The ELETTRA Storage Ring Steerer Power Supplies

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Abstract

The 82 H+V combined steerer magnets of the Storage Ring ELETTRA are powered by 164 linear transistor power supplies, arranged in 12 cabinets, 14 channels each. The DC nominal current is ±16 A. Besides the DC mode there is an additional superimposed AC modulation of 2.5% of the nominal current, with a phase rotation between output current and reference set voltage less than 3° at frequency up to 100 Hz.

1. INTRODUCTION

The ELETTRA Storage Ring is a Double Bend Achromat structure, with period 12. Seven combined H+V correction magnets have been included in each achromat. Since in the injection region two of the correctors' positions have been used for the kickers, the total number of steerers is 82 (11x7+5). The steerer magnets have a C shape laminated iron core with one horizontal coil to perform the vertical correction and two series connected vertical coils for the horizontal correction [1]. The 82 combined magnets are powered by 164 bipolar linear power supplies.

The power supplies (PS) have been arranged in 12 cabinets, 16 PS each (7 horizontal corrector PS + 1 spare and 7 vertical corrector PS + 1 spare).

Since the parameters of the horizontal and the vertical magnets are not very different, the same power supplies' parameters have been chosen in order to maintain a high degree of standardisation.

Apart from a standard DC closed orbit correction the steerers have also to be able to fulfil the additional requirements for an harmonic closed orbit feedback and a local feedback correction [2]. These requirements lead to a superimposed AC modulation of 2.5% of the nominal current at 50 Hz. In order to keep a sufficient margin for the overall loop (whose bandwidth is 100 Hz), the maximum phase rotation between the reference signal (current set) and the actual output current have to remain within 3 deg up to 100 Hz. For those dynamic requirements the output voltage had to be increased significantly respect the DC parameters. Table 1 reports the main characteristics.

Table 1
Steerer Power Supplies main characteristics

DC (peak) voltage:	±80 V
DC (peak) current:	±16 A
Current Ripple:	$\pm 5\ 10^{-5}$
Current Stability 24 h:	$\pm 5\ 10^{-4}$
Load inductance at 50 Hz	
horizontal corrector:	150 mH
vertical corrector:	230 mH
Load resistance	
horizontal corrector:	2.9 Ohm
vertical corrector:	2.0 Ohm

2. THE POWER SUPPLIES' STRUCTURE

In terms of reliability, interchangeability and last, but not least, costs, a multichannel linear structure has been chosen. Special care was dedicated in the design to permit a fast replacement of the channels in order to ease maintenance and repair. This solution is described in the following figures 1 and 2.

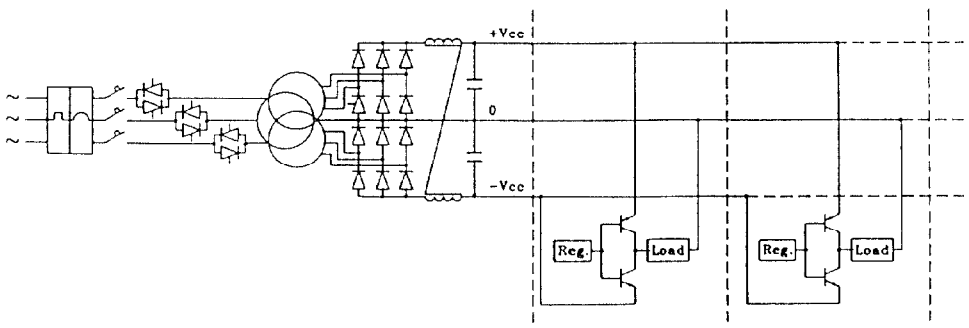

Figure 1. Scheme of a multichannel PS

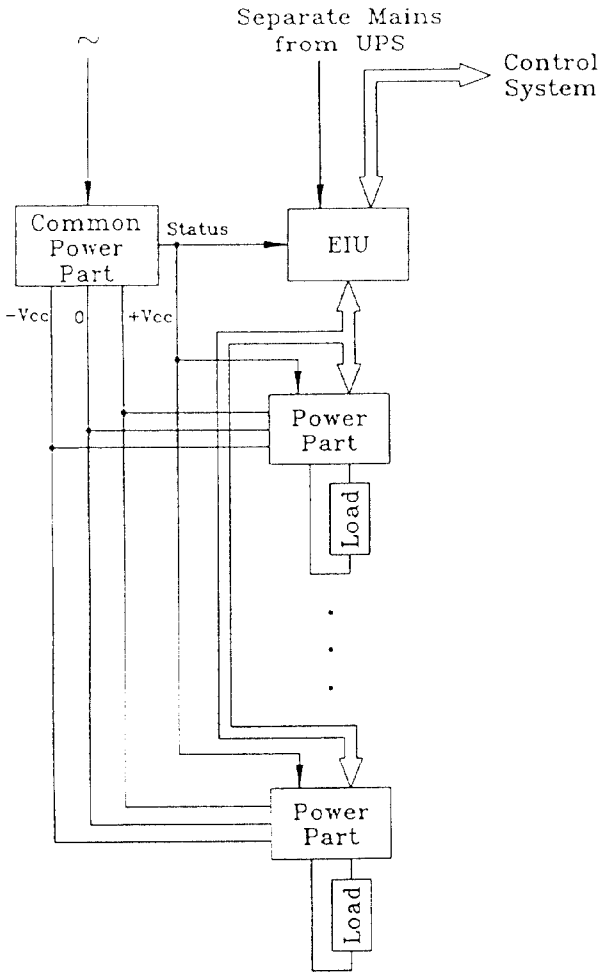

Figure 2. Block diagram of a multichannel power supply

Looking more in detail to the single components, we find.

- Common power part
  On the AC side a preregulator adjust the voltage level to reduce the losses on the transistors banks in case none of the channels is involved in the AC modulation. The common power part includes the circuit breaker on the grid, the transformer, the rectifier bridge and the passive filter. The common power part supplies the DC voltage which is distributed to the individual power boxes.

- Power boxes
  Each box, "channel", is a complete, independent linear regulator. It includes the regulation board with the safety interlocks, too. Each channel is water cooled. Each box can be easily disconnected and removed from the cabinet permitting a fast replacement of a box.

- Equipment Interface Unit
  The two feedback systems will require dedicated boards to be inserted in the power supply. For this reason there are two Equipment Interface Units (EIU's) in each cabinet, one for the horizontal steerer power PS and one for the vertical steerer PS. Each EIU includes a CPU, two communication boards and 8 Analog/Digital Input/Output boards for Steerer (ADIOS). The ADIOS board includes a 16 (15 + sign) bit bipolar DAC to generate the reference voltage to set the output current, an ADC to convert the read current and 16 digital channel (configurable as Input or Output) for the remote commands and status indications.

3. REQUIRED AC PERFORMANCE

Besides a DC operation mode, whose main characteristics have been summarised in the previous table 1, the steerer PS have to operate in AC mode too. The foreseen electron beam position feedback systems, the global harmonic closed orbit feedback and the local feedback, have to be able to correct electron beam oscillation up to 50 Hz[2].

The global harmonic closed orbit feedback will act via the EIU, i.e. via the DAC of the power supply. The separation between the DC and AC set will be done digitally on the DAC board itself.

The local feedback will act using an external analog signal ±10 V of amplitude. This properly weighted signal will be added directly to the output of the reference DAC at the sum point of the current regulation loop of the power supply.

Both feedback systems require that the AC modulation can be superimposed on any DC level maintaining its characteristics, reported in table 2.

Table 2
Steerer Power Supplies AC characteristics

Max. current amplitude at 50 Hz:	400 mA_{peak}
Max. current amplitude at 100 Hz:	200 mA_{peak}
Max. phase rotation[1] at 100 Hz:	3 deg.

4. TESTS ON FINAL LOAD

Tests have been performed on all the power supplies connected to their final loads. The DC and the AC characteristics of the power supplies have been verified, in particular the stability of the output current and the frequency response of the power supplies in term of output current vs. set voltage.
Figure 3 shows a stability measurement on about 1 hour of a vertical corrector power supply at -12 A.

[1] The phase is the angle between the analog set voltage and the corresponding output current.

Figure 4 shows a frequency response of a horizontal corrector power supply with a DC offset level of 8 A and an AC excitation of 400 mA of amplitude.

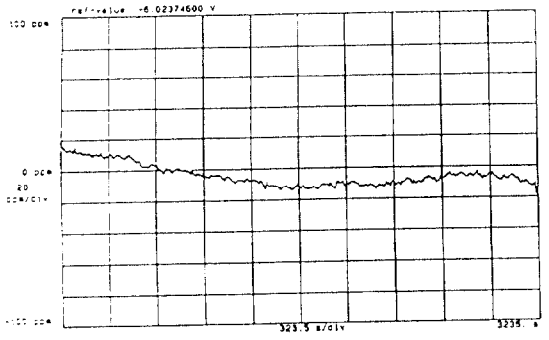

Figure 3. Example of stability measurement

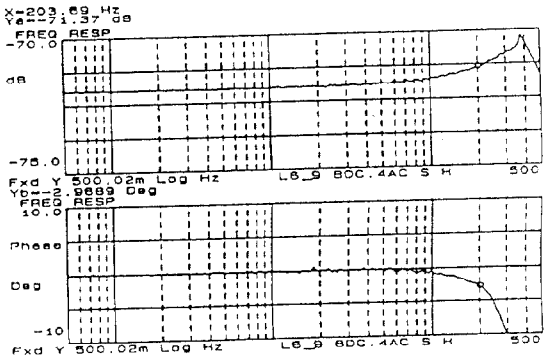

Figure 4. Example of frequency response measurement

5. REFERENCES

[1] Design, Construction & Testing of the Corrector Magnets for ELETTRA - D. Tommasini, R.P. Walker, D. Zangrando and G. Petrucci - This Proceedings.

[2] Design Considerations for the ELETTRA Beam Position Feedback System - D. Bulfone, A. Carniel, J.-C. Denard, F. Iazzourene, R. Richter, A. Wrulich - presented at the 2nd European Particle Accelerator Conference, Nice, June 12-16, 1990.