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Research paper



Implementation of Parallel Execution Algorithm on Multiple Drives using PLC

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Abstract

Drive is one among the very vital equipment in any power industry which require continuous monitoring and inspection at frequent intervals. And this paper deals with the implementation of parallel execution of multiple drives using Programmable Logic Controller (PLC). We have designed the ladder code using Add on Instructions (AOI) which is the most used feature of RS Logix 5000. For the operation of each axis of a drive we require an instance of the AOI in the main routine. At every phase the failure mechanism is also added in order to take care of the failed conditions. Parallel execution of multiple drives can reduce the execution time by a huge a margin.

Keyword: *PLC,Drive,AOI, parallel execution*

1. Introduction

In industries with so many drives around, operating on several similar drives for testing individually has become a challenge. Generally, testing can be done on drives serially or one at a time. But this is highly counterproductive because when more number of machines is to be used more errors will be there and thus increasing the execution time .Therefore, a level of automation is required which widens the test analysis. The scope and the depth of tests are increased by automated software testing in order to enhance the quality of testing. Tests that are commonly avoided due to their lengthy test cases can be run without any supervision. These tests can also be run using different configurations on multiple computers. Furthermore, performing operations on single drives individually consumes a lot of time. Therefore, there is a need of parallel execution wherein the drives can be operated at the same instant.

2. Existing System

In the current system all the tests performed on the drives are either completely manual or with minimal amount of automation. Each drive is tested upon individually.This is highly counterproductive because when more number of drives are to be used more errors will be there and thus eradicating them becomes cumbersome. It does not function for negative test cases and leaves the system undirected in case of a failure/error.

3. Proposed System

The system that has been proposed will automate the test cases on the drives in a concurrently using Add on Instructions (AOI) [v], a feature of RSlogix 5000. It will also incorporate perform failure routine that clears the error, shutdowns the system, setting default values, capturing the error message when an error is encountered [2]. And most importantly all the test cases having more number of instructions can be run unattended.

4. Programmable Logic Controller (Plc)

A PLC (programmable logic controller) is a device used to control various field components in an industrial facility [6]. It transcribes relay contact control mechanism. There are various kinds of equipments that PLCs can control in industrial facilities. In places like Conveyor systems, food processing systems, auto assembly lines, etc PLCs are applicable. The control devices are wired directly to one another in a manner such that the system can operate as desired, in case of a conventional industrial control system. With PLC in use, it replaces all the physical connections between the devices. Thus, all equipments are wired to the PLC instead of being directly wired to each other. The wiring connection between the devices is provided by the control program inside the PLC. In the controller's memory there is a control program which is a computer program that commands the PLC. Softwiring refers to the use of a PLC to provide the wiring connections between system devices.

PLC Programming

PLC's require suitable programming software where the user can download his/her desired program into the PLC [1]. For the controller to complete a particular task, it has to be programmed accordingly. The PLC Software used is RS LOGIX 5000 series. These three programming languages are offered by this controller namely Function Block Diagram (FBD), Structured Text

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Language (STL) and Ladder Language (LD). Of the three programming languages mentioned above the most commonly used language is the ladder logic.

Ladder Language

There is a necessity for sequentially control the program for it function a certain way. It can be used to program any combinational system. Any modifications can be made by editing the program. Different PLCs consists of different sorts of instructions which make every PLC unique. But the basic instructions that are common to all PLCs are contact and coils. Contacts are instruction that send the input conditions from the field devices to the control program. Each contact monitors a certain field device and waits for any change in the inputs. Coils are instruction that send the outputs of the control program i.e what a device has to do in a system. Similar to a contact every coil also monitors field device. But unlike the contact that monitors a field device and directs the PLC , a coil monitors the PLC control program and directs the field device.

5. Add on Instruction (aoi)

A. About AOI

Add-On Instructions is one of the most eminently used newer features of the RSLogix 5000. Through this facility the user can define an instruction that contains a regularly used function or algorithm (as a set of instructions), and use it as a single instruction.

B. Features of AOI

Any set of repeated operations can be performed using AOI which is somewhat similar to functions in C++ language. Many instances of a single AOI can be created and multiple drives can be operated using these instances. For every distinct drive the same set of instructions can be executed as the drives will have the same properties and functions.

6. System Configuration

A. Set up

Main three phase Input power (480 Vac) is given to the drives. For the circuit protection the following equipments are added circuit breaker, fuse, and line filter. Control voltage is also given with a nominal voltage of 24v to power the drive display. After all these protections the main then goes to the contactor which energizes the DUT's with ability to open any phase on main input or control input. And then it is given to the converter drive which converts the input AC voltage to its corresponding DC voltage and is fed to the Single axis inverter through a DC bus. Converter uses semiconductor switches like diode bridges to convert the AC to DC voltage. The switches can be turned off and on anytime. The inverter then supplies electrical energy to the motors attached to it to spin it. The inverter drives used are single axis and dual axis drives. The single axis drive can drive only a single motor at a time and the dual axis drive can drive two motors. The PLC consists of slots for attaching the motion controller, Ethernet and other modules. The Ethernet can be either connected using a switch or in loop pattern. The Ethernet connections should be properly done for communicating with the entire systems. The motors attached to the drive perform any operation like jogging or moving according to the ladder code designed. The PLC used is Allen Bradley which controls the drives through the ladder logic.

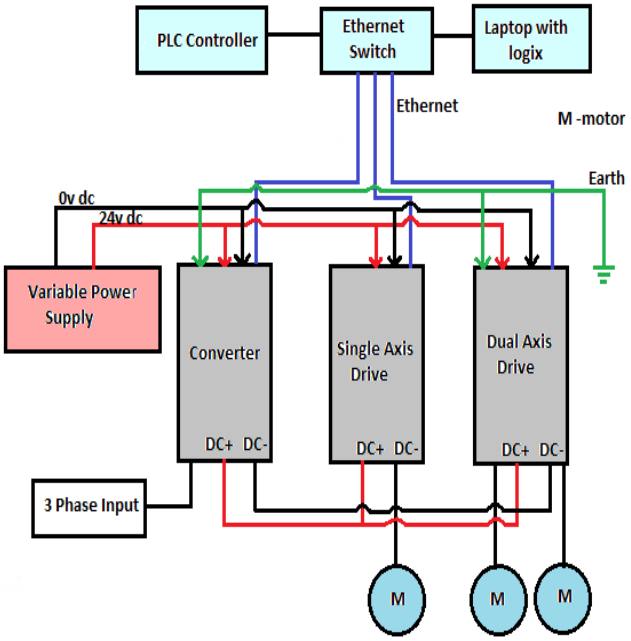


Fig. 1: Set up diagram

B. Interfacing and communicating

To communicate with drives, there is a need to set up a communication link between the controller and the personal computer/laptop which has the RSlogix 5000 software. There are different tools used to download the firmware into the controller and drive. *Control flash* and *file zilla* are the tools used download the firmware into the controller and drive respectively.

7. Instructions Used in The Ladder Code

The ladder code has been created using many motion instructions to command the drive and operate on it. The instructions include some motion and read/write instructions. Some motion and read/write instructions used have been listed in the TABLE I and TABLE II respectively.

Table 1: M motion Instructions

Motion Instructions	***Function Performed***
MSO (Motion Servo On)	The servo drive is enabled and the axis servo loop is activated.
MSF (Motion Servo Off)	Servo drive is disabled and the axis servo loop is deactivated.
MASR (Motion Axis Shutdown Reset)	An axis state is changed from the already existing shutdown operating state to an axis ready state.
MAFR (Motion Axis Fault Reset)	All motion faults for an axis are cleared.
MAS (Motion Axis Stop)	Any motion process on an axis is stopped.
MAJ (Motion Axis Jog)	An axis is jogged.

Table 2: Read/Write Instructions

Read/Write Instructions	**Functions Performed**
MSG (Message Instruction)	Sends data to and from other modules
GSV (Get System Value)	Get controller status information
SSV (Set System Value)	Set controller status information

Structure of the AOI

The ladder code consists of two sections one is the main routine or the main program and the other one is called the subroutine/AOI.

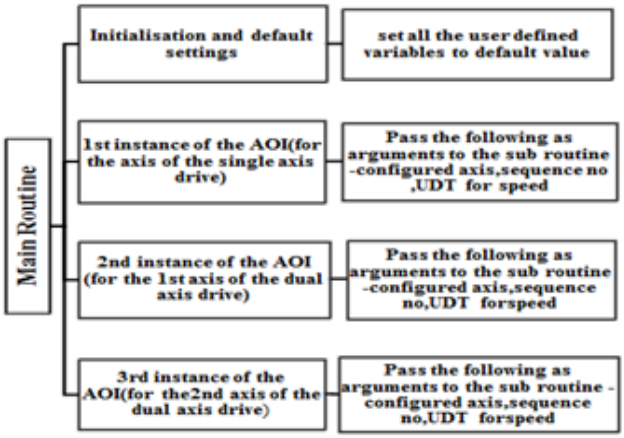


Fig. 2: Flow of the ladder code in main routine

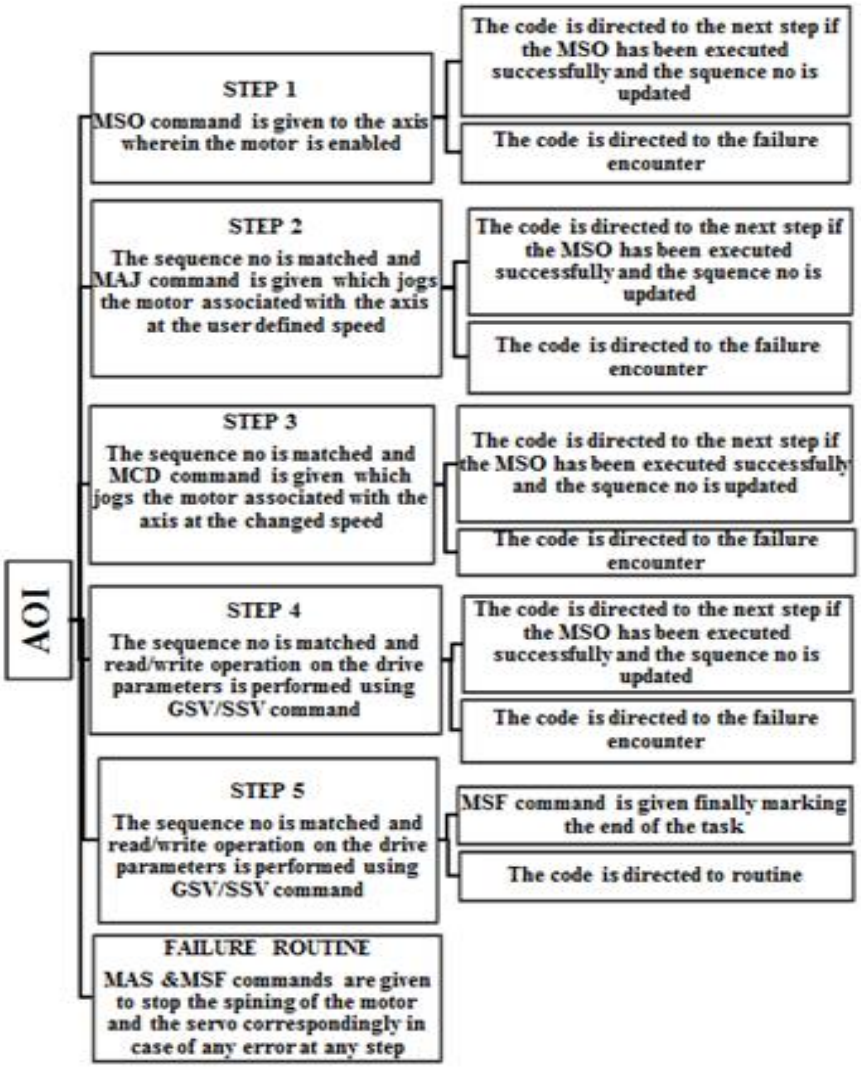


Fig. 3: Flow of the ladder code in AOI

This is where the AOI implementation comes into use. The generic code has a set of instructions (algorithm) that has to be performed by the all drives.

Since the instructions are common to all the drives, the algorithm can be grouped into an AOI and can be instantiated in the main routine. The overall flow the main routine and sub routine has been shown in the Figure1 and Figure2 respectively.

8. Results

Every drive has various parameters which can be read and written using GSV/SSV instructions. When the drive is given a MSO or MAJ command to spin the motor with a constant speed, the speed can be checked via the code also by using the velocity feedback parameter i.e. reading the velocity feedback value from the particular drive using the GSV instruction.

Table 3: Drive Output validation

Drives	***Commanded Speed (Units per sec)***	***Velocity Feedback Parameter (Units per sec)***	***Errror (%)***	***Error tolerance (%)***	***Drive Status***
Single axis drive	10.0	11.7	+0.7	-5 to +5	Running
1st axis of dual axis drive	10.0	9.2	-0.8	-5 to +5	Running
2nd axis of dual axis drive	10.0	11.5	+1.5	-5 to +5	Running

From the TABLE III we can infer that the velocity feedback value for the all the three axis is within the error tolerance range (-5% to +5%). This validates that the motors are driven at the commanded speed within the error tolerance using the algorithm.

9. Conclusion

The parallel execution reduces the execution time by 30% and hence the required effort for testing the drives is also reduced. This ladder code which uses multiple instances of the AOI in the main routine is validated by the results which show that the motors are driven at the commanded speed within the defined error tolerance.

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