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# Introducción a los procesadores ARM Cortex-M4



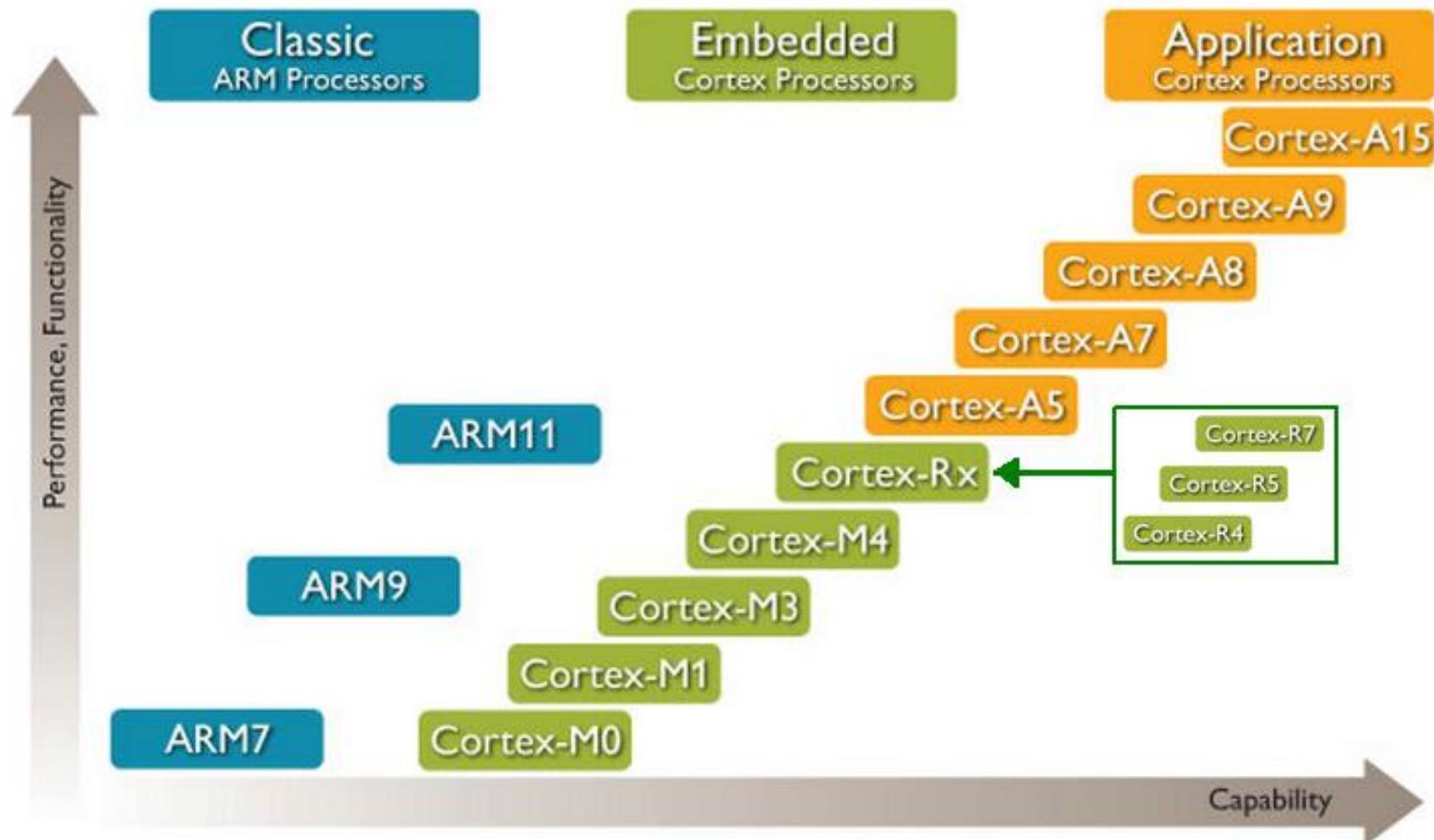
# Introducción a la familia ARM

- ARM siglas de "Advanced RISC Machines", empresa creada en 1990.
- Hasta ese momento las arquitecturas CISC, lideradas por Intel, habían dominado el mercado: familias x86, 8051...
- Actualmente las arquitecturas predominante son las RISC, debido a su simplicidad (lógica cableada, no microprogramado).
- Advanced RISC Machines no fabrica procesadores. Los diseña y licencia su diseño para ser fabricado por terceros.
- Actualmente los procesadores con núcleos ARM de 32 bits están presentes una gran cantidad de dispositivos.

# Introducción a la familia ARM

- **ARM7TDMI:** Game Boy Advance, Nintendo DS, Apple iPod, Lego MindStorm.
- **StrongARM:** Ipaq H36x0, HP Jornada 7xx, Jornada 560 serie
- **ARM9TDMI:** GP32, GP2X (ARM920T+ARM940T), Calculadoras HP-49/50, HTC TyTN (Samsung S3C2442) , TomTom (S3C2410)
- **ARM9E:** Nintendo DS, Nokia N-Gage, Sony Ericsson (K, W series), LG Arena
- **ARM11:** Nokia E90, N93, N95, E63, E71, 5800, E51, 6210 Navigator, E75, N97, N81... HTC Dream, Magic, Hero... Apple iPhone (EDGE y 3G), iPod touch (1ra y 2da gen.)
- **Cortex A8 (600Mhz-1Ghz):** iPod touch (3rd Gen.), iPad, iPhone 4.
- **Cortex A9 (hasta 2GHz):** Tablets con procesadores multi-núcleo, servidores de disco (NAS), routers/switchs de alta prestaciones...

# Familia ARM en la actualidad



# Introducción a la familia ARM (4)

- Algunos fabricantes de semiconductores:
  - **ATMEL**: Familias SAM3 (MCU) y SAM9 (MPU)
  - **NXP**: LPC1300, LPC1700 y LPC1800 (Cortex M3), LPC2100, LPC2200 y LPC2300 (ARM7), LPC2900 (ARM9)
  - **Texas Instruments**: Stellaris (Cortex M3 MCU).
  - **ST Microelectronics**: STM32 (Cortex M4)
  - **ACTEL**: SmartFusion FPGA con Cortex-M3 incorporado.
  - **Altera**: Stratix 10, Arria V y Cyclone V (Cortex A9).
  - **Xilinx**: Familia Zynq (Cortex A9 dual core).

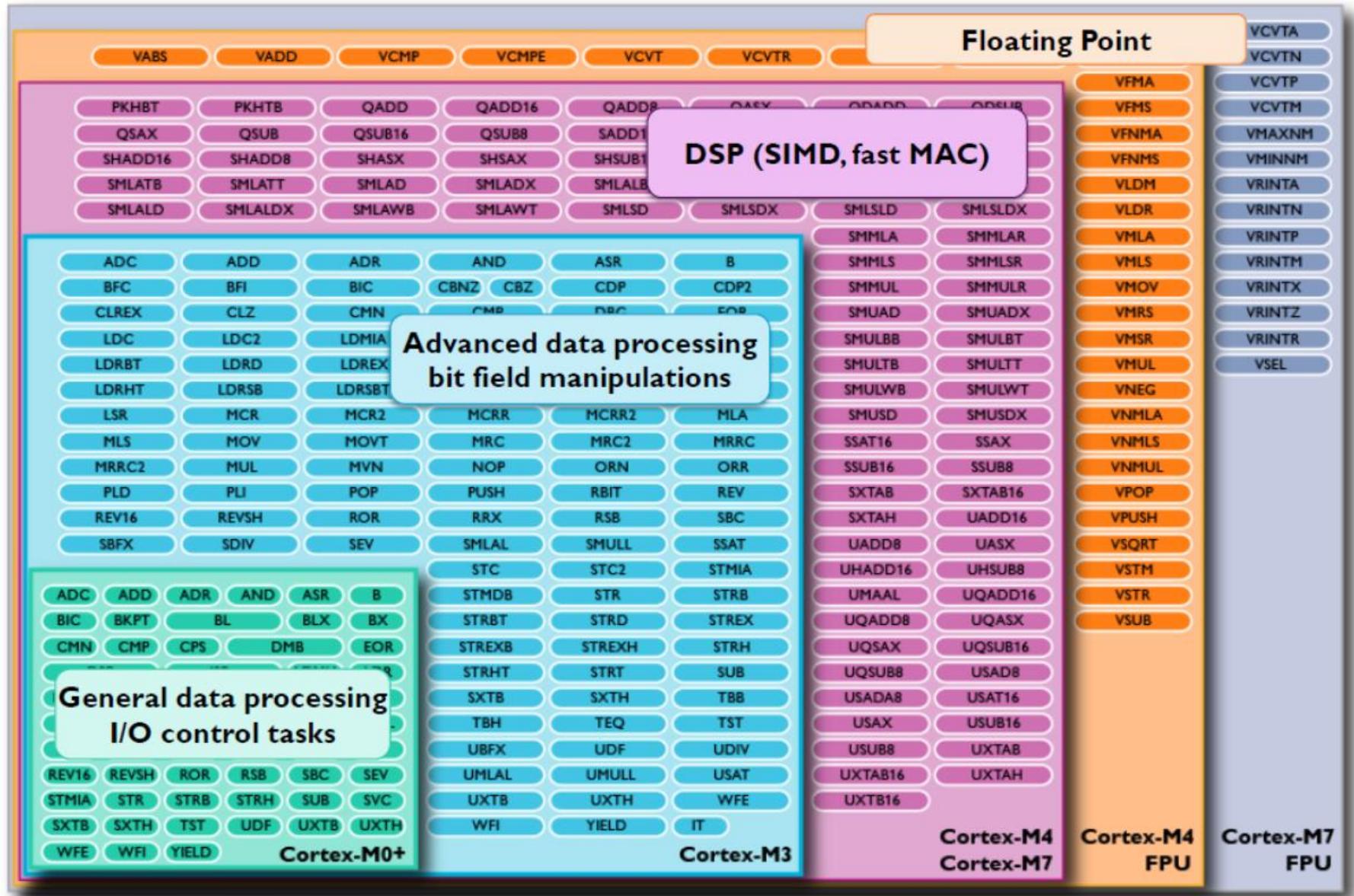
# La familia Cortex-M

- Vamos a utilizar microcontroladores de 32 bits de la familia ARM Cortex-M4.
- En concreto los CM4 de la familia STM32 (STM32F407).
- Los Cortex-Mx han evolucionado en su arquitectura y rendimiento.

ARM Cortex-M Instruction sets<sup>[6][7]</sup>

ARM Cortex-M	Thumb	Thumb-2	Hardware multiply	Hardware divide	Saturated math	DSP extensions	Floating-Point Unit (FPU)	ARM architecture
Cortex-M0 <sup>[1]</sup>	Entire	Subset	1 or 32 cycle	No	No	No	No	ARMv6-M
Cortex-M0+ <sup>[2]</sup>	Entire	Subset	1 or 32 cycle	No	No	No	No	ARMv6-M
Cortex-M1 <sup>[3]</sup>	Entire	Subset	3 or 33 cycle	No	No	No	No	ARMv6-M
Cortex-M3 <sup>[4]</sup>	Entire	Entire	1 cycle	Yes	Yes	No	No	ARMv7-M
Cortex-M4 <sup>[5]</sup>	Entire	Entire	1 cycle	Yes	Yes	Yes	Optional, SP	ARMv7E-M
Cortex-M7	Entire	Entire	1 cycle	Yes	Yes	Yes	Optional, SP, or SP & DP	ARMv7E-M

# Juegos de instrucciones en Cortex M



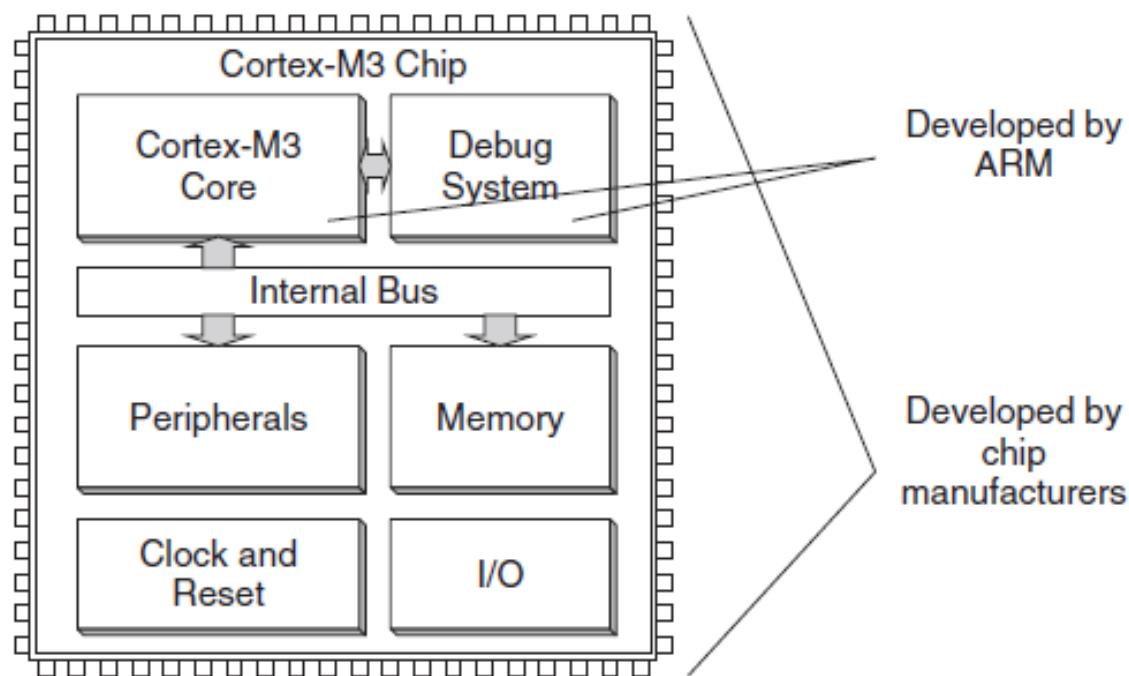
# Cortex-M feature set comparison



	Cortex-M0	Cortex-M3	Cortex-M4
Architecture Version	V6M	v7M	v7ME
Instruction set architecture	Thumb, Thumb-2 System Instructions	Thumb + Thumb-2	Thumb + Thumb-2, DSP, SIMD, FP
DMIPS/MHz	0.9	1.25	1.25
Bus interfaces	1	3	3
Integrated NVIC	Yes	Yes	Yes
Number interrupts	1-32 + NMI	1-240 + NMI	1-240 + NMI
Interrupt priorities	4	8-256	8-256
Breakpoints, Watchpoints	4/2/0, 2/1/0	8/4/0, 2/1/0	8/4/0, 2/1/0
Memory Protection Unit (MPU)	No	Yes (Option)	Yes (Option)
Integrated trace option (ETM)	No	Yes (Option)	Yes (Option)
Fault Robust Interface	No	Yes (Option)	No
Single Cycle Multiply	Yes (Option)	Yes	Yes
Hardware Divide	No	Yes	Yes
WIC Support	Yes	Yes	Yes
Bit banding support	No	Yes	Yes
Single cycle DSP/SIMD	No	No	Yes
Floating point hardware	No	No	Yes
Bus protocol	AHB Lite	AHB Lite, APB	AHB Lite, APB
CMSIS Support	Yes	Yes	Yes

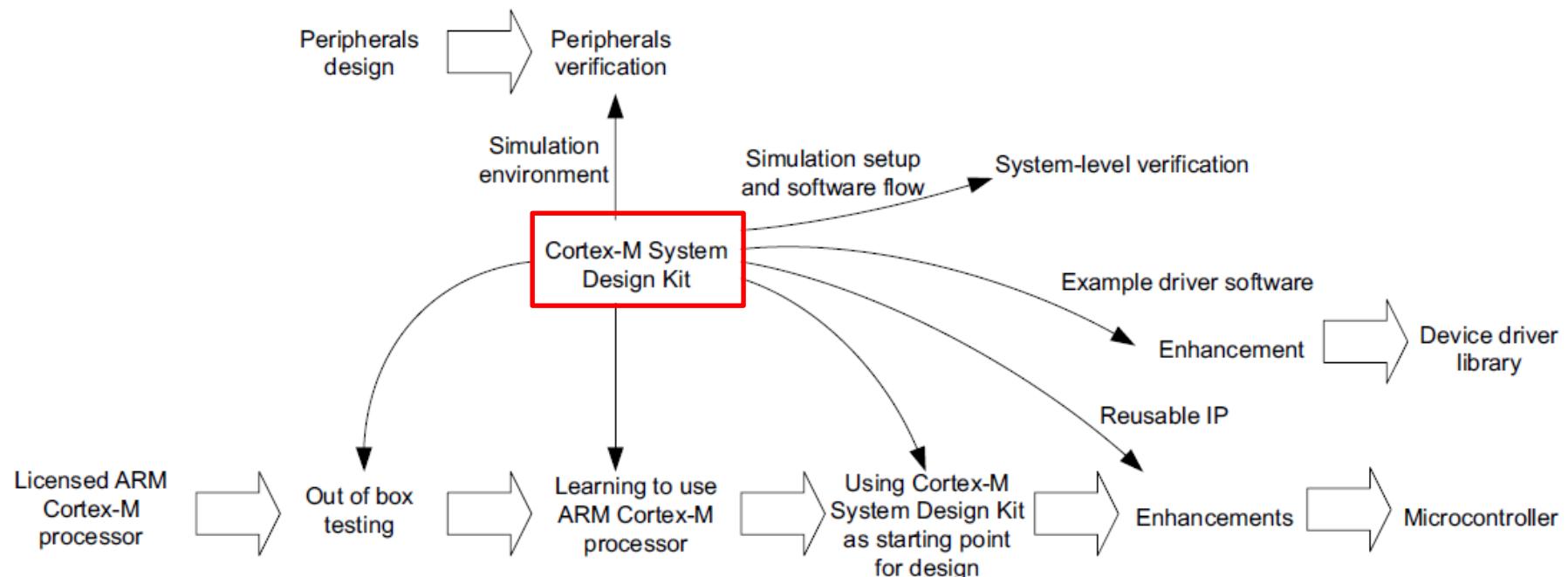
# Cortex-Mx

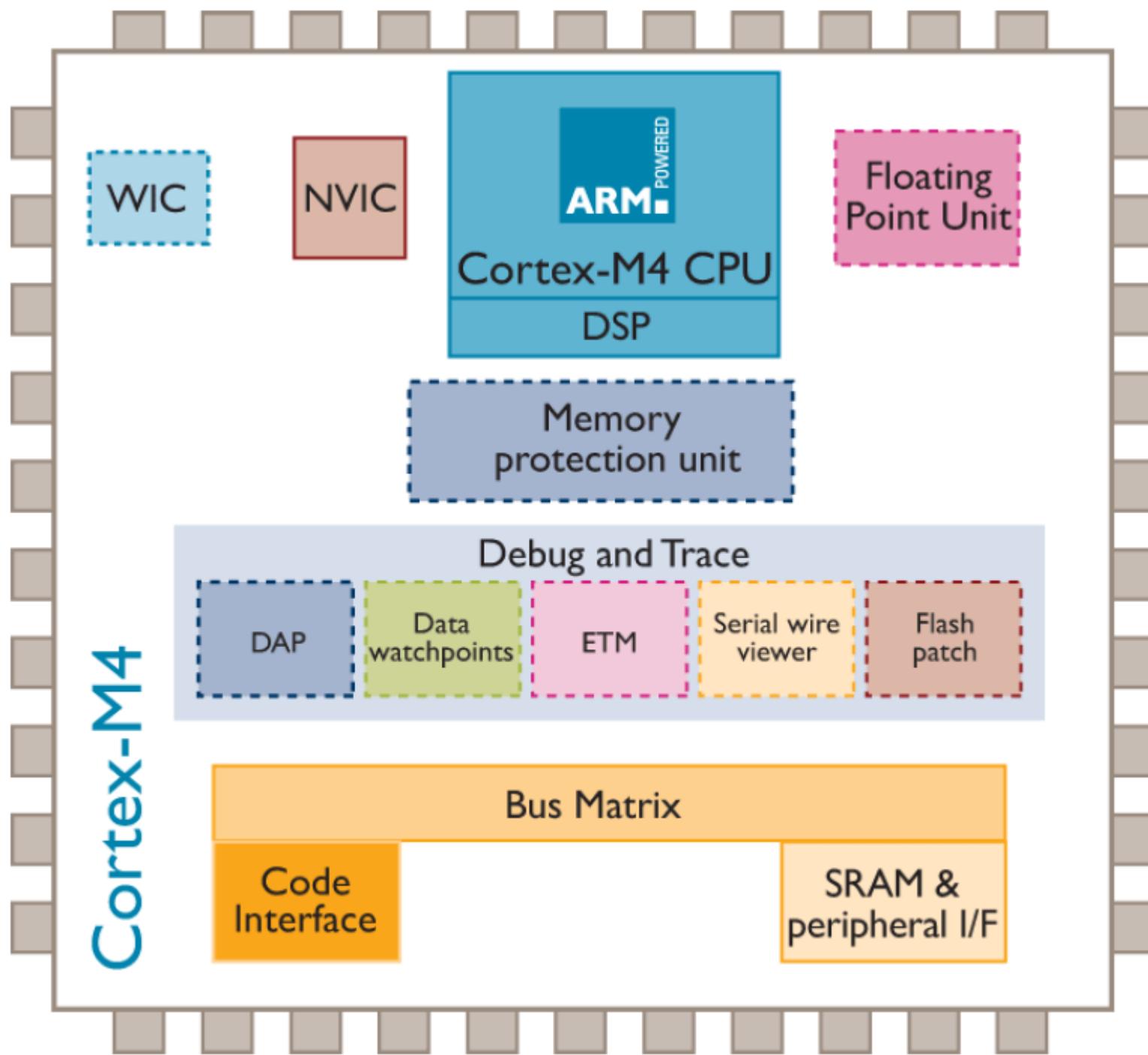
- El core Cortex-Mx es propietario de ARM y similar en los procesadores de los distintos fabricantes.
- Sin embargo, los periféricos son específicos de cada fabricante / familia. (GPIO, Timers, ADC, Relojes...)

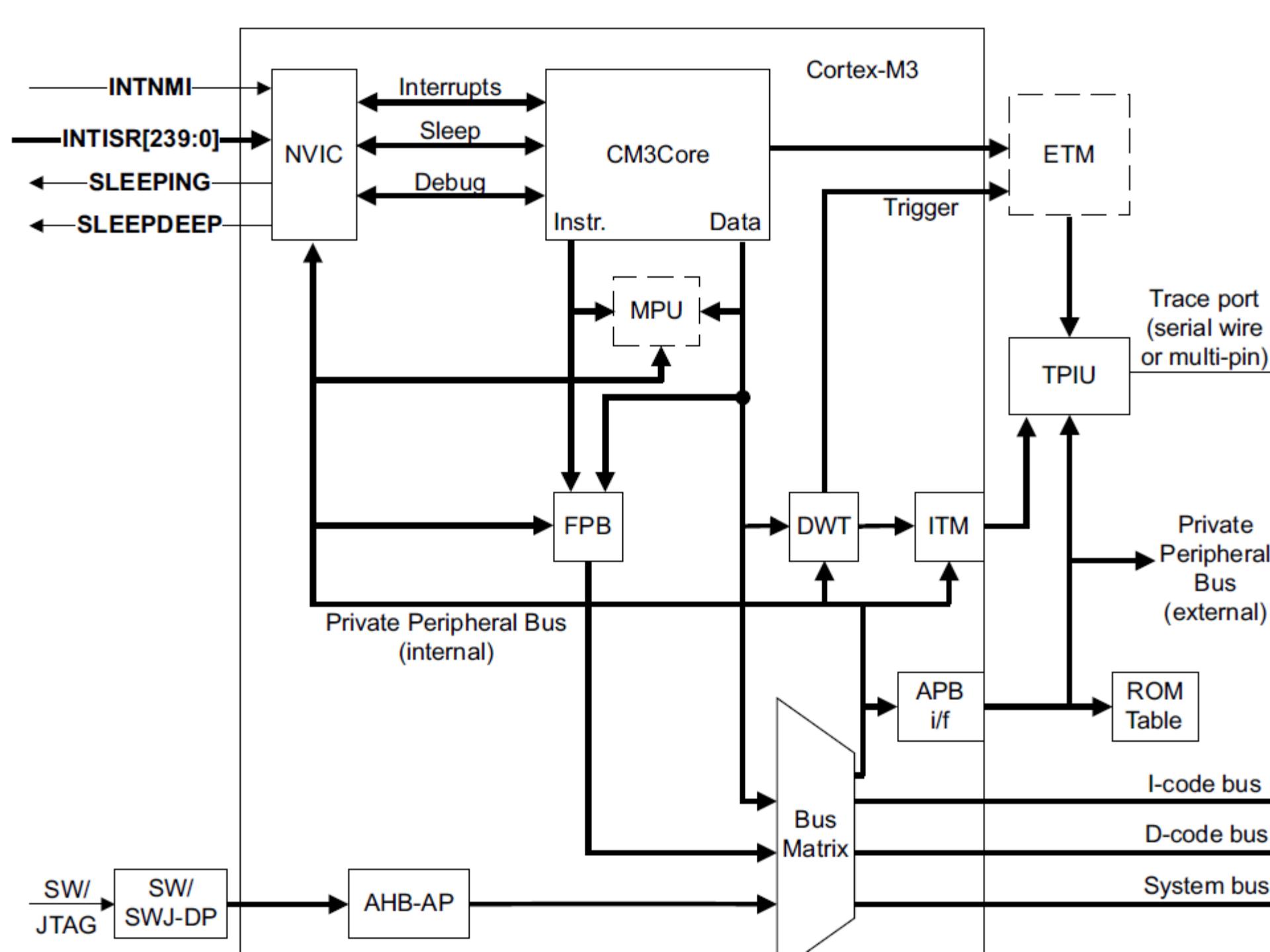


# Proceso de Diseño

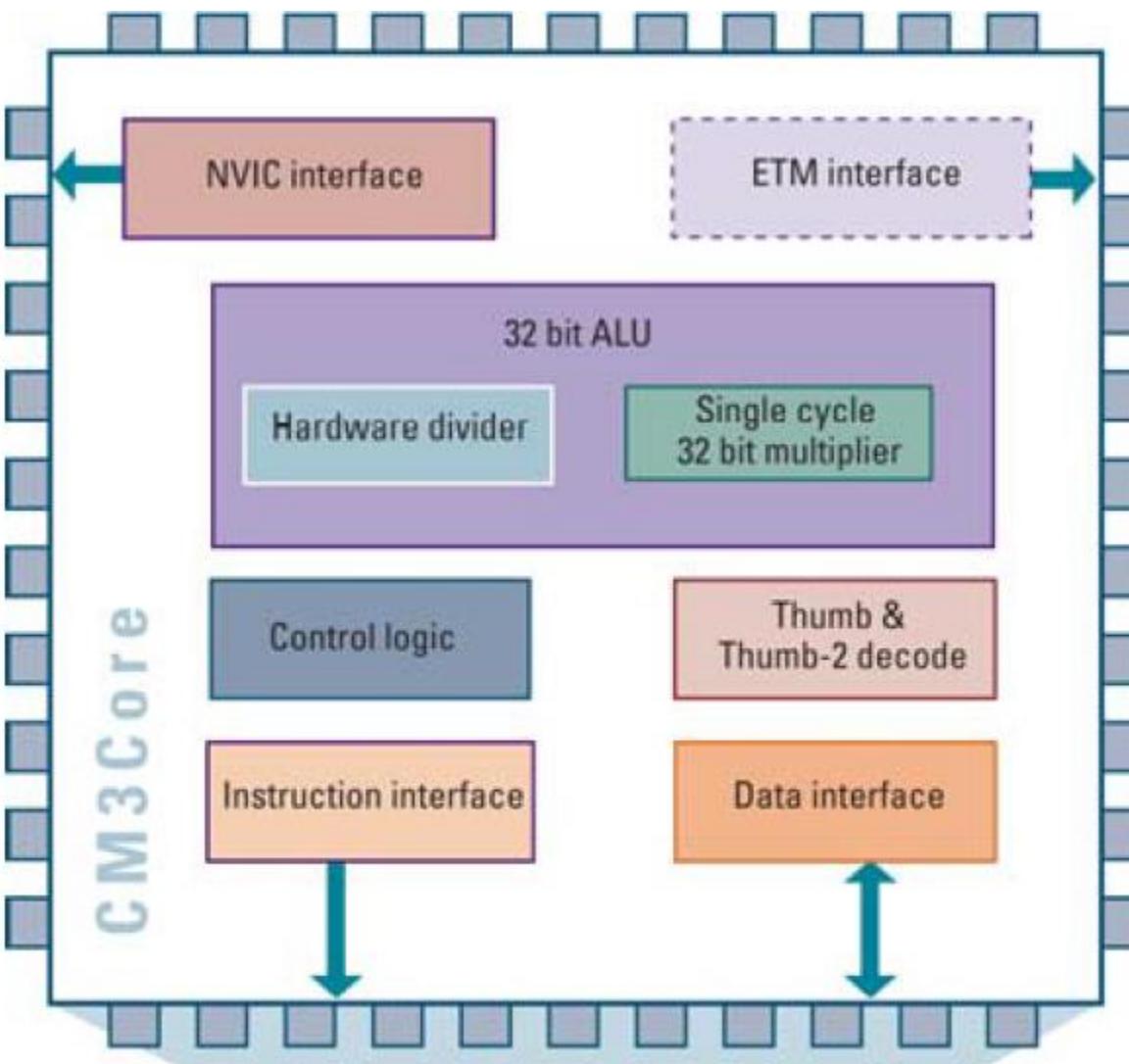
Figure 1-1 shows the use of the design kit in various stages of a design process.



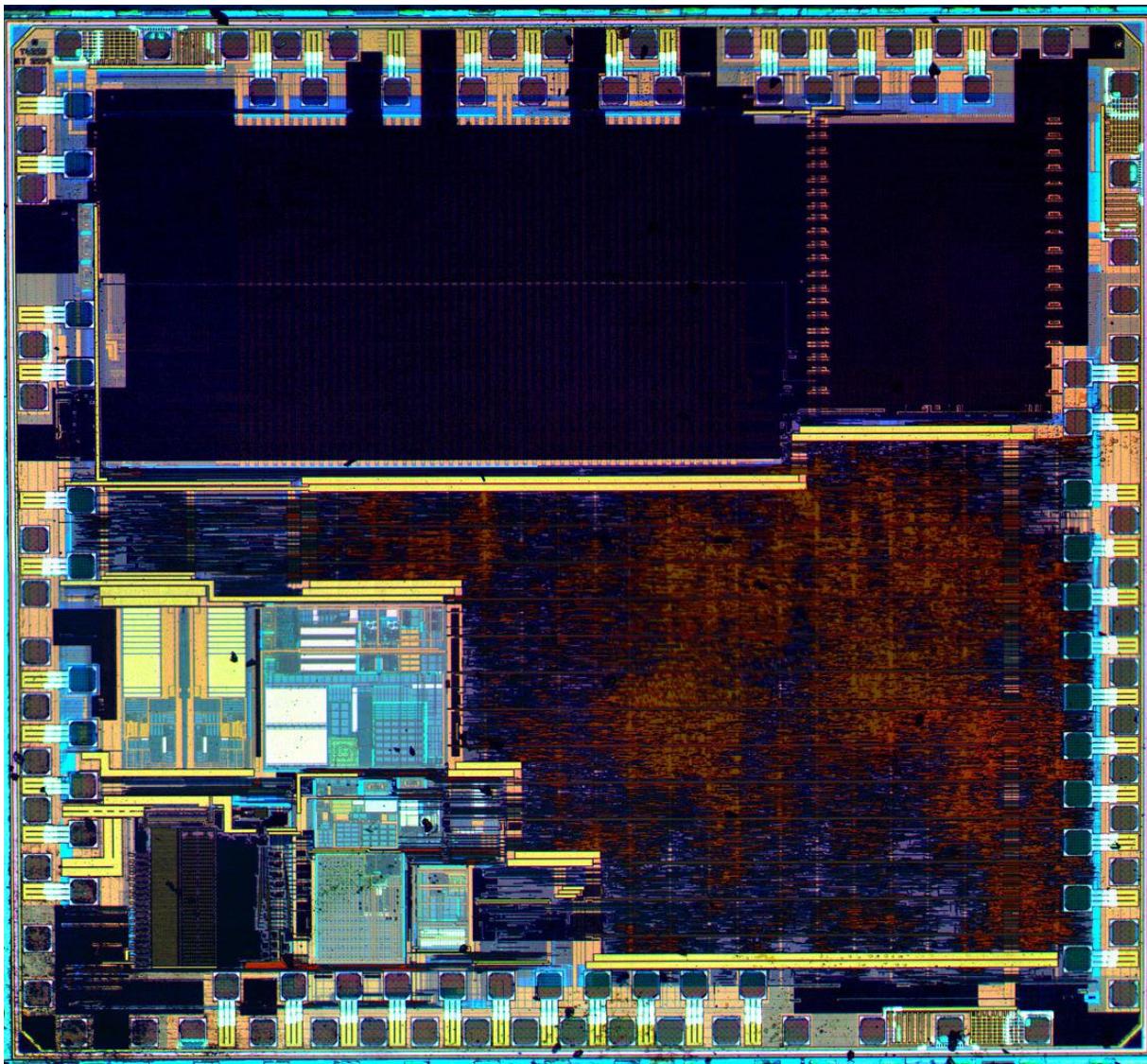




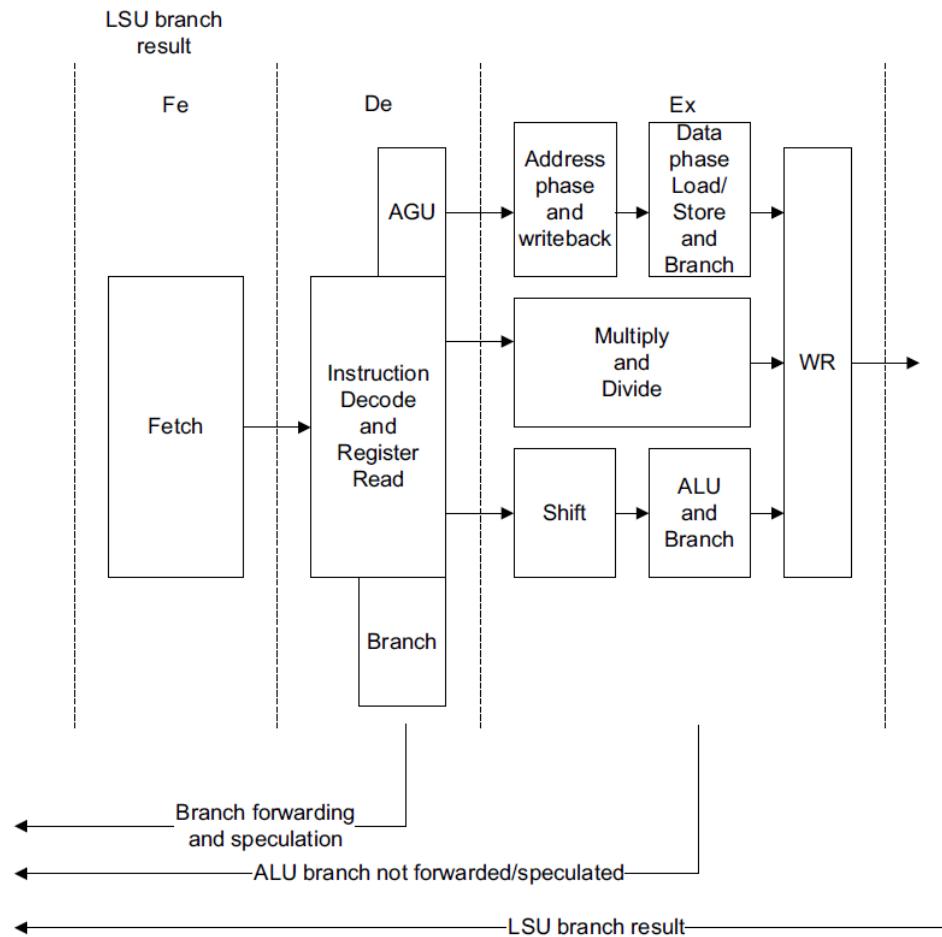
# En el interior del Cortex



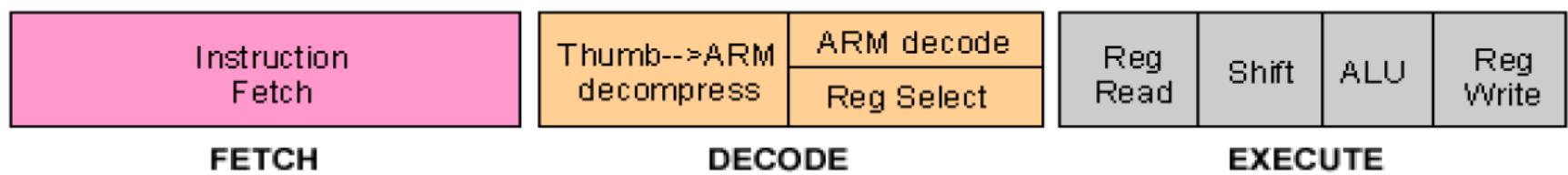
# STM32F103 Die



# Pipeline en el Cortex M3

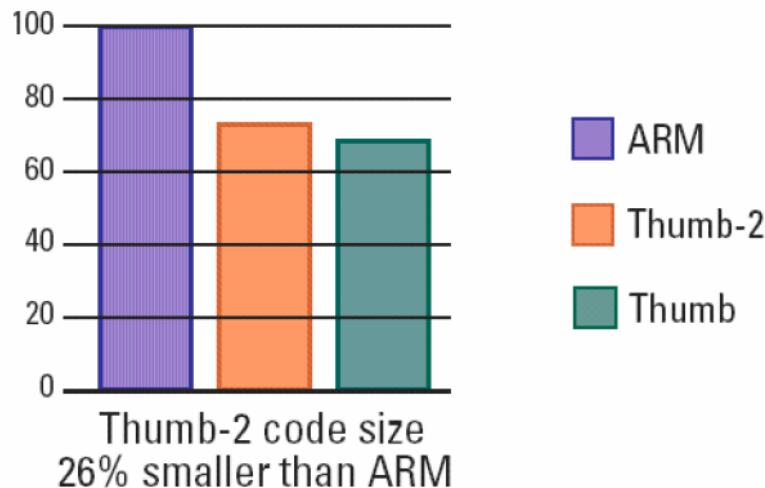
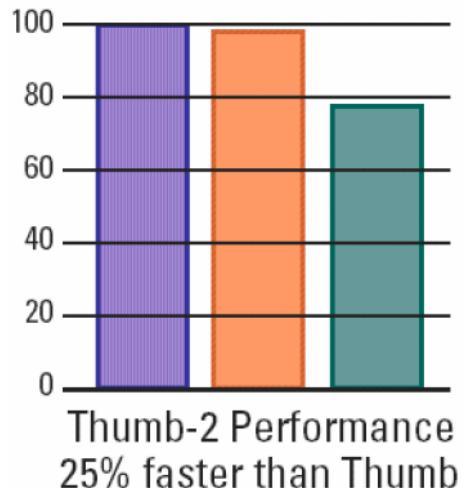


**ARM7TDMI - Pipeline**



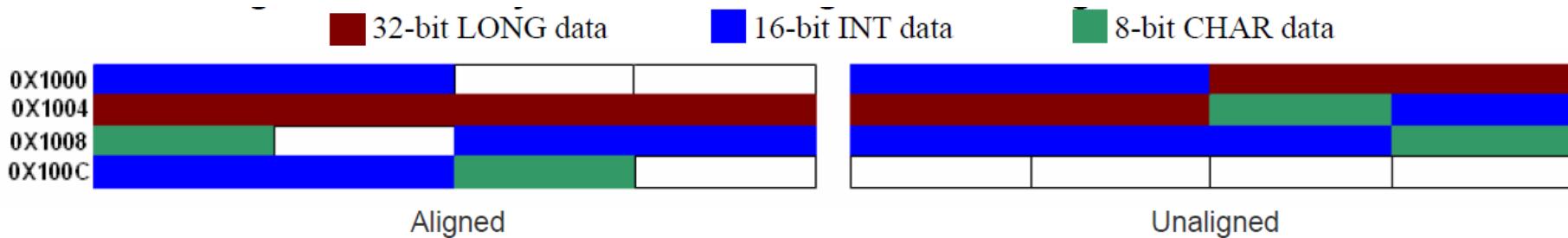
# Instrucciones Thumb y Thumb-2

- Las instrucciones en los Cortex ocupan 32 bits.
- Se necesitan 4 bytes por instrucción: **baja densidad de código**.
- Un mismo programa ocupa **4 veces más** para un Cortex que para un 8051.
- Se introduce un nuevo juego de **instrucciones de 16 bits**, las instrucciones Thumb, para mejorar la densidad de código.
- Actualmente soportan el juego de instrucciones Thumb-2: **combinan instrucciones de 32 y 16 bits**.
- El introducir estos juegos de instrucciones implica un descenso del rendimiento: **latencia de descodificación**.

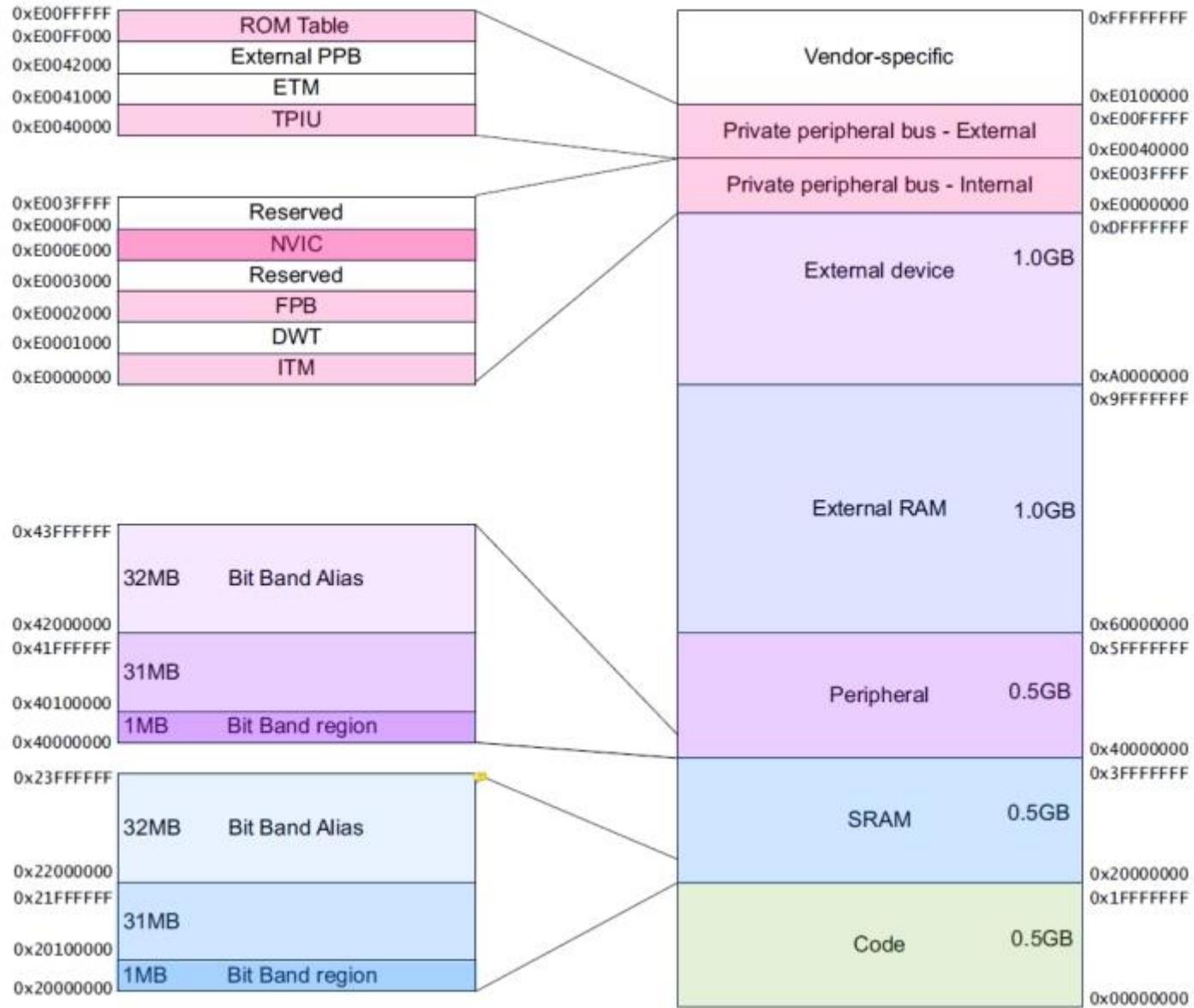


# Alineación memoria de datos

- Los ARM no permiten el acceso a memoria de datos desalineado, todos los datos ocupan **bloques de 16 bits**.
- Por ejemplo, un char ocupa 16 bits aunque sólo use 8 bits.
- En el marco de los sistemas empotrados **se desperdicia mucha memoria de datos**.
- Los Cortex implementan un **acceso desalineado a memoria**.
- Permite el **empaqueado de los datos**, mejorando la densidad datos en memoria.

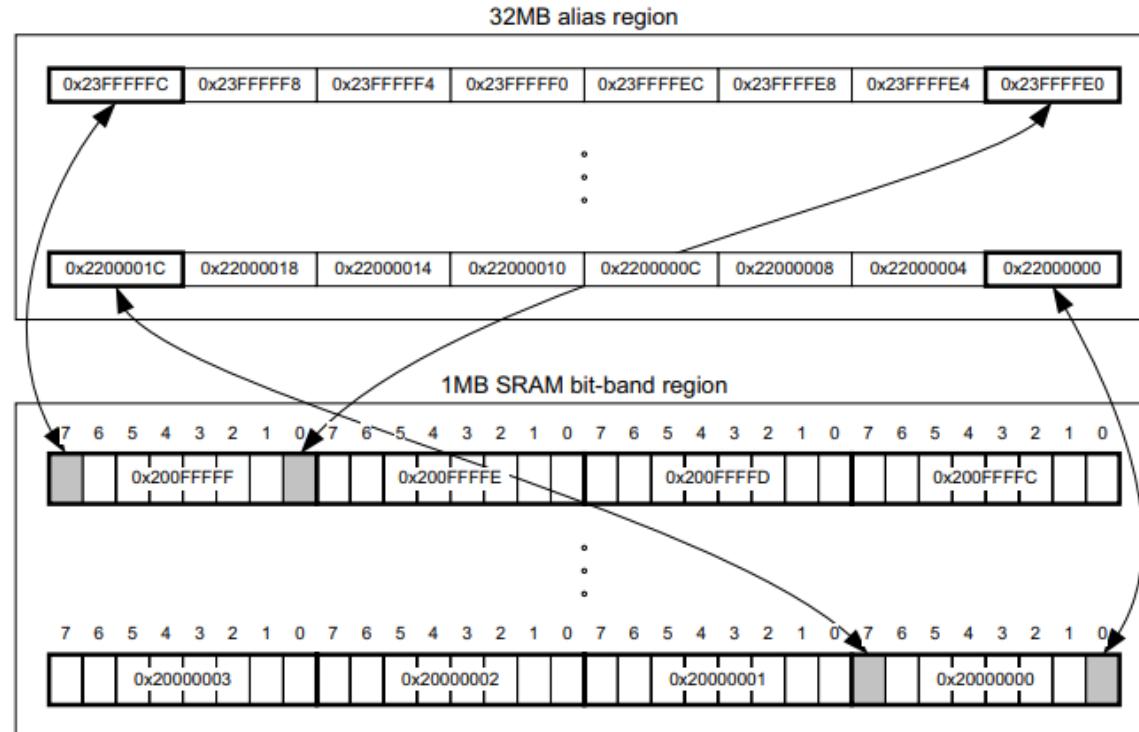


# Mapa de memoria



# Bit-band Mapping

- Se reservan dos regiones bit-band.
- Se permite el direccionamiento de bits individuales de una palabra de 8 bits mediante alias.
- Ejemplo: Podemos acceder a una palabra completa de 8 bits en la dirección 0x20000000 o a su LSB en la “dirección alias” 0x22000000.

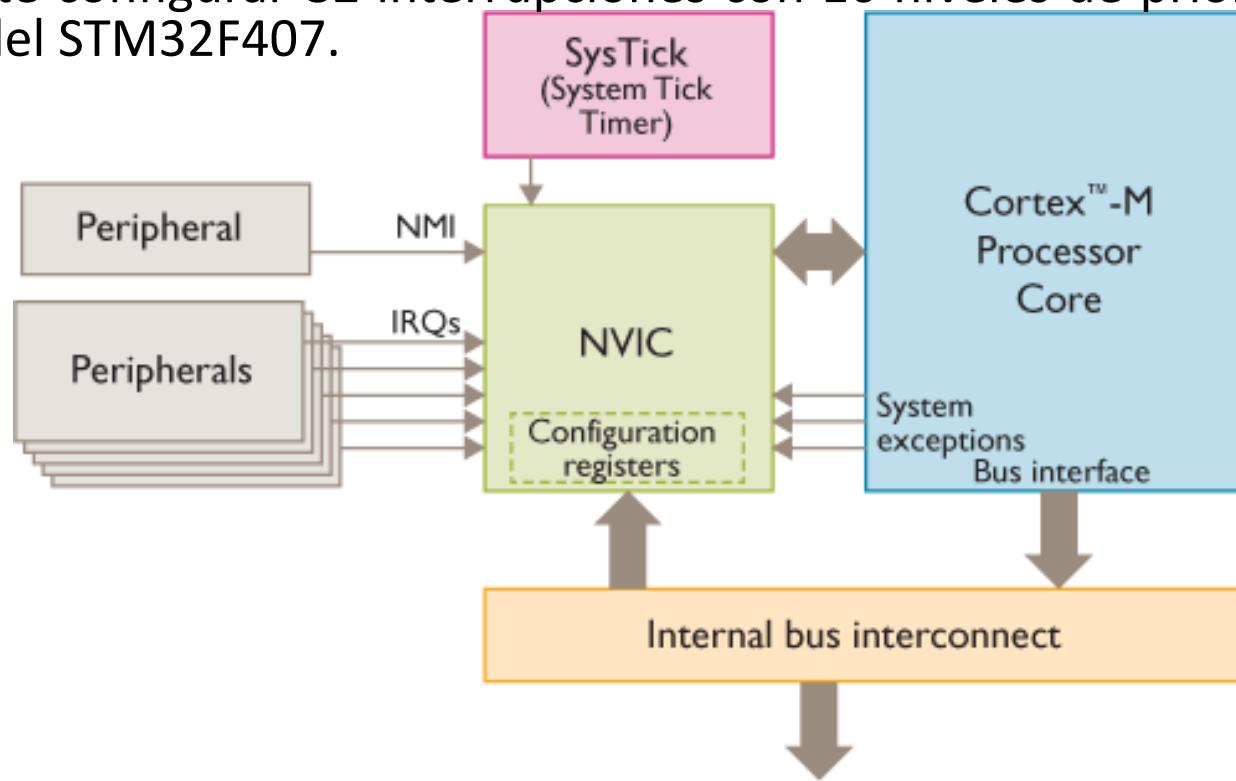


# Componentes Sistema Cortex M4

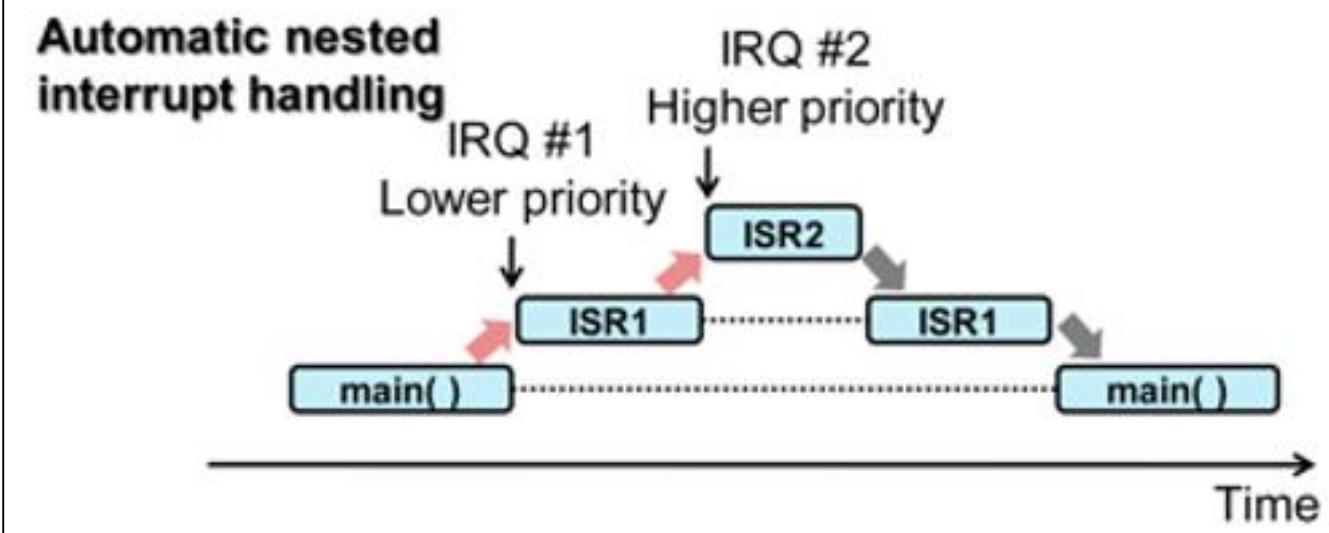
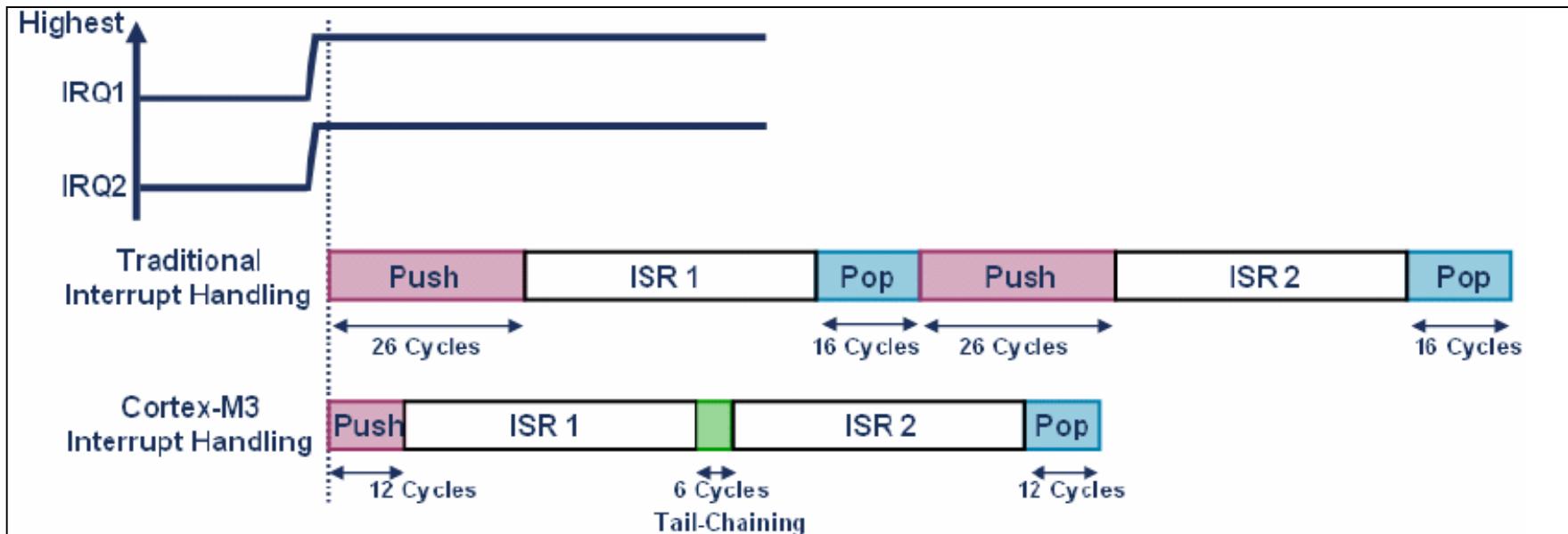
- **Nested Vectored Interrupt Controller:**
  - Controlador de interrupciones vectorizadas anidadas, permitiendo fijar diferentes niveles de prioridad.
- **System Control Block:**
  - Información de implementación y de control del sistema, incluyendo configuración, control y reporte de excepciones.
- **Memory Protection Unit:**
  - Define atributos para diferentes regiones de la memoria.
- **Systick (24 bits countdown counter):**
  - Contador decreciente de 24 bits que puede ser utilizado como tick del sistema en los RTOS, o como un simple timer.

# NVIC: Nested Vector Interrupt Controller

- El controlador de interrupciones está **integrado en el núcleo del Cortex**.
- Permite asignar a cada interrupción **un nivel de prioridad**.
- Las interrupciones más prioritarias “interrumpen” a las de menos prioridad: **interrupciones anidadas**.
- **Control de excepciones**: Interrupciones disparadas por el propio Cortex.
- Permite configurar 82 interrupciones con 16 niveles de prioridad en el caso del STM32F407.



# Interrupciones: cambio en caliente y anidamiento



# Interrupciones del sistema (excepciones)

Position	Priority	Type of priority	Acronym	Description	Address
	-	-	-	Reserved	0x0000 0000
	-3	fixed	Reset	Reset	0x0000 0004
	-2	fixed	NMI	Non maskable interrupt. The RCC Clock Security System (CSS) is linked to the NMI vector.	0x0000 0008
	-1	fixed	HardFault	All class of fault	0x0000 000C
	0	settable	MemManage	Memory management	0x0000 0010
	1	settable	BusFault	Pre-fetch fault, memory access fault	0x0000 0014
	2	settable	UsageFault	Undefined instruction or illegal state	0x0000 0018
	-	-	-	Reserved	0x0000 001C - 0x0000 002B
	3	settable	SVCall	System service call via SWI instruction	0x0000 002C
	4	settable	Debug Monitor	Debug Monitor	0x0000 0030
	-	-	-	Reserved	0x0000 0034
	5	settable	PendSV	Pendable request for system service	0x0000 0038
	6	settable	SysTick	System tick timer	0x0000 003C

# Interrupciones de los periféricos

Table 46. Vector table for STM32F42xxx and STM32F43xxx

Position	Priority	Type of priority	Acronym	Description	Address
33	40	settable	I2C2_EV	I <sup>2</sup> C2 event interrupt	0x0000 00C4
34	41	settable	I2C2_ER	I <sup>2</sup> C2 error interrupt	0x0000 00C8
35	42	settable	SPI1	SPI1 global interrupt	0x0000 00CC
36	43	settable	SPI2	SPI2 global interrupt	0x0000 00D0
37	44	settable	USART1	USART1 global interrupt	0x0000 00D4
38	45	settable	USART2	USART2 global interrupt	0x0000 00D8
39	46	settable	USART3	USART3 global interrupt	0x0000 00DC
40	47	settable	EXTI15_10	EXTI Line[15:10] interrupts	0x0000 00E0
41	48	settable	RTC_Alarm	RTC Alarms (A and B) through EXTI line interrupt	0x0000 00E4
42	49	settable	OTG_FS WKUP	USB On-The-Go FS Wakeup through EXTI line interrupt	0x0000 00E8
43	50	settable	TIM8_BRK_TIM12	TIM8 Break interrupt and TIM12 global interrupt	0x0000 00EC
44	51	settable	TIM8_UP_TIM13	TIM8 Update interrupt and TIM13 global interrupt	0x0000 00F0

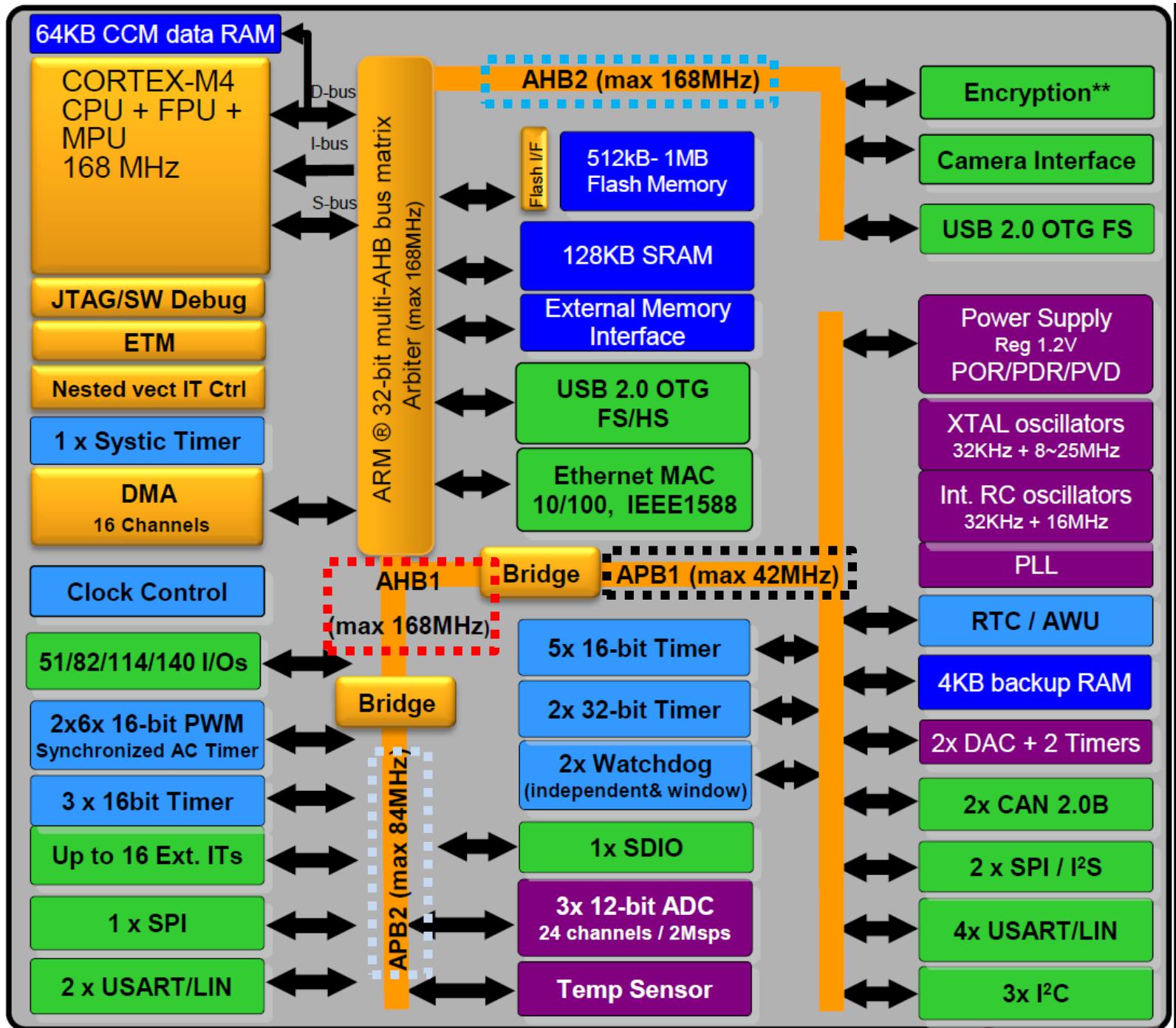
# Características de STM32F407

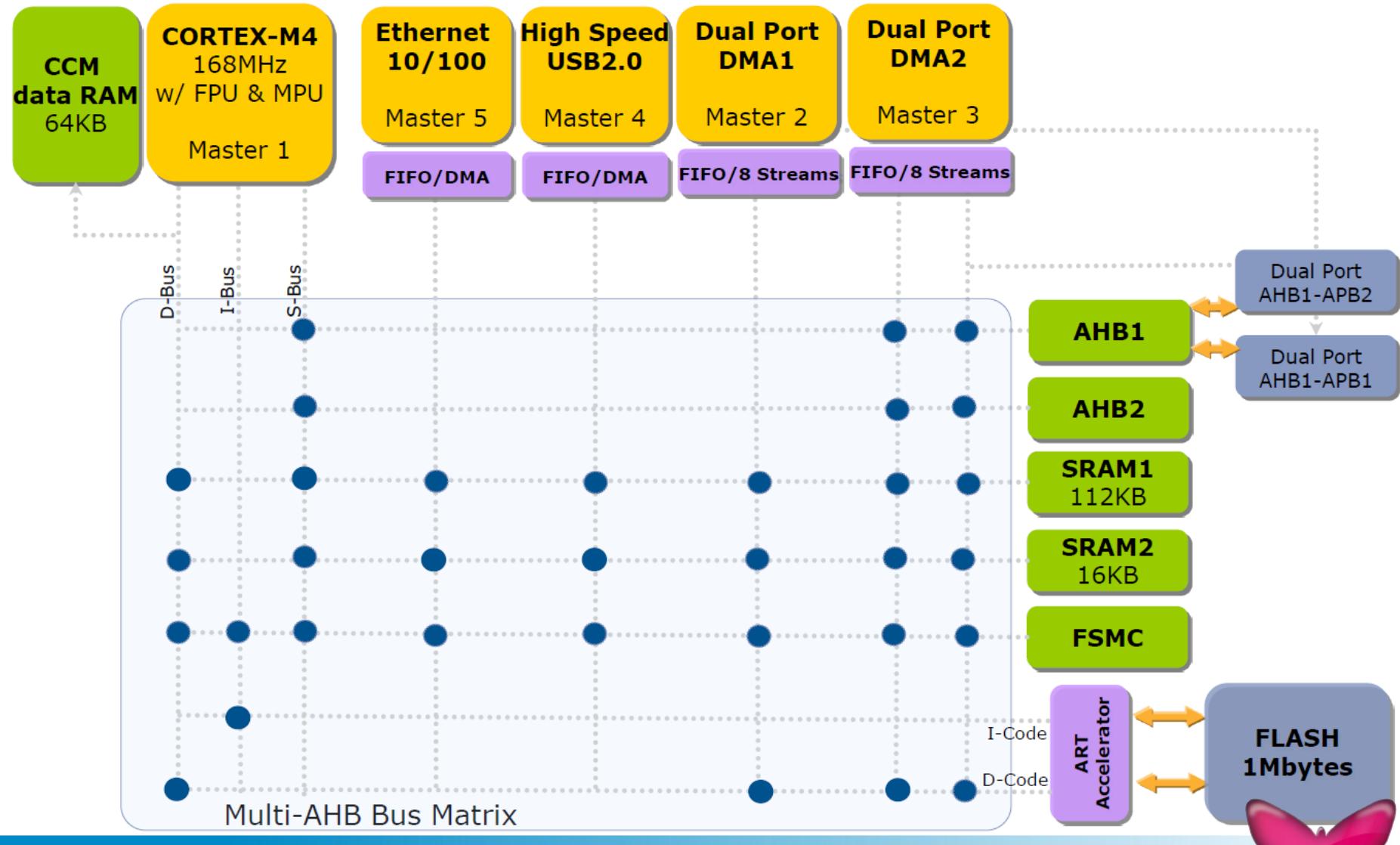
- Es el **Cortex-M4** de STMicroelectronics, puede funcionar hasta **168MHz**, con una eficiencia de **210DMIPS**.
- **Memoria:**
  - 1MBytes de memoria flash.
  - 192kBytes de memoria SRAM.
  - Controlador de memoria externa para ampliaciones con flash, SRAM...
- **GPIO:** dependiendo del encapsulado, entre 50 y 140 pines de GPIO.
- **ADC:** 3 conversores de 12 bits de 16 canales. Individualmente alcanzan 2.1MSPS, en modo intercalado hasta 7.2MSPS.
- **DAC:** 2 conversores de 12 bits.
- **DMA:** 2 controladores de DMA con 16 canales cada uno.
- **Timers:** 17 timers de 16 y 32 bits
- **Interfaces de comunicación:**
  - 3 puertos I2C, 4 puertos serie asíncronos (USART), 3 puertos SPI, 2 interfaces CAN, Interfaz para tarjeta SD (SDIO).
- Interfaz paralelo para **LCD gráfico** (8080/6800).
- Puerto **USB Full-Speed OTG** integrado, con un PHY-USB (ULPI) externo puede implementar **USB High-Speed**.
- Nivel **MAC Ethernet** integrado, necesita el nivel PHY externo.
- Interfaz de cámara digital de 8/14 bits hasta 54Mbytes/s (**DCIM**).

# Características de STM32F407

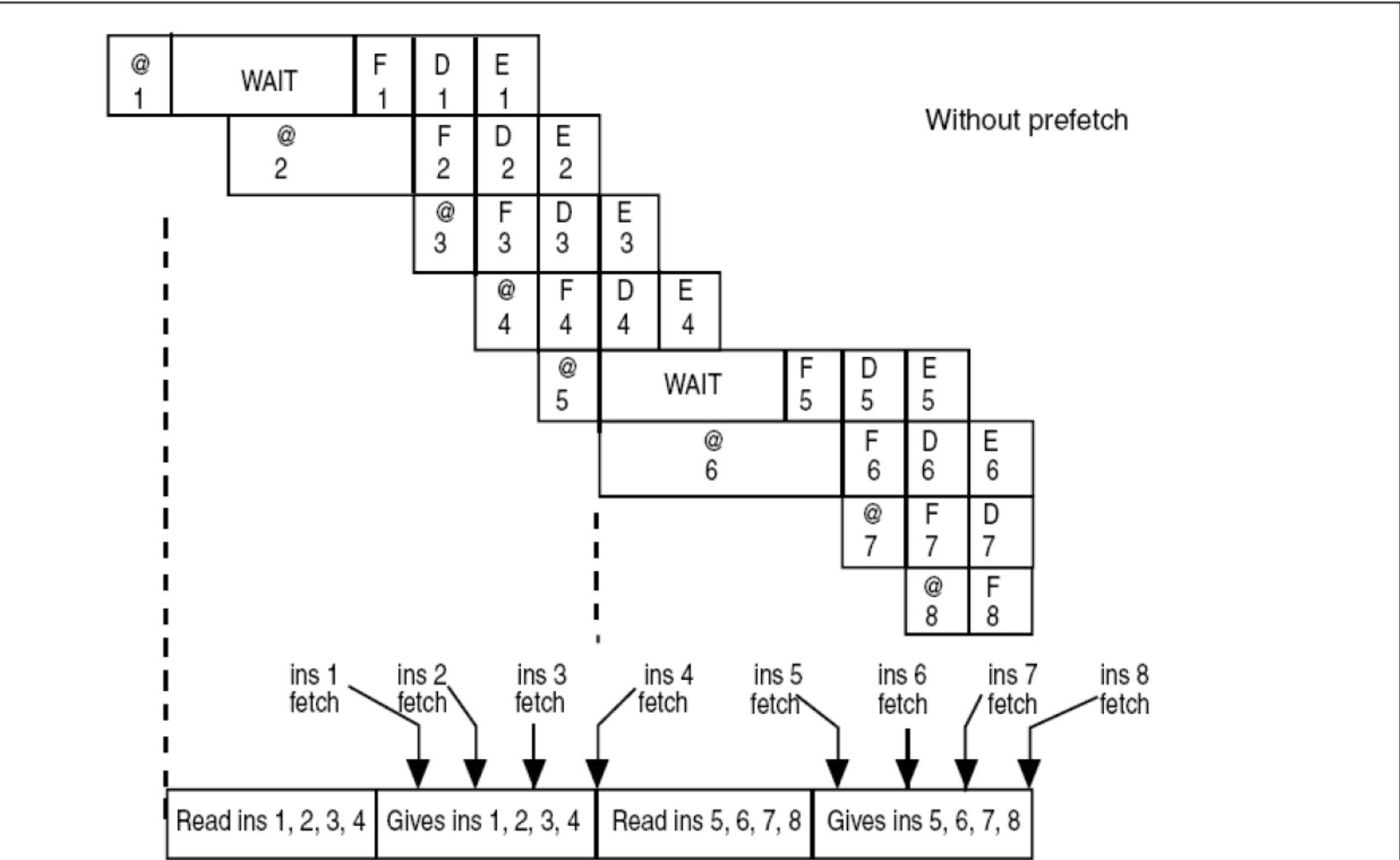
Table 2. STM32F405xx and STM32F407xx: features and peripheral counts

Peripherals	STM32F405RG	STM32F405VG	STM32F405ZG	STM32F407Vx	STM32F407Zx	STM32F407Ix
Flash memory in Kbytes	1024			512	1024	512
SRAM in Kbytes	System			192(112+16+64)		
	Backup			4		
FSMC memory controller	No			Yes		
Ethernet		No			Yes	
Timers	General-purpose			10		
	Advanced-control			2		
	Basic			2		
Random number generator				Yes		
Communication interfaces	SPI / I <sup>2</sup> S			3/2 (full duplex)		
	I <sup>2</sup> C			3		
	USART/UART			4/2		
	USB OTG FS		No		Yes	
	USB OTG HS		Yes		Yes	
	CAN			2		
Camera interface		No			Yes	
GPIOs	51	82	114	82	114	140
12-bit ADC				3		
Number of channels	16	16	24	16	24	24
12-bit DAC				Yes		
Number of channels				2		
Maximum CPU frequency				168 MHz		
Operating voltage				1.8 to 3.6 V <sup>(1)</sup>		

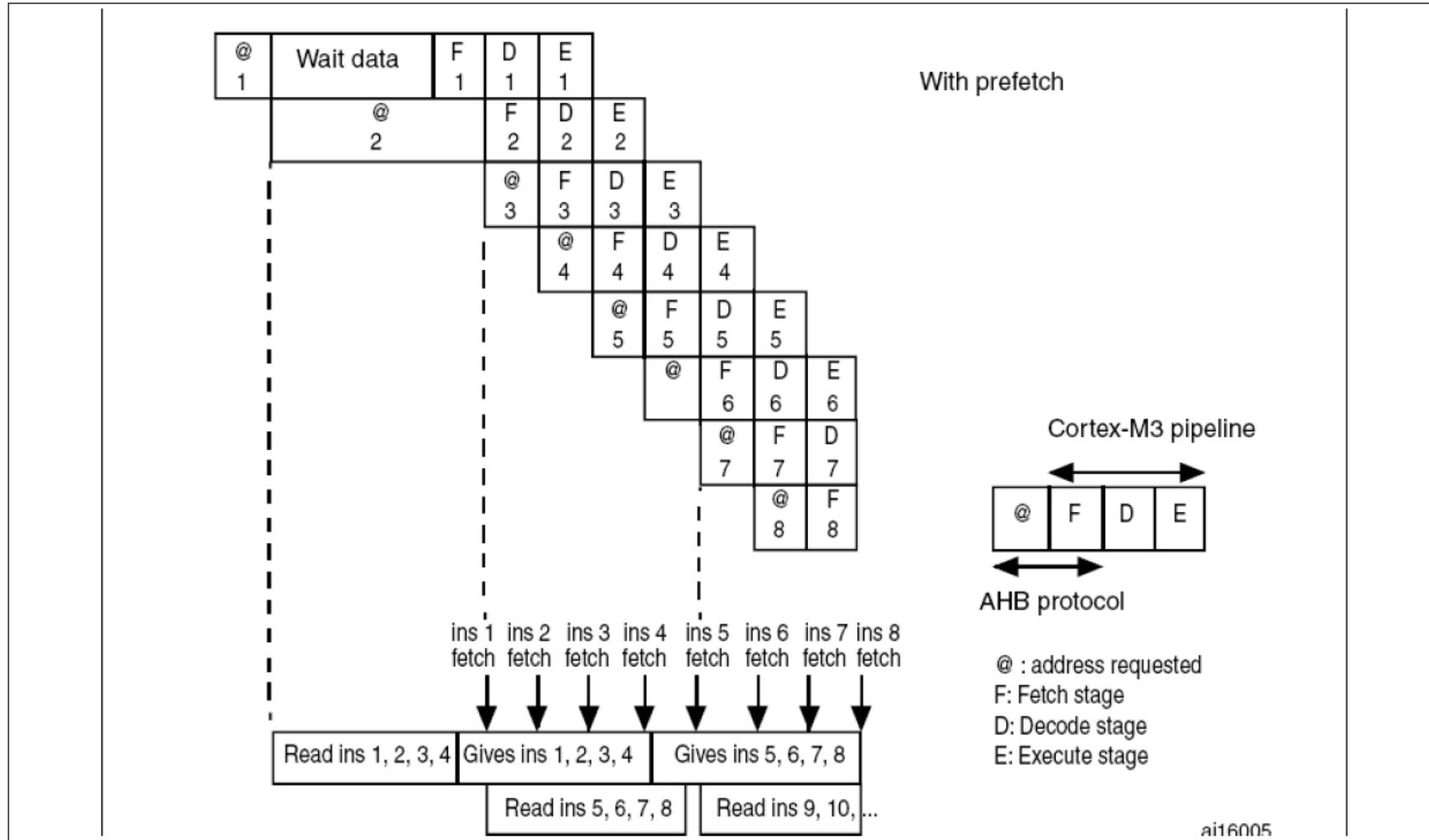




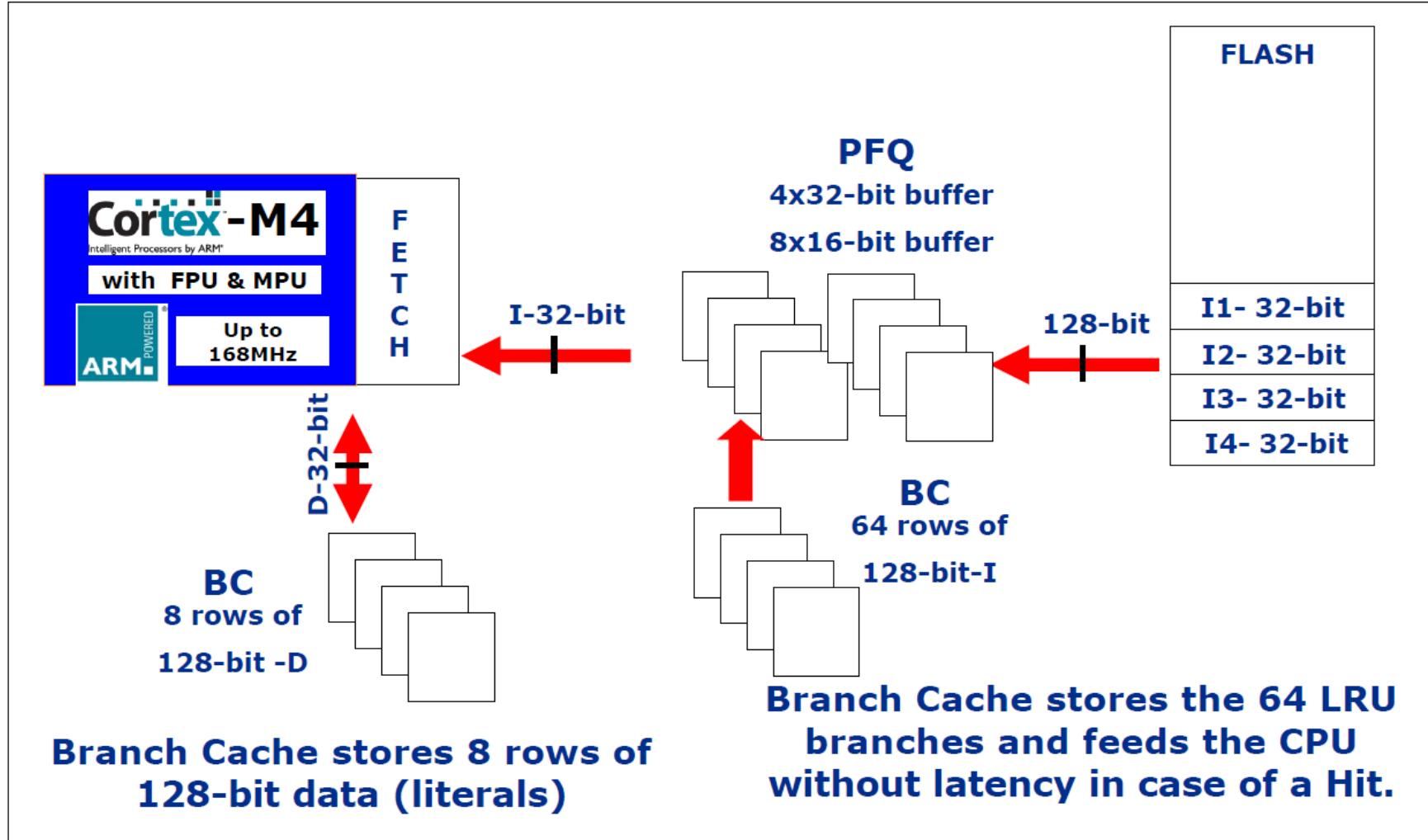
# System Architecture – Flash performance



# System Architecture – Flash performance



# System Architecture – Role of the ART accelerator



# System Architecture - Bootloader



BOOT Mode Selection Pins		Boot Mode	Aliasing
BOOT1	BOOT0		
X	0	Flash memory	Main Flash memory is selected as boot space
0	1	System memory	System memory is selected as boot space
1	1	Embedded SRAM	Embedded SRAM is selected as boot space

- The **Bootloader** supports
  - USART1(PA9/PA10)
  - USART3(PC10/PC11 or PB10/PB11)
  - CAN2(PB5/PB13)
  - USB OTG FS in Device mode (PA11/PA12) through DFU (device firmware upgrade)

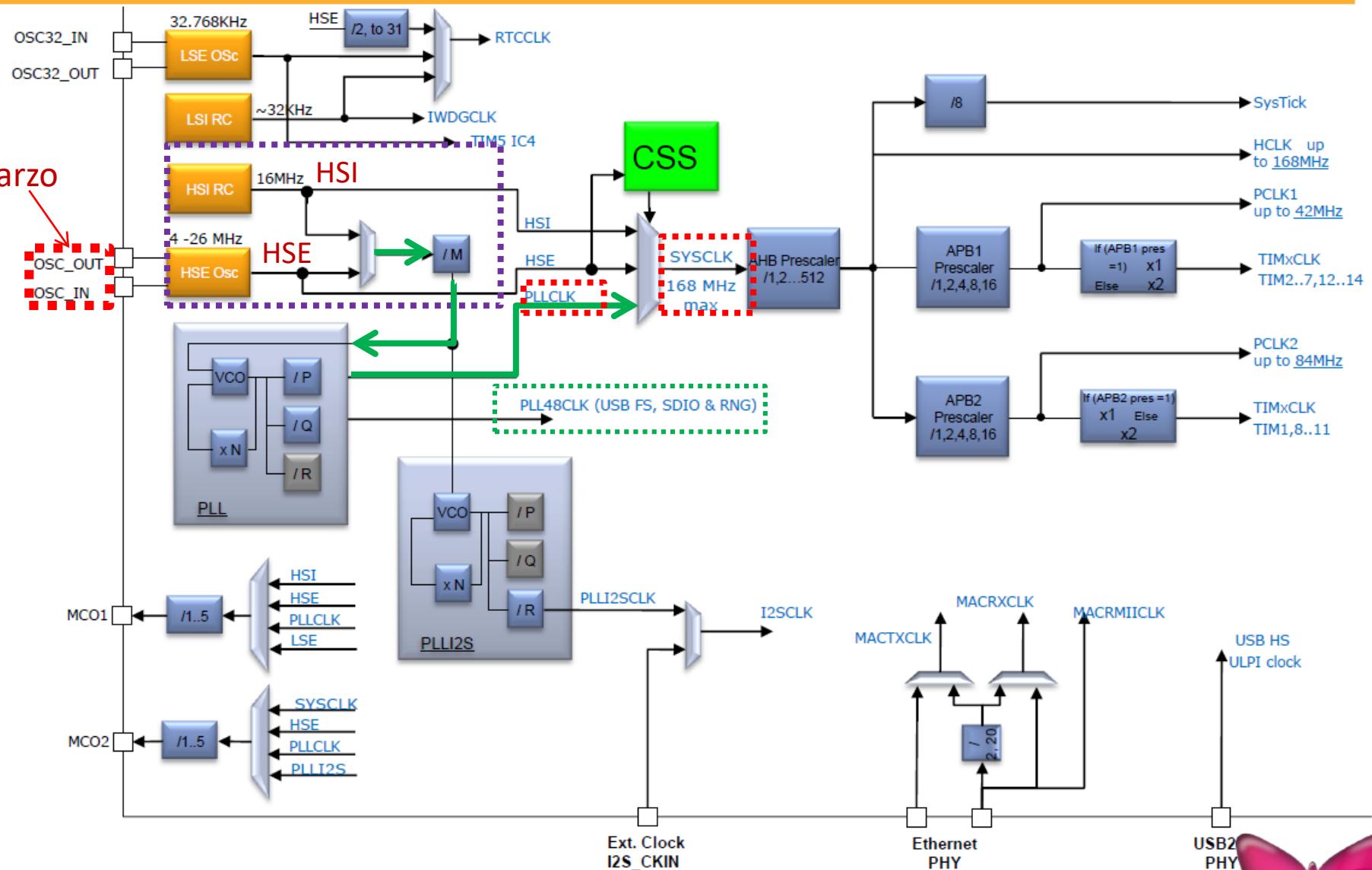
## Note

- The DFU/CAN may work w/ different value of external quartz in the range of 4-26 MHz, and the USART uses the internal HSI
- This Bootloader uses the same USART, CAN and DFU protocols as for STM32F2xx/STM32F10x

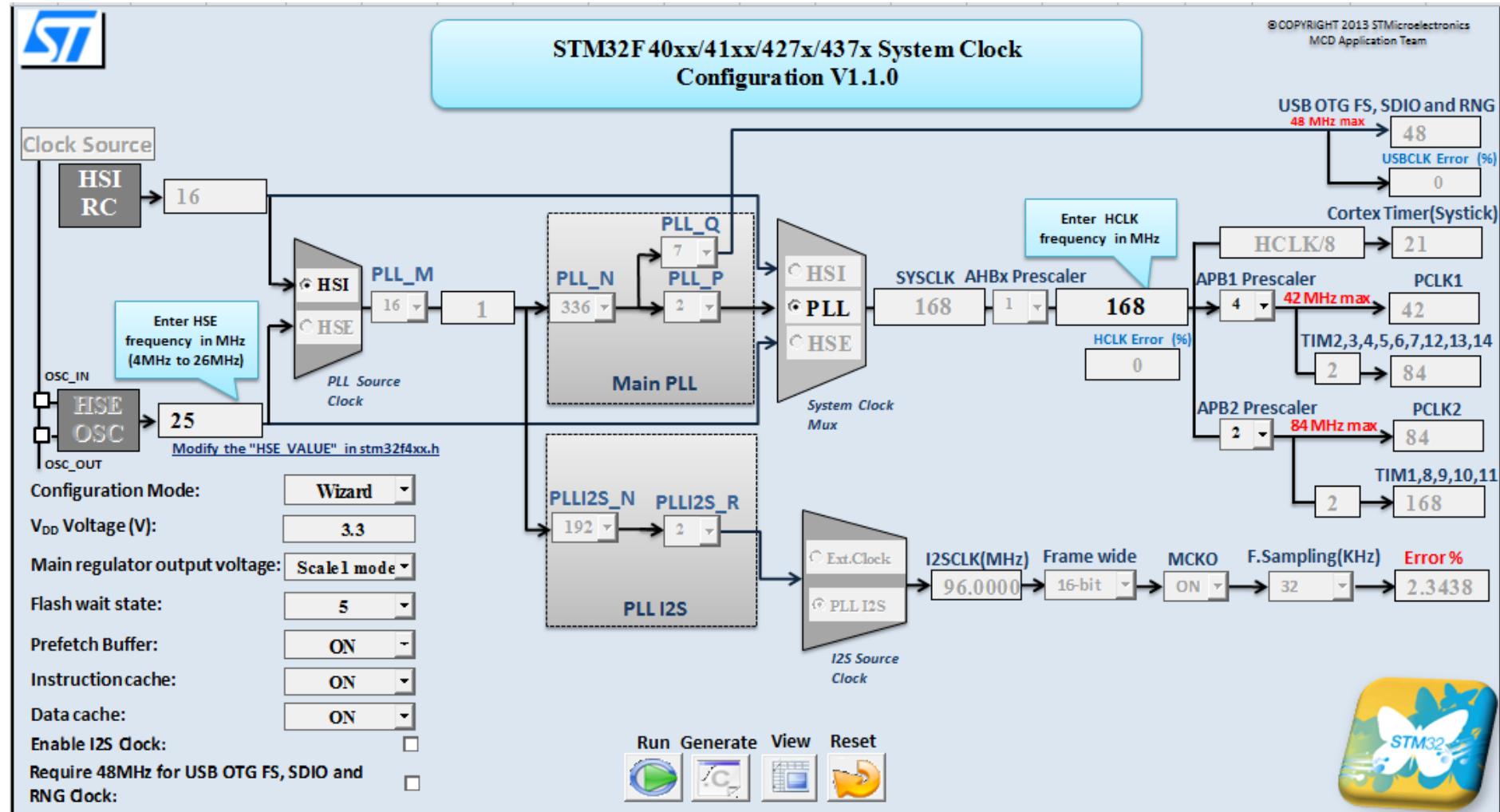
# Relojes en el STM32

- El reloj se puede obtener de dos fuentes:
  - **HSI**: Oscilador interno, fijo a 16MHz.
  - **HSE**: Cristal de cuarzo externo, entre 4-26MHz.
- Un PLL, con un multiplexor a su entrada, puede multiplicarlas hasta los 168MHz.
- El reloj del sistema (**SYSCLK**) se puede seleccionar entre:
  - **HSI / HSE directamente**: no recomendado
  - **PLL**: Alcanzando la máxima frecuencia.
- **Un reloj mal configurado puede bloquear el núcleo: usar bits de boot para poder reprogramarlo.**
- El HSI tiene menos precisión temporal que el HSE, **hay periféricos que requieren el uso del HSE**:
  - USB, I2S (sonido), SDIO (tarjetas SD).

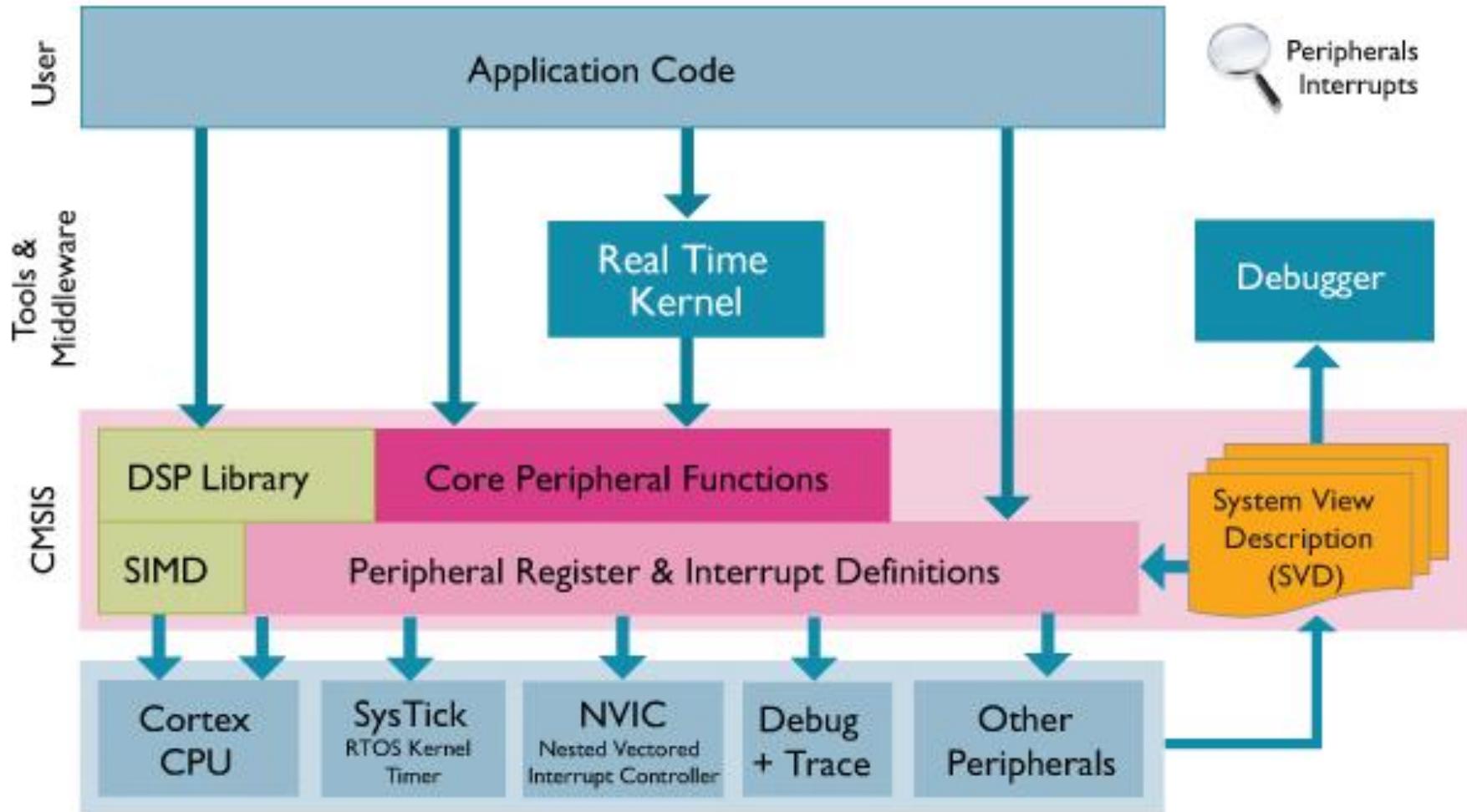
# STM32F4 - clock scheme



# Herramienta para la configuración del reloj



# Modelo de programación

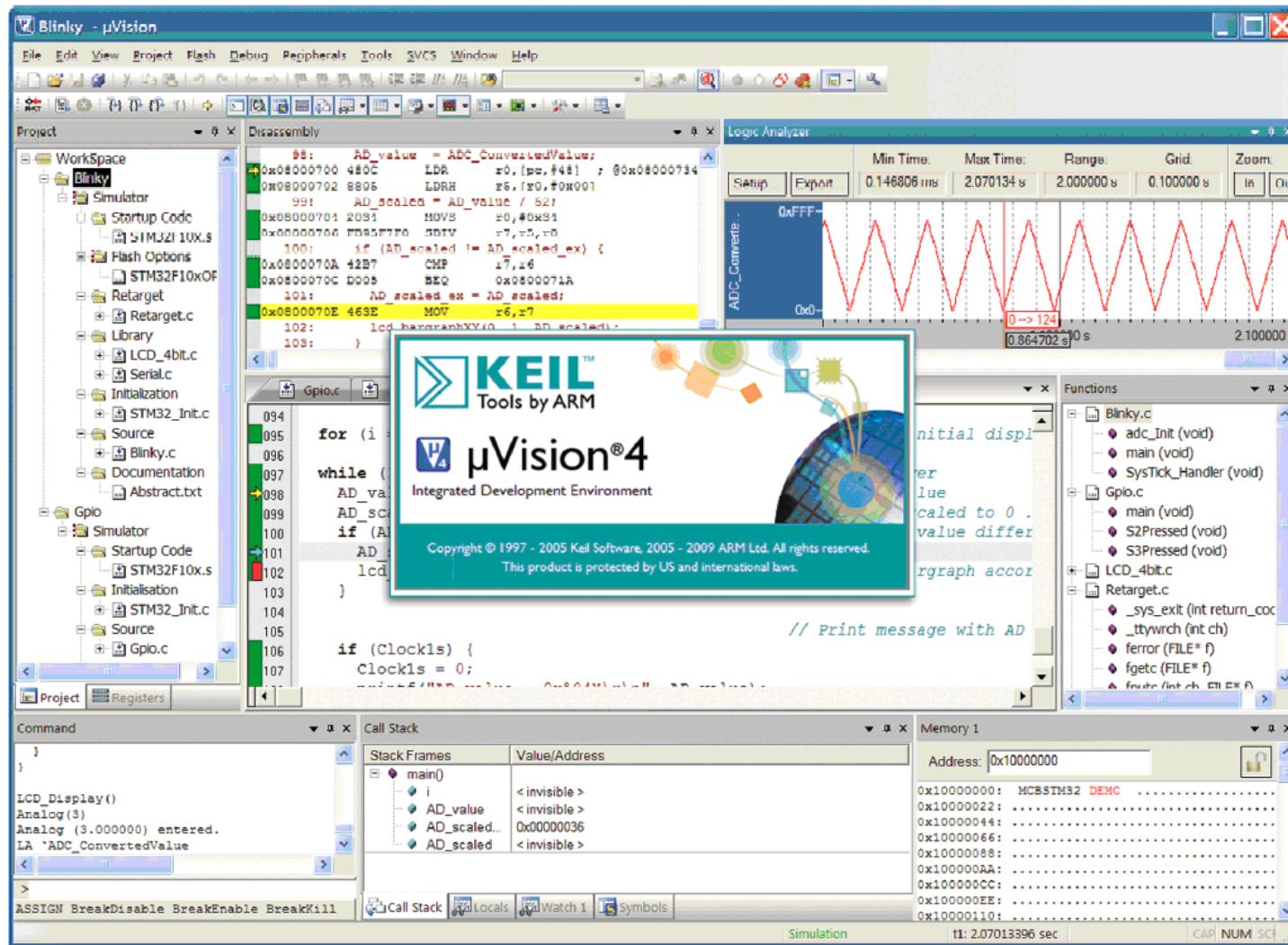


# Entornos de desarrollo (IDEs)

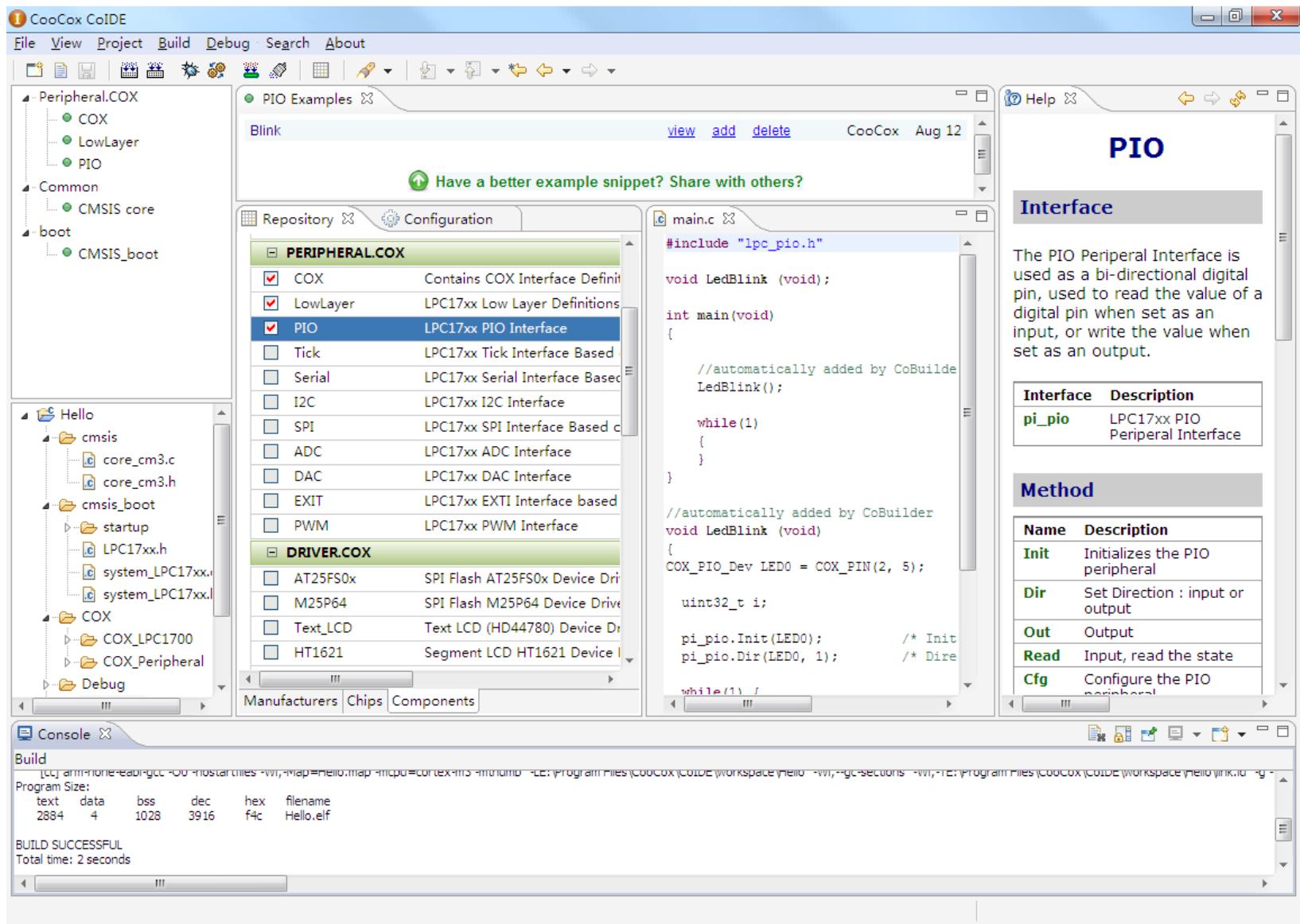
- Comerciales:
  - **Keil MDK-ARM**: Es el compilador oficial de ARM. Lo usan en la mayoría de los ejemplos. La versión de evaluación está limitada a 32k.
  - **IAR EWB**: Versión de evaluación limitada a 30 días.
  - **Crossworks**: 30 días de prueba.
- Gratuitos:
  - + **CooCox IDE**: Basado GCC y Eclipse.
  - + **System Workbench for STM32 (SW4STM32)**: Basado GCC y Eclipse.
  - + **Atollic True Studio**: Gratis para STM32 (Diciembre 2017)
  - + **MBED**: On-line ([mbed.org](http://mbed.org))



# Keil uVision 4



# CooCox Colde



# MBED IDE

The screenshot shows the mbed Compiler IDE interface. The title bar reads "mbed Compiler - /testLED". The address bar shows the URL "https://mbed.org/compiler/#nav:/testLEDblinkFREEDOM/main.cpp". The menu bar includes "File", "Edit", "View", "Tools", "Help", and "Guide". The toolbar has icons for New, Import, Save, Save All, Compile, Commit, Revisions, and Format. A dropdown for "Freescale KL25Z" is also present.

The left sidebar is titled "Program Workspace" and lists several projects:

- My Programs
  - blinkingetc
  - HelloWorldFreedom
  - LCDtest
  - serialtest
  - test
    - main.cpp
    - mbed
  - testLEDblinkFREEDOM
    - main.cpp
    - mbed
  - TextLCD
    - mbed
    - TextLCD.cpp
    - TextLCD.h
  - mbed

The main workspace displays the content of "main.cpp" for the "testLEDblinkFREEDOM" project. The code is as follows:

```
1 #include "mbed.h"
2
3 DigitalOut myled1(LED1);
4
5
6 int main() {
7     while(1) {
8         myled1= 1;
9         wait(.5);
10        myled1= 0;
11        wait(.5);
12    }
13 }
```

The bottom panel shows the "Compiler Output for Program: testLEDblinkFREEDOM" table:

Description	ErrNc	Resource	In Folder	Location
Success!			<a href="#">Build Details</a>	

Statistics at the top right of the output panel indicate: Errors: 0, Warnings: 0, Infos: 1.

# Recursos

The screenshot shows the STM32F407VG product page. At the top, there's a navigation bar with links for Home, Products, Applications, Support, Sample & Buy, About, Contact, My ST Login, and Parametric Search. Below the navigation is a search bar and a dropdown menu for Part Number/ Keyword or Cross Reference. The main content area displays the product name 'STM32F407VG' and its description: 'High-performance and DSP with FPU, ARM Cortex-M4 MCU with 1 Mbyte Flash, 168 MHz CPU, Art Accelerator, Ethernet'. A 'Quick View' button is highlighted. The page also includes a breadcrumb navigation: Home > Embedded Processing > Microcontrollers > STM32 32-bit ARM Cortex MCUs > STM32F4 Series > STM32F407/417 > STM32F407VG. There are also Save to MyST, Share, and Print buttons.

## STM32F407VG

High-performance and DSP with FPU, ARM Cortex-M4 MCU with 1 Mbyte Flash, 168 MHz CPU, Art Accelerator, Ethernet

● Active

The STM32F405xx and STM32F407xx family is based on the high-performance ARM® Cortex™-M4 32-bit RISC core operating at a frequency of up to 168 MHz. The Cortex-M4 core features a Floating point unit (FPU) single precision which supports all ARM single-precision data-processing instructions and data types. It also implements a full set of DSP instructions and a memory protection unit (MPU) which enhances application security. The Cortex-M4 core with FPU will be referred to as Cortex-M4F throughout this document.

The STM32F405xx and STM32F407xx family incorporates high-speed embedded memories (Flash memory up to 1 Mbyte, up to 192 kbytes of SRAM), up to 4 kbytes of backup SRAM, and an extensive range of enhanced I/Os and peripherals connected to two APB buses, three AHB buses and a 32-bit multi-AHB bus matrix.

All devices offer three 12-bit ADCs, two DACs, a low-power RTC, twelve general-purpose 16-bit timers including two PWM timers for motor control, two general-purpose 32-bit timers, a true random number generator (RNG). They also feature standard and advanced communication interfaces.

Download Datasheet

### Key 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 168 MHz, memory protection unit, 210 DMIPS/1.25 DMIPS/MHz (Dhrystone 2.1), and DSP instructions
- Memories Up to 1 Mbyte of Flash memoryUp to 192+4 kbytes of SRAM including 64-kbyte of CCM (core coupled memory) data RAMFlexible static memory controller supporting Compact Flash, SRAM, PSRAM, NOR and NAND memories
- LCD parallel interface, 800x600 modes
- Clock, reset and supply management1.8 V to 3.6 V application supply and I/OsPOR, PDR, PVD and BOR4-to-26 MHz crystal oscillator/internal 16 MHz factory-trimmed RC (1% accuracy)32 kHz oscillator for RTC with calibrationInternal 32 kHz RC with calibrationSleep, Stop and Standby modeV<sub>BAT</sub> supply for RTC, 20+32 bit backup registers + optional 4 KB backup SRAM
- 3x12-bit, 2.4 MSPS A/D converters: up to 24 channels and 7.2 MSPS in triple interleaved mode
- 2x12-bit D/A converters
- General-purpose DMA: 16-stream DMA controller with FIFOs and burst support
- Up to 17 timers: up to twelve 16-bit and two 32-bit timers up to 168 MHz, each with up to 4 IC/O/PWM or pulse counter and quadrature (incremental) encoder input
- Debug modeSerial wire debug (SWD) & JTAG interfacesCortex-M4 Embedded Trace Macrocell™
- Up to 140 I/O ports with interrupt capabilityUp to 136 fast I/Os up to 84 MHzUp to 138 5 V-tolerant I/Os
- Up to 15 communication interfacesUp to 3 x I<sup>2</sup>C interfaces (SMBus/PMBus)Up to 4 USARTs/2 UARTs (10.5 Mbit/s, ISO

The screenshot shows the STM32F407VG product page with the 'Technical Documentation' section expanded. It includes a 'Product Specifications' table and an 'Application Notes' table.

Description	Version	Size
DS8626: ARM Cortex-M4 32b MCU+FPU, 210DMIPS, up to 1MB Flash/192+4KB RAM, USB OTG HS/FS, Ethernet, 17 TIMs, 3 ADCs, 15 comm. interfaces & camera	4.0	5.427 KB

Description	Version	Size
AN1015: Software techniques for improving microcontroller EMC performance	1.7	104 KB
AN1181: Electrostatic discharge sensitivity measurement	1.4	59 KB
AN1709: EMC design guide for ST microcontrollers	1.7	657 KB
AN2606: STM32™ microcontroller system memory boot mode	17.0	1.805 KB
AN2639: Soldering recommendations and package information for Lead-free ECOPACK microcontrollers	3.2	448 KB
AN2945: STM8S and STM32™ MCUs: a consistent 8/32-bit product line for painless migration	1.2	213 KB
AN3070: Managing the Driver Enable signal for RS-485 and IO-Link communications with the STM32™'s USART	1.2	191 KB

### Online Support

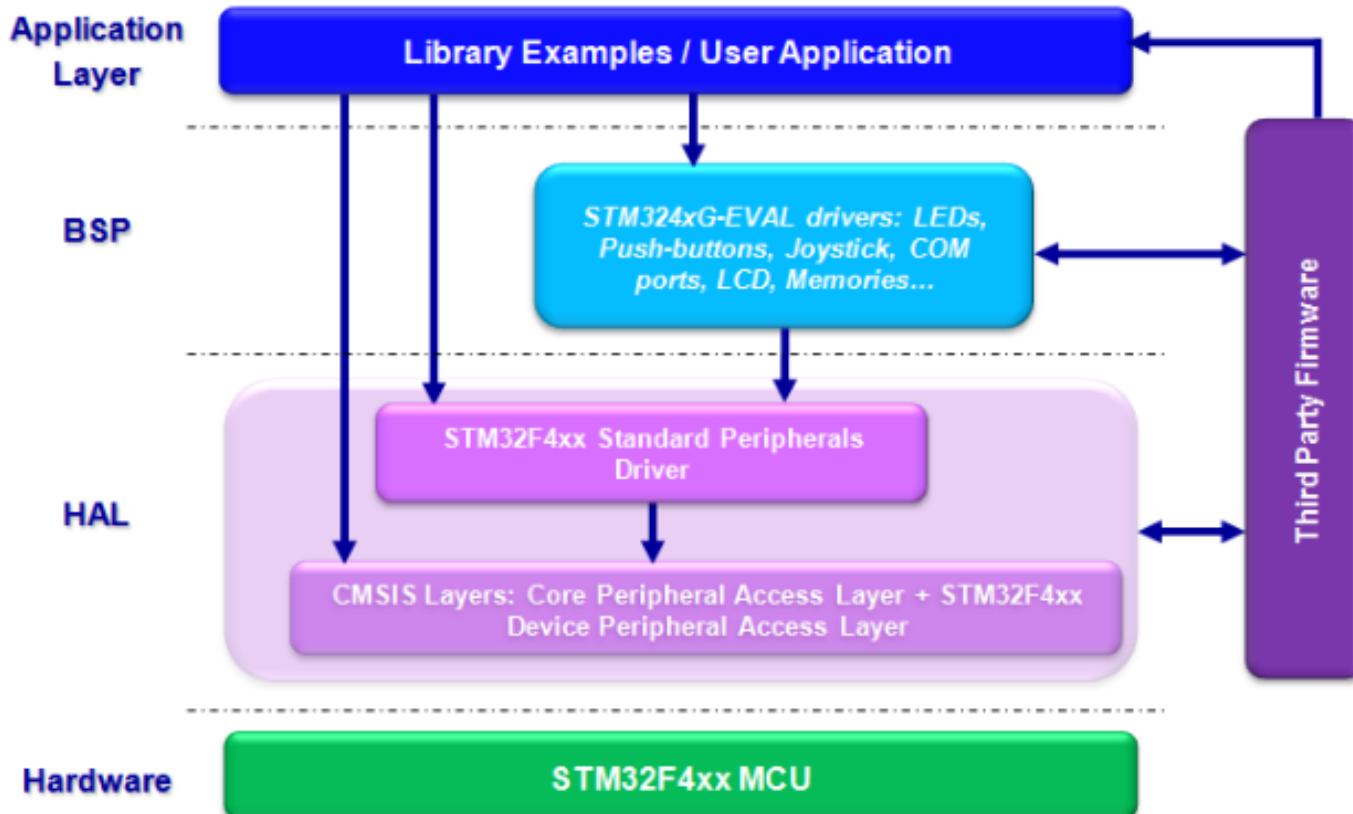
Online Support  
FAQ  
EE2 Communities  
Learning

### Featured Videos

- MATLAB/Simulink design workflow for STM32F4
- STM32 F4 series - World's fastest Cortex-M MCUs
- STM32F4 Cortex-M4 benefits in audio processing vs Cortex-M3
- STM32 F4 floating point unit benefits
- STM32 F4 point unit performance live demonstration
- STM32 F4 series - World's fastest Cortex-M MCUs

# Librerías ST – Hardware Abstraction Layer (HAL)

- ST proporciona unas librerías para el manejo a bajo nivel de los periféricos del STM32.



STM32F4xx DSP and Standard Peripherals Library

Ocultar Buscar Atrás Adelante Detener Actualizar Inicio Fuerite Imprimir Opciones

Contenido | Índice | Buscar | Favoritos |

STM32F4xx DSP and Standard Peripherals Library

Main Page Related Pages Modules Data Structures Files Directories

## STM32F4xx DSP and Standard Peripherals Library

STM32 Releasing your creativity



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The **STM32F4xx DSP and Standard Peripherals Library** is a complete package, consisting of device drivers for all of the standard device peripherals, for STM32F4xx devices 32-bit Flash microcontrollers.

This library is a firmware package which contains a collection of routines, data structures and macros covering the features of STM32F4xx peripherals. It includes a description of the device drivers plus a set of examples for each peripheral. The firmware library allows any device to be used in the user application without the need for in-depth study of each peripheral's specifications.

This Library contains also the **CMSIS DSP Software Library**, which feature a suite of common signal processing functions for use on Cortex-M processor based devices. The library is completely written in C and is fully CMSIS compliant. High performance is achieved through maximum use of Cortex-M4F intrinsics. For more details, please refer to [CMSIS DSP Software Library](#)

Using the Standard Peripherals Library has two advantages: it saves significant time that would otherwise be spent in coding, while simultaneously reducing application development and integration costs.

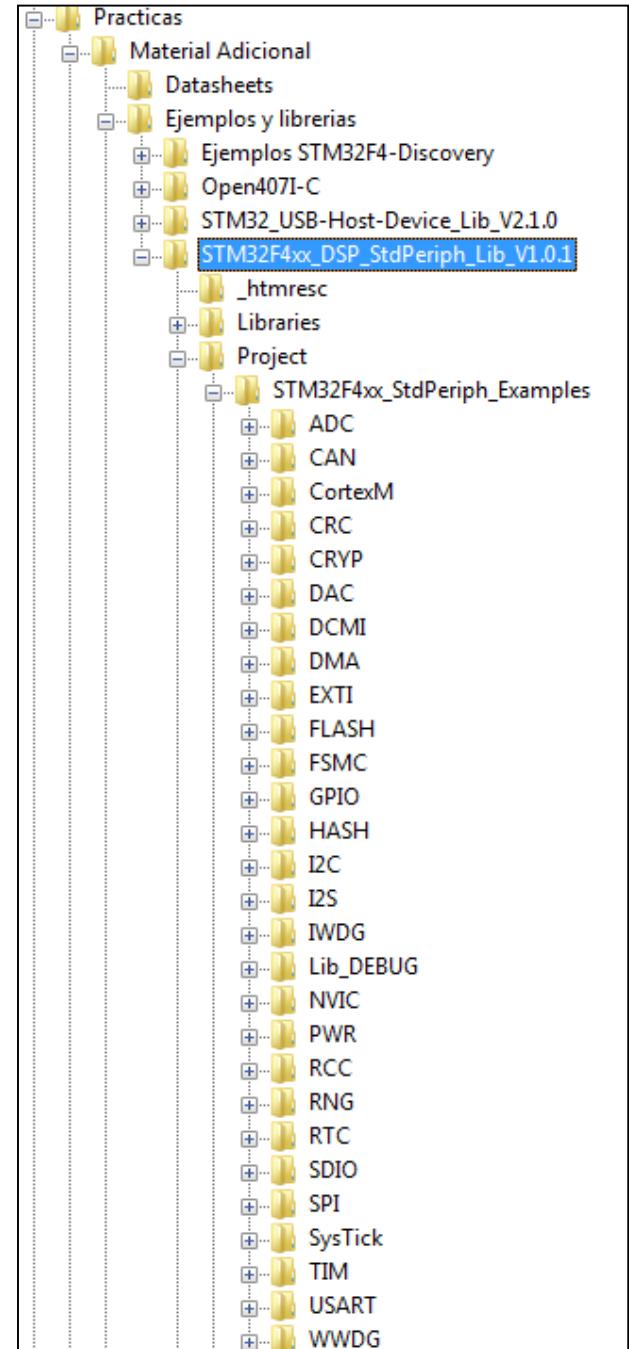
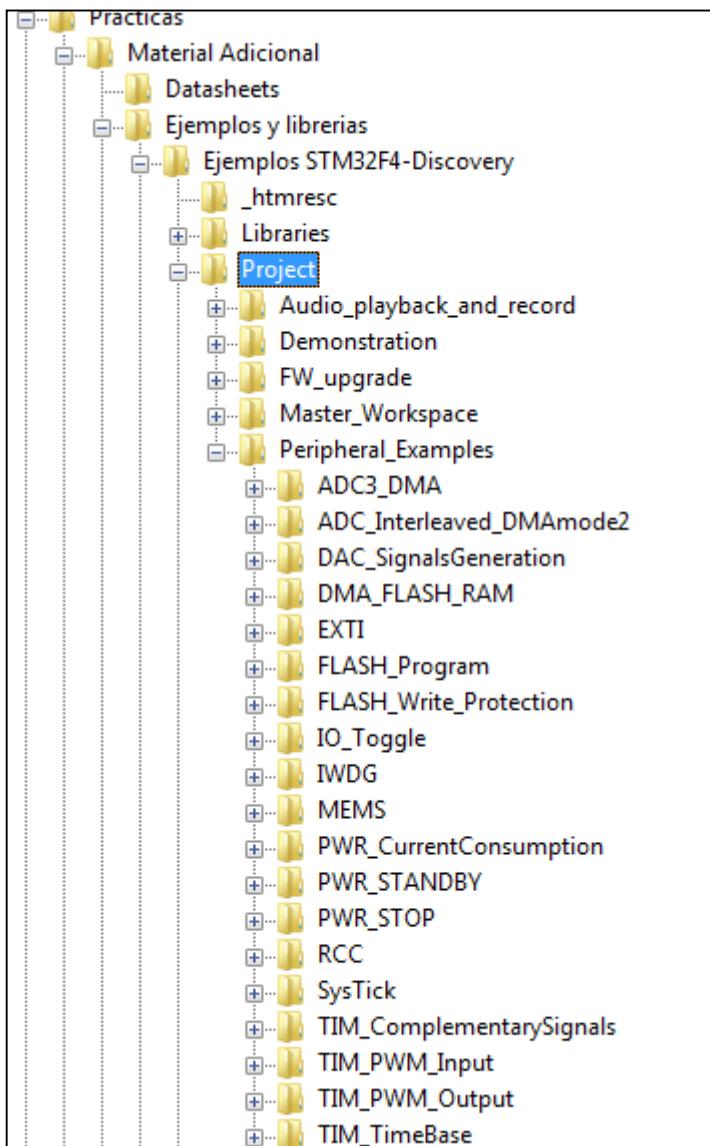
The STM32F4xx DSP and Standard Peripherals Library is full CMSIS compliant.



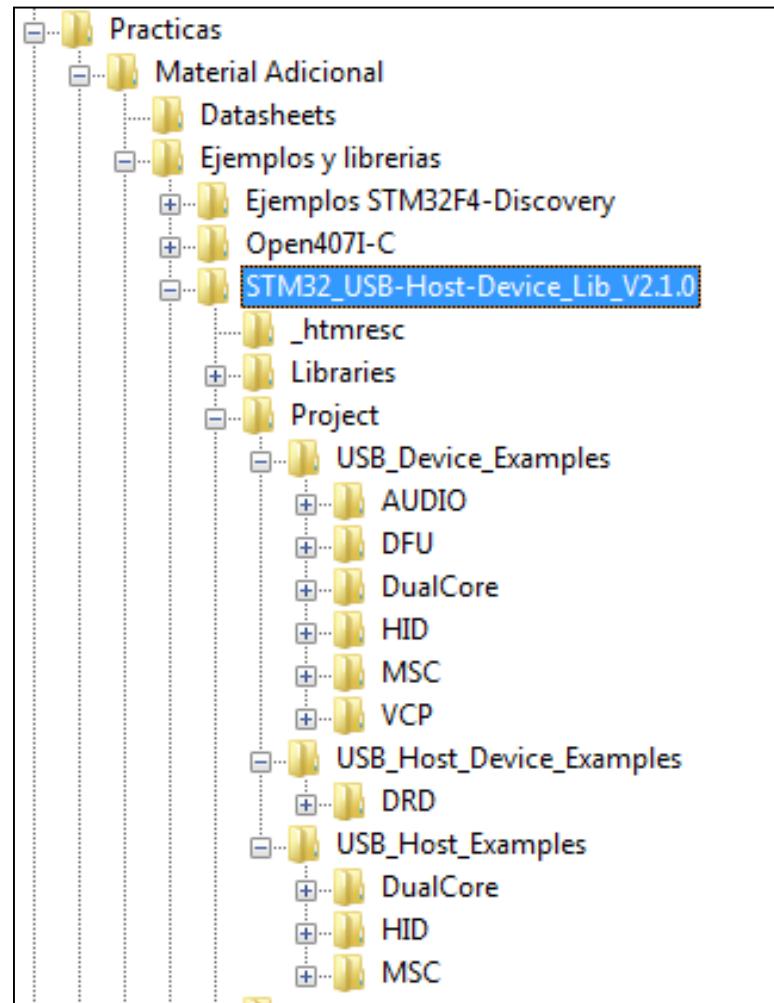
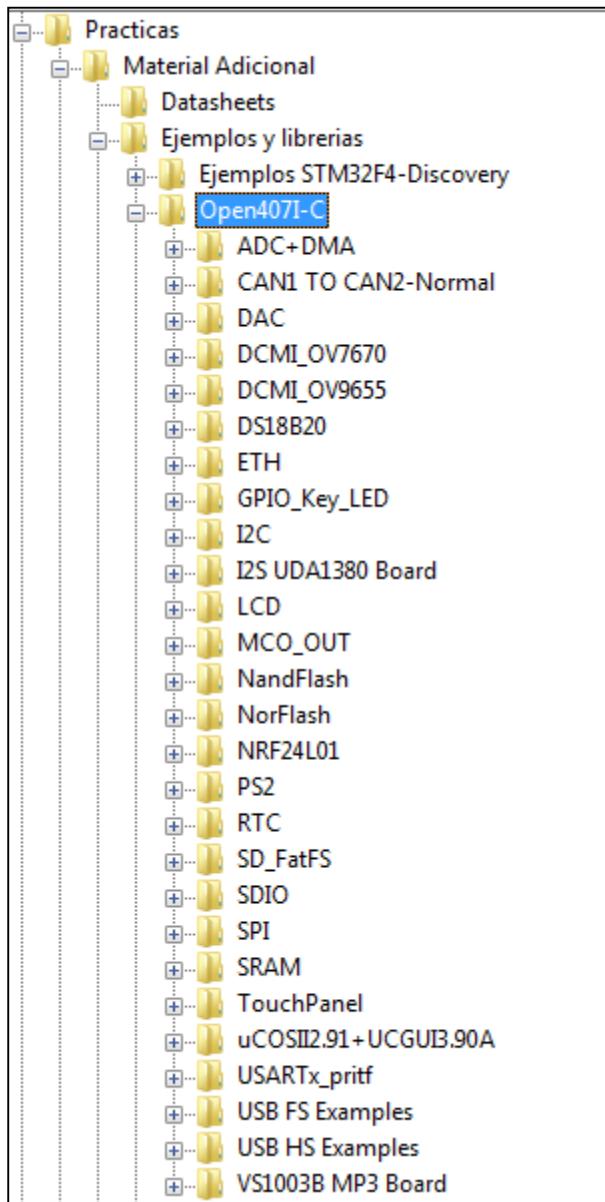
The manual is structured as follows:

- ▶ Standard Peripherals Library
  - \* [Overview](#)
  - \* [MISRA-C 2004 Compliance](#)

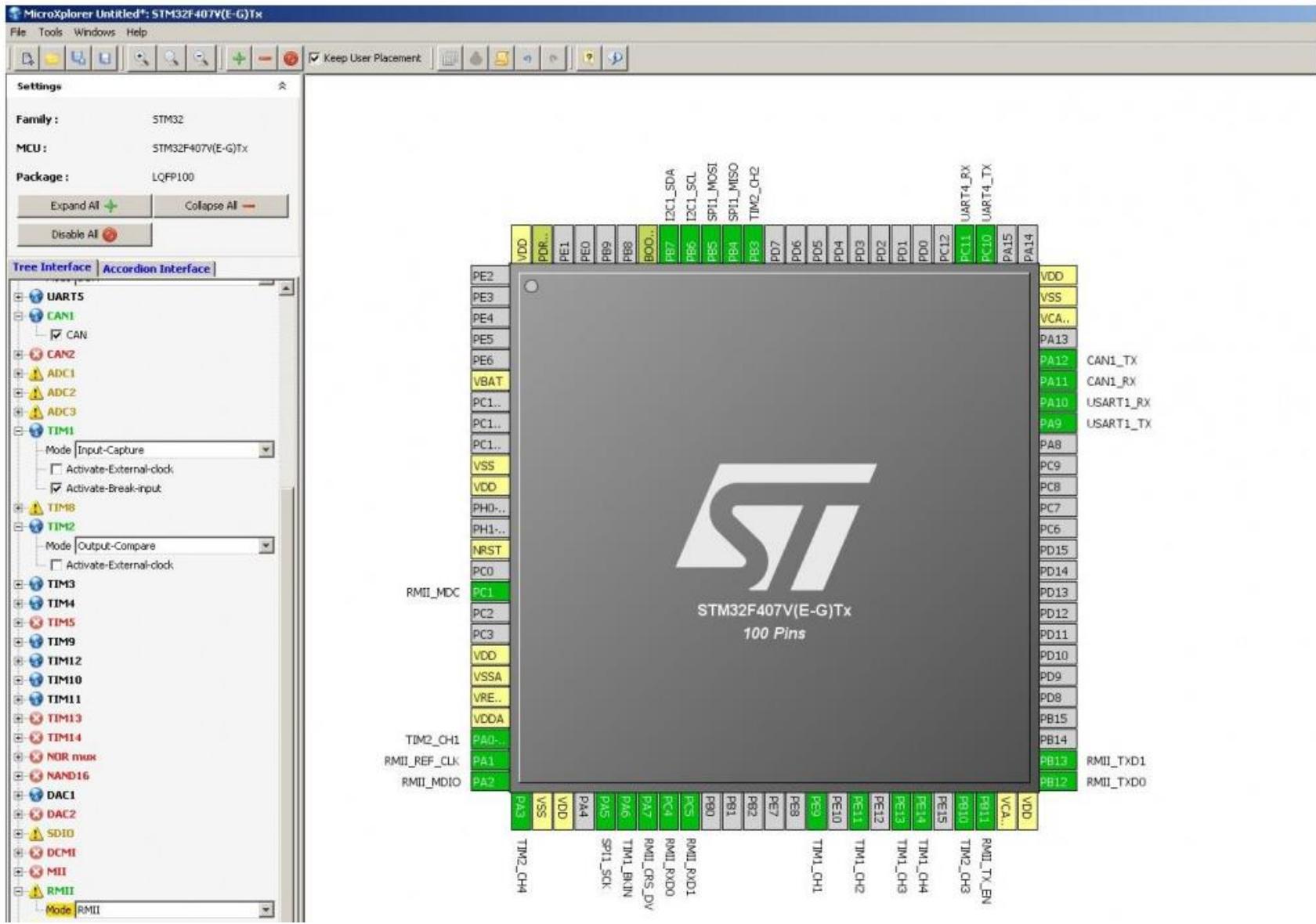
# Ejemplos



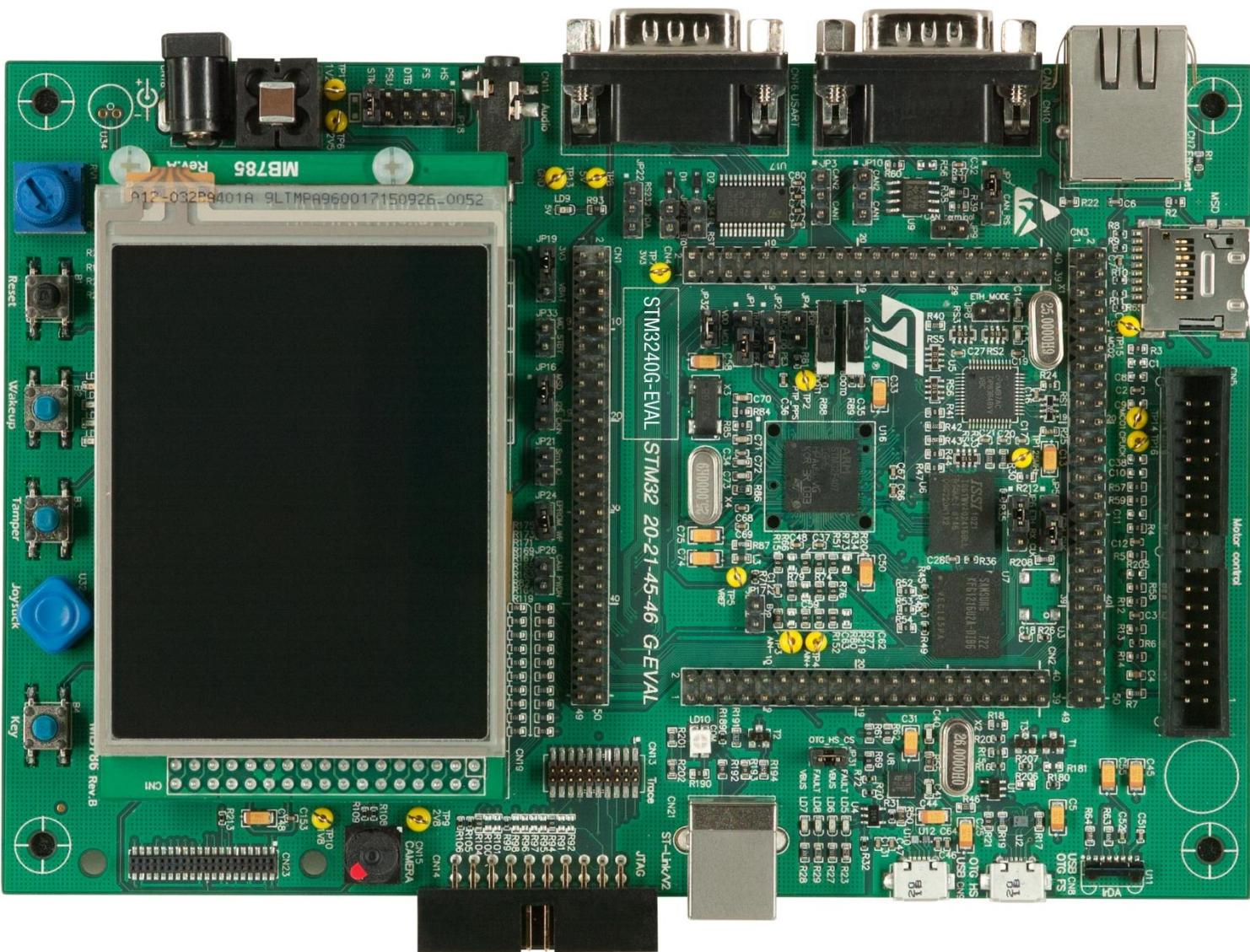
# Ejemplos



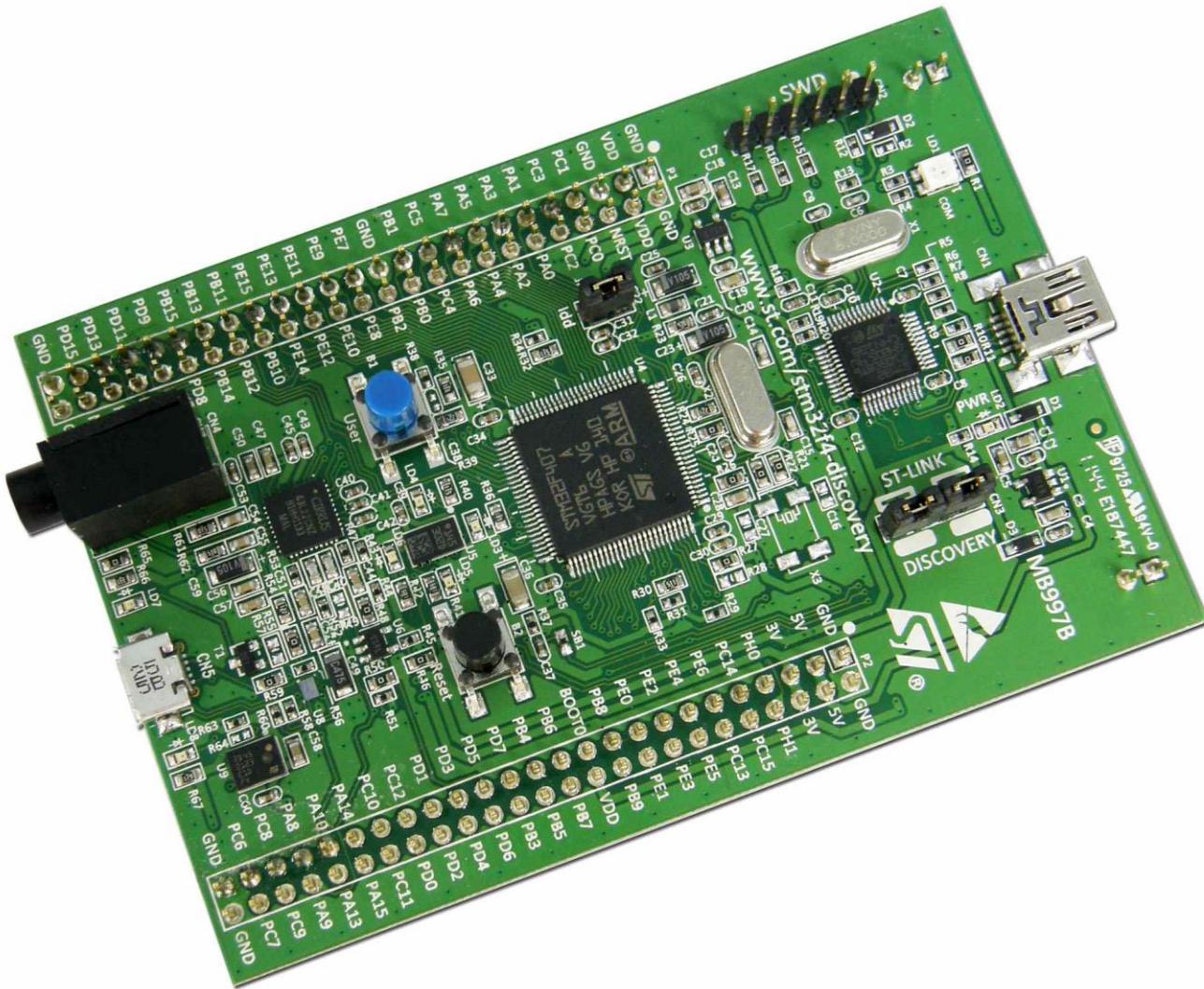
# STM32CubeMX (en desarrollo)



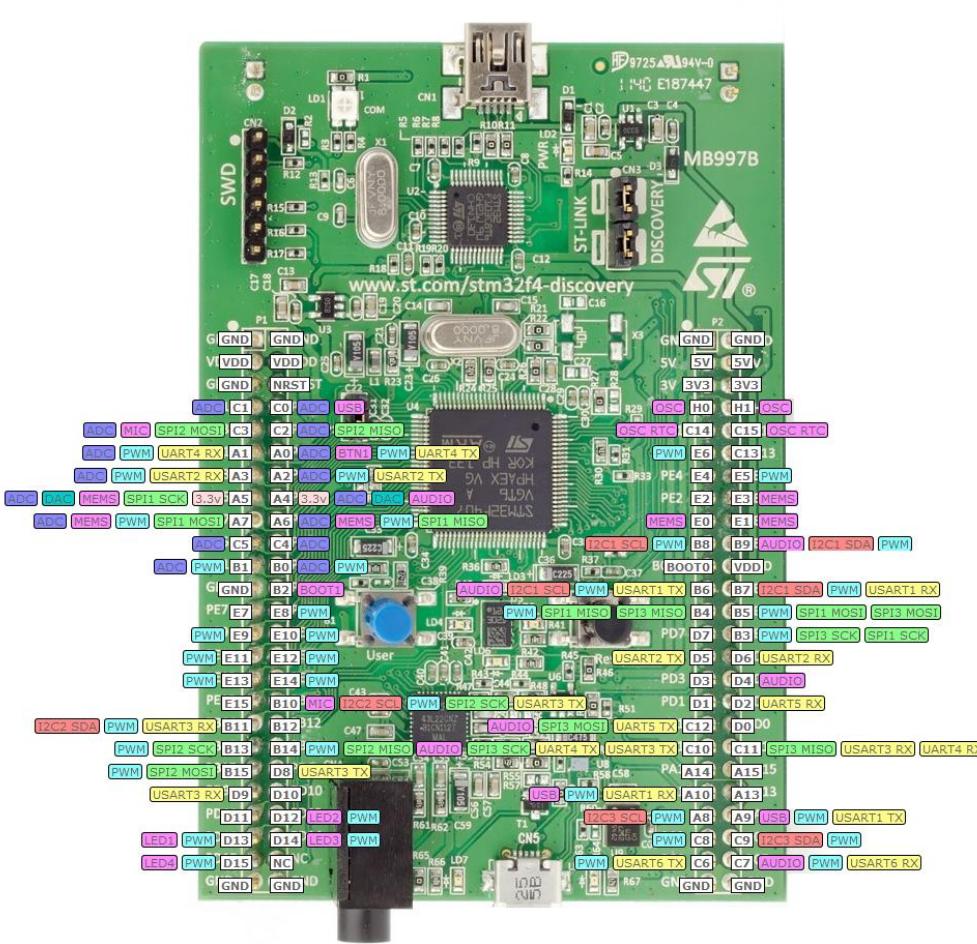
# STM3240 Eval



# STM32F4-Discovery



# STM32F4-Discovery

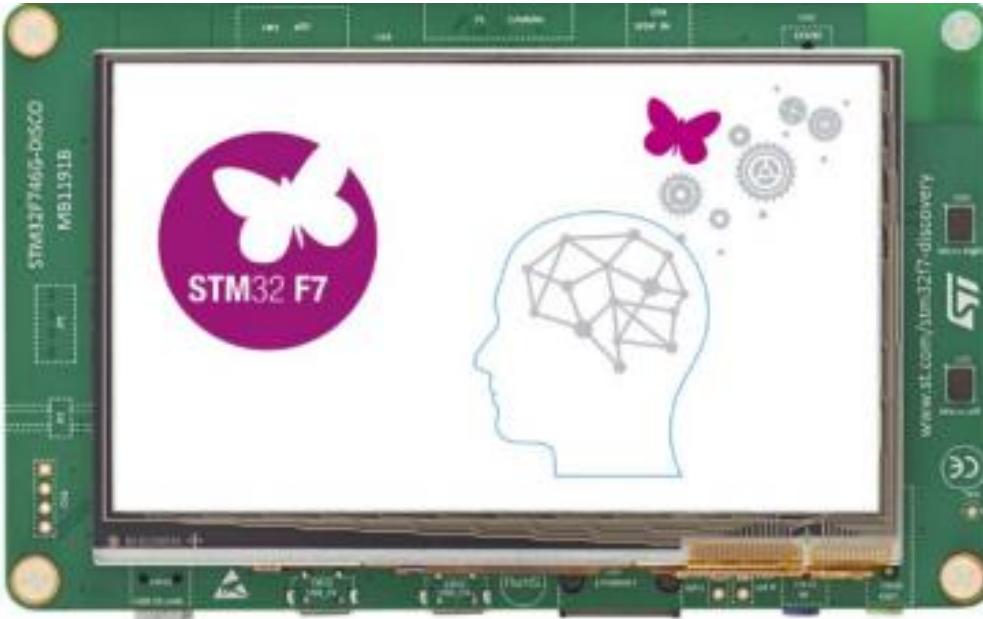


# STM32F4DIS-EXT



# STM32F429 - Discovery

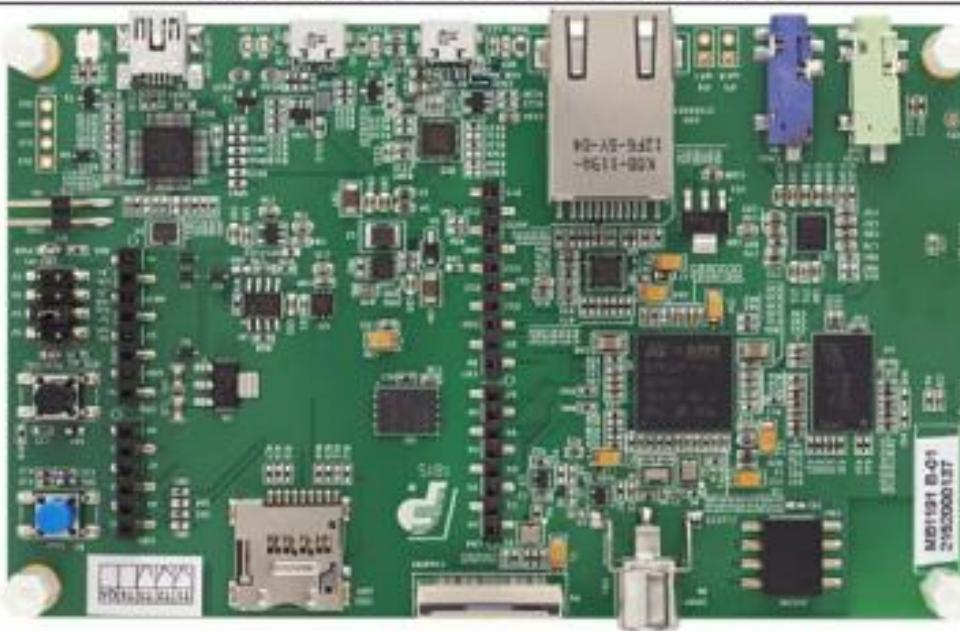




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**STM32F746G-DISCO board**

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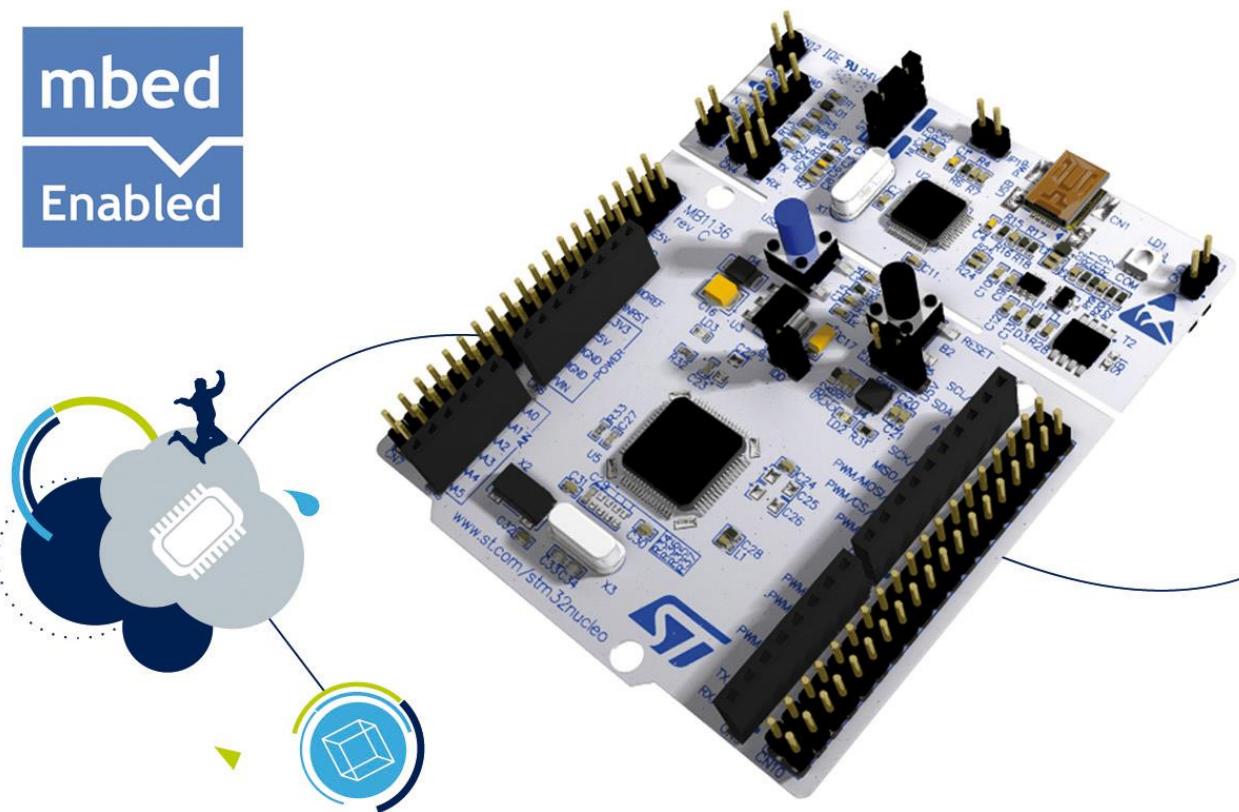


# TouchGFX

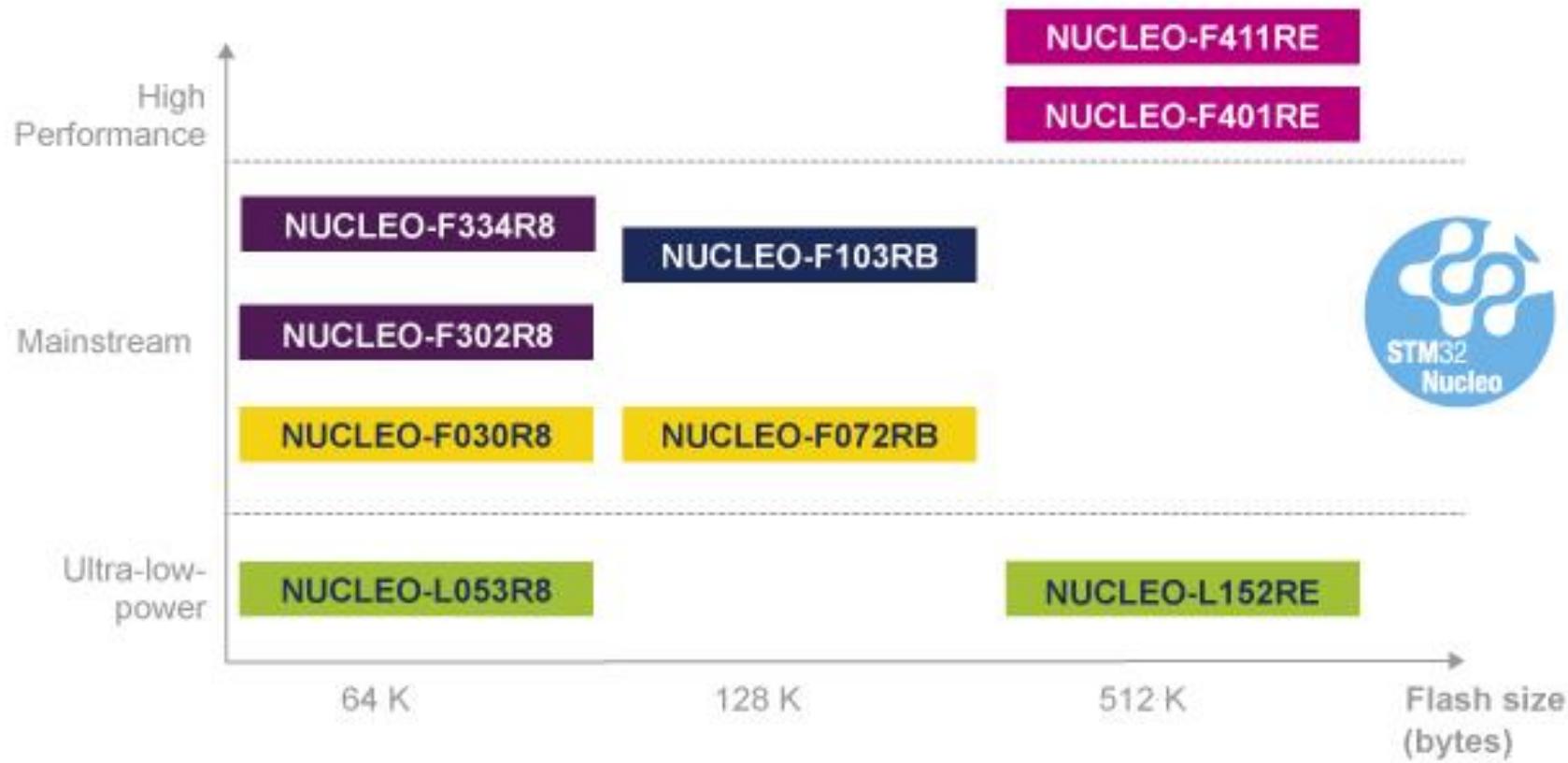


# STM32 Nucleo

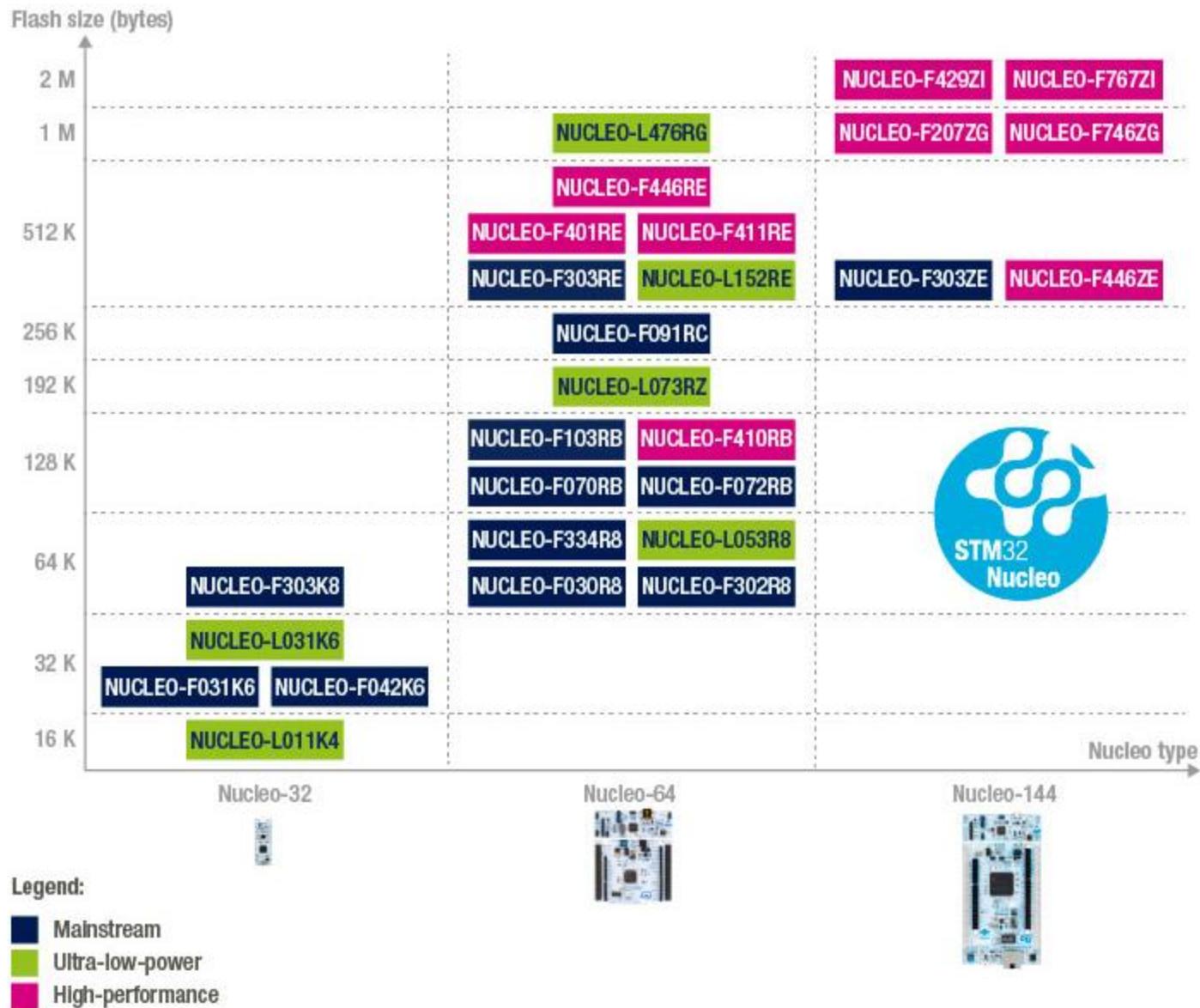
## open development platform



# Familia STM32-Nucleo (2016)



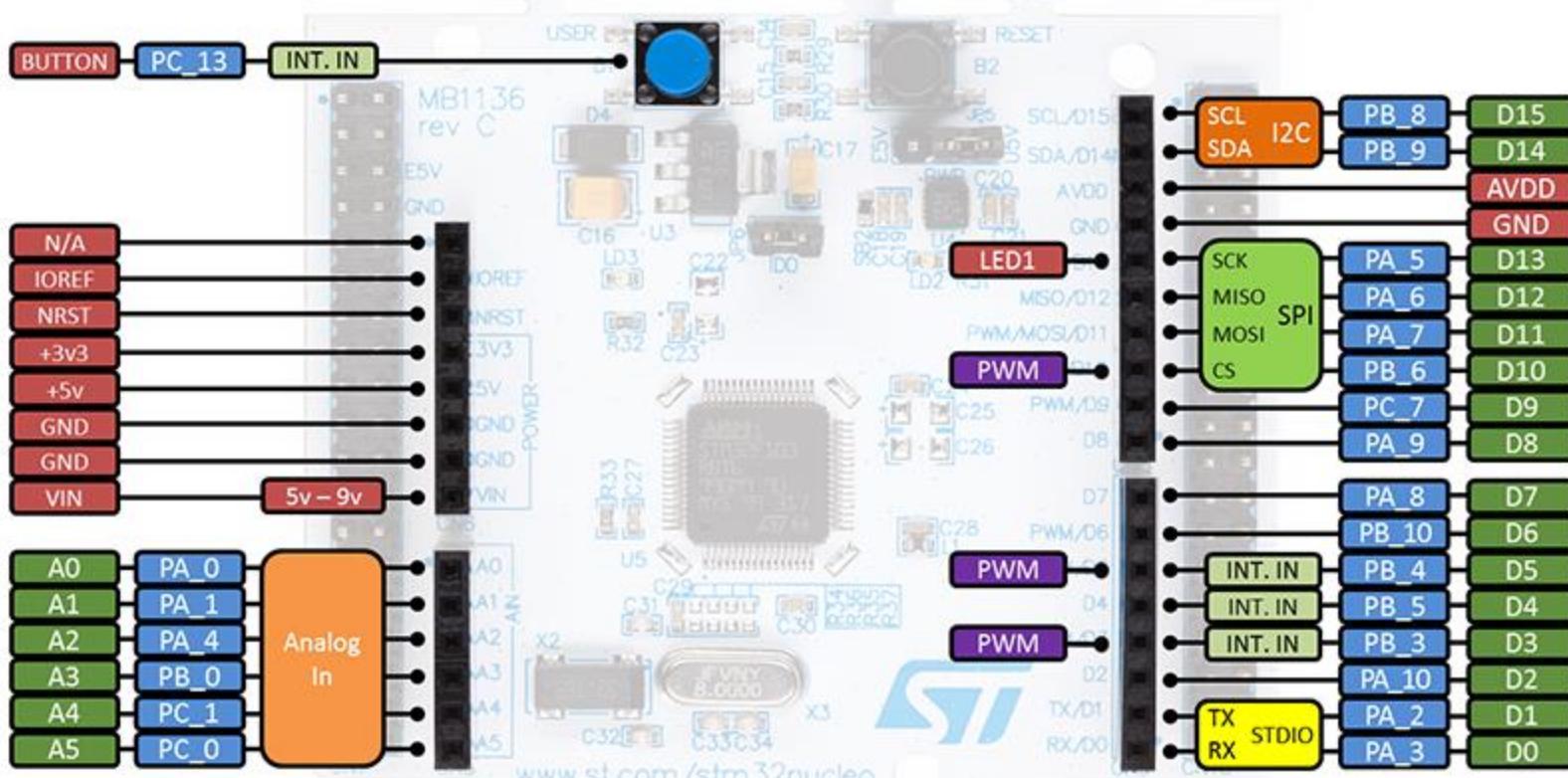
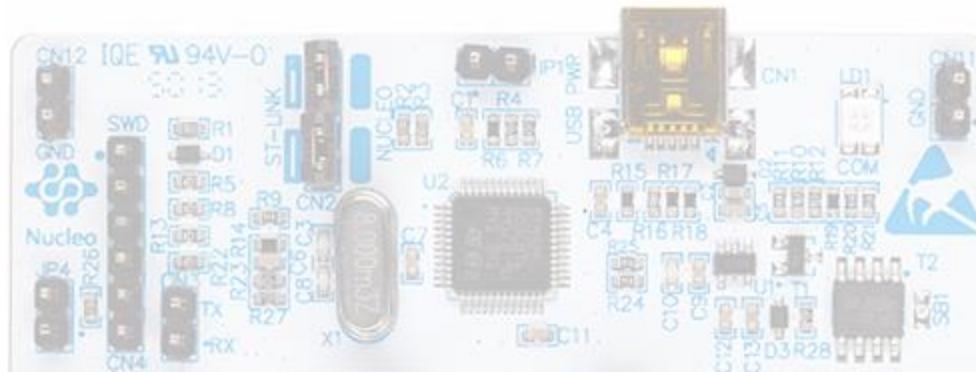
# Familia STM32-Nucleo (2018)





life.augmented

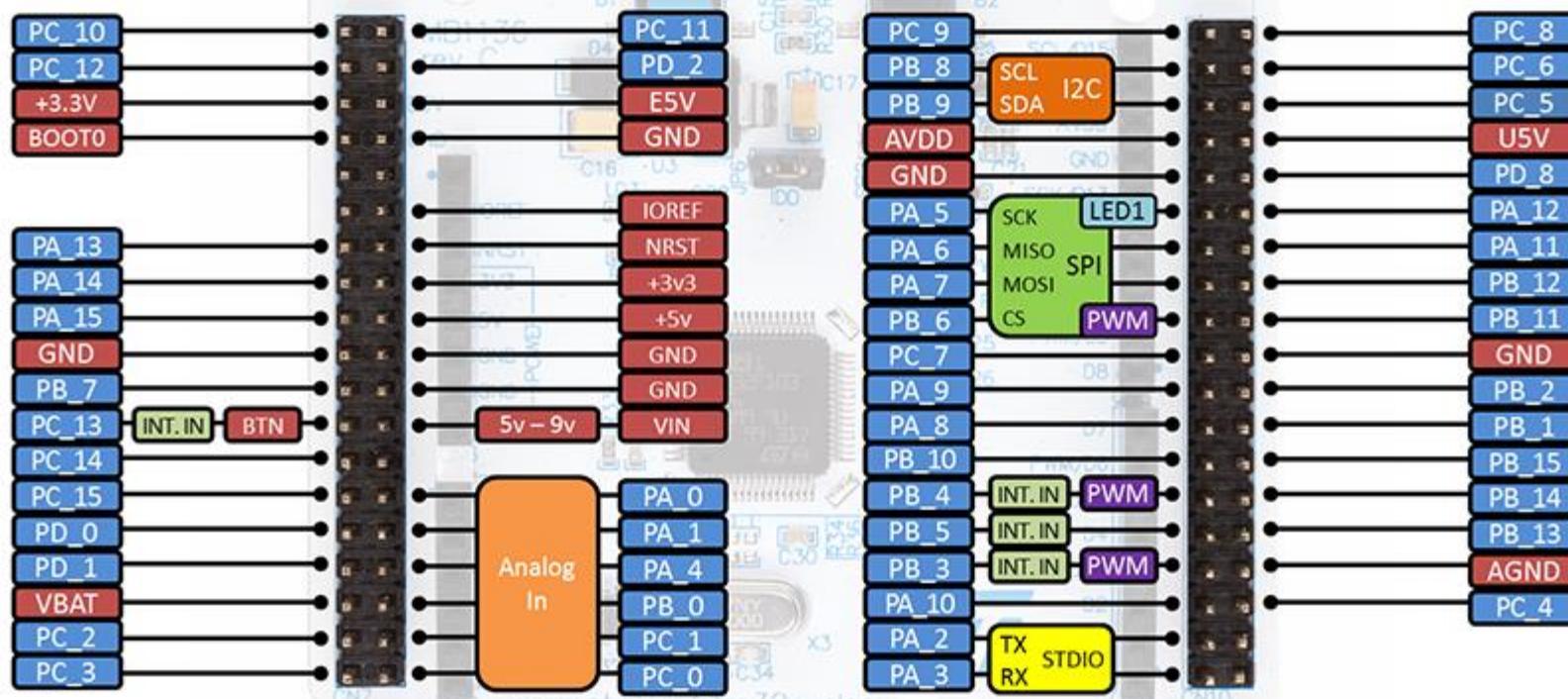
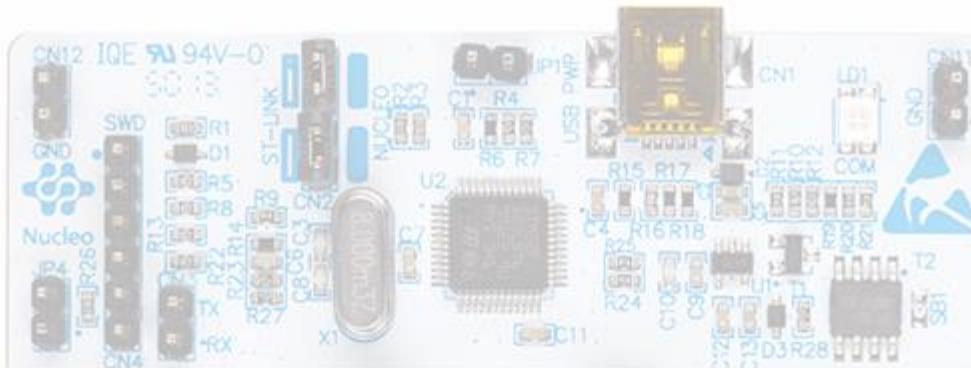
## Nucleo F103RB Arduino Headers



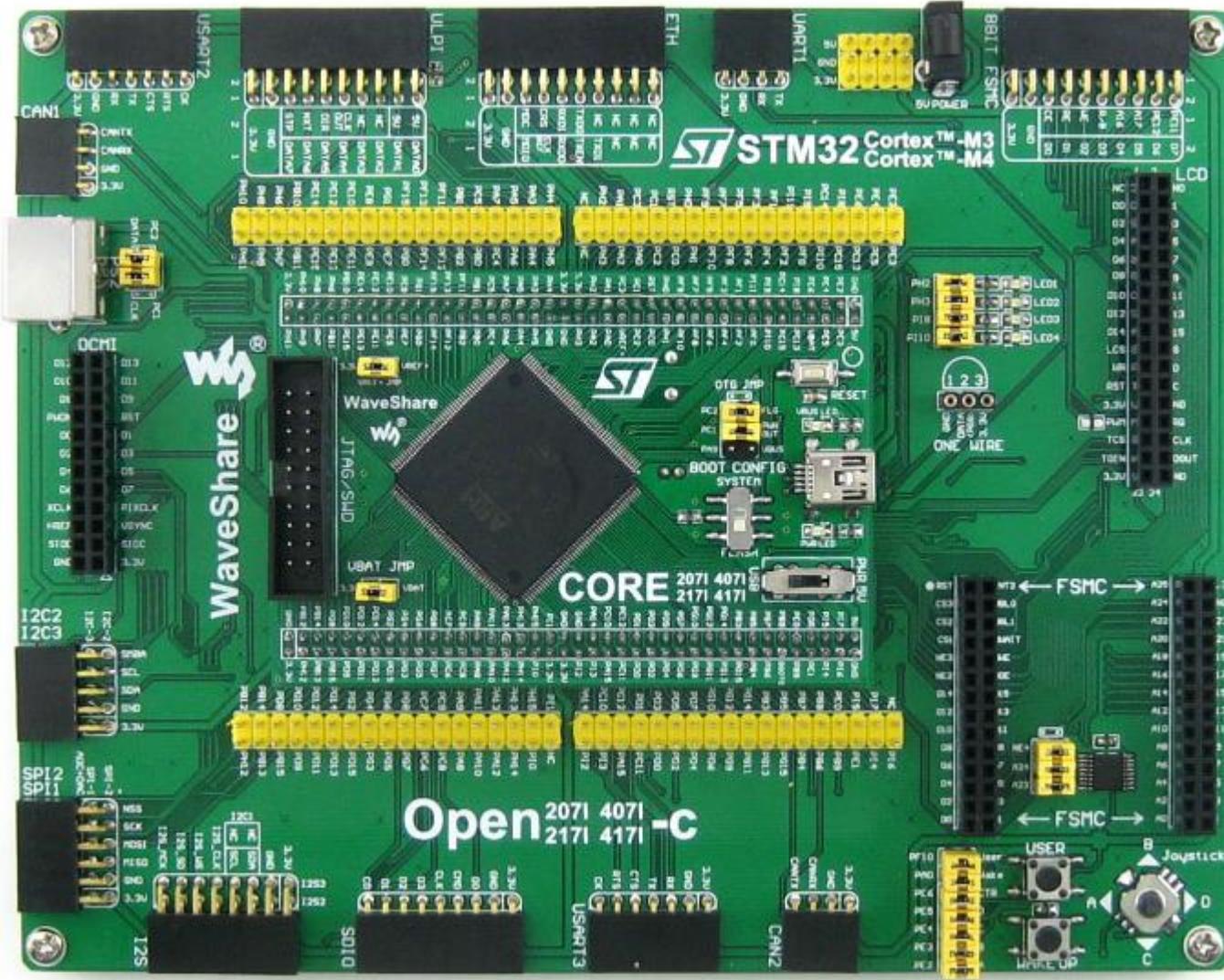


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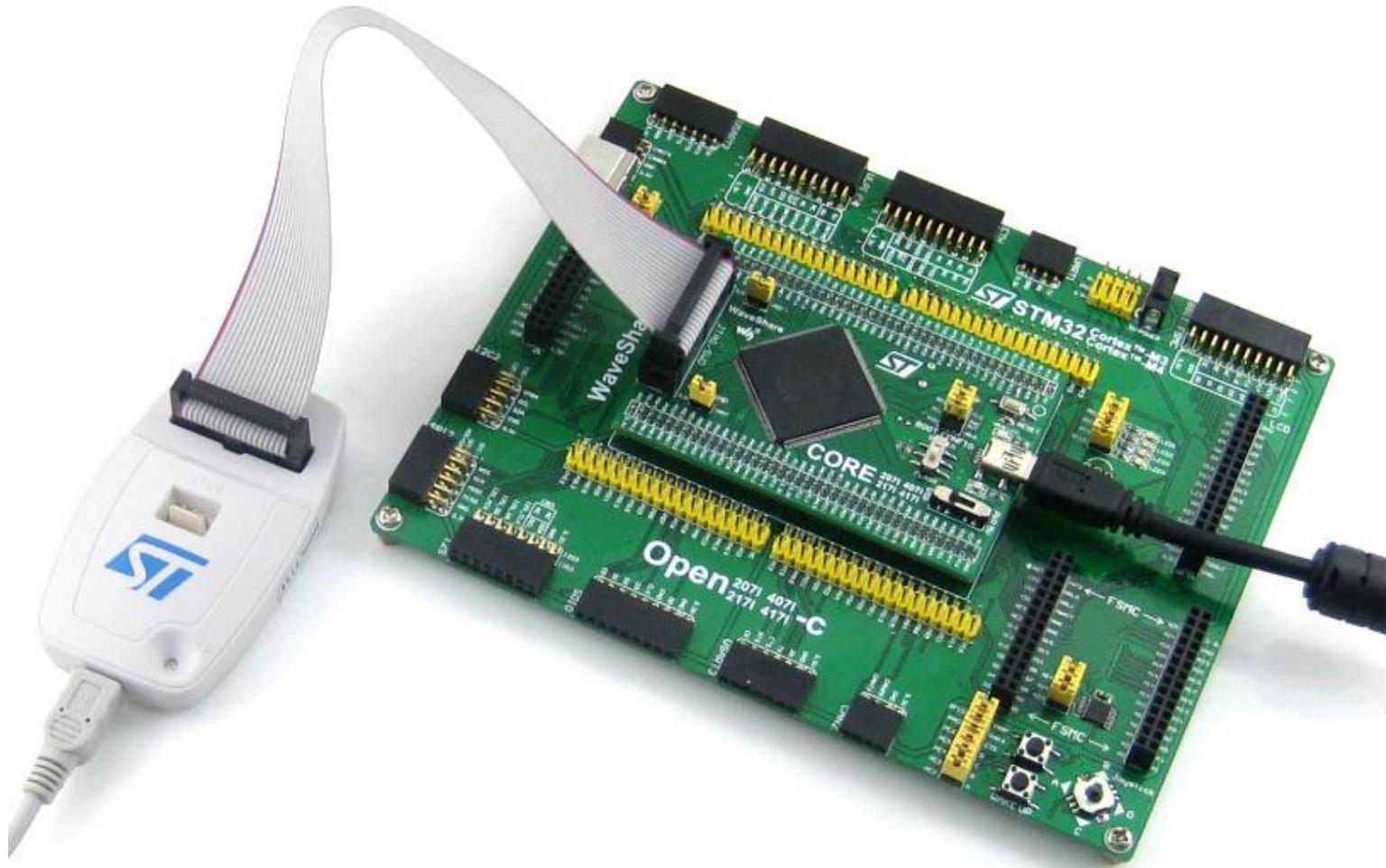
## Nucleo F103RB Morpho Headers

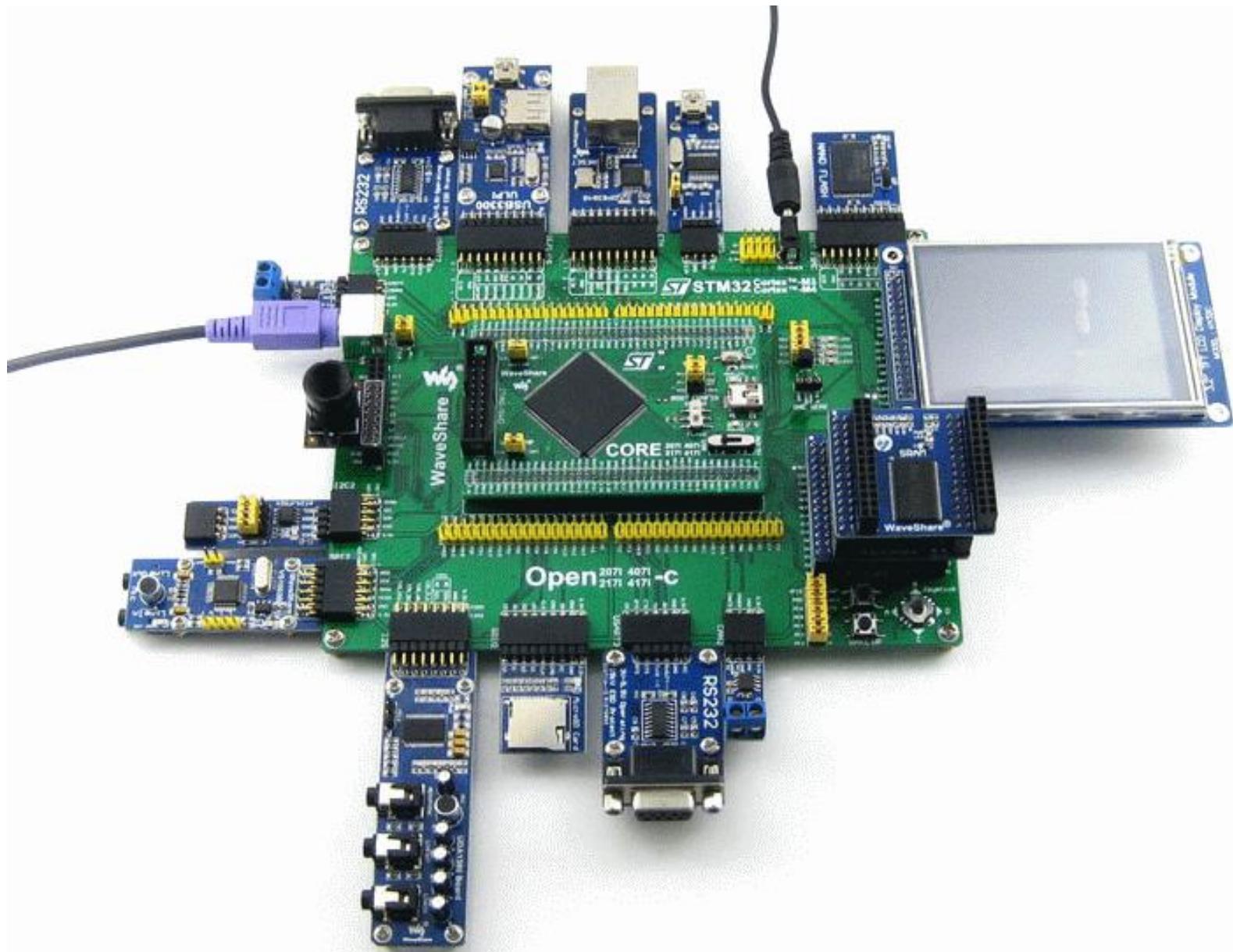


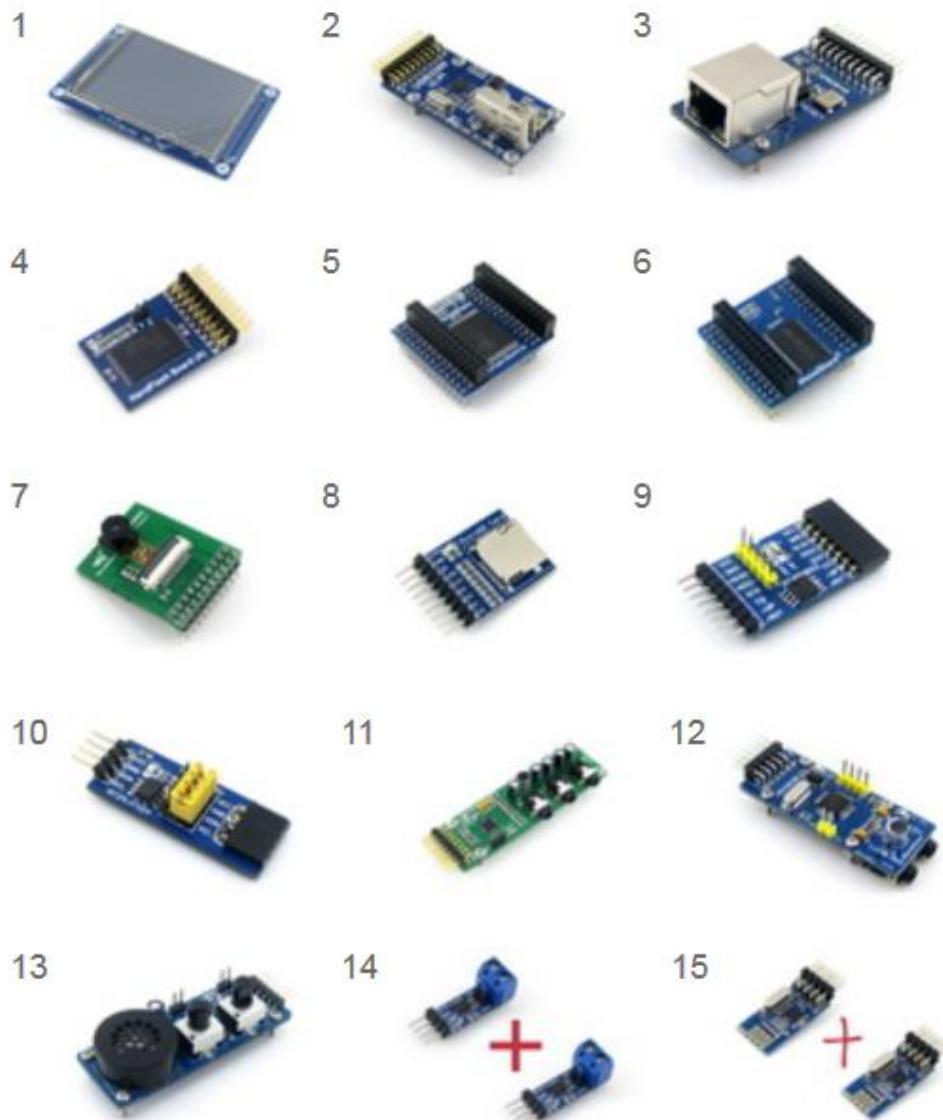
# Open407i



# Open407i con ST-LINKV2







### Accessory Boards Package

1. 3.2inch 320x240 Touch LCD (A) x 1
2. USB3300 USB HS Board x 1
3. DP83848 Ethernet Board x 1
4. NandFlash Board (A) x 1
5. NorFlash Board (A) x 1
6. IS62WV12816BLL SRAM Board x 1
7. OV9655 Camera Board x 1
8. Micro SD Storage Board x 1
9. AT45DBXX DataFlash Board x 1
10. FM24CLXX FRAM Board x 1
11. UDA1380 Board x 1
12. VS1003B MP3 Board x 1
13. Analog Test Board x 1
14. SN65HVD230 CAN Board 2pcs x 1
15. NRF24L01 RF Board (B) 2pcs x 1