JOHN DEERE CONFIDENTIAL

Installation Manual

PD400 Single

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JOHN DEERE

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Document Use and Legal Agreements

This document will be made available to customers as a reference after an NDA is completed and prior to any legal agreements being in place. JDES requires each customer to sign either a Prototype Agreement or a Supply Agreement prior to any shipment of John Deere Electronic Solutions hardware. These agreements detail the terms and conditions related to the use of John Deere Electronic Solutions hardware.

Foreword

Read this manual carefully to learn how to install your PD400 Single inverter correctly.

Because of the variety of uses for the products described in this manual, those responsible for the application and use of this equipment must satisfy themselves that all necessary steps have been taken to ensure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes, and standards. Illustrations, charts, sample programs, and layout examples shown in this manual are intended solely for purposes of example.

Measurements in this manual are given in metric units. Use only correct replacement parts and fasteners.

!	**Disclaimer**	While every effort has been made to ensure that the information and content within this document is accurate, up-to-date, and reliable, JDES cannot be held responsible for inaccuracies, errors, or omissions. Actions taken based on information provided within this document are solely at the user's own risk.

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Tables

1. PREFACE

1.1 PUBLICATION HISTORY

Table 1: Publication History

Version	Date	Comment
0.1	21 March 2016	– First draft of PD400 Single IM created from V0.4 of PD400 Dual IM
0.2	27 March 2017	– Various updates to harmonize with PD400 Dual IM.
0.3	31 March 2017	– Add coolant flow chart
2.3	8 Feb 2019	– General consolidation – Revised torque values, new voltage graphic – Corrected error in vehicle connector part number – Updated phase connector mating part number – Update drawings –Correct coolant flow rate in Table 5 –Correct DC link Max Loc torque value –Correct name to "Standard DC Link Junction Box" –Change drawings in Fig. 5 to correct bolt size information. –Added new section on heat rejection. –Correct minor spelling error –Correct polarity of std. jbox (remove drawing and refer to assembly drawing)

1.2 REFERENCES

Table 2: Reference Documents

No.	Title/Description	Revision/Info
1	User Manual – PD400	DOC-227358
2	CAN Specification – PD400	DOC-227357
3	PD400 Single Customer Interface Drawing	Consult JDES
4	CalPro Manual	
5	PD400 Single CAD Model	STP format
6	Degrees of Protection Provided by Enclosures (IP Code)	IEC 60529
7	Serial Control and Communications Heavy Duty Vehicle Network	SAE J1939

No.	Title/Description	Revision/Info
8	Temperatures of Touchable Hot Surfaces	IEC Guide 117
9	Low Voltage Electrical Installations: Selection and Erection of Electrical Equipment – Earthing Arrangements and Protective Conductors	IEC 60634-5-54
10	Electrically Propelled Road Vehicles – Safety Specifications – Part 3: Protection of Persons Against Shock	ISO 6469-3
11	Insulation Coordination for Equipment Within Low-voltage Systems – Part 1: Principles, Requirements, and Tests	IEC 60664-1
12	Protection Against Electric Shock – Common Aspects for Installation and Equipment	IEC 61140
13	Safety Requirements for Power Electronic Converter System and Equipment – Part 1: General	IEC 62477-1

1.3 DEFINITIONS

Table 3: Definitions for Common Terms

Item	Definition
Battery	Refers to the power input from 12 V or 24 V vehicle electrical system.
CAN	Controller Area Network
Earth Ground Chassis Ground	Reference point for the voltage or signal being described. Earth Ground is in a lab setting while Chassis Ground is the vehicle frame/chassis
EMI	Electromagnetic interference
Equipotential Bond	A protective electrical connection between all accessible conductive parts and chassis. IEC 62477-1 and IEC 61140 provide additional information.
High Voltage	1. In this document, refers to the voltages present on the DC Link and phase connections. 2. Also, refers to high voltage terminals
IT System	IEC 62477-1 category for the supply system earthing: An IT system has all live parts isolated from earth or one point connected to earth through an impedance, the accessible conductive parts of the installation being earthed independently or collectively to the system earthing
JDES	John Deere Electronic Solutions (the factory)
Live Part	Conductor or conductive part intended to be energized in normal use
Low Voltage	1. Any voltage related to the common 12 V DC or 24 V

Item	Definition
	DC vehicle system. 2. Also, refers to low voltage connectors
Minimum required prospective short-circuit current	r.m.s. value of a short circuit current, needed to ensure safe interruption using a specific type of short-circuit protective device
Nm or N-m	Newton-meter, SI unit of torque
Over Voltage Category I	IEC 62477-1 defines this as "Equipment for connection to circuits in which measures are taken to limit the transient overvoltages to an appropriate low level"
PE conductor	IEC 62477-1 defines this as connecting a protective earthing terminal in the equipment to an earth point in the installation.
Pollution Degree 4	IEC 62477-1 defines this as "The pollution generates persistent conductivity caused, for example by conductive dust or rain or snow"
PPE	Personal Protective Equipment
Protective Class 1	IEC 62477-1 defines protective class 1 as shock protection comprised of basic insulation and grounded conductive enclosures.
PWM	Pulse-width modulation
Recommended	Items that are "recommended" are suggestions to consider but not required to meet specifications
Required	Items that are "required" are not optional and must be followed to meet specifications
SCPD	Short Circuit Protective Device
WEG	Water Ethylene Glycol (coolant mixture)

2. Proper Operation and Use of This Product

USE CAUTION! Due to the high voltages present in and around the inverter, JDES recommends that you put in place a detailed set of procedures to follow that include PPE and training for all people working with or around the inverter and motor.

2.1 Recognize Critical Information

!	**Note**	The signal word NOTE indicates a situation that, if not avoided, could result in property damage.
	**Caution**	The signal word CAUTION indicates a hazardous situation that, if not avoided, could result in minor or moderate injury. CAUTION may also be used to alert against unsafe practices associated with events that could lead to personal injury.
	**Warning**	The signal word WARNING with this symbol indicates a hazardous situation related to electric shock that, if not avoided, could result in death or serious injury.
	**Warning**	The signal word WARNING with this symbol indicates a hazardous situation that, if not avoided, could result in death or serious injury.

2.2 Follow Instructions

	Carefully read all messages in this manual. Learn how to operate the inverter properly. Do not let anyone operate without proper instruction. Keep your inverter in proper working condition. Unauthorized modifications to the inverter may impair the function and affect its life. If you do not understand any part of this manual and need assistance, contact John Deere Electronic Solutions.

3. General Description

3.1 Functionality

See the User Manual and CAN Specification for a generic description of product functionality.

3.2 System Block Diagram

Figure 1 provides a high level view of the PD400 Single with all hardware connections depicted.

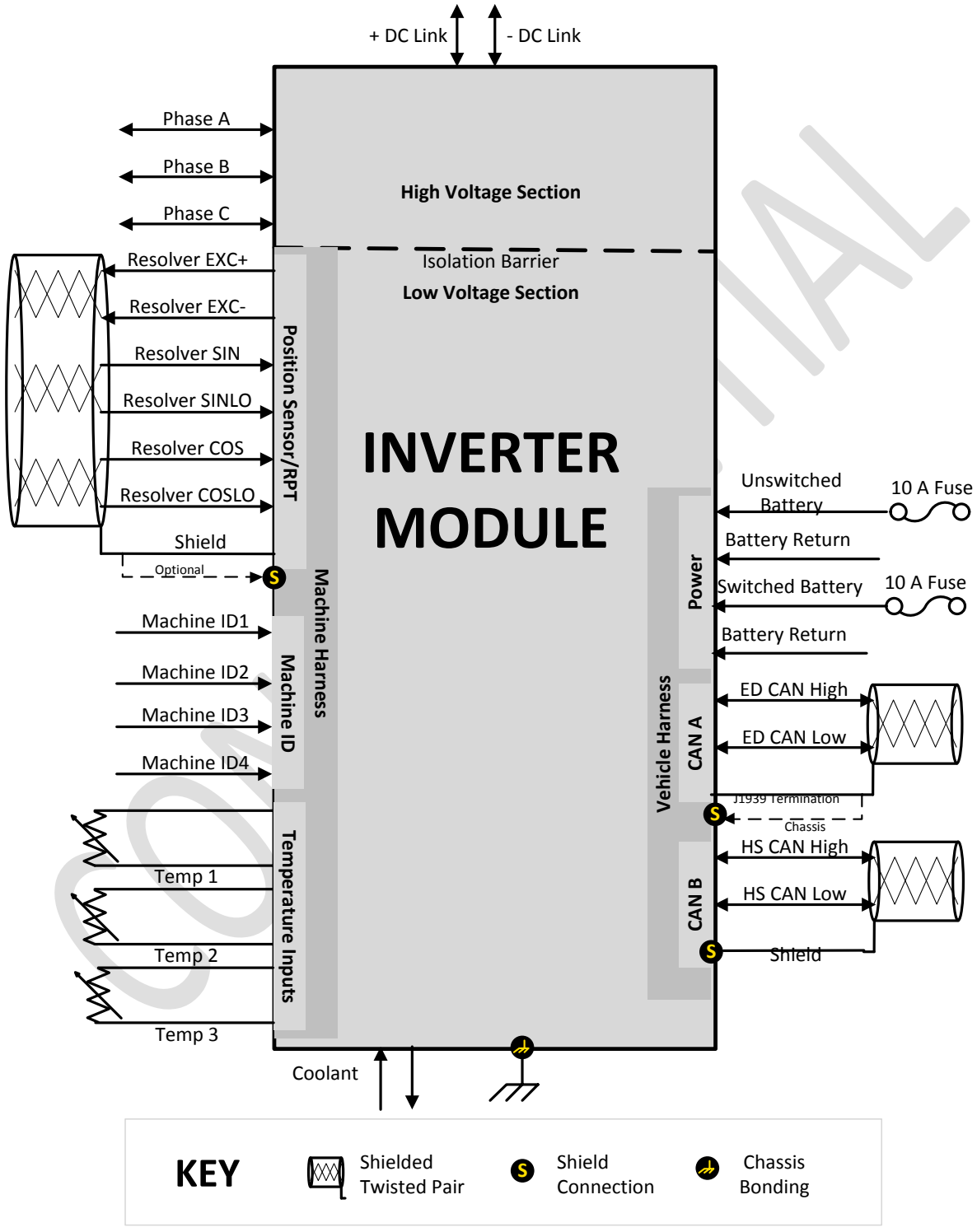

Figure 1: System Block Diagram

3.3 HIGH VOLTAGE SECTION BLOCK DIAGRAM

Figure 2 provides a block diagram of the high voltage section including internal structure. Table 4 provides the values of internal energy storage and dissipative components.

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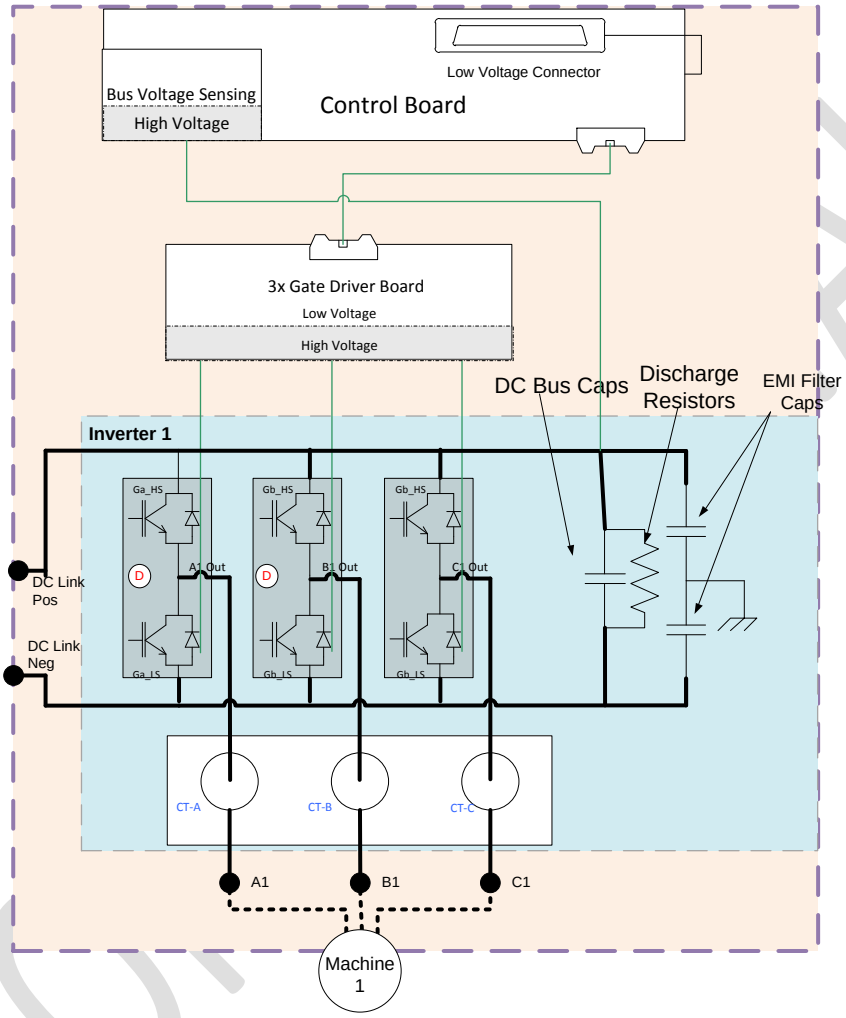


Figure 2: High Voltage Section Block Diagram

Table 4: High Voltage Component Values

Description	Value
DC Bus Capacitance	1.0 mF
Discharge Resistor	12 kΩ ± 1%
EMI Filter Capacitors	0.47 uF Each

	Warning	DC bus capacitor self-discharge time is up to five minutes

4. SPECIFICATIONS

4.1 ELECTRICAL SPECIFICATIONS

4.1.1. HIGH VOLTAGE BUS RANGES

Figure 3 provides a quick graphical reference to the DC bus voltage ranges. The Three Phase Short Active Clamp forces the inverter output to short across the phases in an attempt to reduce over voltage caused by uncontrolled regeneration.

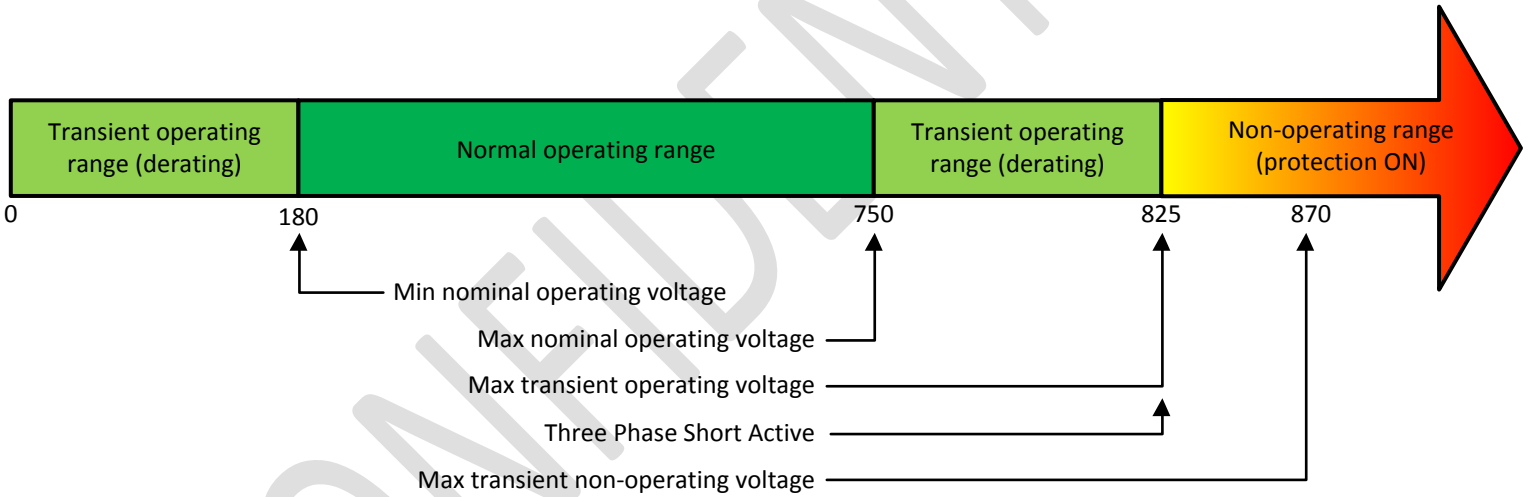


Figure 3: Bus Voltage Ranges Graphic

4.1.2. ELECTRICAL RATINGS

Table 5: Electrical Ratings

Parameter	Minimum	Nominal	Maximum	Units	Conditions
Output Power			320	kVA	700 V, 2 kHz PWM, 70 °C coolant @ 15 L/min, 70 °C ambient air
Continuous Output Current Rating			400	ARMS	3 kHz PWM, 70 °C coolant, 70 °C ambient, 15 L/min
Peak Output Current Rating			600	ARMS	Duration managed by software overload feature

Parameter	Minimum	Nominal	Maximum	Units	Conditions
High Voltage Bus Normal Operating Range	180	700	750	VDC	Minimum Bus Voltage is dependent on Motor Selection
High Voltage Bus Upper Transient Operating Range	750		825	VDC	Derated operation
High Voltage Bus Transient Non-Operating Range	825		870	VDC	Protection active
Output Voltage	0		480	VRMS	Phase to Phase, VBus = 700 V
Off-state Battery Drain Current			1	mA	At 32 V
Off-state DC Bus Leakage Current			75	mA	DC bus at 700 V
PWM Frequency	0.8		10	kHz	
CAN Bus Interface	250		500	kBaud	J1939 Physical Layer
Battery Voltage	9		32	VDC	12 V or 24 V DC systems
On-state Battery Current Draw			3.5	A	9 V, 10 kHz PWM
Off-state battery drain current			300	μA	
Battery fusing for switched and unswitched power inputs			10	A	Switched and unswitched power inputs should be separately fused with a fuse which does not exceed the current-time characteristics of a Bussmann ATM-10 fuse
Low Voltage Pre-Charge		20		VDC	Low voltage precharge for diagnostics
High Voltage Pre-charge		N/A			Not included, but required for D.C. bus connection to an energized source
Pre-charge current			50	A	Supplied by external source
Position Sensor					Resolver
Control Modes					Torque, speed, voltage
Passive DC Bus Discharge			5	Minutes	800 V to <60 V

4.2 Protection Functions

Table 6: Protection Functions

Parameter	Minimum	Maximum	Units	Conditions
Over-Current Trip High	0	1150	A	Programmable
Over-Voltage Trip Point	100	825	V	Programmable
IGBT Over-Temperature Trip Point	N/A	110	°C	Programmable

4.3 Mechanical Specifications

4.3.1. Dimensions

Figure 4 shows the orientations for length, width and height.

Table 7: Mechanical Specifications

Parameter	Minimum	Nominal	Maximum	Units	Conditions
Width		326		mm	Does not include junction box
Length		389		mm	
Height		126		mm	
Weight		20.5		kg	No coolant
Enclosure Rating		IP66			With connectors mated
Pollution Degree		4			
Enclosure Material					Die-cast aluminum with aluminum cover
Coolant Inlet Temperature	-20 -40		70 65	C° 	50/50 WEG 40/60 WEG
Coolant Channel Working Pressure			345 50	kPa PSI	
Coolant Proof Pressure			690 100	kPa PSI	

Parameter	Minimum	Nominal	Maximum	Units	Conditions
Coolant Burst Pressure			1035 150	kPa PSI	
Coolant Flow Rate	15		19	l/m	At max temperature
Ambient Operating Temperature	-40		70	C°	
Storage Temperature	-40		85	C°	
Operating Altitude			5000	m	Limited by electrical clearances
Vibration			30	$m\text{-}s^{-2}$ RMS	Random profile — 8 hours per axis
Coolant Cavity Volume		435 0.46		cm^3 qt	

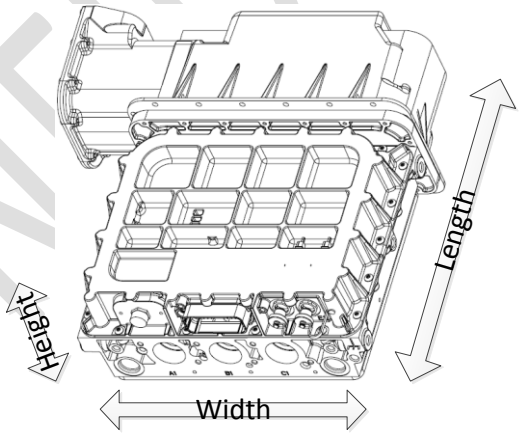


Figure 4: Dimensional Orientation

4.4 SAFETY REQUIREMENTS

	**Warning**	Understand and apply the following standards along with your applicable industry standards to protect users against electric shock. IEC 60664-1 for insulation coordination IEC 61140 for protection against electric shock
	**Caution**	Enclosure and cable temperatures can get very hot! Exposed surfaces of the product should not be touched during use. Refer to IEC Guide 117 for guidance on touchable surface temperatures. The IEC 6014-5014 symbol may be used to warn users of exposed hot surfaces.

4.4.1. GENERAL

The product has been developed in accordance with IEC 62477-1 for equipment of protective class 1, overvoltage category I[1], and with a type IT system grounding.

Protective class 1 requires PE conductors be maintained over the life of the product. Have policies to ensure bonding conductors are reinstalled if they are removed during repair operations.

Overvoltage category I requires that any high voltage inputs to this product have known and controlled transient overvoltages. This product has been tested to 3060 V_{peak} between the High Voltage system and chassis ground.

It is recommended that the IT system be maintained through the use of an isolation monitor or periodic testing of leakage resistance between DC Bus and chassis.

4.4.2. DC LINK SHORT CIRCUIT PROTECTION

4.4.2.1. General

The PD400 specifies a conditional short-circuit current (I_{CC}) in accordance with IEC 62477-1, paragraph 4.3.1. This rating relies on the characteristics of the SCPD and the specific test conditions. Table 8 provides information on SCPD characteristics and conditions to which the PD400 has been tested. To maintain compliance with IEC 62477-1 for systems not covered by the table, new testing will be required.

The maximum short circuit current from the source must be less than I_{CC}. The interrupt rating of the primary SCPD must be greater than I_{CC}. The primary SCPD cannot be solely relied on if the fault current is below the value of $I_{CP,mr.}$ The system must provide secondary short circuit protection means when this is the case. The secondary means could be a lower ampere rated fuse or circuit breaker.

[1] Overvoltage Category 2 when operated below 3000 m altitude.

Table 8: DC Link Short Circuit Protection

Parameter	Value	Conditions
Standard Junction Box		
Conditional short-circuit current I_{CC}	8500 A[2]	VBUS ≤ 700 VDC, L/R time constant ≤ 10 ms
SCPD characteristics	Type	Current Limiting Fuse
	Model	A700QS600
	Mfg	Ferraz Shawmut
	Current rating	600 A
	Voltage rating	700 VDC (at ≤ 10 ms L/R time constant)
	Peak let-through current	100 kA DC
	I2T	222 X 10^3 A^2s
Minimum required prospective short-circuit current $I_{CP,mr}$	3000 A[3]	

4.5 Operation

1. Brake Chopper Module

The Brake Chopper Module option is not available with the PD400 Single inverter.

4.5.1. Low Voltage Inputs

4.5.1.1. Drive Disable Input

Drive disable is not currently available for OEM customers. Consult the factory for more information.

4.5.1.2. Resistive Temperature Sensors

The PD400 Single accepts four resistive temperature sensor inputs. The range of acceptable resistances should be between 50 Ω to 2 MΩ. Refer to the User Manual for more information.

4.5.1.3. Resolver Input

The PD400 Single features one resolver position sensor interface. The PD400 Single can be factory configured to work with a variety of resolver types. Consult the factory for more information.

The standard resolver interface is given in Table 9.

[2] Tested value, consult JDES if higher value is desired
[3] Tested value, consult JDES if lower value is desired

Table 9: Standard Resolver Interface

Parameter	Minimum	Nominal	Maximum	Units	Conditions
Transformation Ratio	.244	.291	.338	1	-40 C to 150 C
Input Impedance	62.6	74.4	86.2	Ω	
Output Impedance	285	360	435	Ω	
Input Voltage		4.2		VRMS	10 kHz
Lobes	5	5	5	1	

4.5.1.4. Digital Output (optional)

Contact the factory for further information.

4.5.1.5. Machine ID

Machine ID can be used by software to verify that the correct machine is connected to the inverter. Contact JDES for further information.

5. Geometry and Mounting

5.1 Dimensions

See Table 7.

5.2 Center of Gravity

Please consult JDES if this information is needed.

5.3 Mounting

Mounting bosses are located on both sides of the inverter. See Figure 5 for location of the mounting bosses and torque values. Both sides of the inverter should be used for mounting.

	**Caution**	A lifting device is recommended when moving or lifting
	**Caution**	Inverter shall not be used for structural purposes including, but not limited to, a step.

!	**Note**	Do not use potential grounding boss for lifting or mounting. There are not sufficient threads.
!	**Note**	**Mounting Orientation** Avoid orientations where water could collect around vehicle connector or phase connectors.
!	**Note**	**Mounting Hardware** It is recommended to use mounting hardware of Class 8.8 or higher.
!	**Note**	**Cable/Harness Routing** Insulation degradation can occur due to improper routing of cables and harnesses. Temperature of nearby components, the potential presence of chemicals, and mechanical wearing are some of the items to be considered. Refer to your cable manufacturer for more information.
!	**Note**	**Vibration Damping** It is recommended to use vibration isolation mounts between the frame of the vehicle and the product for applications with moderate to severe vibrations.

Figure 5: Mounting Boss Locations

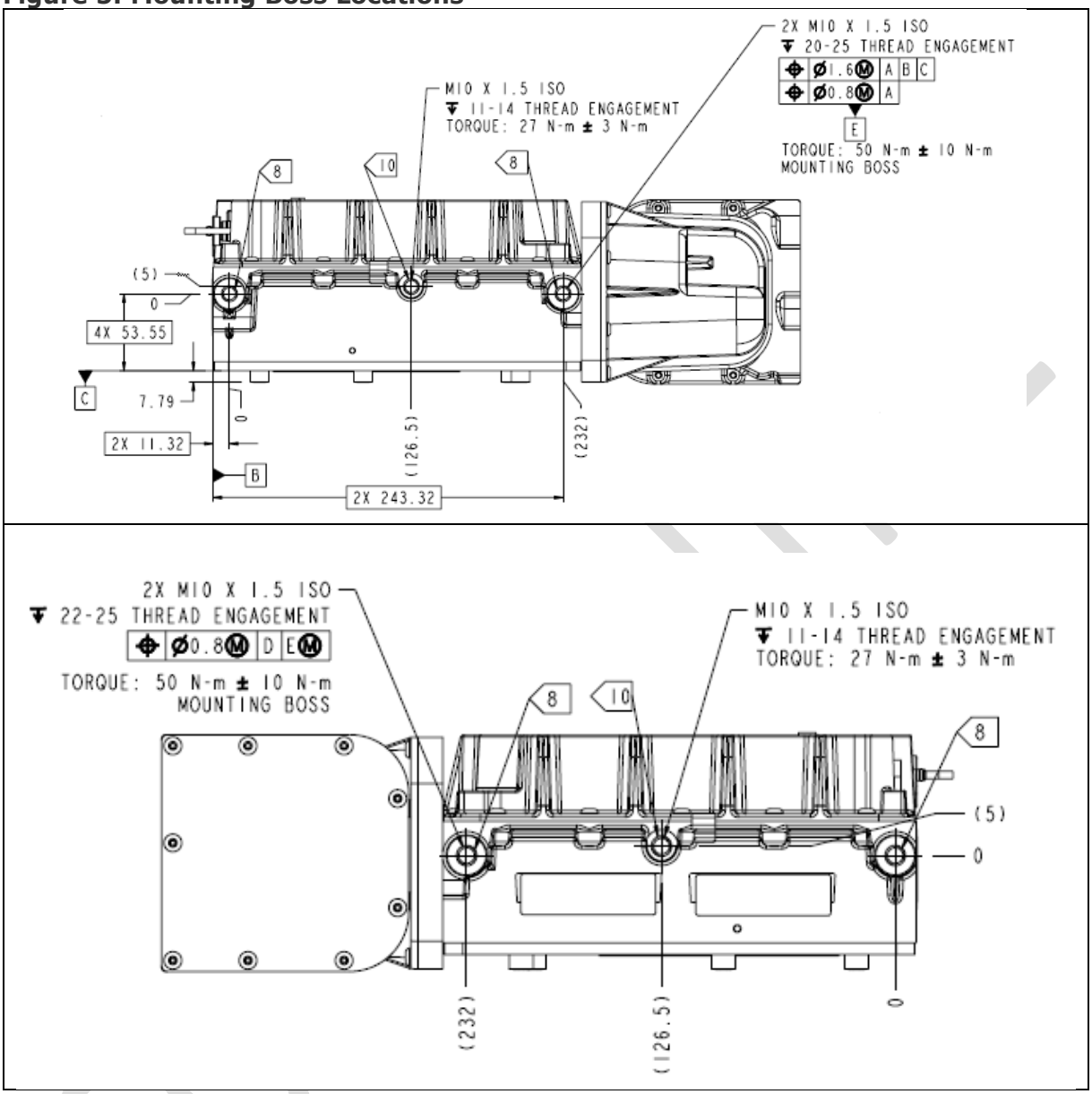


Table 10: Bolt Torque

Bolt	Min	Max	Units	Bolt Size	Notes
Mounting boss	40	60	Nm	M10 X 1.5 ISO	See Customer Interface Drawing for max thread engagement

6. ELECTRICAL CONNECTIONS

6.1 LOW VOLTAGE

6.1.1. ETHERNET CONNECTOR

Ethernet functionality is not supported at this time. The Ethernet covers should not be removed.

6.1.2. VEHICLE CONNECTOR

See Figure 6 for pin number identification in the connector. See Table 11 for the vehicle connector supplier part numbers. See Figure 8 for the location of the vehicle connector.

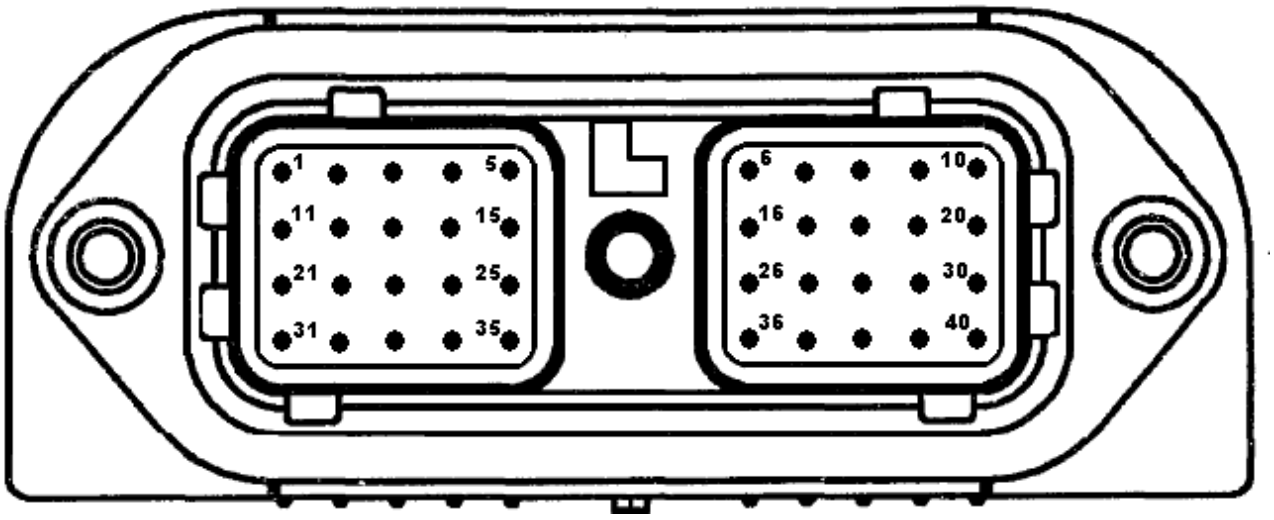


Figure 6: Vehicle Connector Pin Identification

Table 11: Vehicle Connector Mating Halves

Connector	Supplier P/N
Inverter (part of PD400)	Deutsch DRC23-40PA-N012
Mating connector (customer supplied)	Deutsch DRC26-40SA

Table 12: Vehicle Connector Pin-Out

PIN	Signal Name	PIN	Signal Name
1	Unswitched Battery	**21**	M1 Resolver SIN -
2	Switched Battery	**22**	M1 Resolver COS -
3	Battery Return	**23**	M1 Resolver EXC
4	Battery Return	**24**	Temp Sensor 2 Return

PIN	Signal Name	PIN	Signal Name
5	Temp Sensor 1	**25**	Machine ID
6	Temp Sensor 3	**26**	Not Used
7	Temp Sensor 3 Return	**27**	Not Used
8	Not Used	**28**	Not Used
9	CAN A High	**29**	High Side Drive
10	CAN A Low	**30**	Not Used
11	M1 Resolver SIN +	**31**	M1 Sensor Shield
12	M1 Resolver COS +	**32**	Not Used
13	M1 Resolver EXC +	**33**	Not Used
14	Temp Sensor 2	**34**	Machine ID 2
15	Temp Sensor 1 Return	**35**	Machine ID 3
16	Not Used	**36**	Machine ID 4
17	Not Used	**37**	Not Used
18	Not Used	**38**	Not Used
19	Not Used	**39**	Can B High
20	Not Used	**40**	Can B Low

!	**Note**	**Unused Pins** Pins that are marked "Not Used" should have no connection to the vehicle harness. Unused cavities in the connector should be sealed.
!	**Note**	**Low Voltage Connector Mating** Refer to mating connector datasheet for proper jackscrew torque.
!	**Note**	**Protection of Low-Voltage wiring harness** Ensure through routing, shielding or other means that the low-voltage wiring harness is protected against damage from road debris.

6.2 HIGH VOLTAGE DC LINK

The PD400 Single comes standard with a cover over the DC Link terminals. JDES offers an optional plug style junction box for accessing the DC Link.

6.2.1. FACTORY DEFAULT TERMINATION AND COVER

The PD400 Single standard terminal configuration is shown in Figure 7. This configuration features threaded terminals to which cable lugs may be attached. Figure 7 also includes torque information for fasteners and dimensional information to assist in fabrication of a junction box.

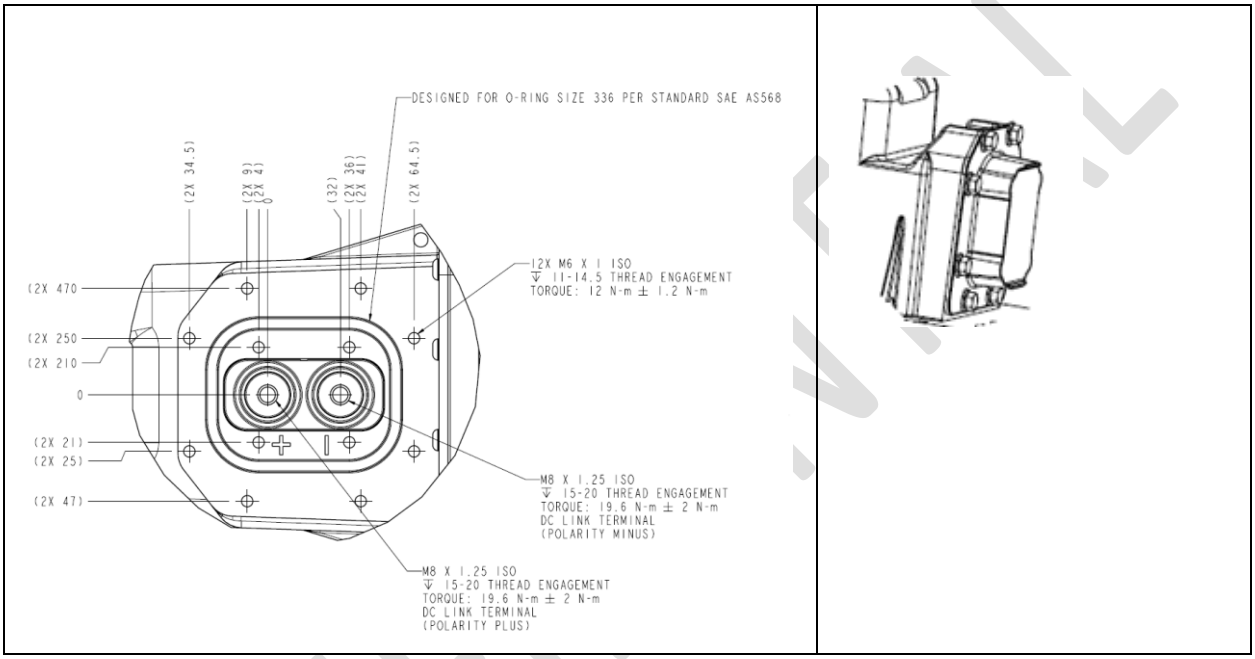


Figure 7: DC Link Terminals and Cover

	**Caution**	Standard termination should include a method to protect against inadvertent contact, terminal loosening, and environmental degradation.
	**Caution**	When the DC link connections are not being used, the cover should remain in place to protect against inadvertent contact and to provide an environmental seal.

6.2.2. STANDARD DC LINK JUNCTION BOX

An optional junction box provides a means to connect to the DC link using a Molex MAXLOC style pluggable connector. The supplier part number of the mating connector can be found in Table 13. The standard junction box provides an IP66 environmental seal when the cables are properly attached. The standard junction box will accept up to 4/0 cable size. The

standard junction box can be factory configured in two orientations, cable openings pointing frontward or rearward. Refer to your interface drawing for polarity and dimensions.

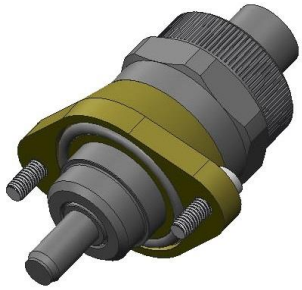
6.3 High Voltage Phases

The phase outputs are labeled A1, B1, and C1. Figure 8 identifies their location.

A Molex MAX-LOC® connector is required to mate to the inverter. For maximum current capacity, the terminal requires ultrasonic welding to the cable conductor. The connector provides a 360 degree connection between the cable shield and inverter enclosure for EMI shielding purposes. The supplier part number of the mating connector can be found in Table 13.

Contact JDES for more information about the connector and the requirements of the cable manufacturer ultrasonic welding capabilities.

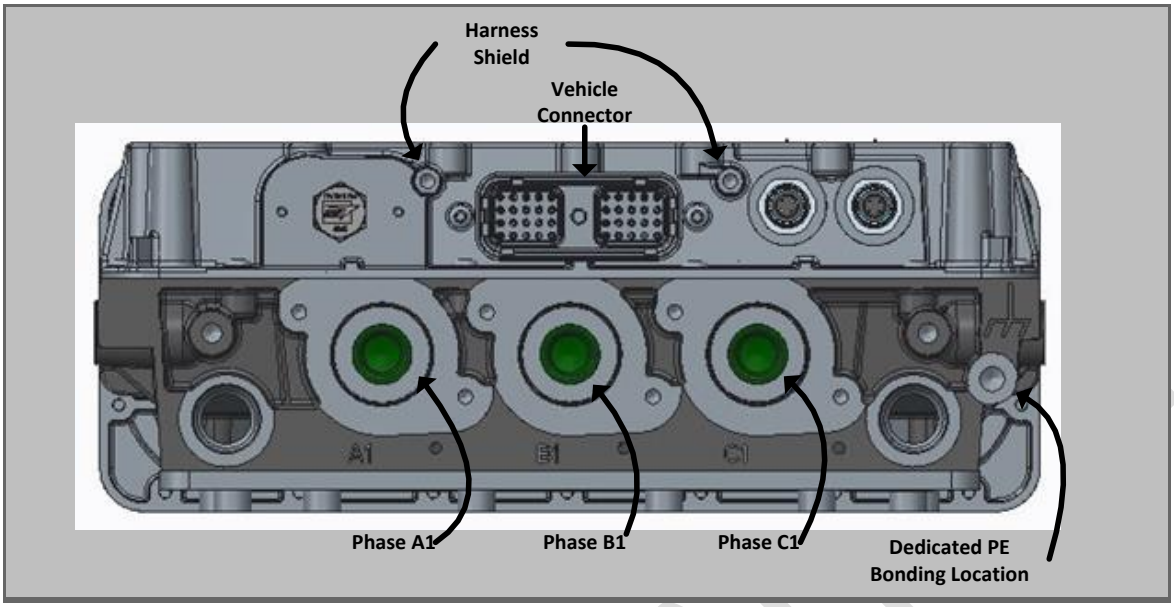
Table 13: Phase and DC Link Connector Torque Specification and Part Numbers

Phase Cable Fastener Torque 6X M6X1.0 11 – 14.5 mm Thread Engagement Torque: 15 Nm +/-15%		Groove designed for O-ring size 336 per SAE AS568 to seal a customer supplied enclosure for the DC Link connections
Standard DC Link Junction Box Fastener Torque 4X M6X1.0 11 – 14.5 mm Thread Engagement Torque: 15 Nm ± 15%		

Cable Size	Molex Shell Part Number	Molex Cable Pin Part Number
2/0	1301991102	172151-0052
4/0	1301991103	172151-0051

	**Warning**	The **Standard DC Link Junction Box Fastener Torque** specification is for the Standard DC Link Junction Box only. Excessive torque may strip threads and cause a shock or fire hazard. Consult the factory if using a non-Standard DC Link Junction Box.

Figure 8: Electrical Connections



6.4 Cable Entry and Support

Proper cable routing and support is necessary to provide a good environmental seal and prevent cable damage. In addition to general cable routing best practices, JDES also recommends that the following two conditions be observed:

The exit angle of the cable from the back of the compression nut should not exceed15° from the centerline of the nut

A cable strain relief should be placed within 120 mm from the back of the compression nut

More application recommendation information about the Molex MAXLOC can be obtained by requesting information from your Molex sales rep.

!	**Note**	**Cable/Harness Routing** Insulation degradation can occur due to improper routing of cables and harnesses. Temperature of nearby components, the potential presence of chemicals, and mechanical wearing are some of the items to be considered. Refer to your cable manufacturer for more information.

6.5 Brake Chopper

A brake chopper is not available with the PD400 Single.

6.6 High Voltage Cable

Table 14 identifies a high voltage cable manufacturer that has been used by customers.

Table 14: High Voltage Cable Manufacturer

Manufacturer	Website	Series
Champlain Cable	www.champcable.com	RADXL FX HYBRID

6.7 Signal Shielding

!	**Note**	**Higher Resistivity Shielding** For high current or high fundamental frequency applications, higher resistivity shielding such as stainless steel should be considered to reduce induced current flow in phase cable shields.

6.7.1. Low Voltage

It is required to shield the position sensor conductors and CAN conductors separately and to terminate these shields to a good grounding point. This will increase the robustness of CAN communication and position signal by minimizing errors caused by electrical noise.

JDES has provided two chassis connections by the low voltage connector to attach shields as depicted in Figure 8.

6.8 Enclosure Bonding

6.8.1. Protective Equipotential Bonding

For compliance with shock protection per IEC 62477-1, it is required to bond the PD400 Single enclosure to the vehicle chassis with a protective equipotential conductor (PE conductor). The PD400 single has only one dedicated PE bonding point. See Figure 8 for PE conductor bond location and Table 15 for minimum PE conductor size. If only a single PE conductor is used, the cross-sectional area must be at least 10 mm^2 copper. Any unused mounting boss may be used to secure a second PE bonding conductor.

Table 15: Protective Equipotential Bond Conductor Size

Cross-sectional area of phase conductors (mm^2)	Minimum cross-sectional area of the PE conductor (mm^2)
S ≤16	S
16 ≤ S ≤ 35	16
35 ≤ S	S/2

6.8.2. Low Voltage Battery Grounding

The Low Voltage Battery must have its negative terminal grounded to the same potential as the PD400 Single enclosure. When in operation, the potential voltage between the PD400

	**Warning**	The PD400 is considered protective class I equipment and bonding of the enclosure to chassis is required for proper operation and safety.
	**Warning**	**Bonding Current** in the protective earth conductor (bond wire) may exceed 3.5 mA AC or 10 mA DC.
!	**Note**	Due to the multiple mounting orientations of the inverter, all mounting locations are a viable bonding location. The bonding connection should never be shared with a mechanical mount.
!	**Note**	It is suggested to make use of a star configuration, also known as a "star point" when bonding multiple enclosures to the vehicle chassis

Single enclosure and the negative terminal of the low voltage battery must not exceed ±0.7 V.

!	**Note**	**Low Voltage Battery Grounding** The inverter may be damaged if the potential between the enclosure and the negative battery terminal exceeds ± 0.7 V.

7. Ingress Protection

The PD400 Single features a breather port to equilibrate inner and outer pressures. The location is shown in Figure 9.

!	**Note**	**Breather Port** Water ingress may occur if the port is immersed in water up to 1 m for more than 30 min.
!	**Note**	**High Voltage Connector Sealing** Proper seating/sealing of the high voltage phase connectors is critical to ingress protection of inverter.

!	**Note**	**High Pressure Wash** The vehicle connector should be protected from direct spray from a high pressure washer with greater than 4000 PSI force.

8. COOLING

The location of the coolant inlet and outlet ports are depicted in Figure 9. The coolant channel is designed to flush entrapped air for any orientation in less than 10 seconds when the flow rate above 10 liters per minute.

!	**Note**	**Loss of Coolant** Loss of coolant may be caused by a variety of reasons. The inverter has protection features but cannot be guaranteed to survive under all loss of coolant conditions.
!	**Note**	**Cooling connection precedence** To reduce the risk of coolant entering the inverter through the high voltage connectors it is recommended to make all electrical connections before making any coolant connections. If this is not possible, then the electrical connectors should be protected against coolant intrusion.
!	**Note**	**Coolant Flow Direction** Coolant flow direction should be observed if making use of the internal sensor for monitoring the coolant outlet temperature.

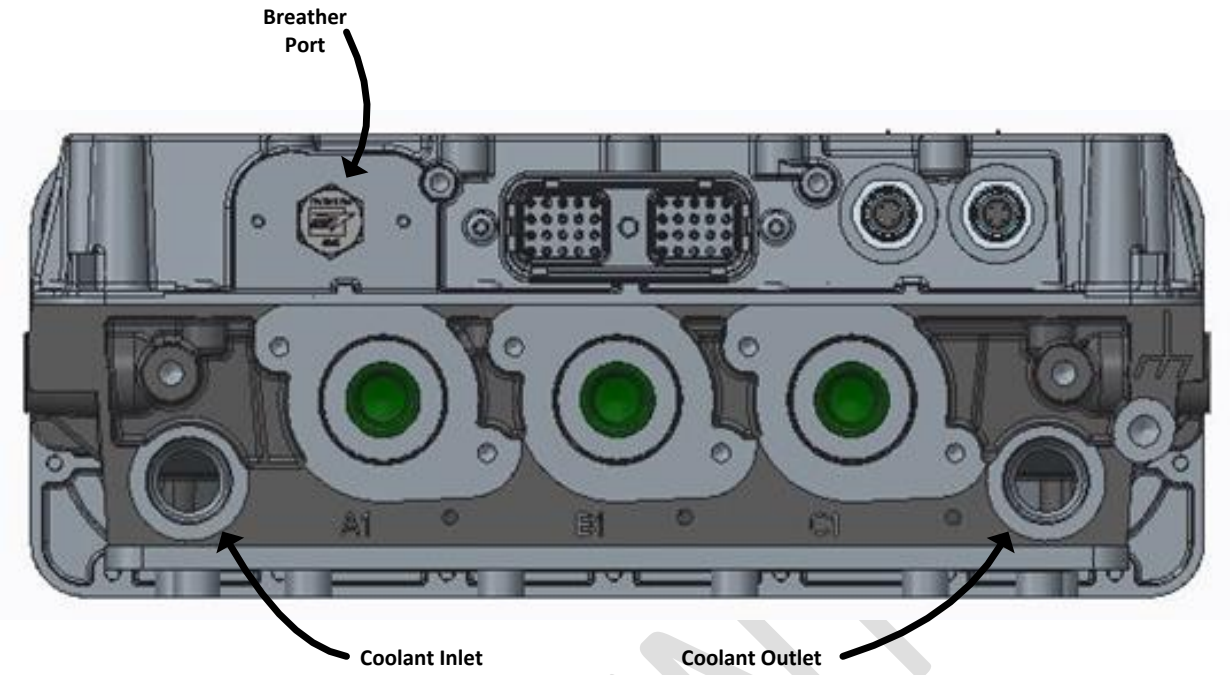


Figure 9: Coolant Ports and Breather Locations

8.1 Continuous Heat Rejection

The PD400 Single can reject up to 3 kW of continuous heat to the coolant at 70 C inlet temperature and 15 l/m coolant flow rate. Consult the factory for heat rejection at other conditions.

8.2 Coolant Flow Direction

Coolant flow can be in either direction without affecting performance. See Figure 9 for the direction used in Factory certification testing.

8.3 Coolant Medium

The inverter cooling medium shall be a 50/50 or 60/40 mixture of water and ethylene glycol.

8.4 Coolant Port Fittings

Specifications for the coolant port fittings are given in Table 16.

Table 16: Coolant Port Fittings

Coolant Port Fitting	
Size	M22 X 1.5
Torque	40 Nm ±5 Nm
Standard	ISO 6149-1

8.5 Pressure Drop vs. Flow Rate

The pressure drop vs. flow through the coolant channel depends on the inner diameter of the fitting. See Figure 10 for a pressure vs. flow curve.

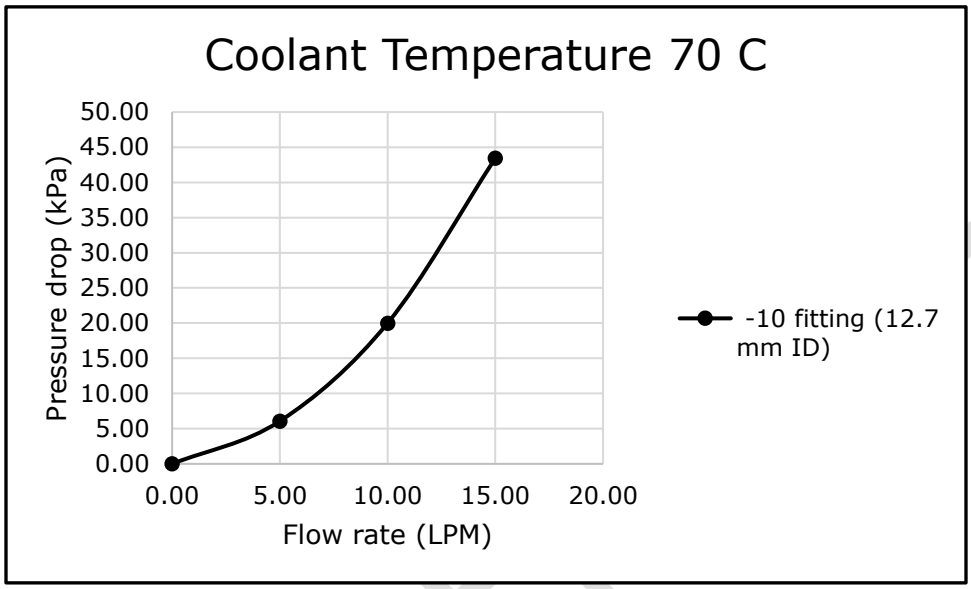


Figure 10: Coolant Channel Pressure Drop vs. Flow Rate

9. Adjustments and Repairs

There are no user hardware adjustments on the PD400 Single. Contact the factory if repairs are necessary.

	**Warning**	In order to ensure a safe voltage state before performing any work on or around the inverter, the customer should ensure that the DC bus is discharged.

9.1 General Safety Guidelines

Hazards associated with the high voltage bus include shock hazard, fire and arc hazard and unintended motion hazard from stored energy.

9.2 Implementing a Safe Work Condition

Develop and follow a strategy for ensuring that the inverter is in, and stays in, a safe state prior to and during adjustment and repair operations. As one suggestion, the following steps, in order, can be implemented:

	**Caution**	The customer safety process should determine a voltage level considered safe for maintenance work

Ensure a safe work area (approach zone).

Ensure the machine is immobilized

Disconnect or disable all incoming energy sources

Ensure energy sources cannot be re-applied without the knowledge of the service technician performing the maintenance (lockout/ tagout procedures).

Discharge the stored inverter internal energy to a safe level.

Measure the bus voltage to ensure it is at a safe level before performing any maintenance. Do not assume passive discharge or other method is working without checking.

Generally a cover will need to be removed to access the DC bus for measurement. Observe all PPE requirements your company has made for this operation.

It is possible sometimes to acquire the bus voltage over CAN. However this requires the presence of 12 V switched power. This method will not be available if disconnection of the 12 V battery was a result of step 3 (disconnecting 12 V to prevent engine start).

To restart the system, reconnect any disconnected connections, replace covers and remove lockout/ tagout devices

After maintenance, follow start up procedures provided by the system integrator

10. PRODUCT LABELS

10.1 SAFETY LABEL

See Figure 11 for Safety Label details. See Figure 12 for the Safety Label location.

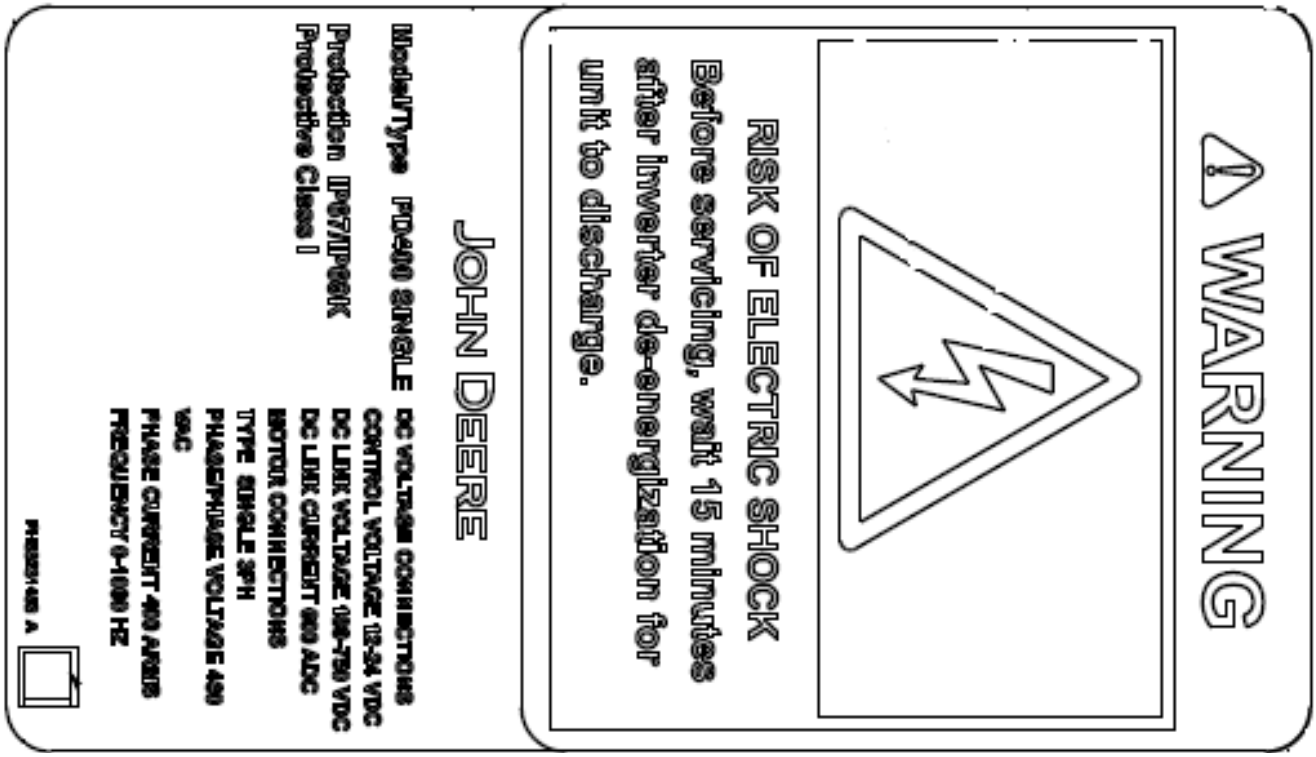


Figure 11: Safety Label

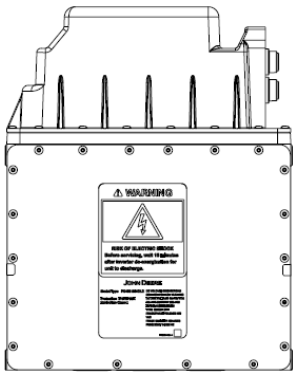


Figure 12: Safety Label Location

10.2 MANUFACTURING LABEL

Black matrix barcode and text on white background. Matrix barcode is 11 mm x 11 mm.

Figure 13: Manufacturing Label

10.3 PE TERMINAL

Identify the single chassis connection point for the PE conductor.

Figure 14: PE Conductor Bonding Point Symbol