

Ultra Efficient Energy Manager with Constant Source Voltage Regulation, Regulated Buck Output and 5 V Charger

Features and Benefits

Harvester source input

- Efficiency above 90 % on the source.
- Harvest from 250 mV after cold start.
- Up to 135 mA current extracted from the harvester.

Maximum Power Point Tracking

- Constant voltage regulation method.
- Optimized for constant voltage PV cells.
- Selectable input regulation voltage.

Cold start from 275 mV / 1.5 μ W input

- Startup at ultra-low power from harvesting source input.

Selectable overdischarge and overcharge protection

- Supports various types of rechargeable batteries (LiC, Li-ion, LiPo...).
- Custom mode configuration.

Regulated output for application circuit

- Buck regulator with efficiency above 90 %.
- Selectable output voltage (2.2 V, 2.5 V or 2.8 V).
- Output current up to 100 mA.

System configuration by GPIO

- All settings are dynamically configurable through GPIO.

Shipping mode

- Disables charging and discharging the battery during shipment.

External 5 V charging capability

- Extra charging input for 5 V power supplies.
- CC/CV charging with configurable current limit (up to 135 mA).
- Provides a fast charging alternative when no source is available for a long time.

Applications

Smart home	Industrial sensor
Smart building	Retail
Edge IoT	PC accessories

Description

The AEM00920 is a fully integrated and compact power management circuit that extracts DC power from a harvesting source to store energy in a rechargeable storage element and supply an application circuit. A 5 V input can also be used to charge the storage element (e.g. if it gets depleted). This compact and ultra-efficient battery charger allows for extending battery lifetime and eliminating the primary energy storage element in a large range of applications.

The AEM00920 implements constant voltage regulation of the source, allowing for harvesting the maximum power available from the source to charge the storage element.

With its unique cold-start circuit, it can start operating with an input voltage as low as 275 mV (min. 1.5 μ W power).

The configurable protection levels determine the storage element voltage protection thresholds to avoid overcharging and overdischarging the storage element and thus damaging it.

A shipping mode is available to avoid charging and discharging the storage element during shipping or storage.

A buck regulator with selectable output voltage allows an application circuit to be supplied with high efficiency.

Device Information

Part Number	Package	Body size
10AEM00920A0002	QFN 24-pin	4 x 4 mm

Evaluation Board

Part number
2AAEM00920A001

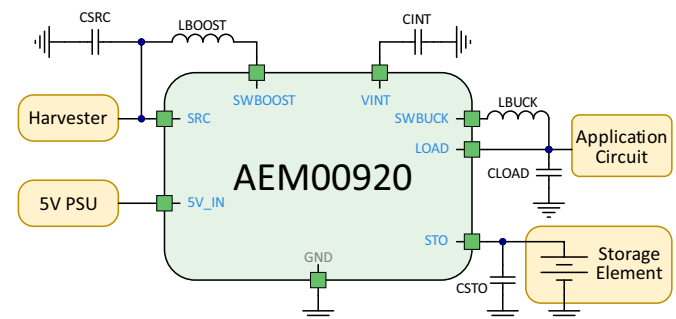


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1. Pin Configuration and Functions

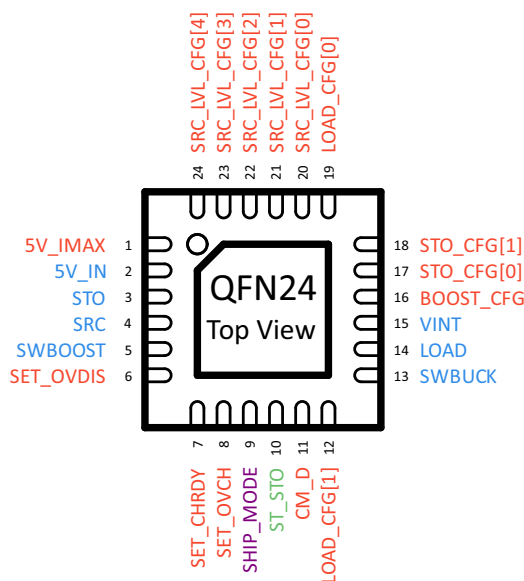


Figure 1: Pinout diagram

NAME	PIN NUMBER	FUNCTION
Power Pins		
SRC	4	Connection to the energy source harvested by the boost converter.
SWBOOST	5	Switching node of the boost converter.
STO	3	Connection to the energy storage element (rechargeable battery).
SWBUCK	13	Switching node of the buck converter.
LOAD	14	Output voltage of the buck converter to supply an application circuit.
5V_IN	2	Input of the 5 V DC power supply (optional). Leave floating if not used.
VINT	15	Connection for C_{INT} buffering capacitor. AEM00920 internal power supply (do not connect any external circuit on VINT).

Table 1: Pins description (part 1)



NAME	PIN NUMBER	LOGIC LEVEL		FUNCTION
		LOW	HIGH	
Control Pin				
SHIP_MODE	9	GND	STO	Used to configure the shipping mode. When HIGH: - Minimum consumption from the storage element. - Storage element charge is disabled (boost converter is disabled). - Buck (LOAD) is disabled. - VINT is charged only if energy is available on SRC. Read as LOW if left floating.
Configuration Pins				
SRC_LVL_CFG[4]	24	GND	VINT	Used to configure the SRC regulation voltage. Read as HIGH when left floating.
SRC_LVL_CFG[3]	23	GND	VINT	
SRC_LVL_CFG[2]	22	GND	VINT	
SRC_LVL_CFG[1]	21	GND	VINT	
SRC_LVL_CFG[0]	20	GND	VINT	
STO_CFG[1]	18	GND	VINT	Used to configure the storage element protection thresholds. Read as HIGH if left floating.
STO_CFG[0]	17	GND	VINT	
LOAD_CFG[1]	12	GND	VINT	Used to configure the LOAD output regulation voltage. Read as HIGH if left floating.
LOAD_CFG[0]	19	GND	VINT	
BOOST_CFG	16	GND	VINT	Used to configure the boost converter timings, as described in Section 5.4. Read as HIGH if left floating.
5V_IMAX	1	Analog Pin		Connection to an external resistor to set the charging current from the 5V_IN supply to STO. Leave floating if the 5V_IN power supply is not used.
SET_OVDIS	6	Analog Pin		Used to configure the storage element protection thresholds when in custom mode (optional). If the custom mode is not used, connect all four pins to GND.
SET_CHRDY	7			
SET_OVCH	8			
CM_D	11			
Status Pin				
ST_STO	10	GND	STO	Logic output. - HIGH when in SUPPLY STATE and SLEEP STATE. - LOW otherwise.
Other pins				
GND	Thermal Pad			The thermal pad must be strongly tied to the PCB ground plane, as it is the only GND connection of the AEM00920.

Table 2: Pins description (part 2)

2. Specifications

2.1. Absolute Maximum Ratings

Parameter		Min	Max	Unit
Operating junction temperature T_j		-40	85	°C
Storage temperature T_{stg}		-65	150	°C
Input voltage	5V_IN, STO, SRC, SWBOOST, SWBUCK, LOAD, 5V_IMAX, LOAD_CFG[1], SET_OVDIS, SET_CHRDY, SET_OVCH, CM_D, SHIP_MODE, ST_STO	-0.3	5.50	V
	VINT, LOAD_CFG[0], BOOST_CFG, STO_CFG[1:0], SRC_LVL_CFG[4:0]	-0.3	2.75	V

Table 3: Absolute maximum ratings

2.2. ESD Ratings

Parameter		Value	Unit
Electrostatic discharge V_{ESD}	Human-Body Model (HBM) ¹	± 2000	V
	Charged-Device Model (CDM) ²	± 1000	V

Table 4: ESD ratings

1. ESD Human-Body Model (HBM) value tested according to JEDEC standard JS-001-2023.
2. ESD Charger-Device Model (CDM) value tested according to JEDEC standard JS-002-2022.

ESD CAUTION	
	ESD (ELECTROSTATIC DISCHARGE) SENSITIVE DEVICE These devices have limited built-in ESD protection and damage may thus occur on devices subjected to high-energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality

2.3. Thermal Resistance

Package	θ_{JA}	θ_{JC}	Unit
QFN-24	60	6	°C/W

Table 5: Thermal data



2.4. Electrical Characteristics at 25 °C

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Power conversion						
$P_{SRC,CS}$	Minimum source power required for cold start.			1.5		μW
$V_{SRC,CS}$	Minimum source voltage required for cold start.			0.275		V
$V_{SRC,REG}$	Target regulation voltage of the source, depending on SRC_LVL_CFG[4:0] configuration.		0.25		3.18 ¹	V
V_{OC}	Open-circuit voltage of the source.		0.00 ²		V_{STO}	V
$I_{SRC,MAX}$	Maximum current extracted from the SRC pin.	BOOST_CFG = L with $L_{BOOST} = 10 \mu H$		44.5		mA
		BOOST_CFG = H with $L_{BOOST} = 10 \mu H$		133.6		mA
		BOOST_CFG = H with $L_{BOOST} = 33 \mu H$		40.5		mA
V_{5V_IN}	Voltage on the 5V_IN pin to allow for charging the battery.		3.60 ³		5.50	V
$I_{5V,CC}$	Maximum charging current of 5 V charger programmed by the resistor on the 5V_IMAX pin.		13.50		135	mA
$T_{5V,RISE}$	Minimum rise time from 0 V to 5 V on the 5V_IN pin.			50		μs
Timing						
T_{CRIT}	When V_{STO} drops below V_{OVDIS} in SUPPLY STATE , the AEM00920 waits for T_{CRIT} before switching to OVDIS STATE and disabling the LOAD output.			2.50		s
$T_{CRIT,ST}$	When V_{STO} drops below V_{OVDIS} in SUPPLY STATE , the AEM00920 waits for $T_{CRIT,ST}$ before setting ST_STO LOW.			1.86		s
$T_{GPIO,MON}$	GPIO reading rate.			1.86		s
$T_{STO,MON}$	Storage element voltage monitoring rate.	In SUPPLY STATE , START STATE , or OVDIS STATE with the buck converter and the 5 V charger disabled.		116		ms
		In SLEEP STATE , with the buck converter disabled.		931		ms
		When the buck converter is enabled (any state).		15		ms
		When the 5 V charger is enabled (any state except SLEEP STATE).		15		ms

Table 6: Electrical characteristics (part 1)

1. To harvest energy from the source, $V_{SRC,REG}$ must remain below V_{OC} .
2. When the open-circuit voltage is below the source regulation voltage, the AEM00920 does not extract power from the source. Voltages down to **GND** do not damage the AEM00920.
3. For the 5 V charger to operate, the voltage on **5V_IN** must be greater than or equal to 3.60 V and at least 200 mV higher than the voltage on **STO**.



Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Storage element						
V_{STO}	Voltage on the storage element.		2.40 ¹		4.59 ²	V
V_{OVDIS}	Minimum voltage accepted on the storage element before stopping to supply LOAD .	Configured by STO_CFG[1:0] or by the custom mode ³ .	2.40		3.58	V
V_{CHRDY}	Voltage required on the storage element to start supplying LOAD in START STATE .	Configured by STO_CFG[1:0] or by the custom mode ³ .	2.50		3.64	V
V_{OVCH}	Maximum voltage accepted on the storage element before disabling its charging.	Configured by STO_CFG[1:0] or by the custom mode ³ .	2.70		4.59	V
Internal supply & quiescent current						
V_{INT}	Internal voltage supply.			2.25		V
$V_{INT,CS}$	Minimum voltage on VINT to allow the AEM00920 to switch from RESET STATE to SENSE STO STATE .			2.30		V
$V_{INT,RESET}$	Minimum voltage on VINT before switching to RESET STATE (from any other state).			2.00		V
$I_{Q,SUPPLY}$	Quiescent current on STO in SUPPLY STATE . ⁴	LOAD disabled.		270		nA
		LOAD enabled. ⁵		480		
$I_{Q,SLEEP}$	Quiescent current on STO in SLEEP STATE . ⁴	LOAD disabled.		205		nA
		LOAD enabled. ⁵		415		
$I_{Q,SHIP}$	Quiescent current drawn on the storage element when the AEM00920 is in shipping mode (SHIP_MODE is HIGH) with or without energy available on SRC .			10		nA
$I_{Q,RESET}$	Quiescent current on STO when the AEM00920 is in RESET STATE .					

Table 7: Electrical characteristics (part 2)

1. As set by the battery overdischarge threshold configuration.
2. As set by the battery overcharge threshold configuration.
3. For configuring the custom mode, please make sure to meet the constraints explained in Section 5.3.2.
4. When neither the boost converter nor the buck converter are running.
5. V_{LOAD} set to 2.2 V and **LOAD** pin left floating.

2.5. Recommended Operating Conditions

Symbol	Parameter	Condition	Min ¹	Typ	Max ¹	Unit
External components						
L _{BOOST}	Inductor of the boost converter.	BOOST_CFG = L	3.3	10 ²		μH
		BOOST_CFG = H	9.9	33 ²		μH
C _{SRC}	Capacitor decoupling the SRC terminal.			22		μF
L _{BUCK}	Inductor of the buck converter.		3.3	10 ²		μH
C _{LOAD}	Capacitor of the buck converter.		10	22		μF
C _{INT}	Capacitor decoupling the VINT terminal.		5	10		μF
C _{STO}	Capacitor decoupling the STO terminal.		5	47 ³		μF
R _{5V_IMAX}	Resistor for configuring the 5V charger maximum current. (Optional)		0.37		3.7	kΩ
R _T	Optional - Total resistor value for setting the battery threshold voltages in custom mode ($R_T = R_1 + R_2 + R_3 + R_4 + 800$).		100		400	kΩ

Table 8: Recommended external components

1. All minimum and maximum values are real components values, taking into account tolerances, derating, temperatures, voltages and any operating conditions (special care must be taken with capacitor derating).
2. L_{BOOST} and L_{BUCK} typical values recommended for best trade-off between boost/buck efficiency and current capability.
3. Recommended value for optimal efficiency, particularly with high-ESR storage elements. If using a smaller value, ensure it meets the minimum requirement.

2.5.1. External Inductors Information

The AEM00920 operates with two external miniature inductors. All inductors must support a minimum switching frequency of 10 MHz. Using inductors with low equivalent series resistance (ESR) improves the power-conversion efficiency of the boost and buck converters.

L_{BOOST}

With the recommended operating conditions (10 μH inductor with BOOST_CFG = L or 33 μH inductor with BOOST_CFG = H), the boost inductor L_{BOOST} must support a minimum peak current of 135 mA.

L_{BUCK}

With the recommended operating condition (10 μH inductor), the buck inductor L_{BUCK} must support a minimum peak current of 135 mA.

2.5.2. External Capacitors Information

The AEM00920 operates with four external miniature capacitors to ensure stable operation of the boost converter input, buck converter output, storage element output, and internal supply. Each capacitor serves as a local energy buffer that limits voltage fluctuations caused by switching activity or dynamic load transition.

To maintain optimal performances and minimized quiescent current, all capacitors must exhibit a low leakage current and follow the recommended nominal values listed in Table 8, with a tolerance of ± 20 %.

2.6. Typical Characteristics

2.6.1. Boost Converter Conversion Efficiency

Figure 2 shows the AEM00920 boost efficiency with:

- $L_{\text{BOOST}} = 33 \mu\text{H}$ (Coilcraft LPS4018-333MRB).
- $\text{BOOST_CFG} = \text{H (x3)}$.

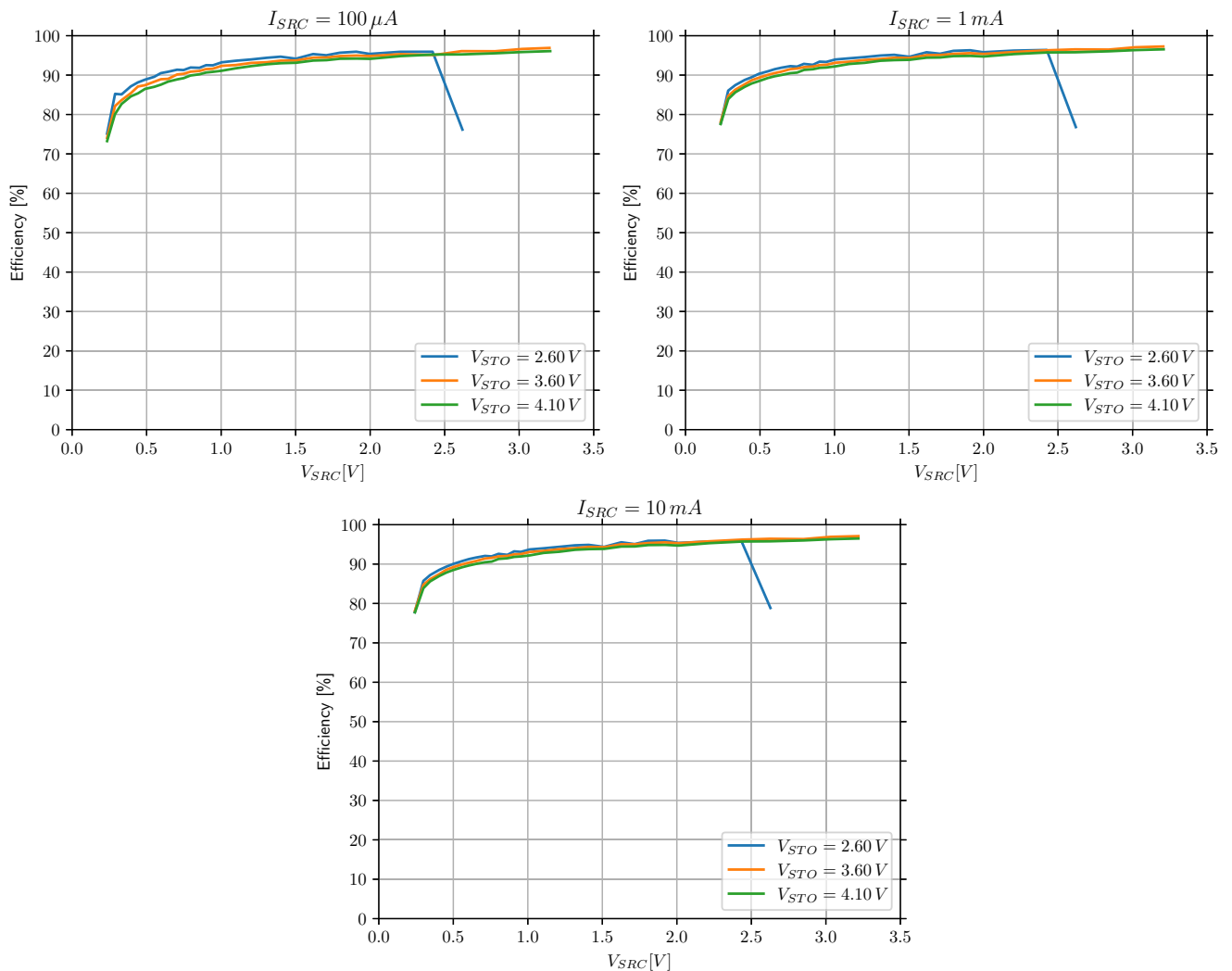


Figure 2: Boost converter efficiency

NOTE: The boost efficiency data presented in Figure 2 include the AEM00920 quiescent current.

2.6.2. Buck Converter Conversion Efficiency

Figure 3 shows the AEM00920 buck efficiency with $L_{BUCK} = 10 \mu\text{H}$ (TDK VLS252012CX-100M-1).

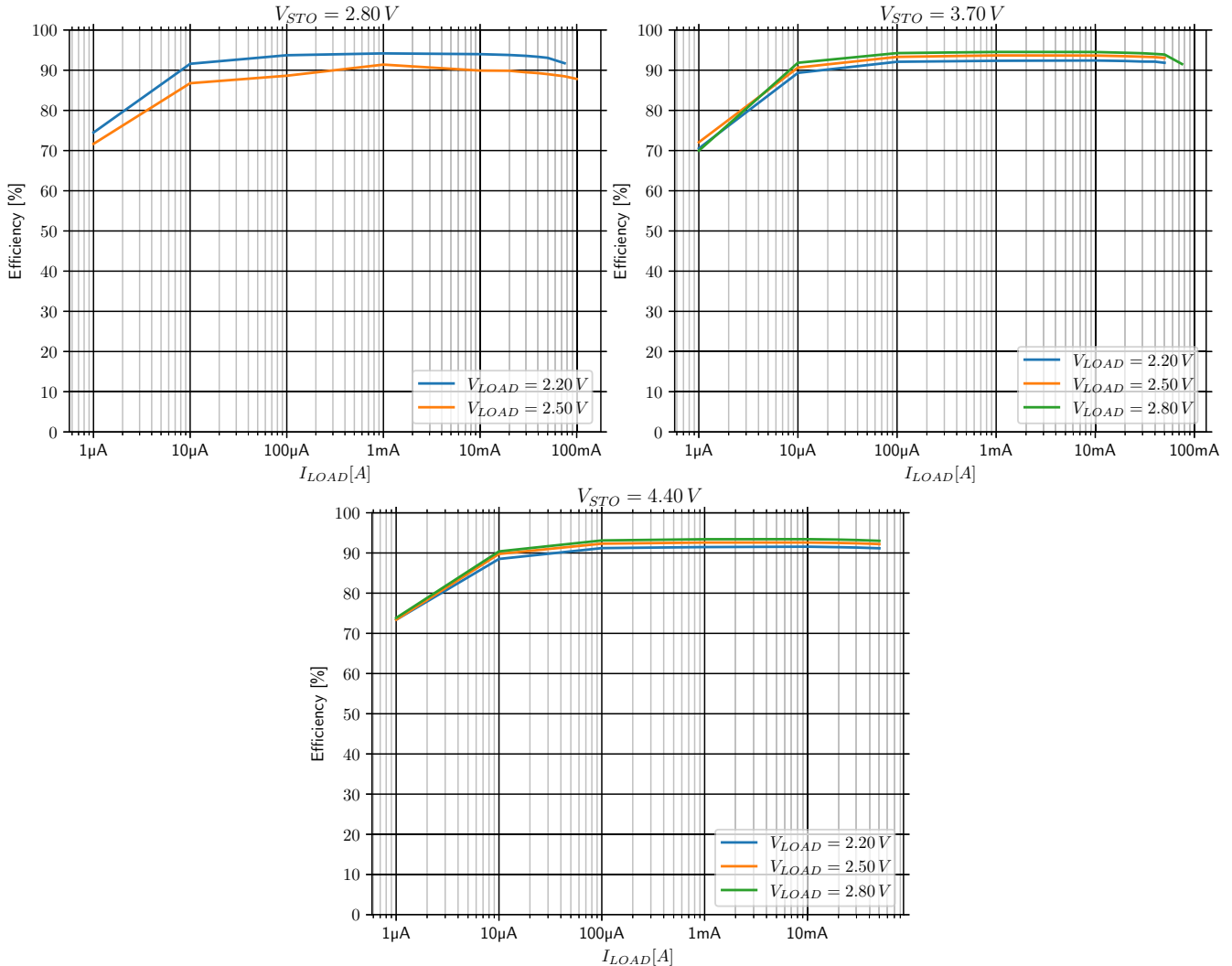


Figure 3: Buck (LOAD) converter efficiency

NOTE: The quiescent current of the AEM00920 is not included in the buck efficiency data presented in Figure 3, as it has already been included in the boost efficiency data shown in Section 2.6.1. This quiescent current has been measured with the boost converter in **SLEEP STATE** and the buck converter switched off.

3. Functional Block Diagram

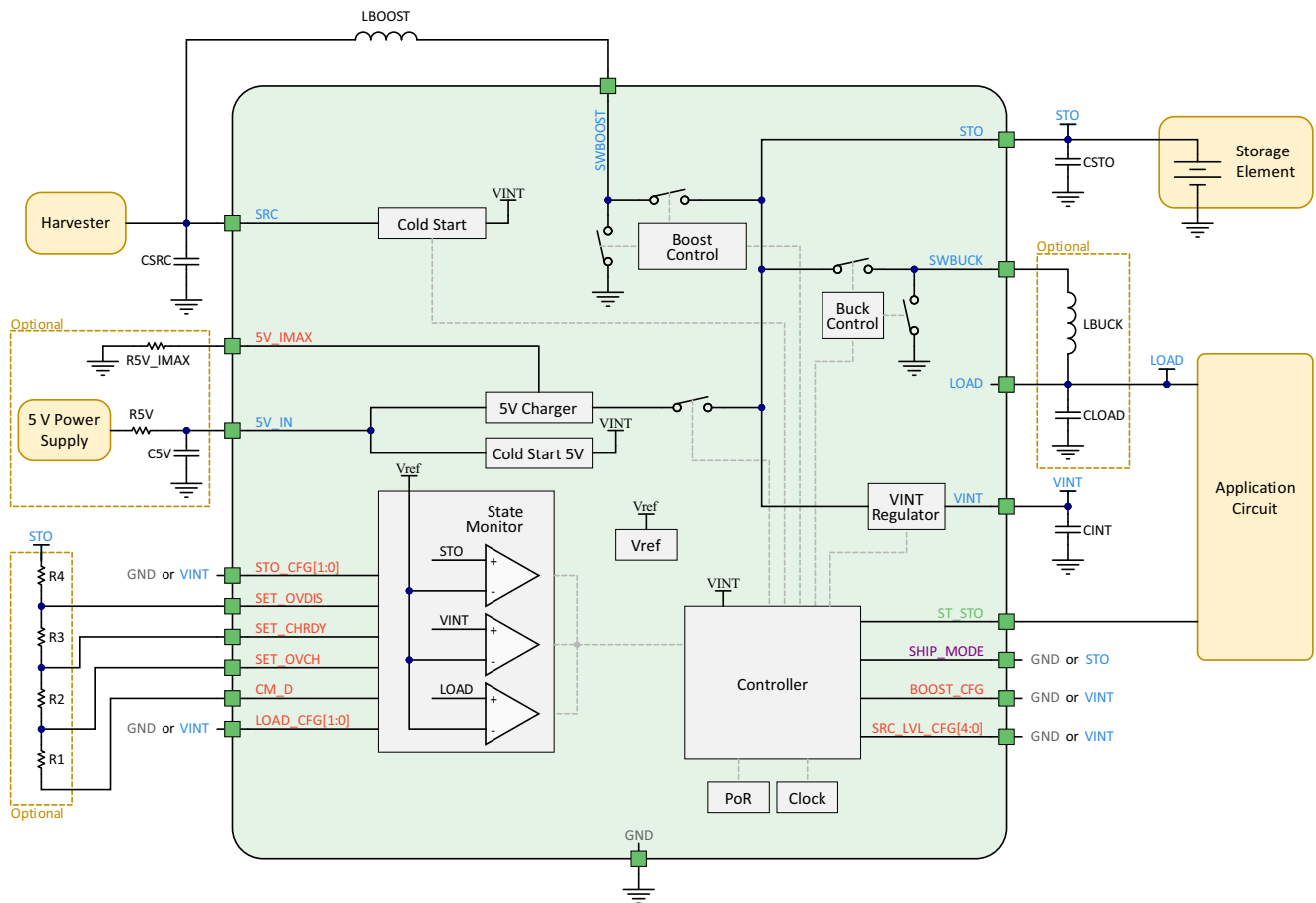


Figure 4: Functional block diagram

4. Theory of Operation

4.1. Cold-Start Circuits

The AEM00920 is able to coldstart from **SRC** or from **5V_IN**. The cold-start circuits supply the AEM00920 internal circuit (connected to **VINT**) when the device is in **RESET STATE**, **SENSE STO STATE** or **OVDIS STATE**.

4.2. Boost Converter

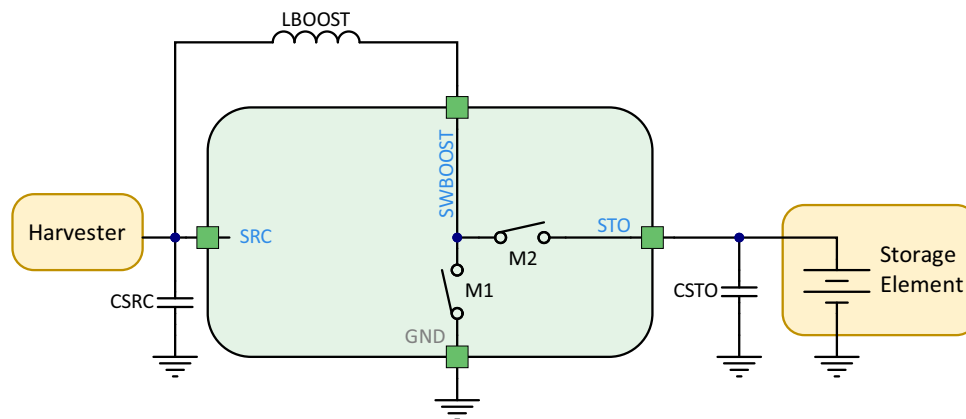


Figure 5: Simplified schematic view of the boost converter

4.2.1. Operation Principle

The boost (step-up) converter raises the voltage available at **SRC** to a level suitable for charging the storage element, in the range of 2.40 V to 4.59 V, according to the system configuration. The switching transistors of the boost converter are M1 and M2. The reactive power component of this converter is the external inductor **LBOOST**.

Target source regulation voltage is determined by the constant voltage regulation setting (**SRC_LVL_CFG[4:0]**).

SRC is decoupled by the capacitor **CSRC**, which smooths the voltage against the current pulses induced by the boost converter.

The storage element is connected to the **STO** pin, which voltage is **VSTO**. This node is linked to the output of the boost converter through transistor M2. When energy harvesting is occurring, the converter charges the battery.

The maximum current supplied to the **STO** pin depends on the value of **LBOOST** and on the **BOOST_CFG** settings (see Section 5.4).

4.2.2. Source Voltage Regulation

During **START STATE**, **OVDIS STATE** and **SUPPLY STATE**, the voltage on **SRC** is regulated to a voltage configured by the user. The AEM00920 offers a wide choice of values for the source regulation voltage **VSRC,REG**.

The AEM00920 behaves as follows:

- If **SRC** voltage is lower than **V_{SRC,REG}**, the AEM00920 does not extract power from the source.
- If **SRC** voltage is higher than **V_{SRC,REG}**, the AEM00920 regulates **V_{SRC}** to **V_{SRC,REG}** and thus extracts power from the source.

4.3. 5 V Charger

The AEM00920 is equipped with a 5 V charger for fast charging of the battery connected on the **STO** pin.

The 5 V charger can be used when the following conditions are met:

- $V_{5V_IN} \geq 3.60 \text{ V}$
- $V_{5V_IN} \geq V_{STO} + 200 \text{ mV}$

The maximum charging current is configured in a range from 13.5 mA to 135 mA by the value of **R_{5V_IMAX}** resistor connected to the **5V_IMAX** pin (see Section 5.6 for further details about **R_{5V_IMAX}** configuration).

With the 5 V charger, the storage element is charged by implementing a constant current / constant voltage operation (CC/CV):

- When V_{STO} is not close to V_{OVCH} , the AEM00920 operates in constant current (CC) mode. In this mode, the storage element is charged from the **5V_IN** input with the configured maximum charging current ($I_{5V,CC}$).
- When V_{STO} approaches V_{OVCH} , the AEM00920 switches to a constant voltage (CV) operation. The AEM00920 gradually reduces the effective charge current down to zero. This reduction is performed digitally using a PWM-based scheme where the configured $I_{5V,CC}$ is applied intermittently to achieve a controlled tapering of the average charge current.

Using the 5 V charger is not mandatory. When not used, leave both **5V_IN** and **5V_IMAX** pins floating.

Please note that the rise time of the voltage applied on the **5V_IN** must not be too short. See Section 5.6 for more information and Section 6.1 for a design example.

4.4. Buck Converter

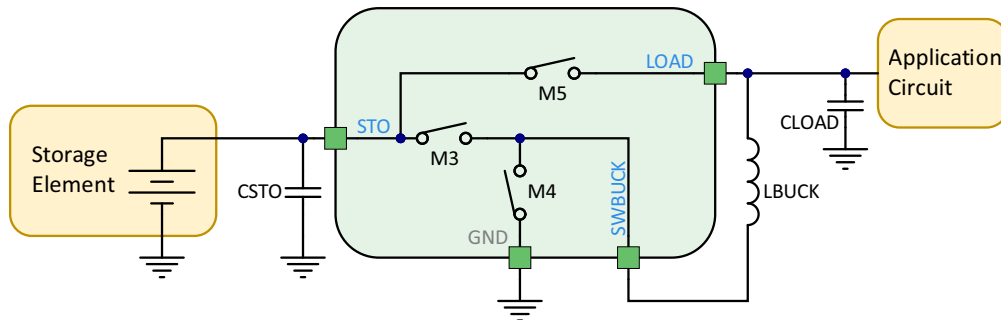


Figure 6: Simplified schematic view of the buck converter

The buck (step-down) converter transfers energy from the storage element connected on **STO** to the regulated **LOAD** output. The switching transistors of the buck converter are M3 and M4. The reactive power component of this converter is the external inductor L_{BUCK} . **LOAD** is decoupled by the capacitor C_{LOAD} , which smooths the voltage against the current pulses induced by the buck converter and by the external circuit connected to **LOAD**.

Setting the **LOAD** regulation voltage V_{LOAD} is done through **LOAD_CFG[1:0]** pins.

After cold start, if the buck converter has been enabled, the **LOAD** output starts to be supplied when:

- V_{STO} rises above V_{CHRDY} , if the 5 V charger is not charging, or
- V_{STO} rises above V_{OVDIS} , if the 5 V charger is charging.

NOTE: When using the 5 V charger, make sure that the configured $I_{5V,CC}$ is high enough to supply the circuit connected on **LOAD**. If not, once V_{STO} rises above V_{OVDIS} , the **LOAD** is directly enabled, and the current drained on the storage element could directly discharge V_{STO} below V_{OVDIS} , thus, disabling the **LOAD** output.

When V_{STO} drops below V_{OVDIS} for longer than $T_{CRIT,ST}$, the AEM00920 sets **ST_STO** LOW, to notify that the system is about to shutdown, and waits for the end of T_{CRIT} to disable the **LOAD** output.

Using the buck converter is not mandatory. If not used, the user must do the following:

- Connect all **LOAD_CFG[1:0]** to GND (LOW) to disable the buck converter.
- Leave **SWBUCK** and **LOAD** pins floating.

When the difference between V_{STO} and V_{LOAD} is smaller than 0.25 V, it switches to “bang-bang” controlled converter mode:

- When V_{LOAD} is too low, the switch M5 connects **STO** directly to **LOAD**, making V_{LOAD} rise.
- When V_{LOAD} is too high, M5 disconnects **STO** and **LOAD** so that V_{LOAD} decreases.

4.5. Shipping Mode

The shipping mode feature allows to force the AEM00920 in **RESET STATE** (see Section 4.6), to disable the boost converter and therefore to prevent the charge of the storage element. Only **VINT** is charged from **SRC** if V_{SRC} is above $V_{SRC,CS}$.

See Section 5.7 for shipping mode configuration.

4.6. State Machine Description

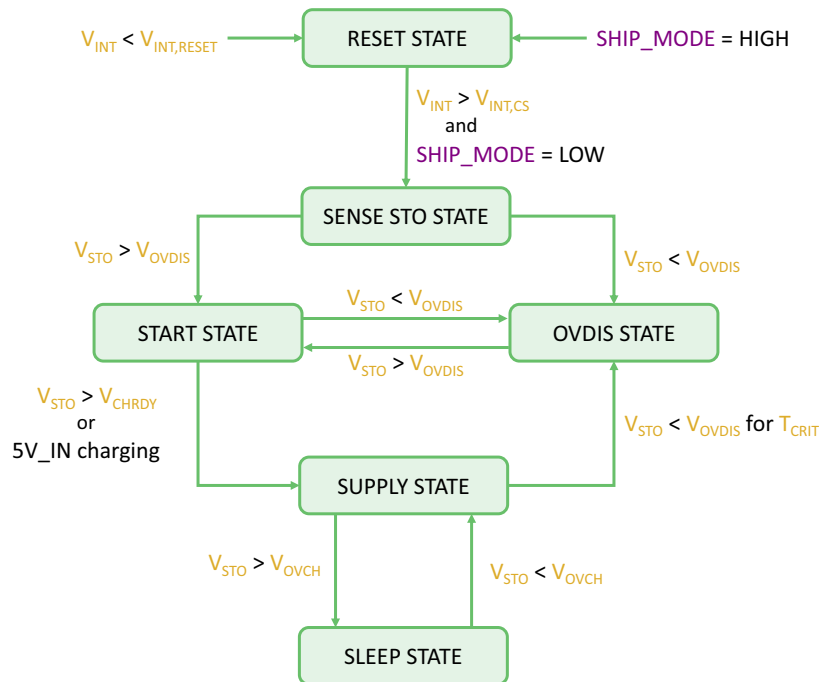


Figure 7: AEM00920 state machine

4.6.1. Reset State

The AEM00920 enters **RESET STATE** if one of the following is true:

- V_{INT} is below $V_{INT,RESET}$.
- shipping mode is enabled (**SHIP_MODE** is HIGH).

In **RESET STATE**, the AEM00920 behaves as follows:

- The AEM00920 is performing a cold start to make V_{INT} rise to 2.3 V. Cold start can be done from any of the following energy sources:
 - **SRC** ($V_{SRC} > 0.275$ V and $P_{SRC,CS} > 1.5$ μ W).
 - **5V_IN** ($V_{5V_IN} > 3.60$ V & $V_{5V_IN} > V_{STO} + 0.2$ V).
- The AEM00920 internal circuit, connected on **VINT**, is supplied by **SRC** or **5V_IN**. No current is drawn from the battery.
- **ST_STO** is LOW.

The AEM00920 stays in **RESET STATE** until the power available on **SRC** or on **5V_IN** meets the cold-start requirements long enough to make V_{INT} reach $V_{INT,CS}$ (see Table 7). Then:

- If shipping mode is disabled (**SHIP_MODE** is LOW), the AEM00920 reads the value on all configuration pins and switches to **SENSE STO STATE**.

- If shipping mode is enabled (**SHIP_MODE** is HIGH), the AEM00920 stays in **RESET STATE** until shipping mode is disabled by setting **SHIP_MODE** LOW. **SHIP_MODE** is read every $T_{GPIO,MON}$.

Please note that, from any state, the AEM00920 will switch to **RESET STATE** if V_{INT} drops below $V_{INT,RESET}$.

4.6.2. Sense STO State

In **SENSE STO STATE**, a first measure of V_{STO} is performed by the AEM00920.

- If $V_{STO} > V_{OVDIS}$, the AEM00920 switches to **START STATE**.
- If $V_{STO} < V_{OVDIS}$, the AEM00920 switches to **OVDIS STATE**.
- **ST_STO** is LOW.

In **SENSE STO STATE**, none of the DCDC converters are running.

4.6.3. Start State

When in **SENSE STO STATE**, the AEM00920 switches to **START STATE** if V_{STO} is above V_{OVDIS} .

In **START STATE**, the AEM00920 behaves as follows:

- The storage element connected on **STO** is charged by the boost converter until V_{STO} reaches V_{CHRDY} .
- The AEM00920 internal circuit connected on **VINT** is supplied by the storage element regardless of the power available on **SRC** or **5V_IN**.
- The buck converter (**LOAD**) is disabled.
- **ST_STO** is LOW.

4.6.4. Supply State

When in **START STATE**, the AEM00920 switches to **SUPPLY STATE** if one of the following conditions is true:

- V_{STO} is above V_{CHRDY} .
- The 5 V charger is charging.

In **SUPPLY STATE**, the AEM00920 behaves the same as when in **START STATE**, but with the following differences:

- The buck converter driving **LOAD** is enabled (if enabled by the user).
- **ST_STO** is HIGH.

When in **SUPPLY STATE**, the AEM00920 switches to **SLEEP STATE** if $V_{STO} > V_{OVCH}$.

If V_{STO} falls below V_{OVDIS} when the AEM00920 is in **SUPPLY STATE**:

- **ST_STO** is set LOW after 1.86 s ($T_{CRIT,ST}$).
- the AEM00920 switches to **OVDIS STATE** and disables the **LOAD** output after 2.5 s (T_{CRIT}).

4.6.5. OVDIS State

The AEM00920 switches to **OVDIS STATE** if:

- V_{STO} is below V_{OVDIS} when in **SENSE STO STATE** or **START STATE**.
- V_{STO} remains below V_{OVDIS} for more than T_{CRIT} when in **SUPPLY STATE**.

In **OVDIS STATE**, the AEM00920 behaves as follows:

- The battery connected on **STO** is charged by the boost converter or by the 5 V charger, until V_{STO} exceeds V_{OVDIS} .
- The AEM00920 internal circuit, connected on **VINT**, is supplied by **SRC** or **5V_IN**. If not enough power is available on either of those pins, the AEM00920 switches to **RESET STATE**. No current is drawn from the storage element.
- The buck converter (**LOAD**) is disabled.
- **ST_STO** is LOW.

4.6.6. Sleep State

SLEEP STATE allows for reducing the AEM00920 internal circuit consumption, and thus, keeping storage element discharge to the minimum.

The AEM00920 switches from **SUPPLY STATE** to **SLEEP STATE** if $V_{STO} > V_{OVCH}$.

In **SLEEP STATE**, the AEM00920 behaves as follows:

- The storage element connected on **STO** is not charged by **SRC**, allowing for reducing the quiescent current on **VINT** and thus, on **STO**.
- The AEM00920 internal circuit connected on **VINT** is supplied by the storage element regardless of the power available on **SRC** or **5V_IN**.
- The buck converter (**LOAD**) is enabled.
- **ST_STO** is HIGH.

When in **SLEEP STATE**, the AEM00920 switches back to **SUPPLY STATE** if V_{STO} falls below V_{OVCH} .

5. System Configuration

5.1. Configuration Pins Reading

After a cold start, the AEM00920 reads the configuration pins. Those are then read periodically every $T_{GPIO,MON}$. The configuration pins can be changed on-the-fly. The floating configuration pins are read as HIGH, except **SHIP_MODE** which is read as LOW.

5.2. Source Voltage Regulation

The user can set the regulation voltage with **SRC_LVL_CFG[4:0]** (see table below).

Configuration pins					Voltage [V]
SRC_LVL_CFG[4:0]					$V_{SRC,REG}$
L	L	L	L	L	0.25
L	L	L	L	H	0.30
L	L	L	H	L	0.35
L	L	L	H	H	0.41
L	L	H	L	L	0.45
L	L	H	L	H	0.50
L	L	H	H	L	0.56
L	L	H	H	H	0.60
L	H	L	L	L	0.65
L	H	L	L	H	0.71
L	H	L	H	L	0.75
L	H	L	H	H	0.80
L	H	H	L	L	0.86
L	H	H	L	H	0.90
L	H	H	H	L	0.95
L	H	H	H	H	1.01

Configuration pins					Voltage [V]
SRC_LVL_CFG[4:0]					$V_{SRC,REG}$
H	L	L	L	L	1.10
H	L	L	L	H	1.20
H	L	L	H	L	1.31
H	L	L	H	H	1.40
H	L	H	L	L	1.50
H	L	H	L	H	1.61
H	L	H	H	L	1.70
H	L	H	H	H	1.79
H	H	L	L	L	1.90
H	H	L	L	H	1.99
H	H	L	H	L	2.19
H	H	L	H	H	2.41
H	H	H	L	L	2.59
H	H	H	L	H	2.82
H	H	H	H	L	3.00
H	H	H	H	H	3.18

Table 9: Configuration of the source constant regulation voltage with SRC_LVL_CFG[4:0] pins

5.3. Storage Element Thresholds

Two methods are available to configure the storage element voltage thresholds V_{OVDIS} , V_{CHRDY} and V_{OVCH} :

- Configuration through the $STO_CFG[2:0]$ pins as described in Section 5.3.1.
- Configuration using the custom mode as described in Section 5.3.2.

5.3.1. Configuration Pins

The storage element protection thresholds V_{OVDIS} , V_{CHRDY} and V_{OVCH} , can be configured through the $STO_CFG[1:0]$ pins as shown in Table 10.

Configuration pins		Overdischarge voltage [V]	Charge ready voltage [V]	Overcharge voltage [V]	Battery Type
$STO_CFG[1:0]$		V_{OVDIS}	V_{CHRDY}	V_{OVCH}	
L	L	2.51	2.61	3.79	Lithium-ion Super Capacitor (LiC)
L	H	3.00	3.21	4.13	Lithium-ion battery
H	L	3.00	3.21	4.35	LiPo battery
H	H	3.51	3.60	3.90	Li-ion battery (ultra long life)

Table 10: Storage element configuration with $STO_CFG[1:0]$ pins

DISCLAIMER: storage element thresholds provided in the table above are indicative to support a wide range of storage element variants. They are provided as is to the best knowledge of e-peas's application laboratory. They should not replace the actual values provided in the storage element manufacturer's specifications and datasheet.

5.3.2. Custom Mode

During startup, when exiting **RESET STATE**, the AEM00920 reads the **CM_D** pin along with the other configuration pins. If **CM_D** is not connected to **GND**, the custom mode is selected regardless of the state of $STO_CFG[1:0]$ pins. The **CM_D** pin is read only at this moment and cannot be modified dynamically.

When the custom mode is enabled, the storage element protection thresholds are defined during **SENSE STO STATE** through all four custom mode configuration resistors wired as shown in Figure 8.

CAUTION: If the custom mode is not used, make sure to connect **CM_D** to **GND**, as this pin cannot be left floating.

V_{OVDIS} , V_{CHRDY} and V_{OVCH} are defined thanks to R_1 , R_2 , R_3 and R_4 . These resistor values are calculated as follows:

- $R_T = R_1 + R_2 + R_3 + R_4 + 800$
- $100k\Omega \leq R_T \leq 400k\Omega$
- $R_1 = R_T \cdot \frac{0.5V}{V_{OVCH}} - 800$
- $R_2 = R_T \cdot \left(\frac{0.5V}{V_{CHRDY}} - \frac{0.5V}{V_{OVCH}} \right)$
- $R_3 = R_T \cdot \left(\frac{0.5V}{V_{OVDIS}} - \frac{0.5V}{V_{CHRDY}} \right)$
- $R_4 = R_T - (R_1 + R_2 + R_3 + 800)$

When using the custom mode, the following constraints must be met to ensure the functionality of the chip:

- $2.40\text{ V} \leq V_{\text{OVDIS}} \leq 3.58\text{ V}$
- $2.50\text{ V} \leq V_{\text{CHRDY}} \leq 3.64\text{ V}$
- $2.70\text{ V} \leq V_{\text{OVCH}} \leq 4.59\text{ V}$
- $V_{\text{OVCH}} > V_{\text{CHRDY}} + 100\text{ mV}$
- $V_{\text{CHRDY}} > V_{\text{OVDIS}} + 100\text{ mV}$
- $V_{\text{OVDIS}} > V_{\text{LOAD}} + 100\text{ mV}$

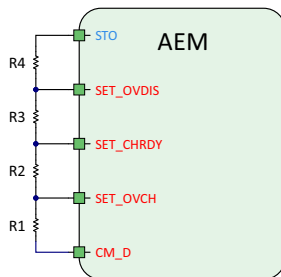


Figure 8: Custom configuration resistors

5.4. Boost Converter Timings

The **BOOST_CFG** pin allows for modifying the peak current of the boost inductor by multiplying the on/off timings of the boost converter, as shown in Table 11. The higher the timing multiplier, the higher the boost inductor peak current, and thus, the higher the average source current pulled from **SRC** to **STO**.

The peak current in the inductor also depends on the value of the inductor. Table 11 shows the minimum inductor value to be implemented for each timing value. Lower value may lead to damaging the AEM00920.

Configuration pin	Timing multiplier	$L_{\text{BOOST}} [\mu\text{H}]$	
		Minimum	Recommended ¹
BOOST_CFG	Value		
L	x1	3.3	10
H	x3	9.9	33

Table 11: Boost converter timings configuration

1. The recommended values provide the best efficiency/current capability trade-off according to the tests carried out in the e-peas laboratory.

5.5. LOAD Output Voltage

Table 12 shows how to configure the regulated voltage on **LOAD** output with the **LOAD_CFG[1:0]** pins.

Configuration pins		LOAD voltage [V]
LOAD_CFG[1:0]		V_{LOAD}
L	L	OFF
L	H	2.2
H	L	2.5
H	H	2.8

Table 12: Configuration of LOAD voltage with **LOAD_CFG[1:0]** pins

NOTE: The buck voltage (V_{LOAD}) cannot be selected higher than the configured V_{OVDIS} . In such situation, the AEM00920 will not start the buck converter.

5.6. 5 V Charger

The 5 V charger implements CC/CV operation. The maximum charging current $I_{5V,CC}$ can be set by connecting a resistor R_{5V_IMAX} between **5V_IMAX** and GND:

$$I_{5V,CC} = \frac{50}{R_{5V_MAX}}$$

R_{5V_IMAX} must be chosen so that $I_{5V,CC}$ complies to the range defined in Table 6. Example values can be found in the following table:

Resistor [Ω]	Maximum Charging Current [mA]
R_{5V_IMAX}	$I_{5V,CC}$
370	135.0
680	73.5
1500	33.3
3700	13.5

Table 13: Typical resistor values for setting 5 V charger max. current

The rise time of the voltage applied on **5V_IN** must not be too short. Thus, it is recommended to add a RC circuit in series with the **5V_IN** pin which matches the following, with R_{5V} in series and C_{5V} between **5V_IN** and GND:

$$R_{5V} \cdot C_{5V} > T_{5V,RISE}$$



- $T_{5V,RISE}$ is the rise time from 0 V to 5 V of the voltage on the **5V_IN** pin (see Table 2.4). Comparing this to the RC constant adds a margin as the RC constant defines 63% of the final voltage.
- R_{5V} must be determined so that, for the configured $I_{5V,CC}$, the voltage on the **5V_IN** pin is:
 - above 3.60 V.
 - above $V_{STO} + 200$ mV.
- C_{5V} is determined from the value of R_{5V} using the equation above. A low charging current allows for high R_{5V} value and thus for a low C_{5V} value.

5.7. Shipping Mode

The shipping mode, described in Section 4.5, can be configured as follows with the **SHIP_MODE** pin:

Configuration pin	Feature state
SHIP_MODE	Shipping mode
L	Disabled
H	Enabled

Table 14: Shipping mode configuration

6. Typical Application Circuit

6.1. Example Circuit 1

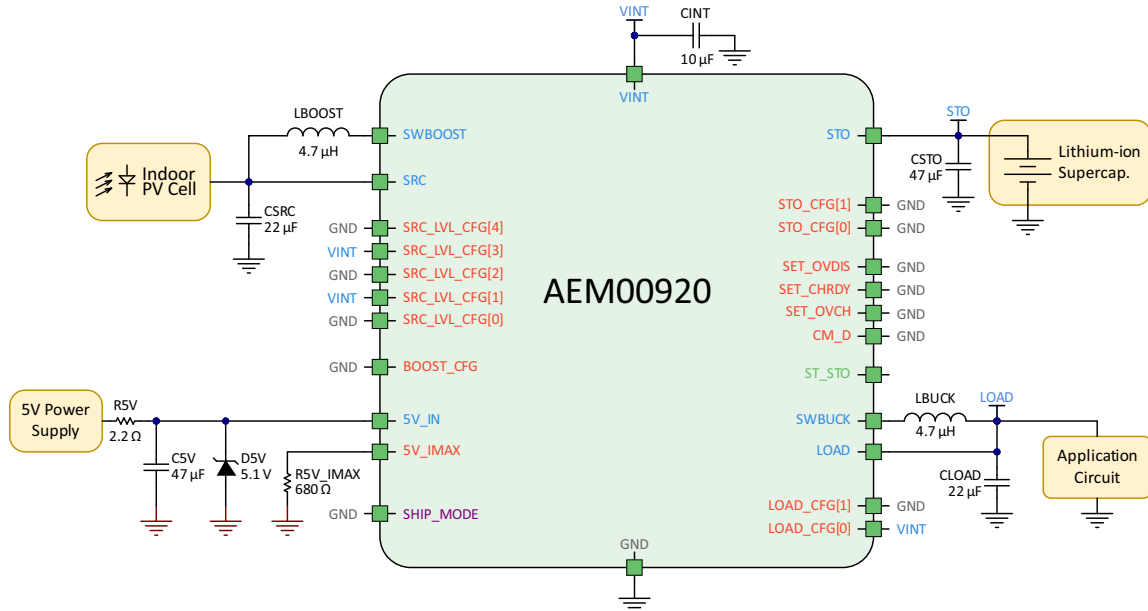


Figure 9: Typical application circuit 1

Figure 9 shows a typical application circuit of the AEM00920.

Configuration of SRC

The energy source is an indoor PV cell which provides the maximum power at 0.75 V. SRC is thus configured as follows:

- SRC_LVL_CFG[4:0] = LHLHL (0.75 V regulation).
- BOOST_CFG = L: x1 boost timing.
- L_{BOOST} = 4.7 μH for high current capability with x1 boost timing (see Section 5.4) and low-cost inductor.

Configuration of STO

The storage element is a Lithium-ion supercapacitor, so storage element threshold voltages are set as follows:

- STO_CFG[1:0] = LL.
 - V_{OVDIS} = 2.51 V.
 - V_{CHRDY} = 2.61 V.
 - V_{OVCH} = 3.79 V.
- Custom mode is not used so CM_D, SET_OVDIS, SET_CHRDY and SET_OVCH are connected to GND.

Configuration of LOAD

The application circuit is supplied with 2.2 V with current peaks up to 40 mA. The buck converter is configured as follows:

- LOAD_CFG[1:0] = LH (2.2 V)
- L_{BUCK} = 4.7 μH for high current capability and low cost inductor.

Shipping mode

Shipping mode is not used.

- SHIP_MODE is connected to GND.

Configuration of 5V_IN

The maximum allowed current to charge the storage element is 75 mA. Closest standard series resistor is 680 Ω, which leads to a 73.5 mA maximum current.

- R_{5V_IMAX} = 680 Ω.
- I_{5V,CC} = 73.5 mA.

The RC filter, which role is to slow down the rise time of the 5 V source, can be determined with the following steps.



R_{5V} is calculated so that its voltage drop across it ensures a voltage on **5V_IN** higher than $V_{OVCH} + 200 \text{ mV}$:

$$I_{5V,CC} \cdot R_{5V} < 5V - V_{OVCH} - 0.2V$$

$$R_{5V} < \frac{5V - V_{OVCH} - 0.2V}{I_{5V,CC}} \Leftrightarrow R_{5V} < \frac{5V - 3.79V - 0.2V}{73.5 \times 10^{-3}}$$

$$R_{5V} < 13.74\Omega$$

C_{5V} is calculated so that the **5V_IN** voltage rise time remains below $T_{5V,RISE}$:

$$R_{5V} \cdot C_{5V} > T_{5V,RISE}$$

$$R_{5V} \cdot C_{5V} > 50\mu s$$

To meet these two conditions, the following component values have been selected:

- $R_{5V} = 2.2 \Omega$
- $C_{5V} = 47 \mu F$

The 5 V source is expected to have ripple and/or over voltages up to 5.5 V, so a 5.1 V zener diode D_{5V} is added to prevent those to damage the AEM00920.

The minimum power rating of D_{5V} is computed as follows, from its maximum reverse current I_{D5V} , its voltage V_{D5V} , and the resistor R_{5V} :

$$P_{D5V} \geq I_{D5V} \cdot V_{D5V} \Leftrightarrow P_{D5V} \geq \frac{5.5V - 5.1V}{R_{5V}} \cdot 5.1V$$

$$P_{D5V} \geq \frac{5.5V - 5.1V}{2.2} \cdot 5.1V \Leftrightarrow P_{D5V} \geq 927 \text{ mW}$$

R_{5V} dissipated power $P_{R5V,idle}$ when the 5V charger does not pull any current to charge the storage element is determined as follows:

$$P_{R5V,idle} = \frac{(5.5V - 5.1V)^2}{R_{5V}} \Leftrightarrow P_{R_{5V},idle} = \frac{(5.5V - 5.1V)^2}{2.2}$$

$$P_{R_{5V},idle} = 73 \text{ mW}$$

Furthermore, R_{5V} dissipated power $P_{R5V,CC}$ at $I_{5V,CC}$ current (73.5 mA) is determined as follows:

$$P_{R_{5V},CC} = R_{5V} \cdot I_{5V,CC}^2 = 2.2\Omega \cdot (73.5 \text{ mA})^2 = 12 \text{ mW}$$

The minimum required power rating of R_{5V} is the maximum of $P_{R5V,idle}$ and $P_{R5V,CC}$, thus, 73 mW.

6.2. Example Circuit 2

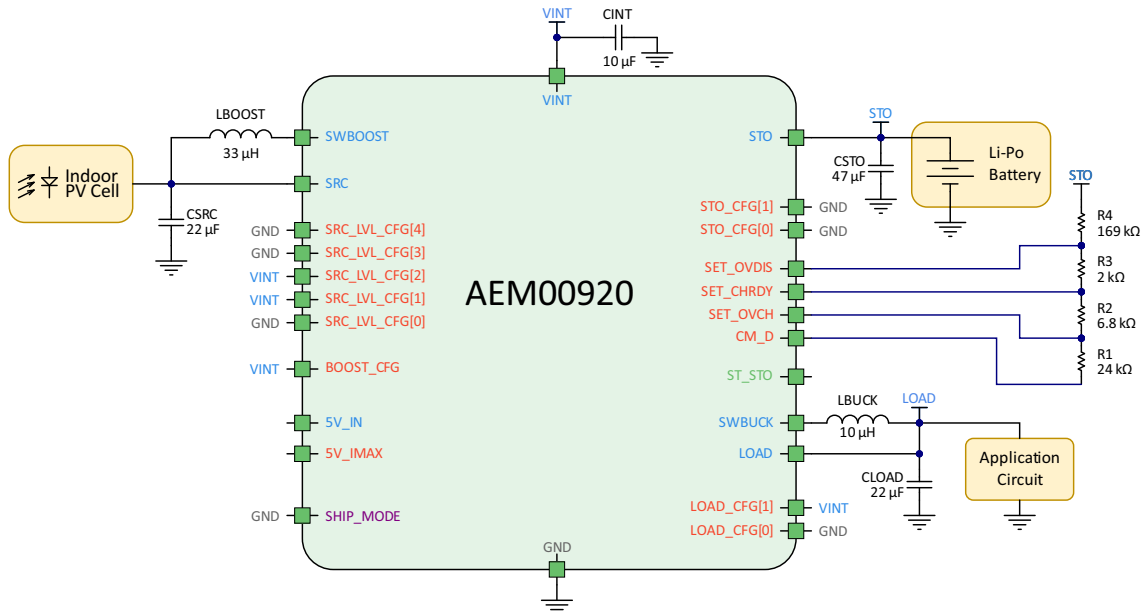


Figure 10: Typical application circuit 2

Figure 10 shows a typical application circuit of the AEM00920.

Configuration of SRC

The energy source is an indoor PV cell which provides the maximum power at 0.56 V. SRC is thus configured as follows:

- SRC_LVL_CFG[4:0] = LLHHL (0.56 V regulation).
- BOOST_CFG = H: x3 boost timing.
- L_{BOOST} = 33 µH for best trade-off between efficiency and current capability with x3 boost timing (see Table 8).

Configuration of STO

The storage element is a Lithium-Polymer (Li-Po) battery used with custom voltage thresholds set as follows:

- STO_CFG[1:0] = LL: AEM00920 ignores STO_CFG[1:0] settings as CM_D is not set to GND (custom mode is used).
- Desired storage element voltage thresholds are the following:
 - V_{OVDIS} = 3.00 V.
 - V_{CHRDY} = 3.20 V.
 - V_{OVCH} = 4.10 V.

- Custom mode resistors are configured as follows:

$$R_T = R_1 + R_2 + R_3 + R_4 + 800 = 202.6 \text{ k}\Omega$$

$$R_1 = R_T \cdot \frac{0.5\text{V}}{V_{OVCH}} - 800 = 24 \text{ k}\Omega$$

$$R_2 = R_T \cdot \left(\frac{0.5\text{V}}{V_{CHRDY}} - \frac{0.5\text{V}}{V_{OVCH}} \right) = 6.8 \text{ k}\Omega$$

$$R_3 = R_T \cdot \left(\frac{0.5\text{V}}{V_{OVDIS}} - \frac{0.5\text{V}}{V_{CHRDY}} \right) = 2 \text{ k}\Omega$$

$$R_4 = R_T - (R_1 + R_2 + R_3 + 800) = 169 \text{ k}\Omega$$

Configuration of LOAD

The application circuit is supplied with 2.5 V with current peaks up to 10 mA. The buck converter is configured as follows:

- LOAD_CFG[1:0] = HL (2.5 V)
- L_{BUCK} = 10 µH for best tradeoff between efficiency and maximum current (see Table 8).

Configuration of 5V_IN

5 V charger is not used so both 5V_IN and 5V_IMAX are left floating.

Shipping mode

Shipping mode is not used.

- SHIP_MODE is connected to GND.

7. Circuit Behavior

7.1. Start Up from SRC

7.1.1. Configuration

- SRC supplied by a SMU configured as 1 mA current source with 1.50 V voltage compliance.
 - $V_{OC} = 1.50 \text{ V}$
 - $I_{SRC} = 1 \text{ mA}$
- SRC_LVL_CFG[4:0] = LHHHH
 - $V_{SRC,REG} = 1.00 \text{ V}$
- BOOST_CFG = H
 - Timing multiplier x3
 - $L_{BOOST} = 33 \mu\text{H}$
- STO_CFG[1:0] = LH
 - $V_{OVDIS} = 3.00 \text{ V}$
 - $V_{CHRDY} = 3.21 \text{ V}$
 - $V_{OVCH} = 4.13 \text{ V}$
- $C_{STO} = 1 \text{ mF}$ electrolytic capacitor charged to 2.8 V beforehand.
- LOAD_CFG[1:0] = HL
 - $V_{LOAD} = 2.50 \text{ V}$
 - $L_{BUCK} = 10 \mu\text{H}$
 - LOAD pin floating
- SHIP_MODE = L
 - Shipping mode disabled.

7.1.2. Observations

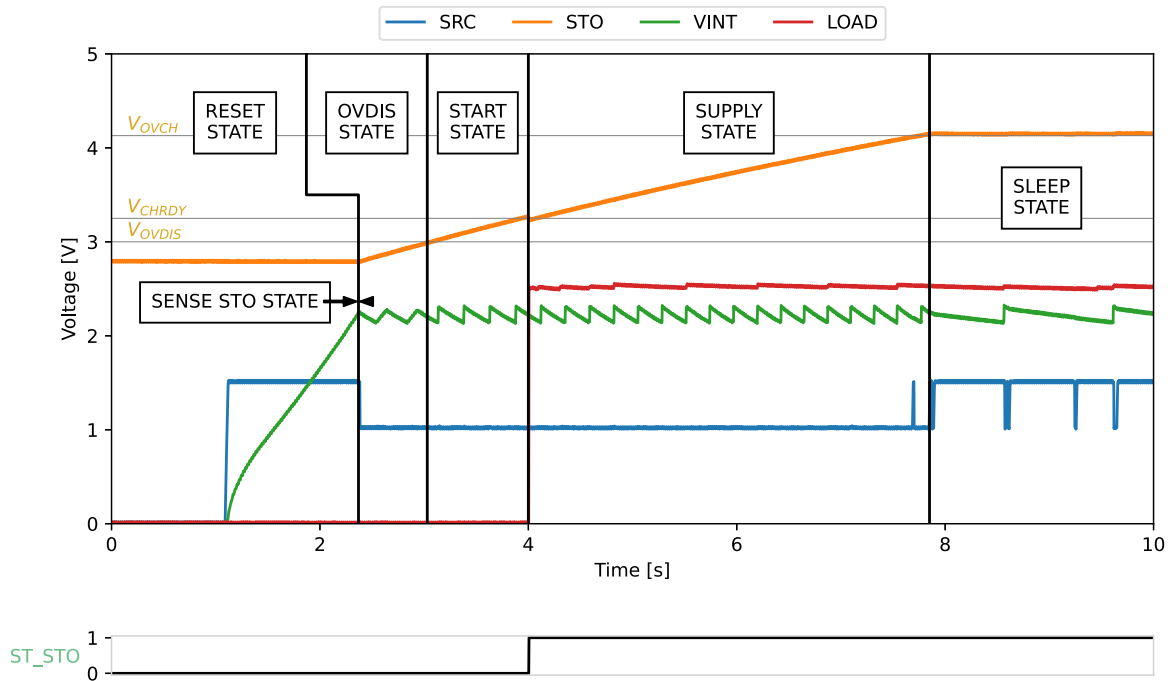


Figure 11: Start up behavior

- The AEM00920 is initially in **RESET STATE**.
- Once the SMU connected on **SRC** is switched on, the AEM00920 coldstarts. C_{INT} is charged until V_{INT} reaches $V_{INT,CS}$. The AEM00920 switches then to **SENSE STO STATE**.
- In **SENSE STO STATE**, the AEM00920 measures V_{STO} , which is below V_{OVDIS} . The AEM00920 switches then to **OVDIS STATE**.
- In **OVDIS STATE**, the AEM00920 charges the storage element on **STO** by harvesting the energy from **SRC**. V_{SRC} is regulated to the configured $V_{SRC,REG}$. **VINT** is supplied by **SRC** as well. Once V_{STO} reaches V_{OVDIS} , the AEM00920 switches to **START STATE**.
- In **START STATE**, the AEM00920 continues to charge the storage element connected on **STO** from the energy harvested by **SRC**. V_{SRC} is regulated to $V_{SRC,REG}$. The **LOAD** output remains disabled, and **VINT** is supplied by **STO**. Once V_{STO} reaches V_{CHRDY} , the AEM00920 switches to **SUPPLY STATE**.
- In **SUPPLY STATE**, the AEM00920 keeps charging the storage element from **SRC**. The **LOAD** output is now enabled, so that V_{LOAD} is regulated to 2.5 V, and the **ST_STO** pin is asserted. Once V_{STO} reaches V_{OVCH} , the AEM00920 switches to **SLEEP STATE**.
- In **SLEEP STATE**, **STO**, **LOAD**, and **VINT** are fully charged. The AEM00920 stops harvesting energy from **SRC**.
- Around 8.6 s and 9.6 s on Figure 11, the AEM00920 recharges **VINT** from **SRC** but remains in **SLEEP STATE**.

7.2. Shutdown

7.2.1. Configuration

- SRC supplied by a SMU configured as 1 mA current source with 1.50 V voltage compliance.
 - $V_{OC} = 1.50 \text{ V}$
 - $I_{SRC} = 1 \text{ mA}$
- SRC_LVL_CFG[4:0] = LHHHH
 - $V_{SRC,REG} = 1.00 \text{ V}$
- BOOST_CFG = H
 - Timing multiplier x3
 - $L_{BOOST} = 33 \mu\text{H}$
- STO_CFG[1:0] = LH
 - $V_{OVDIS} = 3.00 \text{ V}$
 - $V_{CHRDY} = 3.21 \text{ V}$
 - $V_{OVCH} = 4.13 \text{ V}$
- $C_{STO} = 10 \text{ mF}$ electrolytic capacitor charged between V_{CHRDY} and V_{OVCH} beforehand.
- LOAD_CFG[1:0] = HL
 - $V_{LOAD} = 2.50 \text{ V}$
 - 500 Ω resistor connected between LOAD and GND.
 - $I_{LOAD} = 5 \text{ mA}$
 - $L_{BUCK} = 10 \mu\text{H}$
- SHIP_MODE = L
 - Shipping mode disabled.

7.2.2. Observations

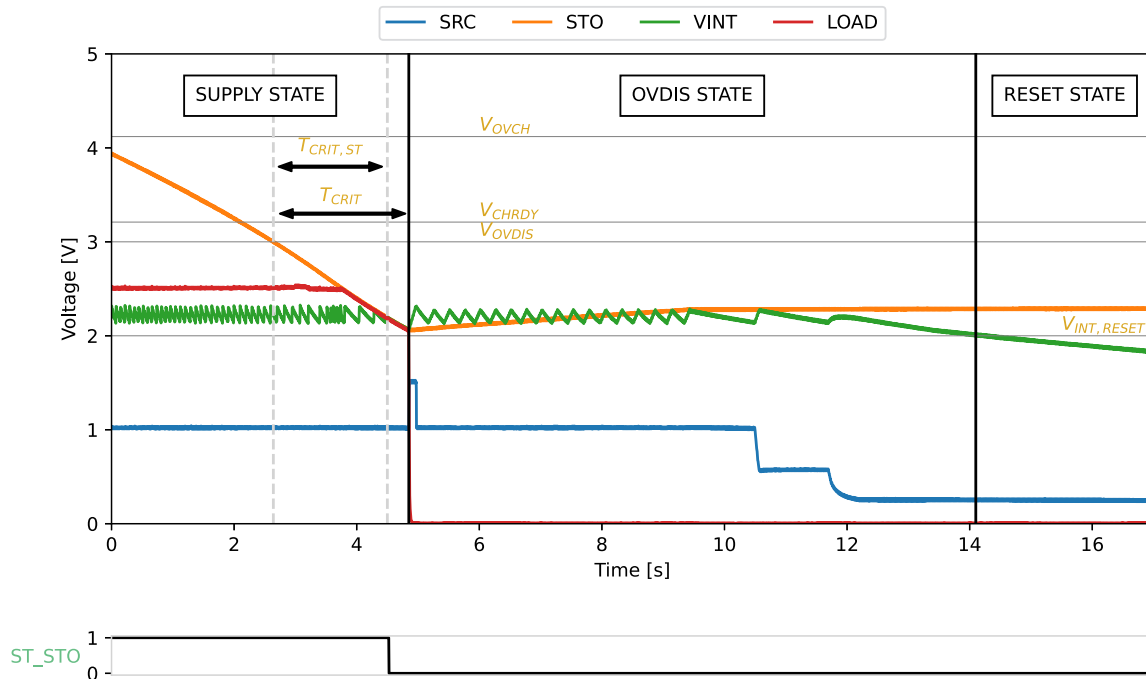


Figure 12: Shutdown behavior

- The AEM00920 is initially in **SUPPLY STATE**. **ST_STO** pin is HIGH. The harvested power on **SRC** (regulated to $V_{SRC, REG}$) is lower than the power supplied through **LOAD**, so that the storage element on **STO** is being discharged. Once V_{STO} remains below V_{OVDIS} for longer than $T_{CRIT, ST}$, the AEM00920 schedules to go in **OVDIS STATE** and sets **ST_STO** pin LOW but stays in **SUPPLY STATE** until the end of T_{CRIT} , and then switches to **OVDIS STATE**.
- In **OVDIS STATE**, the **LOAD** output is disabled and **VINT** is supplied by **SRC**. There is no more current drawn on the **LOAD** pin, and thus, on the storage element, so that the power budget is positive and the storage element is charged again.
- Around 9.5 s, the SMU connected on **SRC** is switched off. The storage element and **VINT** node are no longer charged. When V_{INT} drops below $V_{INT, RESET}$, the AEM00920 switches to **RESET STATE**.
- In **RESET STATE**, the energy present on the storage element is preserved as the **STO** pin is set to high impedance.

8. Minimum BOM

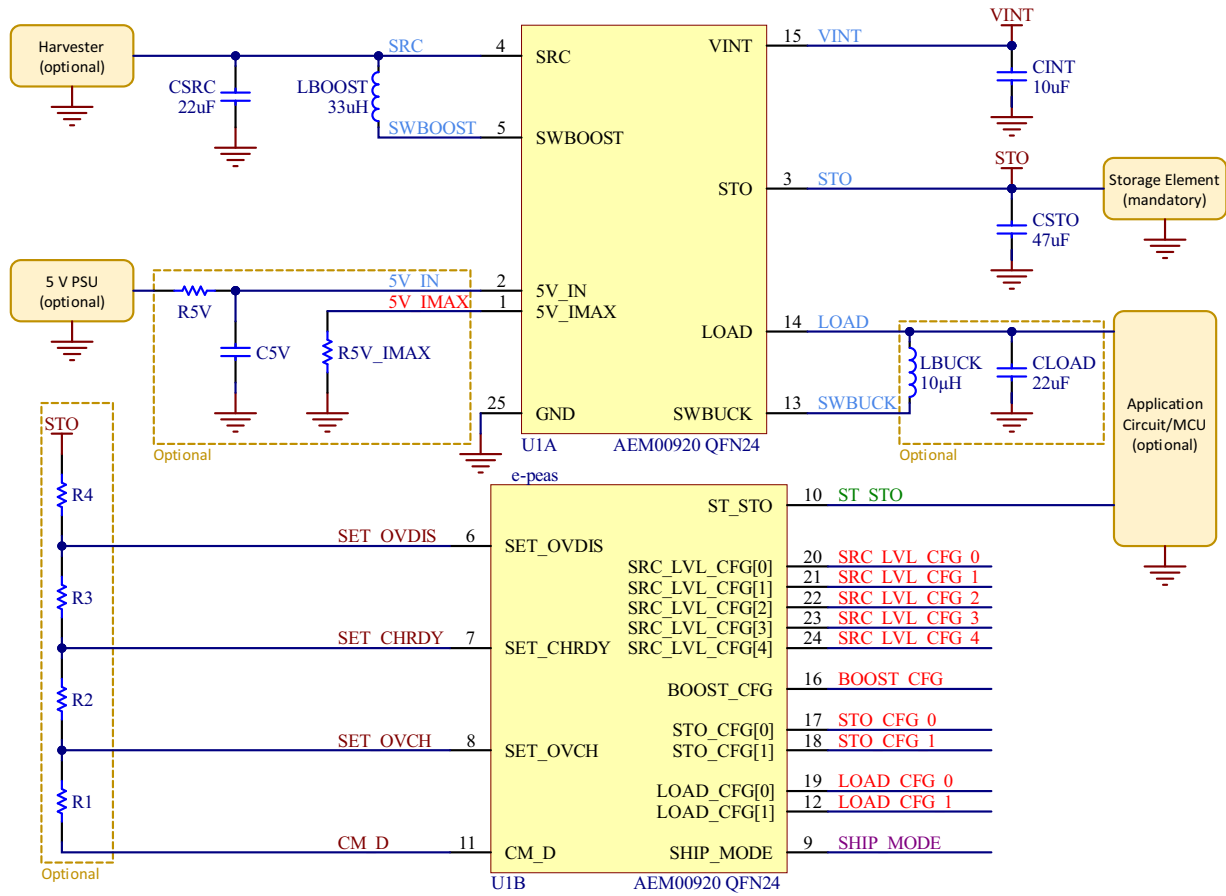


Figure 13: Schematic with minimum BOM

Designator	Description	Quantity	Manufacturer	Part Number
Mandatory	U1	1	e-peas	order at sales@e-peas.com
	CSRC ¹	1	Murata	GRM188R61A226ME15D
	LBOOST ¹	1	Coilcraft	LPS4018-333MRB
	CINT	1	Murata	GRM155R60J106ME44D
	CSTO ²	1	Murata	GRM188R60J476ME15D
Optional	R5V_IMAX ¹	1	To be defined	
	C5V ¹	1	To be defined	
	R5V ¹	1	To be defined	
	LBUCK	1	TDK	VLS252012CX-100M-1
	CLOAD	1	Murata	GRM188R61A226ME15D
	R1	1	To be defined	
	R2	1		
	R3	1		
	R4	1		

Table 15: Minimum BOM

1. The AEM00920 must have at least one energy source to work: boost (SRC), 5 V input (5V_IN) or both.

2. Recommended CSTO for optimal efficiency, particularly with high-ESR storage elements. If using a smaller value, ensure it meets the minimum requirement (see Table 8).

9. Layout

9.1. Guidelines

Figure 14 shows an example of PCB layout with AEM00920.

The following guidelines must be applied for best performances:

- Make sure that ground and power signals are routed with large tracks. If an internal ground plane is used, place via as close as possible to the components, especially for decoupling capacitors.
- Reactive components related to the boost/buck converter must be placed as close as possible to the corresponding pins (**SWBOOST**, **SRC**, **STO**, **SWBUCK** and **LOAD**), and be routed with large tracks/polygons.

9.2. Example

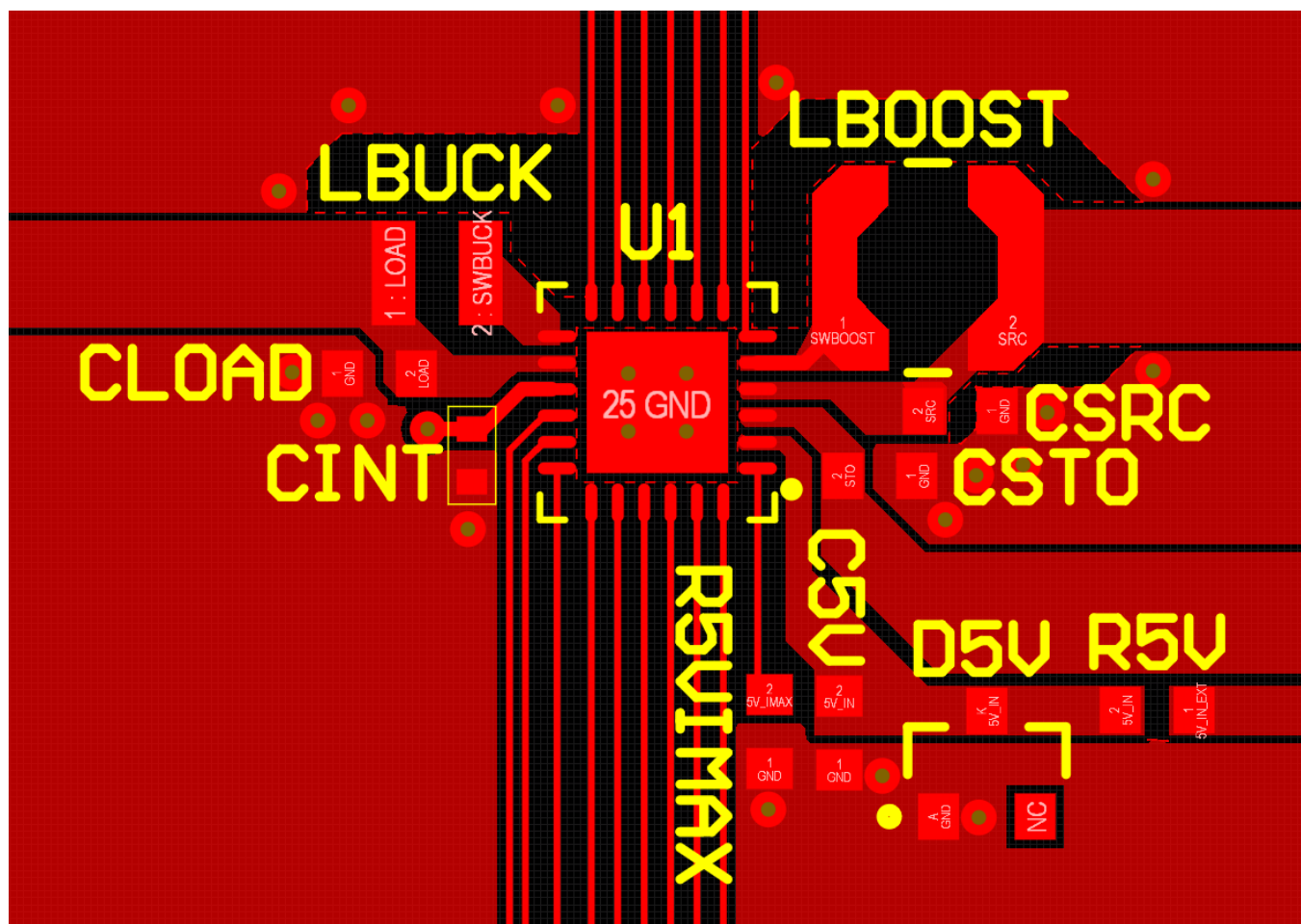


Figure 14: Layout example for the AEM00920 with associated passive components

10. Package Information

10.1. Moisture Sensitivity Level

Package	Moisture Sensitivity Level (MSL) ¹
QFN-24	Level 1

Table 16: Moisture sensitivity level

1. According to JEDEC 22-A113 standard.

10.2. RoHS Compliance

e-peas product complies with RoHS requirement.

e-peas defines “RoHS” to mean that semiconductor end-products are compliant with RoHS regulation for all 10 RoHS substances.

This applies to silicon, die attached adhesive, gold wire bonding, lead frames, mold compound, and lead finish (pure tin).

10.3. REACH Compliance

The component and elements used by e-peas subcontractors to manufacture e-peas PMICs and devices are REACH compliant. For more detailed information, please contact e-peas sales team.

10.4. Tape and Reel Dimensions

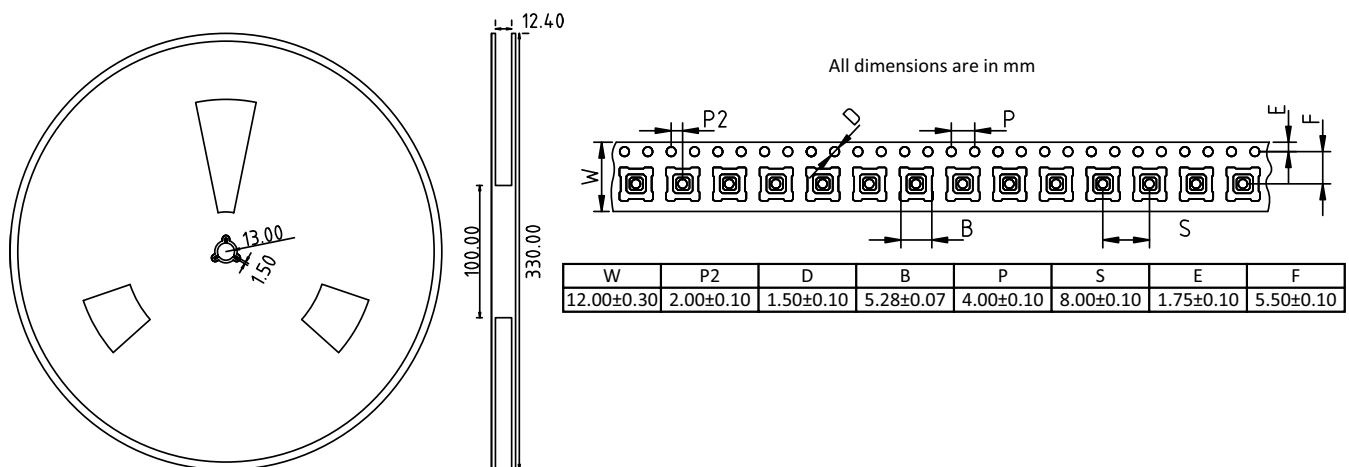


Figure 15: Tape and reel dimensions

10.5. Package Dimensions

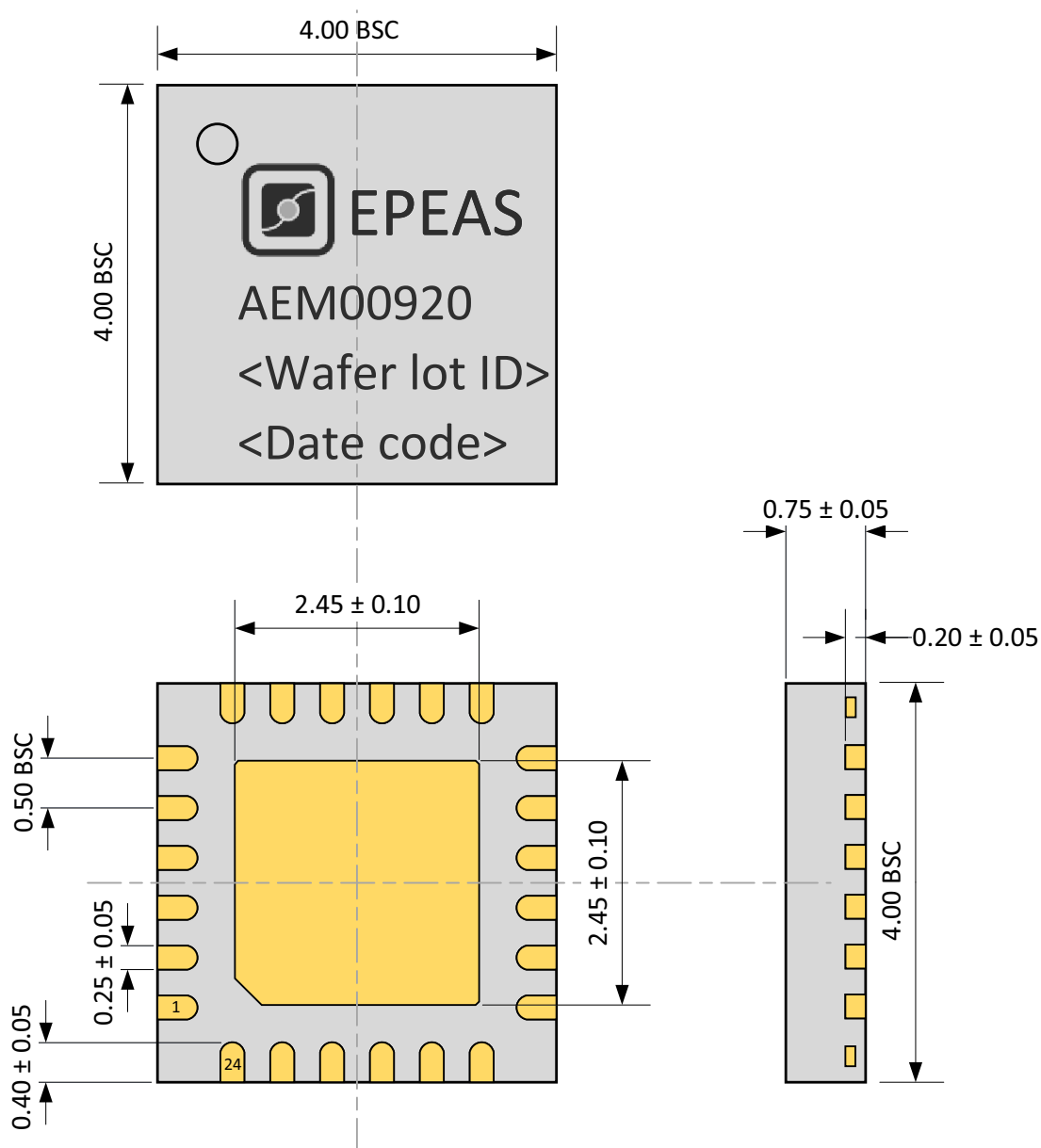


Figure 16: QFN 24-pin 4x4mm drawing (all dimensions in mm)

10.6. Board Layout

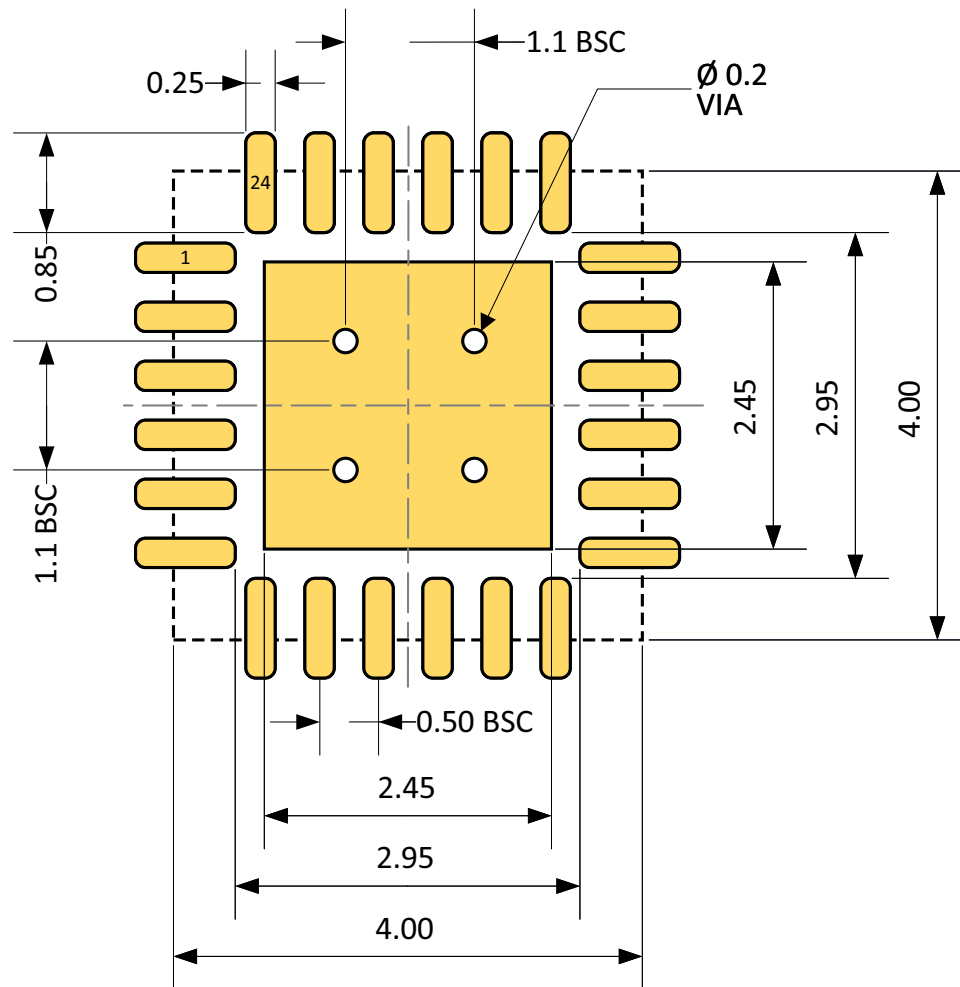


Figure 17: Recommended board layout for QFN24 package (all dimensions in mm)

11. Glossary

C_{5V}	Capacitor creating a RC filter with R_{5V} to slow down the rising time of the voltage on the 5V_IN pin.	P_{R5V,idle}	Power dissipated by R_{5V} when no current is pulled by the 5 V charger (current only flowing in the zener protection diode).
C_{INT}	Decoupling capacitor on the VINT pin.	P_{SRC,CS}	Minimum power required on SRC for the AEM00920 to coldstart.
C_{LOAD}	Decoupling capacitor on LOAD pin.	R_{5V}	Resistor creating a RC filter with C_{5V} to slow down the rising time of the voltage on the 5V_IN pin.
C_{SRC}	Boost converter input capacitor.	R_{5V_IMAX}	Resistor connected between 5V_IMAX and GND that defines the maximum current provided to the storage element by the 5 V charger (5V_IN pin).
D_{5V}	Zener diode that ensures that the voltage on 5V_IN stays below 5.5 V at any time.	T_{CRIT}	When V_{STO} drops below V_{OVDIS} in SUPPLY STATE , the AEM00920 waits for T_{CRIT} before switching to OVDIS STATE and disabling the LOAD output.
I_{5V,CC}	Current provided to the storage element by the 5V_IN when in constant current mode.	T_{CRIT,ST}	When V_{STO} drops below V_{OVDIS} in SUPPLY STATE , the AEM00920 waits for T_{CRIT,ST} before setting ST_STO LOW.
I_{Q,RESET}	Quiescent current on STO when the AEM00920 is in RESET STATE .	T_{GPIO,MON}	GPIO reading rate.
I_{Q,SHIP}	Quiescent current drawn on the storage element when the AEM00920 is in shipping mode (SHIP_MODE is HIGH) with or without energy available on SRC .	T_{STO,MON}	Storage element voltage monitoring rate.
I_{Q,SLEEP}	Quiescent current drawn on STO when the AEM00920 is in SLEEP STATE .	V_{5V_IN}	Voltage the 5V_IN pin.
I_{Q,SUPPLY}	Quiescent current drawn on STO when the AEM00920 is in SUPPLY STATE .	V_{5V_IN,MIN}	Minimum voltage on the 5V_IN pin.
I_{SRC,MAX}	Maximum current extracted from the SRC pin.	V_{CHRDY}	Minimum voltage accepted on the storage element before starting to supply LOAD in START STATE (see Section 5.3).
L_{BOOST}	Boost converter inductor.	V_{ESD}	Electrostatic discharge voltage.
L_{BUCK}	Buck converter inductor.	V_{INT}	Voltage on the VINT pin.
P_{R5V,CC}	Power dissipated by R_{5V} with the 5 V charger constant current (CC).	V_{INT,CS}	Minimum voltage on VINT to allow the AEM00920 to switch from RESET STATE to SENSE STO STATE .

$V_{\text{INT,RESET}}$

Minimum voltage on **VINT** before switching to **RESET STATE** (from any other state).

 V_{LOAD}

Voltage on the **LOAD** pin.

 V_{OC}

Open circuit voltage of the harvester connected to **SRC**.

 V_{OVCH}

Maximum voltage accepted on the storage element before disabling its charging (see Section 5.3).

 V_{OVDIS}

Minimum voltage accepted on the storage element before stopping to supply **LOAD** (see Section 5.3).

 V_{SRC}

Voltage on the **SRC** pin.

 $V_{\text{SRC,CS}}$

Minimum voltage required on **SRC** for the AEM00920 to coldstart.

 $V_{\text{SRC,REG}}$

Target regulation voltage of the source, depending on **SRC_LVL_CFG[4:0]** configuration.

 V_{STO}

Voltage on the **STO** pin.

12. Revision History

Revision	Date	Description
1.0	December, 2023	Creation of the document.
1.1	January, 2024	Added typical application circuits.
1.2	January, 2024	- Added Glossary. - "LOAD Output Voltage" section: "buck voltage cannot be selected smaller higher than V_{OVDIS}"
1.3	June, 2024	- L_{BUCK} in BOM in μH instead of μF. - Specified BOOST_CFG state when left floating in "Pin Configuration and Functions" section. - Added BOOST_CFG pin info to "Logic input pin connections" table. - Added cautionary statement about the AEM00920 storage element thresholds presets. - Added $I_{Q,SUPPLY}$ and $I_{Q,SLEEP}$ values in "Electrical characteristics" table. - "State Machine Description" section: Added missing transition from START STATE to SUPPLY STATE when 5V charger is enabled.
1.4	June, 2024	- Added REACH and RoHS compliances. - Added info about 5 V charger voltage rise time limit and how to handle it. - Added cautionary statement along with storage element threshold voltages. - Corrected state machine transitions: - From START_STATE to SUPPLY_STATE. - From SUPPLY_STATE to SLEEP_STATE. - Pin description table: fixed pin 4 name. - Fixed cold start minimum power value.

Table 17: Revision history (part 1)

Revision	Date	Description
1.5	November, 2024	- Reworked of the first page. - Corrected the maximum input and output currents on the first page. - Added Absolute Maximum Ratings values. - Added ESD ratings table. - Added Moisture Sensitivity Level section. - Moved the RoHS and REACH compliances sections into the "Package Information" section. - Renamed "Typical Electrical Characteristics at 25°C" section to "Electrical Characteristics at 25°C". - Modified the typ. minimum source power required for cold start to 1.5 μW. - Modified the evaluation board part number on first page. - Corrected pin 4 name to SRC in "Pins description" table. - In "Recommended external components" table: - Added BOOST_CFG configuration condition for L_{BOOST} values and the corresponding min. and typ. values. - Modified L_{BUCK} typical value to 10 μH. - Modified L_{BOOST} minimum values. - Added minimum and typical values for C_{LOAD}. - In "Boost converter timings configuration" table: - Modified L_{BOOST} minimum values for each boost converter timing. - Added recommended L_{BOOST} values for best efficiency. - Added $V_{SV_IN} \geq V_{STO} + 200$ mV condition for the 5 V charger to operate in the different 5 V charger sections. - Updated the state machine figure SLEEP STATE input and output conditions and the "Sleep State" section. - Modified "Example Circuit 1" section for $R5V = 2.2 \Omega$ and $C5V = 47 \mu$F. - Renamed "Performances" section to "Typical Characteristics" and moved it in "Specifications" section. - Updated "Minimum BOM" section to specify C_{STO}, L_{BUCK} and C_{LOAD} as optional. - Updated layout example figure by adding $R5V$, $C5V$, $D5V$ and $R5V_IMAX$. - Updated package dimensions and added markings in "QFN 24-pin 4x4mm drawing" figure. - Added "Board Layout" section and figure.
1.6	December, 2024	- Updated the part number on first page to 10AEM00920A0002. - Added custom mode feature explanation throughout the document. - Updated the storage element protection threshold values. - Added disclaimer about V_{CHRDY} and V_{OVDIS} thresholds for LL and HH $STO_CFG[1:0]$ configurations. - Removed constant voltage operation mode for 5 V charger. - Added notes to leave the buck converter enabled and to connect LOAD to STO when the 5 V charger is used. - Removed the "Logic input pin connections" table. - Added $T_{CRIT,ST}$ as the delay before setting ST_STO LOW when the storage element falls below V_{OVDIS}.

Table 17: Revision history (part 2)

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