Low Voltage Power Supply Test

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1. Overview and Test Setup:

Fig 1: The overview of the test setup

This memo is written in detail about the low voltage power supply testing and can be used as a manual for further low voltage supply testing. All of the tests were performed at Fermi National Lab in work space made available in Feynman computing center.

These power supplies are Wiener PL506 power supplies in the proposed NOvA configuration. The supply was equipped with 3 supply pods with variable voltage ranges from 2-7V, and three supply pods that ranged from 12-30V. The pods are numbered 0-5 from left to right (back view). The Wiener power supplies use 110-264VAC, 50-60Hz powers.

Other technical details of PL506 can be looked up at the following website:

http://www.wiener-d.com/products/20/100.html

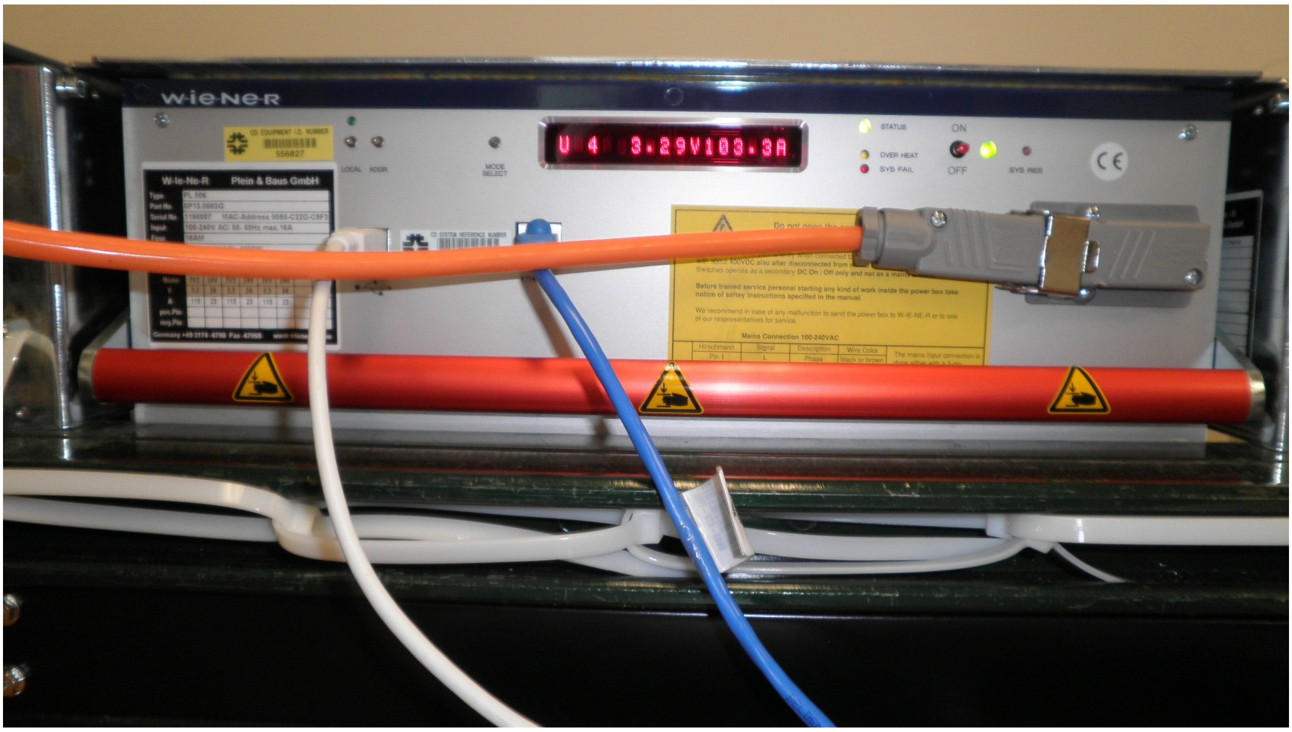

Fig 2: Front view of power supply

There are 4 ways to operate the power supplies.

1. There is a mode select switch on the left side of the LED on the front of the supply, which is used to select the channel we want to operate or monitor. One can turn on and off the specific channel directly by switching the switch on the right.
2. The supplies can also be turned on and off with a USB connection (MUSEcontrol) with a PC. This allows more complicated operations like setting the ramp speed and software trips with Muse Control, which will be mentioned later.
3. Via Ethernet connection, the power supply can also be controlled by a labVIEW or other similar program.
4. One can also control and monitor the power supply remotely (wireless), though we did not try this way during the testing. With the knowing ip address of the power supplies, which are located at surface building, we succeeded turning them on at our office in Wilson Hall.

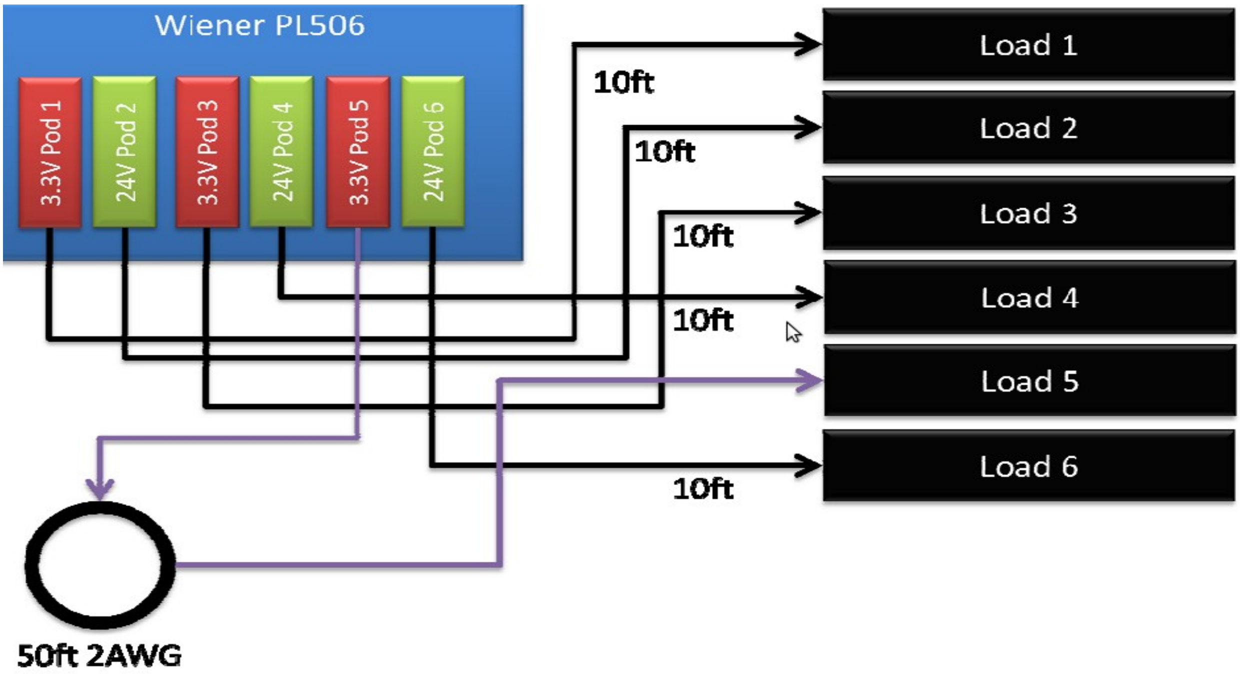

Fig 3: The topology of this configuration for the Wiener PL506 setup

The first testing area was composed of a single rack, which was populated with a Wiener PL506 power supply in the proposed NOvA configuration. The supply is equipped with 3 supply pods with variable voltage ranges from 2-7V (set to be 3.3V), and three supply pods that ranged from 12-30V (set to be 24V).

Fig 4: Side view of the rack and the fan

All of the units that supported Ethernet communications were connected to a personal computer for programming and readout during the tests.

External to the rack were a set of 8 (6 of them were used) dynamic load boxes (AC/DC Model EL750B Electronic Load) which had the ability to sink a maximum of 200A per channel, and to dynamically change the load between two set points on a fixed frequency (1kHz minimum). These load boxes were stacked in a 2x4 array (we used only 6 of them) beside the power supply, and were connected to a local power strip which was in turn connected to the building 110AC.

Fig 5: The back view of the loads array, but tow boxes were not used

Measurements of external voltage (both terminal and sense) were made using a National Instruments PXI crate/controller populated with a calibrated 2GS/s digitizer (oscilloscope), and high precision multi-meter (6 1⁄2 digit precision).

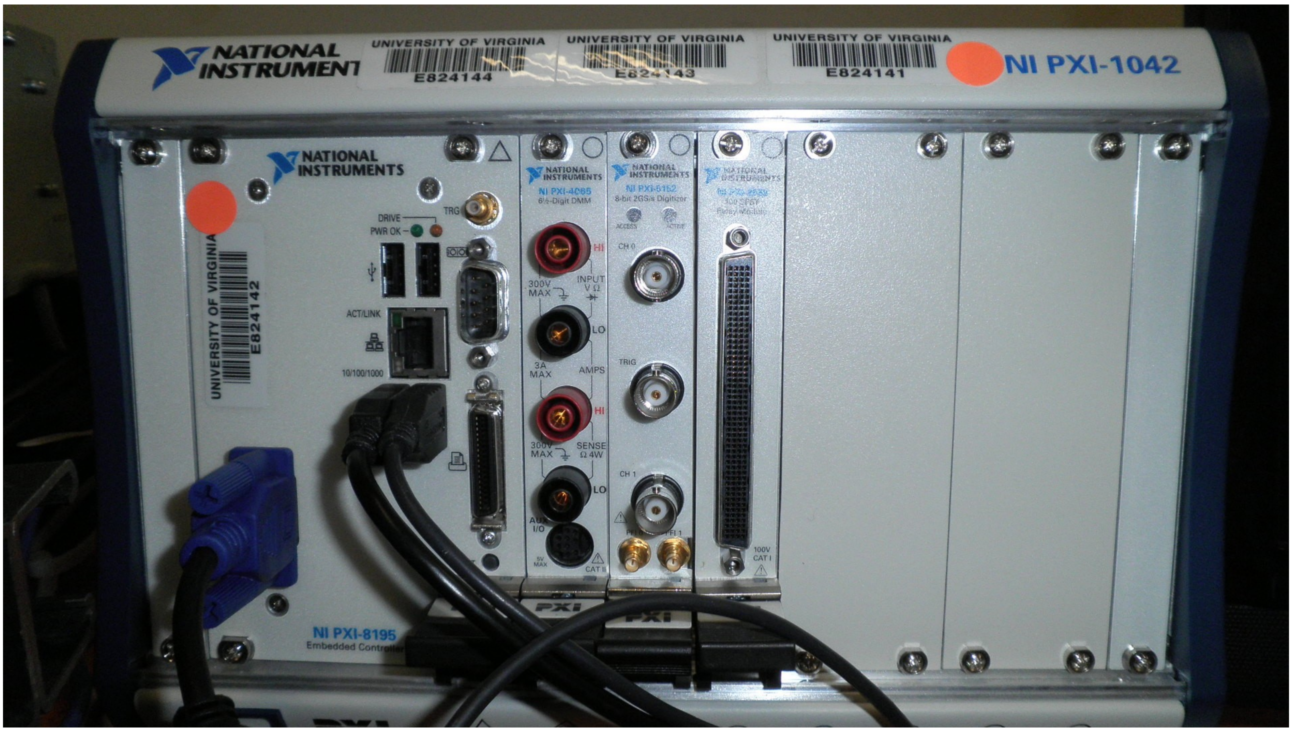

Fig 6: The front view of the PXI crate

Control of the setup was performed using a series of custom LabVIEW 8.6 programs which were able to configure and readout the devices, and through a specialty USB based interface (MUSEcontrol) that was provided by Wiener for the firmware reprogramming of their devices and direct control of the normally hidden control registers.

Six PL506 power supplies were tested, whose id numbers are 556826, 556827, 556828, 556829,556830, 556831 and one with serial number 0891075 on the following 3 aspects:

1) Voltage Set-point Accuracy. This determines the reproducibility of a given set-point, and the characteristic turn on curve for the supplies under different conditions. 525 min is needed for this part of test.

2) Remote Sense Operation Accuracy. This verifies the correct operation of the power supply's low voltage remote sense and correction circuit. For this test the supply was connected to a variable load box as described above.

3) Voltage Stability: this was a three hour test with each pod under load. Measurements were taken once per second. For this test the load level of the system each pod was chosen to be 90% of its rated capacity.

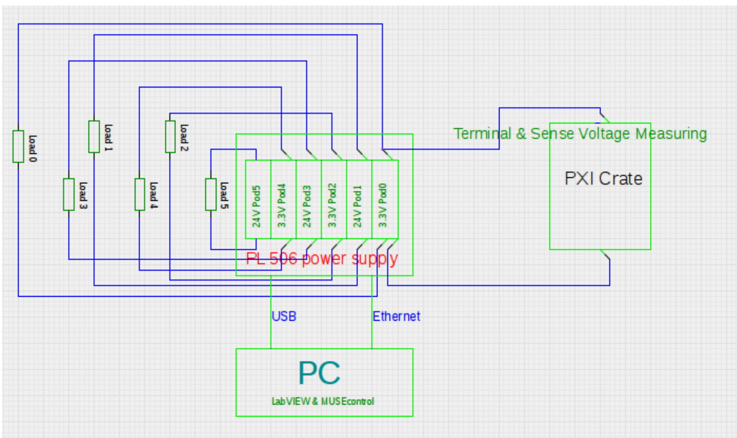

Fig 7: The sample diagram of the electrical set up

2. Voltage Set-point Accuracy

For each channel, we took over 100 trials which consisted of turning a single pod on and off, making sure it remained at its set-point value for at least 1 second. One labview program was written for this test.

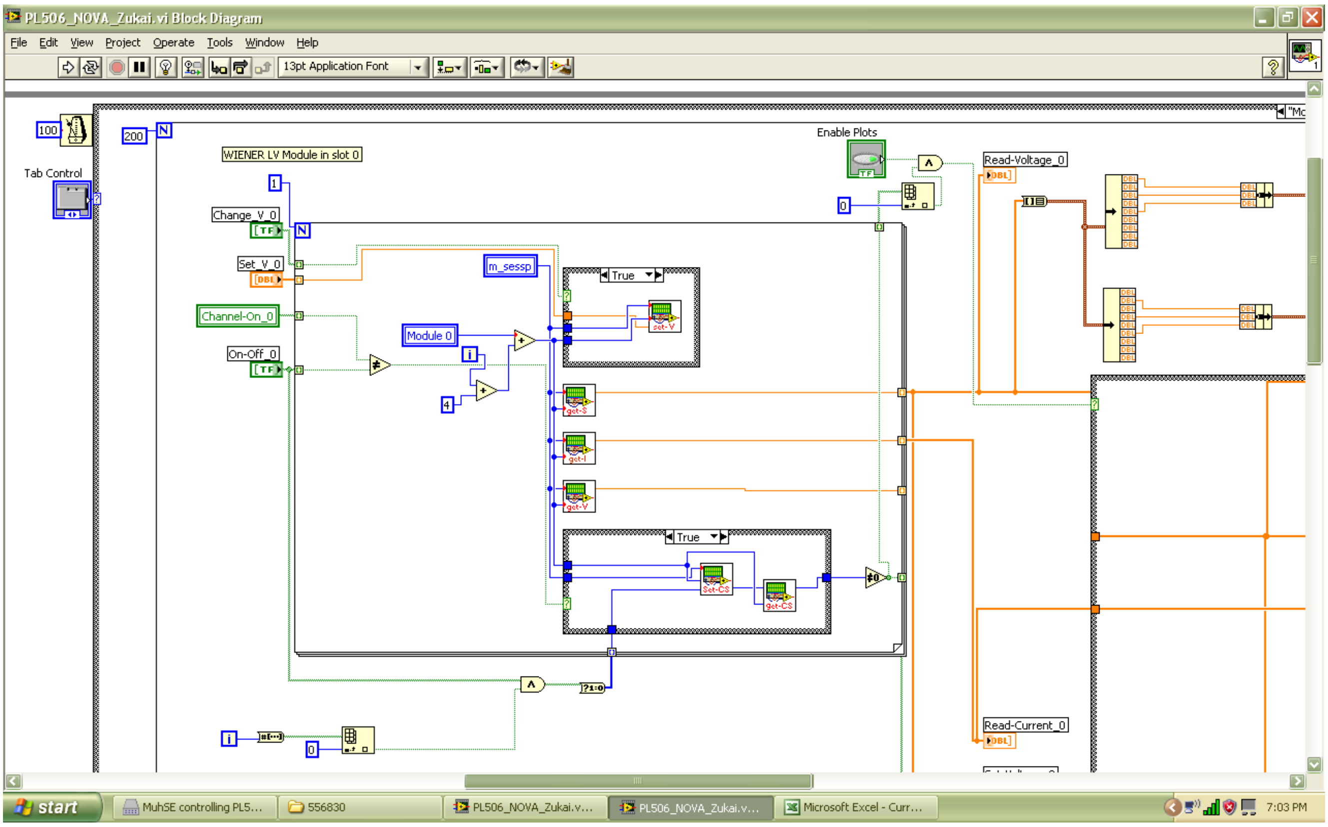

Fig 8: The on-off trigger part of the block diagram

A time delay function is applied in the on-off cycling period, 7 s is suggested and it takes 25 min for each pod to accumulate more than 100 measurements.

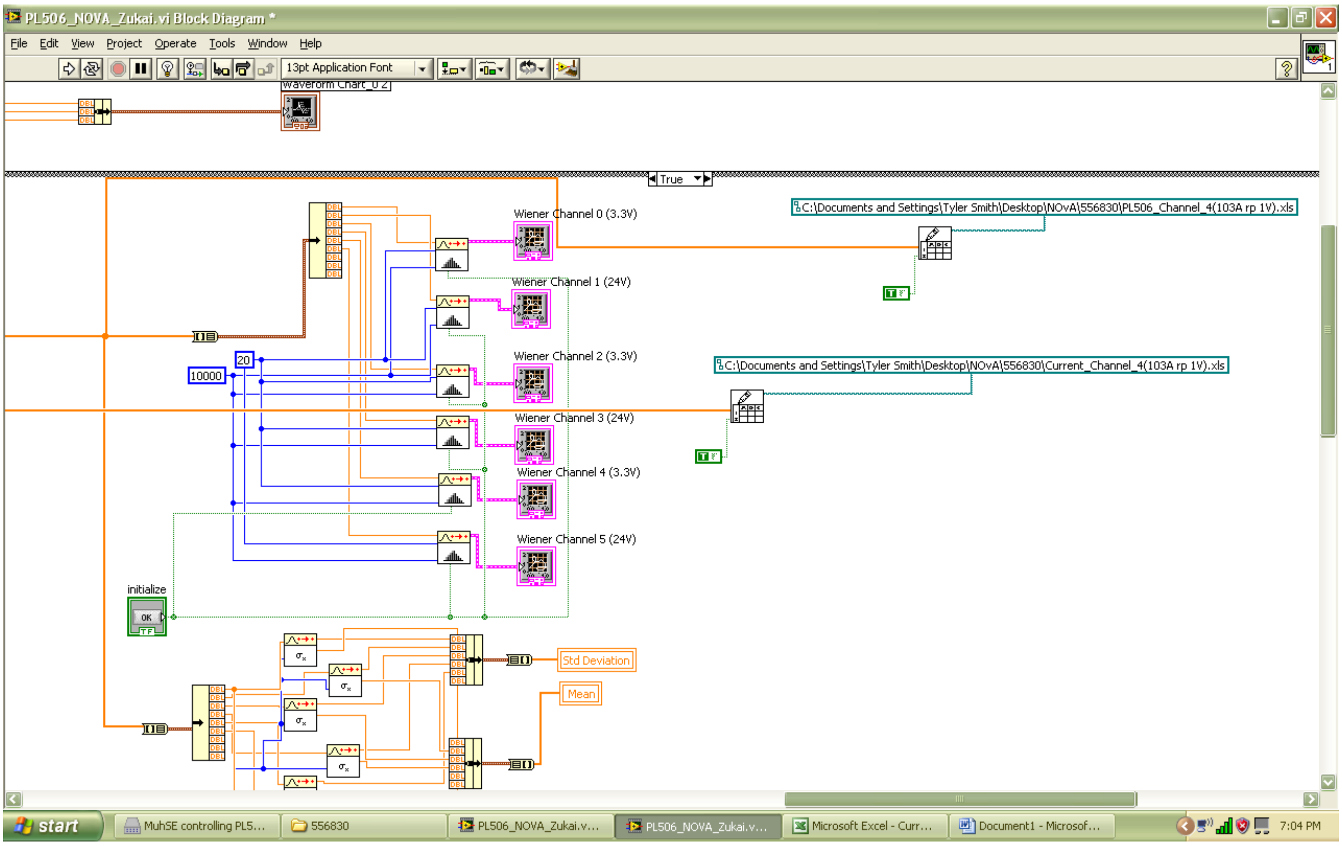

Fig 9: The data output part of the block diagram

In this part of test we must ignore the min sense voltage and max current failure in the MUSEcontrol configuration, because the instantaneous current can exceed the maximum current for a short time when it is turned on.

The ramp up speed for even number channels (3.3V pods) was set to be 1V/s with and without a load. For the odd number channels (24V pods) the ramp up speed was set to 5V/s and 10V/s without a load, and 5V/s while testing with a load.

The ramp down speed was set to 100V/s for each pod.

Testing configuration

Min Sense Voltage [V]	3.13	ignore
Max Sense Voltage [V]	5.00	Switch off
Max Terminal Voltage [V]	6.00	Switch off
Max Current [A]	115	ignore
Max Power [W]	600	Switch off
Max Temperature[C]	110	Switch off
Communication Timeout [s]	100	Switch off

Table 1: Muse Controlling PL506 settings for 3.3V pods in set-point accuracy test

Min Sense Voltage [V]	22.8	ignore
Max Sense Voltage [V]	25.20	Switch off
Max Terminal Voltage [V]	27.00	Switch off
Max Current [A]	23	ignore
Max Power [W]	550	Switch off
Max Temperature[C]	110	Switch off
Communication Timeout [s]	100	Switch off

Table 2: Muse Controlling PL506 settings for 24V pods in set-point accuracy test

When doing the set-point accuracy test with load on, adjust the desired current by rotating both dynamic and static current knobs in the front of the electric loads and select the appropriate current range.

Test result:

Note:

1. FC: fraction of trials whose deviation is larger than 1%, where the deviation is given by |Actual Value – Set-point|/Set-point
2. Nominal: 45% of rated capacity load. During the test, the current was at about 15A for 24V channels and 64A for 3.3V channels. For twice nominal, the current was set at about 21A for 24V channels and 103.5V for 3.3V channels, which is the highest current these pods withstand.

Channel No.		0	1	2	3	4	5
Set-point/V		3.3	24	3.3	24	3.3	24
without load (ramp up speed 1V/s)	FC	0.03		0.03		0.02	
	Mean (V)	3.23302		3.20114		3.23429	
	Std (V)	0.464187		0.565799		0.464370	
without load (ramp up speed 5V/s)	FC		0.04		0.03		0.01
	Mean (V)		23.28484		23.27248		23.76655
	Std (V)		4.115574		4.11		2.400662
without load (ramp up speed 10V/s)	FC		0.03		0.04		0.01
	Mean (V)		23.52456		23.03803		23.76665
	Std (V)		3.377582		4.726309		2.400672
nominal	FC	0.04	0.06	0.02	0.04	0.01	0.02
	Mean (V)	3.16704	22.80478	3.20102	23.03821	3.26799	23.52725
	Std (V)	0.649726	5.258132	0.565777	4.726346	0.3301	3.377968
2*nominal	FC	0.02	0.02	0.04	0.04	0.01	0.02
	Mean (V)	3.23302	23.52501	3.16853	23.03852	3.20197	23.52766
	Std (V)	0.464187	3.377646	0.650032	4.726410	0.565945	3.378027

Table 3: Voltage Set-point Accuracy test for 556826

Channel No.		0	1	2	3	4	5
Set-point/V		3.3	24	3.3	24	3.3	24
Without load (ramp up speed 1V/s)	FC	0.00		0.00		0.01	
	Mean (V)	3.26601		3.30023		3.26656	
	Std (V)	0.32990		0.00066		0.32996	
Without load (ramp up speed 5V/s)	FC		0.08		0.00		0.00
	Mean (V)		22.07755		23.76024		24.00775
	Std (V)		6.54311		2.40002		0.00056
Without load (ramp up speed 10V/s)	FC		0.02		0.01		0.00
	Mean (V)		23.51694		23.76066		24.00799
	Std (V)		3.37649		2.40007		0.00054
nominal	FC	0.05	0.00	0.00	0.04	0.01	0.01
	Mean (V)	3.13405	23.99809	3.30066	23.04162	3.26700	23.76815
	Std (V)	0.72262	0.00067	0.00048	4.72705	0.33000	2.40082
2*nominal	FC	0.07	0.00	0.05	0.03	0.00	0.01
	Mean (V)	3.06808	23.99848	3.13595	23.28171	3.30100	23.76779
	Std (V)	0.84597	0.00050	0.72306	4.11502	0.00000	2.40079

Table 4: Voltage Set-point Accuracy test for 556827

Channel No.		0	1	2	3	4	5
Set-point/V		3.3	24	3.3	24	3.3	24
without load (ramp up speed 1V/s)	FC	0.04		0.00		0.01	
	Mean (V)	3.16826		3.29816		3.26757	
	Std (V)	0.64998		0.00304		0.33006	
without load (ramp up speed 5V/s)	FC		0.03		0.02		0.00
	Mean (V)		23.28296		23.52956		23.99935
	Std (V)		4.11524		3.37830		0.00048
without load (ramp up speed 10V/s)	FC		0.02		0.03		0.00
	Mean (V)		23.76332		23.28949		23.99941
	Std (V)		2.40034		4.11640		0.00049
nominal	FC	0.03	0.02	0.01	0.02	0.02	0.03
	Mean (V)	3.20092	23.52435	3.26700	23.52282	3.23484	23.28638
	Std (V)	0.56576	3.37755	0.33000	3.37733	0.46445	4.11585
2*nominal	FC	0.06	0.03	0.01	0.00	0.02	0.03
	Mean (V)	3.11835	23.28468	3.23400	24.00287	3.23498	23.28644
	Std (V)	0.73802	4.11555	0.46433	0.00034	0.46447	4.11586

Table 5: Voltage Set-point Accuracy test for 556828

Channel No.		0	1	2	3	4	5
Set-point/V		3.3	24	3.3	24	3.3	24
without load (ramp up speed 1V/s)	FC	0.02		0.00		0.00	
	Mean (V)	3.23421		3.29920		3.30006	
	Std (V)	0.46436		0.00068		0.00076	
without load (ramp up speed 5V/s)	FC		0.03		0.03		0.01
	Mean (V)		23.28378		23.28858		23.76785
	Std (V)		4.11539		4.11624		2.40079
without load (ramp up speed 10V/s)	FC		0.02		0.01		0.00
	Mean (V)		23.52440		23.76884		24.00800
	Std (V)		3.37756		2.40089		0.00000
nominal	FC	0.05	0.01	0.01	0.01	0.01	0.02
	Mean (V)	3.13534	23.76409	3.26601	23.76409	3.26786	23.52793
	Std (V)	0.72292	2.40041	0.32990	2.40041	0.33009	3.37807
2*nominal	FC	0.01	0.03	0.01	0.04	0.00	0.00
	Mean (V)	3.26799	23.28421	3.26605	23.28421	3.30100	24.00871
	Std (V)	0.33010	4.11546	0.32990	4.11546	0.00000	0.00046

Table 6: Voltage Set-point Accuracy test for 556829

Channel No.		0	1	2	3	4	5
Set-point/V		3.3	24	3.3	24	3.3	24
without load (ramp up speed 1V/s)	FC	0.03		0.00		0.01	
	Mean (V)	3.20005		3.29933		3.26656	
	Std (V)	0.56561		0.00062		0.32996	
without load (ramp up speed 5V/s)	FC		0.02		0.00		0.01
	Mean (V)		23.52448		24.00386		23.75930
	Std (V)		3.37757		0.00035		2.39993
without load (ramp up speed 10V/s)	FC		0.01		0.06		0.01
	Mean (V)		23.76396		22.56374		23.75928
	Std (V)		2.40040		5.72935		2.39993
nominal	FC	0.02	0.03	0.05	0.03	0.02	0.01
	Mean (V)	3.23323	23.28475	3.13462	23.28391	3.23400	23.76049
	Std (V)	0.46422	4.11556	0.72275	4.11541	0.46433	2.40005
2*nominal	FC	0.03	0.02	0.01	0.05	0.03	0.03
	Mean (V)	3.20090	23.76485	3.26684	22.80388	3.20100	23.28115
	Std (V)	0.56576	2.40049	0.32998	5.25792	0.56577	4.11492

Table 7: Voltage Set-point Accuracy test for 556830

Channel No.		0	1	2	3	4	5
Set-point/V		3.3	24	3.3	24	3.3	24
without load (ramp up speed 1V/s)	FC	0.04		0.00		0.01	
	Mean (V)	3.16826		3.29816		3.26757	
	Std (V)	0.64998		0.00304		0.33006	
without load (ramp up speed 5V/s)	FC		0.03		0.02		0.00
	Mean (V)		23.28296		23.52956		23.99935
	Std (V)		4.11524		3.37830		0.00048
without load (ramp up speed 10V/s)	FC		0.02000		0.03000		0.00000
	Mean (V)		23.76332		23.28949		23.99941
	Std (V)		2.40034		4.11640		0.00049
nominal	FC	0.00	0.01	0.03	0.04	0.04	0.01
	Mean (V)	3.30066	23.76392	3.19956	23.04961	3.16896	23.75925
	Std (V)	0.00048	2.40040	0.56552	4.72868	0.65012	2.39992
2*nominal	FC	0.00	0.03	0.05	0.03	0.02	0.01
	Mean (V)	3.30062	23.28388	3.13405	23.28980	3.23499	23.75924
	Std (V)	0.00049	4.11540	0.72262	4.11645	0.46447	2.39992

Table 8: Voltage Set-point Accuracy test for 556831

Channel No.		0	1	2	3	4	5
Set-point/V		3.3	24	3.3	24	3.3	24
Without load (ramp up speed 1V/s)	FC	0.02		0.03		0.02	
	Mean (V)	3.24476		3.22052		3.26422	
	Std (V)	0.46587		0.56922		0.46867	
Without load (ramp up speed 5V/s)	FC		0.03		0.02		0.02
	Mean (V)		23.28397		23.52690		23.52367
	Std (V)		4.11542		3.37793		3.37746
Without load (ramp up speed 10V/s)	FC		0.02		0.01		0.00
	Mean (V)		23.52495		23.28702		23.52402
	Std (V)		3.37764		4.11598		3.37752
nominal	FC	0.01	0.02	0.00	0.04	0.02	0.00
	Mean (V)	3.27789	23.52482	3.32093	23.04631	3.26438	24.00554
	Std (V)	0.33110	3.37762	0.00026	4.72801	0.46869	0.00050
2*nominal	FC	0.05	0.03	0.02	0.02	0.03	0.01
	Mean (V)	3.14545	23.28504	3.25458	23.52678	3.23159	23.76557
	Std (V)	0.72525	4.11561	0.46728	3.37790	0.57118	2.40056

Table 9: Voltage Set-point Accuracy test for 0891075

All of the trials which failed to set voltage accurately enough simply failed to ramp up at all (0V). For most trials, the deviation is less than 0.1%. We think it was the LabVIEW program that did not properly record some trials, because we never saw the lower supply fail to ramp up during the test. All the raw data for each trial (including the current value for loads on measurement) has been recorded for further analysis.

The data we took without these failure reading due to labVIEW program is given below, which indicates a really good precision of the set point of the power supplies.

Channel No.		0	1	2	3	4	5
Set-point/V		3.3	24	3.3	24	3.3	24
Without load (ramp up speed 1V/s)	Mean (V)	3.29900		3.30007		3.30032	
	Std (V)	0.00000		0.00069		0.00063	
Without load (ramp up speed 5V/s)	Mean (V)		24.00498		23.99790		24.00663
	Std (V)		0.00013		0.00040		0.00049
Without load (ramp up speed 10V/s)	Mean (V)		24.00466		23.99795		24.00672
	Std (V)		0.00048		0.00072		0.00045
nominal	Mean (V)	3.29900	24.00503	3.30003	23.99814	3.30100	24.00554
	Std (V)	0.00000	0.00018	0.00018	0.00040	0.00000	0.00050
2*nominal	Mean (V)	3.29900	24.00514	3.30051	23.99846	3.30100	24.00781
	Std (V)	0.00000	0.00035	0.00050	0.00050	0.00000	0.00040

Refined data for 556826

Channel No.		0	1	2	3	4	5
Set-point/V		3.3	24	3.3	24	3.3	24
Without load (ramp up speed 1V/s)	Mean (V)	3.299		3.30022		3.29953	
	Std (V)	0		0.00065		0.00050	
Without load (ramp up speed 5V/s)	Mean (V)		23.99736		24.00027		24.00769
	Std (V)		0.00048		0.00048		0.00056
Without load (ramp up speed 10V/s)	Mean (V)		23.99691		24.00058		24.00797
	Std (V)		0.00043		0.00050		0.00053
nominal	Mean (V)	3.29900	23.99817	3.30073	24.00169	3.30000	24.00819
	Std (V)	0.00000	0.00072	0.00045	0.00047	0.00000	0.00043
2*nominal	Mean (V)	3.29902	23.99853	3.30100	24.00183	3.30100	24.00784
	Std (V)	0.00012	0.00050	0.00000	0.00046	0.00000	0.00041

Refined data for 556827

Channel No.		0	1	2	3	4	5
Set-point/V		3.3	24	3.3	24	3.3	24
Without load (ramp up speed 1V/s)	Mean (V)	3.3002835821		3.29803		3.30064	
	Std (V)	0.0004541382		0.00367		0.00071	
Without load (ramp up speed 5V/s)	Mean (V)		24.00303		24.00979		23.99939
	Std (V)		0.00017		0.00041		0.00049
Without load (ramp up speed 10V/s)	Mean (V)		24.00340		24.00978		23.99939
	Std (V)		0.00049		0.00042		0.00049
nominal	Mean (V)	3.29990	24.00443	3.30000	24.00287	3.30087	24.00657
	Std (V)	0.00031	0.00050	0.00000	0.00034	0.00034	0.00050
2*nominal	Mean (V)	3.27515	24.00485	3.30000	24.00288	3.30100	24.00664
	Std (V)	0.20341	0.00036	0.00000	0.00033	0.00000	0.00048

Refined data for 556828

Note: When doing twice nominal for channel 0, one trial recorded 1.625V, causing the relatively larger standard deviation. That was also the only failure ramp up event due to the power supply we observed during the test.

Channel No.		0	1	2	3	4	5
Set-point/V		3.3	24	3.3	24	3.3	24
Without load (ramp up speed 1V/s)	Mean (V)	3.3002266667		3.29923		3.30003	
	Std (V)	0.0004214946		0.00067		0.00075	
Without load (ramp up speed 5V/s)	Mean (V)		24.00395		24.00885		24.00792
	Std (V)		0.00049		0.00039		0.00027
Without load (ramp up speed 10V/s)	Mean (V)		24.00452		24.00892		24.00800
	Std (V)		0.00050		0.00036		0.00000
nominal	Mean (V)	3.30036	24.00415	3.29900	24.00415	3.30087	24.00808
	Std (V)	0.00048	0.00065	0.00000	0.00065	0.00034	0.00027
2*nominal	Mean (V)	3.30100	24.00435	3.29905	24.00435	3.30100	24.00873
	Std (V)	0.00000	0.00058	0.00023	0.00058	0.00000	0.00045

Refined data for 556829

Channel No.		0	1	2	3	4	5
Set-point/V		3.3	24	3.3	24	3.3	24
Without load (ramp up speed 1V/s)	Mean (V)	3.299		3.29932		3.29955	
	Std (V)	0		0.00060		0.00050	
Without load (ramp up speed 5V/s)	Mean (V)		24.00462		24.00387		23.99932
	Std (V)		0.00049		0.00034		0.00047
Without load (ramp up speed 10V/s)	Mean (V)		24.00400		24.00398		23.99922
	Std (V)		0.00000		0.00013		0.00042
nominal	Mean (V)	3.29922	24.00493	3.29952	24.00405	3.30000	24.00048
	Std (V)	0.00042	0.00025	0.00050	0.00022	0.00000	0.00050
2*nominal	Mean (V)	3.29992	24.00490	3.29983	24.00407	3.30000	24.00117
	Std (V)	0.00028	0.00030	0.00038	0.00025	0.00000	0.00038

Refined data for 556830

Channel No.		0	1	2	3	4	5
Set-point/V		3.3	24	3.3	24	3.3	24
Without load (ramp up speed 1V/s)	Mean (V)	3.3002205882		3.29797		3.25213	
	Std (V)	0.0004177262		0.00365		0.40027	
Without load (ramp up speed 5V/s)	Mean (V)		24.00303		24.00976		23.99932
	Std (V)		0.00017		0.00043		0.00047
Without load (ramp up speed 10V/s)	Mean (V)		24.00338		24.00975		23.99943
	Std (V)		0.00049		0.00044		0.00050
nominal	Mean (V)	3.30065	24.00396	3.29859	24.01001	3.30100	23.99929
	Std (V)	0.00048	0.00021	0.00050	0.00012	0.00000	0.00046
2*nominal	Mean (V)	3.30065	24.00400	3.29900	23.65700	3.30101	23.99926
	Std (V)	0.00048	0.00000	0.00000	2.91165	0.00012	0.00044

Refined data for 556831

Channel No.		0	1	2	3	4	5
Set-point/V		3.3	24	3.3	24	3.3	24
Without load (ramp up speed 1V/s)	Mean (V)	3.311		3.26656		3.33079	
	Std (V)	0		0.42166		0.00060	
Without load (ramp up speed 5V/s)	Mean (V)		24.00376		24.00700		24.00365
	Std (V)		0.00369		0.00804		0.00714
Without load (ramp up speed 10V/s)	Mean (V)		24.00526		24.00747		24.00384
	Std (V)		0.00497		0.01334		0.00942
nominal	Mean (V)	3.31100	24.00495	3.32092	24.00663	3.33100	24.00556
	Std (V)	0.00000	0.00064	0.00027	0.00049	0.00000	0.00050
2*nominal	Mean (V)	3.31100	24.00524	3.32100	24.00689	3.33150	24.00561
	Std (V)	0.00000	0.00064	0.00000	0.00032	0.00050	0.00049

Refined data for 0891075

Voltage Stability

The long term stability of the supplies was measured under maximal load condition. This process was also operated by a labVIEW 8.6 program.

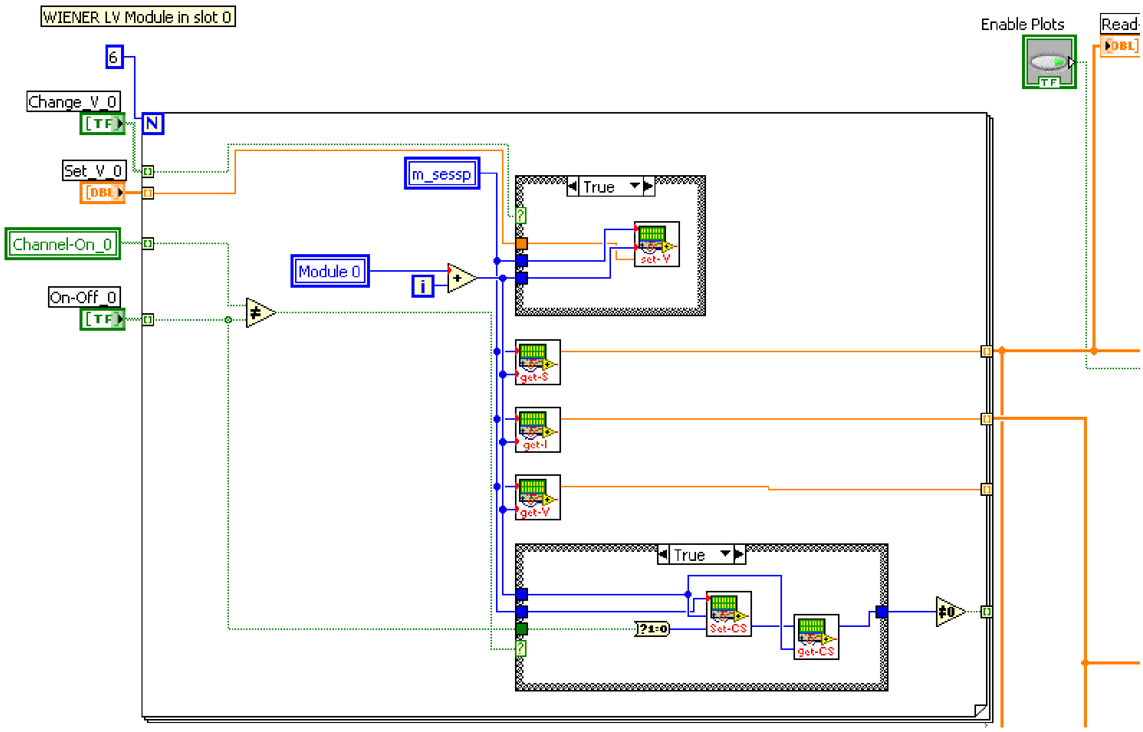

Fig 10: Block diagram for voltage stability test

Each channel is ramped up to the appropriate set-point voltage and kept running for three hours. This process was done with a load of approximately 90% of the rated capacity. The MUSEcontrol settings are as follows:

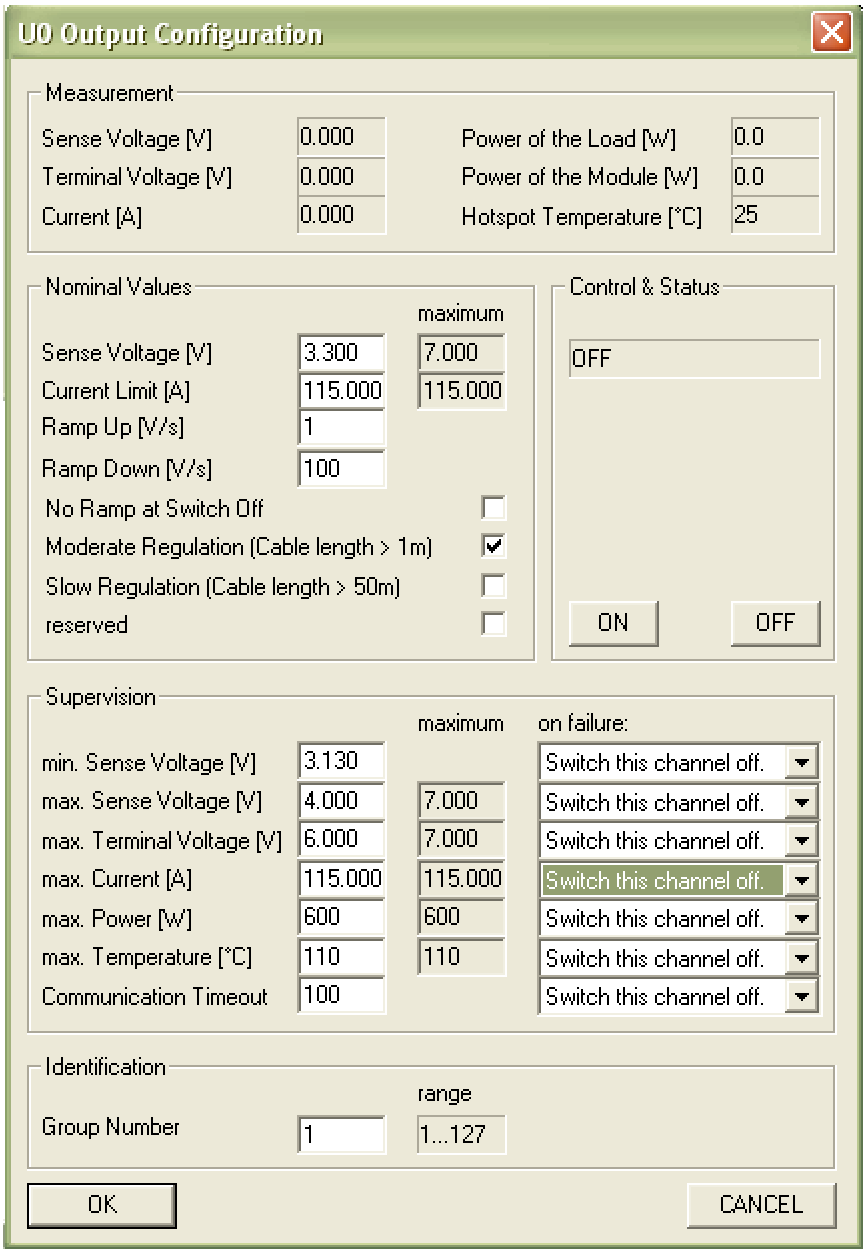

Fig 11: Settings for 3.3V channels for voltage stability test (MUSEcontrol interface)

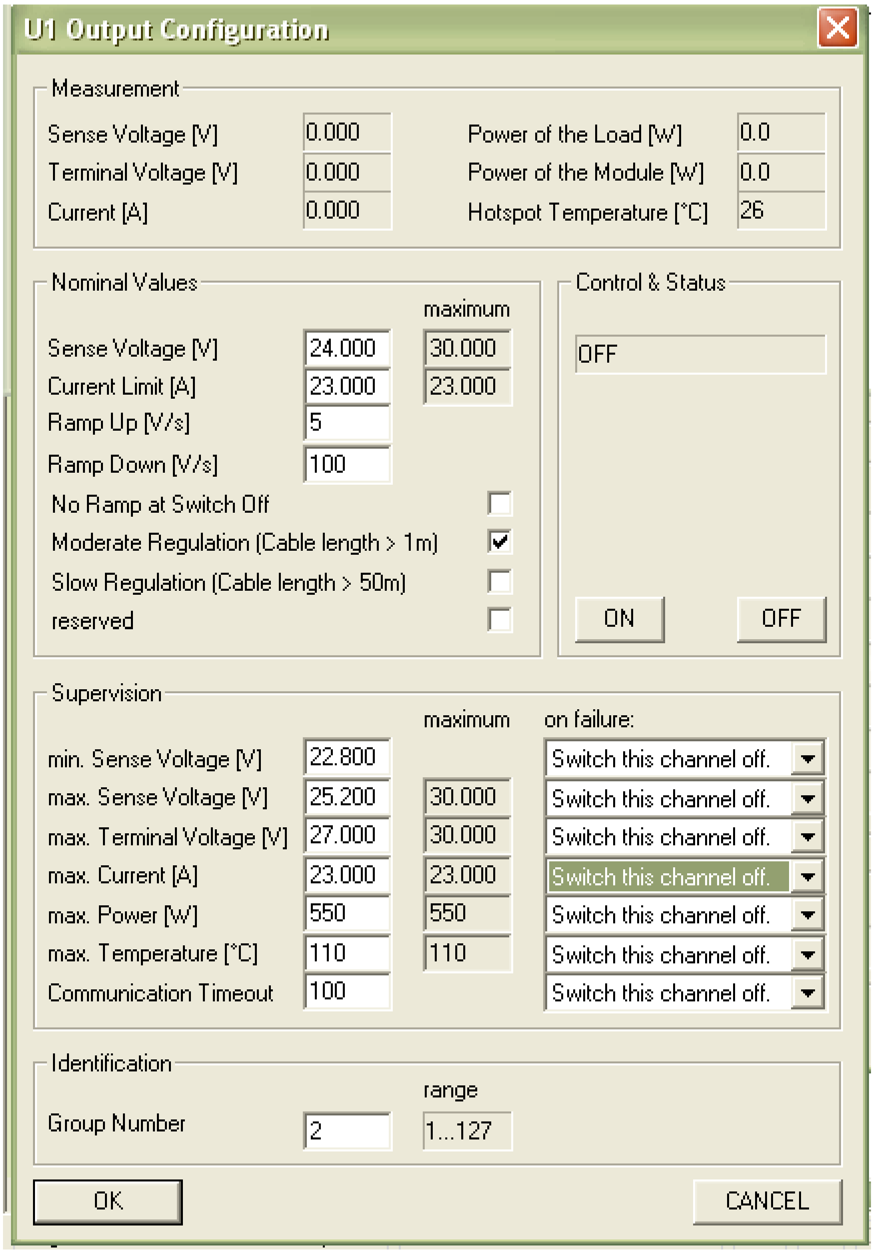

Fig 12: Settings for 24V channels for voltage stability test

To perform the tests, the units were connected to their respective load boxes in the fashion described above (Fig 2). Each channel was ramped to the desired set point with loads. Channels were verified to come to the set point value, and then measured using the LabVIEW test setup at one second intervals. The results were displayed on strip charts and histograms, and running averages and deviations were measured.

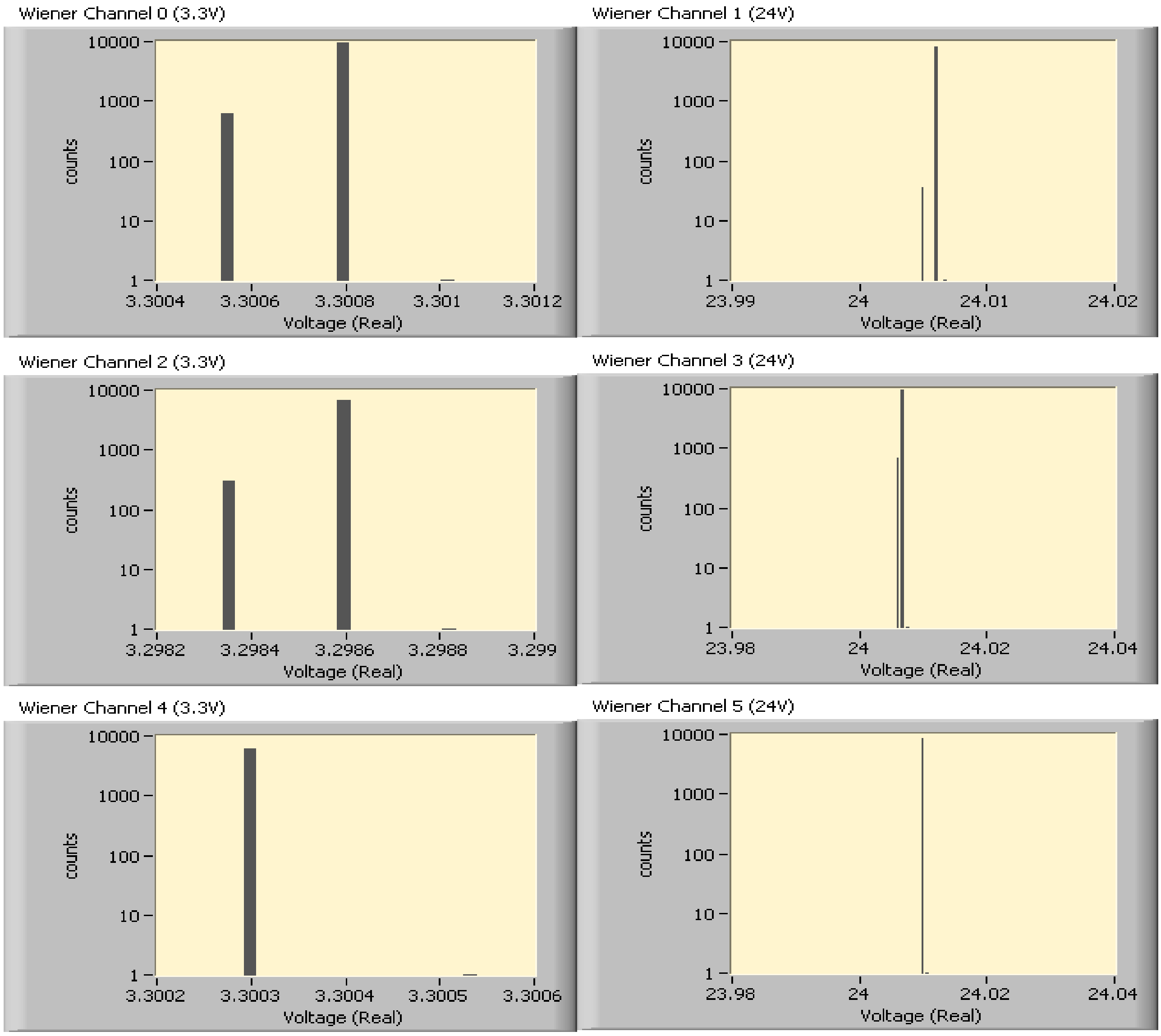

Fig 13: Histogram of the voltage stability test for all pods of 556829

Here we illustrate the histogram for the test result of the supply whose id is 556829, the results for the other supplies are similar and all the data has been kept in separate spreadsheets for different supplies.

The plots in Fig 11 were taken during the stability test of the supplies. While the statistical variation is consistent with the previous measurements, the actual structure of the variation shows a long term instability in the base level at which the pods operate. This was captured by triggering on a discrete transition which is shown in the figure below.

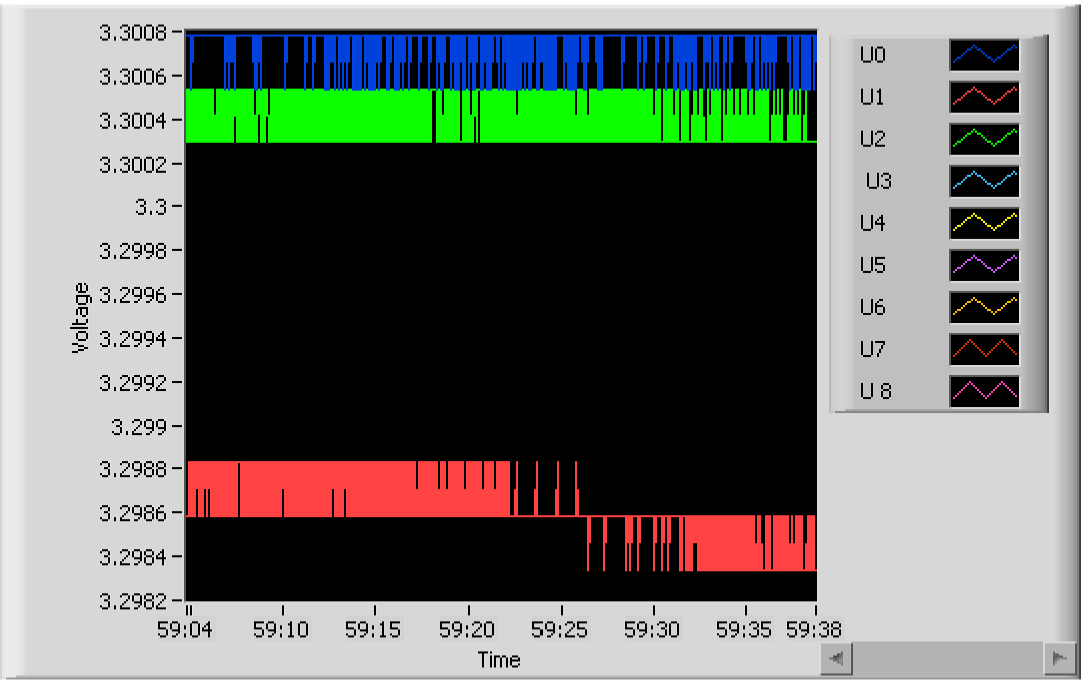

Figure 14: Strip chart of testing 3.3V channels for 556829

The blue trace corresponds to the first 3.3V pod(channel 0), the red one corresponds to the second 3.3V pod(channel 2), and the green one corresponds to the second 3.3V pod (channel 4). The normal ripple that is present on a channel is evident from the traces for channel 1 (red) and channel 5 (green) corresponding to roughly 2mV peak to peak.

Mean voltage and Standard deviation

Channel	0	1	2	3	4	5
Mean(V)	3.2990	24.0053	3.3001	24.0012	3.3010	24.0067
Std(V)	0.0001	0.0005	0.0002	0.0008	0.0001	0.0005
Load(A)	103.4	20.8	104.1	20.9	104.0	20.8

Table 9: Mean voltage and Std of voltage stability test for 556826

Channel	0	1	2	3	4	5
Mean(V)	3.2992	24.0015	3.3000	24.0056	3.3000	19.4581
Std(V)	0.0004	0.0010	0.0001	0.0011	0.0000	6.8141
Load(A)	104.0	21.6	103.5	22.1	103.3	21.7

Table 10: Mean voltage and Std of voltage stability test for 556827 (Data for Channel 5 is not valid)

A special incident happened to channel 5 of supply 556827: the load current drifted up. After 20 min, the increment of current reached 0.24A and the power of this channel exceeded its maximum power limit 550 W. So it turned off by the software protection. For further testing, we should avoid keeping loads on for more than 5 hours (we did set point accuracy test with loads on previously), and the current should be set no more than 21A for 24V channels during this test.

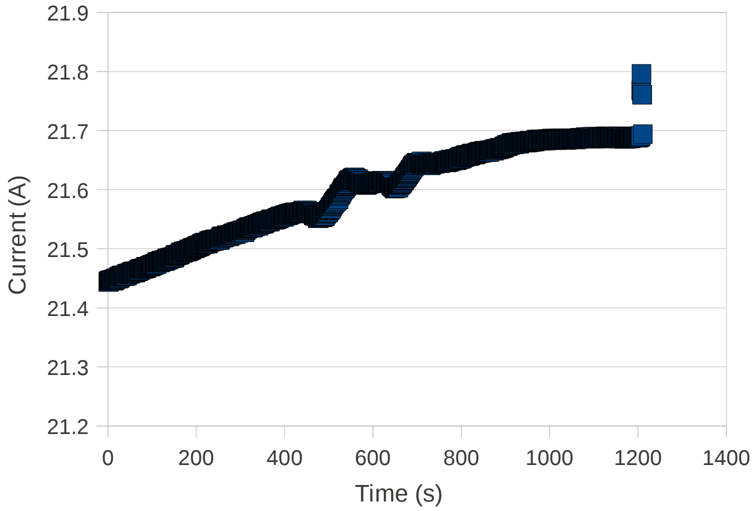

Fig 15: The excursion of current for channel 5 in the first 20 min

However, the excursion of the current may not be a problem of the load. As the temperature goes up, the resistance of the wire tends to go up too and draw more voltage over the wire, which requires larger terminal voltage to supply the required sense voltage (24V). This assumption is reasonable because we did observe a drop of sense voltage during that 20min.

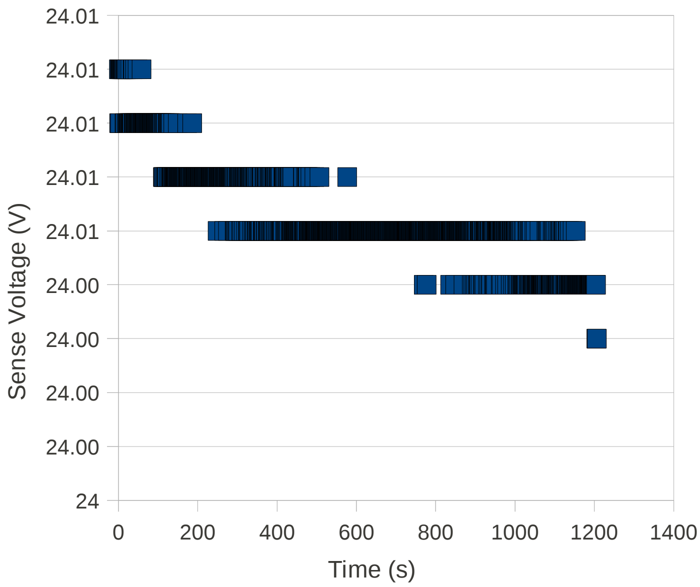

Fig 16: Sense Voltage drop for channel 5 in the first 20 min

However we did not observe this drop for other pods. In normal situation, the resistor of the load should have a more significant changing due to rising temperature, which should make the current drop a little bit.

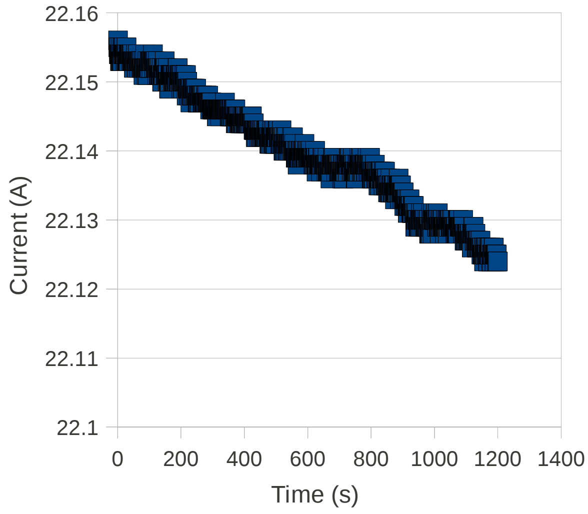

Fig 17: The excursion of current for channel 3 in the first 20 min (normal excursion)

Channel	0	1	2	3	4	5
Mean(V)	3.3000	24.0062	3.2998	24.0016	3.3002	24.0024
Std(V)	0.0000	0.0004	0.0004	0.0005	0.0004	0.0008
Load(A)	103.5	20.6	104.0	20.7	103.7	20.8

Table 11: Mean voltage and Std of voltage stability test for 556828

Channel	0	1	2	3	4	5
Mean(V)	3.3010	24.0062	3.2989	24.0069	3.3003	24.0102
Std(V)	0.0000	0.0006	0.0003	0.0005	0.0005	0.0004
Load(A)	103.7	20.9	104.0	20.9	103.9	20.9

Table 12: Mean voltage and Std of voltage stability test for 556829

Channel	0	1	2	3	4	5
Mean(V)	3.2980	23.9991	3.2989	24.0037	3.3000	24.0185
Std(V)	0.0001	0.0006	0.0001	0.0005	0.0000	0.0017
Load(A)	104.4	21.1	103.9	20.9	103.9	21.3

Table 13: Mean voltage and Std of voltage stability test for 556830

Channel	0	1	2	3	4	5
Mean(V)	3.3000	24.0042	3.2990	24.0091	3.3000	23.9952
Std(V)	0.0002	0.0004	0.0001	0.0003	0.0002	0.0007
Load(A)	103.9	21.0	103.8	21.0	103.7	21.3

Table 14: Mean voltage and Std of voltage stability test for 556831

Channel	0	1	2	3	4	5
Mean(V)	3.3110	24.0081	3.3204	24.0077	3.3310	24.0099
Std(V)	0.0000	0.0005	0.0005	0.0005	0.0000	0.0005
Load(A)	103.8	20.9	103.2	20.9	104.0	21.0

Table 15: Mean voltage and Std of voltage stability test for 0891075

These results are based on over 10,000 measurements taken by LabVIEW during a three hour period for each power supply.

After a three hour period testing the power supplies were relatively hot though we kept the fan on during the test. The increasing temperature seems to have little effects on the stability of output voltage. Further tests will be done on the effects of increased temperature on the power supplies.

Remote Sense Accuracy

For the remote sense accuracy test procedure we set the configuration to be the same as the voltage stability test.

The settings for the electric load should be as follows. Mode: I. Dynamic Loading: DC. Current Range: 100A.

Fig 19: The load settings

We used the NI PXI-4065 DMM to measure the external sense voltage and external terminal voltage in the following way. DMM probes were applied to the terminal of the power supply and electric load boxes to measure the external terminal voltage and external sense voltage respectively as shown in Fig. 15 and Fig. 16.

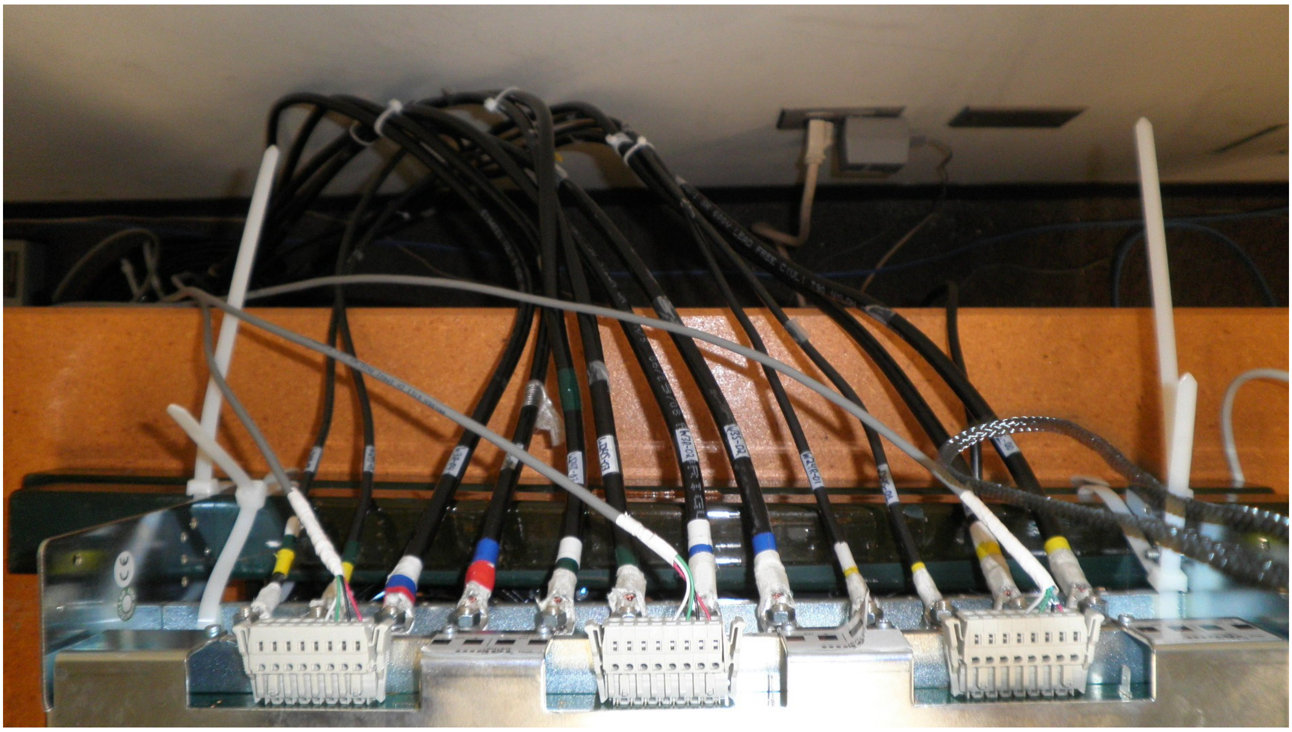

Fig 20:Wiring of the power supply

Fig 21: Back view of loads wiring

We recorded the current, internal sense voltage, and internal terminal voltage using MUSEcontrol. The current was increased in the following way; the 3.3V pods were increased from 0A to 60A in 10A increments, the 24V pods were increased from 0A to 22A (or as high as it will go without tripping) in 5A increments. At each of these values all of the voltages were recorded.

Test Result of Sense Accuracy

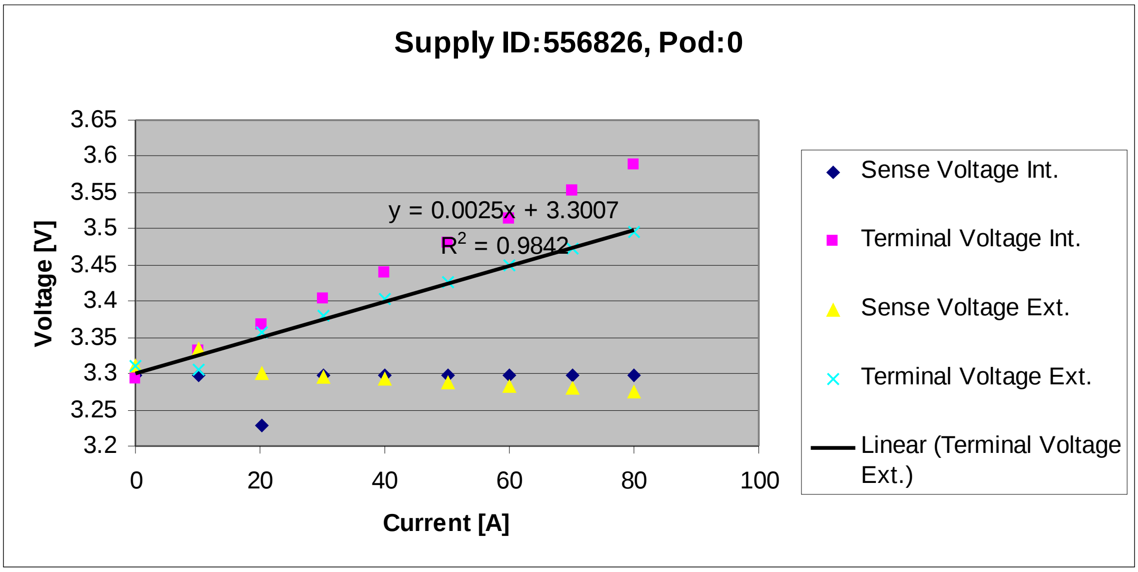

Chart 1: Supply linearity under remote sense operations for 3.3V pods

The linear response of terminal voltage was used to determine the resistance (the slope of terminal voltage) of the lines leading to the load boxes. This effect is shown in the above plot.

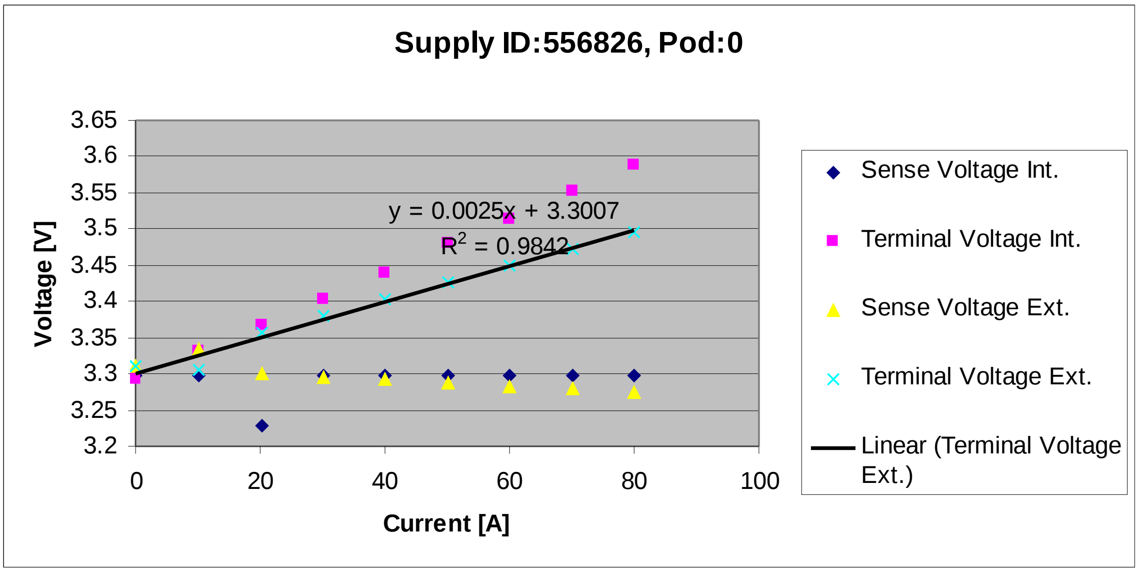

Chart 2: Supply linearity under remote sense operations for 24V pods

The data for other plots are also recorded and will be put into document database.

The power supply whose serial number is 0891075 was acting weird in this test. Those 24V pods were suffering a terrible noise without a load current but were quit stable when the loads were on. And channel 1 seemed to reporting a fake internal sense voltage all the time.

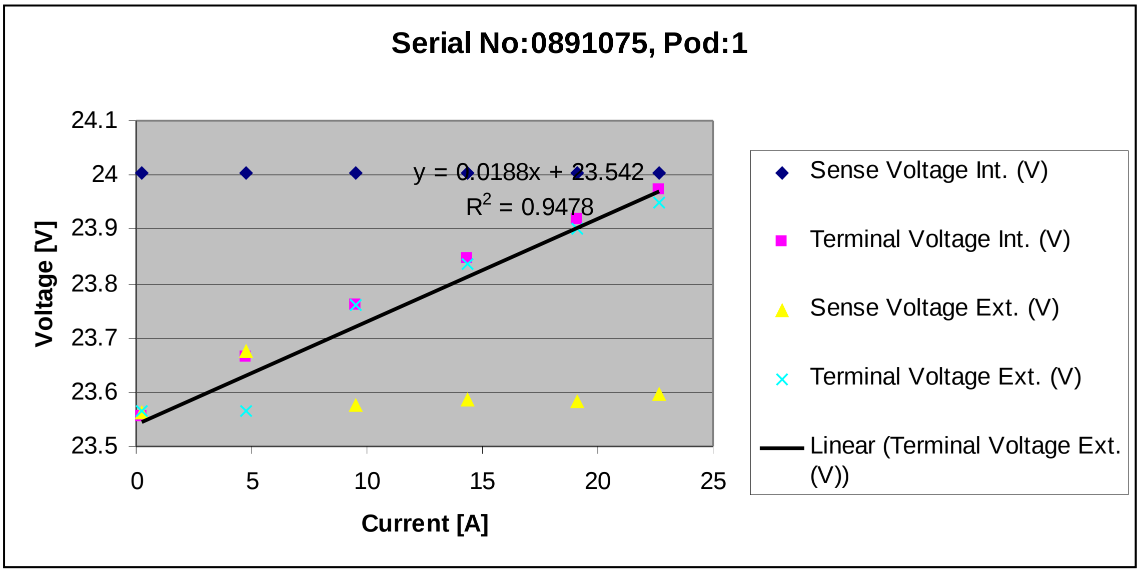

Chart 3: Fake reporting of internal sense voltage of Channel 1

The sense accuracy was also tested by simulating a “cut” in the sense line. This was done by removing the sense connector on the back of the chassis. For a normal result the internal terminal voltage should slightly decrease towards the set-point value (a few tenths of a volt decrease was common). A failure would be any other result. This test was done under twice nominal load.

Test Result of Cut Simulation

Supply ID	Pod 0	Pod 1	Pod 2	Pod 3	Pod 4	Pod 5
556826	normal	normal	normal	normal	normal	normal
556828	normal	normal	normal	normal	normal	normal
556829	normal	normal	normal	normal	normal	normal
556831	normal	normal	normal	normal	normal	normal
556830	normal	normal	normal	normal	normal	normal
556827	normal	normal	normal	normal	normal	normal
891075	normal	normal	normal	normal	normal	normal

Table 21: All power supplies perform properly under this fault condition

Note: the normal case is that the power supply moved to internal regulation and the terminal voltage dropped to the set point voltage. In the test, we did observe the drop of the terminal voltage. However the terminal voltage was still a little higher than the set point voltage. For 3.3V pods, the difference was about 0.13V; for 24V pods the difference was about 0.03V.

Finally the sense accuracy was further tested by simulating a short in the circuit by touching the ends of the sense line. This test was done WITHOUT a load.

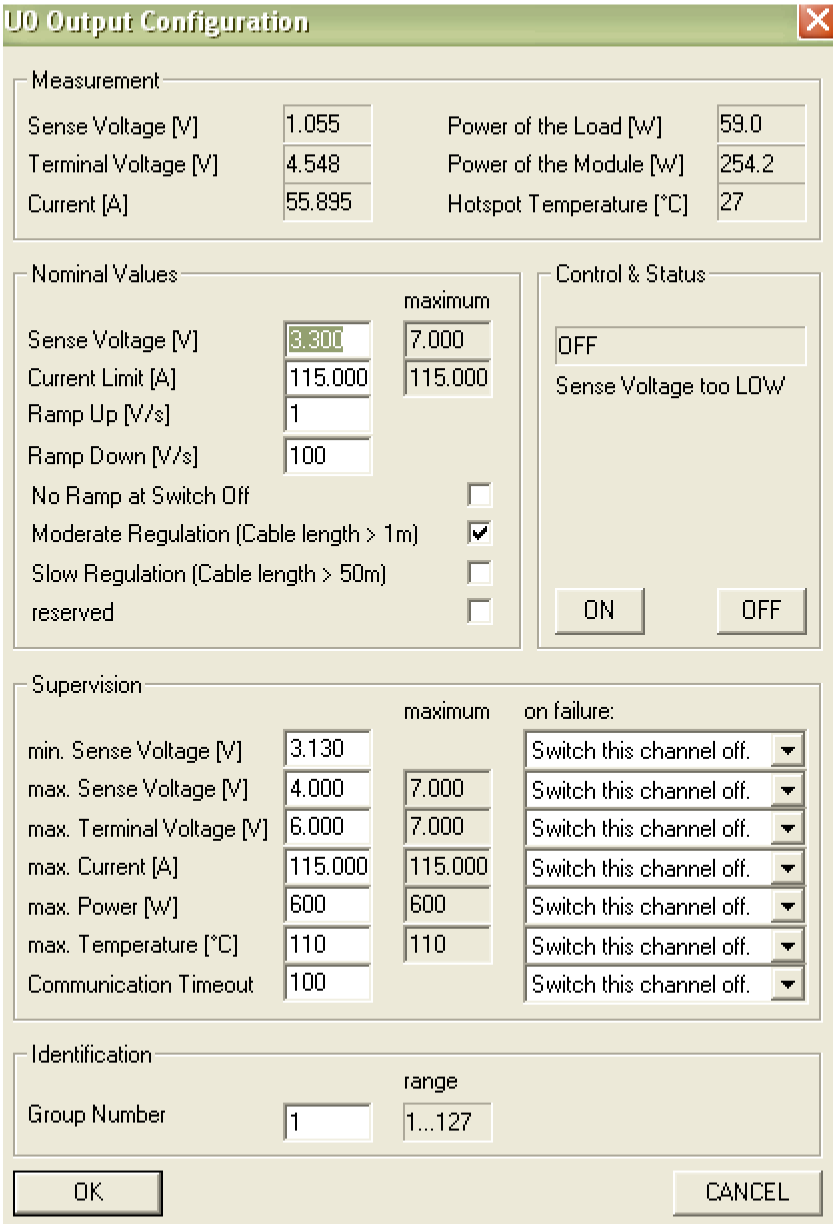

Fig 22: Muse Control configuration for 3.3V pods for short simulation

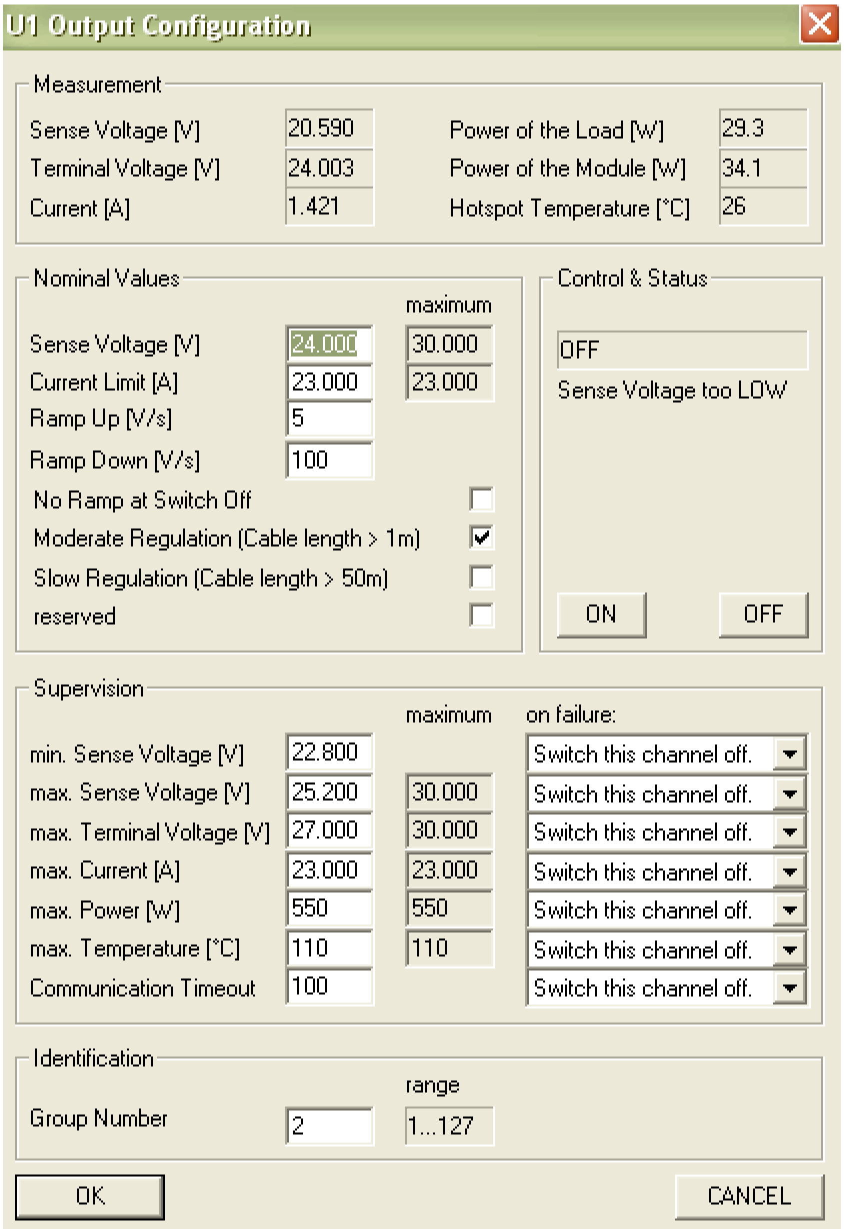

Fig 23: Muse Control configuration for 24V pods for short simulation

WARNING: make sure that the trip point settings are as shown above. Do not ignore failures in the configuration. Do not set the trip point at the maximum capacity of the pod.

Test Result of Short Simulation

Under this fault condition the supply registered a zero voltage across the sense lines, raised the supply voltage to its maximum and tripped at the programmed set-point.