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PV198 – One-chip Controllers

USB

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What is USB

- **USB** – **U**niversal **S**erial **B**us

- Serial interface bus

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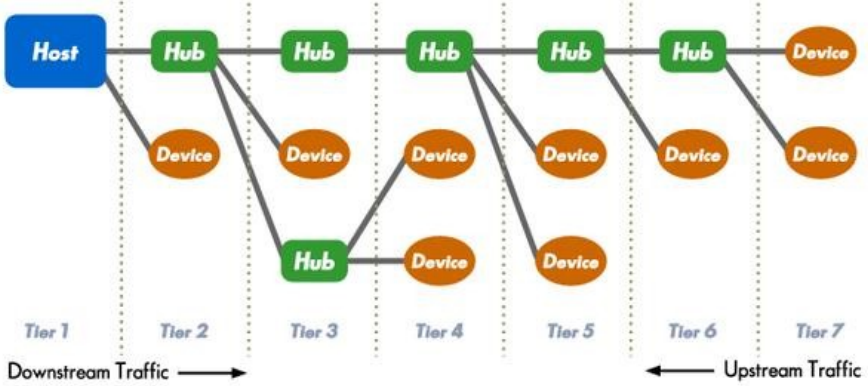
What is it used for

- Communication between computer and peripherals

- Human Interface Devices (mouse, keyboard)
- Mass Storage
- Printers
- Personal Healthcare

How does it work – High-level

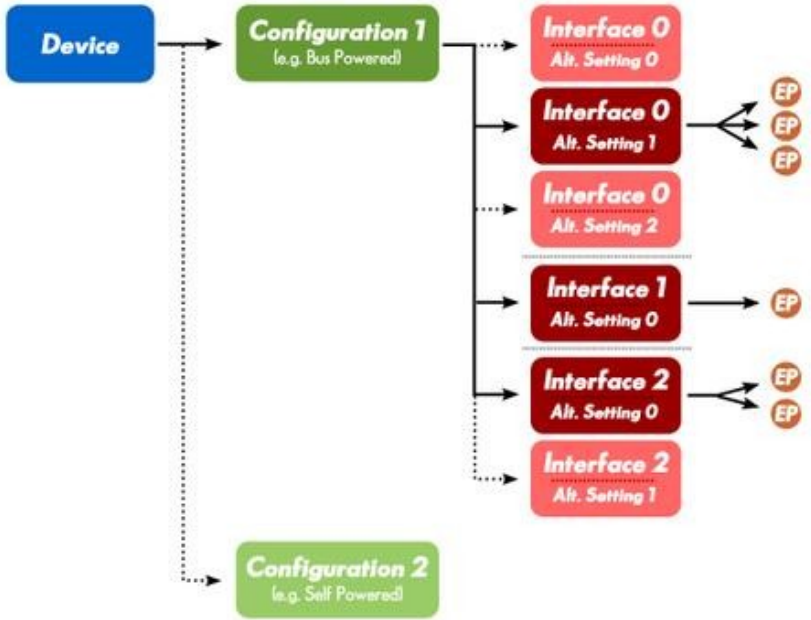
- Tiered star topology
- Host scheduled, token based
- Up to 127 devices on USB host controller
- Speed: Low, Full, High, Super
- 1.5 Mbit/s – 40 Gbit/s



https://www.totalphase.com/support/articles/200349256-USB-Background

How does it work

- 7-bit device address
- Host starts communication
- Device can have multiple:
  - Configurations
  - Interfaces
  - Interface settings (Alt. Settings)
  - Endpoints
- Endpoint defines:
  - Transfer direction
  - Transfer type (control, interrupt, bulk, isochronous)



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How does it work – Signaling

- 4-24 signals (OTG – 5, Super Speed – 9, USB-C – 24)
- 2 data (D+, D-), GND, Vcc
- Asynchronous (sync sequence at the beginning of the frame)
- Half-duplex
- NRZI line code (bit stuffing after 6 ones)

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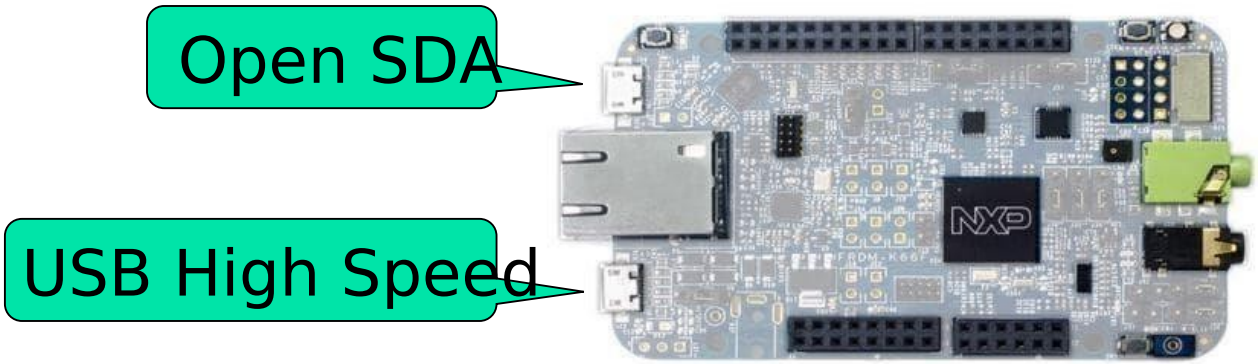
FRDM-K66F USB

- USB Full Speed OTG Controller
- USB High Speed OTG Controller
- Complies with USB specification rev 2.0
- Host / Device mode
- DMA
- Interrupts

Application – Overview

- The application behaves as an USB mouse, when the board is connected to a PC
- The cursor is moved by roll and pitch angles of the board
- Buttons SW2 and SW3 are used as mouse buttons



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Application

- Peripherals used:
  - GPIO (GPIO_A and GPIO_D): buttons
  - I2C: accelerometer → used to move cursor
- Middleware used:
  - USB

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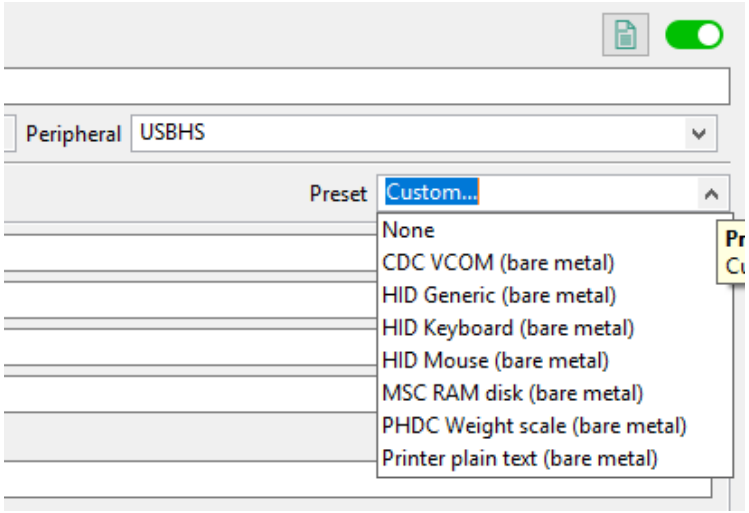
Application – USB configuration

- Standard USB configurations are predefined in peripherals tool
- *Check USB configuration in the tool*



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Application – USB implementation

- Endpoint defined with direction “in” (host in, device out) and “Interrupt” transfer type
  - Host asks for data from device every “interval” ms → we have to prepare data to send

```
112 /* Update mouse pointer location. Draw a rectangular rotation*/
113 static usb_status_t USB_DeviceHidMouseAction(void)
114 {
115     /* Send mouse report to the host */
116     return USB_DeviceHidSend(g_UsbDeviceHidMouse.hidHandle, USB_HID_MOUSE_ENDPOINT_IN, g_UsbDeviceHidMouse.buffer,
117                              USB_HID_MOUSE_REPORT_LENGTH);
118 }
119
```

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Application – Input Report for USB HID mouse

Usage	Bits	Description
Button 1	1	1 = pressed, 0 = not pressed
Button 2	1	1 = pressed, 0 = not pressed
Button 3	1	1 = pressed, 0 = not pressed
Not Used	5	5 bits in first Byte are not used
X	8	X movement – 8 bit signed integer (negative = left)
Y	8	Y movement – 8 bit signed integer (negative = up)
Wheel	8	Movement of the mouse wheel (negative = scroll down)

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Application – Source Code

- Main:
  - Configure (pins, clocks, peripherals – I2C, USB, accelerometer)
  - Loop:
    - Read data from accelerometer
    - Update USB buffer
- Interrupts:
  - GPIO: update USB buffer
- USB Callback:
  - Send USB buffer

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Application

- Update USB buffer on every change (button pressed, board tilted)

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Homework (not mandatory)

Implement one of these tasks:

- Easy: Use SW3 button to scroll down (scroll only once per button press)
- Medium: Create “trackball” by using Joystick from lecture 5 to control cursor, instead of accelerometer
- Hard: Implement medium Homework + choose USB configuration to act as Joystick, instead of Mouse