

VERSATILE MULTIFUNCTION ELECTRICAL DIGITAL METER BASED ON PERSONAL COMPUTER

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Abstract - *The objective of this work is to describe a versatile multifunction electrical digital meter based on personal computer; it has been developed for incorporation into a laboratory testing system. The meter uses two 12-bit A/D. The A/Ds are connected to parallel printer port of PC. The work was developed for Measurement of power. Using a programming language Turbo C++ was calculated: rmsVolts, rmsAmps, volt-amps, Reactive Power, Phase angle, frequency, Active power, watts-hour, resistance, capacitance and period. The values are shown at the monitor as a 4-digit display. The accuracy of meter is within 0.1%. The virtual power meter has a virtual two-channel oscilloscope. The meter was developed to senses power supply of electronic devices. (TV, PC) and electromagnetic device.*

Keywords: Virtual Power Meter, Power Factor Meter, Electrical Digital Meter, Digital Oscilloscope, and Frequency Meter

1. INTRODUCTION

Using instruments such as electrostatic dynamometer, thermal, or Hall effect meter makes the conventional method of measuring electrical greatness. All of them use analog methods. A digital sampling meter, a pioneer instrumental concept as shown in [1], has replaced them.

Digital techniques now predominate in the area of voltage and current measurement and offer an improved accuracy and speed of response over electromechanical instruments. It is natural, therefore, to investigate the use of digital techniques in electrical greatness measurements. Particularly, where a high degree of accuracy and speed of response are necessary.

The power active is measured by multiplying digitized samples of the current and voltage waveforms, using the sampling concepts of [1], [2] and [3]. The high-precision and low cost analog-to-digital converters and personal computer are now readily available.

Then the development of a virtual multifunction electrical power meter instruments based on accurate digital ac measurement algorithm is increasing the used in electrical laboratories.

Boards that plug into computers are attractive alternatives to conventional instruments for many test and measurement applications. The PC has had a dramatic impact on the industrial test and measurement field.

2. BASIC THEORY

The time Domain of the RMS values of V and I measured over an period T for AC input is given by:

$$\text{rmsVolts} \quad V = \sqrt{\left(\frac{1}{T} \int_0^T v^2(t) dt\right)} \quad (1)$$

$$\text{rmsAmps} \quad I = \sqrt{\left(\frac{1}{T} \int_0^T i^2(t) dt\right)} \quad (2)$$

Where $v(t)$ is instantaneous voltage, $i(t)$ is instantaneous current.

The average power measured over an interval T is given by

$$P = \frac{1}{T} \int_0^T v(t)i(t) dt. \quad (3)$$

From Eqs. (1)- (3) we get:

$$\begin{aligned} \text{Volt - amps} \quad S &= VI \\ \text{Reactive Power} \quad Q &= (S^2 - P^2)^{\frac{1}{2}} \\ \text{Power factor} &= P/S \end{aligned} \quad (4)$$

$$\text{Phase angle} = \tan^{-1}(Q/P)$$

3. THE DIGITAL SAMPLING TECHNIQUE

If the voltage and current waveforms are regularly sampled at rate $1/T_s$, where T_s is time of sample. To calculate

the rms voltage, rms current and power active, a typical problem might be to determine the period by zero crossings. The numerical period approximation can be approximates by:

$$\text{rmsVolts } V = \sqrt{\frac{1}{CT} \int_0^{CT} v^2(t) dt} \quad (5)$$

$$\text{rmsAmps } I = \sqrt{\frac{1}{CT} \int_0^{CT} i^2(t) dt} \quad (6)$$

$$P = \frac{1}{CT} \int_0^{CT} v(t) i(t) dt. \quad (7)$$

$$CT = N_s T_s + T_i - T_f \quad (8)$$

Where CT is the sum of N_s sampled time over two consecutive zero crossings and T_i and T_f are the sampled time calculated at initial and at end two zero crossings, using consecutive negative and positive value of sampled voltage (V_{pi} , V_{ni} , V_{pf} , and V_{nf}) as show the Fig1.

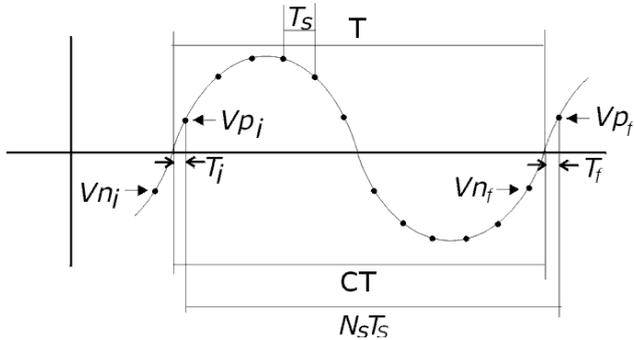


Fig. 1. - Sampling parameter of Voltage waveforms

The integrals in Eqs. (5) to (7) can be calculated by numerical integral approximation using the trapezoidal rule [4].

From Eqs. (5) - (8) we get the discrete greatness:

$$\begin{aligned} \text{Volt - amps } \tilde{S} &= \tilde{V} \tilde{I} \\ \text{Reactive Power } \tilde{Q} &= (\tilde{S}^2 - \tilde{P}^2)^{\frac{1}{2}} \\ \text{Power factor} &= \tilde{P} / \tilde{S} \\ \text{Phase angle} &= \tan^{-1}(\tilde{Q} / \tilde{P}) \end{aligned} \quad (9)$$

To calculate the Frequency of V we can use the Eq. (8).

To implement the Watts-Hour meter we using the interval of time dT from the timer of the personal computer, therefore:

$$\tilde{KWH} = \sum_{i=0}^t \tilde{P}_i dT / 3600 \quad (10)$$

To meter Resistance or temperature we using a DC voltage reference precision and precision resistor. By software is calculate the resistance using the principles of DC voltage sense is proportional to resistance

To meter capacitance we used a capacitor precision and a circuit oscillator, then by software is calculate de capacitance

Using the principles of time constant RC, where it is direct proportional to period, then we calculating the period of the signal and get the capacitance by software.

4. HARDWARE METER CONFIGURATION

The hardware is a portable data acquisition unit, has two parts.

4.1 A/D converter unit:

This unit communicates trough the parallel port of IBM compatible PCs and notebook computers. Using programmable gain voltage amplifiers the signal input of the analog-to-digital converters. By using two 12-bit A/D converters, which are simultaneously triggered at a sampling interval previously determined by the timer of PC. The minimum sampled timer is 28 microseconds, and the maximum sampled timer is 168 sec.

4.2 Signal condition:

The potential transformer provided voltage isolation, and Current isolation was achieved by using a current sensor (LEM), which consists of a Rogowski coil and a Hall-effect device in an encapsulated package. The current sensor has a hole, which the current-carrying wire is passed. The current sensor output is a voltage proportional to the current with a typical frequency response from DC to 50 kHz. The accuracy of current sensor is less than 0.1.

4.3 Parallel ports:

A personal computer cannot contain more than 3 parallel ports. These parallel ports are by default at the basic I/O port addresses 0x3BC, 0x378 and 0x278. We have used 0x378.

4.4 Data Control:

The bits D0-D7 are used to start the conversion of the converters, by selecting the gain and the control of multiplexing data.

4.5 Data Reading:

The unidirectional parallel port has 5 input data bits, reading in data uses 4 bit, and one is used to end the conversion.

4.6 Signal Processing:

The samples from each converter are normalized. During data acquisition process 2000 samples are obtained. The software was developed in C++, and was denominated PCMETER. The flow diagram for the multifunction meter is shown in Fig. 2

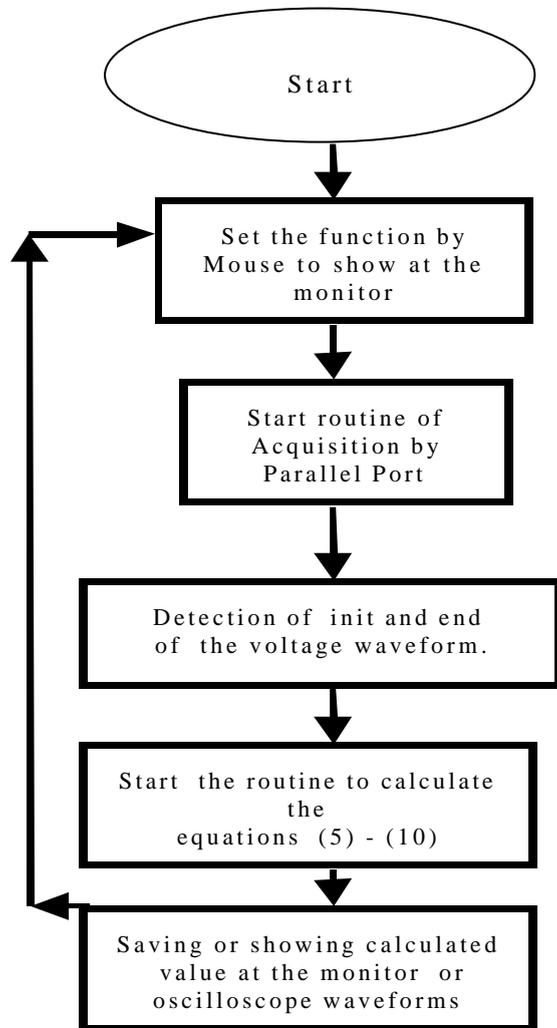


Fig. 2 - Flow Diagram for the Virtual Electrical Meter

5. EXPERIMENTAL RESULTS

Virtual meter interface

The Multifunction Electrical Digital Meter interface is shown in Fig. 3. It can be used to evaluate the electrical performance of domestic devices of low power, as TV, radio, electronic reactor and other types of devices. The accuracy for the instrument is given by the number of bits of A/D converter, number of samples per cycle, current sensor and numerical integral approximation used. Due to the AD used in this paper, it was considered that a value n of 750 (number of samples) for each cycle of 60 Hz, would achieve the desired accuracy. %.

Oscilloscope interface

The most popular PC-based test instrument is the digital sampling oscilloscope because it has the widest range of applications, and it takes advantage of the computer monitor's large display screen. The core of the PC-based oscilloscope is the analog-to-digital converter (ADC). The resolution of the sampled input is 12 bits, and the time base minimum is 1.8 millisecond /div. The Oscilloscope interface is shown in Fig. 4 and the hardware is shown in Fig. 5.

6. CONCLUSION

A Multifunction Electrical Digital Meter based on personal computer has been developed for measurement of electrical greatness like RMS Volts, RMS Amps, Volt-Amps, Reactive Power, Active Power and Phase Angle, Frequency, Period, What-Hour, and other greatness. The virtual instrument can be used in laboratory instrument meters.

In order to reduce approximation error of numerical integration is necessary the use of fast and the high-precision Analog converter. The instrument has proved to be stable, reliable and easy to keep within its accuracy of 0.1 %.

The Multifunction Electrical Digital Meter circuit board is plug into parallel printer port or ISA-bus (Industry Standard Architecture) slots in IBM-PC/AT computers or compatibles.

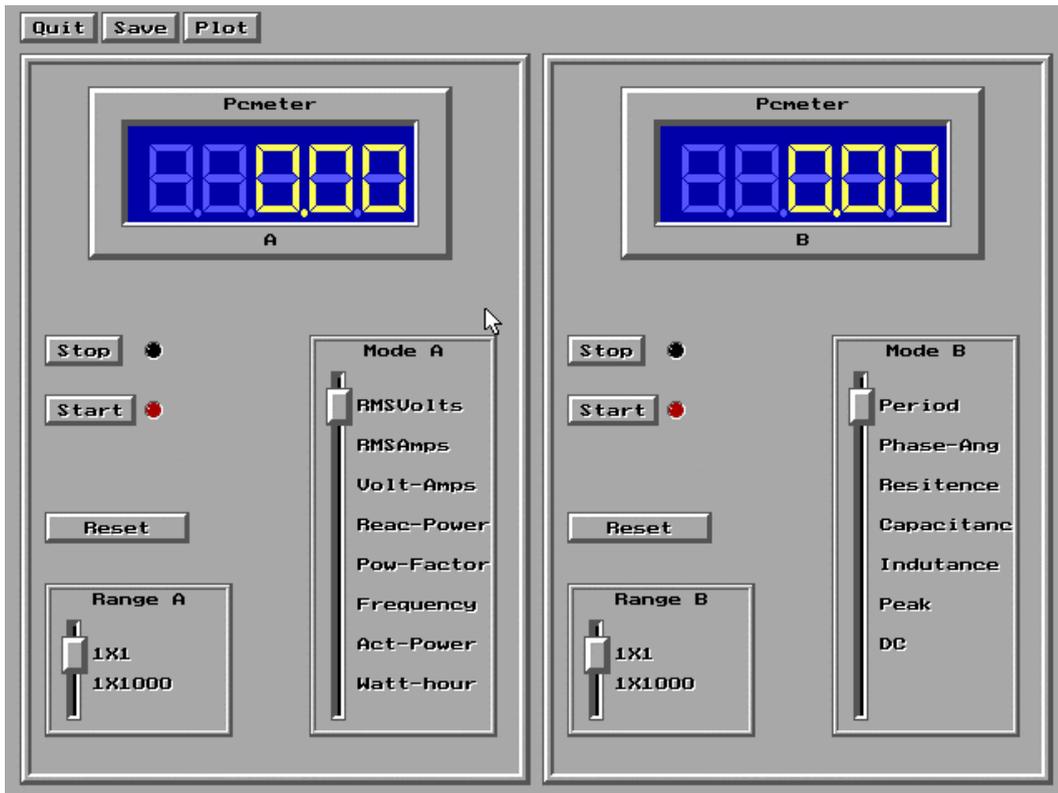


Fig.3 - Multifunction Electrical Digital Meter Interface

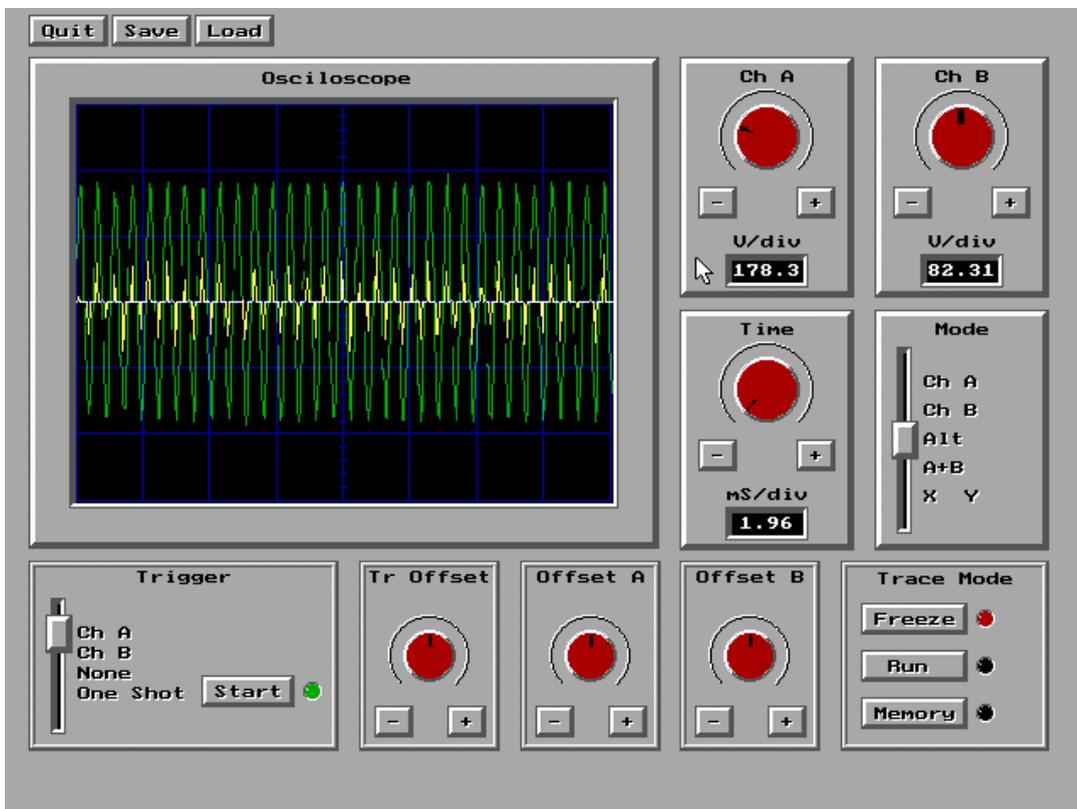


Fig.4. - Digital Oscilloscope Interface

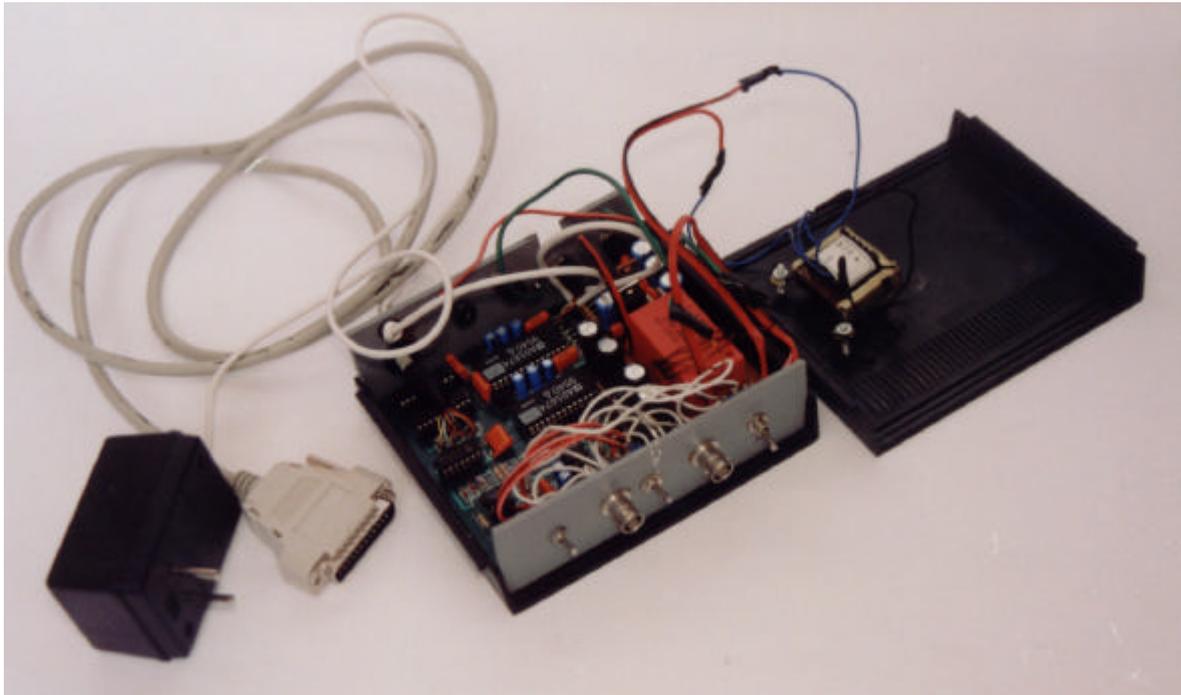


Fig.5 Hardware of. Multifunction Electrical Digital Meter

The accuracy of current sensor is less than 0.1.

The system was developed to create a pure digital environment for a safe and easy operation.

Actually we are building new software's and hardware to expand to new computer-based instruments on the Multifunction Electrical Digital Meter, such as, spectrum analyzer and others instruments.

7. REFERENCES

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