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DATABASE WITH REAL MEASUREMENTS, A NECESSITY FOR VOLTAGE SAGS STUDY

BY

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Abstract. The paper, presents several theoretical and practical aspects of field data collecting and processing, to prepare a database with real measurements recorded during voltage sags. In this context, a procedure for reading the specific files has been described and a database with real measurements was created. In addition, the recorded data can be saved into general files format as recommended by international standards.

Key words: voltage sag; database; data processing.

1. Introduction

The voltage sags, defined as a decrease in root mean square (rms) voltage at consumers' terminals are one of the important power quality disturbances that have been focus considerable research in recent years (Aung *et al*., 2004). The level of rms voltage drop, to be considered as voltage sag, is from 0.1 to 0.9 pu of nominal voltage, for duration from 0.5 cycles to 1 min. The duration of voltage sag is defined as the time measured from the moment the rms voltage drops below 0.9 pu of nominal voltage to when it rises above this level (Naidoo & Pillay, 2007).

The voltage sags can cause major problems in several types of

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equipment, especially electronic equipment, or adjustable-speed drives, very sensitive to such perturbations. Acquiring of a less sensitive equipment is, of course, more expensive, so the designers have to know the sag characteristics on the distribution buses to make a good decision concerning the compromise between equipment cost and it's supplying solutions (Juarez & Hernandez, 2007).

On the other side, the network operators need to estimate the effects of voltage sags on the load connected to the distribution buses to make appropriate settings of the protection and automation devices. Harmless voltage sags can be the origin of system load loss due to the protection device sensitivity (Gomez *et al.*, 2002). Consequently, it is necessary to obtain accurate information about voltage sags characteristics.

Voltage sags characteristics can be estimated either by field data processing or by simulation tool based on a time-domain technique. The increasing of the recorders number located through distribution system make the first alternative to became more attractive.

However, when we consider the large amount of data that may be collected in a given power system, the manual inspection and extraction of information about the events is no longer a practical option. Therefore, it is necessary to have automatic analysis tools, integrated with the monitoring systems, for automatic analysis and classification of voltage sags and others power quality events. This information is important for identifying the type and parameters of the voltage sags occurred at a specific bus.

In this context, the present paper describes a procedure for data processing of the field information, recorded during voltage sags, to highlight the type and parameters of the voltage sags.

Using field recorded instantaneous values of the phase-to-neutral voltages during system perturbations, the processing algorithm computes rms voltages, identifies duration of the voltage sag, establish it amplitude and phase angle shift. On this information the voltage sag is classified, using "ABC" classification, proposed by Bollen & Gu (2007). On this way the voltage sag statistics can become valuable information to the end user.

This paper is organized as follows: Section **2** presents the problem formulation and some theoretical aspects; Section **3** describes the algorithms proposed for field data processing and the next, Section **4**, presents some case studies using proposed algorithms for data processing in a real case.

2. Problem Formulation

Usually voltage sag is characterized simply by two parameters, its magnitude and duration. This characterization assumes a balanced voltage sag and do not include phase angle shift.

In reality most voltage sags are unbalanced due to unbalanced faults in different points of the network. Consequently, voltage sag needs a more complex characterization. So, in literature, were developed several methods for voltage sags characterization and classification. In this paper three phase voltage sags are considered as a single event. In terms of classification, it has been choose to use as was mentioned above, “*ABC* Classification” proposed by Bollen & Gu (2007).

This classification proposes to define seven types of voltage sags as follows: type *A* corresponding to symmetrical three phase voltage sags, types *B*, *D*, *F* corresponding to sag that have a major voltage drop on a single phase, types *C*, *E*, *G* corresponding to sags with major voltage drop on two phases.

In this sense it proposes the realization of an analysis tool which will treat step by step the necessary stages to solve this problem.

The developed software has a specific purpose. The measurements files obtained from the monitoring devices are converted for easier processing into an international format. Subsequently all the files have been inserted in the database and will be classified depending on where and when they were recorded. For each file, the measurements will be processed to obtain all necessary information such as: rms voltages time variation, the characteristics of voltage sags.

3. Field Data Processing

To create a database with information recorded during voltage sags it is necessary to obtain measurements at various monitoring points of the system. This is not very difficult because, in recent years, electricity transmission and distribution companies had gradually equipped the electrical substations (especially those at high voltage levels), with more efficient monitoring equipments. One inconvenient of the gradual development is that recorded data is saved in different file formats, because each monitoring equipment manufacturer has developed its own software for analysis, which led to save data in personal formats. If you buy monitoring equipment from a particular manufacturer is required to acquire also the analysis tool from the same manufacturer, so, in case of new monitoring equipment purchases, there appears the trend to buy from the same manufacturer to remove acquisition cost of a new analysis tool.

Consequently it appears the necessity to develop a unique database, and to this end has been developed the software whose algorithm is shown in Fig.1.

This software is based on the specification of international standard C37.111-1991 modified in 1999, which establish an international protocol to organize files containing recordings made in the power system. This protocol is known as COMTRADE (COMmon Format for TRAnsient Data Exchange), and involves dividing the information into three files namely

a) Header File (*.hdr), which contains general information about the recorded event.

b) Configuration File (*.cfg) file that contains information about each recording channel.

c) Data File (*.dat) that contains data obtained through acquisition.

To convert files from special formats to COMTRADE format, there are two ways: either the manufacturer has implemented in his program a procedure to convert files in COMTRADE format, or the manufacturer provides to the user the protocol used to create his special file. For the second case, the program which is used for the database creation contains a procedure for converting the special file in COMTRADE file. Of course if there are new protocols there have to be implemented software and this to be enclosed in the already developed software.

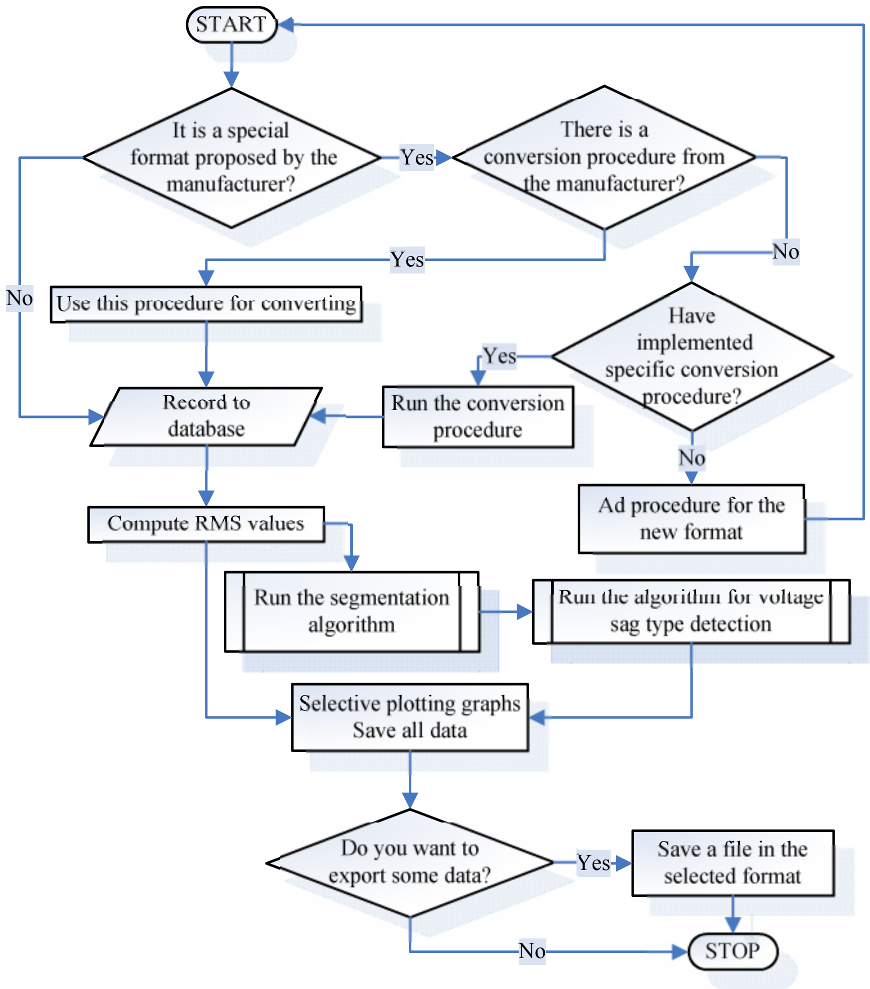

Fig. 1 – The software algorithm.

In the second stage, information about the monitoring place, date and time of registration are read from the new formed COMTRADE files. These information will be embedded in the database. Finally, from the tool it can be selected a specific event which is in a COMTRADE file, and then it can be converted to other common used formats such as: .txt, .xls, .csv.

Data processing is quite a complex problem occurred once with the modern technique of measuring electrical quantities.

Data processing involves reading instantaneous values from the measurements files, processing them to obtain values of interest. For that purpose was developed the second part of the algorithm which contains several functions namely

a) electrical values computation function – aims to determine for each moment of time the rms values of voltage;

b) segmentation function – aims to determine the segments in which voltage sags appear;

c) identification of voltage sags characteristics function – aims to determine the voltage sag characteristics according to ABC classification;

d) functions for graphics plotting and save information in files of .txt, .xls, .csv format.

Since all analysis is done offline, was chosen as a method for determining the rms values, the discrete Fourier transforms (DFT).

Segmentation algorithm is based on rms values calculated at each point of time (Bollen & Gu, 2007). Thus it is determined an index named *change index* (Mrms), which represents the difference between two values (in this case, actual values) of the obtained signal at two consecutive points of time. Index varies when there is a transient phenomenon.

The identification of the voltage sags characteristics is based on *ABC* Classification. With this view an algorithm was developed to determine the voltage sag type from actual measurements, algorithm that is presented in author's Ph. D. dissertation (2010).

At the end of this procedure it can be drawn graphs for rms values of voltages and for segmentation process. After that the information can be selectively saved in file types such: .txt, .xls, .csv.

4. Database Presentation

To achieve the proposed analysis was started from the operation scheme of the electricity transmission system from the west part of the country. In this scheme have been identified lines equipped with a digital protection, which also has the function of "disturbance recorder".

Thus in the database was found some files, containing voltage curves recorded during some voltage sags. Also it was established to monitor in 2010 and 2013, to achieve new records.

On the one hand, the founded old files and on the other hand those that are obtained during the monitoring process are used for implementing the database. The read files are grouped in the form of events, depending on the place where data acquisition was done and according to the date and time the event occurred (Fig. 2).

After the database was implemented, the event that should be analysed is selected and based on its information, the file in COMTRADE format is identified and this will be used in data processing procedure.

For exemplification it was selected the recorded file from 01.06.2010, at 05:01. From the event information it can be seen that the acquisition was achieved with a sampling frequency of 1 kHz. Even in power system studies frequency used is usually at least 4 kHz, regarding that the study refers only to voltage sags, the sampling frequency of 1 kHz is good enough.

Location name	Station name	Recording device ident	Total number of channels	Number of analog channels	Number of status channels	Line frequency	Event date
Oradea	Statia 110 kV Alesd	1	48	16	32	50	5/5/2008 9:50 PM
Oradea	Statia 110 kV Alesd	1	48	16	32	50	7/9/2010 5:21 AM
Oradea	Statia 110 kV Alesd	1	48	16	32	50	2/24/2009 6:48 PM
Oradea	Statia 110 kV Alesd	1	48	16	32	50	1/1/2010
Oradea	Statia 110 kV Alesd	1	48	16	32	50	1/1/2010
Oradea	Statia 110 kV Alesd	1	48	16	32	50	1/6/2010 5:01 AM
Arad	S.D.E. DEVA	1	40	8	32	50	9/30/2009 12:46 ...
Arad	S.D.E. DEVA	1	40	8	32	50	4/10/2009 12:46 ...
Arad	ST TIMISOARA seri...	1	48	16	32	50	5/4/2009 8:03 PM
Arad	ST TIMISOARA seri...	1	48	16	32	50	4/10/2009 12:46 ...
Arad	STD TIMISOARA	2	48	16	32	50	4/10/2009 12:46 ...
Arad	STD TIMISOARA	2	48	16	32	50	10/18/2009 7:44 ...
Sacalaz	S.T. TIMISOARA St...	1	48	16	32	50	1/1/2010

Fig. 2 – Figure's caption.

As noted above, the first stage of data processing procedure begins with data reading from COMTRADE format files. After reading the information from files can be viewed graphically (Fig. 3, for voltage curves).

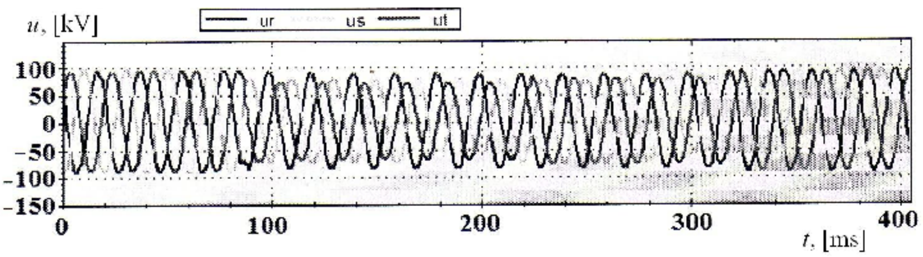

Fig. 3 – Phases voltages during voltage sag.

As a first conclusion that can be drawn from these graphs is that at the system load terminals we have a non-sinusoidal regime.

Further the DFT transform is applied to determine the measurements only for the fundamental frequency and then the determination of rms values. To achieve this step is necessary to specify the sampling frequency. Voltage curves obtained for rms values, computed on the fundamental frequency, are shown in Fig.4.

The next step that has to be covered by the program is to make segmentation. To perform this step, the reduction of samples index is set to value 8, and then the threshold above which are considered transient segments set to value 0.01 if the analysis is performed in pu.

Fig. 4 shows the segmentation process that is applied to the considered event. In this figure it can be observed that there are five segments, which lead to the conclusion that there is sag. The first transition segment occurs at t = 67 ms and ends at t = 106 ms. The second transition segment occurs at t = 205 ms and ends at t = 231 ms. The third transition segment occurs at t = 305 ms and ends at t = 332 ms. Therefore we can say that it was a voltage sag in two steps and the segments where the voltage sag analysis is made are given by the ranges (106…205) ms and (231…305) ms.

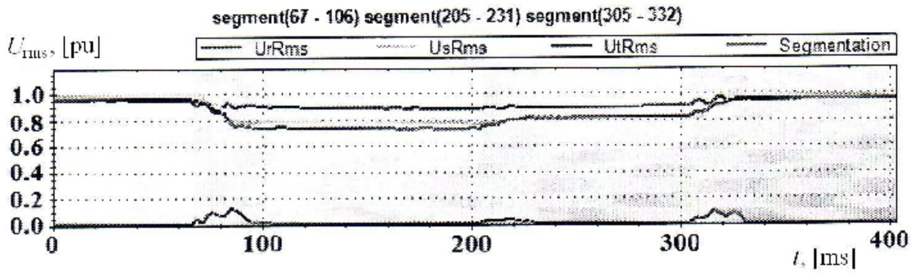

Fig. 4 – The segmentation process.

After segmentation it is started the procedure of identification of voltage sag parameters and type, for each step of sag determined, using the method proposed in author's Ph. D. dissertation (2010). After running the algorithm the parameters for the two steps of voltage sag are presented in Fig. 5.

	No	Start	End	Sag type	Amplitude	Afected phase	Duration
▶	0	107	205	C	0.6070610...	R, S	138
	1	231	305	B	0.7913197...	S	100
*							

Fig. 5 – Parameters for voltage sags.

Finally, the charts presented above were extracted and the information about voltage sag has been saved in database. This information can be export to various formats (.txt, .xls, .csv).

5. Conclusions

In this paper have been presented some theoretical and practical considerations needed to prepare a database with field data recorded during voltage sags. In this way it was collected and processed files from the recorders placed in the electrical network. The recorded files were converted to COMTRADE format and the general information is saved in the database.

Signal processing techniques are classical, since this processing is done offline and does not require the use of more complex techniques such as Kalman filters, Wavelet. However, the sag type detection was made with an algorithm developed by author.

In future works we propose to develop an online procedure for data processing which will lead to the use of more advanced techniques of signals processing.

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BAZE DE DATE CU MASURATORI REALE, NECESARE PENTRU STUDIUL GOLURILOR DE TENSIUNE

(Rezumat)

Se prezintă câteva aspecte teoretice şi practice, referitoare la colectarea şi procesarea datelor din instalațiile electrice, în scopul pregătirii unei baze de date cu măsurători reale înregistrate pe durata golurilor de tensiune. În acest sens a fost concepută o procedură de citire a fişierelor specifice şi a fost creată o bază de date cu măsurători reale. În plus, datele înregistrate pot fi salvate în fişiere cu formate generale, recomandate de standardele internaționale în domeniu.