Open-SEC Manual V1.3

Operating manual for Open-SEC Bi-directional smart DC-DC Converters

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CONNECTORS AND PINOUT ERROR! BOOKMARK NOT DEFINED.

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Open Smart Energy Converters

Exceptional Efficiency for Maximum Power Point Tracking

TPEE's Maximum Power Point Trackers are crafted with efficiency at the forefront, designed specifically for the high-performance demands of solar car applications and other high-voltage environments. Through extensive modeling and design optimization, we achieve industry-leading efficiency, ensuring your solar energy is harnessed to its fullest potential. TPEE MPPTs offer a highly competitive power solution for solar car racing and other demanding projects without compromise.

Seamless Integration with Powerful, Open-Source Tools

TPEE MPPTs are built for easy, adaptable integration. With our open-source software and the Reboot PC tool, you have the flexibility to adjust settings, update software, and monitor live data effortlessly. Whether you're fine-tuning a solar car or optimizing a high-voltage system, our MPPTs deliver reliable, high-efficiency performance that's easy to control—empowering you to focus on what matters most.

Features

- Open-source Software
- High efficiency, high bandwidth Hardware
- Maximum power point tracking
- Battery charge controller
- Isolated CAN-bus interface
- Over-current and over-voltage protection
- Integrated fuse
- Easy integration with the Reboost PC for editing settings

Hardware

TPEE supplies a range of products to suit your project needs. Designed for high-efficiency, high-performance applications in solar energy management. Our range of Maximum Power Point Trackers includes models primarily differentiated by output voltage, allowing you to choose the right fit for your specific power needs while maintaining the same compact size and high efficiency across the series.

The models are displayed in the table below, providing a quick comparison of output voltage specifications and capabilities. From moderate to high-voltage outputs, TPEE MPPTs offer seamless integration, reliability, and consistent performance across diverse applications. Explore the table to find the model that best matches your project requirements.

Part Number	High Side Voltage	Low Side Current	Peak Efficiency	Weight
SEC-B175-7A	175V	7A	99.4%	200g
SEC-B80-8A	80V	8A	99.4%	160g

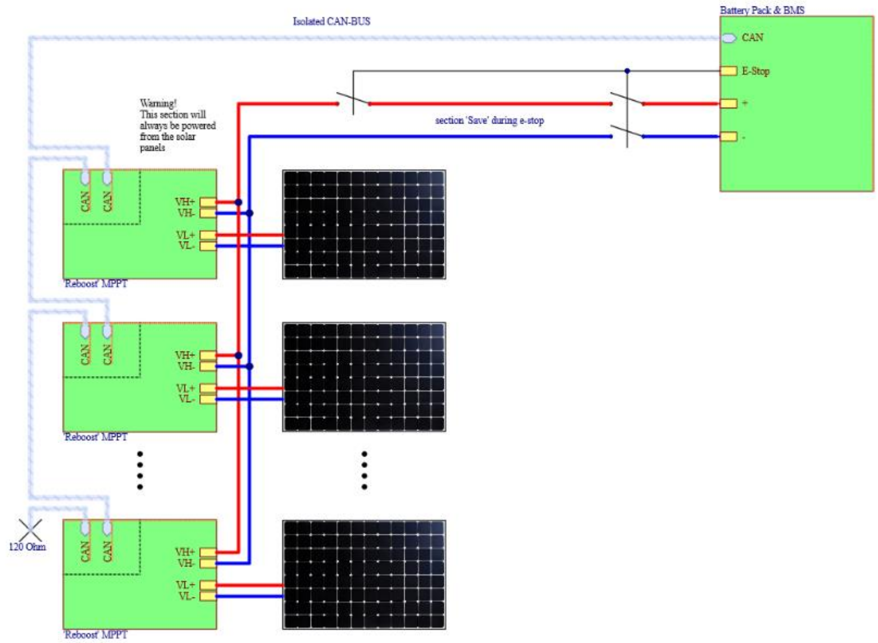
Name Convention

SEC-	B	175	-7A
Smart Energy Converter	Bi-directional	High side voltage	7 Ampere current rating

Functional Description

Installation

The SEC-B175 is typically used to charge a battery, with multiple units in parallel. Care must be taken that the negative side of the PV connection is not connected to any other unit. An example of a typical installation is can be seen in the following figure.



Turn on and Pre-charging

The device is turned on by applying a voltage higher than 6V on the CAN-bus supply voltage and providing a voltage higher than 30V to the output. This voltage might come from the PV panel connected to the unit, via the internal bypass diode.

If the device is connected to a battery via contactors or switches, the device must first be properly pre-charged and connected to the battery before turning on the device. If the voltage on the output of the unit does not match the voltage of the battery, large current spikes might appear when the contactors or switches are engaged. This can damage the device or other parts of the system.
The device contains 440μF of capacitance on the battery output.

When connecting units connected in parallel, they might already be charged. They are usually charged when connected to a PV panel. Hence the device should also be pre-charged when connecting units in parallel.

Cooling

Even though the device is energy efficient, heat is still generated in the device. If the temperature of the device rises above its specified limit, it will try to reduce heat generation by limiting the input current. To prevent this from happening, adequate cooling must be provided through airflow over the heatsink of the device.

MPPT Algorithm
The algorithm to track the maximum power point is a variable step size perturb and observe (P&O) algorithm with a random jump algorithm to potentially find a global maximum power point.

There are six settings associated with the algorithm. These are:

- Meter filter coefficient
- P&O Step size
- P&O step time
- P&O step gain
- Jump power threshold
- Jump rate

Filter
A moving average filter is implemented to filter noise from the raw measurements. Setting the ‘Meter filter coefficient’ sets the strength of the filter. Setting it to zero disables the filter while setting it closer to 1 makes the filter more aggressive but slower. A value of 1 makes the response time infinite.

Variable Step Size P&O
The P&O algorithm works by taking a step in the voltage setpoint after a fixed time step. By measuring the power at the current setpoint, and comparing it with the power from the previous setpoint the algorithm calculates the slope of the power-voltage curve of the PV panel.

When the ‘P&O Step Gain parameter is set to anything above zero, the algorithm uses a variable step size based on the slope of the power-voltage curve. The step size is then calculated as follows:

$$V_{step} = V_{stepmin}(1 + \frac{\partial P}{\partial V} G_{po})$$

Where $V_{stepmin}$ is the minimum step size set with the parameter ‘P&O Step Size’. $\frac{\partial P}{\partial V}$ is the slope of the power-voltage curve measured by the MPPT, and G_{po} is the P&O step gain.

Random Jump Algorithm
The algorithm can be configured to make random guesses. This guess aims to find a global maximum power point if the algorithm is stuck in a local maximum.

The time between each guess can be configured with the ‘jump rate’ variable. The time between guesses is the jump rate times the P&O step time. Setting the jump rate to zero disables the random jumps.

If a random jump is performed, the power output of the random setpoint is compared to the power from the previous setpoint. If the power is not lower than the previous power, minus a threshold, the algorithm continues to track from the random guess point. Otherwise, the algorithm immediately jumps back to the previous setpoint and starts tracking from there. The threshold can be configured using the ‘jump threshold variable.

Modes of Operation

The controller of the converter has the goal, besides stabilizing the input filter, to protect the device if it can. To do this, it can switch between a few operating modes.

Input Voltage Regulation (Nominal operation)

In normal operation, the device regulates the input voltage to a set point. The setpoint is given by the MPPT algorithm.

Input current Limit

If the current provided by the power source is bigger than the maximum allowed current, the converter enters a constant current mode. This way the current through the converter is never higher than its maximum.

Output Current Regulation

In this mode the output current is limited.

Output Voltage Regulation

if the output voltage rises too high, the converter gets into a constant output voltage control mode. This happens for example when the Battey is fully charged, the load impedance is too high or the load is suddenly disconnected. The constant output voltage controller does not have a lot of overshoot and is able to provide full output current at the constant output voltage setpoint.

Temperature De-rating

If the temperature of the heatsink rises above the temperature derating start temperature, the input current is limited to make sure the temperature does not rise any further. The input current is scaled from its maximum to zero starting at the 'Temperature Limit Start' temperature to the 'Temperature limit End' temperature.

Faults

A fault is indicated by a blinking Limit LED. The fault can be analyzed by using the Reboost-Tool.

0. OK (No Error)
1. Configuration Error
2. Input Over Voltage
3. Output Over Voltage
4. Output Over Current
5. Input Over Current
6. Input Under Current
7. Phase Over Current

LED Indicators

LED Name	Pattern	Meaning
Power		Indicate the device is powered on
CAN		The device is sending or receiving CAN messages.
UP		Indicates the MPPT algorithm made a step up in voltage
DOWN		Indicates the MPPT algorithm made a step down in voltage
Limit		The device is in one of its limit control modes.
		Hard fault: the device is inactive to protect itself.

CAN-Bus interface

CAN ID

The default Device ID is set to 32, resulting in the CAN bus ID: 0x200 (512) when the encoder is set to 0.

Standard ID

Bit:	10	9	8	7	6	5	4	3	2	1	0
Content:	Device ID set in tool + encoder value							Packet ID			

Extended ID

Bit:	-	-	-	28	27	26	25	24
Content:				0	0	0	0	0
Bit:	23	22	21	20	19	18	17	16
Content:	0	0	0	0	0	0	0	0
Bit:	15	14	13	12	11	10	9	9
Content:	0	Device ID set in tool + encoder value						
Bit:	7	6	5	4	3	2	1	0
Content:	Packet ID							

Send Messages

Packet ID 0: Power Measurements
Rate: 0.5 Second, standard ID

Variable	Type	Location	Scale factor	unit	Range
Input Voltage	INT16	Byte 0-1	0.01	Volt	±327V
Input Current	INT16	Byte 2-3	0.0005	Ampere	±16A
Output Voltage	INT16	Byte 4-5	0.01	volt	±327V
Output Current	INT16	Byte 6-7	0.0005	Ampere	±16A

Packet ID 1: Status
Rate: 1.0 seconds, standard ID

Variable	Type	Location	Scale factor	unit	Range
Mode	UINT8	0	-	-	0. Constant Input Voltage 1. Constant input Current 2. Minimum Input Current 3. Constant Output Voltage 4. Constant Output Current 5. temperature De-rating 6. Fault
Fault	UINT8	1			0. OK (No Error) 1. Configuration Error 2. Input Over Voltage 3. Output Over Voltage 4. Output Over Current 5. Input Over Current 6. Input Under Current 7. Phase Over Current 8. Fault
Enabled	UINT8	2			0. Disabled 1. Enabled
Ambient Temperature	INT8	3	1	C	±128
Heatsink Temperature	INT8	4	1	C	±128

Received Messages

Packet ID 5: Fill RX Buffer
Packet ID 6: Fill RX Buffer Long
Packet ID 7: Process RX Buffer
Packet ID 8: Process RX Buffer Short

Packet ID 9: Set Mode

Variable	Type	Location	Scale factor	unit	Range
Mode	Uint8	0	-	-	0. Disable 1. Enable Rest: nothing

Reserved Messages

Packet ID 2, 3, 4, 9, 10, 11, 12, 13, 14 and 15 are reserved for future use.

Open-SEC Firmware Changes

V1.3 Latest

Added startup delay setting
Added default off setting

V1.2

- Fixed wrong gain in SEC-B80-8A Hardware
- Added CAN command to turn on and off the device
- Added 4A Hardware
- Made simulator parameters depend on user settings

V 1.1

- Added MPPT sweep delay
- Fixed CAN bus interface bug
- Allow negative lower current limit

V1.0

- Major code restyling
- Got rid of CubeMX
- Added support for different hardware configurations
- Added boot-loader
- Added firmware upgrade feature
- Simplified interface with tool
- Separated calibration data from settings

Document History

Revision	Changes
Rev. 1	Initial release, preliminary datasheet.
Rev. 2	Added mechanical drawings Added functional description Updated Electrical specifications
Rev 3	Added Can bus protocol
Rev 4	Added changes for Firmware version 1.3