Design and Implementation of Robotic Arm Pick-and-place Using PIC Microcontroller

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Abstract

A robotic arm is constructed with electronic devices and mechanical parts and it is based on the PIC microcontroller. The robotic arm is designed to pick a ball coming into the predetermined place. After that the arm will place the ball to another predetermined place. The arm can move either to the right or to the left by the control of the operator. The number of balls picked by the arm are counted and displayed on the 7-segment LED display. Two digits of 7-segment displays are used in this system. The number of balls to be picked up by the arm are limited to 10 by the program instruction. An Pic Basic Pro language is used to control the operation of the robotic arm. Opto-isolators and switches are applied to detect the status of the arm and incoming ball.

1. Introduction

The "Robot" is a mechanical device capable of performing human tasks, or behaving in a human-like manner. Many of the robots in use today do jobs that are especially difficult for human workers. Robots are particularly useful in

- auto manufacturing industry
- spray painting task
- installing chips in printed circuit boards.

These are the types of jobs that require great strength or pose danger [4].

In this system, the PIC microcontroller - based pick-and-place robotic arm is constructed by using PIC 16F84A microcontroller, stepper motors, optical sensors and switches, counter circuits, seven segment LED display circuits and mechanical parts.

The system is designed to pick a ball from a predefined place and then places that ball to another place. The number of balls picked by the arm will be displayed on the seven segment LED display. The operation of the arm is controlled by the predefined instructions embedded into the PIC microcontroller. The block diagram of the microcontroller based pick-and-place robotic arm is shown in Figure1.

This paper is organized with six section. The first section deals with introduction of the system. Section two explains overview of PIC 16F84A microcontroller. Section three is a detailed explanation of components of the system. Section four describes design and implementation. Advantages of the system is five and conclusion and further extension is section six.

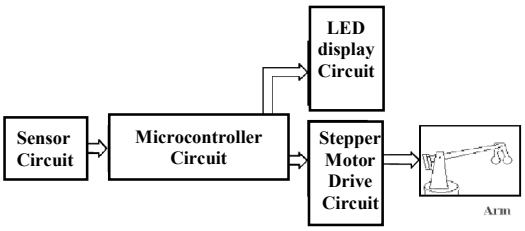

Figure 1. Block Diagram of Robotic Arm System

2. PIC16F84A microcontroller

The PIC 16 F 84 A is used as the main control part of the robotic arm. It provides the following features: only 35 single word instructions to learn, all instructions single - cycle except for program branches, 8-bit wide data bytes, 15 special function hardware registers, eight-level deep hardware stack, direct, indirect and relative addressing modes, 1,000 erase\ write cycles program memory typical and so on[1]. The pin diagram of the PIC16F84A is shown in Figure 2.

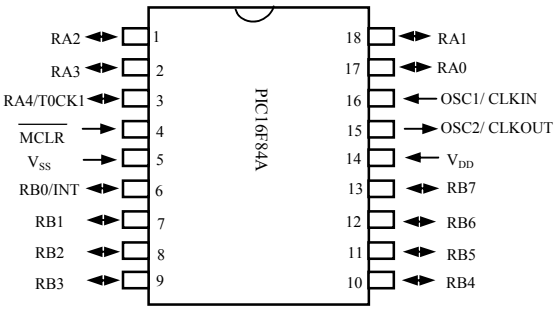

Figure 2. The Pins Diagram of PIC16F84A

3. Components of the system

Based on PIC Microcontroller, robotic arm is constructed for picking an object which is placed on a predetermined place. This section includes stepper motor, opto-isolator, LM324OP-AMP as a comparator, counter circuit, power supply circuit, and mechanical parts of the arm.

3.1. Stepper Motor

Nowadays, there are many kinds of motor. They are DC motor, servo motor, stepper motor ... etc. Servo motor are widely used in the robotic arms constructed today. The operation of servo motor controlled with the pulse width. The speed of stepper motor are controlled with clock pulses. The speed of stepper motor can be specified by the clock speed of control device. And definite movement or revolution can be obtained.

There are many kinds of stepper motors: unipolar type, bipolar type, single-phase type, multi-phase type. Stepper motors are made up of strong permanent magnet and electro–magnet [4].

Permanent magnet is fixed on the rotating shaft called rotor. Electromagnets are fixed on the laminated iron former called stator. In the stepper motor, the rotor rotates in the magnetic field induced by the stator.

The PIC 16F84A controlled stepper motor driver circuit is shown in the Figure 3. RB0 and RB1 are used as output pins to drive stepper motor driver circuit. Stepper Motor "Step modes" include full-stepping and half-stepping. The sequence of pulses for the stepper motor driver circuit for full-stepping mode is shown in Table 1.

Table 1. Sequence of Pulses for Stepper Motor

Step	RB1	RB0
1	0	0
2	0	1
3	1	1
4	1	0
1	0	0

(a) Sequence of Clockwise Direction

Step	RB1	RB0
1	1	0
2	1	1
3	0	1
4	0	0
1	1	0

(b) Sequence of Counter-clockwise Direction

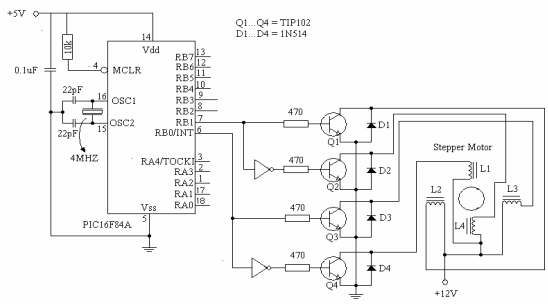

Figure 3. Stepper Motor Driver Circuit

3.2. Opto-isolator Circuit

An Opto-isolator circuit is one kind of device which caught the input that has come and go on working. The schematic view (a) and the circuit diagram of the opto-isolator (b) are shown in the Figure 4. The diode of the isolator is forward biased and produced IR radiation. The output is obtained from the collector pin of the opto-isolator. The IR radiation produced by the diode is received by the transistor and the transistor is ON. The output is approximately 0.6V or LOW state. When the radiation is interrupted by some opaque objects, the transistor does not receive the radiation. The transistor is OFF and the output is about 5V or HIGH state [5].

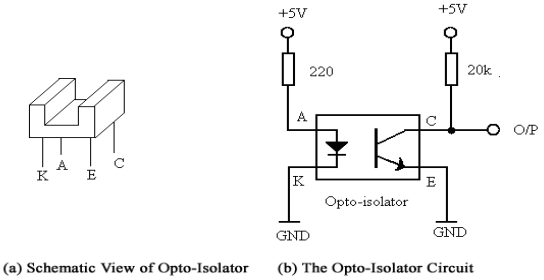

Figure 4. Schematic View and the Circuit Diagram of the Opto-isolator

3.3. LM324 operational amplifier as a comparator

The LM324 is the Quad- operational amplifier. It can be used as an amplifier, a buffer, a comparator, etc. In this research work, it is used as a comparator. A comparator circuit compares two input voltages Vi and Vr as shown in Figure 5. The comparator circuit is used in conjunction with the opto-isolator circuit and the microcontroller.

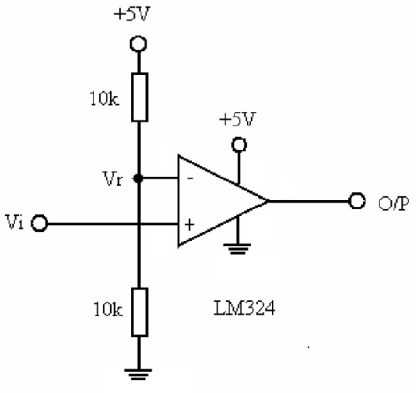

Figure 5. Voltage Comparator Circuit

3.4. Counter circuit

The counter circuit as shown in Figure 6 is the part of the robotic arm. The counter circuit displays the number of balls picked up by the arm on the two digit LED displays. It consists of the 74LS90 decade counter, the CD4543E BCD-to-7-Segment Decoder/Driver IC and common-anode 7-segment LED displays. The clock signal from the PIC microcontroller circuit is put into the clock input A (pin 14) of decade counter IC. The counter advanced counting with every clock pulse from the PIC microcontroller circuit. Pin-3 of the counters are controlled from the PIC to set display "00" at the start of the program [2].

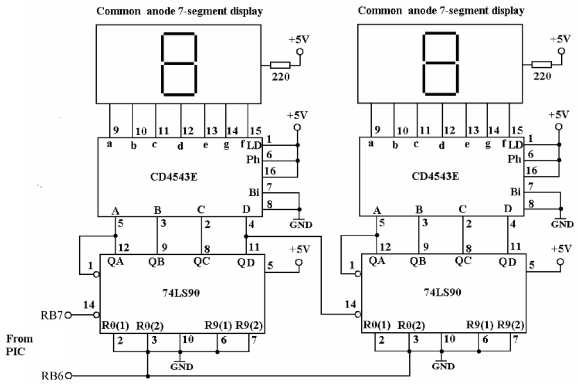

Figure 6. Two-decade Counter Circuit

The BCD outputs, QA, QB, QC and QD, are connected with the corresponding inputs of the BCD to 7-segment decoder ICs. The seven segment outputs from the decoder ICs are then connected to the common anode LED display. The counter circuit counts the number of the clock pulses from the microcontroller circuit and displays the numbers on the 7-segment LED displays. The total number of the counts that can be detected by the circuit, without resetting the counter, is 99.

3.5. Power supply circuit

The power supply circuit of the system is shown in Figure 7. The 220V (AC) voltage from the main power outlet is supplied to the input of the step-down transformer. The secondary side of the transformer is wounded to get 12V (AC) at its output with center-tapped. Rectifier IC with two built in diodes is used to convert the ac voltage to unregulated dc voltage. Three terminals series voltage regulator 7812 is used to obtain regulated +12V. The 7805 voltage regulator is used to obtain regulated +5V [3].

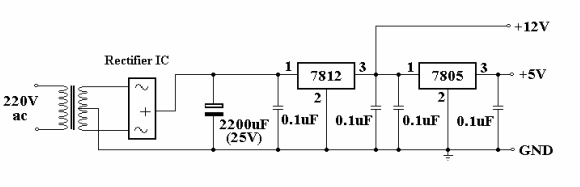

Figure 7. Power Supply Circuit

3.6. Mechanical parts of the arm

The Robotic arm is made with aluminum in order to be light. Though arms have five fingers, this arm has two. Having only two fingers, it is better in gripping the object. Actually having five fingers is more powerful. Motor and Gear are fixed at elbow joint. The arm is long about twelve inches. A small plastic pinion is attached on top of it for gripping. Up/down motor is attached to the elbow joint. The left/right motor is attached to the circuit box.

4. Design and implementation

The construction of the microcontroller-based robotic arm is divided into five sections: the sensor input circuit, microcontroller circuit, stepper motor driver circuit, counter circuits and power supply circuit. The flow chart of the system is shown in Figure 8.

The sensor input circuit consists of opto-isolators, comparators and switches. The sensors are placed at the gripper of the arm, in the enter point of the ball, at the source position and at the destination positions. The sensors detect the status of the entering balls and the arm. And then, the signals from the sensor circuit are put to the inputs of the microcontroller (RA0, RA3 and RA4).

The PIC16F84A is the heart of the microcontroller circuit. It controls all operations of the robotic arm pick-and-place. The microcontr- oller circuit accepts sensor inputs from the various sensor circuits and produces appropriate outputs to stepper motor driver circuits and counter circuit. Six output pins from the microcontroller circuit are used to control three stepper motor drive circuits.

Three stepper motors are used in the robotic arm. One motor is used to drive the arm to left or right. Another one is used to drive the arm up or down. The last one is applied for the gripper. The stepper motor driver circuit consists of power transistors, TIP102, inverter gates and diodes. The inputs are operated with clock pulses from the microcontroller output pins. The clock sequence of the inputs, define the direction of rotation of the stepper motor.

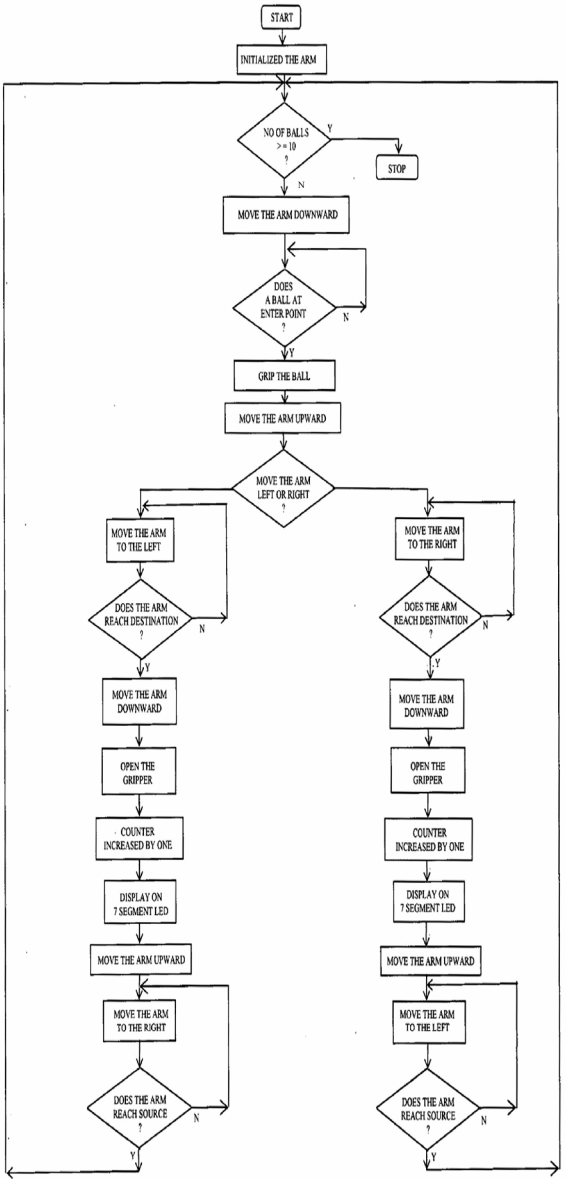

Figure 8. Flow Chart of the System

The counter circuit consists of BCD counters, BCD-to-7-segment decoders and common-anode 7-segment LED displays. The clock signal from the microcontroller circuit is routed into the clock input of the counter circuit. One clock signal means that the robotic arm has already picked up one ball and placed it at the predetermined place. The counter circuit displays the number of balls on the LED displays. The program instructions are written to pick up to 10 balls.

5. Advantages of the system

The constructed robotic arm pick-and-place has several advantages over human workers. It is tedious and repetitive works without any mistakes like human workers. It also do precisely under the program control. It is also used in the poisonous places where human workers can't work without proper protection.

6. Conclusion and further extension

In this system, the microcontroller-based pick-and-place robotic arm is constructed to lift small and light objects (e.g. pin pong balls) and the performance of the arm is quite satisfactory as expected. The microcontroller is programmed using Pic Basic Pro to control the operation of the robotic arm. Although two digits7-segment display are used in the system, the number of balls to be picked up by the arm is limited to 10 by the program instruction. The operation of the robotic arm can be enhanced by using more powerful motors, video camera and powerful arm assembly. The robotic arm constructed for this system has only two fingers. It works well with some light and small objects. The operation and strength of the robotic arm can be enhanced by using human like five-finger hand. So it can grip objects more firmly than two-finger gripper. Furthermore, the robotic arm can be used in industries to handle heavy loads, to work with poisonous materials and so on.

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