BERKELEY LAB
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U.S. DEPARTMENT OF ENERGY
Office of Science

Pre-Production B QC Summary

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(under direction of Timon Heim and Zhicai Zhang)

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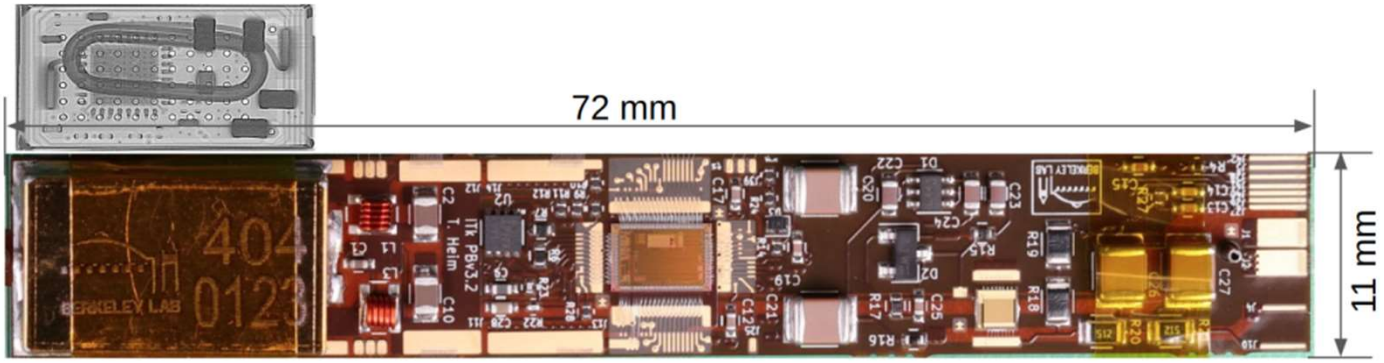
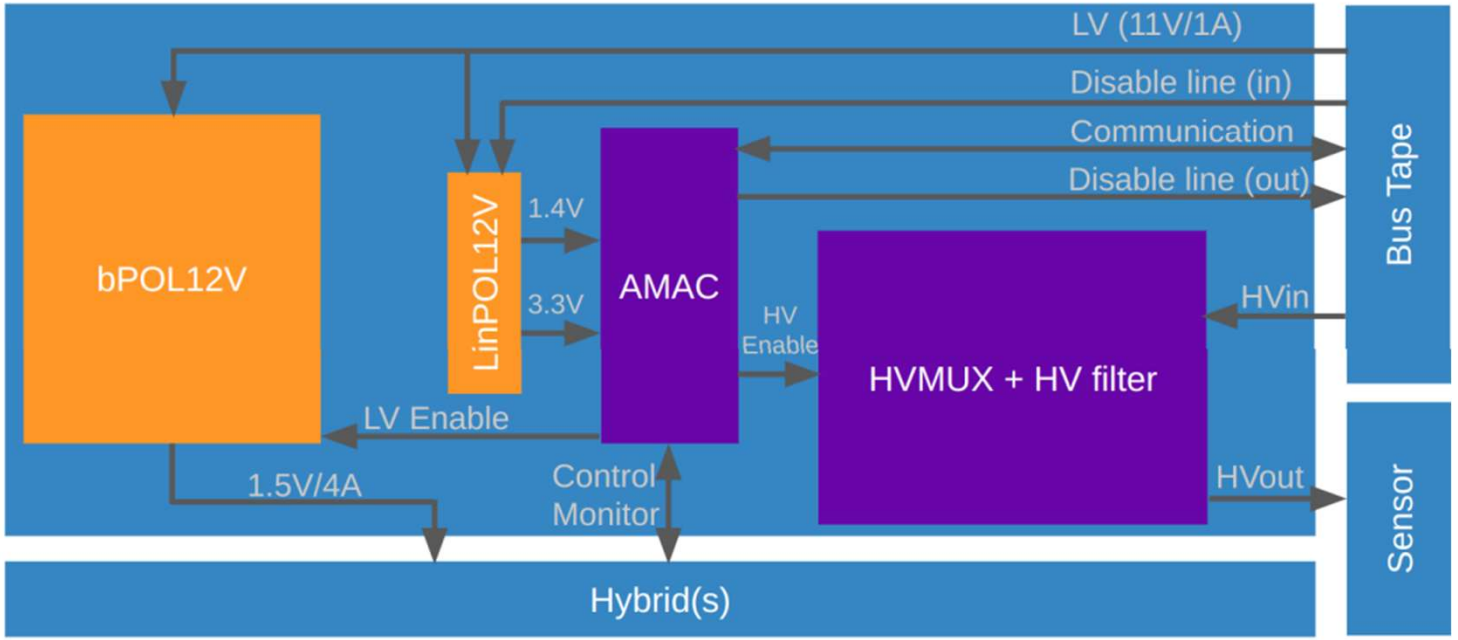
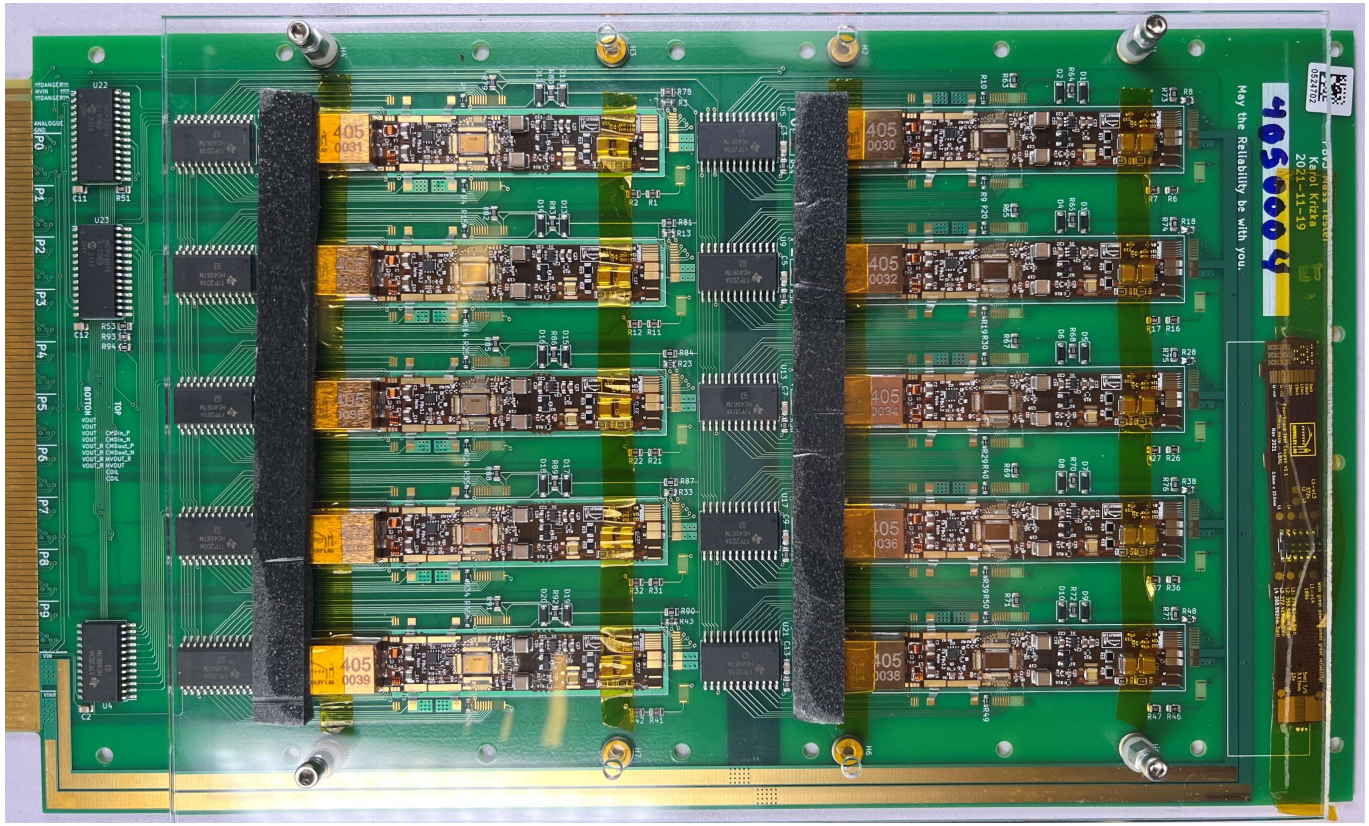
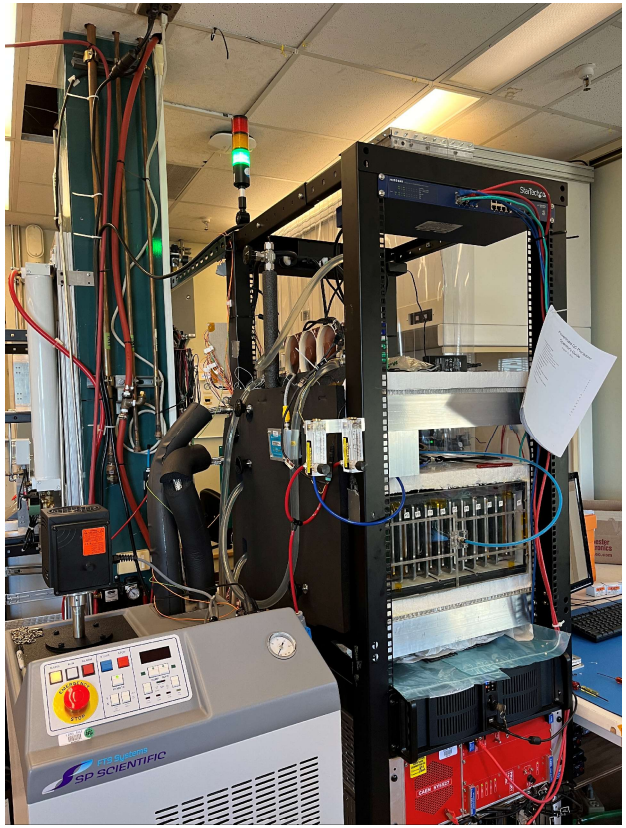
The Powerboard





The Panel and Rack





QC Tests

- **Visual inspection**: Take high resolution picture of each powerboard and examine the powerboard to check for missing/tombstoned components, missing/broken wirebonds, solder splash on bond pads, and incomplete seams on the shield box
- **Thermal cycling**: Cycle the temperature of powerboards between -35 °C and 40 °C (as measured by the temperature sensors on powerboard) three times
- **Burn-in**: Load the DC-DC converter at 2 A for 24 hours without interruption
- **Electrical tests**: Basic tests of the powerboard functionalities, e.g. bPOL12V and linPOL12V ON/OFF measurements, HV ON/OFF measurements, AMAC function tests, etc., as well as characterization of LV, HV and AMAC settings, e.g. scan of the DC-DC converter efficiency/temperatures/currents at different loads
  - Electrical tests are performed at both room temperature (20 °C) and cold temperature (-35 °C) in between visual inspection, thermal cycling, and burn-in

QC Procedure

- Database registration
- Visual inspection
- Load the crate. Turn on chiller, set to 20 °C
- Electrical test (full) - warm (20 °C)
- Upload test result
- Cool down to -50 °C
- Electrical test (full) - cold (-50 °C)
- Upload test result
- Thermal cycle
- Electrical test (full) - warm (20 °C)
- Stage transition to “Thermal Cycle”
- Upload test result
- Burn-In
- Electrical test (full) - warm (20 °C)
- Stage transition to “Burn-In”
- Upload test result
- Cool down to -50 °C
- Electrical test (full) - cold (-50 °C)
- Upload test result
- Warm up to 20 °C and turn off chiller. Then unload the crate

Duration: ~60 hours of chiller on
~4.5 days of real time

Good Results: Basic Functionality Tests

Basic Functionality Tests

			linPOLV [V]		DC/DC Out [V]		HV In Current [A]		HV Out Current [A]		HVret [counts]	
Powerboard	Pad ID	BER	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON
0	0	1.00	0.12	1.40	0.00	1.49	0.0000010	0.0010	2.4e-7	0.00094	137.00	458.00
1	0	1.00	0.11	1.43	0.00	1.50	6.0e-7	0.0010	1.4e-7	0.00094	152.00	482.00
2	0	1.00	0.12	1.42	0.00	1.53	4.0e-7	0.0010	4.1e-7	0.00094	131.00	456.00
3	0	1.00	0.10	1.44	0.00	1.43	4.0e-7	0.0010	1.2e-7	0.00094	134.00	462.00
4	0	1.00	0.10	1.42	0.00	1.45	4.0e-7	0.0010	4.6e-8	0.00094	128.00	448.00
5	0	1.00	0.09	1.39	0.00	1.54	4.0e-7	0.0010	1.2e-7	0.00094	134.00	447.00
6	0	1.00	0.09	1.39	0.00	1.50	4.0e-7	0.0010	4.0e-7	0.00094	134.00	455.00
7	0	1.00	0.11	1.38	0.00	1.46	4.0e-7	0.0010	1.1e-7	0.00094	145.00	481.00
8	0	1.00	0.09	1.42	0.00	1.46	4.0e-7	0.0010	3.7e-7	0.00094	133.00	462.00
9	0	1.00	0.10	1.42	0.00	1.50	2.0e-7	0.0010	1.8e-7	0.00094	131.00	452.00

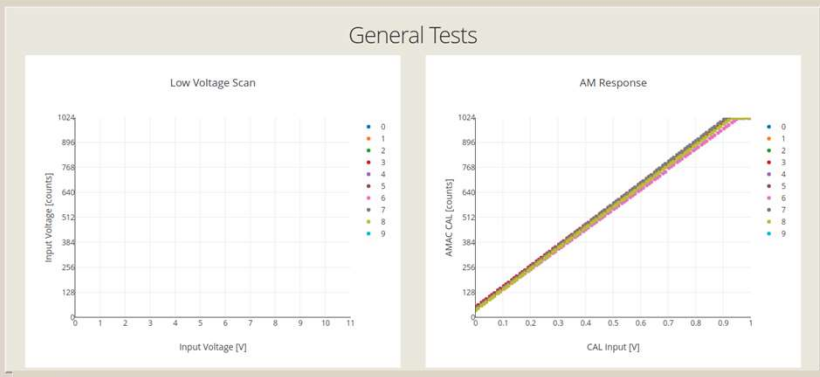
	OFout [V]		CALx [V]		CALy [V]		Shuntx [V]		Shunty [V]	
Powerboard	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON
0	0.00	1.39	0.02	0.87	0.02	0.86	0.20	1.13	0.20	1.13
1	0.00	1.43	0.02	0.87	0.01	0.86	0.20	1.12	0.20	1.12
2	0.00	1.42	0.02	0.88	0.01	0.87	0.19	1.12	0.19	1.12
3	0.00	1.43	0.02	0.87	0.02	0.87	0.20	1.14	0.20	1.13
4	0.00	1.42	0.01	0.88	0.01	0.88	0.20	1.12	0.18	1.12
5	0.00	1.39	0.02	0.87	0.02	0.88	0.20	1.13	0.20	1.13
6	0.00	1.39	0.02	0.87	0.01	0.86	0.19	1.13	0.20	1.13
7	0.00	1.38	0.02	0.87	0.01	0.87	0.19	1.12	0.20	1.11
8	0.00	1.42	0.02	0.89	0.02	0.88	0.19	1.13	0.19	1.13
9	0.00	1.42	0.02	0.86	0.02	0.86	0.19	1.13	0.18	1.13

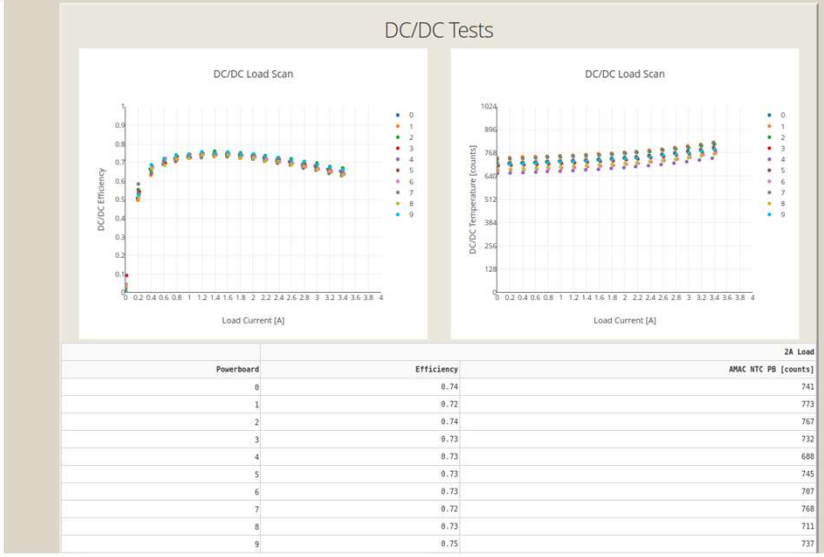
	LDx0EN [V]		LDx1EN [V]		LDx2EN [V]		LDy0EN [V]		LDy1EN [V]		LDy2EN [V]	
Powerboard	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON
0	0.00	1.39	0.00	1.39	0.00	1.39	0.00	1.39	0.00	1.39	0.00	1.39
1	0.00	1.43	0.00	1.43	0.00	1.43	0.00	1.43	0.00	1.43	0.00	1.43
2	0.00	1.42	0.00	1.42	0.00	1.42	0.00	1.42	0.00	1.42	0.00	1.42
3	0.00	1.43	0.00	1.43	0.00	1.43	0.00	1.43	0.00	1.43	0.00	1.43
4	0.00	1.42	0.00	1.42	0.00	1.42	0.00	1.42	0.00	1.42	0.00	1.42
5	0.00	1.39	0.00	1.39	0.00	1.39	0.00	1.39	0.00	1.39	0.00	1.39
6	0.00	1.39	0.00	1.39	0.00	1.39	0.00	1.39	0.00	1.39	0.00	1.39
7	0.00	1.38	0.00	1.38	0.00	1.38	0.00	1.38	0.00	1.38	0.00	1.38
8	0.00	1.42	0.00	1.42	0.00	1.42	0.00	1.42	0.00	1.42	0.00	1.42
9	0.00	1.42	0.00	1.41	0.00	1.41	0.00	1.41	0.00	1.42	0.00	1.41

Powerboard	NTCx [cnt]	NTCy [cnt]	NTCpb [cnt]	CTAT [cnt]	PTAT [cnt]
0	766	772	680	483	712
0					
0					
1	802	800	727	486	745
1					
1					
2	793	791	719	483	737
2					
2					
3	785	791	713	476	702
3					
3					
4	763	776	687	478	659
4					
4					
5	739	771	694	468	716
6	750	768	709	456	677
7	782	812	754	498	739
8	784	806	701	496	681
9	765	777	699	475	710

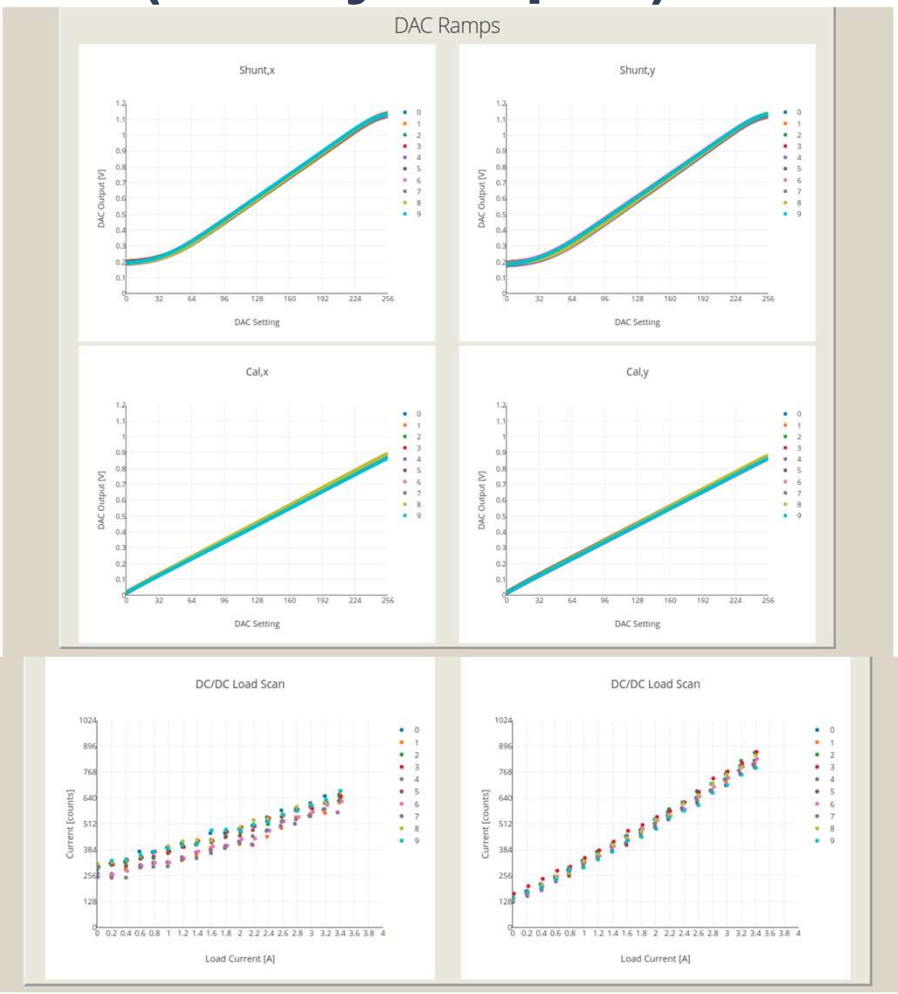
Powerboard	-13%	-6%	+6%
0	-13.0	-6.5	6.6
1	-13.1	-6.5	6.6
2	-13.0	-6.5	6.6
3	-13.4	-6.7	6.8
4	-13.2	-6.6	6.7
5	-13.0	-6.5	6.6
6	-13.1	-6.5	6.7
7	-13.5	-6.7	6.8
8	-13.2	-6.6	6.8
9	-13.1	-6.5	6.6

Good Results: Everything Else (Mostly Graphs)





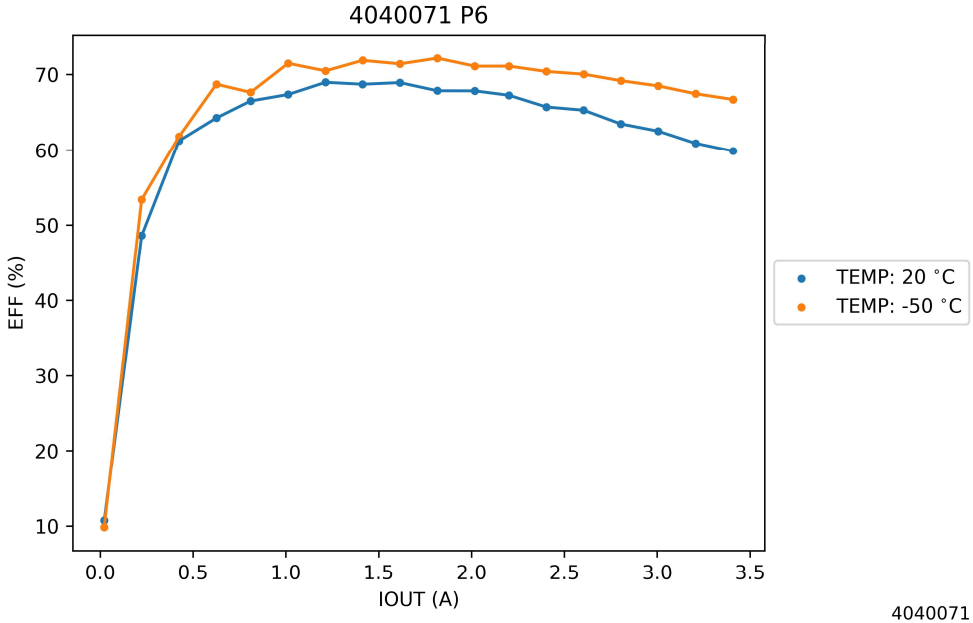
	2A Load	
Powerboard	Efficiency	AMAC NTC PB [counts]
0	0.74	741
1	0.72	773
2	0.74	767
3	0.73	732
4	0.73	688
5	0.73	745
6	0.73	707
7	0.72	768
8	0.73	711
9	0.75	737

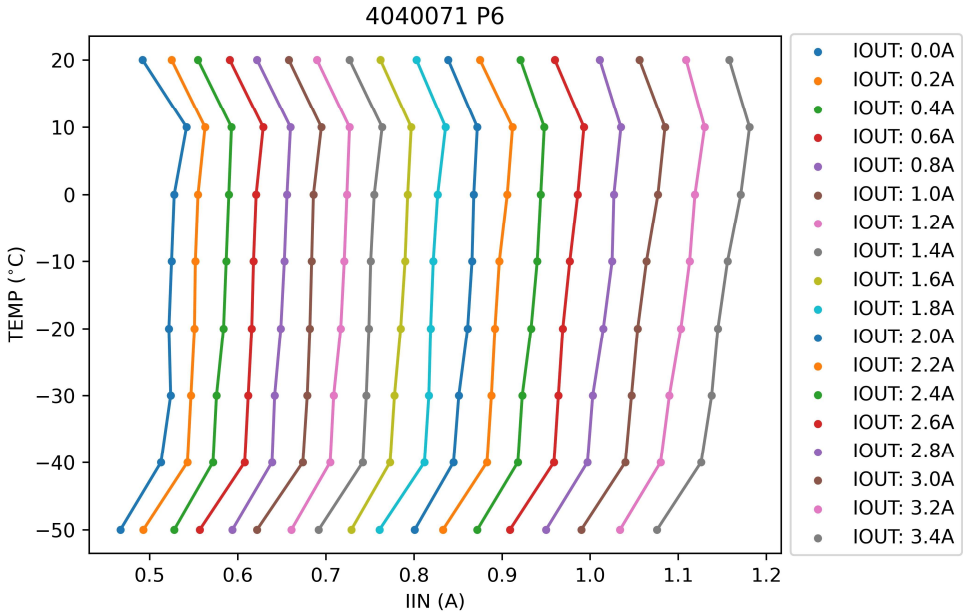


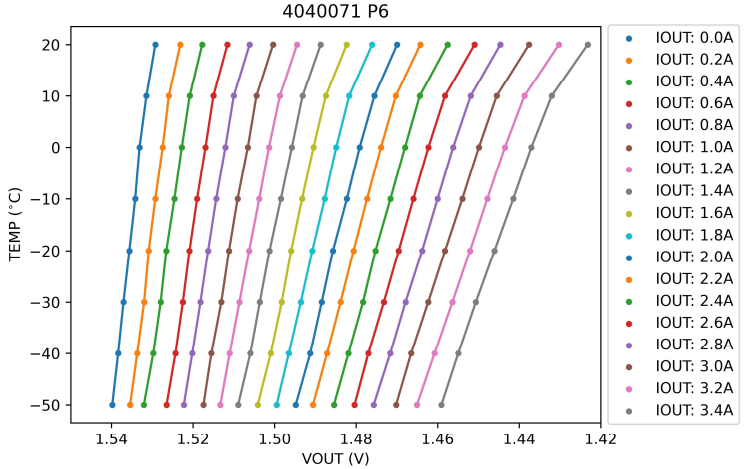
QC Problem: DC-DC efficiency drop-off at 1A during cold electrical tests (< -30 °C)

- Cause: abnormal behaviour in IIN starting at 1A
  - Abnormal behaviour in VOUT starting at 1A as well, but not significant to efficiency
  - 3/500 (< 1%) of boards exhibit efficiency drop-off
  - Efficiency equation: $\frac{VOUT * IOUT}{VIN * (IIN - IINOFFSET)}$
    - IIN increase → efficiency decrease
- Boards with these abnormalities fail QC

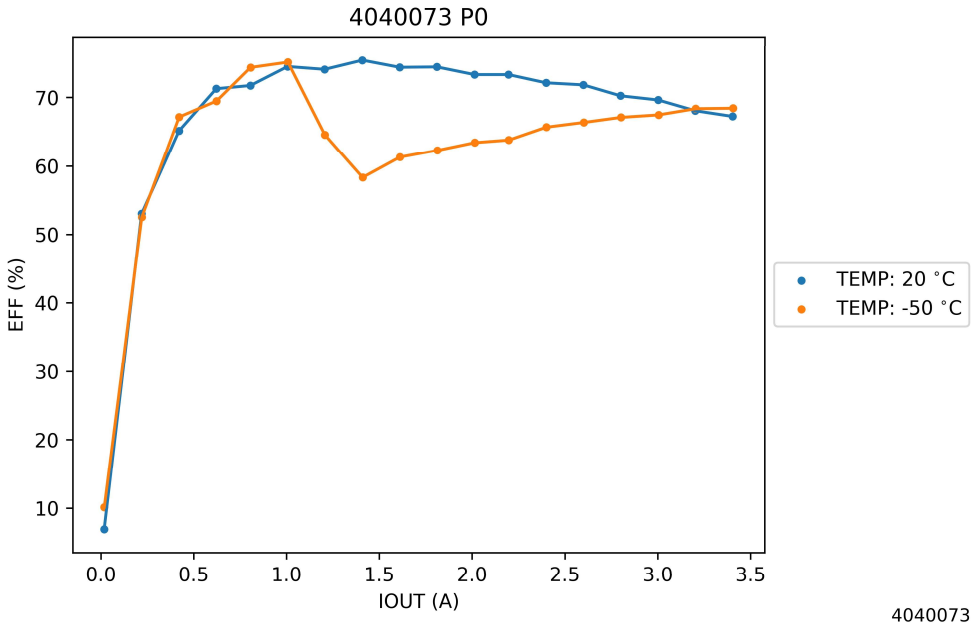
good board: 4040071 P6

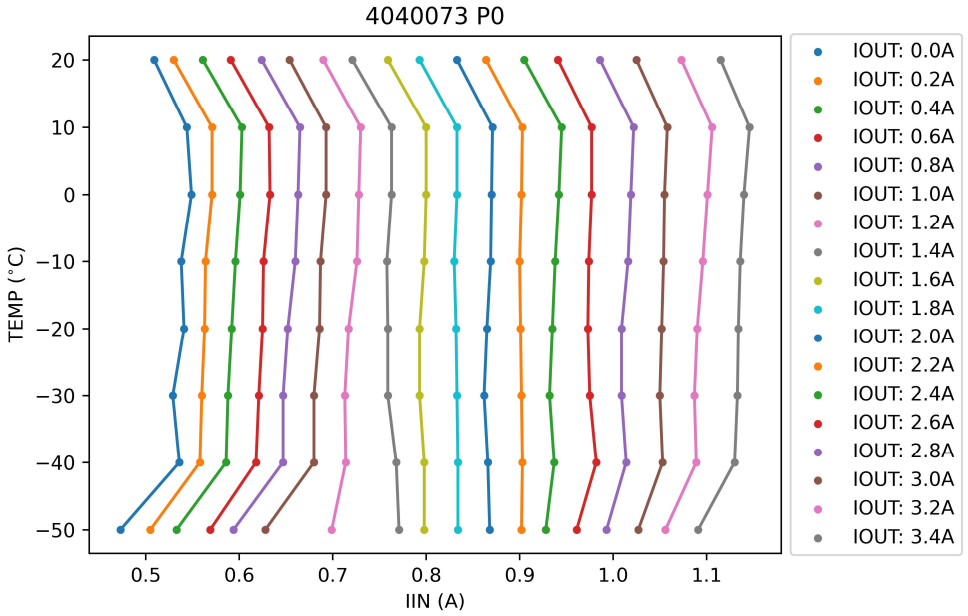


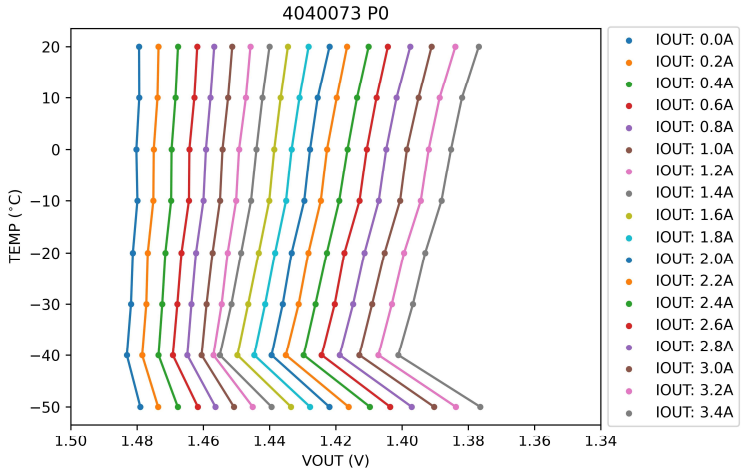




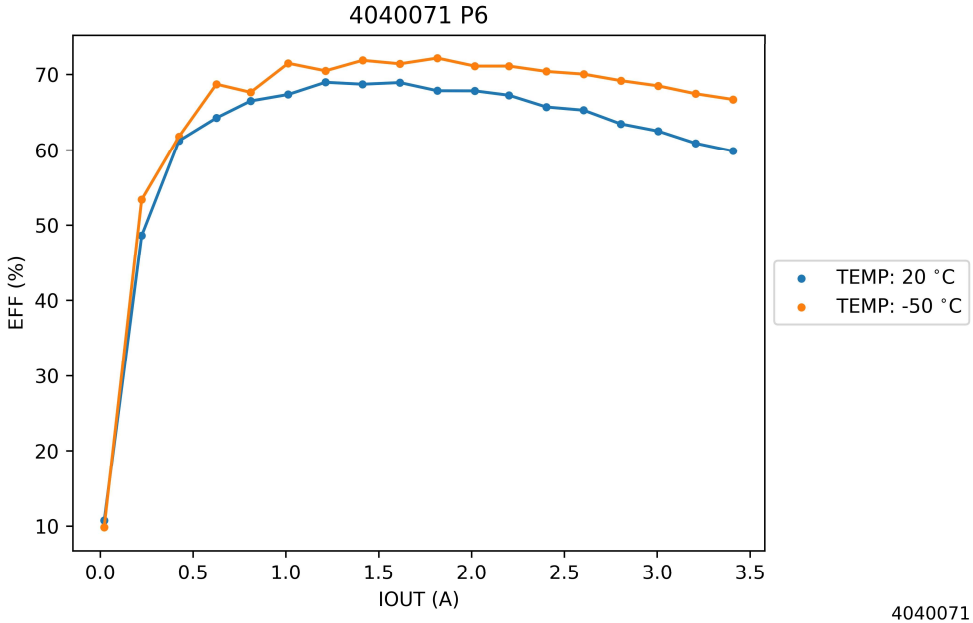
bad board: 4040073 P0

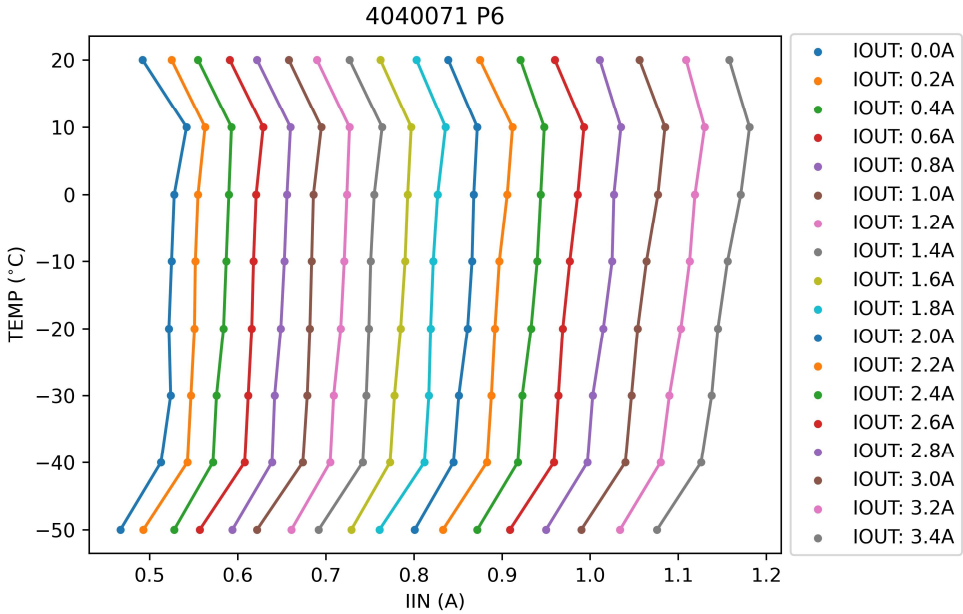


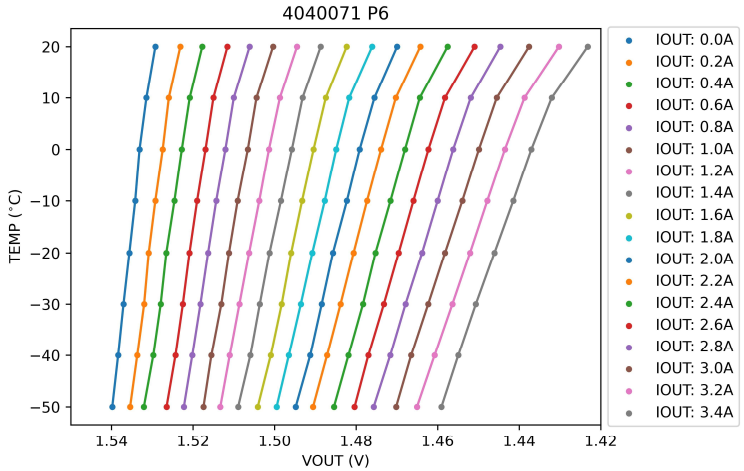




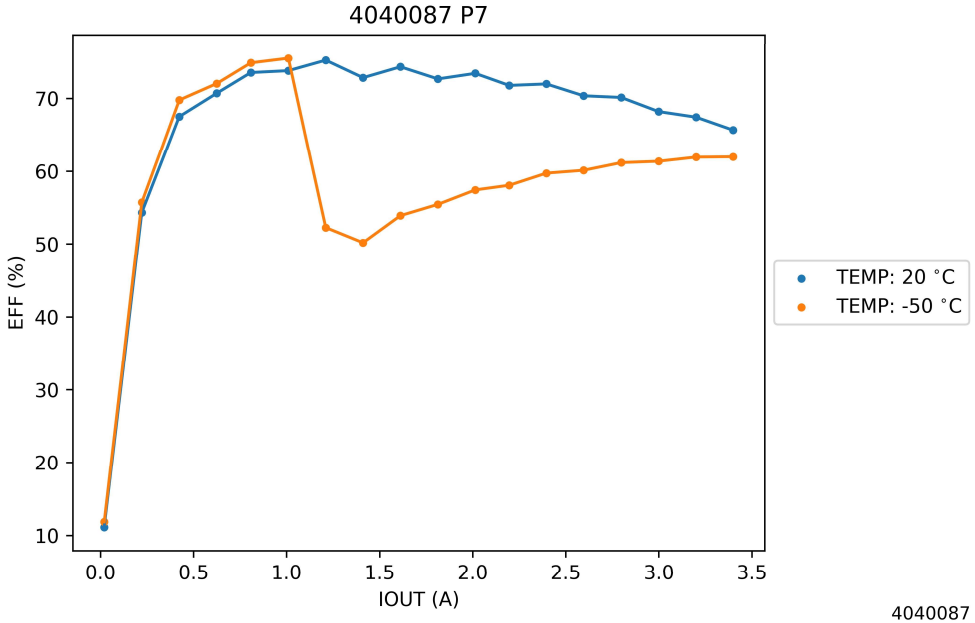
good board: 4040071 P6

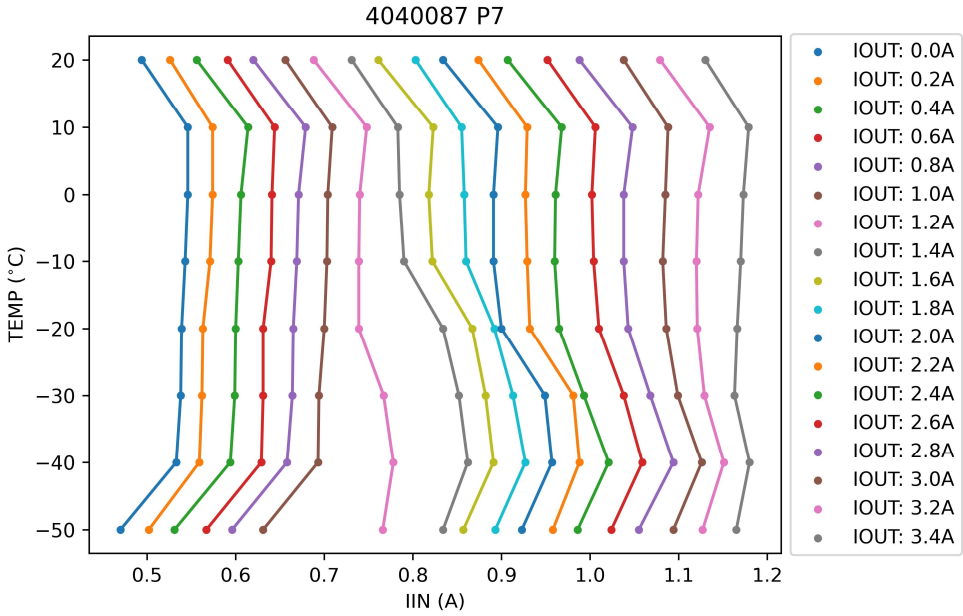


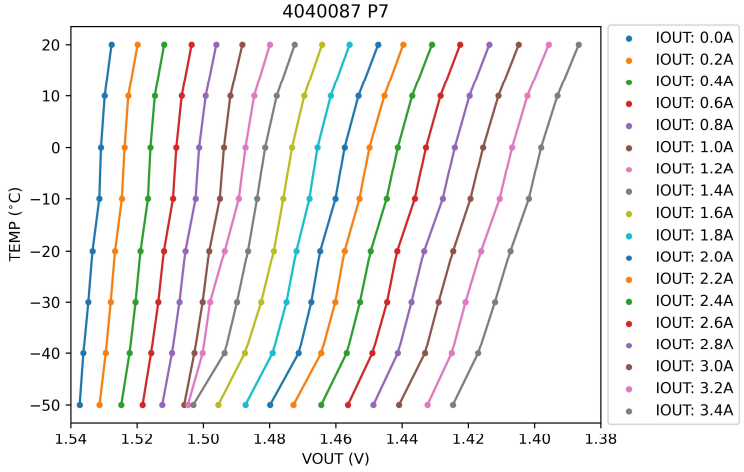




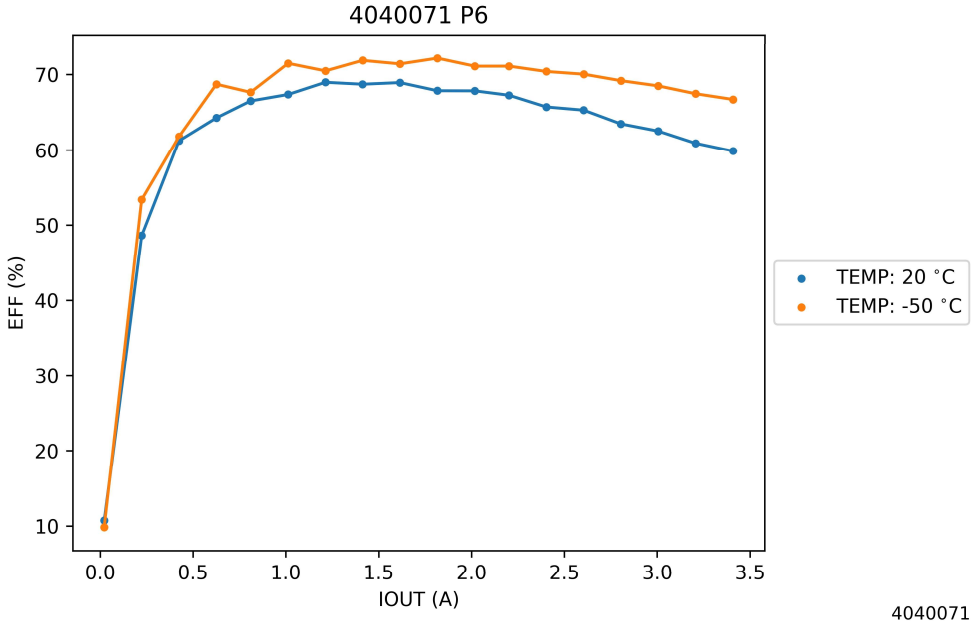
bad board: 4040087 P7

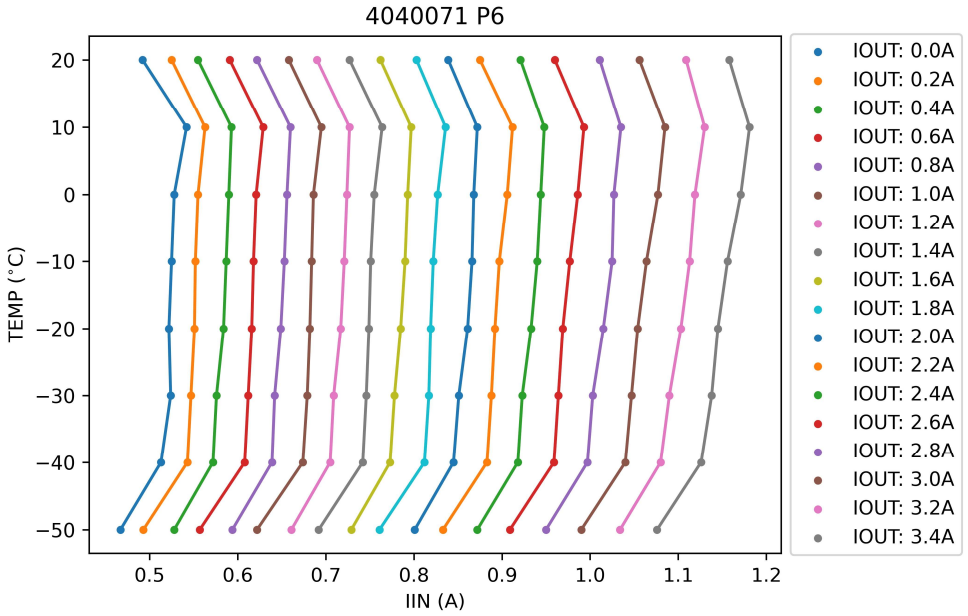


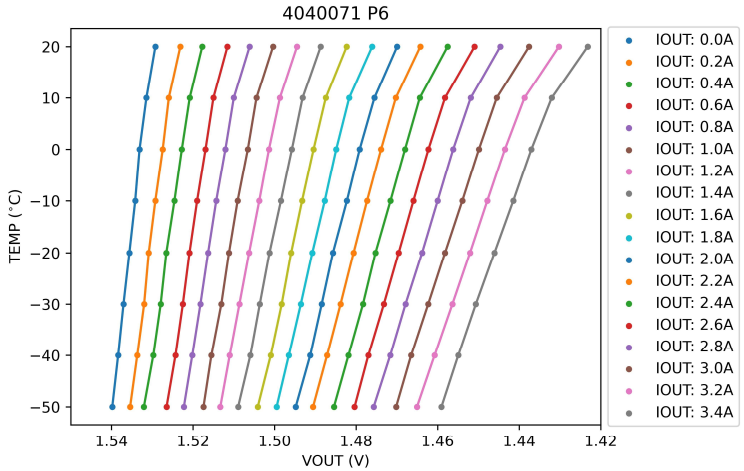




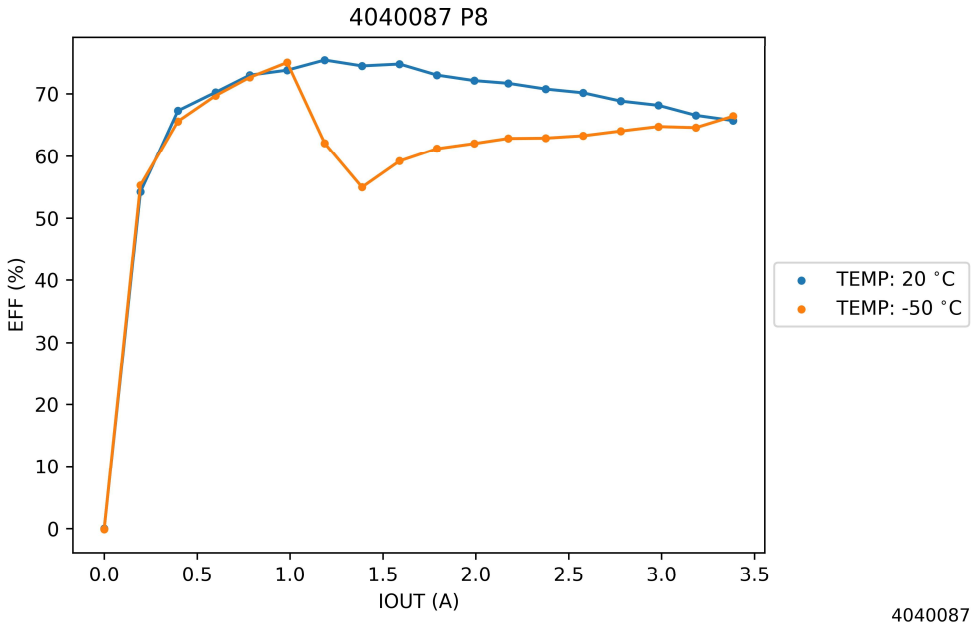
good board: 4040071 P6

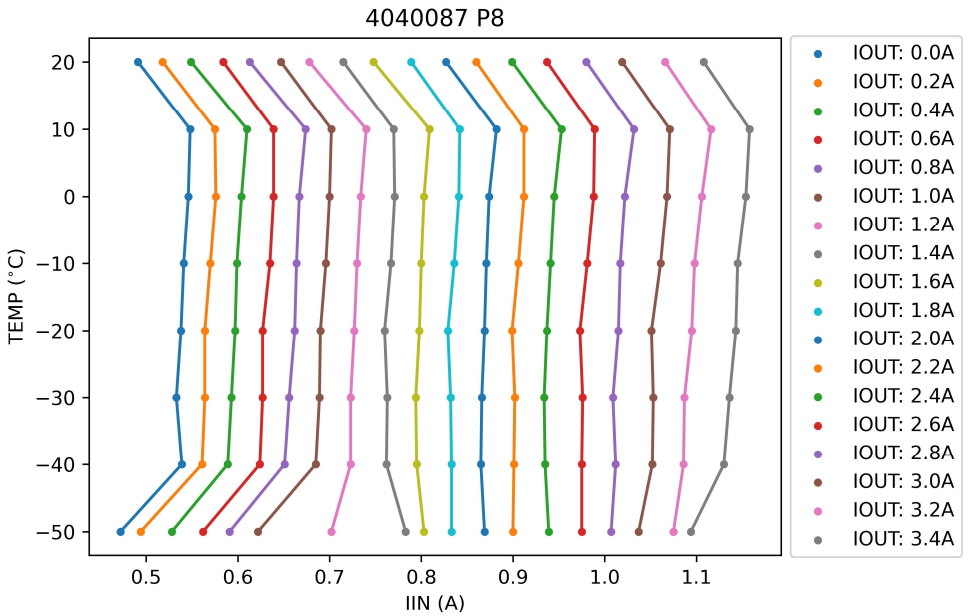


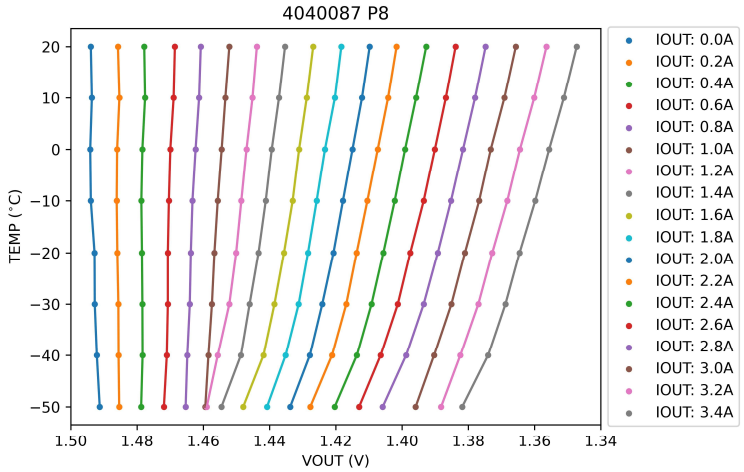




bad board: 4040087 P8

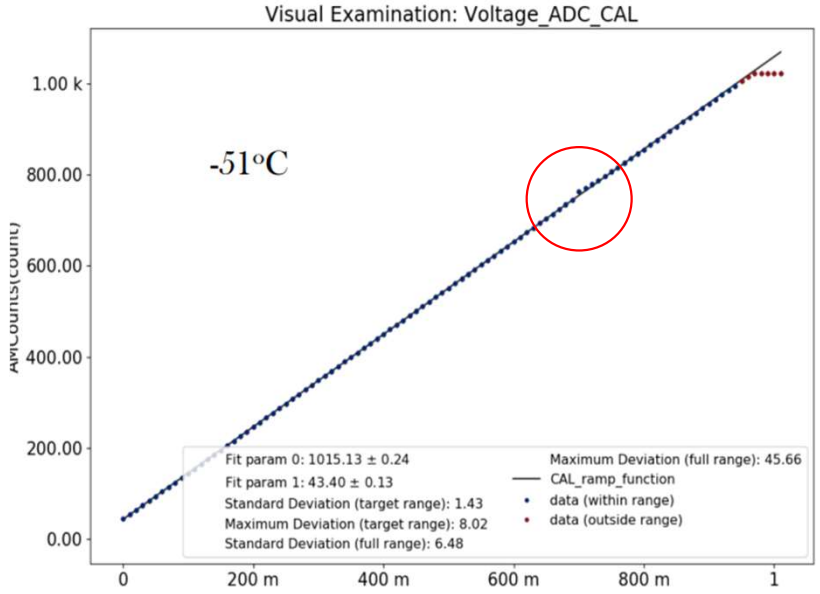


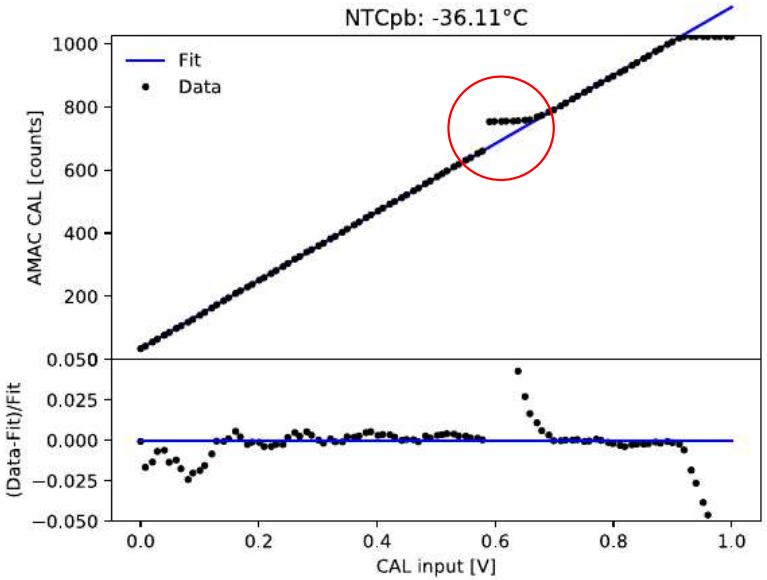




QC Problem: discontinuity at 750 counts in AM Response graphs during cold electrical tests (< -30 °C)

- Cause: technology transition at 750 counts
  - Was present in AMACv2, much better in AMACstar





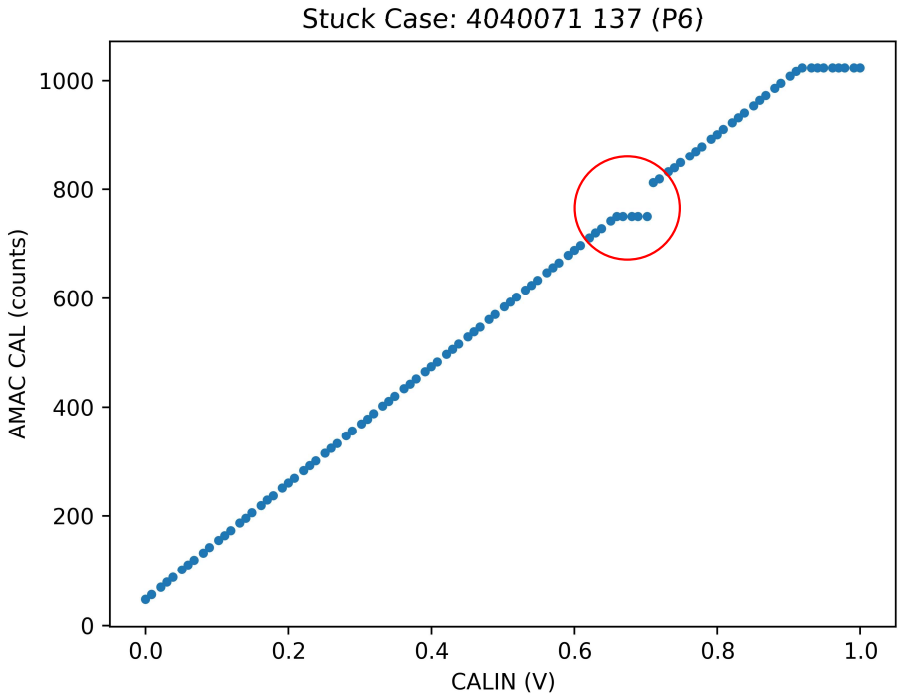
Conclusion: Abnormalities present in AMACstar

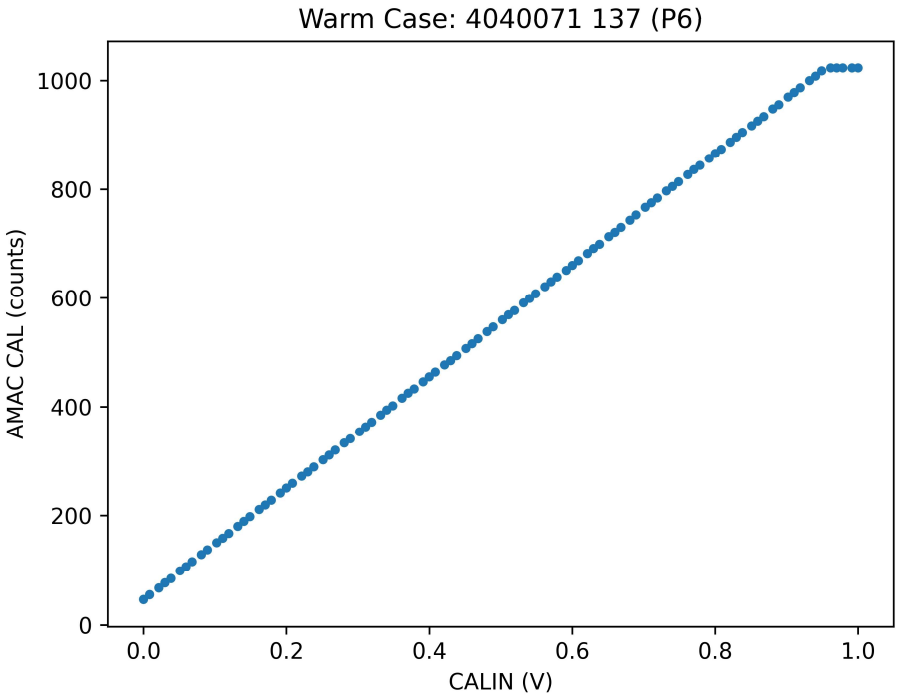
- 171/348 of boards (49%) have abnormalities in AM Response graphs during cold electrical tests (< -30 °C)
  - Looked at cold and warm electrical tests after burn-in
    - All boards with accessible data in rackop/storage/…/results analysed
      - Most of Pre-Production B, but not all
  - Two types of abnormalities: “jump” and “stuck”
  - Boards with these abnormalities still pass QC

42/348 of boards (12%) get “stuck” at 750 counts

Conditions:

1. two or more consecutive measurements of 750 counts
2. not visible in warm electrical tests

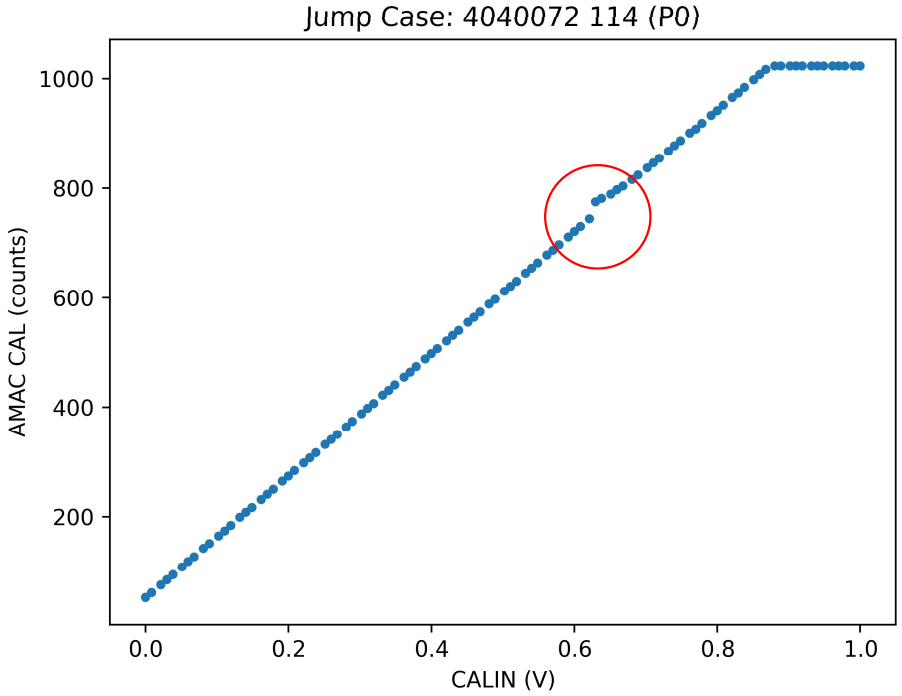


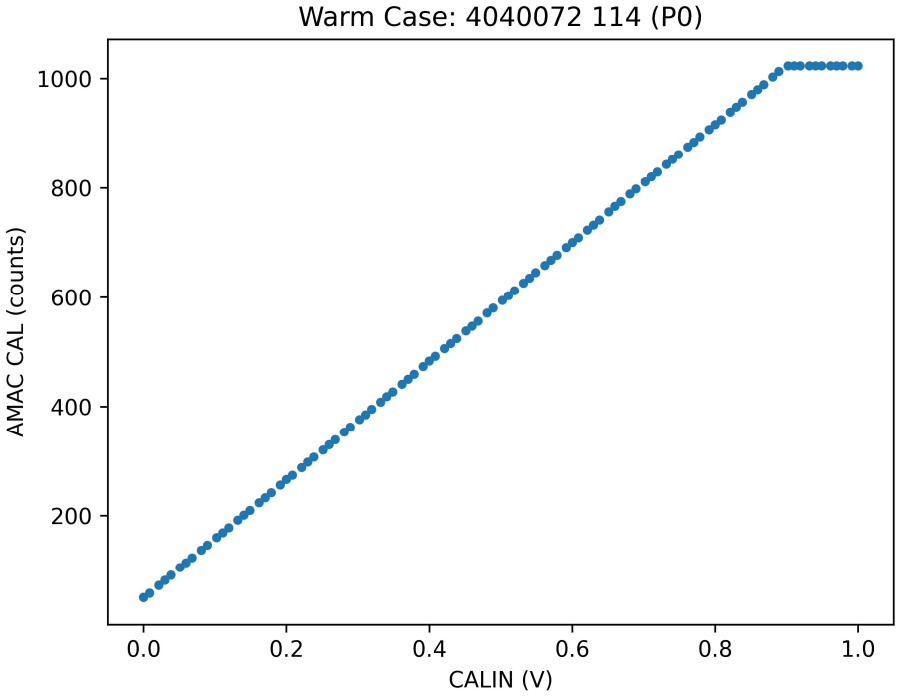


129/306 of boards (42%) “jump” over 750 counts

Conditions:

1. Step between nth and (n-1)th AMAC CAL value > 2*Step between (n-1)th and (n-2)th AMAC CAL value
2. nth AMAC CAL value < 750 < (n-2)th AMAC CAL value
3. not visible in warm electrical tests
4. not a board previously flagged as getting “stuck”





Pre-Production B Summary

- 500 boards tested from Batches 4 and 5 for Pre-Production B
  - 9 failed boards, 97.4% yield
    - All other boards passed with no issues
  - 400 boards tested from Batch 4
    - 6 failed boards, 98.5% yield
      - 1 Pad ID error
      - 3 low efficiencies after 1A at cold temperatures
      - 2 low efficiencies at all temperatures
  - 100 boards tested from Batch 5
    - 3 failed boards, 97% yield
      - 1 low PTAT reading
      - 1 linPOL failure at cold temperatures
      - 1 Pad ID error
    - 20 boards skipped burn-in due to low Novec supply