## Title

# *Electrical reference manual and power supply requirements for ALBA project*

## Abstract


*This document summarizes Electrical reference manual and power supply requirements for ALBA project*



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*Distribution List*

## *History of Changes*

| *Rev. No.* | *Date* | *Pages* | *Description of changes* |
| --- | --- | --- | --- |
| *1.0 – Draft* | *06-06-06* | *** | *Initial release* |
| *2.0* | *07-03-07* | *4, 5, 6, 8, 9* | *Minor changes* |

## *References*

# 1 APPLICABLE ENGINEERING STANDARDS AND DESIGN PRINCIPLES

## 1.1 Standards

The equipment shall conform to the following European standards:

- IEC 61204 Stabilized Power Supplies DC Output: Conducted electromagnetic interference.
- EN 61010-1 Safety requirements for electrical equipment for measurement, control and laboratory use.
- EN 55011 Class A / Group 1 – Industrial, scientific and medical radio frequency equipment. Electromagnetic disturbance characteristics. Limits and methods of measurement.
- IEC 61204-3 Low voltage power supplies. Electromagnetic compatibility (emission).
- IEC 61000-4 Level 4 Electromagnetic compatibility (immunity).

## 1.2 Safety

It is requested that:

- All polymer materials and cable insulators must be halogen and sulphur free with low smoke density, toxicity and corrosivity in case of fire (Flame Retardant Non Corrosive cable type) for all cables working larger than $50V_{DC}$.
- For all the converters, no materials containing halogens shall be used in any part. The contractor must indicate any material that might not be halogen free. CELLS reserves the right to give written approval or refusal.
- The doors from the racks shall be interlocked. These interlocks can be bypassed manually during tests.
- All live parts at a voltage greater than $50V_{DC}$ must be protected by removable PERSPEX panels or covers against inadvertent contact.
- Any energy stored in capacitors shall be discharged to a voltage less than 50V in less than 60 seconds.
- The metallic frames, doors and magnetic circuits must be earthen.
- The components and cables must be clearly identified.
- “High Voltage” warning labels must be used for voltages above $50V_{DC}$.

# 2 SERVICE CONDITIONS

## 2.1 General conditions

The power converter will power electromagnet loads. All components shall be rated for continuous operation at nominal DC current and voltage under the worst-case conditions (up to 6000 hours a year with virtually no interruption for at least 25 years). All components shall be rated to withstand fault conditions until the protection devices actuate.

## 2.2 Ambient conditions

The following conditions must be considered:

| | |
| --- | --- |
| Altitude | 500m |
| Temperature variation for storage | -25°C to +50°C |
| Temperature variation for design of the converter | +10°C to +40°C |
| Temperature variation in “stable operation” | 23°C ±5°C |
| Relative humidity | 30% to 90% |

## 2.3 Electrical mains network

The ac distribution board is feed from an 2 MA, 25kV/400V - 5% distribution transformer, via power switches with magneto-thermal protection. The 400V secondary star mid-point is earthed at the transformer and the neutral is directly distributed to the equipment. Thus, the neutral must not be earthen at any other point.

CELLS 400VAC network characteristics:

| | |
| --- | --- |
| Line voltage | 400V rms ±10%. (TNS neutral mode: three phases + neutral + PE) |
| Frequency | 50Hz ±1% |
| Voltage harmonic distortion | 5% rms |
| Phase imbalance | ± 1.5% |
| Conductor distribution | 3 phases + neutral + PE |
| Short circuit capacity | <40 MVA |
| Peak main surges | 1200V rms for 0.2ms |
| | 600V rms for 10ms. |

### 2.4 Water cooling

Power converters with an output power of more than 4 kW must be water cooled, taking advantage of the available demineralised water system available:

| | |
| --- | --- |
| Water conductivity | 0.2 uS/cm |
| Inlet temperature | 23°C±1°C |
| Maximum temperature variation | 17°C |
| Inlet pressure | 10 bar |
| Minimum outlet pressure | 4 bar |

The materials in the cooling circuit shall be compatible with the use of demineralised water. Any material other than stainless steel and EPDM (for the o-rings) must be identified in the design report.

## 3 CONTROL SYSTEM AND REGULATION

### 3.1 Modes of operation

Four operation modes are defined as the combination of:

- Local/Remote mode. Local and remote control functionality will be identical, except for the Emergency Stop Button. Only one of them can be active at a time. In Local mode any Remote action is impossible and vice versa.

  Remote mode is to be used by the ALBA control system.

  Local mode means interfacing with the converter via:
  - Local computer control to be used from a laptop.
  - Local manual control through the front panel. It must include as a minimum set:
    - Emergency Push Button.
    - Local/Remote Mode selection switch.
    - An isolated output (LEMO or BNC connector) showing the DCCT measurement (±10V) will be available in the front panel of the POWER SUPPLY, allowing the supervision without perturbation of the stability and the accuracy of the magnet current.
    - ON/OFF/STANDBY/RESET buttons.
    - Status and Faults shall be displayed in the front panel.
    - Voutput & Ioutput shall be also displayed in the front panel.
    - Trigger to synchronize waveform intensity to be applied, if needed.

- Voltage/Current Regulation mode. To be selected via the local computer control or the remote control. Digital regulation is preferred.

In all operation modes the output current and voltages values of the POWER SUPPLY shall be available for display both locally and in the control room through the remote control.

Other more complex alternatives, like one based on Local Front Panel / Local Computer / Remote modes will be preferred and its implementation details agreed upon with the contractor.

### 3.2 Functionality and Interlocks

The Local/Remote control must perform the following functions:

- Status management. Four status have been foreseen as a result of the commands explained just below:
    - ON = Main contactor ON. Gate pulses enabled and regulation operative.
    - OFF = Main contactor OFF. Faults have been reset.
    - STANDBY = Main contactor ON. Gate pulses disabled and regulation non operative.
    - FAULT = Following an interlock the main contactor is OFF and the fault has not been reset.

- Commands management. The given commands are to be used:
    - ON = Main contactor ON. Regulation and gate pulses enabled.
    - OFF = Main contactor OFF.
    - STAND-BY = Main contactor ON. Gate pulses disabled and regulation non operative.
    - RESET = Reset possible interlock memories once the fault / warning has been cleared. After clearing the fault the converter remains in OFF.
    - IREF = Setting the current.
    - DELTAIDELTAT = Setting the current slope in A/s.
    - ILIMIT = Maximum desired current.
    - VREF = Setting the voltage.
    - REGMODE = Setting the Voltage/Current regulation mode.

- Operation management. 2 + 2 modes of operation:
    - LOCAL/REMOTE:

      LOCAL = converter in Local mode.

      REMOTE = converter in Remote mode.
    - VOLTAGE/CURRENT:

      VOLTAGE = LOCAL/REMOTE VREF is send to voltage loop, current loop inactive.

      CURRENT = LOCAL/REMOTE IREF is send to current loop and inner cascade voltage loop remains active.

- Converter output monitoring
    - Output current
    - Output voltage

- Converter interlocks monitoring:
    - Output over-voltage
    - Output over-current
    - DC Filter capacitor over-voltage
    - Coils over-temperature of transformers and filters
    - Semiconductors heat sink over-temperature
    - Regulation fault
    - Circuit breaker protection fault
    - Earth fault
    - Fuse fault
    - Driver fault
    - Water fault
    - Emergency stop button
    - Doors open (when open, the door switch can be manually set to closed position)
    - AC Phase fault
    - Fan fault
    - Magnet interlock fault (external)
    - 4 spare interlocks fault (external)

Any of these interlocks shall force the converter to the FAULT state. The contractor may add to this list any safety interlock that is considered as necessary. Current Limit and Earth faults must have an adjustable threshold. Faults must be memorized for back tracking.

Interlock signals shall be +24VDC when active/live i.e. open contact when there is a failure.

The circuit breaker shall be equipped with two auxiliary contacts for ALBA use: One normally close and the other normally open.

### 3.3 Computer control links

Two types as described above:

- Local: from a movable monitoring station equipped with a laptop, via a RS232 (DB9 female connector) link or USB2.0 (standard USB connector). A graphical interface is preferred.
- Remote: from the ALBA control system via Ethernet 100BaseT link (RJ45 connector) + TCP/IP (preferred) or ProfibusDP V2 (standard sub-D profibus connector). Other interfaces might be accepted under conditions to be defined during the discussion with ALBA-CELLS.

The supplier shall provide a set of commands, attributes and properties to be written / read through the communication links, as well as a detailed documentation of the protocol.

The contractor shall provide a detailed documentation of all commands with the corresponding inputs and actions, and all the variables (attributes and properties) including a full description and the data types. Also the contractor shall provide example programs (written in C or C++) showing how to access data, send commands and receive alarms for all the interfaces. In addition to the "raw" protocol, the contractor can provide graphical interfaces, Windows DLLs and/or Linux shared libraries for the local (and remote) control. All of those will be considered an asset.

The protocol preferred by ALBA is ASCII encoded, but others can be negotiated.

### 3.4 Layout

- The Converter shall be installed on 19" racks and placed over a false floor metal structure.
- The contractor is responsible for the integration of the POWER SUPPLY into the racks (600x800x2000mm). If the power supply does not fit, the alternative should be commented and agrees with CELLS.
- The power converter must be equipped with a base and 4 lifting lugs located symmetrically about its centre of gravity. It must be transportable by a forklift truck and a crane. The centre of gravity must be low enough to allow safe handling with a forklift truck.
- The weight of any single module inside the power supply must not exceed 50 kg.
- Cooling air intake shall be at the bottom and the hot air outlet at the top of the enclosure.
- Water cooled power converters shall be supplied with an inlet and outlet manifold. The manifold shall be manufactured from stainless steel tube, grade 316, suitable for connection to the supply and return water system via a single SWAGELOK compression fitting onto each manifold. The manifold pipe will be mounted vertically and the connection point will be at the bottom end of the rack.
- The hydraulic circuit of the converters shall be equipped with isolating valves. The low point of the cooling circuit will be equipped with an outlet gate and the high point with an air bleeder valve.
- The hydraulic circuit distribution shall be made from the bottom of the rack.
- A flow meter to control the water flow, giving the corresponding interlock signal to stop the converter if needed. The flow meter switch shall be placed at the outlet of the hydraulic circuit.
- Every electrical connection shall be made from the bottom of the rack.
- The electrical interfaces with CELLS will be defined in agreement with CELLS.
- The protection degree of the racks must be IP20.
- Each electronic crate must have an ON/OFF switch for the incoming 230 V AC supply, which should be taken from the incoming 400V AC. This 230 V AC supply must have an accessible connector in the metallic panel that houses the electronic boards.
- The converters should be vibrations free. If any, it must be eliminated or damped.
- The noise level of any rack must not exceed 35 dBA at any point 1 meter away from the rack.
- The colour of the rack will be defined by CELLS at an early stage of the contract.

# 4 WIRING AND COLOUR CODE

The minimum section for all the wiring is 0.5 $mm^2$, except for the earth wire, whose section must be greater than 4 $mm^2$. Colour code for cables and conductors:

- AC current:
  - Unspecified phase - white
  - R phase - brown
  - S phase - black
  - T phase - grey
  - Neutral - blue
  - Earth - yellow and green striped
- DC current:
  - Positive - red
  - Negative - black
  - Mid conductor - blue
  - Earth - yellow and green striped

# 5 FAILURES AND RELIABILITY

The converters shall withstand the following fault situations without suffering any further damage:

- Output short circuit while at full power.
- Output short circuit at ON command.
- Output open circuit at full power.
- Internal faulty components.
- Lost of one, two or three AC phases.
- Regulation malfunction.

With the exception of the filter capacitors and the general switch, all components must have an individual Mean Time Between Failures (MTBF) greater than 100.000 hours under the worst operating conditions described in this specification and 1.000.000 hours for the electronics.