Sistemas Basados en Microprocesador

B1 ARM Cortex M4 - MDK - CMSIS

1. ARM Cortex M4
2. ARM MDK
3. CMSIS
4. MDK first project
5. Information

4 product series

Common core peripherals and architecture:

- Communication peripherals: USART, SPI, I²C
- 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)
- Dual 12-bit DAC
- Up to 3x 12-bit ADC (up to 0.41 µs)
- 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) 5.0 V tolerant I/Os
- 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 I²S audio Camera IF	Ethernet IEEE 1588	Crypto/hash processor and RNG

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 I²S audio Camera IF	Ethernet IEEE 1588	Crypto/hash processor and RNG

STM32 F1 series - Connectivity line (STM32F105/107)

72 MHz Cortex-M3 CPU	Up to 64-Kbyte SRAM	Up to 256-Kbyte Flash	USB 2.0 OTG FS	3-phase MC timer	2x CAN 2.0B	2x I²S audio	Ethernet IEEE 1588

STM32 F1 series - Performance line (STM32F103)

72 MHz Cortex-M3 CPU	Up to 96-Kbyte SRAM	Up to 1-Mbyte Flash	USB FS device	3-phase MC timer	CAN 2.0B	SDIO 2x I²S

STM32 F1 series - USB Access line (STM32F102)

48 MHz Cortex-M3 CPU	Up to 16-Kbyte SRAM	Up to 128-Kbyte Flash	USB FS device

STM32 F1 series - Access line (STM32F101)

36 MHz Cortex-M3 CPU	Up to 80-Kbyte SRAM	Up to 1-Mbyte Flash

STM32 F1 series - Value line (STM32F100)

24 MHz Cortex-M3 CPU	Up to 32-Kbyte SRAM	Up to 512-Kbyte Flash	3-phase MC timer	CEC

STM32 L1 series - Ultra-low-power (STM32F151/152)

32 MHz Cortex-M3 CPU	Up to 48-Kbyte SRAM	Up to 384-Kbyte Flash	USB FS device	Data EEPROM up to 12 Kbytes	LCD 8x40 4x44	Comparator	BOR MSI VScal	AES 128-bit

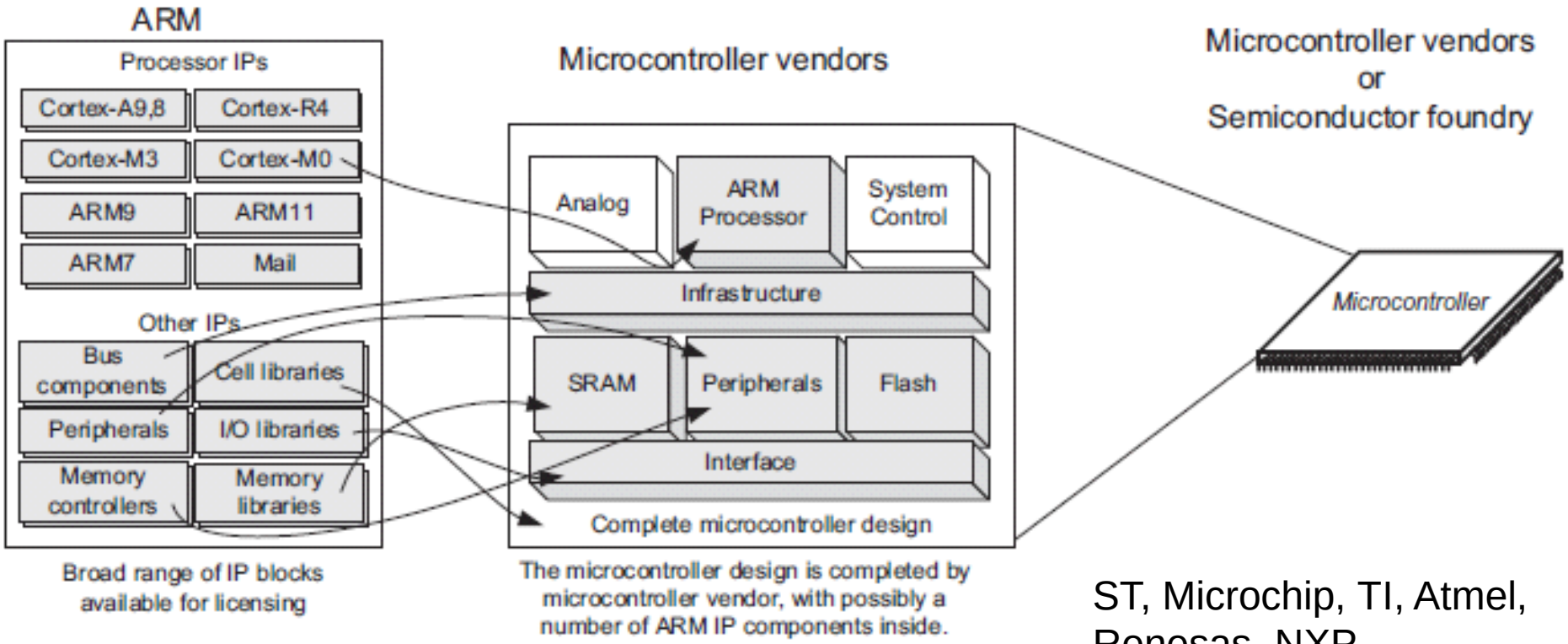
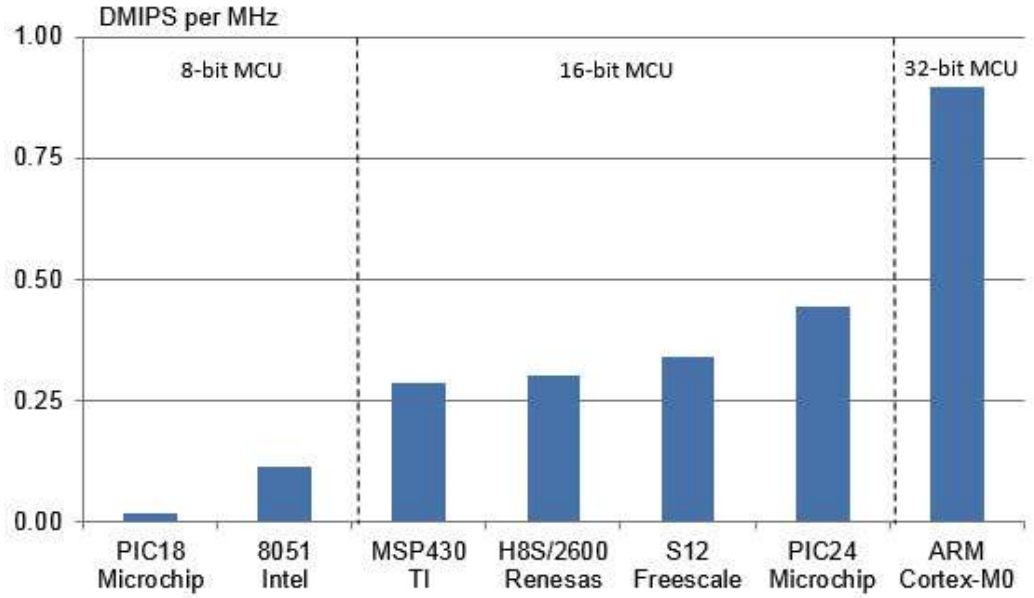


Figure 1.1:
Use of intellectual property (IP) in microcontroller design.



ARM Cortex-M Performance , Power and Area

	90LP (7-track, typical 1.2v, 25C)		40G (9-track, typical 0.9v, 25C)	
	Dynamic power (µW/MHz)	Area mm²	Dynamic power (µW/MHz)	Area mm²
Cortex-M0	16	0.04	4	0.01
Cortex-M0+	9.8	0.035	3	0.009
Cortex-M3	32	0.12	7	0.03
Cortex-M4	33	0.17	8	0.04

- Static power <0.7 µW/MHz

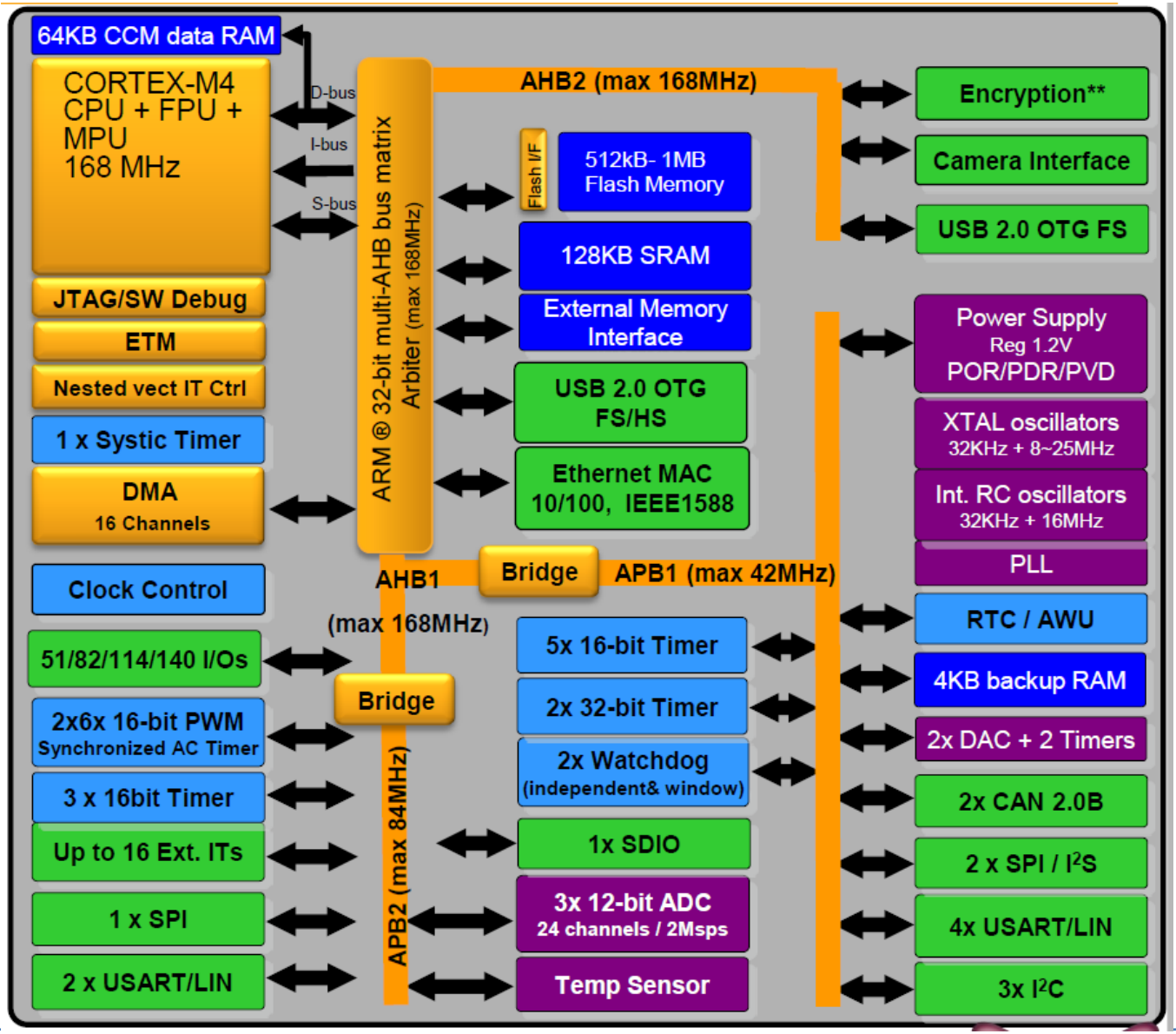
CoreMark® and Dhrystone

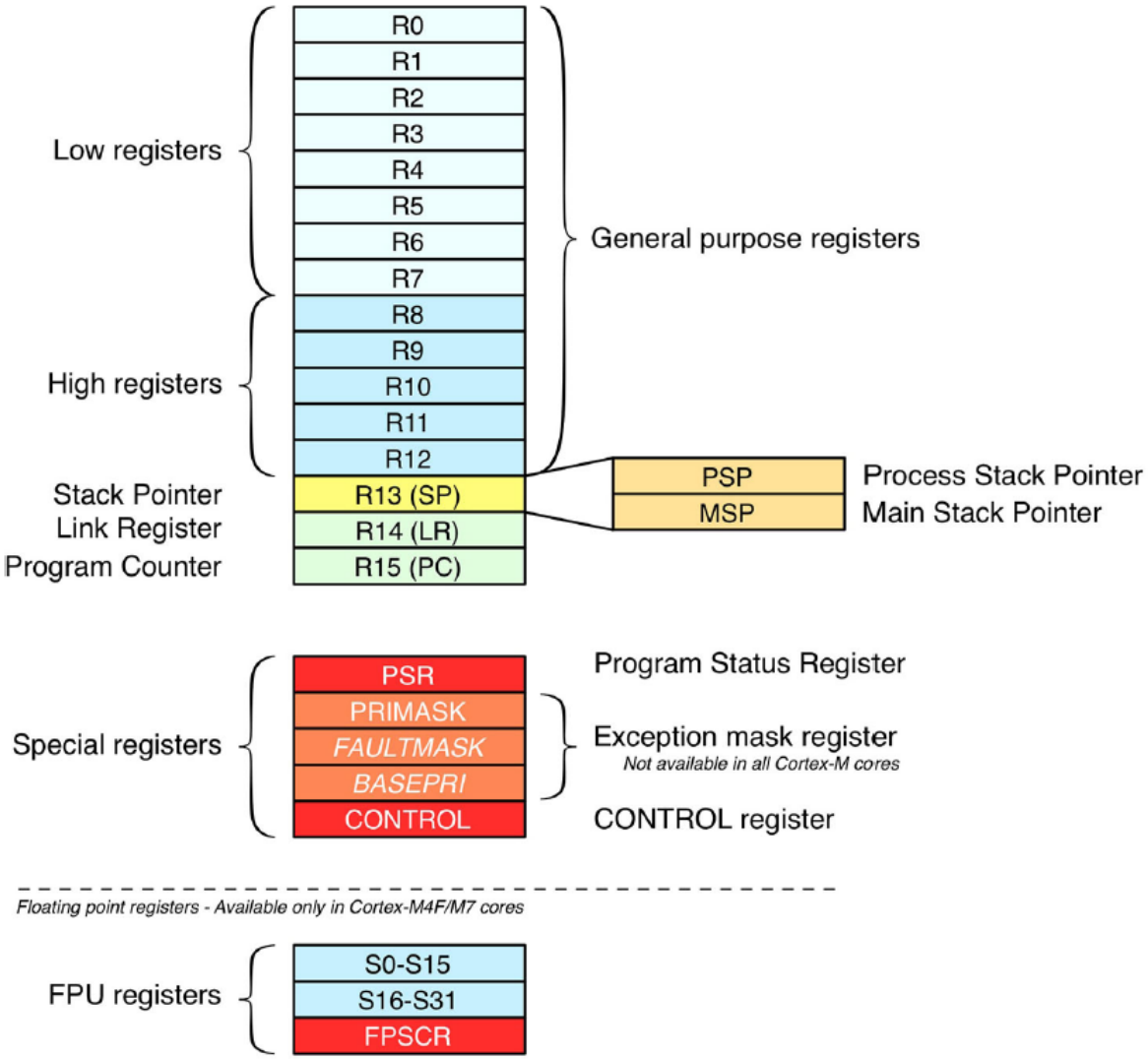
Dhrystone (official)	Dhrystone (max options)	CoreMark
DMIPS/MHz	DMIPS/MHz	CoreMark/MHz
0.84	1.21	2.33
0.94	1.31	2.42
1.25	1.89	3.32
1.25	1.95	3.40

* CoreMark data from ARM website & CoreMark.org website

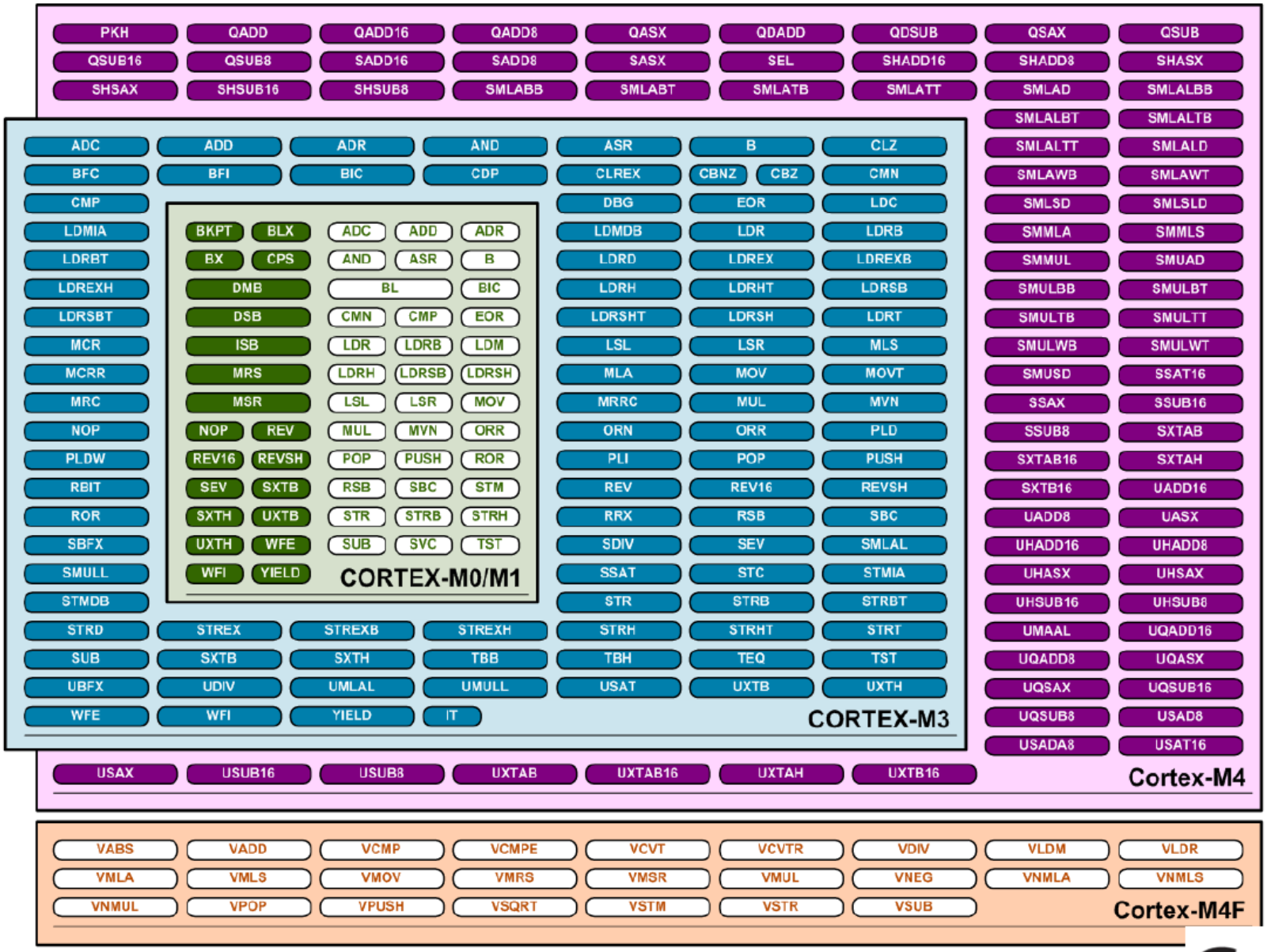
Cortex-M0 Base usable configuration includes 1 IRQ + NMI, excludes debug
Cortex-M0+ Base usable configuration includes 1 IRQ + NMI, excludes debug
Cortex-M3 Base usable configuration includes 1 IRQ + NMI, excludes ETM, MPU and debug
Cortex-M4 Base usable configuration includes DSP extensions, 1 IRQ + NMI, excludes ETM, MPU, FPU and debug

Ultra low power for the performance of a 32 bit processor


64KB CCM data RAM
CORTEX-M4
CPU + FPU +
MPU
168 MHz
D-bus
I-bus
S-bus
ARM ® 32-bit multi-AHB bus matrix
Arbiter (max 168MHz)
AHB2 (max 168MHz)
Flash I/F
512kB- 1MB
Flash Memory
128KB SRAM
External Memory
Interface
USB 2.0 OTG
FS/HS
Ethernet MAC
10/100, IEEE1588
Encryption**
Camera Interface
USB 2.0 OTG FS
JTAG/SW Debug
ETM
Nested vect IT Ctrl
1 x Systic Timer
DMA
16 Channels
Clock Control
51/82/114/140 I/Os
2x6x 16-bit PWM
Synchronized AC Timer
3 x 16bit Timer
Up to 16 Ext. ITs
1 x SPI
2 x USART/LIN
AHB1
(max 168MHz)
Bridge
APB1 (max 42MHz)
Bridge
APB2 (max 84MHz)
5x 16-bit Timer
2x 32-bit Timer
2x Watchdog
(independent& window)
1x SDIO
3x 12-bit ADC
24 channels / 2Msps
Temp Sensor
Power Supply
Reg 1.2V
POR/PDR/PVD
XTAL oscillators
32KHz + 8~25MHz
Int. RC oscillators
32KHz + 16MHz
PLL
RTC / AWU
4KB backup RAM
2x DAC + 2 Timers
2x CAN 2.0B
2 x SPI / I²S
4x USART/LIN
3x I²C


R0
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13 (SP)
R14 (LR)
R15 (PC)
Low registers
High registers
Stack Pointer
Link Register
Program Counter
General purpose registers
PSP
MSP
Process Stack Pointer
Main Stack Pointer
Special registers
PSR
PRIMASK
FAULTMASK
BASEPRI
CONTROL
Program Status Register
Exception mask register
Not available in all Cortex-M cores
CONTROL register
Floating point registers - Available only in Cortex-M4F/M7 cores
FPU registers
S0-S15
S16-S31
FPSCR

ARM Cortex M4



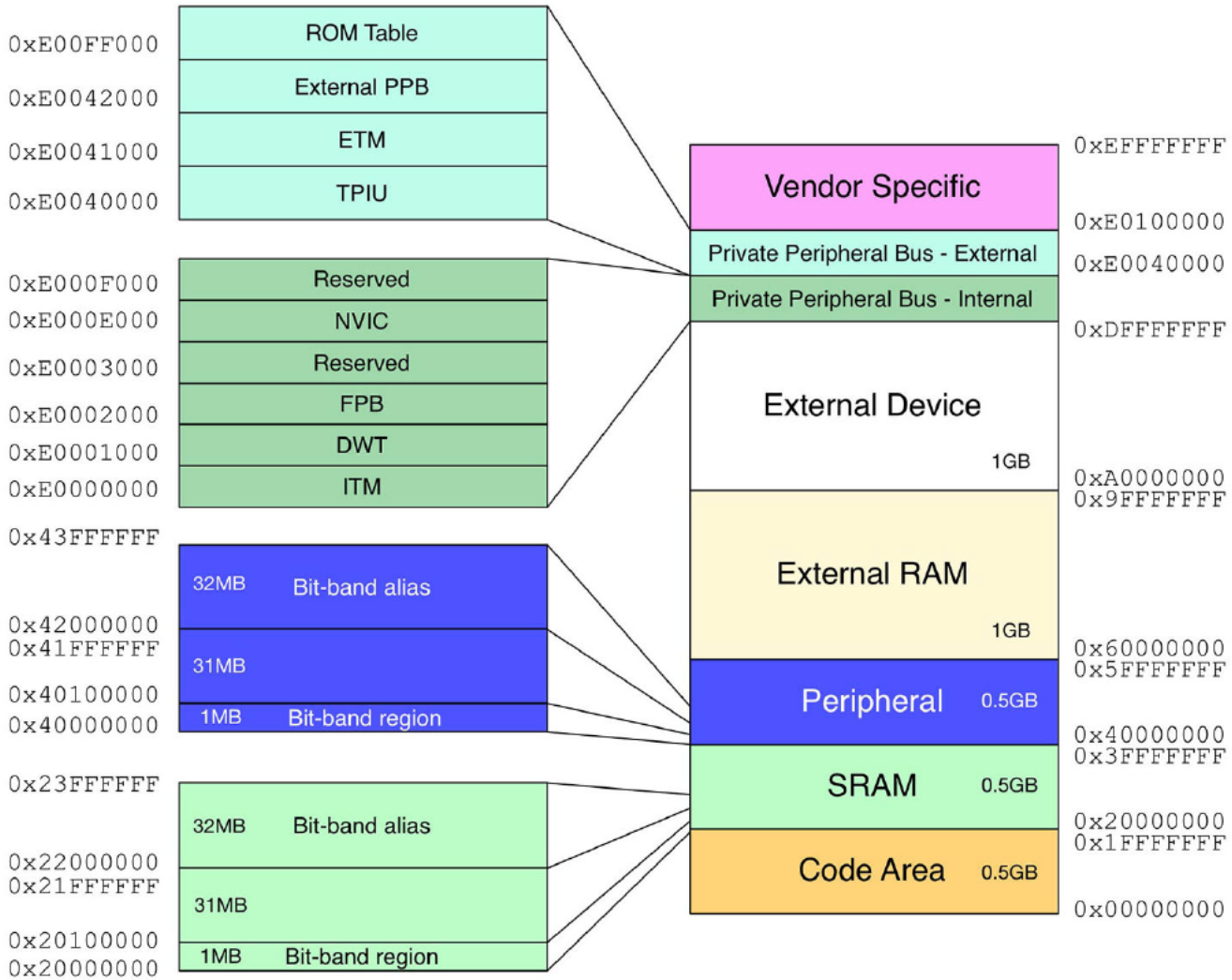

0xE00FF000
ROM Table
0xE0042000
External PPB
0xE0041000
ETM
0xE0040000
TPIU
0xE000F000
Reserved
0xE000E000
NVIC
0xE0003000
Reserved
0xE0002000
FPB
0xE0001000
DWT
0xE0000000
ITM
0x43FFFFFF
0x42000000
32MB
Bit-band alias
0x41FFFFFF
0x40100000
31MB
0x40000000
1MB
Bit-band region
0x23FFFFFF
0x22000000
32MB
Bit-band alias
0x21FFFFFF
0x20100000
31MB
0x20000000
1MB
Bit-band region
Vendor Specific
0xEFFFFFFF
0xE0100000
Private Peripheral Bus - External
0xE0040000
Private Peripheral Bus - Internal
0xDFFFFFFF
External Device
1GB
0xA0000000
0x9FFFFFFF
External RAM
1GB
0x60000000
0x5FFFFFFF
Peripheral
0.5GB
0x40000000
0x3FFFFFFF
SRAM
0.5GB
0x20000000
0x1FFFFFFF
Code Area
0.5GB
0x00000000

Figure 1. Nucleo-144 board (top view)

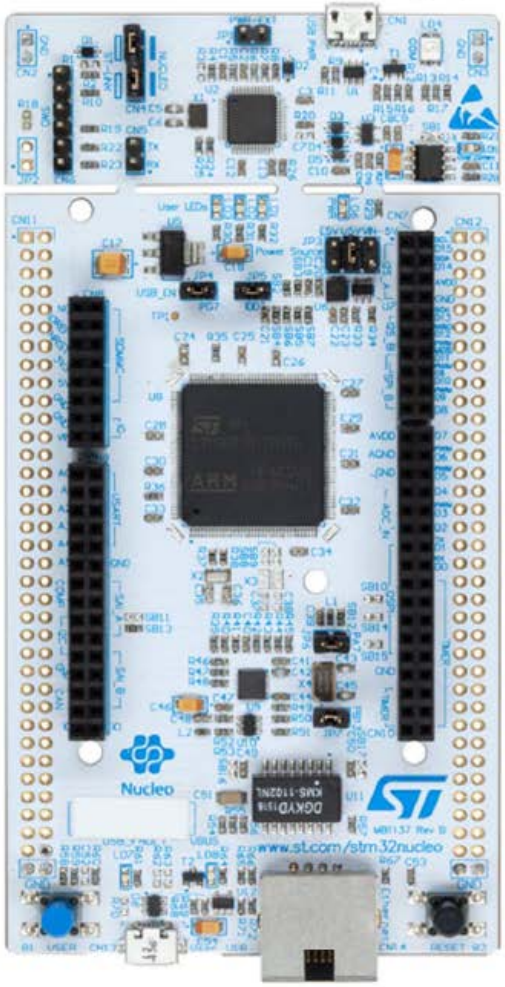
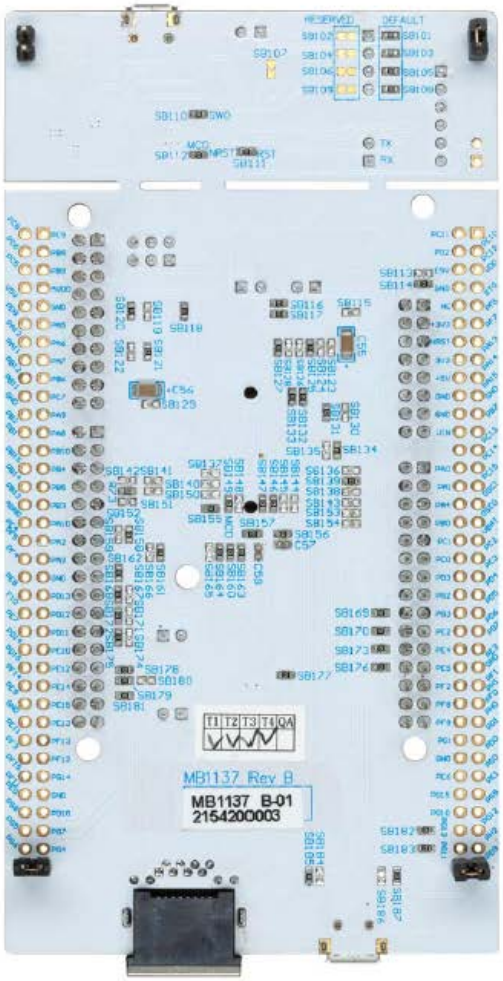
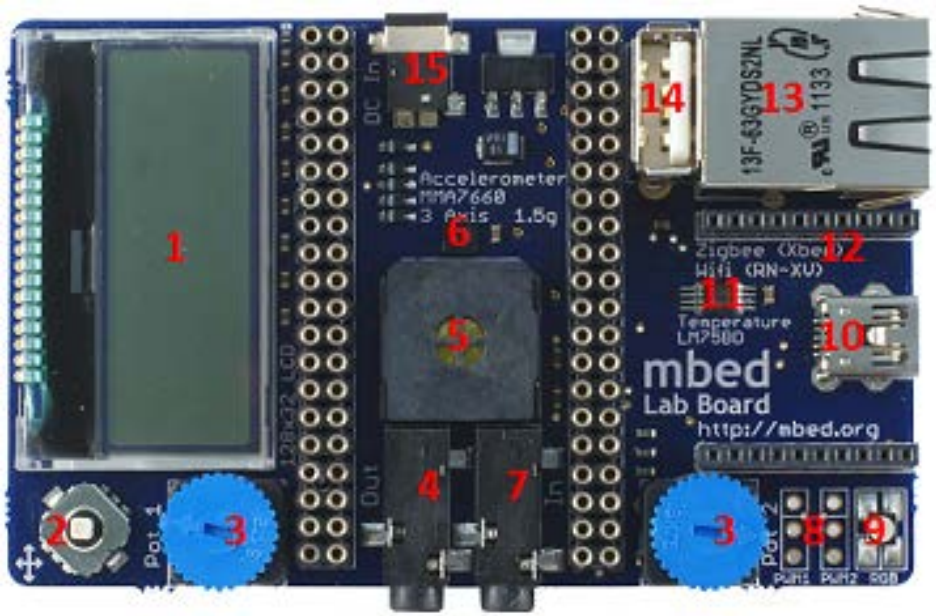


Figure 2. Nucleo-144 board (bottom view)



https://www.st.com/en/evaluation-tools/nucleo-f429zi.html

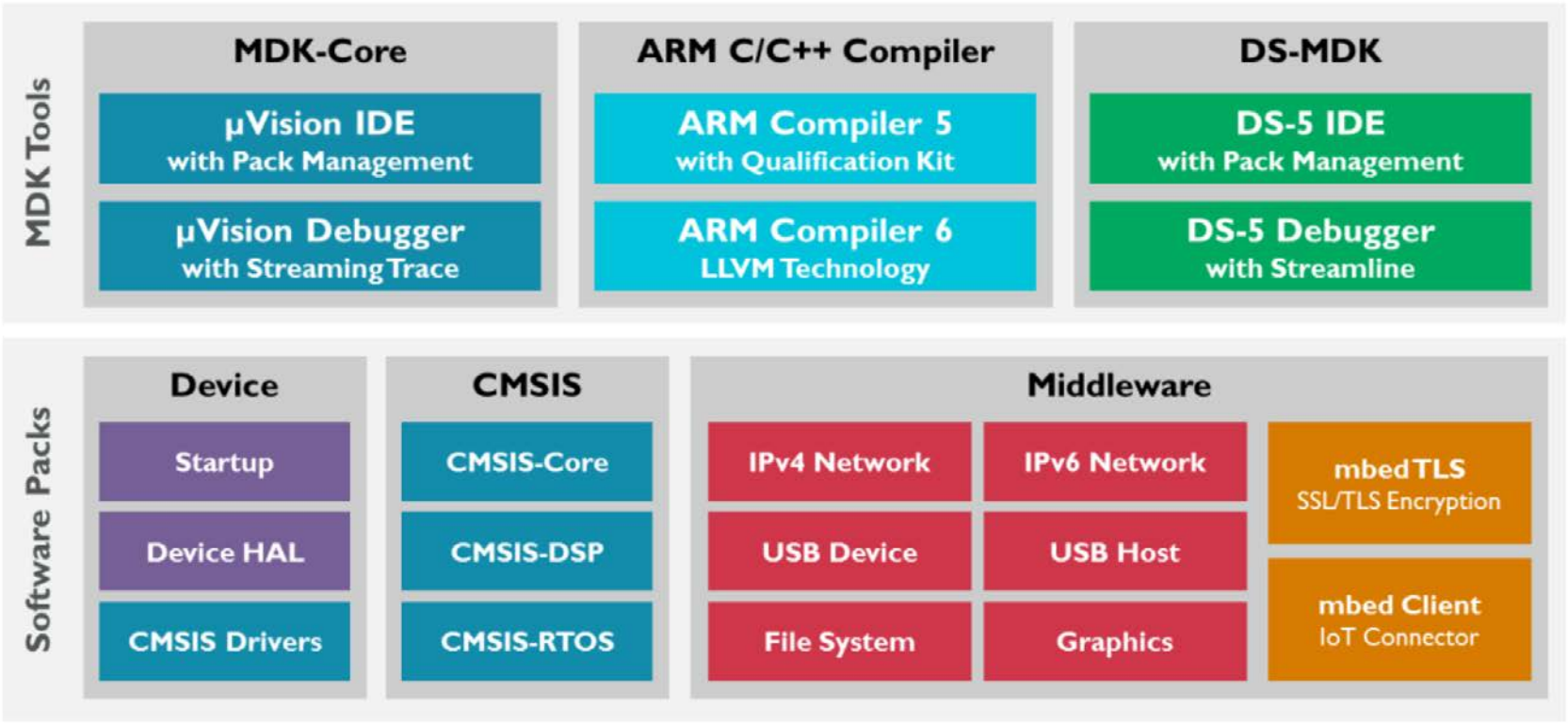
- **mbed Application Board**

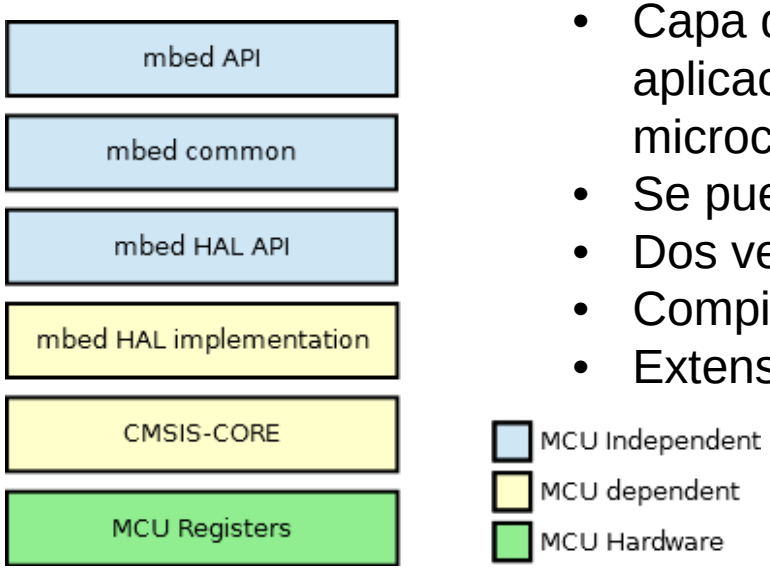


1. 128x32 Graphics LCD
2. 5 way joystick
3. 2 x Potentiometers
4. 3.5mm Audio jack (Analog Out)
5. Speaker, PWM Connected
6. 3 Axis +/1 1.5g Accelerometer
7. 3.5mm Audio jack (Analog In)
8. 2 x Servo motor headers
9. RGB LED, PWM connected
10. USB-mini-B Connector
11. Temperature sensor
12. Socket for for Xbee (Zigbee) or RN-XV (Wifi)
13. RJ45 Ethernet connector
14. USB-A Connector
15. 1.3mm DC Jack input

http://mbed.org/cookbook/mbed-application-board

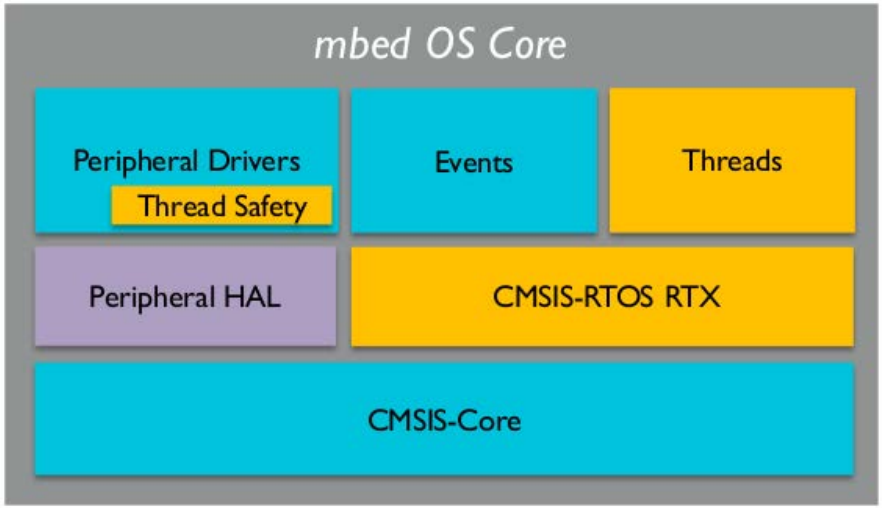
ARM MDK


MDK Tools
MDK-Core
µVision IDE
with Pack Management
µVision Debugger
with Streaming Trace
ARM C/C++ Compiler
ARM Compiler 5
with Qualification Kit
ARM Compiler 6
LLVM Technology
DS-MDK
DS-5 IDE
with Pack Management
DS-5 Debugger
with Streamline
Software Packs
Device
Startup
Device HAL
CMSIS Drivers
CMSIS
CMSIS-Core
CMSIS-DSP
CMSIS-RTOS
Middleware
IPv4 Network
IPv6 Network
USB Device
USB Host
File System
Graphics
mbed TLS
SSL/TLS Encryption
mbed Client
IoT Connector



- Capa de abstracción software para desarrollar aplicaciones rápidamente que utilicen microcontroladores ARM.
- Se puede trabajar en C/C++.
- Dos versiones mbed 2.0 /mbed OS (>5.0).
- Compilador online.
- Extensa comunidad de desarrollo.

- Disponible solo para un conjunto de HW determinado
- Orientado a aplicaciones IoT en su últimas versiones.
- Versiones muy cambiantes.
- Poco control de los recursos hardware del microcontrolador.
- Se generan binarios demasiado grandes para pequeñas funcionalidades.

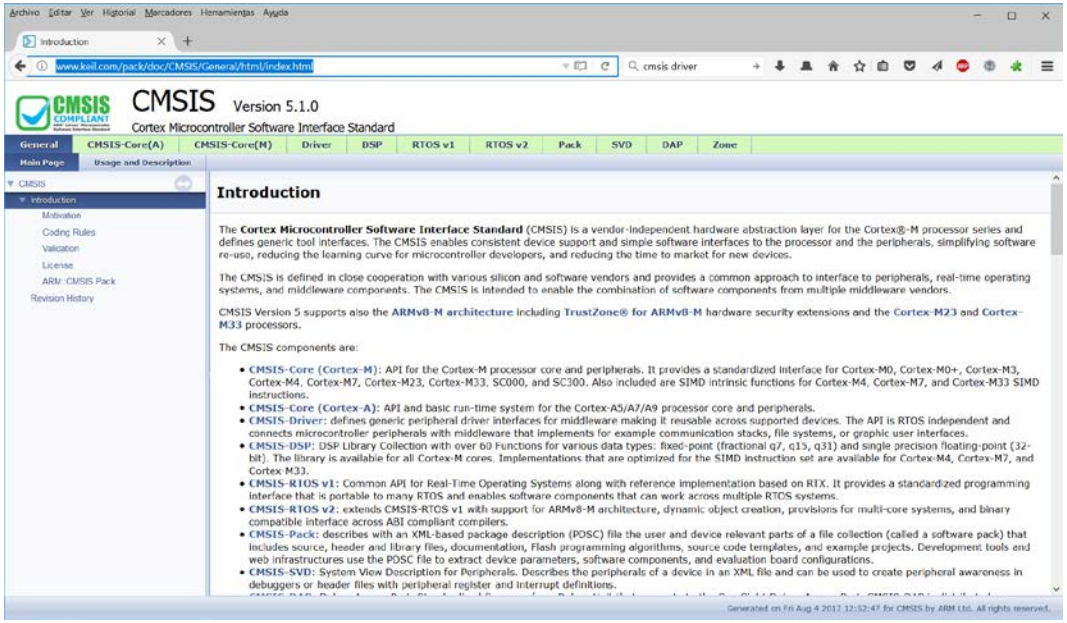


- ARM provee de un estándar para que los fabricantes que utilicen sus núcleos puedan desarrollar software
- Sólo tienen que añadir el soporte para los periféricos que incluyan en el microcontrolador
- Periféricos típicos: USART, I2C, SPI, ADC, DAC, Host/Device USB, Ethernet MAC, SDIO controller, LCD interface.

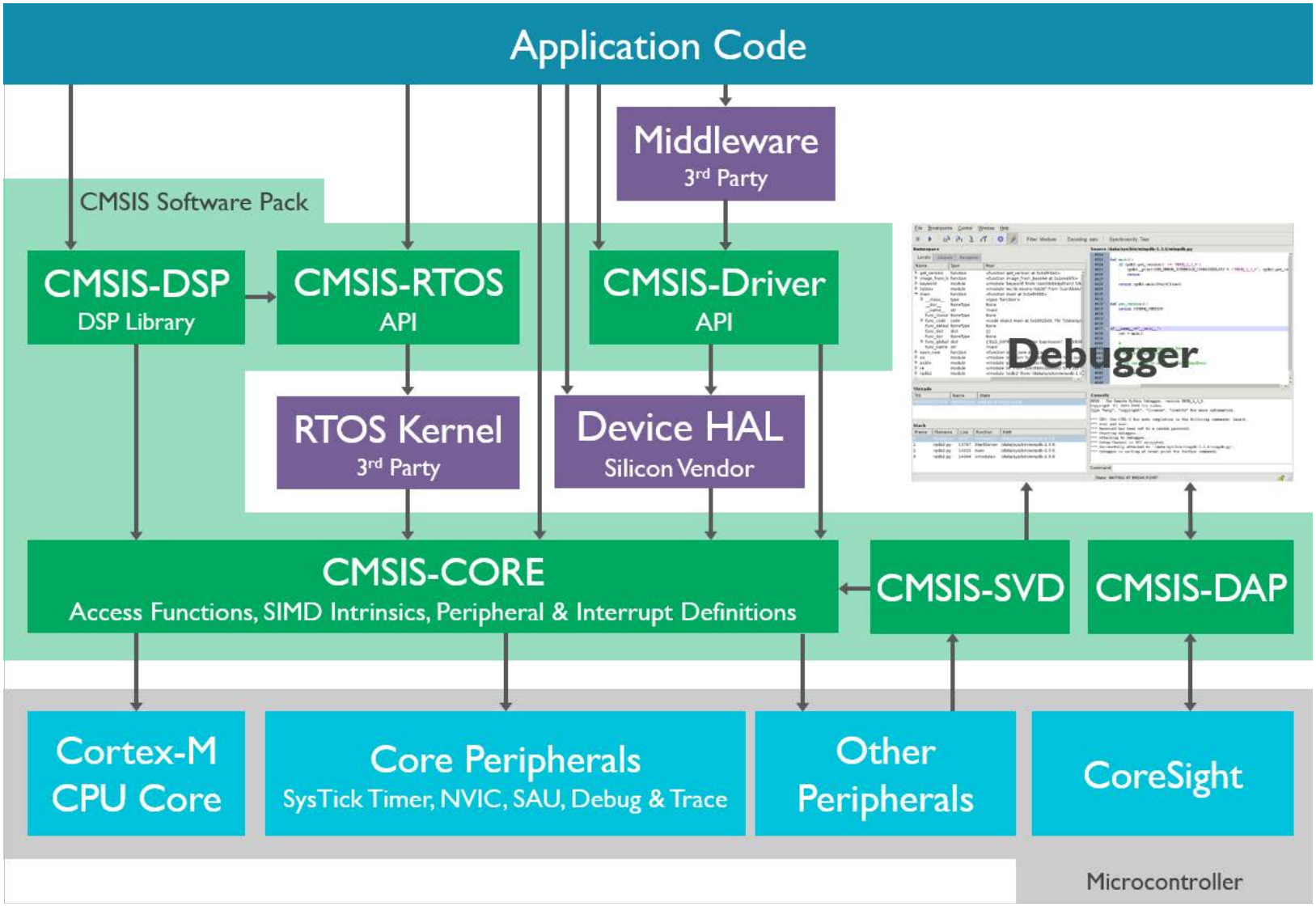
CMSIS COMPLIANT
ARM® Cortex™ Microcontroller Software Interface Standard

Componentes:

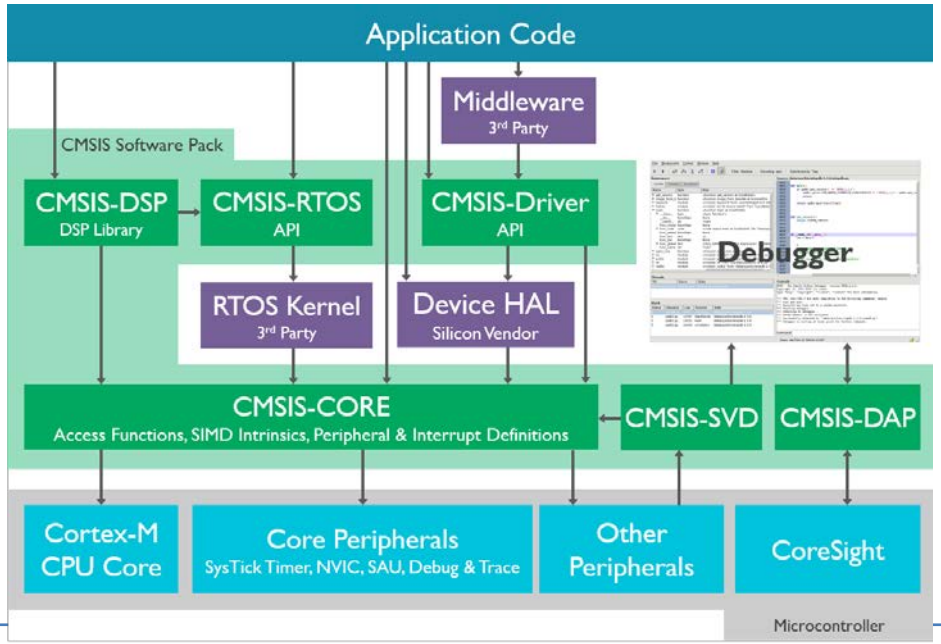
- CMSIS Core
- CMSIS Driver
- CMSIS Pack
- CMSIS RTOS
- CMSIS DSP
- CMSIS SVD-DAP



http://www.keil.com/pack/doc/CMSIS/General/html/index.html

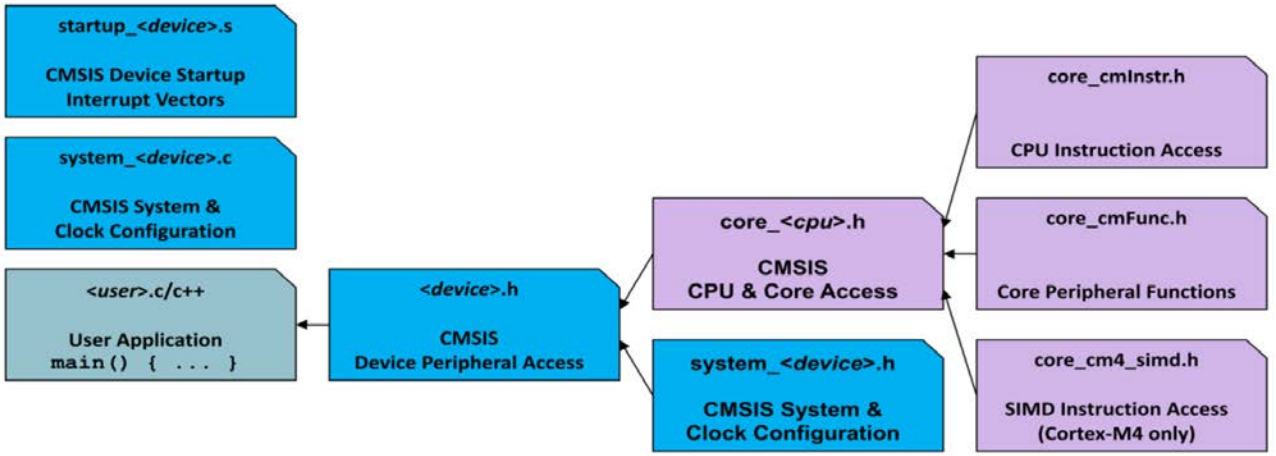

Application Code
Middleware
3rd Party
CMSIS Software Pack
CMSIS-DSP
DSP Library
CMSIS-RTOS
API
CMSIS-Driver
API
Debugger
RTOS Kernel
3rd Party
Device HAL
Silicon Vendor
CMSIS-CORE
Access Functions, SIMD Intrinsics, Peripheral & Interrupt Definitions
CMSIS-SVD
CMSIS-DAP
Cortex-M
CPU Core
Core Peripherals
SysTick Timer, NVIC, SAU, Debug & Trace
Other
Peripherals
CoreSight
Microcontroller

- Es posible reutilizar código y proyectos entre distintos dispositivos de un fabricante, además de compartir desarrollos entre distintas herramientas.
- No es una capa software con multitud de ficheros que generan binarios muy grandes. Se generan pocos kilobytes de código y se utiliza poca RAM.
- Puede ser utilizado desde no solo las herramientas de ARM (MDK, DS-MK), también puede ser utilizado desde IAR, Eclipse (Windows-Linux) utilizando el *toolchain* adecuado.



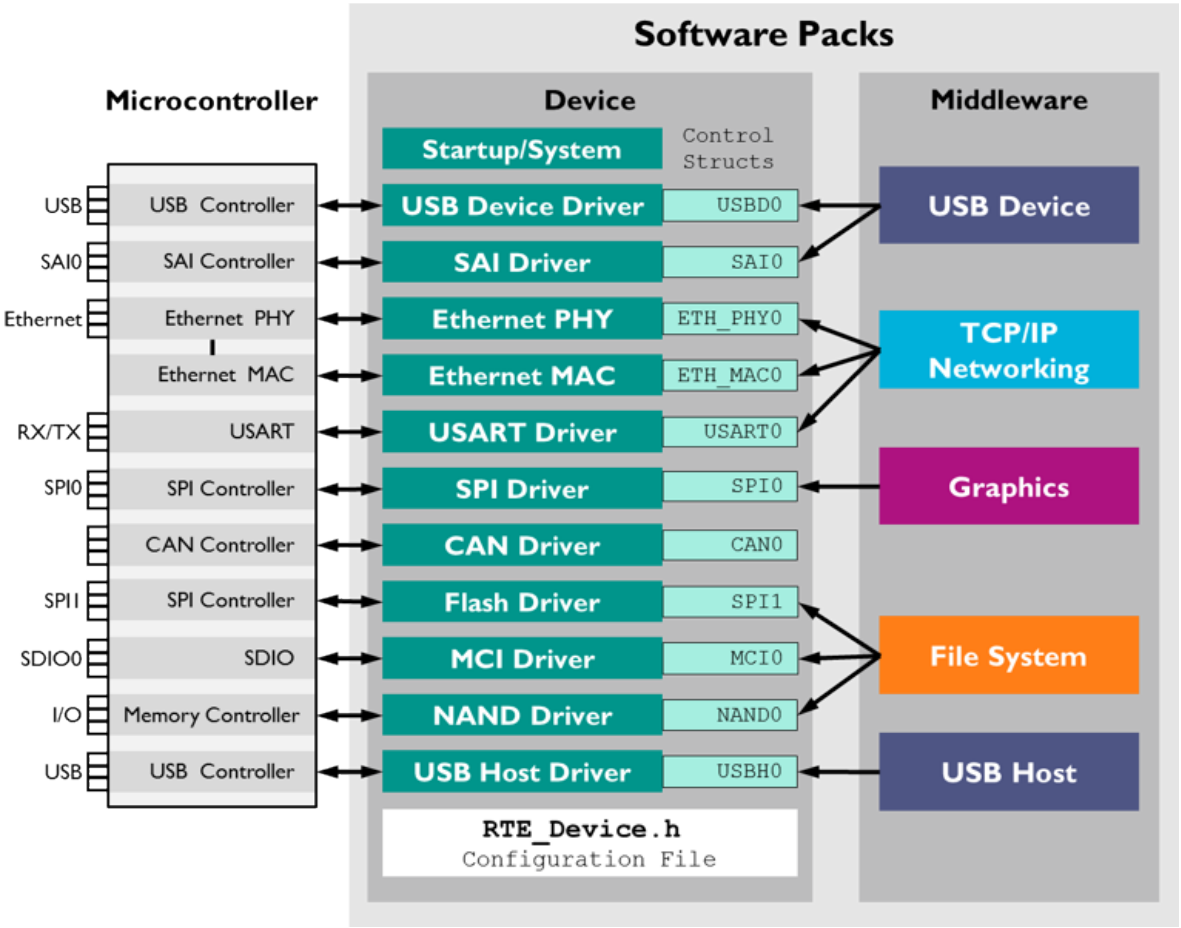
Define los recursos mínimos para acceder al core del uC:

- Hardware Abstraction Layer (HAL)
- System exception names
- Methods to organize header files
- Methods for system initialization (`SystemInit`())
- System clock frequency

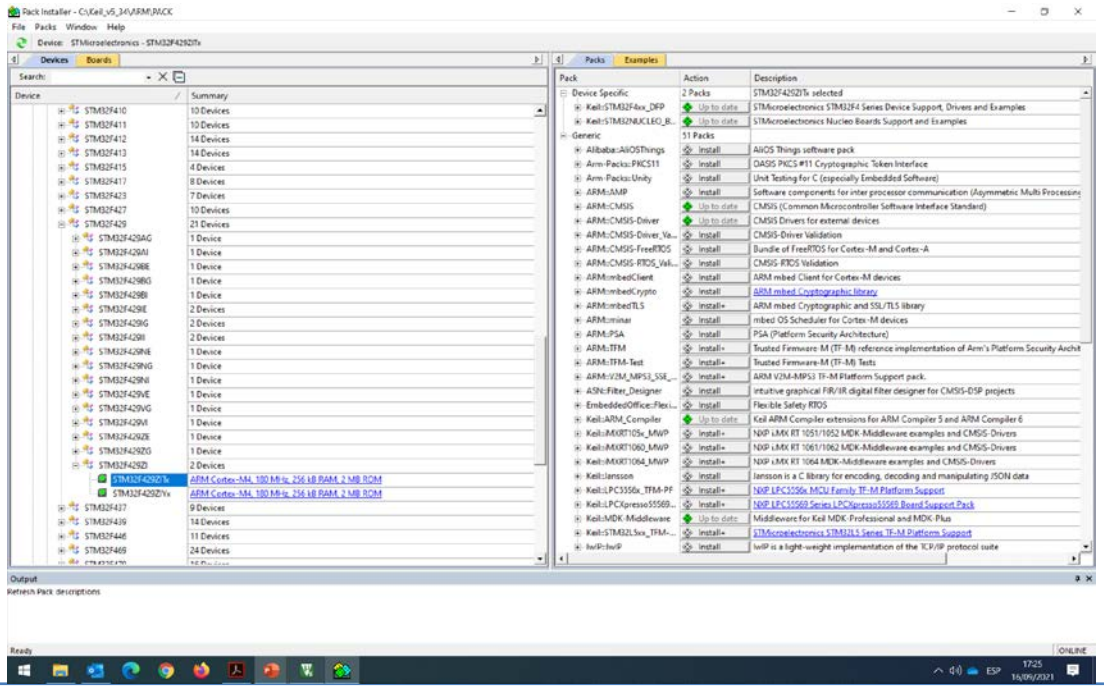


driver.c(h) – p.e. I2C LPC17xx.c(h)

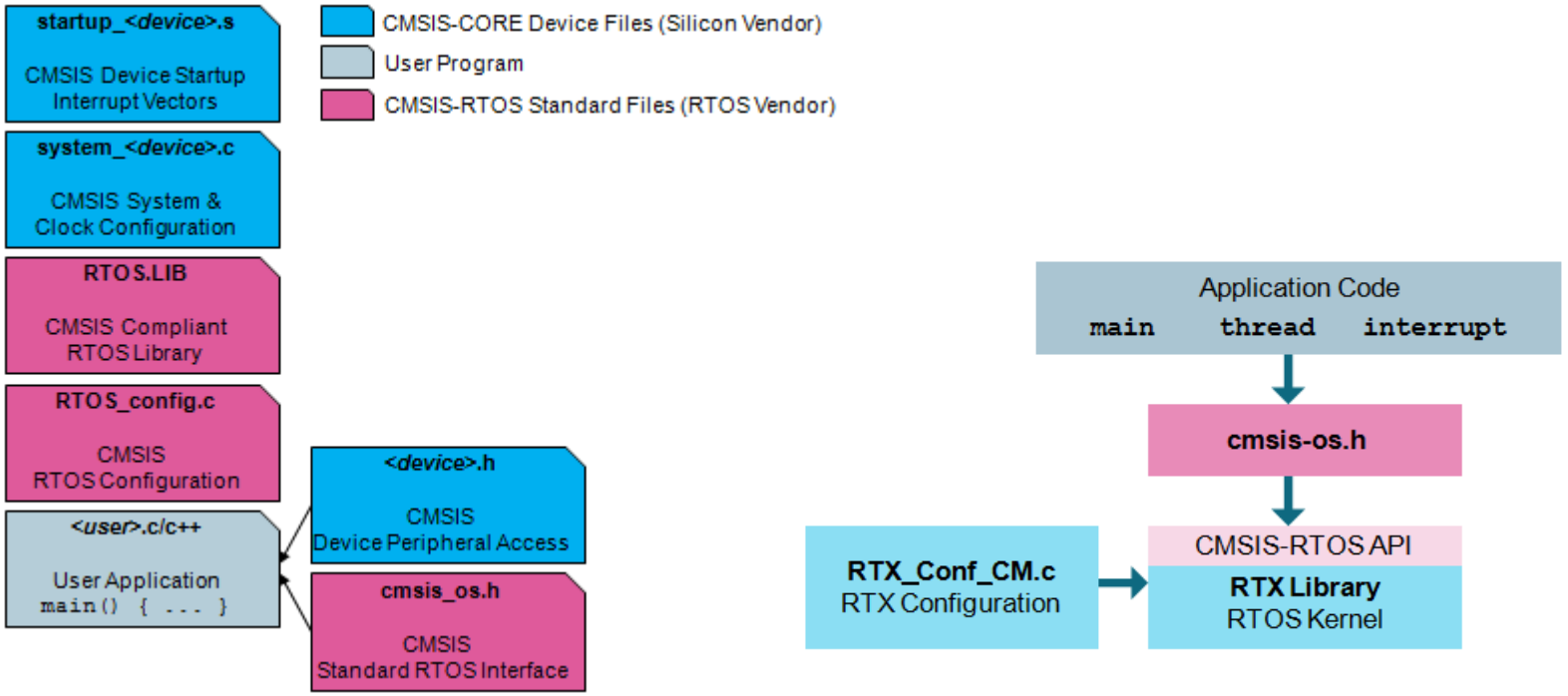
- Define la API para cada uno de los periféricos que integra el microcontrolador.



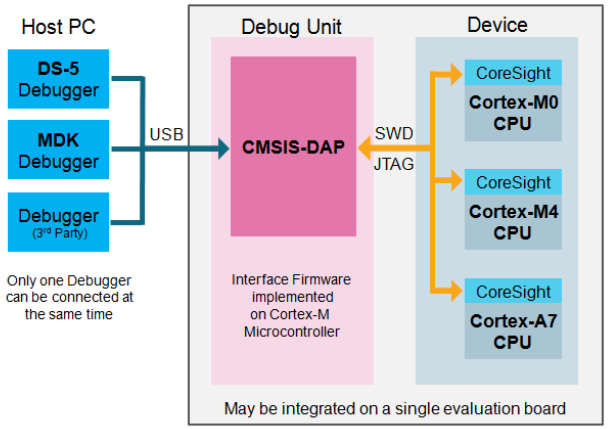
- Especificación para añadir componentes (devices, boards, middlewares)

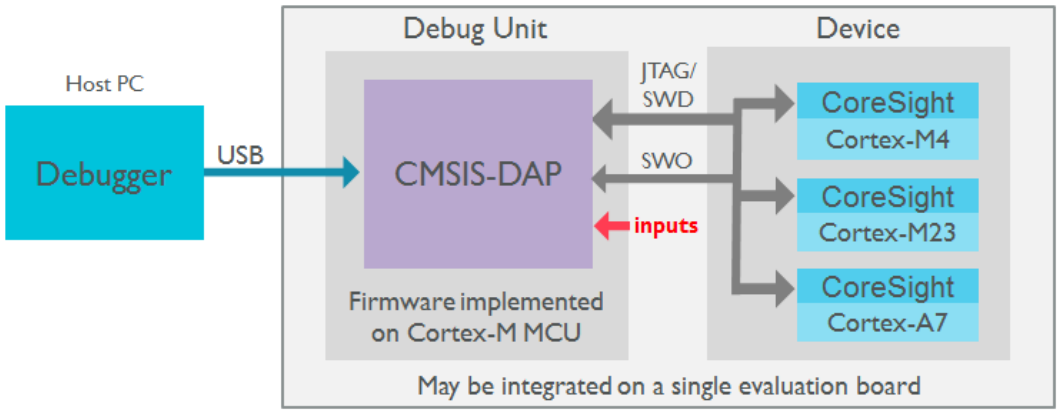


- Especificación utilizar el API del sistema operativo en tiempo real.
- Pueden elegirse distintas implementaciones (RTX, FreeRTOS, etc).



CMSIS SVD-DAP





Uso información

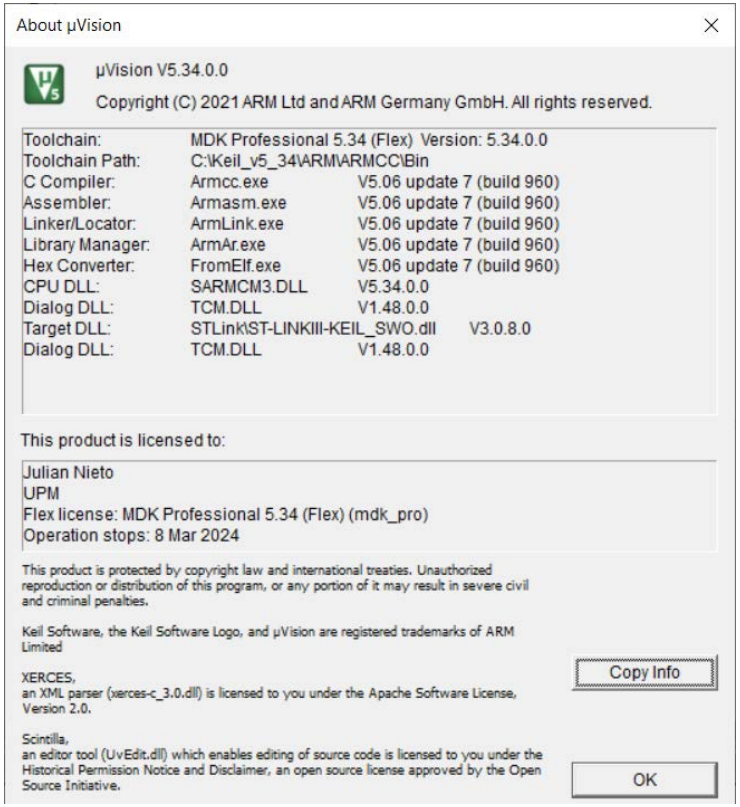
Documentos de referencia	Ubicación
Mastering STM32 (Carmine Noviello)	
ST Microelectronics resources	https://www.st.com/en/microcontrollers-microprocessors/stm32f4-series.html https://www.st.com/content/st_com/en/support/learning/stm32-education.html https://www.st.com/content/st_com/en/support/learning/stm32-education/stm32-online-training.html
MDK5 Getting Started	http://www2.keil.com/docs/default-source/default-document-library/mdk5-getting-started.pdf?sfvrsn=2[NC,L]
CMSIS (Cortex Microcontroller Software Interface Standard)	http://www.keil.com/pack/doc/CMSIS/General/html/index.html

Sistemas Basados en Microprocesador

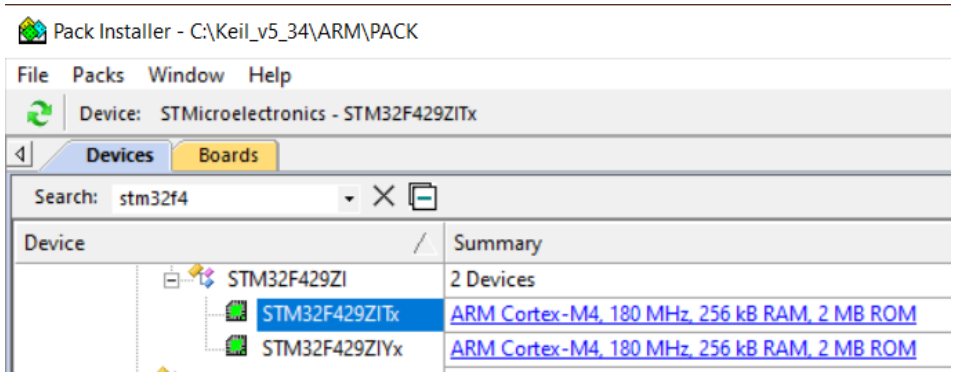
Instalación de Keil µVision

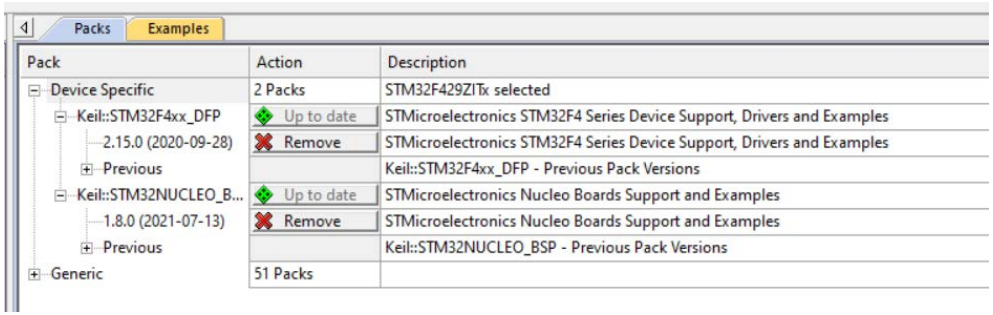
Instalación µVision

Instalacion como administrador: MDK534.exe



Agregar soporte para STM32F429ZiTX usando la utilidad Pack Installer





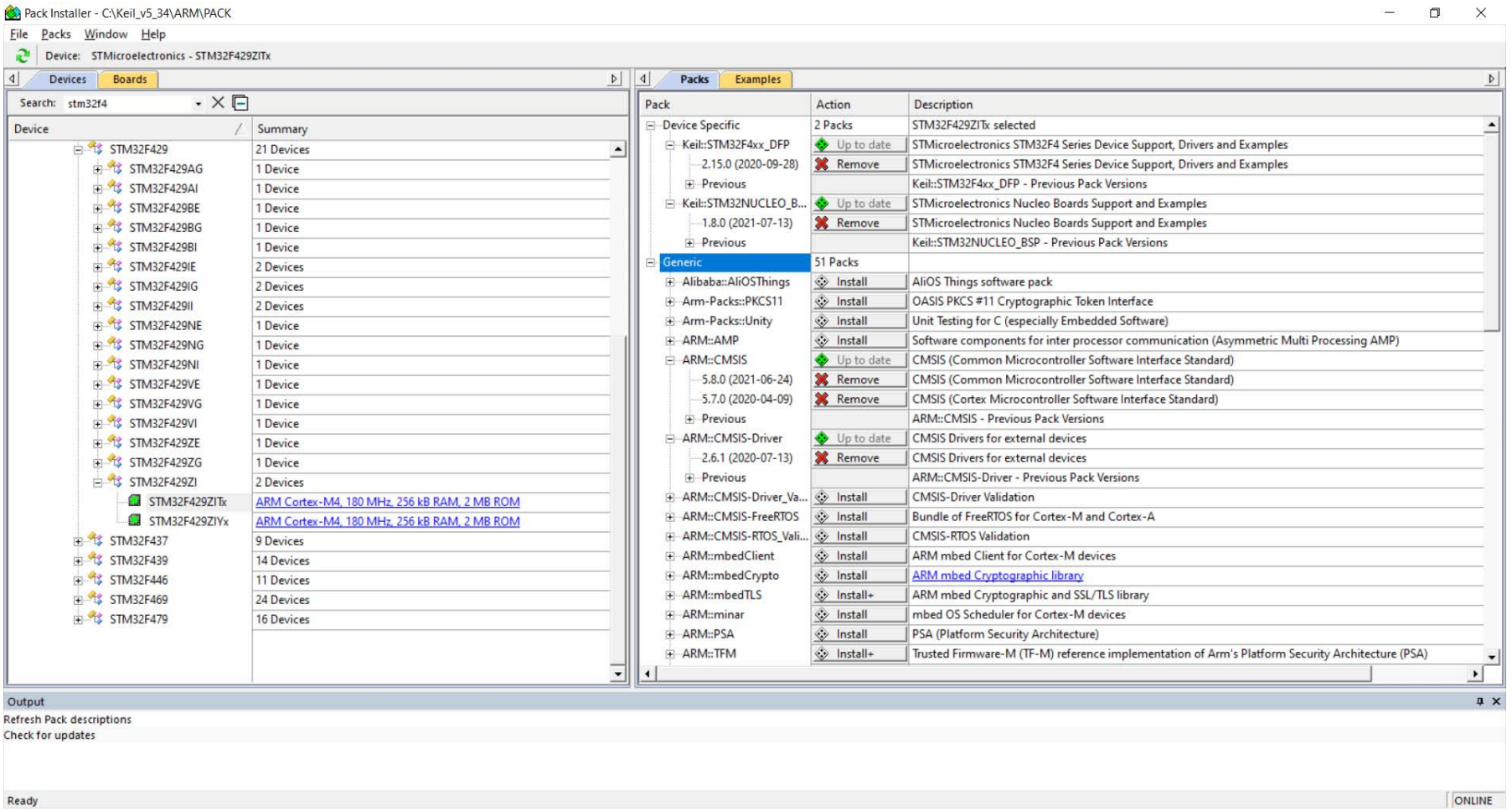
Instalacion del driver para Windows del interface de depuración STLink:

stlink_winusb_install.bat (como Administrador)

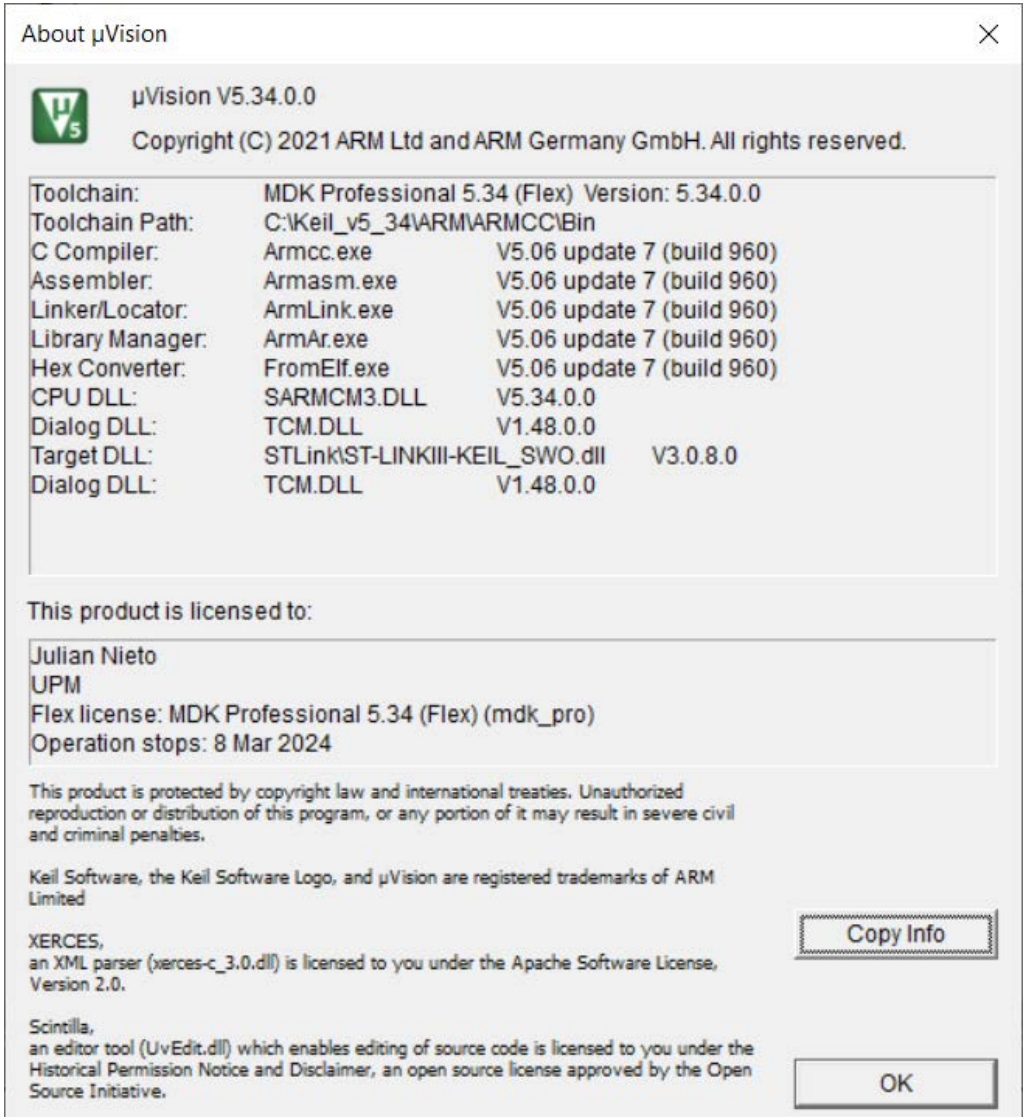
dentro de la carpeta descomprimida del fichero en.stsw-link009_v2.0.2.zip

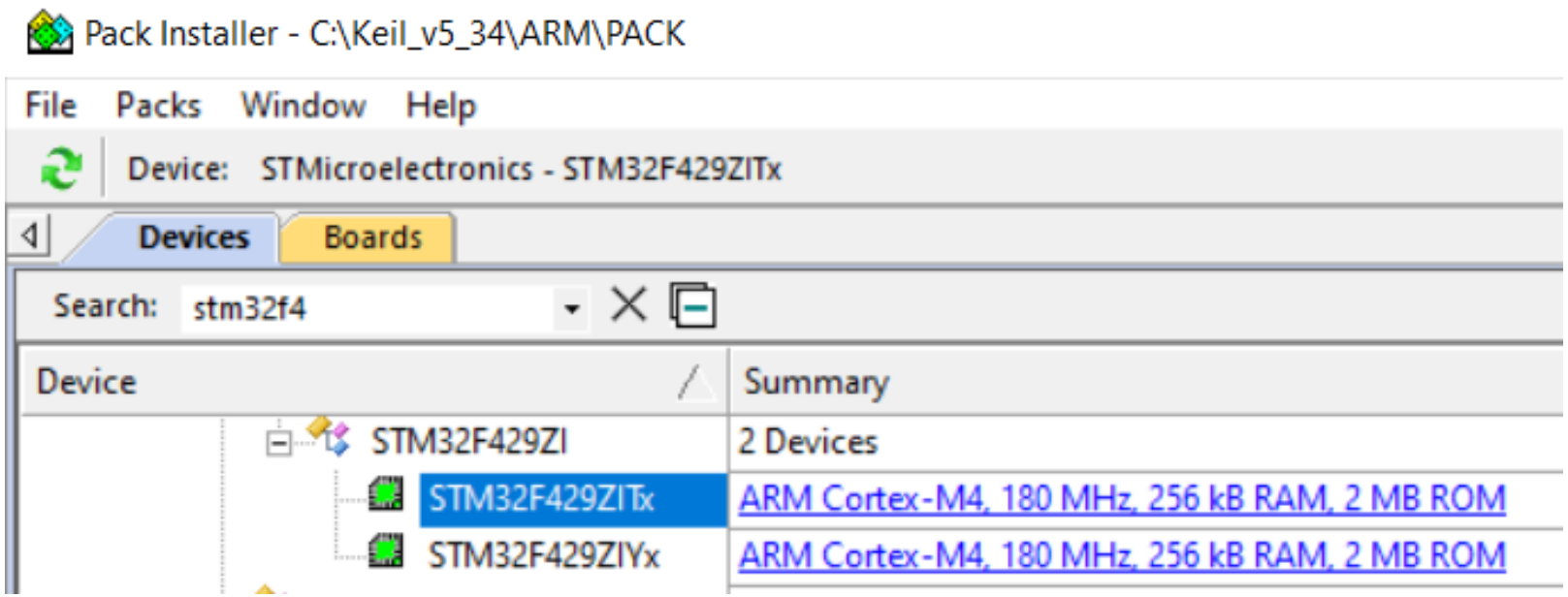
Pack installer

Es muy importante que las versiones instaladas sean las mismas que aqui se indican

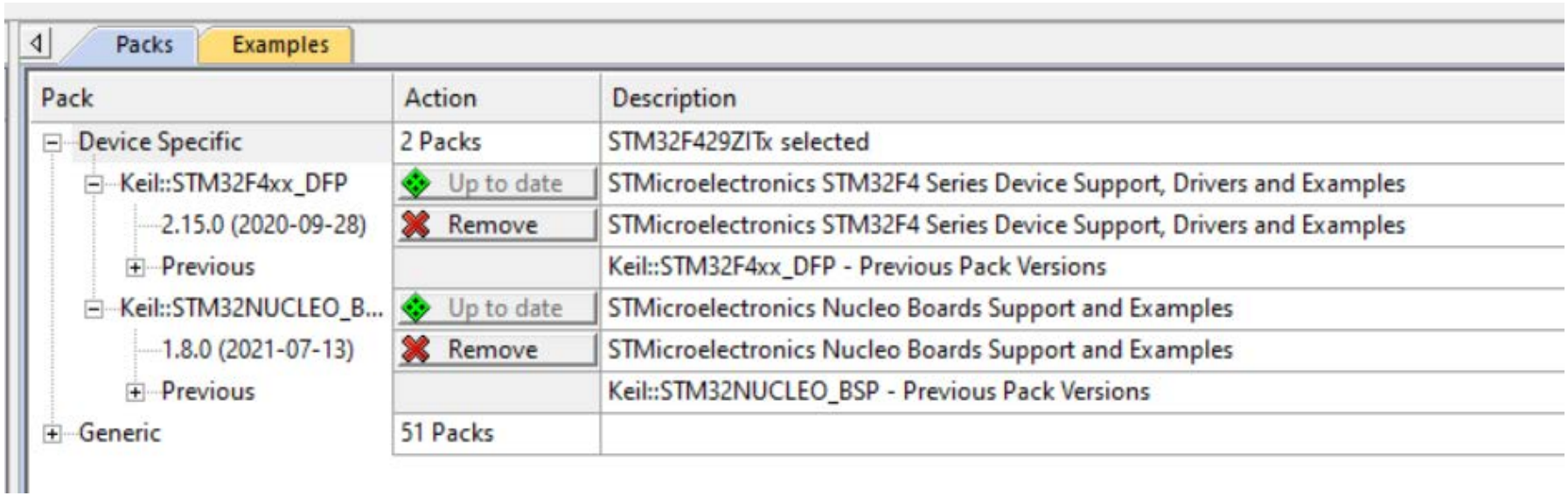


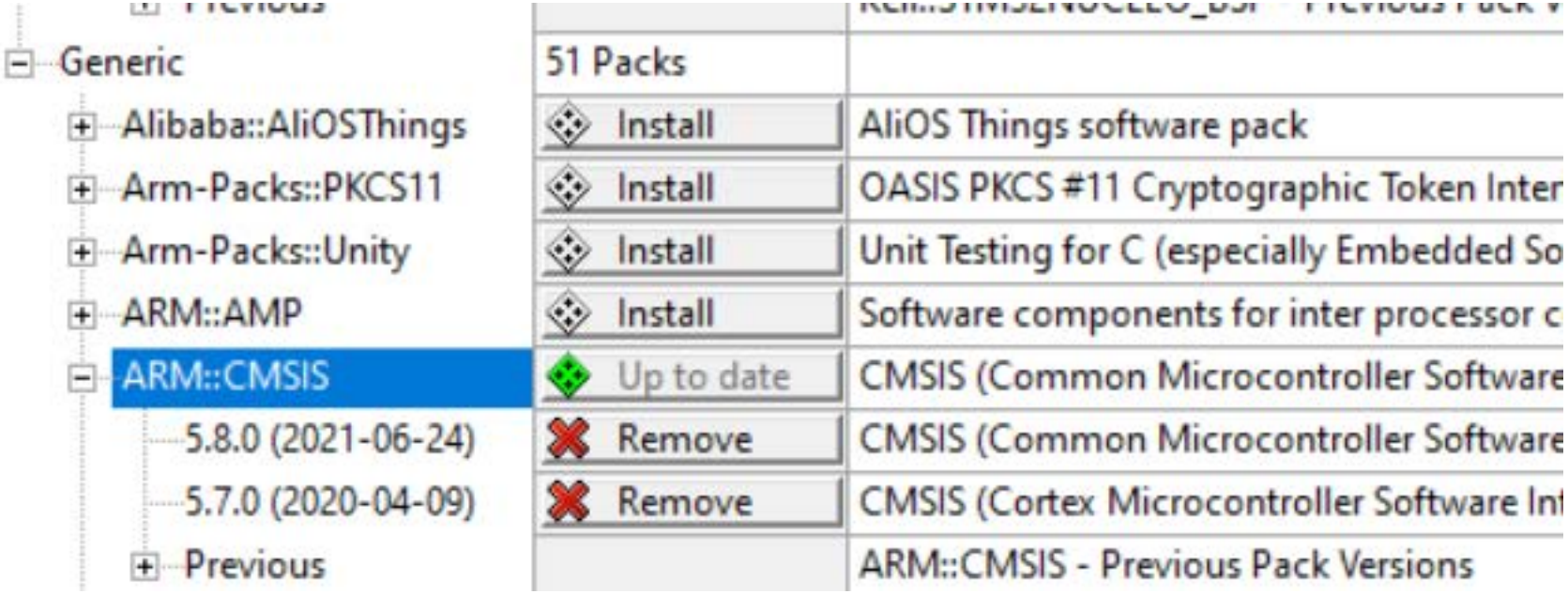
Anexo. Versiones SW

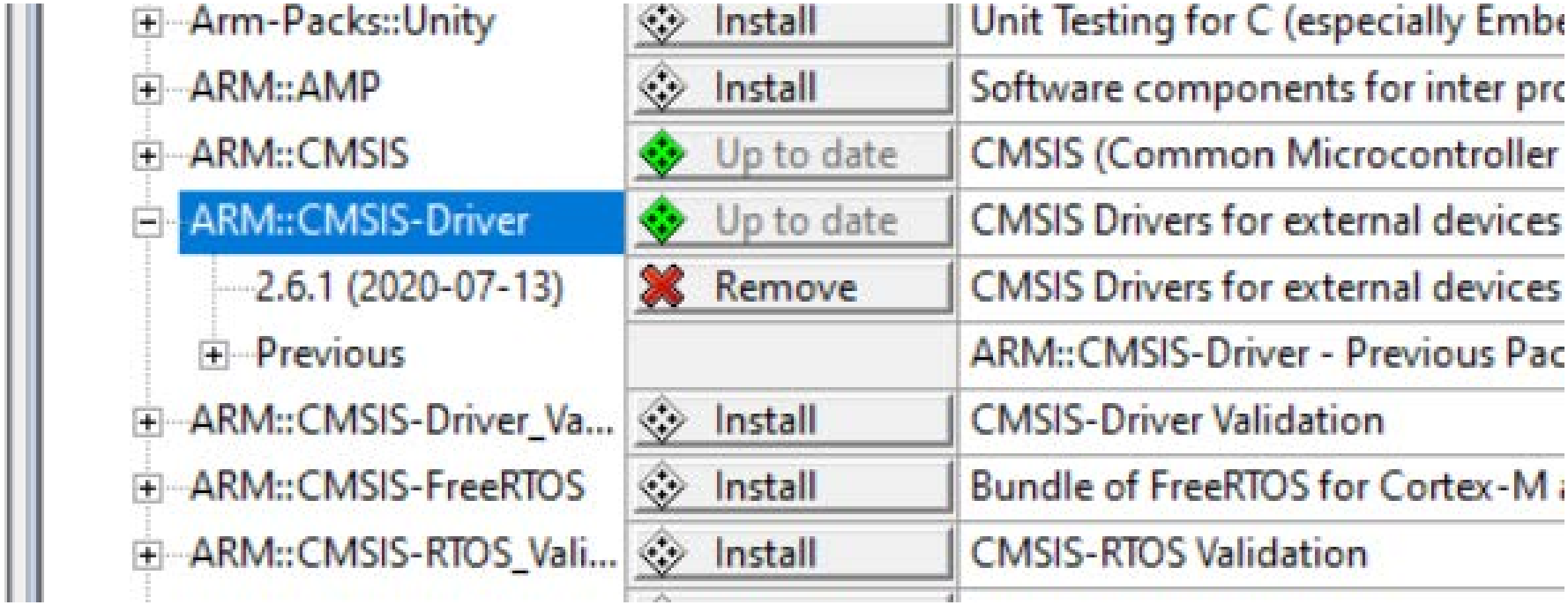


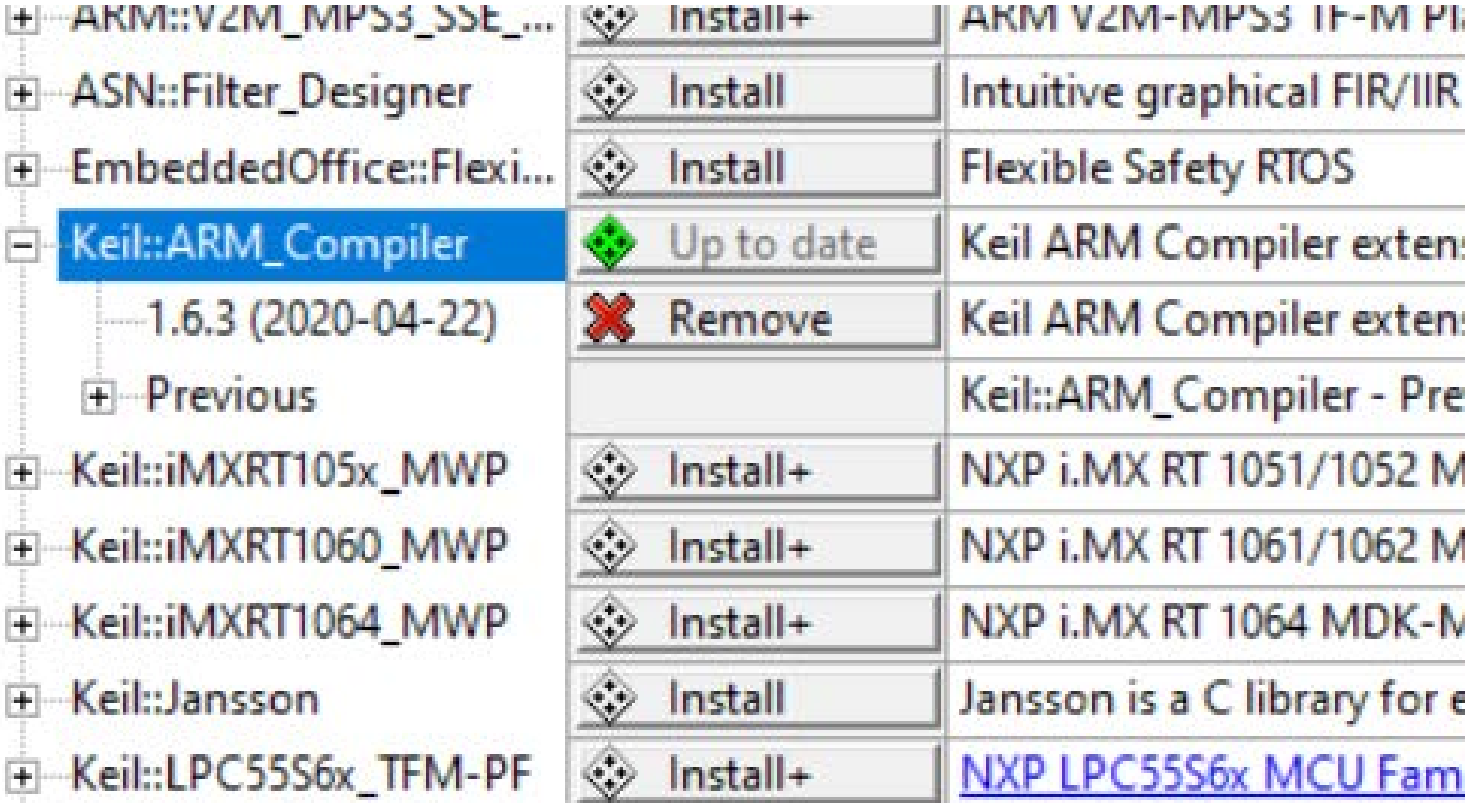

Pack Installer - C:\Keil_v5_34\ARM\PACK
File
Packs
Window
Help
Device: STMicroelectronics - STM32F429ZITx
Devices
Boards
Search: stm32f4
Device
Summary
STM32F429ZI
2 Devices
STM32F429ZITx
ARM Cortex-M4, 180 MHz, 256 kB RAM, 2 MB ROM
STM32F429ZIYx
ARM Cortex-M4, 180 MHz, 256 kB RAM, 2 MB ROM

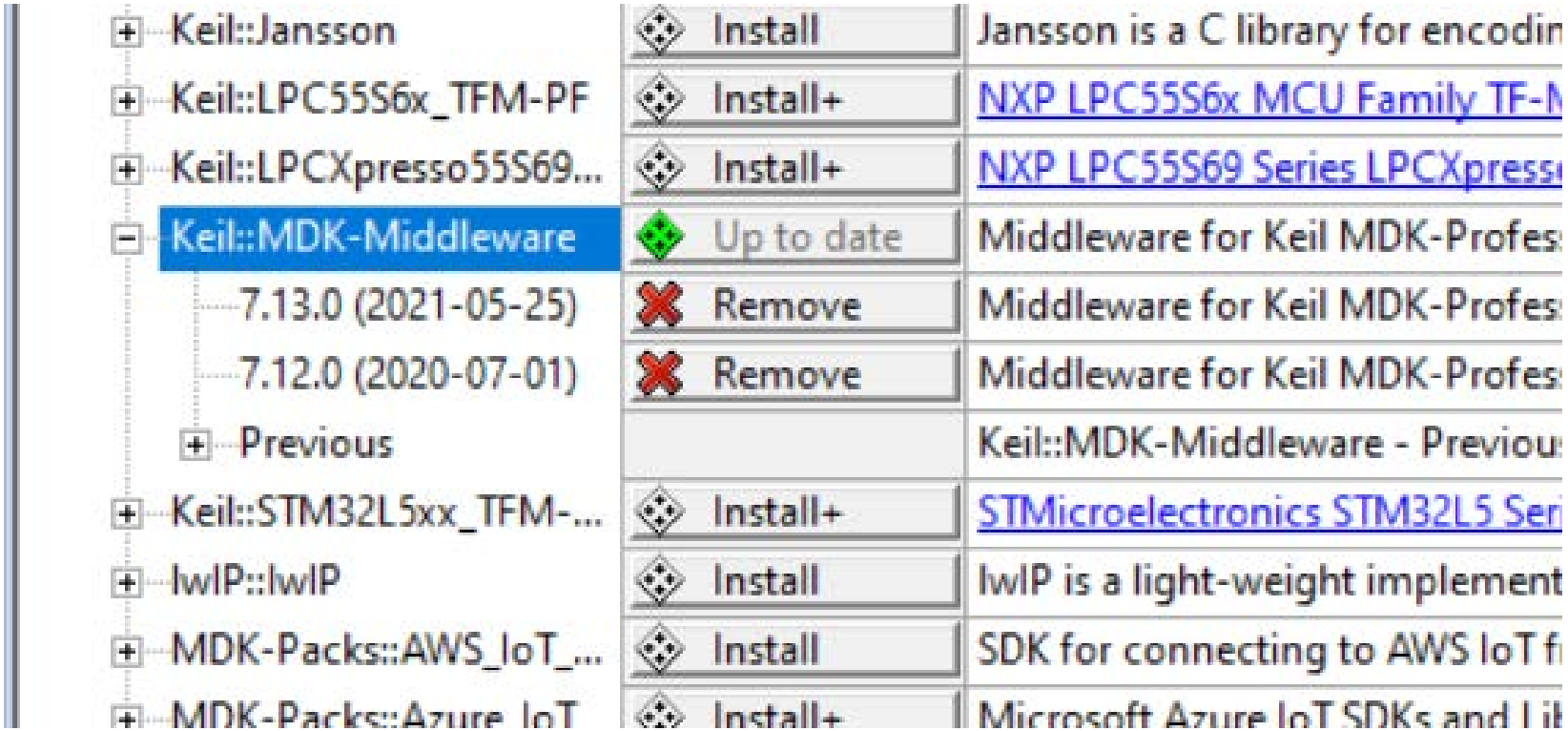
Anexo. Versiones SW



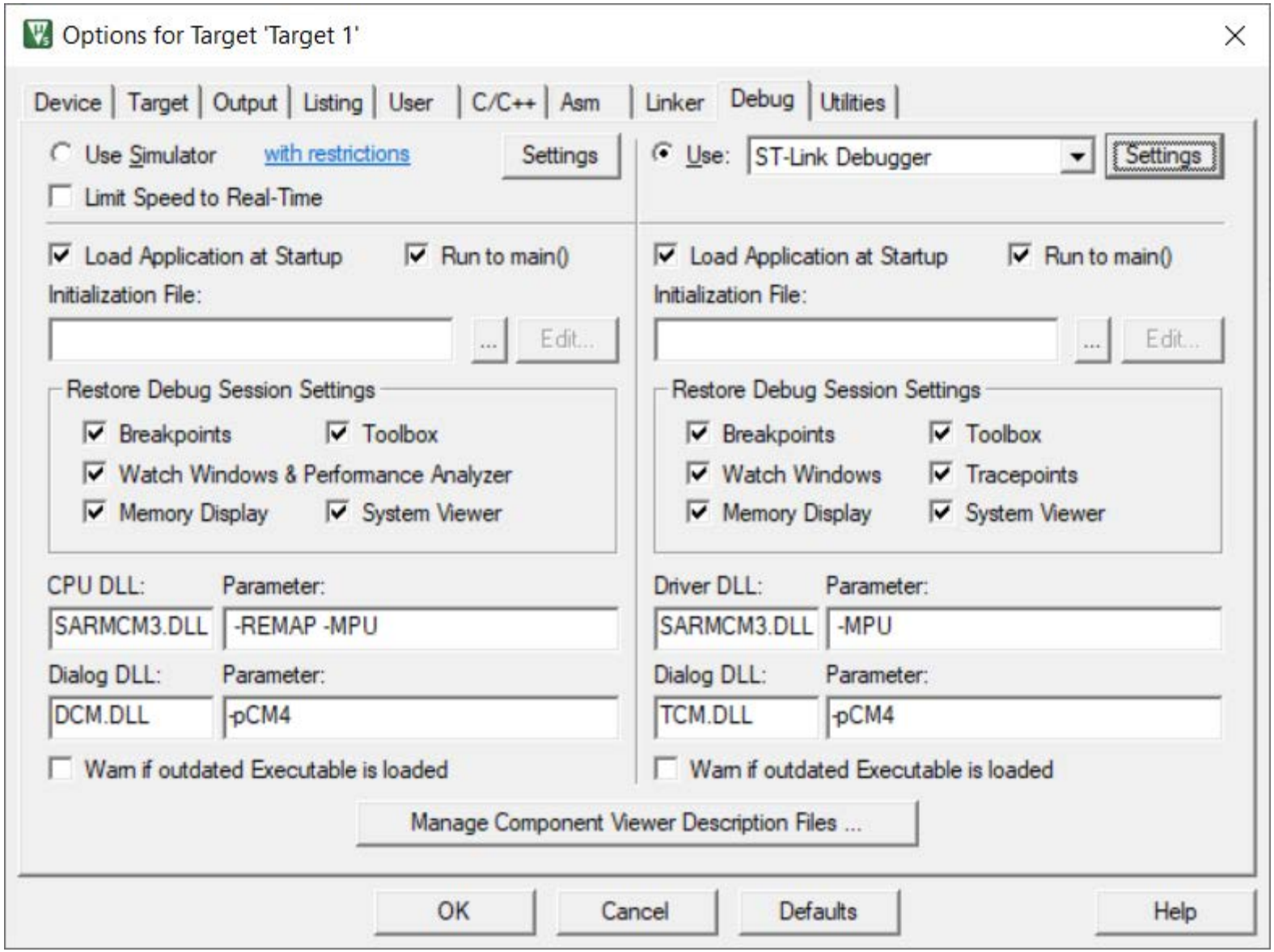

Generic
51 Packs
Alibaba::AliOSThings
Install
AliOS Things software pack
Arm-Packs::PKCS11
Install
OASIS PKCS #11 Cryptographic Token Inter
Arm-Packs::Unity
Install
Unit Testing for C (especially Embedded So
ARM::AMP
Install
Software components for inter processor c
ARM::CMSIS
Up to date
CMSIS (Common Microcontroller Software
5.8.0 (2021-06-24)
Remove
CMSIS (Common Microcontroller Software
5.7.0 (2020-04-09)
Remove
CMSIS (Cortex Microcontroller Software Int
Previous
ARM::CMSIS - Previous Pack Versions


Arm-Packs::Unity
Install
Unit Testing for C (especially Embe
ARM::AMP
Install
Software components for inter pro
ARM::CMSIS
Up to date
CMSIS (Common Microcontroller
ARM::CMSIS-Driver
Up to date
CMSIS Drivers for external devices
2.6.1 (2020-07-13)
Remove
CMSIS Drivers for external devices
Previous
ARM::CMSIS-Driver - Previous Pac
ARM::CMSIS-Driver_Va...
Install
CMSIS-Driver Validation
ARM::CMSIS-FreeRTOS
Install
Bundle of FreeRTOS for Cortex-M
ARM::CMSIS-RTOS_Vali...
Install
CMSIS-RTOS Validation

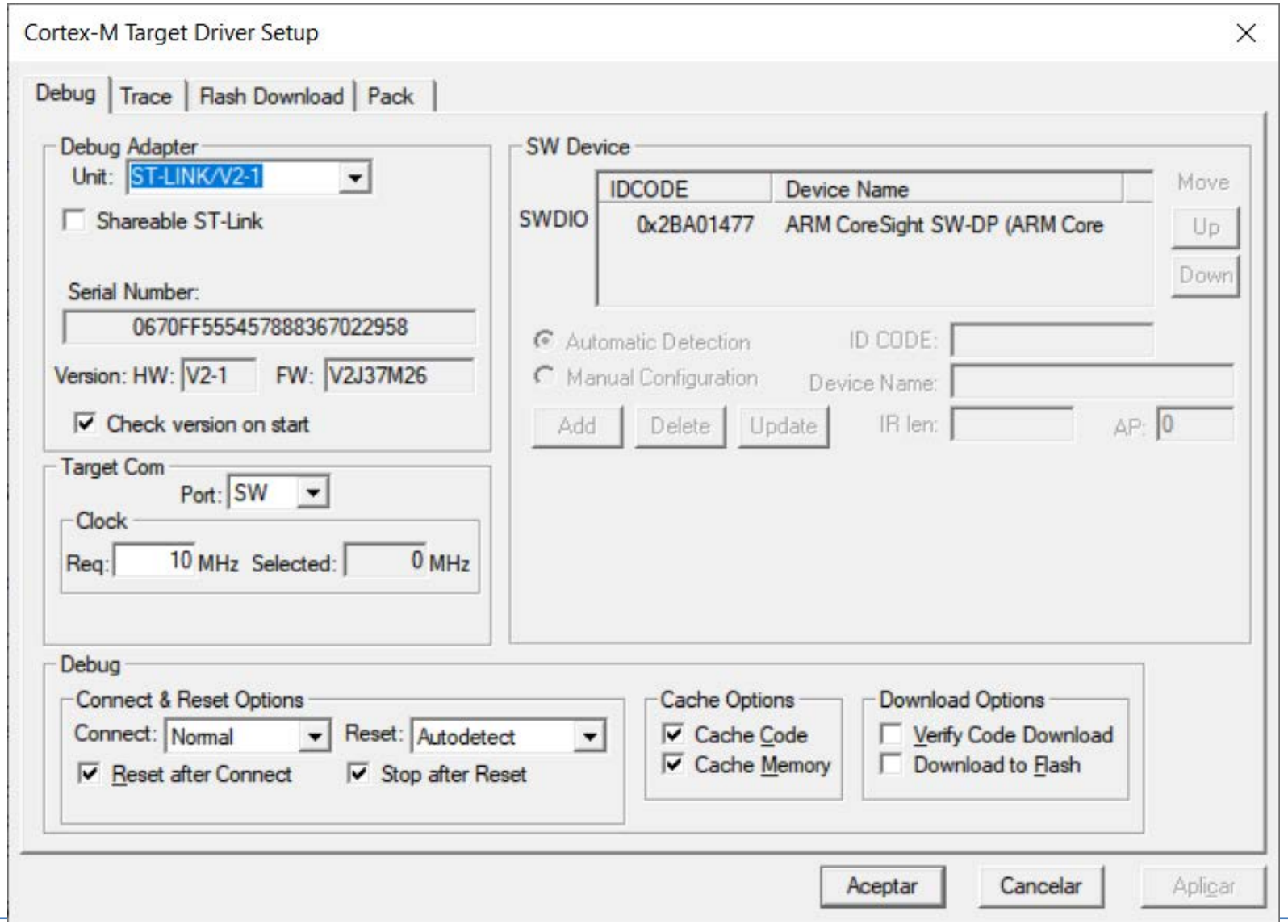

ARM::V2M_MPS3_SSE_...
Install+
ARM V2M-MPS3 TF-M PI
ASN::Filter_Designer
Install
Intuitive graphical FIR/IIR
EmbeddedOffice::Flexi...
Install
Flexible Safety RTOS
Keil::ARM_Compiler
Up to date
Keil ARM Compiler exten
1.6.3 (2020-04-22)
Remove
Keil ARM Compiler exten
Previous
Keil::ARM_Compiler - Pre
Keil::iMXRT105x_MWP
Install+
NXP i.MX RT 1051/1052 M
Keil::iMXRT1060_MWP
Install+
NXP i.MX RT 1061/1062 M
Keil::iMXRT1064_MWP
Install+
NXP i.MX RT 1064 MDK-M
Keil::Jansson
Install
Jansson is a C library for e
Keil::LPC55S6x_TFM-PF
Install+
NXP LPC55S6x MCU Fam


Keil::Jansson
Install
Jansson is a C library for encodin
Keil::LPC55S6x_TFM-PF
Install+
NXP LPC55S6x MCU Family TF-M
Keil::LPCXpresso55S69...
Install+
NXP LPC55S69 Series LPCXpress
Keil::MDK-Middleware
Up to date
Middleware for Keil MDK-Profes
7.13.0 (2021-05-25)
Remove
Middleware for Keil MDK-Profes
7.12.0 (2020-07-01)
Remove
Middleware for Keil MDK-Profes
Previous
Keil::MDK-Middleware - Previou
Keil::STM32L5xx_TFM-...
Install+
STMicroelectronics STM32L5 Seri
lwIP::lwIP
Install
lwIP is a light-weight implement
MDK-Packs::AWS_IoT_...
Install
SDK for connecting to AWS IoT fi
MDK-Packs::Azure_IoT
Install+
Microsoft Azure IoT SDKs and Lib

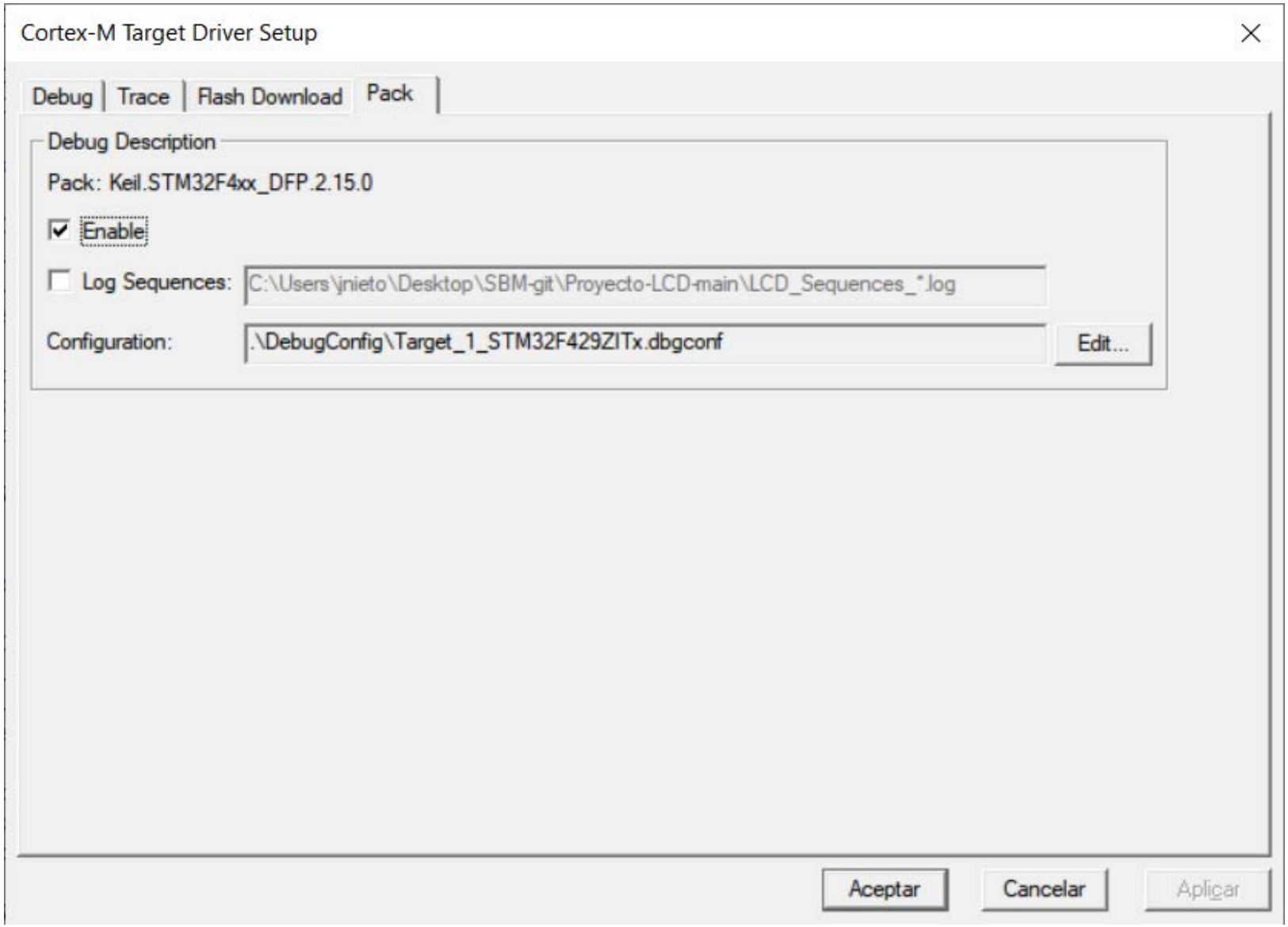
Anexo. Opciones Debug



Anexo. Opciones Debug



Anexo. Opciones Debug

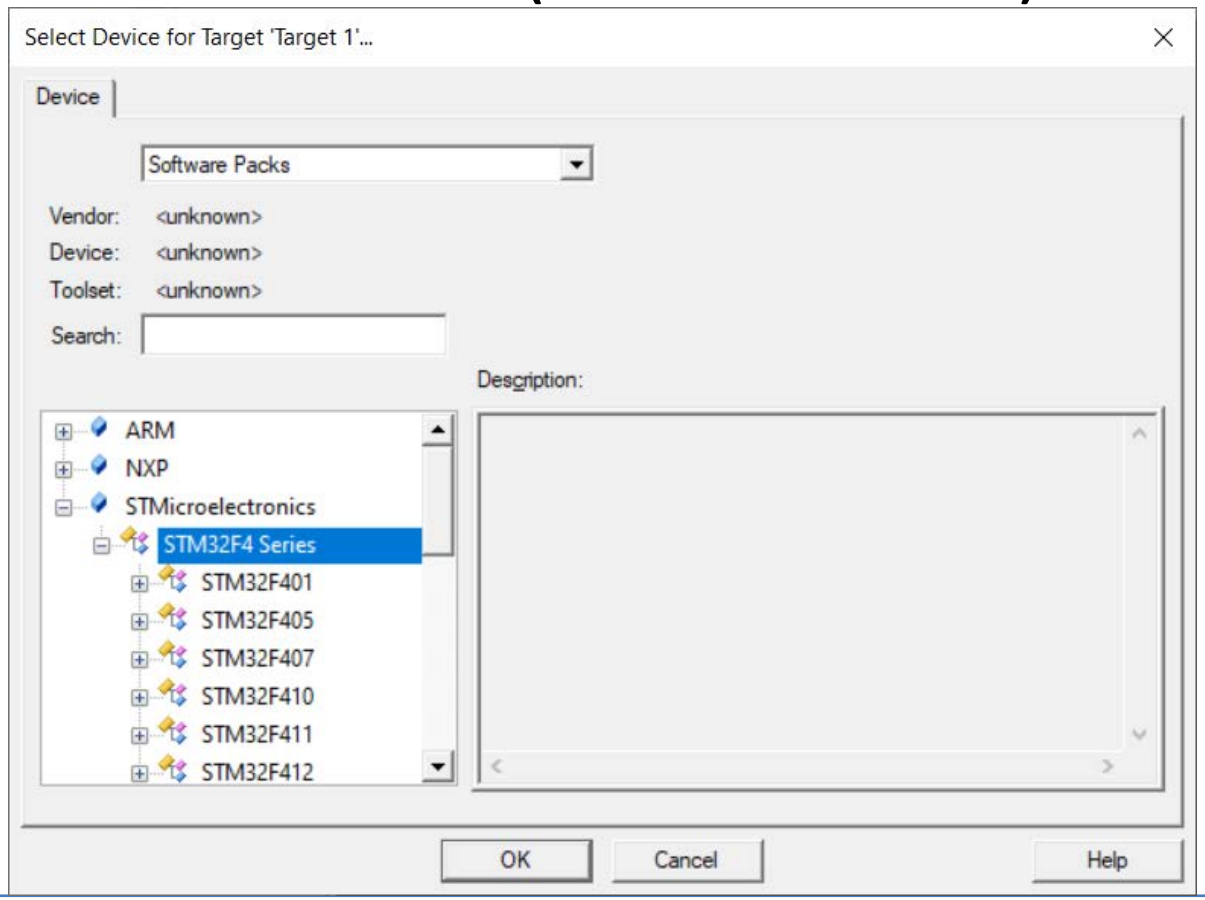


Keil Microvision

First Project from scratch

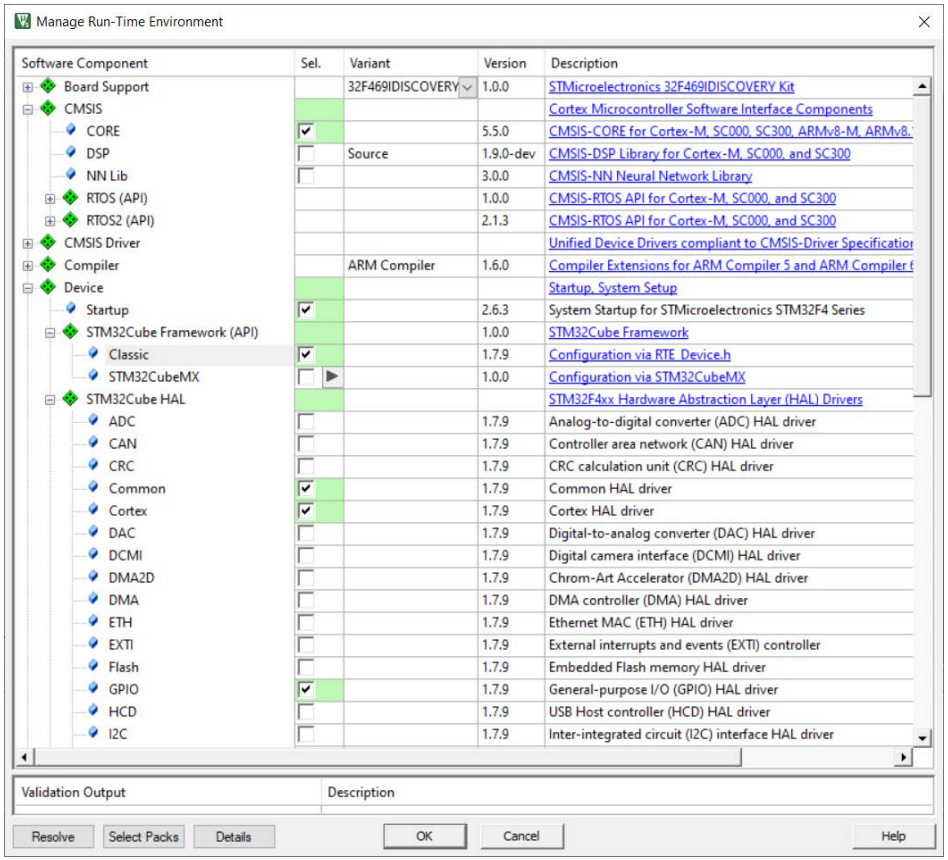
Step I

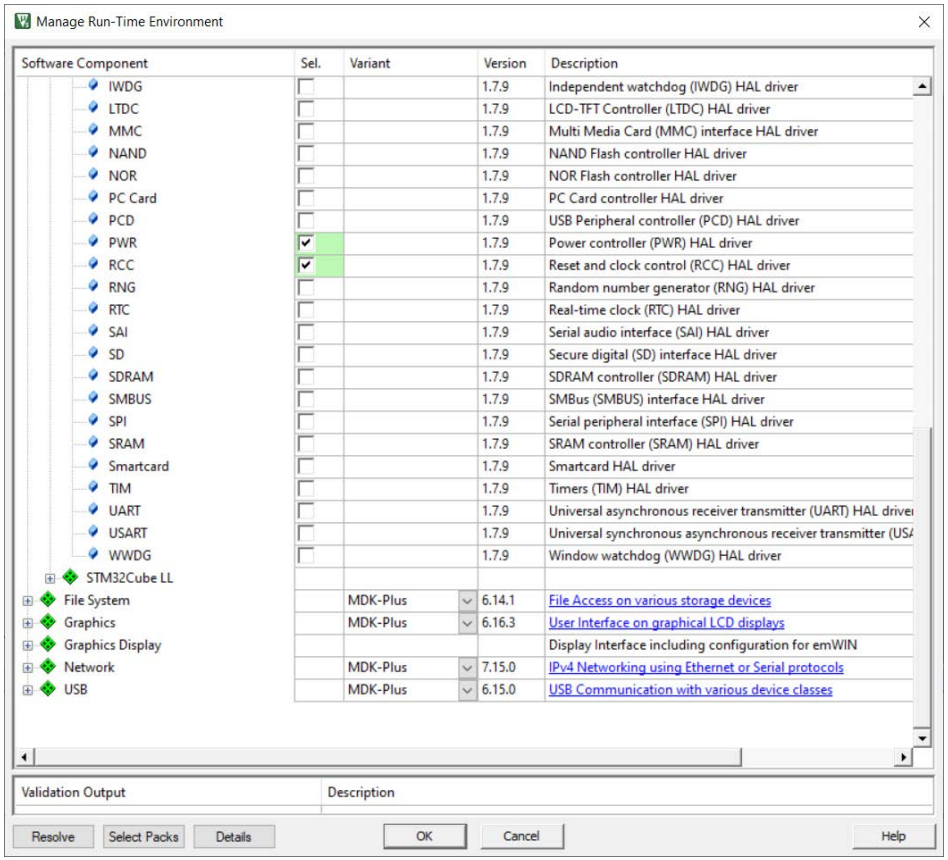
- Project->New Microvision Project
- Device selection (STM32F429ZI)



Step II

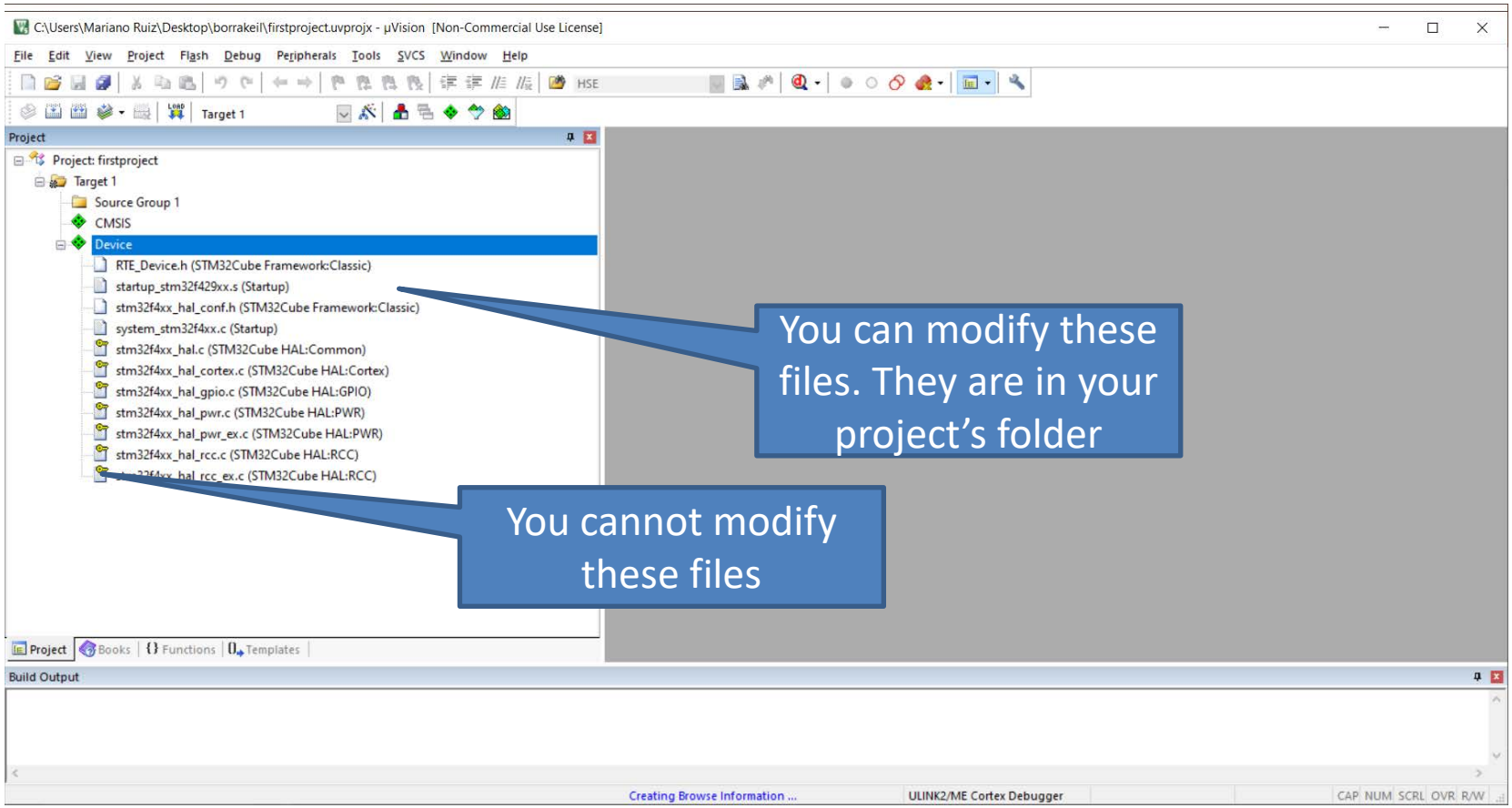
- Configuration of the Run Time Environment





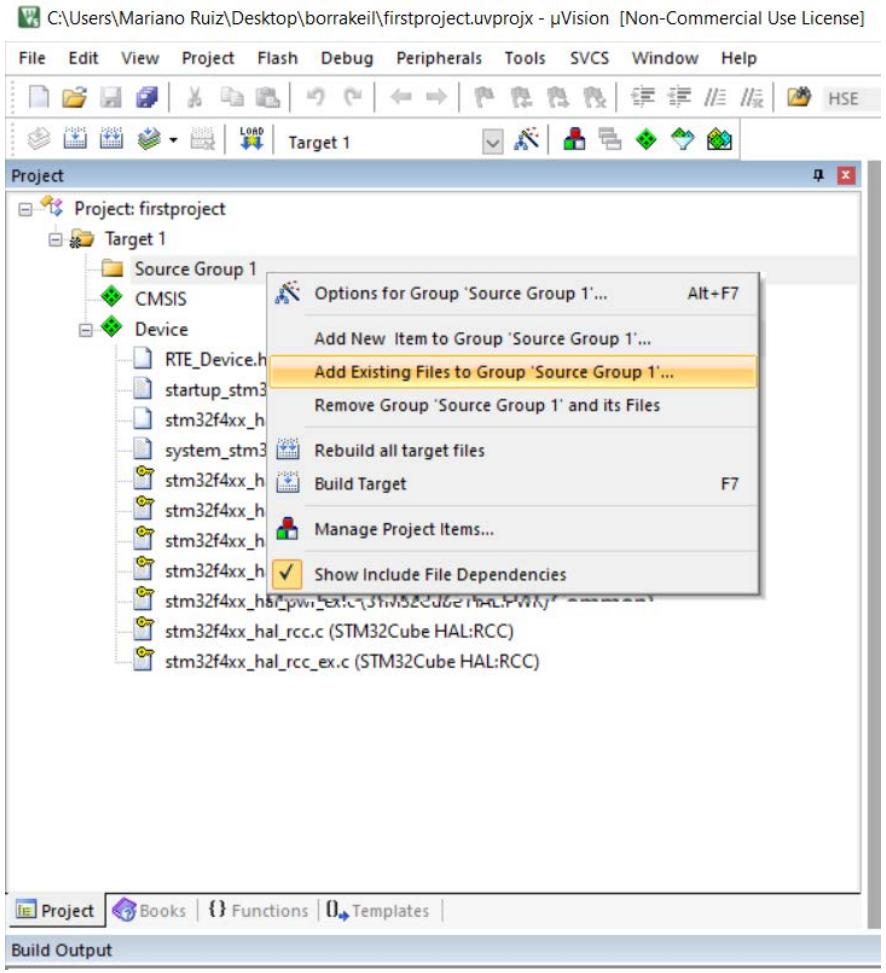
Step III

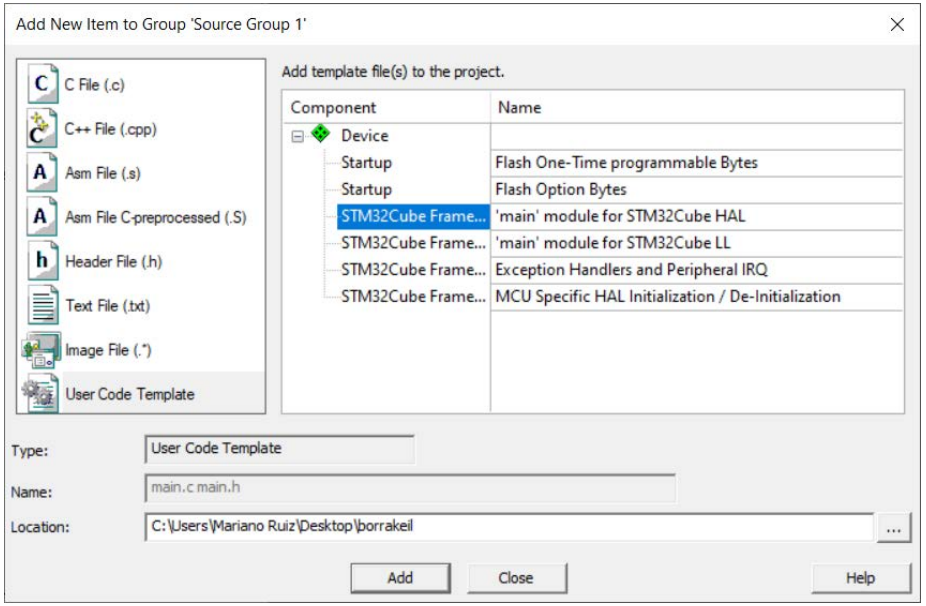
- Project created



Step IV

- Adding a basic “main.c” file





Step V

- Some details of “main.c”
  - RTE_Components.h added
  - main() calls to
    - HAL_Init()
    - SystemClock_Config();
    - SystemCoreClockUpdate();
  - SystemClock_Config() and Error_Handler functions code
  - Main code is an infinite loop

Step VI

- Add definition of HSE_VALUE to the Keil project
- Compile and debug