



DRI-10

User Manual



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About This Manual

Purpose

The purpose of this User Manual is to provide guidance for setting up and using the DRI-10

Scope

The manual provides safety guidelines and setup information, as well as information about troubleshooting the unit. It does not provide details about particular brands of batteries. Consult individual battery manufacturers for this information. Reference the DRI-10 installation manual for installation instructions and additional DRI-10 related information.

Audience

The manual is intended for product users who will configure and operate the DRI-10.

Organization

This user manual is organized into 6 sections and 2 appendices.

Section 1 welcomes the user and provides background information about the DRI-10 Inverter and Princeton Power Systems.

Section 2 provides general information about the DRI-10 and introduces several of the important system components. This section can also be found in the installation manual of the DRI-10.

Section 3 describes the DRI-10 HMI which can be used to control the DRI-10. The different screens of the HMI are explained and instructions are provided on how set points can be changed.

Section 4 provides a list and explanation of all DRI-10 data points and measurements.

Section 5 provides a list and explanation of all DRI-10 set points.

Section 6 explains the battery charging profiles that can be implemented using the DRI-10. Information is provided that allows the user to fully customize the charging profiles.

Appendix A, Technical specifications of the DRI-10.

Appendix B, “Return Material Authorization, and Contact Information”.

Abbreviations and Definitions

The following table provides a glossary of technical terms used in this manual. The glossary also defines some common electrical terms and acronyms that may be used in this manual.

Abbreviations	Definition
AC	Alternating Current
ATS	Automatic Transfer Switch
CEC	California Energy Commission
DC	Direct Current
DPDT	Double Pole Double Throw
DRI	Demand Response Inverter
ESD	Electro-Static Discharge
GFDI	Ground Fault Detector and Interrupter
HMI	Human/Machine Interface
I/O	Input/Output

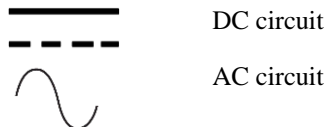
Abbreviations	Definition
IEEE	Institute for Electrical and Electronics Engineers
MPPT	Maximum Power Point Tracking
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
PCB	Printed Circuit Board
PPS	Princeton Power Systems
PSU	Power Supply Unit
PV	Photovoltaic
SPDT	Single Pole Double Throw
SPST	Single Pole Single Throw
THD	Total Harmonic Distortion
UL	Underwriters Laboratories
VPC	Volts Per Cell

Important Safety Instructions

SAVE THESE INSTRUCTIONS– This manual contains important instructions for the DRI-10 that shall be followed during installation and maintenance of the inverter.

Symbols

The following is a list of symbols used in this manual and on labels in the DRI-10.





Phase indicator



Protective earth ground.



Other grounding conductor.

Warning Symbols used in this manual



Attention: This symbol identifies information about circumstances or practices that could lead to personal injury, death, internal component damage, reduced product life, equipment damage, economic loss, or other adverse effects.



Shock Hazard: This symbol identifies information about a condition or procedure that could be potentially lethal or harmful to personnel or damaging to components due to live voltages within the system, components holding stored energy, or electrostatic discharge (ESD).

General Precautions

Maintenance by Qualified Personnel: Only personnel familiar with the Princeton Power DRI-10 Inverter and associated machinery should attempt installation, commissioning, or maintenance of the system. Untrained or unauthorized personnel run the risk of grave personal injury, death, or equipment damage. These servicing instructions are for use by qualified personnel only. To reduce the risk of electric shock, do not perform any servicing other than that specified in the operating instructions unless you are qualified to do so. Use appropriate tools only and wear appropriate protective gear. Remove all conducting jewelry when working on the inverter (e.g. rings, watches and other metal objects). Ensure that all tools, paperwork, and other foreign objects not designed for use in the Inverter are removed from the enclosure prior to closing the door and re-energizing the equipment.



High Voltage Electric Shock Hazard: The Princeton Power DRI-10 Inverter and equipment connected to it, contains electrical components carrying potentially lethal voltages and currents. Extreme caution should be exercised around the system, especially when the cabinet door is open. Before opening the cabinet, all supply power and loads, including all DC sources (batteries and PV arrays) should be disconnected externally using a standard physical lock-out procedure and the service personnel should wait 5 minutes prior to opening the enclosure door to allow internal components to discharge. Note that a PV array must always be disconnected when performing maintenance, even in no-light conditions. Avoid hazardous voltage situations that could result from unsafe conditions such as, but not limited to, the following:



- Back-feed from the utility
- Improper grounding
- Handling electrical leads or devices with wet hands or on wet ground
- Frayed electrical leads
- Working with or on an electrically hot system or component, or when connected to an energized load
- An ungrounded battery pack
- Improper connection or re-connection of the terminal leads
- Short circuits
- Energized normal and emergency power sources

Installation to Code: The following instructions are merely a guide for proper installation. The National Electric Codes (NEC), local codes, and similar standards outline detailed requirements for safe installation of electrical equipment. Installation must comply with specifications for wire types, conductor sizes, electrical and thermal insulation, branch circuit protection, grounding, and disconnect devices. Princeton Power Systems cannot assume responsibility for compliance or noncompliance to any national or local code. Princeton Power cannot assume responsibility for personal injury and/or equipment damage exists if codes are ignored or misapplied during installation.

CAUTION: To reduce the risk of fire, connect each AC circuit of the inverter only to a circuit provided with 50 amperes maximum branch-circuit over-current protection in accordance with the National Electrical Code, ANSI/NFPA 70.



Improper Use: Princeton Power cannot assume responsibility for personal injury and/or equipment damage as a result of improper installation, use, maintenance, reconfiguration, reprogramming, or other improper actions. An incorrectly serviced or operated Inverter system can cause personal injury, component damage, or reduced product life. Malfunction may result from wiring errors, an incorrect or inadequate DC supply or AC grid connection, excessive ambient temperatures or obstructed ventilation, or incorrect software configuration. Keep the door closed at all times when operating the system. Additionally, keep all guards, screens, and electrical enclosures in place when the system is operating. Close the inverter enclosure and put all guards and screens in place before energizing the unit.



Heat Hazard: The cabinet should not be mounted on a combustible surface nor should combustible materials be placed on or against the cabinet. The system should not be installed in a confined space that prevents proper ventilation or allows the build-up of excessive heat. A minimum of 12 inches of spacing clearance must exist for proper cooling airflow into and out of ventilation openings. Keep vents and air outlets clear of debris and provide proper airflow. Do not place or store any objects on the enclosure roof



ESD Sensitive Components: The inverter contains Electrostatic Discharge (ESD) sensitive components. Standard ESD control precautions must be followed when

installing, commissioning, testing, servicing, or repairing the system. Component damage, component degradation, or an interruption in control system operation may occur upon an electrostatic discharge event. Use anti-static wristbands when servicing electronic components.



Locked Doors: The inverter enclosure should remain locked at all times during normal operation and should only be unlocked for maintenance by qualified personnel. Enclosure keys should be stored in a safe place and should be accessible to appropriate personnel only.



Electrical Connections: Be sure that all electrical connections and connectors are properly installed and connected with proper torque.



Fuses: For continued protection against risk of fire, only use replacement fuses of the same type and rating as the original fuse. Replacing of fuses should be done by knowledgeable and trained personnel only.

Safety Check

Performing a routine safety check before energizing the Inverter will minimize the risk of injury to the operator and minimize the potential for damaging the unit.

Before operating the unit, check for obvious signs of damage or concern. The following is a list of suggested items to be checked before operating the unit:

1. Check the enclosure for obvious signs of damage.
2. Verify that all inlet and outlet vents are clear of debris.
3. Check external wires and cables for signs of damage, such as fraying or cracked insulation.
4. Check room for potential hazards, such as standing water on the floor or on the DRI-10 Inverter.

Note: Additional safety checks may be necessary depending on the particular installation of the unit. The safety checklist above is not intended to be all-inclusive.

Resolve all issues before operating the inverter. Contact Princeton Power Systems if necessary.

Terms of Use

Because of the wide variety of uses for power electronics equipment, this manual does not describe every possible application or configuration. All technicians responsible for installing, commissioning, and operating this equipment must satisfy themselves of the suitability and proper implementation of the intended application of this power conversion product.

In no event will Princeton Power Systems, Inc., its subsidiaries, partners, employees, or affiliates be responsible or liable for any damages, indirect or direct, resulting from the misuse or incorrect application of this equipment.

The examples and diagrams in this manual are for illustrative purposes only. Because of the wide variety of uses, applications, peripheral equipment, and facility configurations particular to each installation, Princeton Power Systems, Inc. cannot assume responsibility or liability for actual use based on the information provided herein.

Battery Information

This system is designed to be operated with a variety of battery types and voltage. Installer must determine if the charging methods outlined in Section 6 are compatible with the type of battery used. Battery voltage and current ratings must comply with the DC port ratings outlined in Section 2.5.3.



WARNING: The battery charge control function has adjustable battery charging settings. The user must confirm that the charge control profile used in this inverter is appropriate and safe for the type of battery used and that all battery charging settings are set correctly for the battery voltage, current, and temperature ratings. Setting these settings incorrectly may damage the battery and the inverter and may cause a hazardous condition that puts personnel at risk of grave injury or death.



WARNING: Programming temperature compensation parameters (See Section 4 Table 7) that are not suitable for the type of battery being used may damage the battery and the inverter and may cause a hazardous condition that puts personnel at risk of grave injury or death. The user must ensure that the battery temperature compensation parameters are appropriate and safe for the type and voltage rating of the battery used.



WARNING: Consult the battery manufacturer for information regarding safe transport, storage, operation and maintenance of batteries. Although this manual contains some information regarding battery safety but it is by no means exhaustive.

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1. Introduction

a. Congratulations

Congratulations on purchasing one of the most advanced inverters in the world, from one of the leading power electronics companies in the world. The DRI-10 Inverter meets Underwriter's Labs' standard 1741 to allow power export to the North American electric grid. It can also power loads directly from PV or Battery, and can automatically transfer to off-grid mode if the electric grid goes down. It is compatible with multiple input sources, including solar arrays, battery banks, and generators.

The DRI-10 is highly reliable, efficient, and flexible. It is backed by a world-class team of engineers at Princeton Power Systems that can ensure the technical and financial success of your application.

b. PPS Company information

Princeton Power Systems designs and manufactures advanced power conversion products and systems to provide customers with cost-effective, reliable, smart distributed generation. Our patented technologies, including AC-linkTM, produce clean electric power simply and efficiently, and our capable and flexible engineering team works closely with our customers to solve their problems. Customer solutions include grid-integrated distributed generation, renewable energy, energy storage, and military power supplies for military applications.

2. System Overview and Configurations

a. System Overview

The DRI-10 is an extremely versatile state of the art multi-port energy management converter system. The DRI-10 can be connected to batteries, solar PV arrays, generators, utility grids and supplies local loads. Unlike most conventional inverters and renewable energy systems, the DRI-10 is designed to support and strengthen the utility grid instead of being a burden on it. It is therefore compatible with next generation smart and micro grids. These new power systems enable a much higher penetration of renewable energy than conventional inverter systems would allow and therefore the DRI-10 helps to facilitate technical solutions to some of the world's most urgent environmental problems.

In an on-grid application, the loads connected to the DRI-10 Load Port are supplied directly from the utility (as long as the grid is available). The DRI-10 charges its batteries from the utility grid if not enough solar PV energy is available to do so. When the batteries are full, the DRI-10 supplies all available solar PV energy to the loads. If there is more solar PV energy available than required by the Load Port, this energy flows into the utility grid (if power export is enabled). At any stage, the utility grid can request the DRI-10 to provide additional energy and supplement the utility grid by feeding additional energy from the batteries into the grid.

The DRI-10 can also be used in off-grid applications. The goal in such applications is to supply reliable, clean and cost-effective power to loads that cannot be supplied directly from the utility grid. In such applications, the DRI-10 uses solar PV energy to supply local loads. By using the energy storage capacity of batteries, the DRI-10 is able to provide a reliable and constant power source from inherent intermittent solar PV energy. The DRI-10 also allows solar PV energy to be supplemented with other AC sources such as combustion generators.

i. Power Ports

The DRI-10 Inverter has two DC ports (battery and PV) and two AC power ports (grid and load) giving the DRI-10 a total of four power ports. In this manual, the DRI-10 is often symbolically represented by a square where each of these four ports is represented by one side of the square. This symbolic representation of the DRI-10 is shown in the center of Figure 1.

1. Battery Port

The battery port is a two wire DC port used to connect a battery bank to the DRI-10.

2. PV Port

The PV Port is a two wire DC port used to connect a PV array to the DRI-10.

3. Load Port

The load port is a three wire AC port with two phases and a neutral line. This port is used to connect local loads to the DRI-10. Optionally, suitable AC generators can also be attached to this port. Additional DRI-10 units can also be connected to this port to form a mini-grid.

4. Grid Port

The grid port is a three wire AC port with two phases and a neutral line. This port can be connected to the utility grid. If no utility grid is available, suitable AC generators can also be connected to this port.

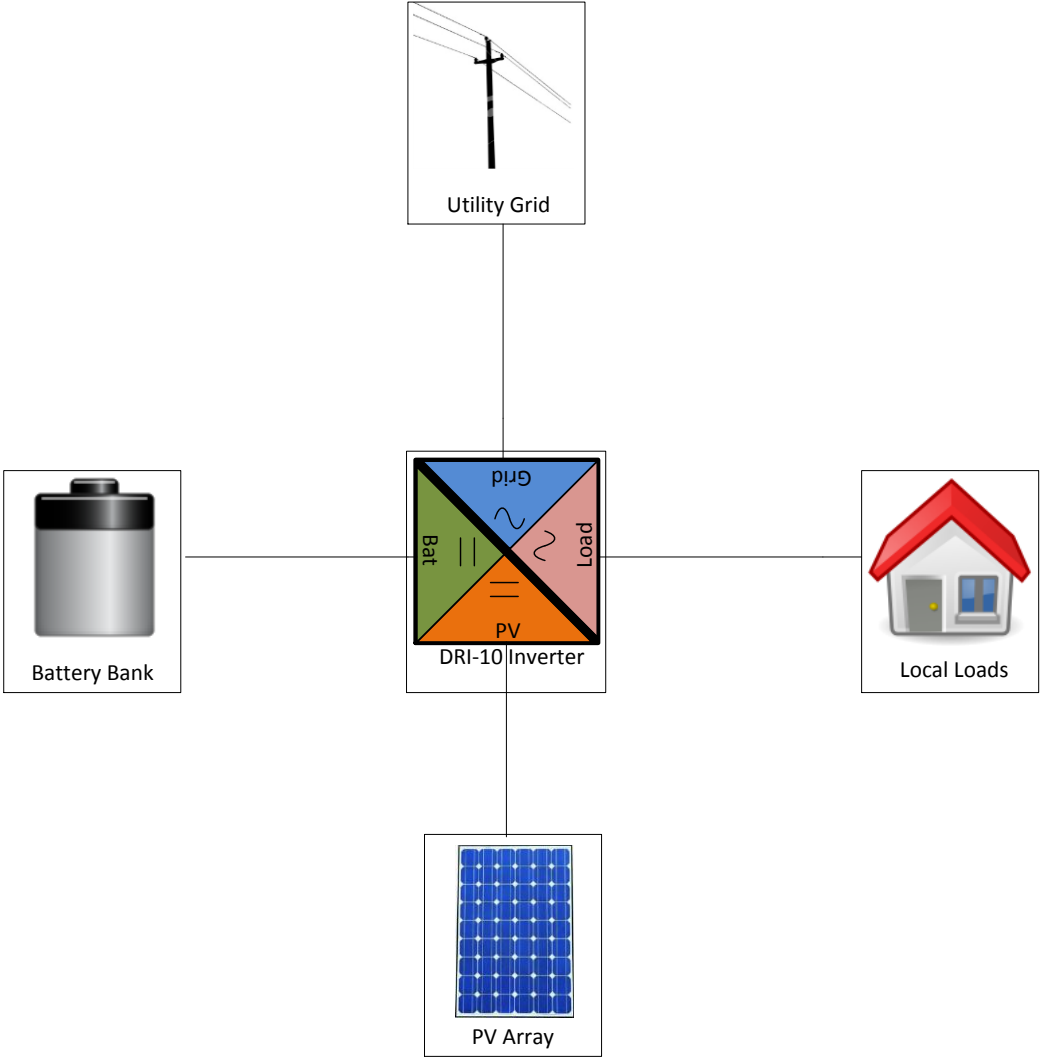


Figure 1: Symbolic single line diagram of DRI-10.

ii. Isolation Transformer

The DRI-10 comes with an internal isolation transformer. The isolation transformer provides electrical isolation between the DC and AC ports. The isolation transformer does not provide electrical isolation between the two DC ports. The isolation transformer also does not provide electrical isolation between the two AC ports.

iii. **Functional Power Block Diagram**

A functional block diagram of the DRI-10 power circuit is shown in Figure 2. This diagram provides information to the interested reader but does not need to be understood for successful installation.

The DRI-10 consists of two DC-DC converter stages and a single DC-AC stage. An internal manual utility disconnect switch is provided. This internal circuit breaker switch is not the same as the external utility grid disconnect switch shown in Figure 1. Internal disconnects switches are provided on both the battery and PV ports. These are not the same as the external disconnect switches shown in Figure 1.

Figure 2 also provides an overview of the grounding arrangements of the DRI-10. A special PV ground terminal is provided which is tied to the utility and load port ground internally after passing through an internal GFDI device.

The external grounding of the negative PV and battery conductor is only allowed, when the optional isolation transformer is installed

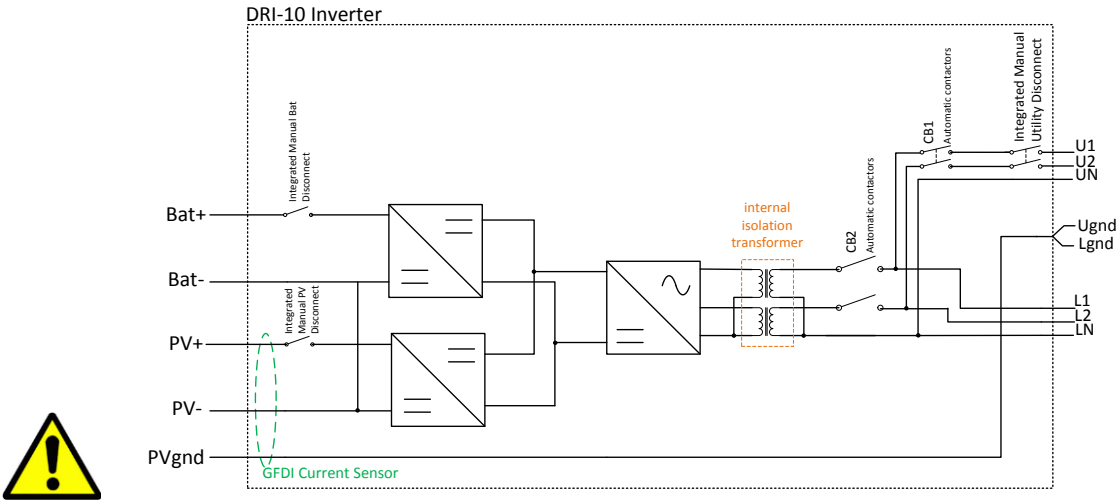


Figure 2: Functional power diagram of the DRI-10.

iv. **Main System Components**

Some of the main system components are introduced in this section. Only system components that are relevant for the installation are mentioned. Please refer to other DRI-10 documentation for information regarding other system components.

1. **Enclosure**

The DRI-10 is housed inside a NEMA 3 rated metal enclosure as shown in Figure 3. Instructions on how to open and close the enclosure, dimensions, placement and

further related information is provided in the DRI-10 Installation Manual Section 3.

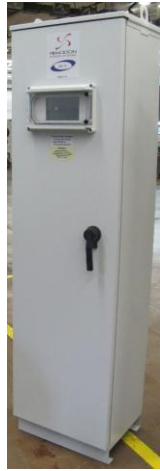


Figure 3: Closed DRI-10 metal enclosure.

2. Human Machine Interface (HMI)

The DRI-10 is controlled via a state of the art touch screen HMI which is installed on the front door of the DRI-10 metal enclosure. The HMI is covered by a separate hinged cover to protect it from water and other environmental factors.

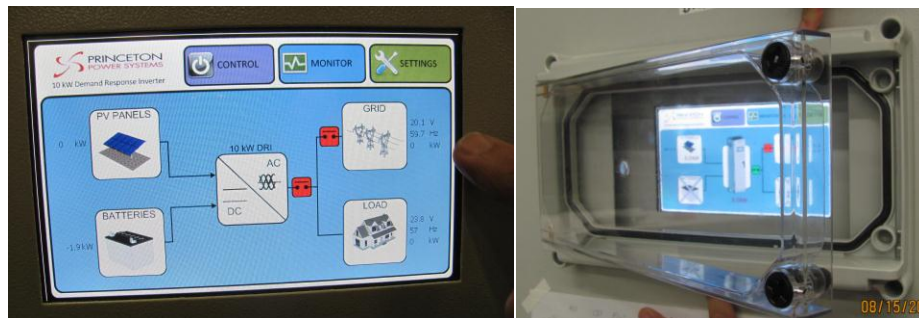


Figure 4: Touch Screen HMI mounted in front door of DRI-10 enclosure.

3. Safety Panels

Once the enclosure front door is opened, the user has access to several switches and breakers on a control panel. The rest of the internal system components are covered by two safety panels.

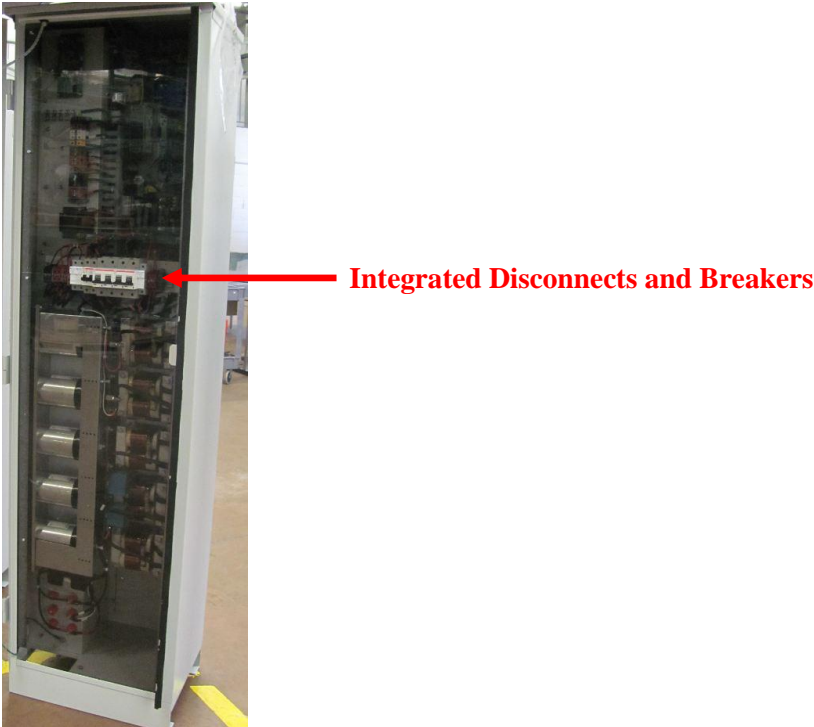


Figure 5: View of DRI-10 enclosure when front door is opened.

4. Integrated Grid Disconnect

The DRI-10 contains an integrated circuit breaker that can be used to connect and disconnect the Grid Port from parts of the DRI-10 system. The electrical position of this three phase circuit breaker is shown in the functional power block diagram in Figure 2 in section iii. This breaker is open when the switch is in down position (as shown in Figure 6) and closed when the breaker is in the up position.

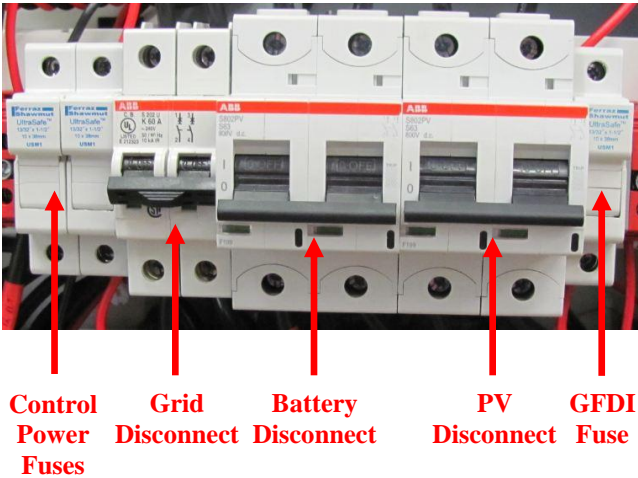


Figure 6: Picture of DRI-10 control Panel showing disconnects in the open position.

5. Integrated Battery Disconnect

The DRI-10's integrated battery disconnect switch is shown in Figure 6. The electrical position of this breaker is shown in the functional power block diagram in Figure 2 in section iii. This breaker is open (disconnected) when in the down position as shown in Figure 6.

The integrated battery disconnect switch must always be in the off (disconnected or down) position before the external battery disconnect switch is closed. Failure to do so will cause severe damage to the DRI-10. The DRI-10 is equipped with a pre-charge circuit that is always on. This means that the DC bus is always charged as long as the external disconnect is closed!



6. Integrated PV Disconnect

The DRI-10's integrated PV disconnect switch is shown in Figure 6. The electrical position of this breaker is shown in the functional power block diagram in Figure 2 in section iii. This breaker is open (disconnected or off) when in the down position as shown in Figure 6 and in the closed (connected or on) position when up.

7. Integrated Control Power Disconnect

The DRI-10's integrated Control Power Supply Unit (PSU) Disconnect switch is shown in Figure 6. This switch can be used to remove power to the HMI and other control systems.

The switch is shown in the open position in Figure 6. The fuse switch must be pushed in to close it to the position shown in Figure 7 .

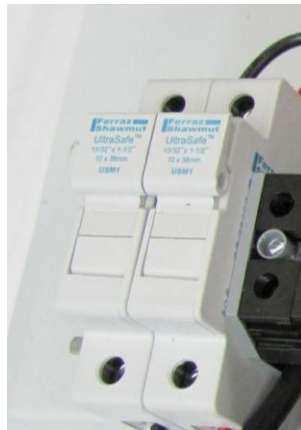


Figure 7: DRI-10 integrated PSU disconnect switch in the closed position.

8. Safety Panels

To access the internals of the DRI-10, the two protective safety panels shown in Figure 5 must be removed. Instructions for removing these panels are provided in the installation manual.



Never attempt to remove the safety panels while the DRI-10 is running or any external disconnect switches are still closed. Wait at least fifteen minutes after opening the last of the four external disconnect switch (grid port, load port, battery



port and PV port) before proceeding to remove the safety panels.

9. Main User Power Terminal Blocks

Once the top safety panel is removed, the user can access the main power connection terminals of the DRI-10. These terminals are shown in Figure 8.

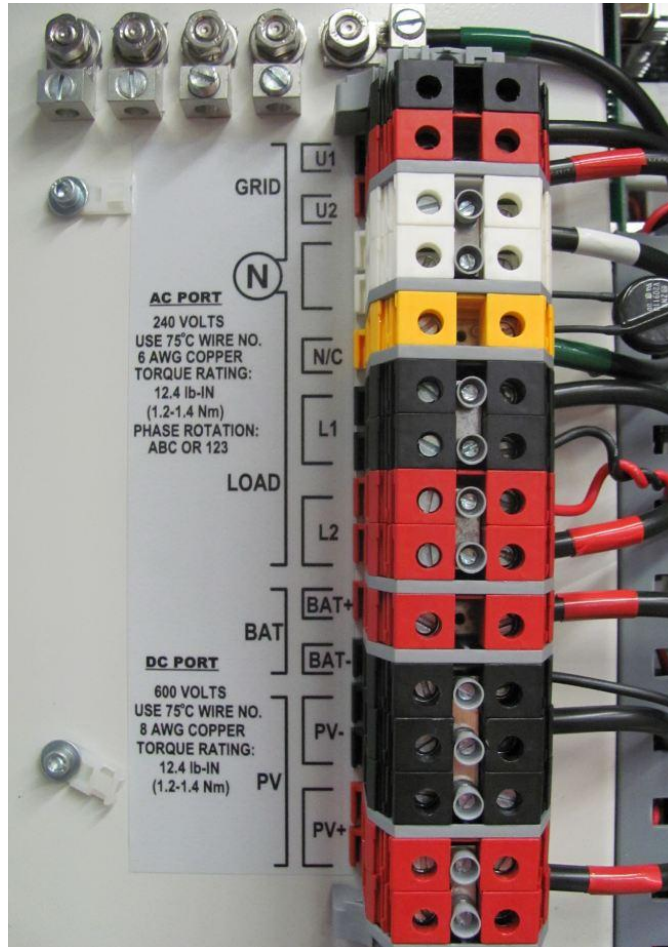


Figure 8: Main User Power Terminal Blocks of DRI-10 in top part of enclosure.

b. Power Format

The DRI-10 inverter AC ports work with a two phase power format. Both AC ports have three wires, two live wires and one neutral wire.

The DRI-10 is capable and compatible with two different power formats, a conventional split phase supply and a two-phase power format. By measuring the voltages between any three power wires using a multimeter and comparing them to the values in Table 1 and Table 2, it is possible to determine which power format is being used.

i. Split Phase Power Format

In this power format, the two phases are 180 degree phase shifted with a magnitude of 120Vrms each and a frequency of 60Hz.

This power format is summarized in Table 1.

Table 1: Summary of split-phase power format.

Frequency	60Hz
Phase1 to Neutral Voltage	120Vrms
Phase2 to Neutral Voltage	120Vrms
Phase1 to Phase2 Voltage	240Vrms

ii. 2-phase power format

In this power format, the two phases are 120 degrees phase shifted with a magnitude of 120Vrms each and a frequency of 60Hz. This power format is summarized in Table 2.

Table 2: Summary of two-phase power format.

Frequency	60Hz
Phase1 to Neutral Voltage	120Vrms
Phase2 to Neutral Voltage	120Vrms
Phase1 to Phase2 Voltage	207.8Vrms

c. DRI-10 Configuration options

This section provides a brief overview of how the DRI-10 can be connected to other system components. For more detailed information, please refer to the Installation Manual Section 4.

i. Offgrid Configuration

In the simplest configuration, the DRI-10 can be run in pure off-grid mode. In this mode, the Grid-port is not utilized. It is possible to connect suitable AC generators to the load port in this configuration. The off-grid configuration is shown in Figure 9.

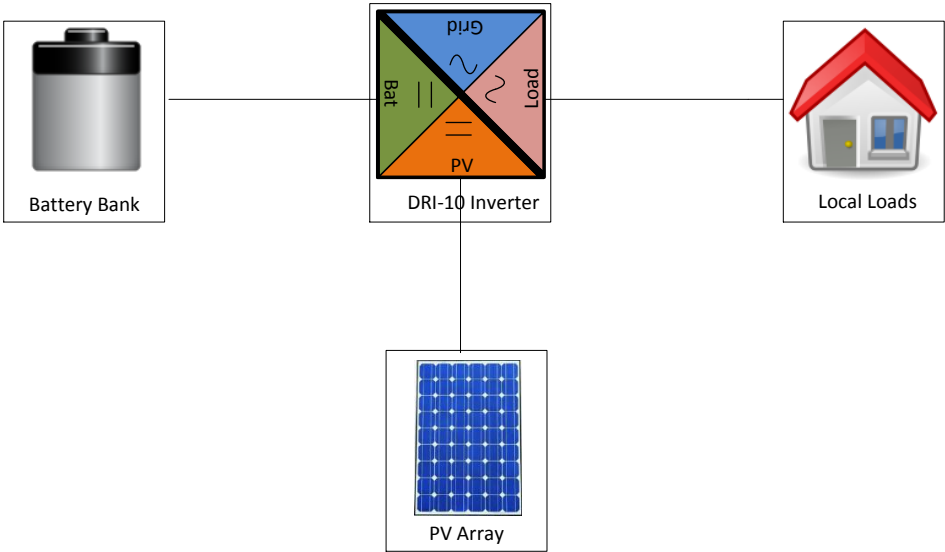


Figure 9: Single line diagram of DRI-10 inverter in off-grid configuration.

ii. On-grid Configuration

The on-grid configuration is similar to the pure off-grid configuration except for the additional connection of the utility grid to the grid port. If grid is available less than 100% of the time, a suitable AC generator can also be connected to the grid port. Alternatively, both a utility and an AC generator can be connected to the grid port if an additional Automatic Transfer Switch (ATS) is installed to switch between generator and grid.



It is recommended that an external bypass switch is installed which is interlocked with the external grid and load disconnect.

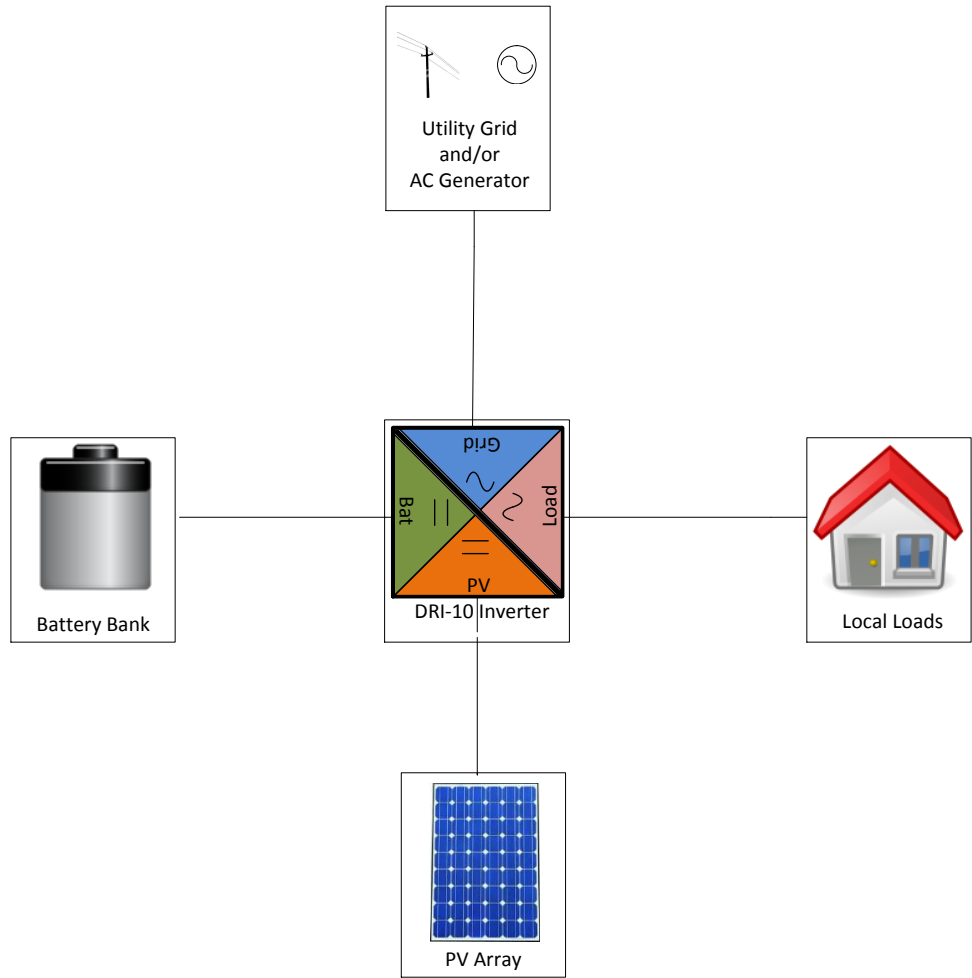


Figure 10: Single line diagram of DRI-10 in on-grid configuration.

d. Optional System Components

i. DRI-10 Client I/O device

The DRI-10 Client I/O device facilitates several advanced features of the DRI-10 inverter. The position of device in the DRI-10 enclosure is shown in Figure 11. A close up of the device can be seen in Figure 12. Features that the DRI-10 Client I/O device facilitates are:

- Digital Inputs
- Digital Outputs
- Load Shedding
- Automatic Generator Starting and Stopping
- Generators connected to load port
- External battery temperature sensor
- External PV temperature sensor

Without the DRI-10 Client I/O device, the above features are not available.

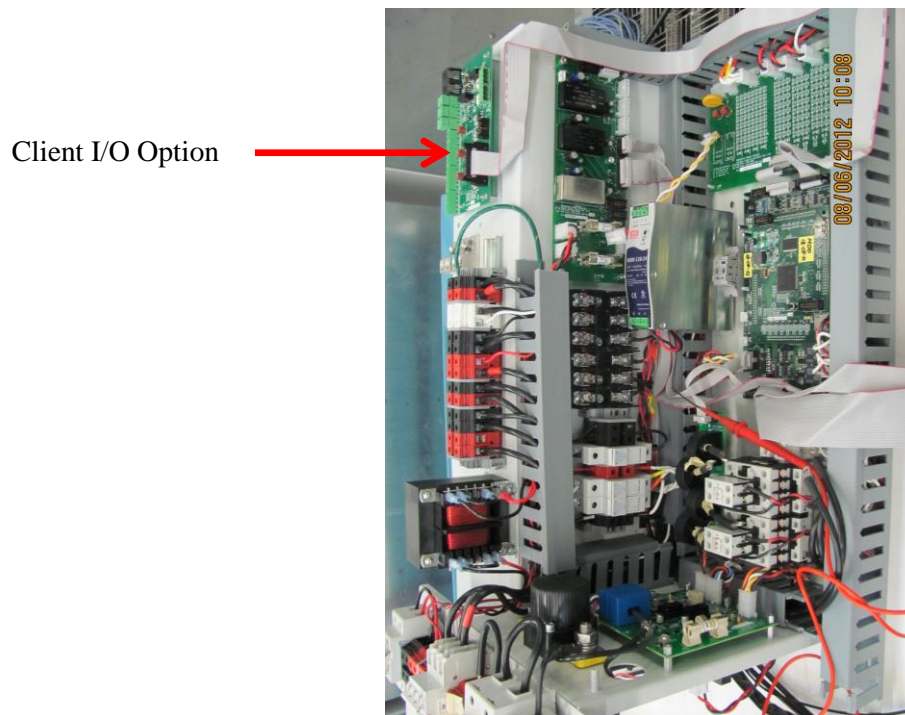


Figure 11: Position of optional DRI-10 Client I/O Device in the enclosure.

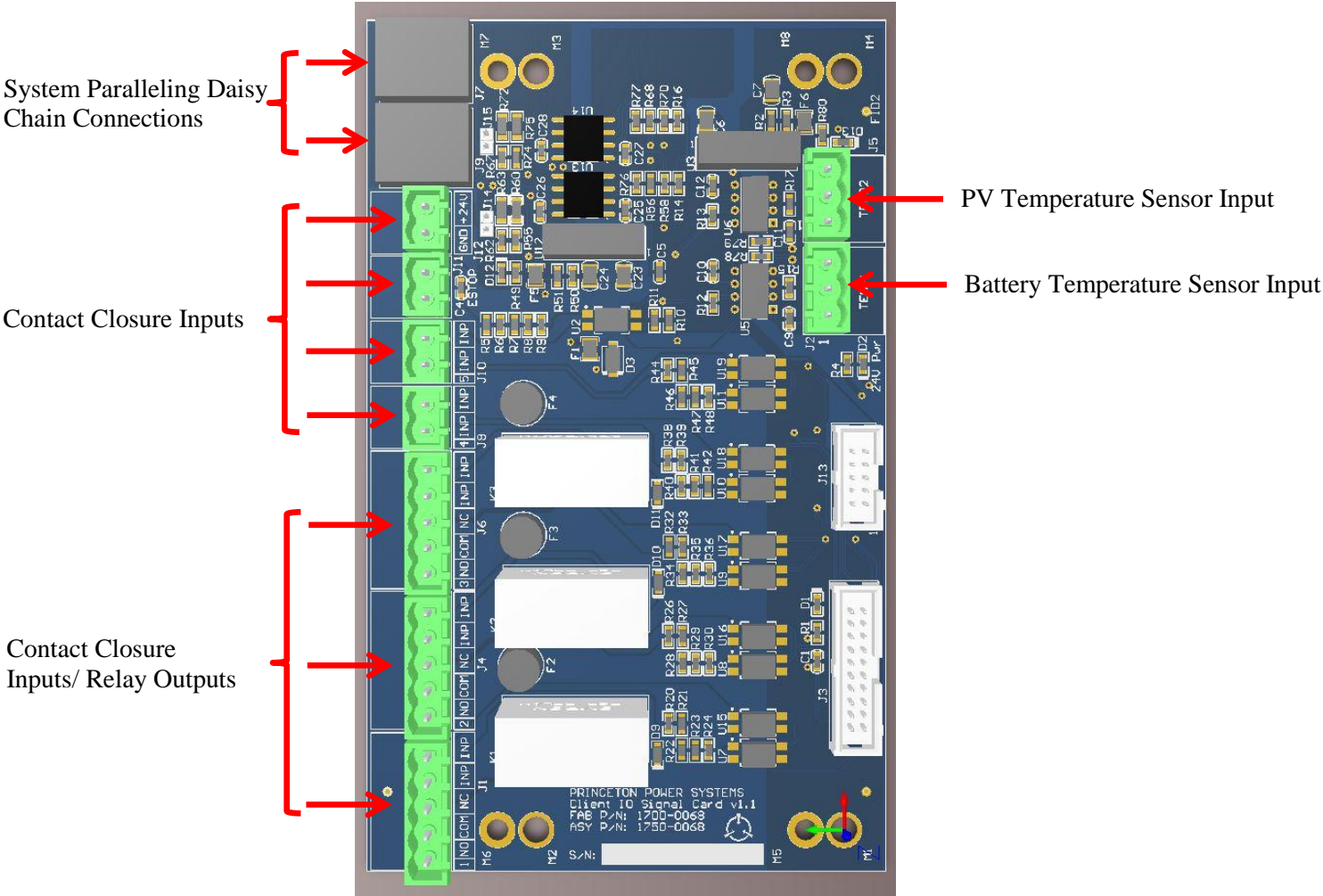


Figure 12: Optional DRI-10 Client I/O Device.

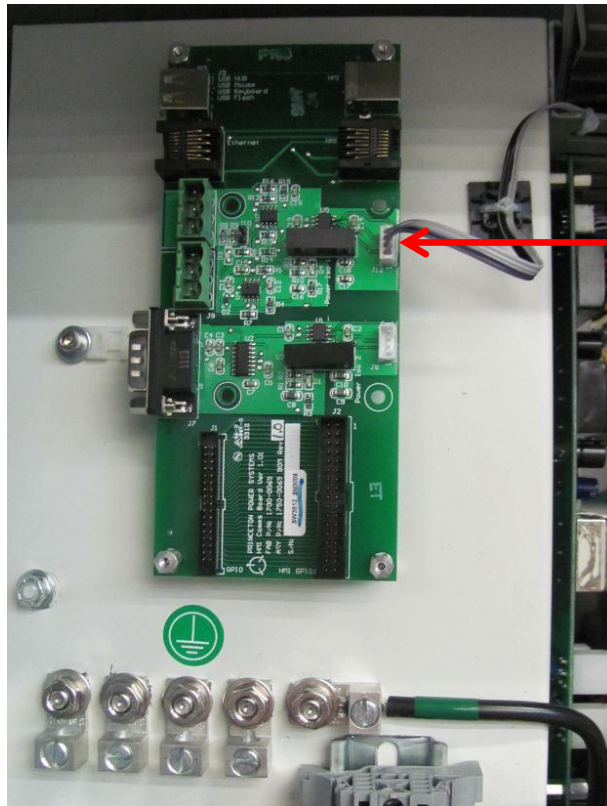
ii. **HMI Communications device**

The DRI-10 HMI Communications device facilitates several advanced features of the DRI-10 inverter. The position of device in the DRI-10 enclosure is shown in Figure 13. A close up of the device can be seen in Figure 14. Features that the DRI-10 Client I/O device facilitates are:

- Ethernet connection to HMI
- Connection of USB devices to HMI

- Serial port interface configurable to either RS-232 or RS-485.
- Connection of external BMS to DRI-10
- Connection of SCADA device or other Modbus Master to the DRI-10 Modbus slave port

Without the DRI-10 Client HMI device, the above features are not available.



Factory configured for RS-485 operation

Figure 13: Position of the DRI-10 HMI Communication Device in the enclosure.

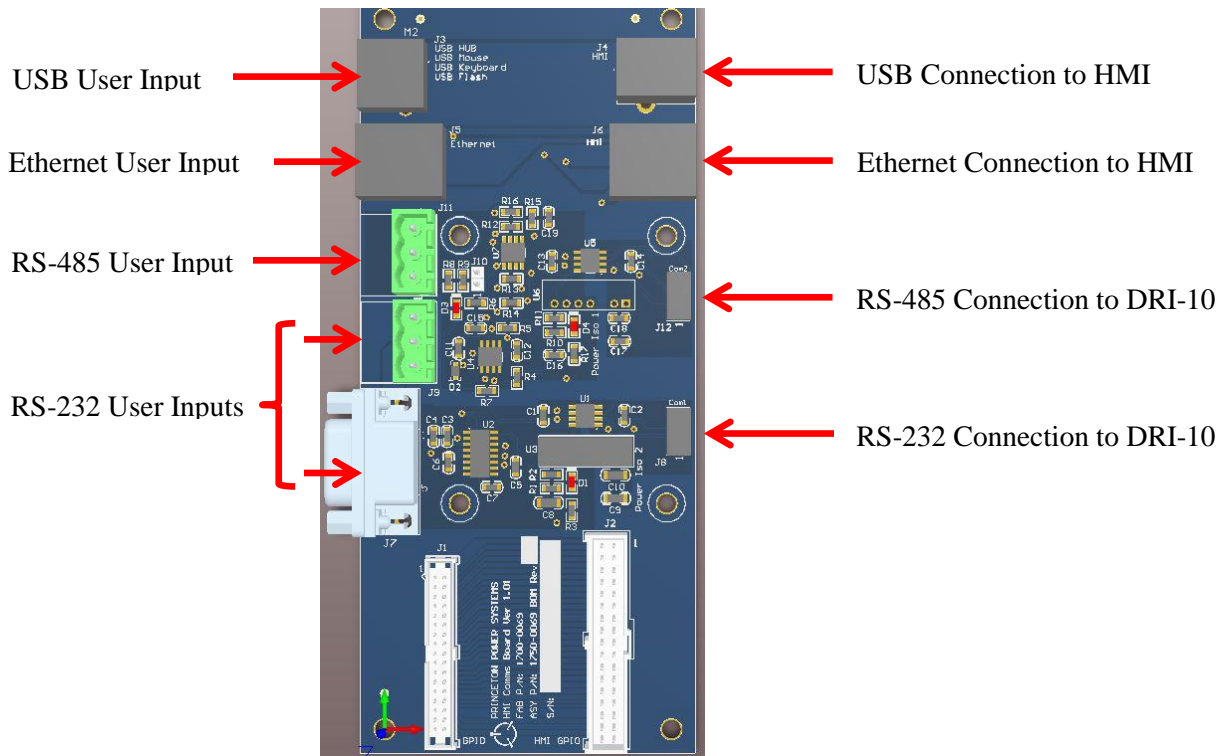


Figure 14: DRI-10 HMI Communications device.

Figure 15 shows the Client HMI serial port configured for RS-485 operation. To use the external RS-232 interface of the DRI-10, the user must move the 4 conductor ribbon cable from J12 to J8 of the Client HMI board.

iii. GFDI Device

Optionally, the DRI-10 can be equipped with an internal GFDI device. If this device is not fitted, an external GFDI device might need to be installed to comply with UL and NEC regulations.

A picture of the GFDI device is shown in Figure 15. The position of the GFDI device in the DRI-10 enclosure is indicated in Figure 16.

iv. Isolation Transformer

The DRI-10 includes an isolation transformer. The transformer provides electrical isolation between the AC and DC ports as explained in section a.ii and allows grounding of the DC ports.

The position of the transformer in the DRI-10 enclosure is shown in Figure 17.



Figure 17: Position of the transformer in the DRI-10 enclosure.

e. Important System Specifications

This section highlights the most important specifications of the DRI-10 that must be taken into careful consideration for system sizing and are useful during the installation process.

i. Load Port Specifications

Electrical parameters of the DRI-10 load port are shown in Table 3.

Table 3: Electrical specifications of DRI-10 Load port.

Voltage	240V or 208V (Line-Line) (see section b) +10%/-12%
Frequency	60Hz (57Hz – 63Hz)
Total Power Rating	6.25kVA per phase (12.5 kVA total) with 150% overload for 10 seconds with 10 minute duty cycle.
Real Power Rating	5kW per phase (10kW) with 150% overload for 10 seconds with 10 minute duty cycle.

ii. Grid Port Specifications

Electrical specifications of the DRI-10 utility grid port are shown in Table 4.

Table 4: Electrical specifications of the Utility Grid port of the DRI-10.

Voltage	240V or 208V (Line-Line) (see section b) +10%/-12%
Frequency	60Hz (57Hz – 63Hz)
Real Power Rating	10kW (with 150% overload for 10 seconds with 10 minute duty cycle) for energy flow to Load or Battery Port. 10kW for power export.
Reactive Power Rating (per phase)	2.5kVAR @ 5kW, 3.9kVAR @ 4kW, 4.75kVAR @ 3kW, 5kVAR @ 2.5kW

iii. Battery Port Specifications

Electrical specifications of the DRI-10 battery port are shown in Table 5.

Table 5: Electrical specifications of Battery Port.

Power Rating	10kW with 150% overload for 10 seconds with 10 minute duty cycle.
Input Voltage Range	150V – 600V

iv. **PV Port Specifications**

Electrical specifications of the PV Port are summarized in Table 6.

Table 6: Electrical specifications of DRI-10 PV Port.

Power Rating	10kW
Input Voltage Range	150V – 600V
Maximum Power Voltage Range	300V – 600V

f. **Choosing and Connecting Generators**

This section discusses different ways of connecting generators to the DRI-10 and gives information on what type of generators are most suitable.

In this document, any source of AC power is referred to as a generator. The primary energy source of such an AC source is assumed to be a gasoline generator.

An important distinction must be made between voltage controlled and current (or power) controlled generators.

i. **Voltage controlled generators**

Generally speaking, any generator that can operate without the presence of an existing grid will be a voltage and frequency controlled generator. For simplicity this document refers to such generators as voltage controlled generators. Many combustion fuel generators are voltage controlled since their main use is in off-grid applications or as a backup system for when the utility grid fails. Voltage controlled generators actively generate voltages. The currents supplied by the generators will depend on the load connected to the generator. Typically, most voltage controlled generators cannot be run in parallel with other voltage controlled generators such as a utility grid (which is also effectively a voltage controlled generator). This would result in two different devices trying to impose slightly different voltages onto the same electrical system

ii. **Current controlled generators**

Most grid-connected generators are current controlled devices. Examples of current controlled generators are grid-tied PV and wind inverters. These devices can generally not function without the presences of a utility grid and by regulation have to turn themselves off as soon as the utility grid fails. These devices generally push a controlled current into the grid. They can be thought of as negative loads in a system and result in the voltage source having to supply less power.

iii. **Grid Port Connected Generators**

As was shown in section c.ii, it is possible to connect a generator to either the load or the utility grid port of the DRI-10. This section focuses on generators connected to

the Utility Grid Port.

1. Off-grid applications for grid port connected, voltage controlled generators

In an off-grid application, it is often very effective to supplement the inherently intermittent solar PV energy source with other forms of energy. Combustion generators are particularly useful in such instances since they can be turned on at any time (assuming enough fuel is available). When no utility grid is available, it is best to connect such generators to the DRI-10 Grid Port. The generator acts like an intermittent grid. When the generator is on, the DRI-10 automatically connects to the generator allowing the loads to draw power directly from the generator. If required, the DRI-10 will automatically charge its batteries from the generator if not enough solar PV energy is available to do so. When the batteries are full, all solar PV energy is supplied to the loads to keep the load on the generator as low as possible. If the generator supports remote starting and stopping, the DRI-10 can be configured to start and stop the generator automatically according to user set preferences. When the generator is turned off (automatically by the DRI-10, manually or due to a fault condition), the DRI-10 seamlessly and automatically disconnects itself from the generator and supplies the loads directly.

Any generator connected to the utility port must be a voltage controlled generator.

2. Off-grid applications for grid port connected, current controlled generators

It is technically possible to connect current controlled generators in parallel to another voltage controlled generator on the Grid Port in off-grid applications. This is however not recommended and does not make technical sense in most cases. Contact PPS for more information should your application require this configuration.

3. On-grid applications for grid port connected, voltage controlled generators

In some areas, a utility grid supply might be available but it might be extremely unreliable. In such situations it sometimes makes sense to connect a voltage controlled generator to the grid port in addition to the utility grid. To avoid both voltage controlled sources (grid and generator) being connected at the same time, an automatic transfer switch or automatic changeover contactor should be installed.

4. On-grid applications for grid port connected, current controlled generators

It is possible to connect current controlled generators to the grid port of the DRI-10 in on-grid applications. These generators effectively reduce the load on the grid. If the grid fails, these generators will no longer be able to supply energy to the DRI-10 and its loads. It therefore sometimes makes more sense to connect additional AC sources to the load port.

3. Human Machine Interface (HMI)

a. HMI Introduction

The DRI-10 is equipped with a state of the art touch screen interface that provides the user with an intuitive and easy way to control and monitor the DRI-10.

The HMI consists of a fully functional Microsoft Windows based mini-computer which is inside the DRI-10. Thus, the HMI has some functionality that will not be covered by this manual. This manual explains those core features of the HMI that allow the user to interface with the DRI-10 central controller unit.

The user can navigate through the menus of the HMI simply by pushing buttons on the screen with his/her finger or a using a stylus. Alternatively, a USB mouse can be connected to the HMI via the USB port on the optional DRI-10 HMI Communication Device.

On power-up, the HMI takes a few minutes to complete its boot sequence. Once the boot sequence is complete, the DRI-10 HMI interface will appear.

b. Three Main Screens

The DRI-10 HMI consists of three different screen categories, Control, Monitor and Settings. These screens are assigned the background colors purple, blue and green respectively. Each of these screens and its sub screens will be briefly explained in subsequent sections.

The three main screens are always accessible via the three buttons in the top panel of the screen as shown in Figure 18.

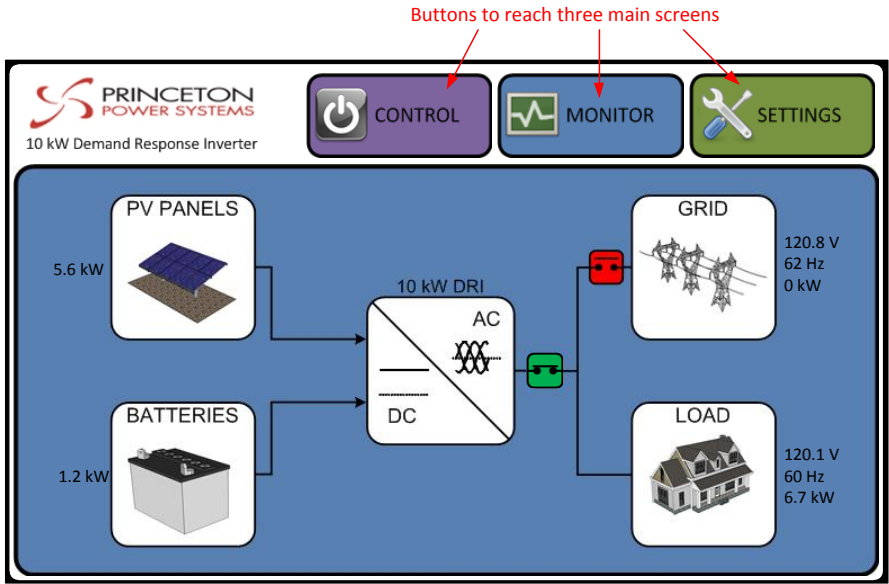


Figure 18 : HMI Monitor screen.

c. Monitor Screens

When the DRI-10 HMI has booted up, the main monitor screen appears. This screen is shown in Figure 18. All Monitor screens have a blue background. The purpose of this screen and its sub-screens is to monitor the state of the DRI-10 system. All important measurements can be viewed via the monitor screens. The main monitor screen can always be accessed by pushing the blue Monitor button in the top panel of the screen.

No system changes can be made via the monitor screens.

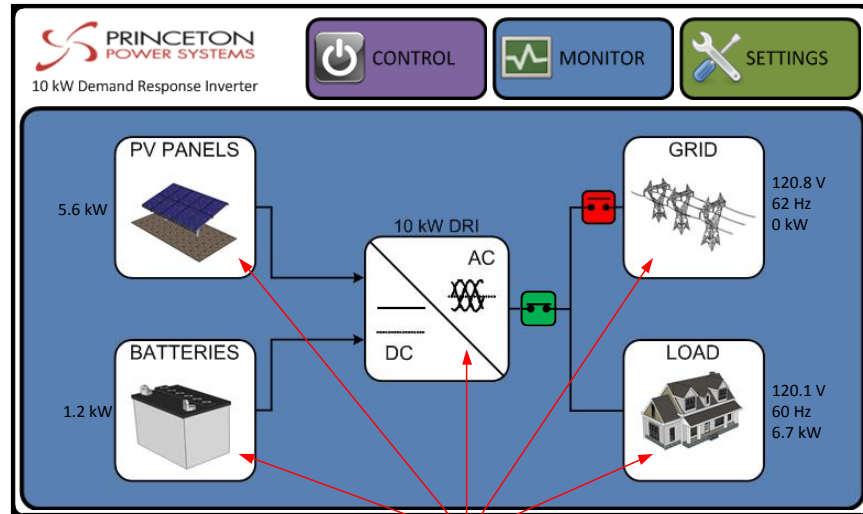
i. Main Monitor Screen

The Main Monitor Screen shown in Figure 18 provides the following measurements:

- Current PV Port power
- Current Battery Port power (positive when discharging)
- Current Grid Port voltage (phase 1 only)
- Current Grid Port frequency (phase 1 only)
- Current Grid Port power (positive when importing from Grid)
- Current Load Port voltage (phase 1 only)
- Current Load Port frequency (phase 1 only)
- Current Load Port power (negative when providing power to Load port)
- Current automatic Load Port contactor status (green when closed and red when open)
- Current automatic Grid Port contactor status (green when closed and red when open)

The above measurements provide the user with a good overview of the current system state and energy flows in the system.

More detailed measurements can be accessed via five buttons on the main Monitor Screen. The position of these buttons is indicated in Figure 21 by red arrows. Pressing on a button associated with a particular port will provide measurements related to that port. Pressing the central DRI-10 Buttons will provide screens with all data points or measurements of the DRI-10.



Five buttons on main monitor screen.

Figure 19: Main Monitor screen of DRI-10 HMI with position of five buttons indicated by red arrows.

ii. Detailed Value Monitor Screens

After pressing on any of the five buttons on the Main Monitor screen (indicated in Figure 19), a new monitor will appear showing up to five parameters at a time of the port that was selected in the Main Monitor screen. The “next” and “previous” buttons in the bottom right and left corners of the screen (indicated in Figure 20) can be used to scroll through the remaining parameters of the selected port.

None of the values shown can be changed since they are generally measurements and not settings.

It is possible to return to the Main Monitor screen or any of the other main screens by using the three buttons in the top panel of the screen.

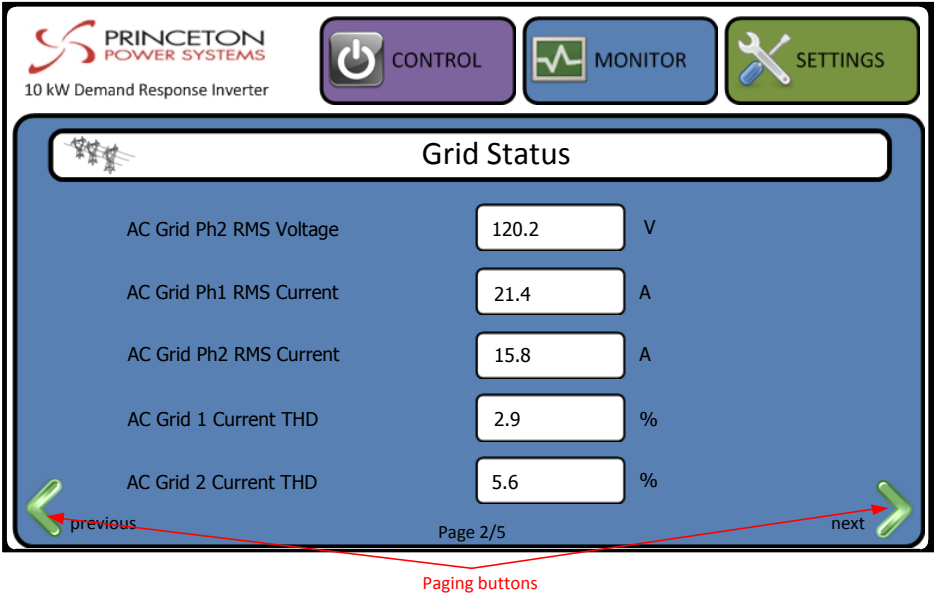


Figure 20: Detailed Value Monitor screen.

d. Control Screens

The purple control screens enable the user to turn the DRI-10 on and off and reset faults. Furthermore, the control screen provides information about the current mode of the inverter and the most recent even (or status).

i. Main Control Screen

The main control screen is shown in Figure 21. The main control screen is always available via the Control button in the top panel of the screen.

The Main Control screen has three buttons: “ON”, “OFF”, and “RESET”.

1. Turning the inverter OFF

The “OFF” button can be used to turn the inverter off at any stage. This will immediately cause all automatic contactors to open and the inverter to stop switching all four ports. Pushing the OFF button will not remove power from the HMI or any of the control circuits inside the DRI. When the inverter is off, it is merely no longer transferring power through any ports.



Turning the inverter “OFF” does not make it safe to touch the inside of the DRI-10. High voltages will still be present inside the inverter even when the inverter has been switched off via the HMI.

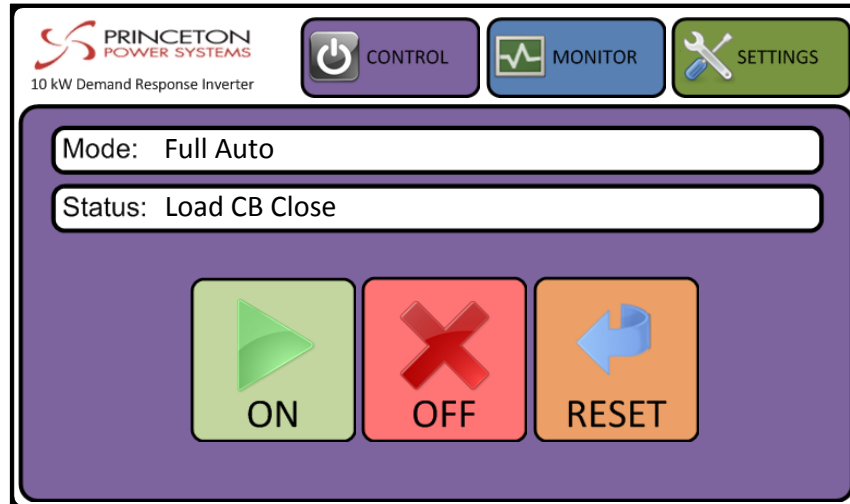


Figure 21: Main Control screen on HMI.

2. Resetting Faults

When certain faults occur, the DRI-10 will automatically turn itself off. In such a case, it is not possible to turn the DRI-10 on again without first resetting the fault. A fault reset is performed by pressing the “RESET” button on the right of the Main Control screen. The “RESET” button will be disabled and grey when no fault has occurred in the system. When a fault has occurred, the button will turn orange and be enabled as shown in Figure 21.

3. Turning the inverter “ON”

Pushing the “ON” button in the Main control screen, will move the user to the next control screen which is shown in the next section.

ii. Turn ON Confirmation Screen

After pressing the “ON” button in the Main Control Screen shown in Figure 21, another control screen appears which is shown in Figure 22.

The purpose of this screen is to confirm that the user wants to turn on the DRI-10 and also to remind the user that the integrated battery disconnect switch must be closed if this is not yet the case. The user is instructed to close the integrated battery breaker of the DRI-10 irrespective of whether or not this breaker is already closed.

Should the user not wish to turn the DRI-10 on at this stage, any of the buttons in the top panel can be used to return to one of the three main menus without turning the DRI-10 on.

By pressing the “ON” button, the DRI-10 will attempt to start into full auto mode and the HMI will return to the Main Control Screen.

1. Normal Turn on sequence

During a successful start-up, the inverter will first start switching the Load Port. Once

the correct voltages have been established successfully, the automatic Load Port contactor will close inside of the machine (usually in less than ten seconds). Closing of the contactor makes a single audible knocking sound. Once the automatic Load Port contactor is closed, the Load is supplied by the DRI-10. If the correct voltages are present on the Grid Port, the DRI-10 will automatically synchronize the Load and Grid Port voltages and the second automatic Grid Contactor will also be closed. Closing of this contactor will also make an audible sound.



Figure 22: The DRI-10 Turn ON Confirmation screen.

e. Settings Screens

The green settings screens enable the user to view and change all DRI-10 settings. The Main Settings screen can be reached at any stage by pressing the Settings button in the top panel of the DRI-10 HMI screen.

i. Main Settings Screen

The main Settings Screen is shown in Figure 23. It consists of eight buttons of different settings categories.

The PV PANELS, BATTERIES, and GRID buttons allow the user to change settings that are specific to the respective port selected. The SYSTEM button lets the user view and change settings that are not specific to any of the four power ports. This includes for example communication settings. The DATE&TIME button allows the user to change the DRI-10 date and time. Pressing the ALL button allows the user access to all settings of the DRI-10 except for the DATE&TIME settings.

The Main Settings Screen can be accessed at any time by pressing the Settings button in the top panel of the DRI-10 HMI screen.

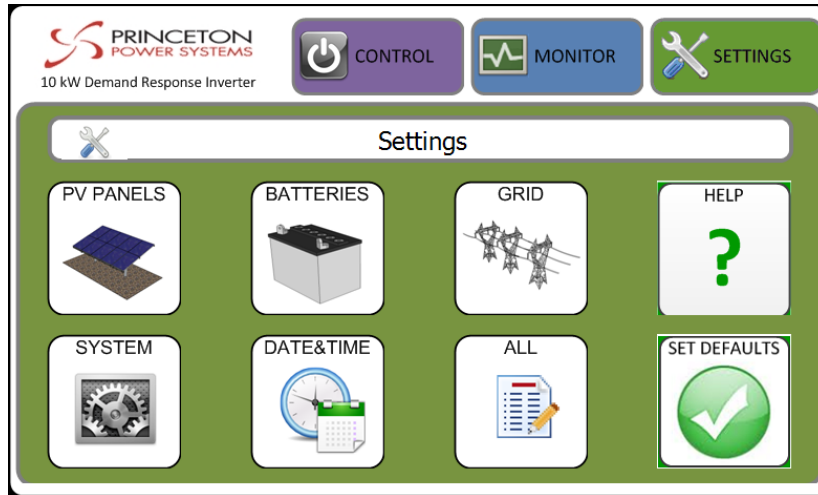


Figure 23: DRI-10 HMI Main Settings Screen.

ii. Settings Values Screens

Once one of the buttons in the Main Settings screen (Figure 23) has been pressed, a screen showing five settings at a time relevant to the button pressed appears. An example of this screen is shown in. Previous and next buttons paging buttons in the bottom left and right corner of the screen can be used to scroll through additional relevant settings.

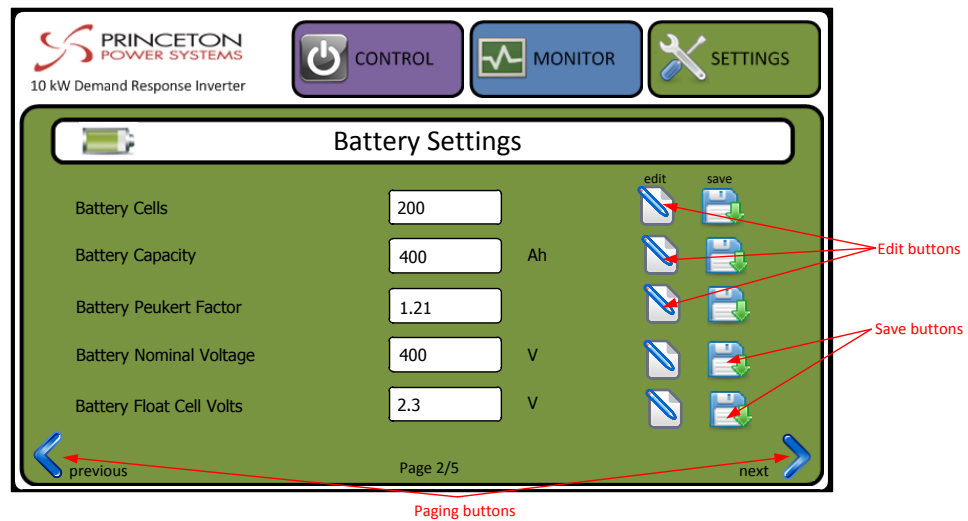


Figure 24: DRI-10 HMI Settings Values Screen example.

1. Changing settings

All settings shown can be changed by the user. To edit a particular setting, the edit button must be pressed next to the setting that needs to be changed. Pressing the edit button of a setting will open a number pad on screen that can be used to enter the new values. This number pad is shown in Figure 25. After entering the new value, the

Enter button can be pressed to close the number pad. The cancel button can also be used to close the number pad but the entered value is ignored in this case. The backspace button can be used to make corrections to the numbers being entered. The backspace, enter and cancel button are marked in Figure 25. While the number pad is open, all other buttons on the screen are disabled. To access any other screens, the cancel or enter button must first be pressed to close the number pad.

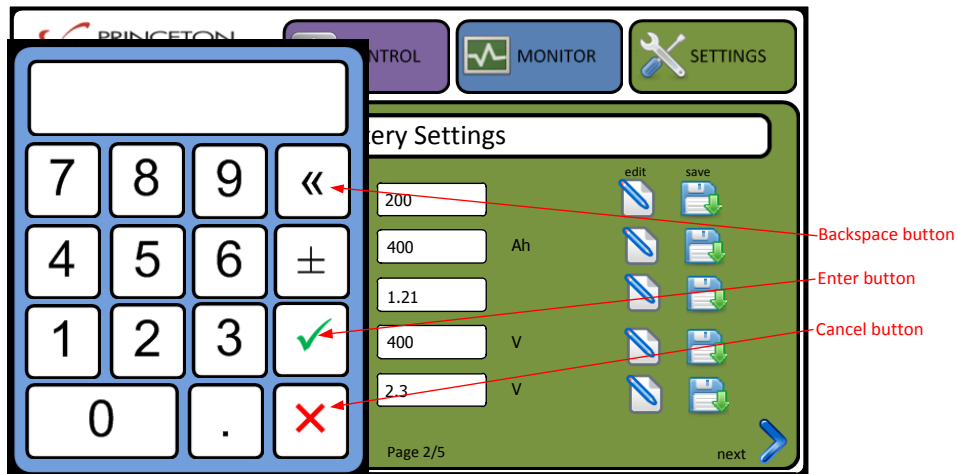


Figure 25: DRI-10 HMI number pad for value editing.

If the enter button has been used to close the number pad, the new value will be shown in red on the Settings Value screen as is shown in the example of the “Battery Float Cell Voltage” in Figure 26.

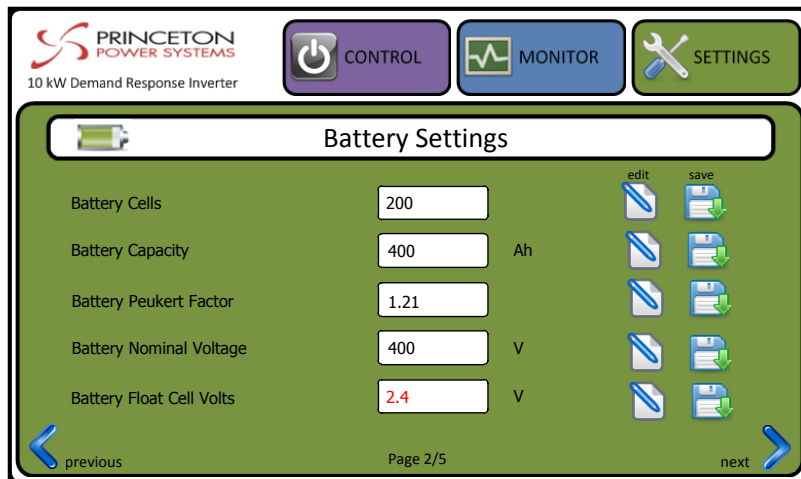


Figure 26: Example of a number that has been edited using the number pad.

The newly entered value is not written to the DRI-10 controller until the save button of the respective setting is pressed. If another screen is opened (by pressing any of the three main buttons in the top panel or the next or previous page buttons) before

the save button is pressed, the new value is lost.

Not all values will be accepted by the DSP controller. Typically, all settings will have a maximum and a minimum allowed value. The largest or smallest allowed value will be used if the entered setting value is too large or small respectively.

2. Password Entry

Some system settings are accessible only after a system password has been entered. Use either the SYSTEM or the ALL button to access the Password Entry screen. Note that the password will be displayed as “????” if it has not yet been entered. Once correctly entered, the password field will be displayed as “*****” and previously protected fields will be accessible.

The password is factory set but can be changed by the system administrator.

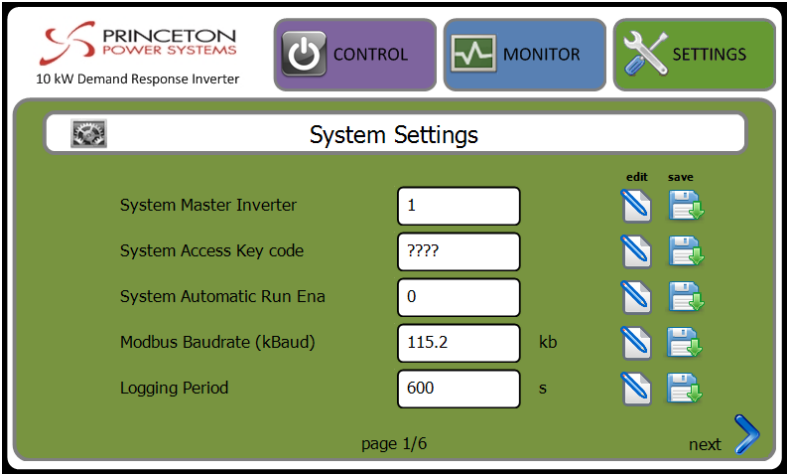


Figure 27: Password entry screen – password not yet entered

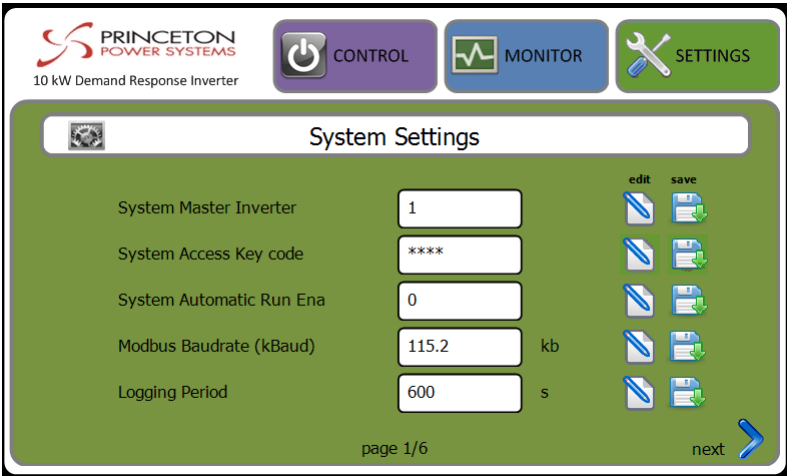


Figure 28: Password entry screen – password correctly entered

4. Datapoints and Measurements

This section provides an overview of important data points of the DRI-10. Depending on the factory settings of your DRI-10 some of the data points listed might not be viewable on the HMI and some data points may be shown that are not discussed in this section. Data points and measurements can be viewed through the Monitor Screens of the DRI-10 HMI.

Table 7: List of all DRI-10 set points

Name	Units	Description / Comments	Modbus Address
Time (ss:msms)		Use the Date &Time Button in the Settings menu to change the DRI-10 date and time	30001
Time (hh:mm)		Use the Date &Time Button in the Settings menu to change the DRI-10 date and time	30002
Date (MM:DD)		Use the Date &Time Button in the Settings menu to change the DRI-10 date and time	30003
Date (YYYY)		Use the Date &Time Button in the Settings menu to change the DRI-10 date and time	30004
Day of Week		Use the Date &Time Button in the Settings menu to change the DRI-10 date and time	30005
Grid Nominal Power	kW	Power setting applied to grid phase 1 and phase 2. Positive value indicates importing power from the grid.	30006
Grid Total Power	kW	Sum of power of phase 1 and phase 2. Positive value indicates importing power from the grid.	30007
Grid Power Phase 1	kW	Positive value indicates importing power from the grid.	30008
Grid Power Phase 2	kW	Positive value indicates importing power from the grid.	30009
Inverter Nominal Power	kW	Power setting applied to the inverter.	30010
Inverter Total Power	kW	Total power flowing from DC ports towards AC ports.	30011
Inverter Power Phase 1	kW	Power from DC Ports flowing into phase 1 of AC ports.	30012
Inverter Power Phase 2	kW	Power from DC Ports flowing into phase 2 of AC ports.	30013
Load Total Power	kW	Sum of power of both phases flowing from DRI-10 to loads connected to Load Port.	30014
Load Power Phase 1	kW	Power in phase 1 flowing from DRI-10 to loads connected to Load Port.	30015

Name	Units	Description / Comments	Modbus Address
Load Power Phase 2	kW	Power in phase 2 flowing from DRI-10 to loads connected to Load Port.	30016
Battery Port Power	kW	Power flowing from battery port. Positive is power that is discharging the battery.	30017
PV Port Power	kW	Power flowing from the PV port. Positive values indicate power being generated by the PV array.	30018
AC Grid Phase 1 RMS Voltage	V	RMS voltage measurement of phase 1 of the Grid input.	30019
AC Grid Phase 2 RMS Voltage	V	RMS voltage measurement of phase 2 of the Grid input.	30020
AC Load Phase 1 RMS Voltage	V	RMS voltage measurement of phase 1 of the Load port output.	30021
AC Load Phase 2 RMS Voltage	V	RMS voltage measurement of phase 2 of the Load port output.	30022
Inverter Phase 1 RMS Voltage	V	RMS voltage measurement of phase 1 of the internal AC bridge.	30023
Inverter Ph2 RMS Voltage	V	RMS voltage measurement of phase 2 of the internal AC bridge.	30024
DC Bus Voltage	V	Measured voltage of the DRI-10 internal DC bus.	30025
Averaged DC Bus Voltage	V	Averaged voltage of the DRI-10 internal DC bus.	30026
Battery DC Voltage	V	Measured battery voltage.	30027
PV DC Voltage	V	Measured PV voltage.	30028
Battery Half DC Voltage	V	Not used.	30029
Battery DC Voltage Unbalance	V	Not used.	30030
Battery Volts per Cell	V	Measured battery voltage divided by the number of battery cells. Number of battery cells can be adjusted in settings.	30031
AC Grid Phase 1 RMS Current	A	Positive current indicates current resulting in power import from the Grid.	30032
AC Grid Phase 2 RMS Current	A	Positive current indicates current resulting in power import from the Grid.	30033
AC Load Phase 1 RMS Current	A	Positive current indicates current resulting in power flow from the DRI-10 to the loads connected to the Load Port.	30034
AC Load Phase 2 RMS Current	A	Positive current indicates current resulting in power flow from the DRI-10 to the loads connected to the Load Port.	30035
AC Inverter Phase 1 RMS Current	A	Positive current indicates current resulting in power flow out of the DRI-10.	30036

Name	Units	Description / Comments	Modbus Address
AC Inverter Phase 2 RMS Current	A	Positive current indicates current resulting in power flow out of the DRI-10.	30037
AC Inverter Phase 3 RMS Current	A	Positive current indicates current resulting in power flow out of the DRI-10.	30038
DC Battery Current	A	Value of most recent battery current measurement.	30039
DC PV Current	A	Value of most recent PV current measurement.	30040
Averaged DC Battery Current	A	Averaged battery current measurement.	30041
Averaged DC PV Current	A	Averaged PV current measurement.	30042
AC Grid Phase 1 Volt THD	%	Total harmonic distortion calculated by the DRI-10 on phase 1 voltage of Grid Port	30043
AC Grid Phase 2 Volt THD	%	Total harmonic distortion calculated by the DRI-10 on phase 2 voltage of Grid Port	30044
AC Load Phase 1 Volt THD	%	Total harmonic distortion calculated by the DRI-10 on phase 1 voltage of Load Port	30045
AC Load Phase 2 Volt THD	%	Total harmonic distortion calculated by the DRI-10 on phase 2 voltage of Load Port	30046
AC Grid Phase 1 Current THD	%	Total harmonic distortion calculated by the DRI-10 on phase 1 current of Grid Port	30047
AC Grid Phase 2 Current THD	%	Total harmonic distortion calculated by the DRI-10 on phase 2 current of Grid Port	30048
AC Load Phase 1 Current THD	%	Total harmonic distortion calculated by the DRI-10 on phase 1 current of Load Port	30049
AC Load Phase 2 Current THD	%	Total harmonic distortion calculated by the DRI-10 on phase 2 current of Load Port	30050
Grid Frequency	Hz	Measured frequency of the grid port.	30051
Load Frequency	Hz	Measured frequency of the load port.	30052
Inductor Temperature	°C	Highest temperature of the 5 power inductors.	30053
Stack Temp	°C	Measured temperature of the stack heat sink.	30054
Cabinet Temperature	°C	Measured temperature of the inside of the DRI-10 enclosure.	30055

Name	Units	Description / Comments	Modbus Address
Isolated Client Temperature 1	°C	Temperature measured on external battery temperature sensor connected to optional DRI-10 Client I/O device.	30056
Isolated Client Temperature 2	°C	Temperature measured on external PV array temperature sensor connected to optional DRI-10 Client I/O device.	30057
Digital Input Grid CB Feedback	Boolean	This data point can be used for troubleshooting faults on the DRI-10.	30058
Digital Input Load CB Feedback	Boolean	This data point can be used for troubleshooting faults on the DRI-10.	30059
Digital Input Trip Zone 1	Boolean	This data point can be used for troubleshooting faults on the DRI-10.	30060
Digital Input IGBT Error 1	Boolean	This data point can be used for troubleshooting faults on the DRI-10.	30061
Digital Input IGBT Error 2	Boolean	This data point can be used for troubleshooting faults on the DRI-10.	30062
Digital Input IGBT Error 3	Boolean	This data point can be used for troubleshooting faults on the DRI-10.	30063
Digital Input IGBT Error 4	Boolean	This data point can be used for troubleshooting faults on the DRI-10.	30064
Digital Input IGBT Error 5	Boolean	This data point can be used for troubleshooting faults on the DRI-10.	30065
Digital Input HOS Fail	Boolean	This data point can be used for troubleshooting faults on the DRI-10.	30066
Digital Input DC Bus Fault	Boolean	This data point can be used for troubleshooting faults on the DRI-10.	30067
Digital Input DC Current Error	Boolean	This data point can be used for troubleshooting faults on the DRI-10.	30068
Digital Input AC Current Error	Boolean	This data point can be used for troubleshooting faults on the DRI-10.	30069
Digital Input Temp Error	Boolean	This data point can be used for troubleshooting faults on the DRI-10.	30070
Digital Input GFDI OK	Boolean	Indicates if the GFDI device is currently not signalling a ground fault. A '1' means OK.	30071
Digital Input GFDI Fail	Boolean	Indicates if the GFDI device has detected a ground fault. A '1' means a Fault.	30072
Digital Input Client 1	Boolean	Reflects the current state of the first digital input on the DRI-10 Client I/O device.	30073

Name	Units	Description / Comments	Modbus Address
Digital Input Client 2	Boolean	Reflects the current state of the second digital input on the DRI-10 Client I/O device.	30074
Digital Input Client 3	Boolean	Reflects the current state of the third digital input on the DRI-10 Client I/O device.	30075
Digital Input Client 4	Boolean	Reflects the current state of the fourth digital input on the DRI-10 Client I/O device.	30076
Digital Input Client 5	Boolean	Reflects the current state of the fifth digital input on the DRI-10 Client I/O device.	30077
Digital Output Precharge	Boolean	Precharge control. This output is controlled by the supervisory software. User operation is not recommended.	30078
Digital Output Grid Contactor	Boolean	Grid contactor control. This output is controlled by the supervisory software. User operation is not recommended.	30079
Digital Output Load Contactor	Boolean	Load contactor control. This output is controlled by the supervisory software. User operation is not recommended.	30080
Digital Output GFDI Reset	Boolean	GFDI reset control. This output is controlled by the supervisory software. User operation is not recommended.	30081
Digital Output Client 1	Boolean	User output for relay control.	30082
Digital Output Client 2	Boolean	User output for relay control.	30083
Digital Output Client 3	Boolean	User output for relay control.	30084
System Operation Mode	Enumerated	Reflects the current state of the DRI-10 operating mode.	30085
System Status	Enumerated	Reflects the current status of the DRI-10.	30086
Utility Interface Mode	Enumerated	Reflects the grid interface mode of the DRI-10.	30087
Battery Internal Mode	Enumerated	Reflects the current operating mode of the DRI-10 battery port.	30088
PV Internal Mode	Enumerated	Reflects the current operating mode of the DRI-10 PV port.	30089

Name	Units	Description / Comments	Modbus Address
Grid CB State	Enumerated	Reflects the current state of the DRI-10 grid port contactor.	30090
Load CB State	Enumerated	Reflects the current state of the DRI-10 load port contactor.	30091
Battery Charge Mode	Enumerated	Reflects the current operating mode of the DRI-10 battery charger.	30092
Battery Charge Stage	Enumerated	Reflects the current charge stage of the DRI-10 battery charger.	30093
System Sync Source	Enumerated	Reflects the current DRI-10 sync source (internal or grid).	30094
Load Port Status OK	Enumerated	Reflects that status of the load port contactor.	30095
Grid Port Status OK	Enumerated	Reflects that status of the grid port contactor.	30096
Target DC Bus Voltage	Enumerated	Desired DC bus operating voltage. Set by the internal control system.	30097
Target Battery Port Voltage	V	Not used in this system.	30098
Target PV Port Voltage	V	Not used in this system.	30099
Target Battery Port Current	A	Not used in this system.	30100
Target Battery Volts Per Cell	V	Not used in this system.	30101
Battery DRI Export Target	A	Used for export power calculation.	30102
PV DRI Export Target	A	Used for export power calculation.	30103
Battery Equalize Charge Active	Boolean	Not used in this system.	30104

5. Settings

This section provides an overview of important settings of the DRI-10. Depending on the factory settings of your DRI-10 some of the settings listed might not be viewable on the HMI and some settings may be shown that are not discussed in this section. Set points can be viewed through the Settings Screens of the DRI-10 HMI.

Table 8: Description of all DRI-10 set points.

Name	Default Value	Lowest allowed Value	Highest allowed Value	Units	Description / Comments	Modbus Address
Spare					Reserved for future use	40001
System Master Inverter	1	0	1	Boolean	For use with paralleled systems. In this scenario, there will be on inverter set as master with the others set a slaves.	40002
System Access Keycode	1234	0	9999	Decimal	Used to set the system access code.	40003
System Automatic Run Enable	0	0	1		Use to enable system to auto-start on power up with no user input.	40004
Modbus Baud rate (kBaud)	115.2	9.6	115.2	kb	Sets the Baud rate of the Communication between HMI and DRI-10 central controller.	40005
Logging Period	600	1	3600	s	Sets the logging period of the internal DRI-10 controller. Note that the log memory is limited and a shorter logging period reduces the effective duration of an historic trend profile.	40006
Serial Number	1	1	9999	Decimal	Serial number of the DRI-10.	40007
Modbus Address	5	1	128	Decimal	Modbus Address of the internal DRI-10 controller	40008
Automatic Fault Reset Time	5	1	3600	s	Sets the amount of time after which the DRI-10 attempts an automatic fault reset	40009
Contactors Timeout Period	5	1	60	s	Sets the amount of time the DRI-10 waits before issuing a fault between giving a contactor open/close command and not receiving the respective feedback signal from the contactor.	40010
Grid High Volt Shutdown	110	100	130	%	Sets the upper RMS line to neutral voltage limit at which the DRI-10 disconnects from the grid port. Expressed as a percentage of the nominal Grid Port Voltage. This set point should not be changed from the default value when connecting to a utility grid.	40011

Name	Default Value	Lowest allowed Value	Highest allowed Value	Units	Description / Comments	Modbus Address
Grid Low Volt Shutdown	90	30	100	%	Sets the lower RMS line to neutral voltage limit at which the DRI-10 disconnects from the grid port. Expressed as a percentage of the nominal Grid Port Voltage. This set point should not be changed from the default value when connecting to a utility grid.	40012
Grid High Frequency Shutdown	110	100	150	%	Sets the upper voltage frequency limit at which the DRI-10 disconnects from the grid port. Expressed as a percentage of the nominal Grid Port frequency. This set point should not be changed from the default value when connecting to a utility grid.	40013
Grid Low Frequency Shutdown	90	50	100	%	Sets the lower voltage frequency limit at which the DRI-10 disconnects from the grid port. Expressed as a percentage of the nominal Grid Port frequency. This set point should not be changed from the default value when connecting to a utility grid.	40014
Grid Detection Time	10	5	60	s	Minimum time for which the Grid Port parameters must remain within range before DRI-10 is allowed to connect to Grid.	40015
Inverter High Volt Shutdown	110	100	130	%	This set point specifies the upper limit of the Line to Neutral Voltage on the Inverter at which the DRI-10 will turn itself off. The voltage is expressed as a percentage of the nominal Inverter voltage. This setting should not be changed from the default value when connecting to a utility grid.	40016
Inverter Low Volt Shutdown	90	30	100	%	This set point specifies the lower limit of the Line to Neutral Voltage on the Inverter at which the DRI-10 will turn itself off. The voltage is expressed as a percentage of the nominal Inverter voltage. This setting should not be changed from the default value when connecting to a utility grid.	40017
Inverter High Frequency Shutdown	115	100	150	%	This set point specifies the upper limit of the frequency on the Inverter at which the DRI-10 will turn itself off. The frequency is expressed as a percentage of the nominal Inverter frequency.	40018
Inverter Low Frequency Shutdown	90	50	100	%	This set point specifies the lower limit of the frequency on the Inverter at which the DRI-10 will	40019

Name	Default Value	Lowest allowed Value	Highest allowed Value	Units	Description / Comments	Modbus Address
					turn itself off. The frequency is expressed as a percentage of the nominal Inverter frequency.	
Inverter Detection Time	10	5	60	s	Minimum time for which the Inverter parameters must remain within range before DRI-10 is allowed to connect to the load.	40020
Inverter Max Export Amps	50	1	52	A	Maximum current that can flow to the Load Port. Expressed as a percentage of nominal Load Port current.	40021
Inverter Max Import Amps	50	1	52	A	Maximum current that can be imported from the Load Port. Expressed as a percentage of nominal Load Port current.	40022
Islanding Islanding Detection	1	0	1	Boolean	This set point can be used to disable active anti-islanding measures. Should never be disabled when connecting to utility grid.	40023
Inverter Reactive Current	0	-52	52	A	Not used in this system.	40024
DC Bus High Voltage	115	100	130	%	DC Bus voltage at which the system will trip if exceeded. Expressed as a percentage of the DC Bus Operating voltage.	40025
DC Bus Low Voltage	65	0	100	%	DC Bus voltage at which the system will trip if less than. Expressed as a percentage of the DC Bus Operating voltage.	40026
DC Bus Operating High Voltage	650	300	700	V	High set point for internal DC Bus operating range.	40027
DC Bus Operating Low Voltage	400	250	700	V	Low set point for internal DC Bus operating range.	40028
Battery Enable	1	0	1	Boolean	This set point can be used to disable the Battery Port of the DRI-10.	40029
Battery Cells	240	10	900	Decimal	This set point must be used to set the number of battery cells in battery bank. If this set point is not set correctly, all charging set points will incorrect.	40030
Battery Capacity	100	0	30000	Ah	This set point should be used to specify the nominal amp-hour capacity of the battery bank connected to the DRI-10.	40031
Battery Peukert Factor	1.21	1	2	VPC	This set point should be used to specify the Peukert Factor of the Battery Bank. Contact Battery Manufacturer if this value is not obtained in the battery documentation. Alternatively, contact PPS to calculate this value for your battery bank. This value is	40032

Name	Default Value	Lowest allowed Value	Highest allowed Value	Units	Description / Comments	Modbus Address
					used to calculate the battery state of charge.	
Battery Float Cell Volts	2.14	1	3	VPC	This set point specifies the target float voltage of the battery bank. The value is specified as a per cell voltage. Ensure that the number of battery cells in the battery bank is set correctly to enable this set point to be used correctly.	40033
Battery Bulk Cell Charge Volts	2.32	1.5	3	VPC	This set point specifies the target bulk voltage of the battery bank. The value is specified as a per cell voltage. Ensure that the number of battery cells in the battery bank is set correctly to enable this set point to be used correctly.	40034
Battery Equalization Cell Volts	2.4	1.5	3	VPC	This set point specifies the target equalization voltage of the battery bank. The value is specified as a per cell voltage. Ensure that the number of battery cells in the battery bank is set correctly to enable this set point to be used correctly. The battery equalization charge cycle must be enabled for this set point to take effect.	40035
Battery Equalization Time Interval	744	24	8766	Hrs	This set point specifies the time interval between consecutive equalization charge intervals. The battery equalization charging cycle must be enabled for this set point to take effect.	40036
Battery Equalization Charge Period	2	1	24	Hrs	This set point sets the maximum amount of time the DRI-10 will remain in a continuous battery equalization charging cycle. This set point prevents further damage to batteries that are not able to complete a equalization charge cycle due to a aging or damage. Under normal conditions, the 'Batt Min Equ Chg' set point should terminate the equalization charging cycle before this set point time expires.	40037
Battery Bulk Charge Period	2	1	24	Hrs	This set point sets the maximum amount of time the DRI-10 will remain in a continuous battery bulk charging cycle. This set point prevents damage to batteries that are not able to otherwise complete a bulk charge cycle. Under normal conditions, the 'Batt Min Bulk Chg' set point should terminate a bulk charging	40038

Name	Default Value	Lowest allowed Value	Highest allowed Value	Units	Description / Comments	Modbus Address
					cycle before this set point time expires.	
Battery Min Bulk Charge	5	1	45	A	This set point sets the lower limit battery charging current at which a bulk charge cycle is completed. This current is expressed as a percentage of the nominal battery charging current.	40039
Equalize Charge Enabled	0	0	1		This set point can be used to disable the equalization charging cycle. Consult the battery manufacturer or supplier to establish if equalization charge cycles are recommended for the battery bank in use.	40040
Battery Min Equalization Charge	5	1	45	A	This set point specifies the lower limit the battery charging current must reach to terminate the equalization charging cycle. If the battery charging current does not reach this set point before 'Batt Equ Chg Period' expires, the equalization charge cycle will be terminated after 'Batt Equ Chg Period' has expired. This set point is specified as a percentage of the nominal battery charging current. The set point only takes effect if the battery equalization charging cycle is enabled.	40041
Future						40042
Future						40043
Future						40044
Future						40045
Min Compensation Upper Temperature	50	0	100	°C	This set point specifies the upper temperature at which the charging of batteries is not further temperature compensated. When the battery temperature goes above the temperature specified here, the charging voltages will be clamped to the compensated value calculated for the temperature set here.	40046
Min Compensation Lower Temperature	1	0	100	°C	This set point specifies the lower temperature at which the charging of batteries is not further temperature compensated. When the battery temperature goes below the temperature specified here, the charging voltages will be clamped to the compensated value calculated for the	40047

Name	Default Value	Lowest allowed Value	Highest allowed Value	Units	Description / Comments	Modbus Address
					temperature set here.	
Max Battery Charge Amps	20	0	45	A	This set point can be used to specify the maximum allowed battery charging current during any charging cycle. This set point is specified as a percentage of the nominal battery current.	40048
Battery Low Shutdown	1.8	0.3	2	VPC	This voltage specifies the battery cell voltage at which the DRI-10 will shut down with a low battery fault during at a C1 discharge rate.	40049
Battery Max Voltage	2.5	2	2.7	VPC	If the battery cell voltage remains above the voltage specified by this set point, the DRI-10 will shut down with a high battery voltage fault. Before shutting down, the DRI-10 will attempt to derate or turn off any sources of energy in the system.	40050
Battery Charge Enable Volts	1.95	0.3	3	VPC	This set point specifies the voltage at which the DRI-10 will start charging the battery.	40051
PV Enable	1	0	1	Boolean	This set point can be used to disable the PV Port of the DRI-10.	40052
PV Turn On Voltage	440	0	800	V	This set point specifies the voltage at which the DRI-10 will start utilizing the PV power. When the PV Port voltage is below the voltage specified here, the PV Port will not be activated by the DRI-10.	40053
PV Nominal MPPT Voltage	400	50	700	V	Target voltage for the MPPT algorithm.	40054
PV High MPPT Voltage	500	300	600	V	Voltage at which the DRI-10 MPPT algorithm begins to execute.	40055
PV Low MPPT Voltage	250	36	500	V	Voltage at which the DRI-10 MPPT algorithm stops executing.	40056
PV Max Import Current	45	0	45	A	This set point specifies the maximum allowed DC current flowing from the PV array.	40057
PV Min Import Current	3	1	45	A	This set point specifies the minimum allowed DC current flowing from the PV array. When the PV Port current drops below this set point, the PV-Port will be shut down.	40058
Maximum Cabinet Temperature	70	0	100	°C	This temperature specifies the maximum temperature the cabinet may have before the DRI-10 starts throttling its power. If the high temperature persists, the DRI-10 will shut-down.	40059

Name	Default Value	Lowest allowed Value	Highest allowed Value	Units	Description / Comments	Modbus Address
Heatsink Max Temperature	70	20	150	°C	This temperature specifies the maximum temperature the DRI-10 internal heat sink may have before the DRI-10 starts throttling its power. If the high temperature persists, the DRI-10 will shut-down.	40060
Inductor Max Temperature	70	20	150	°C	This temperature specifies the maximum temperature the DRI-10 inductors may have before the DRI-10 starts throttling its power. If the high temperature persists, the DRI-10 will shut-down.	40061
Isolated Temp. 2 Max Temperature	70	20	150	°C	This set point specifies the maximum PV temperature before the DRI-10 shuts down with a high battery temperature fault.	40062
Battery Max Temperature	55	20	80	°C	This set point specifies the maximum battery temperature before the DRI-10 shuts down with a high battery temperature fault.	40063
Isolated Temp 1 Enabled	0	0	1	Boolean	Set point to enable/disable system trips based on temperature sensor data.	40064
Isolated Temp 2 Enabled	0	0	1	Boolean	Set point to enable/disable system trips based on temperature sensor data.	40065
DRI Export Power Target	0	-15	15	kW	DRI-10 power command: set from 1 to 10 kW to export power. A setting of 0 can be used to charge the battery bank.	40066
Battery Export Power Target (Test Mode)	0	-15	15	kW	Test only. Do not use.	40067
PV Export Power Target (Test Mode)	0	0	15	kW	Test only. Do not use.	40068

6. Battery Charging Profiles

The DRI-10 is designed to work with a wide range of different battery technologies. To achieve this, the DRI-10 allows customized battery charging profiles. This section explains how to set battery parameters to achieve the desired charging profile.

a. Charging Cycles

The DRI-10 has four different charging stages:

- Constant current charge stage
- Bulk charge stage
- Float charge stage
- Equalize charge stage

A battery charging cycle will typically consist of three of the above four stages. All charging cycles begin with the constant current charge stage. After the constant current charge state is complete, either a bulk equalize or equalize charge is initiated. After this, the batteries are kept at float voltage during the float charge state.

b. Standard Charging Cycle

A standard charging cycle consisting of a constant current, bulk and float charge stage is shown in Figure 29.

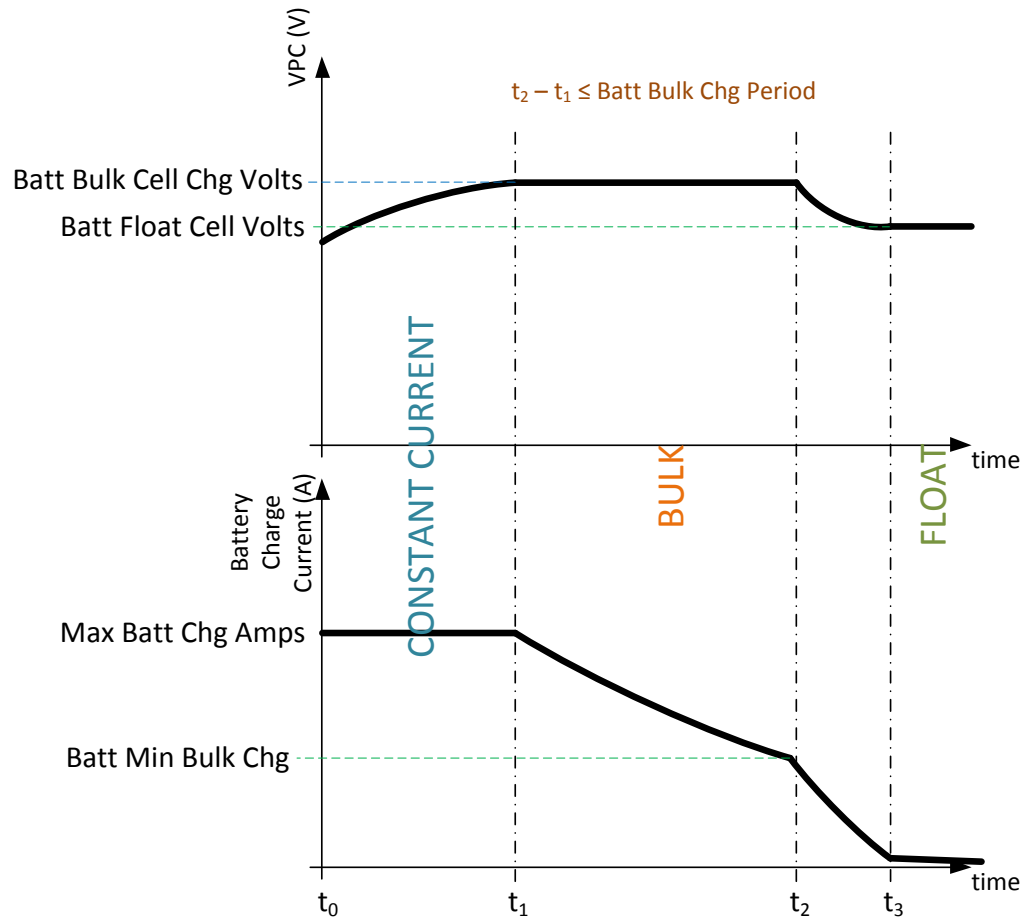


Figure 29: Standard charging cycle consisting of constant current, bulk and float charge stage.

i. Constant Current Charge Stage

At the beginning of a standard charging cycle is a constant current charge stage. The 'Max Batt Chg Amps' set point sets this constant current level. The set point is specified as a percentage of the nominal battery current ('Battery Nom Amps'). As the batteries are charged, the battery voltage increases slowly. Once the battery cell voltage reaches the level set by the 'Batt Bulk Cell Chg Volts' set point, the constant current charging stage is completed. This charge state is represented by the time between t_0 and t_1 in Figure 29.

ii. Bulk Charge Stage

The second stage in a constant current charging cycle is a constant voltage charging stage. This charging stage occurs between t_1 and t_2 in Figure 29. During this stage, the cell voltage of the batteries is kept at the 'Batt Bulk Cell Chg Volts' voltage. The current slowly decreases from its initial 'Max Batt Chg Amps' value.

There are two events that can result in the bulk charge stage being terminated at t_2 . Whichever event occurs first will terminate the bulk charge stage and initiate the next charging stage. If the charging current drops to or below the current set by the 'Batt Min Bulk Chg' set point, the bulk charge stage is completed. Alternatively if the time between t_1 and t_2 reaches the time period specified by the 'Batt Bulk Chg Period' set point before the 'Batt Min Bulk Chg' set point is reached, the bulk charge state is also terminated.

iii. Float Charge Stage

Once the bulk charge stage is complete, the DRI-10 lets the battery voltage taper of to the cell voltage specified by 'Batt Float Cell Volts'. This process is indicated by the period between t_3 and t_4 in Figure 29. The battery voltage is then kept at the float voltage, the charging current will continue to drop and the battery has completed its standard charging cycle.

c. Equalization Charge Stage

Battery lifetime of some battery technologies can be extended if they regularly receive an equalization charge. An equalization charge is a constant voltage charge stage that replaces the normal bulk charge stage of the standard charging cycle. The equalization voltage is typically significantly higher than the bulk charge voltage. Since gassing of the batteries occurs during this charge stage, it is not allowed for sealed battery technologies (e.g. lead-gel) and should therefore be disabled for such technologies using the 'Equalize Charge Enabled' set point.

Equalization charges are typically performed once a month. The exact amount of time between successive equalization charge stages is specified by the 'Batt Equ Time Interval' set point. Once this time interval has elapsed after the previous equalization charge stage was completed, the DRI-10 will start an equalization charge stage as soon as a generator or utility grid becomes available. The equalization charge stage is not initiated if a grid or generator is not available. This is done to prevent the possibility of having to terminate an equalization charge stage prematurely if not enough PV energy is available during the charging stage. If no grid or generator becomes available after the time specified by the 'Max Delay to Equalise' set point, the DRI-10 will try to force a generator to start or connect to a grid if possible.

The 'Batt Equ Cell Volts' setpoint is used to set the battery cell voltage during the equalization charge stage. During the equalization charge, this voltage is used instead of the 'Batt Bulk Cell Chg Volts' set point in the standard charging cycle in Figure 29.

There are two ways an equalization charge stage can be completed. Either the charging current drops below the current specified by the 'Batt Min Equ Chg' set point or the time specified by the 'Batt Equ Chg Period' expires. Whichever of these two criteria occurs first will complete the equalization charge stage. This is analogous to the bulk charge completion criteria explained in section b.ii.

A. DRI 10 Specifications

A.1 System Specifications

Table 9: DRI-10 Key Specifications.

General Specifications	
Real Power Rating	10kW
Inverter Technology	4-port PWM with central DC bus
Size and Weight (w,d,h)	19.69"(500mm) 15.75"(400mm) 74.73"(1900mm), 520lbs
Enclosure Rating	NEMA 3
Power Ports	4 (Grid (AC), Load (AC), Battery (DC), PV (DC))
Battery Port Specifications	
Voltage Range	150 - 600 VDC ¹
Power	10kW bi-directional with 150% overload capability for 10 seconds width 10 minute duty cycle
Charging Modes	Bulk, Float, Equalize, Constant current and Constant Voltage, Temperature Compensation with fully adjustable parameters
Max Short Circuit Current	5000A
PV Port Specifications	
Voltage Range	150-600 VDC ¹
Full Power Voltage Range	300 - 600 VDC ¹
MPPT Range	260 - 590 VDC ¹

¹ The power terminals on the DRI can be configured and programmed; contact PPS to discuss your application

Grounding	Positive or negative
Load Port Specifications	
Power Format	3 wire, 2 phases: L-N 120Vrms, L-L 240Vrms
	OR: 3 wire, 2phases, L-N 120Vrms, L-L 208Vrms
Output Frequency	60Hz (57 Hz - 63Hz) ¹
Voltage Range	+10%/-12% of nominal ¹
Power Rating	12.5 kVA (6.25 per phase) with 150% overload capability for 10 seconds with 10 minute duty cycle
Real Power Rating	10 kW (5kW per phase) with 150% overload capability for 10 seconds with 10 minute duty cycle
Load Deactivation	Up to 4 load priority levels
Grid Port Specifications	
Power Format	3 wire, 2 phases: L-N 120Vrms, L-L 240Vrms
	OR: 3 wire, 2phases, L-N 120Vrms, L-L 208Vrms
Output Frequency	60Hz (57 Hz - 63Hz) ¹
Voltage Range	+10%/-12% of nominal ¹
Power Rating	12.5 kVA (6.25 per phase) with 150% overload capability for 10 seconds with 10 minute duty cycle
Real Power Rating	10 kW (5kW per phase) with 150% overload capability for 10 seconds with 10 minute duty cycle
Reactive Power Rating (Total)	5kVA @ 10kW, 7.8kVA @ 8kW, 9.5kVA and 6kW, 10kVA @ <5kW

Harmonics	< 5% THD (IEEE 1547 Compliant ²)
Control	Electronically controlled connect and disconnect with full anti-islanding functionality (UL1741) ²
Other Features and Specifications	
Automatic Generator control	Starting and stopping
Parallel operation	Up to 8 DRI-10 can have AC ports paralleled for total of 80kW
GFDI	Optionally integrated GFDI unit
Peak DC to Grid efficiency	98%
CEC PV to Grid efficiency	96.50%
Night time Tare Losses	<25W
Signal Inputs and Outputs	3 digital outputs, 5 digital inputs
Communication Ports	Ethernet, USB, RS485 and RS232 MODBUS.
Temperature Operating Range	-10°C to +40°C
Temperature Storage Range	-20°C to +60°C
Humidity	5 - 95%
Rated Maximum Elevation	5000t

² UL certification Pending

B. Return Material Authorization, Contact, and Product Information

A.2 Return Material Authorization Policy

Before returning a product directly to PPS, you must obtain a Return Material Authorization (RMA) number and the correct factory "Ship To" address. Products must also be shipped prepaid. Product shipments will be refused and returned at your expense if they are unauthorized, returned without an RMA number clearly marked on the outside of the shipping box, if they are shipped collect, or if they are shipped to the wrong location.

When you contact PPS to obtain service, please have your instruction manual ready for reference and be prepared to supply:

- The serial number of your product
- Information about the installation and use of the unit
- Information about the failure and/or reason for the return
- A copy of your dated proof of purchase

Record these details on page 71.

A.3 Out of Warranty Service

For information regarding out of warranty service, contact a PPS Customer Service Representative.

A.4 Contact Information

Corporate Headquarters
Princeton Power Systems
3175 Princeton Pike
Lawrenceville, NJ 08648
USA

Tel. +1 609.955.5390
Fax. +1 609.751.9225
Email. info@princetonpower.com

Technical Support
Email. support@princetonpower.com
Tel. +1 609.955.5390

Sales
Email. sales@princetonpower.com
Tel. +1 609.955.5390

www.princetonpower.com

A.5 Information About This System

Record the following information and be sure to keep your proof of purchase.

- Serial Number _____
- Purchased From _____
- Date of Purchase _____

If you need to contact Customer Service, please record the following details before calling. This information will help our representatives give you better service.

- Type of installation (e.g. PVwith storage, EV Charging, Microgrid) _____
- Length of time inverter has been installed _____
- Battery/battery bank size _____
- Battery type (e.g. PbA, LiPh, PbC, other) _____
- DC wiring size and length _____
- Alarm sounding? _____
- Description of indicators on front panel _____
- Appliances operating when problem occurred _____
- Description of problem _____