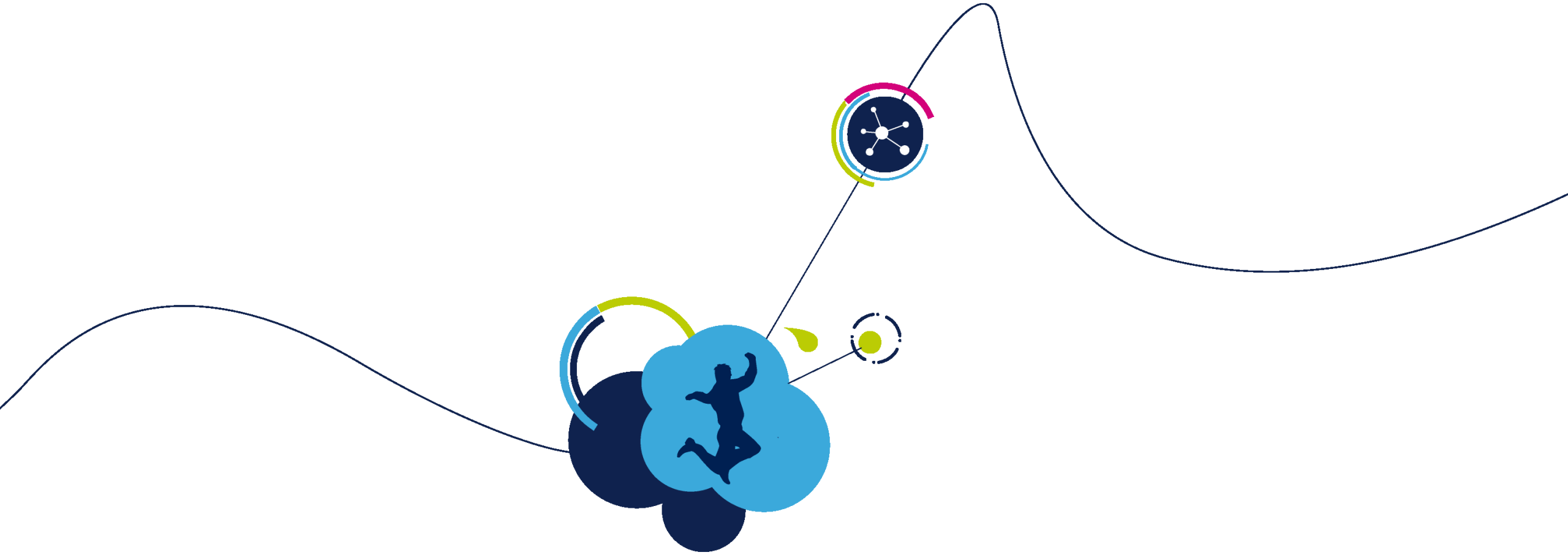


# USB HW design

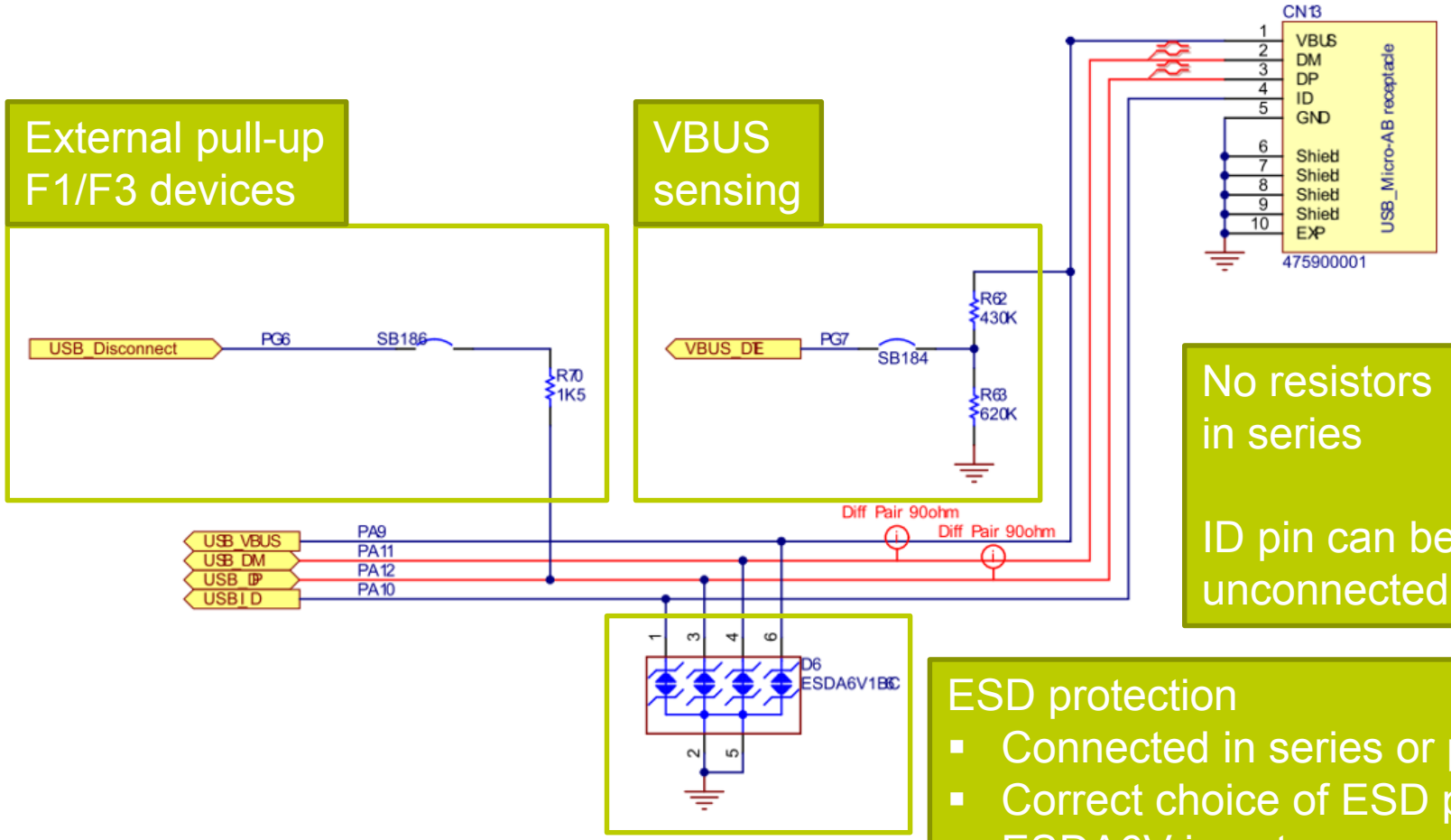
Updated on 22/11/2017

# USB device HW design with STM32



External pull-up F1/F3 devices

VBUS sensing




No resistors in series

ID pin can be unconnected

ESD protection

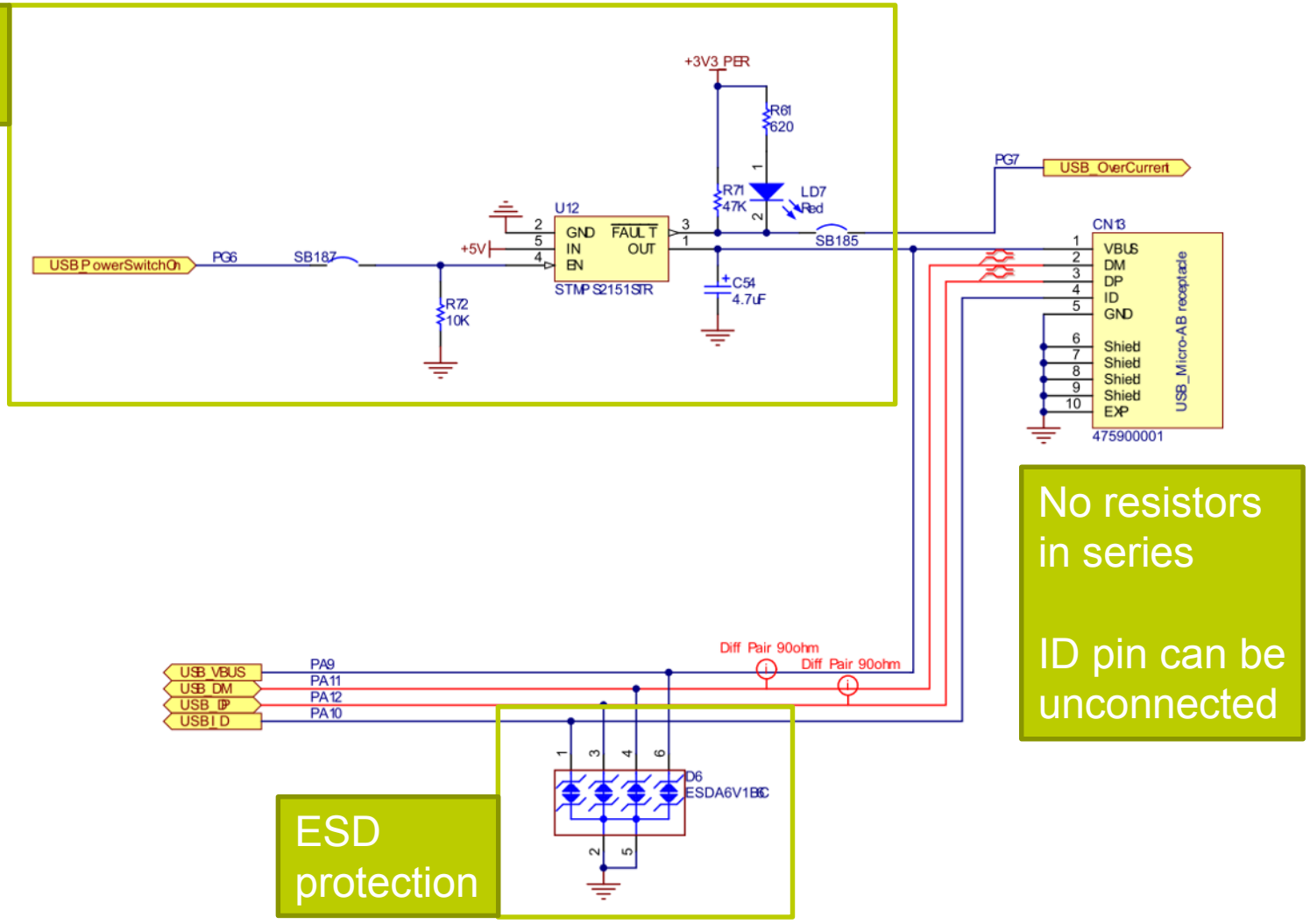
- Connected in series or parallel, it depends on the ESD part
- Correct choice of ESD protection – see next slides
- ESDA6V is not recommended – capacitance too high and protection characteristic is not met
- But USB signals are not violated by ESDA6V
- No serial resistance on the data lines

life.augmented

# USB host HW design with STM32



VBUS driving




No resistors in series

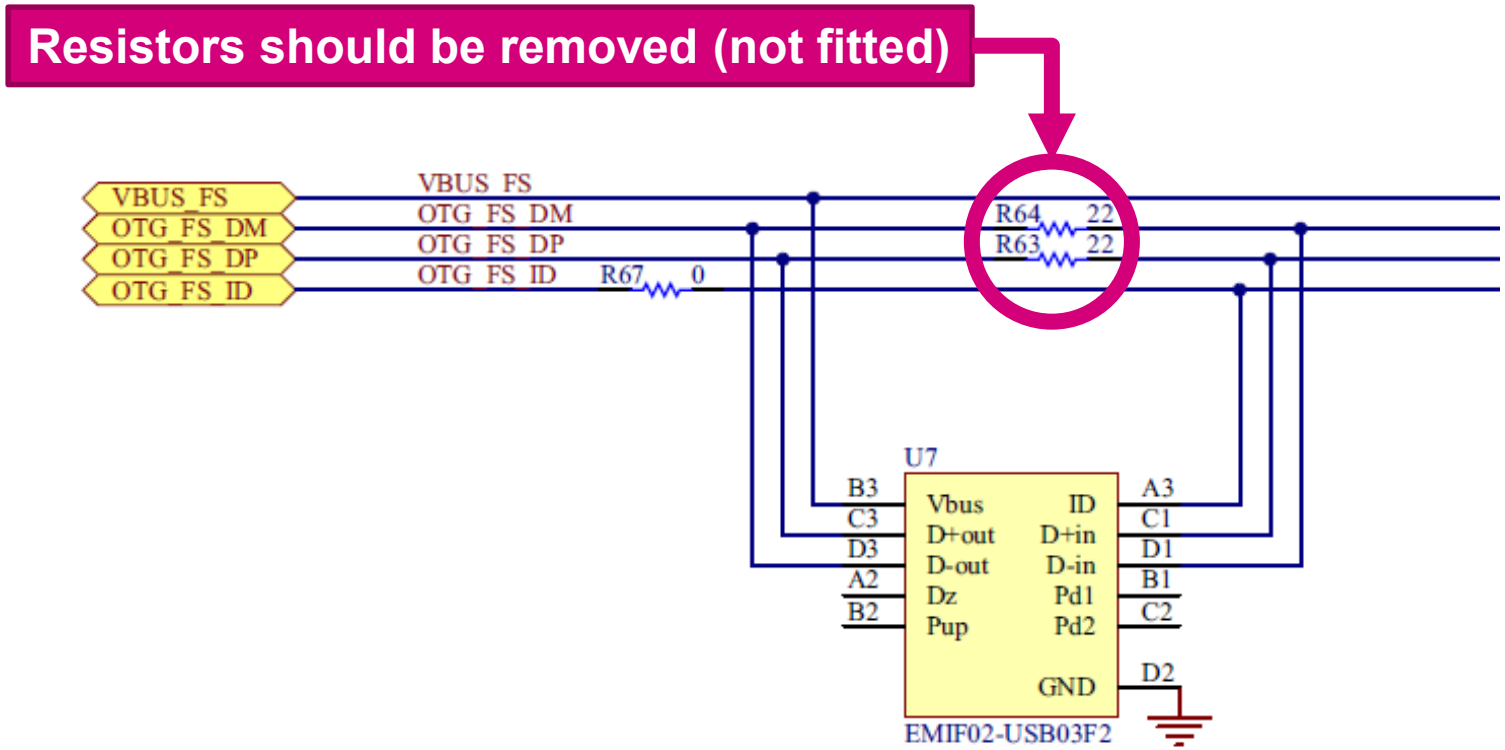
ID pin can be unconnected

ESD protection

# Bad ESD design



- Incorrect ESD part – there are 33 Ω resistors on data lines inside EMIF02, 22 Ω resistors in parallel are used as workaround to add lower resistance on the bus




**D+ and D- pins have matching impedance for USB**

# USB Protections



- The STM32 Internal USB driver impedance is inline with specification and is not necessary to add external impedance
- Only ESD protection without internal serial resistance are recommended
- We can recommend to use protection without internal resistors:
  - USBLC6-2 for VBUS powered DEVICE/HOST only (no ID pin)
  - USBLC6-4SC6 for self powered DEVICE/OTG (protect also ID pin)
  - ECMF02-4CMX8 for HS (ESD+EMI)

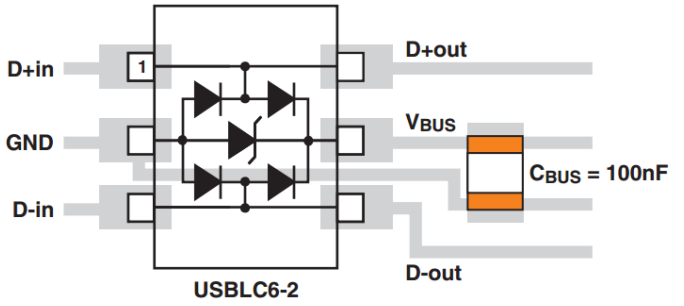
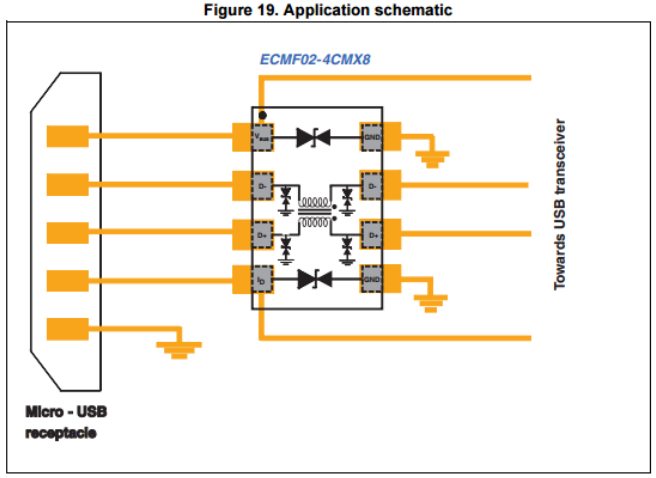



Figure 19. Application schematic

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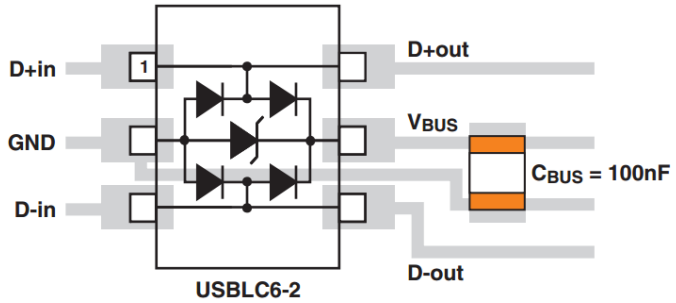
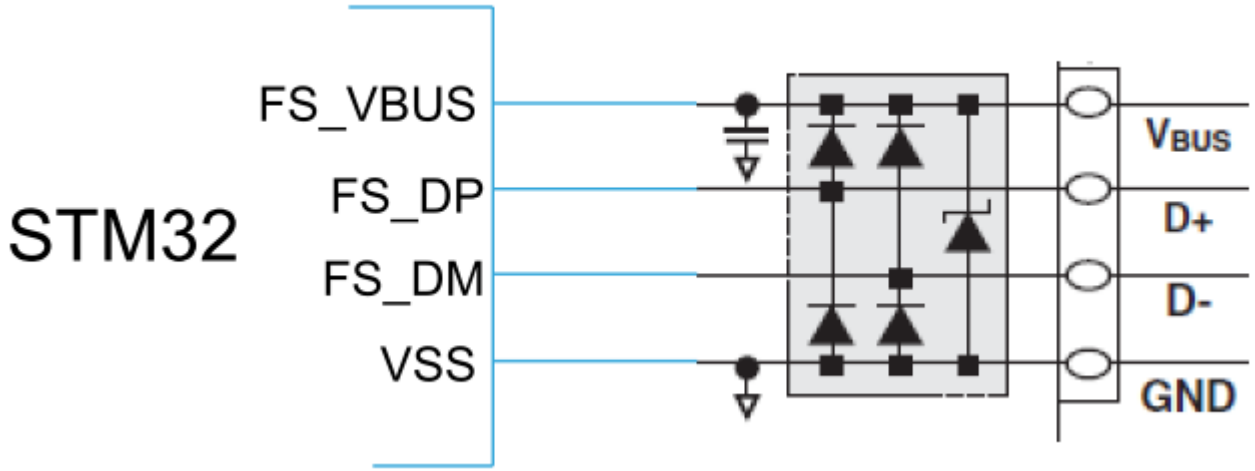
# USB Protections



- USBLC6-2 for DEVICE/HOST only (no ID pin)




- Connection for VBUS powered application
  - Cable deatach event cannot be detected in Self powered application due to the D+ pull-up and the diode connection to VBUS

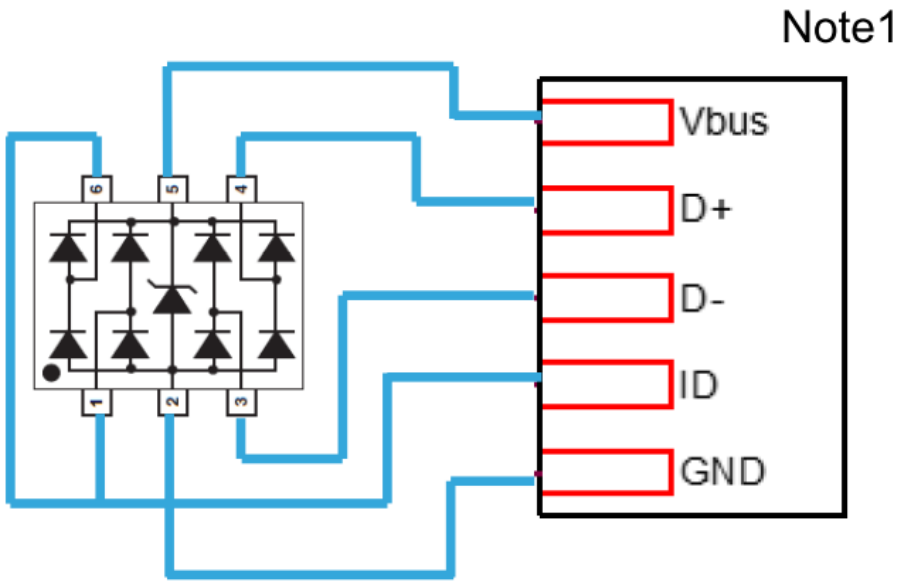


# USB Protections

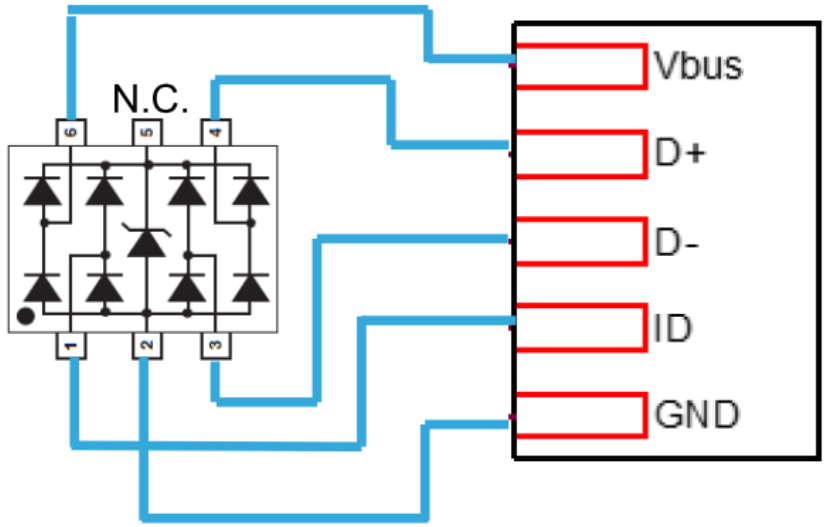


- For self powered application or OTG (ID usage) USBLC6-4SC6 is recommended

## VBUS powered implementation




## Self powered implementation

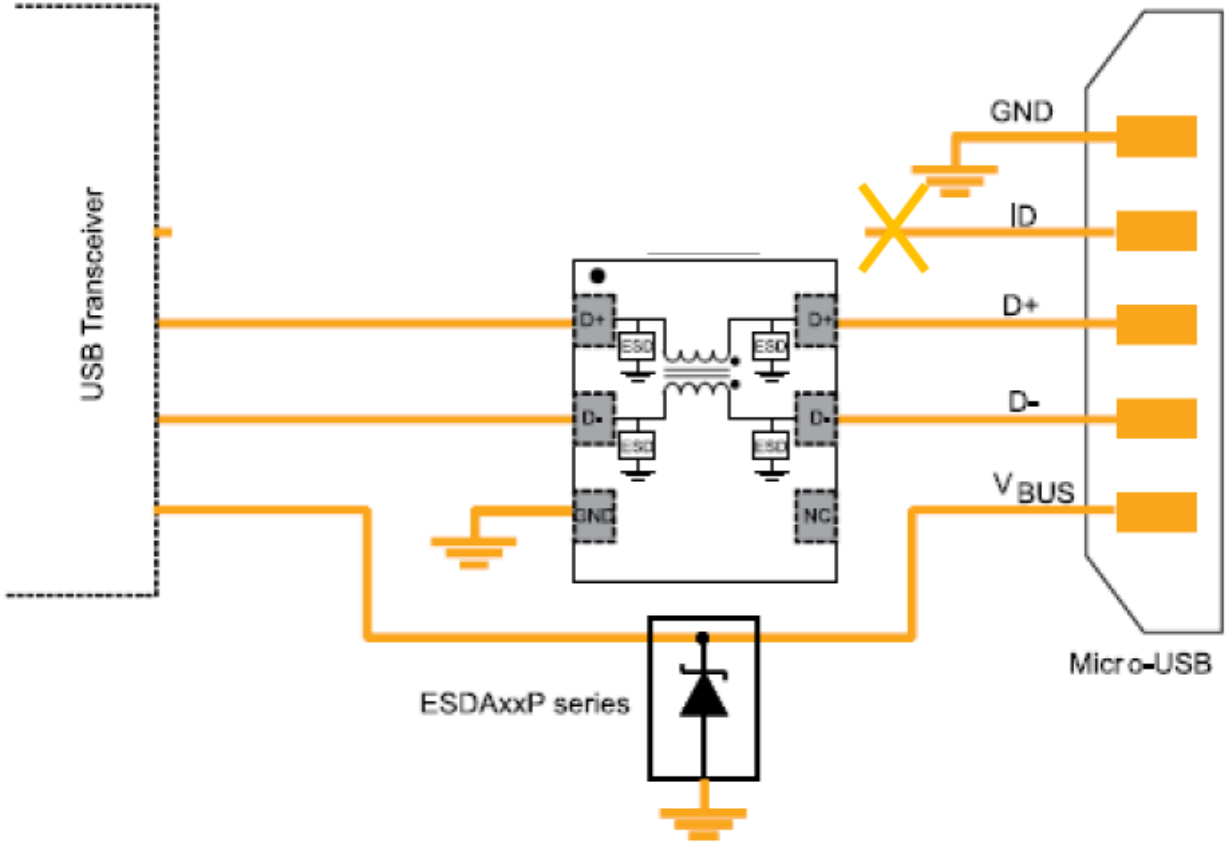



- Note1: If system is Self powered, cable detach event cannot be detected due to the D+ pull-up and the diode connection to VBUS

# USB Protections



- ECMF02-4CMX8 recommended for HS (ESD+EMI)
- The EMI common mode filter is mandatory for the USB HS signaling point of view.
  - USBLC6-2SC6 can be also used, but additional EMI common mode filter need to be added



# Device VBUS sensing

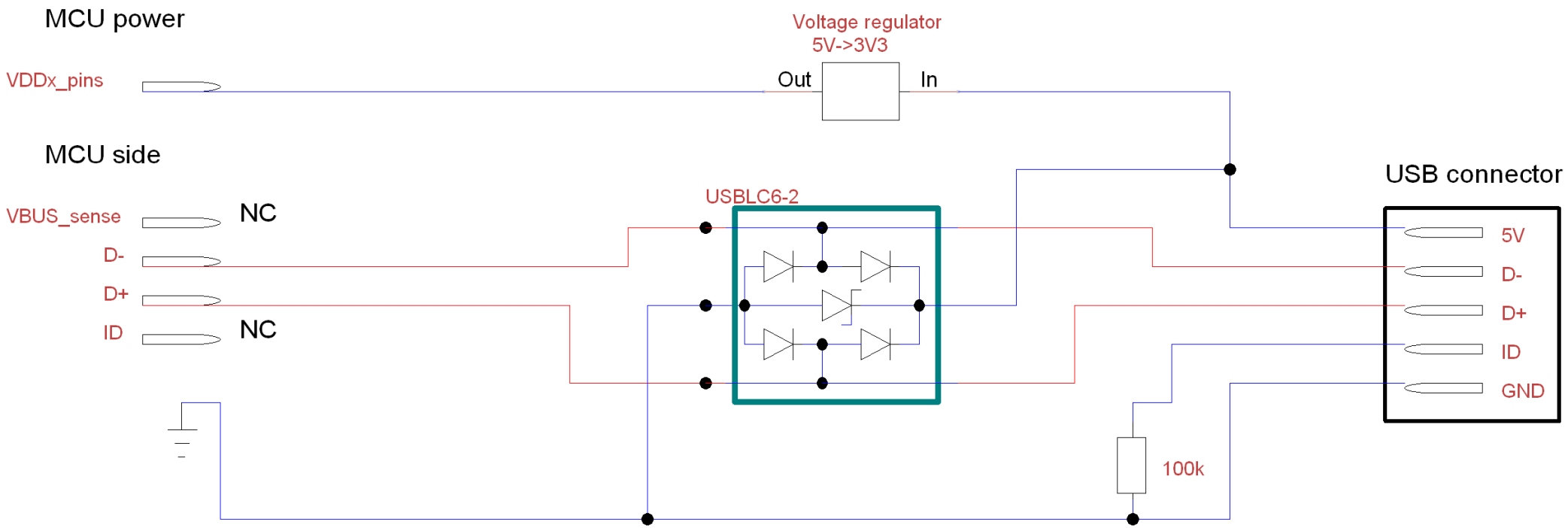


- Differentiate suspend and disconnection event
  - Mandatory for self-powered devices
  - Bus-powered application don’t need VBUS sensing
- Pin dedicated to be connected to USB VBUS (5V)
  - PA9 on OTG FS, PB13 on OTG HS with internal PHY
  - Not 5V tolerant – only VDD + 4.0V
    - Requires external voltage divider
  - Requires 200 µA minimal current for the detection to work
    - Limits maximum resistor values in voltage divider
- Any GPIO can be used instead
  - Also requires external voltage divider
  - Requires handling in software

# USB bus-powered device



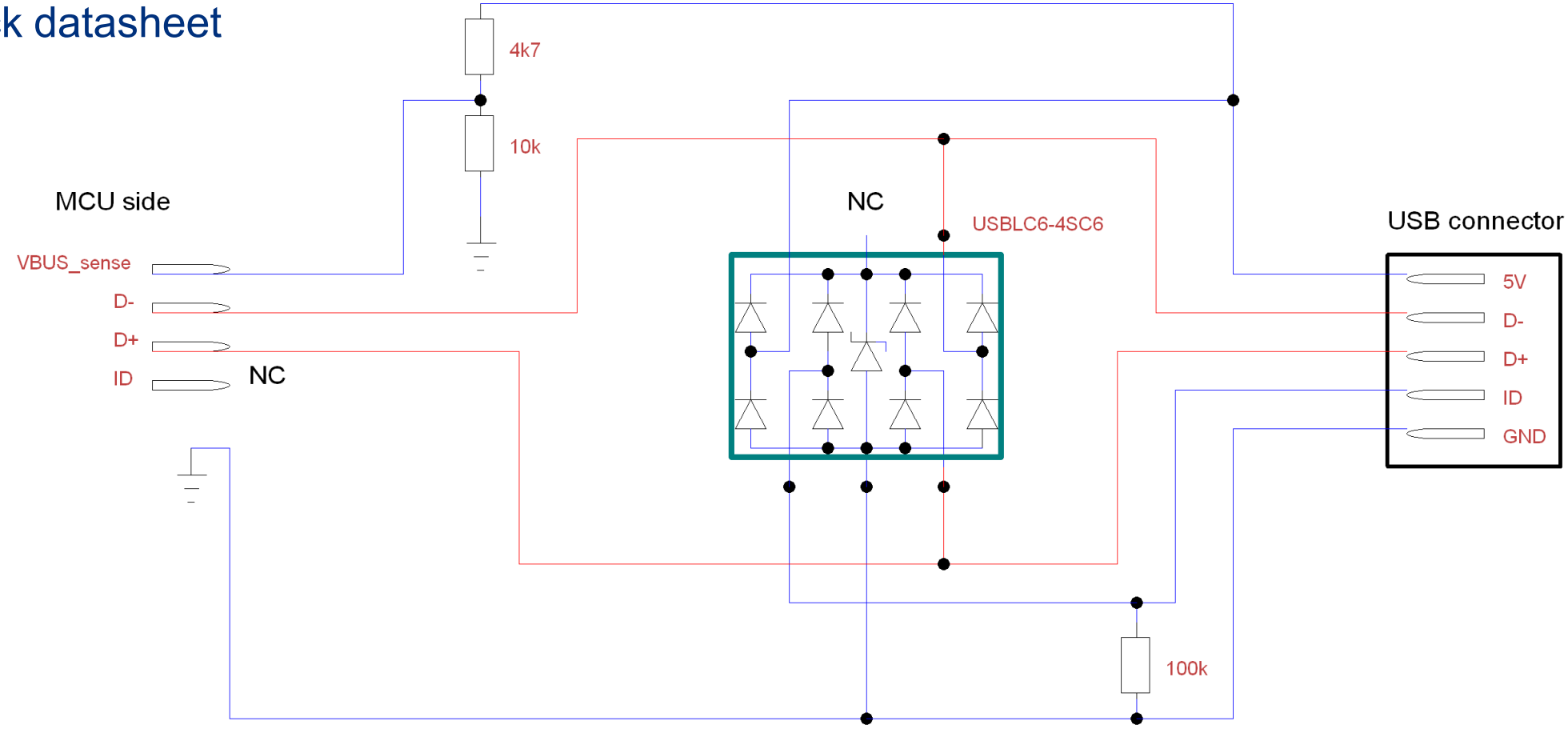
- MCU powered from USB bus
  - No need for ID line or VBUS sensing
  - For some STM32 (F1, F3 families) additional pull up resistor on D+ need to be added, please check datasheet



# USB self-powered device



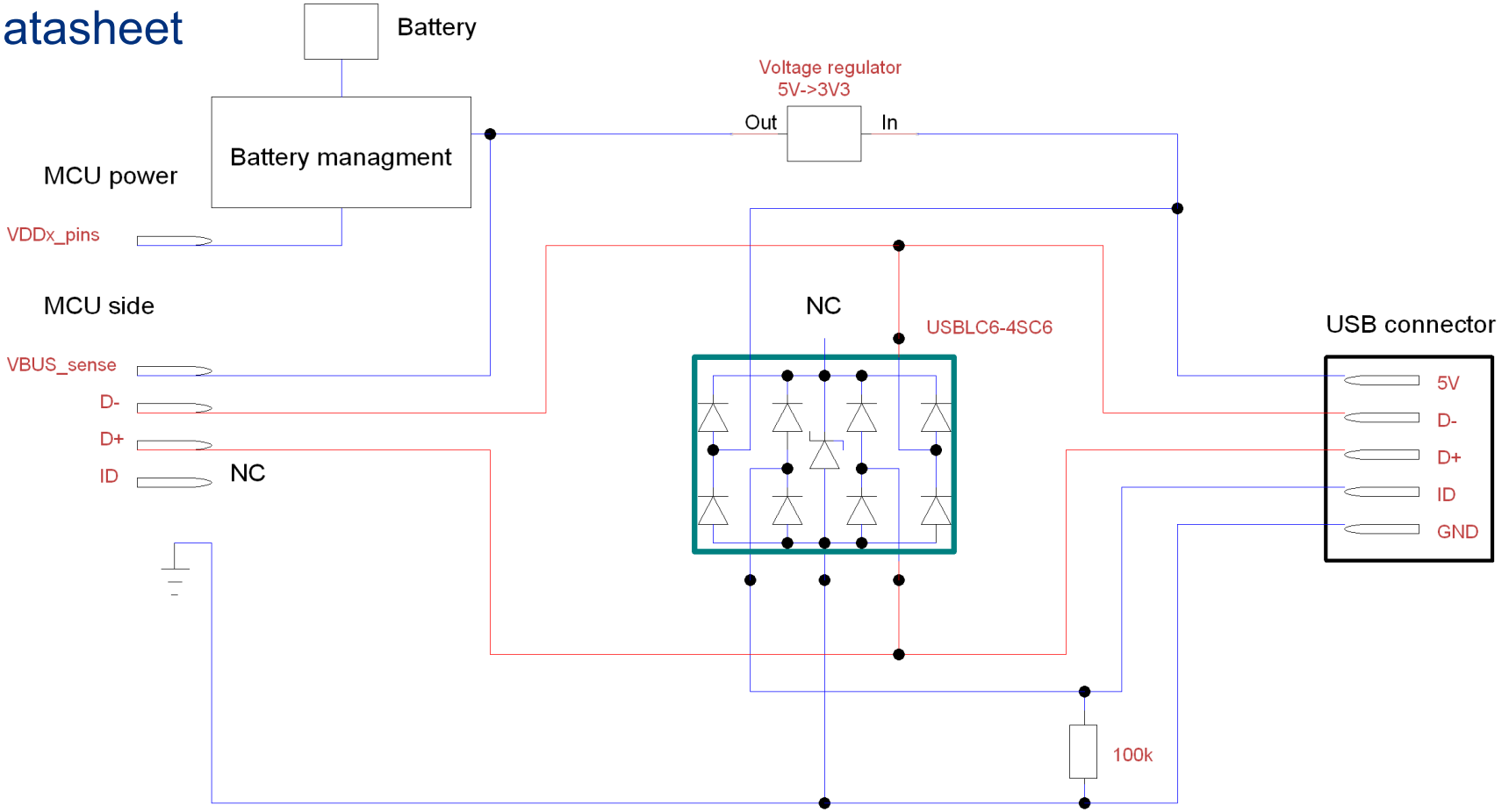
- VBUS sensing mandatory to differentiate disconnect and suspend
  - Scenario with OTG dedicated GPIO for VBUS sensing
  - For some STM32 (F1, F3 families) additional pull up resistor on D+ need to be added, please check datasheet



# USB self-powered device



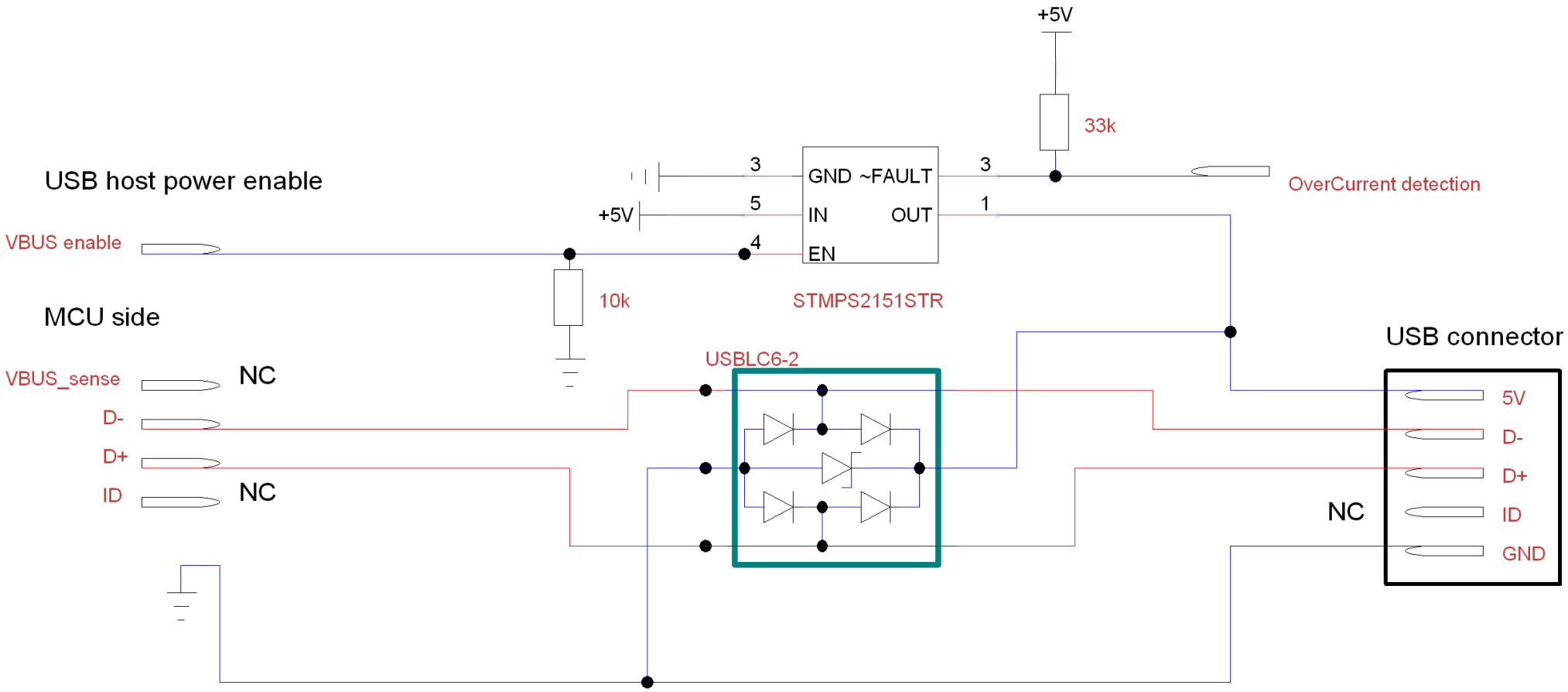
- Similar to previous slides, battery charged from VBUS
  - Battery management not illustrated – application dependent
  - For some STM32 (F1, F3 families) additional pull up resistor on D+ need to be added, please check datasheet



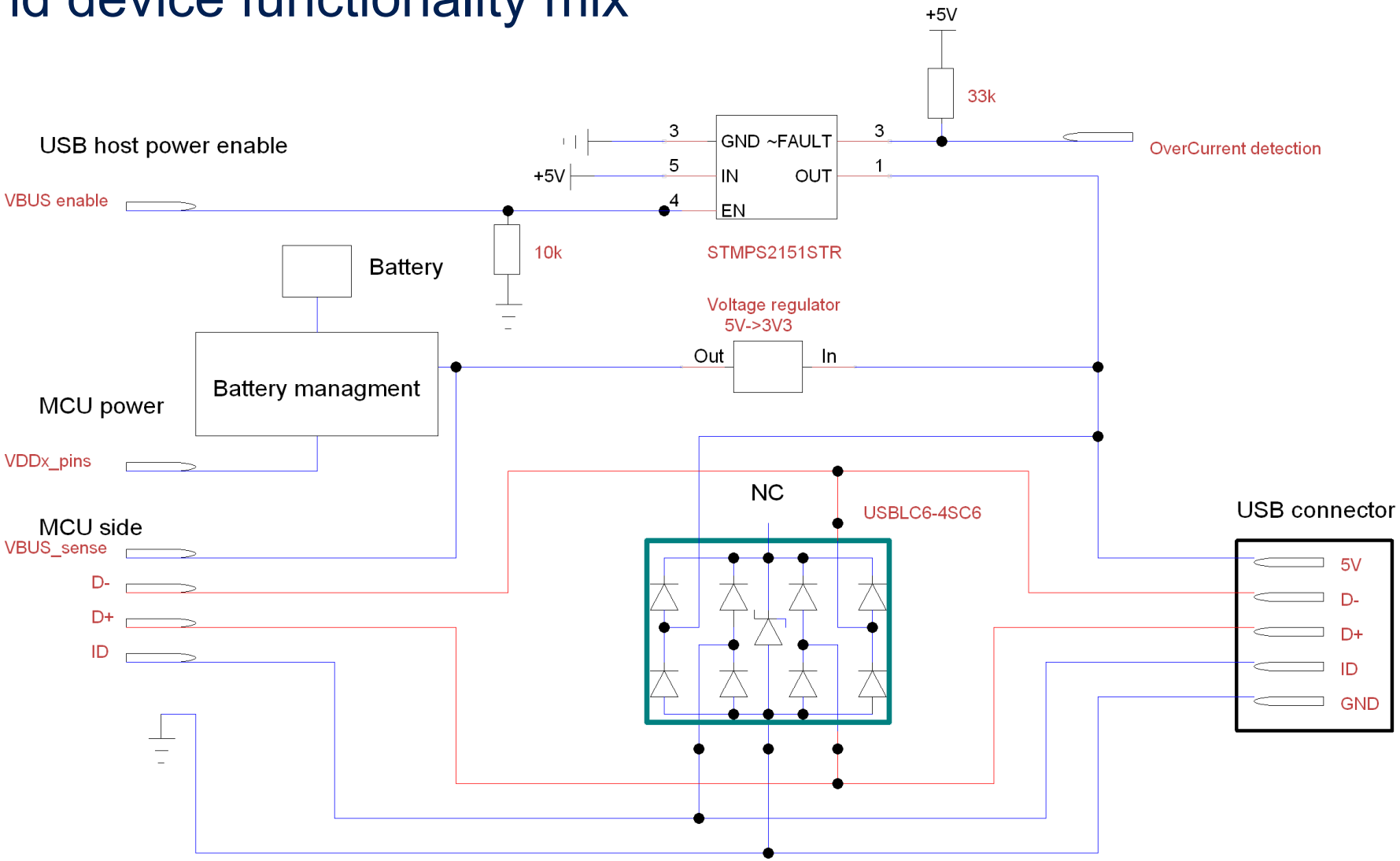
# USB host



- Host is managing +5V on VBUS



- Host and device functionality mix



# Recommended HS PHY



- USB3300
- USB331x
- USB3320C
- FUSB2805 (FW fix needed)
- ISP1705
- STULPI01

- Not compatible!
- USB3330
- USB334x

- For USB HS board design BOM and schematic from ST evaluation boards shall be used

# HW design summary



- **No resistors in series on data lines**
  - Even though it is on some of ST Evaluation boards
  - It can shift the electrical characteristic out of USB specification
- ESD protection
  - E.g.: USBLC6-4SC6 (from ST)
  - Must match the USB speed (full-speed or high-speed)
- VBUS sensing
  - Voltage divider is required to match Absolute maximum ratings
- USB_OTG_HS peripheral can work in FS mode using internal PHY

# HW design summary



- Power supply (internal PHY)
  - Most devices require at least 3V supply voltage
    - The peripheral might work to 2.7V, but electrical characteristic will be out of specification
  - Some devices (low-power family) has dedicated power supply for USB
    - 3V is required only for this power supply
  - STM32H7 has dedicated voltage regulator for USB from 5V
    - Can be used only for the USB peripheral
    - Voltage detector must be enabled in both cases – bit cleared only by power-on reset
- Clocking (internal PHY)
  - External HSE crystal required, except for crystal-less devices
- External high-speed PHY
  - Power supply and clocking depends on the PHY IC
  - Connected via ULPI interface
  - E.g.: STULPI01