Date Prepared: April 13, 2004

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Location: MINOS Near Detector Hall (Underground)

Equipment: The MINOS Near Detector front-end, clock, high voltage, readout and data-acquisition system. This includes 4 racks of commercial equipment, and 35 racks of VME and NIM electronics designed by the MINOS project.
OVERVIEW
Floor plan

- Floor Level Rack
- Platform Level Rack
- East Wall
- North-East Stairwell
- MINOS DETECTOR PLANES
  - Front End
  - Readout
  - MINOS DETECTOR PLANES
  - DAQ
  - Timing System

Not to scale

Network

HV
**Racks**


1 Network Rack: Commercial Network routers, switchers

3 DAQ Rack: 6 commercial PCs each for the Data Acquisition and Detector Control systems. 1 PowerWare 5125RM UPS each. 1 APC 9218 Power Distribution Unit each.

1 Timing Rack: 9U VME Crate (Schroff) with CES RIO3 8064CB processor and MINOS Electronics. Lantronix UDS-10 Serial-Ethernet Converter. Ortec NIM Bin with MINOS Electronics PC, as in DAQ rack. GPS Receiver: Truetime 142-612.

8 Readout Racks (MASTER): 9U VME Crate with CES RIO3 8064CB processor and MINOS electronics. Rack Protection System. Lantronix UDS-10 Serial-Ethernet Converter. MINOS MASTER Fan Pack with External 12VDC supply for tachometer circuit. MINOS LED Pulser Box (in 3/8 racks)

26 Front End Racks: 2 6U VME Crate with MINOS electronics. 2 VME Power Supply. Rack Protection System. 2 MINOS MINDER Fan Packs. Up to 8 MINOS Near Detector PMT boxes.
SAFETY SYSTEMS AND PROCEDURES

Fusing

Fusing of power supplies and crates is described in the DC Power Distribution section.

Power Supply Procedures

Power supply current and voltage limits are set according to a procedure outlined in APPENDIX A.

Rack Turn On Procedure.

Racks are energized according to the procedure given in APPENDIX A.

Power Supply Covers

The racks are enclosed for normal operations. In the event that the power supply output connections on the MASTER and MINDER power supplies are shielded from accidental contact by plastic covers. The VME Timing crate power supply and crate backplane are shielded by a single cover.

Rack Protection System and Rack AC Power Distribution

The Rack Protection System (RPS) and its role in AC Power Distribution within each HV, MINDER (Front End) and MASTER (Readout) rack is described in the remainder of this section.
Rack Protection System and AC Power Distribution

RPS Controller: The RPS Controller, based on the Byra 8884 (http://www.bira.com/cat/rps.htm), uses input from rack status sensors to control a permit for the rack AC Relay. The controller is a commercial product, but modified by the manufacturer for the specific application required by MINOS. Further modifications have been made by MINOS to bypass the internal switcher DC power supply with an external linear supply (APPENDIX C). Schematics of both the original design and the power modifications can be found in
APPENDIX B. The RPS controller takes 120V from a line external to the rack.

Remote Sensing:

The RPS Controller has an Ethernet interface that allows remote sensing of its Warning and Alarm conditions.

AC Relay:

All power to the rack, other than that used to power the RPS Controller, is provided through the Byra model 8880-208/120 AC Relay. There are two independent circuits: a 120V 5-20P Input feeds two 5-20R outputs via a 20 A circuit breaker, and a 208V input feeds 1 (MASTER) or 2 (MINDER) 208 V L6-20R outputs. The outputs are only energized when a permit is supplied by the RPS Controller. The Timing system rack does not use an RPS or AC relay.

Sensors:

The following sensors are required to be in normal state for the RPS controller to issue the AC Relay Permit:

- Smoke Detectors (System Sensor model 1412) (1 per MASTER Crate, 1 per Light Injection Box, 1 per MINDER Crate, 1 per HV Rack)
- Air Flow/Temperature/Humidity (AFTH).
- Drip sensor below the plumbing.

A fan speed monitor causes a warning condition in the RPS controller, which does not affect the AC Relay Permit.

The smoke detector and AFTH are active, operating at +12 and +/-12 V, respectively. The RPS controller senses the resistance of the fan failure circuit.

Fan Trays:

Both MASTER and MINDER crates are air cooled with fan trays supplied by MINOS. In the MASTER version, 4 ??model number?? fans are powered by 120V. The fan failure circuit ??pn?? schematic is included in
appendix ??. The MINDER version uses ??how many?? ??p/n??, monitored by the circuit shown in appendix??
RPS SYSTEM LOGIC SKETCH

AC 120V Line In

Warning

AC Permit

Smoke
AFTH
AFTH
Drip

Fan Fail

RPS Controller

AC Out

L6-20R

5-20R

AC Relay

AC Line In

208V/20A

120V/20A
MINDER (FRONT END) SYSTEM
Rack overview

Note:

Racks U10, U12, U13, and V10, V11, V12, V13 have only 1 crate each.

Enclosure:

Racks are enclosed on all sides, except for a filtered air input near the bottom, and on the bottom, except for a hole cut to allow cables to pass in some racks. The tops are open.
PMT Boxes:

Designed and built by MINOS. No safety concerns were identified in a January, 2002 review. See APPENDIX C.

Plumbing:

(Not shown above) Cooling water runs through heat exchanger to cool air, and underneath PMT box shelves to moderate PMT temperature fluctuations.

6U VME Crate:

Described in detail below.

PMT Cables:

(Not shown above) 1 m long RG-174 cables connect PMT Dynode output to KEEPER Dynode trigger input. 1m long bundles of up to 64 RG-174 cables connect each PMT to up to 4 MINDER aux cards. See APPENDIX D.
Crate and Components

Crate:

6U VME manufactured by Pentair/Schroff, with custom J2 backplane designed to MINOS specification by the manufacturer. (A previous iteration, designed by MINOS, was internally reviewed. See APPENDIX C for this and reviews of the following modules.)

KEEPER Module:

Designed by MINOS, it occupies the leftmost slot. It serves as an interface for the corresponding MASTER module to control the crate.

KEEPER Auxiliary:

Passive PCB designed by MINOS. It plugs in to the backside of the backplane, in the same slot as the KEEPER. It feeds signals between the MASTER-KEEPER cable and the KEEPER.

MINDER:

Designed by MINOS. This is the Front End Mother board, housing 16 MENU daughter cards. MENU is the basic channel unit of the MINOS Near Detector readout. Up to 16 MINDERs occupy a MINDER crate.
**MINDER Auxiliary:**

Passive PCB designed by MINOS. One per MINDER plugs into the backside of the backplane, to feed PMT output signals into the MINDER.

**PIN Diode Auxiliary:**

Active auxiliary PCB designed by MINOS. Each card contains up to 16 PIN Diodes. The PIN diodes take optical fibers as input, and provide analogue output signals for digitization in the MINDER/MENU modules. Rack FE U11 only.

**MINDER TIMING MODULE (MTM):**

A double width PCB module designed by MINOS. It provides timing signals to the KEEPERs and MINDERs.
MASTER (READOUT) SYSTEM
**Rack overview**

<table>
<thead>
<tr>
<th>Without Light Injection Box</th>
<th>With Light Injection Box</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoke</td>
<td>Smoke</td>
</tr>
<tr>
<td>RPS Controller</td>
<td>Light Injection Box</td>
</tr>
<tr>
<td>Filter</td>
<td>AC Relay</td>
</tr>
<tr>
<td>Power Supply</td>
<td>Filter</td>
</tr>
<tr>
<td>VME Crate</td>
<td>VME Crate</td>
</tr>
<tr>
<td>Fan Pack</td>
<td>Fan Pack</td>
</tr>
<tr>
<td>AC Relay</td>
<td>Filter</td>
</tr>
<tr>
<td>AFTH</td>
<td>AFTH</td>
</tr>
</tbody>
</table>

**Enclosure:**

The Platform level rack sides, front, and back are totally enclosed above the bottom of the VME crate. For racks with Light Injection Pulser Boxes, the sides, front, and back are totally enclosed above the bottom of the VME crate, except for the back, which is open above the bottom of the Light
Injection box. There is a second smoke detector in this rack below the Light Injection box.

**Fan Packs:**

Designed and built by MINOS. Schematics are shown in Appendix.

**Power Supply:**

Wiener Plein & Baus model PL 6021. 19” x 3U power chassis. DC outputs: +5V/230A, +3.3V/115A, +12V/46A, -12V/46A.

**Light Injection Box:**

Designed and fabricated by MINOS. LI Box consists of LEDs for MINOS Light Injection system. Powered by internal 110V supply. The LI box design underwent an internal review in May, 2001, and all resulting recommendations were accepted and implemented (APPENDIX C).
Crate and Components

Crate:

Wiener UEV6021 9U VME. The backplane J1 line B21 has been severed, to bypass the factory termination on this line. A connector with a 33Ohm resistor between B21 and Ground (and no other components) will be inserted into slot 2 to terminate this line, which is used in MINOS to carry a 26.5 MHz clock signal.

Processor:

Rio Co. VME processor in a 6U support

MASTER Modules:

VME Readout Boards designed by MINOS, at most 12 per crate. The MASTER board was internally reviewed in Nov. 2002, and the resulting recommendations were implemented in the final design. See APPENDIX C for reviews of all PCBs.
MASTER Auxiliary Cards:

Designed by MINOS, they are a passive interface between the MASTER module and a control module in the Front End (MINDER) crates.

VME Timing Module (VTM):

Designed by MINOS, it controls and distributes timing signals within the MASTER crate. It resides in the rightmost slot.
TIMING SYSTEM
9U VME Crate (Timing Crate):

Described in detail below.
NIM BIN:

Described in detail below.

GPS Receiver:

Truetime 142-612 Connected via RG58 to LAN Rack.

Timing Rack Interconnects:???
GPS Fanout:

Designed and built by MINOS. Fans out GPS timing information from GPS receiver to Master Timing Module in VME timing crate, and to the VME Timing Module (VTM) in each MASTER crate. See APPENDIX C.
**VME Crate and Components**

**RIO VME Processor**

**Master Clock Controller (MCC)**

**Master Clock Fanout (MCF)**

**VME Crate**: A standard 9U VME crate, modified how???

**MCC**: Designed by MINOS. Uses input from GPS receiver and AD Controls Signals to generate timing signals for Front End and Readout System. See APPENDIX C.

**MCF**: Designed by MINOS. Receives timing signals from MTM on VME bus. Fans signals out to 16 front-panel RJ-45 connectors, for transmission to VTM and MTM. See APPENDIX C.
DC POWER DISTRIBUTION
OVERVIEW

The general configuration of the power distribution for the Near Detector front end electronics is shown in Fig. 1. All cards and subcomponents in the system have this same general configuration.

Fig. 1. General Power Distribution Scheme
For Near Detector Front End Electronics
POWER HARNESSES

The power supplies are commercial supplies made by Weiner, Model 6021. A wiring harness connects the power supply to the crate. Fuses F1 and F2 are external to the power supply. They are sized for the wire gauge of the harness, since the supplies can generally put out more power than the rating of the wires in the harness. In some cases, multiple wires are used in the power harness for a given voltage. When multiple wires are used, each wire is individually fused as shown. In all cases, the number and size of return conductors equals the number and size of the source conductors. Harness fusing and cable gauges are shown in the following drawings.
Figure 1: MINDER (Front End) Power Harness

NOTES:
1: All harness wiring will be 10 AWG Weico Style 3210 or equivalent. 105deg C; passing vertical flame test VW-1 FT1
2: Each back plane power connector (bug) is rated for 30 Amps.
Figure 2: MASTER (Readout) Power Harness

Note: All Sensing wires are 24 AWG. VME Crate has internal current limiting resistors rated at 1Amp.
Figure 3: Timing VME Crate Power Harness

All fuses are
Quick-Blow Glass
Enclosed, Ferrule Contact,
250V., Littlefuse type 3AG

Crate Backplane

ALL WIRES
18 AWG

6A 6A 6A 6A 6A

+5V/25A +12V/9A -12V/0.3A RETURN

Power Supply
PCB FUSING

Power is distributed on crate backplanes through the use of power planes. The front end cards connect to the power plane through the use of DIN connectors. The different cards have a different number of power pins for each voltage. The pins for a given voltage are connected together at the input to the card, and then routed to a fuse, one fuse for each voltage. Fuses F3 and F4 are sized based on the rating of the pins and the total number of pins used for each voltage. The pins for the power returns come from a common plane on the cards. Generally, the number of return pins equals or exceeds the sum of the power pins. In the cases where there are separate digital and analog voltages, the analog voltages share a common set of return pins, while the digital voltage has a separate set.

Details for the specific front end cards are provided in the tables that follow.

Power Distribution Parameters for the MASTER

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Power Supply</th>
<th>Power Harness</th>
<th>Backplane Connector</th>
<th>Card</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size</td>
<td>Wire</td>
<td># Wires</td>
<td># Wires</td>
</tr>
<tr>
<td></td>
<td>F1/F2</td>
<td>Gauge</td>
<td>Source</td>
<td>Return</td>
</tr>
<tr>
<td>+5V</td>
<td>NONE</td>
<td>00</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1. Power Distribution Parameters for the MASTER

Power Distribution Parameters for the MINDER

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Power Supply</th>
<th>Power Harness</th>
<th>Backplane Connector</th>
<th>Card</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size</td>
<td>Wire</td>
<td># Wires</td>
<td># Wires</td>
</tr>
<tr>
<td></td>
<td>F1/F2</td>
<td>Gauge</td>
<td>Source</td>
<td>Return</td>
</tr>
<tr>
<td>+12 V</td>
<td>25 A</td>
<td>10 Ga.</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>+5 V Ana</td>
<td>25 A</td>
<td>10 Ga.</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>+3.3 V</td>
<td>25 A</td>
<td>10 Ga.</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>-5 V</td>
<td>25 A</td>
<td>10 Ga.</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>-12 V</td>
<td>25 A</td>
<td>10 Ga.</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>+5 V Dig</td>
<td>25 A</td>
<td>10 Ga.</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 2. Power Distribution Parameters for the MINDER

Power Distribution Parameters for the KEEPER
### Table 3. Power Distribution Parameters for the KEEPER

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Power Supply</th>
<th>Wire</th>
<th># Wires</th>
<th>Source</th>
<th># Wires</th>
<th>Return</th>
<th># Pins</th>
<th>Total Ampacity</th>
<th># Pins</th>
<th>Return Ampacity</th>
<th>Source</th>
<th># Pins</th>
<th>Card Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>+12 V</td>
<td>Power Supply</td>
<td>25 A</td>
<td>2</td>
<td>10 Ga.</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>4.5 A</td>
<td>20 (Analog)</td>
<td>1 A</td>
<td></td>
<td></td>
<td>1 A</td>
</tr>
<tr>
<td>-5 V</td>
<td>Power Supply</td>
<td>25 A</td>
<td>1</td>
<td>10 Ga.</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4.5 A</td>
<td>20 (Analog)</td>
<td>1 A</td>
<td></td>
<td></td>
<td>1 A</td>
</tr>
<tr>
<td>-12 V</td>
<td>Power Supply</td>
<td>25 A</td>
<td>1</td>
<td>10 Ga.</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4.5 A</td>
<td>20 (Analog)</td>
<td>1 A</td>
<td></td>
<td></td>
<td>1 A</td>
</tr>
<tr>
<td>+5 V Dig</td>
<td>Power Supply</td>
<td>25 A</td>
<td>2</td>
<td>10 Ga.</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4.5 A</td>
<td>7 (Digital)</td>
<td>2 A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 4. Power Distribution Parameters for the VTM

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Power Supply</th>
<th>Wire</th>
<th># Wires</th>
<th>Source</th>
<th># Wires</th>
<th>Return</th>
<th># Pins</th>
<th>Total Ampacity</th>
<th># Pins</th>
<th>Return Ampacity</th>
<th>Source</th>
<th># Pins</th>
<th>Card Size</th>
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</thead>
<tbody>
<tr>
<td>+5 V</td>
<td>Power Supply</td>
<td>NONE</td>
<td>00</td>
<td>6 Ga.</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>9 A</td>
<td>47 (total)</td>
<td>2.5 A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+12 V</td>
<td>Power Supply</td>
<td>NONE</td>
<td>6 Ga.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.5 A</td>
<td>47 (total)</td>
<td>1 A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-12 V</td>
<td>Power Supply</td>
<td>NONE</td>
<td>6 Ga.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.5 A</td>
<td>47 (total)</td>
<td>1 A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 5. Power Distribution Parameters for the MTM

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Power Supply</th>
<th>Wire</th>
<th># Wires</th>
<th>Source</th>
<th># Wires</th>
<th>Return</th>
<th># Pins</th>
<th>Total Ampacity</th>
<th># Pins</th>
<th>Return Ampacity</th>
<th>Source</th>
<th># Pins</th>
<th>Card Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5 V</td>
<td>Power Supply</td>
<td>25 A</td>
<td>10 Ga.</td>
<td>2</td>
<td>2</td>
<td></td>
<td>3</td>
<td>4.5 A</td>
<td>9</td>
<td>2 A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 6. Power Distribution Parameters for the PIN Diode Auxiliary Card

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Power Supply</th>
<th>Wire</th>
<th># Wires</th>
<th>Source</th>
<th># Wires</th>
<th>Return</th>
<th># Pins</th>
<th>Total Ampacity</th>
<th># Pins</th>
<th>Return Ampacity</th>
<th>Source</th>
<th># Pins</th>
<th>Card Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5 V</td>
<td>Power Supply</td>
<td>25 A</td>
<td>10 Ga.</td>
<td>2</td>
<td>2</td>
<td></td>
<td>3</td>
<td>4.5 A</td>
<td>3</td>
<td>1 A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-5 V</td>
<td>Power Supply</td>
<td>25 A</td>
<td>10 Ga.</td>
<td>1</td>
<td>1</td>
<td></td>
<td>3</td>
<td>4.5 A</td>
<td>3</td>
<td>1 A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-12 V</td>
<td>Power Supply</td>
<td>25 A</td>
<td>10 Ga.</td>
<td>1</td>
<td>1</td>
<td></td>
<td>3</td>
<td>4.5 A</td>
<td>5</td>
<td>1 A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SYSTEM INTERCONNECTS
Not Shown:
- Multiple Ethernet connection from Gateway rack to each rack
- Optical Fibers From Detector to PMTs
- Optical Fibers from Light Injection to Detector
HV:
LeCroy HV – PMT Box (up to 8 to each MINDER Rack)
RG-58/U FT6 Plenum Rated
P/N: Belden 82240
Length: variable

Digital Data:
MINDER-MASTER (12 Max/MASTER crate)
KEEPER- MASTER AUX (1/crate)
28AWG 64 Pair (UL) CL2
P/N: 3M 3644B/68
Length: 30’

PVIC: (PCI to PCI transparent Vertical Interconnection)
DAQ Racks to MASTER Crates
Optical: 62.5/125 um OFNR, NEC-770, ??m
Copper: Furukawa AWM 2789, VW-1, 10m

Timing:
MCF (Timing Crate) – VTM (MASTER Crates)
MCF (Timing Crate) – MTM (MINDER Crates)
Belden?? Type/rating
Length: 60’

LED Monitoring:
Light Injection Box – PIN MINDER Aux Card (22 Max.)
Light Injection Box – “trigger PMT” (1)
EHV 4001 Optical Fiber
Length: varies

Ethernet:
Network rack to each RPS (4)
Network rack to each VME processor (3)
Belden 1752-A RJ-45 (UL 1581)
Length: 30
APPENDIX A

SAFETY PROCEDURE DOCUMENTS
The following attached document is the written procedure followed when current and voltage limits are set on the MINDER (Front End) and MASTER (Readout) power supplies.
The following attached document is the written procedure followed when energizing a rack for the first time, or following substantial work on the rack.
The following document shows the Byra RPS controller schematic provided by the manufacturer.
The following document shows the modifications made to bypass the internal Byra controller power supply with an external one.
APPENDIX C

Internal Safety and Quality Control Reviews
Comments and summary from the MINOS internal safety and quality control review for the PMT boxes follow.
Comments and summary from the MINOS internal safety and quality control review for the Byra RPS controller power modification follow.
Comments and summary from the MINOS internal safety and quality control review for the PIN Diode Auxiliary cards follow.
Comments and summary from the MINOS internal safety and quality control review for Printed Circuit Boards follow.
Comments and summary from the MINOS internal safety and quality control and review for the LED Light Injection Pulser boxes follow.
Comments and summary from the MINOS internal safety and quality control review for the MINDER Crate J2 backplane follow.
APPENDIX D

CABLE Safety
The following table shows the cables listed in the MINOS Near Detector electronics system.
Comments and summaries of safety reviews by the ES&H cable experts follow.