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CONTROLL OF AN ELECTRIC STEPPER MOTOR USING THE SIEMENS SIMATIC S7-200 PLC CONTROLLER

Abstract: The article is focused on the system dedicated for controlling an electric motor (the Siemens Simostep drive) using the SIEMENS S7-200 PLC. The authors have extended the research scope by specifying the electric drive sequence and to visualize the process using the HMI panel. The main goal was to design different motion sequences of the stepper motor, whose parameters can be set using the HMI panel.

1. Introduction

The dynamic development of industry and modern technologies as well as striving to increase security have contributed to the automation of many production processes.

PLCs belong to the most dynamically developing area of industrial automatics. In modern industry more and more complicated production processes are used, which brings with a greater interest in PLC controllers. Such state is caused by easy connection with PC, software availability and lower installation costs of innovative automatic control systems [1,2]. The basic principle of PLCs operation is sequential processing of an algorithm, the controller carries out individual signals in the order in which they were saved in the program.

Control of stepper drives is one of the challenges of many production plants. The stepper motors are characterized by [3,6,9]:

- high precision positioning outputs,
- wide range of applications, among other things: usage in general arrangement of drives automation systems, positioning drives, robotics, etc.,
- optional holding brakes for fixing the position after switching off,
- positioning realized by dedicated controllers.

For the group of disadvantages of stepper motors can be included [3,6,9]: low efficiency, torque drop, low accuracy, prone to resonances, requirement micro stepping to smooth movement, no feedback to indicate missed steps, low torque to inertia ratio, low output power for size and weight. Despite many disadvantages, stepper motors are still a solution that enjoys popularity in many industrial applications.

2. Description of the laboratory stand and software

The laboratory stand (Fig. 1) has been built on the basis of industrial automation components, among which can be distinguished:

- the Siemens PLC Simatic S7-200XP (CPU 224XP),
- the Siemens EM 253 Positioning Module,
- the FM-STEPDRIVE/SIMOSTEP Power Controller,
- the Siemens Simostep Stepdrive 1FL3041,
- the Siemens TP 177micro Touch Panel.

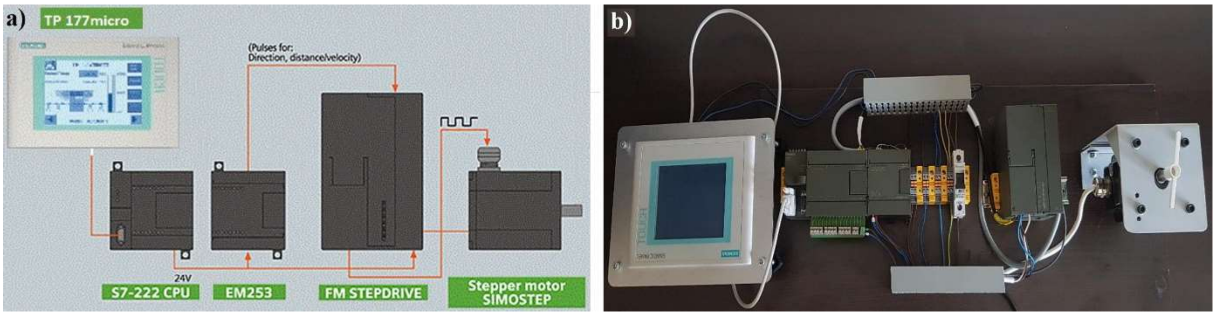

Fig. 1. Views of: a) the schematic layout of the system [4], b) the real layout of the laboratory stand

The S7-200 PLC is an example of controllers family designed to automate machines and small devices. The controller's task is to handle the main control algorithm, supervise the connected modules, distribute and download data from the HMI panel. The STEP 7 Micro/WIN software has been used for the purpose of developing algorithms.

The EM 253 Positioning Module [4,5] is a function unit for simple positioning tasks. The module can control stepper motors and actuators through high frequency pulse output. The Siemens FM-STEPDRIVE Power Controller can be used for stepper motors with torques within the range 2÷15Nm. The FM STEPDRIVE power section controls the motion of the stepper motors in the SIMOSTEP 1FL3 series with high precision. In combination with the S7-200 and the EM 253 function module, it performs highly accurate positioning tasks in the lower output range of 600W [5].

Depending on the program, the positioning module EM 253 generates specific pulses (that define a direction, a distance and a speed). The transfer of these impulses to the inverter and the stepper motor takes place via two outputs (P0 - speed and P1 - direction of rotation).

The hybrid SIMOSTEP Stepdrive motor is a combination of a stepper motor with permanent magnets (a permanent excitation type) and a reluctance stepper motor.

Easy and clear reading of not only the PLC input and output states, but also the current motor movements are possible thanks to the Siemens TP177 Micro touch HMI panel. Communication between the panel and the controller enables visualization of inputs or outputs status, as well as controlling of motor movements [7,8].

The SIMATIC WinCC flexible 2005 micro programme was used to create the visualization structure. Described software is a part of the SIMATIC WinCC platform. This package, as a visualization software, is efficient and optimized for applications where a local control and reliable monitoring is required. The WinCC flexible is designed for all industrial branches and is the most optimal software solution dedicated for SIMATIC HMIs.

3. The PLC programme in the Step7 Micro Win environment

The PLC program has a tree structure. The main block uses *Call* functions that call subroutines located in the other blocks. This way of writing the program is characterized by transparency and allows the use of local variables. The controller program consists of 10 networks. Each network has its purpose to control the Siemens Simostep Stepdrive motor. Table 1 presents a list of subprograms with a short functional characteristics.

Tab. 1. The list of subprograms used for movement control of the Siemens Simostep Stepdrive

Subprogram name	Functional characteristics
POS0_DIS	• used to enable or disable the *DIS* output positioning module (it allows to use this output for the pulse edition for the STEPDRIVE FM drive unit), • the program is started by stating the input *I0.0* (PLC) or *M0.0* (HMI),
POS0_CTRL	• activates and initializes the EM 253 positioning module (this is done by automatically sending the command to the EM253 positioning module to load the configuration each time), • the S7-200 automatically goes into the RUN operating state,
POS0_MAN	• sets the positioning module for manual operation, • in this mode, the drive can be operated at different speeds or in positive or negative pulse mode direction, • the program is started by stating the input: *I0.2* (PLC) or *M0.2* (HMI) for RUN mode, *I0.3* (PLC) or *M0.3* (HMI) for JOG in positive direction mode, *I0.4* (PLC) or *M0.4* (HMI) for JOG in negative direction mode,
POS_RUN	• subroutine instructs the position module to move within a specific profile described by the user, • turning on EN bit allows to execute the desired instruction, turning the START parameter on sends the RUN command to the EM 253 Position Module, • it is a parameter that causes turning on the START parameter to perform the intended motion with a stepper motor, • the program is started by stating the input: *I1.1* (PLC) or *M1.7* (HMI) for START mode of Profile 0_0:VB646,
POS0_GOTO	• sends the positioning command to the EM 253 module to go to the desired position specified by user, • the program is started by stating the input: *I0.6* (PLC) or *M1.2* (HMI) for START mode of movement in position specified by user using HMI, • the program can be stopped by stating the input: *M1.1*(HMI),
READ_RTC	• used to provide the current time value on the HMI, • using VB0 address and Tag user can get the real time on Touch panel.

4. Cycles programming

The Step Micro/Win software allows to program cycles to control the stepper motor. On the other hand wizards are a very useful tool, which in a graphical way enable the exact programming of a given profile (calling via a digital input) of moving the motor. The wizard included in the software allowing adjustment the parameters of the engine's operation and to program the relevant parameters or entire work cycles [4,5].

In order to perform the parameterization of the motor, basic parameters should be set between the others (Fig. 2): the speed (a maximum, an initial and the final speed), JOG parameters (JOG_INCREMENT - the distance to move the tool with each JOG command, JOG_SPEED - the maximum speed obtained, when the JOG command remains active), acceleration and deceleration times (ACCEL_TIME - the time required to accelerate the engine from SS_SPEED to MAX_SPEED, DECEL_TIME - the time required for the engine to be released from MAX_SPEED to SS_SPEED).

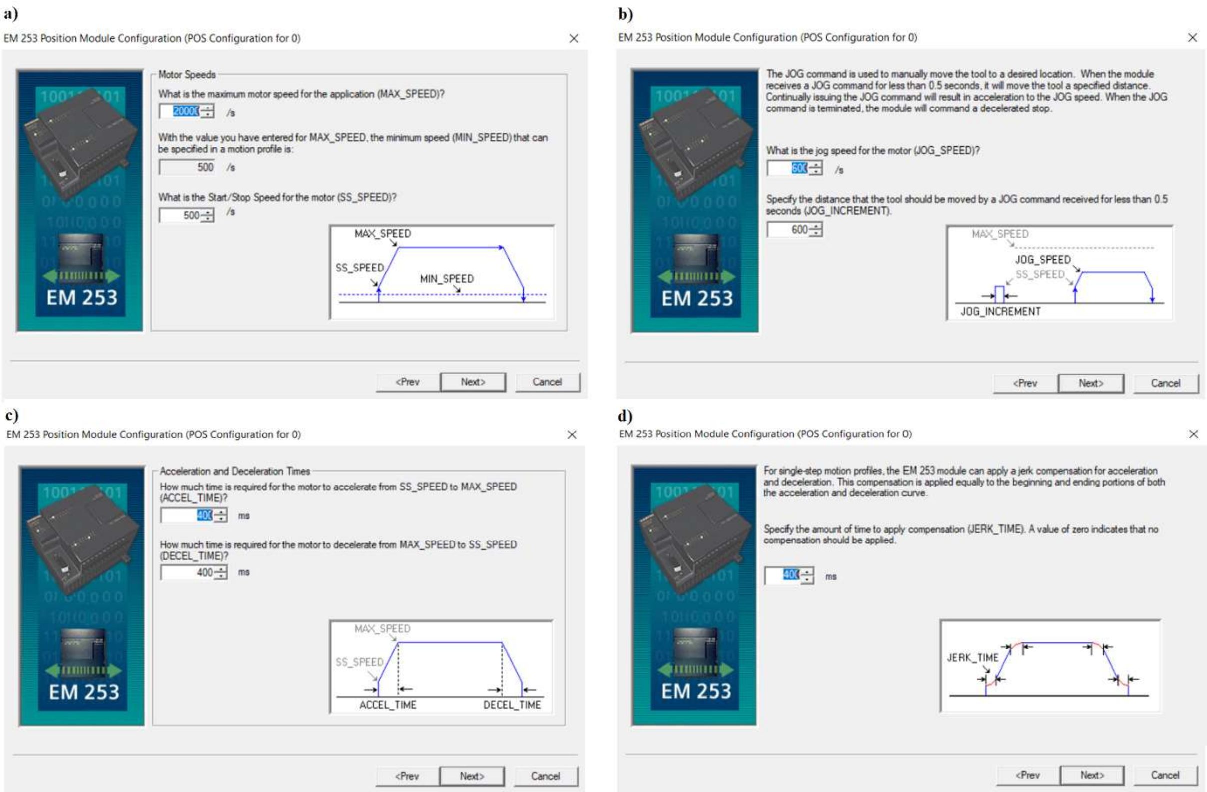

Fig.2. Views of: a) engine speed configuration window, b) the jog speed and jog increment definition window, c) acceleration and deceleration times window, d) jerk time parameters configuration window

As a result of the work, eight different cycles of the stepper motor were made. The relative position mode is presented to indicate the programming characteristics. In relative position mode, the motion profile block should specify from one to four steps, with each step containing both the position (POS) and the speed (SPD), which describes the traffic segment. Figure 3 shows definition window of cycle programming.

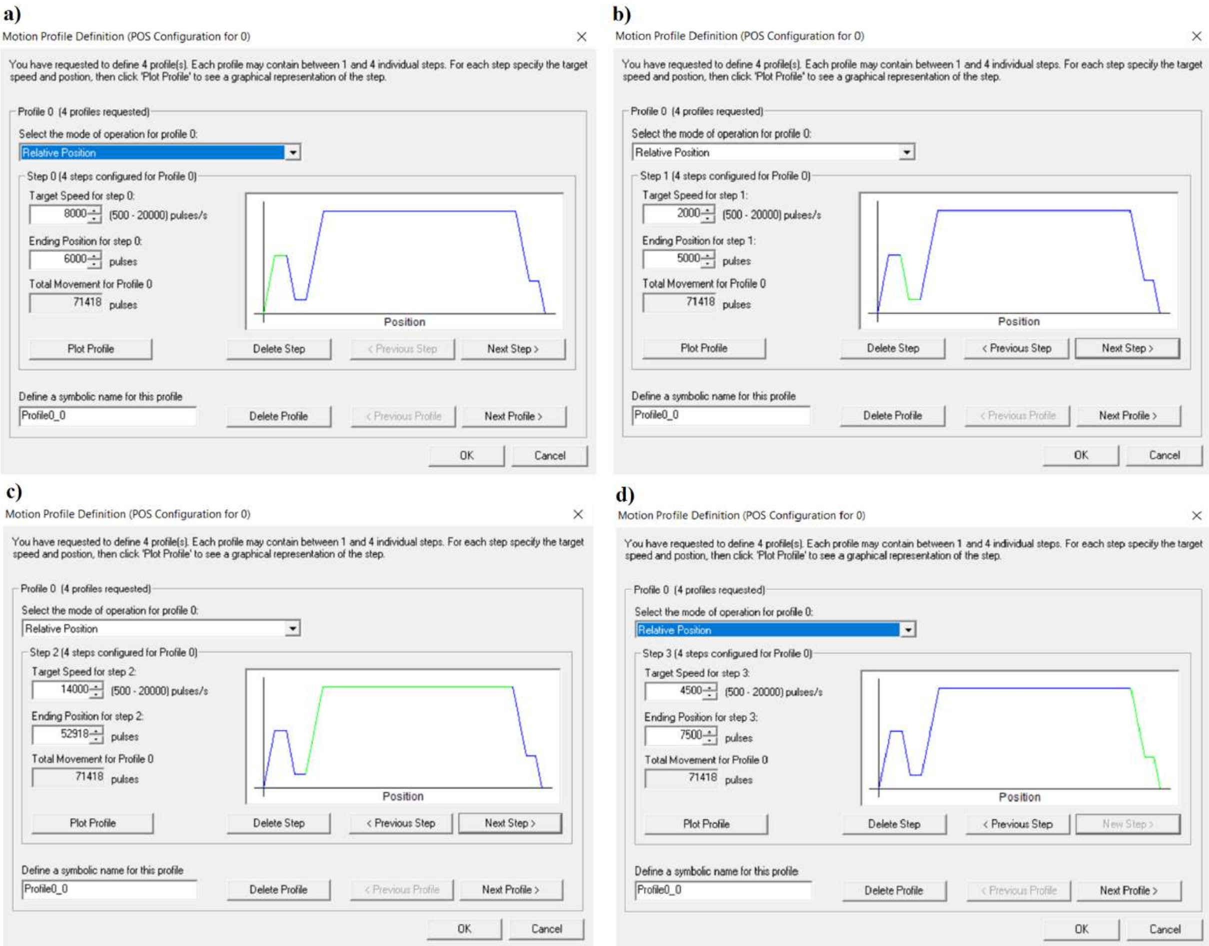

Fig.3. Views of cycle definition: a) first, b) second, c) third, d) fourth

The idea of creating visualization in the Siemens WinCC flexible software involves linking elements such as switches, text boxes, and controls with appropriate areas in a PLC memory.

The program in the device consists of screens that support individual subprograms. The most important element in the entire program is the correct configuration and assignment of the tag for each element displayed on the screen. The tag is used to recall a specific item on the screen with the S7-200 controller memory register [4÷7].

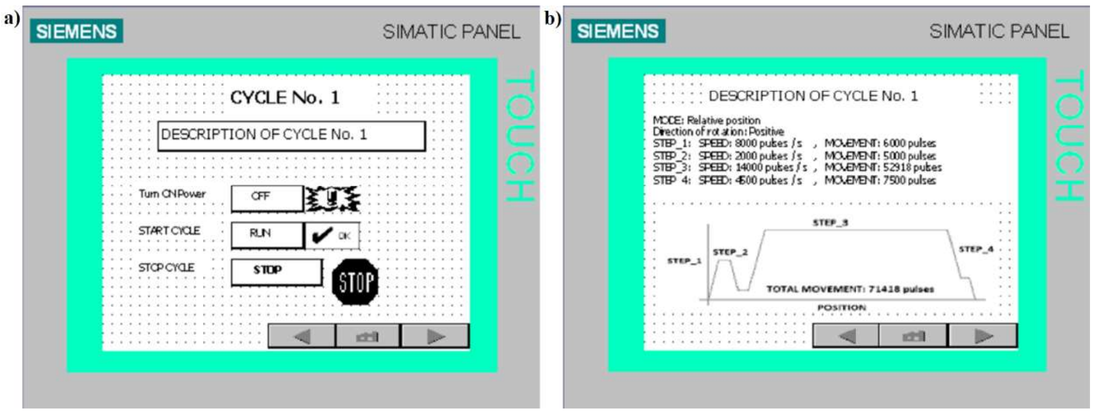

Fig.4. Views of: a) the main screen of an exemplary cycle, b) visualization of motor movement

Using the screen, which enable to start the engine work cycle using the function buttons. User can easily read the parameters of each step of the engine's work, speed and displacement. Using the keys at the bottom of the screen, it is possible to go back to the previous screen or return to the main menu.

5. Conclusions

The PLC controllers are finding more and more applications, not only in the classically understood machines, but also among other applications related to an automation. This is due to the drop in their prices and broad application possibilities.

Programming the PLC controllers requires a lot of knowledge and experience, which allows to eliminate such phenomena as, among others, overwriting registers, confusing the logic of the program, implementation of an algorithm that causes damage to machines or production lines, etc.

The software for programming PLCs and the wizards included in it, make programming very easy, which shortens the programming time in a significant amount. All programmed cycles have the possibility of an emergency stop due to which the engine operation is safe.

The ability to control the motor with a touch panel and physical switches located on the PLC gives the possibility to control the motor in two ways and enables operation in case the touch panel fails.

The disadvantage of the software used to program the TP 177micro Touch Panel is that user cannot create a backup program located on the device, if operator does not have a project file, it is impossible to get it from the device. It may induced serious problems during making changes to the device program.

References

1. Collins K.: PLC Programming for Industrial Automation. London: Exposure Publishing, 2006.
2. De Silva C.W.: Mechatronics: an integrated approach. New York: CRC Press, 2005.
3. Dutta N.K., De S.K.: Electric Machines and Electric Drives: Problems with Solutions. New Delhi: PHI Learning Pvt. Ltd., 2012.
4. Jones C.T.: Step 7 in 7 steps. Atlanta: Patrick-Turner Publishing, 2009.
5. Siemens Manual: Application and tools. Nuernberg: Siemens, 2003.
6. Siemens Manual: FM-Stepdrive/SIMOSTEP Power Controller and 3-Phase Stepping Motors. Nuernberg: Siemens, 2005.
7. Siemens Manual: S7-200 Programmable Controller System Manual. Neurnberg: Siemens, 2005.
8. Siemens Manual: Simatic HMI WinCC flexible 2008. Neurnberg: Siemens, 2008.
9. Toliyat H.A., Kliman G.B.: Handbook of electric motors. New York: CRC Press, 2004.