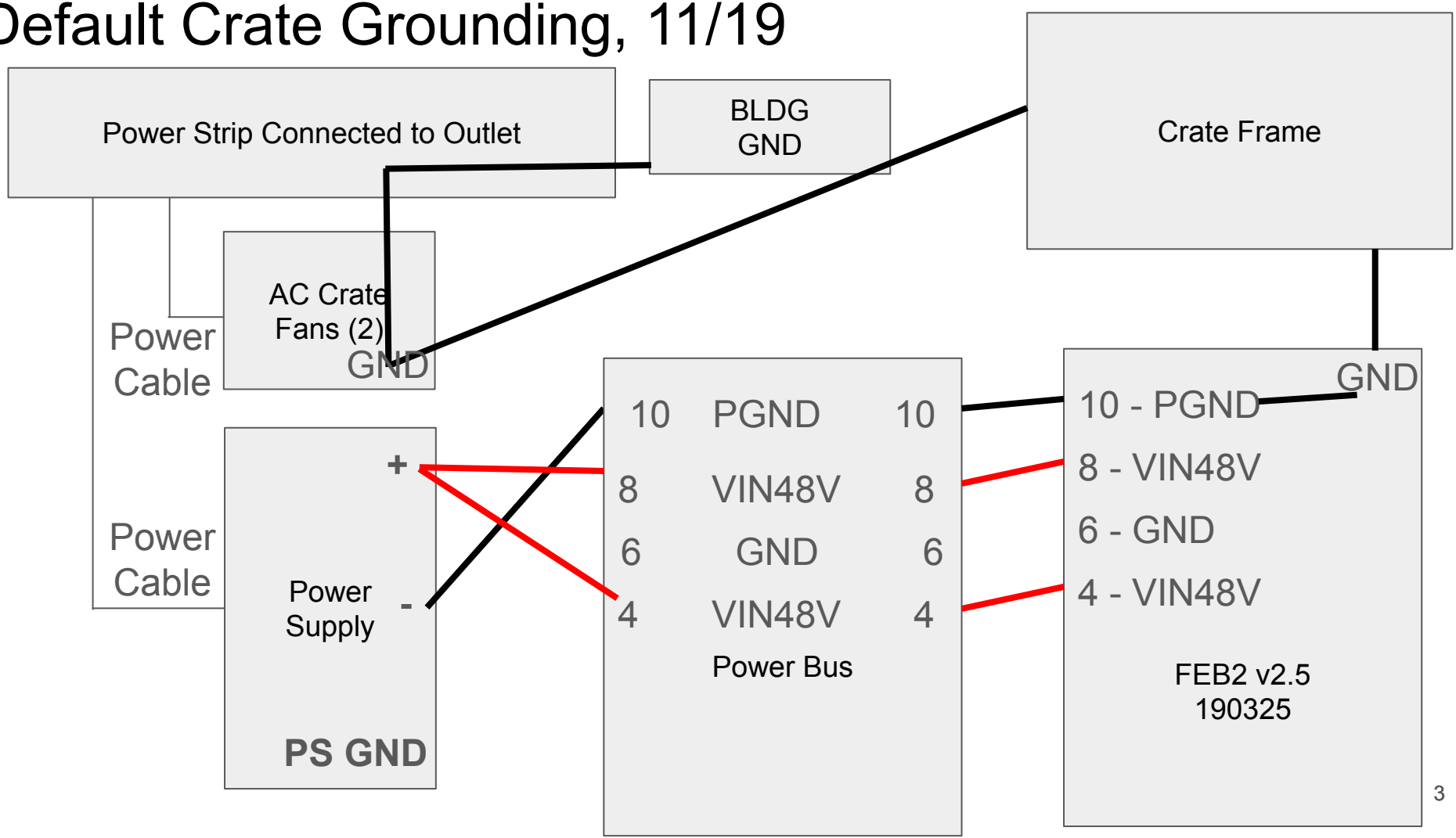
v2.5 Power Bus Noise Tests

2024-11-14 to 19

Test Setup

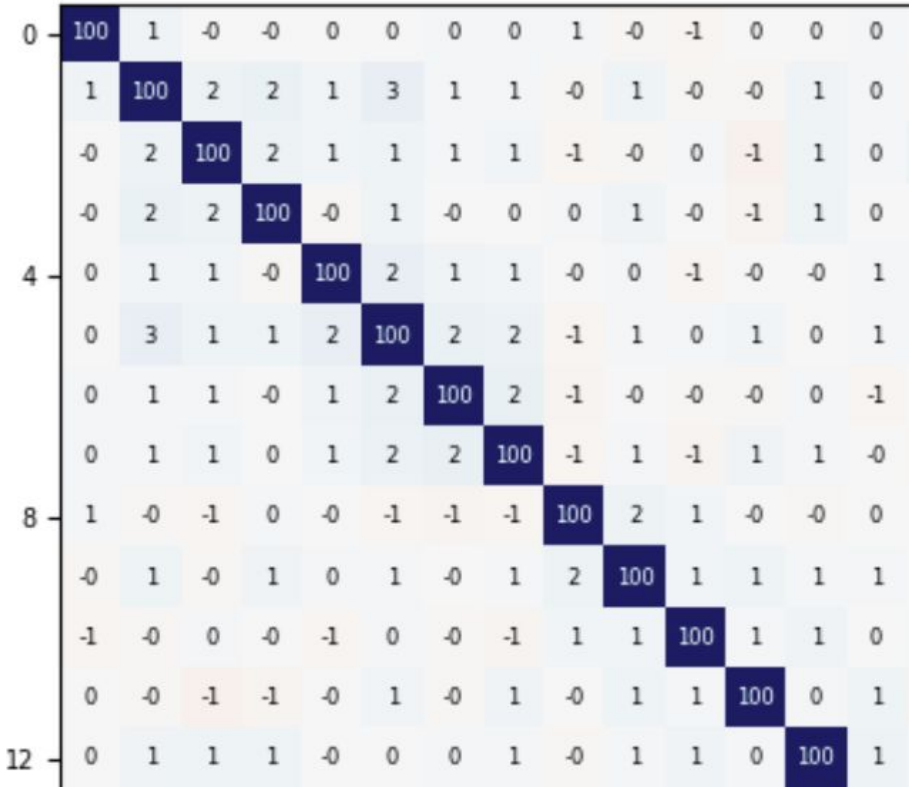
- Use board 190324 for all tests
- Start with “standard”/”simplest” recommended power and grounding scheme shown on next slide
  - Use this scheme unless otherwise noted
- Using GUI version 3a8b731
- Ch 126-127 HG pearson correlation percentage and ch 127 HG RMS are the metrics to use to evaluate noise

Default Crate Grounding, 11/19

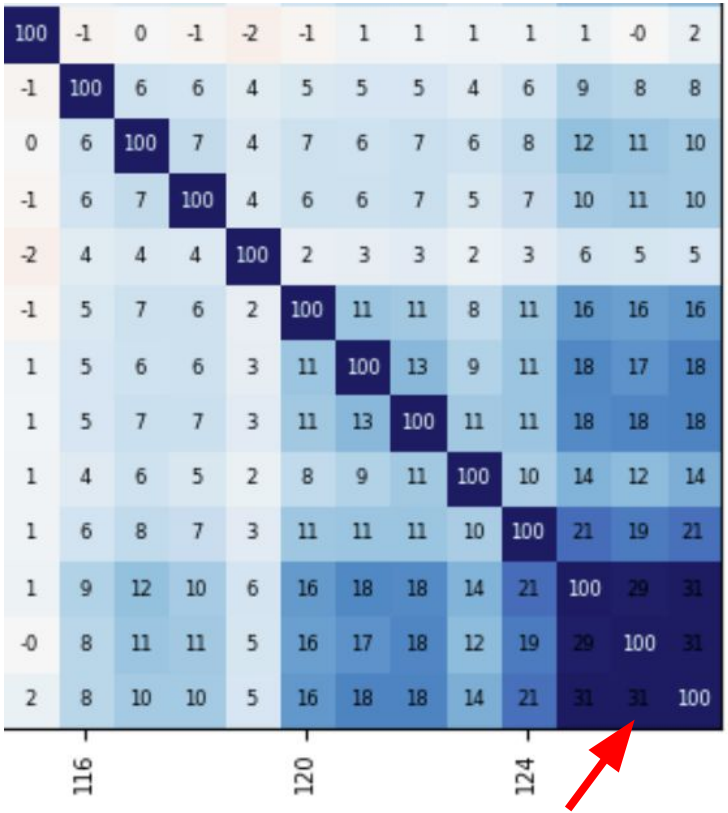


Metric to Use: Ch 126-127 HG Pearson Correlation %

Bottom of Board Ch 0-12

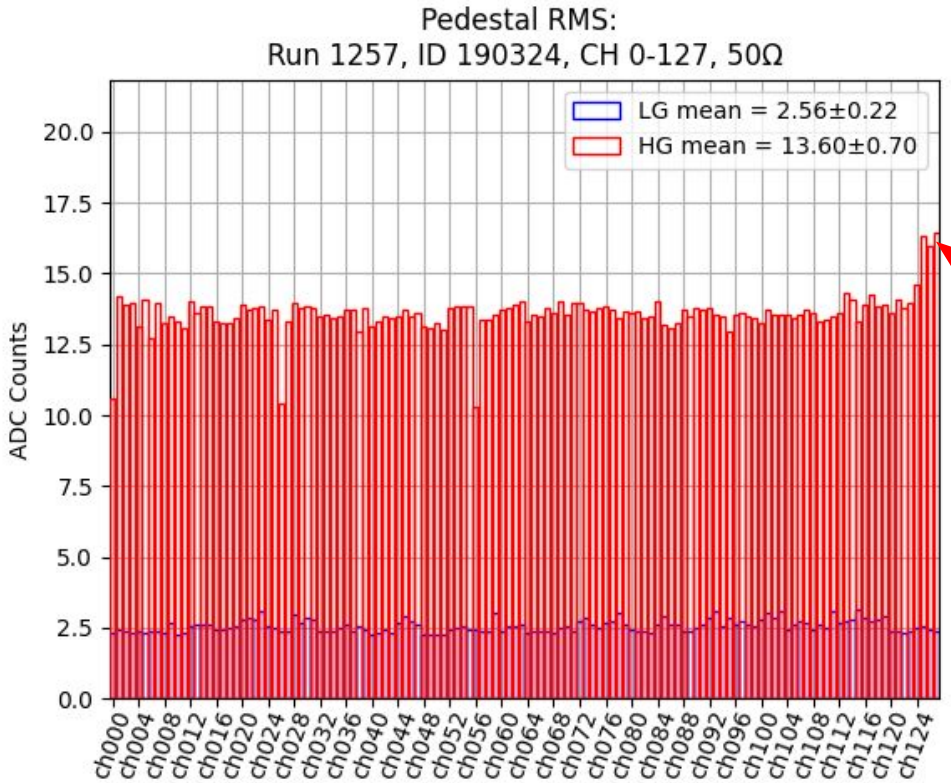


Top of Board Ch 115-127



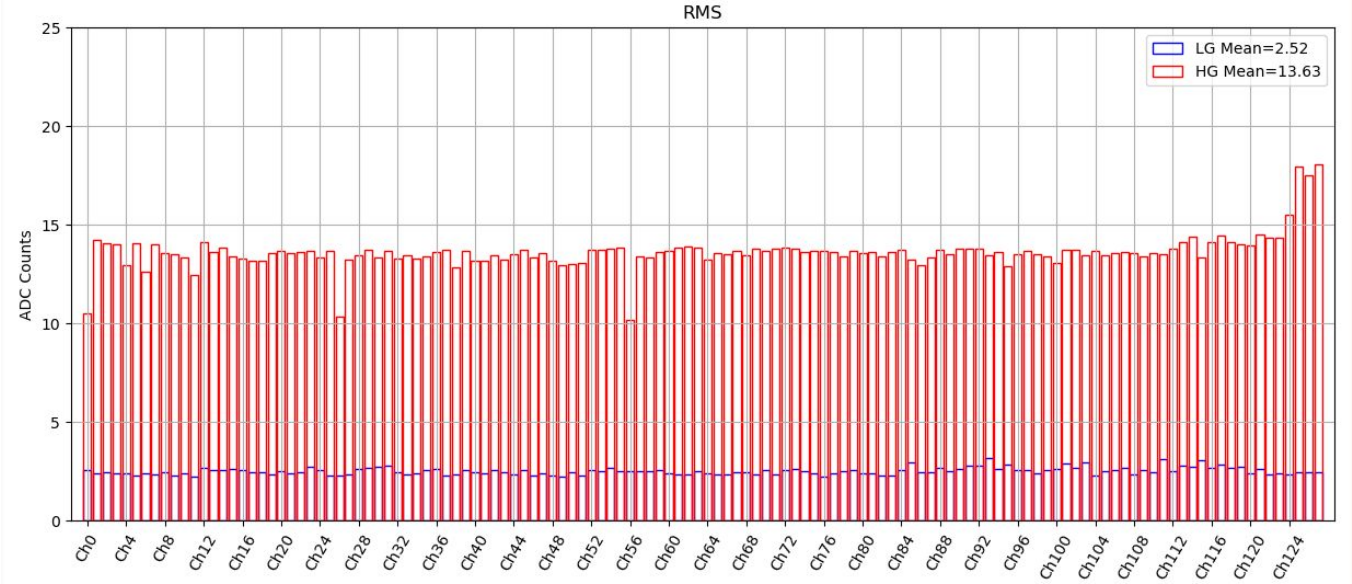
Ch 126 to 127 correlation percentage should be ~1-2%, instead measure 31%

Metric to Use: Ch 127 HG RMS



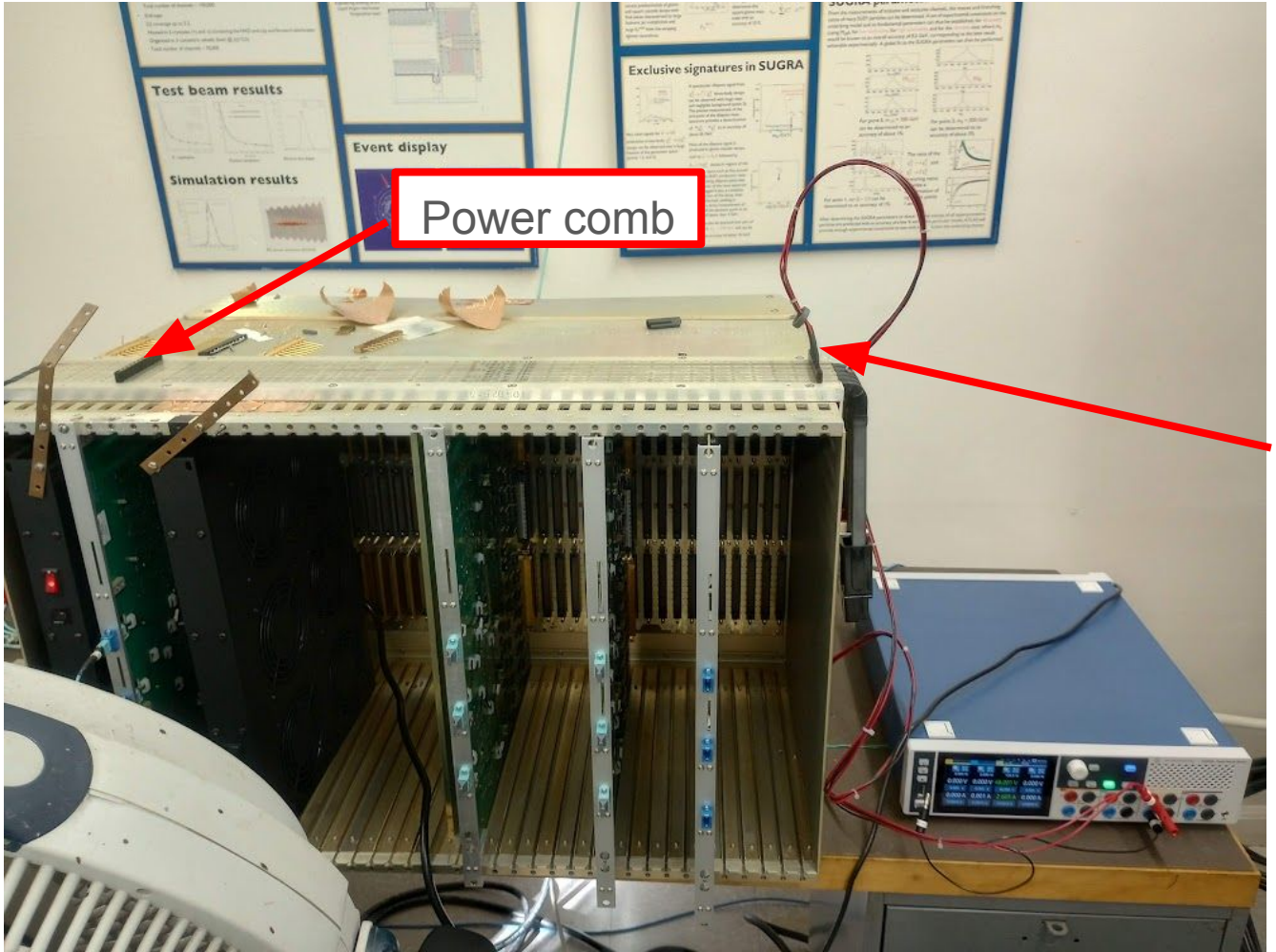
Should measure 13.5 ADC,
instead measure ~16 ADC

Initial Noise Measurement with Default Setup on 11/08



Board	Config.	PS Power [W]	Trigger Mode Ped.	Single ADC Mode Ped.	Ch 126-127 HG Corr. %	Ch 127 HG RMS
190324	Default	124.8	1261	1262	43.3	18.3

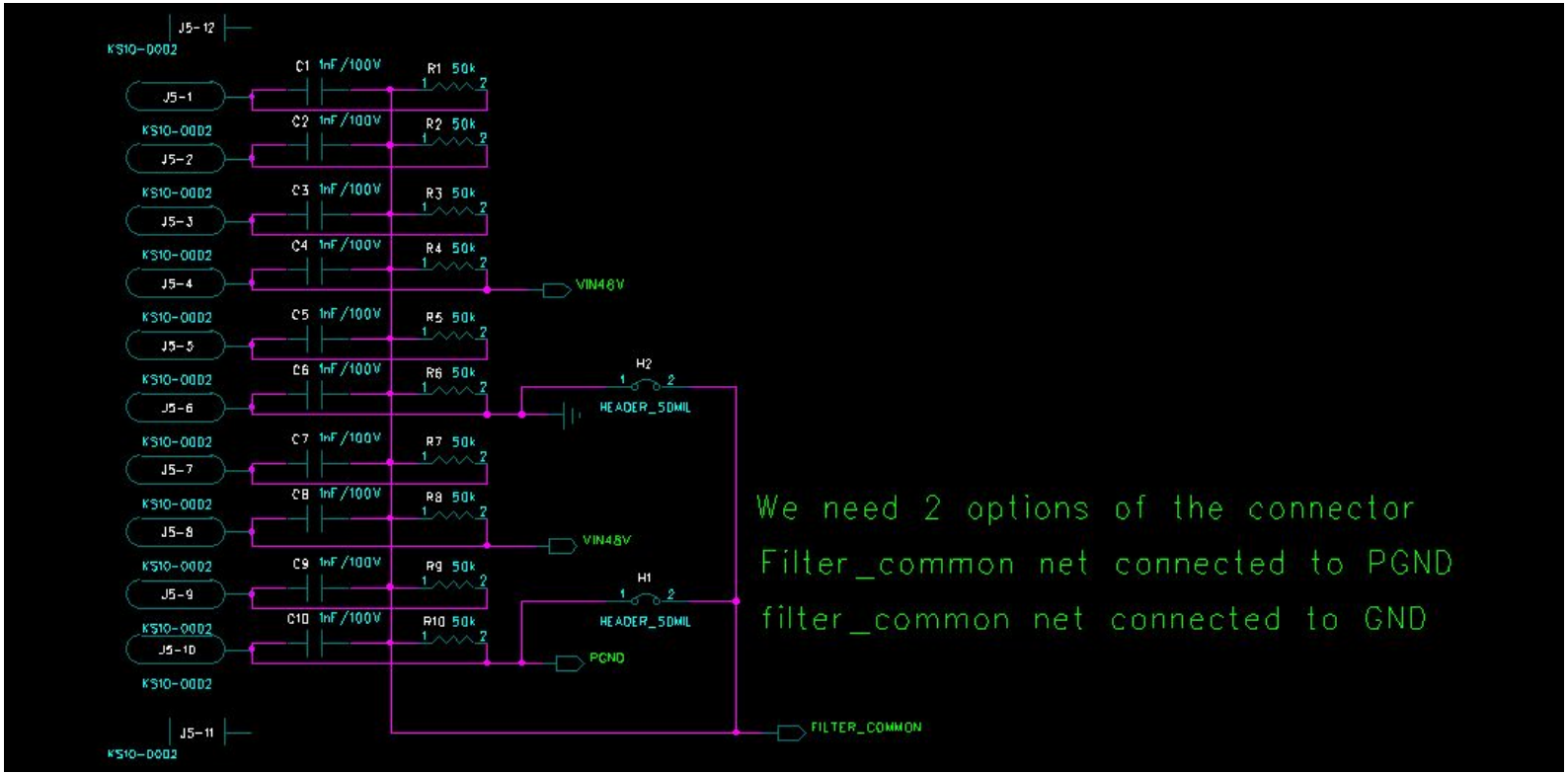
Picture of Default Setup



-Power cable directly from supply output to power bus

-Note: power bus bars not directly electrically connected to crate frame or board except via power comb pins

Recent Tests with “AC filter” comb



- Evaluate noise impact of applying AC filtering to all bus bars via a “AC filter” comb
- Initial implementation tied all bars to common net via 1nF and 50k
- Common net in turn tied to power supply ground (PGND)

Initial AC comb tests at different positions 11/14

Board	Config.	PS Power [W]	Trigger Mode Ped.	Single ADC Mode Ped.	Ch 126-127 HG Corr. %	Ch 127 HG RMS
190324	Default + PGND combs	124.9	1321	1322	27.9%	16.2
190324	Default + AC combs at bus ends w common filter to PGND	124.9	1323	1324	18.6%	15.0
190324	Default + AC combs beside cable w common filter to PGND	125.2	1325	1326	29.9%	16.3
190324	Default + AC combs beside cable w common filter to PGND + 0.1uF on 48V to PGND	125.1	1327	1328	30.3%	16.3
190324	Default + AC combs at bus ends w common filter to PGND + 0.1uF on 48V to PGND	124.9	1329	1330	7.6%	13.9
190324	Default + AC combs at bus ends w common filter to GND + 0.1uF on 48V to GND + 0.1uF on PGND to GND	124.9	1331	1332	12.0%	14.3

Noise Consistency Checks, 11/15

Board	Config.	PS Power [W]	Trigger Mode Ped.	Single ADC Mode Ped.	Ch 126-127 HG Corr %	Ch 127 HG RMS
190324	AC combs beside cable w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on PGND to PGND	125.1	NA	1352 1353 1354	~8.3%	14.1
190324	AC combs at bus ends w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on PGND to PGND	125.1	NA	1355 1356 1357	~12.5%	14.4
190324	AC combs beside cable w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on PGND to PGND	125.2	NA	1358 1359 1360	~8.4%	14.1
190324	AC combs at bus ends w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on PGND to PGND	125.2	NA	1361 1362 1363	~12.6%	14.5
190324	AC combs beside cable w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on PGND to PGND	125.2	NA	1364 1365 1366	~8.3%	14.1

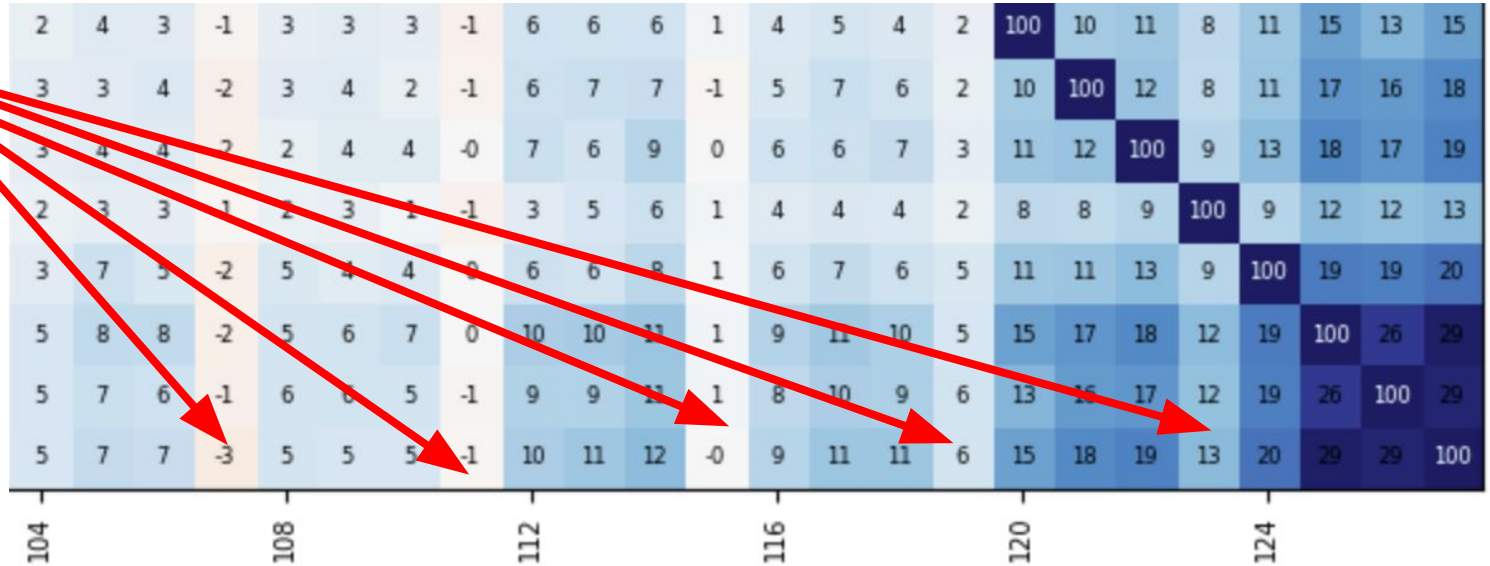
- Revised measurement method to improve reproducibility
- Clearly established that AC combs near cable is preferred in terms of noise performance

Board	Config.	PS Power [W]	Trigger Mode Ped.	Single ADC Mode Ped.	Ch 126-127 HG Corr %	Ch 127 HG RMS
190324	Default cabling + AC combs at bus ends w common filter to GND + 0.1uF on 48V to GND + 0.1uF on PGND to GND	125.0	1334	NA	10.9	14.4
190324	Default cabling + AC combs at bus ends w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on PGND to PGND	124.8	1335	NA	11.2	14.1
190324	Repeat Default cabling + AC combs at bus ends w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on PGND to PGND	125.1	1336	NA	10.4	14.4
190324	Repeat + power cycle Default cabling + AC combs at bus ends w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on PGND to PGND	124.9	1337	NA	11.3	14.3
190324	Default cabling + AC combs beside cable w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on PGND to PGND	125.1	1340	NA	6.9%	14.1
190324	Repeat AC combs beside cable w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on PGND to PGND	125.1	1341	NA	7.4%	14.1
190324	Repeat AC combs beside cable w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on PGND to PGND	125.1	1342	NA	6.4%	14.0

Note AC combs have each pin connected to common filter via 50k and 1nF

Comparison of PA/S Channel Routing

PA ch 3 tends to be quiet, why?



PA/S Channel Comparison	Ch 0	Ch 1	Ch 2	Ch 3
Noise Status	Loud	Loud	Loud	Quiet
Trace to connector	L5	L10	L5	L10
Input Diodes	Top	Bottom	Top	Bottom
Protection Diodes	Top	Bottom	Top	Bottom
Inductor + 200 Ohm	Bottom	Bottom	Bottom	Bottom
10u Capacitor	Bottom	Bottom	Bottom	Bottom
Trace to PA/S input	L5	Bottom	L5	L5

Impact of Unused Pins/Bars Floating, No AC Combs 11/18

Board	Config.	PS Power [W]	Trigger Mode Ped.	Single ADC Mode Ped.	Ch 126-127 HG Corr %	Ch 127 HG RMS
190324	AC combs beside cable w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on PGND to PGND	124.9	1381	1382 1383 1384	8.0% 8.0% 8.2%	14.0 14.1 14.0
190324	AC combs beside cable w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on PGND to PGND + unused pins floating	125.0	1385	1386 1387 1388	8.0% 7.8% 7.8%	14.0 14.0
190324	No AC combs	124.9	NA	1389 1390 1391	13.1% 13.0% 13.0%	14.4 14.4 14.4

- Floating unused pins and power bus bars don’t appear to impact noise
- Removing AC filtering from 48V and/or GND increases noise significantly

Impact of Removing 50k, Adding 1uF to AC Filter, New Mezzanines (1)

- Removing 50k from AC comb does not appear to change noise
- Adding 1uF to 48V + PGND +GND does not appear to change noise
- Disconnecting GND pin from bus does not appear to change noise
- Removing G1 PGND-GND connection does increase noise
- New 48V mezzanines also increase noise

Board	Config.	PS Power [W]	Trigger Mode Ped.	Single ADC Mode Ped.	Ch 126-127 HG Corr %	Ch 127 HG RMS
190324	AC combs beside cable w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on GND to PGND + unused pins floating	125.1	1393	1394 1395 1396	7.8% 7.9% 7.9%	14.0 14.0 14.0
190324	AC combs beside cable w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on GND to PGND + unused pins floating + 1uF on used pins to PGND	125.1	1397	1398 1399 1400	7.7% 7.8% 7.7%	14.0 14.0 14.0
190324	AC combs beside cable w common filter to PGND + 0.1uF on 48V to PGND + 0.1uF on GND to PGND + unused pins floating + 1uF on used pins to PGND + 50k resistors removed	125.2	1401	1402 1403 1404	7.9% 8.0% 7.7%	14.0 14.1 14.1
190324	AC combs beside cable w common filter to PGND 1nF/0.1uF/1uF on 48V to PGND (GND pin disconnected)	125.1	1405	1406 1407 1408	8.2% 7.8% 8.1%	14.1 14.1 14.1
190324	AC combs beside cable w common filter to PGND 1nF/0.1uF/1uF on 48V to PGND + G1 connection removed	125.0	1409	1410 1411 1412	15.1% 15.3% 15.2%	14.7 14.7 14.7
190324	AC combs beside cable w common filter to PGND 1nF/0.1uF/1uF on 48V to PGND + new 48V mezzanines	125.5	1413	1414 1415 1416	17.5% 17.7% 17.6%	14.9 14.9 14.9

Tests with new 48V Mezzanines, PGND-GND Connections

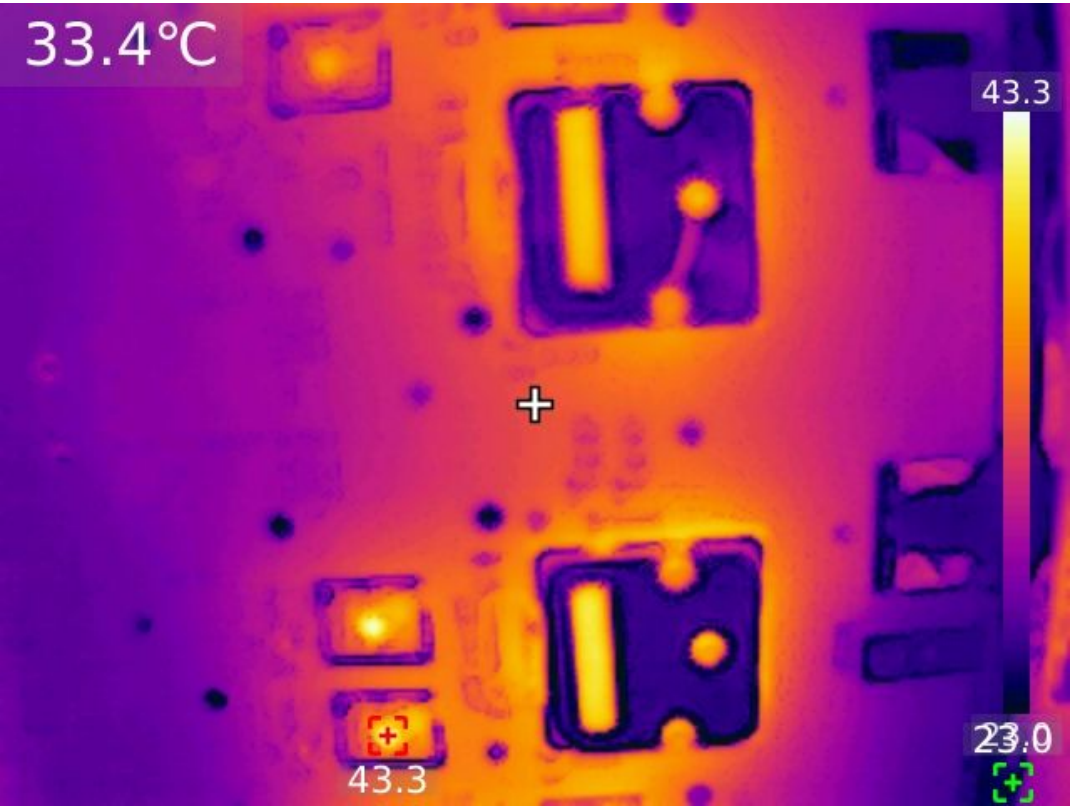
Board	Config.	PS Power [W]	Trigger Mode Ped.	Single ADC Mode Ped.	Ch 126-127 HG Corr %	Ch 127 HG RMS
190324	AC combs beside cable w common filter to PGND 1nF/0.1uF/1uF on 48V to PGND + old 48V mezzanines	125.0	1409	1410 1411 1412	15.1% 15.3% 15.2%	14.7 14.7 14.7
190324	AC combs beside cable w common filter to PGND 1nF/0.1uF/1uF on 48V to PGND + new 48V mezzanines	125.5	1413	1414 1415 1416	17.5% 17.7% 17.6%	14.9 14.9 14.9
190324	AC combs beside cable w common filter to PGND 1nF/0.1uF/1uF on 48V to PGND + new 48V mezzanines + G1 connection used	125.4	1417	1418 1419 1420	9.4% 9.1% 9.5%	14.2 14.2 14.2
190324	AC combs beside cable w common filter to PGND 1nF/0.1uF/1uF on 48V to PGND + new 48V mezzanines + G1 connection used + PGND-GND wire	125.1	1421	1422 1423 1424	7.5% 7.5% 7.3%	14.0 14.0 14.0

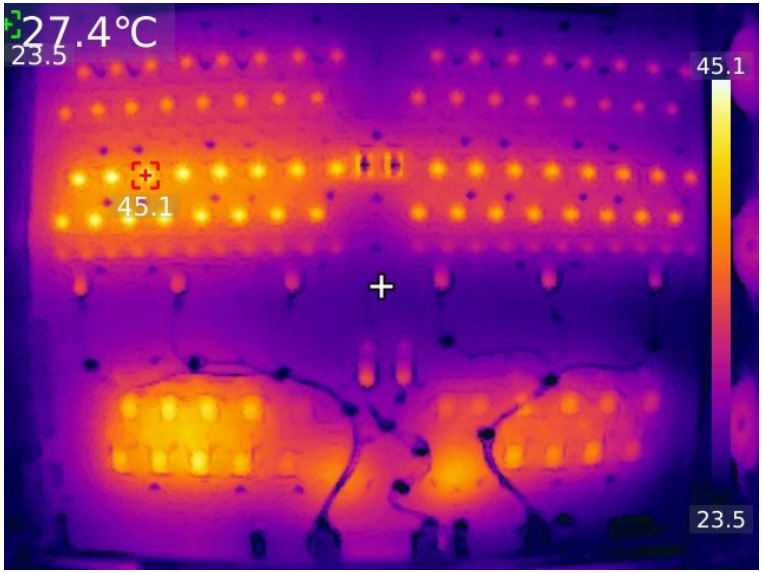
-New 48V mezzanines increase noise

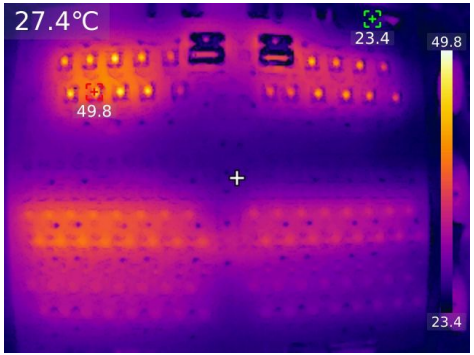
-Adding additional connections between PGND and GND on board consistently improves noise performance

Board with New 48V Mezzanines Installed

Board Thermal Images with New 48V Mezzanines







Summary

- Distributing power through 48V power bus leads to excess noise on top of board
- AC filtering 48V supply to PGND appears to significantly improved noise performance (slide 12)
  - Still need to determine optimal filter implementation
  - Should also repeat filtering vs no filtering comparison with additional PGND-GND connections
- Adding additional connections between board ground (GND) and power supply GND (PGND) significantly improves noise performance
  - This conflicts with recommendation to only have one PGND-GND connection on mezzanine
- New 48V mezzanines appear to slightly increase power consumption by 0.5W and slightly decrease noise performance
  - Still need to check with other boards