3상 전력을 기반으로 한 시스템 해석 컴퓨터

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Computer Based Three Phase Power Analysing System

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Abstract - The computer based three phase power analysing system has been developed as a traveling standard for onsite power calibration. The system is utilized with digital-to-analog converts which were synchronized each other. Using digital signal processing technique the software has been developed to calculate power parameters. The calibration system is fully traceable to national standard system and, accuracy allows the calibration of industrial power measurement systems.

1. INTRODUCTION

The interest in three-phase power measurement capabilities and testing has grown and the demand on national standard laboratories to provide calibration facilities and traceability for such measurements has increased. In order to provide such facilities to the changing needs of the industry for electrical measurements, KRISS power laboratory is conducting research programme to accommodate power parameters such as active and reactive power, power factor and harmonics etc. Industrial and korean research laboratories which requirer traceability to the National standard laboratory have option to perform the calibration on their laboratories. In oder to provide on site calibration facilities, KRISS require high precision traveling Standard.

Computer based sampling method can be used for the measurement of the ac voltage, current and power. The precision of a sampling method mainly depend on the choice of the analog to digital converters (ADC). In this system we used 16bit resolution high speed data aquisition card manufactured by National Instrument. The designed sampling wattmeter makes use of a high seed digital six channel data aquisition system to generate the power data in real time and uses a fixed sampling rate. Then the developed software calculated voltage, current, power and harmonics.

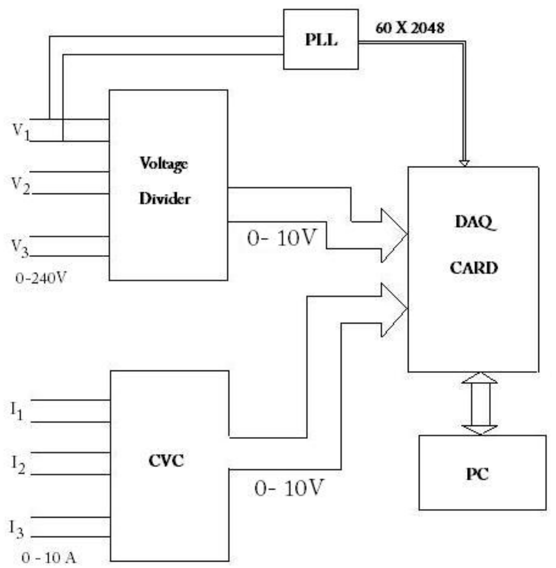
2. Theory

2.1 Layout

The basic circuit of the three phase power measuring system is shown in Figure 1. The system consist of active voltage divider, current to voltage converter (CVC) PLL circuit, Data Aquisition system and laptop computer.

The voltage divider of the system is used to divide input voltage into 5V signal to facilitate the sampling of the voltage by Data Aquisition System. The current inputs terminals are connected to the three 0.1 Ohm standard current shunts attached to instrumentation amplifier and produced 1V full scale value for nominal input currents of 1A, 2A, 5A and 10A.

The current shunts were designed using PCB strips with compensating leads effect. The PLL circuit synchronize all channels with the running frequency of 2048*60 Hz. The data aquisition board consist of six channels and the input voltages of the channels are limited to $\pm$10 V.



<Fig. 1> layout of the measuring circuit

2.2 Power Calculations

Processing periodical signal, whether in Time Domain or in the frequency domain, includes integrating over a cycle or an integrate number of cycles of the signal. The average approximate power P for a periodic signal can be calculated as follows,

$$P \approx W = \frac{1}{n}\sum_{i=0}^{n-1} V_i I_i \qquad (1)$$

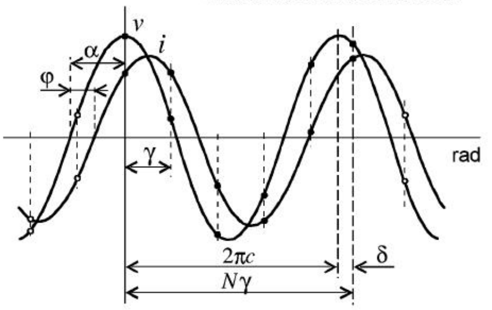
Where V_i and I_i are uniformly spaced samples of the voltage current respectively, and W is the indicated power.

Considering single phase the current and voltage waveform can be represent as shown in Figure 2, where only one single cycle is indicated and parameters are explain in terms of the phase angles. In Fig. 2, α is the initial phase angle of the voltage and φ is the phase angle between current and voltage signals. The phase difference between samples is γ and can be represent as in equation (2).

$$\gamma = wT_s = 2\pi \frac{f}{f_s} \qquad (2)$$

where T_s is the sample time. The f_s and f are sample frequency and signal frequency respectively. Similarly initial phase angle α can be written as

$$\alpha = wT_i \tag{3}$$



<Fig. 2> Dual channel sampling

Equation (1) can be used to calculate power over a summation period $n\gamma$. In real situation, the summation interval of equally spaced samples should be equal to an integer number of periods of a periodic voltage and current signal

$$n\gamma = 2\pi c \tag{4}$$

However, equality (4) is not fulfill perfectly and introduce difference called truncation angle error δ

$$\delta = 2\pi c - n\gamma \tag{5}$$

Therefore indicated power with the correction factor is as follows

$$W = VICos\psi - VI\epsilon \tag{6}$$

Where ϵ is truncation error can be written as

$$\epsilon = \frac{1}{2n}\frac{Sin\delta}{Sin2\pi\frac{f}{f_s}}Cos\left(2wT_i + \psi - \delta - 2\pi\frac{f}{f_s}\right) \tag{7}$$

A similar equation can be derived for the truncation error of voltage and current when calculate the rms values

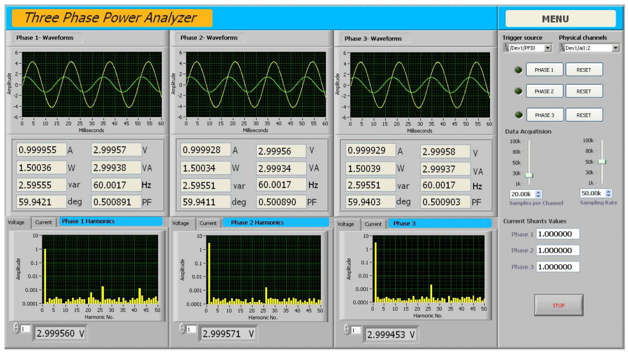
$$\epsilon = \frac{1}{2n}\frac{Sin\delta}{Sin2\pi\frac{f}{f_s}}Cos\left(2wT_i - \delta - 2\pi\frac{f}{f_s}\right) \tag{8}$$

Minimizing truncation error we can obtain accurate results. Therefore, sampling parameters should be chosen to fulfill equation (5) as much as possible. Furthermore, it is advantages to increase the number of samples 'n'.

In Digital Signal Processing, the ratio of f_s to f should be more than two to avoid the aliasing according to the Nyquist criteria.

2.3 Software

The software is developed using LabView for the three phase power calibration system. The control functions of the system such as number of samples per channel, Sampling rates, single or three phase operations are set before run the programme. Common electrical parameters such as rms voltage and current, active and apparent power, total harmonic distortion are calculated. FFT algorithm calculate compleat harmonic analysis for the first 50 harmonics and their peak frequencies. Figure 3 shows a screen printout of the computer based power calibration system software.



<Fig. 3> Screen printout of the power and harmonic calibration software.

3. Results

The software was tested giving voltage and current waveforms to the all phases. As a first step voltage and current signals directly apply to the each channel and validate the software calculations. Some test results are shown in Table 1.

<Table 1> Results of the power measurements

	App.	Software Value			Std. Power Analyser		
	Value	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3
Voltage (V)	3.0000	2.99957	2.99956	2.99958	3.00080	3.00076	3.00084
Current (A)	1.0000	0.99995	0.99993	0.99996	1.00005	1.00008	1.00007
PA. Deg	60	59.9	59.9	59.9	60.0	60.0	60.0
Power Factor	0.5	0.500	0.500	0.500	0.499	0.499	0.499
App. Power	3.0000	2.99938	2.99934	2.99937	3.00096	3.00090	3.00088
True Power	1.5000	1.50036	1.50034	1.50037	1.50038	1.50041	1.50034

Conclusion

The desired objective of the computer based power analysing system is to analyse the three phase power systems onsite thats fulfil the industrial demand. The designed system is capable to use as a travelling standard accuracy upto 0.05%. Furthermore, the software is more flexible and many reference quantities can be calculated particularly those need for harmonics measurements. Further work is planed to improve the accuracy using of discrete fourier transform algorithm.

Reference

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