A VIRTUAL APPARATUS FOR POWER MEASUREMENT

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Abstract. This paper presents a virtual measurement apparatus used for active power measurement. The apparatus use, for the values of measured voltage and current sampling a data acquisition device such as PCI/LPM/16 made by National Instrument. The apparatus is an LABVIEW programming environment application. The main advantage of this apparatus is than is possible to be measured with some precision both sine wave and not sine-wave signals power.

Keywords: Virtual apparatus, quality standards, slow variations, data acquisition, energy**.**

1. THEORETICAL CONSIDERATION

According by the definition, power supply of a generator of power used in a circuit is:

$$P = UI \tag{1}$$

In alternative current circuit, considering that voltage and current like two dynamics variable with momentary value *i* and *u* respectively, the expression of momentary power is:

$$p = u \cdot i \tag{2}$$

Generally, the average value of power is used in a time period T, computed with expression:

$$P_{med} = \frac{1}{T}\int_{t}^{t+T} u \cdot i dt \tag{3}$$

If voltage and current are sine-wave form with some period, then the period of integration in equation number 3 is an integer number of signal cycle period, and active power is computed with:

$$P_{med} = \frac{1}{nT}\int_{0}^{nT} u \cdot i dt = \frac{1}{nT}\int_{0}^{nT} U\sqrt{2}\sin\omega t \cdot I\sqrt{2}\sin(\omega t - \varphi)dt = U \cdot I \cdot \cos\varphi \tag{4}$$

where *U* and *I* are effectively values of voltage and current. It can be defined the reactive power by:

$$Q = U \cdot I \cdot \sin\varphi \tag{5}$$

and apparent power:

$$S = U \cdot I \tag{6}$$

If in complex representation is used, are obtained the following relationship:

$$P = \mathrm{Re}[\underline{S}] = \mathrm{Re}[\underline{U} \cdot \underline{I}] = U \cdot I \cdot \cos\varphi \tag{7}$$

$$Q = \mathrm{Im}[\underline{S}] = \mathrm{Im}[\underline{U} \cdot \underline{I}] = U \cdot I \cdot \sin\varphi \tag{8}$$

If voltage and current are not sine-wave form, but there are periodically, then can be used the Fourier series:

$$u = U_0 + \sum_{k=0}^{\infty} U_k \sqrt{2} \sin(k\omega t + \varphi_k); \qquad i = I_0 + I \sum_{k=0}^{\infty} U_k \sqrt{2} \sin(k\omega t + \gamma_k) \tag{9}$$

The active power a next expression:

$$P = U_0 \cdot I_0 + \sum_{k=0}^{\infty} U_k I_k \cos\theta_k \tag{10}$$

where

$$\theta_k = \varphi_k - \gamma_k \tag{11}$$

is phase difference between ordain k harmonic of current and order k harmonic of voltage.
The power in multiphase circuit is obtained by summing the each phase power.

2. OPERATING PRINCIPLE

Assuming that the average power is integral from momentary power (defined like product of u-momentary phase voltage and I-momentary phase current), was realized in LabVIEW integrated programming medium, a program that allow to measure the average power value in monophase systems.
For data acquisition was used a PCI/LPM-16 DAQ device produced by National Instruments.
The nominal Frequency of measured signal is 50Hz while the maximum sampling rate is 10000 sample per second; this one is the maximum sampling rate permitted by DAQ device in multichannel acquisition mode.
From this value, there are computed the number of sample that will be acquisitioned so the data are acquisition is realized during one period of measured signal.
The multiplication and integration of obtained sample are numerical realized. For the signal integration, the amount signal in absolute value was multiply by the interval between two successive samples; this one is determined like inverse of sampling frequency.
For average power value determination, the previously obtained value is divided by signal period.

3. THE APPARATUS PRESENTATION

Like any LabVIEW application, this virtual apparatus are two windows: the panel windows and the diagram windows.

3.1 The panel window

The panel windows of virtual apparatus for power measurement are presented in figure 1. On this windows, the input and output elements of apparatus are positioned.

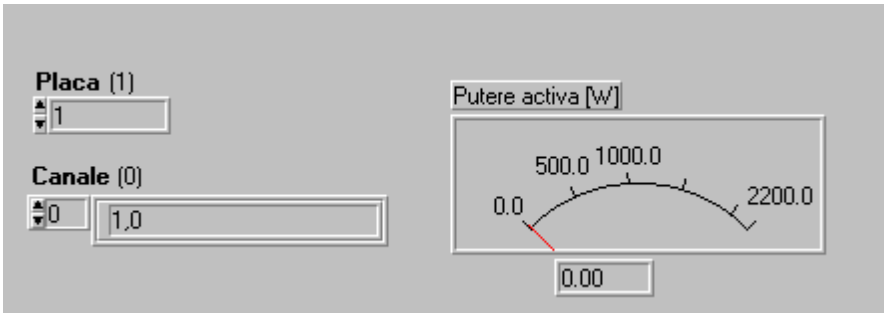

Fig. 1. The panel window

The input elements are:
- an digital control with label ‘placa’ which establish the number of device used in data acquisition;
- an array type control with label ‘canale’ which establish the succession of acquisition channels; the implicit order is channel number one and channel number 0.
The output element of apparatus which is positioned in panel window is a digital meter type element with label ‘putere activa’ the element have the possibility to display digital and pdeudoanalogicals power values.

3.2 The diagram window

The diagram window of any LabVIEW application, describe the operating mode of virtual apparatus. A string of data acquisition specific function forms the diagram window of the virtual apparatus. These functions are: AI CONFIG, AI START, AI READ, and AI CLEAR. This function work in behind specified mode:
-AI CONFIG configures an analog input operation for a specified set of channels. This function configures the hardware and allocation buffer for a buffered analog input operation. This VI calls several advanced analog inputs VIs to setup a task for a buffered analog input acquisition. The AI Config VI calls the AI Group Config VI for the specified device, group, and channels to create a taskID. The AI Config VI then calls the AI HardwareConfig VI to record information about hardware configuration. The input limits input passes to the AI Hardware Config VI, which set up the lower and upper voltage limits for each channel. If theare are not specified new voltage limits the implicit voltage limits are used.
- AI START, start buffered analog input operation. This VI sets scan rate the number of scans to acquire, and the trigger conditions. The input information for this VI is:

- the device number used for data acquisition; furnished by the input element with label ‘placa’
- the order of channels used in acquisition specified by the input element with label ‘canale’;
- the buffer size that is computed by sampling frequency and signal frequency.

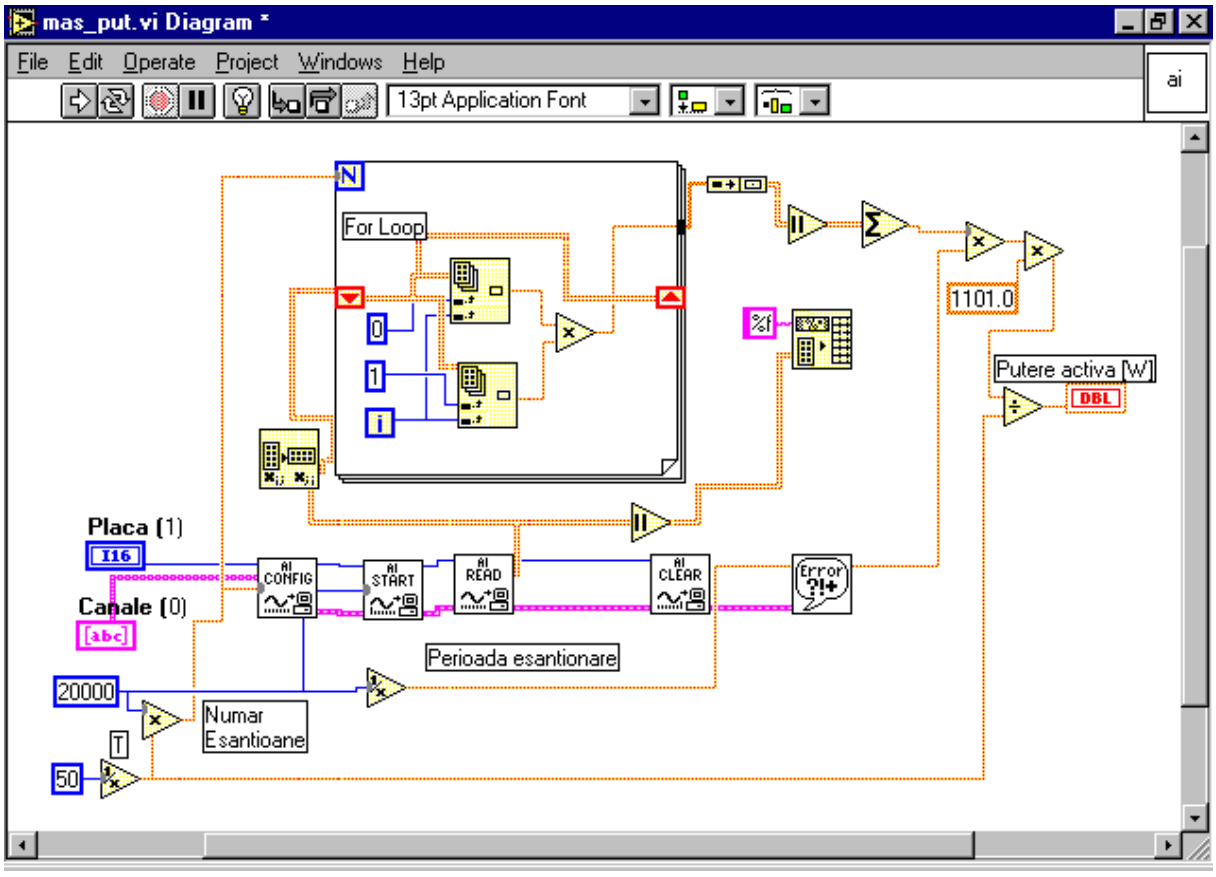

Fig. 2. The diagram window

The output information furnished by this VI is:

- TaskID than specifies the channels number and group, the device number defined in AI Group Cofig
- Error information which is a cluster element with error in channel configuration code;
- Channels is a list of analog input channels to use

-AI READ, read data from a buffered data acquisition. The buffered data, in a numeric matrix form to output of this function are furnished.

- AI CLEAR, clear the analog input task associated with task ID defined in AI CONFIG. In a FOR loop the produce of adequate sample is realized. In the final zone of diagram the numerical integration is realized.

If an error acquisition appears the acquisition is stopped and an error message appear.

4. CONNECTING

The connecting of apparatus to the measurement circuit is realized by resistive divisors. The divisors were dimensioned for maximum 5V signal corresponding both maximum voltage and maximum current in circuit measurement. To protégé the device analog inputs, Zenner diode was used.

The maximum current value is 10A and the maximum voltage is assuming 220V.

Trough adequate admeasurements of input divisors is possible to modify the measurement range of apparatus; in this case is necessary to modify some constants in diagram window of virtual apparatus.

5. CONLUSION

The virtual apparatus can measure the average power value in monophase circuit. The work values are 220V and 10A; is simple to modify input limit for voltage and current. There are used resistive divisors for input signal. The apparatus can measure with some precision both sine wave and non sine wave signal.

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