Implementation of Motor Speed Controller Based on Infra-Red Communication

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Abstract

PIC controlling system is widely used and very popular around the world. Most of the mobile robots used motor for their movements. Microcontroller based Infra-Red control system with remote object is proposed in this paper. The proposed system is a combination of hardware devices, as computing devices and software interfacing to control motor speed using Infra-Red communication technology. And this is the real time control system with fast dynamics situation. This is implemented by using assembly language programming.

1. Introduction

In recent years there has been an increasing need to improve the efficiency and effectiveness of industrial machines. The direct interface between human operator and machine is slowly but steadily being eliminated. This change is being accomplished by the addition of automated control to industrial processes. In the early 1960s, computers were used effectively to control the industrial environment. However, those computer systems had little success, because of their expense, their unreliability, and the skepticism of management and operating personnel.

Today computers are efficiently running the industrial control programs. The development of the microprocessor has been a major factor in this change because the microcontroller provides more computer power at lower cost and in less space. These newer microcontroller systems use complex programming to regulate, monitor and control the operation of industrial processes [7].

As the technologies are developing, not only systems are developed but also control technologies are improved. Most of the developed countries used even robots and automated systems in industrial control and home. In this paper PIC based optoelectronic control system is used to control motor speed by Infra-Red remote transmitter. The speed of the motor is driven with keyboard and its path counting status displayed on LCD. The control programmed receives R/C signal from the transmitter and PIC 16F628 microcontroller.

2. Background Theory

Wireless communication is a flexible data communication system implemented as an extension to, or as an alternative for, a wired communication network. Using electromagnetic waves, wireless communication transmits and receives data without the need for wired connections.

Communications occurs when information is transmitted or sent between an information source and the user of that information. For information to get from one place to another there must be a transmission medium or channel between the source and receptor (information sink). The three parts, source, channel and sink represent the entire information system. When information is put into a language understood by machines it becomes data. Data transmission occurs when data is moved electronically between two points. The resulting electronic information system can be a telemetry system, computer/digital system, or telecommunications system [1].

Machines can deal with two types of electronic information: analog and digital. An analog signal is a continuously varying voltage waveform made up of various frequencies. A frequency is the number of times a sinusoidal waveform repeats during a one second interval (cycles per second). When all of the individual frequencies making up a waveform are combined, the resulting signal can appear in numerous ways. A digital rectangular signal also made up of analog waveforms located at specific frequencies. The square wave is made up of a fundamental frequency, plus a number of odd harmonics. The higher harmonics contribute to the steepness of the rising and falling edge of the waveform, and also result in greater bandwidth needs for the communications channel. However, regardless of components of the digital signal, the resulting combined waveform is dominated by two principal states, high or 1 and low or 0. When the communications medium is air, there is little impedance to prevent a particular pulse shape from reaching its destination in the same configuration as when it was transmitted.

2.1 Infra-Red Light

Infra-Red actually is normal light with a particular color. Humans can't see this color because its wave length of 950 nm is below the visible spectrum. That's one of the reasons why IR is chosen for remote control purposes, we want to use it but we're not interested in seeing it. Another reason is because IR LEDs are quite easy to make, and therefore can be very cheap.

Although humans can't see the Infra-Red light emitted from a remote control doesn't mean we can't make it visible. A video camera or digital photo camera can “see” the Infra-Red light as human can see in this picture.

Unfortunately for us there are many more sources of Infra-Red light. The sun is the brightest source of all, but there are many others, like: light bulbs, candles, central heating system, and even our body radiate Infra-Red light. In fact everything that radiates heat also radiates Infra-Red light. Therefore we have to take some precautions to guarantee that our IR message gets across to the receiver without errors [3].

2.2 Modulation

Modulation is the answer to make signal stand out above the noise. With modulation make the IR light source blink in a particular frequency. The IR receiver will be tuned to that frequency, so it can ignore everything else. Human can think of this blinking as attracting the receiver's attention. Humans also notice the blinking of yellow lights at construction sites instantly, even in bright daylight.

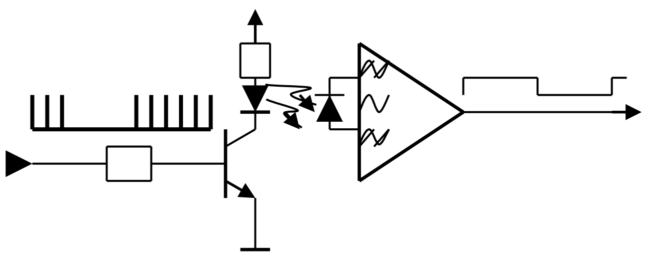


Figure 1: Infra-Red Transmission

In the picture above can see a modulated signal driving the IR LED of the transmitter on the left side. The detected signal is coming out of the receiver at the other side. In serial communication we usually speak of "marks" and "spaces". The "space" is the default signal, which is the off state in the transmitter case. No light is emitted during the "space" state. During the "mark" state of the signal the IR light is pulsed on and off at a particular frequency. Frequencies between 30 kHz and 60 kHz are commonly used in consumer electronics. At the receiver side a "space" is represented by a high level of the receiver's output. A "mark" is then automatically represented by a low level.

Please note that the "marks" and "spaces" are not the 1-s and 0-s we want to transmit. The real relationship between the "marks" and "spaces" and the 1-s and 0-s depends on the protocol that's being used. More information about that can be found on the pages that describe the protocols.

2.3 The Transmitter

The transmitter usually is a battery powered handset. It should consume as little power as possible, and the IR signal should also be as strong as possible to achieve an acceptable control distance. Preferably it should be shock proof as well.

Many chips are designed to be used as IR transmitters. The older chips were dedicated to only one of the many protocols that were invented. Nowadays very low power microcontrollers are used in IR transmitters for the simple reason that they are more flexible in their use. When no button is pressed they are in a very low power sleep mode, in which hardly any current is consumed. The processor wakes up to transmit the appropriate IR command only when a key is pressed.

Quartz crystals are seldom used in such handsets. They are very fragile and tend to break easily when the handset is dropped. Ceramic resonators are much more suitable here, because they can withstand larger physical shocks. The fact that they are a little less accurate is not important. The current through the LED (or LEDs) can vary from 100mA to well over 1A. In order to get an acceptable control distance the LED currents have to be as high as possible. A trade-off should be made between LED parameters, battery lifetime and maximum control distance. LED currents can be that high because the pulses driving the LEDs are very short. Average power dissipation of the LED should not exceed the maximum value though. The maximum peek current for the LED is not exceeded. All these parameters can be found in the LED's data sheet.

A simple transistor circuit can be used to drive the LED. A transistor with a suitable switching speed should be selected for this purpose. The resistor values can simply be calculated using Ohm's law. Remember that the nominal voltage drop over an IR LED is approximately 1.1V. The normal driver, described above, has one disadvantage. As the battery voltage drops, the current through the LED will decrease as well. This will result in a shorter control distance that can be loss of data signals.

2.4 Features of Modulation

The modulation is done in accordance with the following features.

- 5-bit address and 7-bit command length (12-bit protocol)
- Pulse width modulation
- Carrier frequency of 40kHz
- Bit time of 1.2ms or 0.6ms

Generally, 12-bit, 15-bit and 20-bit version of the protocols exist.12-bit version is used in this work.

3. Protocol

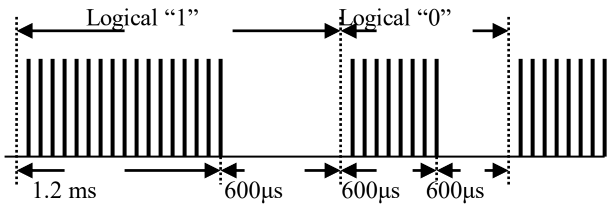


Figure 2: Infra-Red Protocol Timer

The SIRC protocol uses a pulse width encoding of the bits. The pulse representing a logical “1” is a 1.2ms long burst of the 40 kHz carrier, while the burst width for a logical “0” is 0.6ms long. All bursts are separated by a 0.6ms long space interval. The recommended carrier duty-cycle is 1/4 or 1/3.

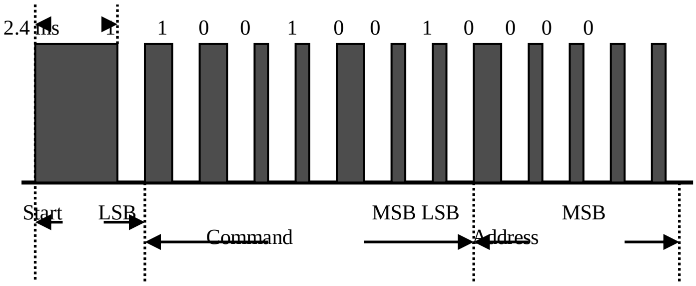


Figure 3: Infra-Red 12-bit Protocol

The picture above shows a typical pulse train of the SIRC (Sony Infra-Red Control) protocol. With this protocol the LSB is transmitted first. The start burst is always 2.4ms wide, followed by a standard space of 0.6ms. Apart from signaling the start of a SIRC message this start burst is also used to adjust the gain of the IR receiver. Then the 7-bit Command is transmitted, followed by the 5-bit Device address.

To detect IR signal from a remote controller is to know how different remote controllers send information. And this is the subject of IR protocol. Basically there are three types of IR protocol; pulse coded protocol, shift coded protocol and space coded protocol.

3.1 Using various kind of Infra-Red light protocols

Pulse coded protocol is to use the varying length of a pulse to represent either 0 or 1.Sony protocol is one of the pulse coded protocols. Space coded protocol uses the length of a space between pulses to represent either 0 or 1.Sharp TV/VCR remote control uses this space coded protocol. In shift coded protocol, the direction of transitions represent either 0 or 1, and the all the bits have a constant time period. Philips remote controller uses this shift coded protocol.

4. Overview of the system

The whole overview control system is shown in the diagram below.

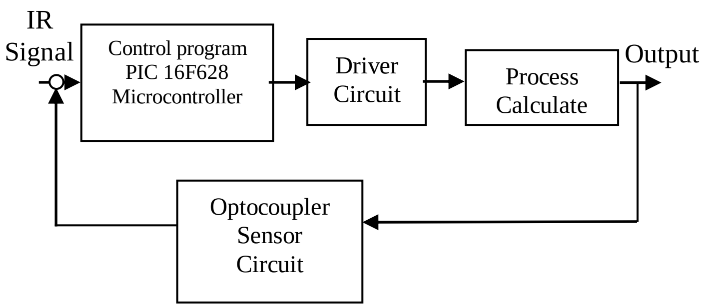


Figure 4: Block Diagram of Motor Speed Controller

The PIC based design and construction of DC motor speed controller uses optocoupler sensor to determine the input and output for speed. The Pulse Width Modulation (PWM) controls the voltage of the motor. The process of sensor read in and PWM output are controlled by PIC Microcontroller (PIC16F628).

4.1. System Flow Diagram

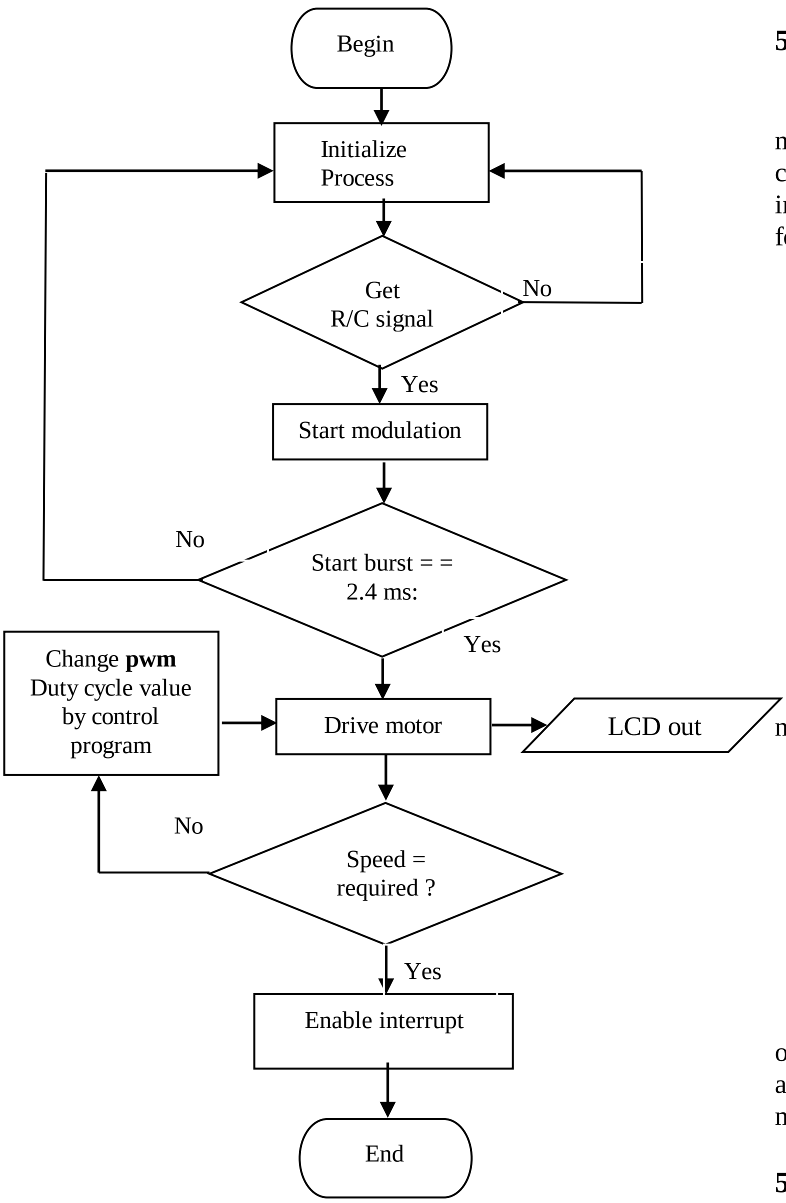


Figure 5: System Flow Diagram

After switching on the power user can enter control key for driving. User selects the driver motor switch, the program will be checked the Infra-Red protocol. If protocol address is false, the program does not work. But protocol address is true, the program drives the motor. Then the speed result can be seen on LCD. When user enters the speed change switch, the program will change PWM Duty cycle value for driving motor.

5. Implementation of the system

5.1 Microcontroller (PIC 16F628)

A circuit containing of a PIC16F628 microcontroller is used as a driver unit for controlling PWM, display and protocol. Some important features of PIC16F628 are described as follows.

High Performance RISC CPU:

- 18-pin package
- Operation speed:
  –DC – 20 MHZ clock input
  –DC – 200 ns instruction cycle
- Interrupt capability
- 16 special function hardware registers
- 8-level deep hardware stack
- Direct, indirect and Relative addressing modes
- Capture is 16-bit, max, resolution is 12.5 ns
- Compare is 16-bit, max, resolution is 200 ns
- PWM max, resolution is 10 bit
- Up to 2K x 14 words of FLASH Program Memory
- Up to 224 x 8 bytes of Data Memory (RAM)
- Up to 128 x 8 bytes of EEPROM Data Memory

In this system, PORTA is used for LCD data output. PORTB is used for sensor input, R/C input and motor drive by using Pulse Width Modulation mode [2].

5.2 Liquid Crystal Display (LCD)

Alphanumeric dot matrix liquid crystal display (LCD) is used for displaying the speed of the motor. User can easily see the visual information on the LCD and can change the speed, direction of the motor. In this system 16 character x 2 line display is implemented and PORTA of PIC micro controlled is used for LCD data output [4].

5.3 Closed Interruptible Optocoupler Device

Closed interruptible optocouplers are variants of the basic closed type but are arranged so that their opto-link passes out of the unit's housing and then back again via an externally interruptible path [6].

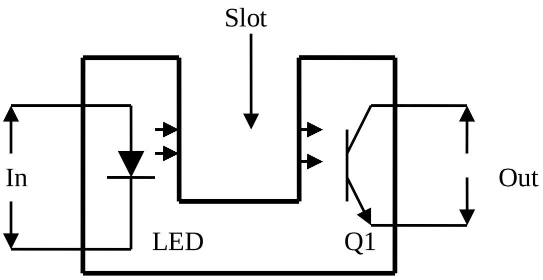


Figure 6: closed interruptible slotted optocoupler

Figure 6 shows the basic construction of a slotted or vane-type optocoupler, which has a slot molded into the package between the LED and Q1. This slot houses transparent windows, so that the LED light can normally freely reach the face of Q1, but can be interrupted or blocked via an opaque object placed within the slot. This slotted optocoupler can thus be used as an object or liquid-level detector.

5.4 Pulse Width Modulated Control

Large DC motor are best controlled by high power transistors, but small to medium permanent-magnet DC motors and some brushless DC motors are more successfully controlled by series-connected switching transistors operated in a pulse width modulated manner.

There are three essential parts in any pulse width modulation system, as illustrated in figure 8b.

–A rump waveform generator, usually operation at a constant frequency.

–A comparer for detecting when the ramp voltage has exceeded the control signal voltage.

–An electronic device that switches the load power at the movement when the comparer detects the critical point on the ramp waveform [5].

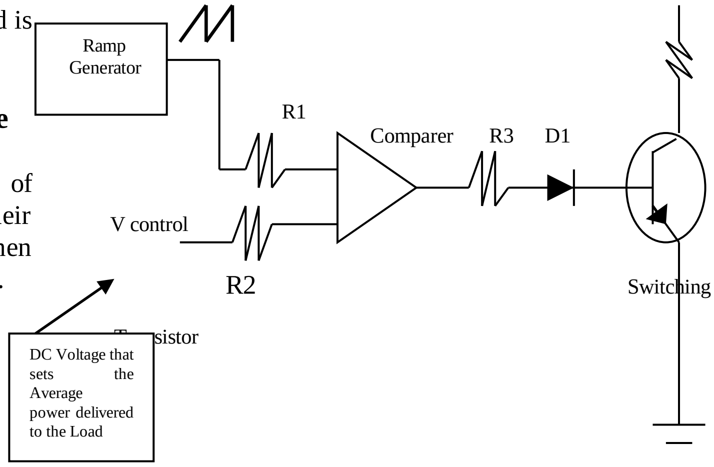
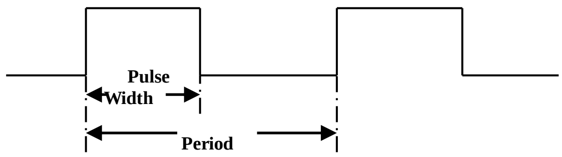


Figure 7: Basic organization of a pulse-width modulation power-control system

In Figure 7 the comparer is implemented by an electronic switch is a bipolar transistor operating in common emitter configuration.



$$\textbf{Duty cycle} = \frac{\textbf{Pulse Width * 100\%}}{\textbf{Period}}$$

Figure 8: Pulse-Width Modulation, Period

5.5 Testing result

The implementation of the motor speed controller based on Infra-Red communication is shown in Figure 9.

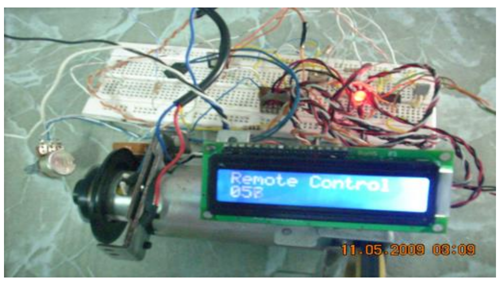


Figure 9: Photo of Constructing and Testing

In this system, only one DC motor is used. The duty cycle controls 65% to 100% of the voltage of motor because the motor does not work fewer than 50% of the voltage. The motor drive circuit is only using one MOSFET; H-bridge circuit should be used for control direction. In this system used one PIC. So, it is little difficult for control process and display function. Two PICs can be used as further extension to achieve good performance and response. This work can be drive with any SONY's remote transmitters.

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Appendix A

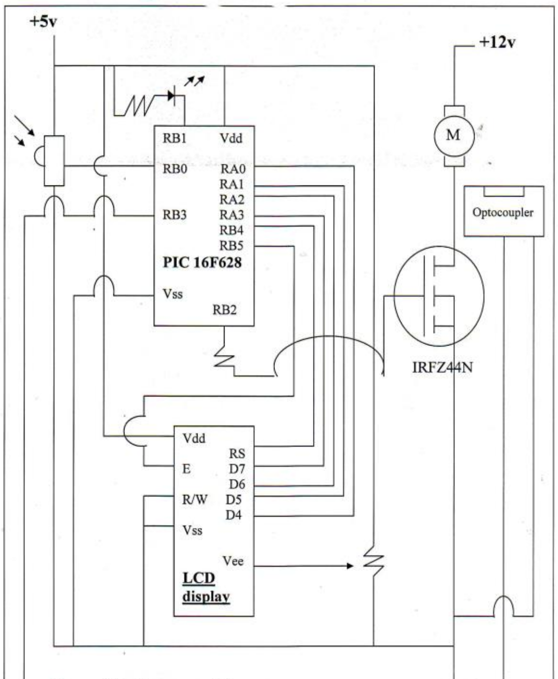

Figure ; Circuit diagram of the system