Low Voltage Floating Power Supply Systems for LHC Experiments
PL 500- PL 600 Basic Systems
in 3U high power boxes

- **PL500 F8, F12**
  
  8- or 12-channel sense operated via **long distance**
  slow integrating sense compensation amplifier

- **PL600 F8, F12**
  
  8- or 12 channel sense operated for **short distance**
  or **not sensed** for long distances, too
  fast sense compensation amplifier

- Outputs floating (>10k Ohm between channels)
General Technical Details

Standard Mains Inputs:

- **SE Version**
  90-265VAC, 47-63 Hz, <17.5A (DC power out <3kW) with PFC
  (also: 155-455VAC 3phase with Neutral)

- **Moderate HE Version**
  230VAC +15/-10%, 47-420Hz, <16A (DC power out <2kW) no PFC
  (also: 275VAC, 380-420Hz, 3phase no Neutral, or 385VDC, >3kW)

- **HE Version**
  385VDC ±5%, <10A (DC power out >3kW)
  (also: 275VAC, 380-420Hz, 3phase no Neutral)

DC output power refers to nom. Voltage of 230/400VAC or 385VDC
Noise and Ripple

after 30m cable length, filtered with 330$\mu$F and ceramic capacitors

5V/100A with 1,94mVpp, 0-30MHz with 2,81mVpp, 0-300MHz, PARD

Low PARD / common mode noise:
prevents resonance upset with cable inductivity
guarantees excellent resolution in Data Acquisitions

LHC Sept 04
Versions for SE-Area  PL 500 / PL 600

- Individual channel trip off with fast output discharge
  Programmable voltage ramps, group behavior (F12) as well as warning and trip levels
- Extremely low noise and ripple
- Wide range sinusodial mains input
- W W W Interface, CAN, Ethernet

Optional:
- Individual Interlock
- Intelligent monitoring display

CANbus, TCP/IP-Telnet, COM port
Versions for moderate HE Area

- 8 channel PL500 / PL6--
- $\leq 300$ G Water cooled version
- 385VDC low current input voltage
  230VAC with reduced output performance, No PFC
- $\leq 130$ G Air cooled version works with PFC and full power even at 230VAC
- Tested up to 3,1krad (PSI)
- Embedded CANbus controller

X-Y-Z directions f. B-field measurements
Versions for moderate HE Area
B-field action related dependence

STANDARD PL500 POWER SUPPLY OUTPUT VOLTAGE vs B FIELD

Uo: 2V/200A

Test: B. Allongue
Versions for HE Area

**Magnet field- and Radiation Tolerant**

**New Power Supply System**

**MARATON**

- Watertaps with cut-off valve (as well as the counterparts)
- Overpressure valve (18 bar)
- Low current DC input 385V/<10A
Versions for HE Area
Low current 385VDC Input

See the Advantage of low input current, i.e. active primary rectifier in SE area and 125 m distance:

MARATON needs 9A at 400VDC for 3kW, 10A at 360VDC (nom = 380V)
\[ U_{\text{drop}} = \left( \frac{250\text{m}}{2,5\text{mm}^2} \right) \times \frac{10\text{A}}{56\text{m} \times \text{mm}^2 / \text{Ohm}} = 17,9 \text{ V} (<5\% \text{ from nominal}) \]

Same calculation for 45,6V (48V less 5%) low voltage version shows 79,2A for a ratio of 380/48 (without considering efficiency!):

\[ U_{\text{drop}} = \left( \frac{250\text{m}}{150\text{mm}^2} \right) \times \frac{79,2\text{A}}{56\text{m} \times \text{mm}^2 / \text{Ohm}} = 2,35 \text{ V} (<5\% \text{ from nominal}) \]

- The relation in cross section is \((380/48)^2\)
Assembly, 19“ Power Bin

- 4U high 19“ assembly with air baffle for front or bottom cooling air entry
  (Custom power bins on request)
- F8 Power Bin with 5 pairs 230A, 4 pairs 115A connector plugs, 8mm and 6mm studs
- F12 Power Bin for 12 x 50 - 85 A connector plugs, 4mm or 5mm threads
- Sense connection terminals
- F8 CANbus and RS232 on rear 9pin Sub D
- F12 CANbus, TCP/IP, COM-port/ Telnet on frontal RJ 45

Optional: Alphanumeric Display
Water cooled Standard Modules

Selection

<table>
<thead>
<tr>
<th>Voltage Range</th>
<th>Optimum Span</th>
<th>max. peak</th>
<th>Current cont.</th>
<th>Output Module</th>
<th>B-Field Tolerance</th>
<th>Rad. Type</th>
<th>Module Type</th>
<th>Reg.- Board</th>
</tr>
</thead>
<tbody>
<tr>
<td>[V]</td>
<td>[V]</td>
<td>[A]</td>
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<td>[W]</td>
<td>[G]</td>
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<tr>
<td>0- 8</td>
<td>2- 7</td>
<td>115</td>
<td>100</td>
<td>1 x 600</td>
<td>&lt;300</td>
<td>0,7kGy</td>
<td>MEH</td>
<td>DAC</td>
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- Customer specified Designs
- Can work in parallel with current sharing
- 6 Modules fit into a 3U power box (6U box for 10 Modules available)
Regulation Boards

Different types fit to all power modules

1. DAC type Processor controlled

2. HE Type with Trim-Pot adjustment

3. SE Type with „on board DSP controlling“
MARATON Test Module

Rad hard type with trim-pot adjustments (Test module)

Version with minimal features (What is not there can not be damaged!)
Water cooled dual Modul

MARATON dual module equipped with rad. tolerant DAC-regulator boards
## Radiation Tested Modules

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<th>Mains Input</th>
<th>2-7V/100A</th>
<th>+/-5V/30A (2-7V)</th>
<th>+/-15V Aux-Power</th>
<th>Controller Board CANbus Micro Processor</th>
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<tr>
<td>A</td>
<td>passed</td>
<td>passed</td>
<td>passed</td>
<td>fails</td>
<td>passed, excl. CAN</td>
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<tr>
<td>B</td>
<td>passed</td>
<td>passed</td>
<td>passed</td>
<td>passed</td>
<td>New Module</td>
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<tr>
<td></td>
<td>New Module</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>passed</td>
<td>passed</td>
<td>passed</td>
<td>not tested</td>
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<tr>
<td>D</td>
<td>passed</td>
<td>not tested</td>
<td>not tested</td>
<td>passed</td>
<td>SEE 3,1krad 3x Power Cycle for passing</td>
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<td>E</td>
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**A-D equipped with DAC-Regulatorboards, E with TrimPot**

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All tests under responsibility of Cern Member

A-D equipped with DAC-Regulator boards, E with TrimPot
Rad Tolerant redundant Converter

- quasi-redundant principle of power conversion
- sharing operating voltage
- each is able to handle the power management alone
MARATON B-Field Test

CERN Magnet Facility, Hall 887, EHNI, Prevesin

Tests made by Bruno Allongue, CERN
MARATON B-Field Test

MARATON Test Device

Modular configuration:

Uo: 5V 100A
U1: 5V 100A
U2: 3.3V 200A
U3: 48V 12A
U4: 5V 100A

Input 385VDC

Ext. Monitoring
MARATON B-Field Test

- X-direction (front-rear)
  Knee-point at 1567.5 G

- Y-direction (horizontal)
  Knee-point at 1280.6 G

- Z-direction (vertical)
  Knee-point at 1867.6 G
MARATON Screening Technology

- Iron box hosting (sealed) choke and transformer for one channel
- Coils for 60A peak current are displayed
Monitoring and Control

Power supplies with embedded controller

- All PS parameters programmed (=> calibration + setup via software / network RS232, CAN-bus, Ethernet)
- Programmable current limits and over- / under voltage trip off points
- Fully self protected (over temp, over load, OC, UV, OV, …)
- Firmware updates via software / network (RS232, CAN-bus, Ethernet)
Monitoring and Control
TCP/IP over Ethernet SNMP

- SNMP is a well defined protocol
- Presently version 2c is in use
  (access control with community names)
- Different access rights
- Many utilities available (Windows/Unix, ):
  Command Line (Batch files),
  PERL,
  PHP (stand alone or in the APACHE WEB-server)
Monitoring and Control
TCP/IP over Ethernet SNMP

Control by SNMP Command Line Tools (www.net-smnp.org)

C:\>snmpget –v 2c –m +WIENER-CRATE-MIB –c puplic 192.168.91.80 outputMeasurementSenseVoltage.U1

WIENER-CRATE-MIB::outputMeasurementSenseVoltage.U1 = Opaque: Float; 12.020000 V

C:\>snmpget –v 2c –m +WIENER-CRATE-MIB –c guru 192.168.91.80 outputVoltage.U0  F4.0

WIENER-CRATE-MIB::outputVoltage.U0 = Opaque: Float; 4.000000 V
Monitoring and Control
TCP/IP over Ethernet

- Pass word protected instruction buttons
- HTTP - Port 80: WWW Interface Pass Word protected
- TCP/IP - Port 69: Special WIENER protocol to access all data
- TELNET - Port 23: Connection to other RS232 ports only
Monitoring and Control

- Open software systems: **OPC server** (OLE for Process Control / Win NT/2k) for CAN-bus
- Available at CERN

Basic design: University of Krakow
MARATON Basic Configuration

Input: 385 V DC, 10 A

EMI Input Filter
FIM

Rectifier
(For Lab
-AC Operation)

385 V DC

Auxiliary Power
MAM

DC-DC Converter
MDM
max. 2*6 Channels

Output: Up to 12
independent channels

Mezzanine-
space

Basic Control
Clock and Powerfail

LHC Sept 04
MARATON  Basic Control

- Clock generation and power fail detection only
- Automatic switch on after input power is applied
- Switch off (by the regulator boards) in case of OVERVOLTAGE or OVERTEMPERATURE
- No other remote control or failure detection foreseen
MARATON Control with Parallel Interface

Input: 385 V DC, 10 A

- EMI Input Filter (FIM)
- Rectifier (For Lab-AC Operation)
- Auxiliary Power (MAM)
- DC-DC Converter (MDM max. 2*6 Channels)

Output: Up to 12 independent channels

External Switches and Measurement

Mezzanine-Board

Basic Control and Observation (MORT)
Parallel Interface (ext. Monitoring)

- Each sense line is connected to the ParIF connector via a protection resistor.

- A combined STATUS / Switch On - line is available for each channel.

- All signals of 6 channels are fed to an 37-pin Sub-D connector.

- Monitoring connection via 40-pin shielded round cable per 6 channels, twisted-pair. The outer diameter of a halogen-free (AWG26) cable is 12 mm.
External Monitoring Module

VME Size

- VME monitoring board for 6 channels with display
- 12 channel module with two Sub- d connectors (no display)
- Both can be used in standard VME /VME64x crates
- Special version with information interchange via J2
MARATON Control with CAN & TCP/IP-Interface

Input: 385 V DC, 10 A

EMI Input Filter FIM

Rectifier (For Lab-AC Operation)

Processor Control CANIF/TCP/IP

Mezzanin Board

Basic Control and Observation MORT

385 V DC

Auxiliary Power MAM

DC-DC Converter MDM max. 2*6 Channels

Output: Up to 12 independent channels

CAN/TCP/IP-Connection
Can Interface (CanIF) Description

- Redundant micro controller system (to be protected against SEE)
- All voltages, currents and temperatures are measured
- Separate status comparator can switch off bad channels in case of over voltage, under voltage or over current
- All information are transferred by CAN bus (2 wires) to the protected zone, TCP/IP could be an option, too
- Development + RAD tests continues
Acknowledgement

We would like to express our very special thanks to Bruno Allongue for his help, assistance and execution of many radiation and B-field tests at CERN and abroad. Also we are indebted to Ivan Hruska who helped us with the first radiation tests as well as Urs Vogt from Elcotron for all his efforts to arrange first TCC2 tests.

References

- B. Allongue, Magnetic field test results for a Wiener Maraton power supply, CERN PH/ESS, May 17, 2004