USB Power Delivery and Type-C
USB Type-C Overview

USB Power Delivery specification introduces USB Type-C receptacle, plug and cable; they provide a smaller, thinner and more robust alternative to existing USB interconnect. Main features are:

- Enable new and exciting host and device form-factors where size, industrial design and style are important parameters
- Work seamlessly with existing USB host and device silicon solutions
- Enhance ease of use for connecting USB devices with a focus on minimizing user confusion for plug and cable orientation
USB Type-C Overview

Type-C Features

• Enable **new** and exciting host and device **form-factors** where size, industrial design and style are important parameters

• Work **seamlessly with existing USB** host and device silicon solutions

• **Enhance ease of use** for connecting USB devices with a focus on **minimizing user confusion** for plug and cable orientation

• Simple Power Delivery implementation (BMC)

<table>
<thead>
<tr>
<th>Mode of Operation</th>
<th>Nominal Voltage</th>
<th>Maximum Current</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB 2.0</td>
<td>5 V</td>
<td>500 mA</td>
<td>Default current, based on definitions in the base specifications</td>
</tr>
<tr>
<td>USB 3.1</td>
<td>5 V</td>
<td>900 mA</td>
<td></td>
</tr>
<tr>
<td>USB BC 1.2</td>
<td>5 V</td>
<td>Up to 1.5 A</td>
<td>Legacy charging</td>
</tr>
<tr>
<td>USB Type-C @ 1.5 A</td>
<td>5 V</td>
<td>1.5 A</td>
<td>Supports high power devices</td>
</tr>
<tr>
<td>USB Type-C @ 3.0 A</td>
<td>5 V</td>
<td>3 A</td>
<td>Supports higher power devices</td>
</tr>
<tr>
<td>USB PD</td>
<td>Configurable up to 20 V</td>
<td>Configurable up to 5 A</td>
<td>Directional control and power level management</td>
</tr>
</tbody>
</table>
USB has evolved from a data interface capable of supplying limited power to a primary provider of power with a data interface.

- **Power Delivery**: More Power with USB Power Delivery (100W)
- **Type-C**: More Flexibility with a new reversible USB-C connector
- **Alternate Mode**: More Protocols (Display Port, HDMI, VGA, Ethernet…)
- **USB IF**: More Speed with USB 3.1 (10 Gbit/s)
USB PD → Power Profiles
as of today .... per USB PD release 2.0

Source capabilities organized as profiles

- PROFILE 0
  Reserved

- PROFILE 1
  5V @ 2A
  10W
  Default start-up profile

- PROFILE 2
  5V @ 2A, 12V @ 1.5A
  18W

- PROFILE 3
  5V @ 2A, 12V @ 3A
  36W

- PROFILE 4
  5V @ 2A, 12V, 20V @ 3A
  60W
  Limit for Micro-B/AB connector

- PROFILE 5
  5V @ 2A, 12V, 20V @ 5A
  100W
  Limit for Standard A/B connector

- Additional capabilities possible as optional extensions to standard pr
<table>
<thead>
<tr>
<th>Power Adapter Examples</th>
<th>Permitted Standard</th>
<th>Include optionality(1)</th>
<th>Not permitted</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>“15 W”</strong></td>
<td>5 V @ 3 A (15 W)</td>
<td>5 V @ 3 A (15 W)</td>
<td>5 V @ 2 A (10 W)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 V @ 1.8 A (15 W)</td>
<td>8 V @ 1.8 A (15 W)</td>
</tr>
<tr>
<td><strong>“27 W”</strong></td>
<td>5 V @ 3 A (15 W)</td>
<td>5 V @ 3 A (15 W)</td>
<td>5 V @ 3 A (15 W)</td>
</tr>
<tr>
<td></td>
<td>9 V @ 3 A (27 W)</td>
<td>9 V @ 3 A (27 W)</td>
<td>9 V @ 3 A (27 W)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 V @ 2.25 A (27 W)</td>
<td>12 V @ 3 A (36 W)</td>
</tr>
<tr>
<td><strong>“45 W”</strong></td>
<td>5 V @ 3 A (15 W)</td>
<td>5 V @ 3 A (15 W)</td>
<td>5 V @ 3 A (15 W)</td>
</tr>
<tr>
<td></td>
<td>9 V @ 3 A (27 W)</td>
<td>9 V @ 3 A (27 W)</td>
<td>9 V @ 3 A (27 W)</td>
</tr>
<tr>
<td></td>
<td>15 V @ 3 A (45 W)</td>
<td>15 V @ 3 A (45 W)</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 V @ 2.8 A (45 W)</td>
<td>16 V @ 2.8 A (45 W)</td>
</tr>
<tr>
<td><strong>“60 W”</strong></td>
<td>5 V @ 3 A (15 W)</td>
<td>5 V @ 3 A (15 W)</td>
<td>5 V @ 3 A (15 W)</td>
</tr>
<tr>
<td></td>
<td>9 V @ 3 A (27 W)</td>
<td>9 V @ 3 A (27 W)</td>
<td>9 V @ 3 A (27 W)</td>
</tr>
<tr>
<td></td>
<td>15 V @ 3 A (45 W)</td>
<td>15 V @ 4 A (60 W)</td>
<td>15 V @ 5 A (75 W)</td>
</tr>
<tr>
<td></td>
<td>20 V @ 3 A (60 W)</td>
<td>20 V @ 3 A (60 W)</td>
<td>20 V @ 3 A (60 W)</td>
</tr>
</tbody>
</table>

(1) Making use of optionality is not encouraged as it diminishes interoperability – should only be utilized in specific use cases where a local optimization is of value and the standard voltages are still supported by Source & Sink.
Type-C Pin Outs Functions

Receptacle

High Speed Data Path (RX for USB 3.1, or reconfigured in Alternate Mode)

<table>
<thead>
<tr>
<th>A1</th>
<th>A2</th>
<th>A3</th>
<th>A4</th>
<th>A5</th>
<th>A6</th>
<th>A7</th>
<th>A8</th>
<th>A9</th>
<th>A10</th>
<th>A12</th>
<th>A12</th>
</tr>
</thead>
<tbody>
<tr>
<td>GND</td>
<td>TX1+</td>
<td>TX1-</td>
<td>VBUS</td>
<td>CC1</td>
<td>D+</td>
<td>D-</td>
<td>SBU1</td>
<td>VBUS</td>
<td>RX2-</td>
<td>RX2+</td>
<td>GND</td>
</tr>
</tbody>
</table>

High Speed Data Path (TX for USB 3.1, or reconfigured in Alternate Mode)

<table>
<thead>
<tr>
<th>B12</th>
<th>B11</th>
<th>B10</th>
<th>B9</th>
<th>B8</th>
<th>B7</th>
<th>B6</th>
<th>B5</th>
<th>B4</th>
<th>B3</th>
<th>B2</th>
<th>B1</th>
</tr>
</thead>
<tbody>
<tr>
<td>GND</td>
<td>RX1+</td>
<td>RX1-</td>
<td>VBUS</td>
<td>SBU2</td>
<td>D-</td>
<td>D+</td>
<td>CC2</td>
<td>VBUS</td>
<td>TX2-</td>
<td>TX2+</td>
<td>GND</td>
</tr>
</tbody>
</table>

USB 2.0 Interface

Secondary Bus

Cable Bus Power

Cable Ground

Configuration Channel

Two pins on the USB Type-C receptacle, CC1 and CC2, are used in the discovery, configuration and management of connections across USB type-C cable.
Type-C Pin Outs Functions

### Plug

<table>
<thead>
<tr>
<th>Function</th>
<th>Pin</th>
<th>Pin</th>
<th>Pin</th>
<th>Pin</th>
<th>Pin</th>
<th>Pin</th>
<th>Pin</th>
<th>Pin</th>
<th>Pin</th>
<th>Pin</th>
<th>Pin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Speed Data Path</strong></td>
<td>A12</td>
<td>A11</td>
<td>A10</td>
<td>A9</td>
<td>A8</td>
<td>A7</td>
<td>A6</td>
<td>A5</td>
<td>A4</td>
<td>A3</td>
<td>A2</td>
</tr>
<tr>
<td><strong>USB 2.0 Interface</strong></td>
<td>GND</td>
<td>RX2+</td>
<td>RX2-</td>
<td>VBUS</td>
<td>SBU1</td>
<td>D-</td>
<td>D+</td>
<td>CC</td>
<td>VBUS</td>
<td>TX1-</td>
<td>TX1+</td>
</tr>
<tr>
<td><strong>High Speed Data Path</strong></td>
<td>B1</td>
<td>B2</td>
<td>B3</td>
<td>B4</td>
<td>B5</td>
<td>B6</td>
<td>B7</td>
<td>B8</td>
<td>B9</td>
<td>B10</td>
<td>B11</td>
</tr>
<tr>
<td><strong>USB 2.0 Interface</strong></td>
<td>GND</td>
<td>TX2+</td>
<td>TX2-</td>
<td>VBUS</td>
<td>VCONN</td>
<td>SBU2</td>
<td>VBUS</td>
<td>RX1-</td>
<td>RX1+</td>
<td>GND</td>
<td></td>
</tr>
</tbody>
</table>

**On a standard USB Type-C cable, only a single CC wire within each plug is connected through the cable to establish signal orientation.**

The other CC pin is repurposed as $V_{CONN}$ for powering electronics.

Also, only one set of USB 2.0 D+/D- wires are implemented.

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**USB 2.0 Interface**

- **D-** and **D+** wires are used for high-speed data transmission.
- **CC** wire is used for configuration and power delivery.

**Configuration Channel**

- **GND** wire is used for ground connections.

**Secondary Bus**

- **B1** to **B12** pins are used for secondary data transmission.

**Cable Bus Power**

- **B1** to **B12** pins are used for cable bus power connections.

**Cable Ground**

- **B1** to **B12** pins are used for cable bus ground connections.
Communication across the channel uses Biphase Mark Coding (BMC) over CC in Type C connector.
**USB Type-C CC Connections**

**DFP - Source**

- Detect attach/detach of USB ports, e.g. a DFP to a UFP
- **Resolve cable orientation and twist connections** to establish USB data bus routing
- Establish DFP and UFP roles between two attached ports
- Discover and configure VBUS
- USB Power Delivery Communication

**UFP - Sink**

**4 possible CC configurations**

- (CC1)
- (CC2)

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*Image of a USB Type-C CC Connections diagram showing DFP and UFP connections, with labels for DFP (Source) and UFP (Sink). The diagram illustrates 4 possible CC configurations and includes notes on connection detection, detection and muxes control, and the establishment of roles between attached ports.*
**USB PD Stack & Policy**

**Policies**

**System Policy Manager** (system wide) is optional. It monitors and controls System Policy between various Providers and Consumers connected via USB.

**Device Policy Manager** (one per Provider or Consumer) provides mechanisms to monitor and control the USB-PD within a particular Provider or Consumer. It enables local policies to be enforced across the system by communication with the System Policy Manager.

**Policy Engine** (one per Source or Sink Port) interacts directly with the Device Policy Manager in order to determine the present local policy to be enforced.

**Protocol Layer**

The **Protocol Layer** forms the messages used to communicate information between a pair of ports. It receives inputs from the Policy Engine indicating which messages to send and indicates the responses back to the Policy Engine.

**Physical Layer**

It is responsible for sending and receiving messages across either the $V_{BUS}$ or CC wire. It consists of a transceiver that superimposes a signal (BFSK on $V_{BUS}$ or BMC on CC) on the wire.

It is responsible for managing data on the wire and for collision avoidance and detects errors in the messages using a CRC.
Product Portfolio

A complete offer to “lean in” USB PD Ecosystem

- SuperSpeed Switch
- USB Power Delivery Controller
- Power Management
- Type-C connector
- PROTECTIONS
- PHY - Type-C interface

Host, USB 3.1 Controller Access Point (optional)
Profile 1-2-3
Power Source Building Blocks

- Flyback Controller: STCH02
- Power MOSFET
- Main transformer
- Pulse transformer
- Optocoupler communication
- Rectifier
- CC/CV SEA01
- Feedback Network Selection
- USB PD Interface IC
- DC/DC Post regulation
- Multi Port case: Post regulation for each port

- It covers profile 1-2-3 from 5W to 45W
- High Efficiency
- Low EMI design: intelligent Jitter for EMI suppression
Primary Side Controller: Adapters up to 45W

Features

- Proprietary Constant current output regulation (CC) with no opto-coupler
- 700V embedded HV start-up circuit
- Quasi-resonant (QR) Zero Voltage Switching (ZVS) operation
- Valley skipping at medium-light load and advanced burst mode operation at no-load for under 10mW consumption
- Accurate adjustable output OVP

Benefits

- Low part count. BOM reduction thanks to an extensive features integration
- Exceeding 5 stars: No-Load power < 10mW
  - HV start-up zero power consumption
  - Advanced burst-mode operation
- Flexibility: suitable for adapters from 5W to 40W
- High Efficiency
- Low EMI design: intelligent jitter for EMI suppression
Profile 4, 5
Power Source Building Blocks

High Voltage
- PFC L6563H
- LLC L6699
- Power MOSFET
- PFC-LLC Integrated New solution STCMB1

Low Voltage
- main transformer
- Power MOSFET
- Synchronous Rectification SRK2001
- CC/CV SEA01

Post Regulation
- DC/DC Post regulation
- USB PD Interface IC
- 1 per port
Transition Mode PFC controller

Features

- 700V High Voltage Start-up circuit
- Fast bidirectional input voltage feedforward
- Adjustable OVP
- AC Brownout Detection
- Tracking boost function
- Inductor saturation protection
- Proprietary THD optimizer circuit
- Interface for cascaded converters
- -600mA/+800mA gate driver

Datasheet: available on www.st.com

- Low steady state ripple and current distortion with limited undershoot or overshoot of the pre-regulator’s output thanks to new input voltage feed-forward implementation
- Reduced THD of the current
- High reliability thanks to a full set of protections
- HV start-up significantly reduces consumption compared to standard discrete circuit solutions
- Facilitated cooperation with cascaded DC-DC converter thanks to several power management & housekeeping functions
High power adapters 90W to 250W

Series-resonant half-bridge topology

Features
- Self adjusting adaptive dead time
- Anti-capacitive mode protection
- Two-level OCP
  - Frequency shift
  - Immediate shutdown
- Safe-start procedure
- Burst-mode operation at light load
- Brown-out protection
- Interface with PFC controller

Benefits
- High efficiency:
  - Reduced internal consumption (Iq=1mA)
  - Adaptive dead time allows design optimization to achieve ZVS with lower magnetizing current
- Improved reliability and lifetime thanks to anti-capacitive protection and smooth start-up circuit
- Reduced audible noise when entering burst-mode operation thanks to smooth restart feature

Datasheet: available on www.st.com
USB-PD

Power MOSFET product families

<table>
<thead>
<tr>
<th>Voltage Range</th>
<th>Product Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>800V-1500V</td>
<td>K5</td>
<td>Flyback</td>
</tr>
<tr>
<td>600V-650V</td>
<td>M2</td>
<td>Price/Performance</td>
</tr>
<tr>
<td>40-120V</td>
<td>F7</td>
<td>Sync Rec</td>
</tr>
</tbody>
</table>

Price/Performance

Premium efficiency
VHV PowerMOSFETs

**Features**
- Unmatched $R_{DS(on)}$ at very high BVDSS 800-950V-1050V
- Ultra-Low $Q_G$ and high switching speed
- Extremely low thermal resistance
- High quality & reliability

**Benefits**
- Lower on-state conduction losses
- Best switching losses
- High efficiency with lower design complexity
- Ultra small Form factor

**Product range example**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>$B_{VDss}$</th>
<th>$R_{DS(on)}$</th>
<th>$I_D$</th>
</tr>
</thead>
<tbody>
<tr>
<td>STB13N80K5</td>
<td>800V</td>
<td>0.45Ω</td>
<td>12A</td>
</tr>
<tr>
<td>STD8N80K5</td>
<td>800V</td>
<td>0.95Ω</td>
<td>6A</td>
</tr>
<tr>
<td>STD9N80K5</td>
<td>800V</td>
<td>0.90Ω</td>
<td>7A</td>
</tr>
</tbody>
</table>

**Flyback Architecture**

**Outstanding Form Factor**

STL8N80K5
800V, 950mOhm, 13nC
PowerFLAT5x6
Power MOSFET

PFC & LLC Architecture

Product range example

<table>
<thead>
<tr>
<th>PFC</th>
<th>V_{DSS}</th>
<th>R_{DS(on)}</th>
<th>I_D</th>
</tr>
</thead>
<tbody>
<tr>
<td>STF24N60M2</td>
<td>600V</td>
<td>0.190Ω</td>
<td>18A</td>
</tr>
<tr>
<td>STF25N60M2-EP</td>
<td>600V</td>
<td>0.188Ω</td>
<td>18A</td>
</tr>
<tr>
<td>STF20N60M2-EP</td>
<td>600V</td>
<td>0.278Ω</td>
<td>13A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LLC</th>
<th>V_{DSS}</th>
<th>R_{DS(on)}</th>
<th>I_D</th>
</tr>
</thead>
<tbody>
<tr>
<td>STF9N60M2</td>
<td>600V</td>
<td>0.750Ω</td>
<td>5.5A</td>
</tr>
<tr>
<td>STF15N60M2-EP</td>
<td>600V</td>
<td>0.378Ω</td>
<td>11A</td>
</tr>
<tr>
<td>STF111N60M2-EP (e.s.available)</td>
<td>600V</td>
<td>0.595Ω</td>
<td>8.0A</td>
</tr>
</tbody>
</table>

- Up to 30% lower Q_g vs main competition (equivalent die size)
- 400 – 700V BV_{DSS} rated
- Back-to-Back G-S Zener protected

Features
- Reduced switching losses
- Enhanced immunity vs ESD & Vgs spikes
- Technologies dedicated to specific topology

Product range example

STL24N60M2
600V, 210mΩ, 28nC
PowerFLAT8x8
Power MOSFETs
Synchronous Rectification

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Voltage</th>
<th>Ron</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>STL260N4LF7</td>
<td>40V</td>
<td>&lt;1.1mΩ</td>
<td>5.5A</td>
</tr>
<tr>
<td>STL200N45LF7</td>
<td>40V</td>
<td>&lt;1.8mΩ</td>
<td>11A</td>
</tr>
</tbody>
</table>

- **Features**
  - Very low $R_{DS(on)}$;
  - Proper $C_{OSS}$;
  - Low $V_{SD}$ and $Q_{RR}$ with soft recovery body-drain diode
  - LL $V_{th}$

- **Benefits**
  - Efficiency improvement due low conduction losses and to static and dynamic diode ones, minimized switching noise and Vds spike at turn OFF
  - Easy driving features
Protections
ESD/CMF/ECMF

High flexibility for the Designers needs to find best compatibilities

- **ESD Protection**
  - Robustness: Surge capability up to 25kV and low clamping
  - Flexibility & Integration: Single or multi lines products
  - Transparency: High bandwidth for high speed signals

- **ESD + CMF**
  - High quality of protection
  - Unique filtering shape capabilities
  - Serial Interface: USB2.0/3.0, MIPI, DP, HDMI
  - Filters radiated noise and limits antenna de-sense

- **ECMF = ESD + CMF integrated**
  - High quality of protection
  - High integration: 1mm2 / 2 differential lines
  - Serial Interface: USB2.0/3.0, MIPI, DP, HDMI
  - Filters radiated noise and limits antenna de-sense
Controller & Interface

Value proposition: offer flexible and scalable solutions for designers

USB PD Controller
MCU Based
STM32
- FW USB PD Stack
- Adaptability versus USB PD specification new release
- PHY-Type-C interface companion chip
- Market proven solution

PHY -Type-C Interface
STUSB16
- Dual Role Type-C Interface with BMC
- Dual role capability
- Configurable start-up profiles
- Interface with external MCU through I²C
- Accessory support

USB PD Hard Coded Controller
STUSB4x
- HW USB PD Stack
- Flexible HW-SW partitioning
- Autorun or Micro based
- Easy Dead Battery Support
- P2P with PHY-Type-C interface
MCU Overview:

STM32F0 HW resources

- Transmission uses: TIM14, SPI1, DMA, GPIO
- Reception uses: TIM3, DMA, 1 comparator
- TIM2 is used to time-schedule tasks
- Embedded ADC to detect device on the CC bus and perform power measurements
- CRC to evaluate message’s CRC
- Standard GP I/Os to control Vconn, Load switch, Vbus discharge switch, Vout selection (primary feedback…

<table>
<thead>
<tr>
<th>Project</th>
<th>Flash Memory</th>
<th>RAM Memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provider only</td>
<td>25.5 kB</td>
<td>4.4 kB</td>
</tr>
<tr>
<td>Provider only (RTOS)</td>
<td>29.0 kB</td>
<td>7.3 kB</td>
</tr>
<tr>
<td>Provider/Consumer DRP (RTOS)</td>
<td>30.2 kB</td>
<td>7.3 kB</td>
</tr>
</tbody>
</table>
USB-PD Interface: STUSB16xx

Features

- Dual Role Type-C Interface with BMC
- Dual role capability
- Configurable start-up profiles
- 600mA VCONN
- 120uA Idle current measured
- Interface with external MCU through I²C+Interrupt
- Integrated Voltage monitoring
- Integrated V_BUS discharge path
- Accessory support
- Dual Power supply:
  - \( V_{SYS} = 3.3V \)
  - \( V_{DD} \) [4.6V; 22V] (from V_BUS)

Benefits

- Low Pin count
- Integrated BMC transceiver
- Simple, Robust
- Configurable, Flexible
- Optimized for Portable applications
- P2P with STUSB4x

https://www.st.com/usb-type-c
USB-PD Type-C Solution

• AC/DC Multi-output 36W Converter
  • Based on STCH02 QR controller
  • Multiple Output voltages (5V, 9V, 12V)

• STM32 Embedded Software Solution
  • to interface with USB-C connector
  • to handle the USB Power Delivery protocol
  • cost effective and popular 32bit Microcontroller

• HW platform based on X-Nucleo Shield
Block Diagram

- Power Connector
- Internal Power Block
- Analog Front End
- Type-C Interface
- STM32Fx
- NUCLEO + MORPHO CONNECTORS
- NUCLEO + X-NUCLEO-USBPDM1
- Modular Approach
- External Power Supply Board
On board functionalities activable if not available on external power supply board.

USB 2.0 hooked to Type-C on Port 0, if available on STM32.
AC/DC 36W 5/9/12V

Efficiency and no Load Consumption

### Efficiency @ 115Vac

<table>
<thead>
<tr>
<th>Load</th>
<th>Iout [A]</th>
<th>5V</th>
<th>9V</th>
<th>12V</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>3.000</td>
<td>83.18%</td>
<td>85.17%</td>
<td>85.41%</td>
</tr>
<tr>
<td>75%</td>
<td>2.250</td>
<td>80.61%</td>
<td>85.34%</td>
<td>85.53%</td>
</tr>
<tr>
<td>50%</td>
<td>1.510</td>
<td>80.20%</td>
<td>84.71%</td>
<td>84.61%</td>
</tr>
<tr>
<td>25%</td>
<td>0.750</td>
<td>80.92%</td>
<td>85.17%</td>
<td>81.67%</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>81.23%</td>
<td>84.45%</td>
<td>84.30%</td>
</tr>
</tbody>
</table>

### Efficiency @ 230Vac

<table>
<thead>
<tr>
<th>Load</th>
<th>Iout [A]</th>
<th>5V</th>
<th>9V</th>
<th>12V</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>3.000</td>
<td>82.42%</td>
<td>85.56%</td>
<td>86.35%</td>
</tr>
<tr>
<td>75%</td>
<td>2.250</td>
<td>81.44%</td>
<td>84.65%</td>
<td>85.47%</td>
</tr>
<tr>
<td>50%</td>
<td>1.510</td>
<td>80.65%</td>
<td>83.44%</td>
<td>84.08%</td>
</tr>
<tr>
<td>25%</td>
<td>0.750</td>
<td>77.89%</td>
<td>80.36%</td>
<td>80.05%</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>80.60%</td>
<td>83.50%</td>
<td>84%</td>
</tr>
</tbody>
</table>

### Input voltage Efficiency @ 10% Pout

<table>
<thead>
<tr>
<th>Voltage</th>
<th>5V</th>
<th>9V</th>
<th>12V</th>
</tr>
</thead>
<tbody>
<tr>
<td>115VAC</td>
<td>76.29%</td>
<td>76.68%</td>
<td>73.28%</td>
</tr>
<tr>
<td>230VAC</td>
<td>73.09%</td>
<td>73.06%</td>
<td>70.54%</td>
</tr>
</tbody>
</table>

### Input voltage No load consumption 5V

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>115Vac</td>
<td>11mW</td>
</tr>
<tr>
<td>230Vac</td>
<td>12mW</td>
</tr>
</tbody>
</table>

- Please note that the values of efficiency are penalized by the power losses on secondary rectifier diode.
- The efficiency can be improved around 4% using synchronous rectification.

- 36W 5/9/12V board
AC/DC 36W 5/9/12V

Schematic
MCU + Discrete AFE Overview

- STM32 Embedded Software Solution to interface with USB-C connector and to handle the USB Power Delivery protocol.
  - **Hardware**: Entry level Cortex-M0 based STM32F0 microcontroller series with simple discrete Analog Front End PHY
  - **Embedded Software**: USB-C & PD Middleware

Best device for 2 ports management: STM32F051 in 48 pin package

Best device for 1 port management: STM32F051/31 in 20/32 pin package
X-NUCLEO-USBPDM1

• USB-C Power Delivery expansion board with two USB Type-C connectors for two port management.

• Main features:
  • Two Dual Role Ports
  • Dedicated Power Connector to interface with external Power Supply board providing different profiles (up to 20V and 5A) and \( V_{CONN} \)
  • On-board Power management able to provide internal needed voltages from \( V_{BUS} \)
  • Six debug LEDs
  • USB 2.0 interface capability available on one port
  • Compatible with STM32 Nucleo boards
  • Equipped with ST morpho connectors
X-NUCLEO-USBPDM1

Board Details

- Power Connector for external Power Source
- User LEDs
- Local Power Management
- Type-C Receptacle Port 1
- Power Role Configuration Port 1
- CC AFE and VCONN Switch Port 1
- VBUS Port 1 Switch and discharge
- VBUS Port 1 Current/Voltage sensing
- Connector for USB Load Port 1
- Type-C Receptacle Port 0 (USB2.0 Capability)
- Power Role Configuration Port 0
- CC AFE and VCONN Switch Port 0
- VBUS Port 0 Switch and discharge
- VBUS Port 0 Current/Voltage sensing
- Connector for USB Load Port 0