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STEPPER MOTOR DRIVEN THREE AXIS ROBOT USING PLC

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Abstract— – The subject of control system design is usually approached from two distinct perspectives: development of general principles such as mathematically or experimentally derived theory, and case studies which describe instances of specific applications in practice. This paper fills the gap between these two approaches for a particular topic, application of PLCs to robotic workcells. Specifically, the subject of interest is organization of PLC program. Robotic workcells are custom built. Despite that, it is possible to discern common physical features and operating characteristics among robotic workcells. As a good design practice, these common traits are used, on an individual device or axis of motion basis, to generate typical portion of code. Similarly, on equipment, workcell or global level, typical organization of code is developed with a standardized program format, order and naming conventions. A library of code segments can be developed for specific sensors, actuators, axis of motion arrangements, robot and workcell configurations. This library can then be used for mix and match software development without sacrificing flexibility to customize or refine programs. Since the structure of the code is standardized and known ahead, the benefits of this approach extend beyond the code development stage to the program debugging and the life of product maintenance and repair troubleshooting of equipment.

Keywords— Stepper Motor, PLC, Custom built, Flexibility, Work cell, Standardize, Three Axis Robot.

INTRODUCTION

Robots are the integral part of manufacturing industry which largely depends upon its productivity for profit. The manufacturing industry may be automotive, textile, good packaging etc. Till date the industrial robot available in the market are microcontroller based for their robotic operation and path calculation. The work cell of the robot is controlled by industrial programmable logic controller. As we are using stepper motor as a drive for axis because no feedback path element is required such as encoder, resolver. As the robot manipulator has three axes so, the work envelope is a cube. Till date there are microcontrollers for the path calculation and PLC for the specific applications. But in this project we are now proposing PLC as an integrated robot architecture.[1]

Even in a typical robotics system, the PLC controls the entire operation of the cell. However, robot operations and path planning are done on a different controls platform that is proprietary to the robot manufacturer. As with any proprietary system, robots require specially trained professionals to program, control and interface them with the PLC for major operational commands. These specially trained technicians are in high demand but short supply, especially when needed unexpectedly for emergency repairs or adjustments. Even qualified robot technicians are usually familiar with only one or two – of many – brands of robots, and not necessarily the ones that you have. This specialization contributes to the technical skills scarcity and related delays and downtime. In most cases, manufacturers rely on their systems integration house or the robot manufacturer for troubleshooting, service and support. This reliance on outside resources is the reason robot "ownership" has been a myth.[1]

In comparison to the scarcity and specialization of robot experts, PLC experts are much more accessible because the programming concepts and foundations remain the same no matter what brand of PLC is being used. Insofar as most machinery in a plant runs on a PLC, there are naturally more PLC experts than robot experts. Also, PLC programming is commonly taught in technical schools, while robot programming is not. To solve this problem, manufacturers and industrial and process engineers sought a way for robots to be programmed and controlled entirely through a PLC. Their work led to the development and implementation of the PLC-integrated robot control concept, also known as Unified Controls Architecture.[5][2]

UNIFIED CONTROLS ARCHITECTURE

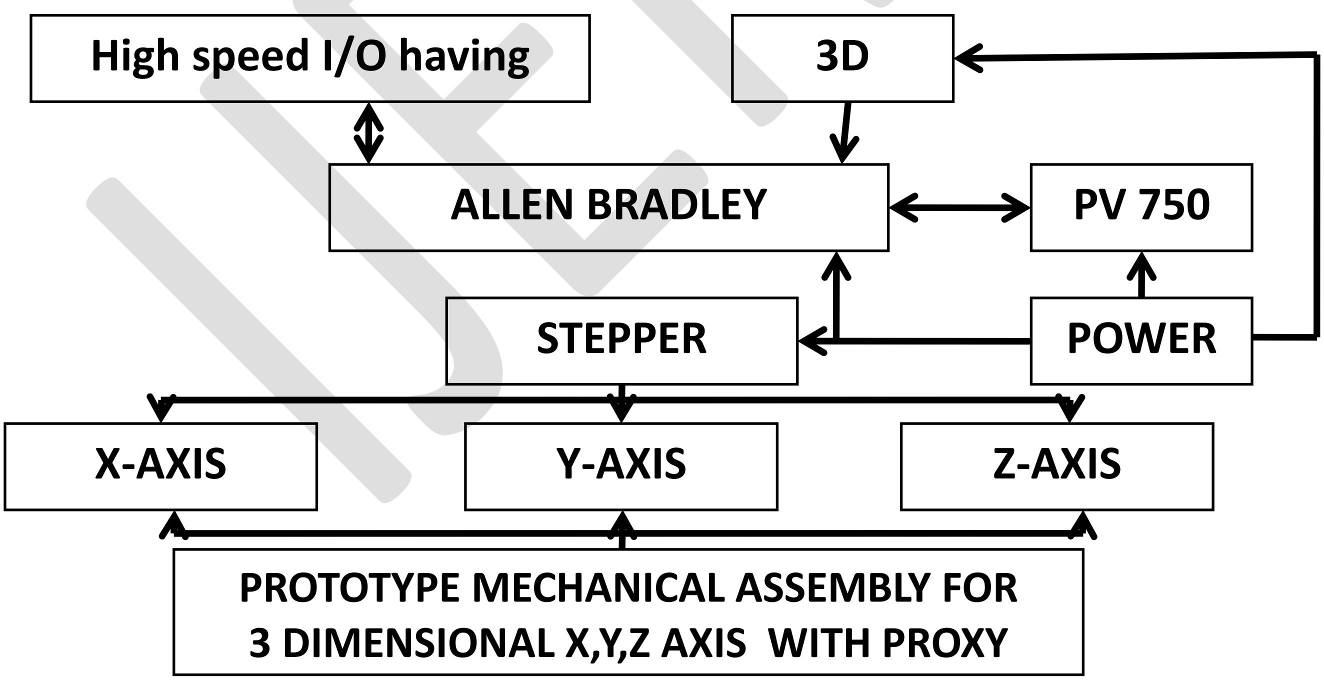
The definition of Unified Controls Architecture changes based on the usage context. In production and packaging systems, we define Unified Controls Architecture as a single unified primary controls platform for the entire workcell, so that the programming, diagnosis and troubleshooting is done in a single place. Unifying controls simplifies the system design because it decreases the number of cables, communication nodes and controls that are necessary in a traditional system's architecture. A reduction in components leads to a reduced number of failure points and spare parts required .The Unified Controls Architecture approach promotes greater inter-operability among components and systems, both upstream and downstream in the packaging line. Unified controls make the system more user-friendly because there is only one programming language to learn and maintain throughout the manufacturing plant. Robots become more maintenance staff -friendly as troubleshooting of the entire system happens in one place, in one language. Multiple programming languages are no longer required. With the advent of smart sensors such as vision systems, the unified architecture makes it simple to integrate sensor guidance and line tracking options that may be required for packaging applications.[1]

The Unified Controls Architecture benefits the end users of the automation by providing maintenance-friendly systems. And it offers tremendous advantages to system integration houses, since programming the robots and all of the peripheral equipment happens in one place. Additionally, a single person can usually both program and debug the systems. This approach makes the system development more efficient in comparison to a traditional approach. Another key benefit that Unified Controls Architecture offers is the ability to redeploy assets with your own maintenance staff. As the robots in this architecture are programmed, taught and controlled entirely through a PLC, your resident experts could easily redeploy them into another application or perform required upgrades as needed. Therefore, a Unified Control Architecture makes robotics system ownership a practical reality.[2]

OBJECTIVE

The main objective of this project is to prepare a PLC programme such that it will calculate path coordinates also at the same time it will drive a stepper motor accordingly. Also to prepare the HMI program to allow user to interface the robot program through appropriate screens. We are going to prepare such a program which allows user to program the robot path manually using joystick at first teaching and then the robot will perform the same function automatically afterwards with desired accuracy

PROPSED MODEL



Proposed model enlightens the following areas

Electrical and electronics, Mechanical, Programming

Electrical and electronics consists of stepper motor and stepper motor driver. The stepper motor driver drives the stepper motor. Mechanical consists of lead screw, nuts and bolts, coupler etc. The whole mechanical assembly runs over the track because of the rotation of stepper motor. Programming mainly is the ladder logic programming of Allen and Bradley. Hybrid stepper motor is used because of its high torque, greater inertia. DM320C is used as the stepper motor driver because of its great compatibility with the stepper motor. The lead screw is made up of stainless steel because of its non- rusty nature. PLC used is Micrologix 500 of ALLEN &BRADLEY mainly because of numerous instructions available in the kit like PTO.[4]

PROBLEM STATEMENT

Restricted authorization to user: - Because of the use of embedded microcontroller in robotics, the users are restricted to a certain level. Use of such system results in low capital cost but high running cost involved in service and troubleshooting. Existing robots need skilled labours to troubleshoot the problem.

Solution: - To solve this problem we will programme a PLC such that it will perform robotic calculations such as calculating path coordinates and will drive the stepper motor in conjunction with each other by using high speed input-output of ALLEN BRADLEY Micrologix 1400 PLC & PV750 plus HMI for user interface.

METHODOLOGY

Robot will have three axis namely x, y, z in both the positive and negative directions so, the work envelope will be a cube having coordinates of the origin as (0, 0, 0). For better accuracy, high resolution stepper motor will be used as an open loop system. As being a open loop position control system we need to check whether the given electrical command (pulses) has successfully converted into desired mechanical movement, a position check must be incorporated using proxy sensor. These sensors will check the positioning operation of the overall system through every cycle.

Fig. 1. Lead screw

Micrologix 1400

Fig. 3. Hybrid stepper motor

SPECIFICATIONS OF HYBRID STEPPER MOTOR

Step angle(deg)	1.8	Rated voltage(v)	12
Temperature rise(deg-c)	80 max	Rated current(A)	0.9
No. of phases	2	Resistance per phase	38.5
Insulation resistance	100M Ohm	Inductance per phase	21
Insulation class	Class B	Holding torque(kg-cm)	1.6
Max. radial force(N)	28	Detain torque(g-cm)	120
Max. axial force(N)	10	Rotor inertia(g-cm)	35

CONCLUSION

The robot manipulator will have position accuracy of about ±2%. Robots can be used for variety of applications like pick and place, palletizing in an array form or drawing a circle, square etc.

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