AMETEK®
PROGRAMMABLE POWER

ELGAR

ReFlex Power™

Operation Manual

M380056-01 Rev L www.programmablepower.com

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AMETEK Programmable Power, Inc., a Division of AMETEK, Inc., is a global leader in the design and manufacture of precision, programmable power supplies for R&D, test and measurement, process control, power bus simulation and power conditioning applications across diverse industrial segments. From bench top supplies to rack-mounted industrial power subsystems, AMETEK Programmable Power is the proud manufacturer of Elgar, Sorensen, California Instruments and Power Ten brand power supplies.

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Date and Revision

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Part Number

M380056-01

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Important Safety Instructions

Before applying power to the system, verify that your product is configured properly for your particular application.

WARNING	**Hazardous voltages may be present when covers are removed. Qualified personnel must use extreme caution when servicing this equipment. Circuit boards, test points, and output voltages also may be floating above (below) chassis ground.**
WARNING	**The equipment used contains ESD sensitive parts. When installing equipment, follow ESD Safety Procedures. Electrostatic discharges might cause damage to the equipment.**

Only *qualified personnel* who deal with attendant hazards in power supplies, are allowed to perform installation and servicing.

Ensure that the AC power line ground is connected properly to the Power Rack input connector or chassis. Similarly, other power ground lines including those to application and maintenance equipment *must* be grounded properly for both personnel and equipment safety.

Always ensure that facility AC input power is de-energized prior to connecting or disconnecting any cable.

In normal operation, the operator does not have access to hazardous voltages within the chassis. However, depending on the user's application configuration, **HIGH VOLTAGES HAZARDOUS TO HUMAN SAFETY** may be normally generated on the output terminals. The customer/user must ensure that the output power lines are labeled properly as to the safety hazards and that any inadvertent contact with hazardous voltages is eliminated.

Guard against risks of electrical shock during open cover checks by not touching any portion of the electrical circuits. Even when power is off, capacitors may retain an electrical charge. Use safety glasses during open cover checks to avoid personal injury by any sudden component failure.

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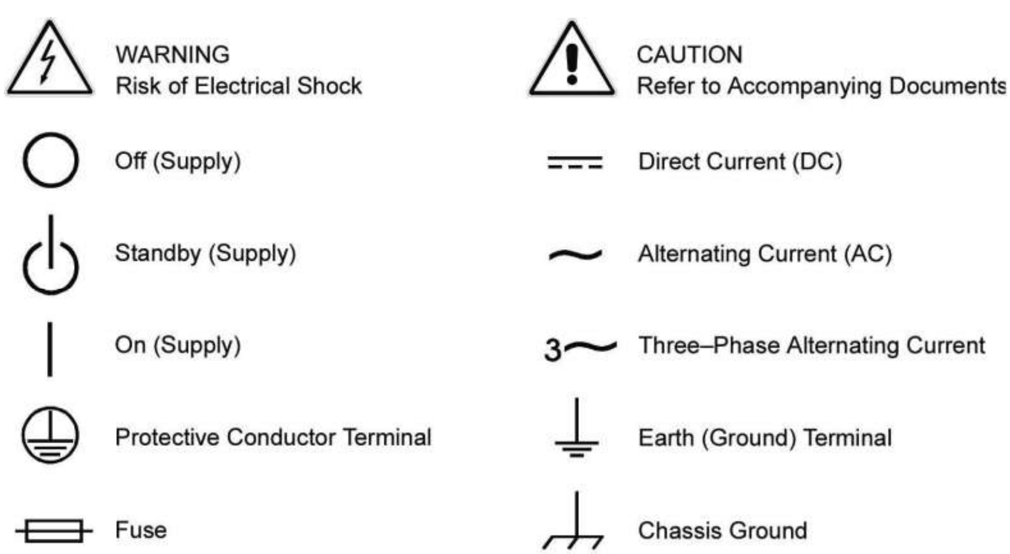
SAFETY SYMBOLS



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Product Family: ReFlex Power™

Warranty Period: One Year

WARRANTY TERMS

AMETEK Programmable Power, Inc. ("AMETEK"), provides this written warranty covering the Product stated above, and if the Buyer discovers and notifies AMETEK in writing of any defect in material or workmanship within the applicable warranty period stated above, then AMETEK may, at its option: repair or replace the Product; or issue a credit note for the defective Product; or provide the Buyer with replacement parts for the Product.

The Buyer will, at its expense, return the defective Product or parts thereof to AMETEK in accordance with the return procedure specified below. AMETEK will, at its expense, deliver the repaired or replaced Product or parts to the Buyer. Any warranty of AMETEK will not apply if the Buyer is in default under the Purchase Order Agreement or where the Product or any part thereof:

- is damaged by misuse, accident, negligence or failure to maintain the same as specified or required by AMETEK;
- is damaged by modifications, alterations or attachments thereto which are not authorized by AMETEK;
- is installed or operated contrary to the instructions of AMETEK;
- is opened, modified or disassembled in any way without AMETEK's consent; or
- is used in combination with items, articles or materials not authorized by AMETEK.

The Buyer may not assert any claim that the Products are not in conformity with any warranty until the Buyer has made all payments to AMETEK provided for in the Purchase Order Agreement.

PRODUCT RETURN PROCEDURE

1. Request a Return Material Authorization (RMA) number from the repair facility (**must be done in the country in which it was purchased**):
   - **In the USA**, contact the AMETEK Repair Department prior to the return of the product to AMETEK for repair:

     Telephone: 800-733-5427, ext. 2295 or ext. 2463 (toll free North America)
     858-450-0085, ext. 2295 or ext. 2463 (direct)
   - **Outside the United States**, contact the nearest Authorized Service Center (ASC). A full listing can be found either through your local distributor or our website, www.programmablepower.com, by clicking Support and going to the Service Centers tab.
2. When requesting an RMA, have the following information ready:
   - Model number
   - Serial number
   - Description of the problem

NOTE: Unauthorized returns will not be accepted and will be returned at the shipper's expense.

NOTE: A returned product found upon inspection by AMETEK, to be in specification is subject to an evaluation fee and applicable freight charges.

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SECTION 1
SYSTEM OVERVIEW

1.1 INTRODUCTION TO REFLEX POWER™

The ReFlex Power™ system is a high-density modular power system that provides a full complement of power and load assets under the control of a single controller, accommodating flexible, scaleable, and extensible customer-defined application configurations. Comprised of a Mainframe, a Controller module, and one or more plug-in power modules (DC modules, AC modules, and active loads with various power levels), the ReFlex Power™ system can be configured for control of discrete, standalone supplies and loads, or it can be extended to as many as eight Mainframes and ninety-five power modules, all controlled through one Controller module.

This programmable system utilizes digital control loops (patent pending) that allow tailoring of performance to match application requirements and maintaining compatibility with legacy characteristics. In addition to the high power densities available in the modular, programmable power supplies, the ReFlex Power™ system provides series, parallel, or multi-phase operation, high-speed up/down programming capability, and extensive communications interface with LXI™-compliant Ethernet interface, IVI drivers, and embedded WEB server.

The ReFlex Power™ system's highly integrated architecture reduces cost of ownership and logistics with its minimal space requirements and low maintenance, a common software interface, and its ability to create "virtual assets" with various voltage/current combinations via a single controller.

1.1.1 OVERVIEW DESCRIPTION- SYSTEM LEVEL

The ReFlex Power™ system is comprised of a Mainframe, a Controller module, and one or more plug-in power modules. Its architecture is based on intelligent power modules under control of and in communication with a Controller module, all integrated through a backplane-based power and signal distribution network. Optimized for automated applications, the ReFlex Power™ system is operated through a computer interface, and, therefore, does not utilize manual controls.

Extensive utilization is made of digital technology with FPGA-implemented digital feedback loops, supervisories, and state controls. Each power module has a native digital controller that communicates with the system Controller module and/or with other power modules. A high degree of user configurability is provided to allow adaptation of functionality to the requirements of a particular application.

The power modules use high-frequency power conversion for implementation of the power processing stages to minimize size, weight, and maximize power density. Their performance has also been optimized in areas of accuracy, output slew rates, and ripple/noise. Power factor correction (PFC) is provided to minimize input current harmonics and the resultant apparent power that is drawn from the input power source.

Ethernet communications, with future extensions of USB, GPIB, CAN-bus, serve to accommodate popular instrumentation control interface buses. All setup, programming, measurement, and calibration functions can be accomplished through the control interface. An embedded Web server allows interactive remote control over the Internet.

The ReFlex Power™ system is housed in a rack-mount compatible enclosure, with modules plugging in the front of the Mainframe. The modular design facilitates accessibility to the modules and maintainability of the system. All internal power/control connections are made through a backplane interface, requiring no internal hardwiring of the modules. All user output and control terminations are at the front of the modules, while the input power connection is at the rear of the Mainframe. Pin/Socket connectors are provided for fast installation and quick connection to application cabling.

1.2 FEATURES

This section provides a general description of the ReFlex Power™ system's features. For details, refer to the applicable section for a specific asset.

1.2.1 GENERAL FEATURES/OPTIONS LIST OVERVIEW

- Scaleable and reconfigurable
- High power density
- Small size; light weight
- Digital control loops
- Mainframe-based extensible system
- Universal assets: AC sources, DC sources, Active Loads
- Flexible asset location in Mainframe
- Single controller per system
- Master/Slave paralleling
- Combined series/parallel configuration capability
- AC assets configurable for standalone, parallel and multi-phase operation
- Active Load assets configurable for standalone or parallel operation
- DC assets configurable for standalone, parallel, series, or parallels in a series operation
- LXI™ conformant, IVI drivers, Web server
- 16-bit programming and measurement
- Power Factor Corrected (PFC)
- Universal inputs: AC (50/60 Hz, 400 Hz), DC, single-phase, three-phase
- Ruggedized to MIL-PRF 28800F
- Software calibration

1.2.2 CONTROLS, CONNECTORS AND INDICATORS- OVERVIEW

Since the ReFlex Power™ system operates within automated test systems, it has no user manual controls other than the power-on switch of the Controller module. At power-on, the ReFlex Power™ system automatically configures itself for operation as preset by the user, and, through the remote interface to the host controller, is ready to accept application commands. All connections to the user application, except for the input power, are accessible on the front panel of the modules. The front panels also provide indicators for annunciation of the module operational states, such as, the conditions of the input power, output power, fault status, and network/bus communications.

Figure 1-1 shows a front view of the Mainframe with a module being inserted. Figure 1-2 shows an inside view of the rear-mounted backplane of the Mainframe with its interface connectors. The Mainframe chassis provides twelve slots for interface with the backplane; modules slide on integral guides and are secured with front-panel captive thumbscrews. Figure 1-3 shows the exterior rear panel of the Mainframe with the input/output connectors.

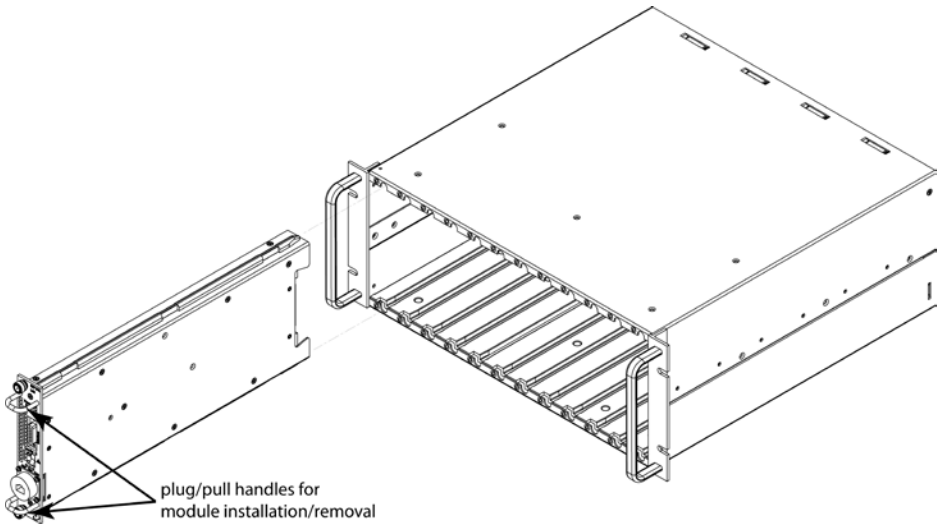


Figure 1-1. Front View Mainframe with Module Installation

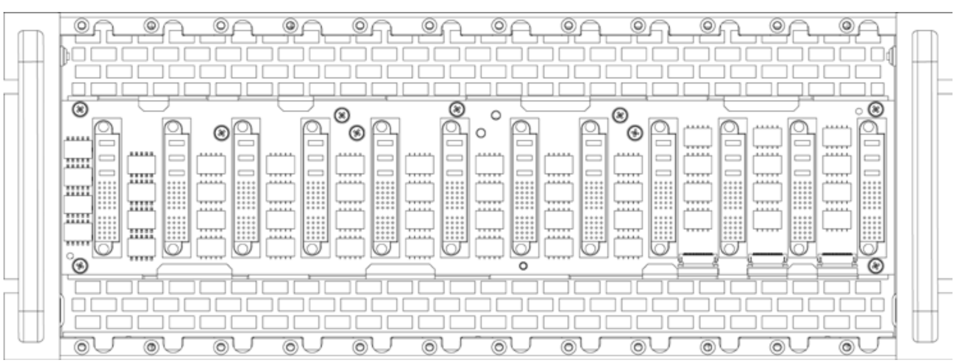


Figure 1-2. Mainframe Backplane

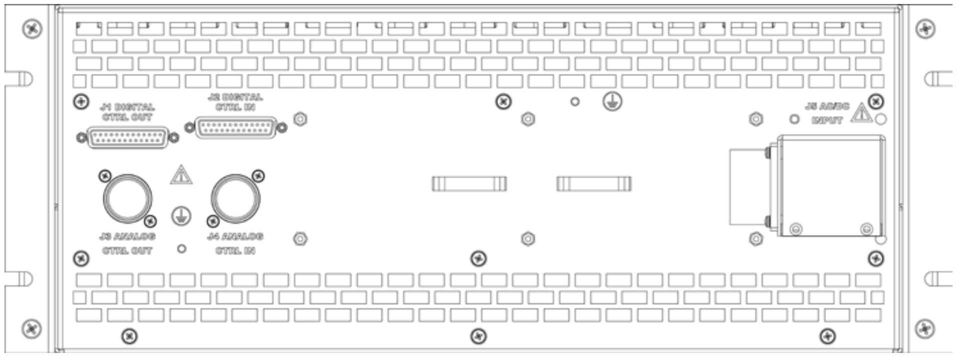


Figure 1-3. Mainframe Exterior Rear

1.2.3 ACCESSORIES

The ReFlex Power™ system includes standard accessories supplied with the modules and Mainframe, as well as some optional accessories:

STANDARD ACCESSORIES

Operation Manual P/N M380056-01 (this manual)

Programming Manual P/N M380056-03

Quick Reference Guide P/N M380056-04

OPTIONAL ACCESSORIES

Mainframe:

- Interconnect cable assembly, 36”: 5380054-01
- Interconnect cable assembly, 97”: 5380054-02
- Interconnect cable assembly, 135”: 5380054-03
- Input power cable assembly: 5380317-01

Filler panel, single-width: 5380059-01

Mating connectors as follows:

- For the Mainframe: Mating connector for AC/DC input power
- For all modules: Mating connectors for output power and user interface (refer to “Connectors” sub-section for each module-type in this manual or to the module-specific Technical Note with wirelists.)

1.3 SPECIFICATIONS

The flexible and reconfigurable characteristics of the ReFlex Power™ system allow any combination of module(s) to be plugged into a Mainframe, and in any of the slot locations; i.e., the various power asset types (high-power/low-power DC, AC, and/or loads), as well as the Controller, can be combined and changed as needed. With twelve slots in the Mainframe, multiple modules of single-width, double-width and/or triple-width can be plugged in. If the combined width of the desired assets exceeds the inner dimensions of the Mainframe (twelve slots at single-width each), the assets can be extended through interconnection of additional Mainframes. Table 1-1 provides an overview of each type of module that can be utilized in the system.

1.3.1 PRODUCT MATRIX- OVERVIEW

Table 1-1. Module Complement

Model	Type	Voltage Rating	Current Rating	Power Rating	Module Width
RFP-D1016-021-xxxx	Low-power DC module	0-16 V	0-20.6 A	330 W	Single (1.4”)
RFP-D1065-5A1-xxxx	Low-power DC module	0-65 V	0-5.1 A	332 W	Single (1.4”)
RFP-D2033-030-xxxx	High-power DC module	0-33 V	0-30 A	990 W	Double (2.8”)
RFP-D2050-020-xxxx	High-power DC module	0-50 V	0-20 A	1000W	Double (2.8”)
RFP-D2050-025-xxxx	High-power DC module	0-50 V	0-25 A	1250W	Double (2.8”)
RFP-D2120-8A3-xxxx	High-power DC module	0-120 V	0-8.3 A	996W	Double (2.8”)
RFP-D2450-2A3-xxxx	High-power DC module	0-450 V	0-2.3 A	1,035 W	Double (2.8”)
RFP-A30XK-875-xxxx	AC power module	0-140/ 0-280V	3.5A/ 7A	875W	Triple (4.2”)
RFP-L3500-750-xxxx	High-power active load	500V	30A	750W	Triple (4.2”)
RFP-L3500-375-xxxx	Low-power active load	500V	15A	375W	Triple (4.2”)
RFP-F1000-001-xxxx	Fixed-power DC module	5/-5V 15/-15V	10/5A 3/3A	50/25W 45/45W	Single (1.4”)
RFP-C1LAN-000-xxxx	Controller module	-	-	-	Single (1.4”)

1.3.2 GENERAL CHARACTERISTICS- OVERVIEW

The Mainframe facilitates quick installation and removal of modules. The modules slide on guides of the Mainframe chassis, and have captive thumbscrews on their front panels to secure them to the chassis. Connectors in modules engage blind-mate connectors on the Mainframe backplane. Guide-pins are integrated into each backplane connector to provide alignment and mechanical support.

SINGLE AND MULTIPLE MAINFRAMES

The ReFlex Power™ system could be configured with a single Mainframe or multiple Mainframes (up to eight), dependent on the total quantity of modules comprising the system. The backplane control/communications bus between modules is extended between Mainframes through external interconnect cables, allowing flexibility in the physical location of modules: except for parallel or multi-phase groups, there are no restrictions as to where modules could be located in the system. Also, there is no requirement to fill all slots in a Mainframe other than to install a filler panel over any empty slot, and there are no restrictions to the placement order of the modules except for parallel and multiphase groups. Within each Mainframe, the backplane also distributes the AC/DC input power to the individual modules. However, the AC/DC input power is not routed between Mainframes; therefore, each Mainframe requires its own independent connection to the AC/DC input power source.

PARALLEL CONNECTIONS

Operation of modules in a parallel group requires routing of analog control signals through the backplane between the modules, as well as the digital control/communications, to implement a master/slave control interface. The routing of signals in this interface requires that parallel modules have no other modules installed within the parallel group, although individual modules of the group can be separated by empty slots (covered by filler panels). The group can be extended among multiple Mainframes. The outputs of the modules must be hardwired externally, while all internal control signal connections are done automatically when the parallel group is set up through software. The parallel group is programmed as a “virtual” module, equivalent to a single module with the combined rating of the parallel group of modules. Only modules of the same model number can be paralleled.

Refer to the sections for the specific assets (DC, AC, loads) for more detailed information.

SERIES CONNECTIONS

DC modules could be operated in a series group regardless of their location in the ReFlex Power™ system. The series group does not utilize the analog control signals of the backplane; therefore, it is not restricted by contiguous physical grouping as in a parallel group. The outputs of the modules must be hardwired externally, while all internal control signal connections are done automatically when the series group is set up through software. The series group is programmed as a “virtual” module, equivalent to a single module with the combined rating of the series group of modules. Only the low-power DC and high-power DC assets are capable of series operation; and, only modules of the same model number could be series connected. Refer to the sections for the specific assets for more detailed information.

SERIES-PARALLEL CONNECTIONS

Series-Parallel groups are also allowed. The requirements for configuring the group are a combination of those for the dedicated series and parallel groups presented above: the parallel modules must not be separated by any modules not assigned to their group, while the series grouping is not location dependent. The series group is programmed as a “virtual” module, equivalent to a single module with the combined rating of the series-parallel group of modules. Only the low-power DC and high-power DC assets are capable of series-parallel operation; and, only modules of the same model number could be series-parallel connected. Refer to the section for the specific asset for more detailed information.

MULTI-PHASE CONNECTIONS

The AC power modules could be connected with multi-phase outputs allowing 2-phase, 3-phase or as many as six phase groups configurations. A neutral is required, so 3-phase outputs are restricted to a wye connection. The master module sets the phase reference and the slave modules are phase-locked to it with programmable phase angles. The internal signal interface is automatically configured, but the outputs must be hardwired externally for the desired output.

CONTROL INTERFACE

The ReFlex Power™ system utilizes a multi-processor command and control architecture wherein the Controller module and each power module has an embedded processor. There is a single Ethernet communication interface to the user host controller through the Controller module, while all modules comprising the system communicate through an internal ARCNET bus. The user communications interface provides direct control using SCPI commands, and IVI-compatible drivers.

1.3.3 MECHANICAL CHARACTERISTICS - OVERVIEW

The ReFlex Power™ system has a modular configuration wherein modules plug into a backplane of the Mainframe. The Mainframe assembly provides an enclosure and functional services for the various assets.

Table 1-2. Asset Physical Characteristics

Asset	Type	Size	Weight
RFP-D1016-021-xxxx	Low-power DC module	1.4” H x 6.75”H x 15”D	4.5 lb
RFP-D1065-5A1-xxxx	Low-power DC module	1.4” H x 6.75”H x 15”D	4.5 lb
RFP-D2033-030-xxxx	High-power DC module	2.8” H x 6.75”H x 15”D	9.0 lb
RFP-D2050-020-xxxx	High-power DC module	2.8” H x 6.75”H x 15”D	9.0 lb
RFP-D2050-025-xxxx	High-power DC module	2.8” H x 6.75”H x 15”D	9.0 lb
RFP-D2120-8A3-xxxx	High-power DC module	2.8” H x 6.75”H x 15”D	9.0 lb
RFP-D2450-2A3-xxxx	High-power DC module	2.8” H x 6.75”H x 15”D	9.0 lb
RFP-A30XK-875-xxxx	AC power module	4.2” H x 6.75”H x 15”D	11.4 lb
RFP-L3500-750-xxxx	High-power active load	4.2” H x 6.75”H x 15”D	12.9 lb
RFP-L3500-375-xxxx	Low-power active load	4.2” H x 6.75”H x 15”D	8.2 lb
RFP-F1000-001-xxxx	Fixed-power DC module	1.4” H x 6.75”H x 15”D	4.7 lb
RFP-C1LAN-000-xxxx	Controller module	1.4” H x 6.75”H x 15”D	2.4 lb
RFP-M000-xxx-xxxx	Enclosure	7” H x 19”H x 17”D	11.6 lb

Mounting Provisions:

Front panel mounting flanges and chassis hole pattern for RETMA rack slides or rails

Color:

Mainframe: Gold color chem-film per Elgar specification 1005019-01

Modules: Black; color number 27038 per FED-STD-595

Cooling Provisions

No Mainframe cooling fans; all fans are incorporated into the individual power modules; front and rear must be unobstructed so that air flow is not impeded

1.3.4 INPUT CHARACTERISTICS - OVERVIEW

The ReFlex Power™ system has enhanced input power capabilities, accepting a wide range of voltages and frequencies. It is compatible with AC and DC input sources, as well as AC single-phase and three-phase sources. The modules incorporate power factor correction to minimize input harmonics, and to reduce the input current draw (and resulting apparent power).

Power Input Range

1-phase: 100/115/120/200/208/230V
3-phase: 115/200V or 120/208V, delta and wye; 230/400V, wye with neutral only
DC Input: 270VDC, nominal; 210-300VDC,

Current

Sum of individual module input currents.

Apparent Input Power

Sum of individual module input power.

Frequency

47-63Hz, 380-420Hz, and DC

Power Factor

Power factor is dependent on module complement installed in Mainframe. Modules with PFC provide the following:
0.95, minimum at full output load
>0.75 at 20% load
>0.3 at no load

Current Harmonic

Complies with IEC 1000-3-2 harmonics limits

Current Inrush

The Mainframe inrush current is equal to the sum of the individual module inrush currents

Sag/Surge Provisions

With AC input: sag to 65% of nominal at 208VAC and 230VAC input for 450ms; surge to 135% of nominal at 208VAC and 230VAC input for 450ms
With DC input: 314VDC, maximum for 2s; 364.5VDC, maximum for 450ms

Hold-Up Time

10ms, with dropout of AC input at full output power except

RFP-D2050-025-xxxx: 8ms, with dropout of AC input at full output power

Aggregate Output Power

Depends on module complement and input voltage: With AC input voltage ≥ 200VAC or DC input, 6kW maximum; with AC input voltage < 200VAC, 3.6kW maximum

1.3.5 Environmental Characteristics

The ReFlex Power™ system has been ruggedized to MIL-PRF 28800F requirements for Class 3. It is capable of operating in military environments, with enhanced capabilities to withstand harsh environmental conditions of temperature, altitude, shock/vibration, and input power.

Operating Environmental Conditions

Temperature:

Standard: 0 to 50 °C

Extended Range Option: -10 to 55 °C

Altitude:

Standard: 0 to 6,500 feet

Extended Range Option:

Low-Power DC, High-Power DC, Fixed-Power DC, AC Power, and Low-Power Load assets: 0 to 15,000 feet

High-Power Load asset: 0 to 15,000 feet, with linear temperature derating from 55°C at 6,500 feet to 40°C at 15,000 feet, or with linear power derating from 750W at 6,500 feet to 600W at 15,000 feet

Humidity:

95% non-condensing

Shock:

Class 3 MIL-PRF-28800F

Vibration:

Class 3 MIL-PRF-28800F

Operation Without Fully Populated Mainframe:

If Mainframe is not fully populated with modules, filler panels must be installed in empty slots to maintain proper airflow and structural integrity.

Calibration Temperature Range:
Performance specifications are valid following calibration at 25°C, +/- 5°C

NON-OPERATING ENVIRONMENTAL CONDITIONS (TRANSPORTABILITY):

Temperature:
-40 to 71°C

Altitude:
0 to 50,000 feet

Humidity:
95% relative humidity non-condensing.

Shock:
Class 3 MIL-PRF-28800F

Vibration:
Class 3 MIL-PRF-28800F

1.3.6 REGULATORY COMPLIANCE

EMC compliance is per EN 61326:1997 and safety compliance is per IEC 61010-1; satisfies MIL-PRF-28800F

Test Environment
CISPR 16-1

Conducted Susceptibility
IEC 1000-4-6, Conducted RF
IEC 1000-4-2, ESD
IEC 10004-4, Burst
IEC 61000-4-5, Surge
IEC 61000-4-11, Input Power Interruptions

Conducted Emission
CISPR 11, CLASS A

Radiated Susceptibility
IEC 1000-4-3, EM FIELD

Radiated Emission
CISPR 11, CLASS A

1.4 MINIMUM REQUIREMENTS

The minimum requirements to operate a ReFlex Power™ system are:

- Mainframe
- Controller module
- One or more power modules

- User host controller with suitable communications interface
- Communications software

1.5 REFLEX POWER™ FIRMWARE COMPATIBILITY

With the release of firmware version 3.000.000 and higher, the controller firmware revision and the firmware in the power and load modules must be at the same major revision level. Thus, it is not possible to mix revision 2.000.000 and revision 3.000.000 assets. When powering up a system with mixed revision assets installed, the red Fault LED will blink on a version 3 controller if a version 2 module is detected. If a version 3 Module detects a version 2 controller, the Module's red Fault LED will blink indicating the firmware miss-match. The *TST? response will also have an error bit set indicating miss-matched firmware.

RFP version 2 Modules can be upgraded to version 3, and version 3 modules can be downgraded to version 2.

The Order numbers for version 2 and version 3 Modules are different, contact Sales for further information.

SECTION 2
MAINFRAME

2.1 GENERAL DESCRIPTION

The ReFlex Power™ system is comprised of modular power and controller assets housed in a backplane-based Mainframe. It provides a universal power platform comprising a wide range of AC/DC source and load assets that are integrated with a common controls and interface framework. The system is based on a modular architecture that maximizes flexibility and minimizes logistical footprint, allowing quick reconfiguration and adaptability to changing ATE functionality or upgrade requirements.

A wide variety of modules are available, encompassing AC and DC sources, active loads, and controllers. To maximize the throughput power of the Mainframe, each module integrates all of the power processing stages, from its AC/DC input to its output, within its enclosure. Multiple Mainframes could be combined into an extended system, all controlled by a single Controller module, and using common communications and software programming. The system is compatible with PC-computer-based host controllers, and supports Ethernet instrumentation communications interface.

2.2 FEATURES

The ReFlex Power™ Mainframe comprises a backplane, AC/DC input filtering and power distribution, and a mechanical supporting structure. The backplane provides power and controls interface for up to twelve single-width plug-in modules. The width of a module is a function of its output power: single-width, double-width, and triple-width modules are available. The modules slide on guides integral to the chassis of the Mainframe, and mate with connectors on the backplane. Each module is secured to the Mainframe with captive hardware on their front panels.

The various modules could be located in any Mainframe slot, and could be quickly interchanged, to produce systems that are highly reconfigurable and adaptable. The modules feature the capability to be connected in configurations such as series, parallel, and multi-phase to expand the voltage, current, and power ratings beyond that of individual modules, minimizing the number of unique assets comprising a system. For larger systems, the number of modules could be further increased by interconnecting several Mainframes with external controls/communications cables. Systems comprising eight Mainframes and up to a maximum of nine-six modules could be produced.

The enclosure complies with industry-standard EIA rack mount requirements. Front mounting flanges are provided, as well as a hole pattern on the chassis that would accept rack slides or mounting rails. The thermal management has been driven by the requirement to allow the dissipation of high power in a small package, from supplies as well as active loads. Each module has integral fans, optimized for the amount of heat that must be eliminated; no fans are required in the Mainframe. Air intake is at the front of the modules, while the exhaust is at the rear.

2.2.1 General Features

- High module count, up to twelve single-width
- Accepts single-width, double-width, triple-width modules
- System extensible up to eight Mainframes and ninety-six modules
- Configuration flexibility, no restrictions on module slot location
- High power per slot, up to 1kW
- High aggregate output power, up to 6,000W
- Universal inputs: AC (50/60 Hz, 400 Hz), DC, single-phase, three-phase
- Auto-Termination communications bus
- Auto-Configuration backplane controls bus
- Small size, 7” H x 19” W x 17” D
- Light weight, 11.6 lb
- EIA RS-310 rack mount, 4U enclosure
- Front entry modules
- Modules mount with captive fasteners
- Ruggedized to MIL-PRF-28800F
- Corrosion-Resistant aluminum chassis

2.2.2 ACCESSORIES LIST AND OPTIONS LIST

The ReFlex Power™ Mainframe has the following standard accessories and options:

STANDARD ACCESSORIES

- Operation Manual, P/N M380056-01 (this manual)
- Programming Manual, P/N M380056-03
- Quick Reference Guide P/N M380056-04

OPTIONS

- Interconnect Cable Assembly, 36”, P/N 5380054-01
- Interconnect Cable Assembly, 97”, P/N 5380054-02
- Interconnect Cable Assembly, 135”, P/N 5380054-03
- Input Power Cable Assembly, P/N 5380317-01
- AC Input Mating Connector, P/N 5380318-01
- Filler Panel, single-width, P/N 5380059-01

2.3 SPECIFICATIONS

The ReFlex Power™ Mainframe serves as the framework for systems integration of the various power and controller modules. It provides the mechanical structure and systems services, such as power distribution and controls/communications interface, as required to support the functionality of the individual modules. As such, the complement of modules installed in the Mainframe determines the systems performance characteristics.

2.3.1 PRODUCT MATRIX

Model	Number of Slots	Maximum Aggregate Output Power	Enclosure
Mainframe	12	6,000W	Rack-mount, 4U

Module Model	Voltage Full-Scale Rating	Current Full-Scale Rating	Power Rating	Module Width
RFP-D1016-021-xxxx	16VDC	20.6A	330W	Single, 1.4”
RFP-D1065-5A1-xxxx	65VDC	5.1A	332W	Single, 1.4”
RFP-D2033-030-xxxx	33VDC	30A	990W	Double, 2.8”
RFP-D2050-020-xxxx	50VDC	20A	1000W	Double, 2.8”
RFP-D2050-025-xxxx	50VDC	25A	1250W	Double, 2.8”
RFP-D2120-8A3-xxxx	120VDC	8.3A	996W	Double, 2.8”
RFP-D2450-2A3-xxxx	450VDC	2.3A	1,035W	Double, 2.8”
RFP-A30XK-875-xxxx	140/280VAC	7/3.5A	875W	Triple, 4.2”
RFP-L3500-750-xxxx	500VDC	30A	750W	Triple, 4.2”
RFP-L3500-375-xxxx	500VDC	15A	375W	Triple, 4.2”
RFP-F1000-001-xxxx	5V/-5VDC 15/-15VDC	10/5A 3/3A	165W	Single, 1.4”
RFP-C1LAN-000-xxxx	-	-	-	Single, 1.4”

2.3.2 INPUT CHARACTERISTICS

INPUT VOLTAGE

1-phase: 100/115/120/200/208/230V
3-phase: 200/208V, delta, 3-wire plus ground
115/200V or 120/208V wye, 4-wire plus ground
230/400V, wye, 4-wire plus ground
DC Input: 270VDC

INPUT VOLTAGE OPERATING RANGE

(input line to return voltage)

AC Input: 85-264VAC;
DC Input: 210-300VDC

INPUT CURRENT

Sum of the input currents of the individual modules installed.

Maximum allowed current per line, 24A

INPUT VOLTAGE SAG/SURGE

With AC input: sag to 65% of nominal at 208VAC and 230VAC input for 450ms;
surge to 135% of nominal at 208VAC and 230VAC input for 450ms
With DC input: 314VDC, maximum for 2s; 364.5VDC, maximum for 450ms

INPUT FREQUENCY RANGE

47-63Hz with 85-264VAC input; 380-420Hz with 85-132VAC input

MAXIMUM OUTPUT AGGREGATE POWER

The maximum aggregate output power is dependent on the AC/DC input voltage:

≥200VAC or ≥210VDC: 6,000W

<200V AC: 3,600W

POWER FACTOR

Dependent on the individual modules installed

2.3.3 GENERAL CHARACTERISTICS

MAINFRAME SLOTS

12 single-width module slots

MODULE COMPATIBILITY

Accepts single-width, double-width, and triple-width modules;
1kW maximum output power per slot

BACKPLANE CONNECTORS

Circuit-Board mounted connectors with integral guide pins

CONNECTOR ACCESSIBILITY

AC/DC input connector and multi-Mainframe interconnect connectors are accessible from the rear of the Mainframe;
backplane connectors are accessible from the front.

MAINFRAME SAFETY GROUND STUD

8-32 stud for connection to the AC/DC utility safety ground

2.3.4 MECHANICAL CHARACTERISTICS

DIMENSIONS

7” H x 19” W x 17” D, EIA RS-310 rack-mount 4U

WEIGHT

11.6 lbs

MOUNTING PROVISIONS

Hole pattern for RETMA rack slides; front mounting flanges

Cooling Provisions

No Mainframe cooling fans; all fans are incorporated into the individual power modules

Color

Gold color chem-film per Elgar specification 1005019-01

2.3.5 Environmental Characteristics

Operating Temperature

Standard: 0 to 50 °C

Extended Range Option: -10 to 55 °C

Operating Altitude

Standard: 0 to 6,500 ft

Extended Range Option: 0 to 15,000 ft

Operating Humidity

95% non-condensing

Operating Shock

Class 3 MIL-PRF-28800F

Operating Vibration

Class 3 MIL-PRF-28800F

Operation Without Fully Populated Mainframe

If the Mainframe is not fully populated with modules, filler panels must be installed in empty slots to maintain proper air flow and structural integrity.

Non-Operating Temperature

-40 to 71 °C

Non-Operating Altitude

0 to 50,000 feet

Non-Operating Shock

Class 3 MIL-PRF-28800F

Non-Operating Vibration

Class 3 MIL-PRF-28800F

2.3.6 REGULATORY AGENCY COMPLIANCE

SAFETY COMPLIANCE

European Low Voltage Directive, IEC 61010-1:90+A1:92+A2:95, as required for the CE mark.

LVD CATEGORIES

Installation Category II; Pollution Degree 2; Class II Equipment;
for Indoor Use Only

EMC COMPLIANCE

EMC Directive, EN 61326:1998

ELECTROSTATIC DISCHARGE

IEC 61000-4-2

RADIATED RF IMMUNITY

IEC 61000-4-3

FAST–TRANSIENTS

IEC 61000-4-4

SURGE

IEC 1000-4-5

CONDUCTED RF IMMUNITY

IEC 1000-4-6

INPUT POWER INTERRUPTIONS

IEC 1000-4-11

CONDUCTED EMISSIONS

CISPR 16-1/2, Class A

RADIATED EMISSIONS

CISPR 16-1/2, Class A

2.4 INSTALLATION

The ReFlex Power™ Mainframe has been fully tested prior to shipment; it is ready for immediate use upon receipt. However, when first unpacked, the Mainframe should be inspected to ensure that no shipping damage has occurred.

2.4.1 INITIAL INSPECTION

Perform a visual inspection of the shipping container prior to accepting the package from the carrier. If damage to the shipping container is evident, a description of that damage should be noted on the carrier's receipt and signed by the carrier's driver.

Verify that the proper Mainframe and associated accessories/options have been received. Perform a visual inspection of the Mainframe after it is removed from the shipping container. Check for shipping damage such as dents, scratches, or distortion of the enclosure.

If external damage is evident, there may be internal damage as well. Immediately contact the carrier and file a claim for concealed damage. In addition, the shipping container and filler material should be saved for inspection. Forward a report of the damage to the Customer Care Department where an associate will provide instructions for repair or replacement of the unit.

2.4.2 LOCATION CONSIDERATIONS

The ReFlex Power™ Mainframe is designed for rack-mounting using slides or rails. It incorporates mounting holes along the sides to accept screws for attachment of rack slides. Front mounting flanges are used to secure the Mainframe chassis to the rack frame.

The modules used with the Mainframe are fan–cooled and require adequate clearance at the front and back of the Mainframe for proper airflow. The air intake is at the front of the Mainframe, through the installed modules, while the exhaust is at the rear.

To fulfill proper air circulation requirements, ensure that:

- Install filler panel(s) in any empty slot(s) of the Mainframe.
- ambient air temperature at the air intake does not exceed 55 °C

Because the modules of the Mainframe use forced convection cooling, the air flow through the unit can pull in dust. In environments having high concentrations of dust, periodic cleaning may be required. The exterior of the unit should be cleaned with a mild solution of detergent and water. The solution should be applied onto a soft cloth, and not directly to the surface of the unit. To prevent damage to materials, do not use aromatic hydrocarbons or chlorinated solvents for cleaning.

2.4.3 MAINFRAME INSTALLATION DRAWINGS

Refer to Figure 2-1 for profile and Figure 2-2 for top view outline drawings showing dimensional information for the Mainframe.

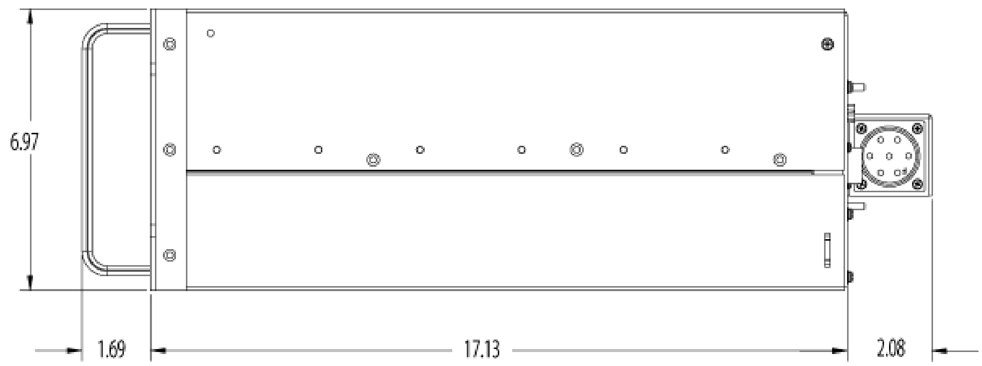


Figure 2-1. Mainframe Profile with Dimensions

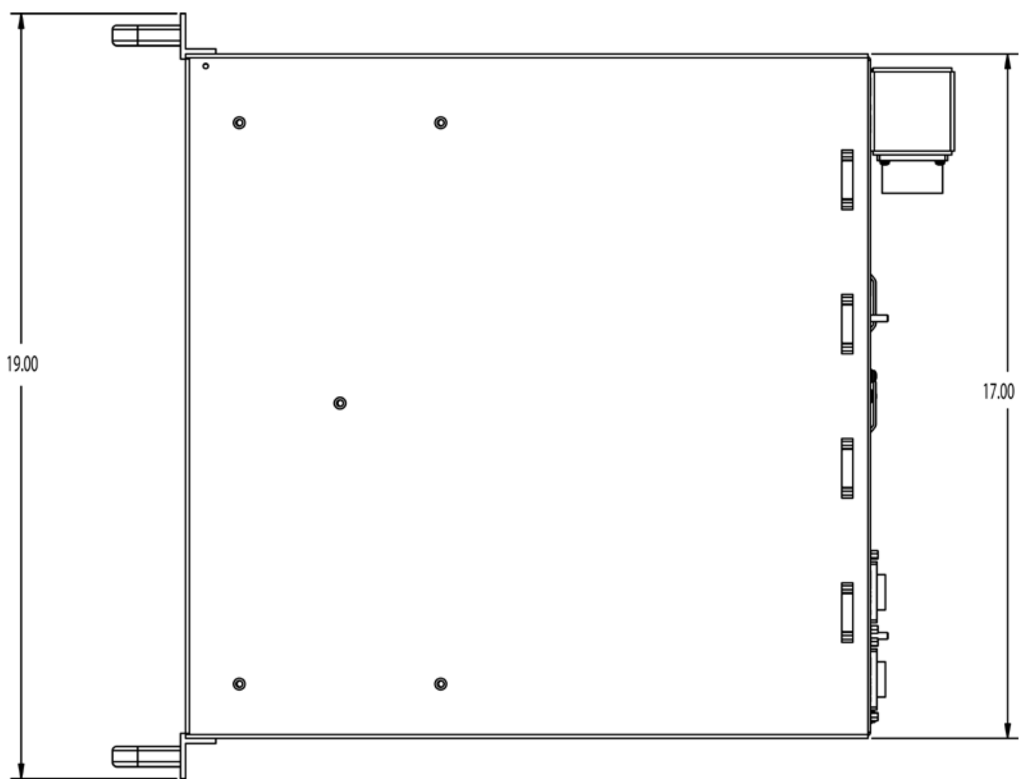


Figure 2-2. Mainframe Top View with Dimensions

2.4.4 MODULE INSTALLATION

CAUTION
Modules and the Mainframe contain ESD sensitive circuitry. Follow appropriate handling and grounding procedures to prevent damage to a module or Mainframe. Modules and Mainframe should be handled by the enclosure, with care to protect the connectors from ESD discharges.

CAUTION
Input power must be disconnected to the Mainframe before a module is inserted or extracted. Inserting or extracting a module with power installed (hot-swapping) could result in damage to the module or Mainframe. Prior to turning power on, ensure that front panel captive thumbscrews are tightened.

Modules are installed into the Mainframe from the front of the chassis. Refer to Figure 2-3 for the orientation of a module and Mainframe during installation.

1. Ensure that the AC/DC input power is disconnected before installing or removing any module(s).
2. Insert the module into the mainframe, rear panel first, aligning the module guide rails the top and bottom Mainframe guides.
3. Gently slide the module completely into the mainframe until the guide pins of the module rear connector engage the mating backplane connector.
4. Fully seat the module until the front panel inner surface is snug against the mainframe chassis.
5. Secure the module(s) to the Mainframe at the top and bottom of each front panel by turning the captive thumbscrews clockwise using a flat head screwdriver to a maximum torque of 20 in-lb.
6. Install a filler panel over any empty slot, and secure in place at the top and bottom by turning the captive thumbscrews clockwise using a flat head screwdriver to a maximum torque of 20 in-lb.

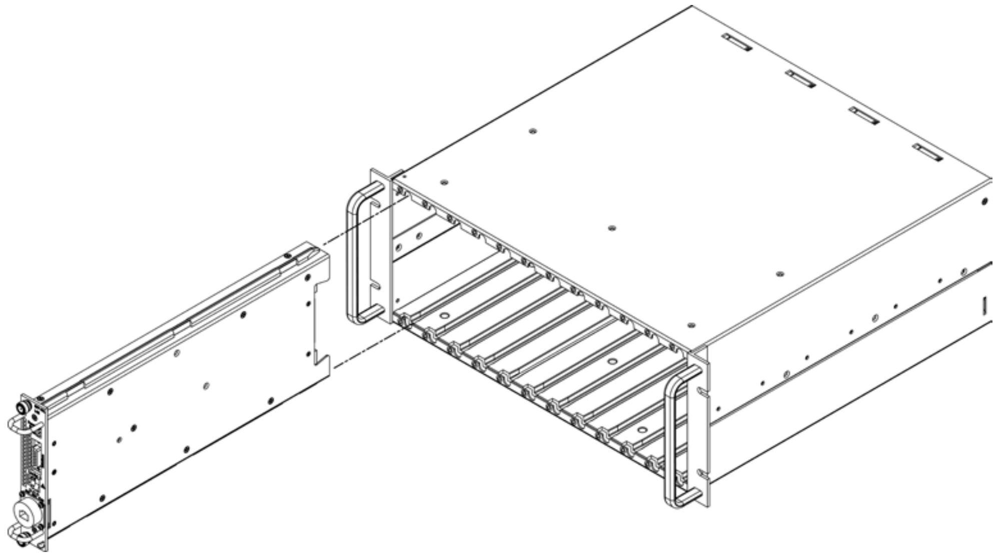


Figure 2-3. Module Installation

2.4.5 INPUT POWER REQUIREMENTS

The input configuration accepts a wide variety of sources: single-phase and three-phase AC inputs, as well as DC. With single-phase inputs, the AC input range spans nominal voltages from 100VAC to 240VAC. Three-phase inputs could be derived from sources configured as delta (3-wire plus ground) and wye (4-wire plus ground). With a delta source, the allowed input voltage is 200VAC, while with a wye source, the input voltage could be 115/200VAC or 230/400VAC. Regardless of the input service, modules are connected either line-to-line or line-to-neutral so that the operating voltage applied to the modules is within the range of 85-264VAC. The allowed frequency range is 50/60/400Hz. The DC input is based on a nominal 270VDC, with an operating range from 210VDC to 300VDC.

CAUTION
Connecting to a wye source at 230/400VAC must be from line to neutral so that the voltage applied to a module input is less than 264VAC. Exceeding the input voltage rating could result in damage of the module.

The input current is dependent on the total aggregate output power supplied by the modules installed in the Mainframe. The maximum input current is limited by the power dissipation produced in the backplane power distribution, interconnects, and wiring. With a limit of 24A per input line, the Mainframe is capable of provided up to 6,000W of aggregate output power.

The input power connector of the Mainframe has three pairs of line connections plus ground, seven contacts in total. Each pair of input lines is distributed through the backplane to a group of four backplane slot connectors, all connected in parallel. The load that would be applied to a particular AC/DC input line is dependent on the location of the modules in the Mainframe slots.

The slots are grouped in sets of four: Slot 1-4, Slot 5-8, and Slot 9-12. Slot 1 is the left-most slot, as viewed from the front (refer to Figure 2-5. Each of the backplane connectors of a set of four slots is connected in parallel and is supplied by one pair of the AC/DC input lines. In a double-width and triple-width module, the module connector is located so that it mates to a backplane connector in the right-most slot, as viewed from the front of the Mainframe. Refer to Figure 2-4 for a diagram showing the power distribution from the input connector to the twelve Mainframe slots.

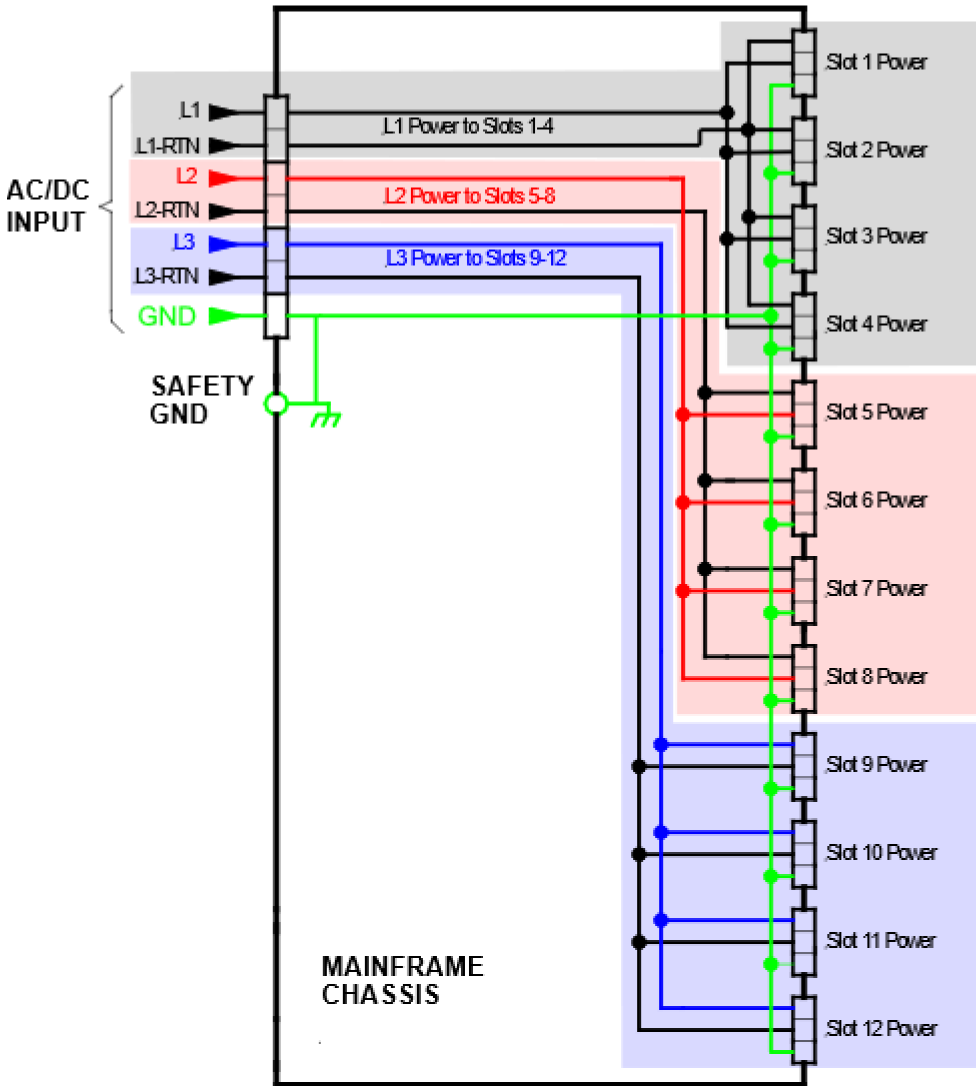


Figure 2-4. Input Power Distribution (Slot 1 at top is left-most slot of Mainframe front view, as in Figure 2-5).

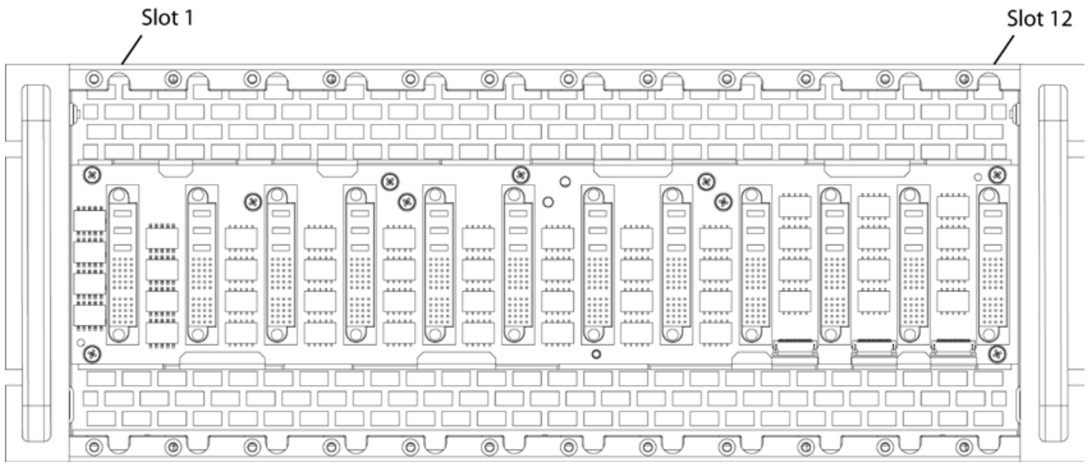


Figure 2-5. Slot Numbering Assignment, Empty Mainfram Front View

With single-phase service, all input lines are connected in parallel. Effectively, the three groups of slots (each group comprising four individual slots) are connected in parallel. However, with three-phase inputs, each line is connected to a separate group of paralleled slots. Therefore, the physical location of a module in the Mainframe will determine from which input line the module will draw power. Balancing of phase currents can be achieved only if the power modules are installed into the Mainframe so that there is an equal distribution of current between the three groups of slots, and provided that the same total load is applied to the set of modules in each group. Refer to Table 2-1 for the power allocation from the input connector pins to the Mainframe slots.

In multi-Mainframe systems, each Mainframe has an independent AC/DC input. The interconnect cable that daisy-chains the Mainframes together does not route input power between assets. Therefore, the input power is not shared among the assets comprising the system.

Table 2-1. Input Power Allocation

Input Service	Phases	Input Designation	Input Connector Pin	Input Service Connection	Slot Supplied
100/115/120VAC 200/208VAC 220/230/240VAC	1	L1	F	Phase	Slot 1-4
		L1-RTN	E	Return	
		L2	A	Phase	Slot 5-8
		L2-RTN	G	Return	
		L3	B	Phase	Slot 9-12
		L3-RTN	C	Return	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
200/208VAC	3, Delta	L1	F	Phase-A	Slot 1-4
		L1-RTN	E	Phase-B	
		L2	A	Phase-B	Slot 5-8
		L2-RTN	G	Phase-C	
		L3	B	Phase-C	Slot 9-12
		L3-RTN	C	Phase-A	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
200/208VAC 220/230/240VAC	3, Wye	L1	F	Phase-A	Slot 1-4
		L1-RTN	E	Neutral	
		L2	A	Phase-B	Slot 5-8
		L2-RTN	G	Neutral	
		L3	B	Phase-C	Slot 9-12
		L3-RTN	C	Neutral	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
210-300VDC	DC	L1	F	Source	Slot 1-4
		L1-RTN	E	Return	
		L2	A	Source	Slot 5-8
		L2-RTN	G	Return	
		L3	B	Source	Slot 9-12
		L3-RTN	C	Return	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis

2.4.6 AC/DC Input Overcurrent Protection

The Mainframe distributes the input power through backplane connectors to three groups of four slots connected in parallel. Each group is connected to a separate pair of pins of the input connector (one line and return per connection); the connector has six power pins plus ground. To properly size the current rating of the disconnect device, the total load current that will be drawn from an input line must be determined based on the location of modules within a Mainframe. The backplane connector from which a module will draw input current is also dependent on the width of the module. Table 2-2 presents the number of slots that a particular module will occupy, to which slot the module will be connected to draw input power, and the maximum current that the module will draw.

For example, a Mainframe with six HPDC modules (each 2U wide) would have modules plugged into the following locations: slot 2, slot 4, slot 6, slot 8, slot 10, and slot 12 (see Figure 2-5). The slots would be connected to the input connector, as follows: line L1 connected to slots 2 and 4, line L2 connected to slots 6 and 8, and line L3 connected to slots 10 and 12. If the modules supplied full rated output power, and the AC input were three-phase, wye with nominal 230/400VAC, each input line would supply 10.8A.

As another example, a Mainframe with four AC power modules would have modules plugged into the following locations: slot 3, slot 6, slot 9, and slot 12. The slots would be connected to the input connector, as follows: line L1 connected to slot 3, line L2 connected to slot 6, and line L3 connected to slots 9 and 12. The input current would not be balanced from a three-phase source. If the modules supplied full rated output power, and the AC input were three-phase, wye with nominal 230/400VAC, lines L1 and L2 would each supply 5.4A, but line L3 would supply 10.8A.

Table 2-2. Module Backplane Slot Connections

Module Model	**Width**	**Number of Slots Occupied**	**Slot Supplying Input Power**	**Maximum Input Current** (at 103.5VAC and full load)
RFP-C1LAN-000-xxxx	single	1	single	0.2A
RFP-F1000-001-xxxx	single	1	single	2.8A
RFP-D1016-021-xxxx *RFP-D1065-5A1-xxxx*	single	1	single	4A
RFP-D2033-030-xxxx *RFP-D2050-020-xxxx* *RFP-D2050-025-xxxx* *RFP-D2120-8A3-xxxx* *RFP-D2450-2A3-xxxx*	double	2	right-most	12A
RFP-A30XK-875-xxxx	triple	3	right-most	12A
RFP-L3500-750-xxxx *RFP-L3500-375-xxxx*	triple	3	right-most	1.1A

The maximum output power per single group of four slots is produced when two HPDC 1kW modules are installed in the group. This sets the maximum aggregate output power limit of the Mainframe at 6kW. The resultant maximum current per input connector line and per input service line is presented in Table 2-3. In general, to determine the actual input currents, the current requirements of the modules that are installed in each group must be summed. This would determine the requirement for the AC/DC input overcurrent protection current rating.

Table 2-3. Mainframe Input Current Demand

Input Service	Input Service Connection	Maximum Input Service Line Current	Maximum Mainframe Input Connector Line Current	Maximum Aggregate Output Power per Mainframe	Maximum Output Power per Slot Group: Slots 1-4, 4-8, and 8-12
100V	1-phase	24A	24A	5kW	1.7kW
115/120V		24/23A	24/23A	6kW	2kW
200/208V		14/13.5A	14/13.5A	6kW	2kW
220/230/240V		13/12.4/11.9A	13/12.4/11.9A	6kW	2kW
200V or 208V	3-phase, delta 3-wire, plus ground	24.3A or 23.4A	14A or 13.5A	6kW	2kW
115/200V or 120/208V	3-phase, wye 4-wire, plus ground	24A or 23A	24A or 23A	6kW	2kW
220/380V, 230/400V, or 240/415V	3-phase, wye 4-wire, plus ground	13/12.4/11.8A	13/12.4/11.9A	6kW	2kW
270VDC	DC	12A at 210VDC	12A at 210VDC	6kW	2kW

2.4.7 AC/DC INPUT DISCONNECT DEVICE

The ReFlex Power™ system does not have any means to disconnect it from the AC/DC input service. The front panel POWER switch of the Controller module in the Mainframe does not disconnect the AC/DC input line from the modules or Mainframe. Ensure that a suitable disconnecting device is incorporated into the system installation, so that isolation will be provided when it is opened. The switch or circuit breaker must be located close to the ReFlex Power™ system, within reach of the operator, and clearly labeled as the disconnection device. In multi-Mainframe systems, each Mainframe has an independent AC/DC input, so the input disconnect device should simultaneously open/close the input connection to all assets comprising the system.

WARNING

To prevent a shock hazard, ensure that the AC/DC input disconnect device is open, and that the safety ground conductor is connected to the rear panel ground stud, before inserting/removing modules into/from the Mainframe. The Mainframe backplane input power distribution remains energized whenever the AC/DC input is connected.

2.4.8 AC/DC INPUT SAFETY GROUND CONNECTION

The AC/DC input connector provides a safety ground termination. The input power cable should include a safety ground wire to connect the chassis of the Mainframe to the safety ground of the AC/DC power source. Depending on the installed modules, and operating voltage/frequency, the AC input leakage current could exceed 3.5mA; therefore, a second safety ground connection is also required. It should be connected to the safety ground stud on the rear panel of the Mainframe.

WARNING
A separate, dedicated safety ground wire must be connected to the Mainframe rear panel safety ground stud. Operating the ReFlex Power™ system with the safety ground wire disconnected could result in a shock hazard.

2.4.9 CONNECTORS

The ReFlex Power™ Mainframe rear panel (Figure 2-6) has connectors for connecting to the AC/DC input service and for interconnecting multiple Mainframes into extended systems. Connections for individual module output power and control interface are available on the front panels of the modules. Refer to Figure 2-6 for a rear panel view of the Mainframe.

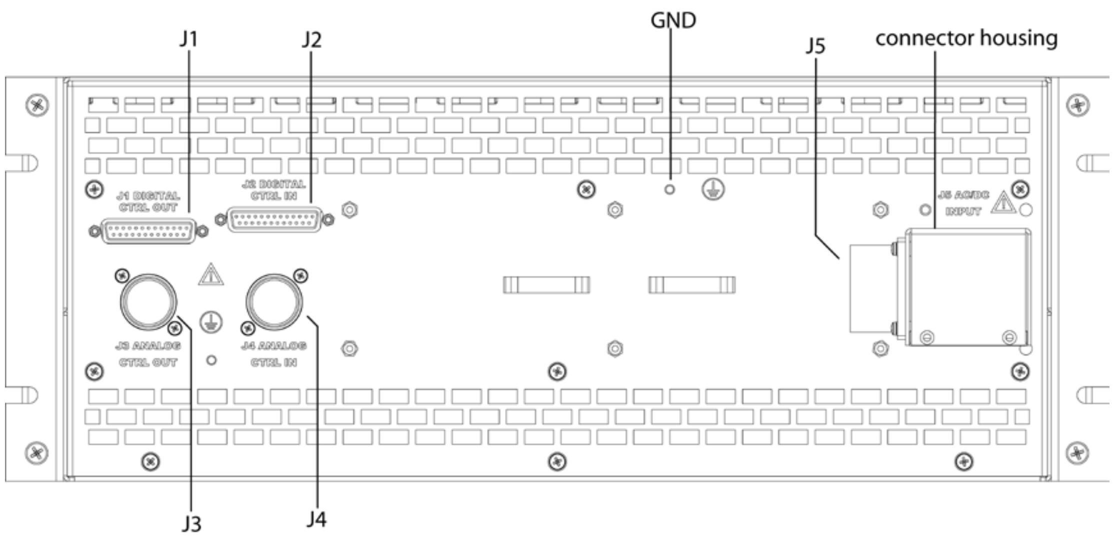


Figure 2-6. Mainframe Rear Panel

J1, DIGITAL CTRL OUT: connector used in multi-Mainframe systems that provides digital control signals to a following Mainframe further down in the daisy-chain

J2, DIGITAL CTRL IN: connector used in multi-Mainframe systems that provides digital control signals to a preceding Mainframe further up in the daisy-chain

J3, ANALOG CTRL OUT: connector used in multi-Mainframe systems that provides analog control signals to a following Mainframe further down in the daisy-chain

J4, ANALOG CTRL IN: connector used in multi-Mainframe systems that provides analog control signals to a preceding Mainframe further up in the daisy-chain

J5, AC/DC INPUT: input connector for the AC/DC input power

GND: safety ground stud

WARNING
To prevent electrical shock, disconnect the AC/DC input service before making any connections to the Mainframe.

AC/DC Input Connector, J5, and Ground Stud

The AC/DC input power is connected through a plug/socket connector, J5, on the rear panel of the Mainframe. Refer to Figure 2-7 for a view of the connector. The pinout and functions of the connector are presented in Table 2-4. The associated maximum wire gauge for connector terminations, and recommended maximum wire lengths, are presented in Table 2-10. Table 2-5 presents information on the safety ground stud.

J5 is the AC/DC input power connector to a Mainframe. AMETEK Mating Connector Kits:

- ReFlex Power™ Mainframe AC/DC Input Mating Connector Kit - AMETEK Part No. 5380318-01, mates with RFP-M000-001-0000, RFP-M000-001-1E00, and RFP-M000-001-2J00, and includes the following:

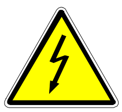
Bill of Material

Item	AMETEK Part No.	Description	Qty	Manufacturer Part No.	Manufacturer	Suggested Source(s)
1	855-130-02	Conn, 7P, 8AWG, Plug, P-Earth, S	1	DL3106A24-10S	Amphenol	Arrow Electronics: http://www.arrownac.com/ Newark: http://www.newark.com/
2	855-16A-X3	Conn, Cable Clamp, SS 24/28 w/Bushing	1	M85049/41-16A, or MS3057-16A	ITT Cannon, Amphenol / Bendix	PEI-Genesis: http://www.pei-genesis.com/

- ReFlex Power™ Mainframe AC/DC Input Mating Connector Kit with 2-Meter Unterminated AC Line Cord - AMETEK Part No. 5380317-01, mates with RFP-M000-001-0000, RFP-M000-001-1E00, and RFP-M000-001-2J00, and includes the following:

Bill of Material

Item	AMETEK Part No.	Description	Qty	Manufacturer Part No.	Manufacturer	Suggested Source(s)
1	855-130-02	Conn, 7P, 8AWG, Plug, P-Earth, S	1	DL3106A24-10S	Amphenol	Arrow Electronics: http://www.arrownac.com/ Newark: http://www.newark.com/
2	855-16A-X3	Conn, Cable Clamp, SS 24/28 w/Bushing	1	M85049/41-16A, or MS3057-16A	ITT Cannon, Amphenol / Bendix	PEI-Genesis: http://www.pei-genesis.com/
3	890-887-07	Cable, 10AWG X 7W, 600V, 80C	2m	87707	Alpha Wire & Cable	Alpha Wire Company: http://www.alphawire.com/index.cfm Industrial Electric Wire & Cable: http://www.iewc.com



WARNING
A separate, dedicated safety ground wire must be connected to the Mainframe rear panel safety ground stud. Operating the ReFlex Power™ system with the safety ground wire disconnected could result in a shock hazard.

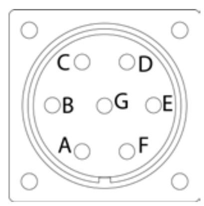


Figure 2-7. J5 AC/DC Input Connector, Mainframe Rear Panel View

Table 2-4. J5 AC/DC Input Connector Pinout

Pin	Name	Function	Signal Level
F	L1	Input: line-1	90-264VAC; 210-300VDC
E	L1-RTN	Input: return for line-1	90-264VAC; 210-300VDC
A	L2	Input: line-2	90-264VAC; 210-300VDC
G	L2-RTN	Input: return for line-2	90-264VAC; 210-300VDC
B	L3	Input: line-3	90-264VAC; 210-300VDC
C	L3-RTN	Input: return for line-3	90-264VAC; 210-300VDC
D	CHAS-GND	Safety ground	Chassis ground

Table 2-5. GND, Safety Ground Stud

Pin	Name	Function	Signal Level
E1	GND	Chassis safety ground; 8-32 stud	Chassis ground

MAINFRAME INTERCONNECT CONNECTORS

The digital control connectors, DIGITAL CTRL IN (J2) and DIGITAL CTRL OUT (J1), and the analog control connectors, ANALOG CTRL IN (J4) and ANALOG CTRL OUT (J3), provide a signal interface for multi-Mainframe

ReFlex Power™ systems, connected in a daisy-chain manner. J1 and J3 are output connectors that provide digital and analog control signals, respectively, to a following Mainframe further down in the daisy-chain. J2 and J4 are input connectors that accept digital and analog control signals, respectively, from a preceding Mainframe further up in the daisy-chain..

The daisy-chain connections are made using the Interconnect Cable Assemblies, P/N 5380054-01, 5380054-02, or 5380054-03, between pairs of Mainframes. Up to eight ReFlex Power™ Mainframes can be controlled by a single ReFlex Power™ Controller module in an extended system. These connectors are dedicated to interconnecting Mainframes, and do not contain any signals that are intended for external user interface. These connectors contain high-speed digital signals that require controlled cable impedances, and noise-sensitive analog signals. Therefore, to maintain signal integrity, cables must conform to construction requirements of AMETEK cable assembly 5380054.

J1 DIGITAL CONTROL OUT

Refer to Figure 2-8 for a view of the DIGITAL CTRL OUT, J1, connector. The pinout and functions of the connector are presented in Table 2-6. The associated maximum wire gauge for connector terminations, and recommended maximum wire lengths are presented in Table 2-10.

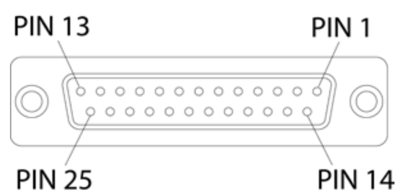


Figure 2-8. J1 Digital Control OutputConnector, Mainframe Rear Panel View

Table 2-6. J1 DIGITAL CTRL OUT Connector Pinout

Pin	Name	Function	Signal Level
1	ADR_MAIN0	Output: chassis address	5V logic level
2	ADR_MAIN1	Output: chassis address	5V logic level
3	ADR_MAIN2	Output: chassis address	5V logic level
4	7.5VB	Output: digital 7.5V source	Backplane 7.5VDC
5	BGND	Digital signal reference	Backplane circuit common
6	ARCNET_H_OUT	Input/Output: ARCNET differential data bus	ARCNET bus referenced to BGND
7	ARCNET_L_OUT	Input/Output: ARCNET differential data bus	ARCNET bus referenced to BGND
8	DIG3_I/O_H_OUT	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
9	DIG3_I/O_L_OUT	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
10	DIG2_I/O_H_OUT	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
11	DIG2_I/O_L_OUT	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
12	DIG1_I/O_H_OUT	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
13	DIG1_I/O_L_OUT	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
14	DIG0_I/O_H_OUT	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
15	DIG0_I/O_L_OUT	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
16	7.5VB	Output: digital 7.5V source	Backplane 7.5VDC
17	BGND	Digital signal reference	Backplane circuit common
18	TERMH	Termination signal	I/O Interconnect PWA 10VDC referenced to BGND
19	TERML_2	Termination signal return	I/O Interconnect PWA 10VDC referenced to BGND
20	REM_INH_OUT	Output: differential remote inhibit signal	RS-485 logic levels referenced to BGND
21	REM_INH_OUT	Output: differential remote Inhibit signal	RS-485 logic levels referenced to BGND
22	BGND	Digital signal reference	Backplane circuit common
23	PWR1	Output: module enable from Controller module	5V referenced to BGND
24	7.5VB	Output: digital 7.5V source	Backplane 7.5VDC
25	CHAS-GND	Chassis ground	Chassis

J2 Digital Control In

Refer to Figure 2-9 for a view of the DIGITAL CTRL IN, J2, connector. The pinout and functions of the connector are presented in Table 2-7. The associated maximum wire gauge for connector terminations, and recommended maximum wire lengths are presented in Table 2-10.

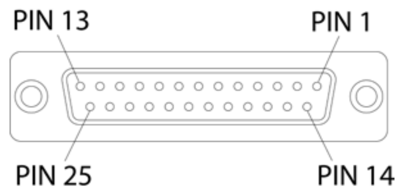


Figure 2-9. J2 Digital Control Input Connector, Mainframe Rear Panel View

Table 2-7. J2 DIGITAL CTRL IN Connector Pinout

Pin	Name	Function	Signal Level
1	A0	Input: chassis address	5V logic level
2	A1	Input: chassis address	5V logic level
3	A2	Input: chassis address	5V logic level
4	7.5VB	Input: digital 7.5V source	Backplane 7.5VDC
5	BGND	Digital signal reference	Backplane circuit common
6	ARCNET_H_IN	Input/Output: ARCNET differential data bus	ARCNET bus referenced to BGND
7	ARCNET_L_IN	Input/Output: ARCNET differential data bus	ARCNET bus referenced to BGND
8	DIG3_I/O_H_IN	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
9	DIG3_I/O_L_IN	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
10	DIG2_I/O_H_IN	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
11	DIG2_I/O_L_IN	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
12	DIG1_I/O_H_IN	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
13	DIG1_I/O_L_IN	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
14	DIG0_I/O_H_IN	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
15	DIG0_I/O_L_IN	Input/Output: digital-I/O differential signal	RS-485 logic levels referenced to BGND
16	7.5VB	Output: digital 7.5V source	Backplane 7.5VDC
17	BGND	Digital signal reference	Backplane circuit common
18	TERMH	Termination signal	I/O Interconnect PWA 10VDC referenced to BGND
19	TERML_1	Termination signal return	I/O Interconnect PWA 10VDC referenced to BGND
20	REM_INH_IN	Output: differential remote inhibit signal	RS-485 logic levels referenced to BGND
21	REM_INH_IN	Output: differential remote inhibit signal	RS-485 logic levels referenced to BGND
22	BGND	Digital signal reference	Backplane circuit common
23	PWR1	Output: module enable from Controller module	5V referenced to BGND
24	7.5VB	Output: digital 7.5V source	Backplane 7.5VDC
25	CHAS-GND	Chassis ground	Chassis

J3 ANALOG CONTROL OUT

Refer to Figure 2-10 for a view of the ANALOG CTRL OUT, J3, connector. The pinout and functions of the connector are presented in Table 2-8. The associated maximum wire gauge for connector terminations, and recommended maximum wire lengths are presented in Table 2-10.

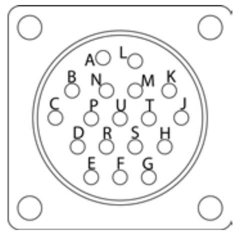


Figure 2-10. J3 Analog Control Output Connector, Mainframe Rear Panel View

Table 2-8. J3 ANALOG CTRL OUT Connector Pinout

Pin	Name	Function	Signal Level
F	SYNCH-OUT	Input/output: SYNC bus differential signal with SYNC-L	RS-485 logic levels referenced to module AGND
R	SYNCL-OUT	Input/output: SYNC bus differential signal with SYNC-H	RS-485 logic levels referenced to module AGND
U	CURRH-OUT	Input/output: CURR bus differential signal with CURR-L	10V analog signal referenced to module AGND
N	CURRL-OUT	Input/output: CURR bus differential signal with CURR-H	10V analog signal referenced to module AGND
S	CMDH-OUT	Output: CMD bus differential signal with CMD-L	10V analog signal referenced to module AGND
H	CMDL-OUT	Output: CMD bus differential signal with CMD-H	10V analog signal referenced to module AGND
K	/FLTBUS-OUT	Input/Output: summary fault signal bus	5V digital signal referenced to module AGND
T	AGND-OUT	Analog signal reference	Module circuit common AGND referenced to output return (negative) terminal
J	CHAS-GND	Chassis ground	Chassis
A,C, D,G, H,I,K, L, M	-	Reserved	-

J4 ANALOG CONTROL IN

Refer to Figure 2-11 for a view of the ANALOG CTRL IN, J4, connector. The pinout and functions of the connector are presented in Table 2-9. The associated maximum wire gauge for connector terminations, and recommended maximum wire lengths are presented in Table 2-10.

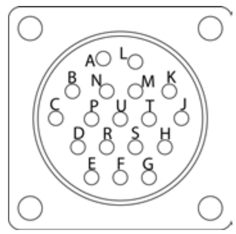


Figure 2-11. J4 Analog Control Input Connector, Mainframe Rear Panel View

Table 2-9. J4 ANALOG CTRL IN Connector Pinout

Pin	Name	Function	Signal Level
F	SYNCH-IN	Input/output: SYNC bus differential signal with SYNC-L	RS-485 logic levels referenced to module AGND
R	SYNCL-IN	Input/output: SYNC bus differential signal with SYNC-H	RS-485 logic levels referenced to module AGND
U	CURRH-IN	Input/output: CURR bus differential signal with CURR-L	10V analog signal referenced to module AGND
N	CURRL-IN	Input/output: CURR bus differential signal with CURR-H	10V analog signal referenced to module AGND
S	CMDH-IN	Output: CMD bus differential signal with CMD-L	10V analog signal referenced to module AGND
H	CMDL-IN	Output: CMD bus differential signal with CMD-H	10V analog signal referenced to module AGND
K	/FLTBUS-IN	Input/Output: summary fault signal bus	5V digital signal referenced to module AGND
T	AGND-IN	Analog signal reference	Module circuit common AGND referenced to output return (negative) terminal
J	CHAS-GND	Chassis ground	Chassis
A,C,D, G,H,I,K ,L, M	-	Reserved	-

Table 2-10. Mainframe Connector Terminations

Mainframe J1, J2, J3, J4, and J5 Connector Wire Size/Length			
Connectors J1 and J2 contain high-speed digital signals that require controlled cable impedances; connectors J3 and J4 contain noise-sensitive analog signals. Therefore, to maintain signal integrity, cables must conform to construction requirements of AMETEK cable assembly 53800054.			
Connector	**Pin**	**Maximum Wire Gauge, AWG**	**Maximum Wire Length, ft**
J1	All	22	30, total aggregate for all Mainframe interconnecting cables
J2	All	22	30, total aggregate for all Mainframe interconnecting cables
J3	All	20	30, total aggregate for all Mainframe interconnecting cables
J4	All	20	30, total aggregate for all Mainframe interconnecting cables
J5	All	10	Dependent on input source voltage and permitted line drop at 24A per line maximum current for fully populated Mainframe

2.4.10 WIRE SELECTION

Input/output wiring must have a current carrying capacity compatible with the current rating of the ReFlex Power™ system. The maximum current rating of a wire is dependent on the materials used in its construction, and is primarily limited by the insulation. The current must be limited so that the temperature rise of the wire does not result in an operating temperature that exceeds the rating of the wire.

WIRE CURRENT CAPACITY

Table 2-11 shows maximum current ratings, based on a cable of three conductors, that will produce an approximate 30ºC temperature rise above ambient. When wiring must operate in areas with an elevated ambient temperature or bundled with other wiring, heavier gauges or higher temperature-rated wiring should be used.

Although wire with higher temperature rated insulation will allow operation at higher currents, the total voltage drop would also be increased for a given wire gauge. For applications where voltage characteristics, such as regulation, are important, it may be necessary to size the wire based on total voltage drop instead of temperature rise.

Table 2-11. Wire Data

AWG	Copper Area, cm^2	Resistance, Ω/m at 20 °C	Resistance, Ω/m at 100 °C	Current Rating, A for 30ºC Rise
6	0.133	0.0013	0.0017	54
8	0.0837	0.0021	0.0028	40
10	0.0526	0.0033	0.0044	27
12	0.0331	0.0052	0.0069	21
14	0.0208	0.0083	0.011	16
16	0.0131	0.0132	0.0174	12
18	0.00823	0.0209	0.0276	10
20	0.00518	0.0333	0.044	7.5
22	0.00326	0.053	0.07	5.5

WIRE VOLTAGE DROP

For applications where regulation is important, the contribution of the load wiring to voltage drop between source terminals and the load must be considered. The wire gauge must be selected to maintain an acceptable total voltage drop for the load wiring under the maximum peak current. The resistance of the load wiring must be determined for the sum total length of the output lead and the return lead. The total voltage drop is the sum of the individual drops in the output and return leads. Table 2-11 gives the resistance per meter (m) of various wire gauges at 20 °C and 100 °C.

Use the following equation to calculate the resistance for other wire temperatures:

R = R20 °C x [1 + 0.004 x (T - 20 °C)]

where,

R = resistance, Ω/m, at temperature T

R20 °C = resistance, Ω/m, at 20 °C

T = temperature of wire, °C

The voltage drop (per output or return lead) could be calculated using the following equation:

V = I x L x R20 °C x [1 + 0.004 x (T - 20 °C)]

where,

V = total voltage drop, V

I = current, A

L = length of wire, m

R20 °C = resistance of wire, Ω/m, at 20 °C

T = temperature of wire conducting current, °C

SECTION 3
CONTROLLER

3.1 GENERAL DESCRIPTION

The ReFlex Power™ system Controller (RFPC) provides a single command and status communication port for all power assets (power supplies, loads) within the ReFlex Power™ system. The ReFlex Power™ architecture is essentially a distributed processor system, and the role of the RFPC is command interpreter and redirector plus manager of module status messages.

The primary functions of the RFPC are:

- Provide the system control interface
- Parse commands into compressed internal formats
- Direct commands to the target assets
- Maintain the system configuration
- Provide direct control system interfaces
- Control power
- Indicate global status
- Return error and fault messages
- Indicate interface communication link activity

The module operates as part of a remotely controlled system. It utilizes the ReFlex Power™ Mainframe backplane for input power distribution and control/communications interface. Through the ReFlex Power™ Controller module, communications with the user host controller is established for operation, configuration control and calibration. All connections to the system and discrete control signal interface are available on the module front panels.

The module utilizes high-frequency power conversion for high efficiency to maximize power density and realize lightweight and small size. The module is housed in a single-width enclosure, 1.4” W x 6.75” H x 15” D, and weighs 2.4 lb. Mounting within the Mainframe is facilitated with chassis guides, backplane guide pins, and front panel captive fasteners for securing the module. The thermal design features integral, variable-speed fans so that the cooling performance scales with internal temperature, minimizing the audible noise and airflow requirements.

The RFPC module may be located in any chassis slot. It will automatically sense both the slot and chassis address provided by the specific backplane connector where it is inserted. This unique physical address is used to form the backplane communication channel number.

The unique features of the ReFlex Power™ system of reconfigurablity and extensibility are made possible through the use of the latest in controls technology. An FPGA-based implementation uses VHDL, embedded processor cores for firmware-based systems control, ARCnet™ inter-module communication and LAN system communications. The RPFC descriptions herein are with a LAN interface unless otherwise stated. The LAN network interface conforms to IEEE 802.3 standard. Network transmission conforms to 10 BASE-T and 100 BASE-TX specifications with rates up to 100 Mbps supported.

The command interface for the RFPC can be direct via Standard Commands for Programmable Instrumentation (SCPI) that conforms to the IEEE 488.2 specification. Alternatively, a set of up to three Interchangeable Virtual Instrument (IVI) Communication Drivers are available, one for DC, for AC, and for Load assets. The driver provides for a convenient Windows programming interface with support for C, C++, C#, VB and related programming languages.

3.2 FEATURES

The ReFlex Power™ system is modular. The mechanical design is ruggedized for harsh environments, including mobile applications, as well as general-purpose industrial and laboratory rack-mount Automatic Test Equipment (ATE).

3.2.1 GENERAL DESCRIPTION

The ReFlex Power™ system does not provide a means to disconnect itself from the AC/DC input service. The front panel POWER switch of the Controller module in the Mainframe does not disconnect the AC/DC input line from the modules or Mainframe. Ensure that a suitable disconnecting device is incorporated into the system installation, so that isolation will be provided when it is opened. The switch or circuit breaker must be located close to the ReFlex Power™ system, within reach of the operator, and clearly labeled as the disconnection device.

3.2.2 General Features

- Small size, light weight
- Digital control
- Universal inputs: AC (50/60 Hz, 400 Hz), single-phase, three-phase, or DC
- Opto-isolated remote turn-on and shutdown of outputs
- Integral variable speed cooling fans for low noise and extended fan life
- Ruggedized to MIL-PRF 28800F
- Auto-Configuration of system assets

3.2.3 Accessories List

The ReFlex Power™ Controller module includes the following standard accessories:

Operation manual P/N M380056-01 (this manual)

Programming manual P/N M380056-03 (to be used in conjunction with this manual)

Quick Reference Guide P/N M380056-04

3.2.4 Controls and Indicators

The RFPC module operates within the ReFlex Power™ system and is the Controller module for data communications and power control. All connections and discrete control interface to the user application are accessible on the front panel of the module (Figure 3-1). The front panel also has LEDs to indicate operational states. (See Section 3.5.1 for a more detailed description). Input power is routed from the Mainframe through a backplane distribution (Figure 3-2).

See Section 3.4.4 for important instructions regarding the procedures for installing and uninstalling the Controller and any modules.

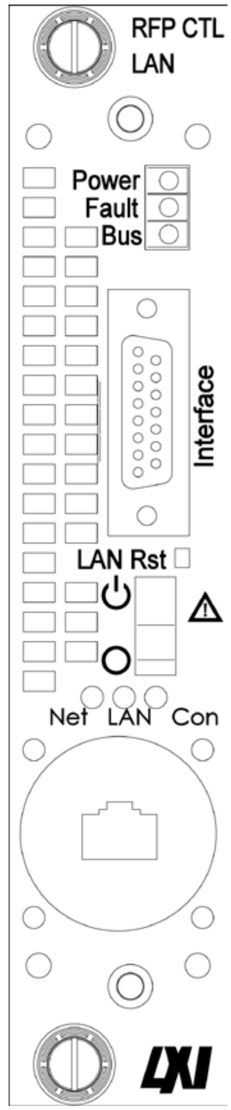


Figure 3-1. ReFlex Power™ Controller Front

The power switch on the Controller front panel (Figure 3-5 for detailed labeling) provides a means to globally turn on/off all modules within all Mainframes comprising a system. Turning on the switch will put the modules in their default power-on states. Turning off the switch will turn off the output power for all AC/DC modules and input power for load modules, open the isolation relays, (if present), and disable internal logic power.

However, the power switch does not disconnect the AC/DC input power to the Mainframes; so, the input sections of the modules remain energized. Therefore, before modules are installed or removed from a Mainframe, the AC/DC input service must be opened with the power disconnect device provided in the system installation. Refer to the Mainframe section of the manual for implementation recommendations.

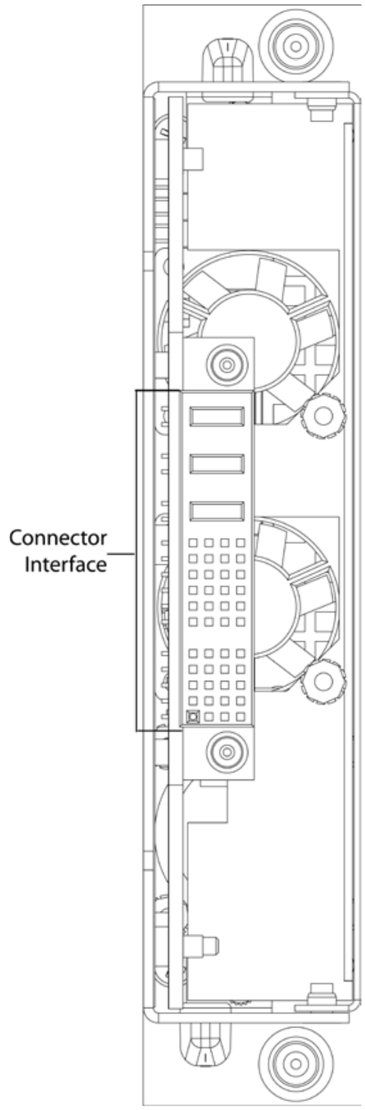


Figure 3-2. ReFlex Power™ Controller Rear

CAUTION

Do not "hot swap" – permanent damage may occur if any ReFlex Power™ module is installed or removed when the AC power is on. See Section 3.4.4 *for correct procedures.*

3.3 SPECIFICATIONS

Performance specifications are valid at 25 °C, +/- 5 °C.

Power On Sequence: Manually operated switch.

Power Off Sequence: Manually operated switch for a controlled power off sequence, or a Remote Inhibit to do an immediate power module output-off sequence.

3.3.1 SUPERVISORY CHARACTERISTICS

OVERTEMPERATURE

Overtemperature protection is implemented with protection monitors that sense excessive internal operating temperature, and will turn off all the modules. The maximum internal temperature is typically 85 °C.

3.3.2 GENERAL CHARACTERISTICS

INPUT VOLTAGE RANGE

103.5-253VAC with AC input; 270VDC, nominal; 210VDC, minimum to 300VDC, maximum; 314VDC, maximum for 2s; 364.5VDC, maximum for 450ms

INPUT CURRENT

Single-phase AC input; unipolar DC input; sinusoidal current with AC input; continuous DC current with DC input.

At 103.5 VAC input, less than 1.7A_{pk}. surge at AC power application; less than 1.3A_{pk} surge when RFPC power switch is turned on and less than 200mA RMS steady state.

3.3.3 INPUT/OUTPUT CONNECTIONS

RJ-45 – host LAN

15-pin D-Subminiature female – control signal interface

3.3.4 Command Sets/Drivers

Direct Communication Language

SCPI

Drivers

IVI DC Class Compliant for DC modules

IVI AC (under review) Class Compliant for AC modules

IVI Loads (projected) Class Compliance for Loads

LAN

IEEE 802.3, 10 BASE T and 100 BASE TX

Command Description

Controller SCPI Standard 1999 command language

Module Response Description

SCPI Standard 1997 command language

Command Execution Time

Command execution time is a function of the module type and grouping. See specific module for detailed specifications.

3.3.5 Mechanical Characteristics

Dimensions

RFPC: 1.4 inch wide, 6.75 inch high, and 15 inch deep

Weight

RFPC: 2.4 pounds, maximum

Cooling Provisions

Operation at maximum limits of output power, ambient temperature, and altitude requires adequate airflow of 15 CFM through module.

Color

Black, color number 27038 per FED-STD-595

3.3.6 Environmental Characteristics

Operating Temperature

Standard: 0 to 50 °C

Extended Range Option: -10 to 55 °C

Operating Altitude

Standard: 0 to 6,500 ft

Extended Range Option: 0 to 15,000 ft

Operating Humidity

95% non-condensing

Operating Shock

Class 3 MIL-PRF-28800F

Operating Vibration

Class 3 MIL-PRF-28800F

Operation Without Fully Populated Mainframe

If Mainframe is not fully populated with modules, filler panels must be installed in empty slots to maintain proper airflow and structural integrity.

Non-Operating Temperature

-40 to 71 °C

Non-Operating Altitude

0 to 50,000 ft

Non-Operating Shock

Class 3 MIL-PRF-28800F

Non-Operating Vibration

Class 3 MIL-PRF-28800F

3.3.7 Regulatory Agency Compliance

Safety Compliance

European Low Voltage Directive, IEC 61010-1:90+A1:92+A2:95, as required for the CE mark.

LVD Categories

Installation Category II; Pollution Degree 2; Class II Equipment; for Indoor Use Only

EMC Compliance

EMC Directive, EN 61326:1998

Electrostatic Discharge

IEC 61000-4-2

Radiated RF Immunity

IEC 61000-4-3

Fast–Transients

IEC 61000-4-4

Surge

IEC 1000-4-5

Conducted RF Immunity

IEC 1000-4-6

Input Power Interruptions

IEC 1000-4-11

Conducted Emissions

CISPR 16-1/2, Class A

Radiated Emissions

CISPR 16-1/2, Class A

3.4 INSTALLATION

This section provides instructions for inspection, installation and initial performance check.

3.4.1 INTRODUCTION

The ReFlex Power™ Controller module has been fully tested prior to shipment; and the module is ready for immediate use upon receipt. However, when first unpacked, the module should be inspected to ensure that no shipping damage has occurred.

3.4.2 INITIAL INSPECTION

Perform a visual inspection of the shipping container prior to accepting the package from the carrier. If damage to the shipping container is evident, a description of that damage should be noted on the carrier's receipt and signed by the carrier's driver.

Verify that the proper module and associated accessories have been received, per the Bill of Materials. Perform a visual inspection of the module after it is removed from the shipping container. Check for shipping damage such as dents, scratches, or distortion of the enclosure.

If external damage is evident, there may be internal damage as well. Immediately contact the carrier and file a claim for concealed damage. In addition, the shipping container and filler material should be saved for inspection. Forward a report of the damage to the Customer Care Department where an associate will provide instructions for repair or replacement of the unit.

3.4.3 LOCATION CONSIDERATIONS

The RFPC module is designed for use within the ReFlex Power™ Mainframe and can be inserted within any slot of the Mainframe. Since the module is fan–cooled, it requires adequate clearance at the air intake of the front panels so that airflow is not impeded.

AIRFLOW REQUIREMENTS

Provide adequate clearance for adequate air intake through the front panels and exhaust through the rear.

Ensure that the ambient air temperature at the front panel air intake does not exceed 55°C.

Install filler panel(s) in any empty slot(s) of the Mainframe.

CAUTION
Inadequate airflow and excessive ambient air temperature could result in overheating and thermal shutdown.

3.4.4 INSTALLATION

CAUTION
The module contains ESD sensitive circuitry. Follow appropriate handling and grounding procedures to prevent damage to the module. The module should be handled by the enclosure, with care to protect the connectors from ESD discharges.

CAUTION
Input power must be disconnected from the Mainframe before a module is inserted or extracted. Inserting or extracting a module with power installed (hot-swapping) could result in damage to the module or Mainframe. Prior to turning power on, ensure that front panel captive fasteners are tightened.

Modules are installed into the Mainframe from the front of the chassis. Refer to Figure 3-3 for the orientation of a module and Mainframe during installation.

1. Ensure that the AC/DC input power is disconnected before installing or removing any module(s).
2. Insert the module into the mainframe, rear panel first, aligning the module guide rails the top and bottom Mainframe guides.
3. Gently slide the module completely into the mainframe until the guide pins of the module rear connector engage the mating backplane connector.
4. Fully seat the module until the front panel inner surface is snug against the mainframe chassis.
5. Secure the module(s) to the Mainframe at the top and bottom of each front panel by turning the captive thumb screws clockwise with a flat head screwdriver to a maximum torque of 20 in-lb.
6. Install a filler panel over any empty slot, and secure in place at the top and bottom by turning the captive thumb screws clockwise with a flat head screwdriver to a maximum torque of 20 in-lb.

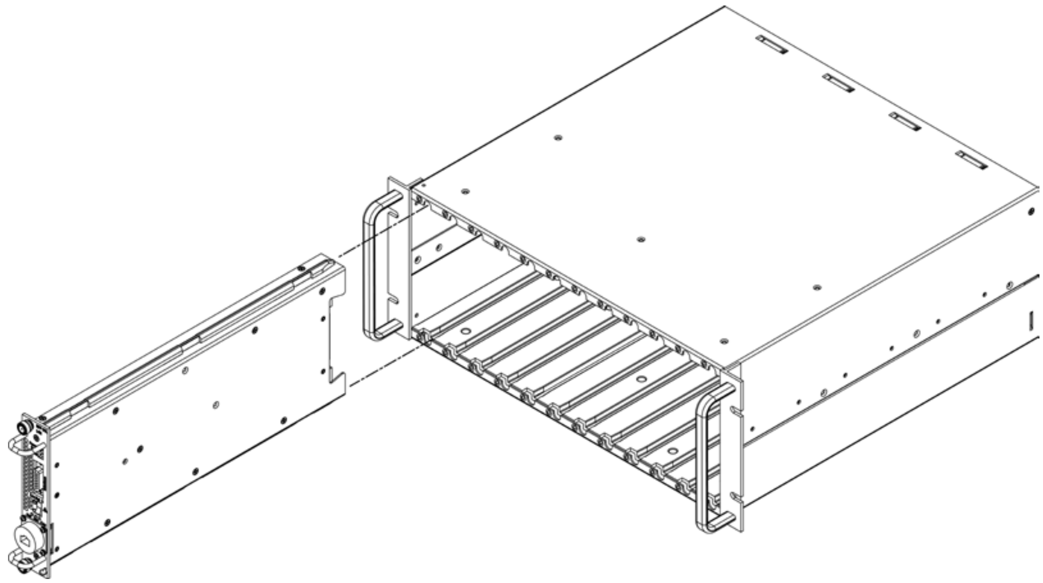


Figure 3-3. Module Installation

3.4.5 INPUT POWER REQUIREMENTS

The RFPC module will operate from a wide variety of AC and DC input power sources, as distributed through the Mainframe. Although the Mainframe could be connected to either single-phase or three-phase AC power, the module has single-phase inputs. It is connected to the source, through the Mainframe, either phase to neutral, or line-to-line, depending on the available source voltage. The power source voltage must be within the range of 103.5-253VAC at 47-63Hz and 400Hz. The input voltage ranges are continuous, and do not require any manual setup.

CAUTION
Exceeding the maximum rated AC/DC input voltage could result in damage to the module.

See Mainframe section for detailed input power requirements, including input power allocation.

3.4.6 AC/DC INPUT OVERCURRENT PROTECTION

Over-current protection must be provided externally, within the system installation, for the AC/DC input of the Mainframe. Refer to the Mainframe section of this manual for recommendations.

3.4.7 AC/DC Input Disconnect Device

The ReFlex Power™ system does not have any means to disconnect it from the AC/DC input service. The front panel POWER switch of the Controller module in the Mainframe does not disconnect the AC/DC input line from the modules or Mainframe. Ensure that a suitable disconnecting device is incorporated into the system installation, so that isolation will be provided when it is opened. The switch or circuit breaker must be located close to the ReFlex Power™ system, within reach of the operator, and clearly labeled as the disconnection device. In multi-Mainframe systems, each Mainframe has an independent AC/DC input, so the input disconnect device should simultaneously open/close the input connection to all assets comprising the system.

WARNING

To prevent a shock hazard, ensure that the AC/DC input disconnect device is open, and that the safety ground conductor is connected to the rear panel ground stud, before removing/inserting modules from/into the Mainframe. The Mainframe backplane input power distribution remains energized whenever the AC/DC input is connected.

3.4.8 CONNECTORS

The ReFlex Power™ Controller module has all user interface connectors located on the front panel. Two connectors are provided: the host LAN RJ-45, and the control signal interface is a 15-Pin D-Subminiature female.

WARNING
To prevent electrical shock, disconnect the AC/DC input service before making any connections to the module.

USER INTERFACE

Mating Connector Kit

ReFlex Power™ Controller (RFPC) Mating Connector Kit - AMETEK Part No. 5380269-01, mates with RFP-C1LAN-0000-XXXX, and includes the following:

Bill of Material

Item	AMETEK Part No.	Description	Qty	Manufacturer Part No.	Manufacturer	Suggested Source(s)
1	856-993-07	Plug, RJ45, ¼ Turn, 26482, NI	1	RJF6MN	Amphenol Socapex	PEI-Genesis: http://www.pei-genesis.com/ Arrow Electronics: http://www.arrownac.com/
2	856-918-15	Conn, 15P, DSUB, 20AWG, Crimp, Male	1	SD15M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
3	856-975-16	Conn, Backshell, 15P	1	D15000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm

RECOMMENDED TOOLS (NOT INCLUDED WITH MATING CONNECTOR KIT)

Hand crimp: Positronic Industries P/N 9507-0-0-0

Pneumatic crimp: Positronic Industries P/N 9550-1-0

Insertion/extraction: Positronic Industries P/N M81969/1-02

INTERFACE CONNECTOR

Provides user access to programmable digital I/O and ReFlex Power™ monitoring signals.

Connector: 15-pin D-SUB
Positronic Connector P/N SD15M1000Z, crimp male,
AMETEK P/N 856-918-15
Crimp contacts: Positronic Industries P/N MC7520D (initially supplied with connector)

Backshell: Positronic P/N D15000Z00, AMETEK P/N 856-975-16

Wire size: Recommended 22 AWG (max 20 AWG)
length: maximum 10 meters (can be extended subject to the environment, cable type, and interface circuits).
Recommend twisted shielded cables.

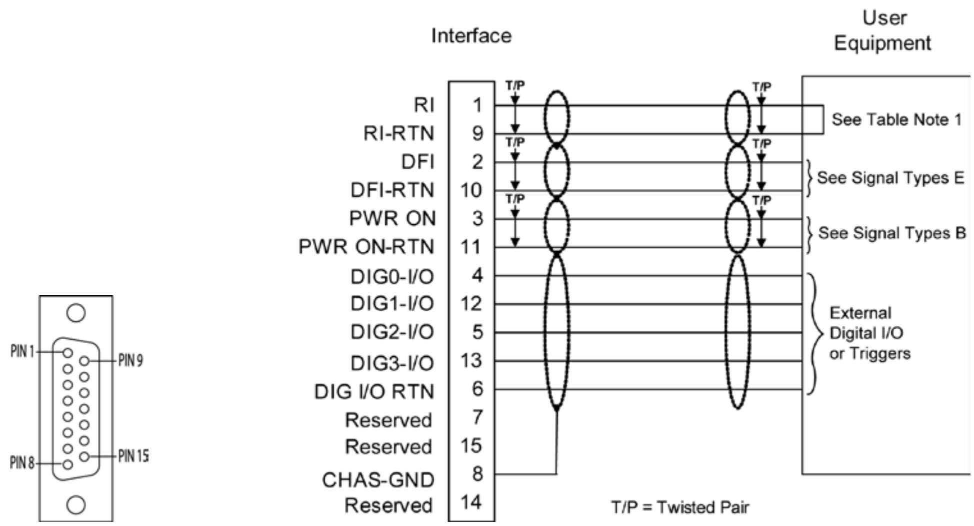


Figure 3-4. Interface Connector, Front Panel View, and Interface Connector Wiring Diagram

Table 3-1. Control Connector Pinout

Pin	Type	Signal	Function	Signal Level
1	A	RI (Remote Inhibit) [1]	Active-High input signal that is utilized to inhibit all power module outputs (Pulled High internally). Low input (or connection between Pins 1 & 9) will enable all outputs.	TTL
2	E	DFI	(Discrete Fault Indicator) Active-High output signal that indicates events/faults within system modules; derived from open collector of floating opto-isolator. External pull-up resistor required.	TTL
3	B	PWR ON	Normally-open relay contacts that close when the ReFlex Power™ Controller power is on	Relay Closure
4	A	DIG0-I/O	Input/Output: programmable digital I/O	TTL

Pin	Type	Signal	Function	Signal Level
5	A	DIG2-I/ O	Input/Output: programmable digital I/O	TTL
6	C	DIGI/O RTN	Signal returns for Programmable Digital Input/Outputs	TTL
7		Reserved		
8	D	CHAS GND	Chassis ground	CHAS GND
9	C	RI RTN[1]	Signal return for RI	TTL_RTN
10	F	DFI RTN	Signal return for DFI emitter of opto-isolator	TTL_RTN
11	B	PWR ON RTN	Return line for PWR ON	Relay Contact
12	A	DIG1-I/O	Input/Output: programmable digital I/O	TTL
13	A	DIG3-I/O	Input/Output: programmable digital I/O	TTL
14		Reserved		
15		Reserved		

Table Note:

[1] The RFPC RI signal must have a low input (or short Pin 16 to Pin 9) to enable all module outputs in an ReFlex Power™ system. If Interface signals are not required in system configuration, order AMETEK P/N 5380509-01, Loop-back Connector Assembly, to short the Remote Inhibit signals, and enable all system module outputs.

SIGNAL TYPES:

A. Bi-Directional Digital I/O. Signals internally pulled up to +5V DC. Externally to be pulled low, (< = 0.5 VDC) relative to the designated signal return, (signal type C).

B. Internal relay contact that is connected to the return when asserted. Absolute maximum rating 2A @ 30 VDC, 0.5A @ 125 VAC. Minimum 10 mA DC or 10 uA AC current required.

C. Return for type A see above.

D. Connected to the metal enclosure of the module. The enclosure of the module is connected to the earth ground connection of the ReFlex Power™ power input.

E. Externally to be pulled up to +5V to +15V DC, relative to Return Type F. Limit sink current to ≤ 40 mA.

F. Return for Type E, Common mode range ≤ 60 Volts.

OPTIONAL INTERFACE CONNECTOR ACCESSORIES

- AMETEK P/N 5380509-01, 15-pin Loop-back Connector Assembly. Includes a jumper wire between Pins 1 and 9 to enable the outputs on all AC/DC/Load modules in a system.
- AMETEK P/N 5380441-01, Controller Module, 9-ft. Unterminated Cable Assembly. Use when interfacing to an external system.
- AMETEK P/N 5380441-03, Controller Module, Right Angle, 9-ft. Unterminated Cable Assembly. Use when interfacing to an external system.

LAN CONNECTOR

Primary user interface to the ReFlex Power™ system via Ethernet connection

Type: RJ45, CAT 5 compatible; protocol conforms to IEEE 802.3 Ethernet-based LANs

Mating connector: Amphenol Socapex P/N RJF6MN, AMETEK P/N 856-993-07

Wire size: Standard CAT 5e 10/100-Base-T cable

Maximum length: 10 meters (can be extended subject to the environment and cable type).

LAN CONNECTOR PINOUT

Pin	Name	Function	Signal Level
1	TX+	Transmit data positive, twisted differential pair with TX-	IEEE 802.3
2	TX-	Transmit data negative, twisted differential pair with TX+	IEEE 802.3
3	RX+	Receive data positive, twisted differential pair with RX-	IEEE 802.3
4	NA		N/A
5	NA		N/A
6	RX-	Receive data negative, twisted differential pair with RX+	IEEE 802.3
7	NA		N/A
8	NA		N/A

3.5 OPERATION

The ReFlex Power™ Controller (RFPC) module functions under remote control through a host controller. The RFPC module serves as a communications portal between the power supply modules and the remote host controller. All aspects of operation could be achieved through use of commands that comply with the requirements of the SCPI Standard 1999 command language. Additional discrete digital control signals are available for dedicated hardware interface. All connectors for control are accessible on the front panel.

3.5.1 CONTROLS AND INDICATORS

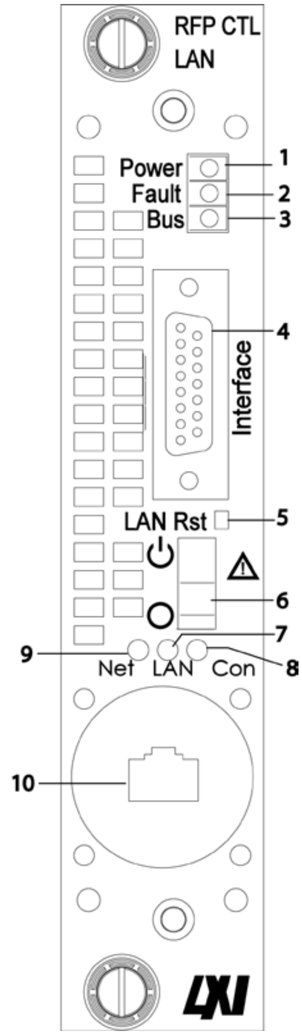


Figure 3-5. RFPC Front Panel Controls, Indicators, and Connectors

1 Power – green LED indicates Controller power is On.

2 Fault – Red LED indicates either the Controller or any power module has detected a high level system fault.

3 Bus - Green LED indicates Controller internal communication is in process.

4 Interface connector providing hardware interface for remote isolated digital control signals. Refer to Section 3.4.8 for connector information.

5 LAN Rst – Recessed pushbutton to reset the Controller to the LXI LAN default requirements.

6 Power 0n/Off switch: rocker switch for RFPC internal power to the modules.

7 Lan – Green LED indicates LXI™ status.

8 Con – Green LED indicates LAN connectivity.

9 Net – Amber LED indicates LAN network activity.

10 LAN Connector for 10/100 Base-T Category 5 Ethernet cable RJ-45. Refer to Section 3.4.8 for connector information.

3.5.2 MODES OF OPERATION

The RFPC Communicates to the Host system through a TCP/IP LAN connection to control the ReFlex Power™ System. No other communication interface exists

3.5.3 DEFAULT OPERATIONAL CONDITIONS

When the RFPC module is first powered on, the following parameters are set to default values:

- RFPC LAN Parameters are at either Factory Default (DHCP enabled; Auto-IP enabled) or User Default settings.
- All Modules are in initial power up default state, relays, if present, are open.
- All status reporting data structures are clear: including the Protection Event Status Register, Standard Event Status Register, and Error/Event Queue. Enable-masks are clear.

3.5.4 INITIAL FUNCTIONAL TESTS

Slot positions count from left to right with the left most slot number in the first chassis designated as 1. The first chassis in the set of chassis contains slots 1 through 12 (Figure 3-6). The first chassis is the one with output connections installed, but no input connections installed, (these can be seen on the rear of the ReFlex Power™ chassis). The second chassis contains slots 13-24 and so forth through all chassis in the system.

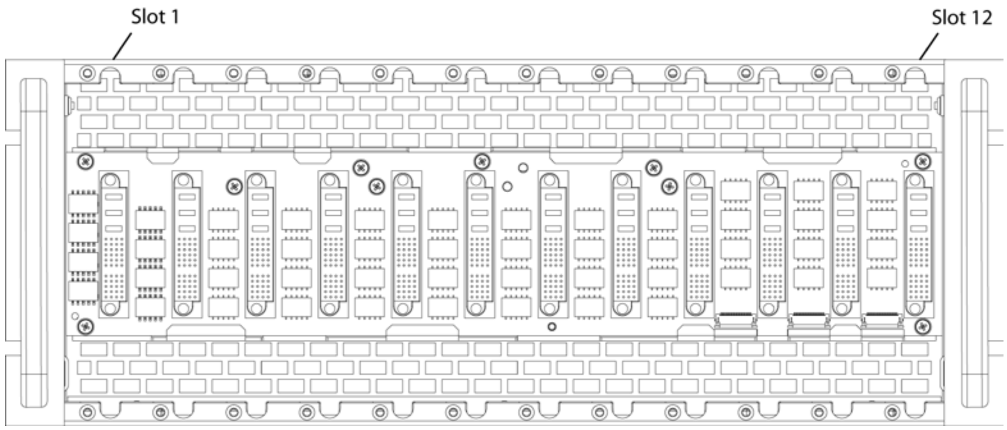


Figure 3-6. Slot Numbering Assignment, Empty Mainframe Front View

All modules use only one backplane connection, which is always the right most backplane connector encompassed by the module's width. This is the slot number that determines the module's address, (that is the sum of the chassis number, zero based, and the slot number).

POWER-ON CHECK

After all the modules are installed, the ReFlex Power™ system is ready for initial operational check. It is recommended that the system be checked prior to connecting any control and/or power to the modules. Turn on the Power switch on the front panel of the RFPC. This will sequentially cause the following to occur:

- The RFPC and all power modules installed will turn on their Power indicators (green) indicating their internal power supplies are on.
- The RFPC and all power modules will start the configuration process. This requires about 15-30 seconds.
- The RFPC typically completes its configuration process first but delays its communication. When it does communicate, its Bus LED (green) lights in an irregular blinking pattern.
- Each power module, after successfully completing the configuration process, will also flash its Bus indicator, (green) signaling that it is starting the internal communication process.
- Any module that steadily illuminates, or blinks it's Fault indicator, (red) at the completion of this process has detected an internal fault during the power on self-test. Troubleshooting information is provided later in this manual.

COMMUNICATION/CONFIGURATION CHECK

After all modules have completed their Power-On Self Test, the ReFlex Power™ is ready for initial communication and configuration check. It is recommended that the system be checked prior to connecting any loads or power to the Power modules.

1. Install a LAN interface cable between the host controller and the RFPC module front panel RJ-45 connector.
2. Configure the RFPC for communications with the host controller. (Refer to either the Quick Reference Guide or to the programming manual for set-up instructions)..
3. The modules will first execute a power-on self-test. Also at power on, the internal fans are run at maximum speed for several seconds, and then revert to a speed dictated by the internal module temperature. Wait until all of the modules have finished initializing before continuing.
4. Verify communications with the RFPC by issuing the SCPI command, **`*IDN?`**

   The RFPC should respond with its identification string.
5. Verify that all of the modules have completed their initialization by issuing the SCPI command, **`EIB:CONF:DNUM?`**.

   This will return the total number of modules including the RFPC that have been initialized in the system.
6. Verify each module type and location by issuing the SCPI command, **`*IDN[n]?`**, where **`n`** is a channel number that corresponds to the module address.

   The module should respond with its identification string.

All modules respond to the SCPI identification query, *__`IDN[n]?`__ where **`n`** is the module address.

To obtain the RFPC's identification information, issue either of the following:

1. Enter the SCPI command, **`*IDN?`**
2. Enter **`*IDN[n]?`** where **`n`** is the RFPC's module address.

The responses are identical.

Repeat the **`*IDN[n]?`** command for each power module in the system using their correct channel address **`[n]`**. The response provides information in four fields: Company name, Model number, Serial number and Firmware version.

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SECTION 4
AC POWER SUPPLY (ACPS)

4.1 GENERAL DESCRIPTION

The ReFlex Power™ system includes an AC power supply rated at 875VA with two output voltage ranges, 0-140VAC and 0-280VAC. There are two models available; one with an output frequency range of 45-1200 Hz, and another with an extended frequency range of 45-5000 Hz. This AC source is part of a modular family of power assets that integrate into the ReFlex Power™ Mainframe to provide a wide range of features, functionality, and extensive configurability and adaptability. The AC module can be set up to operate as a standalone asset, in combinations of parallel, and in multi-phase groups to extend their voltage, current, and power ratings.

The module operates as part of a remotely controlled system. They utilize the ReFlex Power™ Mainframe backplane for input power distribution and control/communications interface. Through the ReFlex Power™ Controller module, communications with the user host controller is established for programming, read back, and configuration control. All connections to the user load and discrete control signal interface are available on the module front panels.

The module utilizes high-frequency power conversion for high efficiency to maximize power density and realize lightweight and small size. The module is housed in a three-width enclosure, 4.2” W x 6.75” H x 15” D, and is only 11.4 lb. Mounting within the Mainframe is facilitated with chassis guides, backplane guide pins, and front panel captive fasteners for securing the modules. The thermal design features integral, variable-speed fans so that the cooling performance scales with the complement of modules in the Mainframe, and their output loading, minimizing the audible noise and airflow requirements.

The unique features of the ReFlex Power™ system for reconfigurability and extensibility are made possible through the use of the latest in controls technology. An FPGA-based implementation uses VHDL digital feedback control systems, embedded processor cores for firmware-based systems control, and ArcNet® inter-module and Controller module communications. Conventional analog circuitry has been consolidated into the digital domain to benefit from its inherent stability, and to enable new levels of functionality and adaptability that is not practical with the analog approach.

4.2 FEATURES

The ReFlex Power™ system of AC power supply brings modularity to AC power assets, and makes possible a high degree of reconfigurability and adaptability through a Mainframe-based architecture. It extends the modular configuration to high power AC assets, without compromising performance or the controls feature set. The mechanical design is ruggedized for harsh environments, including mobile applications, as well as general-purpose industrial and laboratory rack-mount ATE.

4.2.1 GENERAL FEATURES

- High power density
- Small size, light weight
- Up to three modules per Mainframe
- Digital control loops
- 16-bit control and measurement
- Remote voltage sensing
- Master/Slave paralleling, and multi-phase group.
- Constant-Voltage and constant-current regulation with automatic crossover
- Power Factor Correction (PFC)
- Universal inputs: AC (50/60 Hz, 400 Hz), DC, single-phase, three-phase
- Opto-isolated remote shutdown of output
- Trigger-In and trigger-out, and general purpose digital I/O user interface
- Integral output relays for isolation
- Integral variable speed cooling fans for low noise and extended fan life
- Ruggedized to MIL-PRF 28800F
- Software calibration
- Auto-Configuration of system assets
- User stored settings

- User programmable supervisories for current and voltage
- ACPS IVI drivers
- 2 models with Output Frequency Range 45 to 1200 Hz or 45 to 5000 Hz
- Auxiliary Output, 22.6 % of Main 140 VAC output, 61VA (low range, 350-1000 Hz), 2A maximum
- Two ranges on output, 0-140VAC, and 0-280 VAC
- Direct-Coupled output
- Measurement capabilities of: $V_{\mathbf{RMS}}$, $I_{\mathbf{RMS}}$, Frequency, Phase, I_{pk} (versions 2.0 and 3.0) and Active Power, Apparent Power, Reactive Power, Power Factor, Crest Factor (version 3.0 only).
- +/- 30 A_{pk}, inrush current.

4.2.2 ACCESSORIES LIST

The ReFlex Power™ AC power supply modules include the following standard accessories:

- Operation Manual, P/N M380056-01 (this manual)
- Programming Manual, P/N M380056-03
- Quick Reference Guide, P/N M380056-04

4.2.3 CONTROLS AND INDICATORS

The AC power supply module operates within the ReFlex Power™ system as part of an automated test system, so there are no user manual controls. They rely on the Mainframe and Controller module for control, status and data communications, and for input/output connections to the user application. All output load connections and discrete control interface to the user application are accessible on the front panel of the modules. Also, the front panel has indicators for annunciation of the operational state. Input power is routed from the Mainframe through a backplane distribution.

Figure 4-1 shows a front view of the 875 VA ACPS module. Figure 4-2 shows a typical rear view of the modules with the backplane connector interface for input power, discrete digital control signals, analog control signals, and data communications.

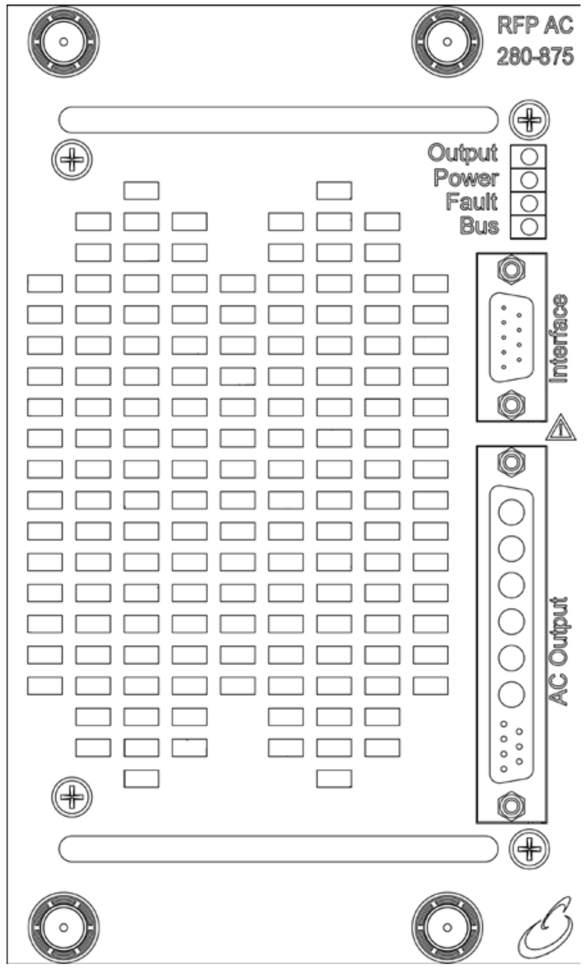


Figure 4-1. ACPS Module Front Panel (875VA)

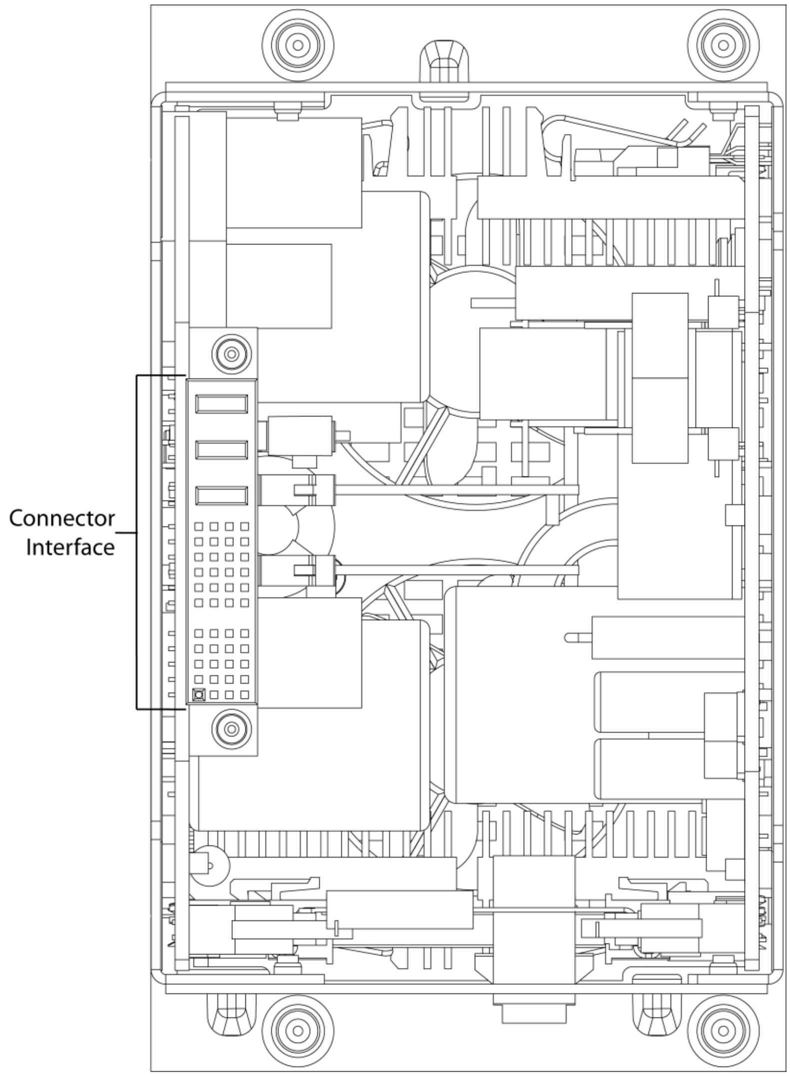


Figure 4-2. Rear View of Typical AC Supply Module

4.3 SPECIFICATIONS

All specifications are valid after a 30-minute warm-up time. Module could be used at reduced accuracy immediately following power-on. All accuracy specifications are plus/minus variations around the nominal parameter values, unless otherwise noted. Unless otherwise specified, requirements apply at the front panel output terminals, over the entire programming range, and with remote sense connected to front panel terminals. Performance specifications are valid following calibration at 25 °C, +/- 5 °C.

4.3.1 PRODUCT MATRIX

Model	Voltage Full-Scale Rating	Current Full-Scale Rating	Power Rating	Module Width
ACPS	0-140V; 0-280V	7.0A; 3.5 A	875 VA	Triple, 4.2”

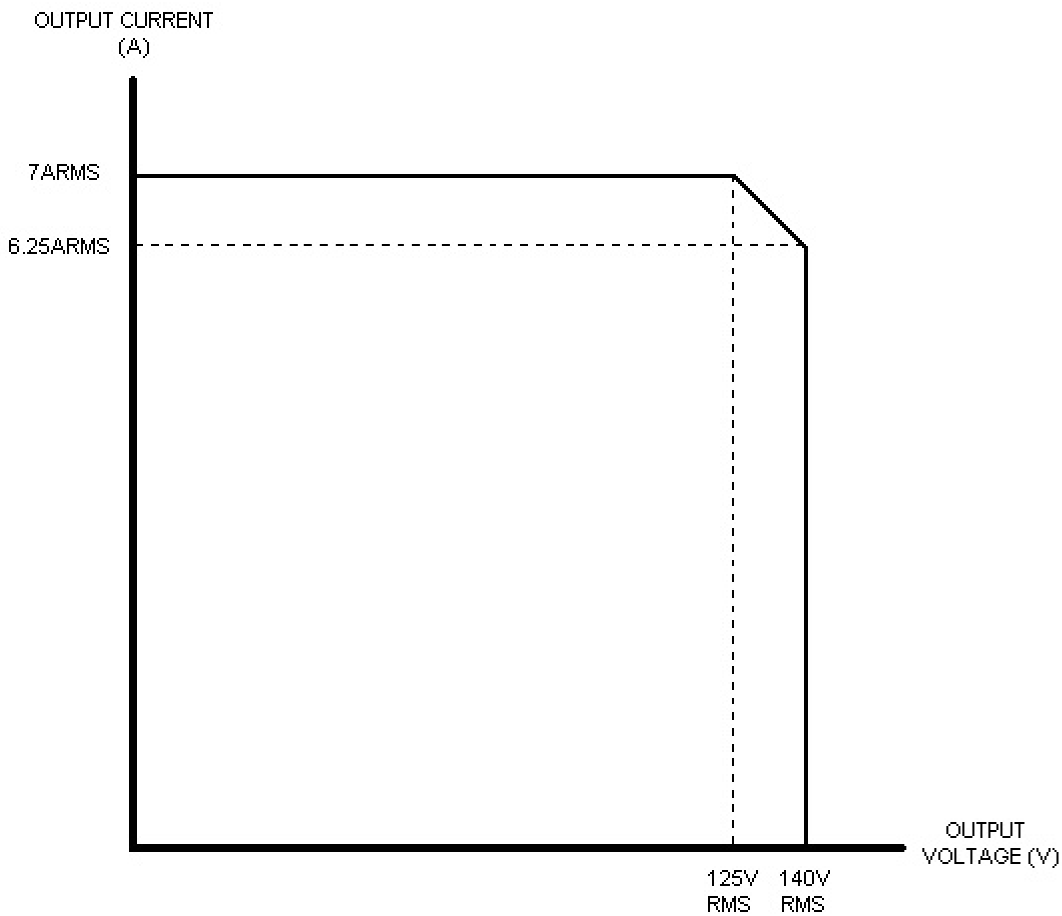


Figure 4-3. Power Limits of AC Supply Module

4.3.2 OUTPUT CHARACTERISTICS

Voltage Programming Range

0 to 102% of full scale

Voltage Digital Programming Accuracy

(0.1% + 0.2%/kHz) of full scale, at 25 °C, +/- 5 °C; from .25% to 102% of voltage range

Voltage Digital Programming Resolution

0-140VAC range: 20mV; 0-280VAC range: 40mV

Voltage Temperature Drift

0.05% of full scale/degree °C, maximum

Voltage Stability

0.1% of full scale per week at constant line, load, and temperature
0.4% of full scale per 1000 hours at constant line, load, and temperature

Voltage Load Regulation

RMS load regulation is 0.1% of full scale for 100% resistive load change

Voltage Line Regulation

RMS line regulation is 0.1% of full scale for line variation of 10% of nominal

Voltage Load Transient

With a load change from no load to full load, or vice versa, the maximum undershoot or overshoot shall be as follows:

0.5% of full scale voltage at 60 Hz

1% of full scale voltage at 400 Hz

5% of full scale voltage at 1200 Hz

10% of full scale voltage at 5000 Hz

And will have a maximum recovery time of 100ms to within .5% of full scale voltage; tested at nominal output voltage and after 1 mSec, to exclude the initial output filter spike.

Voltage Line Transient

Less than 1% of full scale maximum excursion decaying to steady-state value, within 0.1% of full scale, within 100ms for 10% line change

Auxiliary Output

The Auxiliary output tracks the primary AC Voltage output, 140 VAC range only, at 22.6% of the output voltage. The Auxiliary Output is limited to 61VA, 31.6 VAC at 2 A maximum. The Auxiliary Output frequency is limited within the range of 350-1000 Hz.

Remote Sense Capability

Remote sense shall compensate for at least 0.75V_{RMS} per load line leg. Opening the sense lines during operation shall not damage the module or the load; module will continue to maintain output, but with reduced programming accuracy to 5%. Misconnection of the sense leads shall not result in an output voltage in excess of the over-voltage protection limit. Sense leads connected with reversed polarity will result in shutdown of the output. Excessive load line voltage drop will result in shutdown of the output.

Current Programming Range

0 to 102% of full scale

Current Digital Programming Accuracy

(0.5% + 0.75%/kHz) of full scale, at 25 °C, +/- 5 °C; from 2% to 102% of current range

Current Digital Programming Resolution

6mA

Current Temperature Drift

0.05% of full scale/°C

Continuous Current

7A, maximum for 0-140VAC range;
3.5A, maximum for 0-280VAC range (Not to exceed 875 VA)

Allowable Transient Current

10A_{RMS}, maximum for 0-140VAC range;
5A_{RMS}, maximum for 0-280VAC range;
time duration of 0.5s, maximum

Frequency

Programming Range: 1.2 kHz option: 45 through 1200 Hz
5.0 kHz option: 45 through 5000 Hz

Programming Accuracy: 0.01% of set point + 0.01%/kHz, at 25 °C, +/- 5 °C

Programming Resolution: 0.1 Hz to 1 kHz
0.5 Hz to 5 kHz

Phase

Programming Range: 0-360 degree; B-phase and C-phase with respect to A-phase; the leftmost module shall be A-phase (the master); adjacent modules to the right of A-phase would be B-phase and C-phase; counterclockwise phaser rotation is assumed; therefore, the phase angle offset is leading the master reference.

Programming Accuracy: 1 degree + 1 degree/kHz for balanced resistive load measured with respect to A-phase, at 25 °C, +/- 5 °C.

Programming Resolution: 0.25 degree

4.3.3 MEASUREMENT

RMS Voltage Range

low range: 0-145VAC
high range: 0-290VAC

Voltage Accuracy

(0.1% + 0.2%/kHz) of full scale, at 25 °C, +/- 5 °C; from 0.25% to 102% of full scale.

Voltage Resolution

0-140VAC range: 20mV; 0-280VAC range: 40mV

RMS Current Range

0-10A_{RMS}

Current Accuracy

(0.5% +0.3%/kHz) of full scale, at 25 °C, +/- 5 °C; from 1.5% to 102% of full scale.

Current Resolution

6mA

Active Power Range (version 3.0 and up only)

0 to 1000 Watt

Active Power Accuracy

+/-(1%+0.5%/kHz), @ PF > 0.5

Active Power Resolution

0.1 Watt

Apparent Power Range (version 3.0 and up only)

0 to 1000 VA

Apparent Power Accuracy

+/-(1%+0.5%/kHz)

Apparent Power Resolution

0.1 VA

Reactive Power Range (version 3.0 and up only)

0 to 1000 VAR

Reactive Power Accuracy

+/-(1%+2%/kHz), @ PF > 0.5

Reactive Power Resolution

0.1 VAR

Power Factor Range (version 3.0 and up only)

0 to 1

Power Factor Accuracy

+/-(.02+0.03/kHz), @ > 10% of RMS current range

Power Factor Resolution

0.001

Crest Factor Range (version 3.0 and up only)

0 to 5

Crest Factor Accuracy

+/- .15, @ > 10% of RMS current range

Crest Factor Resolution

0.01

4.3.4 SUPERVISORY CHARACTERISTICS

OverVoltage Protection (OVP)

Programmable OVP shall cause a shutdown in a trip event. It is programmable from 1.4 to 110%, with a resolution of 0.027% of full scale, and an accuracy of 2%.

OverCurrent Protection (OCP)

Programmable OCP shall cause shutdown in a trip event. Programmable from 0.4 to 106% of full scale output current.
Accuracy: 3% of full scale
Resolution: 0.027% of full scale.

Over Temperature

Over temperature protection is implemented with hardware monitors that sense excessive internal heat sink operating temperature, and shut down the power converter.

Short-Circuit

The power supply shall withstand a continuous short-circuit across the output connections, or from output to chassis ground, with no damage to the supply.

4.3.5 GENERAL CHARACTERISTICS

Input Voltage Range

103.5-253VAC with AC input; 270VDC, nominal; 210VDC, minimum to 300VDC, maximum; 314VDC, maximum for 2s; 364.5VDC, maximum for 450ms. Derate output power to 75% at 85VAC, and 85% at 95VAC.

Input Current

Power factor corrected single-phase AC input; unipolar DC input; sinusoidal current with AC input; continuous DC current with DC input.

Power Factor

> 0.95 at full output load, >0.65 at 20% output load, >0.45 at no load

Efficiency

72%, minimum

Front Panel Indicator LEDs

- OUTPUT: green = output enabled and isolation relay closed
- POWER: green = input AC/DC power applied to module
- FAULT: red = internal abnormal operating condition detected; output disabled and isolation relay opened
- BUS: green = internal bus communication established

4.3.6 INPUT/OUTPUT CONNECTIONS

Parallel Grouping

Three modules can be connected in parallel: any module could be a master; adjacent modules to the right (when viewed from the front of the unit) of the master would be slaves; paralleling could be extended between mainframes; control interface is automatically configured; outputs must be externally hardwired in parallel.

Paralleling Performance Degradation

Conforms to requirements of individual module. Programming and measurement accuracy of output current is reduced to 2% of full scale, at 25 °C, +/- 5 °C.

Multi-Phase

Modules are configured as individual AC sources. Their outputs can be combined and programmed to produce multi-phase configurations, up to six phases. Delta and wye loads are supported. Modules must be configured as wye sources with neutrals connected. Delta-connected modules are prohibited.

Output Float Voltage

280V_{RMS}, maximum from either output terminal to chassis

Output Relays

Isolation relays are optionally provided on the main and auxiliary outputs.

4.3.7 COMMAND SETS/DRIVERS

Command Description

SCPI Standard 1999 command language, through Controller Module

Response Description

SCPI Standard 1999 command language, through Controller Module

Command Execution Time

100ms from command request

4.3.8 MECHANICAL CHARACTERISTICS

Dimensions

4.2 inch wide, 6.75 inch high, and 15 inch deep

Weight

11.4 pound, maximum

Cooling Provisions

Operation at maximum limits of output power, ambient temperature, and altitude requires adequate airflow through module: 40 CFM

Color

Black, color number 27038 per FED-STD-595

Acoustic Noise

The speed of the integral fans is linearly variable, as a function of internal heatsink temperature rise, to minimize acoustic noise and extend the fan life. The speed varies from nominally 50% of full-speed to full-speed as the heatsink temperature varies with ambient temperature and power dissipation resulting from the output load.

4.3.9 Environmental Characteristics

Operating Temperature

Standard: 0 to 50 °C

Extended Range Option: -10 to 55 °C

Operating Altitude

Standard: 0 to 6,500 ft

Extended Range Option: 0 to 15,000 ft

Operating Humidity

95% non-condensing

Operating Shock

Class 3 MIL-PRF-28800F

Operating Vibration

Class 3 MIL-PRF-28800F

Operation Without Fully Populated Mainframe

If Mainframe is not fully populated with modules, filler panels must be installed in empty slots to maintain proper airflow and structural integrity.

Non-Operating Temperature

-40 to 71 °C

Non-Operating Altitude

0 to 50,000 ft

Non-Operating Shock

Class 3 MIL-PRF-28800F

Non-Operating Vibration

Class 3 MIL-PRF-28800F

4.3.10 Regulatory Agency Compliance

Safety Compliance

European Low Voltage Directive, IEC 61010-1:90+A1:92+A2:95, as required for the CE mark.

LVD Categories

Installation Category II; Pollution Degree 2; Class II Equipment; for Indoor Use Only

EMC Compliance

EMC Directive, EN 61326:1998

Electrostatic Discharge

IEC 61000-4-2

Radiated RF Immunity

IEC 61000-4-3

Fast–Transients

IEC 61000-4-4

Surge

IEC 1000-4-5

Conducted RF Immunity

IEC 1000-4-6

Input Power Interruptions

IEC 1000-4-11

Conducted Emissions

CISPR 16-1/2, Class A

Radiated Emissions

CISPR 16-1/2, Class A

4.4 INSTALLATION

The ReFlex Power™ AC power supply module has been fully calibrated and tested prior to shipment; the modules are ready for immediate use upon receipt. However, when first unpacked, the module should be inspected to ensure that no shipping damage has occurred.

4.4.1 INITIAL INSPECTION

Perform a visual inspection of the shipping container prior to accepting the package from the carrier. If damage to the shipping container is evident, a description of that damage should be noted on the carrier's receipt and signed by the carrier's driver.

Verify that the proper module and associated accessories have been received. Perform a visual inspection of the module after it is removed from the shipping container. Check for shipping damage such as dents, scratches, or distortion of the enclosure.

If external damage is evident, there may be internal damage as well. Immediately contact the carrier and file a claim for concealed damage. In addition, the shipping container and filler material should be saved for inspection. Forward a report of the damage to the Customer Care Department where an associate will provide instructions for repair or replacement of the unit.

4.4.2 LOCATION CONSIDERATIONS

The AC power supply module is designed for use within the ReFlex Power™ Mainframe. A standalone module could be inserted within any slot of the Mainframe. Parallel-grouped, and Multi-phase grouped modules must occupy contiguous slot locations. Unused slots are allowed within the parallel group, but they must be occupied by a filler panel and no other modules may be placed between paralleled modules; also, the group could extend across two Mainframes.

Since the module is fan–cooled, it requires adequate clearance at the air intake of the front panels so that airflow is not impeded.

AIRFLOW REQUIREMENTS

Provide adequate clearance for adequate air intake through the front panels and exhaust through the rear.

Ensure that the ambient air temperature at the front panel air intake does not exceed 55°C.

Install filler panel(s) in any empty slot(s) of the Mainframe.

CAUTION
Inadequate airflow and excessive ambient air temperature could result in overheating and thermal shutdown.

4.4.3 INSTALLATION

CAUTION
The module contains ESD sensitive circuitry. Follow appropriate handling and grounding procedures to prevent damage to the module. The module should be handled by the enclosure, with care to protect the connectors from ESD discharges.

CAUTION
Input power must be disconnected to the Mainframe before a module is inserted or extracted. Inserting or extracting a module with power installed (hot-swapping) could result in damage to the module or Mainframe. Prior to turning power on, ensure that front panel captive fasteners are tightened.

Modules are installed into the Mainframe from the front of the chassis. Refer to Figure 4-4 for the orientation of a module and Mainframe during installation.

1. Ensure that the AC/DC input power is disconnected before installing or removing any module(s).
2. Insert the module into the mainframe, rear panel first, aligning the module guide rails the top and bottom Mainframe guides.
3. Gently slide the module completely into the mainframe until the guide pins of the module rear connector engage the mating backplane connector.
4. Fully seat the module until the front panel inner surface is snug against the mainframe chassis.
5. Secure the module(s) to the Mainframe at the top and bottom of each front panel by turning the captive thumbscrews clockwise to a maximum torque of 20 in-lb, using a flat blade torque screwdriver.
6. Install a filler panel over any empty slot, and secure in place at the top and bottom by turning the captive thumbscrews clockwise to a maximum torque of 20 in-lb, using a flat blade torque screwdriver.

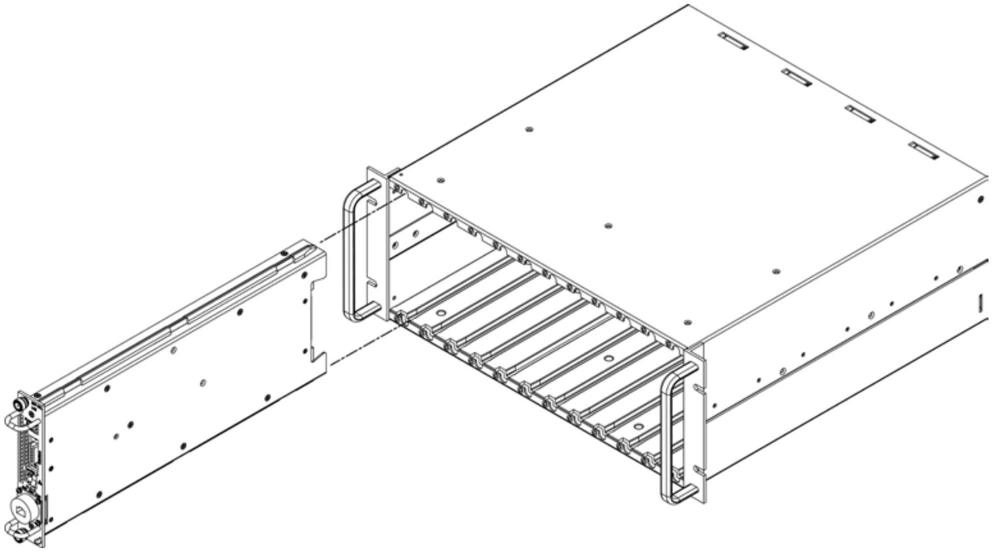


Figure 4-4. Module Installation (1-U-wide shown)

4.4.4 INPUT POWER REQUIREMENTS

The AC power supply module will operate from a wide variety of AC and DC input power sources, as distributed through the Mainframe. Although the Mainframe could be connected to either single-phase or three-phase AC power, the modules have single-phase inputs. They are connected to the source, through the Mainframe, either phase to neutral, or line to line, depending on the available source voltage. The power source voltage must be within the range of 85–264VAC at 47-63Hz and 400Hz, or 210-300VDC. The input voltage ranges are continuous, and do not require any manual setup.

CAUTION
Exceeding the maximum rated AC/DC input voltage could result in damage to the module.

The modules could produce full rated power down to 103.5VAC input. At lower voltages, output power is derated to 85% at 90VAC and 75% at 85VAC. Total aggregate output power of the Mainframe is limited to 6,000W with 200VAC or greater input, and 3,600W at 132VAC and lower input. Each module has power factor correction (PFC) that provides linear AC input current and high power factor, minimizing the required input apparent power.

The Mainframe distributes the input power through backplane connectors to three groups of four slots connected in parallel. The groups are connected to separate pair of pins in the Mainframe rear panel AC/DC input connector (one line and return per connection); the connector has six power pins plus ground. Balance in phase currents can be achieved only if the power modules are located in the Mainframe so that equal distribution between the three groups of slots is maintained, and if the same load is applied to the set of modules in each group.

The load applied to a particular AC/DC input line is dependent on the location of the modules in the Mainframe slots. The slots are grouped in sets of four: Slot 1-4, Slot 5-8, and Slot 9-12. Slot 1 is the left-most slot, as viewed from the front (Figure 4-5). Each of the four slots is supplied by one of the AC/DC input lines. In a double-width and triple-width module, the module connector is located so that it mates to a backplane connector in the right-most slot, as viewed from the front of the Mainframe. Refer to Table 4-1 for Mainframe input connector pinout and power allocation to the Mainframe slots.

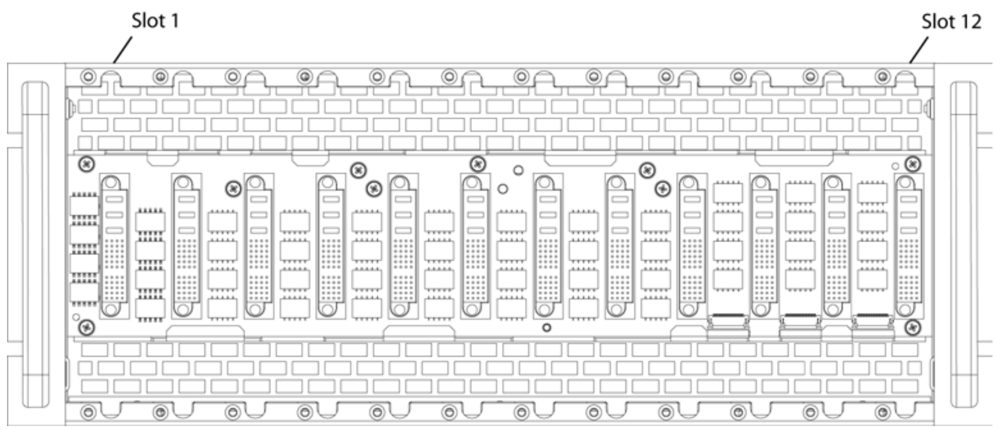
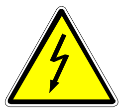


Figure 4-5. Slot Numbering Assignments, Empty Mainframe Front View

Table 4-1. Input Power Allocation

Input Service	Phases	Input Designation	Input Connector Pin	Input Service Connection	Slot Supplied
100/115/120VAC 200/208VAC 220/230/240VAC	1	L1	F	Phase	Slot 1-4
		L1-RTN	E	Return	
		L2	A	Phase	Slot 5-8
		L2-RTN	G	Return	
		L3	B	Phase	Slot 9-12
		L3-RTN	C	Return	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
200/208VAC	3 Delta	L1	F	Phase-A	Slot 1-4
		L1-RTN	E	Phase-B	
		L2	A	Phase-B	Slot 5-8
		L2-RTN	G	Phase-C	
		L3	B	Phase-C	Slot 9-12
		L3-RTN	C	Phase-A	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
200/208VAC 220/230/240VAC	3 Wye	L1	F	Phase-A	Slot 1-4
		L1-RTN	E	Neutral	
		L2	A	Phase-B	Slot 5-8
		L2-RTN	G	Neutral	
		L3	B	Phase-C	Slot 9-12
		L3-RTN	C	Neutral	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
210-300VDC	DC	L1	F	Source	Slot 1-4
		L1-RTN	E	Return	
		L2	A	Source	Slot 5-8
		L2-RTN	G	Return	
		L3	B	Source	Slot 9-12
		L3-RTN	C	Return	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis

A plug/socket connector is provided on the rear panel of the Mainframe for connecting the unit to the AC/DCpower source. The connector also provides a safety ground termination. The input power cable should include a safety ground wire to connect the chassis of the Mainframe to the safety ground of the AC/DC power source. Since the AC input leakage current could exceed 3.5mA, a second safety ground connection is required. It should be connected to the safety ground stud on the rear panel of the Mainframe.



WARNING
A separate, dedicated safety ground wire must be connected to the Mainframe rear panel safety ground stud. Operating the ReFlex Power™ system with the safety ground wire disconnected could result in a shock hazard.

4.4.5 AC/DC INPUT OVERCURRENT PROTECTION

The modules have internal overcurrent protection to provide fault isolation in case failure occurs of internal components or wiring. However, overcurrent protection must also be provided externally, within the system installation, for the AC/DC input of the Mainframe. Refer to the Mainframe manual for recommendations.

4.4.6 AC/DC INPUT DISCONNECT DEVICE

The ReFlex Power™ system does not have any means to disconnect it from the AC/DC input service. The front panel POWER switch of the Controller module in the Mainframe does not disconnect the AC/DC input line from the modules or Mainframe. Ensure that a suitable disconnecting device is incorporated into the system installation, so that isolation will be provided when it is opened. The switch or circuit breaker must be located close to the ReFlex Power™ system, within reach of the operator, and clearly labeled as the disconnection device.

WARNING
To prevent a shock hazard, ensure that the AC/DC input disconnect device is open, and that the safety ground conductor is connected to the rear panel ground stud, before removing/inserting modules from/into the Mainframe. The Mainframe backplane input power distribution remains energized whenever the AC/DC input is connected.

4.4.7 CONNECTORS

The AC power supply module has all user interface connectors located on the front panel. Two connectors are provided: one for the power connections to the load, and the other for control signal interface.

MATING CONNECTOR KIT

ACPS Mating Connector Kit - AMETEK Part No. 5380272-01, mates with RFP-A301K-875-XXXX and RFP-A305K-875-XXXX, and includes the following for both Interface and DC output connectors:

Bill of Material

Item	AMETEK Part No.	Description	Qty	Manufacturer Part No.	Manufacturer	Suggested Source(s)
1	856-214-07	Conn, 13P, DSUB, 8/20AWG, Male	1	CBD13W6M2000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
2	856-745-53	Contact, F-Volt, 3600VRMS, 500C, Male	6	MS4820D-50	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
3	856-247-39	Conn, Backshell, 37P, Strt, 2 PC	1	D37000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
4	856-214-09	Conn, 9P, DSUB, 20-24AWG, Crimp, Male	1	SD9M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
5	856-247-10	Conn, Backshell, 9P, DSUB, 2 PC	1	D9000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm

RECOMMENDED TOOLS (NOT INCLUDED WITH MATING CONNECTOR KIT)

Hand crimp: Positronic Industries P/N 9507-0-0-0

Pneumatic crimp: Positronic Industries P/N 9550-1-0.

Insertion/extraction: Positronic Industries P/N M81969/1-02

Pins A1 through A6 insertion/extraction: Positronic Industries P/N 4311-0-0-0

WARNING
To prevent electrical shock, disconnect the AC/DC input service before making any connections to the module.

AC OUTPUTS

The AC Output connector provides terminations for the output and remote sense connections to the load. Refer to Figure 4-6 for a view of the AC output connector showing pin numbers. The pinout and functions of the AC output connector signals are presented in Table 4-2.

Connector: Positronic P/N CBD13W6M2000Z, AMETEK P/N 856-214-07

Pins A1-A6: Positronic Industries P/N MS4820D-50, AMETEK P/N 856-745-53

Pins 1-7: supplied with connector

Backshell: Positronic P/N D37000Z00/ AMETEK P/N 856-247-39

Wire size:

Pins A1 through A4 maximum gauge 20 AWG (recommended); maximum length 15 ft (Voltage drop at full-rated current ≅1.1V)

Pins A5, A6 maximum gauge 20 AWG (recommended); maximum length 15 ft

Pins 2, 6 maximum gauge 20 AWG (recommended); maximum length 15 ft (Voltage drop at full-rated current ≅0.6V)

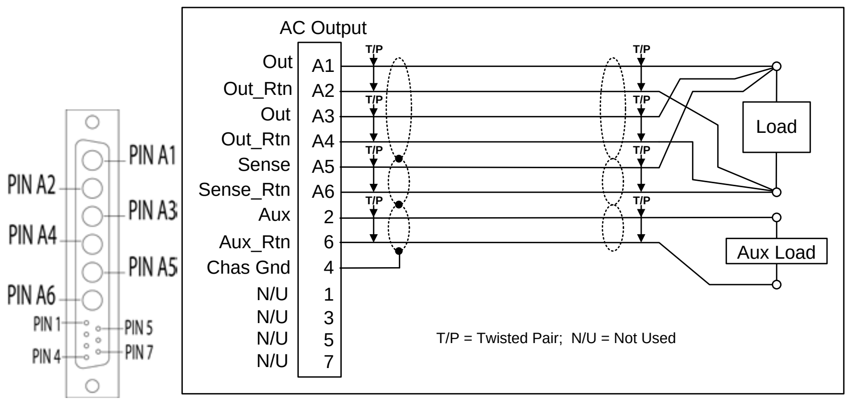


Figure 4-6. ACPS Output Connector, Front Panel View, and Wiring Diagram

Table 4-2. AC Output Connector Pinout

Pin	Name	Function	Signal Level
A1	OUT	Output: module source; connected to A3	280VAC; ±440V_{pk}, maximum to chassis
A2	OUT-RTN	Output: return for source, OUT; connected to A4	280VAC; ±440V_{pk}, maximum to chassis
A3	OUT	Output: module source; connected to A1	280VAC; ±440V_{pk}, maximum to chassis
A4	OUT-RTN	Output: return for source, OUT; connected to A2	280VAC; ±440V_{pk}, maximum to chassis
A5	SNS	Input: remote sense connection for OUT	280VAC; ±440V_{pk}, maximum to chassis
A6	SNS-RTN	Input: remote sense connection for OUT-RTN	280VAC; ±440V_{pk}, maximum to chassis
2	AUX	Output: Module auxiliary output source	35VAC; ±100V_{pk}, maximum to chassis
6	AUX-RTN	Output: return for auxiliary output source, AUX	35VAC; ±100V_{pk}, maximum to chassis
4	CHAS-GND	Shield Ground	Chassis Ground

AC OUTPUT CONNECTOR ACCESSORIES

- AMETEK P/N 5380450-01, ACPS Module, 9ft. Unterminated AC Output Cable Assembly
- AMETEK P/N 5380450-03, ACPS Module, Right Angle, 9ft. Unterminated AC Output Cable Assembly

REMOTE SENSE

Remote sensing is used to compensate for the voltage drop that occurs across the wires connecting the load to the output of the AC power supply module. A separate pair of wires is routed to measure the voltage at the load terminals where precise regulation of the output voltage is desired.

The remote sense leads are connected at the AC Output connector on the front panel of the module. Refer to the subsection above, AC *Outputs*, for information on connector pinout. Connect the SNS terminal to the load terminal connected to the module OUT terminal, and the SNS-RTN terminal to the load terminal connected to OUT-RTN terminal.

Special care is required in routing the sensing leads to prevent noise pickup or coupling to the power leads; refer to the section, Noise and Impedance Effects. The sense leads should be a twisted-pair of at least AWG #22 wire, and may require shielding in high noise environments. Connect the shield to the shield ground terminal, CHAS-GND, of the AC Output connector as required to maximize its effectiveness.

If the remote sense leads are not connected, the AC module will continue to operate but the voltage at the load will no longer be precisely regulated. An internal resistor network exists within the module that connects the output terminals to the remote sense terminals. This network provides the measurement of the output voltage when the remote sense leads are not connected. However, since the voltage is now measured at the output terminals, the voltage drop of the load wiring would no longer be compensated.

Several conditions related to remote sensing are treated as faults and result in shutdown of the output: short-circuiting of the remote sense terminals; connecting the remote sense leads in reverse polarity; excessive line drop in the load wires. When the fault condition is detected, shutdown will result with the output voltage being programmed to zero and the output isolation/sense relays being opened.

INTERFACE CONNECTOR

The Interface connector provides terminations for external connections to digital and analog control signals.

Refer to Figure 4-7 for a view of the connector showing pin numbers. The pinout and functions of the connector signals are presented in Table 4-3.

Connector: Positronic Industries P/N SD9M1000Z, AMETEK P/N 856-214-09
Crimp contacts: Positronic Industries P/N MC7520D (initially supplied with connector)
Backshell: Positronic Industries P/N D9000Z00, AMETEK P/N 856-247-10
Wire size: Maximum gauge 20 AWG (recommended)
Length: maximum 10 meters (can be extended subject to the environment, cable type, and interface circuits).

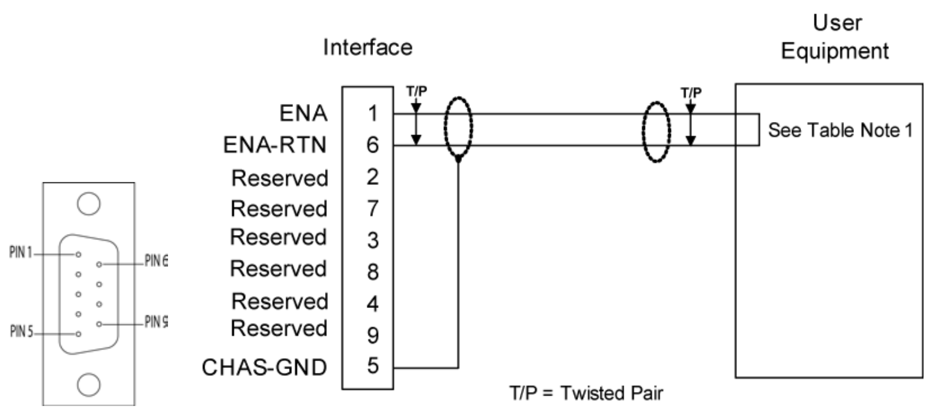


Figure 4-7. Interface Connector, Front Panel View, and Wiring Diagram

Table 4-3. Interface Connector Pinout

Pin	Name	Function	Signal Level
1	ENA[1]	Input: module output enable	TTL logic level
6	ENA-RTN[1]	Input: return for ENA signal; connected to Pin-7/8	Signal common
2	Reserved		
7	Reserved		
3	Reserved		
8	Reserved		
4	Reserved		
9	Reserved		
5	CHAS-GND	Shield ground	Chassis ground

[1] Enable signal is internally pulled up to +5 V with a 10 K resistor. To enable the module, the signal is pulled low (<= 0.5 V) with respect to the ENA RTN signal; this may also be accomplished by shorting Pin 1 to Pin 6.

OPTIONAL INTERFACE CONNECTOR ACCESSORIES

- AMETEK P/N 5380508-01, 9-pin Loop-back Connector Assembly. Includes a jumper wire between Pins 1 and 6 to enable the module outputs.
- AMETEK P/N 5380443-01, Power Module, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.
- AMETEK P/N 5380443-03, Power Module, Right Angle, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.

4.4.8 WIRE SELECTION

Input/output wiring must have a current carrying capacity compatible with the current rating of the ReFlex Power™ system. The maximum current rating of a wire is dependent on the materials used in its construction, and is primarily limited by the insulation. The current must be limited so that the temperature rise of the wire does not result in an operating temperature that exceeds the rating of the wire.

WIRE CURRENT CAPACITY

Table 4-4 shows maximum current ratings, based on a cable of three conductors, that will produce an approximate 30ºC temperature rise above ambient. When wiring must operate in areas with an elevated ambient temperature or bundled with other wiring, heavier gauges or higher temperature-rated wiring should be used.

Although wire with higher temperature rated insulation will allow operation at higher currents, the total voltage drop would also be increased for a given wire gauge. For applications where voltage characteristics, such as regulation, are important, it may be necessary to size the wire based on total voltage drop instead of temperature rise.

Table 4-4. Wire Data

AWG	Copper Area, cm^2	Resistance, Ω/m at 20°C	Resistance, Ω/m at 100°C	Current Rating, A for 30ºC Rise
6	0.133	0.0013	0.0017	54
8	0.0837	0.0021	0.0028	40
10	0.0526	0.0033	0.0044	27
12	0.0331	0.0052	0.0069	21
14	0.0208	0.0083	0.011	16
16	0.0131	0.0132	0.0174	12
18	0.00823	0.0209	0.0276	10
20	0.00518	0.0333	0.044	7.5
22	0.00326	0.053	0.07	5.5

WIRE VOLTAGE DROP

For applications where regulation is important, the contribution of the load wiring to voltage drop from the output terminals of the AC module to the load must be considered. The wire gauge must be selected to maintain an acceptable total voltage drop for the load wiring under the maximum current. The resistance of the load wiring must be determined for the sum total length of the output lead and the return lead. The total voltage drop is the sum of the individual drops in the output and return leads. Table 4-4 gives the resistance per meter (m) of various wire gauges at 20 °C and 100 °C.

Use the following equation to calculate the resistance for other wire temperatures:

R = R20°C x [1 + 0.004 x (T - 20°C)]

where,

R = resistance, Ω/m, at temperature T

R20°C = resistance, Ω/m, at 20°C

T = temperature of wire, °C

The voltage drop (per output or return lead) could be calculated using the following equation:

V = I x L x R20°C x [1 + 0.004 x (T - 20°C)]

where,

V = total voltage drop, V

I = current, A

L = length of wire, m

R20°C = resistance of wire, Ω/m, at 20°C

T = temperature of wire conducting current, °C

NOISE AND IMPEDANCE EFFECTS

To minimize noise pickup or radiation from load circuits, load wires and remote sense wires should be twisted-pair with minimum lead length. Shielding of the sense leads may be necessary in high noise environments. Even if noise is not a concern, the load and remote sense wires should be twisted-pairs to reduce coupling between them, which could impact the stability of the output converter. If connectors are utilized for the power and sense leads, be careful not to introduce coupling between the leads. Ensure that the connector terminals for the sense leads are in adjacent locations, and minimize the physical loop area of the untwisted portions.

Twisting the load wires provides an additional benefit in reducing the parasitic inductance of the cable. This improves the dynamic response characteristics at the load by maintaining a low source impedance at high frequencies. Also, with long load wires, the resultant inductance and resistance could produce high frequency voltage fluctuations at the load because of current variations in the load itself.

4.5 OPERATION

The AC power supply module function within the ReFlex Power™ system under remote control through a host controller. The ReFlex Power™ Controller module serves as a communications portal between the power supply modules and the remote host controller. All aspects of operation could be achieved through use of commands that comply with the requirements of the SCPI Standard 1997 command language. Additional discrete digital and optional analog control signals are available for dedicated hardware interface. All connectors for control and power interface are accessible on the front panel

4.5.1 CONTROLS AND INDICATORS

The ACPS has no controls. Figure 4-8 shows the front panel indicators and connector interfaces.

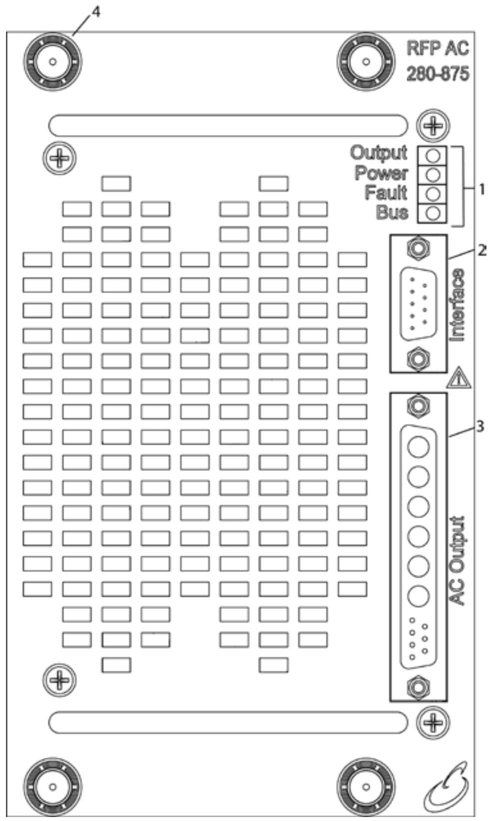


Figure 4-8. ACPS Front Panel

1 Operational Status Indicators:

OUTPUT (LED, green): output enabled and isolation relay closed
POWER (LED, green): input AC/DC power applied to module
FAULT (LED, red): internal abnormal operating condition detected; output disabled and isolation relay opened
BUS (LED, green): Internal bus communication established

2 User Interface Connector: connector for isolated discrete digital control interface, or the optional isolated analog interface.

3 Output Connector: connector for making output and remote sense connections to the user load.

4 Mounting screws: Captive fasteners to secure the module to the Mainframe.

4.5.2 MODES OF OPERATION

The AC power supply module is capable of operating in either standalone or in groupings of parallel, and multi-phase output configurations. This allows extending the power, voltage, and current ratings while minimizing the number of unique modules comprising a system. When configured in groups, the modules are programmed and controlled as single, virtual channels. All configuration setup within the modules for implementing groups is performed automatically. However, the output power and remote sense leads must be appropriately hardwired before issuing the grouping commands.

STANDALONE OPERATION

Modules operated in standalone mode function as independent AC power supplies. The outputs are isolated from adjacent modules, and either output terminal may be grounded, or left floating with respect to the chassis ground. The Mainframe backplane control and data communications interface is also isolated; therefore, there are no restrictions as to the physical location of a module within the Mainframe when it is operated in standalone mode.

PARALLEL OPERATION

Operation of modules in a parallel group requires routing of analog control signals through the backplane between the modules, as well as the digital control/communications, to implement a master/slave control interface. The routing of signals in this interface requires that parallel modules must be located in a contiguous physical group; no intervening modules (which are not part of the parallel group) are allowed to be located within the parallel group. Empty slots can separate individual modules of the group, and the group can be extended between two Mainframes. The outputs of the modules must be hardwired externally, while all internal control signal connections are configured automatically when the parallel group is set up through software. The remote sense leads are connected to all the modules of the group. The parallel group is programmed as a “virtual” module, equivalent to a single module with the combined current rating of the parallel group of modules. Modules must be set to the same output range when paralleled.

MULTI-PHASE OPERATION

Modules could be operated in a multi-phase group regardless of their location in the ReFlex Power™ system. The multi-phase group does utilize the analog control signals of the back plane, as well as the digital control/communications, to implement a master/slave control interface. The outputs and remote sense of the modules must be hardwired externally, while all internal control signal connections are configured automatically when the multi-phase group is set up through software. In a multi-phase group the load could be connected in wye or delta configuration, but the module outputs must be wye connected.

CAUTION
Do not connect the AC modules in a delta configuration.

Modules must be set to the same output range when multi-phase connected.

OUTPUT VOLTAGE/CURRENT REGULATION

The AC power supply module is capable of operating while regulating either the output voltage, constant–voltage mode (CV), or the output current, constant–current mode (CC). Which parameter would be regulated is dependent on the programmed settings of the output voltage and current in relation to the resistance of the load. If the load resistance is greater than the voltage setting divided by the current setting, the output voltage would be regulated in voltage-mode. If the load resistance is less than the voltage setting divided by the current setting, the output current would be regulated in current-mode. The crossover point is when the load resistance equals the voltage setting divided by the current setting. The AC power supply can automatically crossover between the two modes of operation in response to load demands. Refer to Figure 4-9 for a diagram showing the operating regions for constant-voltage and constant-current.

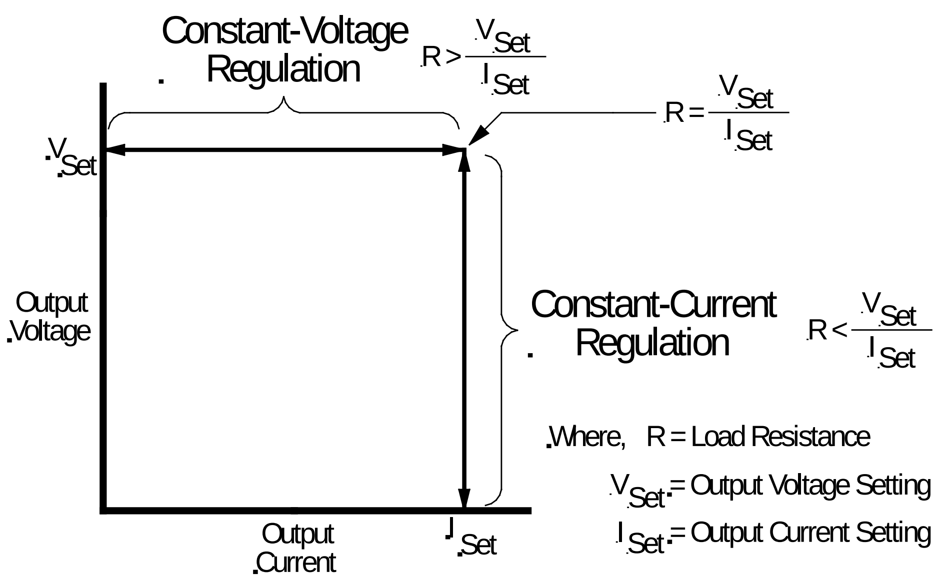


Figure 4-9. CV and CC Regulation

CONSTANT VOLTAGE

The AC power supply will operate in constant–voltage regulation whenever the load current is less than the programmed current setting. In this mode, the power supply maintains the output voltage precisely regulated to the programmed voltage setting while the load current varies with the load requirements. This condition is maintained as long as the load current is less than the current setting. If the load resistance decreases to where the load current attempts to exceed the current setting, the output current is then regulated at the programmed current setting, and the output voltage decreases until that condition is satisfied. This is the automatic crossover point to constant–current mode of operation.

CONSTANT CURRENT

The AC power supply will operate in constant–current mode whenever the load resistance times the programmed current setting is less than the programmed voltage setting. In this mode, the power supply maintains the output current precisely regulated to the current setting while the load voltage varies with load requirements. This condition is maintained as long as the load resistance is less than the voltage setting divided by the current setting. If the load resistance increases to where the load voltage attempts to exceed the voltage setting, the output voltage is then regulated to the programmed voltage setting, and the output current decreases until that condition is satisfied. This is the automatic crossover point to constant–voltage mode of operation.

4.5.3 LOAD CONNECTION CONFIGURATIONS

The output of the AC power supply module is isolated from chassis ground, allowing either positive, negative, or floating outputs with respect to chassis ground. Connections to the load are made at the front panel output connector terminals. Ensure that a wire gauge is utilized that can carry the programmed current without overheating.

Remote sensing of the output voltage is required to meet accuracy and regulation specifications. The sense leads should be connected to the point in the load circuit where the voltage is to be precisely regulated. If a distribution bus is utilized for multiple loads, the point of voltage sensing is important to ensure that the voltage regulation is acceptable for all of the loads. In general, the point of sensing is selected to minimize interaction of the various loads through line drops caused by their load currents.

CAUTION
Operating the power supply with either output lead at greater than the float voltage specification limit above chassis ground could result in damage to the module.

STANDALONE CONFIGURATION

Single loads are connected directly to the front panel output terminals, and the AC power supply module is configured to operate in the standalone mode. Twist the load wires or maintain them closely in parallel for their entire length to minimize parasitic inductance and coupling from external circuits. Use the heaviest gauge practical to minimize line drop. The remote sense wires should be twisted, and may need shielding depending on the electrical noise environment of the application. Figure 4-10 shows a standalone load connection with remote sensing.

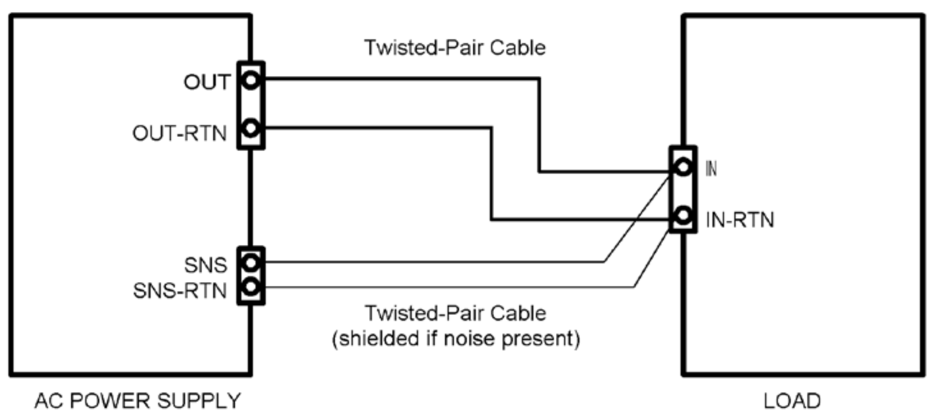


Figure 4-10. Standalone Output Configuration

PARALLEL CONFIGURATION

AC power supply modules can be connected in parallel. The paralleled supplies operate in a master/slave configuration, where the master controls the output voltage and total current, and provides control signals through the Mainframe backplane to the slaves to set their output current. The routing of signals in this interface requires that parallel modules must be located in a contiguous physical group; no intervening modules (which are not part of the parallel group) are allowed to be located within the parallel group. Empty slots can separate individual modules of the group, and the group can be extended between two Mainframes.

The outputs of the modules must be hardwired externally, while all internal control signal connections are configured automatically when the parallel group is set up through software. The remote sense leads are connected to all the modules. Figure 4-11 shows a parallel connection of two units with remote sensing.

The paralleled modules are programmed as a single, virtual channel with a current rating equal to the sum of the number of modules connected in parallel. The master and slave supplies will share the output current equally. Fault shutdown is coordinated across all modules: a fault within any module of the group will result in shutdown of all modules.

CAUTION

The outputs of paralleled modules must be wired in parallel at the front panel output terminals of the units. Use the shortest practical cable length. Operation of a paralleled module with its return (negative) terminal not connected to the load could result in damage to the module.

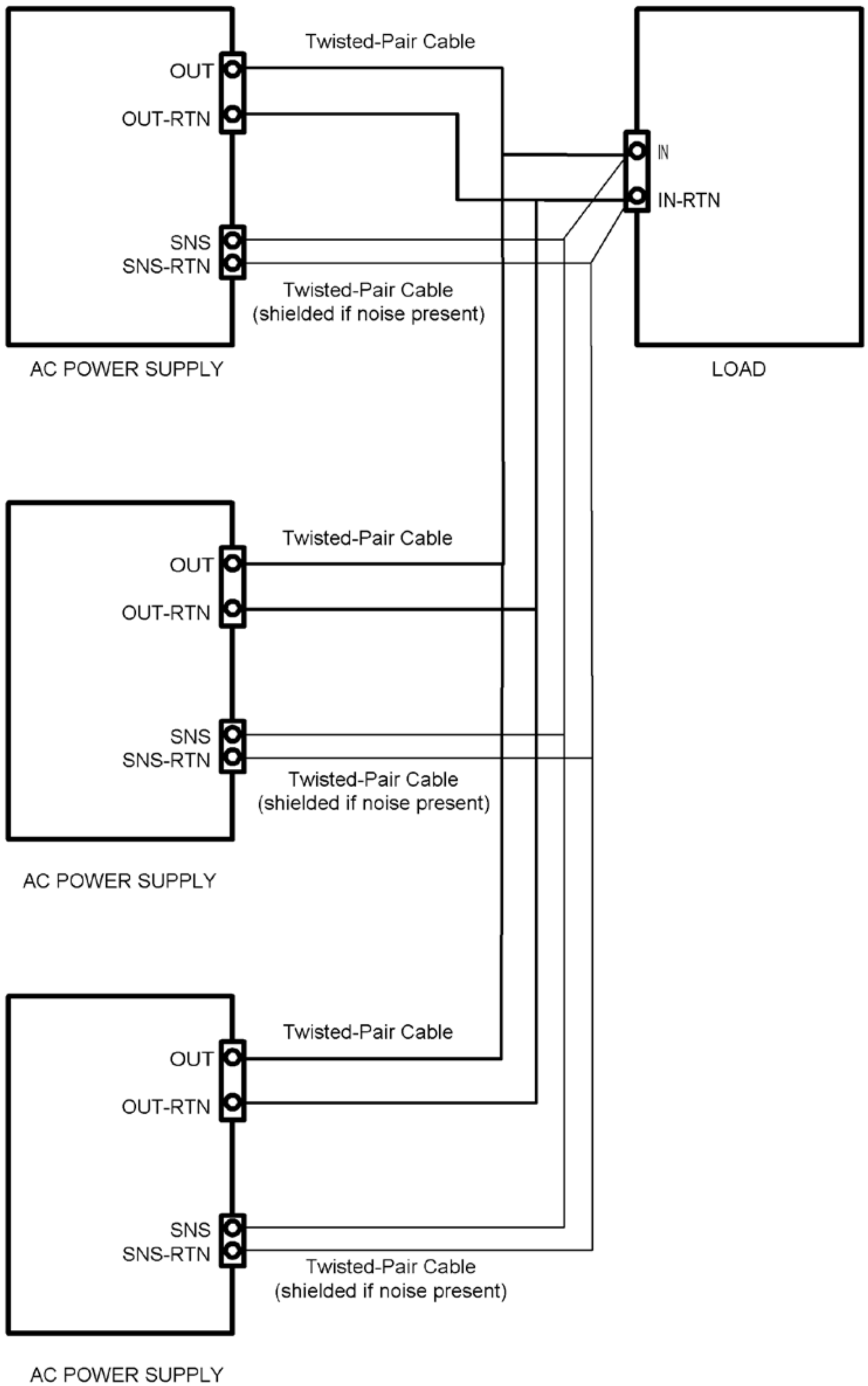


Figure 4-11. Parallel Output Configuration

MULTI-PHASE CONFIGURATION

Multiple modules can be connected in a multi-phase configuration. Wye or delta load configurations are supported. The AC power supply modules may be connected in only a wye configuration; they must never be connected in a delta configuration. The supplies are interconnected with the output return terminals as common (“wye” connected source).

CAUTION
Do not connect the AC modules in a delta configuration.

The multi-phase group utilizes the analog control signals of the backplane; therefore, it is restricted by contiguous physical location, as in a parallel group. The outputs of the modules must be hardwired externally, while all internal control signal connections are configured automatically when the multi-phase group is set up through software. In order not to compromise the load regulation of the output voltages, the connection of the remote sense leads must be made to every load, and must not have any intervening load wiring.

Figure 4-12 shows the multi-phase connection of three units with remote sensing on a Wye type load. Figure 4-13 shows the multi-phase connection of three units with remote sensing on a “delta” type load.

Fault shutdown is coordinated across all modules: a fault within any module of the group will result in shutdown of all modules.

CAUTION
To prevent damage to a supply, do not exceed the float voltage specification limit for either of the output terminals to chassis.

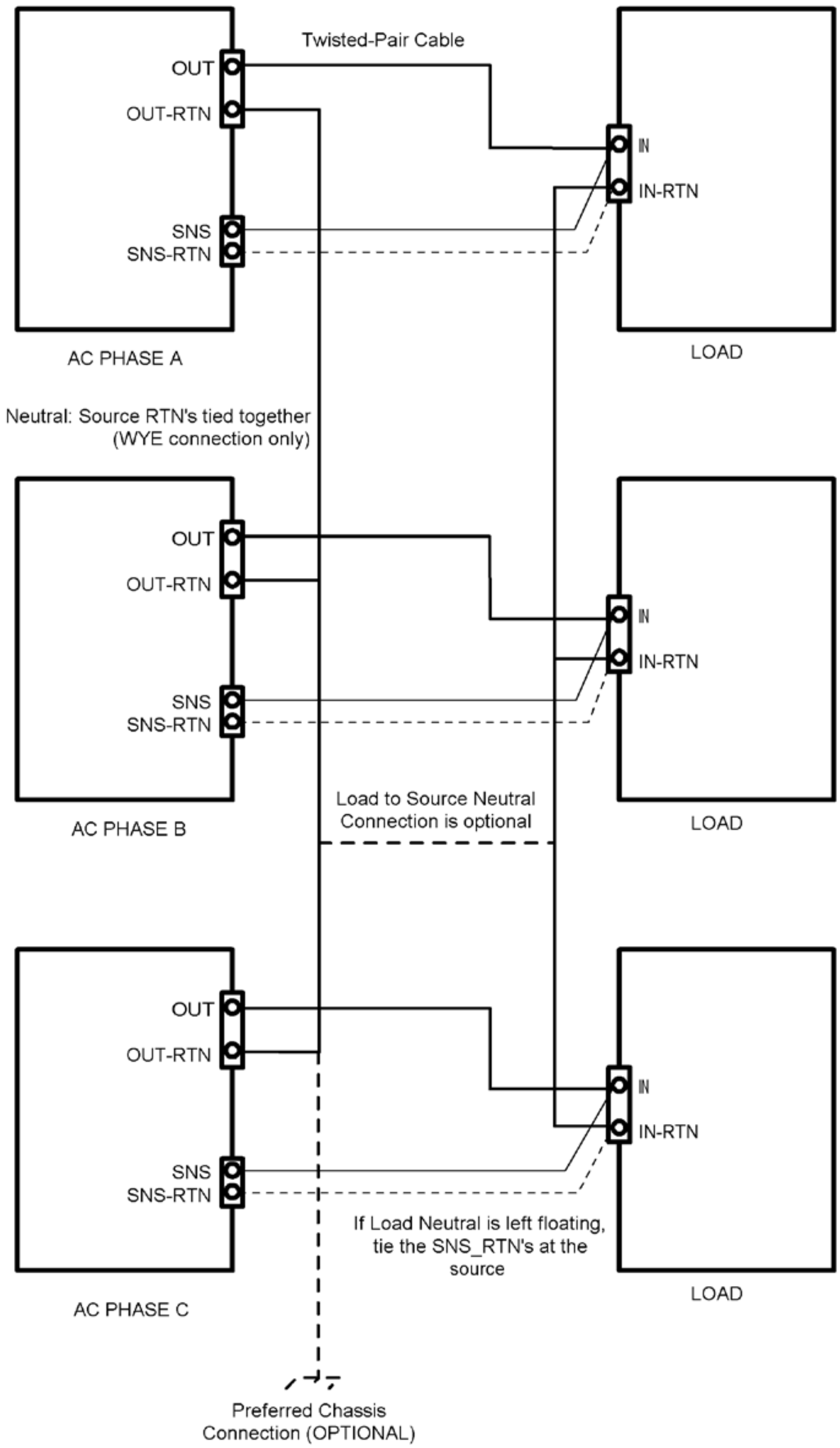


Figure 4-12. Multiphase Output Configuration with Wye Load Connection

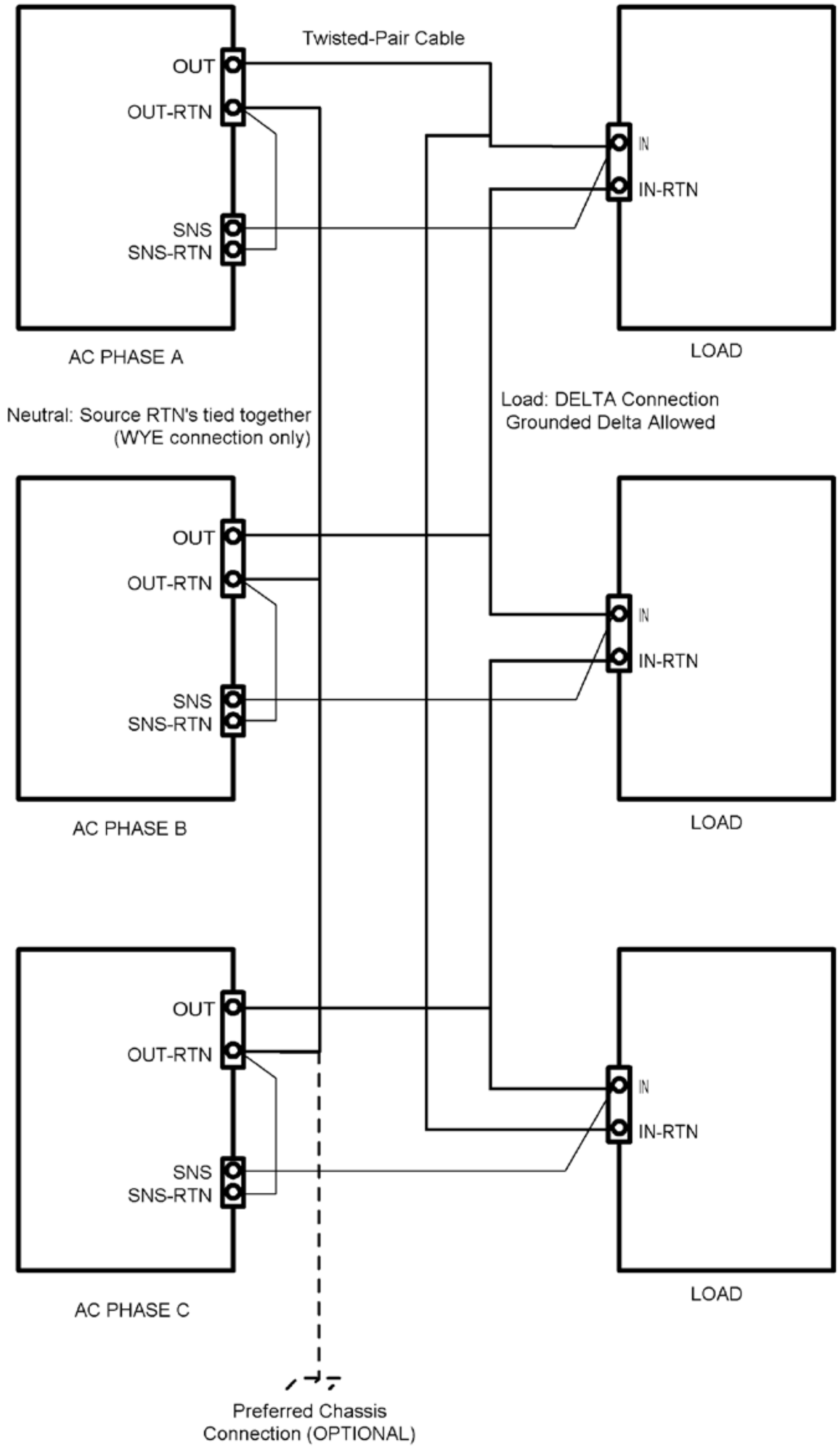


Figure 4-13. Multi-phase Output Configuration with Delta Load Connection

4.5.4 DEFAULT OPERATIONAL CONDITIONS

POWER-ON CONDITIONS

When an AC power supply module is first powered on, the following parameters are set to factory default values:

- Output configuration: standalone
- Output voltage: 0V
- Output current: full scale
- Overvoltage protection (OVP): 106% of full scale voltage; programmable mode
- Undervoltage protection (UVP): 0V, programmable mode
- Overcurrent protection (OCP): 106% of full scale current; programmable mode
- Output state: off
- Output isolation and remote sense relays: open
- Frequency set to 60 Hz

RESET CONDITIONS

If a module is reset with the SCPI command, *RST[n], (where n is the module address), the following default conditions are set:

- Output configuration: unchanged
- Output voltage: 0V
- Output current: full scale
- Overvoltage protection (OVP): 106% of full scale voltage; programmable mode
- Undervoltage protection (UVP): 0V, programmable mode
- Overcurrent protection (OCP): 106% of full scale current; programmable mode
- Output state: off
- Output isolation and remote sense relays: open
- Frequency set to 60 Hz
- All status reporting data structures are cleared. Enable-masks are not cleared.

4.5.5 INITIAL FUNCTIONAL TESTS

POWER-ON CHECK

Ensure that the AC/DC input service is disconnected.

Install the interface cable between the host controller and the ReFlex Power™ Controller module.

Connect an appropriate output load to the AC power supply module.

Configure the host controller for communications with the ReFlex Power™ Controller module.

Turn on the AC/DC input service, and the power switch on the ReFlex Power™ Controller.

The modules will first execute a power-on self-test. Also the internal fans are run at maximum speed for several seconds, and then back to slow speed.

In the following paragraphs, commands include a channel number, **`[n]`**. The channel number corresponds to the slot of the ReFlex Power™ Mainframe where the module is located, counting left to right, 1 through 12. For example:

`SOUR[n]:VOLT 5` will be

`SOUR1:VOLT 5` for slot-1

`SOUR2:VOLT 5` for slot-2

Additionally, model specific parameter values must be added for full scale voltage and current. They are shown in the following examples as floating point numerical values, **`<fval>`**. For the AC power supply modules, the values are as follows:

Full-Scale Voltage:

140/280V_{RMS}

Full-Scale Current:

7/3.5 A_{RMS}

Therefore, the command for full scale voltage would be:

`SOUR1:VOLT 140.`

Verify communications with the ReFlex Power™ Controller module by issuing an SCPI **`*IDN[n]?`**, where “n” is a channel number that corresponds to the slot of the ReFlex Power™ Mainframe where the module is located, counting left to right, 1 through 12.

The ReFlex Power™ Controller module should respond with its identification string.

Verify communications with the ReFlex Power™ AC power supply module by issuing an SCPI **`*IDN[n]?`**, where “n” is a channel number that corresponds to the slot of the ReFlex Power™ Mainframe where the module is located, counting left to right, 1 through 12.

The AC power supply module should respond with its identification string. The default settings of the module will not be affected.

STANDALONE CONFIGURATION OPERATION CHECK

Connect the output for standalone operation per the section, Standalone Configuration.

Connect appropriate instrumentation for measuring the output voltage and current, as well as a load.

Perform the power-on verification test per the section, Power-On Check.

Turn on the isolation and remote sense relays, turn on the output converter, and program full scale voltage and current with the following commands:

```
*RST[n]

OUTP[n]:STATE 1

SOUR[n]:VOLT <fval>

SOUR[n]:CURR <fval>
```

Measure the output voltage and current with the external instruments.

Ensure that the actual values of the output parameters are within specifications of the programmed values.

Query the values of the output parameters with the following commands:

```
MEAS[n]:VOLT?

MEAS[n]:CURR?
```

Ensure that the readback values of the output parameters are within specifications of the actual values.

Set the frequency to 400 Hz: **`SOUR[n]:FREQ 400`**

Close the auxiliary relay: **`OUTP[n]:AUXR 1`**

Verify the proper output voltage at the AUX output (should equal 22% of VOLT fval as entered in Step 4 above).

Open the aux relay: **OUTP[n]:AUXR 0**

Open the main isolation relay: **OUTP[n]:STATE 0**

Set 280VAC range

SOUR[n]:VOLT:RANGE 1

Repeat steps 2 through 8

Turn off the output with the following command:

***RST[n]**

Parallel Configuration Operation Check

1. Before attempting to verify parallel operation, perform the power-on test of the individual modules per the section, Power-On Check, and then the standalone operation test per section, Standalone Configuration.
2. Connect the outputs for parallel operation per the section, Parallel Configuration. Ensure that the outputs and remote sense are appropriately hardwired prior to issuing any of the paralleling SCPI commands.
3. Connect appropriate instrumentation for measuring the output voltage and current, as well as a load.
4. Configure the modules into a parallel group with the following command, where `[n1]` is the master module of the group. Although the example is for two modules, it could be extended to a greater number by listing additional parameter slot numbers, `[n]`.

   SYST:GRO:DEF:PAR [n1],[n2]

5. Verify that the parallel group has been properly set up with the following command. **SYST:GRO:CAT:PAR?.** The response to the query is a listing of the master module of the parallel group. For example, a group of modules with a master in slot 3 and a slave in slot 7 would return the parameter, 1003. The parameter, `[1000+n1]`, is the sum of 1000 and the slot number of the master module; the master module is the left-most module of the parallel group.
6. Turn on the isolation and remote sense relays, turn on the output converters, and program full scale voltage and current with the following commands. The parameter, `<fval>`, is the full scale output voltage or current of the particular model under test. The parameter, `[1000+n1]`, is the sum of 1000 and the slot number of the master module; the master module is the left-most module of the parallel group. For example, if the master module is located in slot 1, the parameter value would be 1001.

   OUTP[1000+n1]:STATE 1

SOUR[1000+n1]:CURR <fval>

SOUR[1000+n1]:VOLT <fval>

7. Measure the output voltage and current with the external instruments.
8. Ensure that the actual values of the output parameters are within specifications of the programmed values.
9. Query the values of the output parameters with the following commands:

MEAS[1000+n1]:VOLT?

MEAS[1000+n1]:CURR?

10. Ensure that the readback values of the output parameters are within specifications of the actual values.
11. Repeat for high range
12. Turn off the output with the following command:

***RST[n]**

MULTI-PHASE CONFIGURATION OPERATION CHECK

1. Before attempting to verify multi-phase operation, perform the power-on test of the individual modules per the section, Power-On Check, and then the standalone operation test per section, Standalone Configuration.
2. Connect the outputs for multi-phase operation per the section, Parallel Configuration. Ensure that the outputs and remote sense are appropriately hardwired prior to issuing any of the multi-phase SCPI commands.
3. Connect appropriate instrumentation for measuring the output voltage and current, as well as a load.
4. Configure the modules into a multi-phase group with the following command, where `[n1]` is the master module of the group. Although the example is for three modules, it could be extended to a greater number by listing additional parameter slot numbers, `[n]`. (up to 6 modules).

SYST:GRO:CAT:PHASE [n1],[n2],[n3]

5. Verify that the multi-phase group has been properly set up with the following command. The response to the query is a listing of the master module in the series group. For example, a group of modules with a master in slot 4 and a slave in slot 8 would return the parameter,1004. The parameter, `[1000+n1]`**,** is the sum of 1000 and the slot number of the master module.

SYST:GRO:CAT:PHASE?

6. Turn on the isolation and remote sense relays, turn on the output converters, and program full scale voltage and current with the following commands. The parameter, <fval>, is the full scale output voltage or current of the particular model under test. The parameter, [1000+n1], is the sum of 1000 and the slot number of the master module. For example, if the master module is located in slot 4, the parameter value would be 1001.

```
OUTP[1000+n1]:STATE 1

SOUR[1000+n1]:CURR <fval>

SOUR[1000+n1]:VOLT <fval>
```

7. Measure the output voltage and current with the external instruments.
8. Ensure that the actual values of the output parameters are within specifications of the programmed values. The default frequency is 60 Hz.
9. Query the values of the output parameters with the following commands:

```
MEAS[1000+n1]:VOLT?

MEAS[1000+n1]:CURR?

MEAS[1000+N1]:FREQ?
```

10. Ensure that the readback values of the output parameters are within specifications of the actual values.
11. Turn off the output with the following command:

```
*RST[n]
```

4.6 CALIBRATION

4.6.1 SCOPE

Procedures are provided in the following sections for calibration of the ReFlex Power™ AC Power supply module: ReFlex Power™ ACPS 1.2KHz module, P/N: RFP-A301K-875-XXXX, and ReFlex Power™ ACPS 5.0KHz module, P/N: RFP-A305K-875-XXXX. Calibration is easily performed through the Controller module interface with SCPI commands, requiring only 2 meters and resistive load.

CAUTION
The calibration procedures are performed with the output of the AC power supply module energized. Do not touch any of the output connections, which could be at hazardous potentials. Calibration must be performed by qualified personnel who are appropriately trained to deal with attendant hazards.

4.6.2 Recommended Calibration Equipment

The recommended calibration equipment is listed in Table below. Equivalent substitutes are acceptable provided that their accuracy is at least four times better than the accuracy of the parameter specification that is being calibrated. If less accurate equipment is utilized, measurement uncertainty may be introduced that would compromise the validity of the calibration.

Instrument	**Requirements**	**Recommended Model**
AC Voltmeter	Resolution: 6 1/2 digits	Agilent 34401A
Current Shunt	RFP-A301K-875-XXXX and RFP-A305K-875-XXXX: 50mΩ, ±0.04%, (15A)	Guildline 9230-15
Adjustable resistive load (non-reactive)	Load should handle two ranges. Range 1: 0 to 10 Amps at 125Volt AC Range 2: 0 to 5 Amps at 250Volts AC	

The calibration procedures described here calibrate all output and read back functions of the RFP AC modules. Measurements derived from primary measurements of voltage and current do not require their own calibration coefficients.

4.6.3 Calibration Setup

Calibration must be performed under controlled environmental conditions:

- ambient temperature must be within 25 °C, +/-5 °C
- humidity must be less than 80%
- allow the unit to warm up for 30 minutes at no load prior to performing the calibration

Refer to Figure 4-14 for a diagram of the test instrument setup.

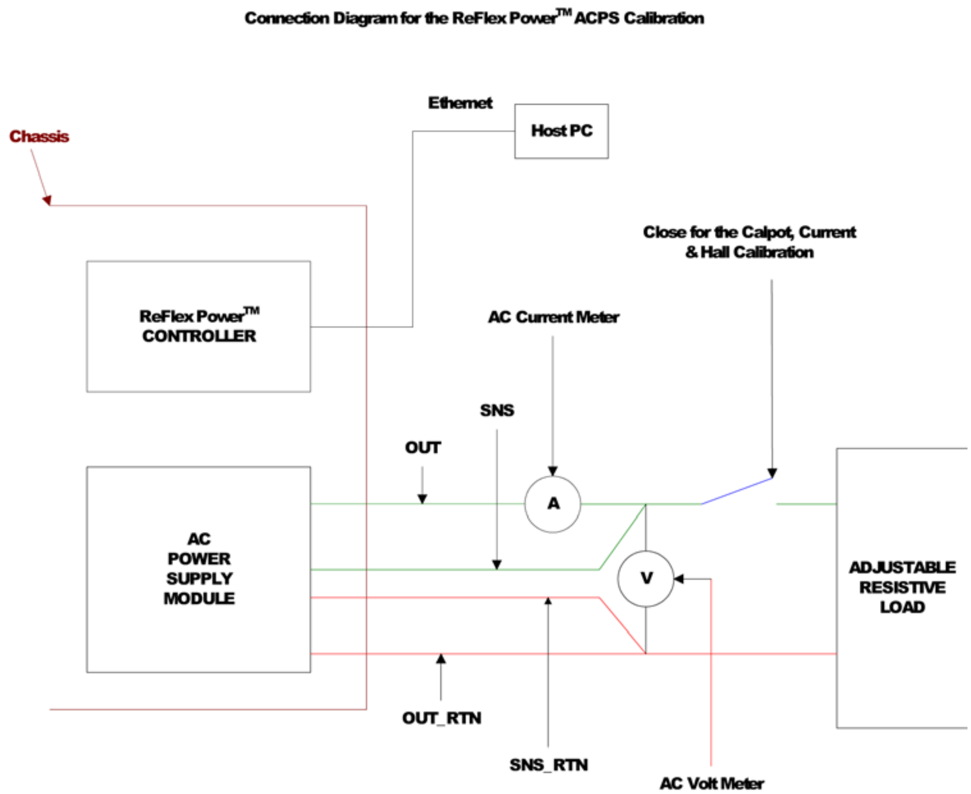


Figure 4-14. Calibration Instrumentation Setup

4.6.4 CalPot Calibration for Voltage Range Low

The following procedure calibrates cal-pot for the voltage range low. This calibration is done with the AC current meter connected to the output lead of the AC power supply.

1. Connect the AC current meter to the output lead of the power supply. Ensure that no load is connected to the output.

2. Issue clear and reset commands:

```
*CLS
*RST<n>
```

3. Start the internal calibration of the offset pot

```
CAL<n>:CALPOTS:OFFSET:CALC
```

4. Start the calibration of the gain pot

```
CAL<n>:CALPOTS:GAIN:START
```

5. Set the load box to approximately 6.5Amps. Wait for the current to stabilize then make the AC current measurement using the meter connected to the power supplies output lead.

```
CAL<n>:CALPOTS:GAIN:CURR <value>
```

6. Finish the gain pot calibration

```
CAL<n>:CALPOTS:GAIN:CALC
```

7. Send the system error query command to make sure calibration was successful.

```
SYST:ERR?
```

8. If there is no error returned at the system error query command then save the calibration result with the following commands

```
CAL<n>:UNLOCK "6867"
CAL<n>:STORE
CAL<n>:LOCK
```

9. Optional Commands:

   To query the offset pot set value: **CAL<n>:CALPOTS:OFFSET?**
   To query the gain pot set value: **CAL<n>:CALPOTS:GAIN?**

10. Reset the unit

```
*RST<n>
```

4.6.5 CalPot Calibration Voltage Range High

This procedure calibrates cal-pot for the voltage range high. This calibration is done with the AC current meter connected to the output lead of the AC power supply.

1. Connect the AC current meter to the output lead of the power supply. Ensure that no load is connected to the output.

2. Issue clear and reset commands:

```
*CLS
*RST<n>
```

3. Set the voltage range of the power supply to high

```
SOUR<n>:VOLT:RANGE 1
```

4. Start the internal calibration of the offset pot

```
CAL<n>:CALPOTS:OFFSET:CALC
```

5. Start the calibration of the gain pot

```
CAL<n>:CALPOTS:GAIN:START
```

6. Set the load box to approximately 3.25 Amps. Wait for the current to stabilize then make the AC current measurement using the meter connected to the power supplies output lead.

```
CAL<n>:CALPOTS:GAIN:CURR <value>
```

7. Finish the gain pot calibration

```
CAL<n>:CALPOTS:GAIN:CALC
```

8. Send the system error query command to make sure calibration was successful.

```
SYST:ERR?
```

9. If there is no error returned at the system error query command then save the calibration result with the following commands

```
CAL<n>:UNLOCK “6867”
CAL<n>:STORE
CAL<n>:LOCK
```

10. Optional Commands:

    To query the offset pot set value: `CAL<n>:CALPOTS:OFFSET?`

To query the gain pot set value: **CAL<n>:CALPOTS:GAIN?**

11. Reset the unit

    ***RST<n>**

4.6.6 DAC Offset Calibration for Voltage Range Low

This procedure calibrates the voltage DAC of the power supply.

1. Connect the meter between the output and the output return lead.
2. Set the voltmeter to read the DC voltage.
3. Ensure that no load is connected to the output.
4. Issue clear and reset commands:

```
*CLS
*RST<n>
```

5. Set the OVP supervisory to limit 12000

```
CAL<n>:OUTP:VOLT:PROT:COUNTS 12000
```

6. Set the OCP supervisory to maximum limit.

```
CAL<n>:OUTP:CURR:PROT:COUNTS 4000
```

7. Set the voltage to zero

```
CAL<n>:OUTP:VOLT:COUNTS 0
```

8. Set the current to maximum limit

```
CAL<n>:OUTP:CURR:COUNTS 4000
```

9. DAC range is from 0 to 65535. Therefore set the DAC at the middle of the range

```
CAL<n>:OUTP:DAC:COUNTS 32768
```

10. Turn the unit on.

```
OUTP<n>:STATE 1
```

11. Set the DC loop off.

```
CAL<n>:OUTP:DCLOOP OFF
```

12. Program the DAC to 0.5% below the middle range

```
CAL<n>:OUTP:DAC:COUNTS 32456
```

13. Wait for the DC voltmeter to stabilize. Make an accurate measurement and then enter the DC voltage using following command. User should enter the voltage including sign (Ex: For Negative 4.15631 enter –4.15631)

```
CAL<n>:OUTP:DAC:POINT1 <value-1>
```

14. Program to DAC to 0.5% above the middle range

```
CAL<n>:OUTP:DAC:COUNTS 33080
```

15. Wait for the DC voltmeter to stabilize. Make an accurate measurement and then enter the DC voltage using following command

```
CAL<n>:OUTP:DAC:POINT2 <value-2>
```

16. Perform the DAC Calibration

```
CAL<n>:OUTP:DAC:OFFSET:CALC
```

17. Measure the DC output voltage, if the voltage is not 0.0 ± 10mVolts, read the DAC offset value with **CAL<n>:OUTP:DAC:OFFSET?**, and then using the value returned (a Hex number) as a starting point, "walk" the DC voltage toward 0.0 volts by increasing the value if the DC value is negative, and decreasing the value if it is positive. One count is ≈ 10mVolts. The command to change the DAC offset value is **CAL<n>:OUTP:DAC:OFFSET <value>**.
18. Turn the DC correction loop back on

```
CAL<n>:OUTP:DCLOOP ON
```

19. Turn off the unit

```
OUTP<n>:STATE 0
```

20. Send the system error query command to make sure calibration was successful.

```
SYST:ERR?
```

21. If there is no error returned at the system error query command then save the calibration result with the following command

```
CAL<n>:UNLOCK "6867"
CAL<n>:STORE
CAL<n>:LOCK
```

22. Reset the unit

```
*RST<n>
```

4.6.7 DAC Offset Calibration for Voltage Range High

This procedure calibrates the voltage DAC of the power supply.

1. Connect the meter between the output and the output return lead.
2. Set the voltmeter to read the DC voltage.
3. Ensure that no load is connected to the output.
4. Issue clear and reset commands:

```
*CLS
*RST<n>
```

5. Set the voltage range of the power supply to high

```
SOUR<n>:VOLT:RANGE 1
```

6. Set the OVP supervisory to limit 12000

```
CAL<n>:OUTP:VOLT:PROT:COUNTS 12000
```

7. Set the OCP supervisory to maximum limit.

```
CAL<n>:OUTP:CURR:PROT:COUNTS 4000
```

8. Set the voltage to zero

```
CAL<n>:OUTP:VOLT:COUNTS 0
```

9. Set the current to maximum limit

```
CAL<n>:OUTP:CURR:COUNTS 4000
```

10. DAC range is from 0 to 65535. Therefore set the DAC at the middle of the range

```
CAL<n>:OUTP:DAC:COUNTS 32768
```

11. Turn the unit on

```
OUTP<n>:STATE 1
```

12. Set the DC loop off

```
CAL<n>:OUTP:DCLOOP OFF
```

13. Program the DAC to 0.5% below the middle range

```
CAL<n>:OUTP:DAC:COUNTS 32456
```

14. Wait for the DC voltmeter to stabilize. Make an accurate measurement and then enter the DC voltage using following command. User should enter the voltage including sign (Ex: For Negative 4.15631 enter –4.15631)

    CAL<n>:OUTP:DAC:POINT1 <value-1>

15. Program to DAC to 0.5% above the middle range

    CAL<n>:OUTP:DAC:COUNTS 33080

16. Wait for the DC voltmeter to stabilize. Make an accurate measurement and then enter the DC voltage using following command

    CAL<n>:OUTP:DAC:POINT2 <value-2>

17. Perform the DAC Calibration

    CAL<n>:OUTP:DAC:OFFSET:CALC

18. Measure the DC output voltage, if the voltage is not 0.0 ± 10mVolts, read the DAC offset value with **CAL<n>:OUTP:DAC:OFFSET?**, and then using the value returned (a Hex number) as a starting point, "walk" the DC voltage toward 0.0 volts by increasing the value if the DC value is negative, and decreasing the value if it is positive. One count is ≈ 10mVolts. The command to change the DAC offset value is **CAL<n>:OUTP:DAC:OFFSET <value>**.

19. Turn the DC correction loop back on

    CAL<n>:OUTP:DCLOOP ON

20. Turn off the unit

    OUTP<n>:STATE 0

21. Send the system error query command to make sure calibration was successful.

    SYST:ERR?

22. If there is no error returned at the system error query command then save the calibration result with the following command

    CAL<n>:UNLOCK "6867"
    CAL<n>:STORE
    CAL<n>:LOCK

23. Reset the unit

    ***RST<n>**

4.6.8 Voltage ADC Offset Calibration for Voltage Range Low

The following procedure calibrates offset of the voltage ADC for the voltage range low.

1. Ensure that no load is connected to the output.
2. Issue clear and reset commands:

   ***CLS**
   ***RST<n>**

3. Perform the voltage ADC offset calibration

   CAL<n>:MEAS:VADC:OFFSET:CALC

4. Send the system error query command to make sure calibration was successful.

   SYST:ERR?

5. If there is no error returned at the system error query command then save the calibration result with the following commands

   CAL<n>:UNLOCK “6867”
   CAL<n>:STORE
   CAL<n>:LOCK

6. Optional Commands:

   To query the voltage ADC offset: **CAL<n>:MEAS:VADC:OFFSET ?**

7. Reset the unit

   ***RST<n>**

4.6.9 VOLTAGE ADC OFFSET CALIBRATION FOR VOLTAGE RANGE HIGH

The following procedure calibrates offset of the voltage ADC for the voltage range high.

1. Ensure that no load is connected to the output.

2. Issue clear and reset commands:

   ***CLS**
   ***RST<n>**

3. Set the voltage range of the power supply to high

   SOUR<n>:VOLT:RANGE 1

4. Perform the voltage ADC offset calibration

   CAL<n>:MEAS:VADC:OFFSET:CALC

5. Send the system error query command to make sure calibration was successful.

   SYST:ERR?

6. If there is no error returned at the system error query command then save the calibration result with the following command

   CAL<n>:UNLOCK “6867”
   CAL<n>:STORE
   CAL<n>:LOCK

7. Optional Commands:

   To query the voltage ADC offset: **CAL<n>:MEAS:VADC:OFFSET ?**

8. Reset the unit

   ***RST<n>**

4.6.10 Current ADC Offset Calibration for Voltage Range Low

The following procedure calibrates offset of the current ADC for the voltage range low.

1. Ensure that no load is connected to the output.

2. Issue clear and reset commands:

   ***CLS**
   ***RST<n>**

3. Set the voltage range of the power supply to low

   SOUR<n>:VOLT:RANGE 0

4. Perform the voltage ADC offset calibration

   CAL<n>:MEAS:IADC:OFFSET:CALC

5. Send the system error query command to make sure calibration was successful.

   SYST:ERR?

6. If there is no error returned at the system error query command then save the calibration result with the following commands

   CAL<n>:UNLOCK “6867”
   CAL<n>:STORE
   CAL<n>:LOCK

7. Optional Commands:

   To query the current ADC offset: **CAL<n>: MEAS:IADC:OFFSET ?**

8. Reset the unit

   ***RST<n>**

4.6.11 CURRENT ADC OFFSET CALIBRATION FOR VOLTAGE RANGE HIGH

The following procedure calibrates offset of the current ADC for the voltage range high.

1. Ensure that no load is connected to the output.

2. Issue clear and reset commands:

   ***CLS**
   ***RST<n>**

3. Set the voltage range of the power supply to high

   SOUR<n>:VOLT:RANGE 1

4. Perform the voltage ADC offset calibration

   CAL<n>:MEAS:IADC:OFFSET:CALC

5. Send the system error query command to make sure calibration was successful.

   SYST:ERR?

6. If there is no error returned at the system error query command then save the calibration result with the following command

   CAL<n>:UNLOCK “6867”
   CAL<n>:STORE
   CAL<n>:LOCK

7. Optional Commands

   To query the voltage ADC offset: **CAL<n>: MEAS:IADC:OFFSET ?**

8. Reset the unit

   ***RST<n>**

4.6.12 HIGH SPEED SUPERVISORY CALIBRATION FOR VOLTAGE RANGE LOW

The following procedure calibrates offset for the V-Local, I-Local and V-Remote.

1. Ensure that no load is connected to the output.

2. Issue clear and reset commands:

   ***CLS**
   ***RST<n>**

3. Set the voltage range of the power supply to low

   SOUR<n>:VOLT:RANGE 0

4. Perform the voltage ADC offset calibration

   CAL<n>:MEAS:OFFSET:CALC

5. Send the system error query command to make sure calibration was successful.

   SYST:ERR?

6. If there is no error returned at the system error query command then save the calibration result with the following commands

   CAL<n>:UNLOCK "6867"
   CAL<n>:STORE
   CAL<n>:LOCK

7. Optional Commands:

   To query the offset of signal V-Local: **CAL<n>:MEAS:VLOCAL:OFFSET ?**

   To query the offset of signal I-Local: **CAL<n>:MEAS:ILOCAL:OFFSET ?**

   To query the offset of signal V-Remote: **CAL<n>:MEAS:VREMOTE:OFFSET ?**

8. Reset the unit

   ***RST<n>**

4.6.13 High Speed Supervisor Calibration for Voltage Range High

The following procedure calibrates offset for the V-Local, I-Local and V-Remote

1. Ensure that no load is connected to the output.

2. Issue clear and reset commands:

   ***CLS**
   ***RST<n>**

3. Set the voltage range of the power supply to high

   SOUR<n>:VOLT:RANGE 1

4. Perform the voltage ADC offset calibration

   CAL<n>:MEAS:OFFSET:CALC

5. Send the system error query command to make sure calibration was successful.

   SYST:ERR?

6. If there is no error returned at the system error query command then save the calibration result with the following commands

   CAL<n>:UNLOCK "6867"
   CAL<n>:STORE
   CAL<n>:LOCK

7. Optional Commands:

   To query the offset of signal V-Local: **CAL<n>:MEAS:VLOCAL:OFFSET ?**

   To query the offset of signal I-Local: **CAL<n>:MEAS:ILOCAL:OFFSET ?**

   To query the offset of signal V-Remote: **CAL<n>:MEAS:VREMOTE:OFFSET ?**

8. Reset the unit

   ***RST<n>**

4.6.14 Voltage Calibration for Voltage Range Low

This procedure calibrates the output voltage of the power supply. This is five-point calibration procedure.

1. Connect the meter between the output and the output return lead.
2. Set the voltmeter to read the AC voltage.
3. Ensure that no load is connected to the output.
4. Issue clear and reset commands:

```
*CLS
*RST<n>
```

5. Set the voltage range of the power supply to low

```
SOUR<n>:VOLT:RANGE 0
```

6. Set the current to maximum limit

```
CAL<n>:OUTP:CURR:COUNTS 4000
```

7. Turn the unit on

```
OUTP<n>:STATE 1
```

8. Set the OVP supervisory to limit 20261

```
CAL<n>:OUTP:VOLT:PROT:COUNTS 20261
```

9. Set the OCP supervisory to maximum limit.

```
CAL<n>:OUTP:CURR:PROT:COUNTS 4000
```

10. Program the output voltage to 5% of the full scale voltage

```
CAL<n>:OUTP:VOLT:COUNTS 965
```

11. Wait for AC voltage to stabilize. Measure the output voltage using the AC voltmeter. Enter the measured voltage using following command

```
CAL<n>:OUTP:VOLT:FIVEPOINT1 <value-1>
```

12. Program the output voltage to 27.5% of the full scale voltage

```
CAL<n>:OUTP:VOLT:COUNTS 5307
```

13. Wait for AC voltage to stabilize. Measure the output voltage using the AC voltmeter. Enter the measured voltage using following command

    CAL<n>:OUTP:VOLT:FIVEPOINT2 <value-2>

14. Program the output voltage to 50% of the full scale voltage

    CAL<n>:OUTP:VOLT:COUNTS 9649

15. Wait for AC voltage to stabilize. Measure the output voltage using the AC voltmeter. Enter the measured voltage using following command

    CAL<n>:OUTP:VOLT:FIVEPOINT3 <value-3>

16. Program the output voltage to 72.5% of the full scale voltage

    CAL<n>:OUTP:VOLT:COUNTS 13990

17. Wait for AC voltage to stabilize. Measure the output voltage using the AC voltmeter. Enter the measured voltage using following command

    CAL<n>:OUTP:VOLT:FIVEPOINT4 <value-4>

18. Program the output voltage to 95% of the full scale voltage

    CAL<n>:OUTP:VOLT:COUNTS 18332

19. Wait for AC voltage to stabilize. Measure the output voltage using the AC voltmeter. Enter the measured voltage using following command

    CAL<n>:OUTP:VOLT:FIVEPOINT5 <value-5>

20. Perform the voltage calibration using following command

    CAL<n>:OUTP:VOLT:CALC

21. Send the system error query command to make sure calibration was successful.

    SYST:ERR?

22. If there is no error returned at the system error query command then save the calibration result with the following command

    CAL<n>:UNLOCK "6867"
    CAL<n>:STORE
    CAL<n>:LOCK

23. Optional Commands:

    Query the voltage calibration points: **CAL<n>:OUTP:VOLT:FIVEPOINT ?**

24. Reset the unit

***RST<n>**

4.6.15 VOLTAGE CALIBRATION FOR VOLTAGE RANGE HIGH

The following procedure calibrates the output voltage of the power supply. This is five- point calibration procedure. Connect the meter between the output and the output return lead. Set the voltmeter to read the AC voltage.

1. Ensure that no load is connected to the output.

2. Issue clear and reset commands:

   ***CLS**
   ***RST<n>**

3. Set the voltage range of the power supply to high

   SOUR<n>:VOLT:RANGE 1

4. Set the current to maximum limit

   CAL<n>:OUTP:CURR:COUNTS 4000

5. Turn the unit on

   OUTP<n>:STATE 1

6. Set the OVP supervisory to limit 20261

   CAL<n>:OUTP:VOLT:PROT:COUNTS 20261

7. Set the OCP supervisory to maximum limit.

   CAL<n>:OUTP:CURR:PROT:COUNTS 4000

8. Program the output voltage to 5% of the full scale voltage

   CAL<n>:OUTP:VOLT:COUNTS 965

9. Wait for AC voltage to stabilize. Measure the output voltage using the AC voltmeter. Enter the measured voltage using following command

   CAL<n>:OUTP:VOLT:FIVEPOINT1 <value-1>

10. Program the output voltage to 27.5% of the full scale voltage

    CAL<n>:OUTP:VOLT:COUNTS 5307

11. Wait for AC voltage to stabilize. Measure the output voltage using the AC voltmeter. Enter the measured voltage using following command

CAL<n>:OUTP:VOLT:FIVEPOINT2 <value-2>

12. Program the output voltage to 50% of the full scale voltage

    CAL<n>:OUTP:VOLT:COUNTS 9649

13. Wait for AC voltage to stabilize. Measure the output voltage using the AC voltmeter. Enter the measured voltage using following command

    CAL<n>:OUTP:VOLT:FIVEPOINT3 <value-3>

14. Program the output voltage to 72.5% of the full scale voltage

    CAL<n>:OUTP:VOLT:COUNTS 13990

15. Wait for AC voltage to stabilize. Measure the output voltage using the AC voltmeter. Enter the measured voltage using following command

    CAL<n>:OUTP:VOLT:FIVEPOINT4 <value-4>

16. Program the output voltage to 95% of the full scale voltage

    CAL<n>:OUTP:VOLT:COUNTS 18332

17. Wait for AC voltage to stabilize. Measure the output voltage using the AC voltmeter. Enter the measured voltage using following command

    CAL<n>:OUTP:VOLT:FIVEPOINT5 <value-5>

18. Perform the voltage calibration using following command

    CAL<n>:OUTP:VOLT:CALC

19. Send the system error query command to make sure calibration was successful.

    SYST:ERR?

20. If there is no error returned at the system error query command then save the calibration result with the following command

    CAL<n>:UNLOCK "6867"
    CAL<n>:STORE
    CAL<n>:LOCK

21. Optional Commands:

    Query the voltage calibration points: **CAL<n>:OUTP:VOLT:FIVEPOINT ?**

22. Reset the unit

    ***RST<n>**

4.6.16 LDF Calibration for Voltage Range Low

The following procedure calibrates the Line drop fault supervisory.

1. Ensure that no load is connected to the output.

2. Issue clear and reset commands:

   ***CLS**
   ***RST<n>**

3. Set the voltage range of the power supply to low

   SOUR<n>:VOLT:RANGE 0

4. Turn the unit on

   OUTP<n>:STATE 1

5. Program the output voltage to count 17000

   CAL<n>:OUTP:VOLT:COUNTS 17000

6. Send the calibration command to start the internal calibration

   CAL<n>:OUTP:LDF:CALC

7. Turn the unit off

   OUTP<n>:STATE 0

8. Send the system error query command to make sure calibration was successful.

   SYST:ERR?

9. If there is no error returned at the system error query command then save the calibration result with the following command

   CAL<n>:UNLOCK “6867”
   CAL<n>:STORE
   CAL<n>:LOCK

10. Optional Commands:

    Query the voltage calibration points: **CAL<n>:OUTP:LDF:GAIN ?**

11. Reset the unit

    ***RST<n>**

4.6.17 LDF Calibration for Voltage Range High

The following procedure calibrates the Line drop fault supervisory.

1. Ensure that no load is connected to the output.

2. Issue clear and reset commands:

   ***CLS**
   ***RST<n>**

3. Set the voltage range of the power supply to high

   SOUR<n>:VOLT:RANGE 1

4. Turn the unit on

   OUTP<n>:STATE 1

5. Program the output voltage to count 17000

   CAL<n>:OUTP:VOLT:COUNTS 17000

6. Send the calibration command to start the internal calibration

   CAL<n>:OUTP:LDF:CALC

7. Turn the unit off

   OUTP<n>:STATE 0

8. Send the system error query command to make sure calibration was successful.

   SYST:ERR?

9. If there is no error returned at the system error query command then save the calibration result with the following commands

   CAL<n>:UNLOCK “6867”
   CAL<n>:STORE
   CAL<n>:LOCK

10. Optional Commands:

    Query the voltage calibration points: **CAL<n>:OUTP:LDF:GAIN ?**

11. Reset the unit

    ***RST<n>**

4.6.18 CURRENT CALIBRATION FOR VOLTAGE RANGE LOW

This procedure calibrates the output current of the power supply. This is a five-point calibration procedure.

1. Close the switch between the power supply and the resistive load.
2. Connect the meter between the output and adjustable resistive load.
3. Set the voltmeter to read the AC current.
4. Ensure that load is connected to the output. Load setting should select a range for 0 to 10Amps at 125Volt AC
5. Issue clear and reset commands:

```
*CLS
*RST<n>
```

6. Set the voltage range of the power supply to low:

```
SOUR<n>:VOLT:RANGE 0
```

7. Set the OVP supervisory to limit 20261:

```
CAL<n>:OUTP:VOLT:PROT:COUNTS 20261
```

8. Set the OCP supervisory to maximum limit:

```
CAL<n>:OUTP:CURR:PROT:COUNTS 4800
```

9. Turn the unit on:

```
OUTP<n>:STATE 1
```

10. Set the output voltage to 100 Volts:

```
SOUR<n>:VOLT 100
```

11. Program the output current to 5% of the full scale current:

```
CAL<n>:OUTP:CURR:COUNTS 228
```

12. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

```
CAL<n>:OUTP:CURR:FIVEPOINT1 <value-1>
```

13. Program the output current to 27.5% of the full scale current:

```
CAL<n>:OUTP:CURR:COUNTS 1252
```

14. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

    CAL<n>:OUTP:CURR:FIVEPOINT2 <value-2>

15. Program the output current to 50% of the full scale current:

    CAL<n>:OUTP:CURR:COUNTS 2276

16. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

    CAL<n>:OUTP:CURR:FIVEPOINT3 <value-3>

17. Program the output current to 72.5% of the full scale current:

    CAL<n>:OUTP:CURR:COUNTS 3527

18. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

    CAL<n>:OUTP:CURR:FIVEPOINT4 <value-4>

19. Program the output current to 95% of the full scale current:

    CAL<n>:OUTP:CURR:COUNTS 4451

20. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

    CAL<n>:OUTP:CURR:FIVEPOINT5 <value-5>

21. Turn the unit off:

    OUTP<n>:STAT OFF

22. Perform the current calibration:

    CAL<n>:OUTP:CURR:CALC

23. Send the system error query command to make sure calibration was successful:

    SYST:ERR?

24. If there is no error returned at the system error query command then save the calibration results:

    CAL<n>:UNLOCK "6867"
    CAL<n>:STORE
    CAL<n>:LOCK

25. Optional Commands:

Query the current calibration points:
CAL<n>:OUTP:CURR:FIVEPOINT ?

26. Reset the unit:

***RST<n>**

4.6.19 Current Calibration for Voltage Range High

This procedure calibrates the output current of the power supply. This is five-point calibration procedure.

1. Close the switch between the power supply and the resistive load.
2. Connect the meter between the output and adjustable resistive load.
3. Set the voltmeter to read the AC current.
4. Ensure that load is connected to the output. Load setting should select range for 0 to 5Amps at 50Volts AC.
5. Issue clear and reset commands:

```
*CLS
*RST<n>
```

6. Set the voltage range of the power supply to high:

```
SOUR<n>:VOLT:RANGE 1
```

7. Set the OVP supervisory to limit 20261:

```
CAL<n>:OUTP:VOLT:PROT:COUNTS 20261
```

8. Set the OCP supervisory to maximum limit:

```
CAL<n>:OUTP:CURR:PROT:COUNTS 4800
```

9. Turn the unit on:

```
OUTP<n>:STATE 1
```

10. Set the output voltage to 50 Volts:

```
SOUR<n>:VOLT 50
```

11. Program the output current to 5% of the full scale current:

```
CAL<n>:OUTP:CURR:COUNTS 228
```

12. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

```
CAL<n>:OUTP:CURR:FIVEPOINT1 <value-1>
```

13. Program the output current to 27.5% of the full scale current:

```
CAL<n>:OUTP:CURR:COUNTS 1252
```

14. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

    CAL<n>:OUTP:CURR:FIVEPOINT2 <value-2>

15. Program the output current to 50% of the full scale current:
    CAL<n>:OUTP:CURR:COUNTS 2276

16. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

    CAL<n>:OUTP:CURR:FIVEPOINT3 <value-3>

17. Program the output current to 72.5% of the full scale current:
    CAL<n>:OUTP:CURR:COUNTS 3527

18. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:
    CAL<n>:OUTP:CURR:FIVEPOINT4 <value-4>

19. Program the output current to 95% of the full scale current:
    CAL<n>:OUTP:CURR:COUNTS 4451

20. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:
    CAL<n>:OUTP:CURR:FIVEPOINT5 <value-5>

21. Turn the unit off:

    OUTP<n>:STAT OFF

22. Perform the voltage calibration:

    CAL<n>:OUTP:CURR:CALC

23. Send the system error query command to make sure calibration was successful:

    SYST:ERR?

24. If there is no error returned at the system error query command then save the calibration results:

    CAL<n>:UNLOCK “6867”
    CAL<n>:STORE
    CAL<n>:LOCK

25. Optional Commands:

    Query the current calibration points: **CAL<n>:OUTP:CURR:FIVEPOINT ?**

26. Reset the unit:

    `*RST<n>`

4.6.20 HALL CALIBRATION FOR VOLTAGE RANGE LOW (5 KHZ UNIT)

The following procedure calibrates the hall gain sensor of the power supply for the **5KHz AC unit only**. This is seven-point calibration procedure.

1. Close the switch between the power supply and the resistive load.
2. Connect the meter between the output and adjustable resistive load.
3. Set the voltmeter to read the AC current.
4. Ensure that a resistive load is connected to the output.
5. Issue clear and reset commands:

```
*CLS
*RST<n>
```

6. Set the voltage range of the power supply to low:

```
SOUR<n>:VOLT:RANGE 0
```

7. Turn the unit on:

```
OUTP<n>:STATE 1
```

8. Set the hall calibration data to the default value:

```
CAL<n>:OUTP:FREQ:CURR:DEFAULT
```

9. Set the output voltage to 120 Volts:

```
SOUR<n>:VOLT 120
```

10. Set the output current to 6.3 Amps:

```
SOUR<n>:CURR 6.3
```

11. Turn on the resistive load and adjust the load until the output voltage is 110 Volts, this will ensure that the AC supply is in Constant Current Mode.
12. Set the output frequency to 60Hz

```
SOUR<n>:FREQ 60
```

13. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

```
CAL<n>:OUTP:FREQ:CURR1 <value-1>
```

14. Set the output frequency to 500Hz

```
SOUR<n>:FREQ 500
```

15. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

    CAL<n>:OUTP:FREQ:CURR2 <value-2>

16. Set the output frequency to 1000Hz

    SOUR<n>:FREQ 1000

17. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

    CAL<n>:OUTP:FREQ:CURR3 <value-3>

18. Set the output frequency to 2000Hz:

    SOUR<n>:FREQ 2000

19. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

    CAL<n>:OUTP:FREQ:CURR4 <value-4>

20. Set the output frequency to 3000Hz:

    SOUR<n>:FREQ 3000

21. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

    CAL<n>:OUTP:FREQ:CURR5 <value-5>

22. Set the output frequency to 4000Hz:

    SOUR<n>:FREQ 4000

23. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

    CAL<n>:OUTP:FREQ:CURR6 <value-6>

24. Set the output frequency to 5000Hz:

    SOUR<n>:FREQ 5000

25. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current:

    CAL<n>:OUTP:FREQ:CURR7 <value-7>

26. Perform the voltage calibration:

    CAL<n>:OUTP:FREQ:CALC

27. Send the system error query command to make sure calibration was successful:

    SYST:ERR?

28. If there is no error returned at the system error query command then save the calibration data:
    CAL<n>:UNLOCK “6867”
    CAL<n>:STORE
    CAL<n>:LOCK

29. Reset the unit:
    ***RST<n>**

4.6.21 HALL CALIBRATION FOR VOLTAGE RANGE HIGH (5 KHZ UNIT)

This procedure calibrates the hall gain sensor of the power supply for the **5KHz AC unit only**. This is seven-point calibration procedure.

1. Close the switch between the power supply and the resistive load.
2. Connect the meter between the output and adjustable resistive load.
3. Set the voltmeter to read the AC current.
4. Ensure that load is connected to the output.
5. Issue clear and reset commands:

   ```
   *CLS
   *RST<n>
   ```

6. Set the voltage range of the power supply to high

   ```
   SOUR<n>:VOLT:RANGE 1
   ```

7. Turn the unit on

   ```
   OUTP<n>:STATE 1
   ```

8. Set the hall calibration data to the default value

   ```
   CAL<n>:OUTP:FREQ:CURR:DEFAULT
   ```

9. Set the output voltage to 240 Volts

   ```
   SOUR<n>:VOLT 240
   ```

10. Set the output current to 3.15 Amps

    ```
    SOUR<n>:CURR 3.15
    ```

11. Turn on the resistive load and adjust the load until the output voltage is 230 Volts, this will ensure that the AC supply is in Constant Current Mode.

12. Set the output frequency to 60Hz

    ```
    SOUR<n>:FREQ 60
    ```

13. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current using following command

    ```
    CAL<n>:OUTP:FREQ:CURR1 <value-1>
    ```

14. Set the output frequency to 500Hz

    SOUR<n>:FREQ 500

15. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current using following command

    CAL<n>:OUTP:FREQ:CURR2 <value-2>

16. Set the output frequency to 1000Hz

    SOUR<n>:FREQ 1000

17. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current using following command

    CAL<n>:OUTP:FREQ:CURR3 <value-3>

18. Set the output frequency to 2000Hz

    SOUR<n>:FREQ 2000

19. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current using following command

    CAL<n>:OUTP:FREQ:CURR4 <value-4>

20. Set the output frequency to 3000Hz

    SOUR<n>:FREQ 3000

21. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current using following command

    CAL<n>:OUTP:FREQ:CURR5 <value-5>

22. Set the output frequency to 4000Hz

    SOUR<n>:FREQ 4000

23. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current using following command

    CAL<n>:OUTP:FREQ:CURR6 <value-6>

24. Set the output frequency to 5000Hz

    SOUR<n>:FREQ 5000

25. Wait for AC current to stabilize. Measure the output current using the AC meter. Enter the measured current using following command

    CAL<n>:OUTP:FREQ:CURR7 <value-7>

26. Perform the voltage calibration using following command
    CAL<n>:OUTP:FREQ:CALC

27. Send the system error query command to make sure calibration was successful.
    SYST:ERR?

28. If there is no error returned at the system error query command then save the calibration result with the following commands
    CAL<n>:UNLOCK "6867"
    CAL<n>:STORE
    CAL<n>:LOCK

29. Reset the unit
    ***RST<n>**

4.6.22 HALL CALIBRATION FOR VOLTAGE RANGE LOW (1.2 KHZ UNIT)

This procedure calibrates the hall gain sensor of the power supply for the **1.2KHz AC unit only**.. This is a seven-point calibration procedure.

1. Close the switch between the power supply and the resistive load.
2. Connect the meter between the output and adjustable resistive load.
3. Set the voltmeter to read the AC current.
4. Ensure that load is connected to the output.
5. Issue clear and reset commands:

```
*CLS
*RST<n>
```

6. Set the voltage range of the power supply to low

```
SOUR<n>:VOLT:RANGE 0
```

7. Turn the unit on

```
OUTP<n>:STATE 1
```

8. Set the hall calibration data to the default value

```
CAL<n>:OUTP:FREQ:CURR:DEFAULT
```

9. Set the output voltage to 120 Volts

```
SOUR<n>:VOLT 120
```

10. Set the output current to 6.3 Amps

```
SOUR<n>:CURR 6.3
```

11. Turn on the resistive load and adjust the load until the output voltage is 110 Volts, this will ensure that the AC supply is in Constant Current Mode.

12. Set the output frequency to 60Hz

```
SOUR<n>:FREQ 60
```

13. Wait for AC current to stabilize. Measure the output current using the AC current meter. Enter the measured current using following command

```
CAL<n>:OUTP:FREQ:CURR1 <value-1>
```

14. Set the output frequency to 250Hz

    SOUR<n>:FREQ 250

15. Wait for AC current to stabilize. Measure the output current using the AC current meter. Enter the measured current using following command

    CAL<n>:OUTP:FREQ:CURR2 <value-2>

16. Set the output frequency to 440Hz

    SOUR<n>:FREQ 440

17. Wait for AC current to stabilize. Measure the output current using the AC current meter. Enter the measured current using following command

    CAL<n>:OUTP:FREQ:CURR3 <value-3>

18. Set the output frequency to 630Hz

    SOUR<n>:FREQ 630

19. Wait for AC current to stabilize. Measure the output current using the AC current meter. Enter the measured current using following command

    CAL<n>:OUTP:FREQ:CURR4 <value-4>

20. Set the output frequency to 820Hz

    SOUR<n>:FREQ 820

21. Wait for AC current to stabilize. Measure the output current using the AC current meter. Enter the measured current using following command

    CAL<n>:OUTP:FREQ:CURR5 <value-5>

22. Set the output frequency to 1010Hz

    SOUR<n>:FREQ 1010

23. Wait for AC current to stabilize. Measure the output current using the AC current meter. Enter the measured current using following command

    CAL<n>:OUTP:FREQ:CURR6 <value-6>

24. Set the output frequency to 1200Hz

    SOUR<n>:FREQ 1200

25. Wait for AC current to stabilize. Measure the output current using the AC current meter. Enter the measured current using following command

    CAL<n>:OUTP:FREQ:CURR7 <value-7>

26. Perform the voltage calibration using following command

CAL<n>:OUTP:FREQ:CALC

27. Send the system error query command to make sure calibration was successful.
    SYST:ERR?

28. If there is no error returned at the system error query command then save the calibration result with the following commands
    CAL<n>:UNLOCK “6867”
    CAL<n>:STORE
    CAL<n>:LOCK

29. Reset the unit
    ***RST<n>**

4.6.23 Hall Calibration for Voltage Range High (1.2 KHz Unit)

This procedure calibrates the hall gain sensor of the power supply for the **1.2KHz AC unit only**. This is a seven-point calibration procedure.

1. Close the switch between the power supply and the resistive load.
2. Connect the meter between the output and adjustable resistive load.
3. Set the voltmeter to read the AC current.
4. Ensure that load is connected to the output.
5. Issue clear and reset commands:

```
*CLS
*RST<n>
```

6. Set the voltage range of the power supply to high:

```
SOUR<n>:VOLT:RANGE 1
```

7. Turn the unit on:

```
OUTP<n>:STATE 1
```

8. Set the hall calibration data to the default value:

```
CAL<n>:OUTP:FREQ:CURR:DEFAULT
```

9. Set the output voltage to 120 Volts:

```
SOUR<n>:VOLT 240
```

10. Set the output

```
SOUR<n>:CURR 3.15
```

11. Turn on the resistive load and adjust the load until the output voltage is 230 Volts, this will ensure that the AC supply is in Constant Current Mode.

12. Set the output frequency to 60Hz:

```
SOUR<n>:FREQ 60
```

13. Wait for AC current to stabilize. Measure the output current using the AC current meter. Enter the measured current:

```
CAL<n>:OUTP:FREQ:CURR1 <value-1>
```

14. Set the output frequency to 250Hz

    SOUR<n>:FREQ 250

15. Wait for AC current to stabilize. Measure the output current using the AC current meter. Enter the measured current:

    CAL<n>:OUTP:FREQ:CURR2 <value-2>

16. Set the output frequency to 440Hz

    SOUR<n>:FREQ 440

17. Wait for AC current to stabilize. Measure the output current using the AC current meter

    CAL<n>:OUTP:FREQ:CURR3 <value-3>

18. Set the output frequency to 630Hz:

    SOUR<n>:FREQ 630

19. Wait for AC current to stabilize. Measure the output current using the AC current meter. Enter the measured current:

    CAL<n>:OUTP:FREQ:CURR4 <value-4>

20. Set the output frequency to 820Hz:

    SOUR<n>:FREQ 820

21. Wait for AC current to stabilize. Measure the output current using the AC current meter. Enter the measured current using following command

    CAL<n>:OUTP:FREQ:CURR5 <value-5>

22. Set the output frequency to 1010Hz

    SOUR<n>:FREQ 1010

23. Wait for AC current to stabilize. Measure the output current using the AC current meter. Enter the measured current using following command

    CAL<n>:OUTP:FREQ:CURR6 <value-6>

24. Set the output frequency to 1200Hz:

    SOUR<n>:FREQ 1200

25. Wait for AC current to stabilize. Measure the output current using the AC current meter. Enter the measured current:

CAL<n>:OUTP:FREQ:CURR7 <value-7>

26. Perform the voltage calibration:

    CAL<n>:OUTP:FREQ:CALC

27. Send the system error query command to make sure calibration was successful:

    SYST:ERR?

28. If there is no error returned at the system error query command then save the calibration data

    CAL<n>:UNLOCK "6867"
    CAL<n>:STORE
    CAL<n>:LOCK

29. Reset the unit

    ***RST<n>**

SECTION 5
FIXED POWER DC POWER SUPPLY

5.1 GENERAL DESCRIPTION

The Fixed Power DC (FPDC) power supply of the ReFlex Power™ system includes one model rated at 165W. It is part of a modular family of power assets that integrate into the ReFlex Power™ Mainframe to provide a wide range of features, functionality, and extensive configurability and adaptability.

The module operates as part of a remotely controlled system. It utilizes the ReFlex Power™ Mainframe backplane for input power distribution and control/communications interface. Through the ReFlex Power™ Controller module, communications with the user host controller is established for operation, configuration control and calibration. All connections to the user load and discrete control signal interface are available on the module front panels.

The module utilizes high-frequency power conversion for high efficiency to maximize power density and realize light weight and small size. The module is housed in a single-width enclosure, 1.4” W x 6.75” H x 15” D, and is only 4.7 lb. Mounting within the Mainframe is facilitated with chassis guides, backplane guide pins, and front panel captive fasteners for securing the module. The thermal design features integral, variable-speed fans so that the cooling performance scales with its output loading, minimizing the audible noise and airflow requirements.

The unique features of the ReFlex Power™ system of reconfigurability and extensibility are made possible through the use of the latest in controls technology. An FPGA-based implementation uses VHDL, embedded processor cores for firmware-based systems control, and ArcNet® inter-module communication and LAN system communications.

5.2 FEATURES

The ReFlex Power™ system FPDC power supply brings modularity to DC power. The mechanical design is ruggedized for harsh environments, including mobile applications, as well as general-purpose industrial and laboratory rack-mount ATE.

5.2.1 GENERAL FEATURES

- Small size, light weight
- Up to twelve modules per Mainframe
- Digital control
- Remote voltage sensing
- Low ripple/noise
- Constant-voltage regulation
- Power Factor Correction (PFC)
- Universal inputs: AC (50/60 Hz, 400 Hz), DC, single-phase, three-phase
- Opto-isolated remote turn-on and shutdown of outputs
- Integral output relays for isolation
- Integral variable speed cooling fans for low noise and extended fan life
- Ruggedized to MIL-PRF 28800F
- Software calibration
- Auto-Configuration of system assets

5.2.2 ACCESSORIES LIST

The ReFlex Power™ FPDC power supply modules include the following standard accessories:

- Operating Manual, P/N M380056-01 (this manual)
- Programming Manual, P/N M380056-03
- Quick Reference Guide, P/N M380056-04
- IVI-COM Drivers

5.2.3 CONTROLS AND INDICATORS

The FPDC power supply module operates within the ReFlex Power™ system as part of an automated test system and can be controlled directly from its front panel. It relies on the Mainframe and Controller module for data communications and power input. All output load connections and discrete control interface to the user application are accessible on the front panel of the module. Also, the front panel has LEDs to indicate the operational state of the module. Input power is routed from the Mainframe through a backplane distribution.

Figure 5-1 shows a front view of the FPDC module. Figure 5-2 shows a typical rear view of the module.

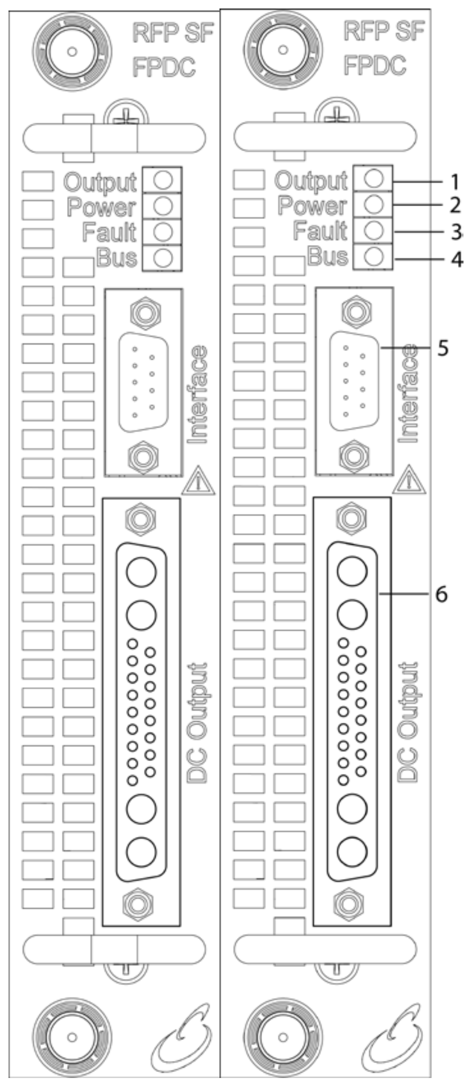


Figure 5-1. FPDC Front View

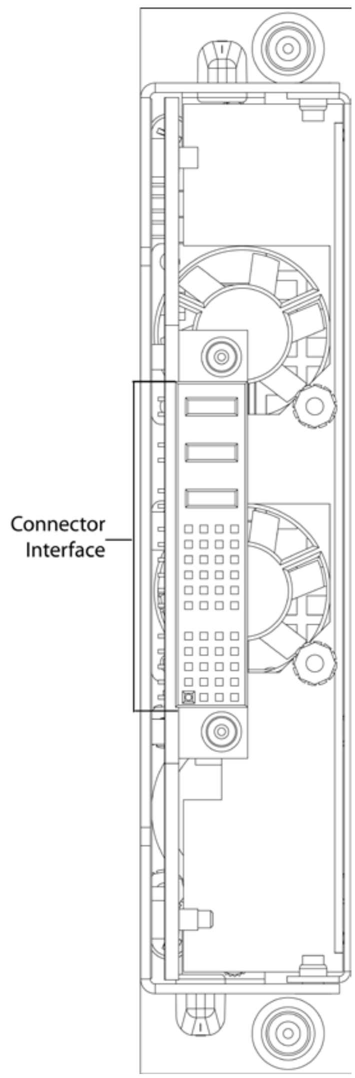


Figure 5-2. Rear View of Typical DC Supply Module

5.3 SPECIFICATIONS

All specifications are valid after a 30-minute warm-up time. Module can be used at reduced accuracy immediately following power-on. All accuracy specifications are plus/minus variations around the nominal parameter values, unless otherwise noted. Unless otherwise specified, requirements apply at the front panel output terminals, and with remote sense leads connected to front panel terminals. Performance specifications are valid following calibration at 25 °C, +/- 5 °C

5.3.1 PRODUCT MATRIX

Model	Output	Current Rating	Power Rating
FPDC	+5V DC	10 A	50W
	-5V DC	5 A	25W
	+15V DC	3 A	45W
	-15V DC	3 A	45W

5.3.2 OUTPUT CHARACTERISTICS

VOLTAGE ACCURACY

+5VDC and –5 VDC: +/- 52 mV
+15VDC and –15VDC: +/-200 mV
All at 25 °C, +/-5 °C

VOLTAGE RIPPLE/NOISE

(measured with 20Hz to 20MHz bandwidth)

+5VDC: 150 mV peak-peak
-5VDC: 80 mV peak-peak
+15VDC and –15VDC: 150 mV peak-peak

VOLTAGE TEMPERATURE DRIFT

0.02% of full-scale/°C, maximum

VOLTAGE LINE PLUS LOAD REGULATION

+5VDC and –5VDC: +20 mV, -100 mV
+15VDC and –15VDC: +/- 150 mV

VOLTAGE LOAD TRANSIENT

Less than 4% deviation for a 25-75% of full-scale load step and back within DC regulation limits after 400 usec

REMOTE SENSE CAPABILITY

Remote sense shall compensate for at least 0.25V per load line leg. Maximum rated output power must not be exceeded at module output terminals. The sense lines can be opened during operation without damaging the module or the load; module will continue to maintain output, but with reduced accuracy to 5%. Misconnection of the sense leads must be prevented. Excessive load line voltage drop will result in shutdown of the output.

POWER ON SEQUENCE

The module when commanded to turn on shall sequence the 4 voltage outputs such that the +/- 15VDC turn on together and first, followed +5VDC and then the –5VDC. The +5VDC shall not turn on until the +15VDC and -15VDC have reached at least 50% of their nominal output level.

POWER OFF SEQUENCE

The module when commanded to turn off shall sequence the 4 output voltage outputs such that the –5VDC turns off first followed by the +5VDC and +/-15VDC turned off last. The +/-15VDC shall not be turned off until the +5VDC output has reached 0.5 VDC or less. The turn off sequence requires reasonable balance in loads and load energy storage.

5.3.3 SUPERVISORY CHARACTERISTICS

OVERVOLTAGE (OVP)

Overvoltage protection is typically 125% of nominal output voltage

OVERCURRENT

Output current is allowed to at least 125% of the full scale current. Short circuit protection is provided for each output voltage.

OVERTEMPERATURE

Overtemperature protection is implemented with protection monitors that sense excessive internal heatsink operating temperature, and shut down the power converter. The maximum internal converter temperature is typically 120 °C.

5.3.4 General Characteristics

Input Voltage Range

103.5-253VAC with AC input; 270VDC, nominal; 210VDC, minimum to 300VDC, maximum; 314VDC, maximum for 2s; 364.5VDC, maximum for 450ms

Input Current

Power factor corrected single-phase AC input; unipolar DC input; sinusoidal current with AC input; continuous DC current with DC input.
At 103.5 VAC input and full power output, the input current is 2.75 A maximum.

Power Factor

> 0.95 at full output load, >0.75 at 20% output load, decreasing to 0.3 at no load

Efficiency

60% minimum

Front Panel Indicators

OUTPUT (LED, green): output enabled and isolation relay closed
POWER (LED, green): input AC/DC power applied to module
FAULT (LED, red): internal abnormal operating condition detected; output disabled and isolation relay opened
BUS (LED, green): internal bus communication established

5.3.5 Input/Output Connections

Output Isolation

Each voltage output is isolated from the input line, the other output voltages, and the module case by at least 1 Meg Ohm.

Output Relays

Each output is provided with an isolation relay.

5.3.6 COMMAND SETS/DRIVERS

COMMAND DESCRIPTION

SCPI Standard 1999 command language, through Controller Module

RESPONSE DESCRIPTION

SCPI Standard 1999 command language, through Controller Module

COMMAND EXECUTION TIME

50ms from command request, not including parameter slew time to set-point

5.3.7 MECHANICAL CHARACTERISTICS

DIMENSIONS

1.4 inch wide, 6.75 inch high, and 15 inch deep

WEIGHT

4.7 pound, maximum

COOLING PROVISIONS

Operation at maximum limits of output power, ambient temperature, and altitude requires adequate airflow of 15 CFM through the module.

COLOR

Black, color number 27038 per FED-STD-595

ACOUSTIC NOISE

The speed of the integral fans is linearly variable, as a function of internal heatsink temperature rise, to minimize acoustic noise and extend the fan life. The speed varies from nominally 50% of full-speed to full-speed as the heatsink temperature varies with ambient temperature and power dissipation resulting from the output load.

5.3.8 Environmental Characteristics

Operating Temperature

Standard: 0 to 50 °C

Extended Range Option: -10 to 55 °C

Operating Altitude

Standard: 0 to 6,500 ft

Extended Range Option: -0 to 15,000 ft

Operating Humidity

95% non-condensing

Operating Shock

Class 3 MIL-PRF-28800F

Operating Vibration

Class 3 MIL-PRF-28800F

Operation Without Fully Populated Mainframe

If Mainframe is not fully populated with modules, filler panels must be installed in empty slots to maintain proper airflow and structural integrity.

Non-Operating Temperature

-40 to 71 °C

Non-Operating Altitude

0 to 50,000 ft

Non-Operating Shock

Class 3 MIL-PRF-28800F

Non-Operating Vibration

Class 3 MIL-PRF-28800F

5.3.9 Regulatory Agency Compliance

Safety Compliance

European Low Voltage Directive, IEC 61010-1:90+A1:92+A2:95, as required for the CE mark.

LVD Categories

Installation Category II; Pollution °C 2; Class II Equipment; for Indoor Use Only

EMC Compliance

EMC Directive, EN 61326:1998

Electrostatic Discharge

IEC 61000-4-2

Radiated RF Immunity

IEC 61000-4-3

Fast–Transients

IEC 61000-4-4

Surge

IEC 1000-4-5

Conducted RF Immunity

IEC 1000-4-6

Input Power Interruptions

IEC 1000-4-11

Conducted Emissions

CISPR 16-1/2, Class A

Radiated Emissions

CISPR 16-1/2, Class A

5.4 INSTALLATION

The ReFlex Power™ FPDC power supply module has been fully calibrated and tested prior to shipment; the module is ready for immediate use upon receipt. However, when first unpacked, the module should be inspected to ensure that no shipping damage has occurred.

5.4.1 INITIAL INSPECTION

Perform a visual inspection of the shipping container prior to accepting the package from the carrier. If damage to the shipping container is evident, a description of that damage should be noted on the carrier's receipt and signed by the carrier's driver.

Verify that the proper module and associated accessories have been received. Perform a visual inspection of the module after it is removed from the shipping container. Check for shipping damage such as dents, scratches, or distortion of the enclosure.

If external damage is evident, there may be internal damage as well. Immediately contact the carrier and file a claim for concealed damage. In addition, the shipping container and filler material should be saved for inspection. Forward a report of the damage to the Customer Care Department where an associate will provide instructions for repair or replacement of the unit.

5.4.2 LOCATION CONSIDERATIONS

The FPDC power supply module is designed for use within the ReFlex Power™ Mainframe and can be inserted within any slot of the Mainframe.

Since the module is fan–cooled, it requires adequate clearance at the air intake of the front panels so that airflow is not impeded.

AIRFLOW REQUIREMENTS

Provide adequate clearance for adequate air intake through the front panels and exhaust through the rear.

Ensure that the ambient air temperature at the front panel air intake does not exceed 55°C.

Install filler panel(s) in any empty slot(s) of the Mainframe.

CAUTION
Inadequate airflow and excessive ambient air temperature could result in overheating and thermal shutdown.

5.4.3 INSTALLATION

CAUTION
The module contains ESD sensitive circuitry. Follow appropriate handling and grounding procedures to prevent damage to the module. The module should be handled by the enclosure, with care to protect the connectors from ESD discharges.

CAUTION
Input power must be disconnected to the Mainframe before a module is inserted or extracted. Inserting or extracting a module with power installed (hot-swapping) could result in damage to the module or Mainframe. Prior to turning power on, ensure that front panel captive fasteners are tightened.

Modules are installed into the Mainframe from the front of the chassis. Refer to Figure 5-3 for the orientation of a module and Mainframe during installation.

1. Ensure that the AC/DC input power is disconnected before installing or removing any module(s).
2. Insert the module into the mainframe, rear panel first, aligning the module guide rails the top and bottom Mainframe guides.
3. Gently slide the module completely into the mainframe until the guide pins of the module rear connector engage the mating backplane connector.
4. Fully seat the module until the front panel inner surface is snug against the mainframe chassis.
5. Secure the module(s) to the Mainframe at the top and bottom of each front panel by turning the captive thumb screws clockwise with a flat blade screwdriver to a maximum torque of 20 in-lb.
6. Install a filler panel over any empty slot, and secure in place at the top and bottom by turning the captive thumb screws clockwise with a flat blade screwdriver to a maximum torque of 20 in-lb.

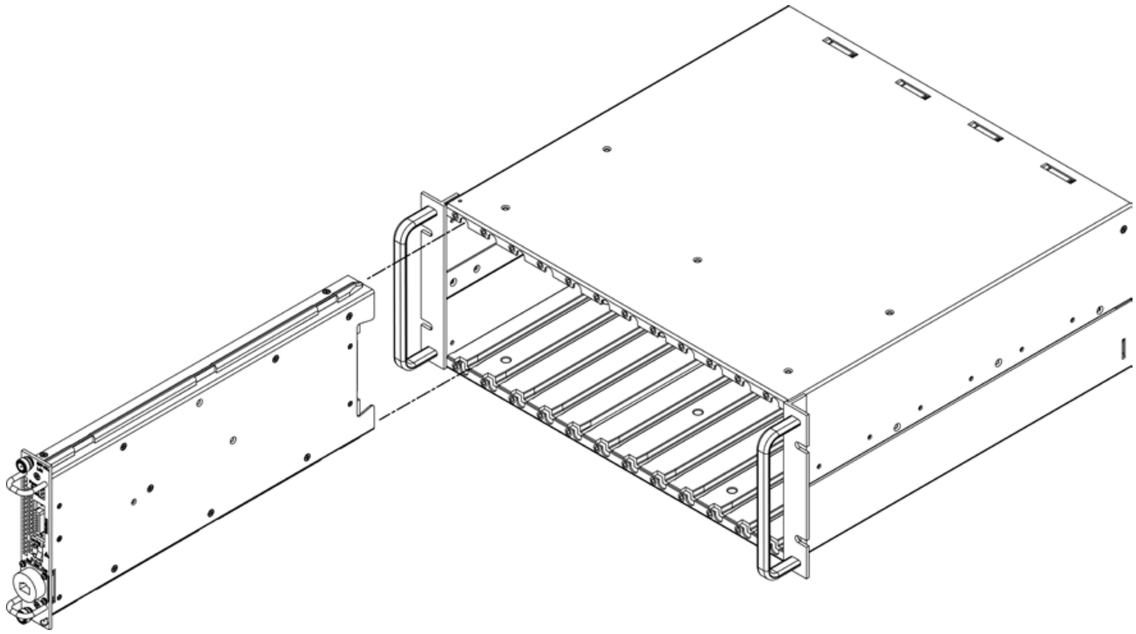


Figure 5-3. Module Installation (1-U wide example)

5.4.4 INPUT POWER REQUIREMENTS

The FPDC power supply module will operate from a wide variety of AC and DC input power sources, as distributed through the Mainframe. Although the Mainframe could be connected to either single-phase or three-phase AC power, the module has single-phase inputs. It is connected to the source, through the Mainframe, either phase to neutral, or line to line, depending on the available source voltage. The power source voltage must be within the range of 90–264VAC at 47-63Hz or 400Hz, or 210-300VDC. The input voltage ranges are continuous, and do not require any manual setup.

CAUTION
Exceeding the maximum rated AC/DC input voltage could result in damage to the module.

The module can produce full rated power down to 103.5VAC input. Total aggregate output power of the Mainframe is limited to 6,000W with 200VAC or greater input, and 3,600W at 132VAC and lower input. The module has power factor correction (PFC) that provides linear AC input current and high power factor, minimizing the required input apparent power.

The Mainframe distributes the input power through backplane connectors to three groups of four slots connected in parallel. The groups are connected to separate pair of pins in the Mainframe rear panel AC/DC input connector (one line and return per connection); the connector has six power pins plus ground.

Balance in phase currents can be achieved only if the power modules are located in the Mainframe so that equal distribution between the three groups of slots is maintained, and if the same load is applied to the set of modules in each group.

The load applied to a particular AC/DC input line is dependent on the location of the modules in the Mainframe slots. The slots are grouped in sets of four: Slot 1-4, Slot 5-8, and Slot 9-12. Slot 1 is the left-most slot, as viewed from the front (Figure 5-4). Each of the four slots is supplied by one of the AC/DC input lines. In a double-width and triple-width module, the module connector is located so that it mates to a backplane connector in the right-most slot, as viewed from the front of the Mainframe. Refer to Table 5-1 for Mainframe input connector pin-out and power allocation to the Mainframe slots.

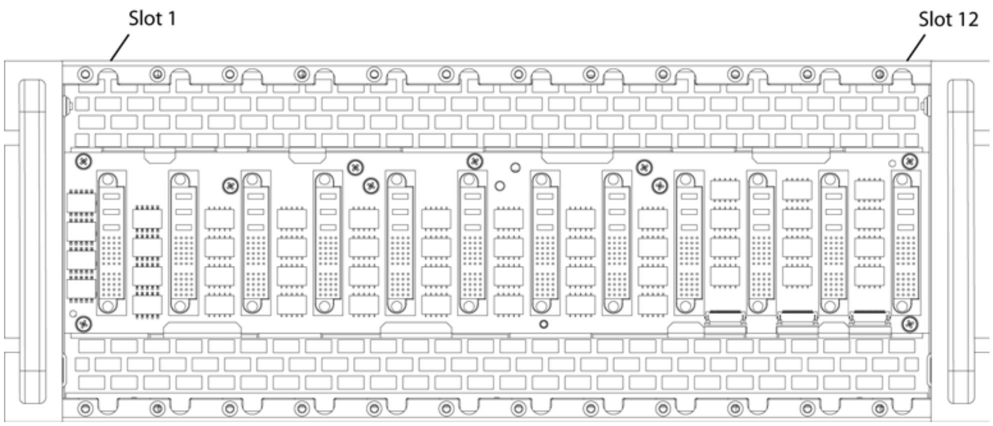


Figure 5-4. Slot Numbering Assignments, Empty Mainframe Front View

Table 5-1. Mainframe Connector and Power Allocation Information

Input Service	Phases	Input Designation	Input Connector Pin	Input Service Connection	Slot Supplied
100/115/120VAC 200/208VAC 220/230/240VAC	1	L1	F	Phase	Slot 1-4
		L1-RTN	E	Return	
		L2	A	Phase	Slot 5-8
		L2-RTN	G	Return	
		L3	B	Phase	Slot 9-12
		L3-RTN	C	Return	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
200/208VAC	3 Delta	L1	F	Phase-A	Slot 1-4
		L1-RTN	E	Phase-B	
		L2	A	Phase-B	Slot 5-8
		L2-RTN	G	Phase-C	
		L3	B	Phase-C	Slot 9-12
		L3-RTN	C	Phase-A	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
200/208VAC 220/230/240VAC	3 Wye	L1	F	Phase-A	Slot 1-4
		L1-RTN	E	Neutral	
		L2	A	Phase-B	Slot 5-8
		L2-RTN	G	Neutral	
		L3	B	Phase-C	Slot 9-12
		L3-RTN	C	Neutral	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
210-360VDC	DC	L1	F	Source	Slot 1-4
		L1-RTN	E	Return	
		L2	A	Source	Slot 5-8
		L2-RTN	G	Return	
		L3	B	Source	Slot 9-12
		L3-RTN	C	Return	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis

A plug/socket connector is provided on the rear panel of the Mainframe for connecting the unit to the AC/DCpower source. The connector also provides a safety ground termination. The input power cable should include a safety ground wire to connect the chassis of the Mainframe to the safety ground of the AC/DC power source. Since the AC input leakage current could exceed 3.5mA, a second safety ground connection is required. It should be connected to the safety ground stud on the rear panel of the Mainframe.

WARNING
A separate, dedicated safety ground wire must be connected to the Mainframe rear panel safety ground stud. Operating the ReFlex Power™ system with the safety ground wire disconnected could result in a shock hazard.

5.4.5 AC/DC INPUT OVERCURRENT PROTECTION

The module has internal over-current protection to provide fault isolation in case failure occurs of internal components or wiring. However, over-current protection must also be provided externally, within the system installation, for the AC/DC input of the Mainframe. Refer to the Mainframe manual for recommendations.

5.4.6 AC/DC INPUT DISCONNECT DEVICE

The ReFlex Power™ system does not have any means to disconnect it from the AC/DC input service. The front panel POWER switch of the Controller module in the Mainframe does not disconnect the AC/DC input line from the modules or Mainframe. Ensure that a suitable disconnecting device is incorporated into the system installation, so that isolation will be provided when it is opened. The switch or circuit breaker must be located close to the ReFlex Power™ system, within reach of the operator, and clearly labeled as the disconnection device.

WARNING
To prevent a shock hazard, ensure that the AC/DC input disconnect device is open, and that the safety ground conductor is connected to the rear panel ground stud, before removing/inserting modules from/into the Mainframe. The Mainframe backplane input power distribution remains energized whenever the AC/DC input is connected.

5.4.7 CONNECTORS

The FPDC power supply module has all user interface connectors located on the front panel. Two connectors are provided: the power connections to the load, and the control signal interface.

WARNING
To prevent electrical shock, disconnect the AC/DC input service before making any connections to the module.

MATING CONNECTOR KIT

FPDC Mating Connector Kit - AMETEK Part No. 5380274-01, mates with RFP-F1000-001-XXXX, and includes the following for both Interface and DC output connectors:

Bill of Material

Item	AMETEK Part No.	Description	Qty	Manufacturer Part No.	Manufacturer	Suggested Source(s)
1	856-214-04	Conn, 21P, DSUB, 8/20AWG, Male	1	CBC21WA4M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
2	856-745-52	Contact, 12AWG, 30A, Male	4	MC4012D	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
3	856-247-39	Conn, Backshell, 37P, Strt, 2 PC	1	D37000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
4	856-214-09	Conn, 9P, DSUB, 20-24AWG, Crimp, Male	1	SD9M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
5	856-247-10	Conn, Backshell, 9P, DSUB, 2 PC	1	D9000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm

RECOMMENDED TOOLS (NOT INCLUDED WITH MATING CONNECTOR KIT)

Hand crimp: Positronic Industries P/N 9507-0-0-0

Pneumatic crimp: Positronic Industries P/N 9550-1-0

Insertion/extraction: Positronic Industries P/N M81969/1-02

Pins A1 – A3 insertion/extraction: Positronic Industries P/N 4711-2-0-0

Pin A4 extraction: Positronic Industries P/N 4311-0-0-0

USER INTERFACE

The User Interface connector provides terminations for external connections to digital control signals.

Interface Connector

Connector: Positronic Industries P/N SD9M1000Z, AMETEK P/N 856-214-09
Crimp Contacts: Positronic Industries P/N MC7520D (initially supplied with connector)

Backshell: Positronic Industries P/N D9000Z00, AMETEK P/N 856-247-10

Wire size: Maximum gauge 20 AWG (22 AWG recommended)
Maximum length 10 meters.

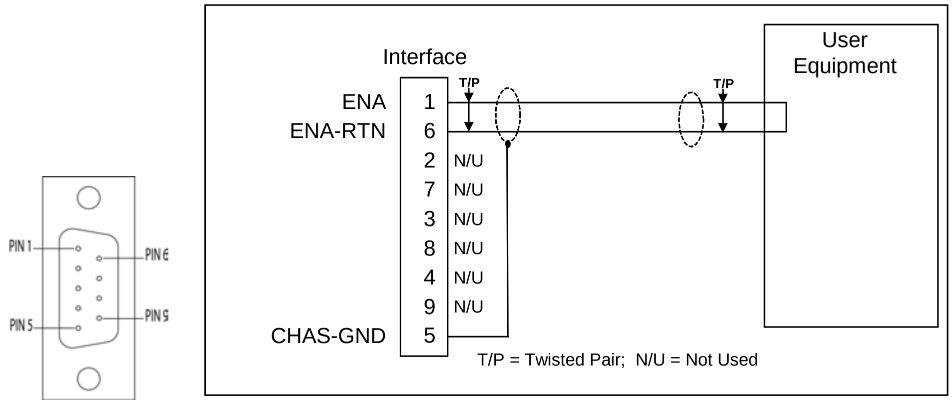


Figure 5-5. FPDC Interface Connector, Front Panel View, and Wiring Diagram

Table 5-2. FPDC Interface Connector Pinout

Pin	Signal	Description
1	ENAB[1]	Enable module output
2	RESERVED	
3	RESERVED	
4	RESERVED	
5	CHAS GND	Chassis Ground
6	ENAB RTN[1]	Enable module output return
7	RESERVED	
8	RESERVED	
9	RESERVED	

1 Enable signal is internally pulled up to +5V with a 10 K resistor. To enable the module, the signal is pulled low (<= 0.5V) with respect to the ENAB RTN signal; this may also be accomplished by shorting Pin 1 to Pin 6.

Optional Interface Connector Accessories

- AMETEK P/N 5380508-01, 9-pin Loop-back Connector Assembly, includes a jumper wire between Pins 1 and 6 to enable the module outputs.
- AMETEK P/N 5380448-01, Power Module, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.
- AMETEK P/N 5380448-03, Power Module, Right Angle, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.

DC OUTPUTS

The FPDC Output connector, J2, provides terminations for the 4 DC voltages and associated remote sense connections to the load(s).

DC Output Connector

Connector: Positronic Industries P/N CBC21WA4M1000Z,
AMETEK P/N 856-214-04 (crimp signal contacts)

Pins 1 – 17: Positronic Industries P/N MC6020D, AMETEK P/N 856-214-04

Wire size: Maximum gauge 20 AWG (recommended)
Length: Maximum 10 meters

Pins A1 – A4: Positronic Industries P/N MC4012D, AMETEK P/N 856-745-52

Wire size: Maximum gauge 12 AWG (recommended
Length: Maximum 10 meters

Backshell: Positronic Industries P/N D37000Z00, AMETEK P/N 856-247-39

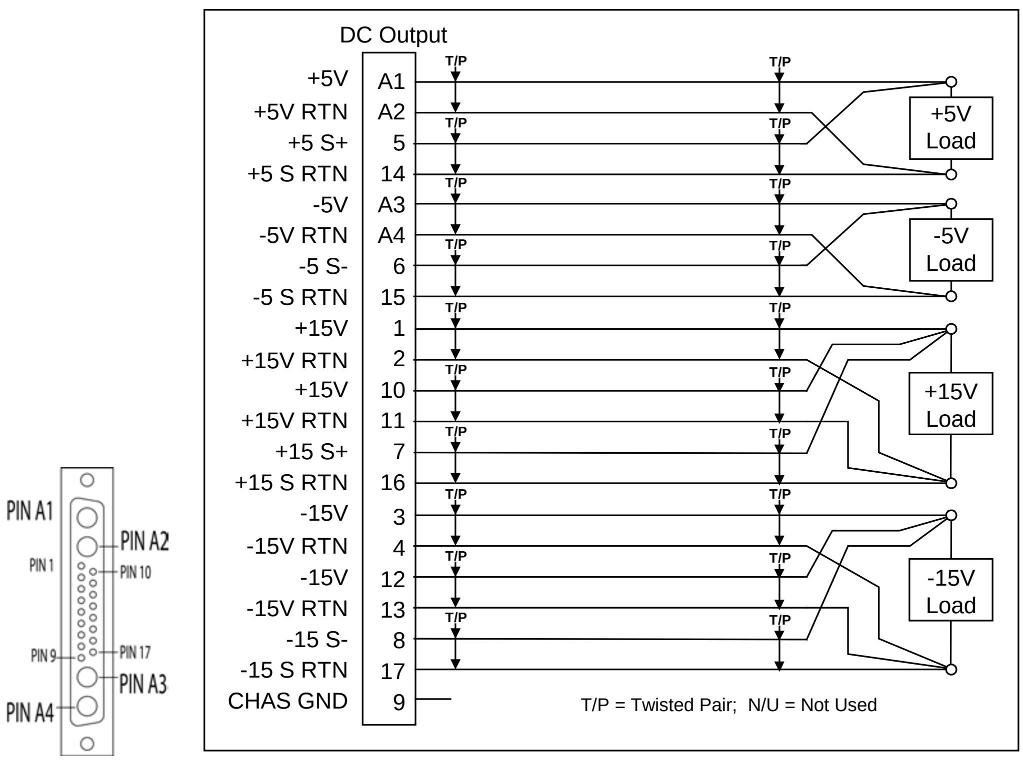


Figure 5-6. FPDC DC Output Connector, Front Panel View, and Wiring Diagram

Table 5-3. FPDC DC Output Connector Pinout

PIN	Name	Description
1	+15V	+15V Positive Output derived after disconnect relay
2	+15V RTN	+15V Return
3	-15V	-15V Negative Output derived after disconnect relay
4	-15V RTN	-15V Return
5	+5V S+	+5V Positive Sense connected after local-remote sense relay
6	-5V S-	-5V Negative Sense connected after local-remote sense relay
7	+15V S+	+15V Positive Sense connected after local-remote sense relay
8	-15V S-	-15V Negative Sense connected after local-remote sense relay
9	CHAS GND	Chassis ground
10	+15V	+15V Positive Output derived after disconnect relay
11	+15V RTN	+15V Return
12	-15V	-15V Negative Output derived after disconnect relay
13	-15V RTN	-15V Return
14	+5V S RTN	+5V Sense Return
15	-5V S RTN	-5V Sense Return
16	+15V S RTN	+15V Sense Return
17	-15V S RTN	-15V Sense Return
A1	+5V	+5V Positive Output derived after disconnect relay
A2	+5V RTN	+5V Return Output
A3	-5V	-5V Positive Output derived after disconnect relay
A4	-5V RTN	-5V Return

DC Output Connector Accessories

- ·AMETEK P/N 5380449-01, FPDC Module, 9ft. Unterminated DC Output Cable Assembly.
- ·AMETEK P/N 5380449-03, FPDC Module, Right Angle, 9ft. Unterminated DC Output Cable Assembly.

REMOTE SENSE

Remote sensing is used to compensate for the voltage drop that occurs across the wires connecting the load to the output of the FPDC power supply module. A separate pair of wires for each voltage output is routed to measure the respective voltage at the load terminals where precise regulation of the output voltage is desired.

The remote sense leads are connected at the DC OUTPUT connector, J2, on the front panel of the module. Connect the SNS terminal to the corresponding voltage terminal, and the SNS-RTN terminal to the corresponding voltage return terminal.

Special care is required in routing the sensing leads to prevent noise pickup or coupling to the power leads; refer to the section, Noise and Impedance Effects. The sense leads should be a twisted-pair of at least AWG #22 wire, and may require shielding in high noise environments. Connect the shield to the shield ground terminal, CHAS-GND, of the DC OUTPUT connector, J2, as required to maximize its effectiveness.

If the remote sense leads are not connected, the FPDC module will continue to operate but the voltage at the load will no longer be precisely regulated. An internal resistor network exists within the module that connects the output terminals to the remote sense terminals. This network provides the measurement of the output voltage when the remote sense leads are not connected. However, since the voltage is now measured at the output terminals, the voltage drop of the load wiring would no longer be compensated.

5.4.8 WIRE SELECTION

Input/output wiring must have a current carrying capacity compatible with the current rating of the ReFlex Power™ system. The maximum current rating of a wire is dependent on the materials used in its construction, and is primarily limited by the insulation. The current must be limited so that the temperature rise of the wire does not result in an operating temperature that exceeds the rating of the wire.

WIRE CURRENT CAPACITY

Table 5-4 shows maximum current ratings, based on a cable of three conductors, that will produce an approximate 30ºC temperature rise above ambient. When wiring must operate in areas with an elevated ambient temperature or bundled with other wiring, heavier gauges or higher temperature-rated wiring should be used.

Although wire with higher temperature rated insulation will allow operation at higher currents, the total voltage drop would also be increased for a given wire gauge. For applications where voltage characteristics, such as regulation, are important, it may be necessary to size the wire based on total voltage drop instead of temperature rise.

Table 5-4. Wire Data

AWG	Copper Area, cm^2	Resistance, Ω/m at 20°C	Resistance, Ω/m at 100°C	Current Rating, A for 30ºC Rise
6	0.133	0.0013	0.0017	54
8	0.0837	0.0021	0.0028	40
10	0.0526	0.0033	0.0044	27
12	0.0331	0.0052	0.0069	21
14	0.0208	0.0083	0.011	16
16	0.0131	0.0132	0.0174	12
18	0.00823	0.0209	0.0276	10
20	0.00518	0.0333	0.044	7.5
22	0.00326	0.053	0.07	5.5

Wire Voltage Drop

For applications where regulation is important, the contribution of the load wiring to voltage drop from the output terminals of the FPDC module to the load must be considered. The wire gauge must be selected to maintain an acceptable total voltage drop for the load wiring under the maximum peak current. The resistance of the load wiring must be determined for the sum total length of the output lead and the return lead. The total voltage drop is the sum of the individual drops in the output and return leads. Table 5-4 gives the resistance per meter (m) of various wire gauges at 20 °C and 100 °C.

Use the following equation to calculate the resistance for other wire temperatures:

R = R20°C x [1 + 0.004 x (T - 20°C)]

where,

R = resistance, Ω/m, at temperature T

R20°C = resistance, Ω/m, at 20°C

T = temperature of wire, °C

The voltage drop (per output or return lead) could be calculated using the following equation:

V = I x L x R20°C x [1 + 0.004 x (T - 20°C)]

where,

V = total voltage drop, V

I = current, A

L = length of wire, m

R20°C = resistance of wire, Ω/m, at 20°C

T = temperature of wire conducting current, °C

NOISE AND IMPEDANCE EFFECTS

To minimize noise pickup or radiation from load circuits, load wires and remote sense wires should be twisted-pair with minimum lead length. Shielding of the sense leads may be necessary in high noise environments. Even if noise is not a concern, the load and remote sense wires should be twisted-pairs to reduce coupling between them, which could impact the stability of the output converter. If connectors are utilized for the power and sense leads, be careful not to introduce coupling between the leads. Ensure that the connector terminals for the sense leads are in adjacent locations, and minimize the physical loop area of the untwisted portions.

Twisting the load wires provides an additional benefit in reducing the parasitic inductance of the cable. This improves the dynamic response characteristics at the load by maintaining a low source impedance at high frequencies. Also, with long load wires, the resultant inductance and resistance could produce high frequency voltage fluctuations at the load because of current variations in the load itself. The impedance introduced between the output of the power supply and the load could make the ripple/noise voltage at the load worse than the specification of the FPDC power supply module (which is valid when measured at the front panel connector) because of the contribution to the ripple/noise by the load current. Additional filtering with bypass capacitors at the load terminals may be required to bypass the high frequency load currents.

5.5 OPERATION

The FPDC power supply module functions under remote control through a host controller or directly from control at its User Interface Connector. The ReFlex Power™ Controller module serves as a communications portal between the power supply modules and the remote host controller. All aspects of operation could be achieved through use of commands that comply with the requirements of the SCPI Standard 1999 command language. Additional discrete digital control signals are available for dedicated hardware interface. All connectors for control and power interface are accessible on the front panel

5.5.1 CONTROLS AND INDICATORS

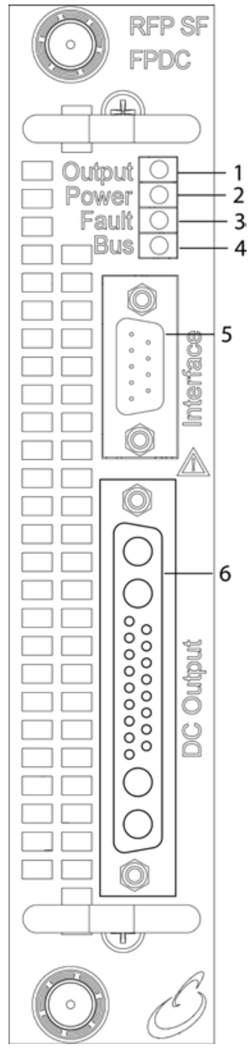


Figure 5-7. FPDC Indicators and Connectors

1 – Output Indicator: Green LED lights when output voltages are enabled or isolation relays are closed
2 – Power Indicator: Green LED lights when AC/DC input power is applied to the module.
3 – Fault Indicator: Red LED lights when an abnormal internal operating condition has been detected; the output would be disabled and the isolation relay opened.
4 – Bus Indicator: Green LED lights when internal inter-module communications has been established.
5 – User Interface Connector for remote isolated digital enable signal.
6 – DC Output connector for the output voltages and remote sense.

5.5.2 MODES OF OPERATION

FPDC modules operate in standalone mode, functioning as independent DC power supplies. The outputs are isolated from each other and from any other adjacent modules, and could be configured for positive, negative, or floating outputs with respect to the chassis ground. The Mainframe backplane control and data communications interface is also isolated; therefore, there are no restrictions as to the physical location of a module within the Mainframe when it is operated in standalone mode.

OUTPUT VOLTAGE/CURRENT REGULATION

The FPDC power supply module is capable of operating only in constant–voltage mode (CV). Hence, the load resistance should be less than or equal to the specific voltage rating divided by its current rating.

5.5.3 LOAD CONNECTION CONFIGURATIONS

The outputs of the FPDC power supply module are isolated from chassis ground, allowing positive, negative, or floating outputs with respect to chassis ground. Connections to the load are made at the front panel output connector terminals. Ensure that a wire gauge is utilized that can carry the programmed current without overheating.

REMOTE SENSING

Remote sensing of the output voltage is required to meet accuracy and regulation specifications. The sense leads should be connected to the point in the load circuit where the voltage is to be precisely regulated. If a distribution bus is utilized for multiple loads, the point of voltage sensing is important to ensure that the voltage regulation is acceptable for all of the loads. In general, the point of sensing is selected to minimize interaction of the various loads through line drops caused by their load currents.

CAUTION

Operating the power supply with either the positive or negative output lead at greater than the float voltage specification limit above chassis ground could result in damage to the module.

WIRING

Single loads are connected directly to one of the front panel output terminals, and the FPDC power supply module is configured to operate in the standalone mode. Twist the load wires or maintain them closely in parallel for their entire length to minimize parasitic inductance and coupling from external circuits. Use the heaviest gauge practical to minimize line drop. The remote sense wires should be twisted, and may need shielding depending on the electrical noise environment of the application. Figure 5-8 shows a standalone load connection with remote sensing.

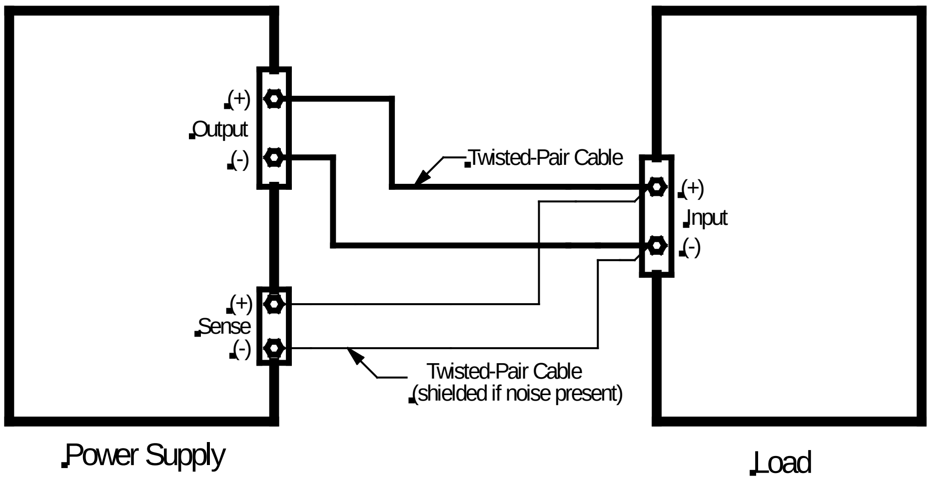


Figure 5-8. Each Output Voltage Configuration

5.5.4 DEFAULT OPERATIONAL CONDITIONS

POWER-ON CONDITIONS

When the FPDC power supply module is first powered on, the following parameters are set to factory default values:

- Output configuration: standalone
- Output voltage: 0V
- Output isolation and remote sense relays: open

RESET CONDITIONS

If a module is reset with the SCPI command, ***RST[n]**, (where n is the module address), the following default conditions are set:

- Output configuration: unchanged
- Output voltage: 0V
- Output isolation and remote sense relays: open
- All status reporting data structures are cleared. Enable-masks are not cleared.

5.5.5 INITIAL FUNCTIONAL TESTS

POWER-ON CHECK

1. Ensure that the AC/DC input service is disconnected.
2. Install the interface cable between the host controller and the ReFlex Power™ Controller module.
3. Connect an appropriate output load to one or more of the FPDC power supply module outputs.
4. Configure the host controller for communications with the ReFlex Power™ Controller module.
5. Turn on the AC/DC input service.
6. The modules will first execute a power-on self-test. Also the internal fans are run at maximum speed for several seconds, and then back to slow speed.
7. Verify communications with the ReFlex Power™ Controller module by issuing an SCPI **`*IDN?`**,
8. The ReFlex Power™ Controller module should respond with its identification string.
9. Verify communications with the ReFlex Power™ FPDC power supply module by issuing an SCPI **`*IDN[n]?`**, where "n" is a channel number that corresponds to the slot of the ReFlex Power™ Mainframe where the module is located, counting left to right, 1 through 12.
10. The FPDC power supply module should respond with its identification string. The default settings of the module will not be affected.

STANDALONE CONFIGURATION OPERATION CHECK

1. Connect the output for standalone operation per the section, Standalone Configuration.
2. Connect appropriate instrumentation for measuring the output voltage and current, as well as a load.
3. Perform the power-on verification test per the preceding section, *Power-On Check*.
4. Turn on the isolation and remote sense relays
5. Turn on the outputs
6. Measure the output voltage and current with the external instruments.
7. Turn off the output with the following command:

   `*RST[n]`

5.6 CALIBRATION

Calibration is not normally required after the FPDC is shipped. However, if necessary, calibration is easily performed through the Controller module interface with SCPI commands, requiring only a meter and a mating connector.

5.6.1 SCOPE

The factory calibration consists of setting the 4 outputs to nominal, that is +5VDC = 5.000, etc. The following procedures can be used to reestablish this as required.

5.6.2 RECOMMENDED CALIBRATION EQUIPMENT

DMM, with at least 6 ½ digit accuracy and must be within its calibration period.
Calibration Power Connector:

- Mating connector: 21 pin D_SUB, special: Positronic Subminiature-D CBC Series, CBC21WA4M1000Z (crimp signal contacts)
- Four male contacts; high-current male contact ratings: MC4012D rated at 20A with 12AWG wire
- 22 AWG insulated wires

5.6.3 CALIBRATION SETUP

Calibration can be done without load, therefore only a meter and a specially configured mating connector is required, made up as follows:

(**Note:** these Test Connectors are used during performance verification as well).

FPDC POWER CONNECTOR FOR CALIBRATION

In all cases, there is a wire for each of the 4 outputs and their corresponding returns. These should be two to three inches in length and have the bare ends soldered, (tinned) for convenient connection to the DMM. These are labeled as Stub in the Type column.

Table 5-5. Calibration Power Connector

Pin	Signal	Connect To	Type
1	+15 V	DMM +	Stub
2	+15 V RTN	DMM -	Stub
3	-15 V	DMM +	Stub
4	-15 V RTN	DMM -	Stub
5		A1	
6		A3	
7		10	
8		12	
9	CHAS GND	NC	
10		7	
11		16	
12		8	
13		17	
14		A2	
15		A4	
16		11	
17		13	
A1	+ 5 V	5 & DMM+	Stub
A2	+ 5 V RTN	14 & DMM -	Stub
A3	- 5 V	6 & DMM -	Stub
A4	- 5 V RTN	15 & DMM +	Stub

Either enable the FPDC module if there is an available means, or create another special connector to insert in the control jack on the FPDC module, see below.

FPDC CONTROL CONNECTOR:

Mating connector: 9 pin D_SUB:

Positronic Subminiature-D SD Series, SD9M1000Z, crimp male contacts

Wire size recommended: 22 AWG

With a short wire connect pins 1 to pin 6. With this connector inserted, the FPDC outputs will be on.

5.6.4 CALIBRATION PROCEDURE

Allow the supply 30 minutes to warm up and stabilize.
The commands to change the output of the supply are in the form of:

CAL[n]:XXXX? To display the calibration value.
CAL[n]: XXXX nn To adjust the calibration value.

Where:

[n] is the module number.
XXXX is one of the following: POS15, POS5, NEG5, NEG15.

+15 CALIBRATION

1. Connect the DMM to the +15 volt supply and measure the DMM voltage. If the voltage is within the range from 14.970 to 15.030 volts the calibration is acceptable so proceed to +5 calibration.
2. Issue a **CAL[n]:POS15?** command. Note the returned value = X.
3. To change the output voltage issue a **CAL[n]:POS15 nn** command.
   Note that a change of one count of nn from the X value returned in Step 2 will change the output by ≈ 30 mV.
4. Repeat Step 3 until the measured voltage is within the range from 14.970 to 15.030 volts.

+5 CALIBRATION

1. Connect the DMM to the +5 volt supply and measure the DMM voltage. If the voltage is within the range from 4.997 to 5.003 volts the calibration is acceptable so proceed to -5 calibration.
2. Issue a **CAL[n]:POS5?** command. Note the returned value = X.
3. To change the output voltage issue a **CAL[n]:POS5 nn** command. Note that a change of one count of nn from the X value returned in Step 2 will change the output by ≈ 3 mV.
4. Repeat Step 3 until the measured voltage is within the range from 4.997 to 5.003 volts.

-5 CALIBRATION

1. Connect the DMM to the -5 volt supply and measure the DMM voltage. If the voltage is within the range from –4.997 to – 5.003 the calibration is acceptable so proceed to -15 calibration.
2. Issue a **CAL<n>:NEG5?** Command. Note the returned value = X.

3. To change the output voltage issue a **CAL[n]:NEG5 nn** command. Note that a change of one count of nn from the X value returned in Step 2 will change the output by ≈ 3 mV.
4. Repeat Step 3 until the measured voltage is within the range from - 4.997 to -5.003 volts.

-15 CALIBRATION

1. Connect the DMM to the -15 volt supply and measure the DMM voltage. If the voltage is within the range from –14.970 to –15.030 volts the calibration is acceptable so proceed to the Saving Calibration section.
2. Issue a **CAL[n]:NEG15?** Command. Note the returned value = X.
3. To change the output voltage issue a **CAL[n]:NEG15 nn** command. Note that a change of one count of **nn** from the X value returned in Step 2 will change the output by ≈ 30 mV.
4. Repeat Step 3 until the required output voltage is within the range from –14.970 to –15.030 volts.

SAVING CALIBRATION

If none of the supplies required adjustment during the calibration procedures, the Calibration Procedure is complete.

If one or more supplies required adjustment, the new calibration values must be saved. To save the calibration values, issue the following commands:

```
CAL[n]:UNLOCK  ”6867”
CAL[n]:STORE
CAL[n]:LOCK
```

This saves the FPDC calibration valves and calibration is now complete.

5.6.5 MODULE SETUP

The FPDC module is quite simple so the steps needed to set it up consist of the following:

1. Unpack the module checking for any shipment damage as herein outlined.
2. The FPDC can be installed in any available slot in any chassis. There may be some established configuration that needs to be followed but the module can function in any position.
3. Check both the connector on the rear of the module and the mating connector in the chassis to be sure that there is no residual debris that may prevent the connectors from mating.

4. Make sure the ReFlex Power™ Controller (RFPC) has the Power switch in the Off position. The ReFlex Power™ modules are not designed for “hot swapping” hence power must be off when the FPDC module is installed.

CAUTION

Installing the FPDC module with the RFPC power switch in the on position may damage the module. Do not install the FPDC with the RFPC power on.

5. Carefully align the module’s rails with the corresponding receivers in the chassis and then inter the module until it is fully seated which occurs when the FPDC front panel is essentially in contact with the front of the chassis.
6. Tighten the both captive retaining screws. This is an important step for proper module and system performance.
7. Connect the power and control connectors and use the retaining screws to secure both.
8. The FPDC module is ready for operation. Turning on the RFPC power switch controls power.

5.7 PERFORMANCE VERIFICATION

5.7.1 INTRODUCTION

Performance verification consists of measuring the 4 outputs initially without any load and then by adding load up to the maximum current for each output voltage. Verification of the line voltage performance requires powering the ReFlex Power™ System from a variable voltage supply with sufficient capability to support the system configuration.

5.7.2 REQUIRED TEST EQUIPMENT

- Digital Multimeter, DMM, with at least 6 ½ digit accuracy that is within its calibration period, to measure the FPDC output voltages.
- Test Connector described in the calibration section or similar means, to connect to the output terminals while having the sense leads connected.
- four-channel digital storage oscilloscope with a bandwidth of at least 200 MHz.
- resistive loads with sufficient wattage, to test the load performance of the FPDC, see the table below:

Table 5-6. Load Resistors

Voltage	Resistor	Wattage
+5VDC	0.5 Ohms	100 Watts
-5VDC	1 Ohm	50 Watts
+15VDC	5 Ohms	100 Watts
-15VDC	5 Ohms	100 Watts

5.7.3 MEASUREMENT SETUP

Turn on the ReFlex Power™ Controller. Insert the Power Test connector and then the Control Test connector to turn on the FPDC output voltages. If the Power Test Connector is not used, the connection leads must be short and the sense leads connected to their respective voltages. Wait for 30 minutes for the FPDC to warm up.

Connect the DMM across each of the four output voltages and verify the no load output voltage is within specification. Add the load resistors to measure the load regulation.

Connect the DSO across the leads to verify the ripple and noise specifications. The return or sense lead must be as short as possible. Remove the probe tip and use a short lead from the ground barrel to the return; also, measure right at the connectors.

To check the output voltage turn on and off sequencing, connect one of the DSO channels to each of the outputs. Removing and inserting the Control Test Connector can verify the turn on and off sequence by observing the voltages.

5.7.4 OUTPUT VOLTAGE ACCURACY

Table 5-7 lists the output voltage accuracies.

Table 5-7. Output Voltage Accuracy

Output	Minimum	Maximum
+5VDC	+ 4.948	+ 5.052
-5VDC	- 4.948	- 5.052
+15VDC	+ 14.800	+ 15.200
-15VDC	- 14.800	- 15.200

5.7.5 OUTPUT VOLTAGE LINE PLUS LOAD REGULATION

Table 5-8 lists the output voltages under both line and load regulation extremes.

Table 5-8. Line and Load Regulation

Output	Minimum	Maximum
+5VDC	+ 4.848	+ 5.072
-5VDC	- 4.848	- 5.072
+15VDC	+14.650	+ 15.350
-15VDC	- 14.650	- 15.350

5.7.6 OUTPUT VOLTAGE RIPPLE AND NOISE

The output voltage ripple and noise specification is listed in the table below. Use the DSO and limit the bandwidth to 20 MHz for all measurements. Also, the scope connections must be made as close as possible to the FPDC output terminals. Excessive lead lengths including the probes ground will cause erroneous measurements.

Table 5-9. Ripple and Noise

Output	Ripple and Noise (peak-peak)
+5VDC	150 mV
-5VDC	80 mV
+15VDC	150 mV
-15VDC	150 mV

5.7.7 VOLTAGE ON/OFF SEQUENCING

The turn on sequence is measured using all 4 channels of the DSO. For turn on, trigger the DSO from either the +15 or –15 connections and observe the other three voltages. The +15VDC and –15VDC turn on first and essentially at the same time. The +5VDC turns on next and shall not start to turn on until the +15VDC and –15VDC have reached at least 50% of their output level. The –5VDC turns on last.

The –5VDC turns off first and hence should be used as the trigger for capturing the turn off sequence. The +5VDC turns off after the –5VDC. The +15VDC and –15VDC outputs turn off last and shall not start off until the +5VDC has reached 0.5V or less.

SECTION 6
DC POWER SUPPLIES

6.1 GENERAL DESCRIPTION

The DC power supplies of the ReFlex Power™ system include models rated at 330W, 1kW, and 1.25kW. They are part of a modular family of power assets that integrate into the ReFlex Power™ Mainframe to provide a wide range of features, functionality, and extensive configurability and adaptability. The modules could be set up to operate as standalone assets, or in combinations of parallel, series, and series/parallel groups to extend their voltage, current, and power ratings.

The modules operate as part of a remotely controlled system. They utilize the ReFlex Power™ Mainframe backplane for input power distribution and control/communications interface. Through the ReFlex Power™ Controller module, communications with the user host controller is established for programming, readback, and configuration control. All connections to the user load and discrete control signal interface are available on the module front panels.

The modules utilize high-frequency power conversion for high efficiency to maximize power density and realize light weight and small size. The 330W module is housed in a single-width enclosure, 1.4” W x 6.75” H x 15” D, and is only 4.5 lb. The 1kW and 1.25kW module are in a double-width enclosure, 2.8” W x 6.75” H x 15” D, and is 9.0 lbs. Mounting within the Mainframe is facilitated with chassis guides, backplane guide pins, and front panel captive fasteners for securing the modules. The thermal design features integral, variable-speed fans so that the cooling performance scales with the complement of modules in the Mainframe, and their output loading, minimizing the audible noise and airflow requirements.

The unique features of the ReFlex Power™ system for reconfigurability and extensibility are made possible through the use of the latest in controls technology. An FPGA-based implementation uses VHDL digital feedback control systems, embedded processor cores for firmware-based systems control, and

ARCNET inter-module and Controller module communications. Conventional analog circuitry has been consolidated into the digital domain to benefit from its inherent stability, and to enable new levels of functionality and adaptability that is not practical with the analog approach.

6.2 FEATURES

The ReFlex Power™ system of DC power supplies brings modularity to DC power assets, and makes possible a high degree of reconfigurability and adaptability through a Mainframe-based architecture. It extends the modular configuration to high power DC assets, without compromising performance or the controls feature set. The mechanical design is ruggedized for harsh environments, including mobile applications, as well as general-purpose industrial and laboratory rack-mount ATE.

6.2.1 GENERAL FEATURES

- High power density
- Small size, light weight
- Up to twelve modules per Mainframe
- Digital control loops
- 16-bit control and measurement
- Output voltage with high slew rate
- Active downprogrammer
- Remote voltage sensing
- Master/Slave paralleling
- Combined series/parallel configuration capability
- Series/parallel configuration change without requiring removal of covers
- Low ripple/noise: as low as 5mV(RMS) and 18mV(PK-PK)
- Constant-Voltage and constant-current regulation with automatic crossover
- Power Factor Correction (PFC)
- Universal inputs: AC (50/60 Hz, 400 Hz), DC, single-phase, three-phase
- Opto-isolated remote shutdown of output
- Trigger-In and trigger-out, and general purpose digital I/O user interface
- Optional integral output relays for isolation and polarity
- Integral variable speed cooling fans for low noise and extended fan life
- Ruggedized to MIL-PRF 28800F

- Software calibration
- Auto-Configuration of system assets
- Extensive triggering and sequencing configurability
- User stored settings
- User programmable supervisories for current and voltage
- LXI™ conformant, IVI drivers
- Web server

6.2.2 ACCESSORIES LIST

The ReFlex Power™ DC power supply modules include the following standard accessories:

Operation Manual, P/N M380056-01 (this manual)

Programming Manual, P/N M380056-03

Quick Reference Guide, P/N M380056-04

6.2.3 CONTROLS AND INDICATORS

The DC power supply modules operate within the ReFlex Power™ system as part of an automated test system; so, there are no user manual controls. They rely on the Mainframe and Controller module for control, status and data communications, as well as AC/DC input power and controller connections to the user application. Input power is routed from the Mainframe through a backplane distribution. All output load connections and discrete control interface to the user application are accessible on the front panel of the modules. The front panel also has LEDs to indicate the operational state of the module.

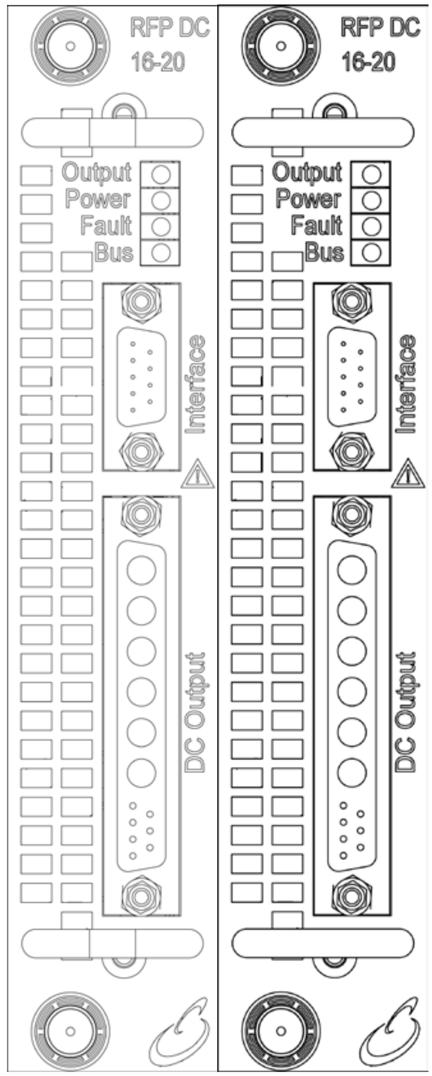


Figure 6-1. ReFlex Power™ DC Front Panel (16-20 single-width model shown)

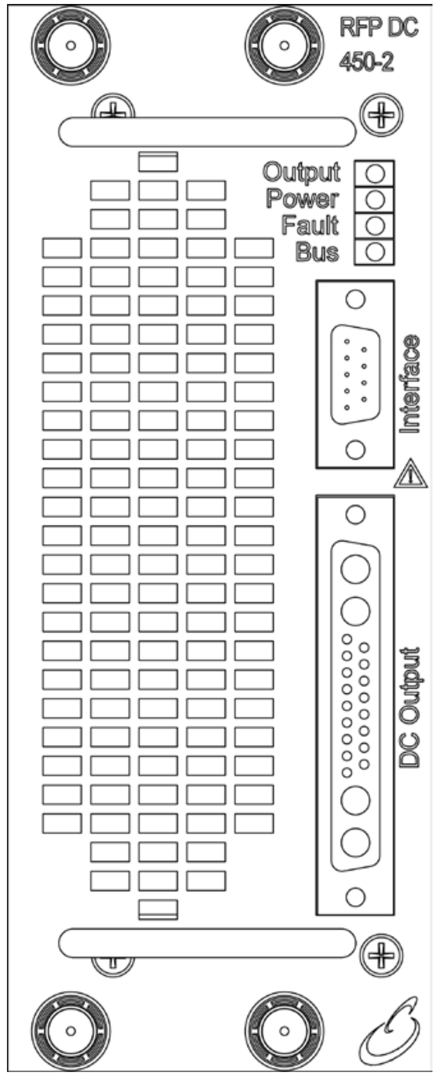


Figure 6-2. ReFlex Power™ DC Front Panel (450-2 double-width model shown)

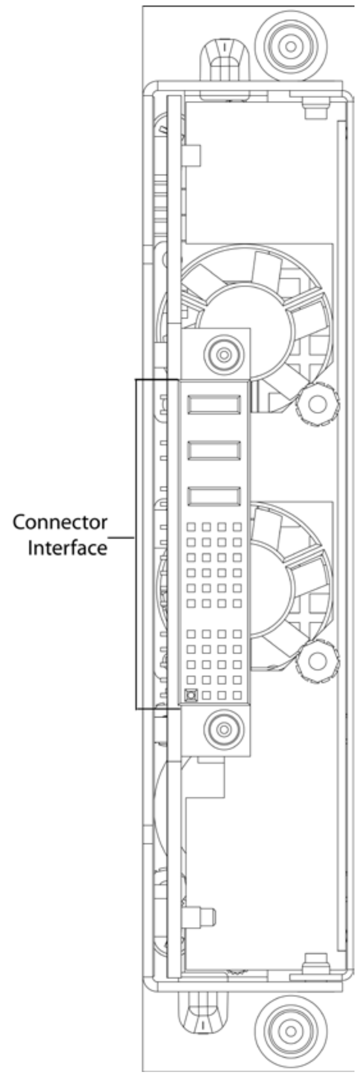


Figure 6-3. Typical Rear View (single-width model shown)

6.3 SPECIFICATIONS

All specifications are valid after a 30-minute warm-up time. Modules could be used at reduced accuracy immediately following power-on. All accuracy specifications are plus/minus variations around the nominal parameter values, unless otherwise noted. Unless otherwise specified, requirements apply at the front panel output terminals, over the entire programming range, and with remote sense connected to front panel terminals. Performance specifications are valid following calibration at 25 °C, +/- 5 °C.

6.3.1 PRODUCT MATRIX

Model	Voltage Range	Current Range	Power Rating	Module Width
RFP-D1016-021-XXXX	0-16V	0-20.6A	330W	Single, 1.4”
RFP-D1065-5A1-XXXX	0-65V	0-5.1A	332W	Single, 1.4”
RFP-D2033-030-XXXX	0-33V	0-30A	990W	Double, 2.8”
RFP-D2050-020-XXXX	0-50V	0-20A	1000W	Double, 2.8”
RFP-D2050-025-XXXX	0-50V	0-25A	1,250W	Double, 2.8”
RFP-D2120-8A3-XXXX	0-120V	0-8.3A	996W	Double, 2.8”
RFP-D2450-2A3-XXXX	0-450V	0-2.3A	1,035W	Double, 2.8”

6.3.2 OUTPUT CHARACTERISTICS

VOLTAGE PROGRAMMING RANGE

0 to 102% of full-scale

VOLTAGE DIGITAL PROGRAMMING ACCURACY

0.05% of full-scale plus 0.05% of set point, or 10mV, whichever is greater, at 25 °C, +/-5 °C

VOLTAGE DIGITAL PROGRAMMING RESOLUTION

RFP-D1016-021-XXXX: 0.47mV
RFP-D1065-5A1-XXXX: 1.9mV
RFP-D2033-030-XXXX: 2mV
RFP-D2050-020-XXXX: 3mV
RFP-D2050-025-XXXX: 3mV
RFP-D2120-8A3-XXXX: 7mV
RFP-D2450-2A3-XXXX: 28mV

VOLTAGE RIPPLE/NOISE (MEASURED WITH 20HZ TO 20MHZ BANDWIDTH)

RFP-D1016-021-XXXX: 5mV(RMS); 25mV(Pk-Pk)
RFP-D1065-5A1-XXXX: 6mV(RMS); 18mV(Pk-Pk)
RFP-D2033-030-XXXX: 15mV(RMS); 60mV(Pk-Pk)
RFP-D2050-020-XXXX: 20mV(RMS); 75mV(Pk-Pk)
RFP-D2050-025-XXXX: 20mV(RMS); 75mV(Pk-Pk)
RFP-D2120-8A3-XXXX: 20mV(RMS); 75mV(Pk-Pk)
RFP-D2450-2A3-XXXX: 40mV(RMS); 200mV(Pk-Pk)

VOLTAGE TEMPERATURE DRIFT

0.01% of full-scale/°C, maximum

VOLTAGE STABILITY

0.05% of full-scale after 24 hours at constant line, load, and temperature
1.0% of full-scale after 2000 hours at constant line, load, and temperature

VOLTAGE LOAD REGULATION

RFP-D1016-021-XXXX, RFP-D1065-5A1-XXXX:
less than 0.01% of full-scale plus 10 mV for 100% load change
RFP-D2033-030-XXXX, RFP-D2050-020-XXXX, RFP-D2050-025-XXXX, RFP-D2120-8A3-XXXX, RFP-D2450-2A3-XXXX:
less than 0.03% of full-scale plus 10 mV for 100% load change

VOLTAGE LINE REGULATION

RFP-D1016-021-XXXX, RFP-D1065-5A1-XXXX:
less than 0.01% of full-scale plus 10 mV for a 10% line change
RFP-D2033-030-XXXX, RFP-D2050-020-XXXX, RFP-D2050-025-XXXX, RFP-D2120-8A3-XXXX, RFP-D2450-2A3-XXXX:
less than 0.03% of full-scale plus 10 mV for a 10% line change

VOLTAGE LOAD TRANSIENT

Less than 5% of full-scale excursion returning to the steady-state value, within 0.5% of full-scale, in 2 ms maximum, and within DC regulation limits after 10 ms for 10, 50, and 90% load step above and below 50% load.

VOLTAGE LINE TRANSIENT

Less than 1% of full-scale excursion returning to steady-state value, within 0.1% of full-scale, in 0.5ms maximum for 10% line change

REMOTE SENSE CAPABILITY

- Remote sense compensates for at least 1.5V per load line connection.
- Maximum output power rating is valid at module output terminals, since line drop subtracts from maximum load voltage.
- Neither the module nor the load would be damaged by opening the sense leads during operation; module will continue to maintain output, but with reduced programming accuracy to 5%, maximum.
- Misconnection of the sense leads would not result in an output voltage in excess of the over-voltage protection limit.
- Output Shutdown would occur if any of the following happen:
    - Sense leads connected with reversed polarity
    - Sense leads short-circuited
    - Excessive load line voltage drop

Voltage Ramp Time

The time required for the output voltage to change from a specified initial value to another programmed value, +/-0.1%, does not exceed 20 ms. The allowed voltage change includes the following worse case conditions:

- Down-programming, at no load, from full-scale output voltage to zero, +/- 0.5% of full-scale
- Up-programming, at full load, from zero to full-scale output voltage

For up-programming, the output voltage ramp speed is proportional to the programmed value of the output current. To achieve the 20ms ramp time for a programmed voltage step change from zero to full-scale, and with full output load, the output current must be programmed to full-scale. To maintain the 20ms ramp time with programmed values of output current at less than full-scale, the programmed voltage step change must be correspondingly reduced.

Current Programming Range

0 to 102% of full-scale

Current Digital Programming Accuracy

RFP-D1016-021-XXXX, RFP-D1065-5A1-XXXX:
0.1% of full-scale plus 0.1% of set point, at 25 °C, +/- 5 °C
RFP-D2033-030-XXXX, RFP-D2050-020-XXXX, RFP-D2050-025-XXXX
RFP-D2120-8A3-XXXX, RFP-D2450-2A3-XXXX:
0.1% of full-scale plus 0.2% of set point, at 25 °C, +/- 5 °C

Current Digital Programming Resolution

RFP-D1016-021-XXXX:	1.28mA
RFP-D1065-5A1-XXXX:	0.32mA
RFP-D2033-030-XXXX:	1.9mA
RFP-D2050-020-XXXX:	1.3mA
RFP-D2050-025-XXXX:	1.6mA
RFP-D2120-8A3-XXXX:	0.6mA
RFP-D2450-2A3-XXXX:	0.14mA

Current Ripple/Noise (measured with 20Hz to 300kHz bandwidth)

0.05% of full-scale, RMS

Current Temperature Drift

RFP-D1016-021-XXXX, RFP-D1065-5A1-XXXX:
0.025% of full-scale/°C
RFP-D2033-030-XXXX, RFP-D2050-020-XXXX, RFP-D2050-025-XXXX,
RFP-D2120-8A3-XXXX, RFP-D2450-2A3-XXXX:
0.03% of full-scale/°C

Current Stability

0.05% of full-scale after 24 hours at constant line, load, and temperature

CURRENT LINE REGULATION

RFP-D1016-021-XXXX, RFP-D1065-5A1-XXXX:
0.05% of full-scale for 10% line change
RFP-D2033-030-XXXX, RFP-D2050-020-XXXX, RFP-D2050-025-XXXX,
RFP-D2120-8A3-XXXX, RFP-D2450-2A3-XXXX:
0.1% of full-scale for 10% line change

CURRENT LOAD REGULATION

0.1% of full-scale for 100% load change

6.3.3 MEASUREMENT

VOLTAGE ACCURACY

0.1% of set point plus 0.1% of full scale, at 25 °C, +/- 5 °C

VOLTAGE RESOLUTION

RFP-D1016-021-XXXX:	0.47mV
RFP-D1065-5A1-XXXX:	1.9mV
RFP-D2033-030-XXXX:	2mV
RFP-D2050-020-XXXX:	3mV
RFP-D2050-025-XXXX:	3mV
RFP-D2120-8A3-XXXX:	7mV
RFP-D2450-2A3-XXXX:	28mV

CURRENT ACCURACY

0.1% of full-scale plus 0.2% of set-point, at 25 °C, +/- 5 °C

CURRENT RESOLUTION

RFP-D1016-021-XXXX:	1.28mA
RFP-D1065-5A1-XXXX:	0.32mA
RFP-D2033-030-XXXX:	1.9mA
RFP-D2050-020-XXXX:	1.3mA
RFP-D2050-025-XXXX:	1.6mA
RFP-D2120-8A3-XXXX:	0.6mA
RFP-D2450-2A3-XXXX:	0.14mA

6.3.4 SUPERVISORY CHARACTERISTICS

OVERVOLTAGE (OVP)

The OVP operation is user -selectable to be programmable or tracking. The default mode of operation is programmable OVP.

- Programmable operation: The OVP threshold is programmable from 5 to 110% of full-scale output voltage.
- Tracking operation: The OVP threshold is automatically adjusted to 110% above the programmed value of the output

voltage. When the programmed value of the output voltage is less than 5% of full-scale, the OVP threshold will be set to a fixed minimum value of 5.5% of full-scale.

- In the event of a trip condition, the voltage at the output terminals is reduced to less than the programmed set-point at a rate of $V_{full-scale}$/20ms, and to less than 1% of full-scale, plus 1V, within 20ms. An active downprogrammer discharges output capacitance.
- Accuracy: 1% of full-scale; Resolution: 0.027% of full-scale

REDUNDANT OVERVOLTAGE (ROVP)

Tracking redundant overvoltage protection set at 120% of OVP value, or 3V above OVP value, whichever is greater, measured at the output terminals. Shorted or reversed sense leads will result in redundant overvoltage shutdown.

OVERCURRENT (OCP)

The OCP operation is user selectable to be programmable or tracking. The default mode of operation is programmable OCP.

- Programmable operation: The OCP threshold is programmable from 5 to 120% of full-scale output current.
- Tracking operation: The OCP threshold is automatically adjusted to 120% above the programmed value of the output current. When the programmed value of the output current is less than 5% of full-scale, the OCP threshold will be set to a fixed minimum value of 6% of full-scale.
- In the event of a trip condition, the voltage at the output terminals is reduced to less than the programmed set-point at a rate of $V_{full-scale}$/20ms, and to less than 1% of full-scale, plus 1V, within 20ms. An active downprogrammer discharges output capacitance.
- Accuracy: 2% of full-scale; Resolution: 0.027% of full-scale

OVERTEMPERATURE

Overtemperature protection is implemented with protection monitors that sense excessive internal heatsink operating temperature. Excessive temperature results in shut down of the power converter and output turn-off.

6.3.5 General Characteristics

Input Voltage Range

With AC input: 85 to 264VAC for 330W, 332W, 990W, 1000W, and 1035W models

153.7 to 264VAC for 1250W model.

With DC input: 210 to 300VDC

Input Voltage Sag/Surge

With AC input: sag to 65% of nominal at 208VAC and 230VAC input for 450ms
surge to 135% of nominal at 208VAC and 230VAC input for 450ms

With DC input: 314VDC, maximum for 2s
364.5VDC, maximum for 450ms

Input Current

Power factor corrected single-phase AC input, sinusoidal AC current; unipolar DC input, continuous DC current.

RFP-D1016-021-XXXX, RFP-D1065-5A1-XXXX: 4A at 103.5VAC; 1.5A at 270VDC

RFP-D2033-030-XXXX, RFP-D2050-020-XXXX, RFP-D2120-8A3-XXXX, RFP-D2450-2A3-XXXX: 12A at 103.5VAC; 4.5A at 270VDC
RFP-D2050-025-XXXX: 8.3A at 187.2VAC; 5.6A at 270VDC

Input Frequency Range

With 85-264VAC input: 47-63Hz

With 85-132VAC input: 380-420Hz

With 153.7-264VAC input: 47-63Hz

Output Power Derating

The output power is derated, dependent on the AC input voltage:

For 330W, 332W, 990W, 1000W, and 1035W models:

≤103.5VAC to ≥95VAC: linearly derated from 100% to 85% of rated power

≤95VAC to ≥85VAC: linearly derated from 85% to 75% of rated power

For 1250W models:

≤187.2VAC to ≥171.8VAC: linearly derated from 100% to 85% of rated power

≤171.8VAC to ≥153.7VAC: linearly derated from 85% to 75% of rated power

POWER FACTOR

> 0.95 at full output load, >0. 65 at 20% output load, decreasing to >0.3 at no load

EFFICIENCY

RFP-D1016-021-XXXX: 78%, minimum at full output power
RFP-D1065-5A1-XXXX: 80%, minimum at full output power
RFP-D2033-030-XXXX: 80%, minimum at full output power
RFP-D2050-020-XXXX: 80%, minimum at full output power
RFP-D2050-025-XXXX: 80%, minimum at full output power
RFP-D2120-8A3-XXXX: 80%, minimum at full output power
RFP-D2450-2A3-XXXX: 80%, minimum at full output power

HOLD-UP TIME

10ms, with dropout of AC input at full output power for 330W, 332W, 990W, 1000W, and 1035W models.

8ms, with dropout of AC input at full output power for 1250W model.

FRONT PANEL INDICATORS

OUTPUT (LED, green): output enabled and isolation relay closed

POWER (LED, green): input AC/DC power applied to module

FAULT (LED, red): internal abnormal operating condition detected; output disabled and isolation relay opened

BUS (LED, green): internal bus communication established

6.3.6 INPUT/OUTPUT CONNECTIONS

PARALLEL GROUPING

Any module could be a master; adjacent modules to the right (when viewed from front of Mainframe) of the master would be slaves; multiple groups of paralleled modules could be present in the same Mainframe; paralleling could be extended between Mainframes; internal control interface is automatically configured; outputs must be externally hardwired in parallel; individual modules could provide full rated output current when paralleled; only like-rated modules could be paralleled.
RFP-D1016-021-XXXX, RFP-D1065-5A1-XXXX:
nine modules could be connected in parallel
RFP-D2033-030-XXXX, RFP-D2050-020-XXXX, RFP-D2050-025-XXXX,
RFP-D2120-8A3-XXXX, RFP-D2450-2A3-XXXX:
six modules could be connected in parallel

Paralleling Performance Degradation

Conforms to specifications of individual module. Programming and measurement accuracy of output current is reduced to 0.75% of full-scale, at 25 °C, +/- 5 °C, with any number of modules paralleled. Output voltage overshoot during power turn-on and turn-off is less than 1%, maximum of full-scale voltage for any number of modules in parallel.

Series Grouping

The lowest numbered module will be the master in a series group; multiple groups of series connected modules could be present in the same Mainframe; series connection could be extended between Mainframes; internal control interface is automatically configured; outputs must be externally hardwired in series; only like-rated modules could be series connected.

RFP-D1016-021-XXXX, RFP-D1065-5A1-XXXX:
five modules could be connected in series

RFP-D2033-030-XXXX, RFP-D2050-020-XXXX, RFP-D2050-025-XXXX:
three modules could be connected in series

Series Performance Degradation

Conforms to specifications of individual modules. Programming and measurement accuracy of the output voltage is n * 0.1% of full-scale for series connection, at 25 °C, +/- 5 °C, where *n* is the number of modules in series. Ripple/noise (RMS and PK-PK) is increased to *n* times that of single module, where *n* is the total number of modules. The maximum output voltage of the series connection is limited by the output float voltage specification. Output voltage overshoot during power turn-on and turn-off is less than 1%, maximum of full-scale voltage for any number of modules in series.

Output Float Voltage (maximum from either output terminal to chassis)

RFP-D1016-021-XXXX:	+/-200V
RFP-D1065-5A1-XXXX:	+/-300V
RFP-D2033-030-XXXX:	+/-200V
RFP-D2050-020-XXXX:	+/-200V
RFP-D2050-025-XXXX:	+/-200V
RFP-D2120-8A3-XXXX:	+/-200V
RFP-D2450-2A3-XXXX:	+/-450V

Output Relays

Optional internal relays are available for output isolation and polarity reversal.

6.3.7 COMMAND-SETS/DRIVERS

COMMAND DESCRIPTION

SCPI Standard 1999 command language, through Controller Module

RESPONSE DESCRIPTION

SCPI Standard 1999 command language, through Controller Module

COMMAND EXECUTION TIME

50ms from command request, not including parameter slew time to set-point

6.3.8 MECHANICAL CHARACTERISTICS

DIMENSIONS

RFP-D1016-021-XXXX, RFP-D1065-5A1-XXXX:
1.4 inch wide, 6.75 inch high, and 15 inch deep
RFP-D2033-030-XXXX, RFP-D2050-020-XXXX, RFP-D2050-025-XXXX, RFP-D2120-8A3-XXXX, RFP-D2450-2A3-XXXX:
2.8 inch wide, 6.75 inch high, and 15 inch deep

WEIGHT

RFP-D1016-021-XXXX, RFP-D1065-5A1-XXXX:
4.5 pound, maximum
RFP-D2033-030-XXXX, RFP-D2050-020-XXXX, RFP-D2050-025-XXXX, RFP-D2120-8A3-XXXX, RFP-D2450-2A3-XXXX:
9.0 pound, maximum

COOLING PROVISIONS

Operation at maximum limits of output power, ambient temperature, and altitude requires adequate airflow through module:
RFP-D1016-021-XXXX, RFP-D1065-5A1-XXXX:
15 CFM
RFP-D2033-030-XXXX, RFP-D2050-020-XXXX, RFP-D2050-025-XXXX, RFP-D2120-8A3-XXXX, RFP-D2450-2A3-XXXX:
30 CFM

COLOR

Black, color number 27038 per FED-STD-595

ACOUSTIC NOISE

The speed of the integral fans is linearly variable, as a function of internal heatsink temperature rise, to minimize acoustic noise and extend the fan life. The speed varies from nominally 50% of full-speed to full-speed as the heatsink temperature varies with ambient temperature and power dissipation resulting from the output load.

6.3.9 Environmental Characteristics

Operating Temperature

Standard: 0 to 50 °C

Extended Range Option: -10 to 55 °C

Operating Altitude

Standard: 0 to 6,500 ft

Extended Range Option: 0 to 15,000 ft

Operating Humidity

95% non-condensing

Operating Shock

Class 3 MIL-PRF-28800F

Operating Vibration

Class 3 MIL-PRF-28800F

Operation Without Fully Populated Mainframe

If Mainframe is not fully populated with modules, filler panels must be installed in empty slots to maintain proper airflow and structural integrity.

Non-Operating Temperature

-40 to 71 °C

Non-Operating Altitude

0 to 50,000 feet

Non-Operating Shock

Class 3 MIL-PRF-28800F

Non-Operating Vibration

Class 3 MIL-PRF-28800F

6.3.10 Regulatory Agency Compliance

Safety Compliance

European Low Voltage Directive, IEC 61010-1:90+A1:92+A2:95, as required for the CE mark.

LVD Categories

Installation Category II; Pollution Degree 2; Class II Equipment; for Indoor Use Only

EMC Compliance

EMC Directive, EN 61326:1998

Electrostatic Discharge

IEC 61000-4-2

Radiated RF Immunity

IEC 61000-4-3

Fast–Transients

IEC 61000-4-4

Surge

IEC 1000-4-5

Conducted RF Immunity

IEC 1000-4-6

Input Power Interruptions

IEC 1000-4-11

Conducted Emissions

CISPR 16-1/2, Class A

Radiated Emissions

CISPR 16-1/2, Class A

6.4 INSTALLATION

6.4.1 INTRODUCTION

The ReFlex Power™ DC power supply modules have been fully calibrated and tested prior to shipment; the modules are ready for immediate use upon receipt. However, when first unpacked, the modules should be inspected to ensure that no shipping damage has occurred.

6.4.2 INITIAL INSPECTION

Perform a visual inspection of the shipping container prior to accepting the package from the carrier. If damage to the shipping container is evident, a description of that damage should be noted on the carrier's receipt and signed by the carrier's driver.

Verify that the proper module and associated accessories have been received. Perform a visual inspection of the module after it is removed from the shipping container. Check for shipping damage such as dents, scratches, or distortion of the enclosure.

If external damage is evident, there may be internal damage as well. Immediately contact the carrier and file a claim for concealed damage. In addition, the shipping container and filler material should be saved for inspection. Forward a report of the damage to the Customer Care Department where an associate will provide instructions for repair or replacement of the unit.

6.4.3 LOCATION CONSIDERATIONS

The DC power supply modules are designed for use within the ReFlex Power™ Mainframe. Standalone or series-grouped modules could be inserted within any slot of the Mainframe. However, parallel-grouped modules must occupy physically contiguous slot locations (no modules outside the group may be placed between parallel-grouped modules) also, the group could extend across two Mainframes. Unused slots are allowed within the parallel group, but they must be occupied by a filler panel.

AIRFLOW REQUIREMENTS

Since the units are fan-cooled, they require sufficient clearance for adequate air intake through the front panels and exhaust through the rear. Ensure that the ambient air temperature at the front panel air intake does not exceed 55 °C. Proper airflow also requires filler panel(s) in any empty slot(s) of the Mainframe.

CAUTION

Inadequate airflow and excessive ambient air temperature could result in overheating and thermal shutdown.

CLEANING

Because the module uses forced convection cooling, the air flow through the unit can pull in dust. In environments having high concentrations of dust, periodic cleaning may be required. The exterior of the unit should be cleaned with a mild solution of detergent and water. The solution should be applied onto a soft cloth, and not directly to the surface of the unit. To prevent damage to materials, do not use aromatic hydrocarbons or chlorinated solvents for cleaning.

6.4.4 INSTALLATION

CAUTION
The module contains ESD sensitive circuitry. Follow appropriate handling and grounding procedures to prevent damage to the module. The module should be handled by the enclosure, with care to protect the connectors from ESD discharges.

CAUTION
Input power must be disconnected to the Mainframe before a module is inserted or extracted. Inserting or extracting a module with power installed (hot-swapping) could result in damage to the module or Mainframe. Prior to turning power on, ensure that front panel captive fasteners are tightened.

The DC power supply modules are installed into the Mainframe from the front of the chassis. Refer to Figure 6-4 for a view showing the orientation of a module and Mainframe during installation.

1. Ensure that the AC/DC input power is disconnected before installing or removing any module(s).
2. Insert the module into the Mainframe, aligning the guide rails at the rear of the module with the top and bottom Mainframe guides.
3. Gently slide the module completely into the Mainframe until the guide pins of the module rear connector engage the mating backplane connector.
4. Fully seat the module until the front panel inner surface is snug against the Mainframe chassis.
5. Secure the module(s) to the Mainframe at the top and bottom of each front panel by turning the captive thumbscrews clockwise to a maximum torque of 20 in-lb, using a flat blade torque screwdriver.
6. Install a filler panel over any empty slot, and secure in place at the top and bottom by turning the captive thumbscrews clockwise to a maximum torque of 20 in-lb, using a flat blade torque screwdriver.

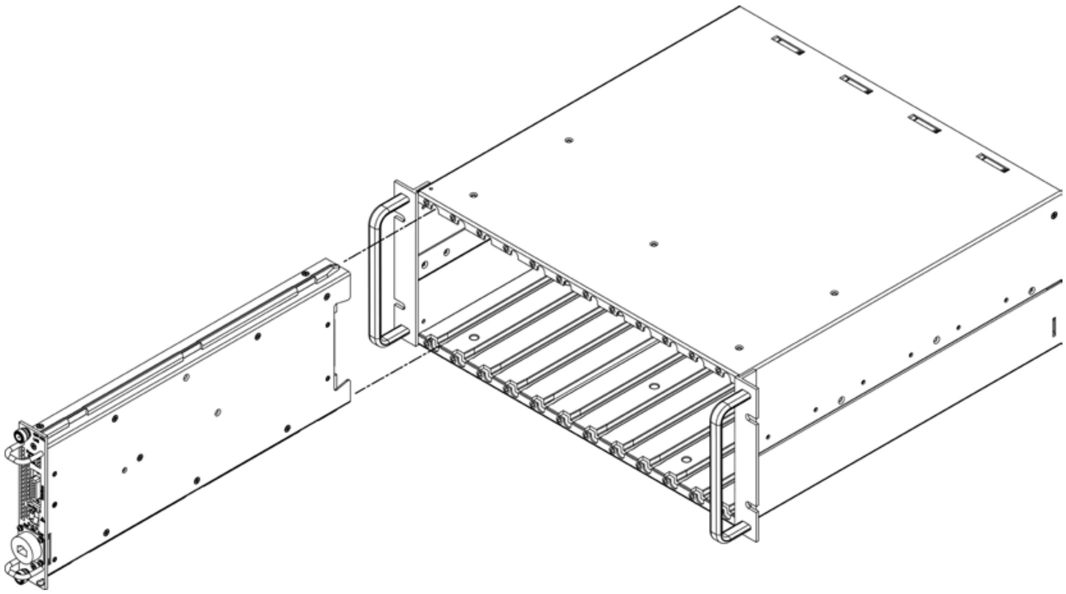


Figure 6-4. Module Installation (single-width module shown)

6.4.5 INPUT POWER REQUIREMENTS

The DC power supply modules will operate from a wide variety of AC and DC input power sources, as distributed through the Mainframe. Although the Mainframe could be connected to either single-phase or three-phase AC power, the modules have single-phase inputs. They are connected to the source, through the Mainframe, either phase to neutral, or line to line, depending on the available source voltage. The power source voltage must be within the range of 85–264VAC or 210-300VDC. The input voltage ranges are continuous, and do not require any manual setup.

CAUTION
Exceeding the maximum rated AC/DC input voltage could result in damage to the module.

The modules could produce full rated power down to 103.5VAC input. At lower voltages, output power is derated to 85% at 90VAC and 75% at 85VAC. Total aggregate output power of the Mainframe is limited to 6,000W with 200VAC or greater input, and 3,600W at less than 200VAC input. Each module has power factor correction (PFC) that provides linear AC input current and high power factor, minimizing the required input apparent power.

The Mainframe distributes the input power through backplane connectors to three groups of four slots connected in parallel. The groups are connected to separate pair of pins in the Mainframe rear panel AC/DC input connector (one line and return per connection); the connector has six power pins plus ground. Balance in phase currents can be achieved only if the power modules are located in the Mainframe so that equal distribution between the three groups of slots is maintained, and if the same load is applied to the set of modules in each group.

The load applied to a particular AC/DC input line is dependent on the location of the modules in the Mainframe slots. The slots are grouped in sets of four: Slot 1-4, Slot 5-8, and Slot 9-12. Slot 1 is the left-most slot, as viewed from the front. Each of the four slots is supplied by one of the AC/DC input lines. In a double-width and triple-width module, the module connector is located so that it mates to a backplane connector in the right-most slot, as viewed from the front of the Mainframe. Refer to Table 6-1 for Mainframe input connector pinout and power allocation to the Mainframe slots.

Table 6-1. Mainframe Input and Power Allocation Information

INPUT SERVICE	PHASES	INPUT DESIGNATION	INPUT CONNECTOR PIN	INPUT SERVICE CONNECTION	SLOT SUPPLIED
100/115/120VAC 200/208VAC 220/230/240VAC	1	L1	F	Phase	Slot 1-4
		L1-RTN	E	Return	
		L2	A	Phase	Slot 5-8
		L2-RTN	G	Return	
		L3	B	Phase	Slot 9-12
		L3-RTN	C	Return	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
200/208VAC	3 Delta	L1	F	Phase-A	Slot 1-4
		L1-RTN	E	Phase-B	
		L2	A	Phase-B	Slot 5-8
		L2-RTN	G	Phase-C	
		L3	B	Phase-C	Slot 9-12
		L3-RTN	C	Phase-A	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
200/208VAC 220/230/240VAC	3 Wye	L1	F	Phase-A	Slot 1-4
		L1-RTN	E	Neutral	
		L2	A	Phase-B	Slot 5-8
		L2-RTN	G	Neutral	
		L3	B	Phase-C	Slot 9-12
		L3-RTN	C	Neutral	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
210-300VDC	DC	L1	F	Source	Slot 1-4
		L1-RTN	E	Return	
		L2	A	Source	Slot 5-8
		L2-RTN	G	Return	
		L3	B	Source	Slot 9-12
		L3-RTN	C	Return	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis

A plug/socket connector is provided on the rear panel of the Mainframe for connecting the unit to the AC/DC power source. The connector also provides a safety ground termination. The input power cable should include a safety ground wire to connect the chassis of the Mainframe to the safety ground of the AC/DC power source. Since the AC input leakage current of the Mainframe could exceed

3.5mA, a second safety ground connection is required. It should be connected to the safety ground stud on the rear panel of the Mainframe.

WARNING
A separate, dedicated safety ground wire must be connected to the Mainframe rear panel safety ground stud. Operating the ReFlex Power™ system with the safety ground wire disconnected could result in a shock hazard.

6.4.6 AC/DC INPUT OVERCURRENT PROTECTION

The modules have internal overcurrent protection to provide fault isolation in case a failure occurs of internal components or wiring. However, overcurrent protection must also be provided externally, within the system installation, for the AC/DC input of the Mainframe. Refer to the Mainframe manual for recommendations.

6.4.7 AC/DC INPUT DISCONNECT DEVICE

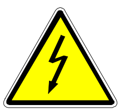
The ReFlex Power™ system does not have any means to disconnect it from the AC/DC input service. The front panel POWER switch of the Controller module in the Mainframe does not disconnect the AC/DC input line from the modules or Mainframe. Ensure that a suitable disconnecting device is incorporated into the system installation, so that isolation will be provided when it is opened. The switch or circuit breaker must be located close to the ReFlex Power™ system, within reach of the operator, and clearly labeled as the disconnection device.

WARNING
To prevent a shock hazard, ensure that the AC/DC input disconnect device is open, and that the safety ground conductor is connected to the rear panel ground stud, before removing/inserting modules from/into the Mainframe. The Mainframe backplane input power distribution remains energized whenever the AC/DC input is connected.

6.4.8 CONNECTORS

The DC power supply modules have all user interface connectors located on the front panel. Two connectors are provided: one for the power connections to the load, and the other for control signal interface. Both connectors are of the D-Subminiature construction.

This section presents first the Interface connector information (part numbers, a drawing of the connector front face, and descriptions) for each of the power supplies, RFP-D1016-021-XXXX, RFP-D1065-5A1-XXXX, RFP-D2033-030-XXXX, RFP-D2050-020-XXXX, RFP-D2050-025-XXXX, RFP-D2120-8A3-XXXX, and RFP-D2450-2A3-XXXX, in that order, followed by the DC Output connector information and then the Remote Sense information.



WARNING
To prevent electrical shock, disconnect the AC/DC input service before making any connections to the module.

RFP DC-16-20 MATING CONNECTOR KIT

LPDC-16V Mating Connector Kit - AMETEK Part No. 5380270-01, mates with RFP-D1016-021-XXXX, and includes the following for both Interface and DC Output connectors:

Bill of Material

Item	AMETEK Part No.	Description	Qty	Manufacturer Part No.	Manufacturer	Suggested Source(s)
1	856-214-07	Conn, 13P, DSUB, 8/20AWG, Male	1	CBD13W6M2000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
2	856-745-51	Contact, 10AWG, 30A, CL ETRY, Male	4	MC4010D	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
3	856-247-39	Conn, Backshell, 37P, Strt, 2 PC	1	D37000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
4	856-214-09	Conn, 9P, DSUB, 20-24AWG, Crimp, Male	1	SD9M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
5	856-247-10	Conn, Backshell, 9P, DSUB, 2 PC	1	D9000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm

RECOMMENDED TOOLS (NOT INCLUDED WITH MATING CONNECTOR KIT)

Hand crimp: Positronic Industries P/N 9507-0-0-0

Pneumatic crimp: Positronic Industries P/N 9550-1-0

Insertion/extraction tool: Positronic Industries P/N M81969/1-02

RFP-D1016-021-XXXX Interface Connector

The INTERFACE connector provides terminations for external connections to isolated digital and analog control signals.

Connector: Positronic Industries P/N SD9M1000Z, AMETEK P/N 856-214-09
Crimp contacts: Positronic Industries P/N MC7520D (initially supplied with connector)

Backshell: Positronic Industries P/N D9000Z00, AMETEK P/N 856-247-10

Wire size: Maximum gauge 20 AWG (recommended)
Maximum length 10 meters (can be extended subject to environment, cable type, and interface circuits).

RFP-D1016-021-XXXX Interface Pinout

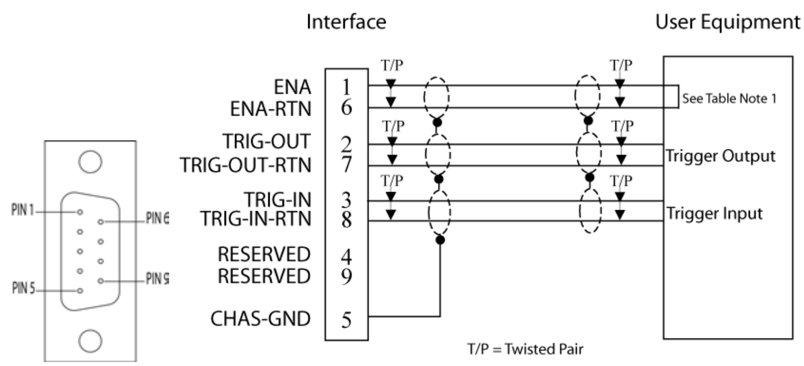


Figure 6-5. RFP-D1016-021-XXXX Interface Connector, Front Panel View, and Wiring Diagram

Table 6-2. RFP-D1016-021-XXXX Interface Connector Pinout

PIN	NAME	FUNCTION	SIGNAL LEVEL
1	ENA[1]	Input: module output enable	TTL logic level
6	ENA-RTN[1]	Input: return for ENA signal; connected to Pin-7/8	Signal common
2	TRIG-OUT	Output: trigger output signal	TTL logic level
7	TRIG-OUT-RTN	Output: return for TRIG-OUT; connected to Pin-6/8	Signal common
3	TRIG-IN	Input: trigger input signal	TTL logic level
8	TRIG-IN-RTN	Input: return for TRIG-IN; connected to Pin-6/7	Signal common
4	RESERVED		
9	RESERVED		
5	CHAS-GND	Shield ground	Chassis ground

[1] Enable signal is internally pulled up to +5 V with a 10 K resistor. To enable the module, the signal is pulled low (<= 0.5 V) with respect to the ENA RTN signal; this may also be accomplished by shorting Pin 1 to Pin 6.

Optional Interface Connector Accessories

- AMETEK P/N 5380508-01, 9-pin Loop-back Connector Assembly. Includes a jumper wire between Pins 1 and 6 to enable the module outputs.

- AMETEK P/N 5380443-01, Power Module 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.
- AMETEK P/N 5380443-03, Power Module, Right Angle, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.

RFP-D1065-5A1-XXXX Mating Connector Kit

LPDC-65V Mating Connector Kit - AMETEK Part No. 5380270-02, mates with RFP-D1065-5A1-XXXX, and includes the following for both Interface and DC Output connectors:

Bill of Material

Item	AMETEK Part No.	Description	Qty	Manufacturer Part No.	Manufacturer	Suggested Source(s)
1	856-214-07	Conn, 13P, DSUB, 8/20AWG, Male	1	CBD13W6M2000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
2	856-745-53	Contact, F-Volt, 3600VRMS, 500C, Male	6	MS4820D-50	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
3	856-247-39	Conn, Backshell, 37P, Strt, 2 PC	1	D37000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
4	856-214-09	Conn, 9P, DSUB, 20-24AWG, Crimp, Male	1	SD9M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
5	856-247-10	Conn, Backshell, 9P, DSUB, 2 PC	1	D9000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm

Recommended Tools (not included with Mating Connector kit)

Hand crimp: Positronic Industries P/N 9507-0-0-0

Pneumatic crimp: Positronic Industries P/N 9550-1-0

Insertion/extraction: Positronic Industries P/N M81969/1-02

Extraction tool: Positronic Industries P/N 4311-0-0-0

RFP-D1065-5A1-XXXX Interface Connector:

External isolated digital and analog control interface.

Connector: Positronic Industries P/N SD9M1000Z, AMETEK P/N 856-214-09

Crimp contacts: Positronic Industries P/N MC7520D (initially supplied with connector)

Backshell: Positronic Industries P/N D9000Z00, AMETEK P/N 856-247-10

Wire size: Maximum gauge 20 AWG (recommended)
Maximum length 10 meters (can be extended subject to environment, cable type, and interface circuits).

RFP-D1065-5A1-XXXX Interface Pinout

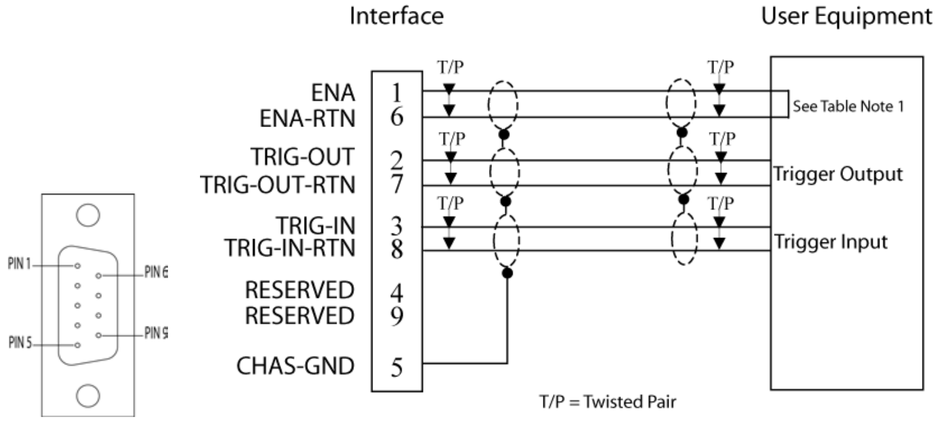


Figure 6-6. RFP-D1065-5A1-XXXX Interface Connector, Front Panel View, and Wiring Diagram

Table 6-3. RFP-D1065-5A1-XXXX Interface Connector Pinout

Pin	Name	Function	Signal Level	Wire Gauge, AWG
1	ENA[1]	Input: module output enable	TTL logic level	20
6	ENA-RTN[1]	Input: return for ENA signal; connected to Pin-7/8	Signal common	20
2	TRIG-OUT	Output: trigger output signal	TTL logic level	20
7	TRIG-OUT-RTN	Output: return for TRIG-OUT; connected to Pin-6/8	Signal common	20
3	TRIG-IN	Input: trigger input signal	TTL logic level	20
8	TRIG-IN-RTN	Input: return for TRIG-IN; connected to Pin-6/7	Signal common	20
4	RESERVED			
9	RESERVED			
5	CHAS-GND	Shield ground	Chassis ground	20

[1] Enable signal is internally pulled up to +5 V with a 10 K resistor. To enable the module, the signal is pulled low (<= 0.5 V) with respect to the ENA RTN signal; this may also be accomplished by shorting Pin 1 to Pin 6.

Optional Interface Connector Accessories

- AMETEK P/N 5380508-01, 9-pin Loop-back Connector Assembly. Includes a jumper wire between Pins 1 and 6 to enable the module outputs.
- AMETEK P/N 5380443-01, Power Module, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.
- AMETEK P/N 5380443-03, Power Module, Right Angle, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.

RFP-D2033-030-XXXX MATING CONNECTOR KIT

HPDC-33V Mating Connector Kit - AMETEK Part No. 5380271-01, mates with RFP-D2033-030-XXXX, and includes the following for both Interface and DC Output connectors:

Bill of Material

Item	AMETEK Part No.	Description	Qty	Manufacturer Part No.	Manufacturer	Suggested Source(s)
1	856-214-04	Conn, 21P, DSUB, 8/20AWG, Male	1	CBC21WA4M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
2	856-745-51	Contact, 10AWG, 30A, CL ETRY, Male	4	MC4010D	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
3	856-247-39	Conn, Backshell, 37P, Strt, 2 PC	1	D37000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
4	856-214-09	Conn, 9P, DSUB, 20-24AWG, Crimp, Male	1	SD9M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
5	856-247-10	Conn, Backshell, 9P, DSUB, 2 PC	1	D9000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm

RECOMMENDED TOOLS (NOT INCLUDED WITH MATING CONNECTOR KIT)

Hand crimp: Positronic Industries P/N 9507-0-0-0

Pneumatic crimp: Positronic Industries P/N 9550-0-2

Insertion/extraction: Positronic Industries P/N M81969/1-02

Insertion/extraction Positronic Industries P/N 4311-0-0-0

RFP-D2033-030-XXXX, Interface Connector:

External isolated digital and analog control interface.

Connector: Positronic Industries P/N SD9M1000Z, AMETEK P/N 856-214-09
Crimp contacts: Positronic Industries P/N MC7520D (initially supplied with connector)

Backshell: Positronic Industries P/N D9000Z00, AMETEK P/N 856-247-10

Wire size: Maximum gauge 20 AWG (recommended)
Maximum length 10 meters (can be extended subject to environment, cable type, and interface circuits).

RFP-D2033-030-XXXX Interface Pinout

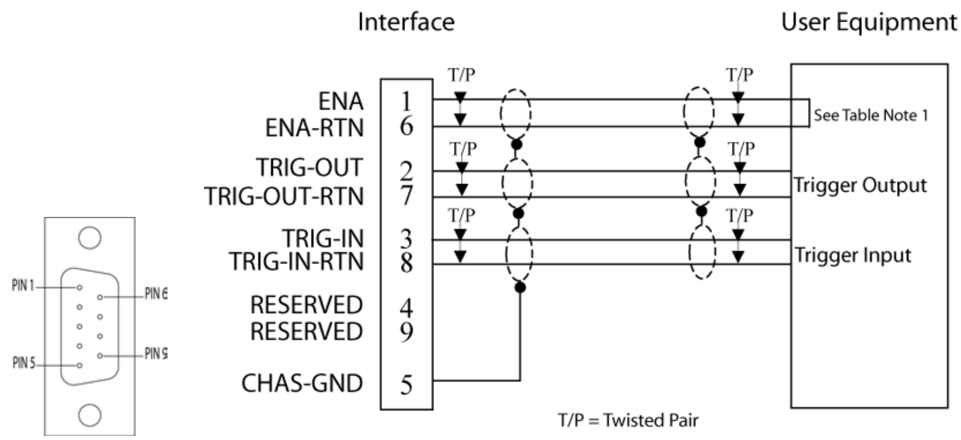


Figure 6-7. RFP-D2033-030-XXXX Interface Connector, Front Panel View, and Wiring Diagram

Table 6-4. RFP-D2033-030-XXXX Interface Connector Pinout

PIN	NAME	FUNCTION	SIGNAL LEVEL
1	ENA[1]	Input: module output enable	TTL logic level
6	ENA-RTN[1]	Input: return for ENA signal; connected to Pin-7/8	Signal common
2	TRIG-OUT	Output: trigger output signal	TTL logic level
7	TRIG-OUT-RTN	Output: return for TRIG-OUT; connected to Pin-6/8	Signal common
3	TRIG-IN	Input: trigger input signal	TTL logic level
8	TRIG-IN-RTN	Input: return for TRIG-IN; connected to Pin-6/7	Signal common
4	RESERVED		
9	RESERVED		
5	CHAS-GND	Shield ground	Chassis ground

[1] Enable signal is internally pulled up to +5 V with a 10 K resistor. To enable the module, the signal is pulled low (<= 0.5 V) with respect to the ENA RTN signal; this may also be accomplished by shorting Pin 1 to Pin 6.

OPTIONAL INTERFACE CONNECTOR ACCESSORIES

- AMETEK P/N 5380508-01, 9-pin Loop-back Connector Assembly. Includes a jumper wire between Pins 1 and 6 to enable the module outputs.
- AMETEK P/N 5380443-01, Power Module, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.
- AMETEK P/N 5380443-03, Power Module, Right Angle, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.

RFP-D2050-025-XXXX, RFP-D2050-020-XXXX MATING CONNECTOR KIT

HPDC-50V Mating Connector Kit - AMETEK Part No. 5380271-01, mates with RFP-D2050-025-XXXX, RFP-D2050-020-XXXX and includes the following for both Interface and DC Output connectors:

Bill of Material

Item	AMETEK Part No.	Description	Qty	Manufacturer Part No.	Manufacturer	Suggested Source(s)
1	856-214-04	Conn, 21P, DSUB, 8/20AWG, Male	1	CBC21WA4M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
2	856-745-51	Contact, 10AWG, 30A, CL ETRY, Male	4	MC4010D	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
3	856-247-39	Conn, Backshell, 37P, Strt, 2 PC	1	D37000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
4	856-214-09	Conn, 9P, DSUB, 20-24AWG, Crimp, Male	1	SD9M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
5	856-247-10	Conn, Backshell, 9P, DSUB, 2 PC	1	D9000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm

RECOMMENDED TOOLS (NOT INCLUDED WITH MATING CONNECTOR KIT)

Hand crimp: Positronic Industries P/N 9507-0-0-0

Pneumatic crimp: Positronic Industries P/N 9550-0-2

Insertion/extraction: Positronic Industries P/N M81969/1-02

Insertion/extraction Positronic Industries P/N 4311-0-0-0

RFP-D2050-025-XXXX, RFP-D2050-020-XXXX Interface Connector:

External isolated digital and analog control interface.

Connector: Positronic Industries P/N SD9M1000Z, AMETEK P/N 856-214-09
Crimp contacts: Positronic Industries P/N MC7520D (initially supplied with connector)

Backshell: Positronic Industries P/N D9000Z00, AMETEK P/N 856-247-10

Wire size: Maximum gauge 20 AWG (recommended)
Maximum length 10 meters (can be extended subject to environment, cable type, and interface circuits).

RFP-D2050-025-XXXX, RFP-D2050-020-XXXX Interface Pinout

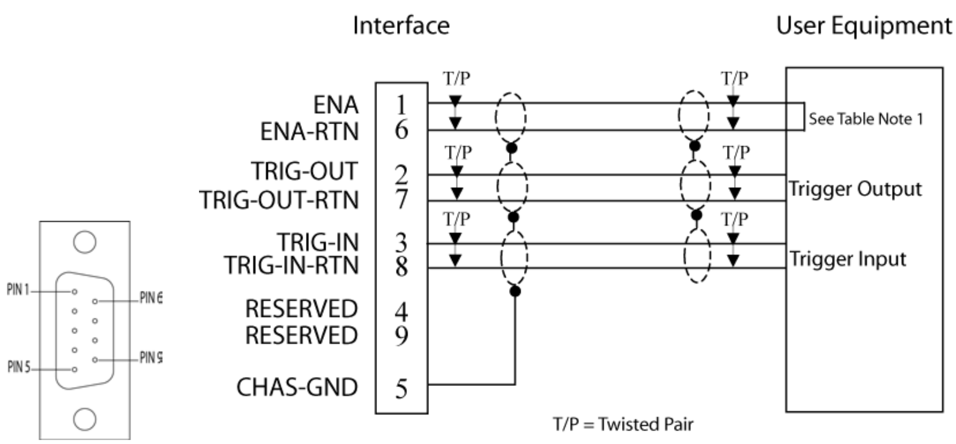


Figure 6-8. RFP-D2050-025-XXXX Interface Connector, Front Panel View, and Wiring Diagram

Table 6-5. RFP-D2050-025-XXXX, RFP-D2050-020-XXXX Interface Connector Pinout

PIN	NAME	FUNCTION	SIGNAL LEVEL
1	ENA[1]	Input: module output enable	TTL logic level
6	ENA-RTN[1]	Input: return for ENA signal; connected to Pin-7/8	Signal common
2	TRIG-OUT	Output: trigger output signal	TTL logic level
7	TRIG-OUT-RTN	Output: return for TRIG-OUT; connected to Pin-6/8	Signal common
3	TRIG-IN	Input: trigger input signal	TTL logic level
8	TRIG-IN-RTN	Input: return for TRIG-IN; connected to Pin-6/7	Signal common
4	RESERVED		
9	RESERVED		
5	CHAS-GND	Shield ground	Chassis ground

[1] Enable signal is internally pulled up to +5 V with a 10 K resistor. To enable the module, the signal is pulled low (<= 0.5 V) with respect to the ENA RTN signal; this may also be accomplished by shorting Pin 1 to Pin 6.

OPTIONAL INTERFACE CONNECTOR ACCESSORIES

- AMETEK P/N 5380508-01, 9-pin Loop-back Connector Assembly. Includes a jumper wire between Pins 1 and 6 to enable the module outputs.
- AMETEK P/N 5380443-01, Power Module, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.
- AMETEK P/N 5380443-03, Power Module, Right Angle, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.

RFP-D2120-8A3-XXXX MATING CONNECTOR KIT

HPDC-120V Mating Connector Kit - AMETEK Part No. 5380271-03, mates with RFP-D2120-8A3-XXXX, and includes the following for both Interface and DC Output connectors:

Bill of Material

Item	AMETEK Part No.	Description	Qty	Manufacturer Part No.	Manufacturer	Suggested Source(s)
1	856-214-04	Conn, 21P, DSUB, 8/20AWG, Male	1	CBC21WA4M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
2	856-745-51	Contact, 10AWG, 30A, CL ETRY, Male	2	MC4010D	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
3	856-745-53	Contact, F-Volt, 3600VRMS, 500C, Male	2	MS4820D-50	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
4	856-247-39	Conn, Backshell, 37P, Strt, 2 PC	1	D37000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
5	856-214-09	Conn, 9P, DSUB, 20-24AWG, Crimp, Male	1	SD9M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
6	856-247-10	Conn, Backshell, 9P, DSUB, 2 PC	1	D9000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm

RECOMMENDED TOOLS (NOT INCLUDED WITH MATING CONNECTOR KIT)

Hand crimp: Positronic Industries P/N 9507-0-0-0

Pneumatic crimp: Positronic Industries P/N 9550-0-2

Insertion/extraction: Positronic Industries P/N M81969/1-02

Insertion/extraction Positronic Industries P/N 4311-0-0-0

RFP-D2120-8A3-XXXX, INTERFACE CONNECTOR:

External isolated digital and analog control interface.

Connector: Positronic Industries P/N SD9M1000Z, AMETEK P/N 856-214-09
Crimp contacts: Positronic Industries P/N MC7520D (initially supplied with connector)

Backshell: Positronic Industries P/N D9000Z00, AMETEK P/N 856-247-10

Wire size: Maximum gauge 20 AWG (recommended)
Maximum length 10 meters (can be extended subject to environment, cable type, and interface circuits).

RFP-D2120-8A3-XXXX INTERFACE PINOUT

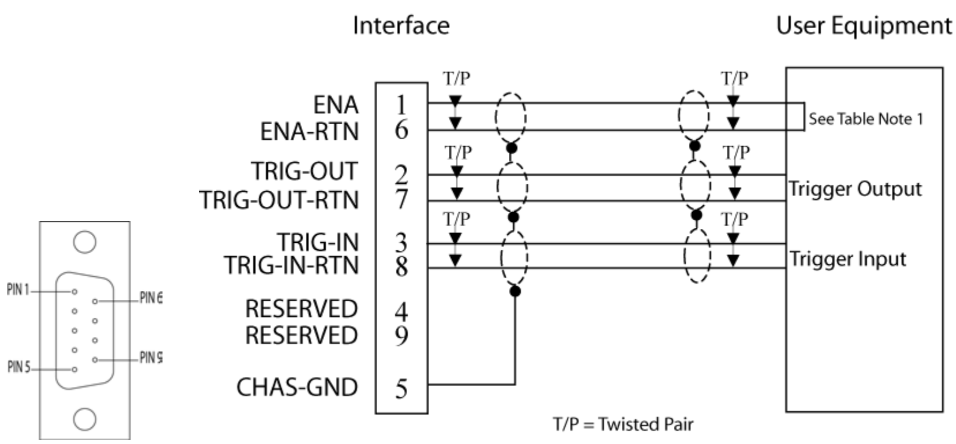


Figure 6-9. RFP-D2120-8A3-XXXX Interface Connector, Front Panel View, and Wiring Diagram

Table 6-6. RFP-D2120-8A3-XXXX Interface Connector Pinout

PIN	NAME	FUNCTION	SIGNAL LEVEL
1	ENA[1]	Input: module output enable	TTL logic level
6	ENA-RTN[1]	Input: return for ENA signal; connected to Pin-7/8	Signal common
2	TRIG-OUT	Output: trigger output signal	TTL logic level
7	TRIG-OUT-RTN	Output: return for TRIG-OUT; connected to Pin-6/8	Signal common
3	TRIG-IN	Input: trigger input signal	TTL logic level
8	TRIG-IN-RTN	Input: return for TRIG-IN; connected to Pin-6/7	Signal common
4	RESERVED		
9	RESERVED		
5	CHAS-GND	Shield ground	Chassis ground

[1] Enable signal is internally pulled up to +5 V with a 10 K resistor. To enable the module, the signal is pulled low (<= 0.5 V) with respect to the ENA RTN signal; this may also be accomplished by shorting Pin 1 to Pin 6.

OPTIONAL INTERFACE CONNECTOR ACCESSORIES

- AMETEK P/N 5380508-01, 9-pin Loop-back Connector Assembly. Includes a jumper wire between Pins 1 and 6 to enable the module outputs.
- AMETEK P/N 5380443-01, Power Module, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.
- AMETEK P/N 5380443-03, Power Module, Right Angle, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.

RFP-D2450-2A3-XXXX MATING CONNECTOR KIT

HPDC-450V Mating Connector Kit - AMETEK Part No. 5380271-02, mates with RFP-D2450-2A3-XXXX, and includes the following for both Interface and DC Output connectors:

Bill of Material

Item	AMETEK Part No.	Description	Qty	Manufacturer Part No.	Manufacturer	Suggested Source(s)
1	856-214-04	Conn, 21P, DSUB, 8/20AWG, Male	1	CBC21WA4M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
2	856-745-53	Contact, F-Volt, 3600VRMS, 500C, Male	4	MS4820D-50	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
3	856-247-39	Conn, Backshell, 37P, Strt, 2 PC	1	D37000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
4	856-214-09	Conn, 9P, DSUB, 20-24AWG, Crimp, Male	1	SD9M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
5	856-247-10	Conn, Backshell, 9P, DSUB, 2 PC	1	D9000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm

RECOMMENDED TOOLS (NOT INCLUDED WITH MATING CONNECTOR KIT)

Hand crimp: Positronic Industries P/N 9507-0-0-0

Pneumatic crimp: Positronic Industries P/N 9550-0-2

Insertion/extraction: Positronic Industries P/N M81969/1-02

Insertion/extraction: Positronic Industries P/N 4311-0-0-0

RFP-D2450-2A3-XXXX INTERFACE CONNECTOR:

External isolated digital and analog control connector.

Connector: Positronic Industries P/N SD9M1000Z, AMETEK P/N 856-214-09
Crimp contacts: Positronic Industries P/N MC7520D (initially supplied with connector)

Backshell: Positronic Industries P/N D9000Z00, AMETEK P/N 856-247-10

Wire size: Maximum gauge 20 AWG (recommended)
Maximum length10 meters (can be extended subject to the environment, cable type, and interface circuits).

RFP-D2450-2A3-XXXX INTERFACE PINOUT

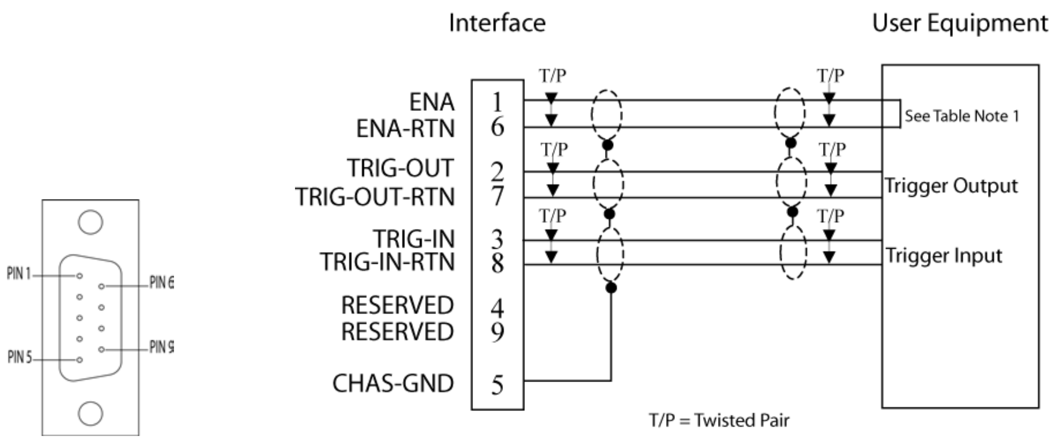


Figure 6-10. RFP-D2450-2A3-XXXX Interface Connector, Front Panel View, and Wiring Diagram

Table 6-7. RFP-D2450-2A3-XXXX Interface Connector Pinout

PIN	NAME	FUNCTION	SIGNAL LEVEL
1	ENA[1]	Input: module output enable	TTL logic level
6	ENA-RTN[1]	Input: return for ENA signal; connected to Pin-7/8	Signal common
2	TRIG-OUT	Output: trigger output signal	TTL logic level
7	TRIG-OUT-RTN	Output: return for TRIG-OUT; connected to Pin-6/8	Signal common
3	TRIG-IN	Input: trigger input signal	TTL logic level
8	TRIG-IN-RTN	Input: return for TRIG-IN; connected to Pin-6/7	Signal common
4	RESERVED		
9	RESERVED		
5	CHAS-GND	Shield ground	Chassis ground

[1] Enable signal is internally pulled up to +5 V with a 10 K resistor. To enable the module, the signal is pulled low (<= 0.5 V) with respect to the ENA RTN signal; this may also be accomplished by shorting Pin 1 to Pin 6.

OPTIONAL INTERFACE CONNECTOR ACCESSORIES

- AMETEK P/N 5380508-01, 9-pin Loop-back Connector Assembly. Includes a jumper wire between Pins 1 and 6 to enable the module outputs.
- AMETEK P/N 5380443-01, Power Module, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.
- AMETEK P/N 5380443-03, Power Module, Right Angle, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.

DC OUTPUT CONNECTOR:

The DC OUTPUT connector provides terminations for the output and remote sense connections to the load.

RFP-D1016-021-XXXX DC Output Connector

Connector: Positronic Industries P/N CBD13W6M2000Z, AMETEK P/N 856-214-07

Pin: Positronic Industries P/N MC4010D, AMETEK P/N 856-745-51

Backshell: Positronic Industries P/N D3T000Z00D37000Z00, AMETEK P/N 856-247-39

Wire size: Refer to table for recommended wire gauge/length

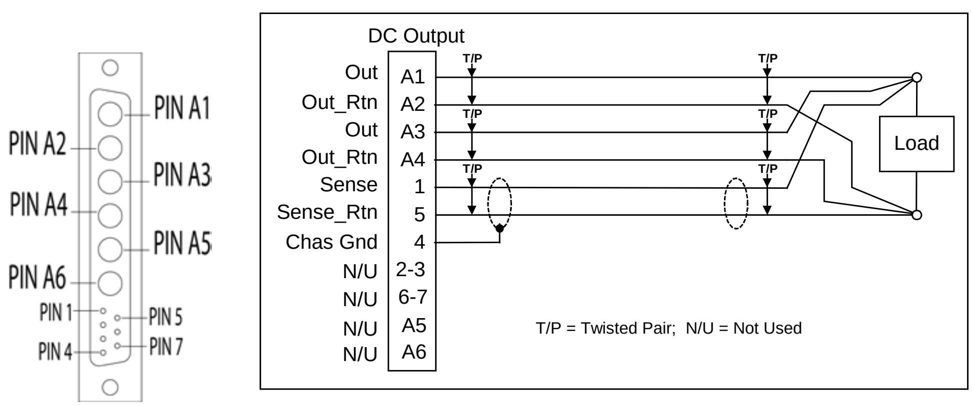


Figure 6-11. RFP-D1016-021-XXXX DC Output Connector, Front Panel View and Wiring Diagram

Table 6-8. RFP-D1016-021-XXXX DC Output Connector Pinout

PIN	NAME	FUNCTION	SIGNAL LEVEL	WIRE GAUGE, AWG	MAX. WIRE LENGTH, FT
A1	OUT	Output: module output source; connected to A3	±16V; ±200V, maximum to chassis	10	100, for 1.5V line drop at 10.3A
A2	OUT-RTN	Output: return for output source, OUT; connected to A4	±16V; ±200V, maximum to chassis	10	100, for 1.5V line drop at 10.3A
A3	OUT	Output: module output source; connected to A1	±16V; ±200V, maximum to chassis	10	100, for 1.5V line drop at 10.3A
A4	OUT-RTN	Output: return for output source, OUT; connected to A2	±16V; ±200V, maximum to chassis	10	100, for 1.5V line drop at 10.3A
1	SNS	Input: remote sense connection for OUT	±16V; ±200V, maximum to chassis	20	100
5	SNS-RTN	Input: remote sense connection for OUT-RTN	±16V; ±200V, maximum to chassis	20	100
4	CHAS-GND	Shield ground	Chassis ground	20	100
A5, A6, 2,3,6,7	-	Reserved	-	-	-

DC OUTPUT CONNECTOR ACCESSORIES

- AMETEK P/N 5380444-01, LPDC 16V Module, 9ft. Unterminated DC Output Cable Assembly.
- AMETEK P/N 5380444-03, LPDC 16V Module, Right Angle, 9ft. Unterminated DC Output Cable Assembly.

RFP-D1065-5A1-XXXX DC OUTPUT CONNECTOR:

Connector: Positronic Industries P/N CBD13W6M2000Z, AMETEK P/N 856-214-07

Pins A1-A6: Positronic Industries P/N MS4820D*, -50, AMETEK P/N 856-745-53

Backshell: Positronic Industries P/N D37000Z00, AMETEK P/N 856-247-39

Wire size: Maximum gauge 20 AWG (recommended) (see table for length)

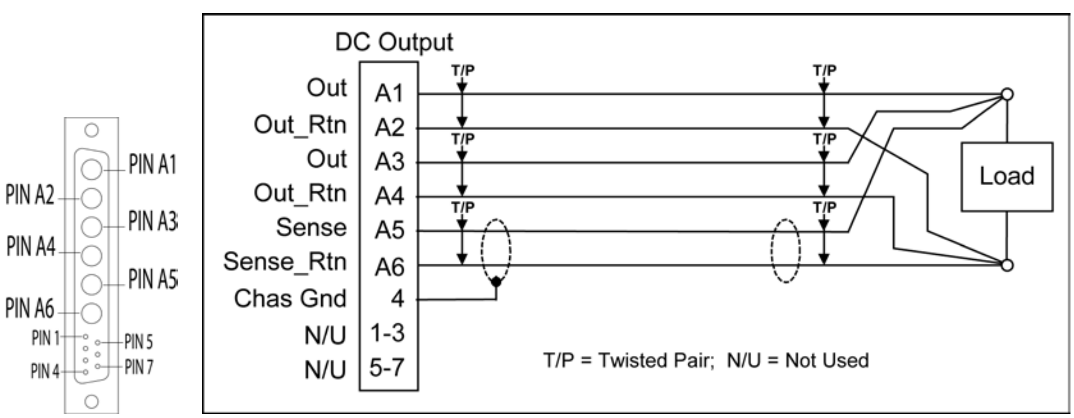


Figure 6-12. RFP-D1065-5A1-XXXX DC Output Connector, Front Panel View, and Wiring Diagram

Table 6-9. RFP-D1065-5A1-XXXX DC Output Connector Pinout

PIN	NAME	FUNCTION	SIGNAL LEVEL	WIRE GAUGE, AWG	MAXIMUM WIRE LENGTH, FT
A1	OUT	Output: module output source; connected to A3	±65V; ±300V, maximum to chassis	20	40, for 1.5V line drop at 2.55A
A2	OUT-RTN	Output: return for output source, OUT; connected to A4	±65V; ±300V, maximum to chassis	20	40, for 1.5V line drop at 2.55A
A3	OUT	Output: module output source; connected to A1	±65V; ±300V, maximum to chassis	20	40, for 1.5V line drop at 2.55A
A4	OUT-RTN	Output: return for output source, OUT; connected to A2	±65V; ±300V, maximum to chassis	20	40, for 1.5V line drop at 2.55A
A5	SNS	Input: remote sense connection for OUT	±65V; ±300V, maximum to chassis	20	40
A6	SNS-RTN	Input: remote sense connection for OUT-RTN	±65V; ±300V, maximum to chassis	20	40
4	CHAS-GND	Shield ground	Chassis ground	20	40
1-3,5-7	-	Reserved	-	-	-

DC OUTPUT CONNECTOR ACCESSORIES

- AMETEK P/N 5380445-01, LPDC 65V Module, 9ft. Unterminated DC Output Cable Assembly.
- AMETEK P/N 5380445-03, LPDC 65V Module, Right Angle, 9ft. Unterminated DC Output Cable Assembly.

RFP-D2033-030-XXXX DC OUTPUT CONNECTOR:

Connector: Positronic Industries P/N CBC21WA4M1000Z, AMETEK P/N 856-214-04
Crimp contacts: Positronic Industries P/N MC6020D

Pins: Positronic Industries P/N MC4010D, AMETEK P/N 856-745-51

Backshell: Positronic Industries P/N D37000Z00, AMETEK P/N 856-247-39

Wire size: Refer to table for recommended wire gauge/length.

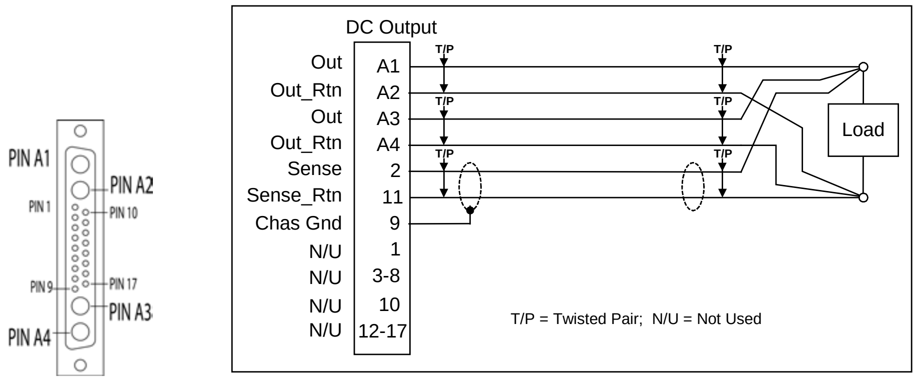


Figure 6-13. RFP-D2033-030-XXXX DC Output Connector, Front Panel View, and Wiring Diagram

Table 6-10. RFP-D2033-030-XXXX DC Output Connector Pinout

PIN	NAME	FUNCTION	SIGNAL LEVEL	WIRE GAUGE, AWG	MAXIMUM WIRE LENGTH, FT
A1	OUT	Output: module output source; connected to A3	±33V; ±200V, maximum to chassis	10	75, for 1.5V line drop at 15A
A2	OUT-RTN	Output: return for output source, OUT; connected to A4	±33V; ±200V, maximum to chassis	10	75, for 1.5V line drop at 15A
A3	OUT	Output: module output source; connected to A1	±33V; ±200V, maximum to chassis	10	75, for 1.5V line drop at 15A
A4	OUT-RTN	Output: return for output source, OUT; connected to A2	±33V; ±200V, maximum to chassis	10	75, for 1.5V line drop at 15A
2	SNS	Input: remote sense connection for OUT	±33V; ±200V, maximum to chassis	20	75
11	SNS-RTN	Input: remote sense connection for OUT-RTN	±33V; ±200V, maximum to chassis	20	75
9	CHAS-GND	Shield ground	Chassis ground	20	75
1,3-8,10,12-17	-	Reserved	-	-	-

DC OUTPUT CONNECTOR ACCESSORIES

- AMETEK P/N 5380446-01, HPDC 33V/50V Module, 9ft. Unterminated DC Output Cable Assembly.
- AMETEK P/N 5380446-03, HPDC 33V/50V Module, right angle, 9ft. Unterminated DC Output Cable Assembly.

RFP-D2050-025-XXXX, RFP-D2050-020-XXXX DC OUTPUT CONNECTOR:

Connector: Positronic Industries P/N CBC21WA4M1000Z, AMETEK P/N 856-214-04
Crimp contacts: Positronic Industries P/N MC6020D

Pins: Positronic Industries P/N MC4010D, AMETEK P/N 856-745-51

Backshell: Positronic Industries P/N D37000Z00, AMETEK P/N 856-247-39

Wire size: Refer to table for recommended wire gauge/length.

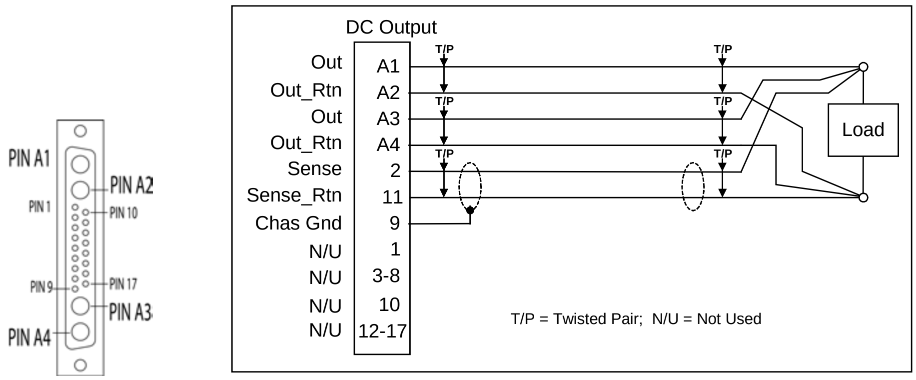


Figure 6-14. RFP-D2050-025-XXXX DC Output Connector, Front Panel View, and Wiring Diagram

Table 6-11. RFP-D2050-025-XXXX, RFP-D2050-020-XXXX DC Output Connector Pinout

PIN	NAME	FUNCTION	SIGNAL LEVEL	WIRE GAUGE, AWG	MAXIMUM WIRE LENGTH, FT
A1	OUT	Output: module output source; connected to A3	±50V; ±200V, maximum to chassis	10	90, for 1.5V line drop at 12.5A
A2	OUT-RTN	Output: return for output source, OUT; connected to A4	±50V; ±200V, maximum to chassis	10	90, for 1.5V line drop at 12.5A
A3	OUT	Output: module output source; connected to A1	±50V; ±200V, maximum to chassis	10	90, for 1.5V line drop at 12.5A
A4	OUT-RTN	Output: return for output source, OUT; connected to A2	±50V; ±200V, maximum to chassis	10	90, for 1.5V line drop at 12.5A
2	SNS	Input: remote sense connection for OUT	±50V; ±200V, maximum to chassis	20	90
11	SNS-RTN	Input: remote sense connection for OUT-RTN	±50V; ±200V, maximum to chassis	20	90
9	CHAS-GND	Shield ground	Chassis ground	20	90
1,3-8,10,12-17	-	Reserved	-	-	-

DC OUTPUT CONNECTOR ACCESSORIES

- AMETEK P/N 5380446-01, HPDC 33V/50V Module, 9ft. Unterminated DC Output Cable Assembly.
- AMETEK P/N 5380446-03, HPDC 33V/50V Module, right angle, 9ft. Unterminated DC Output Cable Assembly.

RFP-D2120-8A3-XXXX DC OUTPUT CONNECTOR:

Connector: Positronic Industries P/N CBC21WA4M1000Z, AMETEK P/N 856-214-04
Crimp contacts: Positronic Industries P/N MC6020D

Pins A1, A2: Positronic Industries P/N MC4010D, AMETEK P/N 856-745-51

Pins A3, A4: Positronic Industries P/N MS4820D-50, AMETEK P/N 856-745-53

Backshell: Positronic Industries P/N D37000Z00, AMETEK P/N 856-247-39

Wire size: Refer to table for recommended wire gauge/length.

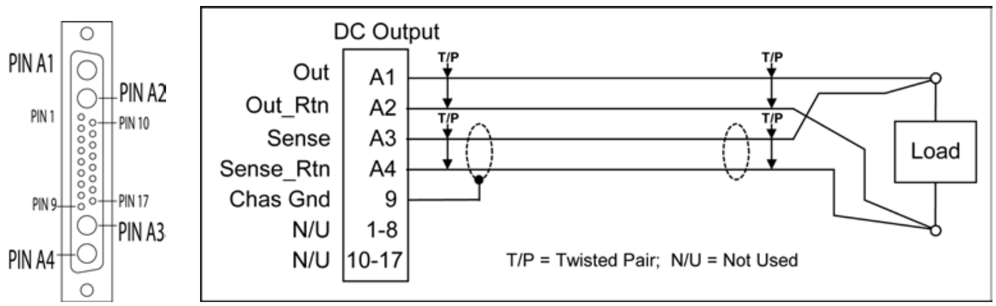


Figure 6-15. RFP-D2120-8A3-XXXX DC Output Connector, Front Panel View, and Wiring Diagram

Table 6-12. RFP-D2120-8A3-XXXX DC Output Connector Pinout

PIN	NAME	FUNCTION	SIGNAL LEVEL	WIRE GAUGE, AWG	MAXIMUM WIRE LENGTH, FT
A1	OUT	Output: module output source	±120V; ±200V, maximum to chassis	10	135, for 1.5V line drop at 8.3A
A2	OUT-RTN	Output: return for output source, OUT	±120V; ±200V, maximum to chassis	10	135, for 1.5V line drop at 8.3A
A3	SNS	Input: remote sense connection for OUT	±120V; ±200V, maximum to chassis	20	135
A4	SNS-RTN	Input: remote sense connection for OUT-RTN	±120V; ±200V, maximum to chassis	20	135
9	CHAS-GND	Shield ground	Chassis ground	20	135
1-8, 10-17	-	Reserved	-	-	-

DC OUTPUT CONNECTOR ACCESSORIES

- AMETEK P/N 5380453-01, HPDC 120V Module, 9ft. Unterminated DC Output Cable Assembly.
- AMETEK P/N 5380453-03, HPDC 120V Module, right angle, 9ft. Unterminated DC Output Cable Assembly.

RFP-D2450-2A3-XXXX DC OUTPUT CONNECTOR:

Connector: Positronic Industries P/N CBC21WA4M1000Z, AMETEK P/N 856-214-04
Crimp contacts: Positronic Industries P/N MC6020D

Pins A1-A4: Positronic Industries P/N MS4820D-50, AMETEK P/N 856-745-53

Backshell: Positronic Industries P/N D37000Z00, AMETEK P/N 856-247-39

Wire size: Maximum gauge 20 AWG (recommended)
Refer to table for recommended wire gauge/length.

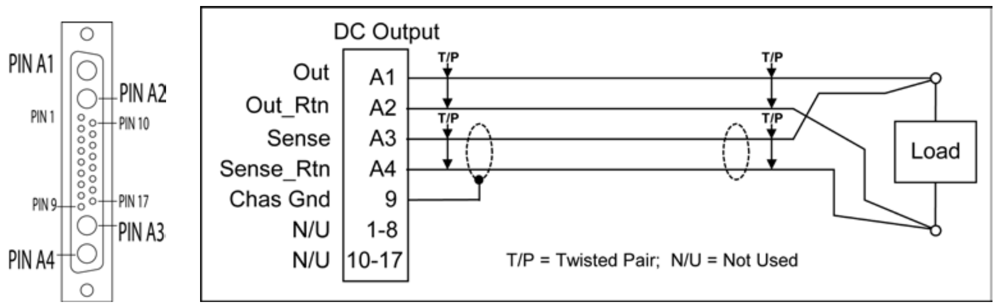


Figure 6-16. RFP-D2450-2A3-XXXX DC Output Connector, Front Panel View, and Wiring Diagram

Table 6-13. RFP-D2450-2A3-XXXX DC Output Connector Pinout

PIN	NAME	FUNCTION	SIGNAL LEVEL	WIRE GAUGE, AWG	MAXIMUM WIRE LENGTH, FT
A1	OUT	Output: module output source	±450V; ±450V, maximum to chassis	20	44, for 1.5V line drop at 2.3A
A2	OUT-RTN	Output: return for output source, OUT	±450V; ±450V, maximum to chassis	20	44, for 1.5V line drop at 2.3A
A3	SNS	Input: remote sense connection for OUT	±450V; ±450V, maximum to chassis	20	44
A4	SNS-RTN	Input: remote sense connection for OUT-RTN	±450V; ±450V, maximum to chassis	20	44
9	CHAS-GND	Shield ground	Chassis ground	20	44
1-8, 10-17	-	Reserved	-	-	-

DC OUTPUT CONNECTOR ACCESSORIES

- AMETEK P/N 5380447-01, HPDC 450V Module, 9ft. Unterminated DC Output Cable Assembly.
- AMETEK P/N 5380447-03, HPDC 450V Module, right angle, 9ft. Unterminated DC Output Cable Assembly.

Remote Sense

Remote sensing is used to compensate for the voltage drop that occurs across the wires connecting the load to the output of the DC power supply modules. A separate pair of wires is routed to measure the voltage at the load terminals where precise regulation of the output voltage is desired.

The remote sense leads are connected at the DC OUTPUT connector on the front panel of the modules. Refer to the section, *DC OUTPUT,* for information on connector pinout. Connect the SNS terminal to the load terminal connected to the module OUT terminal, and the SNS-RTN terminal to the load terminal connected to OUT-RTN terminal.

Special care is required in routing the sense leads to prevent noise pickup or coupling from the power leads; refer to the section, *NOISE AND IMPEDANCE EFFECTS*. The sense leads should be a twisted-pair of at least AWG #22 wire, and may require shielding in high noise environments. Connect the shield to the shield ground terminal, CHAS-GND, of the DC OUTPUT connector, as required to maximize its effectiveness.

If the remote sense leads are not connected, the DC modules will continue to operate but the voltage at the load will no longer be precisely regulated. An internal resistor network exists within the module that connects the output terminals to the remote sense terminals. This network provides the measurement of the output voltage when the remote sense leads are not connected. However, since the voltage is now measured at the output terminals, the voltage drop of the load wiring would no longer be compensated.

Several conditions related to remote sensing are treated as faults and result in shutdown of the output: short-circuiting of the remote sense terminals; connecting the remote sense leads in reverse polarity; excessive line drop in the load wires. When the fault condition is detected, shutdown will result with the output voltage being programmed to zero and the output isolation relay being opened.

Module Enable (ENA)

The module output enable signal, ENA, of the front panel INTERFACE connector provides an external control input for turning the output of the module on/off. This signal is pulled up through a 10kΩ resistor to an internal 5VDC source, and is isolated from the output terminals of the DC OUTPUT connector. A logic-low signal (ENA to ENA-RTN at $\leq$ 0.8V) will turn the output on, while a logic-high (ENA to ENA-RTN at $\geq$ 3.7V) will turn the output off. The module output follows the logic state of ENA, with the output changing between 0V when off and the programmed value when on. An 100ms delay exists between the application of ENA (going logic-low) and the output turning on, and a 100μs delay exists between removal of ENA (going logic-high) and the output turning off. The ENA signal will open the sense / output isolation relays, and turn off the front-panel output indicator. The condition of the ENA signal is stored in the FAULTS register; it could be queried using the SCPI command, STAT[n]:MOD:FAUL?.

6.4.9 WIRE SELECTION

Input/output wiring must have a current carrying capacity compatible with the current rating of the ReFlex Power™ system. The maximum current rating of a wire is dependent on the materials used in its construction, and is primarily limited by the insulation. The current must be limited so that the temperature rise of the wire does not result in an operating temperature that exceeds the rating of the wire.

WIRE CURRENT CAPACITY

Table 6-14 shows maximum current ratings, based on a cable of three conductors, that will produce an approximate 30ºC temperature rise above ambient. When wiring must operate in areas with an elevated ambient temperature or bundled with other wiring, heavier gauges or higher temperature-rated wiring should be used.

Although wire with higher temperature rated insulation will allow operation at higher currents, the total voltage drop would also be increased for a given wire gauge. For applications where voltage characteristics, such as regulation, are important, it may be necessary to size the wire based on total voltage drop instead of temperature rise.

Table 6-14. Wire Data

AWG	COPPER AREA, CM^2	RESISTANCE, Ω/M AT 20°C	RESISTANCE, Ω/M AT 100°C	CURRENT RATING, A FOR 30ºC RISE
6	0.133	0.0013	0.0017	54
8	0.0837	0.0021	0.0028	40
10	0.0526	0.0033	0.0044	27
12	0.0331	0.0052	0.0069	21
14	0.0208	0.0083	0.011	16
16	0.0131	0.0132	0.0174	12
18	0.00823	0.0209	0.0276	10
20	0.00518	0.0333	0.044	7.5
22	0.00326	0.053	0.07	5.5

WIRE VOLTAGE DROP

For applications where regulation is important, the contribution of the load wiring to voltage drop from the output terminals of the DC modules to the load must be considered. The wire gauge must be selected to maintain an acceptable total voltage drop for the load wiring under the maximum peak current. The resistance of the load wiring must be determined for the sum total length of the output lead and the return lead. The total voltage drop is the sum of the individual drops in the output and return leads. Table 5-10 gives the resistance per meter (m) of various wire gauges at 20°C and 100°C.

Use the following equation to calculate the resistance for other wire temperatures:

R = R20°C x [1 + 0.004 x (T - 20°C)]

where,

R = resistance, Ω/m, at temperature T

R20°C = resistance, Ω/m, at 20°C

T = temperature of wire, °C

The voltage drop (per output or return lead) could be calculated using the following equation:

V = I x L x R20°C x [1 + 0.004 x (T - 20°C)]

where,

V = total voltage drop, V

I = current, A

L = length of wire, m

R20°C = resistance of wire, Ω/m, at 20°C

T = temperature of wire conducting current, °C

NOISE AND IMPEDANCE EFFECTS

To minimize noise pickup or radiation from load circuits, load wires and remote sense wires should be twisted-pair with minimum lead length. Shielding of the sense leads may be necessary in high noise environments. Even if noise is not a concern, the load and remote sense wires should be twisted-pairs to reduce coupling between them, which could impact the stability of the output converter. If connectors are utilized for the power and sense leads, be careful not to introduce coupling between the leads. Ensure that the connector terminals for the sense leads are in adjacent locations, and minimize the physical loop area of the untwisted portions.

Twisting the load wires provides an additional benefit in reducing the parasitic inductance of the cable. This improves the dynamic response characteristics at the load by maintaining a low source impedance at high frequencies. Also, with long load wires, the resultant inductance and resistance could produce high frequency voltage fluctuations at the load because of current variations in the load itself. The impedance introduced between the output of the power supply and the load could make the ripple/noise voltage at the load worse than the specification of the DC power supply modules (which is valid when measured at the front panel connector) because of the contribution to the ripple/noise by the load current. Additional filtering with bypass capacitors at the load terminals may be required to bypass the high frequency load currents.

6.5 OPERATION

The ReFlex Power™ DC power supplies can be configured for stand-alone, parallel, series, and series-parallel operation.

6.5.1 INTRODUCTION

The DC power supply modules function within the ReFlex Power™ system under remote control through a host controller. The ReFlex Power™ Controller module serves as a communications portal between the power supply modules and the remote host controller. All aspects of operation could be achieved through use of commands that comply with the requirements of the SCPI Standard 1999 command language. Additional discrete digital and optional analog control signals are available for dedicated hardware interface. All connectors for control and power interface are accessible on the front panel

6.5.2 CONTROLS AND INDICATORS

Figure 6-17 shows the connectors and indicators of a typical DC module front panel, followed by a description.

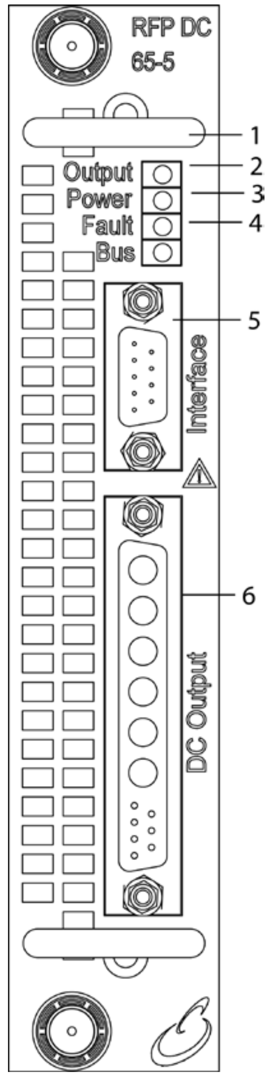


Figure 6-17. Programmable DC Module Front Panel (RFP-D1065-5A1-XXXX shown)

1 –OUTPUT Indicator: Green LED lights when output voltages are enabled or isolation relays are closed
2 – POWER Indicator: Green LED lights when AC/DC input power is applied to the module.
3 – FAULT Indicator: Red LED lights when an abnormal internal operating condition has been detected; the output would be disabled and the isolation relay opened.
4 – BUS Indicator: Green LED lights when internal inter-module communications has been established.
5 – INTERFACE connector for remote isolated digital signals.
6 – DC OUTPUT connector for the output voltages and remote sense.

6.5.3 MODES OF OPERATION

The DC power supply modules are capable of operating in either standalone or in groupings of parallel, series, or series/parallel output configurations. This allows extending the power, voltage, and current ratings while minimizing the number of unique modules comprising a system. When configured in groups, the modules are programmed and controlled as single, virtual channels. All configuration setup within the modules for implementing groups is performed automatically. However, the output power and remote sense leads must be appropriately hardwired before issuing the grouping commands.

STANDALONE OPERATION

Modules operated in standalone mode function as independent DC power supplies. The outputs are isolated from adjacent modules, and could be configured for positive, negative, or floating outputs with respect to the chassis ground. The Mainframe backplane control and data communications interface is also isolated; therefore, there are no restrictions as to the physical location of a module within the Mainframe when it is operated in standalone mode.

PARALLEL OPERATION

Operation of modules in a parallel group requires routing of analog control signals through the backplane between the modules, as well as the digital control/communications, to implement a master/slave control interface. The routing of signals in this interface requires that parallel modules must be located in a contiguous physical group; no intervening modules (which are not part of the parallel group) are allowed to be located within the parallel group. Individual modules of the group can be separated by empty slots, and the group can be extended between two Mainframes. The outputs of the modules must be hardwired externally, while all internal control signal connections are combined automatically when the parallel group is set up through software. The remote sense leads are connected only to the master module. The parallel group is programmed as a “virtual” module, equivalent to a single module with the combined current rating of the parallel group of modules. Only modules of the same model number could be paralleled.

SERIES OPERATION

Modules could be operated in a series group regardless of their location in the ReFlex Power™ system. The series group does not utilize the analog control signals of the backplane; therefore, it is not restricted by contiguous physical location as in a parallel group. The module with the lowest address [n], is the series group master. The outputs and remote sense of the modules must be hardwired externally, while all internal control signal connections are done automatically when the series group is set up through software. The series group is programmed as a "virtual" module, equivalent to a single module with the combined voltage rating of the series group of modules. Only modules of the same model number could be series connected.

SERIES/PARALLEL OPERATION

Series-Parallel groups are also allowed. The requirements for configuring the group are a combination of those for the dedicated series and parallel groups: the parallel modules must be physically contiguous, while the series grouping is not location dependent. The outputs must be hardwired as parallel groups connected in series. The remote sense leads are connected only to the paralleling-master modules. The series group is programmed as a "virtual" module, equivalent to a single module with the combined voltage/current ratings of the series-parallel group of modules. Only modules of the same model number could be series-parallel connected.

OUTPUT VOLTAGE/CURRENT REGULATION

The DC power supply module is capable of operating while regulating either the output voltage, constant–voltage mode (CV), or the output current, constant–current mode (CC). Which parameter would be regulated is dependent on the programmed settings of the output voltage and current in relation to the resistance of the load. If the load resistance is greater than the voltage setting divided by the current setting, the output voltage would be regulated in voltage-mode. If the load resistance is less than the voltage setting divided by the current setting, the output current would be regulated in current-mode. The crossover point is when the load resistance equals the voltage setting divided by the current setting. The DC power supply can automatically crossover between the two modes of operation in response to load demands. Refer to Figure 6-18 for a diagram showing the operating regions for constant-voltage and constant-current.

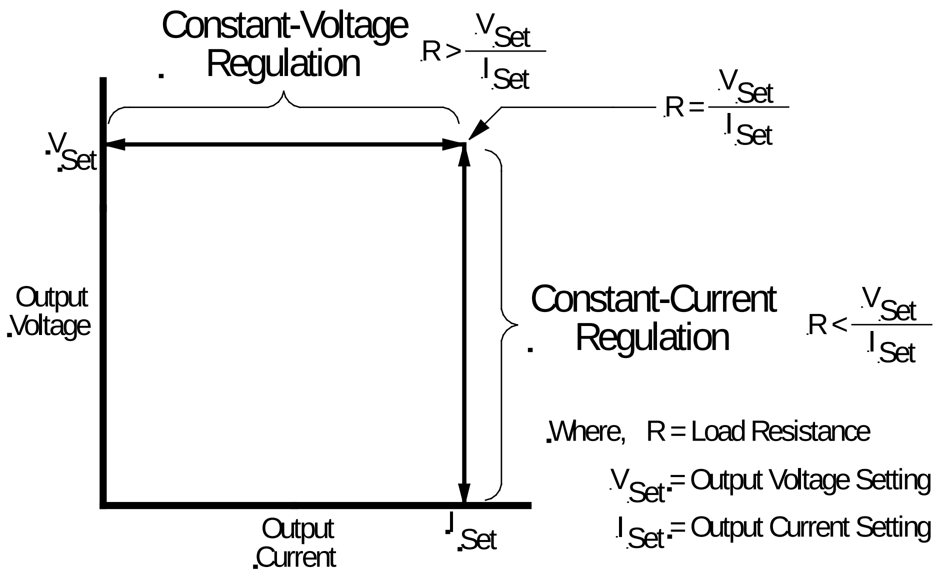


Figure 6-18. CV and CC Regulation

CONSTANT VOLTAGE

The DC power supply will operate in constant–voltage regulation whenever the load current is less than the programmed current setting. In this mode, the power supply maintains the output voltage precisely regulated to the programmed voltage setting while the load current varies with the load requirements. This condition is maintained as long as the load current is less than the current setting. If the load resistance decreases to where the load current attempts to exceed the current setting, the output current is then regulated at the programmed current setting, and the output voltage decreases until that condition is satisfied. This is the automatic crossover point to constant–current mode of operation.

CONSTANT CURRENT

The DC power supply will operate in constant–current mode whenever the load resistance times the programmed current setting is less than the programmed voltage setting. In this mode, the power supply maintains the output current precisely regulated to the current setting while the load voltage varies with load requirements. This condition is maintained as long as the load resistance is less than the voltage setting divided by the current setting. If the load resistance increases to where the load voltage attempts to exceed the voltage setting, the output voltage is then regulated to the programmed voltage setting, and the output current decreases until that condition is satisfied. This is the automatic crossover point to constant–voltage mode of operation.

6.5.4 LOAD CONNECTION CONFIGURATIONS

The output of the DC power supply module is isolated from chassis ground, allowing either positive, negative, or floating outputs with respect to chassis ground. Connections to the load are made at the front panel output connector terminals. Ensure that a wire gauge is utilized that can carry the programmed current without overheating.

Remote sensing of the output voltage is required to meet accuracy and regulation specifications. The sense leads should be connected to the point in the load circuit where the voltage is to be precisely regulated. If a distribution bus is utilized for multiple loads, the point of voltage sensing is important to ensure that the voltage regulation is acceptable for all of the loads. In general, the point of sensing is selected to minimize interaction of the various loads through line drops caused by their load currents.

CAUTION

Operating the power supply with either the positive or negative output lead at greater than the float voltage specification limit above chassis ground could result in damage to the module.

STANDALONE CONFIGURATION

Single loads are connected directly to the front panel output terminals, and the DC power supply module is configured to operate in the standalone mode. Twist the load wires or maintain them closely in parallel for their entire length to minimize parasitic inductance and coupling from external circuits. Use the heaviest gauge practical to minimize line drop. The remote sense wires should be twisted, and may need shielding depending on the electrical noise environment of the application. Figure 6-19 shows a standalone load connection with remote sensing.

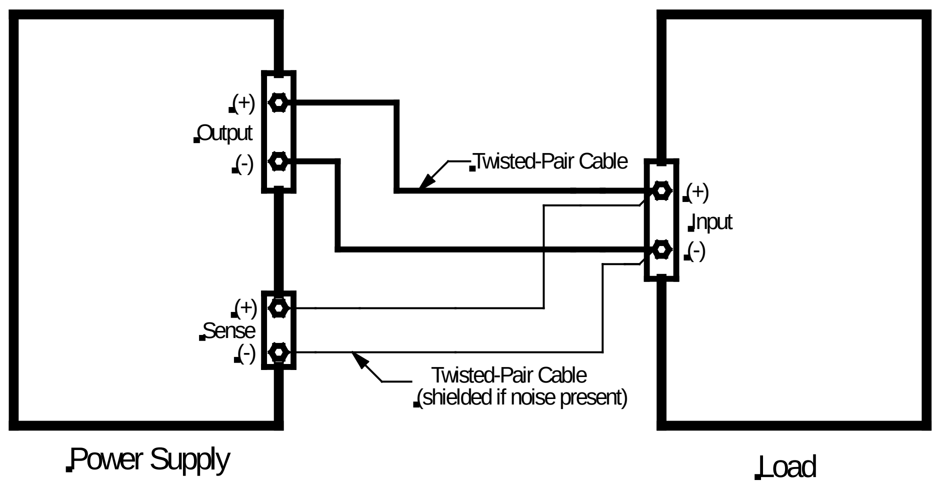


Figure 6-19. Standalone Output Configuration

PARALLEL CONFIGURATION

DC power supply modules of the same model can be connected in parallel. The paralleled supplies operate in a master/slave configuration, where the master controls the output voltage and total current, and provides control signals through the Mainframe backplane to the slaves to set their output current. The routing of signals in this interface requires that parallel modules must be located in a contiguous physical group; no intervening modules (which are not part of the parallel group) are allowed to be located within the parallel group. Individual modules of the group can be separated by empty slots, and the group can be extended between two Mainframes.

The outputs of the modules must be hardwired externally, while all internal control signal connections are done automatically when the parallel group is set up through software. The remote sense leads are connected only to the master module. Figure 6-20 shows a parallel connection of two units with remote sensing.

The paralleled modules are programmed as a single, virtual channel with a current rating equal to the sum of the number of modules connected in parallel. The master and slave supplies will share the output current equally. Fault shutdown is coordinated across all modules: a fault within any module of the group will result in shutdown of all modules. The parallel master will be the module that has the lowest slot number in the parallel group.

CAUTION

The outputs of paralleled modules must be wired in parallel at the front panel output terminals of the units. Use the shortest practical cable length. Operation of a paralleled module with its return (negative) terminal not connected to the load could result in damage to the module.

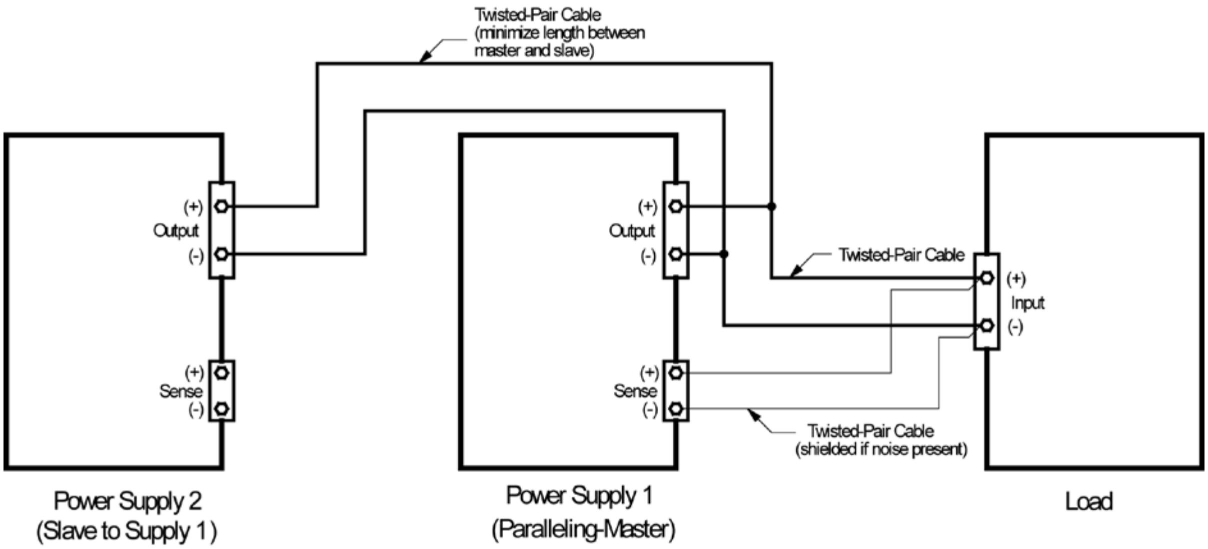


Figure 6-20. Parallel Output Configuration

SERIES CONFIGURATION

Multiple modules of the same model can be connected in series to obtain a higher output voltage, within the limits of the float voltage specification. The series master is the module with the lowest slot number in the group of modules that are connected together. The supplies are interconnected with the negative terminal of one supply being connected to the positive terminal of other. The output voltage is derived from the positive and negative terminals of the total string.

The series group does not utilize the analog control signals of the backplane; therefore, it is not restricted by contiguous physical location, as in a parallel group. The outputs of the modules must be hardwired externally, while all internal control signal connections are done automatically when the series group is set up through software. In order not to compromise the load regulation of the output voltage, the series connection of the remote sense leads must be made to single points, and must not have any intervening load wiring. Figure 6-21 shows the series connection of three units with remote sensing.

The series connected modules are programmed as a single, virtual channel with a voltage rating equal to the sum of the number of modules connected in series. The modules will share the output voltage equally. The output current is the same for each module. Fault shutdown is coordinated across all modules: a fault within any module of the group will result in shutdown of all modules.

CAUTION
To prevent damage to a supply, do not exceed the float voltage specification limit for either of the output terminals to chassis.

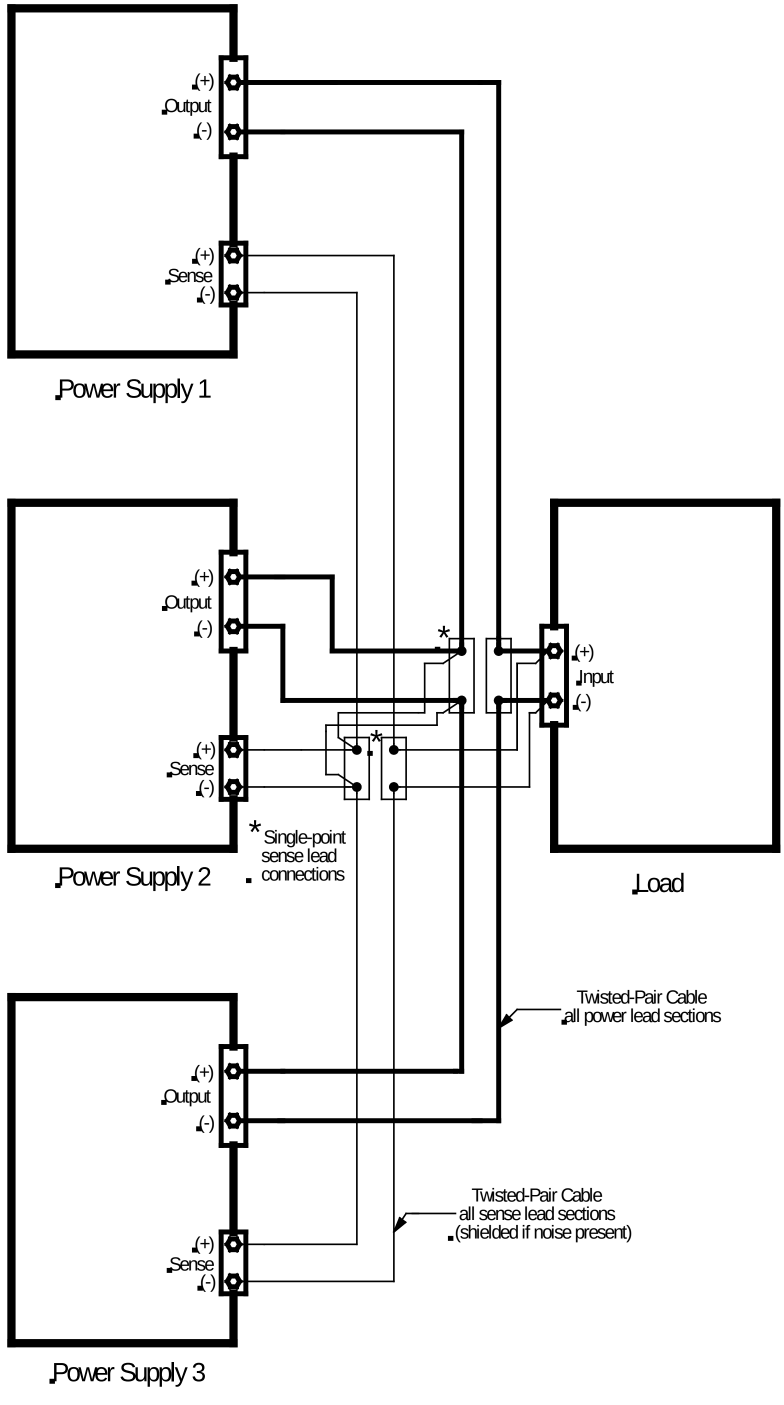


Figure 6-21. Series Output Configuration

SERIES/PARALLEL CONFIGURATION

The series output configuration could be combined with the parallel configuration to produce a composite series/parallel configuration. Only modules of the same model could be interconnected in series/parallel. The restrictions listed in the sections on the series and parallel configurations must be followed: the parallel modules must be physically contiguous, while the series grouping is not location dependent. The outputs must be hardwired as parallel groups connected in series. The remote sense leads are connected only to the paralleling-master modules; ensure that single point connections are maintained for the series connected sense leads. Figure 6-22 shows the series/parallel connection of six units with remote sensing.

The series/paralleled modules are programmed as a single, virtual channel with a current rating equal to the sum of the number of modules connected in parallel, and a voltage rating equal to the sum of the number of modules connected in series. The master and slave supplies of a parallel group will share the output current equally, while the series connected parallel groups of modules will equally share the output voltage. Fault shutdown is coordinated across all modules: a fault within any module of the group will result in shutdown of all modules.

CAUTION
To prevent damage to a supply, do not exceed the float voltage specification limit for either of the output terminals to chassis.

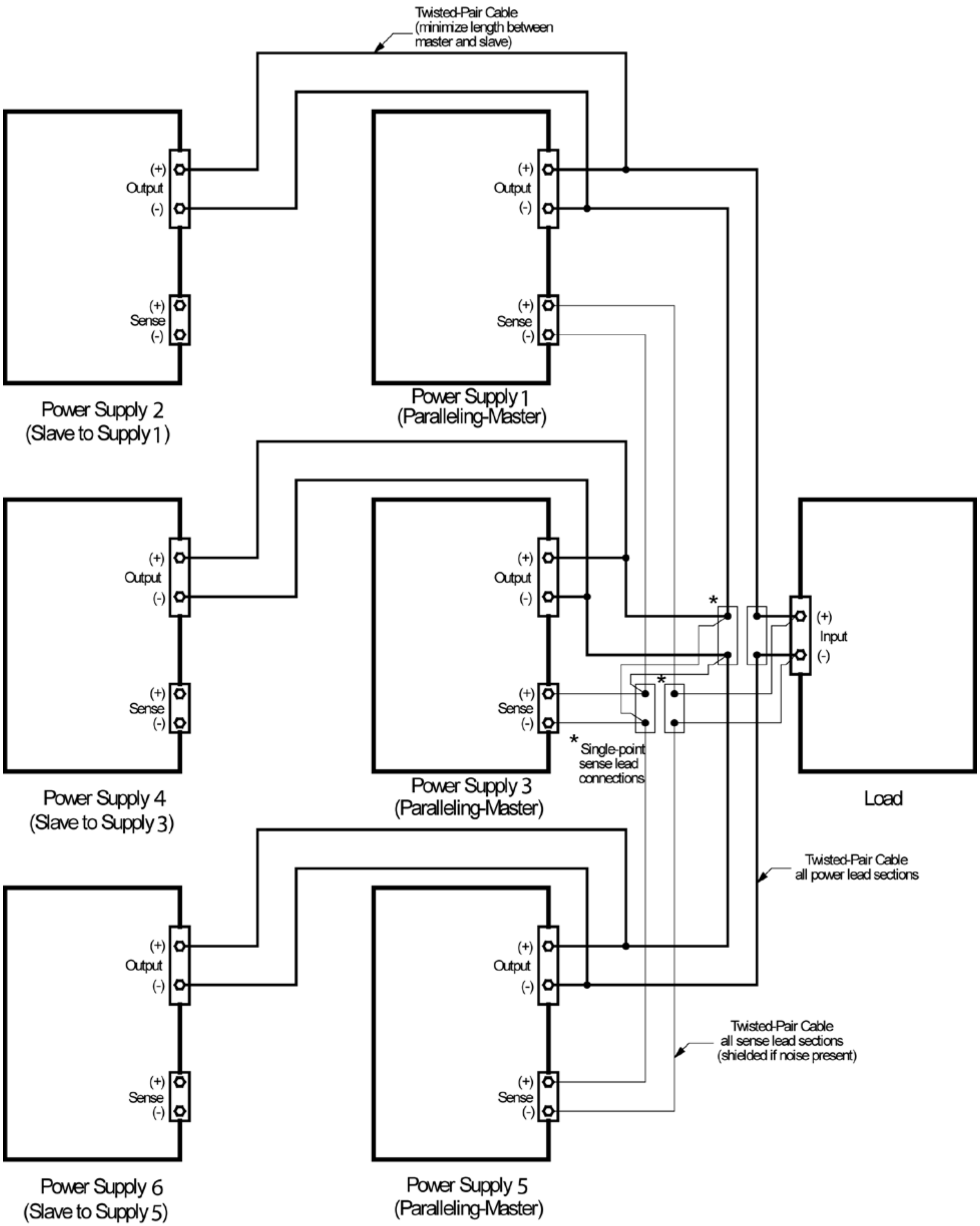


Figure 6-22. Series/Parallel Output Configuration

6.5.5 DEFAULT OPERATIONAL CONDITIONS

POWER-ON CONDITIONS

When an DC power supply module is first powered on, the following parameters are set to factory default values:

- Output configuration: standalone
- Output voltage: 0V
- Output current: 0A
- Overvoltage protection (OVP): 110% of full-scale voltage; programmable mode
- Undervoltage protection (UVP): 0V
- Overcurrent protection (OCP): 120% of full-scale current; programmable mode
- Output state: off
- Output isolation and remote sense relays: open

RESET CONDITIONS

If a module is reset with the SCPI command, ***RST[n]**, (where n is the module address), the following default conditions are set:

- Output configuration: unchanged
- Output voltage: 0V
- Output current: 0A
- Overvoltage protection (OVP): 110% of full-scale voltage; programmable mode
- Undervoltage protection (UVP): 0V
- Overcurrent protection (OCP): 120% of full-scale current; programmable mode
- Output state: off
- Output isolation and remote sense relays: open
- All status reporting data structures are cleared; enable-masks are not cleared.

6.5.6 INITIAL FUNCTIONAL TESTS

POWER-ON CHECK

1. Ensure that the AC/DC input service is disconnected.
2. Install the interface cable between the host controller and the ReFlex Power™ Controller module.
3. Connect an appropriate output load to the DC power supply module.

4. Configure the host controller for communications with the ReFlex Power™ Controller module.
5. Turn on the AC/DC input service.
6. The modules will first execute a power-on self-test. Also the internal fans are run at maximum speed for several seconds, and then back to slow speed.
7. In the following paragraphs, commands include a channel number, **[n]**. The channel number corresponds to the slot of the ReFlex Power™ Mainframe where the module is located, counting left to right, 1 through 12. For example:

   SOUR[n]:VOLT 5 will be
   SOUR1:VOLT 5 for slot-1
   SOUR2:VOLT 5 for slot-2

8. Additionally, model specific parameter values must be added for full-scale voltage and current. They are shown in the following examples as floating point numerical values, **<fval>**. For the DC power supply modules, the values are as follows:

   Full-Scale Voltage:

   RFP-D1016-021-XXXX: 16
   RFP-D1065-5A1-XXXX: 65
   RFP-D2033-030-XXXX: 33
   RFP-D2450-2A3-XXXXA3: 450

   Full-Scale Current:

   RFP-D1016-021-XXXX: 20.6
   RFP-D1065-5A1-XXXX: 5.1
   RFP-D2033-030-XXXX: 30
   RFP-D2450-2A3-XXXXA3: 2.3

   Therefore, for an RFP-D1016-021-XXXX module in slot 1, the command for full-scale voltage would be **SOUR1:VOLT 16**, while for an RFP DC 065-5A1 module it would be **SOUR1:VOLT 65**.

9. Verify communications with the ReFlex Power™ Controller module by issuing an SCPI ***IDN[n]?**, where "n" is a channel number that corresponds to the slot of the ReFlex Power™ Mainframe where the module is located, counting left to right, 1 through 12.
10. The ReFlex Power™ Controller module should respond with its identification string.
11. Verify communications with the ReFlex Power™ DC power supply module by issuing an SCPI ***IDN[n]?**, where "n" is a channel number that corresponds to the slot of the ReFlex Power™ Mainframe where the module is located, counting left to right, 1 through 12.

12. The DC power supply module should respond with its identification string. The default settings of the module will not be affected.

STANDALONE CONFIGURATION OPERATION CHECK

1. Connect the output for standalone operation per the section, Standalone Configuration.
2. Connect appropriate instrumentation for measuring the output voltage and current, as well as a load.
3. Perform the power-on verification test per the section, Power-On Check.
4. Turn on the isolation and remote sense relays, turn on the output converter, and program full-scale voltage and current with the following commands:

   ***RST[n]**
   OUTP[n]:ISOL 1
   OUTP[n]:SENS 1
   OUTP[n]:STAT 1
   SOUR[n]:VOLT <fval>
   SOUR[n]:CURR <fval>

5. Measure the output voltage and current with the external instruments.
6. Ensure that the actual values of the output parameters are within specifications of the programmed values.
7. Query the values of the output parameters with the following commands:

   MEAS[n]:VOLT?
   MEAS[n]:CURR?

8. Ensure that the readback values of the output parameters are within specifications of the actual values.
9. Turn off the output with the following command:

   ***RST[n]**

PARALLEL CONFIGURATION OPERATION CHECK

1. Before attempting to verify parallel operation, perform the power-on test of the individual modules per the section, Power-On Check, and then the standalone operation test per section, Standalone Configuration.
2. Connect the outputs for parallel operation per the section, Parallel Configuration. Ensure that the outputs and remote sense are

appropriately hardwired prior to issuing any of the paralleling SCPI commands.

3. Connect appropriate instrumentation for measuring the output voltage and current, as well as a load.
4. Configure the modules into a parallel group with the following command, where <n1> is the master module of the group. Although the example is for two modules, it could be extended to a greater number by listing additional parameter slot numbers, **[n]**.

   SYST:GRO:DEF:PAR [n1],[n2]

5. Verify that the parallel group has been properly set up with the following command. The response to the query is a listing of the parallel group, the master module of the parallel group, and the slave module of the parallel group. For example, a group of modules with a master in slot 3 and a slave in slot 4 would return the following parameters: 1003,3,4. The parameter, **[1000+n1]**, is the sum of 1000 and the slot number of the master module; the master module is the left-most module of the parallel group.

   SYST:GRO:CAT:PAR?

6. Turn on the isolation and remote sense relays, turn on the output converters, and program full-scale voltage and current with the following commands. The parameter, **<fval>,** is the full-scale output voltage or current of the particular model under test. The parameter, **[1000+n1]**, is the sum of 1000 and the slot number of the master module; the master module is the left-most module of the parallel group. For example, if the master module is located in slot 1, the parameter value would be 1001.

   OUTP[1000+n1]:ISOL 1
   OUTP[1000+n1]:SENS 1
   OUTP[1000+n1]:STAT 1
   SOUR[1000+n1]:CURR <fval>
   SOUR[1000+n1]:VOLT <fval>

7. Measure the output voltage and current with the external instruments.
8. Ensure that the actual values of the output parameters are within specifications of the programmed values.
9. Query the values of the output parameters with the following commands:

   MEAS[1000+n1]:VOLT?
   MEAS[1000+n1]:CURR?

10. Ensure that the readback values of the output parameters are within specifications of the actual values.

11. Turn off the output with the following command:

    ***RST[n]**

SERIES CONFIGURATION OPERATION CHECK

1. Before attempting to verify series operation, perform the power-on test of the individual modules per the section, Power-On Check, and then the standalone operation test per section, Standalone Configuration.
2. Connect the outputs for series operation per the section, Series Configuration. Ensure that the outputs and remote sense are appropriately hardwired prior to issuing any of the series-connection SCPI commands.
3. Connect appropriate instrumentation for measuring the output voltage and current, as well as a load.
4. Configure the modules into a series group with the following command, where [n1] is the master module of the group. Although the example is for two modules, it could be extended to a greater number by listing additional parameter slot numbers, **[n]**.

    SYST:GRO:DEF:SER [n1],[n2]

5. Verify that the series group has been properly set up with the following command. The response to the query is a listing of the series group, the master module of the series group, and the slave module of the series group. For example, a group of modules with a master in slot 3 and a slave in slot 4 would return the following parameters: 2003,1003,1004. The parameter, **[2000+n1]**, is the sum of 2000 and the slot number of the master module.

    SYST:GRO:CAT:SER?

6. Turn on the isolation and remote sense relays, turn on the output converters, and program full-scale voltage and current with the following commands. The parameter, **<fval>**, is the full-scale output voltage or current of the particular model under test. The parameter, **[2000+n1]**, is the sum of 2000 and the slot number of the master module. For example, if the master module is located in slot 1, the parameter value would be 2001.

    OUTP[2000+n1]:ISOL 1
    OUTP[2000+n1]:SENS 1
    OUTP[2000+n1]:STAT 1
    SOUR[2000+n1]:CURR <fval>
    SOUR[2000+n1]:VOLT <fval>

7. Measure the output voltage and current with the external instruments.

8. Ensure that the actual values of the output parameters are within specifications of the programmed values.

9. Query the values of the output parameters with the following commands:

   MEAS[2000+n1]:VOLT?
   MEAS[2000+n1]:CURR?

10. Ensure that the readback values of the output parameters are within specifications of the actual values.

11. Turn off the output with the following command:

    ***RST[n]**

SERIES/PARALLEL CONFIGURATION OPERATION CHECK

1. Before attempting to verify series/parallel operation, perform the power-on test of the individual modules per the section, Power-On Check, and then the standalone operation test per section, Standalone Configuration.

2. Connect the outputs for series/parallel operation per the section, Series/Parallel Configuration. Ensure that the outputs and remote sense are appropriately hardwired prior to issuing any of the series/paralleling SCPI commands.

3. Connect appropriate instrumentation for measuring the output voltage and current, as well as a load.

4. Configure the first set of modules into a parallel group with the following command, where [n11[is the first master module. Although the example is for two modules, it could be extended to a greater number by listing additional parameter slot numbers, **[n]**.

   SYST:GRO:DEF:PAR [n11],[n12]

5. Configure the second set modules into a parallel group with the following command, where [n21] is the second master module. Although the example is for two modules, it could be extended to a greater number by listing additional parameter slot numbers, **[n].**

   SYST:GRO:DEF:PAR [n21],[n22]

6. Verify that the parallel group has been properly set up with the following command. The response to the query is a listing of the parallel group, the master module of the parallel group, and the slave module of the parallel group. For example, two groups of parallel modules, with the first group having a master in slot 3 and a slave in slot 4, and the second group having a master in slot 5 and a slave in slot 6, would return the following parameters:

1003,3,4,1005,5,6. The parameter, **[1000+n]**, is the sum of 1000 and the slot number of the master module.

SYST:GRO:CAT:PAR?

7. Configure the two groups of parallel modules into a series group with the following command, where [1000+n11] is the master module of the first parallel group, and [1000+n21] is the master module of the second parallel group. Although the example is for two groups of modules, it could be extended to a greater number by listing additional parameter slot numbers, **[1000+n].**

   SYST:GRO:DEF:SER [1000+n11],[1000+n21]

8. Verify that the series group has been properly set up with the following command. The response to the query is a listing of the master of the series group, which is also the master module of its parallel group. For example, two groups of parallel modules, with the first group having a master in slot 3 and the second group having a master in slot 5, would return the parameter, 2003. The parameter, **[2000+n],** is the sum of 2000 and the slot number of the master module of the series group, which also serves as the master of its parallel group.

   SYST:GRO:CAT:SER?

9. Turn on the isolation and remote sense relays, turn on the output converters, and program full-scale voltage and current with the following commands. The parameter, **<fval>**, is the full-scale output voltage or current of the particular model under test. The parameter, **[2000+n11]**, is the sum of 2000 and the slot number of the master module of the series group, which also serves as master of the parallel group; the master module is the left-most module of the parallel group. For example, if the master module of the parallel group is located in slot 1, the parameter value would be 2001.

   OUTP[2000+n11]:ISOL 1
   OUTP[2000+n11]:SENS 1
   OUTP[2000+n11]:STAT 1
   SOUR[2000+n11]:CURR <fval>
   SOUR[2000+n11]:VOLT <fval>

10. Measure the output voltage and current with the external instruments.

11. Ensure that the actual values of the output parameters are within specifications of the programmed values.

12. Query the values of the output parameters with the following commands:

MEAS[2000+n11]:VOLT?
MEAS[2000+n11]:CURR?

13. Ensure that the readback values of the output parameters are within specifications of the actual values.

14. To turn off the output and break down the group with the following command:

    ***RST[n]**

6.6 CALIBRATION

6.6.1 SCOPE

Procedures are provided in the following sections for calibration of the ReFlex Power™ DC power supply modules: RFP-D1016-021-XXXX, RFP-D1065-5A1-XXXX, RFP-D2033-030-XXXX, RFP-D2050-020-XXXX, RFP-D2050-025-XXXX, RFP-D2120-8A3-XXXX, and RFP-D2450-2A3-XXXX. Calibration is easily performed through the Controller module interface with SCPI commands, requiring only a voltmeter and current shunt.

WARNING

The calibration procedures are performed with the output of the DC power supply module energized. Do not touch any of the output connections which could be at hazardous potentials. Calibration must be performed by qualified personnel who understand the associated hazards and could appropriately contend with them.

CAUTION

If calibration is not performed properly, functional problems could arise, preventing the DC power supply module from operating properly.

6.6.2 RECOMMENDED CALIBRATION EQUIPMENT

The recommended calibration equipment is listed in Table 5-14. Equivalent substitutes are acceptable provided that their accuracy is at least four times better than the accuracy of the parameter specification that is being calibrated. If less accurate equipment is utilized, measurement uncertainty may be introduced that would compromise the validity of the calibration.

Table 6-15. Recommended Calibration Equipment

INSTRUMENT	REQUIREMENTS	RECOMMENDED MODEL
DC Voltmeter	Resolution: 6 1/2 digits	Agilent 34401A
Current Shunt	RFP-D1016-021-XXXX, RFP-D2033-030-XXXX, RFP-D2050-020-XXXX, and RFP-D2050-025-XXXX: 10mΩ, ±0.04%, (100A) RFP-D1065-5A1-XXXX, RFP-D2120-8A3-XXXX, and RFP-D2450-2A3-XXXX: 50mΩ, ±0.04%, (15A)	Guildline 9230-100 Guildline 9230-15

6.6.3 CALIBRATION SETUP

Calibration must be performed under controlled environmental conditions. The ambient temperature must be between 20 to 30 °C. Also, the humidity must be less than 80%. Allow the unit to warm up for 30 minutes at no load prior to performing the calibration. Refer to Figure 6-23 for a diagram of the test instrumentation setup.

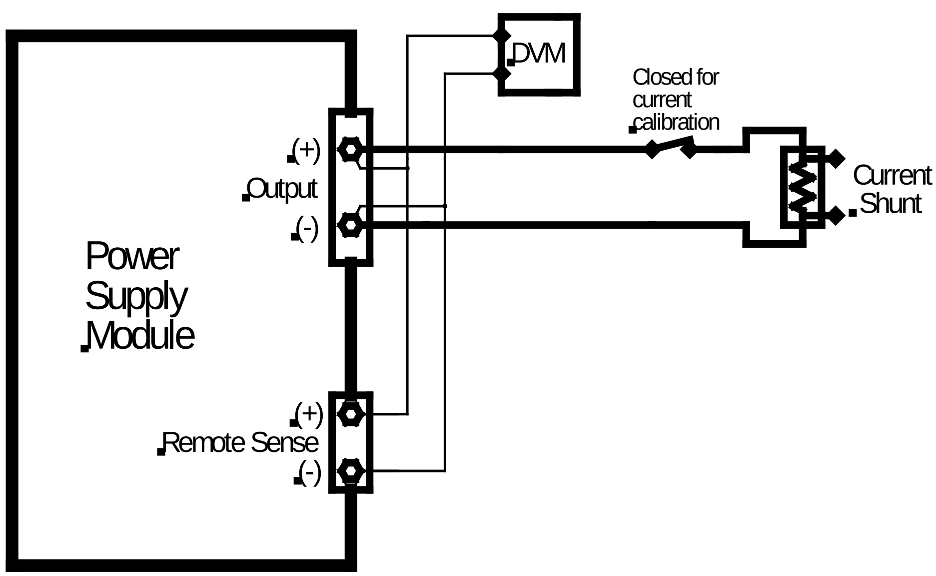


Figure 6-23. Calibration Instrumentation Setup

6.6.4 OUTPUT VOLTAGE PARAMETER CALIBRATION

The following procedure calibrates parameters associated with the output voltage: programming voltage (remote sense), readback voltage, overvoltage protection (OVP), undervoltage protection (UVP), and readback of local voltage (internally sensed). Voltage calibration is made with remote sensing, and with external sense leads connected to the front panel output terminals. Voltage measurements with the external voltmeter are made at the front panel output terminals, at the same points where the sense leads are connected.

1. Connect a voltmeter across the output terminals. Ensure that no load is connected to the output.

2. Issue clear and reset commands:

   ***CLS[n]**
   ***RST[n]**

3. Set the OVP supervisory to non-tracking and at maximum range:

   CAL[n]:OUTP:VOLT:PROT:COUNTS 4095

4. Turn on the output:

   OUTP[n]:ISOL on
   OUTP[n]:SENS on
   OUTP[n]:STAT on

5. Set the output current to full-scale:

   CAL[n]:OUTP:CURR:COUNTS 32768

6. Program the output voltage to the first value near 5% of full-scale, (count = 48852*0.05+768 = 3210):

   CAL[n]:OUTP:VOLT:COUNTS 3210

7. Measure the output voltage with the external voltmeter. Enter this as value-1 with the following command:

   CAL[n]:OUTP:VOLT:FIVEPOINT 1 <value-1>

8. Program the output voltage to the second value near 27.5% of full-scale, (count = 48852*0.275+768 = 14202):

CAL[n]:OUTP:VOLT:COUNTS 14202

9. Measure the output voltage with the external voltmeter. Enter this as value-2 with the following command:

CAL[n]:OUTP:VOLT:FIVEPOINT 2 <value->2

10. Program the output voltage to the third value near 50% of full-scale, count = 48852*0.50+768 = 25194):

CAL[n]:OUTP:VOLT:COUNTS 25194

11. Measure the output voltage with the external voltmeter. Enter this as value-3 with the following command:

CAL[n]:OUTP:VOLT:FIVEPOINT 3 <value-3>

12. Program the output voltage to the fourth value near 72.5% of full-scale, (count = 48852*0.725+768 = 36185):

CAL[n]:OUTP:VOLT:COUNTS 36185

13. Measure the output voltage with the external voltmeter. Enter this as value-4 with the following command:

CAL[n]:OUTP:VOLT:FIVEPOINT 4 <value-4>

14. Program the output voltage to the fifth value near 95% of full-scale, (count = 48852*0.95+768 = 47177):

CAL[n]:OUTP:VOLT:COUNTS 47177

15. Measure the output voltage with the external voltmeter. Enter this as value-5 with the following command:

CAL[n]:OUTP:VOLT:FIVEPOINT 5 <value-5>

16. Save the calibration results with the following commands:

CAL[n]:UNLOCK "6867"
CAL[n]:STORE
CAL[n]:LOCK

(The entered voltage data could be verified with the following query:
CAL[n]:OUTP:VOLT:FIVEPOINT?)

17. Turn off the output:

***RST[n]**

6.6.5 OUTPUT CURRENT PARAMETER CALIBRATION

The following procedure calibrates parameters associated with the output current: programming current, readback current, overcurrent protection (OCP), and readback of local current. Output current calibration is performed with the unit operating in current-mode and with the output short-circuited through a current shunt. The current is determined by measuring the burden voltage and calculating the corresponding current.

1. Connect a current shunt across the output terminals, and connect the external voltmeter to measure the burden voltage of the shunt.

2. Issue clear and reset commands:
   ***CLS[n]**
   ***RST[n]**

3. Set the OVP supervisory to non-tracking and at maximum range:

   CAL[n]:OUTP:VOLT:PROT:COUNTS 4095

4. Set the OCP supervisory to non-tracking and at maximum range:

   CAL[n]:OUTP:CURR:PROT:COUNTS 4095

5. Turn on the output:

   OUTP[n]:ISOL on
   OUTP[n]:SENS on
   OUTP[n]:STAT on

6. Set the output voltage to full-scale:

   CAL[n]:OUTP:VOLT:COUNTS 49152

7. Program the output current to the first value near 5% of full-scale, (count = 32768*0.04611 =1511):

   CAL[n]:OUTP:CURR:COUNTS 1511

8. Measure the output current with the external shunt. Enter this as value-1 with the following command:

   CAL[n]:OUTP:CURR:FIVEPOINT 1 <value-1>

9. Program the output current to the second value near 27.5% of full-scale,

(count = 32768*0.25256 = 8276):

CAL[n]:OUTP:CURR:COUNTS 8276

10. Measure the output current with the external shunt. Enter this as value-2 with the following command:

CAL[n]:OUTP:CURR:FIVEPOINT 2 <value-2>

11. Program the output current to the third value near 50% of full-scale, (count = 32768*0.46219 = 15145):

CAL[n]:OUTP:CURR:COUNTS 15145

12. Measure the output current with the external shunt. Enter this as value-3 with the following command:

CAL[n]:OUTP:CURR:FIVEPOINT 3 <value-3>

13. Program the output current to the fourth value near 72.5% of full-scale, (count = 32768*0.67258 = 22039):

CAL[n]:OUTP:CURR:COUNTS 22039

14. Measure the output current with the external shunt. Enter this as value-4 with the following command:

CAL[n]:OUTP:CURR:FIVEPOINT 4 <value-4>

15. Program the output current to the fifth value near 95% of full-scale, (count = 32768*0.88132 = 28879):

CAL[n]:OUTP:CURR:COUNTS 28879

16. Measure the output current with the external shunt. Enter this as value-5 with the following command:

CAL[n]:OUTP:CURR:FIVEPOINT 5 <value-5>

17. Save the calibration results with the following commands:

CAL[n]:UNLOCK "6867"
CAL[n]:STORE
CAL[n]:LOCK

(The entered current data could be reviewed with the following query:
CAL[n]:OUTP:CURR:FIVEPOINT?)

18. Turn off the output:

    ***RST[n]**

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SECTION 7
ACTIVE LOADS

7.1 GENERAL DESCRIPTION

The High Power Active Load (HPAL) and the Low Power Active Load (LPAL) of the ReFlex Power™ system include models rated at 375 W and 750 W. They are part of a modular family of power assets that integrate into the ReFlex Power™ Mainframe to provide a wide range of features, functionality, and extensive configurability and adaptability. The modules could be set up to operate as standalone assets, or in combinations of parallel groups to extend their current, and power ratings.

The modules operate as part of a remotely controlled system. They utilize the ReFlex Power™ Mainframe back plane for input power distribution and control/communications interface. Through the ReFlex Power™ Controller module, communications with the user host controller is established for programming, read back, and configuration control. All connections to the user load and analog control signal interface are available on the module front panels.

The modules utilize FET active current sinks in modular form to get the flexibility of the two power ranges. The 375 W module is housed in a triple-width enclosure, and weighs 8.2 lb. The 750 W module is also triple-width, and weighs 12.9 lb. Mounting within the Mainframe is facilitated with chassis guides, back plane guide pins, and front panel captive fasteners for securing the modules. The thermal design features integral, variable-speed fans so that the cooling performance scales with the complement of modules in the Mainframe, and their output loading, minimizing the audible noise and the airflow requirements.

The unique features of the ReFlex Power™ system for reconfigurability and extensibility are made possible through the use of the latest in controls technology. An FPGA-based implementation uses VHDL digital feedback control systems, embedded processor cores for firmware-based systems control, and ArcNet® inter-module and Controller module communications. Conventional analog circuitry has been consolidated into the digital domain to benefit from its inherent stability, and to enable new levels of functionality and adaptability that is not practical with the analog approach.

7.1.1 Low Power Active Load (LPAL)

The LPAL is rated at 375W continuous and 500V/15A maximum, with linear operation down to 3V.

7.1.2 High Power Active Load (HPAL)

The HPAL is rated at 750W continuous and 500V/30A maximum, with linear operation down to 3V.

7.2 FEATURES

The ReFlex Power™ system of HP/LP Active Loads brings modularity to active load assets, and makes possible a high degree of reconfigurability and adaptability through a Mainframe-based architecture. It extends the modular configuration to high power Active Load assets, without compromising performance or the controls feature set. The mechanical design is ruggedized for harsh environments, including mobile applications, as well as general-purpose industrial and laboratory rack-mount ATE.

7.2.1 General Features

- FET Active Devices
- High power density
- Small size, light weight
- Up to four modules per Mainframe
- 16-bit control and measurement
- Remote voltage sensing
- Constant current regulation
- Universal inputs: AC (50/60 Hz, 400 Hz), DC, single-phase, three-phase
- Opto-isolated remote shutdown of input
- Optional integral output relays for isolation
- Integral variable speed cooling fans for reduced noise and extended fan life
- Ruggedized to MIL-PRF 28800F
- Software calibration
- Auto-Configuration of system assets
- User programmable supervisories for current, voltage, and power
- LXI™ conformant, IVI-type drivers

- Web server
- Optional Isolated Remote Analog Control, uses 16 bit digital interface
- Integral Active Damper (for stable operation with inductive sources)
- Surge power SOA protection envelope

7.2.2 ACCESSORIES LIST

The ReFlex Power™ Load modules include the following standard accessories:

- Operation Manual, P/N M380056-01 (this manual)
- Programming Manual, P/N M380056-03Quick Reference Guide, P/N M380056-04

7.2.3 CONTROLS AND INDICATORS

The Active Load modules operate within the ReFlex Power™ system as part of an automated test system, so there are no user manual controls. They rely on the Mainframe and Controller module for control, status and data communications, and for input/output connections to the user application. All input source connections and discrete control interface to the user application are accessible on the front panel of the modules (Figure 7-1 and Figure 7-2). Also, the front panel has LEDs to indicate the module's operational state. Input power is routed from the Mainframe through a backplane distribution (see Figure 7-3 for a view of the module rear panel connector interface).

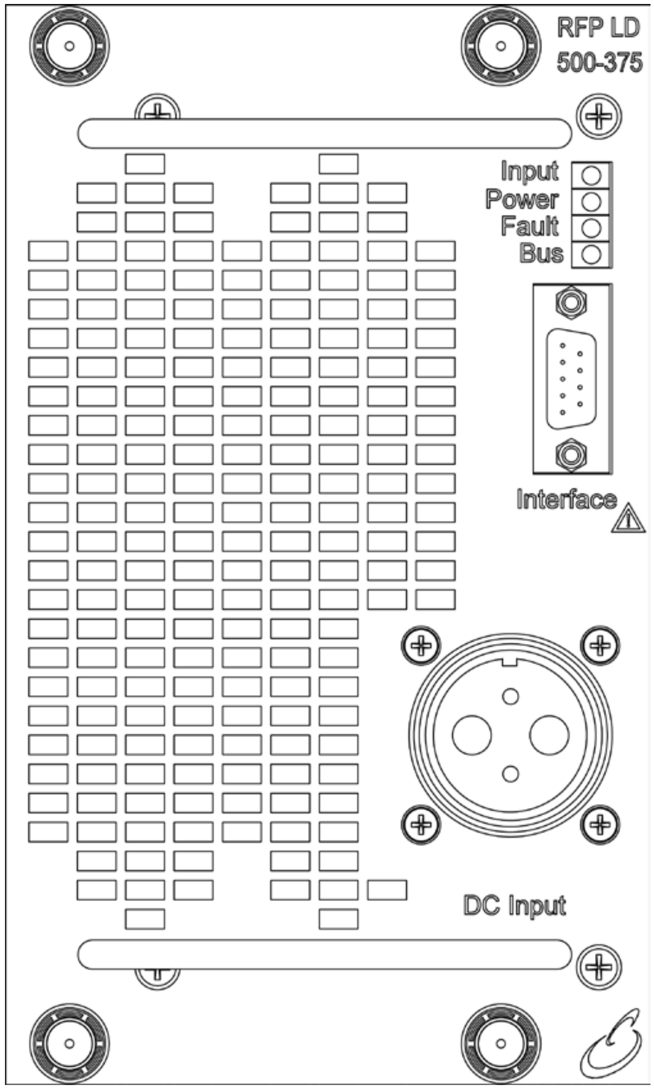


Figure 7-1. LPAL (375W) Front Panel

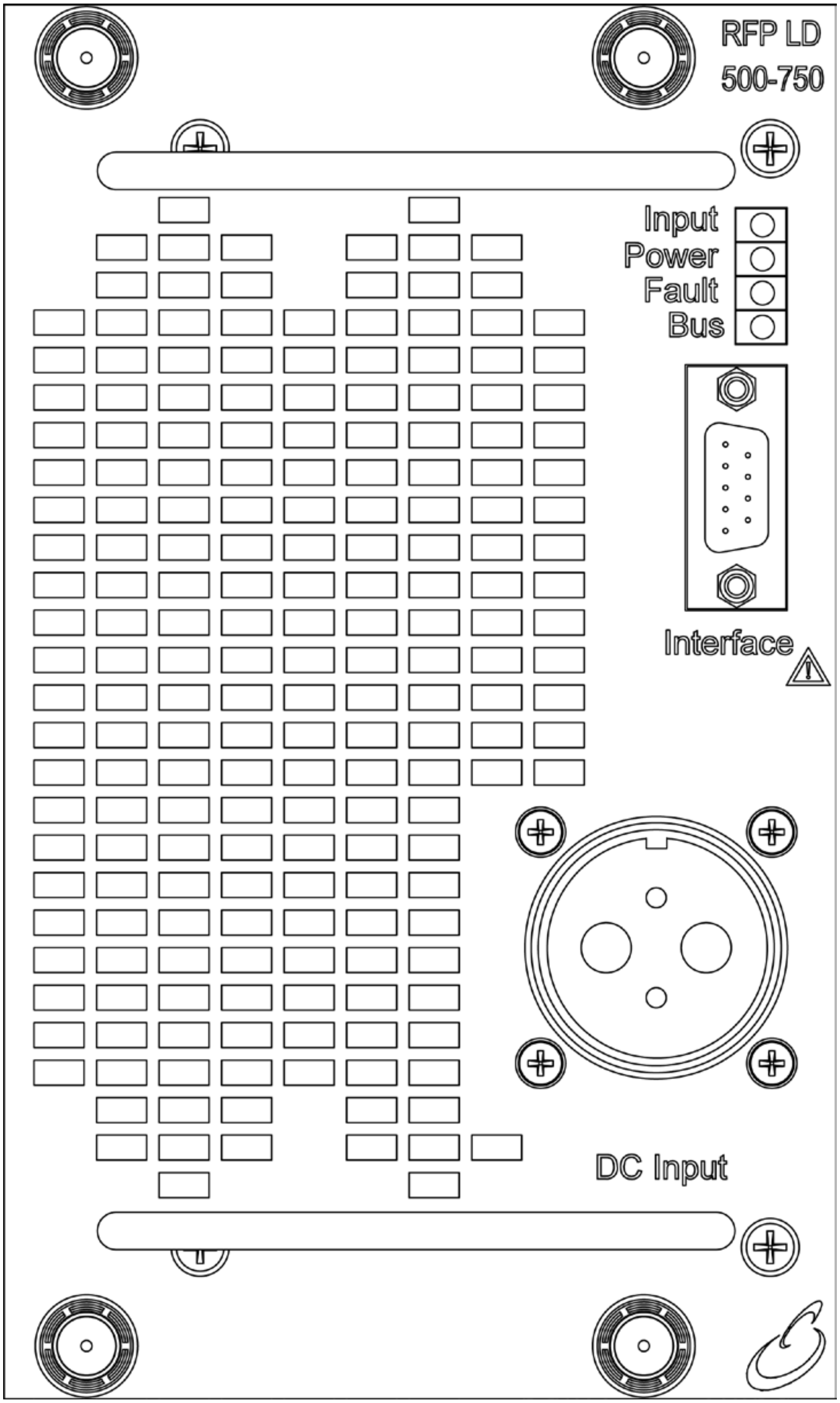


Figure 7-2. HPAL (750W) Front Panel

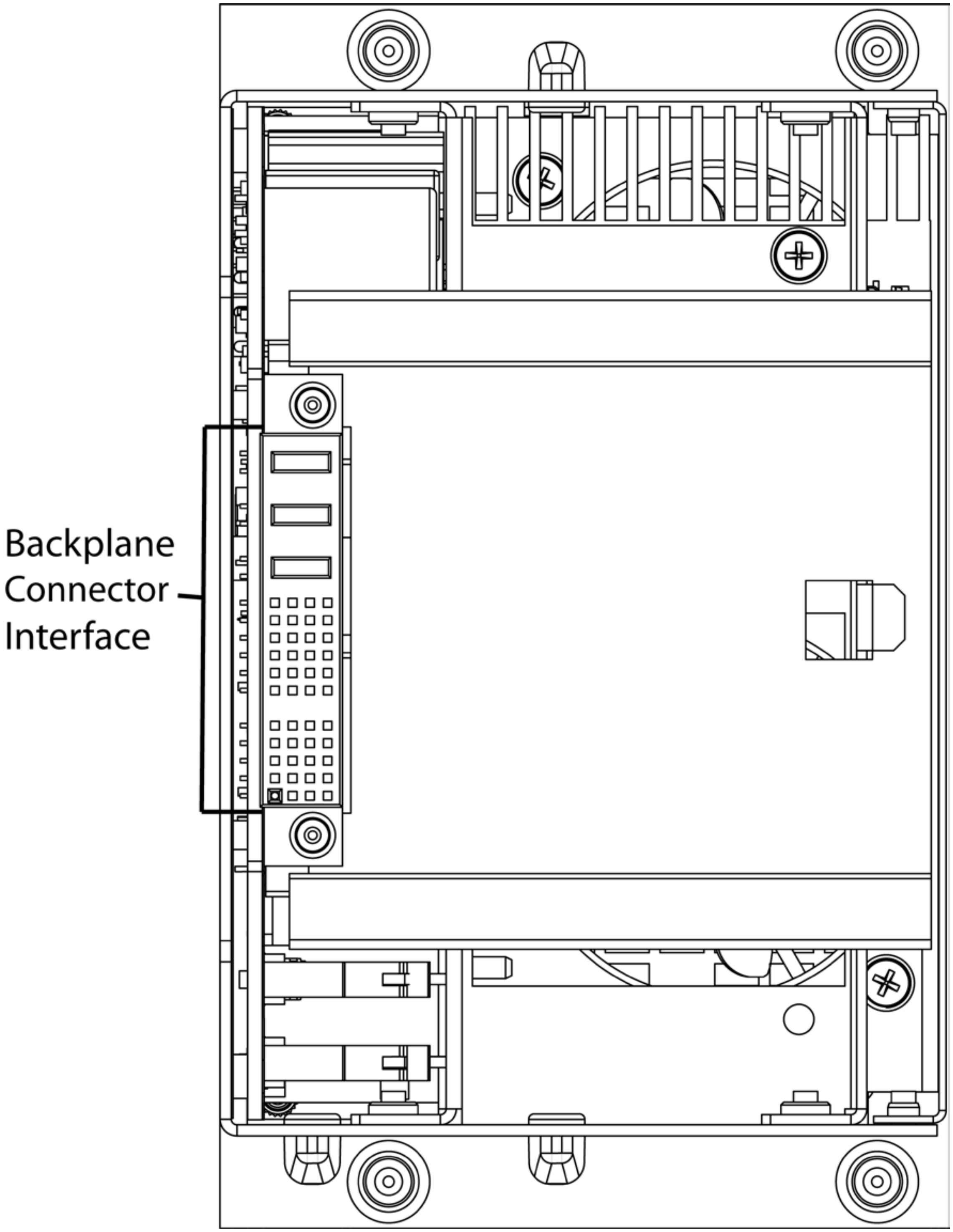


Figure 7-3. Typical Active Load Rear Panel

7.2.4 PROGRAMMABLE FUNCTIONS

The Active Load module can be programmed several variables:

- Input Current
- Resistance
- Over Power Protection
- Over Voltage Protection
- Over Current Protection

7.2.5 READBACK FUNCTIONS

- Input Current
- Input Voltage
- Power
- Over Power Protection value
- Over Voltage Protection value
- Over Current Protection value

7.3 SPECIFICATIONS

All specifications are valid after a 30-minute warm-up. Modules could be used at reduced accuracy immediately following power-on. All accuracy specifications are plus/minus variations around the nominal parameter values, unless otherwise noted. Unless otherwise specified, requirements apply at the front panel output terminals, over the entire programming range, and with remote sense connected to front panel terminals. Performance specifications are valid following calibration at 25 °C, +/- 5 °C

7.3.1 PRODUCT MATRIX

Model	Voltage Full-Scale Rating	Current Full-Scale Rating	Power Rating	Module Width
HPAL	500V	30A	750W	Triple, 4.2”
LPAL	500V	15A	375W	Triple, 4.2”

7.3.2 INPUT CHARACTERISTICS

EXTERNAL DC INPUT

The modules are rated as follows:
LPAL: 375W/500V/15A
HPAL: 750W/500V/30A.

READBACK RESOLUTION

Input Voltage resolution: 33mV

Current resolution: 375W model: 0.9mA
750W model: 1.8mA

READBACK ACCURACY

Voltage accuracy: 0.1% of full-scale, at 25 °C, +/- 5 °C

Current accuracy: 0.3% of full-scale, at 25 °C, +/- 5 °C

CURRENT MODE

Programming Range

375W: 0.045-15ADC; 750W: 0.090-30ADC

Digital Programming Resolution

375W model: 1.0mA; 750W model 2.0mA

Digital Programming Accuracy

0.3% of full-scale, at 25 °C, +/- 5 °C

Analog Programming Accuracy

0.3% of full-scale, at 25 °C, +/-5 °C

Analog Programming Range

0Vdc to 10Vdc (full scale current)

Analog Programming Bandwidth

10kHz, -3dB frequency

Analog Programming Input Impedance

≥10k ohm

Temperature Drift

0.05% of full-scale/°C

Stability

0.1% of full-scale after 8 hours at constant line, load, and temperature.

7.3.3 SUPERVISORY CHARACTERISTICS

SUPERVISORY PROTECTION

Exceeding a supervisory threshold will result in the current being programmed to zero, and the input isolation relays opened (if present).

REDUNDANT OVERVOLTAGE THRESHOLD

Fixed, 525VDC

REDUNDANT OVERVOLTAGE THRESHOLD ACCURACY

3%, at 25 °C, +/- 5 °C

REDUNDANT OVERCURRENT THRESHOLD

Fixed: 20A for 375W; 40A for 750W

REDUNDANT OVERCURRENT THRESHOLD ACCURACY

3%, at 25 °C, +/- 5 °C

OVERPOWER THRESHOLD

Programmable 38-788W for 750W; 19-394W for 375W

OVERPOWER RESOLUTION

1W

OVERPOWER ACCURACY

5% of full scale, at 25 °C, +/- 5 °C

REVERSE VOLTAGE PROTECTION

-15VDC

REVERSE VOLTAGE PROTECTION ACCURACY

+/- 1VDC , at 25 °C, +/- 5 °C

OVERTEMPERATURE PROTECTION

Internal heatsink temperature is monitored

7.3.4 General Characteristics

AC INPUT POWER

Range

103.5-253VAC with AC input; 270VDC, nominal; 210VDC, minimum to 300VDC, maximum; 314VDC, maximum for 2s; 364.5VDC, maximum for 450ms

Current

Non-linear pulsed current from full-wave rectified AC input; continuous DC current from DC input

Input Characteristics

Rectifier with capacitive input filter

Connector

Backplane-mounted connector

Power Factor

0.6, typical

Current Harmonic

Nonlinear AC input current from rectifier/capacitor-filter

Current Inrush

Inrush current protection at power-on with AC and DC input: $5A_{PK}$ at 115VAC; $10A_{PK}$ at 230VAC;

$8.5A_{PK}$ at 270VDC

Frequency

47-63Hz AC input; up to 132VAC in 400 Hz; DC Input

Brownout Provisions

Sag to 65% of nominal for 450ms maximum at full output power with AC input at ≥ 200VAC.

Surge to 135% of nominal for 450ms at full output with AC input ≤ 230VAC.

Hold-Up Time

Dropout of AC input at zero for 10ms at full input power.

Input Power Voltage Threshold

The input power voltage is monitored for under voltage conditions. External DC input is disabled if operating voltage range is exceeded.

7.3.5 COMMAND SETS/DRIVERS

COMMAND DESCRIPTION

SCPI Standard 1999 command language, through Controller Module

RESPONSE DESCRIPTION

SCPI Standard 1999 command language, through Controller Module

COMMAND EXECUTION TIME

50ms from command request.

7.3.6 MECHANICAL CHARACTERISTICS

DIMENSIONS

4.2 inch wide, 6.75 inch high, and 15 inch deep.

WEIGHT

375W: 8.2 pound maximum.
750W: 12.9 pound maximum.

MOUNTING PROVISIONS

Captive retaining screw affixed to the front panel mating with the mainframe. No module extraction provisions, such as levers, are provided; modules are extracted using front-panel mounted handles

COOLING PROVISIONS

Operation at maximum limits of output power, ambient temperature, and altitude requires 110CFM of airflow through module. Integral fans have variable fan speed control that is dependent on internal module temperatures.

ACOUSTIC NOISE

The speed of the integral fans is linearly variable, as a function of internal heatsink temperature rise, to minimize acoustic noise and extend the fan life. The speed varies from nominally 50% of full-speed to full-speed as the heatsink temperature varies with ambient temperature and power dissipation resulting from the input load.

FRONT PANEL CONNECTOR MATING LIFE

500 mating cycles, maximum.

7.3.7 Environmental Characteristics

Operating Temperature

Standard: 0 to 50 °C

Extended Range Option: -10 to 55 °C

Operating Altitude

Standard: 0 to 6,500 ft

Extended Range Option:
Low-Power Load assets: 0 to 15,000 feet

High-Power Load asset: 0 to 15,000 feet, with linear temperature derating from 55°C at 6,500 feet to 40°C at 15,000 feet, or with linear power derating from 750W at 6,500 feet to 600W at 15,000 feet

Operating Humidity

95% non-condensing

Operating Shock

Class 3 MIL-PRF-28800F

Operating Vibration

Class 3 MIL-PRF-28800F

Operation Without Fully Populated Mainframe

If Mainframe is not fully populated with modules, filler panels must be installed in empty slots to maintain proper airflow and structural integrity.

Non-Operating Temperature

-40 to 71 °C

Non-Operating Altitude

0 to 50,000 ft

Non-Operating Shock

Class 3 MIL-PRF-28800F

Non-Operating Vibration

Class 3 MIL-PRF-28800F

7.4 INSTALLATION

The ReFlex Power™ Active Load modules have been fully calibrated and tested prior to shipment; the modules are ready for immediate use upon receipt. However, when first unpacked, the modules should be inspected to ensure that no shipping damage has occurred.

7.4.1 INITIAL INSPECTION

Perform a visual inspection of the shipping container prior to accepting the package from the carrier. If damage to the shipping container is evident, a description of that damage should be noted on the carrier's receipt and signed by the carrier's driver.

Verify that the proper module and associated accessories have been received. Perform a visual inspection of the module after it is removed from the shipping container. Check for shipping damage such as dents, scratches, or distortion of the enclosure.

If external damage is evident, there may be internal damage as well. Immediately contact the carrier and file a claim for concealed damage. In addition, the shipping container and filler material should be saved for inspection. Forward a report of the damage to the Customer Care Department where an associate will provide instructions for repair or replacement of the unit.

7.4.2 LOCATION CONSIDERATIONS

The Active Load modules are designed for use within the ReFlex Power™ Mainframe. Standalone modules could be inserted within any slot of the Mainframe.

Since the modules are fan–cooled, they require adequate clearance at the air intake of the front panels so that airflow is not impeded.

AIRFLOW REQUIREMENTS

Provide adequate clearance for adequate air intake through the front panels and exhaust through the rear.

Ensure that the ambient air temperature at the front panel air intake does not exceed 55°C.

Install filler panel(s) in any empty slot(s) of the Mainframe.

CAUTION
Inadequate airflow and excessive ambient air temperature could result in overheating and thermal shutdown.

7.4.3 INSTALLATION

CAUTION
The module contains ESD sensitive circuitry. Follow appropriate handling and grounding procedures to prevent damage to the module. The module should be handled by the enclosure, with care to protect the connectors from ESD discharges.

CAUTION
Input power must be disconnected to the Mainframe before a module is inserted or extracted. Inserting or extracting a module with power installed (hot-swapping) could result in damage to the module or Mainframe. Prior to turning power on, ensure that front panel captive fasteners are tightened.

Modules are installed into the Mainframe from the front of the chassis. Refer to Figure 7-4 for a view showing the orientation of a module and Mainframe during installation.

1. Ensure that the Mainframe AC/DC input power is disconnected before installing or removing any module(s).
2. Insert the module into the Mainframe, aligning the guide rails at the rear of the module with the top and bottom Mainframe guides.
3. Gently slide the module completely into the Mainframe until the guide pins of the module rear connector engage the mating backplane connector.
4. Fully seat the module until the front panel inner surface is snug against the Mainframe chassis.
5. Secure the module(s) to the Mainframe at the top and bottom of each front panel by turning the captive thumb screws clockwise using a flat blade screwdriver to a maximum torque of 20 in-lb.
6. Install a filler panel over any empty slot, and secure in place at the top and bottom by turning the captive thumb screws clockwise using a flat blade screwdriver to a maximum torque of 20 in-lb.

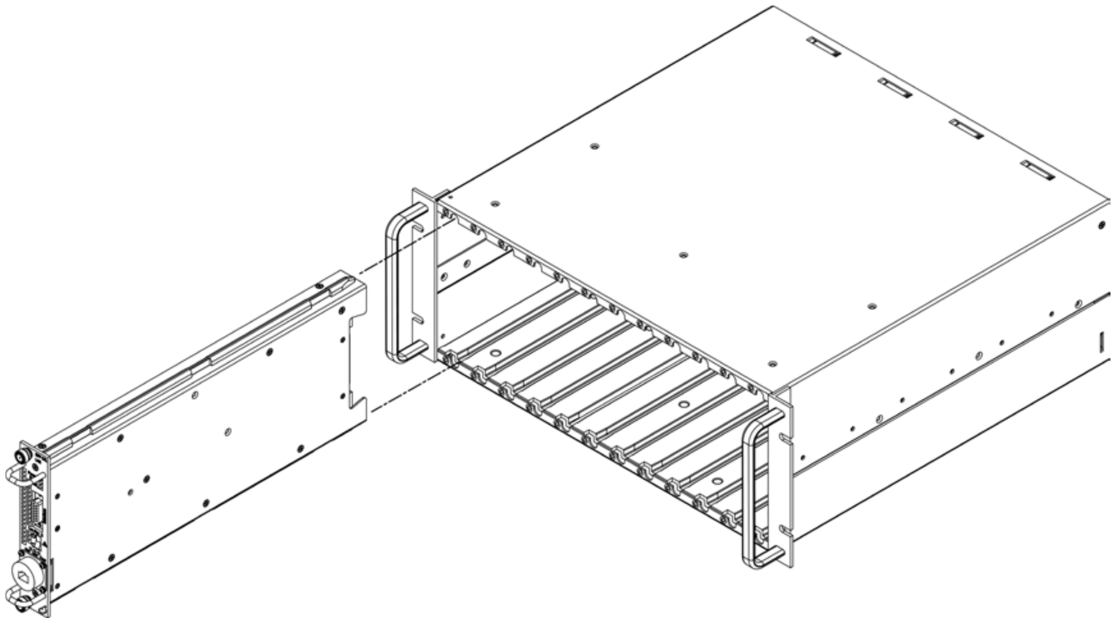


Figure 7-4. Module Installation (example shows 1-U-wide power supply)

7.4.4 INPUT POWER REQUIREMENTS

7.4.5 AC/DC INPUT OVERCURRENT PROTECTION

The modules have internal overcurrent protection to provide fault isolation in case failure occurs of internal components or wiring. However, overcurrent protection must also be provided externally, within the system installation, for the AC/DC input of the Mainframe. Refer to the Mainframe manual for recommendations.

7.4.6 AC/DC INPUT DISCONNECT DEVICE

The ReFlex Power™ system does not have any means to disconnect it from the AC/DC input service. The front panel POWER switch of the Controller module in the Mainframe does not disconnect the AC/DC input line from the modules or Mainframe. Ensure that a suitable disconnecting device is incorporated into the system installation, so that isolation will be provided when it is opened. The switch or circuit breaker must be located close to the ReFlex Power™ system, within reach of the operator, and clearly labeled as the disconnection device.

7.4.7 CONNECTORS

MAINFRAME AC/DC INPUTS

The Active Load modules will operate from a wide variety of AC and DC input power sources, as distributed through the Mainframe. Although the Mainframe could be connected to either single-phase or three-phase AC power, the modules have single-phase inputs. They are connected to the source, through the Mainframe, either phase-to-neutral or line-to-line, depending on the available source voltage. The power source voltage must be within the range of 90–264VAC at 47-63Hz and 400Hz, or 210-300VDC. The input voltage ranges are continuous, and do not require any manual setup.

CAUTION
Exceeding the maximum rated Mainframe AC/DC input voltage could result in damage to the module.

The Mainframe distributes the input power through backplane connectors to three groups of four slots connected in parallel. The groups are connected to separate pair of pins in the Mainframe rear panel AC/DC input connector (one line and return per connection); the connector has six power pins plus ground. Balance in phase currents can be achieved only if the power modules are located in the Mainframe so that equal distribution between the three groups of slots is maintained, and if the same load is applied to the set of modules in each group.

The load applied to a particular Mainframe AC/DC input line is dependent on the location of the modules in the Mainframe slots. The slots are grouped in sets of four: Slot 1-4, Slot 5-8, and Slot 9-12. Slot 1 is the left-most slot, as viewed from the front (Figure 7-5). Each of the four slots is supplied by one of the AC/DC input lines. In a double-width and triple-width module, the module connector is located so that it mates to a backplane connector in the right-most slot, as viewed from the front of the Mainframe. Refer to Table 7-1 for Mainframe input connector pinout and power allocation to the Mainframe slots.

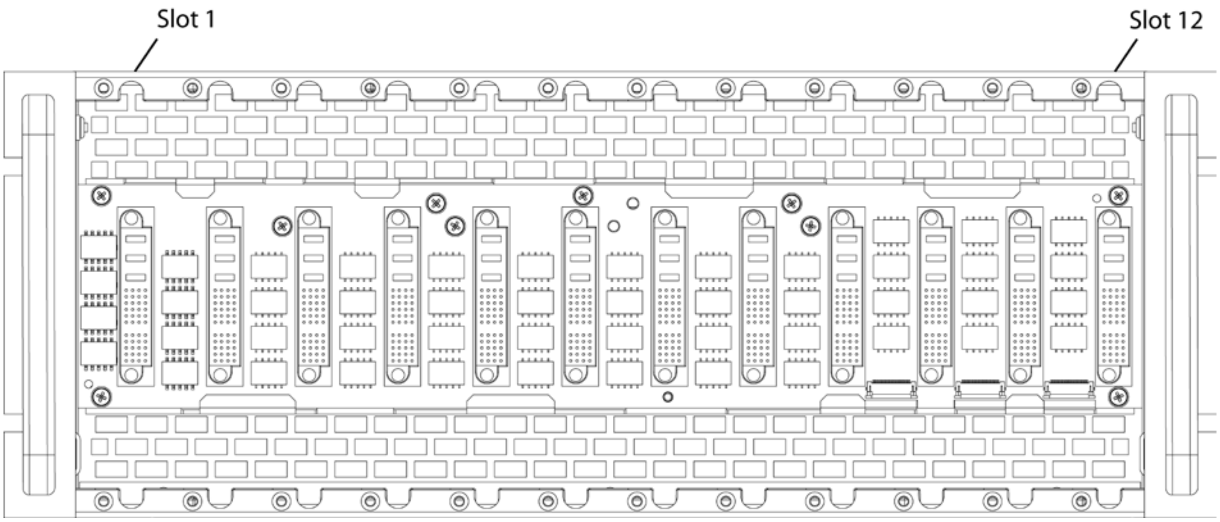


Figure 7-5. Slot Numbering Assignment, Empty Mainframe Front View

Table 7-1. Input Power Allocation

Input Service	Phases	Input Designation	Input Connector Pin	Input Service Connection	Slot Supplied
100/115/120VAC 200/208VAC 220/230/240VAC	1	L1	F	Phase	Slot 1-4
		L1-RTN	E	Return	
		L2	A	Phase	Slot 5-8
		L2-RTN	G	Return	
		L3	B	Phase	Slot 9-12
		L3-RTN	C	Return	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
200/208VAC	3 Delta	L1	F	Phase-A	Slot 1-4
		L1-RTN	E	Phase-B	
		L2	A	Phase-B	Slot 5-8
		L2-RTN	G	Phase-C	
		L3	B	Phase-C	Slot 9-12
		L3-RTN	C	Phase-A	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
200/208VAC 220/230/240VAC	3 Wye	L1	F	Phase-A	Slot 1-4
		L1-RTN	E	Neutral	
		L2	A	Phase-B	Slot 5-8
		L2-RTN	G	Neutral	
		L3	B	Phase-C	Slot 9-12
		L3-RTN	C	Neutral	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis
210-360VDC	DC	L1	F	Source	Slot 1-4
		L1-RTN	E	Return	
		L2	A	Source	Slot 5-8
		L2-RTN	G	Return	
		L3	B	Source	Slot 9-12
		L3-RTN	C	Return	
		GND	D	Ground	Slot 1-12
		Safety GND	Chassis GND	Ground	Chassis

A plug/socket connector is provided on the rear panel of the Mainframe for connecting the unit to the AC/DC power source. The connector also provides a safety ground termination. The input power cable should include a safety ground wire to connect the chassis of the Mainframe to the safety ground of the AC/DC power source. Since the AC input leakage current could exceed 3.5mA, a second safety ground connection is required. It should be connected to the safety ground stud on the rear panel of the Mainframe.

WARNING
A separate, dedicated safety ground wire must be connected to the Mainframe rear panel safety ground stud. Operating the ReFlex Power™ system with the safety ground wire disconnected could result in a shock hazard.

MATING CONNECTOR KIT

Load (HPAL/LPAL) Mating Connector Kit - AMETEK Part No. 5380273-01, mates with RFP-L3500-375-XXXX and RFP-L3500-750-XXXX, and includes the following for both the Interface and DC Input connectors:

Bill of Material

Item	AMETEK Part No.	Description	Qty	Manufacturer Part No.	Manufacturer	Suggested Source(s)
1	855-363-08	Conn, 4P, 8/16AWG, Plug, SR, Skt	1	MS3106F-20-24S	Amphenol, ITT Cannon	PEI-Genesis: http://www.pei-genesis.com/ Arrow Electronics: http://www.arrownac.com/
2	856-214-09	Conn, 9P, DSUB, 20-24AWG, Crimp, Male	1	SD9M1000Z	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm
3	856-247-10	Conn, Backshell, 9P, DSUB, 2 PC	1	D9000Z00	Positronic Industries	Positronic Ind. http://www.connectpositronic.com/default.cfm

RECOMMENDED TOOLS (NOT INCLUDED WITH MATING CONNECTOR KIT)

Hand crimp: Positronic Industries P/N 9507-0-0-0

Pneumatic crimp: Positronic Industries P/N 9550-1-0

Insertion/extraction: Positronic Industries P/N M81969/1-02

INTERFACE CONNECTOR

The user Interface connector (see Figure 7-6 with wiring diagram) provides terminations for external connections to digital and analog control signals (see Table 7-2 for pinouts).

Connector: Positronic Industries P/N SD9M1000Z, AMETEK P/N 856-214-09
Crimp contacts: Positronic Industries P/N MC7520D (initially supplied with connector)

Backshell: Positronic Industries P/N D9000Z00, AMETEK P/N 856-247-10

Wire size: Maximum gauge 20 AWG (22 AWG recommended)
Maximum length 10 meters.

INTERFACE PINOUT

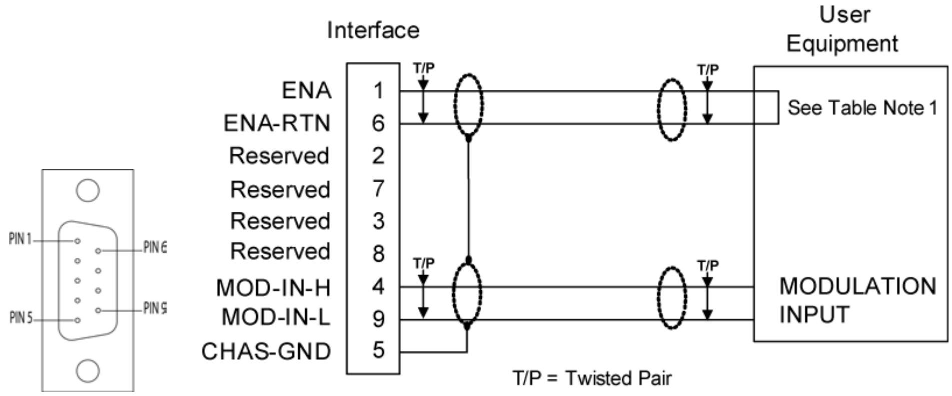


Figure 7-6. Interface Connector, Front Panel View, and Wiring Diagram

Table 7-2. Interface Connector Pinout

Pin	Name	Function	Signal Level
1	ENA[1]	Input: module output enable	TTL logic level
6	ENA-RTN[1]	Input: return for ENA signal; connected to Pin-7/8	Signal common
2	Reserved		
7	Reserved		
3	Reserved		
8	Reserved		
4	MOD-IN-H	Input: external modulation signal; differential input with MOD_IN_L	5V/10V analog signal
9	MOD-IN-L	Input: return for external modulation signal, MOD_IN_H	5V/10V analog signal
5	CHAS-GND	Shield ground	Chassis ground

[1] Enable signal is internally pulled up to +5 V with a 10 K resistor. To enable the module, the signal is pulled low (<= 0.5 V) with respect to the ENA RTN signal; this may also be accomplished by shorting Pin 1 to Pin 6.

OPTIONAL INTERFACE CONNECTOR ACCESSORIES

- AMETEK P/N 5380508-01, 9-pin Loop-back Connector Assembly. Includes a jumper wire between Pins 1 and 6 to enable the module outputs.
- AMETEK P/N 5380443-01, Power Module, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.
- AMETEK P/N 5380443-03, Power Module, Right Angle, 9ft. Unterminated Interface Cable Assembly. Use when interfacing to an external system.

DC INPUT CONNECTOR

The DC Input connector (Figure 7-7) provides terminations for the input and remote sense connections to the load (see Table 7-3 for pinouts).

Connector: MIL P/N MS3106F-20-24S, AMETEK P/N 855-363-08

Backshell: Included with connector.

Wire size: see Table 7-3.

Twisted cable recommended, 25uH max. wire inductance

DC INPUT PINOUT

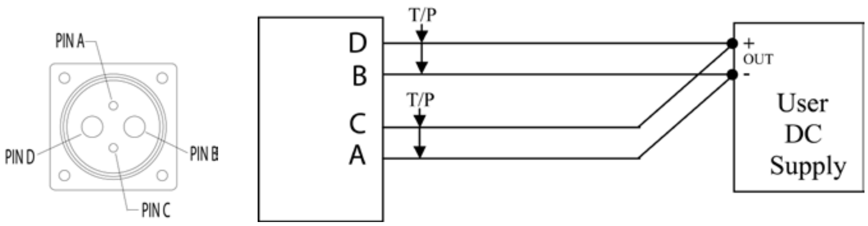


Figure 7-7. DC Input Connector and Wiring Diagram

Table 7-3. DC Input Pinout and Wire Information

Pin	Name	Function	Signal Level	Max Wire Gauge
D	DCIN	INPUT:INPUT SOURCE	+500V; 500V, MAX TO CHASSIS	8
B	DCIN_RTN	INPUT: RETURN FOR INPUT SOURCE DCIN	0V; 500V, MAX TO CHASSIS	8
C	SNS	INPUT; REMOTE SENSE FOR DCIN	+500V; 500V, MAX TO CHASSIS	16
A	SNS_RTN	INPUT REMOTE SENSE FOR DCIN_RTN	0V; 500V, MAX TO CHASSIS	16

DC INPUT CONNECTOR ACCESSORIES

AMETEK P/N 5380452-01, Load Module, 9ft. Unterminated DC Input Cable Assembly

REMOTE SENSE

Remote sensing is used to compensate for the voltage drop that occurs across the wires connecting the source to the input of the Active Load modules. A separate pair of wires is routed to measure the voltage at the source terminals where precise measurement of the output voltage is desired.

The remote sense leads are connected at the DC INPUT connector on the front panel of the modules. Refer to the section, *DC Inputs*, for information on connector pinout. Connect the SNS terminal to the load terminal connected to the module DCIN terminal, and the SNS-RTN terminal to the load terminal connected to DCIN-RTN terminal.

Special care is required in routing the sensing leads to prevent noise pickup or coupling to the power leads; refer to the section, Noise and Impedance Effects. The sense leads should be a twisted-pair of AWG #16-20 wire, and may require shielding in high noise environments. Connect the shield to the shield ground terminal, CHAS-GND, of the DC INPUT connector, as required to maximize its effectiveness.

If the remote sense leads are not connected, the Active Load modules will continue to operate but the voltage at the Source will no longer be precisely measured. An internal resistor network exists within the module that connects the input terminals to the remote sense terminals. This network provides the measurement of the input voltage when the remote sense leads are not connected. However, since the voltage is now measured at the input terminals, the voltage drop of the Source wiring would no longer be compensated.

Several conditions related to remote sensing are treated as faults and result in shutdown of the output: short-circuiting of the remote sense terminals; connecting the remote sense leads in reverse polarity; excessive line drop in the load wires. When the fault condition is detected, shutdown will result with the output isolation relays being opened.

Refer to the section, *User Interface*, above for the Interface connector, pinout, and wire information.

7.4.8 WIRE SELECTION

Input/output wiring must have a current carrying capacity compatible with the current rating of the ReFlex Power™ system. The maximum current rating of a wire is dependent on the materials used in its construction, and is primarily limited by the insulation. The current must be limited so that the temperature rise of the wire does not result in an operating temperature that exceeds the rating of the wire.

WIRE CURRENT CAPACITY

Table 7-4 shows maximum current ratings, based on a cable of three conductors, that will produce an approximate 30 ºC temperature rise above ambient. When wiring must operate in areas with an elevated ambient temperature or bundled with other wiring, heavier gauges or higher temperature-rated wiring should be used.

Although wire with higher temperature rated insulation will allow operation at higher currents, the total voltage drop would also be increased for a given wire gauge. For applications where voltage characteristics, such as regulation, are important, it may be necessary to size the wire based on total voltage drop instead of temperature rise.

Table 7-4. Wire Data

AWG	Copper Area, cm^2	Resistance, Ω/m at 20°C	Resistance, Ω/m at 100°C	Current Rating, A for 30ºC Rise
6	0.133	0.0013	0.0017	54
8	0.0837	0.0021	0.0028	40
10	0.0526	0.0033	0.0044	27
12	0.0331	0.0052	0.0069	21
14	0.0208	0.0083	0.011	16
16	0.0131	0.0132	0.0174	12
18	0.00823	0.0209	0.0276	10
20	0.00518	0.0333	0.044	7.5
22	0.00326	0.053	0.07	5.5

WIRE VOLTAGE DROP

For applications where regulation is important, the contribution of the Source wiring to voltage drop from the input terminals of the Active Load modules to the Source must be considered. The wire gauge must be selected to maintain an acceptable total voltage drop for the load wiring under the maximum peak current. The resistance of the Source wiring must be determined for the sum total length of the output lead and the return lead. The total voltage drop is the sum of the individual drops in the output and return leads. Table 7-4 gives the resistance per meter (m) of various wire gauges at 20 °C and 100 °C.
Use the following equation to calculate the resistance for other wire temperatures:

R = R20°C x [1 + 0.004 x (T - 20°C)]

where,

R = resistance, Ω/m, at temperature T

R20°C = resistance, Ω/m, at 20°C

T = temperature of wire, °C

The voltage drop (per output or return lead) could be calculated using the following equation:

V = I x L x R20°C x [1 + 0.004 x (T - 20°C)]

where,

V = total voltage drop, V

I = current, A

L = length of wire, m

R20°C = resistance of wire, Ω/m, at 20°C

T = temperature of wire conducting current, °C

NOISE AND IMPEDANCE EFFECTS

To minimize noise pickup or radiation from load circuits, load wires and remote sense wires should be twisted-pair with minimum lead length. Shielding of the sense leads may be necessary in high noise environments. Even if noise is not a concern, the Source and remote sense wires should be twisted-pairs to reduce coupling between them, which could impact the stability of the system. If connectors are utilized for the power and sense leads, be careful not to introduce coupling between the leads. Ensure that the connector terminals for the sense leads are in adjacent locations, and minimize the physical loop area of the untwisted portions.

Twisting the load wires provides an additional benefit in reducing the parasitic inductance of the cable. This improves the dynamic response characteristics of the load by maintaining a low source impedance at high frequencies. Also, with long load wires, the resultant inductance and resistance could produce high frequency voltage fluctuations at the load because of current variations in the load itself or reduce the dynamic performance.

7.5 OPERATION

The Active Load modules function within the ReFlex Power™ system under remote control through a host controller. The ReFlex Power™ Controller module serves as a communications portal between the power supply modules and the remote host controller. All aspects of operation could be achieved through use of commands that comply with the requirements of the SCPI Standard 1997 command language. Additional discrete digital and optional analog control signals are available for dedicated hardware interface. All connectors for control and power interface are accessible on the front panel

7.5.1 Controls and Indicators

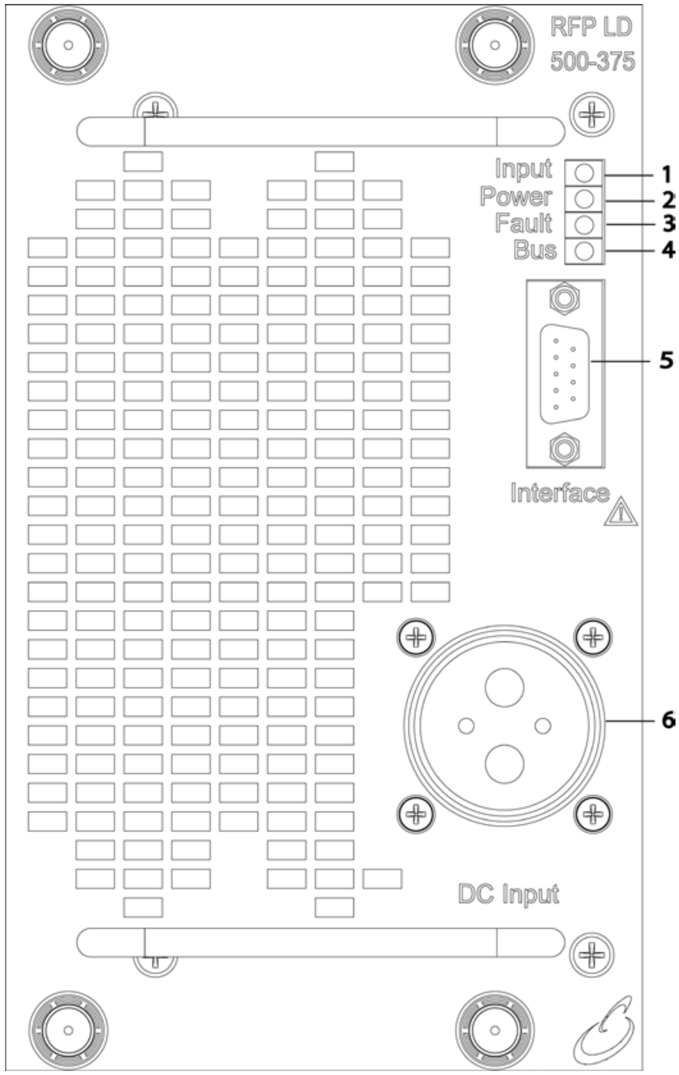


Figure 7-8. Active Load Front Panel (375W shown)

1 – Input: Green LED indicates input is enabled and/or isolation relay is closed.

2 – Power: Green LED indicates AC/DC housekeeping input power is applied to the module.

3 – Fault: Red LED indicates abnormal internal operating or a protection supervisory active condition; output is disabled and the isolation relay is opened.

4 – Bus: Green LED indicates internal inter-module communication is in process.

5 – User Interface connector for remote isolated digital signals: enable. The optional Isolated Remote Analog Interface is also terminated at this connector.

6 – DC Input connector for the output load and remote sense.

7.5.2 MODES OF OPERATION

CONSTANT CURRENT

In this mode, the Active Load maintains the input current precisely regulated to the current setting while the source voltage varies with user requirements.

CONSTANT RESISTANCE

In this mode, the Active Load maintains the input resistance setpoint by adjusting the current as a function of the applied voltage.

7.5.3 LOAD CONNECTION CONFIGURATION

The input of the Active Load module is isolated from chassis ground, allowing positive, negative, or floating inputs with respect to chassis ground. Connections to the load are made at the front panel output connector terminals. Ensure that a wire gauge is utilized that can carry the programmed current without overheating.

Remote sensing of the load is required to meet accuracy and regulation specifications. The sense leads should be connected to the point in the source circuit where the voltage is to be precisely measured. If a distribution bus is utilized, the point of voltage sensing is important to ensure that the voltage measurement is acceptable. In general, the point of sensing is selected to minimize interaction through line drops caused by source currents.

CAUTION
Operating the active load with either the positive or negative input lead at greater than the float voltage specification limit above chassis ground could result in damage to the module.

STANDALONE CONFIGURATION

A single source is connected directly to the front panel input terminals, and the Active Load module is configured to operate in the standalone mode. Twist the source wires or maintain them closely in parallel for their entire length to minimize parasitic inductance and coupling from external circuits. Use the heaviest gauge practical to minimize line drop. The remote sense wires should be twisted, and may need shielding depending on the electrical noise environment of the application. Figure 7-9 shows a standalone load connection with remote sensing.

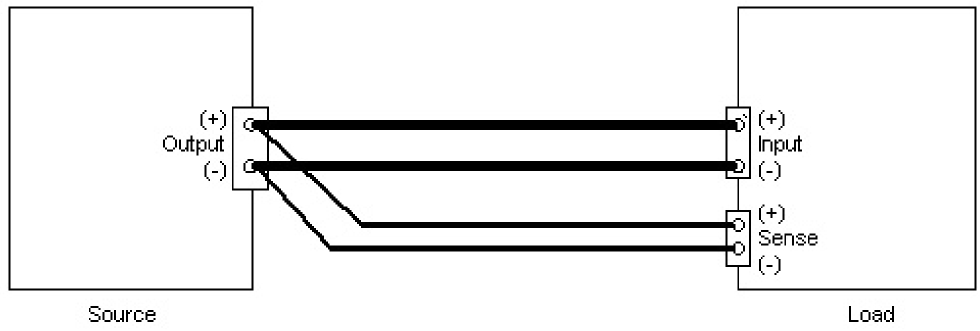


Figure 7-9. Standalone Input Configuration

7.5.4 Default Operational Conditions

Power-On Conditions

When an Active Load module is first powered on, the following parameters are set to factory default values:

- Input configuration: standalone
- Input current: 0A
- Overvoltage protection (OVP): 110% of full-scale voltage; programmable mode
- over power protection (OPP): 105% of the Load/s power rating
- Overcurrent protection (OCP): 120% of full-scale current; programmable mode
- Input state: off
- Input isolation and remote sense relays: open

Reset Conditions

If a module is reset with the SCPI command, ***RST[n]**, (where n is the module address), the following default conditions are set:

- Input configuration: unchanged
- Input current: 0A
- Overvoltage protection (OVP): 110% of full-scale voltage; programmable mode
- Undervoltage protection (UVP): 0V
- Overcurrent protection (OCP): 120% of full-scale current; programmable mode
- Input state: off
- Input isolation and remote sense relays: open (if present)
- All status reporting data structures are cleared. Enable-masks are not cleared.

7.5.5 INITIAL FUNCTIONAL TESTS

POWER-ON CHECK

1. Ensure that the AC/DC input service is disconnected.
2. Install the interface cable between the host controller and the ReFlex Power™ Controller module.
3. Connect an appropriate input source to the Active Load module.
4. Configure the host controller for communications with the ReFlex Power™ Controller module.
5. Turn on the Mainframe AC/DC input service.
6. The modules will first execute a power-on self-test. Also the internal fans are run at maximum speed for several seconds, and then back to slow speed.
7. In the following paragraphs, commands include a channel number, **`[n]`**. The channel number corresponds to the slot of the ReFlex Power™ Mainframe where the module is located, counting left to right, 1 through 12. For example:

   ```
   SOUR[n]:CURR 5 will be
   SOUR4:CURR 5 for slot-1
   SOUR7:CURR 5 for slot-2
   ```

8. Additionally, model specific parameter values must be added for full-scale voltage and current. They are shown in the following examples as floating point numerical values, **`<fval>`**. For the Active Load modules, the values are as follows:

   Full-Scale Current:

   HPAL: 30

   LPAL: 15

   Therefore, for an 750W Active Load module in slot 4, the command for full-scale current would be **`SOUR4:CURR 30;`** for a 375W Active Load module, it would be **`SOUR4:CURR 15`**.

9. Verify communications with the ReFlex Power™ Controller module by issuing an SCPI **`*IDN[n]?`**, where “n” is a channel number that corresponds to the slot of the ReFlex Power™ Mainframe where the module is located, counting left to right, 1 through 12.

10. The ReFlex Power™ Controller module should respond with its identification string.
11. Verify communications with the ReFlex Power™ active load module by issuing an SCPI ***IDN[n]?**, where "n" is a channel number that corresponds to the slot of the ReFlex Power™ Mainframe where the module is located, counting left to right, 1 through 12.

    The Active Load module should respond with its identification string. The default settings of the module will not be affected.

STANDALONE CONFIGURATION OPERATION CHECK

1. Connect the input for standalone operation per the section, Standalone Configuration.
2. Connect appropriate instrumentation for measuring the input voltage and current, as well as a load.
3. Perform the power-on verification test per the section, Power-On Check.
4. Turn on the isolation and remote sense relays, turn on the active devices, and program full-scale current with the following commands:

```
*RST[n]
OUTP[n]:ISOL 1
OUTP[n]:SENS 1
INP[n]:STAT 1
SOUR[n]:CURR <fval>
```

5. Measure the input current and voltage with the external instruments.
6. Ensure that the actual values of the input parameters are within specifications of the programmed values.
7. Query the values of the output parameters with the following commands:

```
MEAS[n]:VOLT?
MEAS[n]:CURR?
```

8. Ensure that the readback values of the output parameters are within specifications of the actual values.
9. Turn off the output with the following command:

```
*RST[n]
```

7.6 CALIBRATION

7.6.1 SCOPE

Procedures are provided in the following sections for calibration of the Re-Flex Power Active Load modules: High Power Active Load (HPAL) and Low Power Active Load (LPAL). Calibration is easily performed through the Controller module interface with SCPI commands, requiring three meters; a shunt and two DC power supplies.

CAUTION
The calibration procedures are performed with the output of the Active Load supply module energized. Do not touch any of the output connections, which could be at hazardous potentials. Calibration must be performed by qualified personnel who are appropriately trained to deal with attendant hazards.

7.6.2 RECOMMENDED CALIBRATION EQUIPMENT

The recommended calibration equipment is listed in Table below. Equivalent substitutes are acceptable provided that their accuracy is at least four times better than the accuracy of the parameter specification that is begin calibrated. If less accurate equipment is utilized, measurement uncertainty may be introduced that would compromise the validity of the calibration.

INSTRUMENT	REQUIREMENTS
DC Voltmeter	Resolution 6 ½ digits
DC Voltmeter	Resolution 6 ½ digits
DC Current Meter	Resolution 6 ½ digits
DC Power Supply	Voltage: 0 to 500 Volts Current: 0 to 30 Amps
DC Power Supply	Voltage: 0 to 10Volts Current: 0 to 0.5Amps
Shunt	Current Rating: 0 to 30Amps or 0 to100Amps

Note: If a power supply of voltage rating 0 to 500V and current rating 0 to 30 Amps is not available, you can change the power supply according to the procedure's maximum current and voltage requirements.

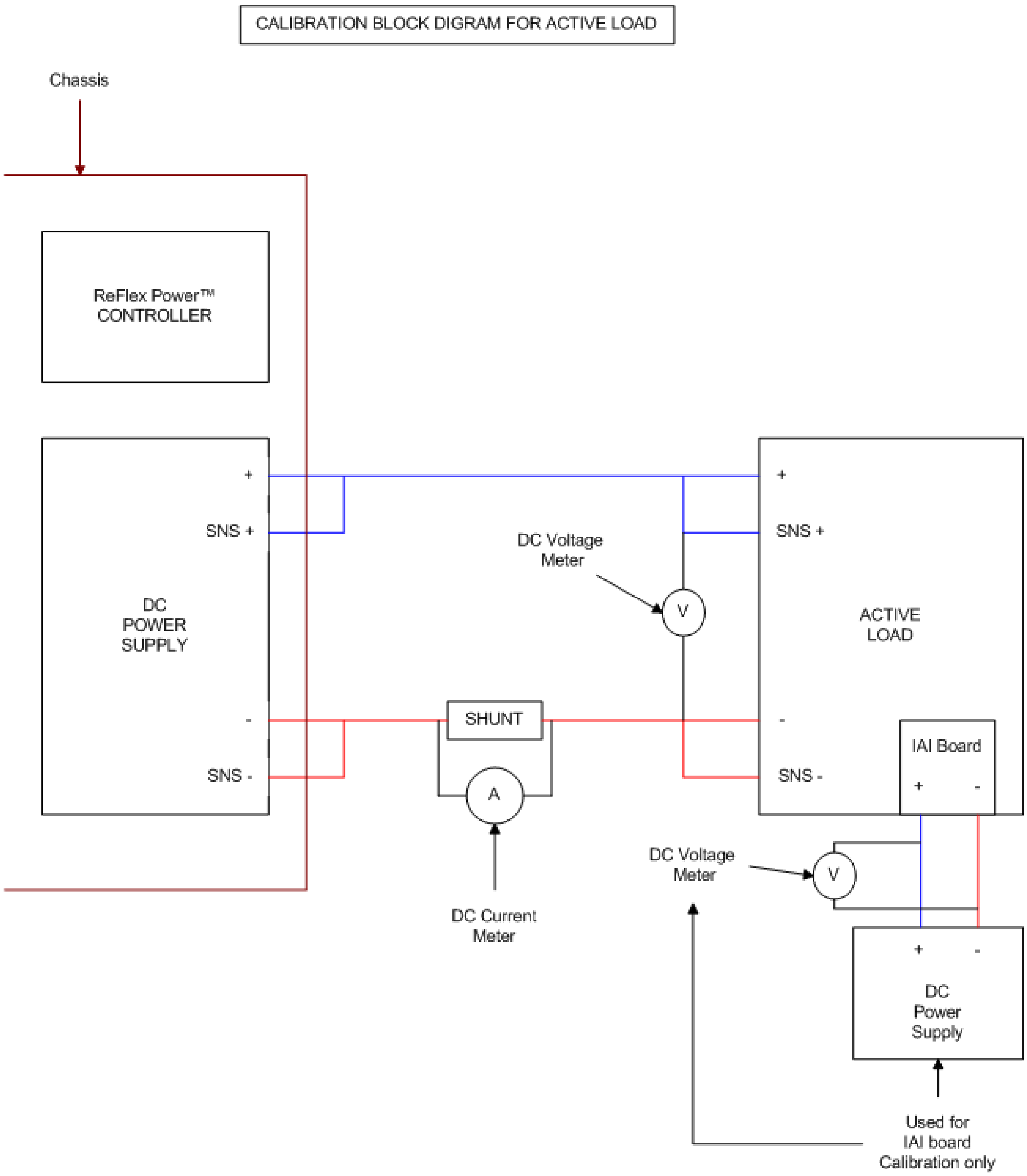
Every procedure has information about the maximum current and maximum voltage required for the procedure. If while performing calibration, unit does not reach maximum current stated in the procedure, there is no cause for alarm. If there is anything wrong, the **SYST: ERROR ?** command will report it.

7.6.3 CALIBRATION SETUP

Calibration must be performed under controlled environmental conditions.

- Ambient temperature must be within 25 °C, +/- 5 °C.
- Humidity must be less than 80%.
- Allow the unit to warm up for 30 minutes at no load prior to performing the calibration.

Test instrument setup diagram is as follows:



7.6.4 CALPOT CALIBRATION FOR HIGH POWER ACTIVE LOAD (HPAL)

The HPAL calpot calibration is done with the DC current meter connected between the DC power supply and the Active Load.

This procedure requires maximum voltage 4.5V and maximum current 30Amps.

1. Connect the shunt between the DC power supply and the active load. Connect the DC current meter across the shunt.
2. Issue clear and reset commands:

   ***CLS<n>**

   ***RST<n>**
3. Set the DC power supply to 4.5 Volts
4. This begins the CalPots calibration sequence. The Load will be set to STATE 1; relays closed and set to 0 current, the 0 current offset value will be calculated.

   CAL<n>:CALPOTS:GAIN:START
5. Program to draw maximum current:

   CAL<n>:INP:CURR:COUNTS 0xFFFF
6. Adjust the current limit on the DC Power supply to just under the limit 27.4 Amps. Use the Current Shunt and Voltmeter to adjust and measure the current. When the current reading is stable, enter the current using following command:

   CAL<n>:CALPOTS:GAIN:CURR <value-1>
7. This will use the current value entered to adjust the Gain Pot. The adjustment will be calculated, ending the procedure and the setting the load to STATE 0:

   CAL<n>:CALPOTS:GAIN:CALC
8. Send the system error query command to make sure calibration was successful:

   SYST:ERR?
9. If there is no error returned at the system error query command then save the calibration result with the following command:

   CAL<n>:UNLOCK “6867”
   CAL<n>:STORE
   CAL<n>:LOCK
10. Optional Commands:

    To query the offset pot set value: **CAL<n>:CALPOTS:OFFSET?**

    To query the gain pot set value: **CAL<n>:CALPOTS:GAIN?**
11. Reset the unit:

    ***RST<n>**

7.6.5 HPAL High Range Current Calibration

This procedure calibrates the input current for current range high. This is a 5-point calibration. Make sure that shunt and the DC current meter are connected between the active load and DC power supply.

This procedure requires maximum voltage 5.0V and maximum current 30Amps.

1. Set the DC input voltage to 5 Volts.
2. Turn on the active load:

   INP<n>:STATE 1

3. Set the DAC count to 5% of its full range:

   CAL<n>:INP:CURR:COUNTS 5700

4. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command:

   CAL<n>:INP:CURR:FIVEPOINT1 <value-1>

5. Set the DAC count to 27.5% of its full range:

   CAL<n>:INP:CURR:COUNTS 16000

6. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command:

   CAL<n>:INP:CURR:FIVEPOINT2 <value-2>

7. Set the DAC count to 50.0% of its full range:

   CAL<n>:INP:CURR:COUNTS 32000

8. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command:

   CAL<n>:INP:CURR:FIVEPOINT3 <value-3>

9. Set the DAC count to 72.5% of its full range:

   CAL<n>:INP:CURR:COUNTS 43000

10. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command:

    CAL<n>:INP:CURR:FIVEPOINT4 <value-4>

11. Set the DAC count to 95% of its full range

    CAL<n>:INP:CURR:COUNTS 56000

12. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command:

    CAL<n>:INP:CURR:FIVEPOINT5 <fval>

13. Set DAC counts to zero:

    CAL12:INP:CURR:COUNTS 0

14. Send calibration command to make sure that all the DAC counts and current values are valid:

    CAL<n>:INP:CURR:CALC

15. Send the system error query command to make sure calibration was successful:

    SYST:ERR?

16. If there is no error returned at the system error query command then save the calibration result with the following commands:

    CAL<n>:UNLOCK "6867"

    CAL<n>:STORE

    CAL<n>:LOCK

17. Reset the unit:

    ***RST<n>**

7.6.6 HPAL Low Range Current Calibration

The following procedure calibrates the input current for the current range low. Make sure that the shunt and the DC current meter are connected between the active load and DC power supply.

This procedure requires maximum voltage 5.0V and maximum current 1.0 Amps.

1. Set the DC input voltage to 5 Volts
2. Turn on the active load

   INP<n>:STATE 1

3. Set the DAC count to 20% of its full range

   CAL<n>:INP:CURR:COUNTS 16000

4. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command

   CAL<n>:INP:CURR1 <value-1>

5. Set the DAC count to 80% of its full range

   CAL<n>:INP:CURR:COUNTS 53000

6. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command

   CAL<n>:INP:CURR2 <value-2>

7. Send the calibration command to calculate the gain and offset of the low range current calibration

   CAL<n>:INP:CURR:CALC

8. Send the system error query command to make sure calibration was successful.

   SYST:ERR?

9. If there is no error returned at the system error query command then save the calibration result with the following command

   CAL<n>:UNLOCK “6867”

   CAL<n>:STORE

   CAL<n>:LOCK

10. Reset the unit

    ***RST<n>**

7.6.7 HPAL Low Range Current Calibration

This procedure calibrates the input current for the current range low. Make sure that the shunt and the DC current meter are connected between the active load and DC power supply.

This procedure requires maximum voltage 5.0V and maximum current 1.0 Amp.

1. Set the DC input voltage to 5 Volts:
2. Turn on the active load:

   INP<n>:STATE 1

3. Set the DAC count to 20% of its full range:

   CAL<n>:INP:CURR:COUNTS 16000

4. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command:

   CAL<n>:INP:CURR1 <value-1>

5. Set the DAC count to 80% of its full range:

   CAL<n>:INP:CURR:COUNTS 53000

6. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command:

   CAL<n>:INP:CURR2 <value-2>

7. Send the calibration command to calculate the gain and offset of the low range current calibration:

   CAL<n>:INP:CURR:CALC

8. Send the system error query command to make sure calibration was successful:

   SYST:ERR?

9. If there is no error returned at the system error query command then save the calibration result:

   CAL<n>:UNLOCK "6867"

   CAL<n>:STORE

   CAL<n>:LOCK

10. Reset the unit:

    ***RST<n>**

7.6.8 HPAL Voltage Calibration – Part I of V

This procedure calibrates the voltage for voltage gain 8 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Also connect the sense positive-to-positive lead and sense negative-to-negative lead.

This procedure requires maximum voltage 54V and maximum current 11Amps.

1. Turn the active load on:

   INP<n>:STATE 1

2. Set the conductance count to 0x33333:

   CAL<n>:INP:COND:COUNTS 0x33333

3. Set the input DC voltage to 13 Volts. After the input DC voltage stabilizes enter the first exact voltage:

   CAL<n>:INP:VOLT 1 <value-1>

4. Set the input DC voltage to 54 Volts. After the input DC voltage stabilizes enter the second exact voltage:

   CAL<n>:INP:VOLT 2 <value-2>

5. Send the calibration command to calculate the gain and offset:

   CAL<n>:MEAS:OFFSET:CALC

6. Send the system error query command to make sure calibration was successful:

   SYST:ERR?

7. If there is no error returned at the system error query command then save the calibration result as follows:

   CAL<n>:UNLOCK “6867”

   CAL<n>:STORE

   CAL<n>:LOCK

8. Reset the unit

   ***RST<n>**

7.6.9 HPAL VOLTAGE CALIBRATION – PART II OF V

This procedure calibrates the voltage for voltage gain 4 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Also connect the sense positive-to-positive lead and sense negative-to-negative lead.

This procedure requires maximum voltage 109V and maximum current 6.0 Amps.

1. Turn the active load on:

   INP<n>:STATE 1

2. Set the conductance count to 0xCCCC:

   CAL<n>:INP:COND:COUNTS 0xCCCC

3. Set the input DC voltage to 27 Volts. After the input DC voltage stabilizes enter the first exact voltage:

   CAL<n>:INP:VOLT 1 <value-1>

4. Set the input DC voltage to 109 Volts. After the input DC voltage stabilizes enter the second exact voltage:

   CAL<n>:INP:VOLT 2 <value-2>

5. Send the calibration command to calculate the gain and offset:

   CAL<n>:MEAS:OFFSET:CALC

6. Send the system error query command to make sure calibration was successful:

   SYST:ERR?

7. If there is no error returned at the system error query command then save the calibration result as follows:

   CAL<n>:UNLOCK "6867"

   CAL<n>:STORE

   CAL<n>:LOCK

8. Reset the unit

   ***RST<n>**

7.6.10 HPAL VOLTAGE CALIBRATION – PART III OF V

The following procedure calibrates the voltage for voltage gain 4 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Also connect the sense positive-to-positive lead and sense negative-to-negative lead.

This procedure requires maximum voltage 218V and will draw maximum current 3.0Amps.

1. Turn the active load on

   INP<n>:STATE 1

2. Set the conductance count to 0x3333

   CAL<n>:INP:COND:COUNTS 0x3333

3. Set the input DC voltage to 54 Volts. After the input DC voltage stabilizes enter the first exact voltage using following command

   CAL<n>:INP:VOLT 1 <value-1>

4. Set the input DC voltage to 218 Volts. After the input DC voltage stabilizes enter the second exact voltage using following command

   CAL<n>:INP:VOLT 2 <value-2>

5. Send the calibration command to calculate the gain and offset:

   CAL<n>:MEAS:OFFSET:CALC

6. Send the system error query command to make sure calibration was successful.

   SYST:ERR?

7. If there is no error returned at the system error query command then save the calibration result as follows:

   CAL<n>:UNLOCK "6867"

   CAL<n>:STORE

   CAL<n>:LOCK

8. Reset the unit:

   ***RST<n>**

7.6.11 HPAL Voltage Calibration – Part IV of V

This procedure calibrates the voltage for voltage gain 1 and current range high. Make sure that shunt and the DC voltmeter is connected between the positive and negative lead of the active load. Also connect the sense positive-to-positive lead and sense negative-to-negative lead.

This procedure requires maximum voltage 500.0V and maximum current 1.0 Amps

1. Turn the active load on:

   `INP<n>:STATE 1`

2. Set the conductance count to 0x831:

   `CAL<n>:INP:COND:COUNTS 0x831`

3. Set the input DC voltage to 10 Volts. After the input DC voltage stabilizes enter the first exact voltage:

   `CAL<n>:INP:VOLT 1 <value-1>`

4. Set the input DC voltage to 500 Volts. After the input DC voltage stabilizes enter the second exact voltage:

   `CAL<n>:INP:VOLT 2 <value-2>`

5. Send the calibration command to calculate the gain and offset:

   `CAL<n>:MEAS:OFFSET:CALC`

6. Send the system error query command to make sure calibration was successful:

   `SYST:ERR?`

7. If there is no error returned at the system error query command then save the calibration result as follows:

   `CAL<n>:UNLOCK “6867”`

   `CAL<n>:STORE`

   `CAL<n>:LOCK`

8. Reset the unit

   `*RST<n>`

7.6.12 HPAL Voltage Calibration – Part V of V

This procedure calibrates the voltage for voltage gain 1 and current range low. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Also connect the sense positive-to-positive lead and sense negative-to-negative lead.

This procedure requires maximum voltage 500V and maximum current 0.18 Amps.

1. Turn the active load on:

   INP<n>:STATE 1

2. Set the conductance count to 0x15D:

   CAL<n>:INP:COND:COUNTS 0x15D

3. Set the input DC voltage to 10 Volts. After the input DC voltage stabilizes enter the first exact voltage using following command:

   CAL<n>:INP:VOLT 1 <value-1>

4. Set the input DC voltage to 500 Volts. After the input DC voltage stabilizes enter the second exact voltage using following command:

   CAL<n>:INP:VOLT 2 <value-2>

5. Send the calibration command to calculate the gain and offset:

   CAL<n>:MEAS:OFFSET:CALC

6. Send the system error query command to make sure calibration was successful:

   SYST:ERR?

7. If there is no error returned at the system error query command then save the calibration result:

   CAL<n>:UNLOCK “6867”

   CAL<n>:STORE

   CAL<n>:LOCK

8. Reset the unit:

   ***RST<n>**

7.6.13 HPAL Resistance Calibration – Part I of V

The following procedure calibrates the resistance for voltage gain 8 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Connect the sense positive-to-positive lead and sense negative-to-negative lead. Also connect the shunt and the DC current meter between the active load and DC power supply

This procedure requires maximum voltage 20.0V and maximum current 17.0 Amps.

1. Set the DC input voltage to 20 Volts

2. Turn the active load

   INP<n>:STATE 1

3. Set the conductance count to 0xD5554.

   CAL<n>:INP:COND:COUNTS 0xD5554

4. After DC voltage stabilizes. Enter the voltage using SCPI commands

   CAL<n>:INP:VOLT 1 <value-1>

5. After DC current stabilizes. Enter the current using SCPI commands

   CAL<n>:INP:CURR 1 <value-1>

6. Set the conductance count to 0x3CF3C.

   CAL<n>:INP:COND:COUNTS 0x3CF3C

7. After DC voltage stabilizes. Enter the voltage using SCPI commands

   CAL<n>:INP:VOLT 2 <value-2>

8. After DC current stabilizes. Enter the current using SCPI commands

   CAL<n>:INP:CURR 2 <value-2>

9. Send the calibration command to calculate the gain and offset

   CAL<n>:INP:COND:CALC

10. Send the system error query command to make sure calibration was successful.

    SYST:ERR?

11. If there is no error returned at the system error query command then save the calibration result with the following command

    CAL<n>:UNLOCK “6867”

    CAL<n>:STORE

    CAL<n>:LOCK

12. Reset the unit

    ***RST<n>**

7.6.14 HPAL Resistance Calibration – Part II of V

This procedure calibrates the resistance for voltage gain 4 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Connect the sense positive-to-positive lead and sense negative-to-negative lead. Also connect the shunt and the DC current meter between the active load and DC power supply

This procedure requires maximum voltage 20.0 V and maximum current 3.0Amps.

1. Set the DC input voltage to 20 Volts

2. Turn the active load on:

   INP<n>:STATE 1

3. Set the conductance count to 0x1FFFF.

   CAL<n>:INP:COND:COUNTS 0x1FFFF

4. After DC voltage stabilizes. Enter the voltage using SCPI commands

   CAL<n>:INP:VOLT 1 <value-1>

5. After DC current stabilizes. Enter the current using SCPI commands

   CAL<n>:INP:CURR 1 <value-1>

6. Set the conductance count to 0xF0F0.

   CAL<n>:INP:COND:COUNTS 0x3CF3C

7. After DC voltage stabilizes. Enter the voltage using SCPI commands

```
CAL<n>:INP:VOLT 2 <value-2>
```

8. After DC current stabilizes. Enter the current using SCPI commands

```
CAL<n>:INP:CURR 2 <value-2>
```

9. Send the calibration command to calculate the gain and offset

```
CAL<n>:INP:COND:CALC
```

10. Send the system error query command to make sure calibration was successful.

```
SYST:ERR?
```

11. If there is no error returned at the system error query command then save the calibration result with the following command

```
CAL<n>:UNLOCK “6867”
CAL<n>:STORE
CAL<n>:LOCK
```

12. Reset the unit

```
*RST<n>
```

7.6.15 HPAL Resistance Calibration – Part III of V

The following procedure calibrates the resistance for voltage gain 4 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative leads of the active load. Connect the sense positive-to-positive lead and sense negative-to-negative lead. Also connect the shunt and the DC current meter between the active load and DC power supply.

This procedure requires maximum voltage 50.0 V and maximum current 2.0 Amps.

1. Set the DC input voltage to 50 Volts

2. Turn the active load on:

   INP<n>:STATE 1

3. Set the conductance count to 0x7FFF:

   CAL<n>:INP:COND:COUNTS 0x7FFF

4. After DC voltage stabilizes, enter the voltage:

   CAL<n>:INP:VOLT 1 <value-1>

5. After DC current stabilizes, enter the current:

   CAL<n>:INP:CURR 1 <value-1>

6. Set the conductance count to 0x3C3C:

   CAL<n>:INP:COND:COUNTS 0x3C3C

7. After DC voltage stabilizes, enter the voltage:

```
CAL<n>:INP:VOLT 2 <value-2>
```

8. After DC current stabilizes, enter the current:

```
CAL<n>:INP:CURR 2 <value-2>
```

9. Send the calibration command to calculate the gain and offset:

```
CAL<n>:INP:COND:CALC
```

10. Send the system error query command to make sure calibration was successful:

```
SYST:ERR?
```

11. If there is no error returned at the system error query command, then save the calibration result as follows:

```
CAL<n>:UNLOCK “6867”
CAL<n>:STORE
CAL<n>:LOCK
```

12. Reset the unit:

```
*RST<n>
```

7.6.16 HPAL Resistance Calibration – Part IV of V

This procedure calibrates the resistance for voltage gain 1 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative leads of the active load. Connect the sense positive-to-positive lead and sense negative-to-negative lead. Also connect the shunt and the DC current meter between the active load and DC power supply

This procedure requires maximum voltage 50.0V and maximum current 0.5 Amps.

1. Set the DC input voltage to 50 Volts

2. Turn the active load on:

   INP<n>:STATE 1

3. Set the conductance count to 0x18F9:

   CAL<n>:INP:COND:COUNTS 0x18F9

4. After DC voltage stabilizes, enter the voltage:

   CAL<n>:INP:VOLT 1 <value-1>

5. After DC current stabilizes, enter the current:

   CAL<n>:INP:CURR 1 <value-1>

6. Set the conductance count to 0x9DB:

   CAL<n>:INP:COND:COUNTS 0x9DB

7. After DC voltage stabilizes, enter the voltage:

   CAL<n>:INP:VOLT 2 <value-2>

8. After DC current stabilizes, enter the current:

   CAL<n>:INP:CURR 2 <value-2>

9. Send the calibration command to calculate the gain and offset:

   CAL<n>:INP:COND:CALC

10. Send the system error query command to make sure calibration was successful:

    SYST:ERR?

11. If there is no error returned at the system error query command, then save the calibration result as follows:

    CAL<n>:UNLOCK "6867"

    CAL<n>:STORE

    CAL<n>:LOCK

12. Reset the unit:

    ***RST<n>**

7.6.17 HPAL Resistance Calibration – Part V of V

This procedure calibrates the resistance for voltage gain 1 and current range low. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Connect the sense positive-to-positive lead and sense negative-to-negative lead. Also connect the shunt and the DC current meter between the active load and DC power supply

This procedure requires maximum voltage 500.0V and maximum current 0.5 Amps

1. Set the DC input voltage to 500 Volts

2. Turn the active load

   INP<n>:STATE 1

3. Set the conductance count to 0x2EC.

   CAL<n>:INP:COND:COUNTS 0x2EC

4. After DC voltage. Enter the voltage using SCPI commands

   CAL<n>:INP:VOLT 1 <value-1>

5. After DC current. Enter the current using SCPI commands

   CAL<n>:INP:CURR 1 <value-1>

6. Set the conductance count to 0xFF.

   CAL<n>:INP:COND:COUNTS 0xFF

7. After DC voltage. Enter the voltage using SCPI commands

```
CAL<n>:INP:VOLT 2 <value-2>
```

8. After DC current. Enter the current using SCPI commands

```
CAL<n>:INP:CURR 2 <value-2>
```

9. Send the calibration command to calculate the gain and offset

```
CAL<n>:INP:COND:CALC
```

10. Send the system error query command to make sure calibration was successful.

```
SYST:ERR?
```

11. If there is no error returned at the system error query command then save the calibration result with the following command

```
CAL<n>:UNLOCK “6867”
CAL<n>:STORE
CAL<n>:LOCK
```

12. Reset the unit

```
*RST<n>
```

7.6.18 HPAL IAI Board Calibration

This procedure calibrates the IAI Board for High Power Active Load.

This procedure requires maximum voltage 5.0 V and maximum current 30 Amps.

Power supply connected to IAI board needs voltage rating of 0 to 10.0 V.

1. Connect the shunt and the DC current meter between the active load and DC power supply.

2. Connect the second power supply to the IAI board. Also connect a DC voltmeter to the IAI board input

3. Set the input voltage to 5V (First power Supply connected to the Input.)

4. Turn the active load unit

   INP<n>:STATE 1

5. Set the mode of the active load to external input mode or IAI mode Wait for a some seconds for unit to make transition

   INP<n>:CURRent:EXTernal 1

6. Set the second power supply (Power supply connected to IAI Board) to 0 Volts

7. After the DMM voltage stabilizes enter the voltage of the DMM (Connected to second power supply or Power supply connected to IAI Board). Use 0.0051 instead of .0051 to enter the voltage.

Note: This voltage should be equal to 0Volts.

   CAL<n>:INP:VOLT1 <value-1>

8. Set the second power supply (Power supply connected to IAI Board) voltage to 10.00 volts.

9. After the DMM voltage stabilizes enter the voltage of the DMM (Connected to second power supply or Power supply connected to IAI Board.)

Note: This voltage should be equal to 10.0 Volts.

CAL<n>:INP:VOLT2 <value-2>

10. Send the command to calculate the gain and offset of the IAI board.

CAL<n>:MEAS:OFFSET:CALC

11. Set the active load back to the SCPI mode

INP<n>:CURRent:EXTernal 0

12. Send the system error query command to make sure calibration was successful.

SYST:ERR?

13. If there is no error returned at the system error query command then save the calibration result with the following command

CAL<n>:UNLOCK “6867”

CAL<n>:STORE

CAL<n>:LOCK

14. Reset the unit

***RST<n>**

7.6.19 LPAL CalPot Calibration

This procedure calibrates cal-pot. This calibration is done with the DC current meter connected between the DC power supply and the Active Load.

This procedure requires maximum voltage 4.5V and maximum current 15Amps.

1. Connect the shunt between the DC power supply and the active load. Connect the DC current meter across the shunt.

2. Issue clear and reset commands:

   ***CLS<n>**

   ***RST<n>**

3. Set the DC power supply to 4.5 Volts

4. This begins the CalPots calibration sequence. The Load will be set to STATE 1; relays closed and set to 0 current, the 0 current offset value will be calculated.

   CAL<n>:CALPOTS:GAIN:START

5. Program to draw maximum current

   CAL<n>:INP:CURR:COUNTS 0xFFFF

6. Adjust the current limit on the DC Power supply to just under the limit 13.7 Amps. Use the Current Shunt and Voltmeter to adjust and measure the current. When the current reading is stable, enter the current using following command

   CAL<n>:CALPOTS:GAIN:CURR <value-1>

7. This will use the current value entered to adjust the Gain Pot. The adjustment will be calculated, ending the procedure and the setting the load to STATE 0

CAL<n>:CALPOTS:GAIN:CALC

8. Send the system error query command to make sure calibration was successful.

SYST:ERR?

9. If there is no error returned at the system error query command then save the calibration result with the following command

CAL<n>:UNLOCK "6867"

CAL<n>:STORE

CAL<n>:LOCK

10. Optional Commands:

To query the offset pot set value: **CAL<n>:CALPOTS:OFFSET?**

To query the gain pot set value: **CAL<n>:CALPOTS:GAIN?**

11. Reset the unit

***RST<n>**

7.6.20 CURRENT CALIBRATION FOR LPAL

This procedure calibrates the current for the high range. This is 5-point calibration. Make sure that the shunt and the DC current meter are connected between the active load and DC power supply.

This procedure requires maximum voltage 5.0 V and maximum current 15.0 Amps.

1. Set the DC input voltage to 5 Volts

2. Turn on the active load

   INP<n>:STATE 1

3. Set the DAC count to 5% of its full range

   CAL<n>:INP:CURR:COUNTS 5700

4. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command

   CAL<n>:INP:CURR:FIVEPOINT1 <value-1>

5. Set the DAC count to 27.5% of its full range

   CAL<n>:INP:CURR:COUNTS 16000

6. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command

   CAL<n>:INP:CURR:FIVEPOINT2 <value-2>

7. Set the DAC count to 50.0% of its full range

   CAL<n>:INP:CURR:COUNTS 32000

8. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command

   CAL<n>:INP:CURR:FIVEPOINT3 <value-3>

9. Set the DAC count to 72.5% of its full range

   CAL<n>:INP:CURR:COUNTS 43000

10. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command

    CAL<n>:INP:CURR:FIVEPOINT4 <value-4>

11. Set the DAC count to 95% of its full range

    CAL<n>:INP:CURR:COUNTS 56000

12. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command

    CAL<n>:INP:CURR:FIVEPOINT5 <fval>

13. Set the DAC to zero counts

    CAL<n>:INP:CURR:COUNTS 0

14. Send calibration command to make sure that all the DAC counts and current values are valid

    CAL<n>:INP:CURR:CALC

15. Send the system error query command to make sure calibration was successful.

    SYST:ERR?

16. If there is no error returned at the system error query command then save the calibration result with the following command

    CAL<n>:UNLOCK "6867"

    CAL<n>:STORE

    CAL<n>:LOCK

17. Reset the unit

    ***RST<n>**

7.6.21 LPAL Low Range Current Calibration

This procedure calibrates the current for the low range. Make sure that the shunt and the DC current meter are connected between the active load and DC power supply.

This procedure requires maximum voltage 5.0 V and maximum current 0.5 Amps.

1. Set the DC input voltage to 5 Volts

2. Turn on the active load

   INP<n>:STATE 1

3. Set the DAC count to 20% of its full range

   CAL<n>:INP:CURR:COUNTS 16000

4. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command

   CAL<n>:INP:CURR1 <value-1>

5. Set the DAC count to 80% of its full range

   CAL<n>:INP:CURR:COUNTS 53000

6. Wait for the DC current to stabilize. After the current reading is stabilized, enter the current using following command

   CAL<n>:INP:CURR2 <value-2>

7. Send the calibration command to calculate the gain and offset of the low range current calibration

   CAL<n>:INP:CURR:CALC

8. Send the system error query command to make sure calibration was successful.

   SYST:ERR?

9. If there is no error returned at the system error query command then save the calibration result with the following command

   CAL<n>:UNLOCK "6867"

   CAL<n>:STORE

   CAL<n>:LOCK

10. Reset the unit

   ***RST<n>**

7.6.22 LPAL Voltage Calibration – PART I of V

The following procedure calibrates the voltage for voltage gain 8 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Also connect the sense positive-to-positive lead and sense negative-to-negative lead.

This procedure requires maximum voltage 55 V and maximum current 6.0Amps.

1. Turn the active load on

   ```
   INP<n>:STATE 1
   ```

2. Set the conductance count to 0x19999

   ```
   CAL<n>:INP:COND:COUNTS 0x19999
   ```

3. Set the input DC voltage to 13 Volts. After the input DC voltage stabilizes enter the first exact voltage using following command

   ```
   CAL<n>:INP:VOLT 1 <value-1>
   ```

4. Set the input DC voltage to 54 Volts. After the input DC voltage stabilizes enter the second exact voltage using following command

   ```
   CAL<n>:INP:VOLT 2 <value-2>
   ```

5. Send the calibration command to calculate the gain and offset:

   ```
   CAL<n>:MEAS:OFFSET:CALC
   ```

6. Send the system error query command to make sure calibration was successful.

   ```
   SYST:ERR?
   ```

7. If there is no error returned at the system error query command then save the calibration result with the following command

CAL<n>:UNLOCK "6867"

CAL<n>:STORE

CAL<n>:LOCK

8. Reset the unit

***RST<n>**

7.6.23 LPAL Voltage Calibration – Part II of V

This procedure calibrates the voltage for voltage gain 4 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Also connect the sense positive-to-positive lead and sense negative-to-negative lead.

This procedure requires maximum voltage 109 V and maximum current 3.0 Amps.

1. Turn the active load on

   INP<n>:STATE 1

2. Set the conductance count to 0x6666

   CAL<n>:INP:COND:COUNTS 0x6666

3. Set the input DC voltage to 27 Volts. After the input DC voltage stabilizes enter the first exact voltage using following command

   CAL<n>:INP:VOLT 1 <value-1>

4. Set the input DC voltage to 109 Volts. After the input DC voltage stabilizes enter the second exact voltage using following command

   CAL<n>:INP:VOLT 2 <value-2>

5. Send the calibration command to calculate the gain and offset:

   CAL<n>:MEAS:OFFSET:CALC

6. Send the system error query command to make sure calibration was successful.

   SYST:ERR?

7. If there is no error returned at the system error query command then save the calibration result with the following command

CAL<n>:UNLOCK “6867”

CAL<n>:STORE

CAL<n>:LOCK

8. Reset the unit

***RST<n>**

7.6.24 LPAL VOLTAGE CALIBRATION – PART III OF V

This procedure calibrates the voltage for voltage gain 2 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Also connect the sense positive-to-positive lead and sense negative-to-negative lead.

This procedure requires maximum voltage 218V and maximum current 1.5 Amps.

1. Turn the active load on

   INP<n>:STATE 1

2. Set the conductance count to 0x1999

   CAL<n>:INP:COND:COUNTS 0x1999

3. Set the input DC voltage to 54 Volts. After the input DC voltage stabilizes enter the first exact voltage using following command

   CAL<n>:INP:VOLT 1 <value-1>

4. Set the input DC voltage to 218 Volts. After the input DC voltage stabilizes enter the second exact voltage using following command

   CAL<n>:INP:VOLT 2 <value-2>

5. Send the calibration command to calculate the gain and offset:

   CAL<n>:MEAS:OFFSET:CALC

6. Send the system error query command to make sure calibration was successful.

   SYST:ERR?

7. If there is no error returned at the system error query command then save the calibration result with the following command

CAL<n>:UNLOCK "6867"

CAL<n>:STORE

CAL<n>:LOCK

8. Reset the unit

***RST<n>**

7.6.25 LPAL Voltage Calibration – Part IV of V

This procedure calibrates the voltage for voltage gain 1 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Also connect the sense positive-to-positive lead and sense negative-to-negative lead.

This procedure requires maximum voltage 500.0 V and maximum current 0.5 Amps.

1. Turn the active load on

```
INP<n>:STATE 1
```

2. Set the conductance count to 0x418

```
CAL<n>:INP:COND:COUNTS  0x418
```

3. Set the input DC voltage to 10 Volts. After the input DC voltage stabilizes enter the first exact voltage using following command

```
CAL<n>:INP:VOLT 1 <value-1>
```

4. Set the input DC voltage to 500 Volts. After the input DC voltage stabilizes enter the second exact voltage using following command

```
CAL<n>:INP:VOLT 2 <value-2>
```

5. Send the calibration command to calculate the gain and offset:

```
CAL<n>:MEAS:OFFSET:CALC
```

6. Send the system error query command to make sure calibration was successful.

SYST:ERR?

7. If there is no error returned at the system error query command then save the calibration result with the following command

CAL<n>:UNLOCK “6867”

CAL<n>:STORE

CAL<n>:LOCK

8. Reset the unit

***RST<n>**

7.6.26 LPAL Voltage Calibration – Part V of V

This procedure calibrates the voltage for voltage gain 1 and current range low. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Also connect the sense positive-to-positive lead and sense negative-to-negative lead.

This procedure requires maximum voltage 500.0V and maximum current 0.2 Amps.

1. Turn the active load on

   INP<n>:STATE 1

2. Set the conductance count to 0x15D

   CAL<n>:INP:COND:COUNTS 0x15D

3. Set the input DC voltage to 10 Volts. After the input DC voltage stabilizes enter the first exact voltage using following command

   CAL<n>:INP:VOLT 1 <value-1>

4. Set the input DC voltage to 500 Volts. After the input DC voltage stabilizes enter the second exact voltage using following command

   CAL<n>:INP:VOLT 2 <value-2>

5. Send the calibration command to calculate the gain and offset:

   CAL<n>:MEAS:OFFSET:CALC

6. Send the system error query command to make sure calibration was successful.

```
SYST:ERR?
```

7. If there is no error returned at the system error query command then save the calibration result with the following command

```
CAL<n>:UNLOCK “6867”
CAL<n>:STORE
CAL<n>:LOCK
```

8. Reset the unit

```
*RST<n>
```

7.6.27 LPAL Resistance Calibration – Part I of V

The following procedure calibrates the resistance for voltage gain 8 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Connect the sense positive-to-positive lead and sense negative-to-negative lead. Also connect the shunt and the DC current meter between the active load and DC power supply

This procedure requires maximum voltage 10.0 V and maximum current 10.0 Amps.

1. Set the DC input voltage to 10 Volts

2. Turn on the active load

   INP<n>:STATE 1

3. Set the conductance count to 0xD5554.

   CAL<n>:INP:COND:COUNTS 873812

4. After DC voltage stabilizes. Enter the voltage using SCPI commands

   CAL<n>:INP:VOLT 1 <value-1>

5. After DC current stabilizes. Enter the current using SCPI commands

   CAL<n>:INP:CURR 1 <value-1>

6. Set the conductance count to 0x1F383.

   CAL<n>:INP:COND:COUNTS 0x1F383

7. After DC voltage stabilizes. Enter the voltage using SCPI commands

   CAL<n>:INP:VOLT 2 <value-2>

8. After DC current stabilizes. Enter the current using SCPI commands

CAL<n>:INP:CURR 2 <value-2>

9. Send the calibration command to calculate the gain and offset

   CAL<n>:INP:COND:CALC

10. Send the system error query command to make sure calibration was successful.

    SYST:ERR?

11. If there is no error returned at the system error query command then save the calibration result with the following command

    CAL<n>:UNLOCK "6867"

    CAL<n>:STORE

    CAL<n>:LOCK

12. Reset the unit

    ***RST<n>**

7.6.28 LPAL Resistance Calibration – Part II of V

This procedure calibrates the resistance for voltage gain 4 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Connect the sense positive-to-positive lead and sense negative-to-negative lead. Also connect the shunt and the DC current meter between the active load and DC power supply

This procedure requires maximum voltage 10.0 V and maximum current 1.0 Amps.

1. Set the DC input voltage to 10 Volts

2. Turn the active load

   INP<n>:STATE 1

3. Set the conductance count to 0xFFFF.

   CAL<n>:INP:COND:COUNTS 0xFFFF

4. After DC voltage stabilizes. Enter the voltage using SCPI commands

   CAL<n>:INP:VOLT 1 <value-1>

5. After DC current stabilizes. Enter the current using SCPI commands

   CAL<n>:INP:CURR 1 <value-1>

6. Set the conductance count to 0x7878.

   CAL<n>:INP:COND:COUNTS 0x7878

7. After DC voltage stabilizes. Enter the voltage using SCPI commands

CAL<n>:INP:VOLT 2 <value-2>

8. After DC current stabilizes. Enter the current using SCPI commands

CAL<n>:INP:CURR 2 <value-2>

9. Send the calibration command to calculate the gain and offset

CAL<n>:INP:COND:CALC

10. Send the system error query command to make sure calibration was successful.

SYST:ERR?

11. If there is no error returned at the system error query command then save the calibration result with the following command

CAL<n>:UNLOCK "6867"

CAL<n>:STORE

CAL<n>:LOCK

12. Reset the unit

***RST<n>**

7.6.29 LPAL Resistance Calibration – Part III of V

This procedure calibrates the resistance for voltage gain 2 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Connect the sense positive-to-positive lead and sense negative-to-negative lead. Also connect the shunt and the DC current meter between the active load and DC power supply

This procedure requires maximum voltage 100.0 V and maximum current 2.0 Amps.

1. Set the DC input voltage to 100 Volts

2. Turn the active load

```
INP<n>:STATE 1
```

3. Set the conductance count to 0x3FFF.

```
CAL<n>:INP:COND:COUNTS 0x3FFF
```

4. After DC voltage stabilizes. Enter the voltage using SCPI commands

```
CAL<n>:INP:VOLT 1 <value-1>
```

5. After DC current stabilizes. Enter the current using SCPI commands

```
CAL<n>:INP:CURR 1 <value-1>
```

6. Set the conductance count to 0x1E1E.

```
CAL<n>:INP:COND:COUNTS 0x1E1E
```

7. After DC voltage stabilizes. Enter the voltage using SCPI commands

   CAL<n>:INP:VOLT 2 <value-2>

8. After DC current stabilizes. Enter the current using SCPI commands

   CAL<n>:INP:CURR 2 <value-2>

9. Send the calibration command to calculate the gain and offset

   CAL<n>:INP:COND:CALC

10. Send the system error query command to make sure calibration was successful.

    SYST:ERR?

11. If there is no error returned at the system error query command then save the calibration result with the following command

    CAL<n>:UNLOCK "6867"

    CAL<n>:STORE

    CAL<n>:LOCK

12. Reset the unit

    ***RST<n>**

7.6.30 LPAL Resistance Calibration – Part IV of V

This procedure calibrates the resistance for voltage gain 1 and current range high. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Connect the sense positive-to-positive lead and sense negative-to-negative lead. Also connect the shunt and the DC current meter between the active load and DC power supply

This procedure requires maximum voltage 100.0 V and maximum current 0.5 Amps.

1. Set the DC input voltage to 100 Volts

2. Turn the active load

   INP<n>:STATE 1

3. Set the conductance count to 0xC7C.

   CAL<n>:INP:COND:COUNTS 0xC7C

4. After DC voltage stabilizes. Enter the voltage using SCPI commands

   CAL<n>:INP:VOLT 1 <value-1>

5. After DC current stabilizes. Enter the current using SCPI commands

   CAL<n>:INP:CURR 1 <value-1>

6. Set the conductance count to 0x4EC.

   CAL<n>:INP:COND:COUNTS 0x4EC

7. After DC voltage stabilizes. Enter the voltage using SCPI commands

```
CAL<n>:INP:VOLT 2 <value-2>
```

8. After DC current stabilizes. Enter the current using SCPI commands

```
CAL<n>:INP:CURR 2 <value-2>
```

9. Send the calibration command to calculate the gain and offset

```
CAL<n>:INP:COND:CALC
```

10. Send the system error query command to make sure calibration was successful.

```
SYST:ERR?
```

11. If there is no error returned at the system error query command then save the calibration result with the following command

```
CAL<n>:UNLOCK “6867”
CAL<n>:STORE
CAL<n>:LOCK
```

12. Reset the unit

```
*RST<n>
```

7.6.31 LPAL Resistance Calibration Part V of V

This procedure calibrates the resistance for voltage gain 1 and current range low. Make sure that the shunt and the DC voltmeter are connected between the positive and negative lead of the active load. Connect the sense positive-to-positive lead and sense negative-to-negative lead. Also connect the shunt and the DC current meter between the active load and DC power supply

This procedure requires maximum voltage 500.0 V and maximum current 0.5 Amps.

1. Set the DC input voltage to 500 Volts.

2. Turn the active load on:

```
INP<n>:STATE 1
```

3. Set the conductance count to 0x246:

```
CAL<n>:INP:COND:COUNTS 0x246
```

4. After DC voltage stabilizes, enter the voltage:

```
CAL<n>:INP:VOLT 1 <value-1>
```

5. After DC current stabilizes, enter the current:

```
CAL<n>:INP:CURR 1 <value-1>
```

6. Set the conductance count to 0xF9:

```
CAL<n>:INP:COND:COUNTS 0xF9
```

7. After DC voltage stabilizes, enter the voltage:

   CAL<n>:INP:VOLT 2 <value-2>

8. After DC current stabilizes, enter the current:

   CAL<n>:INP:CURR 2 <value-2>

9. Send the calibration command to calculate the gain and offset:

   CAL<n>:INP:COND:CALC

10. Send the system error query command to make sure calibration was successful:

SYST:ERR?

11. If there is no error returned at the system error query command, then save the calibration result was follows:

    CAL<n>:UNLOCK “6867”

    CAL<n>:STORE

    CAL<n>:LOCK

12. Reset the unit:

    ***RST<n>**

7.6.32 LPAL IAI BOARD CALIBRATION

This procedure calibrates the IAI Board.

This procedure requires maximum input voltage 5.0 V and maximum input current 15.0 Amps.

Power supply connected to IAI board needs voltage rating of 0 to 10.0 V

1. Connect the shunt and the DC current meter between the active load and DC power supply.

2. Connect the second power supply to the IAI board. Also connect a DC voltmeter to the IAI board input.

3. Set the input voltage to 5 V (First power Supply connected to the Input).

4. Turn the active load unit on:

   INP<n>:STATE 1

5. Set the mode of the active load to external input mode or IAI mode, and wait for a 1/2 second for unit to make transition:

   INP<n>:CURRent:EXTernal 1

6. Set the second power supply (Power supply connected to IAI Board) to 0 Volts.

7. After the DMM voltage stabilizes, enter the voltage of the DMM (Connected to second power supply or Power supply connected to IAI Board). Use 0.0051 instead of .0051 to enter the voltage.

Note: This voltage should be equal to 0 Volts.

   CAL<n>:INP:VOLT1 <value-1>

8. Set the second power voltage to 10.0 Volts.

9. After the DMM voltage stabilizes enter the voltage of the DMM (Connected to second power supply. or Power supply connected to IAI Board)

Note: This voltage should be equal to 10.0 Volts.

CAL<n>:INP:VOLT2 <value-2>

10. Send the command to calculate the gain and offset of the IAI board.

CAL<n>:MEAS:OFFSET:CALC

11. Set the active load back to the SCPI mode:

INP<n>:CURRent:EXTernal 0

12. Send the system error query command to make sure calibration was successful.

SYST:ERR?

13. If there is no error returned at the system error query command then save the calibration result with the following command

CAL<n>:UNLOCK “6867”

CAL<n>:STORE

CAL<n>:LOCK

14. Reset the unit

***RST<n>**

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