ANALOG DEVICES

AHEAD OF WHAT'S POSSIBLE™

SINGLE EVENT EFFECTS TEST REPORT LT8650S & LTM8060

October 2023

Radiation Test Report	
Product:	LT8650S & LTM8060
Effective LET:	≤ 40.8 MeV-cm^2/mg
Fluence:	1E7 Ions/cm^2
Facilities:	TAMU
Tested:	October 2023

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SEE Test Report for the LT8650S – Dual Channel 4A 42V, Synchronous Step-Down Silent Switcher

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Braxton Houlden, Nolan Carr

Test Dates:
October 21-23, 2023

I. Introduction

The purpose of this test is to determine the Single-Event Effects (SEE) susceptibility of the LT8650S using the LTM8060, a Quad 40V, silent switcher µModule regulator with configurable 3A output array. Single Event Latchup (SEL) and Single Event Transient (SET) data collection was performed on October 21-23, 2023, at the TAMU heavy ion facility. The I/O voltages and the supply currents were monitored for the device during SEE testing. **The LTM8060 consists of two LT8650S dual channel synchronous step-down silent switcher ICs: the first IC operates channels 1 and 2 while the second IC operates channels 3 and 4 of the LTM8060.**

II. Device Under Test

The LTM8060 is a silent switcher µModule regulator whose architecture minimizes EMI while delivering high efficiency at switching frequencies up to 3MHz. It can support output voltages from 0.8V to 8V at a maximum output current of 3A (4A, peak) per channel. The DC2820A evaluation board was used to characterize its performance. The LTM8060 was set up to evaluate the SEL threshold with a targeted effective LET of 40.8 MeV·cm^2/mg. The LTM8060 was set up to evaluate the SET threshold for nominal voltage outputs.

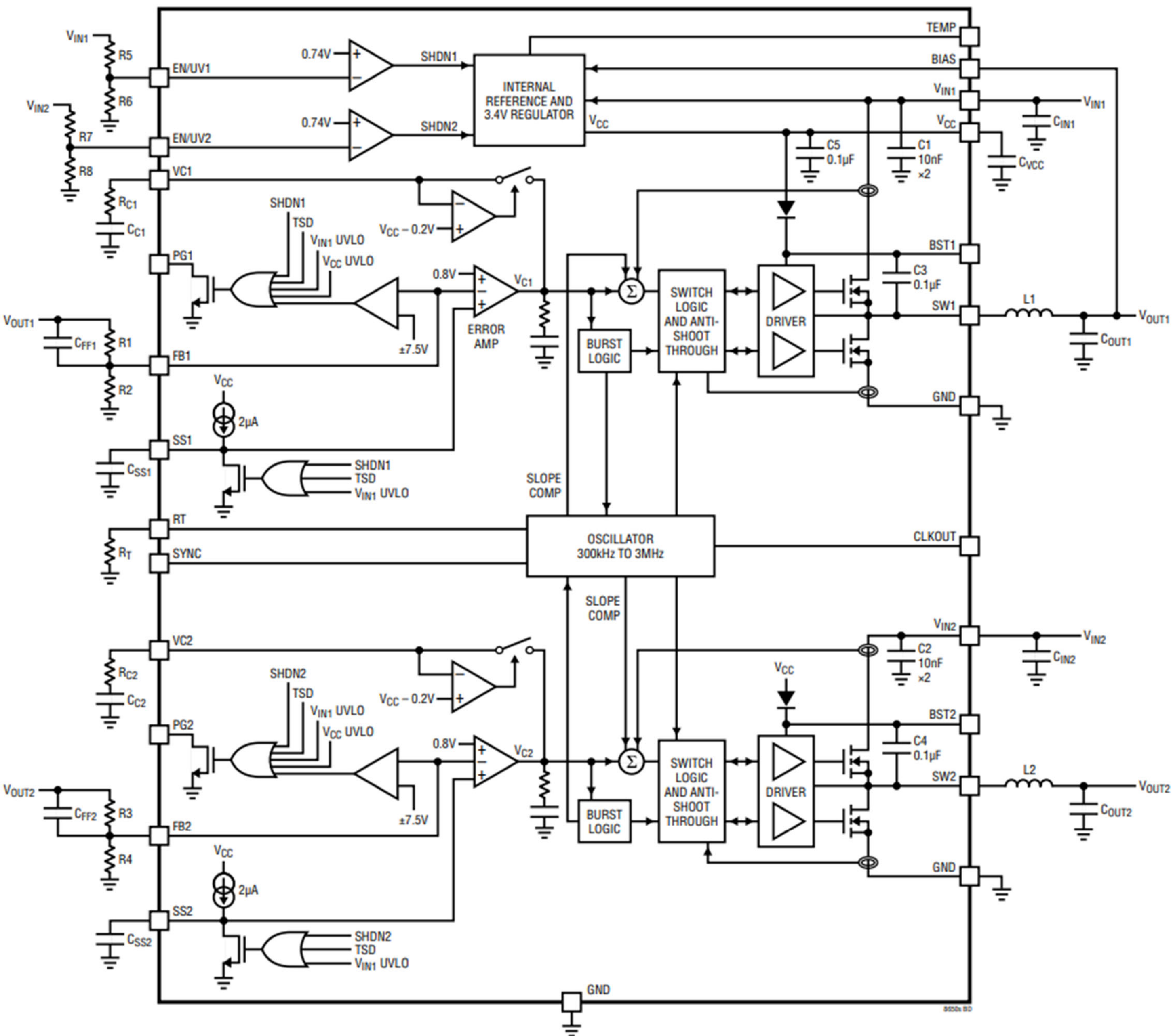


Figure 1A. LT8650S Functional block diagram.

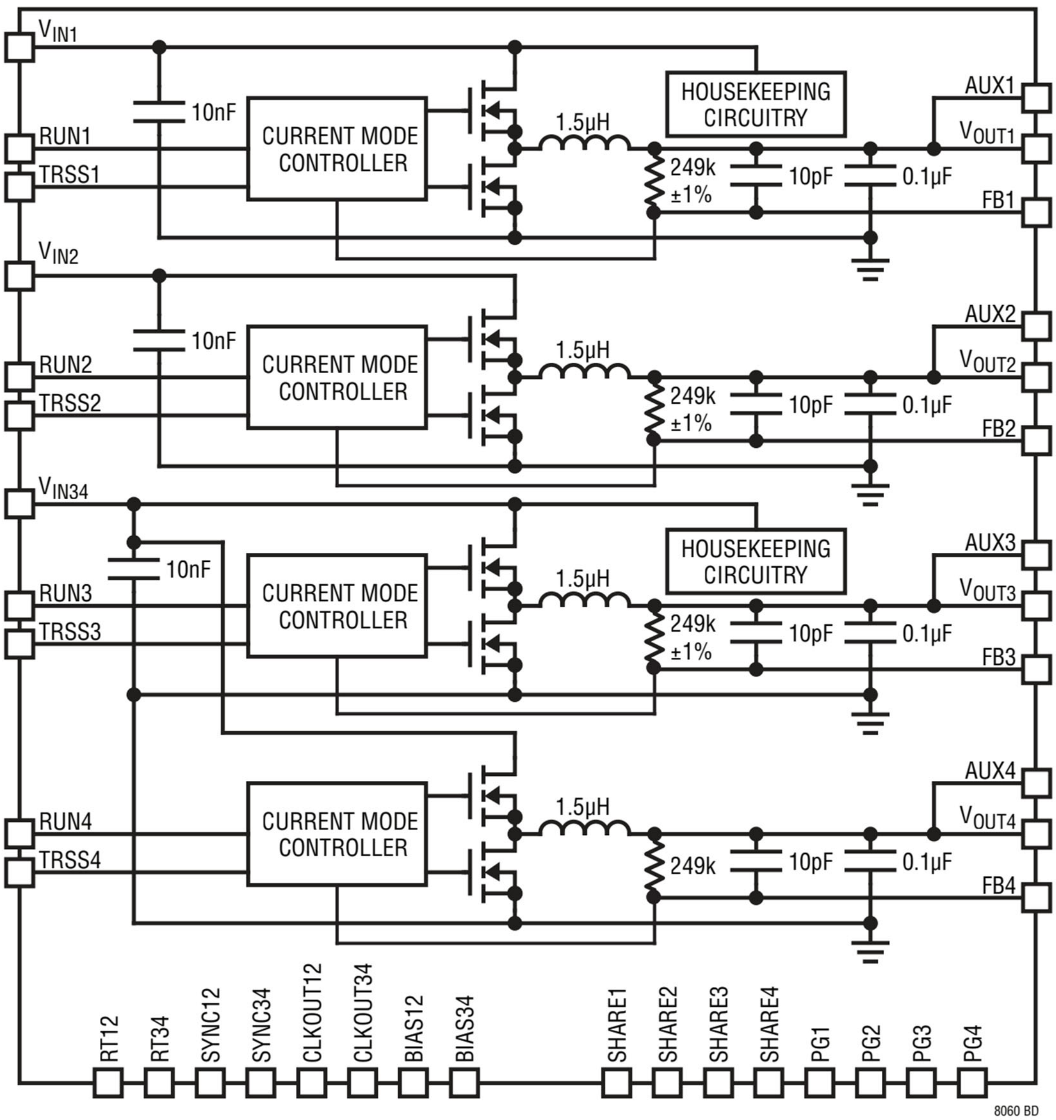


Figure 1B. LTM8060 Functional block diagram.

Table 1
Part and test information.

Generic Part Number:	LT8650S & LTM8060
Date of Test:	October 21 through 23, 2023
Manufacturer:	Analog Devices, Inc.
Part Function:	Dual Channel 4A, 42V, Synchronous Step-Down Silent Switcher
Part Technology:	BCDMOS (flip chip)
Package Style:	165 lead BGA
Test Equipment:	Power Supply (Keithley 2230G-30-6), LabVIEW, NI PXI-1095 with PXIe5172 oscilloscope, TCPA300 current amp and TCP312 current probe

III. Test Facilities

The heavy-ion beam testing was carried out at the Texas A&M University Cyclotron Facility. The facility utilizes the K500 cyclotron with a superconducting magnet which generates the magnetic field used to accelerate the ions. The test setup was in an open-air environment.

Facility: Texas A&M University Cyclotron Facility
Cocktail: 15 MeV/nuc
Flux: 1×10^5 ions·s^{-1}
Fluence: 1×10^7 total ions (per run)
Ions: Shown in Table 2

Table 2.
Heavy-ion specie, linear energy transfer (LET) value, range, and energy.

Ion	LET at Bragg Peak (MeV·cm^2/mg)	Range in Si (µm)	Energy (MeV)
Cu	34.0	151.7	130
Kr	41.0	142.0	180
Ag	59.4	112.9	351

IV. Test Method

A. Test Setup

The devices under test (DUT) were de-processed to expose the die. The LTM8060 was configured, as shown in Figure 2, by connecting the power supplies to the VEMI port which powers all VIN channels. The enable circuit (LTM8060: RUN 1-4; LT8650S: the EN/UV pins) for all channels were tied to VEMI. The output loads were connected to maximize the current draw. The supply current is monitored through a current probe on the input channel. The input voltage, input current, and output voltages were recorded through a LabVIEW program on a PXI-1095 chassis. Note that Figure 2 does not show the power good test points on the back of the board. These points were also connected to the PXI-1095 chassis in a similar configuration as the power input and output readings. If the supply current increased above a predefined threshold, or if the output voltages decreased below the same percent threshold, a power cycle was applied automatically to the DUT. Power cycling would take about 600ms during which time no data was recorded. This automatic mitigation was disabled during the SET testing; however, if the SET was observed to be greater than ~1 second, a manual power cycle was executed.

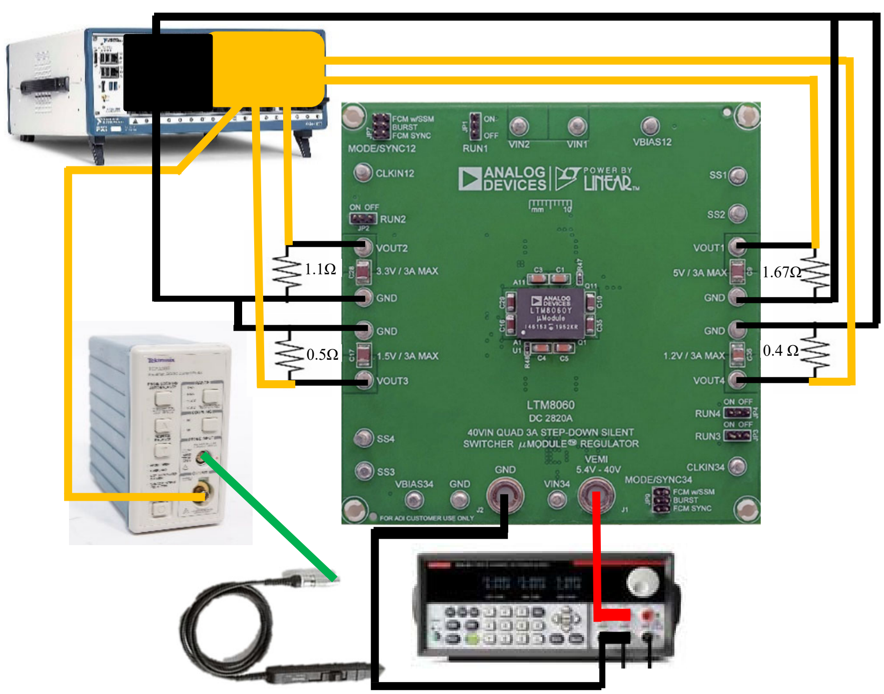


Figure 2. LTM8060 test setup.

B. Irradiation procedure

SEL: The device was powered on and brought up to 125°C. The software to monitor the supply current and voltages was turned on. The ion beam was turned on.

SET: The device was powered on at room temperature. The software to monitor the I/O voltages was turned on. The ion beam was turned on.

C. Test Conditions

Test Temperature:	Ambient temperature – air (transient), 125°C (latchup)
Power Supply(s):	3-16V
Angles of Incidence:	0° (normal), 20°
Parameters:	Resistor Loads (0.4Ω, 0.5Ω, 1.1Ω, 1.67Ω)

V. Results

SEL – The LTM8060 was tested up to the effective LET of 40.8 MeV-cm^2/mg. Two devices were tested, and each device contained two LT8650S die. SEL plots are shown in the Appendix. For conciseness in the graph captions, the unit "MeV·cm^2/mg" is shortened to "MeV".

Table 3
SEL Test Runs

Run	Board Serial Number	Ion	Effective LET	Angle	Ave. Flux	Fluence	Voltage Input	SEL
#			*MeV·cm²/mg*	*degrees*	*ions/sec*	*total ions*	*V*	
13	1	Ag	35.7	0	1.188E+05	9.966E+06	16.0	0
14	1	Kr	40.8	0	9.752E+04	9.968E+06	16.0	SED
15	2	Kr	40.8	0	1.082E+05	9.985E+06	12.0	0
16	2	Kr	40.8	0	1.157E+05	1.004E+07	12.0	0
17	2	Kr	40.8	0	1.722E+05	1.006E+07	12.0	0
18	2	Kr	40.8	0	1.634E+05	1.005E+07	14.0	0
19	2	Kr	40.8	0	1.042E+05	9.981E+06	15.0	0

SET –Two LTM8060 devices were tested at the highest effective LET of 30.4 MeV·cm^2/mg. Each device contained two LT8650S ICs with one IC monitored at a time. Four waveforms of each IC were monitored at a time: Vout1, Vout2, PGood1, PGood2 or Vout3, Vout4, PGood3, PGood4. Transients were counted if the measured value deviated from the nominal voltage output or power good signal by more than three percent. Voltages in the graphs are reported as roughly peak to peak. Transients were categorized based on the number of waveforms they impacted: a single waveform, a transient common between two of the four waveforms, or a transient common to all four waveforms. SET plots for the voltage output and the power good signal are shown in the Appendix. For conciseness in the graph captions, the unit "MeV·cm^2/mg" is shortened to "MeV".

The test runs are shown in Tables 4a and 4b. Table 5a and 5b show the single waveform transients. Table 6a and 6b show the dual waveform transients. Table 7a and 7b shows the 4 waveform transients.

Table 4a: SET Test Runs

Run	Board Serial Number	Ion	Effective LET	Angle	Ave. Flux	Fluence	Voltage Input	Channels Monitoring
#			*MeV·cm²/mg*	*degrees*	*#/cm²/sec*	*total ions*	*V*	
30	4	Cu	30.4	20	9.69E+04	1.0E+07	8.5	1,2
31	4	Cu	30.4	20	9.49E+04	1.0E+07	11.0	1,2
32	4	Cu	30.4	20	8.49E+04	1.0E+07	14.0	1,2
41	3	Cu	30.4	20	1.27E+05	1.0E+07	8.5	1,2
42	3	Cu	30.4	20	1.29E+05	1.0E+07	11.0	1,2
43	3	Cu	30.4	20	1.21E+05	1.0E+07	14.0	1,2

Table 4b: SET Test Runs

Run	Board Serial Number	Ion	Effective LET	Angle	Ave. Flux	Fluence	Voltage Input	Channels Monitoring
#			*MeV·cm²/mg*	*degrees*	*#/cm²/sec*	*total ions*	*V*	
33	4	Cu	30.4	20	1.03E+05	1.0E+07	3.0	3,4
34	4	Cu	30.4	20	1.205E+05	1.0E+07	6.5	3,4
35	4	Cu	30.4	20	1.19E+05	1.0E+07	10.0	3,4
36	4	Cu	30.4	20	1.21E+05	1.0E+07	14.0	3,4
37	3	Cu	30.4	20	1.18E+05	1.0E+07	3.0	3,4
38	3	Cu	30.4	20	1.24E+05	1.0E+07	6.5	3,4
39	3	Cu	30.4	20	1.22E+05	1.0E+07	10.0	3,4
40	3	Cu	30.4	20	1.24E+05	1.0E+07	14.0	3,4

Table 5a: Single Waveform SET

Run	Voltage Input	LT8650S (#1 of LTM8060) SET Observed on Single Channel Output Only											
		Vout1 (5.0V)			Vout2 (3.3V)			PG1			PG2		
#	*V*	#	*Longest Duration (s)*	*Largest Amplitude (V)*	#	*Longest Duration (s)*	*Largest Amplitude (V)*	#	*Longest Duration (s)*	*Largest Amplitude (V)*	#	*Longest Duration (s)*	*Largest Amplitude (V)*
30	8.5	0			0			1	0.007	0.137	0		
31	11.0	0			0						0		
32	14.0	0			0			0			1	0.007	0.103
41	8.5	0			0			3	0.007	0.145	2	0.008	0.100
42	11.0	0			0			0			1	0.007	0.112
43	14.0	0			0			1	0.008	0.149	1	0.008	0.109

Table 5b: Single Waveform SET

Run	Voltage Input	LT8650S (#2 of LTM8060) SET Observed on Single Channel Output Only											
		Vout3 (1.5V)			Vout4 (1.2V)			PG3			PG4		
#	*V*	#	*Longest Duration (s)*	*Largest Amplitude (V)*	#	*Longest Duration (s)*	*Largest Amplitude (V)*	#	*Longest Duration (s)*	*Largest Amplitude (V)*	#	*Longest Duration (s)*	*Largest Amplitude (V)*
33	3.0	0			0			0			0		
34	6.5	0			0			0			0		
35	10.0	0			0			0			0		
36	14.0	0			0			0			0		
37	3.0	0			0			0			0		
38	6.5	0			1	0.832	1.165	0			0		
39	10.0	0			0			0			0		
40	14.0	0			0			0			0		

Table 6a: Two Waveform SET

Run	Voltage Input	LT8650S (#1 of LTM8060) SET Observed on Both Channels											
		Voltage Output 1 (5.0V) Power Good 1			Voltage Output 2 (3.3V) Power Good 2			Voltage Output 1 (5.0V) Voltage Output 2 (3.3V)			Power Good 1 Power Good 2		
#	*V*	#	*Longest Duration (s)*	*Largest Amplitude (V)*	#	*Longest Duration (s)*	*Largest Amplitude (V)*	#	*Longest Duration (s)*	*Largest Amplitude (V)*	#	*Longest Duration (s)*	*Largest Amplitude (V)*
30	8.5	2	0.008	Fig A12-A15	1	0.008	Fig A12-A15	1	0.007	Fig A12-A15	1	0.008	Fig A12-A15
31	11.0	6	1.586	Fig A16-A19	1	0.008	Fig A16-A19	0			6	0.008	Fig A16-A19
32	14.0	3	0.201	Fig A20-A23	3	0.008	Fig A20-A23	0			3	0.008	Fig A20-A23
41	8.5	1	0.008	Fig A56-A59	2	0.008	Fig A56-A59	0			8	0.008	Fig A56-A59
42	11.0	0	0.008	Fig A60-A63	0			0			226	0.016	Fig A60-A63
43	14.0	2	0.163	Fig A64-A67	2	0.008	Fig A64-A67	0			16	0.008	Fig A64-A67

Table 6b: Two Waveform SET

Run	Voltage Input	LT8650S (#2 of LTM8060) SET Observed on Both Channels											
		Voltage Output 3 Power Good 3			Voltage Output 4 Power Good 4			Voltage Output 3 Voltage Output 4			Power Good 3 Power Good 4		
#	*V*	#	*Longest Duration (s)*	*Largest Amplitude (V)*	#	*Longest Duration (s)*	*Largest Amplitude (V)*	#	*Longest Duration (s)*	*Largest Amplitude (V)*	#	*Longest Duration (s)*	*Largest Amplitude (V)*
33	3.0	1	17.393	Fig A24-A27	0			0			0		
34	6.5	0			0			0			0		
35	10.0	0			0			0			0		
36	14.0	0			1	0.031	Fig A36-A39	0			0		
37	3.0	1	18.810	Fig A40-A43	0			0			0		
38	6.5	0			0			0			0		
39	10.0	0			2	0.741	Fig A48-A51	0			1	0.008	Fig A48-A51
40	14.0	0			3	0.180	Fig A52-A55	0			0		

Table 7a: Four Waveform SET

Run	Voltage Input	SET on All Monitored Channels			Total
#	V	#	Longest Duration (s)	Largest Amplitude	#
30	8.5	167	1.310	Fig A12-A15	173
31	11.0	229	3.248	Fig A16-A19	241
32	14.0	212	2.580	Fig A20-A23	222
41	8.5	208	1.711	Fig A56-A59	219
42	11.0	213	1.653	Fig A60-A63	441*
43	14.0	230	1.599	Fig A64-A67	248

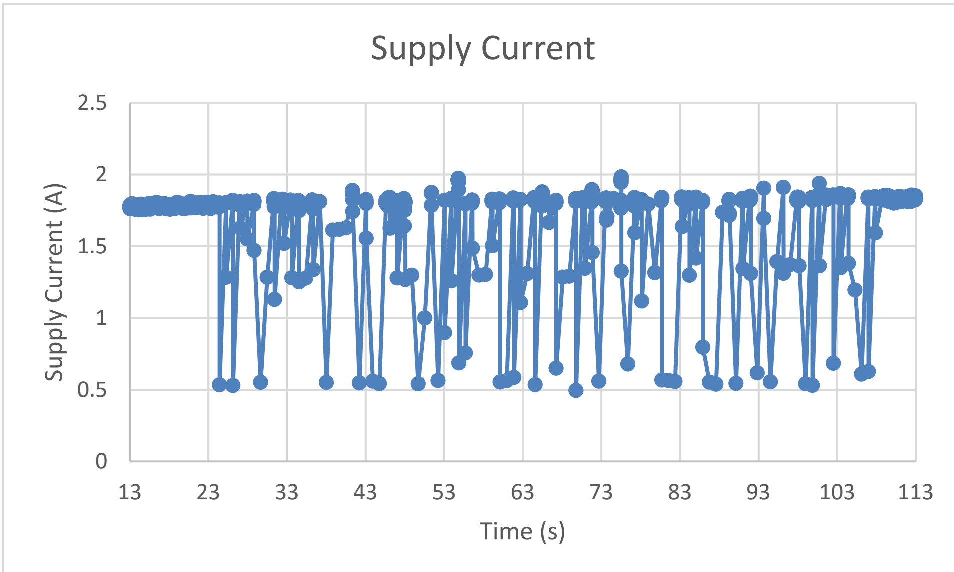
1 extra transient occurred on Vout2, Power Good 1, and Power Good 2, simultaneously.

Table 7b: Four Waveform SET

Run	Voltage Input	SET on All Monitored Channels			Total
#	V	#	Longest Duration (s)	Largest Amplitude	#
33	3.0	4	3.073	Fig A24-A27	5
34	6.5	10	4.968	Fig A28-A31	10
35	10.0	0			0
36	14.0	5	1.491	Fig A36-A39	6
37	3.0	5	1.544	Fig A40-A43	6
38	6.5	6	4.681	Fig A44-A47	6
39	10.0	10	1.623	Fig A48-A51	13
40	14.0	13	2.595	Fig A52-A55	16

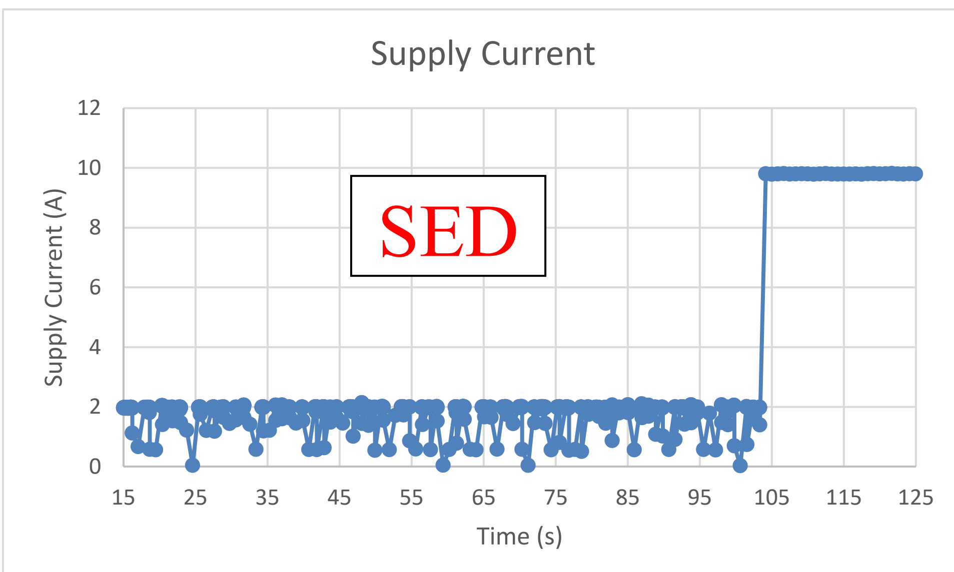
Appendix

SEL:



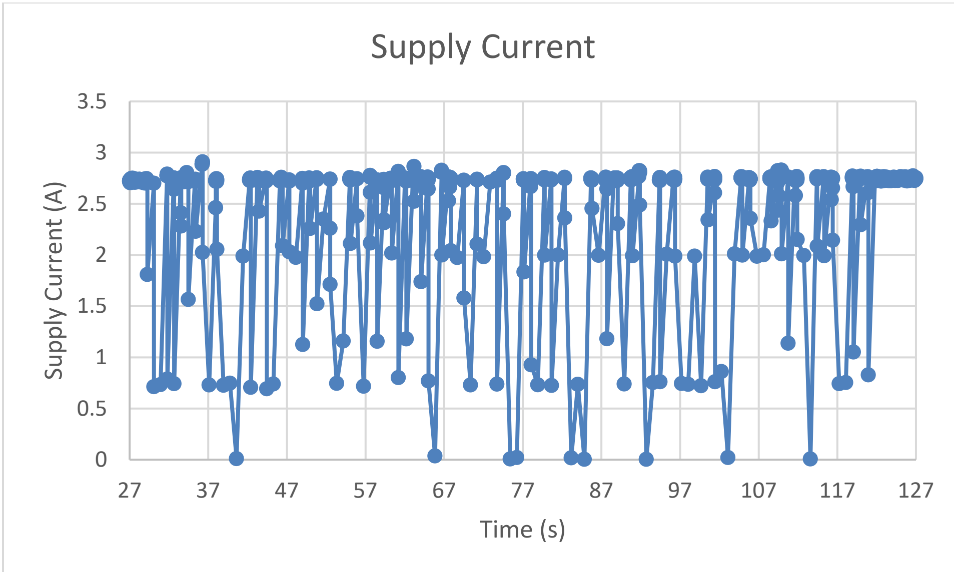
Board 1, LET= 35.7 MeV
VIN=16V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A
TJ=125°C

Figure A1: Supply Current SEL run 13 Voltage Input = 16V



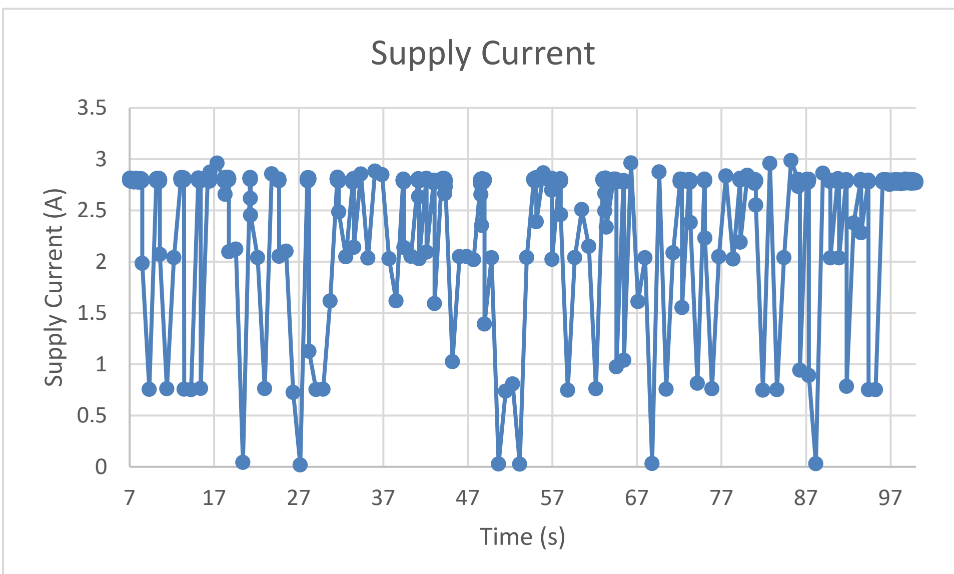
Board 1, LET= 40.8 MeV
VIN=16V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A
TJ=125°C

Figure A2: Supply Current SEL run 14 Voltage Input = 16V



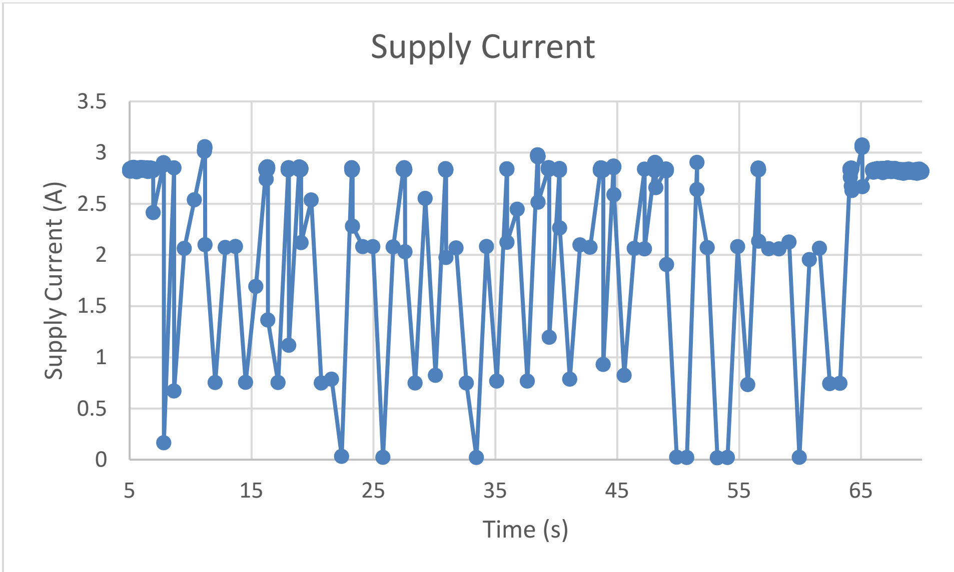
Board 2, LET= 40.8 MeV
VIN=12V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A
TJ=125°C

Figure A3: Supply Current SEL run 15 Voltage Input = 12V



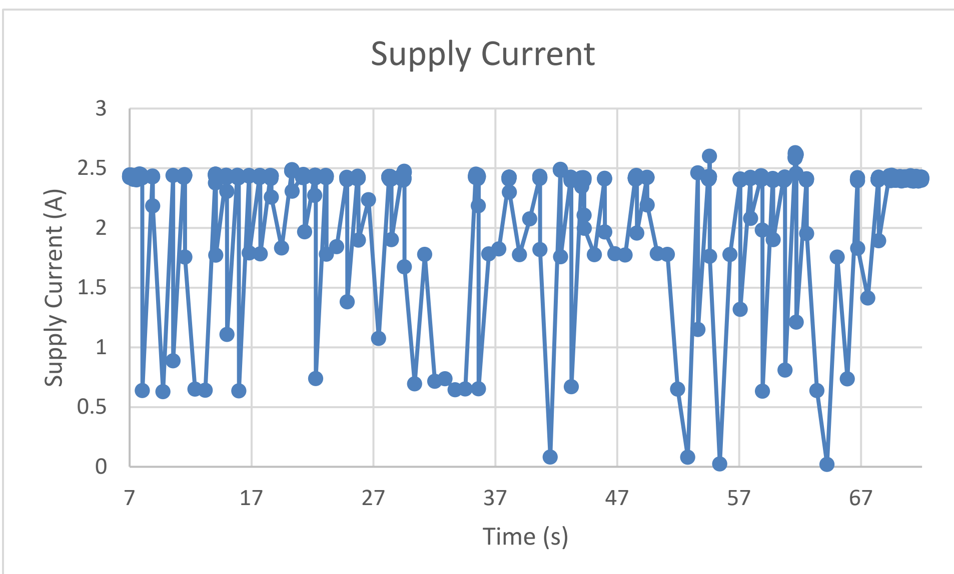
Board 2, LET= 40.8 MeV
VIN=12V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A
TJ=125°C

Figure A4: Supply Current SEL run 16 Voltage Input = 12V



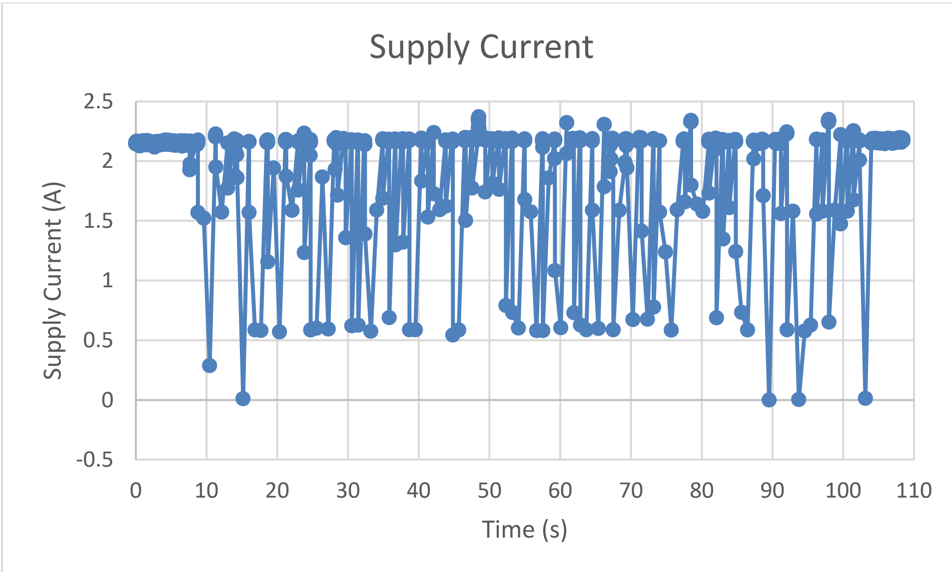
Board 2, LET= 40.8 MeV
VIN=12V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A
TJ=125°C

Figure A5: Supply Current SEL run 17 Voltage Input = 12V



Board 2, LET= 40.8 MeV
VIN=14V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A
TJ=125°C

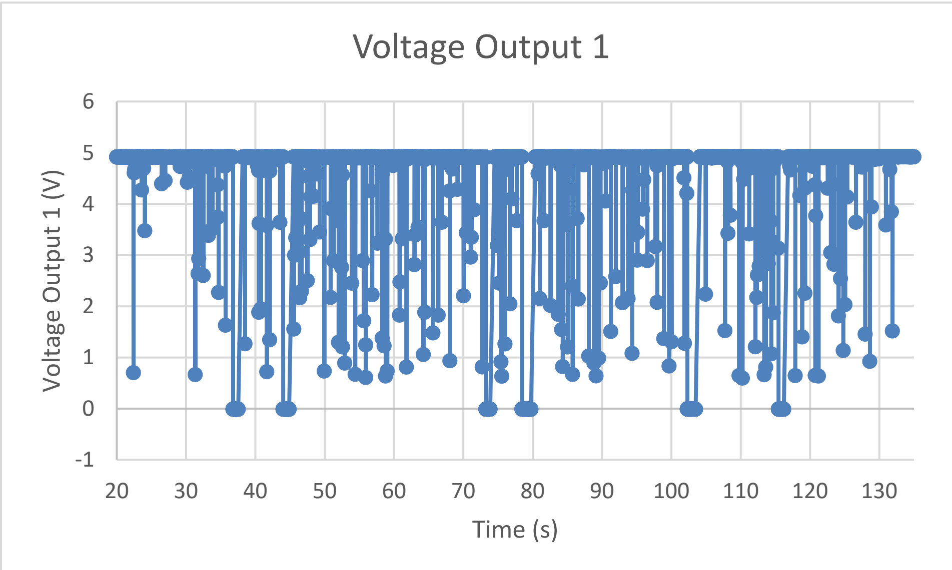
Figure A6: Supply Current SEL run 18 Voltage Input = 14V



Board 2, LET= 40.8 MeV
VIN=15V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A
TJ=125°C

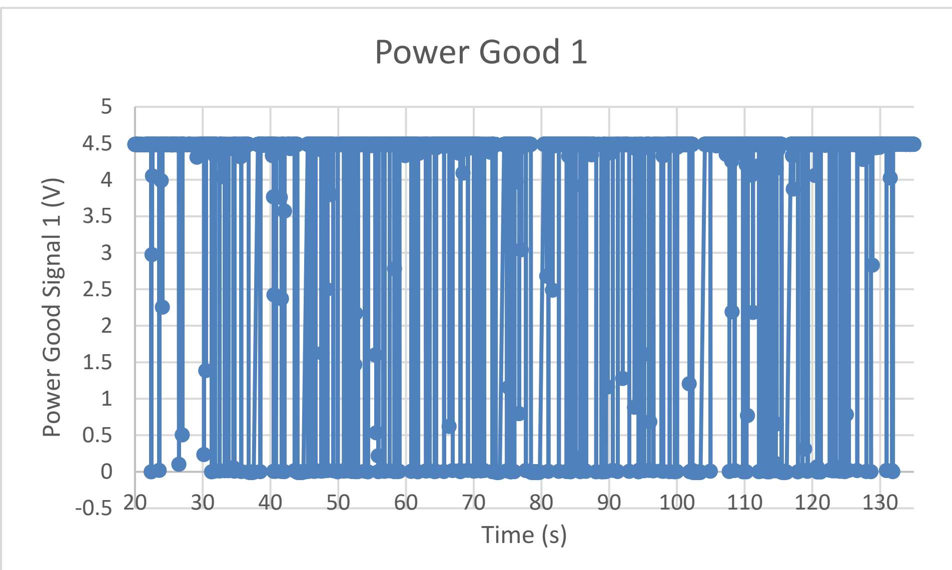
Figure A7: Supply Current SEL run 19 Voltage Input = 15V

SET:



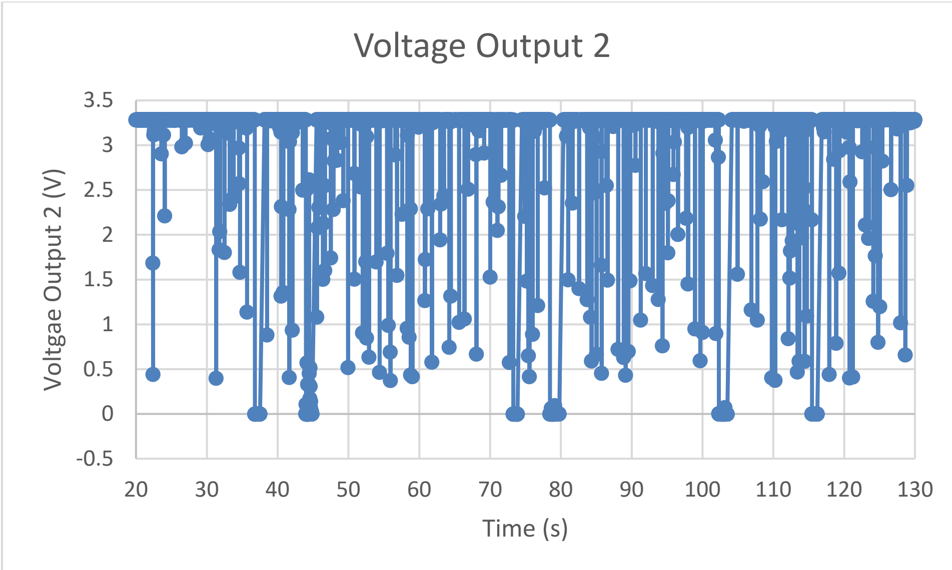
Board 4, LET= 30.4 MeV
VIN=8.5V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A12: Voltage Output 1 (5V) SET run 30 Voltage Input = 8.5V



Board 4, LET= 30.4 MeV
VIN=8.5V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A13: Power Good Signal 1 SET run 30 Voltage Input = 8.5V

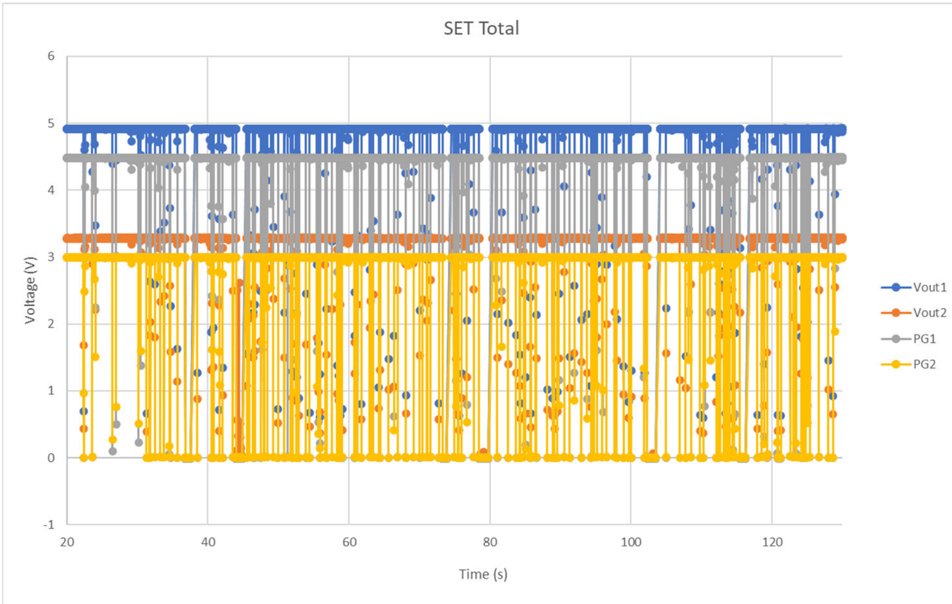


Board 4, LET= 30.4 MeV
VIN=8.5V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A14: Voltage Output 2 (3.3V) SET run 30 Voltage Input = 8.5V

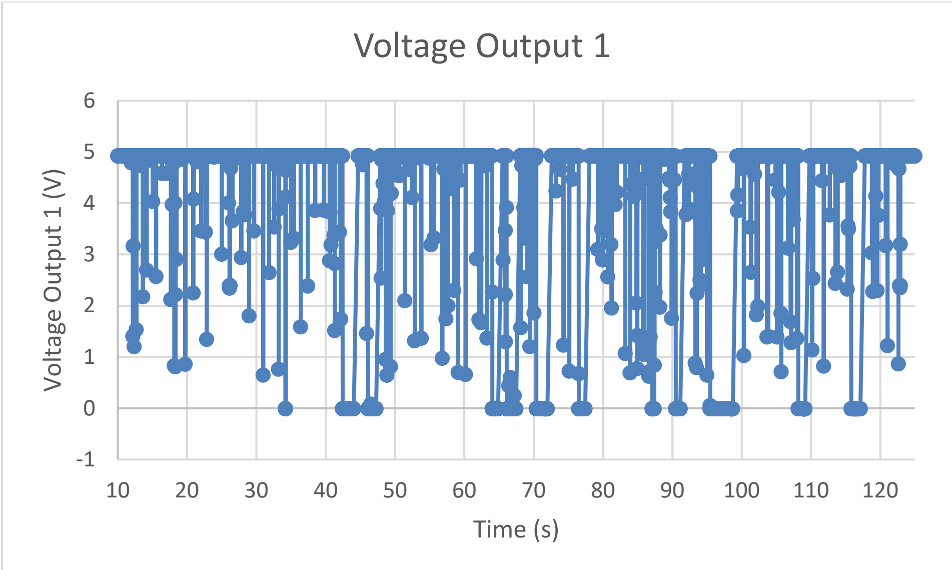
Board 4, LET= 30.4 MeV
VIN=8.5V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A15: Power Good Signal 2 SET run 30 Voltage Input = 8.5V



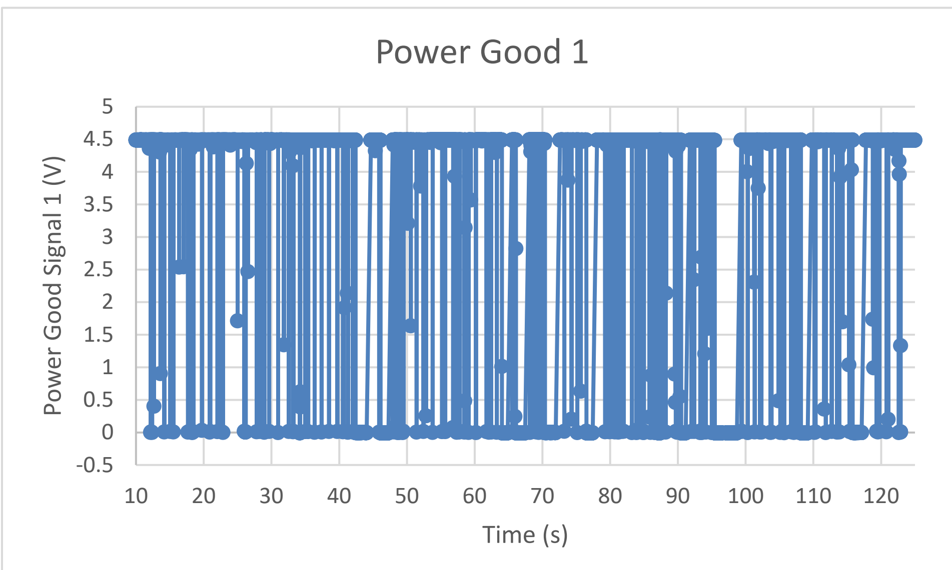
Board 4, LET= 30.4 MeV
VIN=8.5V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A15a: Overlaid Total SET run 30 Voltage Input = 8.5V



Board 4, LET= 30.4 MeV
VIN=11V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A16: Voltage Output 1 (5V) SET run 31 Voltage Input = 11V



Board 4, LET= 30.4 MeV
VIN=11V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A17: Power Good Signal 1 SET run 31 Voltage Input = 11V

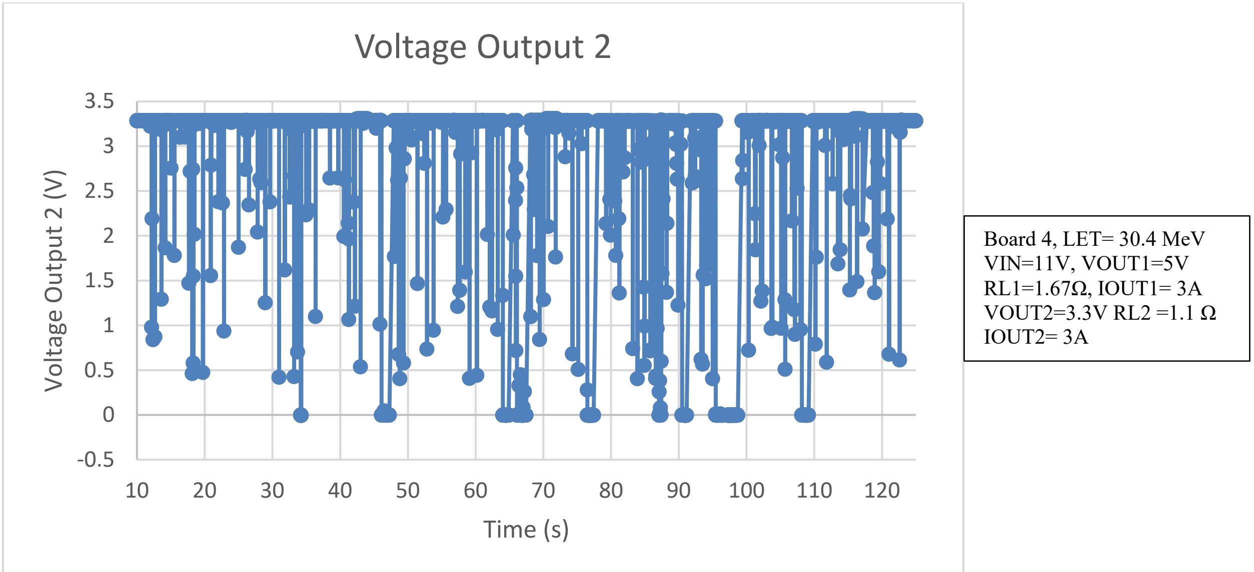


Figure A18: Voltage Output 2 (3.3V) SET run 31 Voltage Input = 11V

Figure A19: Power Good Signal 2 SET run 31 Voltage Input = 11V

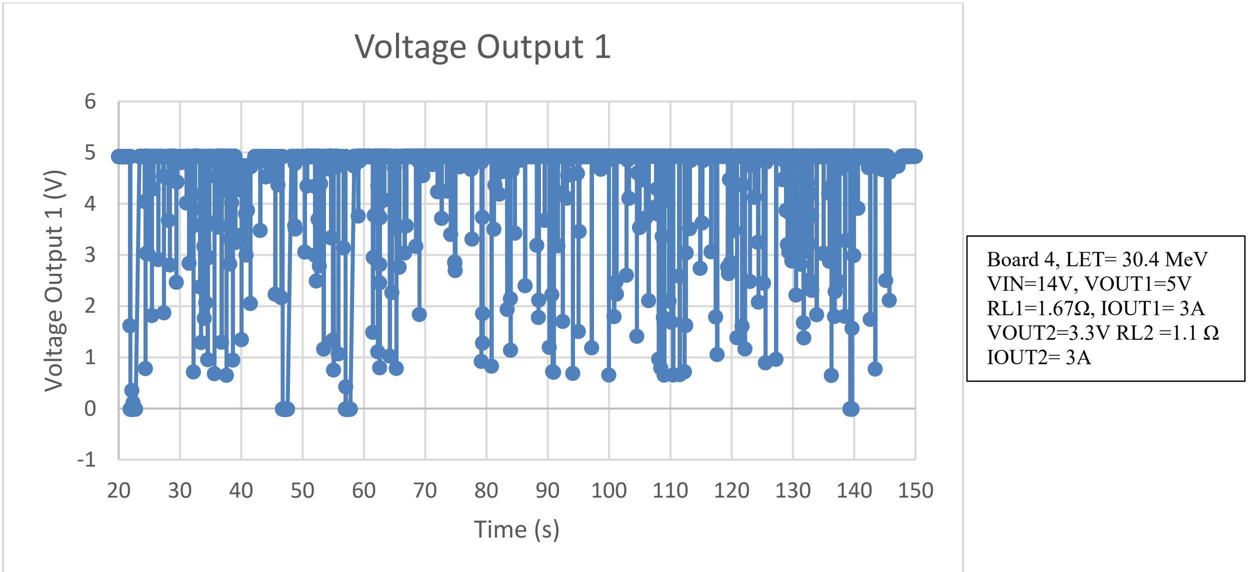


Figure A20: Voltage Output 1 (5V) SET run 32 Voltage Input = 14V

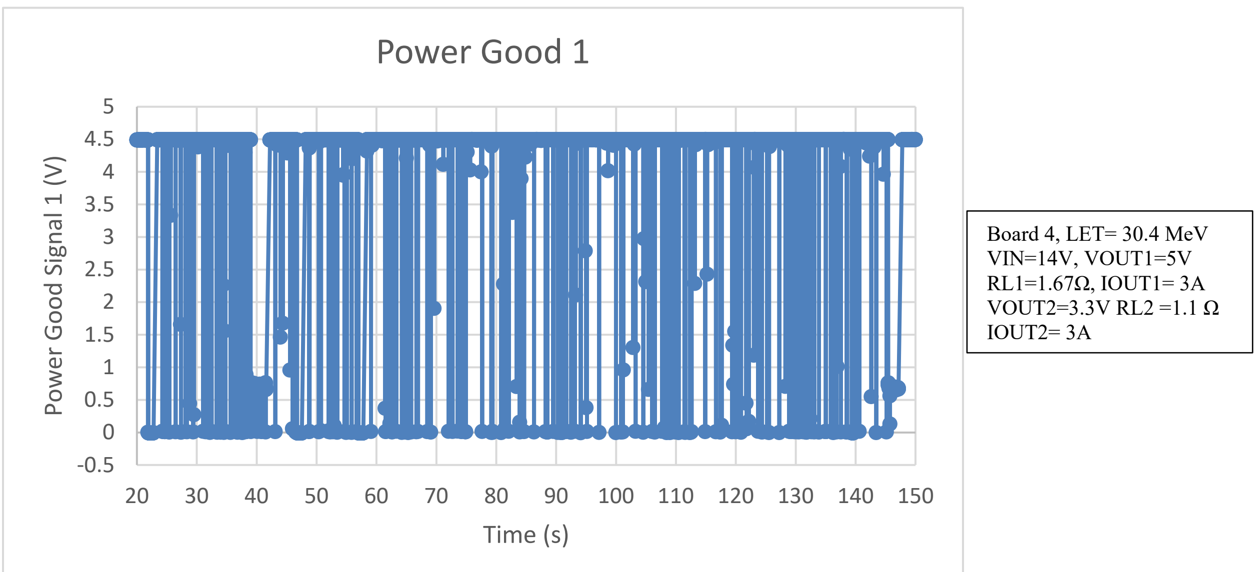
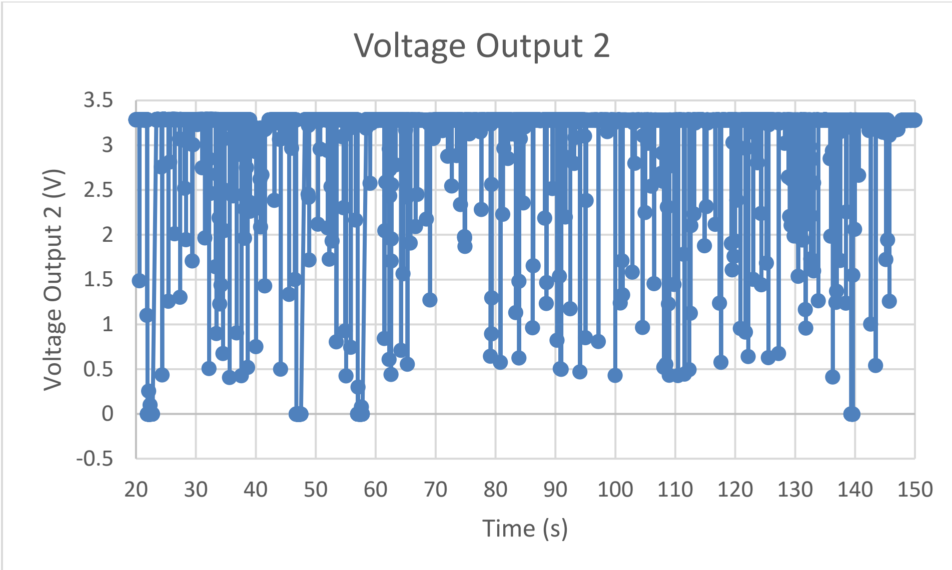
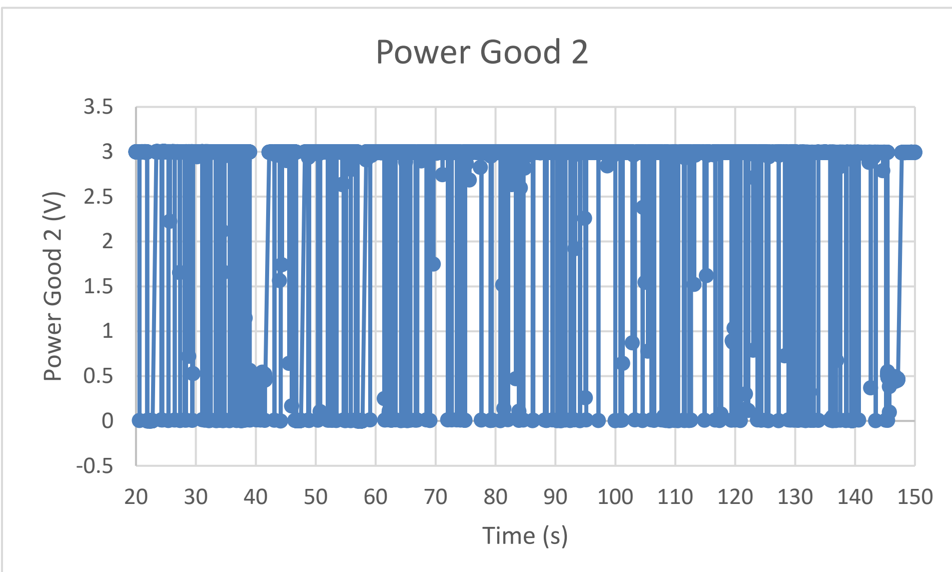


Figure A21: Power Good Signal 1 SET run 32 Voltage Input = 14V



Board 4, LET= 30.4 MeV
VIN=14V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A22: Voltage Output 2 (3.3V) SET run 32 Voltage Input = 14V



Board 4, LET= 30.4 MeV
VIN=14V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A23: Power Good Signal 2 SET run 32 Voltage Input = 14V

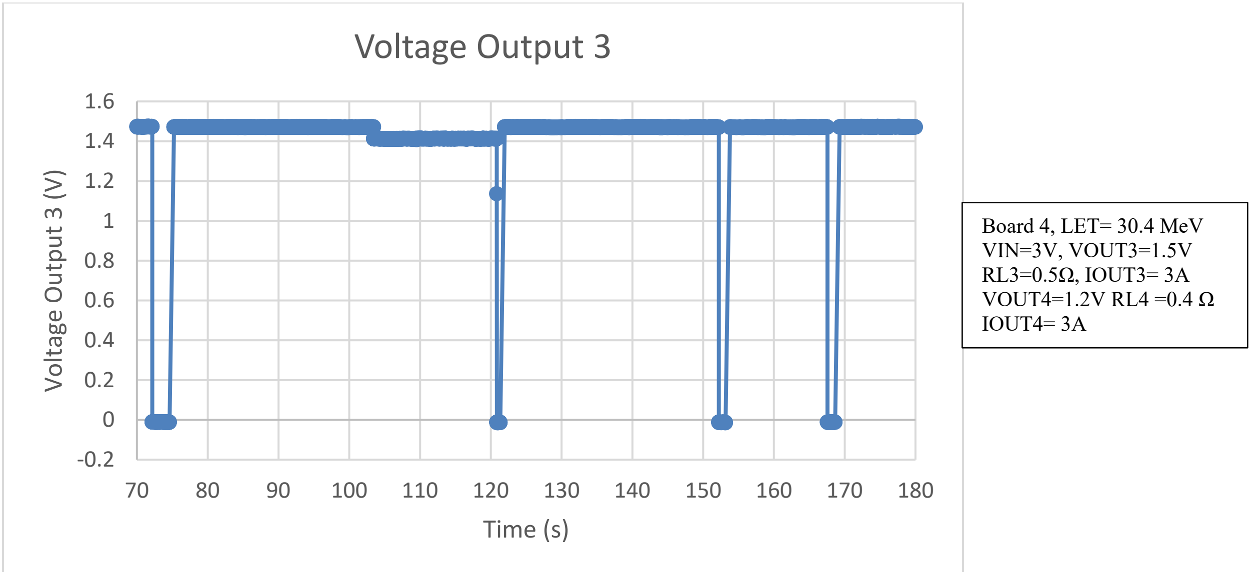


Figure A24: Voltage Output 3 (1.5V) SET run 33 Voltage Input = 3V

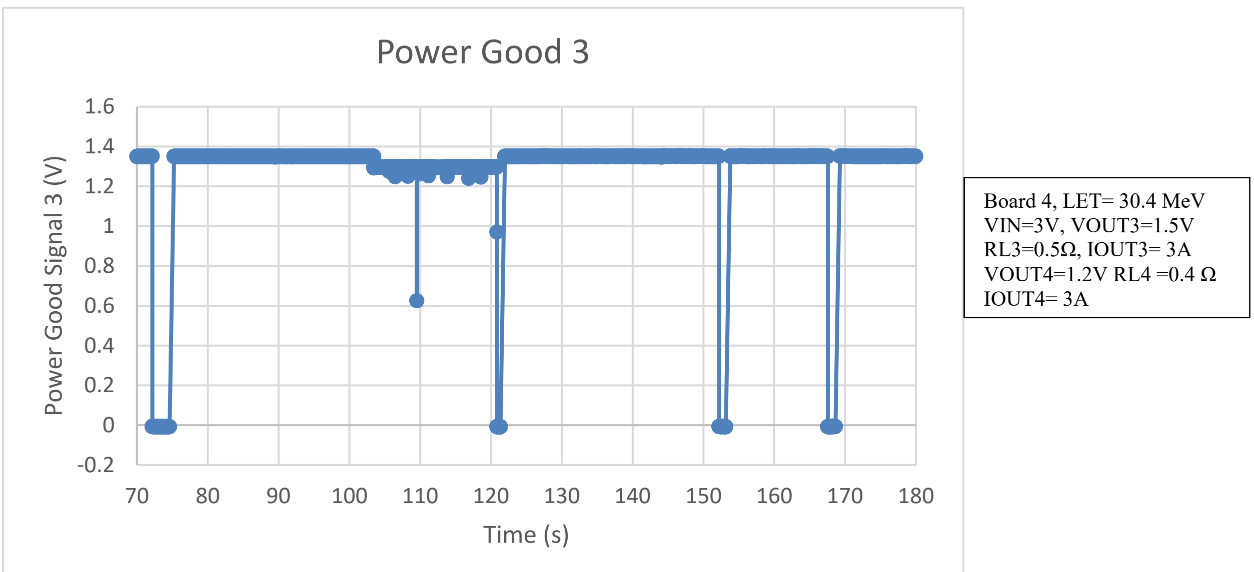
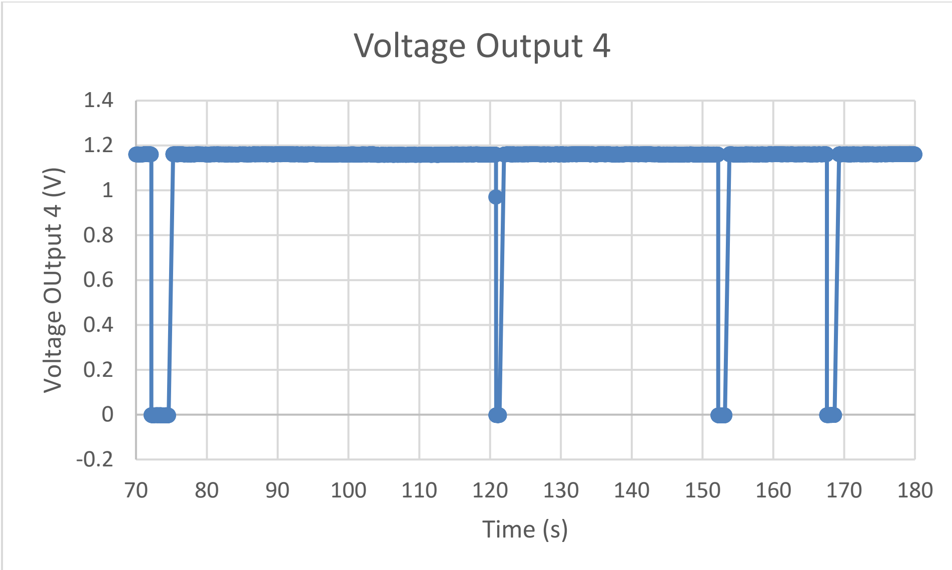


Figure A25: Power Good Signal 3 SET run 33 Voltage Input = 3V

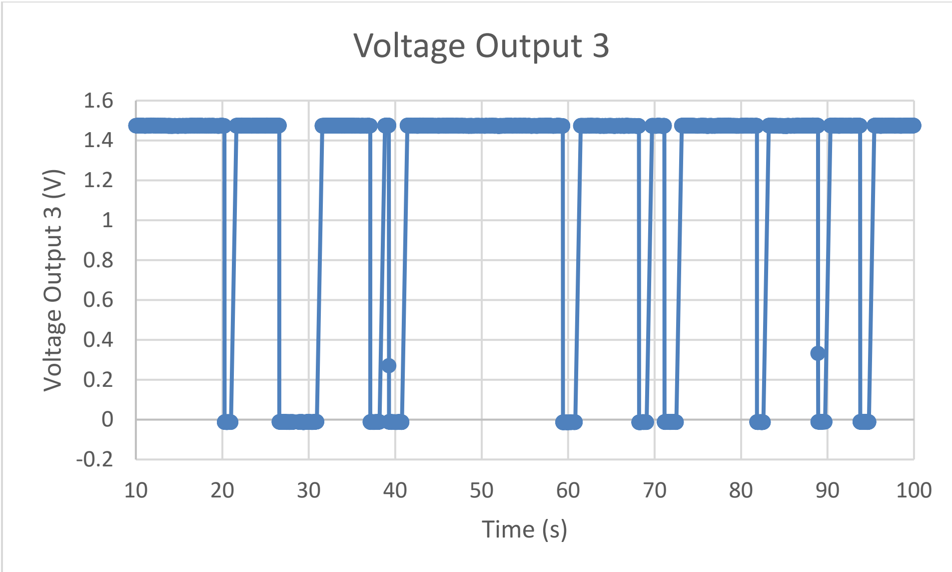


Board 4, LET= 30.4 MeV
VIN=3V, VOUT3=1.5V
RL3=0.5Ω, IOUT3= 3A
VOUT4=1.2V RL4 =0.4 Ω
IOUT4= 3A

Figure A26: Voltage Output 4 (1.2V) SET run 33 Voltage Input = 3V

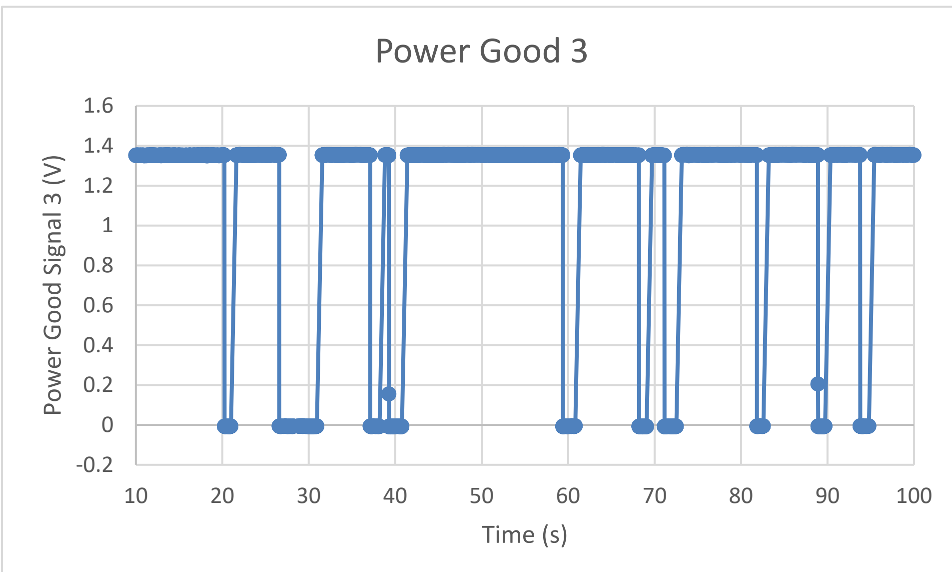
Board 4, LET= 30.4 MeV
VIN=3V, VOUT3=1.5V
RL3=0.5Ω, IOUT3= 3A
VOUT4=1.2V RL4 =0.4 Ω
IOUT4= 3A

Figure A27: Power Good Signal 4 SET run 33 Voltage Input = 3V



Board 4, LET= 30.4 MeV
VIN=6.5V, VOUT3=1.5V
RL3=0.5Ω, IOUT3= 3A
VOUT4=1.2V RL4 =0.4 Ω
IOUT4= 3A

Figure A28: Voltage Output 3 (1.5V) SET run 34 Voltage Input = 6.5V



Board 4, LET= 30.4 MeV
VIN=6.5V, VOUT3=1.5V
RL3=0.5Ω, IOUT3= 3A
VOUT4=1.2V RL4 =0.4 Ω
IOUT4= 3A

Figure A29: Power Good Signal 3 SET run 34 Voltage Input = 6.5V

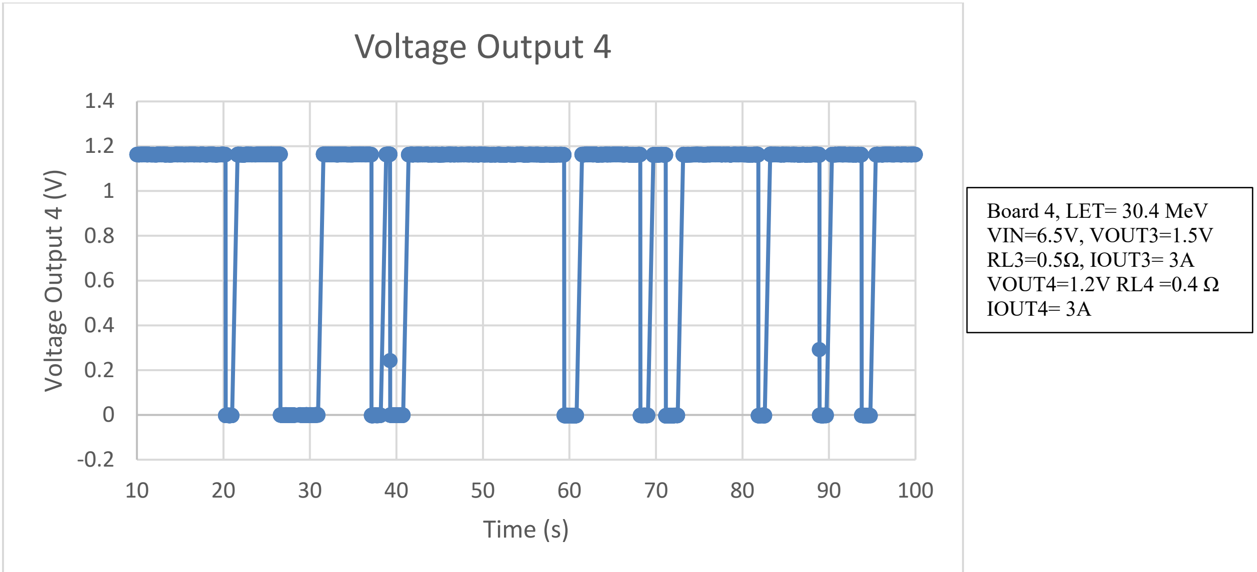


Figure A30: Voltage Output 4 (1.2V) SET run 34 Voltage Input = 6.5V

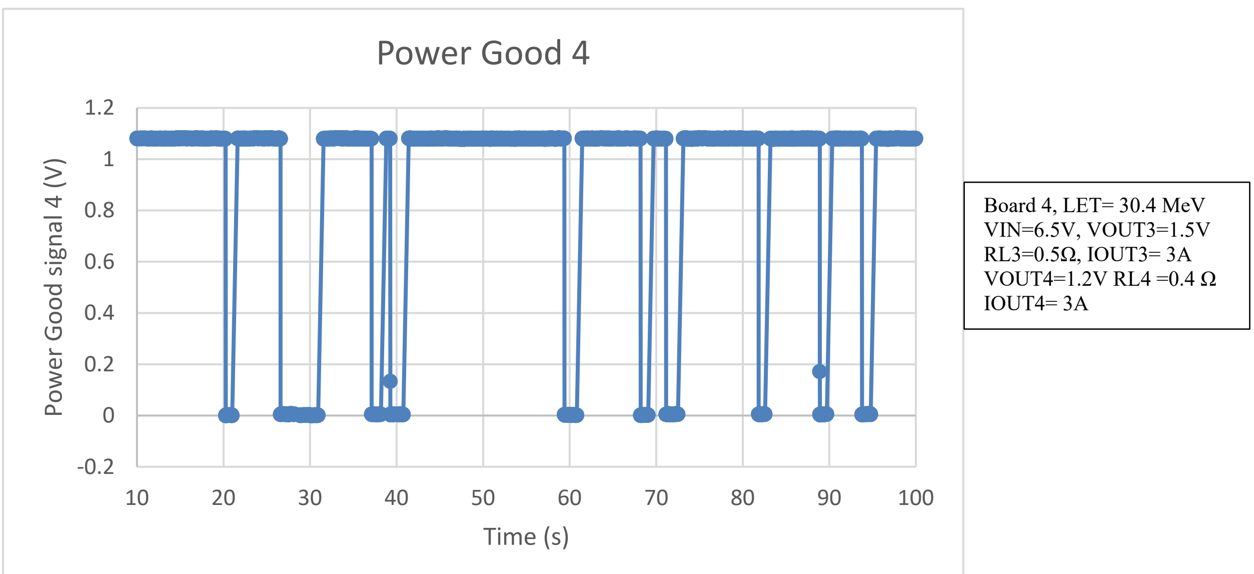
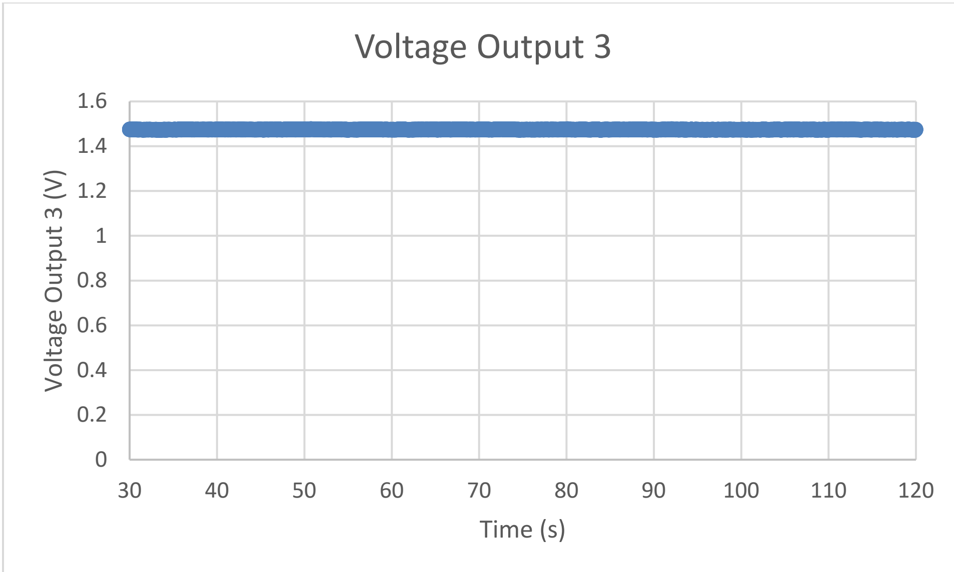
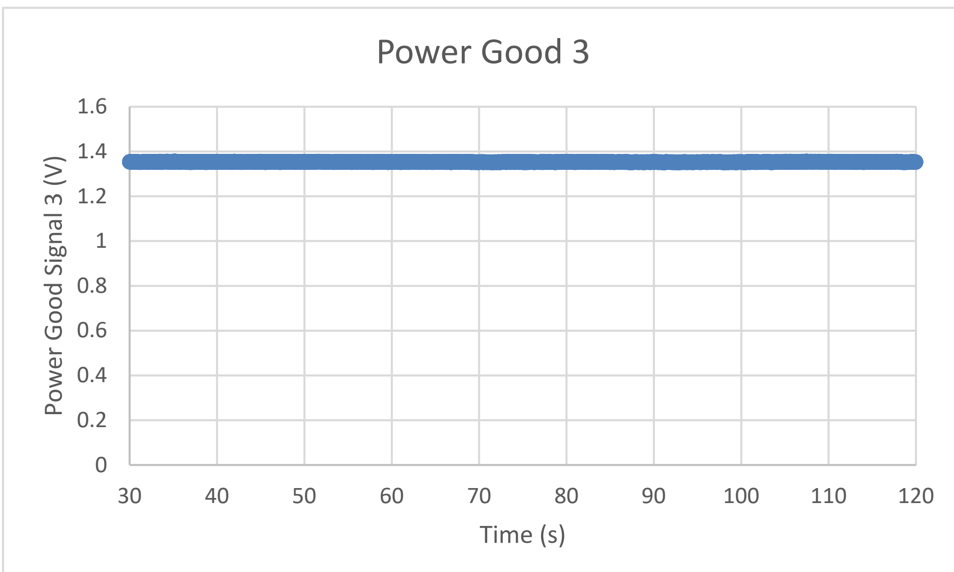


Figure A31: Power Good Signal 4 SET run 34 Voltage Input = 6.5V



Board 4, LET= 30.4 MeV
VIN=10V, VOUT3=1.5V
RL3=0.5Ω, IOUT3= 3A
VOUT4=1.2V RL4 =0.4 Ω
IOUT4= 3A

Figure A32: Voltage Output 3 (1.5V) SET run 35 Voltage Input = 10V



Board 4, LET= 30.4 MeV
VIN=10V, VOUT3=1.5V
RL3=0.5Ω, IOUT3= 3A
VOUT4=1.2V RL4 =0.4 Ω
IOUT4= 3A

Figure A33: Power Good Signal 3 SET run 35 Voltage Input = 10V

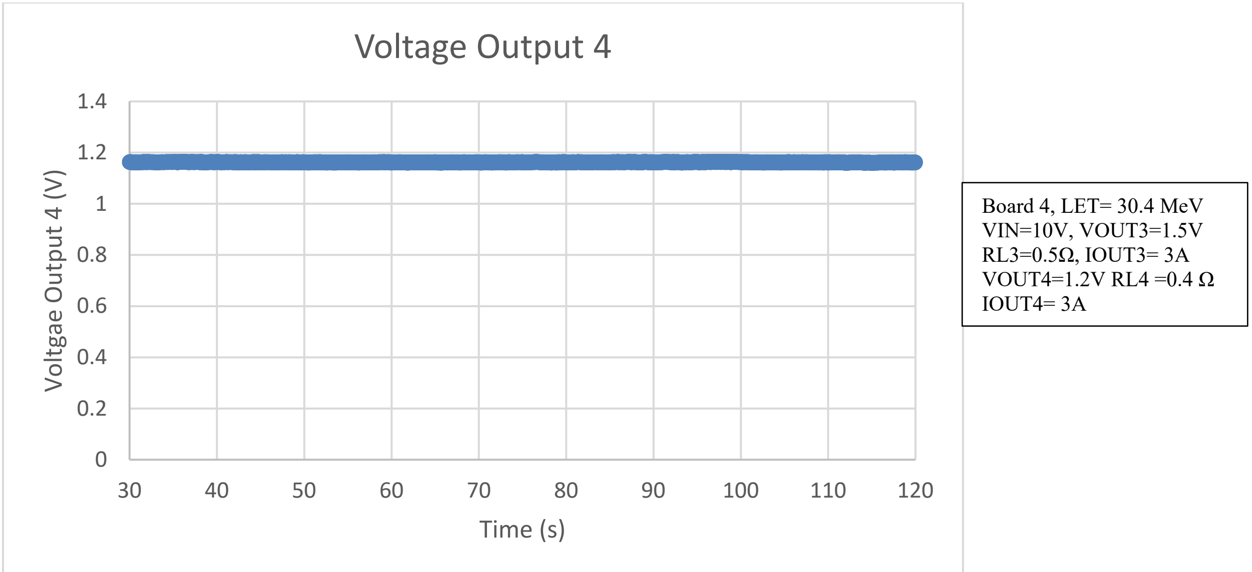


Figure A34: Voltage Output 4 (1.2V) SET run 35 Voltage Input = 10V

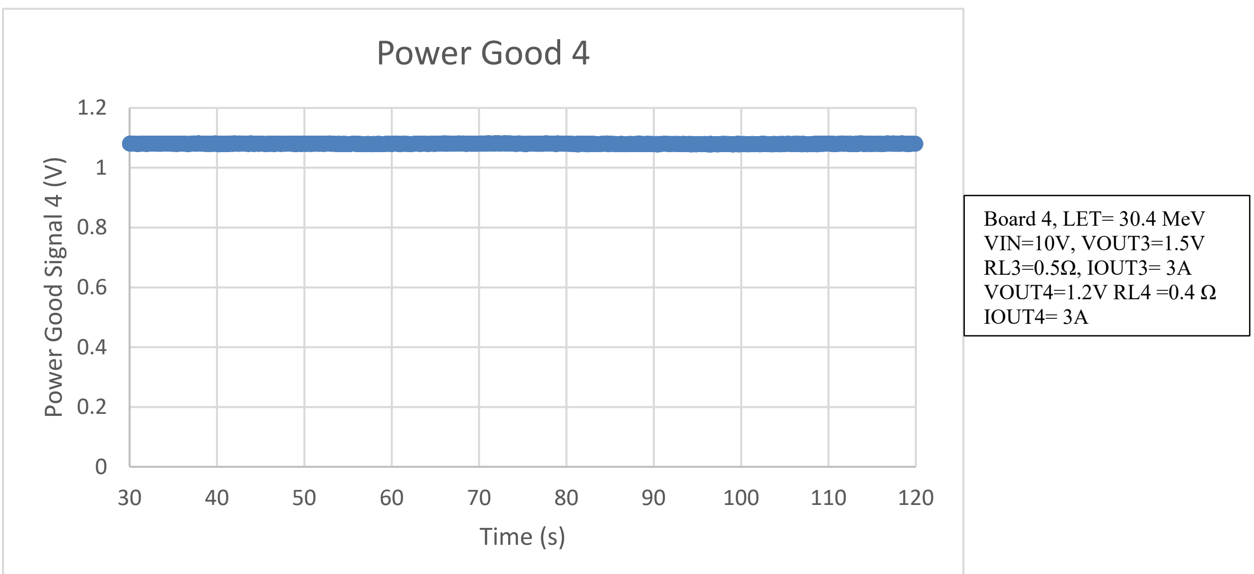


Figure A35: Power Good Signal 4 SET run 35 Voltage Input = 10V

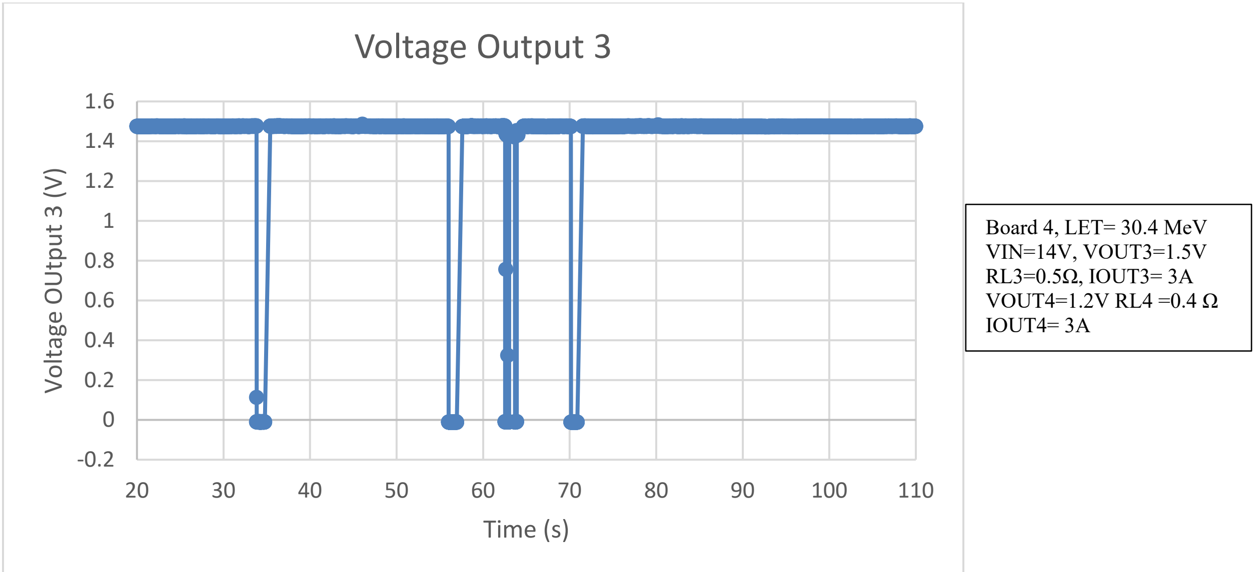


Figure A36: Voltage Output 3 (1.5V) SET run 36 Voltage Input = 14V

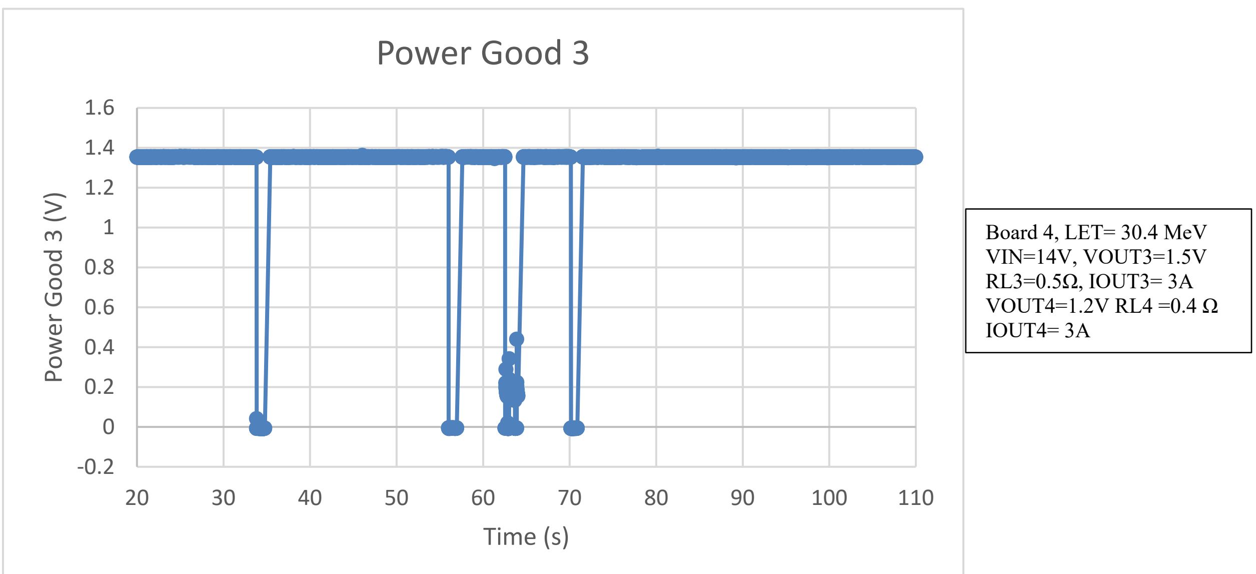
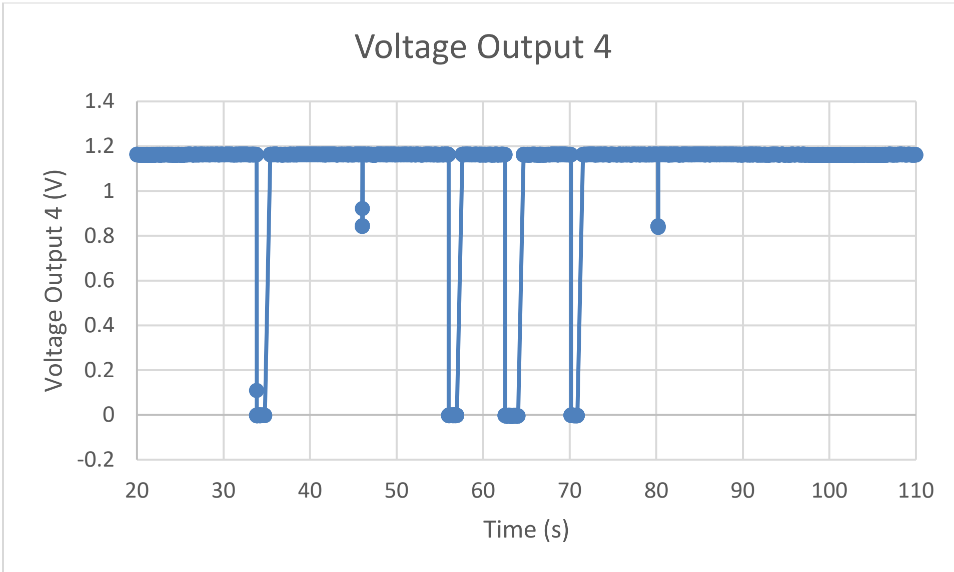
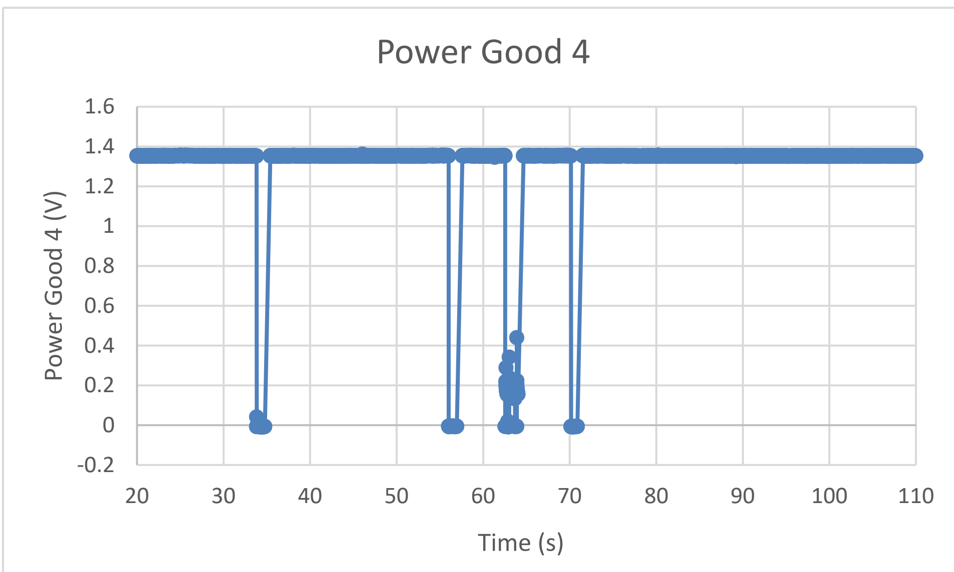


Figure A37: Power Good Signal 3 SET run 36 Voltage Input = 14V



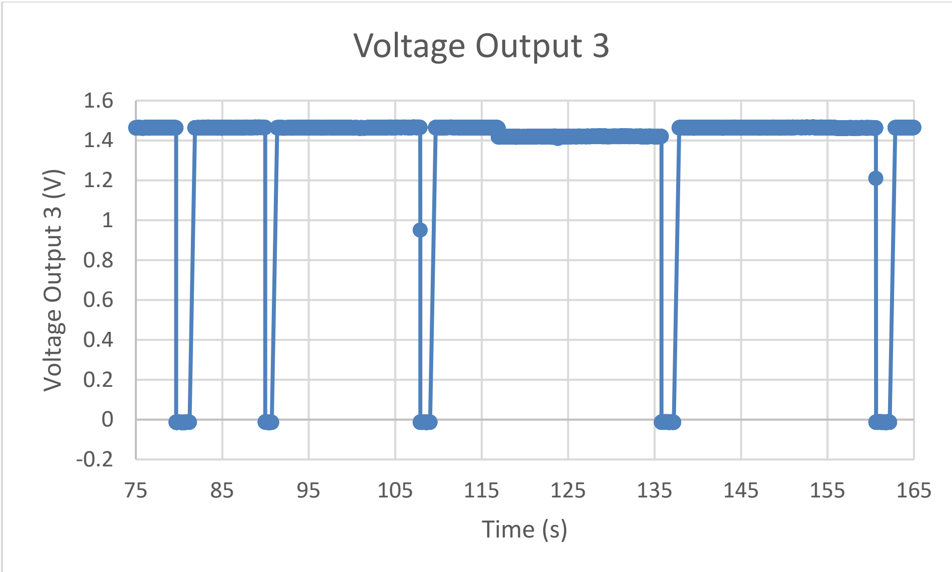
Board 4, LET= 30.4 MeV
VIN=14V, VOUT3=1.5V
RL3=0.5Ω, IOUT3= 3A
VOUT4=1.2V RL4 =0.4 Ω
IOUT4= 3A

Figure A38: Voltage Output 4 (1.2V) SET run 36 Voltage Input = 14V



Board 4, LET= 30.4 MeV
VIN=14V, VOUT3=1.5V
RL3=0.5Ω, IOUT1= 3A
VOUT4=1.2V RL4 =0.4 Ω
IOUT4= 3A

Figure A39: Power Good Signal 4 SET run 36 Voltage Input = 14V



Board 3, LET= 30.4 MeV
VIN=3V, VOUT3=1.5V
RL3=0.5Ω, IOUT3= 3A
VOUT4=1.2V RL4 =0.4 Ω
IOUT4= 3A

Figure A40: Voltage Output 3 (1.5V) SET run 37 Voltage Input = 3V

Board 3, LET= 30.4 MeV
VIN=3V, VOUT3=1.5V
RL3=0.5Ω, IOUT3= 3A
VOUT4=1.2V RL4 =0.4 Ω
IOUT4= 3A

Figure A41: Power Good Signal 3 SET run 37 Voltage Input = 3V

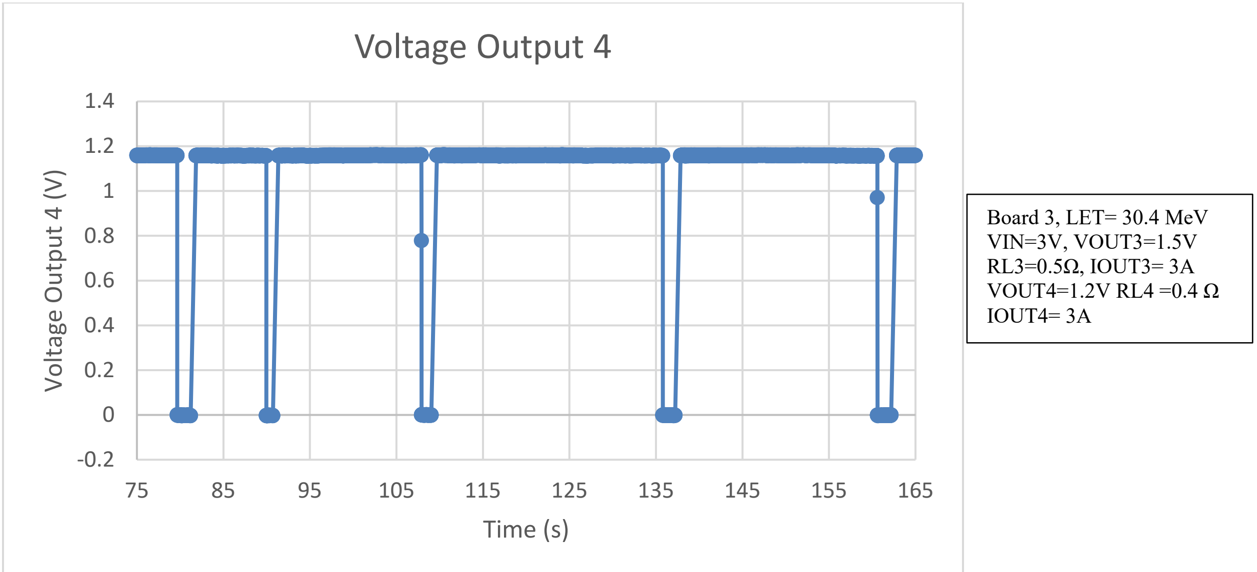


Figure A42: Voltage Output 4 (1.2V) SET run 37 Voltage Input = 3V

Figure A43: Power Good Signal 4 SET run 37 Voltage Input = 3V

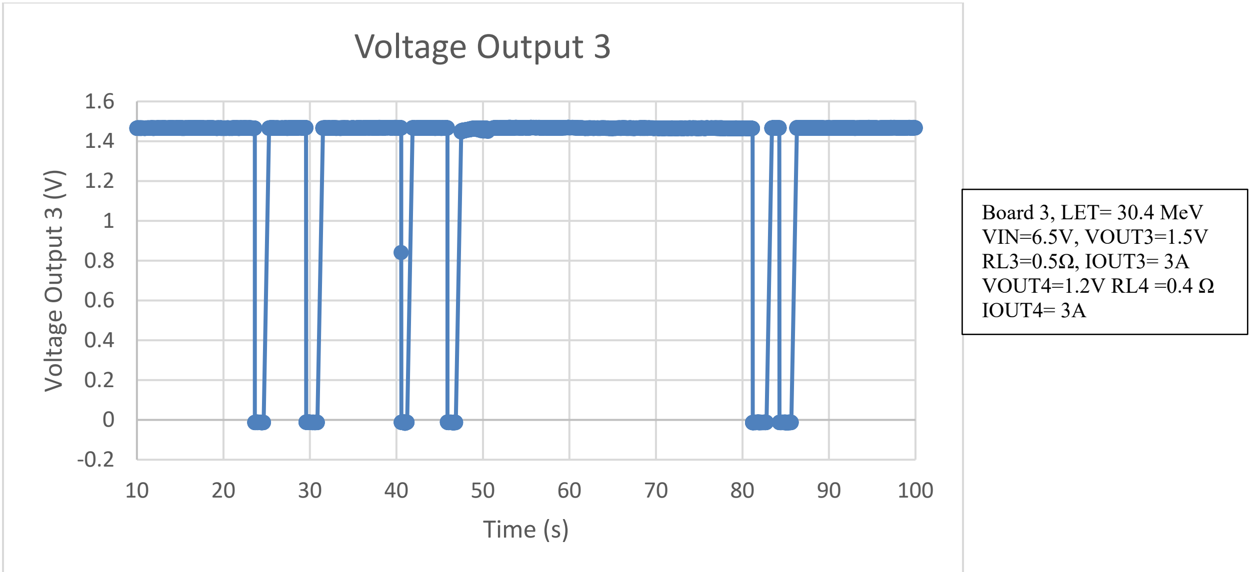


Figure A44: Voltage Output 3 (1.5V) SET run 38 Voltage Input = 6.5V

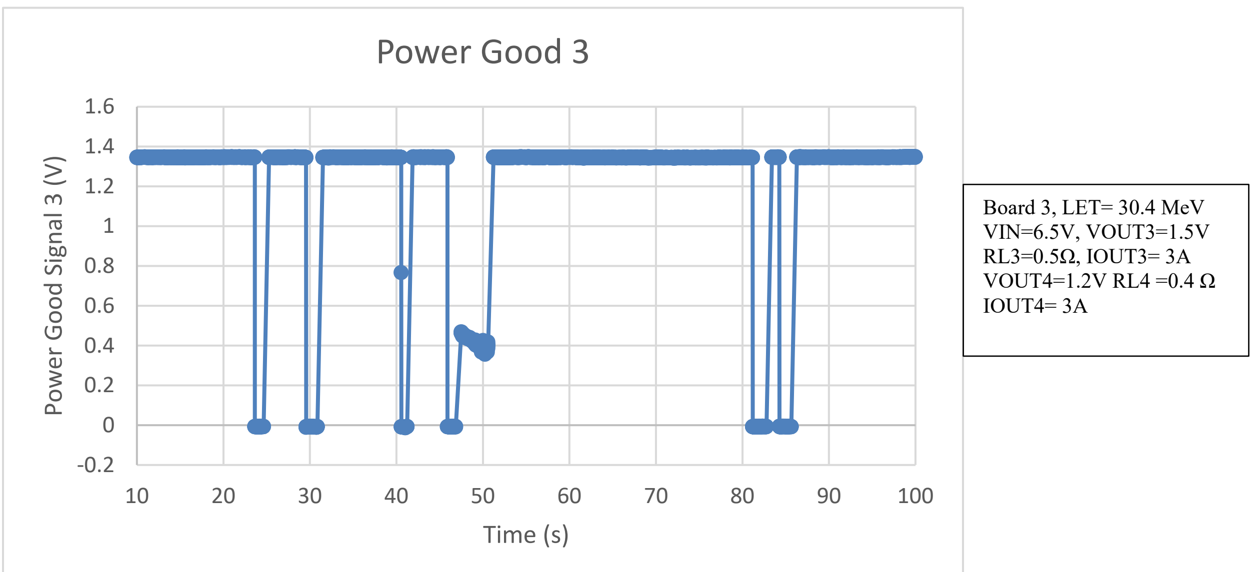


Figure A45: Power Good Signal 3 SET run 38 Voltage Input = 6.5V

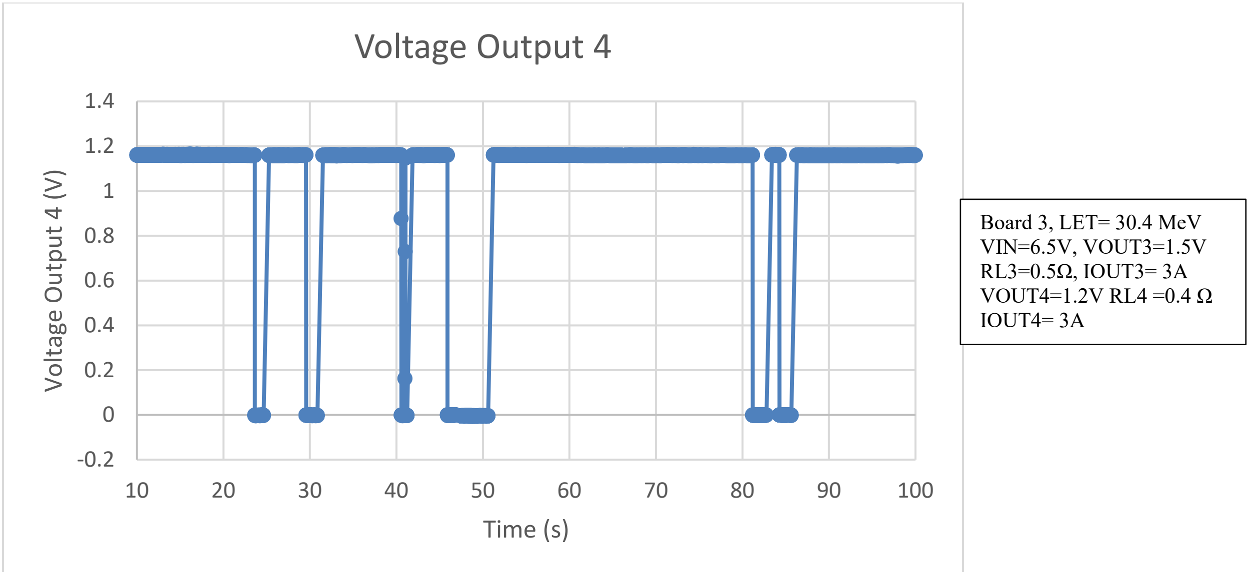


Figure A46: Voltage Output 4 (1.2V) SET run 38 Voltage Input = 6.5V

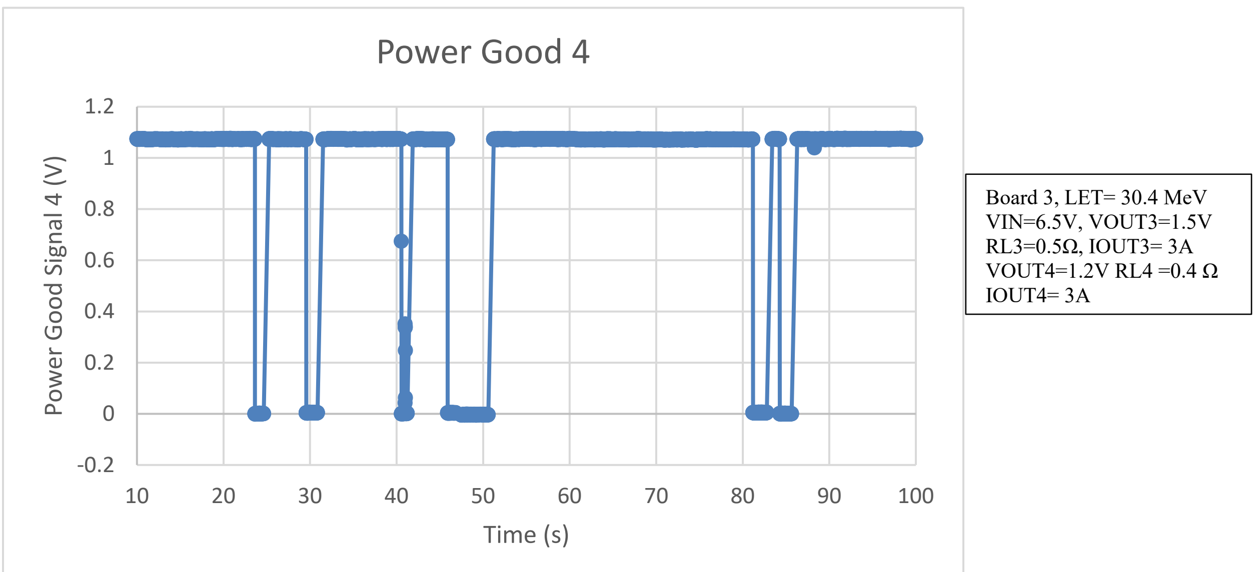
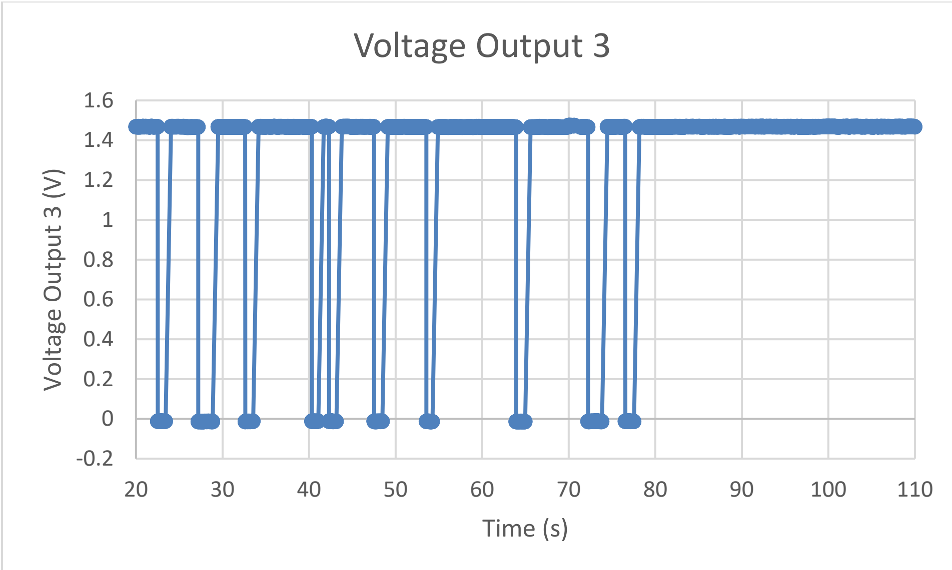
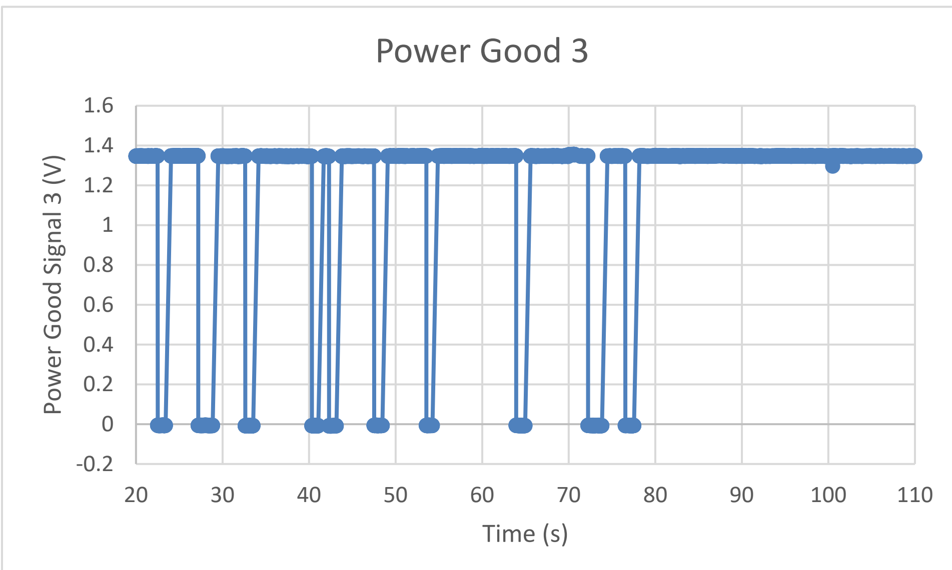


Figure A47: Power Good Signal 4 SET run 38 Voltage Input = 6.5V



Board 3, LET= 30.4 MeV
VIN=10V, VOUT3=1.5V
RL3=0.5Ω, IOUT3= 3A
VOUT4=1.2V RL4 =0.4 Ω
IOUT4= 3A

Figure A48: Voltage Output 3 (1.5V) SET run 39 Voltage Input = 10V



Board 3, LET= 30.4 MeV
VIN=10V, VOUT3=1.5V
RL3=0.5Ω, IOUT3= 3A
VOUT4=1.2V RL4 =0.4 Ω
IOUT4= 3A

Figure A49: Power Good Signal 3 SET run 39 Voltage Input = 10V

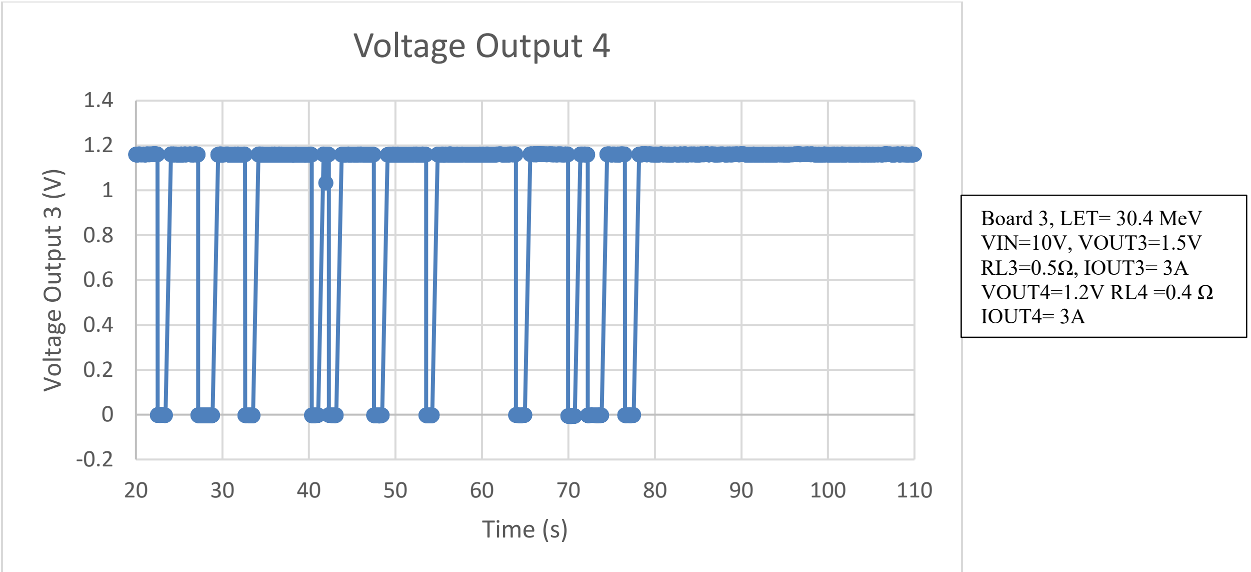


Figure A50: Voltage Output 4 (1.2V) SET run 39 Voltage Input = 10V

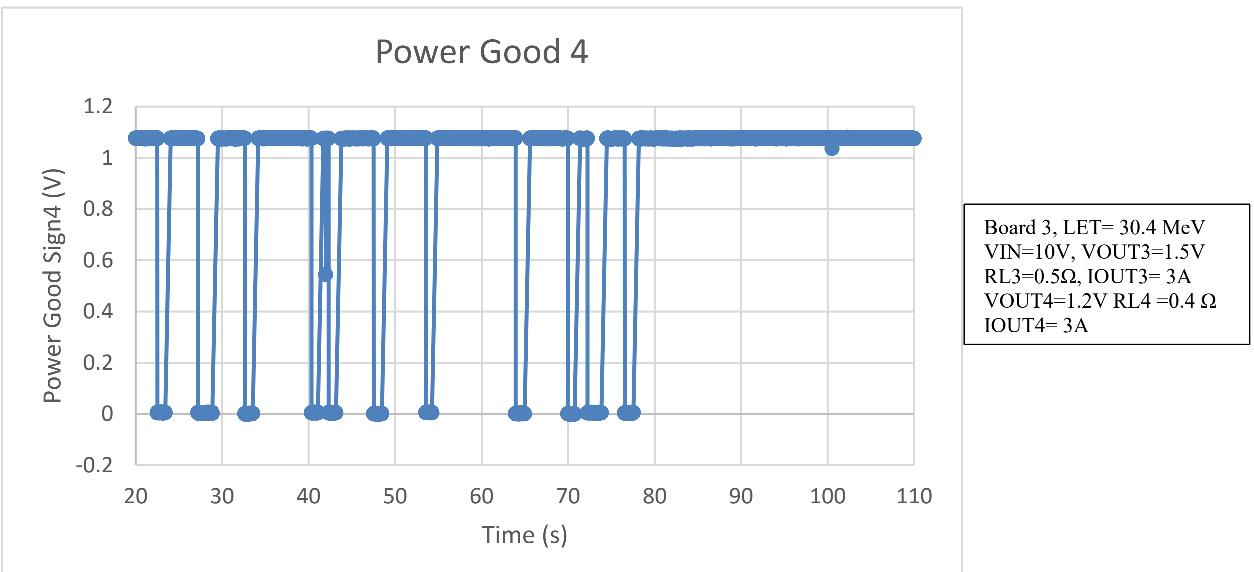


Figure A51: Power Good Signal 4 SET run 39 Voltage Input = 10V

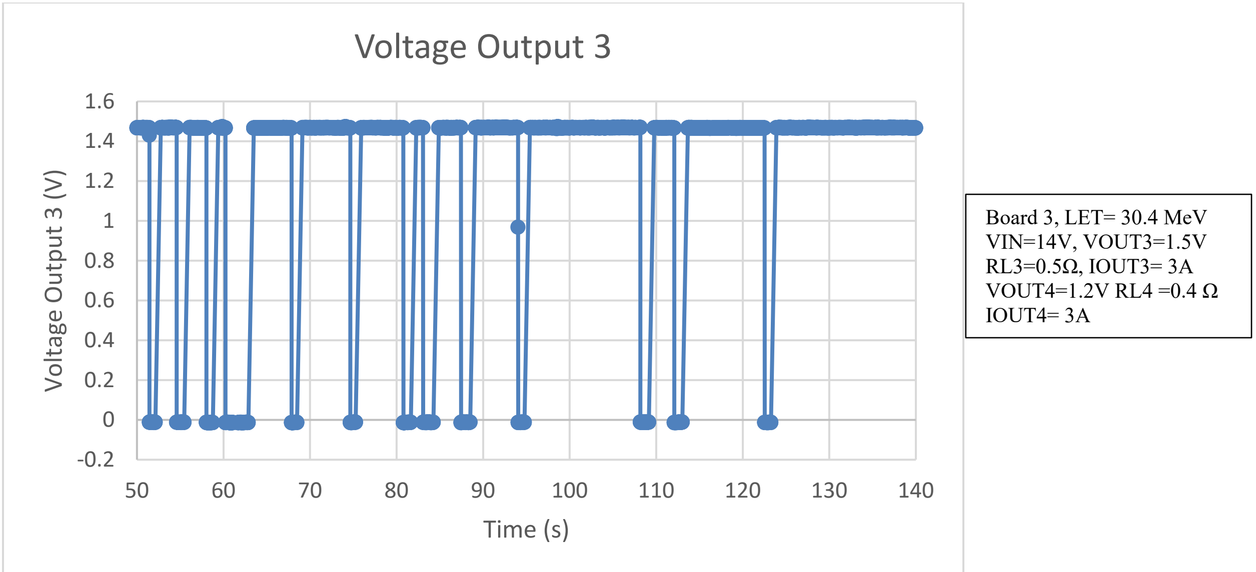
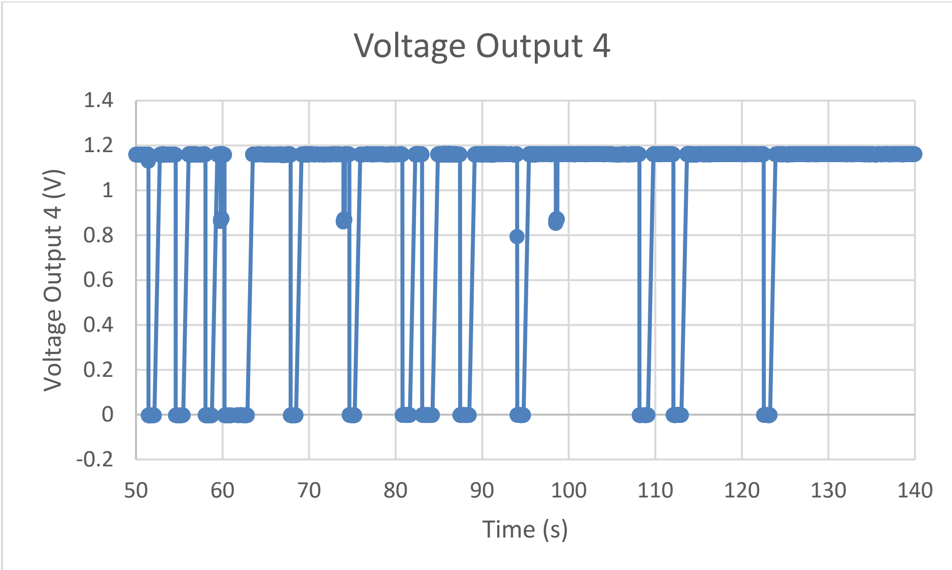


Figure A52: Voltage Output 3 (1.5V) SET run 40 Voltage Input = 14V

Figure A53: Power Good Signal 3 SET run 40 Voltage Input = 14V

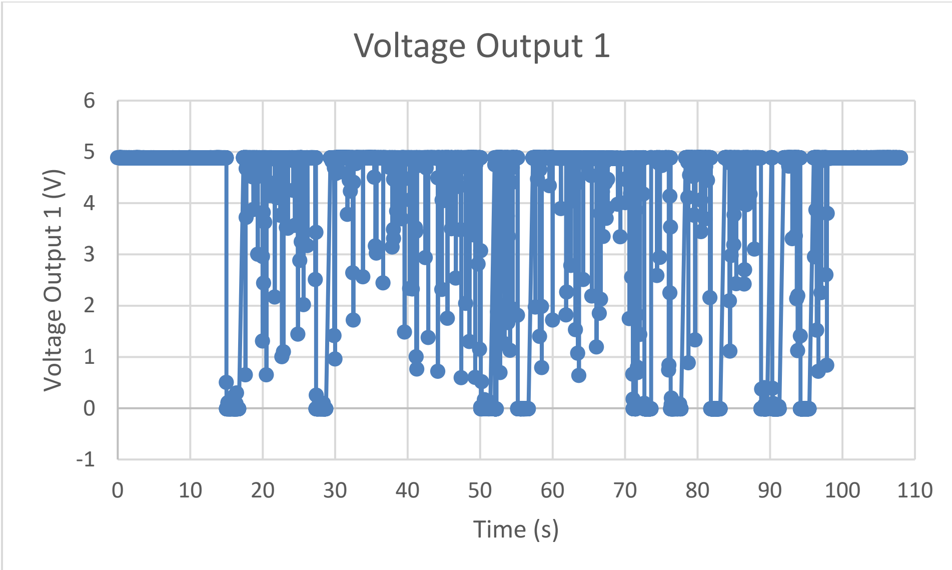


Board 3, LET= 30.4 MeV
VIN=14V, VOUT3=1.5V
RL3=0.5Ω, IOUT3= 3A
VOUT4=1.2V RL4 =0.4 Ω
IOUT4= 3A

Figure A54: Voltage Output 4 (1.2V) SET run 40 Voltage Input = 14V

Board 3, LET= 30.4 MeV
VIN=14V, VOUT3=1.5V
RL3=0.5Ω, IOUT3= 3A
VOUT4=1.2V RL4 =0.4 Ω
IOUT4= 3A

Figure A55: Power Good Signal 4 SET run 40 Voltage Input = 14V

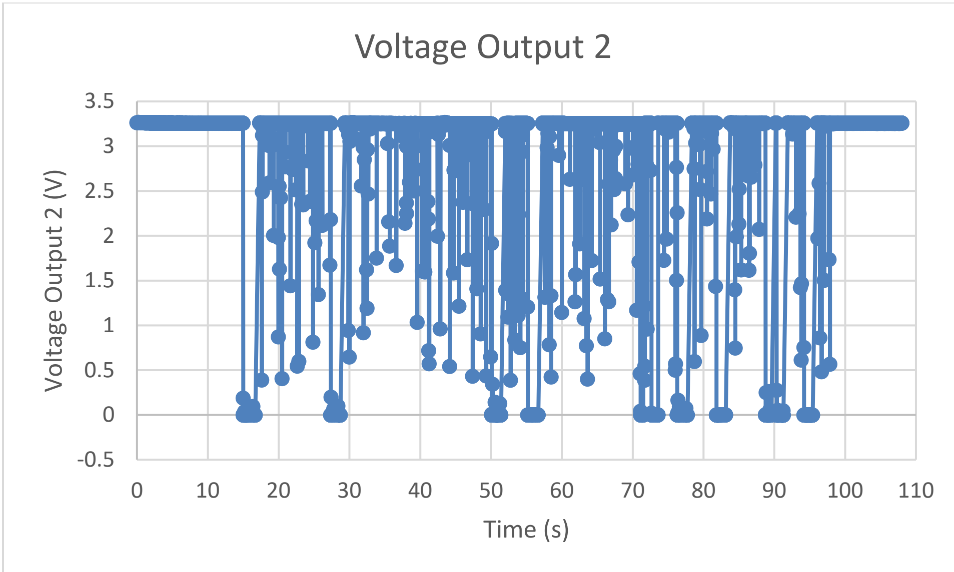


Board 3, LET= 30.4 MeV
VIN=8.5V, VOUT1=1.5V
RL1=0.5Ω, IOUT1= 3A
VOUT2=1.2V RL2 =0.4 Ω
IOUT2= 3A

Figure A56: Voltage Output 1 (5V) SET run 41 Voltage Input = 8.5V

Board 3, LET= 30.4 MeV
VIN=8.5V, VOUT1=1.5V
RL1=0.5Ω, IOUT1= 3A
VOUT2=1.2V RL2 =0.4 Ω
IOUT2= 3A

Figure A57: Power Good Signal 1 SET run 41 Voltage Input = 8.5V

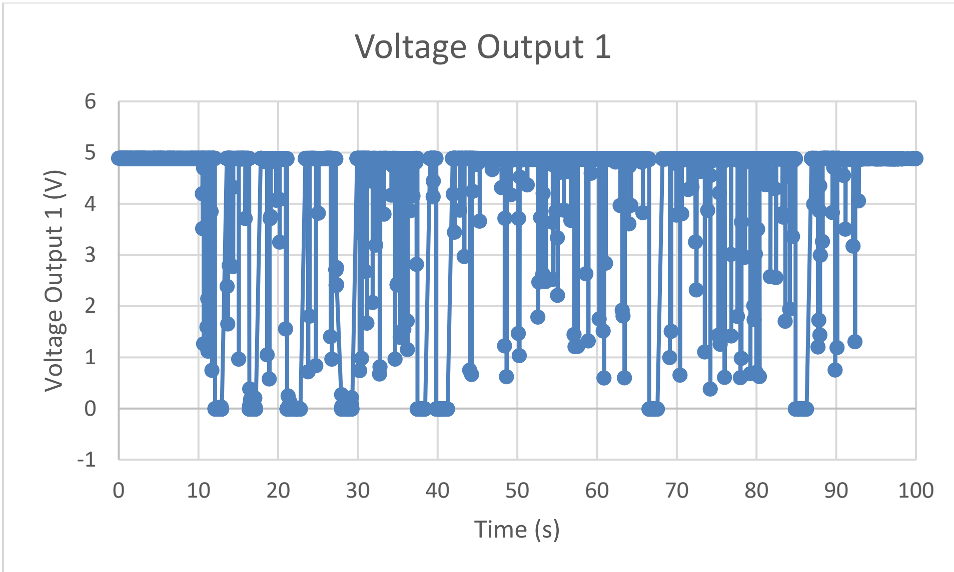


Board 3, LET= 30.4 MeV
VIN=8.5V, VOUT1=1.5V
RL1=0.5Ω, IOUT1= 3A
VOUT2=1.2V RL2 =0.4 Ω
IOUT2= 3A

Figure A58: Voltage Output 2 (3.3V) SET run 41 Voltage Input = 8.5V

Board 3, LET= 30.4 MeV
VIN=8.5V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A59: Power Good Signal 2 SET run 41 Voltage Input = 8.5V

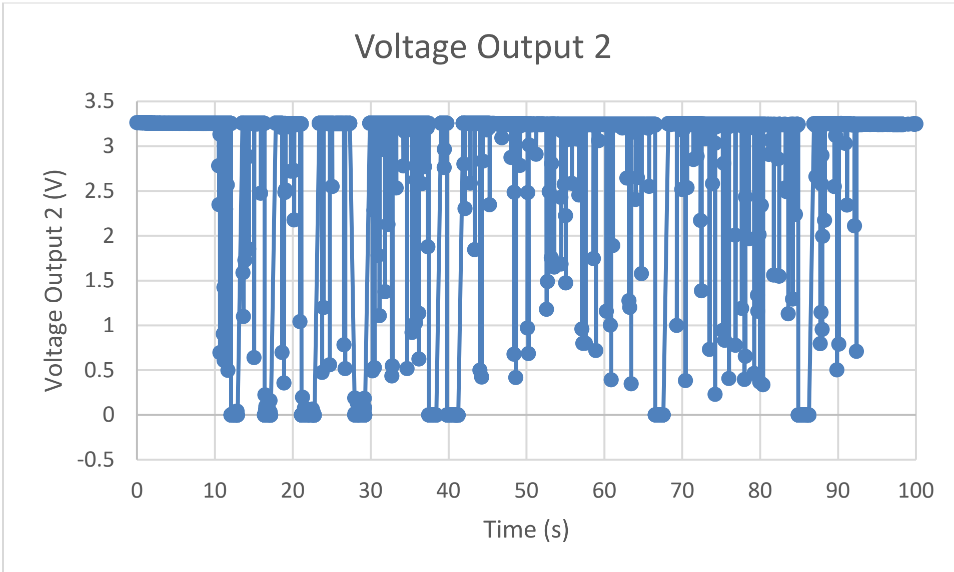


Board 3, LET= 30.4 MeV
VIN=11V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A60: Voltage Output 1 (5V) SET run 42 Voltage Input = 11V

Board 3, LET= 30.4 MeV
VIN=11V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A61: Power Good Signal 1 SET run 42 Voltage Input = 11V

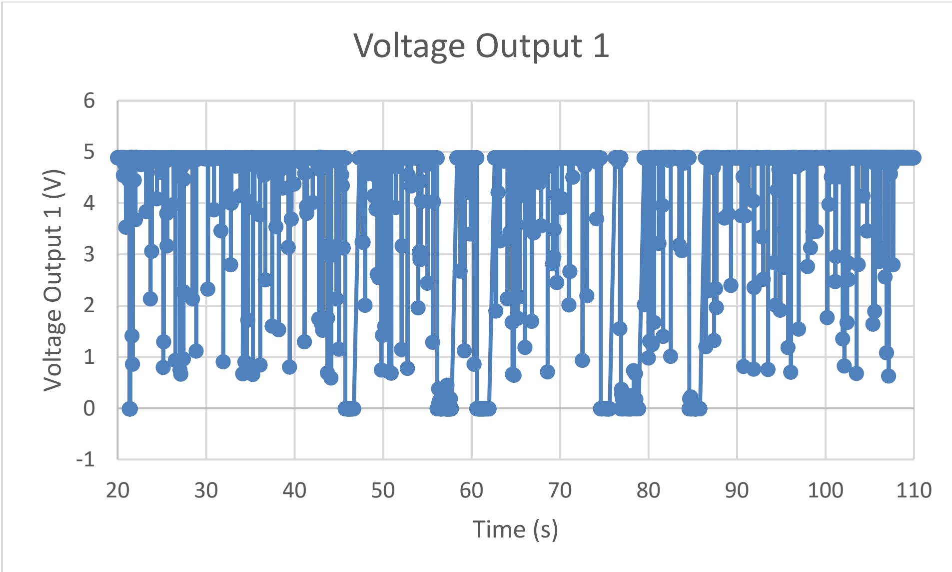


Board 3, LET= 30.4 MeV
VIN=11V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A62: Voltage Output 2 (3.3V) SET run 42 Voltage Input = 11V

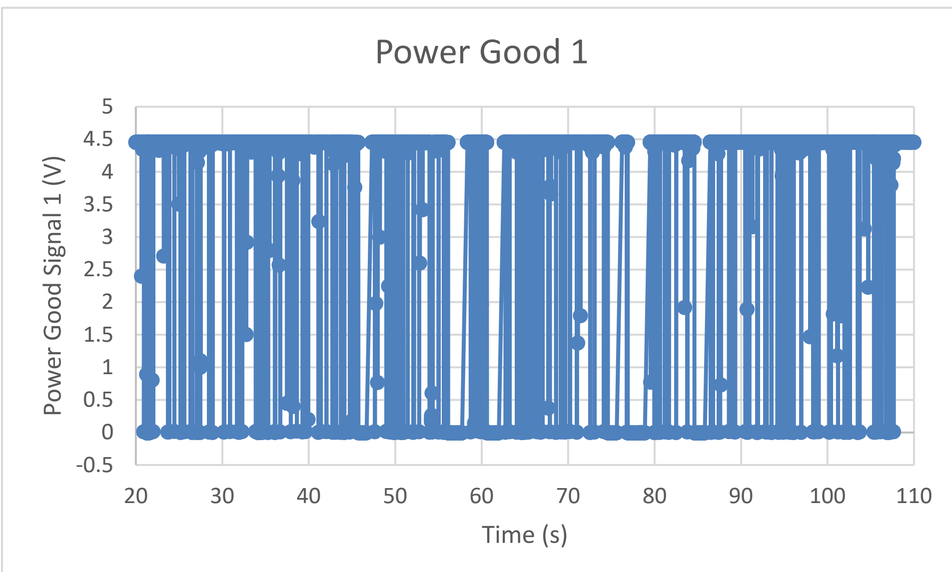
Board 3, LET= 30.4 MeV
VIN=11V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A63: Power Good Signal 2 SET run 42 Voltage Input = 11V



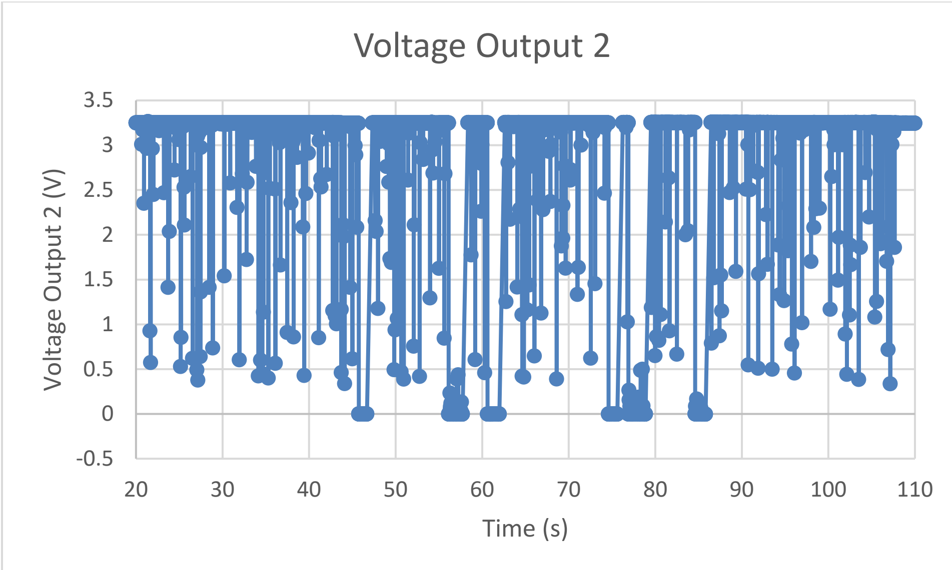
Board 3, LET= 30.4 MeV
VIN=14V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A64: Voltage Output 1 (5V) SET run 43 Voltage Input = 14V



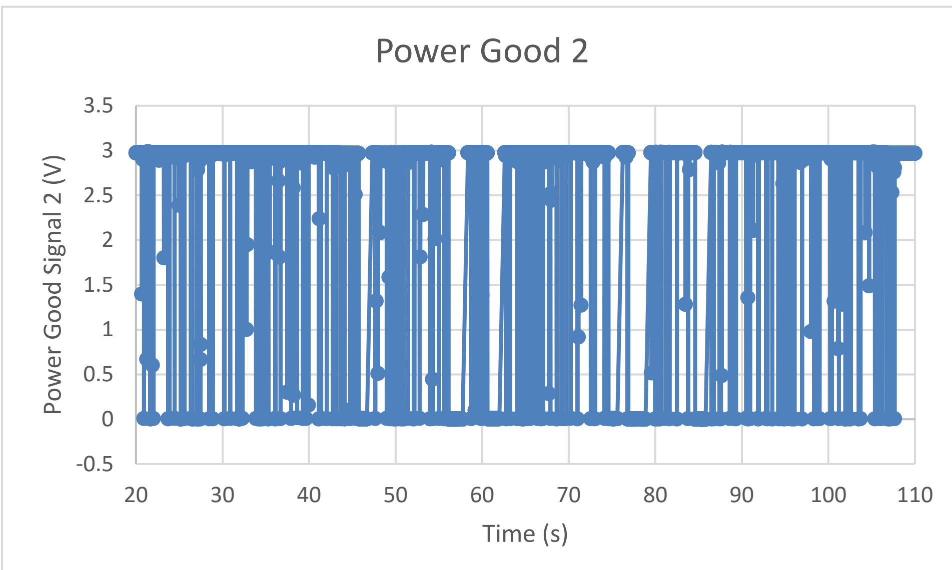
Board 3, LET= 30.4 MeV
VIN=14V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A65: Power Good Signal 1 SET run 43 Voltage Input = 14V



Board 3, LET= 30.4 MeV
VIN=14V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A66: Voltage Output 2 (3.3V) SET run 43 Voltage Input = 14V



Board 3, LET= 30.4 MeV
VIN=14V, VOUT1=5V
RL1=1.67Ω, IOUT1= 3A
VOUT2=3.3V RL2 =1.1 Ω
IOUT2= 3A

Figure A67: Power Good Signal 2 SET run 43 Voltage Input = 14V