Description

The AEM00920 evaluation kit (EVK) is a printed circuit board (PCB) featuring all the required components to operate the AEM00920 integrated circuit (IC) in QFN 24-pin package.

The AEM00920 evaluation board allows users to test the e-peas IC and analyze its performances in a laboratory-like setting or in product mock-ups.

It allows easy connections to one energy harvester, an optional 5 V power source, a storage element and an application circuit. It also provides all the configuration accesses to set the device in any of the modes described in the datasheet. The status signal is available on a standard pin header.

The AEM00920 EVK is a plug and play, intuitive and efficient tool to optimize the AEM00920 configuration, allowing users to design a highly efficient subsystem for the desired target application. Component replacement and operating mode switching is convenient and easy.

More detailed information about AEM00920 features can be found in the datasheet.

Applications

- Remote Controls
- Wireless Keyboards

Features and Benefits

Two-way screw terminals
- DC source of energy (SRC).
- Energy storage element (STO).
- Application circuit (LOAD).
- 5 V DC power input (5V_IN).

3-pin headers
- Source voltage regulation mode configuration.
- Storage element voltage thresholds configuration.
- Load voltage regulation configuration.
- Shipping mode enable/disable.

2-pin headers
- 5 V power input max current presets.

USB connector
- 5 V DC power input (max. 5.5 V peak).

Evaluation Kit Information

<table>
<thead>
<tr>
<th>Part number</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2AAEM00920A0011</td>
<td>76 mm x 49 mm</td>
</tr>
</tbody>
</table>

Device Information

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
<th>Body size</th>
</tr>
</thead>
<tbody>
<tr>
<td>10AEM00920A0000</td>
<td>QFN 24-pin</td>
<td>4x4mm</td>
</tr>
</tbody>
</table>
1. EVK Connection Diagram

Figure 1: AEM00920 EVK connection diagram
# 2. Pin Configuration and Functions

<table>
<thead>
<tr>
<th>NAME</th>
<th>FUNCTION</th>
<th>CONNECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power Pins</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRC</td>
<td>Connection to the energy source harvested by the boost converter.</td>
<td>Connect the source element.</td>
</tr>
<tr>
<td>STO</td>
<td>Connection to the energy storage element (rechargeable battery or LiC).</td>
<td>Connect the storage element.</td>
</tr>
<tr>
<td>LOAD</td>
<td>Output voltage of the buck converter to supply an application circuit.</td>
<td>Connect the application circuit.</td>
</tr>
<tr>
<td>5V_IN</td>
<td>Input of the 5 V DC power supply.</td>
<td>Connect a 5 V DC power source.</td>
</tr>
</tbody>
</table>

| **Control Pin** | | |
| SHIP_MODE | Logic input. When HIGH:  
- Minimum consumption from the storage element.  
- Storage element charge is disabled (boost converter is disabled).  
- Buck (LOAD) is disabled.  
- Only VINT is charged if energy is available on SRC. | Connect jumper to H. | Read as LOW if left floating. |

Table 1: Signals description
3. General Considerations

3.1. Safety Information

Always connect the elements in the following order:

1. Reset the board by temporarily connecting the “RESET” pads to GND, from top to bottom (as shown on PCB) silkscreen.
2. Completely configure the PCB (jumpers/resistors):
   - Sources voltage regulation mode (SRC_LVL_CFG[4:0]).
   - Storage element voltage thresholds (STO_CFG[1:0]).
   - Load output regulation voltage (LOAD_CFG[1:0]).
   - 5 V charger maximum current.
3. Connect a storage element on the STO screw connector.
4. Connect the application circuit on the LOAD screw connector.
5. Connect the harvester to the source.

3.2. AEM00920 Reset

The following procedure must be followed to properly reset the AEM00920:

- Connect a wire to GND.
- Use it to short the “Reset” pads to GND from top to bottom, as indicated on the EVK silkscreen.

### Table 1: Signals description

<table>
<thead>
<tr>
<th>NAME</th>
<th>FUNCTION</th>
<th>CONNECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration Pins</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRC_LVL_CFG[4:0]</td>
<td>Used for the configuration of SRC constant voltage regulation.</td>
<td>Connect jumpers. Read as HIGH is left floating.</td>
</tr>
<tr>
<td>STO_CFG[1:0]</td>
<td>Used to configure the storage element voltage thresholds.</td>
<td>Connect jumpers. Read as HIGH is left floating.</td>
</tr>
<tr>
<td>LOAD_CFG[1:0]</td>
<td>Used to configure the LOAD output regulation voltage.</td>
<td>Connect jumpers. Read as HIGH is left floating.</td>
</tr>
<tr>
<td>CM_D</td>
<td>Used to enable the custom mode.</td>
<td>Place a jumper on CM_D and GND</td>
</tr>
<tr>
<td>5V_IMAX</td>
<td>Connection to an external resistor to set the charging current from the 5V_IN supply to STO.</td>
<td>Connect jumper on one of the three 2-pin headers or connect a resistor on R5. Leave floating if 5V_IN is not used.</td>
</tr>
<tr>
<td>Status Pin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST_STO</td>
<td>Logic output. High when in SUPPLY STATE or in SLEEP STATE. Low otherwise.</td>
<td>Connect to application circuit. High level is STO. Leave floating.</td>
</tr>
</tbody>
</table>
3.3. Configurations

3.3.1. Source Constant Voltage Configuration

<table>
<thead>
<tr>
<th>Configuration pins</th>
<th>Voltage [V]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRC_LVL_CFG[4:0]</td>
<td>$V_{SRC,REG}$</td>
</tr>
<tr>
<td>L L L L L</td>
<td>0.25</td>
</tr>
<tr>
<td>L L L H L</td>
<td>0.30</td>
</tr>
<tr>
<td>L L L H H</td>
<td>0.40</td>
</tr>
<tr>
<td>L L H L L</td>
<td>0.45</td>
</tr>
<tr>
<td>L L H H L</td>
<td>0.50</td>
</tr>
<tr>
<td>L L H H H</td>
<td>0.55</td>
</tr>
<tr>
<td>L H H H L</td>
<td>0.60</td>
</tr>
<tr>
<td>L H L L L</td>
<td>0.65</td>
</tr>
<tr>
<td>L H L H L</td>
<td>0.70</td>
</tr>
<tr>
<td>L H H L L</td>
<td>0.75</td>
</tr>
<tr>
<td>L H H H L</td>
<td>0.80</td>
</tr>
<tr>
<td>L H H H L</td>
<td>0.85</td>
</tr>
<tr>
<td>L H L L H</td>
<td>0.90</td>
</tr>
<tr>
<td>L H H L L</td>
<td>0.95</td>
</tr>
<tr>
<td>L H H L L</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 2: Configuration of the source constant regulation voltage with SRC_LVL_CFG[4:0] pins

3.3.2. Storage Element Configuration

<table>
<thead>
<tr>
<th>Configuration pins</th>
<th>Overdischarge voltage [V]</th>
<th>Charge ready voltage [V]</th>
<th>Overcharge voltage [V]</th>
<th>Storage element type</th>
</tr>
</thead>
<tbody>
<tr>
<td>STO_CFG[1:0]</td>
<td>$V_{OVDIS}$</td>
<td>$V_{CHRDY}$</td>
<td>$V_{OVCH}$</td>
<td></td>
</tr>
<tr>
<td>L L</td>
<td>2.50</td>
<td>2.55</td>
<td>3.80</td>
<td>Lithium-ion Super Capacitor (LiC)</td>
</tr>
<tr>
<td>L H</td>
<td>3.00</td>
<td>3.20</td>
<td>4.12</td>
<td>Lithium-ion</td>
</tr>
<tr>
<td>H L</td>
<td>3.00</td>
<td>3.20</td>
<td>4.35</td>
<td>Lithium Polymer (LiPo)</td>
</tr>
<tr>
<td>H H</td>
<td>3.50</td>
<td>3.55</td>
<td>3.90</td>
<td>Lithium-ion (ultra-long life)</td>
</tr>
</tbody>
</table>

Table 3: Storage element configuration with STO_CFG[1:0] pins
3.3.3. Custom mode

When CM_D is not connected to GND, the custom mode is selected regardless of STO_CFG[1:0] pins and all four configuration resistors shown in Figure 6, must be wired as follows:

\[ V_{OVCH}, V_{CHRDY} \text{ and } V_{OVDIS} \text{ are defined thanks to } R_1, R_2, R_3 \text{ and } R_4. \]

If we define the total resistor \((R_1+R_2+R_3+R_4)\) as \(R_T\), \(R_1, R_2, R_3\) and \(R_4\) are calculated as:

- \( R_T = R_1 + R_2 + R_3 + R_4 \)
- \( R_1 = 0.5 \frac{R_T}{V_{OVCH}} \)
- \( R_2 = 0.5 \frac{R_T}{V_{CHRDY} - 1/V_{OVCH}} \)
- \( R_3 = 0.5 \frac{R_T}{V_{OVDIS} - 1/V_{CHRDY}} \)
- \( R_4 = R_T (1 - 0.5/V_{OVDIS}) \)

The following constraints must be met to ensure the functionality of the chip:

- \( 2.4 \text{ V} < V_{OVDIS} < 3.58 \text{ V} \)
- \( 2.46 \text{ V} < V_{CHRDY} < 3.64 \text{ V} \)
- \( 2.70 \text{ V} < V_{OVCH} < 4.59 \text{ V} \)
- \( V_{CHRDY} + 0.05 \text{ V} < V_{OVCH} < 4.59 \text{ V} \)
- \( V_{OVDIS} + 0.05 \text{ V} < V_{CHRDY} < V_{OVCH} - 0.05 \text{ V} \)
- \( V_{OVDIS} > V_{LOAD} \)

3.3.4. Load Configuration

<table>
<thead>
<tr>
<th>Configuration pins</th>
<th>LOAD voltage [V]</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOAD_CFG[1:0]</td>
<td>V_LOAD</td>
</tr>
<tr>
<td>L      L</td>
<td>Buck disabled</td>
</tr>
<tr>
<td>L      H</td>
<td>2.2</td>
</tr>
<tr>
<td>H      L</td>
<td>2.5(^1)</td>
</tr>
<tr>
<td>H      H</td>
<td>2.8(^2)</td>
</tr>
</tbody>
</table>

Table 4: Configuration of LOAD voltage with LOAD_CFG[1:0] pins

1. This configuration is only available if \( V_{OVDIS} \geq 2.5 \text{ V} \).
2. This configuration is only available if \( V_{OVDIS} \geq 2.8 \text{ V} \).
3.3.5. 5 V Charger Configuration

<table>
<thead>
<tr>
<th>Resistor [Ω]</th>
<th>Maximum Charging Current [mA]</th>
</tr>
</thead>
<tbody>
<tr>
<td>R5V_IMAX</td>
<td>5V_CC</td>
</tr>
<tr>
<td>370</td>
<td>135.0</td>
</tr>
<tr>
<td>680</td>
<td>73.5</td>
</tr>
<tr>
<td>1500</td>
<td>33.3</td>
</tr>
<tr>
<td>3700</td>
<td>13.5</td>
</tr>
</tbody>
</table>

Table 5: Typical resistor values for setting 5 V charger max.
current

1. Can be obtained by installing a 1.5 kΩ resistor on R5 and leaving all 3 headers without jumpers.

Three 2-pin headers corresponding to three current presets are available on the EVK. Install a jumper on the corresponding header to enable a preset.

Furthermore, R5 allows users for an easy installation of a custom resistor, either in through-hole or in SMD 0603 package. In that case, do not install any jumper on the three preset headers and install a resistor on R5 footprint.

3.3.6. Shipping Mode

The shipping mode feature allows for forcing the AEM00920 in RESET STATE (see datasheet), thus disabling all AEM00920 functionalities including both boost converters, the buck converter and the 5 V charger. Only VINT is charged from SRC if energy is available from it. The battery is no longer charged or discharged.

Shipping mode is enabled by installing a jumper to HIGH on the EVK dedicated header. It is disabled if a jumper is connected to LOW or if SHIP_MODE pin is left floating.

<table>
<thead>
<tr>
<th>Resistor [Ω]</th>
<th>Maximum Charging Current [mA]</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
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<td>73.5</td>
</tr>
<tr>
<td>1500</td>
<td>33.3</td>
</tr>
<tr>
<td>3700</td>
<td>13.5</td>
</tr>
</tbody>
</table>

Table 5: Typical resistor values for setting 5 V charger max. current

1. Can be obtained by installing a 1.5 kΩ resistor on R5 and leaving all 3 headers without jumpers.
4. Functional Tests

This section presents a few simple tests that allow users to understand the functional behavior of the AEM00920. To avoid damaging the board, follow the procedure found in Section 3.1. If a test has to be restarted, make sure to properly reset the system to obtain reproducible results.

Users can adapt the setup to match the use case system as long as the source limitations are respected, as well as the minimum storage voltage and cold-start constraints (see “Typical Electrical Characteristics at 25 °C” Section of AEM00920 datasheet).

In the following sections, when a “power supply” is required, it can be either a standard one quadrant positive voltage / positive current laboratory power supply with regulated voltage, or an SMU set as voltage source with current compliance.
4.1. Start up

4.1.1. Description
The following example allows users to observe the start-up behavior of the AEM00920.

4.1.2. Setup
- Oscilloscope:
  - Channel 1: STO.
  - Channel 2: VINT (may be probed on H pin on STO_CFG[1] header for example).
- SRC (2 alternatives, initially disconnected):
  - 1 V / 10 mA power supply with a 100 Ω resistor in series ($I_{SRC} = 2.5 \text{ mA with } V_{SRC,REG} = 0.75 \text{ V}$).
  - SMU set as 1 V voltage source with 2.5 mA current compliance.
- SRC_LVL_CFG[4:0] = LHLHL.
  - $V_{SRC,REG} = 0.75 \text{ V}$.
  - $I_{SRC} = \frac{1\text{ V} - 0.75\text{ V}}{100\text{ Ω}} = 2.5\text{ mA}$.
- 1000 μF capacitor connected to STO as storage element.
- 3 V power supply or SMU connected to STO beforehand.
- STO_CFG[1:0] = LH.
  - $V_{OVDIS} = 3.00 \text{ V}$.
  - $V_{CHRDY} = 3.20 \text{ V}$.
  - $V_{OVCH} = 4.12 \text{ V}$.
- LOAD is floating.
- LOAD_CFG[1:0] = LL.
  - LOAD disabled.
4.1.3. Measurements

- Reset the AEM00920 as described in Section 3.2.
- Start with:
  - 3 V power supply connected to STO so that $C_{STO}$ is charged to 3.0 V beforehand.
  - No source connected to SRC.
- Disconnect the power supply from STO.
- Connect the 1 V / 100 Ω power supply to SRC.

- Observe $V_{INT}$ rise up to 2.2 V and be regulated at that voltage.
- Energy is transferred from SRC to STO: $V_{STO}$ rises from its initial 3.0 V voltage to $V_{OVCH}$ (4.12 V).
- $V_{STO}$ is regulated to $V_{OVCH}$ (4.12 V) as the AEM00920 prevents the storage element to be charged any further.
- $5V_{IN}$ left floating.

Figure 2: AEM00920 start-up behavior
4.2. Cold start

4.2.1. Description
The following example allows users to observe the cold-start behavior of the AEM00920.

4.2.2. Setup
- Oscilloscope:
  - Channel 1: SRC.
  - Channel 2: VINT (may be probed on H pin on STO_CFG[1] header for example).
- SRC (2 alternatives, initially disconnected):
  - 1 V / 10 mA power supply with a 68 kΩ resistor in series. Please note that using a standard power supply allows for validating the minimum cold-start voltage but does not allow for validating the minimum cold-start power.
  - SMU set as 1 V voltage source with 10 µA current compliance. Using an SMU allows for validating the minimum cold-start power as well as the minimum cold-start voltage.
- SRC_LVL_CFG[4:0] = LHLHL.
  - $V_{\text{SRC,REG}} = 0.75$ V.
  - $I_{\text{SRC}} = \frac{1V - 0.3V}{68k\Omega} = 10\mu$A (PSU).
- $I_{\text{SRC}} = 10\mu$A (SMU).
- 1000 µF capacitor connected to STO as storage element.
- 3 V power supply connected to STO beforehand.
- STO_CFG[1:0] = LH.
  - $V_{\text{OVDIS}} = 3.00$ V.
  - $V_{\text{CHRDY}} = 3.20$ V.
  - $V_{\text{OVCH}} = 4.12$ V.
- LOAD is floating.
- LOAD_CFG[1:0] = LL.
  - LOAD disabled.
- ISRC
4.2.3. Measurements

- Reset the AEM00920 as described in Section 3.2.
- Start with:
  - 3 V power supply connected to STO so that $C_{STO}$ is charged to 3.0 V beforehand.
  - No source connected to SRC.
- Disconnect the power supply from STO.
- Connect the power supply or SMU to SRC.
- Cold-start phase:
  - Observe $V_{SRC}$ clamped to 0.3 V.
  - Observe $V_{INT}$ rise up to 2.2 V and be regulated at that voltage.
- Once $V_{INT}$ has reached its 2.2 V regulation voltage, the AEM00920 regulates the source at $V_{SRC,REG}$.

![Figure 3: AEM00920 cold-start behavior](image)
4.3. Load

4.3.1. Description

The following example allows users to observe how the AEM00920 switches ON and OFF the buck converter supplying the LOAD pin.

4.3.2. Setup

- Oscilloscope:
  - Channel 1: STO.
  - Channel 2: LOAD.
- SRC (2 alternatives, initially disconnected):
  - 1 V / 10 mA power supply with a 100 Ω resistor in series ($I_{SRC} = 2.5$ mA with $V_{SRC,REG} = 0.75$ V).
  - SMU set as 1.0 V voltage source with 2.5 mA current compliance.
- $SRC\_LVL\_CFG[4:0] = LHLHL$.
  - $V_{SRC,REG} = 0.75$ V.
  - $I_{SRC} = \frac{1V - 0.75V}{100\Omega} = 2.5$ mA.
- 1000 μF capacitor connected to STO as storage element.
- 2.8 V power supply connected to STO beforehand.
- $STO\_CFG[1:0] = LH$.
  - $V_{OVDIS} = 3.00$ V.
  - $V_{CHRDY} = 3.20$ V.
  - $V_{OVCH} = 4.12$ V.
- $LOAD\_CFG[1:0] = LH$.
  - LOAD is regulated at 2.2 V.
  - $LOAD$ is a $5\,k\Omega$ resistor connected between $LOAD$ and GND.
  - $I_{LOAD} = 440$ μA.
4.3.3. Measurements

- Reset the AEM00920 as described in Section 3.2.
- Start with:
  - 2.8 V power supply connected to STO so that \( C_{STO} \) is charged to 2.8 V beforehand.
  - No source connected to SRC.
- Disconnect the power supply from STO.
- Connect the power supply or SMU to SRC.
- After cold start, observe the storage element charging.
- When \( V_{STO} > V_{CHRDY} \), LOAD starts being regulated to 2.2 V, thus providing current to the 5 kΩ resistor. There is more energy harvested than consumed (positive power budget), so the storage element keeps being charged.
- Disconnect the power supply from SRC (done at about 4.75 s on Figure 4).
- The current drawn by the 5 kΩ is now discharging the storage element, as no more energy is harvested to compensate for the load.
- When \( V_{STO} < V_{VDIS} \), the AEM00920 waits for \( T_{CRIT} \) (2.5 s) and then switches OFF the buck converter. LOAD is no longer regulated and drops down to 0 V.

![Figure 4: AEM00920 LOAD output behavior](image)

Please note that, in a real application, the storage element would be a battery or a supercapacitor, with much higher stored energy, so that \( V_{STO} \) would not drop as low as on Figure 4 during \( T_{CRIT} \).
4.4. 5 V Charger

4.4.1. Description

The following example allows users to observe how the AEM00920 coldstarts and charges the storage element from the 5 V charger.

4.4.2. Setup

- Oscilloscope:
  - Channel 1: STO.
  - Channel 2: 5V_IN.
- SRC left floating.
- 5V_IN: 5.0 V / 200 mA power supply or SMU (initially disconnected).
- 5V_IN constant current set to 13.5 mA by installing a jumper on the corresponding header.
- 10 mF capacitor connected to STO as storage element (1000 µF will also work but STO charging slope will be even steeper).
- 2.8 V power supply connected to STO beforehand.
- STO_CFG[1:0] = LH.
  - V_DVDIS = 3.00 V.
  - V_CHRDY = 3.20 V.
  - V_OVCH = 4.12 V.
- LOAD_CFG[1:0] = LL.
  - LOAD is disabled.
- LOAD left floating.
4.4.3. Measurements

- Reset the AEM00920 as described in Section 3.2.
- Start with:
  - 2.8 V power supply connected to STO so that $C_{STO}$ is charged to 2.8 V beforehand.
  - No source connected to 5V_IN.
- Disconnect the power supply from STO.
- Connect the power supply or SMU to 5V_IN.
- After cold start, observe the storage element charging up to $V_{OVCH}$ (4.12 V).

![Figure 5: AEM00920 cold start and storage element charge from 5V_IN](image-url)
5. Performance Tests

This section presents the tests to reproduce the performance graphs found in the AEM00920 datasheet. To be able to reproduce those tests, you will need the following:

- 2 source measure units (SMU, typically Keithley 2450). Those must be set with longest integration time.
- 1 voltage source (only for coldstarting the AEM00920 when performing buck efficiency measurement).

To avoid damaging the board, follow the procedure found in Section 3.1 “Safety information”. If a test has to be restarted, make sure to properly reset the system to obtain reproducible results, as shown in Section 3.2.

5.1. Boost Converter Efficiency

5.1.1. Description

The boost converter efficiency is determined for a fixed set point of the AEM00920:

- Fixed SRC voltage $V_{SRC}$.
- Fixed SRC current $I_{SRC}$.
- Fixed STO voltage $V_{STO}$.
- Fixed inductor value $L_{BOOST}$. Please note that the inductor model has a subsequent influence on the efficiency.

Boost efficiency measurement is about measuring the current provided to STO with all other parameters fixed.

Please note that to avoid any leakage that would affect the measurement, no probe or voltmeter must be connected to the AEM00920 pins while measuring the boost efficiency.

5.1.2. Setup

- SRC_LVL_CFG[4:0] set according to the desired $V_{SRC}$ set point (see Table 2).
- SRC: SMU set as voltage source.
  - Voltage set to 0.5 V above the desired $V_{SRC}$ set point.
  - Current compliance set to the desired $I_{SRC}$.
- STO: SMU set as voltage source:
  - Voltage set to the desired $V_{STO}$ set point.
  - Current compliance set so that the power on STO ($V_{STO} \times I_{STO}$) is at least higher that the power of the SMU connected to SRC ($V_{SRC} \times I_{SRC}$). Do not lower the current compliance lower than 100 µA.
5.1.3. Measurements

Cold start and initialization

This part must only be done for the first efficiency data point measurement. To avoid having to do it between two subsequent set points, users must make sure that $V_{STO}$ does not drop below $V_{OVDIS}$ between measurements.

- Start with both SMU switched OFF.
- Reset the AEM00920.
- STO SMU: set the voltage to 5.0 V and switch ON, to make sure that $V_{STO}$ is above $V_{OVCH}$.
- SRC SMU: set the voltage source to 1.0 V with 1 mA current compliance to trigger the AEM00920 cold start.
- Wait for $V_{INT}$ to rise to its regulation voltage of 2.2 V.
- The AEM00920 is now ready to perform an efficiency measurement. Do not lower $V_{STO}$ below $V_{OVDIS}$ from that point to avoid the AEM00920 going to OVDIS STATE. Keep STO SMU current compliance at least 100 µA.

Efficiency measurement

The following needs to be done for all desired set points:

- Set SRC SMU to the desired voltage and current set point.
- Set STO SMU to the desired voltage and current set point.
- Clear both SMU buffers.
- Wait for the number of measures of both SMU to be sufficient (the lower the current the higher the necessary number of measures).
- Determine the average currents and voltages from both SMU buffers.
- Determine the boost efficiency with the following formula:

$$\eta(\%) = \frac{V_{STO} \cdot I_{STO}}{V_{SRC} \cdot I_{SRC}} \times 100$$

![Figure 6: Boost converter efficiency with $L_{BOOST} = 33 \, \mu H$ (Coilcraft LPS4018-333MRB)](image)
5.2. Buck Converter Efficiency

5.2.1. Description
The buck converter efficiency is determined on a fixed set point of the AEM00920:
- Fixed STO voltage $V_{STO}$.
- Fixed LOAD voltage $V_{LOAD}$.
- Fixed LOAD current $I_{LOAD}$.
- Fixed inductor value $L_{BUCK}$. Please note that the inductor model has a subsequent influence on the efficiency.

Buck efficiency measurement is about measuring the current that needs to be pulled from STO at a given $V_{STO}$ to provide a given current/voltage on LOAD, with all other parameters fixed.

Please note that, to avoid any leakage that would affect the measurement, no probe or voltmeter must be connected to the AEM00920 pins while measuring the buck efficiency.

5.2.2. Setup
- **STO**: SMU set as voltage source:
  - Voltage set to the desired $V_{STO}$ set point.
  - Current compliance set so that the power on STO ($V_{STO} \times I_{STO}$) is at least higher that the power of the SMU connected to LOAD ($V_{LOAD} \times I_{LOAD}$).
- **LOAD**: SMU set as voltage source.
  - Voltage set to 0.5 V below the desired $V_{LOAD}$ set point, forcing the SMU to pull the compliance current when the buck converter is regulating its output voltage.
5.2.3. Measurements

Cold start and initialization

This part must only be done for the first efficiency data point measurement. To avoid having to do it between two subsequent set points, users must make sure that STO voltage doesn’t drop below VOVDIS between measurements, with at least 100 µA current compliance.

- Start with both SMU switched OFF.
- Reset the AEM00920.
- STO SMU: set the voltage to 5.0 V and switch ON, to make sure that the VSTO is above VOVCH.
- Switch ON SRC power supply.
- Wait for VIN to be regulated at 2.2 V.
- Switch OFF SRC power supply.
- The AEM00920 is now ready to perform an efficiency measurement. Do not lower VSTO below VOVDIS from that point to avoid the AEM00920 going to OVDIS STATE. Keep the STO SMU current compliance at least 100 µA.

Efficiency measurement

The following needs to be done for all desired set points:

- Set STO SMU to the desired voltage and current set point.
- Set LOAD SMU to the desired voltage and current set point.
- Clear both SMU buffers.
- Wait for the number of measures of both SMU to be sufficient (the lower the current the higher the necessary number of measures).
- Determine the average currents and voltages from both SMU buffers.
- Determine the buck efficiency with the following formula:

$$\eta[\%] = \frac{V_{LOAD} \cdot I_{LOAD}}{V_{STO} \cdot I_{STO}} \cdot 100$$

*Figure 7: Buck (LOAD) converter efficiency with LBUCK = 10 µH (Coilcraft LPS4018-103MRB)*
6. EVK Schematic

Figure 8: EVK schematic
## 7. Revision History

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<thead>
<tr>
<th>EVK Version</th>
<th>User Guide Revision</th>
<th>Date</th>
<th>Description</th>
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<td>1.1</td>
<td>1.0</td>
<td>December, 2023</td>
<td>Creation of the document.</td>
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Table 6: Revision History