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Parameter identification of electrical power quality by a new synchronisation method and an innovative measuring instrument

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ABSTRACT

The measuring and analysing of the quality and efficiency of electrical power usage is an important topic today and in the future. Electrical energy measurement must be synchronised with power frequency to analyse integer cycles and provide accurate power quality analysis. In this paper a new synchronisation method is presented which is realised from the software side without using PLL (Phase-Locked Loop). The paper also deals with real-time data processing, which is achieved with a multi-core personal computer (PC). In this way the power of the modern PC can be exploited in the area of electrical energy measurement. A measuring device was developed to implement the new synchronisation method and exploit the power of multi-core CPUs.

1. Introduction

Today electrical energy is a significant energy source for industrial and commercial applications, and it will continue to be so in the future. This energy looks like a typical product from one perspective, as it is produced in a plant and transported to consumers, but it is a very special product in another aspect, as it is produced, transported and utilised at the very same time. As with all goods, in general its quality and quantity can be determined, but the quantity is more visible than the quality, therefore in most cases consumers do not care about the quality of the electrical energy. However, the quality has a direct effect on the cost, since consumers could reduce their electricity bills if electrical energy had better quality, and poor quality also can cause damage to equipment.

Providing a standard quality of electrical energy at the utilisation site is not an easy task, because non-standard energy cannot be removed from the network and consumers can also disturb each other's usage. The power supplier would like to know who contaminates its power network, while the consumers want to know whether they receive the appropriate quality. Examination of the quality and study of the efficiency of the energy consumption of companies is of economic significance [1].

The standards EN 61000-4-30 and 61000-4-7 [2,3] define methods and the system structure of electrical energy measurement. According to the standards' requirements, the sampling rate must be more than 18 kHz per channel. In the case of a high number of channels this speed requires a powerful hardware configuration. Although there are many commercial devices whose operation meets the requirements of the above-mentioned standards, these devices are somewhat limited in further off-line analysing, and are intended to carry out measurement only of pre-defined variables.

More powerful and flexible measuring systems are needed in order to examine the electrical energy more quickly and effectively. A flexible system can be developed that integrates a personal computer equipped with a data acquisition board and transducers. Using an advanced computer and measurement method including a self-implemented software algorithm and solution of high

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efficiency, the measurement system can offer more power and flexibility than any commercially available analyser. The new configuration of the measurement process is more flexible, the sample rate can be higher than that defined by the standard if the measurements need it, and the calculation process of parameters is faster and more accurate than before. In many cases the consumers and power suppliers want a different type of power analysis; therefore, in such cases deviation from standards is a must [4,5].

One of the most significant problems in power quality analyses is the power frequency fluctuation. The correctly executed Fourier transformation demands analysis of integral cycles of the time signal. The duration of cycles will be different if network frequency changes. There is a widely used solution to eliminate this problem, when PLL is applied [6–8] but there are some less frequently used methods involving synchronisation as well [9,10]. In this paper yet another method is used: a synchronisation method ensuring analysis of integral cycles is proposed. Details of a new measuring device for the new synchronisation method are also discussed.

The aim of the development of a measuring device using the new synchronisation algorithm was to carry out the on-line data processing measuring in 15 channels using more than 20 kHz sample rate per channel. In this case evaluating all power parameters during measurement is a computing intensive task; therefore, it was decided to implement the software in a multithread environment to exploit the performance of today's multi-core CPUs. Different cores execute different types of operations and parameter estimations, which results in real-time calculation of all parameters.

2. Synchronisation

The network's frequency fluctuation makes it more difficult to analyse the power quality. When using a rectangular window to analyse power quality, it is important to synchronise the measurement window with the power system frequency to avoid spectral leakage error (Fig. 1) [11].

According to the standard EN 61000-4-30:2008 [2], exactly 10 fundamental cycles must be used for analysis as a rectangular window. When the power frequency changes, the width of this window changes as well. The measurement window (T_{reg}) can be calculated from the number of samples for 10 cycles ($N_{10cycles}$) and the sample rate (f_{sr}):

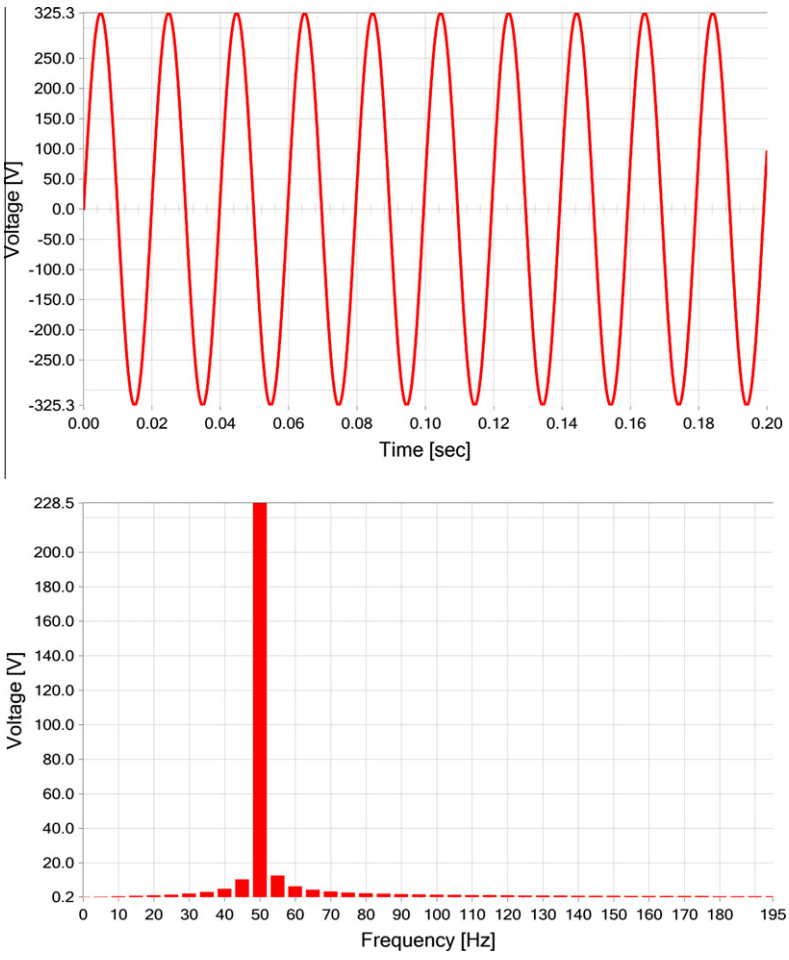

Fig. 1. Spectral leakage error (f_{signal} = 50.25 Hz T_{reg} = 0.2s ≈ 10.05 cycles).