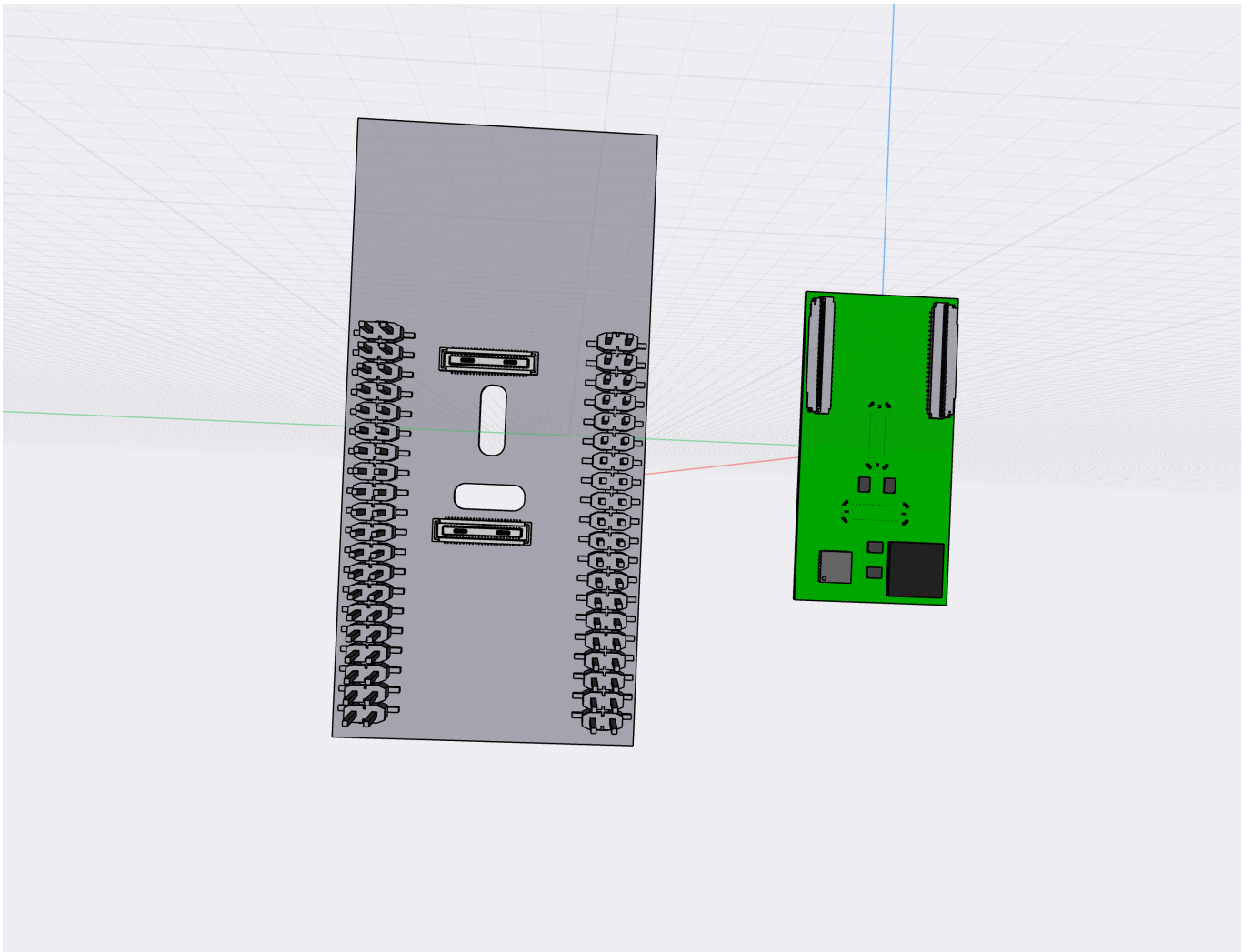
801 T-USB daughterboard

The 801 is a bridge board that connects daughter boards. 801 T-USB is one such daughter board.

The T-USB daughterboard has two functions

- Supply the system with power
- Provide data signals in the system over two USB-C connectors

The T-USB board exposes two vertical USB-C sockets and connects to the carrier board through two 50 pin B2B connectors.



To facilitate feature development two additional connectors are added.

Open points

- Which GPIO receives interrupt
- Mux chips shutdown mode
- Power LED & Indicator LEDs
- Add battery connector with temp. sensor
- Optional connectors debug uart / jtag
- Annotations and Logo on the board

- TEST The Mux pin configurations
- How should PP_HV1 & PP_HV2 / PP1_CABLE PP2_CABLE be wired ?
- Default boot/SEL states connect USB 2.0/3.0 data routing and full power delivery / charging
- Enable VIN_5V/3V3 from PWR_SYS (TBD)

Core Components

- 2 * Hirose DF40-50DP-0.4V mated height 1.5mm Mouser
- 2 * Hirose USB-C CX80B1-24P
- 1 * TPS65988 Dual Port USB Type-C® and USB PD Controller, Power Switch, and High-Speed Multiplexer. Mouser
- 2 * HD3SS460 4 x 6 Channels USB Type-C Alternate Mode MUX. Connected to T-USB Host. Mouser. Dock Eval Kit
- 1 * PCA9555 I/O Expander
- 4 * TS5USBC410 Dual 2:1 USB 2.0 Mux/DeMux Switch. Mouser
- 1 * BQ24250RGER battery charger $2 JLCPCB (4x4 mm package) Mouser

Dev. Connectors

- 2 * TE Connectivity 45PIN 0.3MM 571-4-2328724-5 FPC 3-2328724-5 $0.41

Alternate Components

- SuperSpeed MUX PI5USB30213A may be an option intead of CBTL04083
- Alternate USB 2.0 Mux/DeMux Mouser JLCPCB part
- Alternate 50 pins DF12NC(3.0)-50DS-0.5V(51)
- Multi cell design with BQ25792
- Optional SPI NOR flash 1Mbit 3.3V, 12MHz
- 2 * TPS63030 buck/boost converters (pick cheaper alternative to up/down regulate with enable pin)

Firmware Drivers

- TPS65988 Linux
- BQ2425x Linux

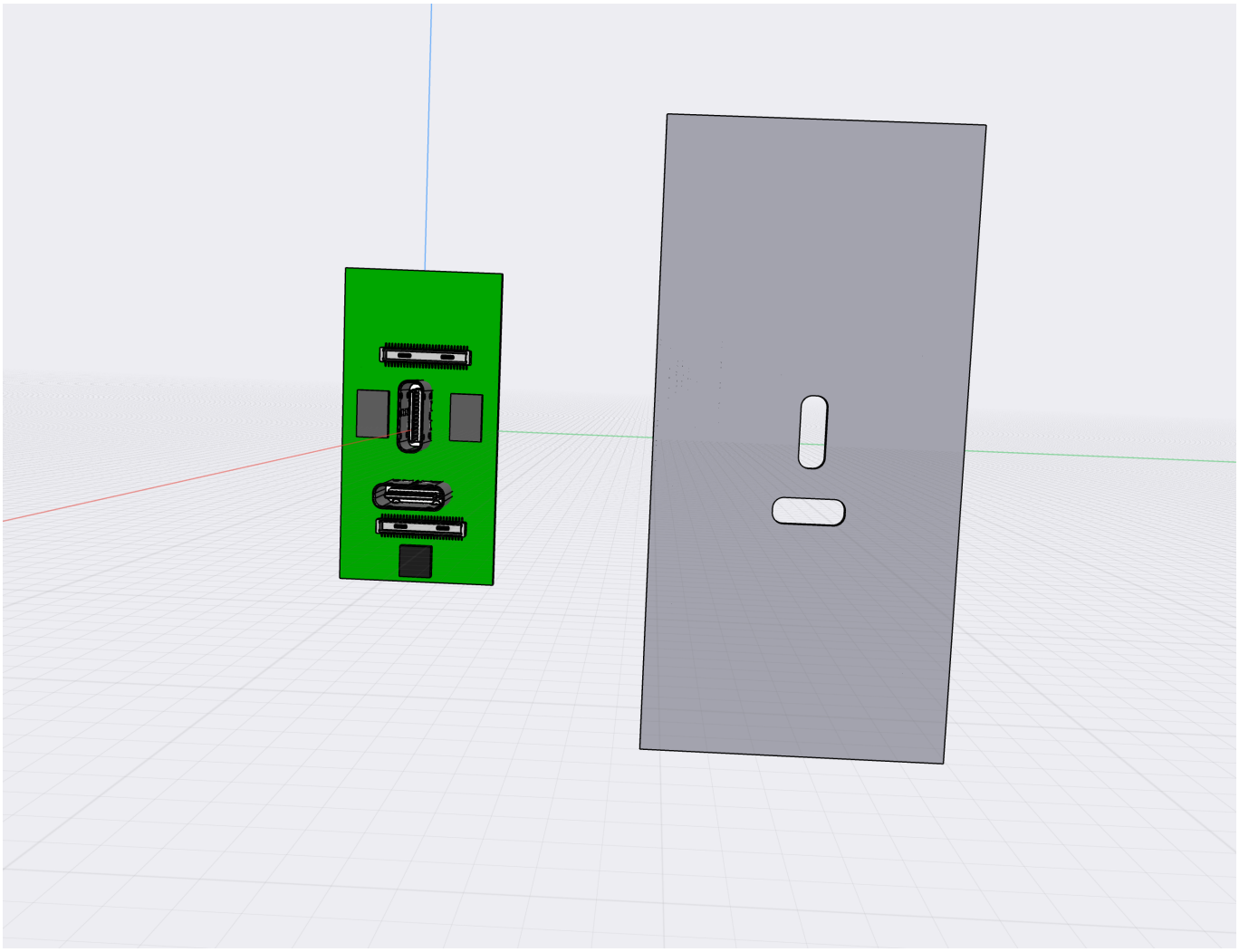
Data Routing

The basic data routing on the board is prepared for future expansion. There are a lot more connections into the board than are actually used.

Possible future extensions

- USB-C Alt. mode HDMI/DP
- UART over USB 2.0
- I2C over USB 2.0

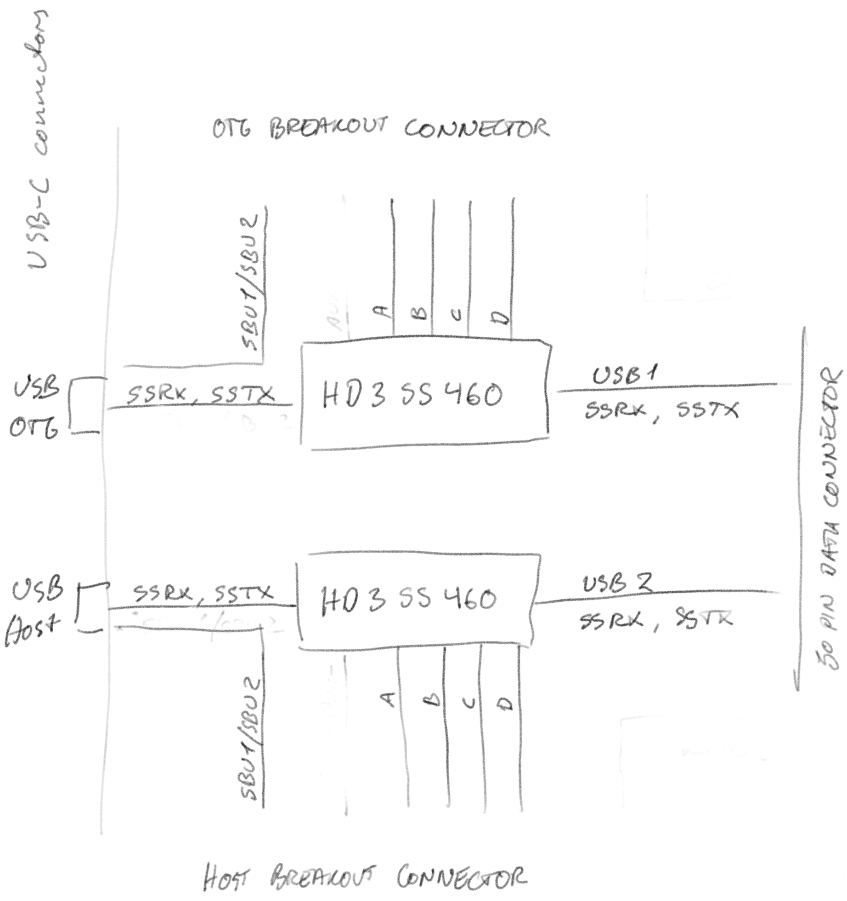
In the base setup without added logic the board routes USB 3.0/2.0 data through the two USB-C connectors.



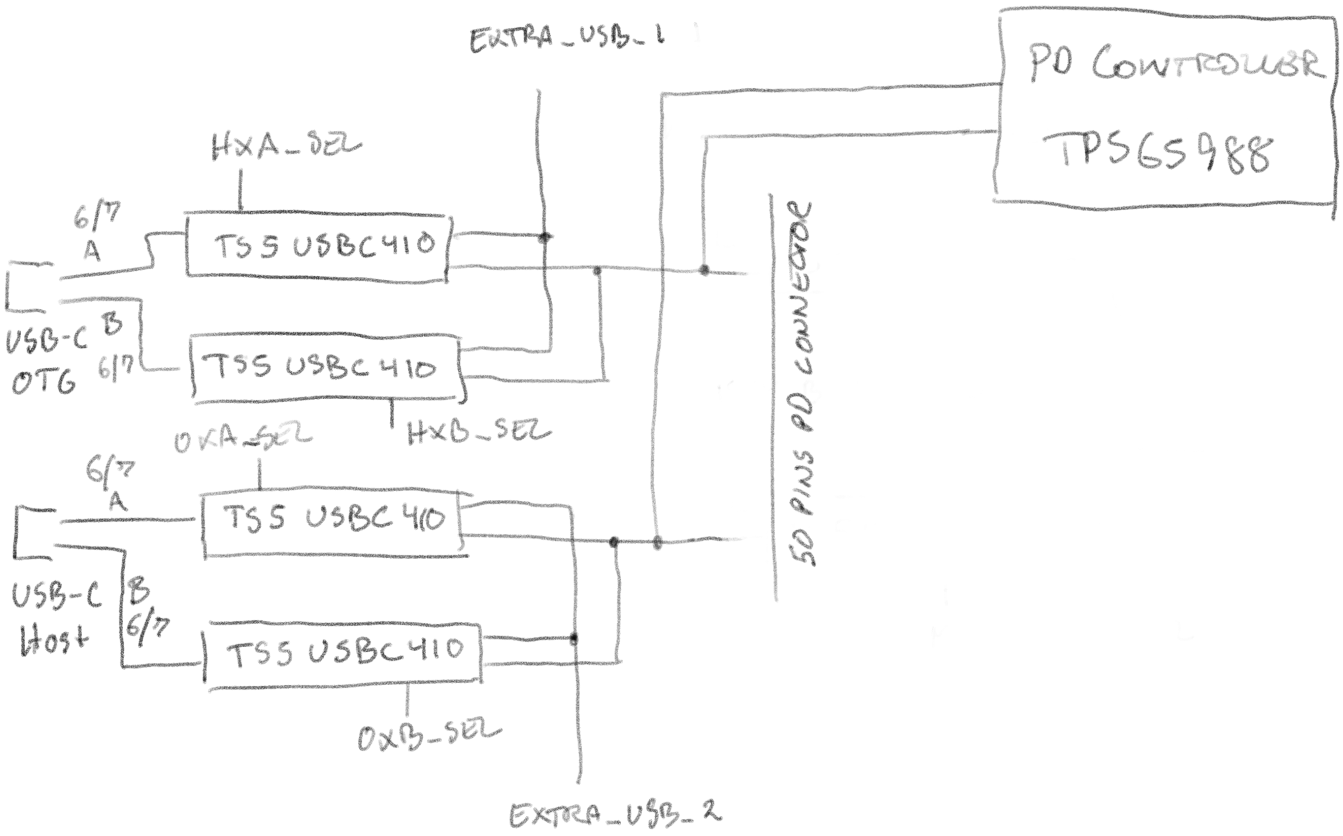
Multiplexing USB

The board has two USB busses 2.0 and 3.0. USB1(supports OTG) and USB2(Host mode only).

USB 3.0 is multiplexed as part of USB-C orientation support and is multiplexed between normal and alternate mode. With additional hardware the OTG USB 3.0 side can be made to support HDMI/DP in Alt. mode. The USB-C connector Alt. mode is managed by HD3SS460.



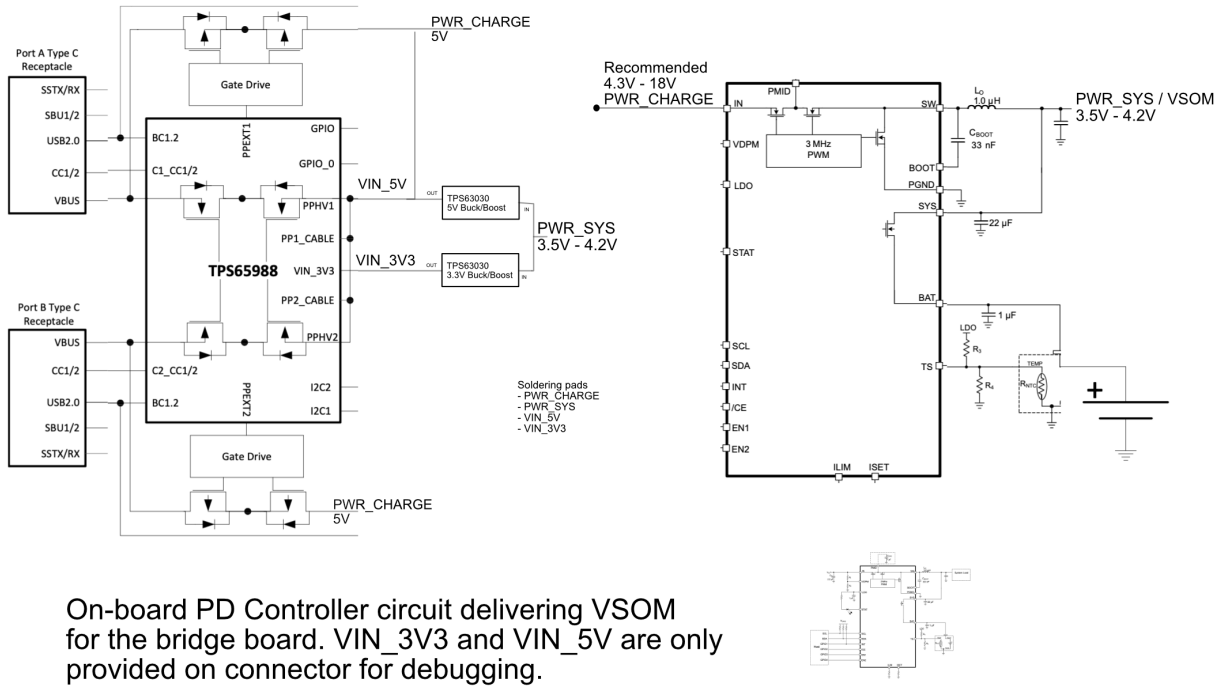
The USB-C connector USB 2.0 signals(A/B 6/7) are managed separately and multiplexed using TS5USBC41. This allows routing an Extra USB 2.0 signal selectively via the Debug Breakout connector.



The default(SEL = low?) state is to connect USB-C 2.0 line to the 50 pin PD Control Connector.

SEL	Connect to
High	m.2
Low	USB-C 2.0 via 50 pin connector

Power Supply



On-board PD Controller circuit delivering VSOM for the bridge board. VIN_3V3 and VIN_5V are only provided on connector for debugging.

Power Output vs Input

The board is primarily a USB power sink, it isn't meant to be a significant source of USB power output. For testing purposes the connectors provide two VIN_5V pins, which are supplied with up to 500 mA from the testing board by upscaling PWR_SYS to 5V. When connected to the regular bridge board VIN_5V and VIN_3V will not be supplied.

The board itself can be a source of 5V on one port, if it is a sink on the other port. For this purpose a direct connection is drawn from PWR_CHARGE to VIN_5V.

System Power

The system power is driven by the PD Controller. There is no need to power the board from other connectors than USB-C.

From it 3V3, 2V8, and 1V8 are derived.

- m.2 connectors are based on 3V3 and 1V8
- Sound is based on 3V3 or 1V8

- Cameras are 1V8, 2V8 and 3V3
- HDMI can supply 5V / 50 mA
- HDMI signal level is 5V
- The 6 pin connector has 5V low current

So there are in total 3 uses of 5V

1. HDMI supply and signal (50 mA)
2. VIN_5V supply (100 mA)
3. 6 pin connectors (directly connected with VIN_5V)

VIN_5V is optional and separate from the power on the board. It is supplied from the soldering pad/point. It is connected to PD Controller and 6 pin connectors.

I suggest that the HDMI 5V is supplied by stepping up VSOM.

I'm trying to understand the voltage diagram. It seems to have a lot of extra regulation.

What is the difference between SYS_PWR and VSOM ?

You have 5-20V_IN going to PA_PP_EXT / PB_PP_EXT and SYS_PWR. It this intended to drive the board? The board MUST work without power supplied to 5-20V_IN

Optional PD Controller Flash

The board features a slot for solderign on a 1MBit NOR Flash connected to the SPI pins of the TPS65988 PD Controller. The flash pins are exposed on one of the 50 pins connectors to enable direct programming and reading via testing board.

Acceptance Criteria on Power

- High voltage USB-C (20V / 12V / 9V) power supplies never produces more than 5V SYS_PWR when connected.
- If one USB port receives power (5V) the other port can deliver power (5V).
- VSOM is 3.45V to 4.4V regardless of charger
- If a Apple Dedicated Charger 5V(1A BC1.2) is connected the board can draw 1A
- If a CDP(5V, 1A) compatible charger is connected the board can draw 1A
- If a CDP(5V, 3A) compatible charger is connected the board can draw 3A

Combined T-USB control I/O Expander

Expander #3 combines control signals.

The development board uses a single Expander. The 909 uses 3x PCA9555 to control more states. The 801 uses 5x PCA9555 to control more states. This EX3 Combined T-USB control I/O Expander is placed on T-USB daughterboard.

The EX3 expander input triggers interrupt via EX_T_nINT (GPIO1_IO1). The pins relate to USB1 OTG, USB2 Host, PD Controller

The EX3 expander allows controlling T-USB maps,

The 3 pins for each Alt. Mode controller determines how signals are mapped to USB-C high speed lines. Refer to the datasheet for HD3SS460 for full truth table. The regular USBSS setup is chosen by POL=L, AMSEL=M, EN=H.

Expander	Connected to
EX3.0	PD_CTL_INT_1
EX3.1	PD_CTL_INT_2
EX3.2	PD_CTL_RESET
EX3.3	T_USB_O_ALT_EN
EX3.4	T_USB_O_ALT_POL
EX3.5	T_USB_O_ALT_AMSEL
EX3.6	T_USB_H_ALT_EN
EX3.7	T_USB_H_ALT_POL
EX3.8	T_USB_H_ALT_AMSEL
EX3.9	T_USB_ALERT
EX3.10	BAT_CHG_REVERSE
EX3.11	BAT_INT
EX3.12	OHX_MODE_BIT_0
EX3.13	OHX_MODE_BIT_1
EX3.14	RESERVED (OHX_MODE_BIT_2)
EX3.15	

OTG and Host USB 2.0 connectivity options. 2 bit switching of USB 2.0 mode. It may be combined with Alt Modes to be 3 bit.

OHX MODE	Signal combination
0	Regular USB 2.0 data on USB1/USB2 A/B
1	USB1 A=Regular, B=Debug UARTs. USB2 3.0 Alt mode = JTAG

Should enable only be over 50 pins connector ?

Ouput BAT_CHG_REVERSE Charge Status Open Drain Output. CHG is pulled low when a charge cycle starts and remains low while charging. CHG is high impedance when the charging terminates and when no supply exists. CHG does not indicate recharge cycles.

Battery Charging

Battery charging is an optional feature enabled by connecting a LiPO battery cell.

- Switch between trickle charge(0.1C) and fast charge(1.5C).
- Charge strategy timout setting
- Suspend on low power
- Resume on good power

!! I2C must be connected to I2C3, not SYS !! Or not!! with the PCIe clock being on address 0x68

Power output from Charging Controller

When operating with single cell Li-Ion batteries, output voltage range can be from 3.0V-4.2V. It is recommended not to operate at minimum battery voltage, to prolong a Li-Ion battery's life. Please refer to the battery manufacturer's data sheet or design guide for details.

- VSOM output Main power for board 3.5V - 4.2V
- Direct power input pads support 4V - 6V

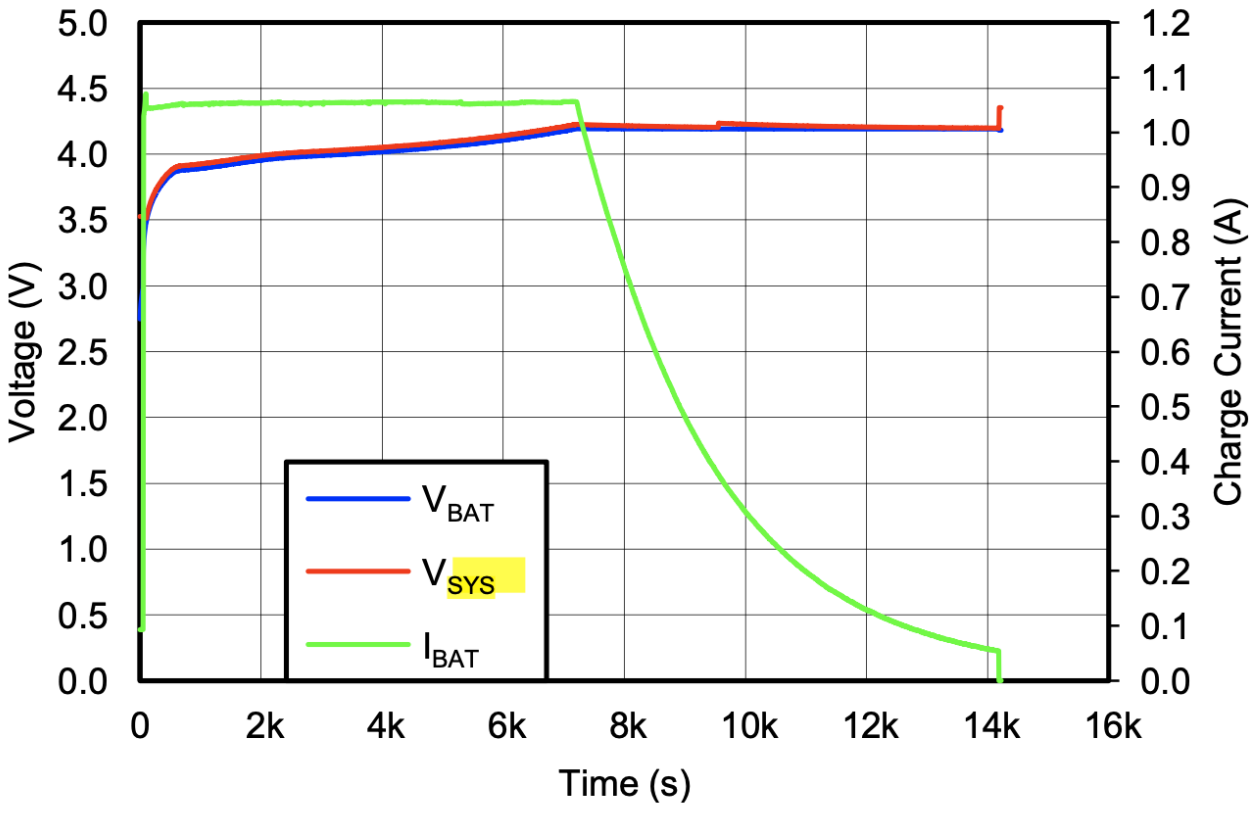
The board will attempt to constantly supply power. Either from a 3.7V LiPO battery, 5V input solder pads, or USB power source.

The system should attempt to detect low power and suspend or power down before reaching VSOM 3.45V.

Measuring battery voltage

https://blog.ampow.com/lipo-voltage-chart/

The battery charger will deliver a voltage close to 4.0V under normal charging conditions. It will deliver a steady 3.5V level during precharge during the ~120 s.



Drawing charger + PD = VSOM

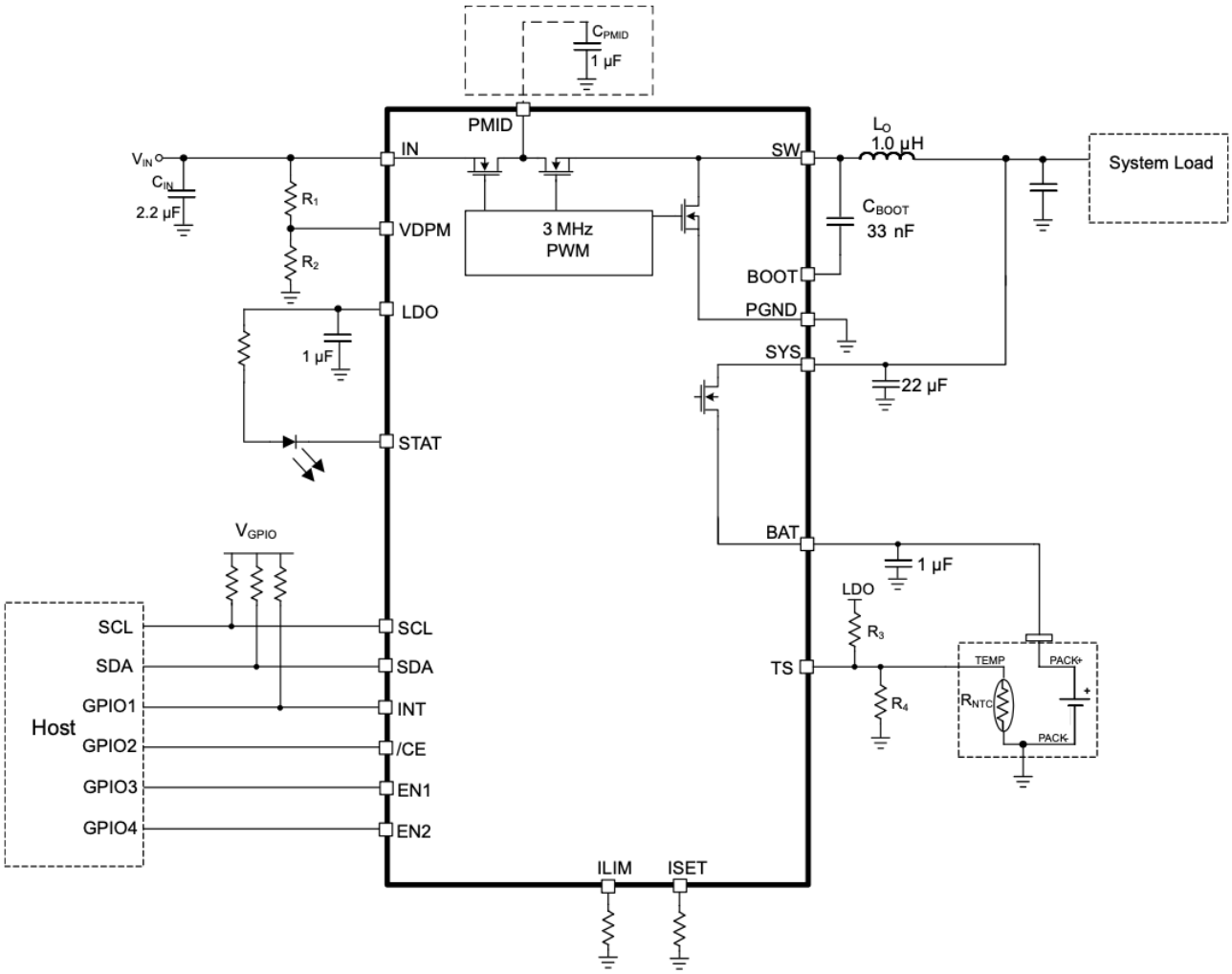
Wireless power input

Trickle charging over secondary connection on BQ24165

Managed charging

- BQ24250RGER $2 JLCPCB (4x4 mm packages)
- BQ25253 $5 JLCPCB (2.4x2.4 mm package)

BQ24250 1-cell, 2-A, I2C controlled buck battery charger with 1uA in SYSOFF mode and TS disable function



Connect battery via GND, TEMP (TS), PACK+ (BAT)

Add LED to indicate charging is connected to STAT.

Charge current ISET resistor 500mA / 1A / 2A (4 resistors in parallel?)

Max input current limit

Short ILIM to GND for default 2A input current(IN) limit. EN2 = Low EN1 = High

EN1 could be driven by extender to enable switching between 0.5A and 2A.

R_ILIM = 270 / I_IC

Does this mean that 4 resistors of 540 ohm in parallel with breakable soldering points would allow adjusting the board to a specific battery?

Acceptance Criteria on Power With Battery

- If power is connected to USB the battery can charge
- If no power is connected the system is battery powered

801 T-USB Connector Pinouts

50 pin B2B connectors

Two connectors tie the daughterboard to the bridge board. Both are of a 50 pin Highrose B2B type.

- JLCPCB plug
- JLCPCB socket

default height 1.5mm

Connector 1: High Speed Data Connector 2: PD Controller, Debug, USB 2.0

Power	Max Current	Pins
VSOM	2.7 A	9
GND	2.7 A	9
VCC_RTC	600 mA	2
VIN_3V3	300 mA	1
VIN_5V	600 mA	2

Connector 1 high-speed data, close to SoM

- 5 * GND, 1 * VIN_3V3
- 5 * VSOM, 2 * VIN_5V

One side

Pin	Code	Type	Details	Voltage
1	GND	Power	Ground	
2	USB1_RX_DP	USB	USB1 RX D+	
3	USB1_RX_DN	USB	USB1 RX D-	
4	GND	Power	Ground	
5	USB1_TX_DP	USB	USB1 TX D+	
6	USB1_TX_DN	USB	USB1 TX D-	

Pin	Code	Type	Details	Voltage
7	GND	Power	Ground	
8	USB1_RX_DP	USB	USB2 RX D+	
9	USB1_RX_DN	USB	USB2 RX D-	
10	GND	Power	Ground	
11	USB1_TX_DP	USB	USB2 TX D+	
12	USB1_TX_DN	USB	USB2 TX D-	
13	GND	Power	Ground	
14	T_USB_O_ALT_EN	AltMode	Exposed EX3	
15	T_USB_O_ALT_POL	AltMode	Exposed EX3	
16	T_USB_O_ALT_AMSEL	AltMode	Exposed EX3	
17	T_USB_H_ALT_EN	AltMode	Exposed EX3	
18	T_USB_H_ALT_POL	AltMode	Exposed EX3	
19	T_USB_H_ALT_AMSEL	AltMode	Exposed EX3	
20				
21				
22	VIN_3V3		Supply for TPS64988 circuitry and I/O. Current 50 mA	3.3V
23				
24				
25	SPI_3V3	Power	Power to the flash chip. Bridge connects to VIN_3V3	3.3V

TODO remove EX3 exposure

Other side

Pin	Code	Type	Details	Voltage
50	LVCLK+	LVDS	LVDS CLK+	
49	LVCLK-	LVDS	LVDS CLK-	
48	VSOM	Power	Main power for board 3.45V - 4.5V	
47	LVD0+	LVDS	LVDS D0+	
46	LVD0-	LVDS	LVDS D0-	
45	VSOM	Power	Main power for board 3.45V - 4.5V	

Pin	Code	Type	Details	Voltage
44	LVD1+	LVDS	LVDS D1+	
43	LVD1-	LVDS	LVDS D1-	
42	VSOM	Power	Main power for board 3.45V - 4.5V	
41	LVD2+	LVDS	LVDS D2+	
40	LVD2-	LVDS	LVDS D2-	
39	VSOM	Power	Main power for board 3.45V - 4.5V	
38	LVD3+	LVDS	LVDS D3+	
37	LVD3-	LVDS	LVDS D3-	
36	VSOM	Power	Main power for board 3.45V - 4.5V	
35				
33				
32	VIN_5V	Power	System 5V power source (PPHV1, PPHV2, PP1_CABLE, PP2_CABLE). 500 mA.	5V
31				
30				
29	VIN_5V	Power	System 5V power source (PPHV1, PPHV2, PP1_CABLE, PP2_CABLE). 500 mA.	5V
28				
27				
26				

Could also be HDMI or PCIe

Connector 2 PD controller, away from SoM

- 3 * VSOM, 3 * GND, 1 * VCC_RTC
- 1 * VSOM, 1 * GND, 1 * VCC_RTC

One side

Pin	Code	Type	Details	Voltage	Misc
1	VSOM	Power	Main power for board 3.45V - 4.5V		
2	GND	Power	Ground		
3	USB1_DP	USB	USB1 D+		
4	USB1_DN	USB	USB1 D-		

Pin	Code	Type	Details	Voltage	Misc
5	GND	Power	Ground		
6	USB2_DP	USB	USB2 D+		
7	USB2_DN	USB	USB2 D-		
8	GND	Power	Ground		
9	SWD_CLK	Debug	PD Controller GPIO12		
10	SWD_DAT	Debug	PD Controller GPIO13		
11	VSOM	Power	Main power for board 3.45V - 4.5V		
12	EX0_nINT	IRQ	Interrupt signal (GPIO4_IO19)		P21.30
13	EX_OH_nINT	IRQ	Interrupt signal (GPIO1_IO0)		P20.12
14	EX_T_nINT	IRQ	Interrupt signal (GPIO1_IO1).		P20.14
15	VSOM	Power	Main power for board 3.45V - 4.5V		
16	SYS_RST_PMIC	Reset	PMIC reset input pin. Internally pulled up with LDO1 power rail. Once low, PMIC performs reset.		P10.9
17	POR_B_3P3	Reset	Power On reset output pin. Open drain output requiring external pull up resistor.		P10.7
18	PMIC_ON_REQ	Reset	PMIC ON input from Application processor. When high, the device starts power on sequence.		P10.5
19	PMIC_STBY_REQ	Reset	Standby mode input from Application processor. When high, device enters STANDBY mode.		P10.3
20	VCC_RTC	Power	Low power mode supply		
21	PWRBTN	Boot	Power button trigger		
22	ALT_BOOT	Boot	Alternate boot		
23	QSPI_BOOT_EN_3P3	Boot	SPI boot		P21.18
24	BAT_CE#	Charger	Charge Enable Active-Low Input. Connect CE to a high logic level to place the battery charger in standby mode.		
25	PD_VIN_EN		Enable VIN_5V/3V3 from PWR_SYS (TBD)		

Other side

Pin	Code	Type	Details	Voltage	Misc

Pin	Code	Type	Details	Voltage	Misc
50	VSOM	Power	Main power for board 3.45V - 4.5V		
49	GND	Power	Ground		
48	UART1_TXD	UART	P1.72 UART1 Tx		P20.9
47	UART1_RXD	UART	P1.19 UART1 Rx		P20.11
46	UART2_TXD	UART	UART2 Tx		P20.1
45	UART2_RXD	UART	UART2 Rx		P20.3
44	UART3_TXD	UART	P1.61 UART3 Tx		P20.2
43	UART3_RXD	UART	P1.21 UART3 Rx		P20.4
42	UART4_TXD	UART	UART4 Tx		P20.8
41	UART4_RXD	UART	UART4 Rx		P20.10
40	I2C SCL	I2C	P1.99 SYS SCL		P21.7
39	I2C SDA	I2C	P1.97 SYS SDA		P21.5
38	I2C3 SCL	I2C	Stem SCL		P21.2 ?
37	I2C3 SDA	I2C	Stem SDA		P21.4 ?
36	VCC_RTC	Power	Low power mode supply		
35					
34					
33	SPI_CS	PD	Programming/External flash directly	3.3V	
32	SPI_CLK	PD	Programming/External flash directly	3.3V	
31	SPI_MISO	PD	Programming/External flash directly	3.3V	
30	SPI_MOSI	PD	Programming/External flash directly	3.3V	
29					
28					
27					
26					

USB-C connectors arranged in a T

Two USB-C connectors are arranged in a T shape and the normal way to use it is with a combined connector attached. This means that the wires will normally be connected in a particular orientation. The system takes advantage of this by detecting when both USBs are connected in the normal arrangement.

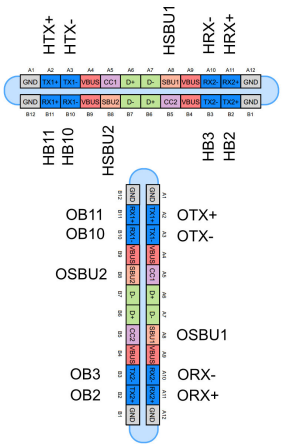
The pins are individually connected to chipsets in order to allow multiplexing based on the situation.

USB OTG reference hookup

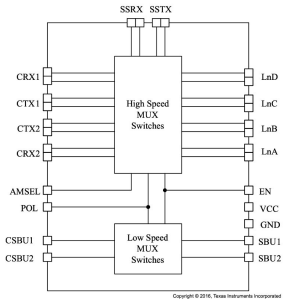
The USB connectors are named H (Host) and O (OTG). Host is the top of the T, OTG is the vertical base. To specify a specific pin H or O is prefixed I.E. OTX1+, HSBU2.

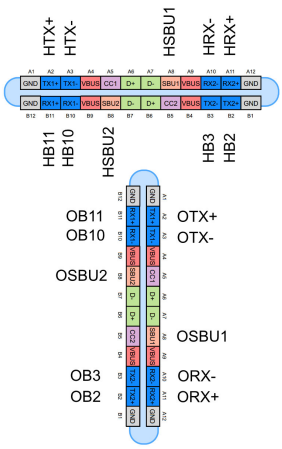
Where possible data pins are not combined but carried through individually.

The GND/VBUS pins are connected to the power charging circuit as normal. The system should accept charging power from either connector.



T-USB plugged in combo





DisplayPort over Host USB

No.	Pin	Usage	OTG connect to..	Host connect to..
1	A1	GND		
2	A2	TX1+		HD3SS460
3	A3	TX1-		HD3SS460
4	A4	VBUS		
5	A5	CC1	TPS65988	TPS65988
6	A6	D+	65988 & MCU	65988 & MCU
7	A7	D-	65988 & MCU	65988 & MCU
8	A8	SBU1		HD3SS460
9	A9	VBUS	65988 & Regs	65988 & Regs
10	A10	RX2-		HD3SS460
11	A11	RX2+		HD3SS460
12	A12	GND		
13	B1	GND		
14	B2	TX2+		HD3SS460
15	B3	TX2-		HD3SS460

No.	Pin	Usage	OTG connect to..	Host connect to..
16	B4	VBUS	65988 & Regs	65988 & Regs
17	B5	CC2	TPS65988	TPS65988
18	B6	X+	65988 & MCU	65988 & MCU
19	B7	X-	65988 & MCU	65988 & MCU
20	B8	SBU2		HD3SS460
21	B9	VBUS	65988 & Regs	65988 & Regs
22	B10	RX1-		HD3SS460
23	B11	RX1+		HD3SS460
24	B12	GND		

The USB Type-C connector has 24 pins. Figures 1 and 2, respectively, show the pins for the USB Type-C receptacle and plug.

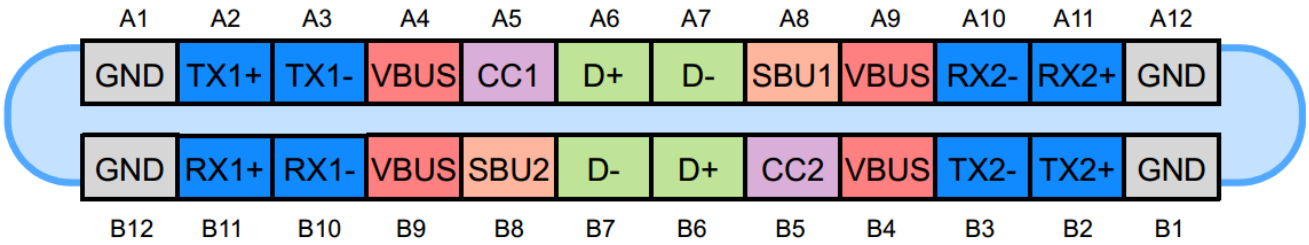


Figure 1. The USB Type-C receptacle. Image courtesy of Microchip.

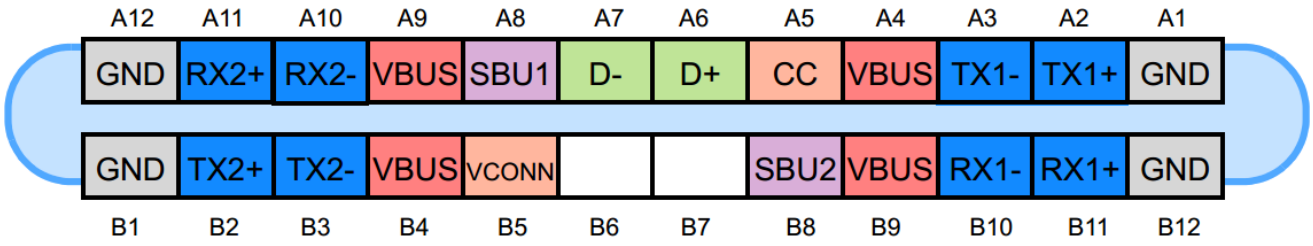


Figure 1. The USB Type-C plug. Image courtesy of Microchip.

For later revision

Only **one side** of the connectors are connected to the matching USB connector that leads to the Dev Board.

The following pins are connected to the extras connector: TX2+, TX2-, SBU1, SBU2, RX-, RX1+, DX+, DX-

The following pins are treated as normally USB-C connection pins: A1-A7, A9-A12, B5.

T-USB alt mode connectors

These connectors(only on the 909 model) enables experimentation with alternate modes and directional pins.

Host ALT

Pin	Code	Description
1	3V3	
2	SBU2	Host AUX+ / SBU2
3	SBU1	Host AUX- / SBU1
4	3V3	
5	HA+	Host A+
6	HA-	Host A-
7	3V3	
8	HB+	Host B+
9	HB-	Host B-
10	3V3	
11	HC+	Host C+
12	HC-	Host C-
13	3V3	
14	HD+	Host D+
15	HD-	Host D-
16	GND	
17		
18		
19	GND	
20	HX+	Host Extra 2.0 D+
21	HX-	Host Extra 2.0 D-
22	HXA_SEL	Select Host Extra A6/A7
23	HXB_SEL	Select Host Extra B6/B7
24	GND	
25	LVCLK+	LVDS CLK+
26	LVCLK-	LVDS CLK-
27	GND	
28	LVD0+	LVDS D0+
29	LVD0-	LVDS D0-

Pin	Code	Description
30	GND	
31	LVD1+	LVDS D1+
32	LVD1-	LVDS D1-
33	GND	
34	LVD2+	LVDS D2+
35	LVD2-	LVDS D2-
36	GND	
37	LVD3+	LVDS D3+
38	LVD3-	LVDS D3-
39	GND	
40	TOUCH_INT	LVDS TOUCH INT EX0.6
41	TOUCH_RST	LVDS TOUCH Reset EX0.7
42	I2C SCL	SYS SCL
43	I2C SDA	SYS SDA
44	UART3_TXD	P1.61 UART3 Tx
45	UART3_RXD	P1.21 UART3 Rx

OTG ALT

Pin	Code	Description
1	3V3	
2	SBU2	OTG AUX+ / SBU2
3	SBU1	OTG AUX- / SBU1
4	3V3	
5	OA+	OTG A+
6	OA-	OTG A-
7	3V3	
8	OB+	OTG B+
9	HB-	OTG B-
10	3V3	
11	OC+	OTG C+

Pin	Code	Description
12	OC-	OTG C-
13	3V3	
14	OD+	OTG D+
15	OD-	OTG D-
16	GND	
17		
18		
19	GND	
20	OX+	OTG Extra 2.0 D+
21	OX-	OTG Extra 2.0 D-
22	OXA_SEL	Select OTG Extra A6/A7
23	OXB_SEL	Select OTG Extra B6/B7
24	GND	
25		
26		
27	GND	
28	TR1+	ETH0 TR 1+
29	TR1-	ETH0 TR 1-
30	GND	
31	TR2+	ETH0 TR 2+
32	TR2-	ETH0 TR 2-
33	GND	
34	TR3+	ETH0 TR 3+
35	TR3-	ETH0 TR 3-
36	GND	
37	TR4+	ETH0 TR 4+
38	TR4-	ETH0 TR 4-
39	GND	
40	ETH0_LED_ACT	LED_ACT
41	ETH0_LINK-LED_10_100	ETH0_LINK-LED_10_100

Pin	Code	Description
42	I2C SCL	P1.99 SYS SCL
43	I2C SDA	P1.97 SYS SDA
44	UART1_TXD	P1.72 UART1 Tx
45	UART1_RXD	P1.19 UART1 Rx

Compress GPIO with expander and stem I2C (wire I2C3 ?)

Soldering Pads

A number of connections should be broken out on the board as soldering pads (no through hole)

Pin	Function
VSOM	Output or Input
VCC_RTC	Power input RTC battery
PP_HV1	PD Controller power
PP_HV2	PD Controller power
VIN_5V	PD Controller System 5V for PP1_CABLE, PP2_CABLE
VIN_3V3	PD Controller System 3.3V
GND	