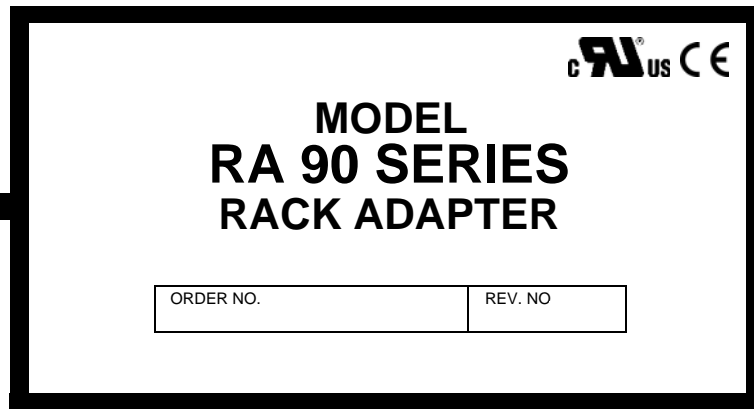


INSTRUCTION MANUAL

RA 90 SERIES RACK ADAPTER

KEPCO INC.
An ISO 9001 Company.



IMPORTANT NOTES:

- 1) This manual is valid for the following Model and associated serial numbers:

MODEL	SERIAL NO.	REV. NO.
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- 2) A Change Page may be included at the end of the manual. All applicable changes and revision number changes are documented with reference to the equipment serial numbers. Before using this Instruction Manual, check your equipment serial number to identify your model. If in doubt, contact your nearest Kepco Representative, or the Kepco Documentation Office in New York, (718) 461-7000, requesting the correct revision for your particular model and serial number.
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Conditions of Conformance Rack Adapter products (EN60950)

When this product is used in applications governed by the requirements of the EEC, the following restrictions and conditions apply:

1. For European applications, requiring compliance to the Low Voltage Directive, 73/23/EEC, this Rack Adapter is considered a component, designed for “building in”. Because it is incomplete in construction, the end product enclosure must provide for compliance to any remaining electrical safety requirements and act as a fire enclosure. (EN60950, CL.2.1, 2.7, 3.3, 4.3 and 4.4.5).
2. This Rack Adapter is designed for stationary installation, with mains power applied via a detachable power supply cord or via direct wiring to a source power terminal block.
3. This Rack Adapter, when properly installed, is considered a Class 1 (earthed) product, and as such depends upon proper connection to protective earth for safety from electric shock. (EN60950 Cl. 2.5)
4. This product is intended for use as part of equipment meant for an Information Technology Equipment environment. It is designed to operate from single phase, three wire TN power systems. This equipment must be installed within a suitably wired equipment rack, utilizing a three wire (grounded) mains connection. See wiring section of this manual for complete electrical wiring instructions.
5. When fitted with the appropriate power supplies, this product may have secondary output circuits that are considered hazardous, and which exceed 240 VA at a potential of 2V or more.
6. The output wiring terminals of this power supply have not been evaluated for field wiring and, therefore, must be properly configured by the end product manufacturer prior to use.
7. For complete circuit protection of the end product, as well as the building wiring, it is required that a primary circuit protection device be fitted to the branch circuit wiring. (EN60950 Cl. 2.5).
8. When installed with other components and/or power supplies, hazardous voltages may be present within the equipment during normal operation. All operator adjustments are made via externally accessible switches, controls and signal lines as specified within the individual power supply operating instructions. There are no user or operator serviceable parts within this product enclosure. Refer all servicing to qualified and trained Kepco service technicians.

SAFETY INSTRUCTIONS

1. Installation, Operation and Service Precautions

This product is designed for use in accordance with EN 60950 and UL 1950 for Installation Category 2, Pollution Degree 2. Hazardous voltages are present within this product during normal operation. The product should never be operated with the cover removed unless equivalent protection of the operator from accidental contact with hazardous internal voltages is provided



There are no operator serviceable parts or adjustments within the product enclosure. Refer all servicing to trained service technician.



Source power must be removed from the product prior to performing any servicing.



This product is factory-wired for the nominal a-c mains voltage indicated on the rating nameplate located adjacent to the source power connection on the product's rear panel.

2. Grounding

This product is a Class 1 device which utilizes protective earthing to ensure operator safety.



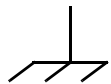
The PROTECTIVE EARTHING CONDUCTOR TERMINAL must be properly connected prior to application of source power to the product (see instructions on installation herein) in order to ensure safety from electric shock.



PROTECTIVE EARTHING CONDUCTOR TERMINAL - This symbol indicates the point on the product to which the protective earthing conductor must be attached.



EARTH (GROUND) TERMINAL - This symbol is used to indicate a point which is connected to the PROTECTIVE EARTHING TERMINAL. The component installer/ assembler must ensure that this point is connected to the PROTECTIVE EARTHING TERMINAL.



CHASSIS TERMINAL -This symbol indicates frame (chassis) connection, which is supplied as a point of convenience for performance purposes (see instructions on grounding herein). This is not to be confused with the protective earthing point, and may not be used in place of it.

3. Electric Shock Hazards

This product outputs hazardous voltage and energy levels as a function of normal operation. Operators must be trained in its use and exercise caution as well as common sense during use to prevent accidental shock.



This symbol appears adjacent to any external terminals at which hazardous voltage levels as high as 500V d-c may exist in the course of normal or single fault conditions.



This symbol appears adjacent to any external terminals at which hazardous voltage levels in excess of 500V d-c may exist in the course of normal or single fault conditions.

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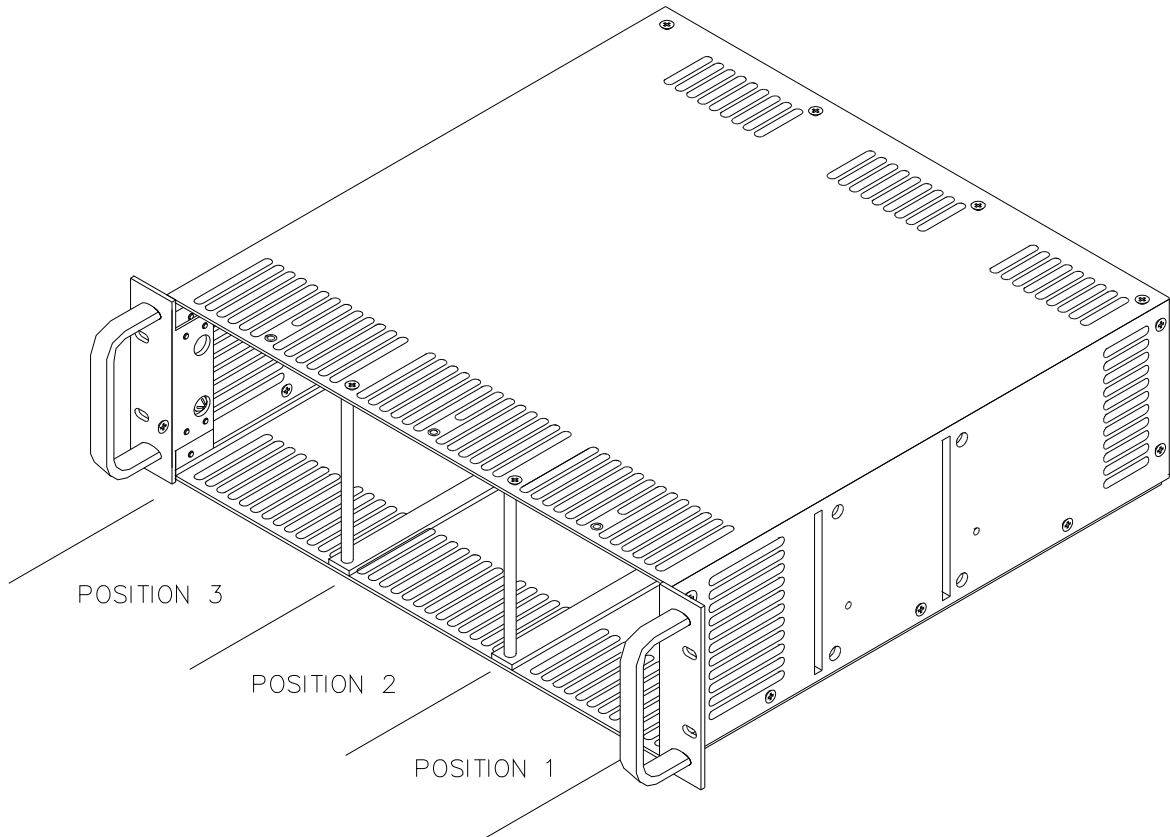
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FIGURE 1-1. SERIES RA 90 RACK ADAPTER

SECTION 1 - INTRODUCTION

1.1 SCOPE OF MANUAL

This manual contains instructions for the installation and operation of RA 90, RA 92 and RA 93 Series plug-in rack adapters (Figure 1-1), used with HSP-A Series power supplies, manufactured by Kepco, Inc., Flushing, New York, U.S.A. Additional Instructions explaining the default (as shipped) configuration of the RA 90 DIP switches are found in the RA 90 Series Quick Start Guide which can be downloaded from the Kepco web site at:

www.kepcopower.com/support/opmanls.htm#ra90

Additional instructions for the HSP-A Series power supplies can be found in the HSP-A Quick Start Guide and HSP-A Operator Manual which can be downloaded from the Kepco web site at:

www.kepcopower.com/support/opmanls.htm#hsp

1.2 GENERAL DESCRIPTION

Kepco Series RA 90 rack adapters are specifically designed for the installation of Kepco HSP-A Series Power Supplies into 19-inch, 23-inch and 24-inch EIA standard equipment racks. Each rack adapter accommodates from one to three HSP-A power supplies. An internal plate assembly mounts connectors which interface directly with the power and signal connectors of HSP-A series power supplies, permitting pluggable insertion and extraction, while a separate external rear panel contains the fixed power and signal connections. Separate source power, signal, and load terminations are provided for each of the three power supply mounting positions. Internal power output configurations differ for the three models as follows:

- RA 90- Output power connections for all three positions are connected by bus bars for parallel/redundant applications. Local sensing and current sharing may be connected internally using rack adapter DIP switches.
- RA 92- Output power connections for positions 1 and 2 are connected by bus bars for parallel/redundant applications. Local sensing and current sharing may be connected internally using rack adapter DIP switches. Position 3 is independent from the other two.
- RA 93- Output power connections are not connected. All three positions are independent of each other. I/O connections for sense, alarms and current share are available from either Euroblocks or I/O (DSUB 37 pin mini) connectors.

External dimensions and mounting provisions are identical for all Series RA 90 Rack Adapter models All mechanical and electrical specifications are contained in the outline drawing, Figure 1-2.

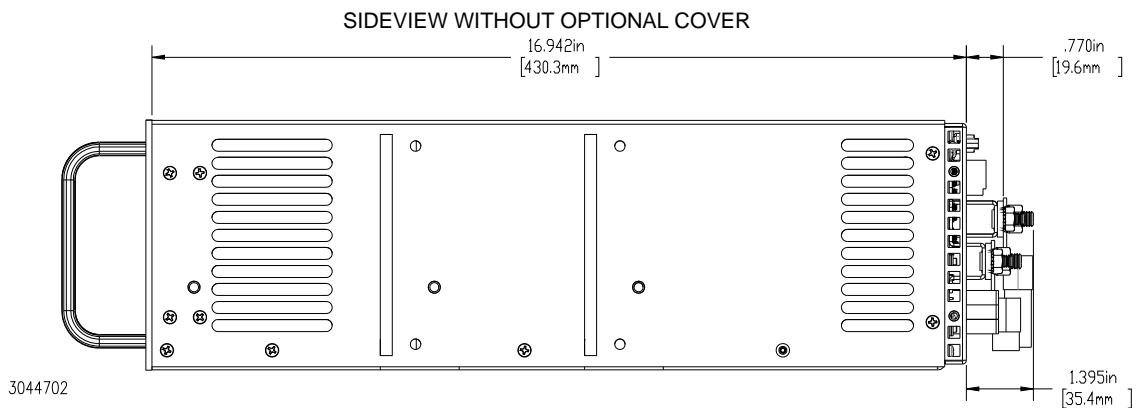
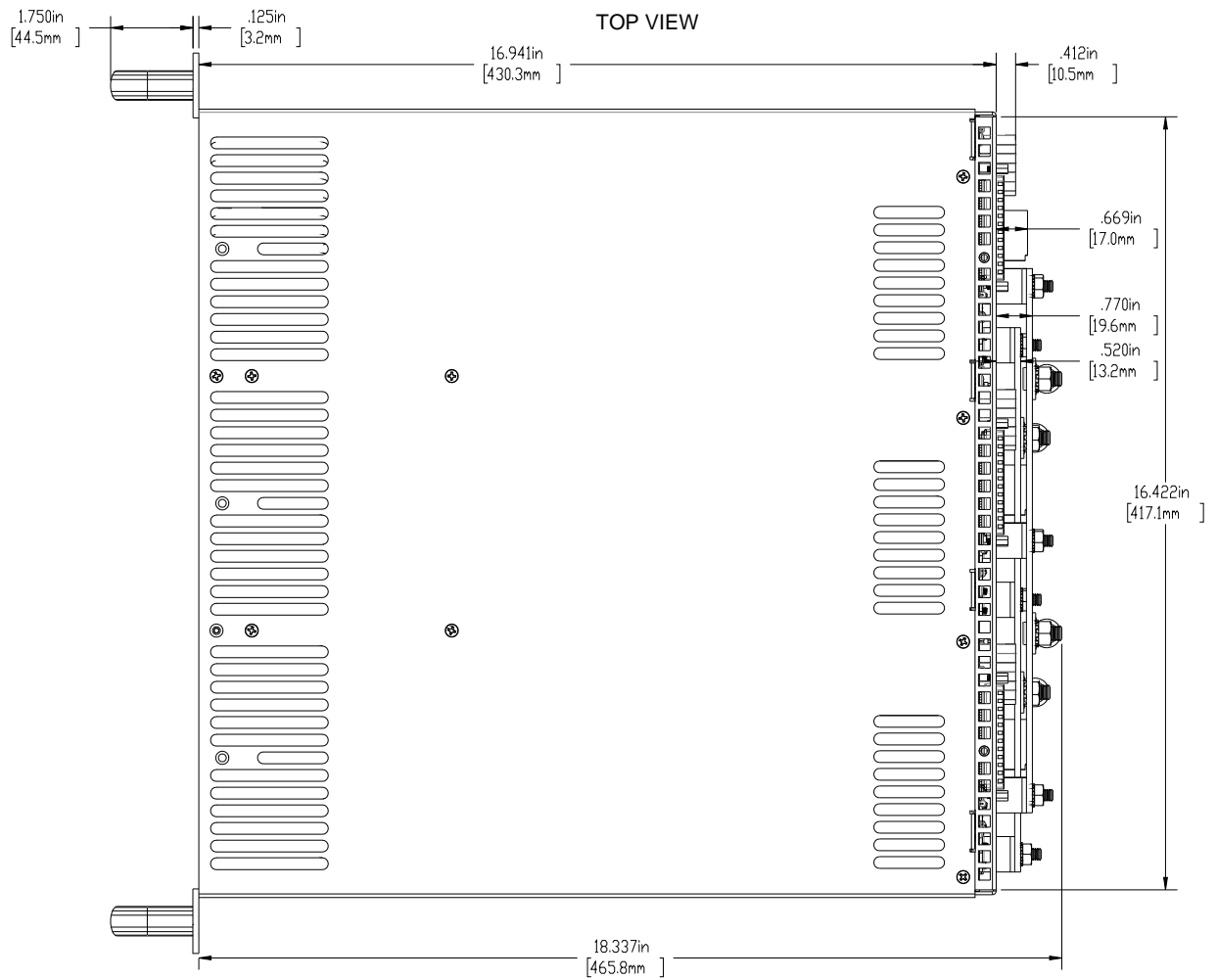
Each rack adapter weighs approximately 27 lbs. and occupies 5.22 inches (132.5 mm) of vertical space and has a maximum depth protrusion of 21 inches measured from the mounting surface of the “ear” brackets. Mounting positions are provided for flush mount as well as ¼ setback and ½ setback (setback mounting ears required - see Table 1-2). All rack adapters are shipped with mounting ears for flush mounting in EIA 19-inch equipment racks. The rack adapters can be fitted with optional blank filler panels in both 1/3 and 2/3 dimensions if the full complement of three power supplies is not utilized.

1.3 OPTIONS

Series RA 90 Rack Adapters are available for 19-inch, 23-inch, and 24-inch wide racks. Table 1-1 below describes the model options available with Series RA 90 rack adapters.

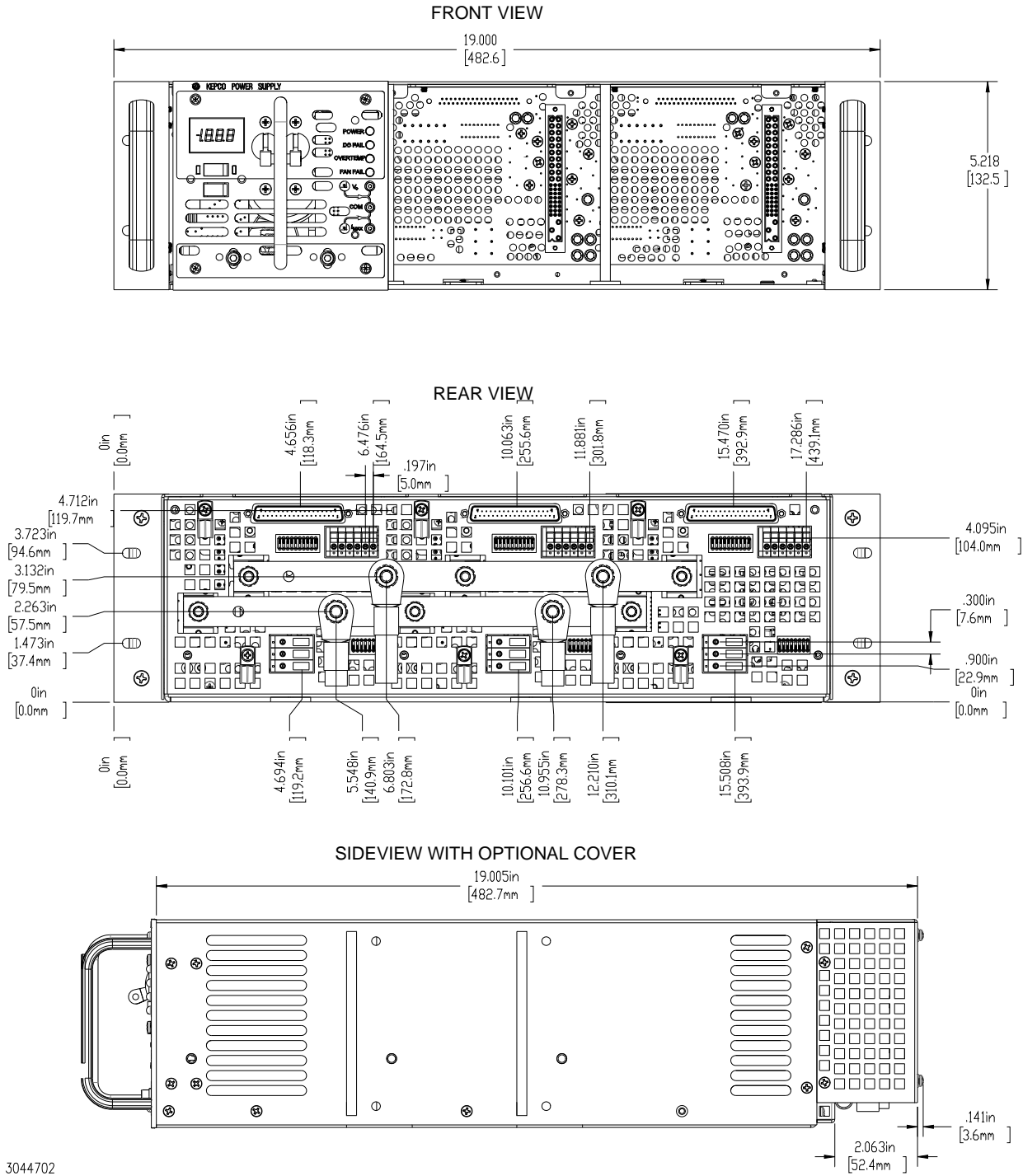
TABLE 1-1. RACK ADAPTER OPTIONS

MODEL	DESCRIPTION
RA 90	Accommodates up to three HSP-A Power Supplies in a 19-inch rack. Bus bars (\pm) connect the outputs of all three slots in parallel for use with hot-swap or parallel/redundant applications Any HSP-A can be easily removed and inserted without affecting system operation.
RA 90-23E	Same as RA 90 except mounting ears are wider to accommodate a 23-inch rack.
RA 90-24E	Same as RA 90 except mounting ears are wider to accommodate a 24-inch rack.
RA 92	Accommodates up to three HSP-A Power Supplies in a 19-inch rack. Bus bars (\pm) connect the outputs of slots 1 and 2 in parallel for use with hot-swap or parallel/redundant applications Slot 3 is independent of the other two. HSP-As can be easily removed and inserted without affecting system operation.
RA 92-23E,	Same as RA 90 except mounting ears are wider to accommodate a 23-inch rack.
RA 92-24E	Same as RA 90 except mounting ears are wider to accommodate a 24-inch rack.
RA 93	Accommodates up to three HSP-A Power Supplies in a 19-inch rack. Used for hot-swap independent, series or parallel/redundant applications. HSP-As are plugged in to the rack adapter and can be easily removed and inserted without affecting system operation.
RA 93-23E,	Same as RA 90 except mounting ears are wider to accommodate a 23-inch rack.
RA 93-24E	Same as RA 90 except mounting ears are wider to accommodate a 24-inch rack.
RA 90-**V	Lower cost RA 90 (three units in parallel), each slot keyed at Kepco to a selected bus voltage (see PAR. 2.2) indicated by ** (e.g., RA 90-28V). These racks may be rekeyed for a different bus voltage by disassembling the rack and using pemnuts supplied in Kepco KIT 210-0666.
RA 92-**V	Lower cost RA 92 (two units in parallel, one independent), each slot keyed at Kepco to a selected bus voltage (see PAR. 2.2) indicated by ** (e.g., RA 92-28V). These racks may be rekeyed for a different bus voltage by disassembling the rack and using pemnuts supplied in Kepco KIT 210-0666.



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FIGURE 1-2. MECHANICAL OUTLINE DRAWING, SERIES RA 90 RACK ADAPTER (SHEET 1 OF 2)



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FIGURE 1-2. MECHANICAL OUTLINE DRAWING, SERIES RA 90 RACK ADAPTER (SHEET 2 OF 2)

1.4 ACCESSORIES

Accessories for RA 90 Series and HSP-A Power Supplies are listed in Table 1-2.

TABLE 1-2. ACCESSORIES

ACCESSORY	PART NUMBER	USE
MOUNTING BRACKETS (SETBACK MOUNTING)	128-1714	Used to mount RA 90 in 19-inch rack using "set back" position (see Figure 2-4).
	128-1736	Used to mount RA 90 in 23-inch rack using "set back" position (see Figure 2-4).
	128-1827	Used to mount RA 90 in 24-inch rack for "set back" position (see Figure 2-4).
MOUNTING BRACKETS (STANDARD, FLUSH MOUNTING)	128-2405	Standard mounting ear for 19-inch rack applications.
	128-2416	Used for standard (flush) mounting of RA 90 in 23-inch rack (see Figure 2-4).
	128-2415	Used for standard (flush) mounting of RA 90 in 24-inch rack (see Figure 2-4).
FILLER PANELS	RFP 60-1	Covers 1/3 of front panel.
	RFP 60-2	Covers 2/3 of front panel.
ALUMINUM FEET	158-0004	Aluminum feet attach to bottom of rack adapter (set of four).
SCREW	101-0215	Used to attach aluminum feet to rack adapter.
SLIDE KIT (preferred)	Kit 219-0433	Slide Kit includes two slides, mounting brackets and attaching hardware; allows rack adapter to be pulled out of rack. Recommended for 18-20 inch setback to intermediate cabinet rail.
SLIDE KIT	Kit 219-0442	Slide Kit includes two slides, extended mounting brackets and attaching hardware; allows rack adapter to be pulled out of rack. Recommended for 22-26 inch setback to intermediate or rear cabinet rail if Kit 219-0433 can not be used.
SAFETY COVER, BACKPLATE	137-0136	Cover source power, d-c, and I/O connections.
SCREW	101-0456	Pan head, phillips, self-forming, 6-32 x 1/4 used to attach safety covers.
SUPPORT BRACKET	128-1775	Pair required. Used to provide side support for rack adapter. Requires rear rail at 18-13/16 in. setback.
CABLE ASSEMBLIES	118-0974	Mates with I/O connector. Provides connection between pins 19 (–error sense) and 37 (+error sense) to two wires terminated in ring lugs for ±error sense connections.
	118-1133	Simplifies I/O connections for two units in parallel. Provides connections between two I/O connectors: pins 14 (current share), 19 (–error sense) and 37 (+error sense). Two wires terminated in ring lugs are provided for ±error sense connections.
	118-1095	Simplifies I/O connections for three units in parallel. Provides connections between three I/O connectors: pins 14 (current share), 19 (–error sense) and 37 (+error sense). Two wires terminated in ring lugs are provided for ±error sense connections.
DSUB TO EUROBLOCK CONVERTER	KIT 219-0646	Allows wiring to Euroblocks rather than pins of I/O (DSUB) connector.
PEMNUT KEYING KIT	KIT 219-666	Provides pemnuts used to change factory preset voltage keying of RA 90-**V and RA 92-**V models,

TABLE 1-2. ACCESSORIES (CONTINUED)

LINE CORD	118-1146	Power cord with IEC 60309 32A/250V plug
	118-1421	Power cord with IEC 60309 16A/220V plug
	118-1422	Power cord with 10AWG conductors, 30A/120V 15-30P locking type connector
	118-0506	Power Cord, 250V a-c NEMA 5-15 plug
	118-1416	Power Cord NEMA 6-20P, 20A-250V plug with splitter: 2 legs, stripped wires.
	118-1415	Power Cord NEMA 6-20P, 20A-250V plug with splitter: 2 legs NEMA 6-20 receptacles
	118-1418	Power Cord, 12 AWG unterminated
	118-1419	Power Cord, 1.5mm ² unterminated
	118-1420	Power Cord, 12 AWG, JIS C8303 Plug
	118-1422	Power Cord, 30A/120V, L5-30P locking plug, 10 AWG
	118-1423	Power Cord, 1.5mm ² , 16A/220V CEE 7/7 plug
	118-1424	Power Cord, 1.5mm ² , 15A/240V, BS 546 plug

SECTION 2 - INSTALLATION

2.1 UNPACKING AND INSPECTION

This instrument has been thoroughly inspected and tested prior to packing and is ready for operation. After careful unpacking, inspect for shipping damage before attempting to operate. If any indication of damage is found, file an immediate claim with the responsible transport service. See Table 2-1 for a list of equipment supplied.

TABLE 2-1. EQUIPMENT SUPPLIED

MODEL	ITEM	QUANTITY	PART NUMBER
RA 90	± Bus Bar * (installed) ties outputs 1, 2 and 3 together	2	172-0703
RA 93	± Bus Bar * (installed) ties outputs 1 and 2 together	2	172-0730
RA 90, 92	Split Lockwasher *	6	103-0005
RA 90, 92	Hex Nut, 5/16-18 *	6	102-0105
RA 93	Keps nut 1/4-20 *	6	192-0198
RA 92	Keps nut 1/4-20 *	2	192-0198
RA 90, 92, 93	Instruction Manual	1	243-0909
* Mounting hardware assembled to output studs.			

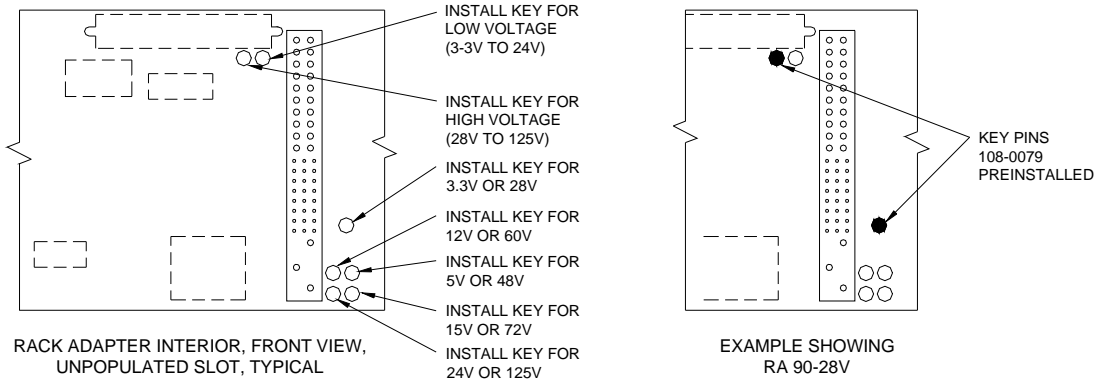
2.2 RACK ADAPTER KEYING INSTRUCTIONS

All RA 90 Series rack adapters incorporate a keying mechanism to prevent accidental insertion of the incorrect model HSP-A power supply into any position. The HSP-A power supplies are keyed by voltage at the factory. The keying mechanism will prevent engagement of any of the HSP-A power supply's connectors with those on the rack adapter's intermediate plate unless the key and keyway align. The user can configure each power supply position of the rack adapters for the desired voltage in the desired position; the factory default keying is for the 5-volt HSP-A module (see Figure 2-1).

The key guide pins (Kepco P/N 108-0079) used for module keying are located on the motherboard (see Figure 2-1) and are accessed through the front of the rack adapter. To alter the keying of any position, simply unscrew the key pin from the intermediate plate using a 1/4" nutdriver or deep socket, reposition key pin at new location and retighten. HSP-A module keying is identified in Figure 2-1 and in the HSP-A operator's manual. **DO NOT ALTER THE KEYING AT THE POWER SUPPLY!**



NOTE: RA 90-**V models do not permit any keying changes using the keying pins accessed through the front panel. Keying changes for these models require the use of pemnuts supplied in KIT 219-0666 installed on the motherboard (see Table 1-2).

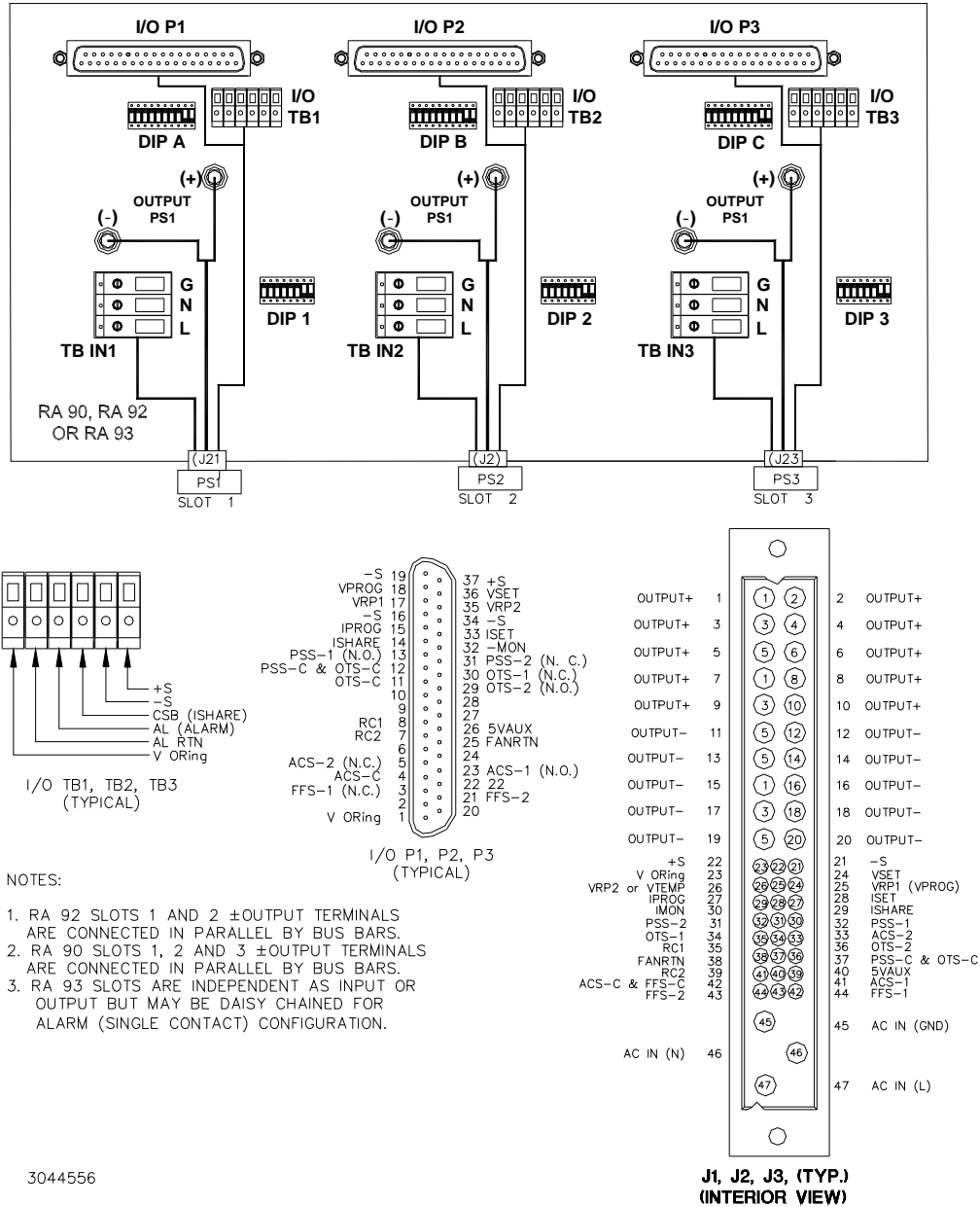


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FIGURE 2-1. KEY PIN LOCATION

2.3 TERMINATIONS

All input, output and control terminations are located on the rear panel of the rack adapter (see Figure 2-2). Refer to PAR. 2.2 module keying, Refer to PAR. 2.5 to configure local/remote sensing, current share, and alarms.



NOTES:

1. RA 92 SLOTS 1 AND 2 ±OUTPUT TERMINALS ARE CONNECTED IN PARALLEL BY BUS BARS.
2. RA 90 SLOTS 1, 2 AND 3 ±OUTPUT TERMINALS ARE CONNECTED IN PARALLEL BY BUS BARS.
3. RA 93 SLOTS ARE INDEPENDENT AS INPUT OR OUTPUT BUT MAY BE DAISY CHAINED FOR ALARM (SINGLE CONTACT) CONFIGURATION.

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FIGURE 2-2. REAR PANEL CONNECTIONS

2.4 COOLING



The HSP-A power supplies mounted within the rack adapter are maintained within their operating temperature range by means of internal cooling fans. ALL INLET AND EXHAUST OPENINGS AROUND THE RACK ADAPTER CASE MUST BE KEPT CLEAR OF OBSTRUCTION TO ENSURE PROPER AIR ENTRY AND EXHAUST. Care must be taken that the ambient temperature, which is the temperature of the air immediately surrounding the rack adapter, does not rise above the specified limits for the operating load conditions of the installed HSP-A power supplies. Kepco recommends providing additional space above and below the rack adapter where possible when the rack adapter is fully populated.

2.5 SLOT CONFIGURATION

The RA 90 Series rack adapters require that each pair of DIP switches associated with the three slots be configured for sense connections, current sharing and alarm reporting. The rack adapters are shipped with the DIP switches set for local sensing, current sharing of parallel-connected slots (slots 1 and 2 of RA 92, and slots 1, 2 and 3 of RA 90), and normally-closed alarms. These settings are documented and explained in the RA 90 Series Quick Start Guide that can be downloaded from the Kepco web site at

www.kepcopower.com/support/opmanls.htm#ra90

The following paragraphs explain alternatives to using the DIP switches. In the case of alarm configurations, using the DIP switches allows simpler wiring to a single pair of monitoring contacts, however this requires monitoring of the HSP-A front panel lights. For very specific alarms, the I/O DB37 connector may be used with alarm monitoring wires connected via KIT 219-0666 DB37 to Euroblock Adapter.



NOTE: If the output bus bars are removed from RA 90 or RA 92, the instructions for RA 93 are then applicable to the altered RA 90 and RA 92 models.

2.5.1 INDEPENDENT SLOTS, SENSE CONNECTIONS

The sense connections of an independent slot must not be connected to an adjacent slot. So for a slot to be independent, positions 3 and 4 of the associated DIP 1, 2, or 3 must be set to OFF (e.g., DIP 1 for slot 1 to be independent).

Since there is no current sharing of independent slots, position 5 of the associated DIP 1, 2, or 3 must be set to OFF.

2.5.1.1 LOCAL SENSING

Local sensing using the DIP switches is described in the RA 90 Series Quick Start Guide. To use local sensing with external wiring, set positions 1 and 2 of the associated DIP 1, 2 or 3 to OFF (e.g., DIP 1 for slot 1).and refer to Figure 2-3. Refer to PAR. 2.8.5.1 for additional details regarding local sense connections of independent slots.

NOTES:

1. POSITION 1 AND 2 OF DIP 1, 2, OR 3 MUST BE OFF WHEN USING EXTERNAL SENSE WIRES.
2. POSITION 3 AND 4 OF DIP 1, 2, OR 3 MUST BE OFF WHEN THE SLOT IS CONFIGURED AS INDEPENDENT.

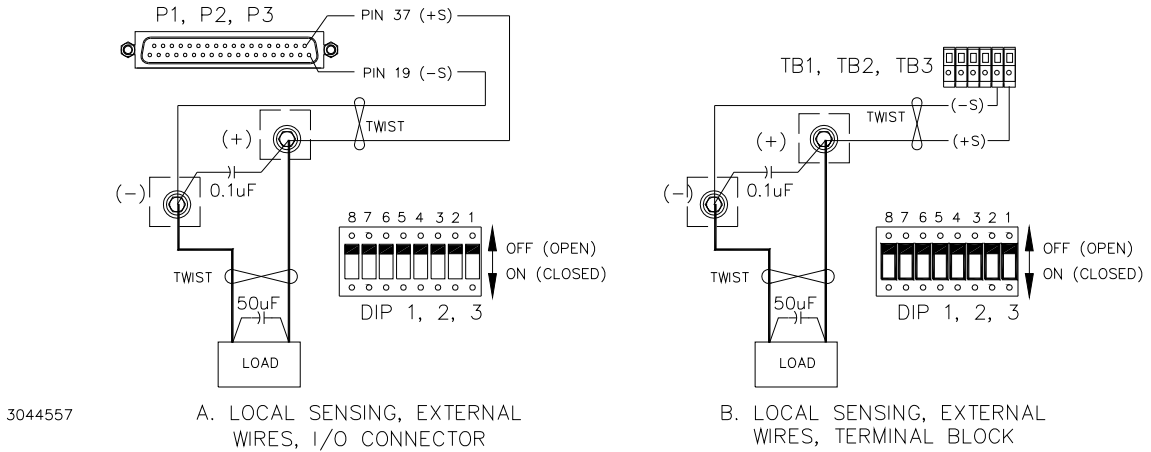


FIGURE 2-3. INDEPENDENT SLOT, LOCAL SENSING USING EXTERNAL WIRES

2.5.1.2 REMOTE SENSING

To use remote sensing with external wiring, set positions 1 and 2 of the associated DIP 1, 2 or 3 to OFF (e.g., DIP 1 for slot 1).and refer to Figure 2-4. Refer to PAR. 2.8.5.2 for additional details regarding remote sense connections of independent slots.

NOTES:

1. SENSE CONNECTION ARE REQUIRED FOR HSP-A POWER SUPPLIES TO WORK.
2. ONLY ONE SET OF SENSE CONNECTIONS ALLOWED: VIA EITHER 1) DIP SWITCHES, 2) I/O CONNECTORS OR 3) TERMINAL BLOCKS.
3. POSITION 1 AND 2 OF DIP 1, 2, OR 3 MUST BE OFF WHEN USING EXTERNAL SENSE WIRES.
4. POSITION 3 AND 4 OF DIP 1, 2, OR 3 MUST BE OFF WHEN THE SLOT IS CONFIGURED AS INDEPENDENT.

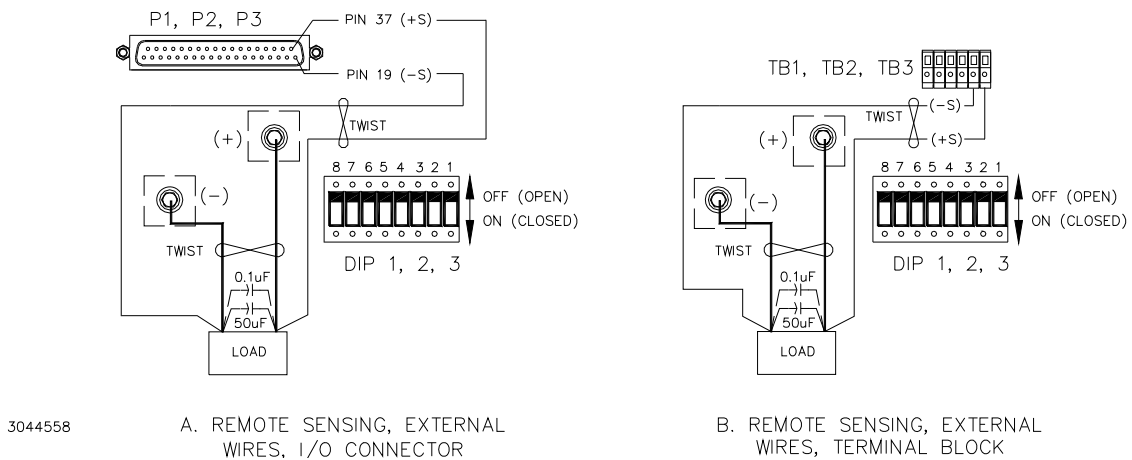


FIGURE 2-4. INDEPENDENT SLOT, REMOTE SENSING USING EXTERNAL WIRES

2.5.2 PARALLEL SLOTS, SENSE CONNECTIONS

For RA 92 the outputs of slots 1 and 2 are already connected in parallel. For RA 90 the outputs of slots 1, 2 and 3 are already connected in parallel.

If converting RA 93 from individual to parallel operation, to convert to RA 90 install two 3X bus bars; to convert to RA 92 install two 2X bus bars. Then follow the instructions local or remote sensing for the applicable model below. NOTE: Paralleling of non-adjacent slots is not recommended.

Once the desired slots have been paralleled as described above, the next step is to connect the outputs of the slots that are to be in parallel: (+) to (+) and (-) to (-). Refer to PAR. 2.8.5.4 for additional details regarding parallel sense connections.

2.5.2.1 LOCAL SENSING

Verify that the desired outputs of the slots have been connected in parallel, then configure DIP 1, 2 and 3 (positions 1 through 4) as shown in Table 2-2 as needed. For RA 90, see Table 2-2 slots 1, 2 and 3 in parallel. For RA 92, see Table 2-2 slots 1 and 2 in parallel.

To connect RA 90 or RA 92 slots 1/2, 2/3, 1/3, or 1/2/3 in parallel with local sensing using external wiring, refer to Figure 2-3, however connect external sensing wires for **ONLY ONE** of the two or three slots in parallel. Then connect +S and -S of paralleled slots in parallel using one of the following methods:

- a). **Sense Lines in Parallel Using DIP switches DIP 1, DIP 2 and/or DIP3, positions 3 and 4.** - When slots 1 and 2 are paralleled, DIP 1 and DIP 2 positions 3 and 4 are ON, DIP 3 positions 3 and 4 must be set to OFF. When all slots are paralleled, DIP 1, DIP 2, and DIP 3 positions 3 and 4 must be set to ON.
- b). **Sense Lines in Parallel Using Euroblocks TB1, TB2 and/or TB3.** - set positions 3 and 4 of paralleled slot DIP switch to OFF (e.g., for slot 1 and 2 in parallel, DIP 1 and 2, positions 3 and 4, must be set to OFF). Then, at TB1, TB2 and TB3 wire S+ to S+ and S- to S- of all the slots to be in parallel.
- c). **Sense Lines in Parallel Using I/O (DB 37 DSUB) connectors P1, P2, or P3, pins 19 and 37.** - set positions 3 and 4 of paralleled slot DIP switch to OFF (e.g., for slot 1 and 2 in parallel, DIP 1 and 2, positions 3 and 4, must be set to OFF). Then, at P1, P2 and P3 pin 37, wire S+ to S+ and at pin 19 wire S- to S- of all the slots to be in parallel.

TABLE 2-2. RA 93 DIP SWITCH SETTINGS FOR LOCAL SENSING*

Convert RA 93 to Rack Adapter Model	Rack Adapter slots in parallel	DIP 1 Positions 1 to 4				DIP 2 Positions 1 to 4				DIP 3 Positions 1 to 4			
		1	2	3	4	1	2	3	4	1	2	3	4
RA 90	1, 2, 3 ⁽¹⁾	ON	ON	ON	ON	OFF	OFF	ON	ON	OFF	OFF	ON	ON
RA 92	1, 2 ⁽²⁾	ON	ON	ON	ON	OFF	OFF	ON	ON	ON	ON	OFF	OFF

2.5.2.2 REMOTE SENSING

To connect remote sensing for paralleled slots use **ONLY ONE** pair of remote sensing wires using external wiring, refer to Figure 2-4. Then connect +S and -S of paralleled slots in parallel using one of the methods described above (see PAR 2.5.2.1, a, b, or c).

2.5.3 LOAD/CURRENT SHARING

Load sharing, (current sharing or current balancing) can be accomplished using either the rack adapter DIP switches, or by using external wires at Euroblocks TB1, TB2 and TB3 or at I/O (DB 37 DSUB) connector P1, P2 and P3.

2.5.3.1 LOAD/CURRENT SHARING USING DIP SWITCHES

For current sharing of paralleled slots using DIP switches, see Table 2-3.

TABLE 2-3. DIP SWITCH SETTINGS FOR CURRENT SHARING

Rack Adapter Model	Current Sharing of Parallel Slots	DIP 1 Positions 5	DIP 2 Positions 5	DIP 3 Positions 5
RA 90	Slots 1, 2 and 3	ON	ON	ON
RA 92	Slot 1 and 2	ON	ON	OFF

2.5.3.2 LOAD/CURRENT SHARING USING EXTERNAL WIRING

For current sharing of paralleled slots using external wires, set position 5 of DIP 1, 2 and 3 to OFF. Then use **ONLY ONE** of the following: (see Figure 2-5).

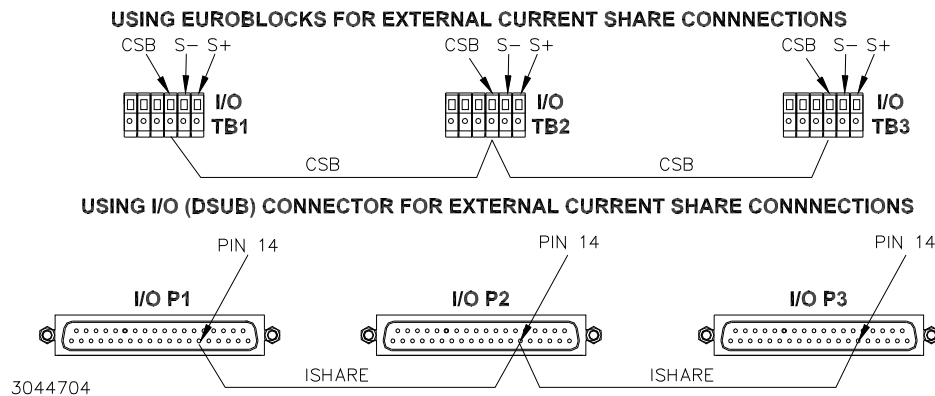


FIGURE 2-5. CURRENT SHARE CONNECTIONS USING EXTERNAL WIRING

- TB1, 2, and/or 3 - connect the CSB terminals of slots to be paralleled. For example to parallel slots 1 and 2, connect the CSB terminal of I/O TB1 to the CSB terminal of I/O TB2.
- P1, P2, and/or P3 - connect pin 14 (ISHARE) of the I/O connector for slots to be paralleled. For example to parallel slots 1 and 2, connect pin 14 (ISHARE) of P1 to pin 14 (ISHARE) of P2.

Up to two racks (six power supplies maximum) may be used in parallel with load sharing without minimum load requirements. This can be accomplished by daisy chaining pin 14 (ISHARE) at the I/O (DSUB) connectors or the CSB terminal of the Euroblocks of all slots (units) in parallel.

2.5.4 ALARMS

Each HSP-A power supply provides alarms for four faults, indicating failures of output, overtemperature, source power and fan. Each alarm has a pair of signals, one for normally-closed (N.C.), one for normally-open (N.O.). The rack adapters are shipped with these four alarm signals OR'ed to provide a common signal (AL and AL RTN) available at the rack adapter terminal blocks, TB1, TB2 and TB3 as defined by DIP A, B and C plus positions 6, 7, and 8 of DIP 1, 2 and 3. The default alarm configurations are established by the DIP settings noted in Table 4 and explained in the corresponding notes.

TABLE 2-4. DIP SWITCH SETTINGS FOR TYPICAL ALARM CONFIGURATIONS

Rack Adapter Model	Alarm Status: N.O. (Normally Open) N.C. (Normally Closed)	SLOT 1				SLOT 2				SLOT 3			
		DIP 1 Positions 6 to 8		DIP A Positions 1 to 10		DIP 2 Positions 6 to 8		DIP B Positions 1 to 10		DIP 3 Positions 6 to 8		DIP C Positions 1 to 10	
		ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
RA 90 (1)	N.O.	None	6,7,8	5 to 9	1,2,3,10	6,7	8	5 to 9	1,2,3,10	6,7	8	5 to 9	1,2,3,10
RA 90 (2)	N.C. (default)	6, 8	7	1,2,3	5 to 10	8	6,7	1,2,3	5 to 10	8	6,7	1,2,3	5 to 10
RA 92 (3)	N.O.	None	6,7,8	4 to 10	1,2,3	6,7	8	4 to 10	1,2,3	None	6,7,8	4 to 10	1,2,3
RA 92 (4)	N.C. (default)	6,7	8	1,2,3	4 to 10	None	6,7,8	1,2,3	4 to 10	None	6,7,8	1,2,3,10	4 to 9
RA 93 (5)	N.O.	N/A	N/A	4 to 10	1,2,3	N/A	N/A	4 to 10	1,2,3	N/A	N/A	4 to 10	1,2,3
RA 93 (6)	N.C. (default)	N/A	N/A	1,2,3,10	4 to 9	1,2,3	N/A	1,2,3,10	4 to 9	N/A	N/A	1,2,3,10	4 to 9

NOTES:

- (1) RA 90 (3 slots in parallel) configured for NO (Normally Open) alarm. Any failure of PS1, PS2 or PS3 causes a short circuit across AL and AL RTN terminals of TB1, TB2 or TB3 at rear panel (normally open with no failures).
- (2) RA 90 (3 slots in parallel) configured for NC (Normally Closed) alarm. Any failure of PS1, PS2 or PS3 causes an open circuit across AL and AL RTN terminals of TB1 at rear panel (normally short circuit with no failures). These N. C. alarm settings are the default settings for RA 90.
- (3) RA 92 (slots 1 and 2 in parallel, slot 3 independent) configured for NO (Normally Open) alarm. Any failure of PS1 or PS2 causes a short circuit across AL and AL RTN terminals of TB1 and TB2 at rear panel (normally open with no failures). A failure of PS3 causes a short circuit across AL and AL RTN terminals of TB3 (normally open with no failures).
- (4) RA 92 (slots 1 and 2 in parallel, slot 3 independent) configured for NC (Normally Closed) alarm. Any failure of PS1 or PS2 causes an open circuit across AL and AL RTN terminals of TB1 and TB2 at rear panel (normally short circuit with no failures). A failure of PS3 causes an open circuit across AL and AL RTN terminals of TB3 (normally short circuit with no failures). These N. C. alarm settings are the default settings for RA 92.
- (5) RA 93 (3 slots independent) configured for NO (Normally Open) alarm. Any failure of PS1, PS2 or PS3 causes a short circuit across AL and AL RTN terminals of the corresponding slot: TB1, TB2 or TB3 at rear panel (normally open with no failures).
- (6) RA 93 (3 slots independent) configured for NC (Normally Closed) alarm. Any failure of PS1, PS2 or PS3 causes an open circuit across AL and AL RTN terminals of the corresponding slot: TB1, TB2 or TB3 at rear panel (normally short circuit with no failures). These N. C. alarm settings are the default settings for RA 93.

2.6 INSTALLATION (Refer to “Mechanical Outline Drawing,” Figure 1-2.

RA 90 Series rack adapters are designed for rack-mounted applications. The rack adapter will mount directly to EIA standard 19" racks; optional mounting ears are available to provide for mounting to EIA standard 23" and 24" racks (see Figure 2-6 and Table 1-2). Other fixed mounting applications are possible; consult factory for details.

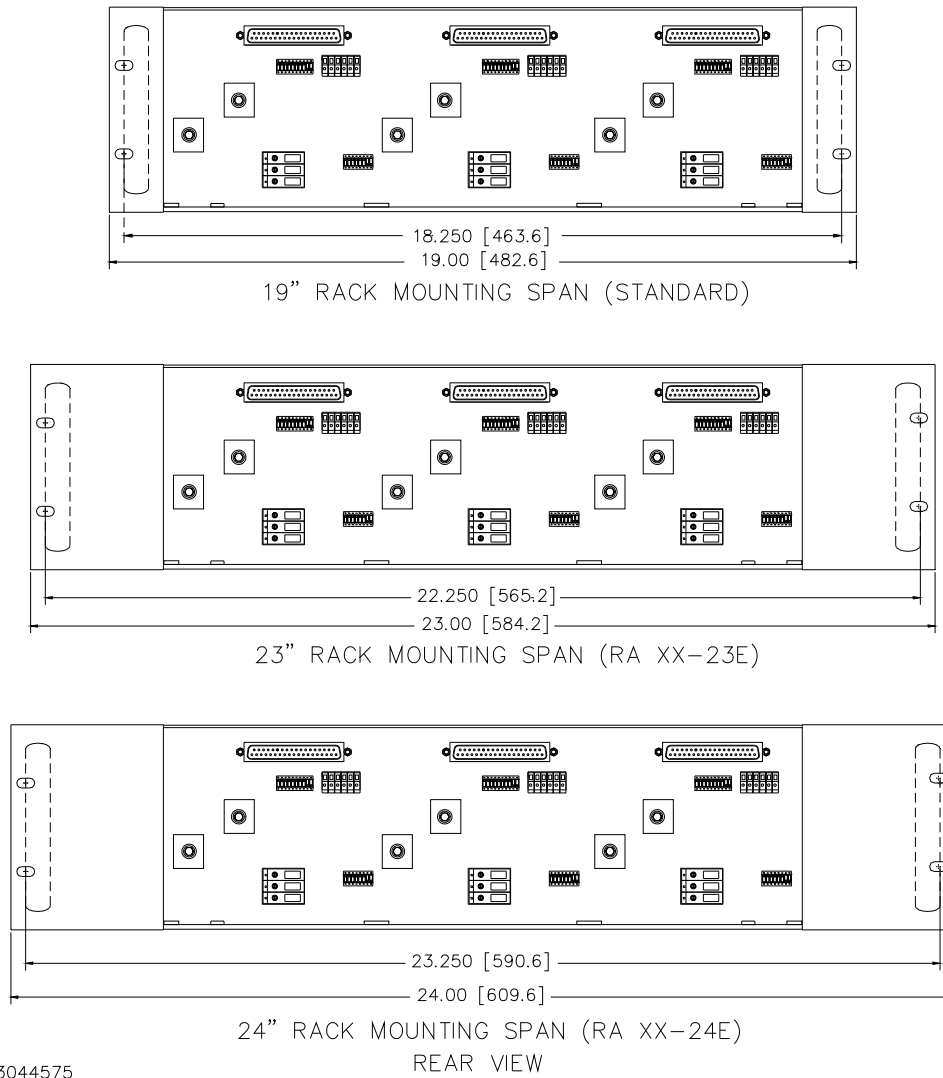


FIGURE 2-6. MOUNTING DIMENSIONS

- (a) When used in fixed rack-mounted applications, the rack adapter is attached to the rack via the two mounting ears; two screws are required per mounting ear for proper support.
- (b) The rack adapter can be attached to the rack using chassis slides; the rack adapter sides are predrilled for 18" (457.2mm) chassis slides (see Table 1-2).

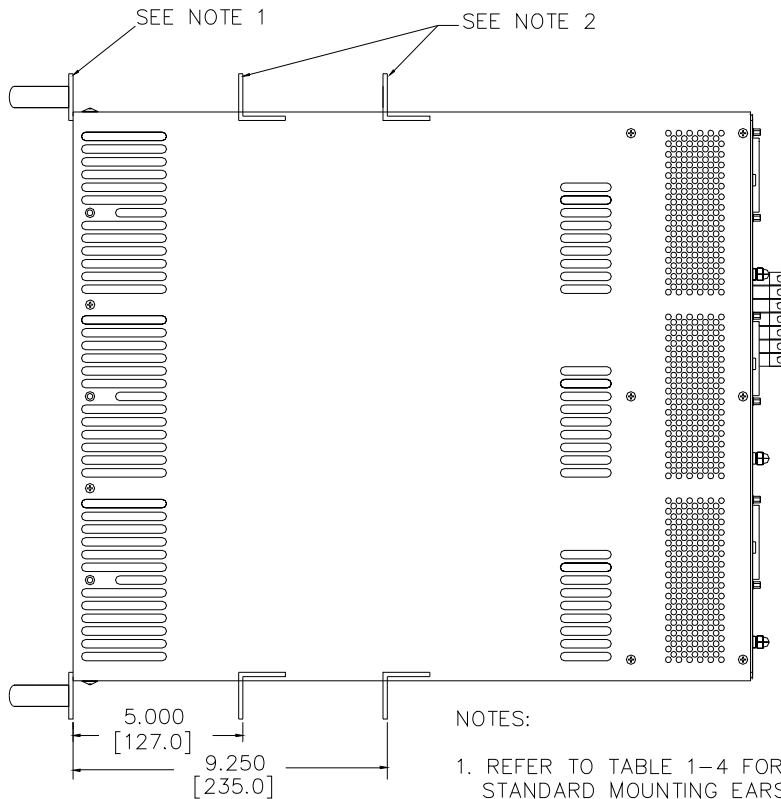
(c) For applications which require less depth protrusion of the rack adapter within the rack, the rack adapters provide two “set-back” positions for use with optional notched mounting ears (see Tables 1-1 and 1-2); see Figure 2-7 for set-back dimensions.

For all installations provide adequate clearance around air inlet and exhaust locations and ensure that the temperature immediately surrounding the unit, and especially near the air inlets, does not exceed the maximum specified ambient temperature for the operating conditions of the installed power supplies.



CAUTION

WHEREVER POSSIBLE RACK ADAPTER SHOULD BE MOUNTED BEFORE INSTALLING POWER SUPPLIES TO AVOID DISTORTION OF THE RACK ADAPTER (INSTALL POPULATED RACK ADAPTER ONLY IF BOTTOM OF RACK ADAPTER IS FULLY SUPPORTED). FAILURE TO OBSERVE THIS CAUTION MAY RESULT IN MISALIGNMENT OF THE POWER SUPPLIES WITH THE RACK ADAPTER.



- NOTES:
1. REFER TO TABLE 1-4 FOR PART NUMBERS OF STANDARD MOUNTING EARS USED FOR FLUSH MOUNTING IN 19-, 23- AND 24-INCH RACKS.
 2. REFER TO TABLE 1-4 FOR PART NUMBERS OF SETBACK MOUNTING EARS USED FOR SETBACK MOUNTING IN 19-, 23- AND 24-INCH RACKS.

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FIGURE 2-7. SET-BACK DIMENSIONS

2.6.1 MOUNTING EAR INSTALLATION

If mounting ears are removed, or optional mounting ears are purchased to allow installation in a different size rack (see Table 1-2), install each standard (flush) mounting ear on the rack adapter cover as shown in Figure 2-8). Attach mounting ear to cover using the four screws provided.

Installation of the setback mounting ears is similar to the above procedure, except the setback flange is first inserted in the slot on the rack adapter cover, then rotated 90 degrees as shown in Figure 2-8).

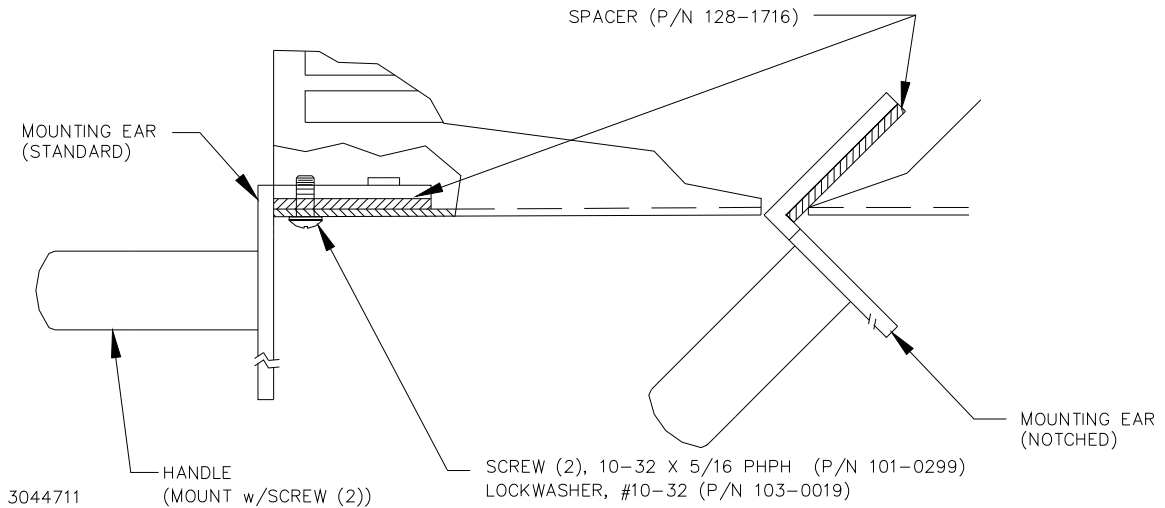


FIGURE 2-8. MOUNTING EAR INSTALLATION

2.7 HSP-A MODULE INSERTION/REMOVAL

Refer to the HSP-A Operator Manual (Section 3 - Operating Instructions), to review the HSP-A features and properly configure them before inserting the module in the rack adapter. Follow the instructions provided in the HSP-A Operator Manual for proper insertion of HSP-A modules into the RA 90 Series rack adapter, as well as for proper removal.

2.8 WIRING INSTRUCTIONS

Interconnections between an a-c power source and a stabilized power supply, and between the power supply and its load are as critical as the interface between other types of electronic equipment. If optimum performance is expected, certain rules for the interconnection of source, power supply and load must be observed by the user. These rules are described in detail in the following paragraphs.

2.8.1 SAFETY GROUNDING

Local, national and international safety rules dictate the grounding of the metal cover and case of any instrument connected to the a-c power source, when such grounding is an intrinsic part of the safety aspect of the instrument. The ground terminal of the source power terminal blocks (see Figure 2-2) is connected to the HSP-A chassis through the rack adapter and the instructions below suggest wiring methods which comply with these safety requirements; however, it is the customer's responsibility to ensure that all applicable electric codes for safety grounding requirements are met.



WARNING: IT IS IMPERATIVE THAT THE USER PROVIDE ALL THREE SOURCE WIRE CONNECTIONS, AS THIS CONNECTION IS THE SAFETY GROUND PROVISION!

Connections between the power supply and the load and sensing connections may, despite all precautions such as shielding, twisting of wire pairs, etc., be influenced by radiated noise, or "pick-up". To minimize the effects of this radiated noise the user should consider grounding one side of the power supply/load circuit. The success of d-c grounding requires careful analysis of each specific application, however, and this recommendation can only serve as a general guideline.

One of the most important considerations in establishing a successful grounding scheme is to avoid GROUND LOOPS. Ground loops are created when two or more points are grounded at different physical locations along the output circuit. Due to the interconnection impedance between the separated grounding points, a difference voltage and resultant current flow is superimposed on the load. The effect of this ground loop can be anything from an undesirable increase in output noise to disruption of power supply and/or load operation. The only way to avoid ground loops is to ensure that the entire output/load circuit is fully isolated from ground, and only then establish a single point along the output/load circuit as the single-wire ground point.

The exact location of the "best" d-c ground point is entirely dependent upon the specific application, and its selection requires a combination of analysis, good judgement and some amount of empirical testing. If there is a choice in selecting either the positive or negative output of the power supply for the d-c ground point, both sides should be tried, and preference given to the ground point producing the least noise. For single, isolated loads the d-c ground point is often best located directly at one of the output terminals of the power supply; when remote error sensing is employed, d-c ground may be established at the point of sense lead attachment. In the specific case of an internally-grounded load, the d-c ground point is automatically established at the load.

The output terminals of HSP-A power supplies are d-c isolated ("floating") from the chassis in order to permit the user maximum flexibility in selecting the best single point ground location. Output ripple specifications *as measured at the output* are equally valid for either side grounded. Care must be taken in measuring the ripple and noise at the power supply: measuring devices which are a-c line operated can often introduce additional ripple and noise into the circuit.

There is, unfortunately, no "best" method for interconnecting the load and power supply. Individual applications, location and nature of the load require careful analysis in each case. Grounding a single point in the output circuit can be of great importance. It is hoped that the preceding paragraphs will be of some assistance in most cases. For help in special applications or difficult problems, consult directly with Kepco's Application Engineering Department.

2.8.2 SOURCE POWER CONNECTIONS

Depending on your application, source branch current rating may be significantly less than the rating of the HSP-A circuit breaker, especially in configurations where HSP-A are used in parallel/redundant applications. The HSP-A circuit breaker rating is based on worst-case operating conditions. However, since HSP-A power supplies are switch-mode power supplies, the source power drain is constant and essentially independent of source voltage, regardless of load power requirements. Therefore under normal, rather than worst case, conditions, HSP-A draw substantially less than the rated maximum input current, particularly at higher source voltages. Contact Kepco Applications Engineering for additional information.

When used in conjunction with Kepco HSP-A series power supplies, these rack adapters can be operated from either single-phase or three-phase a-c source power without adjustment or modification. Voltage and frequency limits are determined by the source power rating of the HSP-A power supplies. Operation from d-c power is also available; please contact factory for limitations imposed when using d-c source power.

The rear panel of RA 90 Series rack adapters includes three terminal blocks: TB IN13, TB IN24, TB IN56 (Figure 2-2) to allow for independent connection of single-phase a-c and d-c input power. The terminals of each terminal block are labeled L, N, and G. Wires must be sized according to expected current. Each terminal block will accommodate up to #6 AWG (16mm²) (minimum #18 AWG), or equivalent conductor size; torque to 15 lb-in (1.5 N•M) maximum. Their functions are:

- **Terminal G** is the safety ground connection for the rack adapter. It is connected to the rack adapter chassis as well as to the safety ground terminal of the three rack adapter/power supply interface connectors (J1, J2, and J3, Figure 2-2), one for each of the three power supply mounting positions. Regardless of the type of source power provided, Terminal G must be connected to safety ground in order to ensure proper grounding of the HSP-A power supplies when installed. The conductor used to connect Terminal G to safety ground must be sized to support the total fault current of all of the power supplies installed in the rack adapter; for HSP-A series power supplies, the ground fault current rating is 20 amperes per power supply. Consult local electric codes for the proper wire size to carry the required fault current.
- **Terminal pairs L, N** are connected to the high-side and low-side pins of the of the three rack adapter/power supply interface connectors (J1, J2, and J3, Figure 2-2), one for each of the three power supply mounting positions. Each terminal pair (L/N) is isolated from the remaining two pairs, facilitating redundant source power connections if desired. The conductor used to connect terminals L and N to source power must be sized for the 16 ampere maximum source current drawn by HSP-A Series power supplies; Kepco recommends #14 AWG (2.5mm²) or equivalent minimum conductor size to support this current.

2.8.3 SOURCE POWER CONFIGURATIONS

The following standard wiring configurations are recommended by Kepco as being compliant with national and international safety standards. It is the user's responsibility to ensure that all applicable local electric codes are met. The minimum and maximum limits for source power voltage are defined in HSP-A series power supply specifications.



CAUTION: UNDER NO CIRCUMSTANCES SHOULD THE STEADY-STATE SOURCE VOLTAGE APPLIED ACROSS ANY L/N PAIR EXCEED 277V rms!

2.8.3.1 A-C SOURCE POWER, SINGLE PHASE FIELD WIRING

For independent single-phase a-c source power of each position, connect source power safety ground to Terminal G of the rack adapter source power terminal blocks TB IN13, TB IN24, TB IN56 (Figure 2-2); then connect a separate wire pair from the power source to each L/N terminal block pair. (see Figure 2-9).

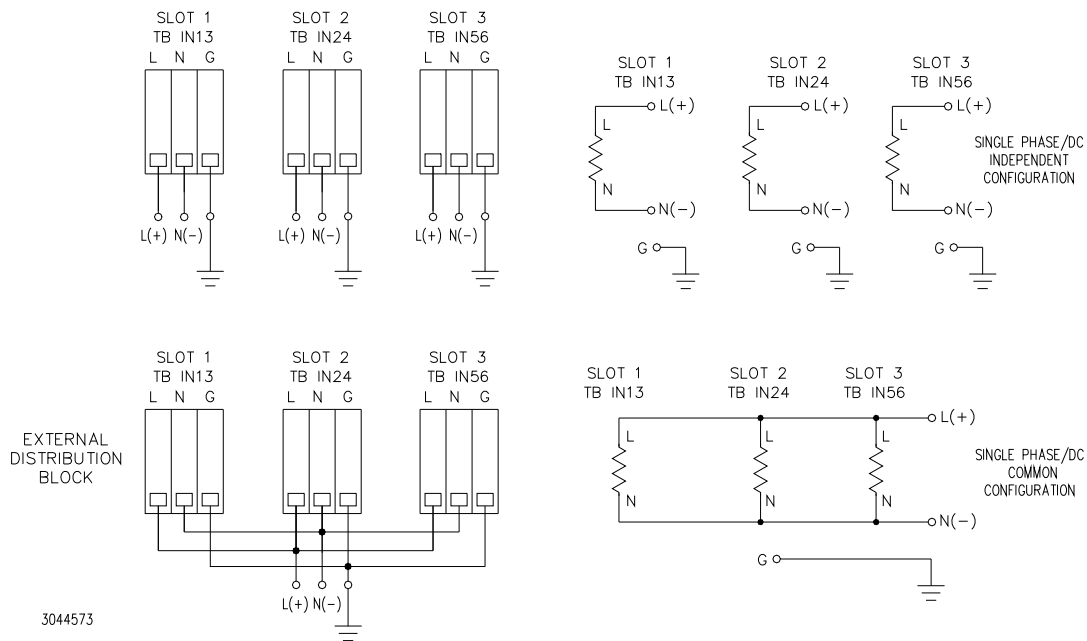


FIGURE 2-9. SINGLE PHASE A-C/D-C SOURCE POWER WIRING

If independent power sources are not required, a single wire pair can be run from the power source to any L/N pair, with jumpers connecting the remaining L/N pairs to the first pair; however, the wires must be adequately rated to support the total current being delivered through them. For the example shown in Figure 2-9, the jumper wires are sized for 16 amps, but the source wires must be sized for 3 times 16 amps, or 48 amps.

2.8.3.2 A-C SOURCE POWER, THREE PHASE FIELD WIRING

Three-phase a-c source power from either delta- or wye-configuration power sources can be used. When using wye-configuration power, the user should configure the power system so as to balance the load drawn from each phase to minimize the current flow in the source power neutral wire whenever possible. When possible, the user should wire the rack adapter in accordance with the instructions for delta power in order to take advantage of the lower input current

requirements. Regardless of the source power configuration, Terminal G of the rack adapter must be connected to safety ground.

- **Delta Power** - Connect a separate wire pair from each Lx/Nx pair on the rack adapter across successive line terminals of the source power (e.g., A-B, B-C, C-A) (see Figure 2-10).

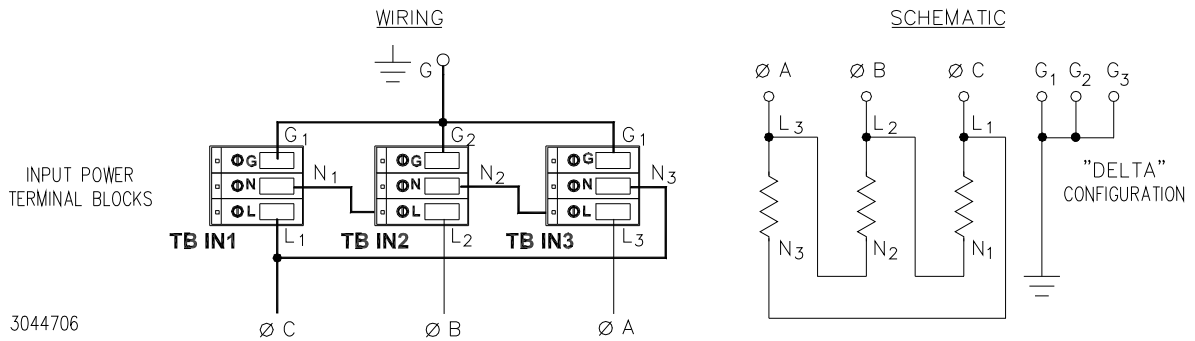


FIGURE 2-10. THREE PHASE DELTA A-C SOURCE POWER WIRING

- **Wye Power** - Connect a separate wire pair from each Lx/Nx pair on the rack adapter to line and neutral terminals of the power source, using successive line terminals (e.g., A-N, B-N, C-N) (see Figure 2-8)

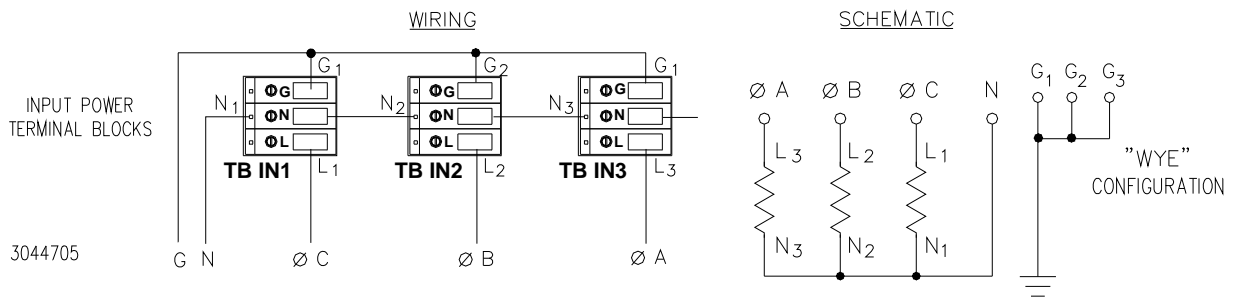


FIGURE 2-11. THREE PHASE WYE A-C SOURCE POWER WIRING

2.8.3.3 D-C SOURCE POWER

For d-c source power, wire the rack adapter in accordance with the instructions for single-phase a-c power per PAR. 2.8.3.1. Contact Kepco Applications Engineering for additional restrictions imposed by d-c source power.

2.8.4 POWER SUPPLY/LOAD INTERFACE

The general function of a voltage- or current-stabilized power supply is to deliver the rated output quantities to the connected load. The load may have any conceivable characteristic: it may be fixed or variable, it may have predominantly resistive, capacitive or inductive parameters; it may be located very close to the power supply output terminals or it may be a considerable distance away. The perfect interface between a power supply and its load would mean that the specified performance at the output terminals would be transferred without impairment to any load, regardless of electrical characteristics or proximity to each other.

The stabilized d-c power supply is definitely not an ideal voltage or current source, and practical interfaces definitely fall short of the ideal. All voltage-stabilized power supplies have a finite source impedance which increases with frequency, and all current-stabilized power supplies have a finite shunt impedance which decreases with frequency. The method of interface between the power supply output and the load must, therefore, take into account not only size with regard to minimum voltage drop, but configuration with regard to minimizing the impedance introduced by practical interconnection techniques (wire, bus bars, etc.). The series inductance of the load wire must be as small as possible as compared to the source inductance of the power supply: error sensing cannot compensate for reactive effects due to this. These dynamic conditions are especially important if the load is constantly modulated or step-programmed, or has primarily reactive characteristics, or where the dynamic output response of the power supply is critical to load performance.

2.8.5 LOAD CONNECTION - GENERAL

Load connections to the rack adapters are achieved via the stud pairs located on the rear panel directly behind each mounting position (see Figure 2-2). Required hardware for attaching output cables are assembled to the output studs. Wires must be sized according to expected current. Wire size range is between 22 and 6 GA, depending on the ring lug; torque to 40 lb-in (45 N•M) maximum. RA 90 rack adapters provide permanent interconnection of the three power supply positions for parallel/redundant configuration. All three load connections must be used when the 3.3 volt and 5 volt modules are used. RA 92 rack adapters provide permanent interconnection of two power supply positions (slots 1 and 2) for parallel/redundant configuration with slot 3 independent. All three slots of RA 93 rack adapters are independent, permitting a variety of load configurations. The following sections describe the basic output bus bar configurations available with Series RA 90 rack adapters. Additional information regarding these and other load interface requirements are contained in the HSP-A operator's manual.

The use of the proper fastener size and inclusion of a lockwasher are critical to maintaining intimate contact between the load conductor and output bus bar; Kepco recommends the use of fasteners made of conductive material (brass, phosphor bronze, etc.) to enhance conductivity; for high current loads (>100A) Kepco recommends the use of Bellville-style constant tension washers in place of conventional lockwashers.



NOTE: REGARDLESS OF OUTPUT CONFIGURATION, OUTPUT SENSE LINES MUST BE CONNECTED FOR OPERATION. OBSERVE POLARITIES: THE NEGATIVE SENSING WIRE MUST BE CONNECTED TO THE NEGATIVE LOAD WIRE, AND THE POSITIVE SENSING WIRE TO THE POSITIVE LOAD WIRE.

2.8.5.1 LOAD CONNECTION - METHOD I (LOCAL ERROR SENSING)

The most basic power supply/load interface is a 2-wire connection between the power supply output terminals and the load. This connection method employs local error sensing which consists of connecting the error sense leads directly to the power supply's output terminals. Its main virtue is simplicity: since voltage regulation is maintained at the power supply output, the regulation loop is essentially unaffected by the impedances presented by the load interconnection scheme. The main disadvantage is that it cannot compensate for losses introduced by the interconnection scheme and, therefore, regulation degrades directly as a function of distance and load current. The main applications for this method are for powering primarily resistive and relatively constant loads located close to the power supply, or for loads requiring stabilized current exclusively. The load leads should be tightly twisted to reduce pick-up. For independent slots refer to PAR. 2.5.1.1 for local sensing and PAR. 2.5.1.2 for remote sensing (see Figures 2-3 and 2-4). For parallel-connected slots refer to PAR. 2.5.2.1 for local sensing and PAR. 2.5.2.2 for remote (see Figure 2-13).

2.8.5.2 LOAD CONNECTION - METHOD II (REMOTE ERROR SENSING)

If the load is located at a distance from the power supply terminals, or if reactive and/or modulated loads are present, remote error sensing should be used to minimize their effect on the voltage stabilization. A twisted shielded pair of wires from the sensing terminals directly to the load will compensate for voltage drops in the load interconnection scheme (see Specifications for available headroom based on model); the termination point of the error sensing leads should be at or as close as practical to the load. For these conditions it is also recommended that some amount of local decoupling capacitance be placed at the error sense termination point to minimize the risk of unwanted pick-up affecting the remote error sense function. See Figure 2-4.

2.8.5.3 LOAD CONNECTION - METHOD III (SERIES CONNECTION)

Units may be connected in series to obtain higher output voltages. For series operation, install a jumper cable from the negative bus bar of one independent position to the positive bus bar of the adjacent independent position for as many positions as required. Each power supply in the series should be protected by a clamping diode connected in its non-conducting direction in parallel with the output; this diode protects the power supply outputs against secondary effects in the event of a load short. (Note that this is NOT the same as the blocking diode used for parallel/redundant operation.) Selection of the clamping diode is entirely dependent upon output voltage/current parameters. The clamping diode must be rated for the maximum voltage and current of the series connection. Several clamping diodes in parallel may be required to meet the total current rating.

The user must also respect the $\pm 500V$ d-c maximum isolation from output to chassis when determining the maximum series voltage. Figure 2-12 shows a series connection of two HSP-A power supplies.

NOTE: The RA 90 cannot be used for series operation except when connecting consecutive rack adapters in series; contact Kepco Applications Engineering for additional information.

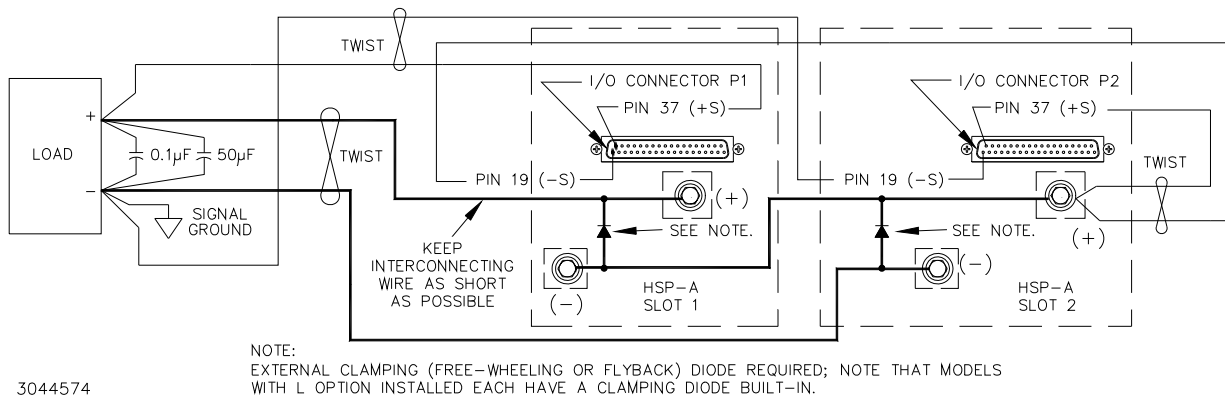


FIGURE 2-12. LOAD CONNECTION - METHOD III - (SERIES CONNECTION)

2.8.5.4 LOAD CONNECTION - METHOD IV (PARALLEL OPERATION)

Identical HSP-A power supply models may be connected in parallel in order to provide increased output current to a common load (see Figure 2-13). This permits the user to obtain significantly higher load ratings than for a single HSP-A power supply. The number of power supplies required is determined by dividing the required load current by the current rating of the applicable HSP-A model, and rounding up to the next whole number when necessary. HSP-A power supplies incorporate fault detection circuitry which precludes the need for output blocking diodes, and utilize active current sharing circuitry to distribute the load current equally among the paralleled units. When operating HSP-A power supplies in any parallel configuration, load sharing **must** be implemented among the paralleled modules; this is required for proper operation of the fault detector (see PAR. 2.9). Figure 2-13 shows a typical parallel configuration using two power supplies; additional parallel modules are added by scaling Figure 2-13.

2.8.5.5 REDUNDANCY AND HOT SWAP APPLICATIONS

HSP-A is specifically designed for use in critical applications where power supply redundancy and on-line replacement of defective power supplies (hot-swapping) is required. Redundant operation is achieved by paralleling one or more power supplies in excess of the minimum number required to support the load so that system operation is not compromised by the failure of a single power supply. Any number of HSP-A power supplies (N+M) can be wired for redundant operation as long as (N) power supplies can support the load, M representing the total number of failed power supplies.

RA 90 series rack adapters provide permanently configured outputs for parallel/redundant operation: all three positions for RA 90, positions 1 and 2 for RA 92. Load wiring is attached to the rack adapter at the output studs. Although load wiring can be attached to any single position, Kepco strongly recommends distributing the load interface evenly among the populated power supply positions to minimize load sharing error; in no case should load current drawn from any one terminal exceed 300 Amperes. Accessory cables are available that simplify current share signal and sense connections for two or three units in parallel (see Table 1-2).

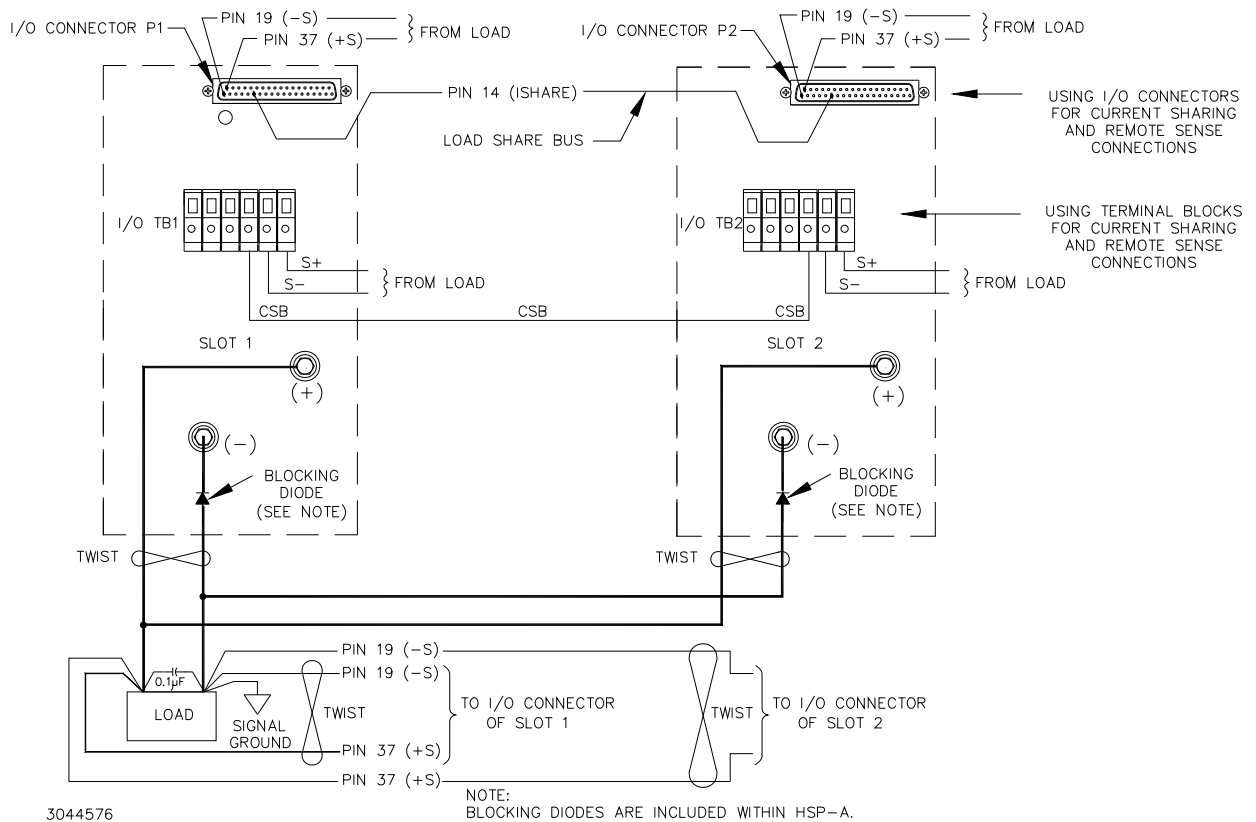


FIGURE 2-13. LOAD CONNECTION - METHOD IV (PARALLEL/REDUNDANT OPERATION WITH HOT-SWAP), REMOTE SENSE

HSP-A is specifically designed for use in critical applications where power supply redundancy and on-line replacement of defective power supplies (hot-swapping) is required. Redundant operation is achieved by paralleling one or more power supplies in excess of the minimum number required to support the load so that system operation is not compromised by the failure of a single power supply. Any number of HSP-A power supplies (N+M) can be wired for redundant operation as long as (N) power supplies can support the load, M representing the total number of failed power supplies.

When operating power supplies in hot-swap applications, output blocking diodes included in the HSP-A prevent excessive output transients and power connector damage due to arcing at the output terminals. In applications where redundancy is required but hot-swapping is not, the blocking diode is beneficial in that it adds a layer of isolation between each power supply output and the common d-c bus, protecting the bus against the possibility of a short at the power supply output. All HSP-A power supply models include this internally mounted blocking diode.

2.9 LOAD SHARING

When operating two or more power supplies in parallel, either for increased output current or redundancy, it is desirable to distribute the load equally among all of the power supplies in order to improve performance, reduce stress, increase reliability and increase MTBF. HSP-A power supplies incorporate active circuitry which forces multiple power supplies wired in parallel to share load current, both in voltage- and current-mode regulation.

The use of forced current sharing and redundancy is derived from the need to significantly increase MTBF and decrease failure rate, a must for critical applications. Forced current sharing increases MTBF by allowing units to work at up to 55% of their maximum output load current (I_{MAX}). Connecting units in parallel without forced current sharing means that if two units were connected in parallel, one (the master) would work at a full constant 100% power while the other (slave) was idle. A failure of the master would cause the slave to then provide 100% of the load current. The permanent high temperature inside the master, when compared with the slave units which are idling at almost ambient temperature, decreases reliability and decreases the MTBF of the master.

2.9.1 HOW DOES HSP-A ACCOMPLISH LOAD SHARING?

The HSP-A employs a single wire connection between paralleled power supplies, forming a master-slave relationship as follows: the highest voltage unit becomes the master, and all of the remaining units are slaved to it via the load share signal (ISHARE), which boosts the slave outputs in order to increase load share. A maximum boost limit of 5% prevents the slave units from following a defective master into an overvoltage condition, or from creating an overvoltage load hazard if either the slave itself or the load sharing system is defective.

2.9.2 WHAT ARE THE REQUIREMENTS FOR LOAD SHARING?

When implementing load sharing, the user must ensure that all power supplies are attempting to regulate to the same voltage at the same location, and must minimize the possibility of load share signal corruption. The power supplies should, as nearly as possible, emulate a single large power supply. For proper load sharing, observe the following:

a. Sensing Wires

- (1).If possible, remote error sensing should be employed, with all error sensing connections terminated at the same physical point, and as close to the power supplies as possible while properly sizing the load wires as described below..
- (2).If local sense is mandated, e.g., to avoid a single point of failure as part of a critical redundant system, power lead voltage drops must be minimized. For local sensing, where the voltage drop on the load is uncompensated, the output voltage will be decreased by the voltage drop on the load wires. So for this case, wire or bus length of load wires is critical to reduce the voltage drop. The larger the cross-section of bus bars or wire gauge (circular mil area, or CMA), i.e., thicker wires, the smaller the voltage drop, making it easier for units to have their outputs within the 2% error band (refer to c. below).
- (3).Install local noise decoupling capacitors across all sense wire termination points.

- b. **Power Supply Location.** The power supplies should be located as near to each other as possible, with power terminations bussed together using adequately sized intercon-

nections. The power supply/load interconnections should be distributed evenly along the power supply output interconnection busses. This is especially important in high-current systems employing several power supply modules in parallel, where voltage drops in the interface connections can be significant in comparison to the load share signal voltage and introduce both d-c and a-c errors.

- c. **Output Voltage Adjustment.** All power supply output voltages should be adjusted as closely as possible, and must be within 2% of each other. Additionally, the current limit setpoints should be identical and high enough to support the load requirements; for (N+M) systems. This means setting the current limits high enough to tolerate a loss of M power supplies and still support the load.
- d. **Load Share Wires.** Minimize the load share signal wire interconnection lengths to reduce risk of noise influence.
- e. **Minimum Load Requirement.** Although a minimum load is recommended for better regulation and a fast transient response time, it is no longer required as for the legacy HSP-A/RA 60 systems. For low load conditions (<5% rated current) current balancing (forced current share) is overridden by one unit which delivers all current while the others idle until the load rises above 5%, at which time the other unit(s) again deliver shared current. This maintains a redundant system while eliminating malfunctions of the load sharing circuit that could cause false triggering of the DC Fail flag.

2.9.3 CONFIGURING PARALLEL COMBINATIONS FOR PROPER LOAD SHARING

To ensure that load sharing works properly, first review and adhere to ALL the requirements described in PAR. 2.9 and summarized as follows:

- Use remote sensing if possible. If local sensing is used ensure load wire voltage drops are minimized. Refer to PAR. 2.5.3 for additional details.
- Install local noise decoupling capacitors across all sense wire termination points.
- Locate units as close to each other as possible.
- Voltage setpoints as close to each other as possible (within 2% max).
- Minimize the load share signal wire interconnection lengths.
- Observe Minimum System Load restriction.
- Use twisted wires or shielded cable (shielded cable is preferred for long runs or between racks) for CSB connections; connect shield to OUT (-).terminal.

2.9.3.1 VERIFY POWER SUPPLY OUTPUT VOLTAGES SET CORRECTLY.

For metered units, set the meter to V position and press the momentary SETPOINTS switch. The meter displays the voltage set point of the unit. Repeat for each unit in the parallel combination. While pressing the momentary SETPOINTS switch, adjust the corresponding V_O trimpot of each unit so that all setpoints are the same.

For units without meters, measure VSET at either the V_O and COM jacks on the front panel or at pin 36 of the I/O connector, referenced to pin 19. VSET is 0 to 10V, representing 10% of the volt-

age set point. E.g., if $V_{SET} = 4.36V$, the voltage setpoint is $43.6V \pm 1\%$. Adjust V_O of each unit while monitoring V_{SET} to set all units to the same programmed output voltage.

Once output voltage of each power supply is set, turn on only one power supply at a time connected to the full load and measure the output voltage of each power supply. Verify that the output voltage readings of each individual power supply are within $\pm 2\%$ of each other. If not, check load wiring for unbalanced resistance.

2.9.3.2 VERIFY CURRENT SHARE WORKING PROPERLY.

Forced current share (current balancing) starts working only when
shared load (Amperes) $> n \times 6\% I_{NOM}$

where: n = number of units in parallel with current balancing implemented
 I_{NOM} = Nominal output current of unit in Amperes

If load current is less than $n \times 6\% I_{NOM}$, the master unit will deliver most of the load current. For example, for three HSP 28-36A units in parallel redundant with current balancing implemented, and load current less than $n \times 6\% I_{NOM}$ the master will deliver $3 \times 6\% \times 36 = 6.48A$. If the load current increases beyond 6.48A, then all units start sharing current. The optimum current share ratio of 55/45 is achieved for load current $\geq n \times 10\% I_{NOM}$ (for this example $3 \times 10\% \times 36 = 10.8A$).

When load current is between $n \times 6\% I_{NOM}$ and $n \times 10\% I_{NOM}$, the share ratio may be between 95/5 and 55/45. The actual ratio depends on a number of factors, e.g., how close the voltage settings of each unit are to each other, load wire gage, and whether local or remote sensing is in place. To verify that load sharing is working properly it is necessary to determine how much load current is being supplied by the master, and how much by the slaves. T

For metered units, set the meter to A and observe the current delivered by that unit on the meter. Record the value and repeat for all units. The sum of the individual currents recorded is the current supplied to the load.

For non-metered units, the current delivered by each unit can be calculated by measuring the IMON signal at pin 32 of the I/O connector referenced to pin 19 (S-). IMON is a 0 to 5V signal representing 0 to 100% of the rated output current of the unit. E.g., for the HSP-A 12-84, IMON of 3V represents 60% or 84A, or 50.4A.

The current share ratio is calculated as follows;

Current share ratio = % of current of one unit/% of current of other unit

E.g., for a parallel combination of two HSP-A 12-84 units,

if one unit delivers 46.2A, ($46.2/84 = 55\%$), and the other delivers 37.8A ($37.8/84 = 45\%$) the ratio is 55/45.

For units using remote sensing as outlined in PAR. 2.9, ratios up to 55/45 are optimum. If the ratio is 57/43 or higher (e.g., 58/42), the DC FAIL light will go on indicating load sharing is not working. Higher ratios can occur for loads that draw more than 10% of I_{Onom} .

For units using local sensing, where the load draws less than 10% of I_{Onom} , ratios outside the range of 55/45 may be experienced without the DC FAIL indication. For this case, it is advisable to revisit ALL the requirements of PAR. 2.9 and take any additional measures necessary to reduce voltage drops on the power leads which can cause the load sharing to be unbalanced. Pay particular attention to increasing wire size, verifying that voltage of each unit is within 2% of each other, and ensuring that the minimum system load restriction is obeyed.

If load sharing is still not within the proper load share ratio of 55/45, it is recommended to measure the output voltage of each power supply one at a time with all the other paralleled units turned off to verify that output voltage matches the VSET (programmed) output voltage.

2.9.3.3 DETECTING A FAILED POWER SUPPLY WITHIN A PARALLEL COMBINATION

As an aid to detecting a failed power supply within a parallel combination, HSP-A provides a V ORing signal. V ORing is the output voltage of the unit prior to the HSP-A blocking (isolation) diodes. Typically, this voltage is equal to the output voltage of the parallel combination (+1V max).

As an example, for a parallel combination of 3 units with an output voltage of 24.5V d-c. V ORing of each unit will be between 24.5 and 25.5 V s-c. If one unit fails, V ORing for that unit will drop to 0 or significantly less than 24.5V. By monitoring each V ORing signal it is possible to a) detect that one of the three units has failed and b) pinpoint exactly which is the failed unit. V ORing can be monitored at either pin 1 of the corresponding I/O connector or the corresponding terminal block (TB1, TB2 or TB3) on the rear panel (see Figure 2-2)..

2.10 CONTROL SIGNAL CONNECTIONS

Access to the control signal (I/O) connector for each HSP-A power supply is provided via the three 37-pin D-subminiature connectors on the rear panel of the rack adapter (see Figure 2-2), one for each slot. Three mating connectors (Kepco PN 142-0422) are provided in a plastic bag. Table 2-5 lists the I/O connector pin assignments and appropriate references.

2.10.1 SENSE CONNECTIONS

Sense connections are available at I/O connector: pins 16, 19 and 34 (-S) and pin 37 (+S) as well as at the three terminal blocks at the rear panel (see Figure 2-2). The user MUST configure either local or remote sensing. Refer to PAR's. 2.5 and 2.8.5 for details.



NOTE: REGARDLESS OF OUTPUT CONFIGURATION, OUTPUT SENSE LINES MUST BE PROPERLY CONNECTED FOR OPERATION

TABLE 2-5. I/O CONNECTOR PIN ASSIGNMENTS

PIN NO.	NAME	DESCRIPTION OF FUNCTION	REF. PAR.
1	V ORing	Allows detection of failed unit within parallel combination	2.9.3.3
2	--	No Connection	--
3	FFS-1	Fan Status - Normally Closed Contact	2.10.2
4	ACS-C	Source Power Status - Common Contact	2.10.2
5	ACS-2 (N.C.)	Source Power Status - Normally Closed Contact	2.10.2
6	--	No Connection ⁽¹⁾	
7	RC2 ⁽²⁾	Remote Inhibit - Normally Low Input ⁽²⁾	2.10.8
8	RC1 ⁽²⁾	Remote Inhibit - Normally High Input ⁽²⁾	2.10.8
9	--	No Connection ⁽¹⁾	--
10	--	No Connection	--
11	OTS-C	Overtemp Status - Common Contact	2.10.2
12	PSS-C & OTS-C	Output Status - Common Contact	2.10.2
13	PSS-2 (N.C.)	Output Status - Normally Closed Contact	2.10.2
14	ISHARE ⁽³⁾	Load Share Signal Bus (0-5.5V) ⁽³⁾	2.10.10
15	IPROG ⁽³⁾	Analog Programming Input - Current (0-10V) ⁽³⁾	2.10.6
16	-S	Negative Error Sense Input	2.10.1
17	VRP-1	Resistive Programming Input (0-50k)	2.10.5
18	VPROG ⁽³⁾	Analog Programming Input - Voltage (0-10V) ⁽³⁾	2.10.5
19	-S	Negative Error Sense Input	2.10.1
20	--	No Connection	--
21	FFS-2	Fan Status - Normally Open Contact	2.10.2
22	FFS-C	Fan Status - Common Contact	2.10.2
23	ACS-1 (N.O.)	Source Power Status - Normally Open Contact	2.10.2
24	- ⁽¹⁾	No Connection ⁽¹⁾	--
25	FANRTN	Fan Supply Return	2.10.4
26	5VAUX	Auxiliary Supply Output	2.10.4
27	--	No Connection ⁽¹⁾	--
28	--	No Connection	--
29	OTS-2 (N.O.)	Overtemp Status - Normally Open Contact	2.10.2
30	OTS-1 (N.C)	Overtemp Status - Normally Closed Contact	2.10.2
31	PSS-1 (N.O.)	Output Status - Normally Open Contact	2.10.2
32	IMON ⁽³⁾	Analog Output Current Monitor (0-5.5V) ⁽³⁾	2.10.8
33	ISET ⁽³⁾	Current Limit Setpoint Monitor (0-10V) ⁽³⁾	2.10.7
34	-S	Negative Error Sense Input	2.10.1
35	VRP2/VTEMP ⁽²⁾⁽⁴⁾	Resistive Programming Input - Voltage (0-50k) ⁽²⁾	2.10.5, 2.10.9
36	VSET ⁽³⁾	Output Voltage Setpoint Monitor (0-10V)	2.10.7
37	+S	Positive Error Sense Input	2.10.1

- (1) These pins are left blank to provide voltage isolation between output and a 5V aux supply which powers the remote inhibit control circuitry.
(2) These signals are referenced to FANRTN (pin 25) and are not galvanically isolated from each other.
(3) These signals are referenced to -S (pins 16, 19 and 34).
(4) This signal is VTEMP (output) instead of VRP2 if Option T or MT is installed (see PAR. 3.7).
(5) See HSP-A Operator Manual for details.

2.10.2 ALARMS

Each HSP-A power supply provides alarms for four faults, indicating failures of output, overtemperature, source power and fan. Each alarm has an associated HSP-A relay which provides pair of signals, one for normally-closed (N.C.), one for normally-open (N.O.) referenced to a common (C). These signals are available at the corresponding I/O connector (see Table 2-6 and Figure 2-2): The rack adapters are shipped with these four alarm signals OR'ed to provide a common signal (AL and AL RTN) available at the rack adapter terminal blocks, TB1, TB2 and TB3 as defined by DIP A, B and C plus positions 6, 7, and 8 of DIP 1, 2 and 3. The default alarm configurations are established by the DIP settings noted in Table 2-7 and explained in the corresponding notes. Refer to the HSP-A Operator Manual for additional details.

TABLE 2-6. ALARM SIGNAL I/O CONNECTOR PIN ASSIGNMENTS

Alarm	I/O Connector Pin No.		
	Normally Closed (NC)	Normally Open (NO)	Common (C)
Fan Status	3	21	22
Source Power Status	5	23	4
Overtemperature Status	30	29	11
Output Status	13	21	12

2.10.3 REMOTE INHIBIT/REMOTE RESET

Remote Inhibit signals are available at I/O Connector pins 7 and 8, referenced to pin 25 (see Table 2-5). Refer to the HSP-A Operator Manual for additional details.

2.10.4 5V AUXILIARY POWER SUPPLY

The auxiliary 5V supply output is available at I/O Connector pin 25, referenced to pin 26 (see Table 2-5). Refer to the HSP-A Operator Manual for additional details.

2.10.5 OUTPUT VOLTAGE PROGRAMMING

Output voltage can be programmed using either external voltage across I/O Connector pins 18 and 19 or external resistance across pins 17 and 35. Note that programming output voltage using external resistance is not possible if Option T or MT is installed since pin 35 used for VTEMP, the output signal used to monitor internal unit temperature (see PAR. 2.10.9). Refer to the HSP-A Operator Manual for additional details.

2.10.6 OUTPUT CURRENT LIMIT PROGRAMMING

Output current limit can be programmed using external voltage across pins 15 and 19 of the corresponding I/O connector. Refer to the HSP-A Operator Manual for additional details.

2.10.7 SETPOINT MONITORS

Voltage setpoint can be monitored at pin 36 referenced to pin 19; current setpoint can be monitored at pin 33 referenced to pin 19 (see Table 2-5). Refer to the HSP-A Operator Manual for additional details.

TABLE 2-7. DIP SWITCH SETTINGS FOR TYPICAL ALARM CONFIGURATIONS

Rack Adapter Model	Alarm Status: N.O. (Normally Open) N.C. (Normally Closed)	SLOT 1				SLOT 2				SLOT 3			
		DIP 1 Positions 6 to 8		DIP A Positions 1 to 10		DIP 2 Positions 6 to 8		DIP B Positions 1 to 10		DIP 3 Positions 6 to 8		DIP C Positions 1 to 10	
		ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
RA 90 (1)	N.O.	None	6,7,8	5 to 9	1,2,3,10	6,7	8	5 to 9	1,2,3,10	6,7	8	5 to 9	1,2,3,10
RA 90 (2)	N.C. (default)	6, 8	7	1,2,3	5 to 10	8	6,7	1,2,3	5 to 10	8	6,7	1,2,3	5 to 10
RA 92 (3)	N.O.	None	6,7,8	4 to 10	1,2,3	6,7	8	4 to 10	1,2,3	None	6,7,8	4 to 10	1,2,3
RA 92 (4)	N.C. (default)	6,7	8	1,2,3	4 to 10	None	6,7,8	1,2,3	4 to 10	None	6,7,8	1,2,3,10	4 to 9
RA 93 (5)	N.O.	N/A	N/A	4 to 10	1,2,3	N/A	N/A	4 to 10	1,2,3	N/A	N/A	4 to 10	1,2,3
RA 93 (6)	N.C. (default)	N/A	N/A	1,2,3,10	4 to 9	1,2,3	N/A	1,2,3,10	4 to 9	N/A	N/A	1,2,3,10	4 to 9

NOTES:

- (1) RA 90 (3 slots in parallel) configured for NO (Normally Open) alarm. Any failure of PS1, PS2 or PS3 causes a short circuit across AL and AL RTN terminals of TB1, TB2 or TB3 at rear panel (normally open with no failures).
- (2) RA 90 (3 slots in parallel) configured for NC (Normally Closed) alarm. Any failure of PS1, PS2 or PS3 causes an open circuit across AL and AL RTN terminals of TB1 at rear panel (normally short circuit with no failures). These N. C. alarm settings are the default settings for RA 90.
- (3) RA 92 (slots 1 and 2 in parallel, slot 3 independent) configured for NO (Normally Open) alarm. Any failure of PS1 or PS2 causes a short circuit across AL and AL RTN terminals of TB1 and TB2 at rear panel (normally open with no failures). A failure of PS3 causes a short circuit across AL and AL RTN terminals of TB3 (normally open with no failures).
- (4) RA 92 (slots 1 and 2 in parallel, slot 3 independent) configured for NC (Normally Closed) alarm. Any failure of PS1 or PS2 causes an open circuit across AL and AL RTN terminals of TB1 and TB2 at rear panel (normally short circuit with no failures). A failure of PS3 causes an open circuit across AL and AL RTN terminals of TB3 (normally short circuit with no failures). These N. C. alarm settings are the default settings for RA 92.
- (5) RA 93 (3 slots independent) configured for NO (Normally Open) alarm. Any failure of PS1, PS2 or PS3 causes a short circuit across AL and AL RTN terminals of the corresponding slot: TB1, TB2 or TB3 at rear panel (normally open with no failures).
- (6) RA 93 (3 slots independent) configured for NC (Normally Closed) alarm. Any failure of PS1, PS2 or PS3 causes an open circuit across AL and AL RTN terminals of the corresponding slot: TB1, TB2 or TB3 at rear panel (normally short circuit with no failures). These N. C. alarm settings are the default settings for RA 93.

2.10.8 OUTPUT CURRENT MONITOR

Output current can be monitored at pin 32

2.10.9 INTERNAL TEMPERATURE MONITOR (OPTION T OR MT)

If the HSP-A has Option T or MT installed, internal temperature can be monitored at pin 35 of the corresponding I/O connector, referenced to pin 25 (see Table 2-5). Refer to the HSP-A Operator Manual for additional details.

2.10.10 CURRENT (LOAD) SHARE

The ISHARE signal generated by each HSP-A is used to ensure that parallel-connected units share current equally. Refer to PAR. 2.9 for details about load sharing. Refer to PAR. 2.5.3 to configure load sharing using the rack adapter DIP switches. The ISHARE signal is also available at pin 14 of the I/O connector to allow configuration of ISHARE using external wiring.

2.11 SHIPPING

Shipping of the rack adapter is recommended *only* after the HSP-A power supplies have been removed from the rack adapter. Contact Kepco Applications Engineering if further assistance is required.

