, Relay and motor. In Figure-7 this is a small prototype of motor control we modify it by using more than one relay and programming part. By pressing the motor input keys we control the motor by remote and keypad. We select the mode of motion and then press start key input take by the microcontroller and a low-signal generate by the output pin. Low signal convert by the invert gate and sent the high signal to trigger pin of the NE555 timer. (we can increase and decrease the time-period of timer by help of potentiometer).and the output of NE555 is connected the relay which is energies by the invert gate and the input of relay is fix in motor driver and motor start rotating at desired time. And when we press stop key.

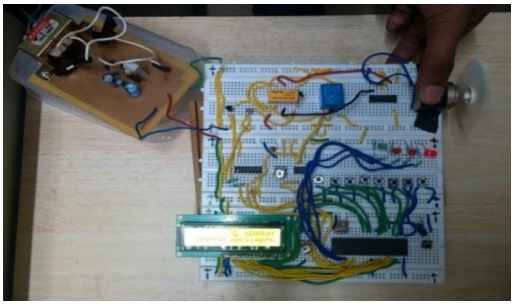

Figure 7. Motor control section

Figure 4, Figure5, Figure6, Figure7 show the small hardware prototype of industrial automation. We compile the software in Keil uVision3, 4 and generate the Intel HEX file. Flash the HEX file by FLASH MAGIC programmer in flash memory of the microcontroller.

Experimental Results

The appliances control model is implemented as shown in Figure-8 and Figure-9. Figure-8 and is the overall setup of appliances controller. And Figure-9 has shown the implemented result after giving the power supply. Implemented is done by both keypad and remote mode. We give the proper input by help of remote keypad and manual keypad. After de-sired time the appliances start on-off dependent on single process and repeated process. In place of appliances we implemented by BULB and 230V power supply and it start successfully work.

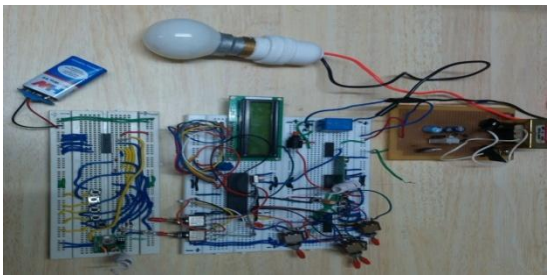

Figure 8. Appliances controller setup.

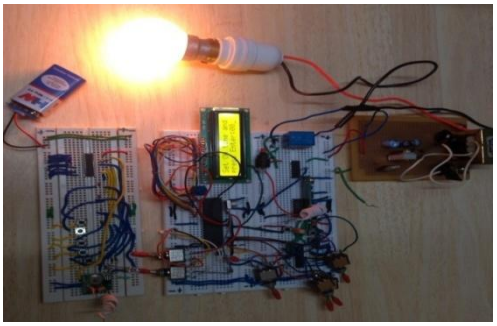

Figure 9. Implemented Result of Appliances controller.

The implementation of motion control section as shown in figure-10. Figure-10 has shown the overall setup up motion controller and also implemented result. After giving the power supply 5V for microcontroller and 6V for Relay and operate the motor as direction of microcontroller.

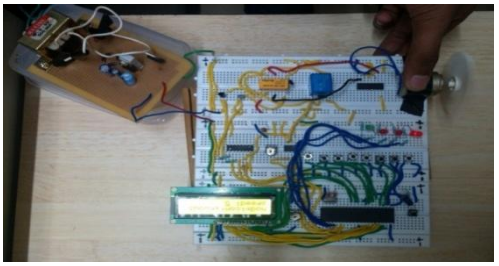

Figure10. Motor control section.

The complete setup of industrial automation is shown in Figure-11.

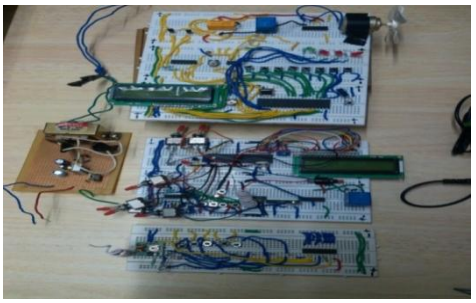

Figure 11. Industrial automation set-up.

Conclusion

In this paper, we have designed and implemented "A low-cost customizable prototype for remote industrial automation". We utilized P89V51RD2 microcontroller and RF-434MHz Receiver Transmitter module. Based on the testing results, the system works according to our predefined specification. This system can be used to help the employee, who works in dangerous industries for safety purpose and fast industrial production. In case the employee is not inside the industries in lunch time, Night time then they can set the working time of an appliances in repeated mode for time safety purpose. The system also can control by remote with 100 meter range or we can improve the range of RF signal by increasing the RF frequency. We can include more than one number of appliances and motor and operate particular appliance and motor according to program. Industrial automation gives lot of benefit to industries 1) Fast production. 2) Operated by less no of employee. 3) Safety for industrial worker. 4) Automatic on/off system.

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