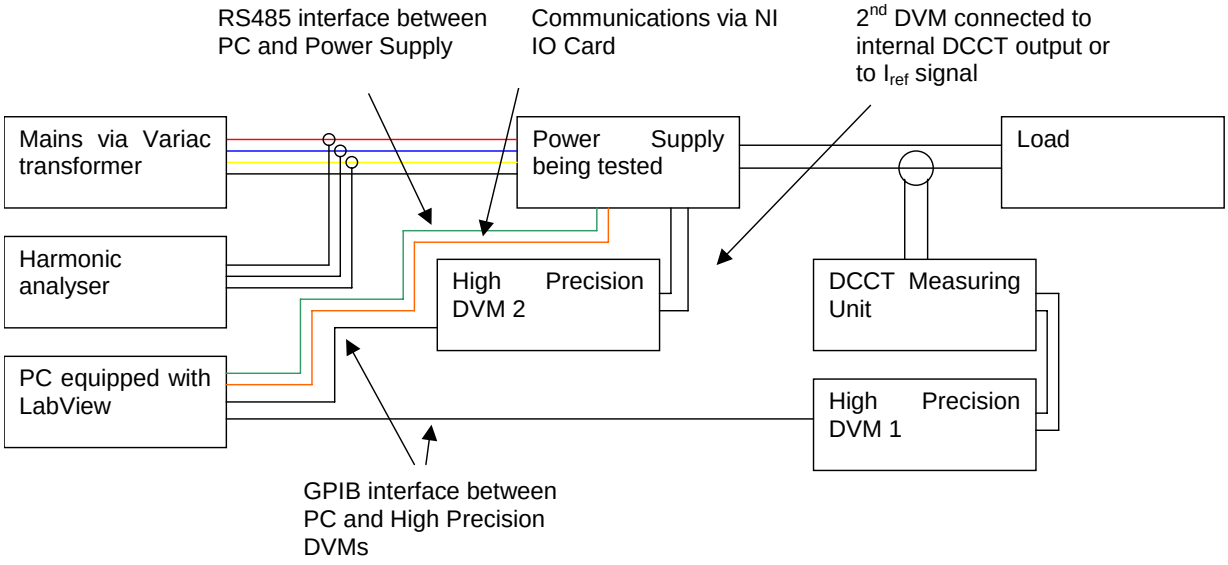
General arrangement

The following diagram shows the general layout of the apparatus used for the test facility.



Test Load

A test load was required for the purpose of evaluating the prototype power converters. The test load was required to have the following approximate parameters.

- Resistance, R = 117.2 mOhm
- Inductance, L = 1.37 mH

A number of dummy loads were available at Daresbury Laboratory, including an octupole magnet, a focusing sextupole magnet and a test bar. Each test load was water-cooled and was capable of carrying the required current. Although the parameters of these test loads were available from records, it was felt that a measurement of these parameters would be beneficial.

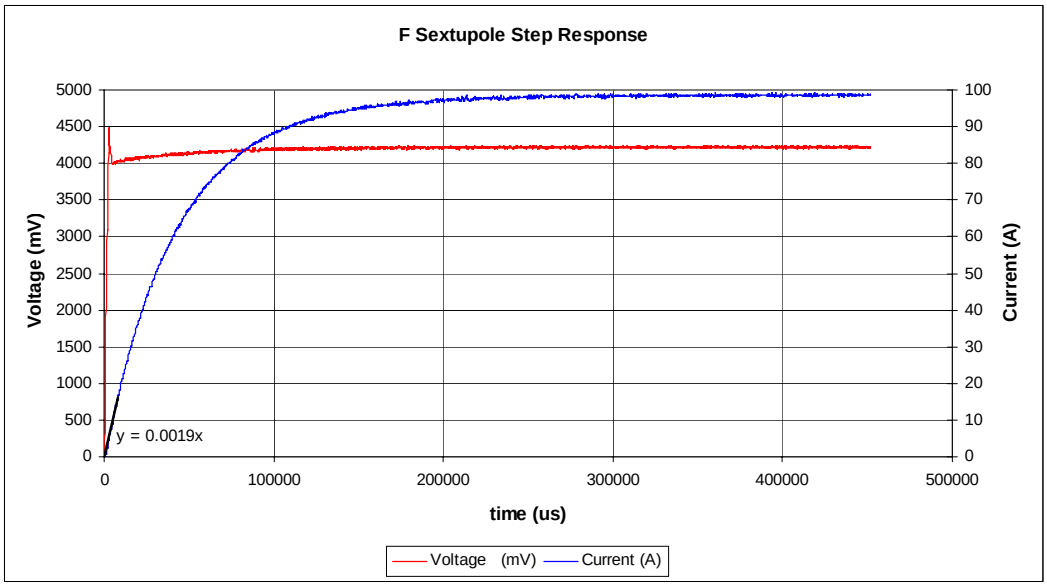
It was demonstrated during the course of the tests that it was important to ensure that the power converter is properly tuned to operate into an inductive load.

DC Measurements:

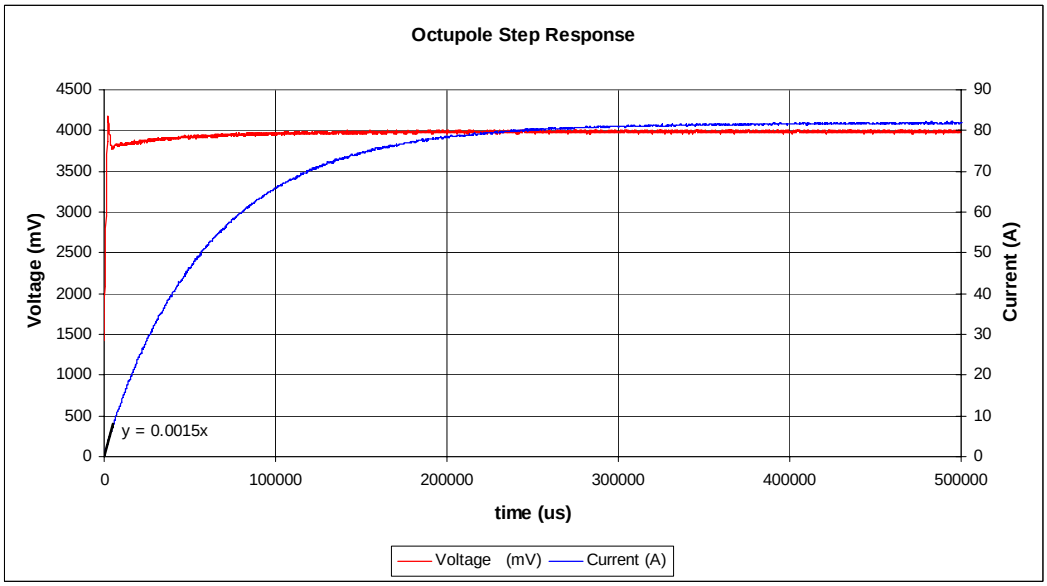
Load	*Voltage (internal meter of power converter unless specified)*	*Current (internal meter of power converter unless specified)*
Test bar + Cables	7.47 V	100 A
Test bar only	7.3 V (external meter)	100 A
Resistance of Test Bar	0.073 Ohm	
Resistance of Cables	0.0013 Ohm	
Octupole + Cables	4.76 V	100 A
	2.37 V	50 A
Resistance of Octupole + Cables	0.0476 Ohm	
Resistance of Octupole	0.0463 Ohm	
F Sext + Cables	4.22 V	99.72 A (external DCCT)
	2.11 V	49.68 A (external DCCT)
Resistance of F Sext + Cables	0.0423 Ohm	
Resistance of F Sext	0.041 Ohm	

Step transient measurements:

The response to a step change in input voltage was measured to calculate the value of the inductance of the two magnets. The step change was achieved using a switched voltage source, and by setting the voltage and current limits on the power supply to ensure that a step output voltage was obtained. The current and voltage waveforms were obtained using a picoscope connected to the output voltage and a DCCT measuring the load current respectively.



Step response of FSext Magnet



Step response of Octupole Magnet

The value of the inductance was obtained from the time constant of the circuit. The time constant was the time taken for the current to reach $\left(1-\frac{1}{e}\right)\times 100\% = 63\%$ of the steady state value and was equal to L/R. Hence, from the knowledge of R from the dc analysis, it was possible to determine L.

Magnet	*Octupole*	*F Sextupole*
Time Constant	67 ms	44 ms
R	0.046 Ohms	0.041 Ohms
L	3.08 mH	1.804 mH

The summary the resistance and inductance of each of the test loads as follows:

Load	*Octupole*	*F Sextupole*	*Test Bar*
R	0.046 Ohms	0.041 Ohms	0.073
L	3.08 mH	1.804 mH	-

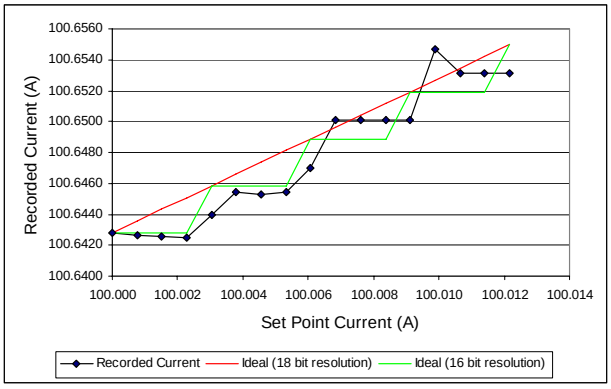
Since the required approximate load for the prototype evaluation was, R = 117.2 mOhm and L = 1.37 mH, the test load consisted of the test bar and F Sextupole in series giving a combined resistance, R = 114 mOhm and inductance, L = 1.8 mH.

Performance Testing

The power supplies were tested in accordance with the test procedure document MCH-POW-PRC-0001 and the specification document PWSP-SR-spc-0001.

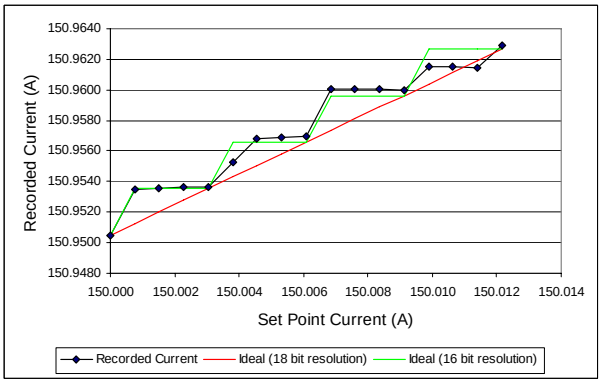
Resolution

The setting resolution of the Unit One and Unit Two varied considerably. The major difference was the use of a 23bit+sign DAC in Unit Two and a 16 bit DAC in Unit One. The specification required 18 bit resolution which is the equivalent of 0.00076 A on a 200A full scale of 3.8 ppm. The resolution of each power converter was tested at three different levels, 100A, 150A and 190A. The set point was incremented by the 18th bit or 0.00076A and the change in output current following the set point change was monitored. The results of the two units are presented graphically in the following tables.

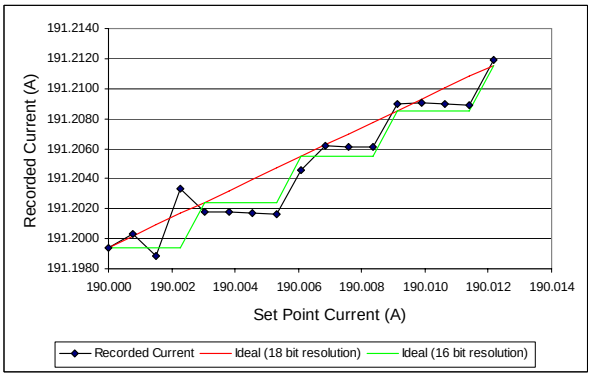


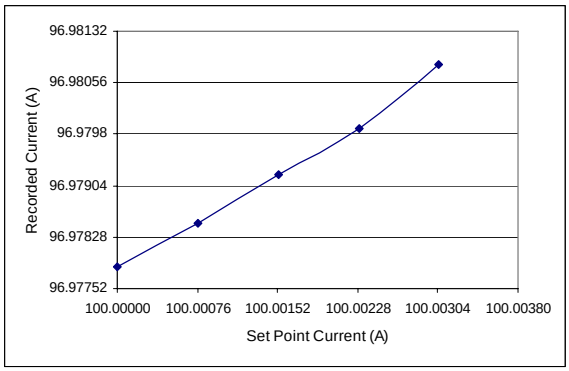
Resolution of unit 1 at 190 A

Resolution of unit 1 at 100 A

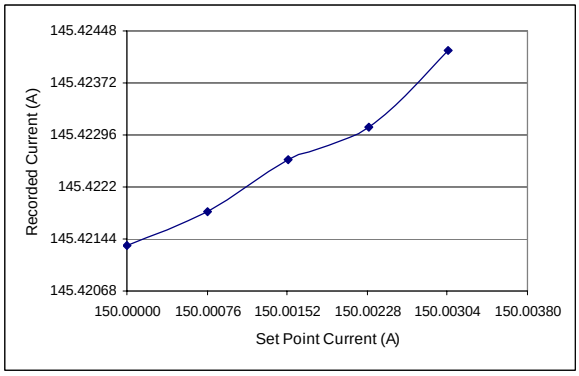


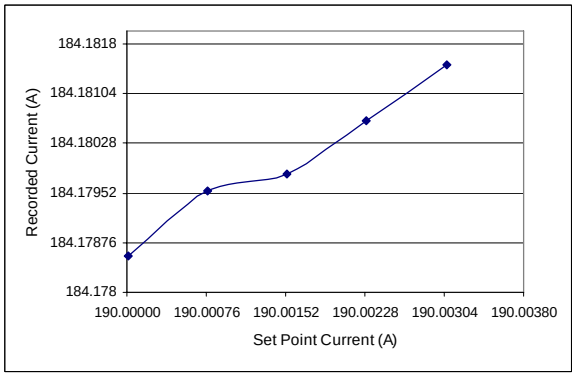
Resolution of unit 1 at 150 A





Resolution of unit 2 at 100 A





Resolution of unit 2 at 190 A

Resolution of unit 2 at 150 A

After allowing for the errors in the measurement of the current, and a reasonable settling time for the current at each set point, unit 2 meets the 18 bit resolution requirement. The limitation of the 16 bit DAC used by unit 1 is apparent. With Unit 1 results, the expected performance from an 18 bit DAC and a 16 bit DAC are shown with the actual results. In order to achieved the required setting resolution of 50ppm, a minimum of 18 bit DAC will be required.

It is recommended that a minimum of 18 bit DAC be required.