Microcontroller Based Reversible Motor Speed Control System

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Abstract

This system is based on the microcontroller based reversible motor speed control system. The sun tracking system uses a reversible motor to rotate the desire direction. A DC motor drives forward and backward direction to track the light. The H-Bridge motor control circuit switches the forward and backward movements of the motor. The two LDRs (Light Dependent Resistors) are used as input sensors. A microcontroller PIC16F877A determines the DC motor to rotate the forward or backward movement based on the Rule-Based system and PWM (Pulse Width Modulation). The PWM (Pulse Width Modulation) controls the speed sequence when motor run only in the backward direction to reach the certain position. The Rule-Based system used in this system to control the motor to rotate the forward and backward direction via the input sensors. The control system is implemented by microcontroller Assembly language.
Keywords: microcontroller, LDR, PWM method, H-Bridge control technique

1. Introduction

Nowadays, there are various uses of motor driving technology. Motors can be used not only forward but also backward movement at present. They play important roles in domestic security and other applications. They are usually designed with H-Bridge motor control circuit. The great ability of H-Bridge motor control circuit is that the motor can be driven forward or backward at any speed.

The PIC (Peripheral Interface Controller) is a special type of microprocessor called a microcontroller. The microcontroller contains all the function of processing, memory and I/O (input and output) on a single chip. All the chips in the PIC series are RISC (Reduced Instruction Set Computer) processors. Although a PIC microcontroller has limited computing power by normal standard. It is more adequate for a vast range of useful applications. [4]

The system uses the two comparators, a microcontroller PIC16F877A and the H-Bridge motor control circuit to control the sun tracker. The comparators, a PIC16F877A and the H-Bridge motor control circuit are placed on the circuit board and connected with the DC motor. The DC motor rotates forward and backward direction of the sun tracker according to the instruction of a microcontroller PIC16F877A.

The block diagram of the system is as shown in figure 1.

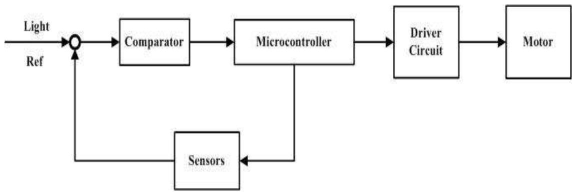

Figure 1. Block diagram of the system

2. Background Theory

Conventional rule-based expert systems use human expert knowledge to solve real-world problems that normally would require human intelligence. Expert knowledge is often represented in the form of *rules* or as *data* within the computer.

Depending upon the problem requirement, these rules and data can be recalled to solve problems. Rule based expert systems have played an important role in modern intelligent systems and their applications in strategic goal setting, planning, design, scheduling, fault monitoring, diagnosis and so on.

A rule-based system consists of *if-then rules*, a bunch of *facts*, and an *interpreter* controlling the application of the rules, given the facts. These *if-then* rule statements are used to formulate the conditional statements that comprise the complete knowledge base. A single *if-then* rule assumes the form 'if *x* is *A* then *y* is *B*' and the if-part of the rule '*x* is *A*' is called the *antecedent* or *premise*, while the then-part of the rule '*y* is *B*' is called the *consequent* or *conclusion*. [1]

The following concepts are essential to rule-based systems:

- Facts represent circumstances that describe a certain situation in the real world.
- Rules represent heuristics that define a set of actions to be executed in a given situation.[3]

3. Design and Implementation

To design the sun tracker, both software and hardware implementation are needed. In software implementation, the system flowchart and decision-making are performed. In hardware implementation, microcontroller and the hardware components are used to move the sun tracker along with the light.

3.1. Software Implementation

The flow chart of the system is shown in figure 2. At the start, the input sensors LDRs sense the light and calculate the recognized voltages. If the voltages are equal to the reference voltage then the motor is stop. And if the left sensor voltage is less than right sensor voltage then motor runs forward movement. And if the left sensor voltage is greater than right sensor voltage then motor runs backward movement. Else if the 'sun set' switch is activated then motor runs the backward action to reach the original position using PWM. In this process, PORT A is used for sensor inputs. PORT B is used for motor to drive forward and backward movements. CCP1 is used for motor to drive only backward with PWM mode.

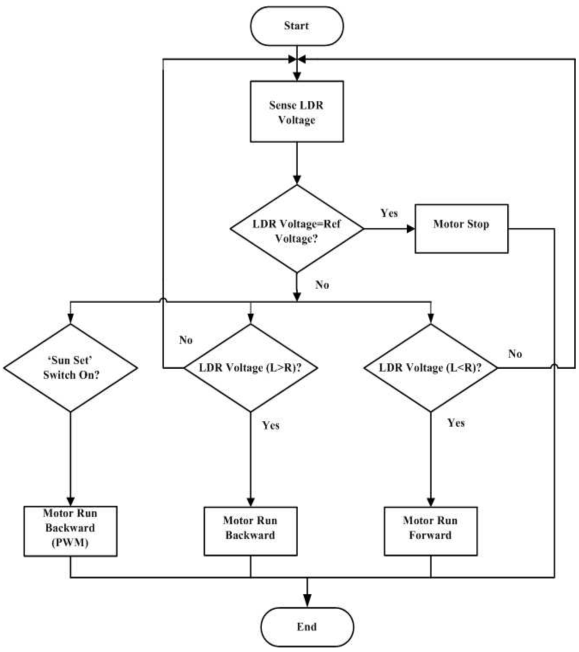

Figure 2. Flow chart of the system

The Rule-Based system used in this system to determine the motor in the direction of forward and backward movements via the input sensors.

To develop an inference engine (Rule Engine) for forward and backward movements of a motor. Components of Rule-Based system are

Chars : left sensor, right sensor
Cond : low volt, high volt, ref volt
Rules : R_1, R_2, R_3
Acts : motor runs forward, motor runs backward, motor stop.

Rules are defined by,

R_1: IF left sensor is low volt OR right sensor is high volt THEN motor runs forward

R_2: IF left sensor is high volt OR right sensor is low volt THEN motor runs backward

R_3: IF left sensor is ref volt AND right sensor is ref volt THEN motor stop.

The Rule-Based system motor control process is shown in figure 3.

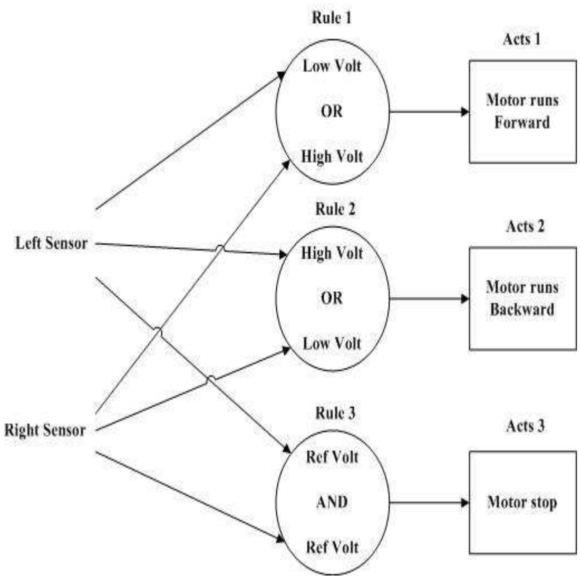

Figure 3. Rule-Based system data structure for motor control process

3.2. Hardware Implementation

The LDRs (Light Dependent Resistors) sense the light and produce voltages. The comparators are used to compare voltages to a defined reference voltage and send input signals to a microcontroller. And the microcontroller controls the motor to move the sun tracker along with the light.

When the sun tracker reaches the certain position, the 'sun set' switch is started to work and move the sun tracker back to the original position using PWM speed control method.

3.2.1. Overview of the system design. In this system, the two LDRs (Light Dependent Resistors), used to detect the light, are shown in figure 4.

Figure 4. Two LDRs used as input sensors

The LDRs (Light Dependent Resistors) sense the light and produce voltages. The comparators compare the voltages and send signals to a microcontroller. A microcontroller determines the motor to drive the forward or backward movement. And H-Bridge motor control circuit switches forward and backward movements of the motor. The control system circuit of the sun tracker is shown in figure 5.

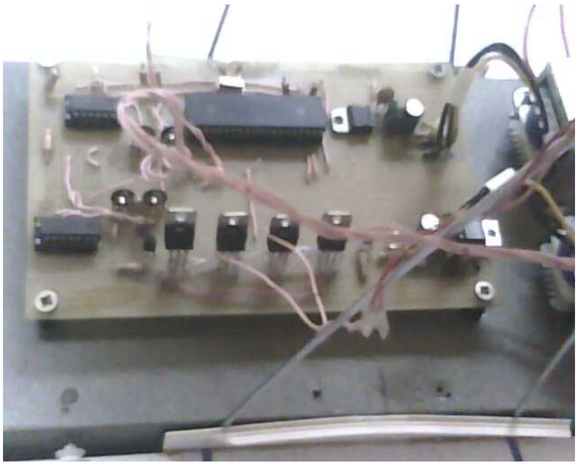

Figure 5. The control system circuit of the sun tracker

The DC motor rotates the forward and backward direction to move the sun tracker along with the light. The PWM speed control mode will be started when the 'sun set' switch is activated. The complete constructed system is shown in figure 6.

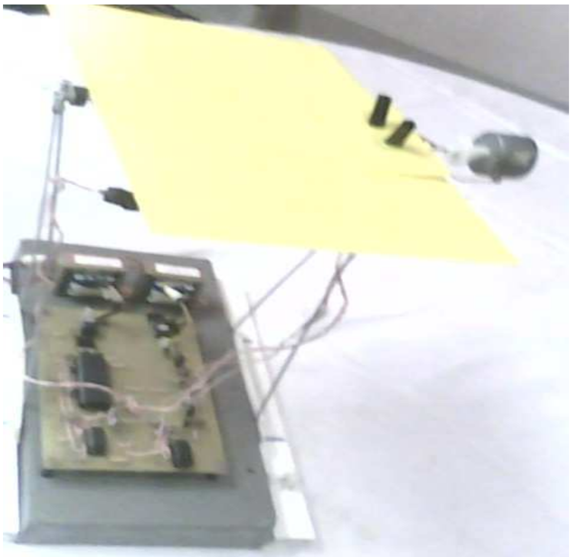

Figure 6. Complete constructed system

3.2.2. Design for PWM control. There are a relation between PWM period and Period Register/Timer2 Prescaler values. Since Timer modules of PIC are running as clock frequency source incremental time out, this frequency of Mega-Hertz (4 MHz here) cannot suitable for motor response. Solution for this is setting up timer as prescaler or postscaler. So, TMR2 module is configured as 1:16 prescaler in this design. Related PWM duty cycle can be calculated as follows.

$$\text{PWM (period)} = (\text{PR2}+1) * 4 * T_{OSC} * \text{TMR2}$$

Therefore, maximum period of this system is 4.069 milliseconds and minimum frequency is 245 Hz. And minimum period of this system is 1 microsecond and maximum frequency of 1 MHz

The shortest duty cycle is the period time of the oscillator. The maximum PWM resolution of the duty cycle is 1024. If the PWM duty cycle value is longer than the PWM period, the CCP1 pin will not be set. In addition, if the value of PWM duty cycle register (CCPR1L+CCP1X+CCP1Y) is set to zero, the CCP1 pin will not be set. [2]

$$\text{PWM (Duty Cycle)}_{min} = 1/F_{OSC} = 1 / 4\text{MHz} = 0.25 \text{ microseconds}$$

3.2.3. Operation of the system. PIC 16F877A operates up to 20 MHz clock input. In this system, 20MHz crystal oscillator is used for operation clock. And the appropriate programming language and voltages are used to operate the whole circuit. Power supply provides DC 5V to the microcontroller. Motor driving circuit uses DC 12V to drive the motor. The circuit design of the system is shown in figure 7.

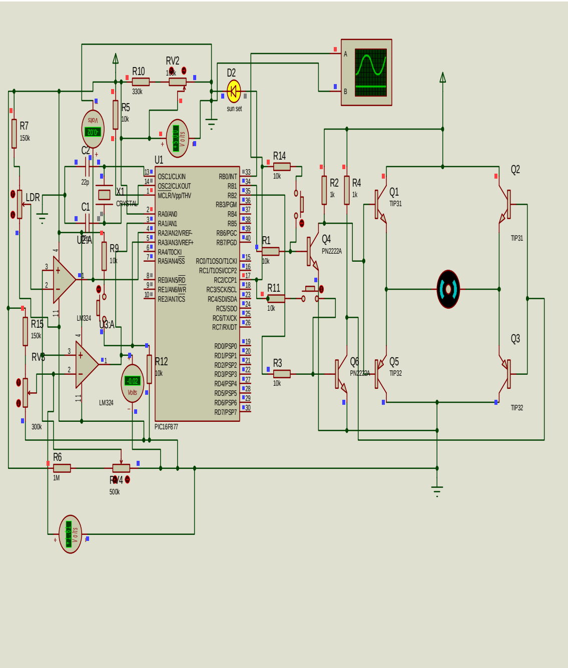

Figure 7. Circuit diagram of the system

4. Experimental Results

The PWM speed control method is simple calculation: the PWM period is specified by writing to the PR2 register. The PWM duty cycle is specified by writing to the CCPR1L register and to the CCP1CON<5:4>bits. TMR2 module is configured as 1:16 prescaler in this design.

25% duty cycle and 50% duty cycle are tested in this paper. For testing the output of CCP1 module, testing procedure is

1. define a constant period (max period used)

2. support 25% of period as the duty cycle and display with digital oscilloscope

3. support 50% of period as the duty cycle and display with digital oscilloscope

For 25% of period,

4.069*(25/100) = (DCxB9:DCxB0)*(1/4M)*16
(DCxB9:DCxB0) = 254.3125
= 254_d
= $0011, 1111, 10_b$

(DCxB9:DCxB0) must be b'0011, 1111, 10'. It means that 0x3F in CCPR1L and 0x2C in CCP1CON register.

For 50% of period,

4.069*(50/100) = (DCxB9:DCxB0)*(1/4M)*16
(DCxB9:DCxB0) = 508.625
= 508_d
= $0111, 1111, 00_b$

(DCxB9:DCxB0) must be b'0111, 1111, 00'. It means that 0x7F in CCPR1L and 0x0C in CCP1CON register.

The 25% duty cycle and 50% duty cycle are tested together with the digital oscilloscope. The photo of PWM test circuit is shown in figure 8. The 25% duty cycle and 50% duty cycle tested with the digital oscilloscope are shown in figure 9 and figure 10.

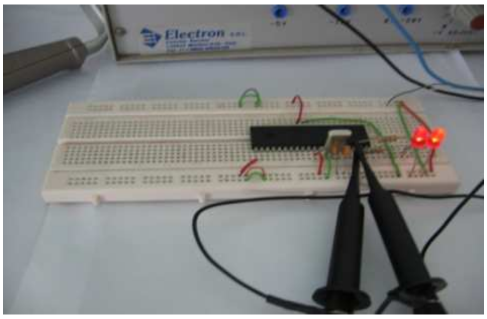

Figure 8. The photo of PWM test circuit

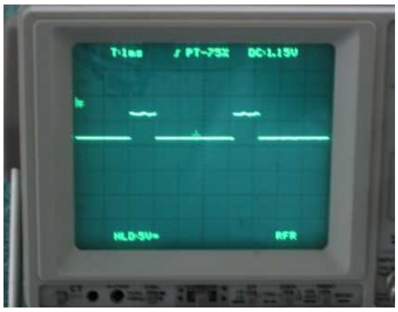

Figure 9. The 25% duty cycle tested with the digital oscilloscope

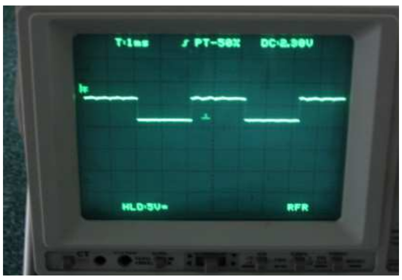

Figure 10. The 50% duty cycle tested with the digital oscilloscope

The PWM (Pulse Width Modulation) simulation tested with 25% duty cycle and 50% duty cycle are shown in figure 11 and figure 12.

The 50% duty cycle is used for the sun tracker and 25% duty cycle is used only for testing purpose. In this design, the PIC16F877A produces the required PWM using CCP1 to control the motor speed.

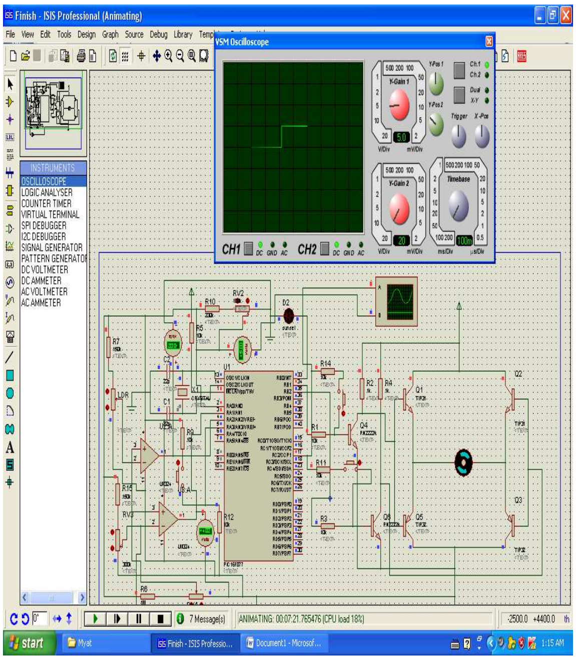

Figure 11. PWM speed control testing photo with 25% duty cycle

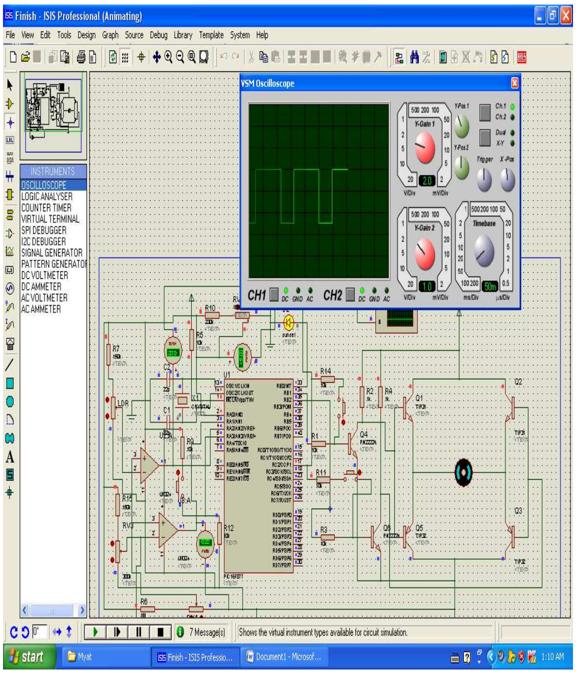

Figure 12. PWM speed control testing photo with 50% duty cycle

5. Conclusion

Most of the sun tracking systems use light sensor to track the light perfectly. This system can detect the light but it does not enough for the real world application. As the experimental results, the accuracy of the system is 92 percent recommended to track the light.

The microcontroller uses Rule-Based system for decision-making in this system. In current system, only single axis is used. For better accuracy, dual axis should be used. DC motor has limited function. Stepping motor should be used for better performance. And the solar cell (module) should be used instead of Light Dependent Resistors (LDRs) in real world application.

The PWM (Pulse Width Modulation) control the speed when the sun tracker moves back to the original position. The default PWM period and duty cycle equation are used for the speed control.

The Rule-Based system used for decision-making in this system is very simple. To work with complex system, it is better to use fuzzy logic.

6. References

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