iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** XI **Month of publication:** November 2025

DOI: https://doi.org/10.22214/ijraset.2025.75514

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue XI Nov 2025- Available at www.ijraset.com

Embedded System for Temperature Control of Large-Scale Integrated Circuits

Dr. K.P. Venkateswara Rao[1], Dr. M. Baba Fakruddin[2]
Department of Physics, Sri Sai Baba National Degree College (Autonomous), Anantapuramu-515001, A.P, India

Abstract: An embedded system is designed for the control of Temperature of VLSI chips during their operation. Due to the very high packing density, VLSI chips get heated very soon and if not cooled properly, the performance is very much affected. In the present work, the sensor which is kept very near proximity to the IC will sense the temperature and the speed of the fan arranged near to the IC is controlled based on the PWM signal generated by the ARM processor. A buzzer is also provided with the hardware, to indicate either the failure of the fan or overheating of the IC. The entire process is achieved by developing a suitable embedded C program.
Keywords: Temperature sensor, ARM processor, VLSI chips, Brushless DC motor

I. INTRODUCTION

In recent times, the industry has witnessed rapid developments in VLSI technology, the IC designers are trying to put more transistors in a very small package. So, the ICs run at higher speeds and produce large amount ofheat which creates the problem of thermal management. For example, nowadays the CPU chips arebecoming smaller and smaller with almost no room for the heat to escape. The total power dissipationlevels now reside on the order of 100 W with a peak power density of 400-500 W/Cm2, and are stillsteadily climbing [1,2]. As the chip temperature increases its performance is very much degraded byparameters shift, decrease in operating frequencies and out-of specification of timings. So the high-speed chips must be cooled to maintain good performance for the longest possible operating time andover the widest possible range of environmental conditions. The maximum allowable temperature for a high speed chip to meet its parametric specifications depends on the process and how the chip is designed.Among the various cooling techniques, heat sinks, heat pipes, fans and clock throttling are usuallyemployed. Among these techniques, fans can dramatically reduce the temperature of a high speed chip,but they also generate a great deal of acoustic noise. This noise can be reduced significantly by varyingthe fans speed based on temperature i.e. the fan can turn slowly when the temperature is low and canspeed up as the temperature increases.

The other prominent method is clock throttling i.e. reducing the clock speed to reduce power dissipation. But it also reduces the system performance and the systems functionality is lost [3].

So, the objective of the present work is, to design a hardware system consisting of a brushless DCmotor fan whose speed is controlled based on the temperature of the chip, sensed by the sensor LM35.

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearlyproportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over lineartemperature sensors calibrated in °Kelvin, as the user is not required to subtract a large constantvoltage from its output to obtain convenient Centigrade scaling. The LM35 does not require anyexternal calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibrationat the wafer level. The LM35's low output impedance, linear output, and precise inherent calibrationmake interfacing to readout or control circuitry especially easy. It can be used with single powersupplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low selfheating,less than 0.1°C in still air. The LM35 is rated to operate over a −55° to +150°C temperaturerange, while the LM35C is rated for a −40° to +110°C range (−10° with improved accuracy). TheLM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is alsoavailable in an 8-lead surface mount small outline package and a plastic TO-220 package [4]. Tomonitor the voltage at the terminals of the DC motor fan, the PWM signal is generated by theARM7TDMI processor. This PWM signal is changed in accordance to the output of the LM35temperature sensor. So the important component of this entire project is the temperature sensor.

II. HARDWARE DESCRIPTION

In the present embedded system built around ARM processor for temperature control, the output of the temperature sensor isfed to the on-chip ADC and the output of the ADC is given to the L293D driver IC which in turn is fedto DC motor fan as shown in the block diagram in Fig. 1. A graphic LCD (128x64 pixels) is interfacedto the ARM LPC 2378 processor to display the temperature of the IC and the speed of the fan.

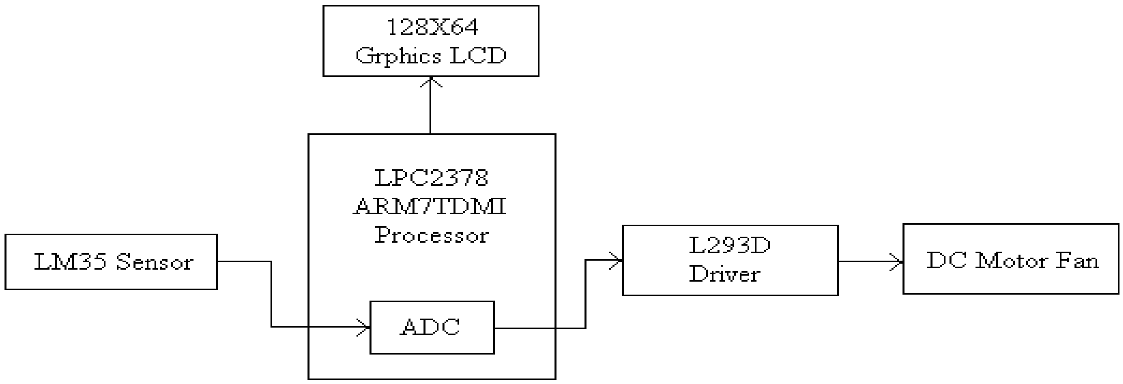


Fig. 1. Block diagram.

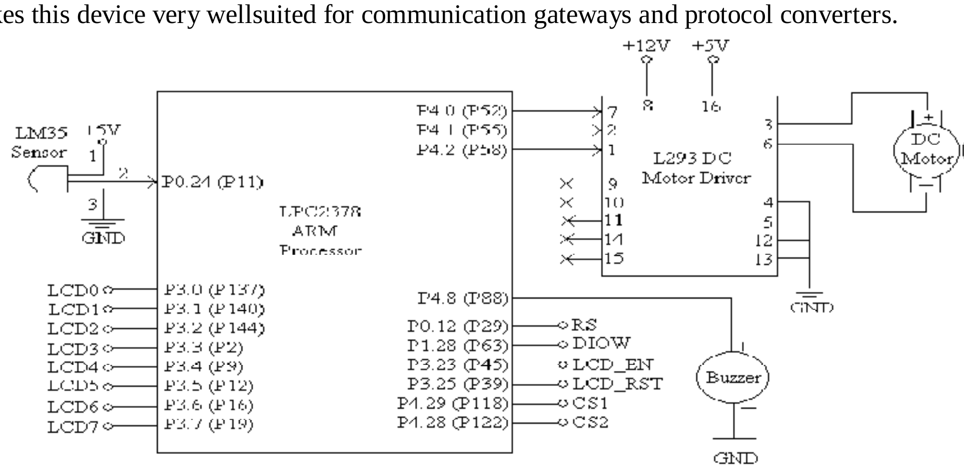
Abuzzer is also connected to the processor which gives an indication, in case of the failure of the fan oroverheating of the chip beyond some level. The entire circuit diagram is shown in Fig. 2.

III. SOFTWARE DESCRIPTION

The present work is implemented using ARM IAR Workbench IDE and the necessary embedded Cprogram is developed and dumped into the embedded processor using Flash magic ISP Utility. TheARM IAR Workbench IDE is a very powerful Integrated Development Environment (IDE) that allows to develop and manage complete embedded application projects [5]. In-System Programming isprogramming or reprogramming the on-chip flash memory, using the boot-loader software and a serialport. The LPC2387 microcontroller is based on a 16-bit/32-bit ARM7TDMI-S CPU with real-timeemulation that combines the microcontroller with 512 kB of embedded high-speed flash memory.

A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution atthe maximum clock rate. For critical performance in interrupt service routines and DSP algorithms,this increases performance up to 30 % over Thumb mode. For critical code size

applications, thealternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty.The LPC2387 is ideal for multi-purpose serial communication applications. It incorporates a10/100 Ethernet Media Access Controller (MAC), USB full speed device with 4 kB of RAM,four UARTs, two CAN channels, an SPI interface, two Synchronous Serial Ports (SSP), threeI2C interfaces, and an I2S interface. This blend of serial communications interfaces combined with anon-chip 4 MHz internal oscillator, 64 kB SRAM, 16 kB SRAM for Ethernet, 16 kB SRAM for USBand general-purpose use, together with 2 kB battery powered SRAM makes this device very wellsuited for communication gateways and protocol converters.



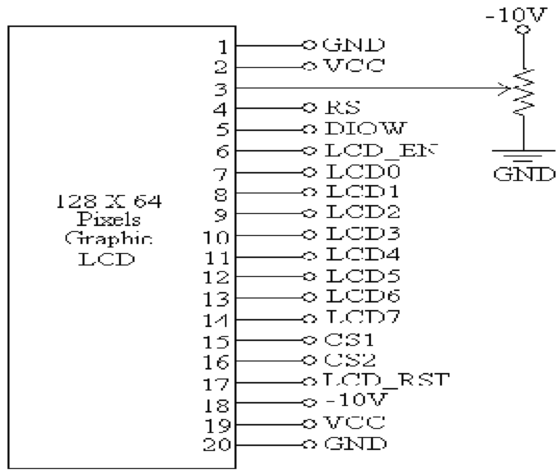


Fig. 2. Complete circuit Diagram.

Various 32-bit timers, an improved 10-bit ADC, 10-bit DAC, one PWM unit, a CAN control unit, and up to 70 fast GPIO lines with up to 12 edge or level sensitive external interrupt pins make this microcontroller particularly suitable forindustrial control and medical systems.

The LPC2378 Microcontroller provides on-chip boot-loader software that allows programming of the internal flash memory over the serial channel [6]. Philips provides a utility program for In-System programming called Flash magic Software [7].

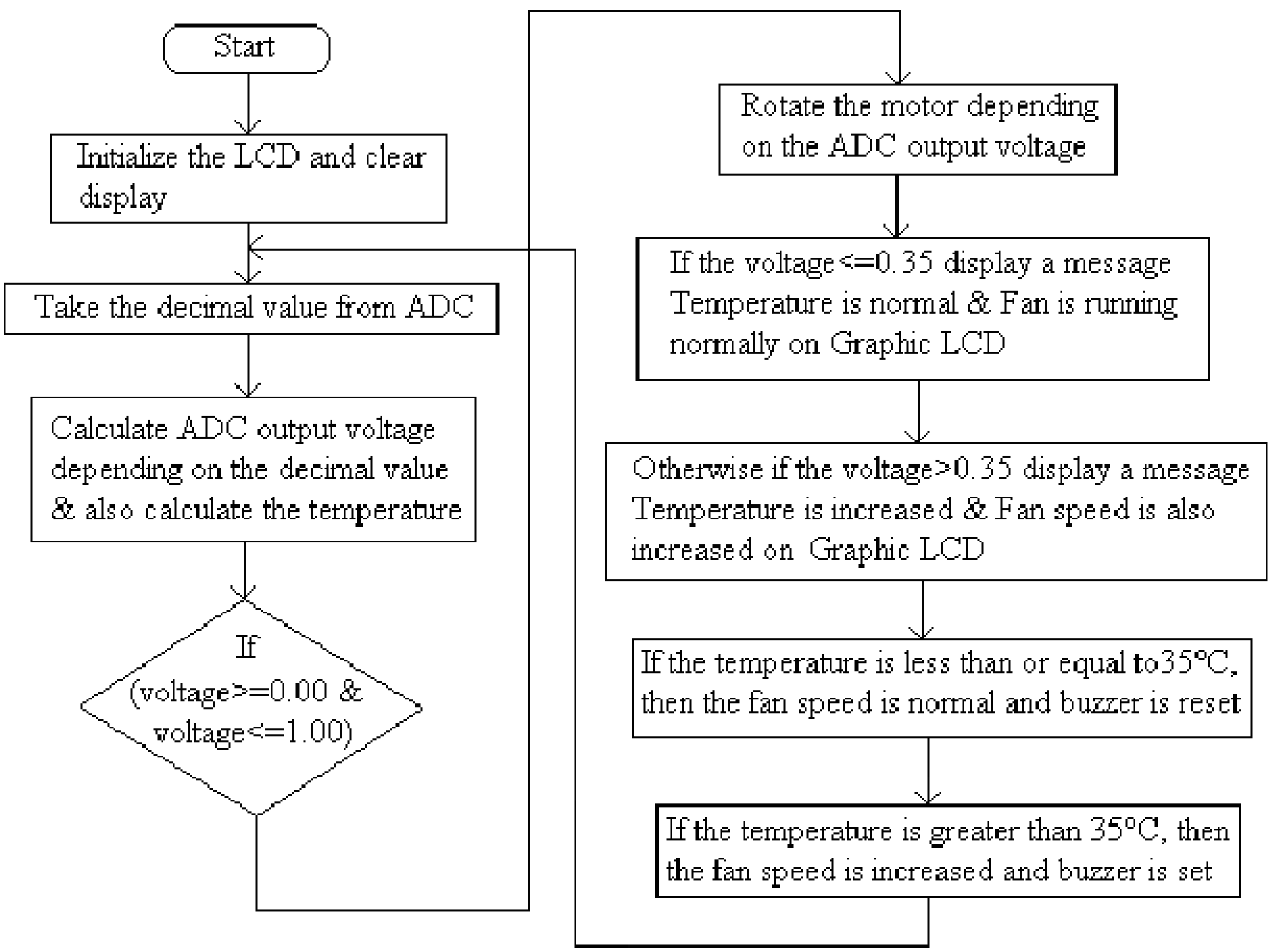


Fig. 3. Flow chart for the Implementation

IV. RESULTS AND DISCUSSION

ARM processor based automatic speed control DC motor fan is designed and used in the present work. To test the validity of the design, the temperature sensor is kept inside a small oven and itstemperature is increased beyond the room temperature. Now the fan is operated to run with full speedand the temperature is found to come back to normal temperature. This is repeated with various VLSIchips like Pentium processor, FPGA chips etc. Now the temperature sensor is kept very near to thePentium processor of the computer and it is observed that, as the time lapses the speed of the fan isautomatically increased and the temperature of the chip is found to be controlled. These results aredisplayed on LCD panel. Though the present system is working well in the given environment, still itis worthwhile to highlight the following conclusions.Normally, controlling fan speed or clock throttling based on temperature requires that the temperatureof the high speed chip should be first measured. This is done by placing a temperature sensor close tothe target chip either directly next to it or in some cases, under it or on the heat sink. The temperaturemeasured in this way corresponds to that of the high speed chip, but can be significantly lower and thedifference between measured temperature and the actual die temperature increases as the powerdissipation increases. So, the temperature of the circuit board or heat sink must be correlated to the dietemperature of the high speed chip [9]. Of course a better alternative is possible with a number of high speed chips. Many CPUs, FPGAs and other high-speed ICs include a thermal diode which is actually adiode connected bipolar transistor, on the die. Using a remote diode temperature sensor connected tothis thermal diode, the temperature of the high speed IC's die can be measured directly with anexcellent accuracy. This not only eliminates the large temperature gradients involved in measuringtemperature outside the target IC's package, but it also eliminates the long thermal time constants,from several seconds to minutes, that cause delays in responding to die temperature changes.There is also a drawback in fan speed control. Normally the fan speed is controlled by adjusting thepower supply voltage of the fan. This is done by a low-frequency PWM signal, usually in the range ofabout 50 Hz, whose duty cycle is varied to adjust the fan's speed. This is inexpensive and alsoefficient. But the disadvantage of this method is that it makes the fan somewhat nosier because of thepulsed nature of the power supply. The PWM waveforms fast edges cause the fans mechanicalstructure to move, which is easily audible.In some systems, it is also important to limit the rate of change of the fan speed. This is critical whenthe system is in close proximity to users. Simply switching a fan on and off or changing speed immediately as temperature changes is acceptable in some environments. But when users are innearby, the sudden changes in fans noise are highly annoying. So to avoid these effects the fan's drivesignal must be limited to an acceptable level.

V. ACKNOWLEDGEMENTS

The authors wish to acknowledge Sri. PL. N. Reddy, Correspondent, SSBN College (Autonomous),Anantapur, India, for his support & encouragement in promoting the research activities in theInstitution.

REFERENCES

[1] Ma Kunquan and Liu Jing, Liquid Metal Cooling in Thermal Management of Computer Chips, FrontiersEnergy Power Engineering China, 2007, Vol.1, No. 4, 2007, pp. 384-402.
[2] Narasimha Murthy Yayavaram, Saritha Chappidi, Sukanya Velamakuri,Embedded Processor Based Automatic Temperature Control of VLSI Chips,Sensors & Transducers Journal,Vol.100, Issue1,January 2009
[3] MAXIM Application note 707, Fan speed Control is Cool, Feb. 02, 2001.
[4] National Semiconductor's Temperature Sensor Hand Book.
[5] ARM Architecture Reference Manual, Addison-Wesley, 2001.
[6] Philips Semiconductors – LPC2378 Manual.
[7] Philips ISP Software, LPC 2000 Flash magic, http://www.esacademy.com
[8] MAXIM Application Note 3173, Automatic Fan Control Techniques: Trends in Cooling High – SpeedChips, July 08, 2004.
[9] http://maxim-ic.com