TPDflex DC
Stand Alone Regulator and Gate Amplifier

User Manual

Language: English

Enabled by Allen-Bradley Technologies

Important User Information

Read this document and any additional resources regarding installation, configuration, and operation of this equipment before installing, configuring, operating, or maintaining it. Users must follow installation and wiring instructions and comply with all applicable codes, laws, and standards.
All activities, including installation, adjustments, commissioning, use, assembly, disassembly, and maintenance, must be performed by properly trained personnel following applicable safety practices.
Using the equipment in ways not specified by the manufacturer may reduce its protective features.
Examples and diagrams are for illustrative purposes only and do not replace proper engineering judgment for actual installations.
No patent liability is assumed regarding the use of the information, circuits, equipment, or software described.

Notes in this manual highlight safety considerations where necessary.

	**WARNING:** Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.
	**ATTENTION:** Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence
	**SHOCK HAZARD:** Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.
	**BURN HAZARD:** Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.
	Identifies information that is critical for successful application and understanding of the product.

This manual contains new and updated information.

Topic	Page
Removed the reference to the S12 / S12R configuration from the Features list.	12

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Purpose of This Manual

This manual provides installation instructions and connection and configuration information for the TPDflex DC Stand Alone Regulator (SAR) and the Gate Amplifier.

What This Manual Contains

This user manual contains the following sections:

- Description of the SAR and Gate Amplifier products and general integration information
- Installation, connection and configuration instructions for the SAR
- Installation and connection instructions for the Gate Amplifier
- Guidelines for retrofit installations with DC power modules
- SAR and Gate Amplifier specifications
- Specifications for additional components and cables used with the SAR and Gate Amplifier products

Drawing Numbers

Throughout this manual, drawings are identified by an eight-digit number, for example, 99999999. Where a drawing number includes an asterisk (*) in the 8th digit, the "*" represents the latest version number of the drawing, for example, 999999*.

Notes:

Introduction

General Precautions

Prior to installation of either the Stand Alone Regulator or Gate Amplifier, read the following precautions.

ATTENTION: Energized industrial control equipment can be hazardous. Severe injury or death can result from electrical shock, burn, or unintended actuation of controlled equipment. Hazardous voltages may exist in the cabinet even with the circuit breaker in the off position. Recommended practice is to disconnect and lock out control equipment from power sources, and discharge stored energy in capacitors, if present. If it is necessary to work in the vicinity of energized equipment, the Safety Related Practices of NFPA 70E, "ELECTRICAL SAFETY FOR EMPLOYEE WORKPLACES" must be followed. DO NOT work alone on energized equipment!

ATTENTION: The following information is merely a guide for proper installation. The National Electrical Code and any other governing regional or local code will overrule this information. Rockwell Automation cannot assume responsibility for the compliance or the noncompliance to any code, national, local or otherwise for the proper installation of this drive regulator or associated equipment. A hazard of personal injury and/or equipment damage exists if codes are ignored during installation.

ATTENTION: The installation of the Stand Alone Regulator and/or the Gate Amplifier must be planned such that all cutting, drilling, tapping and welding can be accomplished with the Gate Amplifier removed from the enclosure. The Stand Alone Regulator and Gate Amplifier are of the open type construction and any metal debris must be kept from falling into the enclosure. Metal debris or other foreign matter may become lodged in the circuitry resulting in component damage.

ATTENTION: An incorrectly applied or installed Stand Alone Regulator or Gate Amplifier can result in component damage or a reduction in product life. Wiring or application errors, such as, incorrect or inadequate supply voltage or excessive ambient temperatures may result in malfunction of the system.

ATTENTION: Only qualified personnel familiar with DC drives and associated machinery should plan or implement the installation, start-up and subsequent maintenance of the system. Failure to comply may result in personal injury and/or equipment damage.

ATTENTION: The Stand Alone Regulator and Gate Amplifier contain ESD (Electrostatic Discharge) sensitive parts and assemblies. Static control precautions are required when installing, testing, servicing or repairing this assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with static control procedures, reference A-B publication 8000-4.5.2, "Guarding Against Electrostatic Damage" or any other applicable ESD protection handbook.

Product Overview

The TPDflex DC Stand Alone Regulator (SAR) and Gate Amplifier products provide an integrated solution for controlling external DC power modules.

Stand Alone Regulator (SAR)

The SAR is a DC drive regulator that provides armature regulation, armature SCR gate signals and a regulated field supply. The SAR field supply consists of a single phase, two quadrant (non-reversing,) full wave rectified bridge, available as 40 or 70 Amps. The SAR supports an AC line input voltage range of 230VAC to 690VAC and a field input voltage range of 100VAC to 460VAC.

The SAR uses feedback signals from the AC input line to monitor the incoming voltage level in order to establish the SCR gate firing sequence relative to the AC line. The SCR gate firing for the field bridge is established from the AC lines that supply the field, independent of the armature firing circuit. DC feedback signals are used to monitor the output voltage from the power module. Additionally, current signals received from current transformers is used by the SAR regulator to monitor and control current. The SAR catalog numbers are listed in Catalog Numbers on page 12. The SAR must be used with the Gate Amplifier in order to interface with a DC power module(s).

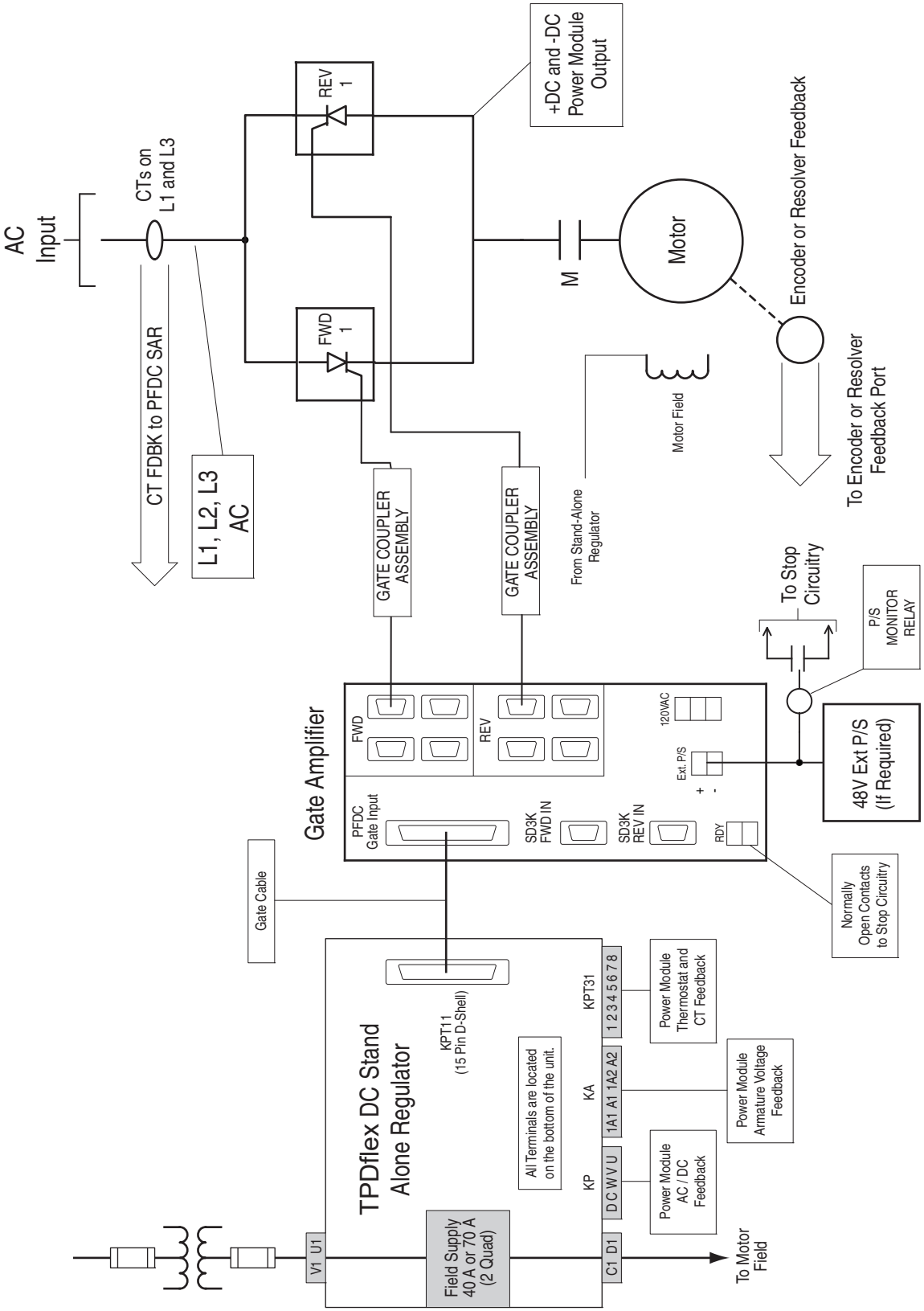
Gate Amplifier

The Gate Amplifier is used to amplify the SCR gate signals supplied by a DC drive regulator. The gate signal source to the Gate Amplifier can be provided by either the TPDflex DC SAR, or the SD3000 *PLUS*. The Gate Amplifier unit provides a separate input D-Shell connector for each product. The Power Module Interface (PMI) Rack is also compatible with the Gate Amplifier and uses the SD3000 *PLUS* inputs. The Gate Amplifier model number and corresponding connection cables part numbers are listed in Model and Cable Model/Part Numbers on page 12.

In addition to amplifying the gate signals, the forward and reverse signals provided by the Gate Amplifier are “fanned-out” to enable the driving of multiple power modules. Four S6 bridges forward and four S6 bridges reverse. When the S6 bridges are connected in an anti-parallel configuration, the topology is an S6R providing both motoring and regenerative capability.

The external 48V gate power supply capability of the Gate Amplifier provides the means to supply additional gate current and voltage and also support the firing of gate coupler boards connected in series (which requires additional voltage). Connecting gate couplers in series forces the simultaneous firing of the SCRs, with power connections in series or parallel. An internal “diode OR” circuit ensures that the gates are powered by whichever gate power supply voltage is the greater in amplitude, the internal or the external power supply.

Figure 1 - Typical Po TPDflex Stand Alone Regulator and Gate Amplifier Interface to S6R



Stand Alone Regulator

Features

- Rockwell Automation Architecture Class networking capable

Catalog Numbers

This table lists the available catalog numbers for the SAR.

230V / 460V AC Input Catalog Number	575V / 690V AC Input Catalog Number:	Field Amps
23PMD4W	23PMF4W	40
23PMD7W	23PMF7W	70

Note: All models contain conformal coated circuit boards.

Gate Amplifier

Features

- Interfaces to the TPDflex DC, SD3000 *PLUS* or PMI regulators
- Flexible configurations S6 and S6R
- Power module interface
- Interlock via “Ready Relay” contacts to main drive control

Available Options

- 48V gate drive capability with an external power supply

Model and Cable Model/Part Numbers

This table lists the cable module numbers and part numbers for the Gate Amplifier.

Product:	Model/Part Number:
Gate Amplifier	23PAMP
TPDflex DC to Gate Amplifier Cable	See Cable Specifications on page 78.
SD3000 *PLUS* to Gate Amplifier Forward Cable	SD3K-CBLGSCLIFxxx(1)
SD3000 *PLUS* to Gate Amplifier Reverse Cable	SD3K-CBLGSCLIRxxx(1)
PMI Rack to Gate Amplifier Forward Cable	612432-xxxS(1)
PMI Rack to Gate Amplifier Reverse Cable	612433-xxxS(1)

(1) xxx = length in inches.

Stand Alone Regulator Installation, Wiring and Configuration

Prepare for Installation

Prior to installation of the TPDflex DC Stand Alone Regulator (SAR) read the General Precautions on page 9.

Mounting Considerations

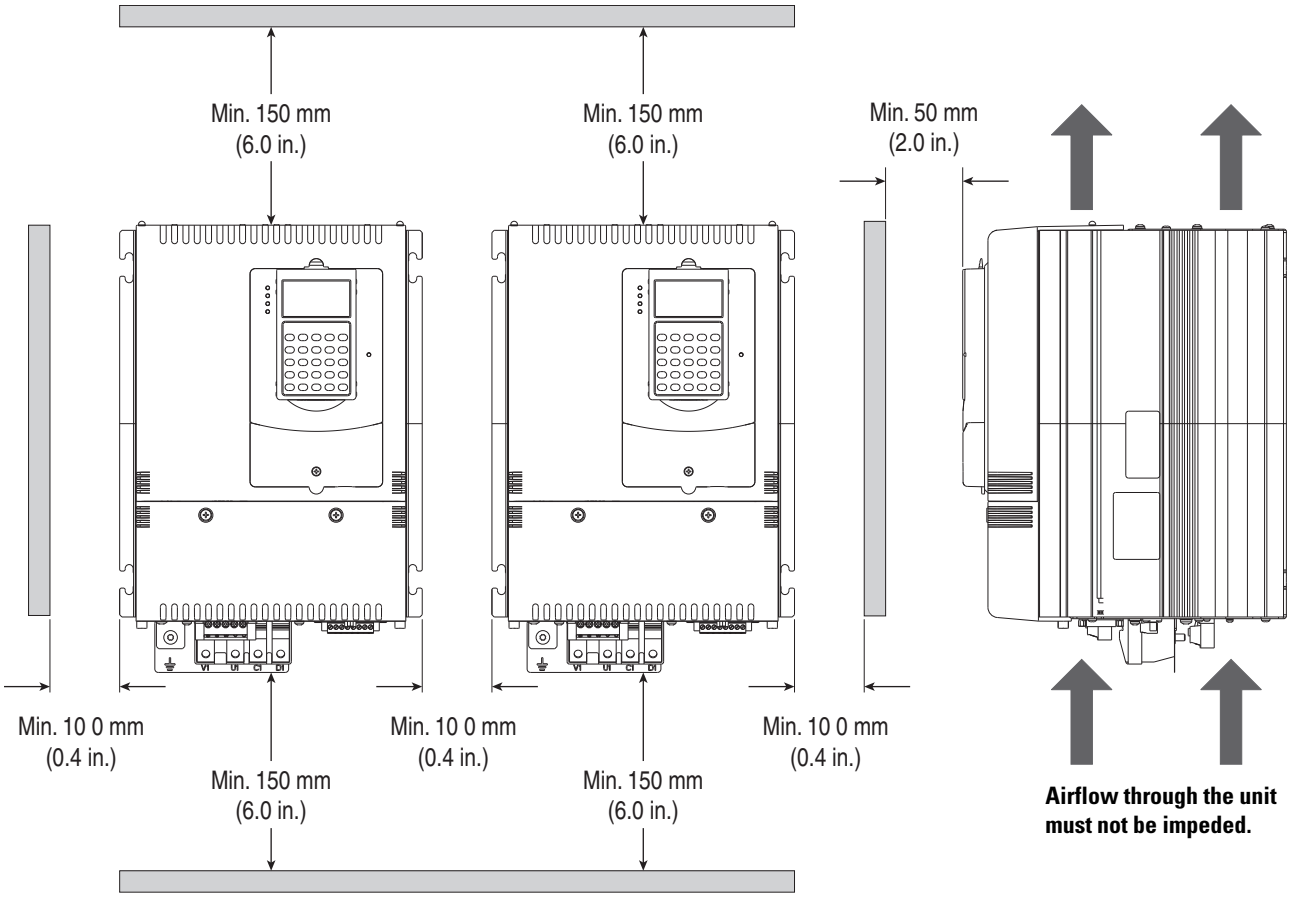
Operating Conditions and Temperatures

The SAR is designed to operate at 0°...50° C (32°... 122° F) surrounding air temperature without derating. The unit must be mounted in a clean, dry location. Contaminants such as oils, corrosive vapors and abrasive debris must be kept out of the enclosure. NEMA/UL Type Open, IP20 enclosures are intended for indoor use primarily to provide a degree of protection against contact with enclosed equipment. These enclosures offer no protection against airborne contaminants.

Minimum Mounting Clearances

Minimum clearance requirements (indicated in Figure 2 - Drive Enclosure Minimum Mounting Clearances) are intended to be from enclosure to enclosure. Other objects can occupy this space; however, reduced airflow may cause protection circuits to fault the SAR. The SAR must be mounted in a vertical orientation as shown and must not be mounted at an angle greater than 30 degrees from vertical. In addition, inlet air temperature must not exceed the product specification.

Figure 2 - Drive Enclosure Minimum Mounting Clearances



Approximate Dimensions and Weights

The SAR is available in a NEMA/UL Type Open, IP20 enclosure only.

ATTENTION: Remove all loose packaging materials, including any desiccant packages from the enclosure before mounting and energizing the SAR.

Dimensions are shown in mm (in.)

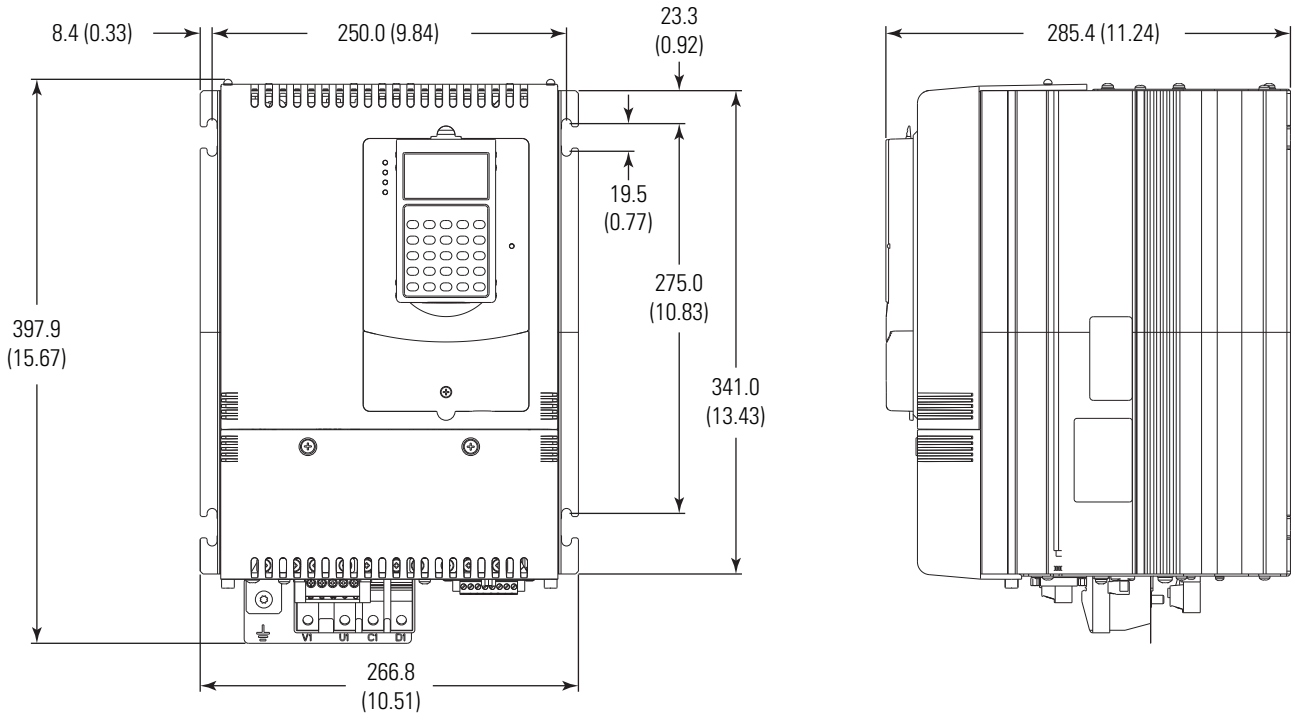


Table 1 - Stand Alone Regulator Weights

Stand Alone Regulator	Stand Alone Regulator and Packaging
12.0 kg (26.5 lb)	14.1 kg (31 lb)

Recommended Mounting Hardware: Metric M6, English 1/4 in.

IMPORTANT Provide a minimum of 150 mm (6.0 in.) below the unit for cable connections.

CE Conformity

Conformity with the Low Voltage Directive and Electromagnetic Compatibility Directive has been demonstrated using harmonized European Norm (EN) standards published in the Official Journal of the European Communities. The TPDflex DC Stand Alone Regulator complies with the EN standards listed when installed according to this User Manual.

CE Declarations of Conformity are available online at:
www.rockwellautomation.com/products/certification/ce/

Low Voltage Directive (2006/95/EC)

- EN 50178 Electronic equipment for use in power installations.

EMC Directive (2004/108/EC)

- EN 61800-3 Adjustable speed electrical power drive systems Part 3: EMC product standard including specific test methods.

General Considerations

- For CE compliance, the SAR installation must satisfy requirements related to both EN 50178 and EN 61800-3 provided in this document.
- The SAR complies with the EMC requirements of EN 61800-3 when installed according to good EMC practices and the instructions provided in this document. However, many factors can influence the EMC compliance of an entire machine or installation, and compliance of the SAR itself does not necessarily ensure compliance of all applications.
- The SAR is not intended to be used on public supply networks which supply domestic premises. Without additional mitigation, radio frequency interference is expected if used on such a network. The installer is responsible to take measures such as supplementary line filters and enclosures to prevent interference, in addition to the installation requirements of this document.

Installation Requirements Related to EN 50178 and the Low Voltage Directive

- The SAR is compliant with the CE LV Directive when used at altitudes no greater than 2000 m (6562 ft).
- The SAR provided in enclosure type IP20 must be installed in a pollution degree 1 or 2 environment to be compliant with the CE LV Directive. Characteristics of the different pollution degree ratings are provided in Table 2 on page 17.

Table 2 - Pollution Degree Ratings According to EN 61800-5-1

Pollution Degree	Description
1	No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.
2	Normally, only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation is to be expected, when the drive is out of operation.
3	Conductive pollution or dry non-conductive pollution occurs, which becomes conductive due to condensation, which is to be expected.
4	The pollution generates persistent conductivity caused, for example by conductive dust or rain or snow.

- The SAR must be installed in a suitable enclosure with at least an IP4X rating at the top of the enclosure.
- The SAR may produce leakage current in the protective earthing conductor which exceeds 3.5 mA AC and/or 10 mA DC. The minimum size of the protective earthing (grounding) conductor used in the application must comply with local safety regulations for equipment with high protective earthing conductor current.
- The SAR may not be powered from a “corner-earthed” supply system in order to maintain compliance with the CE LV Directive.

Installation Requirements Related to EN 61800-3 and the EMC Directive

- The SAR must be earthed (grounded) as described in this User Manual.
- Output power wiring to the motor (field excitation) must employ cable with a braided shield providing 75% or greater coverage, or the cable must be housed in metal conduit, or equivalent shielding must be provided. Continuous shielding must be provided from the SAR enclosure to the motor enclosure. Both ends of the motor cable shield (or conduit) must terminate with a low-impedance connection to earth.
- At the motor end, the motor field excitation cable shield or conduit must terminate in a shielded connector which must be properly installed in an earthed motor wiring box attached to the motor. The motor wiring box cover must be installed and earthed.
- All control (I/O) and signal wiring to the SAR, including gate firing control, must use cable with a braided or foil shield providing 75% or greater coverage, or the cables must be housed in metal conduit, or equivalent shielding must be provided. Only the SAR end of the cable shield should be terminated with a low impedance connection to earth.
- Power cabling must be separated from control and signal wiring wherever possible.

Terminal/Signal and Wiring Diagrams

Use the diagram in Figure 3 - Stand Alone Regulator Terminal/Signal Block Diagram as a guide for the general location of and connection signals for the main input/output terminal blocks on the SAR. The diagram in Figure 4 on page 19 represents the recommended wiring for a typical SAR interface to a S6R power module.

Figure 3 - Stand Alone Regulator Terminal/Signal Block Diagram Bottom View

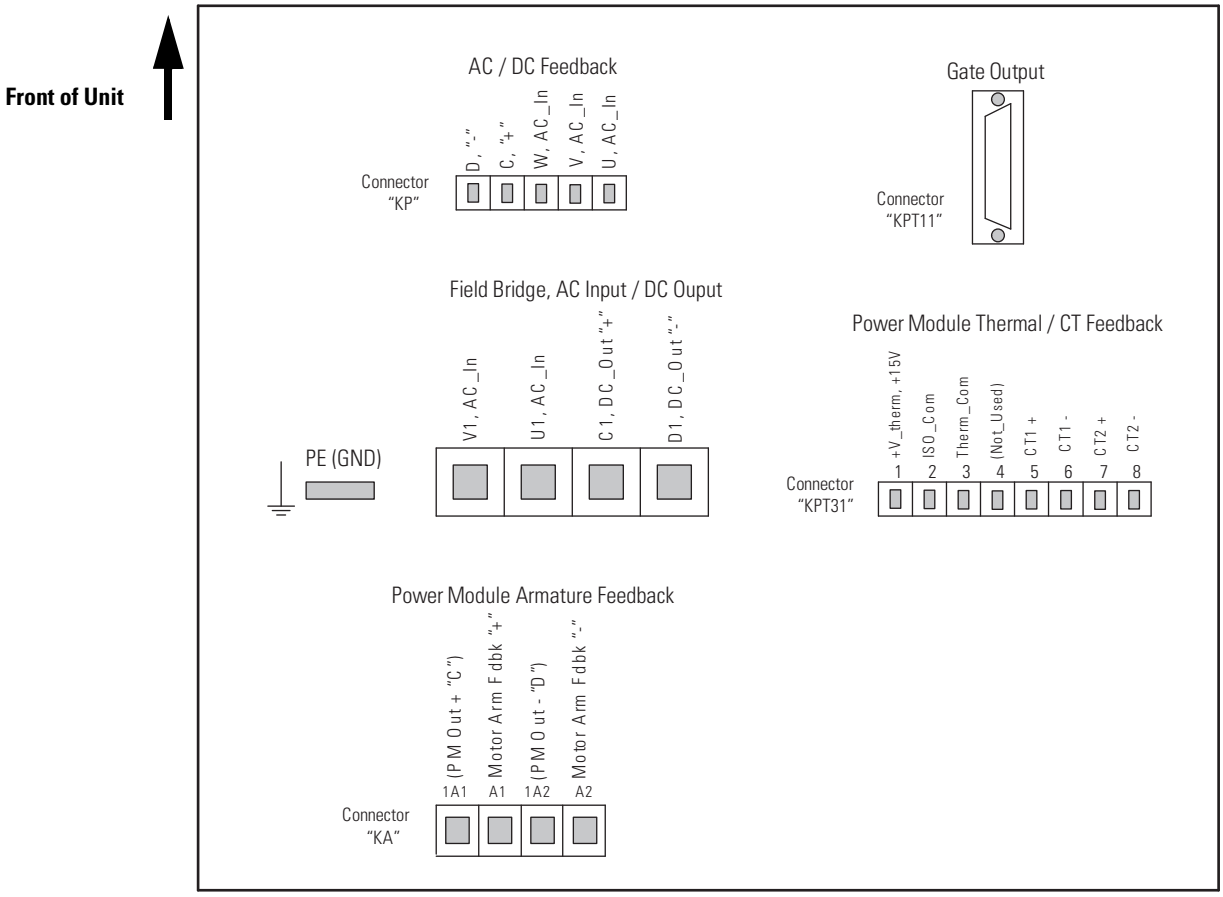
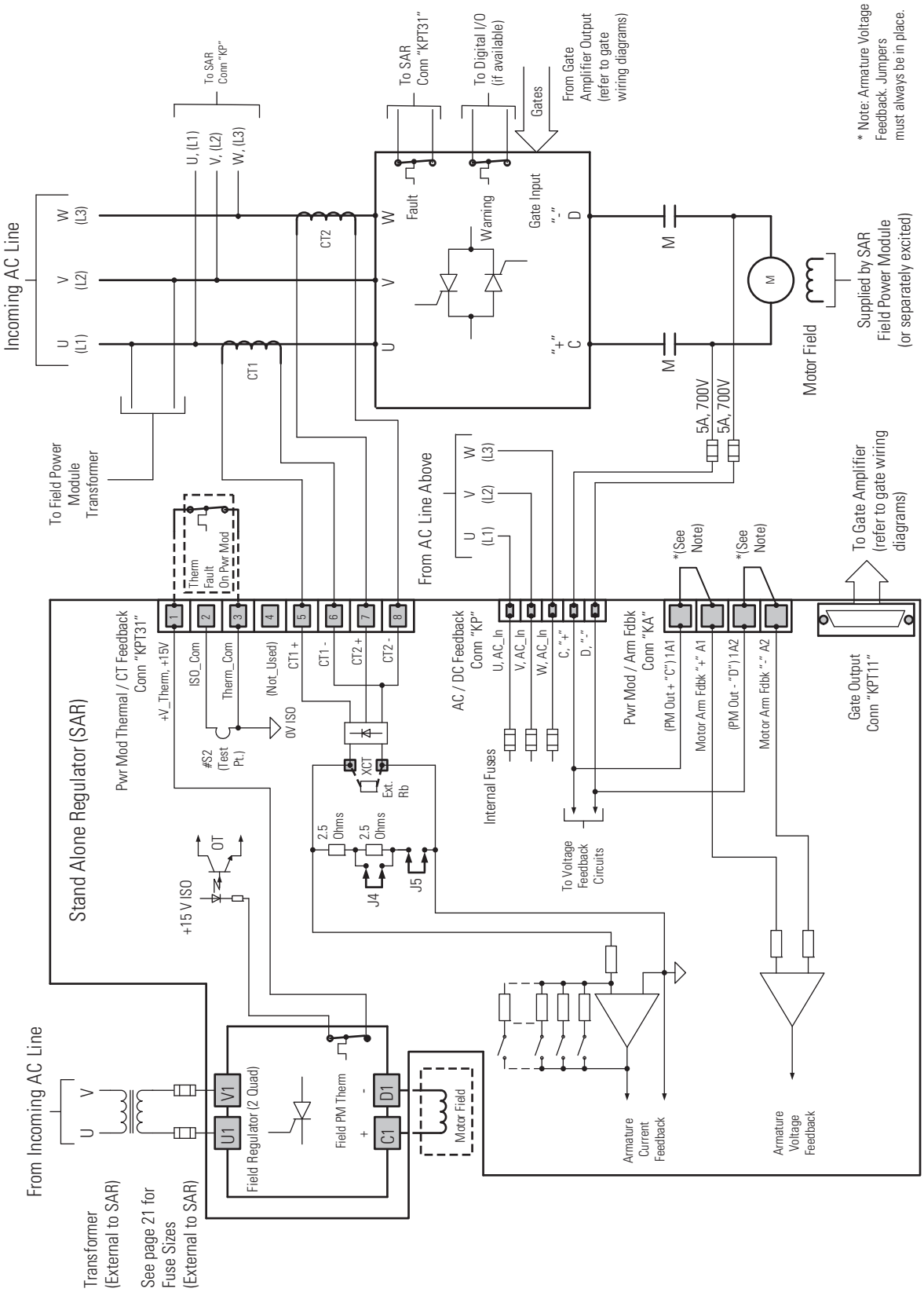


Figure 4 - Typical Stand Alone Regulator Interface to S6R Power Module



Field Power Module Bridge and Ground Wiring

The SAR contains a two quadrant field power module bridge. The field bridge input circuit is rated for 100VAC...460VAC, ±10%, 50/60 Hz. The input and output connections to/from the field bridge are on the bottom of the SAR as shown.

An external transformer with appropriate primary fusing is required to supply the field. External fusing is also required at the input terminals V1 and U1 to protect the field bridge. The recommended fuse types are shown in the Table 4 on page 21.

The SAR motor field current must configured with a hardware DIP switch and in firmware. See SAR Motor Field Current Configuration on page 26 for more information.

Figure 5 - Field Power Module Bridge Terminal Block and Ground Connection

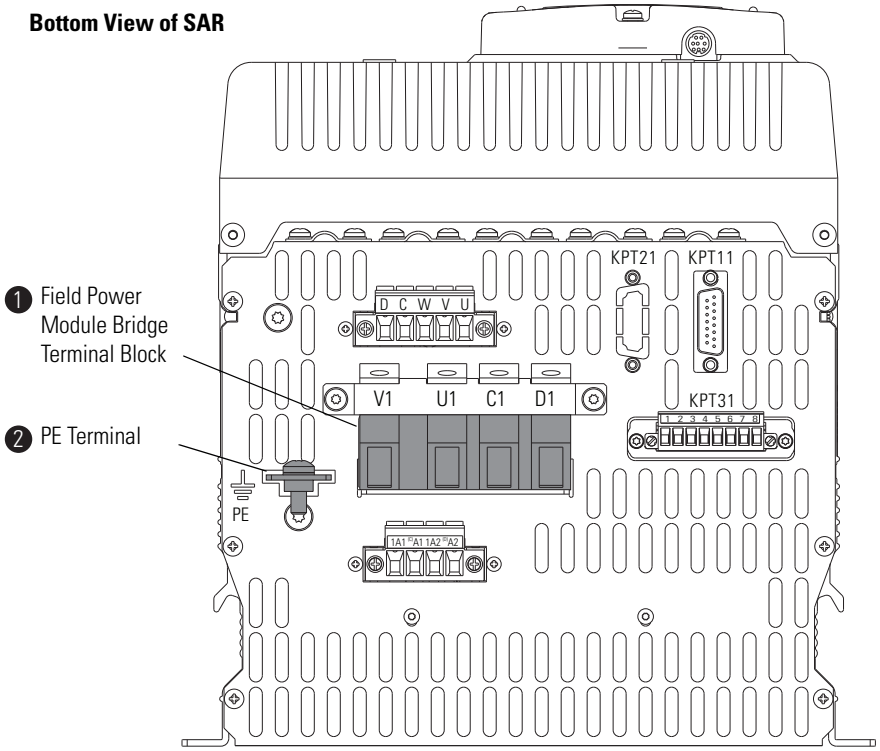


Table 3 - Field Power Module Bridge and Ground Terminal Specifications

No.	Terminal	Description	Wire Size Range		Recommended Torque
			Maximum	Minimum	
1	V1, U1	AC Input Power	25.0 mm^2 (2 AWG)	10.0 mm^2 (10 AWG)	4.0...4.5 N•m (35.4...39.8 lb•in)
1	C1, D1	DC Output Power to Motor Field			
2	PE	Safety Ground (1)	16.0 mm^2 (6 AWG)	10.0 mm^2 (8 AWG)	6.0...8.0 N•m (53.1...70.8 lb•in)

(1) See Safety Ground (PE) on page 21 for more information.

Table 4 - Recommended Field Power Module Bridge Input Fuses

SAR Field Bridge Rating	Fuse Type:		
	Bussmann	**Ferraz Shawmut**	**Siba**
40 A	FWP-50A22Fa	A70QS50-22F	5014006.50
70 A	FWP-100A22Fa	A70QS100-22F	5014006.100

The recommended fuse holder is a Cooper-Bussman, CH222D or equivalent - to accommodate 22 mm x 58 mm fuses.

Safety Ground (PE)

The Safety Ground - PE must be connected to system ground. Ground impedance must conform to the requirements of national and local industrial safety regulations and/or electrical codes. The integrity of all ground connections should be periodically checked.

For installations within a cabinet, a single safety ground point or ground bus bar connected directly to building steel should be used. All circuits should be grounded independently and directly to this point/bar.

AC/DC Voltage and Motor Armature Voltage Feedback Wiring

The SAR requires AC feedback connections to connector KP (terminals U, V, and W) from the incoming line to monitor the incoming voltage level and establish the SCR gate firing sequence relative to the AC line. DC feedback connections to connector KP (terminals C and D) are required to monitor the voltage output from the DC power module. The combined information from the AC and DC feedback inputs is used to determine if the SCRs are firing properly. See Figure 4 on page 19 for recommended wiring for a typical SAR interface to S6R.

Fuses are required between the DC output power wiring on the DC power module to connector KP on the SAR. This will limit the current to the regulator in the event of an internal fault in the SAR. The recommended fuse types are shown in DC Feedback Fusing Requirements on page 22.

Figure 6 - AC /DC Voltage Feedback (KP) and Motor Armature Voltage Feedback (KA) Terminal Blocks

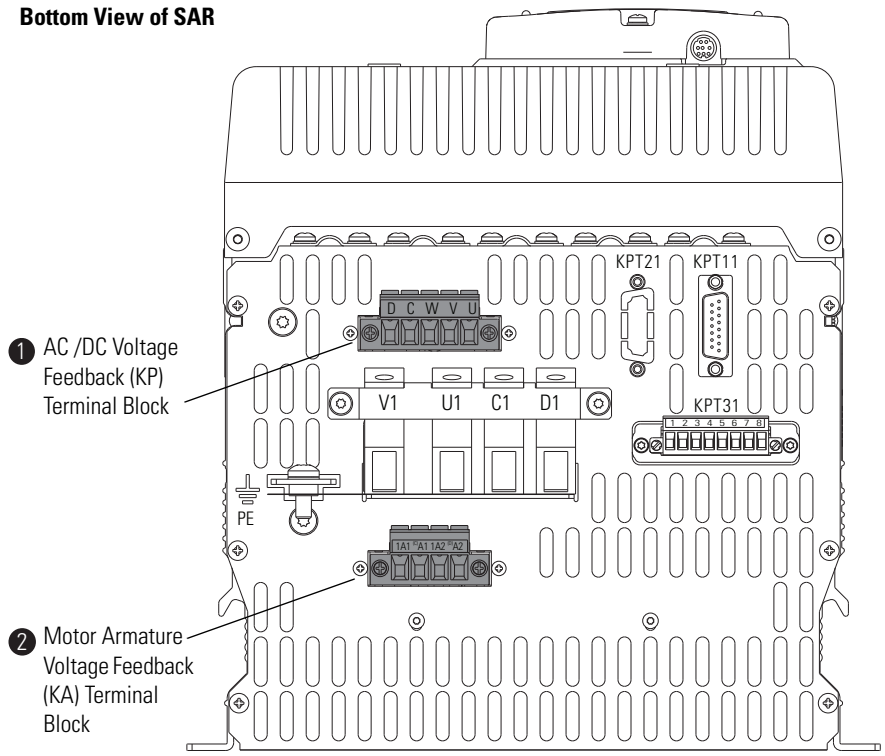


Table 5 - AC / DC Voltage and Motor Armature Voltage Feedback Terminal Specifications

No.	Terminal	Description	Wire Size Range		Recommended Torque
			Maximum	Minimum	
1	W, V, U	AC Input Feedback (connector KP)	6.0 mm^2 (10 AWG)	0.2 mm^2 (24 AWG)	0.7…0.8 N•m (6.2…7.1 lb•in)
1	D, C	DC Output Feedback (connector KP)			
2	1A1, A1, 1A2, A2	Motor Armature Voltage Feedback (connector KA)			

DC Feedback Fusing Requirements

The recommended fuses are:

- Bussmann fuse FWP-5A14F (5 A, 700V, Type FWP, 14 x 51mm), or equivalent.

Note: The AC voltage feedback inputs on the SAR are fused internally.

Connector KP Wiring

- Connect the motor armature terminal C to terminal C on connector KP
- Connect the motor armature terminal D to terminal D on connector KP

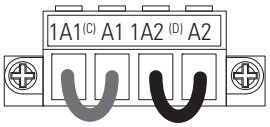
Connector KA Wiring

Connector KA must be wired to provide DC voltage feedback to the field regulator to control the field current based on the armature voltage. Terminal 1A1 is connected internally to terminal C (on connector KP) and terminal 1A2 is connected internally to terminal D (on connector KP). The default configuration is shown in Figure 7 and is wired as follows:

- Jumper terminal 1A1 to terminal A1
- Jumper terminal 1A2 to terminal A2

The jumpers will provide the field regulator with the power module/armature voltage feedback. This is the default wiring scheme for connector KA at the factory.

Figure 7 - Terminals on Connector KA Jumpered



Place jumpers between terminals as shown

Power Module Thermal Switch and Current Transformer Wiring

Connector KPT31 is used for power module thermal switch monitoring and current feedback via current transformer connections. Note that the thermal monitor circuit includes a thermal switch on the field power module within the SAR.

Figure 8 - Power Module Thermal Switch and Current Transformer Terminal Block (KPT31)

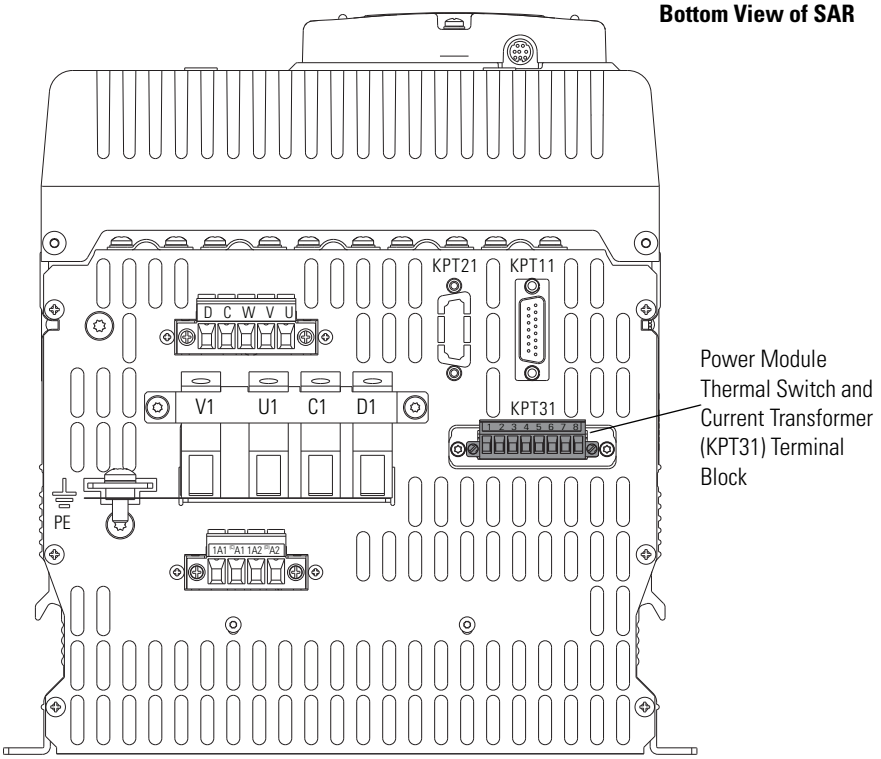


Table 6 - Power Module Thermal Switch and Current Transformer Terminal Specifications

Terminal	Description	Wire Size Range		Recommended Torque
		Maximum	Minimum	
1, 2, 3	Thermal Switch Monitor(1)	2.5 mm^2 (12 AWG)	0.2 mm^2 (24 AWG)	0.5…0.6 N•m (4.4…5.3 lb•in)
5, 6, 7, 8	Current Transformer Feedback			

(1) These terminals are jumpered by default. The jumper wires must remain in place if a power module thermal switch is NOT connected.

Current Transformer Connections

Current transformer 1 (CT1) monitors the U phase, with the "+" output of CT1 connected to terminal 5 of KPT31 and the "-" output of CT1 connected to terminal 6 of KPT31.

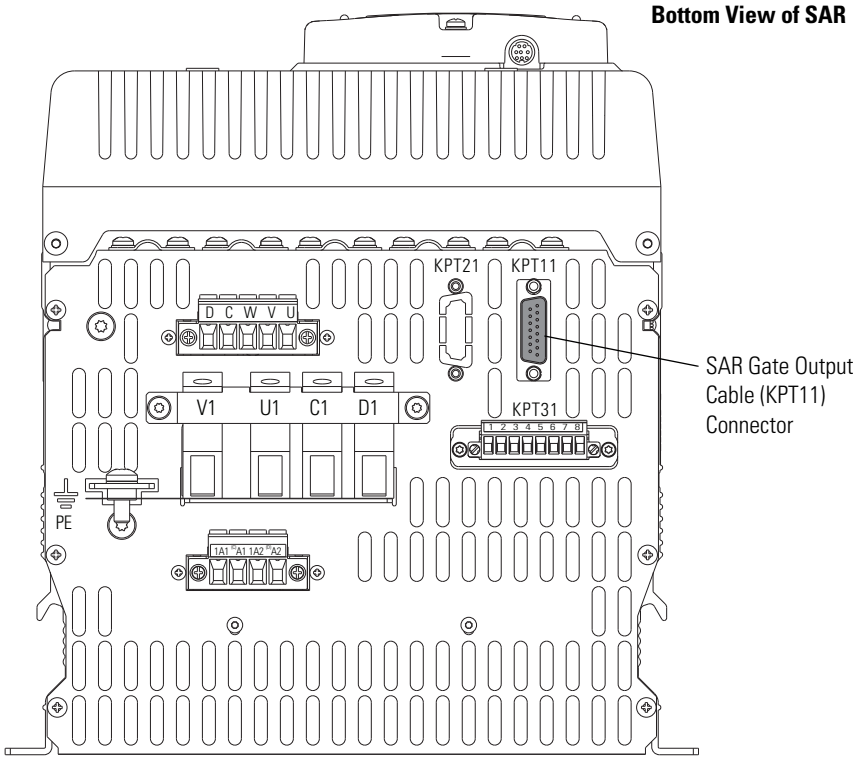
Current transformer 2 (CT2) monitors the W phase, with the "+" output of CT2 connected to terminal 7 of KPT31 and the "-" output of CT2 connected to terminal 8 of KPT31.

The "-" side of the CTs are connected together internally in the SAR.

SAR Gate Output Cable

Connect the SAR gate output cable (23PAMP-C*x*) to connector KPT11 on the SAR unit. The opposite end connects to the TPDflex DC SAR GATE INPUT on the Gate Amplifier. See Chapter 3 Gate Amplifier Installation and Wiring on page 41 for more information on Gate Amplifier installation and connections. See Cable Specifications on page 78 for information on available cable lengths for the 23PAMP-C*x* cable.

Figure 9 - SAR Gate Output Cable Connection (KPT11)



Control Circuit Power Wiring

The control circuit for the SAR (not identified in the drawings contained in this manual) must be powered by an external 230V AC or 115V AC, single phase power supply. This power supply provides power for the SAR cooling fans and a HIM, communication adapter, I/O, encoder, or DC analog tachometer (if installed). See “Control Circuit Input Power” in the TPDflex DC Converters User Manual, publication 1S7TFLEXUMO for details.

In addition, the control circuit power input terminals require short circuit protection. See “Control Power Protection” in the TPDflex DC Converters User Manual, publication 1S7TFLEXUMO for details.

Relay Output and Thermistor / Thermal Switch Wiring

Two normally open relay outputs and one motor thermistor (PTC) or thermal switch input are available for use and must be configured with the appropriate parameters. See “Relay Outputs” and “Thermistors and Thermal Switches” in the TPDflex DC Converters User Manual, publication 1S7TFLEXUMO for details.

I/O, Digital Encoder, and DC Analog Tachometer Wiring

The following standard I/O and feedback options are available with the SAR.

- Eight digital inputs, four digital outputs, three analog inputs, and two analog outputs are available. Additional digital and analog I/O is available when using the optional I/O expansion circuit board.

- An input terminal block is available for an incremental, dual channel, two channel optional (with jumper), differential (recommended) or single-ended encoder with an input voltage configurable for +2.5V...5.2V or +5.4V...15.2V.

- An input terminal block is available for a DC analog tachometer with a maximum input voltage of 22.7V, 45.4V, 90.7V, 181.6V, or 302.9V and an input current of 8 mA full scale.

See “I/O Wiring” in the TPDflex DC Converters User Manual, publication 1S7TFLEXUMO for details.

SAR Motor Field Current Configuration

The SAR motor field current must be configured with both a hardware DIP switch (S14) and by setting parameter 374 [Drv Fld Brdg Cur] to the appropriate value. For each field current rating, in this case 40 and 70 A, there are several ranges to choose from with regard to the maximum range of the field current. The lowest range that is greater than the maximum motor field current should be selected to ensure the best resolution. See “Field Current Configuration” in the TPDflex DC Converters User Manual, publication 1S7TFLEXUMO for instructions.

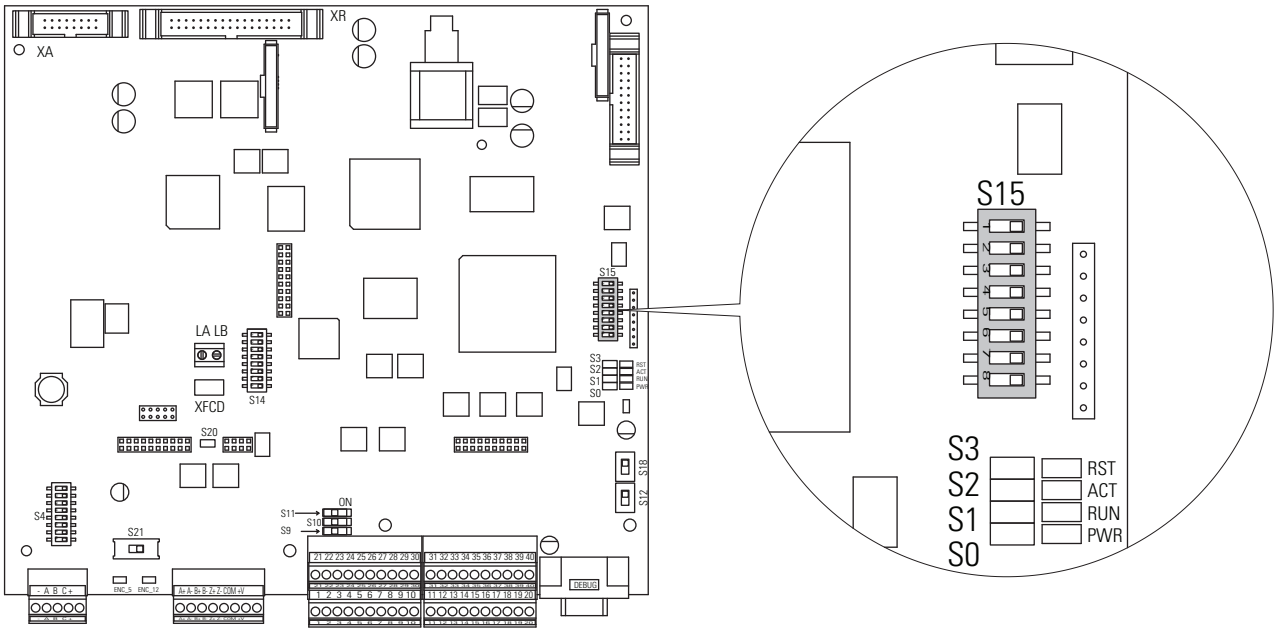
SAR Sizing

DIP switch S15 is configured for the appropriate SAR size at the factory. Do not change the settings unless you are installing a replacement control board.

Table 7 - SAR DIP Switch S15 Settings

Description	S15-1	S15-2	S15-3	S15-4	S15-5	S15-6	S15-7	S15-8
SAR 200V (230V)	Off	Off	Off	Off	Off	On	Off	Off
SAR 400V (460V)	Off	Off	Off	Off	Off	On	On	Off
SAR 600V (575V)	Off	Off	Off	Off	Off	On	Off	On
SAR 690V (690V)	Off	Off	Off	Off	Off	On	On	On

Figure 10 - DIP Switch S15 Location on Control Board



SAR Current Feedback Configuration

Overview

The current feedback to the SAR, provided via current transformers (CTs) that monitor the U and W phase inputs to the power module, is rectified via a three phase diode bridge. The output of the diode bridge is connected to a burden resistor. The voltage across the burden resistor is directly proportional to the amount of current being drawn by the motor load. This voltage is used by the regulator to monitor and control the current by comparing its value with the reference command. There are two on board burden resistor settings to choose from, depending on the variables of the application. In addition, an optional external burden resistor may be used for very specific cases. However, consult with Rockwell Automation Development Engineering prior to using this option to ensure that the circuit board ratings, as well the power dissipation ratings of the burden resistor, are properly considered. See Figure 11 on page 37 for details on the burden resistor circuit and Figure 13 on page 39 for burden resistor jumper locations.

Note: The current limit of the on-board burden resistors is 1 Amp. This includes not exceeding 1 Amp for the internal burden resistors in the event of an instantaneous over-current (IOC).

For retrofit situations current transformers are often already in place on the L1 (U) and L3 (W) AC incoming line conductors to the power module. However, the secondary current rating of the current transformers may not be 1 Amp and not well suited for the current feedback scaling and burden resistors of the SAR. For high current systems, current transformers with 5 Amp secondary windings are not unusual. These cases can be handled by using an interposing set of current transformers (cascading the current transformers) between the existing current transformers and the SAR. The resulting turns ratio is the product of the existing current transformer's turns ratio multiplied by the interposing current transformer's turns ratio.

The type of transformer for this application is a wound primary current transformer. The advantage of this implementation is that existing current transformers can remain in place, which eliminates the need to disassemble/ reassemble heavy bus bars, and the wiring to the existing and interposing current transformers is signal level wiring. Care must be taken in the implementation of the interposing current transformers to ensure that all considerations of sizing the current transformer configuration are met, such as the following:

- IOC Limits for the existing and interposing current transformers.
- Minimum magnetization currents required.
- Proper resulting turns ratio.

Consult with Engineering for assistance in implementing a current feedback configuration with interposing (cascade) current transformers.

The voltage across the burden resistor must be normalized for the full load rating of the power module. The regulator expects a value of 0.612 Volts at the current feedback input at 100% load of the power module. To ensure that the regulator receives 0.612 Volts at 100% load of the power module, a scaling operational

amplifier (Op-Amp) circuit has been provided. For reference, the name of this circuit will be called the "Binary Gain Amp," because the gain of the amplifier is set via binary DIP switches. See Figure 12 on page 38 for a diagram of the Binary Gain Amp circuit and Figure 13 on page 39 for DIP switch locations. When properly configured, the output of the Binary Gain Amp is 0.612 Volts at 100% load of the power module.

Note that the basis for scaling the current feedback is the power module, not the motor. This is a different approach than legacy systems where the motor was used as the basis for all of the current loop feedback scaling. This scaling works well as long as the power module and the motor are closely matched. However, when multiple power modules of the same size are used in the same process to run different size motors, it may be desirable to enter lower values for parameter 465 [Drive Size] and scale the regulator rating from the motor full load amps. This will reduce the size of the CT required and increase the resolution of the current feedback signal.

Though the power module is used as the basis for the current feedback calculation, the motor load must fall within the rating of the power module. If it does not, the power module may trip on an overload or IOC when the motor is running within its rating.

For example, if the regulator is configured so that the power module rating and the motor rating are equal, and the "Heavy Duty" option is chosen for the motor, the regulator will trip on a power module overload in 10 seconds when the system is running at 200% current, instead of the 1 minute desired.

In the SAR configuration the power module rating will be entered by the user and the regulator will use this value to determine overload and IOC trip points.

- Power Module Overload = 150% for 1 minute, or 200% for 10 seconds.
- Motor Overload - Standard Duty = 150% for 1 minute, (selection via parameter 376 [MtrOvrld Type])

  OR

- Motor Overload - Heavy Duty = 200% for 1 minute, (selection via parameter 376 [MtrOvrld Type])
- Motor Full Load Amps entered in parameter 179 [Nom Mtr Arm Amps]

Current Feedback Calculations

Inputs to the CT Calculation:

- The variable "IdN_pm_rtg" used in the calculations is the value of parameter 465 [Drive Size]
- Rb is the burden resistor which can be either 2.5 Ohms or 5.0 Ohms
- CT_pri is the current transformer primary rating
- CT_sec is the current transformer secondary rating

A range of CT values is initially calculated based on the system constraints of IOC and the recommended gain range of the Binary Gain Amp. For the constraint based on IOC, the CT minimum size would be at the IOC trip point of 250%. The CT sizing based on the Binary Gain Amp is based on the error encountered when using the DIP switch configuration to select the gain versus exact resistor values. As the gain is increased, the gain becomes more granular and the error is greater when compared with the exact gain. A gain value of 1.2 has been chosen as a guideline to keep the error to 1% or less. Lower values of CT ratio result in the improvement of "real system" resolution. The comparison between the exact value of gain and the actual gain is shown at the end of the calculation. There are trade offs between the value of the burden resistor and the gain of the amplifier. With a larger value of burden resistor (5.0 Ohms), the required gain is less and the binary value calculated is greater resulting in a more accurate signal. However, the feedback level at IOC needs to be considered as discussed later in this section.

Again, a value of 0.612 Volts represents 100% power module current. The required gain of the Binary Gain Amp is calculated with this in mind. The value of 0.612 Volts is divided by the actual voltage across the burden resistor at 100% power module current. This provides the value of gain required to ensure that 0.612 Volts is fed back to the regulator at 100% power module current.

There is a maximum limit of 2.5 Volts that can be accepted by the regulator current feedback. Beyond 2.5 Volts the circuitry will saturate. To ensure that this does not occur, the maximum value of current feedback is calculated at the IOC level.

The binary switch setting is based on the gain desired. The actual binary switch setting will be obtained by rounding the calculated value to the nearest integer. To convert from decimal to the required binary value, a calculator or personal computer can be used.

SAR Current Feedback Calculation Examples

Example 1:

CT, Burden Resistor and Gain Calculation

Input Values	Units	Description
IdN_pm_rtg: = 2600	Amp	Power module rating
Rb:= 5.0	Ohms	Jumper J5 in the "On" position and jumper J4 in the "Off" position. See Figure 13 on page 39 for jumper locations.
CT_pri: = 10000	Amp	
CT_sec: = 1	Amp	

Minimum CT Primary based on IOC trip point of 2.5 x Power Module rating

Value/Calculation	Units	Description
IOC_mult: = 2.5		
CT_pri_min: = IOC_mult x IdN_pm_rtg x 0.85		0.85 is the ratio of AC to DC current
CT_pri_min = 5.525 x 10^3	Amp	Based on IOC trip point
CT_ratio_min_based_on_ioc: = CT_pri_min / CT_sec		
CT_ratio_min_based_on_ioc = 5.525 x 10^3		Based on IOC trip point

Maximum CT ratio based on Gain Range of Scaling Op-Amp in the Current Feedback circuit

Value/Calculation	Units	Description
CT_ratio_max: = 1.2 x (IdN_rtg x Rb) / 0.612		
CT_ratio_max = 2.55 x 10^4		Based on Gain <= 1.2

Value/Calculation	Units	Description
Vf_at_IdN_pm_rtg = 0.612	Volts	Fixed Value
CT_ratio: = CT_pri / CT_sec		
CT_ratio = 1 x 10^4		
Ib_at_IdN_pm_rtg: = IdN_pm_rtg / CT_ratio		
Ib_at_IdN_pm_rtg = 0.26	Amps	
Vb_at_IdN_pm_rtg: = (IdN_pm_rtg / CT_ratio) x Rb		
Vb_at_IdN_pm_rtg = 1.3	Volts	
Gain_Required: = Vf_at_IdN_pm_rtg / Vb_at_IdN_pm_rtg		
Gain_Required = 0.471		Note: Recommended Gain <= 1.2 (for best accuracy)

Binary Gain Calculation and Checking Gain Error

Binary_Sw_Setting = 108.758

Value to use - 109, Binary = 1101101

	MSB											LSB
Bit Value	B11: = 0	B10: = 0	B9: = 0	B8: = 0	B7: = 0	B6: = 1	B5: = 1	B4: = 0	B3: = 1	B2: = 1	B1: = 0	B0: = 1
DIP Switch Setting	SW3-1 = Off	SW3-2 = Off	SW3-3 = Off	SW3-4 = Off	SW4-1 = Off	SW4-2 = On	SW4-3 = On	SW4-4 = Off	SW4-5 = On	SW4-6 = On	SW4-7 = Off	SW4-8 = On

For DIP switch SW3 and SW4 layout, refer to Table 14 - Binary Gain Amp DIP Switch to Bit Layout on page 39.

Resistor values are in K Ohms

$$R\_fdbk: = \frac{1}{B11 / 0.50 + B10 / 1 + 9 / 2 + B8 / 4 + B7 / 8 + B6 / 16 + B5 / 32 + B4 / 64 + B3 / 128 + B2 / 256 + B1 / 512 + B0 / 1024}$$

Value/Calculation	Units	Description
R_fdbk = 9.394		
R_input = 20		Fixed input resistor
Gain_Binary_OA: = R_fdbk / R_input		
Gain_Binary_OA = 0.47 versus Gain_Required = 0.471		Comparing the “Binary Gain Amp” to the “Calculated Required Gain”
Per_Cent_Gain_Error: = (Gain_Binary_OA - Gain_Required / Gain_Required) x 100		
Per_Cent_Gain_Error = -0.222		

Example 2:

CT, Burden Resistor and Gain Calculation

Input Values	Units	Description
IdN_pm_rtg: = 226	Amp	Power module rating
Rb:= 2.5	Ohms	Jumpers J4 and J5 in the "On" position. See Figure 13 on page 39 for jumper locations.
CT_pri: = 2000	Amp	
CT_sec: = 1	Amp	

Minimum CT Primary based on IOC trip point of 2.5 x Power Module rating

Value/Calculation	Units	Description
IOC_mult: = 2.5		
CT_pri_min: = IOC_mult x IdN_pm_rtg x 0.85		0.85 is the ratio of AC to DC current
CT_pri_min = 480	Amp	Based on IOC trip point
CT_ratio_min_based_on_ioc: = CT_pri_min / CT_sec		
CT_ratio_min_based_on_ioc = 480		Based on IOC trip point

Maximum CT ratio based on Gain Range of Scaling Op-Amp in the Current Feedback circuit

Value/Calculation	Units	Description
CT_ratio_max: = 1.2 x (IdN_rtg x Rb) / 0.612		
CT_ratio_max = 1.108 x 10^3		Based on Gain <= 1.2

Value/Calculation	Units	Description
Vf_at_IdN_pm_rtg = 0.612	Volts	Fixed Value
CT_ratio: = CT_pri / CT_sec		
CT_ratio = 2 x 10^3		
Ib_at_IdN_pm_rtg: = IdN_pm_rtg / CT_ratio		
Ib_at_IdN_pm_rtg = 0.113	Amps	
Vb_at_IdN_pm_rtg: = (IdN_pm_rtg / CT_ratio) x Rb		
Vb_at_IdN_pm_rtg = 0.283	Volts	
Gain_Required: = Vf_at_IdN_pm_rtg / Vb_at_IdN_pm_rtg		
Gain_Required = 2.166		Note: Required Gain = 2.166, which is greater than the Recommended Gain <= 1.2 (for best accuracy)

Binary Gain Calculation and Checking Gain Error

Binary_Sw_Setting = 23.634

Value to use - 24, Binary = 11000

	MSB											LSB
Bit Value	B11: = 0	B10: = 0	B9: = 0	B8: = 0	B7: = 0	B6: = 0	B5: = 0	B4: = 1	B3: = 1	B2: = 0	B1: = 0	B0: = 0
DIP Switch Setting	SW3-1 = Off	SW3-2 = Off	SW3-3 = Off	SW3-4 = Off	SW4-1 = Off	SW4-2 = Off	SW4-3 = Off	SW4-4 = On	SW4-5 = On	SW4-6 = Off	SW4-7 = Off	SW4-8 = Off

For DIP switch SW3 and SW4 layout, refer to Table 14 - Binary Gain Amp DIP Switch to Bit Layout on page 39.

Resistor values are in K Ohms

$$R\_fdbk: = \frac{1}{B11 / 0.50 + B10 / 1 + 9 / 2 + B8 / 4 + B7 / 8 + B6 / 16 + B5 / 32 + B4 / 64 + B3 / 128 + B2 / 256 + B1 / 512 + B0 / 1024}$$

Value/Calculation	Units	Description
R_fdbk = 42.667		
R_input = 20		Fixed input resistor
Gain_Binary_OA: = R_fdbk / R_input		
Gain_Binary_OA = 2.133 versus Gain_Required = 2.166		Comparing the “Binary Gain Amp” to the “Calculated Required Gain”
Per_Cent_Gain_Error: = (Gain_Binary_OA - Gain_Required / Gain_Required) x 100		
Per_Cent_Gain_Error = -1.525		The error exceeds 1%. The application will work but it is not optimal.

Example 3:

The only difference between Example 2 and Example 3 is the value of the burden resistor. In this example the burden resistor is chosen as Rb = 5.0 Ohms.

In this example a standard CT ratio is chosen and the ratio no longer exceeds the recommended CT ratio based on the gain calculation. This is due to the change of the burden resistor from 2.5 Ohms to 5.0 Ohms.

CT, Burden Resistor and Gain Calculation

Input Values	Units	Description
IdN_pm_rtg: = 226	Amp	Power module rating
Rb: = 5.0	Ohms	Jumper J5 in the "On" position and jumper J4 in the "Off" position. See Figure 13 on page 39 for jumper locations.
CT_pri: = 2000	Amp	
CT_sec: = 1	Amp	

Minimum CT Primary based on IOC trip point of 2.5 x Power Module rating

Value/Calculation	Units	Description
IOC_mult: = 2.5		
CT_pri_min: = IOC_mult x IdN_pm_rtg x 0.85		0.85 is the ratio of AC to DC current
CT_pri_min = 480	Amp	Based on IOC trip point
CT_ratio_min_based_on_ioc: = CT_pri_min / CT_sec		
CT_ratio_min_based_on_ioc = 480		Based on IOC trip point

Maximum CT ratio based on Gain Range of Scaling Op-Amp in the Current Feedback circuit

Value/Calculation	Units	Description
CT_ratio_max: = 1.2 x (IdN_rtg x Rb) / 0.612		
CT_ratio_max = 2.216×10^3		Based on Gain <= 1.2

Value/Calculation	Units	Description
Vf_at_IdN_pm_rtg = 0.612	Volts	Fixed Value
CT_ratio: = CT_pri / CT_sec		
CT_ratio = 2×10^3		
Ib_at_IdN_pm_rtg: = IdN_pm_rtg / CT_ratio		
Ib_at_IdN_pm_rtg = 0.113	Amps	
Vb_at_IdN_pm_rtg: = (IdN_pm_rtg / CT_ratio) x Rb		

Value/Calculation	Units	Description
Vb_at_IdN_pm_rtg = 0.565	Volts	
Gain_Required: = Vf_at_IdN_pm_rtg / Vb_at_IdN_pm_rtg		
Gain_Required = 1.083		Note: Required Gain = 1.083, which is within the Recommended Gain <= 1.2 (for best accuracy)

Checking the Maximum Voltage Feedback to Regulator

Value/Calculation	Units	Description
Binary_Sw_Setting: = 51.2 / Gain_Required		
Binary_Sw_Setting = 47.268		
Ib_at_IOC: = (IdN_pm_trg x IOC_mult / CT_ratio)		
Ib_at_IOC = 0.282	Amps	
Vb_at_IOC: = (IdN_pm_rtg x IOC_mult / CT_ratio)		
Vb_at_IOC = 1.412	Volts	
V_curr_fdbk_to_reg_at_IOC: = Gain_Required x Vb_at_IOC		Maximum allowable value of V_curr_fdbk_to_reg_at_IOC = 2.5V
V_curr_fdbk_to_reg_at_IOC = 1.53	Volts	

Binary Gain Calculation and Checking Gain Error

Binary_Sw_Setting = 47.268

Value to use - 47, Binary = 101111

	MSB											LSB
Bit Value	B11: = 0	B10: = 0	B9: = 0	B8: = 0	B7: = 0	B6: = 0	B5: = 1	B4: = 0	B3: = 1	B2: = 1	B1: = 1	B0: = 1
DIP Switch Setting	SW3-1 = Off	SW3-2 = Off	SW3-3 = Off	SW3-4 = Off	SW4-1 = Off	SW4-2 = Off	SW4-3 = On	SW4-4 = Off	SW4-5 = On	SW4-6 = On	SW4-7 = On	SW4-8 = On

For DIP switch SW3 and SW4 layout, refer to Table 14 - Binary Gain Amp DIP Switch to Bit Layout on page 39.

Resistor values are in K Ohms

$$R\_fdbk: = \frac{1}{B11 / 0.50 + B10 / 1 + 9 / 2 + B8 / 4 + B7 / 8 + B6 / 16 + B5 / 32 + B4 / 64 + B3 / 128 + B2 / 256 + B1 / 512 + B0 / 1024}$$

Value/Calculation	Units	Description
R_fdbk = 21.787		
R_input = 20		Fixed input resistor
Gain_Binary_OA: = R_fdbk / R_input		
Gain_Binary_OA = 1.089 versus Gain_Required = 1.083		Comparing the "Binary Gain Amp" to the "Calculated Required Gain"
Per_Cent_Gain_Error: = (Gain_Binary_OA - Gain_Required / Gain_Required) x 100		
Per_Cent_Gain_Error = 0.57		The error is now less than 1%.

Figure 11 - Bridge Rectifier and Burden Resistor Circuit Diagram

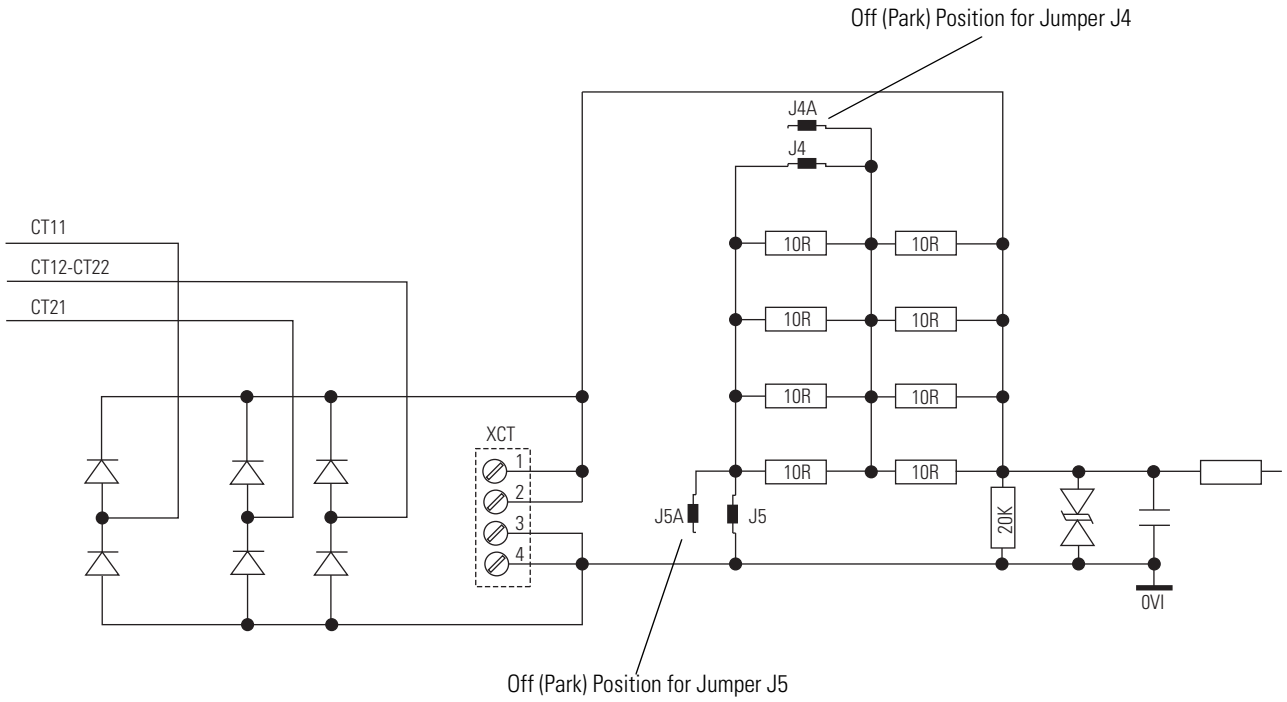


Figure 12 - Binary Gain Amplifier Circuit Diagram

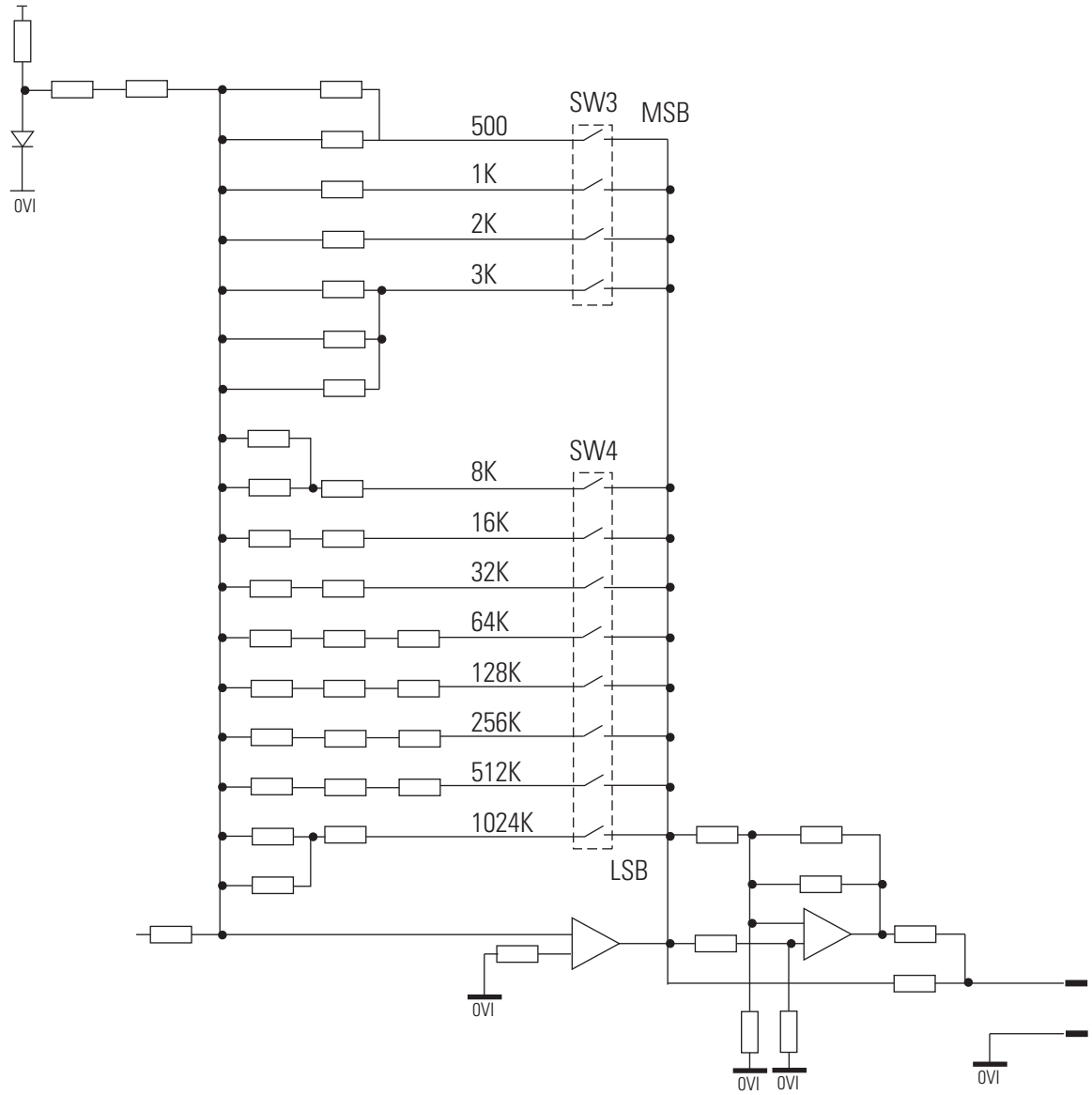


Figure 13 - Burden Resistor Jumpers (J4 and J5), Binary Gain Amp DIP Switches (SW3 and SW4), and External Burden Resistor Terminal Block (XCT) Locations

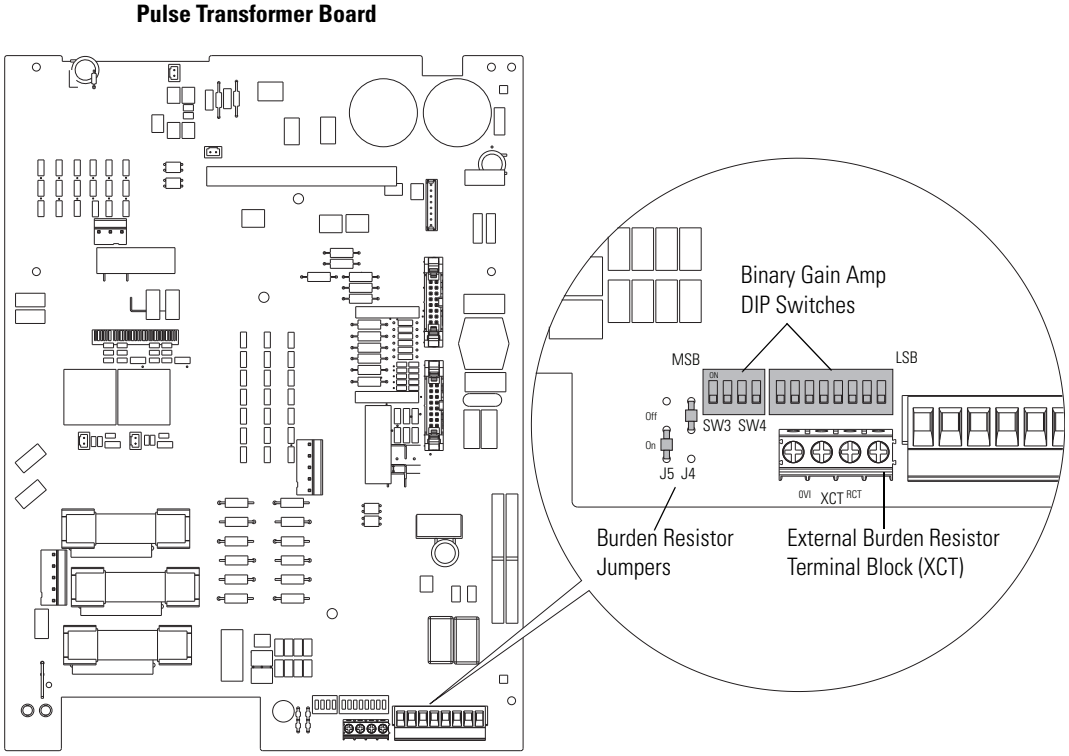
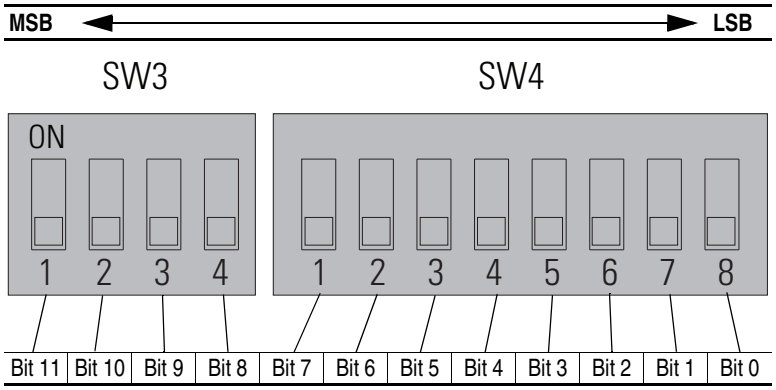


Figure 14 - Binary Gain Amp DIP Switch to Bit Layout



IMPORTANT The labels on DIP switches SW3 and SW4 do NOT correspond to the bit numbers used to set the amplifier gain.

SAR Programming and Startup

SAR programming and startup require a Human Interface Module (HIM) or DriveExplorer™ or DriveTools SP™ software with a network connection made using a communication adapter. The SAR is not sold with a HIM or communication adapter. These products must be purchased separately. See Appendix B - "HIM Overview" and Appendix E - "Installing a Communication Adapter", respectively, in the TPDflex DC Converters User Manual, publication 1S7TFLEXUMO for details.

SAR Parameter Configuration

To accommodate incoming line voltages that are greater than 690VAC, parameter 464 [SAR Volts Scale] is used to scale the actual values of the system voltages so that they can be displayed on the HIM or in programming software without having the regulator directly connected to the higher voltage levels. The upper limit is 1200VAC. However, there are means to accommodate greater voltages.

The SAR has a maximum rating of 690VAC. The incoming AC line and the power module output / motor voltage needs to be scaled to ensure that the voltages the regulator receives are within its' rating. When the voltage is reduced, the scaling parameter (464) provides the means to add a multiplier to the voltage values so that the displayed voltages reflect those at the actual regulator input and output.

Example:

If the actual voltage that appears at the AC input to the SAR is 400VAC (due to resistor scaling) and the incoming line is at 1000VAC, then the scaling value is the ratio of the two voltages:

464 [SAR Volts Scale] = 1000VAC / 400VAC = 2.5

The external scaling of the voltage to the regulator will be done via resistors.

Consult with Development Engineering for component sizing and gate configuration wiring guidelines, for systems greater than 690VAC incoming line, or low voltage.

All other parameter settings for the SAR are the same as those documented in Chapter 3 "Programming and Parameters" in the PTPDflex DC Converters User Manual, publication 1S7TFLEXUMO.

SAR Startup

When installation of the SAR is complete, perform the procedures in Chapter 2 "Drive Start Up" in the TPDflex DC Converters User Manual, publication 1S7TFLEXUMO for details.

Gate Amplifier Installation and Wiring

Prepare for Installation

Prior to installation of the Gate Amplifier read the General Precautions on page 9.

Operating Temperatures

The surrounding air temperature must be within 0 ° C to 50 ° C (32 ° F to 122 ° F). Humidity must remain between 5% and 95% non-condensing.

Mounting and Cooling

The Gate Amplifier is an open type construction and is intended to be installed on a flat surface in a suitable enclosure. The unit must be mounted in the upright position (faceplate lettering legible and the mounting back plate vertical) to ensure effective convection cooling.

Follow these instructions when mounting the Gate Amplifier:

- Mount in a clean, dry location. Contamination from oils, corrosive vapors and abrasive debris must be kept out of the enclosure.
- Do not mount heat-generating equipment directly underneath the unit.
- Mount the unit in a vertical position only.
- Power dissipation, 50 Watts.

Figure 15 - Minimum Mounting Clearances

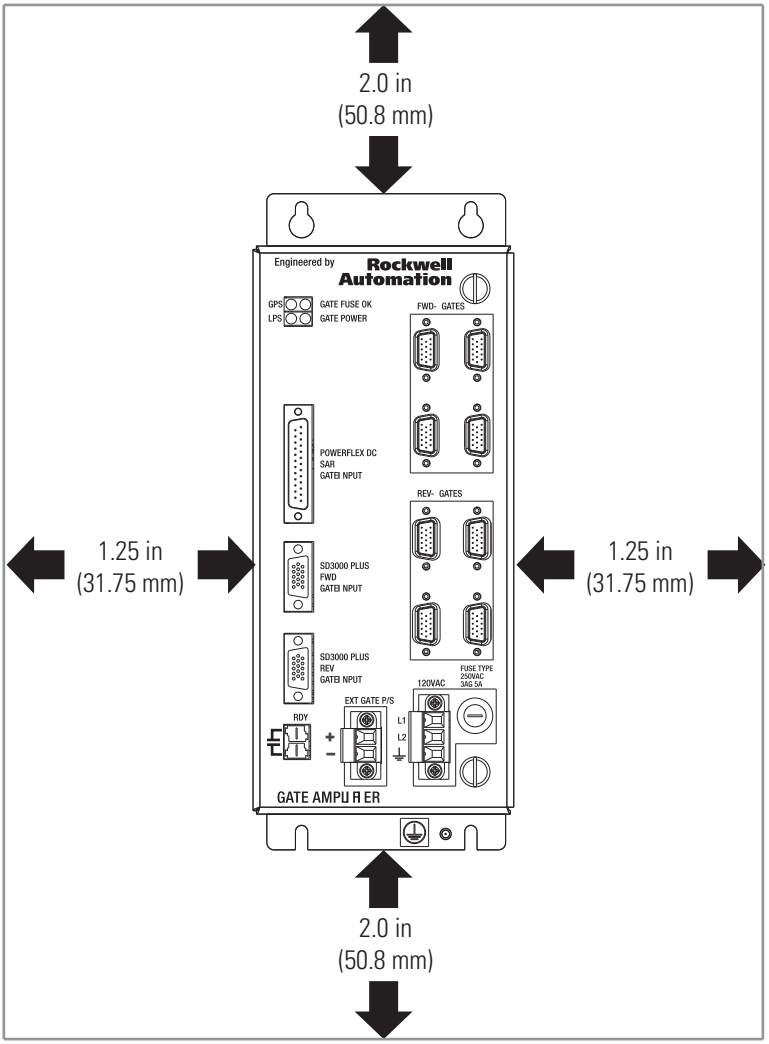


Figure 16 - Approximate Dimensions

Dimensions in inches and (millimeters)

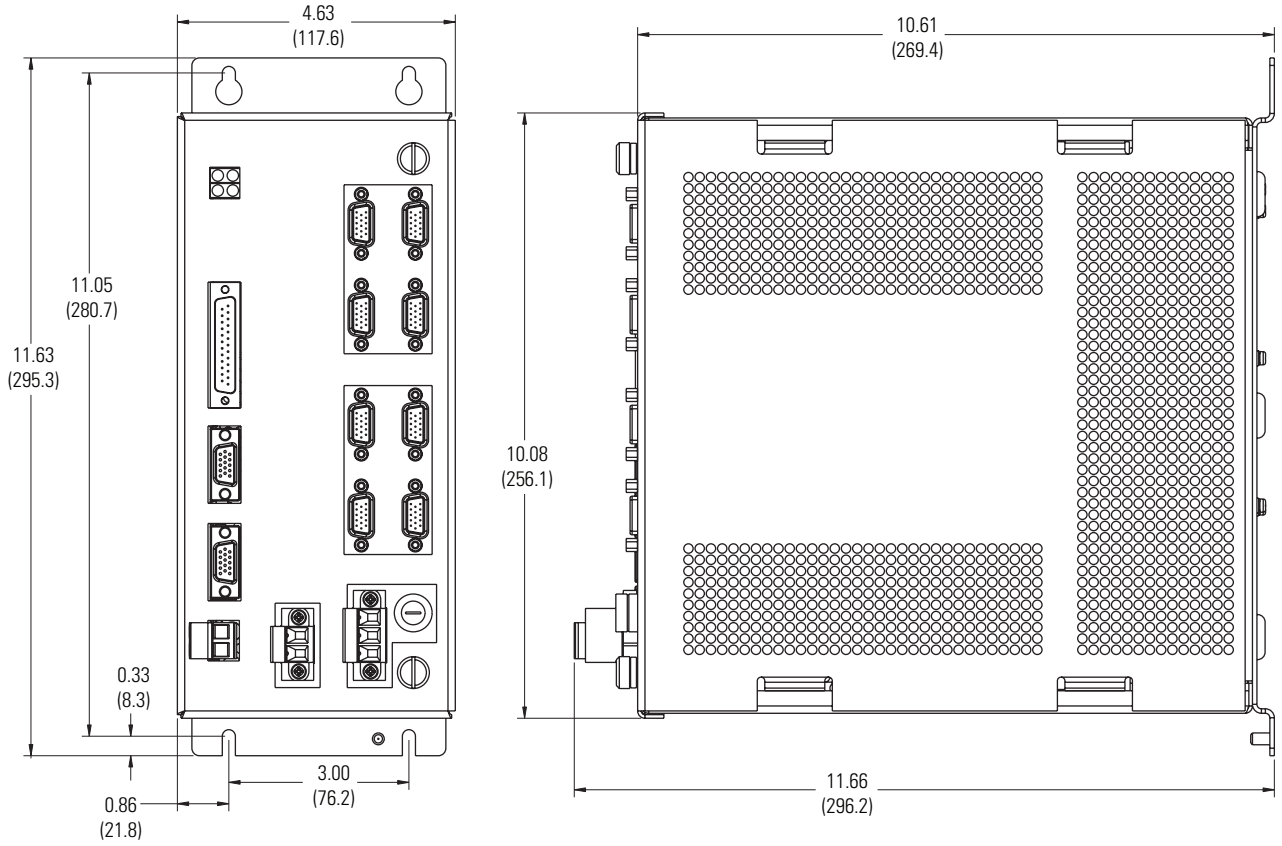


Table 8 - Gate Amplifier Weights

Gate Amplifier	Gate Amplifier & Packaging
5.0 kg (11.0 lb)	5.7 kg (12.5 lb)

Recommended Mounting Hardware: Metric M5, English #10

IMPORTANT Provide at least 114 millimeters (4.5 inches) in front of unit for connectors and cable bend radius.

Power and Ground Wiring

Figure 17 - Power and Ground Connections

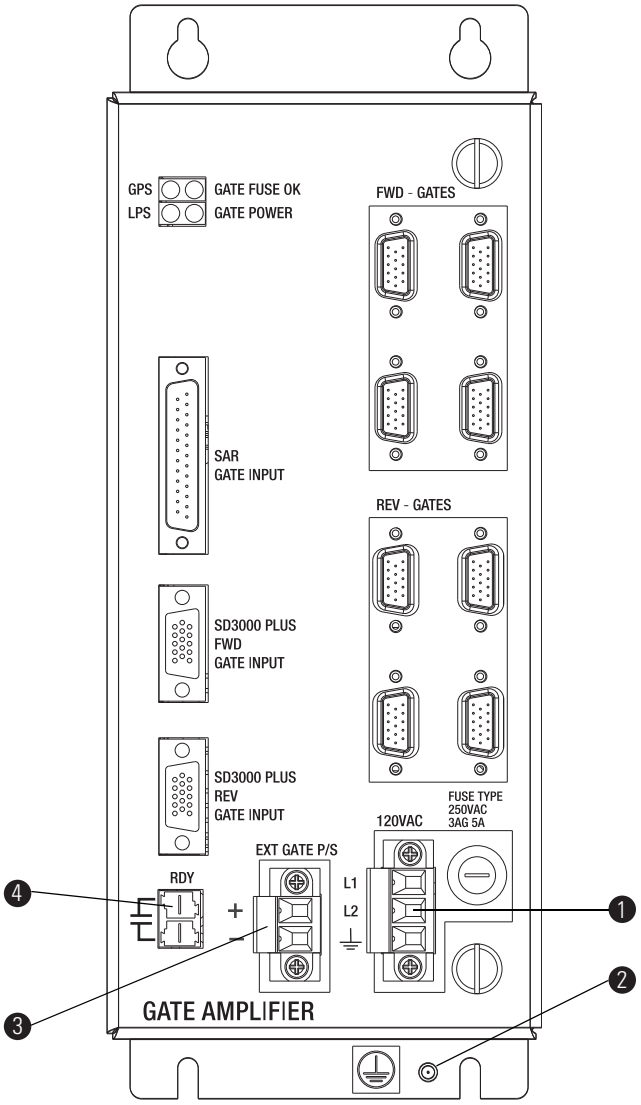


Table 9 - Terminal Specifications

No.	Name	Description	Part Number for Customer Plug (provided with Gate Amplifier)	Wire Size Range		Recommended
				Maximum	Minimum	Torque
1	Input Power Terminal Block L1, L2, Ground	Input power - Line (L1), Neutral (L2) and Ground	94809302	4.0 mm^2 (10 AWG)	2.5 mm^2 (14 AWG)	0.68 N•m (6.0 lb•in)
2	Ground Stud	Chassis Ground	Refer to Chassis Grounding on page 45 for more information.			
3	External Gate Power Supply	External Gate Power Supply (if used)	94809301	10 AWG, Twisted Pair, 2 Twists / in.	18 AWG, Twisted Pair, 2 Twists / in.	0.68 N•m (6.0 lb•in)
4	Ready Relay	Ready Relay Drive Run Permissive Interlock(1)	PN-26501	4.0 mm^2 (10 AWG)	2.50 mm^2 (14 AWG)	0.55 N•m (5.0 lb•in)

(1) Ready relay contacts are normally open rated at 2 Amps, 120VAC.

Chassis Grounding

A ground stud is provided on the lower right corner of the chassis mounting flange for making a ground connection. Connect the grounding wire provided to the ground stud and the metal panel. Make sure that the lug makes a good connection to the panel.

To provide additional grounding, with regard to noise immunity, the upper and lower "mounting feet" of the unit have areas that are free of paint to provide a positive connection between the unit and the enclosure mounting panel.

It is important that the panel that the Gate Amplifier is mounted to is properly grounded to the power system ground in the customer's plant. Ideally, the panel that the Gate Amplifier is mounted on, as well as the associated components should be at the same potential as the Armature Power Module and the Motor. Each of the signals that go to/from the Gate Amplifier are bypassed to chassis ground through small capacitors. These capacitors aid in removing noise from the signal lines. If the Gate Amplifier or the panel that it mounts to is not properly grounded, the bypass capacitors can actually inject noise onto the signal lines resulting in nuisance trips.

For example, if the motor frame and the Gate Amplifier chassis are not grounded together, the motor frame potential can fluctuate as the drive is run. If the motor frame fluctuates in potential, the case of the feedback device (encoder) will also "see" this fluctuation. The capacitive coupling between the case of the feedback device and the internal wiring and/or electronics can result in a common mode noise signal being injected into the wiring. This can result in noise on the feedback lines. Another source of noise in the feedback path are the voltage fluctuations of the motor shaft, especially in higher hp motors (above 300 Hp). In these cases, an insulated "Thomas" coupling is recommended for interfacing with the feedback device. The internal part number of an insulated Thomas coupling is 406041-17, (Power Division Part Number).

For retrofit installations, lack of sufficient bonding/grounding is often the cause of noise problems. If the regulator components are installed on a sub-panel, a 1/0 fine strand welding cable should be used to connect the panel to the ground bus. Panels within the cabinet(s) must be bonded together. If the panels within the cabinet are not bonded together, use 1/0 fine strand welding cable to connect the panels. Be sure that all paint is scraped off at the connection points; a 2 milli-Ohms connection or less is ideal. In the absence of a milli-Ohm or micro-Ohm meter to actually measure the connection resistance, the connections should be made suitable enough to support the "cranking current required to start a car." This means that the connection must be clean and free of paint and other debris. The supply transformer frame, drive cabinet panels, and motor frame must be bonded together to provide a "preferred path" for high frequency noise.

Key Grounding/Bonding Points Outside of the Cabinet

The high frequency grounding/bonding outside of the cabinet should be treated in a manner similar to a power supply mounted on a ground plane with all of the components that it supplies, mounted on the same ground plane. In the case of the drive system, the transformer can be thought of as the power supply for the downstream components; AC entry bay, drive cabinets, and motors. The high frequency grounding/bonding of the components is effectively like mounting them on a virtual ground plane. All components from the power transformer to the motor needs to viewed as a whole system.

All currents used to run the drives and motors originate at the power transformer. As the power is being controlled by the drive system to regulate the amount of the energy supplied to the motor, high frequencies are generated through the switching action of the drive power components. The capacitive coupling of the high frequencies to the metal that is within proximity to the conductors creates ground currents (ic=Cdv/dt). The major components of the system, motor, conduit, and cabinet will all be "charged" by this capacitive coupling effect. The ground currents seek a return path back to the source, the drive, and ultimately the transformer. If a known good path is not provided, more currents will flow through the machine and other undesirable paths. The power transformer provides a magnetic isolation barrier that prevents the ground currents from going into the power grid. In the transformer there is capacitive coupling between the transformer core and the windings. Attachment of the transformer frame (which is attached to the core) to the drive cabinet(s) will complete the ground current path for these components through a known path.

- Motor to cabinet - the connections for the motor ground must be made directly to the frame of the motor, not the conduit box. The connection between the motor frame and the conduit box does not provide a good high frequency conduction path.
- Drive cabinet to bus power entry cabinet.
- Power entry cabinet to power transformer case/frame.

If insufficient grounding/bonding is suspected, then additional wiring must be added (as shown in the system diagram that follows) to ensure that there is a proper path for electrical noise.

Welding cable is needed for grounding/bonding where high frequency noise currents are present. Table 10 - Recommended Welding Cable for High Frequency Grounding/Bonding on page 47 provides an overall guideline for the wire size to use for the high frequency bonding between the major system components shown in Figure 18 - DC Drive High Frequency Grounding / Bonding Configuration on page 47.

Table 10 - Recommended Welding Cable for High Frequency Grounding/Bonding

Drive System Nominal Motor FLA Per Section	Recommended Welding Cable Size	Cable Type
100…3000 Amps	2/0	Anixter #5J-2021 or Equivalent
3001…5000 Amps	3/0	Anixter #5J-3031 or Equivalent
5001…9000 Amps	250 MCM	Anixter #5J-2501 or Equivalent
9001…20000 Amps	500 MCM	Anixter #5J-5001 or Equivalent

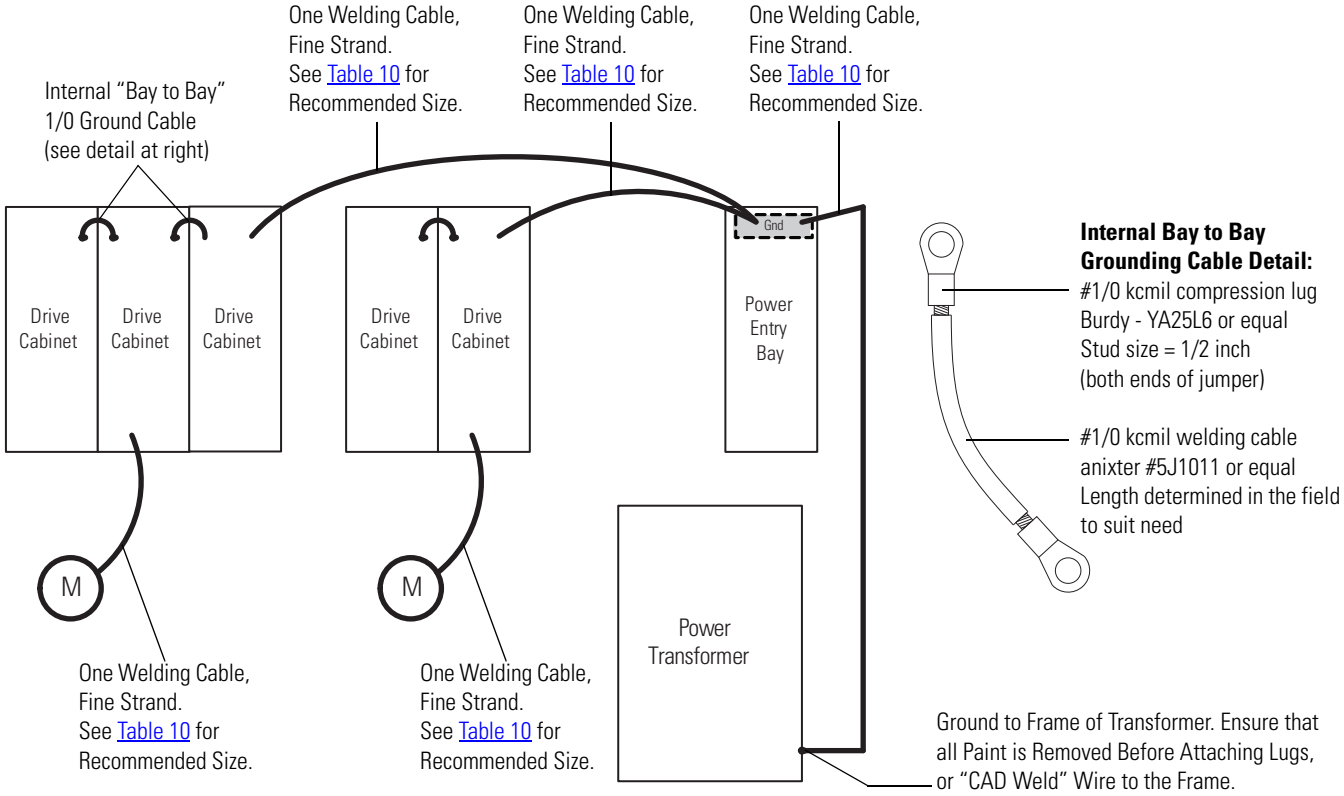
DC Drive High Frequency Grounding of Adjacent Cabinet Panels

Unless there is good continuity from panel to panel, the potential between the panels will be different.

Notes on cabinet grounding:

- This grounding scheme is for high frequency grounding only. The customer is responsible for all safety grounds and meeting local and state equipment grounding codes.
- If the DC Drive Regulator components are mounted to a sub-panel, then there must be a 1/0 Welding cable ground jumper between the sub-panel and the main cabinet control panel.

Figure 18 - DC Drive High Frequency Grounding / Bonding Configuration



Control Wiring Connections

Refer to Table 11 on page 49 for a description of the control connections identified in Figure 19 - Gate Amplifier Drive Control.

Figure 19 - Gate Amplifier Drive Control

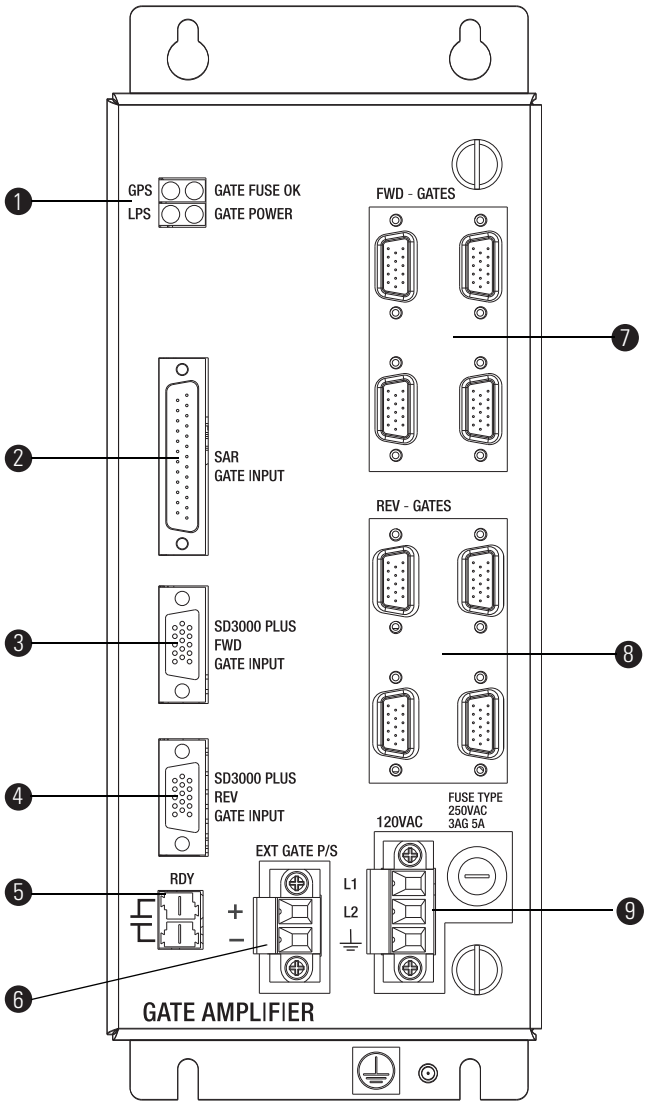


Table 11 - Indicators and Control Connection Descriptions

No.	Label on Gate Amplifier	Description	Function
1	GPS	+28V Gate Power Supply output present LED	This LED is illuminated when the gate power supply output is present. See GPS below for more information.
	LPS	+5V Logic Power Supply output present LED	This LED is illuminated when the logic power supply output is present. See LPS below for more information.
	GATE FUSE OK	External Power Supply fuse OK LED	This LED is illuminated when the fuse is "OK". See GATE FUSE OK on page 50 for more information.
	GATE POWER	Gate power systems OK LED	This LED is illuminated when all onboard systems are functioning normally. See GATE POWER on page 50 for more information.
2	TPDflex DC SAR GATE INPUT	TPDflex DC Stand Alone Regulator Gate Input	Input for the TPDflex DC Stand Alone Regulator (SAR) Gates. See TPDflex DC SAR GATE INPUT on page 50 for more information.
3	SD3000 PLUS FWD GATE INPUT	SD3000 *PLUS* Forward Gate Input	Input for the SD3000 *PLUS* forward gates. See SD3000 PLUS FWD GATE INPUT on page 50 for more information.
4	SD3000 PLUS REV GATE INPUT	SD3000 *PLUS* Reverse Gate Input	Input for the SD3000 *PLUS* reverse gates. See SD3000 PLUS REV GATE INPUT on page 50 for more information.
5	RDY	Normally Open relay contacts	Used to indicate that the Gate Amplifier is "ready to run." See RDY on page 51 for more information.
6	EXT GATE P/S	External Gate Power Supply	This input is used to increase the gate driver level. See EXT GATE P/S on page 51 for more information.
7	FWD - GATES	Armature Forward Gates	Four forward gate outputs to provide gate signals for up to four power modules. See FWD - GATES and REV - GATES on page 52 for more information.
8	REV - GATES	Armature Reverse Gates	Four reverse gate outputs to provide gate signals for up to four power modules. See FWD - GATES and REV - GATES on page 52 for more information.
9	120VAC	Power Input to Gate Amplifier	Cabinet control power. See 120VAC on page 52 for more information.

GPS

The +28V Gate power supply provides all of the DC power for the Gate Amplifier. All other voltages are derived from the +28V Gate power supply. If the GPS LED is off, all of the other indicating LEDs will also be off. Confirm that 120VAC is present at the power input terminal if the GPS LED is not illuminated.

LPS

The +5V Logic Power Supply voltage is derived from the +28V Gate power supply. If the +28V Gate power supply power is not present the logic power supply LED will not be illuminated.

GATE FUSEOK

The “GATE FUSE OK” LED circuit is used to monitor the fuse for the external power supply. To sense whether the fuse is open, the voltage across the fuse is monitored. If the fuse is open and the Gate Amplifier is provided with gate firing pulses, the “GATE FUSE OK” LED will turn off and the Ready Relay will drop out.

The fuse is internal to the Gate Amplifier and is soldered to the Gate Driver Output board, it is not replaceable in the field.

GATE POWER

The Gate Power function also picks up the Ready relay. The Ready relay is a Double Pole Single Throw relay. One set of the Normally Open contacts provides the power connection for the Gate Power LED and the second pair of Normally Open contacts provides the Ready relay contacts for the drive control interlocks.

TPDflex DC SAR GATE INPUT

Input for the TPDflex DC Stand Alone Regulator (SAR) gates - includes both forward and reverse gates at this connector.

Note: The SD3000 *PLUS* ports cannot be used at the same time as the SAR port.

SD3000 PLUS FWD GATE INPUT

Input for the SD3000 *PLUS* forward gates. This input is also compatible with the PMI Rack DC Drive Regulator.

Note: The SAR port cannot be used at the same time as the SD3000 *PLUS* ports.

SD3000 PLUS REV GATE INPUT

Input for the SD3000 *PLUS* reverse gates. This input is also compatible with the PMI Rack DC Drive Regulator.

Note: The SAR port cannot be used at the same time as the SD3000 *PLUS* ports.

RDY

This is the Ready relay interlock. The Gate Amplifier has Normally Open relay contacts that close when the Gate Amplifier is "ready to run." The Ready relay is to be wired into the drive "Run Permissive" logic. The Ready relay will "drop out" when the Gate Amplifier has a malfunction. The Ready relay circuit is rated at 1.4 Amps, (fused at 2 Amps, relay contacts rated at 2 Amps).

EXT GATE P/S

If an external power supply is required, it should meet the following ratings:

- For the TPDflex DC SAR, 48V DC, 5 A (minimum), (250 W)
- For the SD3000 *PLUS*, 48V DC, 3 A (minimum), (150 W).

The power supply must also have current limit protection. For noise protection, an AC line filter must be used in the 120V AC supply line to the 48V power supply. The filter is Corcom part number 10VVI, (Rockwell Automation part number 612421-1C) or equivalent.

Note: When using the external power supply, the Gate Coupler Assembly "SD3K-GATMDL HIGH" must be used for firing the SCRs. If the Gate Coupling boards are to be separately mounted, then the 97306101 Gate Coupler board should be used.

Twisted pair should be used for the output wiring of the power supply. The power supply should be mounted near the Gate Amplifier. As a general rule, the wiring between the external power supply and the Gate Amplifier should be approximately 40 inches (1 meter) or less.

- When installing a 48V external gate power supply and/or wiring the 120VAC input, a fuse block with a 10 A fuse and line filter (as mentioned above) are required. The output is wired to the two point connector that plugs into the front of the Gate Amplifier.
  - 48V Relay part number: 700-HC24Z48-3-4
  - Socket part number: 700-HN104 Series D
  - Fly Back Diode/LED part number: 700-ADL2 Series B

  Note: The coil is polarity sensitive when the Fly Back diode is connected.

- An interlock relay is required for the external gate power supply. The relay coil is wired to the output of the 48V external gate power supply to indicate that the power supply is active. The contacts of the relay need to be wired into the "Run Permissive" logic.

FWD - GATES and REV - GATES

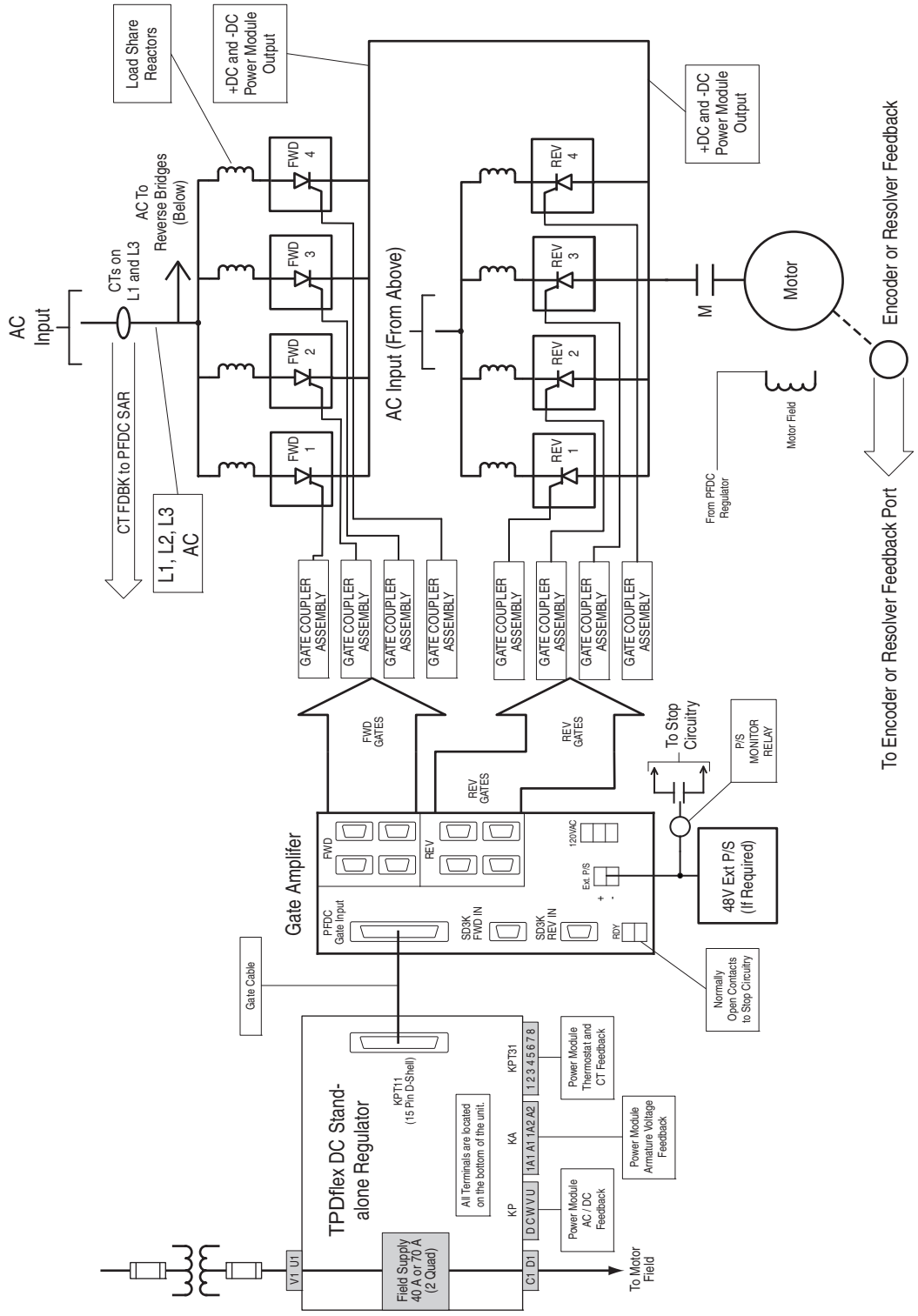
Four identical forward and four identical reverse gate outputs provide gate signals for up to four power modules. The output is a burst pattern that has a maximum amplitude dependent on the gate power supply that is used, internal or external. The internal "ORing" diode determines whether the internal or external power supply is used. The maximum gate voltage is 28V with the internal gate supply and 48V when using the external gate power supply.

120VAC

This is the control power input to the Gate Amplifier. Wire into the cabinet control power.

Figure 20 - Typical Gate Amplifier Interface to Multiple S6Rs

See Parallel Power Modules and Load Share Reactors on page 65 for more information.



Gate Amplifier, Cascade Configurations

It is permissible to cascade Gate Amplifiers. The time delay through the Gate Amplifier is 0.5 µSec. This amount of time delay is not significant with regard to the gate firing of parallel power modules. For any configuration with multiple Gate Amplifiers, be sure to connect the Ready relay into the "Run Permissive" circuit.

The external +48V power supply cannot be used on a Gate Amplifier or SD3000 *PLUS* whose output acts as an input source for a "downstream" Gate Amplifier. The continuous application of the high amplitude gate pulses to the input will cause excessive heating of the components of the input stage. If the external 48V power supply is used, the interlocking relay must also be used as described in the "EXT GATE P/S" section on page 51.

Illustrations are included for both the Stand Alone Regulator (see Figure 21 below and Figure 22 on page 55) and the SD3000 *PLUS* (see Figure 23 on page 56 and Figure 24 on page 57).

Figure 21 - Cascading Gate Amplifiers Using the Stand Alone Regulator

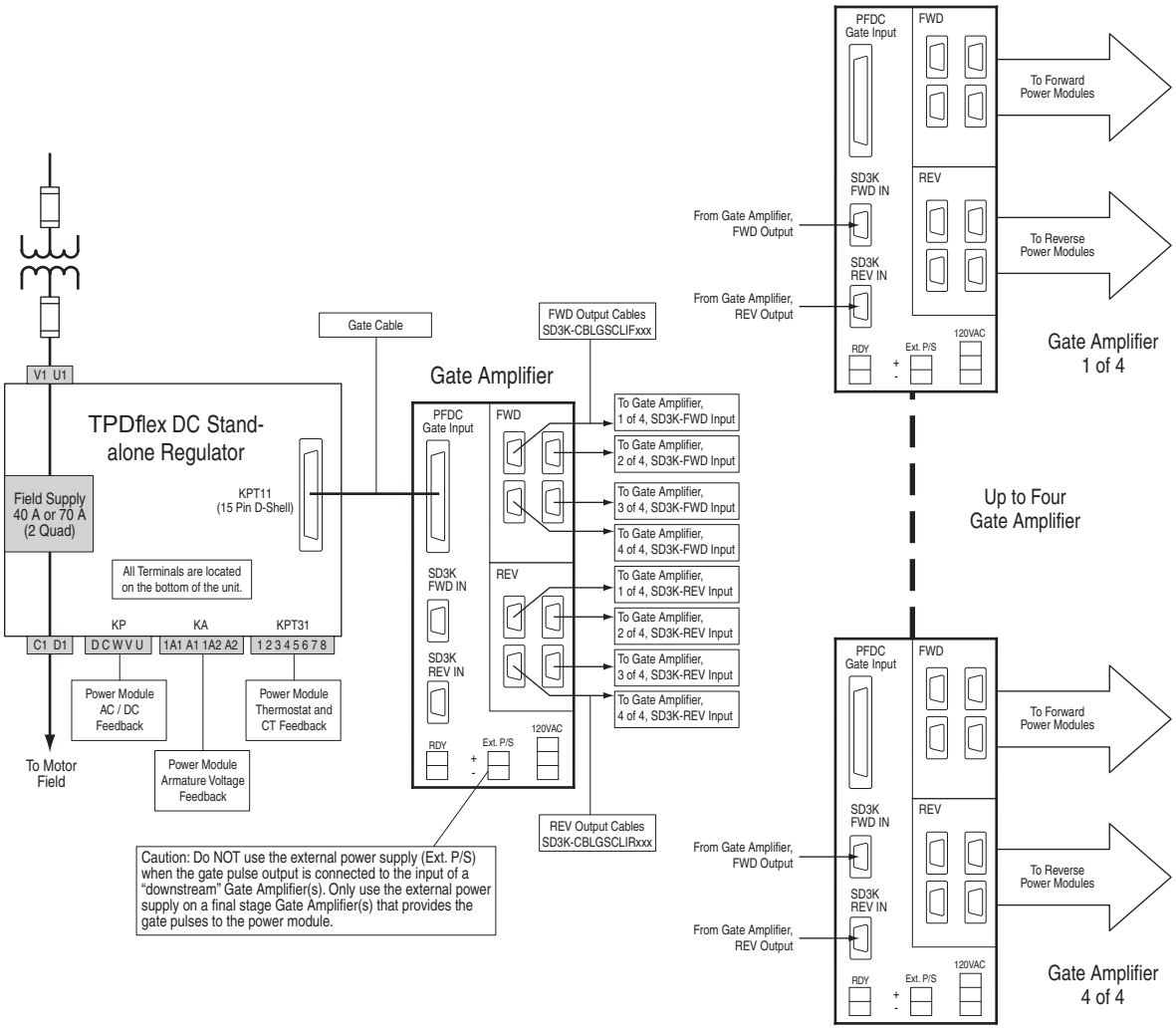


Figure 22 - Cascading Gate Amplifiers Using the Stand Alone Regulator, Mixed Configuration

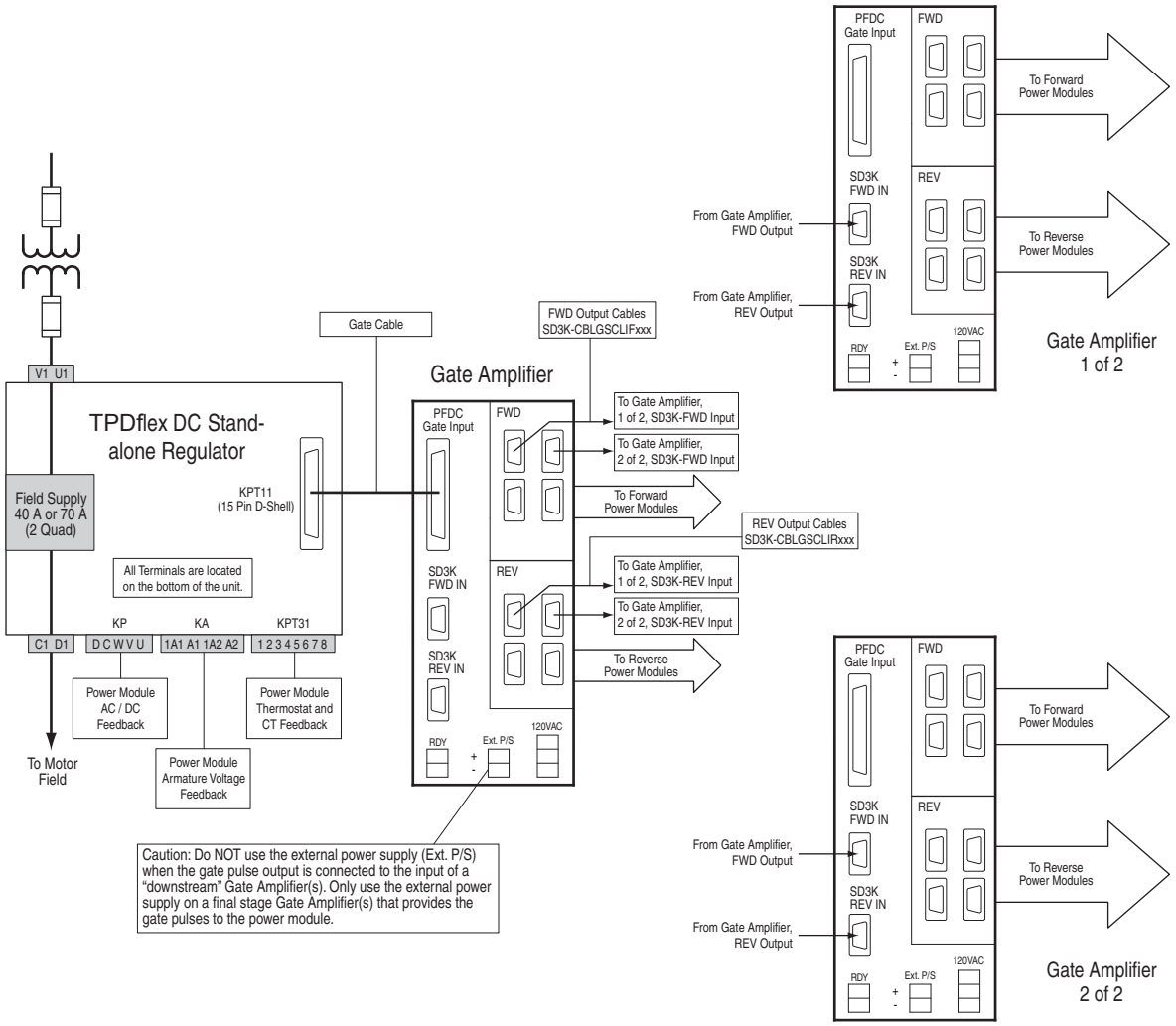


Figure 23 - Cascading Gate Amplifiers Using the SD3000 *PLUS*

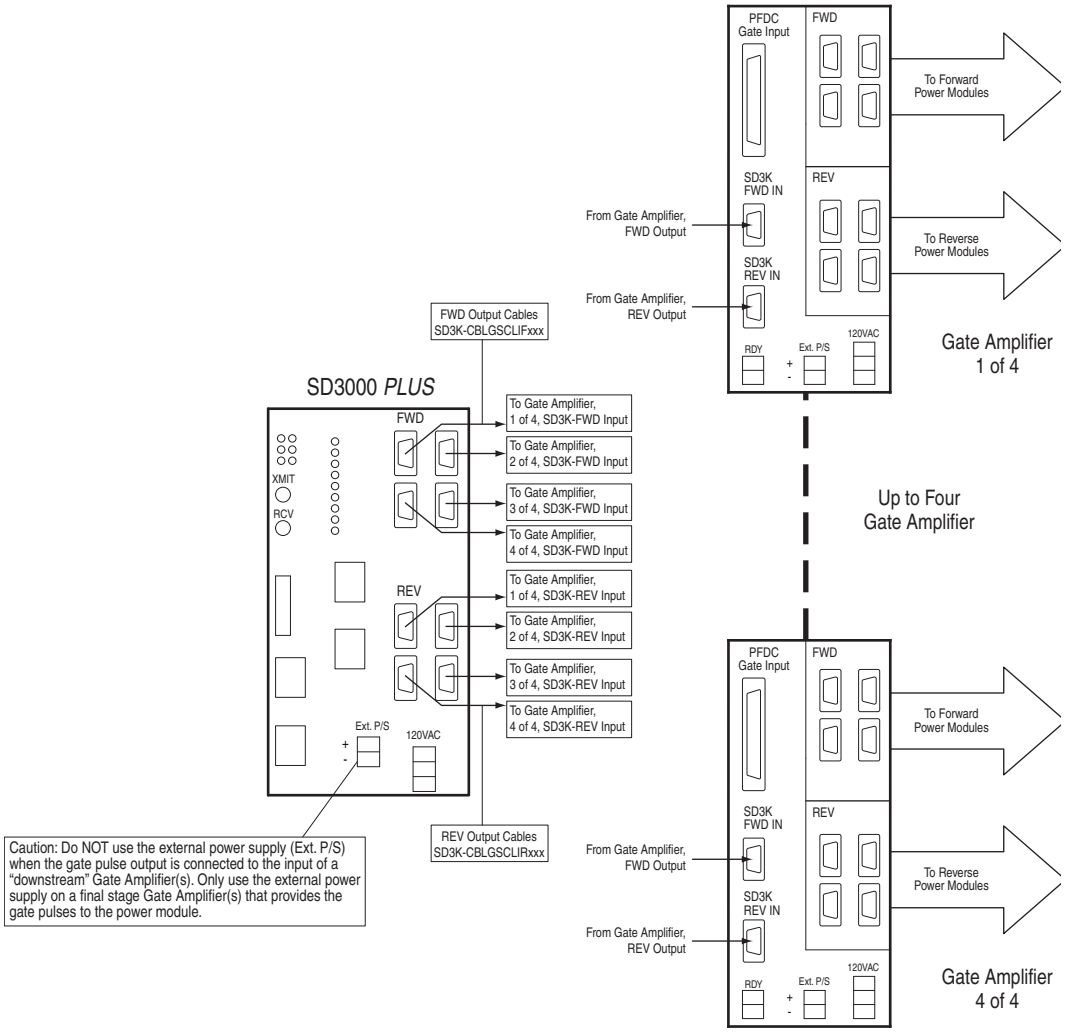
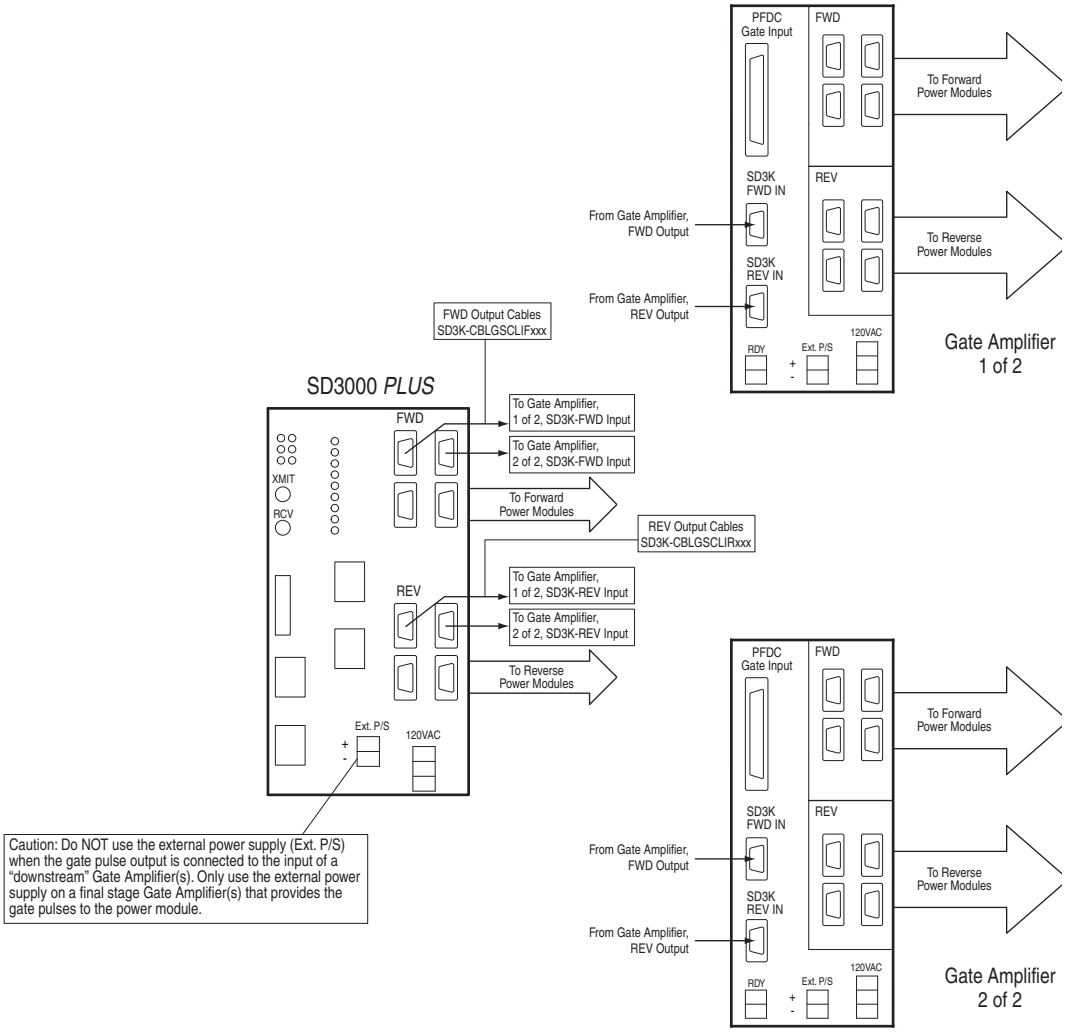


Figure 24 - Cascading Gate Amplifiers Using the SD3000 *PLUS*, Mixed Configuration



Gate Interface to Rockwell Automation Power Modules

Rockwell Automation power modules 356405-Cxx, 356406-Cxx and 356407-Cxx do not contain gate couplers. The gate couplers are contained in a separate unit called the Gate Coupler Assembly. The basic interface configuration is shown in Figure 25 - Connection to Rockwell Automation Power Modules. Cables appear in the tables following the illustration below.

Figure 25 - Connection to Rockwell Automation Power Modules

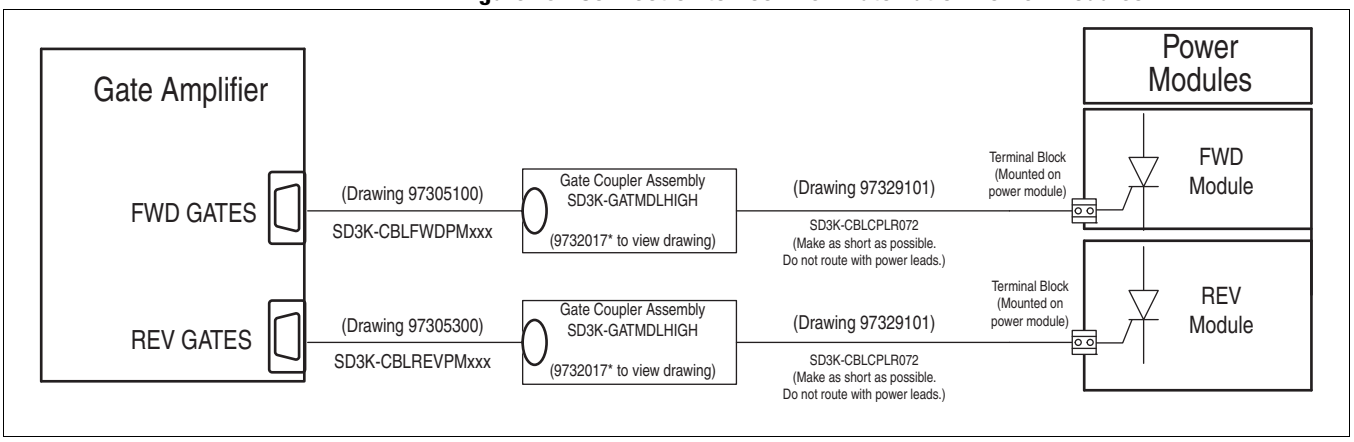


Table 12 - Round Style Connector Forward Gate Cables

Catalog Number	Length
SD3K-CBLFWDPM060	5 Feet
SD3K-CBLFWDPM120	10 Feet
SD3K-CBLFWDPM180	15 Feet
SD3K-CBLFWDPM240	20 Feet

Additional lengths can be found on drawing 97305100.

Table 13 - Round Style Connector Reverse Gate Cables

Catalog Number	Length
SD3K-CBLREVPM060	5 Feet
SD3K-CBLREVPM120	10 Feet
SD3K-CBLREVPM180	15 Feet
SD3K-CBLREVPM240	20 Feet

Additional lengths can be found on drawing 97305300.

Table 14 - Output of Gate Coupler Assembly to SCR Gate Cable

Catalog Number	Description
SD3K-CBLCPLR072	The cable is a twisted pair wire with "box" connectors on one end that plug onto the Gate Coupler Boards that are in the Gate Coupler Assembly. The opposite ends are "pig-tails" for connecting the power module gate input terminal blocks. Use a second set of this cable type for an S6R configuration. (Cut to desired length, as short as possible.) Do not route with power leads.

To view drawing, 97329100, (an increased length cable may be added in the future, it will appear on the drawing when available.)

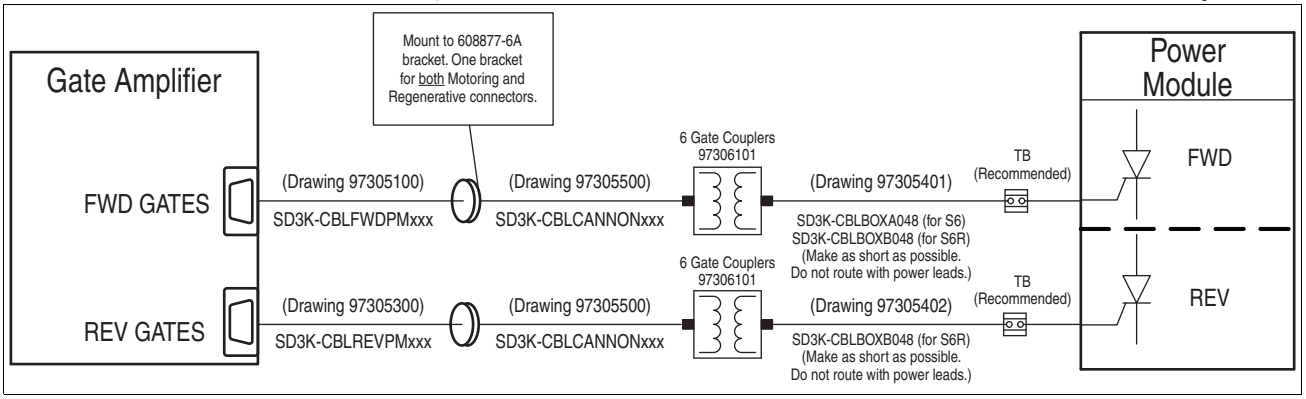
Retrofit Guidelines

Gate Interface to Non-Rockwell Power Module, Retrofit

To interface to the SCR gates of a "non-Rockwell" power module, any existing gate couplers in the power module should be replaced with the Rockwell Automation gate couplers. This will greatly simplify the gate interface because the characteristics of a standard Rockwell Automation interface are already defined. There may be unique cases where there is a need to re-use existing gate coupler hardware in a non-Rockwell power module - if this occurs, consult with Development Engineering.

The diagram in Figure 26 shows a gate interface where the gate coupler boards are individually mounted to accommodate physical constraints that may exist in the assembly. A bracket, 608877-6A, is used as a landing point for the gate cabling. Between the Gate Amplifier and the 608877-6A bracket the SD3K-CBLFWDPMxxx (or SD3K-CBLREVPMxxx) cable is used. The flange of cable SD3K-CBLCANNONxxx is mounted to the 608877-6A bracket. The opposite end of the cable has box connectors that plug into the gate couplers. The output of the gate couplers are connected to the SCR gates using cable SD3K-CBLBOXA048 (or SD3K-CBLBOXB048 for S6R). The SD3K-CBLBOXA048 cable has box connectors on one end to interface with the gate coupler output and "pig-tails" on the SCR gate side of the cable for connection to a terminal board. The SD3K-CBLBOXA048 and SD3K-CBLBOXB048 cables for the S6R are pre-labeled as forward and reverse. They are 48 inches long and are cut to the required length when installed.

Figure 26 - Retrofit of Non-Rockwell Power Module (S6R) w/Six Gate Couplers



Cables appear in the following tables.

Table 15 - Round Style Connector Forward Gate Cables

Catalog Number	Length
SD3K-CBLFWDPM060	5 Feet
SD3K-CBLFWDPM120	10 Feet
SD3K-CBLFWDPM180	15 Feet
SD3K-CBLFWDPM240	20 Feet

Additional lengths can be found on drawing 97305100.

Table 16 - Round Style Connector Reverse Gate Cables

Catalog Number	Length
SD3K-CBLREVPM060	5 Feet
SD3K-CBLREVPM120	10 Feet
SD3K-CBLREVPM180	15 Feet
SD3K-CBLREVPM240	20 Feet

Additional lengths can be found on drawing 97305300.

Table 17 - Round Style Connector to Gate Coupler

Catalog Number	Length
SD3K-CBLCANNON060	5 Feet
SD3K-CBLCANNON072	6 Feet
SD3K-CBLCANNON096	8 Feet
SD3K-CBLCANNON120	10 Feet

To view drawing, 97305500.

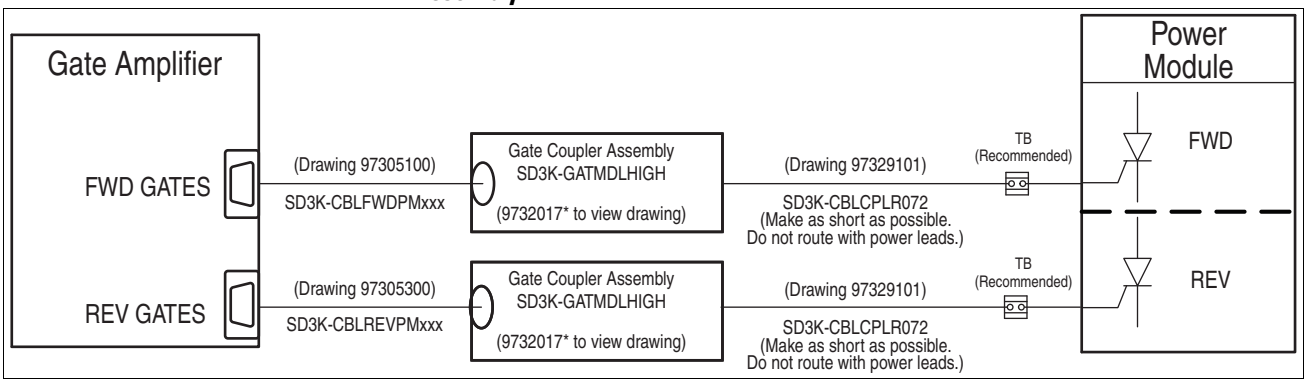
Table 18 - Output of Gate Coupler Boards to SCR Gate Cable

Catalog Number	Configuration	Description
SD3K-CBLBOXA048	S6	These cables have box connectors on one end to interface with the gate coupler output and "pig-tails" on the SCR gate side for connection to a terminal board. Do not route with power leads.
SD3K-CBLBOXB048	S6R	

To view drawing, 97305400.

If there is sufficient mounting space for the mounting of the Gate Coupler Assembly, it is recommended to use the configuration shown in Figure 27 on page 61. This will greatly simplify the mechanical aspects of the retrofit.

Figure 27 - Retrofit of Non-Rockwell Power Module (S6R) w/Gate Coupler Assembly



To interface the Gate Coupler Assembly to the SCR gates, the SD3K-CBLCPLR072 cables are used (as shown in the diagram above). The labeling on the SD3K-CBLCPLR072 cable set identifies the SCRs as THY1, THY2,...THY6. The same cable set is used for both forward and reverse. If the forward and reverse gate labeling are needed, then SD3K-CBLBOXA048 (or SD3K-CBLBOXB048 for the S6R), 48 inch cables can be used instead of the SD3K-CBLCPLR072, 72 inch cables.

Gate Interface to Reliance Electric U.S. Power Modules, Retrofit

To interface to the SCR gates of a Reliance Electric U.S. power module, a Gate Scaling Module is used in the SCR gate circuit. The Gate Scaling Module inserts a resistor into each of the SCR gate circuits to reduce the gate drive current. This is necessary because the gate driver voltage from the Gate Amplifier is 28V versus the 18V that would be produced by the Distributed Power System, Power Module Interface (PMI) rack. The reduced drive current ensures that the resistors on the primary side of the gate coupler transformer are running well within their maximum power dissipation ratings. The most common type of gate coupler used in the Reliance Electric power modules is the O-51378-19. There are several variations of the O-51378-19 gate coupler with regard to physical interface methods, but the basic components are the same. To confirm this, compare the schematic of the O-51378-19 gate coupler with the schematic of the gate couplers of the retrofit power module. The Gate Scaling Module was designed to interface the Gate Amplifier to a Reliance Electric power module with O-51378-19 gate couplers or electrically equivalent gate couplers.

The cables between the Gate Amplifier and the Gate Scaling Module are the SD3K-CBLGSCLIFxxx (forward) and SD3K-CBLGSCLIRxxx (reverse). The output cables to the power modules are dependent on the power module type. One type uses the “round” style of connector and an older line of the power module uses a “rectangular” style of connector. Cables appear in the following tables.

Figure 28 - Retrofit of Reliance Electric Power Module (S6R) with "Round" Style Gate Connector and with O-51378-19 (or Equivalent) Gate Couplers

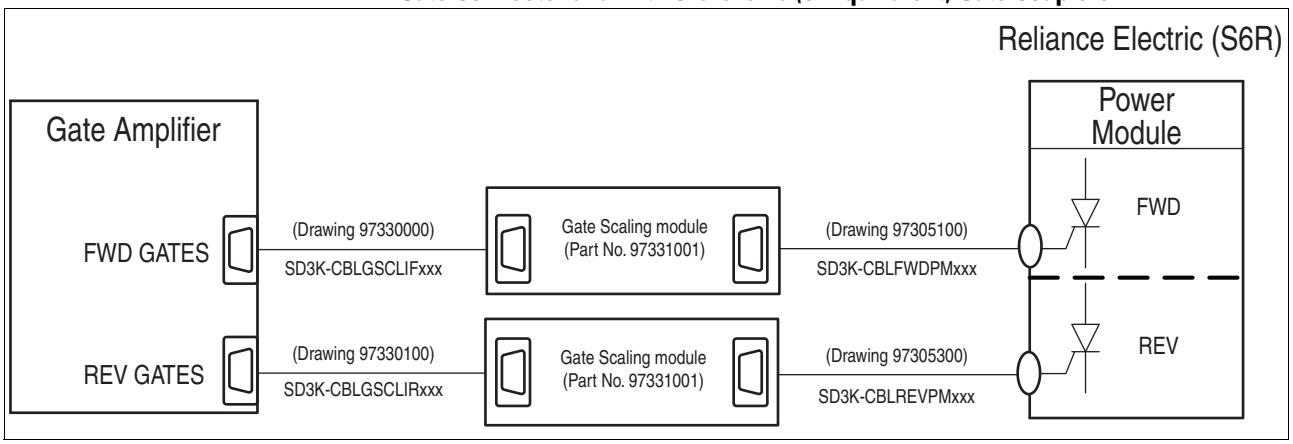


Figure 29 - Retrofit of Reliance Power Module (S6R) with "Rectangular" Style Gate Connector and with O-51378-19 (or Equivalent) Gate Couplers

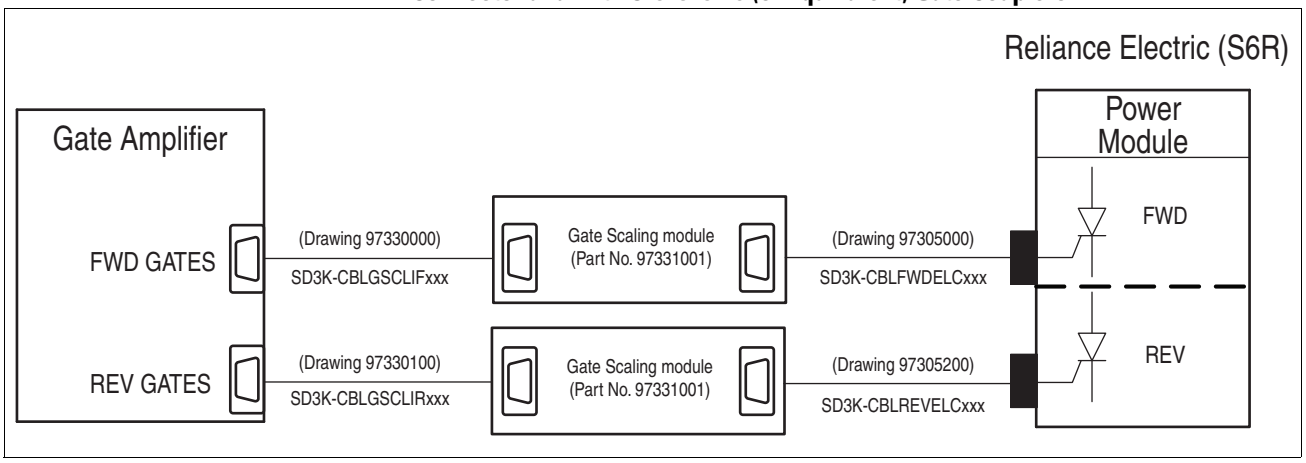


Table 19 - Gate Amplifier to Gate Scaling Module Forward Gates Cables

Catalog Number	Length
SD3K-CBLGSCLIF024	2 Feet(1)
SD3K-CBLGSCLIF036	3 Feet
SD3K-CBLGSCLIF060	5 Feet

(1) Before using this cable length consider the mounting position of the Gate Scaling Module, as the cable may not be long enough to reach between the gate output port of the Gate Amplifier and the panel where the Gate Scaling Module is mounted.

Additional lengths can be found on drawing 97330000.

Table 20 - Gate Amplifier to Gate Scaling Module Reverse Gates Cables

Catalog Number	Length
SD3K-CBLGSCLIR024	2 Feet(1)
SD3K-CBLGSCLIR036	3 Feet
SD3K-CBLGSCLIR060	5 Feet

(1) Before using this cable length consider the mounting position of the Gate Scaling Module, as the cable may not be long enough to reach between the gate output port of the Gate Amplifier and the panel where the Gate Scaling Module is mounted.

Additional lengths can be found on drawing 97330100.

Table 21 - Round Style Connector Forward Gates Cables

Catalog Number	Length
SD3K-CBLFWDPM060	5 Feet
SD3K-CBLFWDPM120	10 Feet
SD3K-CBLFWDPM180	15 Feet
SD3K-CBLFWDPM240	20 Feet

Additional lengths can be found on drawing 97305100.

Table 22 - Round Style Connector Reverse Gates Cables

Catalog Number	Length
SD3K-CBLREVPM060	5 Feet
SD3K-CBLREVPM120	10 Feet
SD3K-CBLREVPM180	15 Feet
SD3K-CBLREVPM240	20 Feet

Additional lengths can be found on drawing 97305300.

Table 23 - Rectangular Style Connector Forward Gates Cables

Catalog Number	Length
SD3K-CBLFWDELC060	5 Feet
SD3K-CBLFWDELC120	10 Feet
SD3K-CBLFWDELC180	15 Feet

Additional lengths can be found on drawing 97305000.

Table 24 - Rectangular Style Connector Reverse Gates Cables

Catalog Number	Length
SD3K-CBLREVELC060	5 Feet
SD3K-CBLREVELC120	10 Feet
SD3K-CBLREVELC180	15 Feet

Additional lengths can be found on drawing 97305200.

Gate Interface to Dierikon Power Modules

To interface to the SCR gates of a Dierikon power module a direct connection can be made to the gate input without the need for the Gate Scaling Module.

- Forward Gate Cable to interface Gate Amplifier to Dierikon Power Module. 612436-xxxW, where xxx is the length in inches.

To view drawing: 612436*

- Reverse Gate Cable to interface Gate Amplifier to Dierikon Power Module. 612567-xxxW, where xxx is the length in inches.

To view drawing: 612567*

Power Interface and SCR Firing Order

Parallel Power Modules and Load Share Reactors

When power modules are placed in parallel, load share reactors must be in place on the AC side of the power modules on each of the phases (see Figure 20 on page 53). The purpose of the load share reactors is to ensure that any one of the group of parallel power modules does not take up more than "its share" of the load. When one of the parallel legs of the power module circuit has an increase in current, an increased voltage drop will appear across the load share reactor in that leg of the circuit. The increased voltage drop of the reactor will result in a reduced current in that leg of the circuit. The reactors provide a self regulating passive means to ensuring balance of current between the parallel power modules. The inductance of the load share reactors is typically 3.5µH. For retrofit situations, the site review must cover this issue. For new installations, the reactors need to be included in the order.

If reactors are not used, then current sharing cannot be expected to work effectively. As Thyristors (SCRs) increase in temperature from additional current, their voltage drop may actually decrease due to their construction as two bipolar transistors (parallel bipolar transistors do not share load very well unless they are "matched"). This causes less voltage drop to occur across the SCR and thus more current will result in that leg of the circuit and the SCR could ultimately fail due to a condition termed "thermal runaway".

Phase Sequence and Armature SCR Firing Order

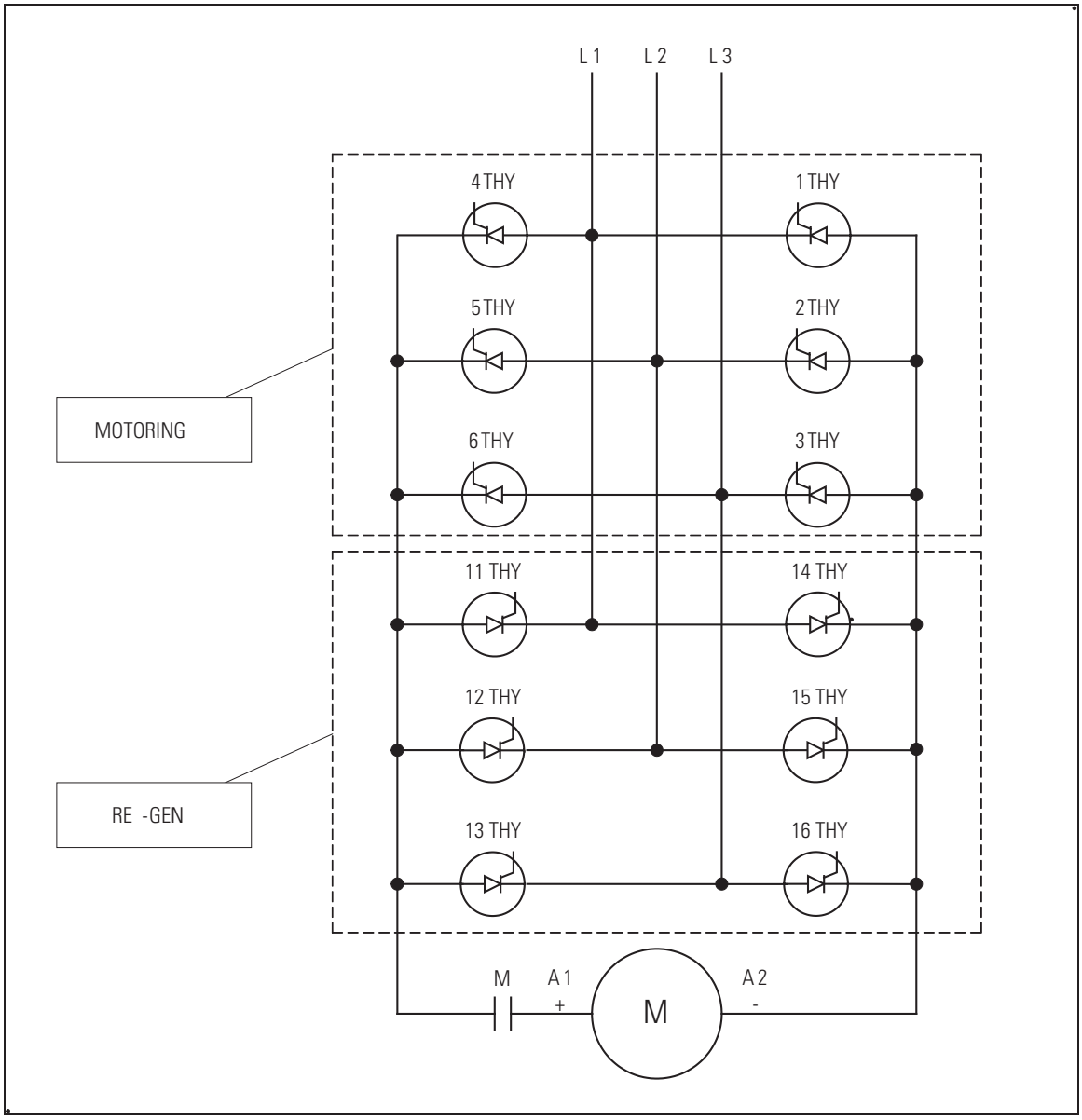
Table 25 - Phase Sequence and Armature SCR Firing Order, Sequence L1, L2, L3

AC Line Pairs		Gated Pairs
+	-	
L1	L3	4THY & 3THY
L2	L3	5THY & 3THY
L2	L1	5THY & 1THY
L3	L1	6THY & 1THY
L3	L2	6THY & 2THY
L1	L2	4THY & 2THY

Table 26 - Phase Sequence and Armature SCR Firing Order, Sequence L3, L2, L1

AC Line Pairs		Gated Pairs
+	-	
L1	L2	4 THY & 2 THY
L3	L2	6 THY & 2 THY
L3	L1	6 THY & 1 THY
L2	L1	5 THY & 1 THY
L2	L3	5 THY & 3 THY
L1	L3	4 THY & 3 THY

Figure 30 - SCR (Thyristor) Positions



If the power module is not firing properly, check the timing relative to the AC Line, with the L1 to L3 signal acting as the reference point. Using a two channel oscilloscope, the L1 to L3 waveform will be on channel 1 and then the gate pulse positions relative to the AC line can be checked one at a time with channel 2.

Caution: Be certain that the oscilloscope probe is rated for the line voltage before taking the measurement from L1 to L3.

Figure 31 below shows an actual oscilloscope image of the gate pulse output relative to the AC Line, L1 to L3, with positive phase rotation (L1, L2, L3). With the Alpha Test, the output of the gates can be checked by using a spare gate output port on the Gate Amplifier along with a Gate Coupler assembly module. Incandescent light bulbs connected in series at the output of the power module serve as a load. Be sure that the rating of all of the incandescent bulbs connected in series is greater than the power module maximum output voltage rating. For the gate waveforms shown here, two diodes connected in series are connected to each gate coupler output, with the anode connected to the "G" (Gate) pin. The output can also be checked in an open circuit mode; the peak voltage will be 15 to 30 volts. The waveform shown in Figure 31 was generated by using the Alpha Test with the firing angle set at 5 Degrees (full on).

Figure 31 - Power Module Thyristor Firing Pattern, Positive Phase Rotation (L1, L2, L3)

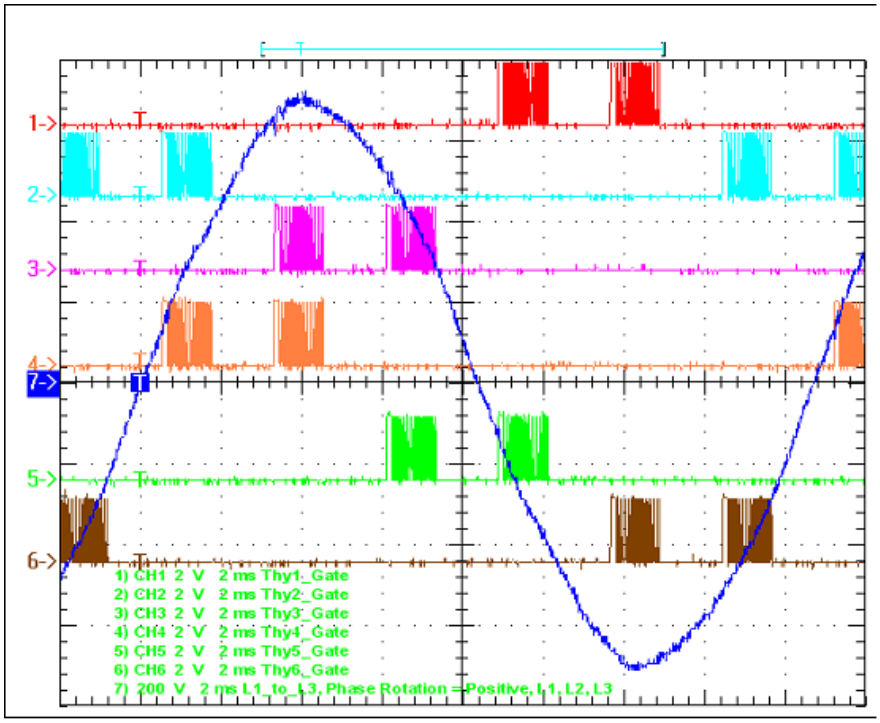


Figure 32 below shows an actual oscilloscope image of the gate pulse output relative to the AC Line, L1 to L3, with negative phase rotation (L3, L2, L1). The waveform shown in Figure 32 was generated by using the Alpha Test with the firing angle set at 5 Degrees (full on).

Figure 32 - Power Module Thyristor Firing Pattern, Negative Phase Rotation (L3, L2, L1)

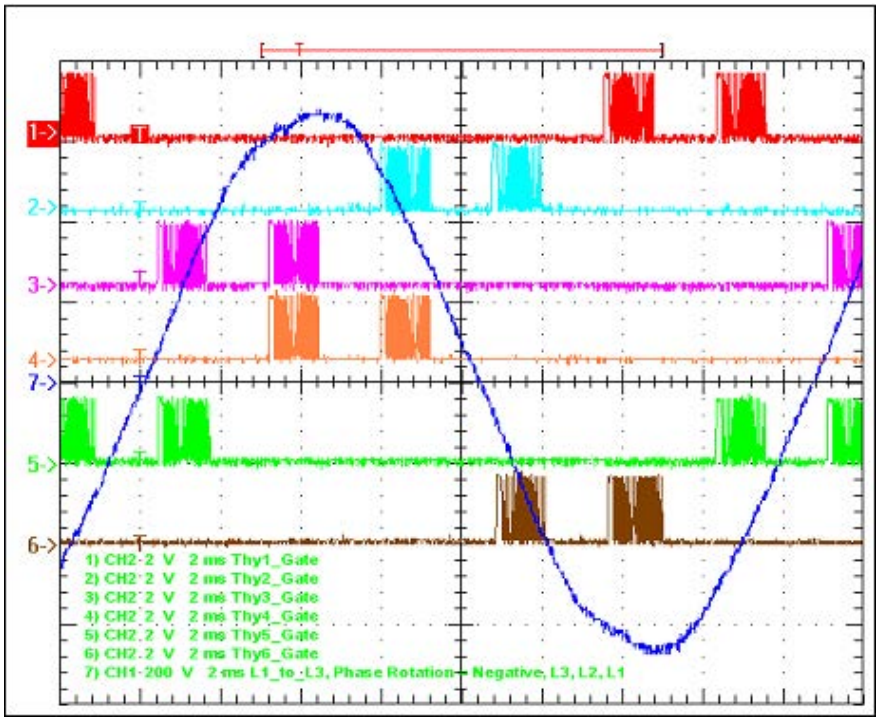
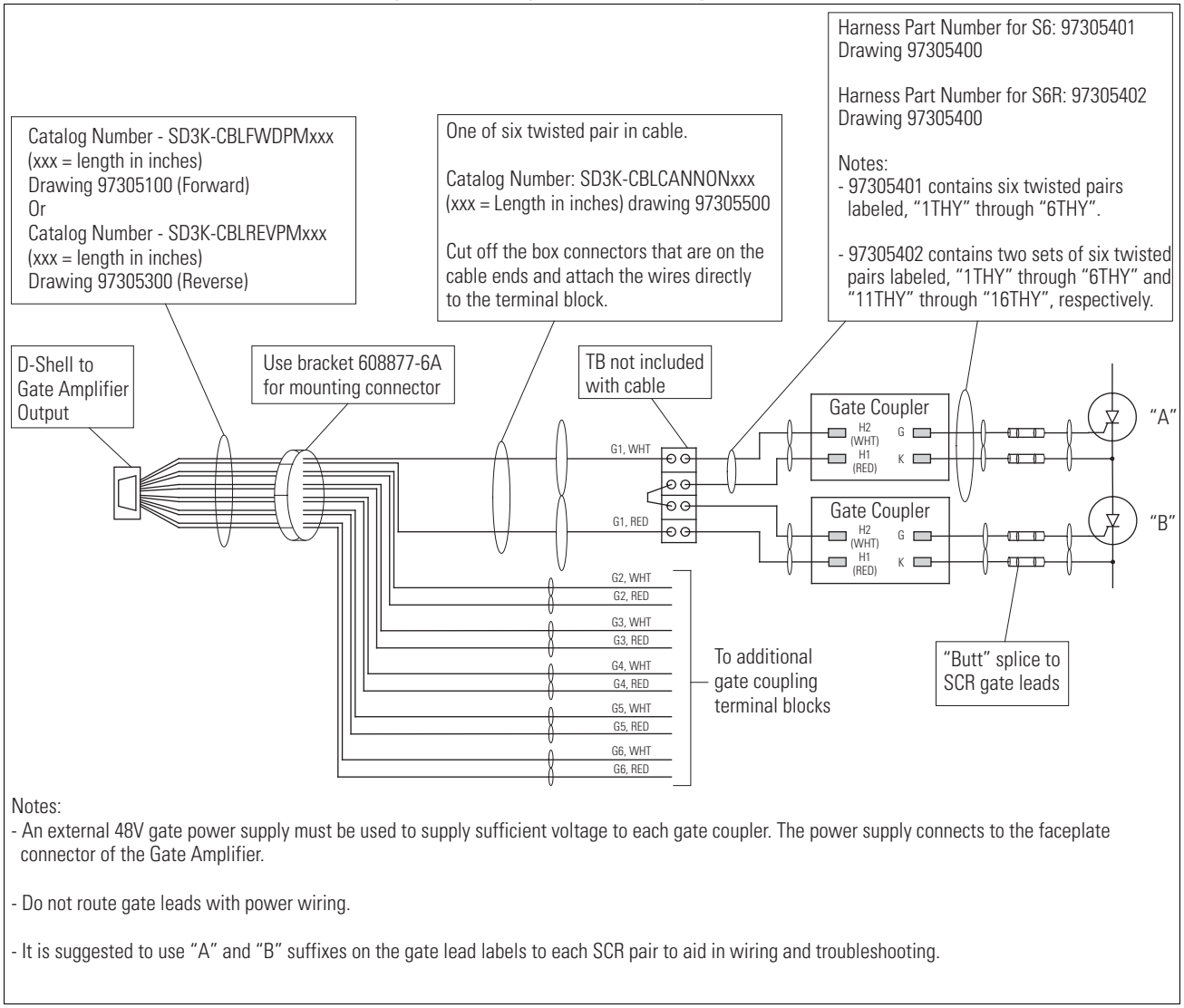


Figure 33 - Firing Series SCRs (Thyristors)

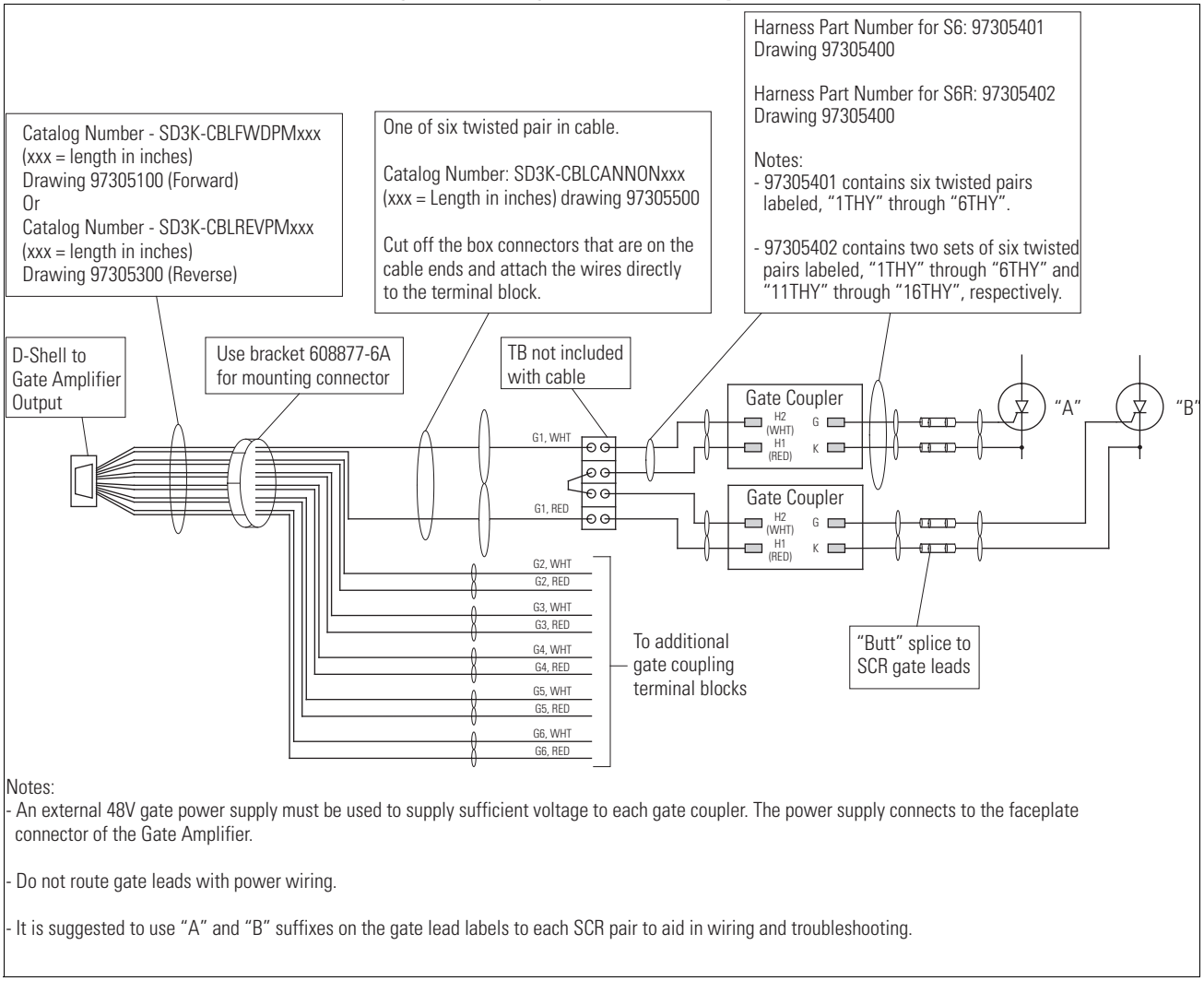


Notes:
- An external 48V gate power supply must be used to supply sufficient voltage to each gate coupler. The power supply connects to the faceplate connector of the Gate Amplifier.

- Do not route gate leads with power wiring.

- It is suggested to use "A" and "B" suffixes on the gate lead labels to each SCR pair to aid in wiring and troubleshooting.

Figure 34 - Firing Parallel SCRs (Thyristors)



Notes:
- An external 48V gate power supply must be used to supply sufficient voltage to each gate coupler. The power supply connects to the faceplate connector of the Gate Amplifier.

- Do not route gate leads with power wiring.

- It is suggested to use "A" and "B" suffixes on the gate lead labels to each SCR pair to aid in wiring and troubleshooting.

Specifications

Stand Alone Regulator

Electrical

Field Bridge Input Voltage	100VAC...460VAC, ±10%, 50/60 Hz
Control Supply Input Current	115VAC/1AAC or 230VAC/0.5AAC

Environmental

Operating Temperature	0 ° C to 50 ° C (32 ° F to 122 ° F)
Storage Temperature	-25 ° C to 55° C (-13 ° F to 131 ° F)
Relative Humidity	5% to 95%, Non-condensing

Note: Contamination from oils, corrosive vapors and abrasive debris must be kept out of the enclosure.

Power Dissipation

Catalog Number	Power Bridge AC Input	Field Ratings			Total Watts Loss
	[V_{AC}]	Input [V_{AC}]	Input [A_{AC}]	Output [A_{DC}]	[W]
23PMD4W	(230 to) 500	(230 to) 460	40	40	303
23PMD7W	(230 to) 500	(230 to) 460	70	70	357
23PMF4W	(575 to) 690	(230 to) 460	40	40	374
23PMF7W	(575 to) 690	(230 to) 460	70	70	428

Gate Amplifier

Electrical

Control Input	120VAC ±10%, 1.9 A, 47-63 Hz
Replacement fuse	Littelfuse 312005, 5 A, 250VAC, 3AG Time Delay or equivalent.

Environmental

Operating Temperature	0 ° C to 50 ° C (32 ° F to 122 ° F)
Storage Temperature	-40 ° C to 70 ° C (-40 ° F to 158 ° F)
Relative Humidity	5% to 95%, Non-condensing

Note: Contamination from oils, corrosive vapors and abrasive debris must be kept out of the enclosure.

Hardware Descriptions

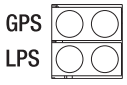
The following table provides a functional description of each printed circuit board and component of the Gate Amplifier.

Table 27 - Printed Circuit Board and Component Descriptions

Board/Component	Description
Main Board PN-25913	The Main board provides an optical isolation layer between the Regulator and the Gate Amplifier circuits. In addition, it provides the necessary permissive interlock circuits and LED annunciation of system status. The output of the Main board is connected to the Gate Driver Output board for the final stage of amplification of the gate signals.
Gate Driver Output (GDO) Board (964310)	The basic overall functionality of the Gate Driver Output board is as follows: Faceplate connections are as follows: Four top D-Shell connectors are for the SCR Forward Gates, square wave burst firing output to power module gates in the range of 28V to 48V. Four lower D-Shell connectors are for the SCR Reverse Gates, square wave burst firing output to power module gates in the range of 28V to 48V. An external power supply for the gates of up to 48V can be used. A "diode OR" function ensures that the module utilizes the 48V supply when it is connected. When the use of an external gate power supply is required, an interlock is required with the drive control in case the external power supply fails. The interlocking is accomplished with a relay with a 48VDC coil that is connected across the external power supply and the normally open contacts are connected into a stop circuit.
Internal Power Supply	The Power Supply provides 28V for the SCR gate firing circuits and is further reduced for on-board logic circuit functions.
Line Fuse	5 A, 250V AC, 3AG, Time Delay

Status LEDs

Each LED is briefly described in this table:

	Label	Description
	GPS	+28V Gate Power Supply output is present.
	LPS	+5V Logic Power Supply output is present.
	GATE FUSE OK	Indicates that the fuse for the External Power Supply is "OK". (The fuse is mounted on the Gate Driver Output board.)
	GATE POWER	Indicates that all on-board systems are functioning normally.

Gate Coupler Assembly Information

Gate Coupler Assemblies, Catalog Numbers SD3K-GATMDLHIGH and SD3K-GATMDLLOW

The Gate Coupler Assembly provides an isolation barrier between the Gate Amplifier and the SCR Gates. Two different units are available depending on the load requirements. The "SD3K-GATMDLHIGH" provides a higher output than the "SD3K-GATMDLLOW". The "SD3K-GATMDLLOW" is usually used in special cases where the power rating of the power module is low and there is concern about excessive SCR gate power dissipation. **As a general guideline for retrofits (non-Reliance power module), when the power output of the power module exceeds 200HP, use the "SD3K-GATMDLHIGH".**

For the Reliance Electric Power Modules with existing Gate Coupler Modules that are O-51378-19 or electrically equivalent (with ½ Watt resistors on the transformer primary), neither SD3K-GATMDLHIGH nor the SD3K-GATMDLLOW would be used. Instead, the Gate Scaling Module would be used in series with the gate leads. This configuration is covered in detail in the Retrofit section of this manual.

Refer to SD3K-GATMDLHIGH - 9732017* to view drawing.

Refer to SD3K-GATMDLLOW - 9732027* to view drawing.

Operating Temperatures

- The surrounding air temperature must be within 0 °C to 50 °C (32 °F to 122 °F). If any heat generating equipment is mounted underneath the unit, ensure that the exhaust air of this equipment is not greater than 50 °C.
- Humidity must remain between 5% and 95% non-condensing.
- Power dissipation, 20 Watts.

Gate Coupler Assembly Mounting Instructions

The Gate Coupler Assembly is an open type construction and is intended to be installed on a flat surface in a suitable enclosure.

- Mount in a clean, dry location. Contamination from oils, corrosive vapors and abrasive debris must be kept out of the enclosure.
- Mount the unit in a vertical or horizontal position depending on the panel layout.
- It is permissible to have all gate leads exit from one side of the assembly if needed, (two pairs per exit port), or one pair of gate leads from each exit port.

Figure 35 - Minimum Mounting Clearances

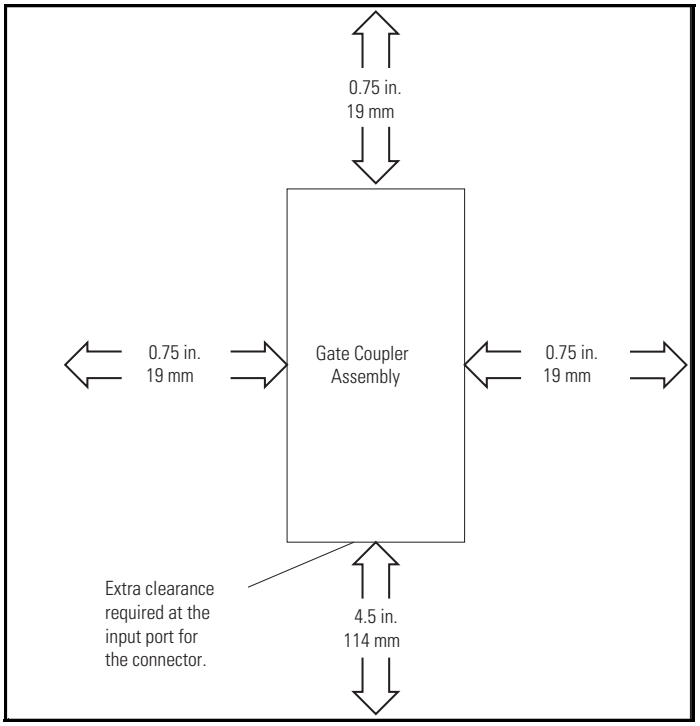


Figure 36 - Gate Coupler Assembly Mounting Dimensions, Ground Terminal, and Input / Output Connections

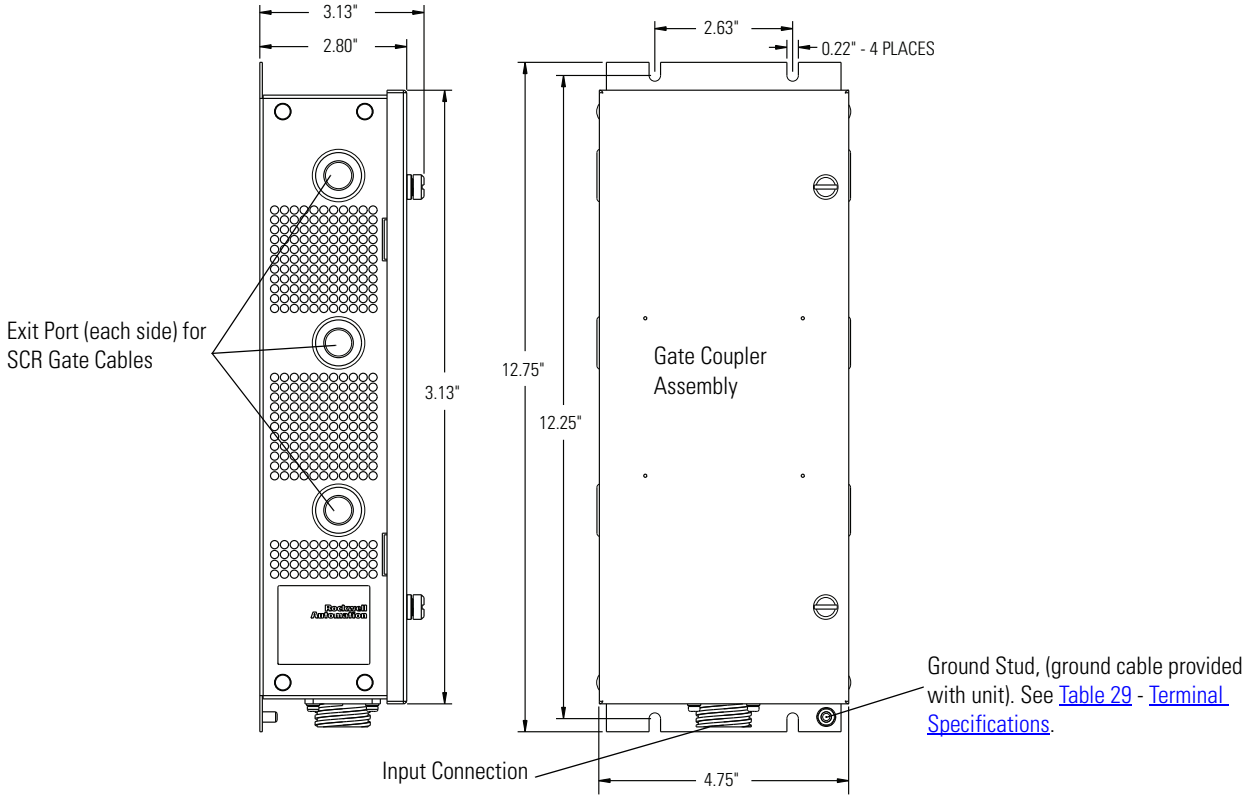


Table 28 - Gate Coupler Assemblies, Catalog Numbers SD3K-GATMDLHIGH and SD3K-GATMDLLOW Weights

Gate Coupler Assembly	Gate Coupler Assembly and Packaging
1.5 kg (3.4 lbs)	1.94 kg (4.4 lbs)

Recommended Mounting Hardware: Metric M5, English #10

IMPORTANT Provide at least 114 mm (4.5 in.) for the input connection cable.

Table 29 - Terminal Specifications

Ground Stud	Chassis Ground	Use the grounding cable that is provided with the unit. Refer to Chassis Grounding on page 45 for more information. Tighten the terminal to 20 lb•in (2.3 N•m).

Gate Scaling Module Information

Gate Scaling Module, Part No. 97331001

The Gate Scaling Module provides a means to interface with Reliance Electric Power Modules with existing Gate Coupler Modules that are electrically equivalent to the "O-51378-19" Gate Coupler. The Gate Scaling Module provides a resistor in each of the SCR gate lines to reduce the voltage applied to the gate couplers in the power module. The O-51378-19 Gate Coupler (and equivalent gate couplers) have 0.5 Watt resistors on the primary of the isolation transformer. The Gate Amplifier provides a higher maximum gate voltage than the Distributed Power System, Power Module Interface (DPS PMI rack). The Gate Scaling Module ensures that the power dissipation of the resistors stays within their maximum ratings.

The configuration using the Gate Scaling Module is covered in detail in the Retrofit Guidelines section of this manual beginning on page 59.

Operating Temperatures

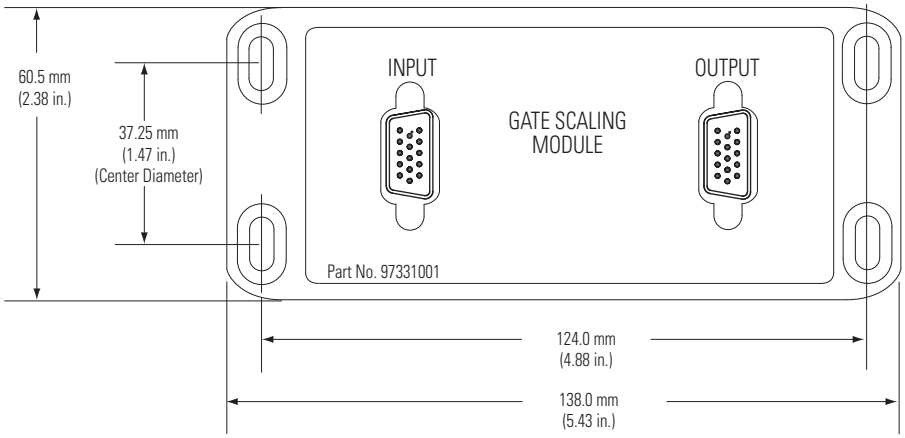
- The surrounding air temperature must be within 0 °C to 50 °C (32 °F to 122 °F).
- Humidity must remain between 5% and 95% non-condensing.
- Power dissipation is 1 Watt.

Mounting Instructions

- Mount to a flat, grounded, metal panel.
- Mount in a suitable enclosure in a clean, dry location. Contamination from oils, corrosive vapors, and abrasive debris must be kept out of the enclosure.
- Mount in a horizontal position only, in order to provide proper cooling. The lettering on the face of unit should be in a readable position, as shown in Figure 37 on page 77.

Note: Grounding of the Gate Scaling Module is accomplished through the mounting screws. The case is made of a unpainted, cast metal box.

Figure 37 - Gate Scaling Module Mounting Dimensions Input / Output Connections



Notes:
Module Depth = 31.0 mm (1.22 in.)
Mounting Holes: 4.25 mm (0.17 in.)

Part No. 97331001 - To view drawing, 97331000.

Table 30 - Gate Scaling Module, Part No. 97331001 Weights

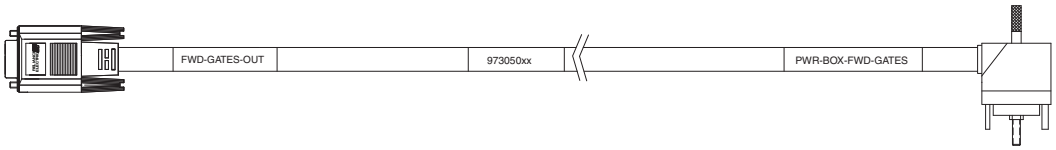
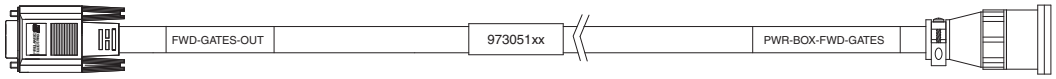
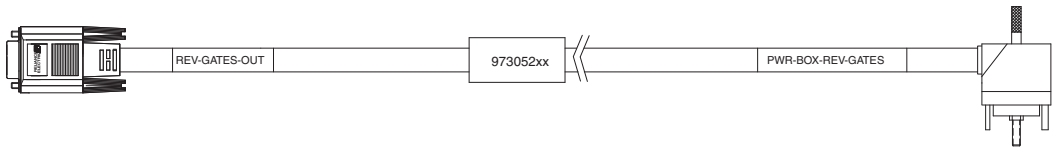
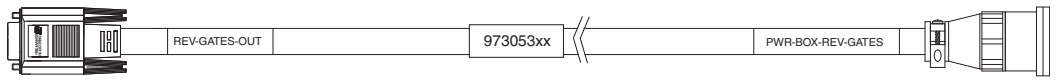
Gate Scaling Module	Gate Scaling Module and Packaging
0.9 kg (0.4 lbs)	1.3 kg (0.6 lbs)

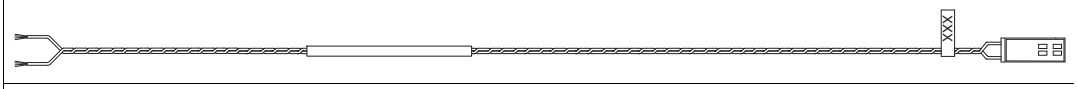
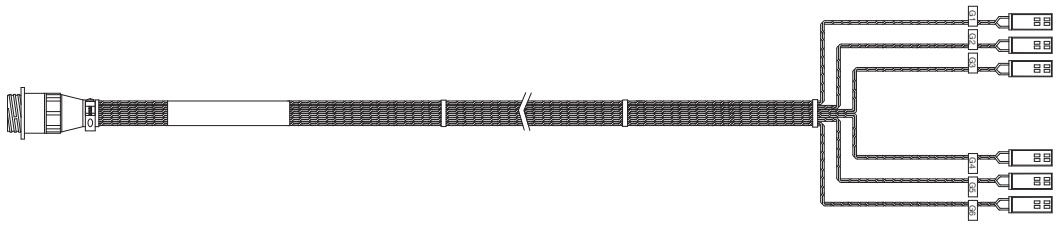
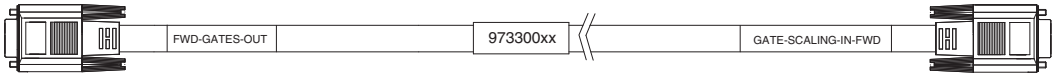
Recommended Mounting Hardware: Metric M4, English #8

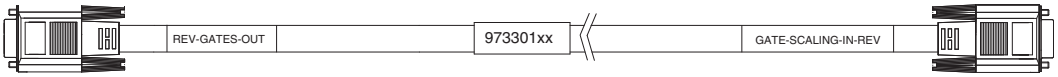
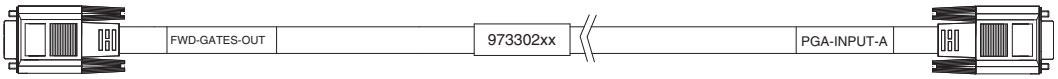
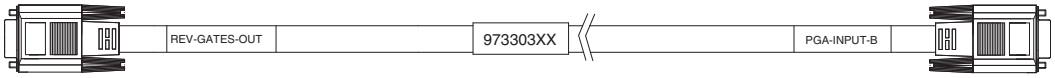
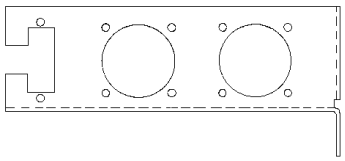
IMPORTANT When mounting the Gate Scaling Module, washers may be required because the mounting holes are tapered. If a mounting screw is over tightened then the cast metal could break.

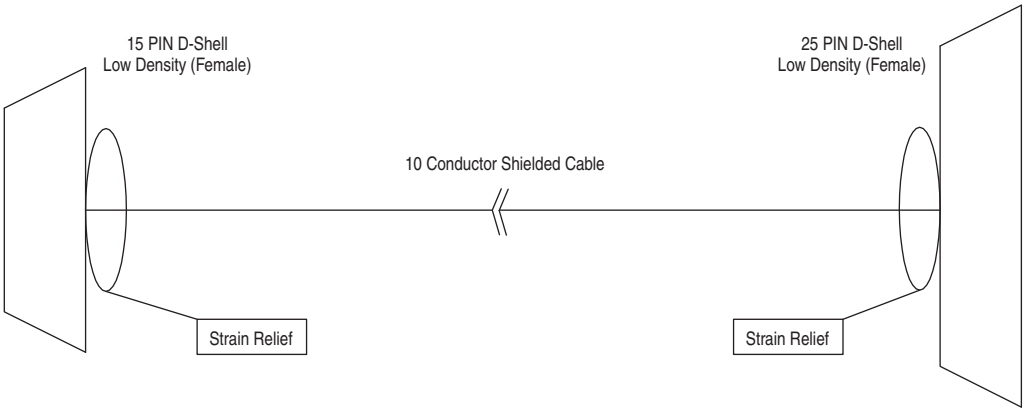
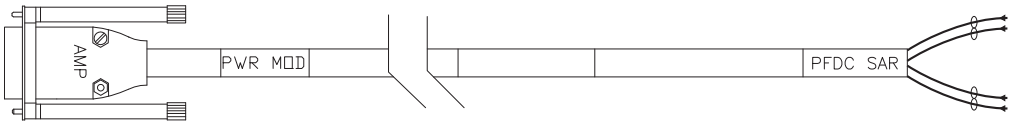
Cable Specifications

Following are the cable assemblies available for use with the Gate Amplifier and Stand Alone Regulator:

Catalog Number	Part Number	Description/Length								
SD3K-CBLFWDELC*** *** (length in inches)	973050**00** (Substitute "**00**" with desired length code)	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**
		60"	120"	180"	240"	300"	360"	480"	600"	720"
		Connects the FORWARD gate signals <u>from</u> the Gate Amplifier Control <u>to</u> a Power Box using an "ELCO" style connector.								
	Picture/Details									
										
	This end connects to one of the FORWARD OUTPUT connectors on the Gate Amplifier.					This end connects to the ELCO connector on the Power Box.				
SD3K-CBLFWDPM*** *** (length in inches)	973051**00** (substitute "**00**" with desired length code)	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**
		60"	120"	180"	240"	300"	360"	480"	600"	720"
		Connects the FORWARD gate signals <u>from</u> the Gate Amplifier Control <u>to</u> a Power Box using a "Round Cannon" style connector.								
	Picture/Details									
										
	This end connects to one of the FORWARD OUTPUT connectors on the Gate Amplifier.					This end connects to the "Round Cannon" style mating connector on the Power Box or Gate Coupler Assembly.				
SD3K-CBLREVELC*** *** (length in inches)	973052**00** (substitute "**00**" with desired length code)	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**
		60"	120"	180"	240"	300"	360"	480"	600"	720"
		Connects the REVERSE gate signals <u>from</u> the Gate Amplifier Control <u>to</u> a Power Box using an "ELCO" style connector.								
	Picture/Details									
										
	This end connects to one of the REVERSE OUTPUT connectors on the Gate Amplifier.					This end connects to the ELCO connector on the Power Box.				
SD3K-CBLREVPM*** *** (length in inches)	973053**00** (substitute "**00**" with desired length code)	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**
		60"	120"	180"	240"	300"	360"	480"	600"	720"
		Connects the REVERSE gate signals <u>from</u> the Gate Amplifier Control <u>to</u> a Power Box using a "Round Cannon" style connector.								
	Picture/Details									
										
	This end connects to one of the REVERSE OUTPUT connectors on the Gate Amplifier.					This end connects to the "Round Cannon" style mating connector on the Power Box or Gate Coupler Assembly.				

Catalog Number	Part Number	Description/Length								
SD3K-CBLBOXA048 SD3K-CBLBOXB048	97305400 (substitute "**00**" with desired code)	**01**							**02**	
		Motoring (S6), 48" gate leads (6 total)							Motoring & Regen (S6R), 48" gate leads (12 total)	
		Connects the output side of one (1) gate coupler to its corresponding SCR in the Power Box.								
	Picture/Details									
										
	(1 of 6 pairs)									
	This end connects to the output pins on the Gate Coupler Board identified as "WW2".								This end connects to the "gate" (white) and "cathode" (red) terminals of the SCR.	
SD3K-CBLCANNON*** *** (length in inches)	97305500 (substitute "**00**" with desired length code)	**01**	**02**	**03**	**04**					
		60"	72"	96"	120"					
		Connects the FORWARD or REVERSE gate signals from a cable with a "Round Cannon" style mating connector to the primary side of six (6) individual gate couplers. This cable assembly should be mounted to bracket P/N 608877-6A for strain relief.								
	Picture/Details									
										
	This end connects to Gate Amplifier cable assembly 973051xx or 973053xx.								Each connector on this end connects to the input pins on the Gate Coupler Board identified as "WW1".	
SD3K-CBLCPLR*** *** (length in inches)	97329100 (substitute "**00**" with desired length code)	**01**								
		72"								
		Connects the output side of the six (6) gate couplers (inside of the Gate Coupler Assembly) to their corresponding SCR gates in the Power Box. (S6 only; use a second set for an S6R application or consider using 97305402.)								
	Picture/Details									
										
	(1 of 6 pairs)									
	This end connects to the output pins on the Gate Coupler Board identified as "WW2".								This end connects to the "gate" (white) and "cathode" (red) terminals of the SCR.	
SD3K-CBLGSCLIF*** *** (length in inches)	97330000 (substitute "**00**" with desired length code)	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**
		24"	36"	60"	120"	180"	240"	300"	360"	480"
		Connects the FORWARD gate signals from the Gate Amplifier Control to the Gate Scaling Module (INPUT connector).								
	Picture/Details									
										
	This end connects to one of the FORWARD OUTPUT connectors of the Gate Amplifier.								This end connects to the INPUT connector of the Gate Scaling Module.	

Catalog Number	Part Number	Description/Length								
SD3K-CBLGSCLIR*** *** (length in inches)	973301**00** (substitute "**00**" with desired length code)	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**
		24"	36"	60"	120"	180"	240"	300"	360"	480"
		Connects the REVERSE gate signals <u>from</u> the Gate Amplifier Control <u>to</u> the Gate Scaling Module (INPUT connector).								
	Picture/Details									
										
	This end connects to one of the REVERSE OUTPUT connectors of the Gate Amplifier.					This end connects to the INPUT connector of the Gate Scaling Module.				
SD3K-CBLPGAFWD*** *** (length in inches)	973302**00** (substitute "**00**" with desired length code)	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**
		18"	24"	60"	120"	180"	240"	300"	360"	480"
		Connects the FORWARD gate signals <u>from</u> the Gate Amplifier Control <u>to</u> the PGA Power Supply Module (INPUT A connector).								
	Picture/Details									
										
	This end connects to one of the FORWARD OUTPUT connectors of the Gate Amplifier.					This end connects to the INPUT "A" connector (on the Power Supply Module) of the Parallel Gate Amplifier (PGA).				
SD3K-CBLPGAREV*** *** (length in inches)	973303**00** (substitute "**00**" with desired length code)	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**
		18"	24"	60"	120"	180"	240"	300"	360"	480"
		Connects the REVERSE gate signals <u>from</u> the Gate Amplifier Control <u>to</u> the PGA Power Supply Module (INPUT B connector).								
	Picture/Details									
										
	This end connects to one of the REVERSE OUTPUT connectors of the Gate Amplifier.					This end connects to the INPUT "B" connector (on the Power Supply Module) of the Parallel Gate Amplifier (PGA).				
NA	608877-6A	Mounting Bracket: Suitable for mounting up to two (2) cable assemblies that utilize "Round Cannon" style connectors (612435, 973055xx).								
										

Catalog Number	Part Number	Description/Length
23PAMP-C2	PN-104829	2 feet (24 inches) TPDflex DC SAR Gate Output to Gate Amplifier cable
23PAMP-C1	PN-104828	5 feet (60 inches) TPDflex DC SAR Gate Output to Gate Amplifier cable
23PAMP-C	PN-54636	10 feet (120 inches) TPDflex DC SAR Gate Output to Gate Amplifier cable
		
	This end connects to the 15 PIN D-Shell connector labeled "KPT11" on the TPDflex DC Stand Alone Regulator.	This end connects to the 25 PIN D-Shell connector labeled "PFDC Gate Input" on the Gate Amplifier.
23PAMP-C-CT060	PN-92598	5 feet (60 inches) Legacy power module to SAR current feedback cable
23PAMP-C-CT096	PN-92599	8 feet (96 inches) Legacy power module to SAR current feedback cable
23PAMP-C-CT120	PN-92601	10 feet (120 inches) Legacy power module to SAR current feedback cable
	Picture/Details	
		
	This end connects to a legacy power module to acquire current feedback from the internal CTs.	This end connects to the current feedback terminal on the SAR unit.

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Waste Electrical and Electronic Equipment (WEEE)

At the end of life, this equipment should be collected separately from any unsorted municipal waste.

User Manual
Series: TPDflex
Revision: 0.1
Date: 10/02/2026
Codice: 1S7TFLEXUMD

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