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Review On 4 DOF PLC Controlled Robotic ARM for Pick and Place Using IR Sensor And HMI

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ABSTRACT

Robotic arms are used in many of the industries, where humans can't work efficiently. The conventional practices used in industries are the work done by the humans (workers) and as humans are working fatigue is there and hence accuracy of work and productivity will affect. Human-machine interface commonly known as HMI is deployed for control and visualization interface between a human and a process, machine, application and appliance. This paper attempts to provide PLC Controlled robotic arm for pick and place using IR sensor and HMI. Implementation of logic is done for pick and place robot in HMI and design a GUI for controlling and monitoring the working of the robot. The proposed paper is to develop a system for pick and place object of weight in between 2-5kg which is teachable i.e. configurable by human via HMI panel whenever object is come in front of IR sensor the controller gives signal to actuator to actuate particular joint as sets on HMI. This is to done for greater accuracy, precision and to work in hazardous conditions where it is difficult for humans to work. IR sensors are used to detect the objects presence as object come in front of that sensor controller gives signal to the actuators to actuated the required joints And accordingly movement of arm takes place object is picked and placed on one particular position, confirm by destination IR when object is placed at destination then only next cycle starts and again object is picked and cycle is repeated.

Keywords : Degree of freedom (DOF); Programmable logic controller (PLC); Human machine interface (HMI);Infra-red (IR) Sensors; Pick and Place; Maximum accuracy, Programming, Communication.

I. INTRODUCTION

Definitions: A robotic arm is a type of mechanical arm, usually programmable, with similar functions to a human arm; the arm may be the sum total of the mechanism or may be part of a more complex robot. The links of such a manipulator are connected by joints allowing either rotational motion (such as in an articulated robot) or translational (linear) displacement. The links of the manipulator can be considered to form a kinematic chain. The terminus of the kinematic chain of the manipulator is called the end effector and it is analogous to the human hand.

In the industrial world, Robotics and automation is one of the most important elements for development. It helps to reduce the need for humans and increase efficiency and productivity. Automation was a general need from the earlier days of industrial revolution where ever industry and its subsystems needed to automate its various processes. The automation was done mainly to reduce operating costs, ensure safety and to reduce human work. The field of automation occupies large areas, mostly in industrial manufacturing and in addition to this; automation is applied to build a lot of sophisticated equipment which are used daily such as medical equipment (x-ray machines, radiography etc.), refrigerators,

automobiles etc. Among all of these outcomes, the Robotic Arm is one of them, which is widely used in industrial proposes. A Robotic Arm can be compared to a human hand. It has a free rotating joint (rotation) and a translational joint (displacement) for the movement of the arm. This arm movement is usually driven by an electric driver (motor) or a pneumatic and a hydraulic system (pistons). These actuators are controlled by a controller (CPU), usually programmable and made to perform a set of sequential tasks. Most of these robotic arms are designed to be used in industrial purposes for fast and reliable performance, helping for mass productions. As days passed several researches and inventions were made to develop efficient automation tool and software. The first logic used was relay logic, which comprised of large coils for switching, looked big bulky and consumed a lot of space. Then the PLCs came which were robust, portable, efficient, which we are using in our industries till date. But by using PLC people were not able to monitor the process taking place i.e. they were not able to see the status of the process, fault detection and the output at a given instant so these problems led to development of graphics-enabled visualization system and of course supervisory systems like HMI and SCADA(Supervisory control and data acquisition). Here we incorporate the use of HMI which is graphic based visualization and control of an industrial process .This project is PLC based 4 DOF (Degree of freedom) robotic arm for pick and place using IR (Infra-Red) and HMI sensor, is developed for industry to pick and place objects in between 2-5 Kgs of weight. Additionally, the necessary research was done to evaluate the best solution of the problem which is part of the project. The project includes the following objectives:

·Comparing the available components from the market which meet the best solution. i.e. (PLCs), Motor controllers, Grippers, Servo motors, Drivers, Encoders etc.

·Designing a layout for the installation of PLC, a Robot and other components together.

·Wiring Design and wiring installation

·Designing and construction of a wiring rail and a servo motor driver support system

·Designing the gripper

·Programming

·Testing and Finalizing

·Documenting

Robotic arm Elements: We present a taxonomy that will aid in defining the components required for Robotic arm from a high level perspective. Specific taxonomies of each component can be found elsewhere. There are three major components for development of arm are :

a) Hardware - made up of sensors, actuators, PLC, HMI, Servo motors, encoders and embedded communication hardware

b) Software - on demand storage and computing tools for data analytics PLC programming software GX Works 2 is recommended for Programming a FX series PLC.

c) Presentation - novel easy to understand visualization and interpretation tools which can be widely accessed on different platforms and which can be designed for different applications. In this section, we discuss a Human machine Interface (HMI) which is a touch screen display for visualization and to provide output .

4 DOF Robotic arm: A robot is a machine—especially one programmable by a computer—capable of carrying out a complex series of actions automatically. Robots can be guided by an external control device or the control may be embedded within. Robots may be constructed to take on human form but most robots are machines designed to perform a task with no regard to how they look. An industrial robot is a robot system used for manufacturing. Industrial robots are automated, programmable and capable of movement on two or more axes.

Typical applications of robots include welding, painting, assembly, pick and place for printed circuit

boards, packaging and labelling, palletizing, product inspection, and testing; all accomplished with high endurance, speed, and precision. They can help in material handling and provide interfaces. A robotic arm is a type of mechanical arm, usually programmable, with similar functions to a human arm; the arm may be the sum total of the mechanism or may be part of a more complex robot. The end effector, or robotic hand, can be designed to perform any desired task such as welding, gripping, spinning etc., depending on the application. For example, robot arms in automotive assembly lines perform a variety of tasks such as welding and parts rotation and placement during assembly. In some circumstances, close emulation of the human hand is desired, as in robots designed to conduct bomb disarmament and disposal. There are different types of robotic arms such as Cartesian robot / Gantry robot, Cylindrical robot, Spherical robot / Polar robot, SCARA robot, Articulated robot, Parallel robot, Anthropomorphic robot among them in this paper we discuss about Articulated robot.

Industrial automation requires wide numbers of machines for repeatedly done the same number of actions. The main difficulty to design such a system is complex programming & constant operating speed. So, it can be overcome by design & develop a robotic arm which works on real-time. An industrial robotic arm based on experience reply learning technique. Different techniques are developed previously based on neuro-fuzzy approach to record actions & convert them into devised motion codes and vice-versa. This type of robotic arm has wide variety of applications in industrial automation like open and close bottle neck, cleaning of specific surface or pick and place particular object. The more increase the number of industries in developing countries, the more require labourers or workers in that. To reduce the cost of labour force and to increase the manufacturing capacity of industries, the advanced robot arms are more needed. [4,5,7]

Figure 1.1 shows Articulated robotic arm which is defined as An articulated robot is a robot with rotary joints[citation needed]. Articulated robots can range from simple two-jointed structures to systems with 10 or more interacting joints. They are powered by a variety of means, including electric motors. Some of the important terms related to robotic arm are :

Revolute joint-A revolute joint (also called pin joint or hinge joint) is a one-degree-of-freedom kinematic pair used in mechanisms.[1]

Prismatic joint- A prismatic joint provides a linear sliding movement between two bodies, and is often called a slider, as in the slider-crank linkage

Robot kinematics- Robot kinematics applies geometry to the study of the movement of multi-degree of freedom kinematic chains that form the structure of robotic systems. The emphasis on geometry means that the links of the robot are modelled as rigid bodies and its joints are assumed to provide pure rotation or translation.[5,1,2,3]

Degrees Of Freedom (DOF)- The number of independent motions in which the end effector can move, defined by the number of axes of motion of the manipulator.

Gripper- A device for grasping or holding, attached to the free end of the last manipulator link; also called the robot's hand or end-effector.

Work Envelope- A three-dimensional shape that defines the boundaries that the robot manipulator can reach; also known as reach envelope.

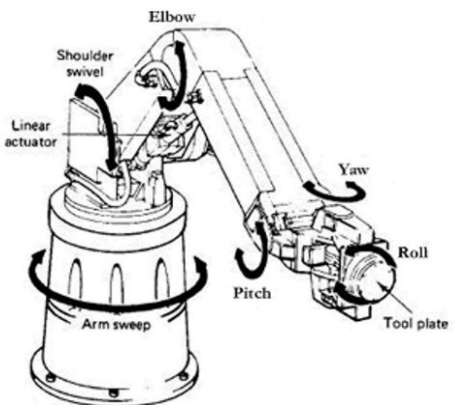

Figure 1.1 Articulated robot arm

In general, 4 DOF PLC Controlled robotic arm using IR sensors consists of programmable logic controller (PLC) which controls all operations of robot and PLC is the heart of the project, also it consists of infra-red (IR) sensors for the purpose of data acquisition meaning that for sensing of an object, motors with their drivers are used for moment of joints three stepper motors are used for three joints and pneumatic cylinder is used for gripper fingers, encoders are used for position detection of arm and HMI (Human machine interface) is for display and giving input.

II. DESIGN AND DESCRIPTION OF PROTOTYPE

The main objective of this project is to pick and place object of weight in between 2-5kg whenever object is come in front of IR sensor the controller gives signal to actuator to actuate particular joint. This is to done for greater accuracy, precision and to work in hazardous conditions where it is difficult for humans to work. IR sensors are used to detect the objects as object come in front of that sensor controller gives signal to the actuators to actuated the required joints And accordingly movement of arm takes place object is picked and placed on one particular position, detected by destination IR when object is placed at destination then only next cycle starts and again object is picked and cycle is repeated.

Hardware and Software Requirements: For this project, we require different hardware component and different software. So that this project is a combination which full fill the definition of both robotics and automation This is a list of all the hardware components that will be used in this guide:

- Programmable logic controller (PLC)
- Human machine interface (HMI)
- Stepper motors with drivers and encoders
- Pneumatic cylinder
- Infra-red (IR) sensors
- Relay board
- Contactor
- Power supply
- Miniature circuit breaker (MCB)
- Wires with dia 0.5sq.mm, 1sq.mm

Three different types of software are required for controlling the major three devices which are PLC ,HMI ,and motor driver. Software used in this project are listed below:

- PLC programming software GX Works 2[8]
- HMI Programming software GT designer 3
- Servo motor driver software

Hardware Configuration:

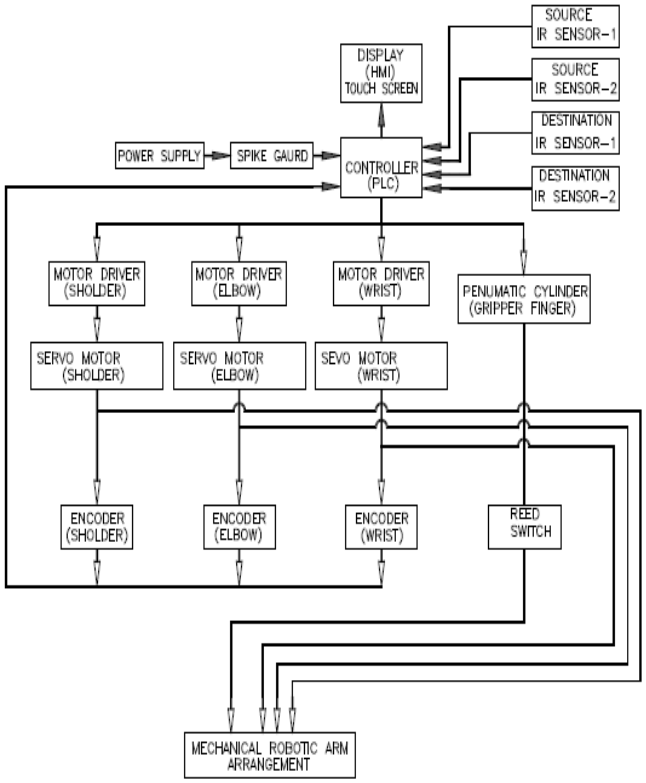

Figure1.2.Block Diagram

We are now going to see main block in detail

- Programmable Logic Controller: A programmable logic controller (PLC) or programmable controller is a digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures. PLCs are

used in many industries and machines. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. A PLC is an example of a hard real time system since output result must be produced in response to input conditions within a limited time, otherwise unintended operation will result[8]

Figure1.3. PLC FX Series (FX3UM)

- **Infra-red (IR) sensor:** An infrared sensor is an electronic device, that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. These types of sensors measures only infrared radiation, rather than emitting it that is called as a passive IR sensor

Figure 1.4 IR Sensor

Servo motor and driver : A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is a signal (either analogue or digital) representing the position commanded for the output shaft. The motor is paired with some type of encoder to provide position and speed feedback. In the simplest case, only the position is measured. The measured position of the output is compared to the command position, the external input to the controller. If the output position differs from that required, an error signal is generated which then causes the motor to rotate in either direction, as needed to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero and the motor stops.

Figure 1.5 Servo motor and driver

Human machine interface (HMI) : An acronym for Human Machine Interface. An HMI is a software application that presents information to an operator or user about the state of a process, and to accept and implement the operators control instructions. Typically information is displayed in a graphic format (Graphical User Interface or GUI)

Figure 1.6 HMI GS series

Here in this project I used Mitshubhishi GS series HMI and GT designer 3 is the software used for programming of it. Basic use of HMI is for providing input to the arm with the help of touch screen display and for displaying output.

III. CONCLUSION

This paper, presents what 4 DOF PLC controlled robotic arm using IR sensor and HMI is, which components are necessary to make a robotic arm Thus at the end the 4 degree of robotic arm using PLC and IR sensors works in hazardous environment with same accuracy and precision for long time. This is one of the low cost solution among all other robotic arms available in market. Also the following objectives of dissertation are accomplished :

- Comparing the available components from the market which meet the best solution. i.e. (PLCs), Motor controllers, Grippers, Servo motors etc.
- Designing a layout for the installation of PLC, a Robot and other components together.
- Wiring Design and wiring installation
- Designing and construction of a wiring rail and a Servo motor driver support system
- Designing the gripper
- Programming
- Testing and Finalizing
- Documenting

This Application notes detailed how to design and install robotic arm and testing them This arm can be used many of the industries not only for the purpose of a specific industry following are Some of the applications of industrial pick and place robotic arm

1. Defense Applications
2. Medical Applications
3. Pharmaceutical Industries
4. Automobile Industries
5. Process industries

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