CONTROL SYSTEM WITH INDUSTRIAL PLC

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Abstract: This paper presents a possible solution of control system based on a programmable logic controller (PLC). It briefly summarizes the theoretical basics of control system requirements. Further, the example of application on small hydro power plant is given and it's benefits are discussed.

Keywords: control system, PLC, small hydro power plant

1 INTRODUCTION

The issue of automated control of small sources of electrical energy is currently one of the main requirements for reconstruction of existing energy sources and the construction of the new ones. As the prices of the programmable logic controllers decreased, more solutions became affordable. These controllers also provide greater comfort in use, and for its equipment and programming possibilities are more appropriate for machine control systems than the relay systems.

In essence, it is used a combination of programmable logic solutions with additional display, or solutions that combine both operator panel and PLC itself. Based on the specified requirements for control system,the number of inputs and outputs machine (which can be both analog and digital) can be determined. Additionally, it can be decided whether it will be necessary to use the communication system using interfaces such as RS232, RS485, GSM, Ethernet, etc. Most of the available systems are modular and can be adapted to the actual configuration requirements.

2 REQUIREMENTS FOR THE CONTROL SYSTEM

The main and also the conflicting requirements for the control system include the requirement for unattended operation with high comfort and low demands on the expertise of the operator and the demand for low cost. While from a technical point of view is especially important mechanical solution of the device. This is the determining factor in whether automation will be designed as active or passive. It defines the control voltage, range of the measured variables and faults detection.

Active solution needs to perform any action command. Automation must eg. for turning on switches send the command "ON", for its shutdown command "OFF". In case of the loss of control voltage the generator switch remains in the same state they was before the power failure. This solution is used for large power plants with a permanent service that has the ability to control devices manually.

Passive solution keeps the device running for the duration of the command. If a switch is turned on, it must be permanently energized its closing coil. Power failure or signal loose will cause the shutdown of the controlled element and whole system will be bring into the standby mode. This solution is used for small energy systems.[1]

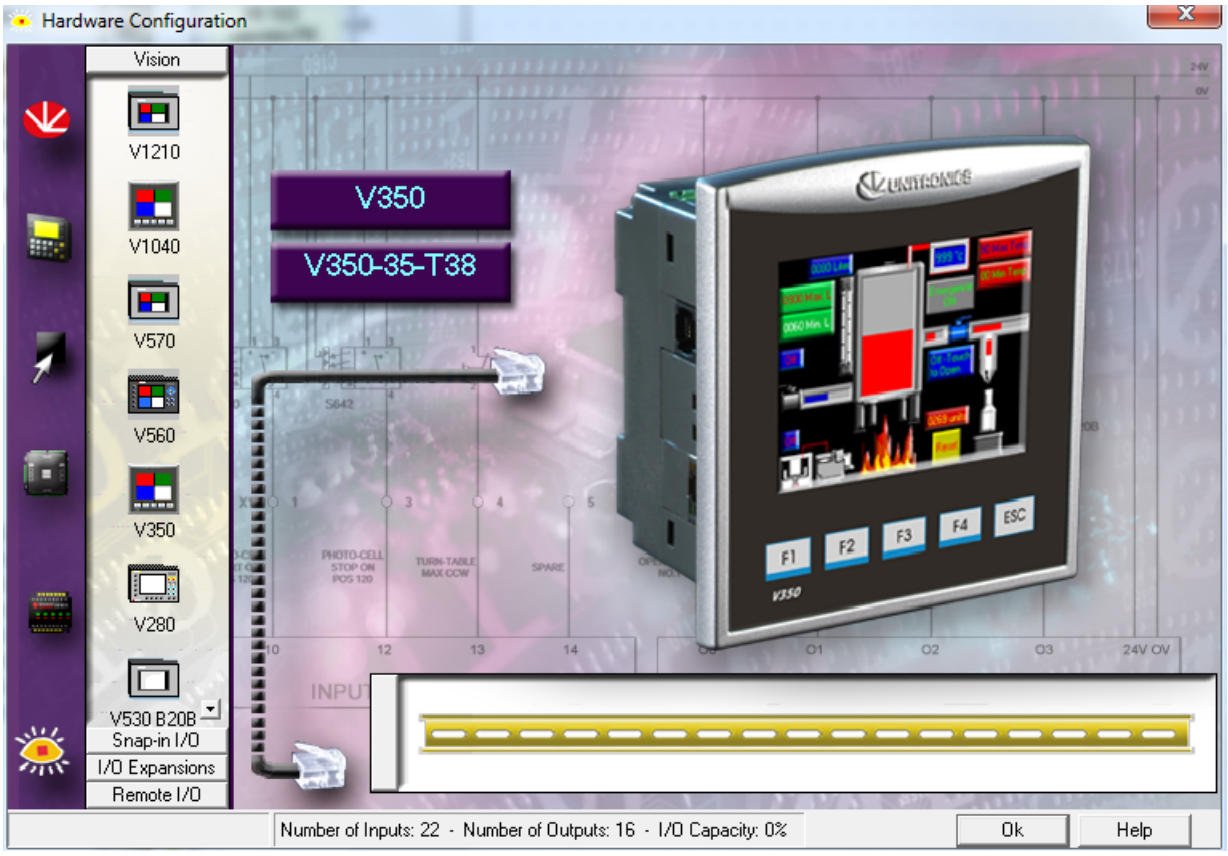

Figure 1: Hardware configuration of Vision V350 in program software

2.1 FUNCTIONS OF THE CONTROL SYSTEM

Automatic control system usually provides several functions described further. But it is important, that into the machine control circuits are fundamentally not included purely security features, such as electrical protection. An exception are systems which are designed as safety and is ensured the superiority of these security features.

2.1.1 SEQUENTIAL CONTROL OF THE MACHINE

Sequential logic is part of the automatic control equipment and ensures at machine's startup, shutdown and the system's behavior in case of malfunctions. It is a sequence of operations controlling elements such as contactors of auxiliary drives, hydraulic systems and other switches. Within this logic, it is also checked for completion of the various commands and subsequent evaluation of continuing the sequence. Individual procedure is ended by completion last command in the list and running or stopping the device.

2.1.2 REGULATION OF THE MACHINE

Control of automatic regulation provides for example turbine regulation, generator excitation, switching power factor correction. This requires current data readings obtained using operational measuring. Based on these data, it is then implemented regulation.

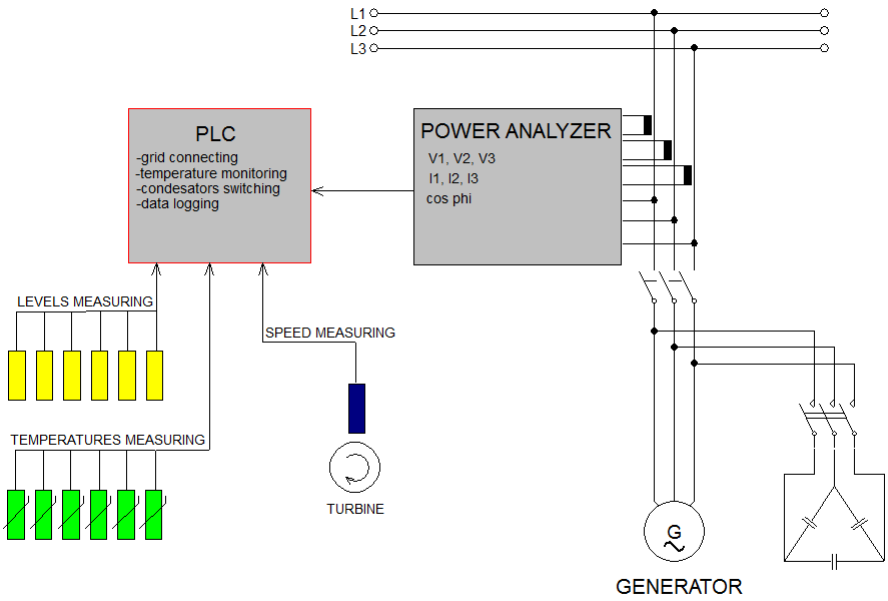

Figure 2: Design of the control system for small hydro power plant

2.1.3 Security features

Security automation part evaluates the desired variable and when the set limits are exceeded, it will react accordingly. Usually it monitors the power of generators or pressure, temperature and levels of fluids. Security features usually work in several stages. as a first step is usually set only a signalization. Only when reaching the critical value, it ensures safety automatic shutdown, sends a command to shut sequential automatics and ensure fault signalizing.

2.1.4 Control of auxiliary drives

This section provides control of the auxiliary drives, like those that are not included in the sequential automatic and are in operation independently of the running gear. An example might be, drives for pumping oil or water, control running pumps, cleaners, etc.

2.1.5 Operating measurement

Provides scanning of selected variables of the machine. This is the measuring of non-electrical quantities such as pressure, temperature, level, speed, operating time. The electrical parameters then measure voltage, current, frequency, produced electricity, etc.

2.1.6 Operating and fault indication

The purpose of the operating indication is briefly inform about the current state of the device. Fault signal is more detailed. It informs about the reason for failure, and communicates instructions for further action. The basic requirement for the archiving of data on fault conditions is required to determine the time and number of occurrences. It is also important to prevent the loss of fault in the absence of arbitrary error signal. Fault reporting is done on the display machine, or even an acoustic signal or a remote alarm via SMS or email.

3 EXAMPLE OF APPLICATION

Based on the research described in the literature [2], the possibilities of using industrial programmable logic controller (PLC) and its suitability for application in controlling of small hydro power plant have been studied. As a result, a PLC Unitronics Vision V350 based control system has been created.

3.1 DESCRIPTION OF THE SELECTED PLC USED IN SMALL HYDRO POWER PLANT

This small PLC combines the logic controller and human–machine interface (HMI) which is ensured by a touch sensible color display. This PLC offers enough inputs and output, including analog inputs used for measuring continuous variables such as water levels.

It can be equipped with GSM modem for remote control or connected via RJ45 to ethernet. It can cooperate with multiple devices such as motion controllers, another PLCs and power analyzers with using MODBUS protocol. The real appearance of this PLC is shown on Fig. 1. This figure also shows the hardware configuration menu in the programming software.

This solution has its benefit in free programming software, therefore it can be suitable for similar applications with just a minor changes, which can be easily done after understanding the programming interface and PLC logic.The program itself is created as a ladder diagram with division into several subroutines. This is in essence the sequential logic of the control system.

Selected PLC offers easy settings of alarms, this feature is used for fault indication. In the application of controlling the small hydro power plant, faults can be divided to reversible and irreversible. The reversible faults are the ones, that don't cause permanent disfunction of the system. As an example can be considered frequency and voltage differencies, which result into stopping the system, but when they get back to the preset limits, system can be started again.

Communication with external power analyzer is based on the MODBUS protocol, this solution allows fast reading of multiple values, which is necessary for proper system function. MODBUS protocol is also used for temperature monitoring with cooperation with A/D converters.

The power regulation of the system is done by the programme function block which works as a PID regulator. For proper function, knowledge of water level, speed of the generator and its actual power output is necessary. This informations are provided to the PLC by the sensors.

The control system is designed to provide standalone solution for unattened operation. It is equipped with GPRS modem for purposes of remote control. The authorized user is able to receive the informations about the status of the system and to contol it by sending the sms.

3.2 DESCRIPTION OF THE SMALL HYDRO POWER PLANT

The system is controlling the small hydro power equipped with Francis water turbine and 45kW asynchronous generator. Output from this generator is connected to the distribution grid. Because of the use of asynchronous generator for easier connecting to the network, compensation of the reactive power is necessary. Compensation is maintained by switching capacitor batteries according to the actual real power in three power steps.

For the purposes of starting the machine, induction sensors are used to measure the rotation speed of the turbine. Then the PLC counts the actual speed of generator according to the transmission, which is ensured by a band. The generator is supposed to be connected to the grid in the moment,when actual speed differs only in 5% of the nominal value. This requirement needs the PLC with fast response, which is accomplished by the Vision V350.

Because of the requirements for failure-free operation, temperatures of the bearings, oil levels and

other data such as service time are needed to be measured. This is maintained by thermistors and pressure sensors. PLC allows to set the limits for warning and for shutting down the facility.

For proper function of the regulation the generator and for logging data, the system needs to be equipped by power analyzer, which provides the PLC data from electrical measurement, such as actual voltages, currents, frequency, real and reactive power, etc.

Fig. 2 shows the intended design of the system and link between the sensors.

4 CONCLUSION

Article proposes the intention to use industrial PLC for controlling small hydro power plant described higher. This solution provides higher comfort, than human controlled solution. Due to simple programming, it is easy to create even complicated control sequences.

Its advantages are cheap price, free programming software, modularity, fast response and combination of HMI and PLC in one unit. Unitronics provides its products with extensive support and high amount of application for remote programming, so the new firmware can be downloaded to the controller via GPRS connection.

Between the main disadvantages belongs the need of additional electrical protections, such as frequency, voltages and currents protections to ensure the safety of the system.

In the literature [2], has been the described design tested and therefore it can be recommended for similar applications.

One of the benefits of this research is the increase of operational efficiency of energy systems. This fact has direct influence on the consumption of prime energy.

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