
Bidirectional Optimizer for Storage Systems (BOSS)

A unique DC-DC Optimizer to help medium and large Energy Storage Systems (ESS)

INSTALLATION, OPERATION AND MAINTENANCE MANUAL FOR
USE WITH THE BOSS 1000 AND 1500

PM003 Revision 12



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2 General Information

All efforts have been made to ensure the accuracy of material provided in this document at the time of release. Items are subject to continuous development and improvements. All specifications and descriptions are subject to change without notice.

2.1 Purpose

This manual provides information about installing, operating, maintaining, and troubleshooting the Alencon's BOSS PV Harvesting System.

Who Should Read this Manual?

This manual should be read by anyone who needs to:

- Understand the product
- Plan the installation
- Install the product
- Commission the product
- Operate the product
- Maintain the product, if necessary

2.2 Glossary

Word(s)/Acronyms	Definition
BOSS	Bi-directional Optimizer for Storage Systems
SPOT	String Power Optimizer and Transmitter
ACE	Alencon Communication Environment – a communication system containing hardware and software elements provided by Alencon to control power conversion equipment.
HUB	Alencon Communication, Monitoring and Control Software

2.3 Product Warranty

Alencon Systems warrants to you, the original purchaser, that each of its products will be free from defects in materials and workmanship for five years from the date of purchase. Extended warranties of an additional five (5), ten (10) and twenty (20) years are also available for purchase.

This warranty does not apply to any products which have been repaired or altered by persons other than repair personnel authorized by Alencon System, or which have been subject to misuse, abuse, accident or improper installation. This warranty does not cover the repair or replacement of any goods which fail as a result of damage in transit, misuse, neglect, accident, Act of God, abuse, improper handling, misapplication, modification, improper storage, excessive stress, faulty or improper installation, testing or repair, negligent maintenance or failure to comply with the written instructions for installation, testing, use or maintenance (if any) provided by Alencon Systems. Alencon Systems assumes no liability under the terms of this warranty as a consequence of such events.




Because of Alencon Systems' high quality-control standards and rigorous testing, most of our customers never need to use our warranty service. If an Alencon Systems product is defective, it will be repaired or replaced at no charge during the warranty period. For out-of-warranty repairs, you will be billed according to the cost of replacement materials, service time and freight. Please consult Alencon Systems for more details. If you think you have a defective product, follow these steps:

1. Collect all the information about the problem encountered. (For example, issues you are encountering in your PV array or battery system) Note anything abnormal when the problem occurs.
2. Call Alencon Systems or your licensed Alencon Systems dealer and describe the problem. Please have your manual, product, and any helpful information readily available.
3. If your product is diagnosed as defective, obtain an RMA (return merchandise authorization) number from your Alencon Systems. This allows us to process your return more quickly.
4. Carefully pack the defective product (preferably in the original packaging material it was shipped in), a fully-completed Repair and Replacement Order Card and a photocopy proof of purchase date (such as your sales receipt) in a shippable container. A product returned without proof of the purchase date is not eligible for warranty service.
5. Write the RMA number

2.4 Technical Support and Assistance

1. Visit the Alencon Systems web site at www.alenconsystems.com where you can find the latest information about the product.
2. Contact your distributor, sales representative, or Alencon Systems' customer service center for technical support if you need additional assistance. Please have the following information ready before you call:
 - Product name, LIN and serial number (see section 6.5 for more information the location of the LIN and serial number)
 - Description of your peripheral attachments including fusing and cables

2.5 Warnings, Cautions and Notes

	Warning!	<i>Warnings indicate conditions, which if not observed, can cause personal injury!</i>
	Caution!	<i>Cautions are included to help you avoid damaging hardware or losing data.</i>
	Note!	<i>Notes provide optional additional information.</i>

2.6 Packing List

Before installation, please ensure the following items have been shipped:

- Correct # of BOSS Units specified for your PV System with appropriate mounting hardware
- 1 x Warranty Card



Bi-Directional Optimizer for Storage Systems

This unit provides a maximum of 4 inputs and 4 outputs.

Figure 1: The BOSS unit

2.7 Ordering Information

Model Number Description

Model Number	Description
<i>BOSS-1000-X4</i>	Bidirectional Optimizer for Storage Systems for 600 & 1000V PV Systems
<i>BOSS-1500-X4</i>	Bidirectional Optimizer for Storage Systems for 1500 V Systems

3 IMPORTANT SAFETY INSTRUCTIONS



WARNING!

SAVE THESE INSTRUCTIONS– This manual contains important instructions for use with the BOSS 600, 1000 and 1500 that shall be followed during installation and maintenance of these devices.



Figure 2: The graphic above indicates that the BOSS is a grounding conductor.



WARNING!

Always ground the BOSS enclosure before energizing the unit. Use the Ground Lug shown in Figure 3 below on the BOSS to ground the unit safely.

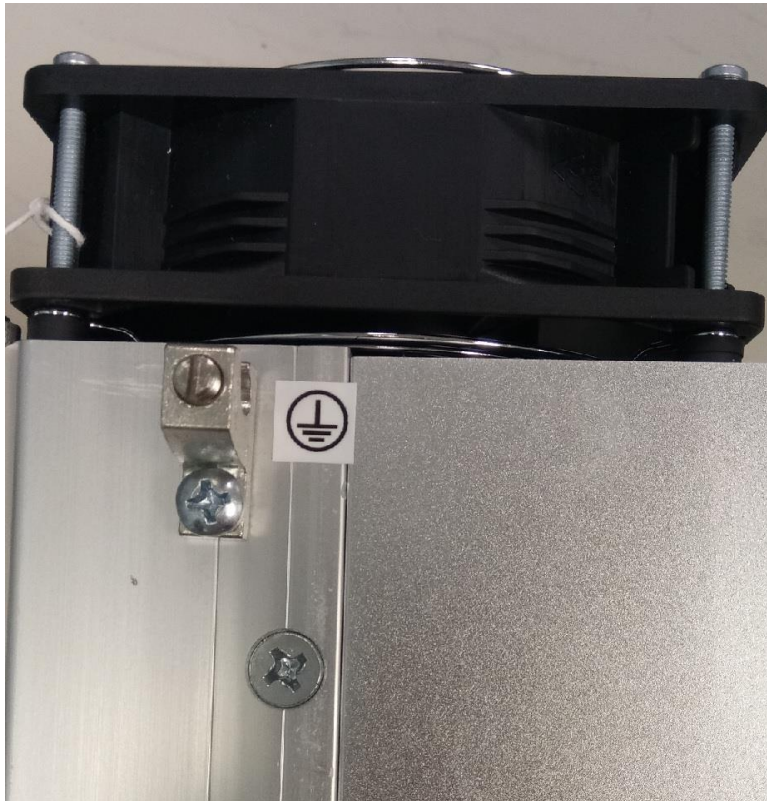


Figure 3: Ground Lug located on the BOSS Unit



WARNING!

A BATTERY CAN PRESENT A RISK OF ELECTRICAL SHOCK, BURN FROM HIGH SHORT-CIRCUIT CURRENT, FIRE OR EXPLOSION FROM VENTED GASES. OBSERVE PROPER PRECAUTIONS.



Figure 4: The graphic above indicates that the BOSS acts as a direct current supply.



Caution!

Do not disconnect input or output contactors or switches while equipment is operating. Shutdown the DC:DC converter by sending “Shutdown” command via communication.



Caution!

1. Installation of this equipment must be performed by an authorized electrician in accordance with the local and NEC ANSI/NFPA 70 and OSHA requirements. Follow CSA C22.1 when installed in Canada.
2. Before installing and using the BOSS, read all instructions presented in this manual and the cautionary markings shown on the BOSS's enclosure.
3. The BOSS contains no user-serviceable parts. For service and maintenance, the BOSS should be returned to Alencon Systems LLC or a certified Alencon Systems service center.
4. During operation, hazardous voltages and currents may be present. Only authorized and qualified personnel should perform servicing/installation.
5. The metallic enclosure surface may become hot during certain operation circumstances.
6. The BOSS 600, 1000 and 1500 requires external fusing. This requirement is explained in detail in Section 8.2 of this manual “Fusing for Input & Output Wiring”.
7. Test any wire or terminal for the voltage before touching them. Disconnect all input and output terminals before performing any work on the equipment.

8. Use only accessories recommended or approved by the manufacturer.
9. Ensure that wiring is in good conditions and that all wiring is sized accordingly. Ignoring to do so may result in a risk of fire.
10. PV modules produce electrical energy when exposed to light and thus can create an electrical shock hazard. Wiring of the PV modules should only be performed by qualified personnel.
11. Always have BOSS manual in hand.

4 Introduction

4.1 Energy Storage Systems Benefits

Energy Storage Systems (ESS) is actively advancing into the portfolio of equipment being offered by the Renewable Energy Industry. In both new and existing PV installations, ESS helps to overcome intermittency – a major shortcoming of solar and wind as sources of energy. With ESS, solar power becomes available on demand, just the same as conventional generation means such as coal and gas. Today, the majority of ESS deployed and being deployed utilize Lithium Ion battery technology. The cost of batteries has significantly fallen in the past few years while the need for energy storage capacity has increased due to the increased levels of renewables on the Grid. These dynamics have made the case for ESS adoption very attractive.

4.2 Energy Storage Systems Challenges

Many megawatt-hours of alternative energy can be stored in large containers filled with Lithium Ion batteries. Individual battery cells are assembled into modules, modules into racks (stacks) and racks into containers. A large amount of energy is packed in one space and presents a danger of a potential explosion if conditions of safe charge and discharge are violated or general deterioration of battery condition is not detected.

4.3 Potential Hazards

Each high voltage battery rack has a positive and negative terminal isolated from the battery case. If all the positive terminals are connected together and all the negative terminals are connected together then in the case of a short on one of the battery racks, the rest will rapidly discharge their stored energy into a shorted component causing a huge current reaching tens of thousands of amperes and risking an explosion. The isolation deterioration of the battery cells to the grounded case is one of the major factors of fault in the battery rack that may cause fault current.

4.4 State-of-Charge and State-of-Health

The capacity of lithium ion batteries to store and discharge electrical energy is measured in MWh or KWh. The amount of *releasable* charge the battery contains at any given time relative to full capacity of a battery is called State-of-Charge (SOC) and is measured in percentiles:

$$SOC = \frac{C_{\text{releasable}}}{C_{\text{max}}} 100\%$$

As batteries age over time as they experience a number of charge/discharge cycles. As such, their capacity to hold charge diminishes. The degree of degradation of the battery measured as a percentage of current full capacity to the initial rated capacity is called State-of-Health (SOH) and is measured in percentiles:

$$SOH = \frac{C_{\text{max}}}{C_{\text{rated}}} 100\%$$

To prevent overcharge or full discharge all battery racks should maintain the same SOC. This means that charge/discharge current should be controlled according to their SOH.

5 BOSS Features

5.1 BOSS- Bi-Directional Optimizer for Storage Systems

Alencon's BOSS is an integral part of multi-rack Electrical Storage System (ESS) that increases the utilization of the battery, extends battery life and improves safety.

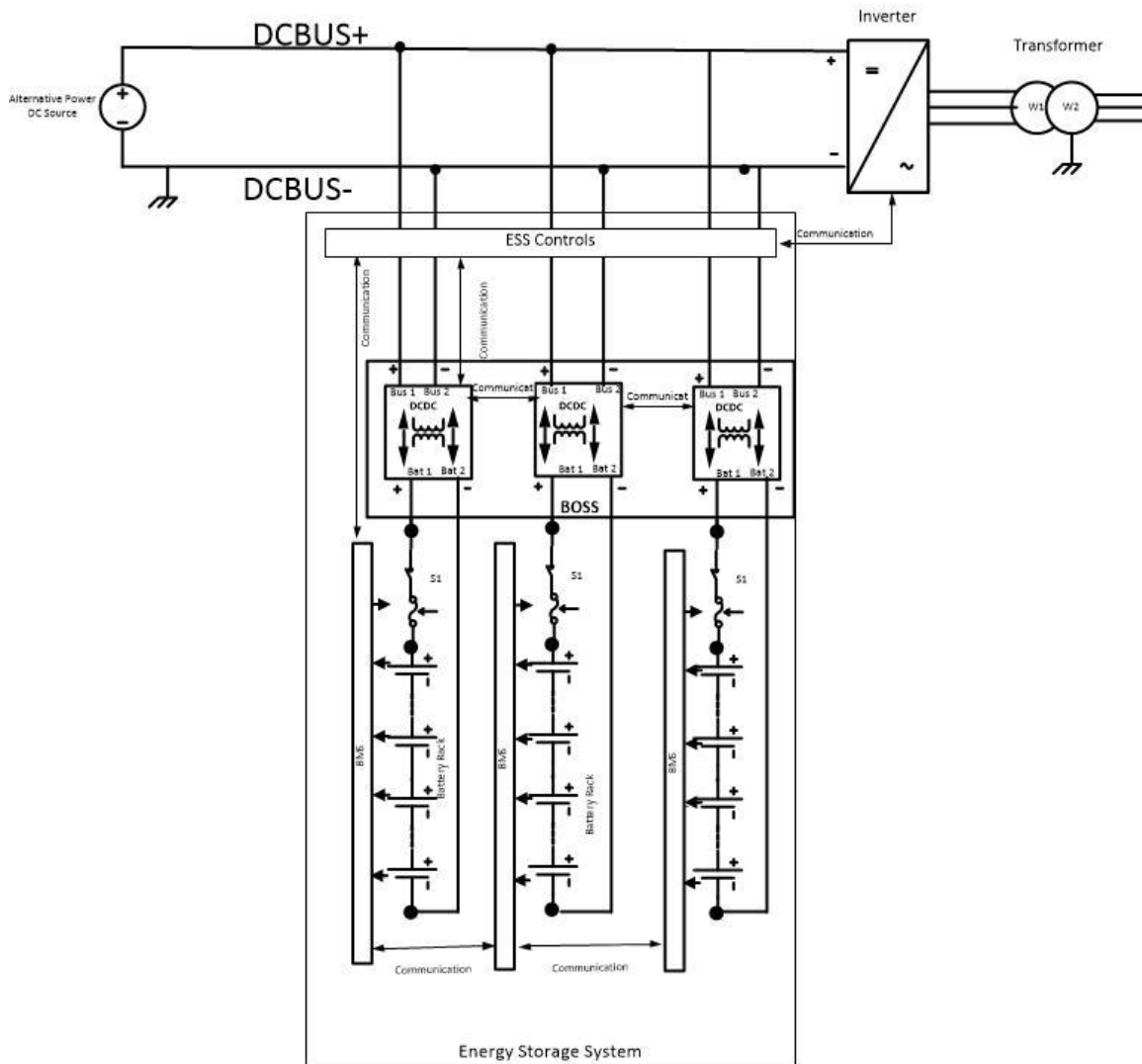


Figure 5: ESS with BOSS

The BOSS is comprised of several DC-to-DC converter units (DCDC) that are connected between a common DC BUS and each individual battery string (rack). Each DC-DC converter autonomously controls the charge and discharge current into a battery rack.

5.2 Galvanic Isolation

The main safety feature of the BOSS is the galvanic isolation incorporated in each DCDC. Due to galvanic isolation each battery rack is isolated from the DC BUS, the common earth ground, and from each other up to 2500 VDC potential. This means that in case of a fault in one rack, the remainder stays completely isolated from the other racks preventing catastrophic fault currents.

5.3 Ground Leak Detection

Many installed PV systems are negatively grounded at the suggestion of the PV panel manufacturer (though some PV panels do require positive grounding). Additionally, guidance from the National Electrical Code (NEC) and certain AHJ rulings also encourage PV arrays to be grounded, as opposed to being allowed to “float.”

By contrast, today's large-scale battery energy storage systems are generally "floating" or ungrounded. Alencon's BOSS leverages the inherent properties of galvanic isolation to provide the customers with a "**Ground leak Detection**" feature.

By continuously monitoring the system's differential voltage, BOSS ground-fault detectors can provide early indication of ground faults before leakage becomes prominent. Galvanic isolation of each battery rack allows each DCDC to measure the isolation resistance from a positive battery terminal (BAT 1) and negative battery terminal (BAT2) to the earthed chasses and compute the leakage current from these terminals.

If the leakage current becomes excessive the ESS may disconnect the DCDC and associated rack from the system.

5.4 Communication

The DC units communicate among themselves and with the ESS controller via an industry standard MODBUS RTU protocol. (An optional MODBUS TCP-IP is available via PODB communication controller). The ESS controller collects the SOC and SOH information from the BMS associated with batteries in the racks as well the power information from the inverter and DC Bus. Based on this information ESS controller assigns the magnitude of the charge or discharge current to each DCDC. The purpose is to keep the same SOC on each rack regardless of its SOH. This way all battery racks can be fully charged and discharged at the same time, thus assuring full utilization of battery capacity.

5.5 Parallel Operation

Each DCDC is designed for a specific maximum current. If a battery rack requires more current than a DCDC can provide, two or more DCDC may be paralleled. Each DCDC should be provided with a separate fuse and disconnect. The ESS controller should be programmed to recognize BOSS configuration.

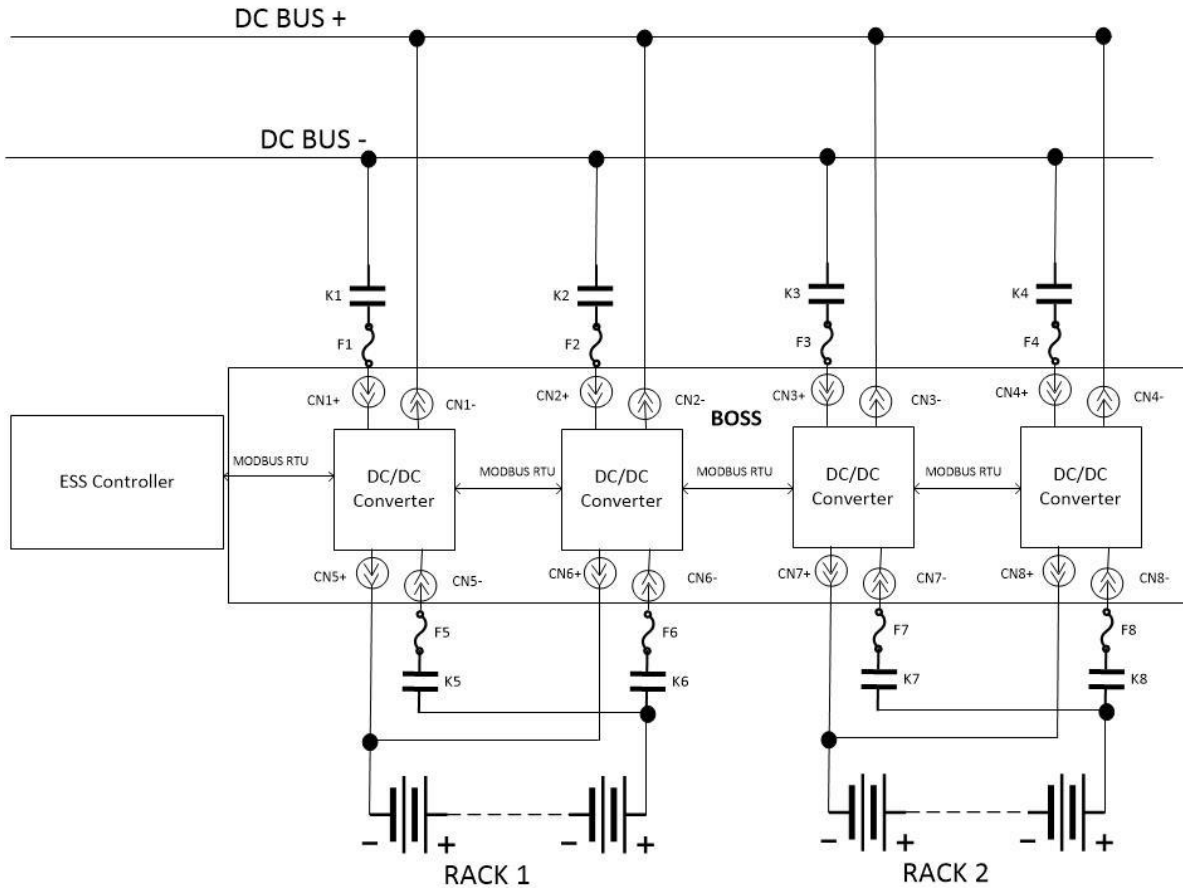


Figure 6: Parallel connection of DCDC - 2 DCDC's connected to a single battery rack.

6 BOSS Operation



Caution!

Do not disconnect input or output contactors or switches while equipment is operating. Shutdown the DC:DC converter by sending “Shutdown” command via communication.

The BOSS is packaged in to a 19” rack mounted enclosure for use inside a battery container or in an IP65 extruded aluminum enclosure for outdoor use. It comprises of four DCDC converter units, each with its own input and output connections. Alencon provides two types of DCDC converters: BOSS-1000 rated at 1000 VDC max and BOSS-1500 rated at 1500 VDC max.

Each DCDC generates charge current (from BUS to BATTERY) or discharge current (from BATTERY to BUS) according to commands it receives from the ESS controller.

6.1 BOSS Controls

Each DCDC included in the BOSS has an independent Sic MOSFET full bridge power inverter/rectifier on the DC BUS side and another Sic MOSFET full bridge power inverter/rectifier on the Battery side. Both power bridges are linked by a deployment specific, high frequency

transformer. The transformer provides the galvanic isolation as well as mapping of the bus and battery voltages.

Both power bridges are fully microcomputer controlled. The microcomputer also monitors the bus voltage and the battery voltage.

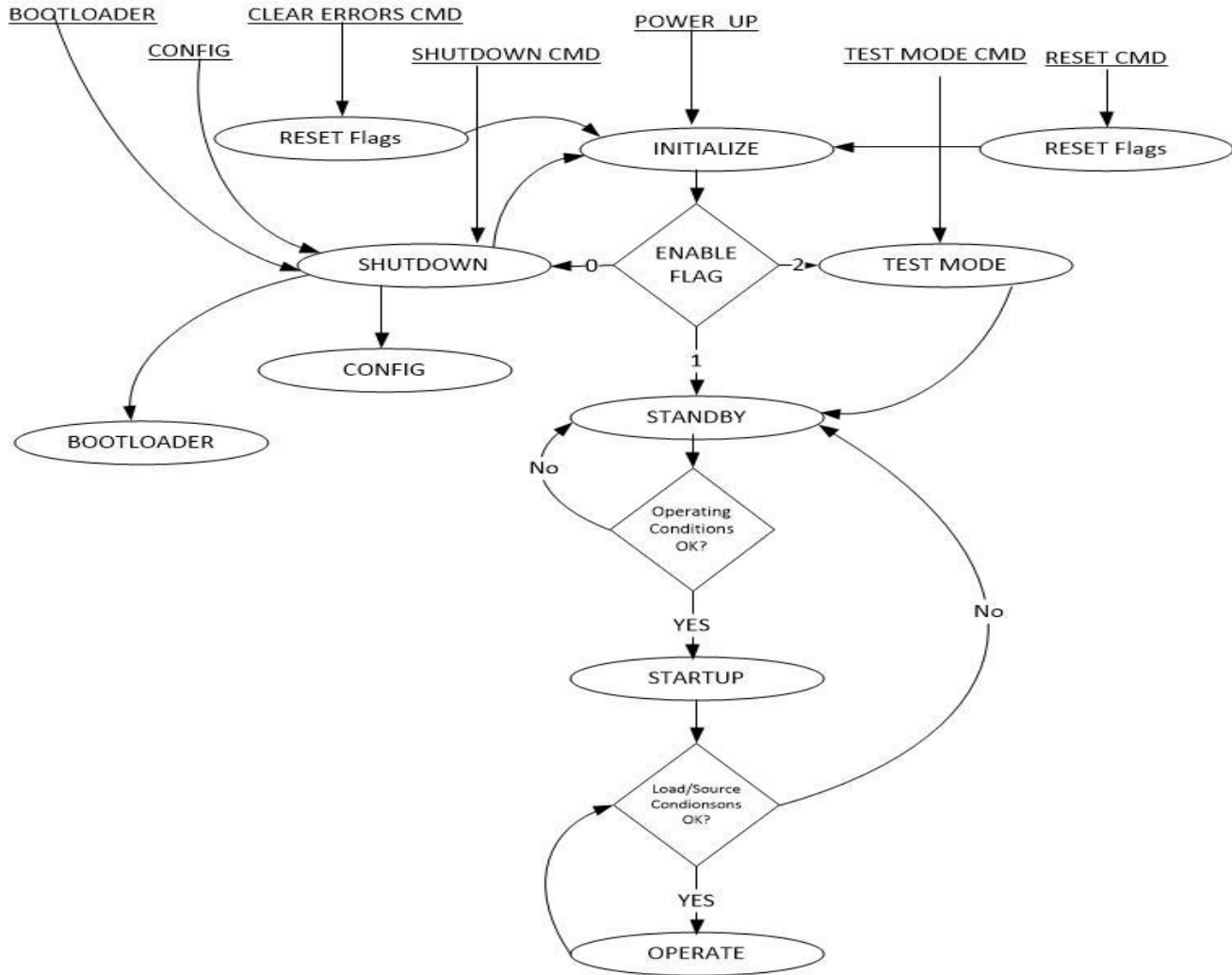
The BOSS receives commands like current direction (charge/discharge) and current magnitude from ESS controller. It DCDC communicates with the ESS controller via MODBUS-RTU.

6.2 STATE Machine

DCDC controls operate as a state machine with states:

- INITIALIZE
- STANDBY
- STARTUP
- BOOTLOADER
- RUN

These states are explained in greater detail in Table 3 of section 7.4 below.



6.3 Technical Specifications

Model	BOSS – 1000	BOSS – 1500/1000	BOSS – 1500
Standard Primary Side Voltage Specifications			
Maximum Voltage	1000 VDC	1500 VDC	1500 VDC
Operating Voltage Range ¹	200 - 1000 VDC	300 - 1500 VDC	200 - 1425 VDC
Max Current – 25 C°	100 A	74 A	74 A
Standard Secondary Side Voltage Specifications			
Maximum Voltage	1000 VDC	1000 VDC	1500 VDC
Operating Voltage Range ²	0 - 1000 VDC	0 - 1000 VDC	200 - 1500 VDC

¹ Can be configured to end user requirements using Alencon Systems' mass customization manufacturing approach.

² Can vary based on input and output voltages being mapped, see note above.

Max Current – 25 C°	100 A	100 A	76 A
Unit Power Specifications			
Maximum Power – 25 C°	88 KW	80 KW	80 KW
Maximum Power – 50 C°	67.76 KW	60 KW	60 KW
Efficiency			
Peak Efficiency	98.5%		
CEC Weighted Efficiency	98.0%		
Isolation			
Galvanic Isolation	Yes		
Standards & Compliance			
Certifications	UL1741, IEC 62109-1, CSA C22.2		
Environmental			
Storage Temperature	-40°C to 60°C		
Cooling	Forced Air		
Humidity	0-95%		
Environmental Rating	NEMA 3R & IPP66		
Operating Ambient Temp.	-40°C to 50°C		
Form Factors			
Packaging	Rack or Rail Mounted, Indoor / Rail Mounted, Outdoor		
Size (H x W x D)	Rack Mount: 8U - 14" x 19" x 27"/Rail Mount: 24.8" × 16.5" × 10.6"		
Weight	Rack Mount: 53 KG/Rail Mount: – 51 KG		
Aux Power	24 V available		
Communications	Modbus TCP via Alencon Communications Environment (ACE)		

7 Communication

The communication with the BOSS is carried out via MODBUS RTU. Please contact Alencon for Modbus map information.

8 BOSS Protection

The BOSS's protection functions are grouped into three classes:

- BUS
- Battery
- Environment

8.1 BUS Protection

Protection caused by conditions on any DC-to-DC converter's unit. The conditions parameters are configurable and are stored in the nonvolatile microcomputer memory

8.1.1 Under voltage

The input voltage is too low for normal operation. BOSS enters into STANDBY mode.

8.1.2 Current Limit

Current magnitude is requested by the ESS controller. Current limit is set in the configuration file and overrides the ESS request.

8.1.3 Short Circuit Protection

When in Discharge mode, Rapid shut down of the DC-to-DC converters unit in case of external short.

8.2 Battery Protection

8.2.1 Under voltage

The output voltage is too low for normal operation. This may prevent upstream equipment to operate below its designed limit. BOSS enters into STANDBY mode

8.2.2 Over current

Current magnitude is requested by the ESS controller. Current limit is set in the configuration file and overrides the ESS request.

8.2.3 Short Circuit Protection

When in Discharge mode, Rapid shut down of the DC-to-DC converters unit in case of external short.

8.2.4 Ground Leak Protection

The BOSS monitors leakage to ground and shuts down if excessive ground leakage current is detected.



The Ground Leak Monitoring built into the BOSS is not a certified feature, therefore it does not satisfy the GLDI requirements of the overall system. The system must have an external GFDI device such as GARD (Alencon's Ground Arc Rapid Disconnect) to

meet the ground fault detection/protection requirements. Please see Alencon's GARD for additional information.

8.3 Environmental Protection

The BOSS mechanicals are designed to protect it from extreme external conditions of high temperature and moisture.

8.3.1 Temperature on Power Semiconductor

Monitors the temperature of the Power Semiconductors. Prevents our optimizer from failure.

8.3.2 Microcomputer Temperature

Monitors the temperature on the Microcomputer. Prevents DC-to-DC converter from failure.

8.3.3 Control Board Temperature

Monitors the temperature on the PCB. Prevents DC-to-DC converter from failure.

8.3.4 Humidity

Monitors the humidity inside sealed electronic compartment. Prevents DC-to-DC converter from failure.

9 BOSS Installation

9.1 Understanding BOSS Hardware

The BOSS unit has many different form factors. The form factor is completely dependent on the application and customer requirement. The possible form factors are –

- Rack Mounted
- Cabinet
- Rail mounted Unit

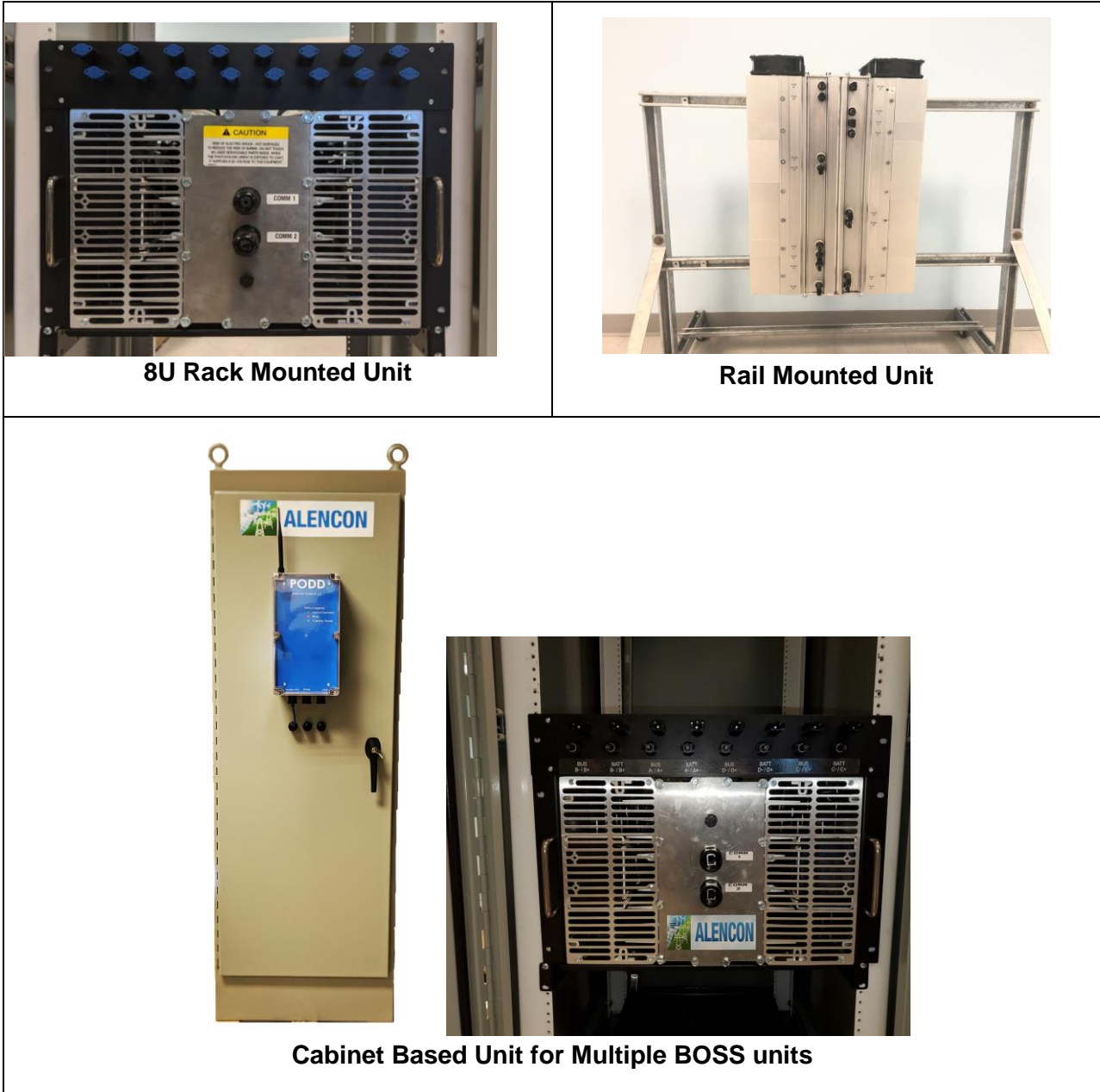


Figure 7: Different form factors of the BOSS

The most common form factor is the 8U rack mounted BOSS unit as shown below



Figure 8: 8U Rack-mounted BOSS UNIT



The unit has four cooling fans. Ensure that there is enough clearance for the fans to have sufficient air flow. Follow BOSS Mounting instructions for more info.

To cater to the many different form factors of the BOSS, Alencon offers a few customizable hardware solutions that will help our customers with installation and integration of the BOSS. These are hardware elements that will have to be purchase separately from Alencon.

The basic external hardware provided to the customer is –

- 4 AWG Single Wire Grounding Mechanical Lug
- Mounting Plate – if BOSS is going to be hung outside or on a Unistrut
- Termination Terminal Block – optional termination scheme
- H4/MC4 Solar Connectors – default termination scheme

9.1.1 BUS & Battery Cable Termination

The BOSS input and output cables have been labelled as BUS and BATT. There are 4 DCDC's within each BOSS labelled serially as A, B, C, and D. Each DCDC contains a single input and single output channel.

Since the BOSS is a bi-directional optimizer that can work in both directions, the connection scheme is flexible i.e.

If,

BUS_A+ } Input then, BATT_A+ } Output
 &
BUS_A- }

Else if,

BUS_A+ } Output then, BATT_A+ } Input
 &
BUS_A- }

Safety Note: After you decide the direction of power flow, please make sure that input and output cables are connected to their commensurate terminal blocks. Any interchange will cause a short and possible damage

H4/MC4 Termination:

The termination requires an H4/MC4 crimping tool to mate the connectors



Figure 9: H4/MC4 Crimping Tool



Figure 10: H4/MC4 Termination

The wires from the cable gland are routed to the H4/MC4 connectors via cable ducts. This is a fairly straight method of terminating the input and output cables without having to deal with DIN rail mounted terminal blocks.

9.1.2 Communication Ports

Each BOSS unit consists of 2 x RJ45, shielded Ethernet jacks. BOSS's are generally co-located and easily daisy chained to a PODD. The BOSS System architecture using a Single PODD configuration is shown below –

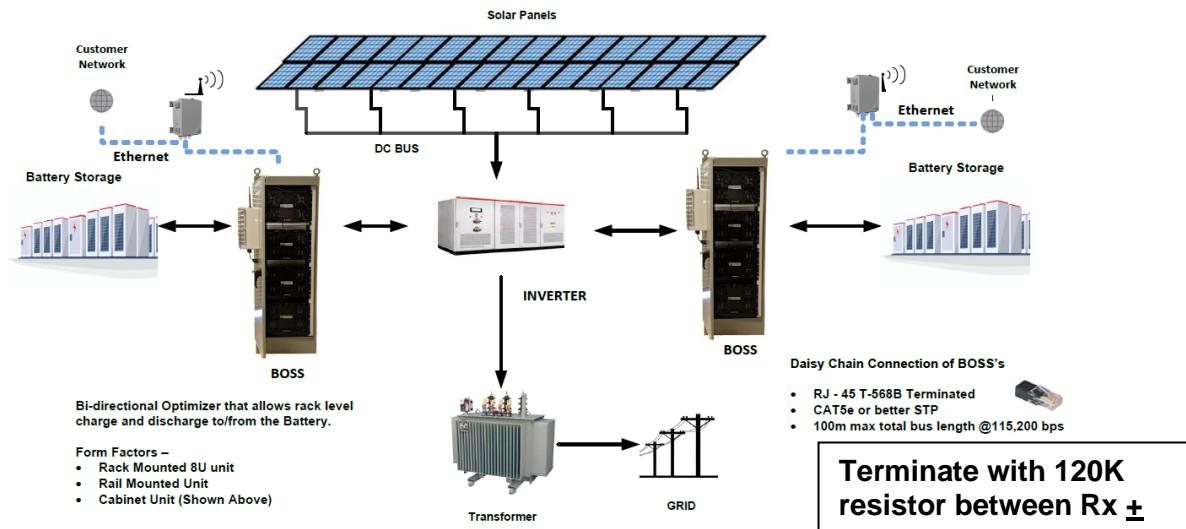


Figure 11: BOSS System Schematic with PODD

9.2 Fusing for Input and Output Wiring

The BOSS input and output wires need to be fused as per BOSS specification. The fusing on the input and output of the BOSS is critical for two reasons –

- Overcurrent Protection/Short Circuit Protection
- Safe Disconnect during Maintenance
- The recommended current rating of the fuses and disconnects is 1.5 times the rated current of the BOSS per channel.
 - For 25 Amp rated input, $25 \times 1.5 = 37.5$, therefore use 40 Amp rated fuse and disconnect per channel.
 - For 18.5 Amp rated input, $18.5 \times 1.5 = 27.75$, therefore use 30 Amp rated fuse and disconnect per channel.

There are several options available to protect the device.

Alencon recommends using –

- Appropriately rated DC disconnects offered by Alencon Systems
- Appropriately rated DC disconnects offered by External Supplier
- Alencon's **G**round **A**rc **R**apid **D**isconnect (GARD)

10 Alencon Communication Environment (ACE) Setup

The ACE is a communication system containing hardware, and software elements provided by Alencon to control power conversion equipment.

- Hardware Element – PODD
- Software Element – HUB

10.1 PODD Installation

10.1.1 Installation Options

Single PODD

A single PODD is installed at one end of a daisy chained RS-422 network. The total length of the RS-422 network should not exceed 100 meters. An antenna will be included for each PODD if wireless package is purchased.

Multi PODD

The centralized PODD will be stand-alone and installed in a central location. The PODD is powered through the 120VAC to 24VDC power supply and POE injector included in the Wi-Fi access point kit. Each distributed PODD will be installed at one end of a daisy chained RS-422 network using an STP CAT5e cable. For a wired network, all distributed PODDs will be daisy chained together, ending with the centralized PODD. If the wireless package is purchased, an antenna will be provided for each distributed PODD and a Wi-Fi access point will be used for the centralized PODD.

10.2 Installation Criteria

The following information should be considered when selecting the topology and the locations for installation of PODDs:

- **Field Size**
- **Application**

Technical support will be provided when purchasing the ACE system to ensure the best PODD configuration is selected for your application.

10.3 PODD Mounting

Each PODD will be shipped with the mounting bracket already installed.

10.3.1 PODD Mounting Location

The distributed PODDs will be mounted near the Alencon devices while the central PODD will be mounted close to the inverter.

10.3.2 Mounting Parts

The PODD can be easily mounted using standard Unistrut® along with spring loaded channel nuts. The attached hook shaped bracket allows for the PODD to be easily hung on the unistrut and then fastened using a Hex head screw. More details on mounting the PODD can be found in the PODD user manual.

10.3.3 Podd Setup

PODDs are accessed remotely over your local server using IP addresses. For the initial setup, download a network IP scanner of your choice. A recommended IP scanner is *Angry IP Scanner* which can be downloaded from <https://angryip.org/download/>. Once installed and opened, your local IP Range should automatically be set. Hit the start button to scan your local network for PODDs.

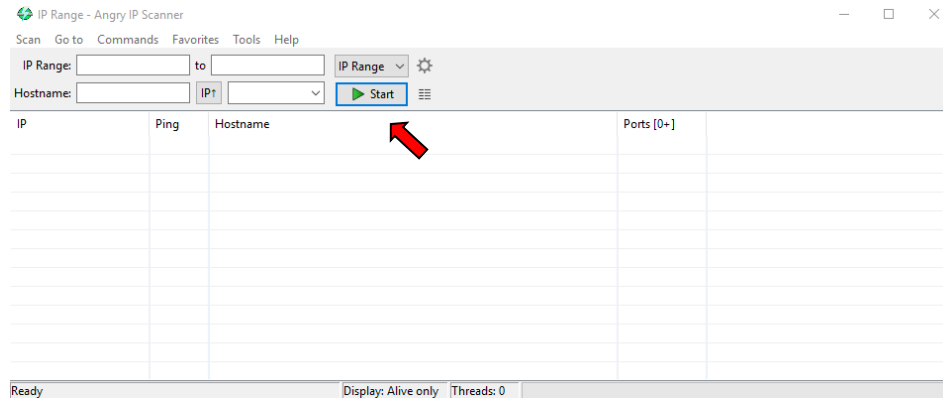


Figure 12: Angry IP Scanner Interface

When a PODD is found, it will appear under the “Hostname” column as PODD-xxxx where the ‘xxxx’ will be the last four digits of its serial number. Locate the IP address of that PODD and type the IP address followed by: 8888 (ex. 123.456.789.012:8888) ; Into the URL bar of your favorite web browser. The PODD setup should then be completed and the HUB should start running. For questions regarding the HUB, please refer to the Alencon HUB manual.

NOTE: All PODDs must be powered during setup and the Centralized PODD must be set up first.

For further information regarding PODD installation, mounting and wiring, please refer Alencon’s PODD manual.

10.4 Communication Interface – “The HUB”

Alencon Systems offers a piece of software called the **Harvesting Unit Block (HUB)** that two-way communication between the ACE hardware i.e. PODD and Alencon’s DC_DC optimizers and DC Interrupters.

10.5 HUB Features

The HUB has 6 tabs –

- Alencon Devices
- Config Update
- Firmware Update
- Maintenance
- Factory test
- Settings



Changes made to these pages would require Alencon Supervision/Training

10.5.1 Alencon Devices Tab

The current version of the HUB provides DCDC information that can be accessed using the commensurate GUID associated with the board. Each BOSS contains 4 DCDC’s each with a separate GUID.

Local HUB - Alencon Devices

Home **Alencon Devices** Config Firmware Update Maintenance Factory Test Settings

Device List

	GUID	LIN	Status
⊕	6472321810186656834	10.1	DEFAULT
⊖	234567	11.1	DEFAULT
⊖	6404767798529689666	12.1	undefined
⊖	456789	13.1	undefined
⊖	567890	14.1	DEFAULT
⊖	678901	15.1	DEFAULT
⊖	789012	16.1	DEFAULT
⊖	8462827794241423104	8.1	DEFAULT

Device Information

Parameter	Value
status	DEFAULT
timestamp	00:00:00.000
guid	6472321810186656834
short_address	1
module_temperature	0
string_id	0
lin	10
device_type	SPOT

Device Command

Target: /All DCDCs - LIN 10 ▾

Command: System Reset ▾

DCDC Data

Telemetry	Value
status	DEFAULT
string_id	0
timestamp	00:00:00.000
error_code_telem	
input_current	0
input_voltage	0
onboard_temperature	0
transistor_temperature	0
output_current	0
output_voltage	0
input_power	0
output_power	0
ground_leak_current	0
dcdc_gate_freq_hz	0
ac_current	0
input_voltage_upper	0
input_voltage_lower	0
mpp_status	0
aux_5volts	0
aux_12volts	0
aux_3_3volts	0

Figure 13: HUB Webpage

10.5.2 Device Commands

- Provides granular control of DCDC’s within a BOSS
- Commands can be sent to a single DCDC or the whole installation of BOSS units.

10.5.2.1 Device Target Selection

Select the DCDC/BOSS to command. The targets available are:

1. DCDC GUID's: Send a command to the individual DCDCs within a BOSS
2. Field Broadcast: Broadcast the command to all the BOSSs in the list i.e. all the GUID's will receive the command

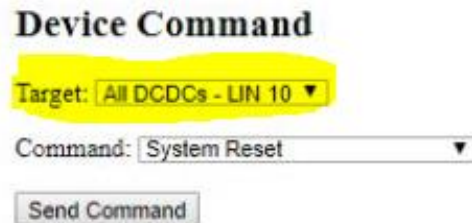


Figure 14: Different targets that can be selected

10.5.2.2 Device Command Selection

The HUB provides a broad set of operational and diagnostic commands. Do not use unlisted commands unless instructed to do so by Alencon personnel. **Failure to do so may damage the BOSS and void the warranty.**

Customer specific commands –

1. System Reset - Restarts the BOSS and enables Run if in the Shutdown state.

Note: BOSS will not transition to start or soft pre-charge without receiving the power direction and the current set point

2. Shutdown – Disables power production. The BOSS or DCDC must receive a System Reset command to enable Run.
3. Clear Fault - This command clears all error flags on the target selected.

Note: It is not necessary to clear faults for the BOSS to run.

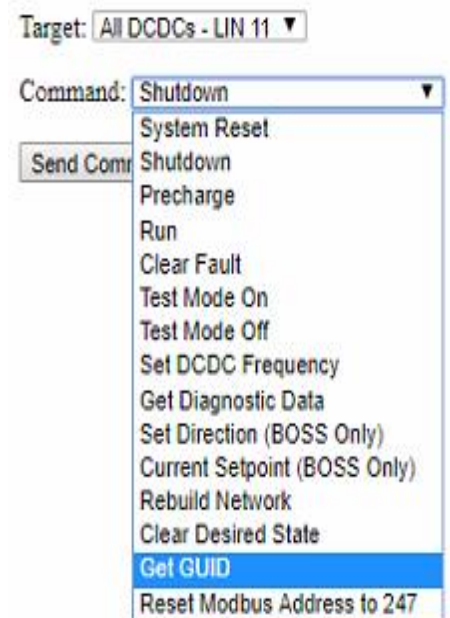


Figure 15: Different Commands for the BOSS

4. Set BOSS Direction – This command will decide if the BOSS is going to RUN from BATT to BUS or from BUS to BATT.

Note: BOSS Default Setup considers the BUS as input and BATT as Output

5. Current Set-Point – this command sets the current required to be drawn from the source
6. Reset Modbus address to 247(Default) – This command resets the Modbus address of the BOSS within a page to default. The customer would then have to re-define the Modbus addresses of each DCDC using the “**metadata**” file available in the **HUB** folder. The file must be edited using Notepad++ or any other text editors (**contact Alencon for training on this**).

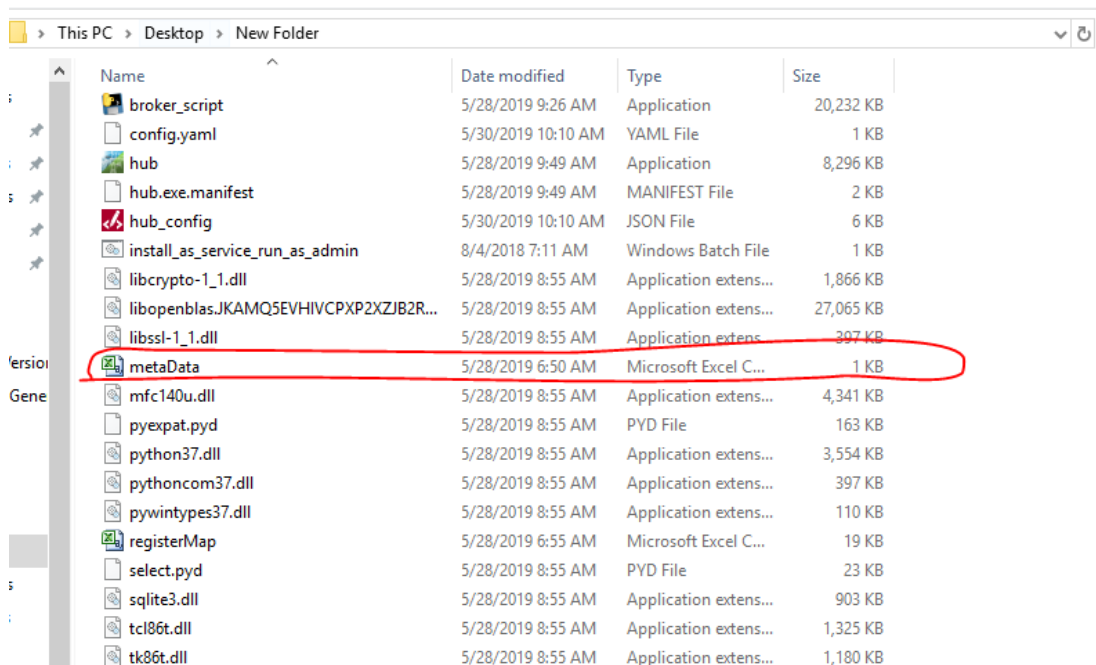


Figure 16: Metadata File containing comm. details - Modbus address, GUID etc.

10.5.3 Config Tab

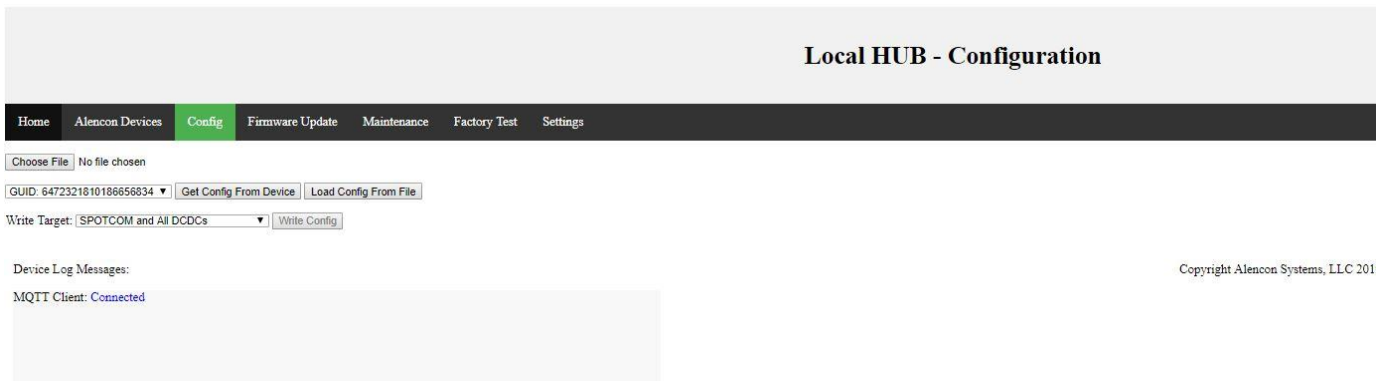


Figure 17: Configuration Tab

The Config Tab allows the user to update the configuration on the BOSS. BOSS configuration is provided to the user in a .factory file as seen below. This file contains specific parameters for your customized BOSSs. Do not edit these parameters unless asked to do so by Alencon personal. Failure to follow these instructions may damage the BOSS and will void your warranty.

Name	Date modified	Type	Size
BOSS_factory_config_5_22_19.factory	5/22/2019 3:31 PM	FACTORY File	3 KB
BOSS-Direction.JPG	5/24/2019 1:10 PM	JPG File	118 KB
Current_Setpoint.JPG	5/24/2019 1:11 PM	JPG File	133 KB
Firmware_Update.JPG	5/24/2019 1:09 PM	JPG File	159 KB
HUB_General.JPG	5/24/2019 1:07 PM	JPG File	120 KB
Log_Messages.JPG	5/24/2019 1:08 PM	JPG File	177 KB

Figure 18: Configuration factory file to be uploaded to BOSS

The BOSSs are selected by GUID (The BOSS LIN can be found the BOSSs tab). Configuration can be sent to the whole field or a single DCDC:

- **BOSSCOM and All DCDCs:** Configures all DCDCs and communication on the selected BOSS
- **BOSSCOM:** Configures communication on the selected BOSS
- **DCDC 1 - 4:** Configures the individual DCDC on the selected BOSS
- **All BOSSs (BOSSCOM and DCDCs):** Configures all DCDCs and communication in the entire field

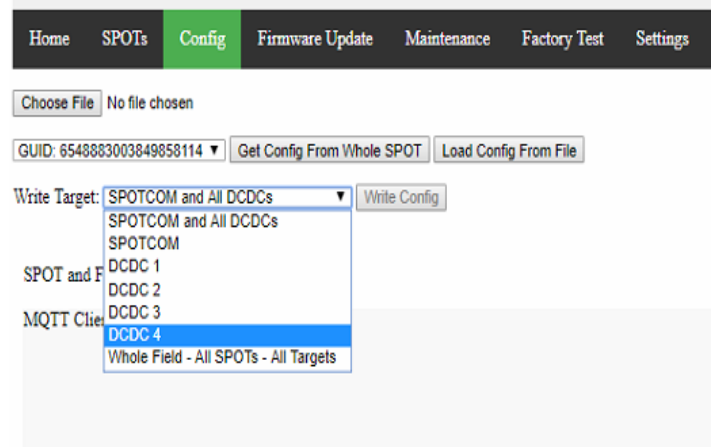


Figure 19: Available DCDC targets

Steps to send a configuration file to the BOSS

Step 1: Choose the file you would like to send to the BOSS. This file has a **‘.factory’** extension. Note: The factory file is a standard json object that is viewable with any text editor.

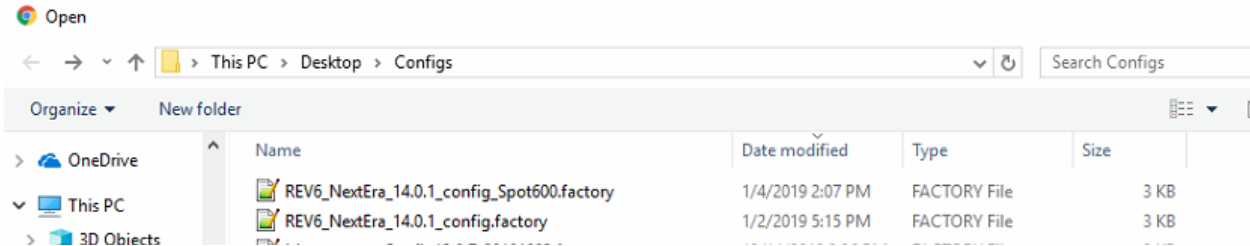


Figure 20: Folder containing .factory files for Alencon products

Step 2: Select the GUID of the target BOSS. The LIN to GUID mapping can be found on the BOSSs Tab.

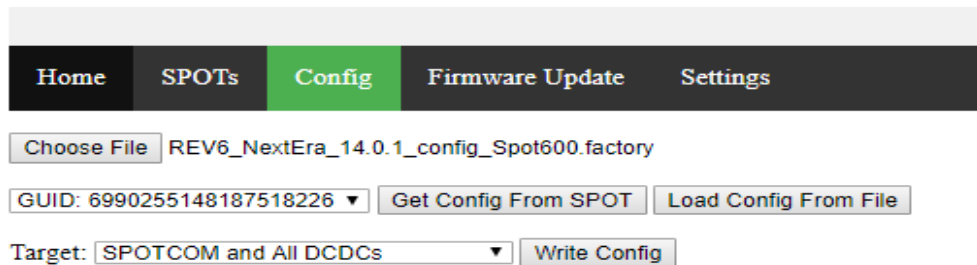


Figure 21: Configuration page upload steps

Step 3: Once you load the **“Config”** file, you will have the option to modify the parameters without editing the file if necessary. Only do this if instructed to do so by Alencon.

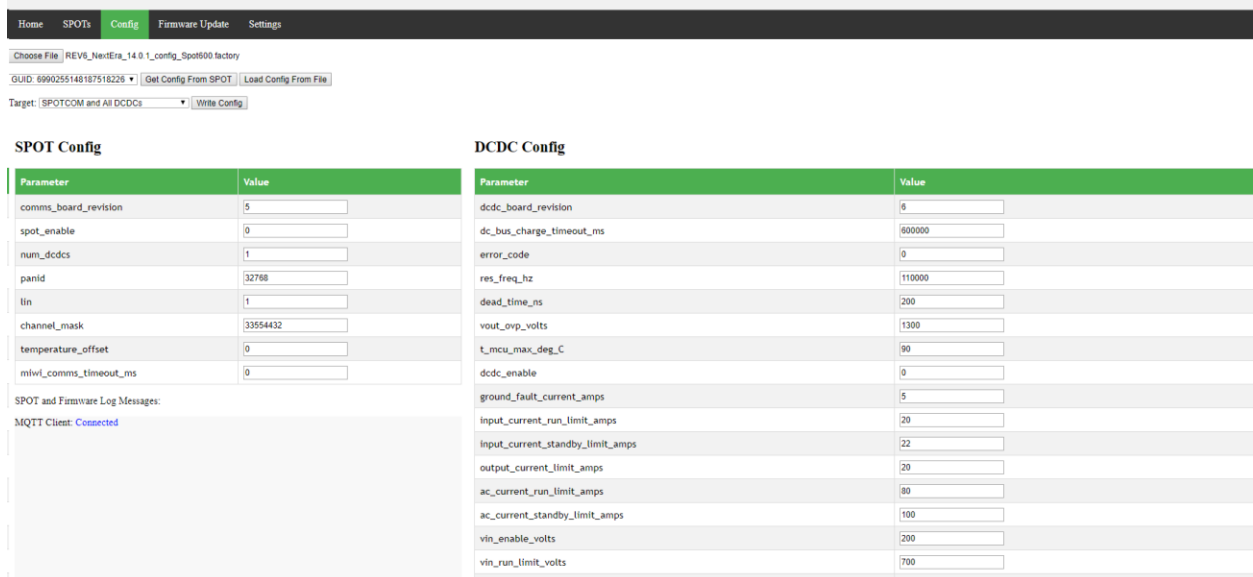
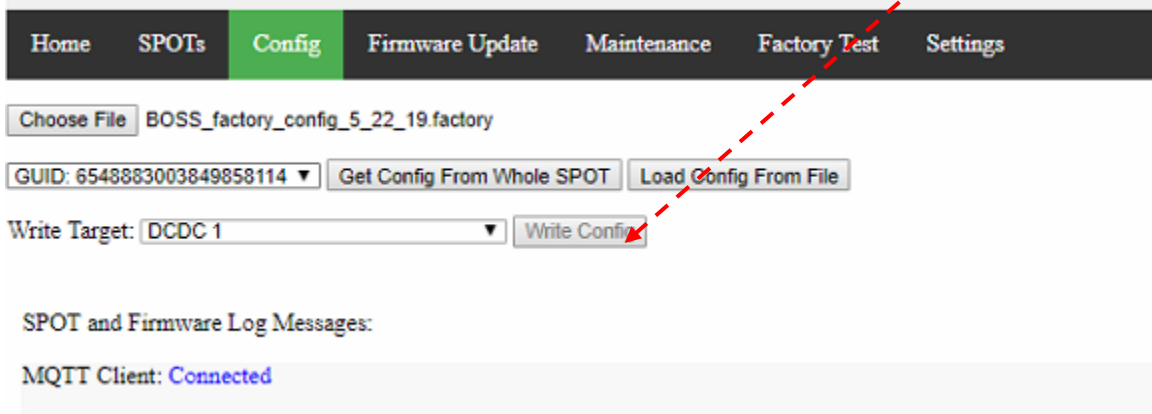


Figure 22: Loaded Configuration can be modified directly on the HUB

Step 4: The final step is to send the loaded configuration BOSS. Click **“Write Config”** button.



The screenshot shows the BOSS web interface. At the top is a navigation bar with tabs: Home, SPOTs, Config (highlighted in green), Firmware Update, Maintenance, Factory Test, and Settings. Below the navigation bar, there is a 'Choose File' button followed by the filename 'BOSS_factory_config_5_22_19.factory'. Below that is a GUID field showing 'GUID: 6548883003849858114' with a dropdown arrow, and two buttons: 'Get Config From Whole SPOT' and 'Load Config From File'. Further down is a 'Write Target' dropdown menu set to 'DCDC 1' and a 'Write Config' button. A red dashed arrow points from the 'Write Config' button to the 'Config' tab in the navigation bar. At the bottom, there is a section titled 'SPOT and Firmware Log Messages:' with a status message 'MQTT Client: Connected'.

Figure 23: Write configuration sends it to the commensurate product being used

11 Interfacing with the BOSS

Please refer to sections 8 & 9 before interacting with the BOSS. This section covers BOSS operating procedure and the various test procedures while interfacing with the BOSS.

11.1 Powering the BOSS

There are two ways to power ON the BOSS –

- 24 V External Connector – panel mounted connector on the end cap
- Applying $\geq 200V$ to the BOSS Auxiliary

The auxiliary of the BOSS is powered by the Battery. The minimum voltage required to power the board is $\geq 200V$.

As long as the battery voltage is sufficiently large, the BOSS will function in either direction without interruption. In the event, the Battery is allowed to discharge below the 200V limit; the BOSS will turn OFF.

If voltage on the Battery is low, the customer will have to power the board via an external 24V power supply. As soon as the Battery is charged to $\geq 200V$, the auxiliary will kick in and provide the necessary current required to keep the board ON.

As soon as you power the BOSS ON, you can access the HUB using the PODD. The two files necessary to ensure communication with the board is –

- *metadata File*
- *Hub_Config File*

Both these files would be pre-loaded onto the PODD or be provided to you by Alencon via secure file transfer. Once the PODD is setup, applying minimum voltage or external 24 V will turn ON the BOSS boards, allowing two way communications with the HUB.

Each board will be in the **shutdown state** as soon it is powered on

SPOT List				SPOT Information		DCDC Data	
	GUID	LIN	Status	Parameter	Value	Telemetry	dc/dc1
⊖	640476781577215810	11.1	RUN	status	DEFAULT	status	RUN
⊖	711183261367658946	12.1	RUN	timestamp	00:00:00.000	string_id	0
⊖	7264955396141702210	13.1	RUN	guid	1811553421323966614	timestamp	00:21:46.798
⊖	1811553421323966614	14.1	RUN	short_address	4	error_code_telem	IDC_FAILURE
				module_temperature	0	input_current	4.8
				string_id	0	input_voltage	685
				lin	14	onboard_temperature	73
				provisioned	NaN	transistor_temperature	47
				telemetry_updated	2019-05-24 13:07:20	output_current	5.1
						output_voltage	716
						input_power	0
						output_power	0
						ground_leak_current	0
						dc/dc_gate_freq_hz	101840
						ac_current	0
						input_voltage_upper	0
						input_voltage_lower	0
						nppt_status	0
						aux_5volts	0
						aux_12volts	12
						aux_3_volts	0
						ac_vout_bus	0
						ac_vout_batt	0
						battery_temperature	45
						humidity_sensor_temperature	50
						humidity	29
						error_code_battery	TRANSISTOR_TEMP
						desired_state	ON

SPOT Command

Target: All DCDCs - LIN 14 ▼

Command: Current Setpoint (BOSS Only) ▼

Current Setpoint: Amps

Figure 24: Populated HUB page

11.2 Soft Pre-Charge of BOSS

Since, the BOSS is a bi-directional optimizer it can pre-charge the output using the BUS side or the BATT side.

Note: *BUS and BATT used throughout the document are nomenclatures that are interchangeable based on the direction of power flow*

To pre-charge the load, you will need to first establish the direction of power flow i.e. Bus → BATT or BATT → BUS. Applied voltage will show up on the HUB in the commensurate field.

- When the BUS is the source, the **“Input_Voltage”** header will display the commensurate source voltage applied
- When the BATT is the source, the **“Output_Voltage”** will display the commensurate source voltage applied

DCDC Data

Telemetry	dcdc1
status	RUN
string_id	0
timestamp	00:21:46.798
error_code_telem	I2C_FAILURE
input_current	4.8
input_voltage	685
onboard_temperature	73
transistor_temperature	47
output_current	5.1
output_voltage	716
input_power	0
output_power	0
ground_leak_current	0
dcdc_gate_freq_hz	101840
ac_current	0
input_voltage_upper	0
input_voltage_lower	0
mppt_status	0
aux_5volts	0
aux_12volts	12
aux_3_3volts	0
ac_vout_bus	0
ac_vout_batt	0
battery_temperature	45
humidity_sensor_temperature	50
humidity	29
error_code_battery	TRANSISTOR_TEMP
desired_state	ON

Figure 25: HUB BOSS data

Before starting the BOSS, we need to provide the power flow **“Set Direction”** and the **“Current Setpoint”** expected from the BOSS. Both these features are available within the command window seen in figure.

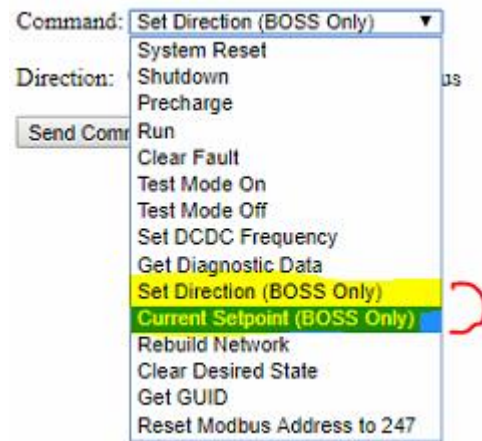


Figure 26: HUB Commands

“Set Direction” Command –

Choose the appropriate direction

- Bus to Battery or
- Battery to Bus

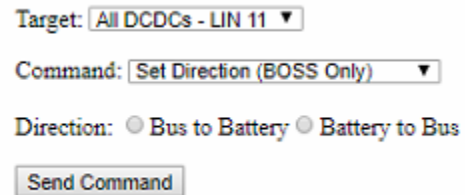


Figure 27: Direction Command for BOSS ONLY

“Current Set Point” Command –

This command sets the current required to be drawn from the source

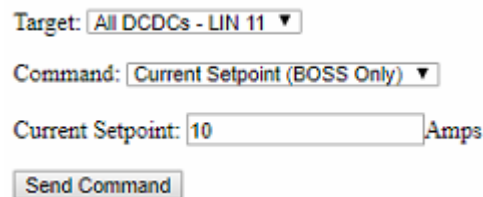


Figure 28: Current Set-Point Command

Once the two parameters are set, the capacitors will begin to precharge at a rate set in configuration.

Reset Command –

This command puts the BOSS in startup allowing it to pre-charge the capacitors connected on the output.

Target: All DCDCs - LIN 11 ▼

Command: System Reset ▼

Send Command

****Note:** The BOSS will not pre-charge or startup without providing the above two parameters.

Figure 29: Reset Command

After pre-charging the capacitors to the desired output voltage, the DCDC's transition to RUN, adjusting the frequency to obtain the desired current set point. As the frequency goes down the current drawn begins to rise. This continues until frequency limits are approached.

****NOTE:** Frequency Range - BOSS: $60 \leq f \text{ (KHz)} \leq 160$

The screenshot displays the Alencon HMI interface with a navigation bar at the top containing: Home, SPOTs, Config, Firmware Update, Maintenance, Factory Test, and Settings. The main content area is divided into three sections:

- SPOT List:** A table with columns GUID, LIN, and Status. It lists four SPOTs, all with a status of 'RUN'.
- SPOT Information:** A table with columns Parameter and Value. It shows various parameters for a selected SPOT, including status (DEFAULT), timestamp, GUID, short_address, module_temperature, string_id, lin, provisioned, and telemetry_updated.
- DCDC Data:** A table with columns Telemetry and dcdc1. It displays a wide range of telemetry data for a DCDC, including status (RUN), string_id, timestamp, error_code_telem, input/output current and voltage, power, ground_leak_current, gate_freq_hz, ac_current, input/output voltage upper/lower, mppt_status, aux voltages, ac vout bus/batt, battery temperature, humidity sensor temperature, humidity, error_code_battery, and desired_state.

Below the SPOT Information table, there is a **SPOT Command** section with a Target dropdown (set to 'All DCDCs - LIN 14'), a Command dropdown (set to 'Current Setpoint (BOSS Only)'), a Current Setpoint input field (set to 5), and a Send Command button.

Figure 30: Alencon's HMI – The HUB

**** NOTE:** Do not change direction of power flow if your DC source cannot act as a load. If this is the case you will have to manually swap input and output cables

11.3 Testing the BOSS using a DC source and a DC Load

To test the BOSS using a DC source and load, power flow must be unidirectional, if source cannot behave as a load. The default direction of flow is BUS to BATT with BUS connected to the source while BATT connected to the load. If direction needs to be changed, connect the DC source to the BATT side and the load to the BUS side, Fig.31, and follow the same procedure outlined below.

Alencon performs this test using Magna Power Supplies and Alencon's very own variable voltage DC load.

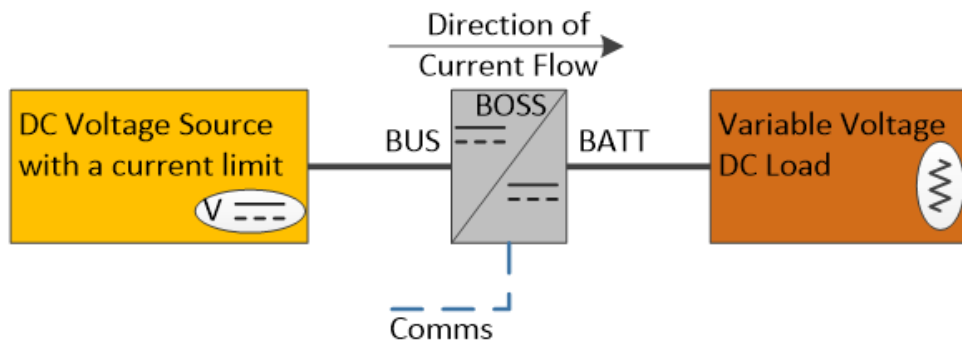


Figure 31: Basic setup for testing the BOSS with a DC voltage source and a variable voltage DC load. BUS side is connected to the DC source

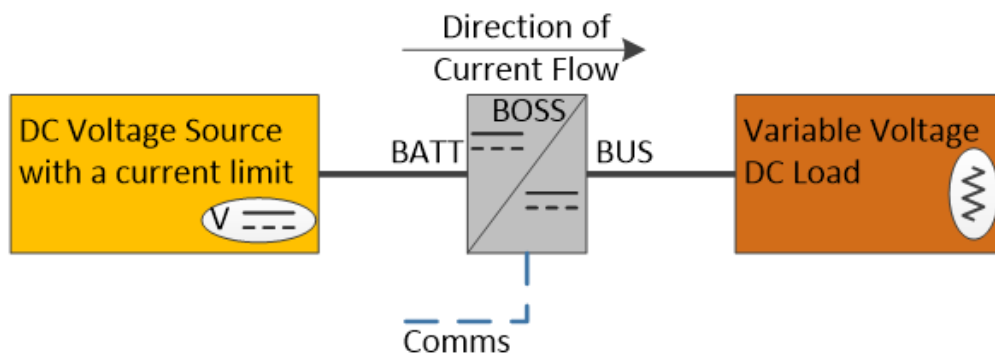


Figure 32: Basic setup for testing the BOSS with a DC voltage source and a variable voltage DC load. BATT side is connected to the DC source.

Please follow the below sequence of instructions to interact with the BOSS

- Read Alencon's documentation.
 - Establish communication the PODD – refer PODD setup instructions
- Power ON the BOSS – refer section 10.1
 - Battery side Auxiliary
 - 24 V External Power Supply

- Verify the BOSS DCDC's communicate via the HUB
 - Check all 4 DCDC's and their GUID's show up
 - Clear any or all existing faults using the clear command

SPOT List				SPOT Information		DCDC Data	
	GUID	LIN	Status	Parameter	Value	Telemetry	dcdc1
○	6404767815773215810	11.1	RUN	status	DEFAULT	status	RUN
○	7111832613676538946	12.1	RUN	timestamp	00:00:00.000	string_id	0
○	7264955396141702210	13.1	RUN	guid	18115534213233966614	timestamp	00:21:46.798
●	18115534213233966614	14.1	RUN	short_address	4	error_code_telem	I2C_FAILURE
				module_temperature	0	input_current	4.8
				string_id	0	input_voltage	685
				lin	14	onboard_temperature	73
				provisioned	NaN	transistor_temperature	47
				telemetry_updated	2019-05-24 13:07:20	output_current	5.1
						output_voltage	716
						input_power	0
						output_power	0
						ground_leak_current	0
						dcdc_gate_freq_hz	101840
						ac_current	0
						input_voltage_upper	0
						input_voltage_lower	0
						mppt_status	0
						aux_5volts	0
						aux_12volts	12
						aux_3_3volts	0
						ac_vout_bus	0
						ac_vout_batt	0
						battery_temperature	45
						humidity_sensor_temperature	50
						humidity	29
						error_code_battery	TRANSISTOR_TEMP
						desired_state	ON

Figure 33: HUB display of the 4 DCDC's

- Apply Input Voltage from the DC Source
- Set the voltage level on the variable voltage DC load.
 - Hit Reset command – wait for BOSS to transition to standby
 - Establish Power Flow Direction i.e. BUS → BAT (when DC Source connected to the BUS terminals)
 - Provide Current Set Point
 - Observe the current flowing at a specified set point.
 - Make small changes to the voltage on the source to simulate DC Bus voltage fluctuations. Observe the current of the BOSS and confirm that it follows the set point.
 - Make small changes to the voltage on the load to simulate battery charge and discharge behavior. Observe the current of the BOSS and confirm that it follows the set point.

- Provide different current set point and observe the current flowing through the BOSS. Confirm that the actual current follows the set point.
- Once the test is complete, shutdown the BOSS using the shutdown command.
- Discharge/Shutdown then disconnects the load.

11.4 Testing the Bi-directional Functionality of the BOSS Using a Single DC Source

This test known as re-circulation allows the test personnel to use a single source to test the BOSS in a bi-directional way. The test setup allows testing personnel to –

- Perform high power tests for long duration.
- Test how the BOSS follows the current set point.
- Change the direction of the current flow on the fly.

On the other hand, since the input is connected to the output,

- The voltages always will be the same on the BUS and the BATT side.
- The test can be performed only when the BOSS is designed for a system where the BUS and the BATT nominal voltages are relatively the same (I.e. 1:1 ratio).

Alencon performs this test using Magna Power Supplies. Below diagram shows the basic test setup for bi-directional testing of the BOSS.

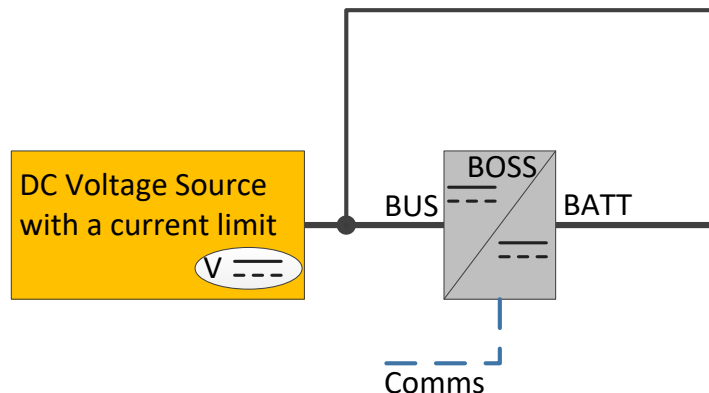


Figure 34: Basic setup for testing the BOSS in a bi-directional way.

Please follow the below sequence of instructions to interact with the BOSS

- Read Alencon's documentation.
 - Establish communication the PODD – refer PODD setup instructions
- Power ON the BOSS – refer section 10.1
 - Battery side Auxiliary
 - 24 V External Power Supply

- Verify the BOSS DCDC's communicate via the HUB
 - Check all 4 DCDC's and their GUID's show up
 - Clear any or all existing faults using the clear command

SPOT List				SPOT Information		DCDC Data	
	GUID	LIN	Status	Parameter	Value	Telemetry	dcdc1
○	6404767815773215810	11.1	RUN	status	DEFAULT	status	RUN
○	7111832613676538946	12.1	RUN	timestamp	00:00:00.000	string_id	0
○	7264955396141702210	13.1	RUN	guid	18115534213233966614	timestamp	00:21:46.798
●	18115534213233966614	14.1	RUN	short_address	4	error_code_telem	I2C_FAILURE
				module_temperature	0	input_current	4.8
				string_id	0	input_voltage	685
				lin	14	onboard_temperature	73
				provisioned	NaN	transistor_temperature	47
				telemetry_updated	2019-05-24 13:07:20	output_current	5.1
						output_voltage	716
						input_power	0
						output_power	0
						ground_leak_current	0
						dcdc_gate_freq_hz	101840
						ac_current	0
						input_voltage_upper	0
						input_voltage_lower	0
						mppt_status	0
						aux_5volts	0
						aux_12volts	12
						aux_3_3volts	0
						ac_vout_bus	0
						ac_vout_batt	0
						battery_temperature	45
						humidity_sensor_temperature	50
						humidity	29
						error_code_battery	TRANSISTOR_TEMP
						desired_state	ON

Figure 35: HUB display of the 4 DCDC's

- Apply Input Voltage from the DC Source
 - Ensure input and output cables are connected to the terminal block
 - Hit Reset command – wait for BOSS to transition to standby
 - Establish Power Flow Direction i.e. BUS → BAT
 - Provide Current Set Point
 - Observe the current flowing at a specified set point.
 - Change the current set point and observe the actual current flowing at the specified set point.
 - Change the direction of the current and give a new current set point. Observe the actual amount of current and its direction.
 - Provide different current set points and observe the current flowing through the BOSS. Ensure that the actual current follows the set point.
 - Once the test is complete, shutdown the BOSS using the shutdown command.
 - Turn off the DC Power Source.

11.5 Testing the Charge-Discharge Functionality of the BOSS Using Battery Racks

This test setup can be used to charge and discharge battery racks at a specific current set point. As the current flows from the BUS to the BATT terminals the battery rack voltage on the BUS side will decrease and the voltage of the battery rack on the BATT side will increase.

See the diagram in Figure 36 for a basic setup and follow the instructions below for the test. Currently Alencon does not have the setup yet to perform battery charge-discharge test.

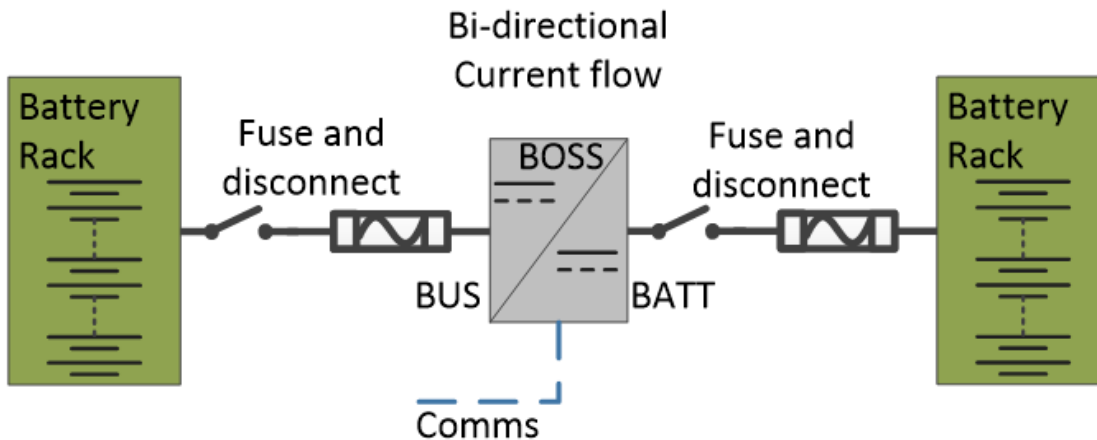


Figure 36: Charging and discharging of two battery racks using the BOSS

- Connect the batteries to the both sides of the BOSS shown in Figure 36.
 - Ensure input and output cables are connected to the terminal block
 - Hit Reset command – wait for BOSS to transition to standby
 - Establish Power Flow Direction i.e. BUS → BAT
 - Provide Current Set Point
 - Observe the current flowing at the specified set point.
 - Change the current set point and observe the actual current flowing at the specified set point.
 - Change the direction of the current and give a new current set point. Observe the actual amount of current and its direction.
 - Observe the voltages on the both sides as the batteries' state of charge change.
 - The voltage of the battery which provides current will drop.
 - The voltage of the battery which takes current will rise.
 - As the voltages on both batteries change due to their state of charge, the current through the BOSS will stay constant at a specified set point. Observe the actual amount of current and confirm that it stays at the specified set point.
 - Once test is complete, shutdown the BOSS using the shutdown command.
 - Disconnect the batteries.

12 Further information

For more information on DC-Coupled products and solutions, please visit <https://alenconsystems.com/>

Contact us @ <https://alenconsystems.com/alencon-and-you/>

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