POWERSIDE®

All our energy, in your power

PowerVar Series and PowerCap Auto Series

Installation and Operations Manual

Table of Contents

1. Safety Warnings and Instructions

IMPORTANT SAFETY INSTRUCTIONS SAVE THESE INSTRUCTIONS

This manual contains important instructions that should be followed during installation, operation and maintenance of the supplied equipment. Please read this manual carefully prior to installation.

- The system contains **LETHAL VOLTAGES**. All repairs and service should be performed by **AUTHORIZED PERSONNEL ONLY.**
- Death, serious injury, or fire hazard could result from improper connection or operation of this instrument. Read and understand this manual before connecting the device.

- This equipment may present an arc flash hazard. Personal Protection Equipment may be required. Refer to NFPA 70E for sections related to Standard for Electrical Safety in the Workplace.
- This system contains energy storage devices (capacitors) that may present a shock hazard even with primary power disconnected. Capacitors remain charged for a period until the internal discharge resistor bleeds off residual charge. Always wait a minimum of one (1) minute before approaching a de-energized capacitor. Always test before touching using insulated gloves and multimeter.
- Ensure that the current transformer's secondary circuit is short-circuited prior to working on current transformer circuits. Under no circumstances should the secondary circuit of the CTs be operated in the open state as lethal voltages may be present.
- All local applicable standards and specifications in addition to the generally recognized codes of practice must be observed.
- All people who are involved in the setting up, commissioning, operation, maintenance or repair of the device must be adequately professionally qualified and must read, and following, operating instructions provided. If you are unsure **TAKE NO ACTION** without contacting qualified personnel.

- Do not install or operation this system close to a gas or electric heat source
- The operating environment should be maintained within the parameters stated in this manual
- Keep surrounding uncluttered, clean, and free from excessive moisture and particulates.

If you find information in this manual that is incorrect, misleading, or incomplete, we would appreciate your comments and suggestions.

2 Product Information

Powerside offers a competitive low-voltage product line designed to solve client's power factor and harmonics issues. This section provides information on the different type of products and associated features. The automatic low-voltage capacitor bank exists in three different types:

- Automatic non-filtered
- Automatic filtered
- Fast switching

- **PowerVar PFC, PowerVar Harmonic and PowerCap Auto Series (automatic non-filtered)**
  This Series of products are automatic, non-filtered capacitor banks designed to improve the power factor at the facility service entrance (point of common coupling) or at a location within the facility, close to the inductive loads requiring correction. These automatically compensate for variations in inductive loads which cause the power factor to fluctuate.

  Systems are available in configurations with a capacity range of 50 kVAR to 1200 kVAR, comprised of up to 12 fused stages operated by contactors. Site harmonics determine which Series is appropriate and can be ordered with standard, cost-efficient capacitor cells, ideal for sites with mostly linear loads and lower levels of harmonic currents, or with high harmonic capacitor cells, recommended for sites with electronic loads and higher levels of harmonics.

- **PowerVar Filter Banks Series**
  This Series of automatic filtered (typically detuned to 3.78^{th} harmonic) capacitor banks are designed to improve the power factor, but which also dampen the harmonic currents generated by non-linear (typically switch mode) loads such as motor drives and other electronic loads. Like with the capacitor banks, these systems automatically compensate for variations in loads which cause the power factor and the harmonic currents to fluctuate.

  Reactors used in each filter stage are built to include Class H insulation for maximum durability under high loads, over temperature sensor to deactivate the stage in case of overheating and tight tolerances (-3%, +3%) for accurate tuning.

  As with other Series, the PowerVar Filter Bank Series is available in configurations with a capacity range of 75 kVAR to 1200 kVAR, with up to 12 contactor operated fused branches.

- **PowerVar FAST Banks Series**
  Instead of mechanical contactors with reaction time measures in seconds, this Series is designed using thyristor switched capacitor banks with sense and switching time measured in cycles for rapidly fluctuating loads and high harmonic distortion. Switching speeds are possible with the use of a high-speed controller which switches bidirectional thyristors at the voltage zero crossing. Thus, transient current peaks are eliminated, and reactive loads are gently switched with a very low wear and tear.

  PowerVar Fast Series comes standard with high temperature, harmonic rated capacitor cells as used in the PowerVar Filter Bank Series.

- **True Industrial-Grade Capacitors**

  The PowerVar and PowerCap Auto models have a continuous current rating of 1.3, 1.65 and as high as 2.7 times the rated current. Selection of current rating is based on the site harmonics level.

  PowerVar capacitors also include 4-fold patented safety system, which consists of:

  1 Self-healing polypropylene film which ensures that the dielectric film automatically isolates any puncture which may develop over time as a result of charging and discharging.
  2 Solder-free contact ring which eliminates the risk of damaging the winding during the fabrication, otherwise a very challenging operation.
  3 3-phase overpressure disconnect system which disconnects the power in case of excessive life limiting internal pressure caused by high voltage and temperature.
  4 Segmented metalization which supplements the self-healing protection in the extreme condition that multiple punctures occurred in the film.

  PowerVar and PowerCap Auto are designed to ensure that its capacitors are kept in the best operating condition with a projected life expectation of 20 years or more with normal use and maintenance. The life of capacitors life is highly sensitive to temperature. This is why they are located at the bottom of the cabinet, isolating them from the heat generated by the reactors.

- **Contactors which will operate reliably with minimum wear**

  The contactors for each step are rated for 3 million operations and specifically designed for capacitor switching applications. This design includes a built-in pre-charge circuit which reduces the instantaneous current during switching operations, currents which would otherwise reduce the life expectancy of the capacitors and the contact surface of the contactors.

  In addition, the internal control power transformer which powers the contactor coils is oversized specifically to ensure an optimal switching performance.

- **Fuses which handle the highest short-circuit current dependability**

  PowerVar and PowerCap Auto use 600 V type JFL or TJS fuses which will operate reliably at interrupting currents as high as 200 kA, avoiding any concern for safety protection. Fuses are typically mounted directly on the bus bar proving a heat sink helping to ensure the longest possible operating lifetime.

  PowerVar and PowerCap Auto are available with or without optional blown fuse indicators or optional main breaker for disconnect protection.

- **Controls made for True Power Quality**

  Three-phase measurement capable power factor controller comes as standard.
  The PowerVar and PowerCap Auto automatic banks come equipped with a smart controller capable of operating by measuring single (standard) or three phases. The controller provides accurate measurements of the power factor and total harmonic distortion and ensures that the optimal level of reactive power and harmonic correction are automatically supplied.
  To further maximize the overall operating life and even out wear of the contactors and capacitors, the controller will automatically rotate the sequencing in which stages are engaged.
  The controller has a backlit LCD for easy local access. Remote communication options include USB, RS232, RS485 and TCP/IP Ethernet. Communications protocols supported natively are Modbus and Profibus.

- **De-Tuned and Tuned Filter Configurations**

  In the standard offering, the PowerVar filters are configured as 'detuned filters' set at 3.78th of the nominal frequency. This is generally preferable to reduce the risk of creating dangerous resonant conditions under varying loads, varying temperatures and progressive component degradation from aging.

  The filter reactors are built to tight tolerances (-3%, +3%) for accurate tuning.

- **Rugged Construction and Ease of Installation**

  The PowerVar cabinet is built with welded 11 GA zinc-plated steel, including the ventilation covers, which provide long-lasting rust protection and superior ruggedness.

  The fans have long-lasting ball bearing mechanisms and the dust filters are removable and can be vacuumed or replaced without exposing the operator to hazardous voltages and surfaces.

  The door opens from a single handle, three-point door latching mechanism, and comes with a regular indoor handle or, optionally, with a heavy-duty stainless steel, padlock able version for outdoor deployment.

  The internal layout of the bank is intended to optimize the heat management of the individual components, specifically the more heat-sensitive capacitors and fuses. For the same reason, the conductors are sized conservatively for minimal losses and heat dissipation.

  The PowerVar design provides for a number of installation and maintenance-friendly details. Each system is supplied with mechanical lugs which simplifies and reduce the cost of installation. The base of the cabinet is built with heavy gauge 4" inch steel channels which allows for easy lifting and placing without the necessity of lifting crane or use of a pallet.
  For ease of maintenance, all components are accessible from the front and easy to replace in case of repair.

- **High quality assembly**

  All control wiring is clearly identified for ease of troubleshooting. Every bolt and connection are torqued to standard, double-checked by separate production and Quality Assurance (QA) inspectors and marked for conformity. Each system is factory tested, and shipped with QA check stamps, inspection and test reports, and operating manuals. Prior to shipping, these documents are scanned and stored electronically and always available in case the client later needed a replacement set.

  The factory is ISO-9001 certified and approved by CSA and UL.

  Product features include:

  - 4-fold patented capacitor safety design with higher current capacity rating
  - Contactor with pre-charge circuit to limit the inrush current into the capacitors
  - Architecture which minimizes heating of the sensitive capacitors and fuses
  - Filters tuned to 3.78th for resonance free compensation
  - Option for ultra-fast and soft switching (FAST series)
  - Rotating duty cycle for longer life of capacitors and breakers
  - Remote communication options via RS232, RS485 and Ethernet TCP/IP supporting the MODBUS and PROFIBUS protocols
  - Multiple options (blown fuse indicators [BFI's], integrated main breaker, filter-ready, expansion-ready)
  - Withstand high harmonic current (HARMONIC, FILTER and FAST series)
  - Lower reactor losses due to multi-gap core

  Benefits

  - 20-year life expectancy with normal maintenance and under normal operating condition
  - Reduced kVA demands—lower utility bills
  - Reduces production downtime and repair costs
  - Compact design and easy to deploy
  - Very low maintenance. Front access for minimum MTTR
  - Centralized solutions at attractive cost
  - Comprehensive and flexible control capabilities
  - Quick delivery

3 Environmental and Site Considerations

- **Enclosure Types**

  PowerVar enclosure can be supplied to meet multiple NEMA std 250 types. Verify from the system rating plate that that the enclosure type provided is correct for that specific location. The most commonly supplied enclosures types:

  - Type 1: Indoor rated
  - Type 12: Indoor (Industrial) rated [PowerVar only]
  - Type 3R: Indoor/outdoor rated

- **Cooling and Air Flow**

  PowerVar and PowerCap auto products rely on their ventilation system to provide enough cooling to internal components and maintain their maximal life cycle. When installed indoor, make sure that the room is ventilated, and that ambient temperature doesn't exceed the following values:

  Operating ambient temperature range shall be -22 °F (-30 °C) to 115 °F (46 °C) maximum.

  PowerVar

  Cooling airflow is bottom-front entry with force air exit through top front. **Do not obstruct vents.** Standard Powervar products are equipped with an internal thermostatically controlled ventilation fan(s) system for cooling. The thermostat is factory set to 25° Celsius. If the internal enclosure temperature reaches 25° Celsius or more, the fans will operate. See maintenance chapter on changing filters.

  PowerCap Auto

  Air Flow is from right side bottom to left side top. **Do not obstruct vents.**

- **Distances (clearance) to walls/other systems**

Side	Rear wall	Ceiling	Front
PowerVar			
----	----	8 in (20 cm)	48 in (door full open)
PowerCap Auto			
6 in (15 cm)	----	----	36 in (door full open)

Table 3-1: Equipment Clearance

4 Current Transformer (CT) Installation (CRITICAL to operations)

Note: Installation of the CT is critical to the proper operation of the power factor correction system

- **Current Transformer (CT) Installation Instructions**

  Proper placement and polarity of the supplied current transformer is crucial for the operation of the automatic power factor capacitor bank.

  The supplied split core current transformer is sized for the total current load of the customer's utility service entrance or the branch circuit to be corrected. Always use the supplied current transformer for the automatic power factor controller, since it is programmed for that specific current transformer ratio.

- **CT Placement**

  The supplied split core current transformer must be installed at a location where it can monitor the total load power of the service entrance or branch circuit to be power factor corrected as shown in Figure 4.1. The CT must be assembled around Phase A cables or bus bar. Note that current direction is critical to accurate measurement. The current transformer must see the current that feeds the capacitor bank as well as the current that feeds the plant load(s) in order to be able to calculate how much reactive power to inject.

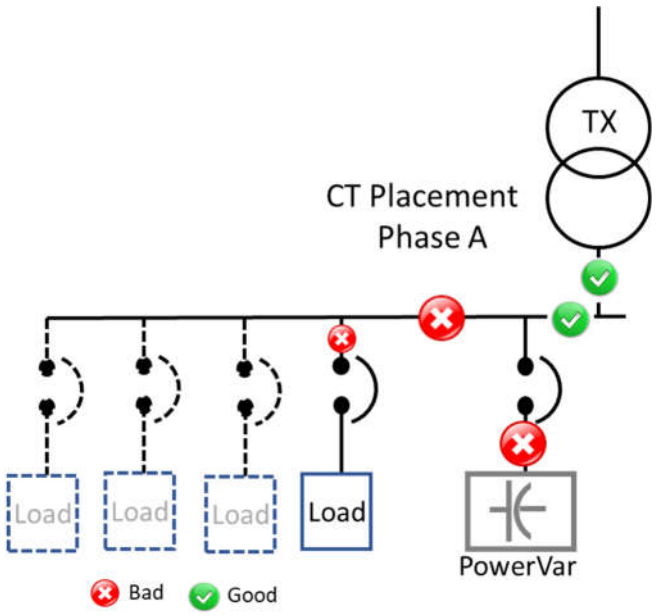


Figure 4.1 CT Placement

- **CT Physical Dimensions and Window Opening**

  Powerside provides as standard, a multi-ratio CT has an external dimension of 7.3 (A3) by 10.9 (B2) inches, internal window dimension is 4.1 (A1) by 7.1 " g or Gin. (B1). See Figure 4.2. If these dimensions are not appropriate for a proper installation around the cables or busbar of phase A, please contact Powerside for other CT dimensions availability.

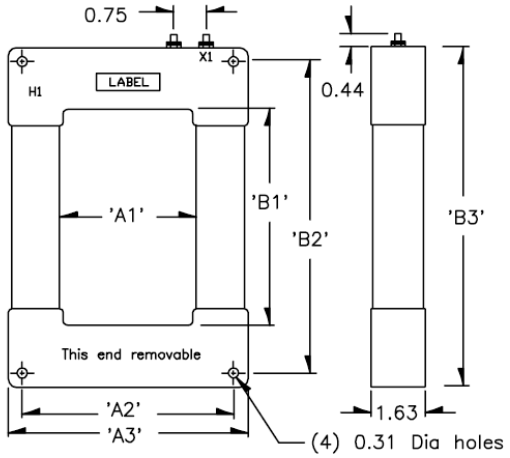


Figure 4.2 CT Dimensions

CT Orientation

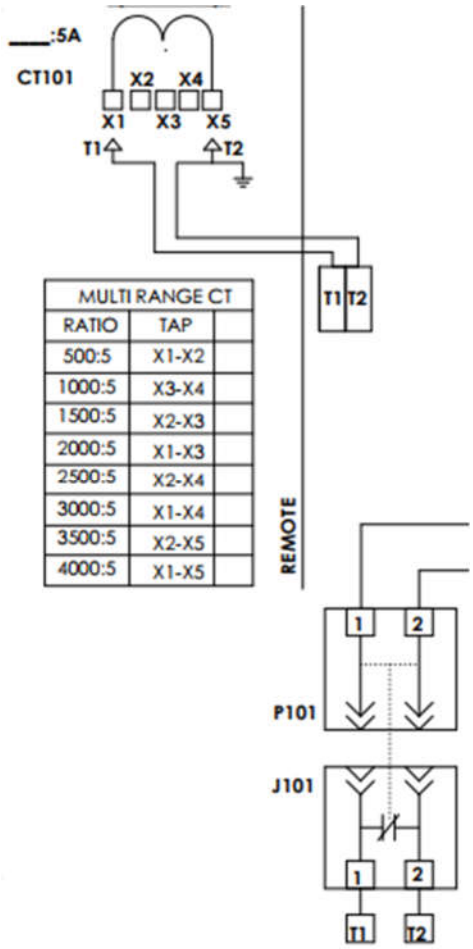
The split-core current transformer is polarized and must be installed around the busbar or cable(s) of phase A in the correct orientation for the system controller to measure power and power factor. The CT labels must face toward the source.

- **CT Secondary:**

DANGER: SEE SAFETY SECTION CONCERNING ENERGIZED SYSTEMS WITHOUT SHORTING BLOCK IN PLACE. POTENTIALLY LETHAL VOLTAGES PRESENT.

The secondary terminals are labeled X1 and X2 (see Table 4.1 for multi-ratio CT). CT secondary terminals X1 and X2 must be routed using #10 AWG copper conductors to capacitor bank control panel T1 and T2 terminals. **The secondary terminal from the CT must be solidly connected to ground. See Table 4.1 or customer drawing for further details.** On the control terminal strip, T1 and T2 terminals are pre-wired to the CT shorting block (J101). When the green plug (P101) is pulled, the CT secondary leads are shorted together, and the controller current inputs are disconnected. When inserted, the controller current inputs are linked to the current transformer leads. Always assure that the green plug is inserted to ensure the proper working of the automatic power factor controller.

For application with multi-ratio CTs, the controller has been factory programmed to the specified ratio. Please refer to the systems test report supplied to controller setup function with this unit to verify the ratio. See the table below to verify the terminal connections from the CT secondary leads (X1-X2-X3-X4-X5). The multi-ratio CT provided is 4000:5 A maximum and offers 500A adjustment from 500A up to 4000A. See table:



MULTI RANGE CT		
RATIO	TAP	
500:5	X1-X2	
1000:5	X3-X4	
1500:5	X2-X3	
2000:5	X1-X3	
2500:5	X2-X4	
3000:5	X1-X4	
3500:5	X2-X5	
4000:5	X1-X5	

Figure 4.3 CT Ratio and Shorting Block

5 PowerVar and PowerCap Auto Installation

- **Receiving and physical placement**
  - ✓ Thoroughly inspect the transport protection for possible shipping damage.
  - ✓ Using a forklift or pallet jack, move the packaged cabinet to the installation site.
  - ✓ Position the unit as close as possible to the operating site before unpacking to prevent damage due to transport.
  - ✓ Set the pallet on a firm, level surface and remove the unit from the pallet.
  - ✓ Remove remaining protection/packing material and inspect for shipping damage.
  - ✓ Compare items received with the bill of lading.
  - ✓ Refer to drawings for system anchoring and all other mechanical considerations.

- **Dimensions and Access**

  Refer to customer drawing for dimensions and access specific to each installation.

6 Primary Power and Cable Entry

- **Cable Rating**

  Refer to the customer drawing for electrical rating information specific to this installation and relevant electric code to determine input wiring size and specification.

  Wiring size and installation are the sole responsibility of the customers designated electrical engineer. For US applications refer to National Electric Code NFPA 70E. For Canadian applications refer to Canadian Electrical Code latest edition.

- **Main Circuit Breaker Rating**

  External circuit breaker rating, installation and related integration coordination study is the sole responsibility of the customers designated electrical engineer. Refer to Table 6.1 for the minimum breaker rating to enable specified kVAR performance at specified voltage levels. If the optional integrated main circuit breaker has been provided, see Table 6.1 for information related to the frame size and rating plug provided.

Minimum protection current rating for specific kVAR at specified voltage. Contact factory for other voltages		
kVAR	Amps @ 480 Vac	Amps @ 600 Vac
75	121.5	97.2
100	162	129.6
125	202.5	162
150	243	194.4
200	324	259.2
250	405	324
300	486	388.8
350	567	453.6
400	648	518.4
450	729	583.2
500	810	648
550	891	712.8
600	972	777.6
650	1053	842.4
700	1134	907.2
750	1215	972
800	1296	1036.8
850	1377	1101.6
900	1458	1166.4
950	1539	1231.2
1000	1620	1296
1050	1701	1360.8
1100	1782	1425.6
1150	1863	1490.4
1200	1944	1555.2

Optional integrated circuit breaker rating				
kVAR	Rating plug @ 480 Vac	Frame size @ 480 Vac	Rating plug @ 600 Vac	Frame size @ 600 Vac
75	150	250	100	250
100	200	250	150	250
125	250	250	200	250
150	250	250	200	250
200	400	400	300	400
250	500	600	400	400
300	500	600	400	400
350	600	600	500	600
400	700	800	600	600
450	800	800	600	600
500	900	1200	700	800
550	900	1200	800	800
600	1000	1200	800	800
650	1100	1200	900	1200
700	1200	1200	1000	1200
750	1300	1600	1000	1200
800	1300	1600	1100	1200
850	1400	1600	1200	1200
900	1500	1600	1200	1200
950	1600	1600	1300	1600
1000	1700	2000	1300	1600
1050	1800	2000	1400	1600
1100	1700	2000	1500	1600
1150	1900	200	1500	1600
1200	2000	2000	1600	1600

Table 6.1 Circuit Breaker sizing and rating. As per NEC and UL, these values are based on 135% of nominal current.

- **Entry and Landing**

  Refer to customer drawing for cable entry and landing specific to each installation.

PowerVar Power and Cable Entry Typical Examples

Figure 6.1 PowerVar Power Entry, Main Lugs Only

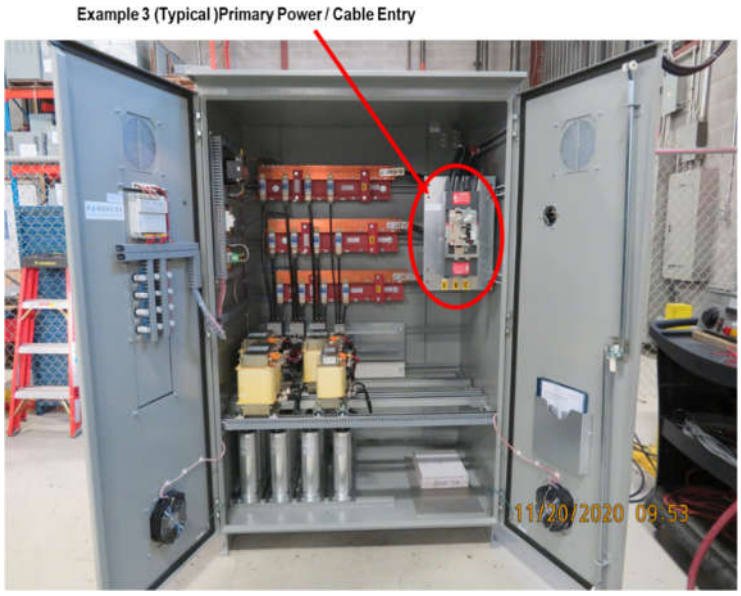


Figure 6.2 PowerVar Power Entry, optional Integrated Circuit Breaker

Figure 6.3 Safety Ground Connection. See table 6.2 for torque specification

Figure 6.4 PowerCap Auto Power Entry

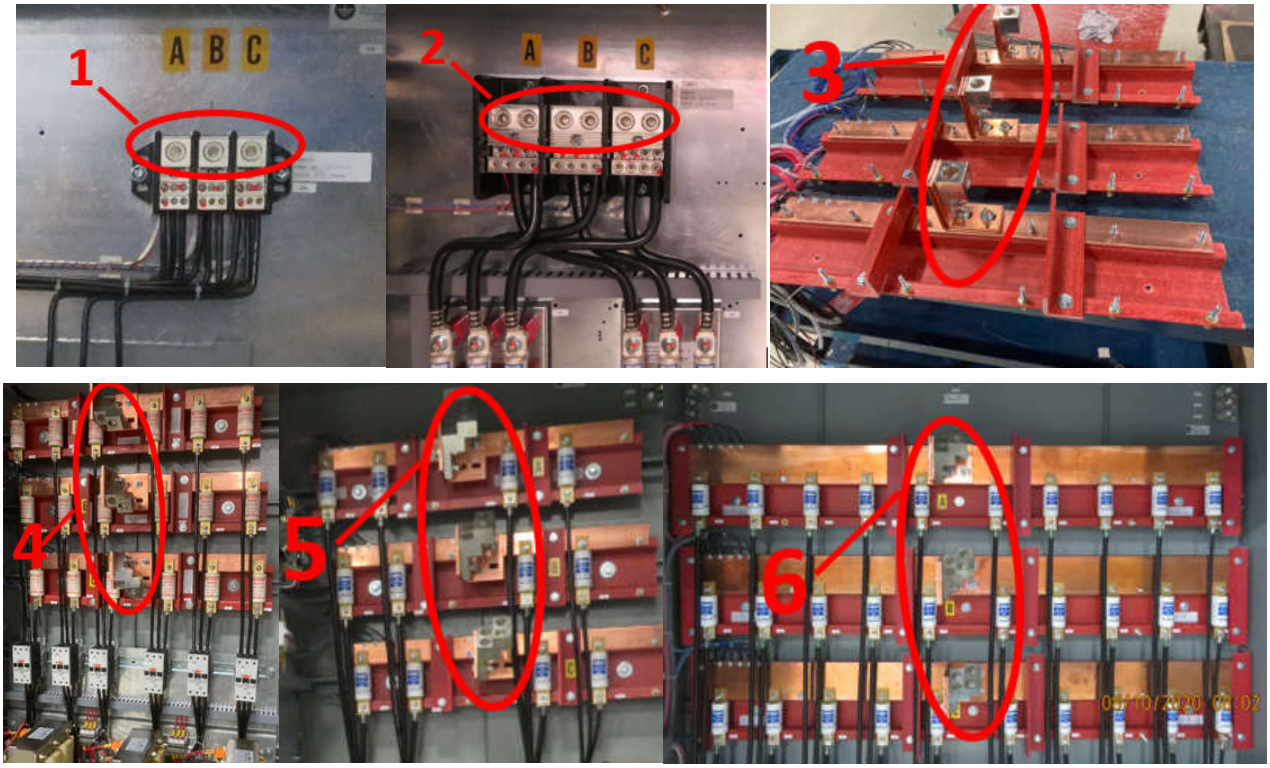


Figure 6.5 Cable Entry Main Power distribution block (PDB) and bus bar lugs torque rating (no optional internal main breaker)

ID#	Power Distribution Blocks and Bus-Bar Lugs Detail	Item#	Cable gauge	Torque Spec.
#1	block #6—350MCM (single cable) per phase	1403404	#6 to 350MCM	275 Lb-In
#2	block #6—500MCM (max 2 cables) per phase	1453586	#6 to 500MCM	375 Lb-in
GND	Lug #1—350MCM (single GND cable)	LAMA350	#6 to #2 #1 to 350MCM	200 Lb-in 375 Lb-in
#3	Lug #2—600MCM (single cable) per phase	KA36U	#2 to 600MCM	500 Lb-in
#4	Lug #2—600MCM per phase (max 2 cables)	ASL6022	1/0 to 2/0 => 150 Lb-in 3/0 to 350MCM => 200 Lb-in 500MCM to 800MCM => 300 Lb-in	
#5	Lug #2—600MCM (max 4 cables) per phase	ASL6042		
#6	Lug 3/0—750MCM (max 4 cables) per phase	ASL7542		

Table 6.2 Cable Entry Main Power distribution block (PDB) and bus bar lugs torque rating (no optional internal main breaker)

- **Cable Entry Lugs Torque rating (with internal main breaker)**

  For torque rating on the optional mains circuit breaker, see the rating information on the actual circuit breaker installed.

Internal Torque Specifications

Torque specifications for every power component except for incoming cables to capacitor bank.

Part Detail	Item#	Cable gauge	Cable Torque
PDB load side 6x #8—#4 max per phase	1403404	#8—#4	35 Lb-in
PDB load side 8x #8 - 2/0 max per phase	1453586	#8 => 40 Lb-in #6 to 2/0 => 120 Lb-in	
Bus bar Cable Distribution (5/16) bolt	N/A	#8 - 2/0	250 Lb-in
Bus bar Cable Distribution (3/8) bolt	N/A	#8 - 2/0	300 Lb-in
Cable distribution from Breaker Lug to busbar	SEE TABLE 6.2	SEE TABLE 6.3	
JFL type fuse	JFL110—JFL200	60 Lb-in	
TJS type fuse	TJS110—TJS200	120 Lb-in	
Lovato contactor pole	BFK3200A12060 BFK8000A12060 BFK15000A12060	25 Lb-in 40 Lb-in 60 Lb-in	
Reactor Cable Primary side (5/16) bolt	N/A	#8 - 2/0	250 Lb-in
Reactor Cable Primary side (3/8) bolt		#8 - 2/0	300 Lb-in
Reactor Load side 2-HOLE LUG (1/4 bolt)	IHI 2S1/0 HEX	N/A	200 Lb-in
Reactor 2 HOLES LUG Cables (3/16 hex screws)		2x #8 per hole	45 Lb-in
		2x #6 per hole	50 Lb-in
AEROVOX 3 bushings capacitor 50–100 kVAR	MMPA0XXXC33	3x #6 - 1/0	50 Lb-in
NGM 3 studs capacitor 1–25 kVAR	33XXXXX3ACDCXNG	2x #8 to #4	25 Lb-in

Table 6.3 Torque specifications for internal connections

7 Commissioning and Initial Energization

Review all safety information at the front of this manual prior to proceeding.

- **PRIOR TO ENERGIZING THE SYSTEM**

_____ General visual inspection to both exterior and interior.

_____ Enclosure is free of scratches. Repaint if required.

_____ Capacitor cabinet properly anchored to the ground.

_____ Ensure the system and work area is clean of any contaminants or debris.

_____ Main power cables properly landed (ABC) versus connection reference and torqued to spec (See section 6).

_____ Ground cable properly installed and torqued to spec (See section 6).

_____ Supplied current transformer (CT) installed per section 4 this manual and connected to terminal T1 and T2.

_____ Supplied current transformer (CT) properly connected for multitap. Refer to Figure 4.2 CT Dimensions

_____ All power connections are torqued to the correct value with torque seals in place. Refer to Table 6.2

_____ Continuity and size of control and step fuses (verify product drawing and fuse label nearby fuse location)

_____ Perform phase-phase capacitor capacity measurements and document in Table A1 Inspection Data Collection worksheet. Min/Max criteria are provided in Table A2. Contact factory if values are outside defined criteria.

_____ Close the control circuit breaker CB 101

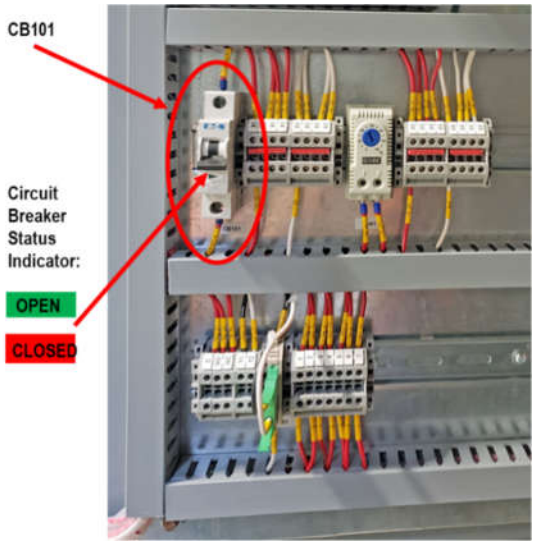


Figure 7-1 PowerVar typical location

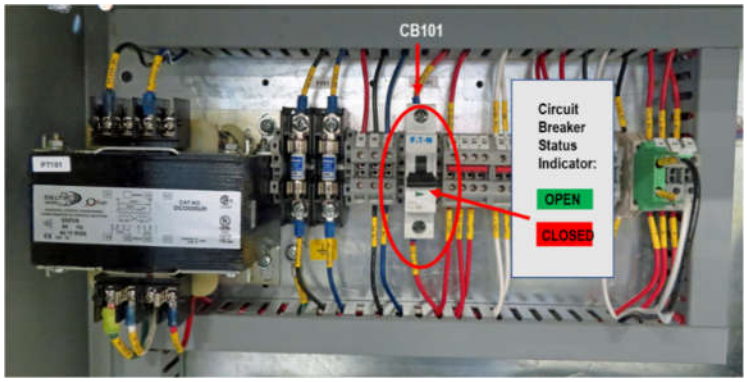


Figure 7-2 PowerCap Auto typical location

- **ENERGIZE THE SYSTEM**

_____ Close internal main capacitor bank circuit breaker

_____ Apply power to the system by closing upstream breaker feeding power to capacitor bank.

_____ Verify controller is functional (display on and able to step through different screens)

_____ Verify that controller is set to Automatic (displays AUT on the home screen)

_____ If there is enough load on the site, the capacitor bank should start to turn on capacitor steps by itself.

In the automatic mode, the system will provide power factor correction immediately and without further configuration.

The controller Main Page will display key information regarding system performance.

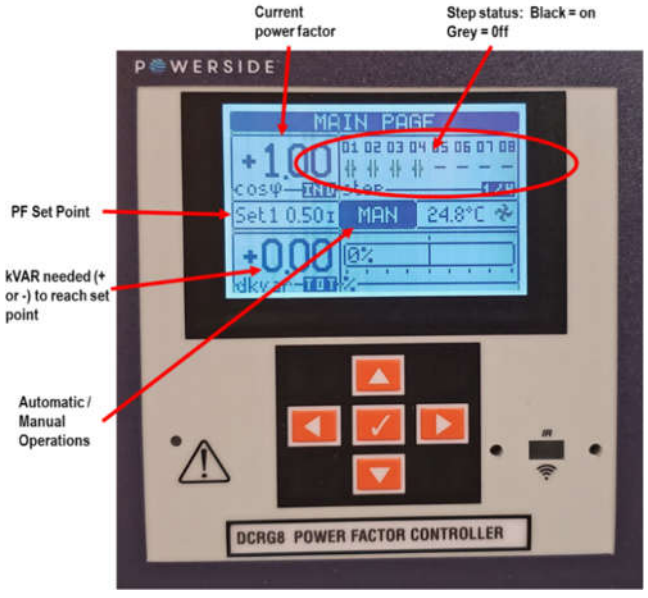


Figure 7.3 Controller Front Panel

_____ Ensure the controller display does not show any alarm(s).

_____ Fan operations confirmed—lower thermostat temperature setting below ambient and observe fan turns on.

Reset fan thermostat to _____ set point.

_____ Heater (optional) operation confirmed—raise thermostat temperature setting above ambient and observe heater turns on.

Reset heater thermostat to _____ set point. If there is no heater, skip this instruction.

_____ Wearing adequate PPE equipment, perform phase current reading for every capacitor stage and document in Table A1 Inspection Data Collection worksheet.
Controller must be set in manual mode.
Measurements should be within parameters of Table A2 Min/Max Testing Values.

_____ Verify no fuses are blown using the optional Blow Fuse Indicator (BFI)

Figure 7.4 BFI will illuminate when fuse is blown (open)

_____ Verify the voltage, current reactive power and power factor on the controller against any available separate metering from switchgear, MCC, etc.

_____ Verify the voltage, current reactive power and power factor on the controller using a handheld multimeter.

_____ Verify that the controller pre-program settings are correctly programmed for site parameters. See Controller Programming Lovato sheet attached to this manual. **Do not modify parameter *Reconnection Time (P02.10).***

_____ Controller is set back to automatic mode

Close and lock the enclosure door. The system can now be approached by non-trained personnel.

Note: For controller configuration and operations refer to the full controller manual.

- **SYSTEM VERIFICATION**

  At 30 and 60 days

  - Verify on the electrical utility bill that power factor penalties are no longer being applied. I

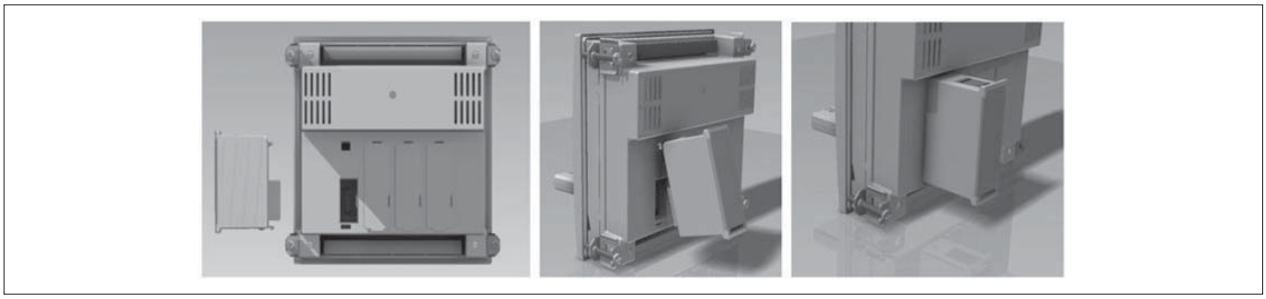
8 DCRG8 Power Factor Controller Options

- **Optional Modules**

  The controller allows for up to four (4) multiple communication and I/O options. See controller manual for details.

MODULE TYPE	CODE	FUNCTION
COMMUNICATION	EXP1010	USB
	EXP1011	RS232
	EXP1012	RS485
	EXP1013	Ethernet
	EXP1014	Profibus® DP
	EXP1015	GSM-GPRS (without antenna0)
INPUTS/OUTPUTS	EXP1000	4 DIGITAL IN
	EXP1002	2 DIGITAL IN + 2 STATIC OUT
	EXP1003	2 RELAY OUTPUTS
	EXP1004	2 ANALOG IN
	EXP1005	2 ANALOG OUT
	EXP1008	2 DIGITAL IN + 2 RELAY OUTPUTS

Modules are installed at the rear of the controller



9 Remote Communications (options)

- **Network access**

  Ethernet communications are available with the EXP1013 ethernet/web server communications module.

  Connect to the router using an RJ45 (ethernet) cable.

  Controller IP address may be manually set via *SETUP MENU/M16*.

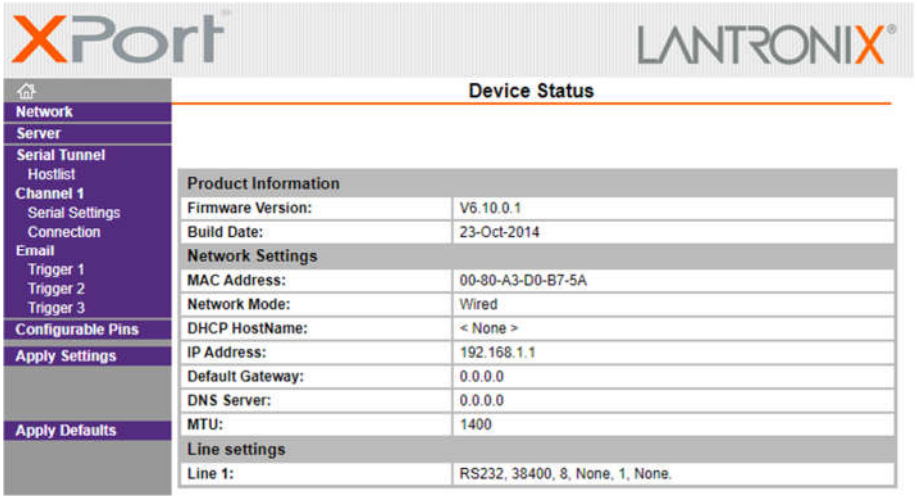
  Setup for Synergy Cloud not required for Modbus communications

  Default IP address is 192.168.1.1

  From any browser, enter the IP address.

  No username or password is required.

  The following screen will display. Site-specific communication requirements can now be established for the PowerVar DCRG8F controller.



  See Lovato DCRG8 Instruction manual for specific details related to network communications.

  See Lovato DCRG8 Modbus Manual for information related to the support of Modbus RTU and Modbus ASCII.

10 PowerVar Product Specifications and Details

General Specification	PowerVar	PowerCap Auto
Topology	Standard capacitance-only bank or detuned filter (3.78th harmonic)	Capacitance only
Voltage range	208/240/480/600 Vac at 60 Hz models [check equipment nameplate]	
Capacity	75–1200 kVAR	50–300 kVAR
Connection	Three phases balanced network	
Capacitor Type	Self-healing, low loss metalized polypropylene dielectric film. Less than 0.2 Watt per KVAR losses	
Capacitor Overvoltage Rating	110%	
Capacitor Overcurrent Rating	System specific. See installation drawings	
Reactors	Dry type resin embedded according to IEC 289, IEC 76	N/A
Stages	1 to 12	Up to 4
Contactor	Mechanical (designed specifically for capacitor applications) or thyristor	Mechanical
Indicators	Optional Blown Fuse Indicator (BFI), Pilot Light, Capacitor Life Indicator (CLI)	
Controller	Front panel LCD, eight stages expandable to twelve, comm. option for RS232, RS485, Ethernet (TCP/IP) Native Modbus support.	
Enclosure	NEMA 1 standard, 12-gauge steel	
	Option: NEMA 3R and NEMA 12, shipping splits, Special paint, bus duct entry, back-to-back construction	NEMA 1 standard, 12-gauge steel. Optional NEMA 3R
Ventilation	Passive and forced air cooling (model dependent)	Passive air cooled
Working ambient temperature	-30 °C (-22 °F) [requires NEMA 3R below 5 °C] to +46 °C (115 °F)	
Storage ambient temperature	5 °C (-41 °F) to +70 °C (+158 °F)	
Max. height above sea level without derating	2000 m	
Power factor setting	From 0.5 inductive to 1.0 (unity)	
Agency	UL and CSA Listed	

Appendix A: Preventive Maintenance Inspection (PMI)

DANGER: WORK SHOULD BE PERFORMED BY QUALIFIED PERSONNEL ONLY. READ AND FOLLOW ALL SAFETY INSTRUCTIONS AT THE FRONT OF THIS MANUAL.

REMOVE POWER FROM SYSTEM

_____ Open upstream feed breaker

_____ Open enclosure door and open CB101 controller power supply

_____ Verify the system is electrically safe.

WARNING: NEVER work on a capacitor that has just been switched off. They remain energized. The capacitors are equipped with a discharge resistor that will de-energize each cell to a safe level in approximately one (1) minute. ALWAYS take the following precautions before working on the capacitor:

- Wait one (1) minute before touching the terminals of the capacitor.
- Use a voltmeter to measure the voltage between the terminals. If the capacitors are not completely de-energized leave the voltmeter connected to the terminals until the reading shows no voltage. (The voltmeter's internal resistance will help discharge the capacitor.) Verify the voltage on all terminals.
- Review all safety information at the front of this manual prior to proceeding.

DEENERGIZED INSPECTION

_____ General visual inspection to both exterior and interior. Ensure there are no traces of overheating such as burnt spots, discoloring, melting or deformed materials.

_____ Inspect capacitors cans for signs of bulging, leaks or deformation.

_____ Clean the system inside and out of dust or other particulates using vacuum or compressed air if required.

_____ Check for loose or disconnected power cables or control wires.

_____ Check electrical connections for proper torque.

_____ Clean ventilation openings and fan

_____ Replace vent filters if applicable.

_____ Measure and record the capacitance of each step using a capacitance or multimeter.

- For steps with multiple capacitors cells measure at a common point. For filters measure at the load side of the reactor (bottom lugs). For non-filtered measure it at the load side of the contactor.
- Sum the reading for all phases (AB + AC + BC = capacitor total) and document in the data collection worksheet
- Compare to minimum / maximum capacitance range in Appendix Table 3

_____ Measure and record fuse continuity using a volt or multimeter.

RESTORE POWER TO SYSTEM

_____ Close CB101 controller power supply

_____ Close enclosure door

_____ Close upstream feed breaker

_____ From the front panel verify system is in Automatic (AUT) mode

ENERGIZED INSPECTION

_____Verify ventilation fan and system heater (when applicable) are operational by adjusting thermostat (adjacent to CB101). Replace fan every 3 years.

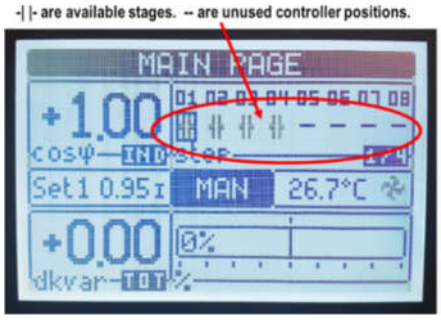
_____ IR Scan: Note: Scan to be performed once the system has been in AUT (automatic) mode for a minimum of four (4) hours. Open door and perform IR scan on all connection [WARNING: Exposed Voltage]. Note any hot spots for tightening connections when the system has been deenergized.

_____ At the controller change the system from AUT to MAN mode.

_____ At the controller verify the PF set point (available from either Aut or Man page).

_____ Verify steps are working on the DCRG8 controller:

- When the controller is in manual mode, select Step 1 and manually connect or disconnect it using the following procedure.
  - ✓ From the main page, press ►. Stage No. 1 is highlighted by a box. To select the step you want, press ◄ or ►.
  - ✓ Press ▲ to connect or ▼ to disconnect the selected step.
  - ✓ If the number above the step is light gray, it means the stage is not available because its reconnection time of 60 seconds has not elapsed yet. In this case, by sending a close command, the stage number will flash to indicate that the operation has been confirmed and will be conducted when the reconnection lockout time expires.
  - ✓ If the stage is working the COS value will increase or decrease as each stage steps in or out. Document results for each stage.
  - ✓ Repeat for all steps utilized in this system.



_____ Measure and record current for each step

- While each step is active measure and record the primary current of each phase of the capacitor in the data collection worksheet. Measure at the contactor.
- See Appendix Table 1 for minimum and maximum acceptable range

Contact Powerside for technical support or to arrange for correction services.

Inspection Data Collection Worksheet PF Set Point:

Location: Part Number: Serial Number:

	Step 1	Step 2	Step 3
KVAR (sum of nameplate rating)	_____ kVAR	_____ kVAR	_____ kVAR
Capacitance value AB	_____ µF	_____ µF	_____ µF
Capacitance value BC	_____ µF	_____ µF	_____ µF
Capacitance value CA	_____ µF	_____ µF	_____ µF
Test fuse continuity	_____	_____	_____
Measured Current Phase A	_____Amps	_____Amps	_____Amps
Measures Current Phase B	_____Amps	_____Amps	_____Amps
Measured Current Phase C	_____Amps	_____Amps	_____Amps
	Step 4	Step5	Step 6
KVAR (sum of nameplate rating)	_____ kVAR	_____ kVAR	_____ kVAR
Capacitance value AB	_____ µF	_____ µF	_____ µF
Capacitance value BC	_____ µF	_____ µF	_____ µF
Capacitance value CA	_____ µF	_____ µF	_____ µF
Test fuse continuity	_____	_____	_____
Measured Current Phase A	_____A	_____A	_____A
Measures Current Phase B	_____B	_____B	_____B
Measured Current Phase C	_____C	_____C	_____C
	Step 7	Step 8	Step 9
KVAR (sum of nameplate rating)	_____ kVAR	_____ kVAR	_____ kVAR
Capacitance value AB	_____ µF	_____ µF	_____ µF
Capacitance value BC	_____ µF	_____ µF	_____ µF
Capacitance value CA	_____ µF	_____ µF	_____ µF
Test fuse continuity	_____	_____	_____
Measured Current Phase A	_____A	_____A	_____A
Measures Current Phase B	_____B	_____B	_____B
Measured Current Phase C	_____C	_____C	_____C
	Step 10	Step 11	Step 12
KVAR (sum of nameplate rating)	_____ kVAR	_____ kVAR	_____ kVAR
Capacitance value AB	_____ µF	_____ µF	_____ µF
Capacitance value BC	_____ µF	_____ µF	_____ µF
Capacitance value CA	_____ µF	_____ µF	_____ µF
Test fuse continuity	_____	_____	_____
Measured Current Phase A	_____A	_____A	_____A
Measures Current Phase B	_____B	_____B	_____B
Measured Current Phase C	_____C	_____C	_____C

Table A1: Minimum and Maximum Total Capacitance (phase measurement) in µF

To be considered in tolerance, the Individual capacitance values will fall within the range provide in Table A3.

- Min / Max Testing Values

	208 Vac (Amps)		240 Vac (Amps)		480 Vac (Amps)		600 Vac (Amps)	
kVAR	Min	Max	Min	Max	Min	Max	Min	Max
0.5	1.4	1.6	1.2	1.4	0.6	0.7	0.5	0.6
1.0	2.8	3.2	2.4	2.8	1.2	1.4	1	1.1
1.5	4.2	4.8	3.6	4.1	1.8	2.1	1.4	1.7
2.0	5.6	6.4	4.8	5.5	2.4	2.8	1.9	2.2
3.0	8.3	9.6	7.2	8.3	3.6	4.1	2.9	3.3
4.0	11.1	12.8	9.6	11.1	4.8	5.5	3.8	4.4
5.0	13.9	16	12	13.8	6	6.9	4.8	5.5
7.5	20.8	23.9	18	20.7	9	10.4	7.2	8.3
10.0	27.8	31.9	24.1	27.7	12	13.8	9.6	11.1
12.5	34.7	39.9	30.1	34.6	15	17.3	12	13.8
15.0	41.6	47.9	36.1	41.5	18	20.7	14.4	16.6
17.5	48.6	55.9	42.1	48.4	21	24.2	16.8	19.4
20.0	55.5	63.8	48.1	55.3	24.1	27.7	19.2	22.1
22.5	62.5	71.8	54.1	62.2	27.1	31.1	21.7	24.9
25.0	69.4	79.8	60.1	69.2	30.1	34.6	24.1	27.7
27.5	76.3	87.8	66.2	76.1	33.1	38	26.5	30.4
30.0	83.3	95.8	72.2	83	36.1	41.5	28.9	33.2
35.0	97.2	111.7	84.2	96.8	42.1	48.4	33.7	38.7
40.0	111	127.7	96.2	110.7	48.1	55.3	38.5	44.3
45.0	124.9	143.6	108.3	124.5	54.1	62.2	43.3	49.8
50.0	138.8	159.6	120.3	138.3	60.1	69.2	48.1	55.3
55.0	152.7	175.6	132.3	152.2	66.2	76.1	52.9	60.9
60.0	166.5	191.5	144.3	166	72.2	83	57.7	66.4
65.0	180.4	207.5	156.4	179.8	78.2	89.9	62.5	71.9
70.0	194.3	223.5	168.4	193.7	84.2	96.8	67.4	77.5
75.0	208.2	239.4	180.4	207.5	90.2	103.7	72.2	83
80.0	222.1	255.4	192.5	221.3	96.2	110.7	77	88.5
85.0	235.9	271.3	204.5	235.2	102.2	117.6	81.8	94.1
90.0	249.8	287.3	216.5	249	108.3	124.5	86.6	99.6
95.0	263.7	303.3	228.5	262.8	114.3	131.4	91.4	105.1
100.0	277.6	319.2	240.6	276.7	120.3	138.3	96.2	110.7

Table A2: Minimum and Maximum Phase Current in Amps

	208 Vac (F)		240 Vac (F)		480 Vac (F)		600 Vac (F)	
kVAR	Min	Max	Min	Max	Min	Max	Min	Max
0.5	15.3	17.6	11.5	13.2	2.9	3.3	1.8	2.1
1.0	30.7	35.3	23	26.5	5.8	6.6	3.7	4.2
1.5	46	52.9	34.5	39.7	8.6	9.9	5.5	6.4
2.0	61.3	70.5	46.1	53	11.5	13.2	7.4	8.5
3.0	92	105.8	69.1	79.4	17.3	19.9	11.1	12.7
4.0	122.6	141	92.1	105.9	23	26.5	14.7	16.9
5.0	153.3	176.3	115.1	132.4	28.8	33.1	18.4	21.2
7.5	229.9	264.4	172.7	198.6	43.2	49.6	27.6	31.8
10.0	306.6	352.5	230.3	264.8	57.6	66.2	36.8	42.4
12.5	383.2	440.7	287.8	331	72	82.7	46.1	53
15.0	459.8	528.8	345.4	397.2	86.3	99.3	55.3	63.6
17.5	536.5	616.9	403	463.4	100.7	115.8	64.5	74.1
20.0	613.1	705.1	460.5	529.6	115.1	132.4	73.7	84.7
22.5	689.8	793.2	518.1	595.8	129.5	148.9	82.9	95.3
25.0	766.4	881.4	575.6	662	143.9	165.5	92.1	105.9
27.5	843	969.5	633.2	728.2	158.3	182	101.3	116.5
30.0	919.7	1057.6	690.8	794.4	172.7	198.6	110.5	127.1
35.0	1073	1233.9	805.9	926.8	201.5	231.7	128.9	148.3
40.0	1226.2	1410.2	921	1059.2	230.3	264.8	147.4	169.5
45.0	1379.5	1586.4	1036.1	1191.6	259	297.9	165.8	190.7
50.0	1532.8	1762.7	1151.3	1324	287.8	331	184.2	211.8
55.0	1686.1	1939	1266.4	1456.4	316.6	364.1	202.6	233
60.0	1839.3	2115.5	1391.6	1588.8	345.4	397.2	221	254.2
65.0	1992.6	2291.5	1496.7	1721.2	374.2	430.3	239.5	275.4
70.0	2145.9	2467.8	1611.8	1853.6	403	463.4	257.9	296.6
75.0	2299.2	2644.1	1726.9	1986	431.7	496.5	276.3	317.8
80.0	2452.5	2820.3	1842.1	2118.4	460.5	529.6	294.7	338.9
85.0	2605.7	2996.6	1957.2	2252.8	489.3	562.7	313.2	360.1
90.0	2759	3172.5	2072.3	2383.2	518.1	595.8	331.6	381.3
95.0	2912.3	3345.1	2187.5	2515.6	546.9	628.9	350	402.5
100.0	3065.6	3525.4	2302.6	2648	575.6	662	368.4	423.7

Table A3: Minimum and Maximum Total Capacitance (phase measurement) in F

Documentation provided in addition to this manual:

Product Drawings

System Configuration and Test Report

DCRG8 Controller Manual

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