Energy Quality in Voltage, Current and Power Signals

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Abstract. This article deals with the processing of electrical signals for use in the analysis of the quality of electrical energy in installations. The calculations are based on a three-phase wave, taking into account the evolution in time of the sequential components. The currents within the system are also factored in, and one of the diverse theories of power in non-sinusoidal regimes is applied.

As a result of the described processing, it was possible to show that the three-phase wave enables a better level of compression of the physical phenomena causing perturbations. Future studies will focus on quality parameters of electrical current signals, as these provide information regarding charge problems. The measurement of power brings a new focus which allows the evaluation of perturbations according to their energy efficiency.

Key words

Signal processing, electrical perturbations, power in non-sinusoidal regimes, voltage gaps.

1. Introduction

This study centres on the measurement of electrical perturbations. There are two parts to the project. The first centres on the processing of electrical signals [1], [2], and the second applies one the theories of the measurement of electrical power in non-sinusoidal regimes. In order to test the validity of this approach, the algorithms studied were applied to measurements taken in power installations.

Using signal measurements recorded using registering devices, a study is performed to determine the appropriate algorithm to apply when dealing with signals in perturbed regimes.

Various theories of power in non-sinusoidal regimes were studied [3], and the one best adapted to the project was evaluated. The theory of V. León [4] was adapted for use with the STFT, and applied to transitory regimes.

2. Database of electrical registers

The signals were processed for a large group of electrical registers. These registers were taken from substations and transformer centres in the Valencia Region. In addition, existing infrastructures, created for other studies [5], could be utilised here.

A. Database structure

The database was implemented using MySQL®. Figure 1 shows the tables comprising the database and its relational structures. The tables may be divided into two types: those storing data taken directly from the systems, and those storing results of processing.

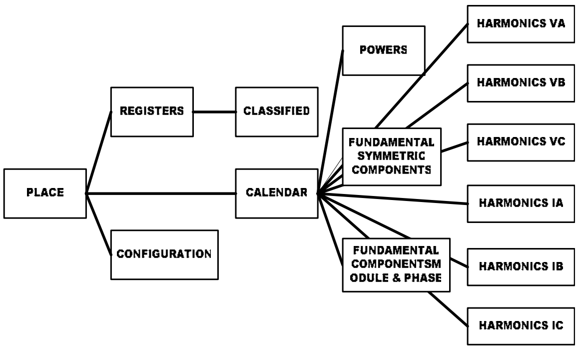

Fig. 1. Relationships among the tables in the database

3. Unified theory of electrical power

There is no consensus within the scientific community regarding the best theory to use.

A. Formulation of the theory

The theory of V. León [4] was selected, as:

1) The components of current confirm Kirchoff´s First Law around a closed circuit.

2) The expressions for instantaneous and apparent power have the same terms, i.e. they are mathematically similar.

3) All the components divided by the instantaneous and apparent power fulfil the superposition principle.

4) This theory encompasses all possible topologies in electrical systems.

5. Application example

In this section the signals obtained from the analysis of a voltage dip in one of the power installations are expounded. Figure 2 shows voltage and instantaneous current in the three phases of a fault measured on the medium voltage side.

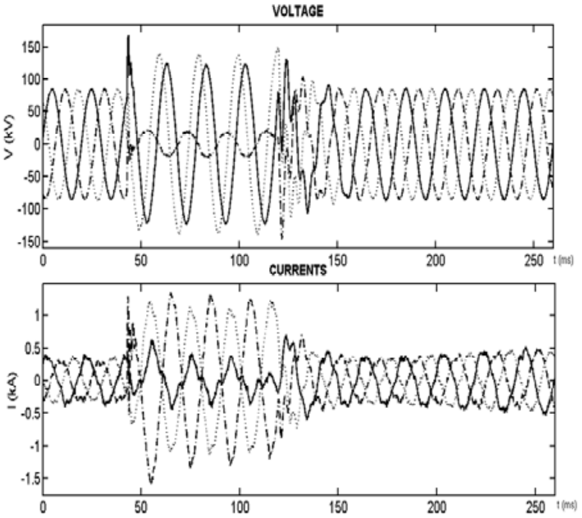

Fig 2. Recording of voltages and currents during a voltage dip.

A. Harmonics

Two formulations have been used to represents the harmonics. The first, shown in figures 3 is based on the representation of the spectrum of the first 32 signal harmonics through a window of one cycle. The figure shows the spectrum during one of the transitory periods of recuperation from the dip.

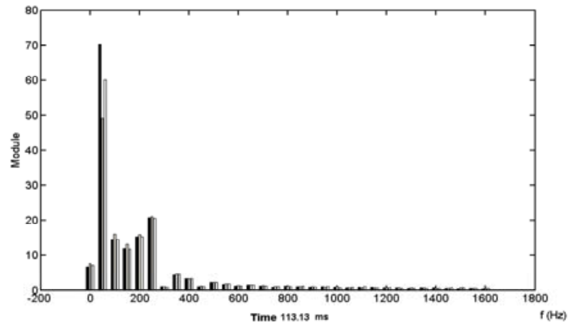

Fig. 3. Spectrum of voltages during the transient time of recuperation form the dip.

C. Power expressions

Once the voltage and current phasors have been computed, the expressions from the unified theory of electrical power may be applied. Values are obtained with a window of one cycle updated for each sample.

Figure 4 shows how the asymmetric and the distortion power expressions increase during the fault. The distortion is maximised at the beginning and end of the fault, as those are the time when the signals are the most deformed. The asymmetry increases much during the dip. For a balanced system, the power is practically nil before and after the dip.

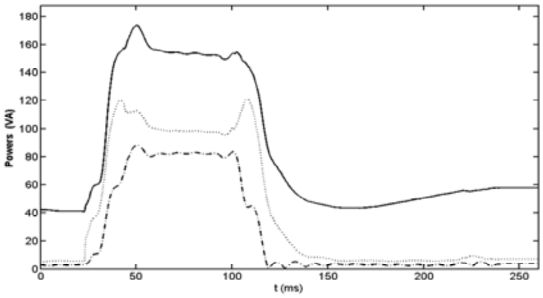

Fig. 4. Time evolution of power expressions

4. Conclusion

This work has served to highlight the following points:

- The STFT does not offer as much time-frequency resolution as might be desired. For this reason, it is necessary to arrive at a compromise between the detection of the perturbation and the exact measurement of the harmonics of the signal. Even so, the STFT affords much information about the perturbation.

- The time evolution of the harmonics enables the detection of problems such as resonances or harmonics appearing after the perturbation. (e.g. voltage dips caused by the starting of a faulty motor).

- Theories of electrical power in non-sinusoidal regimes must be applied in order to analyse the perturbations from an energy standpoint.

References

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