POWER CONVERTERS FOR ALBA STORAGE RING

M.Pont, D.Alloza, R.Petrocelli, D.Yépez, CELLS, Cerdanyola del Vallès, Spain,
R.Camell, G.Gross, M.Teixidó, CITCEA-UPC, Barcelona Spain

Abstract

ALBA is a 3 GeV third generation synchrotron light source under construction in Spain. The design and performance of the ALBA Storage Ring Power Converters will be described. All converters are switched-mode with full digital regulation and a common control interface. The paper will describe the performance of the power converters and compare it with the design specifications.

INTRODUCTION

The ALBA storage ring is a 3 GeV electron accelerator with a circumference of 268.8 m under completion in Spain [1]. The Storage Ring is composed of 32 dipole magnets, 112 quadrupole magnets and 120 sextupole magnets, plus the corrector magnets.

The 32 dipole magnets are connected in series and are fed by a single power converter. The sextupoles are arranged in 9 families of magnets. Each family is fed by a power converter. The 112 quadrupole magnets are fed individually. The corrector magnets are integrated in the core of the sextupoles and they are feed by individual power converters, which will not be further described on this paper.

STORAGE RING POWER CONVERTERS OVERVIEW

All the storage ring main power converters are switched-mode power converters and have been produced by Hazemeyer (France). Different topologies where used depending on the power to be delivered to the load. The power converters provide a regulated DC current to the magnet and operate in only one quadrant.

The control units are the same for all these power converters and are complete digital which facilitate the tuning of the control loops. Control units provide two PID controllers which are used to control an inner voltage feedback loop and an outer current feedback loop. A brief description of each type of power converter with their specifications is given in the following sections. All semielectronics on the power converters are water cooled with a ΔP=4 bar and flows ranging from 1.2 to 6.0 l/min.

Dipole power converters

A single power converter feeds all the dipole magnets of the storage ring. This power converter consists of two buck converters connected in series in order to reduce the voltage across de semiconductors. The switching frequency for the converters is 13 kHz. The main characteristics of the power converter are summarised in Table 1.

Table 1: PC Dipole Specifications

Max. output I	600 A
Max. output V	780 V
Resolution	5 ppm
Stability, 24 h	± 10 ppm
Ripple	10 ppm
Load	
Resistance	1152 mΩ
Inductance	2013 mH

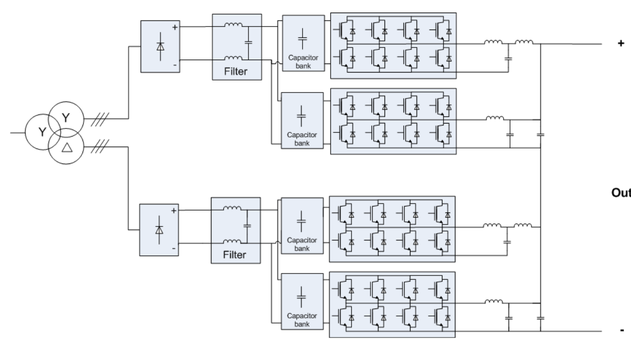

Figure 1: Diagram of the dipole PC.

Figure 2: Picture of the dipole PC.

Factory acceptance test was successfully carried out at the manufacturer while the site acceptance test will be performed in July 2010 at the final location and with the final load, i.e. with all the SR dipoles connected in series.

Quadrupole power converters

Each of the 112 magnets is fed by a single power converter. These power converters are mounted in cabinets forming groups of 6 and 8, depending on the storage ring lattice. The specifications for the PCs are given in table 2.

Table 2: PC Quadrupole specifications

Max. output I	200 / 225 A
Max. output V	20 / 25 V
# of Power Converters	88 / 24
Resolution	5 ppm
Stability, 24 h	± 10 ppm
Ripple	10 ppm
Load	
Resistance	67 / 108mΩ
Inductance	35 / 64 mH

The isolation in these power converters is provided by a high frequency transformer operating at 20 kHz. The rectified voltage is chopped by a half-bridge, and after the transformer there is a two-stage LC filter. Figure 3 presents the schematics of the power converter and Fig. 4 shows its compact mechanical design.

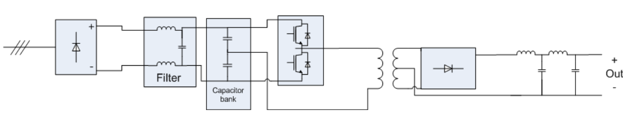

Figure 3: Diagram of quadrupole power converter.

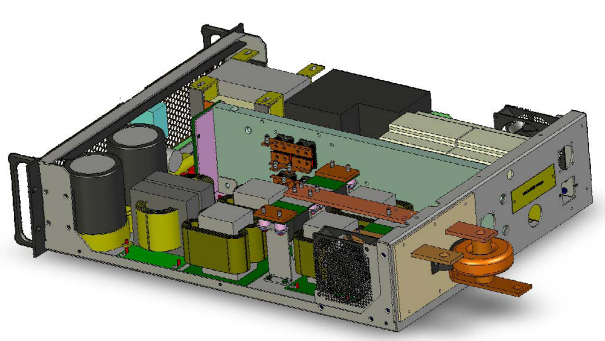

Figure 4: 3D model of a quadrupole power converter.

Sextupole Power Converters

Each one of the 9 families of sextupoles magnets is fed by a single power converter. A summary of the specifications and load of each circuit is given in the following table:

Table 2: PC Sextupole Specifications

	S150A	S150B	S220A	S220B
Number	4	2	2	1
Max. output I	215 A			
Max. output V	100V	190V	350V	125V
Resolution	15 ppm			
Stability, 24 h	± 50 ppm			
Ripple	50 ppm			
Load				
Resistance	457mΩ	884mΩ	1626mΩ	174mΩ
Inductance	122mH	245mH	512mH	214mH

The power converter is formed by a transformer to provide the isolation and adapt the voltage for a buck converter. The output ripple is filtered out by a double stage LC filter. A diagram of the power converter is shown in Fig. 5.

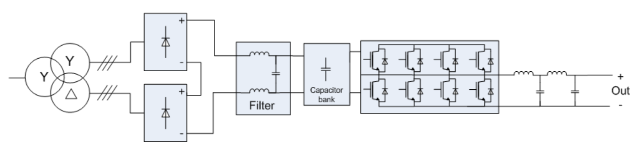

Figure 5: Diagram of sextupole power converter.

TESTS PERFORMED

All power converters were tested at the manufacturer before delivery. Once at CELLS the following tests have been performed on all the power converters to assess their compliance to the specifications: Warm-up time measurement, long term stability, linearity, resolution and repeatability, among others.

The test bench was composed of a DCCT from the Danfysik's Ultrastab Saturn precision series and a 7 ½ digits voltmeter (Keithley model 2182A). The voltmeter is connected to a PC where a Matlab script runs the testing automatically. Several power converters would be tested simultaneously using a Multifunction Switch / Measure Unit model 34980A from Agilent. In this case resistive loads were used and DCCTs were calibrated against the Danfysik one and used for current measurement.

Warm-up Time and Stability

The measure of the warm-up time and the stability is performed by turning on the power converters and acquiring their output current for a period of 8 hours.

The room temperature and water temperature are also recorded as the tests had not been performed on a temperature stabilised room. In this case it has been possible to measure a drift of the output current of 10ppm/ºC (worst case). Even so, the stability results show the power converters comply with the specifications, as indicated in Fig. 6, which shows the output current as a function of time for a typical quadrupole and in Fig. 7 which shows the same result in a histogram form.

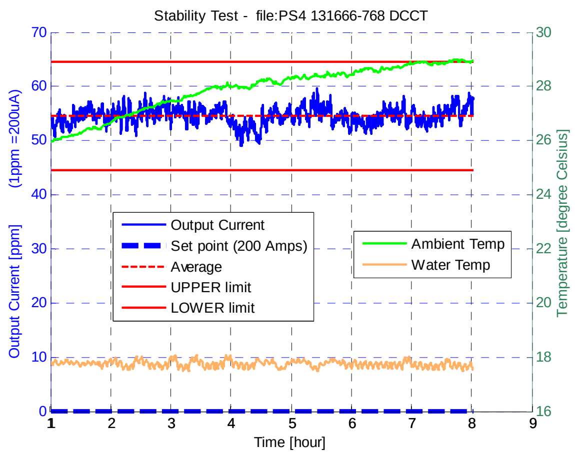

Figure 6: Output current, room and cooling water during stability test of a typical quadrupole PC

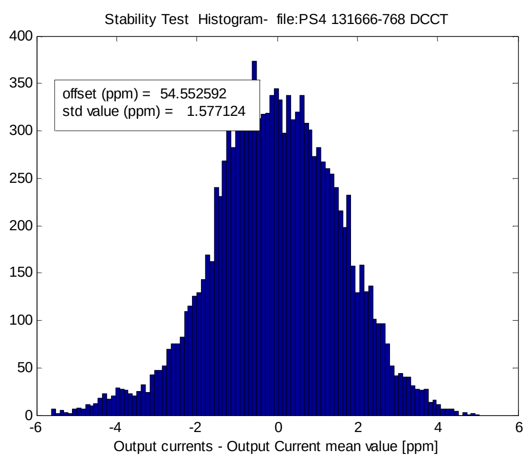

Figure 7: Histogram of output current values during a stability test.

Resolution

The resolution is defined as the minimum step that a power converter will produce. A typical output of this test is shown in Fig. 8, where the output currents for a given set point were recorded during 15 minutes. The red circle indicates the average of the output values and shows clearly the specified resolution of 5 ppm.

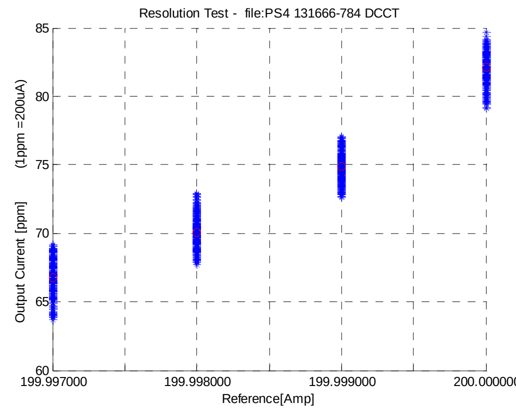

Figure 8: Output current values vs. set points, the red circlesare the outputs average over xx min.

Linearity.

The results of the linearity tests, offset and gain for each power converter are available and corrections could be implemented in a later stage, after the first commissioning is done.

Repeatability.

Repeatability test were performed in order to evaluate the capacity of the power converter to repeat the output current after a short interruption. After the warm-up period the power converter was switch off for 15 min. After this period, the power converter was turn on and the output current value was compared with the previous one.

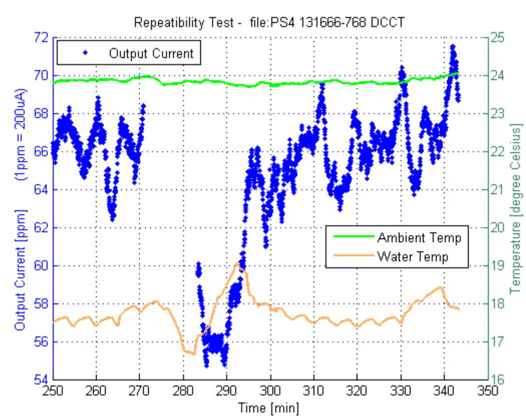

Figure 9: Repeatability test on a quadrupole PC.

REFERENCES

[1] ALBA Status, these proceedings.