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DEVELOPMENT OF A MODEL OF A MICROPROCESSOR RELAY PROTECTION AND AUTOMATION DEVICE IN MATLAB

Baishev Yu.T., Kugusheva N.N.
Ammosov North-Eastern Federal University, Yakutsk, Russia

Keywords: microprocessor device, relay protection, mathematical model, algorithm, MatLab software package.
Abstract. Within the framework of this work, the development of a model of a microprocessor relay protection and automation device in the MatLab software package using transformerless analog signal input devices, as well as a discrete signal oscilloscope device is presented. In addition, various types of algorithms for detuning from known noise and disturbances were tested both in analog and discrete circuits.

РАЗРАБОТКА МОДЕЛИ МИКРОПРОЦЕССОРНОГО УСТРОЙСТВА РЕЛЕЙНОЙ ЗАЩИТЫ И АВТОМАТИКИ В MATLAB

Баишев Ю.Т., Кугушева Н.Н.
Северо-Восточный федеральный университет им. М.К. Аммосова, Якутск, Россия

Ключевые слова: микропроцессорное устройство, релейная защита, математическая модель, алгоритм, пакет программ MatLab.
Аннотация. В рамках данной работы представлена разработка модели микропроцессорного устройства релейной защиты и автоматики в пакете программ MatLab с использованием бестрансформаторных устройств ввода аналоговых сигналов, а также устройства осциллографирования дискретных сигналов. Кроме того, апробированы различные виды алгоритмов по отстройке от известных помех и возмущений как в аналоговых, так и в дискретных цепях.

Introduction. The development of new approaches in the implementation of relay protection devices is of great importance. Thanks to the use of new materials, methods and tools that were not available at the dawn of the development of microprocessor relay protection terminals, there are opportunities for advanced research to solve a wide range of problems. At the moment, the electric power industry is experiencing the so-called digital transformation, namely: digital substations are being built, new types of current transformers are being used, etc. Therefore, the creation of a mock-up of a microprocessor relay protection device for the purpose of experimental testing of new approaches will make it possible to develop more efficiently, and in the future to implement the results obtained. Within the framework of this work, the development of a model of a microprocessor-based relay protection device using transformerless analog signal input devices, as well as a discrete signal oscilloscope device is presented. In addition, various types of algorithms for detuning from known noise and disturbances were tested both in analog and discrete circuits [1, 2].

Features of the conversion of analog and discrete signals. Traditionally, current and voltage measuring transformers are used as secondary measuring converters of analog input signals. The main disadvantage of these passive functional devices is the presence of conversion errors, mainly due to power losses due to magnetization reversal and an increase in error as a result of increasing load. Even in conditionally ideal open circuit and short circuit conditions for voltage transformers and current transformers, respectively, errors are not eliminated [3].

In the developed device, it is proposed to use current and voltage sensors from LEM. They differ in miniature dimensions acceptable for installation on a printed circuit board, but at the same time they have a sufficiently high transformation accuracy (relative error less than 0.005). An LA25-NP series sensor with a primary rated current of 5 to 25 A is used as an active measuring current transducer. An LV25-P type sensor is used as a voltage sensor, designed to convert level voltage from 10 to 500 V [4].

To date, a large number of conducted interferences propagating in the network have been identified. One of these is impulse noise. These interferences occur due to sufficiently large capacitances of the branched network relative to the ground. During lightning strikes as a result of switching power equipment and short circuits on the high voltage side of the network, transients occur, accompanied by voltage surges. In some cases, these interferences are of short duration. However, in addition to short-term perturbations, pulses of large duration and amplitude can also come, as a result, the existing delay is no longer able to help in detuning from this interference, which leads to false operation of the protection. The source of such interference is DC switching of electromagnets for closing switches (Fig. 1).

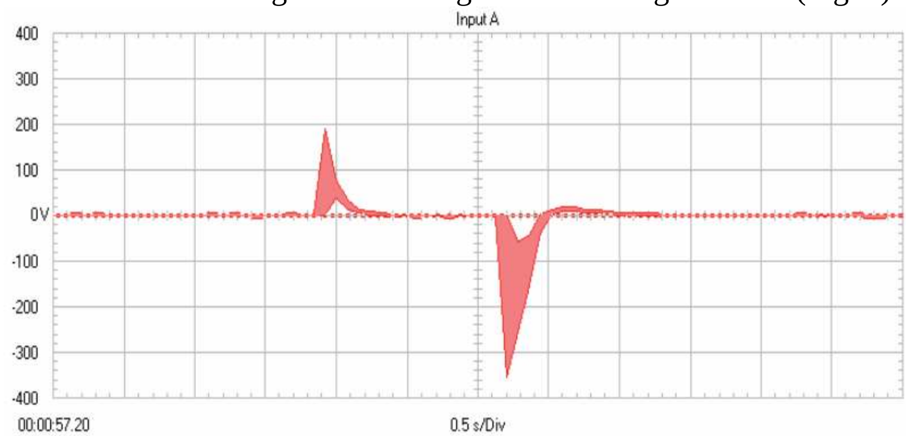
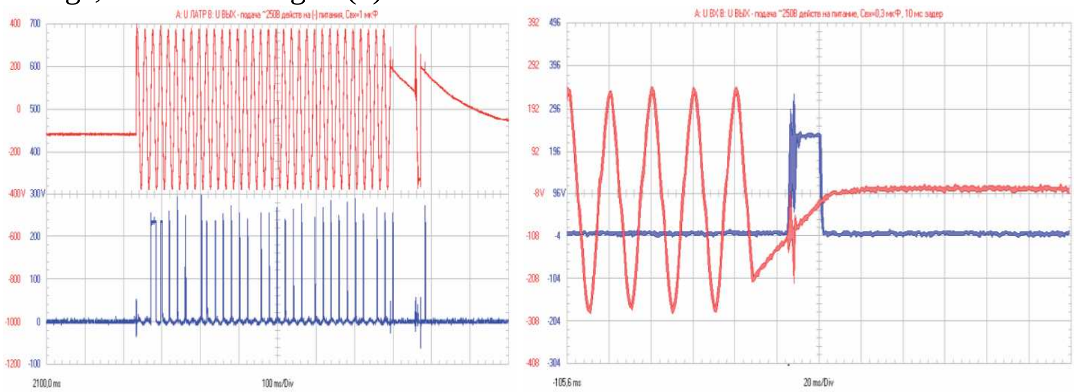


Fig. 1. Interference when turning on/off the electromagnets of switches

Currently, protective diodes or surge suppressors are most widely used to limit impulse noise in DC circuits. The protective ability of the diodes is sufficient to cut the amplitude of long-term pulses, but with sudden voltage surges, they quickly fail. In such cases, surge arresters have proven themselves well, having a non-linear current-voltage characteristic and a short response time, which helps to limit high-frequency interference, but at the same time, the amplitude of these interferences is quite small, which leads to burnout of the surge arrester with powerful pulses [5].

On fig. 2 (a) shows in blue the contact of the relay protection output relay, in red - an alternating voltage with an amplitude of 250 V. As a detuning from this phenomenon, a delay in operation can help, however, even in this case, excessive operation is possible, but only at the moment of the disappearance of the alternating voltage, as shown in fig. 2 (b).



a b

Fig. 2. Operation of protection when exposed to alternating voltage (a), reverse operation in the event of an alternating voltage failure (b)

Based on the fact that the proposed solutions for detuning from the above disturbances in the form of adding a delay do not always work properly, it was decided to develop a universal intelligent device with the possibility of flexible detuning from all types of interference.

Device for oscillography of analog and discrete input circuits. To implement the oscillography of discrete signals, an isolation amplifier (Fig. 3) was developed according to the optocoupler circuit. Since the signal is galvanically isolated in this device, two parts are distinguished in the circuit: the first, powered from the network, and the second, powered from the power supply of the relay protection microprocessor. Thanks to the linearizing feedback, the input signal is accurately transmitted. So, this device was tested when working with the current relay RT-40. A feature of the device is the use of one multi-channel multi-digit ADC for oscillography, due to which the dimensions of the device are significantly reduced.

As an algorithm for processing a discrete signal, a simple algorithm for checking the state of the signal at the input and comparing it with the value at the previous point in time can be presented, as shown in Fig. 4. At the first moment of time, the ADC reads the signal value and stores it, then the algorithm introduces a delay, and then compares the current signal value with the previous one. As a result, if the values match, then the protection is triggered, otherwise the algorithm starts the check from the beginning. This approach will allow you to correctly tune out from long pulses and power frequency signals if the delay is less than 20 ms.

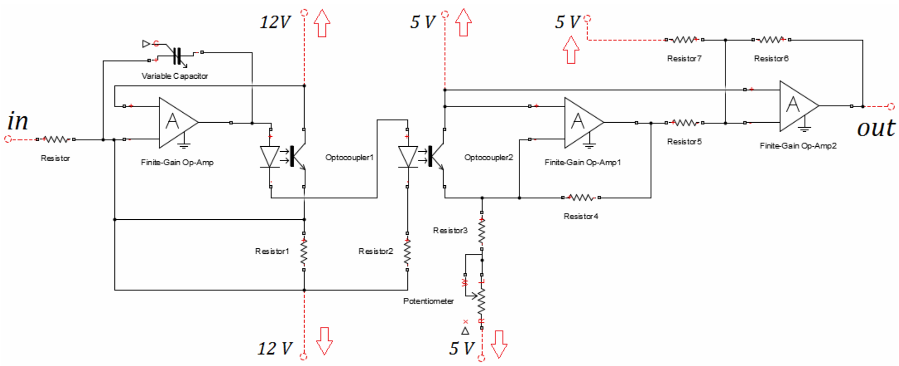


Fig. 3. Isolating amplifier model on optocouplers for implementation of oscillography of discrete signals in the MatLab environment

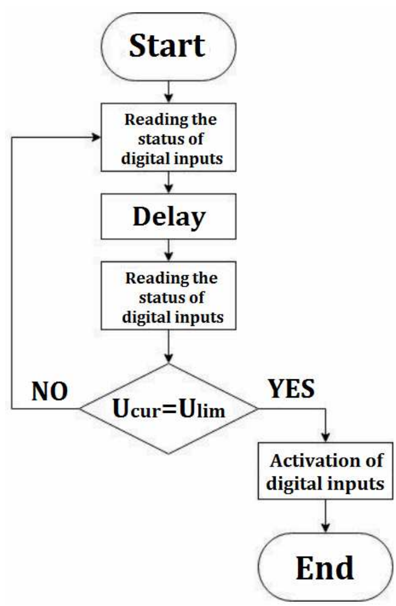


Fig. 4. Discrete signal processing algorithm

Conclusion. Thus, in the course of the work carried out, a model of a microprocessor relay protection and automation device was developed, the main feature of which is its compactness due to the processing of both analog and discrete channels by one multichannel ADC, as well as its prospects due to the use of new approaches not only with the hardware, but also from a software point of view. The next step in the development of the project is to test it in laboratory conditions in various electromagnetic environments, namely testing under the influence of various interferences. In addition, due to the use of a flexibly configured single-board computer, it is possible to expand the functionality of the device in the future.

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Кугушева Наталья Николаевна – старший преподаватель	**Kugusheva Natalia Nikolaevna** – senior lecturer
Баишев Юрий Тимофеевич – студент	**Efremova Elena Nikolaevna** – student
natali_k-80@mail.ru	

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