AEM10941 Evaluation Kit with Fujikura PV Cell and NGK Storage Element User Guide

Description

The **AEM10941** is an ambient energy manager that extracts power from photovoltaic harvesters to simultaneously store energy in a rechargeable element and supply your system with two independent regulated voltages.

The evaluation kit allows users to test the e-peas IC, the Fujikura PV cell and the NGK storage element and analyse its performances in a laboratory-like setting.

It allows an easy connection to a 3 V regulated voltage provided by a DCDC BUCK converter. 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 test point, allowing users to configure it for any usage scenario and evaluate the relevant performances.

The **AEM10941** evaluation board with **Fujikura** PV cell and **NGK** storage element is a plug and play, intuitive and efficient tool for making the appropriate decisions for the design of a highly efficient subsystem in your target application.

Applications

Solar/light harvesting	IoT industrial sensors
Asset tracking	Smart home/building

Device Information

Part Number	Dimensions
3AAEM10941CFN10	85 mm x 44 mm
FDSC-FSC5FGC	85 mm x 44 mm
EC382704P-C	38 mm x 27 mm

Features

E-peas PMIC: AEM10941

- Ratio MPPT: 75%
- Storage element configuration: Custom mode for NGK storage element
- Status: Test points
- LDO output: Disabled
- Configuration resistances
  - MPPT Ratio
  - Storage element configuration
  - LDO configuration

Fujikura PV Cell: FDSC-FSC5FGC

- Typical open circuit voltage: 0.5 V
- Power at 200 LUX: 165 µW

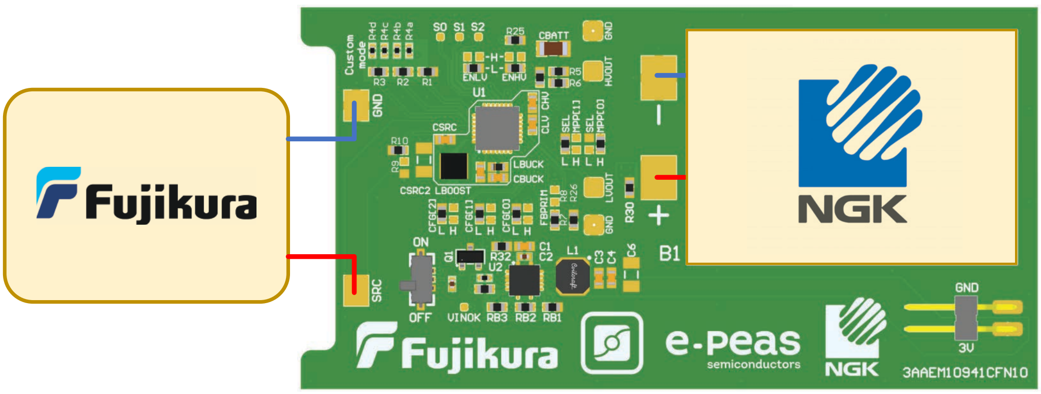
NGK Storage Element: EC382704P-C

- Maximum charge voltage: 4.2 V
- Discharge cut-off voltage: 3 V

DCDC converter

- Output voltage: 3 V
- Typical maximum average current: 200 mA
- Disabled with a switch.

Appearance



1. Connections Diagram

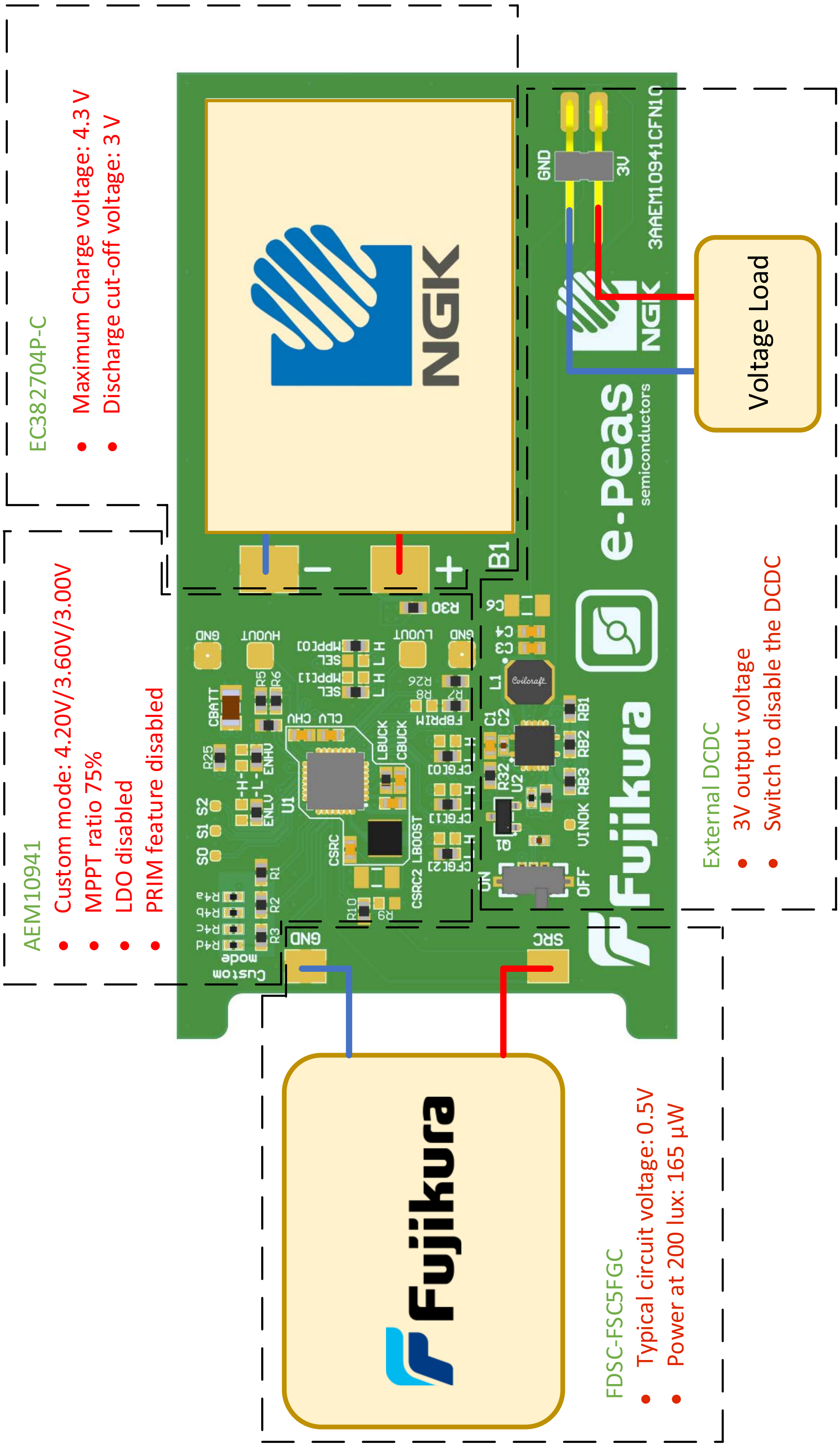


Figure 1: Connection diagram

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.	Leave floating.
BATT	Connection to the energy storage element.	Connect the storage element in addition to CBATT (150 µF).	Do not remove CBATT
LVOUT	Output of the low-voltage LDO regulator.	Connect a load	
HVOUT	Output of the high-voltage LDO regulator.	Connect a load	
Debug signals			
VBOOST	Output of the boost converter.		
VBUCK	Output of the buck converter.		
BUFSRC	Connection to an external capacitor buffering the boost converter input.		
Configuration signals			
FB_HV	Configuration of the high-voltage LDO in the custom mode	Use resistor R5-R6	Leave floating.
Control signals			
ENHV	Enabling pin for the high-voltage LDO.	Place a 0Ω resistor in the ENHV H position	Place a 0Ω resistor in the ENHV L position
ENLV	Enabling pin for the low-voltage LDO.	Place a 0Ω resistor in the ENLV H position	Place a 0Ω resistor in the ENLV L position
Status signals			
STATUS[2]	Logic output. Asserted when the AEM performs the MPP evaluation.		
STATUS[1]	Logic output. Asserted if the battery voltage falls under Vovdis or if the AEM is taking energy from the primary battery.		
STATUS[0]	Logic output. Asserted when the AEM LDOs can be enabled.		
VINOK	Logic output. Asserted when the DCDC input voltage (Vbatt) is above 3.12 V.		

Table 1: Pin description

2. AEM10941

The AEM10941 is an integrated energy management circuit that extracts DC power from up to 7-cell solar panels to simultaneously store energy in a rechargeable element and supply the system with two independent regulated voltages. The AEM10941 allows to extend battery lifetime and ultimately eliminates the primary energy storage element in a large range of wireless applications, such as industrial monitoring, geolocation, home automation, e-health monitoring and wireless sensor nodes.

The AEM10941 harvests the available input current up to 110 mA. It integrates an ultra-low-power boost converter to charge a storage element, such as a Li-ion battery, a thin film battery, a supercapacitor or a conventional capacitor. The boost converter operates with input voltages in a range from 50 mV to 5 V. With its unique cold start circuit, it can start operating with empty storage elements at an input voltage as low as 380 mV and an input power of just 3 µW.

2.1. BOOST efficiency

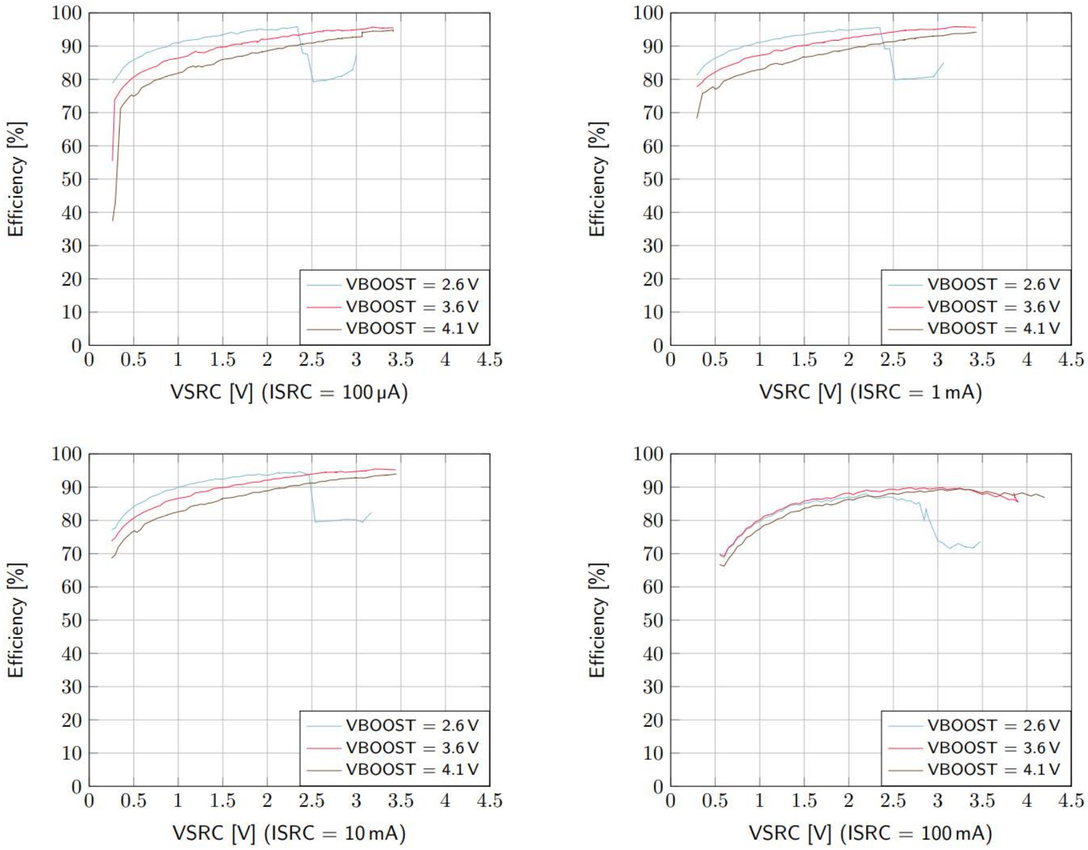


Figure 2: Boost efficiency

3. Fujikura PV Cells

The DSSC modules can be used in low light conditions with a high efficiency. In fact, DSSC harvests in a wide array of situation to generate energy from the environment.

The FDSC-FSC5FGC PV cell is available on the evaluation kit and all the information is present on the Fujikura website. The PV cell dimensions are shown on the first page of this document.

The PV cells can be used over a wide range of lighting conditions and temperatures. It can be installed indoors and outdoors with high durability.

This highly efficient PV cells can generate up to 165 µW power with a white LED at 200 lux. The Figure 3 presents the performance between 10 and 100 000 lux.

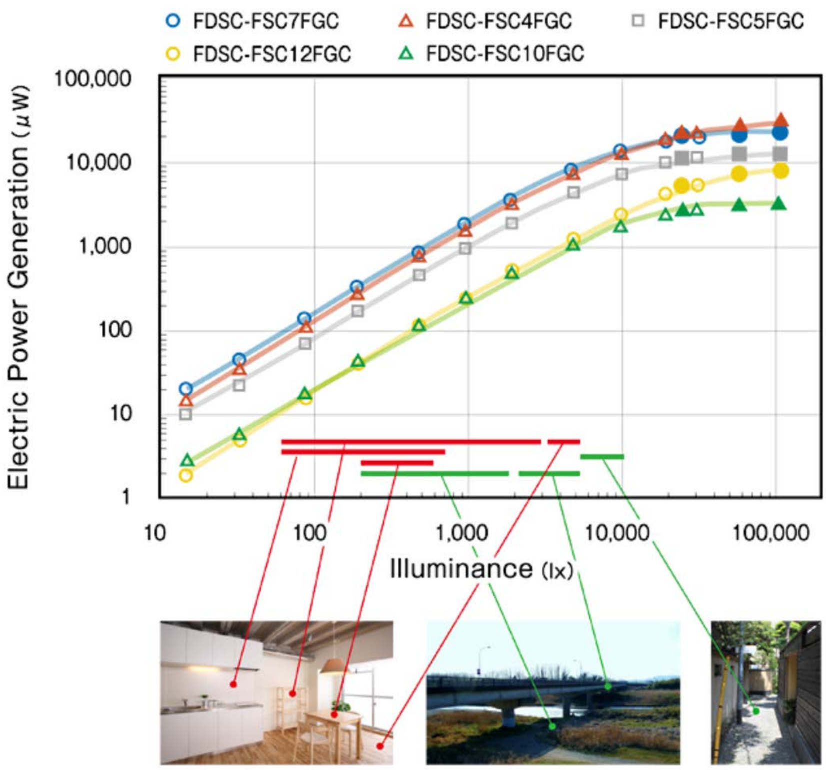


Figure 3: PV cell performance

3.1. Test Cases

Item	Value
Temperature cycle test	-40 to 90°C, 200 cycles
Temperature and humidity cycle test	-40 to 85°C, 85%RH, 10 cycles
High-temperature high-humidity test	85 °C, 85%RH, 1000 hrs
Light irradiation test	AM 1,5G 1000W/m², 40°C, 500 hrs
Model test	Terminal strength test, vibration/shock/drop test, overcurrent application test

Table 2: Test cases

4. NGK Storage element

The EC382704P-C Enercera Pouch is an ultra-thin (0.45 mm), bend-resistant rechargeable Lithium-ion battery that can be embedded into a lot of applications, like a credit card. It is also the first ever lithium-ion battery able to wish-stand the hot lamination process used in smart card manufacture. EnerCera Pouch batteries can be charged rapidly using contactless card readers.

This batteries have a high energy density and low electrical resistance. It can be used in many environment conditions due to its high thermal resistance and its long life expectancy. More information is available at the NGK website.

Item	Unit	Value
Nominal capacity (Charging voltage)	mAh	27 (4.3 V) 24 (4.2 V)
Nominal Voltage	V	3.8
Peak Discharge current	mA	260

Table 3: Electrical characteristics

4.1. Operation condition

Item	Unit	Minimum	Maximum
Temperature Discharge	°C	-20	45
Temperature Charge	°C	0	45
Charging mode	Constant current (CC) - Constant voltage (CV) charging		

Table 4: Operation condition

5. Functional Tests

This section presents a few simple tests that allow the user to understand the functional behaviour of the AEM10941, the PV cell and the storage element.

5.1. Start-up

The following example allows users to observe the behaviour of the AEM10941 in the wake-up mode.

Setup

- Place the probes on the nodes to be observed.
- Expose the PV cell to a luminosity source.

Observations and measurements

- BATT: Voltage rises as the power provided by the source is transferred to the storage element.
- SRC: Regulated at Vmpp, which is a voltage equal to the open-circuit voltage (Voc) times the MPP ratio of 75%. Vsrc equals Voc during MPP evaluation (see Figure 4). Note that Vsrc must be higher than 380 mV to coldstart.
- STATUS[2]: Asserted each time the AEM10941 performs a MPP evaluation (See Figure 4).

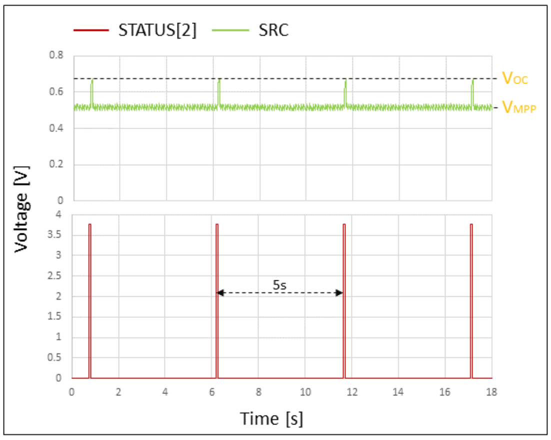


Figure 4: SRC and STATUS[2] while energy is extracted from SRC (BATT under Vovch)

5.2. Shutdown

This test allows users to observe the behaviour of the AEM10941 when the system is running out of energy.

Setup

- Place the probes on the nodes to be observed.
- Let the system reach a steady state (i.e. voltage on BATT between Vchrdy and Vovch and STATUS[0] asserted).
- Connect a load (a resistor) to the DCDC output in order to make the battery voltage fall. Other possibility is to disconnect the NGK battery through the R30 resistor and enable the DCDC without a load, doing this we will see the discharge of the 150uF CBATT capacitor.
- Hide the PV cell from the luminosity source to stop the harvesting

Observations and measurements

- BATT: Voltage decreases as the system consumes the power accumulated in the storage element. The voltage remains stable after crossing Vovdis (see Figure 5).
- STATUS[0]: De-asserted when the LDOs are no longer available as the storage element is running out of energy. This happens 600 ms after STATUS[1] assertion (see Figure 5).
- STATUS[1]: Asserted for 600ms when the storage element voltage (BATT) falls below Vovdis (see Figure 5).
- DCDC 3V output. Disabled when the battery voltage falls below Vovdis, as the external DCDC BUCK converter is enabled by the STATUS[0] signal.

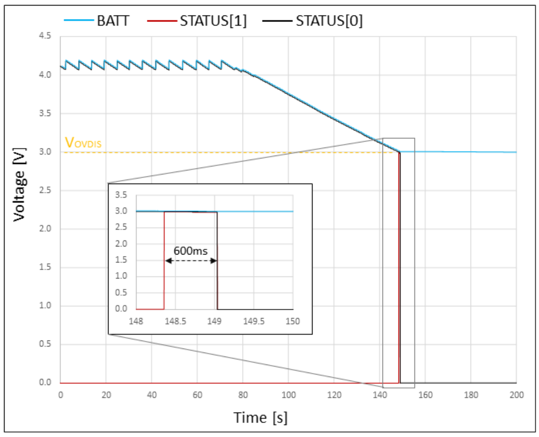


Figure 5: LDOs and external DCDC BUCK converter disabled around 600 ms after BATT reaches Vovdis