Computer Controlled Measurement System

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Abstract. *Simple computer (PC) controlled data-acquisition board which enables to measure basic electrical quantities such as DC and AC (true RMS value) voltages and currents, resistance and frequency has been designed. The board contains all the necessary circuits for such measurements. Microcontroller on the board is connected with PC by a serial channel, so it is possible to set the measuring conditions from the PC and to read the measured results on the PC monitor. The final corrected measured results are calculated in the PC. The program for system control and calculations is written in C++. The system is intended to be used in education process.*

Keywords: data-acquisition board, automated measurement system, true RMS value measurement.

1. Introduction

Computer controlled measurement systems can be created in a few ways. Personal computer (PC) can control single instruments via some kind of serial or parallel interface, [1]. Such systems may have different configurations and, sometimes, limited number of instruments. Generally, they are expensive and need relatively complicated software [1], [2]. Simpler and cheaper systems use data-acquisition boards (cards) installed in the computer, [1], [3]. The board contains all the necessary circuits for the required measurement applications, such as analog inputs and outputs, simple or programmable-gain amplifiers, A/D and D/A converters, digital inputs and outputs, counter inputs, etc. The PC controls the operation of the card, makes necessary processing of the measured values, their display and storing. Such boards are manufactured by many manufacturers. Usually, they have worse metrological parameters than single instruments. Similar solution is used also in the systems which have crate configuration of the boards, [1]. The boards here are placed into a normalized crate and form a compact measurement system controlled by a computer.

Simple measurement systems or instruments can be also created using a separate board which contains all the necessary circuits for the required measurement applications. This board is connected with a PC via serial interface such as RS-232. The execution of commands from the PC is very simple if the board contains a microcontroller. This is the case of the proposed measurement system for DC and AC (true RMS value) voltage and current, resistance and frequency measurement. It is intended to be used in education process.

2. Measurement System Description

Block diagram of the proposed PC controlled measurement system is in Fig. 1, [4]. Measured voltage is modified by a resistive voltage divider used as the range switch. DC voltage is connected directly to the input of A/D converter while AC voltage is first converted to DC value by integrated RMS converter. Measured current is converted to a proportional voltage value by shunt resistors in I/U converter which also contains a range switch. The following handling is the same as for the voltage. Resistance is converted to a DC voltage by a feedback R/U converter with operational amplifier which also contains a range switch. This DC voltage is then connected to the input of A/D converter by a function switch. Any AC voltage is shaped to the rectangular form by shaping circuits and its frequency is measured automatically by the counter in the microcontroller.

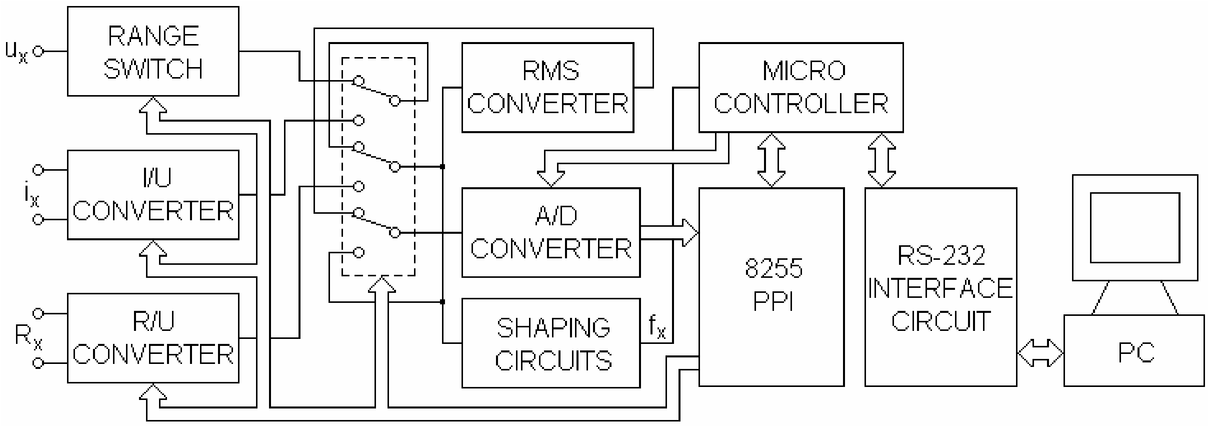

Fig. 1. Block diagram of the proposed PC controlled measurement system.

The operation of A/D converter is controlled directly by the microcontroller. Digital output data of A/D converter is transmitted through parallel programmable peripheral interface (PPI) and, after some processing in the microcontroller, is sent to the PC via RS-232 serial interface. All other processing and calculations are made in the PC and the measured results are displayed on the monitor screen.

3. Practical Considerations

All the measurement system is realized on a printed circuit board. Range switches, except for resistance range switching, and function switch are realized by mechanical relays controlled from the digital part. Resistance ranges are switched by field-effect transistors with low on-resistance. Five voltage ranges, namely 0.2 V, 2 V, 20 V, 200 V, 500 V, five current ranges 0.2 mA, 2 mA, 20 mA, 200 mA, 2 A and five resistance ranges 200 Ω, 2 kΩ, 20 kΩ, 200 kΩ, 2 MΩ are user or automatically selectable from the PC. The current range 2 A uses two relay switches in parallel and voltage drop across the shunt resistor is sensed directly from the shunt to overcome a voltage drop across the switch. Measured resistance is connected in the feedback of operational amplifier and range switching is accomplished by selection of the other resistor of the amplifier feedback circuit. The DC voltage proportional to the RMS value of AC voltage is obtained by AD736 RMS converter integrated circuit. The board also contains power supply stabilizers ±5 V and ±12 V.

The principle of RMS conversion used in the RMS converter is shown in Fig. 2, [5]. The output voltage of this converter can be expressed by the equation

$$U_o = avg\left(\frac{|u_i(t)|^2}{U_o}\right), \tag{1}$$

or, after rearrangement

$$U_o^2 = avg\left(\left|u_i(t)\right|^2\right), \tag{2}$$

$$U_o = \sqrt{avg\left(\left|u_i(t)\right|^2\right)}. \tag{3}$$

Hence, the output voltage is equal to the RMS value of the input voltage.

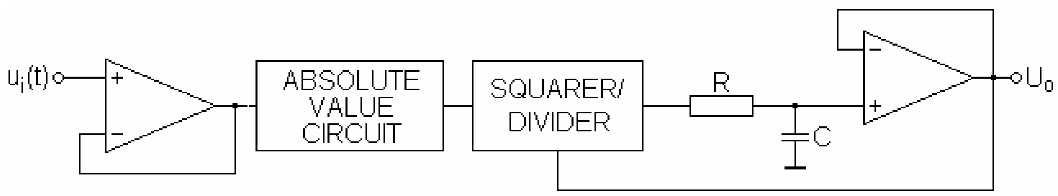

Fig. 2. The principle of RMS conversion.

In digital part AD7892 12-bit successive approximation A/D converter, MHB8255A PPI circuit, AT89C2051 microcontroller and HIN232CP RS-232 transmitter/receiver interface circuit are used. The A/D converter is set to the parallel mode of operation. The 12 bits of the A/D converter data output are connected to the port PB and to the lower 4 bits of the port PC of the 8255 PPI circuit. The port PA of the PPI circuit is used as the output port to control the range switches in the analog part. All the programming of the 8255 PPI circuit is accustomed through the data port directly from the microcontroller.

The microcontroller has been programmed in assembler. After programming of 8255 PPI circuit two timers of the microcontroller are programmed. The timer 1 is used to time the RS-232 serial 8-bit UART interface. The transfer speed TS is set to 2400 Bd according to the equation

$$TS = \frac{2^{SM}}{32} \cdot \frac{f_{CLK}}{12 \cdot \left[256 - (TH1)\right]}, \tag{4}$$

where

SM the MSB of the PCON register used to enable the doubling of the transfer speed

f_{CLK} the microcontroller clock frequency (24 MHz)

(TH1) the contents of the TH1 register used to set the transfer speed by setting the frequency of overflows of the timer 1.

From Eq. 4 it is possible to calculate the number stored in TH1 register to get the desired transfer speed.

The timer 0 together with the 8-bit register B create a 24-bit counter which is used to measure the period of the input signal and then to calculate the frequency in the PC.

The program in the PC is written in C++ programming language. From the keyboard, it is possible to select the serial channel COM1 or COM2, the type and the character (DC, AC) of the measured quantity. The proper range can be selected automatically. Then, the information about the measured quantity is received (measured value, the actual range) and the actual value is calculated. The measured results (including the input AC signal frequency) are displayed on the monitor screen.

4. Conclusions

Simple computer (PC) controlled data-acquisition board which enables to measure basic electrical quantities such as DC and AC (true RMS value) voltages and currents, resistance and frequency has been designed and is described. The board contains all the necessary circuits for such measurements. True RMS to DC voltage conversion method used in RMS converter integrated circuit is shortly described. The program for the microcontroller on the board is written in assembler. The microcontroller is connected with PC by a serial channel, so it is possible to set the measuring conditions from the PC and to read the measured results on the PC monitor. The final corrected measured results are calculated in the PC. The program in the PC for system control and calculations is written in C++. The system has been constructed without any precautions to increase its accuracy and is intended to be used in education process.

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