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ANALYSIS OF THE USE OF THE MICROCONTROLLER TO DETERMINE THE CHARACTERISTICS OF INSTALLATION SWITCHES

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Abstract: *The paper presents the design and construction of a test stand for determining current-time characteristics of electrical installations protection using a microcontroller. Solution concepts were proposed, diagrams and algorithms built, and software code written. Measurements were made and test results presented on the selected installation protection, which were analyzed to check the correct operation and determine the measuring range. Steps were taken to determine the measurement errors of the device and the method of balancing was presented. In addition, the design and implementation of the test stand was carried out in such a way that the tests were carried out primarily in a safe, automated manner, and that further development of the measuring system was possible.*

Keywords: Protection of electrical installations, Time current characteristics of fuses, Microcontroller.

1. Introduction

Rapid technological progress has a significant impact on the metrology development and the possibilities of building measuring systems with considerable accuracy are expanding (Peszyński and Siemieniako, 2014). The possibility of using programmable integrated microprocessor circuits makes it possible to carry out more and more accurate measurements and control the measurement process. Thanks to this progress also has a significant impact on the emergence of more and more effective security systems for electrical installations.

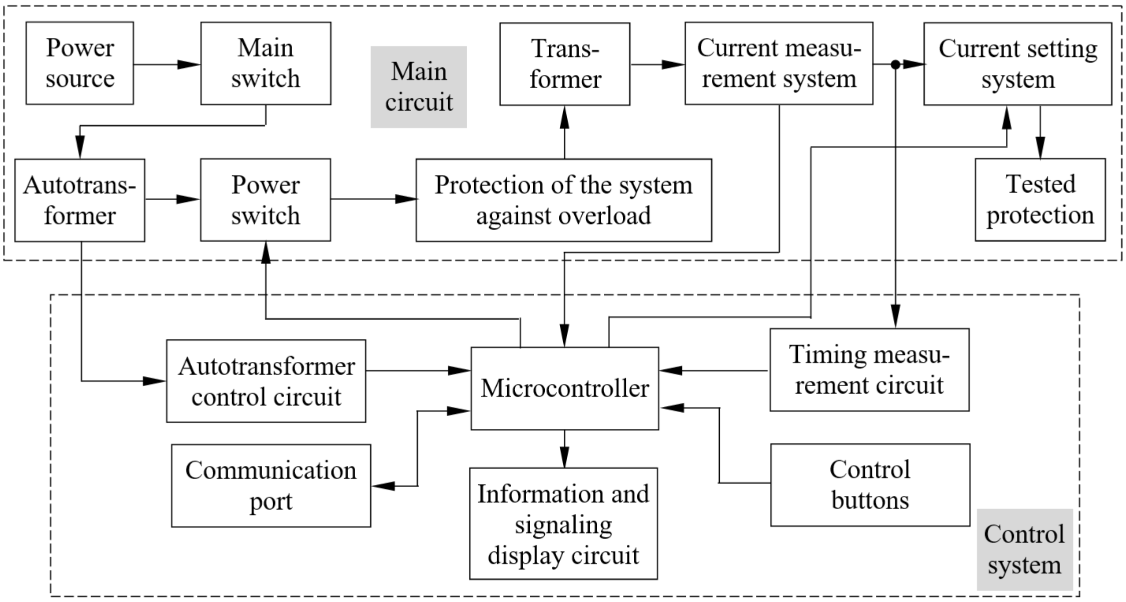

Fig. 1: Block diagram of test stand.

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Electrical receivers, electrical installations and components included in their circuits are subject to interference in proper operation of devices. One of such disturbances are overcurrents, which include short circuits and overloads. Circuit short circuits most often result from its damage and are usually manifested by a surge in current over the permissible value. Overloading, on the other hand, is manifested by an increase in the current over the long-term value in the intact circuit and is usually due to the excessive power consumption of the receivers. In order to avoid the effects of overcurrents in electrical installations, overcurrent protection is applied. An important parameter determining the correct operation of the electrical installation protection system is the selectivity of operation. Its correct determination can be made on the basis of metrological measurements.

2. The use of a microcontroller in a measuring system

The use of a microcontroller in a measuring system can fully or partially enable the measurement process to be carried out in an automated manner, and thus the tests can be carried out safely in a much shorter time. In addition, it is also possible to perform mathematical operations by calling the appropriate functions contained in the libraries or by directly entering mathematical activities in the software code using the data entered or collected (https://www.ti.com). Based on the results of the tests, the user can introduce corrections in the form of taking into account a systematic error or by introducing an error characteristic which ultimately affects the minimization of measurement errors. Measurement systems based on microcontrollers (Perczynski et al., 2016, Perczynski et al., 2018) give the possibility of minimizing mechanical elements such as relays or contactors, which through the way they operate introduce a certain delay in signal transmission and increase the failure rate of the system due to the wear of both moving and contact elements. The design uses the Arduino Uno module with AVR ATmega328 microcontroller.

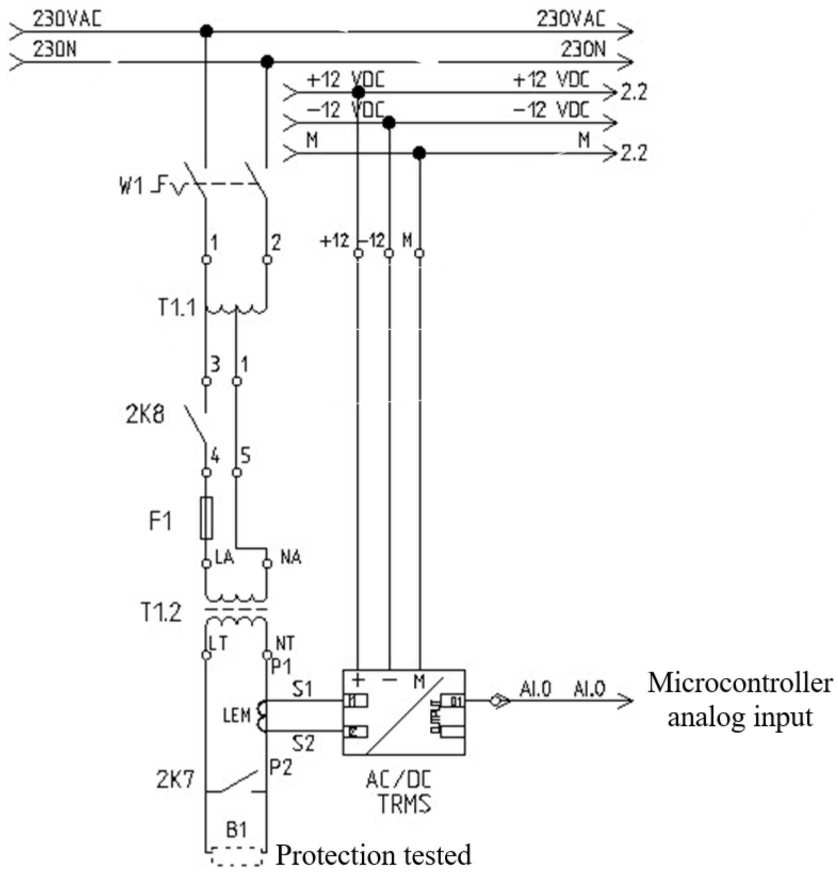

Fig. 2: Diagram of the main circuit.

The microcontroller board has input ports to which signals from peripheral elements (sensors, buttons) and output ports by means of which the actuators of the system are controlled. Depending on the microcontroller used, it is also possible to receive and send signals wirelessly. How the process proceeds depend on the program code in which the programmer has a measurement algorithm. The user is able to adjust the nature of the device's operation to the needs of the performed test by modifying the software via the communication port.

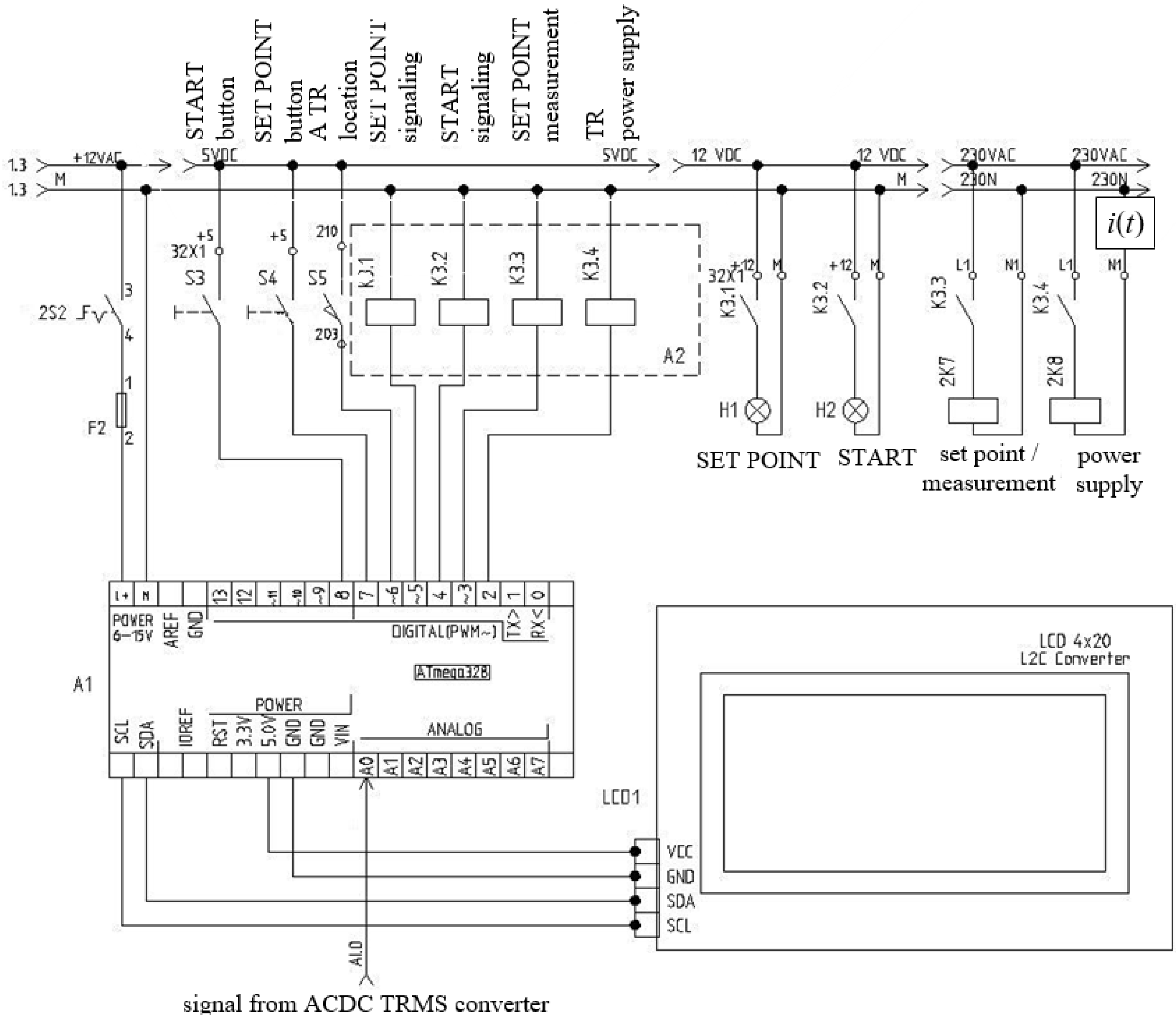

Fig. 3: Control system diagram.

3. Block diagram of the system

The system consists of a main circuit and a control one. The main circuit has power, control, and protection elements together with the current measurement system and the protection element being tested, while the elements in the control circuit are responsible for the implementation of control, measurements, ensuring communication and transferring information.

The measurement of the current in the main circuit is made via a LEM current transformer with AC/DC TRMS (True-Root-Mean-Squared – effective value) converter and a microcontroller. Measurement of operating time consists in the analysis of signals from control buttons and the analysis of the signal from the current measuring system. Pressing the button responsible for starting the measurement, i.e. subjecting the tested protection element to an electric current of a given intensity, also starts the countdown of the time until switching off. The time measurement ends when the switch will operate, i.e. by the main circuit current stops flowing through.

This moment is recorded on the basis of signal analysis from the current measurement system. In Fig. 2 is a schematic diagram of the main circuit, however, Fig. 3 shows a diagram of the control system.

4. Error analysis

In order to determine the error with which the current in the main circuit of the device is measured, a direct comparison method was used. The LE-3P laboratory ammeter with accuracy class 0.5 was used to measure the current standard value. Based on the obtained measurement results, the absolute value was determined from the difference in the device's current indication and the reference system, and its highest value was determined. On this basis, the value of the relative error was calculated, which was described by the relationship (1).

$$\delta_i = \frac{\Delta I_{max}}{Z} \cdot 100\ \% = \frac{0.1}{20} = 0.5\ \% \tag{1}$$

The specificity of the measuring system operation means that the measured time is made with some error. In order to determine the analyzed error, tests were carried out to determine the time delay of switching on and off time registration.

The oscillogram (Fig. 4) shows the time delay that occurs from the time recording begins to the actual appearance of voltage on the tested protection. In a similar way, the error value of time measurement ending was determined.

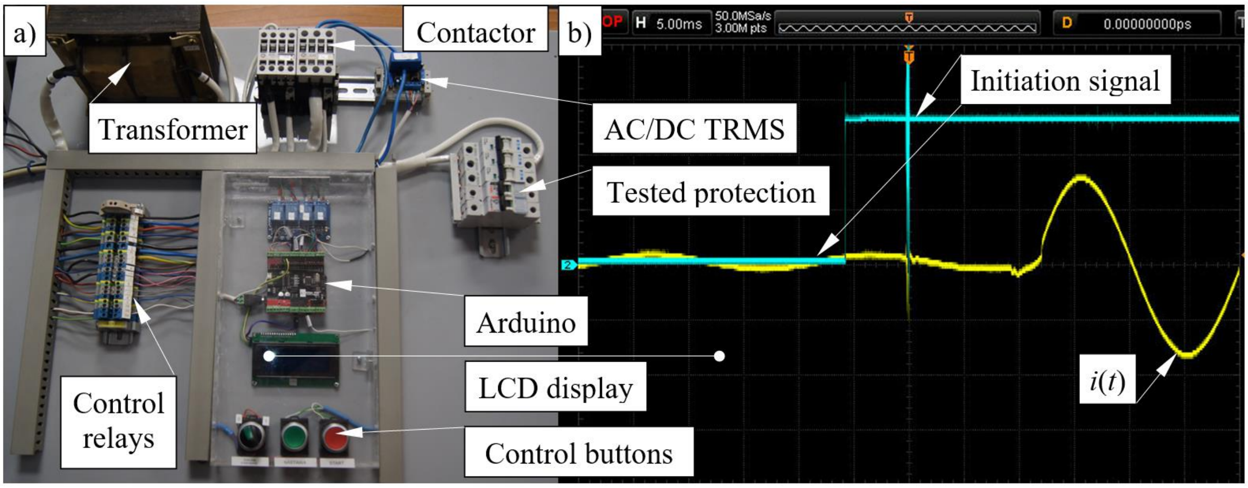

Fig. 4: Security test stand: a) general view; b) test results on the display.

The analysis shows that at the beginning of the measurement time recording begins with about 20 ms in advance, while the time the switch trips, the countdown stops with a delay of about 15 ms. The sum of these two time intervals is the total error with which time registration is made and is 35 ± 10 ms.

5. Conclusions

Security testing is performed in an automated manner. The measurement results are displayed as text information on the LCD display during and after the test. Tasks entrusted to the user include the selection of the tested protection, setting the system in setting mode or measurement mode using control buttons and setting the desired value of the overcurrent using an autotransformer. The order of performed actions is displayed in the form of instructions on the LCD display. In addition, through the software code, the system was protected against performing activities posing a threat to the user or falsifying the result.

To determine the error with which the measurement of the switch-off time of the selected apparatus is made, the oscilloscope waveforms of the trigger signal of the start or end of the countdown time in relation to the signal in the main time recording circuit were analyzed. The results of the analysis showed that the relative time measurement error is 35 ± 10 ms. The use of a microcontroller has enabled the measurement error to be reduced by making a correction in the software code.

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