

STM32 & USB

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Ver. 1.0



the Universal Serial Bus

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- The USB - Universal Serial Bus is an industry standard **developed** in the mid-1990s that **defines**
 - Bus architecture
 - Cables, Connectors, Electrical levels
 - Communications protocols
- USB was designed to **standardize** the connection of computer peripherals
 - keyboards, pointing devices, digital cameras, printers, portable media players, disk drives and network adapters
- It has become common interface on **other devices**, such as smartphones, PDAs and video game consoles.
- USB has effectively **replaced** a variety of earlier interfaces, such as serial and parallel ports.



Certified USB logo

the Universal Serial Bus

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Hot pluggable	YES
Protocol	Serial, pooled, host centric
Bitrate	1.5/ 12/ 480/ 5,000/ 10,000 Mbit/s
Max Length	5m
Max Voltage	5V
Max Current	0.5A general 5A charging device
Max Devices	127
Pins	4 1 supply, 2 data, 1 ground
Topology	Tired star



- The original USB **1.0** specification was introduced in January 1996
 - Defined data transfer rates of **1.5 Mbit/s** "Low Speed" and **12 Mbit/s** "Full Speed"
The first widely used version of USB was **1.1**, was released in September 1998.
- The USB **2.0** specification was released in April 2000
 - Develop a higher data transfer rate achieving **480 Mbit/s**
 - a 40-times increase over the original USB 1.1 specification
- The USB **3.0** specification was published on 12 November 2008.
 - Increase the data transfer rate (up to **5 Gbit/s**)
 - decrease power consumption, increase power output
 - backwards-compatible with USB 2.0. USB 3.0 includes a new, higher speed bus called SuperSpeed in parallel with the USB 2.0 bus.
- The **USB 3.1** specification was released on 31 July 2013
 - Introducing a faster transfer mode called "SuperSpeed USB **10 Gbps**"

Universal Serial Bus

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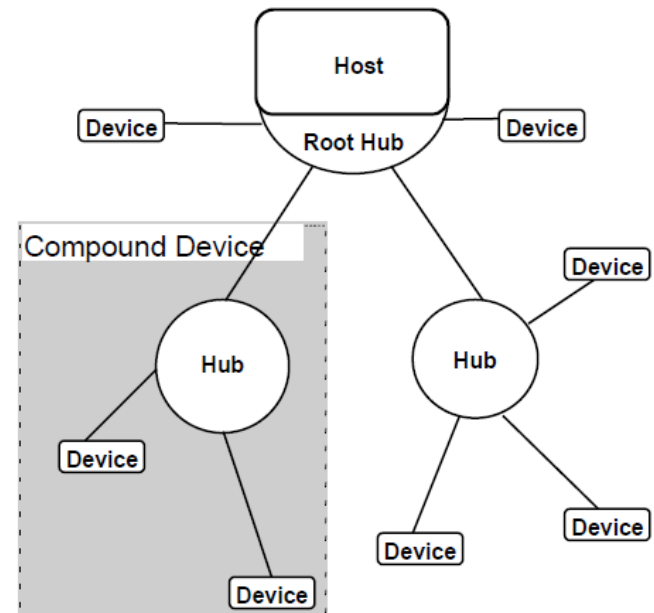
- USB Implementers Forum, Inc.

- is a non-profit corporation that **developed** the USB **specification**
- The Forum **facilitates the development** of high-quality compatible USB peripherals (devices), and the quality of products that have passed **compliance testing**. Some of the many activities that the USB-IF supports include:

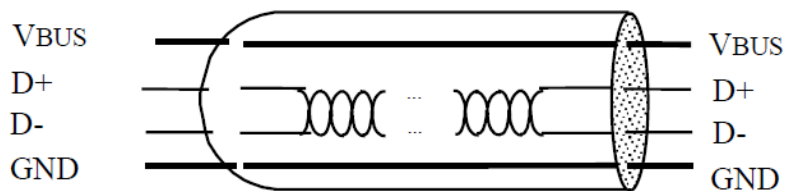
- ☐ USB **Compliance Workshops** and **compliance test** and tool development
- ☐ USB Developer **Conferences**
- ☐ Assignment of a **vendor ID**
- ☐ www.usb.org **Web site**
- ☐ and many more...

Bus Topology 7

- The USB physical interconnect is a **tiered star** topology.
- The USB **connects** USB devices with the USB host.
- A hub is at the **center** of each star. Each wire segment is a **point-to-point** connection.
- The maximum of **127 devices** can be connected in the bus
- The maximum of **5 hubs** can be connected in series
- The maximum number of tiers allowed is **seven**
- The maximum cable length is **5meter**



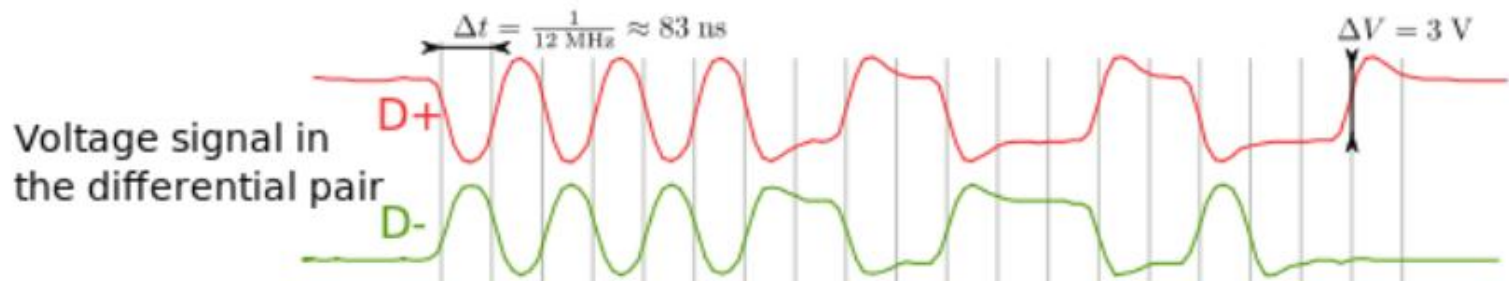
- USB is a serial bus, using **four** shielded **wires** for the USB 2.0 variant:
 - two for power (VBUS and GND),
 - two for differential data signals (D+ and D-).



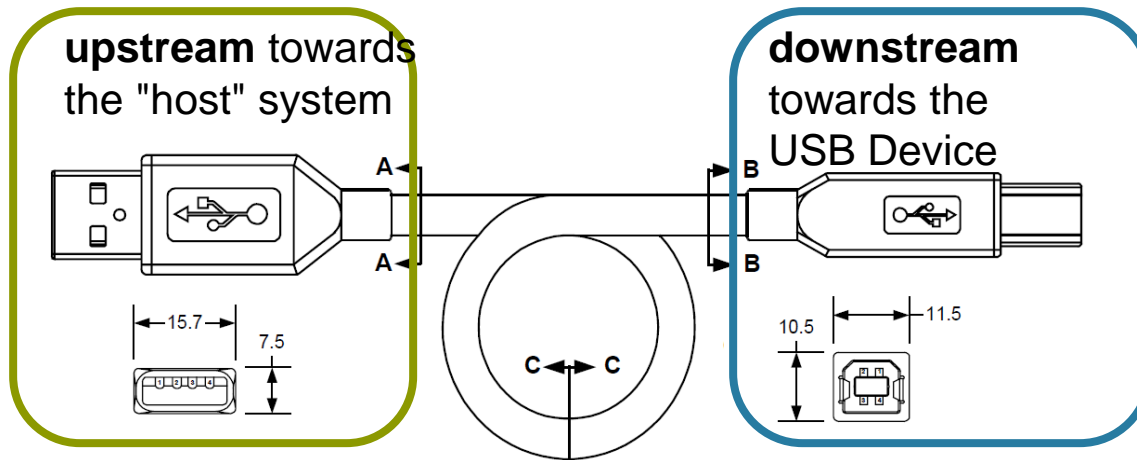
USB 1.x/2.0 standard pinout

Pin	Name	Wire color	Description
1	V _{BUS}	Red (or Orange)	+5 V
2	D-	White (or Gold)	Data-
3	D+	Green	Data+
4	GND	Black (or Blue)	Ground

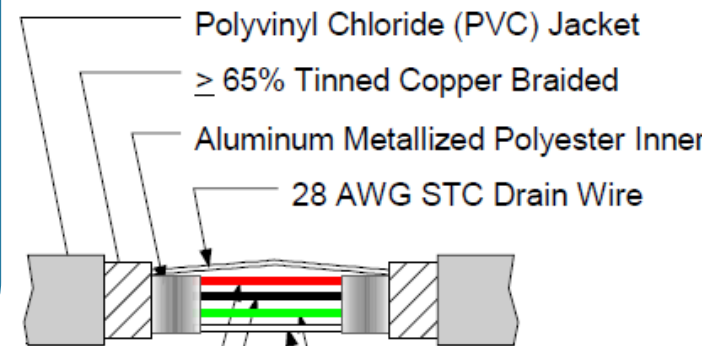
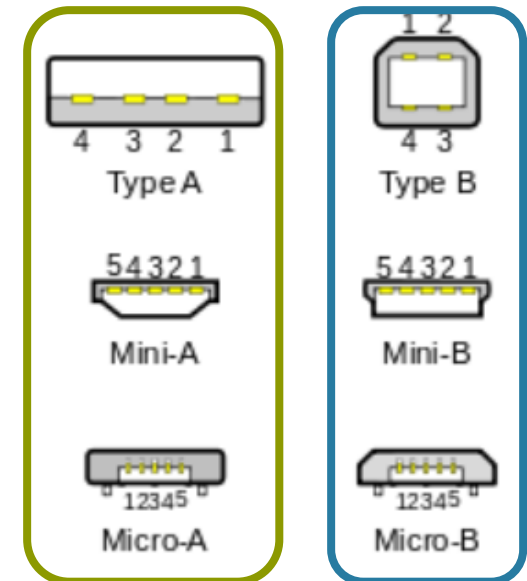
- Non-Return-to-Zero Inverted (**NRZI**) encoding scheme is used for transferring data.



- USB specification provides the **mechanical** and **electrical** specifications for the **cables**, **connectors**
 - The USB physical topology consists of connecting the **downstream** hub port to the **upstream** port of another hub or to a device
- “**keyed connector**” are used to minimize end user termination problems



Standard, Mini, and Micro USB plugs.



USB over STM32 Family


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MCU	Core	USB controller
STM32L0x2 STM32L0x3	Cortex-M0+	1x <i>Crystal less</i> USB 2.0 FS device with Link Power Managment (LPM) and Battery Charger detection (BCD)
STM32F0x2 STM32F0x8	Cortex-M0	1x <i>Crystal less</i> USB 2.0 FS device controller with Link Power Managment (LPM) and Battery Charger detection (BCD)
STM32L1	Cortex-M3	1x USB 2.0 FS device with internal 48 MHz PLL
STM32F102/103	Cortex-M3	1x USB 2.0 FS device controller
STM32F105/107	Cortex-M3	1x USB 2.0 FS device/host/OTG controller with on-chip PHY with 1.25 Kbytes of dedicated SRAM
STM32F2	Cortex-M3	1x USB 2.0 FS device/host/OTG controller with on-chip PHY 1x USB 2.0 FS/HS device/host/OTG controller with dedicated DMA, on-chip full-speed PHY and ULP
STM32F3	Cortex-M4	1x USB 2.0 FS device controller and LPM
STM32F4	Cortex-M4	1x USB 2.0 FS device/host/OTG controller with on-chip PHY 1x USB 2.0 FS/HS device/host/OTG controller with dedicated DMA, on-chip full-speed PHY and ULPI

STM32 on USB-IF integrators list

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Universal Serial Bus



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Product Search

All Results for: STM32

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STM32

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Select a Product

15 total results

Page: 1 Results per page: [10](#) [20](#) [50](#) [100](#) [200](#)

Name	Product Type	Company	Categories
STM32L053	Low/Full Speed	STMicroelectronics	Development > Peripheral Silicon > Low/Full Speed > Silicon Building Blocks
STM32F103	Low/Full Speed	STMicroelectronics	Development > Peripheral Silicon > Low/Full Speed > Silicon Building Blocks
STM32F205/7	Low/Full Speed	STMicroelectronics	Development > Peripheral Silicon > Low/Full Speed > Silicon Building Blocks
STM32F405/7	Low/Full Speed	STMicroelectronics	Development > Peripheral Silicon > Low/Full Speed > Silicon Building Blocks
STM32F207	Hi-Speed	STMicroelectronics	Development > Embedded Hosts > Hi-Speed > Other
STM32F072	Low/Full Speed	STMicroelectronics	Development > Peripheral Silicon > Low/Full Speed > Silicon Building Blocks
STM32F205/7	Hi-Speed	STMicroelectronics	Development > Peripheral Silicon > Hi-Speed > Silicon Building Blocks
STM32F407	Hi-Speed	STMicroelectronics	Development > Embedded Hosts > Hi-Speed > Other
STM32F105	Low/Full Speed	STMicroelectronics	Development > Peripheral Silicon > Low/Full Speed > Silicon Building Blocks
STM32F405/7	Hi-Speed	STMicroelectronics	Development > Peripheral Silicon > Hi-Speed > Silicon Building Blocks
STM32F407	Low/Full Speed	STMicroelectronics	Development > Embedded Hosts > Full Speed > Other
STM32F303	Low/Full Speed	STMicroelectronics	Development > Peripheral Silicon > Low/Full Speed > Silicon Building Blocks
STM32F373	Low/Full Speed	STMicroelectronics	Development > Peripheral Silicon > Low/Full Speed > Silicon Building Blocks
STM32F207	Low/Full Speed	STMicroelectronics	Development > Embedded Hosts > Full Speed > Other
STM32L152	Low/Full Speed	STMicroelectronics	Development > Peripherals > Low/Full Speed > Other

<http://www.usb.org>

USB VID/PID sublicensing service

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Process & Schedule for PID request

- Request details:
 - 1) COMPANY NAME AUTHORIZING USE TO :
 - 2) Contact Name /Address and E-mail address:
 - 3) Name/Sales type of the STMicrocontroller product name :
 - 4) Name of USB end-product : { if possible USB device string Product }
- PID Booked in an internal ST Database
- By end of each quarter
 - ST send the approval list to the USB-IF
 - Approval by USB-IF
 - PID send to the customer with a “letter form Agreement”

The screenshot shows a web form titled "Request USB PIDs: New Item". It includes an "Attach File" button and a list of required fields marked with a red asterisk. The fields are: Company Name, Customer Contact Name, Customer E-mail address, Customer Full Address, Sales-Type of the Microcontroller, Name of USB End-product, Qty/Year, Production Start date, ST Requester Name, Request Date (pre-filled with 3/26/2014), and Status (a dropdown menu). A note at the bottom says "Please Do not fill this field" next to the PID field.



peripheral (F0/L0)

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- *Crystal-less** USB 2.0 FS interface (12Mbit/s)
 - Integrated on-chip 48 MHz oscillator with clock recovery system. No external resonator/ crystal needed (cost saving is in range of 0.10\$).
 - Up to 16 mono-directional or 8 bidirectional configurable endpoints
 - Up to 1024 Bytes of dedicated packet buffer memory SRAM
- Complies with *Link Power Management feature* (LPM) and *Battery Charging Detection* (BCD) specification 1.2
- Device Firmware Upgrade on the field over USB (boot loader)
- USB FS Device Library with intuitive USB device class drivers API
 - Examples and demo based on a set of 6 classes (Audio, CCID, CDC, HID, VCP, MSC).
 - Easy development of applications using USB full speed transfer types (control, interrupt, bulk and isochronous).
- Free PID/VID program for end-product certification

(USB) Clock recovery principle

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- Provide the precise USB clock (48Mhz @ 0.25%) without any external resonator. It uses the USB Start-of-Frame (SOF) sent by a host at precise 1ms intervals (0.05% accurate), as a timing reference.
- SOF timing reference allows to automatically trim the int 48 MHz RC frequency based on the actual frequency error measured by a counter.
- HSI48 oscillator trimming step is 0.14% typical (0.2% max) to guarantee with a good margin the 0.25% accuracy needed for USB.
- Other synchronization sources (LSE, ext pin or SW trigger) works too.

Note : to calcul the precision of the output, +/-0.1% of error must be added on top of the reference signal precision. Ex : to reach 0.5% output, you need to have at worst 0.4% reference input.

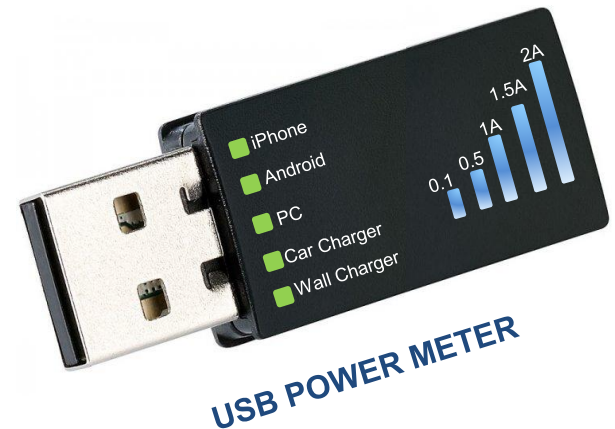
USB Battery Charging Detection

(USB BCD)

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- Battery Charging Specification introduces new port definitions
 - **Standard downstream port (SDP)** same port as defined by the USB 2.0 spec.
 - **Charging downstream port (CDP)** normal port with extended current capability
 - **Dedicated charging port (DCP)** car / wall charger, not able to enumerate
- STM32F0x2 identifies the nature of the USB host (SDP, CDP, DCP) and its power source capability (...100mA, 500mA, 1.5A etc)
- Typical use-case is to speed-up battery charging of portable devices connected to the USB port.

Port Category		USB Name	Acronym	Host Current Capability (mA)	Notes
Downstream		Standard Downstream Port	SDP	2.5	Unconnected or suspended
				100 (USB 2.0) 150 (USB 3.0)	Connected and not suspended
				500 (USB 2.0) 900 (USB 3.0)	Configured and not suspended
Charging		Charging Downstream Port*	CDP	Up to 1500	Low- or full-speed, suspended or not
		Dedicated Charging Port	DCP	500 (min) to 1500 (max)	Not capable of enumeration



USB Link Power Management (LPM)

- LPM is a new power-saving state called “*Sleep*”, with fast entry and exit times, compared to traditional “*Suspend*” mode.
- Benefits : Power consumption optimization across both the host and USB devices while idle, and extend battery life of hand-held applications.

	L1 (Sleep)	L2 (Suspend)
Entry	Explicitly entered via LPM extended transaction	Implicitly entered via 3 ms of link inactivity
Exit	Device- or host-initiated via resume signaling; Remote-wake can be (optionally enabled/disabled via the LPM transaction	Device- or host-initiated via resume signaling; Remote-wake can be (optionally enabled/disabled by software
Signaling	Low- and full-speed idle	Low- and full-speed idle
Latencies	Entry: ~10 μ s Exit: ~70 μ s to 1 ms (host-specific)	Entry : ~ 3ms Exist : > 20 ms (Resume signaling) + 10 ms (Resume recovery)
Link Power Consumption	~0.6 mW (data line- pull-ups)	~0.6 mW (data line- pull-ups)
Device Power Consumption	Device power consumption level is application/implementation specific	Device consumption is limited to ≤ 2.5 mA
Hot Removal	Natively detected per USB 2.0 mechanisms	Natively detected per USB 2.0 mechanisms





Middleware – USB

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Universal Serial Bus requires a dedicated software stack. This serial bus is organized in a star topology with host and device roles, host organizing the traffic. Several device classes are specified, in order to ease communication in different application cases.

- **ST provides a complete offer for STM32**

Often seen acronyms

OTG	On-The-Go: An OTG peripheral can switch host and device role on the fly
HUB	Defines what protocols to implement to build a hub application
MS	Mass storage: Protocols to interact with storage block devices (for files)
HID	Human interface device: Protocols for peripherals interacting with human body (mouse, keyboard, etc.)
CDC	Communication device class: Protocols for serial communications, different sub-classes define details, for instance ACM for a standard COM port, or ECM for modems
Printer	Defines what protocols to implement to build a printer application
Audio	Defines what protocols to implement to build an audio application (microphone, headset, etc.)
DFU	Device firmware upgrade: Protocols to implement firmware upgrade ability



STM32 – USB solutions (1/2)

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Provider	Solution name	Model	Cost	Availability				
				F1	F2	F3	F4	L1
CMX	CMX-USB Device , Host	Source	License	Y	Y	Y	Y	Y
EUROS	USB Host & Device	Binaries	License	Y	Y	Y	Y	Y
Express Logic	USBX	Source	License	Y	Y	Y	Y	Y
HCC	HCC-USB	Source	License	Y	Y	Y	Y	Y
Jungo	USBware	Source	License + royalties	On demand				
Keil/ARM	MDK-ARM USB	Source	License	Y	Y	Y	Y	Y
Mentor Embedded	Nucleus USB	Source	License	Y	Y	Y	Y	Y
Micrium	µC/USB	Source	License	Y	Y	Y	Y	Y
Micro Digital	smxUSB	Source	License	Y	Y	Y	Y	Y
Quadros	RTXCusb	Source	License	Y	Y	Y	Y	N ¹
Rowebots	Unison USB System	Source	License	Y	Y	Y	Y	Y
SEGGER	emUSB	Source	License	Y	Y	Y	Y	Y

1/ Available on customer request. Please contact supplier



STM32 – USB solutions (2/2)

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Provider	Solution name	Model	Cost	Availability						
				F0	F1	F2	F3	F4	L0	L1
ST	STM32Cube	Source	Free	<u>Y</u>	N	<u>Y</u>	<u>Y</u>	<u>Y</u>	<u>Y</u>	N
ST	Continua USB certified stack ²	Source	Free	N ³		N ³	N ³	N ³	N ³	<u>Y</u> ²
Thesycon	<u>Embedded USB Device</u>	Source	License	N ¹		Y	N ¹	Y	N ¹	N ¹

1/ Available on customer request. Please contact supplier

2/ Available to Continua members only. Refer to your local ST sales office.

3/ Can be ported



STM32 – USB solutions details (1/2)

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Provider	Solution name	Details
CMX	CMX-USB Device , Host	Device: HID, MS, CDC (ACM, ECM, RNDIS), Audio, Midi, MTP, PHDC Host: HID, MS, CDC (ACM, ECM, RNDIS, OBEX), Audio, Midi, Printer, HUB
EUROS	USB Host & Device Stack	Device: HID, MS, CDC (ACM, ECM) Host: HID, MS, CDC (ACM, ECM), HUB
Express Logic	USBX	Device: HID, MS, CDC (ACM, ECM, RNDIS), Still Image, PTP, PictBridge Host: HID, MS, CDC (ACM, ECM), Audio, Printer, HUB, Prolific
HCC	HCC-USB	Device: HID, MS, CDC (ACM, ECM, RNDIS), Printer, Audio, Midi, MTP, Still Image Host: HID, MS, CDC (ACM, ECM, RNDIS), Audio, Midi, Printer, HUB
Jungo	USBWare	Device: HID, MS, CDC (ACM, ECM, RNDIS, WMC, OBEX), Audio, Video, SICD, PTP, MTP, PictBridge, CCID, DFU Host: HID, MS, CDC (ACM, ECM, EEM, NCM), Audio, Video, PTP, MTP, ICCD, iPod, HUB
Keil/ARM	MDK-ARM USB	Device: HID, MS, CDC (ACM), Audio Host: HID, MS
Mentor Embedded	Nucleus USB	Device: HID, MS, CDC (ACM, ECM) Host: HID, MS, CDC (ACM, ECM), HUB
Micrium	μC/USB	Device: HID, MS, CDC (ACM), Audio, PHDC (Medical) Host: HID, MS, CDC (ACM), Audio, Printer, PHDC (Medical)
Micro Digital	smxUSB	Device: HID, MS, CDC (ACM, RNDIS, Single Interface and mult. ports), Audio, Video, Midi, PTP, MTP, DFU Host: HID, MS, CDC (ACM), Audio, Printer, HUB
Quadros	RTXCusb	Device: MS, CDC (ACM, ECM, RNDIS) Host: HID, MS, CDC (ACM), HUB
Rowebots	Unison USB System	Device: MS, CDC (ACM) Host: MS, CDC (ACM), HUB, others on demand (inc . PHDC)
SEGGER	emUSB	Device: HID, MS, CDC (ACM), Printer Host: HID, MS, CDC (ACM), Printer



STM32 – USB solutions details (2/2)

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Provider	Solution name	Details
ST	<u>STM32Cube</u>	Device: HID, MS, CDC (ACM), Audio, DFU, Host: CDC, HID (RTOS), MSC (RTOS), Audio, DFU, MTP
ST	<u>Continua USB certified stack</u>	USB PHDC Class (Personal Health Device Class), 11073-20601 = Base Framework. Agents: 1073-10417 = Glucose, 11073-10408 = Thermometer Other Agents can be implemented on demand
Thesycon	<u>Embedded USB Device</u>	Device: HID, MS, CDC (ACM, ECM, NCM)

Software Development – STM32Cube

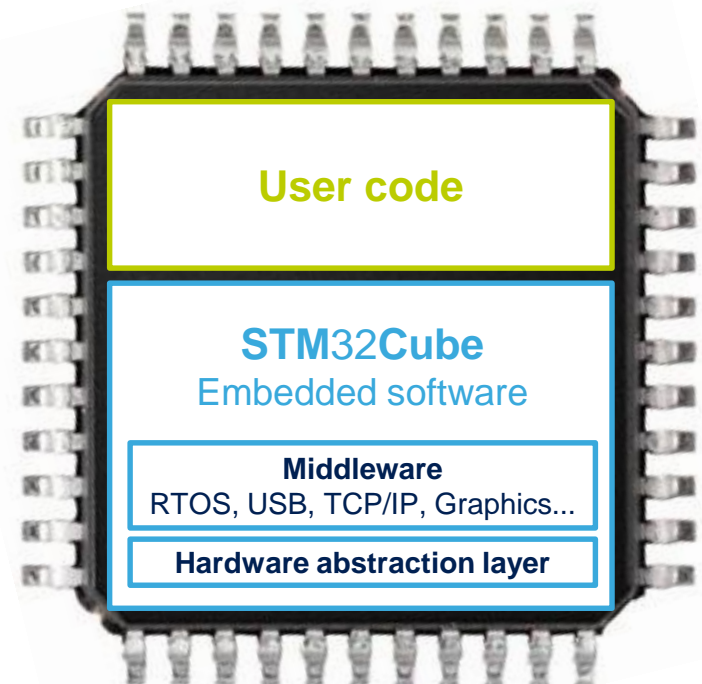
24

- Get configuration code generated* from a tool with STM32Cube and focus on your added-value software !
 - 4 configuration wizards: pinout, clock, peripherals & middleware, power consumption
 - Portable Hardware Abstraction layer, from one serie to another
 - Middleware with RTOS, **USB**, TCP/IP, File System, Graphics

STM32CubeMX
Configuration tool on PC



Initialization C code
generation
depending on user choices



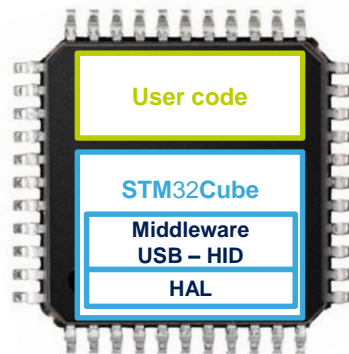
STM32Cube & USB – Let's try it out!!!

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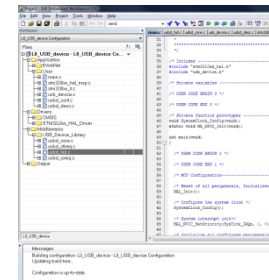
- HID (Human Interface Device) with STM32L053 in 10minutes



STM32CubeMX



IAR
SYSTEMS



STM32Cube & USB – Let's try it out!!!

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- Conditions

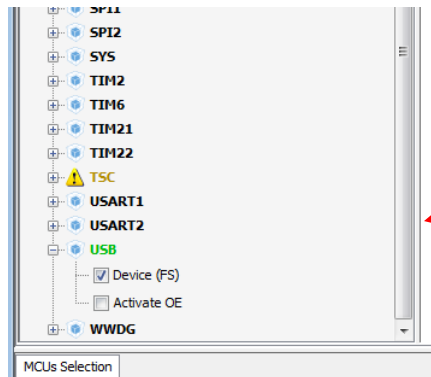
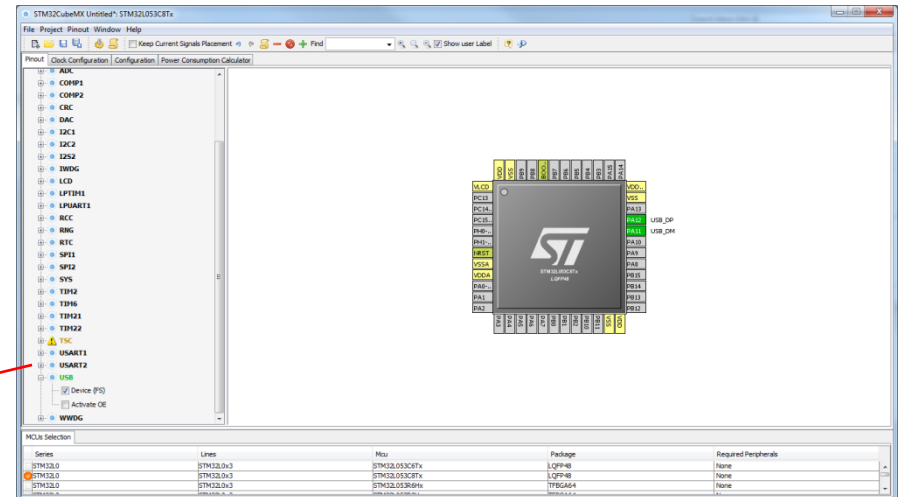
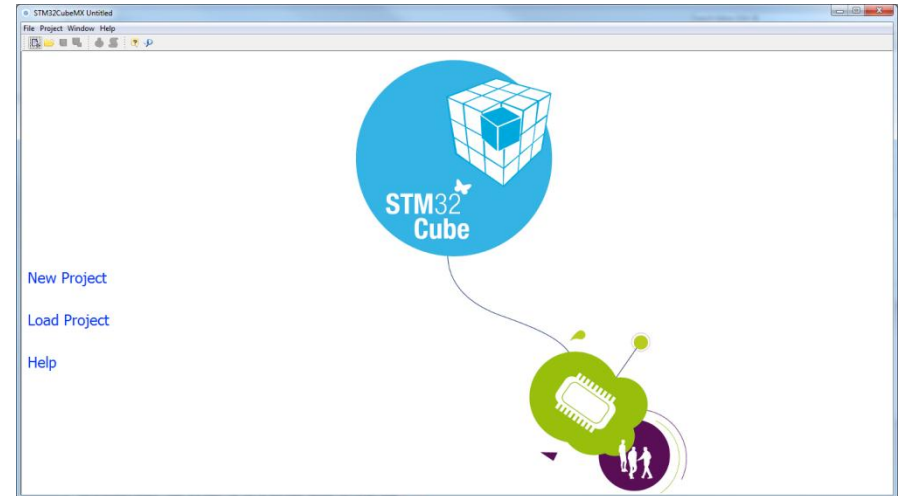
- Installed latest version of STM32CubeMX
- Installed latest version of STM32L0 Cube package
- Installed IAR EWARM 7.20 and higher
- STM32L0 Discovery kit
- USB mini B cable



STM32Cube & USB – Let's try it out!!!

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- Check the time 😊
- Launch **STM32CubeMx** tool
- Start **New Project**
- Select device **STM32L053C8T6**
- Enable **USB Device (FS)**

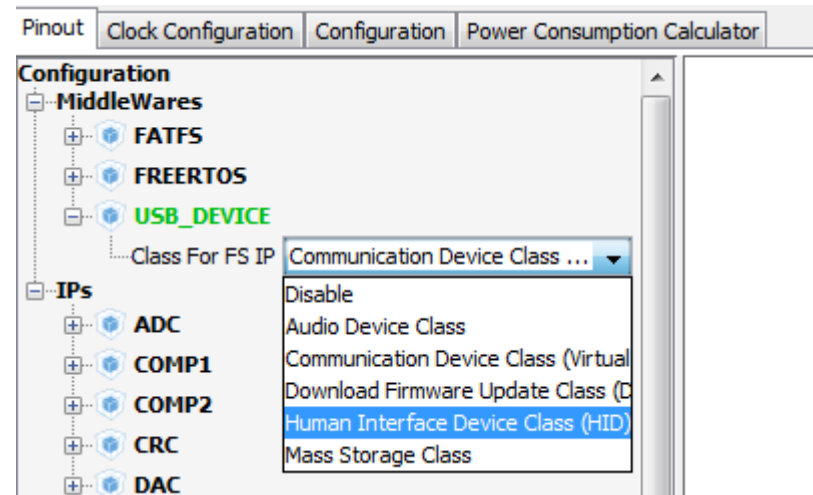
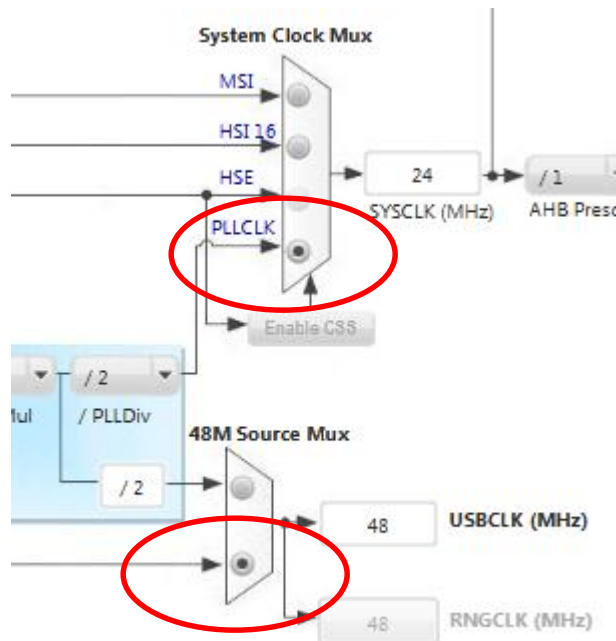


STM32Cube & USB – Let's try it out!!!

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- Include MiddleWare *USB_DEVICE* -> **HID class**

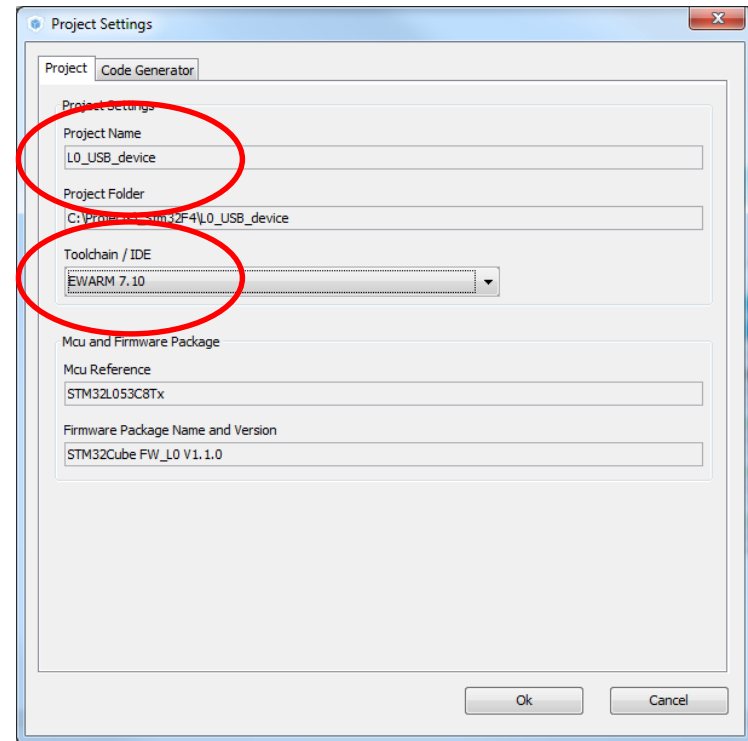
- Clock configuration



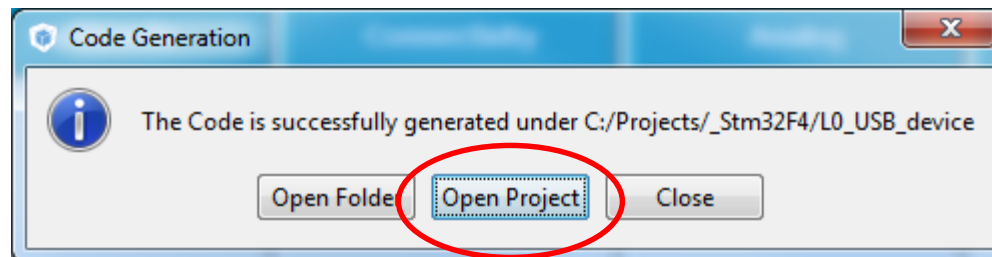
STM32Cube & USB – Let's try it out!!!

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- Menu: *Project -> Settings ...*
 - Give your project a name
 - Select EWARM 7.xx as IDE



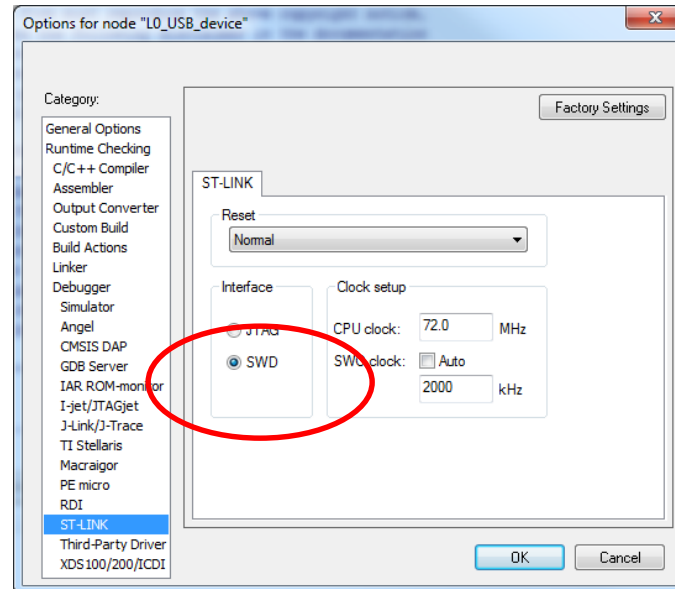
- Menu: *Project -> Generate Code -> Click Open Project*



STM32Cube & USB – Let's try it out!!!

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- In IAR EWARM, Menu: *Project -> Options -> ST-LINK* (select **SWD**)

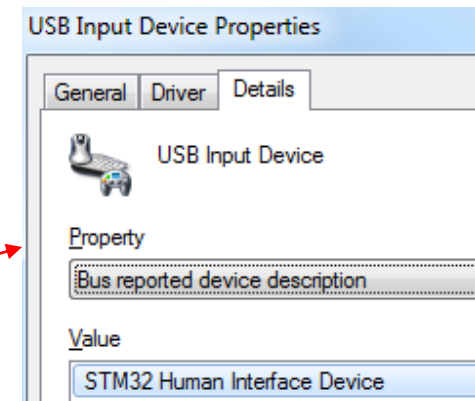
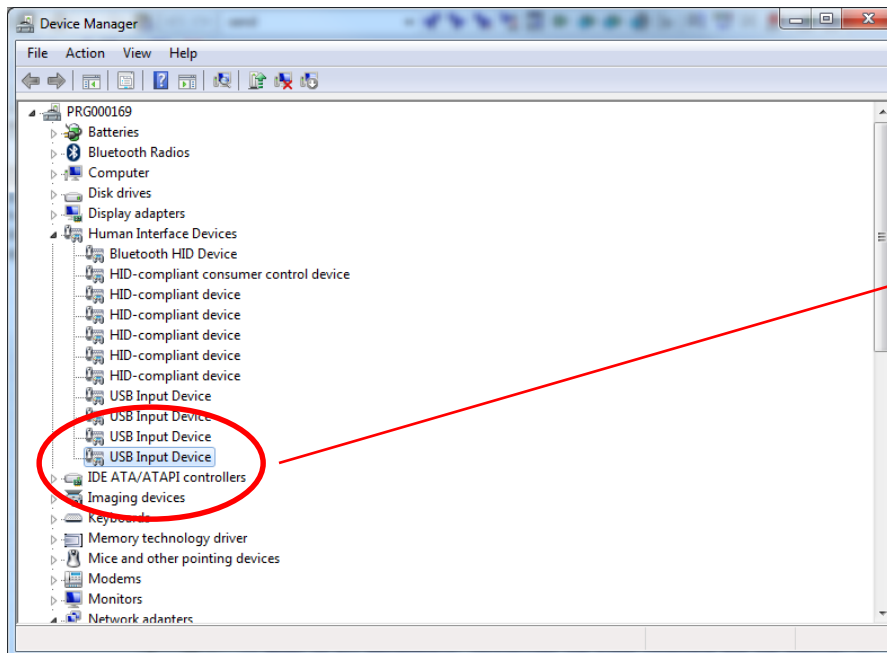


- Compile the code: *F7* or Menu: *Project -> Make*
- Connect the STM32L0 Discovery ST-LINK to PC over USB mini B cable
- Download the code: *Ctrl+D* or Menu: *Project -> Download and Debug*

STM32Cube & USB – Let's try it out!!!

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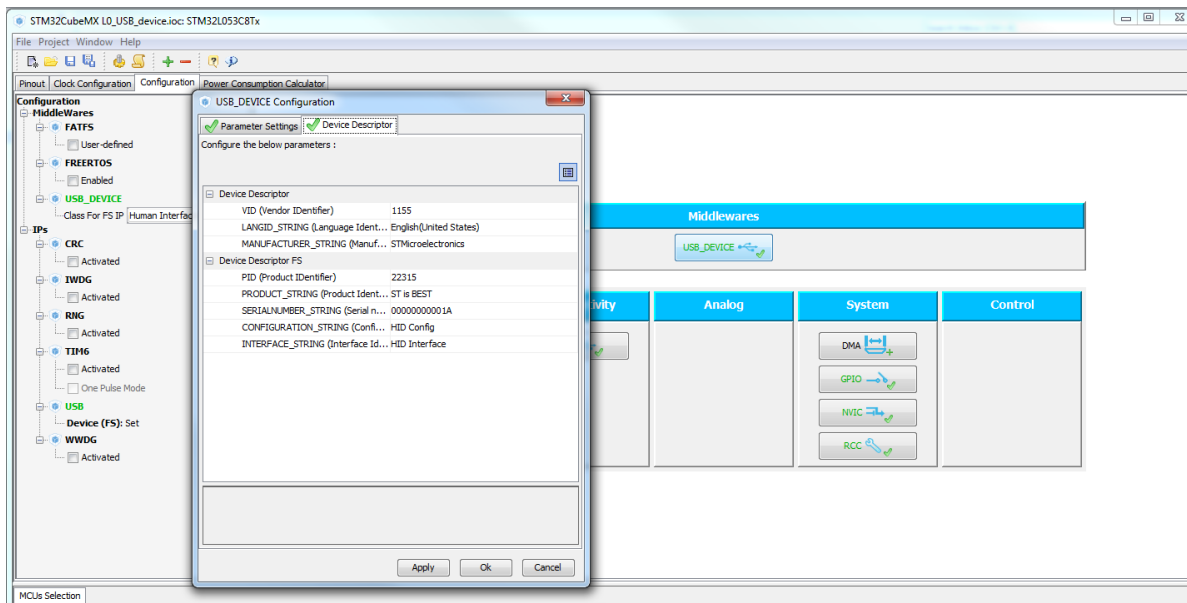
- After successful download of the code in IAR EWARM, close the debug session by: *Ctrl+Shift+D* or Menu: *Debug -> Stop Debugging*
- Change the USB mini B cable connection on the STM32L0 Discovery kit from ST-LINK to USB USER connector
- On PC: *Device Manager -> Human Interface Device*



STM32Cube & USB – Let's try it out!!!

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- As **bonus** you can change the *Bus reported device description* text to any other one, e.g. **ST is BEST**
- It's easy just go back to STM32CubeMX and find the way ☺



- Another option is directly in the code, Do you know where?

STM32 & USB out-of-box solutions

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	STM32Cube FW package	STM32F0 (v1.0.0)		STM32F2 (v1.1.0)	STM32F3 (v1.0.0)				STM32F4 (v1.3.0)		STM32L0 (v1.0.0)	
	STM32 HW development boards	STM32072B_EVAL	STM32F072B-Discovery	STM322xG_EVAL	STM32303C_EVAL	STM32373C_EVAL	STM32F302R8-Nucleo	STM32F3-Discovery	STM324x9I_EVAL	STM324xG_EVAL	STM32L053C8-Discovery	STM32L053R8-Nucleo
USB Device	CDC Standalone	X		X	X	X			X	X		
	Custom HID Standalone	X			X	X			X	X		
	HID Standalone	X	X	X	X	X	X	X	X	X	X	X
	DFU Standalone	X	X	X	X	X	X	X	X	X	X	X
	MSC Standalone	X			X	X			X	X		
	Audio Standalone			X					X	X		
	DualCore Standalone								X	X		

STM32 & USB out-of-box solutions

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	STM32Cube FW package	STM32F2 (v1.1.0)	STM32F4 (v1.3.0)				
	STM32 HW development boards	STM322xG_EVAL	STM324x9I_EVAL	STM324xG_EVAL	STM32F401- Discovery	STM32F429I- Discovery	STM32F4- Discovery
USB Host	CDC Standalone	X	X	X			
	Dynamic Switch Standalone		X	X			
	HID Standalone	X	X	X			
	HID RTOS		X	X			
	MSC Standalone		X	X			
	MSC RTOS		X	X			
	Audio Standalone		X	X			
	DualCore Standalone		X	X			
	FWupgrade Standalone	X	X	X		X	
	MTP Standalone	X	X	X			
	Audio playback and record with USB disk		X		X		X
	Camera to USB disk	X	X	X			
	FatFS with USB disk	X	X	X	X	X	X
	FatFS with USB disk & RTOS	X	X	X			
	FatFS with USB disk & RTOS multi access		X	X			
	LTDC Animated picture from USB disk					X	

Other STM32 USB related materials

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<http://www.youtube.com/watch?v=Kx7yWVi8kbU>



Thank you

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