TRANSIENT SIGNAL GENERATOR FOR FAULT INDICATOR TESTING

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ABSTRACT

The paper describes an application for testing of a fault indicator but it could be used for other network protection testing. The application is created in the LabVIEW environment and consists of three parts. The first part of the application is determined for transient phenomenon generation and imitates voltage and current transient signal at ground fault originate. The second part allows to set sequences of trend for each current and voltage output signal, up to six trends for each phase. The last part of the application generates harmonic signal with continuously controllable amplitude of current or voltage output signal and phase shift of each signal can be changed there. Further any sub-harmonics and upper-harmonics can be added to selected current output signal.

1. INTRODUCTION

The fault indicator is a device for identification and location of ground faults according to the analysis of transient signal. The operation of the network with a ground fault belongs to operations with an increased risk of the origination of heavy failures which would result in the interruption of electricity supply to customers. Great stress is therefore laid on a high reliability of indicating or measuring instruments. This is a reason why each fault indicator has to be checked at final inspection. There is tested hardware of fault indicator and correct pre-set of designed algorithm so that sensitivity of the all manufactured indicators was maximal. In case that testing procedure is appointed properly, amount of the wrong indicators (it means which failed) will be decreasing and expenses incurred by claim will be minimal.

2. APPLICATION FOR TESTING OF FAULT INDICATOR

The application for purpose of fault indicator testing is created in the LabVIEW 8.5 environment. The application is composed from three exe parts: Transient signal generator, Trend sequencer and Harmonic signal generator. Each of these parts is proposed for different aim of the testing such as appreciation of indicator pre-set, measuring accuracy and for calibration of the all indicator configuration. All parts of the application are described in detail below.

2.1. TRANSIENT SIGNAL GENERATOR

The Transient Signal Generator application is mainly designed for testing of the fault indicator pre-set. The indicator consists of special algorithm which can evaluate type and place or direction of the fault. Suitable pre-set of the algorithm is very difficult and dependent on network topology and its parameters. Just the Transient Signal Generator (TSG) can verify correct function of the algorithm and fault indicator sensitivity.

Figure 1 shows front panel of the TSG application. On the tab “Nastavení” user can choose type of ground fault, which will be generated to the output of the tester. Radio buttons (No. 4) are used for option of the type of fault from low-impedance to high-impedance ground faults. All these signals were recorded in real compensated MV network at two places, in front of the ground fault location (it means between feeder and fault location) and behind ground fault location. With the aid of controller (No. 6), user can choose ground fault location and then check directional indication of fault indicator. When type and direction of fault are chosen, push button “Spustit” (No. 1) can be used for initiation of transient signal generation. Other tabs show oscillographic three-phase current or phase to neutral voltage and zero-sequence current and voltage. Stop button (No. 2) allow emergency interrupt of signal generation.

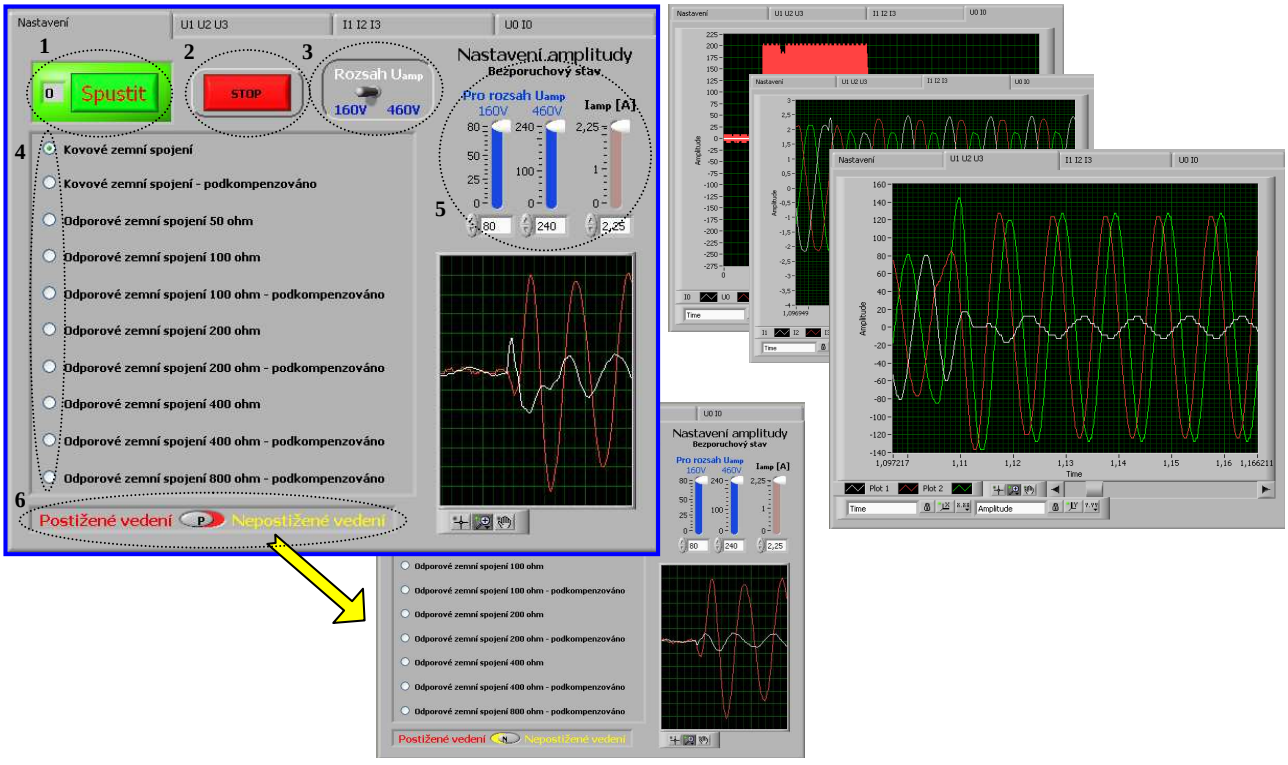

Figure 1: Transient signal generator application

Voltage range is set by toggle switch (No. 3) according to the range on output signal booster. There are two possibilities of voltage amplitude range up to 160V and 460V. Rated (steady-state) three-phase current and phase to neutral voltage can be set by slide (No. 5). This setting depend on type of tested fault indicator, on its measuring inputs.

2.2. TREND SEQUENCER

Accuracy of fault indicator configuration (fault indicator unit coupled with measuring sensors or transformers) can be tested with the aid of Trend Sequencer application. As results of this test could be verification of indicator or algorithm desired sensitivity, eventually determination of new calibration constants.

First tab of application´s front panel is shown in Figure 2. There are three basic parts (No. 1, 2 and 3), figure No. 2 is designed for pre-set of the output signal profile. There is possible to set amplitude and time duration for each part of output signal profile. All profile is divided to three sections (I, I-II, I-III) for easier pre-set. When the section I is selected, number of trends is reduced to 2 from maximum 6 trends (section I-III). Amplitude profile of output signal is continually shown in figure No. 1.

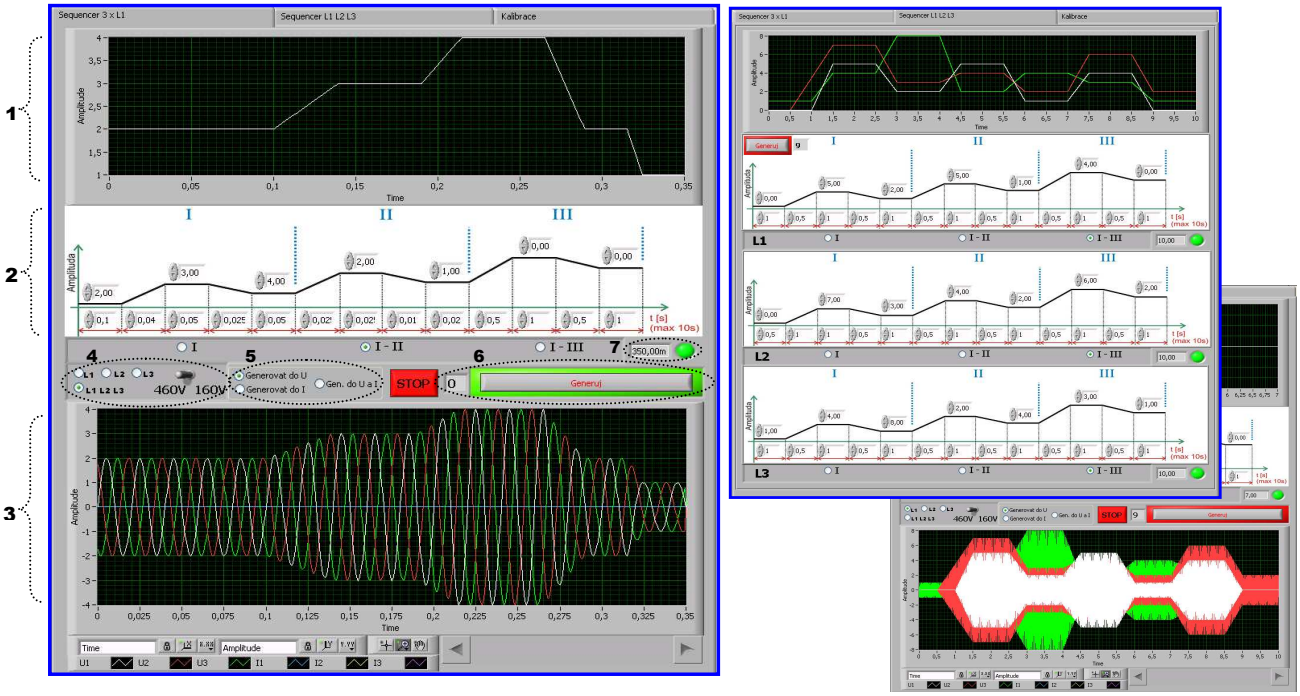

Figure 2: Trend Sequencer application

Maximal time duration of output signal is 10 seconds with regard to used output board, therefore total time is restricted to 10 seconds. Actual pre-set time of shaped signal is shown in frame No. 7. When the maximal time is exceeded, display message and red LED warnings are displayed. Designed signal can be generated to current or voltage output by "Generuj" button (No. 6). Type of output signal and number of phase, where is signal generated, is selected by radio buttons No. 4 and 5. On left side of the "Generuj" button is counter for countdown of time to the end of generating.

On second tab "Sequencer L1 L2 L3", right side of Figure 2, there is possible to design amplitude profile separately for each phase L1, L2 and L3. Possibilities of signal pre-set are similar as with the first tab "Sequencer 3 x L1", which is described above.

2.3. HARMONIC SIGNAL GENERATOR

The last application, Harmonic Signal Generator is primary designed for generation of continuous harmonic current and voltage signal whose amplitude can be fluently changed. There is possible to change shift phase between any current and voltage output signals too.

In this application it can be created arbitrary harmonic signal (higher or sub-harmonics signal), which can be added to current output signals. The Harmonic Signal Generator (HSG) could be used for verification of desired measuring accuracy and for determination of new calibration constants. With the aid of HSG application, it can be generated signal for all quadrants of electric power. Setting possibilities of the HSG are shown in Figure 3 and its description is below.

Amplitudes and shift phases of current or voltage output signals are regulated by slides No. 2. Amplitudes of each phase can be regulated continuously, but for change of shift phases have to be used “SET” button (No. 4). When switch ON/OFF is pressed, extended setting of phase shift (No. 1) is activated. After that it can be set phase shifts between output voltage and current signals (U1-U2, U1-U3, U1-I1, U2-I2 and U3-I3), voltage signal U1 is referential. Slides “Amp I” and “Amp U” (No. 3) allow continual regulation of amplitude of selected current or voltage phases. Checkboxes OFF/ON (No. 2) are prepared for this selection. Generated output signals are displayed in the graphs (No. 6). There are current output signals on left side and voltage signals on right side. Toggle switch (No. 4) is designed for range change of voltage signal. LED indicator “Rele 2V-5V” signals impulse from fault indicator relay.

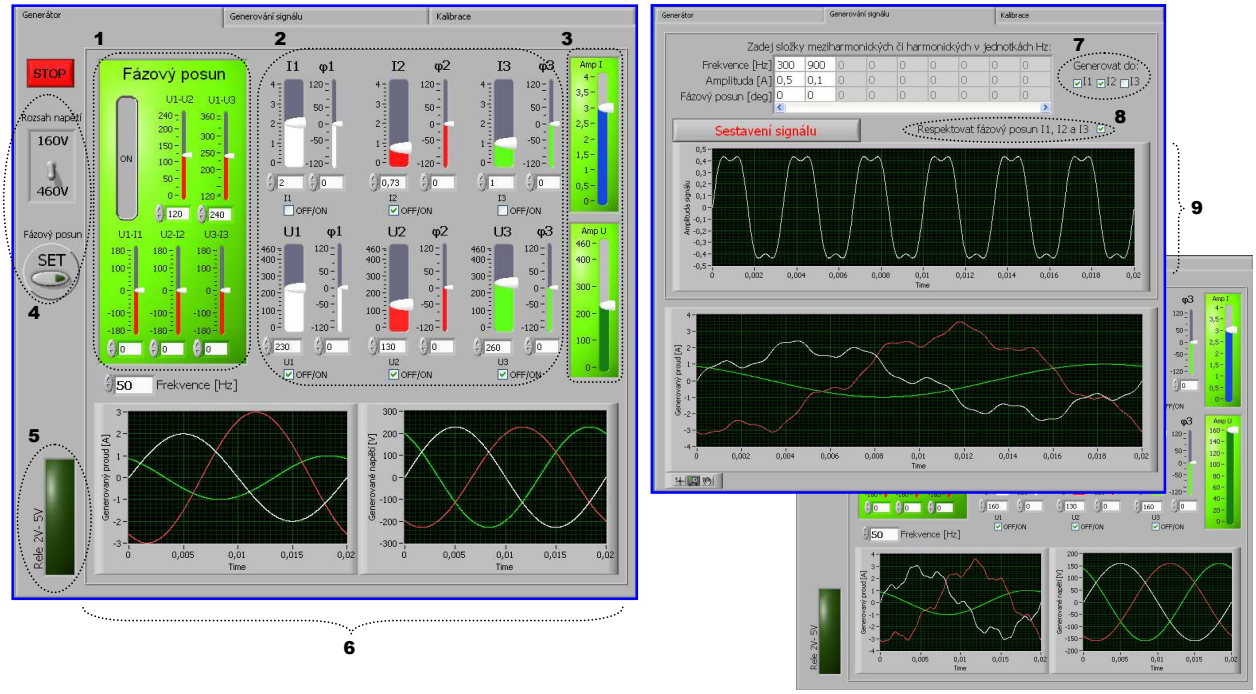

Figure 3: Harmonic Signal Generator application

The HSG allows creation of harmonic signal, which can be added to fundamental current signal. Second tab “Generování signálu” contains table, where it is possible enter tone frequencies, tone amplitudes and tone phases of the signal. When it is pressed button “Sestavení signálu”, desired waveform is depicted (No. 9) that is the sum of integer cycle sine tones. After that it is possible add the waveform to selected current signal (No. 7). Last checkbox (No. 8) enables option of the waveform phase shift which respects phase shifts of phase currents.

3. TRANSIENT SIGNAL GENERATOR SYSTEM

All these applications are designed for control of analog output card NI PCI 6713. The PCI card is equipped with 8 analog voltage output channels. Maximum voltage of each channel is 10V and update rate is 1Ms/s. The card contains 8 digital bidirectional channels whose maximum input/output range is 5 V. The card is connected to output signal booster by SCSI 68 pins cable. The cable is reduced to six voltage channels and it is linked to output signal booster by BNC connectors. The booster amplifies low voltage of the card's outputs to testing. Booster unit is composed of voltage and current source. The voltage source has switchable rang of output voltage and therefore it can generate voltage signal up to 460 V_p or 160 V_p. The current source can generate current signal up to 4 peak amps. Schema of the Transient signal generator system is shown in Figure 4.

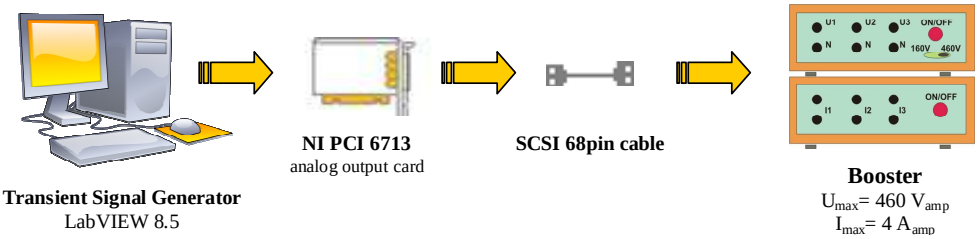

Fig-ure 4: Transient signal generator system

All configuration of the Transient signal generation system can be calibrated, for this purpose "Kalibrace" tab is designed. The tab is part of Trend sequencer and Harmonic signal generator applications. This tool is not required for Transient signal generation application because there are no requirements for high accuracy of fault indicator testing process. In the case, that user needs recalibration of the system, user has to enter correct password and than calibration menu is activated (Figure 5). The menu contains three tables, two for voltage outputs (160 V_p and 460 V_p range) and last is for current output calibration.

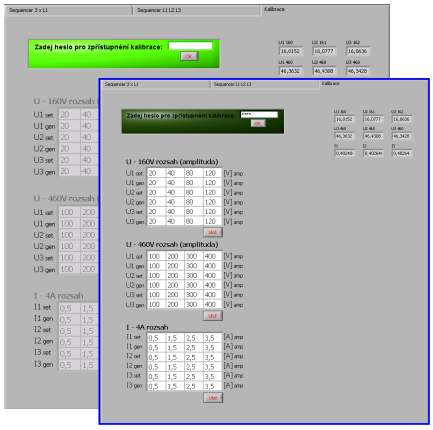

Figure 5: Calibration menu

4. CONCLUSION

Because simple process for fault indicator testing still no exists, the designed applications can help to simplification and utilization of all routine test procedure. Thanks to Transient signal generator and unified testing process, number of failed fault indicators could be lower. When sensitivity and selectivity of all produced fault indicators will be on high level, their popularity will be higher.

ACKNOWLEDGMENTS

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