

# MICROCONTROLLERS AND INTERFACING USING ARM PROCESSOR

# Course Goals

- At the end of this course, you should be able to:
  - ▣ Understand the architecture of one of the most popular microcontroller (MCU) families
  - ▣ Use an integrated development environment (IDE) to program and debug an MCU
  - ▣ Program an MCU using Assembly and C languages
  - ▣ Understand and use peripherals integrated into an MCU
  - ▣ Interface an MCU to simple external components
  - ▣ Use timers in various modes
  - ▣ Understand and use interrupts
  - ▣ Understand and use analog to digital converters (ADC) and digital to analog converters (DAC)
  - ▣ Communicate using a serial interface (if time allows)

# Course Prerequisites

- A course in Electric Circuits that includes understanding basic electronic components such as resistors, capacitors, diodes and transistors
- A course in basic digital logic design that includes logic gates and Boolean arithmetic
- Ability to program in a high-level programming language such as C or C++

# Microprocessors and Microcontrollers

- **Microprocessor: general-purpose CPU**
  - ▣ Emphasis is on flexibility and performance
  - ▣ Generic user-interface such as keyboard, mouse, etc.
  - ▣ Used in a PC, PDA, cell phone, etc.
  
- **Microcontroller: microprocessor + memory on a single chip**
  - ▣ Emphasis is on size and cost reduction
  - ▣ The user interface is tailored to the application, such as the buttons on a TV remote control
  - ▣ Used in a digital watch, TV remote control, car and many common day-to-day appliances

# Microcontroller Architectures

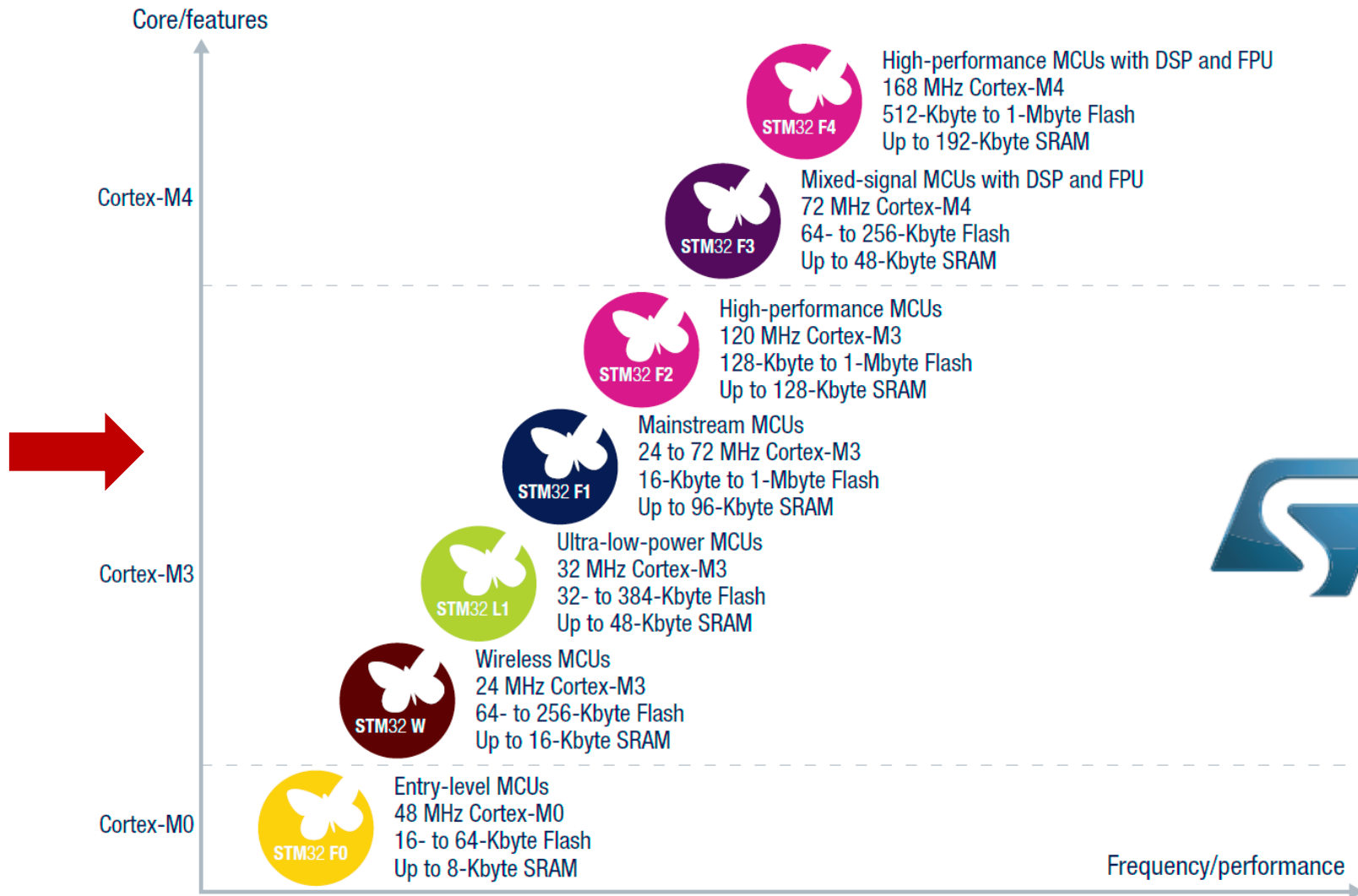
- Microcontroller architecture refers to the internal hardware organization of a microcontroller
- Each hardware architecture has its own set of software instructions called assembly language that allows programming of the microcontroller
- Some of the popular microcontroller architectures
  - ▣ Intel 8051
  - ▣ Zilog Z80
  - ▣ Atmel AVR
  - ▣ Microchip PIC
  - ▣ ARM

# ARM Processors

- ARM: Advanced RISC Machines
  - ▣ Previously “Acorn RISC Machines”
  - ▣ ARM1: 1985
  - ▣ Now: ARM11, ARM Cortex A, ARM Cortex R, ARM Cortex M



# STM32 Platform



# STM32 Product Lines

Common core peripherals and architecture:

Communication peripherals: USART, SPI, I <sup>2</sup> C
Multiple general-purpose timers
Integrated reset and brown-out warning
Multiple DMA
2x watchdogs Real-time clock
Integrated regulator PLL and clock circuit
External memory interface (FSMC)
Up to 3x 12-bit DAC
Up to 4x 12-bit ADC (Up to 5 MSPS)
Main oscillator and 32 kHz oscillator
Low-speed and high-speed internal RC oscillators
-40 to +85 °C and up to 105 °C operating temperature range
Low voltage 2.0 to 3.6 V or 1.65/1.7 to 3.6 V (depending on series)
Temperature sensor

## STM32 F4 series - High performance with DSP (STM32F405/415/407/417)

168 MHz Cortex-M4 with DSP and FPU	Up to 192-Kbyte SRAM	Up to 1-Mbyte Flash	2x USB 2.0 OTG FS/HS	3-phase MC timer	2x CAN 2.0B	SDIO 2x I <sup>2</sup> S audio Camera IF	Ethernet IEEE 1588	Crypto/hash processor and RNG
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## STM32 F3 series - Mixed-signal with DSP (STM32F302/303/313/372/373/383)

72 MHz Cortex-M4 with DSP and FPU	Up to 48-Kbyte SRAM & CCM-SRAM	Up to 256-Kbyte Flash	USB 2.0 FS	2x 3-phase MC timer (144 MHz)	CAN 2.0B	Up to 7x comparator	3x 16-bit ΣΔ ADC	4x PGA
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## STM32 F2 series - High performance (STM32F205/215/207/217)

120 MHz Cortex-M3 CPU	Up to 128-Kbyte SRAM	Up to 1-Mbyte Flash	2x USB 2.0 OTG FS/HS	3-phase MC timer	2x CAN 2.0B	SDIO 2x I <sup>2</sup> S audio Camera IF	Ethernet IEEE 1588	Crypto/hash processor and RNG
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## STM32 F1 series - Mainstream - 5 product lines (STM32F100/101/102/103 and 105/107)

Up to 72 MHz Cortex-M3 CPU	Up to 96-Kbyte SRAM	Up to 1-Mbyte Flash	USB 2.0 OTG FS	3-phase MC timer	Up to 2x CAN 2.0B	SDIO 2x I <sup>2</sup> S audio	Ethernet IEEE 1588
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## STM32 F0 series - Entry level (STM32F050/051)

48 MHz Cortex-M0 CPU	Up to 8-Kbyte SRAM	Up to 64-Kbyte Flash	3-phase MC timer	Comparator	CEC	
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## STM32 L1 series - Ultra-low-power (STM32L151/152/162)

32 MHz Cortex-M3 CPU	Up to 48-Kbyte SRAM	Up to 384-Kbyte Flash	USB FS device	Up to 12-Kbyte EEPROM	LCD 8x40 4x44	Comparator	BOR MSI VScal	AES 128-bit
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## STM32 W series - Wireless (STM32W108)

24 MHz Cortex-M3 CPU	Up to 16-Kbyte SRAM	Up to 256-Kbyte Flash	2.4 GHz IEEE 802.15.4 Transceiver	Lower MAC Digital baseband	AES 128-bit	
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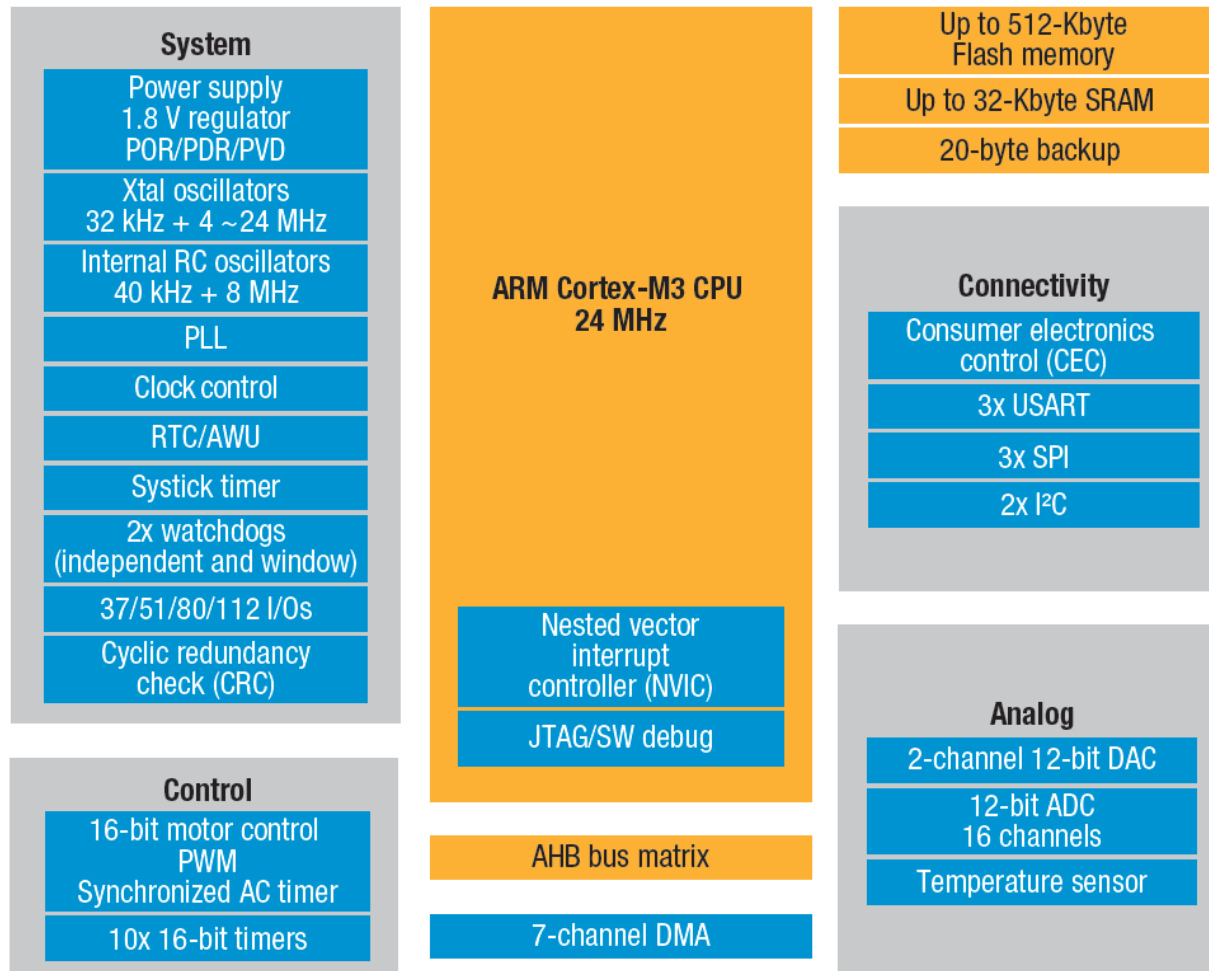


Abbreviations:

- FS: Full speed
- HS: High speed
- MC: Motor control
- MSI: Multi-speed internal oscillator
- RNG: Random number generator
- SDIO: Secure digital input/output
- VScal: Voltage scaling
- FPU: Floating point unit
- DSC: Digital signal controller



# STM32 Value Line Block Diagram



**Abbreviations:**

AWU: Auto wake up from halt  
 BOR: Brown-out reset  
 I<sup>2</sup>C: Inter integrated circuit

PDR: Power-down reset  
 POR: Power-on reset  
 PVD: Programmable voltage detector

RTC: Real-time clock  
 SPI: Serial peripheral interface  
 USART: Universal sync/asynch receiver transmitter

# STM32 Value Line Devices

Part number	Package	Flash size (Kbytes)	Internal RAM size (Kbytes)	Timer functions		ADC	DAC	I/Os	Serial interface	Supply voltage (V)
				16-bit	Others					
<b>STM32F100 Value line - 24 MHz CPU</b>										
STM32F100C4	LQFP48 (7x7)	16	4	6x16-bit	2xWDG, RTC, 24-bit down counter, 2x16-bit basic timers	10x12-bit	2x12-bit	37	1xSPI, 1xI <sup>2</sup> C, CEC, 2xUSART (IrDa, ISO 7816)	2 to 3.6
STM32F100C6	LQFP48 (7x7)	32	4	6x16-bit		10x12-bit	2x12-bit	37	1xSPI, 1xI <sup>2</sup> C, CEC, 2xUSART (IrDa, ISO 7816)	2 to 3.6
STM32F100C8	LQFP48 (7x7)	64	8	7x16-bit		10x12-bit	2x12-bit	37	2xSPI, 2xI <sup>2</sup> C, CEC, 3xUSART (IrDa, ISO 7816)	2 to 3.6
STM32F100CB	LQFP48 (7x7)	128	8	7x16-bit		10x12-bit	2x12-bit	37	2xSPI, 2xI <sup>2</sup> C, CEC, 3xUSART (IrDa, ISO 7816)	2 to 3.6
STM32F100R4	LQFP64 (10x10), TFBGA6 (5x5)	16	4	6x16-bit		16x12-bit	2x12-bit	51	1xSPI, 1xI <sup>2</sup> C, CEC, 2xUSART (IrDa, ISO 7816)	2 to 3.6
STM32F100R6	LQFP64 (10x10), TFBGA64 (5x5), Unseen wafer V.I. 100%	32	4	6x16-bit		16x12-bit	2x12-bit	51	1xSPI, 1xI <sup>2</sup> C, CEC, 2xUSART (IrDa, ISO 7816)	2 to 3.6
STM32F100R8	LQFP64 (10x10), TFBGA64 (5x5)	64	8	7x16-bit		16x12-bit	2x12-bit	51	2xSPI, 2xI <sup>2</sup> C, CEC, 3xUSART (IrDa, ISO 7816)	2 to 3.6
STM32F100RB	LQFP64 (10x10), TFBGA64 (5x5)	128	8	7x16-bit		16x12-bit	2x12-bit	51	2xSPI, 2xI <sup>2</sup> C, CEC, 3xUSART (IrDa, ISO 7816)	2 to 3.6
STM32F100RC	LQFP64 (10x10)	256	24	11x16-bit		16x12-bit	2x12-bit	51	3xSPI, 2xI <sup>2</sup> C, CEC, 5xUSART (IrDa, ISO 7816)	2 to 3.6
STM32F100RD	LQFP64 (10x10)	384	32	11x16-bit		16x12-bit	2x12-bit	51	3xSPI, 2xI <sup>2</sup> C, CEC, 5xUSART (IrDa, ISO 7816)	2 to 3.6
STM32F100RE	LQFP64 (10x10)	512	32	11x16-bit		16x12-bit	2x12-bit	51	3xSPI, 2xI <sup>2</sup> C, CEC, 5xUSART (IrDa, ISO 7816)	2 to 3.6
STM32F100V8	LQFP100 (14x14)	64	8	7x16-bit		16x12-bit	2x12-bit	80	2xSPI, 2xI <sup>2</sup> C, CEC, 3xUSART (IrDa, ISO 7816)	2 to 3.6
STM32F100VB	LQFP100 (14x14)	128	8	7x16-bit		16x12-bit	2x12-bit	80	2xSPI, 2xI <sup>2</sup> C, CEC, 3xUSART (IrDa, ISO 7816)	2 to 3.6
STM32F100VC	LQFP100 (14x14)	256	24	11x16-bit		16x12-bit	2x12-bit	80	3xSPI, 2xI <sup>2</sup> C, CEC, 5xUSART (IrDa, ISO 7816)	2 to 3.6
STM32F100VD	LQFP100 (14x14)	384	32	11x16-bit	16x12-bit	2x12-bit	80	3xSPI, 2xI <sup>2</sup> C, CEC, 5xUSART (IrDa, ISO 7816)	2 to 3.6	
STM32F100VE	LQFP100 (14x14)	512	32	11x16-bit	16x12-bit	2x12-bit	80	3xSPI, 2xI <sup>2</sup> C, CEC, 5xUSART (IrDa, ISO 7816)	2 to 3.6	
STM32F100ZC	LQFP144 (20x20)	256	24	11x16-bit	16x12-bit	2x12-bit	112	3xSPI, 2xI <sup>2</sup> C, CEC, 5xUSART (IrDa, ISO 7816)	2 to 3.6	
STM32F100ZD	LQFP144 (20x20)	384	32	11x16-bit	16x12-bit	2x12-bit	112	3xSPI, 2xI <sup>2</sup> C, CEC, 5xUSART (IrDa, ISO 7816)	2 to 3.6	
STM32F100ZE	LQFP144 (20x20)	512	32	11x16-bit	16x12-bit	2x12-bit	112	3xSPI, 2xI <sup>2</sup> C, CEC, 5xUSART (IrDa, ISO 7816)	2 to 3.6	

# STM32 Value line Discovery Kit

- The cheapest and quickest way to discover the STM32 Value line family
- Embedded ST-LINK or ST-LINK/V2 included to debug applications
- Works with several popular IDEs
  - ▣ MDK-ARM (Keil)
  - ▣ EWARM (IAR)

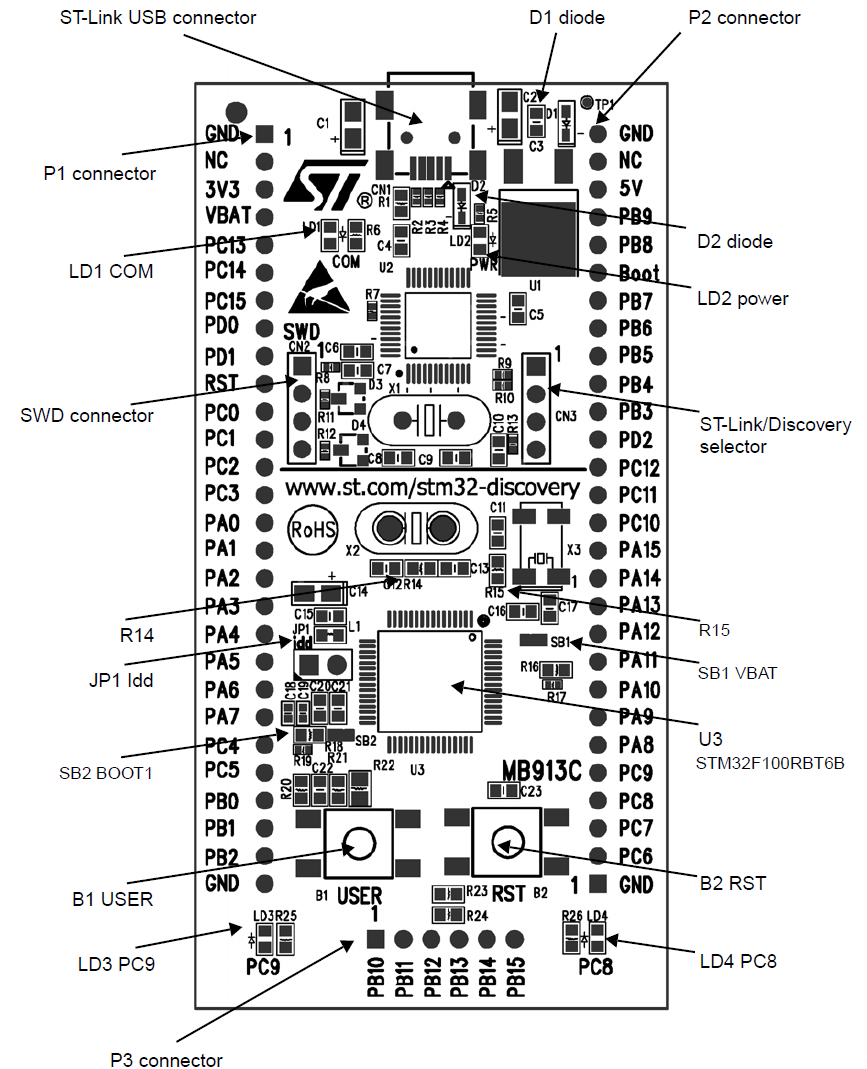
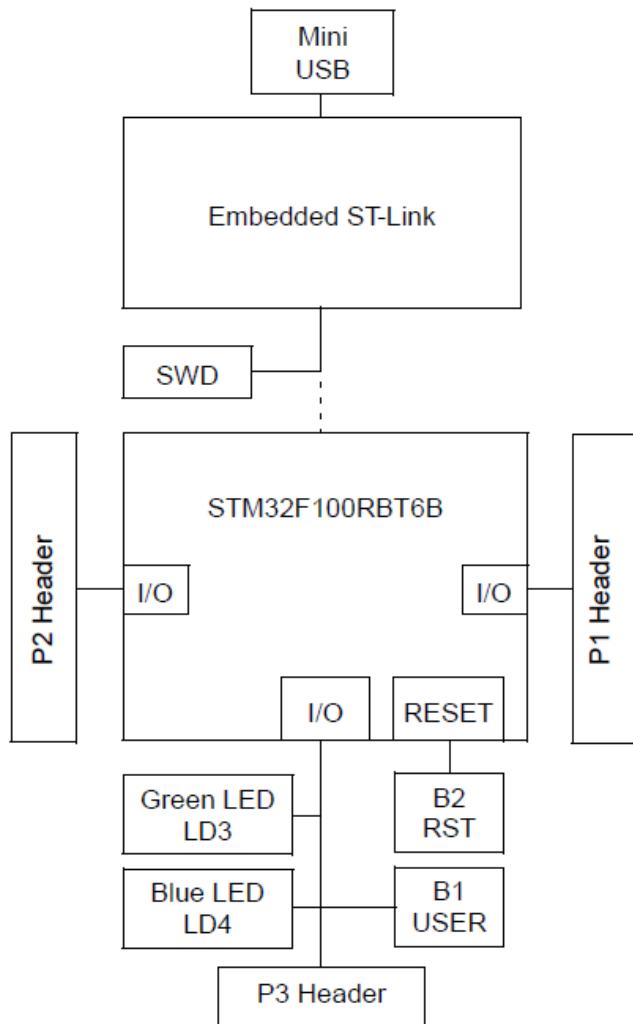


# Kit Features

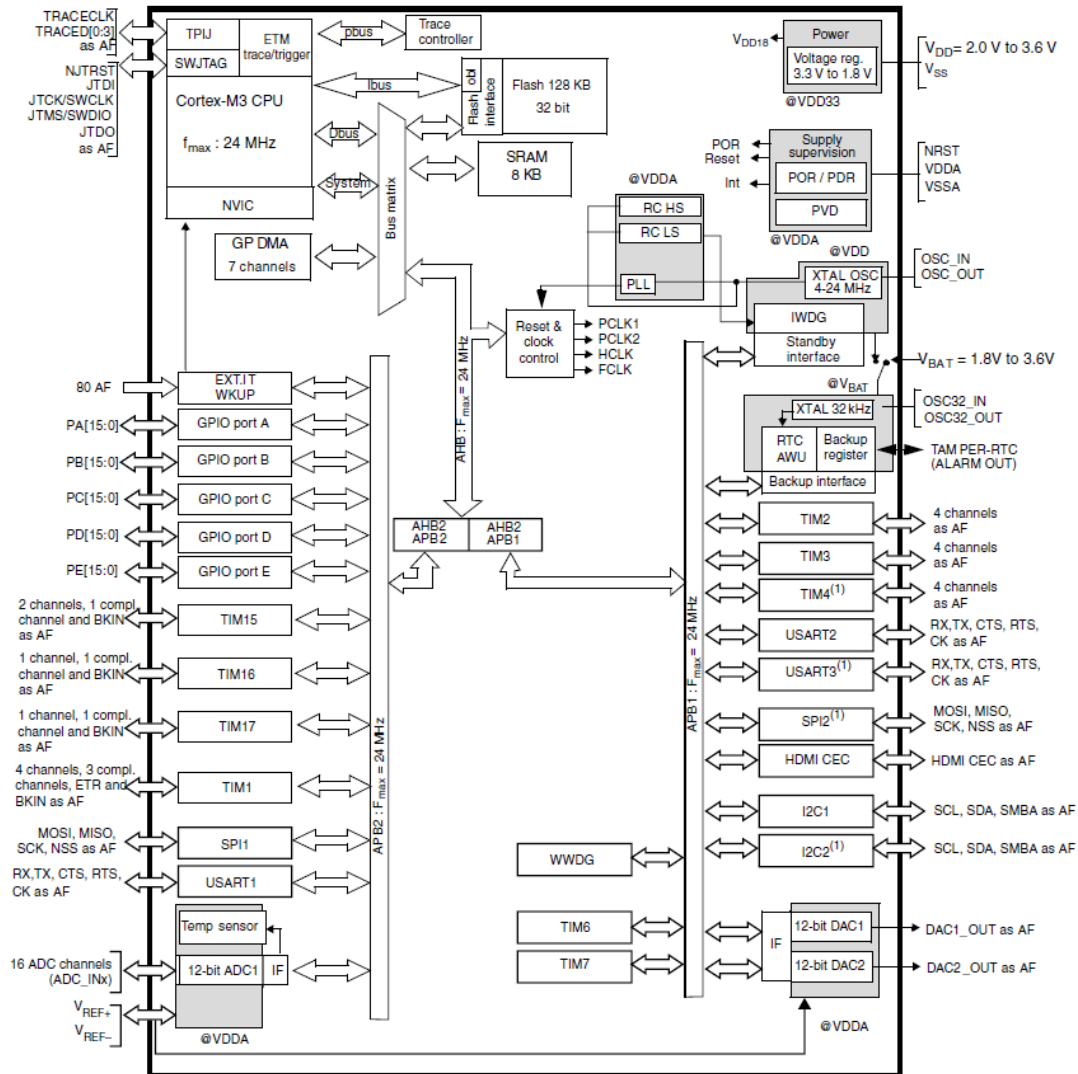
- STM32F100RBT6B microcontroller, 128 KB Flash, 8 KB RAM in 64-pin LQFP
- On-board ST-Link (for programming and debugging)
- Two red LEDs; LD1 for USB communication, LD2 for 3.3 volts power on
- Designed to be powered by USB or an external supply of 5 V or 3.3 V
- Can supply target application with 5 volts and 3 volts
- Two user LEDs, LD3 and LD4 (green and blue)
- Two push buttons (User and Reset)
- Extension header for all QFP64 I/Os for quick connection to prototyping board or easy probing



# Kit Hardware Block Diagram



# STM32F100RBT6B Microcontroller



# Assignments

- Explain the differences between MIPS and DMIPS.
- Compare the major ARM processor families available today from the points of view of processing power, cost, applications. (Hint: focus on ARM11 and ARM Cortex series processors)
- Install the MDK-ARM Evaluation Version and compile and link the kit's demo software available from ST web site.
- Revision of C programming.
- Next week: Lab demonstration of kit and development tools