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THE APPLICATION OF PROGRAMMABLE RELAYS IN DOMESTIC ELECTRICAL INSTALLATIONS

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Abstract: The paper presents the possibilities of using automatic switching, as a system for providing uninterrupted power supply in buildings located in the area of frequent interruptions in the power supply or equipped with renewable energy sources. Apart from the idea of the installation the paper presents an example of the program to control various functions of the system and software for visualization by tracking the availability of some power sources, to simulate their readiness for operation. The main focus is on simplicity and intuition in the use of programs that are available to the average user and can be used and modified from home, eg. a notebook or phone. For the analysis we used a fictitious electrical wiring design of a residential building, which is connected to renewable energy sources. Having selected the appropriate equipment and security, we divided the installation into sections of receiving power in terms of the validity of the power, which includes the automatic control.

Keywords: automation, electrical power, control, automatic switching, programmable relays, PLC.

Introduction

In recent years, changes in the conditions of design and installation of electrical systems were observed. Different kinds of systems have become the main piece of equipment in the residential, office and production buildings to improve their functionality, comfort and safety. For several years, renewable sources, ie. household power plants have become popular and the existing energy consumer has become her prosumer. This allows to obtain additional opportunities in the power control of selected energy sources, with the possibility of selling energy establishment. In addition, many people live in the areas of frequent interruptions in the supply of electricity, they now have a chance to ensure the uninterrupted supply of energy in a simple manner through automatic switching reserves. Before moving on to the implementation phase of such a system in a residential building, an important element is to make the design phase, shown by [2]. The article presents the results of the sample design intelligent installation in a building detached from the example of the use of programmable relays, currently available in a wide range on the market.

Material and methods

The house described is connected with renewable energy sources, such as wind turbines and solar panels to optimize energy production. The composition of the plant wills also batteries for storing energy produced and uses it when there is a lack of appropriate conditions for the production of electricity. Furthermore, the controller will also need a battery charger that achieves its long-term use by appropriate charging current which will be greater when the batteries are exhausted and smaller when they reach their maximum capacity. To build the appropriate Automatic Transfer Switch (ATS) system also a controller charging status of batteries is demanded, which will communicate when the energy level in the cells is low. The whole will be complemented by the adjustable voltage and frequency characteristics that turn electrical energy in batteries for those which are useful for use in the building. In the event that the equipment is not supplied with enough energy produced by renewable sources, it will be able to switch on the energy supplied by the power company and in the worst case also suitable generator with the electronic starter.
The main switchgear internal power line will be divided into three supply sections through contactors installed between sections. Each section will have a power source assigned to it: 1- external supply, 2- renewable sources and generator, 3- lack of reserve power sources.
In relation to the defined division into sections, we divided the appropriate equipment installed at home, lighting and socket outlets. It is used in the following diagram accordingly:

- The first section of the power is supplied only in case of availability of the mains voltage and phase receivers classified by major powers, the power from renewable energy sources would not make sense, because it would lead to a rapid discharge of the available power.
- The second power supply section is powered by renewable energy and the generator that is activated in case of low-power RES including all the lighting that does not consume high power, electrical appliances, which are necessary in the house from the point of view of the user and a special key-AD socket for receivers with low power. In addition, this section can also include UPS, which will be accompanied by receipts which do not tolerate interruptions in the voltage at the time of switching the system and emergency lighting.
- The third section of the power is supplied from renewable sources ultimately classified as receivers that are least needed from the point of view of the user and the majority of electrical outlets in the room. In case of low battery status, this section is completely disconnected from all top-ups.

The diagram (Fig. 1) is presented with hints joined to the ATS system (Fig. 2), taken from [4].

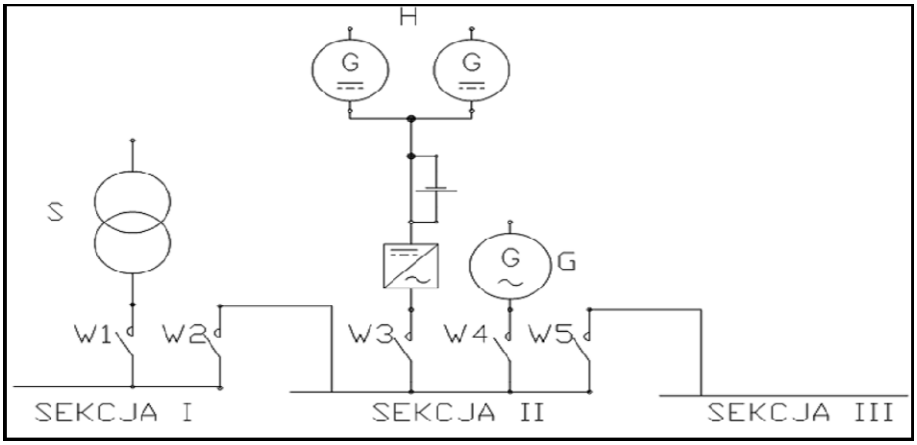

Fig.1. Diagram of the ATS.

S	H	G	W1	W2	W3	W4	W5
1	1	0	Z	Z	Z	0	Z
0	1	0	0	0	Z	0	Z
0	0	1	0	0	0	Z	0

Fig. 2. Schematic switching system: S – external grid, H – hybrid renewable energy sources (RES) system, G – generator, W – contactors, O – open contactor, Z – closed contactor, 1 – presence of the voltage, 0 – absence of the voltage.

Programmable relays were used here to control the output signals of specific contactors at home.

The project also requires electrical power to determine the demand for the building, short circuit calculations, lead selection, security, verifying the effectiveness of protection, earthing design, selection of current transformers aim billing sold to the electricity grid and design of the switchgear and the ATS system [3]. An important element is the selection of appropriate renewable energy sources and their batteries, depending on the needs, in this case under the receiver-powered speakers from the source to Sections II and III. Besides, it is also important to choose the right generator for the devices whose power is necessary and the right lighting. All the components of the system should work integrally with each other.

In the analyzed example ATS system consists of a programmable relay EASY 819-DC-RC, contactors, selected on the basis of [1] type DILM115 (RDC24) to control sections and power networks, contactor type DILM25-10 (RDC24) to control the hybrid system and contactor type DILM12-10 (RDC24) to the control unit. Using a programmable relay Easy is a free program the control outputs contactors, depending on the signals at the inputs. The input signals will include signals from the under voltage relay type REUVM, auxiliary contactors and controlled by the state of battery charge controller VE.NET Battery Controller.

To satisfy the relevant requirements for fire protection, selectivity of the ATS must be provided, which results from [5]. Switching times contactors must be greater than the operating times of short circuit breakers to prevent being attached to an additional source of a short-circuit. Opening time delay under voltage relay equals 500ms. In addition, between the unit and the network lock mechanical contactors were installed what prevents the power supply network with its own generator. In the case of standby power supply, a temporarily solution which disconnects the inverter via a contactor and completely disconnects the generator was established. After disconnecting the power supply network short-circuit power is generated only by renewable or unit, working in the IT supply system which, with proper grounding of receivers, provides shock protection system without grounded neutral point.

The diodes indicating which power source is currently being used by the user and which sections are powered will be installed on the main switchgear.

During operation three situations discussing the description of the planned system were established:

a) Situation A:

In the absence of the voltage relay will send a signal to the Easy, which then controls the appropriate contactor opening contacts on AC power and the clutch to Sections I and II. If the voltage returns to the mains, or in the absence of a signal from the relay under voltage relay Easy will send a signal to close contacts and momentary open contactor RES time switching voltage to avoid the impact on the inverter.

b) Situation B

In the case of low battery VE.NET Baterry Controller will send a signal to the relay Easy, which then opens the contactor between sections II and III, and supplies the system from the renewable sources. If the voltage returns, ie when the under voltage relay stops sending the signal input Easy, contactors will be closed again.

c) Situation C

After an appropriate time power failure from basic sources, meaning the power supply and renewable sources, needs to achieve 80% power generator, Easy relay will send a pulse to close the contactor at the output of the generator and connects it to the mains. In the event of a break of voltage powered devices will still be supported by UPS, while the rest of sources will record a temporary interruption of power supply.

One of the main objectives of the project was to enable intelligent building self-programming and use of the relay purpose of installation configurations to the user. For this purpose an EasySoft Pro software was used. It enables a completely flexible configuration of the system in order to adjust it to the appropriate conditions. Depending on what is demanded to achieve, the user can change the program of the relay, which then controls the contactors, which are actuators built in this way, for example ATS. Fig. 3 present an example of automation control power sources and sections.

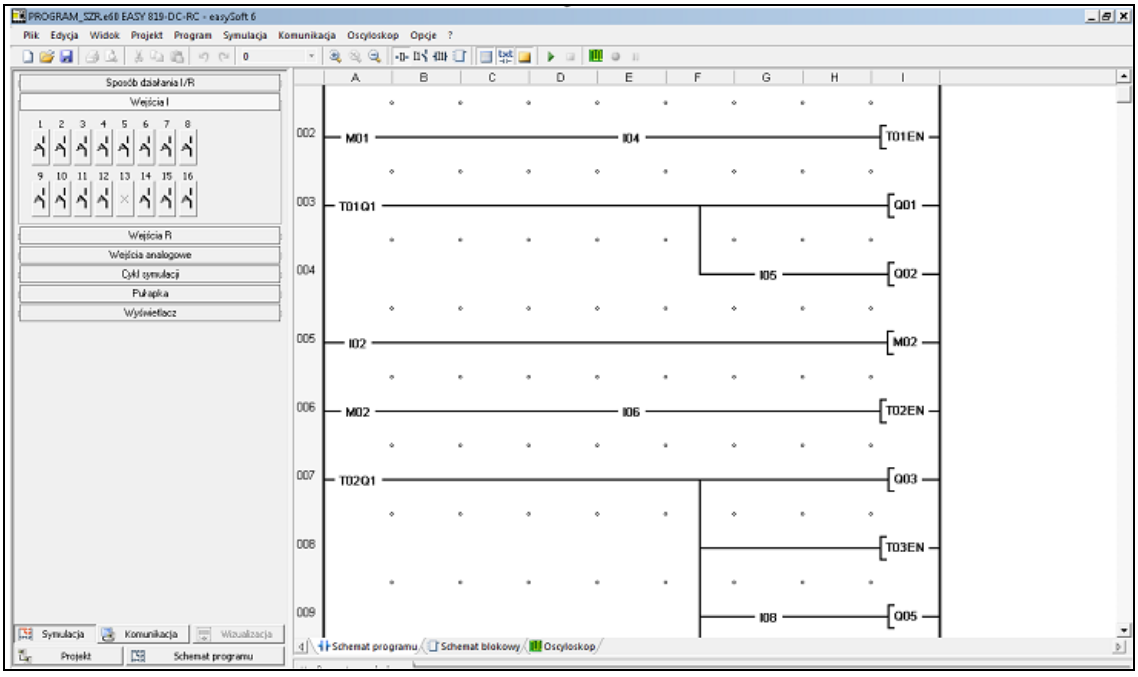

Fig. 3. Sample control program.

Additionally, the program allows for the simulation of system performance, depending on the signal at the input of the relay. In this way, the user can check the correctness of the program and the relay will behave in the correct way. The simulation can be performed both on the ladder diagram written in the program, as well as in the time domain in a virtual oscilloscope. The former one is presented in the Fig. 4.

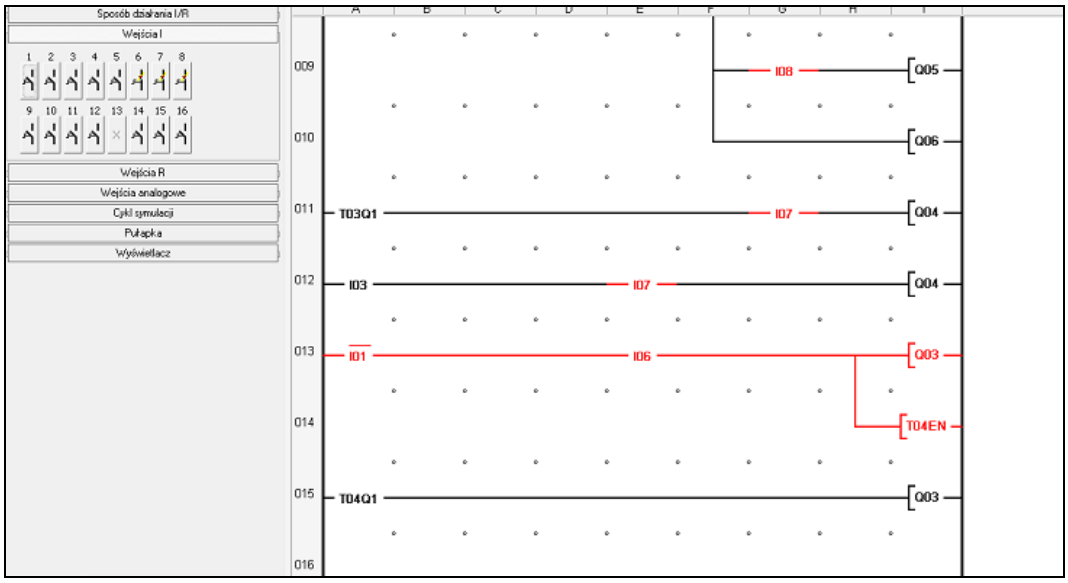

Fig. 4. Simulation of the ladder diagram.

Results

The latter way the simulation can be performed is in the time domain in a virtual oscilloscope. The software is already included in the relay and allows for the visualization of its action (Fig. 5).
After being tested with the use of an oscilloscope, it turned out that the system was working correctly, while the respective contactors, which controls the relay to switch the sections are activated with an appropriate delay, which is set to the under voltage relay, whose input is active at a time. In the same way all situations analyzed the behavior of the system under different conditions and the appropriate software proved successful.
Besides the appropriate configuration of the user's position using eg. Home laptop, it is also possible to make visualization of the operating data sources or even the position of the contactors informing about the status of the installation.

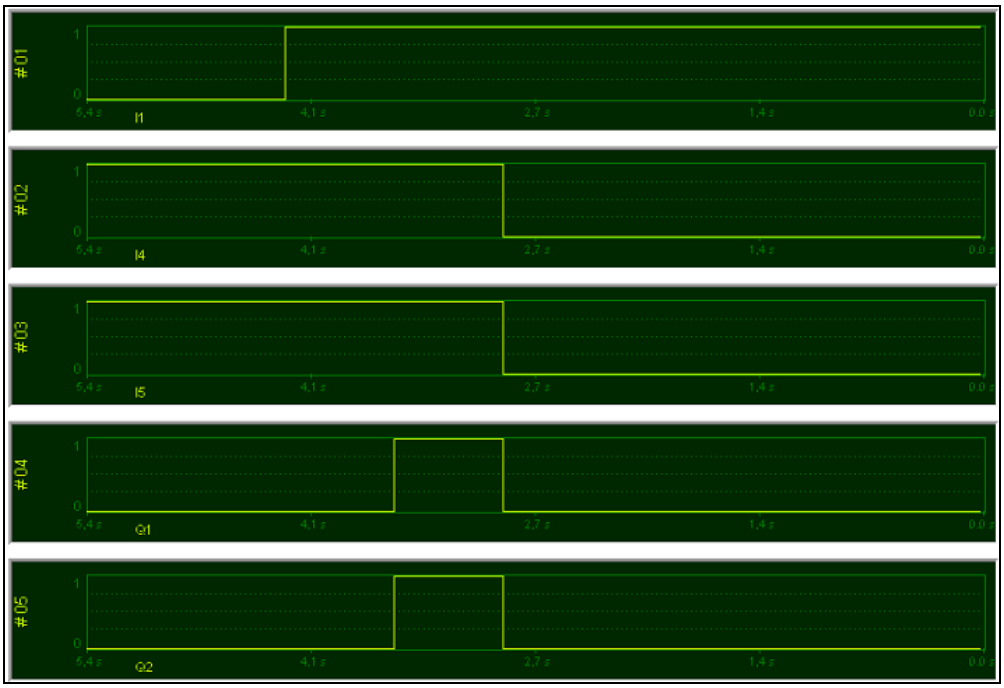

Fig. 5. Simulation I-O oscilloscope.

Visualizations of the work sources were performed using LabView with a computer attached to the card data acquisition measurement via transformers. The card will be installed in a PC for visualizing work sources in the environment of LabView. Interface National Instruments Compact DAQ will be used to transfer information from the card to the computer, and their reading using the "DAQ Assistant." It also enables voltage measurement and visualization of operation of sources. In order to confirm the possibility of such a system the easiest program was created in LabView environment. It assumes three channels of data acquisition by means of which transformers acquired data measured voltage. They are displayed in the form of numerical indicators, along with the voltage level of the source. An example of such visualization is (Fig. 6).

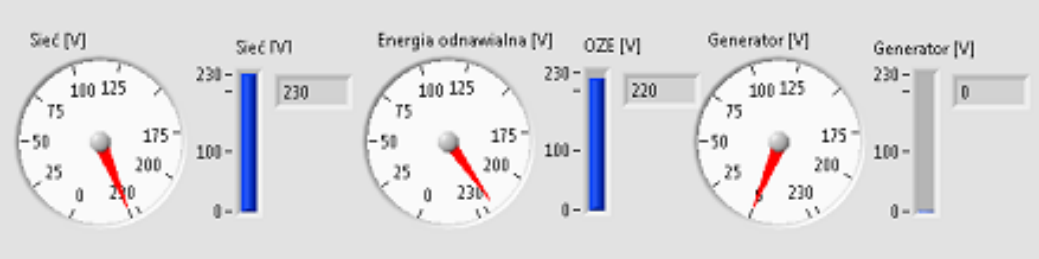

Fig. 6. Example visualization program.

Conclusions

Based on the project, it was found out that the use of ATS automation which is based on control of contactors and relays works correctly. Distinguished receipts need continuous power, as well as those that are really necessary to the functioning of the building. In this way the user can create more advanced control systems as well as available sources and acceptances. When one source consumes too much energy and building is disconnected from the power plant, some of the loads could be disconnected. It provides more effective use of the available energy. Another advantage is the ability to modify the system and create their own visualizations from the level of the user. Here only our imagination is a limit. The user can also make his own visualization programs to see how it works. This innovation provides easy diagnostic system to any customer and it requires only some extra equipment whose programming is very easy. The solution is still too expensive to become ~~a~~ popular, but we have to consider the costs of such a system in comparison to the loss of production costs for small business, which is located eg. in the mountains, where the power is carried by overhead lines and all power outage losses are much greater than expenditure on the components. In recent years the case described serves as a good example of how customer can become more independent in using energy sources.

References

1. Aparatura i osprzęt elektryczny niskiego napięcia, Katalog, Eaton, Gdańsk, 2012.
2. Markiewicz, H., Instalacje elektryczne, WNT, Warszawa, 2007.
3. Niestępski, S., Parol, M., Wiśniewski T., Instalacje elektryczne budowa, projektowanie i eksploatacja, Wydawnictwo Politechniki Warszawskiej, Warszawa, 2011.
4. Wiatr, J., Uproszczony projekt układu automatyki SZR z funkcją wyłącznika ppoż. *elektro.info*, 2013, nr 10, s. 70-72.
5. Winkler, W., Wiszniewski A., Automatyka zabezpieczeniowa w systemach elektroenergetycznych, WNT, 2013.