



مرکز آموزش نیرا سیستم

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Universal Serial Bus (USB)

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Introduction

- USB On-The-Go Full-Speed (USB OTG FS) is a versatile and powerful feature integrated into the STM32F407 microcontroller, enabling dynamic switching between host and device roles in USB communications.
- This functionality allows the STM32F407 to interact seamlessly with a variety of USB peripherals, enhancing its adaptability in embedded systems.
- USB OTG FS operates at a Full-Speed rate of 12 Mbps, making it suitable for applications that require moderate data transfer speeds without the complexity and power consumption associated with High-Speed USB interfaces.



Applications

- **Mobile Devices**

- Facilitates direct connection between smartphones and peripherals like keyboards, mice, and storage devices.

- **Industrial Automation**

- Enables communication between microcontrollers and industrial sensors, actuators, and control units.

- **Consumer Electronics**

- Supports connections with cameras, game controllers, and audio devices.

- **Data Acquisition Systems**

- Allows for efficient data transfer between sensors and data processing units.

- **IoT Devices**

- Enhances connectivity options for Internet of Things (IoT) applications by enabling peripheral expansion and direct device communication.



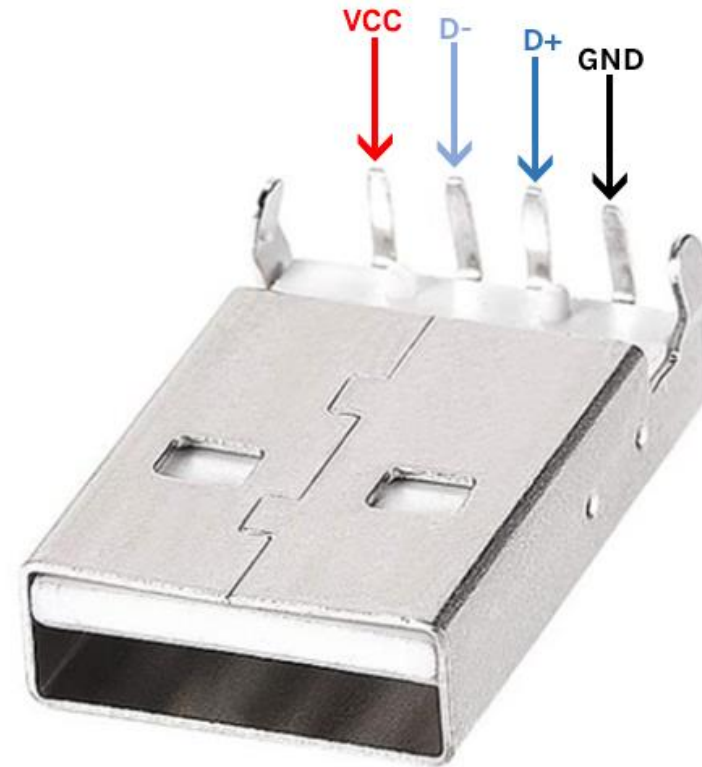
Features

- **Dual Role Capability**
 - Can function either as a host or a device, allowing flexible communication setups.
- **Full-Speed Operation**
 - Supports data transfer rates up to 12 Mbps, balancing speed and power efficiency.
- **Low Power Consumption**
 - Optimized for energy-efficient operations, crucial for battery-powered devices.
- **Integrated PHY**
 - The STM32F407 includes a built-in Physical Layer (PHY) for USB, simplifying hardware design.
- **Support for Multiple Endpoints**
 - Facilitates simultaneous communication with multiple USB devices or peripherals.

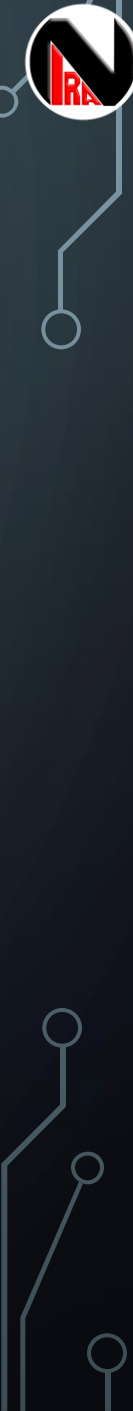


Properties

- Connection Type: Serial
- Communication Type: Half-Duplex
- Data Type: Packet
- Synchronize: Async
- Channel Type: Copper Wire
- Voltage State: TTL (Differential)



USB TYPE-A Connector Pinout



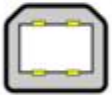





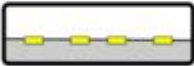
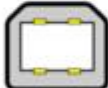















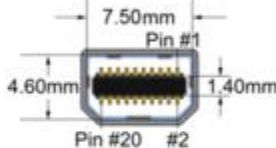

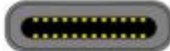


Versions

Name	Version	Communication Type	Speed (Mbps)	Connector
Low Speed (LS)	1.0	Half-Duplex	1.5	A, B
Full Speed (FS)	1.1	Half-Duplex	12	A, B
High Speed (HS)	2.0	Half-Duplex	480	A, B
Super Speed (SS)	3.0	Full-Duplex	5000	A, B
Super Speed+ (SS+)	3.1	Full-Duplex	10000	A, C
Super Speed++ (SS++)	3.2	Full-Duplex	20000	C
USB4	4.0	Full-Duplex	40000	C

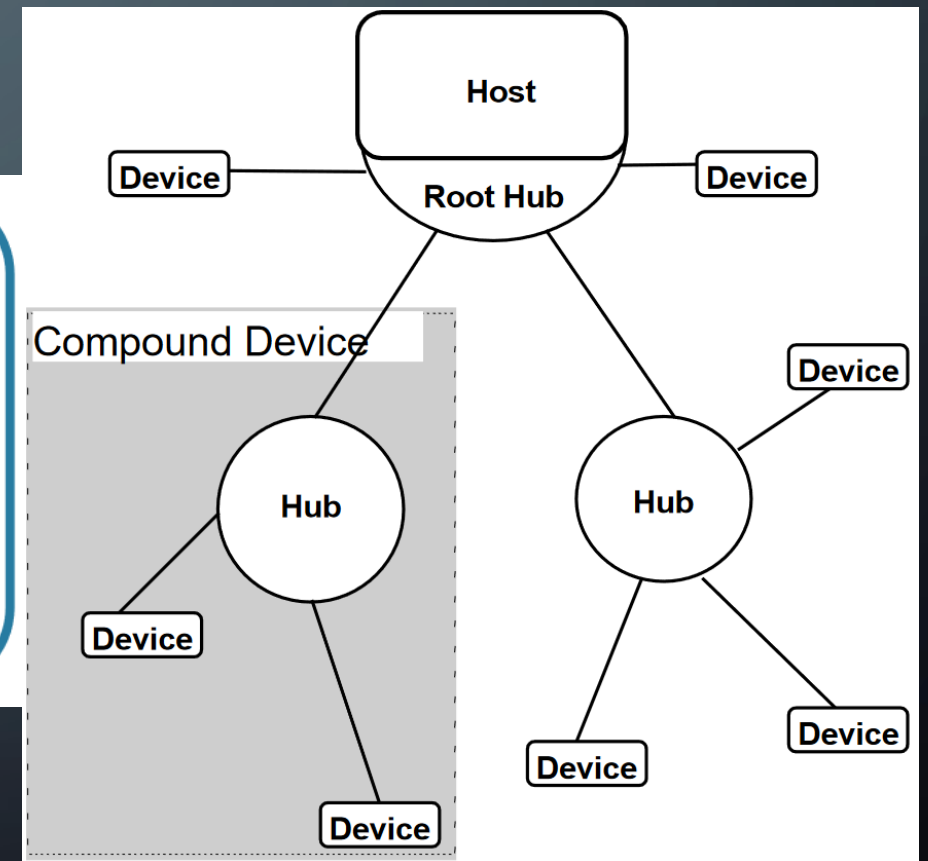
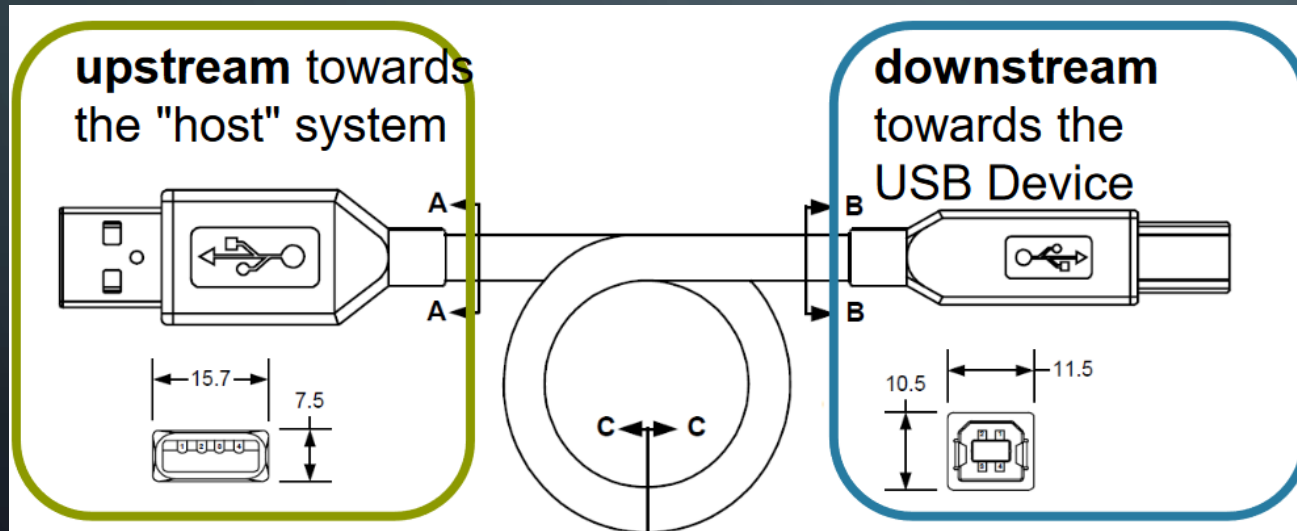


Connectors

<p>USB 1.0 12mbps</p>   <p>Type A</p>  <p>Type B</p>   <p>Mini-A Mini-B</p>   <p>Micro-A Micro-B</p>	<p>USB 2.0 480mbps</p>   <p>Type A</p>  <p>Type B</p>   <p>Mini-A Mini-B</p>   <p>Micro-A Micro-B</p>	<p>USB 3.1 Gen1 (Previously 3.0) 5gbps</p>   <p>Type A</p>  <p>Type B</p>  <p>Mini-B</p>  <p>Micro-B</p>	<p>USB 3.1 Gen2 10gbps</p>   <p>Type A</p>  <p>Type-C</p>	<p>USB 3.2 20gbps</p>   <p>Type-C</p>	<p>Thunderbolt 2 20gbps</p>  <p>Mini DisplayPort Connector</p>  <p>Thunderbolt 3 40gbps</p>   <p>Type-C</p>
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Connectors





Stream

- **Control Streams**

- Handle setup, configuration, and control signals essential for managing the USB connection.

- **Bulk Streams**

- Transfer large amounts of data without real-time constraints, suitable for applications like file transfers.

- **Interrupt Streams**

- Manage small, time-sensitive data packets, ideal for devices like keyboards and mice.

- **Isochronous Streams**

- Provide consistent, real-time data delivery, necessary for audio and video streaming applications.



Packets

- **Token Packets**
 - Initiate data transactions and indicate the type of transfer (e.g., IN, OUT, SETUP).
- **Data Packets**
 - Carry the actual payload data between the host and device.
- **Handshake Packets**
 - Provide status information and acknowledgments (e.g., ACK, NAK, STALL).
- **Start-of-Frame (SOF) Packets**
 - Signal the beginning of a new frame and synchronize data transfers.

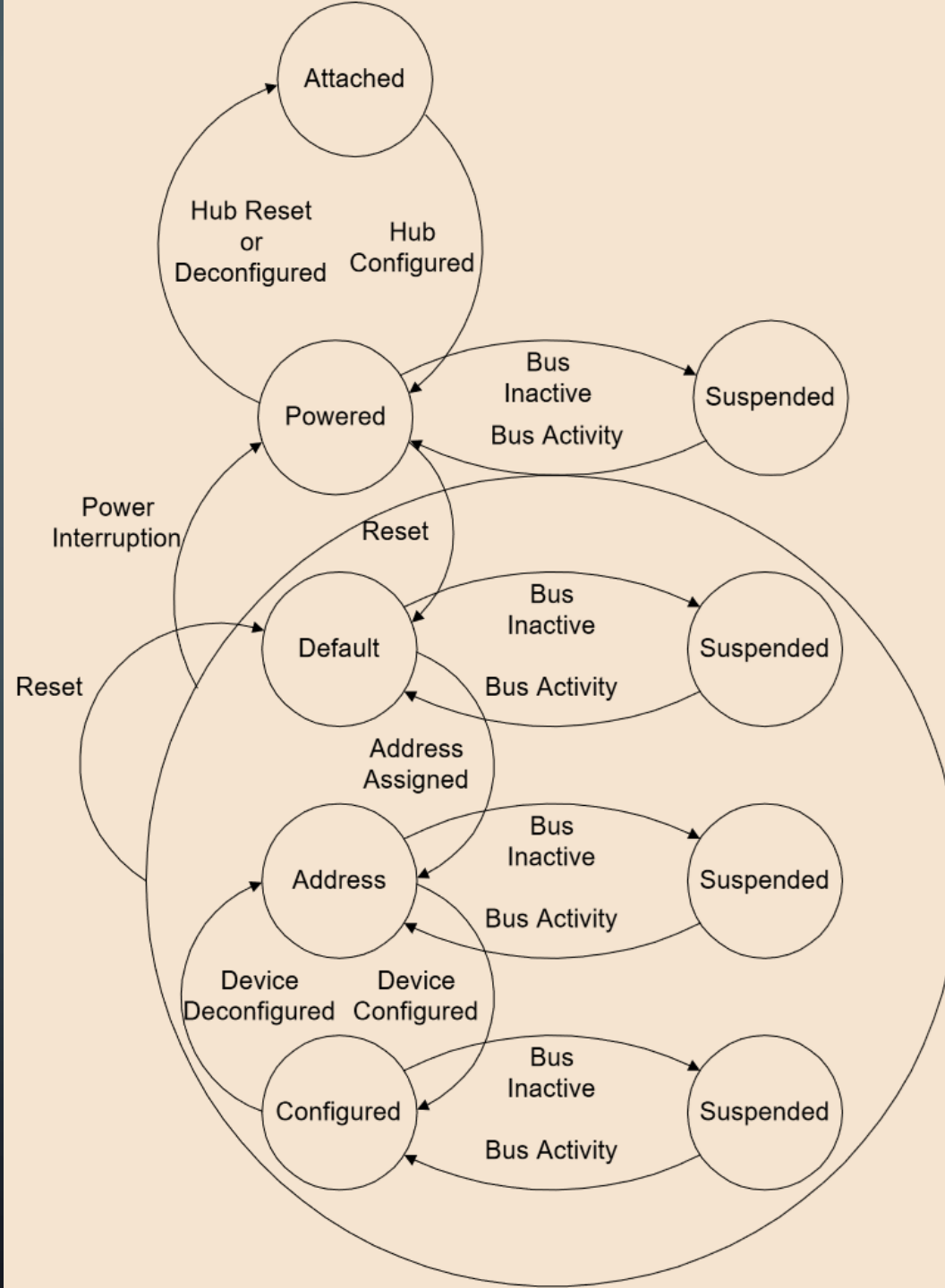


States

- **Idle**
 - The default state when no USB activity is occurring.
- **Reset**
 - Entered during USB initialization or when a reset signal is detected, preparing the interface for communication.
- **Addressing**
 - Assigns a unique address to the device during enumeration.
- **Configured**
 - Indicates that the device is properly configured and ready for data transfer.
- **Suspended**
 - Activates low-power mode when the USB connection is idle or not in use.
- **Error**
 - Triggered by communication errors, requiring error handling and recovery procedures.

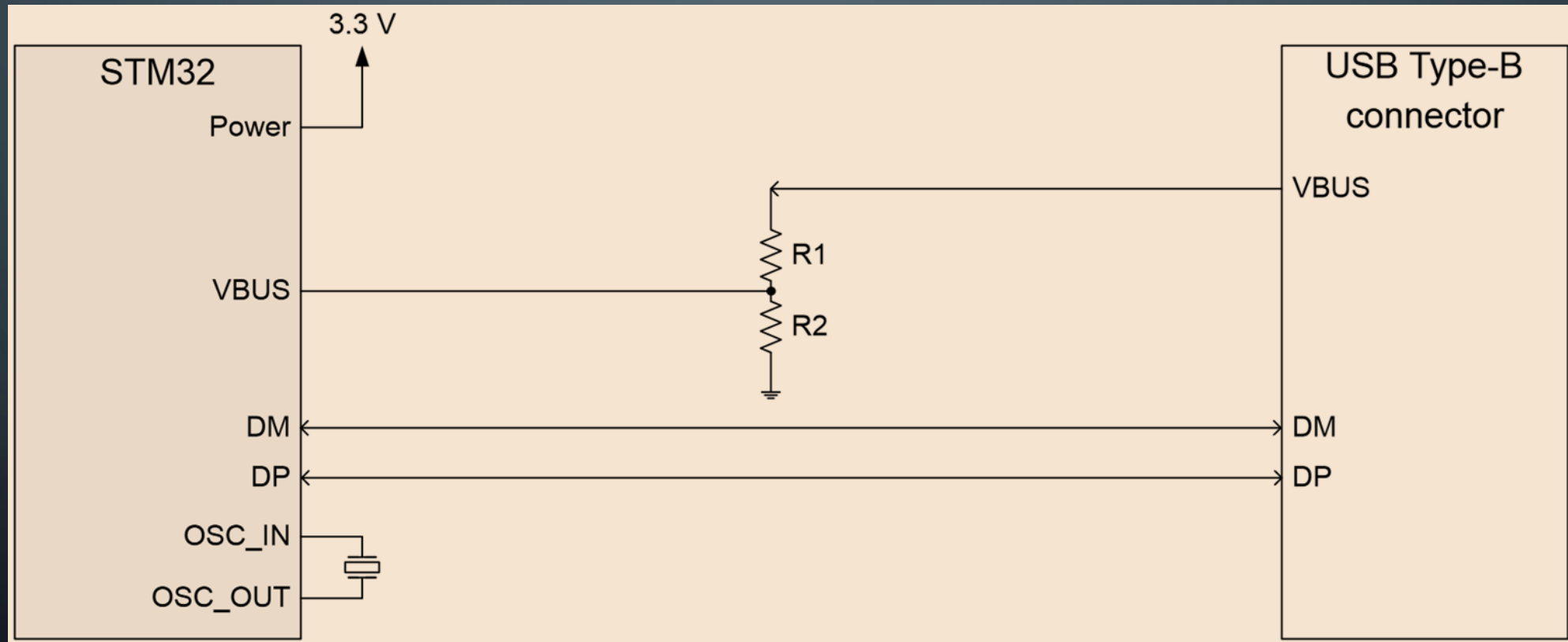


States





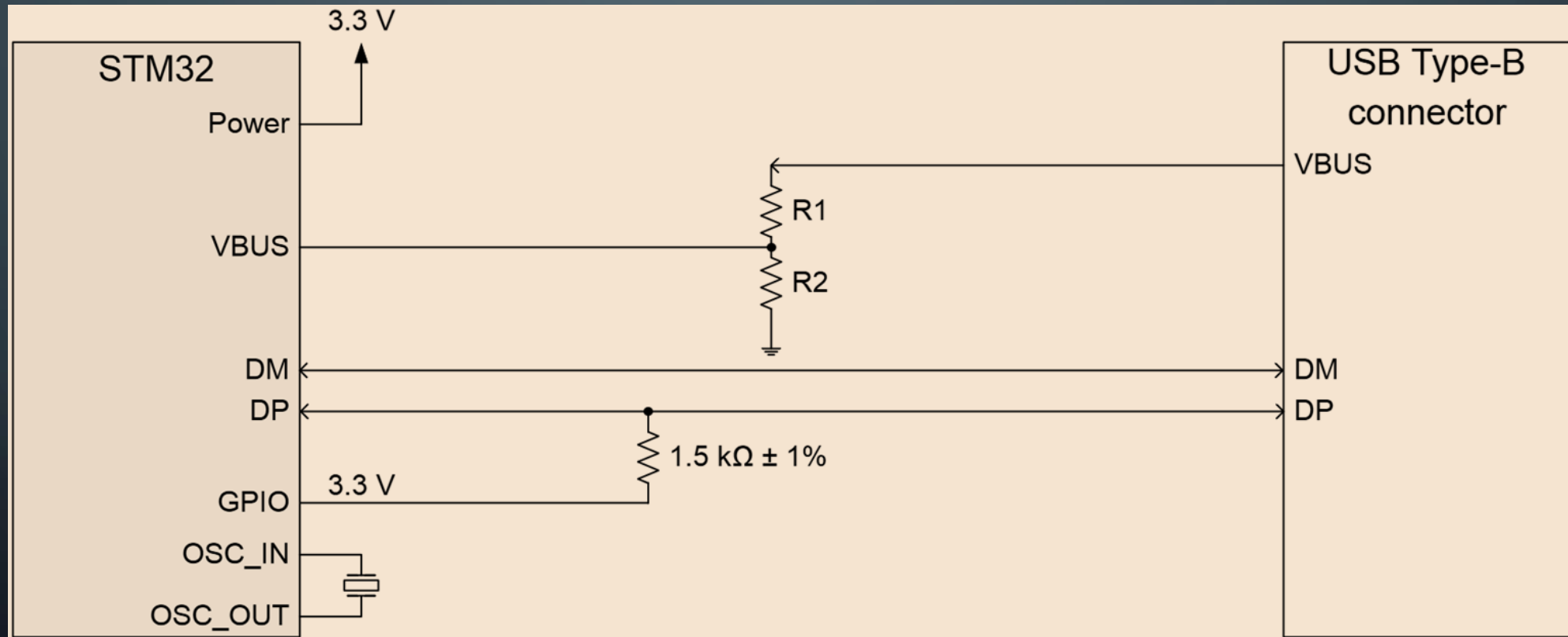
Upstream Schematics (1/4)



USB FS upstream port with embedded pull-up resistor in self-powered applications



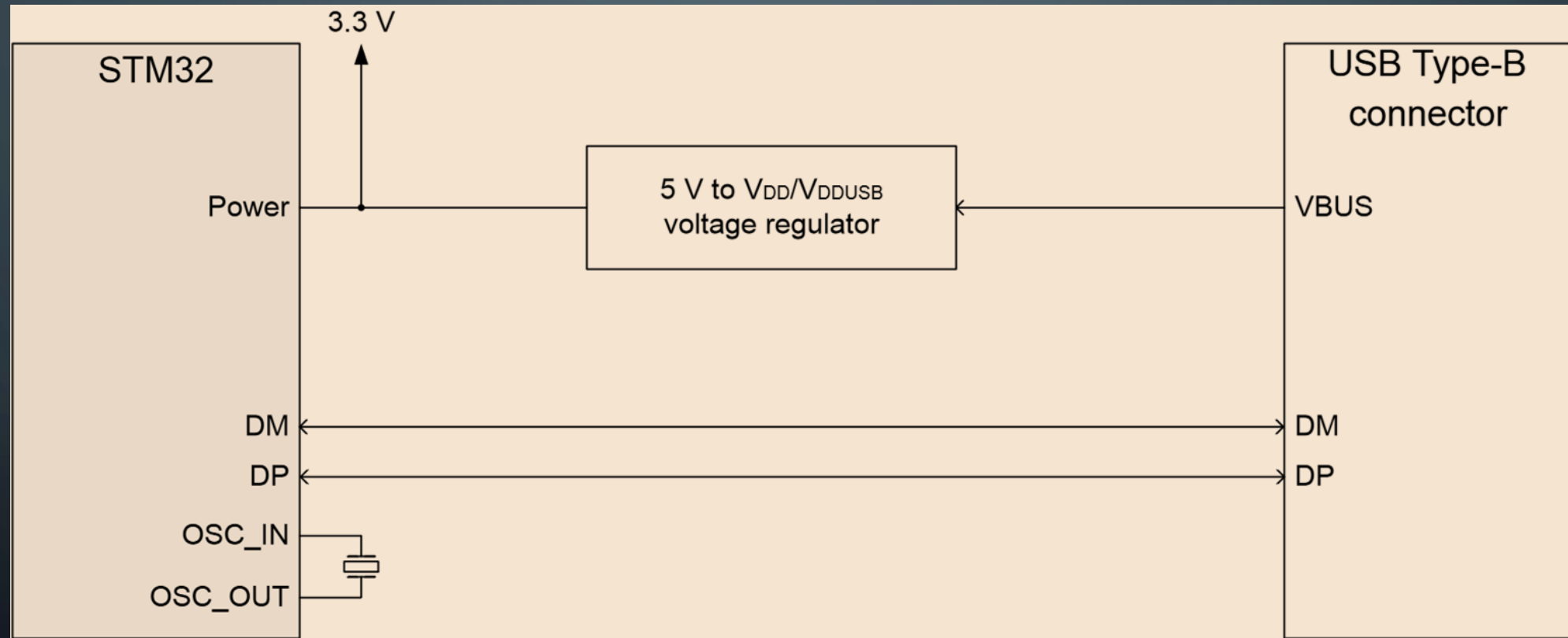
Upstream Schematics (2/4)



USB FS upstream port without embedded pull-up resistor in self-powered applications



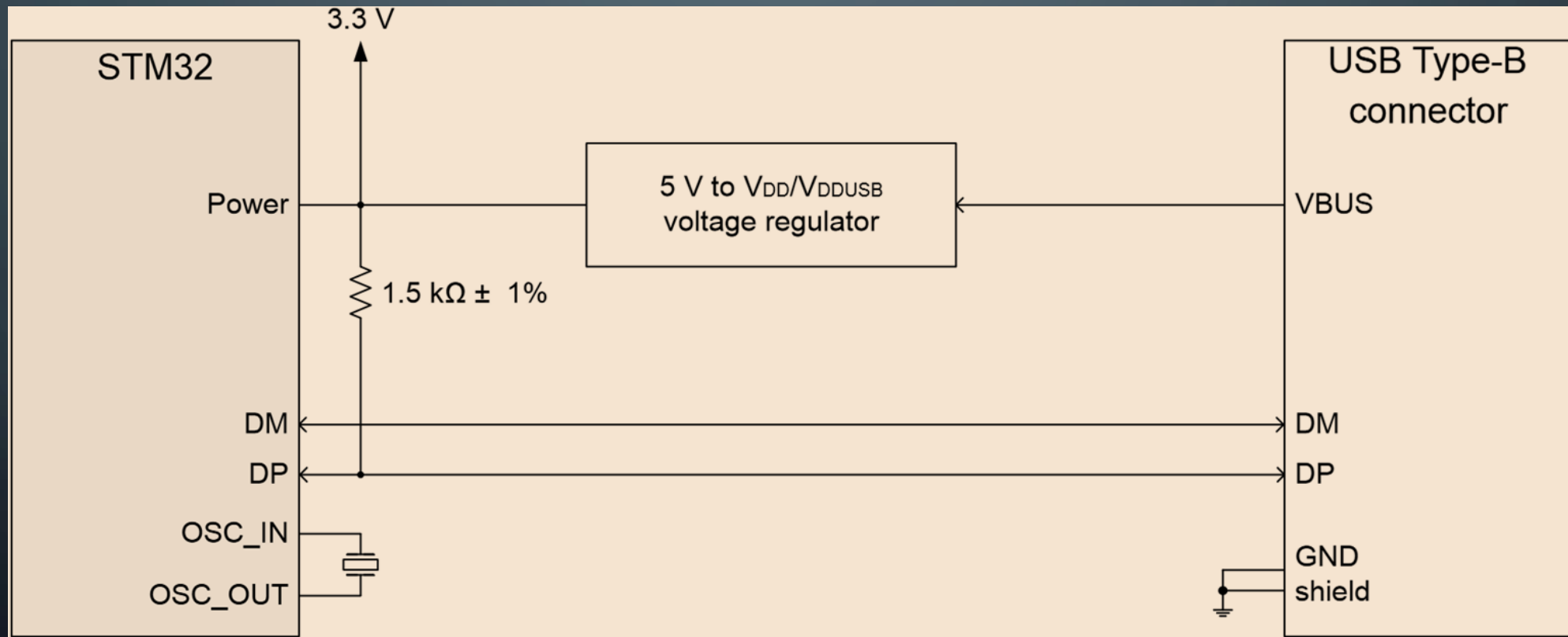
Upstream Schematics (3/4)



USB FS upstream port with embedded pull-up resistor in bus-powered applications



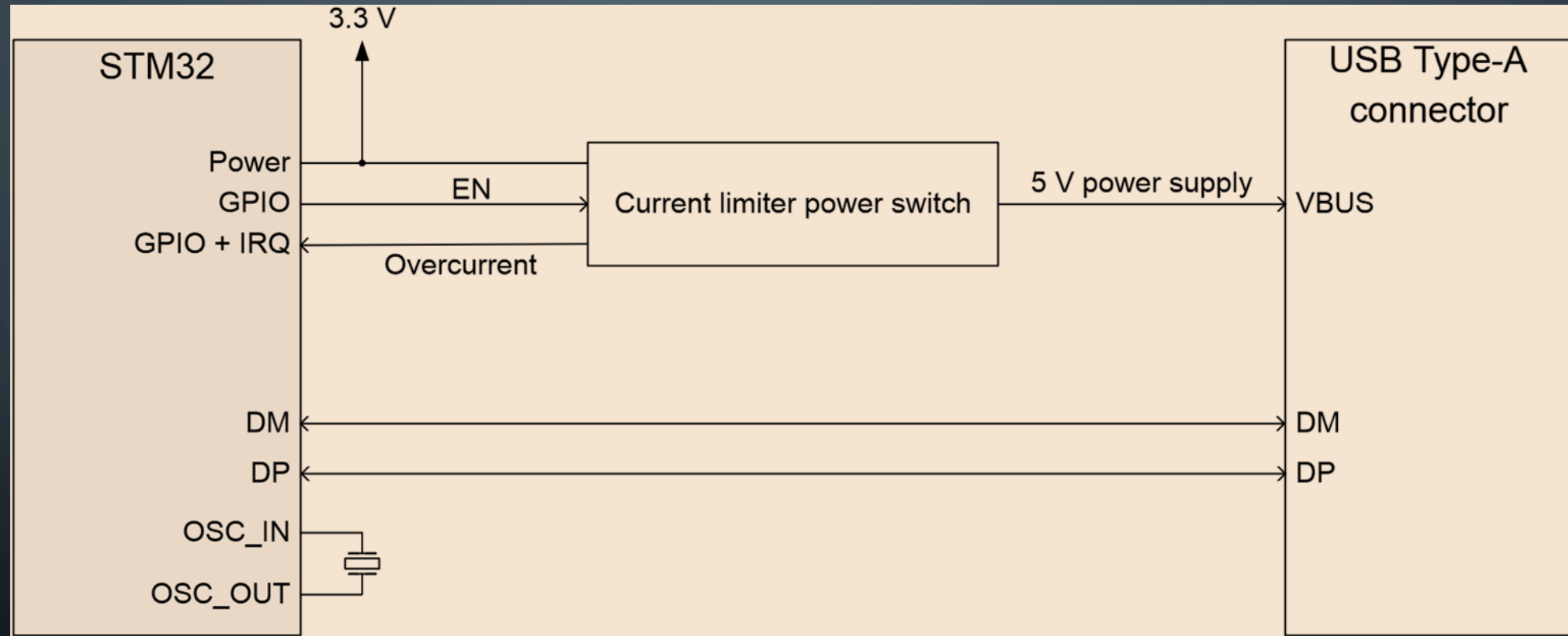
Upstream Schematics (4/4)



USB FS upstream port without embedded pull-up resistor in bus-powered applications



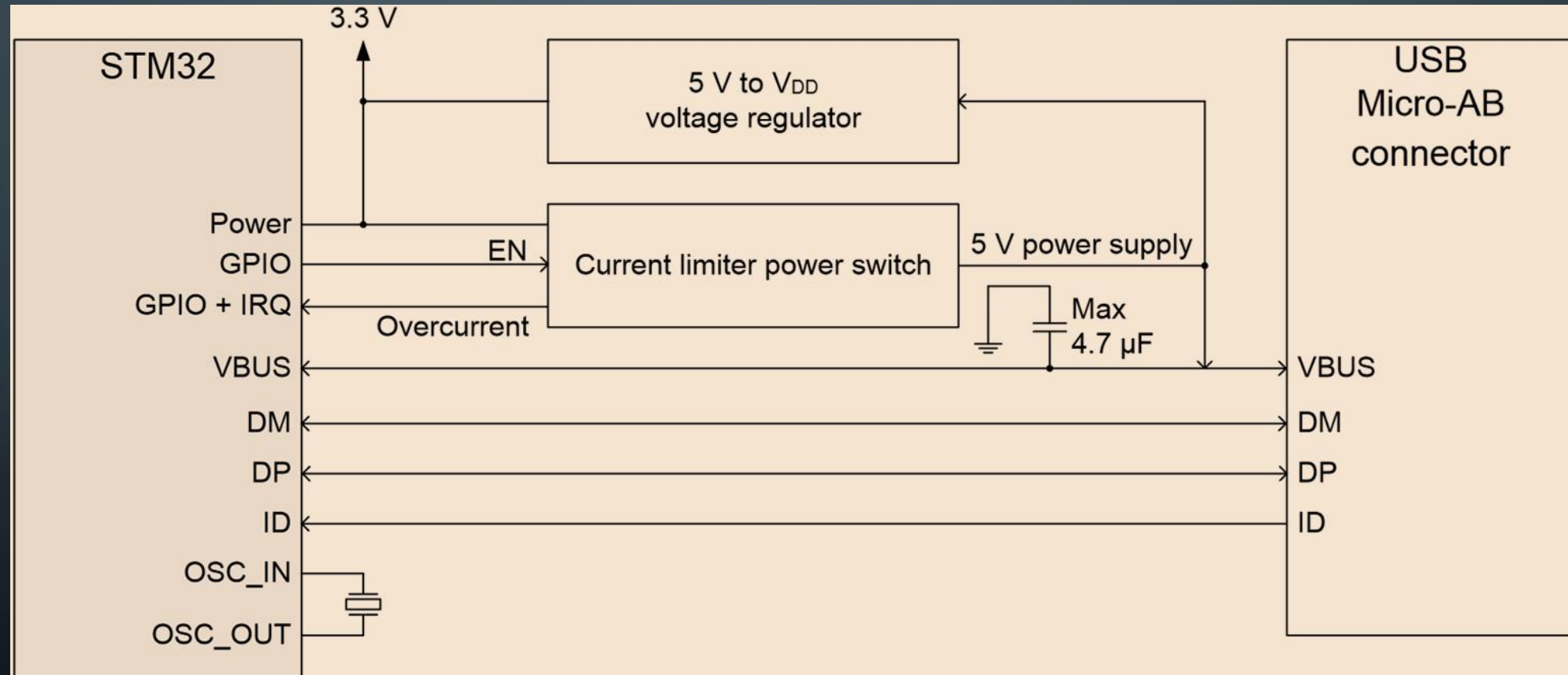
Downstream Schematic



USB FS downstream implementation



OTG Schematic



OTG schematic implementation (dual-mode)



Registers

- **USB_OTG_FS Control and Status Registers (GOTGCTL, GOTGINT)**
 - Manage OTG-specific controls and interrupts.
- **USB_OTG_FS Global Registers (GUSBCFG, GRSTCTL, GINTMSK, GINTSTS)**
 - Configure global USB settings, handle resets, and manage global interrupts.
- **USB_OTG_FS Device Registers (DCFG, DCTL, DSTS, DIEPCTL_n, DOEPCTL_n)**
 - Control device-specific configurations, status, and endpoint controls.
- **USB_OTG_FS Host Registers (HCFG, HCTL, HFNUM, HPRT, HPTXSTS, HAINIT)**
 - Manage host-specific configurations, port status, transfer scheduling, and host interrupts.