POZNAN UNIVERSITY OF TECHNOLOGY ACADEMIC JOURNALS
No 99 Electrical Engineering 2019

DOI 10.21008/j.1897-0737.2019.99.0017

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MODEL OF A SLIDING GATE CONTROLLED BY A PLC DRIVER

Due to low costs, PLC controllers are used not only in technological processes but also in everyday life. The article presents the possibility of using a PLC controller to control the operation of a sliding gate. For this purpose, a design was created and a sliding gate model made controlled with a Siemens S7-1200 PLC controller. This model is used to develop various gate control algorithms, especially for appropriate gate protection against crushing or uncontrolled closing. In addition, this model is connected via the Internet to a stand equipped with the SCADA application. The iFix 5.8 PL application was used to visualise the operation of the door, which, by means of a communication driver, allows the elevator operation to be controlled remotely. In addition, elements are shown in a graphic way, whereby it is possible to assess the position of the gate..

KEYWORDS: PLC, sliding gate, visualisation.

1. INTRODUCTION

The history of PLC controllers begins in the late 1970s when the first PLC (Programmable Logic Controller) Modicon 084 (Modular Digital Controller) [1, 2, 3] was constructed. Since then, there has been a rapid development of these devices. At the initial stage, manufacturers competed with each other for programming methods and available interfaces, which resulted in numerous difficulties when trying to use several devices from different manufacturers. Only the IEC 61131 standard published in 1993 organised information about programmable controllers. This standard is divided into five parts in which each part deals with other issues related to PLCs:

– Part 1. General Information;
– Part 2. Equipment Requirements and Tests;
– Part 3. Programming Languages;
– Part 4. User Guidelines;
– Part 5. Messaging Service Specifications.

The standard presented above describes programming languages that are the same for all types of PLCs regardless of the manufacturer of these devices. In

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spite of that, various manufacturers of PLC controllers use applications for programming only their own controllers. The following are some examples of applications:

- Siemens family of Simatic controllers – TIA Portal;
- Mitsubishi – GX Works;
- Allen Bradley – RSLogix 5000;
- Eaton – Easy Soft.

Controllers are used everywhere where there are electrical signals and the need to control various types of processes [4, 5]. The present study introduces a didactic model of a sliding door, controlled by a PLC controller. This model was constructed in accordance with the assumptions made for the sliding doors. In particular, the emphasis was placed on ensuring the safety of users through the use of various types of protection against crushing or uncontrolled closing. In addition, various PLC work algorithms have been proposed that focus on the safety of using the doors.

2. DESIGN ASSUMPTIONS

Since the sliding door model is supposed to reflect the real system operation, it must be subject to the same design assumptions as the actual gates. Since gates belong to the group of construction products, in order to be legally traded they must meet a number of criteria, described, among others, in the PN-EN 13241-1+A1:2012 or PN-EN 12453:2002 norms. Among the most important assumptions for sliding gates, the following ones can be mentioned:

- Protection against crushing and shearing – in order to meet this point, gates are equipped with various safeguards, whose task is to protect the persons operating against danger;
- Forces exerted – these are the forces that a gate can produce. The value of the force depends on the size of the gate and the time of operation. Examples of values are presented in Table 1.
- Electrical safety – all electrical components included in the gate equipment should be designed and made in such as way as not to pose a threat to the health and life of users during operation.
- Electromagnetic compatibility – Gates should not be a source of electromagnetic interference and should be resistant to such interference.
- Protection against self-closing – especially for raised gates.
- Water tightness – there should not be any water leakage.
- Resistance to wind load – the gate must withstand pressure differences caused by wind gusts [6, 7, 8].

In the present model, the largest emphasis was put on ensuring the safety of the gate users. For this purpose, triple protection against crushing and uncontrolled closing has been used. As the norms show, the value of crushing forces varies and depends primarily on the weight of the gate. Exemplary values of forces depending on the weight of the gate are summarised in Table 1.

Table 1. Examples of forces exerted by the gate.

Permissible dynamic forces	The width of the door opening slit	
	slit up to 500 mm	slit over 500 mm
gate moving horizontally	400 N	1400 N
gate rotating in relation to the axis perpendicular to the ground	400 N	1400 N
gate moving vertically	400 N	400 N
gate rotating in relation to the axis parallel to the ground	400 N	400 N

Protection of the motor moving the gate from one side should be set to the minimum value, so as to prevent crushing by the gate [8]. On the other hand, it must be large enough to overcome the rolling resistance of the gate as well as other resistances that occur during use (e.g. dirt or snow covered). The model discussed focuses on the development of algorithms that will prevent the possibility of crushing the gate while maintaining the correct operation of this element.

3. GATE CONTROL

The gate is controlled by the SIEMENS S7 1214 DC/DC/DC controller. The TIA Portal application in version 14 was used to program the PLC. The application window is shown in Figure 1. The window is divided into 5 smaller panels used to configure the PLC and to write the correct program.

The program for controlling the gate was written in the ladder language LD (*Ladder diagram*). An example of a block diagram of the operation of the gate is shown in Figure 2.

The front panel contains buttons that reflect the functions available on the remote control in the actual gate. In addition, the STOP button was used to protect the control system in case one of the protections should not activate. It also plays a key role in the testing of various types of control algorithms and the selection of security sensitivity.

Because nowadays more and more functions are automated and available remotely, in the case of sliding gates they must cooperate with other installations available in the building.

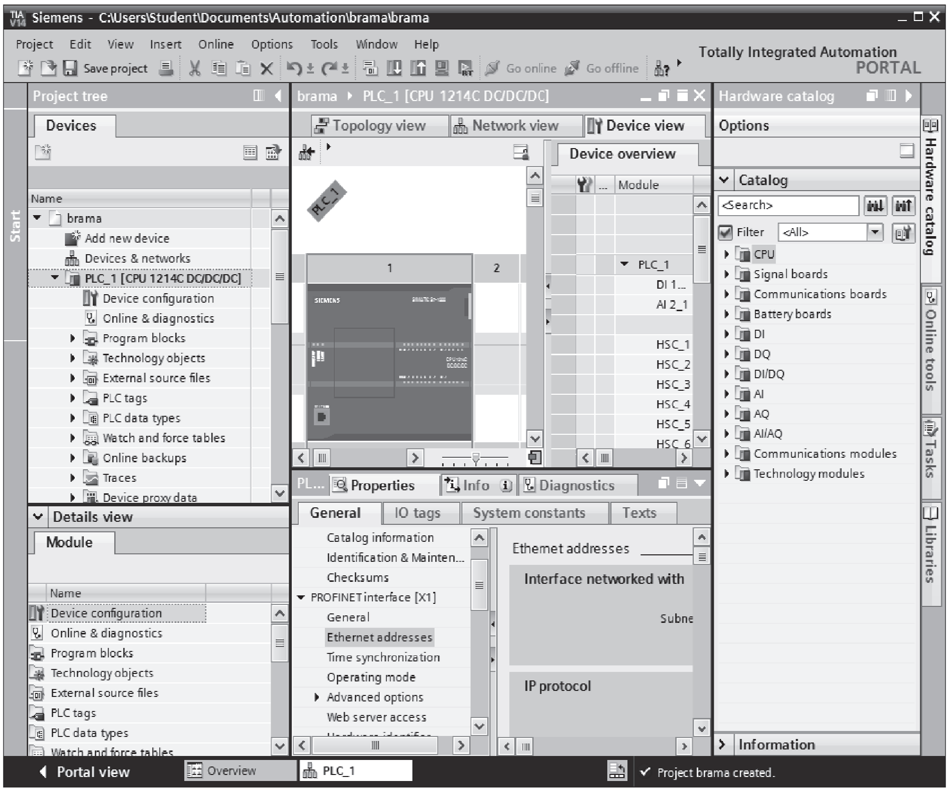

Fig. 1. The TIA Portal application window

In the case of PLC controllers, SCADA (*Supervisory Control and Data Acquisition*) applications dedicated for this purpose are used. One of them is the iFix 5.8 PL application. This application is equipped with an HMI (*Human Machine Interface*) panel thanks to which it is possible to read the status of the controller inputs and outputs [9, 10]. By visualising the model as in Figure 3, it is possible to generate signals simulating the work of inputs (through markers) which gives the possibility of remote control of the gate's operation. This application makes it possible to read signals generated by sensors via a PLC. This allows the creation of animations which gives the possibility of remotely observing the location of the gate via the Internet [11, 12].

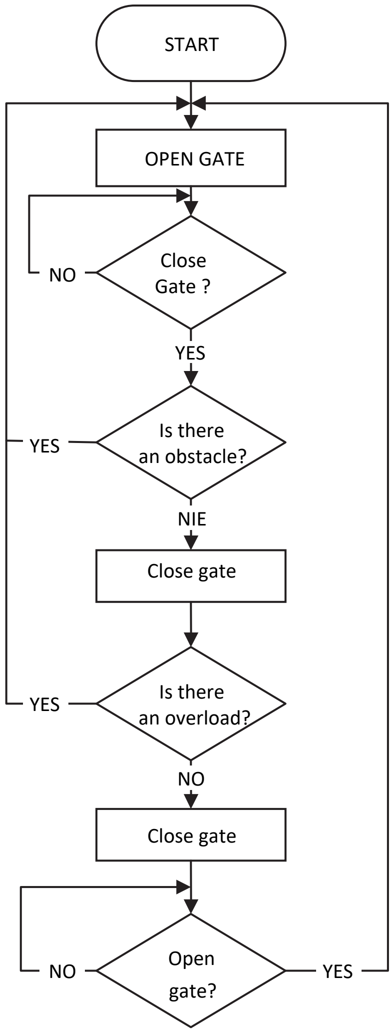

Fig. 2. Block diagram of the program

From the point of view of the selection of security measures, it is also important to be able to observe the moment of operation of individual protections. In the present model, this is indicated by three virtual controls.

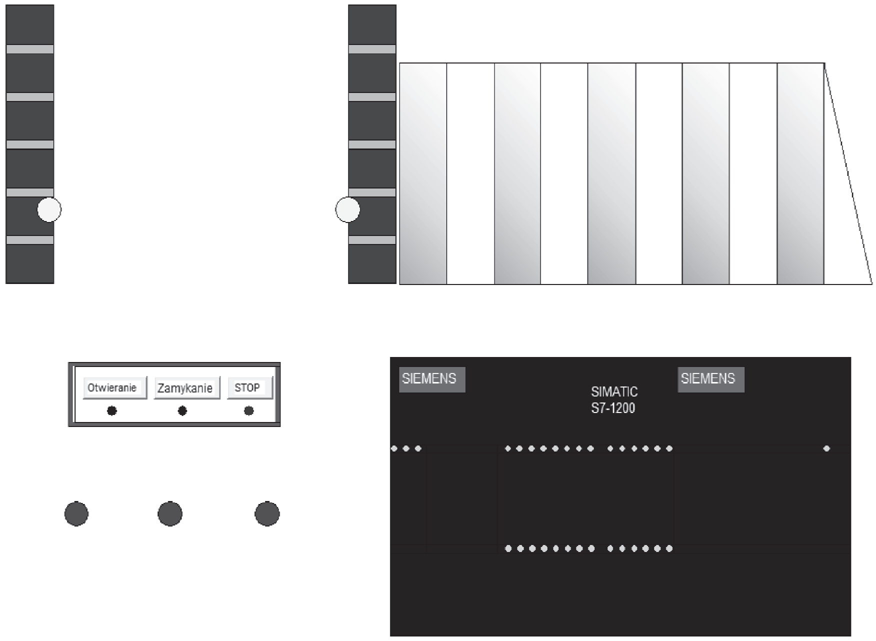

Fig. 3. Visualisation of the gate operation in the iFix program

4. CONSTRUCTION OF THE MODEL

In the construction of the model, commonly available electronic components were used:

- Resistors;
- Photoresistor – PGM5526;
- Laser diode – SPLPL90-3;
- Limit switch – FR551.

On the other hand, the gate's operation is provided by the SIEMENS S7 1214 DC/DC/DC PLC controller. In addition, an SB 1231 signal board with an analogue input (+/- 10V DC – 12 bits) was used. The signal for additional analogue input is supplied from the motor power supply resistor. This solution allows the measurement of the engine load and detection of possible hazards.

The model built performs the same functions as the real system. The model is shown in Figure 4.

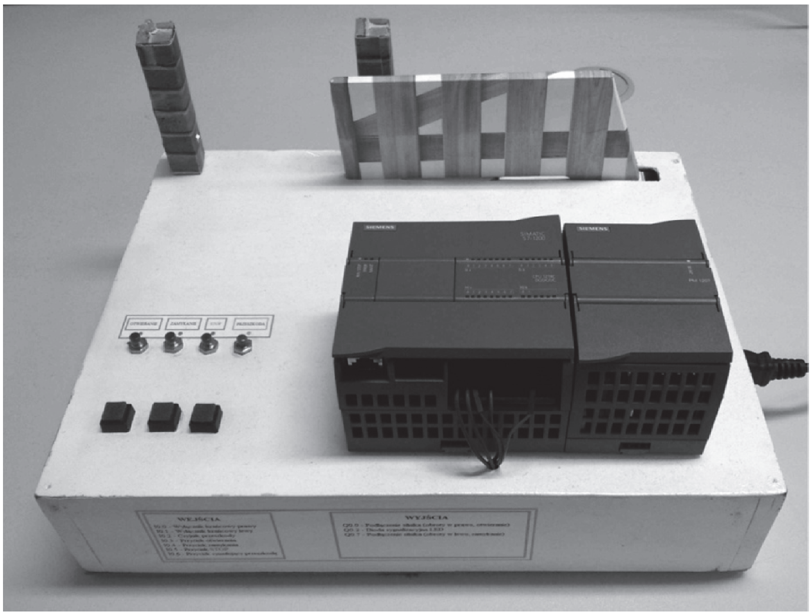

Fig. 4. Model view

The main elements responsible for safety are sensors:

– Optical – in the form of a photoresistor and a laser diode. The diode shines perpendicularly to the photoresistor; in the case of interruption of the light beam, the resistance value of the photoresistor changes, which informs the driver about the appearance of an obstacle in the path of the gate's operation.
– Overload – realised by reading the motor current. If the current drawn by the motor exceeds the set value, the controller receives information about a possible obstacle in the gate's movement field.
– Limit switch – sending information to the controller about the extreme position of the gate. It protects the door's drive mechanism against damage.

Table 2. Protection type depending on the sensor used.

Safeguard type / Protection type	Optical	Overload	Limit switch
obstacle	yes	yes	no
extreme position of the gate	no	yes	yes
object in the gate's work area	yes	yes	no

5. SUMMARY

PLC controllers are devices that are increasingly used in many branches of life. The following work presents the use of the Siemens S7 1200 series PLC to control sliding doors. Based on the model constructed, it can be stated that the PLC can fully control the operation of the gate. Due to the complex functions of the PLC, complex algorithms can beimplemented for the safety of user service. In addition, it is possible to remotely control the operation of the PLC controller via the Internet, which is important when integrating the gate operation with other building automation systems [13].

The model built uses optical sensors and the measurement of the current absorbed by the engine. Each of the proposed sensors has obvious disadvantages in addition to its advantages.

The optical sensor, although very accurate, is usually placed at one point of the gate height. This solution does not protect against an obstacle placed at a different height than the light beam incident on the sensor. An unquestionable advantage of this type of protection is actuation without contact with the gate wing.

In the case of current measurement consumed by the motor, the problem is the rejection of states in which the gate starts to move and, therefore, the current consumption is increased. This type of protection works only when the gate encounters an obstacle and exerts a certain amount of force on it, which can lead to a risk to the health and life of users. This type of protection also protects the drive mechanisms of the gate.

In turn, limit switches give only information about the extreme position of the gate: open or closed. They do not in any way protect the user from being crushed.

In terms of safety, it has been found that the optimal solution is to use triple crush protection. The three types of protection presented in the paper complement each other and provide optimum protection for the gate users as well as being responsible for its proper functioning.

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(Received: 18.01.2019, revised: 04.03.2019)