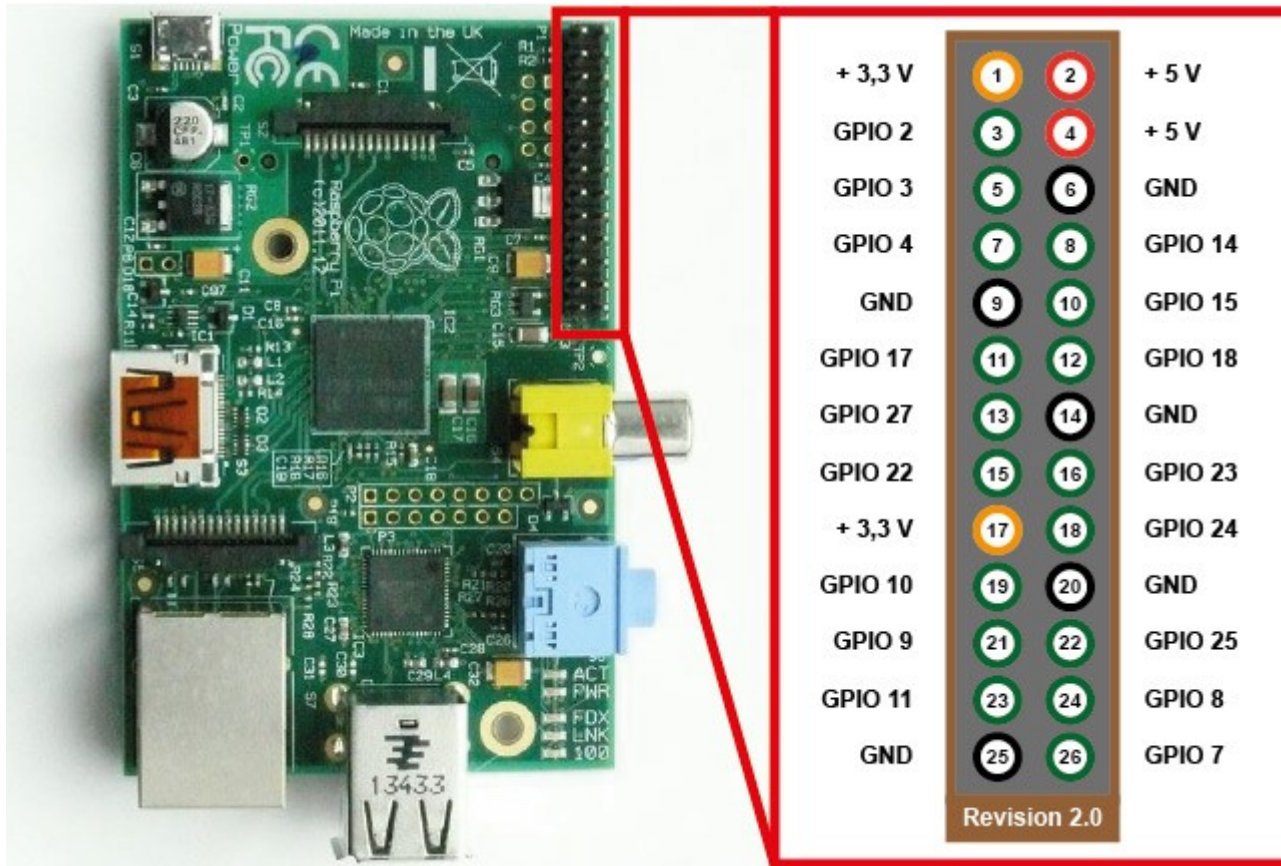


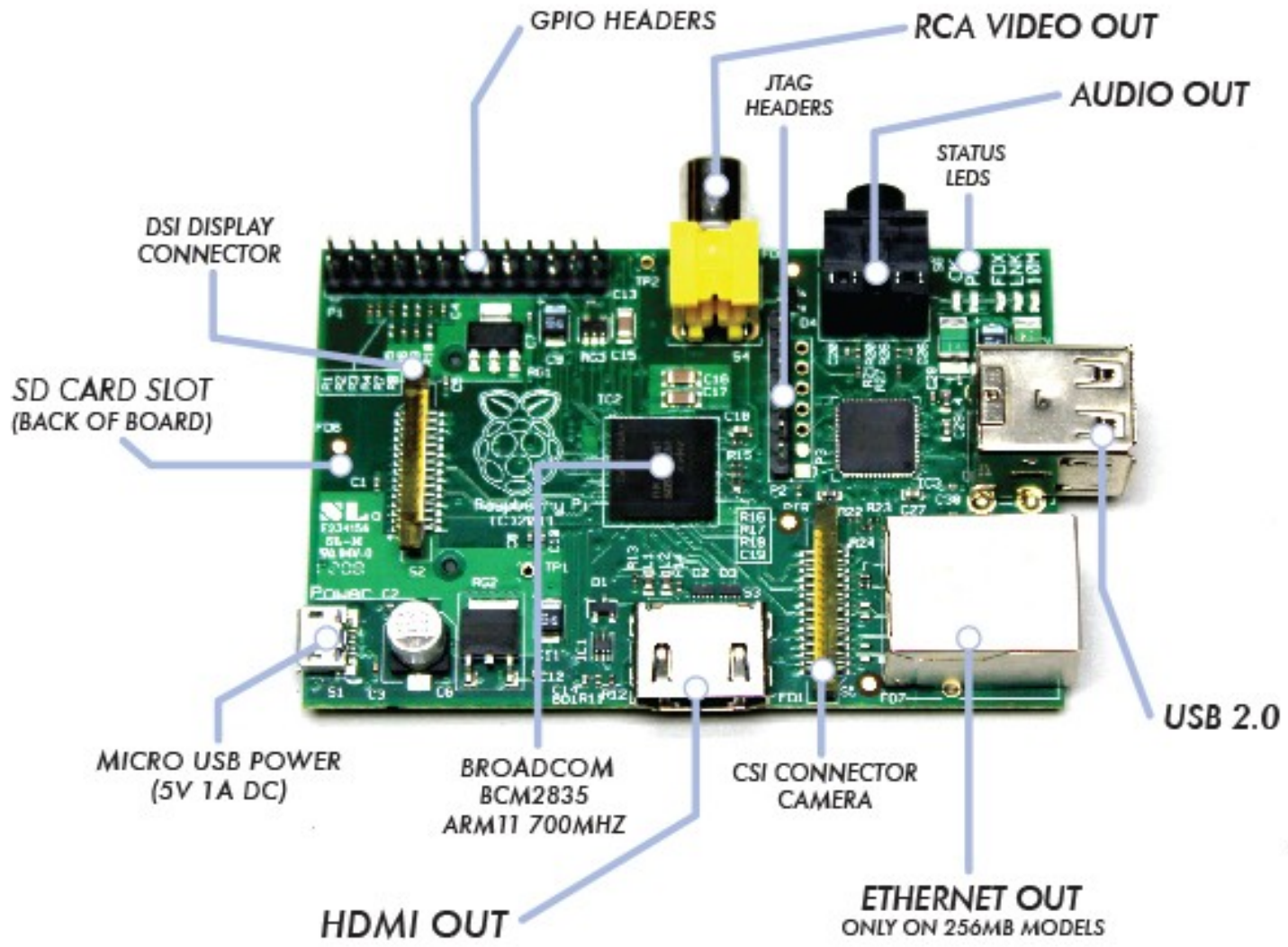
# **Introducing Embedded Systems and the Microcontrollers**

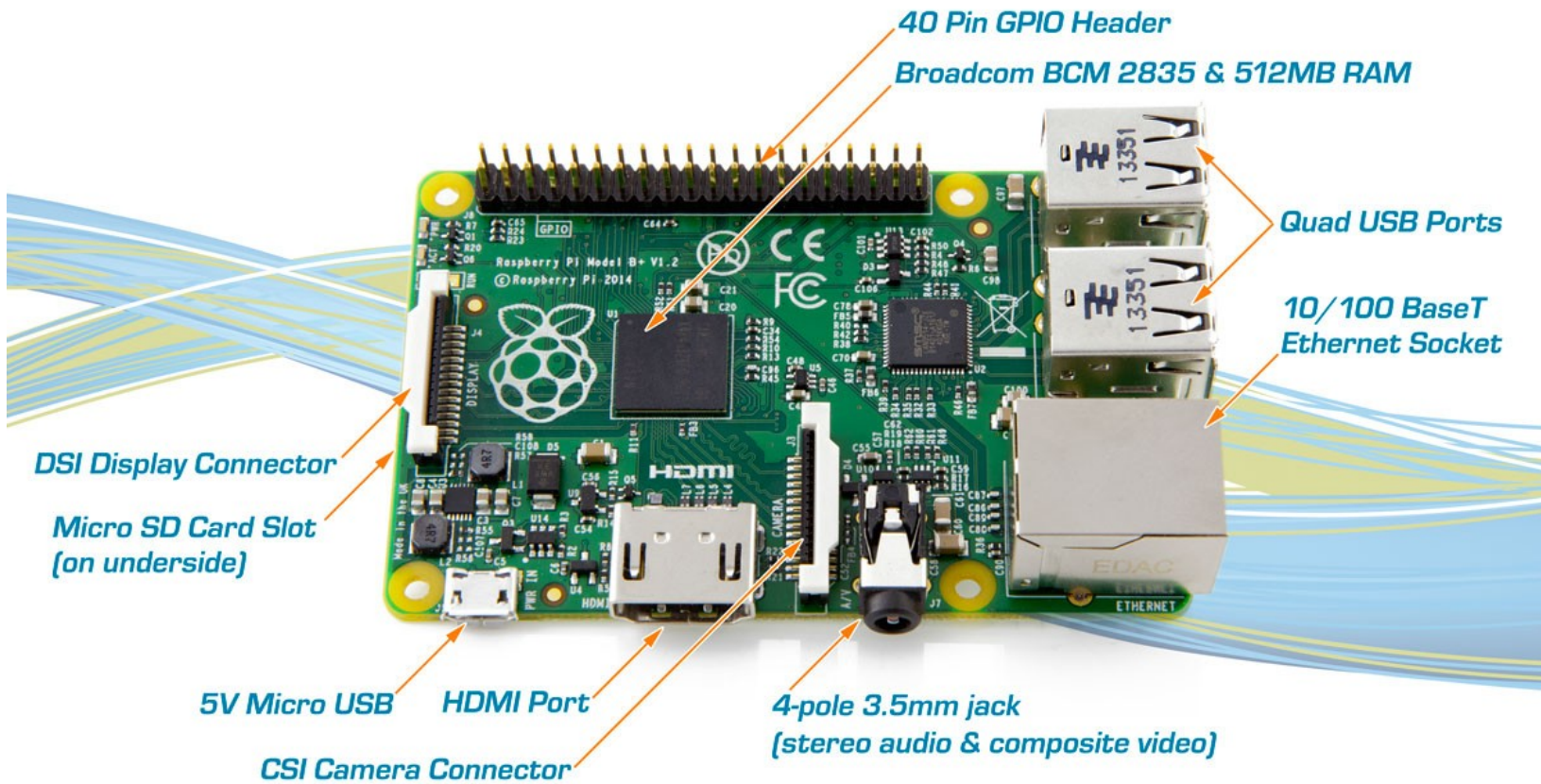
# General Purpose System

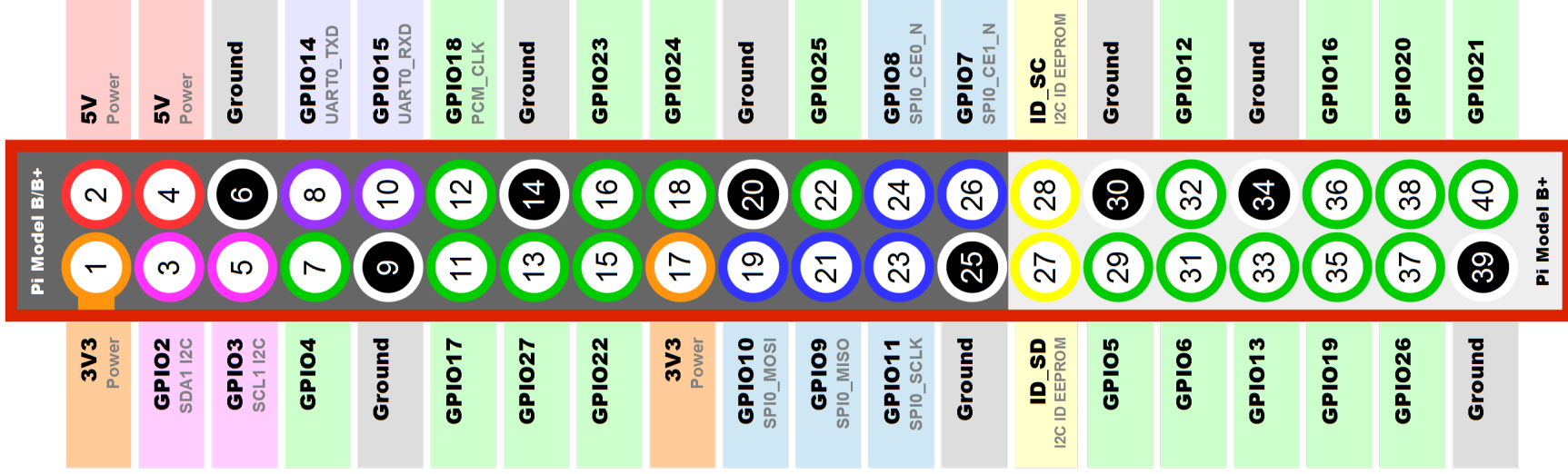
- Server
- PC
- Desktop
- Laptop
- Smartphone ??
- Raspberry ??

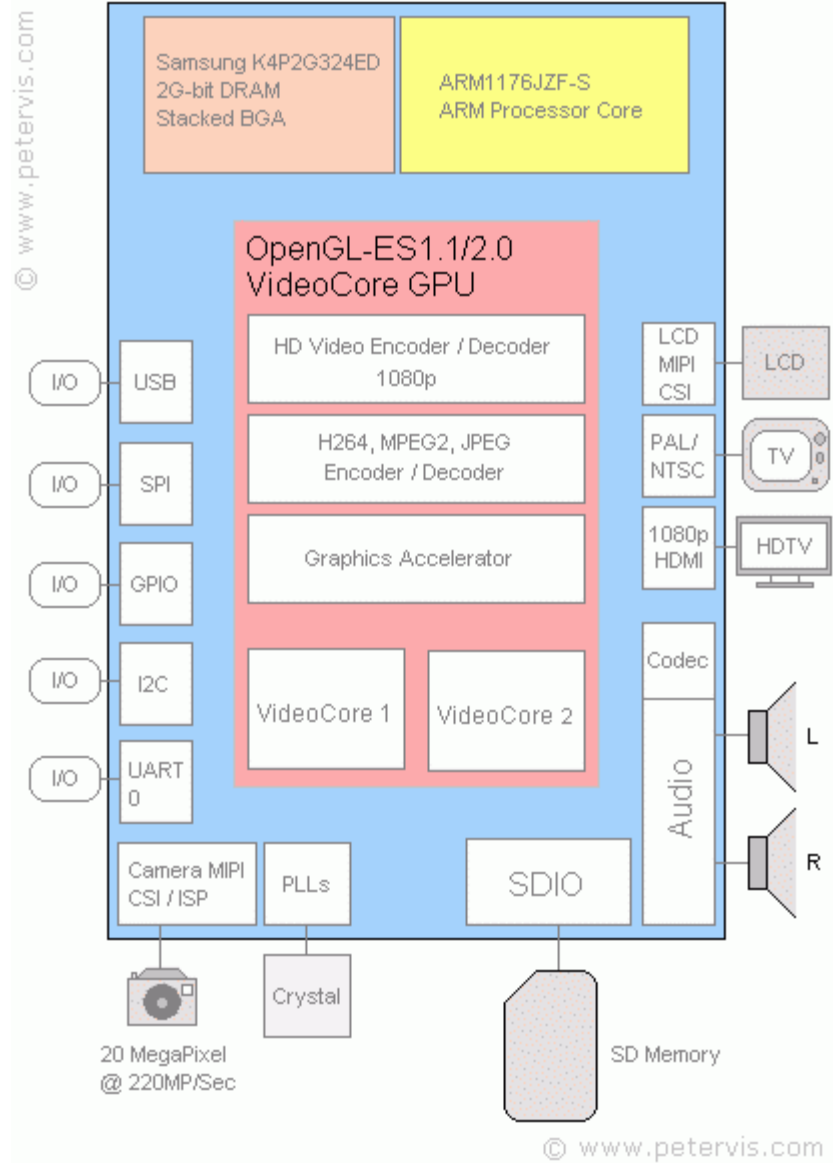
# Raspberry examples



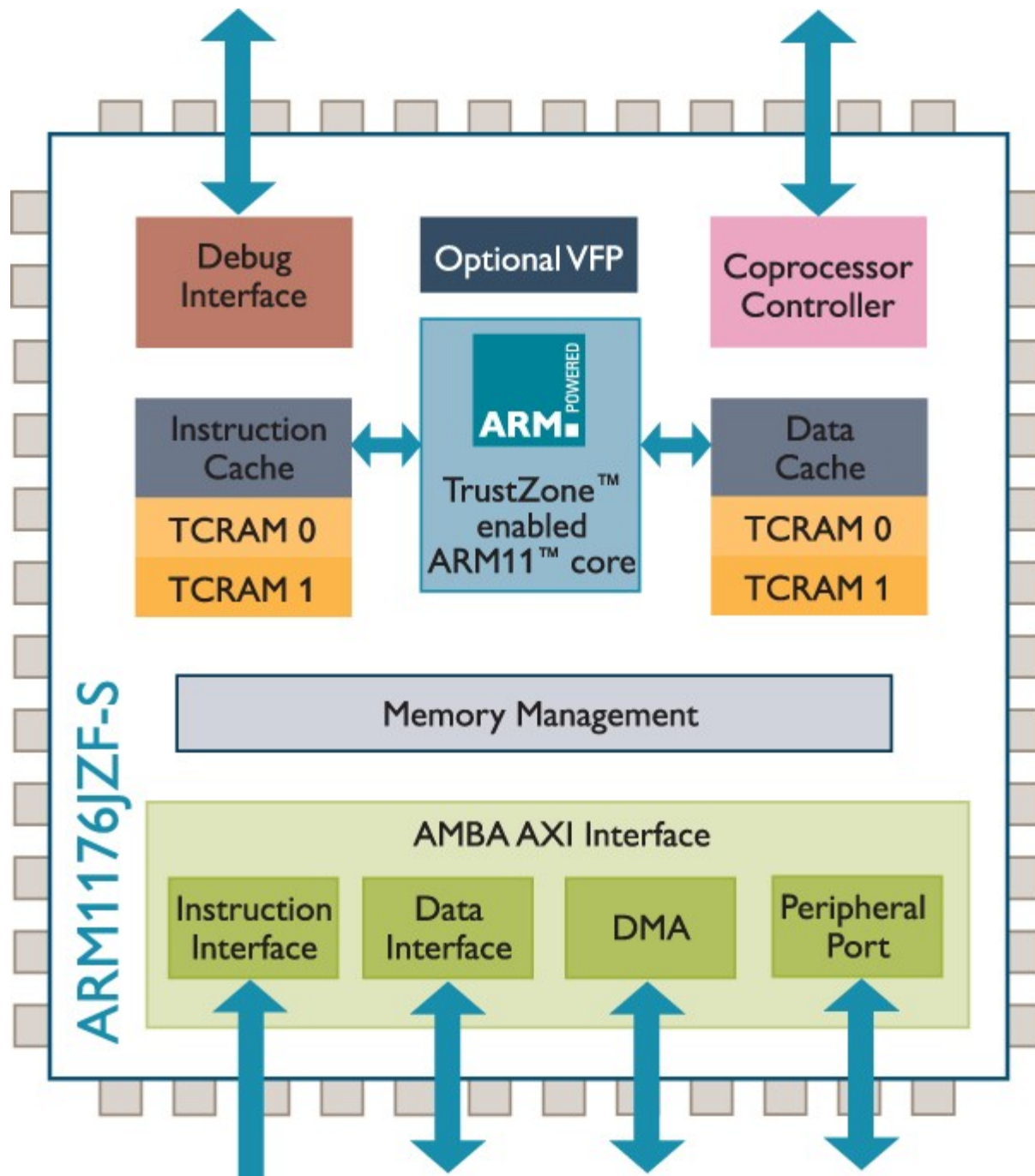










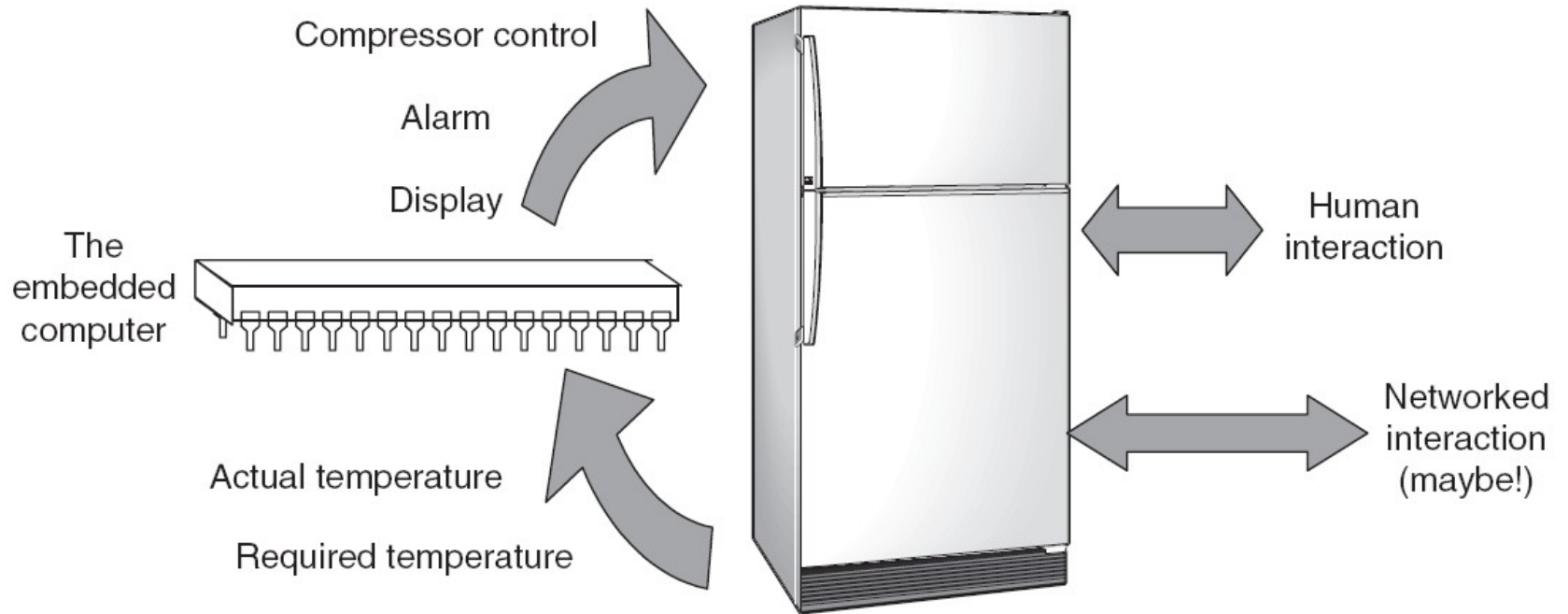




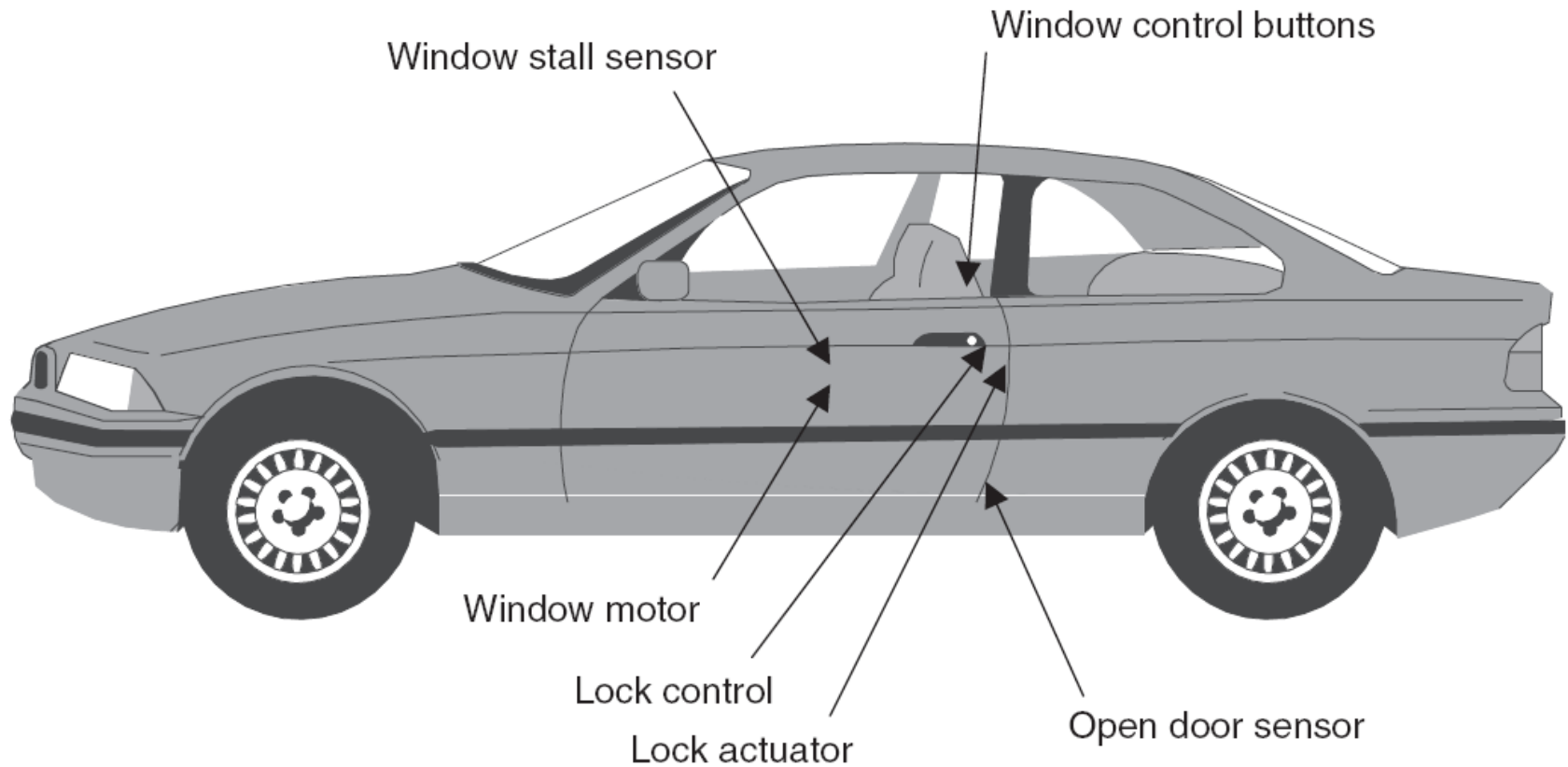
# Definition

- **Embedded system:**
  - is a system whose principal function is not computational,
  - but which is controlled by a computer embedded within it.

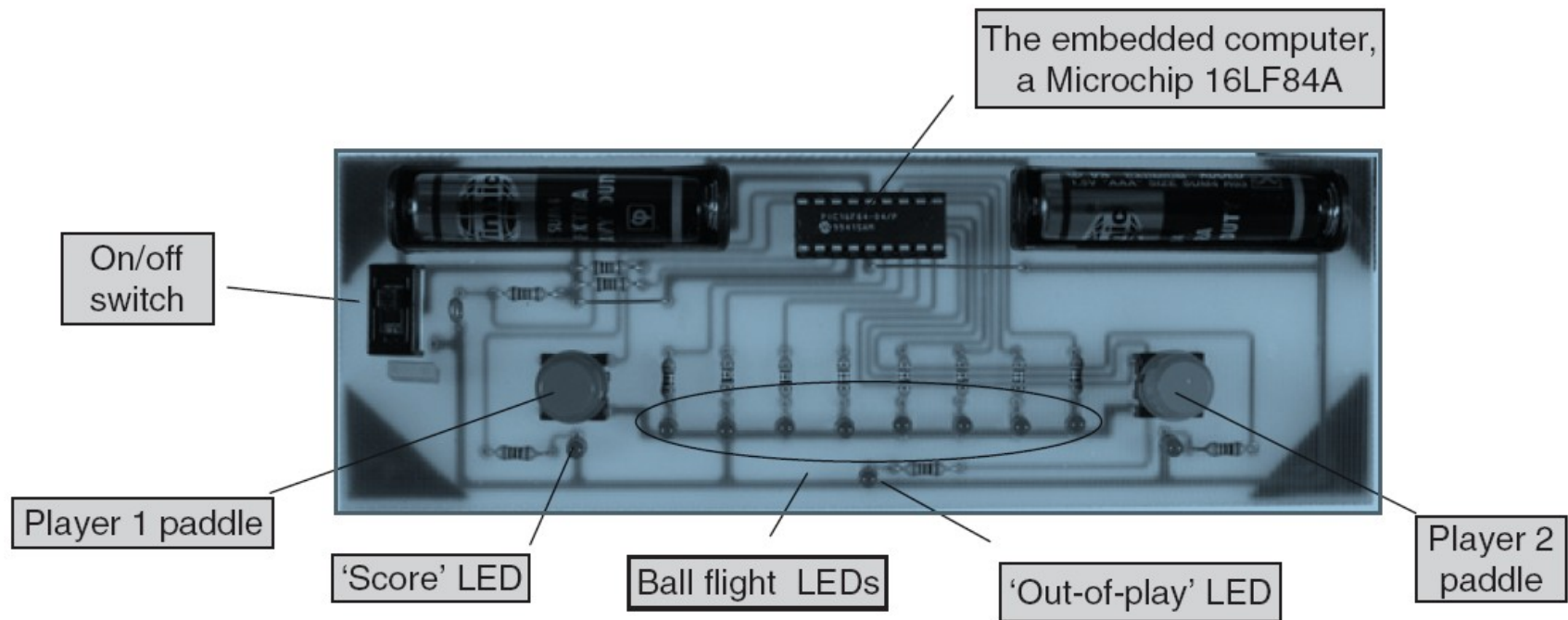
# Examples: Refrigerator



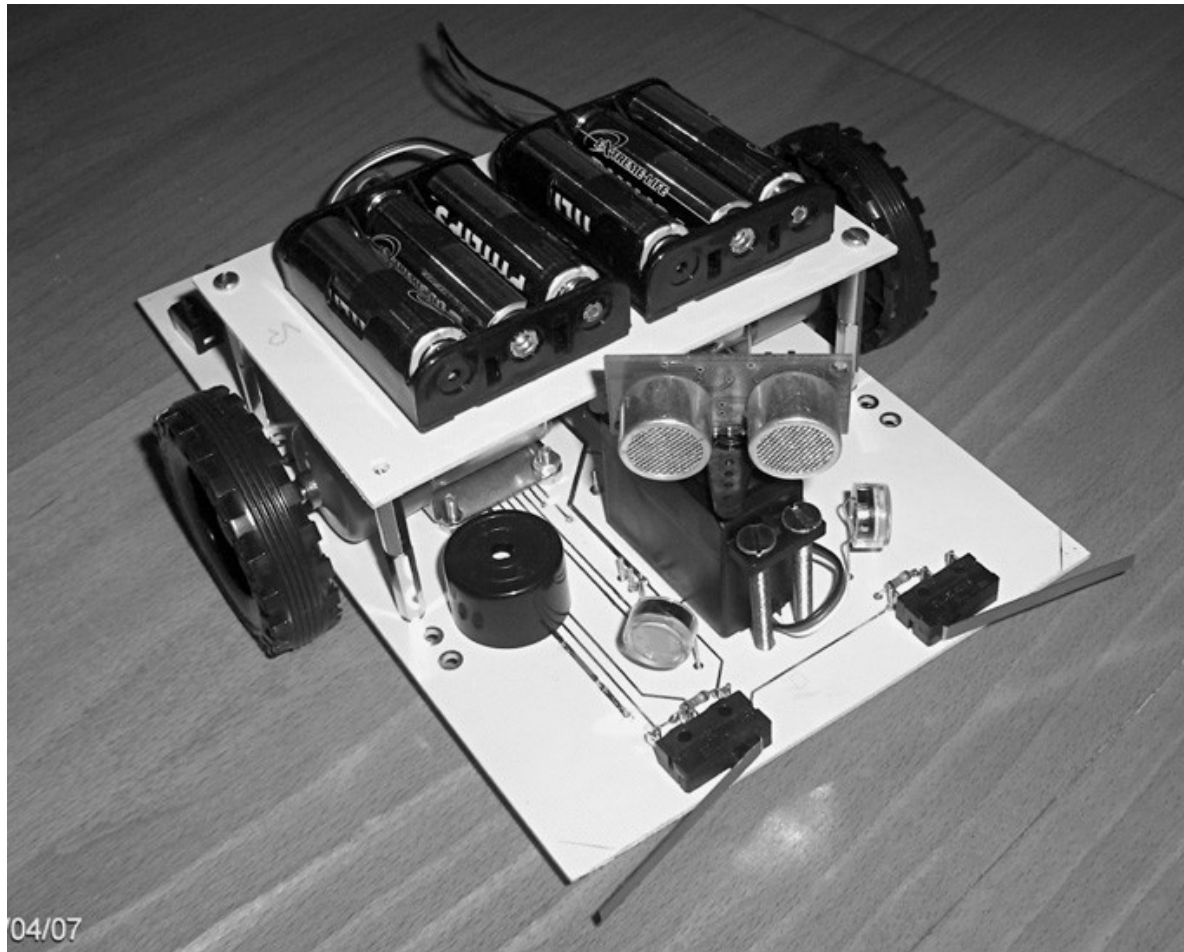
# Examples: Car Door



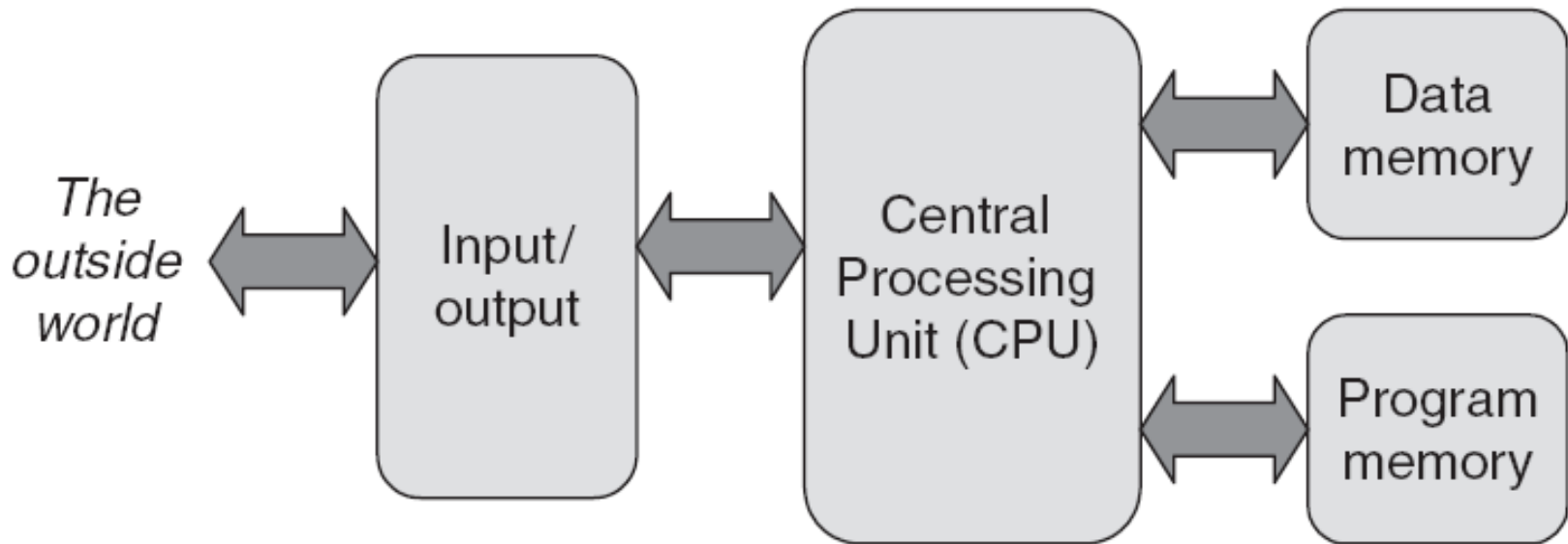
# Examples: Electronic Ping-pong



# Examples: Derbot Autonomous Guided Vehicle

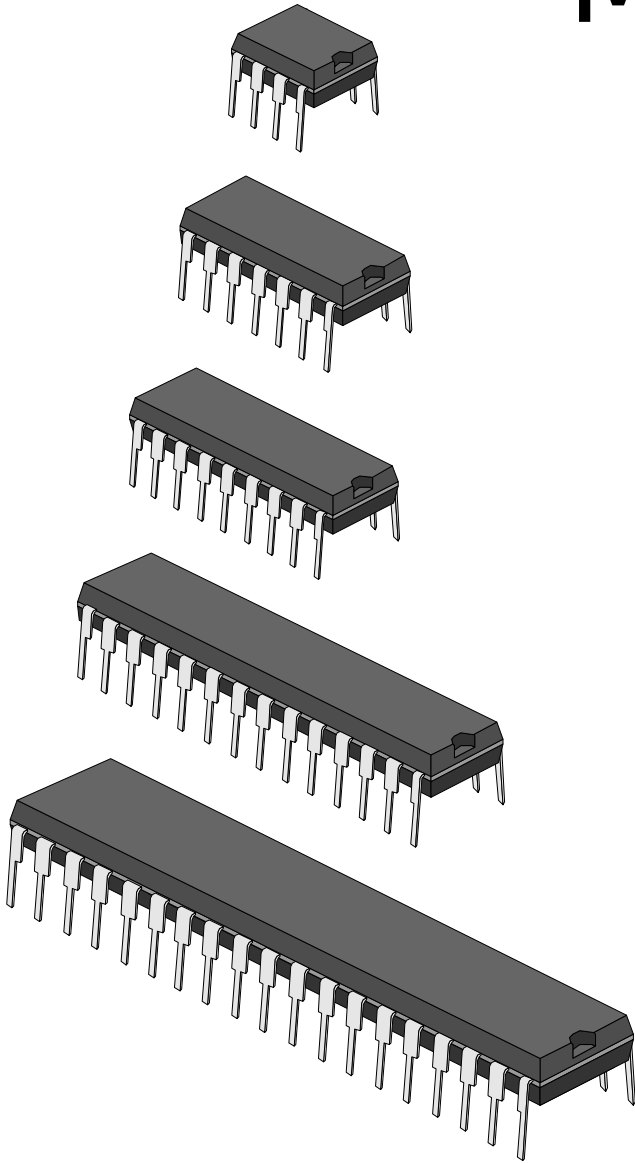


# Computer Essentials



# MCU chip

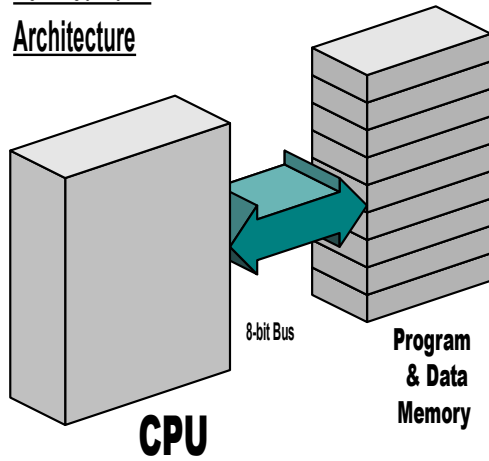
- Harvard Architecture
- Instruction Pipelining
- Long Word Instructions
- Single Cycle Instructions
- Single Word Instructions
- Large Register File
- Reduced Instruction Set
- Orthogonal Instruction Set



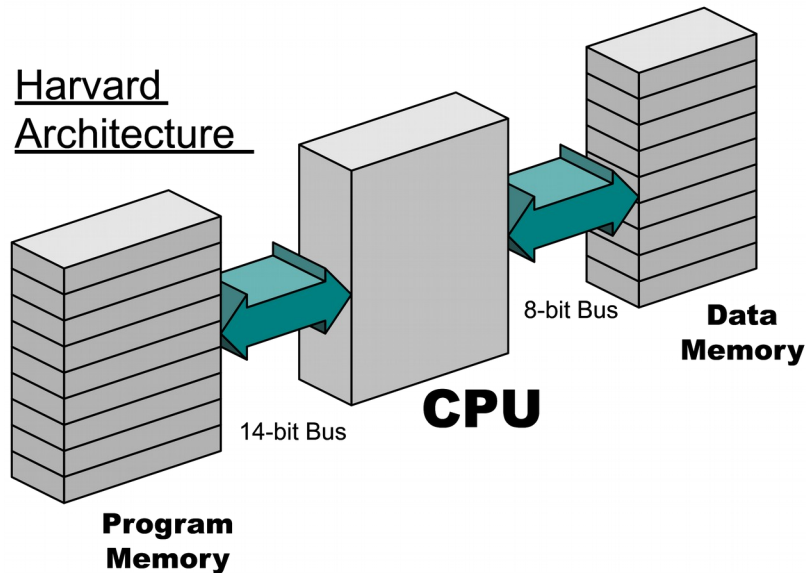


# MCU - Architecture

## Von Neumann Architecture



## Harvard Architecture

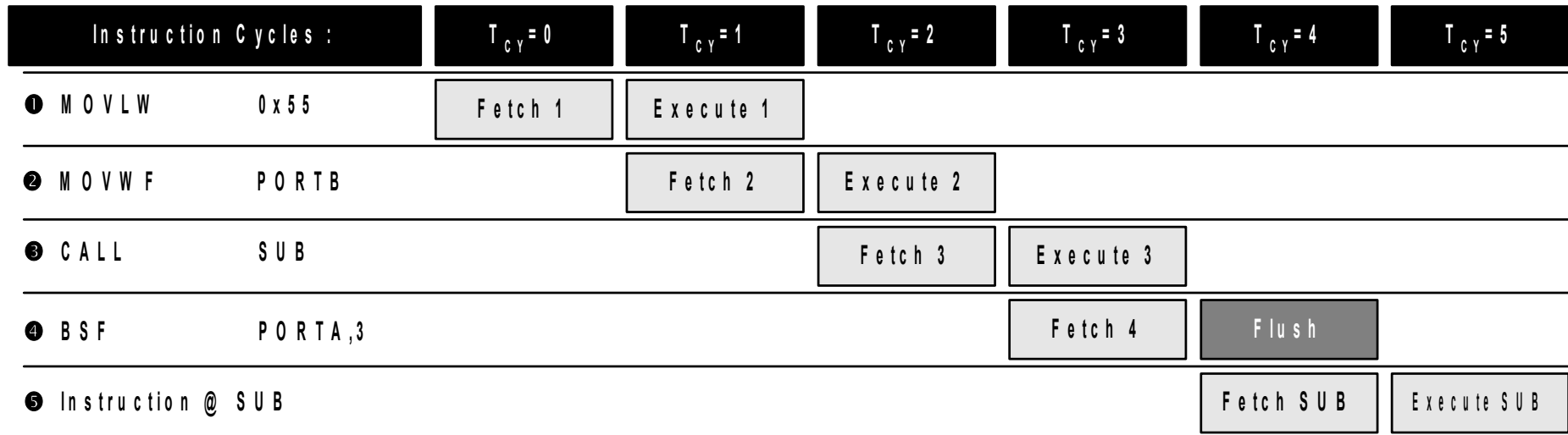


- Traditional Von Neumann Architecture:
  - Fetches instructions and data from a single memory space
  - Limits operating bandwidth
- Harvard Architecture:
  - Uses two separate memory spaces for program instructions and data
  - Improved operating bandwidth
  - Allows for different bus widths

# MCU - Pipelining

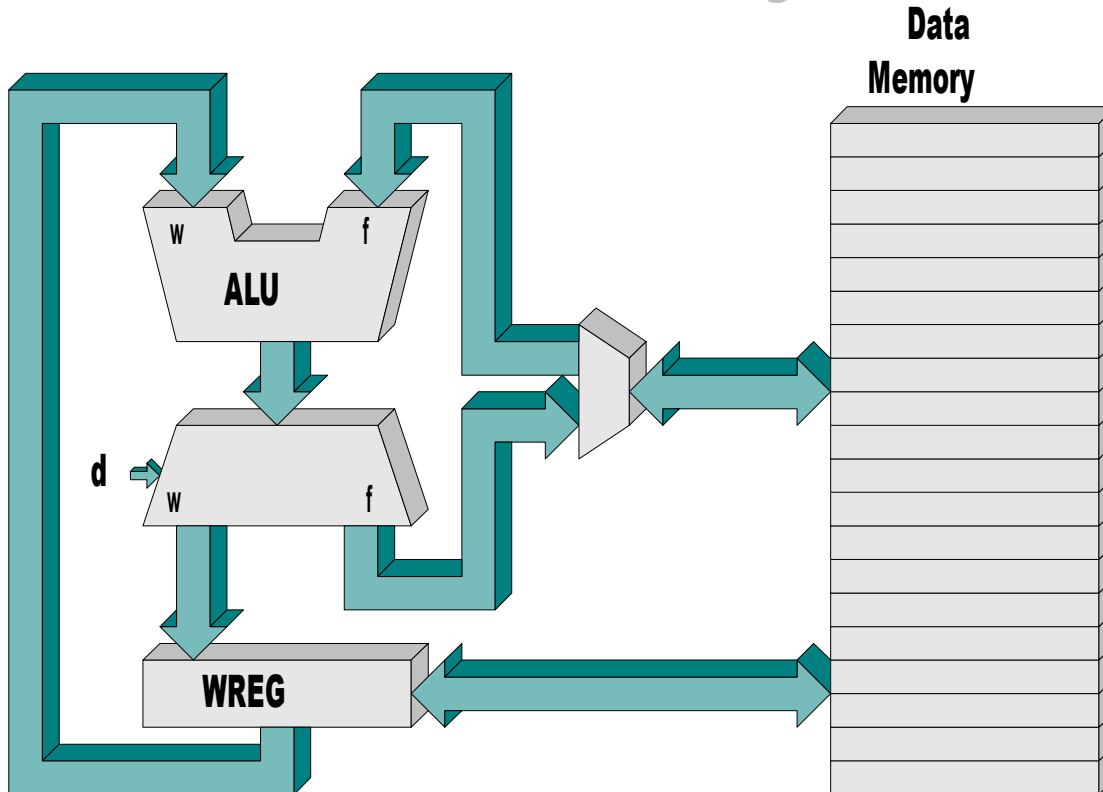
## Pipelining

- In most micro controllers, instructions are fetched and executed sequentially
- The pipelined architecture overlaps fetch and execution, making single cycle execution possible



# MCU - Register File Concept

## Register File Concept



- Register File Concept: Unlike other RISC processors, all of data memory is part of the register file, so any location in data memory may be operated on directly
- All peripherals are mapped into data memory as a series of registers
- Orthogonal Instruction Set: ALL instructions can operate on ANY data memory location
- The Long Word Instruction format allows a directly addressable register file

# PIC16F877 - Caratteristiche

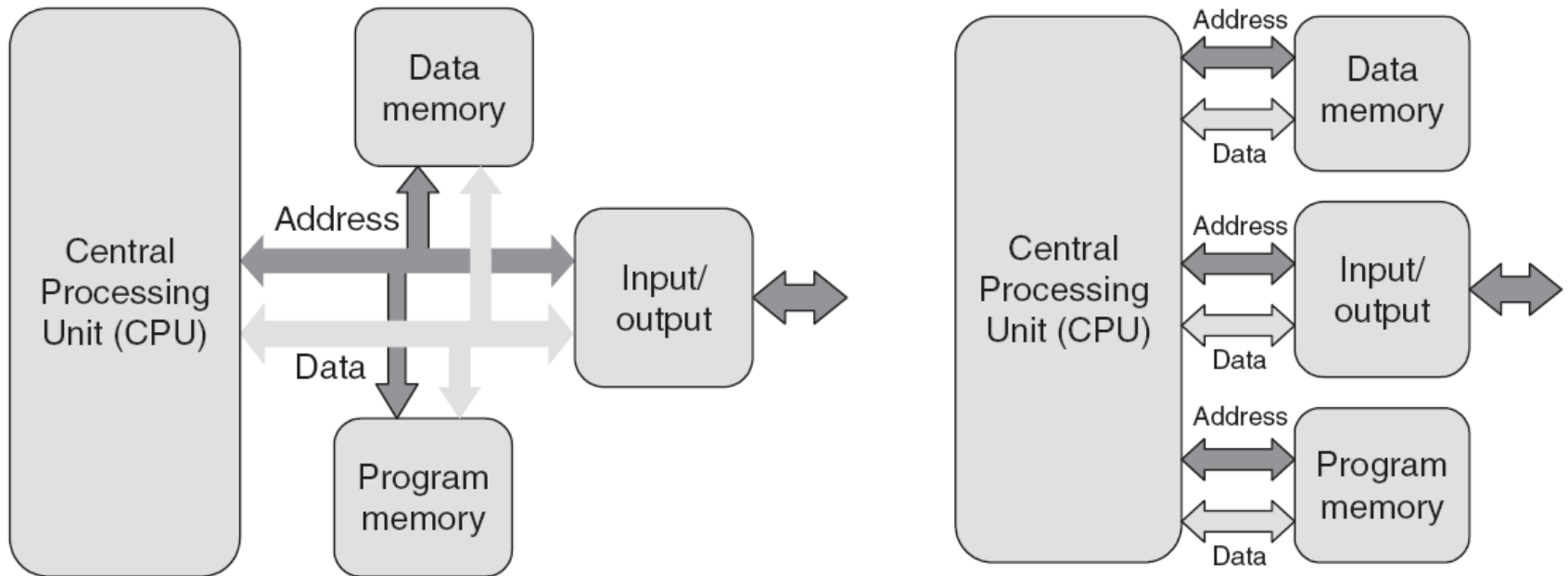
## Caratteristiche principali

- Velocita` massima: 20Mhz
- Fino a 8K words (da 14bit)
- Pinout compatibile con altri PIC16
- Internal timers (8bit e 16bit)
- PWM (capture, compare)
- SSP (SPI o IIC)
- USART
- PSP (slave)
- Brown-out detection
- 10bit A/D converter
- Brown-out reset
- Comparatore analogico
- 256byte internal data EEPROM
- Oscillatore configurabile
- ICSP (debug/ICD)
- Protezione del codice
- Watch-dog timer
- Modalita` SLEEP

# Computer Essentials

- Instruction Sets
  - CISC: Complex Instruction Set Computer
  - RISC: Reduced Instruction Set Computer
- Memory Types
  - Volatile: Random Access Memory (RAM)
  - Non-volatile: Read Only Memory (ROM)

# Von Neumann and Harvard Computers

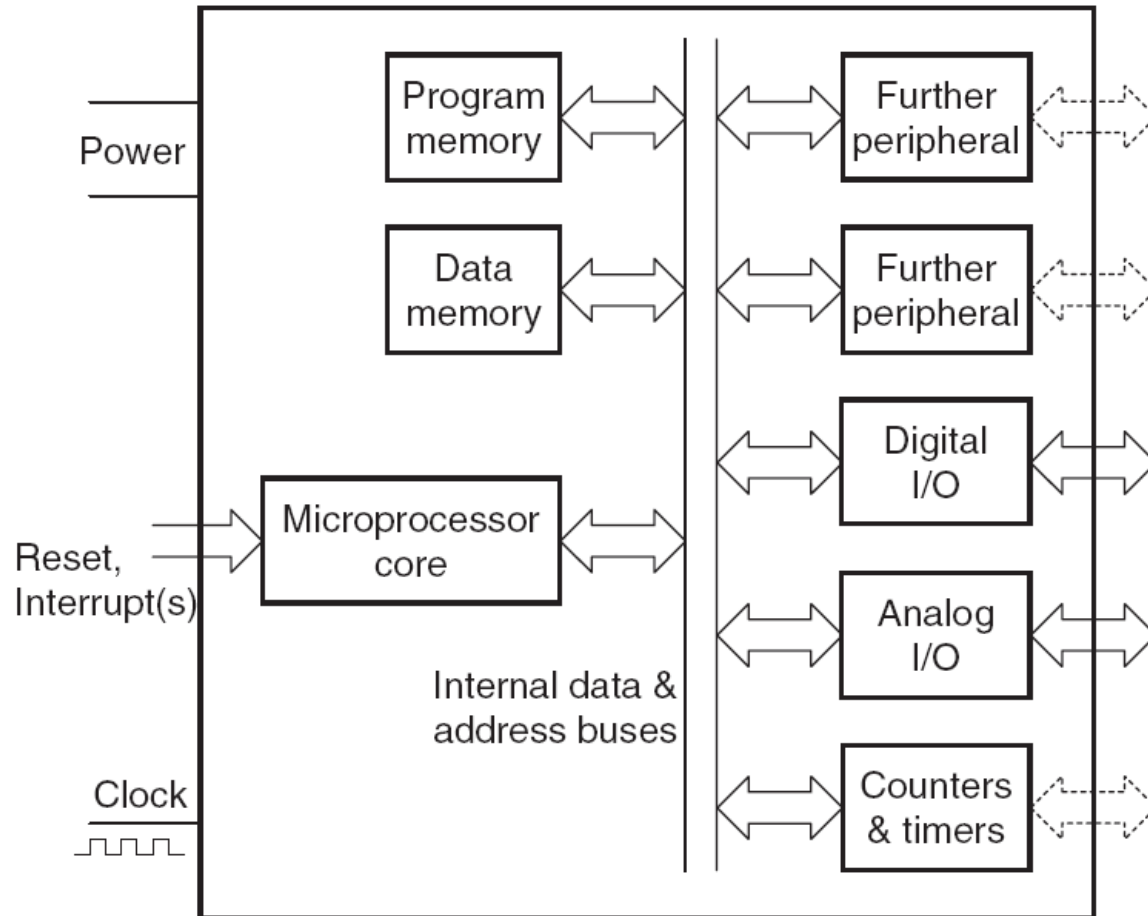


# Microprocessors and Microcontrollers

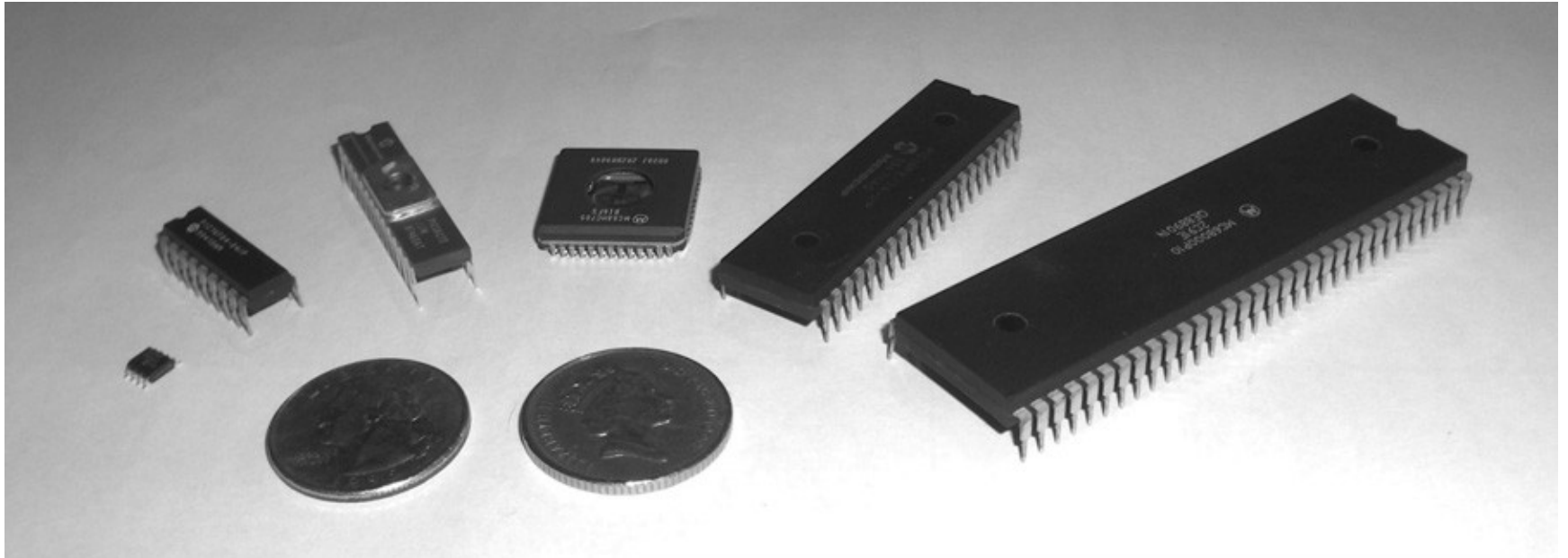
- The microprocessor is a processor on one silicon chip.
- The microcontrollers are used in embedded computing.
- The microcontroller is a microprocessor with added circuitry.



# Microcontrollers



# Microcontroller Packaging and Appearance



From left to right: PIC 12F508, PIC 16F84A, PIC 16C72, Motorola 68HC05B16, PIC 16F877, Motorola 68000

# PIC Microcontrollers

- Peripheral Interface Controller (PIC) was originally designed by General Instruments
- In the late 1970s, GI introduced PIC® 1650 and 1655 – RISC with 30 instructions.
- PIC was sold to Microchip
- Features: low-cost, self-contained, 8-bit, Harvard structure, pipelined, RISC, single accumulator, with fixed reset and interrupt vectors.

# PIC Families

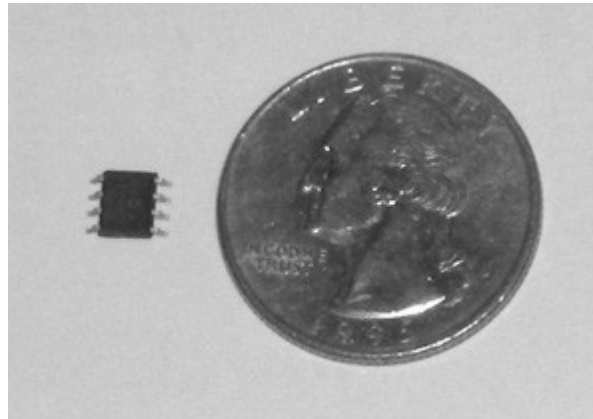
PIC Family	Stack Size	Instruction Word Size	No of Instructions	Interrupt Vectors
12CX/12FX	2	12- or 14-bit	33	None
16C5X/16F5X	2	12-bit	33	None
16CX/16FX	8	14-bit	35	1
17CX	16	16-bit	58	4
18CX/18FX	32	16-bit	75	2

‘C’ implies CMOS technology; Complementary Metal Oxide Semiconductor

‘F’ insert indicates incorporation of Flash memory technology

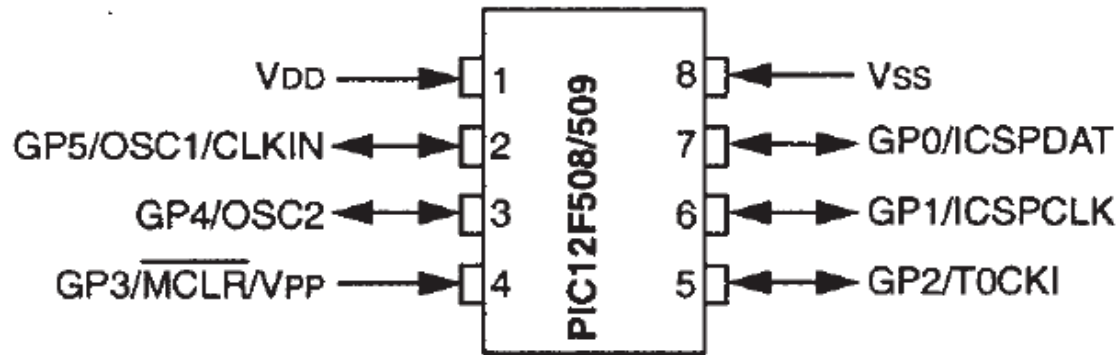
Example: 16C84 was the first of its kind. It was later reissued as the 16F84, incorporating Flash memory technology. It was then reissued as 16F84A.

# 12 Series PIC



The small 12F508

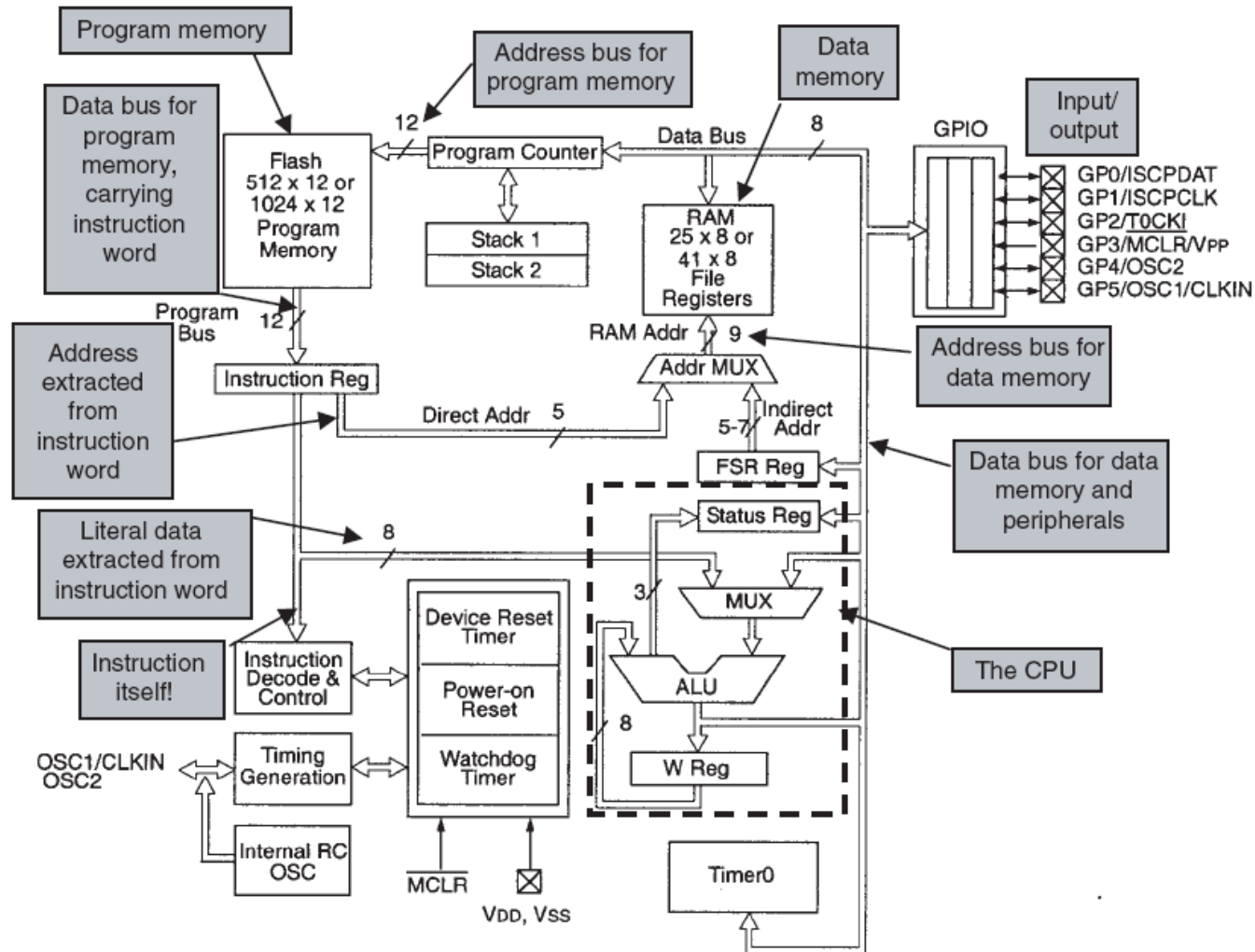
# PIC 12F508/509 pin connection diagram



## Key

$V_{DD}$ :	Power supply	$V_{SS}$ :	Ground
$V_{PP}$ :	Programming voltage input	MCLR:	Master clear
OSC1, OSC2:	Oscillator pins	CLKIN:	External clock input
GP0 to GP5:	General-Purpose input/output pins (bidirectional except GP3)		
CSPDAT:	In-Circuit Serial Programming™ data pin.		
CSPCLK:	In-Circuit Serial Programming™ clock pin.		

# The 12F508 Architecture





# Summary

- An embedded system is a product that has one or more computers embedded within it, which exercise primarily a control function.
- The embedded computer is usually a microcontroller: a microprocessor adapted for embedded control applications.
- Microcontrollers are designed according to accepted electronic and computer principles, and are fundamentally made up of microprocessor core, memory and peripherals.
- Microchip offers a wide range of microcontrollers, divided into a number of different families. Each family has identical central architecture and instruction set. However, common features also appear across all their microcontrollers.
- The Microchip 12F508 is a good microcontroller to introduce a range of features of microcontrollers in general and of PIC microcontrollers in particular.