

# ***Embedded Systems***

## ***Embedded Systems components***

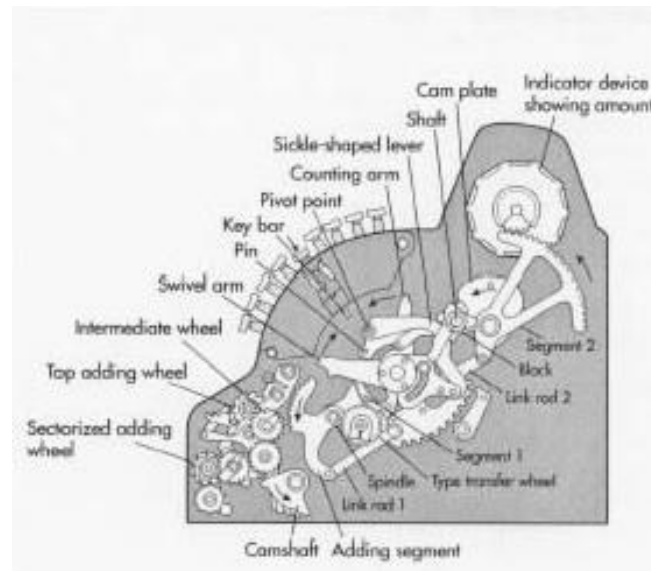
### ***Lesson 02***

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# Embedded systems architectures

- Theoretically embedded systems can be built without using electronic devices



# Embedded systems architectures

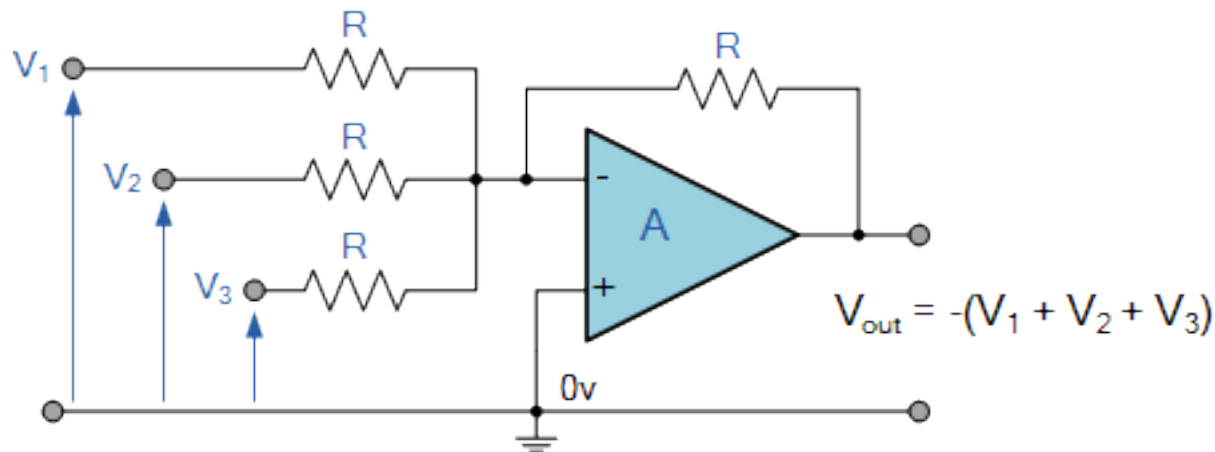
- Or using analog electronics



Any form of computer that uses continuously changeable aspects of physical phenomena such as electrical, mechanical, or hydraulic quantities to model the problem being solved.

# Embedded systems architectures

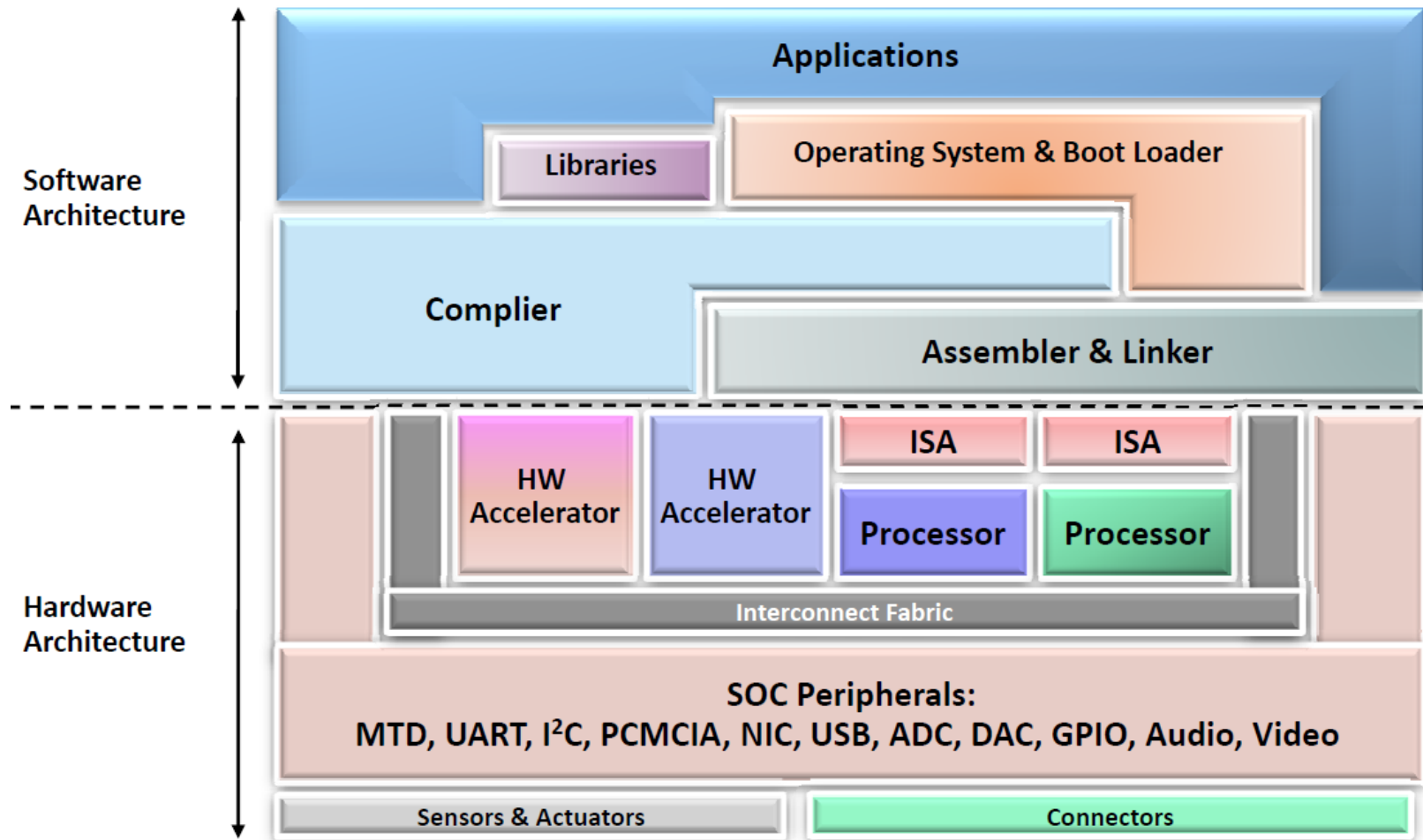
- Example: analog adder



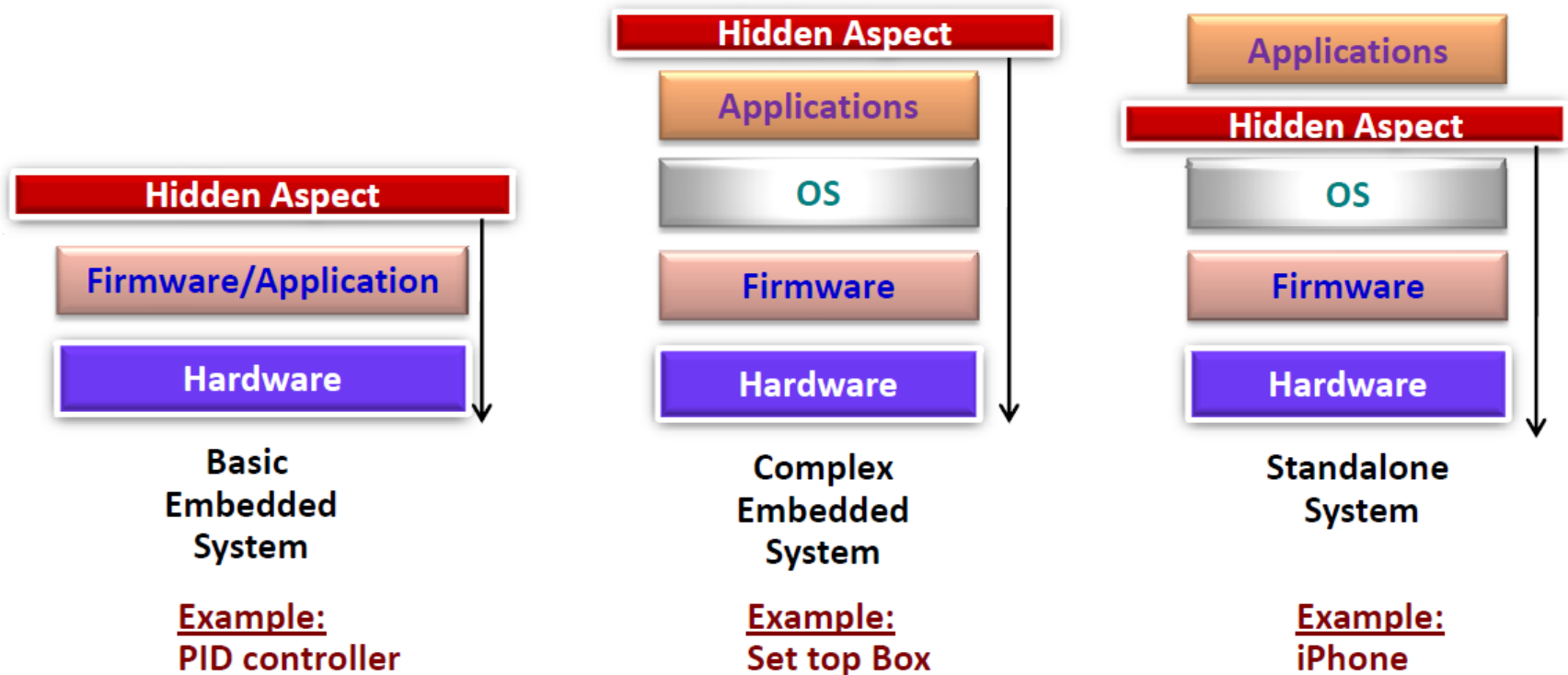
# Embedded systems architectures

- Why using microprocessor architectures in embedded systems?
  - Easy to build complex system behavior
  - Flexibility
  - Easy to upgrade
  - Maintainability

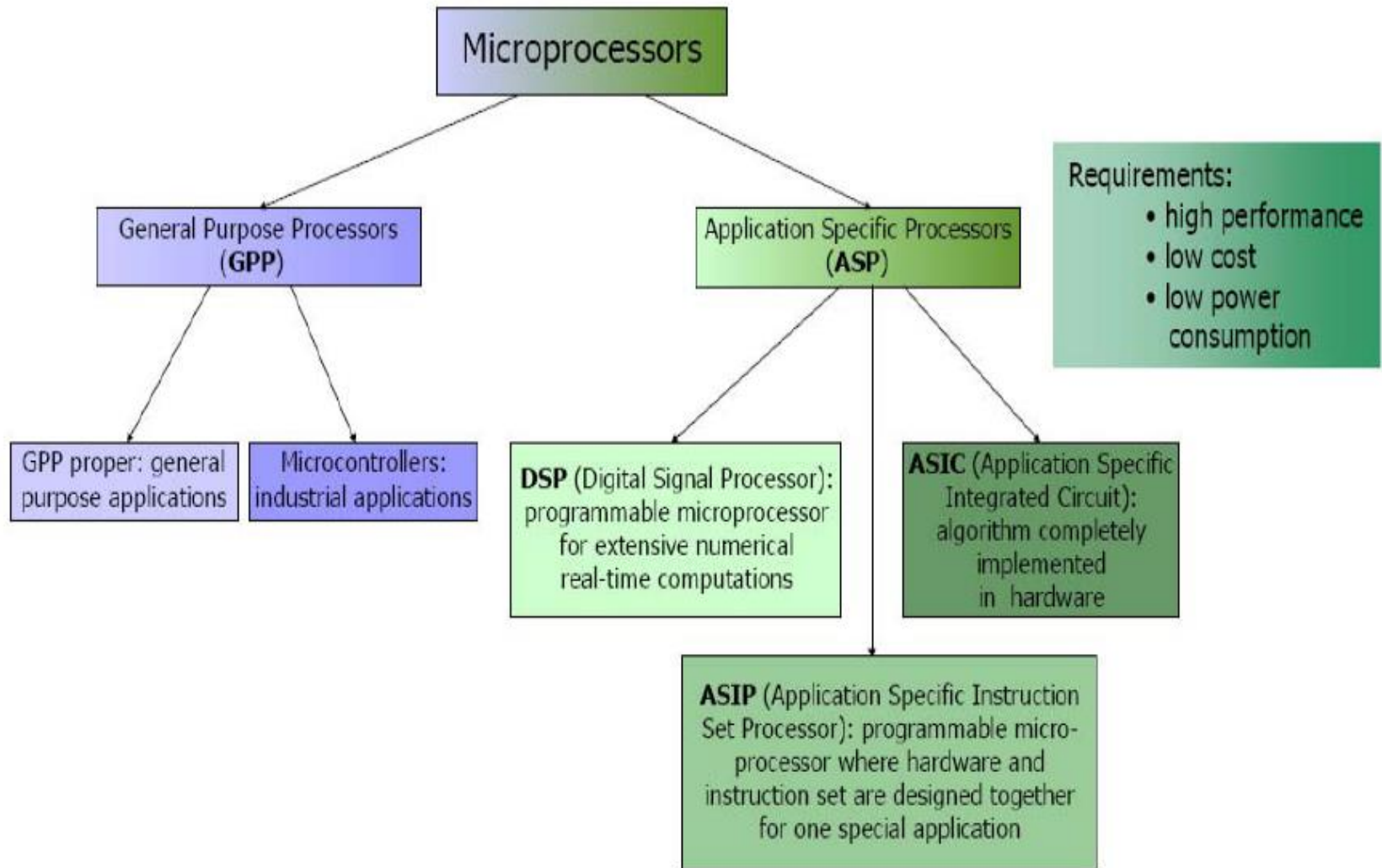
# A Typical Embedded System



# Types of System Abstraction

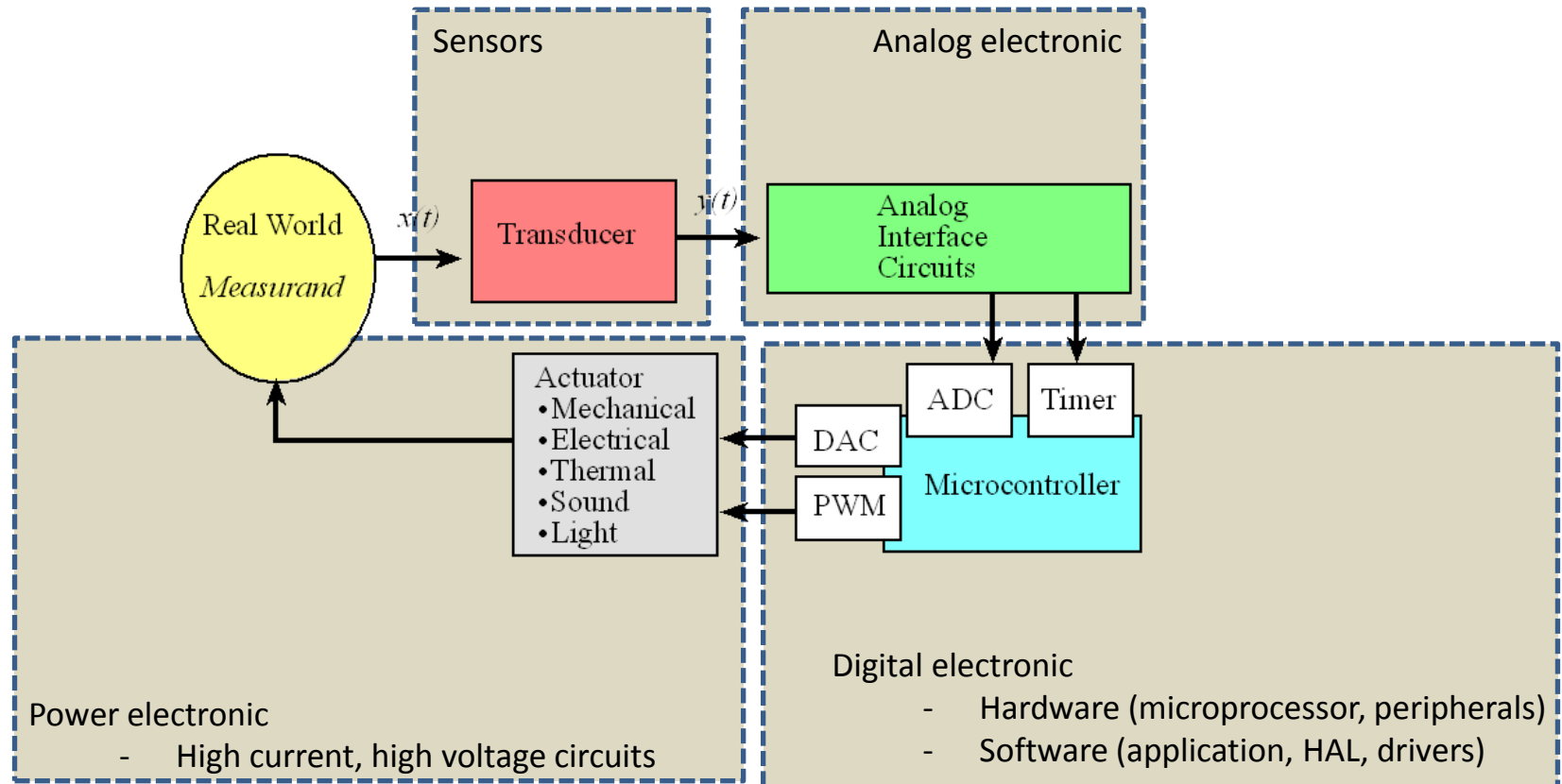


# Processor Classification

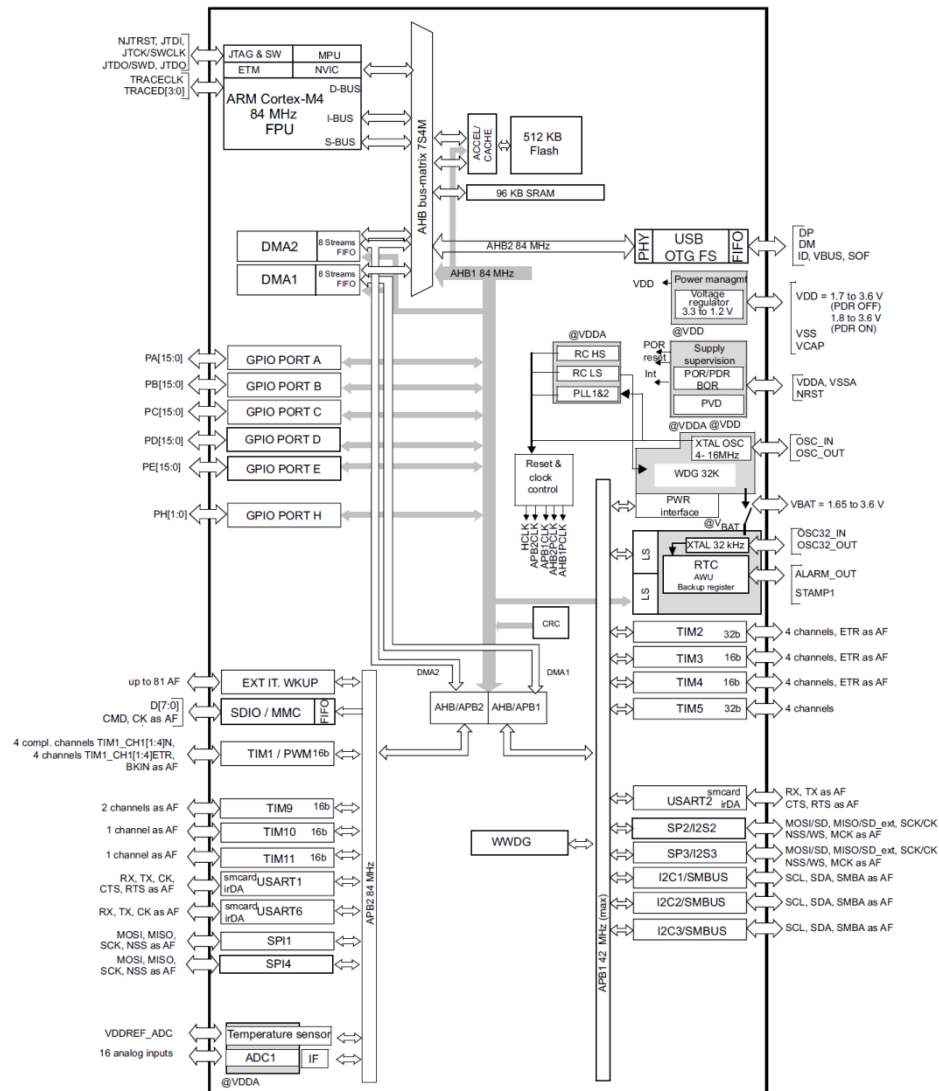




# Embedded systems

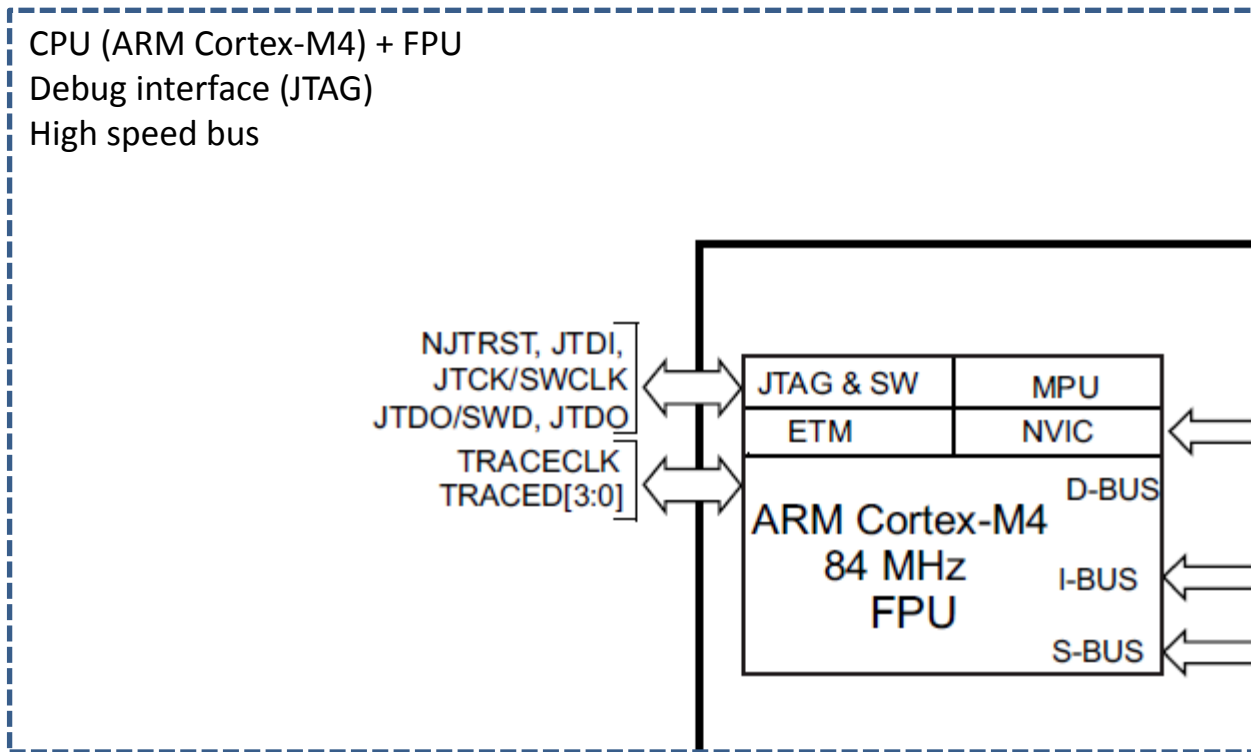


# Microcontroller architecture



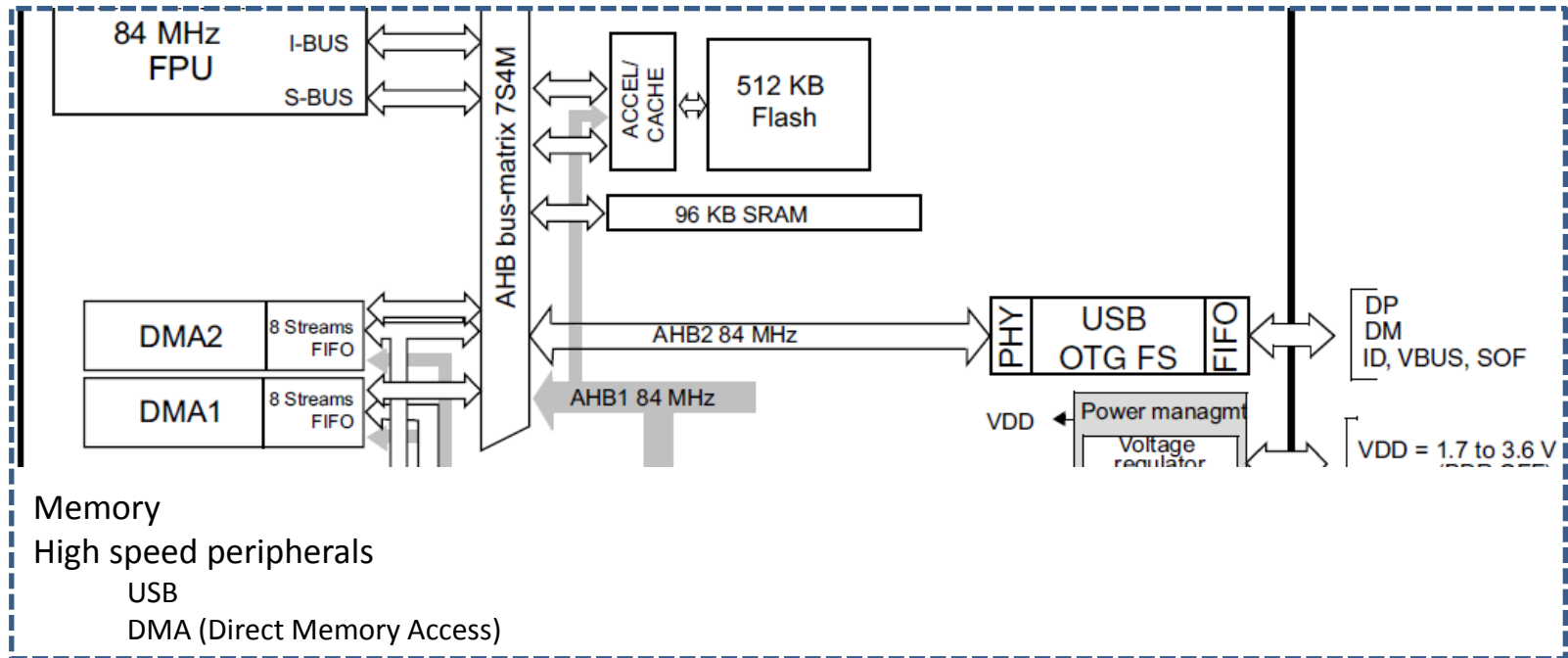
STM32F401 (ST Microelectronics)

# Microcontroller architecture



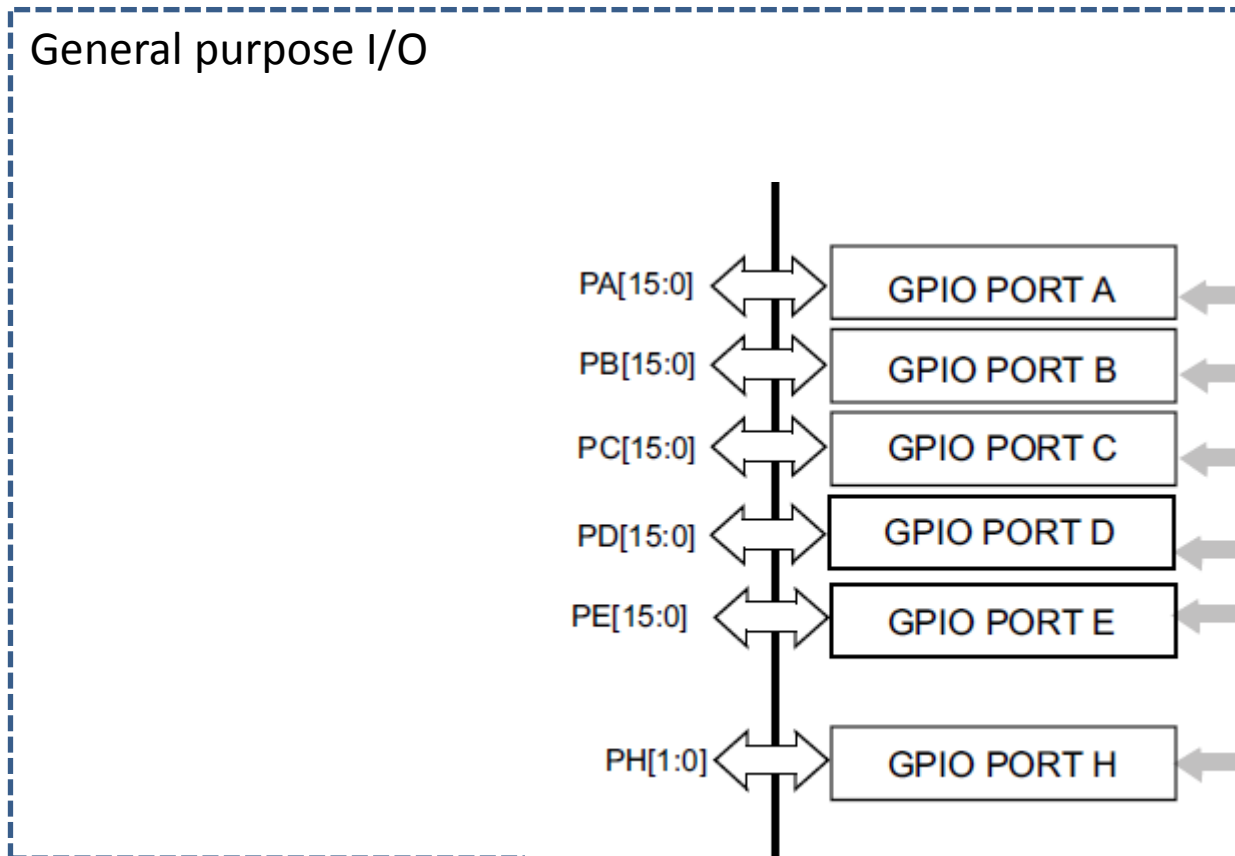
**STM32F401 (ST Microelectronics)**

# Microcontroller architecture



**STM32F401 (ST Microelectronics)**

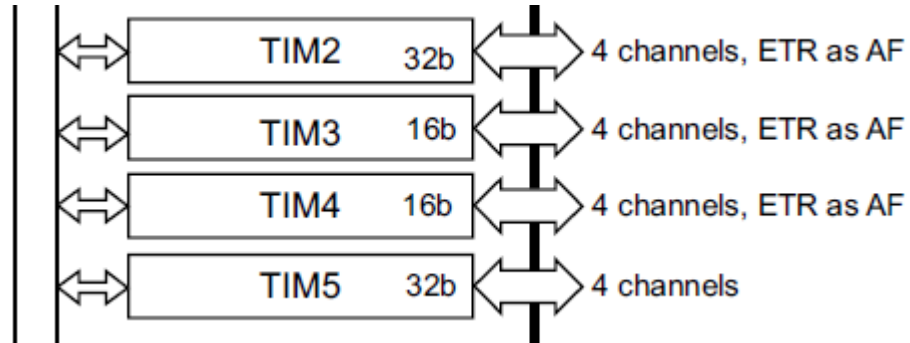
# Microcontroller architecture



**STM32F401 (ST Microelectronics)**

# Microcontroller architecture

## TIMERS

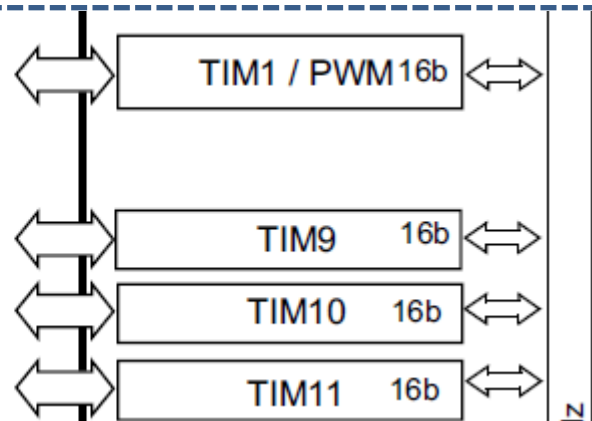


4 compl. channels TIM1\_CH1[1:4]N,  
4 channels TIM1\_CH1[1:4]ETR,  
BKIN as AF

2 channels as AF

1 channel as AF

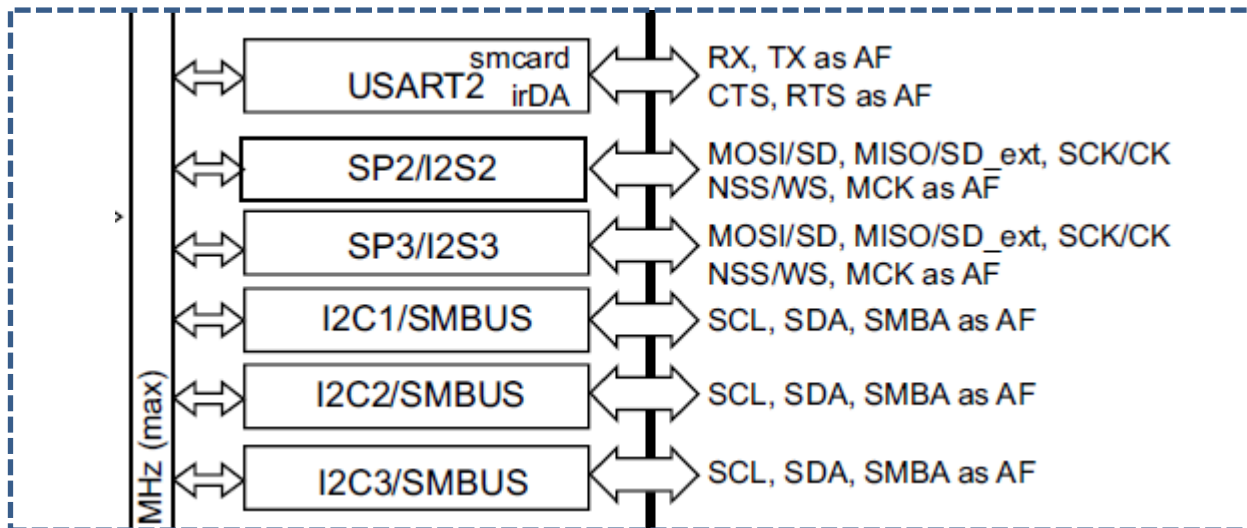
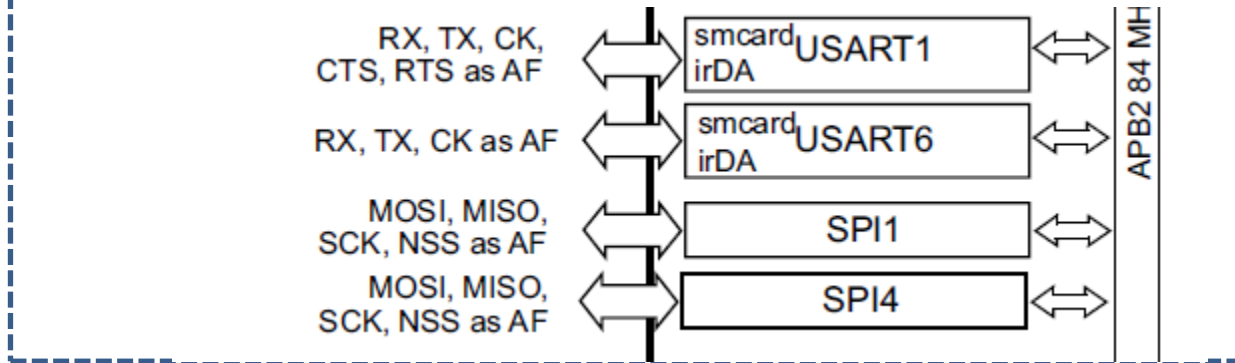
1 channel as AF



STM32F401 (ST Microelectronics)

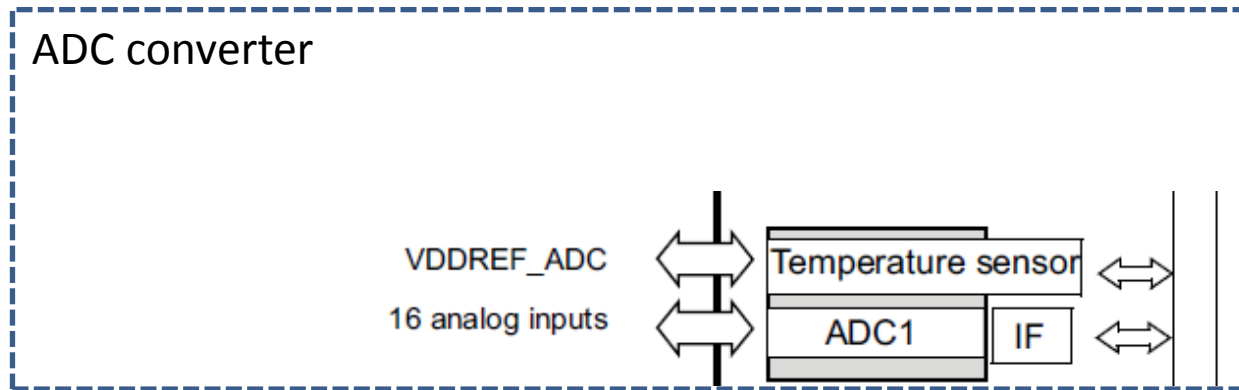
# Microcontroller architecture

## Communication interfaces



**STM32F401 (ST Microelectronics)**

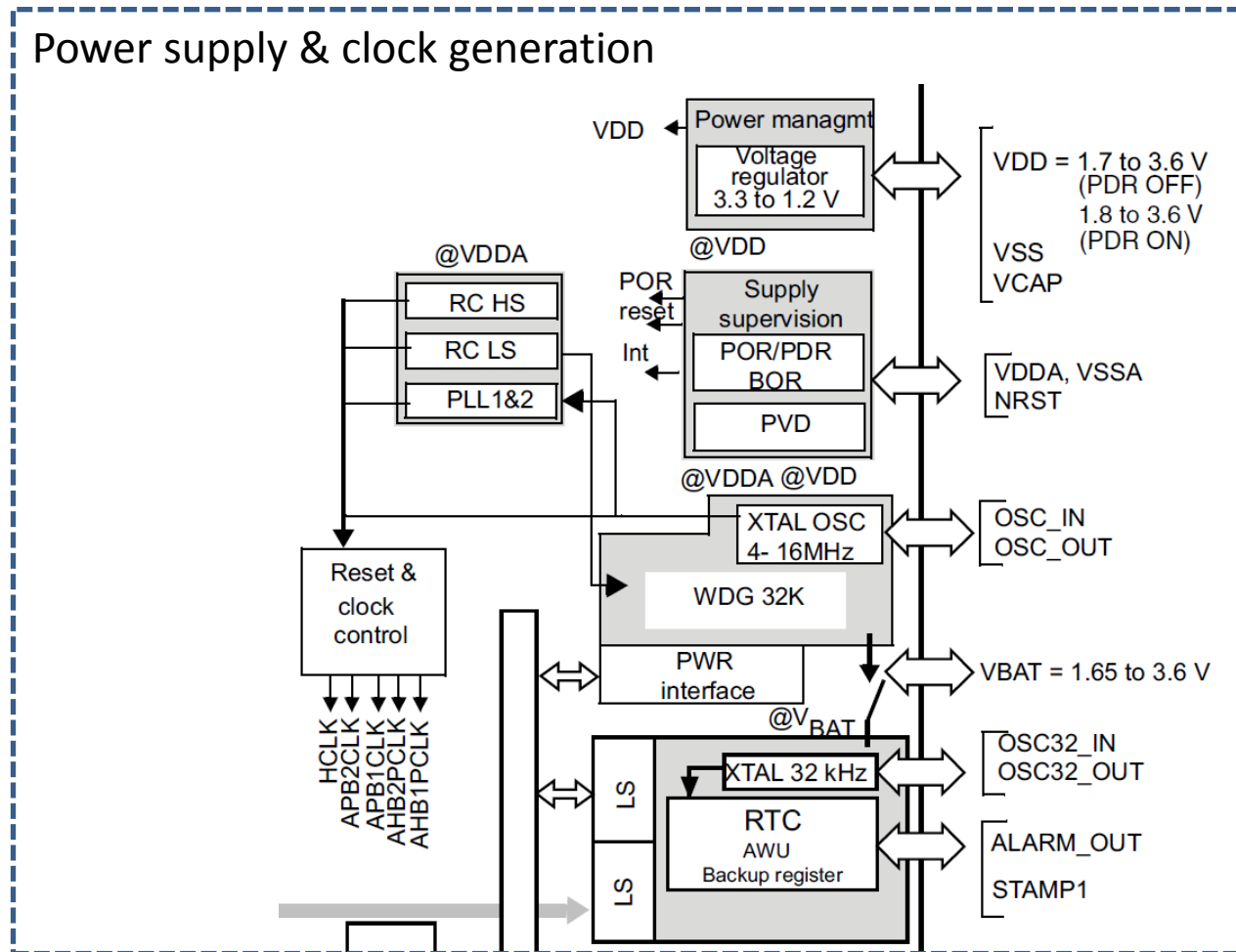
# Microcontroller architecture



**STM32F401 (ST Microelectronics)**

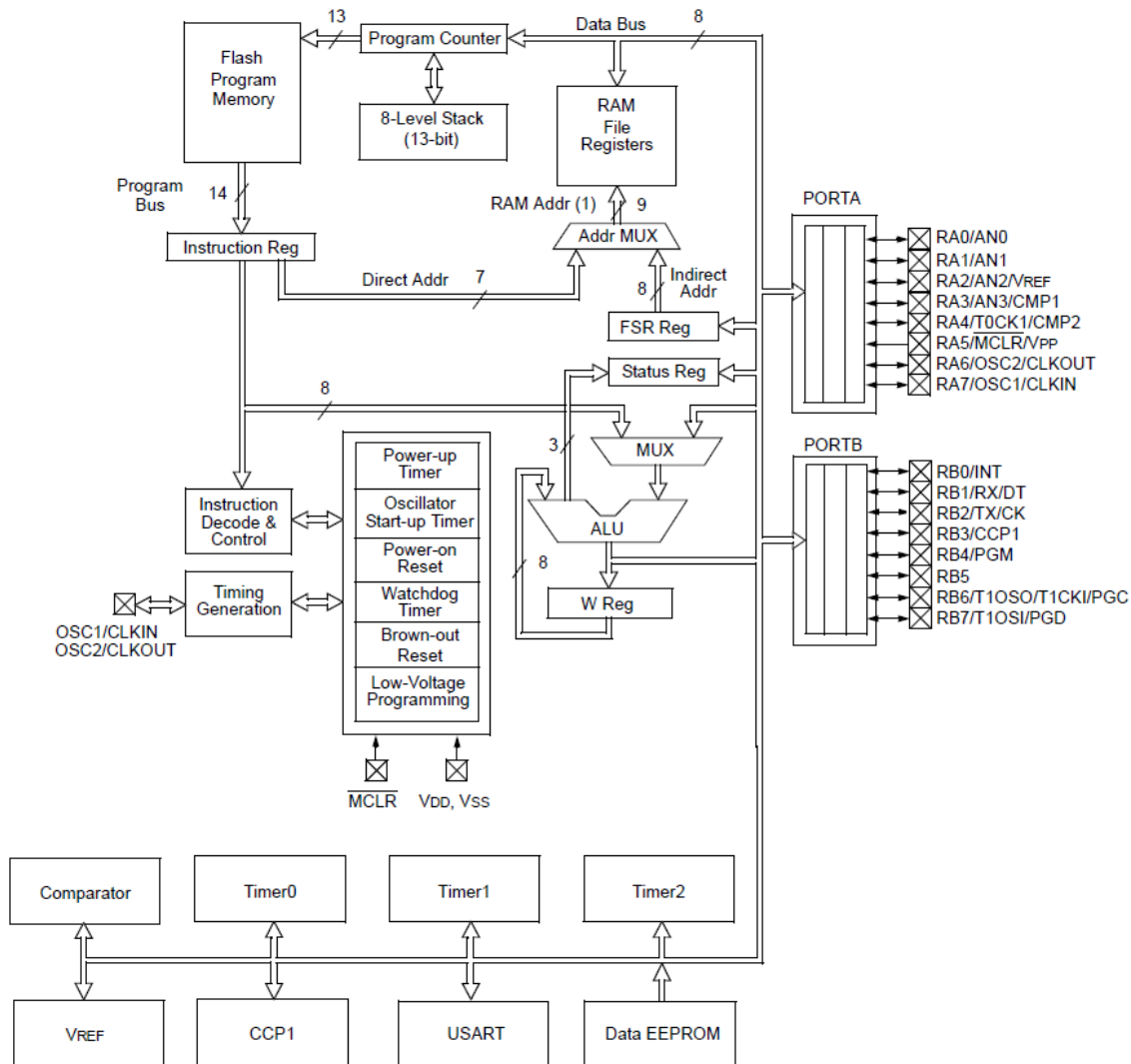


# Microcontroller architecture



STM32F401 (ST Microelectronics)

# Microcontroller architecture



**PIC16F648 (Microchip)**

# Microcontroller datasheets

- Hardware datasheet
  - Contains information on physical aspects of the microcontroller
    - Package, pinout
    - Power supply, Oscillators
    - Electrical pin characteristics
  - The main document for circuit and PCB design

# Microcontroller datasheets



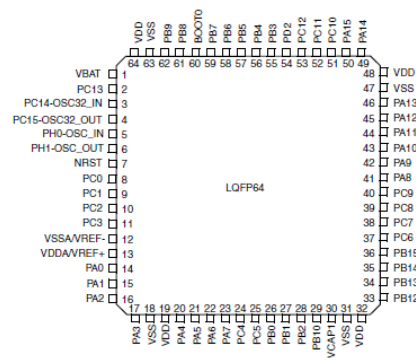
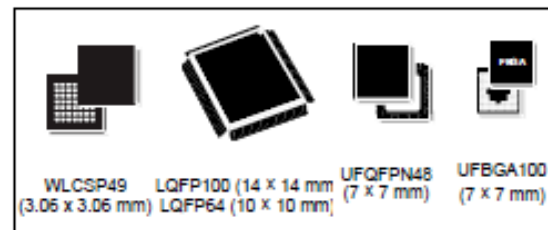
## STM32F401xD STM32F401xE

ARM® Cortex®-M4 32b MCU+FPU, 105 DMIPS,  
512KB Flash/96KB RAM, 11 TIMs, 1 ADC, 11 comm. interfaces

Datasheet - production data

### Features

- Core: ARM® 32-bit Cortex®-M4 CPU with FPU, Adaptive real-time accelerator (ART Accelerator™) allowing 0-wait state execution from Flash memory, frequency up to 84 MHz, memory protection unit, 105 DMIPS/1.25 DMIPS/MHz (Dhrystone 2.1),



DS10086 - STM32F401 (ST Microelectronics)

# Microcontroller datasheets

- Microcontroller family/reference manual datasheet
  - Different microcontrollers (different package, different number of peripherals) share the same kind of peripherals
  - They can share a single document with in-depth documentation of each subsystem and peripheral
  - The main document for programming software drivers or simple applications with direct hardware access

# Microcontroller datasheets

- Typical contents of the Microcontroller family/reference manual datasheet
  - Memory and bus architecture, memory organization, memory map
  - Flash memory programming
  - Detailed description of each peripheral: functionality, configuration, control registers, status registers, timings.

# Microcontroller datasheets



## RM0368 Reference manual

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STM32F401xB/C and STM32F401xD/E  
advanced ARM<sup>®</sup>-based 32-bit MCUs

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### Introduction

This Reference manual targets application developers. It provides complete information on how to use the memory and the peripherals of the STM32F401xB/C and STM32F401xD/E microcontrollers.

STM32F401xB/C and STM32F401xD/E are part of the STM32F401xx family of microcontrollers with different memory sizes, packages and peripherals.

For ordering information, mechanical and electrical device characteristics refer to the datasheets.

For information on the ARM<sup>®</sup> Cortex<sup>®</sup>-M4 with FPU core, refer to the *Cortex<sup>®</sup>-M4 with FPU Technical Reference Manual*.

### Related documents

Available from STMicroelectronics web site (<http://www.st.com>):

- STM32F401xB/C datasheet
- STM32F401xD/E datasheet
- For information on the ARM<sup>®</sup>-M4 core with FPU, refer to the *STM32F3xx/F4xxx Cortex<sup>®</sup>-M4 with FPU-M4 programming manual (PM0214)*.

**RM0368 - STM32F401 (ST Microelectronics)**

# Microcontroller datasheets

- Programmer Manual/CPU Programming Manual
  - The CPU in a microcontroller can be
    - Designed in-house (generally for simple microcontrollers)
    - Bought as IP (Intellectual Property) from an external company (generally done for 32-bit architectures)
  - A specialized document describes in-depth the CPU
    - Published by the microcontroller manufacturer (i.e. ST Microelectronics, Microchip)
    - Published by the IP designer (i.e. ARM, MIPS)



# Microcontroller datasheets

- Typical contents of the Programmer Manual/CPU Programming Manual
  - Programmers model
    - Core Registers, Stack, Interrupts
    - Instruction set
  - Memory model
    - Memory regions, types and attributes
    - Behavior of memory accesses
  - Exception mode
    - Exception states , type, handlers
    - Vector table, priorities
    - Exception entry and return

# Microcontroller datasheets



## PM0214 Programming manual

### STM32F3 and STM32F4 Series Cortex<sup>®</sup>-M4 programming manual

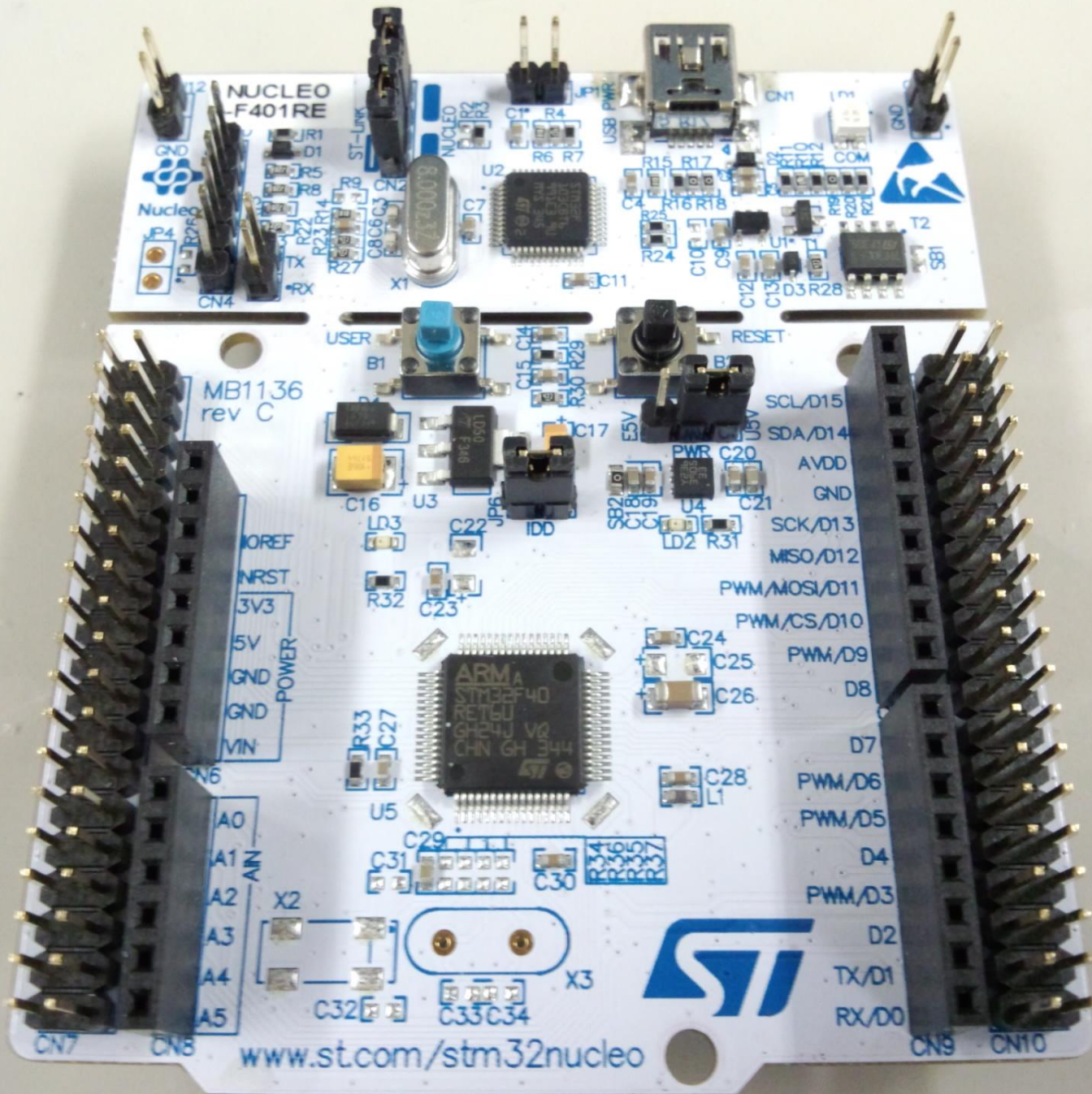
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#### Introduction

This programming manual provides information for application and system-level software developers. It gives a full description of the STM32F3 and STM32F4 Series Cortex<sup>®</sup>-M4 processor programming model, instruction set and core peripherals.

The STM32F3 and STM32F4 Series Cortex<sup>®</sup>-M4 processor is a high performance 32-bit processor designed for the microcontroller market. It offers significant benefits to developers, including:

- Outstanding processing performance combined with fast interrupt handling
- Enhanced system debug with extensive breakpoint and trace capabilities
- Efficient processor core, system and memories
- Ultra-low power consumption with integrated sleep modes
- Platform security



NUCLEO-F401RE

Nucleo

MB1136 rev C

www.st.com/stm32nucleo

