Introduction to USB Type-C and Type-C Solutions from NXP

Emmanuel T. Nana

Technical Marketing Manager
Secure Interfaces & Power

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SECURE CONNECTIONS FOR A SMARTER WORLD

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NXP Secure Interfaces & Power Solutions

Signal Integrity & Routing Solutions

- Signal Switches & Re-drivers
  - USB 3.1, USB Type-C
  - Thunderbolt
  - PCIe, SATA, SAS
  - DP, HDMI, VGA
  - Audio, Data
  - Memory Interface

Industry leader in high-speed switching.

Lowest-power consumption re-drivers

Load Switches

- Over Voltage Protection
- Over Current Protection
- Reverse Current Protection
- Under voltage Lockout
- Thermal Shutdown
- Low R_{ON}
- Low Quiescent Current

HV Load switching with 100V surge protection.

Interface Solutions

- DisplayPort Bridges
- UARTS
- Comparators
- I^2C Bus Buffers
- I^2C Bus Controllers
- I^2C Muxes & Switches
- Voltage Level Translators

Industry's largest I^2C Portfolio for Mobile, Computing and Industrial.

Wireless Connectivity & Smart Sensor Solutions

- NTAG Smart Sensors
- NFMI Radio
- Audio over BLE
- RF & IF Discretes
  - Transceivers
  - LNA's
  - Mixers
  - Switches

Integrated temperature logging solutions.

Ultra low-power single-chip solution, providing robust wireless audio streaming.

Security & Authentication

- Anti-Counterfeit Solution

Industry's smallest package with lowest power.

Power Solutions

- USB Power Delivery
- AC-DC Controllers
- DC-DC Boost Converters
- Direct Charging (Rapid Battery Charging)
- Wireless Charging (Qi/A4WP)
- Micro-PMIC
- Powerline Communication Modem

High efficiency power conversion.

Support of multi-charging protocols (Direct, USB-PD, QC, BC1.2, and proprietary).

Bus Peripherals

- Real Time Clocks
- GPIO Expanders
- Temperature Sensors
- LCD Drivers
- LED Controllers
- Capacitive Sensors
- Stepper Motor Controllers
- EEPROM
- Watch IC
- Data Converter
- DIP Switches

Ultra low-power RTC's.

Widest portfolio of GPIO Expanders.

Smart Audio Solutions

- Class AB Amplifiers
- Class D Amplifiers
- Smart Amplifiers (/w integrated DSP)
- Software
- Speaker Protection
- Audio DAC & ADC

Best-in class speaker protection hardware and software Class D Amplifier solutions.

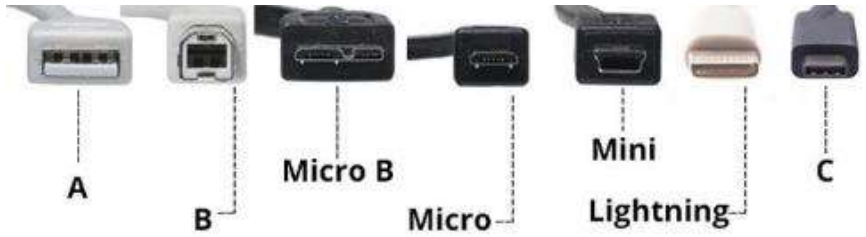
Agenda

- Introduction to USB Type-C & USB Power Delivery
- System Solutions
- NXP USB Type-C Solutions
  - PD PHY and CC-Logic Controllers
  - Signal Switches
  - Re-Drivers
  - Load Switches
  - Port Protection
  - Analog Switches
  - AC/DC Power Supply Solutions
- Tools

Introduction to USB Type-C & Power Delivery

USB Basics

- USB Type A, Type B, & Type C refer to the CONNECTOR type

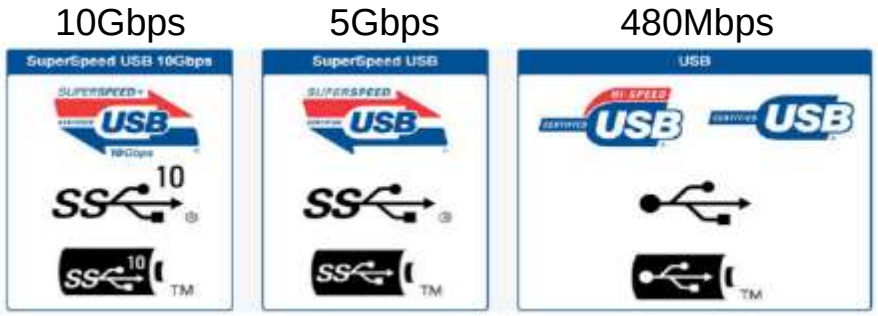


- USB Type C connectors are reversible, unlike Type A and Type B
- USB 2.0, USB 3.0, & USB 3.1 refer to the SPEED of the signal
  - USB 2.0 (also referred to as USB High Speed) is 480 Mbit/s
  - USB 3.0 (also referred to as USB SuperSpeed) is 5 Gbit/s
  - USB 3.1 (also referred to as USB SuperSpeed+) has two modes:
    - Gen 1 is 5 Gbit/s
    - Gen 2 is 10 Gbit/s

- USB Type A connectors typically support 2.5W - 4.5W
- USB Type C connectors can support up to 15W (5V, 3A) if Power Delivery (PD) is not implemented and up to 100W (20V, 5A) if Power Delivery (PD) is implemented.

USB Basics – Normative References

USB Data



- USB 2.0 Specification
- USB 3.1 Specification
- USB Battery Charging Specification, Revision 1.2
- USB Power Delivery Specification, Revision 2.0 (3.0)
- USB Billboard Device Class Specification, Revision 1.2

USB Power

Type-C VBUS Power Options

Mode of Options	Nominal Voltage	Maximum Current	Note
USB 2.0	5V	500mA	• **Mandatory**
USB 3.1	5V	900 mA	• **Mandatory**
BC1.2	5V	1.5A	• **Optional** Legacy charging
USB Type-C Current (without PD)	5V	Default USB2.0 or USB3.1; 1.5A; 3A	• **Optional** Supports higher power devices
USB PD	Configurable up to 20 V	Configurable up to 5A	• **Optional** Directional control and power level management

Features Supported by Type-C

Emerging Application

Thin and Light Laptop

Virtual Reality

Turn Smartphone into a computer

Compute Stick

- USB Data
  - USB signals: USB3.1 Gne1 (5Gbps), USB3.1 Gen2 (10Gbps), USB2.0
- Digital Video
  - Displayport
  - MHL, HDMI 1.4
- Analog audio
- Power Supply
  - Type-C default (15 Watts max)
  - USB PD (100 Watts max)
- USB Type-C cable
  - eMarker for cable identification
- New support
  - Digital Audio
  - Authentication
- Proprietary
  - Intel Thunderbolt

Introduction to USB Type-C & Power Delivery

USB Type-C (Rev 1.2)

- Mechanical connector, plug and cable spec
- Polarity detection, DFP/UFP/DRP role detection

USB Power Delivery (PD 3.0) Standard

- Protocol to negotiate higher voltage (>5V) & current over CC line
- Protocol to swap power role and data role
- Protocol to negotiate other functions (VDM) over the connector

USB Type-C Alternate Mode Standard

- How to negotiate DisplayPort over USB Type-C
- How to negotiate Thunderbolt over USB Type-C
- How to negotiate MHL video date over
- How to authenticate for security over USB Type-C

Simpler Implementation

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More Complex Implementation

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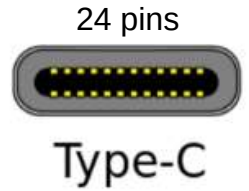
System Designer can choose to implement partial or all features based on their requirement

USB Type-C Connector – Pinout and Alignment



Receptacle (Front View)

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
GND	TX1+	TX1−	VBUS	CC1	D+	D−	SBU1	VBUS	RX2−	RX2+	GND
GND	RX1+	RX1−	VBUS	SBU2	D−	D+	CC2	VBUS	TX2−	TX2+	GND
B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1

USB3.0 USB2.0 USB3.0

Normal Plug

Reverse Plug

A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1
GND	RX2+	RX2−	VBUS	SBU1	D−	D+	CC	VBUS	TX1−	TX1+	GND
GND	TX2+	TX2−	VBUS	VCONN			SBU2	VBUS	RX1−	RX1+	GND
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12

Receptacle (24 Pins)

- 1 CC1
- 1 CC2
- 2 SBU1/SBU2
- 4 VBUS
- 4 GND
- 8 Signal (4 DIFF Pair)
- 4 Signal (USB 2.0)

Plug (22 Pins)

- 1 CC
- 1 VCONN
- 2 SBU1/SBU2
- 4 VBUS
- 4 GND
- 8 Signal (4 DIFF Pair)
- 2 Signal (USB 2.0)

USB Type-C Roles – DFP, UFP, and DRP

DFP – Downstream Facing Port

- Typically, the ports on the host or the ports on the hub to which devices are connected
- In its initial state, the DFP sources VBUS and VCONN and supports data
- A charge-only DFP port only sources VBUS

UFP – Upstream Facing Port

- The port on a device or a hub that connects to a host or the DFP of a hub
- In its initial state, the UFP sinks VBUS and supports data

DRD – Dual Role Data

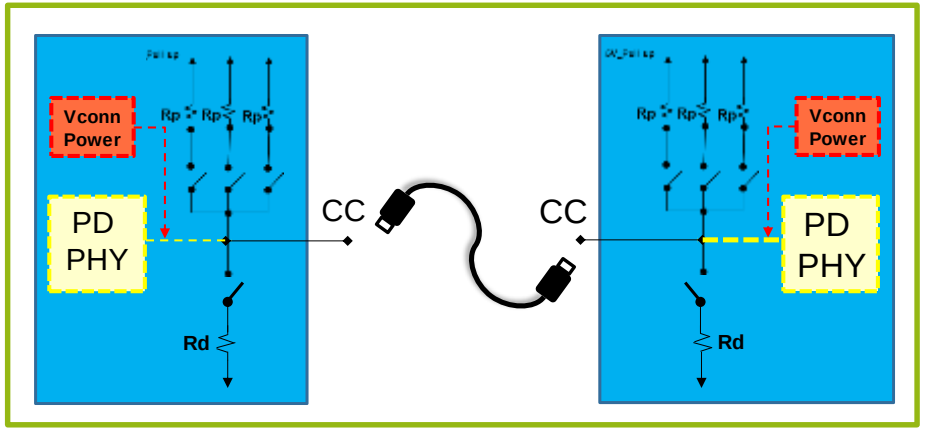
- USB data port that can operate as either a DFP or a UFP
- The port's role may be changed dynamically

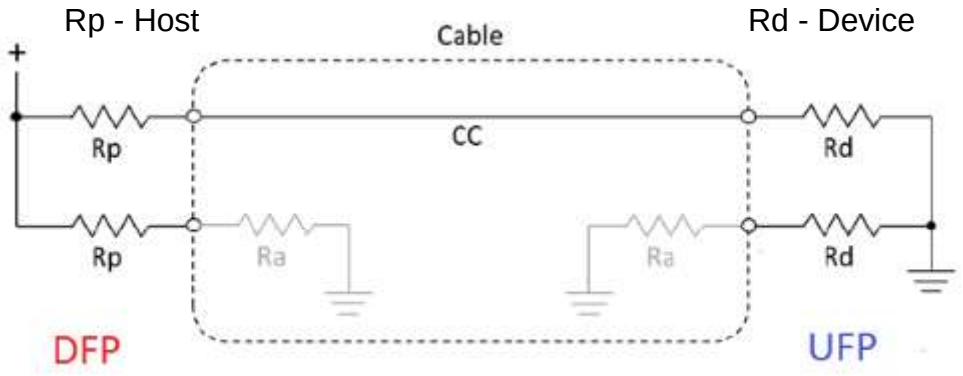
DRP – Dual Role Power

- Capability of operating as either a Power Source or Power Sink
- The power role may be changed dynamically

USB Type-C Configuration Channel Functionality

- Source-to-Sink Attach/Detach detection
- Determination Plug orientation
- Initial power role (Source-to-Sink) and data role (Host-to-Device) setup between two attached ports
- Discovery and configure VBUS: USB Type-C Current Modes or USB Power Delivery (PD)
- USB PD Protocol Communication
  - Modification of initial port roles
  - Negotiation of USB PD power contracts
  - Management of Functional Extensions (Alternate Mode, Vendor Defined Messages - VDM)
- VCONN Power
  - Unused CC pin is re-purposed to VCONN power pin at receptacle
  - 1 Watt supply minimum (5V @ 200mA); maximum is 6W (5V @ 1.2A)

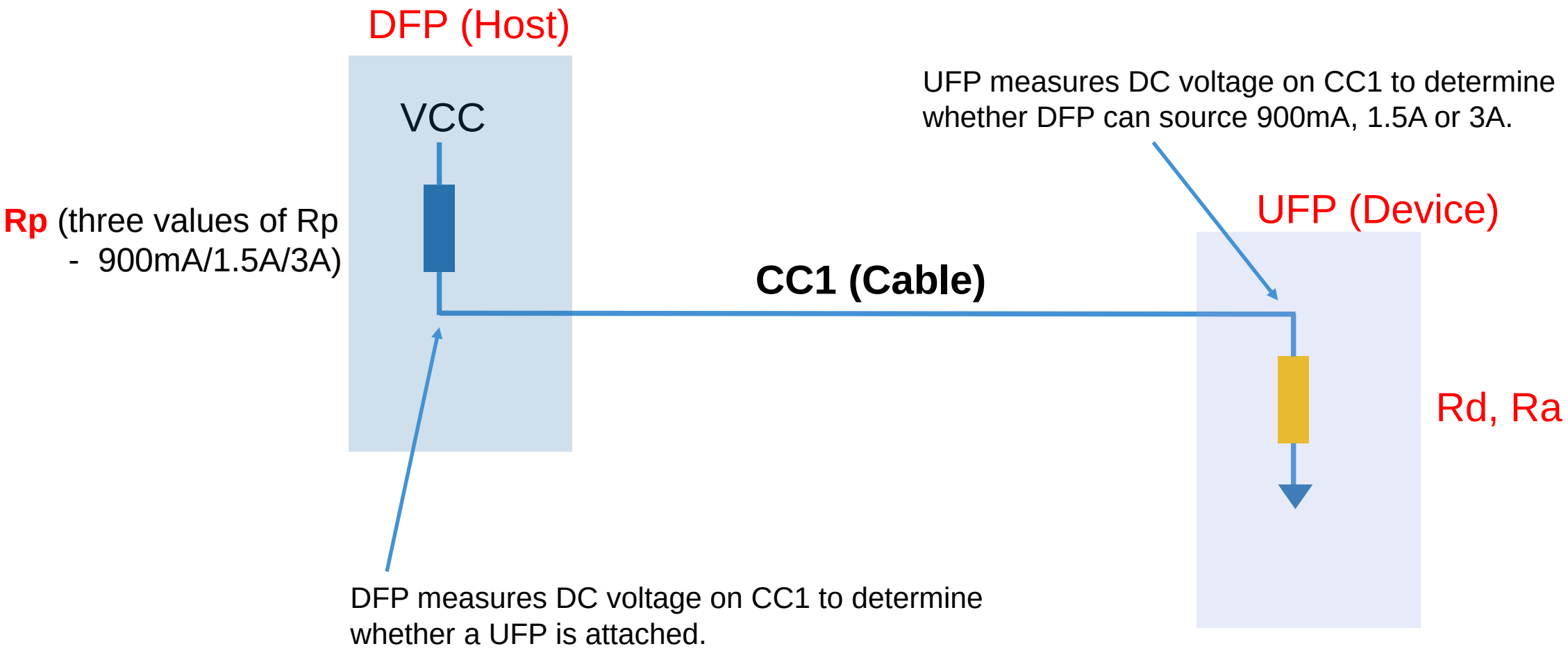




USB2.0 or USB3.1

DFP Advertisement	Current Source to 1.7 – 5.5 V	Resistor pull-up to 4.75 – 5.5 V	Resistor pull-up to 3.3 V ± 5%
Default USB Power	80 µA ± 20%	56 kΩ ± 20%	36 kΩ ± 20%
1.5 A @ 5 V	180 µA ± 8%	22 kΩ ± 5%	12 kΩ ± 5%
3.0 A @ 5 V	330 µA ± 8%	10 kΩ ± 5%	4.7 kΩ ± 5%

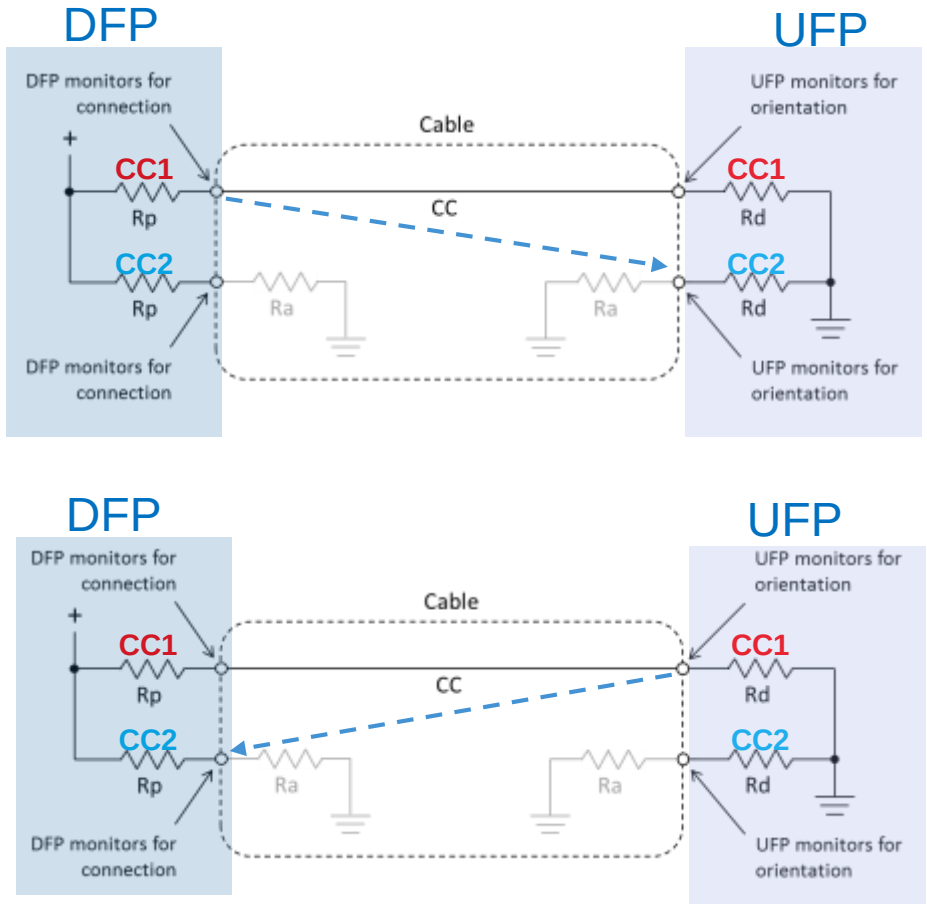
USB Type-C Attachment, Roles, and Current Determination



USB Type-C DFP-to-UFP Connection Detection

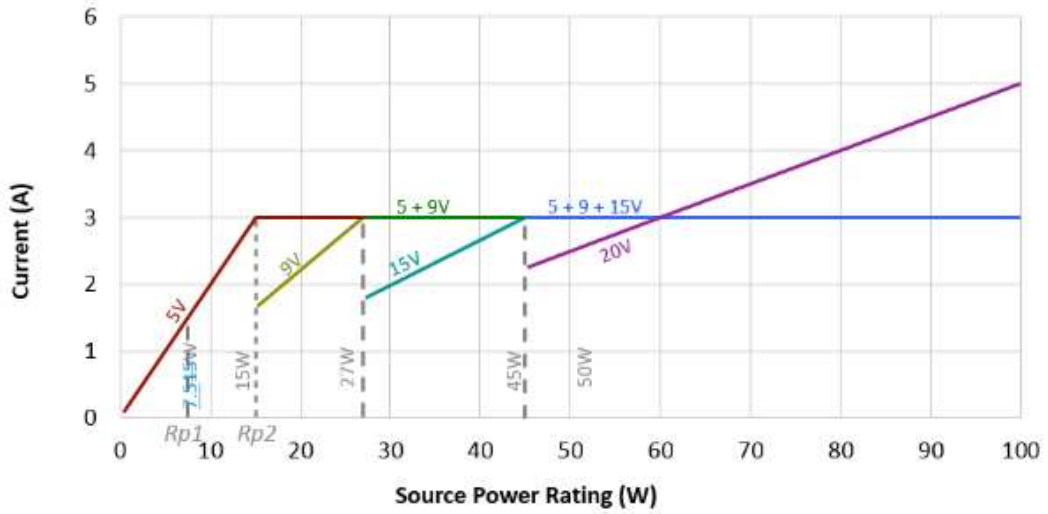
- Concept: detection of the terminations residing in the product being attached.
- CC Line is used with pull up / pull down resistors or current source / pull down resistors implementation
- Summary from the DFP perspective:

CC1	CC2	State	Position
Open	Open	Nothing Attached	N/A
Rd	Open	UFP Attached	①
Open	Rd		②
Open	Ra	Powered Cable / No UFP attached	①
Ra	Open		②
Rd	Ra	Powered Cable / UFP attached	①
Ra	Rd		②
Rd	Rd	Debug Accessory Mode attached	N/A
Ra	Ra	Audio Adapter Mode attached	N/A



USB Power Delivery (PD)

- USB-PD specification extends USB capability to 100W
- Various power configurations possible – fixed, programmable, battery, fast charging
- Possible to change the power flow (power role swap)
- Source power profiles



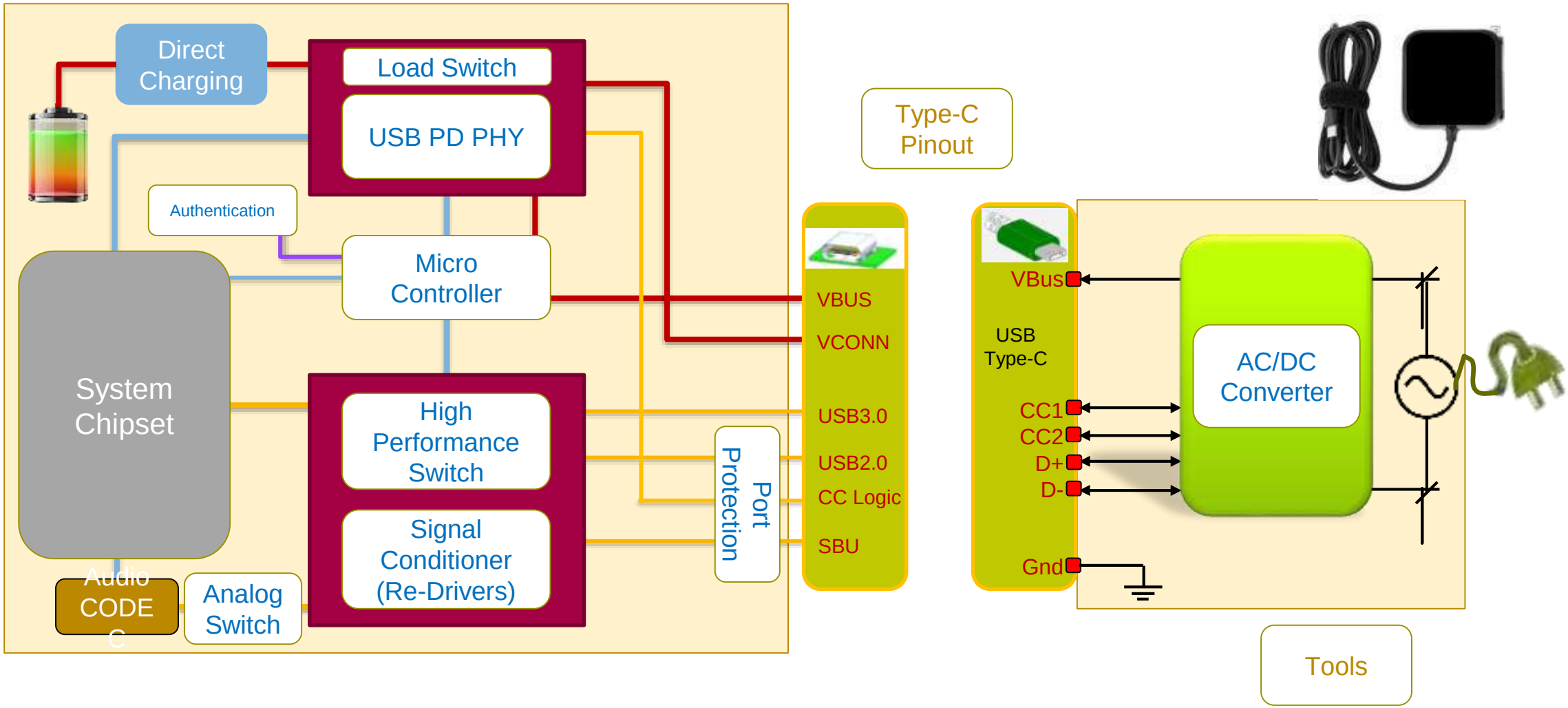
Type	Voltage	Current
USB 2.0	5V	500mA
USB 3.0/USB 3.1	5V	900 mA
USB BC1.2	5V	1.5A
USB Type-C (without PD)	5V	1.5A, 3A
USB Type-C PD	Up to 20V	Up to 3A (Cable) Up to 5A (Elec. Marked Cable)

Alternate Mode Support

- Alternate Mode support allows signals other than USB to pass through the Type-C connector.
- Under Alternate mode, a Type-C DRP can check the capability on the other end and send DisplayPort data over Type-C.
- Up to 4-lanes of DP signals can be sent through Type-C interface.
- This way video connectors other than DisplayPort (like VGA, HDMI) can be supported through Type–C protocol converters

System Solutions

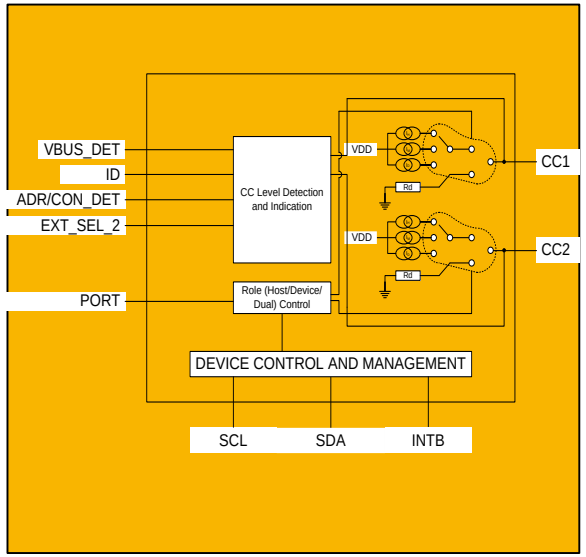
System Solution for Type-C with PD & Alt Mode Support



NXP USB Type-C Solutions
PD PHY and CC Logic Controller

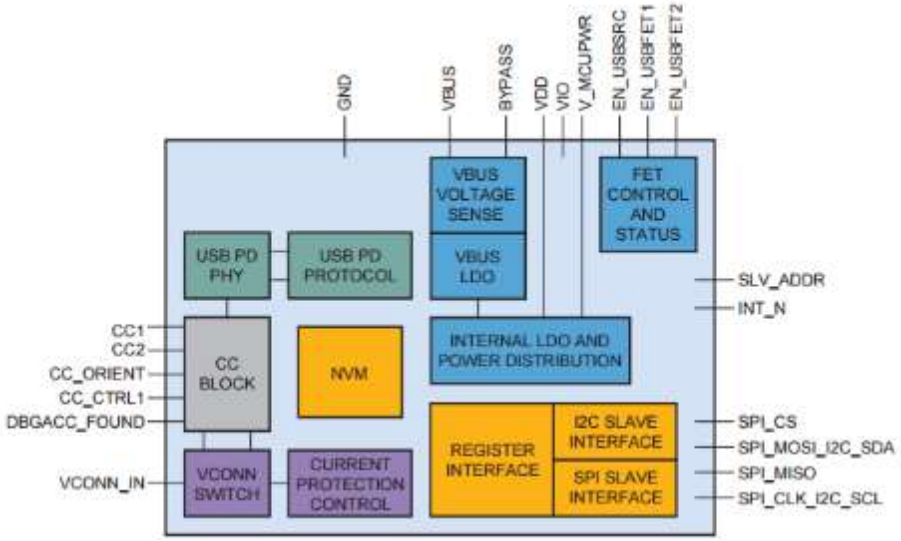
USB Type-C PD PHY and CC Logic Controller

PTN5150
CC Logic



Type-C CC logic, Legacy USB, OTG

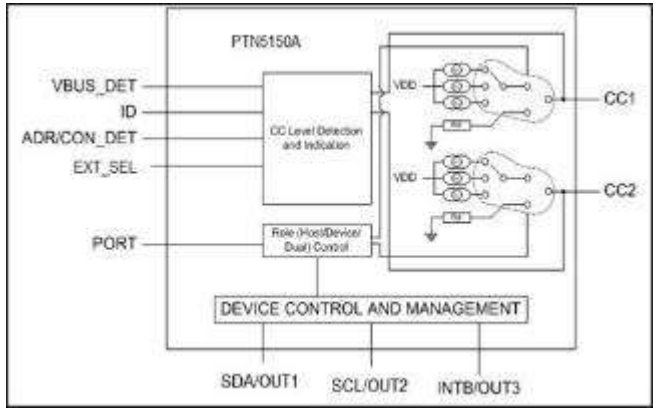
PTN5110
PD PHY

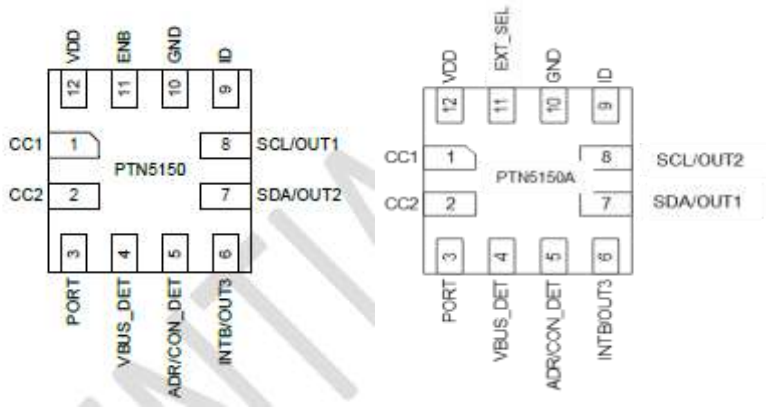


USB TCPC PHY

PTN5150/PTN5150A – USB Type-C CC Logic Controller

- Features:
  - Complies to USB Type-C Rev 1.1
  - Can work autonomously or can connect to a controller through I2C-bus interface
  - PTN5150A: Pin 11 = EXT_SEL output to control USB data switch, e.g. PTN36043 (USB 3.0 Active Switch)
  - PTN5150: Pin 11 = ENB (Enable input pin, active low)
- DFP/DRP/UFP Advertisement
  - DFP Rp = 80/180/330µA
  - UFP Rd = 5.1KΩ
- Supports:
  - Cable/plug insertion / removal detection
  - Orientation detection
  - Role and charging current detection
  - Dead battery mode
- Current consumption:
  - Standby in dual-role mode: 50µA
  - Standby in host mode: 40µA
  - Standby in device mode : 40µA
- Package: 12-pin HVQFN (1.6mm x 1.6mm)





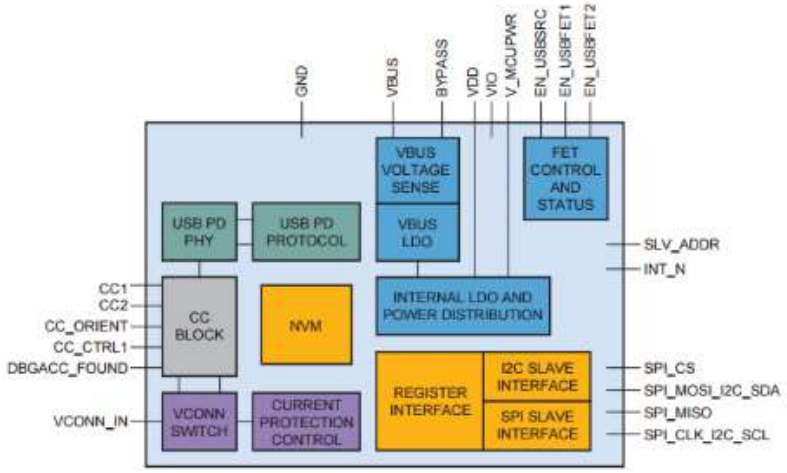
Applications	Part Number	Interface	Use Case
Smartphone, Computing and Accessories	PTN5150A	Pin 11 = EXT_SEL	EXT_SEL directly controls PTN36043 or CBTL02043. Save one GPIO pin from PMIC to USB 3.0 Switch
Smartphone, Computing and Accessories	PTN5150	Pin 11 = ENB Active Low	Pin-to-pin compatible with competitors (TI & Pericom). When PMIC use active low to enable CC logic chip.

PTN5110 – USB Type-C Port Controller (TCPC) PD PHY

Description

- Target compliance to PD3.0, Type-C 1.2 and TCPC Version 1.0, Rev. 1.2
- Implements TCPC PHY with register interface towards TCPM along with vendor defined extensions to support PD3.0
- VDD range from 2.7V to 5.5V
- Integrated VCONN with over current limiting, short-to-GND and temperature protection
- VBUS discharge (Force and Bleed) support
- VBUS dead battery power supply (4.0V to 25V, 28V Max Tolerance)
- VBUS voltage monitor with 10-bit ADC
- I^2C based host interface (up to 1Mbps). Provides up to 4 slave addresses, enabling PHY user for multiple ports.
- Provides GPIO for debugging accessory indication, fast role swap for “arming” 5V load switch, and 5V load switch ILIM selection control
- Provides VBUS source and sink power path control signal

Available in: X2QFN16 2.6 x 2.6 mm, 0.4 mm pitch



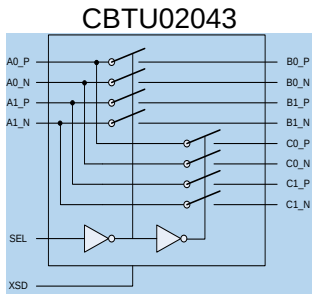
Applications	Part Number	Power-Up Mode	Interface	Use Case
Notebook	PTN5110	DRP	I^2C	Notebook, Ultrabook
Desktop	PTN5110T	DFP	I^2C	Desktop, AIO
Dongle Docking	PTN5110D	UFP	I^2C	Docking and Dongle
Enables the Embedded Controller (EC) to act as a PD Controller.				

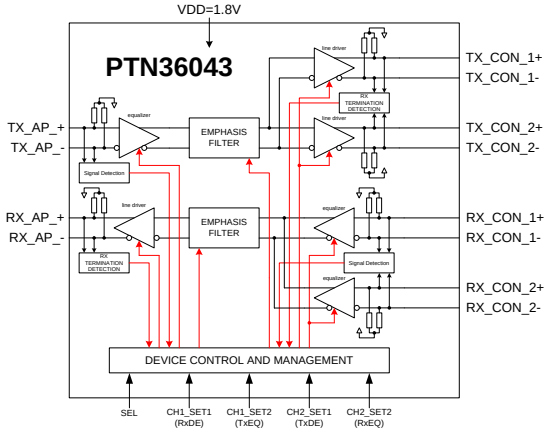
OM13585UL - PTN5110 Host Board
OM13586UL - PTN5110 Dock Board
OM13587JP - PTN5110 Type-C Demo Kit
OM13588xx - Shield Board for i.MX/Kinetis (xx [TBD] will be either UL or JP)

NXP USB Type-C Solutions
Signal Switches

Signal Switches for USB Type-C Applications

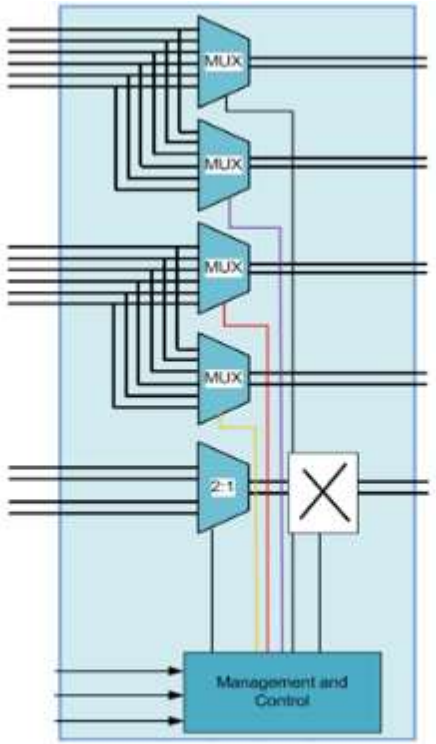
CBTU02043
PTN36043





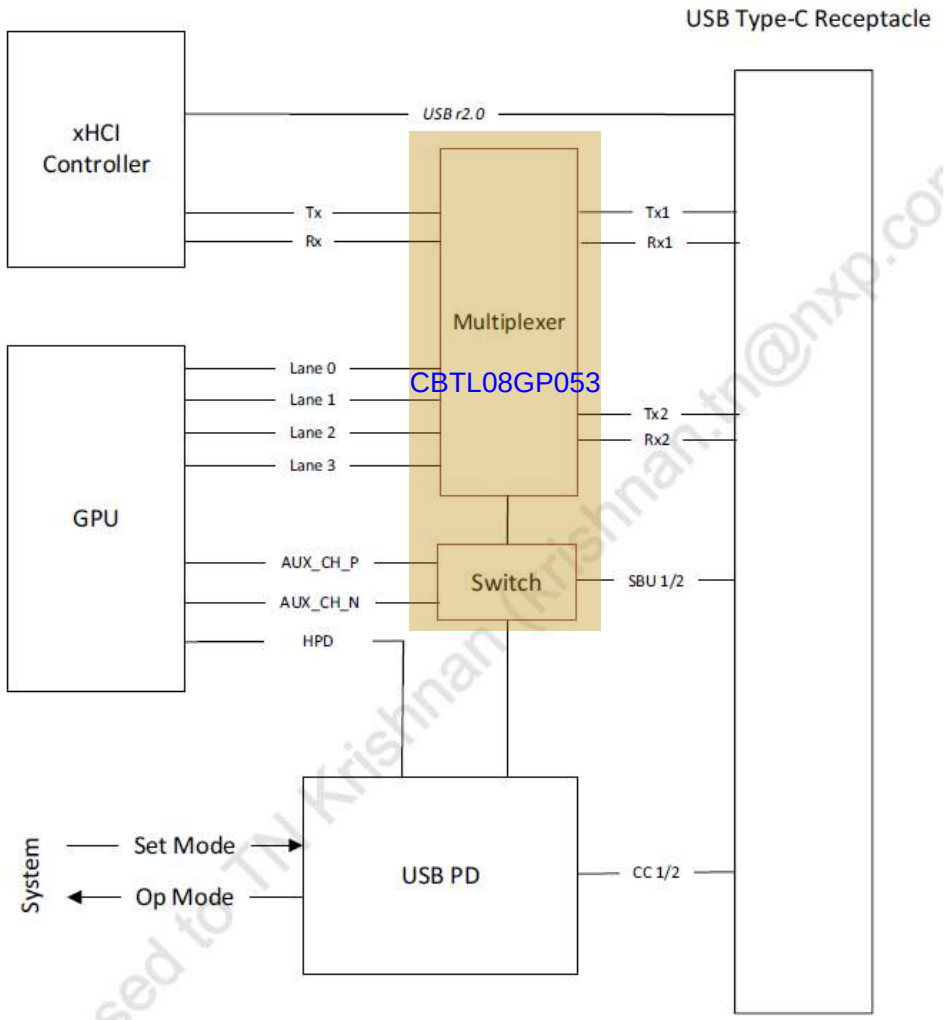
Mobile & Portable Applications

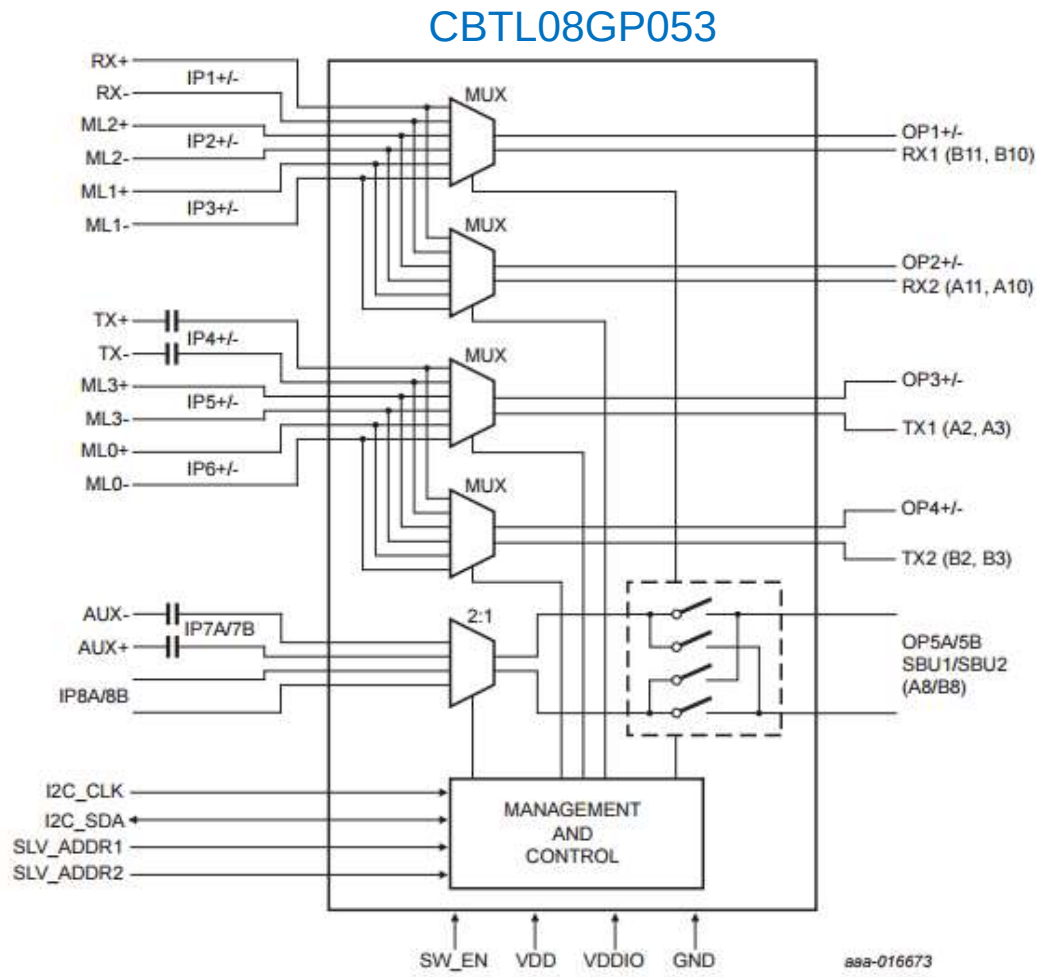
CBTL08GP053



Computing & Docking Applications

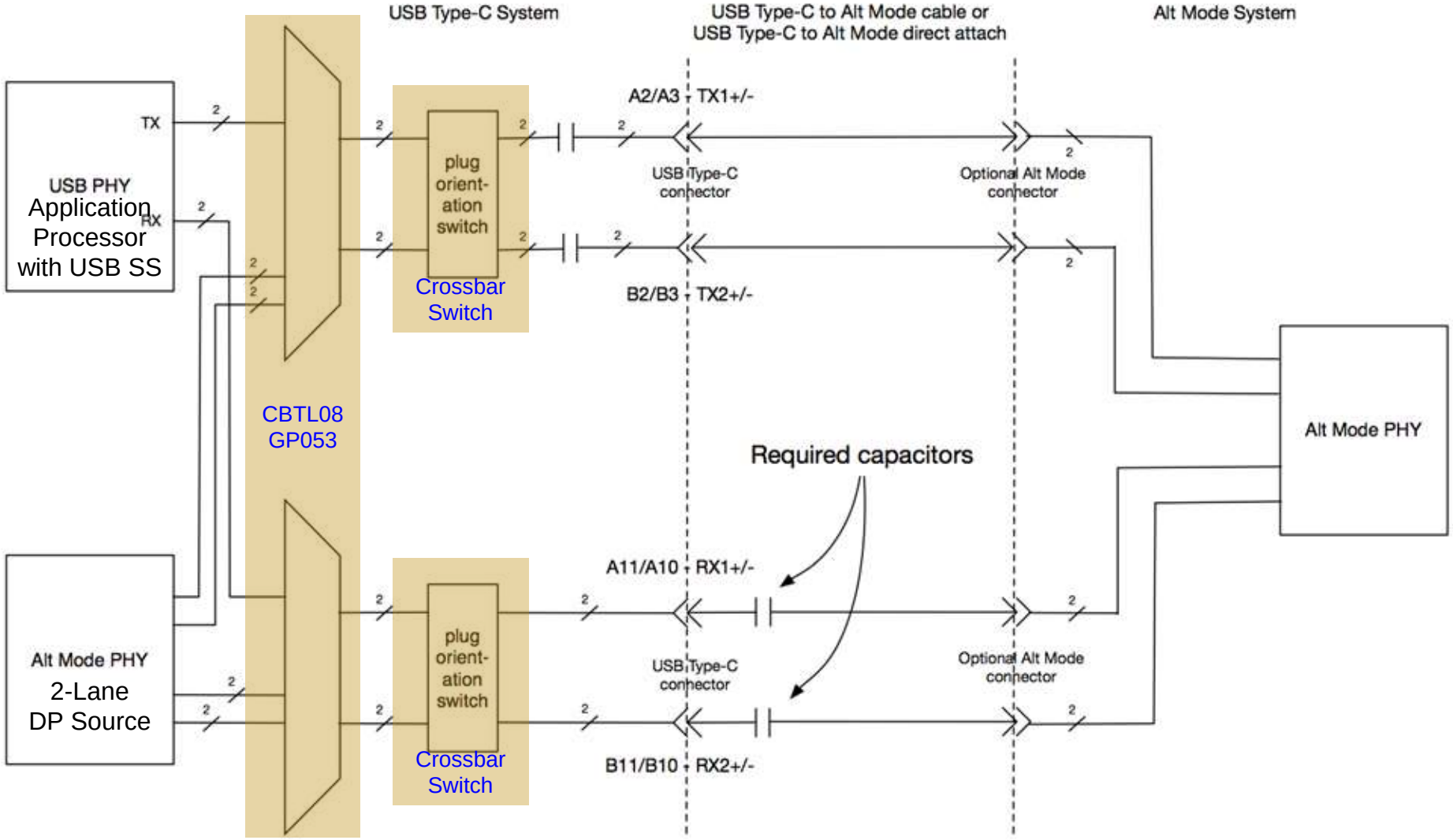
CBTL08GP053 Application in DP ALT Mode (Host System)





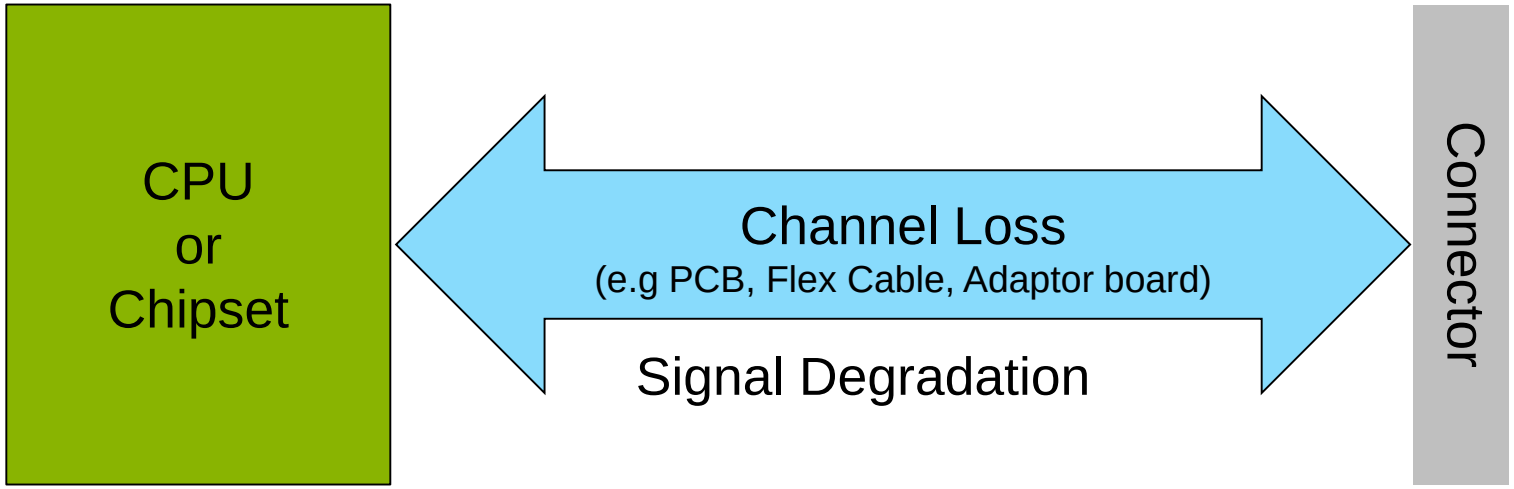
sed to TN Krishnan (krishnan.tn@nxp.com)

CBTL08GP053 Application in DP ALT Mode



NXP USB Type-C Solutions
Re-Drivers

Why is Signal Conditioner Needed?



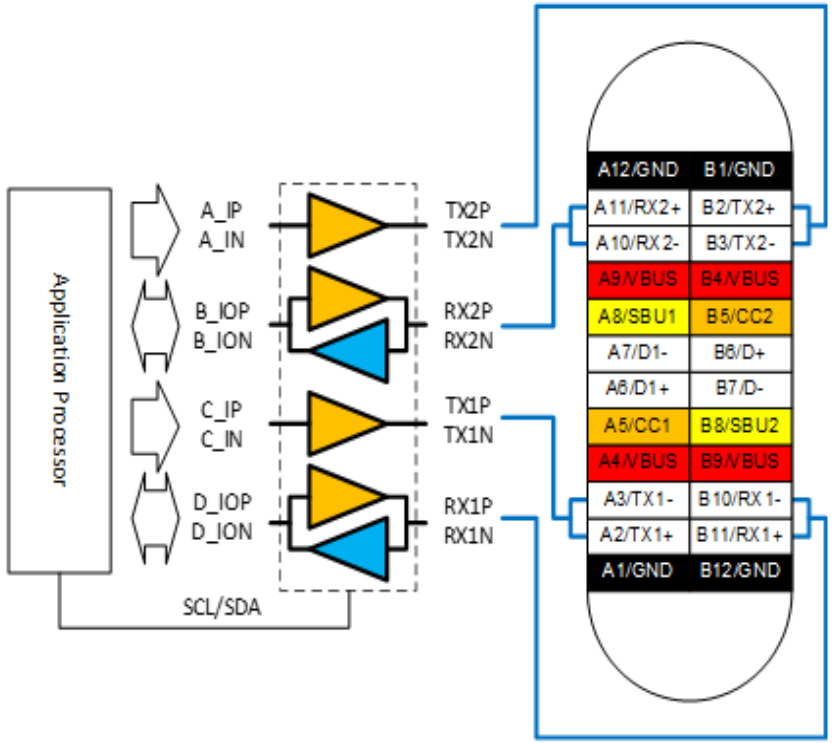
- Channel loss problem get worst when:
  - Long PCB length or cable between CPU to connector
  - Addition adaptor board in the middle of channel
  - The higher the data rate, the loss will become worst.
- To compensate the signal loss, system requires a signal conditioner to boost back the signal integrity

USB3.0 Re-Drivers

Description	Bandwidth	Settings	Power Saving	Part #	
USB 3.0 Single Port	5 Gbps	5-state quinary pins OS, EQ, DE	53 mW @ U2/U3 20 mW @ No Connect 10 mW @ Sleep mode	PTN36241B	3.3V Devices
USB 3.0 Dual Port	5 Gbps	binary pins OS, EQ, DE	66 mW @ U2/U3 26 mW @ No Connect 0.5 mW @ Sleep mode	PTN36242L	
USB 3.0 Half Port (Single Channel)	5 Gbps	adjustable RX equalization, TX de-emphasis & output swing	active: 97 mW (54mA) deep power saving: 18µW (10µA)	PTN36221A	1.8V Devices
USB 3.0 Single Port	5 Gbps	adjustable RX equalization both channels, TX de-emphasis & output swing	VDD=1.8V	PTN36241G PTN36001	
USB3.0 Single Port Active SW	5 Gbps	adjustable RX equalization both channels, TX de-emphasis & output swing	VDD=1.8V	PTN36043	
USB3.0 + DP1.2 Combo Re-driver	USB3: 5Gbps DP: 1.62Gbps, 2.7Gbps, 5.4 Gbps	I^2C or GPIO	VDD=1.8V	PTN36502	
USB3.0 Dual Port	5 Gbps	adjustable RX equalization both channels, TX de-emphasis & output swing	VDD=1.8V	PTN36002	
USB3.2 + DP1.4 Combo Re-driver	10 Gbps	I^2C or GPIO	VDD=1.8V	PTN38003	
DP1.4	8Gbps	I^2C or GPIO	VDD=1.8V	PTN3814	

PTN36502: 5GB DP/USB Combo Re-Driver

- Combo USB and DisplayPort re-driver function
  - USB3.0 and 4-lane DP1.2 (HBR2) operation
  - Works with Host processor that integrates DP/USB Crossbar Switch
  - Complies with USB3.0 and DP1.2 specifications
  - Automatic Output driver adjustment for DP path through AUX channel
  - Good signal integrity with minimum near end crosstalk
  - Low power design with very low power saving modes
  - I2C slave interface for programmability
  - Configurable Receive equalization, Transmit de-emphasis and output swing capability
- Single power supply: VDD=1.8V±10%
- Robust protection - ESD 8kV HBM; 1kV CDM
- Wide operating temperature Range: -40oC to 85oC
- Optimized pinout and package for Type-C applications
  - Very small thin package DHX2QFN24
  - 2.4mm X3.2mm x 0.35mm with 0.4mm pitch

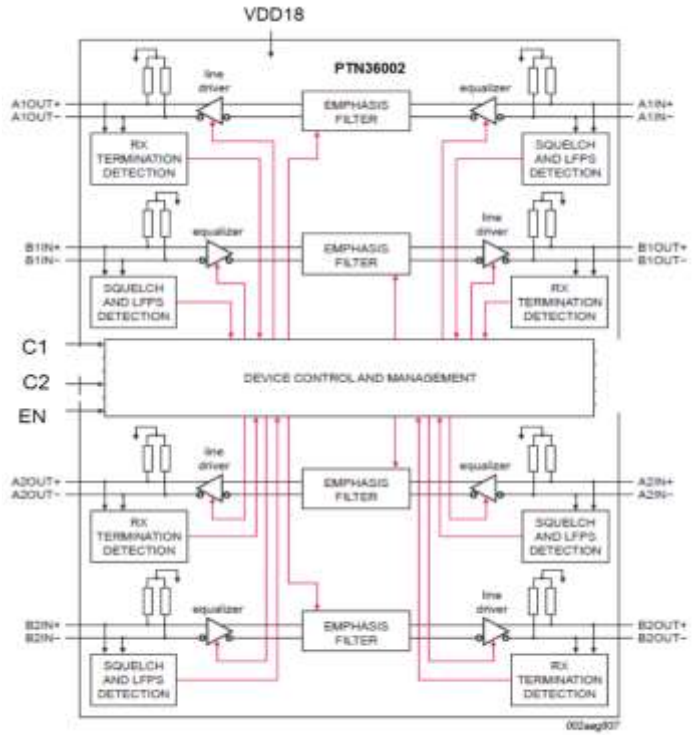


Mode	Usage
Standard USB Type-C mode	USB3 signaling only
DP Alt mode & USB3	USB3 & 2-lane DP signaling
DP Alt mode only	4-lane DP signaling with USB2 only

PTN36002: 5Gb USB Type-C/DP Combo Linear Re-Driver

- Product Features
  - Supports USB 3.1 Gen 1 data rate (aka. USB3.0) of 5Gbps
  - Support USB type A/B/C connector through either I2C slave interface or ternary GPIO pins
  - Support RX equalizers on all inputs to compensate receiver side channel attenuation
  - Support TX De-emphasis and Output swing on all outputs to compensate transmitter side channel loss
  - Low power design with very low power saving modes
  - Small thin package DHX2QFN24 2.4mm X3.2mm x 0.35mm

- Product Benefits
  - Lowest power consumption
    - Active power: 1.8v (NXP) vs 3.3v (Competitor) Vdd power supply
    - Standby power (U2/U3 mode): 1.8mW
  - Good signal integrity for full USB compliance.
  - Enhanced surge protection at Rx pins: ~14v surge capability (Tx pins are covered by the required coupling cap per USB spec.)
  - Support both I2C and GPIO mode. I2C mode has more programmability (Ex. Threshold voltages, EQ, De-emphasis, amplitude, etc.)
  - Higher HBM ESD: 8kV vs 6kV (Competitor)
  - Better system level ESD protection: 8kV contact (target)
  - Smaller package

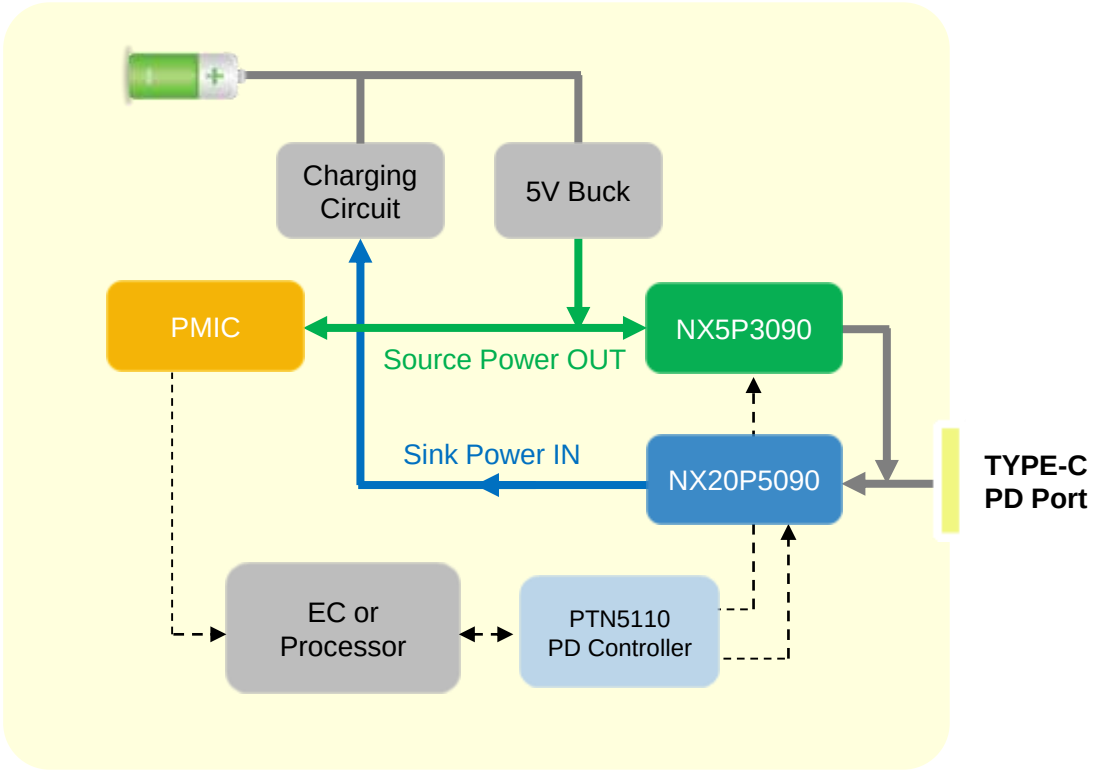


Applications

- Smartphone
- Personal Computer
- Accessory/Docking
- LCD Monitor

NXP USB Type-C Solutions
Load Switches

USB Type-C PD Load Switches in System



NX5P3090 (Source Path)

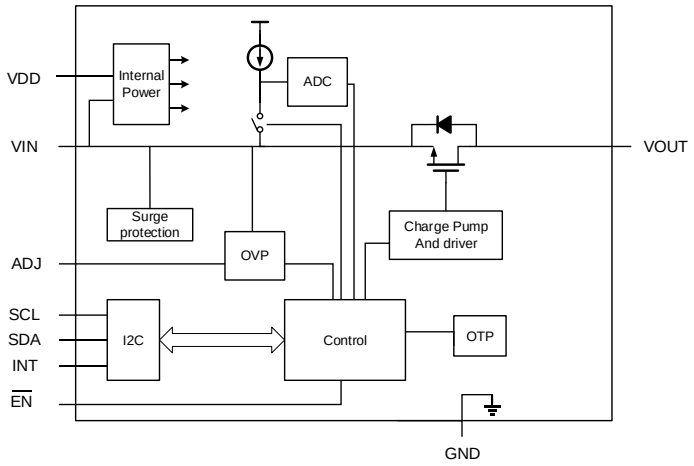
- 5V/3A adjustable Current limiting output
- 29V DC tolerance on VBUS
- 30mΩ Low Ron
- 90V surge protection on VBUS
- Reverse current / voltage protection
- 1.35 x 1.65mm WLCSP-12

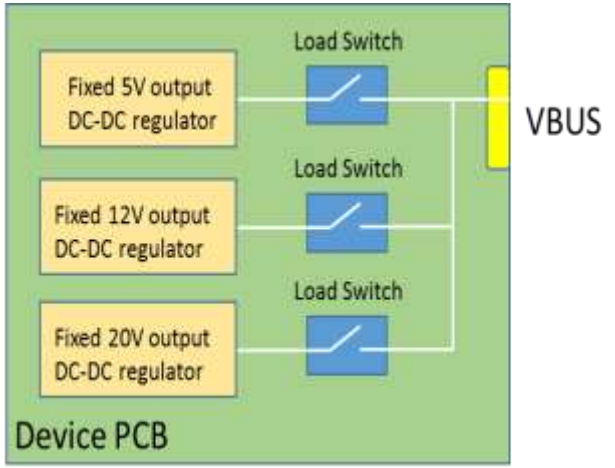
NX20P5090 (Sink Path)

- 5-20V/5A operation with adjustable OVP
- 29V tolerance on both VBUS and VINT
- 30mΩ Low Ron
- 90V surge protection on VBUS
- Reverse current / voltage protection
- 1.54 x 2.56mm WLCSP-15

NX30P6093 / 6093A – 30V Programmable Load Switch

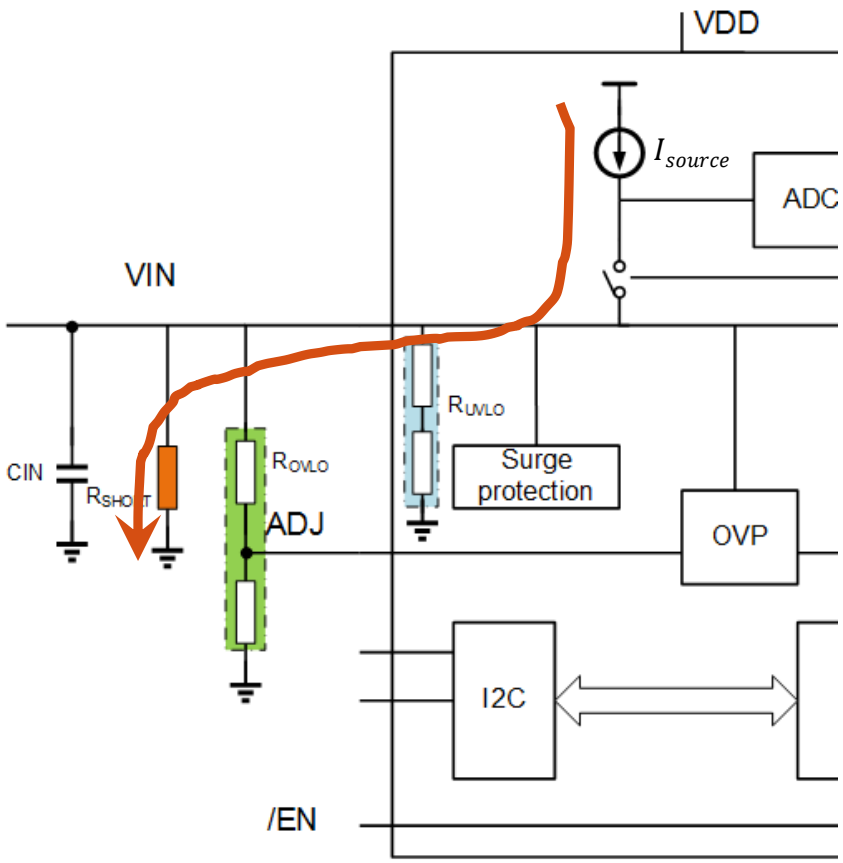
- **NX30P6093 is Uni-directional (Sink Path)** and **NX30P6093A is Bi-directional (Sink & Source Path)**
- Over voltage protection up to 29V on VIN
- Adjustable OVP by I²C (6V, 10V, 11.5V, 14V,17V, 23V)
- High current support
  - **NX30P6093**: Maximum switch continuous **current 8A**
  - **NX30P6093A**: **Bi-directional and support OTG up to 1.5A (source path)**
    Maximum switch continuous **current of 6A (sink path)**
- Integrated current source for **VIN pin resistance detection**
- Ultra-low for high current operation
  - **NX30P6093**: **$R_{DS(ON)}$ = 8.95mΩ** (Typ)
  - **NX30P6093A**: **$R_{DS(ON)}$ = 17mΩ** (Typ)
- Short circuit protection from VIN to VOUT
- Slew rate control for inrush current limit
- Input discharge path for USB PD specification
- **I²C control and programmability** for OVP threshold, timing control, pin resistance current source value, interrupt flag, etc.
- Surge protection: IEC61000-4-5 exceeds ±100 V on VIN without capacitor
- Protection circuitry for over-Temperature Protection, Over-Voltage Protection, and Under-Voltage Lockout
- ESD
  - IEC61000-4-2 contact discharge exceeds 8 kV on VIN
  - IEC61000-4-2 air discharge exceeds 15 kV on VIN
  - HBM ANSI/ESDA/JEDEC JS-001 Class 2 exceeds 3 kV on all pins



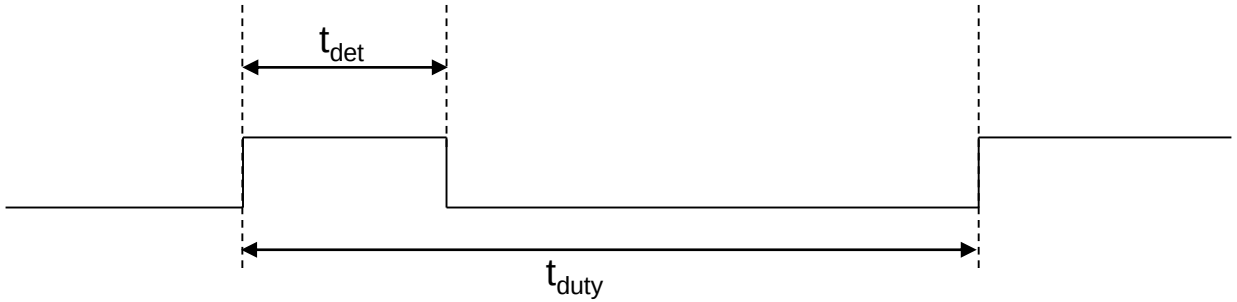


Key: NX30P6093 6093A

NX30P6093 / 6093A – V_{IN} Impedance Detection



Key: NX30P6093 6093A



The detected resistance,

$$R_{DETECT} = RSH_{ORT} \,//\, ROVLO \,//\, RUVLO$$

The stable VIN voltage after charging by current source,

$$V_{VIN} = I_{source} * RDETECT$$

However, due to CIN capacitance, the voltage would be,

$$V_{VIN} = I_{source} * RDETECT * (1 - e^{-\frac{t_{det}}{t_{rc}}})$$

Where, $t_{rc} = RDETECT * CIN$

Smartphone OS notification to your end user,

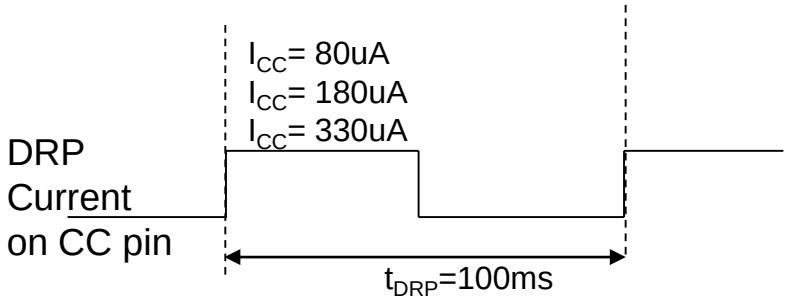
1. Plug out any of the accessory on USB connector
2. Clear the USB connector to remove possible moisture or dusty etc @ Type-C connector

Type-C Connector Moisture Testing

Moisture Type	Full Liquid in Connector[1)]	Little Liquid in Connector[2)]
Drink Water	78kΩ	260kΩ
Coffee	65kΩ	252kΩ
Sugar Water	72kΩ	255kΩ
Salt (Sea) Water	28kΩ	212kΩ
Coca Cola	38kΩ	255kΩ

1. Inject the liquid in Type C connector and make the liquid full in the connector
2. A small drop liquid in connector

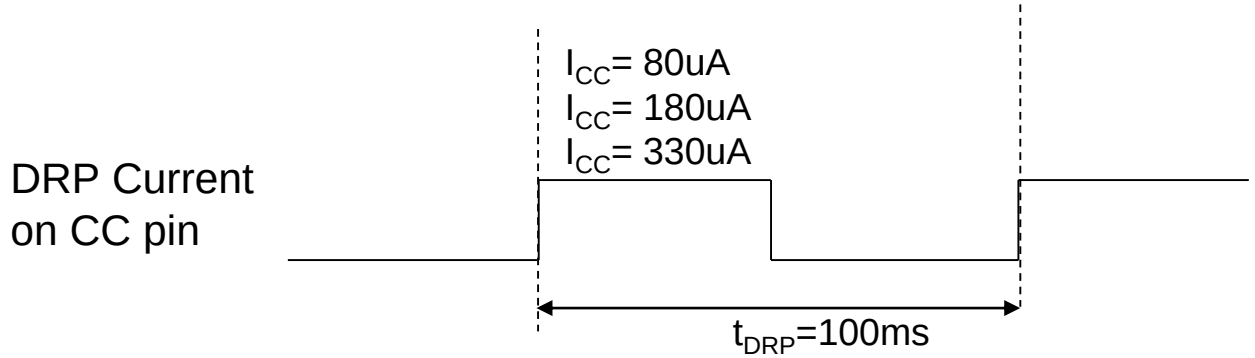
- The DRP CC pins have periodically current according to Type-C specification as shown in the diagram
- With the moisture, the chemical-electronic effect will corrode the metal and damage the pins and connector as shown in the following tested impedance on CC pin to ground



DRP CC current	Liquid in Connector	1 hour @ DRP CC current	2 hour @ DRP CC current	5 hour @ DRP CC current
I_{CC}= 80uA	78kΩ	20kΩ	1.7kΩ	0.4kΩ

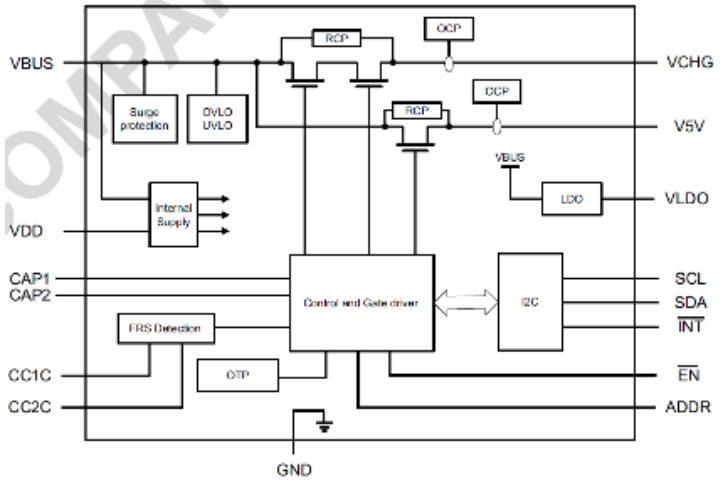
Moisture Detection & Corrosion Prevention with NX30P6090

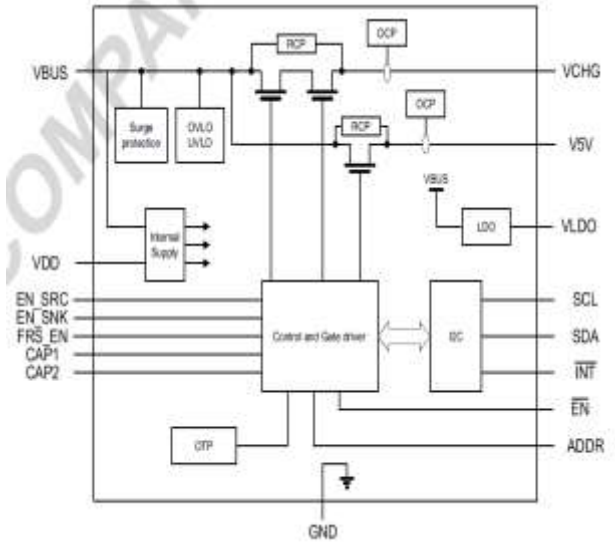
- Run moisture detection by NX30P6093 periodically
  - Such as, detect the VBUS impedance every 6s by set Tduty=6s.
- When the abnormal impedance detected (detected VIN < VTAG)
  - Notify the end user in OS
  - Turn off CC logic or set CC logic to UFP mode to avoid CC pin corrosion issue
- When the connector is cleaned or fixed and detected impedance is good
  - Turn on CC logic again or set CC logic back to DRP mode



NX20P3483 / 81 – Integrated Sink & Source Combo Switch

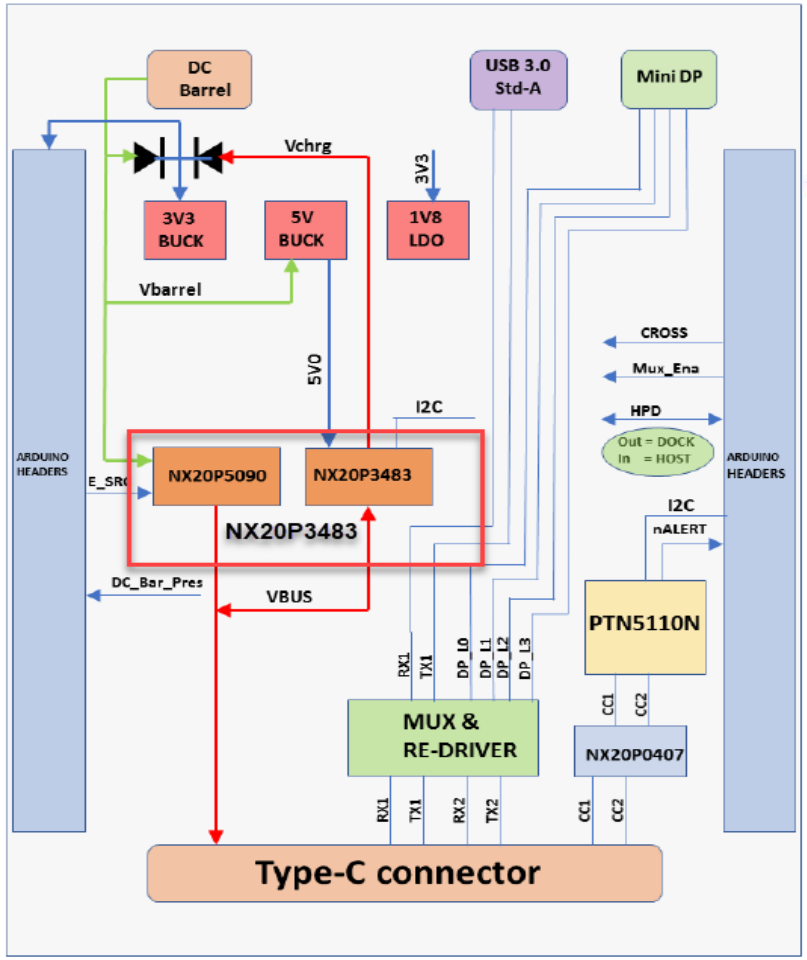
- Adjustable OVP on VBUS via I²C interface (6V, 10.5V, 13.9V, 17.0V, 23V)
- On-chip ultra-low RDSON
  - 18mΩ for VBUS-to-VCHG path
  - 33mΩ for V5V-to-VBUS path
- Bi-directional Operation
  - I²C-Configurable current limit; From 400mA to 3.3A for V5V-to-VBUS path
  - Maximum switch current of 5A for VBUS-to-VCHG path
  - Maximum switch current of 3.4A for V5V-to-VBUS path
- 29-V Tolerance on VBUS and VCHG pins; breakdown voltage up to 35V
- Slew rate control for inrush current limit
- Supports 4 different I²C addresses on ADDR pin
- **Support fast role swap and dead battery conditions**
  - **NX20P3481: FRS detected by CC1C & CC2C pins according to the USB PD FRS specification**
  - **NX20P3483: FRS enabled when FRS_EN=High**
- Integrated always-on LDO to supply EC or TCPM for dead battery operation
- Protection circuitry for OTP, OVP, UVLO, and RCP
- Surge protection: IEC61000-4-5 exceeds ±100 V on VBUS
- ESD Performance:
  - ✓ IEC61000-4-2 contact discharge exceeds 8 kV on VBUS
  - ✓ IEC61000-4-2 air discharge exceeds 15kV on VBUS
  - ✓ HBM ANSI/ESDA/JEDEC JS-001 Class 2 exceeds 2 kV on all pins
- Available in WLCSP42 (2.51 x 2.91 x 0.525 mm), 0.4-mm pitch



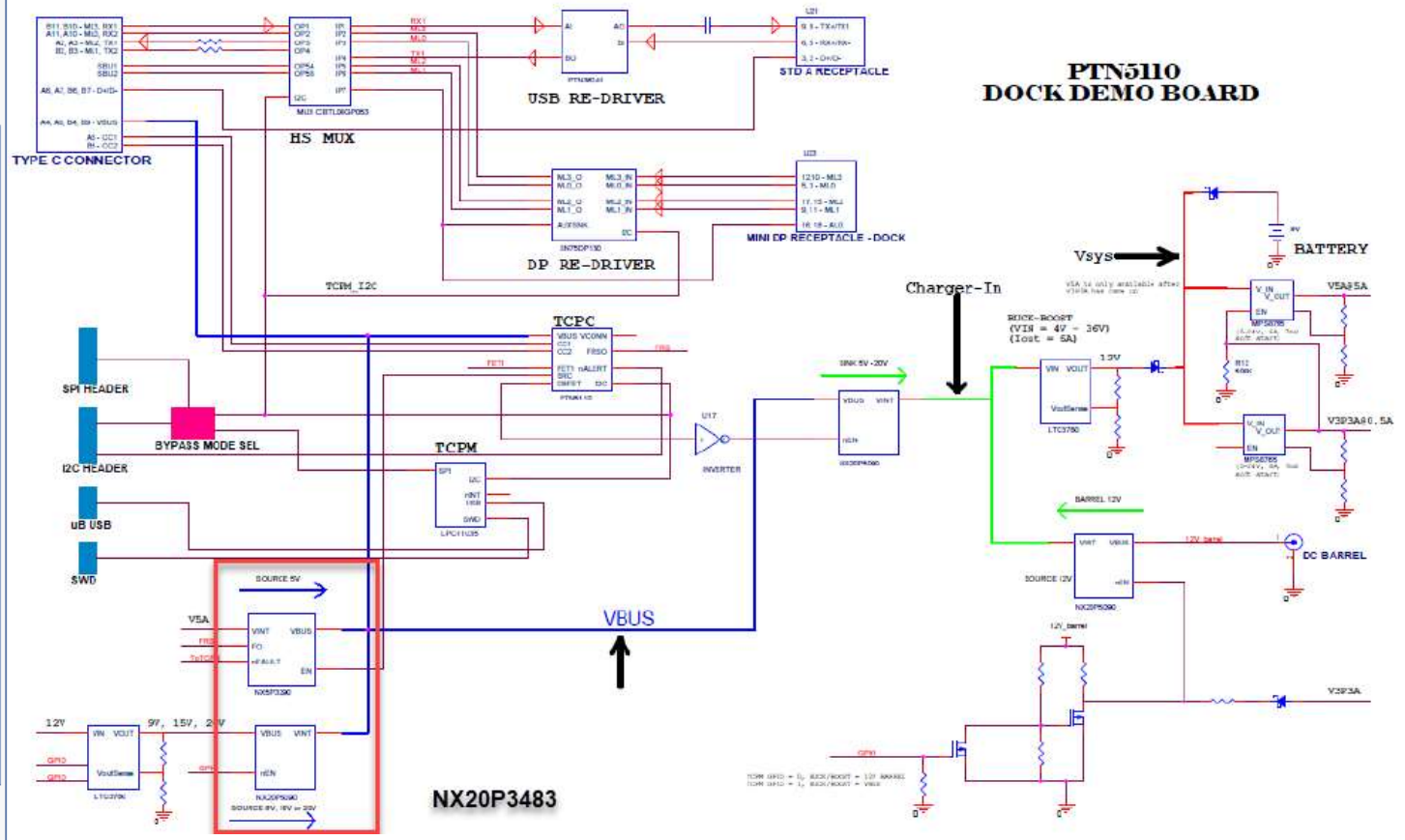


Key: NX20P3481 NX20P3483

Shield Board Block Diagram with the NX20P3483



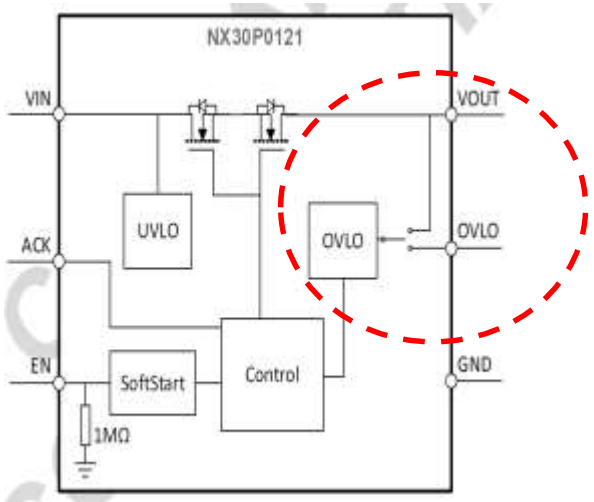
USB PD/ Type C Shield Board

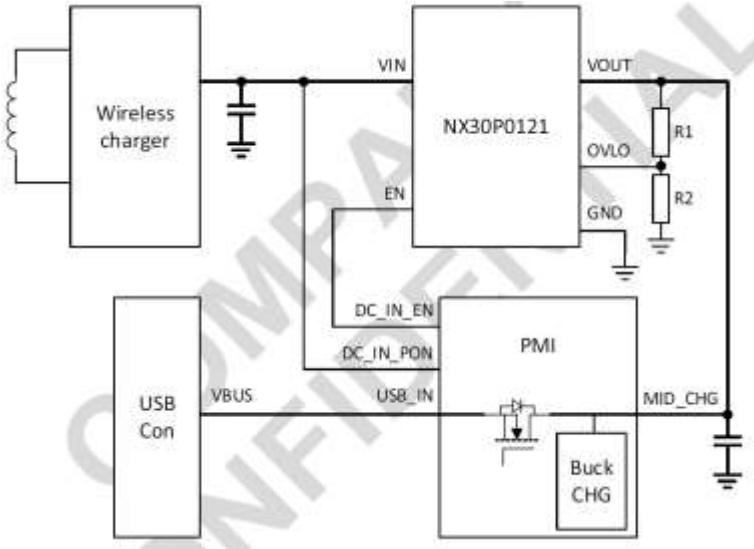


NX30P0121 – 3A Back-to-Back OVP Load Switch

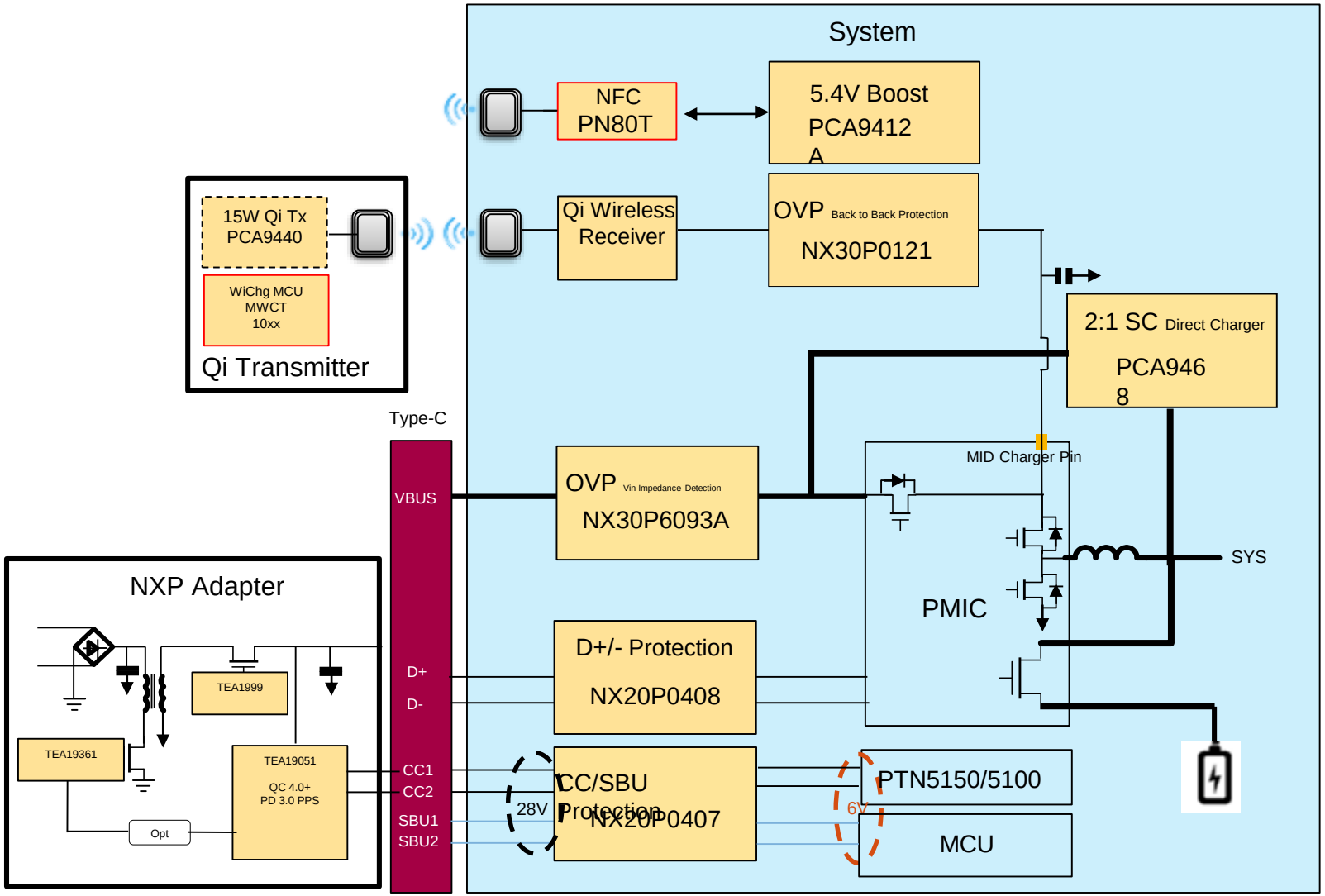
Features and Benefits:

- Wide operation voltage from 2.8V to 29V for VOUT
- 29V tolerance on both VIN and VOUT pins, break down voltage up to 35V
- Adjustable VOUT overvoltage protection
- On-chip back-back MOSFET with low RDSON <50mΩ (Typical)
- Built in slew rate control for inrush current limit
- 5ms deglitch time for VOUT pin
- FAULT condition notification to system
- Maximum switch current 3A
- Protection circuitry
  - Over-Temperature Protection
  - Under-Voltage Lockout
- ESD
  - HBM ANSI/ESDA/JEDEC JS-001 Class 2 exceeds 2 kV on all pins





Example Block Diagram – Smartphone, Tablet, etc.

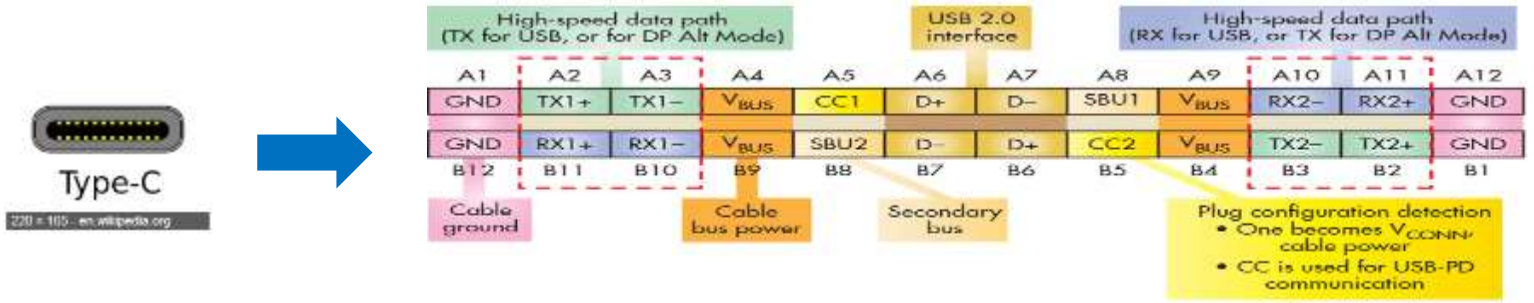


NXP USB Type-C Solutions
Port Protection

Introducing the Need for Port Protection

- Description
  - USB Type-C CC&SBU or CC&D+/- Protector
  - Short-to-VBUS (28 VDC) Overvoltage Tolerant and IEC ESD Protection

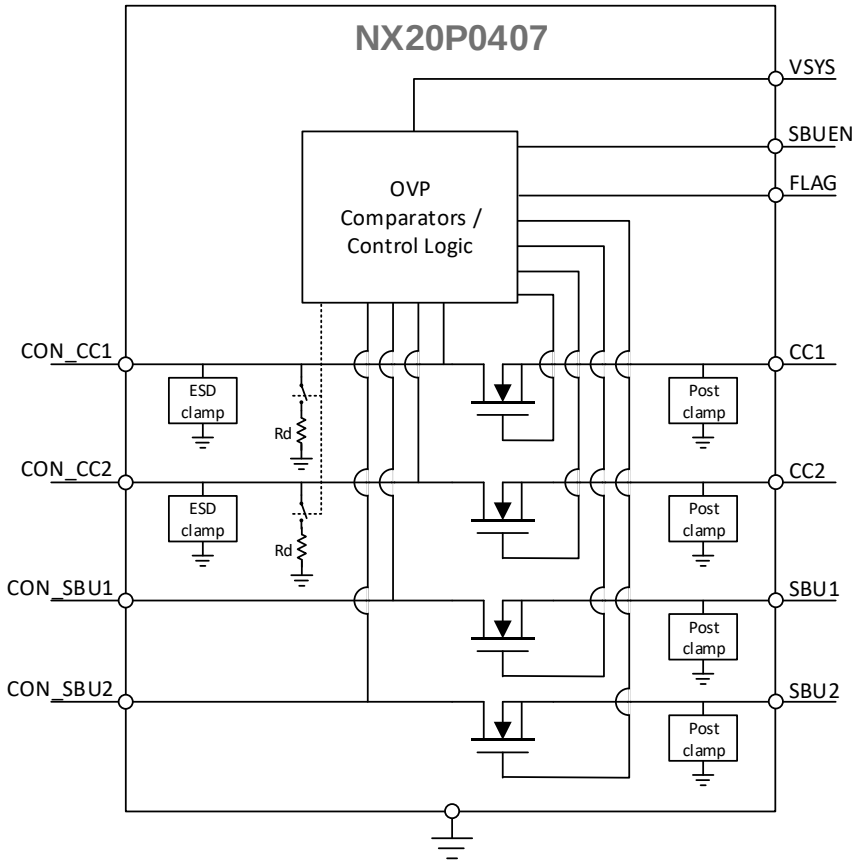
- Justification
  - Since the release of the USB Type-C connector, many products and accessories for USB Type-C have been released which do not meet the USB Type-C specification.
    - One example is the mechanical twisting and sliding of the connector that could short pins due to the close proximity in the small connector. This can cause 20-VBUS to be shorted to the CC and SBU pins in the Type-C connector.
    - Further, there is a heightened concern that debris and moisture will cause the 20V VBUS pin to be shorted to the CC and SBU pins.
  - Port Protection device will protect downstream components for high voltage damage.



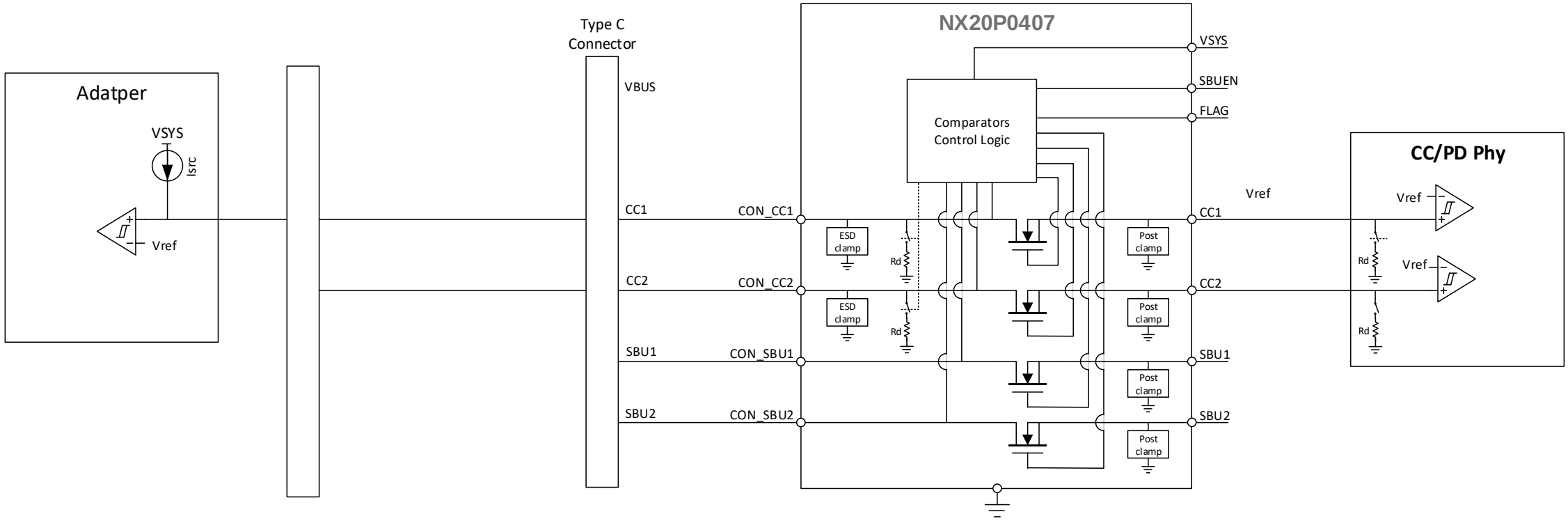
NX20P0407 – CC/SBU or CC/D+/D- Protection in Type-C

Features and Benefits

- USB Type-C CC and SBU (or D+/-) short protection to VBUS
  - CON_CC1 / CON_CC2 : +28VDC
  - CON_SBU1 / CON_SBU2 : +28VDC
- Rd circuit in CON_CC1/CON_CC2 for dead battery
- Low Rdson switch
  - CC switch : 170mΩ
  - SBU switch : 4Ω
- Robust ESD immunity for CON_CC1/2
  - IEC 61000-4-2 Contact discharge: 8KV
  - IEC 61000-4-2 Air discharge: 15KV
- ±34V surge protection on CON_CC1/2
- High speed Bandwidth of SBU switch: 1GHz (capable of USB HS signals)
- Low battery leakage current: 20µA
- CC1/2 leakage current: < 1µA
- Fast OVP turn-off time: 60ns for CC, 45ns for SBU
- 1.27 x 1.67 mm 12 WLCSP with 0.4 mm pitch



System Diagram



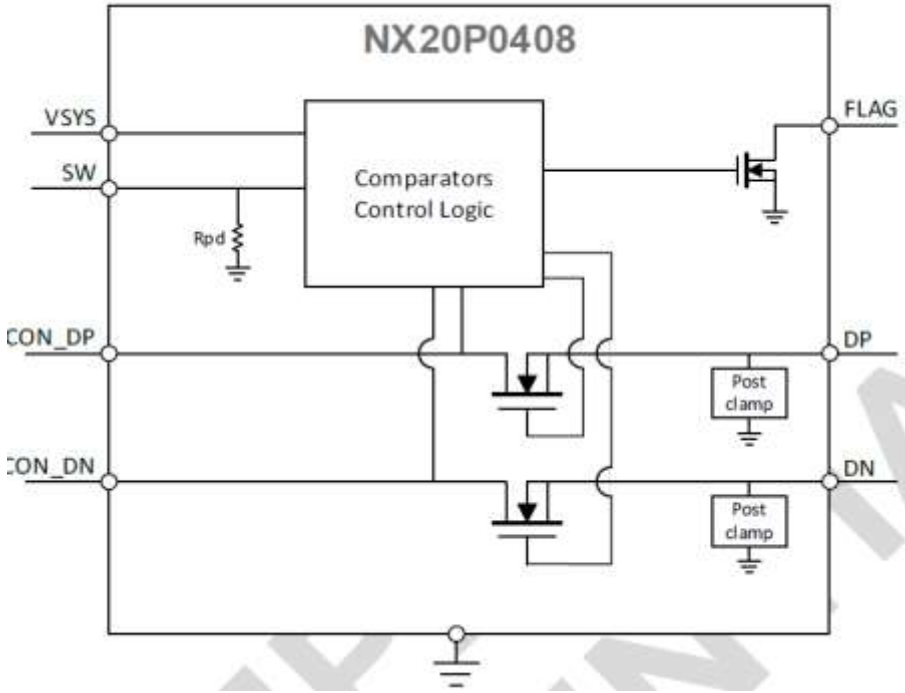
NX20P0407 – Comparison Table

		NXP NX20P0407UK	ON Semi FUSB252UMX	TI TPD6S300	Comments
Package		4x3 WLCSP	16-pin UMLP	20-pin QFN	
Size		1.67 x 1.27 mm	2.6 x 1.8 mm	3.0 x 3.0 mm	Smallest package size
SW Config		4CH (CC & D+/- or SBU)	2CH CC / Dual SPDT	4CH (CC & D+/- or SBU)	
CC	ABS max	28V	24V	24V	Higher Rating voltage
	Ron	250mΩ	350mΩ	392mΩ	
	IVCONN	1.20A	1.25A	600mA	
	OVP res	60ns	500ns	70ns	Competitor has slow response. High VBUS can be passed without post clamp.
	Post Clamp	Yes	No	Yes	
	Rd	Yes	Yes	Yes	
	ESD	IEC (15KV / 8KV)	IEC (15KV / 8KV)	IEC (15KV / 8KV)	
SBU / USB SW	ABS max	28V	16V	24V	16V is not suitable to protect VBUS 20V
	OVP res	45ns	500ns	70ns	Competitor has slow response. High VBUS can be passed without post clamp.
	Post Clamp	Yes	No	Yes	
	Ron/Con	4Ω / 6pF	5Ω / 4pF	4Ω / 6pF	Ron/Con combination limit bandwidth
	BW	1.5GHz	1.4GHz	1GHz	

NX20P0408 – USB Type-C D+/D- Protection

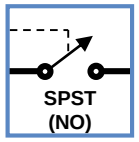
Features and Benefits

- USB Type-C DP & DN short protection to VBUS
  - CON_DP / CON_DN: +28VDC
- High speed Bandwidth: 1.5GHz (capable of USB HS signals)
- Low Rdson switch
  - DP & DN Switch: 4Ω
- 35V Surge protection on CON_DP / CON_DN
- Fast OVP turn-off time: 60ns
- 1.27 x 1.67 mm 12 WLCSP with 0.4 mm pitch



NXP USB Type-C Solutions
Analog Switches

Analog Switch Configurations and Nomenclatures



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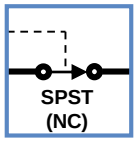

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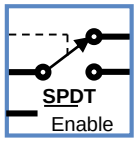

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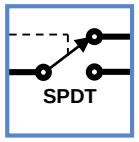

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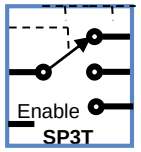

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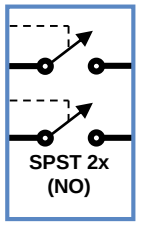

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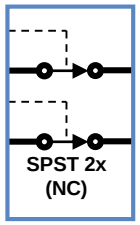

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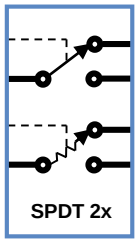

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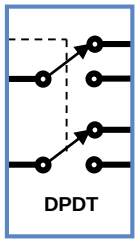

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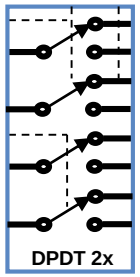
42



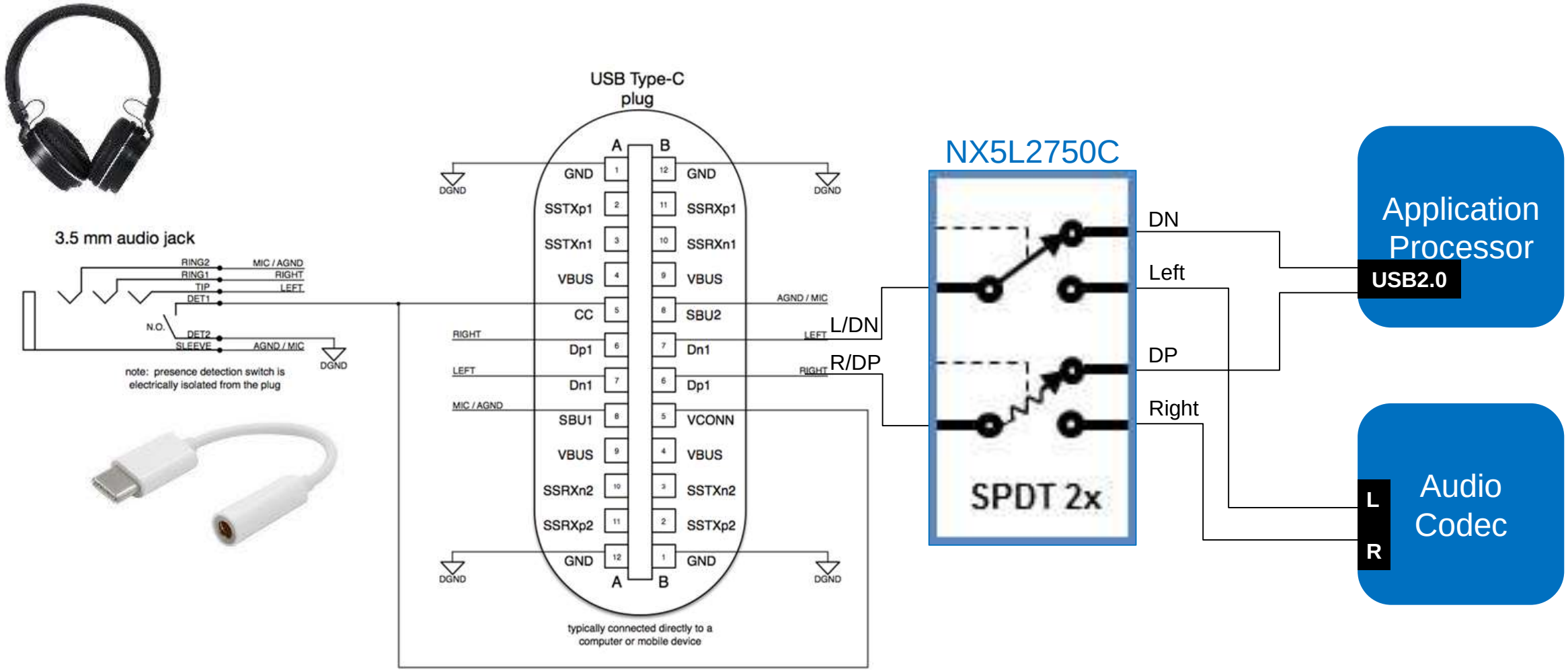
2467
2567
3899

Part Number	ANALOG SWITCHES (sideband signal control)	Status
NX3L2T66	Dual SPST analog switch (0.5 ohm, 60 MHz)	Production
NX3DV3899	Dual DPDT analog switch (2.4 ohm, 200 MHz)	Production
NX5DV715	Dual DPDT analog switch (4.0 ohm, 500 MHz)	Production
NX3DV221, NX3DV42	Single DPDT analog switch (4.0 ohm, 950MHz) for USB2.0 Applications	Production

Config	Device type	R_{ON} (Ω)	f_{-3dB} (MHz)	THD (%)	X-talk (dB)
1x SPST	NX3L1G66	0.75	60	0.024	-90
	NX3VT384	0.45	25	0.01	-90
2x SPST	NX3L2G66	0.75	60	0.024	-90
	NX3VT384	0.45	25	0.01	-90
1x SPDT	NX3L1G3157GW-Q100	0.75	60	0.024	-90
	NX3L1T3157	0.75	60	0.024	-90
	NX3L1G53	0.75	60	0.024	-90
	NX3L1T53	0.75	60	0.024	-90
2x SPDT	NX3L4684	0.8	60	0.01	-90
		0.5	25		
	NX3L2267GU-Q100	0.75	60	0.024	-90
2x DPDT or 4PDT	NX3L2467	0.75	60	0.02	-90
	NX3DV2567HR-Q100	9.5	330	-	-60
	NX3DV3899	4.5	200	0.01	-90
1x SPTT	NX3L4357	0.75	30	0.02	-90
1x SP8T	NX3L4051HR-Q100 NX3L4051PW-Q100	0.75	15	0.02	-90
3x SPDT	NX3L4053HR-Q100 NX3L4053PW-Q100	0.8	60	0.02	-90

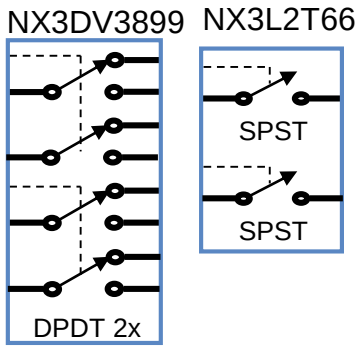
Devices listed in Blue are AEC-Q100 Qualified

NX5L2750C Use in USB Type-C Analog Audio Application



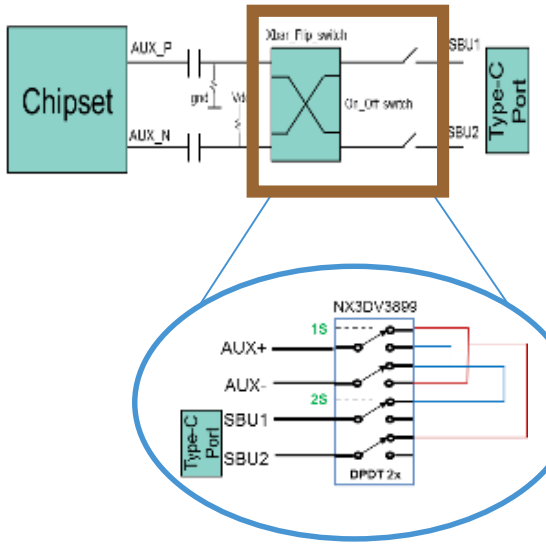
Analog Switches for Type-C Connector SBU Link

- USB Type-C Pin Safe State
  - The USB Safe State defines an electrical state for the SBU1/2 and SSTX/SSRX for DFPs, UFPs, and Active Cables when transitioning between USB and an Alternate Mode.
  - SBU1/2 and SSTX/SSRX must transition to the USB Safe State before entering to or exiting from an Alternate Mode.
- Type-C ALT Mode Sideband signals
  - Displayport: AUX
  - HDMI: DDC (I2C)
  - MHL: CBUS
  - Thunderbolt: LS (Low Speed UART)
- NX3DV3899 provides SBU Xbar and Safe State On-Off switch function
- NX3L2T66 provides Safe State On-Off switch function

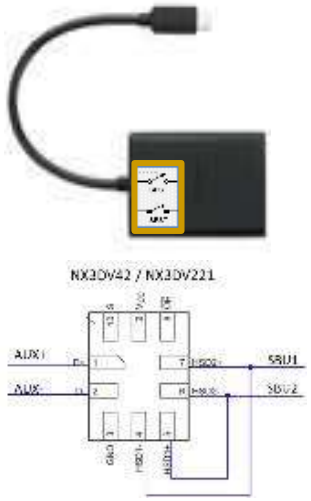


Part number	Configuration	Ron (Ω)	f_{3dB} (MHz)	Package
NX3L2T66	Dual SPST	0.75	60	XSON8, XQFN8
NX3DV3899	Dual DPDT	2.4	200	XQFN16 (1.8 x 2.6 mm), HXQFN16U (3 x 3 mm)

Xbar &Safe State Switch in System



Safe State Switch in Dongle



Application & Benefits of Audio Jack Switches

Reliable Insert Detection	Moisture false detection Prevention
Multi Standard Support	Supports 3 pole, 4 pole AHJ & OMTP headphone
Simply Design Better Performance	Low Crosstalk by Low Ron & common voltage feedback No insertion noise with built in MIC switch

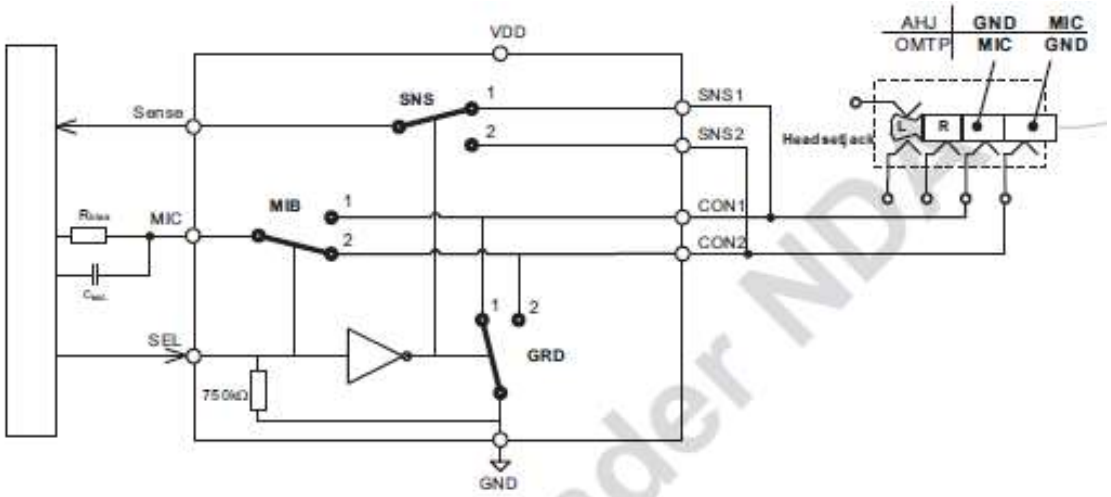
	3 Pole Stereo	L R G
	4 Pole AHJ **(American Headset Jack)**	L R G M
3.5 mm Headset	**4 Pole OMTP** **(Open Mobile Terminal Platform)**	L R M G

NCX8200UK: Audio Jack Configuration Switch Matrix

Description

- The NXP-NCX8200 is an advanced audio jack configuration switch matrix device.
- It supports 3- and 4-pole connectors and allows re-configuration of the GND and microphone-bias contact to comply with the American Headset Jack (AHJ) and the Open Mobile terminal Platform (OMTP) pinout. Furthermore, a GND sense path is automatically connected to the GND path chosen to support quasi-differential amplifier architectures..

Available in: WCSP 9pin 1.22X1.22mm 0.4mm pitch



(1) Default configuration with SEL = L is AHJ compliant in this example.

Applications

- Notebook and tablet PC
- Cellular handsets
- Portable media players
- Navigation devices

Features

- Low power standby
- Click free switching
- Extra Low resistance GND FET, 60mΩ typ
- Sensing pin for Codec compensation
- 8kV HBM ESD protection

Under NDA

NX5L2750C: Negative Swing Audio Signal Switch

Description

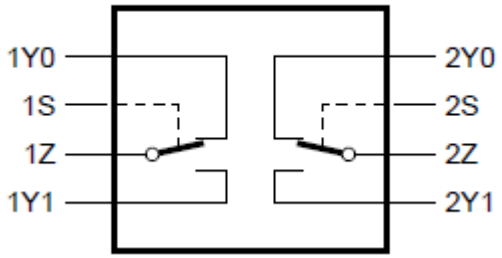
The NX5L2750 is a dual low-ohmic single-pole double-throw analog switch suitable for use as an analog or digital 2:1 multiplexer/ de-multiplexer. Each switch has a digital select input (nS), two independent inputs/outputs (nY0 and nY1) and a common input/output (nZ).
The NX5L2750 is capable of switching audio signals with negative swing without the need of a coupling capacitor.

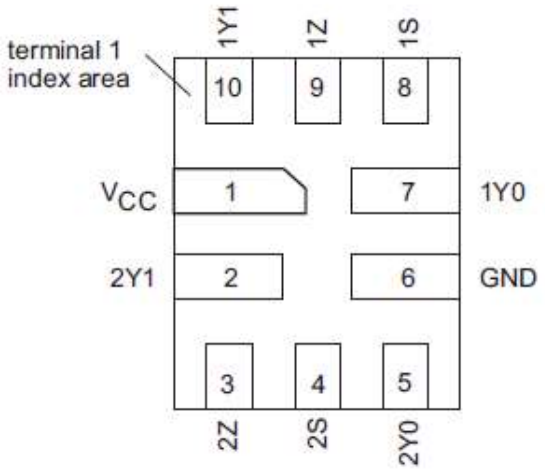
Available in: XQFN10 (SOT1160-1) 1.4 x 1.8 x 0.5 mm, 0.4 mm pitch

Replaces: FSA3157, DG2750

Applications

- Notebook and tablet PC
- Cellular handsets
- Portable media players
- Set top boxes
- Navigation devices



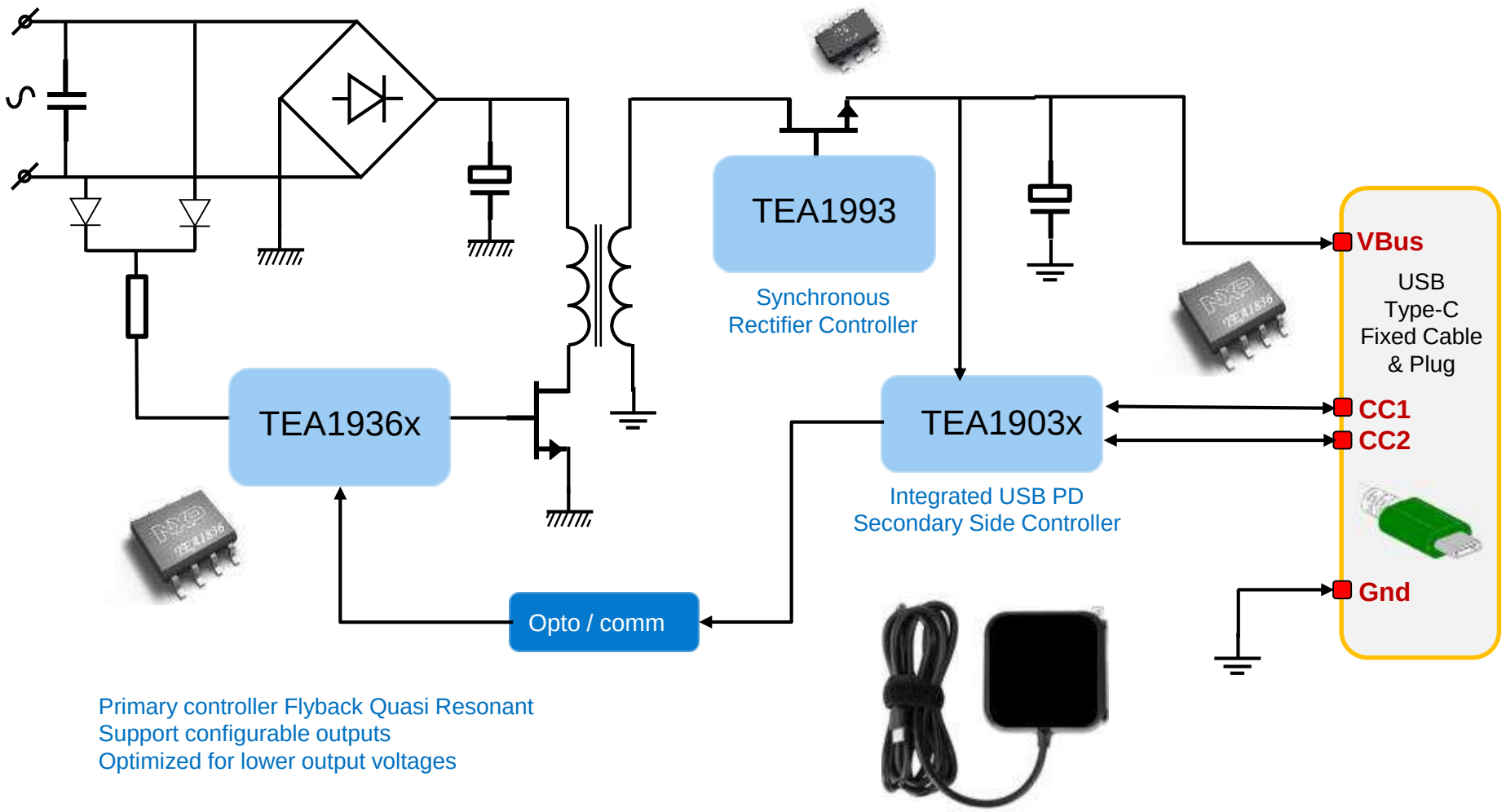


Features

- Operates at 1.8 – 5.0 V supply.
- Switch voltage: -2.5V to Vcc
- Supply current I_{CC} < 2µA.
- On resistance R_{ON} = 0.6 W typ.
- Typical $C_{S(ON)}$ = 75 pF
- High Bandwidth $f_{(-3dB)}$ = 35 MHz

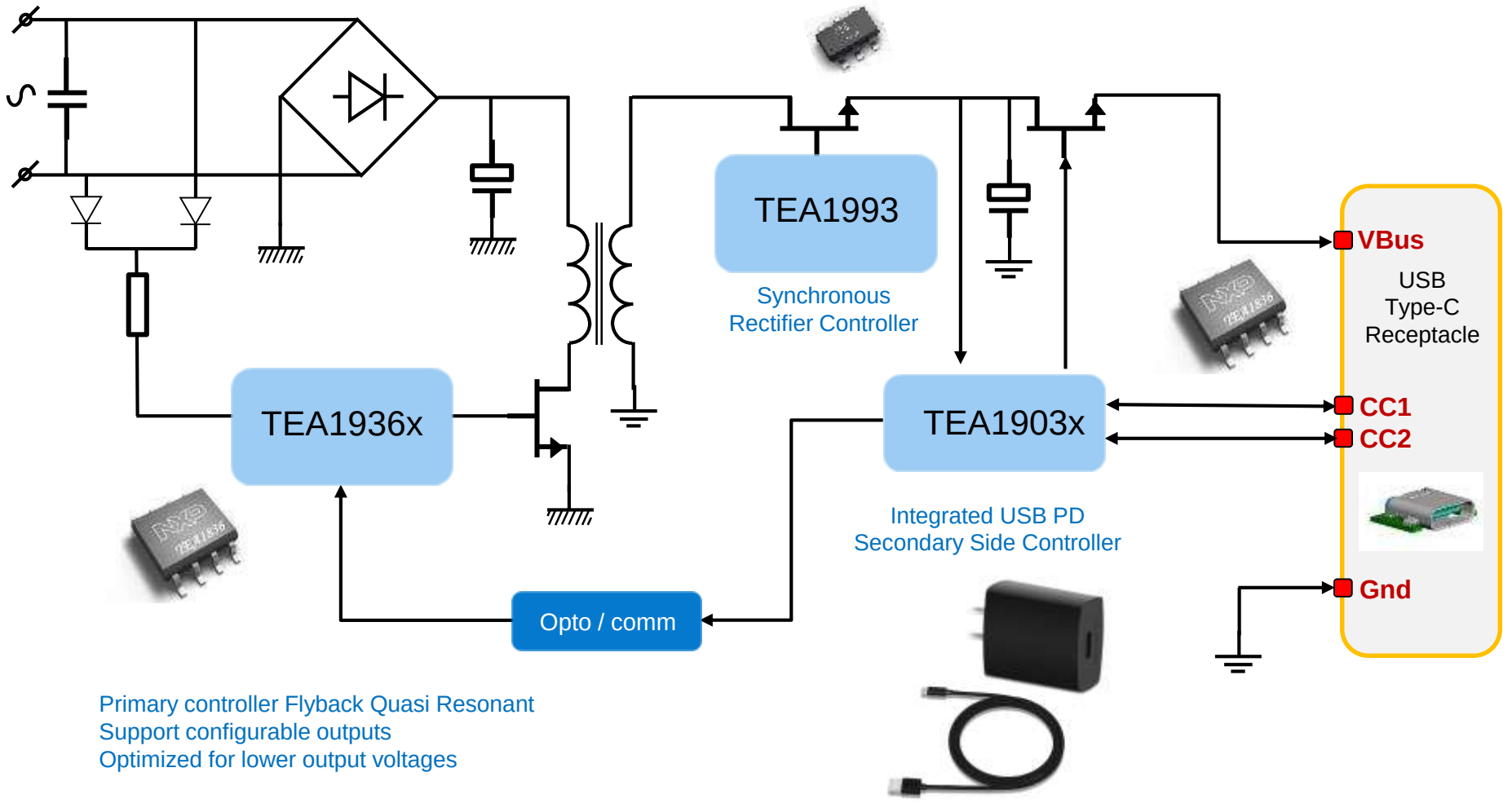
NXP USB Type-C Solutions
AC/DC Power Supply Solutions

Block Diagram for Type-C AC/DC PSU (Captive Cable)



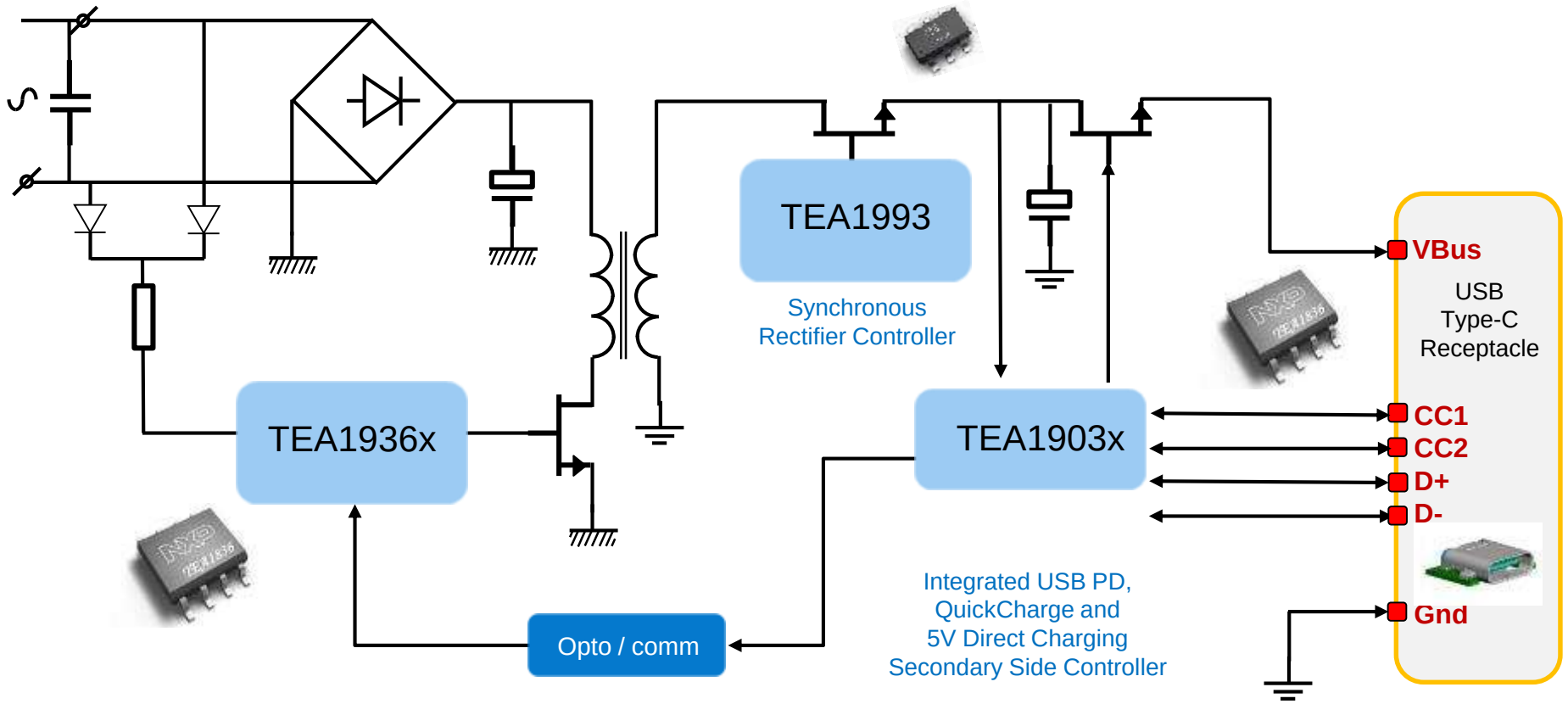
Primary controller Flyback Quasi Resonant
Support configurable outputs
Optimized for lower output voltages

Block Diagram for Type-C AC/DC PSU (Receptacle)



Primary controller Flyback Quasi Resonant
Support configurable outputs
Optimized for lower output voltages

Block Diagram for Type-C AC/DC PSU (Receptacle /w QC)



Primary controller Flyback Quasi Resonant
Support configurable outputs
Optimized for lower output voltages

USB Type-C AC/DC Power Supply Solutions

TEA1936x DCM Flyback Controller

- Flyback QR Controller with true valley switching
- Adaptive dual-supply for highest efficiency
- Active Xcap discharge integrated
- High efficiency at low loads
- No load stand by power dissipation < 30mW
- Low ripple ±1% at any output voltage
- Switching frequency up to 140kHz (QR with true valley switching)

TEA1993 Secondary Controller and SR

- Adaptive gate driver for maximum efficiency
- Supply current in “no load” operation <250µA
- Self-supporting for high-side rectification without the use of an auxiliary winding
- Operates with standard logic level SR MOSFETs
- Optimized for fast charger applications, like USB BC 1.2, USB-PD, QC2.0/3.0 and any other proprietary protocol application

TEA1903x USB-PD Controller for SMPS

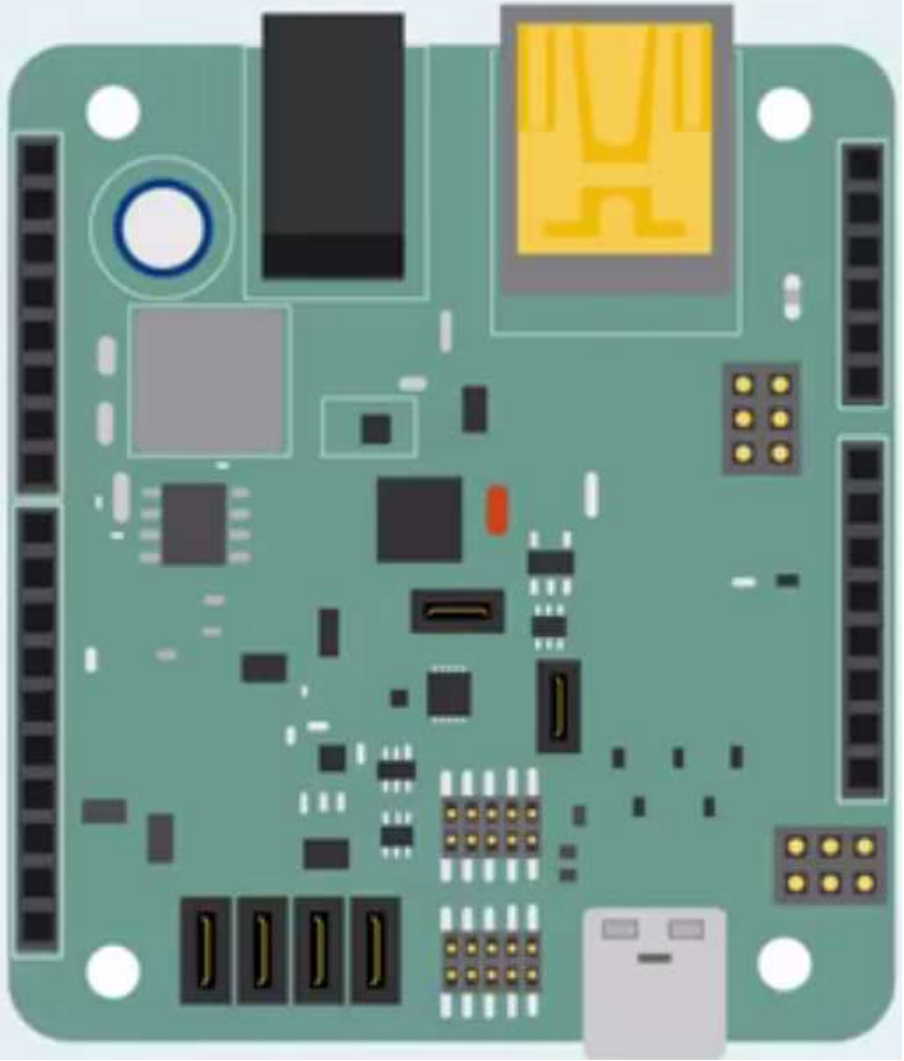
- Flexible system due to embedded DSP and ROM, RAM and MTP memory
- Built-in BMC Communication protocol for USB-PD
- Integrated driver for Type-C external N-MOSFET isolation switch

TEA19051 USB-PD Controller for SMPS

- Similar to TEA1903x with the inclusion of the D+ & D- pins
- Firmware supports multiple protocols
  - BMC Communication protocol for USB-PD
  - QC2.0
  - QC3.0 (Adds continuous mode ±200mV steps)
  - BC1.2

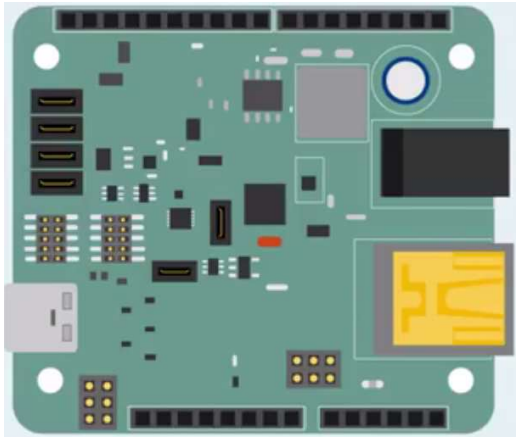
NXP USB Type-C Solutions Tools

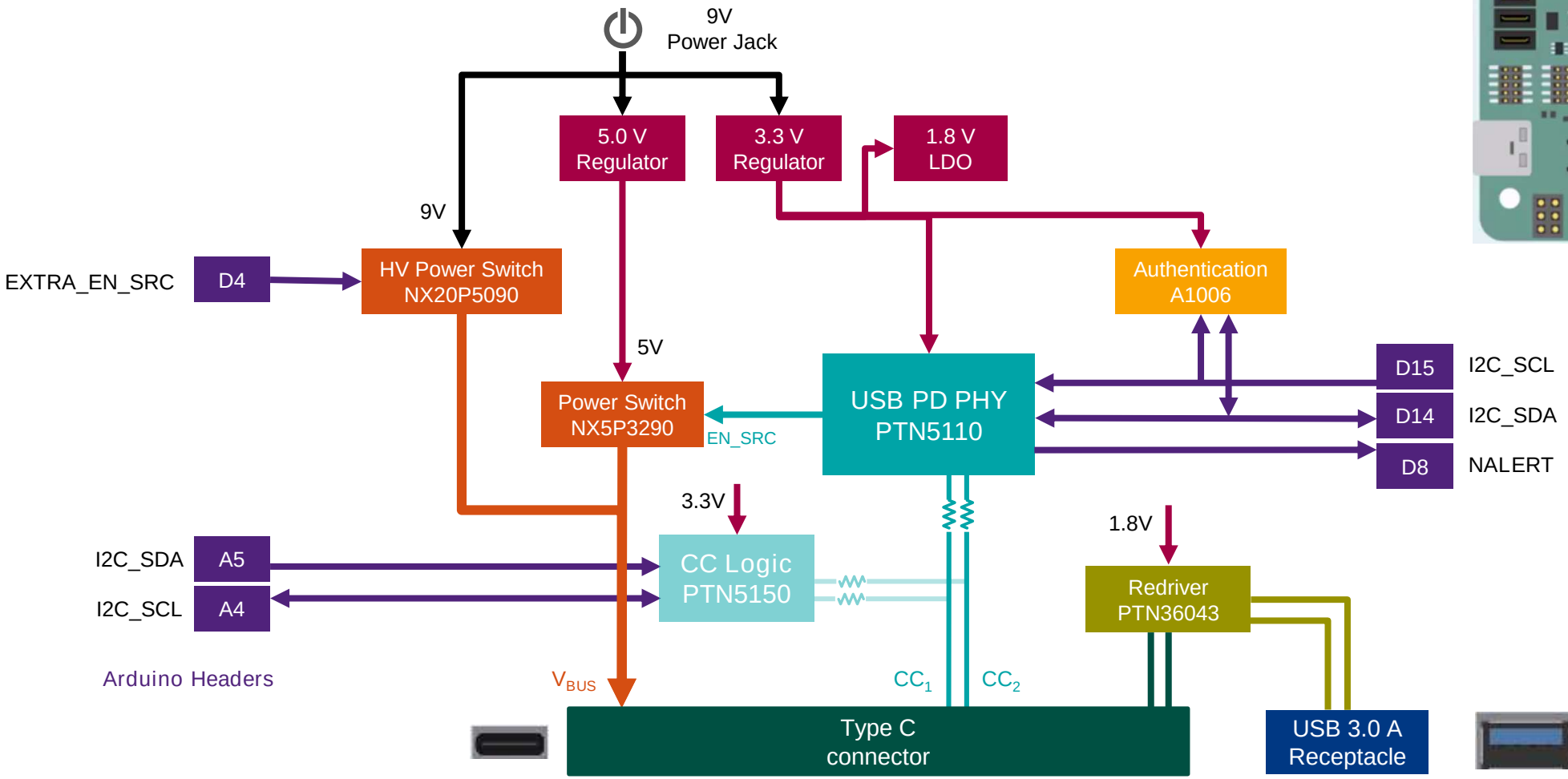
USB PD Shield & MCUXpresso SDK



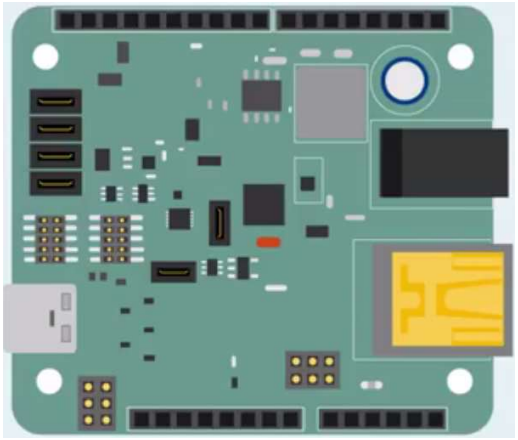
- USB Type-C Shield with TCPC PHY, Power Switch and USB 5Gbps signal condition.
- Arduino headers that is compatible with multiple NXP MCU development boards.
- PD firmware source code available from MCUXpresso SDK builder. Including example code for power source and sink.
- Enable customer to quickly add USB Type-C to Embedded or IoT hardware design.

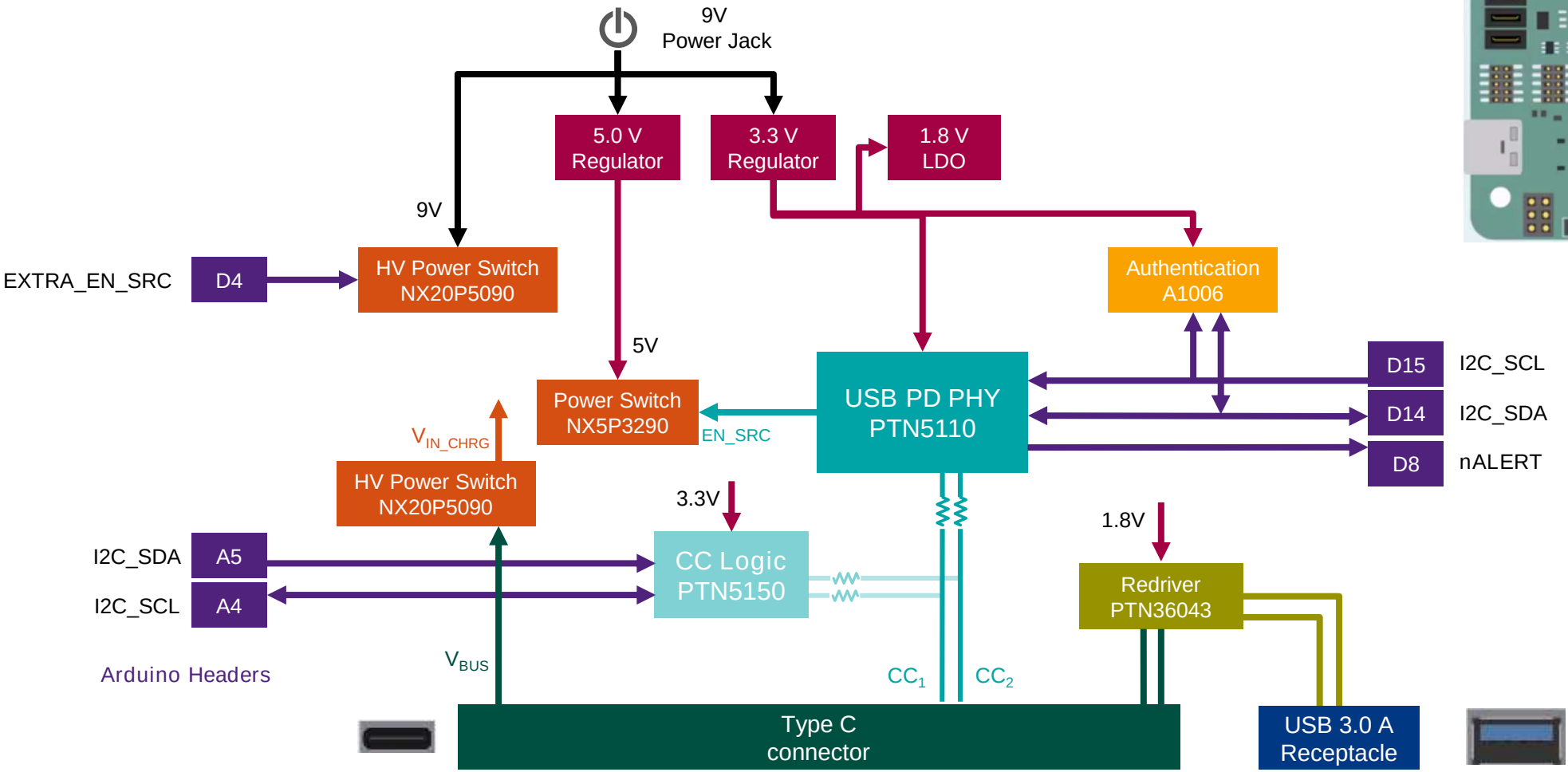
USB PD Shield Hardware – Source Mode





USB PD Shield Hardware – Sink Mode





MCUXpresso Dev. Board Supporting USB Type-C Shield

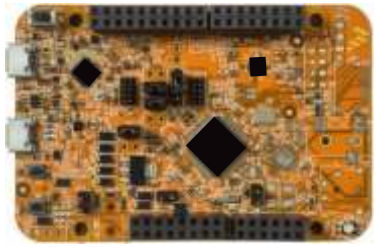
64 kB Flash
16 kB RAM

FRDM-KL27

512 kB Flash
128 kB RAM

FRDM-KL28

EVK i.MX RT1050



512 kB Flash
128 kB RAM

FRDM-K22F

1024 KB Flash
256 KB RAM

FRDM-K64F

256 KB Flash
192 KB RAM

LPCXpresso54114

512 kB Flash
200 kB RAM

LPCXpresso54608

LPCXpresso54018

Useful Links for USB Type-C Shield and MCUXpresso

USB Type-C Shield OM13588
https://www.nxp.com/products/analog/interfaces/usb-interfaces/usb-type-c-true-plugn-play/usb-type-c-shield-board-for-kinetis-freedom-board:OM13588

USB Type-C Shield OM13588 Getting Started
https://www.nxp.com/products/analog/interfaces/usb-interfaces/usb-type-c-true-plugn-play/usb-type-c-shield-board-for-kinetis-freedom-board:OM13588?tab=In-Depth_Tab

USB Type-C Shield OM13588 Schematics
https://www.nxp.com/downloads/en/schematics/sch-29705.pdf

MCUXpresso USB PD Migration Guide
https://www.nxp.com/docs/en/user-guide/USBPDMUG.pdf?fsrch=1&sr=1&pageNum=1

i.MX RT1050 Combined demo of USB Type-C with GUI
https://community.nxp.com/docs/DOC-340143

Key NXP Contacts

- Product Marketing Manager (PD PHY & Switches)
  - Jay Li
  - Office: 408-518-5641
  - Jay.Li@nxp.com
- Product Marketing Director (Power Management)
  - Dave Kim
  - Office: 408-204-3277
  - Dave.Kim@nxp.com
- Technical Marketing Manager
  - Emmanuel T. Nana
  - Office: 408-518-5306
  - Emmanuel.Nana@nxp.com
- Regional Marketing Manager
  - Ravi Shah
  - Office: 408-518-5309
  - Ravi.Shah@nxp.com

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