Work-Ready Electronics

Synchronizing Curriculum to the Rapidly Changing Workplace

Module: Micro & Embedded Controllers
Part 2: Popular Microcontrollers and Software

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Popular Microcontrollers and Software

This module is a continuation of the Microcontrollers and Embedded Controllers Module. In this module, we will look at some of the features of common microcontrollers.

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Prerequisites

To complete this module successfully, you should have the following knowledge and background:

Electronic fundamentals including DC/AC circuits and semiconductor devices and basic circuits

Digital logic fundamentals

You should complete Part 1 of the Micro & Embedded Controllers module before attempting this module.

What Technicians Need to Know

The most common and popular 8, 16, 32, and 64-bit microcontrollers

Concepts of digital signal processing (DSP)

Software related to embedded controllers

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Popular 8 and 16-Bit Microcontrollers

Characteristics of 8-Bit Controllers

The first microprocessor (Intel 4004) appeared in 1971. The first complete single chip embedded controllers came later in the 1970s (8048/51 and 6801). Since then there have been many different controllers developed and sold. Some have become very popular and widely used while others have disappeared from the market. Others have found a niche of applications.

Microcontrollers are specified by the size of the binary words that they process. The most common size is 8-bits. With 8-bits, you can represent values up to 256. This is often large enough for many applications. Most 8-bit controllers also process 16-bit words if necessary. With a 16-bit word values to $2^{16} = 65,536$ can be represented.

Other Key Characteristics

Another key characteristic is how much memory is available to the processor. The amount of memory in terms of number of words or bytes that can be accessed is set by the size of the address word.

In 8-bit processors, a 16-bit address word is common. This allows up to 2^{16} = 65,536 words or bytes of program or data to be addressed. Some smaller special processors may have less memory capacity than this.

A few microcontrollers have limited RAM and ROM, often only 1kB to 4KB as smaller applications require.

Note: The term kB (or kb) means kilobits while the term KB (or Kb) means kilobytes. Kilo in computer terminology is 1K or 1024.

Most Popular 8-bit Products

The most popular products have changed over the years and new, updated versions have been developed. Yet, there are three 8-bit controllers that continue to dominate the embedded controller market. These are (1) Intel 8051 and all its variations, (2) Freescale (formerly Motorola) 68HC11 series and its variations and offshoots, and (3) Microchip Technology PIC controllers and variants.

You no doubt learned one of these devices in the micro course you have taken.

The 8051

One of the oldest and still most widely used embedded controllers is the 8051. It was developed originally by Intel in the late 1970s and early 1980s. Its predecessor was the 8048, a simpler version that gained wide usage as the keyboard controller in virtually every IBM PC and compatible computers.

The 8051 was originally made with NMOS IC technology but the newer versions use CMOS which makes them faster and less power hungry. The designation is 80C51 for CMOS.

As semiconductor process technology has decreased feature size of the CMOS, speeds have naturally increased from original clock speeds as low as 8 to 12 MHz up to 100 MHz today.

8051 Key Features

The 8051 controller uses Harvard architecture. It has two 8-bit accumulator registers. It has either 128 or 256 bytes internal RAM and 64KB or 128 KB external.

It also has 512 bytes to 128 KB internal ROM. It can also use flash memory.

It has multiple 8-bit parallel I/O ports. It can have various serial ports (UART, SPI, I^{2}C, etc.) depending upon the model.

It uses either an 8 or 10 bit ADC in some versions.

80C51 Vendors

The 8051 is still made by Intel. www.intel.com

One of the oldest second sources of the 80C51 is European semiconductor giant NXP (formerly Philips). www.nxpcom .

The newer suppliers of 80C51 devices are:

Atmel www.atmel.com

Dallas Semiconductor/Maxim Integrated Devices www.maxim-ic.com

Infineon Technologies www.infineon.com

Silicon Laboratories www.silabs.com

Freescale 68HC11

The Freescale 68HC11 is derived from earlier Motorola 6800 MPU. There are lots of different versions and models available with different memory and I/O options.

It is one of the simpler architectures and designs and it is easy to learn.

There is a 16-bit version available (68HC12).

The 68HC11 uses Von Neumann architecture and has two 8-bit accumulators and 1- 16-bit accumulator. It has memory mapped I/O.

The total memory space is 64 KB. It also has 128 or 256 byte RAM and 1KB to 48 KB ROM/flash.

It has multiple parallel 8-bit I/O ports and serial ports on some modules (UART, SPI, etc.)

Some models have an 8-bit ADC.

Microchip PIC Series

The highest volume embedded controller is the Microchip Technology PIC series. The Freescale 8-bit controllers run a close 2nd place.

PICs are mostly 8-bit but some 16-bit models are available.

Hundreds of versions are available depending upon computing, memory, and I/O needs.

Main designations for 8-bit devices are PIC10, PIC12, PIC14, PIC16, PIC18. The PIC24 is 16-bit.

DSP enhanced versions are designated with a ds preceding the number such as dsPIC30F2010.

Major PIC Features

One example chip, the 16C54-58A, uses Harvard architecture.

It is reduced instruction set computing (RISC) design.

It contains a long instruction word (12-bits) and has single clock cycle execution.

24 – 73 bytes of SRAM serves as the register bank. ROM sizes are from 512 bytes to 2 KB.

It has one 4-bit I/O port and two 8-bit I/O ports.

Another PIC Example

Another example is the PIC18F248/258. It also has RISC and Harvard architecture. It uses an 8-bit word with 16-bit instructions.

It has up to 2 MB program memory and data memory up to 4 KB external.

It also has a 10-bit ADC and a 40 MHz clock with performance to 10 MIPS.

It has controller area network (CAN) interface.

Additional 8-Bit Micros

There are literally dozens of other commercial 8-bit controllers.

Here is a list of some of these newest and most widely used.

Atmel AVR www.atmel.com

Cypress PsoC www.cypress.com

National Semiconductor COP8 www.national.com

Rabbit Semconductor www.GetWithRabbit.com

Renesas Technology www.renesas.com

ST Microelectronics ST6 www.stmicro.com

Zilog Z8 www.zilog.com

16-bit Micros

Many 16-bit microprocessors and controllers have been developed over the years. Most have disappeared since 8-bit controllers became more powerful and capable of handling some 16-bit operations.

The older and once widely used Freescale (formerly Motorola) 68000 and the Intel 186/286 designs can still be found in some designs because of the huge software data base available. Embedded versions are also available.

Rationale for More Bits

16-bit MCUs process data in 16-bit parallel chunks, 32-bit processors in 32-bit chunks, and so on. They just process more data faster.

Larger processors can also represent larger binary values since the value $M = 2^N$ where N is the number of bits.

Larger word sizes also mean larger address words so in general larger word sizes mean that the processor can address more memory.

16-Bit Controllers

Currently one of the most popular 16-bit controllers is the Texas Instruments MSP430. It is a RISC design with Von Neumann architecture.

It features 16 general purpose registers. It has a clock to 16 MHz (16 MIPS operation). SRAM is from 128 Bytes to 10 KB.

ROM (flash) is from 1 KB to 120 KB.   It has both an ADC and a DAC as well as UART, I^2C, SPI, timers.

Its number one claim to fame is its extreme low power operation making it ideal for portable and battery powered devices.

Other 16-bit controllers are the Freescale 68HC12 and related versions, the Maxim MAXQ3120 or MAXQ2000, and the Microchip PIC24.

32 and 64-bit Controllers

32 and 64-bit controllers are used because micros with larger word sizes can process more data faster as required by many modern applications.

All are RISC designs, pipelined with cache.

Major vendors include ARM Holdings PLC, Freescale Semiconductor, and MIPS Technologies

Most appear as cores rather than individual ICs.

The ARM Processor Family

ARM dominates the 32-bit sector with over 75% share.

They are a 32-bit design but they can process 16-bit words.

There are several different models based on applications and performance needs. Some of the models are ARM7, ARM9, ARM9E, ARM10, ARM11, ARM Cortex, SecurCore, StrongARM (XScale).

Performance ranges from 200 to 2000 MIPS. The models are cores only. They are offered as intellectual property (IP) not chips.

Primary applications are in cell phones and PDAs.

Freescale Power PC

The Freescale Power PC was invented by Motorola for PCs. It was used previously in Apple Macintosh and is 2nd sourced by IBM.

It uses 32-bit RISC, pipelined architecture and can handle 64-bit data words.

Most common embedded applications are in networking and communications, automotive, and industrial.

It includes memory management for large external memories and floating point math instructions.

MIPS Technologies

MIPS technologies controllers are 32 and 64-bit RISC cores. They are pipelined with cache on chip. Some come with floating point math capability.

Clock speeds are up to 600 MHz.

It can perform up to 2.4 GFLOPS (giga floating point operations per second).

Primary applications are in consumer electronics and networking.

Test your knowledge

Micro & Embedded Controllers
Part 2: Popular Microcontrollers and Software
Knowledge Probe 1
Popular 8 and 16 Bit Microcontrollers

Click on Course Materials at the top of the page.

Then choose **Knowledge Probe 1**.