AEM10300 Evaluation Board User Guide

Description

The AEM10300 evaluation board is a printed circuit board (PCB) featuring all the needed components to operate the AEM10300 integrated circuit (IC).

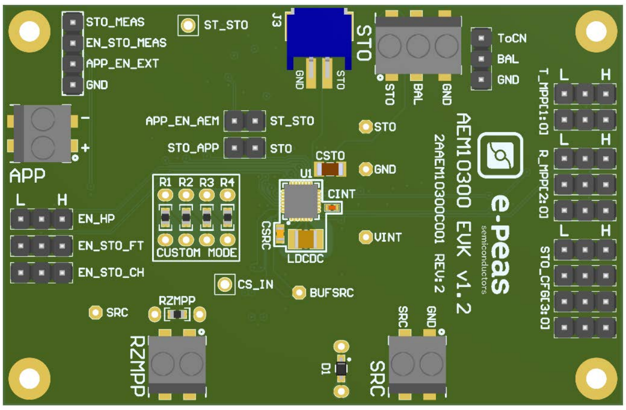
The AEM10300 evaluation board allows users to test the e-peas IC and analyze its performances in a laboratory-like setting.

It allows easy connections to the energy harvester and the storage element. 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 standard pin headers, allowing users to wire for any usage scenario and evaluate the relevant performances.

The AEM10300 evaluation board is a plug and play, intuitive and efficient tool for making the appropriate decisions (component selection, operating modes, etc.) for the design of a highly efficient subsystem in your target application.

More detailed information about AEM10300 features can be found in the datasheet.

Appearance



Features

Three two-way screw terminals
- Source of energy (DC).
- ZMPP configuration.
- External output supply.

One three-way screw terminal
- Energy storage element (battery or (super)capacitor).

One 2-pin “Shrouded Header”
- Alternative connector for the storage element.

3-pin headers
- Maximum power point ratio (R_MPP) configuration.
- Maximum power point timing (T_MPP) configuration.
- Storage element voltage configuration.
- Dual-cell supercapacitor configuration.
- Modes configuration.

Provision for resistors
- Custom mode configuration.
- ZMPP configuration.

Configuration by 0 Ω resistors
- Cold start input configuration.

One 1-pin header
- Access to status pin.

Device Information

Part Number	Dimensions
2AAEM10300C001	76 mm x 50 mm

1. Connections Diagram

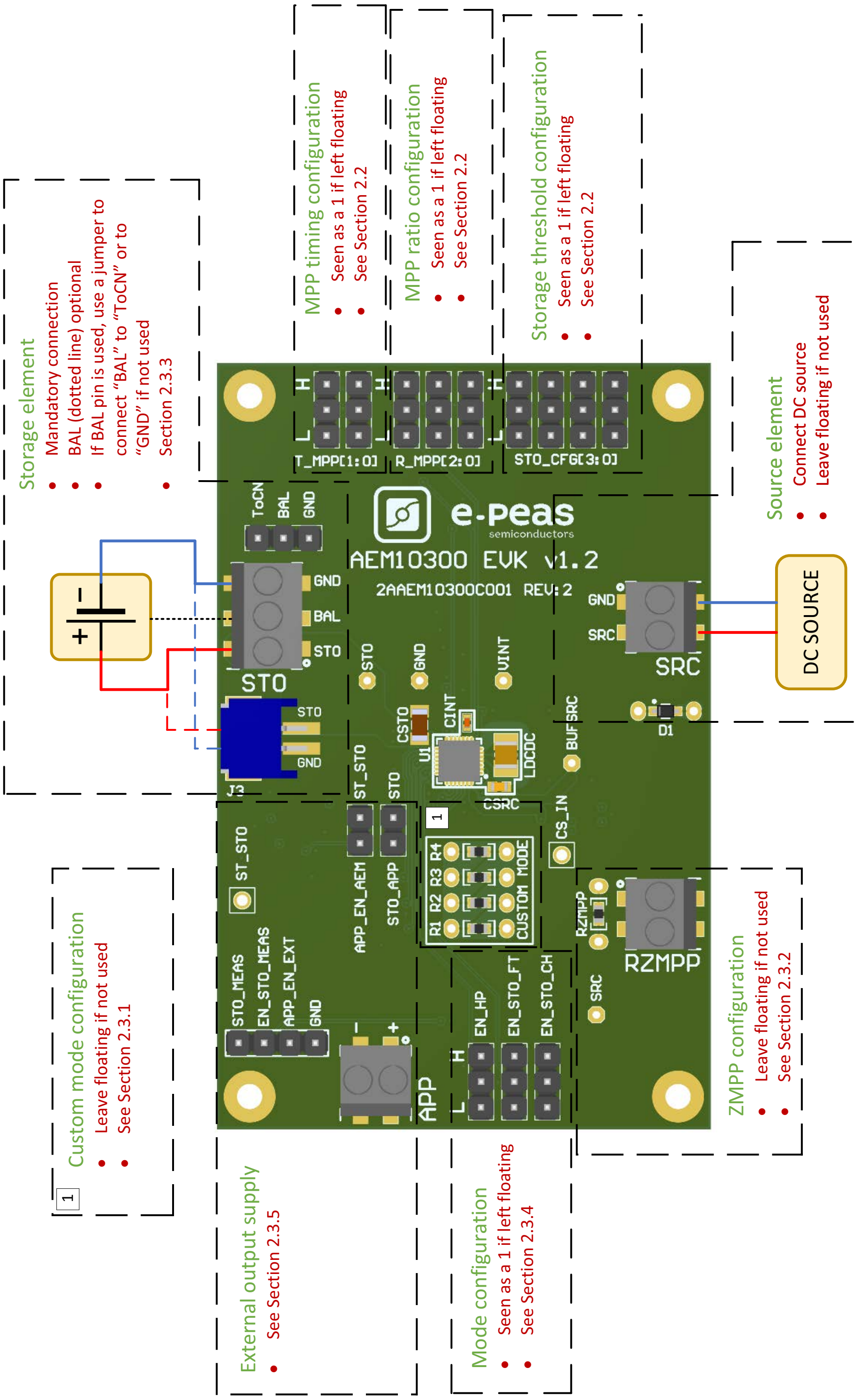


Figure 1: Connection Diagram

1.1. Signals Description

NAME	FUNCTION	CONNECTION	
		If used	**If not used**
Power signals			
SRC	Connection to the harvested energy source.	Connect the source element.	
STO	Connection to the energy storage element.	Connect the storage element in addition to CSTO (150 µF).	Do not remove CSTO.
BAL	Connection to mid-point of the dual-cell supercapacitor.	Connect balancing and place a jumper shorting “BAL” and “ToCN”.	Use a jumper to connect “BAL” to “GND”.
APP	Connection to the application.	Connect the jumper on APP_EN_AEM and a jumper on STO_APP.	Remove the jumper on APP_EN_AEM and the jumper on STO_APP.
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 jumpers.	Leave floating.
T_MPP[1:0]	Configuration of the MPP timing.	Connect jumpers.	Leave floating.
STO_CFG[3:0]	Configuration of the threshold voltages for the energy storage element.	Connect jumpers.	Leave floating.
ZMPP	Configuration of the constant impedance MPP.	Use resistor R_{ZMPP}.	Leave floating.
Control signals			
EN_HP	Enabling pin for the high-power mode.	Connect jumper.	
EN_STO_FT	Enabling pin for the feed-through feature.	Connect jumper.	
EN_STO_CH	Enabling pin for the storage charging.	Connect jumper.	
APP_EN_AEM	Enabling pin for the application supply.	Connect jumper.	
APP_EN_EXT		External signal.	Leave floating.
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}.		
STO_MEAS	Voltage level on the storage element.	High level in EN_STO_MEAS (from external signal) to enable the measure.	Leave floating EN_STO_MEAS.

Table 1: Signals Description

2. General Considerations

2.1. Safety Information

Always connect the elements in the following order:

1. Reset the board: Short VINT, STO and SRC test points to GND.

2. Completely configure the PCB (jumpers/resistors):

- MPP configuration (Ratio/Timing).
- Battery configuration.
- Balancing circuit configuration.
- Mode configuration.

3. Connect the storage elements on STO.

4. Connect the source (DC or AC) to the SRC connector.

To avoid damaging the board, users are required to follow this procedure.

The pin "BAL" cannot remain floating.

2.2. Basic Configurations

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

Table 2: Storage Element Configuration Pins

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

Table 3: MPP Ratio Configuration Pins

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

Table 4: MPP Timing Configuration Pins

2.3. Advanced Configurations

A complete description of the system constraints and configurations is available in the AEM10300 datasheet “System Configuration” Section.

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.

2.3.1. 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, according to the following equations:

- $R_T = R_1 + R_2 + R_3 + R_4$
- $1\,M\Omega \leq R_T \leq 100\,M\Omega$
- $R_1 = R_T \cdot \frac{1V}{V_{OVCH}}$
- $R_2 = R_T \cdot \left(\frac{1V}{V_{CHRDY}} - \frac{1V}{V_{OVCH}}\right)$
- $R_3 = R_T \cdot \left(\frac{1V}{V_{OVDIS}} - \frac{1V}{V_{CHRDY}}\right)$
- $R_4 = R_T \cdot \left(1 - \frac{1V}{V_{OVDIS}}\right)$

User must ensure that the protection levels satisfy the following conditions:

- $V_{CHRDY} + 0.05V \leq V_{OVCH} \leq 4.5V$
- $V_{OVDIS} + 0.05V \leq V_{CHRDY} \leq V_{OVCH} - 0.05V$
- $1V \leq V_{OVDIS}$

If unused, leave the resistor footprints (R1 to R4) empty.

2.3.2. ZMPP Configuration

If this configuration is chosen (see Table 3), the AEM10300 regulates V_{SRC} at a voltage equals to the product of R_{ZMPP} times the current available at the source SRC.

- $10\,\Omega \leq R_{ZMPP} \leq 1\,M\Omega$

If unused, leave the resistor footprint R_{ZMPP} empty.

2.3.3. 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 jumper to connect “BAL” to “ToCN”.

If unused, use a jumper to connect “BAL” to “GND”.

2.3.4. 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 H to enable the high-power mode.
- Use a jumper to connect EN_HP to L 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 H to enable the charge of the storage element.
- Use a jumper to connect the EN_STO_CH to L to disable the charge of the storage element.

An internal pull-up resistor is setting the EN_STO_CH at H by default.

EN_STO_FT

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

- Use a jumper to connect the EN_STO_FT to H to activate the feature.
- Use a jumper to connect the EN_STO_FT to L to disable the feature.

2.3.5. External Output Supply

The AEM10300 is a battery charger. An external application can be supplied from the battery using the APP connector in the EVK.

To enable this feature a jumper may be placed connecting STO to STO_APP. A switch will connect the storage element to the APP connector if one of these two signals, APP_EN_AEM or APP_EN_EXT, have a high logic level.

Placing a jumper linking ST_STO and APP_EN_AEM will enable the APP output when the voltage in the storage element rises above V_{CHRDY} (if the AEM comes from RESET STATE) and while the storage element voltages is over V_{OVDIS}. The AEM10300 goes to RESET STATE if there is no more energy to harvest in the SRC input, the ST_STO signal is also reset. The APP_EN_EXT signal may be asserted from the application to continue using the APP output when the AEM is in RESET STATE.

The storage element voltage can be measured in the STO_MEAS pin. This pin is connected to a power gated resistor bridge that can be enabled through the EN_STO_MEAS signal.

3. Functional Tests

This section presents a few simple tests that allow the user to understand the functional behavior of the AEM10300. To avoid damaging the board, follow the procedure found in Section 2.1 “Safety Information”. If a test has to be restarted make sure to properly reset the system to obtain reproducible results.

The following functional tests were made using the following setup:

- R_MPP[2:0] = LLL.
- T_MPP[1:0] = LH.
- STO_CFG[3:0] = LLLL.
- EN_HP = H.
- EN_STO_FT = L.
- EN_STO_CH = H.
- Storage element: Capacitor (4.7 mF + CSTO).
- SRC: current source (1mA or 100uA) with voltage compliance (4V).

Setup can be adapted to match user’s system as long as the input and cold-start constraints are met (see the AEM10300 datasheet “Introduction” Section).

3.1. Start-up

The following example allows the user to observe the behavior of the AEM10300 in Wake-up state.

Setup

- Place the probes on the nodes to be observed.
- Referring to Figure 1, follow steps 1 to 5 explained in Section 2.1 “Safety Information”.

Observations and Measurements

- STO: Voltage rises as the power provided by the source is transferred to the storage element.
- ST_STO: Asserted when the voltage on STO rises above V_{CHRDY}.

3.2. Shutdown

This test allows users to observe the behavior of the AEM10300 when the system is running out of energy.

Setup

- Place the probes on the nodes to be observed.
- Referring to Figure 1, follow steps 1 to 5 explained in Section 2.1 “Safety Information”. Configure the board in the desired state and start the system (see Section 3.1).
- Let the system reach a steady state (i.e. voltage on STO between V_{CHRDY} and V_{OVCH} and ST_STO asserted.
- Remove your source element and let the system discharge through quiescent current.

Observations and Measurements

- STO: Voltage decreases as the system consumes the power accumulated in the storage element. The voltage reaches V_{OVDIS}.
- ST_STO: De-asserted when the storage element is running out of energy (V_{OVDIS}).

3.3. Cold Start

The following test allows the user to observe the minimum voltage required to coldstart the AEM10300. To prevent leakage current induced by the probe the user should avoid probing any unnecessary node. Make sure to properly reset the board to observe the cold-start behavior.

Setup

- Place the probes on the nodes to be observed.
- Referring Figure 1, follow steps 1 and 2 explained in Section 2.1. Configure the board in the desired state. Do not plug any storage element in addition to CSTO.
- SRC: Connect your source element.

Observations and Measurements

- SRC: Equal to the cold-start voltage during the cold-start phase. Regulated at the selected MPPT percentage of V_{OC} when cold start is over. Be careful that the cold-start phase time will shorten with the input power. Limit it to ease the observation.
- STO: Starts to charge the storage element when the cold-start phase is over.

3.4. Dual-cell Supercapacitor Balancing Circuit

This test allows users to observe the balancing circuit behavior that maintains the voltage on BAL at half the voltage on STO.

Setup

- Following steps 1 and 2 explained in Section 2.1 and referring to Figure 1, configure the board in the desired state. Plug the jumper linking “BAL” to “ToCN”.
- STO: Connect capacitor C1 between the positive (+) and the BAL pins and a capacitor C2 between BAL and the negative (-) pins. Select C1 and C2 so that:
  - $C1 \neq C2$
  - $C1 > 1mF$
  - $C2 > 1mF$
  - $\frac{C2 \cdot V_{CHRDY}}{C1} \geq 0.9V$
- SRC: Plug your source element to start the power flow to the system.

Observations and Measurements

- BAL: Equals to half the voltage on STO.

Do not leave BAL floating, doing so could damage the AEM.

3.5. Source to Storage Element Feed-Through

This example allows users to observe the feed-through feature.

Setup

- Place the probes on the nodes to be observed.
- Referring to Figure 1, follow steps 1 to 5 explained in Section 2.1 “Safety Information”. Configure the board in the desired state and start the system (see Section 3.1).
- Let the system reach a steady state (i.e. voltage on STO between V_{CHRDY} and V_{OVCH} and ST_STO asserted.
- EN_STO_FT: Connect to VINT.
- SRC: current source (1mA or 100uA) with voltage compliance (5V).
- Connect a capacitor (>1mF) on SRC and STO to avoid perturbation due to the SMU behavior.

Observations and Measurements

- STO: The current from the source is transfered directly to the storage element.

4. Schematics

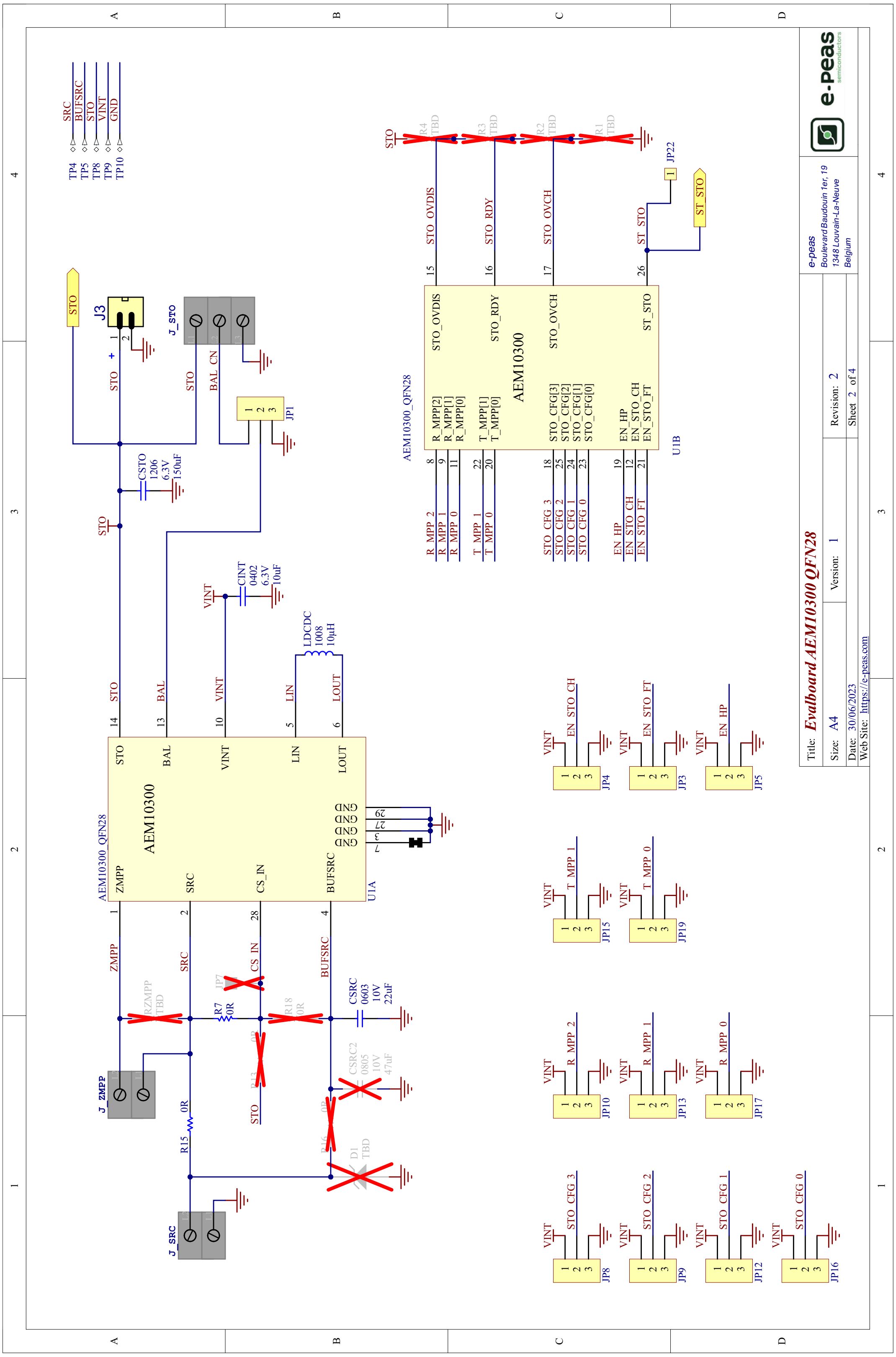


Figure 2: Schematic Part 1

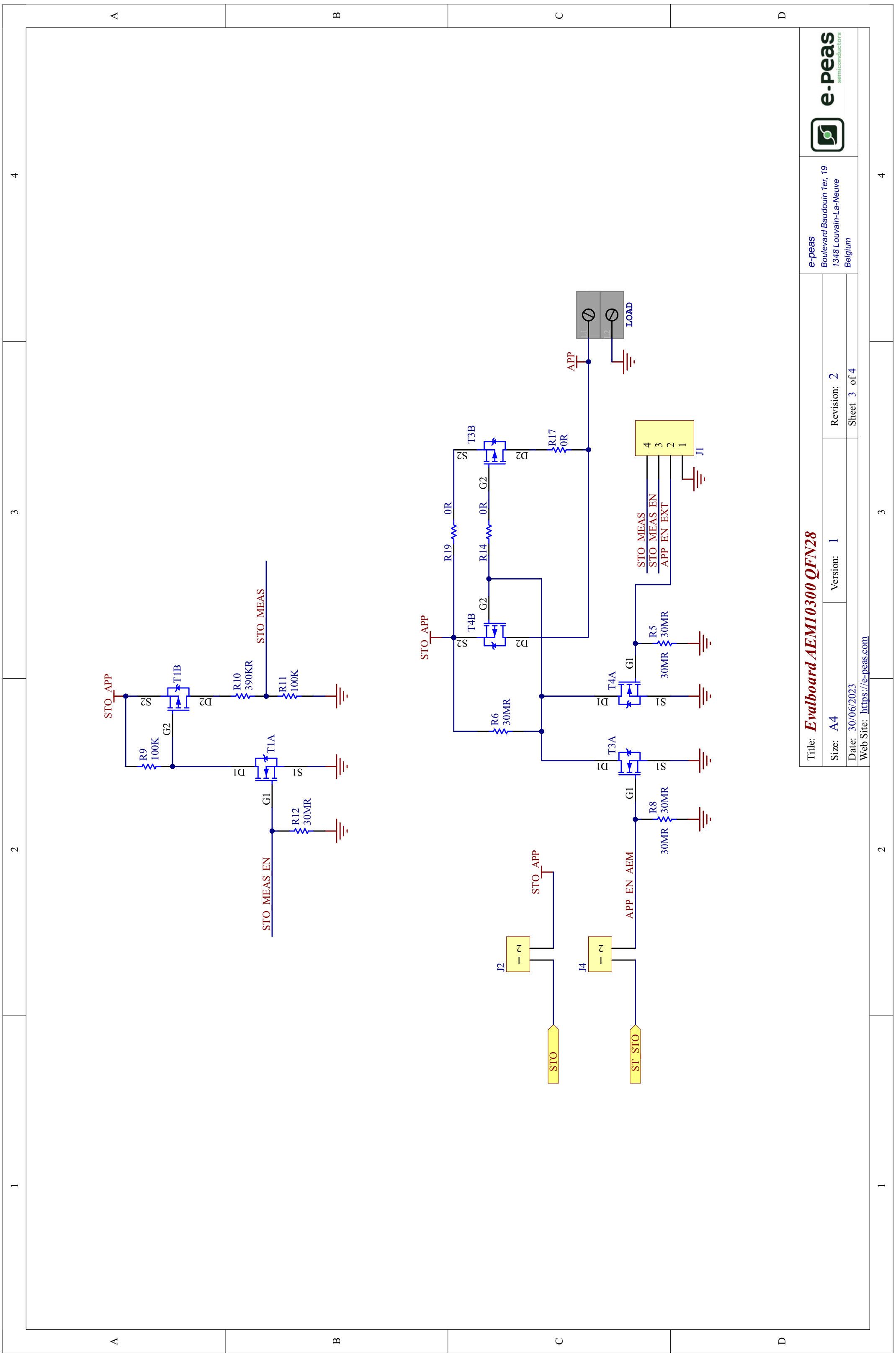


Figure 3: Schematic Part 2

5. Revision History

EVK Version	User Guide Revision	Date	Description
Up to 1.1	1.0	September, 2021	Creation of the document.
	1.1	November, 2022	Fixed some inconsistencies and updated images.
1.2	1.0	August, 2023	Images and schematics update to EVK v1.2.
1.2	1.1	December, 2023	- Updated Revision History table to separate EVK version and User Guide version. - Replaced 0/1 by L/H.

Table 5: Revision History