24-7 EvK User Guide

Description

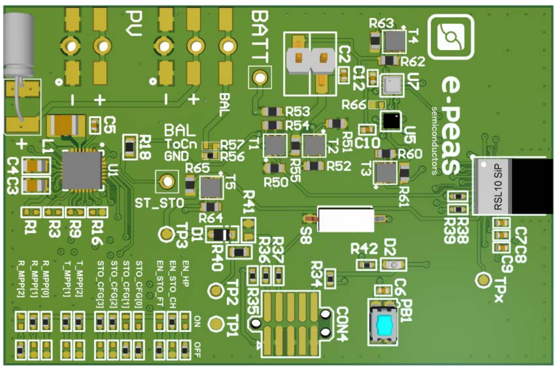
The 24-7 EVK is enabling hardware and firmware developers to validate Energy Harvesting paradigm change, demonstrating a self-powered, connected sensor node can stay active while its main energy source has disappeared. The tests have demonstrated that 2 months autonomous operations are possible while the device is put in complete darkness. The EVK implements an ambient energy awareness strategy to adapt its activity not only the energy harvesting source availability but also to the micro-storage element state of charge. The selection of AEM10300 allows the application to run from storage element only, while the PMIC is in shut down mode, consuming only 5nA. During normal activity, the AEM10300 behaves as the storage element charger, moving energy from the PV source to the storage element with high efficiency. The EVK is populated with high performance organic PV cell and an mini-storage element of 350µAh. BLE connectivity is supported by a BLE SoC. The EVK is made of 2 sections: one for developers programming and hardware setting, one regrouping all active components. It has an optimized selection of components and offers a large choice of alternative hardware. It comes with a mobile app for monitoring the various ambient energy aware states (Daylight, Night fast duty cycle, Night slow duty cycle). The EVK comes ready to work from out of the box.

Applications

• Asset Tracking/Monitoring	• Industrial applications
• Retail ESL/Smart sensors	• Smart home/building

Appearance

Part Number	Dimensions
4AAEM000190010	60 mm x 40 mm



Features

AEM10300 high performance battery charger
- Ultra low quiescent current (5 nA)
- High conversion efficiency from Source
- Optimized Storage element preset for charging and discharging protection
- Storage element status pin

One two-way screw terminals
- Connexion for alternative PV cell

One three-way screw terminal
- Connexion for alternative energy storage element

Optional custom mode configuration

Configuration by 0 Ω resistors
- Maximum power point ratio (R_MPP) configuration
- Maximum power point timing (T_MPP) configuration
- Storage element voltage configuration
- Supports dual-cell supercapacitor configuration
- Modes configuration

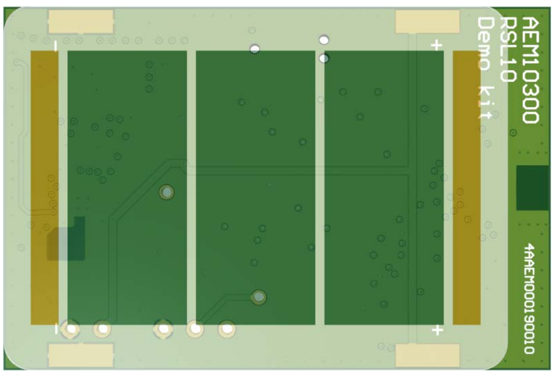
One 2-pin header
- Allows easy current consumption measurement

DRACULA technologies PV cell
- 3 elements organic PV cell

Nichicon SLB
- 0.35 mAh
- 2.4 V nominal voltage

onsemi BLE 5.2 MCU
- RSL10 SiP

Two environmental sensors
- Temperature and pressure
- Tri-axis accelerometer



1. Connections Diagram

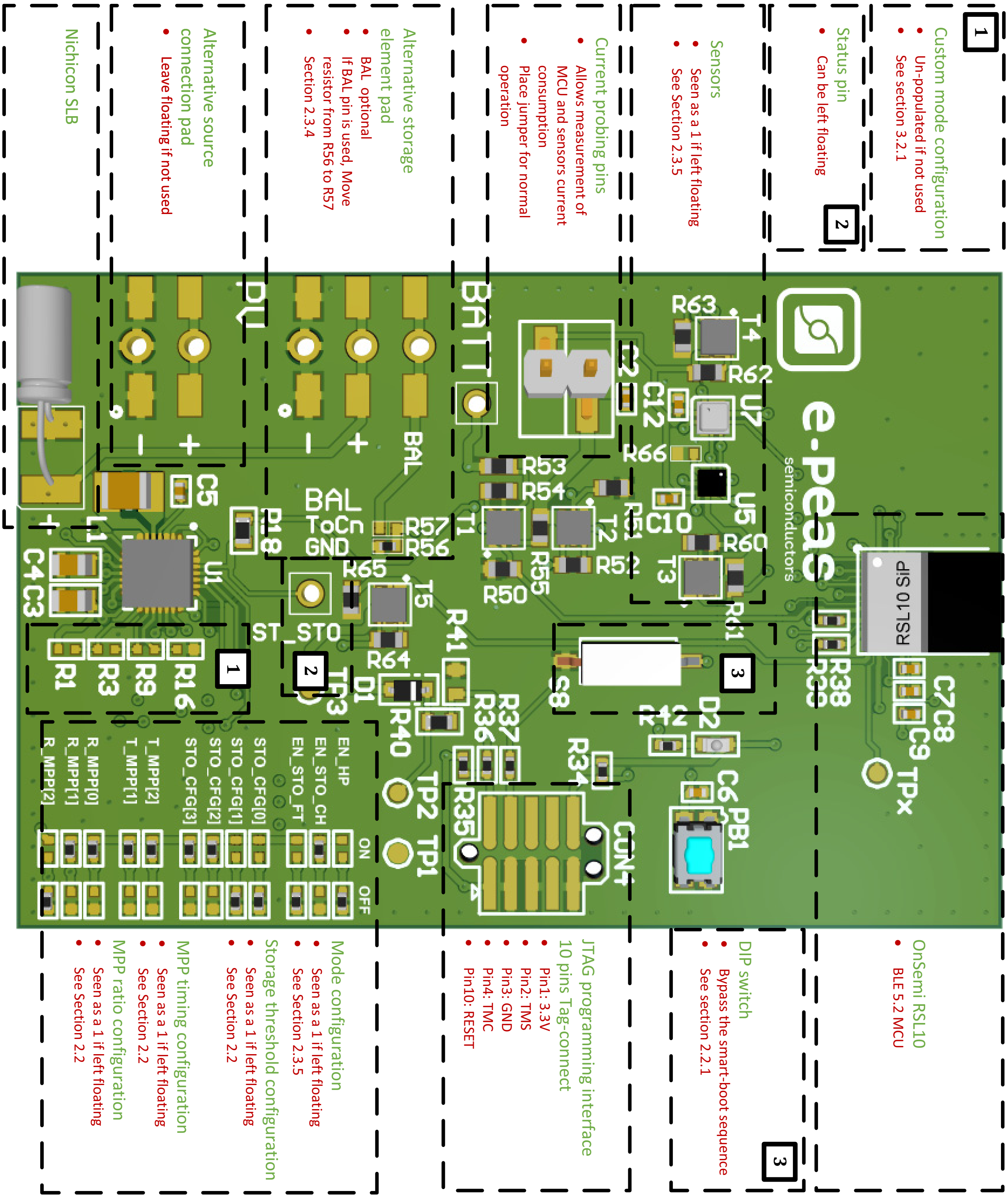


Figure 1: Connection diagram

1.1. Signals Description

The default configuration of the board is in bold

NAME	FUNCTION	CONNECTION	
		If used	**If not used**
Power signals			
SRC	Connection to the harvested energy source.	Connect the source element.	
STO	Connection to the energy storage element.	Connect the storage element.	
BAL	Connection to balancing of the dual-cell supercapacitor.	Connect balancing and place a resistor shorting BAL and "ToCN".	**Use a resistor to connect "BAL" to "GND".**
Debug signals			
VINT	Internal voltage supply.		
BUFSRC	Connection to an external capacitor buffering the buck-boost converter input.		
Configuration signals			
R_MPP[2:0]	Configuration of the MPP ratio.	Connect resistor	Leave floating
T_MPP[1:0]	Configuration of the MPP timing	Connect resistor	Leave floating
STO_CFG[3:0]	Configuration of the threshold voltages for the energy storage element.	Connect resistor	Leave floating
Control signals			
EN_HP	Enabling pin for the high-power mode	Connect resistor	
EN_STO_CH	Enabling pin for the feed-through feature	Connect resistor	
EN_STO_MEAS	Enabling pin for the storage element measure	External signal	Leave floating
Status signals			
ST_STO	Logic output. Asserted when the storage device voltage rises above the V_{CHRDY} threshold. Reset when the storage device voltage drops below V_{OVDIS} threshold. High level is V_{STO}.		

Table 1: Pin description

2. Board utilization

2.1. Out of the box

When first taken out of the box, the device might be in its lowest power setting (see Section 2.2.4) or simply out of energy. Simply place the device with the PV cell facing a light source to make the device aware that the ambient energy context has changed (It can take 1 hour maximum if the device was in "Night low duty cycle" mode). In case the device is discharged, it will enter in a fast charge mode for 40 minutes.

2.2. Device behavior

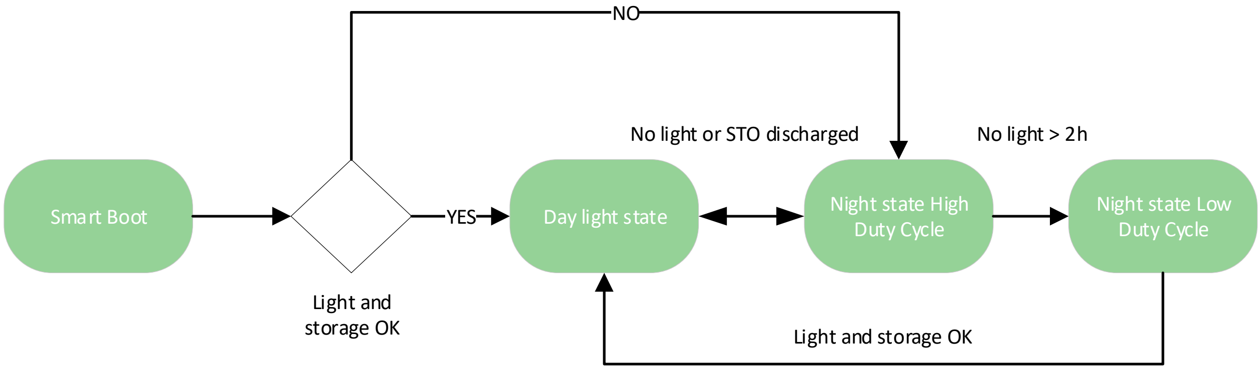


Figure 2: Device behavior flow chart

2.2.1. Smart Boot

The smart boot sequence starts when the device is powered on. If the battery voltage level is above V_{CHRDY}, the micro controller will enter a low power state for 40 minutes to allow the battery to charge further. It is possible to bypass this charge up sequence by switching S8 in the ON position. After the Smart Boot state, the device will perform a measurement on the PV cell voltage to see if there is enough light and check if the battery level is above 2.2V. If the two conditions are met, it will go in the Day light state, if not, it will switch to the Night state high duty cycle

2.2.2. Day light state

In this state, the device is advertising the sensors data every 10 seconds as long as the PV cell and battery voltage are above the nominal level. If the PV cell voltage falls below the threshold level (1V) or the battery falls below 2.2V, the device will go into the Night state High Duty Cycle.

2.2.3. Night State High Duty Cycle

In the Night state high duty cycle, the device is sending 3 advertisement messages in 10 seconds every 2 minutes. If it stays in the mode for more than 2 hours, it will go into the Night state low duty cycle. If the lightning level is rising above the threshold voltage when the device is performing the sampling (every 2 minutes), the device will return in the Day light state.

2.2.4. Night State Low Duty Cycle

Night State Low Duty Cycle This is the lowest power consumption state. When in the Night state low duty cycle, Enter in ultra low consumption mode and stay for 1 hour before waking up, checking ambient energy condition, sending Environmental conditions (3 advertisement messages in 10 seconds) and getting back to sleep. The device is able to remain functional in this mode up to 2 months.

2.3. IOS App

Figure 3: Apple store link

AEM10300 mobile application is the first power management evaluation application for iOS dedicated to energy harvesting, using Bluetooth low energy.

It comes together with e-peas new Smart sensor node Evaluation kit (24-7 EVK), featuring e-peas AEM10300 PMIC (Power Management IC), a PV cell, a storage element and a couple of temperature and pressure sensors.

The tool is designed for OEM developers, not only to display the environmental data of the sensor node, but also the key parametric of the device: state of lighting conditions, PV cell voltage, Micro storage element voltage and connectivity duty cycle indication

The tool automatically filters in 24-7 EvKs so there is no need to create a specific setting in the application.

By varying the external conditions of lighting, developers get a real-time indication of the energy conditions of the sensor node. The mobile application supports relative altitude computation and can track 3D movement.

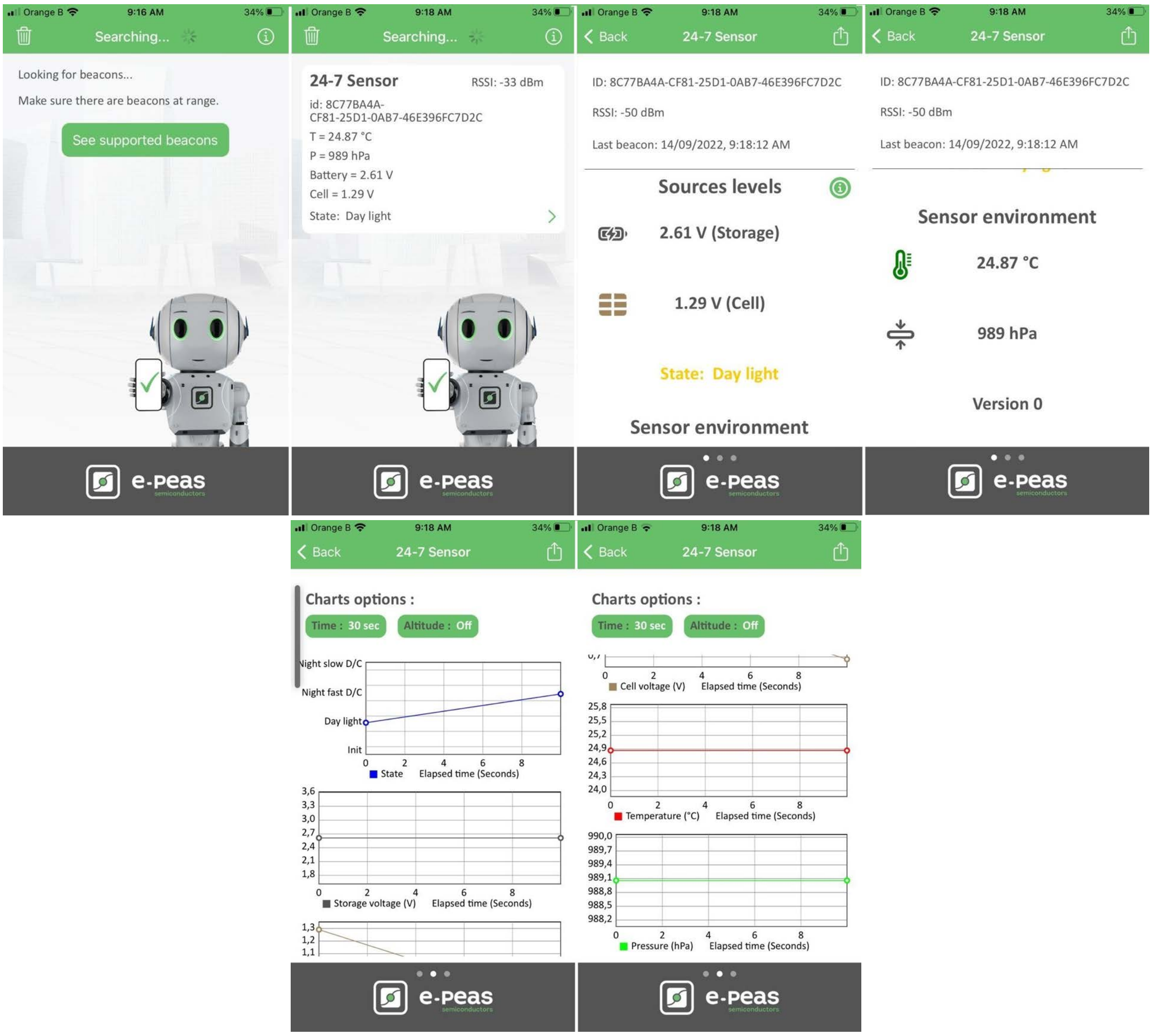


Figure 4: Views from the AEM10300 app

2.4. Android App

Figure 5: Google store app link

Alternatively, developers using Android type of smartphones can use nRF Connect for Mobile, a powerful tool that allows to scan and explore your Bluetooth Low Energy devices.
In this case nRF connect: Scans for Bluetooth Low Energy devices, parses advertisement data, shows RSSI graph and logs events.

Tip: It is recommended to isolate the MAC address of the 24-7 EVK sensor node by running the app with the smartphone sitting nearby the sensor node while filter by higher RSSI level (ex -30dBm). Once the device is identified by the smartphone, Its MAC address is displayed. It it is easy to create a MAC address filter in the filter pop down menu.
The device can also be defined as “favorite” by pressing and holding the finger on the icon so that a red start is popping under the Bluetooth icon (see pictures below) .

When the device is listed on the screen, one can push and hold the device name. A light grey window will pop down. It is possible to rename the device using the “pencil icon”.

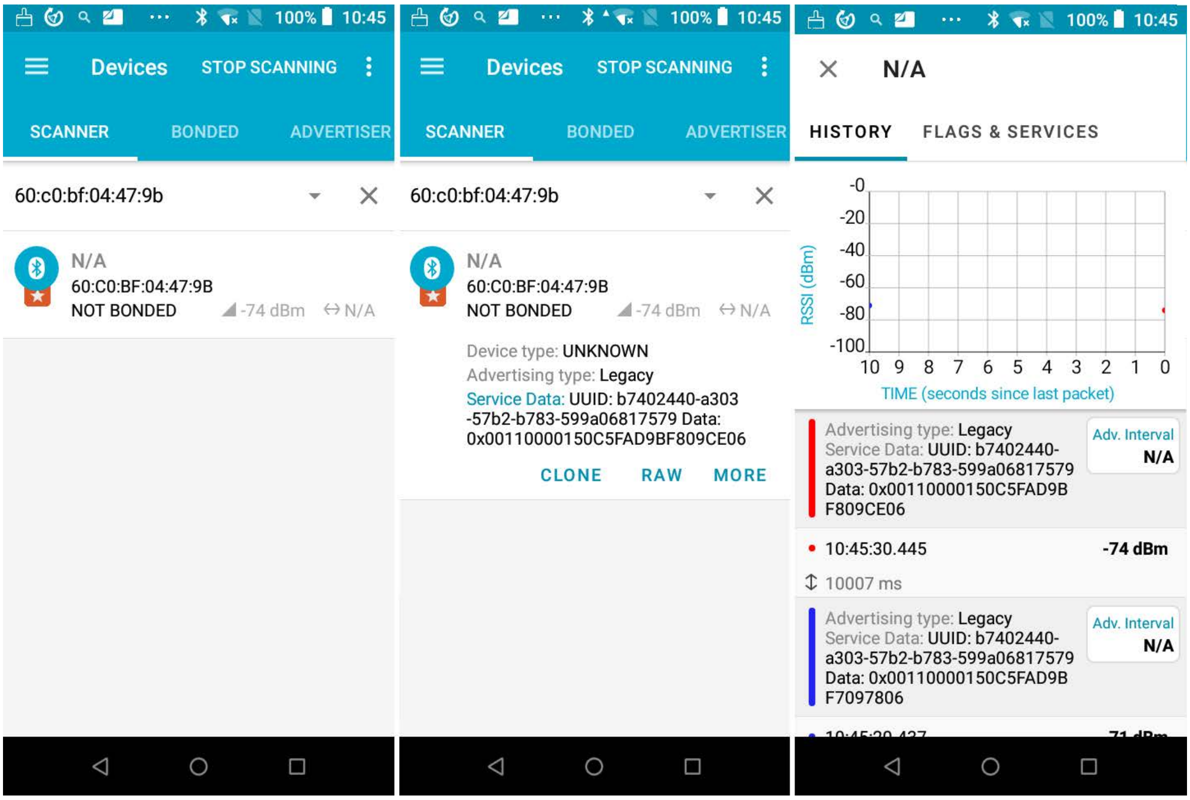


Figure 6: Views from the nRF app

2.5. Custom Firmware adaptation

In case a modification of the embedded firmware is needed, one can contact e-peas’s partner BLINQY.
https://www.blinqy.be/contact/

3. General Considerations

3.1. Basic Configurations

The default configuration of the board is in bold

Configuration pins				Storage element threshold voltages			Typical use
STO_CFG[3]	STO_CFG[2]	STO_CFG[1]	STO_CFG[0]	V_{OVDIS}	V_{CHRDY}	V_{OVCH}	
0	0	0	0	3.00 V	3.50 V	4.05 V	Li-ion battery
0	0	0	1	2.80 V	3.10 V	3.60 V	LiFePO4 battery
0	**0**	**1**	**0**	**1.85 V**	**2.40 V**	**2.70 V**	**NiMH battery**
0	0	1	1	0.20 V	1.00 V	4.65 V	Dual-cell supercapacitor
0	1	0	0	0.20 V	1.00 V	2.60 V	Single-cell supercapacitor
0	1	0	1	1.00 V	1.20 V	2.95 V	Single-cell supercapacitor
0	1	1	0	1.85 V	2.30 V	2.60 V	NGK
0	1	1	1	Custom Mode			
1	0	0	0	1.10 V	1.25 V	1.50 V	Ni-Cd 1 cells
1	0	0	1	2.20 V	2.50 V	3.00 V	Ni-Cd 2 cells
1	0	1	0	1.45 V	2.00 V	4.65 V	Dual-cell supercapacitor
1	0	1	1	1.00 V	1.20 V	2.60 V	Single-cell supercapacitor
1	1	0	0	2.00 V	2.30 V	2.60 V	ITEN / Umal Murata
1	1	0	1	3.00 V	3.50 V	4.35 V	Li-Po battery
1	1	1	0	2.60 V	2.70 V	4.00 V	Tadiran TLI1020A
1	1	1	1	2.60 V	3.50 V	3.90 V	Tadiran HLC1020

Table 2: Storage Element Configuration Pins

Configuration pins			MPPT ratio
R_MPP[2]	R_MPP[1]	R_MPP[0]	V_{MPP} / V_{OC}
0	0	0	60%
0	0	1	65%
0	**1**	**0**	**70%**
0	1	1	75%
1	0	0	80%
1	0	1	85%
1	1	0	90%
1	1	1	ZMPP

Table 3: MPP Ratio Configuration Pins

Configuration pins		MPPT timing	
T_MPP[1]	T_MPP[0]	Sampling duration	Sampling period
0	0	5.19 ms	280 ms
0	1	70.8 ms	4.5 s
1	0	280 ms	17.87 s
1	**1**	**1.12 s**	**71.7 s**

Table 4: MPP Timing Configuration Pins

3.2. Advanced Configurations

A complete description of the system constraints and configurations is available in Section 8 “System configuration” of the AEM10300 datasheet.
A reminder on how to calculate the configuration resistors value is provided below. Calculation can be made with the help of the spreadsheet found on the e-peas website.

3.2.1. Custom Mode

In addition to the pre-defined protection levels, the custom mode allows users to define their own levels via resistors R1 to R4.

By defining RT = R1 + R2 + R3 + R4 (1 M ≤ RT ≤ 100 M)

- R1 = RT (1 V / V_{OVCH})
- R2 = RT (1 V / V_{CHRDY} - 1 V / V_{OVCH})
- R3 = RT (1 V / V_{OVDIS} - 1 V / V_{CHRDY})
- R4 = RT (1 - 1 V / V_{OVDIS})

Make sure the protection levels satisfy the following conditions:

- V_{CHRDY} + 0.05 V ≤ V_{OVCH} ≤ 4.5 V
- V_{OVDIS} + 0.05 V ≤ V_{CHRDY} ≤ V_{OVCH} - 0.05 V
- 1 V ≤ V_{OVDIS}

If unused, leave the resistor footprints (R1, R3, R9 & R16) empty.

3.2.2. Balancing Circuit Configuration

When using a dual-cell supercapacitor (that does not already include a balancing circuit), enable the balancing circuit configuration to ensure equal voltage on both cells. To do so:

- Connect the node between the two supercapacitor cells to BAL (on STO connector)
- Use a resistor to connect “BAL” to “ToCN”

If unused, use a resistor to connect “BAL” to “GND”

3.2.3. Mode Configuration

EN_HP

When EN_HP is pulled up to VINT, the DCDC converter is set to HIGH POWER MODE. This allows higher currents to be extracted from the buck-boost input (SRC) to the buck-boost output (STO or VINT).

- Use a jumper to connect EN_HP to 1 to enable the high-power mode.
- Use a jumper to connect EN_HP to 0 to disable the high-power mode.

EN_STO_CH

To disable battery charging, the 3-pin header is available.

- Use a jumper to connect the EN_STO_CH to 1 to enable the charge of the storage element
- Use a jumper to connect the EN_STO_CH to 0 to disable the charge of the storage element

EN_STO_CH at 1 by default.

EN_STO_FT

To disable the source to storage element feed-through, the 3-pin header is available.

- Use a resistor to connect the EN_STO_FT to 1 to activate the feature.
- Use a resistor to connect the EN_STO_FT to 0 to disable the feature.

Default configuration

The default advanced configuration of the board is the following:

- Custom mode: unpopulated.
- Balancing: connected to ground
- EN_HP: connected to 0
- EN_STO_CH: connected to 1
- EN_STO_FT: connected to 0

4. Revision History

Revision	Date	Description
1.0	September, 2022	Creation of the document.