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Design a position control system for 3-phase asynchronous motor using PLC and inverter.

Kim Nhi Vu Thi[1,2], Hong Tham Tran Thi[1], Trung Hieu Pham[1]
Faculty of Electrical Engineering Technology, Hanoi University of Industry, Hanoi, Vietnam.

Abstract: *The explosion of scientific progress in the field of electricity - automation today has had profound changes in both theory and practice. First of all, the introduction and improvement of power electronic converters, namely frequency converters, with compact size, high performance, easy connection to control circuits. using microelectronic circuits, microprocessors, PLCs... Today's automatic electric drive systems often use inverters for AC motors and mainly to solve speed problems. In addition, in the problem of motor position control, inverters are also used instead of drivers of servo motors or stepper motors in some specific applications where too high accuracy is not required. Thanks to that, it saves a lot of costs from installation to repair and maintenance; Therefore, the above method is quite common in the field of automation.*

Keywords: *Control system, inverter, PLC S7-1200*

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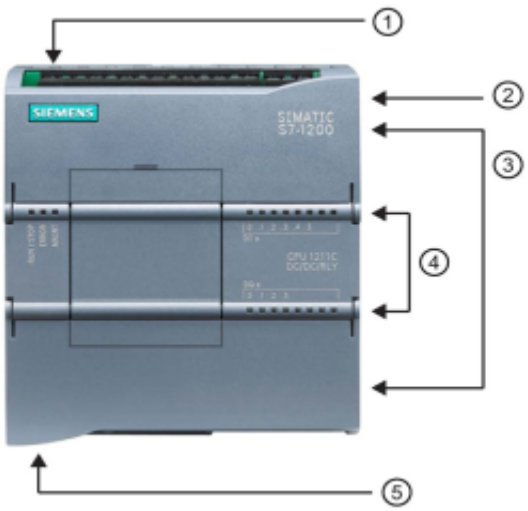
I. Pose the problem

In fact, to solve the problem of position control in industry, people will often use it to control servo motors, stepper motors to ensure accuracy, and for applications that do not require high accuracy. position control of three-phase asynchronous motors is more commonly used. From that fact, the topic aims to: - Applying professional knowledge in practice -Designed a 3-phase asynchronous motor position control system by PLC S7-1200.

II. Components of Control system.

The topic uses a semi-closed control system, so the system includes:
one Controller (PLC)
one set of drivers to control the motor (inverter)
one feedback (encoder)
one three-phase asynchronous motor
one actuator (screw-drive set) Structure of the controller Siemens CPU S7-1200



① Power connector
② Memory card slot under top door
③ Removable user wiring connectors (behind the doors)
④ Status LEDs for the on-board I/O
⑤ PROFINET connector (on the bottom of the CPU)

Feature		CPU 1211C	CPU 1212C	CPU 1214C	CPU 1215C	CPU 1217C
Physical size (mm)		90 x 100 x 75		110 x 100 x 75	130 x 100 x 75	150 x 100 x 75
User memory	Work	50 Kbytes	75 Kbytes	100 Kbytes	125 Kbytes	150 Kbytes
	Load	1 Mbyte	2 Mbytes	4 Mbytes		
	Retentive	10 Kbytes				
Local on-board I/O	Digital	6 inputs/ 4 outputs	8 inputs/ 6 outputs	14 inputs/ 10 output		
	Analog	2 inputs			2 inputs/2 output	
Process image size	Inputs (I)	1024 bytes				
	Outputs (Q)	1024 bytes				
Bit memory (M)		4096 bytes		8192 bytes		
Signal module (SM) expansion		None	2	8		
Signal board (SB), Battery board (BB), or communication board (CB)		1				
Communication module (CM) (left-side expansion)		3				
High-speed counters	Total	Up to 6 configured to use any built-in or SB inputs				
	1 MHz	-				Ib.2 to Ib.5
	100/180 kHz	Ia.0 to Ia.5				
	30/120 kHz	–	Ia.6 to Ia.7	Ia.6 to Ib.5		Ia.6 to Ib.1
	200 kHz[3]					
Pulse outputs[2]	Total	Up to 4 configured to use any built-in or SB outputs				
	1 MHz	–				Qa.0 to Qa.3
	100 kHz	Qa.0 to Qa.3				Qa.4 to Qb.1
	20 kHz	–	Qa.4 to Qa.5	Qa.4 to Qb.1		--
Memory card		SIMATIC memory card (optional)				
Data logs	Number	Maximum 8 open at one time				
	Size	500 MB per data log or as limited by maximum available load memory				
Real time clock retention time		20 days, typ./12 day min. at 40 degrees C (maintenance-free Super Capacitor)				
PROFINET Ethernet communication port		1			2	
Real math execution speed		2.3 µs/instruction				
Boolean execution speed		0.08 µs/instruction				

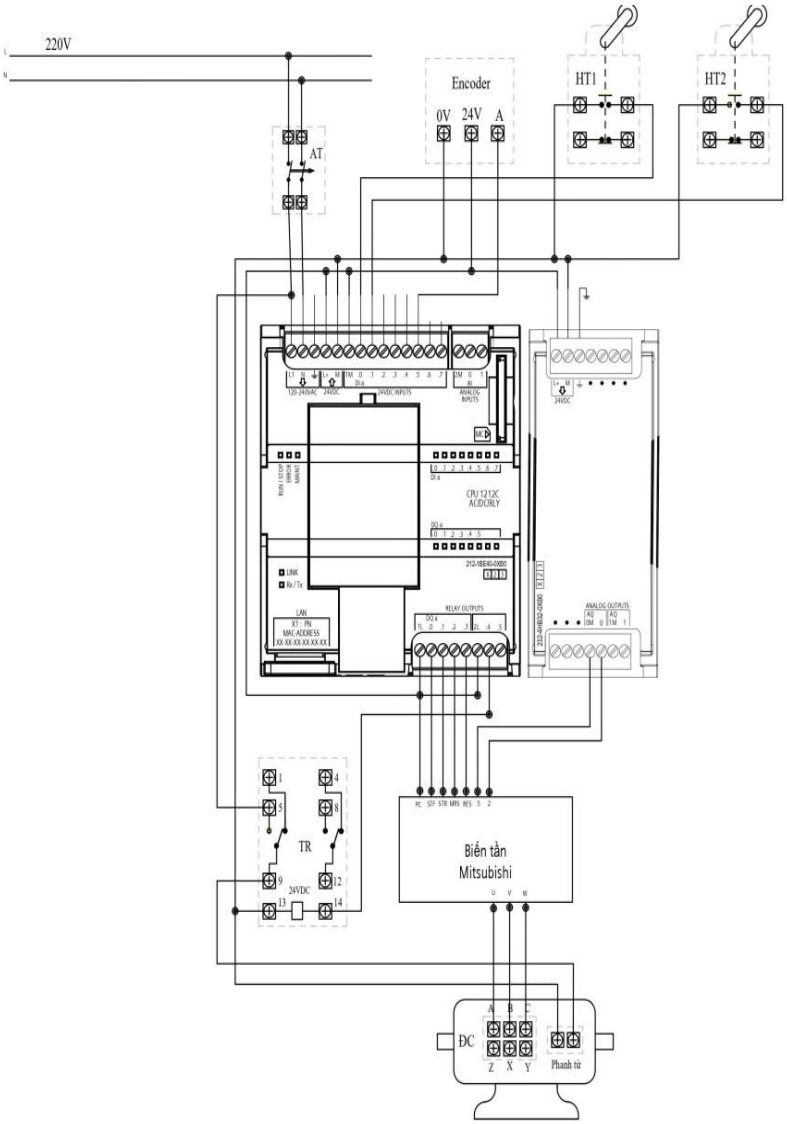
The software used to program the S7-1200 is Step7 Basic. Step7 Basic supports three programming languages, FBD, LAD and SCL. This software is integrated in Siemens TIA Portal V11 and the latest version is TIA Portal V16.

III. System selection and design

Select Mitsubishi E700 inverter type FR-E710W-0.2K Specifications : Power : 0.2kW Rated current : 1.5 A Voltage for inverter: single phase voltage 220V Voltage for 3-phase asynchronous motor: 220VAC Overload capacity :150% for 60s Analog input: 2 ports Analog input signal: 0-10V, 0-5V,4-20mA Digital input: 7 ports Choose a resolution: Engine speed is 2720 rpm. The response rate of the PLC S7-1214C is 100 kHz. There are n = 2720 rpm = (2720/60) = 136/3 (rpm). We choose the resolution for the largest Encoder to measure engine speed will be: (100*1000)/136/3 = 2250 PPR (Pulses Per Revolution)

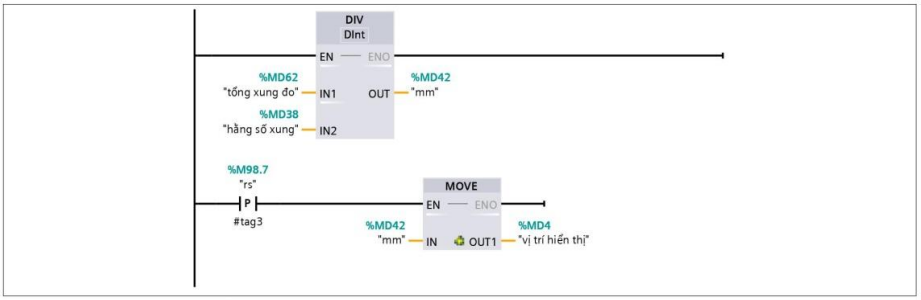
Choose the resolution for the Encoder as high as possible but not exceed 2250 PPR. So choose an encoder whose code is E6B2-CWZ6C of omron.

Specifications : Resolution : 2000 P/R Output Phase: A,B and Z. Shaft diameter: 6mm Body diameter: 40mm Operating voltage: 5-24VDC Current consumption: max 70mA Frequency response: 100KHz. Standard: IEC 60529 IP50 Cable length: 2m Working temperature: -10 ~ 70C Encoder type : relative Output type: NPN open collector.



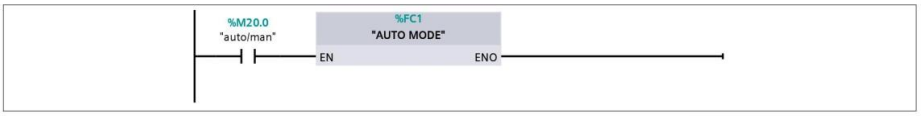
PLC programming

Totally Integrated Automation Portal

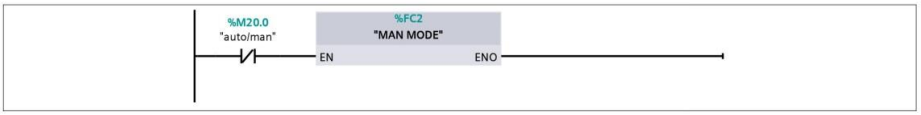


Network 7: Chu kỳ kỳ lây mẫu

Network 8: chế độ chạy tự động



Network 9: chế độ chạy tay



Network 10: Xác định chiều di chuyển

chạy thuận là hướng về điểm gốc 0
chạy nghịch là hướng ra xa điểm gốc 0

Totally Integrated Automation Portal

the first test / PLC_1 [CPU 1212C AC/DC/Rly] / Program blocks

AUTO MODE [FC1]

AUTO MODE Properties					
General					
Name	AUTO MODE	**Number**	1	**Type**	FC
Language	LAD	**Numbering**	Automatic		
Information					
Title		**Author**		**Comment**	
Family		**Version**	0.1	**User-defined ID**	

AUTO MODE

Name	Data type	Default value	Supervision	Comment
Input				
Output				
InOut				
▼ Temp				
đếm sườn lên	Bool			
▼ in	Array[0..5] of Int			
in[0]	Int			
in[1]	Int			
in[2]	Int			
in[3]	Int			
in[4]	Int			
in[5]	Int			
temp1	Bool			
temp2	Bool			
số bước	Int			
Constant				
▼ Return				
AUTO MODE	Void			

Network 1:

Network 2: chọn chương trình

Next, we set the basic parameters for the inverter. Pr.1 = 50 (Hz) : set the maximum frequency Pr.2 = 0 (Hz) : set the minimum frequency Pr.3 =50 (Hz) : set the base operating frequency Pr.7 = 2 s: Set acceleration time Pr.8= 1 s : Set deceleration time Group of motor parameters (can not be set with small, low-power motors).

Pr.80 = 180 W: Set the rated power of the motor Pr.81 = 9999 : The inverter will automatically determine the number of pole pairs of the motor Pr.82= 0.92 A : No-load current of the motor Pr.83 = 220V : Rated voltage of motor Pr.84 = 50 Hz : rated frequency of motor Next, install the input pins: Pr.73 = 0 : Select the analog input voltage type 0-10V Pr.125 =50 Hz : Set the frequency corresponding to the maximum value

that the analog voltage input can change, namely the range from 0-10V. Finally, select Pr. 79 = 2 : Select the running and stopping control mode from the outside, specifically from the PLC

IV. Conclusion

Result : -Three-phase asynchronous motor with squirrel-cage rotor. - Inverter system. - PLC S7 1200 and TIA PORTAL . programming software - Electromagnetic brake - Screw drive unit

• Design and control the system to satisfy the proposed technology requirements. Grasping basic knowledge about PLC, inverter, encoder, 3-phase asynchronous motor • Know how to connect PLC, inverter, motor, encoder.

• Know how to set inverter parameters The limitations and disadvantages of the model

• Because the design of the vitme slide shaft has errors that lead to misalignment, causing strong vibrations when running. Encoder does not have a fixture to hold, resulting in the number of measured pulses being erroneous, causing the measured result to be deviated from the desired position.

• Due to using an old engine and partly because the brake is too tight, when rotating at low frequency, the motor takes almost a while to move, even sometimes gets stuck.

• When running at high speed over about > 1400 RPM , the engine will not stop in time to the desired position , the vitme will move continuously forward and backward without stopping. The topic of building a closed control system, speed feedback (using encoder), to control the position of a three-phase asynchronous motor with squirrel cage rotor using PLC, inverter. This system allows efficient use of asynchronous motors, not only for speed control but also for position control in electric powertrain applications in industrial plants.

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