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State Program Vs. Ladder Program for Stepper Motor Control

Anita Azmi
anita@uthm.edu.my
Universiti Tun Hussein Onn Malaysia

***Abstract*—** Stepper motor is a brushless electric motor and an electromagnetic device that uses magnetic field for movement with the aid of digital pulses. Stepper motor is precise and accurate in producing discrete stationary angular rotations and because of this characteristic it has been used in various applications such as printer, sorter and so forth. Generation and controlling of digital pulses for stepper motor can be obtained by using different controller such as PC, microcontroller or Programmable Logic Controller (PLC) via different languages. This paper focuses the controlling of the pulses for stepper motor by Programmable Logic Controller (PLC) using State Program language and Ladder Program. Both languages are compared and it is found that State Program has the advantages of minimizing the number of program steps, simplifies the program, friendlier and easier to program and understand compared to Ladder Program.

***Keywords*: stepper motor control, digital pulses generation, PLC, State Program language, Ladder Program Language**

I. Introduction

Overview

The control of an industrialized process in the proper sequence especially that involve groups of machines and material-handling equipment has traditionally been formed by hardware devices based on mechanical, electromechanical and pneumatic controlling principles. Beginning of 1968, programmable logic controller known as PLC was introduced to replace the traditional devices [1]. As automation become more intelligent and flexible, the controller is improved by upgrading the software from ladder logic to higher language to cater the evolution of the automation level.

Motion control is one of the capability of PLC. Motion control is the control of how accurate the degree of hardware movement based on speed, distance, load, inertia or a combination of all these factors. There are various types of motion control systems including stepper motor, dc brush, brushless, servo, brushless servo etc.

This paper concentrates on stepper motor control. Stepper motor needs pulses to move according to the direction set. A stepper motor is normally commanded by two digital inputs: a digital pulse train and a direction bit. A single pulse on the pulse input moves the motor one step increment in the direction clockwise (CW) or counterclockwise (CCW) set by the direction bit [2].

There are two types of software being used for stepper motor control, CX-Programmer software is a program based on ladder logic and the PLC used is OMRON CQM1H. For the state program , PLC used is CTC with Quickstep program. Both PLCs used are the controller that can generate and control digital pulses except they are from different manufacturer.

II. Ladder Programming

Ladder logic programming is the adaptation of the relay connections. It is widely used in the industries when PLC is introduced until now but as the projects become more complex then the ladder logic program is upgraded into higher language to cater the advancement of the system.

For stepper motor control using OMRON CQM1H, the setting of the rotation direction is by setting it externally as in Figure 1.

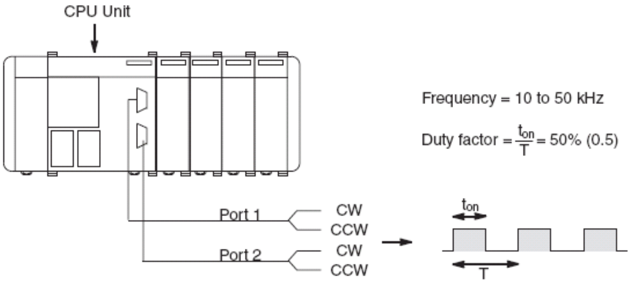

Figure 1 : Setting of rotation Direction of Stepper Motor

The selection of the rotation will be the input signal to C of the Pulse Function Block.

The example program for controlling the stepper motor is as Figure 2 :

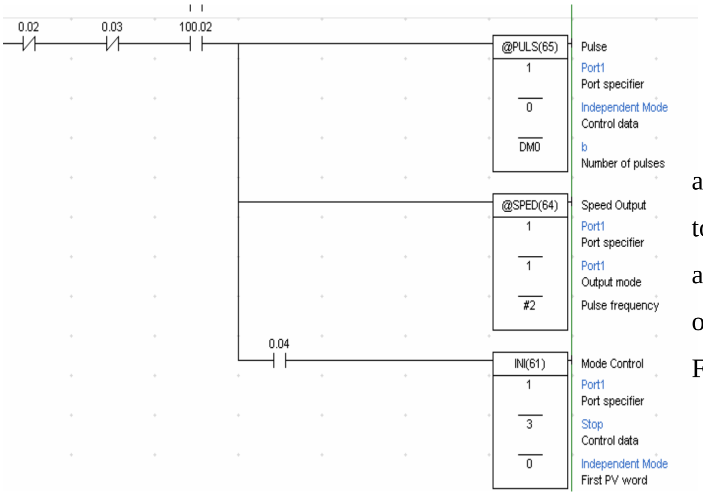

Figure 2 : Ladder Logic for Stepper Logic

The function block that involve in forming the stepper motor control for Ladder logic Program are Pulse Function Block, Speed Function Block and INI Function Block.

P is the port specifier, 000 or 001; C is the control data to set the direction of pulses output to port 1 or port 2 to indicate the rotation direction as clockwise (CW) or counter clockwise (CCW); N is the number of pulses to be output. Figure 3. shows the diagram of pulse functional block.

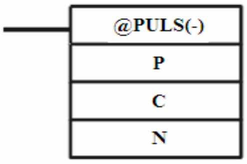

Figure 3: Diagram Of Pulse Functional Block

The functional block @SPED(-) is also triggered together with functional block @PULS(-). P is the port specifier, 000 or 001; M is the output mode; F is the value of pulse frequency . Figure 4 is the diagram of speed functional block.

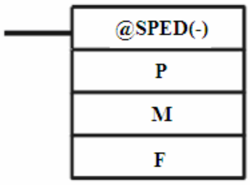

Figure4 : Diagram Of Speed Functional Block

The functional block @INI(61) in Figure 5 is applied when the limit switch is triggered. Pulse output has to be stopped immediately when the functional block is applied. P is the port specifier, 001 or 002. The current ouput status can be read from the pulse output in Progress Flag (AR0515 / AR0615) [6].

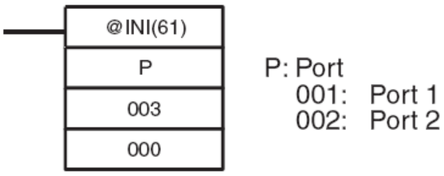

Figure 5: Diagram Of INI Functional Block

The mnemonics for Figure 2 is:

```
LDNOT 0.02
ANDNOT 0.03
AND 100.02
@PULS(65) 1 0 DM0
@SPED(64) 1 1 #2
AND 0.04
INI(61) 1 3 0
```

Besides drawing the ladder logic the corresponding mnemonics is as shown above and it is quite hard to program if the program needs motor than 1 motor to control.

III. STATE PROGRAM

State Program is a high level program language. This program is similar to daily language and easier understand. Example below is the program to control stepper using Sate Program.

```
profile motor_1 (half) basespeed = reg_200  maxspeed
= reg_201  accel = reg_202 decel=reg_203
pr ofile motor_2 half) basespeed = reg_200  maxspeed
= reg_201  accel = reg_202 decel=reg_203
monitor (and motor_1:stopped motor_2:stopped)
```

To do the homing, another line of statement is as below,

```
profile and zero motor_1 (half) basespeed=reg_10
```

To set the rotation direction, the program should be as below:

```
maxspeed=reg_11 accel=reg_12 decel=reg_13
search  cw  and  zero motor_1
turn  motor_1  ccw   750  steps [9]
```

Figure 6 : Sample of Stepper Motor Control

The max speed is maintained until stepping motor control module calculates that the motor must begin to decelerate and the unit is in steps/sec. Acceleration speed (accel) determines the rate at which the motor accelerate to maximum speed. A relative factor 1 to 500 and 500 is the instantaneous acceleration. Typical range 200 to 475.

IV. COMPARISON

These two languages is compared and the result is as Table 7.

Program types	Rotation Direction setting	Homing position	Stepper Motor Type Settying	Frequency of pulses	Program Structure
State Program	Using internal instruction cw or ccw	Use instruction : search cw and **zero motor_1**	Use instruction: profile motor_3 (half) or profile motor_3 (2 coils)	Can varies depends on the setting values.	Use statement that is clear and easy to understand
Ladder program	Using external setting cw or ccw	Use external switches for the setting	Use external setting and driver	From 20 Hz to 1 kHz	Ladder logic and graphical.

Table 7 : Comparison of State Program and Ladder Logic program

It is shown that even though both PLC and software can control stepper motor but State Program is easier, clear and offers more flexibility in setting the steps, rotations, homing, types of stepper motor and many other features.

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