AEM00940 Evaluation Board User Guide

Description

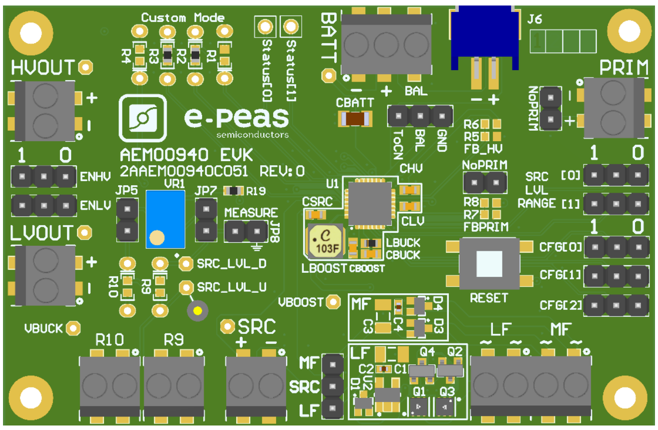
The AEM00940 evaluation board is a printed circuit board (PCB) featuring all the needed components to operate the AEM00940 integrated circuit (IC). Please refer to the datasheet for all the useful details about the AEM00940.

The AEM00940 evaluation board allows users to test the e-peas IC and analyse its performances in a laboratory-like setting.

It allows easy connections to the energy harvester, the storage element and the low-voltage and high-voltage loads. It also provides all the configuration access to set the device in any one of the modes described in the datasheet. The control and status signals are available on external pins, allowing users to wire for any usage scenario and evaluate the relevant performance.

The AEM00940 evaluation board is an intuitive and efficient tool for making the appropriate decisions (component selection, operating modes…) for the design of a target application that is powered by energy harvesting in a highly efficient way.

Appearance



Features

Two-way screw terminals

- Source of energy (harvester)
- High-voltage load
- Low-voltage load
- Primary storage element
- Resistors for source level setting
- Low frequency rectifier AC input
- Medium frequency rectifier AC input

Three-way terminals

- Energy storage element (Battery or (super)capacitor, BATT)

2-pin “shrouded header”

- Alternative connection for the storage element

3-pin headers

- Source level range configuration
- AC rectifier selection
- Low drop-out regulator (LDOs) configuration
- Energy storage element and LDOs configuration
- Dual-cell supercapacitor configuration

2-pin header

- Primary battery configuration
- Connection of the on-board potentiometer for source level setting
- Source level measurement enabling

1-pin headers

- Access to status pins

Provision for five resistors

- Source level configuration
- Custom mode configuration
- Primary battery configuration

One tactile switch

- AEM00940 reset

Device Information

Part Number	Dimensions
2AAEM00940C051	76 mm x 50 mm

1. Connections Diagram

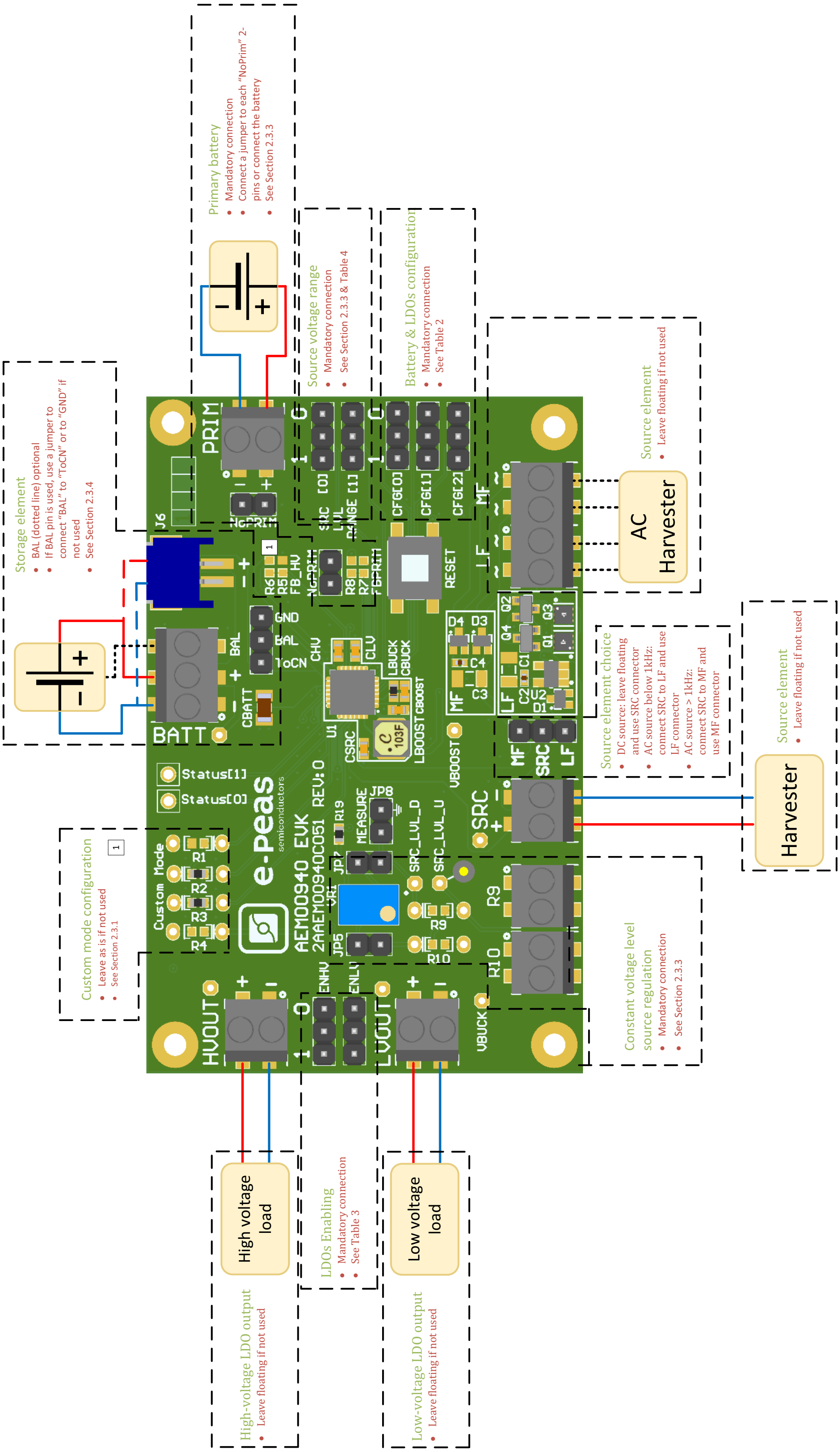


Figure 1: Connection diagram

1.1. Signals Description

NAME	FUNCTION	CONNECTION	
		If used	If not used
Power signals			
SRC / LF / MF	Connection to the harvested energy source.	Connect the source element.	Leave floating.
BATT	Connection to the energy storage element.	Connect the storage element in addition to CBATT (150 µF).	Do not remove CBATT.
BAL	Connection to mid-point of a dual-cell supercapacitor.	Connect mid-point and jumper BAL to “ToCN”.	Use a jumper to connect “BAL” to “GND”.
PRIM	Connection to the primary battery.	Connect primary battery.	Connect a jumper to each NoPRIM 2-pins.
LVOUT	Output of the low-voltage LDO regulator.	Connect a load.	Leave floating.
HVOUT	Output of the high-voltage LDO regulator.	Connect a load.	Leave floating.
Debug signals			
VBOOST	Output of the boost converter.		
VBUCK	Output of the buck converter.		
Configuration signals			
CFG[2:0]	Configuration of the threshold voltages for the energy storage element.	Connect jumper (see Table 2).	Cannot be left floating (see Table 2).
SRC_LVL_RANGE[1:0]	Constant voltage harvesting range multiplier.	Connect jumper (see Table 4).	Cannot be left floating (see Table 4).
SRC_LVL_D SRC_LVL_U	Constant voltage harvesting range.	Three alternatives (see Section 2.3.3): • Connect jumpers on JP5 and JP7 to use potentiometer VR1 • Connect resistors on R9-R10 connectors • Solder SMD resistors on R9-R10 footprints	Cannot be left floating (see Section 2.3.3).
FB_PRIM	Configuration of the primary battery.	Use resistors R7-R8 (see Section 2.3.2).	Connect a jumper to each NoPRIM 2-pins.
FB_HV	Configuration of the high-voltage LDO in the custom mode.	Use resistor R5-R6 (see Section 2.3.1).	Leave floating.
Control signals			
ENHV	Enabling pin for the high-voltage LDO.	Connect jumper (see Table 3).	Cannot be left floating (see Table 3).
ENLV	Enabling pin for the low-voltage LDO.	Connect jumper (see Table 3).	Cannot be left floating (see Table 3).
Status signals			
STATUS[1]	Logic output. Asserted if the battery voltage falls under Vovdis or if the AEM is taking energy from the primary battery.	May be connected to a monitoring circuit.	Can be left floating.
STATUS[0]	Logic output. Asserted when the LDOs can be enabled.	May be connected to a monitoring circuit.	Can be left floating.

Table 1: Pin description

2. General Considerations

2.1. Safety Information

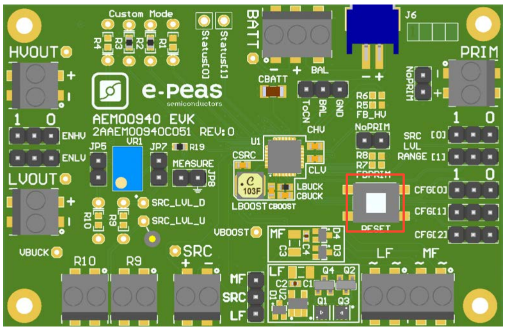
Always connect the elements in the following order:

1. Reset the board - see “How to reset the AEM00940 evaluation board” below.
2. Completely configure the PCB (jumpers/resistors);
   - Constant voltage harvesting configuration (SRC_LVL, SRC_LVL_RANGE[1:0]- see Table 4 and Section 2.3.3.
   - Battery and LDOs configuration (CFG[2:0] and, if needed, R1-R2-R3-R4-R5-R6) - see Table 2.
   - Primary battery configuration (R7-R8) - see Section 2.3.2.
   - LDOs enabling (ENHV and ENLV) - see Section 2.2
   - Balun circuit connection (BAL) - see Section 2.3.3.
3. Connect the storage elements on BATT and optionally the primary battery on PRIM.
4. Connect the high and/or low voltage loads on HVOUT/LVOUT (optional).
5. Connect the source on SRC (DC source) or on LF/MF (AC source).

To avoid damage to the board, users are urged to follow this procedure.

How to reset the AEM00940 evaluation board:

To reset the board, simply disconnect the source, the storage device and the optional primary battery and briefly press the “RESET” button on the board.



2.2. Basic Configurations

Configuration pins			Storage element threshold voltages			LDOs output voltages		Typical use
CFG[2]	CFG[1]	CFG[0]	V_{OVCH}	V_{CHRDY}	V_{OVDIS}	V_{HV}	V_{LV}	
1	1	1	4.12 V	3.67 V	3.60 V	3.3 V	1.8 V	Li-ion battery
1	1	0	4.12 V	4.04 V	3.60 V	3.3 V	1.8 V	Solid state battery
1	0	1	4.12 V	3.67 V	3.01 V	2.5 V	1.8 V	Li-ion/NiMH battery
1	0	0	2.70 V	2.30 V	2.20 V	1.8 V	1.2 V	Single-cell (super) capacitor
0	1	1	4.50 V	3.67 V	2.80 V	2.5 V	1.8 V	Dual-cell supercapacitor
0	1	0	4.50 V	3.92 V	3.60 V	3.3 V	1.8 V	Dual-cell supercapacitor
0	0	1	3.63 V	3.10 V	2.80 V	2.5 V	1.8 V	LiFePO4 battery
0	0	0	Custom mode - see Section 2.3.1				1.8 V	

Table 2: Usage of CFG[2:0]

ENLV	ENHV	LV output	HV output
1	1	Enabled	Enabled
1	0	Enabled	Disabled
0	1	Disabled	Enabled
0	0	Disabled	Disabled

Table 3: LDOs enabling

$V_{SRC,REG}$	SRC_LVL_RANGE[1]	SRC_LVL_RANGE[0]	Multiplier
0 V - 1.35 V	0	0	1
1.35 V - 2.7 V	0	1	2
2.7 V - 4.47 V	1	0	4
	1	1	4

Table 4: Usage of SRC_LVL_RANGE[1:0]

2.3. Advanced Configurations

A complete description of the system constraints and configurations is available in Section 8 "System configuration" of the AEM00940 datasheet.

A reminder on how to compute the configuration resistors value is provided below. Calculation can be made with the help of the spreadsheet found at the e-peas website.

2.3.1. Custom mode

In addition to the pre-defined storage element protection levels, the custom mode allows users to define their own levels via resistors R1 to R4 and to tune the output of the high voltage LDO HVOUT via resistors R5-R6.

Here is how to determine the values of R1-R4 to set the desired storage element protection levels:

- $RT = R1 + R2 + R3 + R4$
- $1M\Omega \leq RT \leq 100M\Omega$
- $R1 = RT \cdot \frac{1V}{V_{OVCH}}$
- $R2 = RT \cdot \left(\frac{1V}{V_{CHRDY}} - \frac{1V}{V_{OVCH}}\right)$
- $R3 = RT \cdot \left(\frac{1V}{V_{OVDIS}} - \frac{1V}{V_{CHRDY}}\right)$
- $R4 = RT \cdot \left(1 - \frac{1V}{V_{OVDIS}}\right)$

Here is how to determine the values of R5-R6 to set the desired HVOUT voltages:

- $1M\Omega \leq RV \leq 40M\Omega$
- $R5 = RV \cdot \frac{1V}{V_{HV}}$
- $R6 = RV \cdot \left(1 - \frac{1V}{V_{HV}}\right)$

Make sure the protection levels satisfy the following conditions:

- $V_{CHRDY} + 0{,}05V \leq V_{OVCH} \leq 4{,}5V$
- $V_{OVDIS} + 0{,}05V \leq V_{CHRDY} \leq V_{OVCH} - 0{,}5V$
- $2{,}2V \leq V_{OVDIS}$
- $V_{HV} \leq V_{OVDIS} - 0{,}3V$

If unused, leave the resistor footprints (R1 to R6) empty and do not set CFG[2:0] to 000.

2.3.2. Primary battery configuration

If the primary storage is used, its battery protection levels have to be defined. To do so, use resistors R7 - R8.

- $RP = R7 + R8$
- $100k\Omega \leq RP \leq 500k\Omega$
- $R7 = \frac{V_{PRIM\_MIN}}{4} \cdot RP \cdot \frac{1}{2{,}2V}$
- $R8 = RP - R7$

If unused, install jumpers on both headers marked "NoPRIM".

2.3.3. Constant voltage configuration

The regulated harvesting voltage $V_{SRC,REG}$ can be defined by the use of the resistors R9 and R10.

SRC_LVL_RANGE[1:0] must be set according to the range of $V_{SRC,REG}$ as shown in Table 4.

By defining M as the range multiplier (see Table 4) and RS as the sum of R9 and R10 we have:

- $RS = R9 + R10$
- $100k\Omega \leq RS \leq 1M\Omega$
- $R10 = \frac{V_{SRC,REG}}{M} \cdot RS \cdot \frac{1}{2{,}2V}$
- $R9 = RS - R10$

Resistors R9 and R10 can be installed on the EVK by soldering SMD resistors on the R9-R10 footprints or by inserting through-hole resistors in the R9-R10 connectors. In those cases do not place jumpers on JP5 and JP7.

The voltage level can also be modified with the potentiometer VR1. VR1 is a 200 kΩ potentiometer which is connected to VBUCK through R19 (100 kΩ). The procedure of setting $V_{SRC,REG}$ through VR1 is the following:

- Make sure R9 and R10 are not installed neither on the SMD footprints or on the screw connectors.
- Install jumpers on JP5 and JP7.
- Make sure the AEM00940 has cold-started and that VBUCK is 2.2 V. The power available on SRC must be larger than 100 µW.
- Connect a jumper on JP8 to ensure that the resistive divider (VR1 and R19) is always grounded.
- Connect a voltmeter between GND and SRC_LVL_U using the dedicated test point below VR1.
- Set VR1 using a screwdriver until SRC_LVL_U reaches the desired voltage considering the above formulas.
- Remove both the jumper on JP8 and the voltmeter.
- Test with your source.

2.3.4. Balun circuit configuration

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

- Connect the node between the two supercapacitor cells to BAL (BATT connector)
- Use a jumper to connect "BAL" to "ToCN"

If unused, use a jumper to connect "BAL" to "GND".

3. Revision History

Revision	Date	Description
1.0	March 2022	Creation of the document