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# Power Supply Assemblies

**for the VIPA Subracks at CDF**

**Specification # CDF / SO-040798**

**Stanley Orr, PE**
**July 1998**

**Approved :** ____________________

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**Specification**

**Power Supply Assemblies for the VIPA Subracks at CDF**

## 1. General

**Power Supply Assemblies**, to meet the DC power requirements of VIPA Subracks ( Crates )of the Collider Detector Facility, are described here.
Each **Power Supply Assembly** shall consist of :

(1) A **3U ventilated enclosure** (box) for relay rack mounting (19"), with a front panel, circuit breaker, power and control connections, and status lights.
(2) **Multiple Output Voltage Power supplies**, with voltage(s) and currents(s), chosen to meet the requirements listed on two tables of "VIPA Subrack Types, Quantities, and Power Requirements" below, and installed in the enclosure.
(3) A **remote data acquisition and serial RS-485 communications** card(s) to monitor the DC voltages and status of the power supplies.

The power supplies and monitoring cards shall be assembled, installed and wired in the enclosure of the **Power Supply Assembly** and tested as a single integrated unit.
Each VIPA subrack shall be powered from one **Power Supply Assembly**. The requirements listed in the table below are to be met with the smallest practical number individual power supply types and sizes. The power supplies should be of broad practical ranges to minimize the number of types**.** The supplier is asked to creatively combine multiple output voltage supplies so that a small number of **Power Supply Assembly 'models'** will serve all 28 different types of VIPA subracks. The electrical input and the physical packaging of all power supply assemblies is the same. The front panel will have a main circuit breaker, status lights, and diagnostics. Input and output voltage terminals shall be on the back, along with sense and control wiring. Local and remote monitoring is specified.

## 2. The "VIPA" Subrack ( Crate )

This paragraph is minimal contextual background information about the VIPA subrack. The VIPA subrack is a 10U VME type card cage. Information about the VIPA subrack is available at ftp://www-ppd.fnal.gov/ett_ftp/Cdf_docs/CDF2388 " A Standard Frontend and Trigger VMEbus based readout crate for the CDF Upgrade : The CDF Readout Crate". The specification covers backplane connectors, electrical and mechanical specifications - power supplies are not included. The power supplies specified herein are for the particular requirements of the VIPA subracks at the Collider Detector Facility.

**3. VIPA Subrack ( Crate) Types, Quantities, and Power Requirements**
The CDF VIPA subracks and their **Power Supply Assemblies** will be installed in two locations - the **CDF COUNTING ROOMS** and the **CDF COLLISION HALL.**
**Table 1 - CDF COUNTING ROOMS - POWER SUPPLY ASSEMBLY REQUIREMENTS** specifies the output ratings of the power supply assemblies which will constitute the **First Phase** of the purchase of this specification.
**Table 2 - CDF COLLISION HALL - POWER SUPPLY ASSEMBLY REQUIREMENTS -** these units are to be quoted as a **Second Phase Option,** to be exercised by Fermilab up to 120 days after delivery of the **First Phase** units. The following tables show the VIPA subrack Crate Types ( by name), the number of each type of crate, and the DC voltages and currents to be supplied by the **Power Supply Assemblies**, at the two locations.

**Table 1 - CDF COUNTING ROOMS**
**POWER SUPPLY ASSEMBLY REQUIREMENTS**

| | | | POWER SUPPLY RATINGS | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Crate Type** | No. of Crates | **+3.3 V** | **+5 V** | **+12.0 V** **Amperes** | **-12.0 V** | **-2.0 V** | **-5.2 V** | No. of Voltages |
| CMU Muon TDC | 2 | | **285** | **2** | | | **32** | 3 |
| CMP Muon TDC | 1 | | **297** | **2** | | | **35** | 3 |
| CSP-CSX-WMS Muon TDC | 1 | | **338** | **2** | | | **37** | 3 |
| CMX Muon TDC | 2 | | **285** | **2** | | | **32** | 3 |
| Hadron TDC | 1 | | **348** | **2** | | | | 2 |
| XFT Finder | 3 | | **273** | | | | | 1 |
| XFT Linker | 3 | | **261** | | | | | 1 |
| Muon Trigger | 1 | | **483** | **2** | | | | 2 |
| XTRP | 1 | **250** | **209** | | | **40** | **40** | 4 |
| DAQ VRB | 6 | | **76** | | | | | 1 |
| SVX VRB | 6 | | **142** | **2** | **2** | | | 3 |
| ISL VRB | 3 | | **160** | **2** | **2** | | | 3 |
| | *30* | | | | | | | |
| L1 Calorimeter | 6 | | **229** | | | | | 1 |
| L1 Decision | 1 | | **87** | | | | **12** | 2 |
| L2 Calorimeter | 6 | | **289** | **19** | | | | 2 |
| L2 Decision | 2 | **53** | **243** | **23** | **6** | | **12** | 5 |
| L2 Control | 1 | | **36** | **4** | | | | 2 |
| TSI | 1 | | **83** | | | | **12** | 2 |
| Trigger XPT | 1 | | **52** | | | | **87** | 2 |
| Done-Error-Busy XPT | 1 | | **87** | | | | | 1 |
| Scalers | 1 | | **64** | | | | | 1 |
| SVT Hit Finder | 6 | **40** | **296** | | | | | 2 |
| SVT Merger | 1 | | **80** | | | | | 1 |
| SVT Track Fitter | 1 | **80** | **240** | | | | | 2 |
| | *28* | | | | | | | |

**Table 2 - CDF COLLISION HALL**
**POWER SUPPLY ASSEMBLY REQUIREMENTS**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | **POWER SUPPLY RATINGS** | | | | |
| **Crate Type** | No. of Crates | **+3.3 V** | **+5 V** | **+12.0 V** | **-12.0 V** | **-2.0 V** | **-5.2 V** | No. of Voltages |
| | | | | **( Amperes )** | | | | |
| COT TDC | 24 | | **413** | **2** | | | | 2 |
| SVX FIB | 4 | | **269** | | | | **120** | 2 |
| ISL FIB | 4 | | **189** | | | | **84** | 2 |
| IMU Muon TDC | 4 | | **222** | **2** | | | **24** | 3 |
| | *( 36 )* | | | | | | | |

Note : Power supplies may be paralleled, with full current sharing, but individual loads shown above cannot be "split". For example, "SVT Track Filter, 240amps@5Vdc needs minimally a 240amp supply.

## 4. Standards

Power supplies shall comply with Conducted and Radiated Emissions Standards according to IEC61000 and shall bear the CE Mark. The Power Supply Assemblies shall comply with applicable sections of the National Electrical Code. NEMA and ANSI standards shall govern the use of components to which they apply.

## 5. Physical Packaging Specification

The **Power Supply Assemblies** required by each VIPA subrack application ( example : SVX FIB or Hadron TDC ) shall consist of power supplies and monitoring cards installed in a 19" relay rack ventilated enclosure, with a 3U ( 5.25") high front panel and 19" total depth. The power supply fan shall exhaust to the rear. Slit louvers on the top, sides and bottom shall allow air into the supply. No air entrance is possible through the front panel of the **Power Supply Assembly**. The space within the 'relay rack ventilated enclosure' shall contain the power supplies, the protection for the incoming line and routing for wiring to output terminals. Space shall also be allocated to local diagnostics and remote monitoring .

## 6. Circuit breaker

The power supply shall be equipped with a line input, three pole, circuit breaker, 20amp rated, mounted on the front panel, with 10000amp min. interrupting capacity. An optional 'undervoltage release' with 24V coil may be required later and purchased as a replacement circuit breaker . The 'footprint' for this undervoltage release circuit breaker needs to be planned in this space. Power supplies inside the Power Supply Assembly may have additional line fuse protection as required.

**7. High reliability Power Supplies**

The power supplies shall be of rugged construction and conservative electrical component ratings. Power terminal studs shall be robust. A minimum 200000hour MTBF, according to MIL-HDBK-217 ( current revision). shall be demonstrated by the manufacturer for the power modules and a two year guarantee provided. A quality assurance program for the entire design shall be provided.

**8. Electrical Input**

The power supplies shall operate on nominal 208V, 60Hz and 400Hz mains, THREE phase, with standard utility regulation (IEEE Std1100-1992.(p.47)) . Each supply shall have a cord and plug connection rated for 20Amp. The cord conductors shall have properly color coded phase conductors and a green safety ground. A line cord (approx. 3ft) and plug shall be provided.

**9. Output Voltages**

All output voltages shall have independent terminals for supply and return, appropriately marked. Output screw terminals shall be arranged along the back of the supply. The output terminals shall be arranged to correspond to the VIPA subrack terminals they supply. The spacing of the terminals shall allow for the easy separation of and connection of cables with compression type connectors. Each pair of supply terminals shall have a corresponding set of sense leads. The supply shall operate normally without sense connection. Sense lead operation shall not be degraded by the use of an optional protective 10k resistor placed near the load. Output power modules designed for parallel operation shall have full current share capability without increase in ripple or noise. The power supply output voltages shall all be independent of each others load. The power supply shall comply with noise specifications at full load and down to at least 10% load without degradation in performance.

**10. Cooling**

The power supplies shall have their own forced air cooling. High reliability fans shall be used. They shall be sized to account for flow impedances of the ‘relay rack’ enclosure, such as the inlet vents on the top, bottom and sides. No air flow through the front panel is possible. Rear exhaust through a fan grill is assumed. An ambient temperature of 20C is expected and the power supply shall operate without derating to at least 40C.

**11. Electrical Noise Specification**

Other requirements of this specification regarding efficiency, power density, and power factor will require the use of switching , rather than linear, supplies. The matching of the sensitive loads to switching supplies is a serious concern to the load designers. The criteria for noise on the voltage outputs is :

Digital 5v - PARD not to exceed 1% ( mv RMS )

( Measure PARD with the following : (1) Oscilloscope with 20MHz BW limit switched on. (2) X1or X10 scope probe with ground clip and spring loaded clip removed.(3) Ripple and noise harness consisting of 12” long #20AWG twisted pair, connect one end to load,

place 3.3-4.7uF Electrolytic and 0.1uF Ceramic or Mylar in parallel at other ( measuring) end. Observe polarity ! )
Power supplies shall comply with Conducted and Radiated Emissions Standards according to IEC61000 and shall bear the CE Mark

The topology of the switching supply, the switching frequency , the derivation of secondary voltages, and other design choices shall be made to minimize output noise. Post-filtering shall be a considered option. The performance of a prototype supply will be analyzed and its affect on the overall performance of the integrated system will be studied with the supplier.

**12. Efficiency and Power Factor and Harmonics**
A demonstrated 80% efficiency is required ( 70% efficiency for 3.3V and 2V). The line power factor shall be better than 0.9. Power quality preservation and harmonic content allowance shall follow guidelines of IEEE Std1100-1992 , ANSI/NFPA 75-1992 and FIPS PUB 94

**13. Line regulation**
A line regulation response of 0.25% output voltage is required for power input according to IEEE Std1100-1992.(p.47)

**14. Load Regulation**
A load regulation of 0.25% output voltage is desired for a 30% output load step

**15. Local Status**
Lights on the front panel of the power supply assembly shall locally indicate the status of the following operating conditions:
For the Power Supply Assembly - one light each
- AC On
- Overtemperature

For each DC output voltage (module) - one light each
- DC On / Power Good
- DC Overvoltage / DC undervoltage
- DC Overcurrent

The alarm annunciation of Overtemperature, Overvoltage, Undervoltage, and Overcurrent shall be latching, requiring ‘reset’ to clear. An AC reset for overtemperature trip is acceptable.

**16. Remote Monitoring**

A PC based, serial communication scheme shall be employed to monitor the **Power Supply Assemblies**. In addition to the Local Status, the monitor system shall encode the DC voltage of each output with at least 12bit resolution. The data serial acquisition device installed in each power supply assembly shall each have a unique address for extended RS485 networking ( 128 devices per port). It shall be powered independently of the power supply assembly power circuit.

Two implementation options for the monitoring system are requested from the power supply assembler. The hardware for each of the two options is listed below along with address of manufacturers. The **Power Supply Assembly** builder/ assembler will provide ‘shop drawings’, with costs, for the two options, and submit for approval. The hardware modules listed below will be installed in each power supply assembly box.

1. Monitoring with DGH Data Acquisition Modules
   Model D5000 for monitoring four analog voltages and Model D1700 for 15 bits of digital I/O. ( DGH, PO Box 5638, Manchester, New Hampshire 03108 Tel (603) 622-0452 Attn: David Reid / Product also supplied by Omega, Industrial Computer, and Data Forth /Burr-Brown)
2. Monitoring with B&B Data Acquisition Modules
   Model 48SDA12 for monitoring analog voltages and Model 48SDD16 for 16 bits of digital I/O. ( B&B Electronics, PO Box 1040, Ottawa, Il. 61350 Tel (815) 433 - 5100 Attn: Mark Konwinski)

It is required that the wiring of the voltage monitoring, internal to the power supply assembly, be made in a manner that will not create ‘ground loop’ paths or allow noise susceptibility. This wiring will be carefully done with Fermilab input.

Tal “Wedge Software” will be used for system checkout. ( Tal Technologies, 2027 Wallace St., Philadelphia, PA 19130 (215) 763 - 7900 http://www.taltech.com).
The front of the power supply shall have a plug for access to the monitoring scheme. It shall be used to plug in a portable PC to access the control link to perform local diagnostics.

**17. Instructions for Suppliers**

The supplier shall provide, with his quotation, a table of power supply ratings and a listing of the power supply combinations recommended to meet the needs of each type of VIPA subrack

The Supplier shall provide, on each of the listed components, the following information before agreement to contract for this project :

1. Catalog cuts or shop drawings of Enclosure, Circuit breaker and other hardware.
2. Specifications, drawings and typical factory 'test sheet' of Power Supplies
3. Specifications, data sheets or catalog cuts of Data Acquisition and RS-485 Communications boards . Cost and reason for selection is requested for the two options offered.

The Supplier shall also submit for each **Power Supply Assembly model** :

1. Electrical schematic drawings, with wire sizes and protection elements.
2. Component Layout drawings, with power supply models identified.
3. Front Panel, Back Panel (Terminal Layout and Connector Pinout ) drawings.

When drawings are reviewed and agreed to, and notice of award is given, the provider shall build a 'first unit' of each model of **Power Supply Assembly**. This (these) unit(s) shall be inspected and approved before release of the contract for full production.

Suppliers shall agree to a pre-award factory visit for discussion of design, production, testing, and schedule. A firm schedule shall be agreed upon based on the following milestones:

Thirty days after award of contract - evaluation of first prototype
Sixty days after award of contract - delivery of 30 Power Supply Assemblies and evaluation of additional prototype models.
Ninety days after award of contract - delivery of additional thirty units
One hundred and twenty days after award of contract - complete shipment and exercise of option for additional units.

For procurement and contractual questions please contact Don Rogus / Fermilab Purchasing/ MS 210/ DON_ROGUS@fnal.gov / (630) 840 - 4177
For technical questions please contact Stan Orr / Fermilab Particle Physics Engineering/ MS222 / Orr@fnal.gov / (630) 840 - 3692.

**18. Options**

Some options to be discussed with the provider are :
Replaceable voltage modules
Diagnostic setups and active and dummy loads.
Portable diagnostic instrument and software.
Spare **Power Supply Assembly** models, spare power supplies

**Appendix 1. Power Supply Assembly - Example of a “two power supply type” implementation of ‘models’ for “Power Supply Assembly” complete solution.**
Two models of power supplies are specified according to output voltage and current ratings required the VIPA subracks . The output voltages and current ratings of the two models of power supplies are shown below :

| **Model** | **Output 1** | **Output 2** | **Output 3** | **Output 4** |
|---|---|---|---|---|
| **A** | **5V / 200A** | **12V / 7A** | **5.2-12V / 7A** | |
| **C** | **5V / 300A** | **3.3-5.2V / 150A** | **2-12V / 20A** | **12V / 7A** |

These supplies, in various combinations and configurations, can be used to meet all the voltage and current requirements as follows :

**TABLE 1 - CDF COUNTING ROOMS**
**POWER SUPPLY ASSEMBLY REQUIREMENTS**

| | | **POWER SUPPLY RATINGS ( AMPERES )** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Crate Type** | No. of Crates | **+3.3 V** | **+5 V** | **+12.0 V ( Amperes )** | **-12.0 V** | **-2.0 V** | **-5.2 V** | **Power Supply Models** | No. of Voltages |
| CMU Muon TDC | 2 | | **285** | **2** | | | **32** | **C2** | 3 |
| CMP Muon TDC | 1 | | **297** | **2** | | | **35** | **C2** | 3 |
| CSP-CSX-WMS Muon TDC | 1 | | **338** | **2** | | | **37** | **C2** | 3 |
| CMX Muon TDC | 2 | | **285** | **2** | | | **32** | **C2** | 3 |
| Hadron TDC | 1 | | **348** | **2** | | | | **C1** | 2 |
| XFT Finder | 3 | | **273** | | | | | **C** | 1 |
| XFT Linker | 3 | | **261** | | | | | **C** | 1 |
| Muon Trigger | 1 | | **483** | **2** | | | | **C1** | 2 |
| XTRP | 1 | **250** | **209** | | | **40** | **40** | **C+C** | 4 |
| DAQ VRB | 6 | | **76** | | | | | **A** | 1 |
| SVX VRB | 6 | | **142** | **2** | **2** | | | **A1** | 3 |
| ISL VRB | 3 | | **160** | **2** | **2** | | | **A1** | 3 |
| | *( 30 )* | | | | | | | | |
| L1 Calorimeter | 6 | | **229** | | | | | **A** | 1 |
| L1 Decision | 1 | | **87** | | | | **12** | **A1** | 2 |
| L2 Calorimeter | 6 | | **289** | **19** | | | | **C3** | 2 |
| L2 Decision | 2 | *53* | *243* | *23* | *6* | | *12* | *C* | 5 |
| L2 Control | 1 | | **36** | **4** | | | | **A1** | 2 |
| TSI | 1 | | **83** | | | | **12** | **A1** | 2 |
| Trigger XPT | 1 | | **52** | | | | **87** | **C** | 2 |
| Done-E/B XPT | 1 | | **87** | | | | | **A** | 1 |
| Scalers | 1 | | **64** | | | | | **A** | 1 |
| SVT Hit Finder | 6 | **40** | **296** | | | | | **C3** | 2 |
| SVT Merger | 1 | | **80** | | | | | **A** | 1 |
| SVT Track Fitter | 1 | **80** | **240** | | | | | **C** | 2 |
| | *( 28 )* | | | | | | | | |

**TABLE 2 - CDF COLLISION HALL**
**POWER SUPPLY ASSEMBLY REQUIREMENTS**

| | | | | **POWER SUPPLY RATINGS ( AMPERES )** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Crate Type** | No. of Crates | **+3.3 V** | **+5 V** | **+12.0 V ( Amperes )** | **-12.0 V** | **-2.0 V** | **-5.2 V** | **Power Supply Models** | **No. of Voltages** |
| COT TDC | 24 | | **413** | **2** | | | | **C1** | 2 |
| SVX FIB | 4 | | **269** | | | | **120** | **C2** | 2 |
| ISL FIB | 4 | | **189** | | | | **84** | **C2** | 2 |
| IMU Muon TDC | 4 | | **222** | **2** | | | **24** | **C2** | 3 |
| | *( 36 )* | | | | | | | | |

C1 is "C" with CH 1& 2 in parallel and CH2 margined to 5V
C2 is "C" with CH 2 margined to 5.2V
C3 is "C" with CH 1 & 2 in parallel, CH 2 margined to 5V, CH 3 margined to 12V
A1 is "A" with CH 3 margined to 12V

**POWER SUPPLY ASSEMBLIES FOR THE VIPA SUBRACKS AT CDF**

**PROPOSED LIST OF BIDDERS**

Pioneer Magnetics
1745 Berkeley St.,
Santa Monica, CA 90404
(310) 829 - 6751
Fax (310) - 453 - 3929

HC Power
17032 Armstrong Ave,
Irvine, CA. 92714-5716
(714) 261 - 2200
Fax (714) 261 - 6584

Foresight Electronics
975 E. Nerge Road #150
Roselle, Il. 60172
(630) 980 - 9890
Fax (630) 980 - 9805

Power Electrical Industries
19520 S. Rancho Way #202
Rancho Dominguez, CA 90220
(310) 763 - 1524
Fax (310) 763 - 8954

Bira Systems
2404 Comanche NE
Albuquerque, NM 87107
(505) 881 - 8887
Fax (505) 888 - 0651