ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering
Tome XX [2022] | Fascicule 3 [August]

[1.] Georgel GABOR, [1.]Gheorghe LIVINŢ

SOLUTION FOR PUMPS CONTROL IN IRRIGATIONS SYSTEM USING S7-1200 PLC

[1.]"Gheorghe Asachi" Technical University Iaşi, Faculty of Electrical Engineering, ROMANIA

Abstract: Irrigation is becoming more and more an area of interest in the cultivation of cereal crops and not only. Pumping station assure the water for watering the plants when the water in the ground has a low level. The pumping station contains 250kW, three-phase asynchronous motors which are used to drive the pumps. The frequency converter is used to maintain the 6bar pressure and the soft starters are used to ensure the necessary flow in case there is a higher demand from the beneficiary.
Keywords: pump station, frequency converter, industrial communication, PLC, HMI

1. INTRODUCTION

The control and monitoring of irrigation systems have become an important subject in the context in which the demand for food has increased in the world due to the growth of the planet's population. The pumping station can vary depend the flow that has to deliver to the beneficiary and contain a number of pumps driven by electrical motors which are controlled by frequency converter or soft starter. The automation system gathers the process values from the electrical equipments and can sends signals via GSM network to a central facility for analysis the data from the pumping station.

This paper analyses the control of a pumping station for irrigation system where the water flow has to be at 6 bars for the end user. In this case the solution agree is to have one frequency converter which will keep the pressure at the demand value and if there is a request for more water flow in the network then additional pumps, powered by soft starter, will keep the flow at the specific value.

2. SYSTEM ARCHITECTURE

The proposed architecture is represented in Figure 1. The pumps motor is powered by the frequency converter and soft starters to ensure the necessary flow to the users who are at some point connected to the network of the pumping station. The manual switch presented in the block diagram, assure the pump to be driven by frequency converter or the soft starter. A pump can be controlled by either the frequency converter or the soft starter at a certain moment. Once the pumping station is on auto mode, it will not be allowed to switch the pump from frequency converter to starter or vice versa. So, the configuration at a certain moment will be one pump connected to a frequency converter and the rest of two will be connected to the soft starters.

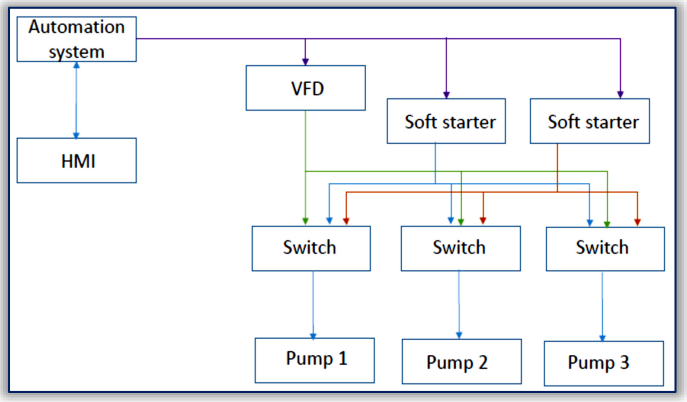

Figure 1 –Block Diagram

The automation system consists in a S7-1200 PLC configuration with a Simatic Basic Panel HMI. The S7-1200 PLC configuration includes Digital Input module, Digital output module and Analog Input module which assure the information exchange between the field and the automation system. The HMI will display useful information for the end-users like flowmeter, the current absorbed by the pumps motor, working hours, warning signals and pump confirmation signals.

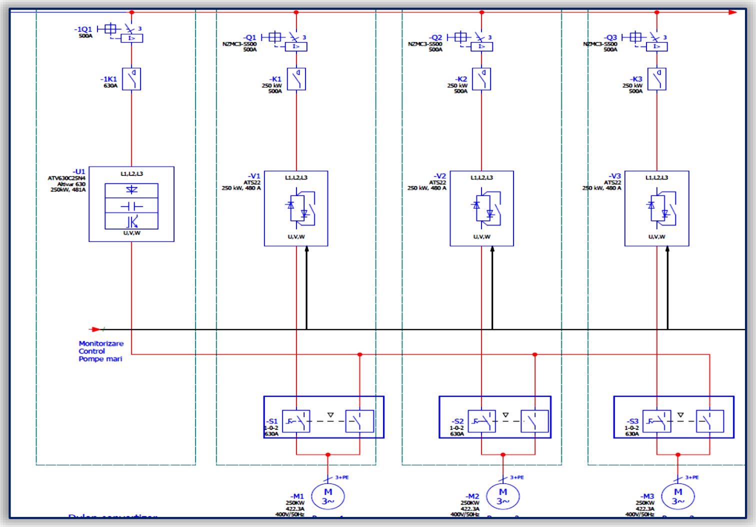
Figure 2 – Single Line Diagram Pump Station

In the block diagram has been highlighted with different color the possibilities for the pumps to be powered by Variable Frequency Drive (VFD) or by the soft starter.

The single line diagram reveal the electrical connection between the frequency converter/ softstarter and the motor pumps. For each circuit line is provided with a switch and a contactor.

3. AUTOMATION SYSTEM

The PLC hardware configuration contains the following modules:

≡ CPU 1214C AC/DC/RLY

≡ Digital input modules 16x24VDC

≡ Digital output module 16xRelay

≡ Analog input module/Analog output module

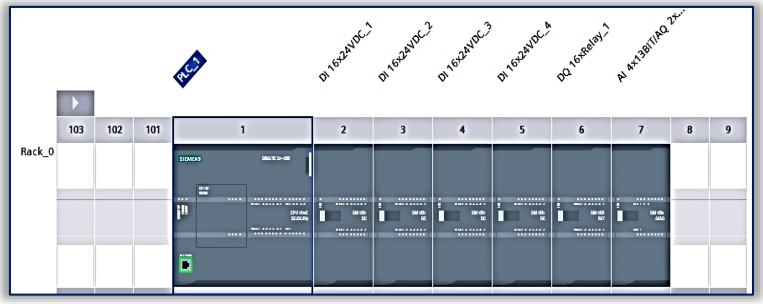

Figure 3 – Hardware Configuration

The CPU has integrated an PROFINET port which can communicate with the HMI and with a SCADA server to send vital data from the pumping station.

The pumps can be controlled from the HMI, designed in TIA Portal software. Each pump has a Start and Stop button for manual control and an hour counting for pump running. It will be necessary to implement the rotating pump according to the hours working in order each pump to have a balanced working for each pump. The Start and Stop button will appear only if the key is switched to Manual, otherwise will be inactivated.

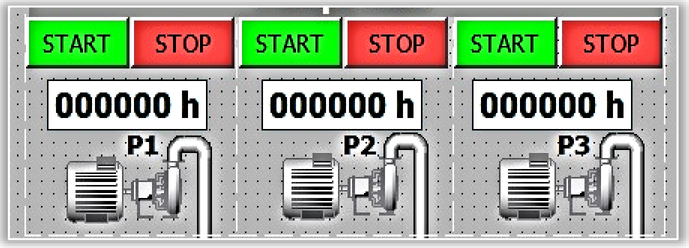

Figure 4 – HMI Layout

In the Figure 5 is represented the pumps control where it can be by soft starter or by frequency converter. The switch represented on the HMI will assure the configuration, assuming that 1 pump will be selected to work on the frequency converter and the rest will work on the soft starter. The buttons Start CF1 and Stop CF1 will be displayed as long the key is on Manual mode, so the operator can make manual commands for start and stop the frequency inverter from the HMI panel.

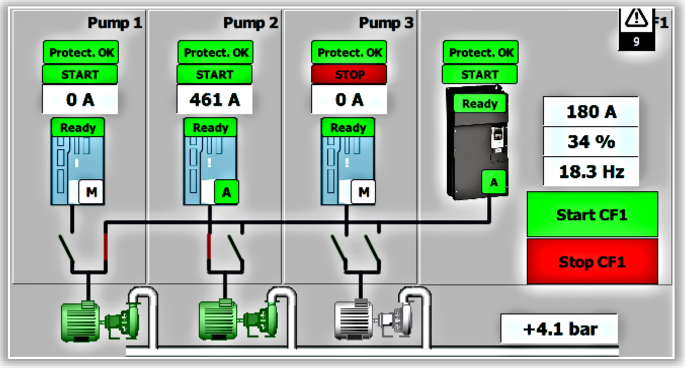

Figure 5 – HMI Layout Pump Station

The logic bloc "Control" was designed for controlling the pumps and each time the function is called, a new instance is created as a function block. The function block has as input parameters the signal Aut_SS_P1 which represents the panel for the pump is in Auto mode. The Start_Pump_Priority is the signal used for controlling the pumps in a certain order depending if the pump is ready or not to be used for pumping.

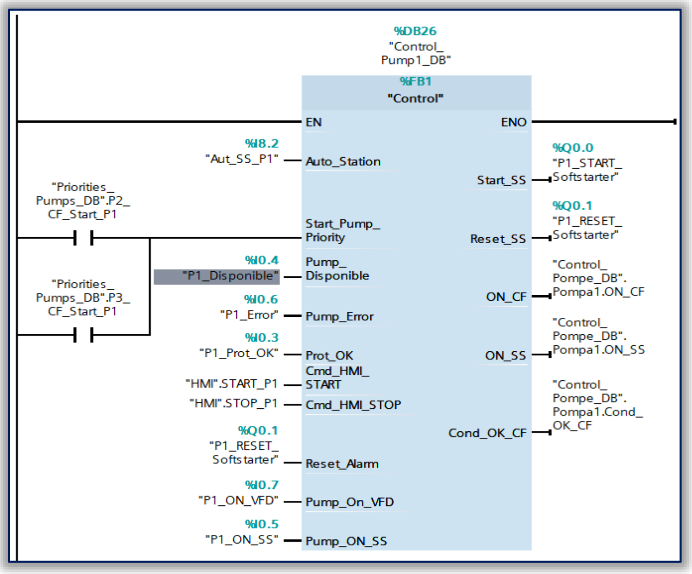

Figure 4 – Control Pump Function

Pump_disponible parameter is used to determine if the pump is switched on to the main switch which assure the connection to the soft starter and Prot_Ok is used for signaling if there are conditions to start the pump. HMI_Start and HMI_Stop are the signals from the HMI for manual command the pump. Reset_Alarm is used for resetting alarm in case of a defect. P1_ON_VFD is the signal from the switch which assure the connection to the frequency converter and P1_ON_SS is signalling the pump is working on a soft starter.

4. CONTROL ALGORITHM OF THE PUMPS

To control the functioning of the pump for a certain amount of water flow, the Figure 5 will show how it is implemented this algorithm. The purpose of the algorithm is to make the pumps wear evenly so that there is approximately the same number of operating hours for all pumps. The Scenario presented is using pump no.1 switched on the frequency converter and pump no.2 and pump no.3 are switched to soft starter. The parameters represented by #, are formal parameter and they will be used as input parameters for the function block when it is called. The timer Ton is used for water flow stabilization and after this timer has elapsed a new pump can start to assure the water flow. The counting hours will be compared and the pump with the less working hours will start first.

The Figure 6 shows the condition for starting the pumps, in the right order, taking into consideration all the conditions necessary the pump need to be available.

The Figure 7 is represented the hours counting using the P_TRIG block. The positive signal edge is queried each time the instruction executes.

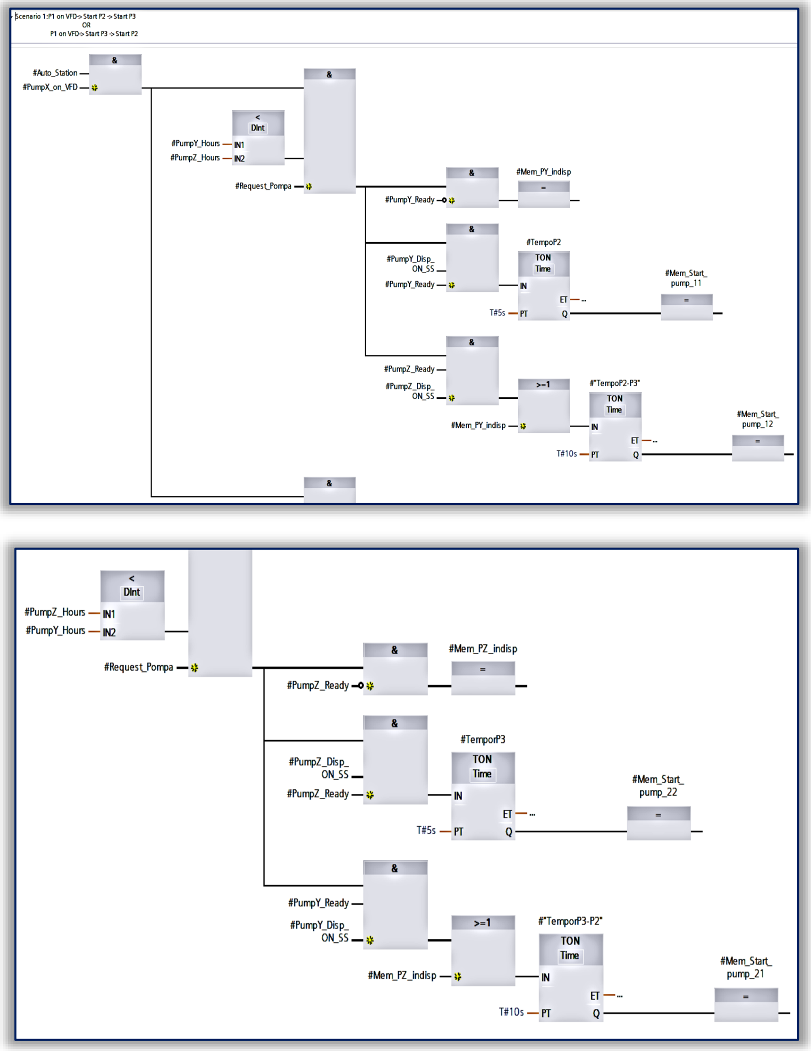

Figure 5 – Pump Control by Water Flow Request

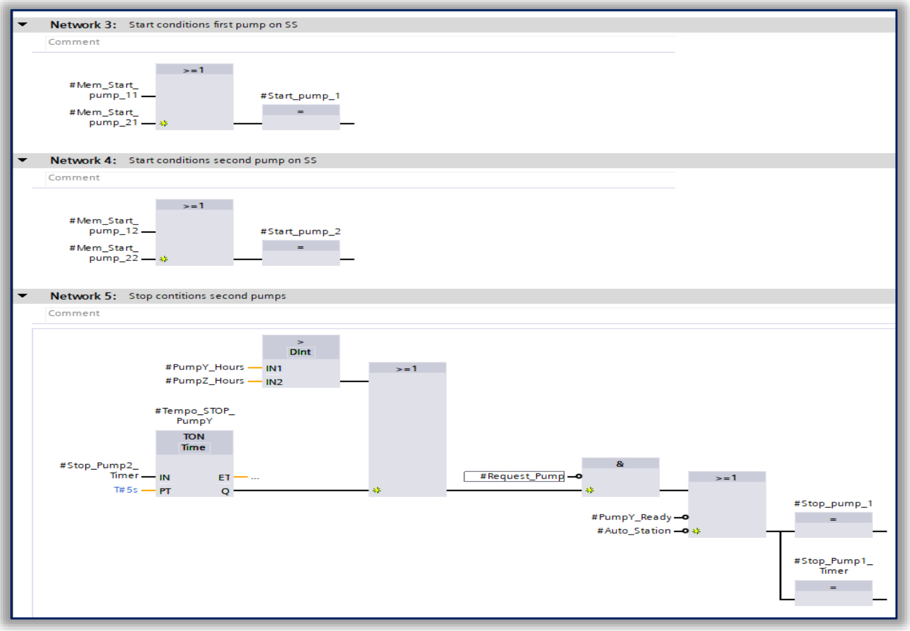

Figure 6 – Pump Control

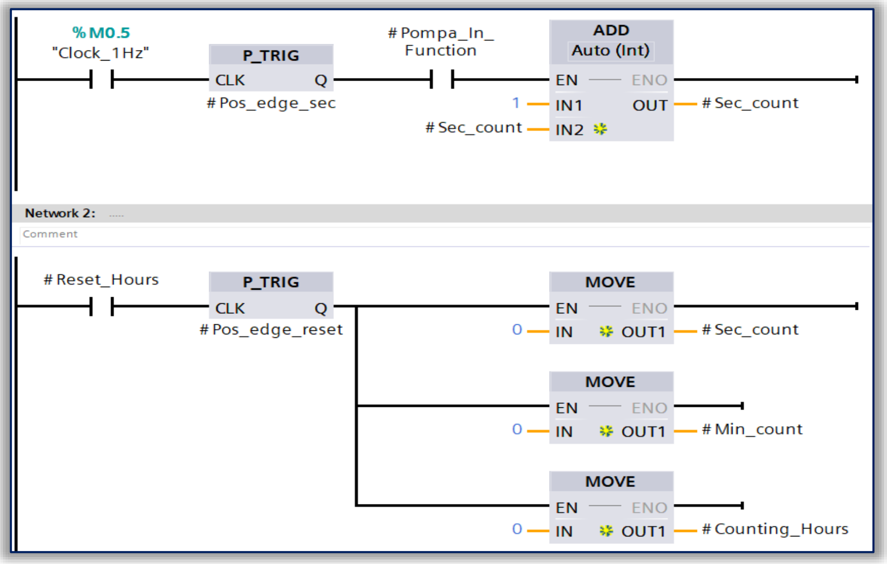

Figure 7 – Hours counting

As soon as a positive single edge is detected, the output Q of the instruction returns the signal state "1" for the length of a program cycle. In all other cases, the output returns the signal state "0". The MOVE block is used to transfer the content of the operand at the IN input to the operand at the OUT1 output. Enable output ENO returns the signal state "0" if one of the following conditions applies: Enable input EN has the signal state "0" or the data type at the IN parameter does not correspond to the specified data type at the OUT1 parameter.

5. CONCLUSIONS

This paper proposes a control algorithm of a pumping station which assure the water flow for different beneficiaries in the agriculture. By implementing this algorithm, the pump station will work on automatic mode and each pump will be rotated in order to have a uniform wear. The automation system can transmit data over internet to a SCADA room where all the information from the pumping station is collected and analyzed for improvement.

Note: This paper was presented at CNAE 2022 – XXth National Conference of Electric Drives, organized by University POLITEHNICA Timisoara, Faculty of Faculty of Electrotechnics and Electroenergetics (ROMANIA), in Timisoara, ROMANIA, in 12-13 May, 2022.

References

[1] Bhushan Pati, Gabhane S.K., Efficient Automated Irrigation System, 2nd International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2018
[2] Bharath Ravi Prakash, Sanket S Kulkarni, Super Smart Irrigation System using Internet of Things, 7th International Conference on Smart Structures and Systems (ICSSS), 2020
[3] Bojan Đurin, Sustainable water and energy use for irrigation demands, World Congress on Sustainable Technologies (WCST), 2015
[4] Hatwar Nikita R., Patil Divya, Gajbhiye Darshika, Langote Harsha, Ingole Pragati, Borkar Tejaswini, Smart Irrigation System, International Journal of Scientific Research in Science and Technology, 2020
[5] Ocoleanu Constantin Florin, Solution for Water Management Using a Smart Irrigation System, International Conference on Electromechanical and Power Systems (SIELMEN), 2019

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665