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INDUCTION MOTOR POSITION CONTROL USING PLC: A REVIEW

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Abstract

Digital position control for Induction Motor Drive is achieved through digital encoders. The digital encoder is a sensor of mechanical motion that generates digital signal in response to motion of the drive. Now a days all PLC's handles the digital signals controlling the pulses generated by digital encoder directly sensed by the PLC. Counting in the counter modules identifying the position of the drive. Depending upon the position of the drive the PLC generates reference to drive to attain the preset position. This makes position control system simpler

Index Terms—Digital encoder, DSM 314, Induction motor drive , MATLAB, PLC.

INTRODUCTION

THIS paper describes about the digital position control for Induction Motor drive. A third of the world's electricity is used by induction motor for driving pumps, fans, compressors, elevators . The AC Induction Motor is used in various industrial application and can be used as various sizes and ratings. As an application of digital position control system, The Induction Motor can be used along with encoder and a PLC. We can identify the position of the shaft. Digital position control system are used in various industrial applications. They are used in steel plants where it is used to transfer the bars and billets cut-ted to the finished lengths to the cooling beds.

The PLC used is a series 90-30 PLC. The series 90-30 PLC is a member of GE Fanuc series 90-30- PLC family. The series 90-30 PLC is very versatile because of its programmability. The DSM314 is an intelligent, fully programmable, motion control option module for series 90-30 PLC. This DSM314 allows the user to combine high performance motion control . It also uses local logical capabilities with PLC logic solving function in one integrated system.

I. Digital position control

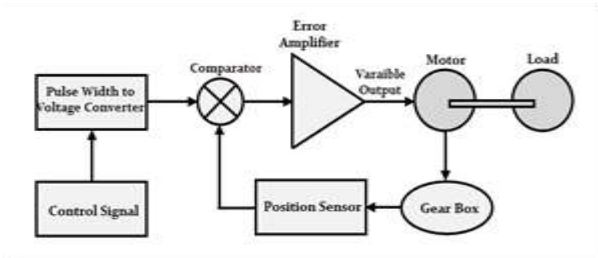

Figure.1.Digital position control system

The MATLAB is used because of the short learning curve that most students require to start using it, its wide distribution and its general purpose nature.

A. Encoder

A rotary encoder or a shaft encoder, Is an electromechanical devise used to convert angular position of of axle to digital code, Making it an angle transducer. These devises are used in industrial controls, robotics and in computer input devices and in rotating radar platform. There are two main types

A Absolute rotary Encoder

B. Incremental rotary encoder.

A Absolute rotary encoder**:** The absolute rotary encoder produces a unique digital code for each distinct angle of the shaft. They come in two basic types:

a. Mechanical.

b. Optical

Figure.2.Absolute rotary encoder

a. Mechanical Absolute Encoders

A metal disc containing a set of concentric rings of openings is affixed to an insulating disc, which is rigidly fixed to the shaft. A row of sliding contacts is fixed to a stationary object so that each contact wipes against the metal disc at a different distance from the shaft. When the disc rotates with the shaft, some of the contacts touch metal, while others fall in the gaps where the metal has been cut out. The metal sheet is connected to a source of electric current, and each contact is connected to a separate electrical sensor. The metal pattern is designed so that each possible position of the axle creates a unique binary code in which some of the contacts are connected to the current source and others are not.

b. Optical Absolute Encoders

The optical encoder's disc is made of glass with transparent and opaque areas. A light source and photo detector array reads the optical pattern that result from the disc's position at any one time.

This code can be read by a controlling device, such as a microprocessor, to determine the angle of the shaft[14].

The absolute analog type produces a unique dual analog code that can be translated into an absolute angle of the shaft by using a special algorithm.

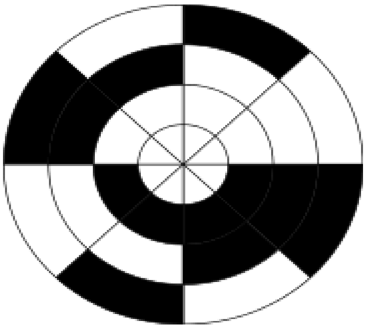

Figure.3. Standard Binary Encoding

Rotary encoder for angle-measuring devices marked in 3-bit binary. The inner ring corresponds to Contact 1 in the table. Black sectors are "on". Zero degrees is on the right-hand side, with angle increasing counter clockwise.

Table 1.Standard Binary Encoding

Sector	Contact 1	Contact 2	Contact 3	Angle
1	Off	Off	off	0° to 45°
2	Off	Off	On	45° to 90°
3	Off	On	off	90° to 135°
4	Off	On	On	135°to 180°
5	On	Off	off	180°to 225°
6	On	Off	On	225°to 270°
7	On	On	off	270°to 315°
8	On	On	On	315°to 360°

An example of a binary code, in an extremely simplified encoder with only three contacts, is shown below.

In general, where there are *n* contacts, the number of distinct positions of the shaft is 2^n. In this example, *n* is 3, so there are 2^3 or 8 positions[14].

In the above example, the contacts produce a standard binary count as the disc rotates. However, this has the drawback that if the disc stops between two adjacent sectors, or the contacts are not perfectly aligned, it can be impossible to determine the angle of the shaft. To illustrate this problem, consider what happens when the shaft angle changes from 179.9° to 180.1° (from sector 4 to sector 5). At some instant, according to the above table, the contact pattern will change from off-on-on to on-off-off. However, this is not what happens in reality. In a practical device, the contacts are never perfectly aligned, and so each one will switch at a different moment[14]. If contact 1 switches first, followed by contact 3 and then contact 2, for example, the actual sequence of codes will be

Off-on-on (starting position)

On-on-on (first, contact 1 switches on)

On-on-off (next, contact 3 switches off)

On-off-off (finally, contact 2 switches off)

Now look at the sectors corresponding to these codes in the table. In order, they are 4, 8, 7 and then 5. So, from the sequence of codes produced, the shaft appears to have jumped from sector 4 to sector 8, and then gone backwards to sector 7, then backwards again to sector 5, which is where we expected to find it. In many situations, this behaviour is undesirable and could cause the system to fail. For example, if the encoder were used in a robot arm, the controller would think that the arm was in the wrong position, and try to correct the error by turning it through 180°, perhaps causing damage to the arm.

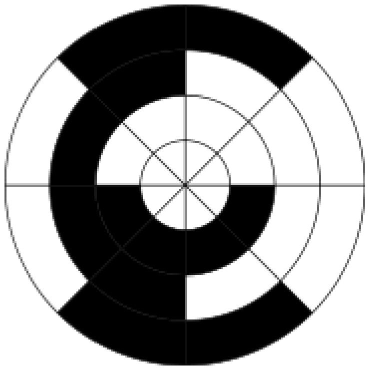

Figure.4.Grey Coding

Rotary encoder for angle-measuring devices marked in 3-bit binary-reflected Gray code (BRGC). The inner ring corresponds to Contact 1 in the table. Black sectors are "on". Zero degrees is on the right-hand side, with angle increasing anticlockwise.

To avoid the above problem, **Gray encoding** is used. This is a system of binary counting in which adjacent codes differ in only one position. For the three-contact example given above, the Gray-coded version would be as follows.

Table 2.gray coding

Sector	Contact 1	Contact 2	Contact 3	Angle
1	Off	Off	off	0° to 45°
2	Off	Off	on	45° to 90°
3	Off	On	on	90° to 135°
4	Off	On	off	135°to 180°
5	On	On	off	180°to 225°
6	On	On	on	225°to 270°
7	On	Off	on	270°to 315°
8	On	Off	off	315°to 360°

In the above example, the transition from sector 4 to sector 5, like all other transitions, involves only one of the contacts changing its state from on to off or vice versa[14]. This means that the sequence of incorrect codes shown in the previous illustration cannot happen here.

B *Incremental rotary encoder*

An incremental rotary encoder, also known as a quadrature encoder or a relative rotary encoder, has two outputs called quadrature outputs. They can be either mechanical or optical. In the optical type there are two gray coded tracks, while the mechanical type has two contacts that are actuated by cams on the rotating shaft. The mechanical type requires debouncing and are typically used as digital potentiometers on equipment including consumer devices. Most modern home and car stereos use mechanical rotary encoders for volume. Due to the fact the mechanical switches require debouncing, the mechanical type are limited in the rotational speeds they can handle. The incremental rotary encoder is the most widely used of all rotary encoders due to its low cost: only two sensors are required.

The fact that incremental encoders use only two sensors does not compromise their accuracy. One can find in the market incremental encoders with up to 10,000 counts per revolution, or more.

There can be an optional third output: reference, which happens once every turn. This is used when there is the need of an absolute reference, such as positioning systems.

The optical type is used when higher RPMs are encountered or a higher degree of precision is required.

Incremental encoders are used to track motion and can be used to determine position and velocity. This can be either linear or rotary motion. Because the direction can be determined, very accurate measurements can be made.

They employ two outputs called A & B which are called quadrature outputs as they are 90 degrees out of phase.

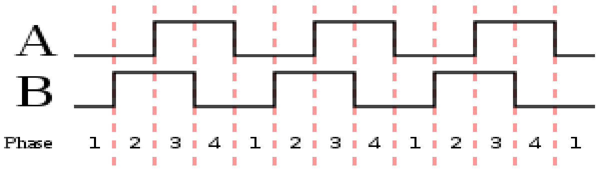

Figure.5. Two square waves in quadrature (clockwise rotation).

The state diagrams.

Table 3.Gray coding for clockwise pattern

Phase	**A**	**B**
1	0	0
2	0	1
3	1	1
4	1	0

Table 4.Gray coding for counter Clockwise

Phase	**A**	**B**
1	1	0
2	1	1
3	0	1
4	0	0

The two output wave forms are 90 degrees out of phase, which is all that the quadrature term means. These signals are decoded to produce a count up pulse or a count down pulse. For decoding in software, the A & B outputs are read by software, either via an interrupt on any edge or polling, and the above table is used to decode the direction. For example if the last value was 00 and the current value is 01, the device has moved one half step in the clockwise direction. The mechanical types would be de-bounced first by requiring that the same (valid) value be read a certain number of times before recognizing a state change.

If the encoder is turning too fast, an invalid transition may occur, such as 00->11. There is no way to know which way the encoder turned; if it was 00->01->11, or 00->10->11.

If the encoder is turning even faster, a backward count may occur. Example: consider the 00->01->11-> 10 transitions (3 steps forward). If the encoder is turning too fast, the system might read only the 00 and then the 10, which yields a 00->10 transition (1 step backward).

PLC

The PLC acts as an interface between the drive and encoder. Programmable Logic Controllers(PLC) is an intelligent system of modules, which performs discrete or continuous logic, that was introduced in the control and instrumentation industry for replacing relay based logic.PLC's were initially called programmable controllers(PC).this caused a small confusion when personal computer appeared. To avoid confusion a designation PC was left to computers, and programmable controllers became programmable logic controllers.

PC or PLC was first developed for general motors corporation in 1968 to eliminate costly scrapping of assembly line relays during model change overs.By 1971 PC's were being used in applications outside automotive industry. First PLC controllers were simple devices. They connected inputs such as switches, digital sensors etc., and based on internal logic they turned output devices on or off. As they were capable of on or off control, only their application was limited to machines and processes that required inter locking and sequencing applications.Todays PLC's can handle highly complex tasks such as position control, various regulation and other complex applications. The speed of work and easiness of programming were also improved. In addition, modules for special purposes were developed. Like communication modules for connecting several PLC controllers to the net. To day it is difficult to imagine a task that could not be handled by a PLC.

`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, control of amusement rides, or control of lighting fixtures. PLCs are used in many different industries and machines such as packaging and semiconductor 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 or non-volatile memory. A PLC is an example of a real time system since output results must be produced in response to input conditions within a bounded time, otherwise unintended operation will result.

The Series 90-30 Programmable Logic Controller (PLC) is a member of the GE Fanuc Series 90-30 PLC family. The Series 90-30 PLC is very versatile because

1. it is programmable, and

2. it is assembled from a wide variety of modular, plug-together components. Therefore, by choosing the correct components and developing an appropriate program, the PLC can be used for an almost unlimited variety of applications.

The DSM314 is an intelligent, fully programmable, motion control option module for the Series90-30 Programmable Logic Controller (PLC). The DSM314 allows a PLC user to combine high performance motion control and Local Logic capabilities with PLC logic solving functions in one integrated system.

i. *Features of the Motion Mate DSM314*

- High Performance
- Digital Signal Processor (DSP) control of GE Fanuc servos
- Block Processing time under 5 milliseconds
- High resolution of programming units
- Position: -536,870,912...+536,870,911 User Units
- Velocity: 1 ... 8,388,607 User Units/sec
- Acceleration: 1 … 1,073,741,823 User Units/sec/sec
- Easy to Use

The DSM314 and Series 90-30 PLC operate together as one integrated motion control package. The DSM314 communicates with the PLC through the backplane interface.

A motion program consists of a group of user-programmed motion command statements that are stored to and executed in the DSM314. The DSM314 executes motion program commands sequentially in a block-by-block fashion once a program is selected to run. The motion program is executed autonomously from the PLC, although the PLC starts the DSM314 motion program and can interface with it (with parameters and certain commands) during execution. In addition, external inputs (CTL bits) connected directly to the DSM314 faceplate or controlled by Local Logic can be used in motion programs to delay or alter program execution flow. The PLC receives status information (such as position, velocity, and Command Block Number) from the DSM314 during program execution. Motion programs 1-10 and subroutines 1-40 are created using VersaPro 1.1 (or later) PLC programming software and are stored along with the module's

Configuration settings to the DSM314 via the PLC backplane. Please refer to the *VersaPro Programming Software User's Guide,* GFK-1670 or the VersaPro 1.1 on-line help for further.

Information.

Motion Program Command Types

The motion program commands are grouped into four categories:

Type 1 Commands

. CALL (Subroutine)

. JUMP

Type 2 Commands

. Block number

. SYNC (Block Synchronization)

. LOAD (Parameter)

. ACCEL (Acceleration)

. VELOC (Velocity)

Type 3 Commands

. PMOVE (Positioning Move)

. CMOVE (Continuous Move)

. DWELL

. WAIT

Program/Subroutine Definition Commands

. PROGRAM

. ENDPROG

. SUBROUTINE

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. ENDSUB

Type 1 commands can redirect the program path execution, but do not directly affect positioning.

- Call (Subroutine) executes a subroutine before returning execution to the next command.
- Jumps may be conditional or unconditional. An unconditional jump always redirects execution to a specified program location. A conditional jump is assigned a CTL bit to Check. If the CTL bit is ON, the jump redirects execution to a specified program location.If the CTL bit is OFF, the jump is ignored.

Type 2 commands also do not affect position.

- Block numbers provide identification or label for the Type 3 command that follows.Block numbers are required with JUMP commands; otherwise, they are optional. If a program block does not contain a block number, the previous block number, if any, remains in effect.
- The SYNC (synchronize block) command is a two-axis synchronization command.
- The Load Parameter command allows the user to load a value into a parameter register.
- The Velocity (VELOC) and Acceleration (ACCEL) commands specify velocity and acceleration rates for the Type 3 MOVE command or commands that follow. Velocity and

Acceleration commands remain in effect until changed.

Type 3 commands start or stop motion and thus affect positioning control.

- Positioning (PMOVE) and Continuous (CMOVE) moves command motion.

-The Dwell, Wait, and End of Program commands stop motion.

Example

ACCEL 1000

VELOC 2000

PMOVE 5000, ABS, LINEAR

This example shows how simple PMOVEs and CMOVEs combine to form motion profiles.

VELOC 1200

PMOVE 10000, ABS, S-CURVE

ACCEL 1500

VELOC 2800

CMOVE 6000, INCR, LINEAR

VELOC 1200

CMOVE 23000, ABS, S-CURVE

ACCEL 1000

VELOC 2800

PMOVE 5000, INCR, LINEAR

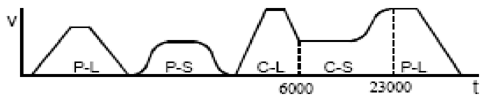

Figure.6.Pulse Generated by encoder

In digital system, the pulses generated by encoder are directly sensed by the PLC, counted in the counter modules and the position of the drive is identified. Depending upon the position of the drive PLC generates the reference to the drive to attain the preset position.

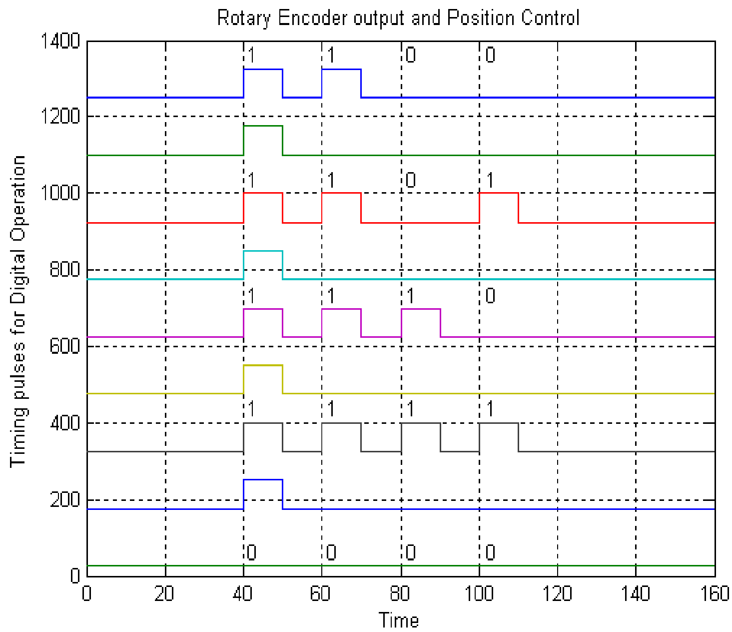

Figure.7.Rotor Encoder Output and Position Control

Conclusion

The new digital position control system consists of very few elements and is supported by the manufacturers. The latest hardware is reliable, consumes less power and failures are less. All the required tuning is possible through software changes and most of the time without shutdown of the equipment such changes can be made online. The position control accuracy is high with digital control system and very easy to diagnose in case of problem in the rolling process in industries. The DSM module which is envisaged for the position control can access 4 independent drives and thus the number of hardware requirement has reduced to a great extent

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BIOGRAPHY

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