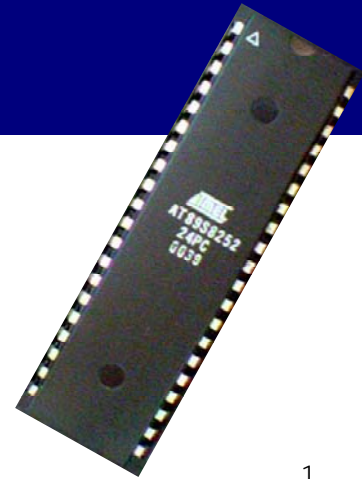


Digital Integrated Circuits & Microcontrollers

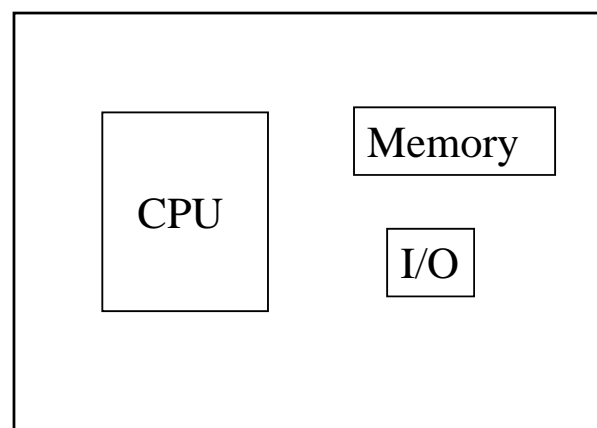
Sl. Mihnea UDREA, mihnea@comm.pub.ro
Conf. Mihai STANCIU, ms@elcom.pub.ro



1

Basic Components of Digital Computer

- CPU (Central Processing Unit)
 - Control and data path
- Memory
 - Stores instruction and data
- Input/output
 - Interact with the outside of computers



Could be a chip, a board,
or several boards

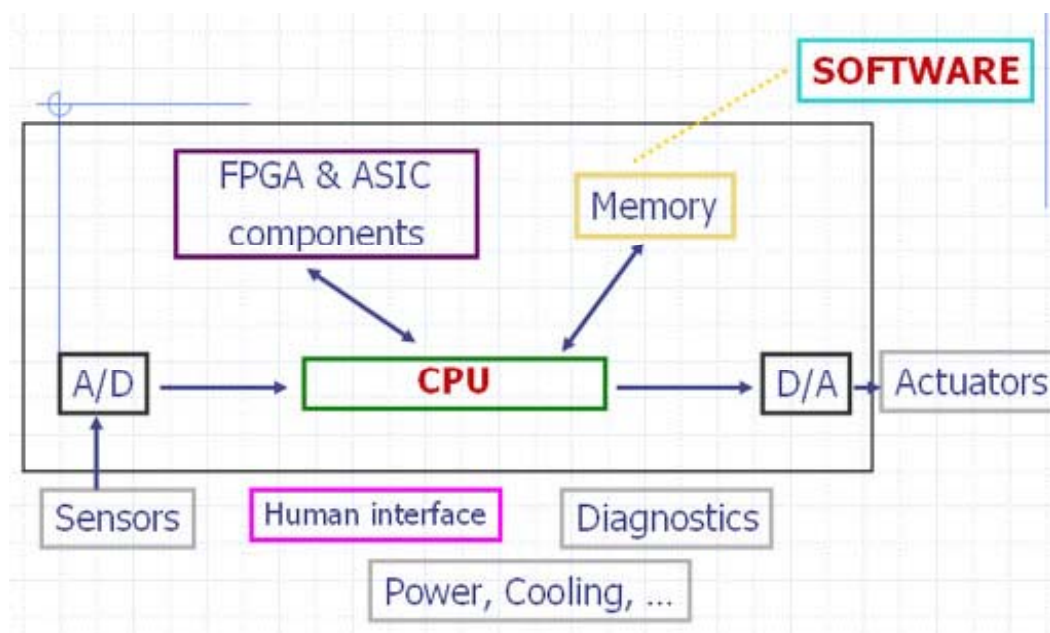
2

What is and Embedded System?

- A **specialized computer** system that is **part of a larger system** or machine.
 - Virtually all appliances that have a digital interface utilize embedded systems
 - watches,
 - microwaves,
 - DVD players,
 - cars
 - Typically, an embedded system is housed on a single microprocessor board with the programs stored in ROM

3

What is and Embedded System?



4



ES, Other definitions

- A **special purpose** computer **built into a larger device**.
 - *Special purpose:*
 - Embedded systems have a (more or less) well-defined purpose
 - Contrast with: general purpose computers (PCs etc)
 - Both hardware and software is tailored to application(s), which are well defined
 - However, re-programmability is a requirement
 - *Built into a larger device:*
 - ESs are (usually) part of a larger device, augmenting its capabilities

5



ES Types & Characteristics

- Types of Processing unit:
 - Hardwired logic
 - Programmable units
- ES Characteristics:
 - Efficiently
 - Cost effective
 - Power efficiently
 - Real-time
 - Predictability

6



ES Solutions

- Embedded Systems Solutions:
 - Microcontrollers
 - Embedded Processors
 - Digital Signal processors



ES Development

- System development
- Electronics
- PCB Layout
- Software
- Mechanical
- Product qualification
- DFM – design for manufacturability

ES Applications

- **Signal processing systems**
 - Real-time video, DVD players, Medical equipment.
- **Distributed control**
 - Network routers, switches, mass transit systems, Elevators
- **“Small” systems**
 - Mobile phones, pagers, home appliances, toys, smartcards, MP3 players, PDAs, digital cameras, sensors, pc keyboard & mouse
- **Modern cars: Up to 100 or more processors**
 - Engine control unit
 - ABS systems (Anti Lock Brake systems)
 - Emissions control
 - Diagnostics and Security systems
 - Accessories (doors, windows etc)



Typical ES Hardware

- **Commercial off-the-shelf components (COTS)**
 - e.g. wireless radios, sensors, I/O devices
 - Cheap
- **Application-Specific ICs (ASICs)**
 - ICs tailored to meet application needs
 - Good performance for their intended task(s)
 - Original ESs were ASICs only
- **Domain-specific processors**
 - DSPs
 - Microcontrollers
- **Microprocessors**
 - General Purpose Processors

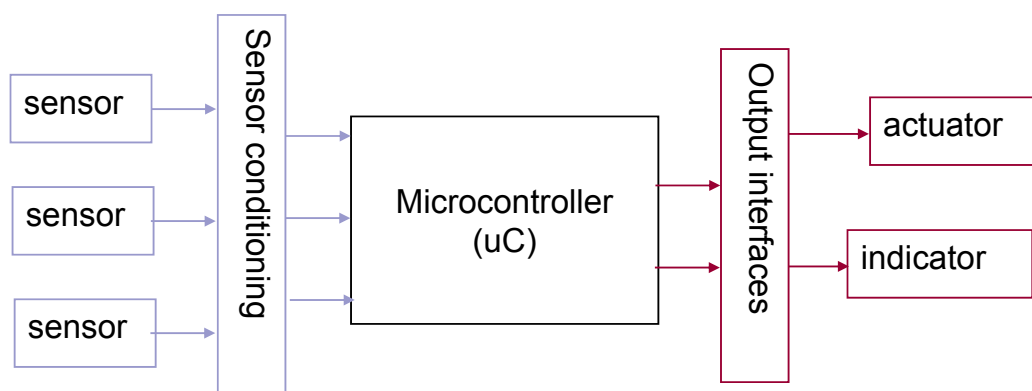
New trends in ES HW

■ Systems-on-chip

- Usual (or desired) specs:
 - 32-bit RISC CPU
 - Built-in interfaces to RAM and ROM
 - Built-in DMA, interrupt and timing controllers
 - Built-in interfaces to disk or flash memory
 - Built-in Ethernet/802.11 interfaces
 - Built-in LCD/CRT interfaces
- New SOCs appearing almost every week!

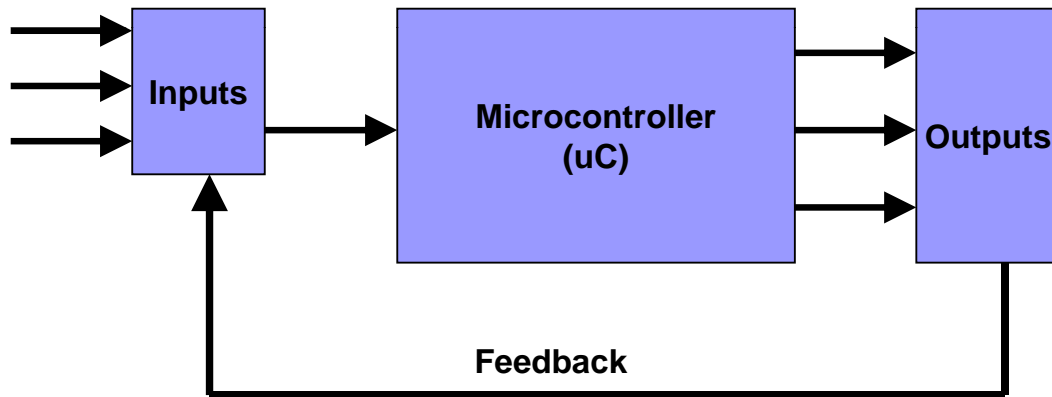
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ES General Block Diagram



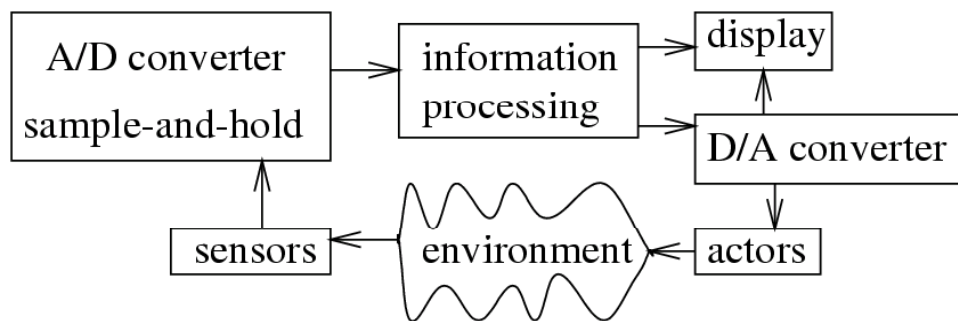
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An Embedded Control System



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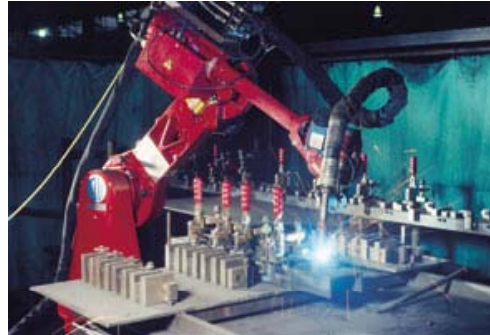
An Embedded Control System



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Real Time Control

- Must be able to respond predictably and in a known amount of time
- Environment cannot wait for microcontroller to respond.



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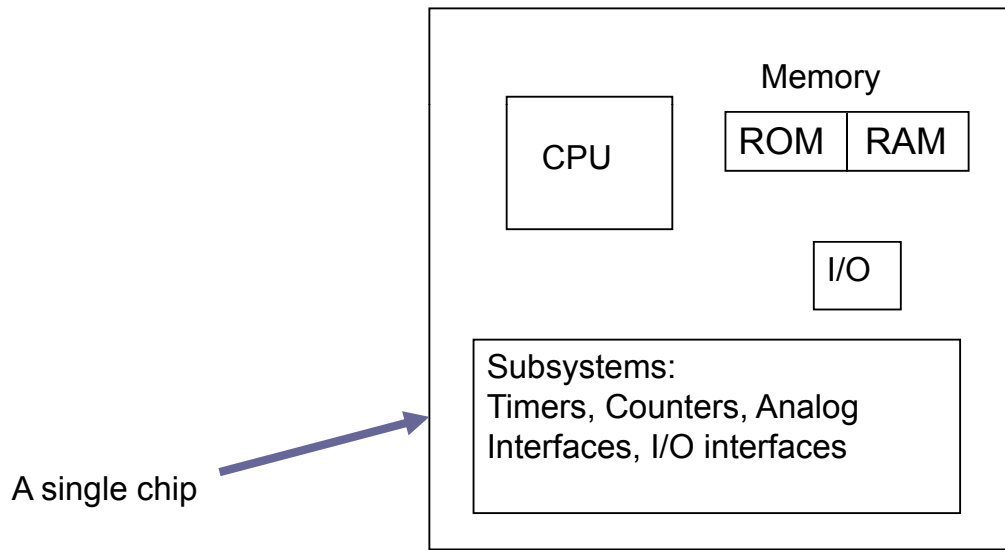
What is a Microcontroller?

- A microcontroller is an entire computer manufactured on a single chip.
 - CPU
 - Memory
 - RAM (Random Access Memory) - FRAM, DDR2
 - ROM (Read Only Memory) - Flash, EEPROM
 - Input/Output (I/O)
 - Serial ports - SPI, I2C, UART
 - Parallel ports
 - USB, CAN-BUS, IR
 - timers, counters,
 - interrupt control,
 - analog-to-digital converters

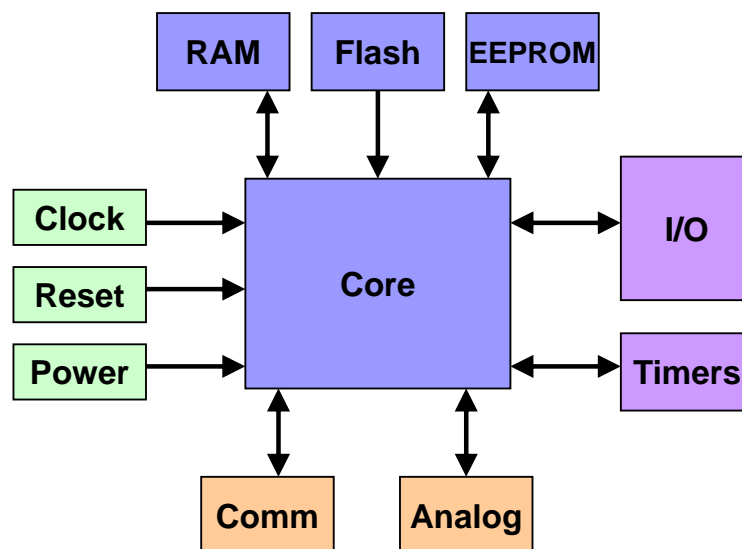


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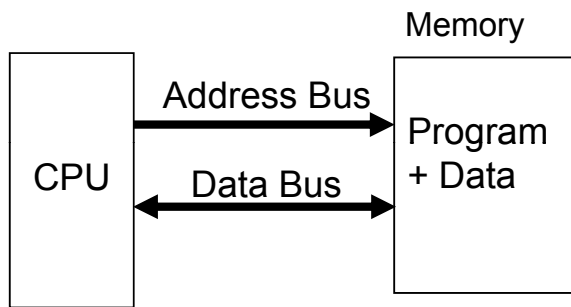
Microcontroller



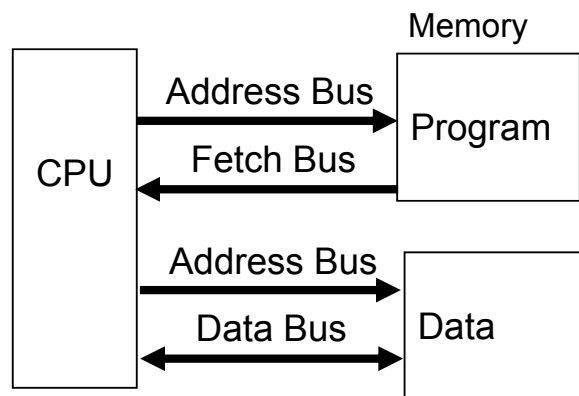
Microcontroller Architecture



Microcontroller Architecture



Von Neumann
Architecture



Harvard
Architecture

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Microcontroller Manufacturers

- ARM – Advanced RISC Machines
- Atmel
- Freescale Semiconductor- uC, DSP
- Intel- 8051/8052 cores
- Microchip
- NEC
- Renesas
- Sharp
- ST Microelectronics
- Texas Instruments- uC, DSP

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Common Microcontrollers

- ARM – Advanced RISC Machines
- Atmel
 - 8-bit tinyAVR
 - 8-bit megaAVR
 - 8/16-bit AVR XMEGA
 - 32-bit AVR UC3
- Freescale Semiconductor - uC, DSP
 - 8-bit
 - 68HC05
 - 68HC08
 - 68HC11
 - 16-bit
 - 68HC12
 - 68HC16
 - 32-bit
 - 683xx
- Intel - 8051/8052 cores
 - 8-bit
 - 8XC42
 - MCS48
 - MCS51
 - 8xC251
 - 16-bit
 - MCS96
 - MXS296
- Microchip
 - 12-bit instruction PIC
 - 14-bit instruction PIC
 - PIC16F84
 - 16-bit instruction PIC
- NEC
- Texas Instruments - uC, DSP

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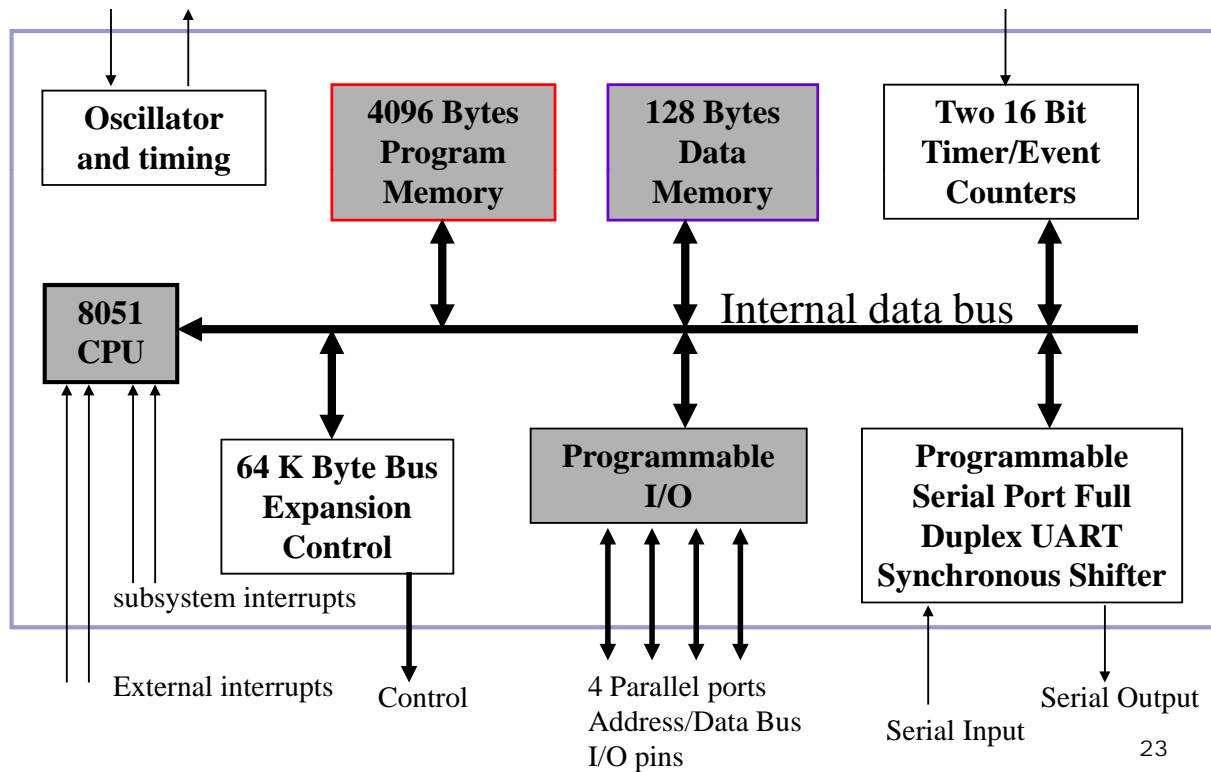


Example: 8051 Microcontroller

- The 8051 is the first microcontroller of the MCS-51 family introduced by Intel Corporation at the end of the 1970's.
- The 8051 family characteristics:
 - 4K Bytes ROM
 - 128 Bytes RAM
 - two timer/counters (16 bit)
 - A serial port
 - 4 general purpose parallel input/output port
 - Interrupt controller
 - The 8051 can address 64K of external data memory and 64K of External program memory

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Example: 8051 Microcontroller



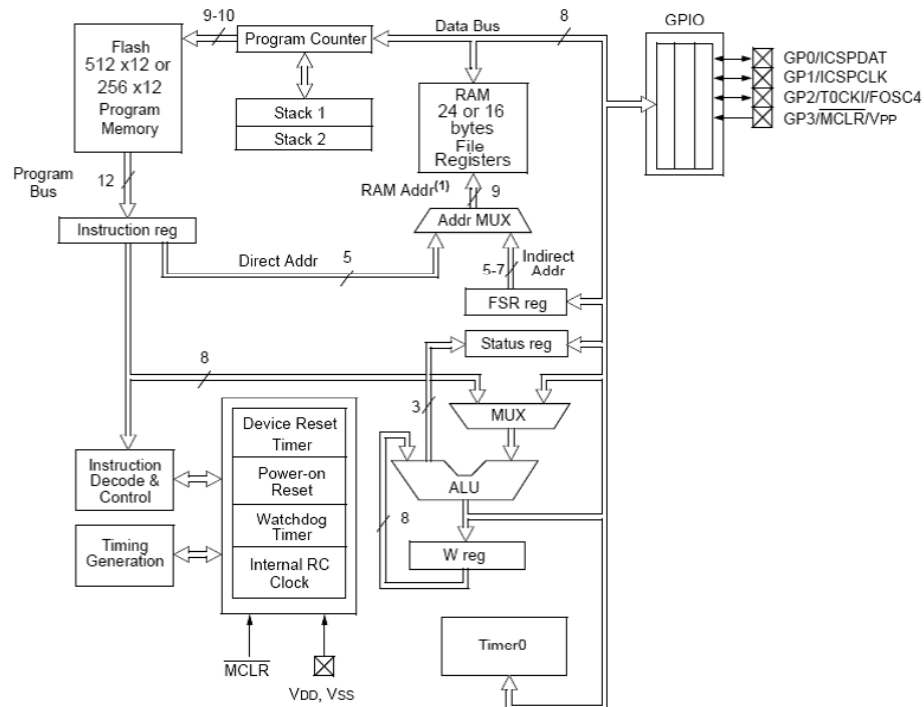
Example: PIC10F200 Microcontroller

- 8 bit microcontroller manufactured by Microchip

- **Caracteristici:**

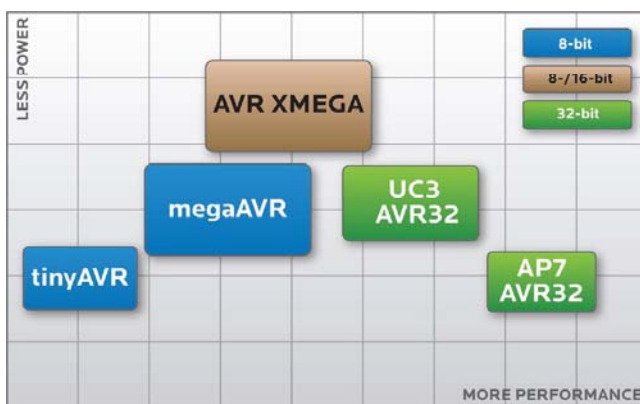
- RISC – 33 instruction set on 12-bit
- 2-level deep stack
- 4MHz precision internal clock
- Sleep mode – 100nA
- Internal pull-ups
- 3 Input/Output – direct LED drive
- 8-bit Timer – programmable prescaler
- Optional – Comparator, memory
- \$0.34/3K, \$0.59/1

Example: PIC10F200 Microcontroller



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Example: Atmel AVR and AVR32



- tinyAVR
 - 1-16 KBytes Flash, 8-32 pin
- megaAVR
 - 4-256 KBytes Flash, 28-100 pin
- AVR XMEGA
 - 16-384 KBytes Flash, 44-100 pin
- AVR32 UC3
 - 16-512 KBytes Flash, 48-144 pin
- AVR32 AP7
 - Up to 32 KBytes On-chip SRAM,
 - 196-256 pin packages

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Example: ATmega16A

- Low-power AVR 8-bit
- Advanced RISC Architecture
- 131 Instructions Single-clock Cycle Execution
- 32 x 8 General Purpose Working Registers
- 16K Bytes Flash program memory
- 512 Bytes EEPROM
- 1K Byte Internal SRAM
- Two 8-bit Timer/Counters
- One 16-bit Timer
- Four PWM Channels
- 8-channel, 10-bit ADC
- 32 Programmable I/O Lines

