Microprocessor-Based Industrial Controllers

Class 2: Microprocessor Architectures

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CEC CONTINUING EDUCATION CENTER

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This Week's Agenda

Monday	Concepts and History
Tuesday	Microprocessor Architectures
Wednesday	Controller Examples - 1
Thursday	Controller Examples - 2
Friday	Connectivity and Trends

Course Description

Industrial controllers at the device level have a long history. Over time they have evolved from relay based, to discrete logic and finally to microprocessor based logic. While the functions have remained the same, the capabilities and sophistication have grown enormously. In this class we will look at the history and development of the field and then look into the modern architectures which are currently in use. We will take a deep dive into several examples of controllers, including the algorithms and implementations for several. Finally we will look at connectivity and trends in the industry.

Today's Agenda

- Microprocessor Types
- Memory
- Input Devices
- Output Devices
- Architectures
- Examples
- Conclusion/Next Class

Microprocessor Types

- Microprocessors come in many sizes and sets of capabilities
  - 8-bit
  - 16-bit
  - 32-bit
  - 64-bit
  - Memory capacities
  - I/O

Microprocessor Types

- We are considering devices with a CPU, internal memory and I/O
- Typically these are single chip devices
- They come in many different form factors
  - Many vendors offer a range of specs with a range of form factors for each one
  - The difference is typically the number and type of I/O and external connections required
    - E.g., whether external memory is required

Microprocessor Types

- In Industrial Control smaller word lengths are often used, since a large number of computations are not required in many applications
  - This implies limited floating-point capability
- If more complex computations are required, larger word length devices are available
- These devices generally are very robust and have low power consumption
  - Allows battery operation if required

Microprocessor Types

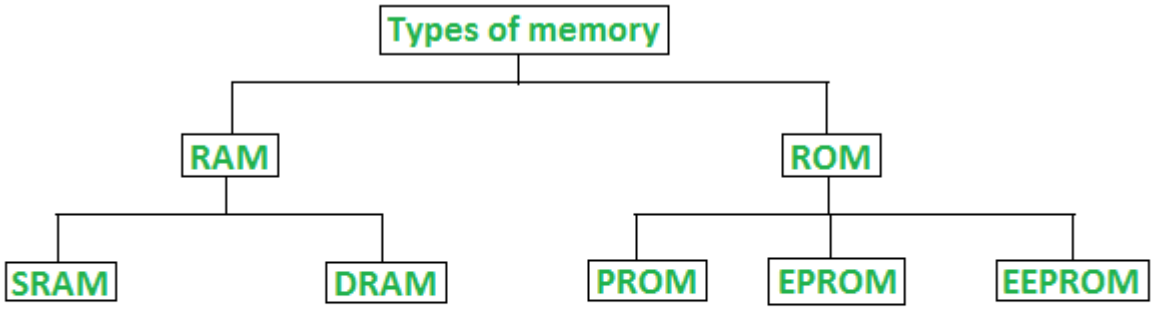
- These embedded devices are often fabricated in “older” semiconductor manufacturing plants
  - Larger “line” widths
  - Lower density
  - Lower speeds
  - Lower power consumption
- Not an issue as they are used in single application modes
  - Minimal O/S requirements

Memory

- A number of types of memory are found in the devices under consideration
  - ROM (Read Only Memory)
  - RAM (Random Access Memory), volatile
  - External
    - ROM or RAM
- Generally not in a hierarchy
  - No cache

Memory

- Memory sizes are typically limited
  - ROM is typically much larger than RAM
- Memory classification



Classification of computer memory

Input Devices

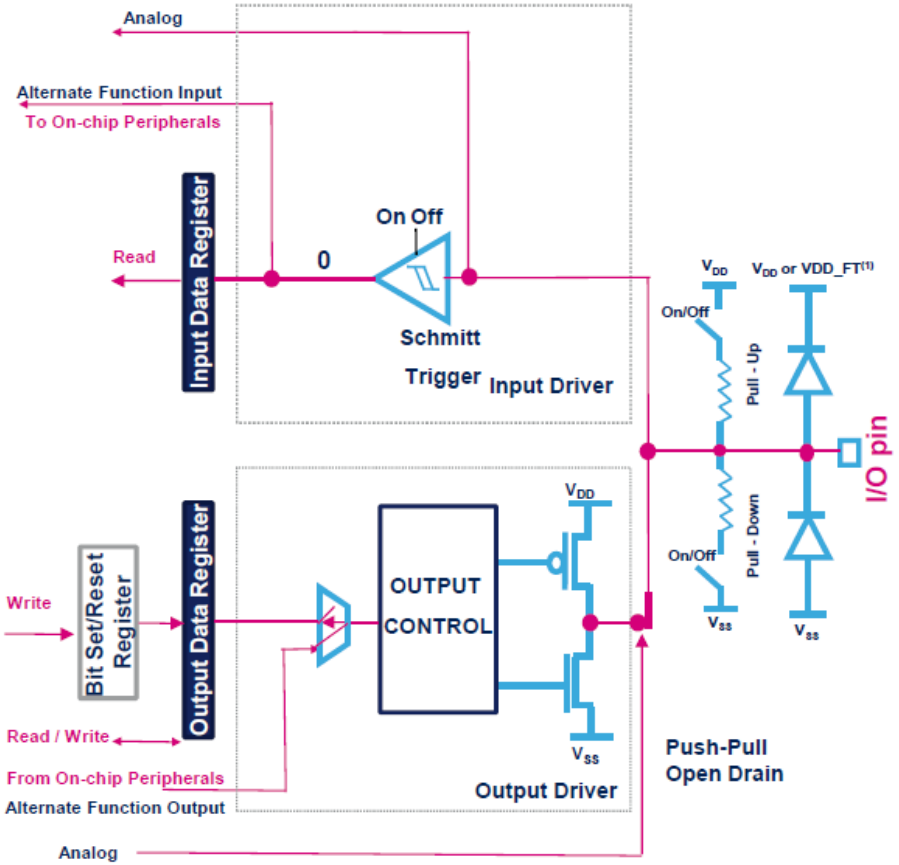
- The typical input devices convert analog signals to digital information
  - A/D or Analog to Digital converter
- These can run at various rates
- Output (digital) value length (in bits) is a typical measurement
  - 12-bit
- Another measure is the sampling rate
  - Usually in Millions of Samples per Second

Input Devices

- Other inputs are digital
  - CAN (Controller Area Network)
    - Device to device
  - USB
  - External Clocks
  - GPIO used for interrupts

Input Devices

- An example of the design for an external input



Output Devices

- Output devices are typically used to control external processes
- These can be digital or analog
  - Generally analog
- D/A (Digital to Analog converter)
  - As with A/D are measured by bit width
- As we have seen, these can also include digital outputs
  - Act as switches

Output Devices

- Other “output” devices include networking capability
  - Some include Ethernet
  - CAN
  - USB
- More sophisticated systems include interfaces to cameras
- Some have built-in motor control outputs
- PWM (Pulse Width Modulators)

Architectures

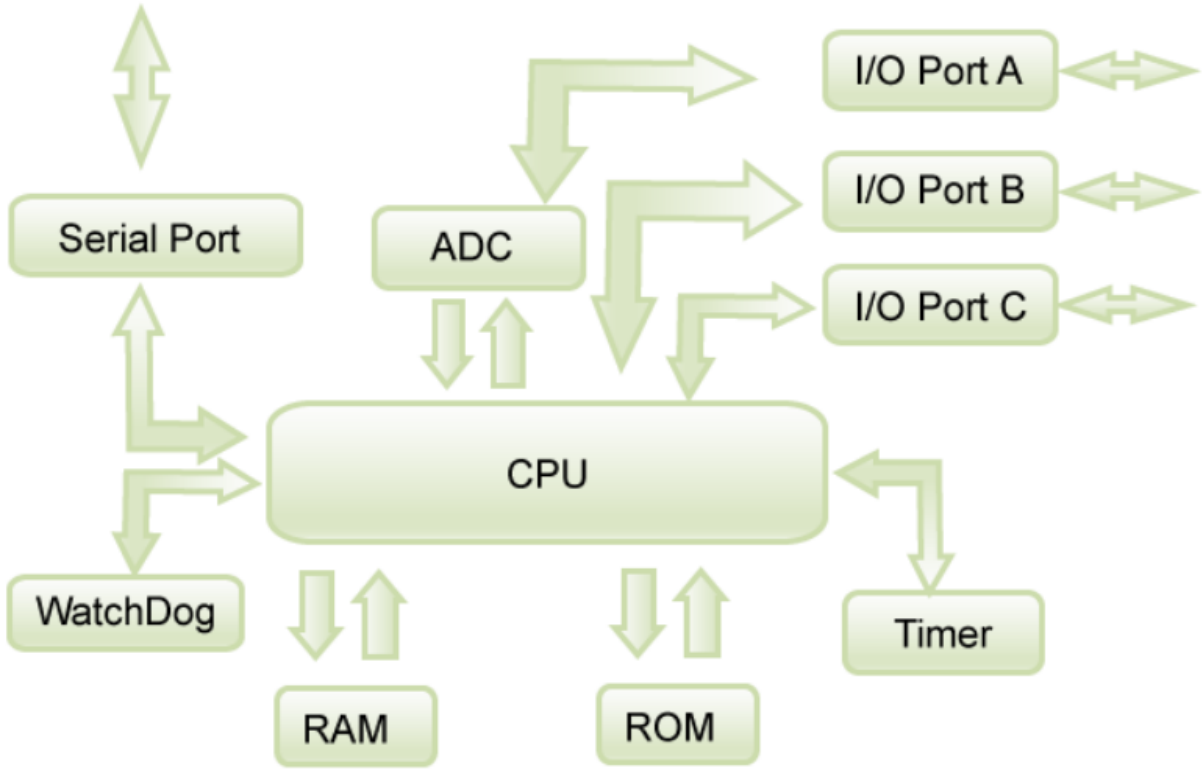
- The devices we are considering are considered SoC (System on Chip)
  - CPU
  - Memory
  - Clocks
  - Oscillators
  - PLL (Phase Locked Loop)
  - Timers
  - I/O

Architectures

- In addition to the functions in the SoC, there may be a need for external devices
  - These are typically memories
- For some complex applications we may have multiple CPUs on a SoC
- A SoC will have an internal bus structure
- In some applications we may want to consider a FPGA device
  - This can include a standard CPU as well

Architectures

- Generic Architecture



Examples

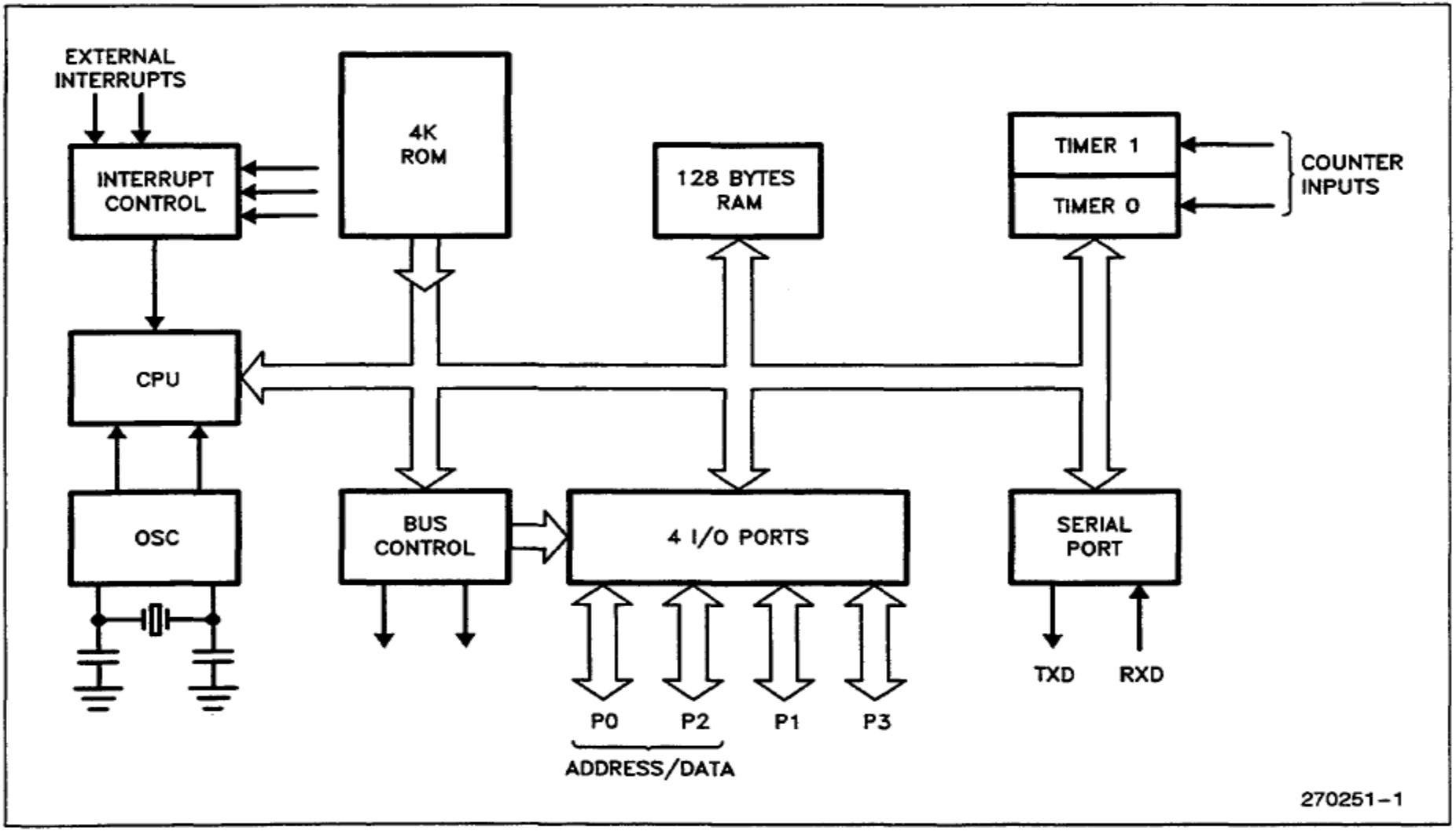
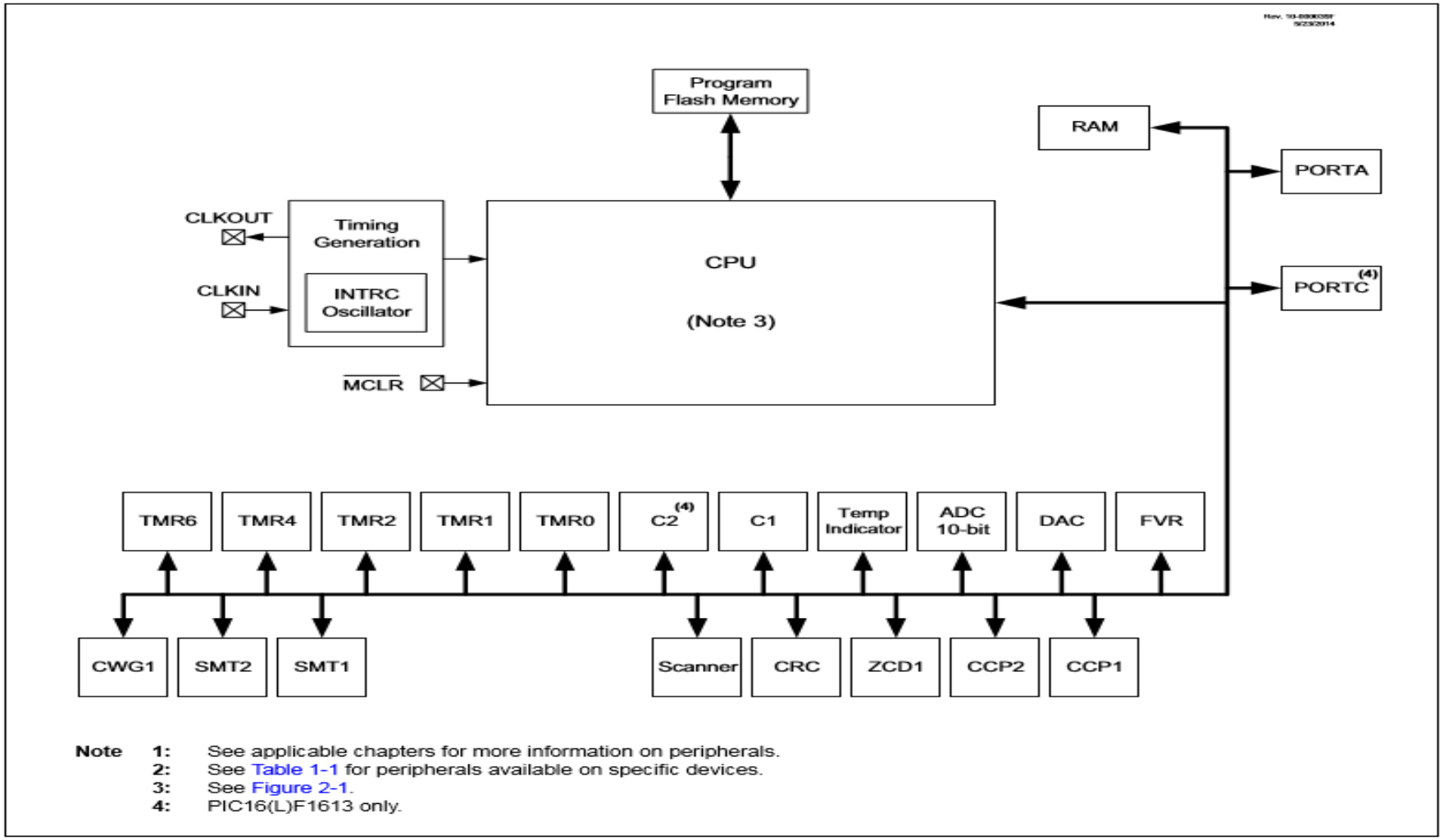


Figure 1. Block Diagram of the 8051 Core

Examples

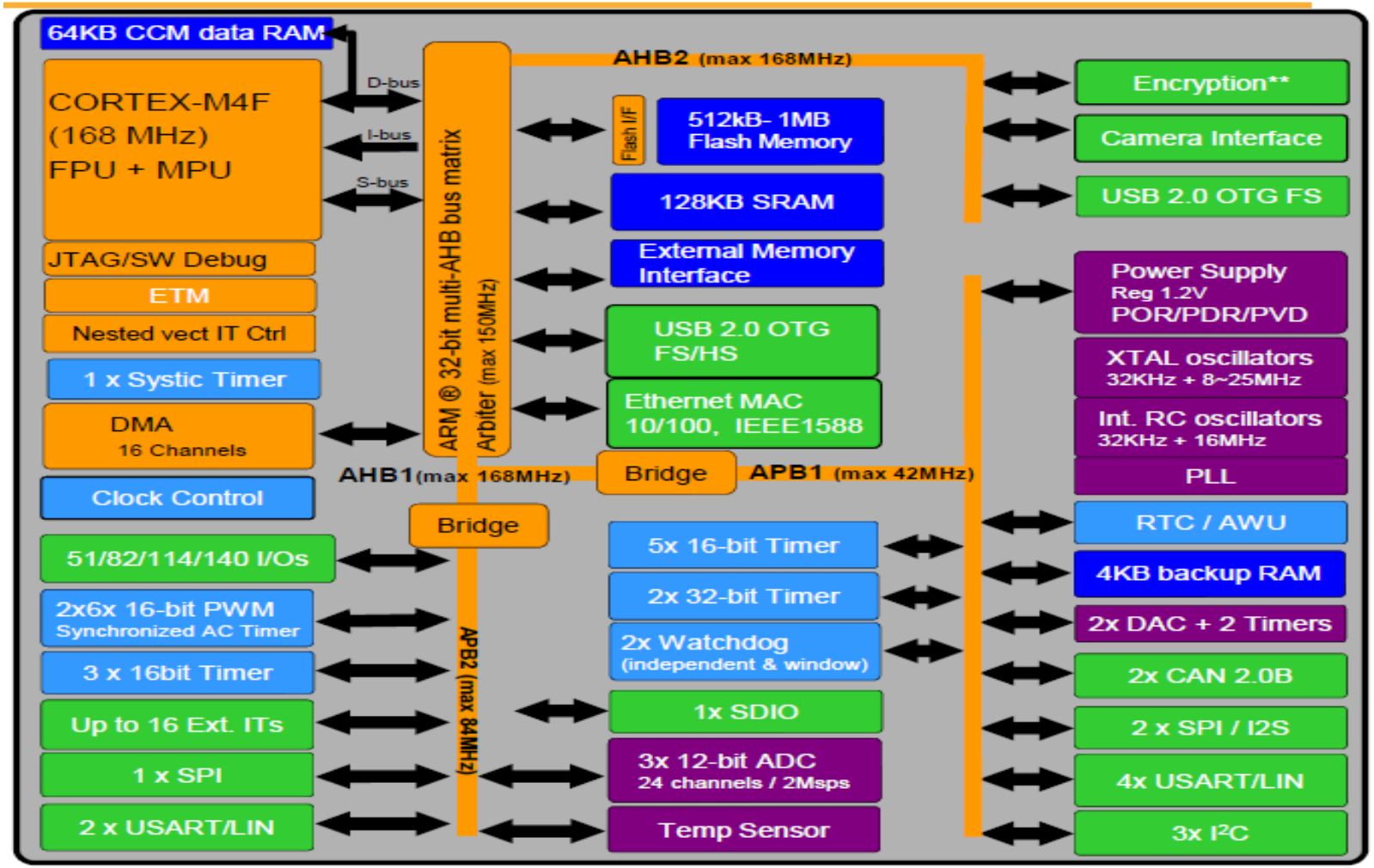
FIGURE 1-1: PIC12(L)F1612/16(L)F1613 BLOCK DIAGRAM



Note 1: See applicable chapters for more information on peripherals.
2: See Table 1-1 for peripherals available on specific devices.
3: See Figure 2-1.
4: PIC16(L)F1613 only.

Examples

- STMicro STM32M4xx



Conclusion/Next Class

- Today we discussed the microcontroller platforms on which we will run algorithms
- We discussed the relevant components
- We looked at the architecture
- We saw some example systems
- Tomorrow we will begin looking at the algorithms in detail