Speed control of three phase induction motors using PowerFlex 525 compact AC drive

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Abstract. Most of the control systems have to make things move and that generally involves motors. Lifting, blowers, conveyors, pumping, robotics, and fans – pretty much everything uses a motor of some kind. All-purpose single or three-phase motors are huge for simple on/off systems and Inverter-duty motors are particularly designed for operation with variable frequency drives (VFD). They convert electrical energy into mechanical energy, which produces a mechanical rotary action that does some form of work. Alternating current motors are the common types of motors used in commercial and industrial applications. The fundamentals of drive programming and configuration with the PowerFlex 525 compact Alternating current drive, the CompactLogix PLC and the Studio 5000 Logix Designer software is used for configuring these drives. A characteristic that provides complete parameter groups for all the range applications used for the PowerFlex 525 AC Drive. The PowerFlex drive is used with ControlLogix, CompactLogix controllers and different Allen-Bradley products. Point-to-point positioning mode options used for the accurate motor stop at positioning in that system to save money and time during system operation, development, and maintenance. The addition of Allen-Bradley motor control devices into the Logix control devices helps to reduce programming time, ease startup, commissioning and streamline diagnostics.

1. Introduction

The VFD (Variable Frequency Drive) is used to reveal and manipulate parameters of an induction motor by using variable frequency and voltage to manage the velocity of induction motor. Change in the frequency is applied to regulate the speed of induction motor using the formula $N = \frac{(120*f)}{p}$ where $f$ = frequency of supply $p$=pole [1]. Change in the frequency gives magnetizing flux among air gaps of induction motor. But the induction motors are meant to on its characteristics. PowerFlex 525 drive is a modern, modular layout to help rapid and easy installation and configuration. This powerflex525 Drive of modular drives offers embedded Ethernet/IP connections, USB programming, and better protection capabilities. PowerFlex 525 drives, which suggest a power rating of 0.4 kW to 22 kW (0.5 to.30 Hp) with global voltage classes of 100v to 600Vand they are used in wide for packages which includes conveyors, fans, pumps, and mixers [2].

The PowerFlex 520-Series drive conveys an imaginative structure that is incredibly flexible and can contain frameworks going from independent machines to basic framework incorporation. By combining a many range of motor control option, energy savings, communications and standard safety features in a cost-effective drive, the PowerFlex 520-Series drive is used for a wide range of applications [3]. It improves the work execution and efficiency by taking benefits of the accompanying key highlights offered in a PowerFlex 520-Series drive. Implanted Ethernet/IP port
permits simple design, control, and gathering of information over the system. Double port Ethernet/IP alternative card used to Device Level Ring (DLR), giving issue tolerant network to most choose drive accessibility [4]. Control Performance on Sensor less Vector Control (SVC), range of motor control alternatives, Volts per hertz control (V/Hz), Closed-loop speed vector control, Permanent Magnet motor control and Variety of Positioning Control, including, point to stop mode is utilized to stop the motor in a consistent position with no encoder criticism and shut circle input with a discretionary encoder gadget. Basic PID usefulness upgrades more application adaptability and Power Flex 525 drives comprise of two PID circles and Point-to-point position. Stop mode alternatives are utilized to stop the motor at any position [5].

![Block diagram of VFD.](image1)

**Figure 1.** Block diagram of VFD.

2. Methodology

2.1. **AB Compact Logix PLC**

Programmable logic controller is an industrial PC used for the automation of numerous electro-mechanical methods in industries which have been ruggedized and modified for the control of overall manufacturing processes. Hydromantic Division of the General Motors Corporation proposed the first criteria for the programmable controller in 1968 [6]. Their foremost purpose changed into to get rid of the high charges and continuous protection. It is associated with inflexible, relay-controlled systems he Compact Logic 5370 L1 controllers that combine the power of the architecture with the easy utilize of POINT I/O modules in a compact, inexpensive package [7]. Machine developers and end users can take advantage of an Integrated Architecture system with which requires low rotate development and I/O point tallies and backing for Coordinated Motion over Ethernet/IP for extended adaptability. Expels the requirement for lithium batteries utilized for inherent vitality stockpiling incorporate 2-GB Secure Digital (SD) card for high speed program, restore and a tiny structure constituent for enlarged field. Open access capability of this PLC support for Modbus TCP like gadgets, for example, printers, barcode reader and server.

![Components of PLC.](image2)

**Figure 2.** Components of PLC.
Expanding on the adaptability of the AB Logic families of controllers, Programmable Automation Controllers (PACs) are intended to meet on the expansion for an unrivalled exhibition controller in a conservative, moderate bundle. These types of controller also support Point IO configuration. It reduces wired connections between controllers to field devices [8].

2.2. Configure the embedded Ethernet/IP adapter
The PowerFlex 525 Embedded Ethernet/IP system adapter requires a network IP address to function on an Ethernet/IP network. The main benefit of this method is to drive PLC system with no wire connection and connect to Ethernet/IP. There are two techniques for configuring the embedded Ethernet/IP adapter IP deal with BOOTP Server – Use BOOTP server if we like enhanced for controlling the IP addresses of the drive with a server. In the BOOTP server the following IP Address, subnet mask, and gateway address are set to enable its function [9]. If it is set ON in the network addresses manually with parameters, it is necessary to set C128 [Enable EN Address] to ‘framework’.

![Figure 3. Hardware setup PLC and VFD.](image)

2.3. Configuring drive parameters

- The keypad operation in the device to the Reset Drive to Defaults section to construct the following Communication group parameter changes:
  
  C129 – Enter IP AddressCfg 1 = 192
  C130 – Enter IP AddressCfg 2 = 168
  C131 – Enter IP Address Cfg 3 = 0
  C132 – Enter IP Address Cfg 4 = 22
  C133 – Enter Subnet Address Cfg 1 = 255
  C134 – Enter Subnet Address Cfg 2 = 255
  C135 – Enter Subnet Address Cfg 3 = 255

- After setting the IP address for Drive and Compact Logix PLC two devices are added with programming software using Ethernet/IP communication protocol. The dominant general for the layer of many industrial protocols together with Ethernet, Ethernet TCP/IP, Modbus TCP/IP and Profibus.

- In Compact Logic controller it is necessary to ensure whether it is NOT in Run Mode. If move the switch to PROG (bottom/down) position at the time of program uploading, the RUN LED on the controller is turned OFF, then REM position goes to middle at a time.

- Using RSLinx classic configuring the ETHERNET/IP address Driver for compact logic controller and PowerFlex 525 Drive. RSLinx classic is also used to know the current status of
communications between PLC and PC. Select EthernetIP driver for PLC and Drive not require for wire these two controllers and it Require Ethernet cable

- Configure the input and output address to assign input address to bush button local: 1:i.Data.0 to Data.3 and select corresponding output parameters form VFD outputs.
- AB compact logic process for these and it has changed with 525 firmware over the years.

The last one I used was: Rung 1: XIC (your Motor start bit) - XIC (Motor1:I.Ready)-OTE (Motor1:O.Start) Rung 2: XIO (your Motor start bit) - XIC (Motor1:I.Active) - OTE (Motor 1:O.Stop) Rung 3: XIO (Motor Reverse Bit)

![Hardware connection of PLC drive.](image)

**Figure 4.** Hardware connection of PLC drive.

### 2.4. PowerFlex 525 drive add-on profile with Studio 5000

A configuring drives like a timed, side-by-side assessment, Integrated Drive Profiles in Studio 5000 Logix Designer and minimize drive system improvement time by as much as 70% compared to predictable design. Studio 5000 Logix Designer software is integral to drive diagnostics, faults, alarms, and event information. It also to gather all data with respect to a drive, its peripherals, different programming segments, and PC working system Drive to Tech maintain Wizard can be run. Studio 5000 Logix Designer software flashed many drive parameters and updated. Having a distinct repository of drive configuration data to the controller scheme file, it reduces downtime by speeding drive configuration. "Add-On Profiles “are Integrated Drive Profiles, independent of exacting releases of Studio 5000 Logix Designer software and many are compatible to work with past versions of the programming software as well, helping to prevent obsolescence of the controller when new drives are connected to it. Click on the tab named “Drive”. The Add-On Profile for the PowerFlex 525 drive in the Logic Designer software provides a general appear and think to the Connected Components Workbench software. This studio5000provides the same ability to download, upload a program, view, and compare drive parameters, as well as access the Wizards. Another characteristic of Logic Designer is to enable Automatic Device Configuration (ADC) in the drive. To expand Ethernet Tree, write click add the PowerFlex 525-EENET Drive and set default parameters values.

The “Parameters” tag is clicked on. It is easy to use the Connected Components, Workbench software and working go online with the drive, analyzing the parameters with the Parameter groups, Custom View groups, AppView, and standard default application parameters like as Conveyor, Mixer, compressor, centrifugal pump and positioning.
Figure 5. Add-on profiles with studio 5000 logic designer.

The PowerFlex 525 Module arrangement window gives the capacity to sort out up to four terms of Input Data and four words of Output Data to be acknowledged throughout the embedded Ethernet link. Drive status and control information will be communicated by default data’s, Status Information “Drive Status” statement contains the drive status bit in sequence, such as Fault, Ready, and at Reference. Open the drive Module Properties window by double-clicking on the “PowerFlex 525 EENET PF525_Drive” node in the I/O design folder. Click the “Download” button, Expand the “AB_ETHIP-1” Ethernet IP driver and select the “192.168.0.22, PowerFlex 525” node.

The “Output Frequency” expression contains speed input data, which demonstrates the genuine working frequency (Hz) of the PowerFlex drive. Control Information on “Logic Command” expression contains the drive control Digital bit information, like Start, Stop, Reverse, Forward, and Clear Faults.

Figure 6. Drive module properties and parameters.

The “Frequency Command” statement contains the Input reference frequency value for the drive to run the motor. Drive parameters are pointed to Data links. Our drive I/O get assembly is dynamic and enables the developer to pick and pick the favoured parameters to impart as system I/O [10]. In another one to storing the port configuration data in the drive through controller and manages the communications to the drive with proper tag-based addressing. The “Controller Tags” double-click on icon under the “Controller Power_flex1.ACD” folder and change the values.
3. Program for speed control of an induction motor

The speed control of induction motor is done with low electrical power factor. PowerFlex 525 point to point speed control uses encoder device and it is used to set stop mode value as 0 in Frequency Command register. Frequency of induction motor is 50 HZ and speed of induction motor is 1500 rpm at no load condition.

Synchronous Speed \( N_s = \frac{120f}{P} \) Where, \( N \) is the speed of a rotor of induction motor, \( N_s \) is the synchronous speed, \( S \) is the slip.

![Figure 7. Ladder diagram for VFD control.](image)

The three phase induction motors is used for two types of speed control method and Changes the frequency of motor speed with variable load.

![Figure 8. Speed vs. frequency charts.](image)

4. Conclusion

The objective of this paper is to control the three-phase induction motor varying with motor input frequency and also to control the motor in forward and reverse direction using PowerFlex525 and Compact Logic PLC with studio 5000 using Ethernet/IP. This Ethernet/IP implementation is used to control the speed of induction Motor automatically with low cost and high speed transmission.
protocol. Comparable sort of work is possible with the assistance of HMI, SCADA, etc. Further restorative measures can also be done while structuring such frameworks. Thus, the speed control strategy in this paper is controlled by utilizing Ethernet/IP technique.

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