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A Low-cost, PC Interfaced Multipurpose Temperature Controlling System

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Abstract: In this paper, a temperature control system is developed using Analog make sensor chip TMP06. The chips generate digital PWM outputs whose ratio of high to low period is proportional to the temperature of the corresponding devices. This waveform is taken into the personal computer through parallel port (LPT1) and after discretization and sampling; the temperature is calculated by using a developed 'C' program. Then the measured temperature values are compared with preset values set by user, and the temperature control devices are turned on or off from an output circuit as per the set value. The system is simple, low cost and can be linked with any general purpose PC with minimum external hardware used. *Copyright © 2008 IFSA.*

Keywords: Low cost, Temperature control, Personal computer (PC)

1. Introduction

Different conventional temperature measurement techniques exist using instruments like Mercury filled thermometers, resistance thermometer, thermocouples, pyrometers etc. In the present maintenance free industrial environment, they have lot of disadvantages like nonlinear temperature voltage relationship, more hardware requirement and expensive controller/recorder etc. Micro electromechanical Systems (MEMS) are being developed and used for different applications today considering many factors like size, full proof performance, less hardware requirement etc. The micromechanical components are fabricated using compatible micromachining processes that selectively etch away parts of the silicon wafer or add new structural layers to form the mechanical and electromechanical devices.

One of the main areas of development of MEMS is Sensors. The design, fabrication and testing of micro-fabricated thermal shear stress and temperature sensors with very thin supporting membrane are discussed in [1]. The fabrication and initial testing of novel optically interrogated pressure and temperature sensors fabricated directly on optical fibers using MEMS technology is reported in [2] where minimum detectable temperature variation of 6 °C is observed. There are two types of MEMS sensors analog and digital. The digital temperature sensors have integrated DAC, ADC. This saves on both cost and unnecessary circuit design.

A high-stability temperature controller is described in [3] where computer interfaced is done via a 16-bit digital to analogue converter, which allows remote control and the heating stage to be heated and cooled at predetermined rates. One data acquisition systems for quasi-digital temperature sensors is described in [4] is based on the Universal Frequency-to-Digital Converter (UFDC-1) working well with any frequency output sensors. Such design approach simplify the design process, reduce time-to-market and production price.

Objective of the present approach of designing temperature system with digital output signal from the sensor TMP 06 is to develop a simple, low cost, trouble-free multipurpose system, which can measure a number of digital signals generated from sensors located in different places of a plant or similar place and generate corresponding controlling signals meant for the heating or cooling devices. A general purpose PC can do the job through its common parallel port. The reasons for using particularly this port because it is flexible, universal to interface and easier than ever to use very simple program statements to access the digital signal.

2. Description of the Scheme

In PC based temperature measuring system, temperature is sensed by a very small temperature sensing IC, TMP06. The TMP06 is a monolithic temperature sensor that generates modulated serial digital output (PWM), which varies in direct proportion to the temperature of the devices [5]. The high period (T_H) of the PWM remains static over all temperatures, while the low period (T_L) varies. It offers a higher temperature accuracy of $\pm 1^\circ\text{C}$ from 0°C to 70°C with excellent transducer linearity. The TMP06 is rated for operation over the -40°C to $+150^\circ\text{C}$ temperature range and is packaged in low cost, low area SC or SOT 5-pin package. The functional block diagram of the chip is shown in Fig. 1.

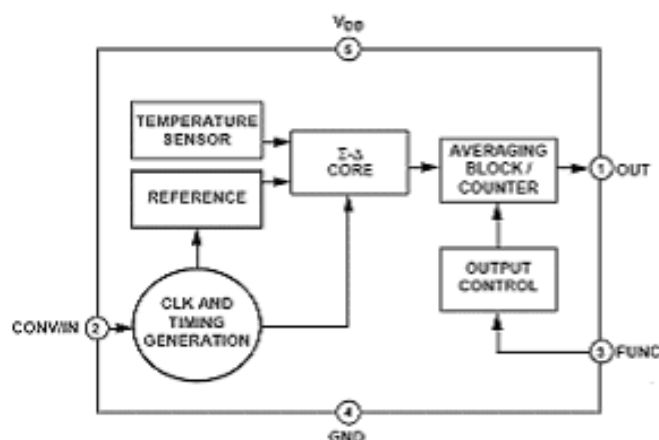


Fig. 1. Functional Block Diagram of TMP06 (courtesy: Analog Devices).

This waveform similar to shown in Fig. 2, generated from the chip is taken into computer by PC printer port (LPT1). The Parallel Port is used, as the Serial Port is harder to interface. In most cases, any device connected to the serial port will need the serial transmission converted back to parallel so that it can be used. Also the parallel port effectively transmits 0 V as digital 0 and 5 V as 1. A “C” program developed computes the ratio of high to low period of the waveform and finally the temperature.

The basic advantage of this monolithic IC chip is its compactness. The chip is very small in size and its output is of very low frequency, hence calculation is possible by common PC. Conventional pyrometers and thermocouples require recording instruments to calibrate the electrical output to temperature, but no recording instrument is required to measure the temperature by this chip.

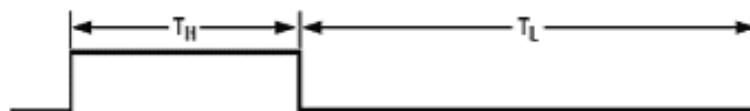


Fig. 2. Output waveform format of sensor chip.

The only additional hardware requirement for the system is the interfacing circuit consisting of normal Optocoupler (with IC MCT2E). IC-TMP06 operates on open drain characteristics. It has the capability to sense the temperature of any device and gives output as square wave. The output of the chip is connected with the optocoupler. The output of the optocoupler is connected to the parallel port of the PC through an opamp and the 25 pin D-connector. Conversion pin is kept floating mode to keep the conversion rate nominal. The TMP06 is decoupled with a 0.1 μF ceramic capacitor between V_{DD} and GND. The complete schematic circuit is shown in Fig. 3.

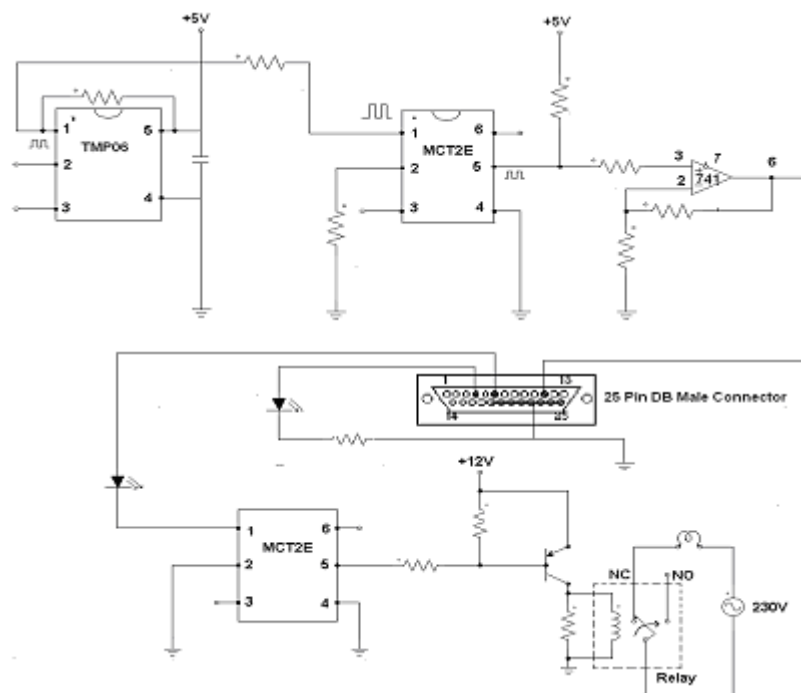


Fig. 3. Schematic Diagram.

After getting the pulse, the input data is scanned by inportb (0x379) function. The system time, at which pulse goes from low to high, is stored in a variable and high to low in another variable. This difference between these two variables will give the T_{ON} . By this way T_{OFF} is also calculated for one full cycle.

For a set of full cycle or pulse, total T_{ON} and T_{OFF} (t_n and t_f in the flowchart) is calculated which gives T_H and T_L as indicated in Fig. 2. T_H and T_L are put in equation $Temperature (^{\circ}C) = 421 - (751 \times (T_H/T_L))$, and after precise calibration the temperature value is obtained.

During this type of measurement some error components are there for the starting/stopping the timer by software (7). Though the error generated for rectangular waveform is less, still some measures should be taken to reduce the error because of the latency time between the occurrence of the interrupt request and the interrupt machine cycle. The errors can be reduced to a lowest level by using upgraded version of CPU and bigger size RAM with clean, well-configured system. It is to be sure that the absolute minimum number of other programs or background services is running when the measurements are done. This includes even the virus scanner and firewall.

System time & system date can be obtained by using (`_dos_gettime`, `_dos_getdate`) two library structures. After measuring temperature, the value is compared with the user-preset values. User can enter two preset values indicate lower control level (l.c.l.) and upper control level (u.c.l.). Lower control level indicates the preset value at which the heating device is switched on. Upper control level is the preset value at which the heating device can be turned off through relay operation controlled by the program itself. Fig 3 shows the operation of such a heater through a relay controlled by a signal generated from the same parallel port. Entering the l.c.l. and u.c.l., start, stop operations are developed with menu based. A visual window is displayed to represent present temperature value and record graphical values, u.c.l., l.c.l. etc.

4. Observation

The scheme meant for control of a single heating device is fabricated, interfaced with PC and the program is run successfully. The graphical window developed is user friendly and having buttons like start, exit with visual indications. Before initiating start, the system asks for the u.c.l. and l.c.l. After entering the values, start will show the numerical and graphical record of the temperatures and two lines. The graphical window representing the heating device control with respect to time plots the curve and displays online in the PC monitor. One such display is shown in Fig. 5. There is also a log chart of temperature data in every preset interval, which can be saved, printed for a record. A small sample of such record is shown in Fig. 6. There are menu-based window where visual indications of temperature status (i.e. whether it is crossing the limits), heating devices on/off are displayed.

5. Conclusion

The temperature sensing without using the conventional sensing devices is getting importance because of lot of reasons and miniature sensor is a few step ahead with lot of further advantages. The actual temperature data can be measured with this sensor cum processor chip. The temperature system developed here is a compact measurement system with practically trouble free possibility of operation. Same PC can be used to sense and control temperatures of a number of other devices. The smaller size and minimum hardware involvement make the system more flexible and user friendly. Further any sort of analysis of the data is easily possible with the data already received in the PC. Inter system data analysis is also very helpful with this type of system. Any process plant section where multiple

measurements are done with number of temperature controllers can be replaced fully with this system. The cost of plant can be significantly reduced for this. Even, in future this system easily can be interlinked with the distributed control system or supervisory control system etc.

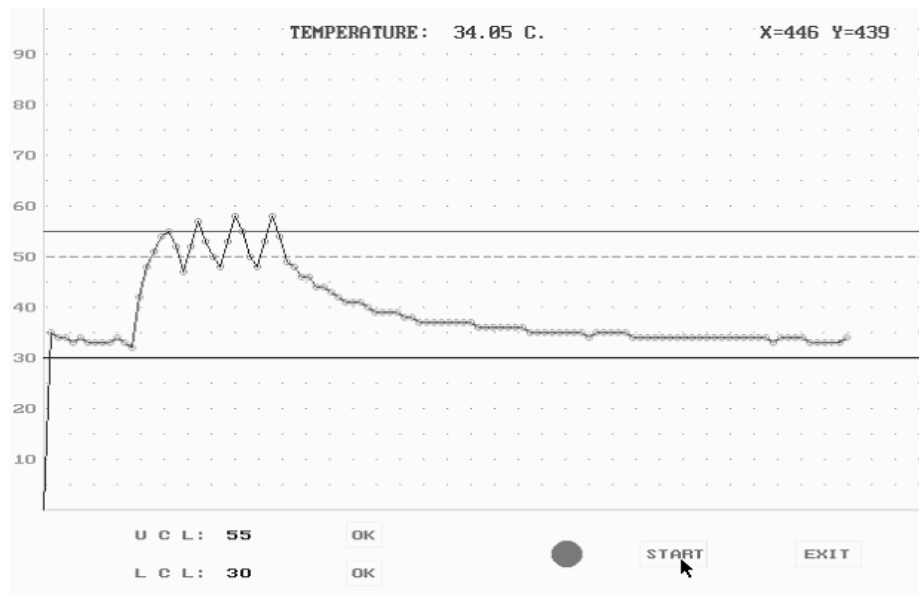


Fig. 5. Graphical display of temperature.

68. TEMPERATURE: 35.65 C AT 16:12:05.76 hrs. ON 27/4/2007.
69. TEMPERATURE: 35.49 C AT 16:12:11.14 hrs. ON 27/4/2007.
70. TEMPERATURE: 35.45 C AT 16:12:16.53 hrs. ON 27/4/2007.
71. TEMPERATURE: 35.09 C AT 16:12:21.85 hrs. ON 27/4/2007.

Fig. 6. Log data of temperature.

Acknowledgements

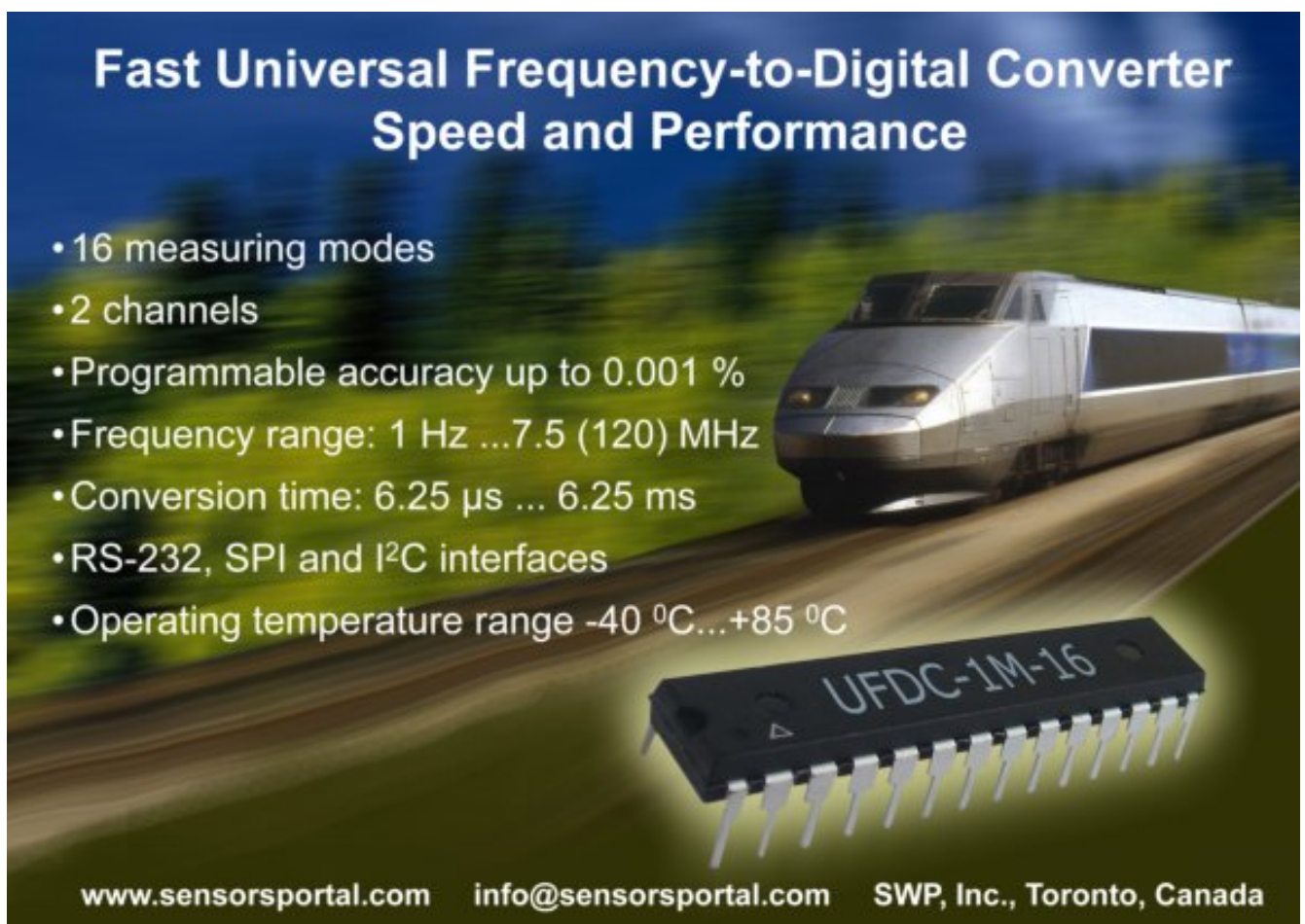
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