VIRTUAL INSTRUMENTATION FOR FREQUENCY OUTPUT SMART SENSORS

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Abstract. *The universal solution for precise virtual instrument system realisation permitting to connect any frequency-time domain (quasi-digital) sensor to IBM PC compatible computers is described in the paper. The virtual instrument system for smart sensors with frequency-time domain output is based on the novel adaptive program-oriented method for frequency-to-code conversion - method of dependent count. The main advantages of this method for virtual sensor instrumentation applications are: high accuracy, constant quantization error in all frequency range, non-redundant conversion time, minimum possible hardware and self-adopting possibilities. The example of virtual instrument for duty-cycle output temperature sensor is given.*

Keywords - virtual instrument, frequency output sensor, smart sensor, data acquisition

1. INTRODUCTION

The processing and interpretation of information arriving from the outside is one of the main task of data acquisition (DAQ) systems and measuring instruments on the PC basis. As a result, the problem of adequate interfacing of various frequency-time domain (quasi-digital) sensors with PC for data acquisition arises for developers and users of any DAQ system [1].

The difficulties of implementation for interface devices consist mainly that modern frequency output sensors have high accuracy up to 0.01 % and various specified frequency ranges from 0.01 Hz up to some MHz. The existing Data Acquisition (DAQ) PC Boards for frequency/time (period) parameters of electric signals, for example [2-4], have rather low accuracy 0.1 ÷ 0.05 %. The low accuracy of measurements and necessity in additional board for input information into computer are common disadvantages of such systems. As a result, created virtual instruments and systems quite satisfy programmers, but not metrologists. Very often, it is preferable to have the sensor interface through standard serial (COM) or parallel (LPT) I/O ports, because of such ports exist in any PC. Furthermore, such solutions do not need any additional software driver. Another disadvantage of traditional DAQ boards for frequency/time/duty-cycle parameters is rather high price. So, according to [2,3] and Price Lists 2000/2001 the prices for DAQ boards are from 435 up to 655 $ USA.

2.VIRTUAL INSTRUMENTS BASED ON METHOD OF DEPENDENT COUNT

The authors offer the universal solution for realisation of precise virtual sensor system permitting to connect any frequency-time domain sensor to the IBM PC compatible computers. This essentially facilitates the task of interface design, which should be able to mimic traditional instruments to provide easy-to-use conventional understanding for non-experts [5]. Except that, all the beneficial features of PC, such as programmability, digital processing and storage capabilities became accessible to the user.

It is known that “DAQ hardware without software is useless - and DAQ hardware with poor software is almost as useless” [2]. It is especially for today, when the obvious lag of algorithms and software development from progress in microelectronics is observed. The new virtual instrument system for smart sensors with frequency-time domain output is based on the novel, proposed by authors, adaptive program-oriented method for frequency-to-code conversion - method of dependent count [6]. The method guarantees the constant quantization error in all specified frequency range and non-redundant conversioon time. The main advantages and features of the method are the following. The method has universality; it provides the precise frequency-to-code conversion for the all known sensors with frequency (period and duty-cycle) output from 0.01 Hz up to some MHz without prescalers with quantization error up to 0.0001% in comparison with 0.1 ÷ 0.005 % accuracy for traditional DAQ boards.

The virtual sensor system therefore not only transmits the sensor output but also other diagnostic validation and maintenance information. The virtual instrument system is based on so called virtual measuring channel [7]. Due to this, the hardware is minimum possible. All circuitry can be embedded into COM - or LPT-port connector. The block diagram of the sensor interfacing is shown in Figure 1.

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3. SOFTWARE

Due to low-level software, the virtual channel is realised inside the microcontroller. One of the possible realisations is based on the microcontroller Atmel AT89C2051. The frequency-to-code conversion is carried out on a virtual level inside the microcontroller. With the aim to reach high conversion speed, the quasi-pipelining data processing is used in microcontroller. In other words, the measurement, calculation and code conversion for transmission by I/O interface are combined in time.

The graphical user interface is realised with the help of high-level software. The actual work was done using the software package ComponentWorks V2.0 [2], a 32-bit ActiveX (OLE) control for building test and measurement, analysis, and presentation systems in MS Visual Basic 6.0 environment. The screen display of one of the possible graphical user interface is shown in Figure 2. Some controls allow to the user to choose the accuracy (quantization error) or time of measurement, informative parameters of the sensor and units. Each press of the "Start" button on the front panel causes the beginning of the measuring cycle. The high-level PC software reads the data from the serial port and puts them in the file for consequent processing.

4. EXAMPLE

The example of the graphical user interface is done for smart temperature sensors with frequency and duty-cycles output [8,9]. Due to this interface, user can set the required error of measurement or measuring time, conversion characteristic, informative parameters and units of measurement. All this, due to universality of the interface and proposed method of measurement, can be easily adapted by the user for any quasi-digital frequency-time domain sensor. So, another virtual instrument for temperature measurements on the basis of silicon duty-cycle output smart temperature sensor SMT160-30 from SMARTEC (The Netherlands) [9, 10] is described in the following Web page: http://members1.infostreet.com/HTML/VI_project.htm.
There is the demo version of proposed virtual instrument for temperature measurements (Internet application). The technical performances are the following:

- Temperature range, ^{0}C - 45 ... + 130;
- Absolute accuracy, ^{0}C ± 0.7;
- Relative error, % ± 0.54;
- Linearity is better than 0.2 ^{0}C;
- Directly connectable to LPT port;
- Cable length up to 20 m;
- Statistics calculation;
- File of results;
- Digital, analog and sound indications.

The minimum hardware requirements are: Pentium PC, 133 MHz, 16 RAM, SVGA monitor. The operation system is Windows' 95/98/Me.

The DAQ board for frequency/time parameters was also proposed based on the mentioned method of measurement. The block diagram of the proposed low-cost DAQ board is shown in Figure 3. The DAQ board uses the 82C54 (Intel) counter/timers for time-related functions. Although full integration of all elements as a single chip implementation is an elegant approach, in most cases it may not be viable for low-cost DAQ boards.

5. CONCLUSIONS

The usage of method of dependent count for frequency (period)-to-code conversion in virtual instruments for different kind of frequency-time domain quasi-digital sensors has the following main advantages:

- High accuracy up to 0.0001%;
- Constant quantization error in all frequency range from 0.01 Hz up to some MHz;
- Non-redundant conversion time;
- Self-adopting possibilities;
- Minimum possible hardware;
- Low cost.

The method lets to design new low cost DAQ boards for different frequency-time parameters of electrical signals as well as virtual instruments, the hardware of which can be embedded into LPT- or COM-port connector.

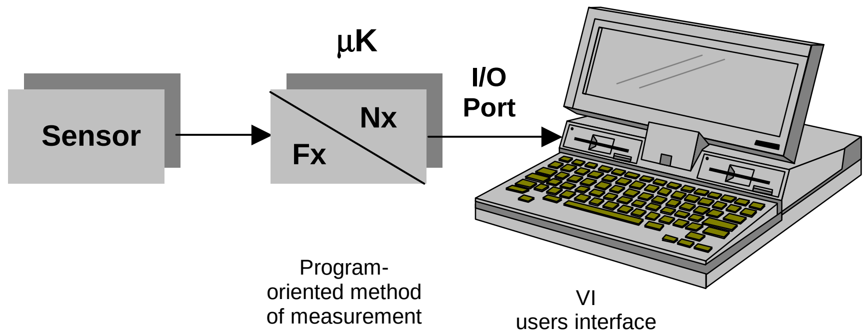

Fig. 1. Block diagram of the sensor interfacing.

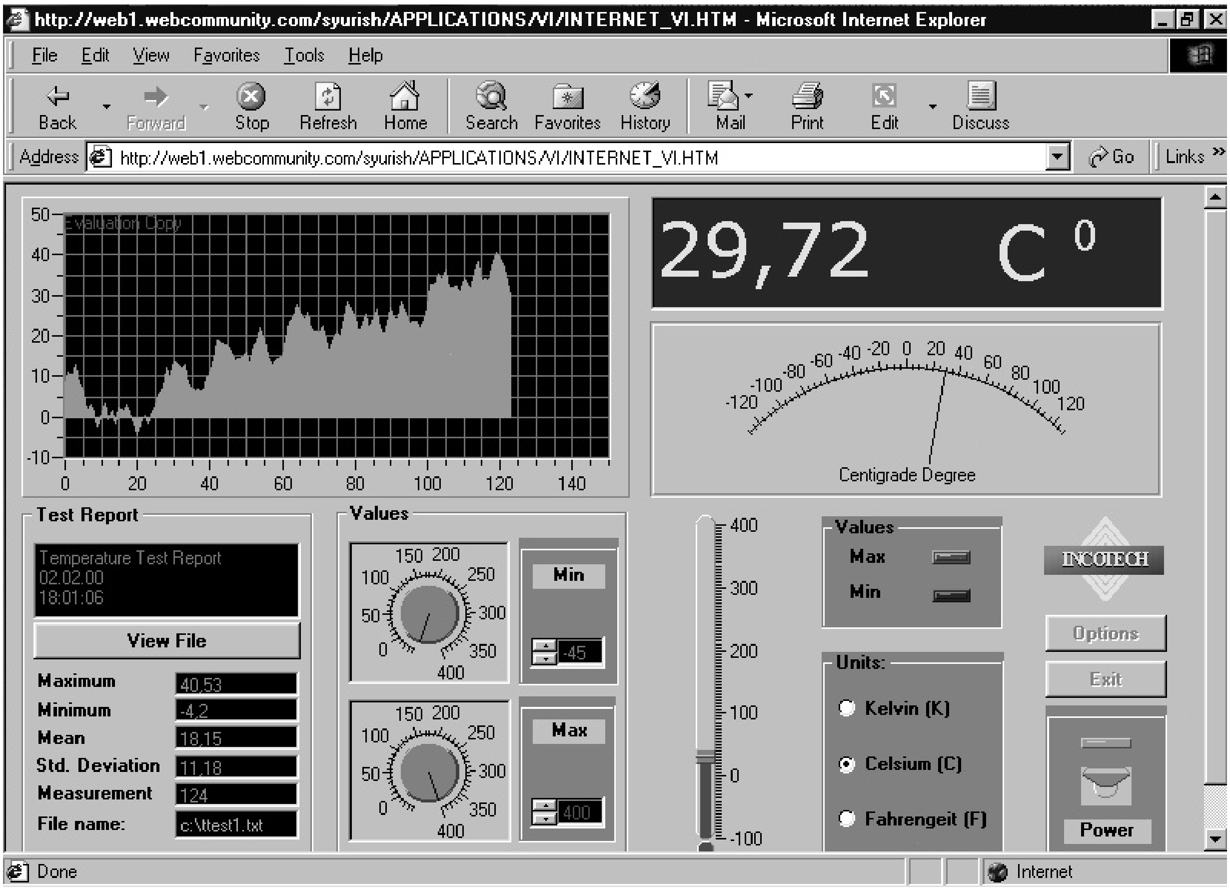

Fig. 2. Screen display of the graphical user interface for virtual instrument system for smart temperature CMOS sensor.

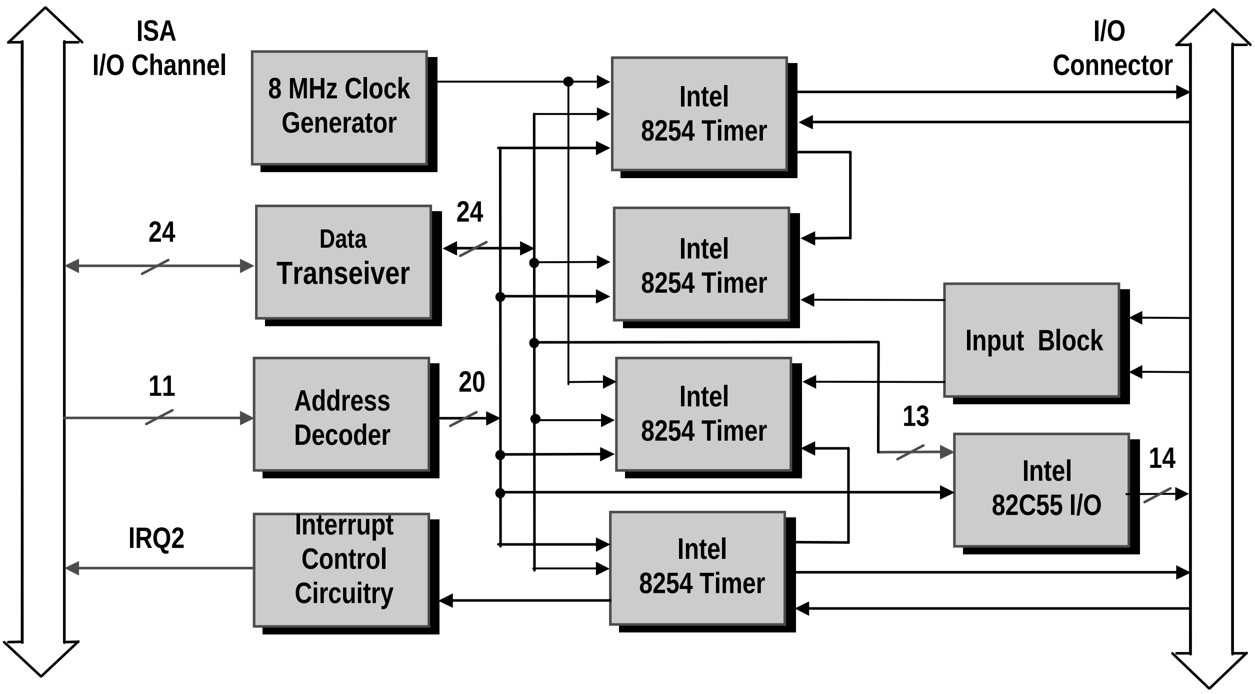

Fig 3. DAQ board block diagram.

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