Power, Cooling, and Control System

(CRAY T916™ System)

HTM-067-B

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Cray Research, Inc.

Power, Cooling, and Control System
-067-B

Record of Revision

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A	June 1996. This version incorporates the mechanical quadrant numbering system throughout the document so that the reference information herein corresponds with other hardware and control system documentation. This version also updates the control system illustrations and the illustration of the WACS switches menu. All other versions of this document are obsolete.
B	April 1997. This version incorporates the new MUX (MX02) board established by ECO/FCO 27216/3228. All other versions of this document are obsolete.

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POWER, COOLING, AND CONTROL SYSTEM

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Overview

The CRAY T916 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 from the mainframe components that is generated during this power distribution. 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 T916 mainframe physical, power, cooling, and control system specifications. Refer to Figure 1 for an illustration of the CRAY T916 mainframe.

Table 1. CRAY T916 Mainframe Specifications

Characteristic	Specification
Dimensions:	
Height	61.85 in. (1,570 mm)
Width	92.20 in. (2,342 mm)
Depth	58.50 in. (1,486 mm)
Weight:	
Mainframe with dielectric coolant	9,300 lbs (4,218 kg)
Cooling requirement:	
Coolant	Dielectric coolant (Fluorinert liquid)
Standard flow rate	180 gpm
Input power:	
To power supplies	6 inputs, 100 A, 330 Vdc each
To control system components	1 input, 4 A, 120 Vac

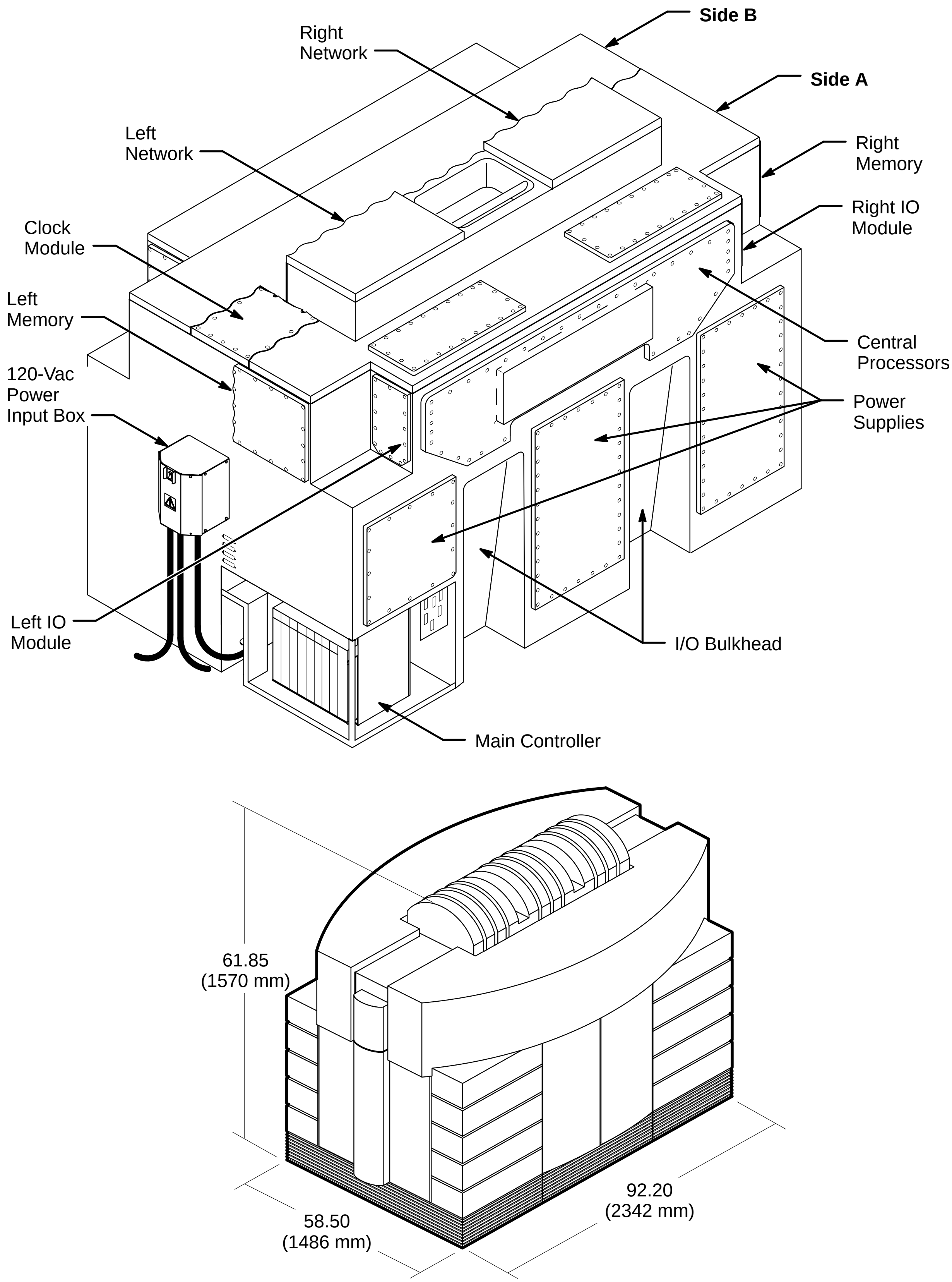


Figure 1. CRAY T916 Mainframe

The CRAY T916 mainframe consists of two sides (side A and side B) and contains a maximum of 16 central processors. This document describes how the subsystems within the mainframe function together. The descriptions throughout this document refer to quadrants, stacks, or specific locations in the mainframe. Refer to Figure 2 for a top-view block diagram of the locations in the mainframe chassis.

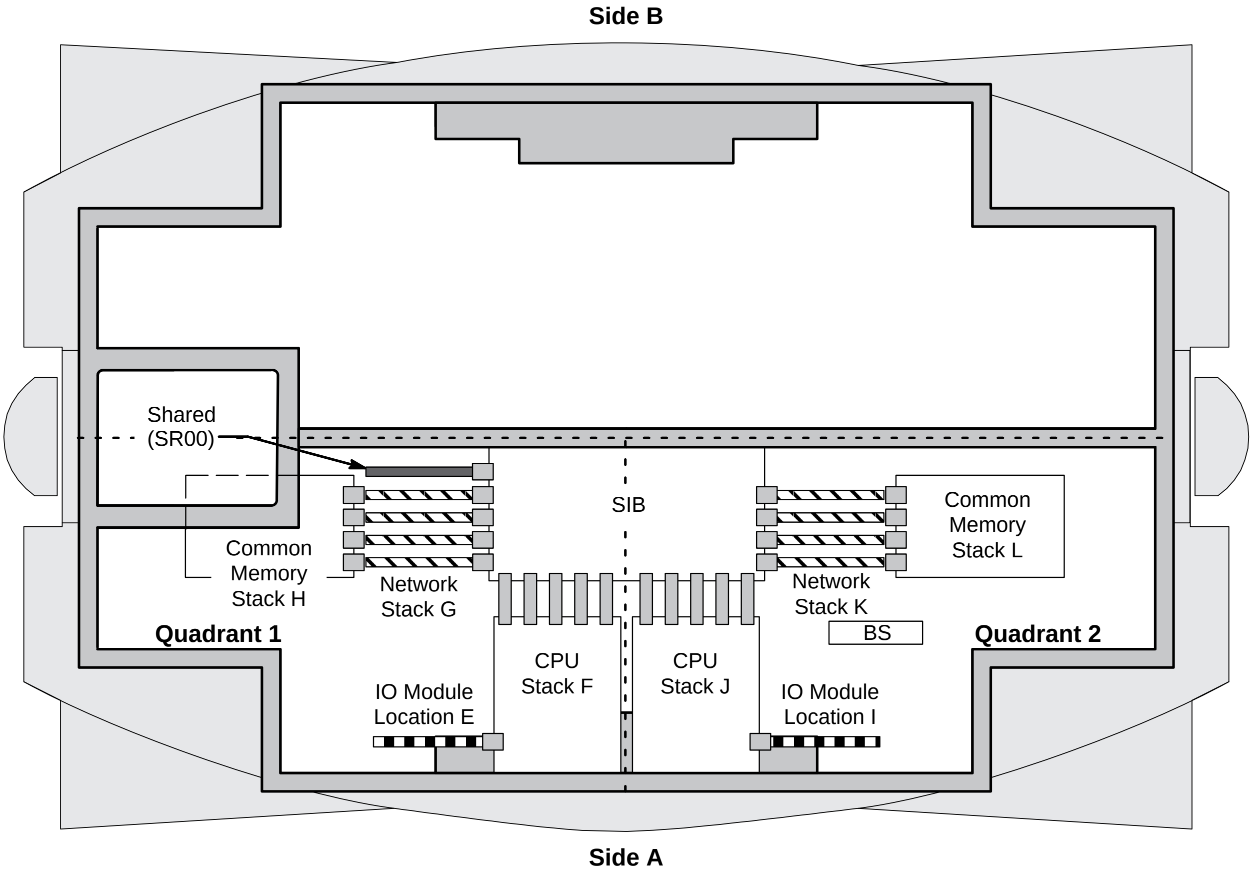
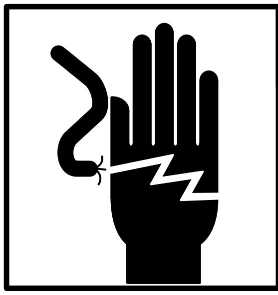


Figure 2. Mainframe Chassis Block Diagram

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 T916 computer system.



WARNING

High leakage current. Secure earth connections before you handle the supply lines. Failure to so could result in severe shock, burns, or death.

Components

330-Vdc Power Input Components

The CRAY T916 computer system receives 330-Vdc power from the high-voltage DC device (HVDC) along six input lines. These six 330-Vdc circuits supply power to the mainframe power supplies and consist of the following components. Figure 3 illustrates the locations of the following components in the mainframe.

330-Vdc Terminal Blocks

The eighteen 330-Vdc terminal blocks (six plus, six minus, and six ground) provide the grounded connections for the 330-Vdc power lines (L1 through L6). These six power lines provide power to the power supplies in the three power-supply rack assemblies.

HVDC Filters

The six HVDC filters (F1 – F6) prevent electrical noise from coming into the mainframe or leaving the mainframe. Each of the six incoming 330-Vdc power lines is filtered by an HVDC filter located between the terminal blocks and the three power supply racks.

HVDC Isolation Boards

The three HVDC isolation boards (ISO 1 – ISO 3) optically isolate the control system from the 330-Vdc power. Each HVDC isolation board connects to two incoming 330-Vdc power lines 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.

Power Supply Rack Assemblies

The three power-supply rack assemblies contain the mainframe power supplies, the master-clock box, and the power-staging box. The 20-position power supply rack holds 20 power supplies and receives

330-Vdc power from HVDC lines 2, 3, and 4. The 16-position power supply rack holds 15 power supplies and the power-staging box. This 16-position rack receives 330-Vdc power from HVDC lines 5 and 6. The 8-position power supply rack holds 7 power supplies and the master-clock power box and receives 330-Vdc power from HVDC line 1.

Power Supply Harness Assemblies

Each of the power-supply rack assemblies contains a harness assembly that distributes 330-Vdc, 100-A power from the output connections of the HVDC filters to the power supplies in the rack assemblies. These harness assemblies also contain the control signal wiring for the power supplies.

NOTE: Refer to the “Power Supplies” subsection, which begins on page 12, for detailed tables and illustrations of the power supply racks and harness connections. The “330-Vdc Power Distribution” subsection later in this document provides detailed information about the isolation boards, the HVDC filters, and the terminal blocks.

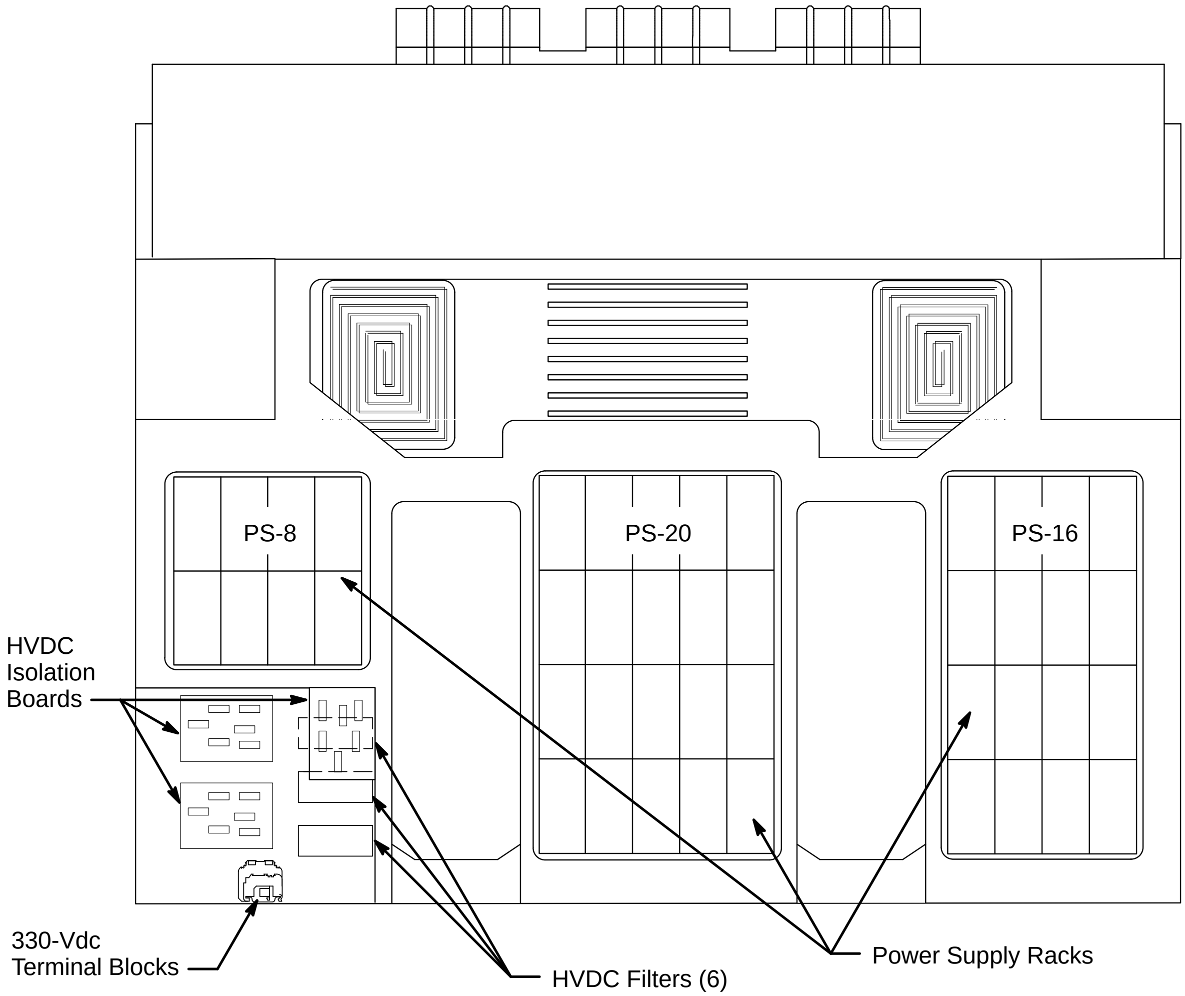


Figure 3. 330-Vdc Power Input Components, Locations

120-Vac Power Input Components

The CRAY T916 computer system receives 120-Vac power from the high-voltage DC device (HVDC). The 120-Vac input circuit consists of three lines: a power line, a neutral line, and a ground line. This circuit supplies power to the two mainframe programmable logic controllers (PLCs) and consists of the following components.

120-Vac Power Input Box

The 120-Vac power input box contains the terminal blocks and the main circuit breaker for 120-Vac power distribution. The box mounts to the chassis on the clock-module end of the mainframe.

120-Vac Terminal Blocks

The 120-Vac terminal blocks provide the grounded connections for the 120-Vac power that is supplied to the mainframe devices. The power and neutral terminals attach to jumpers that, in turn, attach to two separate terminals. These jumpered connections split the single input line and result in two 120-Vac output lines from the terminal blocks.

Main Circuit Breaker

The main circuit breaker in the power input box connects to the two 120-Vac power lines that come from the 120-Vac terminal blocks. The circuit breaker provides protection for the computer equipment for 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, which disables the high-voltage DC (HVDC) unit and the low-voltage DC (LVDC) buses.

120-Vac Drop Cords

The two 120-Vac drop cords supply power to the two PLCs (main and standby) from the two 120-Vac output circuits in the power input box. Each 3-wire drop cord contains a plug on each end to provide power, neutral, and ground continuity between a receptacle on the 120-Vac power input box and a corresponding receptacle in one of the PLC rack assemblies.

PLC Circuit Breakers

Each of the PLC racks (main and standby) contains a 120-Vac circuit breaker that receives power from the receptacle attached to the corresponding drop cord plug. When this circuit breaker is tripped (or turned off), 120-Vac power is disconnected from the PLC rack, which allows service or replacement of the PLC components.

Figure 4 illustrates the locations of the 120-Vac input components in the clock-module end of the mainframe. Side B contains one of the drop cord receptacles and a 120-Vac circuit breaker in the standby PLC.

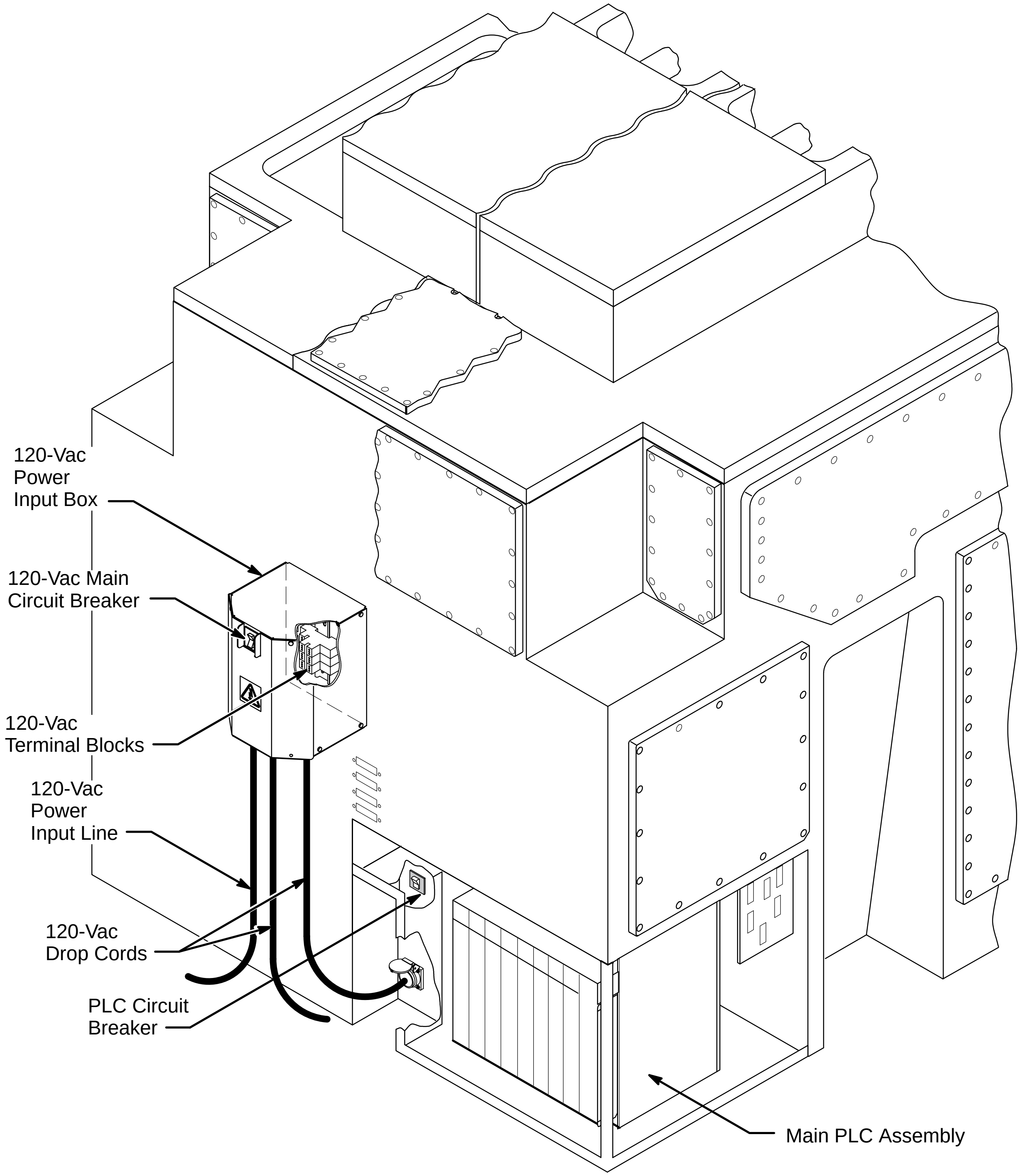


Figure 4. 120-Vac Power Input Components, Locations

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 three power supply racks and are cooled by dielectric coolant. All of the mainframe power supplies are immersed in dielectric coolant. Figure 5 illustrates the three power supply racks and their locations in the mainframe chassis. The following subsection provides detailed information about the power supplies in these power supply racks.

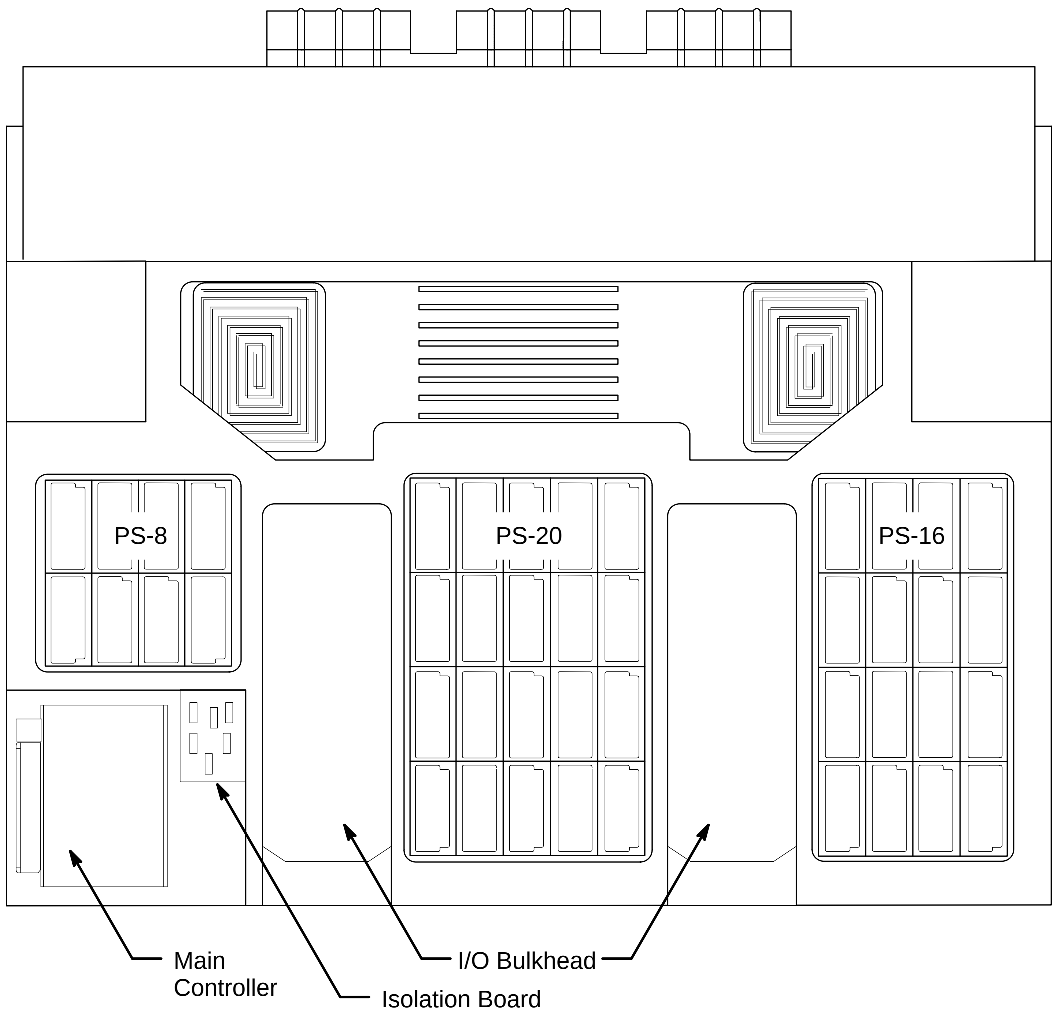
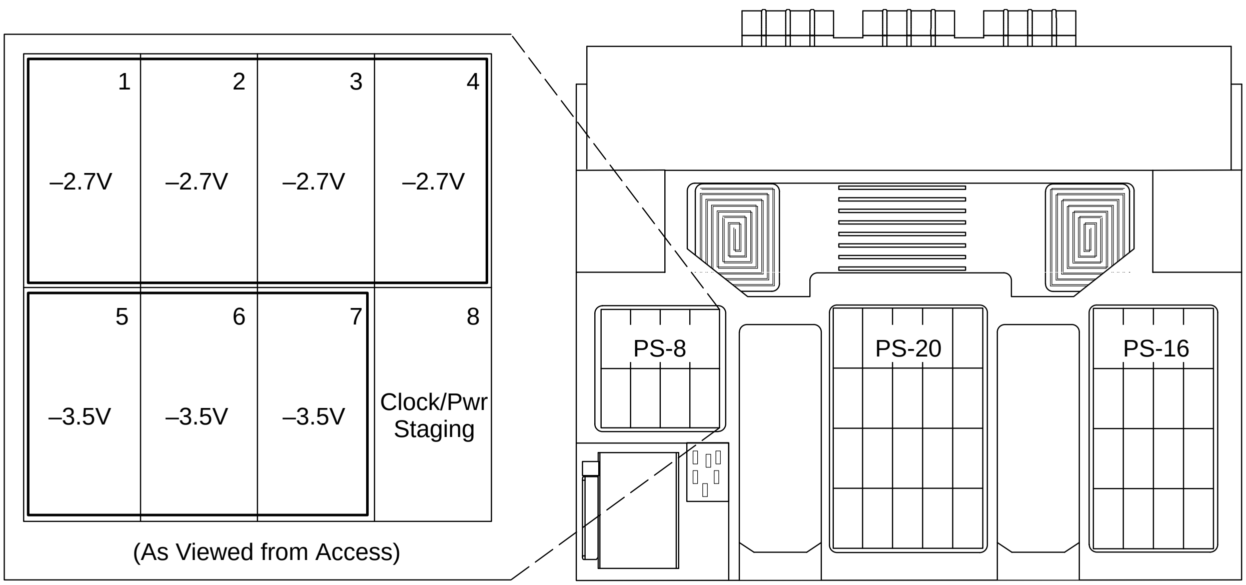


Figure 5. Power-supply Rack Locations

The power supplies are bused in parallel and configured in an N+1 configuration, which enables the power supplies to share the current load. 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 on any bus line fails, the other power supplies pick up the load of the failed power supply until the failed power supply is replaced. These extra power supplies provide increased power reliability for the computer system.

Figure 6 illustrates the power supply configuration of the 8-position power supply rack.

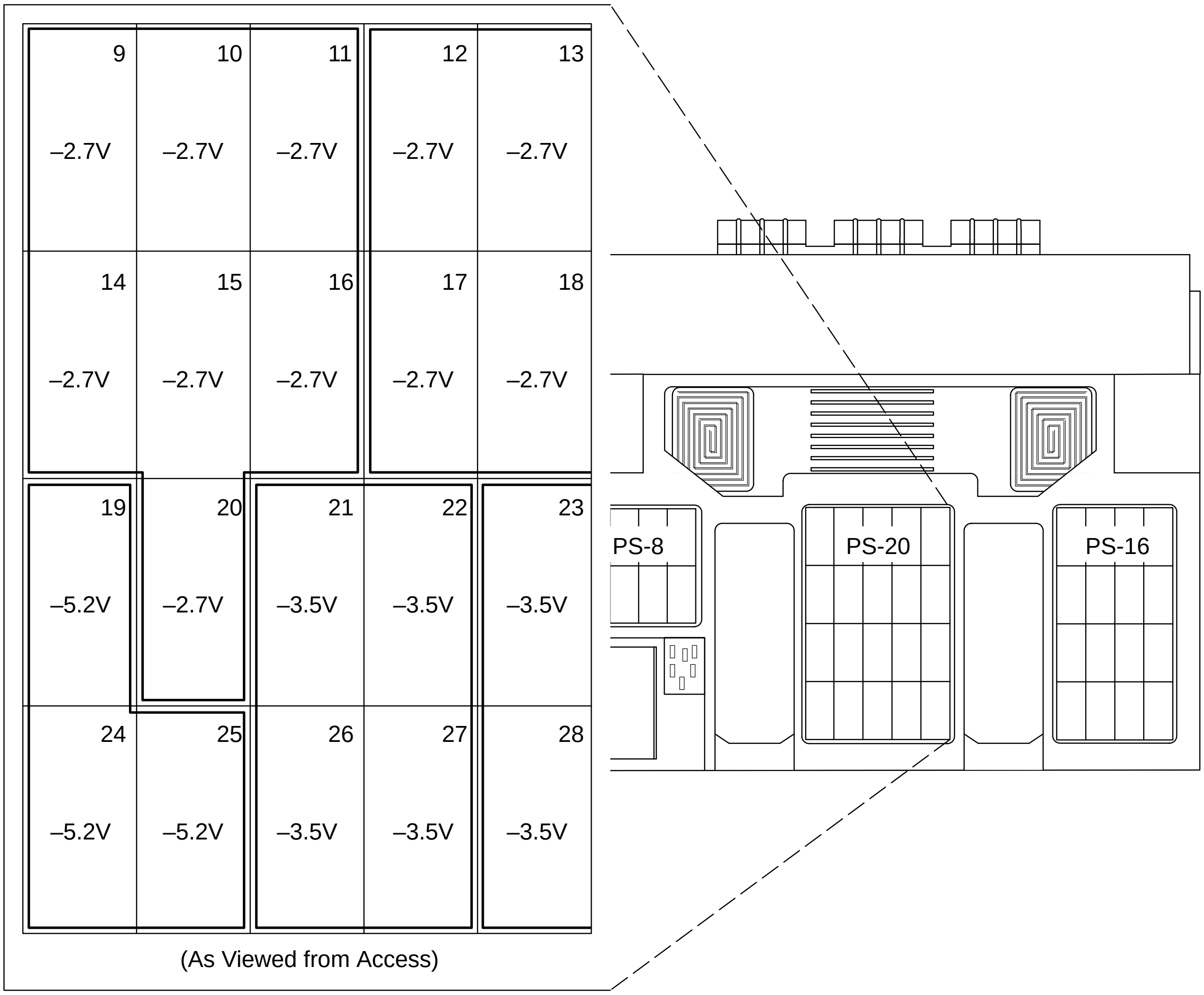


Slot Number	Voltage	Function
1, 2, 3, 4	–2.7 Vdc	Provides power to the shared (SR) module, common memory (CM) modules, and network (NW) modules in quadrant 1
5, 6, 7	–3.5 Vdc	Provides power to the SR module, CM modules, and NW modules in quadrant 1
8	–5.2 Vdc	Provides power to the clock module †

† Power supply slot number 8 also contains the power staging board for quadrant 1.

Figure 6. Power Supply Rack, 8-position

Figure 7 illustrates the configuration of the 20-position power supply rack.



Slot Number	Voltage	Function
9, 10, 11, 14, 15, 16, 20	–2.7 Vdc	Provides power to the input/output (IO) module and central processor (CP) modules in quadrant 1
12, 13, 17, 18	–2.7 Vdc	Provides power to the IO and CP modules in quadrant 2, bused with power supplies in slots 29 and 30
19, 24, 25	–5.2 Vdc	Provides power to the CM modules in quadrant 1
21, 22, 26, 27	–3.5 Vdc	Provides power to the CP and IO modules in quadrant 1
23, 28	–3.5 Vdc	Provides power to the CP and IO modules in quadrant 2, bused with power supplies in slots 37 and 41

Figure 7. Power Supply Rack, 20-position

Figure 8 illustrates the power supply configuration of the 16-position power supply rack.

Slot Number	Voltage	Function
29, 30	–2.7 Vdc	Provides power to the IO and CP modules in quadrant 2, bused with power supplies in slots 12, 13, 17, and 18
31, 32, 34, 35, 36	–2.7 Vdc	Provides power to the boundary scan (BS), CM, and NW modules in quadrant 2
33	N/A	Contains the power staging box
37, 41	–3.5 Vdc	Provides power to the IO and CP modules in quadrant 2, bused with power supplies in slots 23 and 28
38, 39, 40	–3.5 Vdc	Provides power to the BS, CM, and NW modules in quadrant 2
42, 43, 44	–5.2 Vdc	Provides power to the CM modules in quadrant 2

Figure 8. Power Supply Rack, 16-position

Clock Power Supply and Power Staging Assemblies

The clock power supply is a –5.2-Vdc power supply that operates in power-supply slot number 8. Although it looks like a regular power supply, the clock power supply contains both a master-clock power board and a power staging assembly. This combination of components allows the clock power supply to perform several functions. 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 in mainframe quadrant 1.

In addition to the power staging assembly in the clock power supply in slot number 8, the mainframe contains another power staging assembly in power supply slot number 33. The two power staging assemblies are used during the initial power-up of the mainframe. When the mainframe powers up, each power staging assembly sends a small voltage across the LVDC power buses in that particular module quadrant to check for any short circuits within the LVDC buses. If no short circuits exist, the control system sequentially enables the power supplies.

Figure 9 illustrates the locations of the clock power supply and the power staging assemblies. The following subsections of this document contain detailed information about these components.

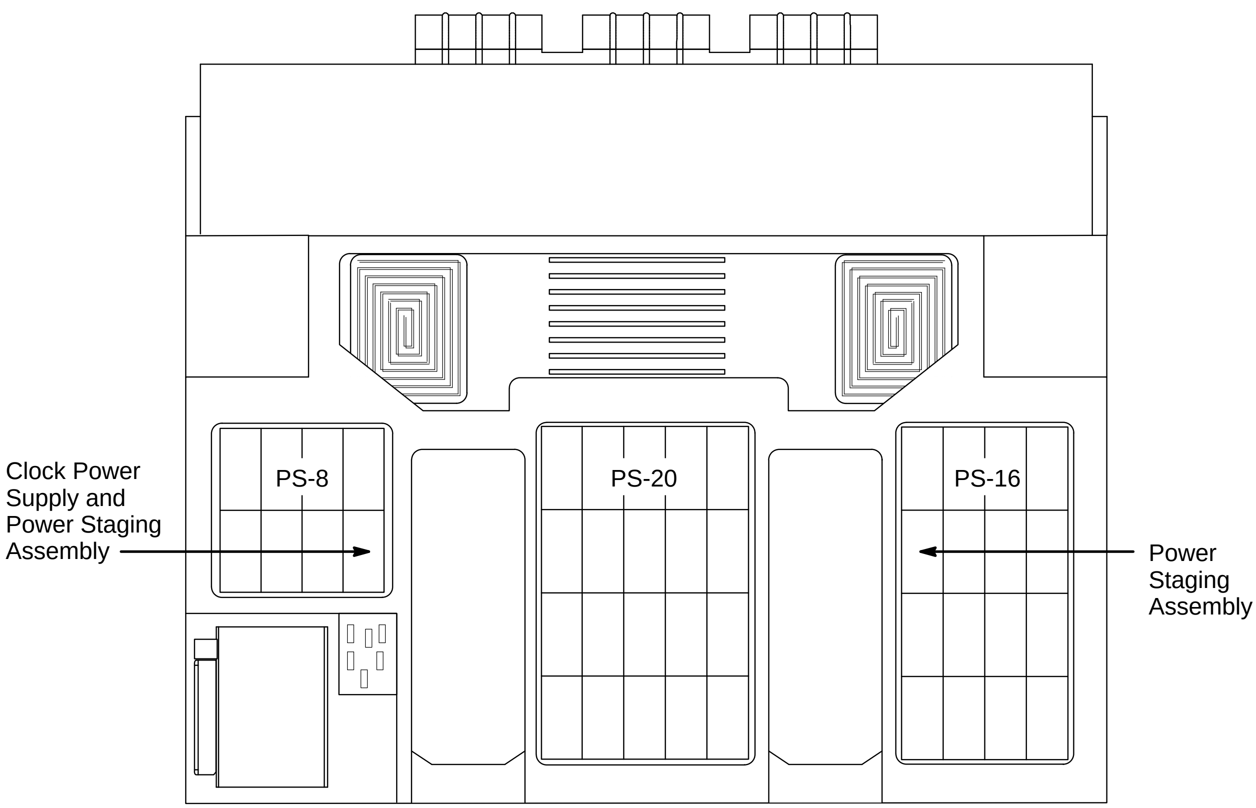


Figure 9. Power Staging Assembly Locations

Refer to Figure 10 for the locations of the following components. The "Power Distribution to the Modules" subsection, which begins on page NO TAG, describes all of these power distribution components in detail.

Power Bus Connections

The power bus connections on the LVDC power buses 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 Buses

The four LVDC power buses route the power from the power supplies to the appropriate modules.

Bus Interface Assembly

Each module assembly has a bus interface assembly attached to it. 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. When a module assembly requires replacement, both the module logic board and the module regulator require replacement.

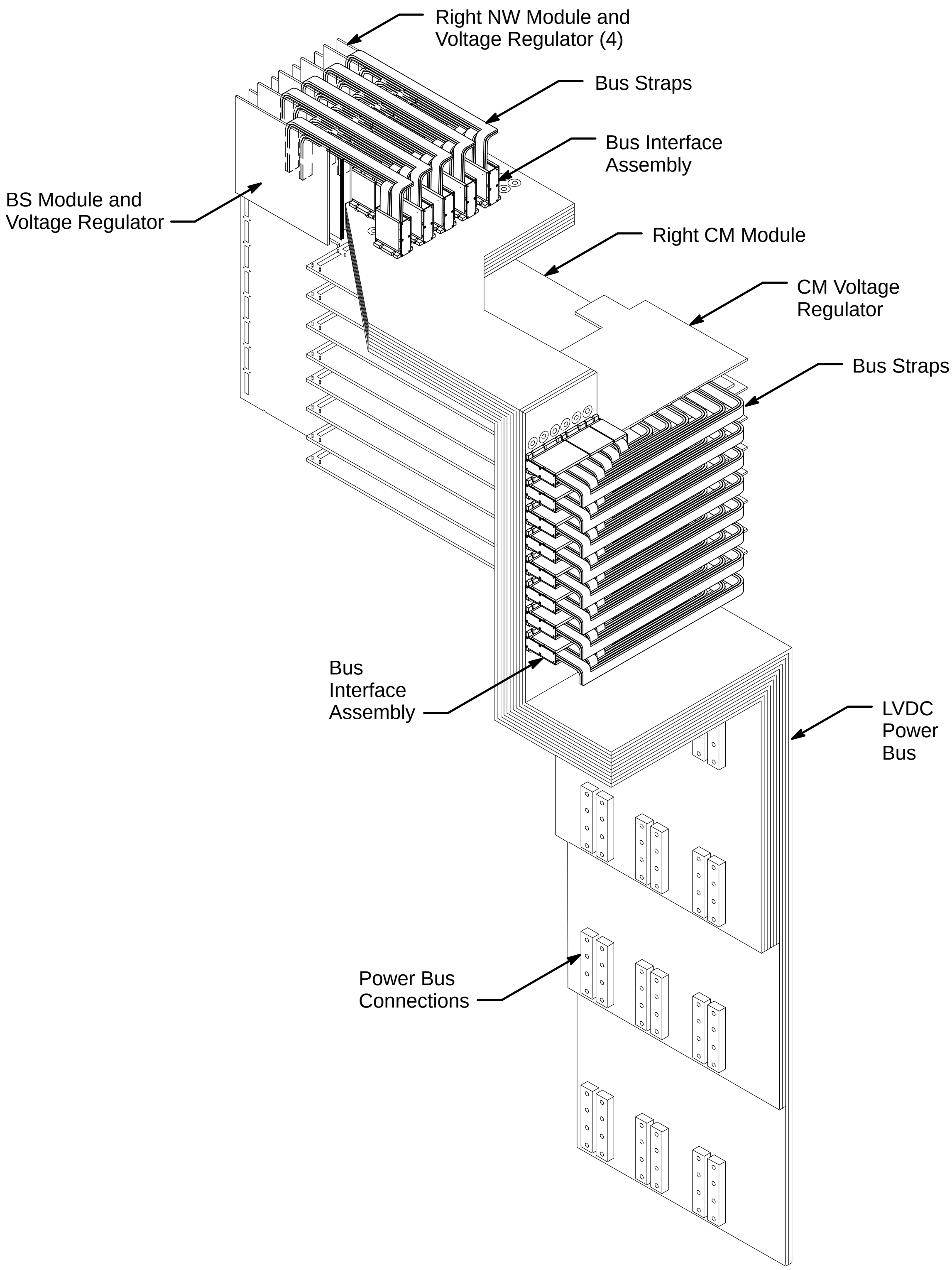
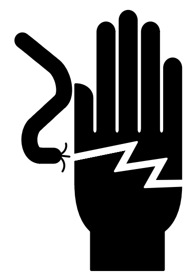


Figure 10. Power Bus Component Locations

Power Distribution

The CRAY T916 mainframe receives two types of electrical power from the HVDC: 120-Vac and 330-Vdc power. The input power to the mainframe consists of six 330-Vdc power lines and one 120-Vac power line. You must disconnect the seven power sources before you service the mainframe.



WARNING

Electrical hazard. Turn off the electrical circuit breakers to ensure that the 7 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 power powers the programmable logic controllers (PLCs). A single-phase, 120-Vac power input line attaches to terminal blocks in the 120-Vac power input box. The main 120-Vac input line contains three wires: the power line, the neutral line, and the ground line.

At the terminal blocks in the 120-Vac power input box, the single 120-Vac input line splits into two 120-Vac outputs. Jumper wires provide the interconnections between the three connections on the main input line and the other three connections on the terminal strip. The ground lines connect to ground lugs in the input box. The power lines connect to the main circuit breaker, and the neutral lines connect to the neutral line in the two 120-Vac drop cords. Figure 11 illustrates the components of the 120-Vac power input box.

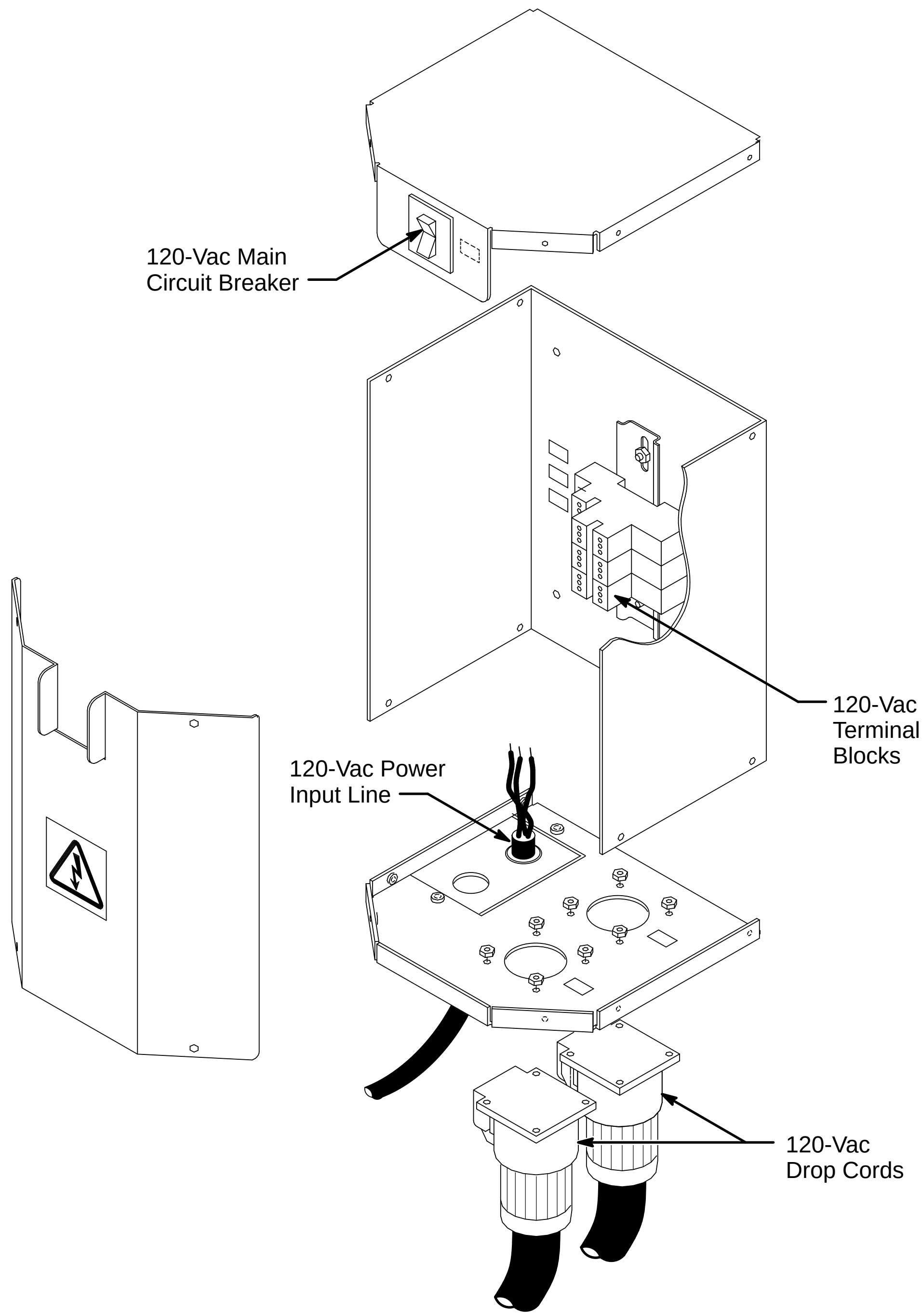


Figure 11. 120-Vac Power Input Box

The two drop cords attach to compatible receptacles in the two PLC racks and provide 120-Vac power to the PLC power supplies. Each 120-Vac power line attaches to a circuit breaker in the control system bulkhead in each controller assembly. When the circuit breaker is turned off, it isolates the PLC rack assembly from 120-Vac power and allows service or replacement of the PLC components.

The 120-Vac power lines also provide power to a 12-Vdc power supply in each PLC rack assembly. Each of the two 12-Vdc power supplies mounts to a bracket on the floor plate behind the control system bulkhead. These power supplies provide power to the 12-Vdc output modules in the PLC racks and to the control system multiplexer (MUX) board. The “Control System” section later in this document describes the PLC and MUX components in detail. Refer to Figure 12 for a block diagram of the 120-Vac power circuits.

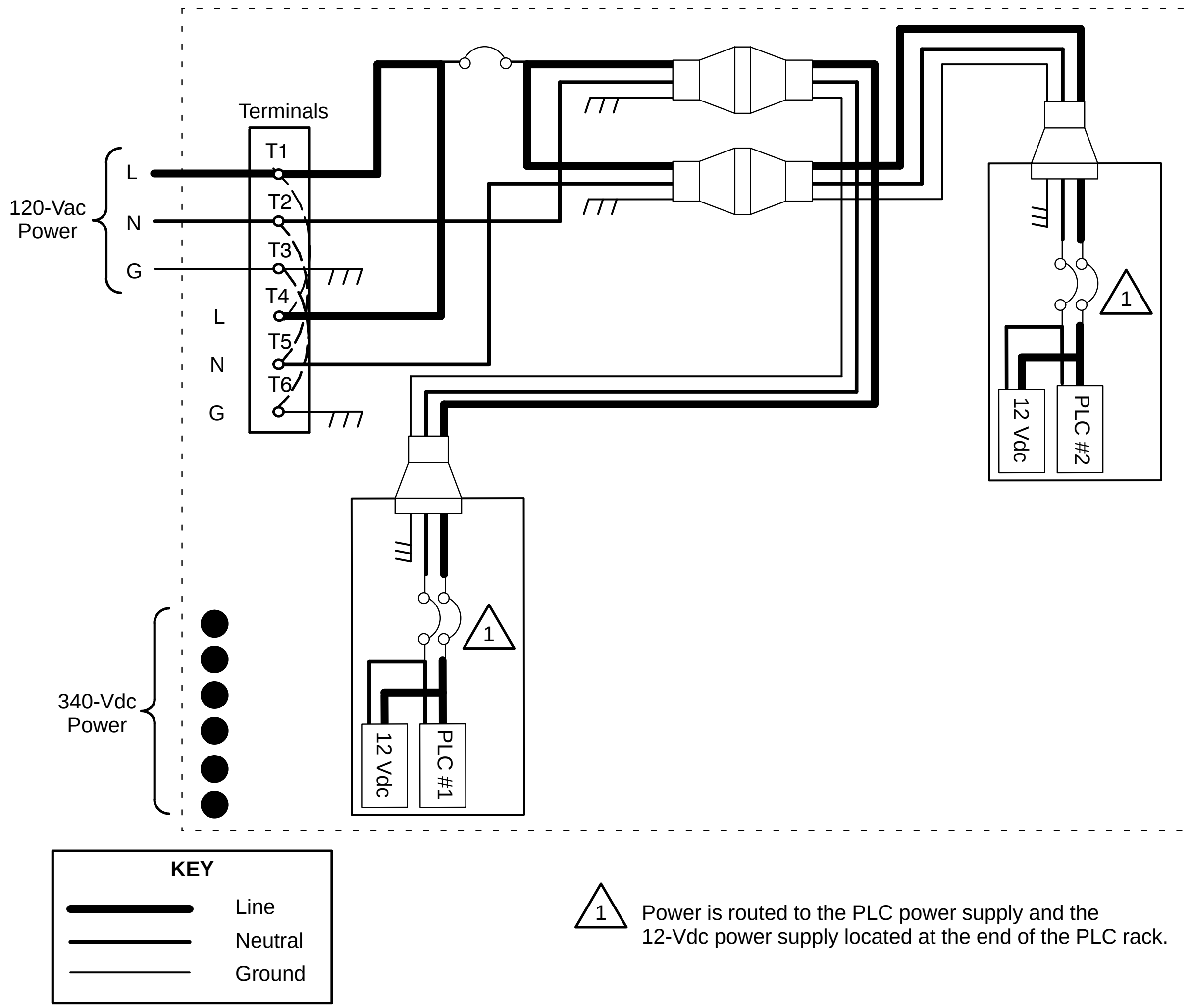


Figure 12. 120-Vac Power Block Diagram

NOTE: One 120-Vac power line (consisting of a line, a neutral, and a ground) enters the CRAY T916 mainframe from the HVDC. This line splits into two lines by jumper wiring T1 to T4, T2 to T5, and T3 to T6.

330-Vdc Power Distribution

The six 330-Vdc input power lines from the high-voltage DC device (HVDC) connect to power circuit line connections in the CRAY T916 mainframe. 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 entering or leaving the mainframe. Each ground line of the 330-Vdc lines connects to a separate ground terminal, which provides ground through the chassis at the terminal blocks.

The power circuit line connections contain high voltage when the HVDC is running and supplying power to the mainframe. When the HVDC is supplying 330-Vdc power to the mainframe, do not disconnect the 330-Vdc connections or attempt to service the mainframe.

WARNING

Do not service the 330-Vdc mainframe connections when the HVDC is running. Before you begin service, open the main HVDC circuit breaker (CB1). Failure to do so could result in severe shock, burns, and possibly death.

The control system also monitors the 330-Vdc power to the power supplies. At each of the six HVDC filter locations, a wire connects to a lug connection and then to one of the three HVDC isolation boards. The isolation boards reduce the voltage by a factor of 100 and then send the reduced voltage to the analog input base converters in the control system.

Figure 13 illustrates the 330-Vdc terminal blocks, HVDC filters, and isolation boards, which are located in the main controller enclosure in side A. Side B does not contain any of the components called out in Figure 13 because side B does not connect to an HVDC. Refer to the *Field Replacement Procedures* document, Cray Research publication number HMM-111-0, before you handle or replace any of these components.

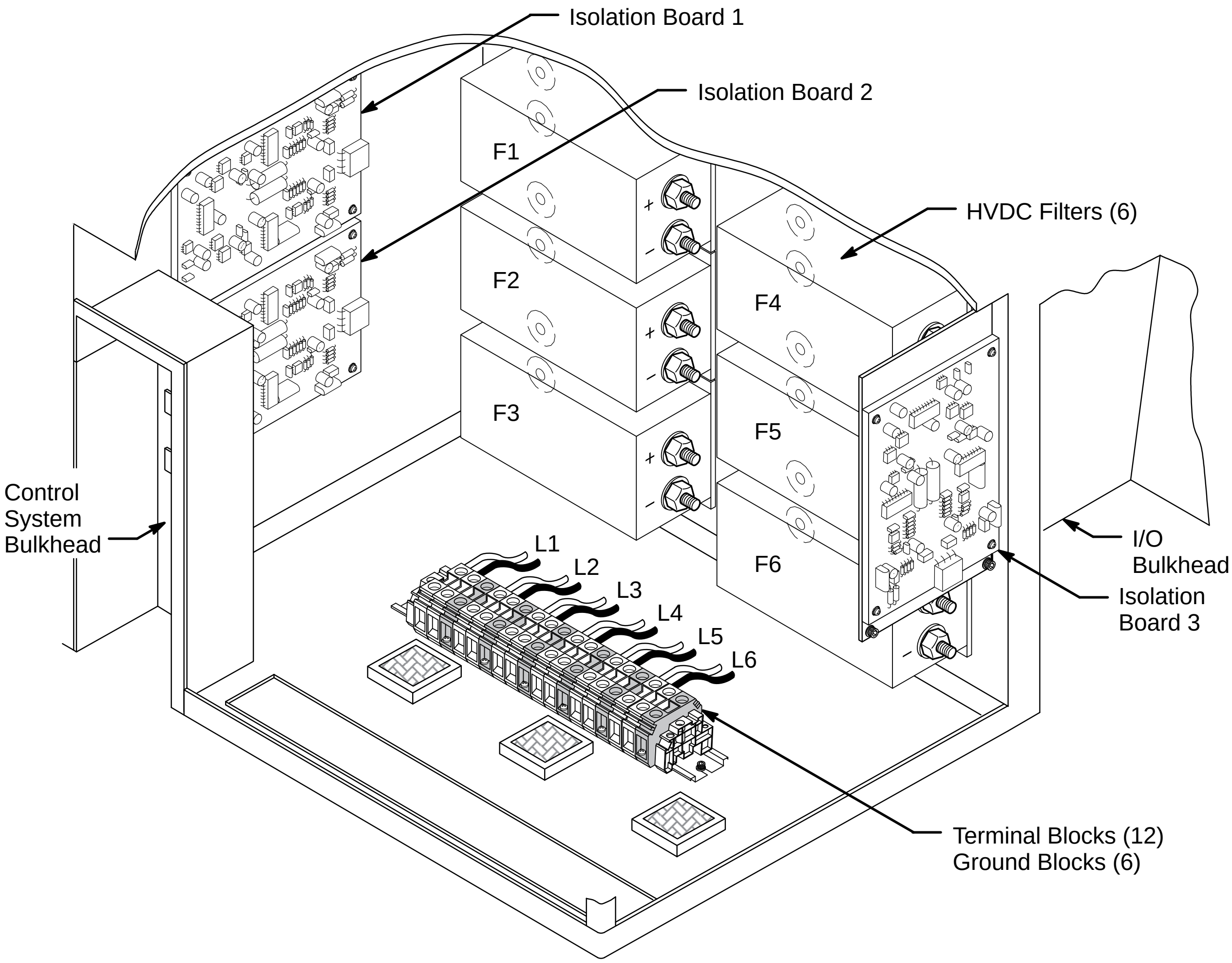


Figure 13. 330-Vdc Power Input Components, Side A

Six screws attach each HVDC filter to the enclosure panel and provide the filter ground connections. The plus and minus input connections on the front of the HVDC filters (F1 through F6) attach to the plus and minus power circuit lines (L1 through L6). The HVDC output connections in the I/O bulkhead supply 330-Vdc power to the power supply harnesses. Each power supply harness distributes 330-Vdc power to specific power supplies in the power-supply rack assemblies. Table 2 provides information about the 330-Vdc input power distribution.

Table 2. 330-Vdc Input Power Distribution

Input Line	HVDC Filter	Isolation Board	Power Supply Locations
L1	F1	Iso 1	1 – 8
L2	F2	Iso 1	9, 14, 19, 24, 25, 26
L3	F3	Iso 2	10, 11, 15, 16, 20, 21, 22, 27
L4	F4	Iso 2	12, 13, 17, 18, 23, 28
L5	F5	Iso 3	29, 30, 31, 32, 36, 37, 41, 44
L6	F6	Iso 3	33, 34, 35, 38, 39, 40, 42, 43

Figure 14 provides a block diagram of the 330-Vdc input power distribution. The blocks in Figure 14 represent the components in the mainframe, but they do not represent the physical shapes or locations of those components.

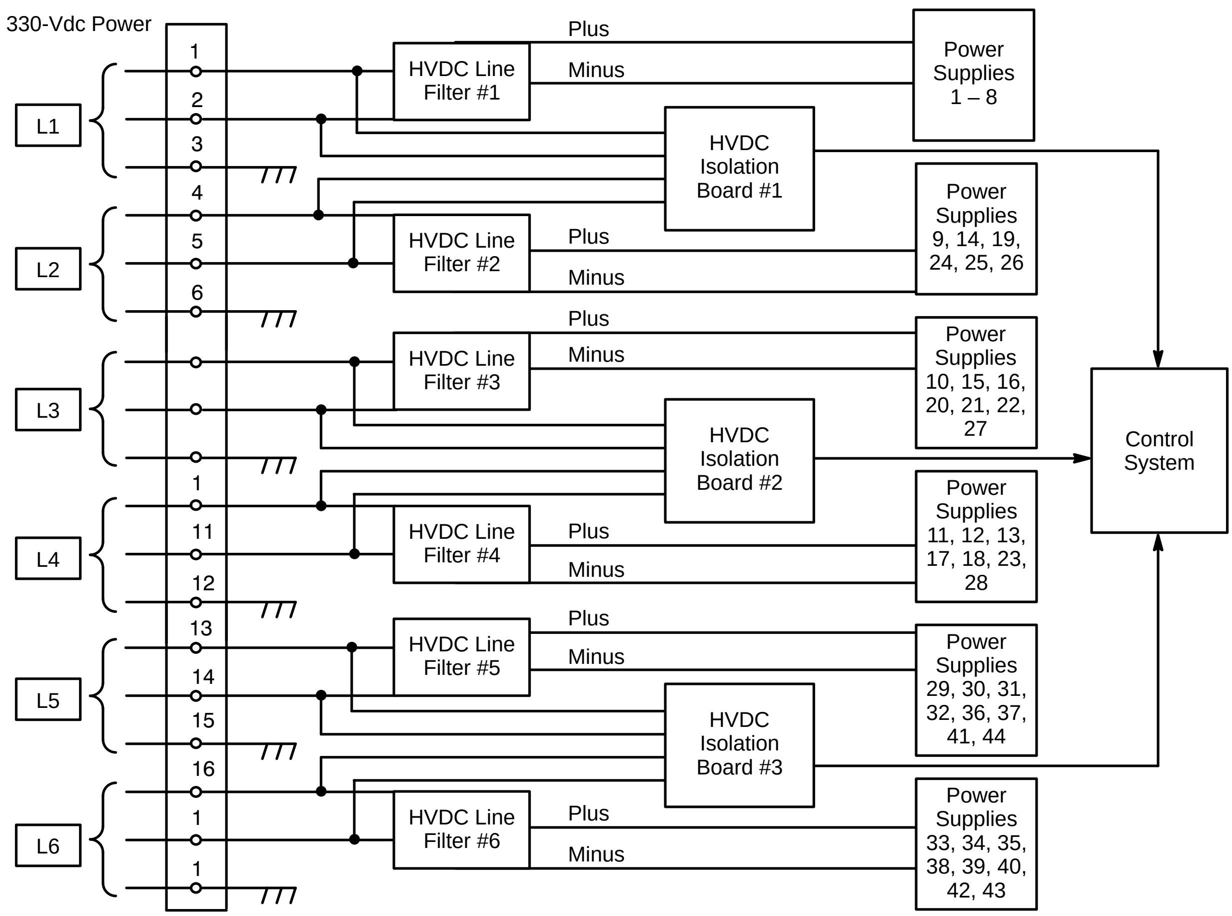


Figure 14. 330-Vdc Power Block Diagram

Power Supply Connections

The power supplies mount in the three power supply racks and route power through the power bus connections to the low-voltage DC (LVDC) module power buses. With the exception of the clock power supply and power staging 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 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 15 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.

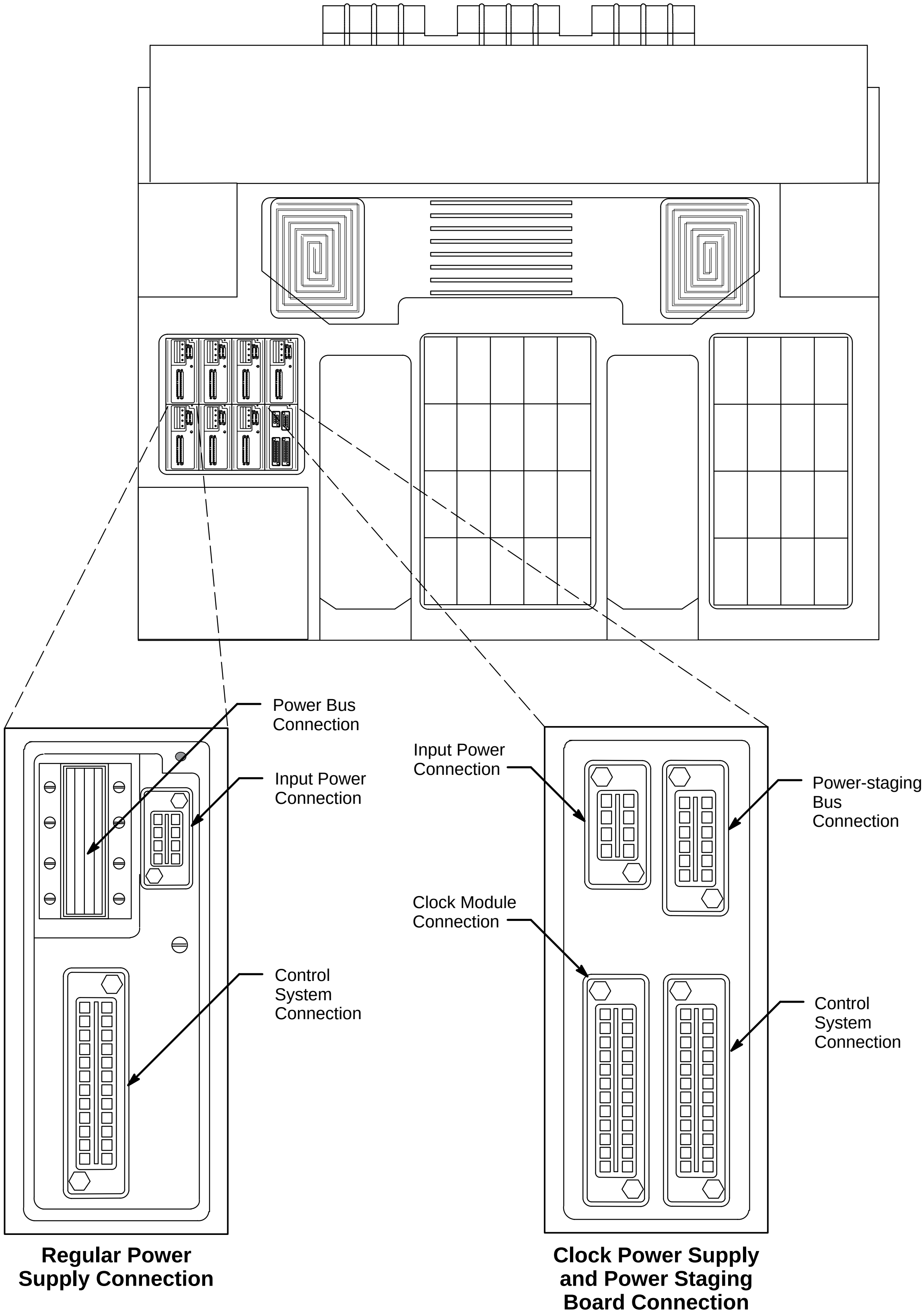


Figure 15. Power-supply Harness Connections

The regular power supplies have three connections: the input power connection, the control system connection, and the power-supply bus connection. Refer to Figure 16 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 16 illustrates this connection.

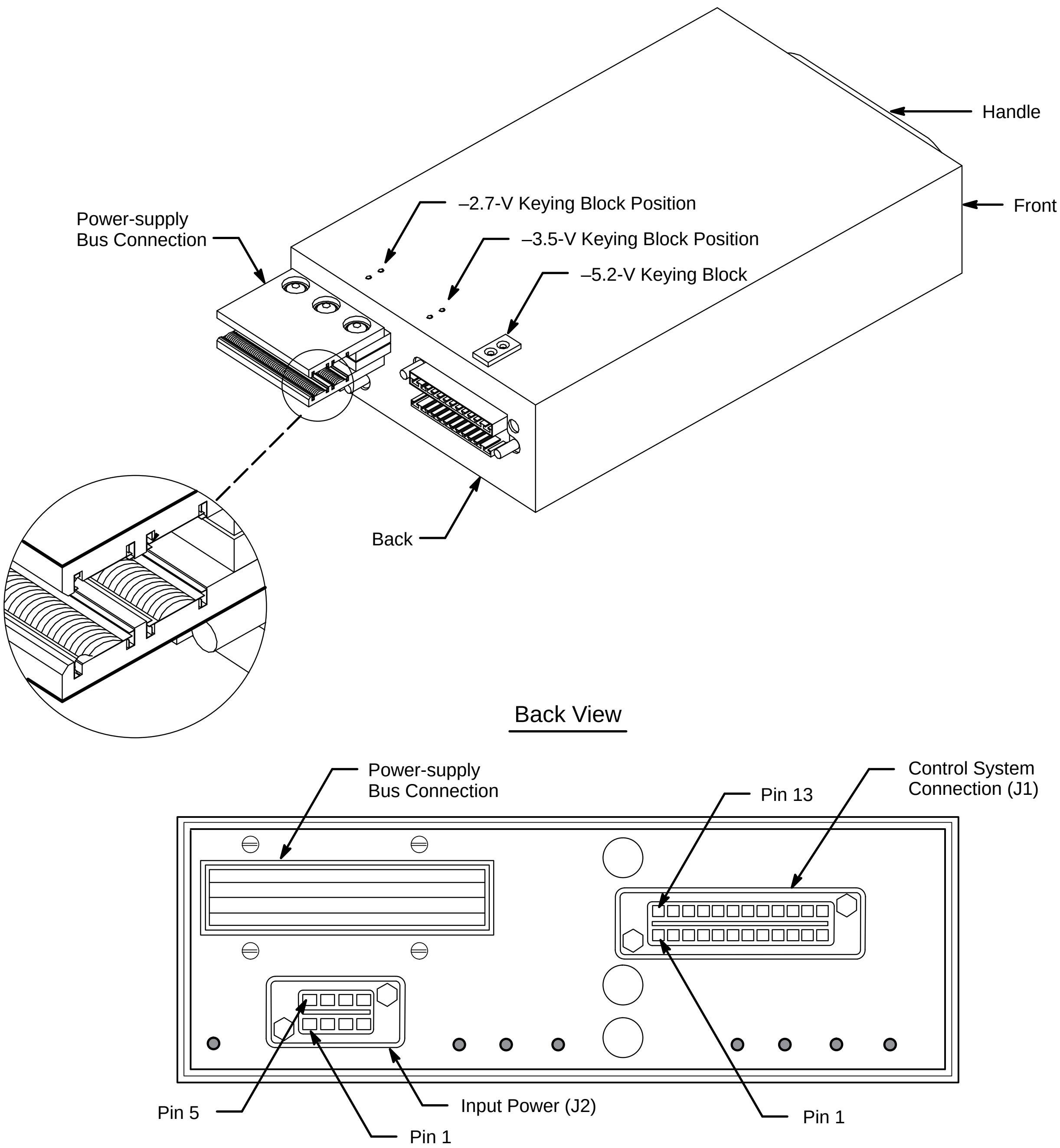


Figure 16. Power Supply Connections

The input power connection on the regular power supplies is an 8-slot blind-mate connector. Table 3 describes the function of each connector position in this connector.

Table 3. Input Power Connection

J2 Connector Position	Function
1	Plus 330-Vdc input
2	Plus 330-Vdc input
3	Not used
4	Ground
5	Minus 330-Vdc input
6	Minus 330-Vdc input
7	Not used
8	Ground

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 other power-supply fault conditions occur, the “power supply good” condition sends a signal to the control system to indicate that the power supply has failed and requires replacement. Table 4 provides the pin numbers and the signal names for this connector.

Table 4. Power-supply Control System Connection

J1 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 clock power supply in power-supply slot number 8 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 17 for an illustration of this field-replaceable assembly and its connections.

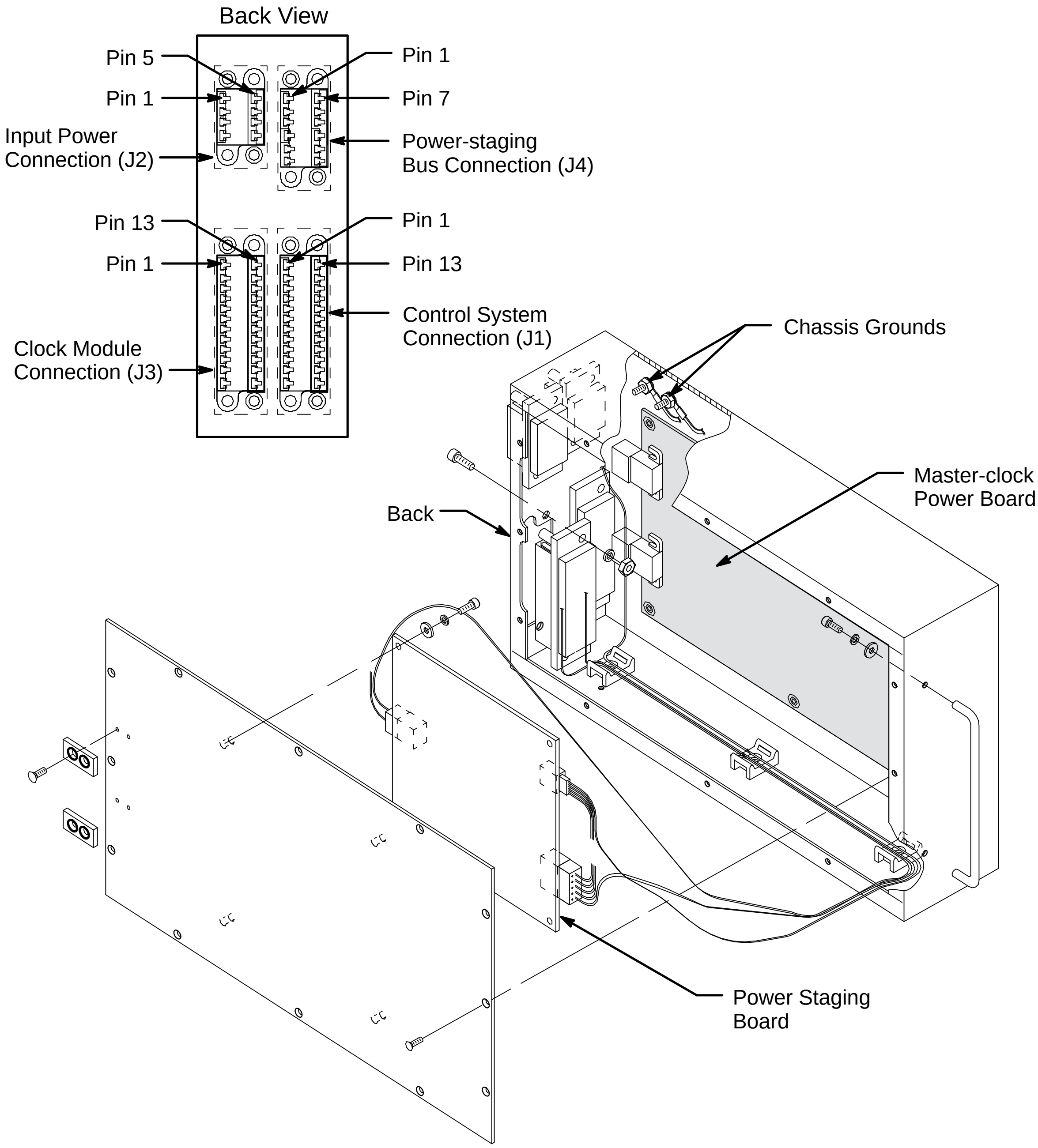


Figure 17. Clock Power Supply and Power Staging Assembly

The input power connection on the clock power supply is an 8-pin connector that receives 330-Vdc power from the HVDC and distributes it to the input connectors on the master-clock power board and on the power staging board. Table 5 provides the pin numbers and the signal names for this connector.

Table 5. Input Power Connection

J2 Pin Number	Board Connector-Pin Number	Signal Name
1	P1-1	HVDC 1 (+)
2	P7-1	HVDC 2 (+)
3	P8-1	HVDC 3 (+)
4	Ring terminal	Chassis GND
5	P1-3	HVDC 1 (–)
6	P7-6	HVDC 2 (–)
7	P8-3	HVDC 3 (–)
8	Ring terminal	Chassis GND

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 buses in that particular quadrant to check for electrical shorts. Table 6 provides the pin numbers and the signal names for this connector.

Table 6. Power-staging Bus Connection

J4 Pin Number	Board Connector- Pin Number	Signal Name
1	P6-6	Short check –5.2 V CM1
2	P6-7	Short check –3.5 V CM1
3	P6-8	Short check –2.7 V CM1
4	P6-9	Short check –3.5 V CP1
5	P6-10	Short check –2.7 V CP1
6	Not used	Not used
7	P6-1	Short check +5.2 V (GND) CM1
8	P6-2	Short check +3.5 V (GND) CM1
9	P6-3	Short check +2.7 V (GND) CM1
10	P6-4	Short check +3.5 V (GND) CP1
11	P6-5	Short check +2.7 V (GND) CP1
12	Not used	Not used

The control system connection on the clock power supply is a 24-pin connector that routes information to and from the control system. Table 7 provides the pin numbers and signal names for this connector.

Table 7. Control System Connection

J1 Pin Number	Board Connector-Pin Number	Signal Name
1	P2-8	Enable clock main
2	P3-7	Enable clock standby
3	P2-1	Laser select main
4	P3-1	Laser select standby
5	P2-4	Clock select 0 main
6	P3-4	Clock select 0 standby
7	P2-5	Clock select 1 main
8	P3-5	Clock select 1 standby
9	P2-6	Clock select 2 main
10	P3-6	Clock select 2 standby
11	P2-2	Laser alarm 1
12	P2-3	Laser alarm 2
13	P2-7	Power good clock
14	P2-11	Margin enable clock
15	P2-9	Margin signal clock
16	P2-10	Margin signal return
17	P3-8	Return
18	P2-12	Return
19	P2-13	– Sense –5.2 V
20	P2-14	+ Sense –5.2 V
21	P5-3	Short check enable –2.7 V Q1
22	P5-2	Short check enable –3.5 V Q1
23	P5-1	Short check enable –2.7 V Q1
24	P5-4	Return

The clock module connection is also a 24-pin connector; it routes control information to the clock module. Table 8 provides the pin numbers and signal names for this connector.

Table 8. Clock Module Connection

J3 Pin Number	Board Connector- Pin Number	Signal Name
1	P4-1	Laser 1 enable
2	P4-2	Laser 1 return
3	P4-3	Laser 2 enable
4	P4-4	Laser 2 return
5	P4-5	Laser 1 alarm
6	P4-6	Laser 1 alarm return
7	P4-7	Laser 2 alarm
8	P4-8	Laser 2 alarm return
9	P4-10	Clock select 0 complement
10	P4-9	Clock select 0 true
11	P4-12	Clock select 1 complement
12	P4-11	Clock select 1 true
13	P4-14	Clock select 2 complement
14	P4-13	Clock select 2 true
15	P4-15	Enable slow
16	P4-18	Enable normal 1
17	P4-17	Enable normal 2
18	P4-16	Enable fast
19	P4-24	– Sense
20	P4-25	+ Sense
21	P4-23	–5.2 V
22	P4-26	–5.2 V return
23	P4-21	–5.2 V
24	P4-22	–5.2 V return

The power staging assembly in power-supply slot number 33 contains one power staging board and two external connections: an input power connection, and a power-staging bus connection. Like the clock power supply and regular power supplies, the power staging assembly is a field replaceable unit. Refer to Figure 18 for an illustration of this assembly and its connections.

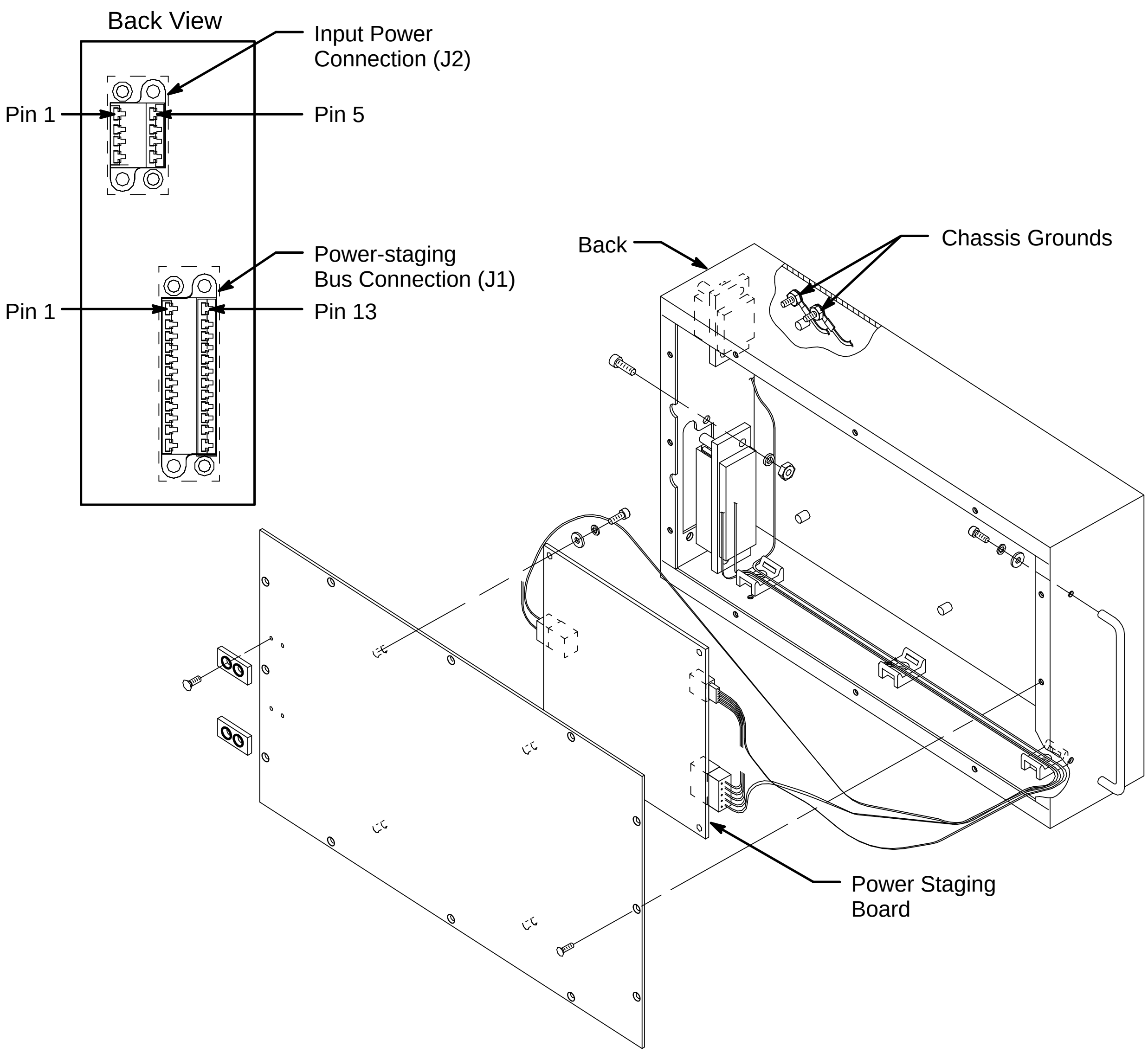


Figure 18. Power Staging Assembly

The input power connection on the power staging assembly is an 8-pin connector that receives 330-Vdc power from the HVDC and distributes it to the input connector on the power staging board. Table 9 provides the pin numbers and the signal names for this connector.

Table 9. Input Power Connection

J2 Pin Number	Board Connector-Pin Number	Signal Name
1, 3, 5, 7	Not used	Not used
2	P7-1	HVDC 1 (+)
4	Ring terminal	Chassis GND
6	P7-6	HVDC 1 (–)
8	Ring terminal	Chassis GND

The power-staging bus connection on the power staging assembly is a 24-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 buses in that particular quadrant to check for electrical shorts. Table 6 provides the pin numbers and the signal names for this connector.

Table 10. Power Staging Bus Connection

J1 Pin Number	Board Connector-Pin Number	Signal Name
1	P6-6	Short check –5.2 V CM2
2	P6-7	Short check –3.5 V CM2
3	P6-8	Short check –2.7 V CM2
4	P6-9	Short check –3.5 V CP2
5	P6-10	Short check –2.7 V CP2
6, 7, 8, 9, 10	Not used	Not used
11	P5-3	Short check enable –2.7 V Q2
12	P5-2	Short check enable –3.5 V Q2
13	P6-1	Short check +5.2 V (GND) CM2
14	P6-2	Short check +3.5 V (GND) CM2
15	P6-3	Short check +2.7 V (GND) CP2
16	P6-4	Short check +3.5 V (GND) CP2
17	P6-5	Short check +2.7 V (GND) CP2
18, 19, 20, 21, 22	Not used	Not used
23	P5-1	Short check enable –5.2 V Q2
24	P5-4	Return

Power Distribution to the Modules

After the power supplies convert the 330-Vdc power to specific voltages, the four low-voltage DC (LVDC) buses distribute the voltage to the appropriate modules in the mainframe. Each of the four LVDC buses consists of up to ten laminated layers of copper; each layer distributes a specific voltage to designated module and sense point locations. Table 11 provides information about the specific voltages and locations of the four LVDC buses. Figure 19 illustrates the locations of these buses in the mainframe.

Table 11. Low-voltage DC (LVDC) Buses

LVDC Bus	Quadrant	Module Sections	Voltages	Modules
CP and IO Left	Q1	E and F	–2.7 V, 2.7-V Gnd, –3.5 V, 3.5-V Gnd	IO module in Location E and CP modules in Stack F
CM and NW Left	Q1	G and H	–2.7 V, 2.7-V Gnd, –3.5 V, 3.5-V Gnd, –5.2 V, 5.2-V Gnd	SR and NW modules in Location G and CM modules in Stack H
CP and IO Right	Q2	I and J	–2.7 V, 2.7-V Gnd, –3.5 V, 3.5-V Gnd	IO module in Location I and CP modules in Stack J
CM and NW Right	Q2	K and L	–2.7 V, 2.7-V Gnd, –3.5 V, 3.5-V Gnd, –5.2 V, 5.2-V Gnd	BS and NW modules in Location K and CM modules in Stack L

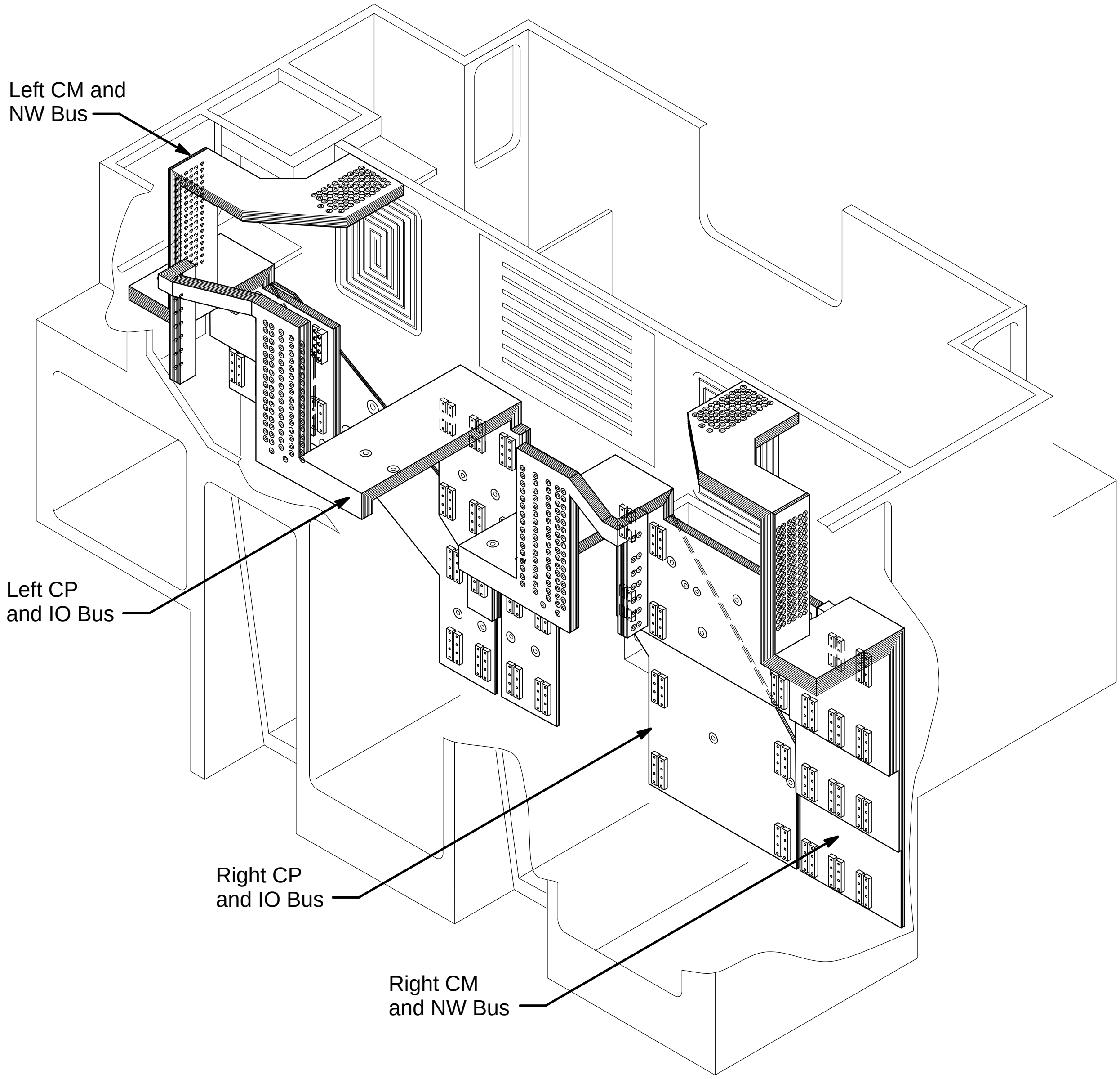


Figure 19. Low-voltage DC (LVDC) Buses

Because the chassis area near the LVDC buses contains other wiring and module hardware, it is difficult to distinguish each bus after it is installed in the mainframe tank assembly. Refer to Figure 20 through Figure 23 for individual illustrations of the four LVDC buses.

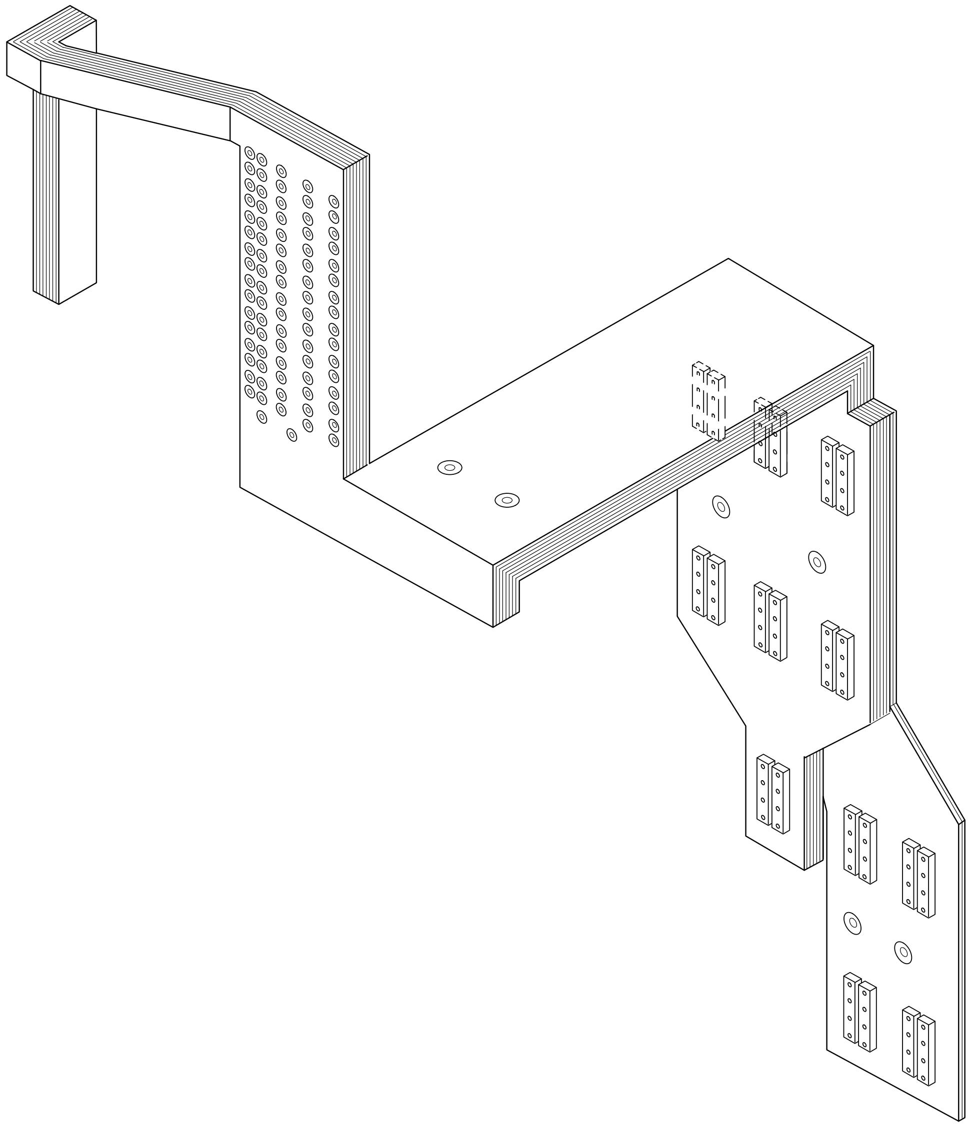


Figure 20. Left CP and IO LVDC Bus

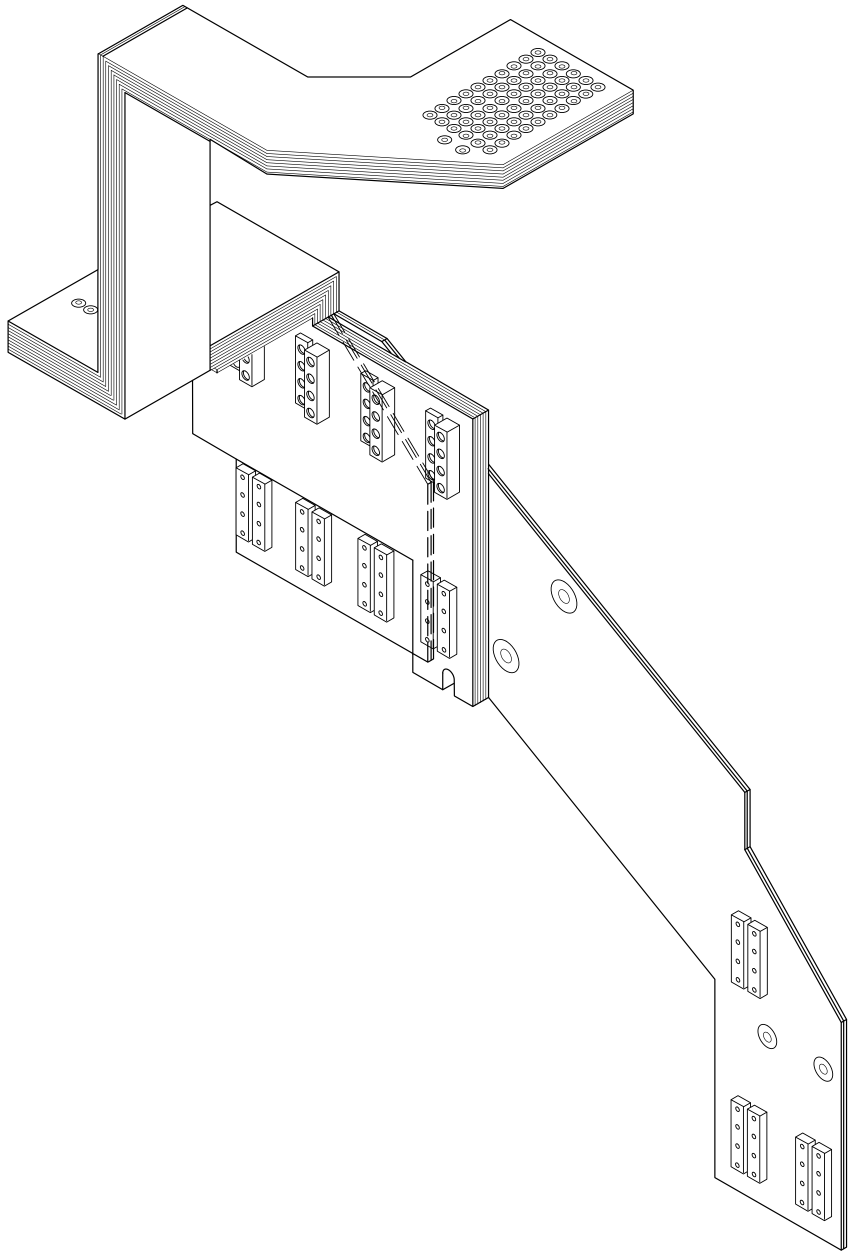


Figure 21. Left CM and NW LVDC Bus

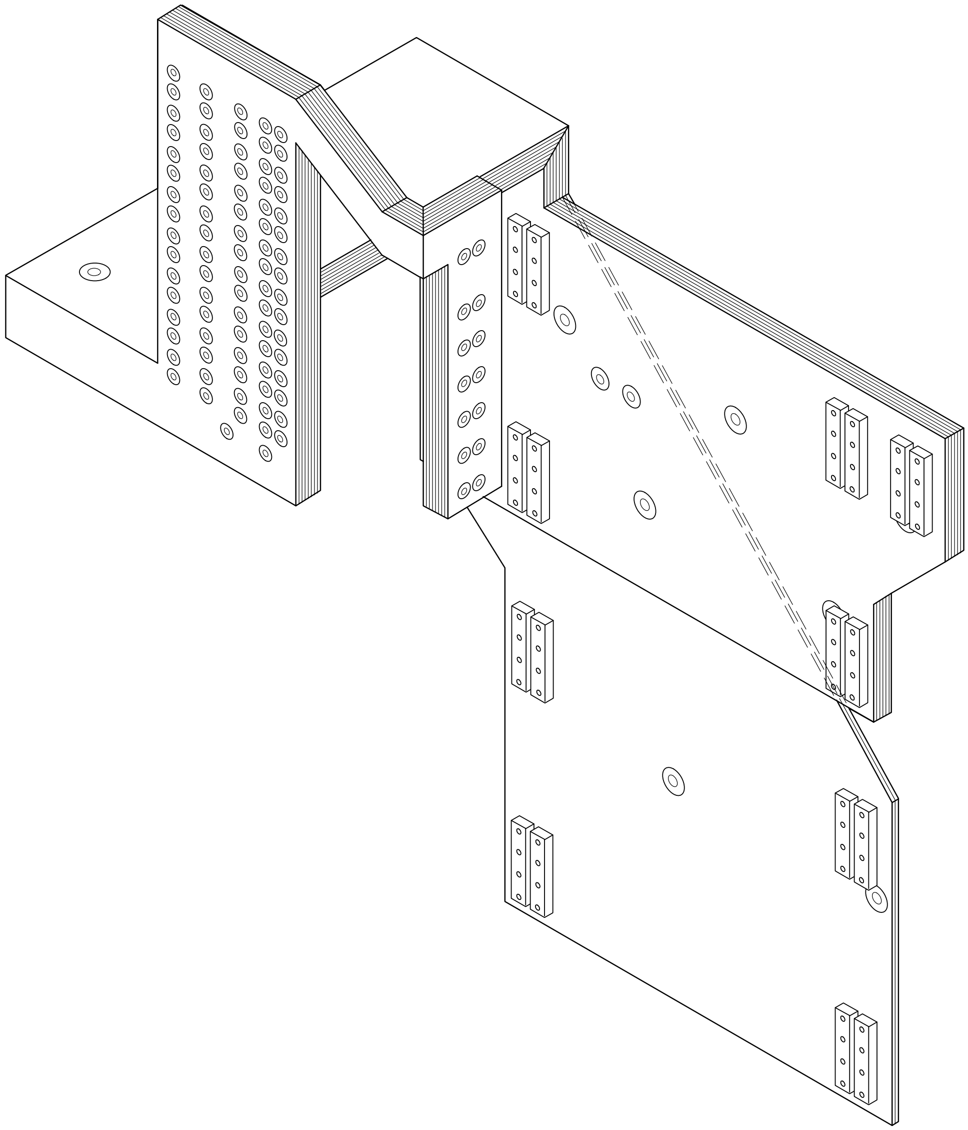


Figure 22. Right CP and IO LVDC Bus

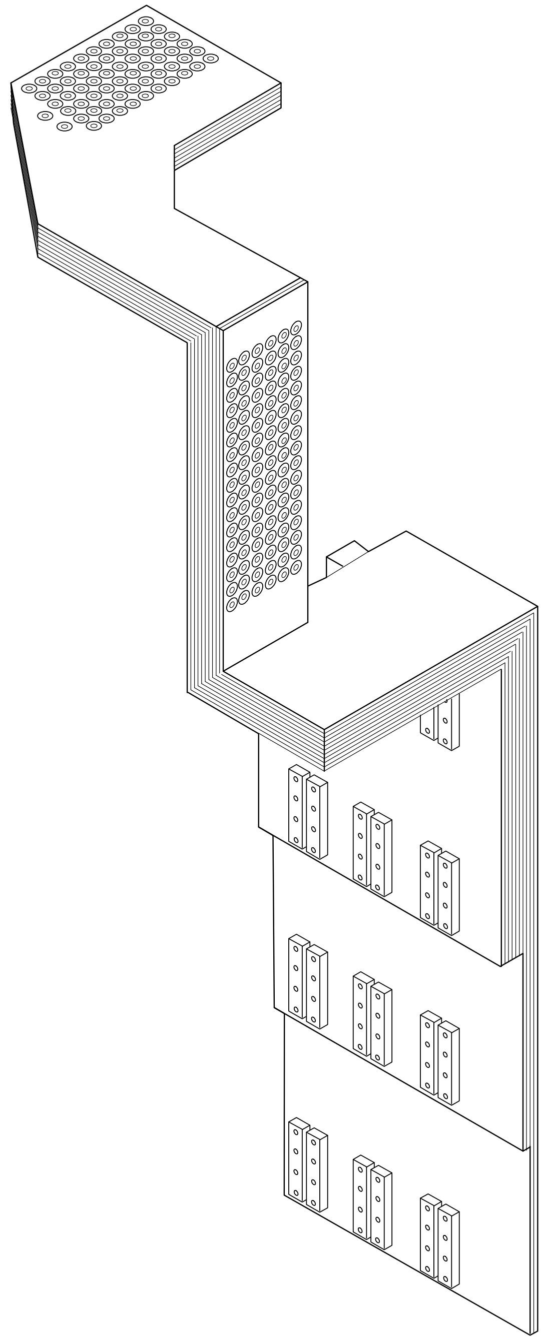


Figure 23. Right CM and NW LVDC Bus

The LVDC buses distribute power to the modules. A bus interface assembly mounts on each 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.

Each module type contains a different voltage regulator, bus interface assembly, and bus strap configuration for power distribution. Refer to Figure 24 through Figure 29 for illustrations of each type of module connection.

NOTE: Some module types have a right-hand and a left-hand orientation in the mainframe, but this section illustrates only one orientation for each module type. Modules in some systems might contain different quantities of bus straps than the modules shown in this section.

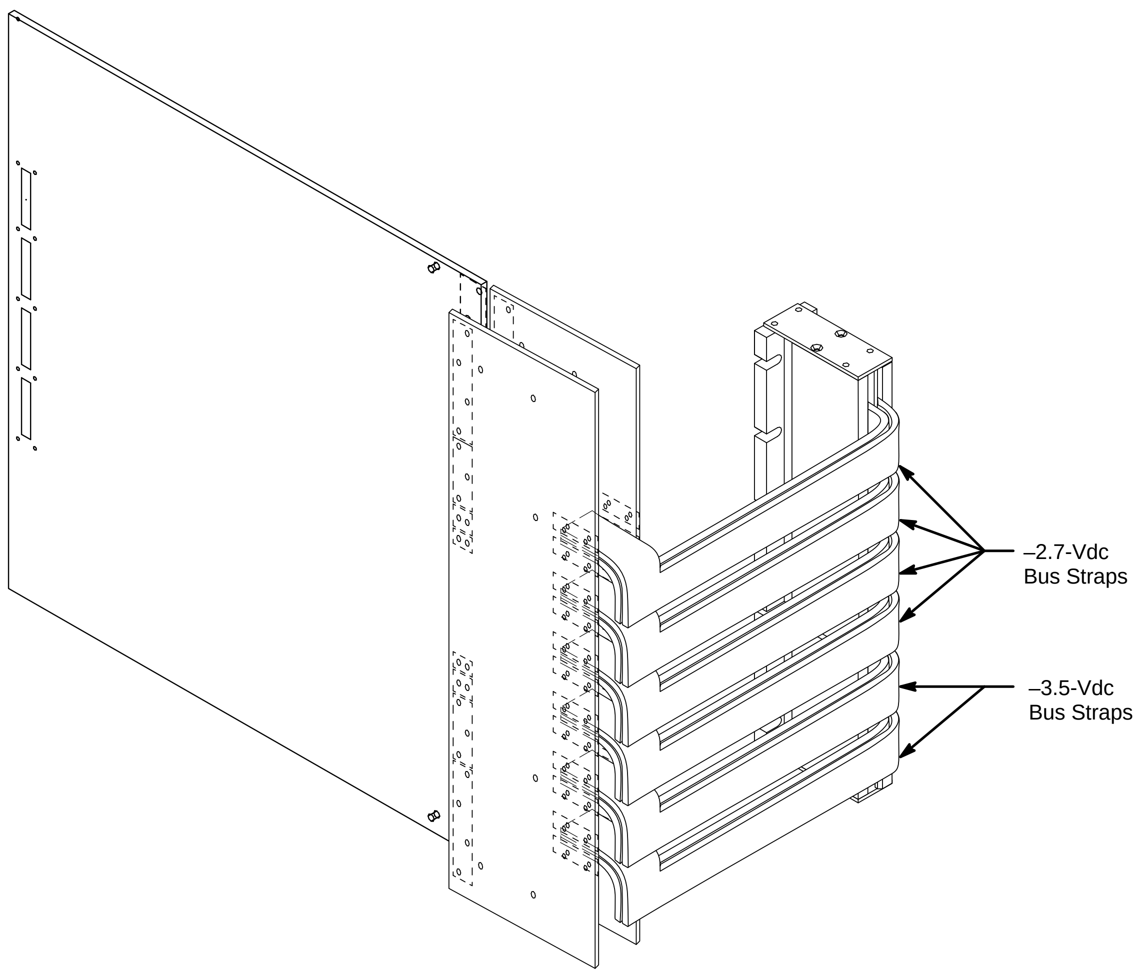


Figure 24. Right IO Module Connections

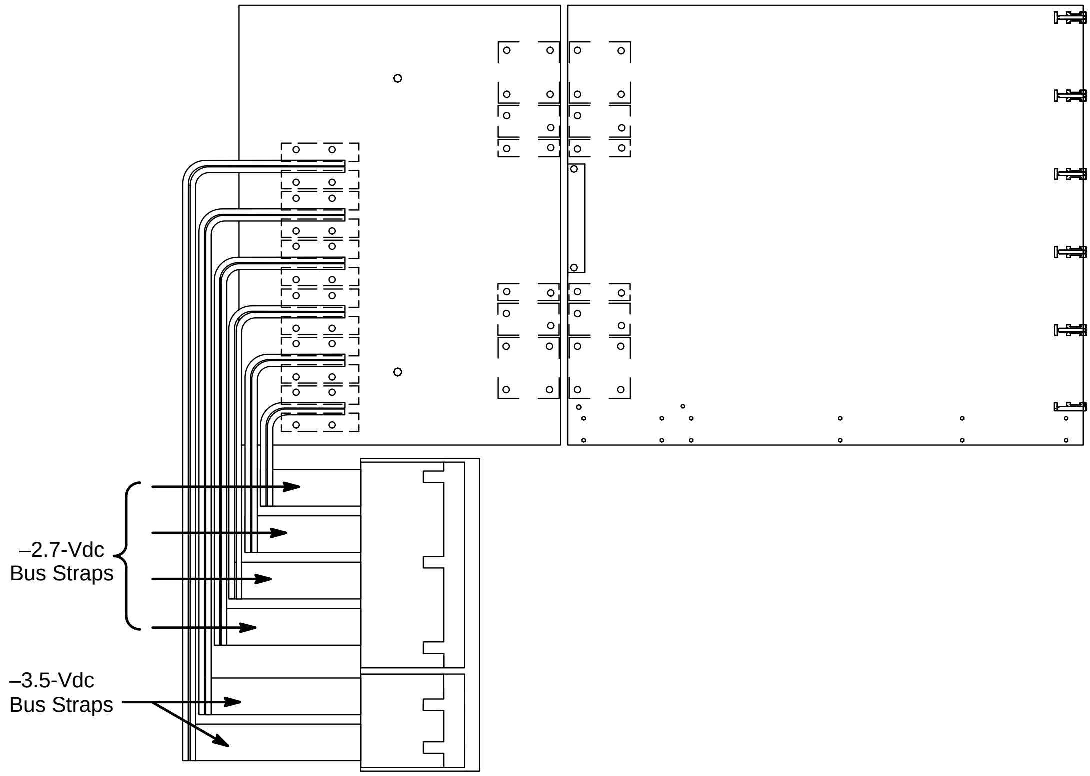


Figure 25. Right CP Module Connections

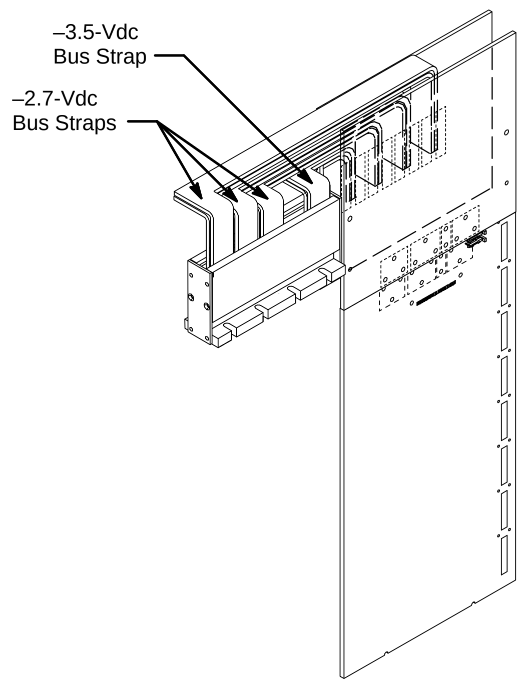


Figure 26. Shared Module Connections

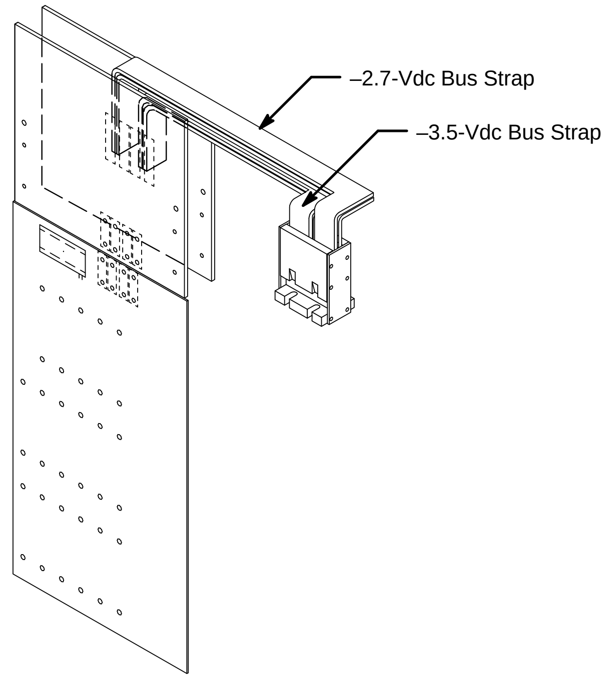


Figure 27. Boundary Scan Module Connections

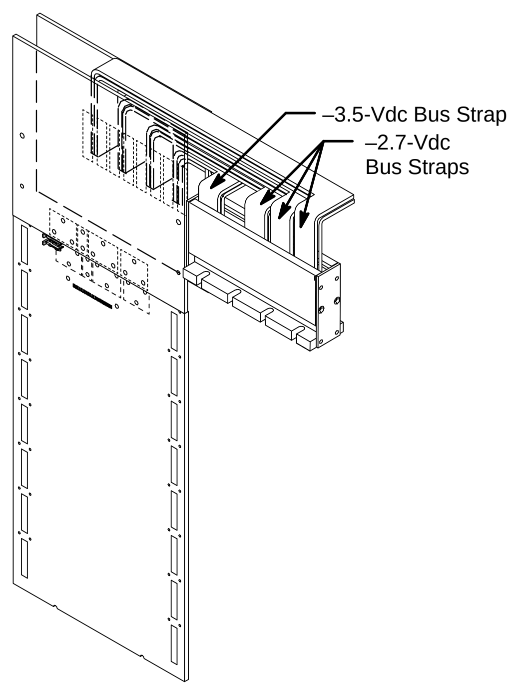


Figure 28. Network Module Connections

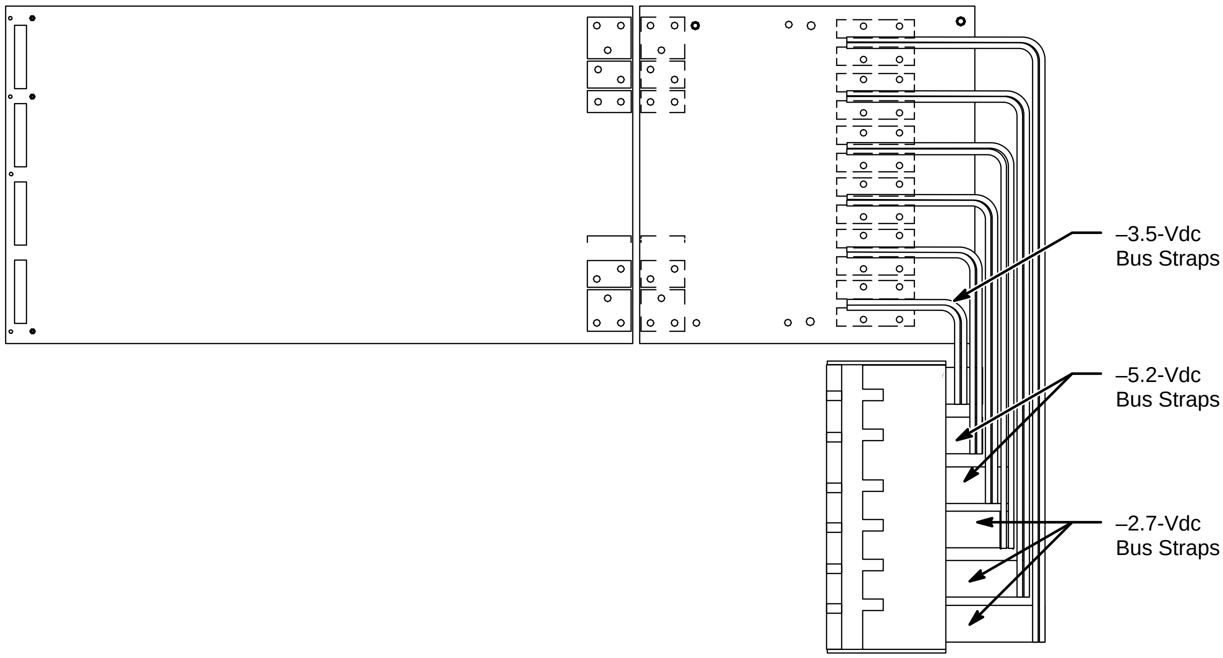


Figure 29. Right Common Memory Module Connections

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Cooling System

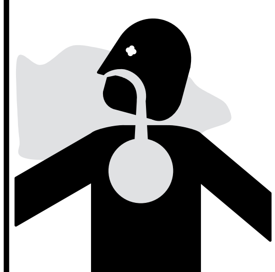
The cooling system removes heat generated by the modules and power supplies and transfers it to the heat exchanger unit (HEU-T90). The modules and power supplies are submersed in dielectric coolant, which absorbs the heat generated by these modules and power supplies. The following subsections describe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

Components

The cooling system in the CRAY T916 mainframe requires very few components, which the following subsections describe. Refer to Figure 30 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 can 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 computer system 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 could result in cooling system contamination and computer system failure.

Vent/Charge Line and Mainframe Stand Pipe

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 into the vertical stand pipe, through the vent/charge line, and back to the HEU-T90 reservoir. Likewise, during the drain process, the change in air pressure forces the air in the HEU-T90 reservoir through the vent/charge line and through the stand pipe to the mainframe chassis.

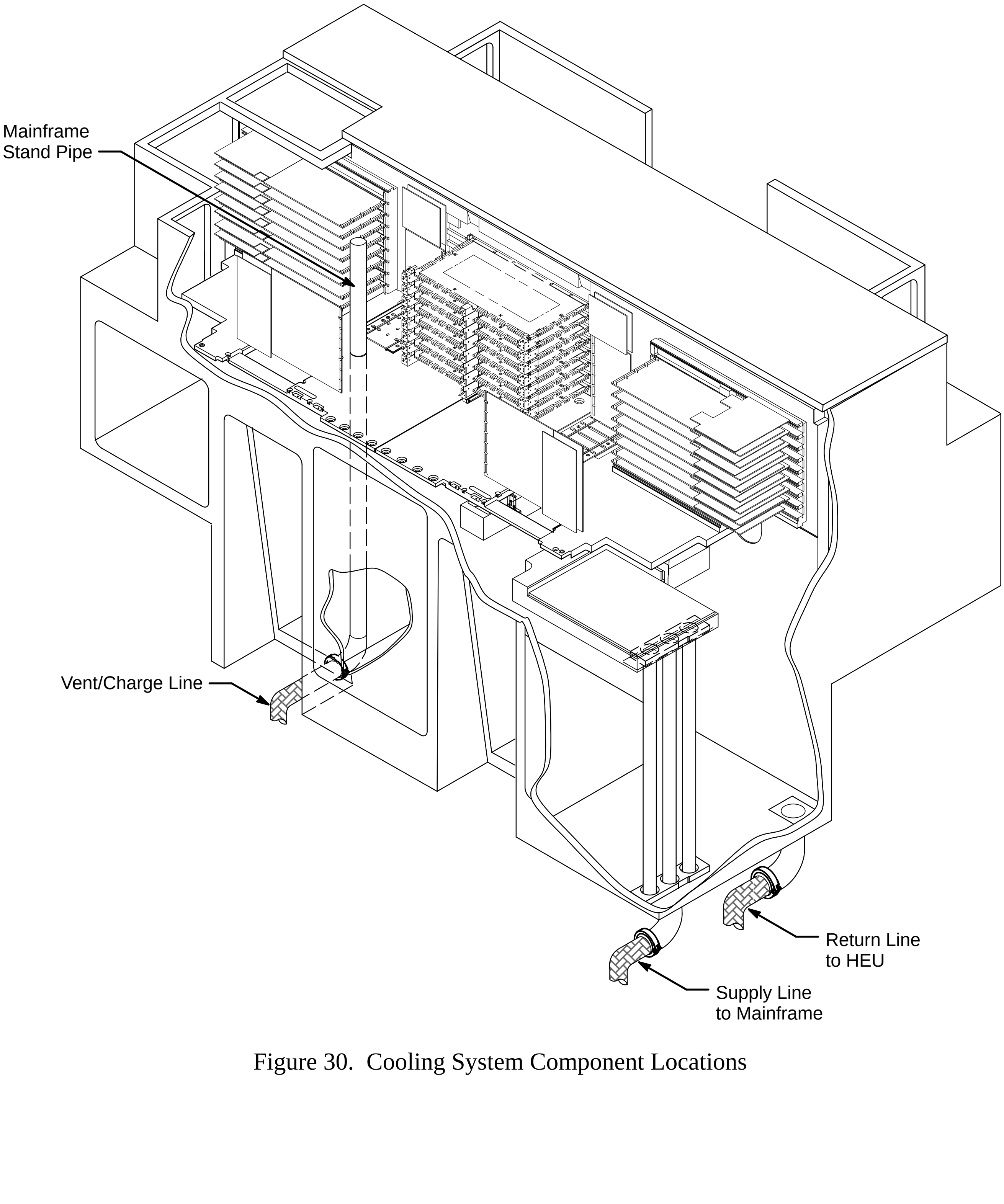


Figure 30. Cooling System Component Locations

Dielectric-coolant Flow Paths

The dielectric-coolant flow paths through the CRAY T916 mainframe are relatively simple. The following subsections describe the flow paths for the fill process, normal operation, and the drain process.

Fill Flow Path

During the mainframe power-up sequence, dielectric coolant flows into the mainframe through the supply line. A pump in the HEU-T90 forces the dielectric coolant through the supply line into the bottom of the mainframe tank. Cutouts in the CRAY T916 tank allow dielectric coolant to flow freely from the I/O section to the power supply sections and module sections. A valve in the HEU-T90 closes to prevent dielectric-coolant flow through the return line to the HEU during the mainframe fill process.

A tank divider isolates the two module quadrants in side A of the CRAY T916 mainframe from side B. In the CRAY T916 mainframe, only side A contains power supplies and modules, and only that specific half of the mainframe fills with dielectric coolant during the mainframe fill cycle.

As the dielectric coolant fills the mainframe, any air that is displaced by dielectric coolant flows through the vent/charge line back to the HEU-T90 reservoir. Figure 31 illustrates the fill flow path.

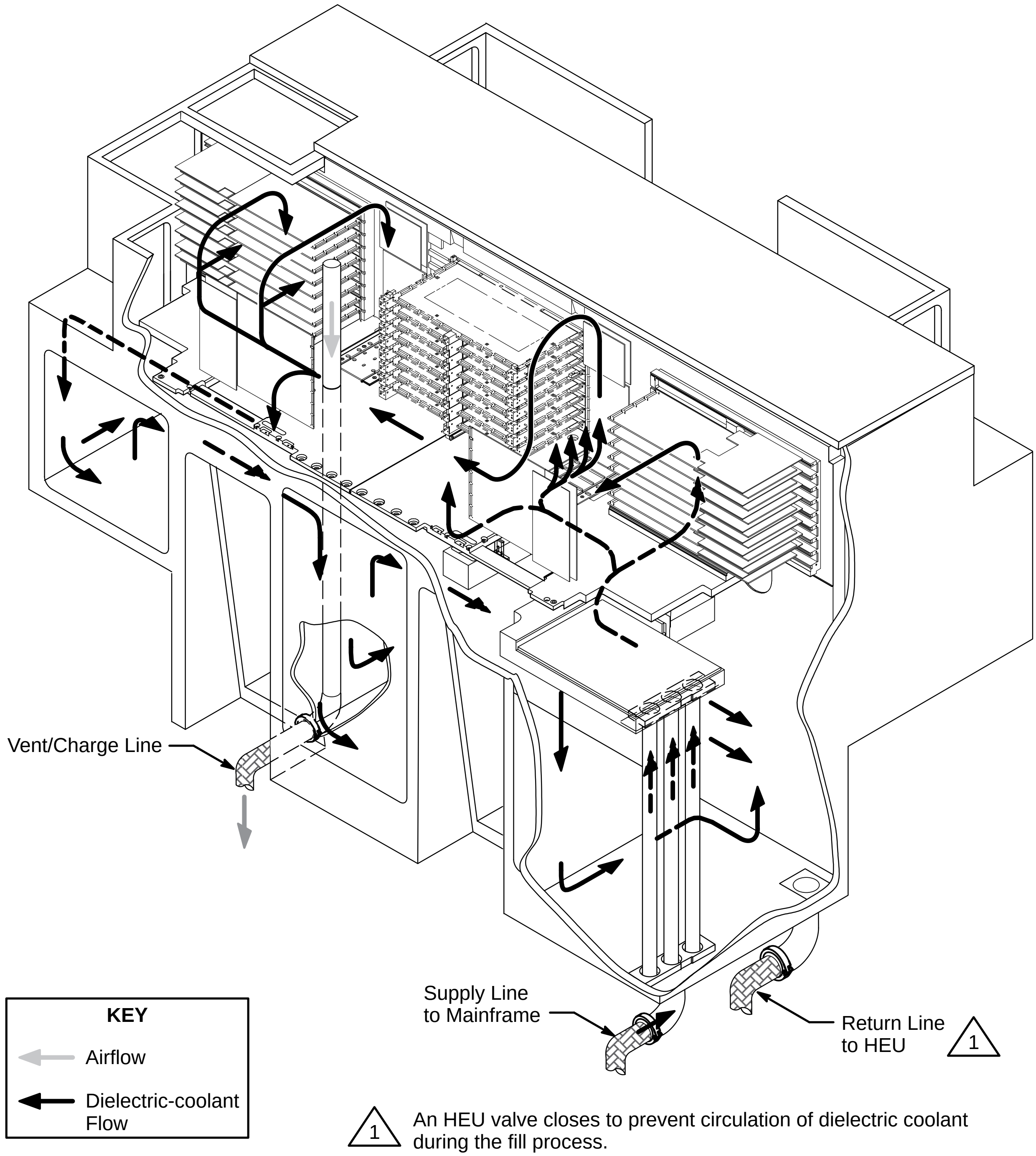


Figure 31. Dielectric-coolant Fill Flow Path

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 180 gpm. Figure 32 illustrates the normal flow path.

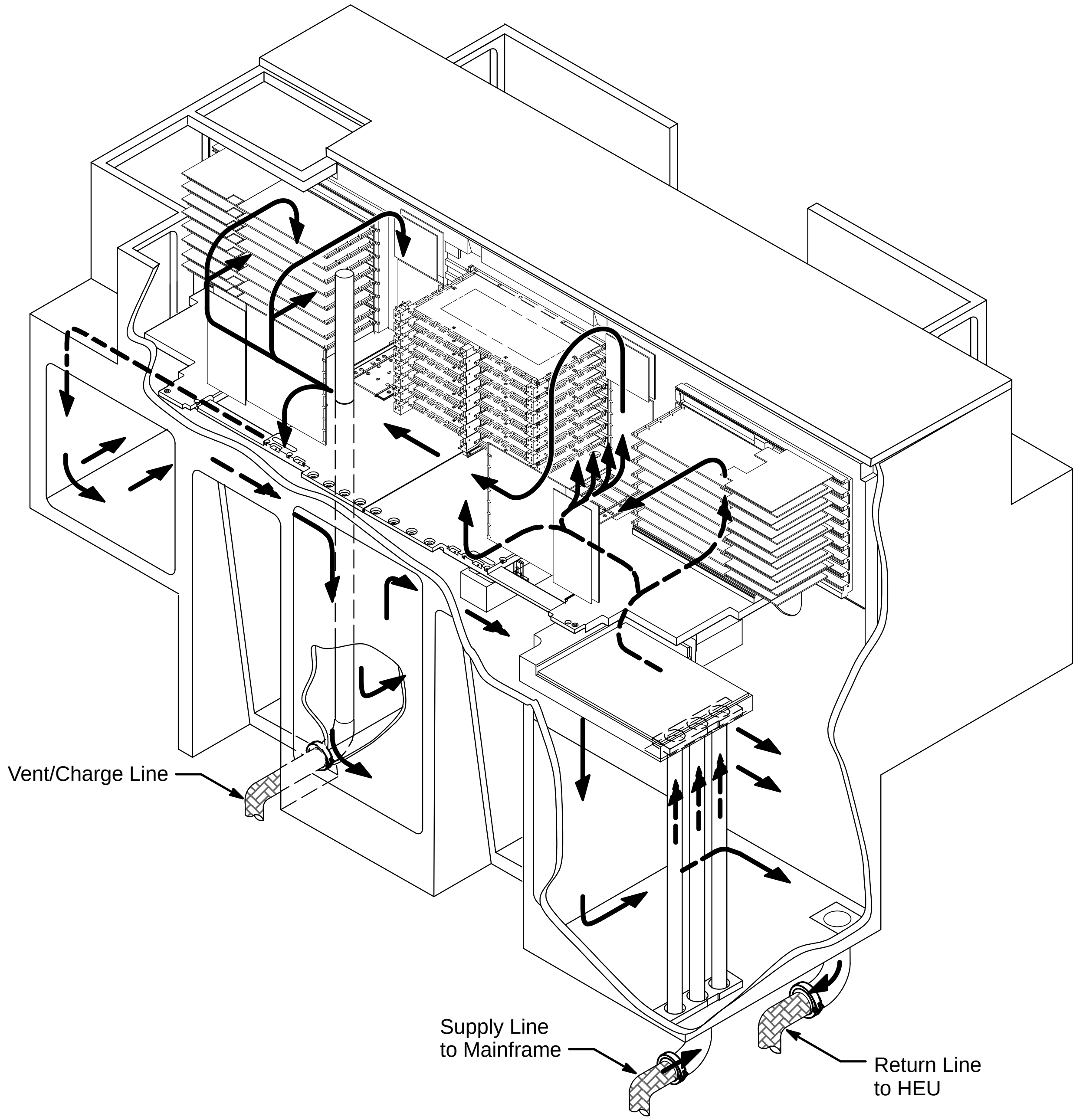


Figure 32. Dielectric-coolant Normal Flow Path

Drain Flow Path

When the mainframe is powered down, the dielectric coolant can be completely drained from the tank or just partially drained, depending on what type of maintenance needs to be performed. If a module needs to be replaced, the mainframe can be partially drained. If access to a power supply or component at a lower level is required, the entire tank must be drained.

During this drain process, the dielectric coolant drains from the mainframe through the return line, which attaches to the bottom of the mainframe at the 16-position power supply section. The pump in the HEU-T90 suctions the dielectric coolant from the mainframe tank, through the return line, and back to the HEU reservoir. Cutouts in the wall sections of the mainframe tank allow the dielectric-coolant level to remain at a relative equilibrium throughout the tank during the drain process.

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

Refer to Figure 33 for an illustration of the drain flow path.

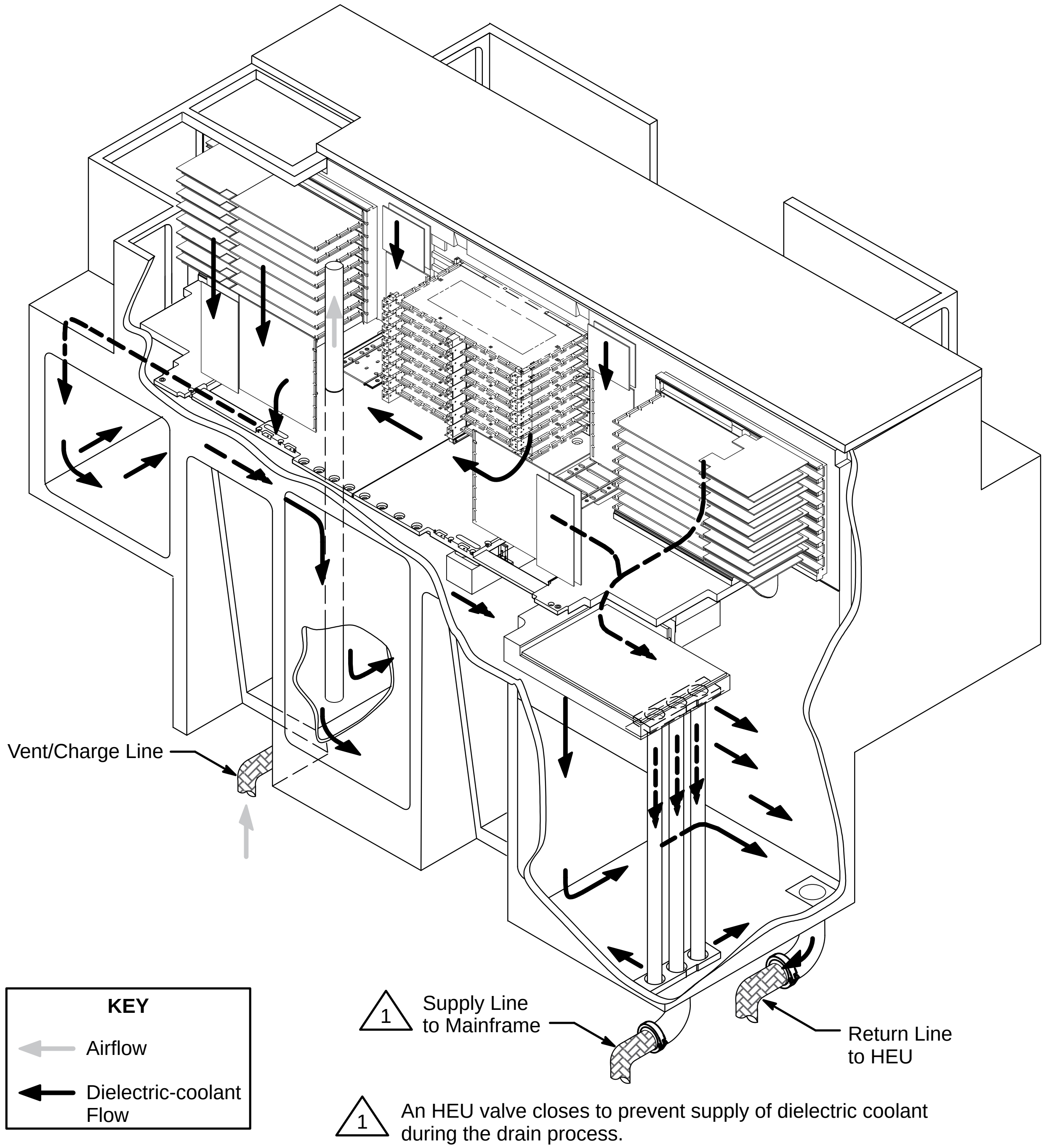


Figure 33. Dielectric-coolant Drain Flow Path

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Control System

The control system for the CRAY T916 mainframe monitors the power bus voltages, power supply current, and the dielectric-coolant level.

This subsection provides control-system information for the CRAY T916 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 34 for an illustration of the locations of the following mainframe control system components.

Programmable Logic Controllers (PLCs)

The two PLC racks (main and standby) are located on opposite sides of the CRAY T916 mainframe. These two controller assemblies are similar, but the main PLC in side A contains two components that the standby PLC in side B does not contain: the voltage-adjust board used for nominal-voltage adjustments and the analog output board used for power supply margining. A local area network (LAN) cable connects the two PLC racks and allows the two controllers to share monitored information. If one PLC fails, this sharing of information enables the other PLC to control the computer system until the failed PLC returns to operation.

Control System Bulkhead

Each controller (main and standby) contains a control system bulkhead that contains the 120-Vac input connection, the 120-Vac circuit breaker, and numerous control cable receptacles. The components in the control system bulkhead are described in detail later in this section.

Air Vents

Each of the two PLC rack enclosures contains five honeycomb air-vent panels. These ten panels allow pressurized underfloor air to enter the two controller compartments to cool the PLC components. These panels also serve as electronic filters, which prevent unacceptable electronic noises from exiting the controller enclosures.

Air Filters

A panel that is located below each of the two PLC rack enclosures contains a replaceable air filter. These two air filters prevent airborne contaminants from entering and exiting the two controller enclosures along with the pressurized underfloor air. These filters are installed during system installation and should be periodically replaced.

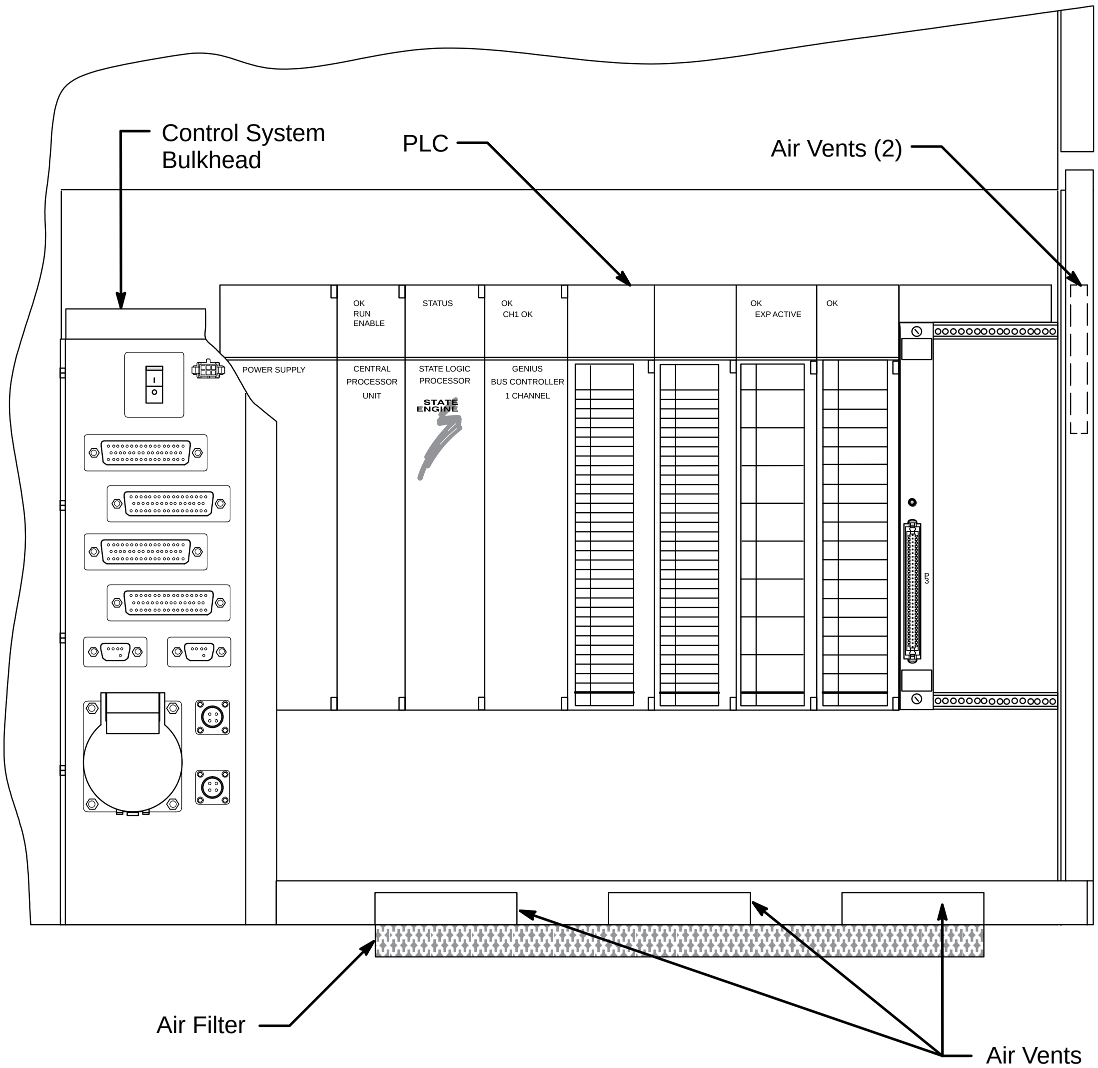


Figure 34. Main PLC Component Locations

Voltage-adjust Board

The voltage-adjust board attaches to the front of the main PLC and contains numerous electromechanical components including 20 potentiometers and 4 switches. The 20 potentiometers provide a means to manually adjust the power-supply output to each LVDC bus. The 4 switches provide a means to manually control the stop, start, circulate, and drain processes in the mainframe.

Figure 35 illustrates the main PLC assembly with the voltage-adjust board. Figure 36 provides a detailed illustration of the main components in the voltage-adjust board.

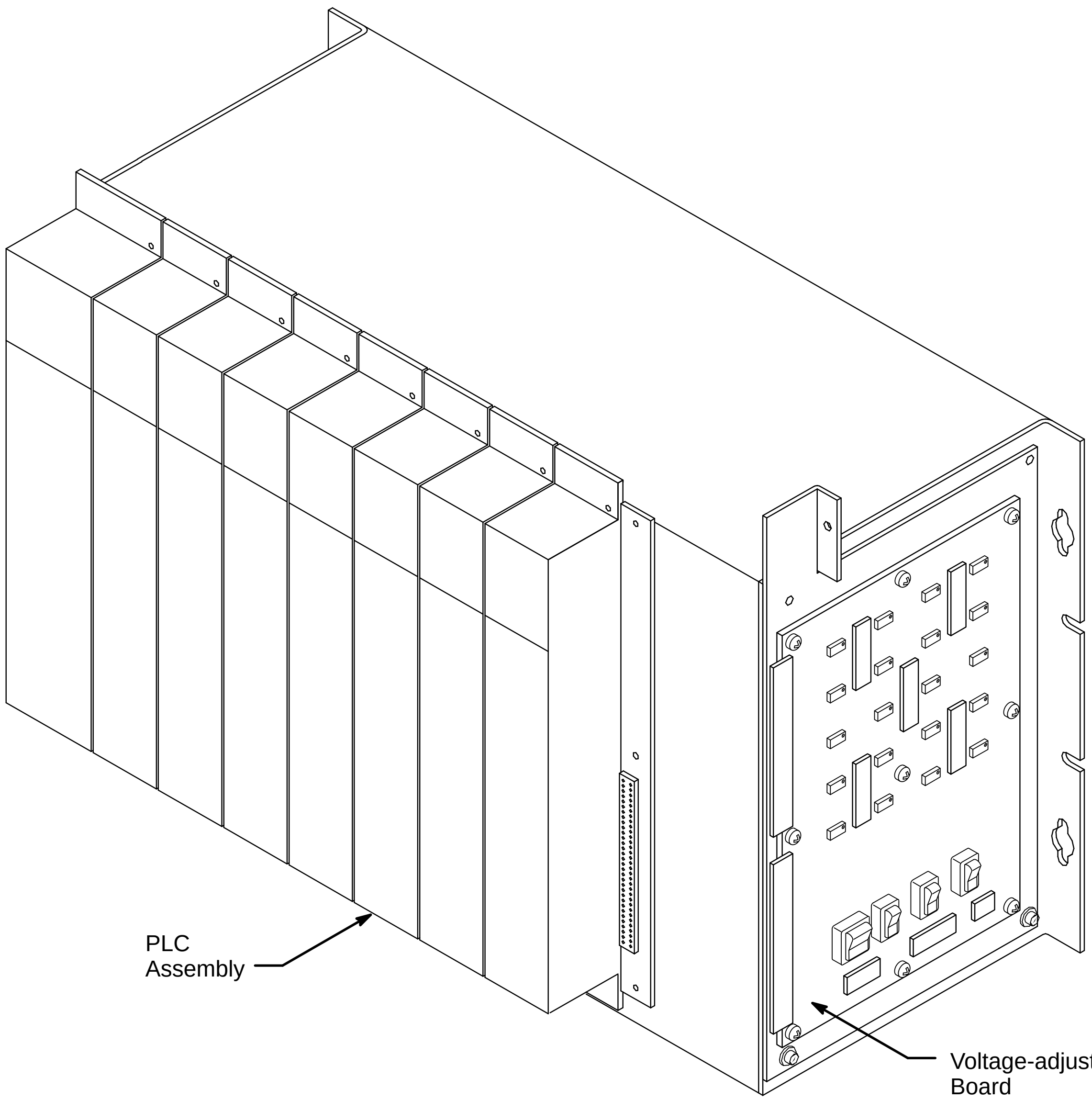
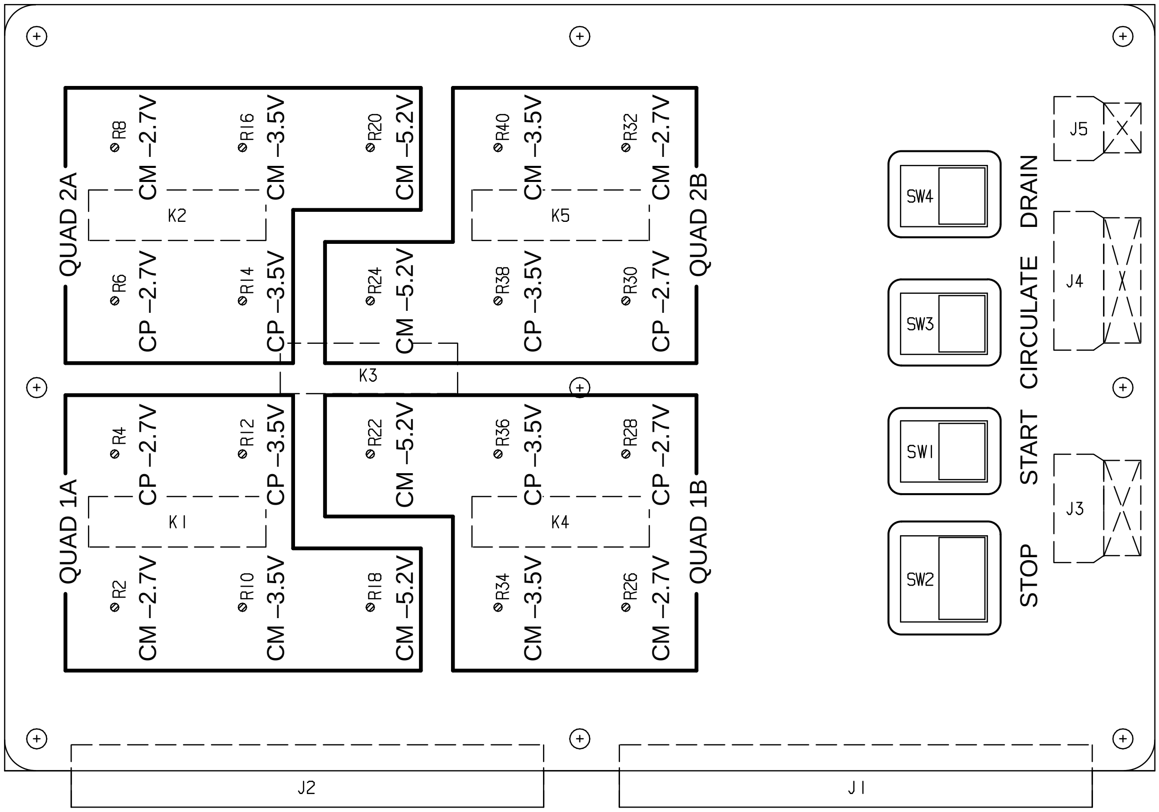


Figure 35. Main PLC Assembly with Voltage-adjust Board



NOTE: Use the Quad 1A and Quad 2A potentiometers (R2 through R20) in the voltage-adjust board to manually adjust the power-supply voltage output in the CRAY T916 mainframe. Side B of the CRAY T916 mainframe contains no power supplies, so the Quad 1B and Quad 2B potentiometers require no adjustment.

Device	Device Type	Function
R2 – R40 †	Potentiometer	Regulates nominal power-supply voltage output
K1 – K5	Relay	Relays margins from support system to power supplies
SW1	Switch	Manual start switch
SW2	Switch	Manual stop switch
SW3	Switch	Manual circulate switch
SW4	Switch	Manual drain switch
J1	64-pin Connector	Receives margin signals from analog output module
J2	64-pin Connector	Sends analog margin signals to the power supplies
J3	12-pin Connector	Margin enable output to power supplies
J4	16-pin Connector	Margin enable input from controller, power input from main controller, and switch signal output to controller
J5	6-pin Connector	12-Vdc input power from standby controller

† The 20 even-numbered devices from R2 to R40 represent potentiometers.

Figure 36. Voltage-adjust Board, Main Components

Control System Bulkhead Components

Each PLC assembly (main and standby) contains a control system bulkhead that contains several interconnection components. These components, which are described below, provide the power connections to the controllers and the cabling interconnections between the control system, the mainframe, and other computer system devices. Figure 37 illustrates the control system bulkhead components in the main PLC assembly. The standby PLC assembly contains the same components.

120-Vac Power Receptacle

The 120-Vac power receptacle (J9) in each control system bulkhead receives 120-Vac power from the 120-Vac input box through the corresponding drop cord and supplies power to the controller circuit breaker.

120-Vac Circuit Breaker

The 120-Vac circuit breaker (CB2) in each control system bulkhead receives power from the 120-Vac power receptacle and supplies power to the controller power supply.

Voltage-adjust Connection

Each control system bulkhead contains a voltage-adjust (VA) connection that attaches to VA cables. The VA connections and cables connect the standby 12-Vdc output module in side B to the voltage-adjust board in side A and provide a secondary power circuit (in addition to the main 12-Vdc output circuit) for the voltage-adjust board.

LAN Connections

Each control system bulkhead contains two 4-pin local area network (LAN) connections (J7 and J8). A cable connects the LAN connection (J8) in the bulkhead in the main PLC to the LAN connection (J8) in the standby PLC; the cable provides the data-exchange interface between the two controllers. Another cable connects the LAN connection (J7) in the bulkhead in the main PLC to the HEU; the corresponding LAN connection (J7) in the standby PLC is terminated.

Serial-port Connections

Each control system bulkhead contains two 9-pin serial-port connections that you can use to load or change the control system microcode. Serial cables connect one of the serial connections (J6) in each controller to serial-port connections in the support system. The other serial connection (J5) in either bulkhead can connect to a personal computer. During normal system operation, when you are not changing microcode, these two serial-port connections (J5) are not used.

Control Connections

Both control system bulkheads in the mainframe contain four (50-pin) control connections (J1 through J4) that provide the interconnections between the controllers and the control sensors inside the mainframe chassis. Cables connect the control connections in the bulkheads to the penetrator receptacles (120 through 123), which are located above the main control system bulkhead. For detailed information about the control system cable connections, refer to the *System Cabling* document, Cray Research publication number HMM-078-A.

NOTE: Side B in the CRAY T916 chassis contains no control system sensors and no penetrator receptacles.

Control Connection	Penetrator Receptacle
J1 Main	120 Side A
J2 Main	121 Side A
J3 Standby	122 Side A
J4 Standby	123 Side A

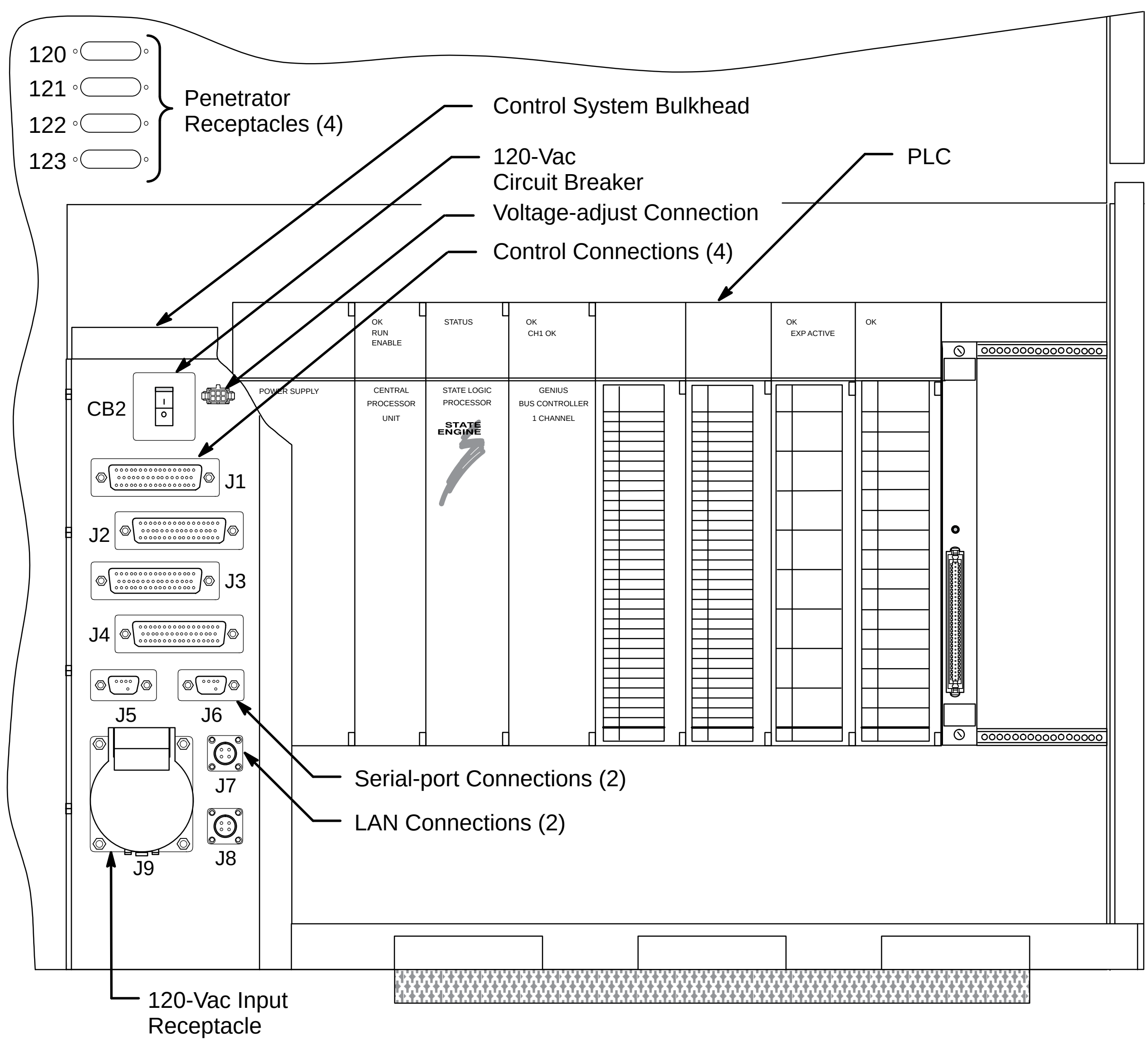


Figure 37. Control System Bulkhead Components, Main PLC Assembly

Level Sensors

Five level sensors monitor the level of dielectric coolant within the CRAY T916 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 (tank full condition) of dielectric coolant in the top area of the mainframe. Two additional level sensors (primary and backup) monitor the presence (power supply full condition) of dielectric coolant in the lower area of the mainframe. One more level sensor in the drain area monitors the presence (tank empty condition) of dielectric coolant at the mainframe-to-HEU return line during the drain process. Figure 38 illustrates the level sensor locations in the CRAY T916 mainframe.

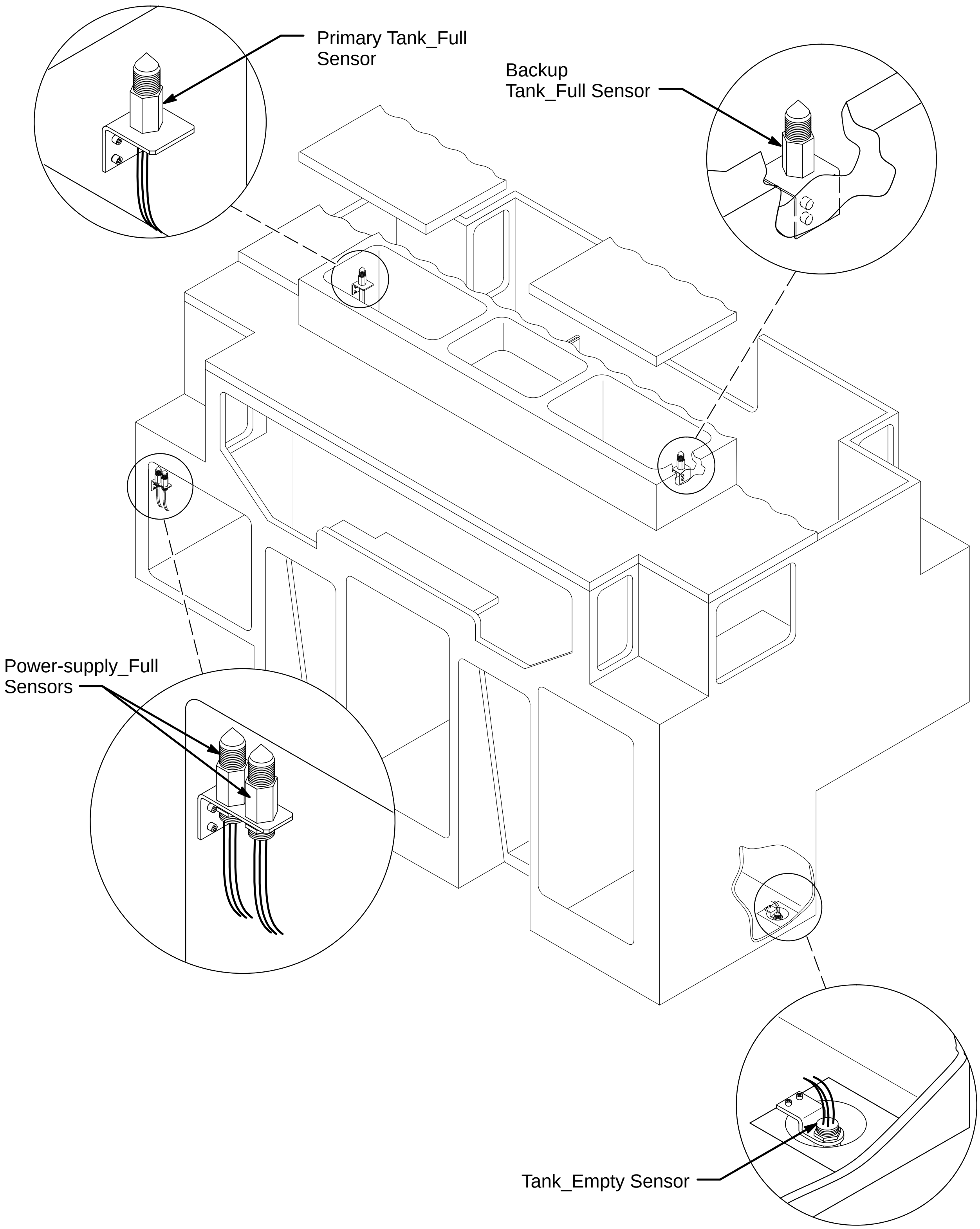


Figure 38. Level Sensor Locations

Voltage Sense Points

Voltage sense points enable the control system to monitor the voltage of each power bus and to signal appropriate adjustments to the power supplies for voltage output. Six voltage sense posts on each common memory (CM) bus and four sense posts on each central processor (CP) bus connect to wires that route information about the voltage levels of each bus to the control system. Figure 39 illustrates the 20 voltage sense-point locations in the CRAY T916 mainframe.

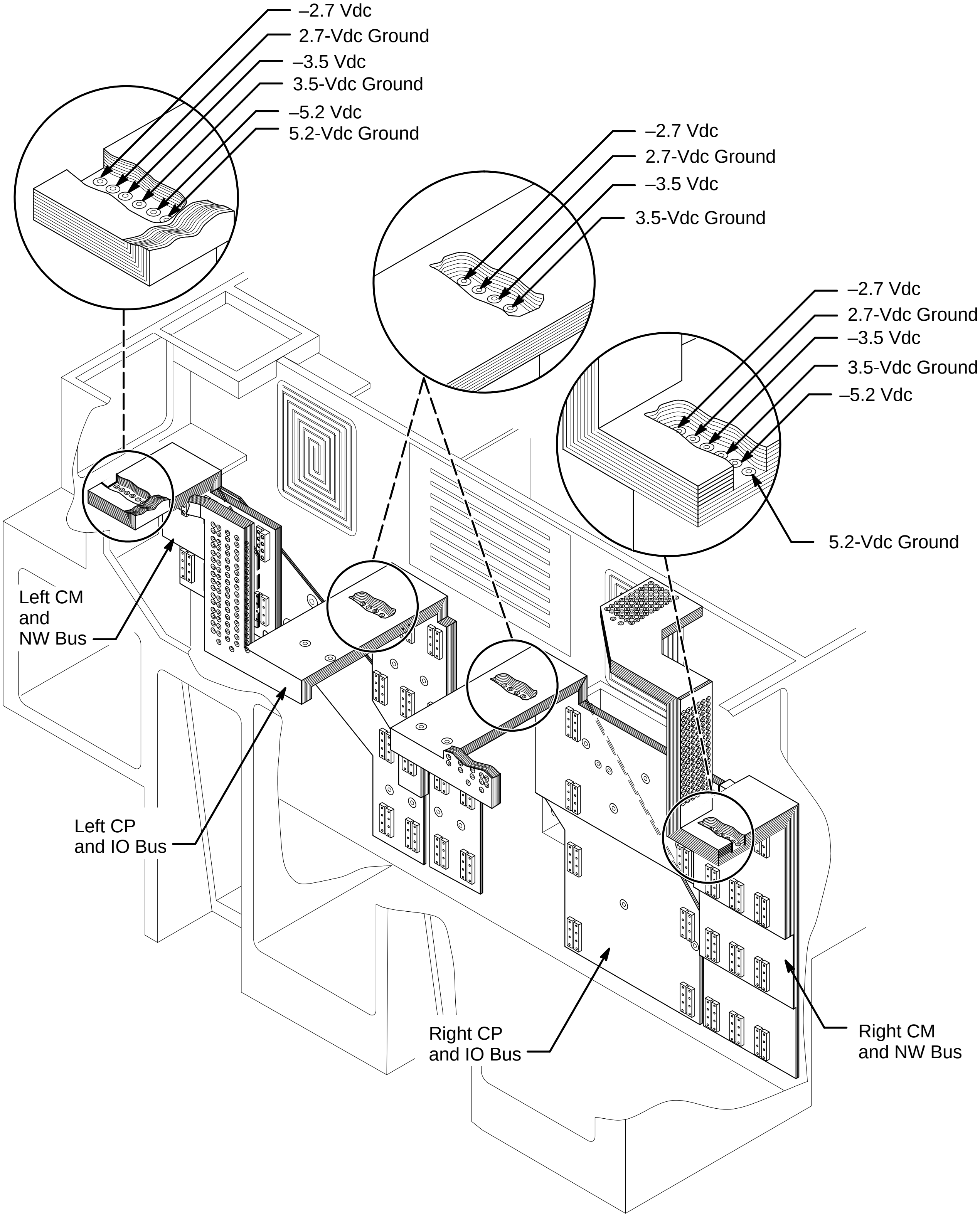


Figure 39. Voltage Sense Points

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 multiplexer (MUX) board and then to the voltage input module of the controller.

Control System MUX Board

The control system MUX board receives the sensor and monitor information and routes the information to the appropriate PLC component. Figure 40 illustrates the MUX board in the CRAY T916 mainframe. Refer also to the following subsection, “Monitored Conditions and Limits,” for a detailed description and illustration of the MUX board and its components.

Figure 40. Control System MUX 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 numbering scheme for the remote monitoring blocks. Each remote monitoring block has a number associated with it; Figure 41 provides the numbering scheme for the CRAY T916 control system.

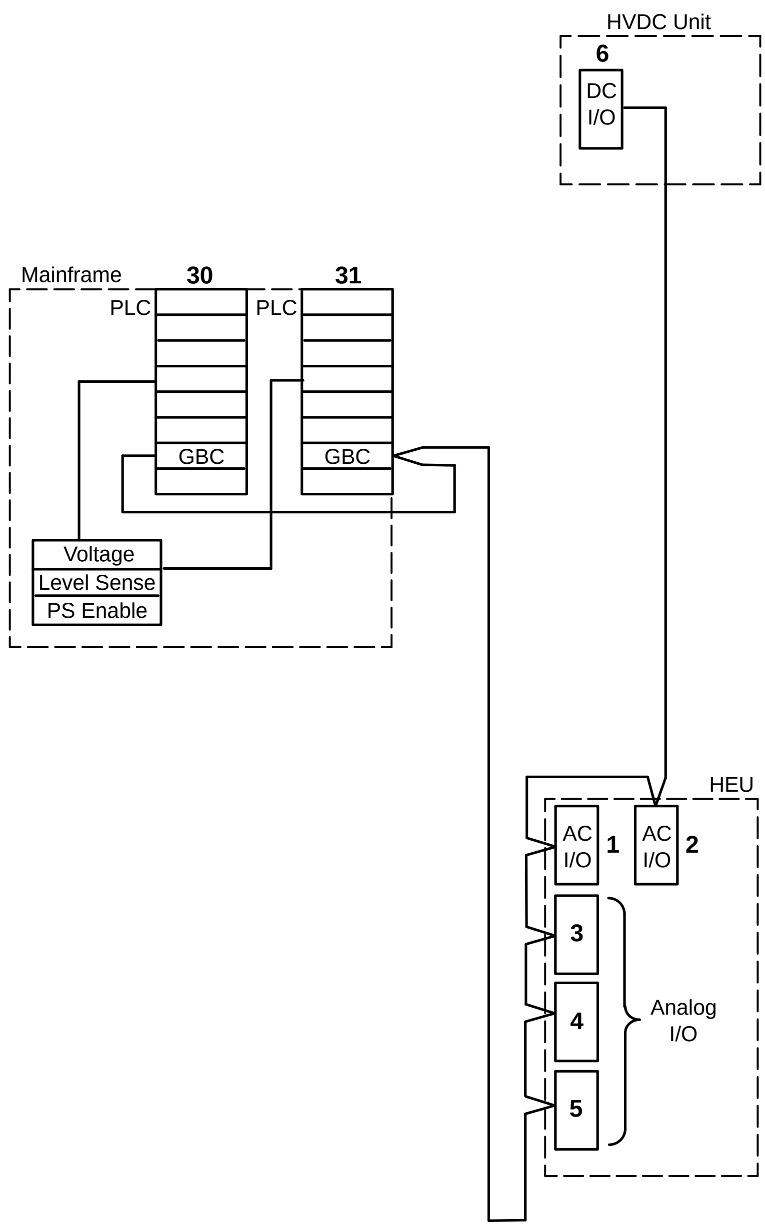


Figure 41. CRAY T916 Control System Configuration

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 analog input voltage expander, and the analog output board.

Table 12 lists the conditions that the control system monitors. Table 13 through Table 18 provide information about the PLC components.

Table 12. 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.
Connector check 1	ConnCheck1	J1 connector	Connector check of the J1 connector to verify correct cabling; system will not power up if this connector is not cabled correctly.
Connector check 2	ConnCheck2	J2 connector	Connector check of the J2 connector to verify correct cabling; system will not power up if this connector is 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	D1, D2, and D3	Power supply	All power supply good signals are multiplexed into the D1 – D3 connections.
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.

Table 12. Monitored Conditions (continued)

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	–2.7 V CM Q1 –3.5 V CM Q1 –5.2 V CM Q1 –2.7 V CP Q1 –3.5 V CP Q1 –2.0 V IO Q1 –2.7 V CM Q2 –3.5 V CM Q2 –5.2 V CM Q2 –2.7 V CP Q2 –3.5 V CP Q2 –2.0 V IO Q2	Module power bus	The control system measures the voltage along each module power bus in the mainframe.
HVDC check	HVDC 1 – 6	HVDC line 1 through line 6	The control system measures the voltage of all six HVDC lines.
Current measurement	imon 1 – 44 multiplexed to A1, A2, and A3	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 clock speed bits 0, 1, and 2.
Boundary scan continuity line (burn-line) 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 13. TTL Input Module

Label	Data Reference	Label Description	Description	LED Status	
				On	Off
A1	%I105	TankFullP	Mainframe tank is full	Wet	Dry
A2	%I106	Spare	Not used		
A3	%I107	TankFullB	Mainframe tank is full	Wet	Dry
A4	%I108	PS_FullP	Mainframe power supply section is full	Wet	Dry
A5	%I109	PS_FullB	Mainframe power supply section is full	Wet	Dry
A6	%I110	Tank Empty	Mainframe tank is completely empty	Wet	Dry
A7	%I111	ConnCheck1	Check J1	ok	Fault
A8	%I112	Spare2	Not used		
B1	%I113	D1	MUX output		
B2	%I114	D2	MUX output		
B3	%I115	D3	MUX output		
B4	%I116	Remote Control	Check other controller (controlling?)	Controlling	Not controlling
B5	%I117	Remote Run	Check other controller (running?)	Running	Not running
B6	%I118	ConnCheck2	Check J2	ok	Fault
B7	%I119		Not used		
B8	%I120		Not used		
C1	%I121		Not used		
C2	%I122		Not used		
C3	%I123		Not used		
C4	%I124		Not used		
C5	%I125		Not used		
C6	%I126		Not used		
C7	%I127		Not used		
C8	%I128		Not used		
D1	%I129		Not used		
D2	%I130		Not used		
D3	%I131		Not used		
D4	%I132		Not used		
D5	%I133		Not used		
D6	%I134		Not used		
D7	%I135		Not used		
D8	%I136		Not used		

Table 14. 12-Vdc Output Module

Label Reference	Data Reference	Label Description	Function	LED Status On	LED Status 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	#1 select	#2 select
A6	%Q110	ClockSel1	Refer to Table 15 for information about the clock speed selection.		
A7	%Q111	ClockSel2			
A8	%Q112	ConnTest1	Test J1	Testing	Not testing
B1	%Q113	S1	MUX select line 1	1	0
B2	%Q114	S2	MUX select line 2	1	0
B3	%Q115	S3	MUX select line 3	1	0
B4	%Q116	S4	MUX select line 4	1	0
B5	%Q117	PS_EN52	Power staging –5.2-V enable	Enabled	Disabled
B6	%Q118	PS_EN35	Power staging –3.5-V enable	Enabled	Disabled
B7	%Q119	PS_EN27	Power staging –2.7-V enable	Enabled	Disabled
B8	%Q120	Spare			
C1	%Q121	InControl	This controller in charge	Controlling	Not controlling
C2	%Q122	Running	This controller running	Running	Not running
C3	%Q123	ConnTest2	Test J2	Testing	Not testing
C4	%Q124	MargEn27	–2.7-V power supplies margin enabled	Enabled	Disabled
C5	%Q125	MargEn35	–3.5-V power supplies margin enabled	Enabled	Disabled
C6	%Q126	MargEn52	–5.2-V power supplies margin enabled	Enabled	Disabled
C7	%Q127	MargEnClk	Clock power supply margin enabled	Enabled	Disabled
C8	%Q128	MargEn20	–2.0-V power supplies margin enabled	Enabled	Disabled
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 15. Clock Select Options

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

Table 16. Analog Input Base Converter

Channel	Data Reference	Label Description	Function	Values	
				High	Low
1	%AI13	Continuity Circuit Primary	Boundary scan primary circuit faults	None	0.5 V
2	%AI14	Continuity Circuit Backup	Boundary scan backup circuit faults	None	0.5 V
3	%AI15	Analog MUX 1	Scan power supply currents		
4	%AI16	Analog MUX 2	Scan power supply currents		
5	%AI17	Analog MUX 3	Scan power supply currents		
6	%AI18	HVDC 1	Voltage on input line 1 from HVDC	350 V	280 V
7	%AI19	HVDC 2	Voltage on input line 2 from HVDC	350 V	280 V
8	%AI20	HVDC 3	Voltage on input line 3 from HVDC	350 V	280 V

Table 17. Analog Input Voltage Expander, Channel Address

Label Reference	Data Reference	Label Description	Function	Values	
				High	Low
Channel 1	%AI21	27CP1	–2.7 V to CP stack in first quad	+20 %	–20 %
Channel 2	%AI22	35CP1	–3.5 V to CP stack in first quad		
Channel 3	%AI23	20IO1	–2.0 V to IO module in first quad		
Channel 4	%AI24	27CM1	–2.7 V to CM stack in first quad		
Channel 5	%AI25	35CM1	–3.5 V to CM stack in first quad		
Channel 6	%AI26	52CM1	–5.2 V to CM stack in first quad		
Channel 7	%AI27	27CP2	–2.7 V to CP stack in second quad		
Channel 8	%AI28	35CP2	–3.5 V to CP stack in second quad		
Channel 9	%AI29	20IO2	–2.0 V to IO module in second quad		
Channel 10	%AI30	27CM2	–2.7 V to CM stack in second quad		
Channel 11	%AI31	35CM2	–3.5 V to CM stack in second quad		
Channel 12	%AI32	52CM2	–5.2 V to CM stack in second quad		
Channel 13	%AI33	Clock	Voltage from clock box		
Channel 14	%AI34	HVDC4	Voltage on input line 4 from HVDC	350 V	280 V
Channel 15	%AI35	HVDC5	Voltage on input line 5 from HVDC	350 V	280 V
Channel 16	%AI36	HVDC6	Voltage on input line 6 from HVDC	350 V	280 V

Table 18. 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

Control System MUX Board

The control system requires numerous connections in order to route the monitored information to the appropriate control system components. The control system multiplexer (MUX) board provides the main interface connections between the PLCs and the mainframe components.

The MUX board consists of a 6-layer printed circuit board and electronic interconnection components such as connectors, integrated circuits, diodes, and resistors. Refer to Figure 42 for an illustration of the MUX board and its components. Refer to Figure 43 for an illustration of the connector pin layouts. Table 19 provides information about the MUX board components to help explain the theory of operation of the control system; the MUX board is a field replaceable unit that does not require field repair.

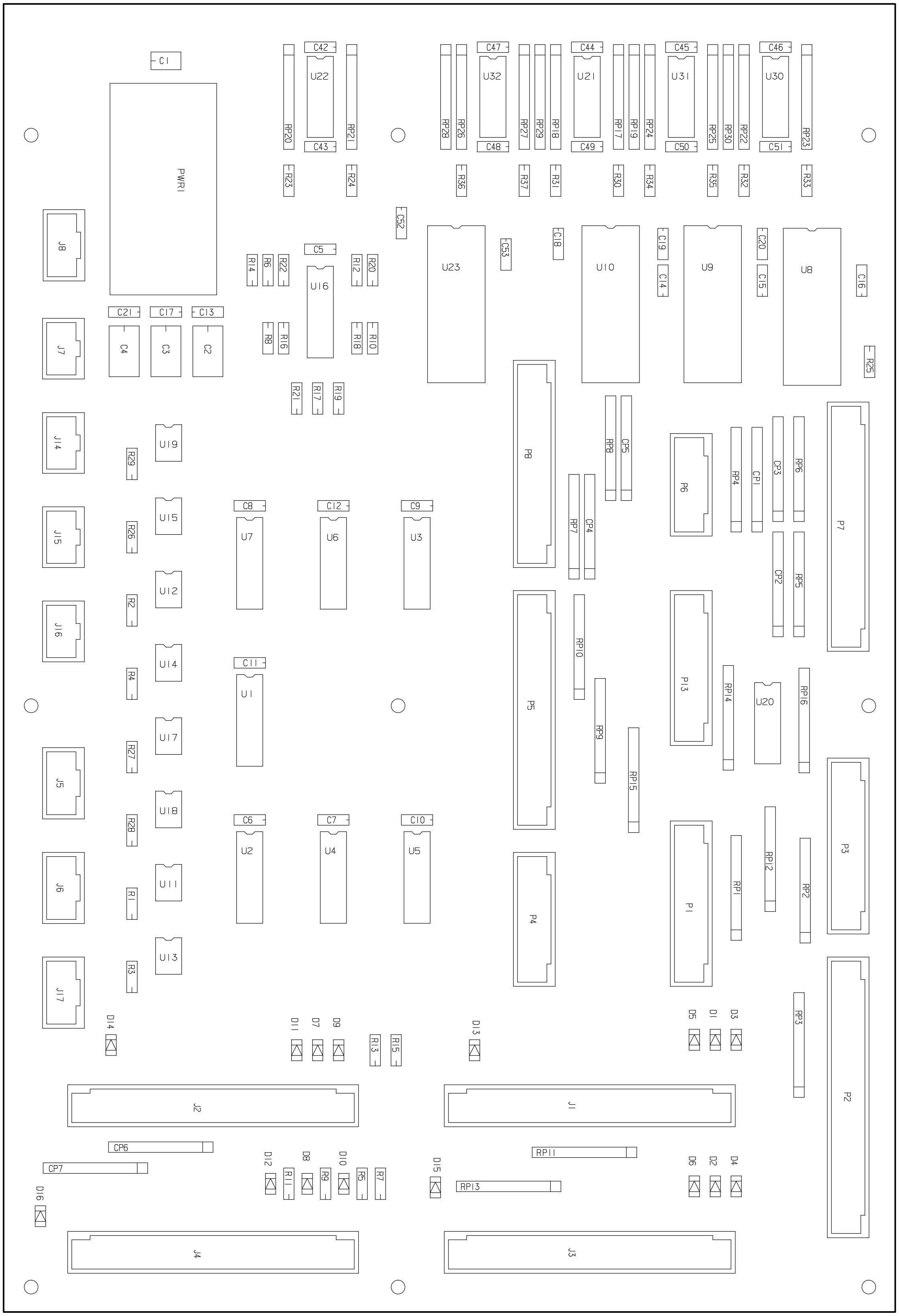
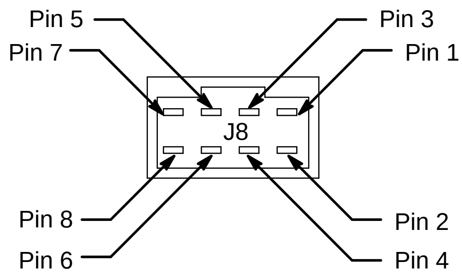
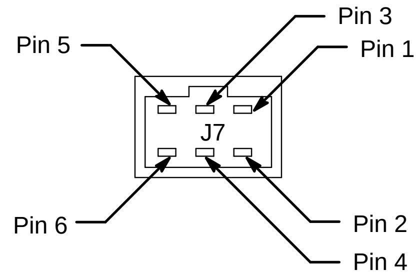


Figure 42. Control System MUX Board



Pin Pattern for J5, J6, J8, J17



Pin Pattern for J7, J14, J15, J16

Figure 43. Connector Pin Layout

Table 19. MUX Board Components

Device	Device Type	Function
PWR1	7-pin DC/DC converter	Converts 12 Vdc to +15 Vdc, –15 Vdc, and +5 Vdc
J1 – J2	50-pin connectors	Connections through bulkhead to main controller
J3 – J4	50-pin connectors	Connections through bulkhead to standby controller
J5	8-pin connector	Connection to IO module in the first quadrant
J6	8-pin connector	Connection to IO module in the second quadrant
J7	6-pin connector	Connection to BS module
J8	8–pin connector	Reserved for future enhancement
J14	6-pin connector	Connection to Tank Empty level sensor
J15	6-pin connector	Connection to Tank Full P level sensor
J16	6-pin connector	Connection to Tank Full B level sensor
J17	8-pin connector	Connection to Power Supply Full level sensor
P1	26-pin connector	Connection to 8-position power supply rack
P6	14-pin connector	Current monitor connection to 8-position rack
P13	24-pin connector	Connection to 8-position power supply rack
P2	48-pin connector	Connection to 20-position power supply rack
P3	28-pin connector	Connection to 20-position power supply rack
P7	42-pin connector	Current monitor connection to 20-position rack
P4	20-pin connector	Connection to 16-position power supply rack
P5	40-pin connector	Connection to 16-position power supply rack
P8	34-pin connector	Current monitor connection to 16-position rack
U1 – U7, U16	16-pin ICs	Digital MUX connections
U8 – U10, U23	28-pin multiplexers	Analog MUX connections
U11 – 15, U17 – U19	6-pin low-input couplers	Opto-coupler connections
U20 – 22, U30 – 32	14-pin ICs	Op amp (quad)
C1 – C21	Capacitors	Circuit current storage
C42 – C53	Capacitors	Circuit current storage
CP1 –CP7	Capacitors	Current filters
D1 – D16	Diodes	Current rectifiers
R1 – R37	Resistors	Line resistance
RP1 – RP10	Resistor packs	Circuit resistance
RP17 – RP30	Resistor packs	Circuit resistance

For more specific information about the MUX board, the bulkhead and PLC interconnections, and the control system operation, refer to the system schematic and the *Power, Cooling, and Control System Troubleshooting Guide*, Cray Research publication number HTM-179-0.

Control System Processes

The control system regulates certain power and cooling processes for the mainframe and peripheral devices. This subsection provides only an overview of the control system processes and a brief description of the warning and control system (WACS) commands used to monitor and control these processes. Additional information about control system processes and WACS commands is available in a separate control system troubleshooting document.

Power-up Process

The power-up process is a complex process because of the many system conditions that must be checked prior to the complete mainframe power-up. The power-up process includes the following tasks:

- Start T16 command sent
- Mainframe filled
- Dielectric coolant circulated
- HVDC enabled
- Power buses checked for shorts
- Power supplies enabled and voltage applied to power buses
- Continuity circuit checked

Refer to Figure 44 for a flowchart of the power-up process.

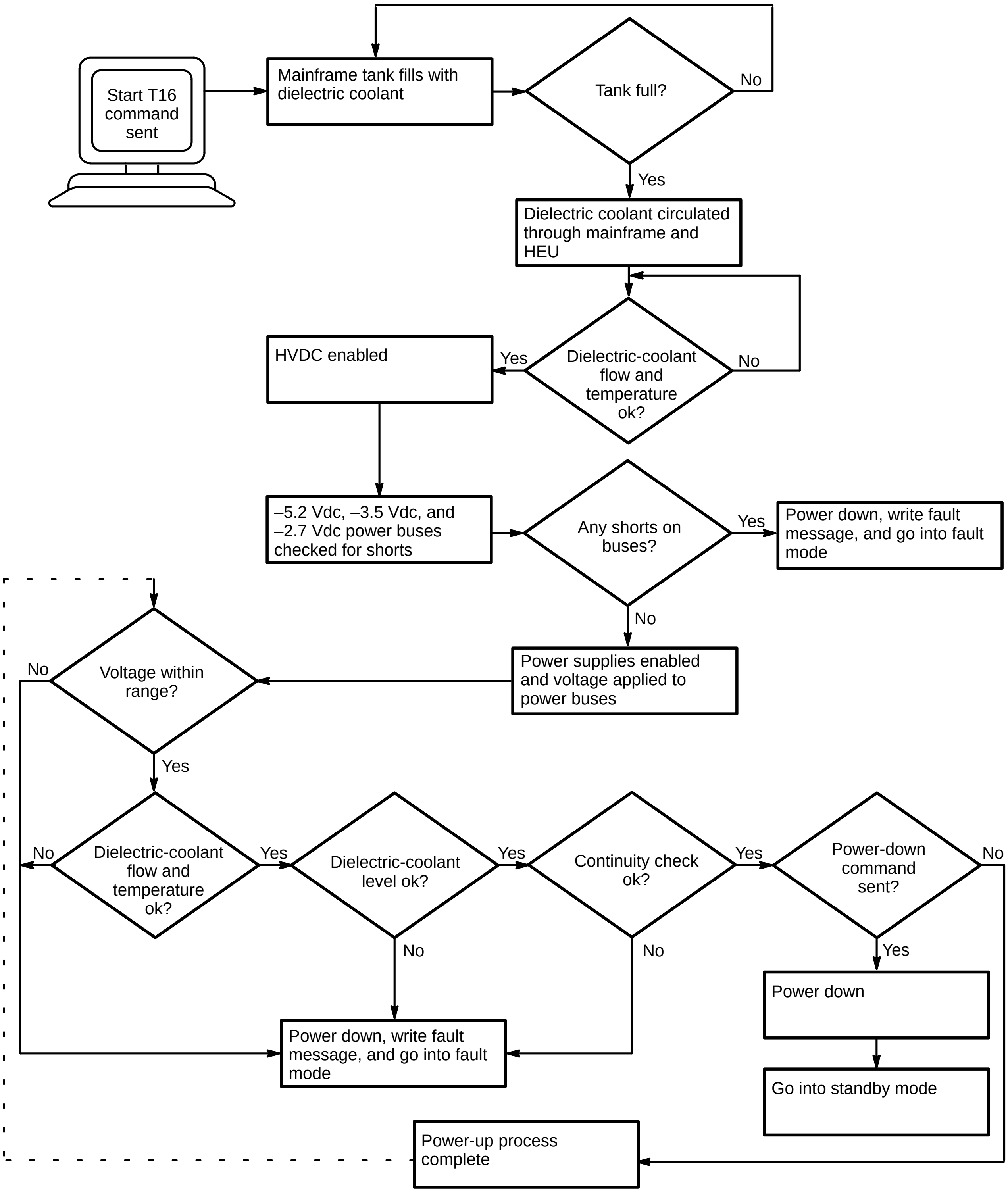


Figure 44. Power-up Sequence of Events

Power-down Process

The power-down process also involves a sequence of events that protects the computer system from internal damage and prevents loss of data. The power-down process includes the following tasks:

- Stop T16 command sent or fault condition detected by controller
- LVDC module buses disabled
- 330-Vdc power disabled to power input terminals (HVDC disabled)
- Pump stopped

Refer to Figure 45 for a flowchart of the power-down process.

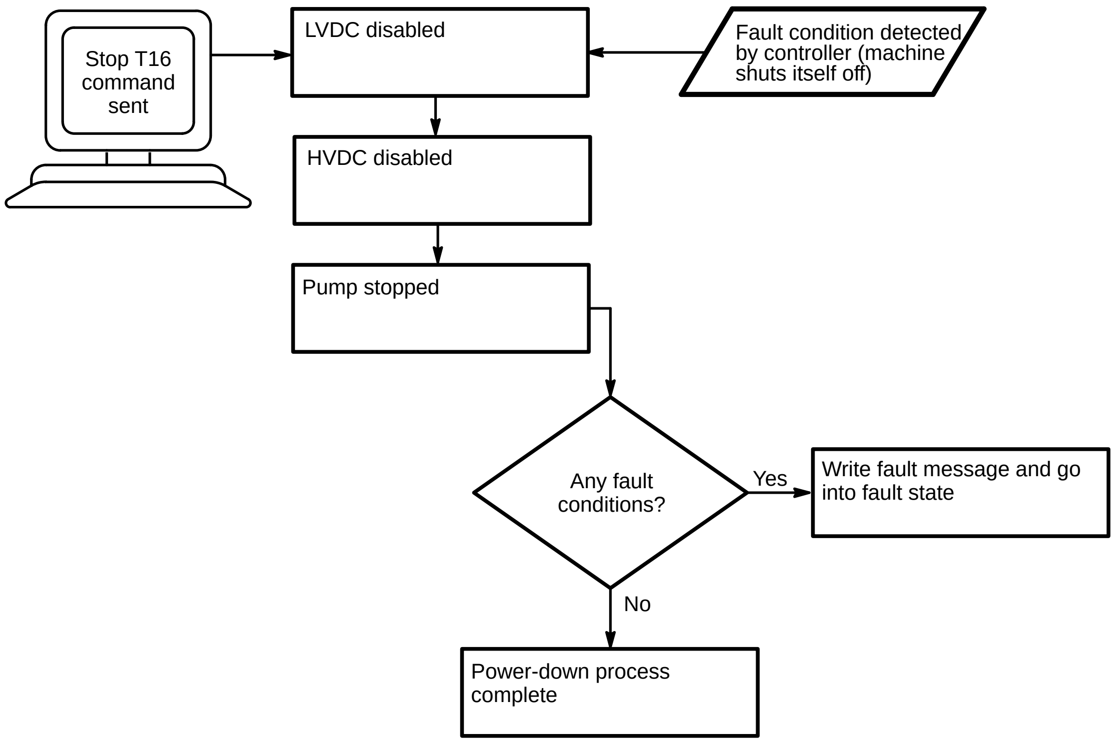


Figure 45. Power-down Sequence of Events

Mainframe Drain Process

The mainframe drain process can operate according to two unique subprocesses; depending on the task, the mainframe can be completely drained or partially drained. If the mainframe is being powered down because of a customer request or a computer system interrupt, the mainframe does not have to be drained. However, if the mainframe requires maintenance, the type of maintenance required determines how the mainframe is drained. If a module needs replacement, the mainframe may be partially drained. If a power supply needs replacement, the mainframe must be completely drained. The mainframe drain process includes the following tasks:

- Drain command sent
- HVDC disabled
- LVDC disabled
- HEU valves set
- Dielectric coolant suctioned into reservoir by HEU pump until the desired tank coolant level is reached

Figure 46 provides a flowchart of the drain process.

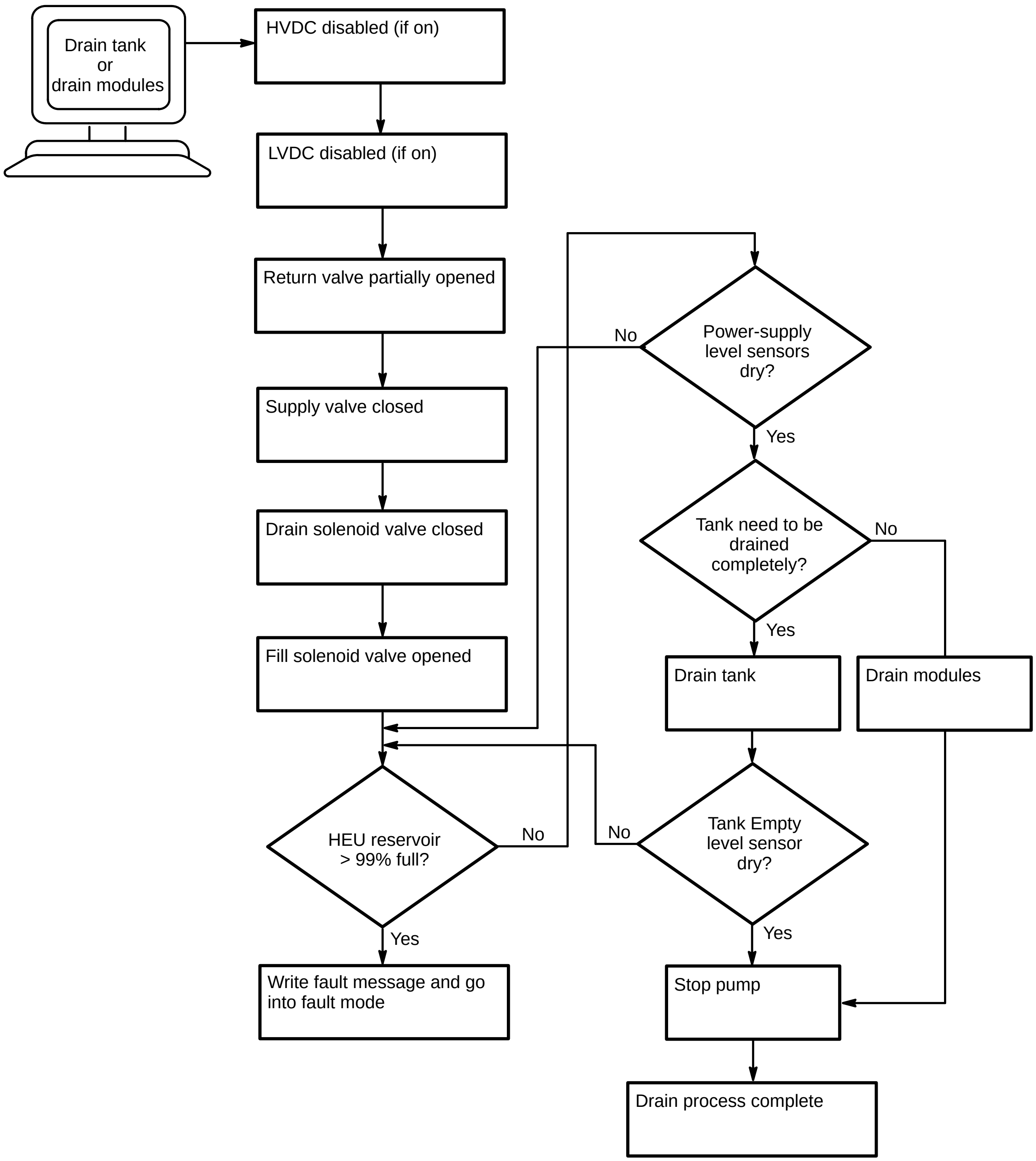


Figure 46. Mainframe Drain Sequence of Events

Mainframe Fill Process

The mainframe fill process appears to be relatively simple. The pump circulates dielectric coolant from the HEU reservoir into the mainframe tank until the level sensors indicate that the tank is full. Even though this process seems simple, it includes the following five basic steps:

- Fill command sent
- HEU valves set
- Pump enabled
- Mainframe filled with coolant until the tank full primary or backup sensor is wet
- Pump stopped

Figure 47 provides a flowchart of the fill process.

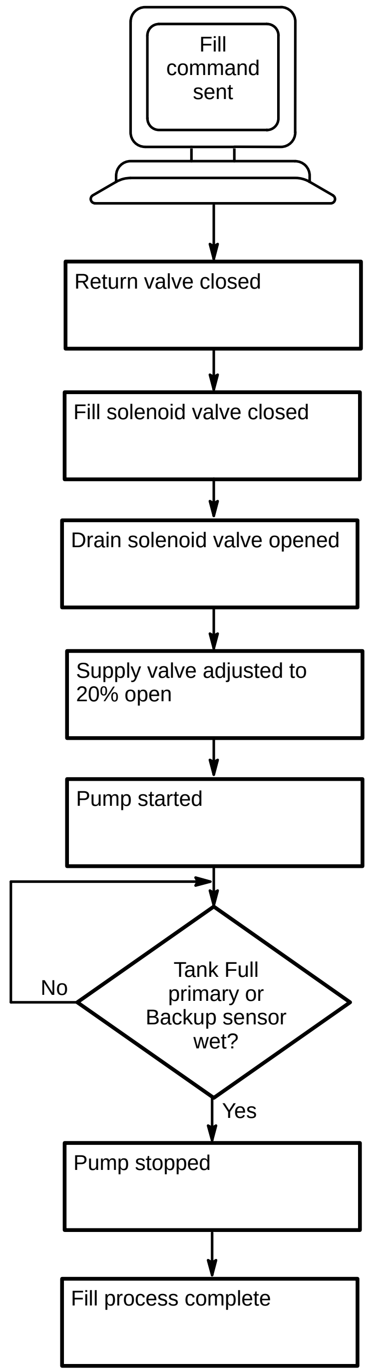


Figure 47. Mainframe Fill Sequence of Events

WACS Commands and Sequence of Events

The computer control system uses commands sent by the WACS program to control the sequences of events in the power and cooling processes. All WACS commands have redundant tasks embedded within them that the control system performs as part of the command selection. The operator can monitor, activate, or change the task sequences of the control processes by selecting a combination of buttons or switches from the WACS menu. The following list describes some of the WACS menu selections:

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

Figure 48 on page 90 illustrates the WACS switches menu for the CRAY T916 mainframe.

WACS Fault Limits

The computer control system monitors the bus voltages, the coolant flow rate, the tank pressure, and other conditions in the CRAY T916 system. The WACS program receives information about the monitored conditions in the system and displays the information on the workstation WACS screen. The computer system operates normally within predefined (normal) limits. When a monitored condition exceeds the normal limit, the WACS 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 20 on page 91 provides the fault limits for the CRAY T916 system during normal operation.

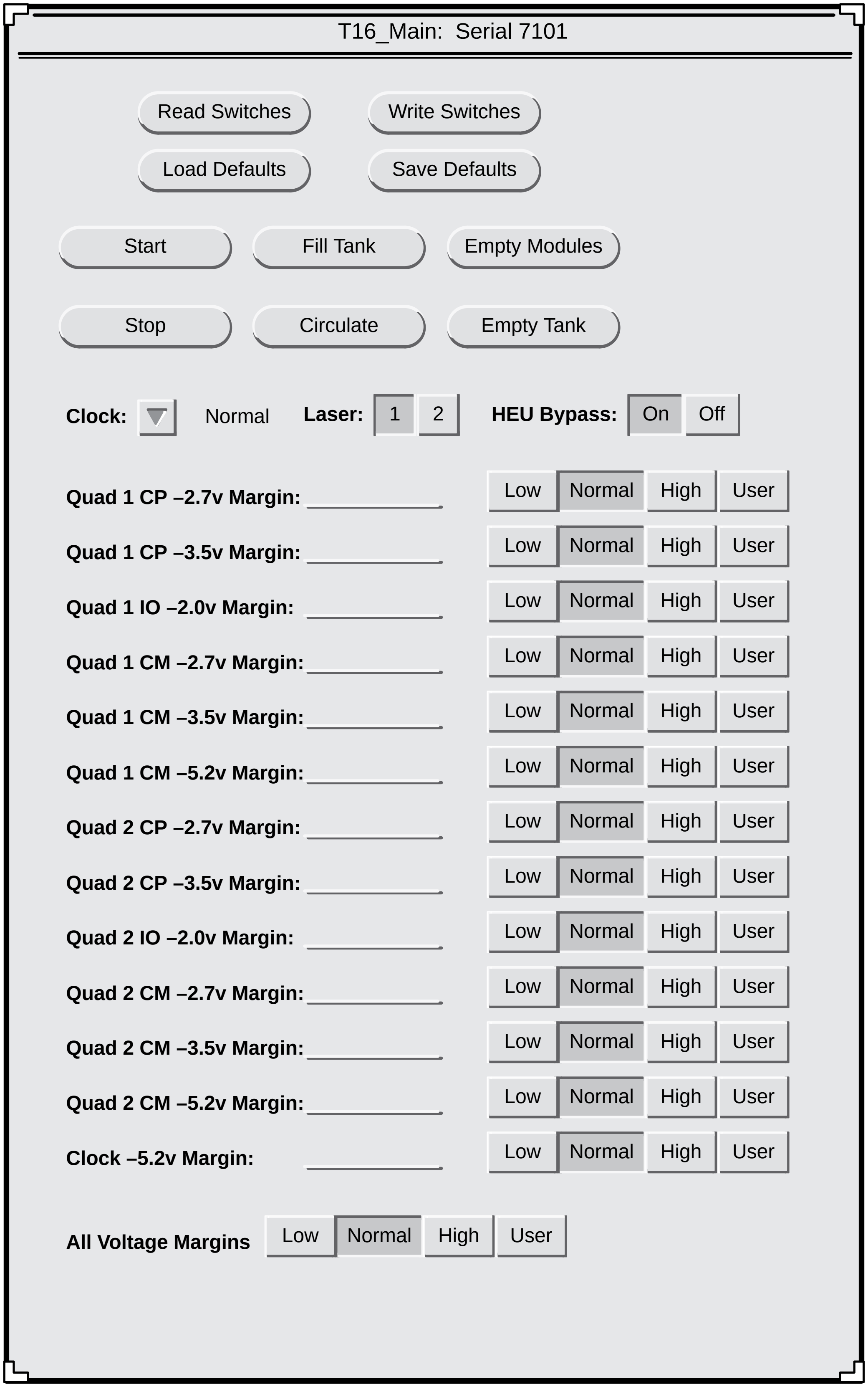


Figure 48. WACS Switches Menu

NOTE: Some of the WACS fault limits change during specific system operations. The values listed in Table 20 represent the fault limits of the CRAY T916 computer system during normal operating conditions.

Table 20. Fault Limits, CRAY T916 System

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
Fluorinert flow rate	174 gpm	188 gpm	Shut-down/60-second delay
Fluorinert supply temperature	22 °C	14 °C	Shut-down/60-second delay
Fluorinert return temperature	No limit	No limit	No message
Tank pressure (low)	20 psi	–	Shut-down/1-second delay
Tank pressure (high)	–	P= (FR ÷ 11.25) + 25 †	Shut-down/25@flow = 0 Shut-down/41@flow = 180 ‡
–2.7-Vdc Bus amps	No limit	200-A change	Shut-down/100-A message
–3.5-Vdc Bus amps	No limit	200-A change	Shut-down/100-A message
–5.2-Vdc Bus amps	No limit	600-A change	Shut-down/350-A message
HVDC voltage	300 Vdc	350 Vdc	Message only
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; P represents the tank pressure and FR represents the Fluorinert flow rate.
‡ The minimum high-pressure fault value is 25 psi (FR = 0), and the maximum high-pressure fault value is 41 psi (FR ≥ 180).

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