UCL

Oxford QuARC Electronics Testing

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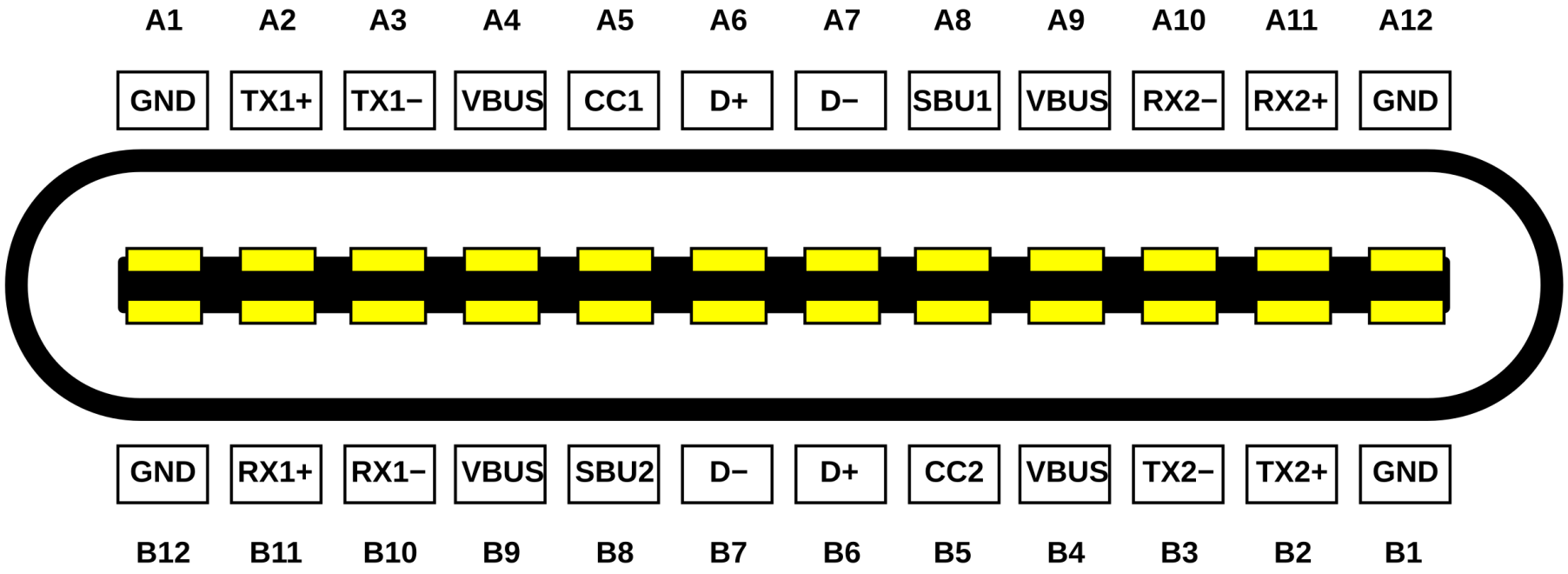
Background

- QuARC DAQ electronics needed upgrading from Cosylab system:
  - USB104 more compact and can be bus powered compared to Nexys Video.
  - ZMOD daughterboard needed in place of FMC with USB-C only.
  - All DDC board connections should be USB-C.
- Pete Hastings (Oxford) has already designed replacement ZMOD daughterboard:
  - Matt Warren able to communicate with Rev.D DDC boards (with modifications…).
  - New Oxford DDC boards just arrived with several design improvements.

USB-C Cable Ideal Pin Connection

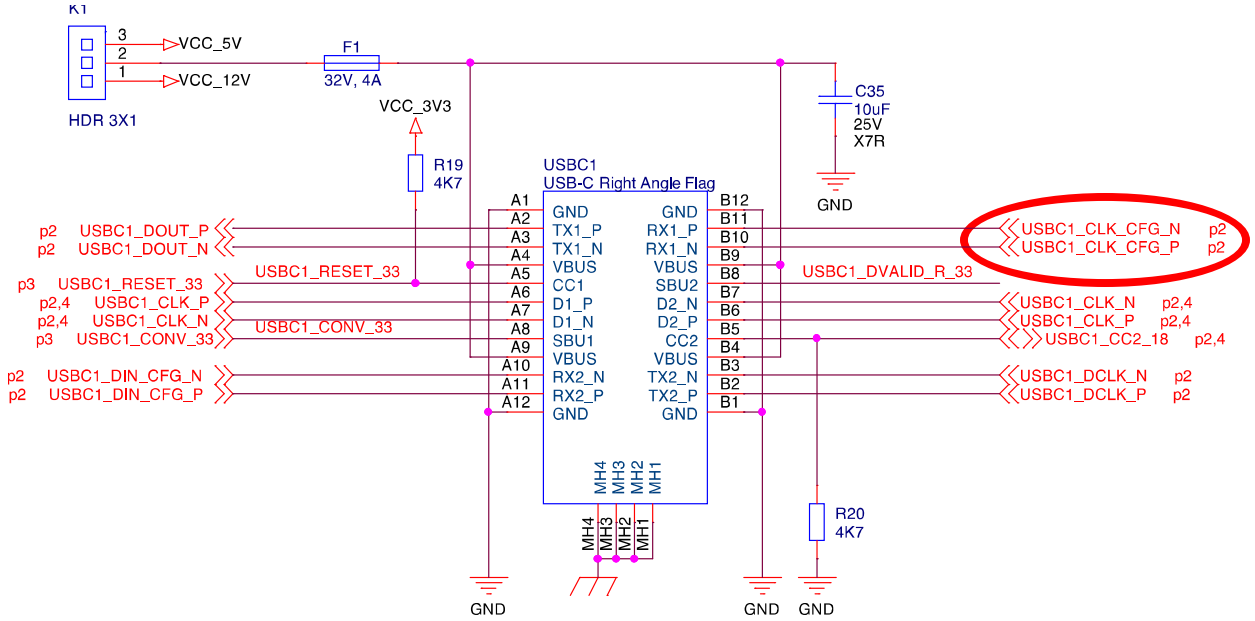


Input	Signals	Output	Signals
A1	GND	**A1**	GND
A2	TX1+	**B11**	RX1+
A3	TX1-	**B10**	RX1-
A4	VBUS	**A4**	VBUS
A5	CC1	**A5**	CC1
A6	D+	**A6**	D+
A7	D-	**A7**	D-
A8	SBU1	**B8**	SBU1
A9	VBUS	**A9**	VBUS
A10	RX2-	**B3**	TX2-
A11	RX2+	**B2**	TX2+
A12	GND	**A12**	GND
B12	GND	**B12**	GND
B11	RX1+	**A2**	TX1+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

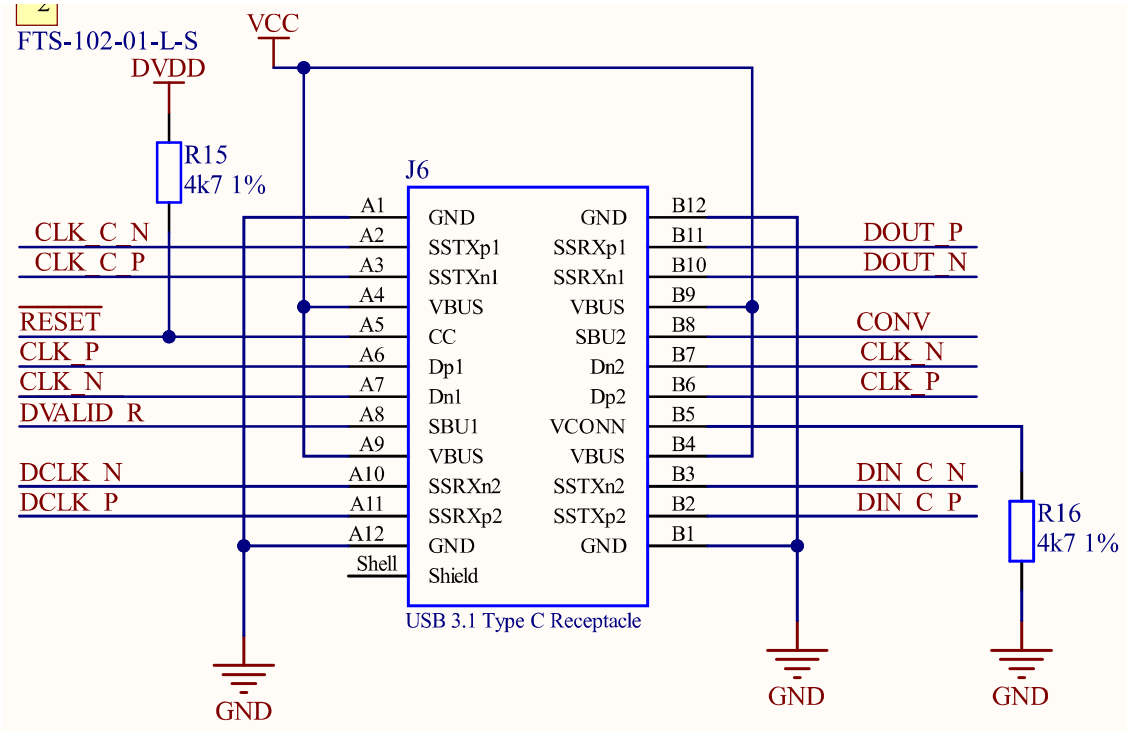
Input	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1
Signals	GND	TX1+	TX1-	VBUS	CC1	D+	D-	SBU1	VBUS	RX2-	RX2+	GND	GND	RX1+	RX1-	VBUS	SBU2	D-	D+	CC2	VBUS	TX2-	TX2+	GND
Output	**A1**	**B11**	**B10**	**A4**	**A5**	**A6**	**A7**	**B8**	**A9**	**B3**	**B2**	**A12**	**B12**	**A2**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

USB-C Connections: Cosylab Rev.D

FMC USB-C Connection

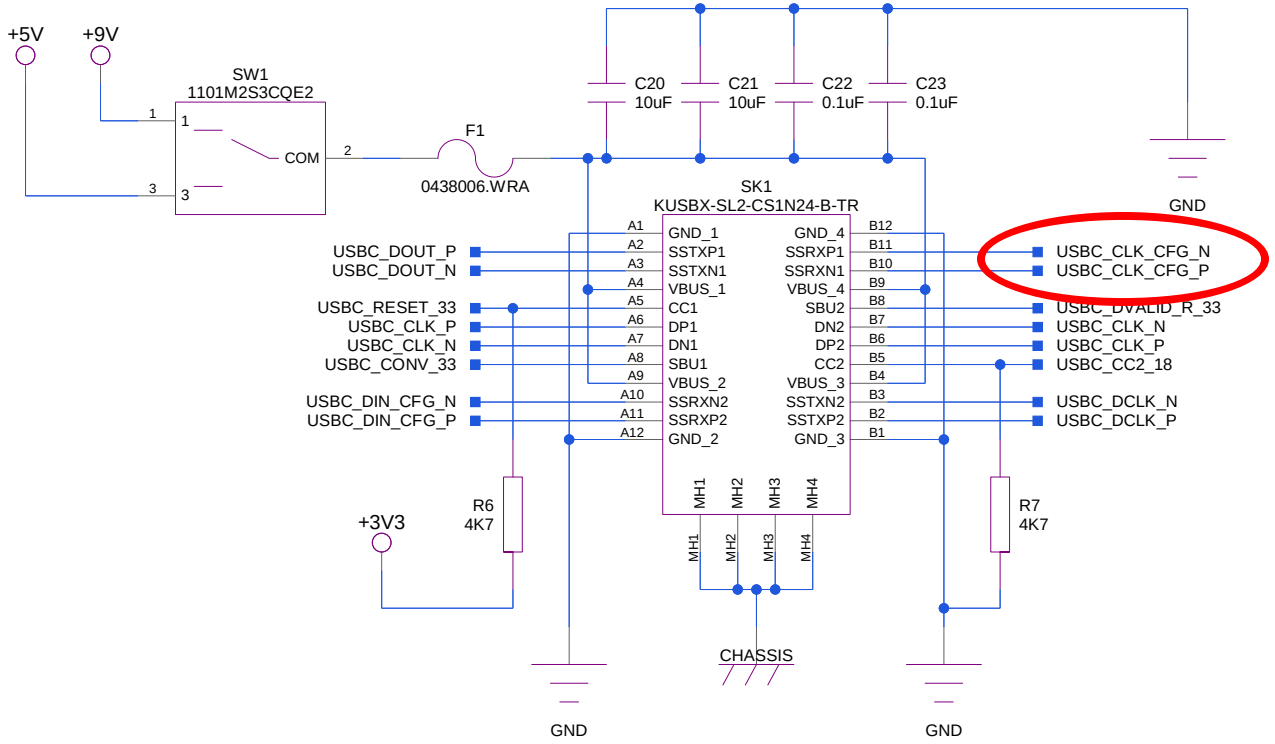


DDC Rev.D USB-C Connection

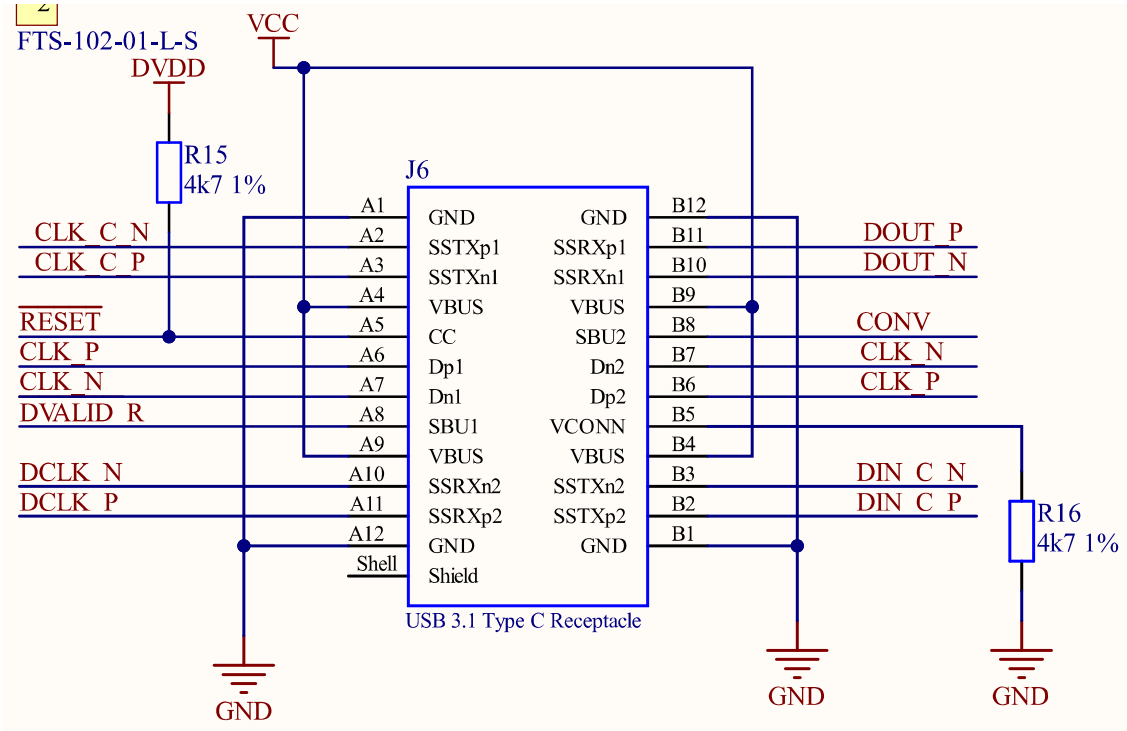


USB-C Connections: Rev.D + ZMOD v.1

ZMOD v.1 USB-C Connection

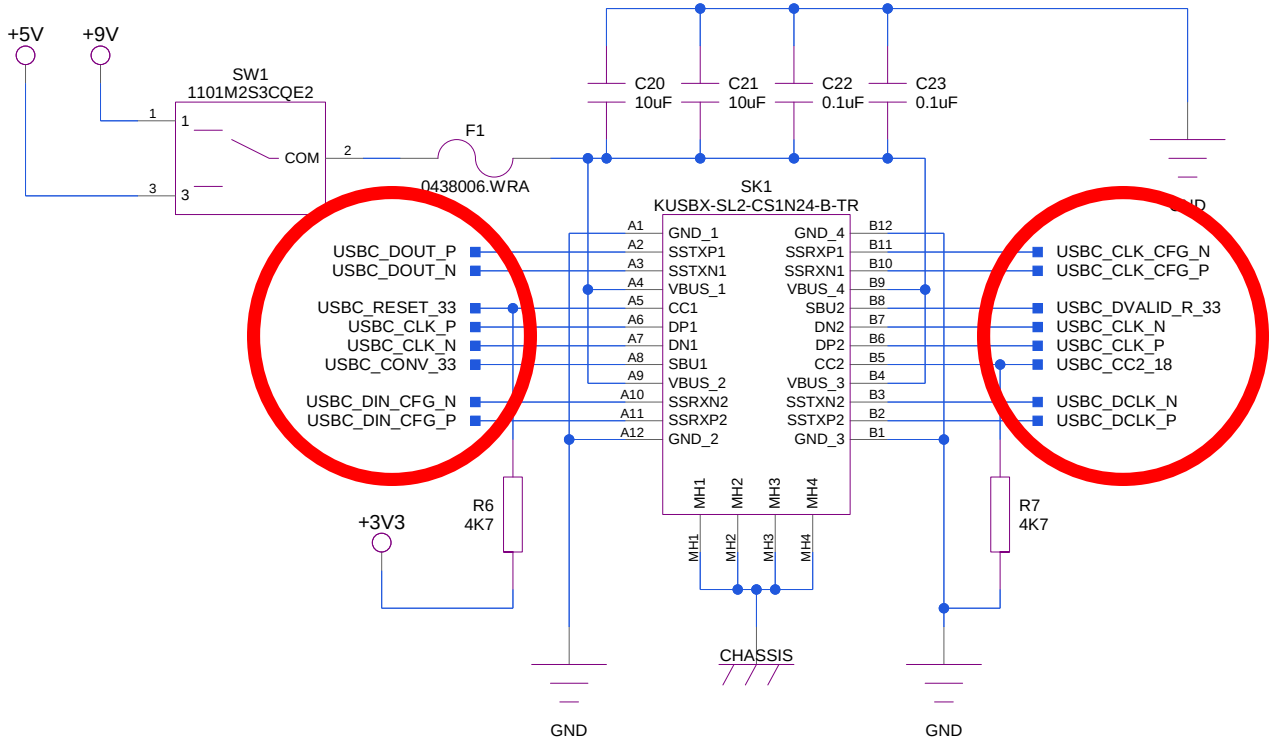


Cosylab DDC Rev.D USB-C

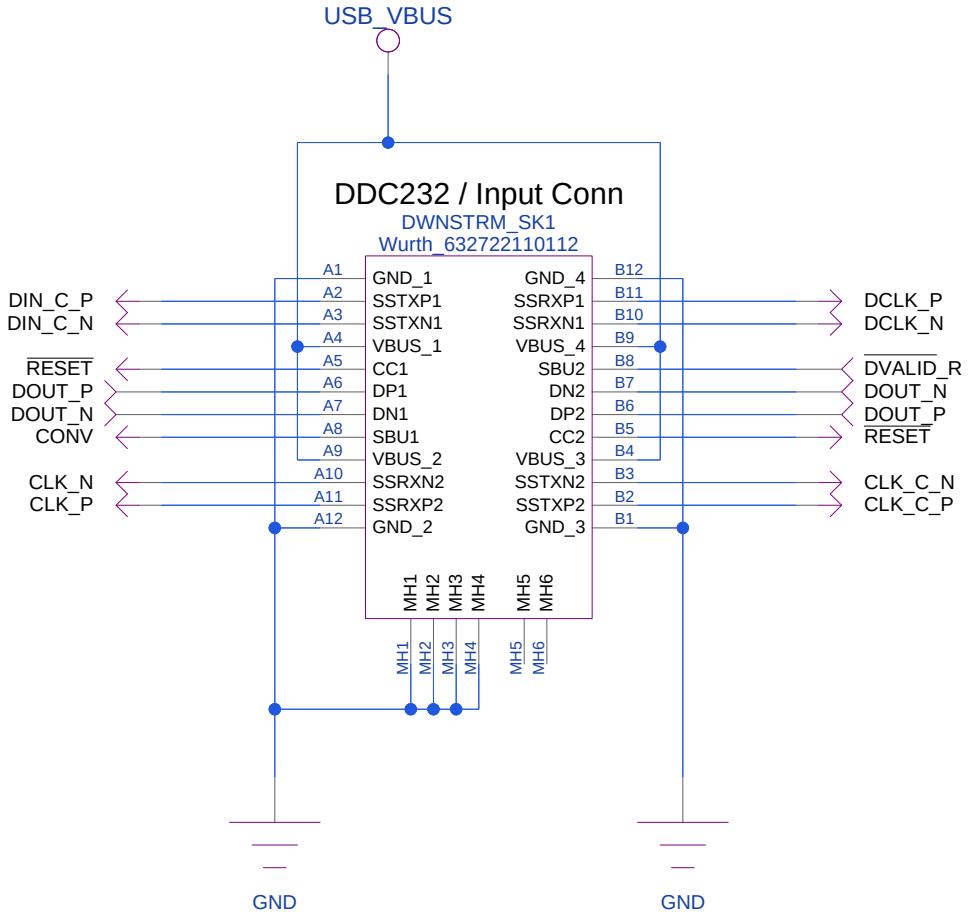


USB-C Connections: Oxford v.1

ZMOD v.1 USB-C Connection

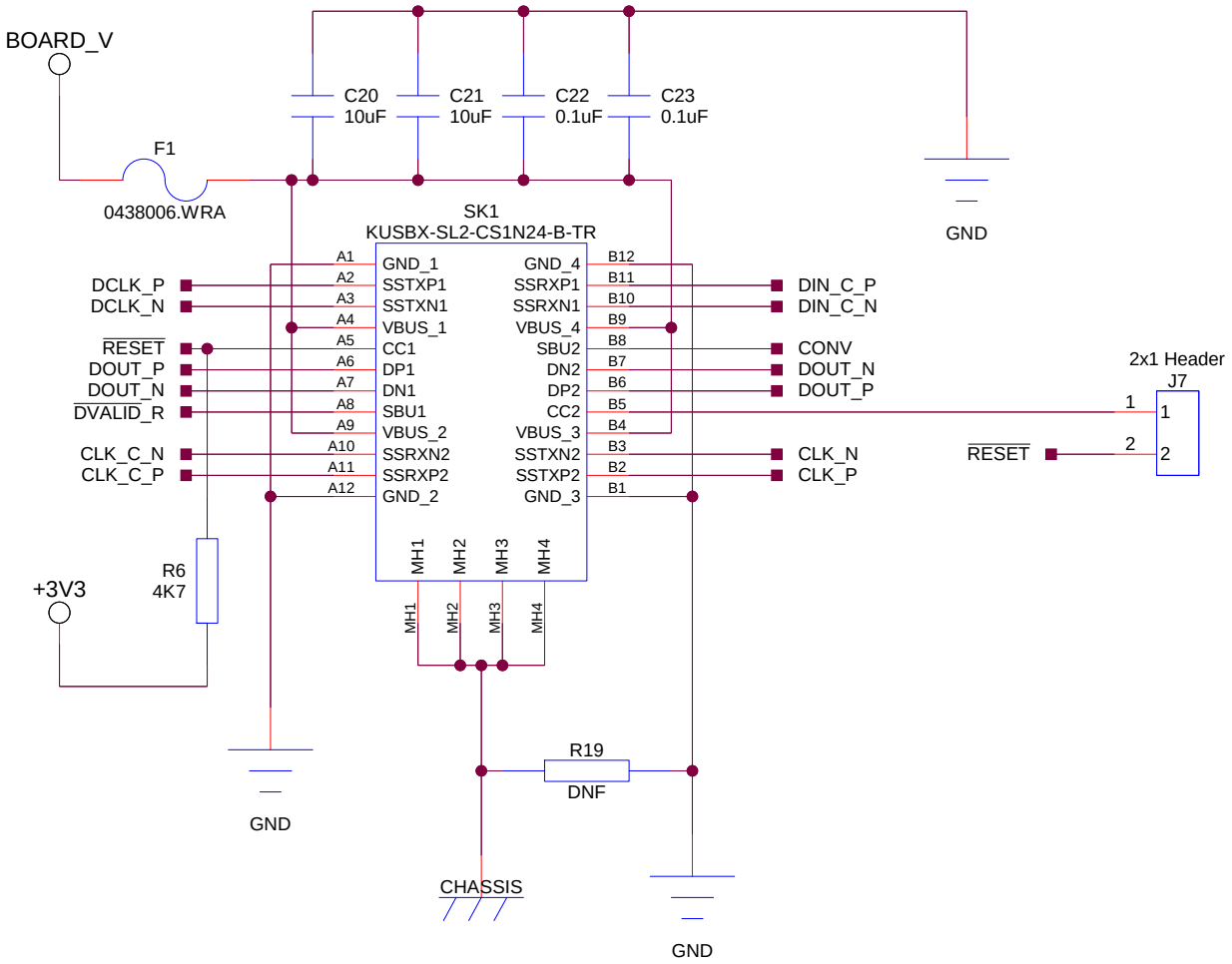


Oxford DDC Rev.E USB-C

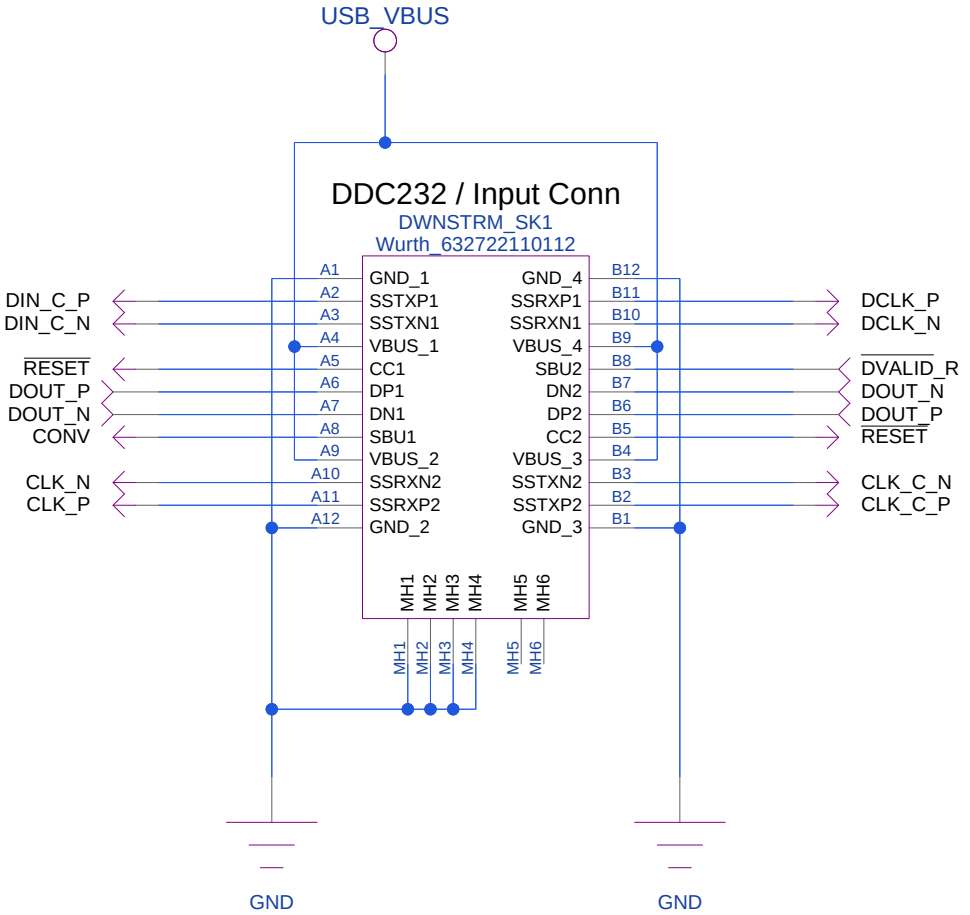


USB-C Connections: Oxford v.2 (Proposed)

ZMOD v.2 USB-C Connection

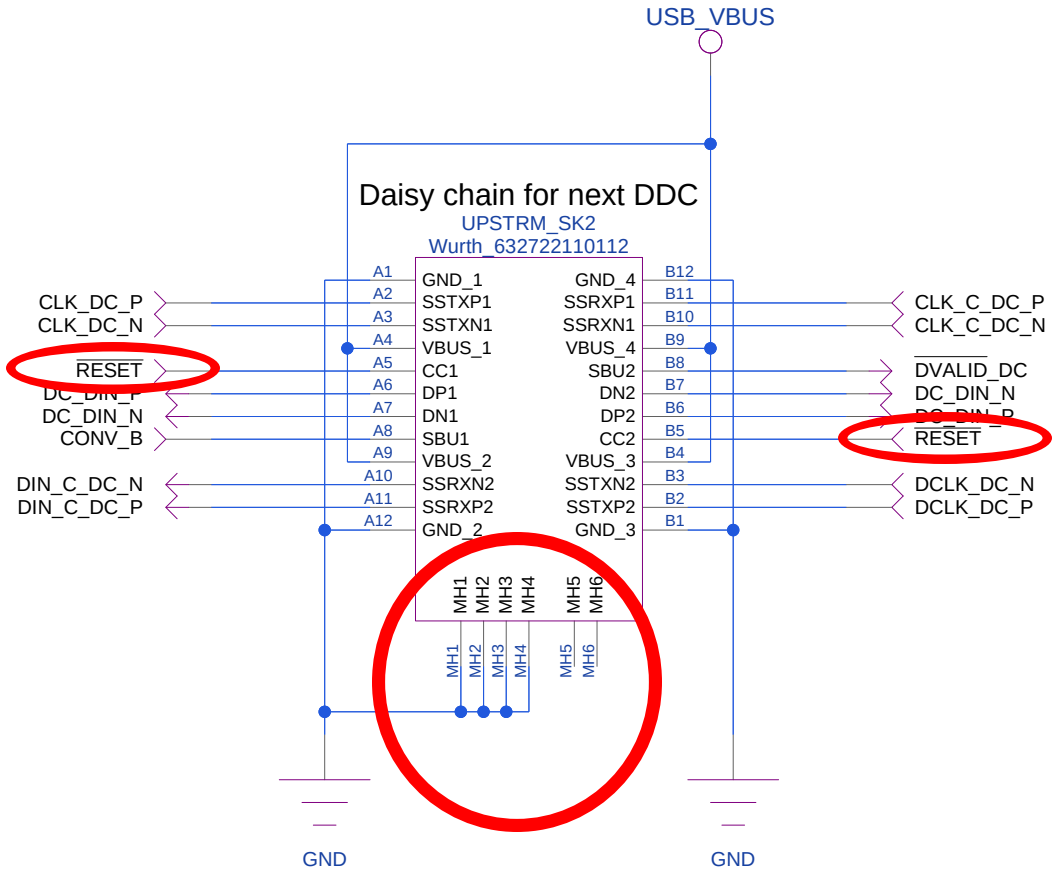


Oxford DDC Rev.E USB-C

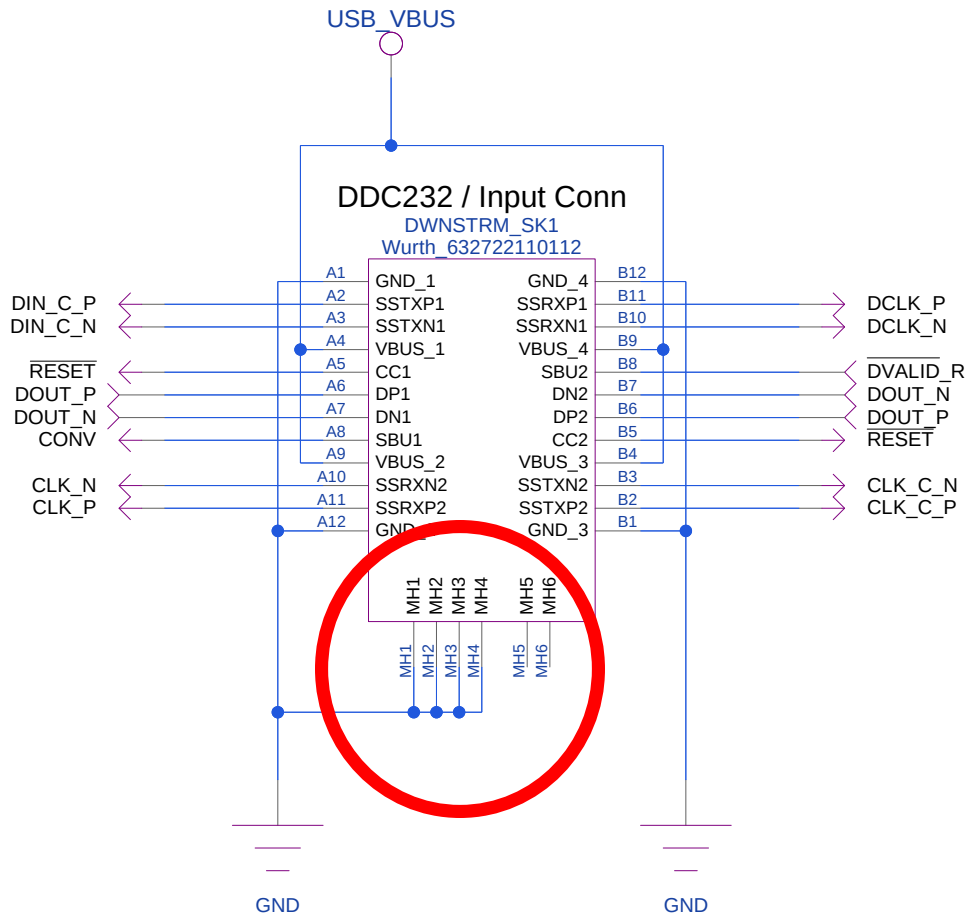


USB-C Connections: Oxford DDC Rev.E

Oxford DDC Rev.E USB-C U/S

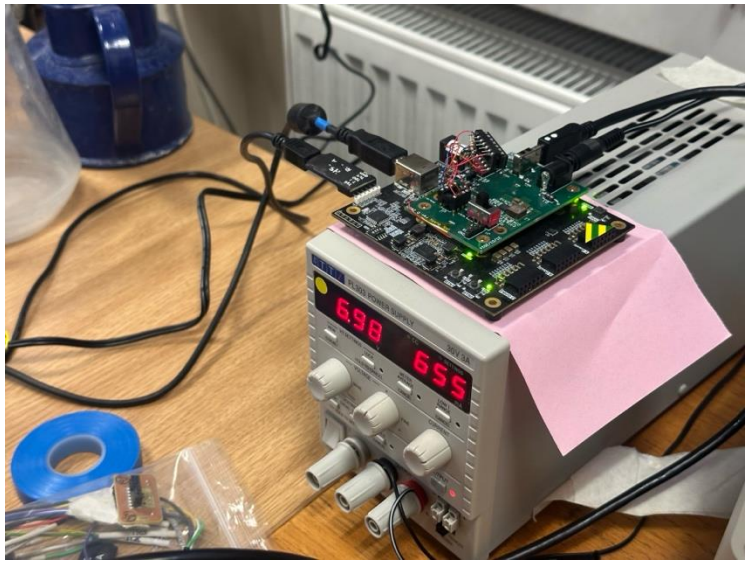


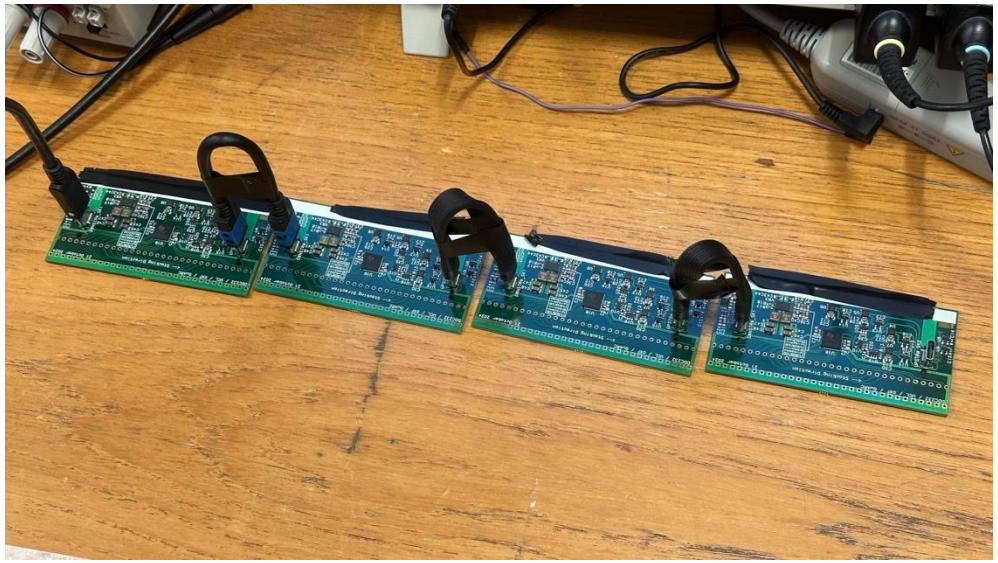
Oxford DDC Rev.E USB-C D/S



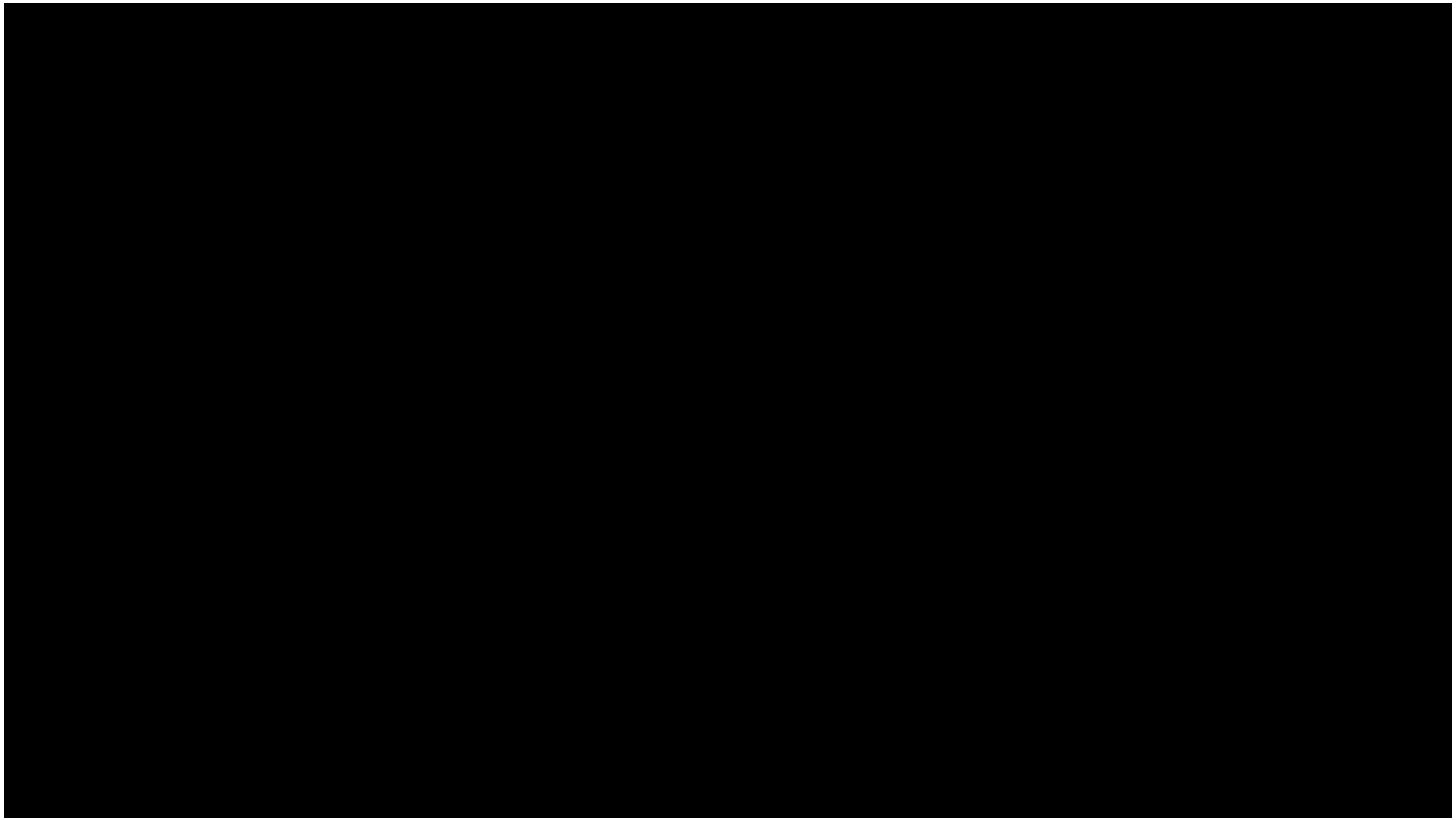
The Good News

- It works!
- After a few days buggering about with ZMOD signal assignments, we get the correct readback pattern:
  - `1801000000000000000000000000000000000000000000000000000000000000000000000000000030F066012480F69055`
- Can daisychain at least 4 boards! Readback pattern is **identical** for all boards.
- Possible to see a response when one moves a finger over photodiode connections (more later…).





Channel Reponse: Note Low Noise!



Testing Results

Good News

- “Noise”/interference that we have seen previously has vanished.
- Setup extremely stable and repeatable.
- Daisy-chaining works exactly as intended: 1–4 boards tested.
- Current draw low (at 7 V): will be able to drive single board from Raspberry Pi USB bus power only (600 mA/1.6 A).

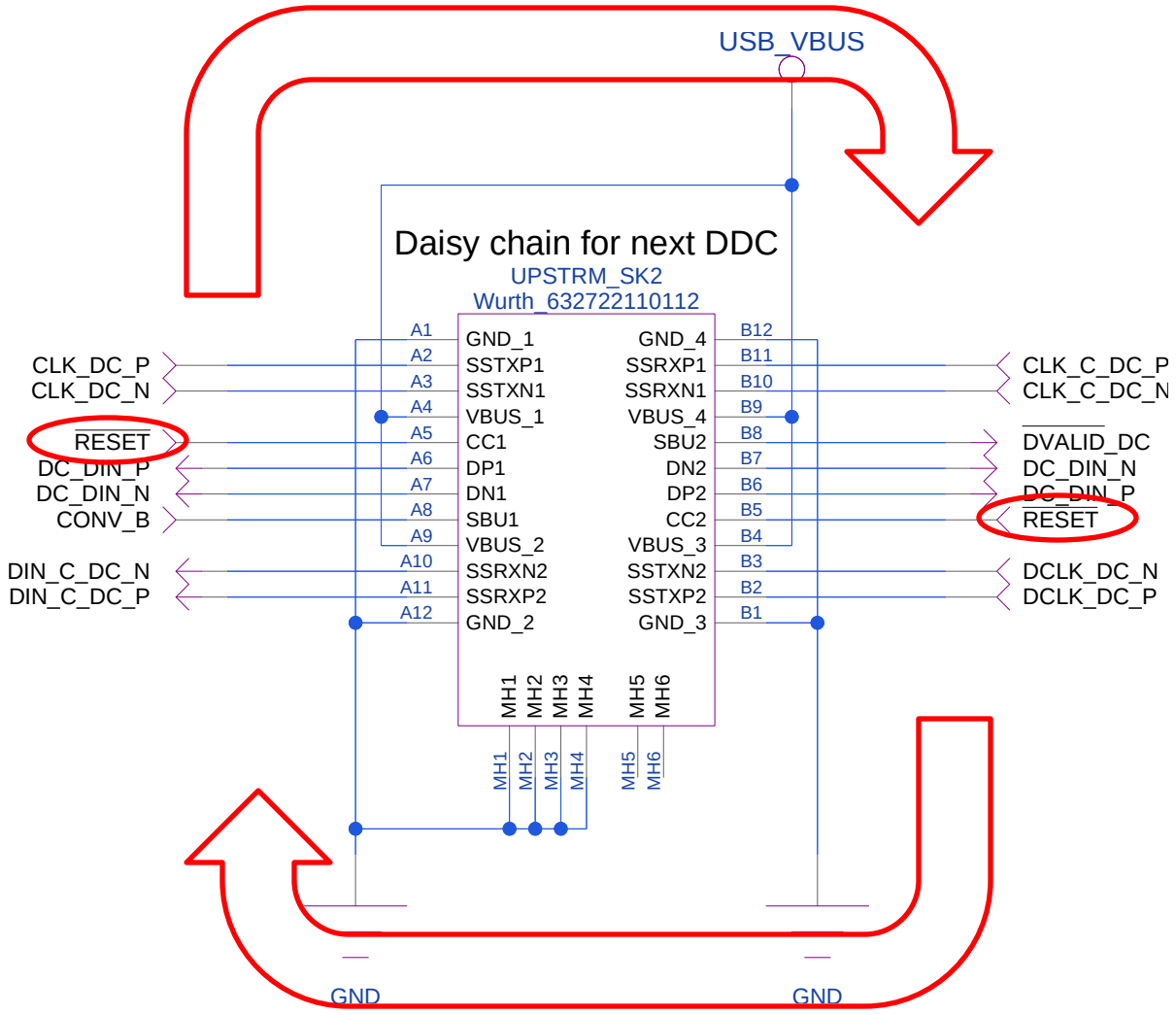
DDC Boards	Unconfigured	Running	Idle
1	169 mA	182 mA	170 mA
2	322 mA	348 mA	325 mA
3	479 mA	519 mA	484 mA
4	637 mA	689 mA	643 mA

Bad News

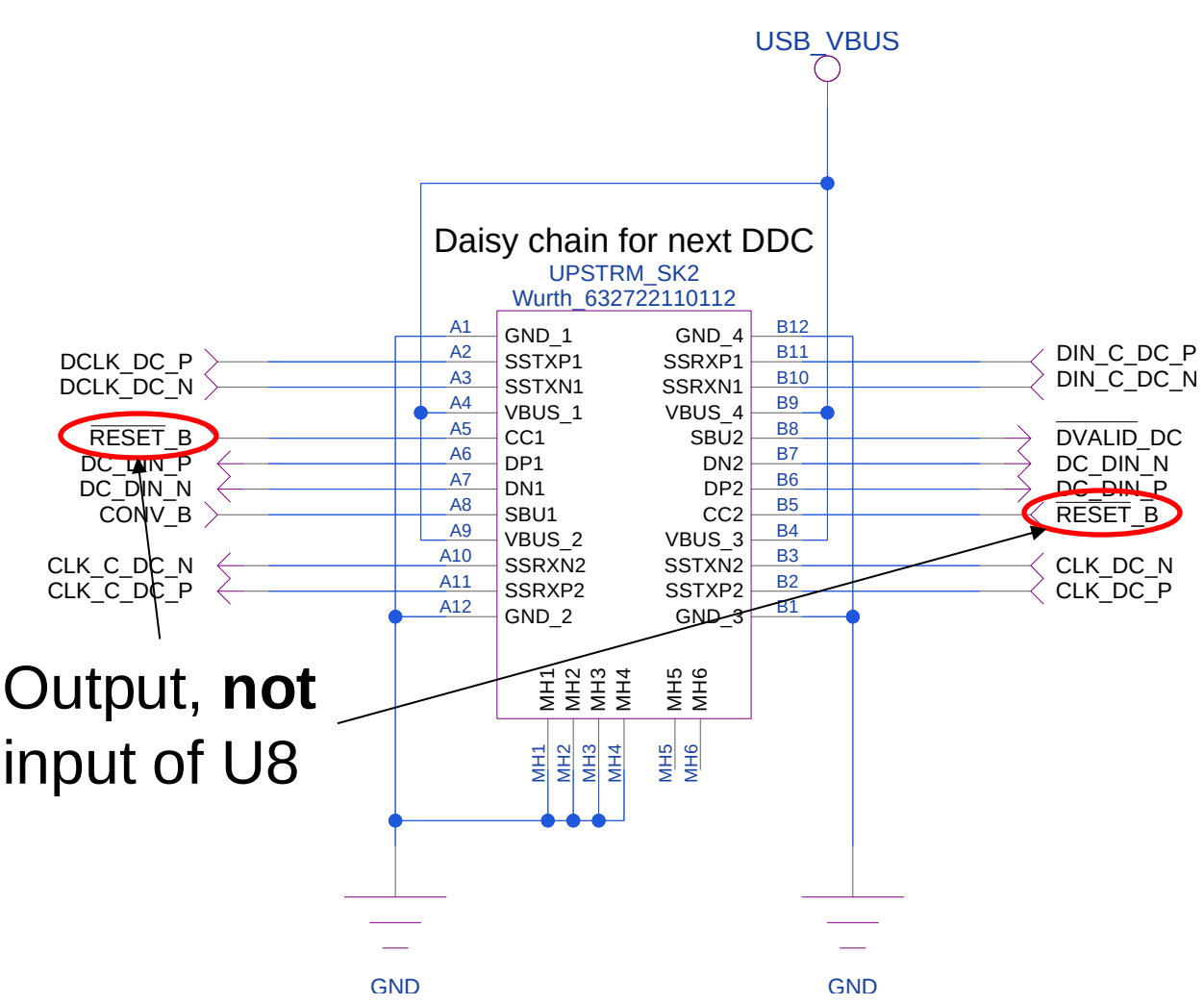
- “Upstream” USB-C socket on DDC board needs rotating 180 degrees: currently all USB-C board-to-board interconnects need 180 degree twist.
- RESET passthrough on DDC does not come from Schmitt trigger: should be RESET_B.
- We cannot fit photodiodes: DDC board is missing pin inserts.
- Not clear whether USB-C cable/connector shielding is correctly grounded.
- Some signals look messy (but everything still works…).

DDC Board Upstream USB-C Socket

Current



Correct



Output, **not** input of U8

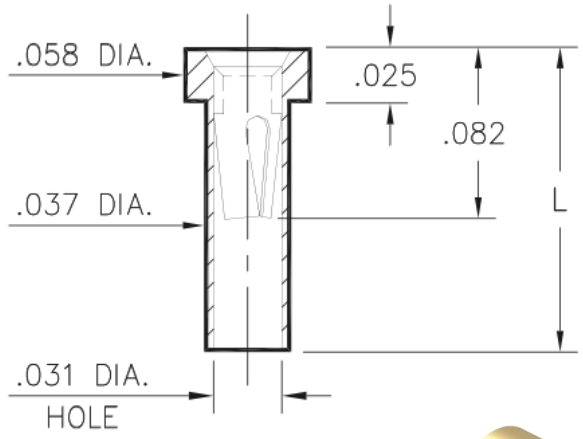
Photodiode Pin Inserts

- DDC boards need pin receptacles soldered to board to take photodiode legs:
  - Need to plug and remove.
  - Adds small amount of elasticity.
- Mill-Max:
  - 0566-1-15-15-21-27-10-0
  - 2 per diode.
  - 64 per board.
- Available from Mouser, Digikey, Farnell.
- Can they be retrofitted to existing boards?

0566

0566-X-15-XX-21-XX-10-0

Solder mount in .039 min. mounting hole
Also available on 16mm wide carrier tape:
See chart for details
See page 194.3 for Tape & Reel details

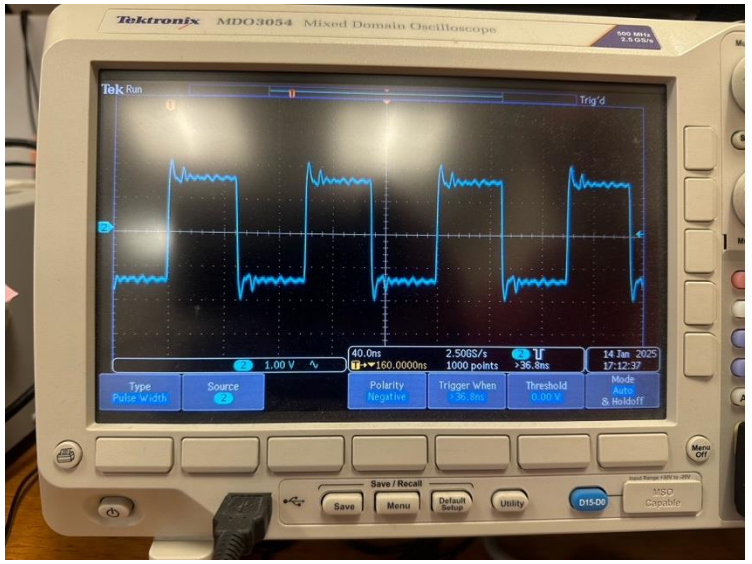


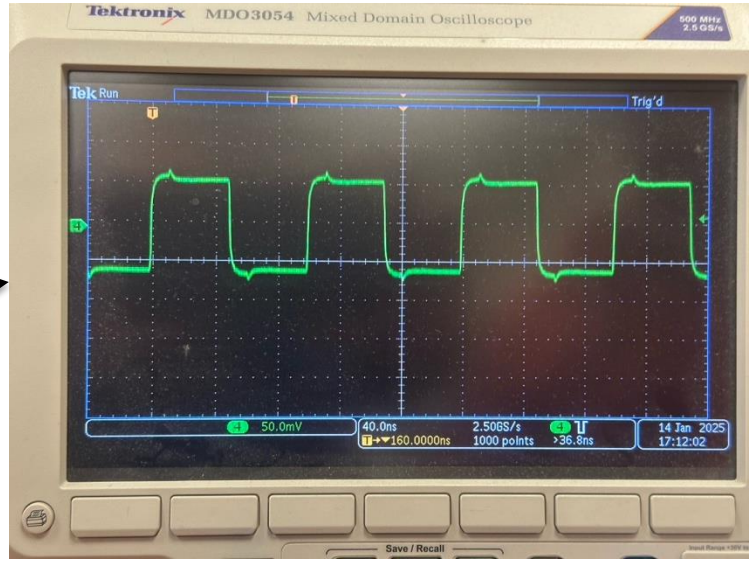
Basic Part Number	Length L	Parts per 13" Reel
0566-1	.083	3,000
0566-2	.138	2,100

https://www.mill-max.com/products/pin-receptacle/receptacle-with-no-tail/0566/0566-1-15-15-21-27-10-0

Signal Ringing

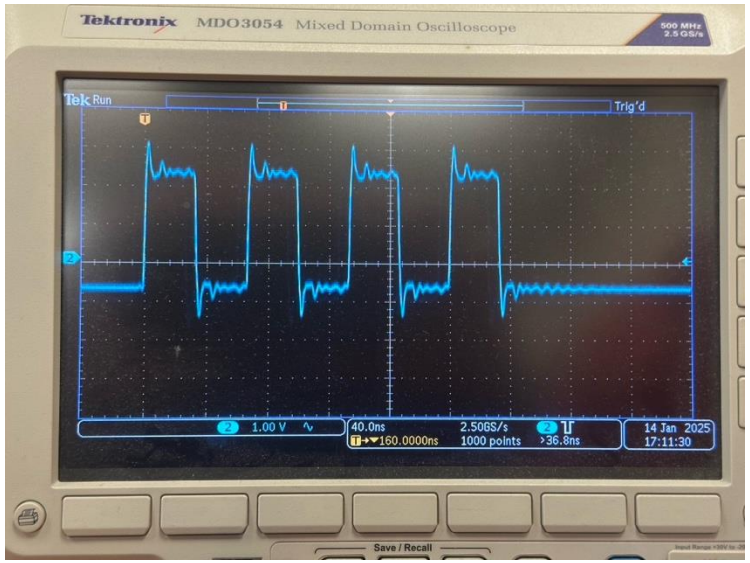
- Some of the digital pulses on the board look…“interesting”…
- Lots of ringing on rising and falling edges.
- Single-ended RESET pulses become more distorted: perhaps due to non-buffering from Schmitt trigger?
- Do USB-C signals need terminating on DDC board? Shouldn’t LVDS buffers etc. be enough?
- May also be due to poor/incorrect termination on scope probe: ringing **not** seen with differential probe.
- DAQ still seems to function perfectly despite this…

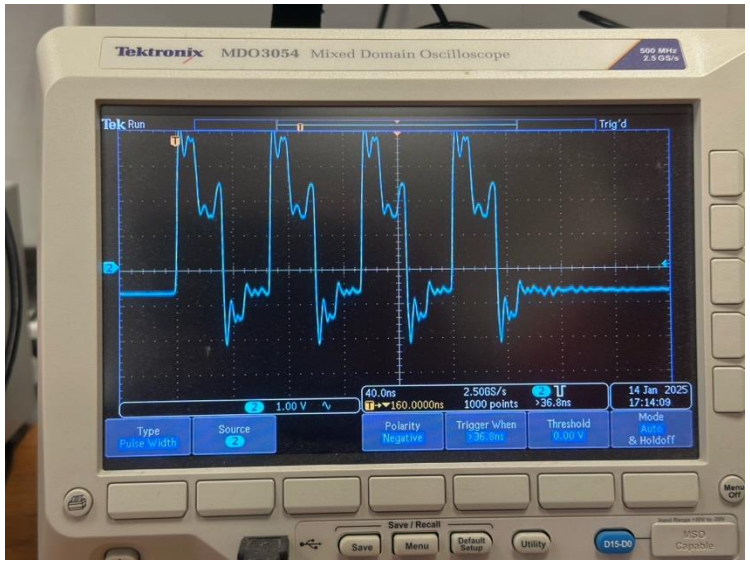


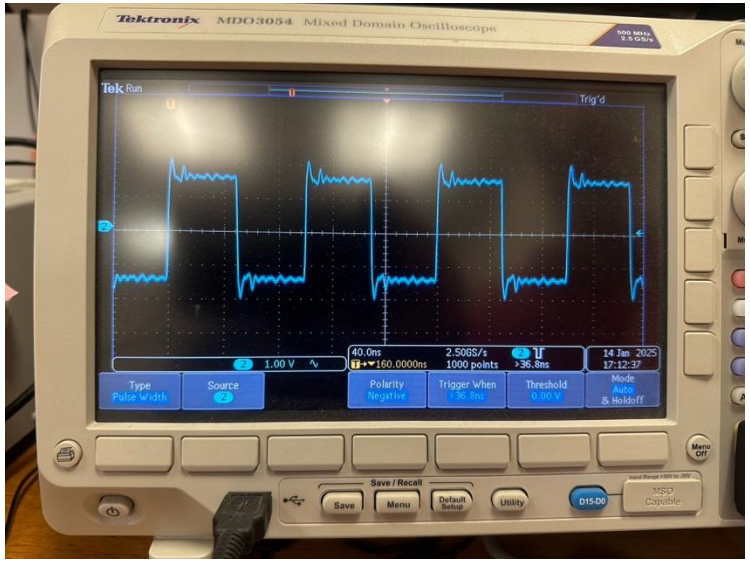


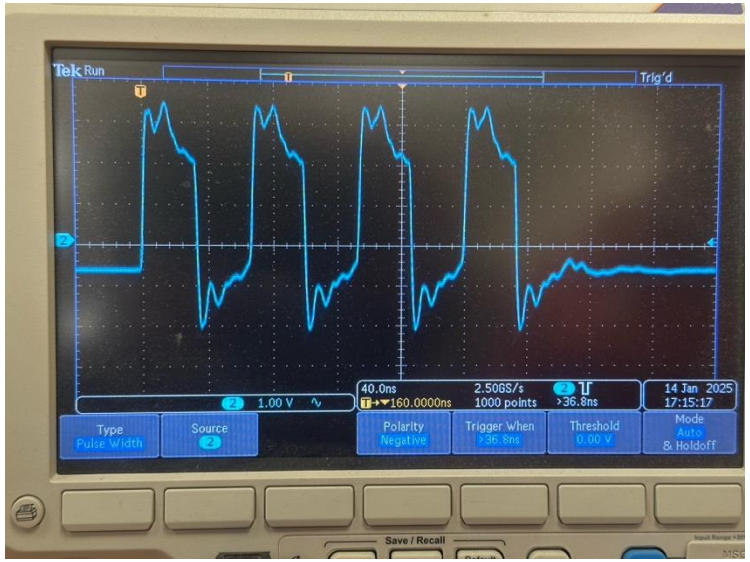
RESET Signal Ringing

CLK





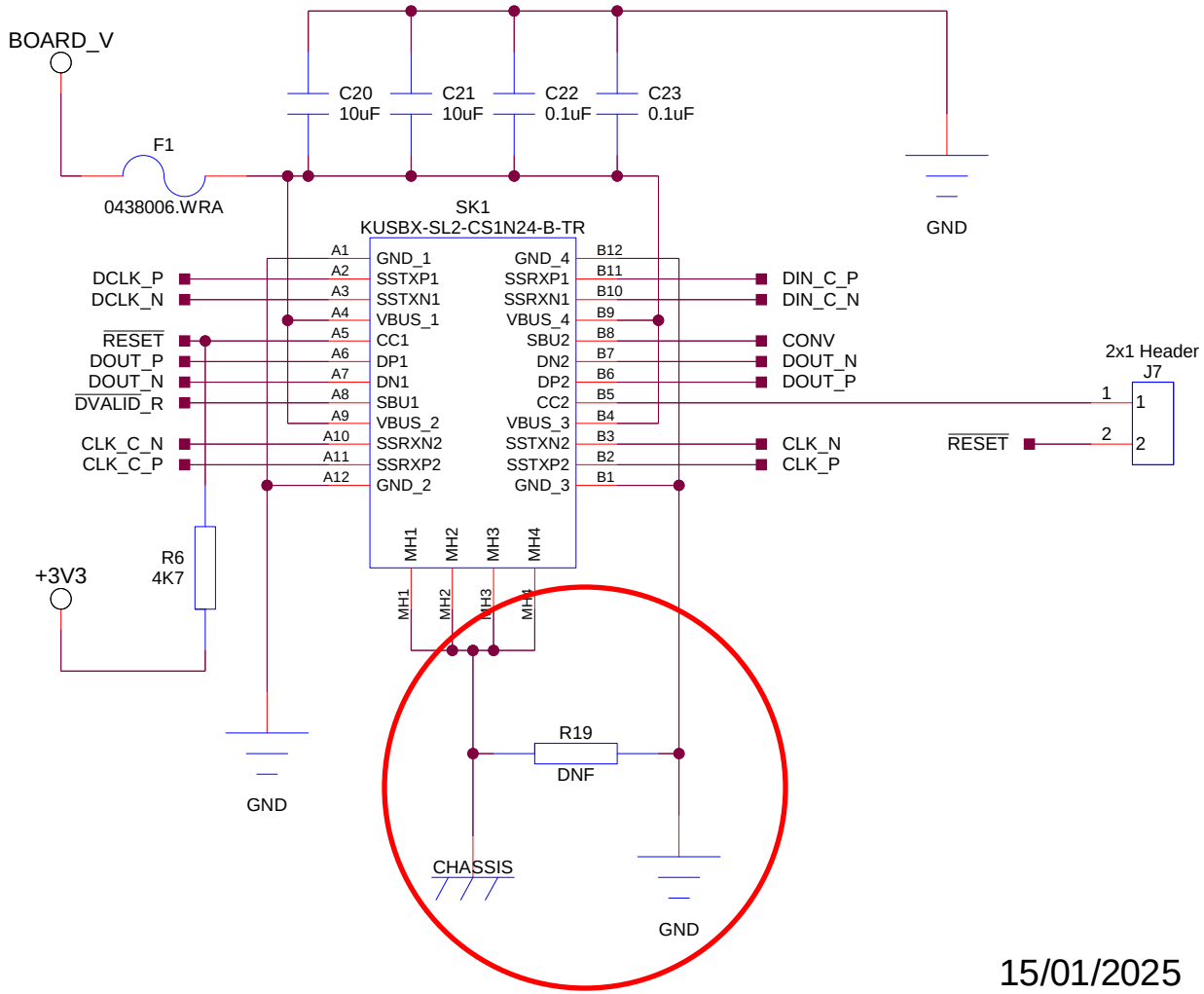




Grounding/Shielding

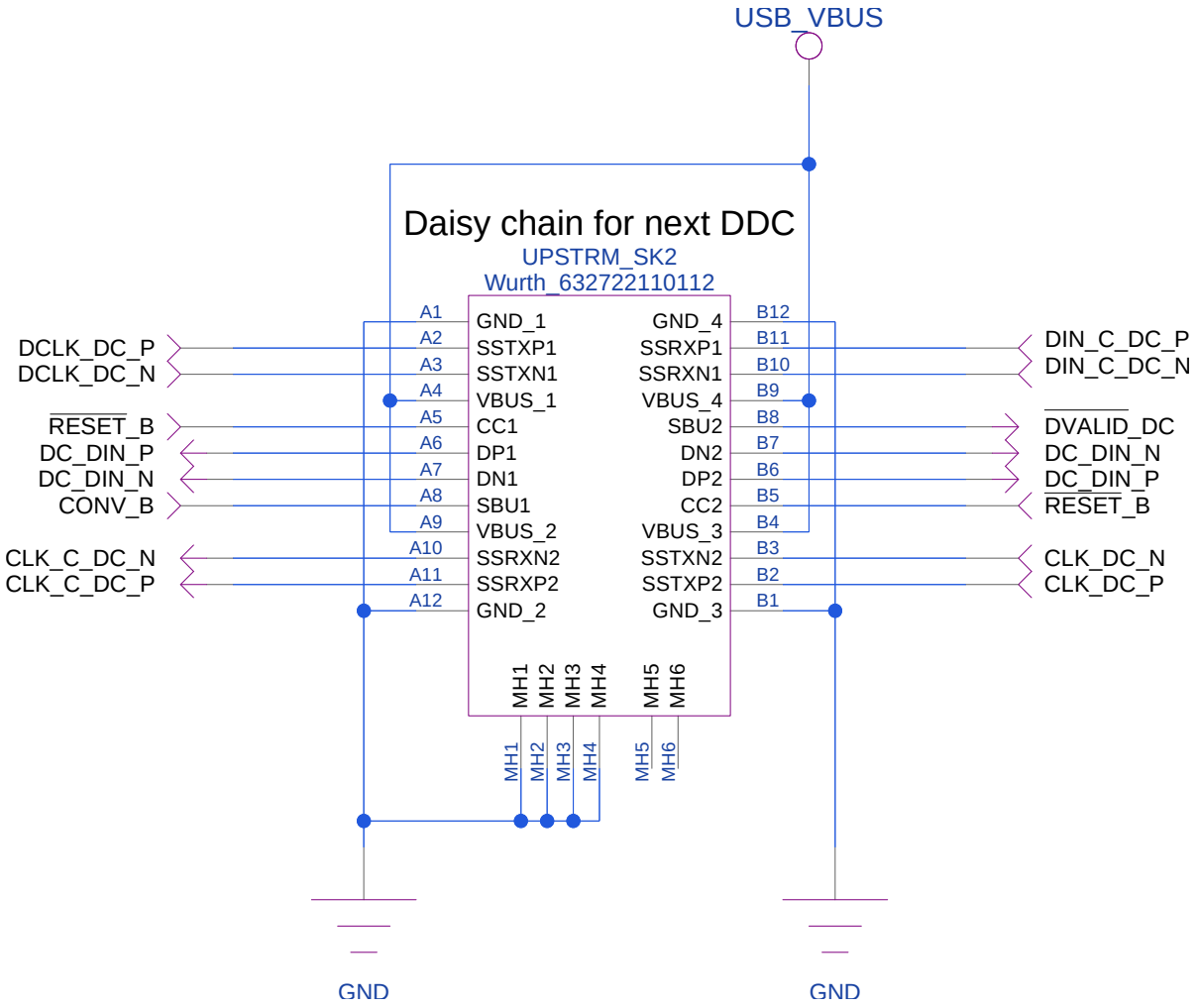
- I'm not sure this is an issue, but worth clarifying.
- Where, if at all, is the USB-C shield supposed to be connected to ground?
  - Currently connected on both sockets of DDC board but left open on ZMOD v.2 (R19, DNF).
  - Not connected **anywhere** on Cosylab design: reason for noise…?
- USB-C specs say:
  - 11. The receptacle shell ***shall*** be connected to the PCB ground plane.
  - 12. All VBUS pins ***shall*** be connected together in the USB Type-C plug.
  - 13. All Ground return pins ***shall*** be connected together in the USB Type-C plug.
- So this implies that shield should be connected to ground at every socket.
- Where is "chassis" on ZMOD?
- Modify ZMOD with 0R at R19…?
- https://www.usb.org/document-library/usb-type-cr-cable-and-connector-specification-release-24

ZMOD v.2 USB-C Connection

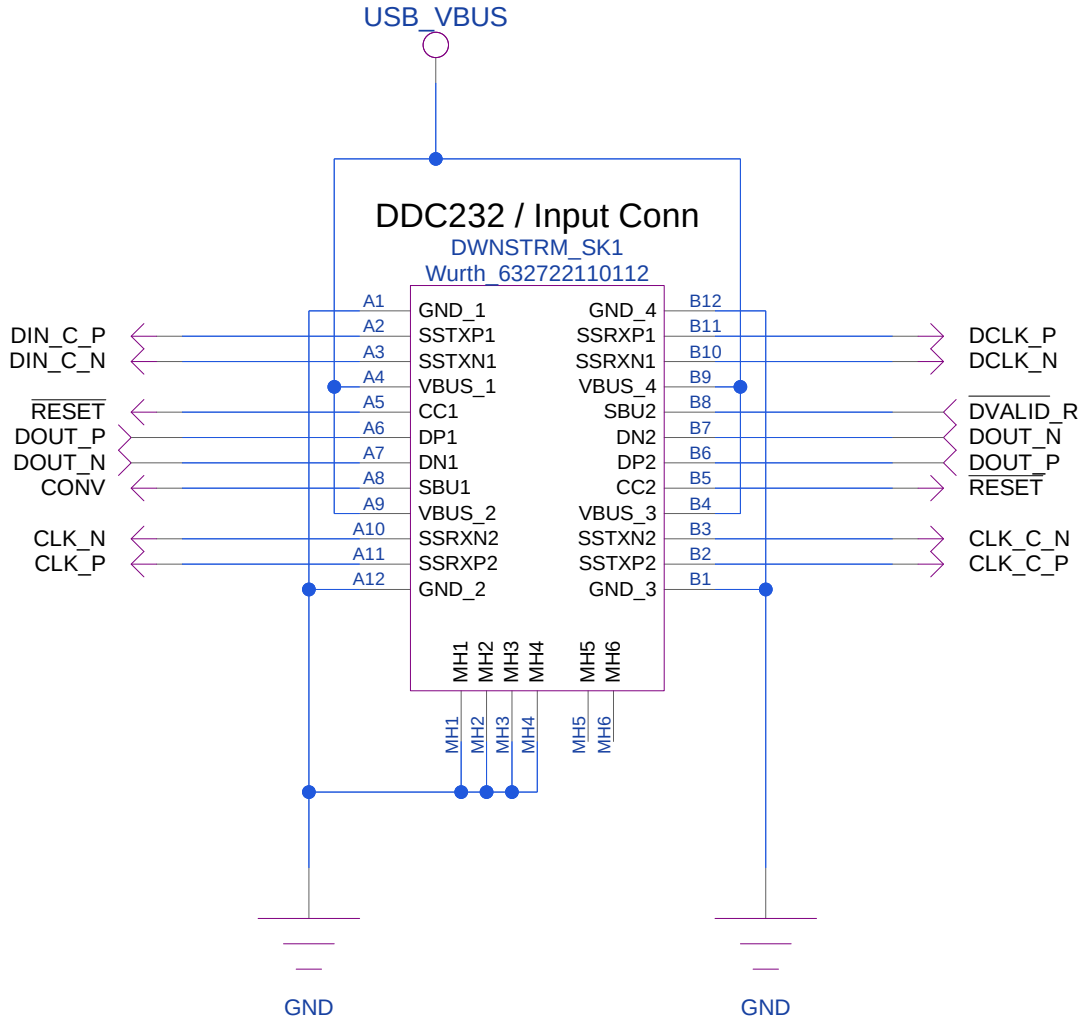


DDC Board Upstream USB-C Connector

DDC Rev.E USB-C U/S (Updated)



DDC Rev.E USB-C D/S



Conclusion

- Design is sound for both ZMOD and DDC boards.
- **NO** changes needed for ZMOD to work:
  - Just check USB-C ground-shield connection. Fit R19?
- DDC board design works but small mods needed:
  - **Add pin receptacles** to take photodiodes.
  - **Rotate** upstream USB-C socket (wiring) by 180 degrees so match downstream orientation.
  - Pass Schmitt triggered **RESET_B** to upstream socket, not RESET.
- Cause of ringing/distortion of square pulses? Is this an issue? DDC boards seem to work…

Follow The Monkey: Onwards…