# Study of Arm based temperature measurement and control system using CPLD

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**ABSTRACT-**In this paper a temperature measurement and control system is proposed using ARM processor S3C2440 as a controlling device. This system uses LM35D sensor and its related peripherals for temperature measurement. This temperature is filtered and transmitted to the ADC MCP3201. ARM and CPLD are used for processing and controlling purpose.S3C2440 ARM9 series micro processor and Cypress CY37256P208 CPLD are respectively selected as CPU and control unit.After being processed by CPU, it displays on the LCD display. The performance of the developed system is analyzed and it consumes very low power as compared to conventional system. This system saves the valuable energy and also provides smart automation logic in electrical systems.

*Keywords-* ARM processor, CPLD, control unit, low power, smart automation
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## I .INTRODUCTION

Temperature is most important parameter in the industrial applications; the accuracy of measured temperature and its control is very essential and has impact on production status and products quality. Therefore, in many industrial applications, the accuracy of temperature measurement and control is highly demanding. The higher temperatuire measurement accuracy can guarantee temperature difference control accuracy. Hence here, the system uses ARM processor as controlling unit.[1 ]-[4]

This system is designed and implemented by using LM35D sensor and associated peripherals to measure and control the temperature. LM35D is analog output sensor and it has an advantage over linear temperature sensors calibrated in degree Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. It does not require any external calibration to provide typical accuracies of ± 1A degree Celsius at room temperature and ± 3A degree Celsius over a full -55 to +150 degree Celsius temperature range. For each degree increase in temperature there will be 10 mV change (10 mV/degree Celcius). The output of temperature sensor is given to ADC MCP3201.The measured temperature is periodically received from the measuring unit. Suitable control signals are sent to electronic relay circuit to maintain the temperature if needed.[5]

## II. BLOCK DIAGRAM OF SYSTEM

Today, there is fast development in the field of microelectronics. Embedded micro processor and other kinds of chips are increasingly used to monitor and control the signals. Embedded system has many advantages, first is it takes much lower manufacturing cost and other is it is portable. ARM9 series micro processor as a signal processing unit is selected. It is a typical RISC CPU with pipeline work mode which accelerates its operational performance. Also, its characteristics comprise small size, low power consumption. After receiving signal from ADC, CPU computes related signal parameters. The final result will be shown by using display unit. CPLD is used as the central control unit, mounts on the address and data bus of CPU to employ communication between both of them. It is also responsible for coordinating the work of the entire circuit in an orderly manner. Before CPLD gets the signal, it goes two ports: i) voltage conversion; ii) signal filtering. The signal parameters will be sent to the CPU after being analyzed by CPLD. The Fig.1 shows the block diagram of control and measurement system.
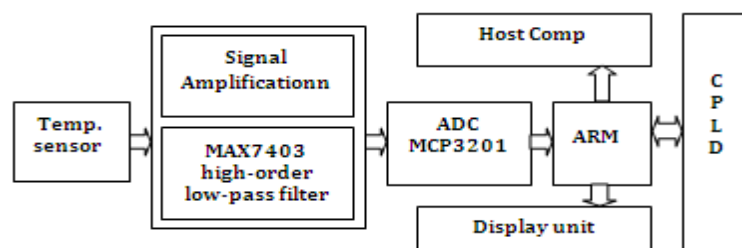


Fig.1.Block Diagram of System

## III. SYSTEM HARDWARE

The output of temperature sensor is given to ADC MCP3201.Before that signal amplification and filtering is carried out by Precision operational amplifier OP77 constitutes a signal amplification unit. MAX7403 is a high-order low-pass active filter, It has signal gain 0dB in transmission bands, the signal gain corresponding to the frequency which was higher than the cut-off frequency attenuated by -80dB. As the temperature is the signal with relatively slow changes, set the cut-off frequency of filter around 38Hz, which can effectively filter out the 50Hz power-line interference caused by system power supply
.

### 3.1Analog to Digital conversion

MCP3201 is ADC. The output of LM35D temperature sensor is given to MCP3201 which convert analog input to corresponding 12 bit digital signals. It is a successive approximation 12-bit Analog-to-Digital (A/D) Converter with on-board sample and hold circuitry. It converts the measured analog signal into digital value. Communication with the device is done using a simple serial interface compatible with the SPI protocol. The device is capable of sample rates of up to 100 ksps at a clock rate of 1.6 MHz. It operates over a broad voltage range (2.7 V - 5.5 V). Three signal lines CS, Data, CIk are used to interface with ARM.

### 3.2 Control and Processing Unit

CPLD is used to control thecircuit signals and converts the original signal to the format that can be required by the CPU. To exchange data between CPLD and CPU fast and correctly, CPLD is directly mounted to the data and address bus of CPU. Then, CPLD is mapped into the SRAM address space of CPU. therefore, to an programmer, it is the same to access SRAM and CPLD. for the moment, programmer must build up the registers correctly to read and write CPLD.

Samsung S3C2440 ARM9 series micro processor and Cypress CY37256P208 CPLD are respectively selected as CPU and control unit. Static memory (SRAM) control signals in S3C2440 are shown in the Table I. The leftcolumn represents signal name, and the right column tells us the function of the signals.

Table I. SRAM control signals[6]

| Signal Name | Function Description |
|---|---|
| HCLK | System clock |
| A[24:0] | Address bus |
| nGCS | Chip selection |
| nOE | Output enable |
| nWE | Write enable |
| nWBE | Byte write enable |
| D[31:0] | Data bus |

For communication between CPU and CPLD in system is very simple and the data used is also very less. Only 4 bit address and 8 bit data is used. The Cypress CPLD simulator software Active-HDL to demonstrate the process of reading data. CPU issue the command reading data in address 0x0, then CPLD responded and put the data 0x00 in the data bus.Fig.2shows the reading and writing timing diagram ofS3C2440 micro processor.
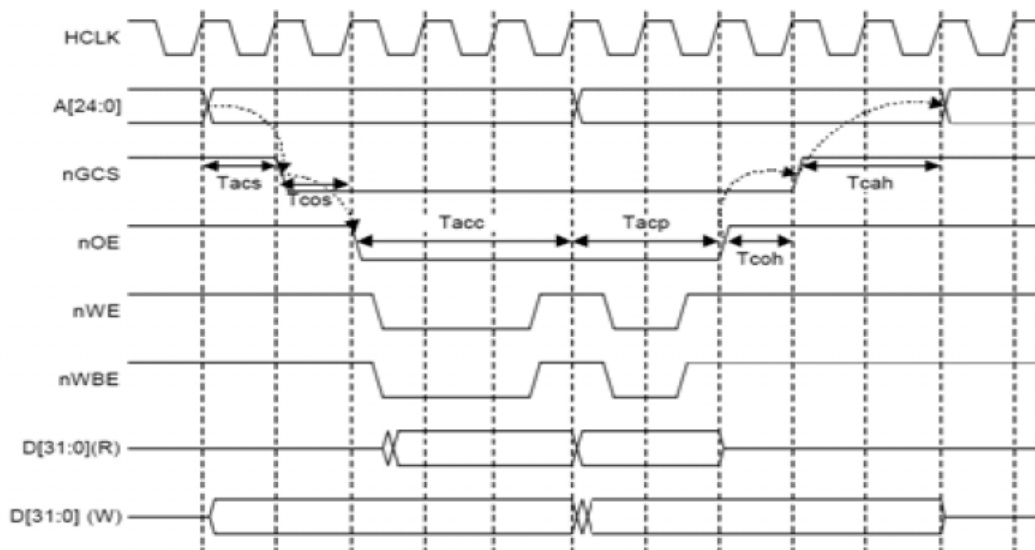


Fig.2The reading and writing timing diagram ofS3C2440 micro processor.[6]

The buffer 74HC244 is used to interface CPU, LCD display and control system. A general purpose alphanumeric LCD, using HD44780 Controller with two lines of 16 characters is used to display the measured temperature. CPU displays the measured data using LCD and send the control signals to electronic relay for controlling the temperature. The interfacing and conversion is implemented to display the desired characters in the LCD display. The temperature is controlled by control signals using pulse width modulation (PWM).

## IV.SOFTWARE IMPLEMENTATION

The Software is implemented for measuring element of the system. It consists a sensor LM35D from National semiconductor, whose output is sensor is given to ADC input to convert analog voltage to digital data. Clock signal is given from the CPU and the temperature value is read through Dout line of ADC serially. Before collecting the data the ADC is enabled through chip select line triggered by the CPU. After acquiring data from ADC, computations are performed using control algorithm in CPU to convert the voltage value into degree Celsius.[7],[8]

The controlling unit includes integer as well as floating-point arithmetic and complex computations. Generally Floating-point representations and operations on floating points depend on CPU architecture and compiler. In this case, the way the hardware is implemented will affect the floating-point operation. In other words, the hardware can be catered to meet the required needs with some basic rules.The Computed result is converted into format appropriate to the LCD display to observe the result in the display.

The code is developed to enable ADC, to send the clock, to receive 12-bit data from the ADC, to convert the data into binary floating-point data, to perform computation to produce the result in degree value, to display temperature in LCD display format and to send control signals to electronic relay which is used to control the temperature.[8],[9] The correctness of the simulation results is checked with the test module which randomly generates the temperature value.

## V. CONCLUSION

Here ARM based monitor and control system is implemented to measure and maintain the temperature. The system is tested and its observed result is improved in speed as compared to conventional system without using ARM and CPLD. The use of this device involves low power consumption and less computation time. The conventional system requires more power and more computation time. The error in measurement of temperature is found to be less than 0.5% for this system.

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