Journal scientific and applied research, vol. 28, 2025
International Journal

ISSN 1314-6289 (Print)
ISSN 2815-4622 (Online)

Original Contribution

SOLVING A SPECIFIC PROBLEM WHEN COMMISSIONING AN AUTOMATIC PRESSURE CONTROL SYSTEM USING SIEMENS SINAMICS V20 FREQUENCY CONVERTER

Tihomir S. Trifonov[1], Hristo H. Hadzhiivanov[2]

[1]DEPARTMENT OF COMMUNICATION AND COMPUTER ENGINEERING AND SECURITY TECHNOLOGIES, FACULTY OF TECHNICAL SCIENCES, KONSTANTIN PRESLAVSKY UNIVERSITY OF SHUMEN, SHUMEN 9712,115, UNIVERSITETSKA STR., E-MAIL: t.trifonov@shu.bg
[2]DEPARTMENT OF COMMUNICATION AND COMPUTER ENGINEERING AND SECURITY TECHNOLOGIES, FACULTY OF TECHNICAL SCIENCES, KONSTANTIN PRESLAVSKY UNIVERSITY OF SHUMEN, SHUMEN 9712,115, UNIVERSITETSKA STR., E-MAIL: h.hadzhiivanov@shu.bg

ABSTRACT: *This article discusses possible problems during the commissioning of a system for automatic water pressure regulation. The pressure is maintained automatically by changing the speed of rotation of the pump motor. The pump motor, in turn, is controlled by a Siemens Synamics V20 frequency converter. Thanks to a careful analysis of the parameters of the frequency converter and the system as a whole, stable operation without fluctuations has been achieved.*

KEY WORDS: *Synamics V20 frequency converter, Water cooling, Three phase AC pump motor, Pressure sensor, Proportional-Integral-Derivative (PID) control mechanism.*

1. Introduction

The Sinamics V20 frequency converters are part of the Siemens [1] motion control line up. They are positioned in the lower class compared to other frequency converters in the Sinamics family. They are designed for speed control of AC induction motors in relatively simple actuators, such as pumps, fans, compressors, etc. The frequency converters are available with single-phase and three-phase supply voltage. They have digital inputs, analog inputs or USS/MODBUS interface, digital and relay outputs [2]. In addition to their hardware capabilities, the frequency converters from this family have various built-in software functionalities, such as brake control, cavitation protection, PID controller, etc. [3].

2. Scheme of the experimental setup

2.1 Hardware

In the case considered in this paper, the frequency converter is used to control a pump driven by a three-phase AC motor and to regulate water pressure in pipes of a cooling system (Fig. 1).

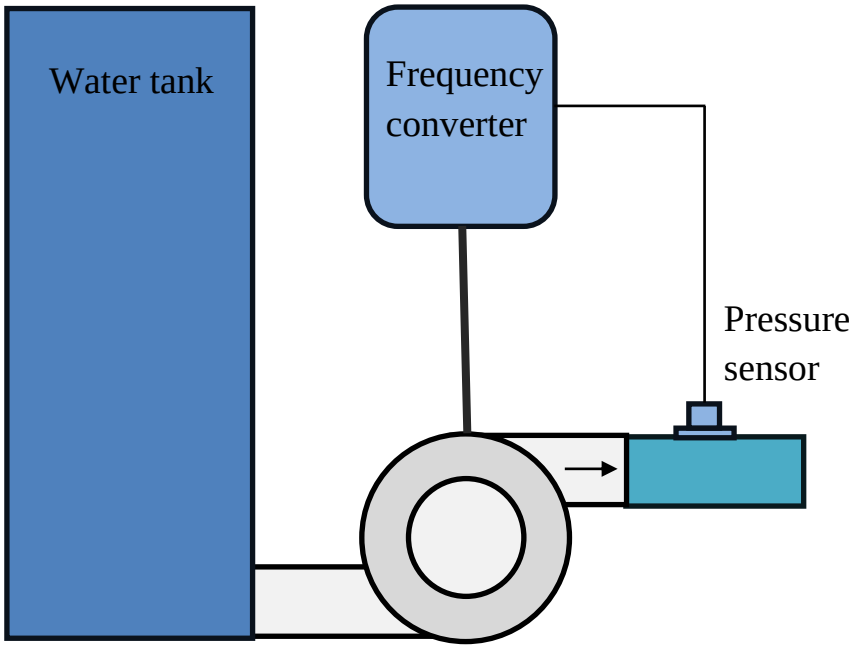

Fig. 1. Functional diagram of the water cooling system.

According to the Siemens [1] operating manual about the Sinamics V20 series, two main electrical connection diagrams are recommended for operation with the built-in PID controller [3]: With analog setpoint and with fixed setpoint of the regulated value [2].

In the considered control system, a wiring diagram with a fixed setpoint is used, which is shown in Figure 2. The control algorithm uses three fixed setpoints of the desired regulated value. The desired setpoint is selected using the built-in digital inputs. As can be seen in the electrical diagram, "true" must be given to only one of them, for this purpose. The current from the pressure sensor, used as feedback for the controlled process, is fed to the second analog input AI2. The controller works with an analog signal with input current values from 0 to 20 mA. In the case under consideration, an analog signal with a current range of 4 to 20 mA is used. This is necessary due to the need to use the built-in 24 VDC power supply of the drive. In this case, the least possible current is consumed and a two-wire sensor connection is used. As a result, two advantages are obtained - reduced power consumption and a simpler electrical diagram.

Shifting the minimum value of the analog signal current from 0 to 4 mA is not a problem, because the desired adjustment value is approximately in the middle of the working range (4÷20 mA).

When a fault occurs in the frequency converter, this is actually a fault of the entire control system - the "Fault" control lamp lights up.

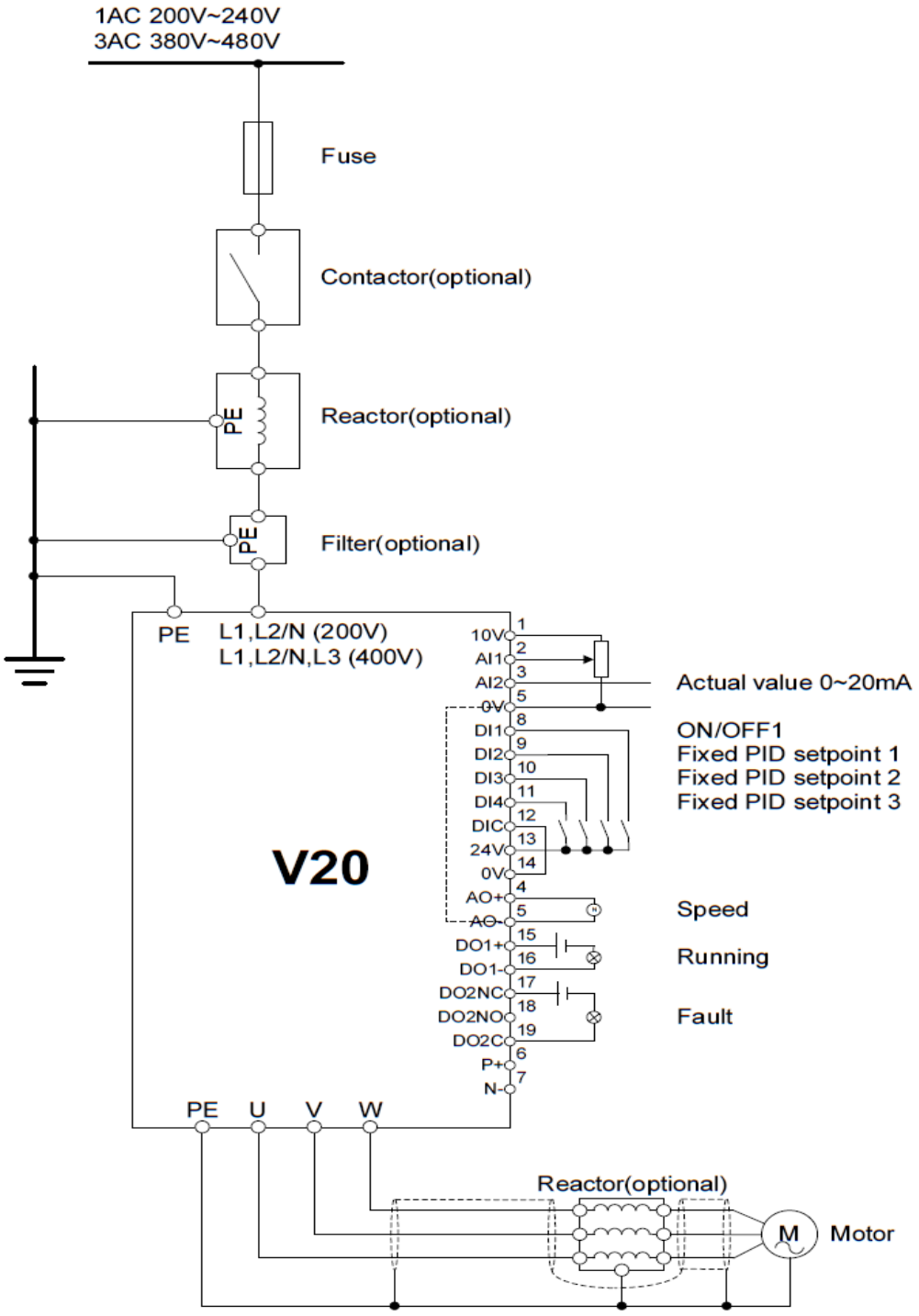

Fig. 2. Wiring with a fixed PID setpoint

2.2 Software

The internal structure of the built-in PID controller algorithm is shown in Figure 3. It schematically depicts the connections between the individual

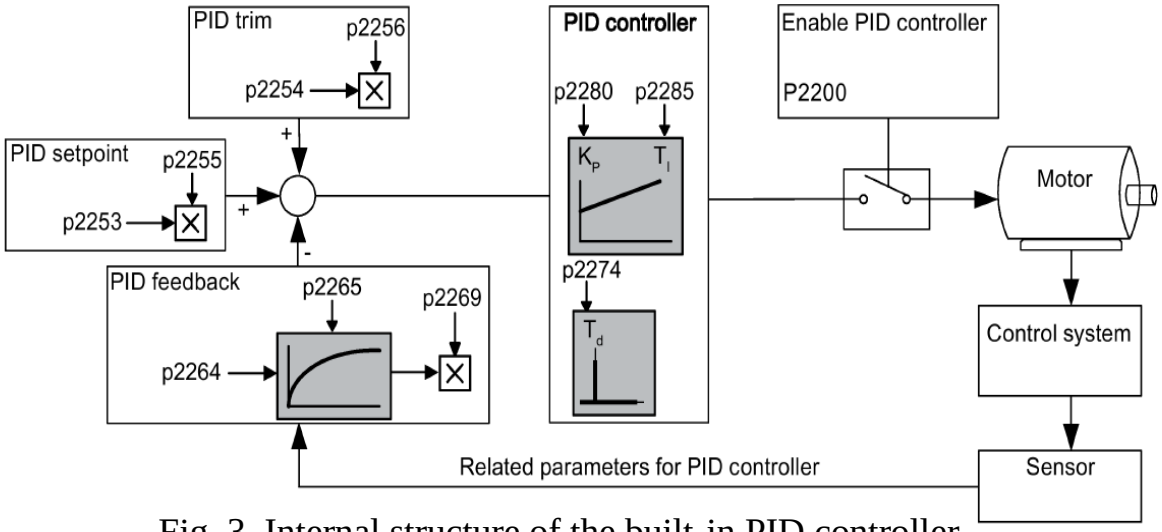

Fig. 3. Internal structure of the built-in PID controller.

components of the control of the regulated process.

Some of the adjustment parameters with a brief description of their functionality, adjustment range, factory setting and setting during commissioning are given in Table 1.

Table 1

Parameter	Function	Range	Factory default	Current settings
P2200	Enable PID controller	0 - 4294967295	0	1
P2201	Fixed PID setpoint 1	-200.00 - 200.00 %	10.00	112.00
P2253	PID setpoint	0 - 4294967295	0	2224
P2254	PID trim source	0 - 4294967295	0	0
P2255	PID setpoint gain factor	0.00 - 100.00 %	100.00	100.00
P2256	PID trim gain factor	0.00 - 100.00 %	100	100
P2264	PID feedback	0 - 4294967295	0	AI2
P2265	PID feedback filter time Constant [s]	0.00 - 60.00	0.00	1.00
P2269	Gain applied to PID feedback	0.00 - 500.00	100.00	70.00
P2274	PID derivative time	0.000 - 60.000	0.00	1.223
P2280	PID proportional gain	0.000 - 65.000	3.00	1.000
P2285	PID integral time	0.000 - 60.000	0.00	0.00

2.3 Commissioning, problems and ways to solve them

When commissioning the considered control system for a pump for regulating the pressure in the pipes of a cooling system, the following difficulties arose. When the system was started and the drive output frequency reached approximately 30 Hz, there was a sudden increase in the operating current of the electric motor, which led to the appearance of the F1 message. This means that the operating current to the electric motor was significantly exceeded. The conclusion that was made at that moment was that there was a mechanical problem or a problem in the controller settings. After examining the mechanical part, no deviations were found. Several attempts to start the system followed, and all of them led to the same result - the appearance of the F1 message. After discussing the problem with the water facilities maintenance group, it was decided to try to start the frequency converter in manual mode and slowly increase the pump speed and monitor the readings of the mechanical pressure gauge and the sensor to the frequency converter, which are installed close to each other. After several manual starts and stops of the pump, it was found that both sensors show the same value. Also, the pump rotates at a frequency of around and slightly above 30 Hz, and no problems with the operating current of the electric motor are observed.

As the system operated correctly in manual mode, it was found that there were no mechanical problems, and that the pressure measurement sensor was in good condition. From which it could be concluded that some adjustments of the frequency converter and the built-in PID controller was necessary. A start-up was made in automatic mode, in which the operating current was monitored with an external measuring device for the system. It was found that when the drive frequency increases and approaches the value of 30 Hz, the measured current begins to fluctuate with large amplitudes.

From this measurement, it was concluded that the PID controller probably reacts very quickly and this leads to the rapid changes in the output response. Various settings of the PID controller parameters P, I and D followed, but they did not lead to a stable result. It was also found that the frequency converter does not perform the time ramps for starting and stopping, which could improve the identified rapid fluctuations in the output current of the electric motor. The operating manual states that when operating with the PID controller, different parameters are used to set the start and stop times compared to operation without the PID controller. After setting the specified parameters when operating with the PID controller, no improvement was achieved.

This was followed by a full review of the PID controller setting parameters and the connections between the individual components in the control schematic shown in Fig. 2. It was found that there is an atypical parameter P2265 for the PID controller. In both manufacturer's operating manuals, the main one for the Sinamics V20 frequency converter series and the Basic application V20 with

PID control manual, the following description for the P2265 parameter is provided without further explanation. If this parameter does some averaging and filtering of the feedback signal from the sensor, it will help, but if the feedback signal is delayed too much, it will lead to a deterioration of the regulated process. Due to this conclusion, a decision to set a value of 1 s to the parameter P2265 was made. As a result, a normal operation of the control system was achieved. Furthermore, the system has been operating without failures for more than three months. This parameter, which is not well described in the manuals, corrects the problem with commissioning the cooling system.

3. Conclusion

1. The commissioning of systems for automatic regulation of a given parameter in the production process requires detailed knowledge of the hardware and the operating algorithms of the controllers used.
2. Sometimes, incomplete description of one or several of the control device parameters can lead to large losses of time and resources when commissioning automatic control systems.
3. In this case, the problems related to the tuning of the PID algorithm can be explained by the mass of water in the cooling system and its inertia with respect to the pressure in the pipes.
4. The experience gained in the above-described experiments may also be useful in the commissioning of other similar systems.

Acknowledgments

This scientific article under project number RD-08-124/07.02.2025 „Renewing the research environment for collecting empirical data in measurement processes“, at Konstantin Preslavsky University of Shumen, Faculty of Technical Sciences is funded.

References:

[1] Boyanov, P., Analysis and monitoring the network traffic in the process of connecting to industrial Siemens controllers. A refereed Journal Scientific and Applied Research, Konstantin Preslavsky University Press, Vol. 22, Shumen, 2022, ISSN 1314-6289 (Print), ISSN 2815-4622 (Online), pp. 41-49, DOI: https://doi.org/10.46687/jsar.v22i1.339.

[2] Siemens, SINAMICS V20 Converter, Programming and Operating Manual, A5E34559884-017, 2024, https://cache.industry.siemens.com/dl/files/897/109977897/att_1309600/v1/V20_op_instr_1224_en-US.pdf [accessed in 5.10.2025].

[3] Siemens, Basic application V20 with PID control, Programming and Operating Manual, Entry-ID: 109483275, V1.0, 04/2016, https://support.industry.siemens.com/cs/attachments/109483275/SINAMICS_V20_PID_Functionality_V1.pdf [accessed in 1.10.2025].