CRAY T94™ Power, Cooling, and Control System

HTM-066-A

Cray Research Proprietary

CRAY T94 Pwr, Cooling, and Cntrl
-066-A

Cray Research, Inc.

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CRAY T94 POWER, COOLING, AND CONTROL SYSTEM

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Overview

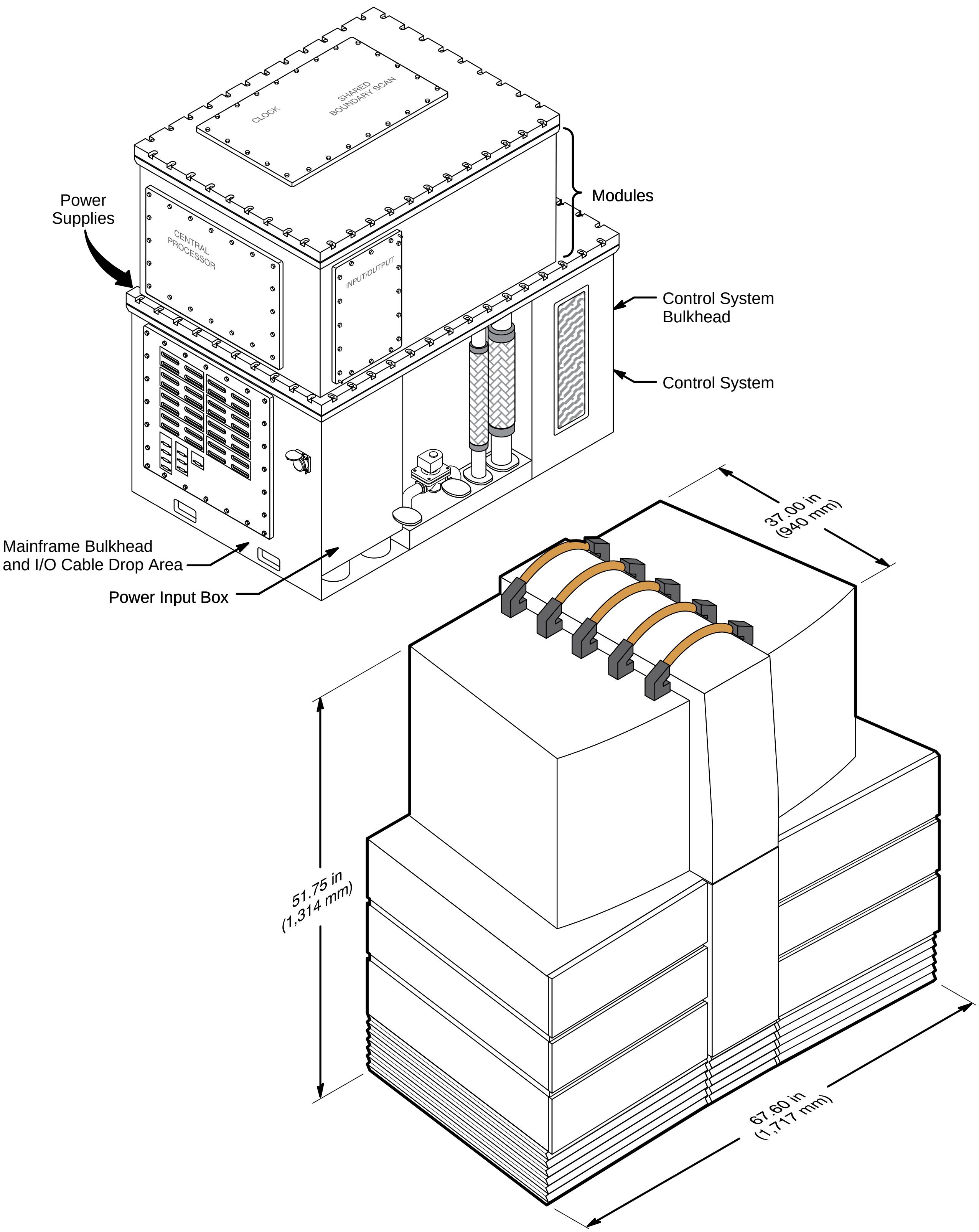
The CRAY T94 power, cooling, and control systems are interrelated and interdependent. The power system provides power to the mainframe mechanical and logic components, while the cooling system removes the heat that is generated during the computer operations. During this process, the power and cooling systems must be monitored by a control system that verifies that both the power system and cooling system are within the correct tolerances. This document provides information about each of these systems.

Refer to Table 1 for the CRAY T94 mainframe physical, power, cooling, and control system specifications. Refer to Figure 1 for an illustration of the CRAY T94 mainframe.

Table 1. CRAY T94 Mainframe Specifications

Characteristic	Specification
Dimensions: Height Width Depth	 51.75 in. (1,314 mm) 67.60 in. (1,717 mm) 37.00 in. (940 mm)
Weight: Mainframe with dielectric coolant	 3,859 lbs (1,748 kg)
Dielectric coolant: Standard flow rate (no IOS)	 100 gpm
Input power: To power supplies To control system components	 330 Vdc 120 Vac

Figure 1. CRAY T94 Mainframe



Power Distribution System

The power distribution system consists of several components. The following subsections describe these components and their respective locations and functions in the CRAY T94 computer system.

Components

Refer to Figure 2 for the location of the following components.

Power Input Box

The power input box provides the connections for the incoming power to the mainframe and consists of the following components:

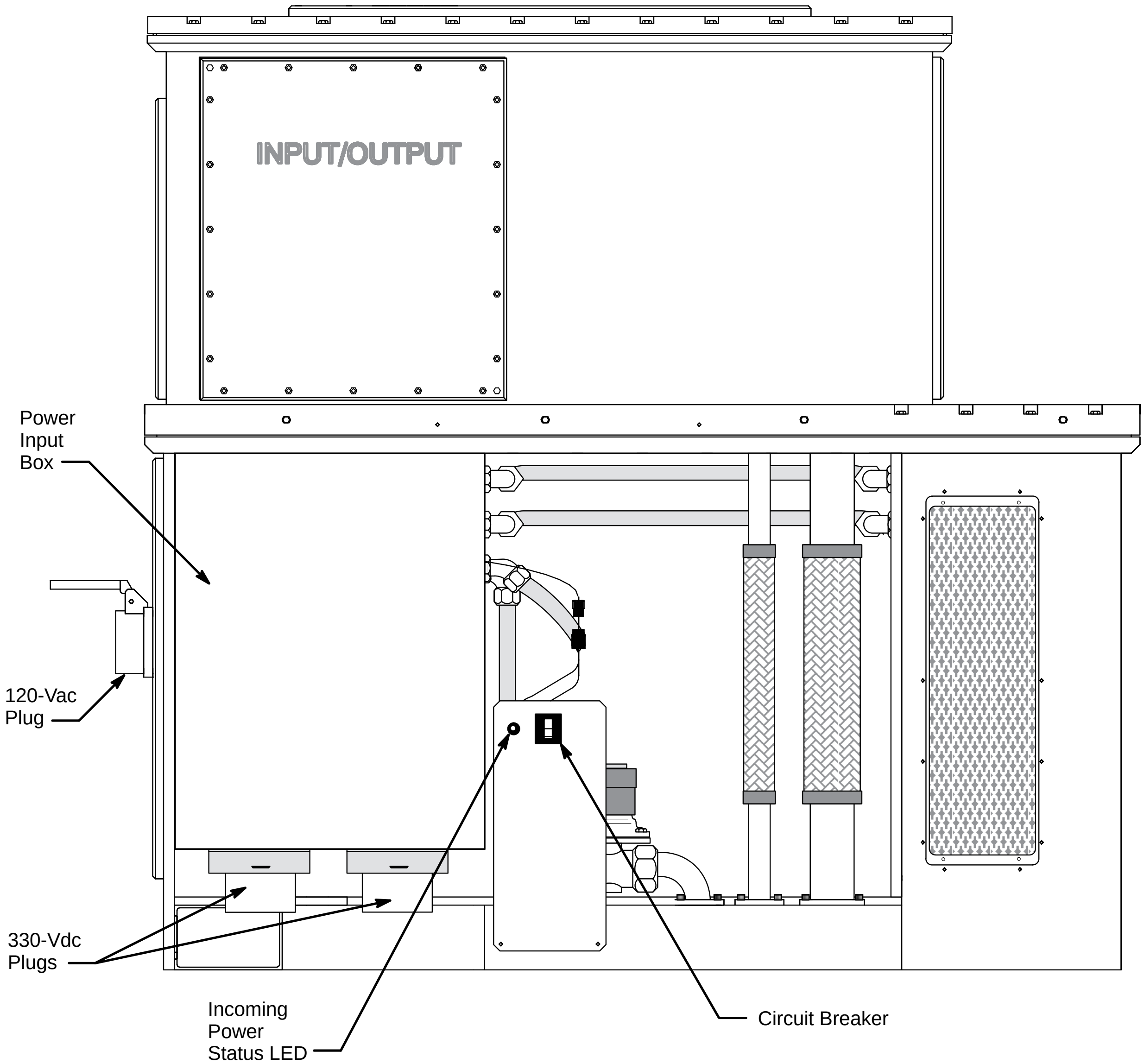
120-Vac Plug – The 120-Vac plug provides the connection for the single-phase, 120-Vac power. The 120-Vac plug contains three posts: one for the line, one for the neutral, and one for the ground circuit.

330-Vdc Plugs – The two 330-Vdc plugs provide the power connections for the two 330-Vdc input power lines (L1 and L2), which supply power to the mainframe power supplies. Each plug contains three posts: one for the plus, one for the minus, and one for the ground circuit.

Incoming Power Status LED – The two 330-Vdc power lines combine in an OR function that illuminates a single incoming power status LED when 330-Vdc power exists on either 330-Vdc input power line.

Circuit Breaker – The circuit breaker connects to the 120-Vac power line and neutral circuits and protects the computer equipment from currents that exceed 4 amps. This circuit breaker also provides the main power disconnect for the mainframe. When this circuit breaker is tripped (or turned off), 120-Vac power is disconnected. Without the 120-Vac power, the control system powers down as well, which disables the high-voltage DC device (HVDC) and the low-voltage DC (LVDC) bus.

Figure 2. CRAY T94 Power Distribution Component Locations



Refer to Figure 3 for the location of the following power input box internal components.

120-Vac Terminal Block – The 120-Vac terminal block provides the connections for the computer system devices that require 120-Vac power. The terminal block consists of a three-pole bus: one level for line, one level for neutral, and one level for ground connections. The top (blue) level is for neutral connections, the second (gray) level is for line connections, and the bottom (yellow/green) level is for ground connections.

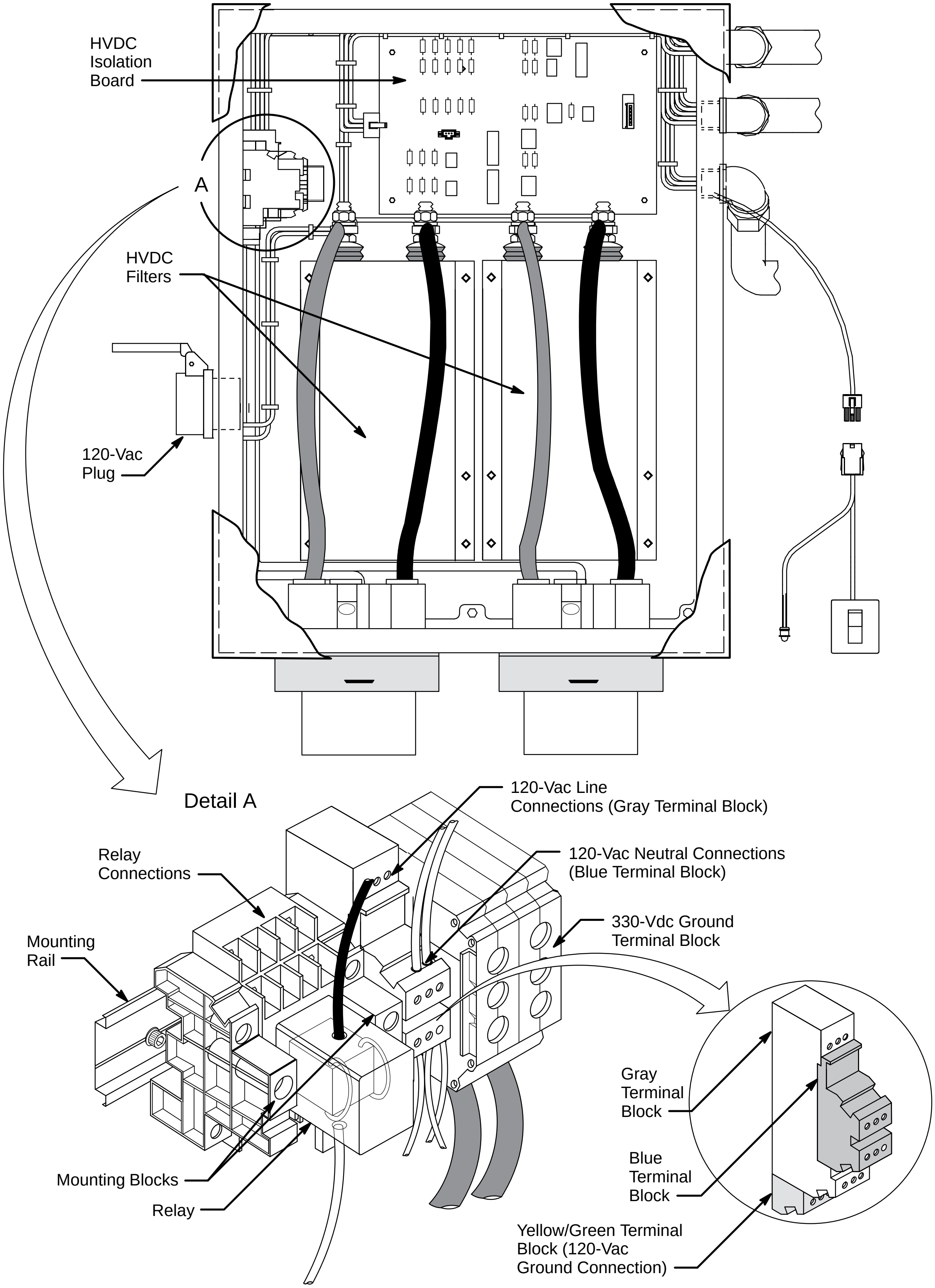
330-Vdc Ground Terminal Block – The 330-Vdc ground terminal block provides the ground connection for the incoming 330-Vdc power.

Relay – The relay controls the on/off status of the solenoid control valve, which is used to drain the mainframe I/O harness area. The relay connects to the gray terminal block and to the 12-Vdc output module in the control system. When the control system energizes the relay, the solenoid valve opens, so that dielectric coolant drains from the mainframe I/O harness area.

HVDC Isolation Board – The HVDC isolation board optically isolates the control system from the 330-Vdc power. The HVDC isolation board connects to each incoming 330-Vdc power line and reduces the voltage by a factor of 100 by sending the input signal through an opto-isolator. This opto-isolator converts the signal into light through an LED and then converts it back to an electrical signal through a photo detector. This process isolates the high-voltage input from the low-voltage output.

HVDC Filters – The HVDC filters prevent electrical noise from entering or leaving the mainframe. Each 330-Vdc power line is filtered by an HVDC filter.

Figure 3. CRAY T94 Power Input Box Components



Refer to Figure 4 for the locations of the following components.

Power Supplies

The power supplies convert the 330-Vdc power to logic level voltages, which are routed to the modules. The power supplies are mounted in the power supply rack and are cooled by dielectric coolant. All of the mainframe power supplies are immersed in dielectric coolant.

The power supplies are bused in parallel and configured in an N+1 configuration. This configuration provides one more power supply on each of the power bus levels than is required to drive the load. If one of the power supplies fails, the other power supplies pick up the load of the failed power supply until the failed power supply is replaced. This extra power supply provides increased power reliability for the computer system.

Table 2 provides the power supply configurations for the CRAY T94 computer system.

Table 2. Power Supply Configurations

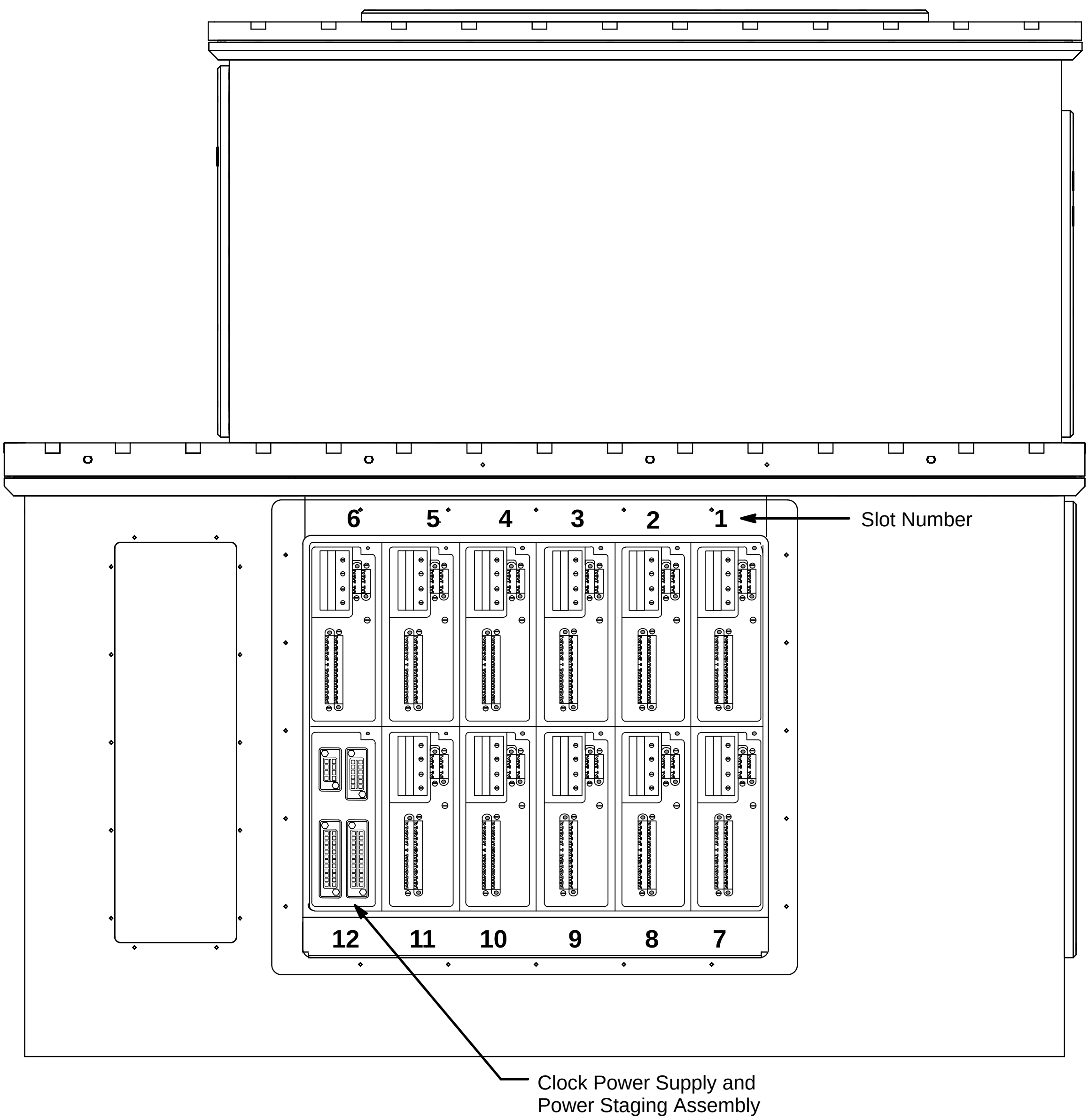
<table>
<tr><th>Slot Number</th><th>Voltage</th><th>Function</th></tr>
<tr><td>1</td><td>–2.7 Vdc</td><td rowspan="4">Provides power to the shared module, common memory, CPU modules, and IO modules</td></tr>
<tr><td>2</td><td>–2.7 Vdc</td></tr>
<tr><td>3</td><td>–2.7 Vdc</td></tr>
<tr><td>4</td><td>–2.7 Vdc</td></tr>
<tr><td>5</td><td rowspan="2">None</td><td rowspan="2">Dummy power supplies that are used to displace flow</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td><td>–3.5 Vdc</td><td rowspan="3">Provides power to the shared module, common memory, CPU modules, and IO modules</td></tr>
<tr><td>8</td><td>–3.5 Vdc</td></tr>
<tr><td>9</td><td>–3.5 Vdc</td></tr>
<tr><td>10</td><td>–5.2 Vdc</td><td rowspan="2">Provides power to the common memory modules</td></tr>
<tr><td>11</td><td>–5.2 Vdc</td></tr>
<tr><td>12</td><td>–5.2 Vdc</td><td>Provides power to the clock module †</td></tr>
</table>

† Power supply slot number 12 also contains the power staging board.

Clock Power Supply and Power Staging Assembly

The clock power supply is a –5.2-Vdc power supply that operates in power-supply slot number 12. Although it looks like a regular power supply, the clock power supply contains both a master-clock power board and a power staging assembly. The master-clock power board receives 330-Vdc power from the HVDC and distributes it to the optical clock module. The power staging assembly performs circuit-check and power staging functions. When the mainframe powers up, the power staging board sends a small voltage across the LVDC power bus to check for any short circuits within the LVDC bus. If no short circuits exist, the control system sequentially enables the power supplies.

Figure 4. CRAY T94 Power Supply Configurations and Locations



Refer to Figure 5 for the locations of the following components.

Power Bus Connections

The power bus connections on the LVDC power bus attach to the power supply bus connections and route power from the power supplies to the appropriate layers in the LVDC power buses.

LVDC Power Bus

The LVDC power bus routes the power from the power supplies to the appropriate modules.

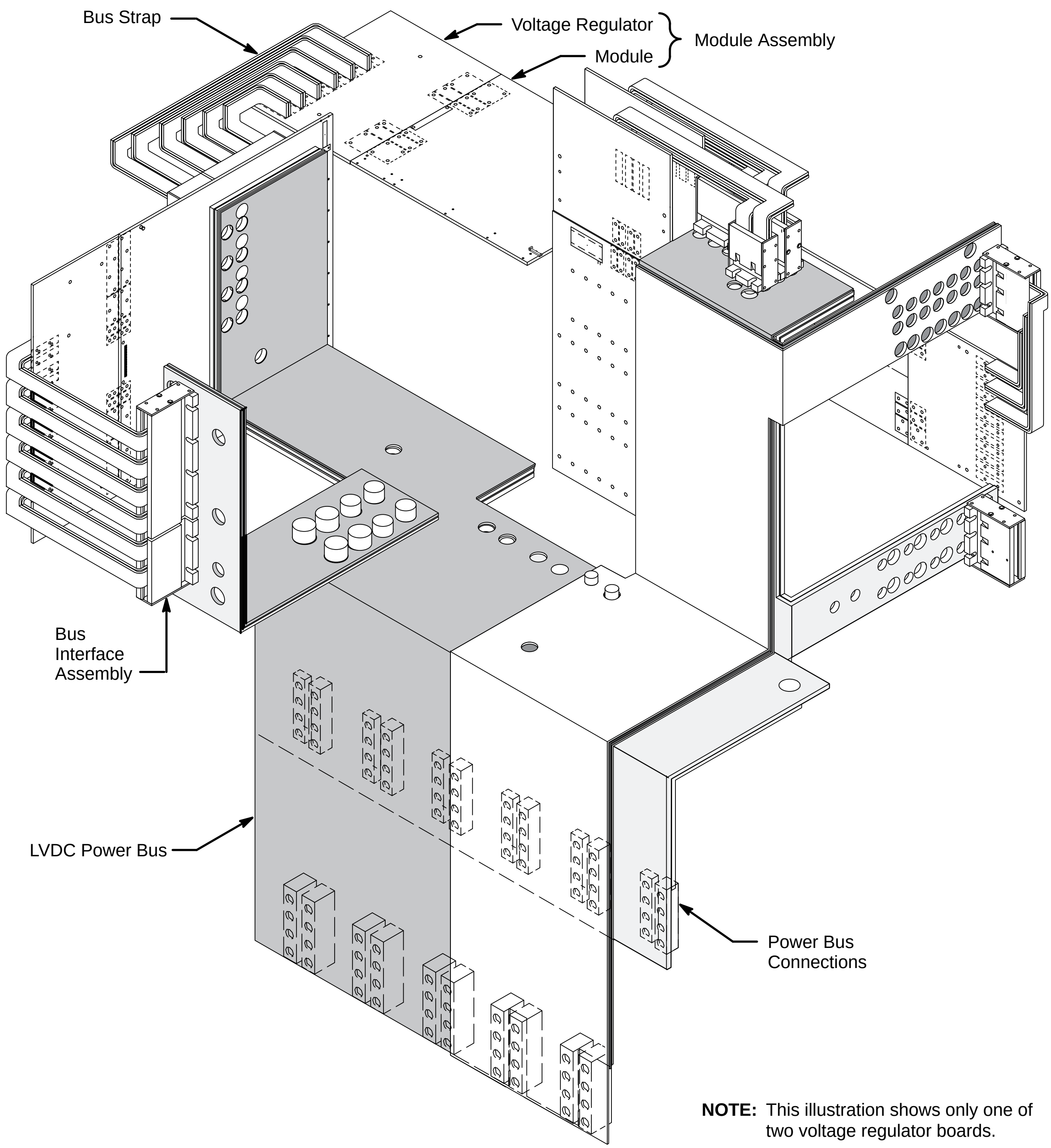
Bus Interface Assembly

Each module attaches to a bus interface assembly. This interface assembly mounts on the power bus, and a bus strap connects the bus interface assembly to the module voltage regulator.

Module Assembly

Each module assembly consists of a module logic board and a voltage regulator that regulates the noise caused by dynamic module loads. Each CRAY T90 series module assembly is a field replaceable unit (FRU); do not attempt to separate the logic board from the voltage regulator in the field.

Figure 5. CRAY T94 Power Bus Component Locations



Power Distribution

The CRAY T94 mainframe receives two types of electrical power from the HVDC: 120-Vac and 330-Vdc power. The input power to the mainframe consists of two 330-Vdc power lines and one 120-Vac power line. You must disconnect the three power sources before you service the mainframe.

WARNING

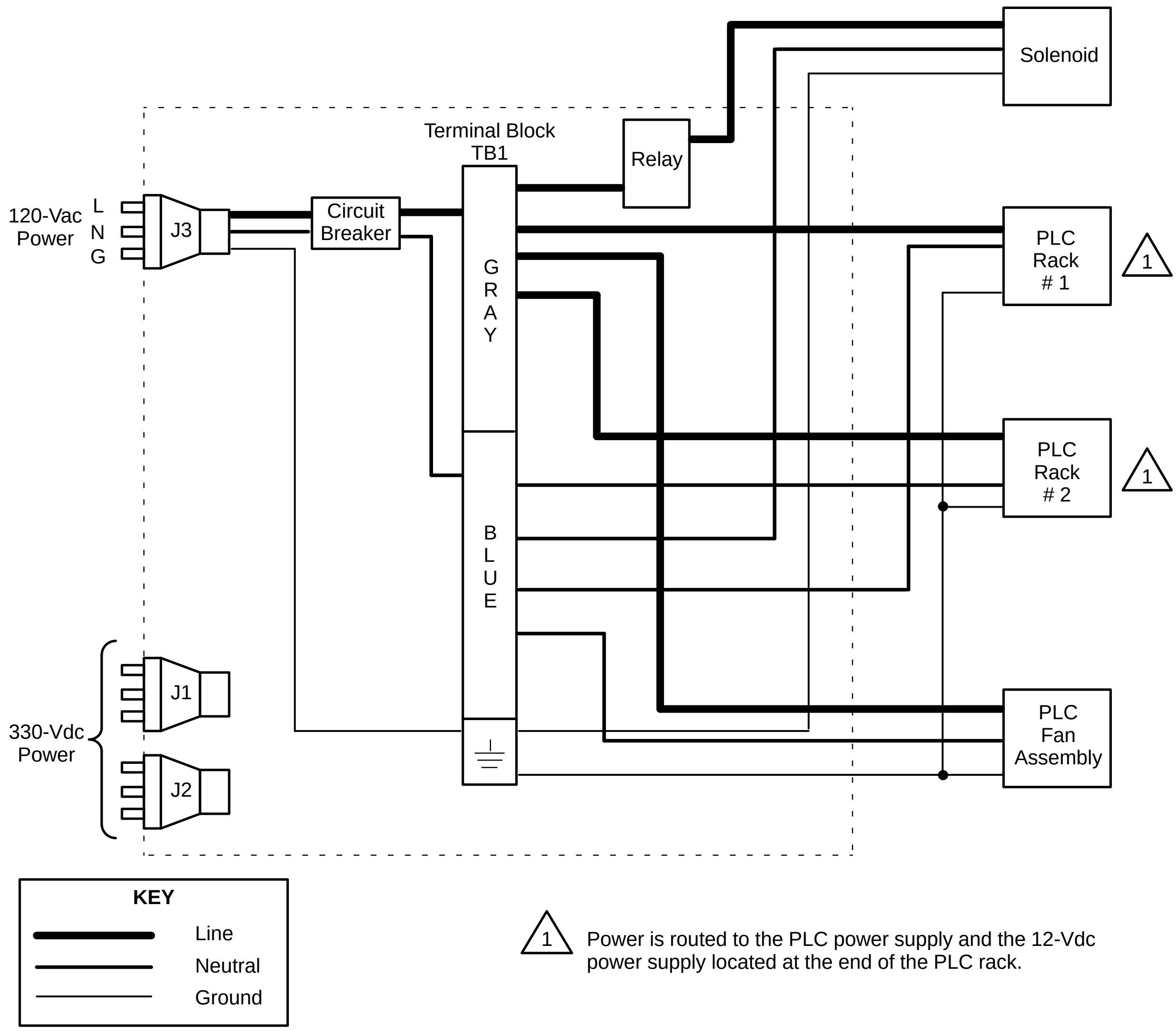
Electrical hazard. Turn off the electrical circuit breakers to ensure that the 3 power sources are disconnected before you begin service. Failure to do so could result in severe shock, burns, or death.

The “Components” subsection of this document provides a general overview of the mainframe power distribution components. The following subsections describe the two types of power and the power distribution components in more detail.

120-Vac Power Distribution

The 120-Vac input power line provides power to the programmable logic controllers (PLCs), the PLC fan assembly, and the solenoid control valve. A power plug routes the single-phase, 120-Vac power into the mainframe at the power input box. The 120-Vac input line contains three wires: line, neutral, and ground. The line and neutral wires connect to the 4-amp circuit breaker and then connect to the blue and gray terminal blocks. The ground wire connects to the ground block at the bottom of the (TB1) terminal block. Figure 6 provides a block diagram of the 120-Vac power distribution.

Figure 6. 120-Vac Power Block Diagram



NOTE: The (TB1) terminal blocks are stacked on top of each other; the ground block is located on the bottom, the gray terminal block is located on top of the ground, and the blue terminal block is on top.

The blue and gray terminal blocks provide the 120-Vac power connections for the PLCs and for the solenoid control valve. (The ground block provides the ground connection for the solenoid control valve and PLC components.) The wires from the terminal blocks that power the PLCs are routed through the power input box and then into flexible conduit. The wires from the terminal blocks that power the solenoid control valve connect to a relay located in the power input box and then are routed into flexible conduit. (Refer to Figure 7.) Table 3 provides information about the terminal block (TB1) connections in the power input box.

Figure 7. Terminal Block and Relay Connections

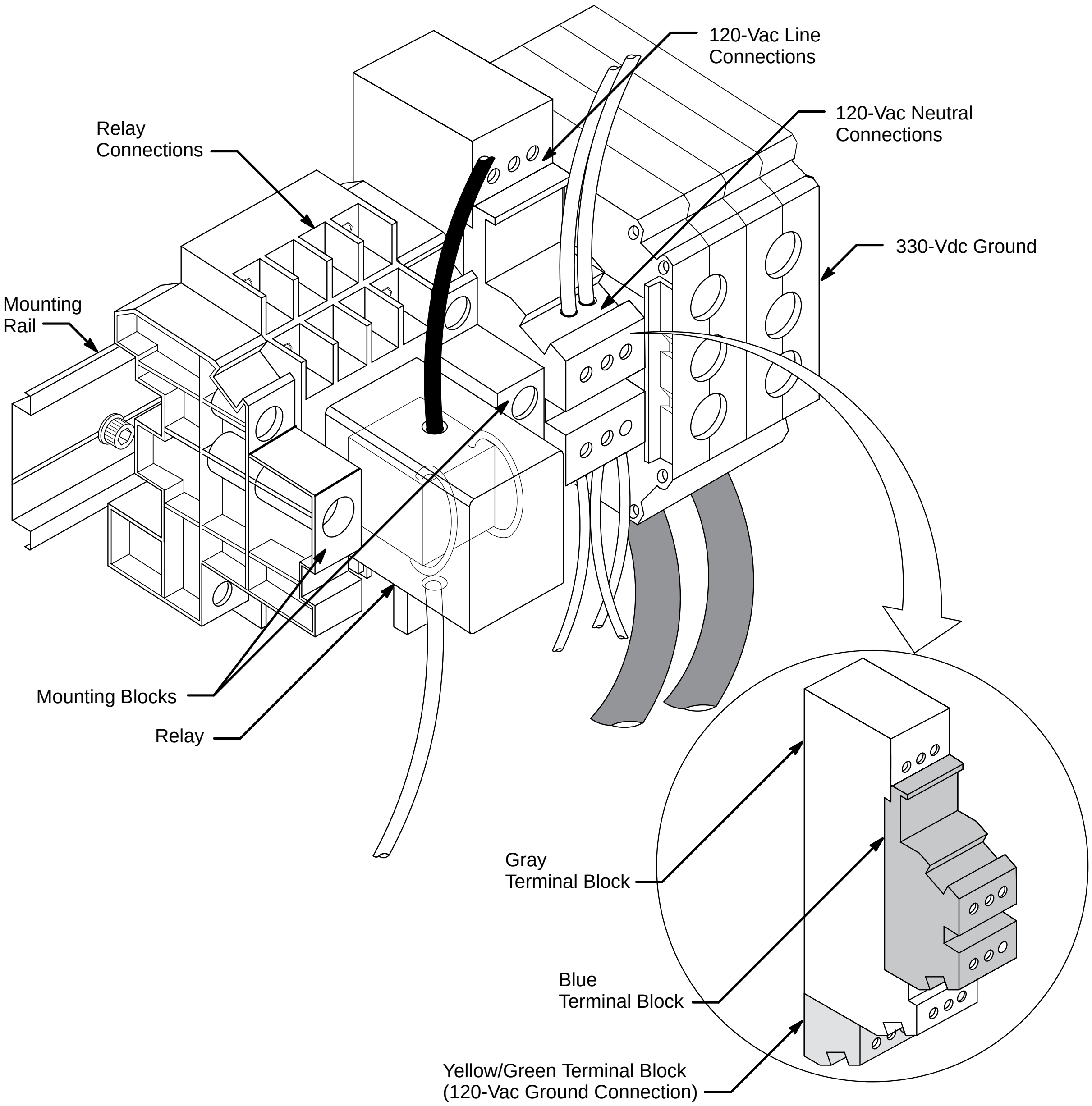


Table 3. Power-input Terminal Block (TB1) Connections

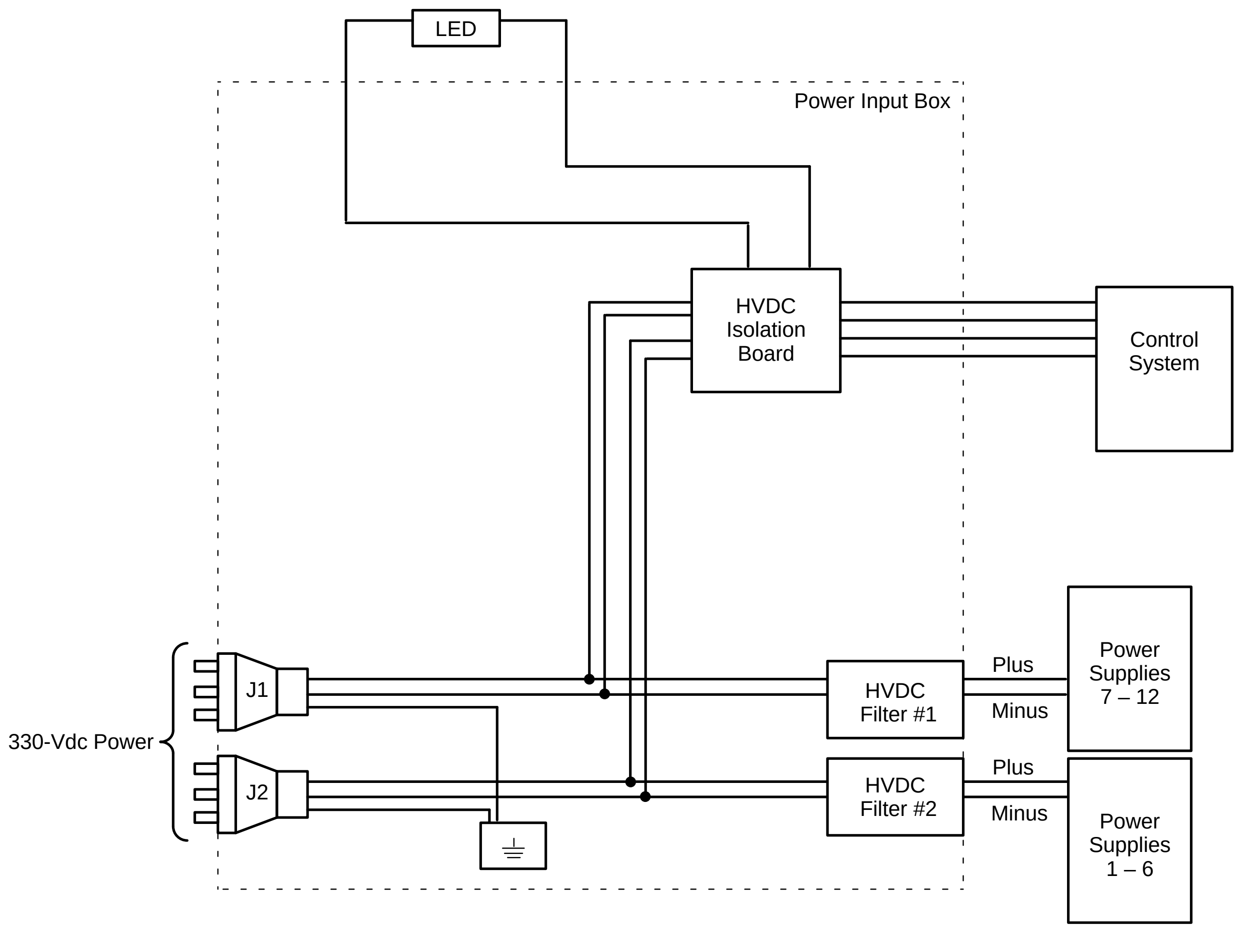
Terminal Block	Connection Number	Source/Destination
Blue	1	120-Vac neutral connection from CB1
	2	Fan assembly 120-Vac neutral connection
	3	PLC power supply and 12-Vdc power supply 120-Vac neutral connection
	4	120-Vac neutral connection for PLC rack 1 power supply and 12-Vdc power supply
	5	Solenoid control valve 120-Vac neutral connection
	6	Not used
Gray	7	120-Vac line connection from CB1
	8	Fan assembly 120-Vac line connection
	9	Rack 2 PLC power supply and 12-V power supply 120-Vac line connection
	10	Rack 1 PLC power supply and 12-V power supply 120-Vac line connection
	11	Relay K1
	12	Not used
Yellow/Green	1	Incoming 120-Vac ground connection
	2	Rack 1 and Rack 2 PLC power supply and 12-V power supply ground connection
	3	Solenoid control valve ground connection

The three 120-Vac circuits that power the PLCs connect to the two power supplies located on each of the PLCs and to the PLC fan assembly. The other 120-Vac circuit powers the solenoid control valve.

330-Vdc Power Distribution to the Power Supplies

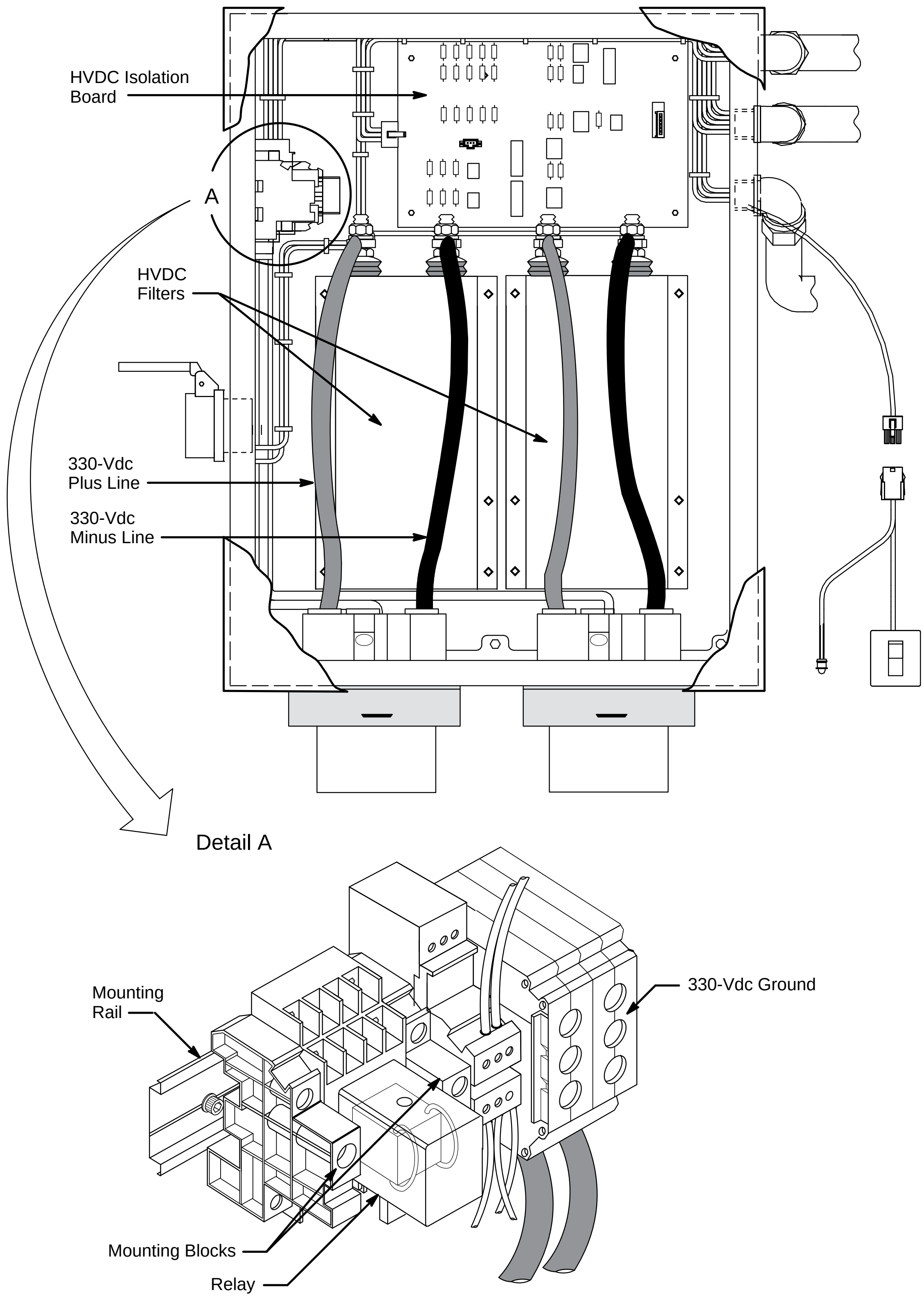
The two 330-Vdc input power lines provide power to the mainframe power supplies. Refer to Figure 8 for a block diagram of the 330-Vdc power distribution.

Figure 8. 330-Vdc Power Block Diagram



Two plug connections connect the two 330-Vdc power lines to the power input box. Each 330-Vdc connection has three lines: plus, minus, and ground. The plus and minus lines connect to HVDC filters, which prevent any electrical noise from leaving or entering the mainframe. Each ground line of the 330-Vdc lines connects to separate ground terminal blocks. Refer to Figure 9 for an illustration of the 330-Vdc connections.

Figure 9. 330-Vdc Power Input Box Connections



The power input box contains high voltage when the HVDC is running and supplying power to the mainframe. When the HVDC is supplying 330-Vdc power to the mainframe, an LED illuminates to show that power exists in the power input box. This LED is mounted through the mainframe panels close to the circuit breaker. The LED has a connector attached to the wires that enables the LED to be disconnected when the panels have to be opened or removed. Refer to Figure 10 for an illustration of this LED and its connections. Refer to NO TAG for information about each connector pin number.

The LED connects to one of the two 330-Vdc power lines through the HVDC isolation board. If this LED is illuminated, do not disconnect the 330-Vdc connections or attempt to service the mainframe.

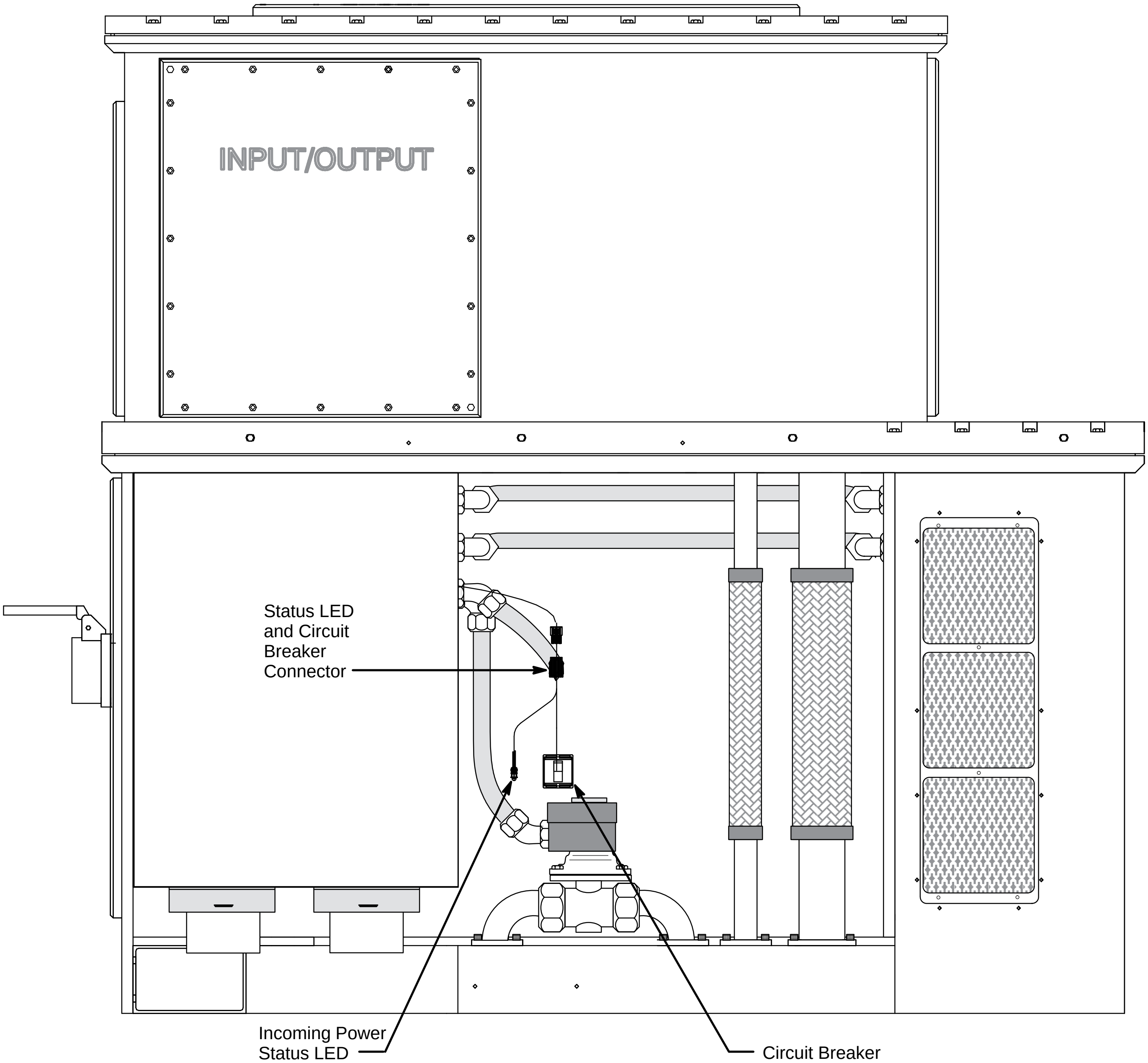
WARNING

Do not attempt to disconnect the 330-Vdc connections when the LED is illuminated. Failure to so could result in severe shock and burns.

Table 4. Circuit Breaker and Input Power Status LED Connection

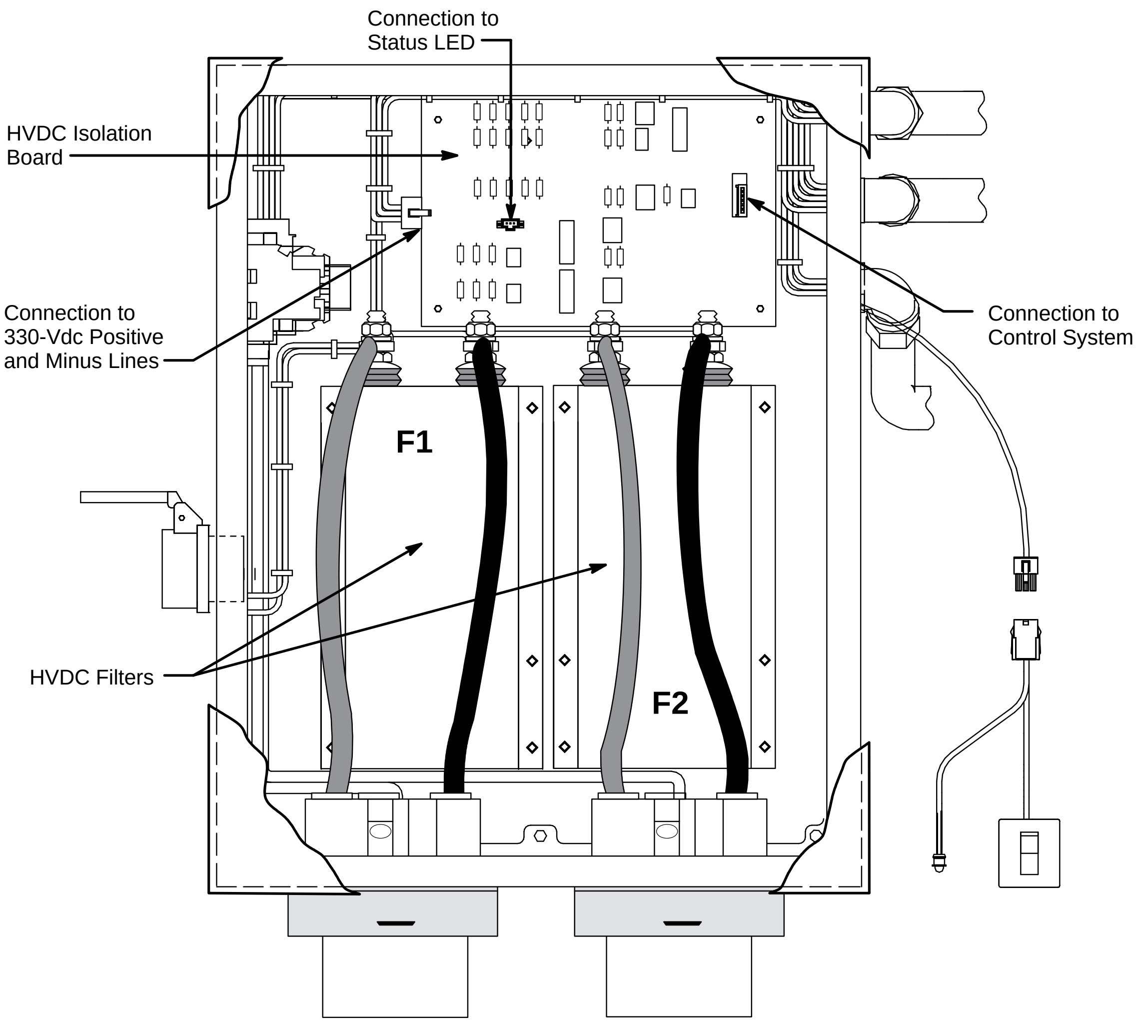
Connector	Pin Number	Description	Connector	Connected To
J7	1	120-Vac line connection	J8	Circuit breaker connection L1
	2	120-Vac neutral connection		Circuit breaker connection L2
	3	Input power connection from HVDC isolation board		Input power status LED
	4	120-Vac line connection		Terminal block TB1; pin #7
	5	120-Vac neutral connection		Terminal block TB1; pin #1
	6	Return input power signal to HVDC isolation board		HVDC isolation board J3, pin #1

Figure 10. 330-Vdc Power LED Indicators



The control system also monitors the 330-Vdc power. At each HVDC filter connection, a wire connects to the lugs and then connects to the HVDC isolation board in the power input box. (Refer to Figure 11 for an illustration of this connection and the HVDC isolation board connection.) This board reduces the voltage by a factor of 100 and then sends the reduced voltage to the analog base converter in the control system PLC rack.

Figure 11. 330-Vdc Power Connection to the HVDC Isolation Board

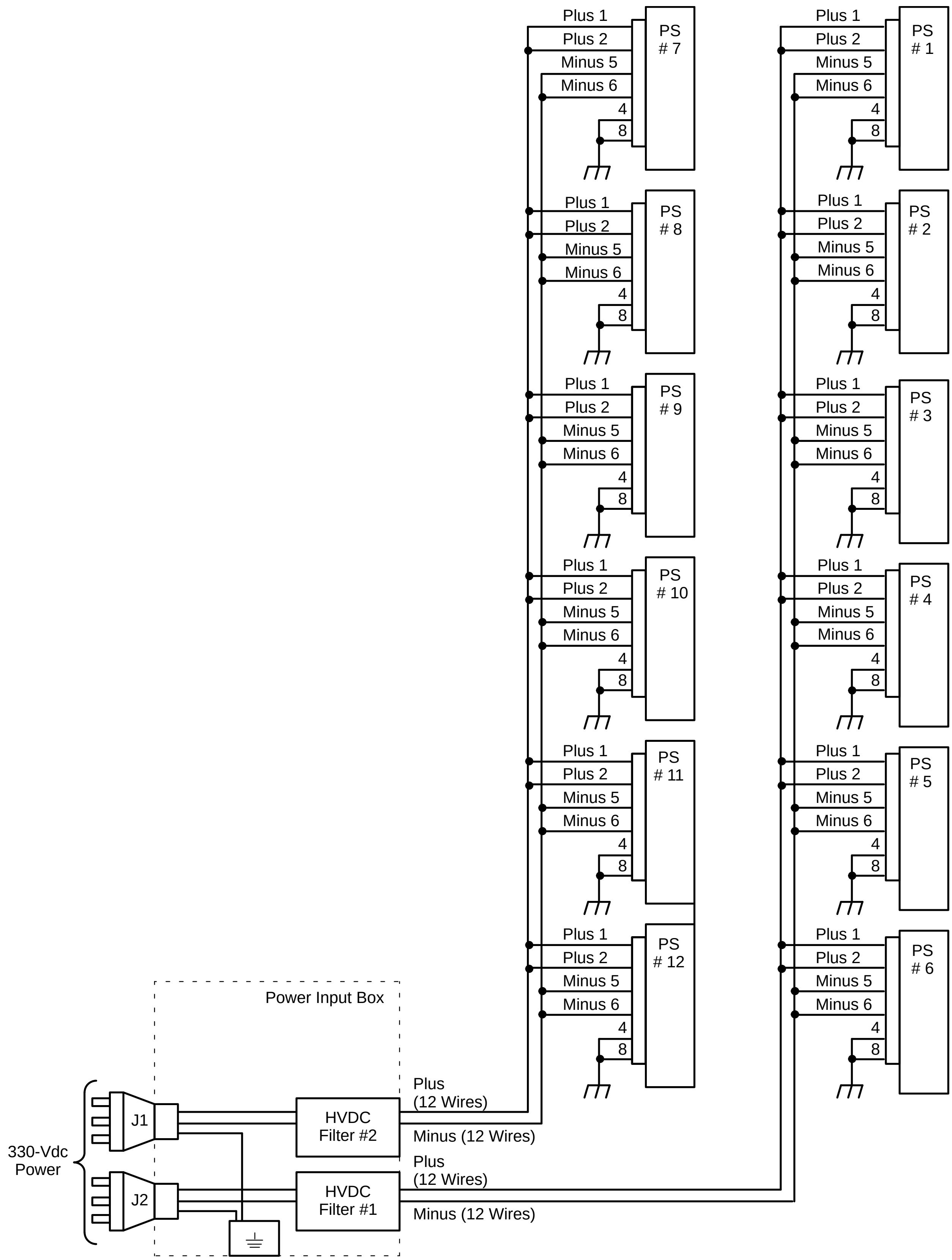


Two lugs are located on the back of each HVDC filter: one for the plus line and one for the minus line. Each lug has 12 wires, which results in 24 wires for each HVDC filter (12 wires carry plus voltage and 12 wires carry minus voltage, two plus and two minus connections per power supply).

The first line (L1) provides power to power supplies 7 through 12, while the second line (L2) provides power to power supplies 1 through 6. (Refer to the "Power Supply Connections" subsection for more information about the power connections to the power supplies.)

Refer to Figure 12 for a block diagram of this power distribution.

Figure 12. 330-Vdc Power Supply Bus Block Diagram



Power Supply Connections

The mainframe power supplies mount in the power supply rack and route power through the power bus connections to the low-voltage DC (LVDC) module power bus. With the exception of the clock power supply and power staging board assembly, each power supply has the same appearance, with a slight variation of the keying block. (The keying block prevents a power supply from being inserted into the wrong slot in the power supply rack.)

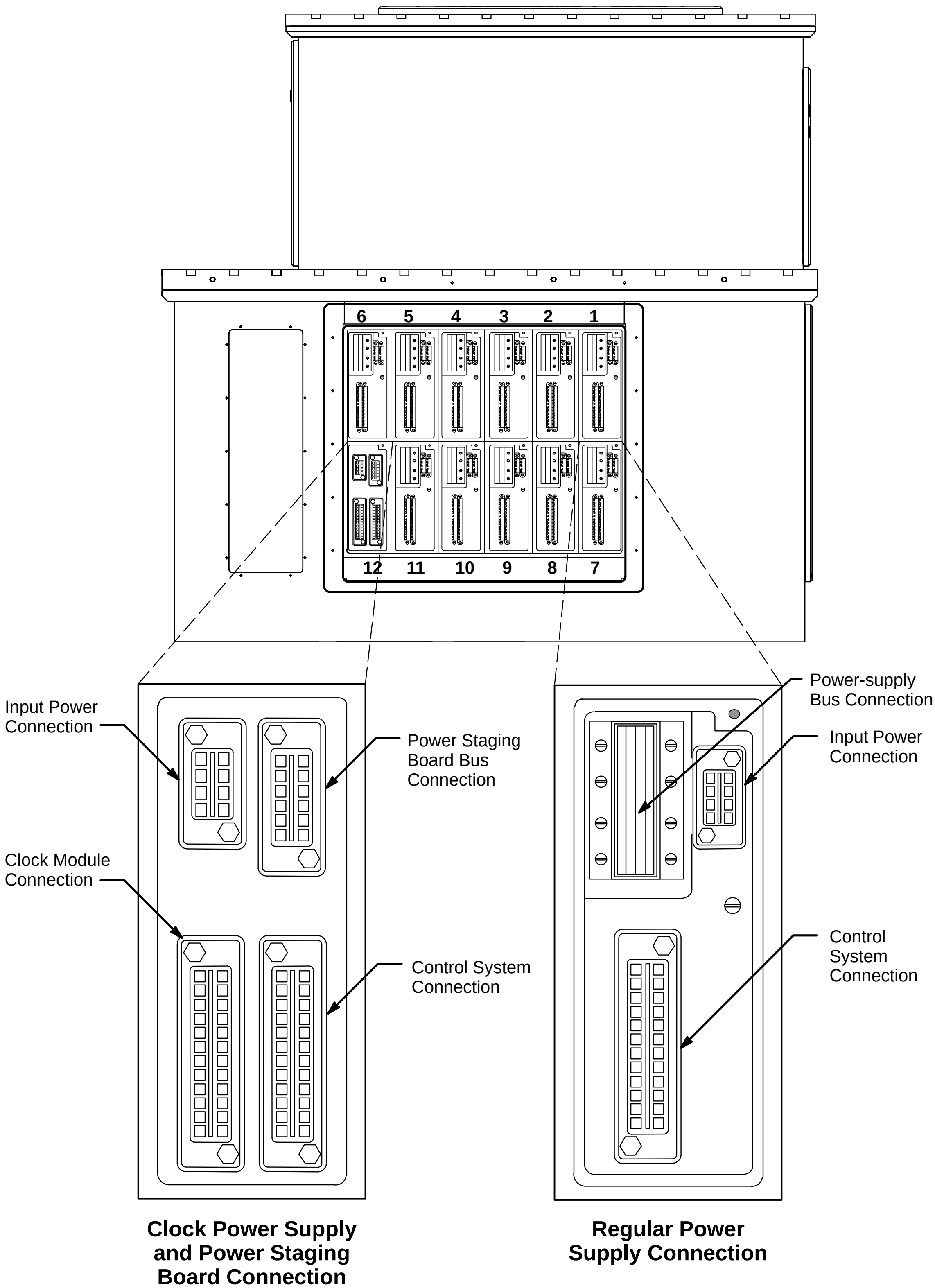
The regular power supplies and the clock power supply and power staging board assembly use blind-mate connections, which are located on the back of the power supply. However, the regular power supplies and the clock power supply and power staging board assembly have different connection configurations. Refer to Figure 13 for an illustration of the power-supply harness connections for both types of power supplies.

NOTE: Each type of mainframe power supply and power staging assembly is a field replaceable unit (FRU); therefore, no field repair is recommended. The following connector descriptions and power supply illustrations provide information intended to help the reader understand the theory of operation of the power system. Refer to the *Field Replacement Procedures*, Cray Research publication number HMM-111-0, before you handle any of the power supply components.

WARNING

Electrical Hazard. Turn off the 330-Vdc circuit breakers in the HVDC before you handle these power supplies. Failure to so could result in severe shock, burns, or death.

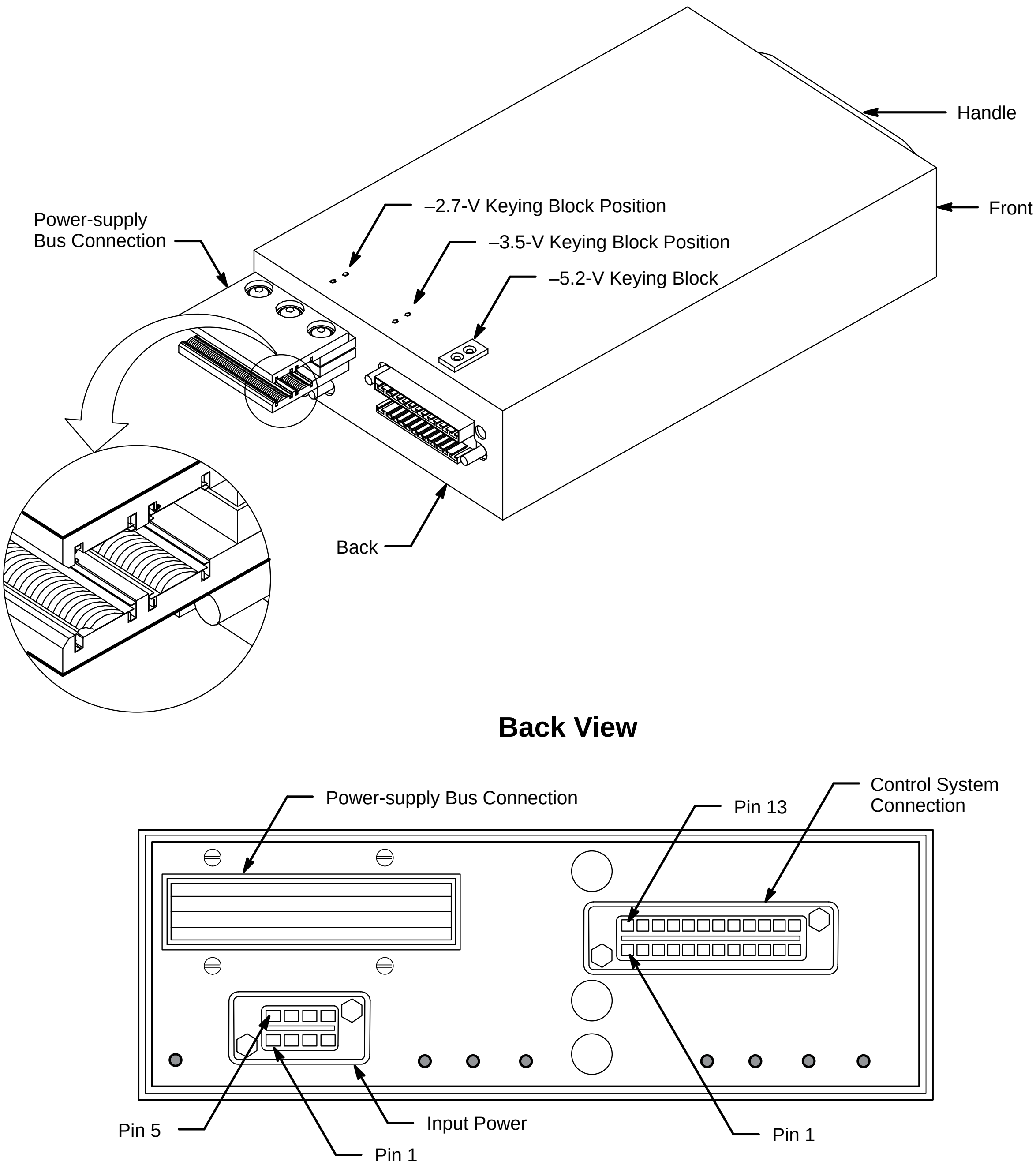
Figure 13. Power Supply Harness Connections



The regular power supplies have three connections: the input power connection, the control system connection, and the power-supply bus connection. Refer to Figure 14 for an illustration of the power supply connections and keying block positions.

The power-supply bus connection is a multicontact connection. This connection transfers the output current from the power supply to the power bus at every contact point. Figure 14 illustrates this connection.

Figure 14. Power Supply Connections



The input power connection is an 8-slot blind-mate connector; however, only six positions are used in this connector.

Connector Position	Function
1 and 2	+ 330-Vdc
5 and 6	– 330-Vdc
4 and 8	Ground
3 and 7	Not used

The control system connection is a 24-slot, blind-mate connector. The only power supply condition that the control system monitors is the “power supply good” condition. If any of the other power supply fault conditions exist, the “power supply good” condition sends a signal to the control system to indicate that the power supply has failed and requires replacement. Table 5 provides the pin numbers and the signal names for this connector.

Table 5. Power-supply Control System Connection

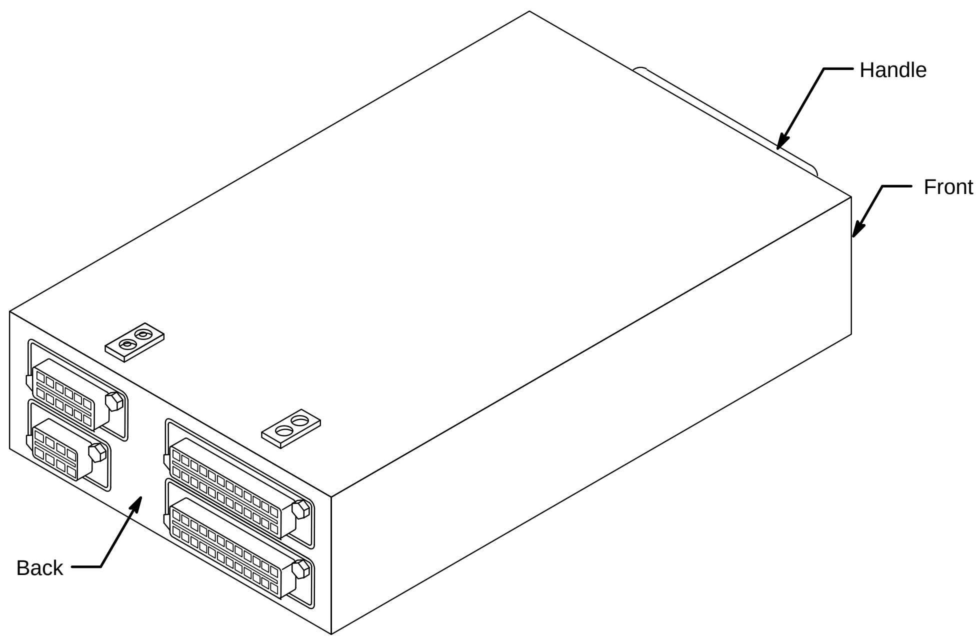
Pin Number †	Signal Name
1	Remote enable
2	Common return
3	Plus voltage remote sense
4	Minus voltage remote sense
5	Current share
6	Current share return
7	Clock
8	Clock return
9	ISO +5V to 15V
10	ISO return (flag return)
11	Power supply good
12	Input power good
13	Overtemperature flag
14	Overvoltage flag
15	Not used
16	Analog margin enable
17	Low margin enable (–5 %)
18	High margin enable (+5 %)
19	Margin return
20	Analog margin input
21	Not used
22	Current monitor return
23	Current monitor
24	Local current share

† Only the pin numbers that are **bold** carry signals that are wired into the power supply harness.

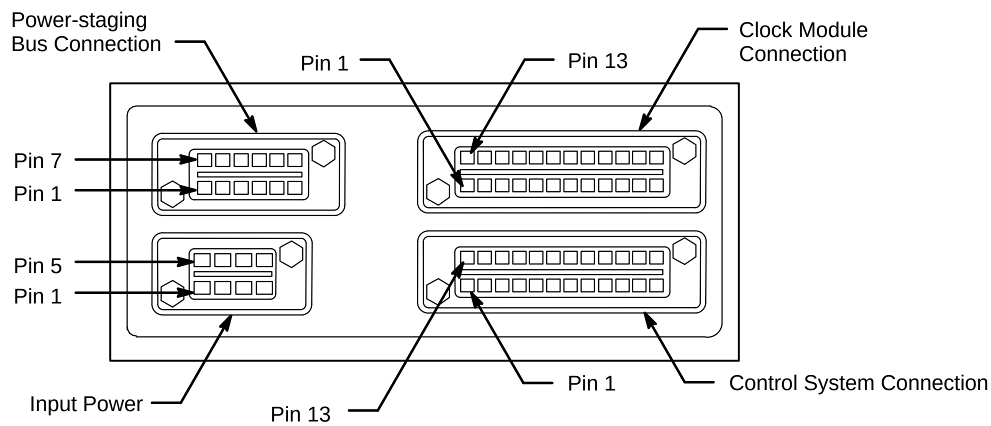
The power supply bus connection is a multicontact connection. This connection transfers the output current from the power supply to the power bus.

The clock power supply in power-supply slot number 12 contains a master-clock power board, a power staging board, and four external connections: an input power connection, a power-staging bus connection, a control system connection, and a clock module connection. Refer to Figure 15 for an illustration of this field-replaceable assembly and its connections.

Figure 15. Clock Power Supply and Power Staging Board Assembly



Back View



The control system connection on the clock power supply is a 24-pin connector that routes information to and from the control system. Table 6 provides the pin information for this connection.

Table 6. Clock Power Supply Control System Connection

Pin Number	Signal Name
1	Laser select primary
2	Laser 1 alarm primary
3	Laser 2 alarm primary
4	Clock select 0 primary
5	Clock select 1 primary
6	Clock select 2 primary
7	Clock power supply enable primary
8	Clock power supply good
9	Clock margin enable
10	Clock margin signal
11	Clock margin return
12	Laser select backup
13	Laser 1 alarm backup
14	Laser 2 alarm backup
15	Clock select 0 backup
16	Clock select 1 backup
17	Clock select 2 backup
18	Clock power supply enable backup
19	–5.2 V
20	–5.2 V Return
21	Plus voltage sense –5.2-V primary
22	Minus voltage sense –5.2-V primary
23	Plus voltage sense –5.2-V backup
24	Minus voltage sense –5.2-V backup

The input power connection is the same as the input connection used with the regular power supplies.

The clock module connection is also a 24-pin connector; it routes control information to the clock module. Table 7 provides the pin numbers and signal names of this connector.

Table 7. Clock Module Connection

Pin Number	Signal Name
1	Laser 1 enable
2	Laser 1 return
3	Laser 2 enable
4	Laser 2 return
5	Laser 1 alarm
6	Laser 1 alarm return
7	Laser 2 alarm
8	Laser 2 alarm return
9	Clock select 0 plus voltage
10	Clock select 0 minus voltage
11	Clock select 1 plus voltage
12	Clock select 1 minus voltage
13	Clock select 2 plus voltage
14	Clock select 2 minus voltage
15	Oscillator 1 enable
16	Oscillator 4 enable
17	Oscillator 3 enable
18	Oscillator 2 enable
19	Minus voltage sense
20	Plus voltage sense
21	–5.2 V
22	–5.2 V return
23	–5.2 V
24	–5.2 V return

The power-staging bus connection on the clock power supply is a 12-pin connector that connects the power staging assembly to the power bus. This connection is the output connection that allows the power staging assembly to send a small current across the LVDC to check for electrical shorts. Table 8 provides the pin numbers and the signal names for this connector.

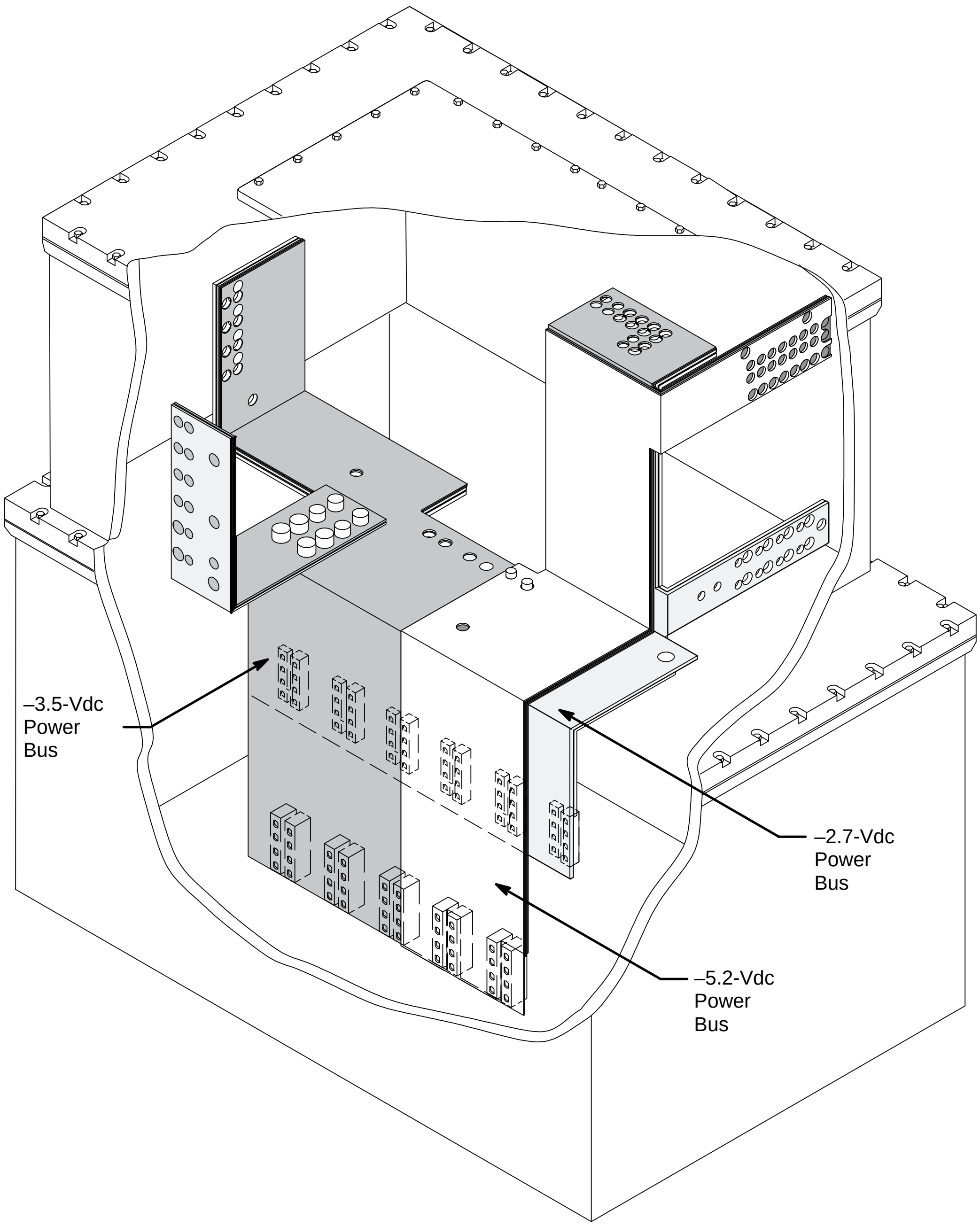
Table 8. Power-staging Bus Connection

Pin Number	Signal Name
1	–5.2-V ground
2	–3.5-V ground
3	–2.7-V ground
4	Not used
5	Enable –5.2 V
6	Enable –2.7 V
7	–5.2-V bus
8	–3.5-V bus
9	–2.7-V bus
10	Not used
11	Enable –3.5 V
12	Return

Power Distribution to the Modules

After the power supplies convert the 340-Vdc power to specific voltages, the low-voltage DC (LVDC) bus distributes the voltage to the appropriate modules. The LVDC bus consists of a –2.7-Vdc power bus, a –2.7-Vdc ground bus, a –3.5-Vdc power bus, a –3.5-Vdc ground bus, a –5.2-Vdc power bus, and a –5.2-Vdc ground bus. Refer to Figure 16 for an illustration of this bus.

Figure 16. Low-voltage DC (LVDC) Bus



The LVDC bus consists of six laminated layers of copper; three voltage layers and three ground layers routed to designated module and sense point locations. Figure 17 through Figure 19 provide illustrations of each power bus in the LVDC bus.

Figure 17. –2.7-Vdc Power Bus

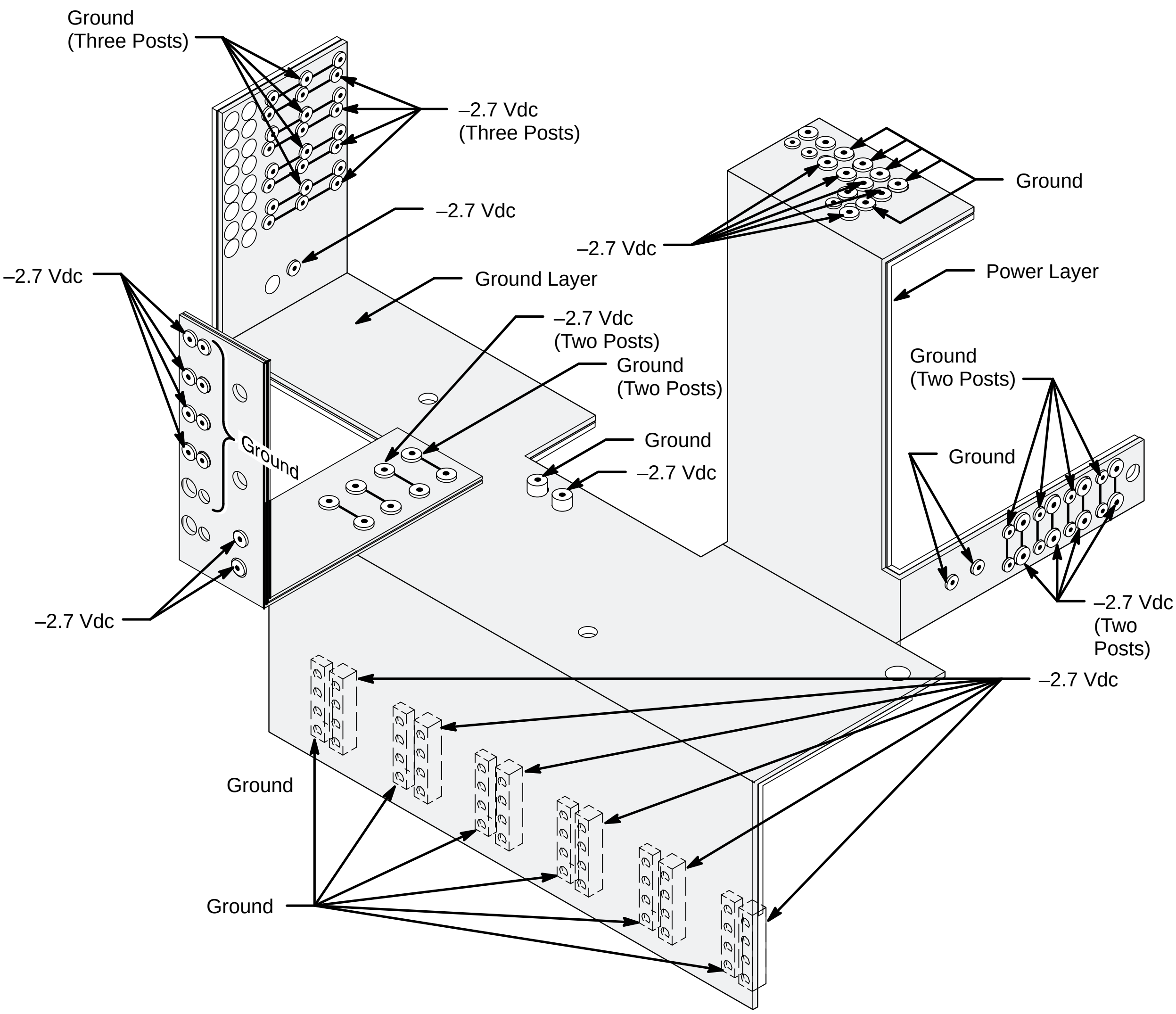


Figure 18. –3.5-Vdc Power Bus

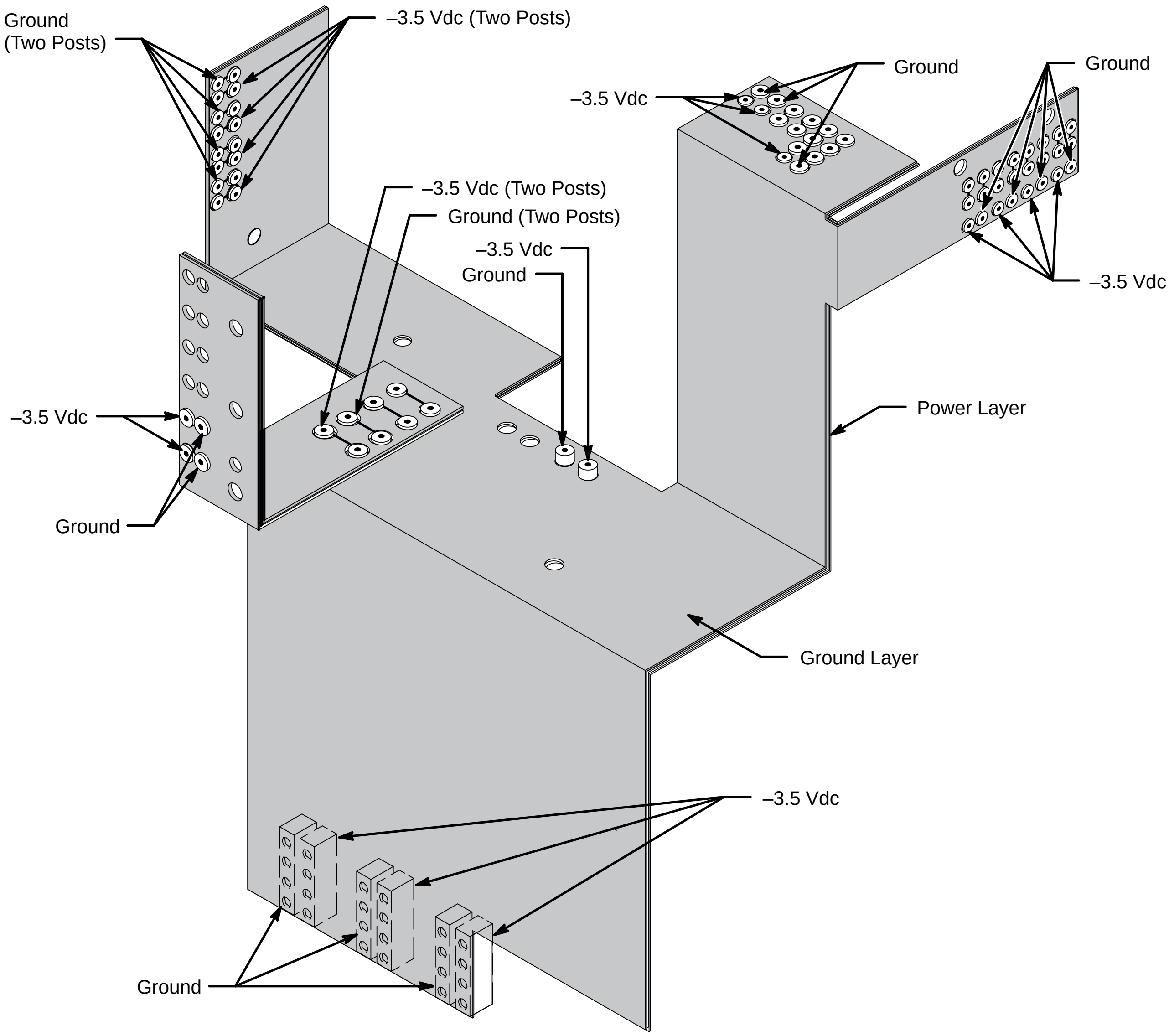
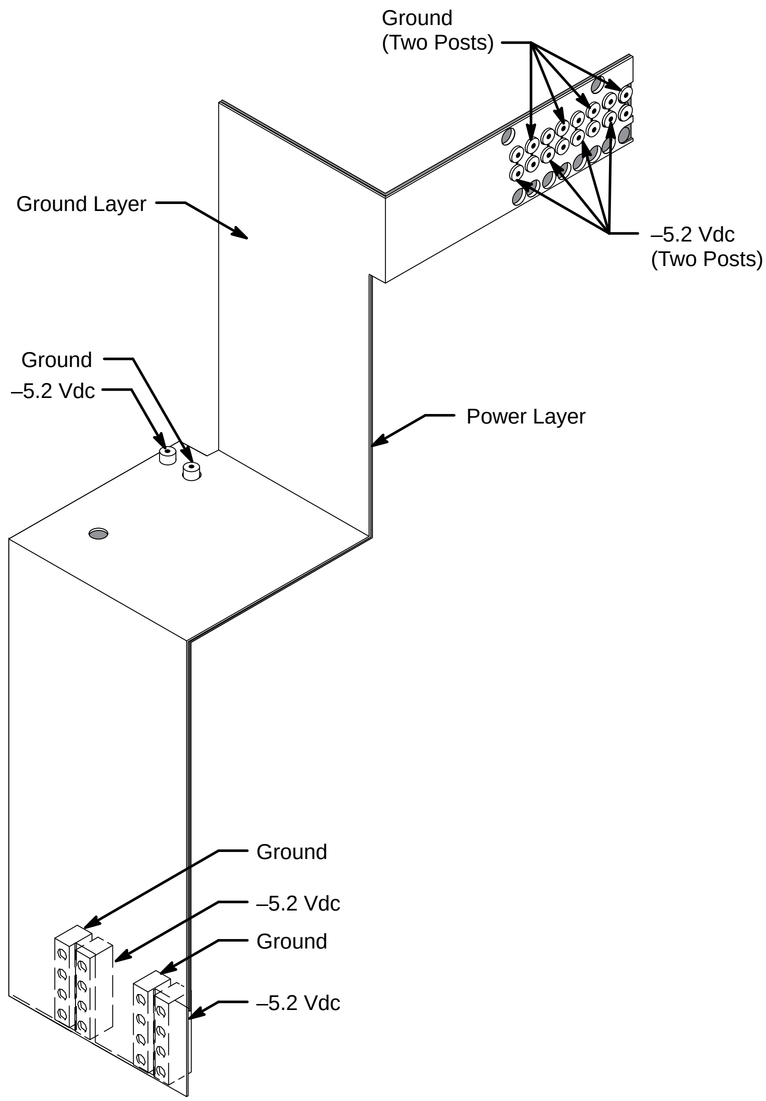
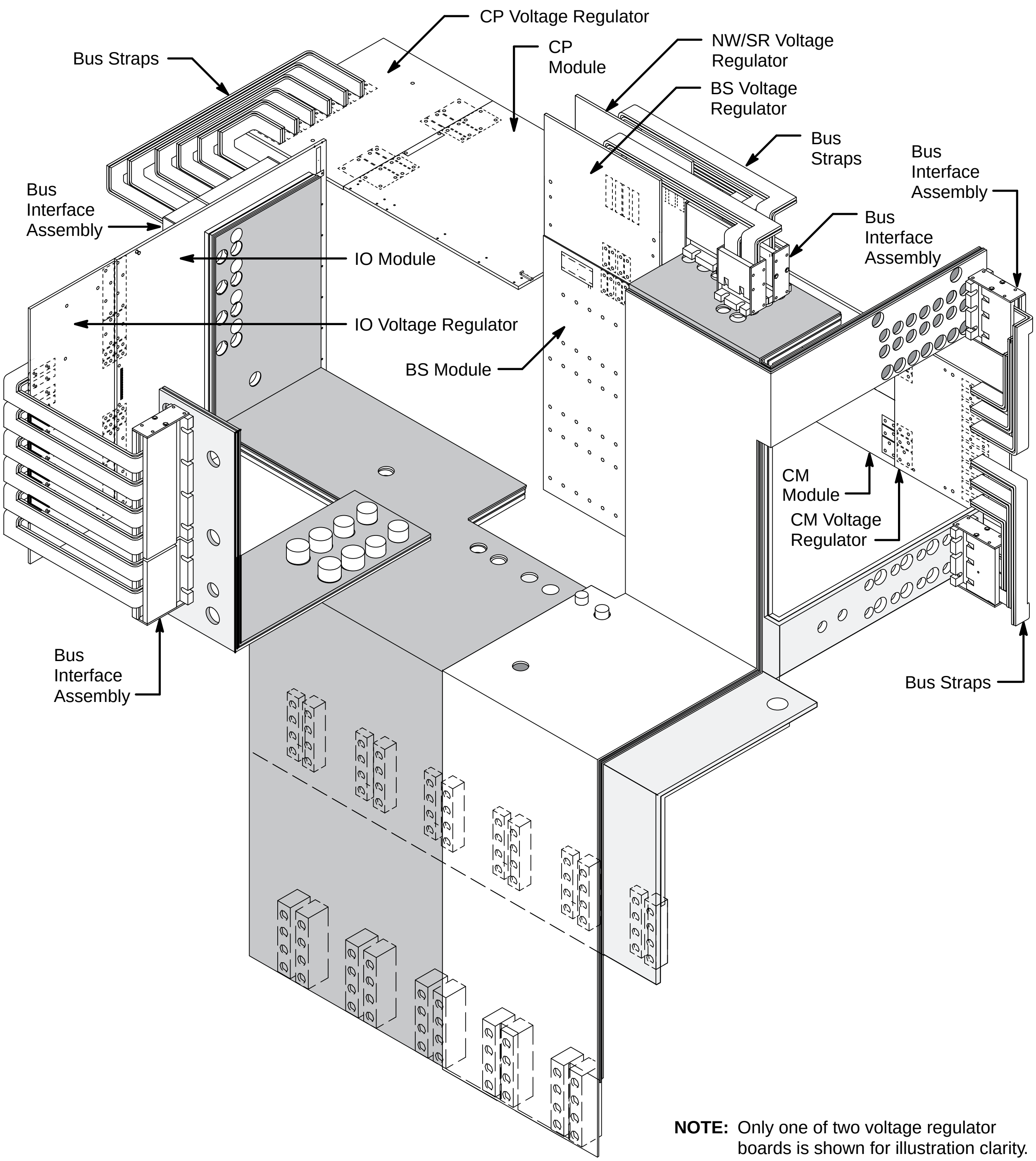


Figure 19. –5.2-Vdc Power Bus



The LVDC bus distributes power to the modules. A bus interface assembly mounts on the LVDC bus and routes the power through metal bus straps to the module voltage regulator Each voltage regulator, in turn, provides a steady voltage to the module power pads and protects the module from any voltage fluctuations or voltage spikes. Refer to Figure 20 for an illustration of the LVDC bus, power connections, and module layout.

Figure 20. LVDC Power Connections and Module Layout



NOTE: Only one of two voltage regulator boards is shown for illustration clarity.

Each module type has a different voltage regulator, bus interface assembly, and bus strap configuration for power distribution. Refer to Figure 21 through Figure 25 for illustrations of each type of module connection.

Figure 21. IO Module Connections

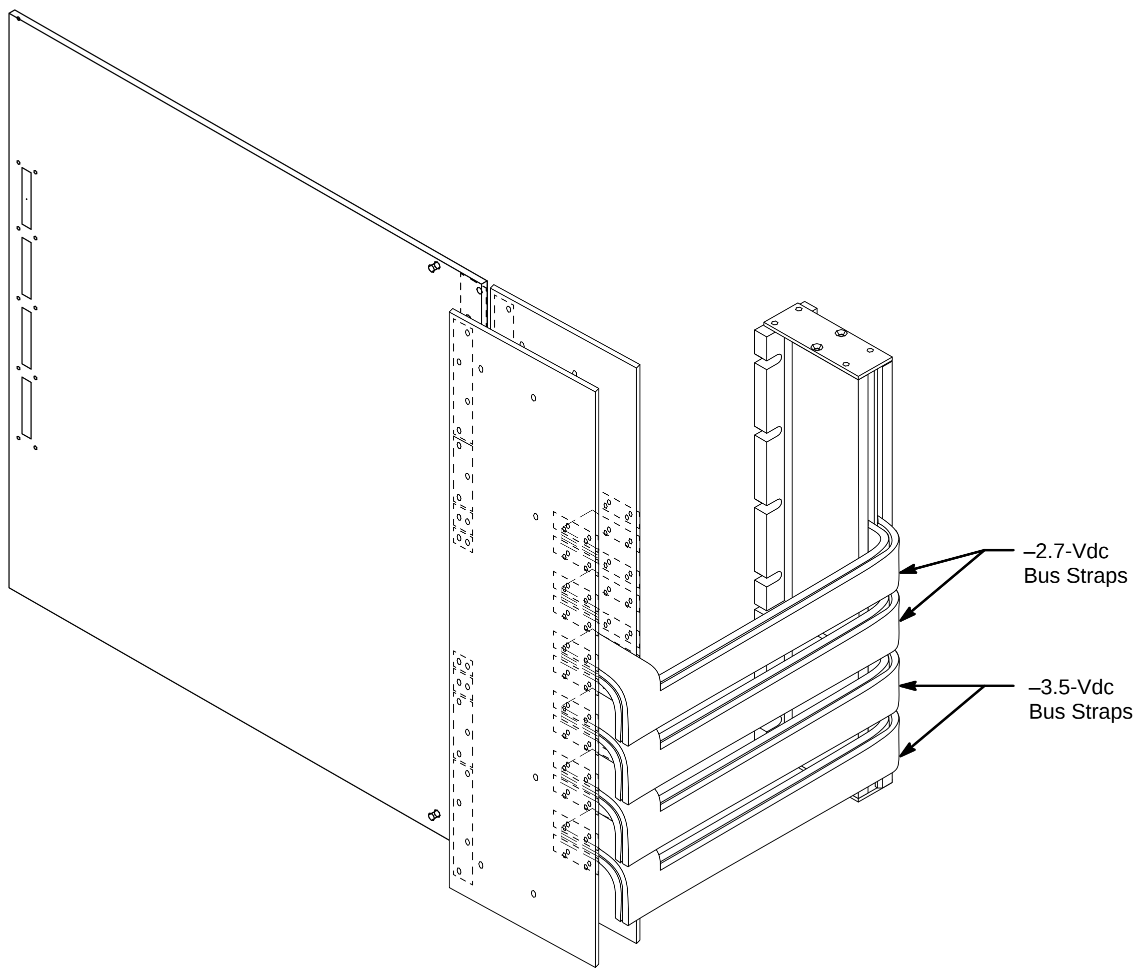


Figure 22. CP Module Connections

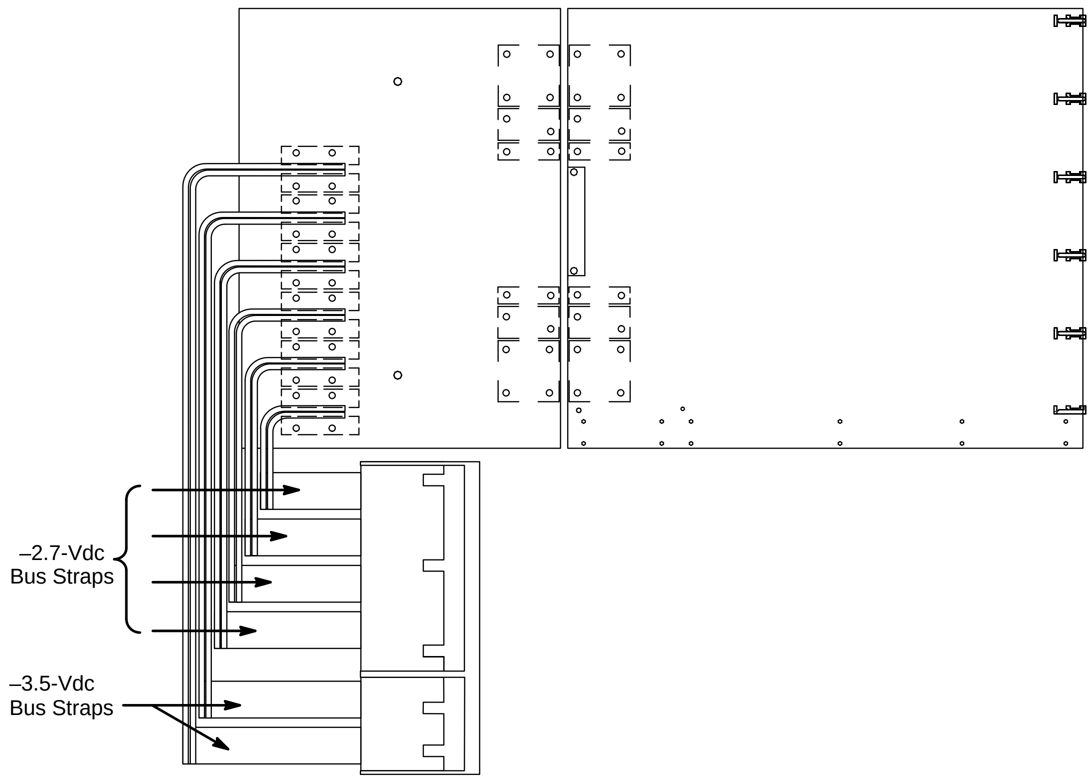


Figure 23. Shared Module Connections

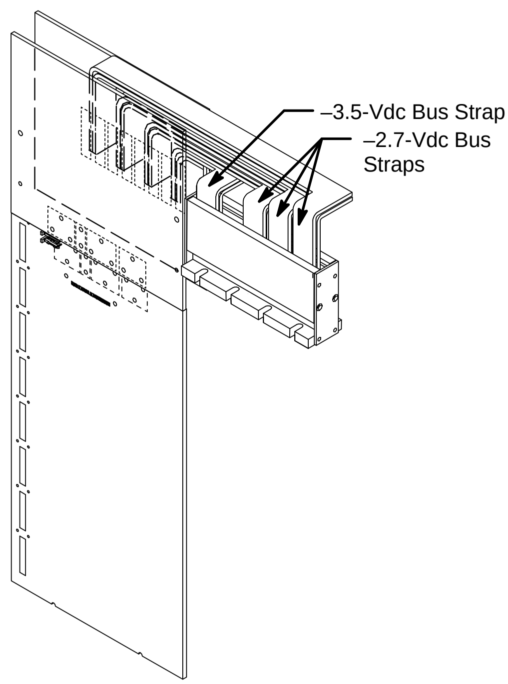


Figure 24. Boundary Scan Module Connections

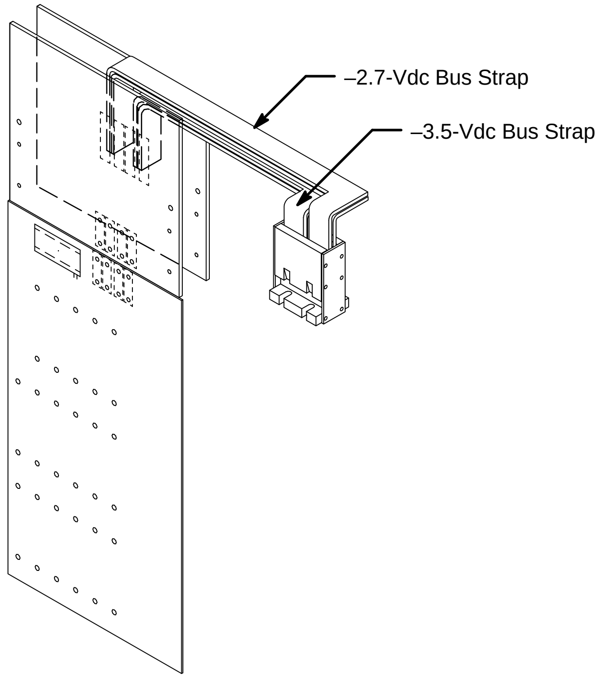
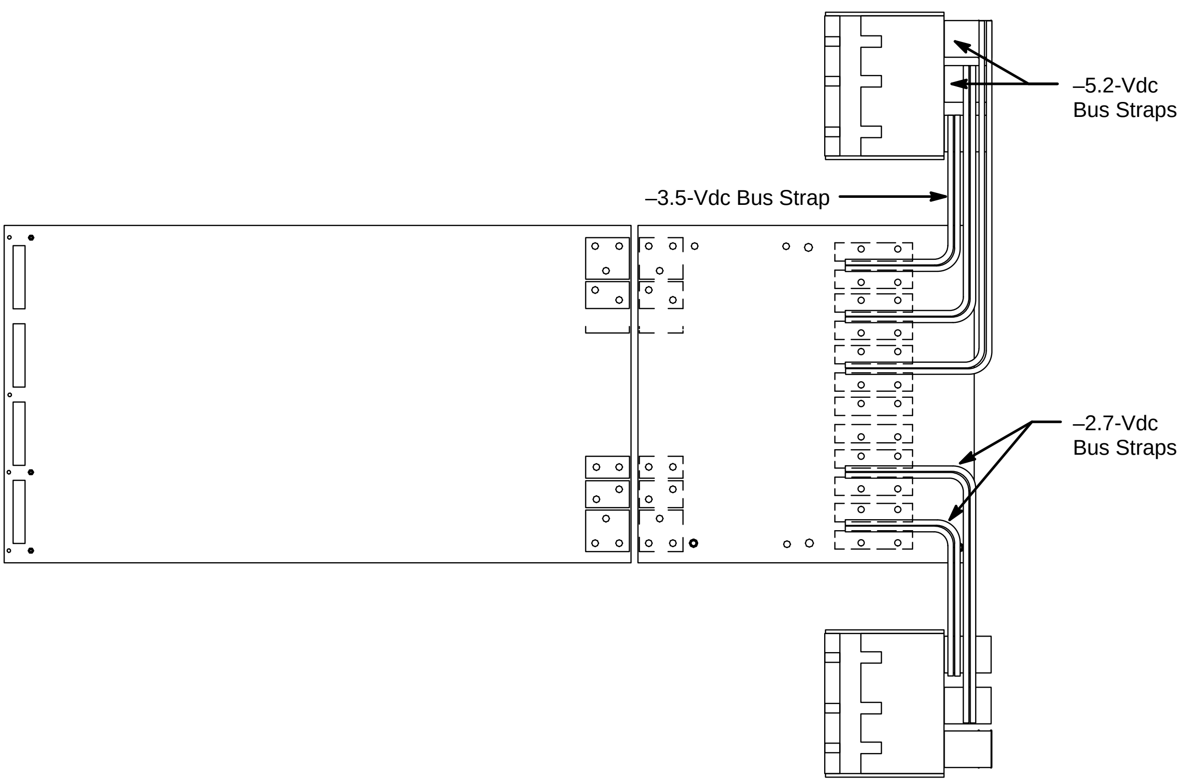


Figure 25. Common Memory Module Connections



Cooling System

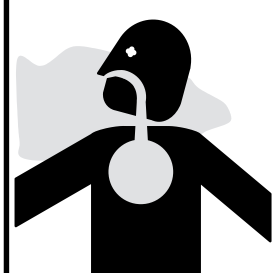
The cooling system removes heat generated by the modules and power supplies and transfers it to the heat exchanger unit (HEU-T90). The modules and power supplies are submersed in dielectric coolant, which absorbs the heat generated by these modules and power supplies. The following subsections describe the cooling system components within the mainframe.

Components

The cooling system in the CRAY T94 mainframe requires very few components, which the following subsections describe. Refer to Figure 26 for an illustration of these component locations.

Dielectric Coolant

Dielectric coolants, such as Fluorinert liquid, are nonconductive liquids that absorb heat and transfer it away from the heat source. These liquids are inert and noncorrosive. Dielectric coolants are safe products when handled with care. Refer to the manufacturer’s Material Safety Data Sheet and the *Safe Use and Handling of Fluorinert Liquids* manual, Cray Research publication number HR-00306, for more information about Fluorinert liquid safety.



WARNING

Prevent dielectric coolant from coming in contact with excessive heat. Dielectric-coolant liquid can decompose and produce hazardous by-products when exposed to excessive heat. Inhalation of gases produced by decomposed dielectric coolant could cause severe injury or possibly death.

Supply Line

The supply line provides cool dielectric coolant to the mainframe from the HEU-T90.

Return Line

The return line routes the dielectric coolant that has flowed through the mainframe and absorbed heat to the HEU-T90, where the dielectric coolant is again cooled for reuse.

NOTE: If any service to the mainframe components results in replenishment of the dielectric coolant, you must replenish the cooling system with Fluorinert liquid.

CAUTION

Replenish the cooling system with 3M Fluorinert electronic liquid only. Failure to do so can result in cooling system contamination and computer system failure.

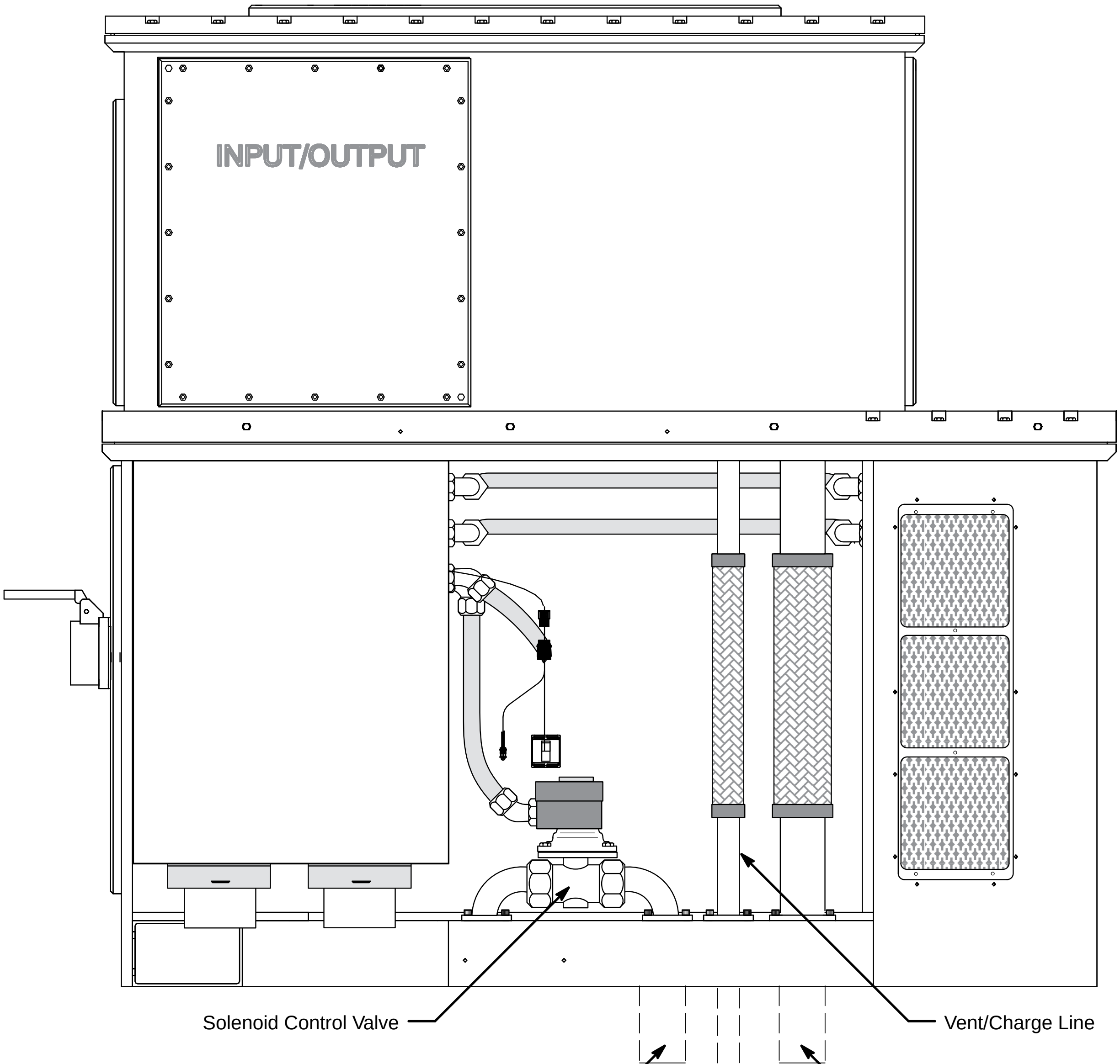
Vent/Charge Line

The vent/charge line provides an air-exchange route during the filling and draining of the mainframe. During the fill process, the change in air pressure forces any air that may be in the mainframe chassis through the vent/charge line and back to the HEU-T90 reservoir. Likewise, during the draining process, the change in air pressure forces the air in the HEU-T90 reservoir through the vent/charge line and back to the mainframe chassis.

Solenoid Control Valve

The solenoid control valve is used to drain the mainframe IO harness section. The valve is normally closed; however, when the valve is enabled, it opens. When the valve is closed, the mainframe I/O section fills or remains filled. When the valve opens, the dielectric coolant flows through the valve and drains into the return line.

Figure 26. Cooling System Component Locations



Dielectric-coolant Flow Paths

The dielectric-coolant flow paths through the CRAY T94 mainframe are relatively simple. Figure 27 and Figure 28 illustrate the dielectric-coolant flow path through the CRAY T94 mainframe. The following subsections describe the flow paths for the fill process, normal operation, and the drain process.

Figure 27. CRAY T94 Dielectric-coolant Flow Path (Part 1 of 2)

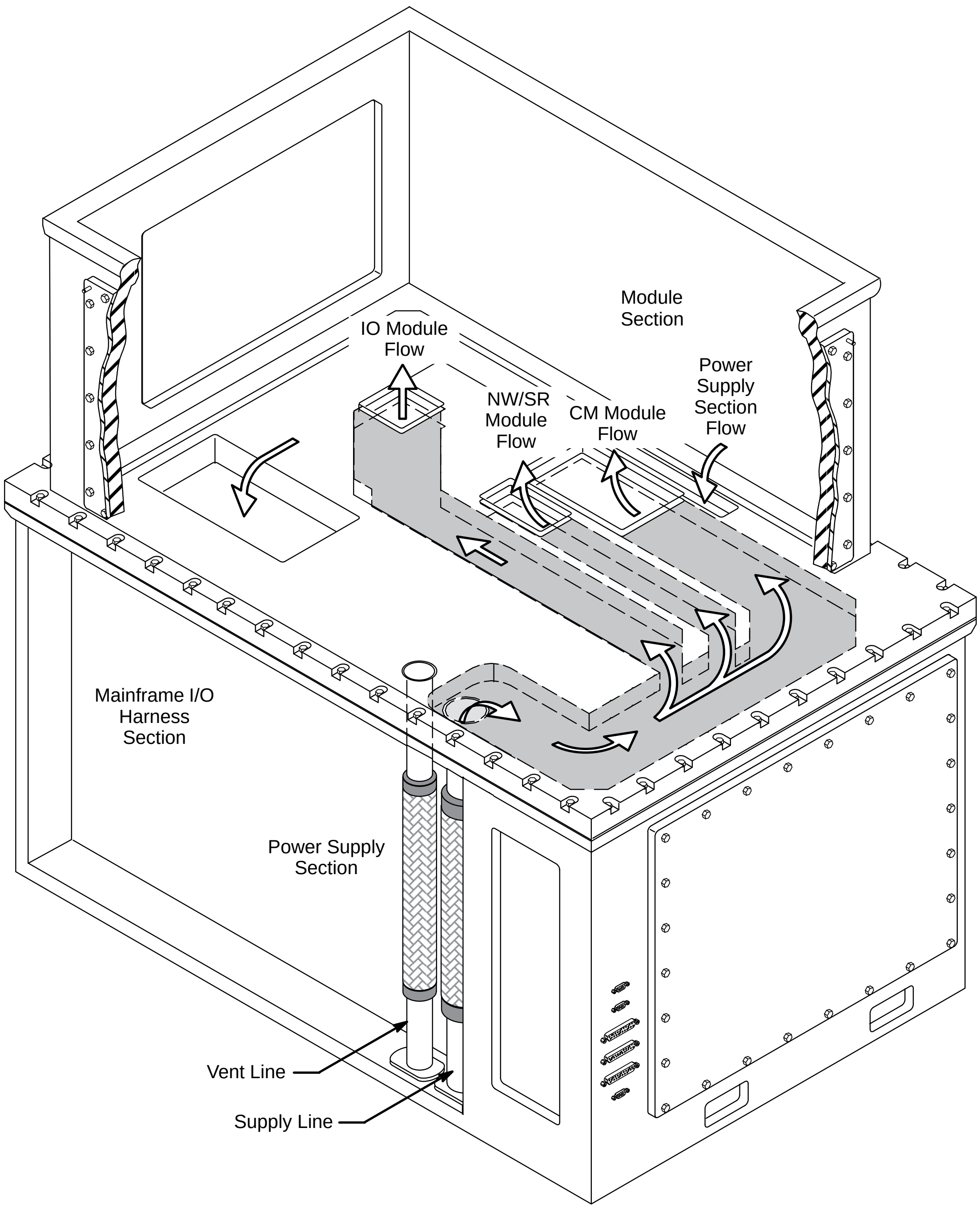
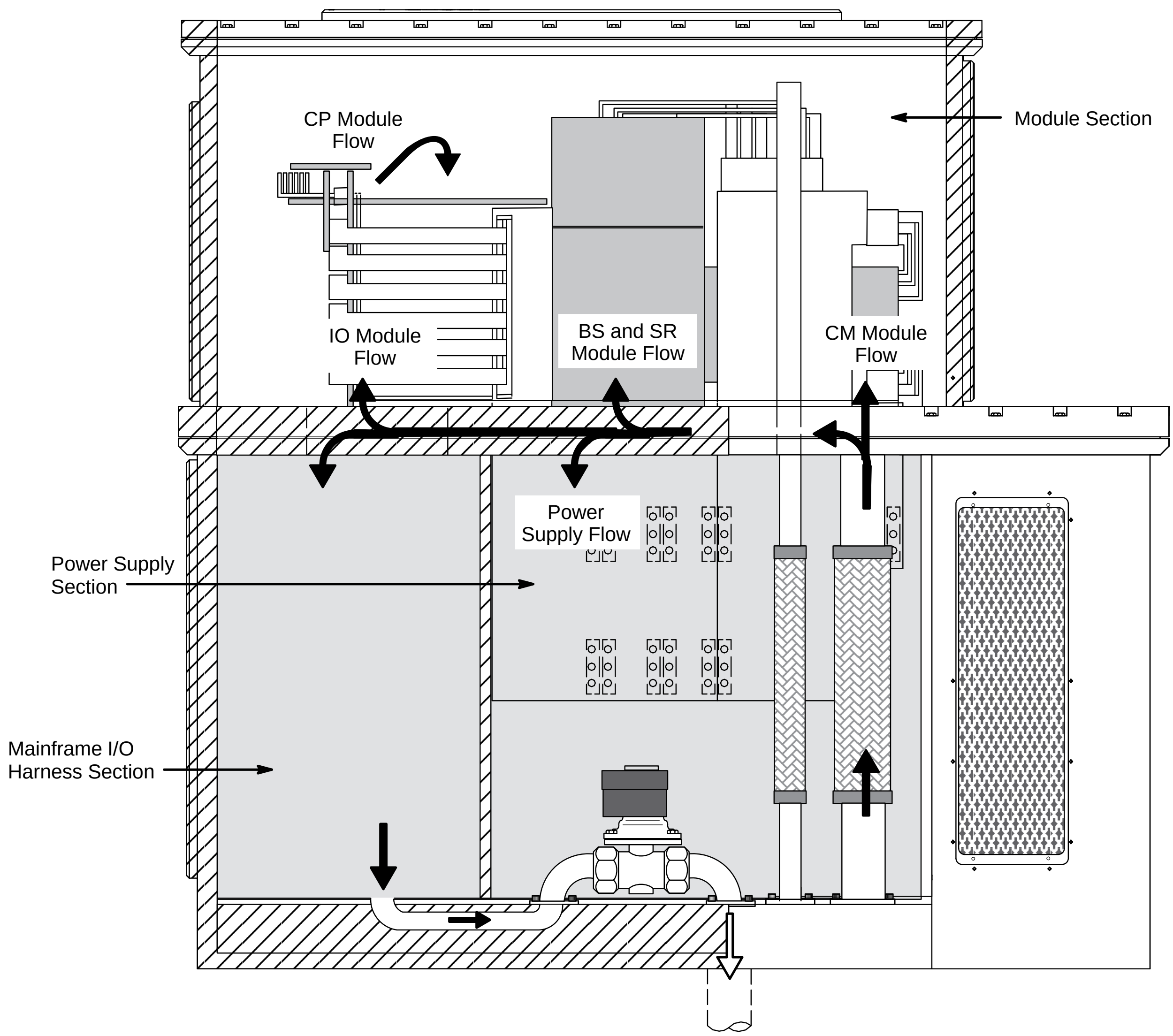


Figure 28. CRAY T94 Dielectric-coolant Flow Path (Part 2 of 2)



Fill Flow Path

During the mainframe power-up sequence, dielectric coolant flows into the mainframe through the supply line, which enters the mainframe just above the power supply section. Gravity forces the dielectric coolant to fall to the bottom of the mainframe tank where the power supplies are located and simultaneously fills the I/O harness section. Once the power supply section and I/O harness section have been filled, the module section fills with dielectric coolant.

As the dielectric coolant fills the mainframe, any air that is displaced by dielectric coolant in the mainframe flows through the vent/charge line back to the HEU-T90 reservoir.

Normal Flow Path

Dielectric coolant flows through the mainframe during normal operation in much the same way as during the fill process, except that instead of only filling the mainframe, the dielectric coolant constantly circulates through the supply line, the mainframe, and the return line to the HEU. While the mainframe is powered up, dielectric coolant flows through the mainframe at approximately 100 gpm.

Drain Flow Path

When the mainframe is powered down, the dielectric coolant can be completely drained from the tank or just partially drained. If a module requires replacement, the mainframe can be partially drained. If access to a power supply or component at a lower level is required, the mainframe must be completely drained.

During the drain process, the dielectric coolant drains from the mainframe through the return line, which attaches to the bottom of the power supply section. The pump in the HEU-T90 suctions the dielectric coolant from the power supply section and the module section into the return line and back to the HEU reservoir.

Because the I/O harness section is separate from the module and power supply section, a special solenoid control valve enables the I/O harness section to drain. The valve connects the I/O harness section with the power supply section. During the Empty Tank process, when the mainframe drains completely, the solenoid control valve opens, which allows the HEU to suction dielectric coolant out of the I/O harness section, into the return line, and back to the HEU reservoir.

Control System

The control system for the CRAY T94 mainframe monitors the power bus voltages, power supply current, and the dielectric-coolant level.

This subsection provides control system information for the CRAY T94 mainframe only; it does not provide information about the entire control system. Refer to the *Control System Overview*, Cray Research publication number HTM-065-0, for detailed information about the control system. Refer to the *Power, Cooling, and Control System Troubleshooting Guide*, Cray Research publication number HTM-179-0, for detailed information about control system troubleshooting.

Components

Refer to Figure 29 for an illustration of the locations of the following mainframe control system components.

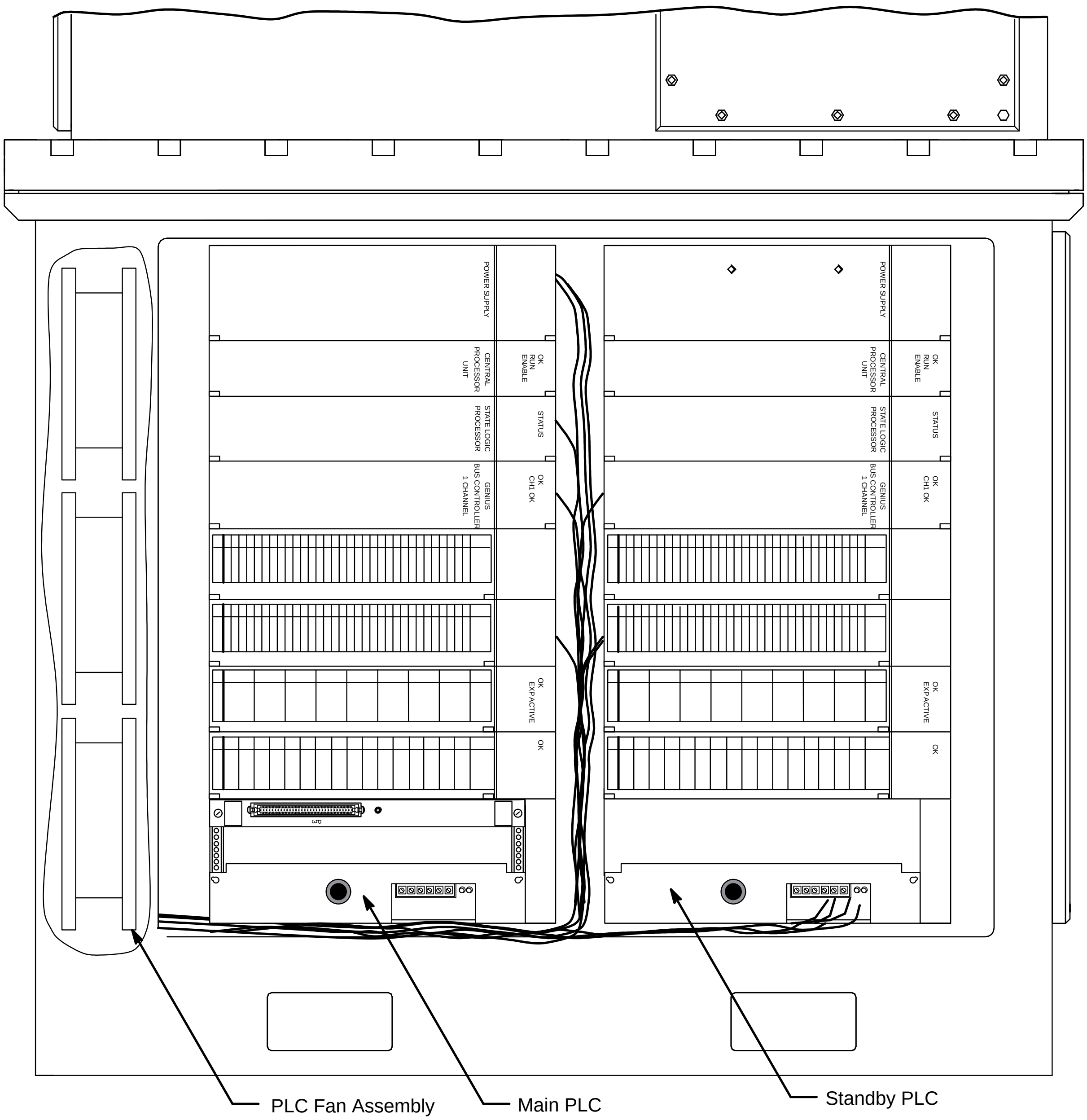
Programmable Logic Controllers (PLCs)

The two PLCs (main and standby) are located next to each other on the front of the mainframe. These two PLCs are identical, except that the standby PLC does not contain the VMIVME-4132 analog output card used for power supply margining. If the main PLC fails, the standby PLC takes control of the computer system until the main PLC is repaired and operating.

PLC Fan Assembly

The PLC fan assembly is mounted in the side of the CRAY T94 mainframe next to the PLCs. The fan assembly blows air around the PLCs and then out the vents located on the other side of the mainframe. This PLC fan assembly receives 120-Vac power from the power input box.

Figure 29. PLC Locations

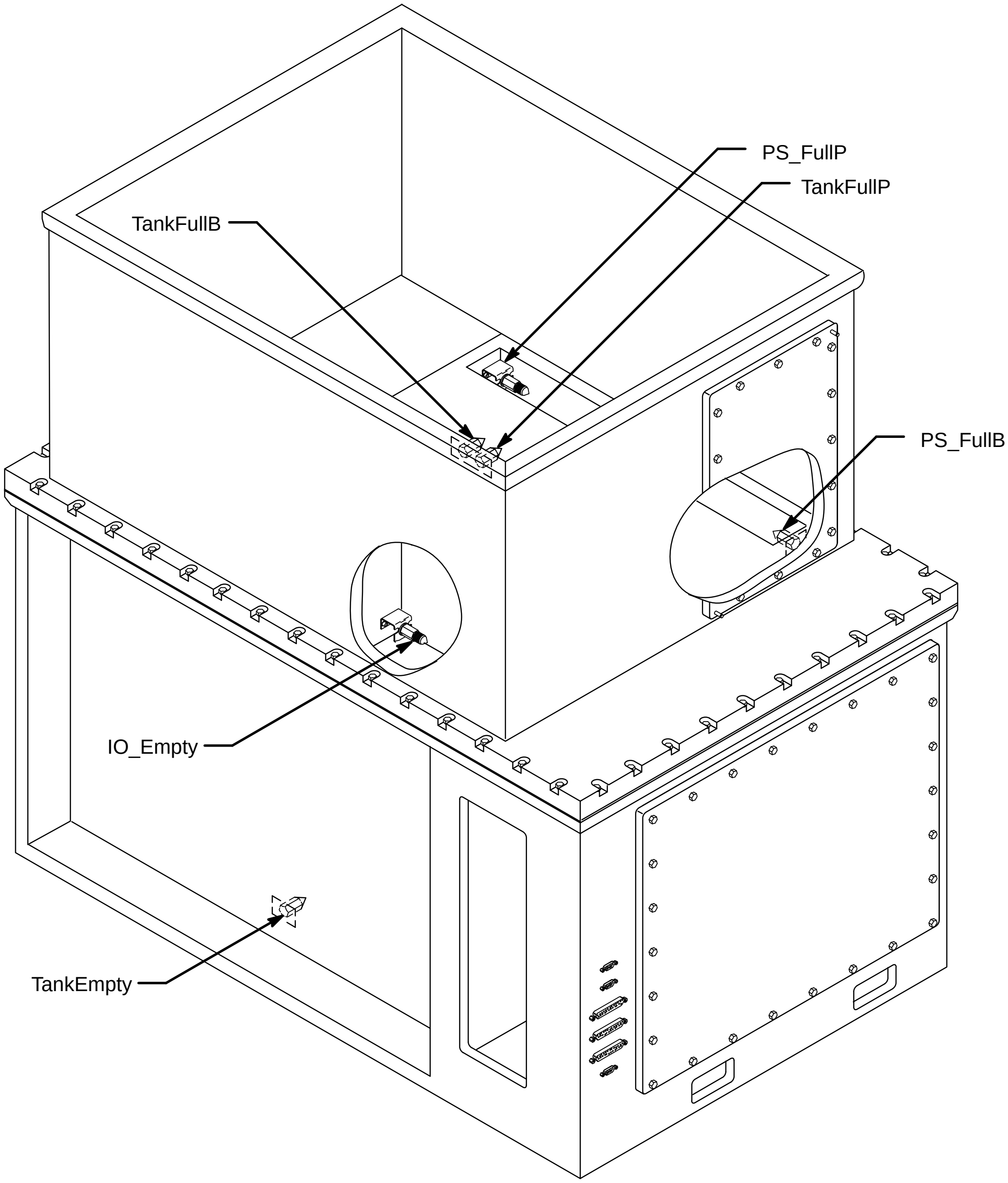


Level Sensors

Six level sensors monitor the level of dielectric coolant within the CRAY T94 mainframe. These sensors are located in strategic positions within the mainframe tank so that they can monitor the presence of coolant at specific levels during the mainframe fill and drain processes.

Two level sensors (primary and backup) monitor the presence of dielectric coolant in the top area of the mainframe. Two additional level sensors monitor the presence of dielectric-coolant in the power supply area of the mainframe. Two more sensors in the drain area and cable drop area monitor the presence of dielectric coolant in the mainframe during the drain process. Figure 30 illustrates the level sensor locations in the CRAY T94 mainframe.

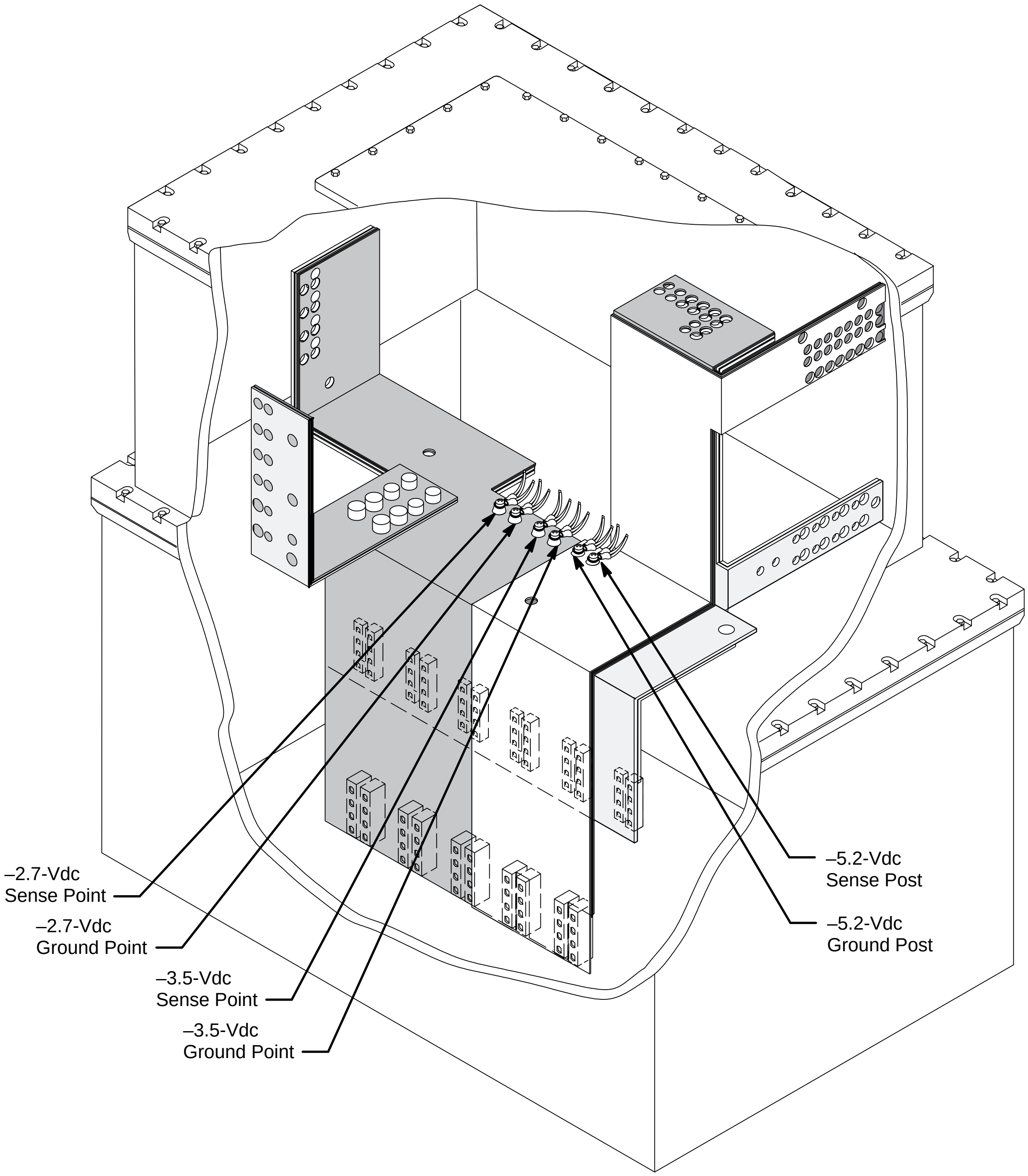
Figure 30. Level Sensor Locations



Voltage Sense Points

Voltage sense points enable the control system to monitor the voltage of each power bus. Six voltage sense posts connect to wires that route the voltage levels of each bus to the control system. Figure 31 illustrates the sense point locations in the CRAY T94 mainframe.

Figure 31. Voltage Sense Points



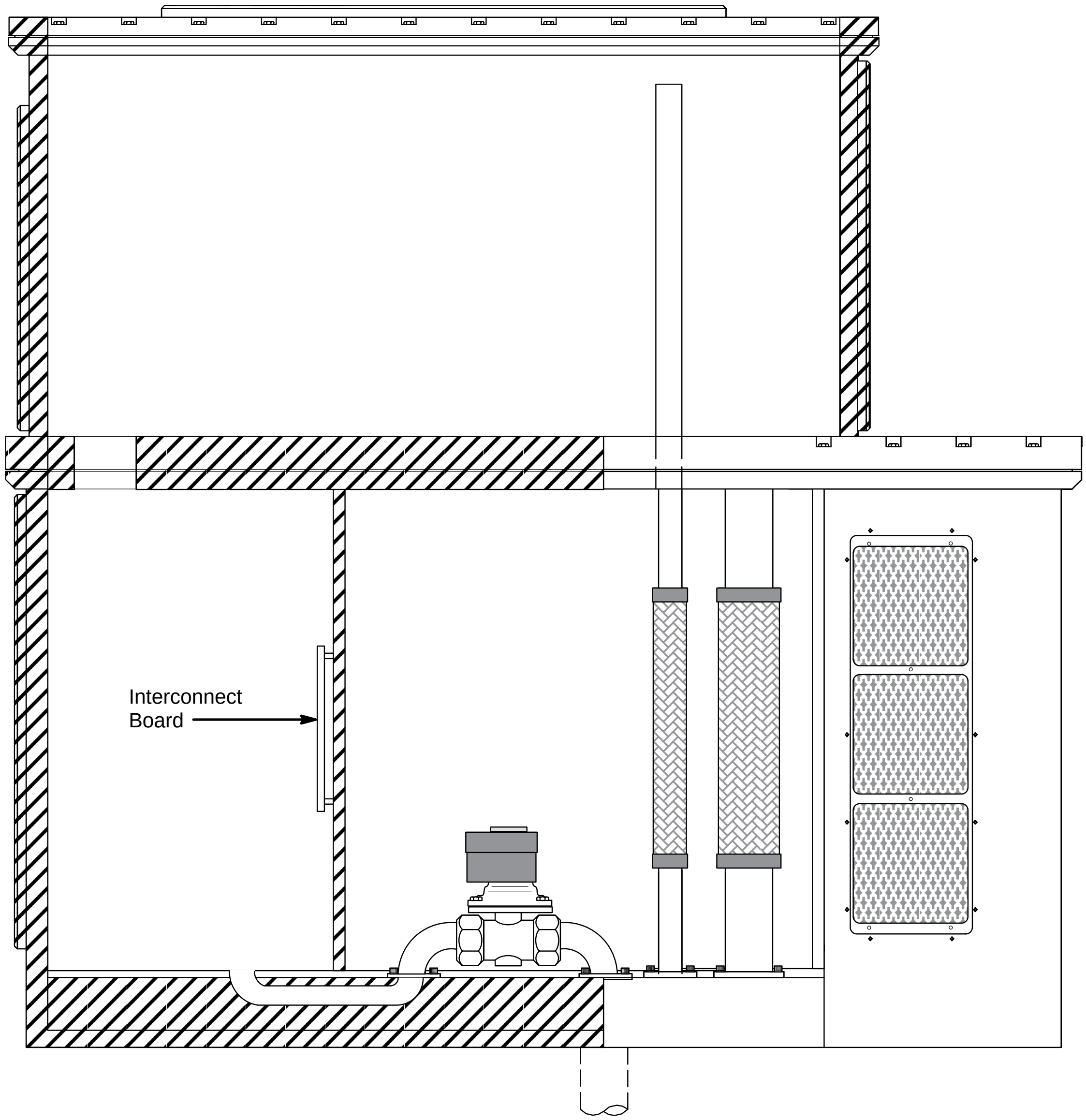
Current Sensors

The current output of each power supply is measured through the imon + and imon – connections on each power supply, except the clock power supply. The power supplies send this current measurement through the control system interconnect board and then to the voltage input module of the controller.

Control System Interconnect Board

The control system interconnect board receives the sensor and monitor information and routes the information to the appropriate PLC component. Figure 32 illustrates the location of the control system interconnect board.

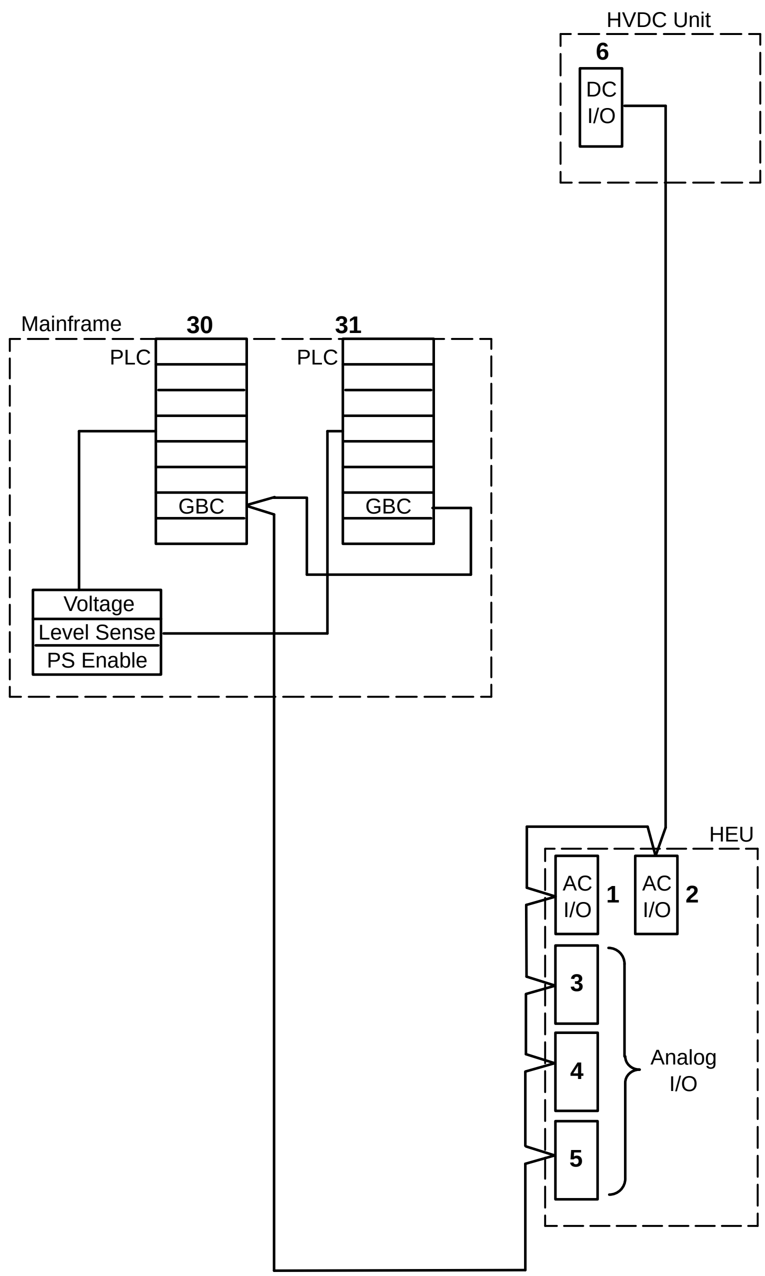
Figure 32. Control System Interconnect Board Location



Control System Configuration

Because each CRAY T90 series computer system has different component configurations, the control system configuration differs as well. Basically, the only change in the control system configuration that occurs among different systems is the component numbering scheme. Each remote monitoring block has a number associated with it; Figure 33 provides the numbering scheme for the CRAY T94 control system.

Figure 33. CRAY T94 Control System Configuration



Monitored Conditions and Limits

The control system monitors and controls numerous conditions. Five PLC components provide this status and control information: the TTL input module, the 12-Vdc output module, the analog input base converter, the voltage input expander module, and the analog output board.

Table 9 lists the conditions that the control system monitors. Table 10 through Table 15 provide information about the PLC components.

Table 9. Monitored Conditions

Conditions	Label Description	Location	Description
Dielectric-coolant level	TankFullP TankFullB	Module section	Two level sensors (primary and backup) monitor the dielectric-coolant level at the top of the module section.
	TankEmpty		One level sensor monitors the dielectric-coolant level at the bottom of the module section.
	PS_FullP PS_FullB	Power supply section	Two level sensors (primary and backup) monitor the dielectric-coolant level at the top of the power supply section.
	IO_Empty	I/O section	One level sensor monitors the dielectric coolant at the bottom of the I/O section.
Connector check	ConnCheck	J2 and J3 connectors	Connector check of the J2 and J3 connectors to verify correct cabling; system will not power up if these two connectors are not cabled correctly.
Laser check	LaserAlarm1 LaserAlarm2	Optical clock module	One signal comes back from each of the two lasers on the optical clock module to indicate whether the laser is functioning properly.
Power supply flag	PS_Flag1 - 11 PS_FlagClk	Power supply	Each power supply sends a signal back to the control system if there is a fault.
Power supply enable	Enable27 Enable35 Enable52 EnableClk PS_EN52 PS_EN35 PS_EN27	Power supply	The control system sends a signal to each power supply to enable it. The power supplies are enabled based upon the type of voltage the power supply produces.

Conditions	Label Description	Location	Description
Power supply margin enable	MargEn27 MargEn35 MargEn52 MargEn20 MargEnClk	Power supply	The control system sends a signal to each power supply to enable the margining control function.
Voltage measurement	Voltage –2.7 Voltage –3.5 Voltage –5.2 Voltage –2.0 Voltage Clk	Power bus and clock power supply	The control system measures the voltage of each power bus and the clock power supply.
HVDC check	HVDC 1 HVDC 2	HVDC line 1 and line 2	The control system measures the voltage of each line of the HVDC.
Current measurement	imon 1 – 11	Power supplies	The control system measures the current of each power supply, except the clock power supply.
Optical clock module select	LaserSelect	Optical clock module	The control system selects which laser will be used.
Clock select	ClockSel0 ClockSel1 ClockSel2	Clock power supply	The control system sets the clock speed bits 0, 1, and 2.
Boundary scan continuity line (burnline) check	Continuity Circuit	Boundary scan module	The control system monitors the boundary scan module continuity line for any error codes. The boundary scan continuity line returns a sum of 1 for an error or a sum of 0 for no errors.

Table 10. TTL Input Module

Label	Data Reference	Label Description	Description	LED Status	
				On	Off
A1	%I105	TankFullP	Mainframe tank is full	Wet	Dry
A2	%I106	PS_FullP	Mainframe power supply section is full	Wet	Dry
A3	%I107	TankFullB	Mainframe tank is full	Wet	Dry
A4	%I108	PS_FullB	Mainframe power supply section is full	Wet	Dry
A5	%I109	TankEmpty	Mainframe tank is completely empty	Wet	Dry
A6	%I110	ConnCheck	Cables are plugged in correctly	ok	Fault
A7	%I111	LaserAlarm1	Laser is ok	ok	Fault
A8	%I112	LaserAlarm2	Laser is ok	ok	Fault
B1	%I113	PS_Flag1	Power supply is ok	Fault	ok
B2	%I114	PS_Flag2	Power supply is ok	Fault	ok
B3	%I115	PS_Flag3	Power supply is ok	Fault	ok
B4	%I116	PS_Flag4	Power supply is ok	Fault	ok
B5	%I117	PS_Flag5	Power supply is ok	Fault	ok
B6	%I118	PS_Flag6	Power supply is ok	Fault	ok
B7	%I119	PS_Flag7	Power supply is ok	Fault	ok
B8	%I120	PS_Flag8	Power supply is ok	Fault	ok
C1	%I121	PS_Flag9	Power supply is ok	Fault	ok
C2	%I122	PS_Flag10	Power supply is ok	Fault	ok
C3	%I123	PS_Flag11	Power supply is ok	Fault	ok
C4	%I124	PS_FlagClk	Power supply is ok	ok	Fault
C5	%I125	IO_Empty	I/O cable drop area is empty	Wet	Dry
C6	%I126				
C7	%I127				
C8	%I128				
D1	%I129				
D2	%I130				
D3	%I131				
D4	%I132				
D5	%I133				
D6	%I134				
D7	%I135				
D8	%I136				

Table 11. 12-Vdc Output Module

Label Reference	Data Reference	Label Description	Function	LED Status	
				On	Off
A1	%Q105	Enable27	–2.7-V power supplies enabled	Enabled	Disabled
A2	%Q106	Enable35	–3.5-V power supplies enabled	Enabled	Disabled
A3	%Q107	Enable52	–5.2-V power supplies enabled	Enabled	Disabled
A4	%Q108	EnableClk	Clock module power supply enabled	Enabled	Disabled
A5	%Q109	LaserSelect	Laser select	Selected	
A6	%Q110	ClockSel0	Refer to Table 12 for information about the clock speed selection.		
A7	%Q111	ClockSel1			
A8	%Q112	ClockSel2			
B1	%Q113	MargEn27	–2.7-V power supplies margin enabled	Enabled	Disabled
B2	%Q114	MargEn35	–3.5-V power supplies margin enabled	Enabled	Disabled
B3	%Q115	MargEn52	–5.2-V power supplies margin enabled	Enabled	Disabled
B5	%Q117	MargEnClk	Clock power supply margin enabled	Enabled	Disabled
B6	%Q118	PS_EN52	Power staging –5.2-V enable	Enabled	Disabled
B7	%Q119	PS_EN35	Power staging –3.5-V enable	Enabled	Disabled
B8	%Q120	PS_EN27	Power staging –2.7-V enable	Enabled	Disabled
C1	%Q121		Enable solenoid	Enabled	Disabled
C2	%Q122		Not used		
C3	%Q123		Not used		
C4	%Q124		Not used		
C5	%Q125		Not used		
C6	%Q126		Not used		
C7	%Q127		Not used		
C8	%Q128		Not used		
D1	%Q129		Not used		
D2	%Q130		Not used		
D3	%Q131		Not used		
D4	%Q132		Not used		
D5	%Q133		Not used		
D6	%Q134		Not used		
D7	%Q135		Not used		
D8	%Q136		Not used		

Table 12. Clock Select Options

Clock Select Status			Clock Speed
2	1	0	
Off	Off	Off	True Slow
Off	Off	On	Complement Slow
Off	On	Off	True Normal
Off	On	On	Complement Normal
On	Off	Off	True Fast
On	Off	On	Complement Fast
On	On	Off	True External
On	On	On	Complement External

Table 13. Analog Input Base Converter

Channel	Data Reference	Label Description	Function	Values	
				High	Low
1	%AI13	Voltage –2.7	–2.7-V power bus voltage level	–3.42 V	–2.28 V
2	%AI14	Voltage –3.5	–3.5-V power bus voltage level	–4.38 V	–2.92 V
3	%AI15	Voltage –5.2	–5.2-V power bus voltage level	–6.42 V	–4.28 V
4	%AI16	Voltage –2.0	I/O voltage regulator		
5	%AI17	Voltage Clk	Clock power supply voltage	–6.24 V	–4.16 V
6	%AI18	Continuity Circuit	Boundary scan module circuit fault information	None	0.5 V
7	%AI19	HVDC 1	Voltage on line 1 coming from the HVDC	350 V	280 V
8	%AI20	HVDC 2	Voltage on line 2 coming from the HVDC	350 V	280 V

Table 14. Analog Input Voltage Expander, Channel Address

Label Reference	Data Reference	Label Description	Function	Values	
				High	Low
CHANNEL 1	%AI21	Imon1	Power supply #1 (–2.7 V) current	Status information only; no limits.	
CHANNEL 2	%AI22	Imon2	Power supply #2 (–2.7 V) current		
CHANNEL 3	%AI23	Imon3	Power supply #3 (–2.7 V) current		
CHANNEL 4	%AI24	Imon4	Power supply #4 (–2.7 V) current		
CHANNEL 5	%AI25	Imon5	Power supply #5 (–2.7 V) current		
CHANNEL 6	%AI26	Imon6	Power supply #6 (–2.7 V) current		
CHANNEL 7	%AI27	Imon7	Power supply #7 (–3.5 V) current		
CHANNEL 8	%AI28	Imon8	Power supply #8 (–3.5 V) current		
CHANNEL 9	%AI29	Imon9	Power supply #9 (–3.5 V) current		
CHANNEL 10	%AI30	Imon10	Power supply #10 (–5.2 V) current		
CHANNEL 11	%AI31	Imon11	Power supply #11 (–5.2 V) current		
CHANNEL 12	%AI32		Not used		
CHANNEL 13	%AI33		Not used		
CHANNEL 14	%AI34		Not used		
CHANNEL 15	%AI35		Not used		
CHANNEL 16	%AI36		Not used		

Table 15. Analog Input Voltage Expander, Address Label

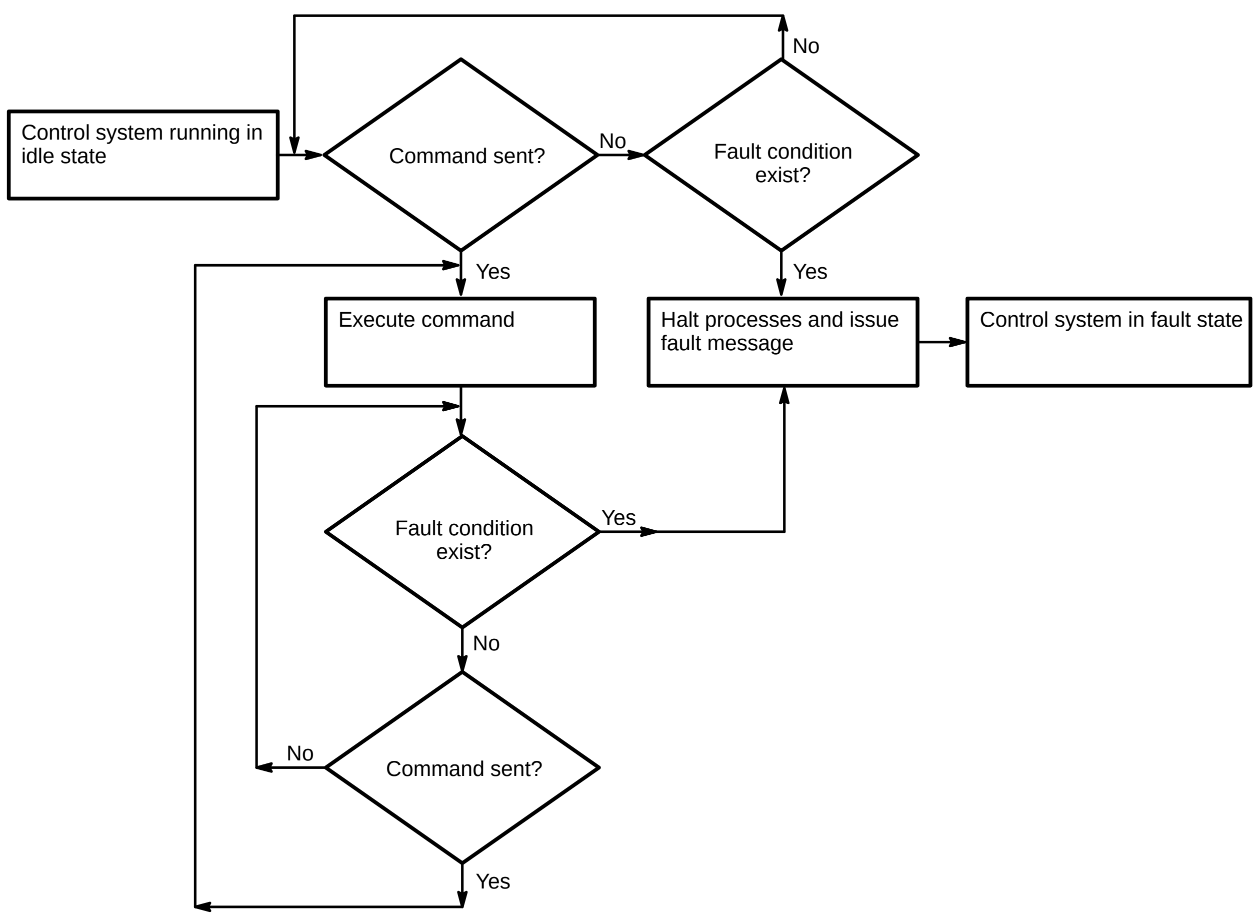
Label Reference	Function
A1	Margin signal for –2.7-V bus
A2	Margin signal for –3.5-V bus
A3	Margin signal for –5.2-V bus
A4	Margin signal for –2.0-V bus
A5	Margin signal for clock
A6 through A32	Not used
C1	Margin return signal for –2.7-V bus
C2	Margin return signal for –3.5-V bus
C3	Margin return signal for –5.2-V bus
C4	Margin return signal for –2.0-V bus
C5	Margin return signal for clock
C6 through C32	Not used

nwacs Commands and Sequence of Events

The control system uses commands sent by the `nwacs` program to control certain sequences of events. This subsection provides a list of the commands available through `nwacs` and then describes the subsequent sequence of events for each command. In addition to the sequences initiated by the `nwacs` commands, the control system has two other states: fault and idle, which this subsection also describes.

Figure 34 illustrates the control system source code basic sequence.

Figure 34. Control System Source Code Basic Sequence of Events

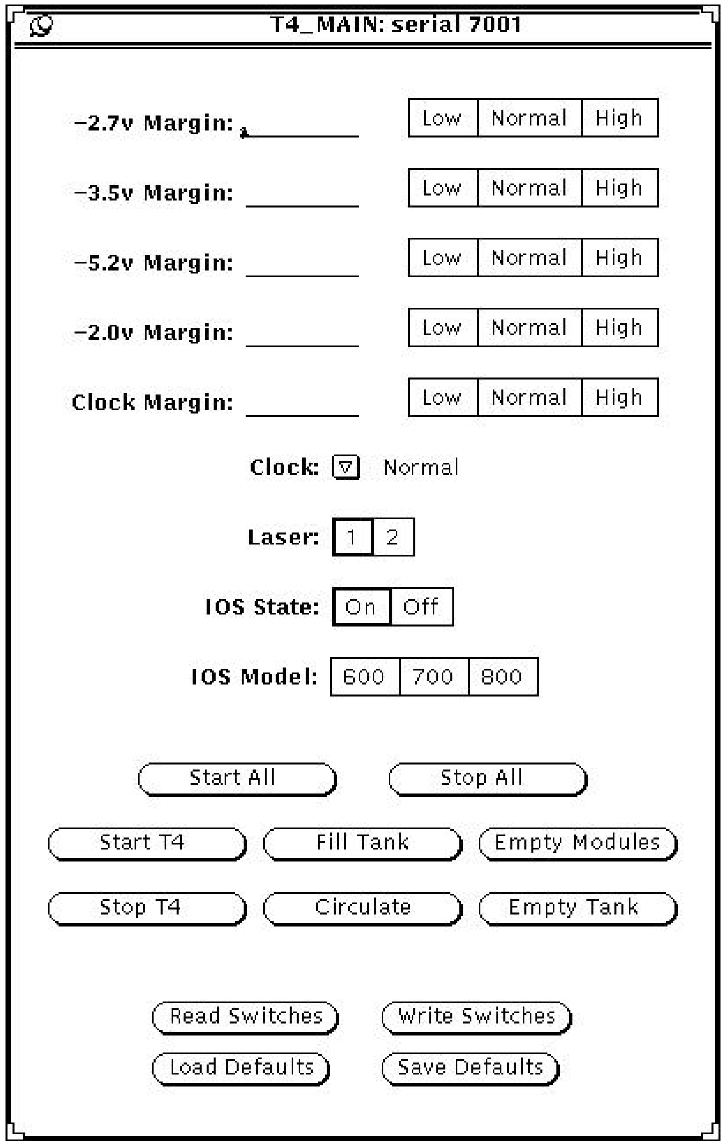


The following commands are available through `nwacs`:

- Fill Tank
- Circulate
- Start T4
- Start All
- Empty Modules
- Empty Tank
- Stop All
- Stop T4

These commands have redundant tasks embedded within them; for that reason, the commands are listed in the order in which the basic sequences occur. Refer to Figure 35 for an illustration of the `nwacs` screen that contains the buttons for these commands.

Figure 35. `nwacs` Command Screen



Idle State

When the control system powers up and is waiting for a command, the control system has a number of default settings. This state is the idle state. Table 16 provides a list of the default settings for devices before a command is sent.

Table 16. Idle State Settings

Device/Condition	Default Setting
Supply Valve	Closed
Return Valve	Closed
IO Solenoid	Closed
Drain Solenoid	Open
Fill Solenoid	Closed

Fault State

When the control system encounters a fault condition that is potentially dangerous to the computer system or the computer environment, the control system shuts down the active processes and provides fault messages. The control system also places certain devices and conditions into a default setting. Table 17 provides a list of the fault state settings.

Table 17. Fault State Settings

Device/Condition	Default Setting
Supply Valve	Closed
Return Valve	Closed
IO Solenoid	Closed
Drain Solenoid	Open
Fill Solenoid	Closed

Fault Limits

The CRAY T94 computer system operates normally within predefined (normal) limits. When a monitored condition exceeds the normal limit, the `nwacs` program records a fault condition and initiates action in the form of either a warning message, an immediate system shut-down, or a time-delayed system shut-down. Table 18 provides the fault limits for the CRAY T94 system during normal operation.

NOTE: Some of the system fault limits change during specific system operations. Table 18 lists values that represent the fault limits of the CRAY T94 computer system during normal operating conditions.

Table 18. CRAY T94 System Fault Limits

Sense Point	Low Limit	High Limit	Action/Notes
–2.7-Vdc Bus voltage	–2.44 Vdc	–3.66 Vdc	Shut-down
–3.5-Vdc Bus Voltage	–3.02 Vdc	–4.54 Vdc	Shut-down
–5.2-Vdc Bus Voltage	–4.30 Vdc	–6.44 Vdc	Shut-down
–2.0-Vdc Bus Voltage	–1.60 Vdc	–2.40 Vdc	Shut-down
Clock Bus Voltage	–4.16 Vdc	–6.24 Vdc	Shut-down
Flow Rate: 700-series IOS	94 gpm	108 gpm	Shut-down/60-second delay
Flow Rate: 600-series IOS	119 gpm	133 gpm	Shut-down/60-second delay
Flow Rate: 800-series IOS	144 gpm	158 gpm	Shut-down/60-second delay
Fluorinert Supply Temperature	14 °C	22 °C	Shut-down/60-second delay
Fluorinert Return Temperature	No limit	No limit	No message
Tank Pressure (Low)	20 psi	35 psi (see entries below)	Shut-down/1-second delay
Tank Pressure (High) with 700-series IOS	20 psi	35 psi P= (FR ÷ 6.67)+20 †	Shut-down/20@flow=0 Shut-down/35@flow=100 ‡
Tank Pressure (High) with 600-series IOS	20 psi	35 psi P= (FR ÷ 8.33)+20 †	Shut-down/20@flow=0 Shut-down/35@flow=125 ‡
Tank Pressure High) with 800-series IOS	20 psi	35 psi P= (FR ÷ 10.00)+20 †	Shut-down/20@flow=0 Shut-down/35@flow=150 ‡
–2.7-Vdc Bus Amps	No limit	100-A change	Shut-down/50-A message
–3.5-Vdc Bus Amps	No limit	100-A change	Shut-down/60-A message
–5.2-Vdc Bus Amps	No limit	300-A change	Shut-down/175-A message
HVDC Voltage	300 Vdc	350 Vdc	Message only

† Use this formula to calculate the tank pressure where P represents the tank pressure and FR represents the Fluorinert flow rate.
‡ The maximum high-pressure fault value is 35 psi, but the high flow threshold and tank pressure formula changes according to the IOS model configured with the system.

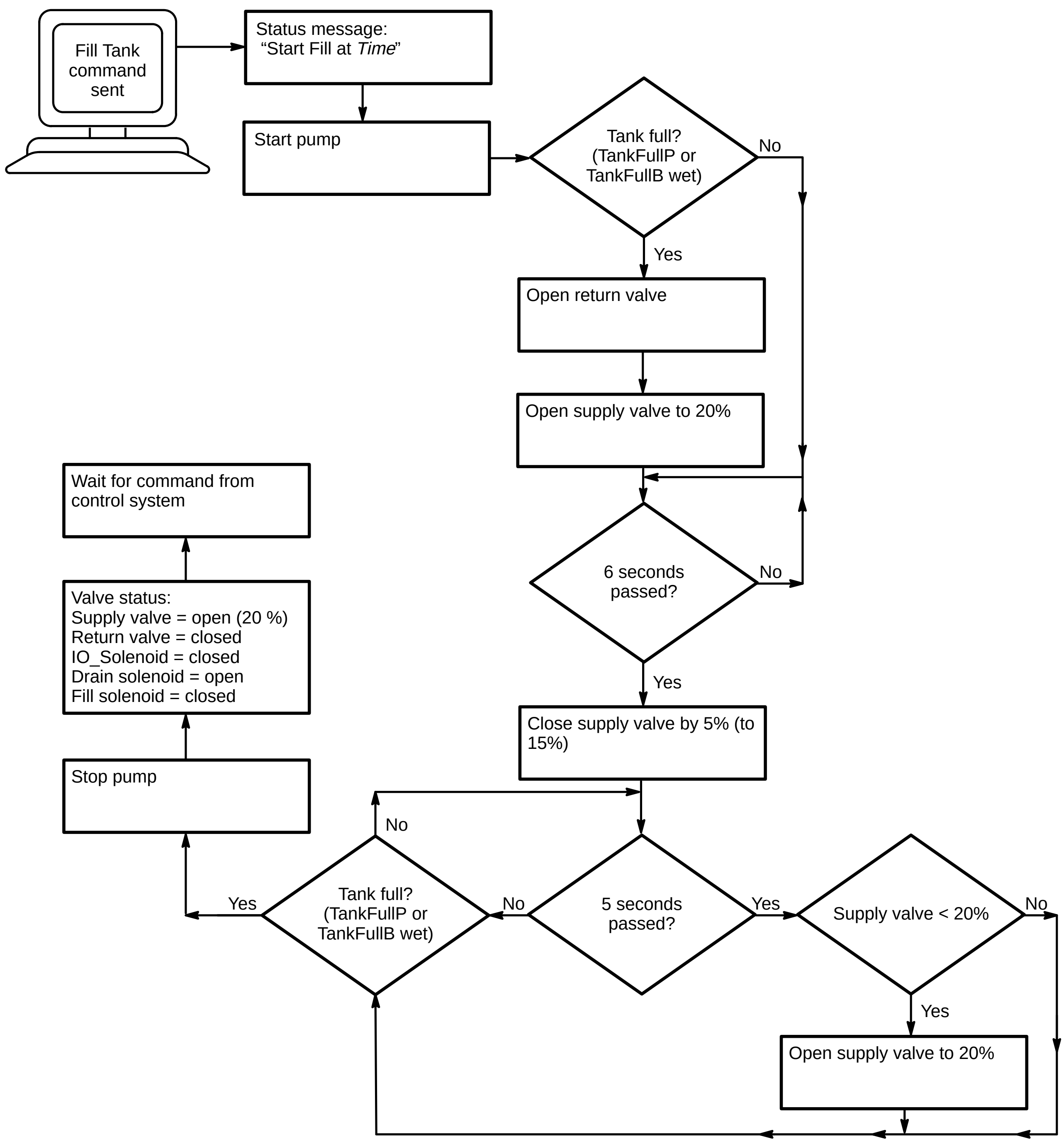
Sense Point	Low Limit	High Limit	Action/Notes
HEU Reservoir Level	5%	No limit	Message only
HEU Water Flow Rate	No limit	No limit	No message
HEU Water Inlet Temperature	No limit	No limit	No message
HEU Water Outlet Temperature	No limit	No limit	No message
HEU Pump Discharge Pressure	No limit	No limit	No message
HEU Pump Suction Pressure	No limit	No limit	No message

† Use this formula to calculate the tank pressure where P represents the tank pressure and FR represents the Fluorinert flow rate.
‡ The maximum high-pressure fault value is 35 psi, but the high flow threshold and tank pressure formula changes according to the IOS model configured with the system.

Fill Tank Command

The Fill Tank command sends a signal to the control system to fill the mainframe with dielectric coolant. Refer to Figure 36 for an illustration of the Fill Tank command sequence of events.

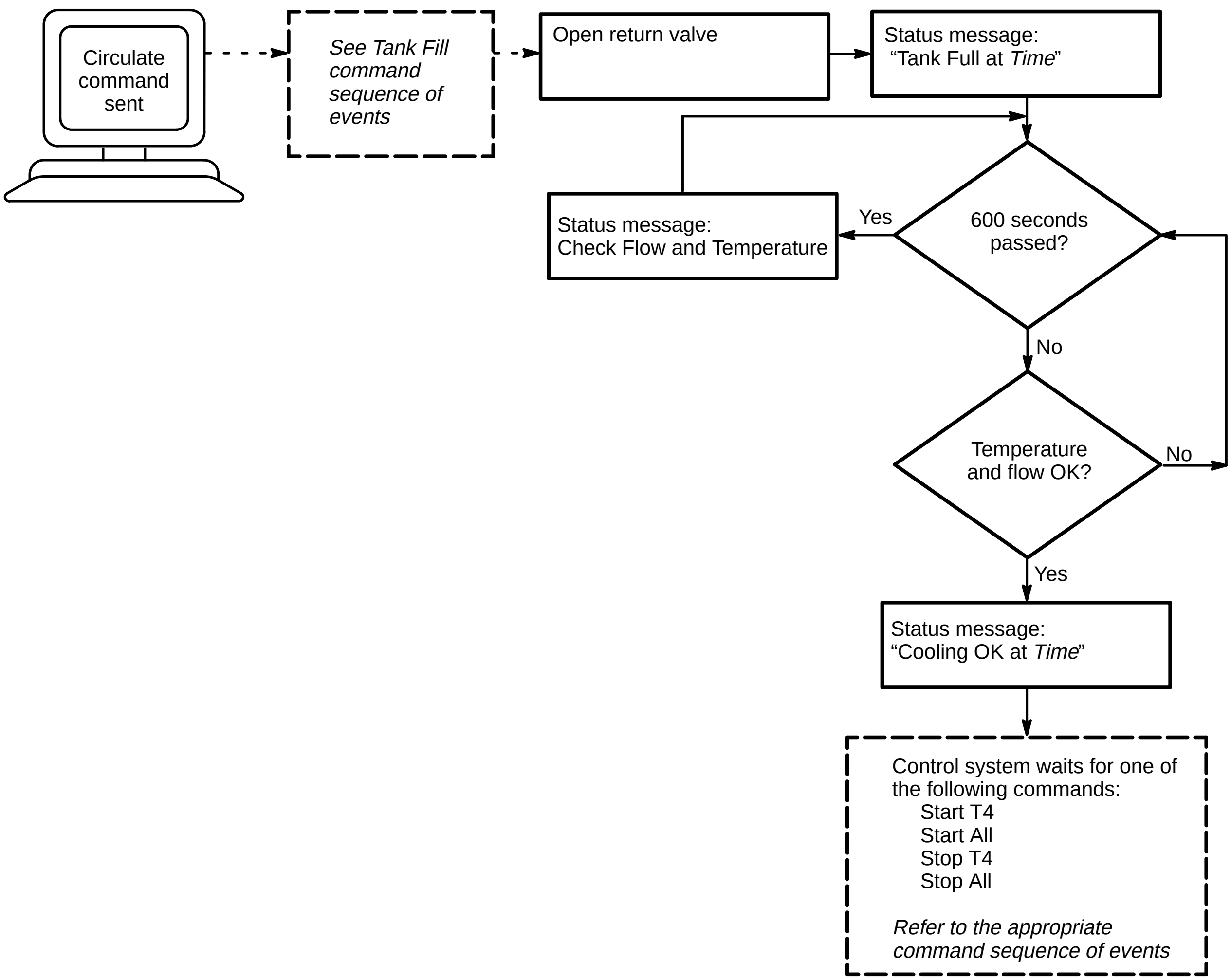
Figure 36. Fill Tank Command Sequence of Events



Circulate Command

The Circulate command sends a signal to the control system to fill the mainframe with dielectric coolant and to circulate the dielectric coolant through the mainframe and HEU. The same sequence of events that occurs during the Fill Tank command occurs during the Circulate command; however, additional events also occur. Refer to Figure 37 for an illustration of these sequences of events.

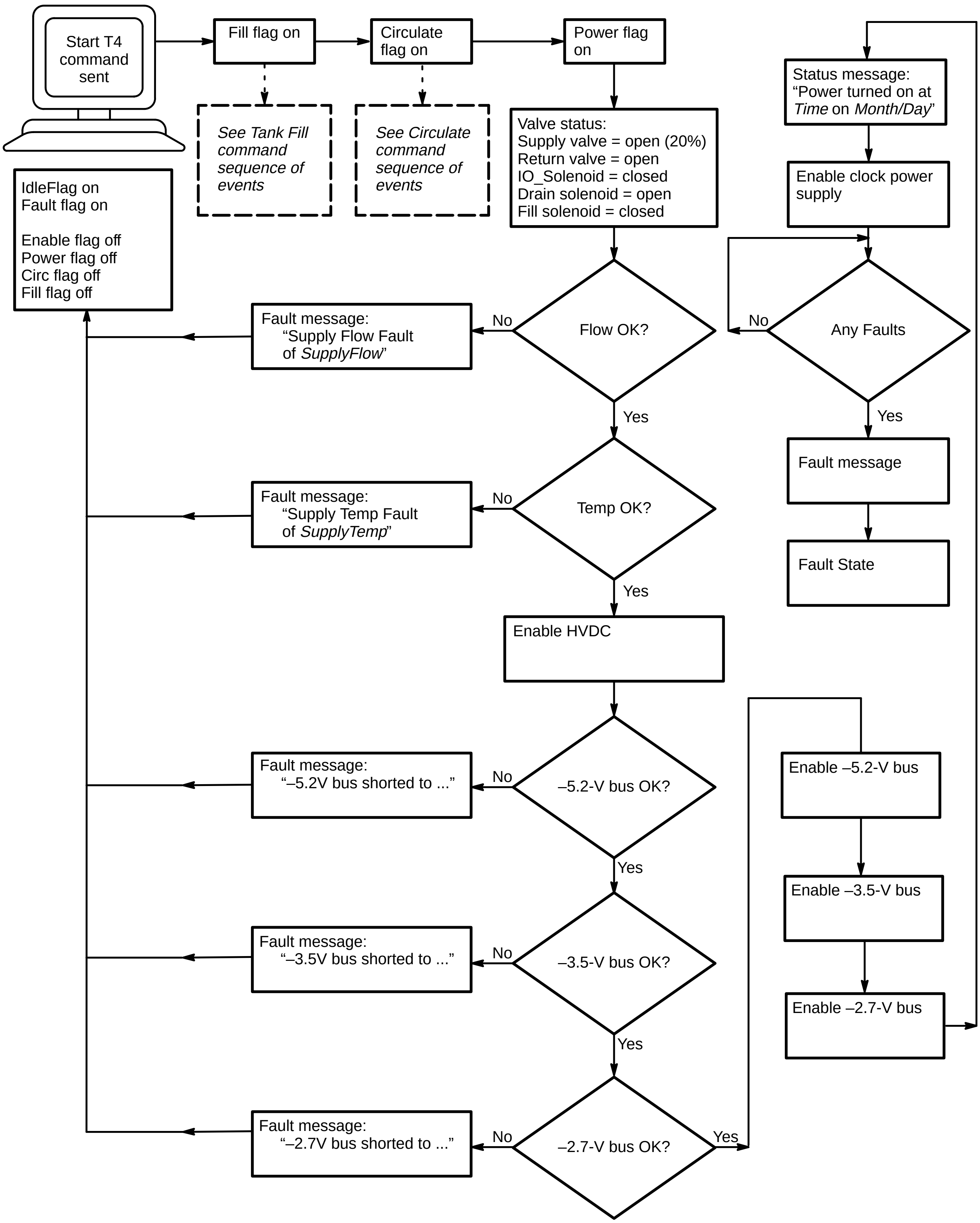
Figure 37. Circulate Command



Start T4 Command

The Start T4 command sends a signal to the control system to fill the mainframe with dielectric coolant, circulate the dielectric coolant through the mainframe and HEU and, once the temperature and flow are OK, apply power to the mainframe power bus. The same sequence of events that occurs during the Circulate Command also occurs during the Start T4 command. If the Fill Tank or Circulate commands have already been sent, the Start T4 command can still be used; sending this command will not cause the control system to go through the Tank Fill command or the Circulate command again. The control system verifies that the dielectric-coolant temperature and flow are OK and then applies power to the mainframe power bus. Figure 38 provides the sequence of events for the Start T4 command.

Figure 38. Start T4 Command



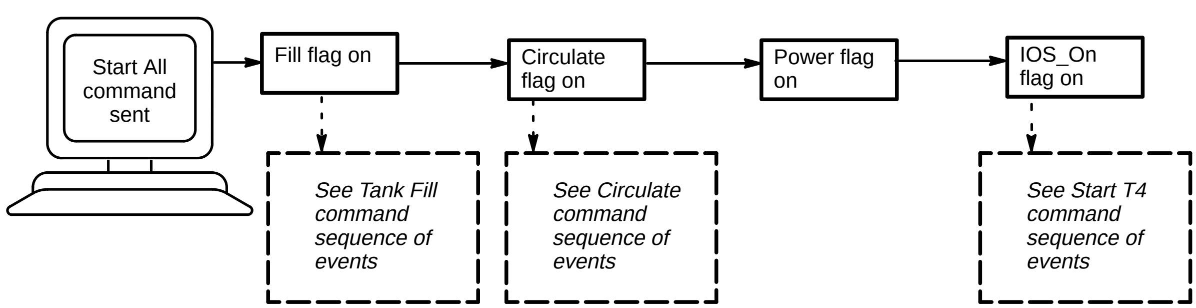
Start All Command

The Start All command sends a signal to the control system to fill the mainframe with dielectric coolant and circulate the dielectric coolant through the mainframe, IOS, and HEU. Once the temperature and flow are OK, the control system applies power to the mainframe power bus. The sequence of events that occurs during the Start T4 command also occurs during the Start All command, with some variation.

If the Fill Tank or Circulate commands have already been sent, the Start T4 command can still be used; sending this command will not cause the control system to go through the Tank Fill command, the Circulate command, or Start T4 command again. The control system verifies that the dielectric-coolant temperature and flow are OK for the mainframe, sets the valves in the HEU for dielectric coolant to be circulated in the IOS, and then applies power to the mainframe power bus. Figure 39 provides the Start All command sequence of events.

NOTE: The Start All command does not start the IOS; this command sets the IOS flag on so that the pump will not shut off if the CRAY T94 mainframe is stopped. The initial version of `nwacs` provides the IOS State buttons (On/Off); an upgraded version of `nwacs` provides the Bypass Mode buttons (On/Off). If the Bypass Mode is set to On, the pump continues to operate until the Stop All command is sent. This enables the pump to continue pumping dielectric coolant through the IOS chassis while the mainframe remains shut off from the HEU-T90.

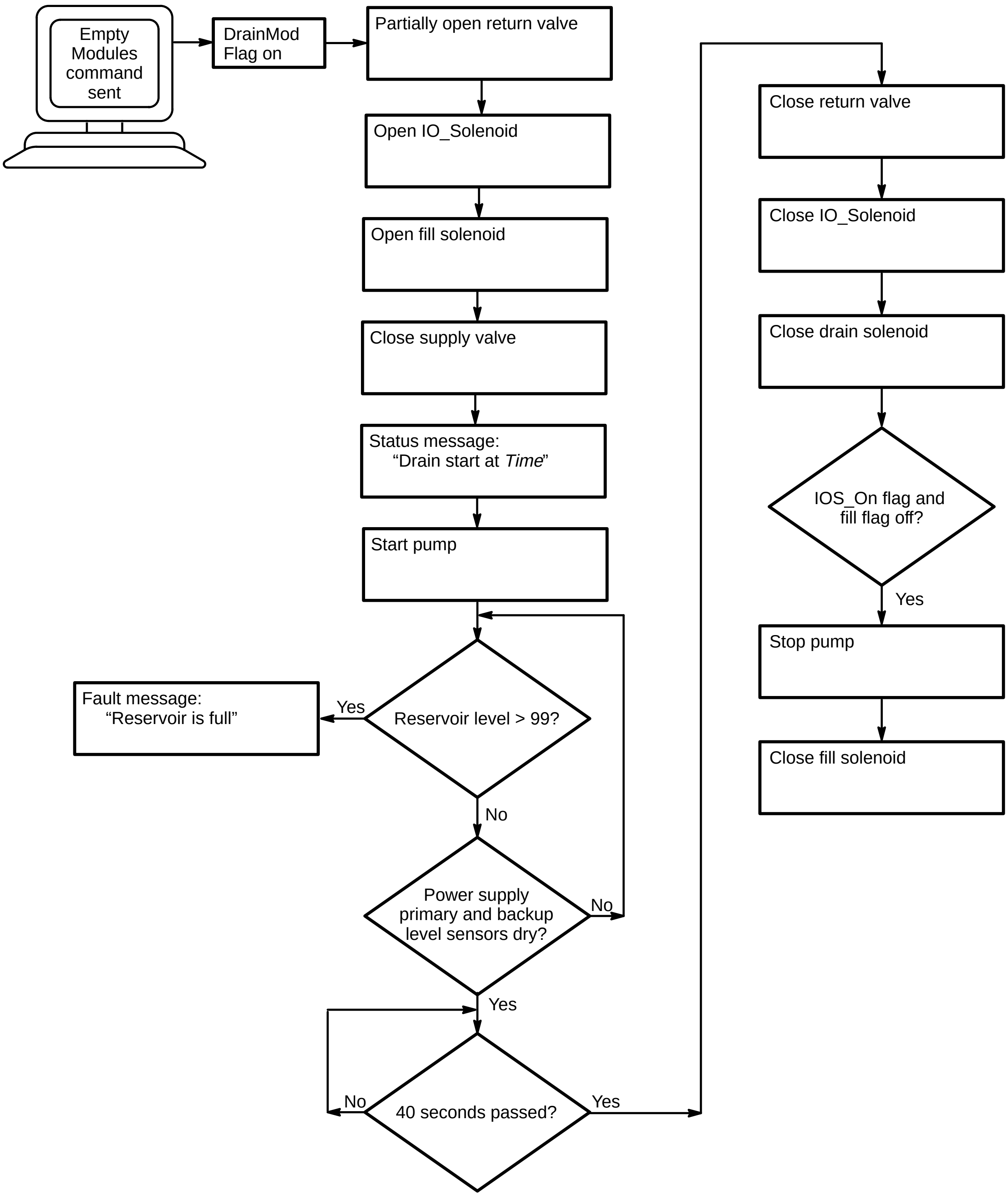
Figure 39. Start All Command Sequence of Events



Empty Modules Command

The Empty Modules command (refer to Figure 40) sends a signal to the control system to empty the mainframe tank just enough to expose the module section of the mainframe.

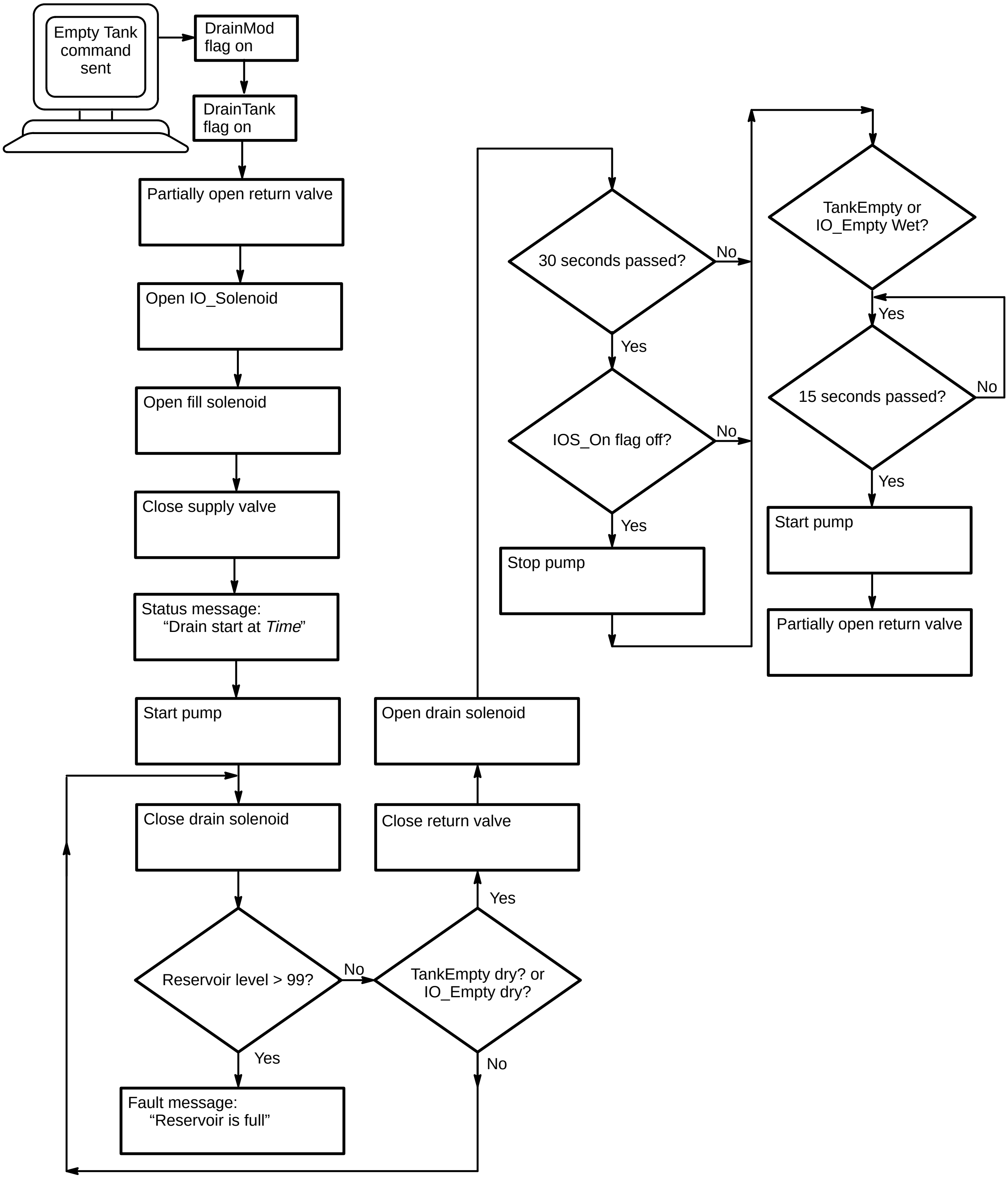
Figure 40. Empty Modules Sequence of Events



Empty Tank Command

The Empty Tank command sends a signal to the control system to empty the mainframe tank completely. Refer to Figure 41 for an illustration of this sequence of events.

Figure 41. Empty Tank Sequence of Events



Stop All Command

The Stop All command starts the power-down sequence for both the mainframe and the IOS/SSD unit. Figure 42 provides the sequence of events for this command.

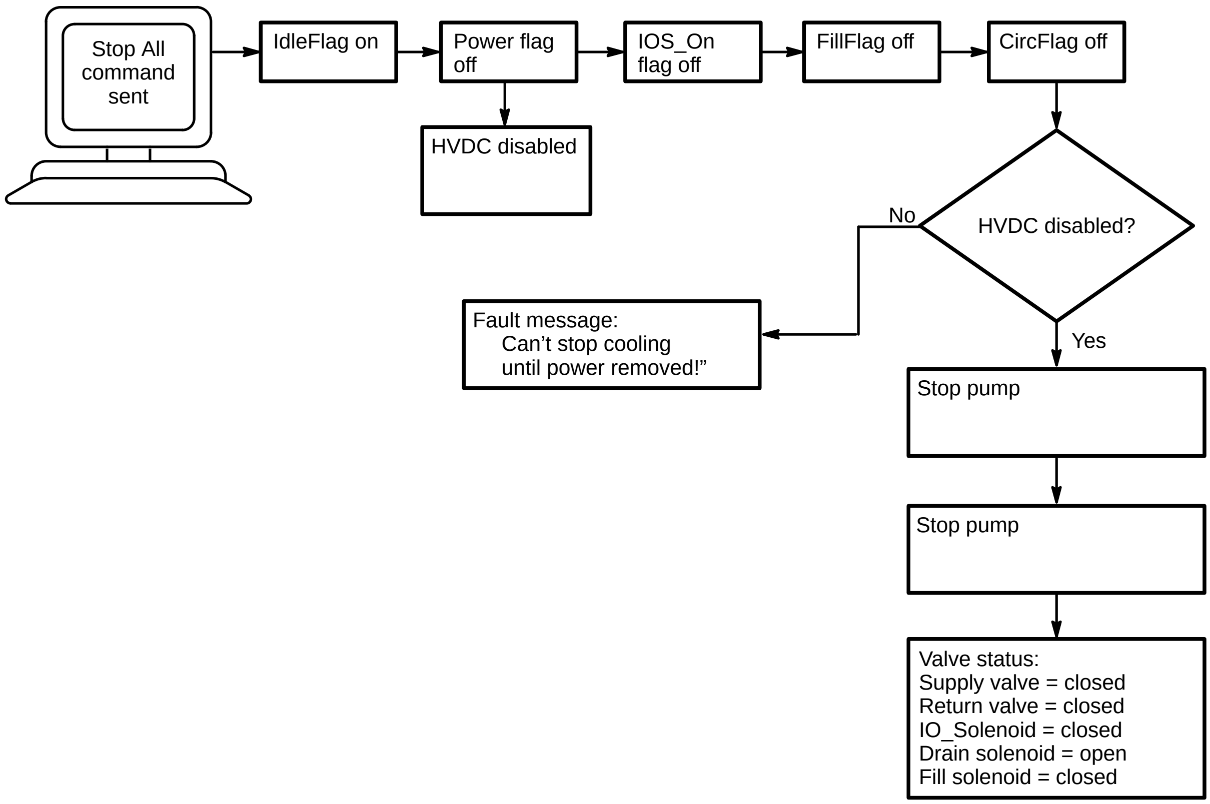
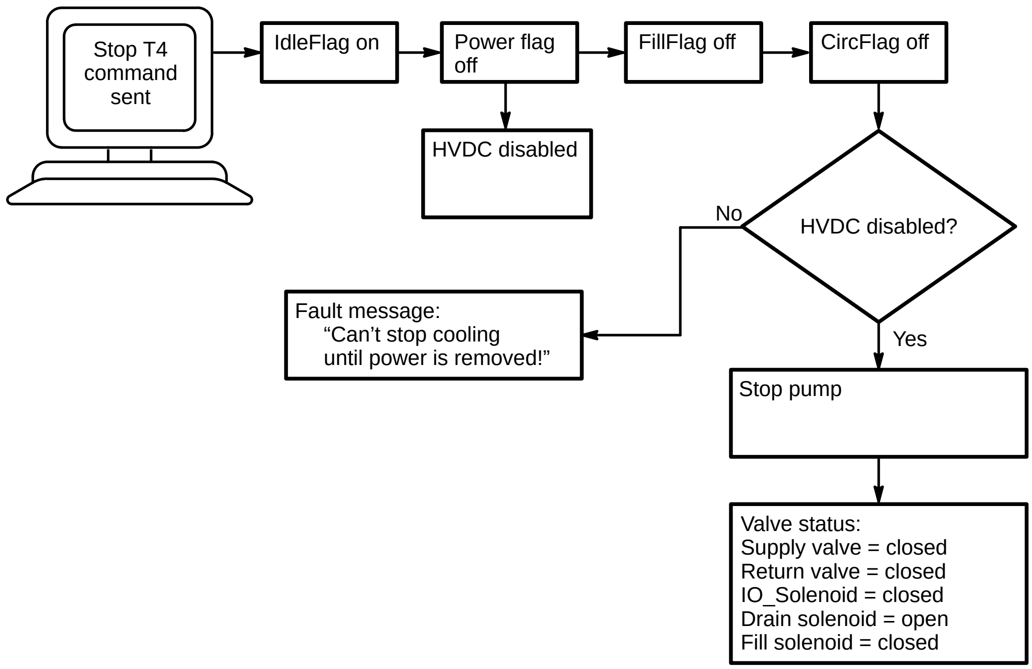


Figure 42. Stop All Command Sequence of Events

Stop T4 Command

The Stop T4 command removes power from the mainframe and IOS/SSD chassis. The pump halts the flow of dielectric coolant, and all monitoring activity ceases. However, the dielectric coolant does not drain from the mainframe until either the Drain Modules command or Drain Tank command is sent. Figure 43 provides the Stop T4 command sequence of events.

Figure 43. Stop T4 Command Sequence of Events



Connections

The control system requires numerous connections between the various components in order to route the information to the appropriate control system component. Figure 44 shows a block diagram of the control system connections.

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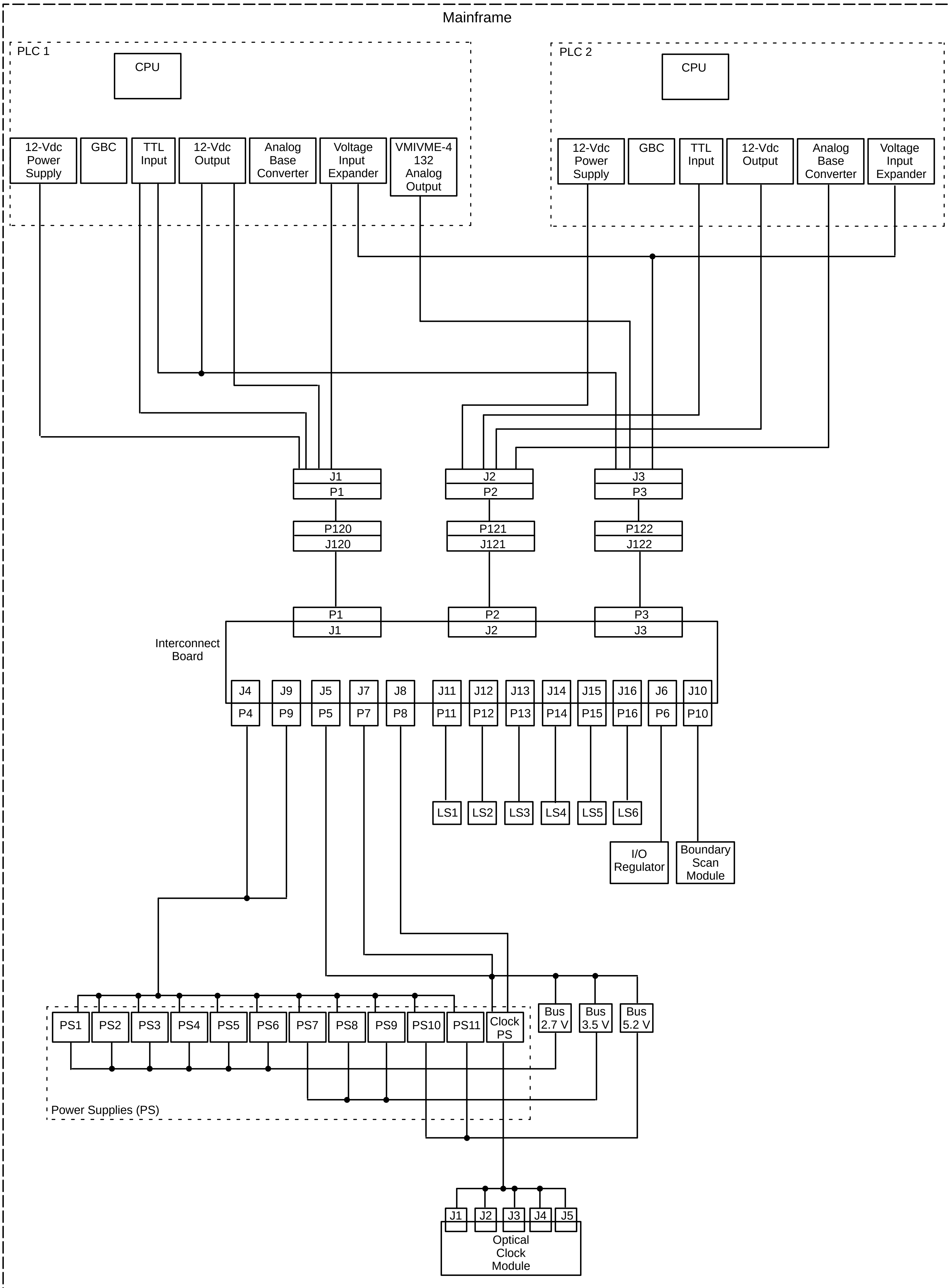


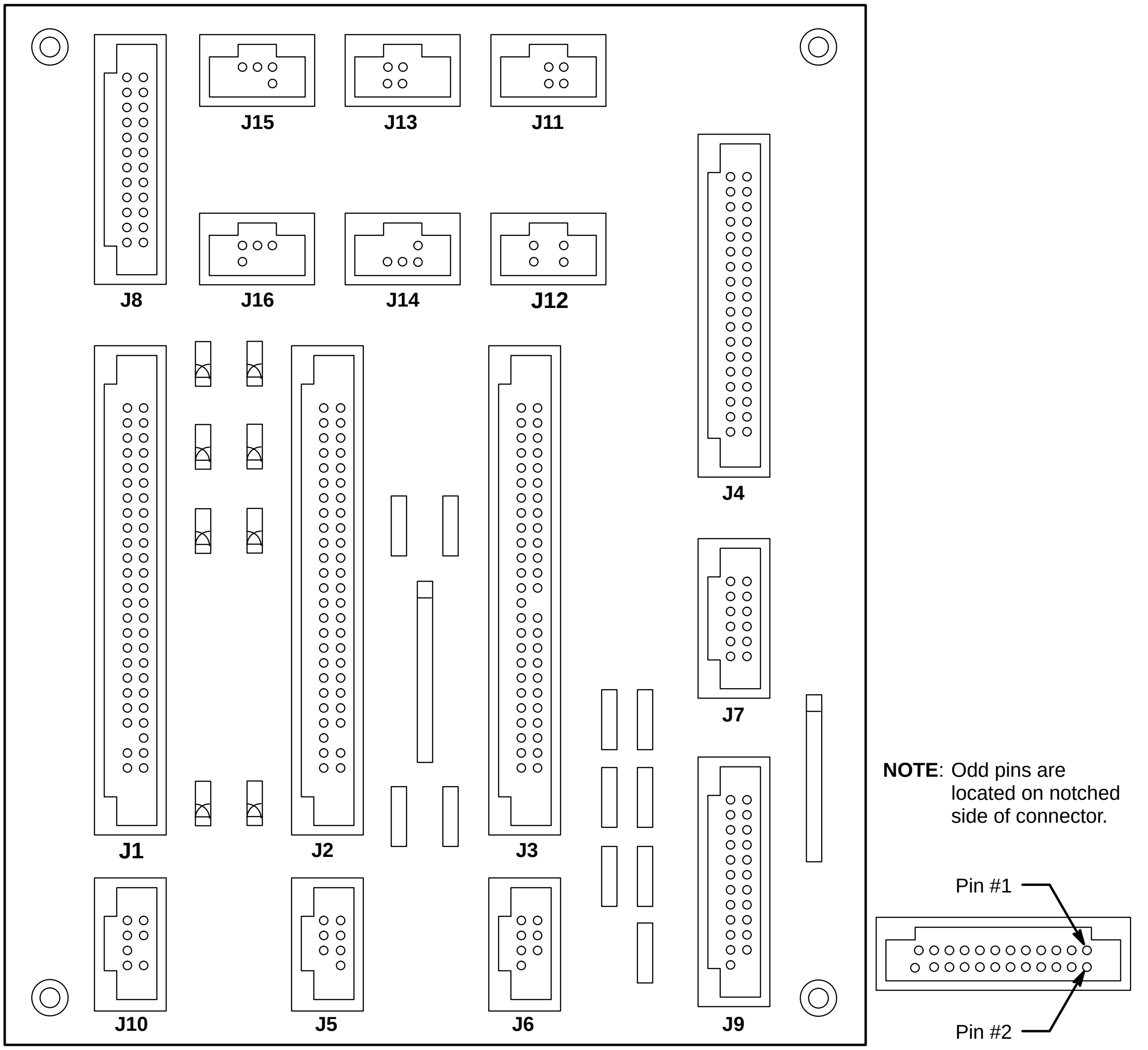
Figure 44. CRAY T94 Control System Block Diagram

As illustrated by the control system block diagram, the interconnect board connects the control system information coming from the mainframe cabinet to the PLC. The interconnect board basically consists of 16 connectors, diodes, and resistors. Figure 45 provides an illustration of the interconnect board, its connectors, and signal information.

Connectors J4 through J16 connect to components within the mainframe. The signals that pass through these connectors are routed through the interconnect board and connect to connectors J1 through J3. NO TAG provides detailed pin information for each interconnect board connector.

From connectors J1, J2, and J3 the cables connect to connectors J120, J121, and J122 on the I/O bulkhead. These connectors are 51-pin micro-D connectors that connect to 50-pin subminiature micro-D connectors J1, J2, and J3 on the mainframe bulkhead, which is located near the PLCs. This bulkhead routes these wires to the appropriate PLC component. NO TAG provides information about the routing paths of signals from the J1, J2, and J3 connectors on the interconnect board.

Figure 45. Control System Interconnect Board



Connector	Description	Connector	Description
J1	To Bulkhead J120 Connection	J9	From Power Supply Current Signals
J2	To Bulkhead J121 Connection	J10	From Boundary Scan Module
J3	To Bulkhead J122 Connection	J11	From Power Supply Full Primary Level Sensor
J4	From Power Supply Bus Enable, Margin Enable, and Power Supply Good Flag Signals Connection	J12	From Power Supply Full Backup Level Sensor
J5	From Voltage Sense Connection	J13	From Tank Empty Level Sensor
J6	From I/O Regulator	J14	From I/O Empty Level Sensor
J7	From Clock Power Supply	J15	From Level Sensor Tank Full Primary
J8	Not Used	J16	From Tank Full Level Sensor Backup

Table 19. Interconnect Board Connections

Connector	Pin Number	Signal	Description	Corresponding Connector †	Pin Number
J4	1	Enable27	Enable –2.7-Vdc power supplies	J1, J2	1
	2	MarEn27	Enable margining function for –2.7-Vdc power supplies	J3	1
	3	Enable35	Enable –3.5-Vdc power supplies	J1, J2	2
	4	MarEn35	Enable margining function for –3.5-Vdc power supplies	J3	2
	5	Enable52	Enable –5.2-Vdc power supplies	J1, J2	
	6	MarEn52	Enable margining function for –5.2-Vdc power supplies	J3	3
	7	MarSig27	Margin signal for –2.7-Vdc power supplies	J3	7
	8	MarRtn27	Return signal for margin signal	J3	8
	9	MarSig35	Margin signal for –3.5-Vdc power supplies	J3	9
	10	MarRtn35	Return signal for margin signal	J3	10
	11	MarSig52	Margin signal for –5.2-Vdc power supplies	J3	11
	12	MarRtn52	Return signal for margin signal	J3	12
	13	GoodFlag1	Power supply #1 status signal	J1, J2	17
	14	Return	Power supply status return signal		
	15	GoodFlag2	Power supply #2 status signal	J1, J2	18
	16	Return	Power supply status return signal		
	17	GoodFlag3	Power supply #3 status signal	J1, J2	19
	18	Return	Power supply status return signal		
	19	GoodFlag4	Power supply #4 status signal	J1, J2	20
	20	Return	Power supply status return signal		
	21	GoodFlag5	Power supply #5 status signal	J1, J2	21
	22	Return	Power supply status return signal		
	23	GoodFlag6	Power supply #6 status signal	J1, J2	22
	24	Return	Power supply status return signal		
	25	GoodFlag7	Power supply #7 status signal	J1, J2	23
	26	Return	Power supply status return signal		
	27	GoodFlag8	Power supply #8 status signal	J1, J2	24
	28	Return	Power supply status return signal		

† In some cases, the corresponding connector has two entries (J1, J2). This case indicates that the same signal is sent to the primary PLC and the hot-standby PLC.

Connector	Pin Number	Signal	Description	Corresponding Connector †	Pin Number
J4	29	GoodFlag9	Power supply #9 status signal	J1, J2	25
	30	Return	Power supply status return signal		
	31	GoodFlag10	Power supply #10 status signal	J1, J2	26
	32	Return	Power supply status return signal		
	33	GoodFlag11	Power supply #11 status signal	J1, J2	27
	34	Return	Power supply status return signal		
	35				
	36				
J5	1	Voltage27	Voltage on –2.7-Vdc power bus	J1, J2	29
	2	Return27	Return signal for voltage signal	J1, J2	30
	3	Voltage35	Voltage on –3.5-Vdc power bus	J1, J2	31
	4	Return35	Return signal for voltage signal	J1, J2	32
	5	Voltage52	Voltage on –5.2-Vdc power bus	J1, J2	33
	6	Return52	Return signal for voltage signal	J1, J2	34
	7				
	8				
J6	1	MarEn20	Enables margining function of –2.0-Vdc I/O voltage regulator	J3	4
	2	Return	Return signal for MarEn20 signal	J3	
	3	MarSig20	Margin signal for I/O voltage regulator	J3	13
	4	MarRtn20	Return signal for MarSig20 signal	J3	14
	5	Voltage20	Voltage produced by I/O voltage regulator	J1, J2	35
	6	Return20	Return signal for Voltage20 circuit	J1, J2	36
	7				
	8				

† In some cases, the corresponding connector has two entries (J1, J2). This case indicates that the same signal is sent to the primary PLC and the hot-standby PLC.

Connector	Pin Number	Signal	Description	Corresponding Connector †	Pin Number
J7	1	PS52_EN	Power staging enables short check of –5.2 Vdc bus from main	J3	17 Main
			Power staging enables short check of –5.2 Vdc bus from standby	J3	21 Standby
J7	2	PS35_EN	Power staging enables short check of –3.5 Vdc bus from main	J3	18 Main
			Power staging enables short check of –3.5 Vdc bus from standby	J3	22 Standby
J7	3	PS27_EN	Power staging enables short check of –2.7 Vdc bus from main	J3	19 Main
			Power staging enables short check of –2.7 Vdc bus from standby	J3	23 Standby
J7	4	Return	Return signal for PS_EN signals		
	5	Spare5	Spare pin	J3	21
	6	Spare6	Spare pin	J3	22
	7	Spare7	Spare pin	J3	23
	8	Spare8	Spare pin	J3	24
	9	Spare9	Spare pin	J3	25
	10	Spare10	Spare pin	J3	26
	11	Power	Power signal for		
	12	Return	Return power signal		

† In some cases, the corresponding connector has two entries (J1, J2). This case indicates that the same signal is sent to the primary PLC and the hot-standby PLC.

Connector	Pin Number	Signal	Description	Corresponding Connector †	Pin Number
J8	1	LaserSelect_a	Primary PLC laser select signal	J1	5
	2	LaserAlarm1_a	Primary PLC laser alarm signal #1	J1	15
	3	LaserAlarm2_a	Primary PLC laser alarm signal #2	J1	16
	4	ClockSel0_a	Primary PLC clock select 0 signal	J1	6
	5	ClockSel1_a	Primary PLC clock select 1 signal	J1	7
	6	ClockSel2_a	Primary PLC clock select 2 signal	J1	8
	7	EnClock_a	Primary PLC enable clock signal	J1	4
	8	GoodFlagClk	Clock power supply status signal	J1, J2	28
	9	MarEnClk	Enable margining function for clock power supplies	J3	5
	10	MarSigClk	Clock power supply margin signal	J3	15
	11	MarRtnClk	Clock power supply margin return signal	J3	16
	12	LaserSelect_b	Standby PLC laser select signal	J2	5
	13	LaserAlarm1_b	Standby PLC laser alarm signal #1	J1	15
	14	LaserAlarm2_b	Standby PLC laser alarm signal #2	J1	16
	15	ClockSel0_b	Standby PLC clock select 0 signal	J1	6
	16	ClockSel1_b	Standby PLC clock select 1 signal	J1	7
	17	ClockSel2_b	Standby PLC clock select 2 signal	J1	8
	18	EnClock_b	Standby PLC enable clock signal	J1	4
	19	Return		J1, J2	41
	20	Return		J1, J2	42
	21	ReturnClk_a	Primary PLC clock voltage return signal	J1, J2	37
	22	VoltageClk_a	Primary PLC clock voltage signal	J1, J2	38
	23	ReturnClk_b	Standby PLC clock voltage return signal	J2	37
	24	VoltageClk_b	Standby PLC clock voltage signal	J2	38

† In some cases, the corresponding connector has two entries (J1, J2). This case indicates that the same signal is sent to the primary PLC and the hot-standby PLC.

Connector	Pin Number	Signal	Description	Corresponding Connector †	Pin Number
J9	1	Imon1	Current for power supply #1	J3	29
	2	Return	Current return signal	J3	30
	3	Imon2	Current for power supply #2	J3	31
	4	Return	Current return signal	J3	32
	5	Imon3	Current for power supply #3	J3	33
	6	Return	Current return signal	J3	34
	7	Imon4	Current for power supply #4	J3	35
	8	Return	Current return signal	J3	36
	9	Imon5	Current for power supply #5	J3	37
	10	Return	Current return signal	J3	38
	11	Imon6	Current for power supply #6	J3	39
	12	Return	Current return signal	J3	40
	13	Imon7	Current for power supply #7	J3	41
	14	Return	Current return signal	J3	42
	15	Imon8	Current for power supply #8	J3	43
	16	Return	Current return signal	J3	44
	17	Imon9	Current for power supply #9	J3	45
	18	Return	Current return signal	J3	46
	19	Imon10	Current for power supply #10	J3	47
	20	Return	Current return signal	J3	48
	21	Imon11	Current for power supply #11	J3	49
	22	Return	Current return signal	J3	50
	23		Not used		
	24		Not used		

† In some cases, the corresponding connector has two entries (J1, J2). This case indicates that the same signal is sent to the primary PLC and the hot-standby PLC.

Connector	Pin Number	Signal	Description	Corresponding Connector †	Pin Number
J10	1	C_LinePlus_a	Continuity line plus signal for primary PLC	J1	39
	2	C_LineMinus_a	Continuity line minus signal for primary PLC	J1	40
	3	C_LinePlus_b	Continuity line plus signal for standby PLC	J2	39
	4	C_LineMinus_b	Continuity line minus signal for standby PLC	J2	40
	5				
	6				
	7				
	8				
J11	1	Power	Power signal for level sensor		
	2	Return	Return power signal for level sensor		
	3	PowerFull(P)	Primary power supply level sensor signal	J1, J2	10
	4	Return	Return signal for primary power supply level sensor		
	5				
	6				
J12	1	Power	Power signal for level sensor		
	2	Return	Return power signal for level sensor		
	3				
	4				
	5	PowerFull(B)	Backup power supply level sensor signal	J1, J2	12
	6	Return	Return signal for backup power supply level sensor		

† In some cases, the corresponding connector has two entries (J1, J2). This case indicates that the same signal is sent to the primary PLC and the hot-standby PLC.

Connector	Pin Number	Signal	Description	Corresponding Connector †	Pin Number
J13	1				
	2				
	3	Power	Power signal for level sensor		
	4	Return	Return power signal for level sensor		
	5	TankEmpty	Tank empty level sensor signal	J1, J2	13
	6	Return	Tank empty level sensor return signal		
J14	1	Power	Power signal for level sensor		
	2	Return	Return power signal for level sensor		
	3				
	4	IO_Empty	I/O section level sensor signal	J3	20
	5				
	6	Return	I/O section level sensor return signal		
J15	1	Power	Power signal for level sensor	J1, J2	
	2	Return	Return power signal for level sensor		
	3	TankFull(P)	Mainframe full primary level sensor signal		9
	4				
	5	Return	Mainframe full primary level sensor return signal		
	6				
J16	1	Power	Power signal for level sensor		
	2				
	3	Return	Return power signal for level sensor		
	4				
	5	TankFull(B)	Mainframe full backup level sensor signal		
	6	Return	Mainframe full backup level sensor return signal		

† In some cases, the corresponding connector has two entries (J1, J2). This case indicates that the same signal is sent to the primary PLC and the hot-standby PLC.

Table 20. Interconnect Board-to-PLC Connections

Interconnect Board Connector	Pin Number	Signal	Mainframe Bulkhead Connector	Pin Number	Control System Bulkhead Connector	Pin Number
J1	1	En27_a	J120	1	J1	34
	2	En35_a		2		1
	3	En52_a		3		2
	4	EnClock_a		4		18
	5	LaserSelect_a		5		19
	6	ClockSel0_a		6		35
	7	ClockSel1_a		7		36
	8	ClockSel2_a		8		3
	9	TankFull(P)_a		9		4
	10	PowerFull(P)_a		10		20
	11	TankFull(B)_a		11		21
	12	PowerFull(B)_a		12		37
	13	TankEmpty_a		13		38
	14	ConnChk_a		14		5
	15	LaserAlarm1_a		15		6
	16	LaserAlarm2_a		16		22
	17	GoodFlag1_a		17		23
	18	GoodFlag2_a		18		39
	19	GoodFlag3_a		19		40
	20	GoodFlag4_a		20		7
	21	GoodFlag5_a		21		8
	22	GoodFlag6_a		22		24
	23	GoodFlag7_a		23		25
	24	GoodFlag8_a		24		41
	25	GoodFlag9_a		25		42
	26	GoodFlag10_a		26		9
	27	GoodFlag11_a		27		10
	28	GoodFlagClk_a		28		26
	29	Voltage27_a		29		27
	30	Return27_a		30		43
	31	Voltage35_a		31		44
	32	Return35_a		32		11
	33	Voltage52_a		33		12

Interconnect Board Connector	Pin Number	Signal	Mainframe Bulkhead Connector	Pin Number	Control System Bulkhead Connector	Pin Number
J1	34	Return52_a	J120	34	J1	28
	35	Voltage20_a		36		29
	36	Return20_a		37		45
	37	ReturnClk_a		38		46
	38	VoltageClk_a		39		13
	39	C_LinePlus_a		40		14
	40	C_LineMinus_a		41		30
	41	Return_a		42		31
	42	Return_a		43		47
	43	Return_a		44		48
	44	Return_a		45		15
	45	Return_a		46		16
	46	Return_a		47		32
	47	Power12V_a		48		33
	48	Return_a		49		49
	49	Power12V_a		50		17
	50	Return_a		51		50

Interconnect Board Connector	Pin Number	Signal	Mainframe Bulkhead Connector	Pin Number	Control System Bulkhead Connector	Pin Number
J2	1	En27_b	J121	1	J2	34
	2	En35_b		2		1
	3	En52_b		3		2
	4	EnClock_b		4		18
	5	LaserSelect_b		5		19
	6	ClockSel0_b		6		35
	7	ClockSel1_b		7		36
	8	ClockSel2_b		8		3
	9	TankFull(P)_b		9		4
	10	PowerFull(P)_b		10		20
	11	TankFull(B)_b		11		21
	12	PowerFull(B)_b		12		37
	13	TankEmpty_b		13		38
	14	ConnChk_b		14		5
	15	LaserAlarm1_b		15		6
	16	LaserAlarm2_b		16		22
	17	GoodFlag1_b		17		23
	18	GoodFlag2_b		18		39
	19	GoodFlag3_b		19		40
	20	GoodFlag4_b		20		7
	21	GoodFlag5_b		21		8
	22	GoodFlag6_b		22		24
	23	GoodFlag7_b		23		25
	24	GoodFlag8_b		24		41
	25	GoodFlag9_b		25		42
	26	GoodFlag10_b		26		9
	27	GoodFlag11_b		27		10
	28	GoodFlagClk_b		28		26
	29	Voltage27_b		29		27
	30	Return27_b		30		43
	31	Voltage35_b		31		44
	32	Return35_b		32		11
	33	Voltage52_b		33		12

Interconnect Board Connector	Pin Number	Signal	Mainframe Bulkhead Connector	Pin Number	Control System Bulkhead Connector	Pin Number
J2	34	Return52_b	J121	34	J2	28
	35	Voltage20_b		36		29
	36	Return20_b		37		45
	37	ReturnClk_b		38		46
	38	VoltageClk_b		39		13
	39	C_LinePlus_b		40		14
	40	C_LineMinus_b		41		30
	41	Return_b		42		31
	42	Return_b		43		47
	43	Return_b		44		48
	44	Return_b		45		15
	45	Return_b		46		16
	46	Return_b		47		32
	47	Power12V_b		48		33
	48	Return_b		49		49
	49	Power12V_b		50		17
	50	Return_b		51		50

Interconnect Board Connector	Pin Number	Signal	Mainframe Bulkhead Connector	Pin Number	Control System Bulkhead Connector	Pin Number
J3	1	MarEn27	J122	1	J3	34
	2	MarEn35		2		1
	3	MarEn52		3		2
	4	MarEn20		4		18
	5	MarEnClk		5		19
	6			6		35
	7	MarSig27		7		36
	8	MarRtn27		8		3
	9	MarSig35		9		4
	10	MarRtn35		10		20
	11	MarSig52		11		21
	12	MarRtn52		12		37
	13	MarSig20		13		38
	14	MarRtn20		14		5
	15	MarSigClk		15		6
	16	MarRtnClk		16		22
	17	PS52_EN_a		17		23
	18	PS35_EN_a		18		39
	19	PS27_EN_a		19		40
	20	IO_Empty		20		7
	21	PS52_EN_b		21		8
	22	PS35_EN_b		22		24
	23	PS27_EN_b		23		25
	24			24		41
	25			25		42
	26			26		9
	27			27		10
	28			28		26
	29	Imon1		29		27
	30	Return1		30		43
	31	Imon2		31		44
	32	Return2		32		11
	33	Imon3		33		12

Interconnect Board Connector	Pin Number	Signal	Mainframe Bulkhead Connector	Pin Number	Control System Bulkhead Connector	Pin Number
J3	34	Return3	J122	34	J3	12
	35	Imon4		36		28
	36	Return4		37		29
	37	Imon5		38		45
	38	Return5		39		46
	39	Imon6		40		13
	40	Return6		41		14
	41	Imon7		42		30
	42	Return7		43		31
	43	Imon8		44		47
	44	Return8		45		48
	45	Imon9		46		15
	46	Return9		47		16
	47	Imon10		48		32
	48	Return10		49		33
	49	Imon11		50		49
	50	Return11		51		50