LABVIEW APPLICATION FOR MONITORING OF VOLTAGE EVENTS IN SUPPLY SYSTEM

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Abstract: The paper deals with problems about precise detection of voltage events occurred in public supply networks. Voltage events (voltage dips, short interruptions and voltage swells) are disturbing phenomena which have a negative influence to proper operation of all connected electrical appliances. Voltage events are considered as two dimensional phenomena whereas residual voltage and time duration of voltage event are their description parameters. For their detection voltage event monitors and analyzers are used. Each voltage event monitor operates along with used detection algorithm which is implemented onto it. Although several types of detection algorithms are known most of actually used voltage event monitors and analyzers have implemented detection algorithm based on computation of root mean square value of voltage over a cycle of voltage signal period with half cycle refresh period – the algorithm is known and signed as "RMS (1/2)" method. The paper presents a virtual LabVIEW application of voltage event monitor which has implemented also others detection algorithms than only "RMS (1/2)" method.

Keywords: voltage event, detection method, voltage event monitor

1. INTRODUCTION

"RMS (1/2)" method is the best known voltage event detection algorithm. Its main advantage is that the algorithm is very simply, so it can be implemented onto many of voltage event monitors which are intended also for outdoor usage. So they do not require a permanent connection with personal computer. However the simplicity of "RMS (1/2)" algorithm causes relatively low level of accuracy in detected voltage event parameters. Many of abroad authors in their researches [4][5][6][9] verify abilities of "RMS (1/2)" algorithm to correct detection of simulated voltage events and compare its results with other detection algorithms results. In [8] author describes limitations of "RMS (1/2)" algorithm (except others author presents that voltage events with specific values of time duration and residual voltage cannot be detected by this algorithm). That is why other possible detection algorithms were considered for usage in developed virtual voltage event monitor described in this paper.

2. VOLTAGE EVENT DETECTION ALGORITHMS

Detection algorithms for voltage events can be divided onto two main groups. In the first group there are algorithms, which compute effective voltage value always over a pre-set time window (for example for each period of input signal). Except "RMS (1/2)" method Discrete Fourier Transform (DFT) method belongs onto this group. The accuracy of detection methods depends on a size of used time window and also on the used refreshing period.

In the second group there are methods which can detect voltage events in real-time. These methods are known as "track algorithms", because they predict voltage magnitude on the basis of voltage value found in previous sample. This group consists of "Ziarani" track algorithm [5], Extended

Kalman filter (EKF) [6][7][9], Wavelet analysis and others [6]. More detailed information about mentioned detection algorithms as well as results of lots of simulations are published in [10][11].

3. VOLTAGE EVENT ANALYZER IN LABVIEW

Using data acquisition card from National Instruments Company a voltage event analyzer was created in Labview software. Analyzer can detect voltage events by "RMS (1/2) algorithm, "Ziarani" algorithm or EKF method (type of algorithm is selected by user before measurement initiation). Analyzer operates with discrete voltage signal (sampling rate is set by user) so in the case of track algorithms for each input voltage sample a new value of voltage magnitude is computed. On the basis of recorded voltage event shape the standard voltage event parameters (residual voltage and time duration) are computed and also voltage values before event origin and after event finishing are computed.

Description of analyzer properties, operations and controls is possible to divide onto three general states (initial analyzer setting, start and voltage events monitoring, analyzing of recorded events) which are described below.

3.1. INITIAL ANALYZER SETTING

First step which user has to do is fulfilling of some information about measuring and its specifics – especially measuring place, the name of person who executes measuring, file name, nominal voltage and frequency of system where analyzer is installed, sampling rate and refresh period of used data acquisition card are requested. Then user can resize allowable voltage range (primarily nominal voltage with tolerances ±10% is considered) and value of voltage hysteresis (2%). User also can choose number and size of classes for detected voltage events classification (example of possible classes [2] is shown in Table 1).

Residual voltage / Time duration	90% > U ≥ 85%	85% > U ≥ 70%	70% > U ≥ 40%	40% > U ≥ 5%	5% > U ≥ 0%
10ms ≤ Δt < 100ms	N_{11}	N_{12}	N_{13}	N_{14}	N_{15}
100ms ≤ Δt < 200ms	N_{21}	N_{22}	N_{23}	N_{24}	N_{25}
200ms ≤ Δt < 500ms	N_{31}	N_{32}	N_{33}	N_{34}	N_{35}
500ms ≤ Δt < 1s	N_{41}	N_{42}	N_{43}	N_{44}	N_{45}
1s ≤ Δt < 3s	N_{51}	N_{52}	N_{53}	N_{54}	N_{55}
3s ≤ Δt < 20s	N_{61}	N_{62}	N_{63}	N_{64}	N_{65}
20s ≤ Δt < 60s	N_{71}	N_{72}	N_{73}	N_{74}	N_{75}
60s ≤ Δt < 180s	N_{81}	N_{82}	N_{83}	N_{84}	N_{85}
180s ≤ Δt	N_{91}	N_{92}	N_{93}	N_{94}	N_{95}

Table 1: Statistical classification of voltage dips in public supply systems [2].

After this initial setting which is identical for all detection methods user choose algorithm by which voltage events should be monitored (in the case of track algorithms user has to set all initial algorithm constants – mi_1, mi_2, mi_3 for "Ziarani" algorithm and constants R, Q for EKF). At this moment analyzer setting is finished (front panel with illustration of initial analyzer setting is shown on Figure 1a) and user can step to next state – "start and voltage event monitoring".

3.2. START AND VOLTAGE EVENTS MONITORING

Analyzer has two possible modes for its running. User can select from "simulation mode" (input voltage signal is simulated in LabVIEW application and voltage events are manually initialized by user) or "measuring mode" where input data are taken from data acquisition card. When input voltage source is selected (switching between input voltage sources when analyzer is in progress is not possible) user can run the application. After application run information about all setup parameters from previous step are saved to text-file (for simpler orientation in many of executed measurements).

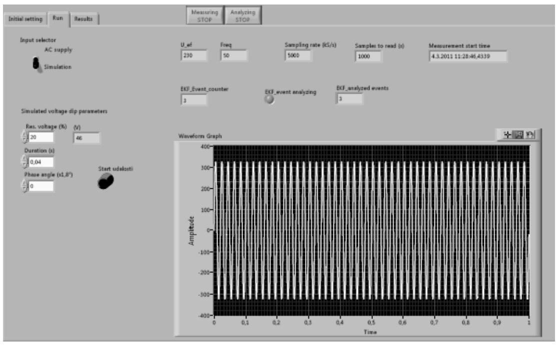
If analyzer is in progress, instantaneous values of computed voltage magnitude and frequency of input signal are indicated on the screen. User also sees the graphic curves of input voltage and analyzer output. Each computed voltage value is classified whether it is inside or outside of allowable voltage range Un ± 10%. Consecutive outside values are saved in buffer until output voltage is in tolerance Un ± 10% when all values from buffer are saved to file signed by order of detected voltage event and buffer is cleared. Indicator of actual event counter is also placed on the screen (screen is shown on Figure 1b).

3.3. ANALYZING OF DETECTED EVENTS

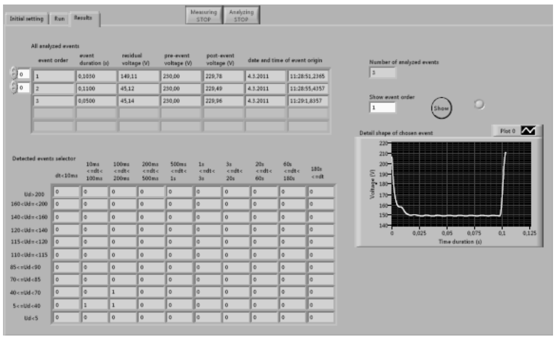
If analyzer detect voltage event, after its finishing user can switch the screen onto the third part where results with detailed information about voltage events are shown. But analyzer has to be still in progress. In principle analyzer consists of measuring loop and analysis loop whereas measuring loop has a higher priority. As soon as the measuring loop finishes a process of recording voltage event values (event is finished and data from buffer are saved), the measurement loop gives a signal to analysis loop to its running. Then analysis loop reads from defined file all data about detected event (except of voltage values during event a time of event origin and a time of event ending were saved). Minimal voltage value for voltage dip or maximal voltage value for voltage swell is found and saved as residual voltage of detected event. From values of event time origin and event time ending the second event parameter (event time duration) is computed. By these event parameters all detected events are sorted into several classes which were set by user in the first step of analyzer initiate setting. A table with set classes is displayed on the screen. User also can display a shape of detected voltage event – he selects an order of detected event and click on the circle “show button”.

Except of these event parameters analyzer also detects pre-event and post-event voltage magnitudes – they are computed always in a whole undisturbed period before and after voltage event respectively. All detected event parameters are displayed on the screen (Figure 1c) and always in preset time intervals they are saved to file.

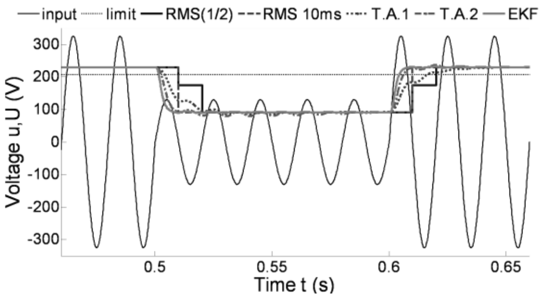
a)



b)



c)



d)

Figure 1: Analyzer screens in possible analyzer states: a) screen for user setting; b) screen during progress; c) screen with analyzed results; and d) comparison of each algorithm response to voltage dip with 100ms of time duration, residual voltage 40% of nominal voltage 230V, rectangular event shape, no voltage wave distortion and zero initial event phase angle.

4. CONCLUSION

The paper presents a voltage event analyzer which is based on virtual instrumentation in LabVIEW. Using data acquisition card analyzer monitors and detects voltage events occurred in supply voltage. Analyzer can operate on the basis of known "RMS 1/2)" detection algorithm but also user can select from others detection algorithms which are presented in abroad researches as algorithms with better accuracy in parameters of detected voltage events. Others detection methods are signed as track algorithms and for purposes of this paper "Ziarani" track algorithm and Extended Kalman filter (EKF) algorithm were used and implemented onto analyzer. Although implemented algorithms cannot run simultaneously (track algorithms have relatively big requirements to memory and computing power) user can compare results of each algorithm in simulation mode or by usage of other computing unit in connection with other data acquisition card.

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