Chapter 1
Introduction

WHERE ARE MICROCONTROLLERS USED?

Microcontrollers reside in almost any gadget you carry or use nowadays. Whether it is a cell phone, a digital camera, a wireless telephone, a camcorder, a digital watch, a remote control, a multimeter, etc., it is certain that it has some sort of embedded microcontroller. Contemporary automobiles can have at least ten of them: The engine is controlled by one, as are the anti-lock brakes, the cruise control, the electric car seats, the air conditioner, the dashboard, etc. Home appliances such as microwave ovens, washing and drying machines, modern refrigerators, satellite receivers, climate controllers, dishwashers, and the list goes on and on; all of these have some kind of microcontroller buried inside. All office equipment: printers, scanners, coffee makers, copy machines, etc. have microcontroller-based electronics. Home automation products (KNX, Modbus, etc.) along with Programmable Logic Controllers (PLC) are designed with microcontrollers too. You get the point. Basically, any product or device that interacts with its user has a microcontroller inside.

WHAT IS A MICROCONTROLLER?

A microcontroller is a small computer integrated on a single chip. It can be programmed to implement just about anything a consumer wants. It is also known as a single-chip microcomputer or simply a microcontroller unit (MCU).

Regardless of the MCU manufacturer, complexity or throughput, microcontrollers have several things in common:

- All microcontrollers have a central processing unit (CPU) in charge of executing programs. Computer programs consist of instructions designed to execute arithmetic and logic operations. A CPU can also execute data move and control instructions.
Microcontrollers have two different memory types: Random Access Memory (RAM) and Read Only Memory (ROM). RAMs hold variables and alterable data. ROMs hold non-volatile information such as a computer program or setpoints. Different ROM technologies (PROM, EPROM, EEPROM) are available on the market.

Microcontrollers are interfaced to I/O devices like push buttons, keypads, Liquid Crystal Displays (LCD), touch screens, relays, etc.

In essence, a microcontroller is very much similar in functionality to a general purpose processor like a Pentium chip. The difference is in scale. A general purpose computer employing a “heavy-duty” microprocessor is capable of executing a large number of programs concurrently through time sharing techniques or via the multi-core technology. A microcontroller generally runs a single program on a single core and is mostly dedicated to handheld devices and dedicated applications. Besides this,

- Microcontrollers are equipped with several I/O subfunctions: serial and parallel ports, A/D and D/A converters, internal memory, timers, etc. Electronic designers use internal blocks to implement sophisticated gadgets with minimal external components. A microcontroller is often called an “embedded controller” since it can be embedded inside a consumer product.
- Microcontrollers are dedicated to a single task and hence run one program perfectly well. The program is stored in non-volatile memory (ROM type) and remains there throughout the lifetime of the processor.
- Since microcontrollers are mostly used in battery-based handheld devices, they are designed to consume only a few milliwatts of power. Nowadays microcontrollers can be supplied from a tiny 3V battery and are armed with many features that optimize power consumption such as the sleep mode and the Watchdog Timer among others.
- A microcontroller is best suited to read data from sensors (analog/digital), process the data, and then control outputs (relays, switching transistors etc.). For instance, the MCU inside a TV receives a command from a remote control via its infrared sensor. It processes the command and sends the appropriate control signals to switch to a new channel, increase/decrease the volume, etc. The engine controller in a car receives data from sensors and accordingly it controls the car speed (cruise control), the spark plug timing, the fuel mix, etc. The controller inside a microwave oven decodes a keypad command and consequently it activates the relay that turns on the oven for the specified time duration.
- Microcontrollers are often small and inexpensive. In our time, it is common to purchase a low pin count MCU, suitable for small applications, for a cost as low as a few dimes.
- Microcontrollers are generally designed to work in harsh environments. For instance, an MCU controlling a car’s engine should be able to operate at a wide temperature range. Hence, it should function properly in Siberia at temperatures below 32 °F as well as in the midst of the Mojave Desert where summer average temperatures surpass 120 °F. On the contrary, a microcontroller embedded in a modern TV ought not to be ruggedized at all since it operates at moderate temperatures.

This textbook covers a line of popular controllers called “PIC microcontrollers” manufactured by Microchip Technology Inc. By today’s standards, these CPUs are incredibly minimal in size; plus they are extremely inexpensive when purchased in large quantities and can often meet the needs of a device’s designer with just one chip.
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