Chapter 10
MSP430 Microcontroller: A Green Technology

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ABSTRACT

In this chapter, the architecture and function of a microcontroller, a device for system operation control at micro-level, is briefed. The need for a low power microcontroller towards sustainability and greening is stressed with various examples. The MSP430 Microcontroller, a product from Texas Instruments, is a very low power microcontroller. The strategies adopted for MSP430 microcontroller power optimization are explained. Some emerging trends for further power optimization are also given. All the concepts are introduced in a simple manner with suitable analogies so that it can be understood by a reader with a different expertise.

INTRODUCTION

What is a microcontroller? The name itself is self explanatory. Microcontroller (Mazidi, 2006) is a tiny integrated circuit chip that controls a system operation at the micro-level. For example, a microcontroller can be used to control the temperature of a furnace (Bogush 2006). Say, a furnace needs to be maintained at 1000 degree centigrade. When the temperature goes above 1000 the microcontroller should be able to sense it. Then it should send a control signal that reduces the electrical power delivered to the heater element. The efficiency of a controller is decided by: (i) its speed. How quickly it brings back the desired temperature? (ii) its accuracy. What minimum temperature deviation it can sense and control? (iii) its control type. The control should not create a temperature oscillation. If the first control brings the temperature below 1000 and the second control shoots up the temperature above 1000 and if oscillation goes on like that it is very much undesirable. The

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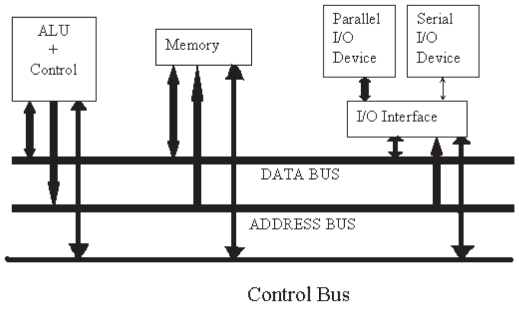
control should be such that it minimizes the deviation smoothly. A positive temperature deviation should remain positive throughout the control (Radakovic 2002).

Microcontroller is a very efficient controller since it has all these attractive features of control. Microcontroller finds wide use in embedded systems (Kamal, 2003). To understand what Embedded System is, we begin with an example. Most of us use automatic washing machine to wash our clothes. A fully automated washing machine may automatically decide the quantity of detergent, water temperature, time for wash etc. (Yin-Win, 2009). These decisions will be made by a microcontroller or a similar processor that is embedded inside the washing machine. Though there is a computing machine inside the washing machine none thinks of doing some computation with the help of a washing machine. Microcontroller is used to make the machine automatic but it still washes clothes and does not function like a computer. For this reason the microcontroller is looked as an embedded system for the washing machine. Embedded system can be defined as a system with electronic processing capability that is embedded in equipment whose primary task is different from electronic processing. A desktop computer has a microprocessor inside it to endow it with computing or electronic processing capabilities. But this microprocessor cannot be called an embedded system, as desktop computer is primarily used for computing i.e. its primary task is quite similar to the microprocessor.

Microcontrollers are good candidates for real time applications. In a real time application the processor should be ready to accept the input at a particular instant and the output from the processor should be guaranteed after a definite time interval. If a delayed output means a disaster then the application is a hard real time application. An embedded system in a satellite launcher may generate specific outputs to control the speed at different instants. Failure to give this specific output at a specific instant shall end up in an unsuccessful mission resulting in a heavy loss and damage. In this case, the application is a hard real time application.

Figure 1. Basic building blocks of a microcontroller



Embedded systems have a great market potential. While purchasing an equipment or device the customer asks for various automatic controls. A customer expects a smooth shaving without any cut in the skin from a safety razor. Proper use of embedded system in a razor may give this satisfaction. As the technology of embedded processor matures it finds more and more widespread applications.

Now with the understanding of the role of a microcontroller with some specific examples, we can identify its basic building blocks and interfaces as given in fig. 1. The function of a microcontroller can be understood for the furnace temperature control discussed earlier. The block, I/O interface, interacts with the external world. The temperature of the furnace is received from a temperature sensor as an input and the control for the heater element is sent as an output through this interface. A microcontroller processes only binary numbers. A stream of 1s (usually high voltage e.g. 2.5 volts) and 0s (usually low voltage e.g. 0 volt) are received at the I/O. This stream can be received serially bit by bit or can be received through the parallel port. The temperature data is brought by the data bus to the Arithmetic Logic Unit or ALU and processed. A suitable algorithm executed in the ALU determines the heater control current.