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AUTONOMOUS DEVICE FOR TESTING TRANSITIONAL RESISTANCE WITH EXTERNAL MEMORY UNIT FOR OUTDOOR TESTING

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SUMMARY

This project is about device for measuring transitional resistance between contacts of disconnectors, switch disconnectors and circuit breakers in transformer stations. Device is developed for and is especially useful during the transformer stations periodical checking when electrical power is completely disconnected (manual mode). Besides measuring transitional resistance, device can be used for thermal relays checking in transformer stations. Device is supplied by electrical power from automotive lead-acid battery 12V= (Cn≥55Ah). Setting of working parameters (reprogramming of stored programs) and data acquisition can be done by computer to which device have to be connected with special software (automatic mode). Regulated current range is from 0A to 100A=, with input voltage (battery voltage) of min. 10V and output voltage of max. 5V (voltage drop on testing contact). External easy removable memory module has capability of storing up to 1000 terrain tests (current and voltage in time). It has a real time clock with calendar and backup battery supply. It also has LCD display for displaying measured variables, device status, warnings etc. Reading the memory module with appropriate software for PC computer could do analysing and storing of the test results. Thanks to the memory module, autonomous device for testing transitional resistance could be fixed in the test car and the only removable part should be the memory module.

1. INTRODUCTION

Transitional resistance between contacts of disconnectors, switch disconnectors and circuit breakers is calculating by dividing measuring value of voltage drop and DC current flow through poles of disconnectors. Producers of disconnector equipment recommend a current of 100ADC as test current. Permitted value of transitional resistance is given as value of permitted voltage drop between poles of disconnectors.
Table 1 shows permitted value of voltage drop for low-oil middle voltage switches, produced by "Minel" [1], [2].

TABLE 1 - Permitted values of voltage drop on switches

Switch nominal voltage kV	Test current =	Nominal switch current A	Permitted voltage drop mV + 25%
12; 17,5; 24	100A	500	14,0
12; 17,5; 24		630	10,0
12; 17,5; 24		800	7,0
12; 17,5; 24		1250	4,2
12; 17,5; 24		1600	3,5
35		630	9,0
35		800	7,0
35		1250/1600	4,3

Device is constructed to reach desired value of test current in very short period of time (less then second), and to maintain it on that constant value during test (measuring time). Test time is settable and operator could optimise it. Preparation time could also be included in test. Preparation time is time from the moment of starting device to the moment when current regulation begins (this could be useful for operator who does the measuring). Test results are readable from device's instruments (ampermeter and mVoltmeter), or if operator saves them into device's internal memory it is possible to analyse results on PC computer by special software. Eight different modes (test programs) could be stored in device for terrain use (manual mode without PC). Device is supplied by electrical power from automotive lead-acid battery 12V= (Cn≥55Ah). As device has full control of current, voltage and time it can be programmed and used for thermal (bimetal) relays checking in transformer stations. Idea for developing this device came from practical reasons. During the transformer stations x/0,4kV periodical checking when electrical power is completely disconnected it was necessary to provide electrical power supply source, besides relatively large (uncompact) equipment for measuring. Usually it was diesel aggregate, which is noisy, problematical for transport and maintenance. Basic project demands for device, which could be used for that purpose, were reliability, small dimensions, accuracy, simplicity and flexibility in changing test parameters. Basic concepts of device, which is developed to accomplish these project items, are described in following text.

2. DEVICE DESCRIPTION

2.1 Hardware

The programmable control unit and power units are in standard 19-inch aluminium reck. The programmable unit is stand-alone microcomputer system for a data logging and precise control of analogue measured values. It also assumes the processing of stored test programs. It has EPROM (32KB), RAM (32KB) and Eeprom memory (2KB).
Measuring is multiplexed in time, with 12-bit multi slope A/D with 10 conversions in one second. Because of demand for current regulation in full range from 0A to 100A with accuracy of less then 1%, and fact that tests with large current (as 100A) are short (less then 60 seconds), device has analogue-digital regulation of bipolar transistors in linear work region. Analogue amplifiers are in inner regulation loop. With 12-bit D/A converter in outside regulation loop it is possible to accomplish different test algorhitms (ramp, pause, jumps…). Also, it is possible to reconfigure regulation loop in the meaning of regulating current or voltage (charge with constant current or constant voltage), as well as automatic change of shunt position in energy circuit (charge or discharge operation). All communication and control lines are opto-isolated. Because of demand for common supply from battery, power supply of electronics and digital instruments is made with DC-DC converters with galvanic isolation, which are resistant on sudden (step) changes and spikes in input voltage (battery voltage when test current is 100A). Device has under-voltage protection and temperature protection of energy components. Alarms sounds and running test is terminating. Energy circuit is cooling by forced air. Command keyboard for manual mode is fitted on the front panel as well as instruments and test points are (Figure 1). Supply cables, test and coax measuring cables, main switch and SUBD connector for serial communication (RS232 or RS485) are fitted on the rear panel.

In the manual operating mode (terrain work), it is possible to select one of the stored programs No1-8, interrupt and terminate the program by pressing the respective button (Figure 2.). Digital instruments for battery voltage and current are fitted on the front panel. Test result from terrain could be saved and analyse latter in the office on PC computer. Automatic operating mode is made via host computer with special party line host computer software.

2.2 Technical data

TABLE 2 - Technical data of device for measuring transitional resistance between contacts of disconnectors, switch disconnectors and circuit breakers in transformer stations

Test current:	0A- 100A
Supply battery nominal voltage:	Automotive lead-acid battery 12V 55Ah min. Uinput > 10V
Test voltage range:	0-5V (voltage drop on disconnector poles...)
Accuracy:	±0,5% of set value
Resolution:	50mA, 0.1mV, 0.2 seconds
Power circuits:	Bipolar NPN transistors
Controlled variables:	Current, voltage, power, resistance
Control elements:	Main switch, automatic/manual switch, program select, push buttons start, stop, pause, reset, save
Displays:	Led's for power, selected program, start, stop, pause, automatic/manual, digital instruments for current and voltage with additional test sockets (0-199.9A, 0-199.9mV)
Termination values:	Test time (charge, discharge*), reached current, voltage, temperature, elapsed Ah
Programmable functions:	Charge, discharge*, ramp (current and voltage as linear function of time), pause, cycles (steps repeating), go to steps, logical operations with conditions...
Display of measuring values:	In manual mode on devices displays, in automatic mode in real time monitoring from central PC or from database (for terrain results)

* This device has no discharge capability

Figure 1. Device for measuring transitional resistance between contacts of disconnectors, switch disconnectors and circuit breakers in transformer stations

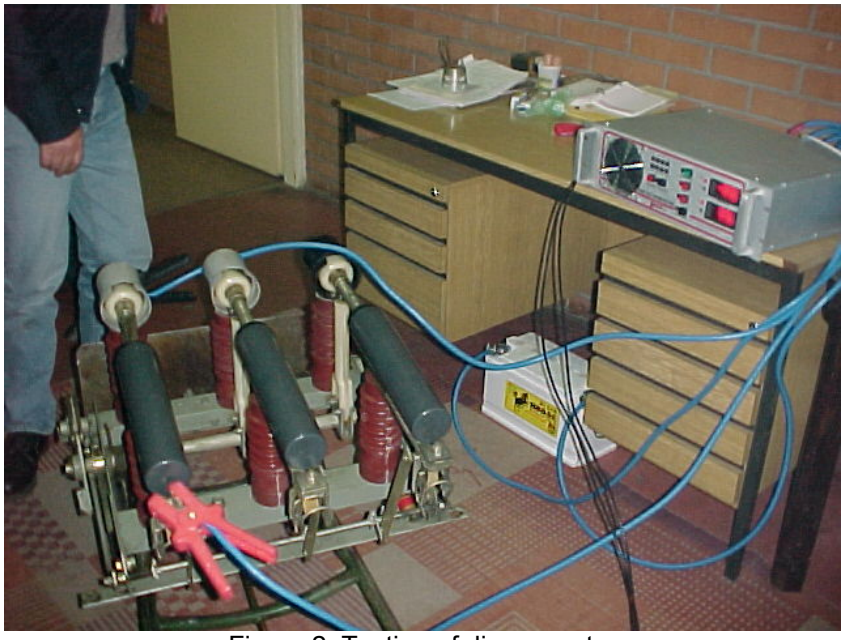

Figure 2. Testing of disconnector

2.3 Software

Software is adaptable programmable party line host computer software for Windows operating system written in Borland's Delphi. It gives to operator opportunity to manage, control, monitor, program, analyse and compare results made by different units (devices) on the same communication line, in the real time, from central PC computer. Without additional amplifiers, on the same communication line it could be registered up to 32 devices. Each device has its own identification number and the registration card. The registration card contains all necessary information about device such as device name, number, and operations, which supports, controllable variables, ranges, capacity etc. It has a few modules. The most interesting module is the one for programming device in automatic or manual mode. A simple original program language is developed for easy defining of test algorithm by making program steps in appropriate table. The program menu is used to create programs, store and retrieve them from the library, send a program to a device's eeprom memory as one of stored programs (for manual mode), or modify a program step and send it to the device to be performed immediately (automatic mode). This module could read terrain result, which is stored in device's memory. Reading of stored results also gives the information about test program, which was performed, and the test chronology. Using this possibility, it could be performed up to 50 outdoor tests with 10 measuring points for each.

2.3.1 The Programs

All tests programs can be split into steps, where certain operations must be executed under well-defined conditions. Each step is fixed in a program line (figure 3.).
Each program step is divided into columns and each column has a headline describing its function.
Column explanations:
Column: Label
Each program step can be labelled which is used for controlling of program executing.
Column: Operation
Each program step starts with an operator determining the function of the test circuit. The operator names are simple abbreviations of the respective functions (charge, discharge, ramp, cycle, pause, and stop).
Column: Set value
As nominal values for this step may be entered current, voltage or resistance of power values.

Column: Term. condition
The termination values current, voltage, time, capacity, energy and temperature determine the end of a program step and thus the beginning of the next program step. In building of condition can be used logical operators AND, OR, NOT.
Column: Term. action
Possibilities for the Term. Action columns are:

- GOTO label -transfers program control to the specified program step

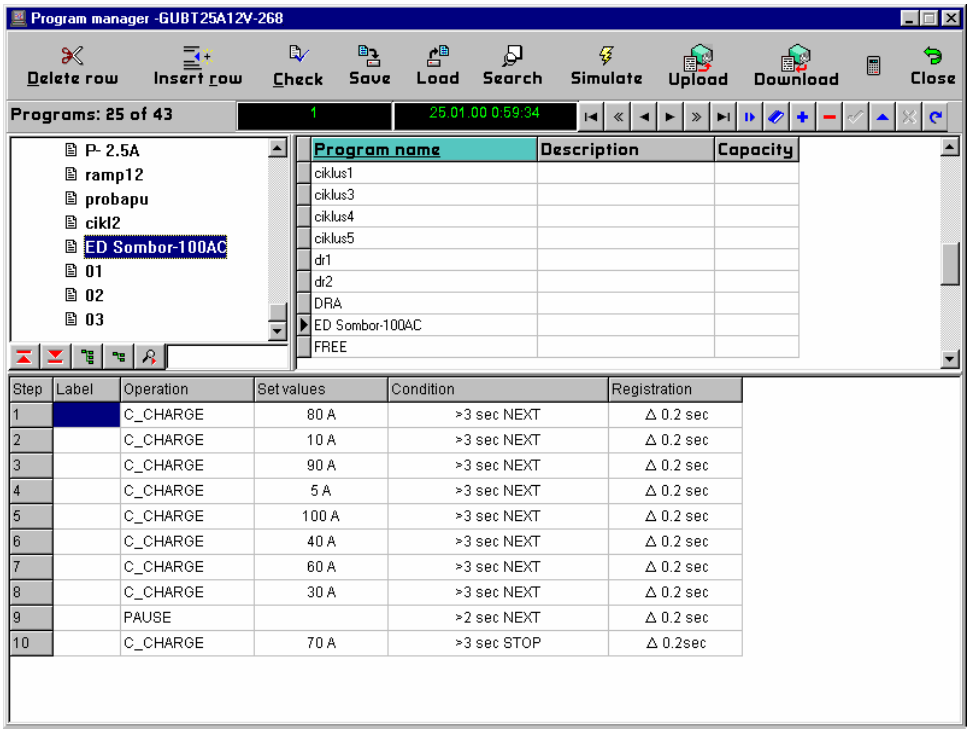

Figure 3. Program example for testing in steps

Results of test from Figure 3. are showed in Figure 4.

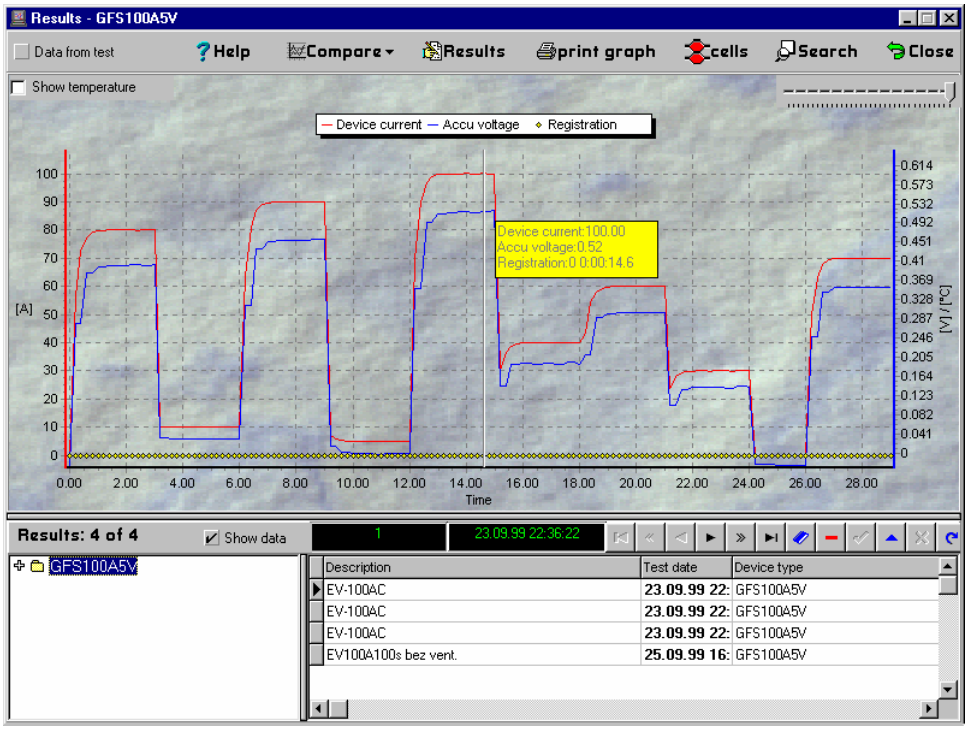

Figure 4. Results of test from figure 3. in database

- NEXT -goes to the next program step
- STOP -terminates program

Column: Abort condition

The values entered under this column may be the same as for the termination values. However, in this case, the program run will be terminated if one of these limit values is reached.

Column: Registration

The conditions for the registration are entered into the last column. These may be time intervals or changes in current, voltage, capacity, energy or temperature.

2.4 Example

Let us assume that, for example, the following program is in the third location of EEPROM memory:

Label	Operation	Nominal value	Condition	Registration
1	Pause		>5sec NEXT	0.2sec
2	Charge	100A	>10sec stop	0.2sec

After starting device with this test program, if all connections are as they should be, 5 seconds after start a current flow of 100ADC should be through test contact. Pause of 5 seconds before current regulation is for operator preparation for reading results. Current flow will elapsed after 10 seconds. Results of measuring control variables will be sampled into internal device's memory in 0.2-second intervals.

After 15 seconds test ends.

For this test to be done in terrain here is a procedure:

1. Connect device's power supply cables to battery on proper polarity (a battery should be previously charged);
2. Turn on the device by pressing the main switch on the rear side (a proper led indication and digital instruments turn on);
3. Connect energy cables on test contact;
4. Connect measuring cable on test points between which a voltage drop (contact quality) is measuring;
5. Press switch for manual mode on command keyboard (respective yellow led diode is on and a red led diode for indication that first program is selected is turn on);
6. Press SET button (Figure 1.) for choosing program (respective red led diode turns on);
7. Press SELECT button to point on desirable program number (red led diode above serial number of program indicates the selected one); each press on SELECT button turns on the next led diode from number 1 to 8; in our example a SELECT button should be pressed twice;
8. When program is selected, a SET button should be pressed (respective red led diode is off);
9. Press START/RESET button (respective green led diode turns on)
10. Test starts, operator should read voltage drop for current of 100ADC;
11. When test ends, led diode STOP is turned on; to repeat the test, a START/RESET button should be pressed to reset device...
12. In a case with software, terrain results are stored in eeprom memory and they could be transfer to the PC computer latter.

3. EXTERNAL MEMORY UNIT

External easy removable memory module has capability of storing up to 1000 terrain tests (current and voltage in time). It has a real time clock with calendar and backup battery supply. It also has LCD display with for displaying measured variables, device status, warnings etc. Reading the memory module with appropriate software for PC computer could do analysing and storing of the test results. All stored test results are with the time and date information. The memory module could be reconfigured by software. Current, voltage and time resolution and range, registration time, delta current and delta voltage are some of parameters that can be changed by reconfiguration. Depending on configuration a storing capability is changing (compression algorithm). Contact-less current measuring with Hall's sond in range from 0A to 1000A is possible with the memory module. Also, a shunt measuring is supported.

3.1 Technical data

- Flash memory of 128Kb or 512Kb
- LCD display 2x16 characters, back light, displaying status, current, voltage, time, Ah, calendar…
- Storing of up to 80000 (128Kb) or 400000 (512Kb) measuring points
- RS232 connector, L.E.M. Hall's sond connector (0 to 1000A), shunt and voltage connectors
- Backup battery 950mAh, 10 years life time
- Industrial temperature range (-45˚ to 85˚C) and IP65
- Dimensions (WxDxH) 120x80x87mm, ABS Bopla.

4. CONCLUSION

This device is in exploitation since October 1999. in Electro Distributions in Sombor and Ruma. Since now, a large number of various tests in different modes are performed. Exploitation shows that, this device is very simple for use and it benefits all project demands. Outdoor testing is more simplified, cheaper and faster. Further steps in exploitation are looking for new possibilities and implementing them into bounds of existing energy capabilities. Also, a large number of periodical tests could show a power of statistical and other methods which software gives. We hope that using this device will help prevention and location of faults in transformer stations, causing by contact quality of disconnectors, switch disconnectors and circuit breakers. Thanks to the memory module, autonomous device for testing transitional resistance could be fixed in the "test car" and the only removable part should be the memory module. That and the fact that all tests are with time and date information additionally improves quality of the transformer stations periodical checking when electrical power is completely disconnected.

5. BIBLIOGRAPHY

[1] Minel, Manual for handling and maintenance of low-oil middle voltage switches for inner mounting, year of 1987, and page 13
[2] IEC 694 Year of 1996, point 6.4