



Fermi National Accelerator Laboratory

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**Energy Discharge Heater Power Supply
FNAL Drwg. #1670-EC-307031/307032**

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**ENERGY DISCHARGE HEATER POWER SUPPLY
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Introduction

The heater power supply is intended to supply capacitively stored energy to embedded heater strips in cryo magnets. The amount of energy can be controlled by setting different charge voltages and by selecting different capacitor values. Two chassis' can be operated in series or parallel. Several safety interlocks are provided. The charge voltage, number of capacitors connected, and the discharge pulse can be monitored. There are single channel and dual channel units. They are the same except the dual channel has two discharge supplies in one chassis. Refer to the schematic drawings for details.

Ratings

	Single Channel	Dual Channel
Input	120VAC, 5A max, 60Hz	120Vac, 5A max, 60 Hz
Maximum stored energy, nom.	2000 Joules	1000 Joules/channel
Maximum charge voltage	450 Vdc	450 Vdc
Charge voltage range/regulation	50-450 Vdc/1%	50-450 Vdc/1%
Maximum discharge current	200 A peak	200 A peak
Output test voltage to GND	1000 Vdc, 1 min	1000 Vdc, 1 min
Discharge rate	1 per 100 sec	1 per 100 sec
Charge time	< 1 min	< 1 min
Number of capacitors	8 x 2400 μ F	4 x 2400 μ F/channel
Select number of capacitors	2,4,6,8	1,2,3,4
Crowbar	capacitor overvoltage 480 Vdc	capacitor overvoltage 480 Vdc
Interlocks and status at ground potential	remote and local	remote and local
Remote readout current	40 A/V _{read}	40 A/V _{read}
Remote readout voltage	100 V/V _{read}	100 A/V _{read}
Drawings	#1670-EC-307031,307032	#1670-EC-307031,307032
Dimensions	8.75" H x 19" W x 20.25" D	8.75" H x 19" W x 20.25" D
Weight	60 lbs	90 lbs

Safety

These power supplies can store a lethal amount of energy. They must therefore be switched off, locked out and discharged before working on the load or the power supply. Discharge of the capacitors happens automatically, when the supply is switched off, but the capacitor voltage should be checked for "ZERO CHARGE" voltage at the build in voltmeter on the front panel.

Front Panel Description

- Control power lighted indicates low voltage D.C. power supplies are operational.
- Interlock complete lighted indicates internal and external interlocks are satisfied and H.V. power supply will charge capacitor bank as soon as inhibit cycle is complete.

- Charging LED is on whenever the capacitor bank voltage is below the set to reference and the interlocks are satisfied and the power supply is not in the inhibit cycle.
- Minimum charge LED indicates the capacitor voltage is equal to or greater than the minimum voltage trip (1V=100V) set by the potentiometer under the cover on the back panel.
- Charge ready LED indicates the capacitor voltage is at 90% of the "SET TO" reference voltage (1V=100V) for the high voltage power supply and minimum charge interlock has been satisfied.
- Charging inhibit light comes on after the capacitor bank has been discharged by either a normal fire command or internal safety discharge of the capacitors due to an interlock trip. The inhibit cycle will also start to run after the AC to the chassis is first turned on. The inhibit cycle prevents charging of the capacitor bank for ~ 60 seconds after they have been discharged.
- External permit light will come on when the normally open remote interlock contact on J14-A and J14-B opens, this condition will internally discharge the capacitor bank through a safety discharge circuit.
- Load ready light will come on if there is an open load across the output terminals of the heater power supply or if the capacitor bank cover on the back of the power supply is lifted up or if the RC time constant of the load resistor and discharge capacitor is greater than 2 seconds, this latter condition will light the load ready LED only momentarily during the discharge cycle but it will activate the internal safety discharge circuit in the power supply.
- Capacitor bank cover will light whenever the access cover on the back of the power supply is lifted up. This condition removes AC power from the high voltage charging supply and the P.C. card mounted on the capacitor bank. It also activates the internal safety discharge circuit.
- Crowbar is lit in the event the voltage on the capacitor bank has reached ~470 to 480 Vdc. The crowbar circuit then discharges the capacitor bank and starts inhibit cycle. When inhibit is over the capacitor bank will recharge and the crowbar will activate again if the fault condition persists. The most probable cause of a crowbar is the external reference voltage has exceeded 4.70 volts. THIS LED SEALS IN to clear the light AC power to the chassis must be turned off.
- Capacitor bank readout LEDS indicate the number of capacitors connected the charging and discharge circuits. This readout is only valid when the interlocks are satisfied and there is 10 volts or more charge in the capacitors. The order that the capacitors are connected on the terminal strip on the back of the power supply is not important, the readout is valid no matter in what order they are connected.
- The LCD panel meter reads out one of three voltages determined by the setting of the adjacent selector switch.
 1. Minimum trip voltage indicates the required capacitor voltage needed to satisfy the minimum charge intlk.
 2. Ref. voltage indicates the set to reference of the high voltage regulator either internal or external reference.
 3. Capacitor voltage indicates the actual voltage measured across the capacitor banks at all times. All these readings are positive voltages.

- The remote/local reference switch switches the source of the high voltage regulator reference between the ten turn pot on the front panel and a differential input located in J13 on the back panel.

Back Panel Description

- J12 inputs two external contacts are required for power supply operations, external permit and external fire command. Both of these connections need to be jumpered for local operation.
- J13 has all the analog input and outputs. These are all 0 to 5 volt signals $\pm 1.0\%$. The output signals on this connector are load voltage, capacitor voltage, reference readout, minimum charge set point, and load current readout. Remote reference input is also in this connector.
- J14 has all the interlock and control status in the form of contact closures. Available on this connector is remote/local reference status, load connected status, charge ready status, interlocks complete status, and the capacitor bank readout indicating the number of capacitors connected
- Heater fired pulse BNC on back panel provides a 5 volt pulse starting at the beginning of the discharge cycle.
- Under the capacitor bank cover is a locking one turn pot used to set the minimum charge set point and a set of test points used to measure this set point, $1V = 100V$. In addition, there is a terminal block that has the power supply output terminals and the interconnect terminals for the various capacitor sections. Capacitor bank #1 is always connected into the circuit. By connecting the terminal labeled common to the terminals labeled Bank #2, Bank #3, or Bank #4 puts these capacitor banks into the charging and discharge circuits. The order that these banks are connected in is not important.

Series/Parallel Operation

It is recommended that no more than two of these heater power supplies be placed in series because of voltage insulation limitations. Any number of these power supplies should be able to be run in parallel with a common load after meeting certain system requirements.

For either series or parallel operation, one power supply is designated as the master unit with all other power supplies as slave units. The slave unit should be physically close to the master and have the same chassis ground. The master power supply reference readout (J13-E and J13-F) is connected to the slave power supply external reference input (J13-P and J13-N). All slave units should be run in remote reference and will track the master power supplies reference. An equal number of capacitors should be connected in all power supplies for current and voltage sharing. It is recommended that each power supply have a separate control contact or opto coupler for the external fire command with the requirement that these contacts all open within 1 msec of each other. The separate contact requirement is also needed for the external permit intlk. This is done to avoid ground loops at higher voltages.

Local fire control is still independent of each other. For series operation the outputs of the TWO power supplies are connected in series, positive of one to the negative of the second. A minimum of AWG #10 should be used for all power leads.

If series operation over 800 volts total (400V/power supply) is desired it is recommended that the 14 mfd 250 volt capacitor in the crowbar trigger circuit be changed to a 30 mfd 100 Vdc mylar capacitor. The circuit with the 14 mfd is under compensated and this may result in false crowbar trips over 800 volt output.

For parallel operation of the power supplies it is best to connect them together at the load with ALL power supplies having approximately the same output lead length. This will help in current sharing between the power supplies.