

Overview of the LArIAT analog front end electronics
up to the CAEN digitizers.

Version: v1

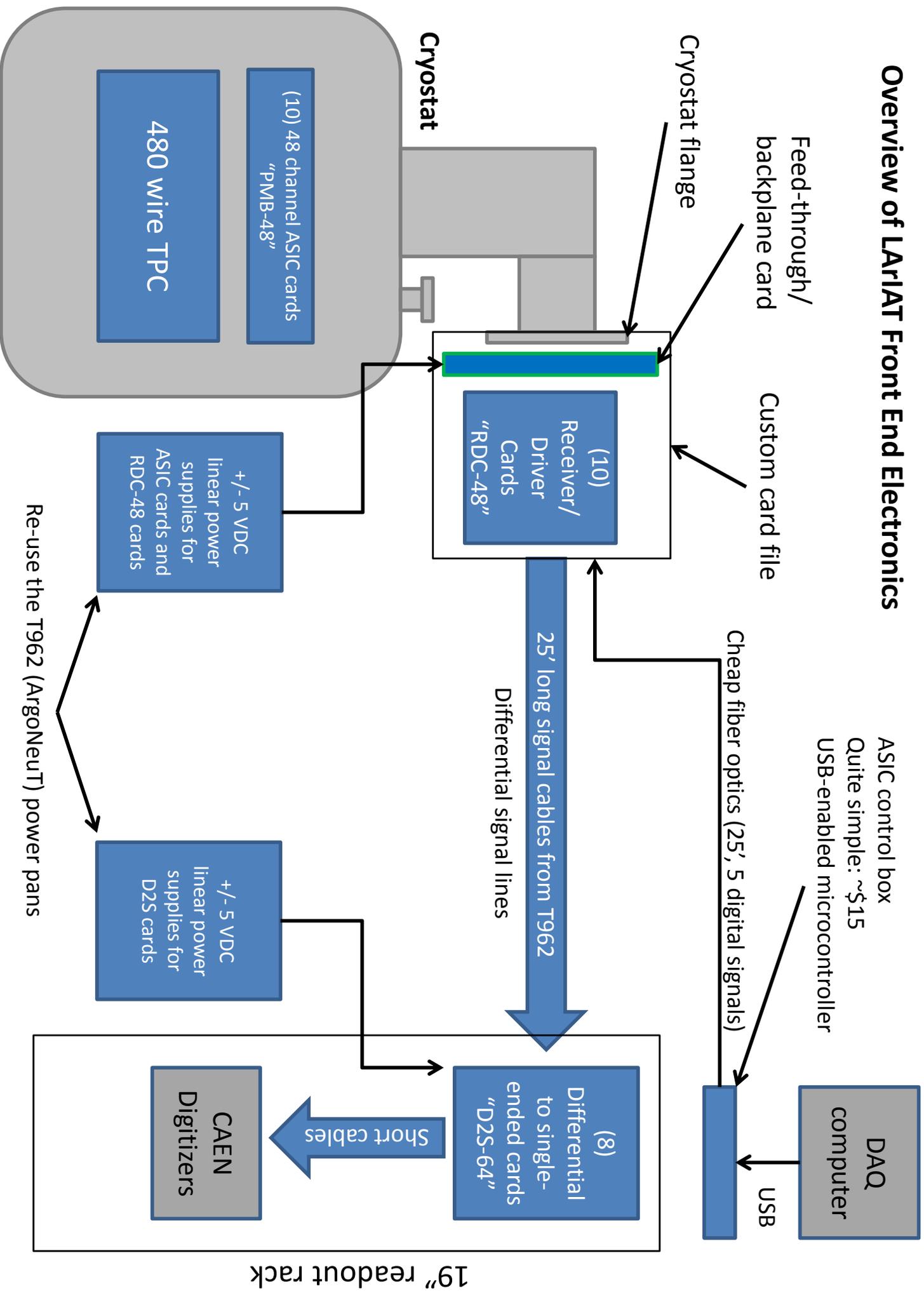
Date: 9 January 2015

The following slides step through the system along the signal path.

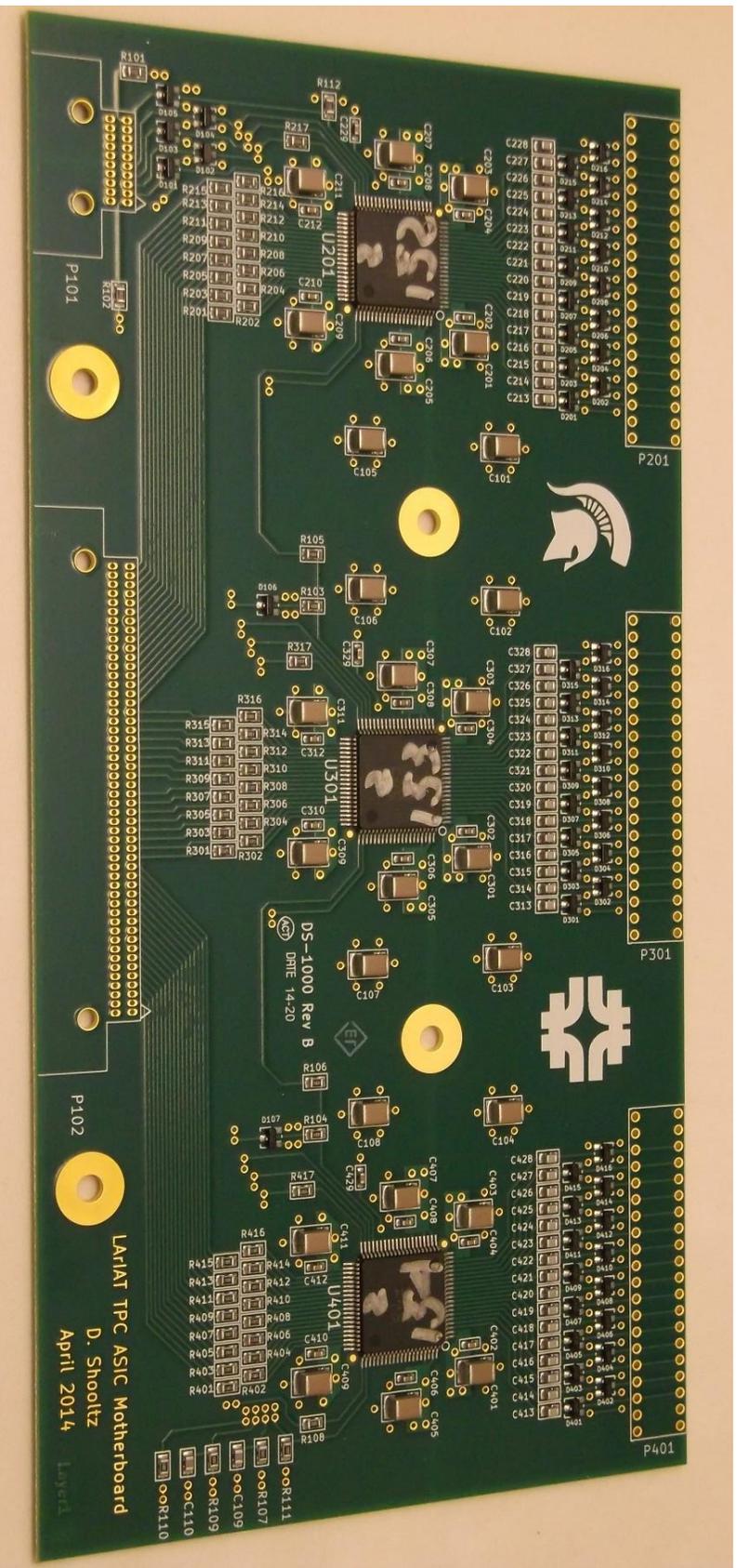
I will expand on this quite a bit in the next few days, but I thought it
would be nice to send this version out as a primer.

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Overview of LArIAT Front End Electronics



ASIC motherboard “PMB-48”



20 pin connector:

- 5 lines for 1.8 VDC 90 mA load
- 5 lines for 1.8 VDC 300 mA load
- 8 digital control lines
- 2 voltage monitor lines

100 pin connector:

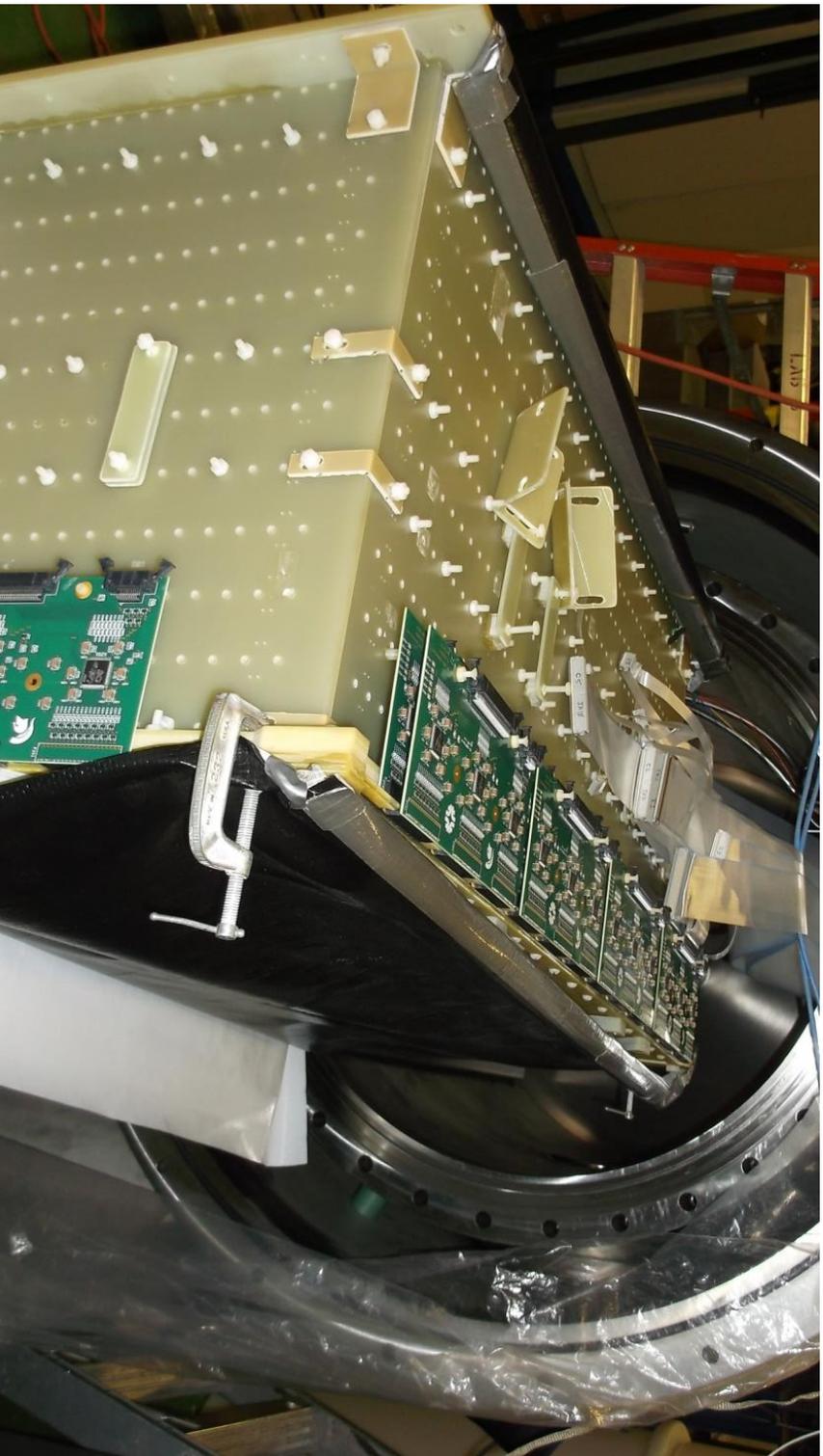
- 48 signal lines
- 52 ground lines

Cabling to flange:

- Ribbon cabling
- 30 AWG solid conductor
- FEP insulation

Note: as you pointed out during meeting at Lab 6, the ASIC power

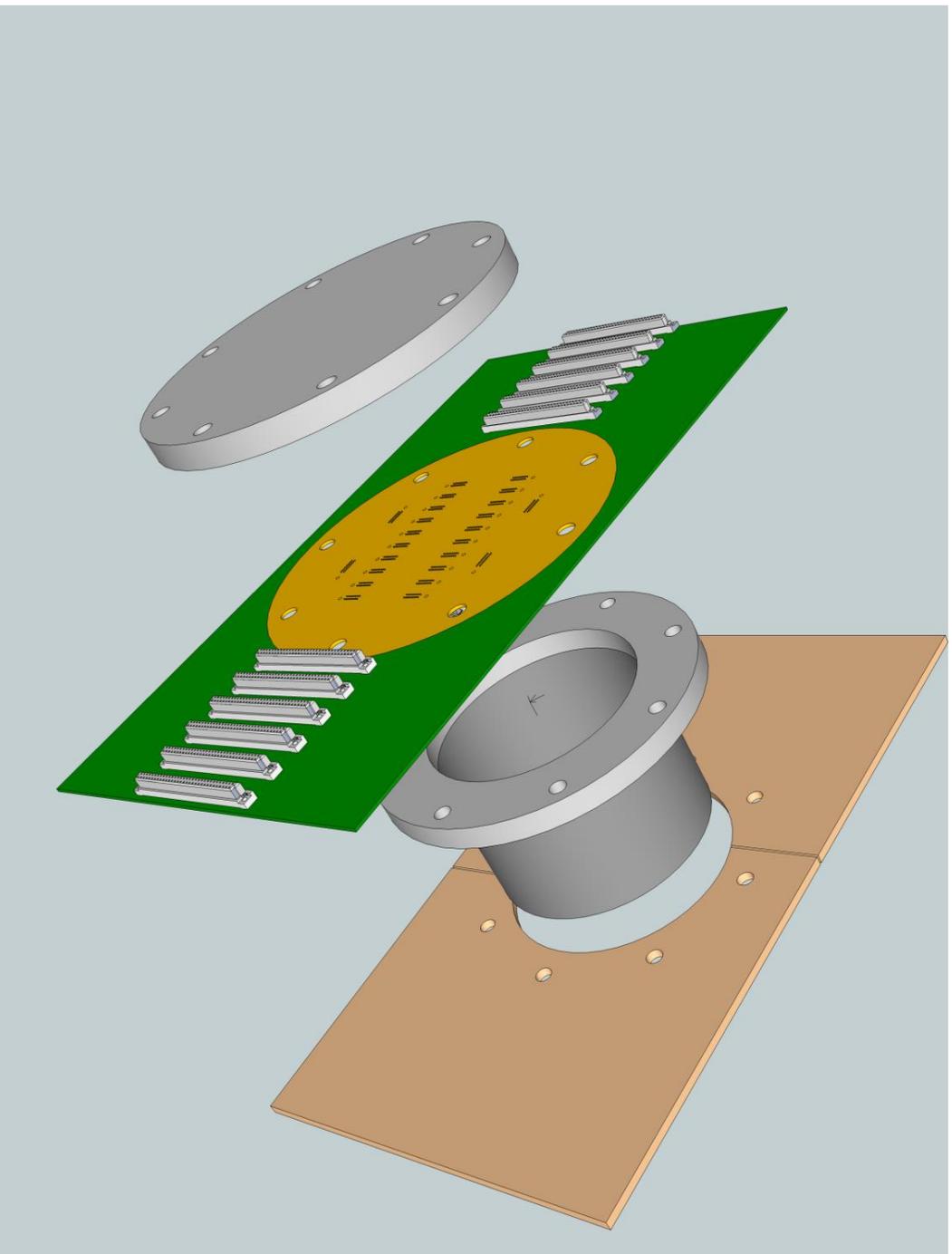
lines and the ground return lines are on separate cables and this might lead to noise pickup or broadcast in the cryostat. This arrangement was a compromise made due to a limited number of lines available at the feed-through and also an effort to have all connections to the cards pass into the cryostat at one point.



Location of the 10 ASIC cards on the LArIAT TPC.

This is now inside the sealed cryostat.

Feed-through/backplane card



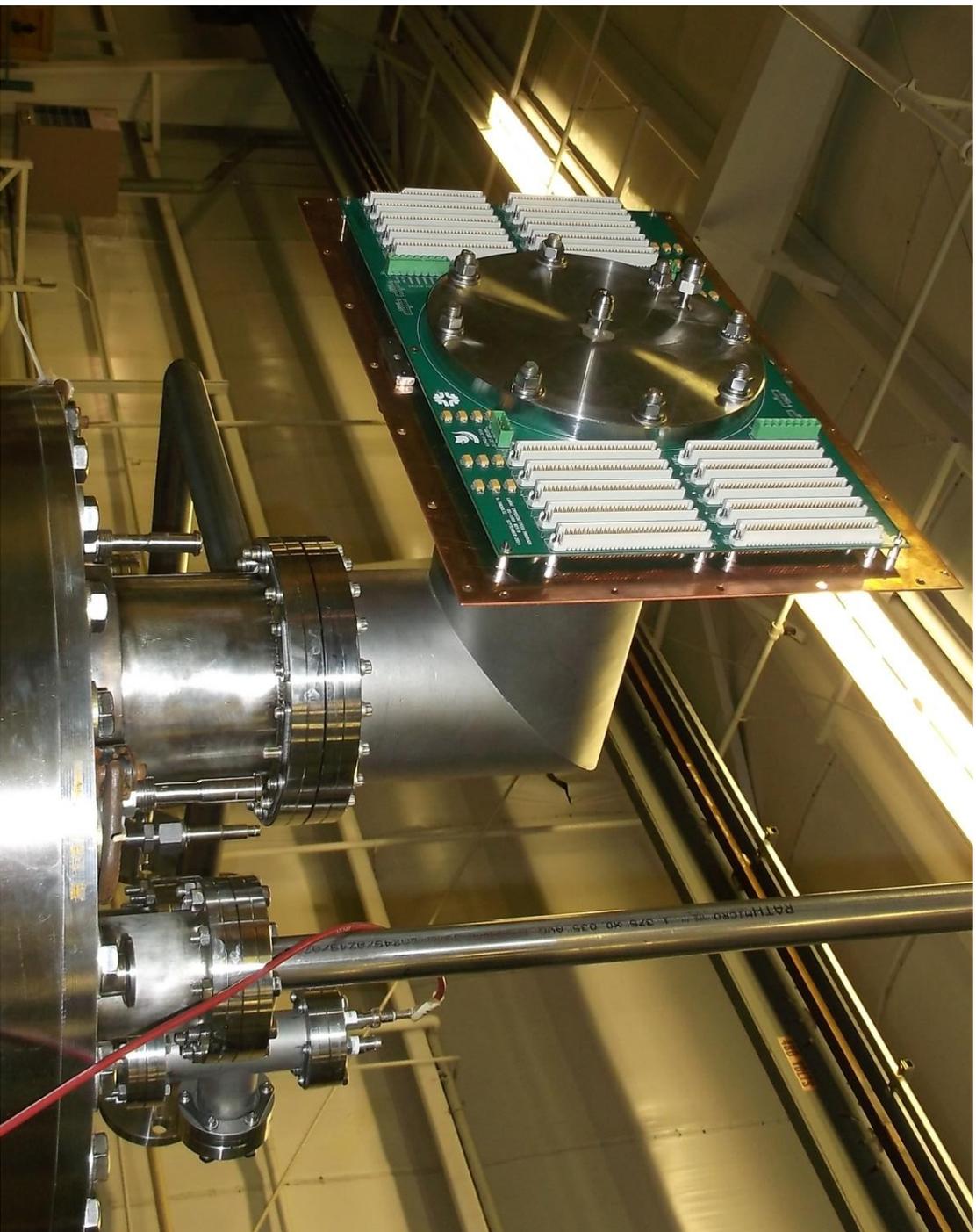
Backplane/feed-through card location at the cryostat flange.

Note: this cartoon is old, but the overall layout is the same.

The current version has double the number of DIN41612 96 pin connectors.

The manufactured version holds power distribution for the WRD-48 cards

Feed-through/backplane card mounted to the cryostat flange



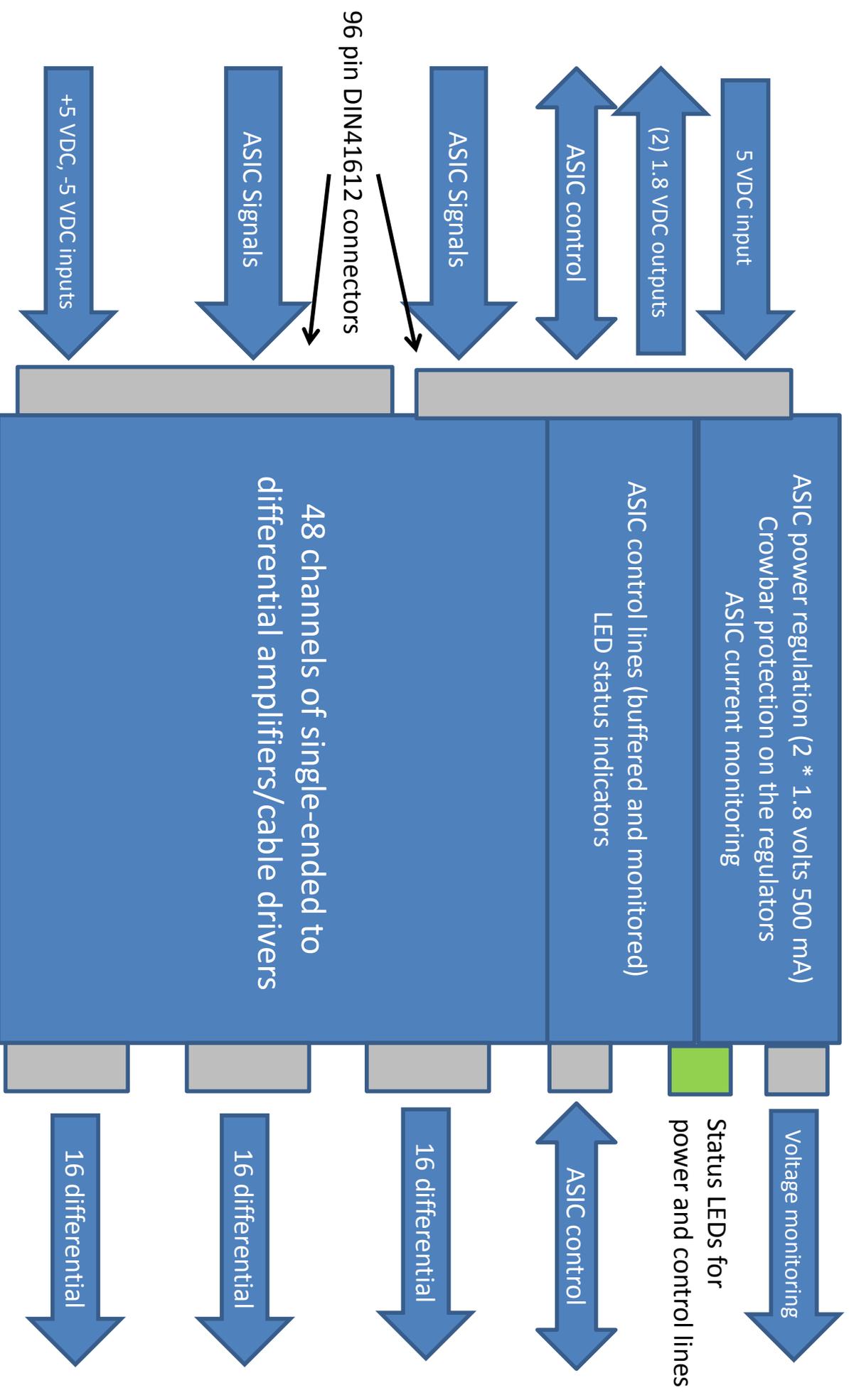
Warm receiver/Driver card block diagram

Each warm receiver card supplies power and control signals to one 48 channel ASIC motherboard.

The ASIC control lines are routed to/from the front panel through buffers to protect the ASICs.

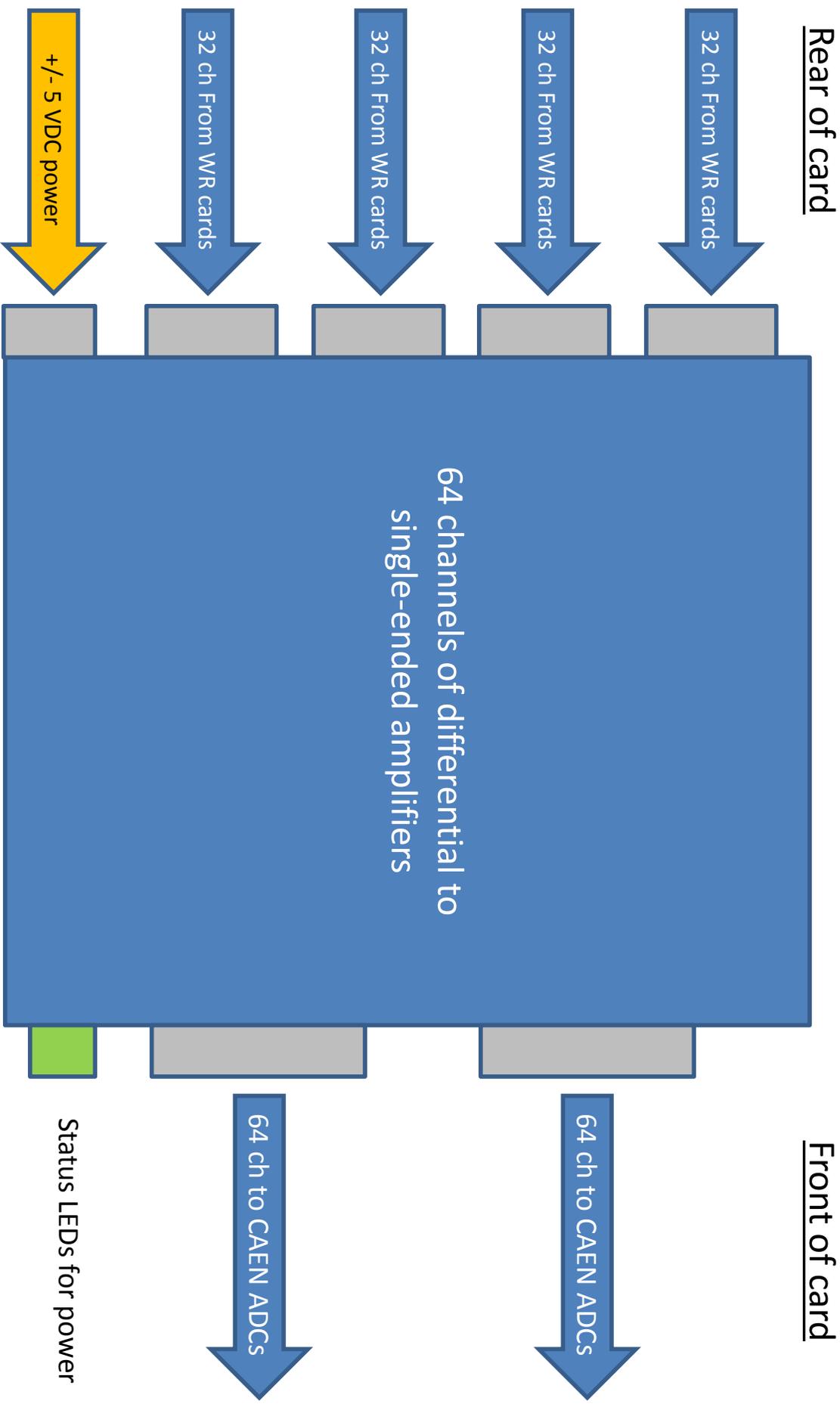
From the front panel the ASIC control lines are daisy chained and then connected to inexpensive fiber optic links.

Front panel status LEDs will assist in diagnosing any problems during a run.



D2S (differential to single-ended) card

Card supplies a simple function- no major design challenges.
Cards will reside in a simple card file above the CAEN ADCs.
Card size will probably be same size as VME 6U.
Cards will be supplied from +/- 5 volt linear power supplies.



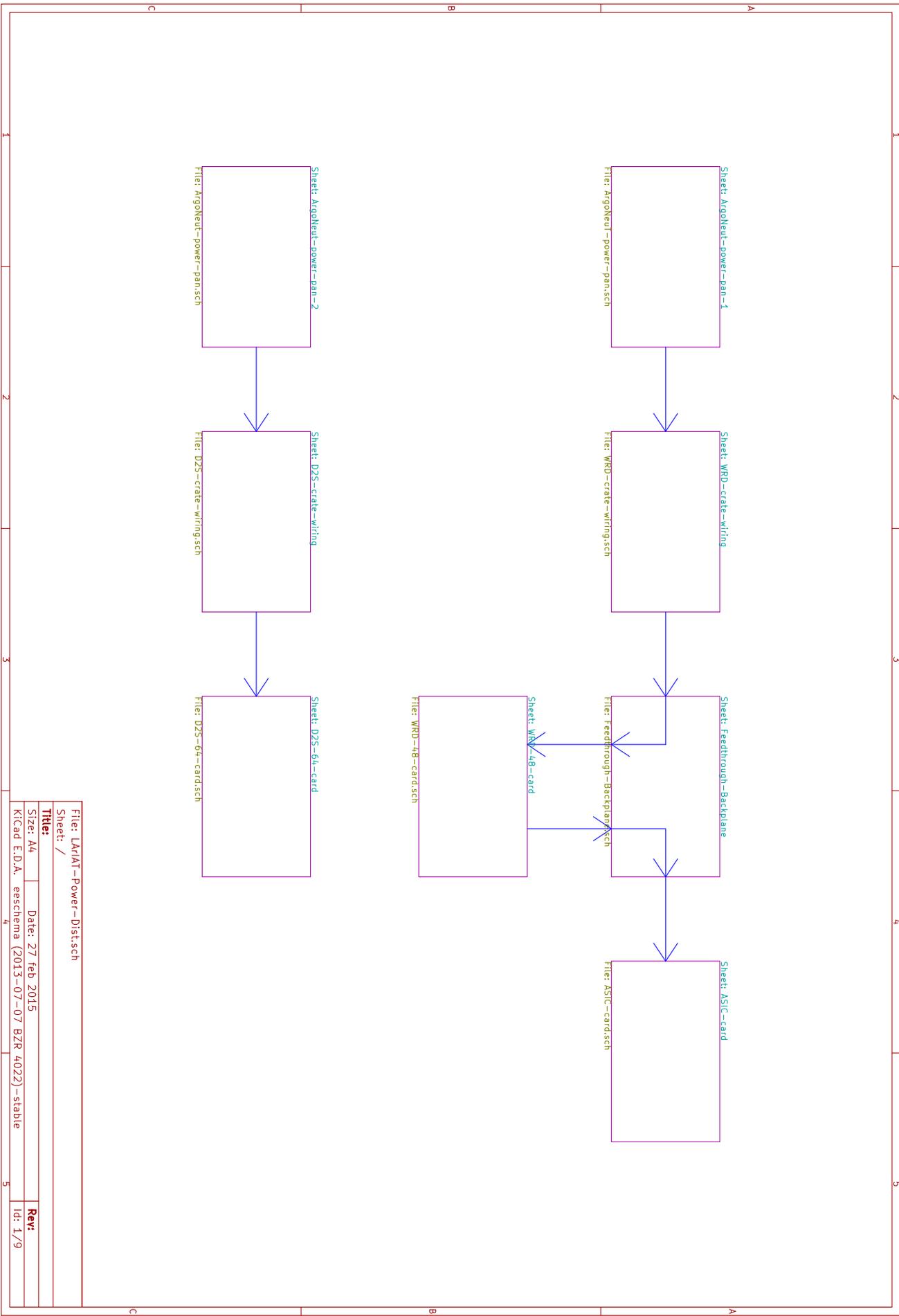
LArIAT Front End electronics

Information for safety and ORC reviews

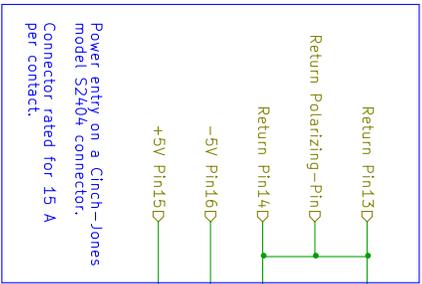
This file: Power distribution block diagram and finer details

Another file: full schematics of all boards

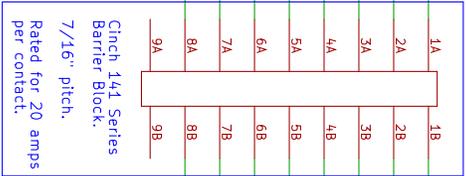
Dean Shooltz Feb. 27, 2015



File: LMIAT-Power-Distsch	
Sheet: /	
Title:	
Size: A4	Date: 27 feb 2015
KiCad E.D.A. eeschema (2013-07-07 BZR 4022) - stable	
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Rev:	Id: 1/9

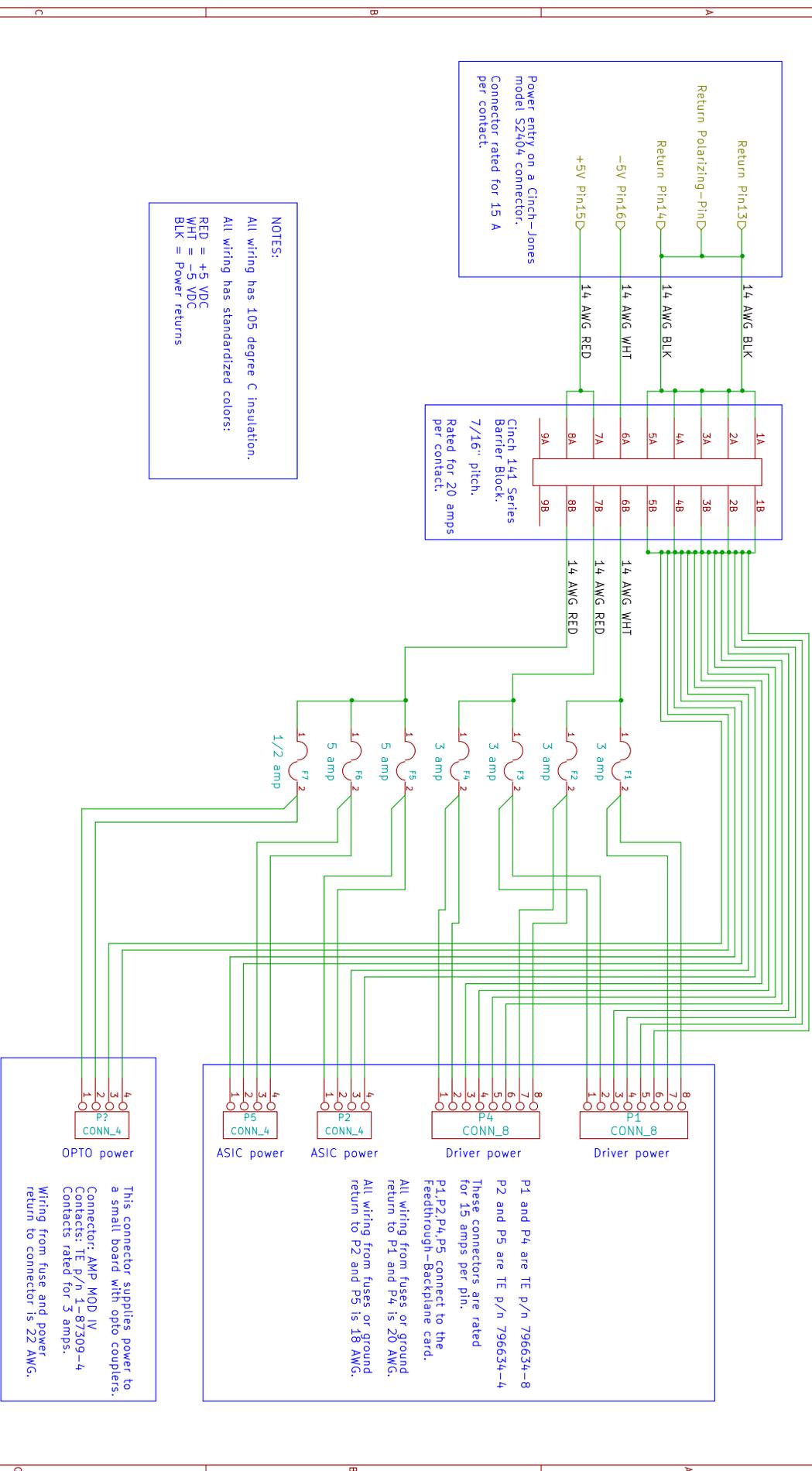


Power entry on a Cinch-Jones model S2404 connector. Connector rated for 15 A per contact.



Cinch 141 Series Barrier Block. Rated for 20 amps 7/16" pitch.

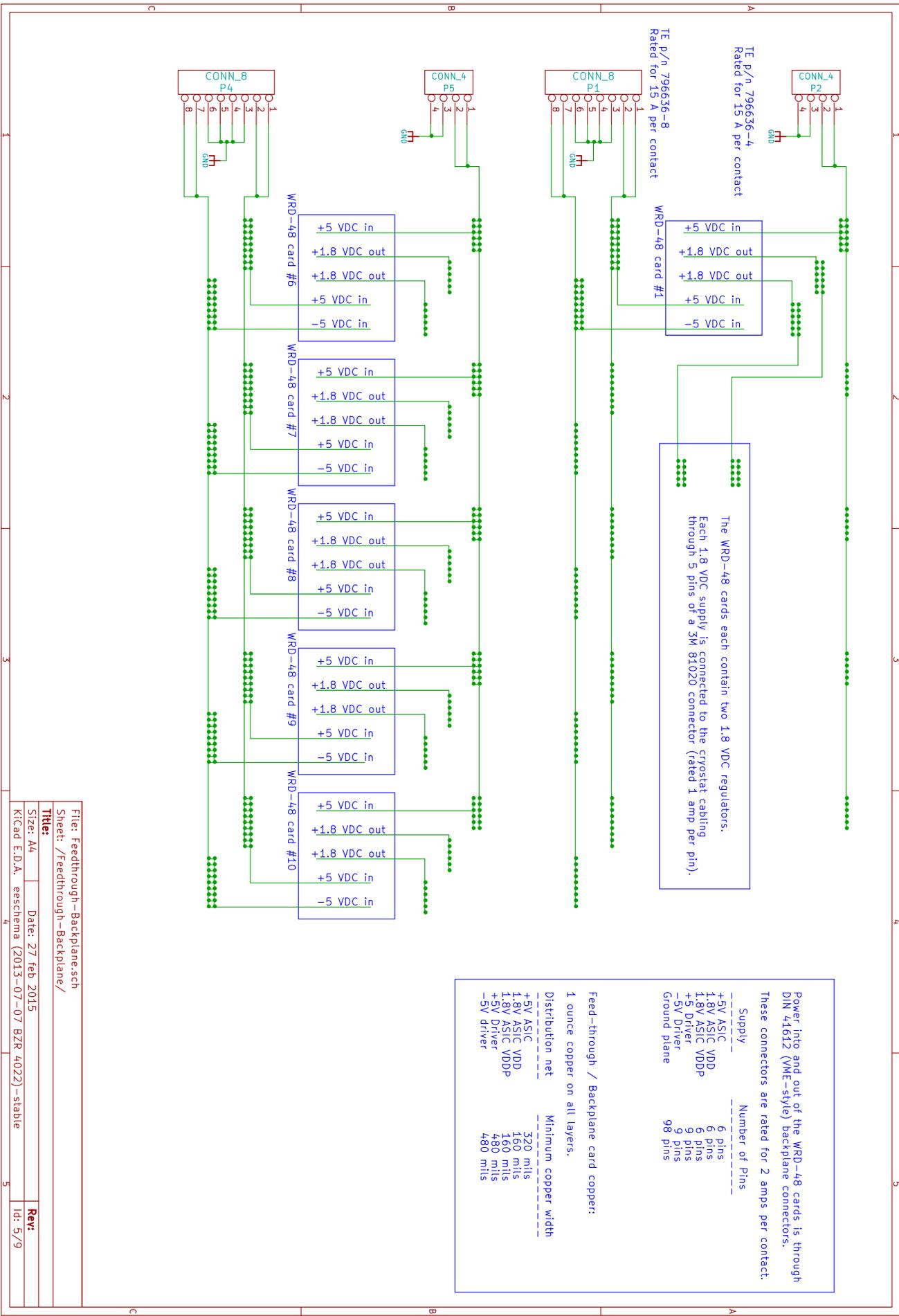
NOTES:
All wiring has 105 degree C insulation.
All wiring has standardized colors:
RED = +5 VDC
WHT = -5 VDC
BLK = Power returns



This connector supplies power to a small board with opto couplers. Connector: AMP MOD IV Contacts: TE p/n 1-87309-4 Contacts rated for 3 amps. Wiring from fuse and power return to connector is 22 AWG.

P1,P2,P4,P5 connect to the Feedthrough-Backplane card. All wiring from fuses or ground return to P1 and P4 is 20 AWG. All wiring from fuses or ground return to P2 and P5 is 18 AWG.

File: WRD-crate-wiring.sch	Date: 27 Feb 2015
Sheet: /WRD-crate-wiring/	
Title:	
Size: A4	Rev: 4/9
KiCad E.D.A. eeschema (2013-07-07 BZR 4022)-stable	



Power into and out of the WRD-48 cards is through DIN 41612 (VME-style) backplane connectors. These connectors are rated for 2 amps per contact.

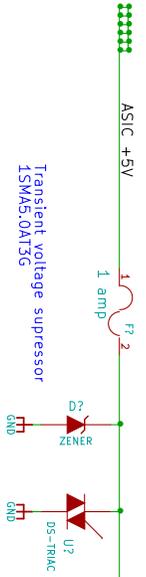
Supply	Number of Pins
+5V ASIC	6 pins
1.8V ASIC VDD	6 pins
1.8V ASIC VDDP	6 pins
+5V Driver	9 pins
-5V Driver	9 pins
Ground plane	98 pins

Feed-through / Backplane card copper: 1 ounce copper on all layers.

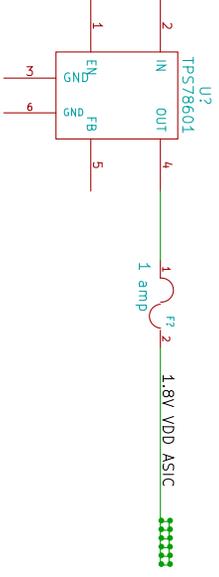
Distribution net	Minimum copper width
+5V ASIC	320 mils
1.8V ASIC VDD	160 mils
1.8V ASIC VDDP	160 mils
+5V Driver	480 mils
-5V driver	480 mils

File: Feedthrough-Backplane.sch	
Sheet: /Feedthrough-Backplane/	
Title:	
Size: A4	Date: 27 Feb 2015
KiCad E.D.A. eeschema (2013-07-07 BZR 4022) - stable	Rev: Id: 5/9

Connection to Feed-through / Backplane card
6 pins of a DIN 41612 VME-style connector.
Contacts rated for 2 amps per pin

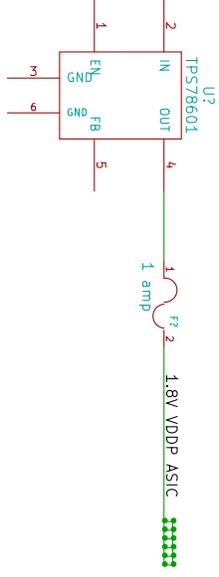


1.8 VDC regulators



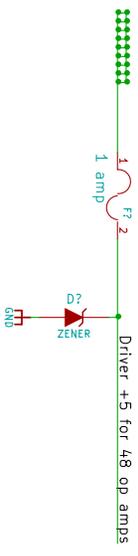
Connection to Feed-through / Backplane card
6 pins if a DIN 41612 VME-style connector.
Contacts rated for 2 amps per pin

Crowbar triac.
Trac: BT137S-6000

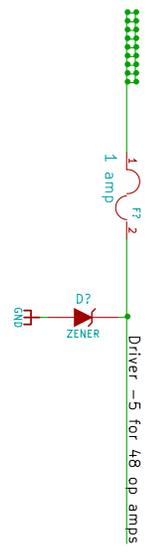


Connection to Feed-through / Backplane card
6 pins if a DIN 41612 VME-style connector.
Contacts rated for 2 amps per pin

Connection to Feed-through / Backplane card
9 pins of a DIN 41612 VME-style connector.
Contacts rated for 2 amps per pin

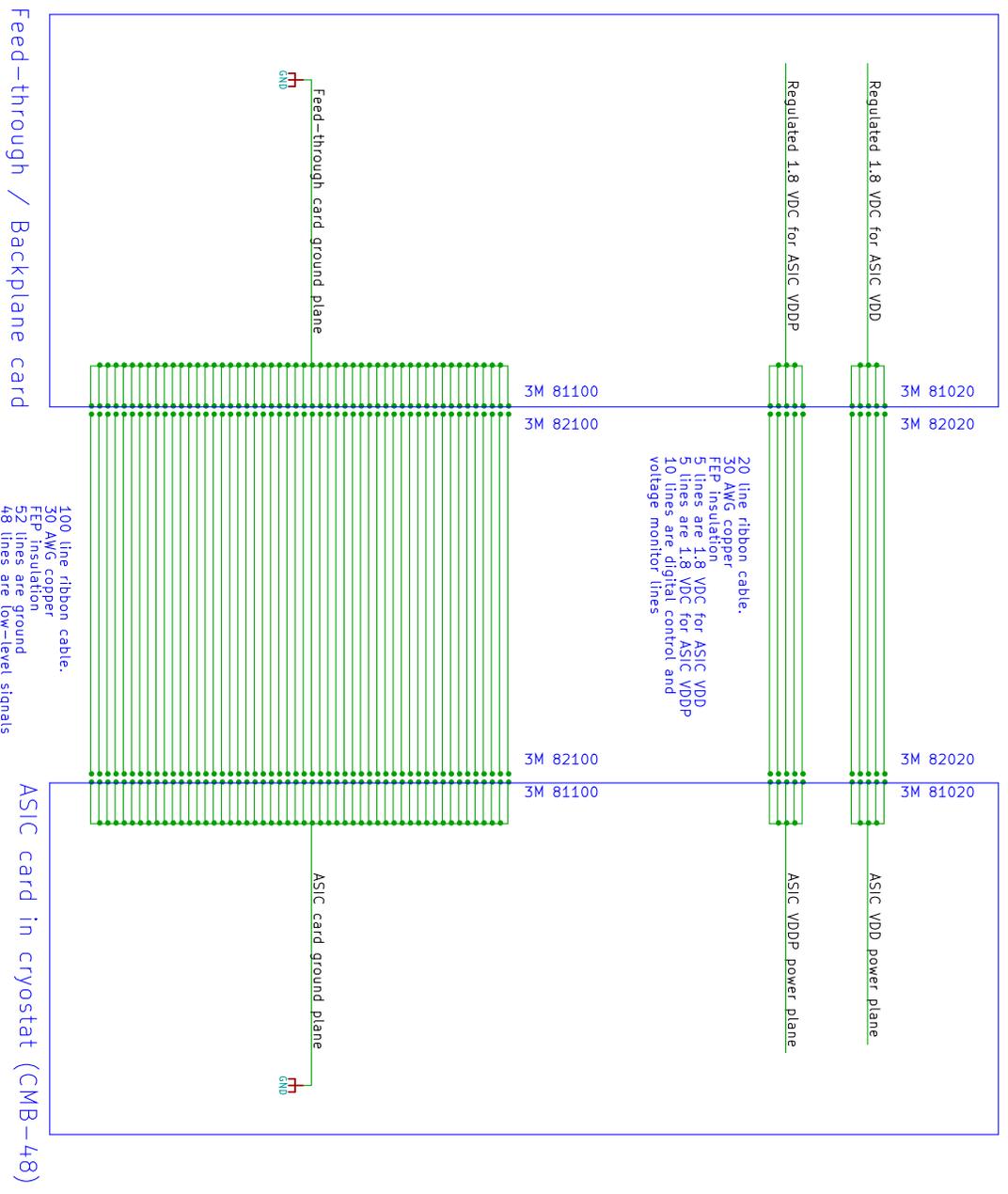


Connection to Feed-through / Backplane card
9 pins of a DIN 41612 VME-style connector.
Contacts rated for 2 amps per pin

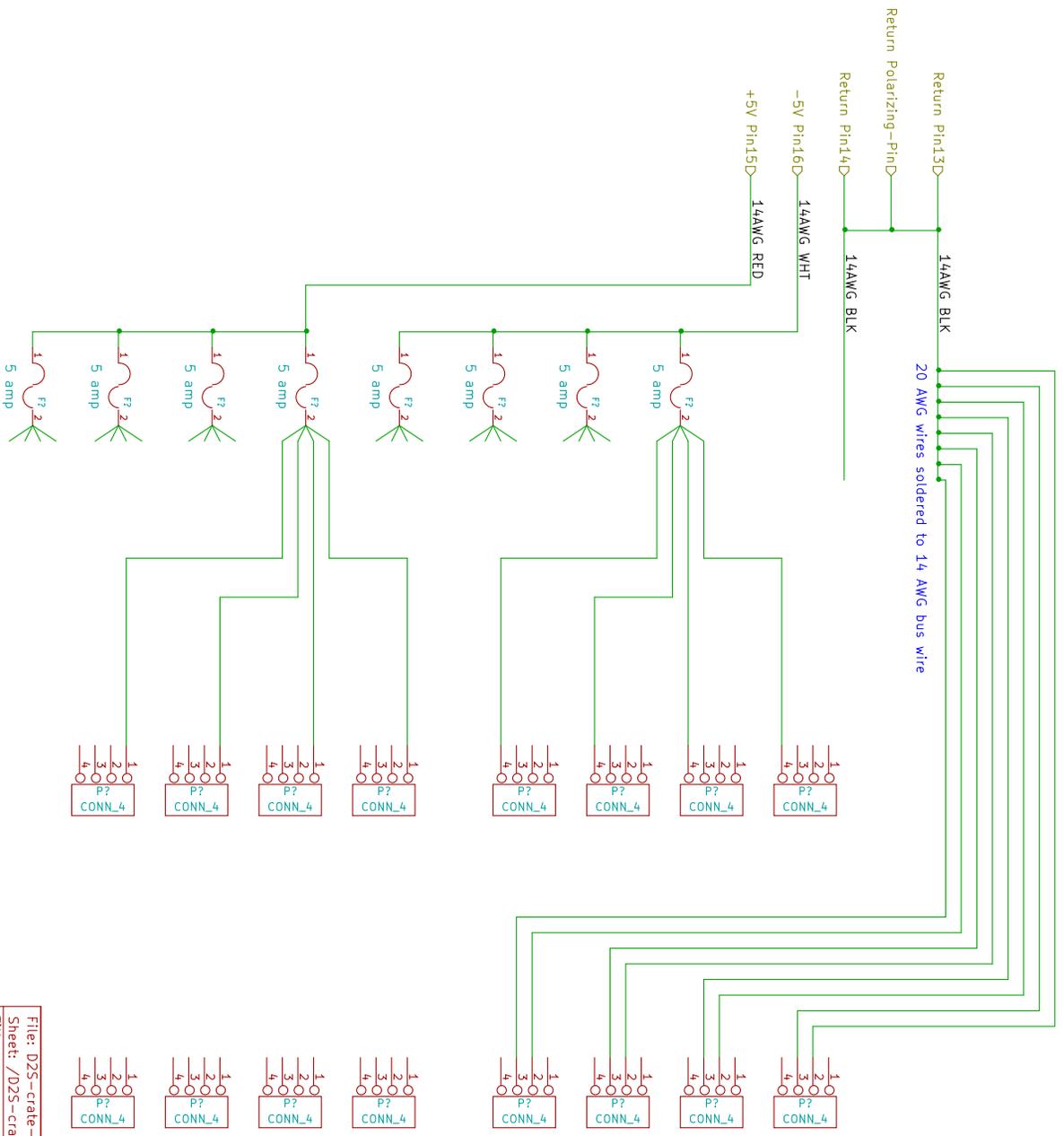


Subset of the full WRD-48 schematic set detailing
the power distribution nets.
PCB is made with 1 ounce copper on all layers.
Distribution Net Minimum copper width from power entry until fuse
+5V ASIC 130 mils
+5V Driver 130 mils
-5V Driver 130 mils

File: WRD-48-card.sch	Date: 27 Feb 2015
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Title:	
Size: A4	Rev: 9/9
KiCad E.D.A. eeschema (2013-07-07 BZR 4022) - stable	

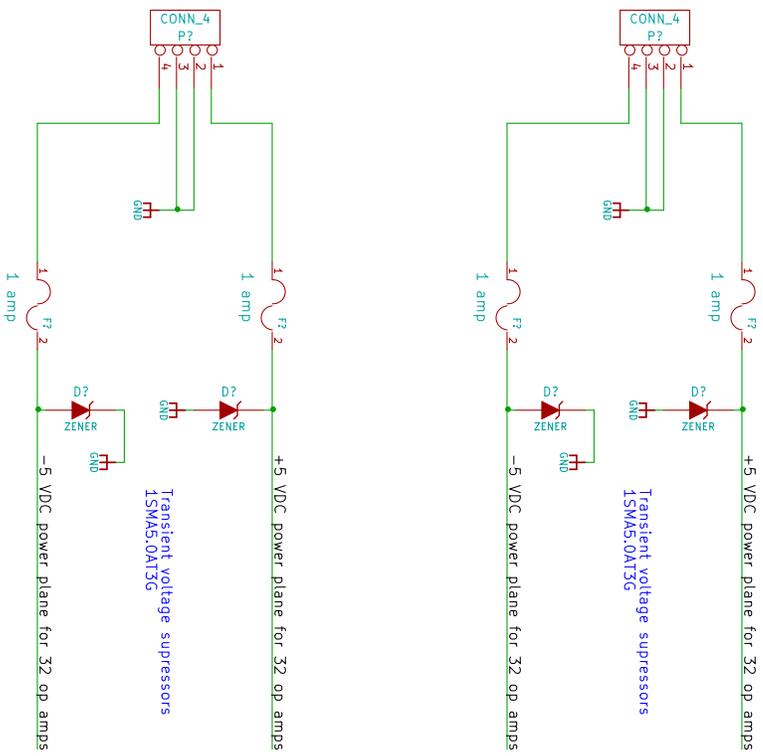


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Title:	
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	Rev:
	Id: 6/9



D2S crate power distribution.
 Representative wiring is shown.
 Wiring up to fuses is 14 AWG w/ 105C insulation.
 Wiring beyond fuses is 20 AWG w/ 105C insulation.
 All fuses are 5 amp.
 All wire colors are standardized:
 RED: +5 VDC
 WHT: -5 VDC
 BLK: Power Returns
 Input connector:
 Cinch—Jones S2404 rated 15 amps/contact
 Connections to D2S-64 cards:
 TE 796634 Terminal Block Plug rated 15 amps/contact

File: D2S-crate-wiring.sch	Date: 27 Feb 2015	Rev:
Sheet: /D2S-crate-wiring/		Id: 7/9
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Size: A4		
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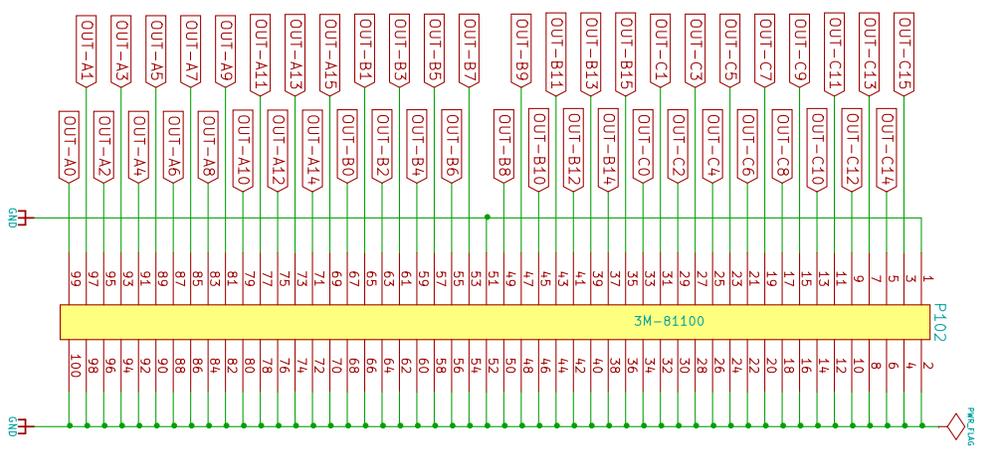
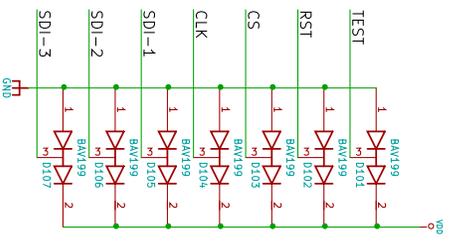
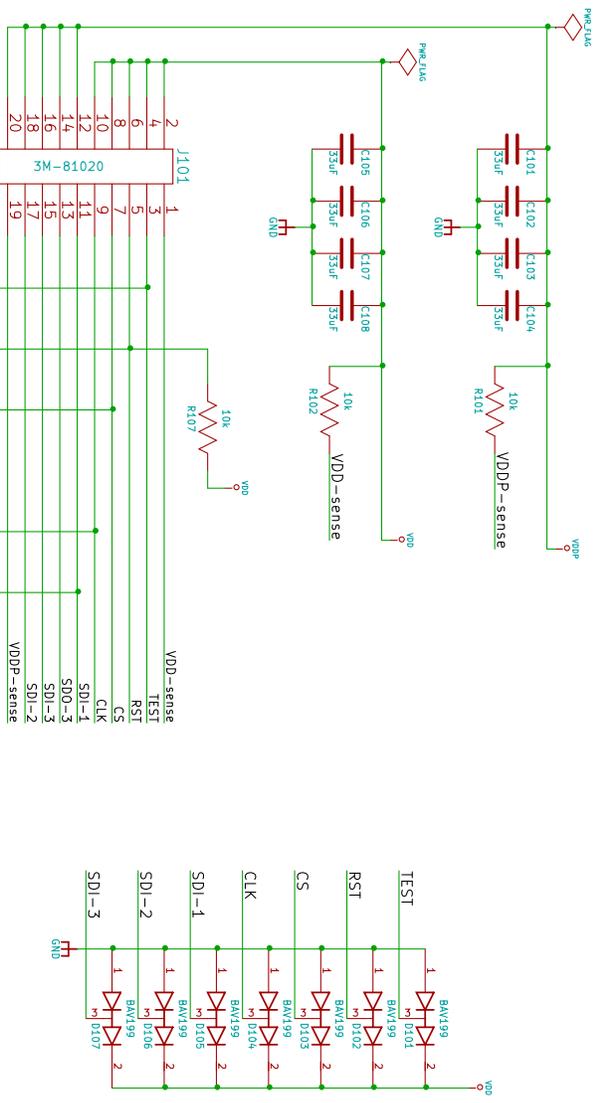
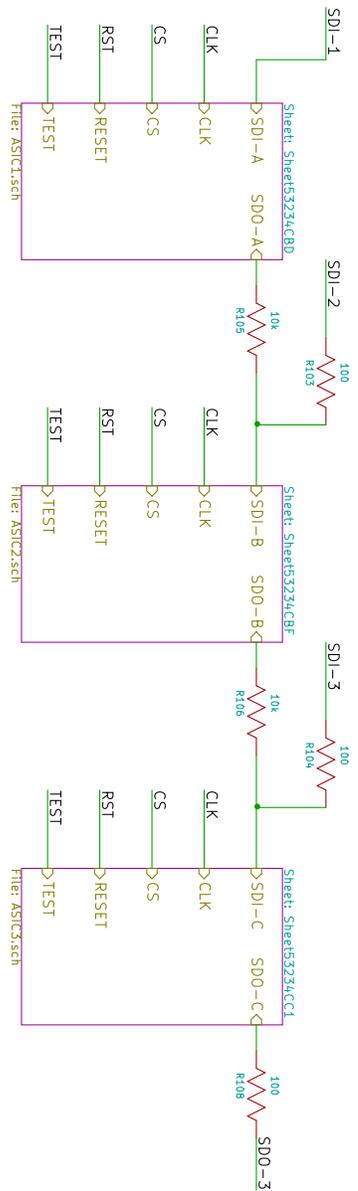


Power Input on TE 796638-4 Terminal Block Headers Rated 15 amp per contact. PCB had 1 ounce copper layers. Minimum trace thickness from power entry to fuse is 120 mils.

File: D2S-64-card.sch	Date: 27 Feb 2015
Sheet: /D2S-64-card/	
Title:	
Size: A4	
KiCad E.D.A. eeschema (2013-07-07 BZR 4022) - stable	
	Rev:
	Id: 8/9

Following two slides: CMB-48 card.

There are ten of these in the LArIAT cryostat.



Shoultz Solutions LLC

File: LARIAT-FE.sch

Sheet: /

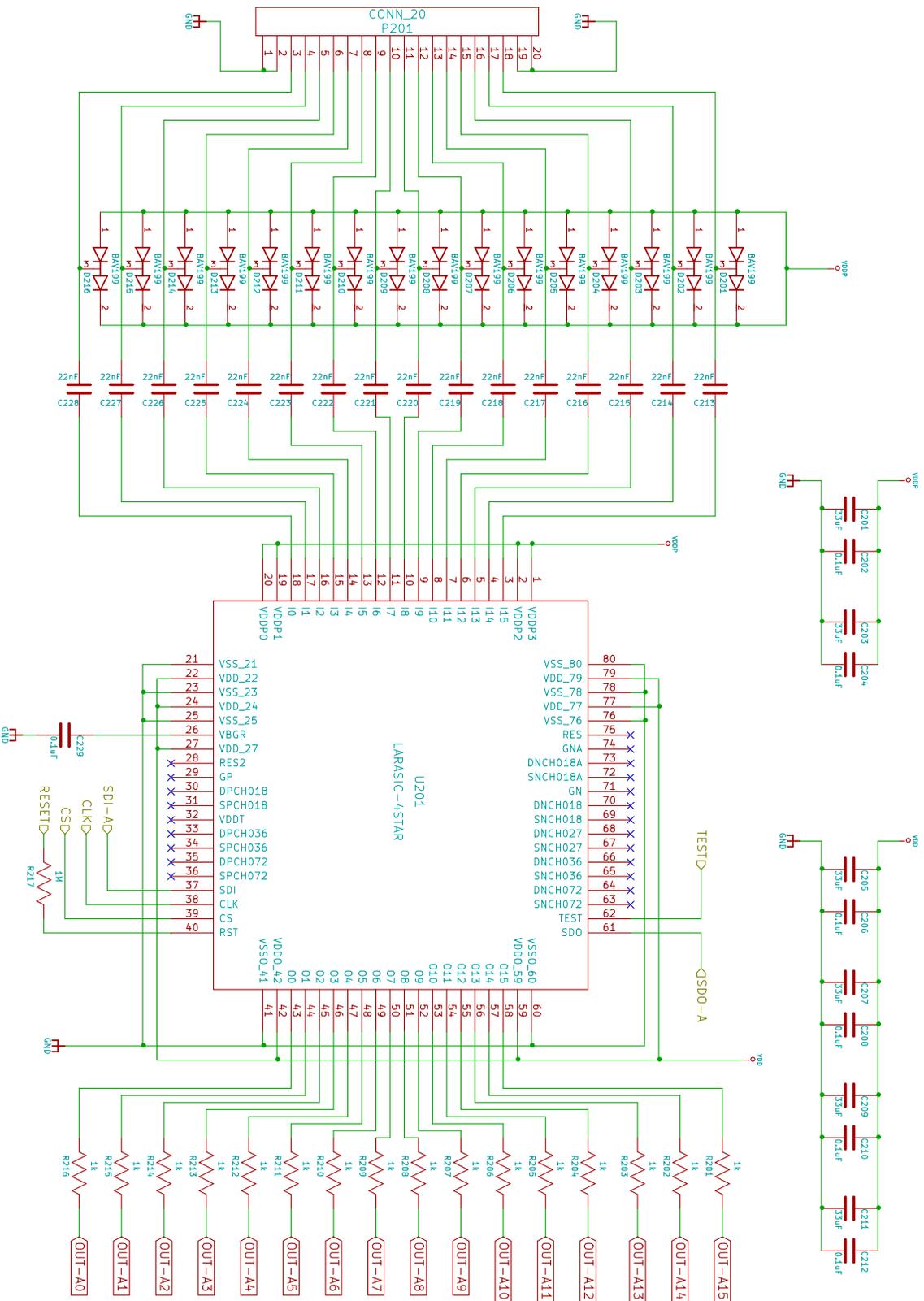
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Size: A Date: 23 apr 2014

Kicad E.D.A. eeschema (2013-07-07 BZR 4022)-stable

Rev: 2.0

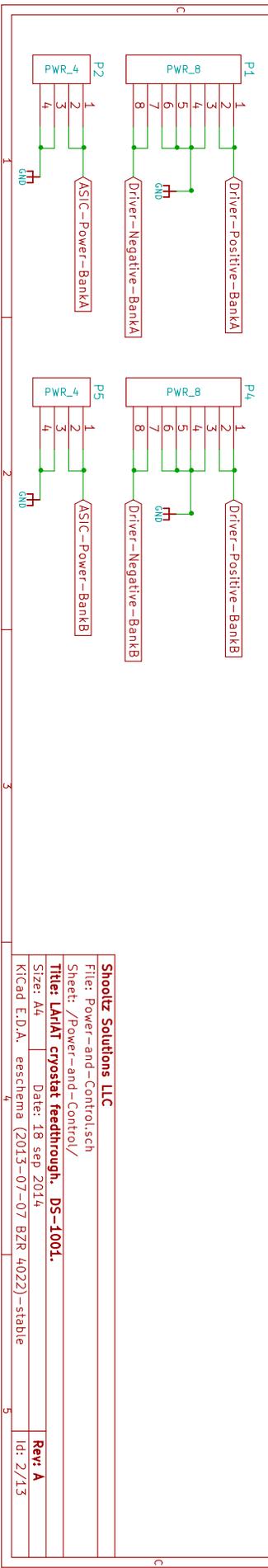
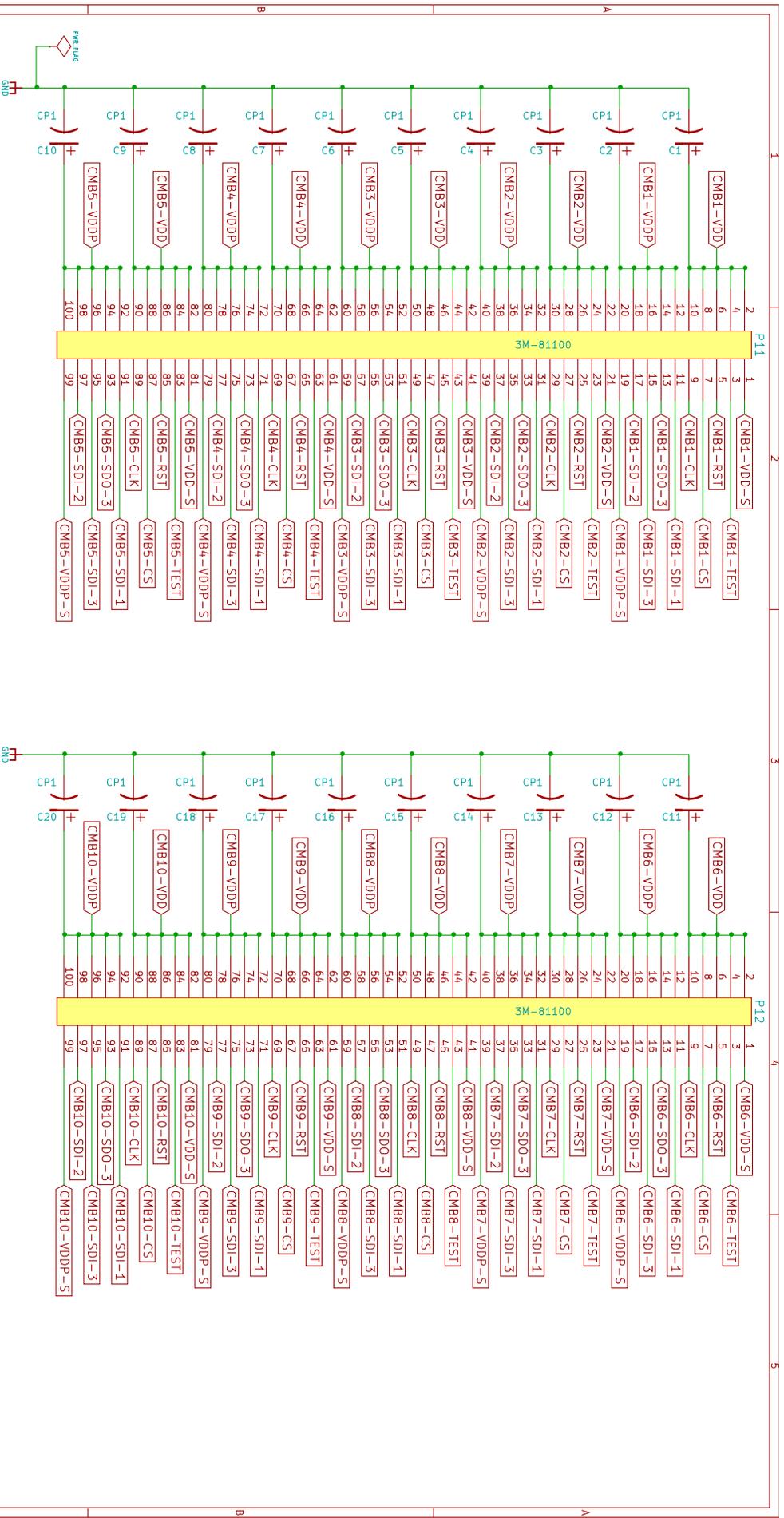
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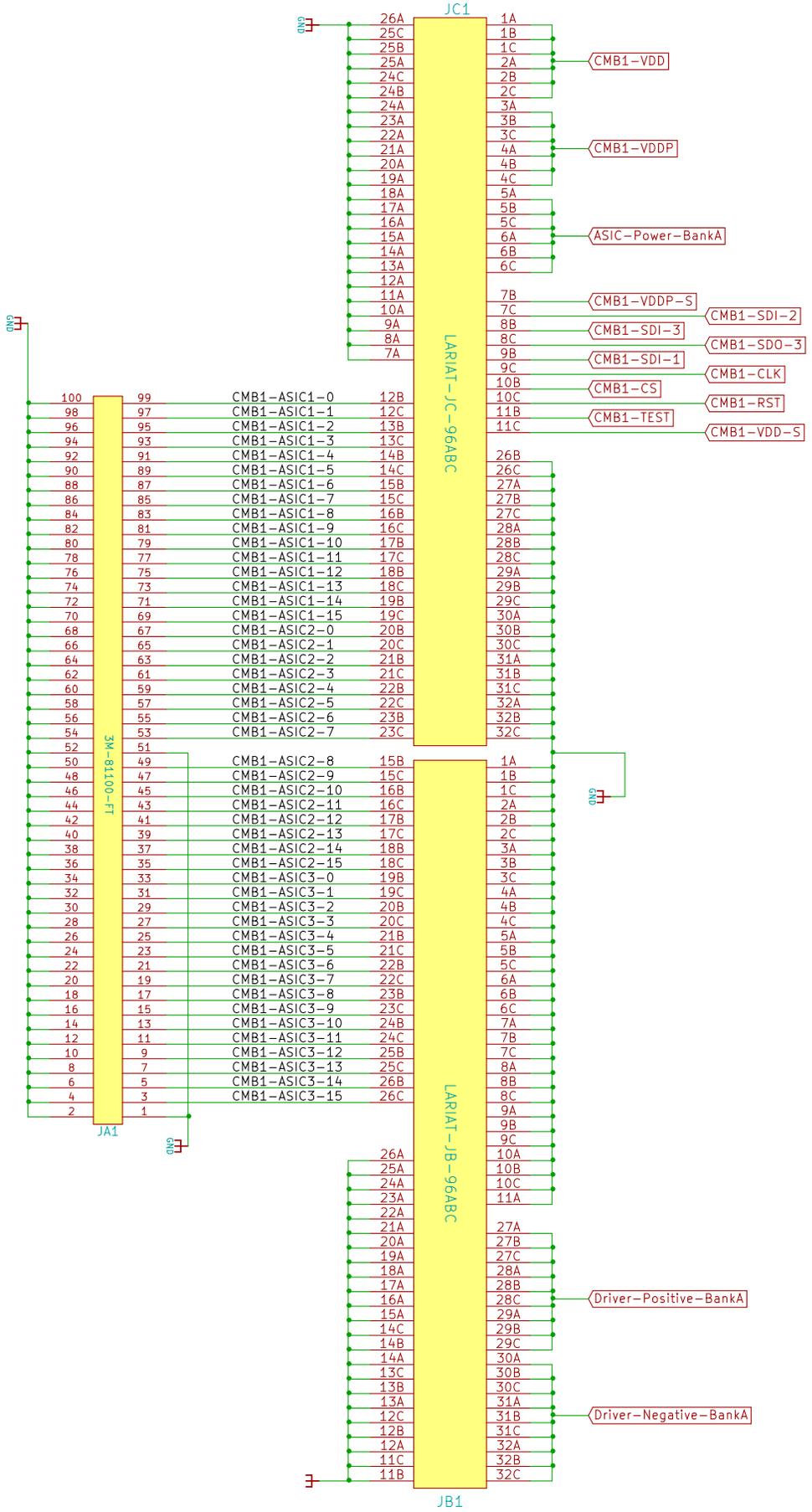
Shoultz Solutions LLC
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Title: LARAT Front End Cold Electronics
 Size: A Date: 25 apr 2014 Rev: 2.0
 KiCad E.D.A. eeschema (2013-07-07 BZR 4022) -stable Id: 2/4

Following two slides: LArIAT cryostat feed-through/backplane card.

This is the large card that is sandwiched between a flange and a cap on top of the cryostat.



Shootz Solutions LLC
 File: Power-and-Control.sch
 Sheet: /Power-and-Control/
Title: LArLAT cryostat feedthrough. DS-1001.
 Size: A4
 Date: 18 sep 2014
 KiCad E.D.A. eeschema (2013-07-07 BZR 4022) - stable
Rev: A
 Id: 2/13



Shootz Solutions LLC
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Title: LARIAT cryostat feedthrough. DS-1001.
 Size: A4 Date: 18 sep 2014
 KiCad E.D.A. eeschema (2013-07-07 BZR 4022) - stable
Rev: A
 Id: 3/13

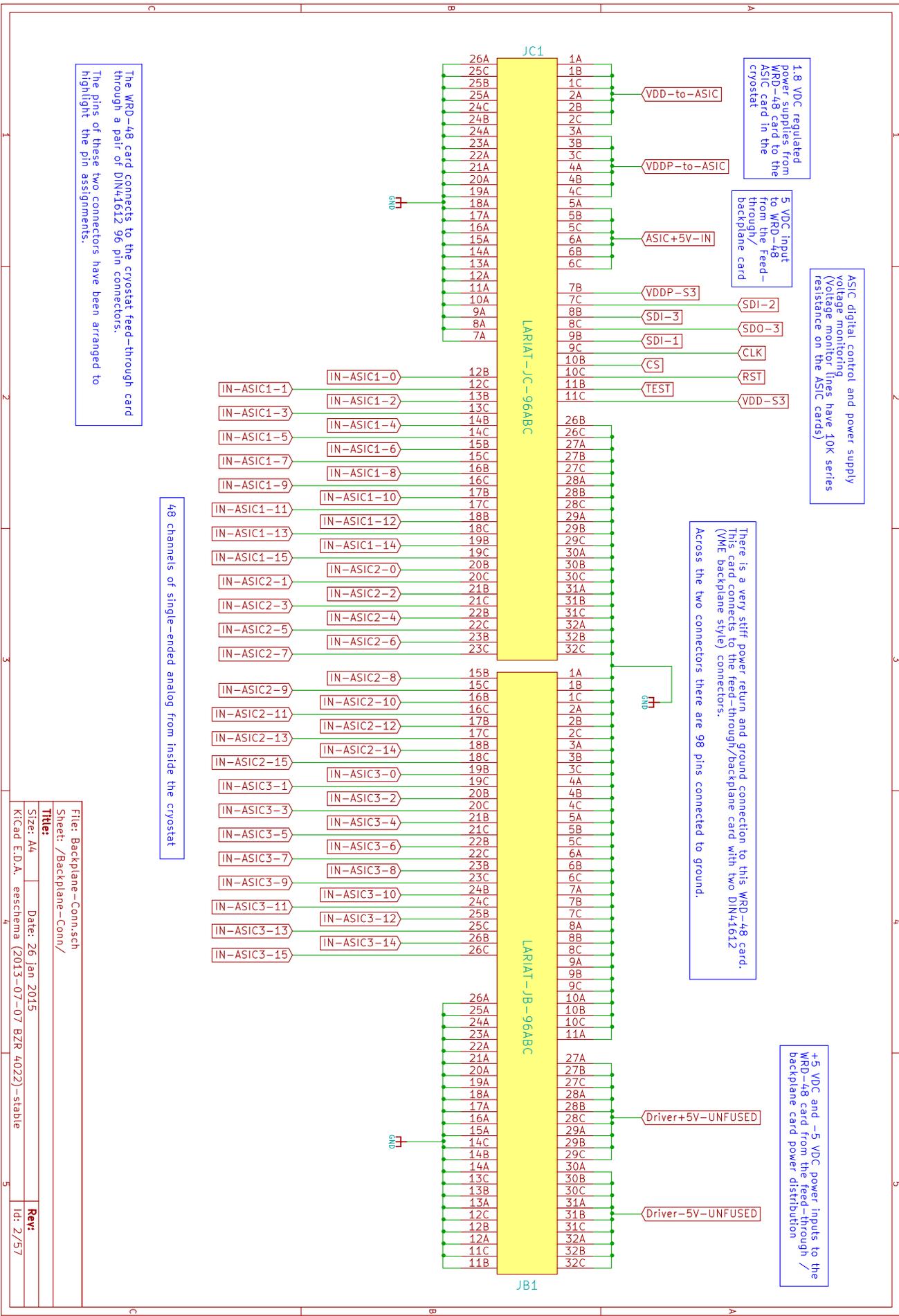
Following 6 slides: Schematics of the WRD-48 card.

There are ten of these cards in the 480 channel LArIAT readout.

These cards plug into the Feed-through / Backplane card.

These cards do the following:

- 1) Provide 1.8 VDC regulated power to the ASIC cards in the cryostat
- 2) Provide buffered and monitored digital control lines to the ASIC cards
- 3) Amplify the ASIC analog output signals as differential analog.
- 4) Connect to the 25 foot long pleated-foil signal cables.



1.8 VDC regulated power supplies from WRD-48 card in the cryostat

5 VDC input to WRD-48 from the Feed-through/backplane card

ASIC digital control and power supply voltage monitoring (Voltage monitor lines have 10K series resistance on the ASIC cards)

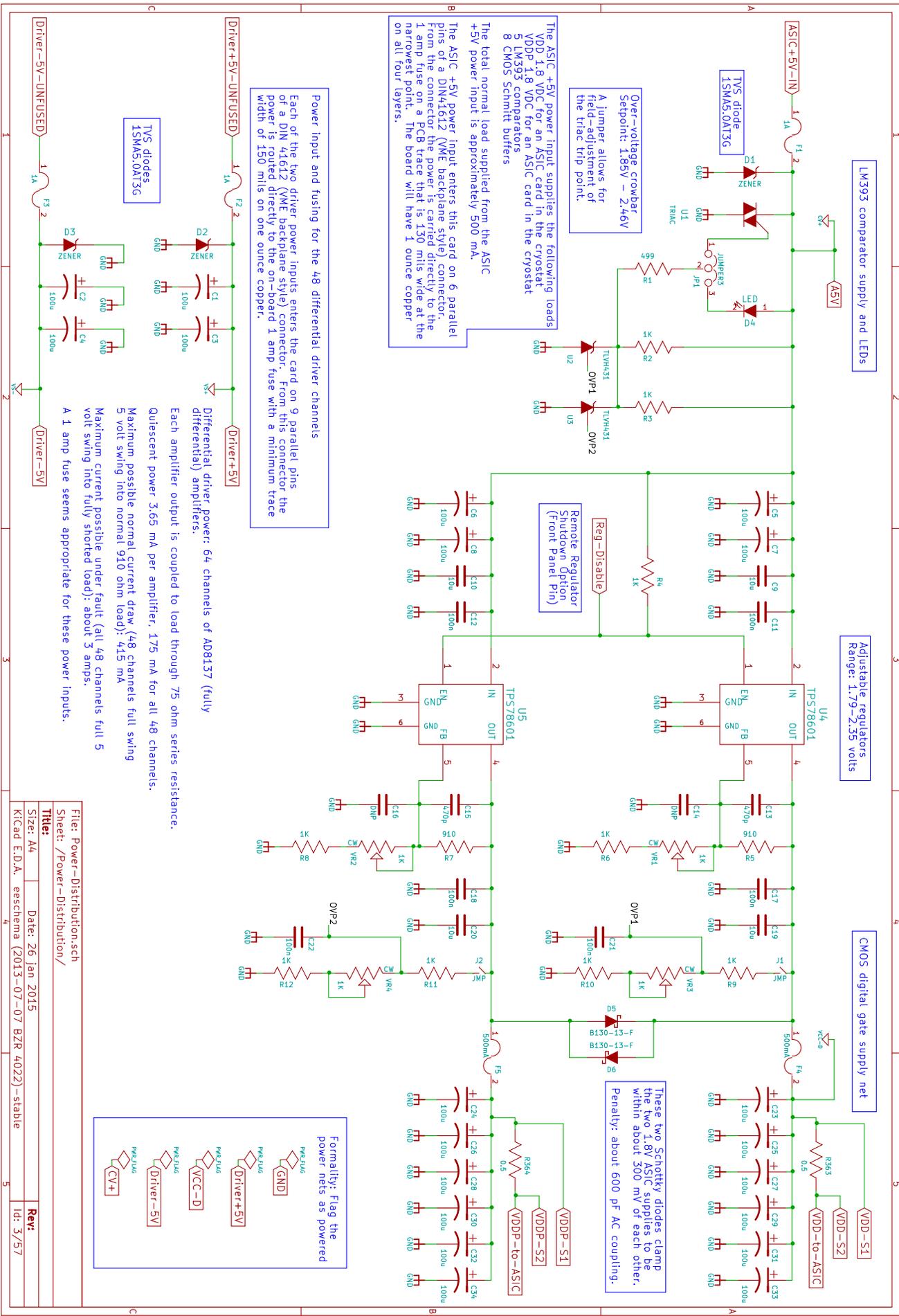
There is a very stiff power return and ground connection to this WRD-48 card. This card connects to the feed-through/backplane card with two DIN41612 (VME backplane style) connectors. Across the two connectors there are 98 pins connected to ground.

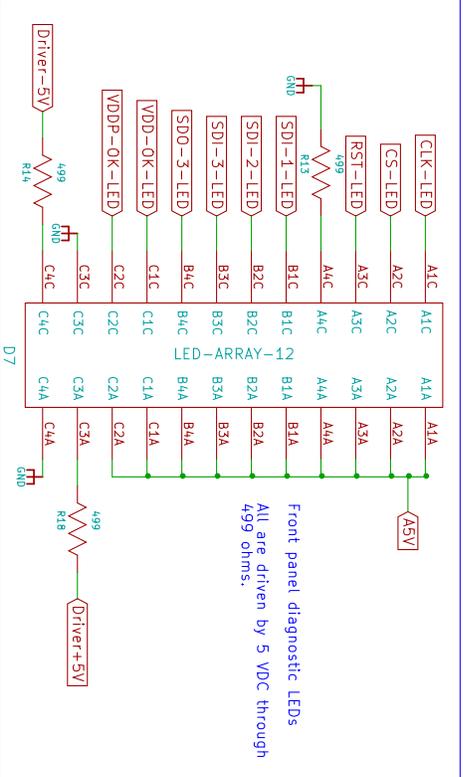
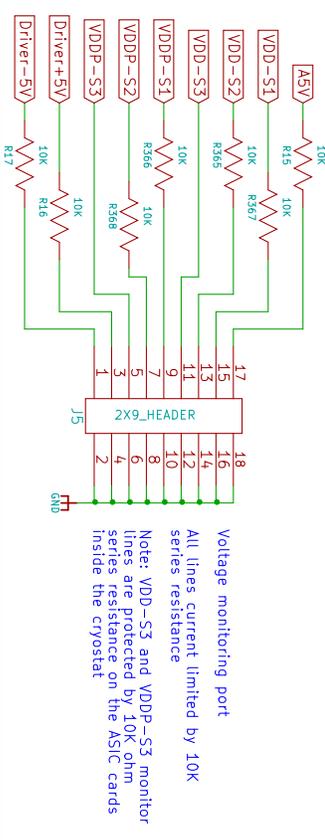
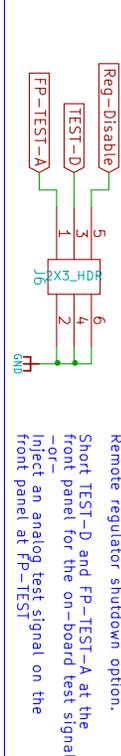
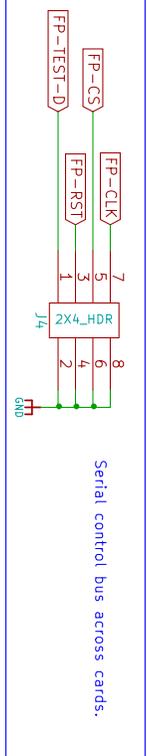
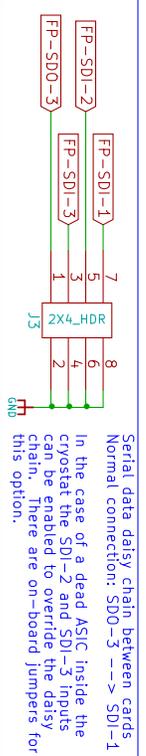
+5 VDC and -5 VDC power inputs to the WRD-48 card from the feed-through/backplane card power distribution

48 channels of single-ended analog from inside the cryostat

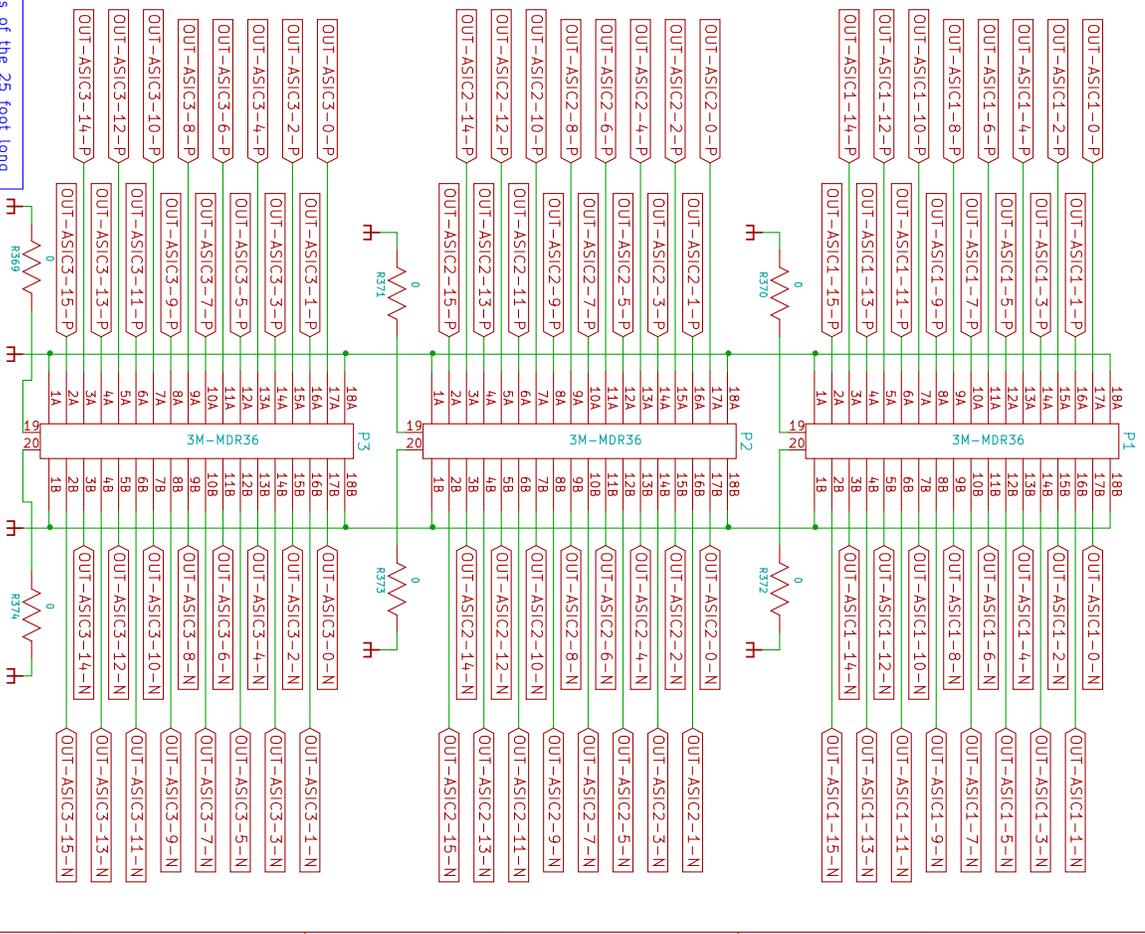
The WRD-48 card connects to the cryostat feed-through card through a pair of DIN41612 96 pin connectors. The pins of these two connectors have been arranged to highlight the pin assignments.

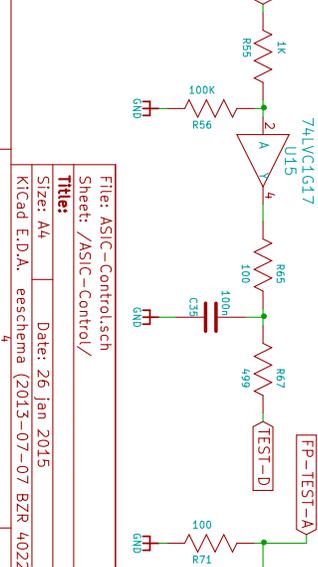
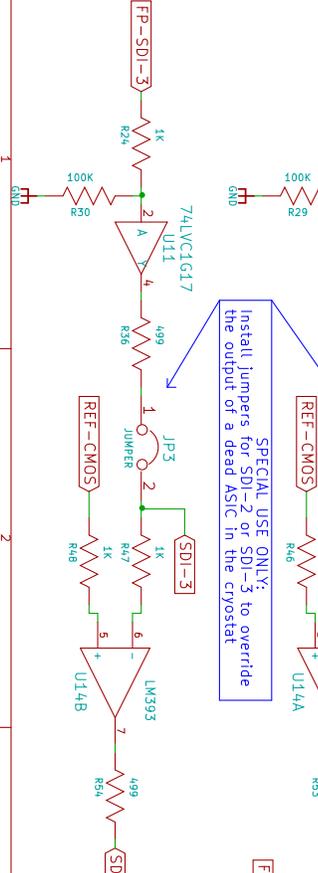
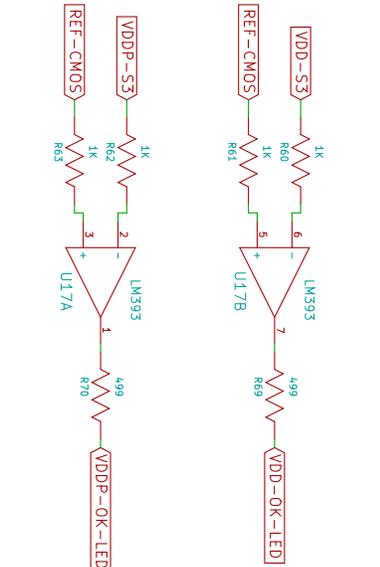
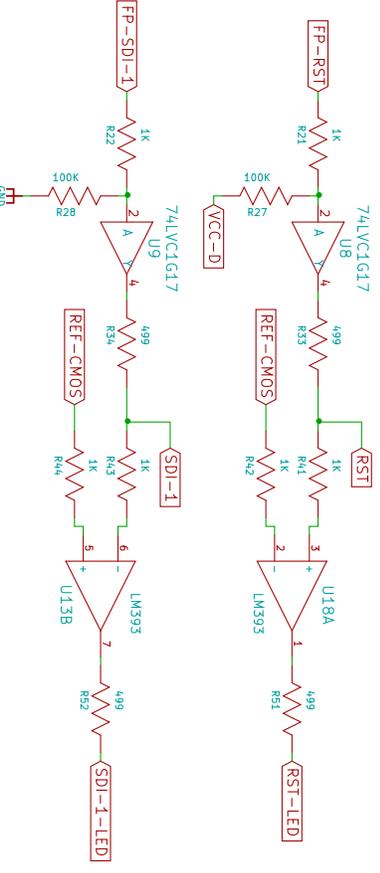
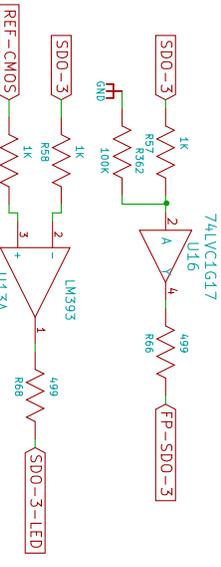
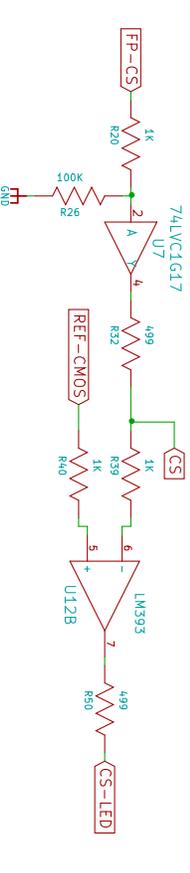
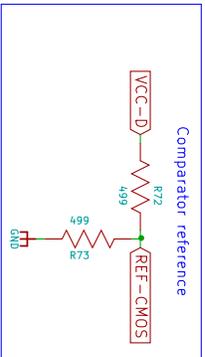
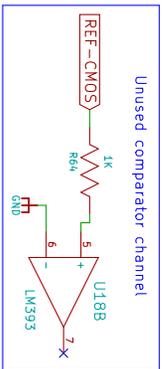
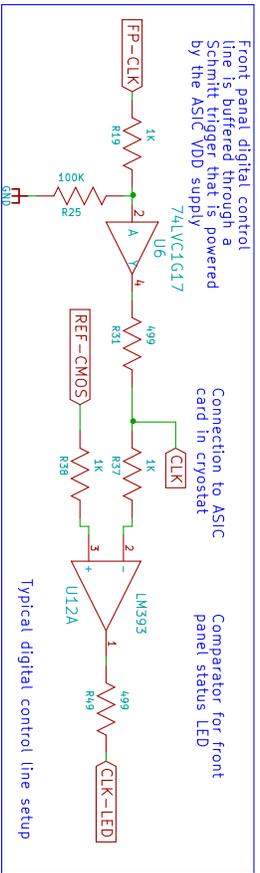
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Sheet: /Backplane-Conn/	
Title:	
Size: A4	
KiCad E.D.A. eschema (2013-07-07 BZR 4022) - stable	
Rev:	Id: 2/57





The shields of the 25 foot long signal cables are connected to the WRD-48 local ground by R369 to R374. By default these are zero ohm resistors

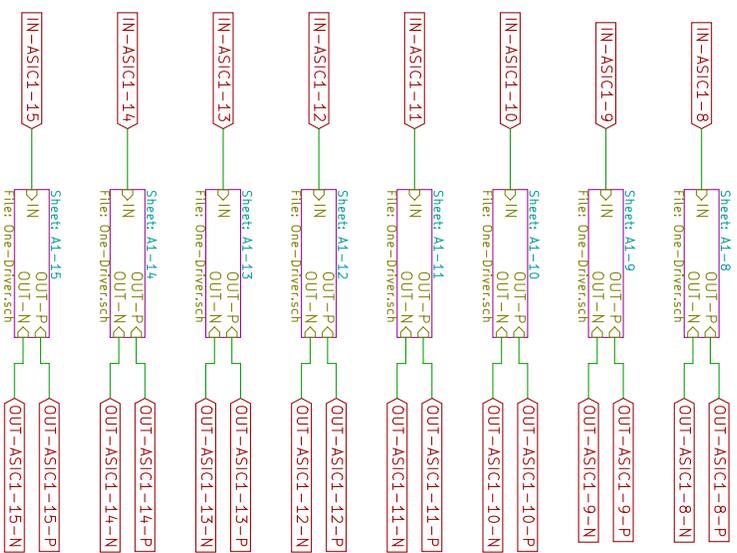
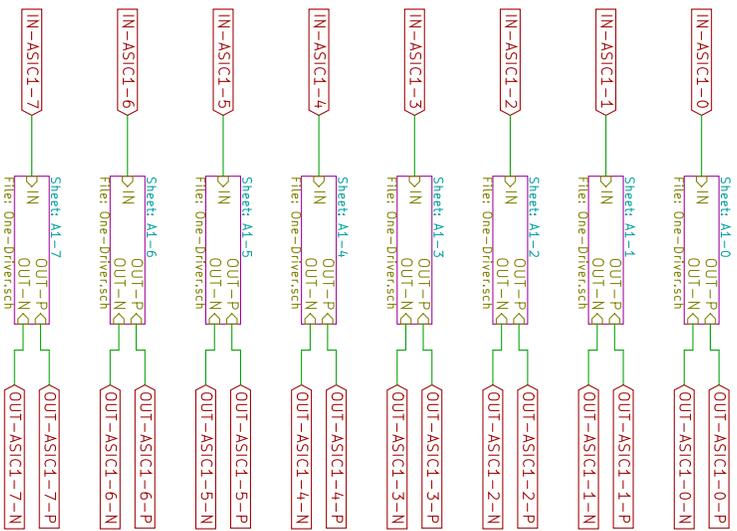




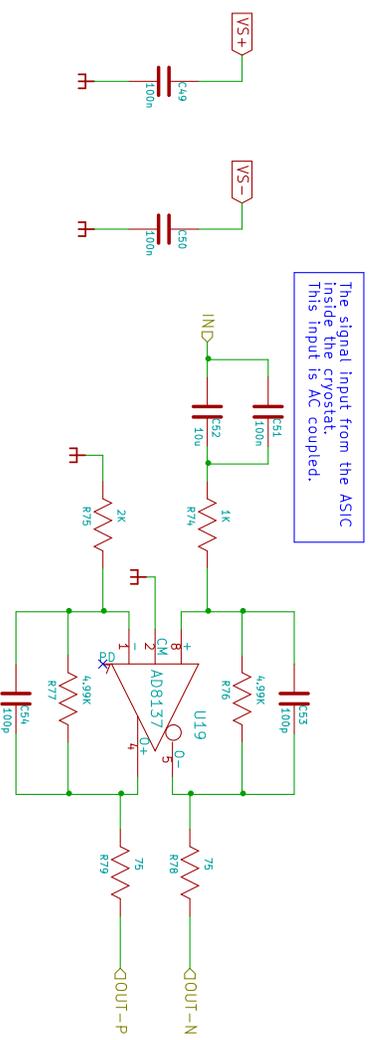
SPECIAL USE ONLY:
Install jumpers for SDI-2 or SDI-3 to override the output of a dead ASIC in the crystal

Short TEST-D and FP-TEST-A at the front panel for the on-board test signal -OR- Inject an analog test signal on the front panel at FP-TEST

File: ASIC-Control.sch	Date: 26 Jan 2015
Sheet: ASIC-Control/	
Title:	
Size: A4	Rev: 5/57
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File: Drivers-Bank1.sch	
Sheet: /Drivers-Bank1/	
Title:	
Size: A4	Date: 26 Jan 2015
KtCad E.D.A. eeschema (2013-07-07 BZR 4022) -stable	
	Rev:
	Id: 6/57



The signal input from the ASIC inside the crystal. This input is AC coupled.

Single-ended to differential amplifier.
 Gain = 2.5
 Feedback network RC = 499 nsec
 Fc = 319 KHz
 Note: the ground reference resistor is 2k. This is to balance the feedback network, since the ASIC output is coupled through a 1k series resistance inside the crystal.

Differential signal output to front panel, through cables, and finally to the DZS-64 cards near the CAEN digitizers. Front panel connection to 25 foot long pleated foil cables. Back termination resistors decouple the amplifier from the capacitive load of the cable.

File: One-Driver.sch	
Sheet: /Drivers-Bank1/A1-0/	
Title:	
Size: A4	Date: 26 Jan 2015
KiCad E.D.A. eeschema (2013-07-07 BZR 4022)-stable	
Rev:	Id: 7/57

Following 6 slides: schematics for the D2S-64 cards.

These cards reside in a custom card file located in the DAQ rack.

They should be located close to the CAEN digitizers.

These cards convert 64 channels of differential analog to single-ended analog.

Power is distributed to two separate banks of 32 channels on each card.

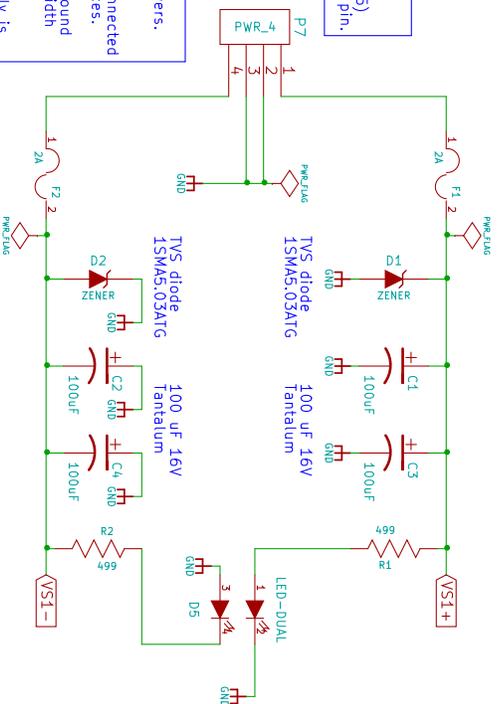
Expected D2S power consumption: 32 channels of AD8091 amplifier per bank. The two banks per D2S card are on separate fused power.
 Quiescent current of each amplifier= 4.8 mA. 32 amplifiers= 154 mA
 Amplifier output current limited by $R=75$ ohms. Normal external load is the 50 ohm input impedance of the CAEN digitizer.
 If all channels go into full voltage swing (unlikely) into the normal 50 ohm load of the CAEN input termination then the current draw will be 1.28 amps.
 If all channels are shorted to ground and all channels go into full voltage swing (very unlikely) then the current draw will be 2.13 amps

Power input connector:
 PCB: TE 796638-4 (Digi-Key A98237)
 CableMount: TE 796654-4 (Digi-Key A98225)
 These connectors are rated at 15 amps per pin.

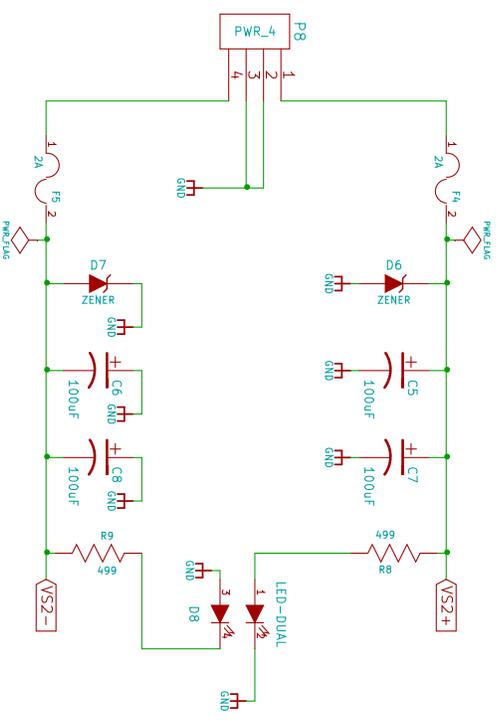
PCB copper details:
 4-layer PCB with 1 ounce copper on all layers.
 Copper pullback is 50 mils from all edges.

The +5VDC and -5VDC power inputs are connected to the on-board fuses on 120 mil wide traces.
 Each power return line is connected to a ground plane through thermal reliefs with a total width of 360 mils.
 After the on-board fuses each voltage supply is connected to a power plane through 15 vias

After the on-board fuses each voltage supply is connected to a power plane through 15 vias



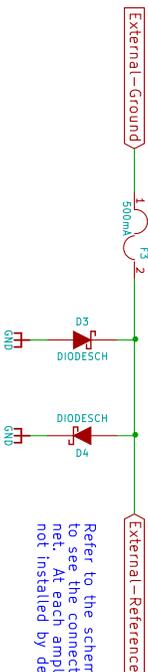
This is the +/- 5 VDC power for the first bank of 32 channels of differential to single-ended converters.
 This arrangement allows for half of a D2S card to be powered while the other half is not powered.
 In LAR1AT we have 480 channels, so 7.5 64-channel D2S cards are needed.



This is the +/- 5 VDC power for the second bank of 32 channels of differential to single-ended converters.
 This arrangement allows for half of a D2S card to be powered while the other half is not powered.
 In LAR1AT we have 480 channels, so 7.5 64-channel D2S cards are needed.

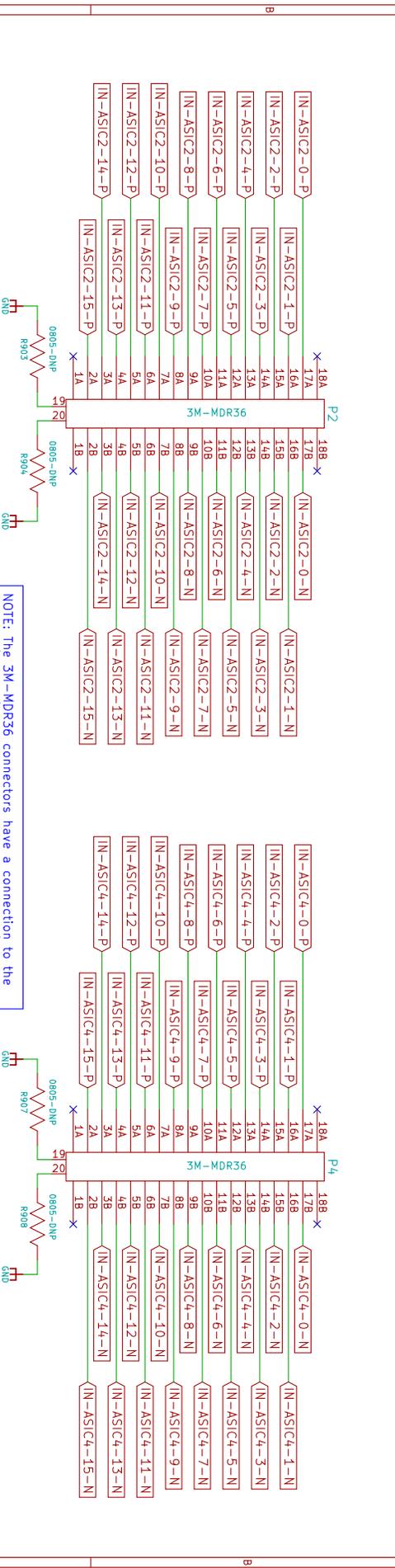
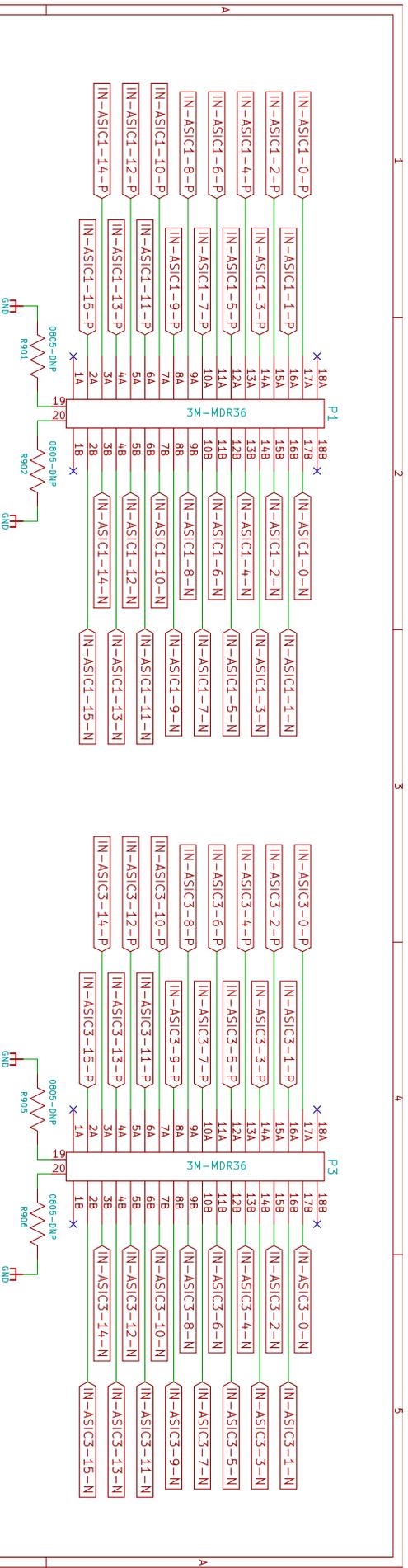
This is an optional way to bring an external ground reference onto the D2S card for the differential amplifiers. The external reference, if used, will be clamped to within about 300 mV of the D2S ground by the Schottky diodes.
 By default this option will not be enabled:
 (1) The fuse will not be installed.
 (2) The External Reference net will not be connected at any individual amplifier.

The reasoning for including this option is as follows:
 The CAEN digitizers measure the single-ended signals relative to the local ground on the CAEN card.
 The ground on the D2S card may be slightly different. It may be fluctuating at frequencies that may affect signal quality.
 We may be able to reduce noise by using the CAEN ground as the reference for the D2S amplifiers.

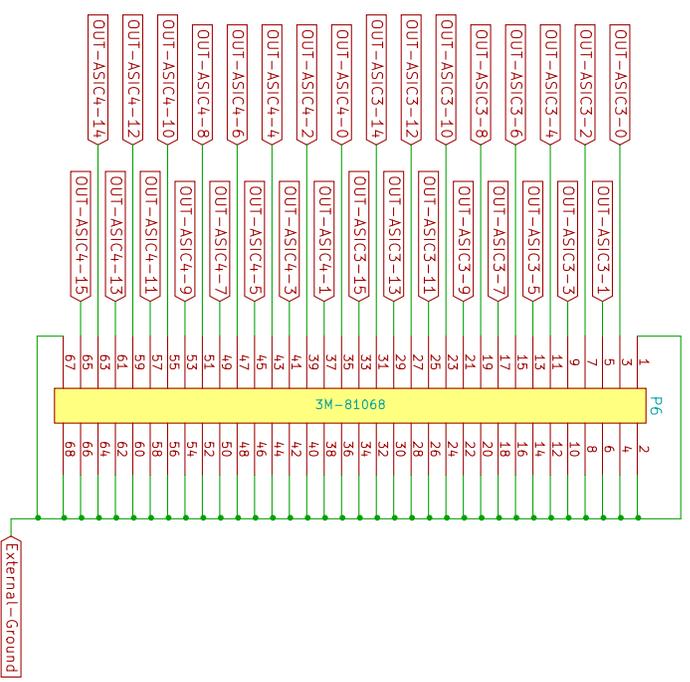
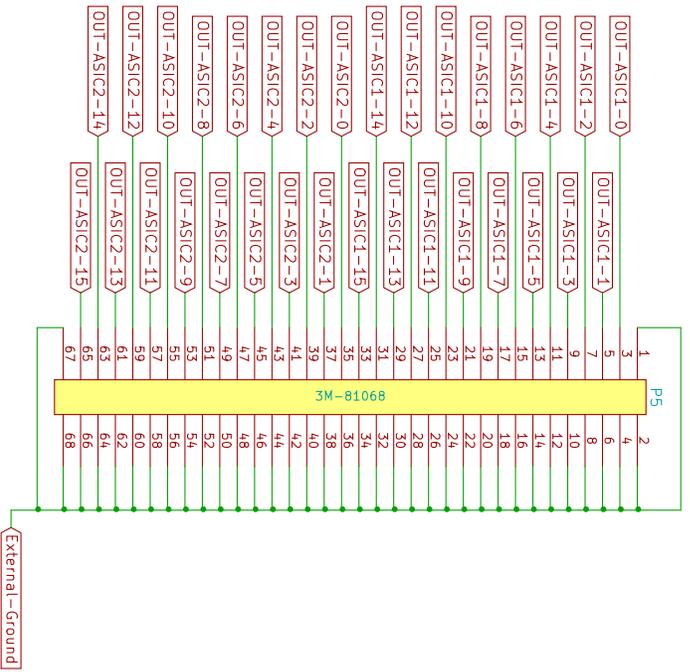


Refer to the schematic of an individual amplifier to see the connectivity of the External-Reference net. At each amplifier there are resistors that are not installed by default.

File: Power_Distribution.sch	Date: 21 Jan 2015
Sheet: /Power_Distribution/	
Title:	
Size: A4	Rev: 4/7/3
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NOTE: The 3M-MDR36 connectors have a connection to the cable shield available through the connector mounting holes. I have explicitly shown the connections to the shield as pins 19 and 20 in the schematic.
 The intent is to have the cable shields grounded only at the source of the signals: the WRD-48 cards.
 By default resistors R901-R908 will not be installed.



The signal outputs to the CAEN V1740 digitizer are single-ended analog with a maximum swing of +/- 2 volts into the CAEN 50 ohm input termination resistors.

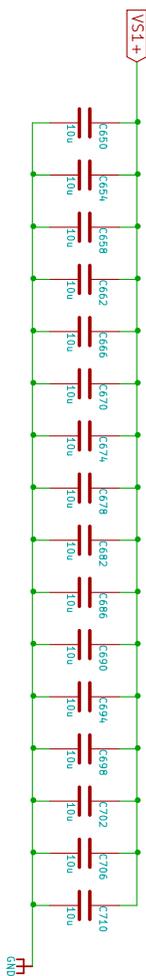
The connection from the D2S to the CAEN card is through two 68-line ribbon cables.

Each ribbon cable connected to the D2S provides 36 lines connected to the local ground of the CAEN card.

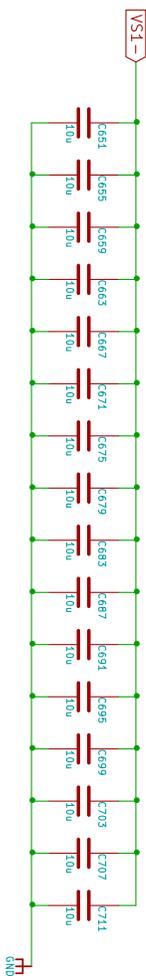
Refer to the sheet entitled "Power Distribution" for the connectivity of this external ground.

File: SignalOutputs.sch	
Sheet: /SignalOutputs/	
Title:	
Size: A4	Date: 21 Jan 2015
KiCad E.D.A. eeschema (2013-07-07 BZR 4022) - stable	
Rev:	
	Id: 3/73

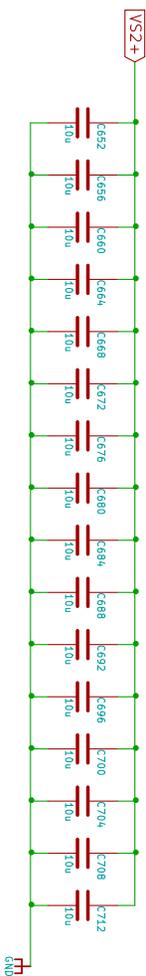
+5 bypass for amplifiers in Bank1 and Bank2.
There are two amplifiers per each capacitor.



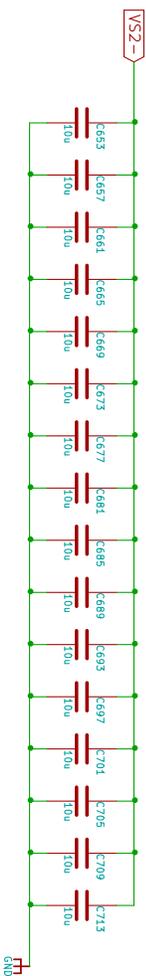
-5 bypass for amplifiers in Bank1 and Bank2.
There are two amplifiers per each capacitor.



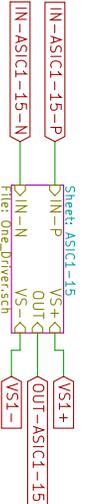
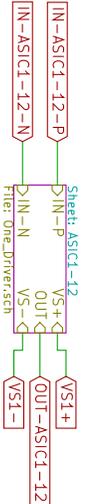
+5 bypass for amplifiers in Bank3 and Bank4.
There are two amplifiers per each capacitor.



-5 bypass for amplifiers in Bank3 and Bank4.
There are two amplifiers per each capacitor.



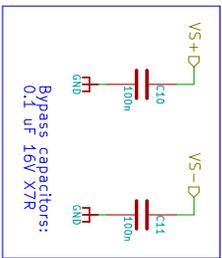
File: Driver-Bypass-Caps.sch	
Sheet: /Driver-Bypass-Caps/	
Title:	
Size: A4	Date: 21 jan 2015
KICad E.D.A. eeschema (2013-07-07 BZR 4022) - stable	
Rev:	Id: 73/73



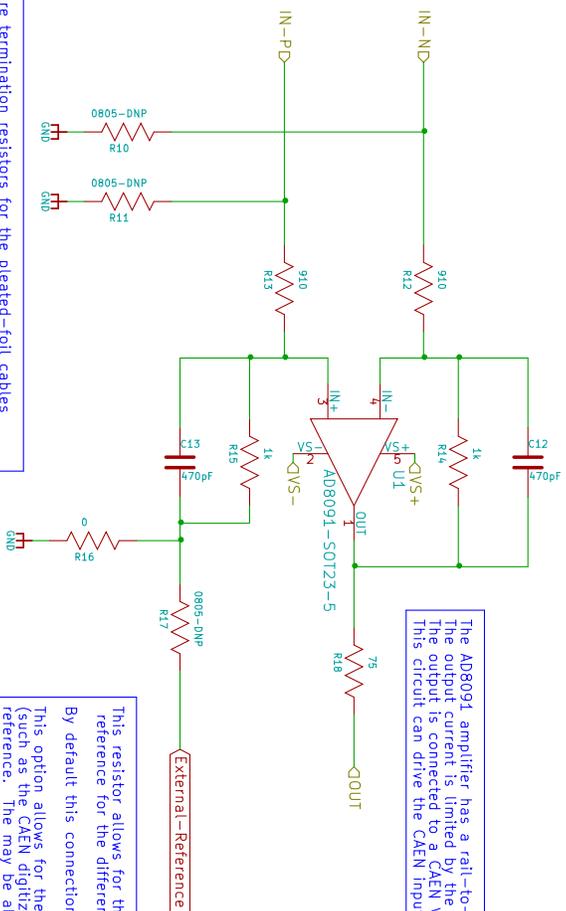
File: Drivers-Bank1.sch
 Sheet: /Drivers-Bank1/

Title:		Rev:
Size: A	Date: 21 Jan 2015	Id: 5/73
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Differential to single-ended amplifier.
 Gain (including source impedance of 75 Ohm) is about 1.02
 The RC in the feedback loop is 0.47 microseconds.
 This will roll off the gain for signals above the frequencies of interest.



These are termination resistors for the pleated-foil cables coming from the warm receivers.
 We are dealing with slow signals (150 kHz), so the termination resistors are not necessary.
 These circuit elements are specified so that the circuit board copper layout includes the possibility of adding termination resistors as an optional feature.



The AD8091 amplifier has a rail-to-rail output section. The output current is limited by the 75 ohm output coupling resistor. The output is connected to a CAEN V1740 digitizer with 50 ohm input termination. This circuit can drive the CAEN input to $(+/-5V)/(125\text{ ohms}) = +/-2V$.

This resistor allows for the optional connection of an external reference for the differential to single-ended amplifier.
 By default this connection will not be enabled.
 This option allows for the ground of an external device (such as the CAEN digitizer) to be used as the output reference. The may be able to reduce signal noise caused by the different ground potentials of the D2S and the input of the CAEN digitizer.

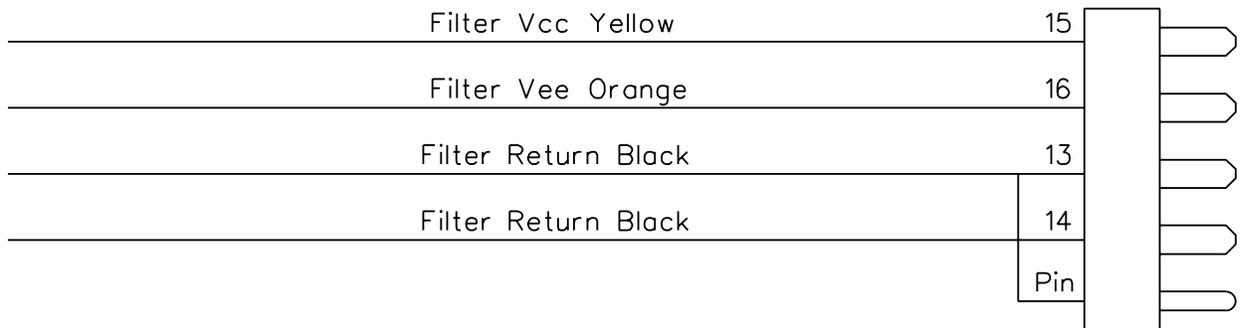
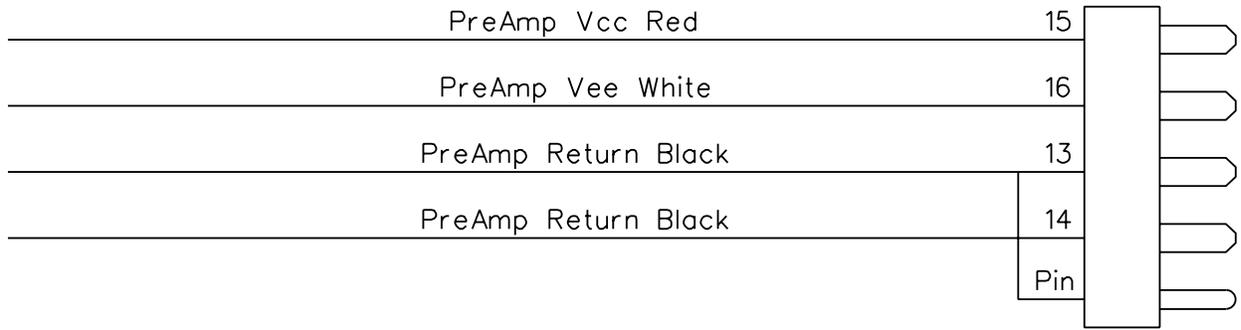
File: One_Driver.sch	Date: 21 Jan 2015	Rev:
Sheet: /Drivers-Bank1/ASIC1-0/		Id: 6/73
Title:		
Size: A4		
KiCad E.D.A. eeschema (2013-07-07 BZR 4022)-stable		

T962 LArTPC Preamp Power Cable

Power Supply
D.C. Output
Terminal Strips

← 25 Feet →

Preamp Box
Power Connectors



These cables are made with number 14 AWG wire. Each set of 4 wires is twisted together and the overall cable is covered with a woven sleeving.

The connectors are Cinch Jones P2404 15 Amps per contact

Rev. 11-SEPT-2008

T962 LArTPC

Preamp

Power Supply

