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Industry Based Automatic Robotic Arm

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Abstract ***- A robotic arm is a robotic manipulator, usually programmable, with similar functions to a human arm. Humans pick things up without thinking about the steps involved. In order for a robot or a robotic arm to pick up or move something, someone has to tell it to perform several actions in a particular order — from moving the arm, to rotating the "wrist" to opening and closing the "hand" or "fingers". So, we can control each joint. . This paper presents a three joint automatic robotic arm which can be used in industries to do repetitive task such as moving the things from conveyor to another place, a sensor will be used to detect the obstacles if present while carrying out the task. If there is any obstacle while moving the object, the arm will wait for a predefined time for the clearance of the object. If the obstacle is cleared, the arm will continue its work. If the obstacle is still present, a buzzer will be turned on so that personnel from the industry can attend the problem and clear the obstacle.***

Keywords: **End effector, Shaft, Degrees of freedom.**

I. INTRODUCTION

The word robot originated from the Czech word robota, meaning work. A definition used by the robot institute of America is: "A robot is a programmable multifunction manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks". In this highly developing society, time and man power are critical constrains for completion of task. The automation is playing important role to save human efforts in most of the regular and frequently carried work. The idea that machines can begin to imitate human actions, even in ways we have not thought of, the main motives for the creation of robot have been very practical. First, as modern industry has become more complex, there has been a growing need for getting work done in environments that are dangerous for humans. As an example, work in a nuclear reactor plant often requires contact with radioactive materials. Second, as robots became more advanced and less expensive, they are being set up in industry situations where working conditions are not so much dangerous as unpleasant for various reasons. These situations typically involve high degrees of the following: - Heat, Noise, Poisonous gases, Risk of injury by machines, Monotonous, boring work. Robots have already taken over a number of such unpleasant jobs in industry- welding in automobile factories, which involves heat, noise and heavy exertion. Robots are obedient, untiring and precision welders. Simple robots do many routine jobs in industry. Pick and place robots are useful in simple assembly operations such as stuffing printed circuit boards and loading and unloading parts from machines[1][2][3].

II. PROPOSED MODEL

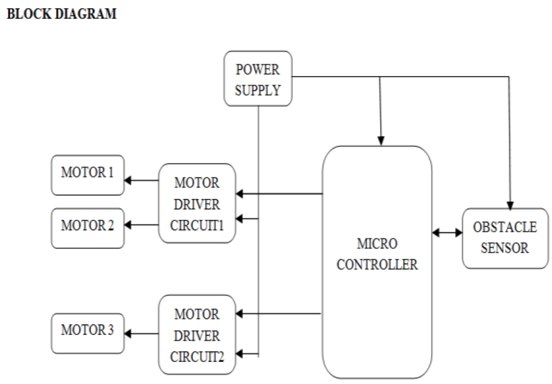

Fig. 1 Block Diagram of Robotic Arm

The block diagram of our project is as shown above. The different components involved in our project are:

A. MICROCONTROLLER

A **microcontrollers** a high integrated functional computer system-on-a-chip. It contains an integrated memory and programmable input/output peripherals. Microcontrollers often operate at very low speed. They consume relatively little power. It is used to controls the motor activation and deactivation operations and also reads sensor signals.

B. MOTOR DRIVER CIRCUIT

In order to provide the required amperage to the motor using the low current signal from the microcontroller, motor driver circuit is used. A motor controller is a device or group of devices that serves to govern in some predetermined manner the performance of an electric motor. A motor controller might include a manual or automatic means for starting and stopping the motor, selecting forward or reverse rotation, selecting and regulating the speed, regulating or limiting the torque, and protecting against overloads and faults.

C. MOTORS

An electric motor is an electromechanical device that converts electrical energy into mechanical energy. Electric motors can be powered by direct current sources, such as from batteries. Microcontrollers command these motors through the driver circuit to take the necessary action.

D. POWER SUPPLY

A regulated power supply is an embedded circuit, the function of which is to supply a stable voltage, to a circuit or device that must be operated within certain power supply limits. This is used to supply the power to the microcontroller and the driver circuits.

E. OBSTACLE SENSOR

This sensor is used to detect the obstacles while carrying out the task. IR sensor is used to sense the

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obstacles in the front. IR led is connected along with three pin sensor or receiver. Here we will use TSOP 1738 for this purpose. IR led will be continuously transmit whenever an obstacle appears IR light is reflected back and this is sensed by a sensor which in turn signals microcontroller to take necessary action.

F. WORKING PROCEDURE

In this project, we are using three geared DC motors each of which can be controlled by L293D motor driver. Here, two reference positions are chosen. First reference position is the place from where the arm has to pick the object and second reference position is the place where the robot has to place the object. First the microcontroller signals the motor-3 via driver circuit one to make the rotation of the arm to the desired direction. Then the signal from microcontroller is given to driver circuit1 to drive the 2nd motor so that it can make up and down movement. Next motor 1 which is situated at the gripper is activated so that gripper holds the object. Next, motor-3 is again activated to turn the motor towards destination direction, motor is then activated to make the down movement of the arm and finally, gripper motor is activated to release the object. Meanwhile, an obstacle sensor, which is connected to the microcontroller, is programmed such that it senses the presence of the obstacle in a radius of about 10cm and first time it senses the obstacle, it pauses its work for some time. If again the obstacle is not cleared, a buzzer will be turned on to grab the attention of a personnel to clear the object.

III. DESIGN OF ROBOTIC ARM

To proceed in the direction of design aspects, first mechanical structure has to be designed. Depending on the design requirements electronic parts are configured with that of mechanical design.

A. MECHANICAL DESIGN

Mechanical design involves the selection of suitable motor for our application, deciding on the material to be used for the construction of the arm, i.e the shaft material and deciding on the location where the motor has to be placed.

- **Selection of motor:**

The main criteria to be considered while selection of motor is Torque and the speed of the motor, many different motors are available in the market like servomotors, stepper motor, dc motors with and without gears. These different motors are used according to their applications and requirements. for e.g. If we want high torque and precise speed we need to use servo motors, if we want to only position and if high torques not required then stepper motors are used. The motor can be selected once we know the torque and speed required for our application.

B. TORQUE AND SPEED CALCULATION

The main criteria to be considered for the selection of motor are torque and speed.

- **Torque calculation**

Torque is the tendency of force to rotate an object about an axis. Mathematically, torque is defined as the cross product of the lever-arm distance and force, which tends to produce rotation. i.e.

T= F * L Nm [1]

Where, F= force acting on the motor
L= length of the shaft

Force, F is given by,

F= m * g N [2]

Where, m=mass to be lifted by the motor
g= gravitational constant = 9.8 m/s

Calculation of the torque starts from the gripper and moves downward till the base joint of the arm. Hence base Joint carries the maximum payload i.e it should carry the weight of the upper 2 motors also. The robotic arm is of three joints. One motor each at the 3 joints.

The torque and speed calculation differs at each joint depending on the payload.

For example,

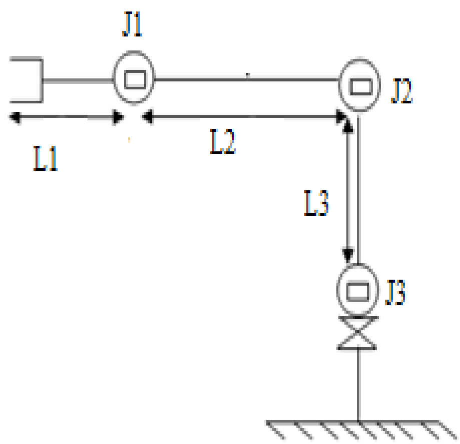

Fig.2 Robotic arm designs

Consider the figure shown above.

Torque for the first joint is calculated as,

T1 = F1 * L1
F1 = m1 * g

Consider,

Weight to be lifted = 150g
Weight of the gripper = 100g
Total weight on joint1 = m1= 250g
Length of the gripper = L1= 4” = 0.1016m
F1 = 0.25*9.8
F1 = 2.45 N
T1 = F1*L1
= 2.45*0.1016
T1 = 0.24892 Nm

Similarly, the torque for the other joints is also calculated but for the succeeding joints, the weight of the above motor and the length get added.

Torque for 2nd joint = T2 = F2 (L1+L2)

Torque for 3rd joint = T3 = F3 (L1+L2+L3)

The calculation of the torque can be tabulated as below:

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Motor locations	Length (inch)	Total mass (gram)	Force N	Torque Nm
Gripper	L1= 4	250	2.45	0.248
Elbow	L2= 9	550	5.39	1.779
Base	L3= 4	850	8.33	3.596

Table 1 Torque calculation

- **Speed calculation:**

For each joint considered, we need to calculate the angular speed and linear speed.

- **Angular velocity:**

Is defined as the rate of change of angular displacement. Rotational Speed tells us how many revolutions has been covered by a body in one second of time.

Example:

$$\text{Angular speed}, w = \frac{\theta}{t} = \frac{\theta \times \pi/180}{pps \times 1.5 \times 10^{-3}} \text{ rad [3]}$$

W = W* 9.45 rpm[4]

Linear speed, V = W * r m/s[5]

Where, r is shaft length.

Speed of every motor is divided as ramp up speed (acceleration), slew and ramp down (deceleration) speed.

- **Ramp up** is the speed with which the motor runs at the very beginning.
- **Slew speed** is the max and uniform speed of the motor.
- **Ramp down** speed is the speed of the motor before coming to halt

Depending on the speed and torque, the motor is selected. The torque- speed characteristic of a motor is as shown in the figure below.

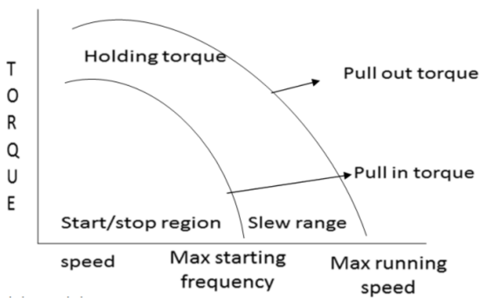

Fig. 3. Torque Speed Characteristics Curve

The above figure shows the relation between speed and torque of the motor. The best region for the motor to operate is the slew region.

- **L239D motor driver:**

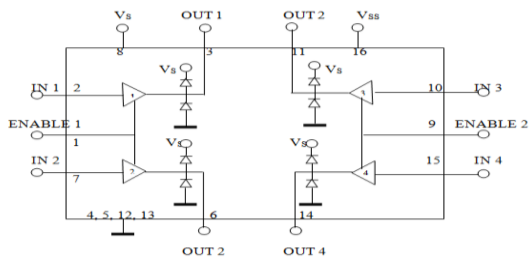

Fig. 4. Schematic diagram of L293D

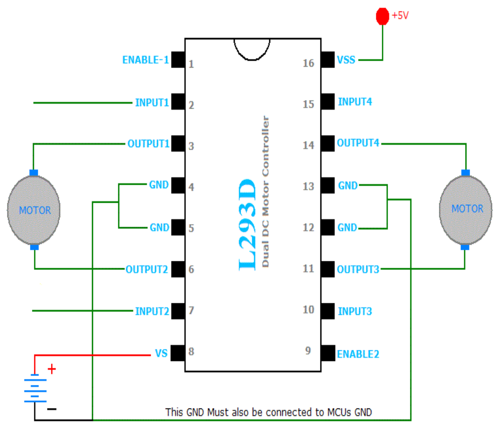

Fig. 5 4 L293D

E	INPUT1	INPUT2	O/P
1	0	0	STOP
1	0	1	CLK
1	1	0	CCLK
1	1	1	STOP

Motor drivers are used to provide the required amperage to the motor using the low current signal from the MCU. Apart from the current, it is also necessary to control the direction of motors as required in a situation. Drivers convert the TTL-level outputs from the microcontroller into high-current drive for the motors. It also serves to isolate the motor power supply from the main logic supply. A L293D is a dual bridge driver IC, with current rating of maximum 2amps, which comes in a 16-pin package. The output from the IC is protected against voltage spikes from the motors by eight fast switching inbuilt rectifier diodes, which will sink any

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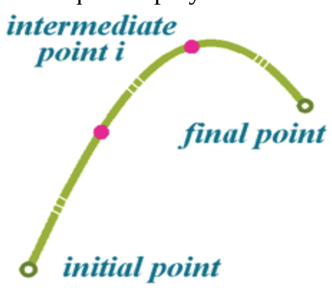
problem voltages into the motor power supply lines. Drivers are enabled by the enable pins, enable1 and enable2. When an enable input is high, the associated drivers are enabled and their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled and their outputs are off and in the high-impedance state. In our project, we are using two l293d drivers to drive three motors. The inputs from the l293d gets connected to the PortD pins of the microcontroller, and the output pins of the motor driver are connected to the motors. Input to the motor is given in the form of voltage. Bit 1 represents +5v which is a high input and bit 0 represents 0v which is a low input. If the input to the driver is “01”, the motor rotates in clockwise direction, if input is “10”, motor rotates in anticlockwise direction. If the input is “00” or “11”, the motor stops.

C. MOTOR

A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM .The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed but increase its torque is known as gear reduction. This concept is explored in this project to make the working of each of the joint precision perfect.

D. Algorithm for movement of the arm

The supposed point-to-point trajectory is connected by several segments with continuous acceleration at the intermediate via point as shown in figure 1. The intermediate points can be given as particular points that should be passed through. For a robot, the number of degrees of freedom of a manipulator is *n* and the number of end-effectors degree of freedom is *m*. If one wishes to be able to specify the position, velocity, and acceleration at the beginning and the end of a path segment, a quadrinomial and a quantic polynomial can be used.



Let us assume that there is *mp* intermediate via points between the initial and final points. Between the initial points to *mp* intermediate via points, a quadrinomial is used to describe these segments as

$\theta_{i.i+1}(t) = a_{i0}+a_{i1}t_i+ a_{i2}t^2_i+ a_{i3}t^3_i+ a_{i4}t^4_i,$
$(i=0,\ldots,mp-1)$ (6)

Where $(a_{i0},\ldots, a_{i4})$ are constants, and the constraint are given as:

$\theta i = a_{i0}$ (7)

$\theta_{i+1}= a_{i0}+ a_{i1}T_i+ a_{i2}T^3_i+ a_{i4}T^4_i$ (8)

$\theta' = a_{i1}$ (9)
$\theta'_{i+1}= a_{i1}+ 2a_{i2}T_i+ 3a_{i3}T^2_i+ 4a_{i4}T^4_i$ (10)
$\theta'' = 2a_{i2}$ (11)

Where $T_i$is the execution time from point i to point i+1. The five unknowns can be solved as:

$a_{i0}=\theta_i$ (12)
$a_{i1}=\theta'_i$ (13)
$a_{i2}=\theta''/2$ (14)
$a_{i3}= (4\theta_{i+1} - \theta'_{i+1}T_i - 4\theta_i - 3\theta''_i T^2_i)/T^3_i$ (15)
$a_{i4}= \theta'_{i+1}T_i - 3\theta_{i+1} + 3\theta_i + 2\theta'_i T_i + \theta''_i T^2_i /2) / T^4_i$ (16)

The intermediate point (i+1)'s acceleration can be Obtained as:

$\theta''_{i+1}= 2a_{i2}+ 6a_{i3}T_i+ 12a_{i4}T^2_i$ (17)

The segment between the number mpof intermediate points and the final point can be described by quantic polynomial as:

$\theta_{i,i+1}(t)= bi0 + b_{i1}t_i+ b_{i2} t^2_i+ b_{i3} t^3_i+ b_{i4} t^4_i+ b_{i5} t^5_i , (i=mp)$ (18)

Where the constants are given as:

$\theta_i = b_{i0}$ (19)
$\theta_{i+1} = b_{i0}+ b_{i1} T_i+ b_{i2} T^2_i+ b_{i3} T^3_i+ b_{i4} T^4_i+ b_{i5} T^5_i$ (20)

$\theta' = b_{i1}$ (21)
$\theta'_{i+1}= b_{i1}+ 2b_{i2} Ti + 3b_{i3} T^2_i+ 4b_{i4} T^3_i+ 5b_{i5} T^4_i$ (22)
$\theta''_i= 2b_{i2}$ (23)
$\theta''_{i+1}= 2b_{i2}+ 6b_{i3} T_i+ 12b_{i4} T^2_i+ 20b_{i5} T^3_i$ (24)

In addition, these constraints specify a linear set of six equations with six unknowns whose solution is:

$b_{i0}=\theta_i$ (25)
$b_{i1}=\theta'_i$ (26)
$b_{i2}=\theta'' / 2$ (27)
$b_{i3}= (20\theta_{i+1} - 20\theta_i - (8\theta'_{i+1}+ 12\theta'_i) T_i - (3\theta''_i - \theta''_{i+1}) T^2_i / 2 T^3_i$ (28)
$b_{i5}= (12\theta_{i+1} - 12\theta_i - (6\theta'_{i+1}+ 6\theta'_i) T_i - (\theta''_i - \theta''_{i+1}) T^2_i / 2 T^5_i$ (29)

As formulated above, the total parameters to be determined are the joint angles of each intermediate via point (n×mp parameters), the joint angular velocities of each intermediate point (n×mpparameters), the execution time for each segment (mp+1 parameters), and the posture of the final configuration (n-m).Therefore, for 3-link robot case, it used mp= 1, n =3 and one degree of freedom of redundancy for the final point, there are nine parameters to be determined. It should be point out that joint angular acceleration at each intermediate point could be obtained via equation (12). If all the intermediate points are connected by quantic polynomial, there will be eight parameters to be determined. This would be more time-consuming, which is why we choose both quadrinomial and quintic polynomial to generate the segments.

IV. ELECTRONIC DESIGN

Electronic design involves designing and choosing of the electrical components as per our requirements. Some of those used in our project are given below.

A. MICRO CONTROLLER

A micro controller is similar to a processor in a computer. The primary difference is that the micro controller has the CPU, the flash memory, the RAM and external ports all built into a single chip. All this makes the micro controller very cheap and is true value for money. The Atmel ATmega8 is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications.

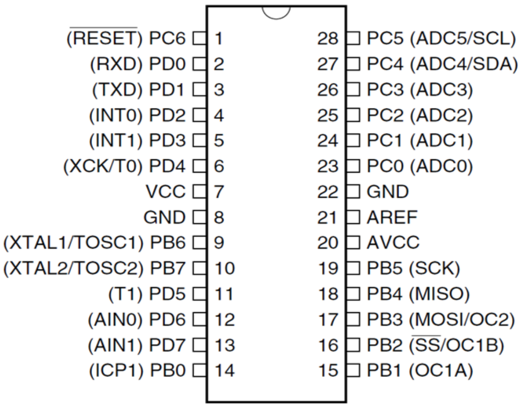


Fig. 6 Pin Diagram of Atmega8

Features of Atmega8:

- 8K BYTES of In-System Programmable Flash Memory.
- 512 Bytes EEPROM (Electrically Erasable Programmable Read-Only Memory).
- 100,000 Write/Erase Cycles.
- 1K Bytes SRAM.
- Inbuilt Watchdog timer.
- Two 8-bit Timer/Counters.
- One 16-bit Timer/Counter.
- Real Time Counter with Separate Oscillator.
- Three PWM Channels.
- 23 Programmable I/O Lines.
- 4.5 to 5.5V operation.
- Clock frequency of 16 Mhz.
- Current consumption:
  Active: 3.6mA
  Idle Mode: 1.0mA

Details of pins used:

1. Port D pins of the micro controller are connected to the motor driver circuit.
2. Pin no. 1 is RESET pin, which is connected to the reset circuit.
3. Pin no. 9 and 10 are connected to 16Mhz crystal oscillator.
4. Pin no. 7 is VCC, supply voltage (+5V).
5. Pin no. 8 is Ground
6. Pin no. 15, 16, 17 are used to produce pwm.
7. Pin no. 20 is AVCC, analog supply voltage.
8. Pin no. 22 is Ground.

B. POWER SUPPLY

A regulated power supply is an embedded circuit, the function of which is to supply a stable voltage, to a circuit or device that must be operated within certain power supply limits. This is used to supply the power to the microcontroller and the driver circuits. Microcontroller and drivers requires +5v supply. A DC source is given as the power supply

C. OBSTACLE SENSOR

Infrared (IR) optical sensors take advantage of invisible light waves to sense objects in their environment. These are very effective for use in non-contact object sensing. The advantage to measuring in the IR range is that ambient lighting has very little effect on the reading (assuming there are only low IR emissions from surrounding lighting). These sensors use an LED to emit light in the IR range and an IR light detector to determine whether an object is "close" or not. The detector varies its output to the computer based on the intensity of IR light it sees. This allows you to adjust how sensitive your proximity sensor is (although most come pre-adjusted for a specific distance) [7]. TSOP 1738 is a miniaturized receiver for infrared remote control systems. Pin diode and pre amplifier are assembled on lead frame. The demodulated output signal can be directly decoded by microcontroller. It supports all major transmission codes.

D. IR Transmitter Design

a. Use 555 timer in astable mode.
b. The IR receiver operates at 38.5 kHz frequency; hence the IR transmitter has to be designed for 38.5 kHz.
c. The duty cycle must be 50 %(slightly>=50%) owing to all the component tolerances in the circuit.
d. The IR LEDs must be checked (tested). This can be done by using a multimeter, in which, across +ve and –ve of IR LED an output of 1V must be obtained for it to be correct.
e. The resistance R1 should be less than R2 for a 50% duty cycle.
f. So the value of capacitor C can be chosen depending upon selection of availability of R1 and

R2.

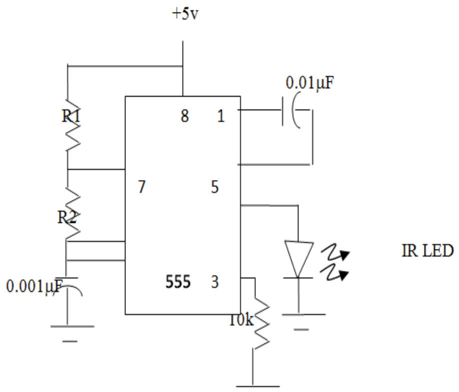


Fig. 7. IR Transmitter

For a stable mode, the time T for one cycle is given by:

$$T=0.693(R1+2R2)\ C$$

Thus the frequency of oscillations will be 1/T

i.e. $f=1/T$

$$f=1.44/(R1+2R2)C$$

With these equations for a given operating frequency the values of R1 and R2 can be calculated by suitably assuming the value of capacitor C.

E. ROBOT PROGRAMMING

Software: These tools include avr-gcc (the command line compiler), avr-libc (the compiler library that is essential for avrgcc), avr-as (the assembler), avrdude (the programming interface), avarice (JTAG ICE interface), avr-gdb(the de-bugger), programmers notepad (editor) and a few others. These tools are all compiled for Microsoft Windows and put together with a nice installer program. Hence it forms a user friendly tool for programming in embedded C language. Since atmega8 has three timers, the timing pulses from each of the timers is connected to the drivers for speed reduction. Since the robot is automatic, the program is written such a way that the motors are activated in a sequence as explained earlier. While moving the second joint, it will detect the obstacle and an interrupt routine is activated to cause the temporary halt of the arm or to ring the buzzer.

V. CONCLUSION

This project finds its application in the many fields. We have used gripper as an end effector. It can be replaced by other appropriate tools for operations like welding, painting, surgery, etc. Further, additional improvements can be done by incorporating wheels to the robot so that it can move from one location to another and thus can be used for multitasking.

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Vijayashri.B.Nagavi, studying in 8th semester, E&C branch in VidyaVikas College of Engineering and Technology, Mysore.

My name is Suresh M, i'm perceiving engineering in vidyavikas institute of eng, and technology , Mysore, 8th sem in electronics and communication ,we working on the project " Pick and place robotic arm " under the guidance of Dr.Bindu A Thomas, HOD ,E &C.