# EE-222: Microprocessor Systems

## The AVR Microcontroller: History & Features

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# Microprocessor vs Microcontroller

# Embedded Systems Overview

- Computing systems are everywhere
- Most of us think of “desktop” computers
  - PC’s
  - Laptops
  - Mainframes
  - Servers
- But there’s another type of computing system
  - Far more common...
    - And that’s an Embedded System

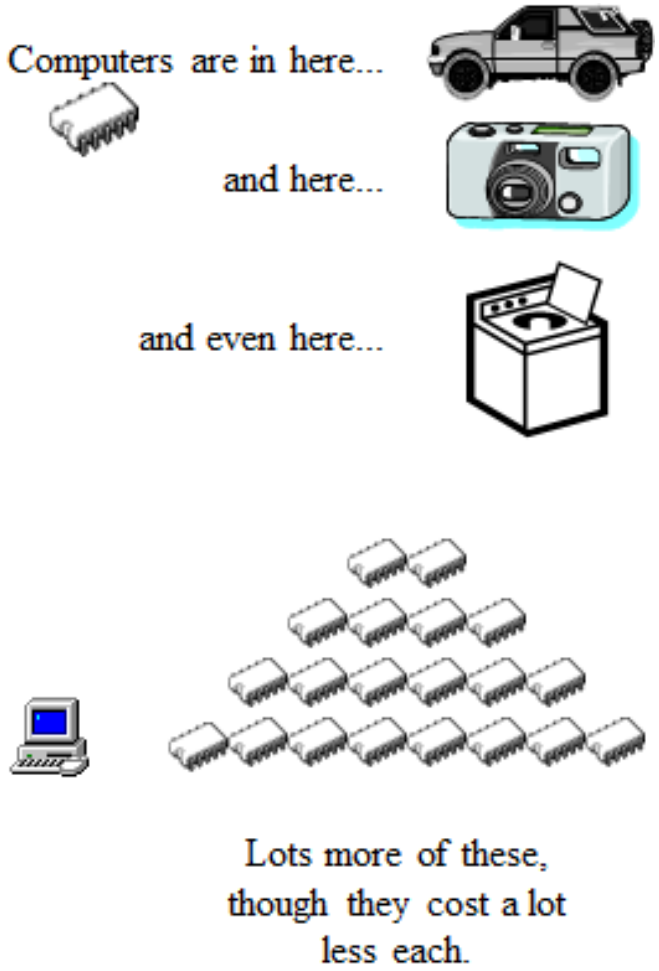
# What is an Embedded system?

- Self Contained
  - CPU
  - Memory
  - I/O

- Application or Task Specific
  - Not a general-purpose computer
  - Appropriately scaled for the job

# Embedded Systems Overview

- Embedded computing systems
  - Computing systems embedded within electronic devices
  - Hard to define. Nearly any computing system other than a desktop computer
  - Billions of units produced yearly, versus millions of desktop units
  - Perhaps 50 per household and per automobile



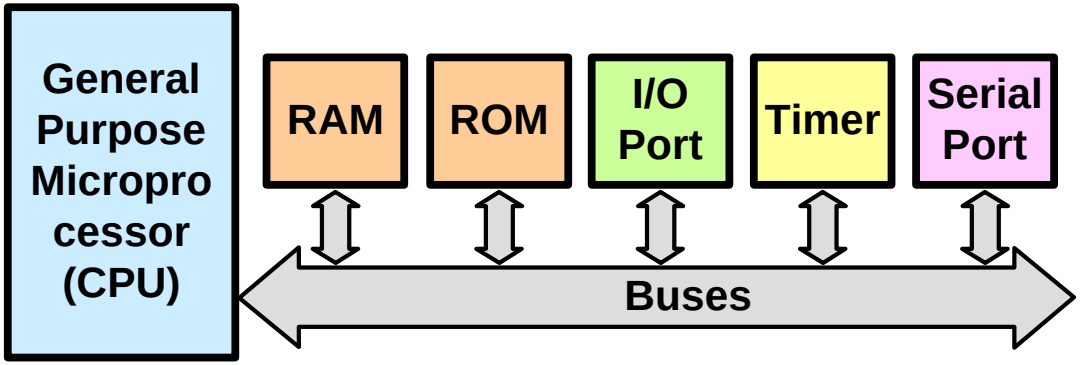
# A “short list” of embedded systems

Anti-lock brakes
Auto-focus cameras
Automatic teller machines
Automatic toll systems
Automatic transmission
Avionic systems
Battery chargers
Camcorders
Cell phones
Cell-phone base stations
Cordless phones
Cruise control
Curbside check-in systems
Digital cameras
Disk drives
Electronic card readers
Electronic instruments
Electronic toys/games
Factory control
Fax machines
Fingerprint identifiers
Home security systems
Life-support systems
Medical testing systems

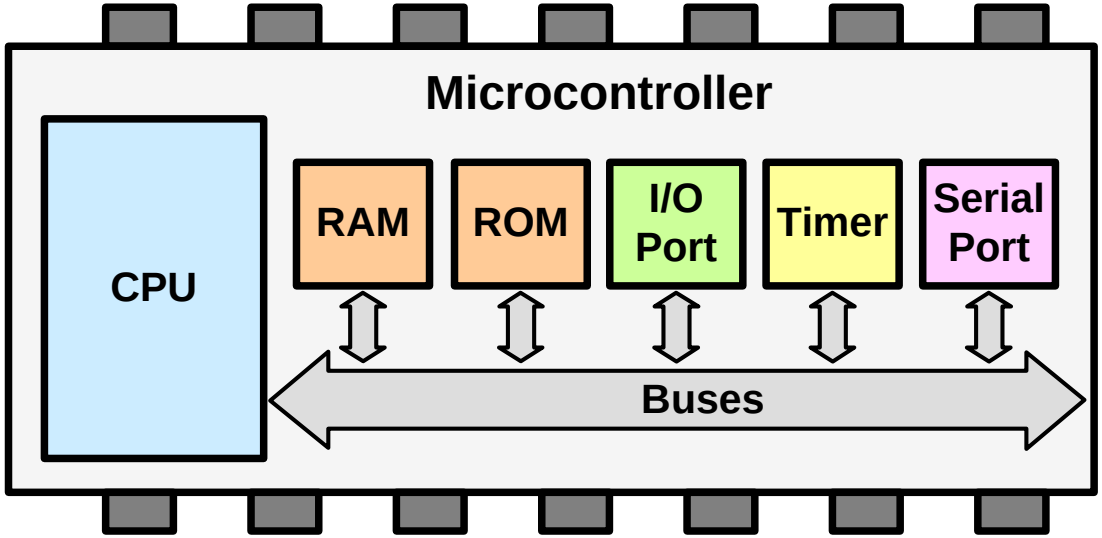
Modems
MPEG decoders
Network cards
Network switches/routers
On-board navigation
Pagers
Photocopiers
Point-of-sale systems
Portable video games
Printers
Satellite phones
Scanners
Smart ovens/dishwashers
Speech recognizers
Stereo systems
Teleconferencing systems
Televisions
Temperature controllers
Theft tracking systems
TV set-top boxes
VCR’s, DVD players
Video game consoles
Video phones
Washers and dryers

And the list goes on and on

# Microcontroller vs. Microprocessor




High-Processing Power, faster but needs to be interfaced with I/O, memory and other devices.




Control-oriented devices: simply add control devices and a program into the ROM.

# Most Common Microcontrollers

- 8-bit microcontrollers
  - AVR
  - PIC
  - HCS12
  - 8051


- 32-bit microcontrollers
  - ARM
  - AVR32
  - PIC32

# AVR History

# History of AVR

***AVR stand for?***
Advanced Virtual RISC,
the founders are Alf Egil Bogen Vegard Wollan RISC

The **Atmel AVR** is a family of 8-bit RISC microcontrollers produced by Atmel.

The AVR architecture was conceived by two students at the **Norwegian Institute of Technology (NTH)** and further refined and developed at **Atmel Norway**, the Atmel daughter company founded by the two chip architects.

Microchip Technology, Inc. Acquires Atmel

# History of AVR

AVR Micro controllers is Family of
**RISC Microcontrollers** from Atmel.

There are multiple architectures

RISC (Reduced Instruction Set Computer)
CISC (Complex Instruction Set Computer)

# CISC Approach

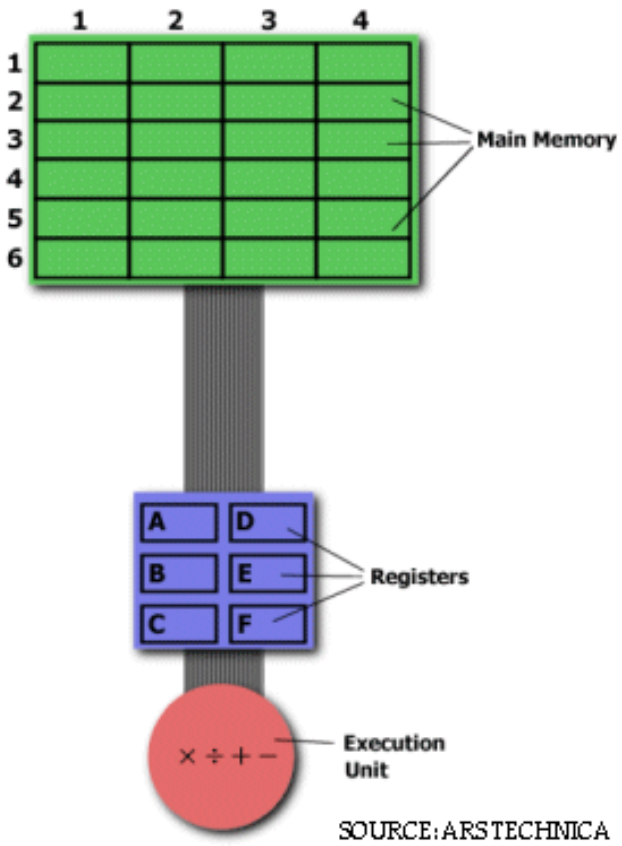
## CISC Approach

**Complete the task in few assembly line code**
**TASK multiply 2:3, 5:2 locations numbers and put output in 5:2 location**

**Command: MULT 2:3, 5:2**

**MULT is what is known as a "complex instruction."**
**Instruction does`t complete in one cycle executio**

**Processor hardware that is capable of understandi**
**and executing a series of operations.**



# RISC Approach

**Reduced Introduction Set Computer**

**Till 1980 Trend was to build increasingly complex CPUs with complex set of instructions like (CISC)**

(RISC)

Instruction execute in single cycle

"Architecture which reduces the chip complexity by simpler processing instructions".

RISC architecture CPUs capable of executing only a very limited (simple) set of instructions.

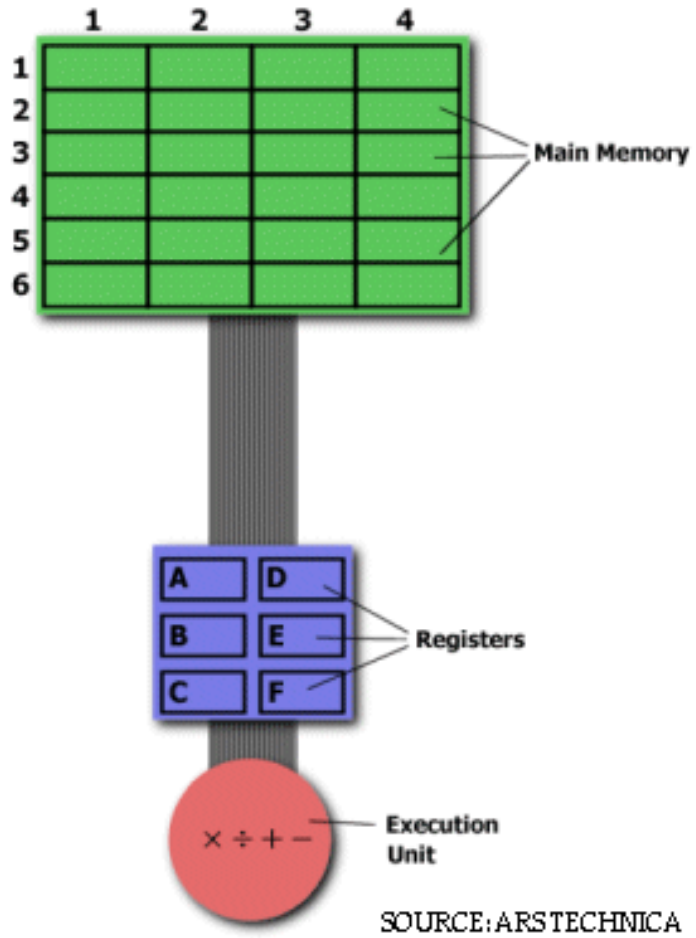
# RISC Approach

## RISC Approach

**RISC processors only use simple instructions that can be executed within one clock cycle. "MULT" command divided into three separate commands:**

```
LOAD   A, 2:3
LOAD   B, 5:2
PROD   A, B
STORE  2:3, A
```

**Single Cycle Execution**



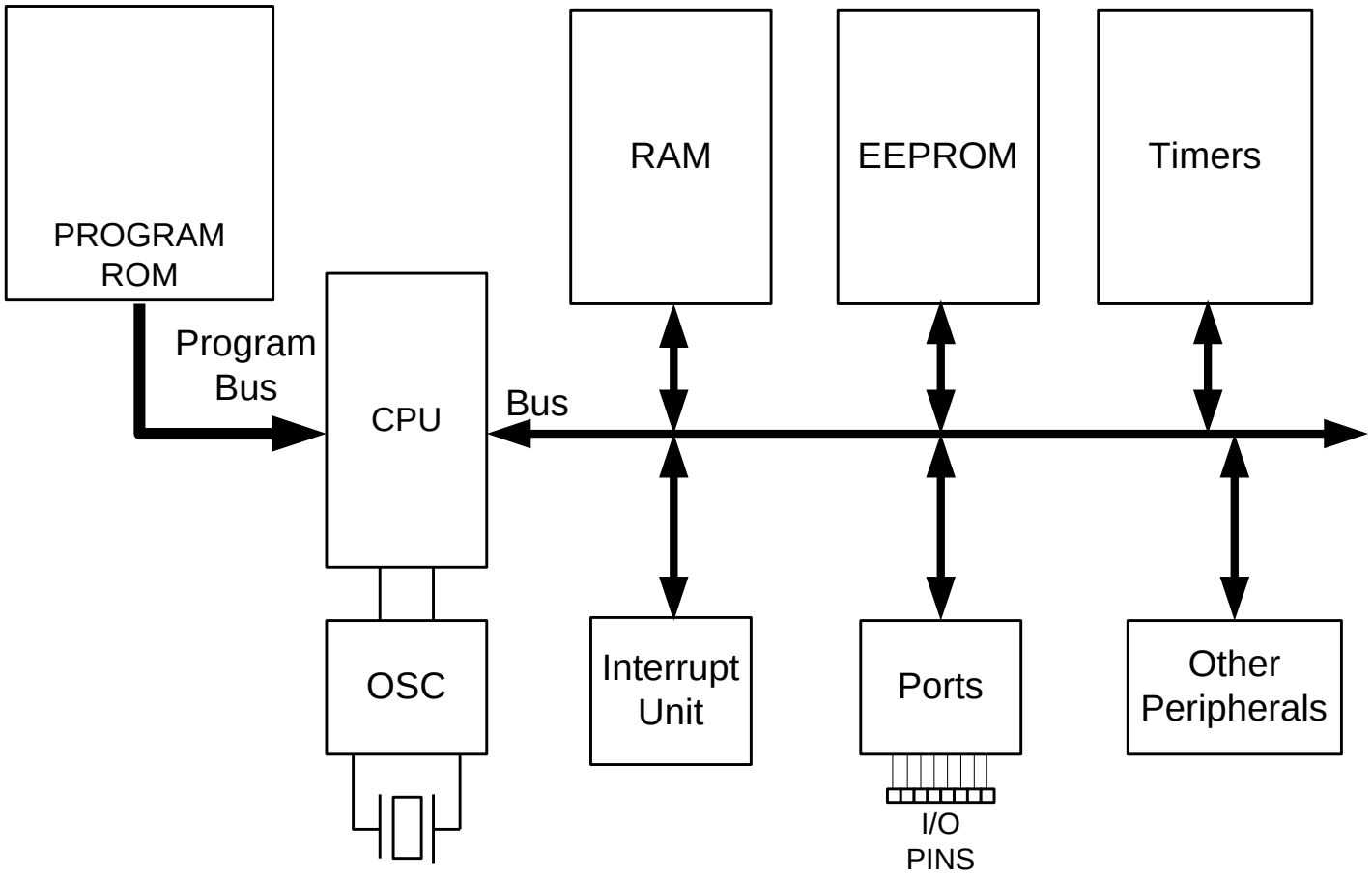
# RISC Microcontroller

Reduced Instruction Set Computers Advantages

- Fast Execution of Instructions due to simple instructions for CPU.
- RISC chips require fewer transistors, which makes them cheaper to design and produce.
- Emphasis on software
- Single-clock,reduced instruction only
- Register to register: "LOAD" and "STORE" are independent instructions
- Spends more transistors on memory registers

# AVR Family Overview

# Simplified View of AVR Microcontroller




8-bit RISC Single-Chip with Harvard Architecture

# AVR Product Family Overview

| Product Family | Pin Count | Program Flash Memory (KB) | SRAM (KB) |
|---|---|---|---|
| ATtiny4/5/9/10 | 6 | 0.5–1 | 0.032 |
| ATtiny102/104 | 8/14 | 1 | 0.032 |
| ATtiny13A | 8–20 | 1 | 0.064 |
| ATtiny20/40 | 12–20 | 2/4 | 0.128/0.256 |
| ATtiny24A/44A/84A | 14–20 | 2–8 | Up to 0.512 |
| ATtiny25(V)/45(V)/85(V) | 8–20 | 2–8 | Up to 0.512 |
| ATtiny48/88 | 28–32 | 4/8 | Up to 0.512 |
| ATtiny87/167 | 20–32 | 8/16 | 0.512 |
| ATtiny261A/461A/861A | 20–32 | 2–8 | Up to 0.512 |
| ATtiny20x/40x/80x/160x | 8–24 | 2–16 | Up to 1 |
| ATtiny21x/41x/81x/161x/321x | 8–24 | 2–32 | Up to 2 |
| ATtiny441/841 | 14–20 | 4/8 | Up to 0.512 |
| ATtiny1634 | 20 | 16 | 1 |
| ATtiny2313A | 20 | 2 | 0.128 |
| ATmega8A/16A/32A | 28–44 | 8–32 | 1–2 |
| ATmega8U2/16U2/32U2 | 32 | 8–32 | 0.5–1 |
| ATmega16U4/32U4 | 32 | 16/32 | 1/2 |
| ATmega48PB/88PB/168PB/328PB | 32 | 4–32 | 0.5–2 |
| ATmega320x/480x | 28–48 | 32–48 | Up to 6 |
| ATmega64A/128A | 64 | 64–128 | 4 |
| ATmega164PA/324PA/644PA/1284P | 44 | 16–128 | 1–16 |
| ATmega165PA/325PA/645P | 44 | 16–64 | 1–4 |
| ATmega169PA/329PA/649P | 64 | 16–64 | 1–4 |
| ATmega324PB | 44 | 32 | 2 |
| ATmega640/1280/2560/1281/2561 | 64–100 | 64–256 | 8 |

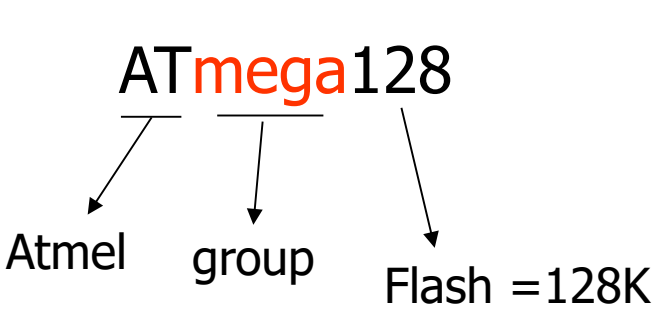
ATmega16A 

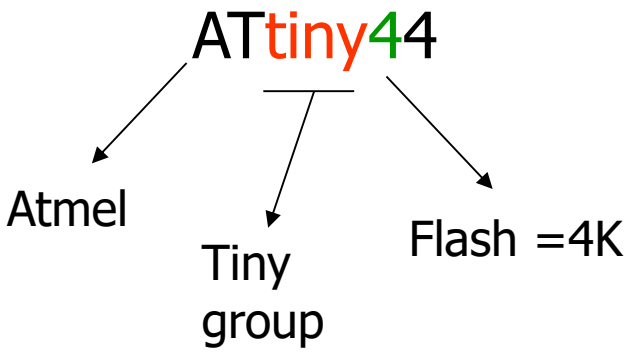
Ref: http://ww1.microchip.com/downloads/en/DeviceDoc/30010135D.pdf

# AVR Parts Variation

- Variations in the parts:
  - TinyAVR [ATtinyxxxx] to MegaAVR [ATmegaxxxx]
- Mega
  - e.g. ATmega328, ATmega32, ATmega128
- Tiny
  - e.g. ATtiny13, ATtiny25
- Special Purpose AVR
  - e.g. AT90PWM216,AT90USB1287
- XMega
  - New features like DMA, DAC, crypto engine, etc.
- Classic AVR [Discountinued]
  - e.g. AT90S2313, AT90S4433

# AVR Parts Variation




- For more details, take a look at: http://ww1.microchip.com/downloads/en/DeviceDoc/30010135D.pdf

# ATmega16A

# ATmega16A

| Name | Value |
|---|---|
| Program Memory Type | Flash |
| Program Memory Size (KB) | 16 |
| CPU Speed (MIPS/DMIPS) | 16 |
| SRAM Bytes | 1,024 |
| Data EEPROM/HEF (bytes) | 512 |
| Digital Communication Peripherals | 1-UART, 1-SPI, 1-I2C |
| Capture/Compare/PWM Peripherals | 1 Input Capture, 1 CCP, 4PWM |
| Timers | 2 x 8-bit, 1 x 16-bit |
| Number of Comparators | 1 |
| Temperature Range (C) | -40 to 85 |
| Operating Voltage Range (V) | 2.7 to 5.5 |
| Pin Count | 44 |

# ATmega16A: Features

- Low-power Atmel AVR 8-bit Microcontroller

- Advanced RISC Architecture
  - 131 Powerful Instructions – Most Single-clock Cycle Execution
  - 32 x 8 General Purpose Working Registers

- Peripheral Features
  - Two 8-bit Timer/Counters
  - One 16-bit Timer/Counter Capture Mode
  - 8-channel, 10-bit ADC

- For more details, take a look at:

http://ww1.microchip.com/downloads/en/devicedoc/atmel-8154-8-bit-avr-atmega16a_datasheet.pdf

# Reading Assignment

- The AVR Microcontroller and Embedded Systems: Using Assembly and C by Mazidi et al., Prentice Hall
  - Chapter 2

# THANK YOU