Presentation Will Begin Shortly

4:00

FEBRUARY SESSIONS

DATE	TIME	SESSION
THURS, FEBRUARY 6TH	10 AM CT	What's New in Matter
TUES, FEBRUARY 18TH	10 AM CT	Harvesting Energy for Smarter IoT with Silicon Labs' xG22E

MARCH SESSIONS

DATE	TIME	SESSION
THURS, MARCH 6TH	10 AM CT	The Most Application-Optimized Bluetooth SoCs for Future-Ready IoT
TUES, MARCH 18TH	10 AM CT	Introducing MG26, PG26, and BG26: A Highly Flexible SoC Platform for All of Your IoT Needs

FUTURE DATES

DATE	TIME
APRIL: THURS, APRIL 3RD & TUES, APRIL 15TH	10 AM CT
MAY: THURS, MAY 1ST & TUES, MAY 13TH	10 AM CT
JUNE: THURS, JUNE 5TH & TUES, JUNE 17TH	10 AM CT

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Harvesting Energy for Smarter IoT with Silicon Labs' xG22E

2025 tech talks
WEBINAR SERIES

BLUETOOTH

Agenda

01 Energy Harvesting - Sources and Applications

02 MG22E Explorer Shields - Unboxing!

03 MG22E Explorer Shield – Out-of-Box Setup

04 MG22E Explorer Shield – Example Setup DEMO

05 *e-peas* – Key Design Considerations

07 *e-peas* – Taking Measurements

08 Going Further

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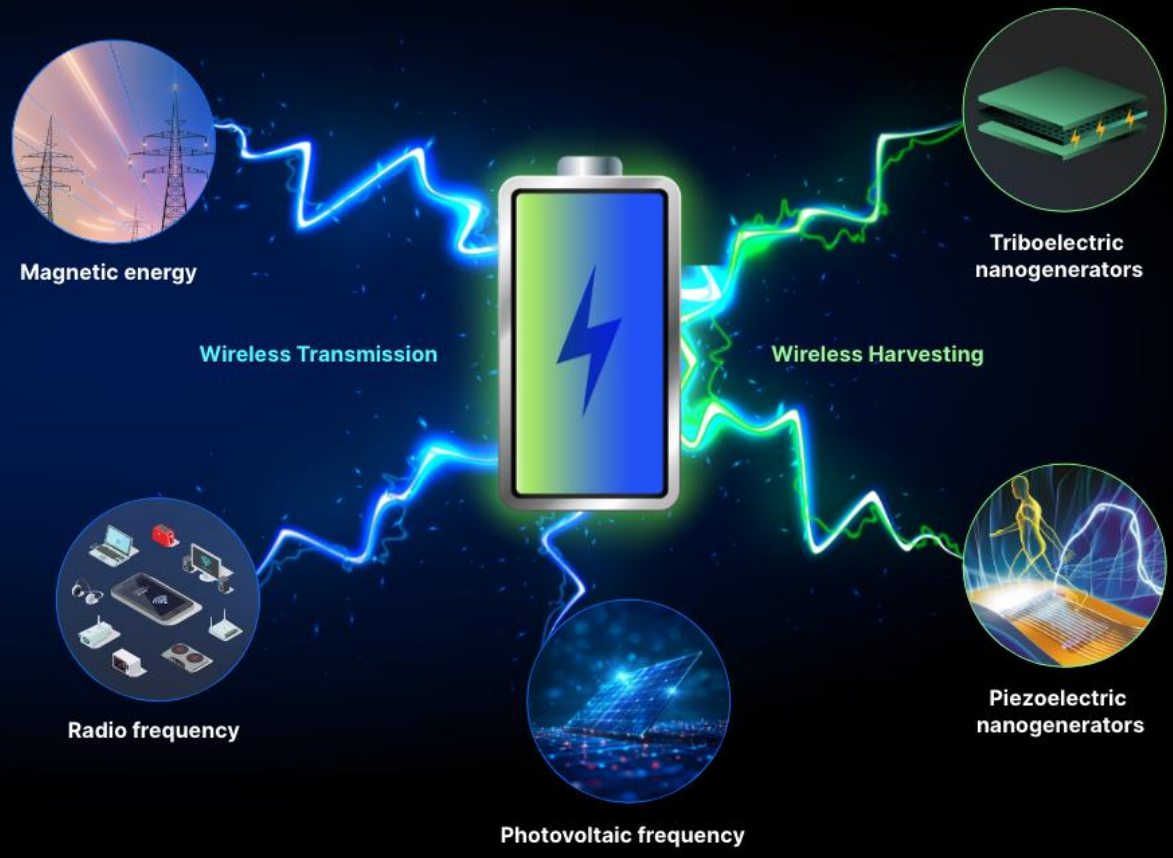
Energy Harvesting – Sources & Applications

- Energy Harvesting sources
- Ambient IoT applications
- Ambient IoT architecture
- Energy Harvesting methodology

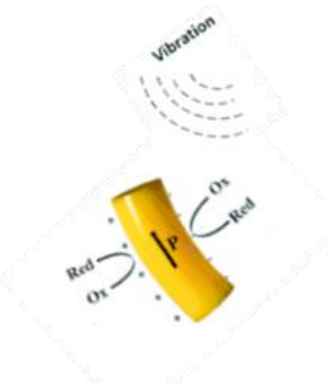


Energy Harvesting Sources

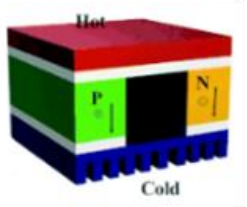
"TRICKLE" ENERGY SOURCES

- For applications with nearly *constant energy supplies*
- For applications that are nearly *always-on (rechargeable)*

PHOTOVOLTAIC



VIBRATION PIEZO



MAGNETIC / THERMAL INDUCTION

RF INDUCTION

"TRANSIENT" ENERGY SOURCES

- For applications with *limited duration energy source*
- For applications that *frequently deep sleep or power off*

KINETIC

Learn more: [WorksWith 2023]

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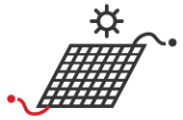
Ambient IoT - Applications

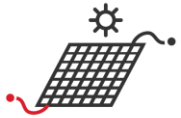
Learn more: TechTalk 2024



SOLAR - OUTDOOR

LOGISTICS / LIVESTOCK TRACKING

Bluetooth® Proprietary



SOLAR - INDOOR

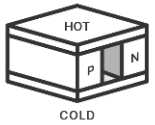
ASSET TRACKING / SMART BUILDING SENSORS

Bluetooth® Proprietary zigbee

KINETIC PULSE

SMART SWITCHES

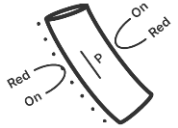
Bluetooth® zigbee



THERMAL

MACHINE MONITORING

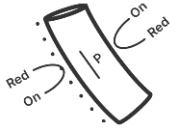
Bluetooth® Proprietary zigbee



VIBRATION / PIEZO

FACTORY AUTOMATION / AGRICULTURE / TPMS

Bluetooth® Proprietary zigbee



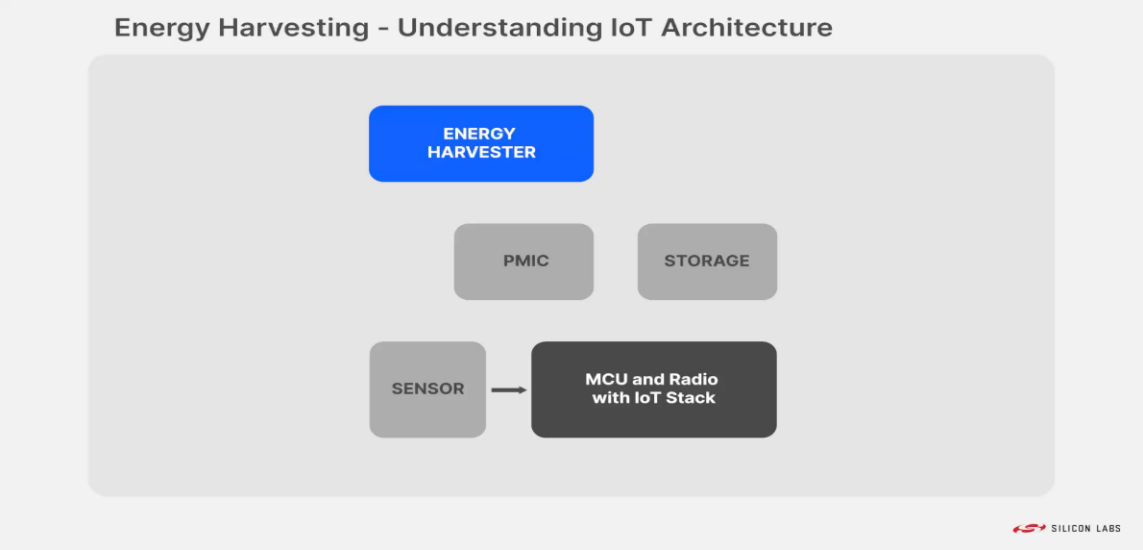
INDUCTION

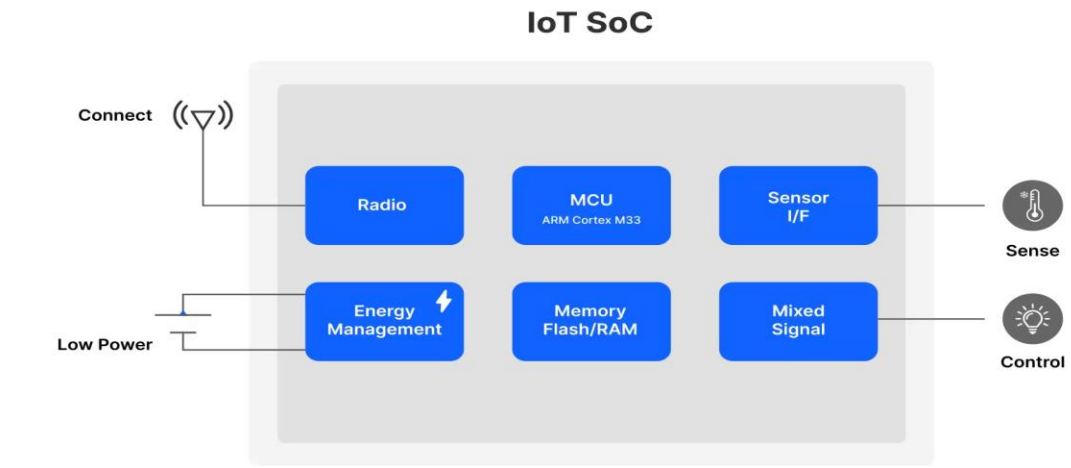
ELECTRIC SUB-METERING

Bluetooth® Proprietary zigbee

Ambient IoT - Methodology

Learn more: WorksWith 2024





1. **Understanding your application power budget**
2. **Assess available energy sources**
3. **Energy measurements – PMIC design**
4. **Storage type and size design**
5. **IoT protocol – energy algorithms**

Learn more: docs.silabs.com/energy_harvesting

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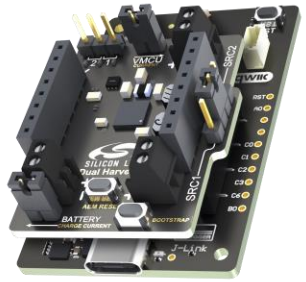
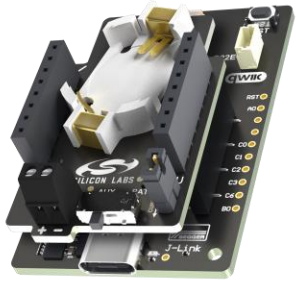
Energy Harvesting Shields for Explorer Kit - EK8200 – Unboxing!

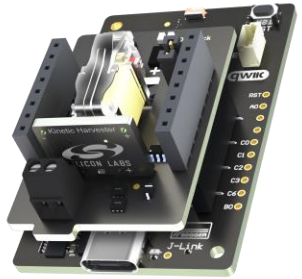
- **BRD8200A Kit**
  - BRD8203 – Battery Shield
  - BRD8202 – Kinetic Shield
  - BRD8201 - Dual Source Shield
  - BRD8204/8205 – AC/DC Bricks
- **Software Examples** - github
- **User Guide** - UG591

UNBOXING – EK8200A – Energy Harvesting Shields for Explorer Kit


MG22E Explorer Kit

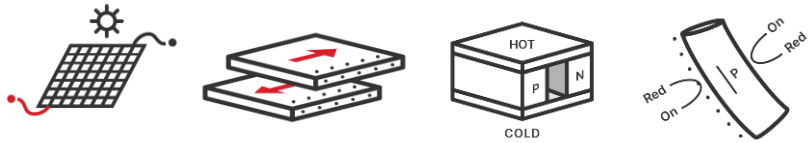

Dual Harvester


Battery Power


Kinetic Button

All-in-one multi-application Ambient IoT prototyping kit!

- **co-designed** by *Silicon Labs* and *e-peas*
- **Shield-compatible** with **MG22E** Explorer Kit (**BRD2710A included**)
- Includes basic **PV cell** and **capacitor** storage
- Compatible with AC and DC **multiple energy sources** (with rectifier/regulator attachments)
- Compatible with **Bluetooth LE, RAIL, Zigbee (Green Power)** and **Proprietary 2.4GHz** protocols



Bluetooth® zigbee Proprietary

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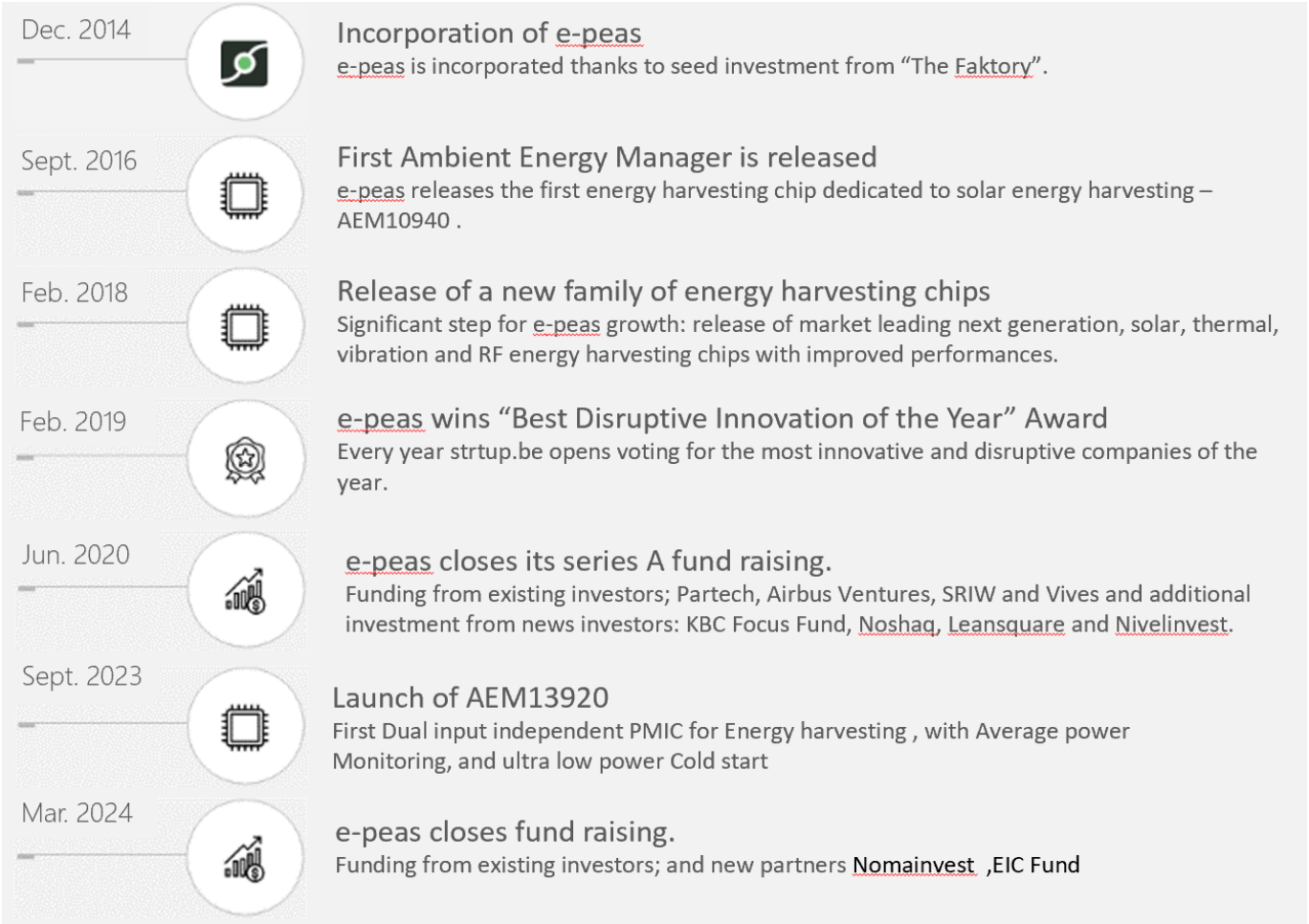
e-peas Intro

- **e-peas is a fabless semiconductor company expert in developing Power Management ICs and solutions for harvesting energy from environment in order to power IoT at the EDGE.**
- **For the past 10 years we have developed 17 PMICs and a rich ecosystem of partners.**
- **Our collaboration with SILICON LABS illustrates this long-term engagement.**

e-peas semiconductors



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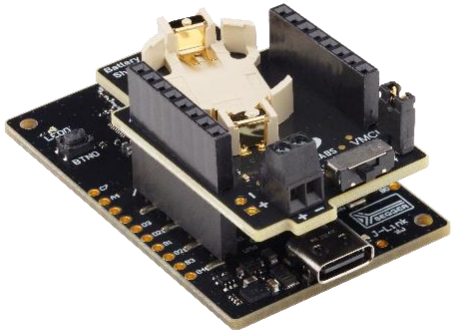
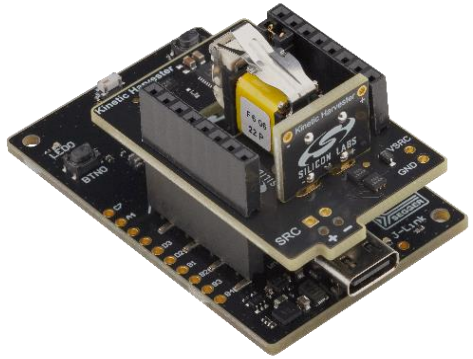
UNBOXING – EK8200A – Energy Harvesting Shields for Explorer Kit



BRD8203

BATTERY BACKPACK

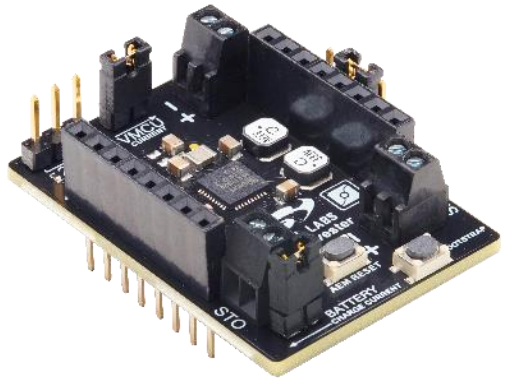
- Coin-cell battery compatible
- Designed with test-points for current and voltage measurements
- USB-power compatible
- Capacitor or alternative-power circuitry adaptable screw terminals



BRD8202

KINETIC SHIELD

- e-peas AEM00300 PMIC
- Battery-less switches and buttons
- Zigbee Green Power ; BLE RAIL examples
- Battery-less Zigbee commissioning



BRD8201

DUAL HARVEST SHIELD

- e-peas AEM13920 PMIC (NEW)
- Simultaneous AC or DC input energy-source
- e-peas i2c 3rd party driver (Github extension for Simplicity Studio)

BRD8204/5

ADAPTER BRICKS

- AC and DC input circuitry
- MOSFET-based rectifier with capacitor wave smoothing
- Over-protection circuitry

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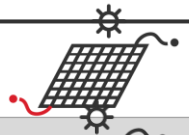
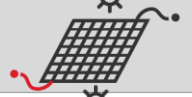
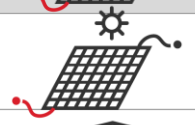
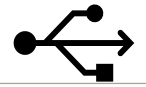
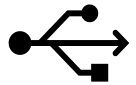
UNBOXING – Github– Energy Harvesting Shields for Explorer Kit

github.com/SiliconLabs/energy_harvesting_applications

#	TYPE	PROTOCOL	ENERGY SOURCE	LINK
1	Energy Harvester *Sensor*	Bluetooth LE	Solar 	README
2	Energy Harvester *Sensor*	Bluetooth RAIL	Solar 	README
3	Energy Harvester *Sensor*	Zigbee GreenPower	Solar 	README
4	Energy Harvester *Switch*	Bluetooth RAIL	Kinetic 	README
5	Energy Harvester *Switch*	Zigbee GreenPower	Kinetic 	README
6	Observer / *Reader*	Bluetooth / RAIL	N/A 	README
7	Coordinator / *Reader*	Zigbee GreenPower	N/A 	README

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UNBOXING – User Guide – Energy Harvesting Shields for Explorer Kit

UG591: User's Guide to EFR32xG22E Energy Harvesting Explorer Kit

EFR32xG22E Energy Harvesting Explorer Kit is an excellent starting point to explore and evaluate different Energy Harvesting solutions with Silicon Labs' Multiprotocol Wireless Systems on Chip (SoC).

This unique Energy Harvesting kit selection includes a lightweight board with one of Silicon Labs most popular Multi-protocol Wireless SoCs, based on the Explorer Kit platform, and different shields and adapters which, combined with the Explorer Kit's features enable evaluation of multiple solutions for Energy Harvesting, making use of energy sources like photovoltaic cells, inductive or piezoelectric sources, Thermoelectric Generators (TEG), in different applications, for example pulsed or continuous supply, single or dual source.

- The Dual Harvester Shield is the most flexible shield, that can be used to harvest energy from one or two sources at the same time. Typical use case scenarios are complimentary photovoltaic cells, one photovoltaic cell and one piezoelectric source taking energy from vibrations, etc. Adapters, for interfacing AC and DC sources to the Dual Harvester Shield, are also provided.
- The Kinetic Button Shield is engineered to demonstrate a specific application, using an inductive switch, aka kinetic switch, to temporary power the Wireless SoC and transmit a sequence of packages, for typical interacting with a light bulb or coordinator
- A supplementary Battery Shield is provided for e.g. debugging stand-alone operation scenarios or evaluating battery lifetime

When connected to the Explorer Kit, the shields supplies exclusively the Wireless SoC, while the debugger is left powered off, allowing stand-alone operation and true real-time current measurements.

Dual Harvester | Kinetic Button | Battery Power

FEATURES

- Energy Harvesting
- Self-powered operation
- Flexible PMIC
- Hardware and Software configurable registers
- AC and DC sources
- Automatic power selection (self-powered or debugger)
- Test Points for current and voltage measurements
- Single or Dual source

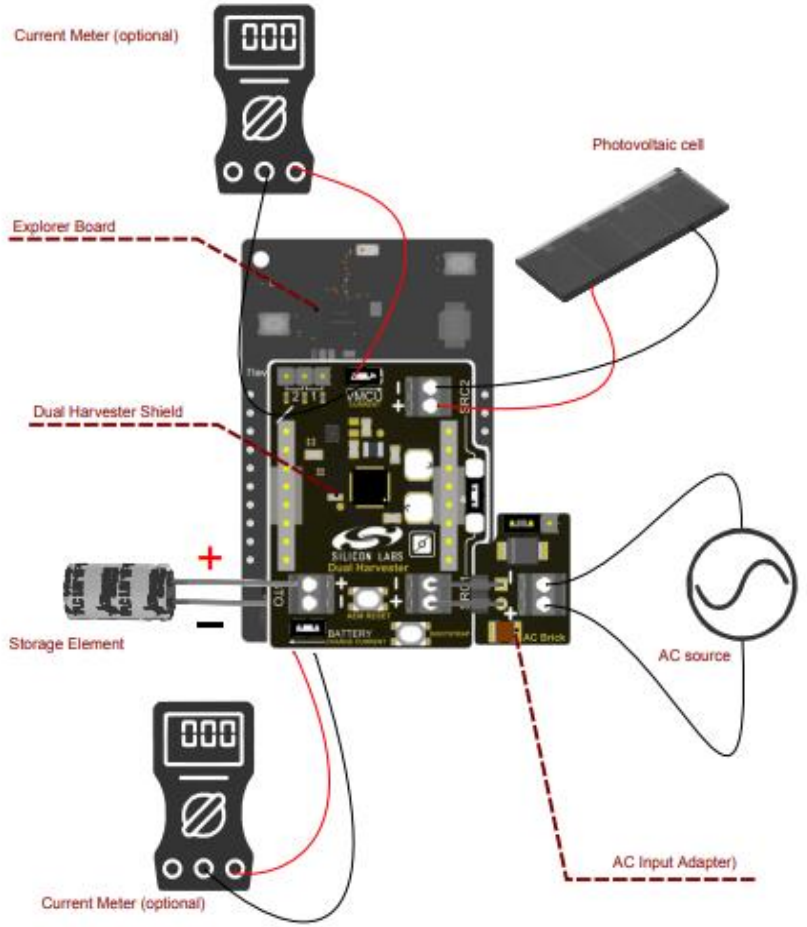
INCLUDED BOARD MODULES IN THIS KIT:

- BRD8201A Dual Harvester Shield
- BRD8202A Kinetic Button Shield, equipped with the BRD8206A Kinetic Switch Adapter
- BRD8203A Battery Shield
- BRD8204A AC Input Adapter
- BRD8205ADC Input Adapter
- BRD2710A Explorer Board
- 1x photovoltaic cell
- 1x lithium capacitor

ORDER INFORMATION:

- xG22-EK8200A

docs.silabs.com/energy_harvesting



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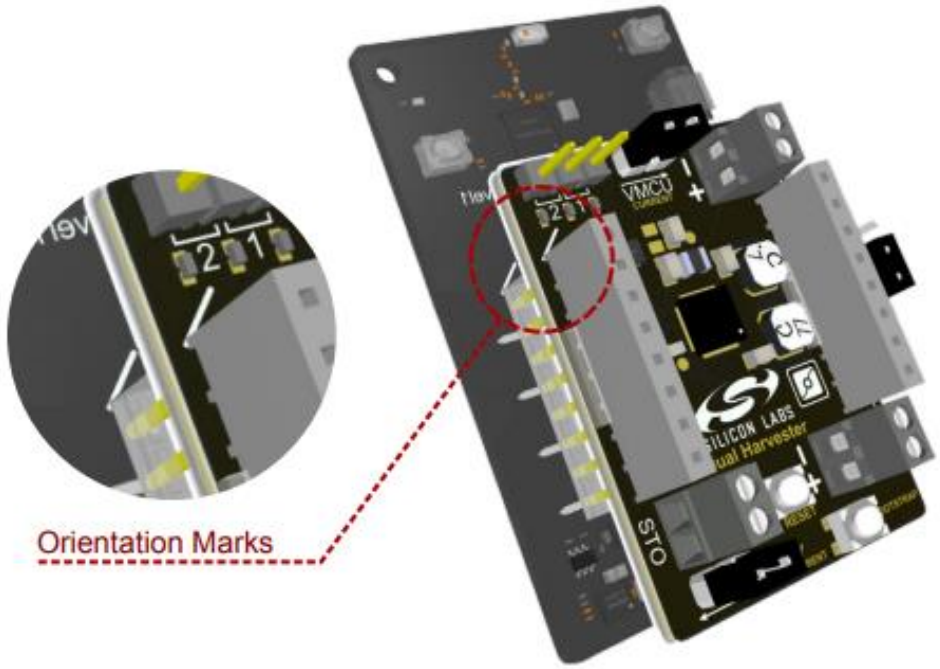
MG22E Explorer Shields - Out-of-the-Box Setup

- **BLE RAIL PV Beacon DEMO (default)**
  - Mobile App – *Simplicity Connect*
  - External Reader – *MG21, MG22, MG24, etc.*

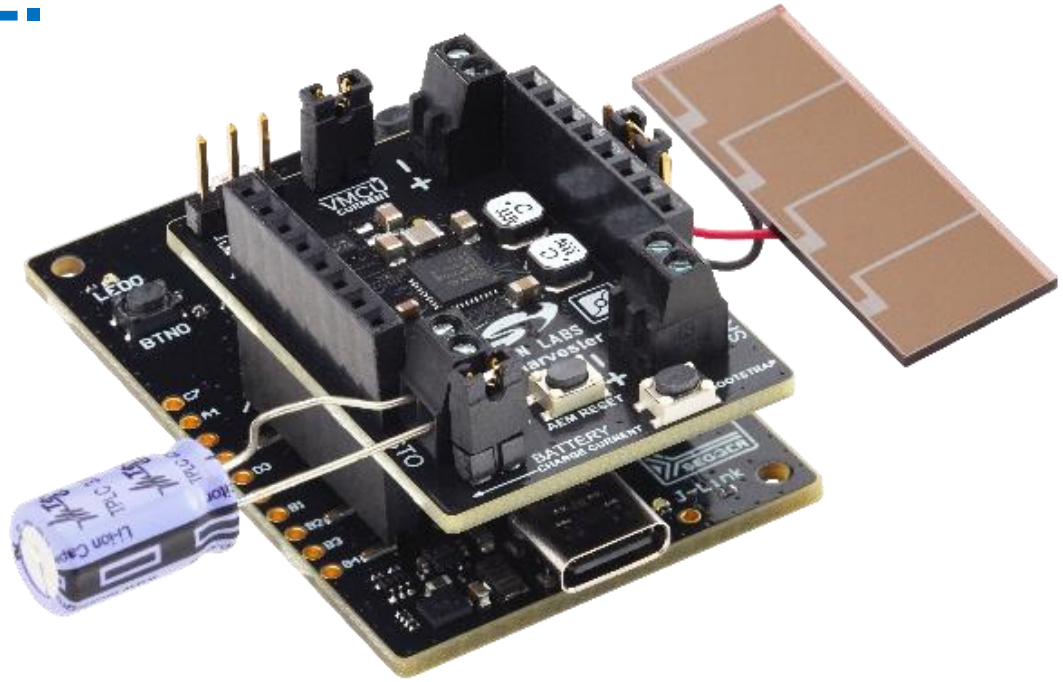
HARDWARE– EK8200A – Energy Harvesting Shields for Explorer Kit

1.



- Install BRD8201 (Dual Harvest) onto BRD2710 Explorer

2.



- First step : Screw in Lithium Capacitor
- Second step : Screw in PV cell to SRC2
- *Always dismantle PV first

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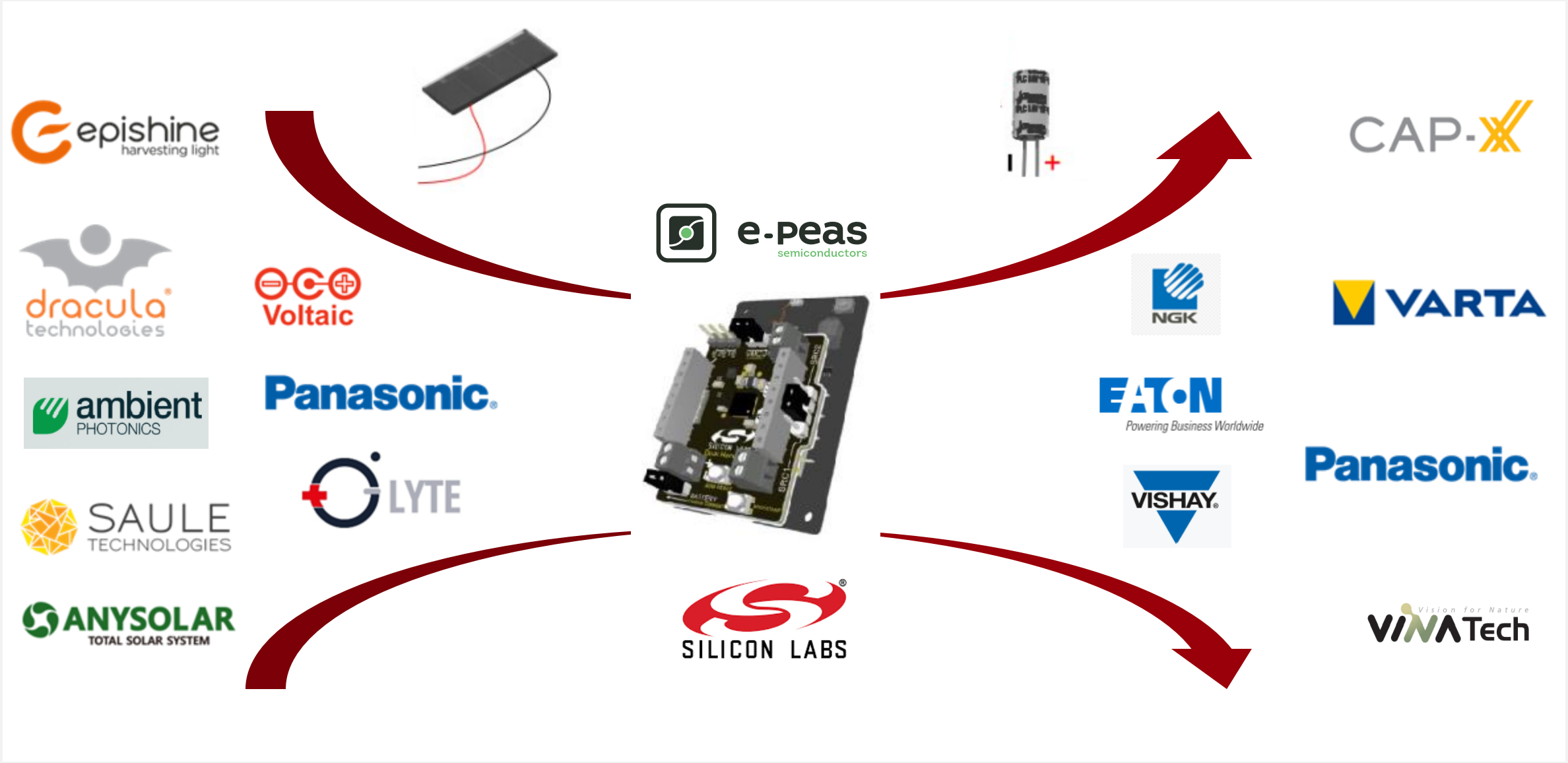
Alternative hardware compatibility – PVs and Storage (Digikey/Mouser)



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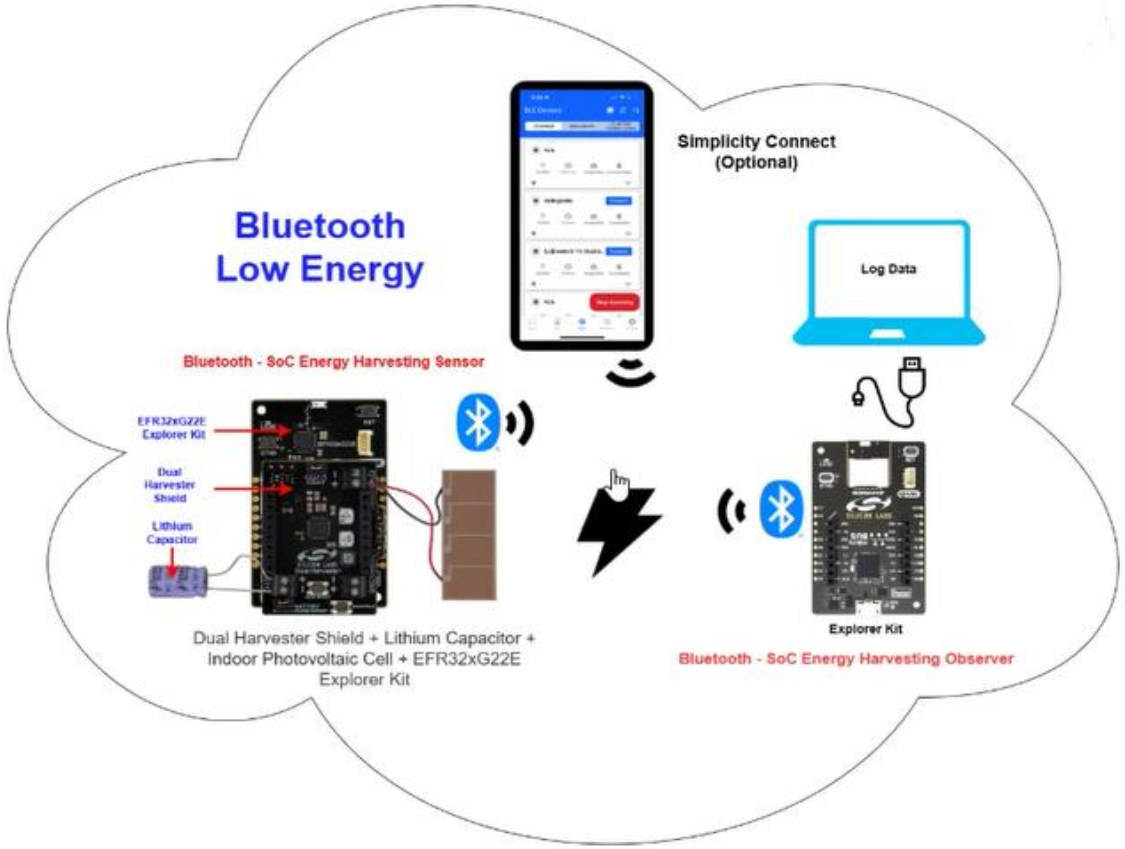
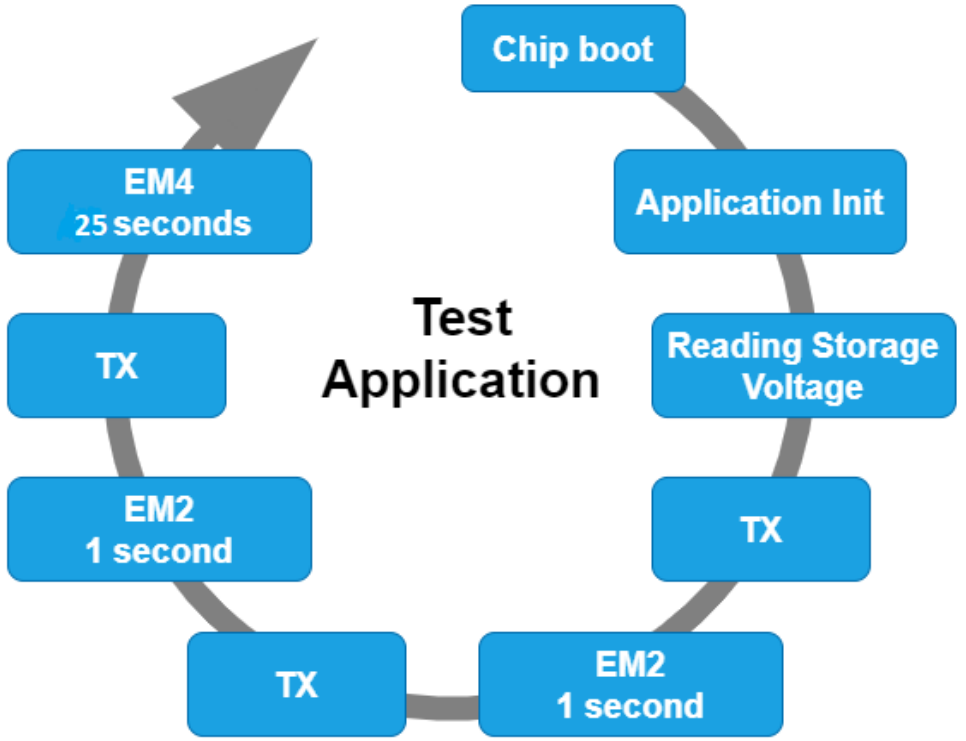
SOFTWARE – EK8200A – Bluetooth RAIL Sensor



- **Bluetooth packets (RAIL) can be detected:**
  - using Simplicity Connect mobile app
  - using alternative Silicon Labs SoC (example provided)



- **Default application execution – preprogrammed on MG22E Explorer (BRD2710A)**

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SOFTWARE – Mobile App – Bluetooth RAIL Sensor

SIMPLICITY CONNECT INSTALLATION

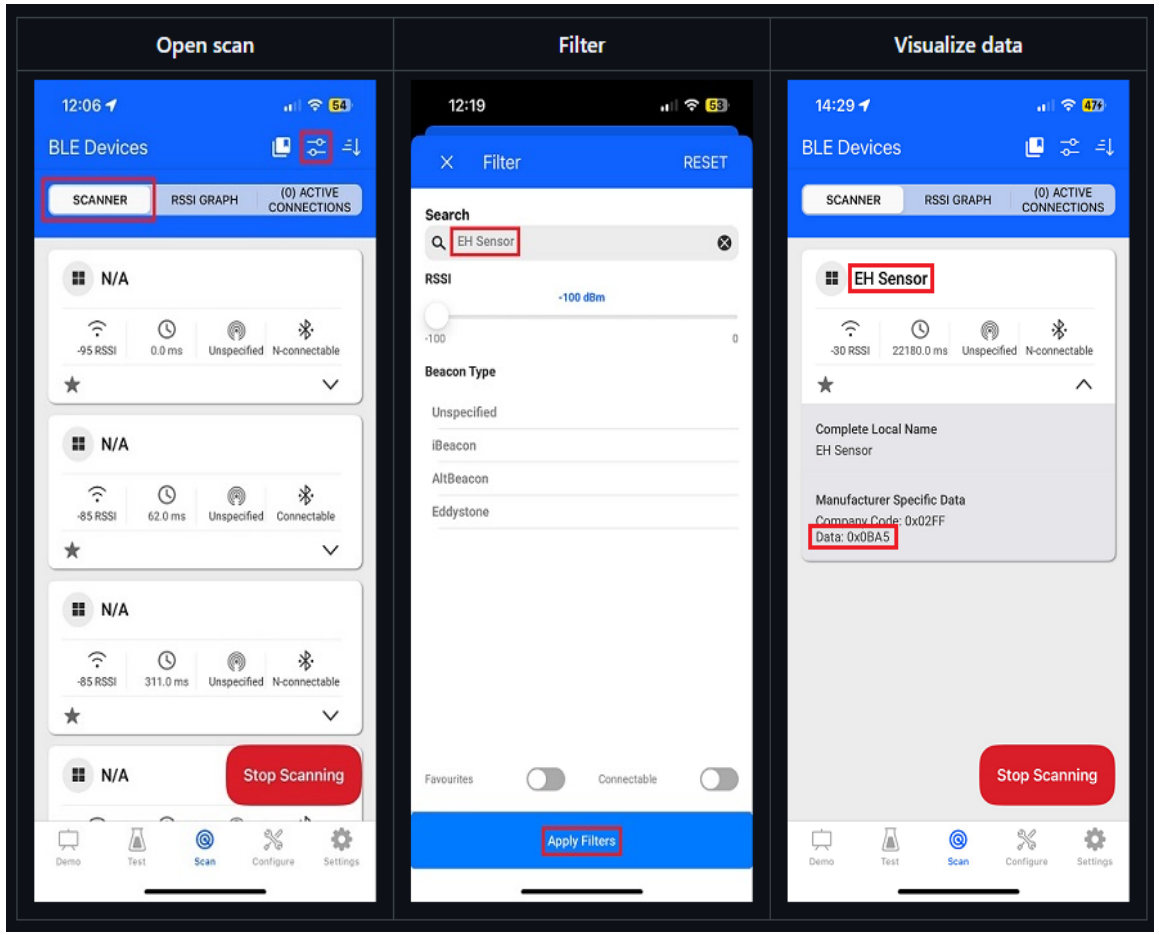
- apps.apple.com/us/app/simplicity-connect
- play.google.com/store/apps/siliconlabs
- Public GitHub repos for Simplicity Connect:
- github.com/SiliconLabs/SimplicityConnect-ios
- github.com/SiliconLabs/SimplicityConnect-android

SIMPLICITY CONNECT RESOURCES

- silabs.com/developer-tools/simplicity-connect-mobile-app
- docs.silabs.com/bluetooth/latest/bluetooth-mobile-applications/efr-connect-mobile-app

Convert '**Data: 0xBA5**' to Decimal to read voltage!
0xBA5 = **2981 mV**

MOBILE INTERFACE



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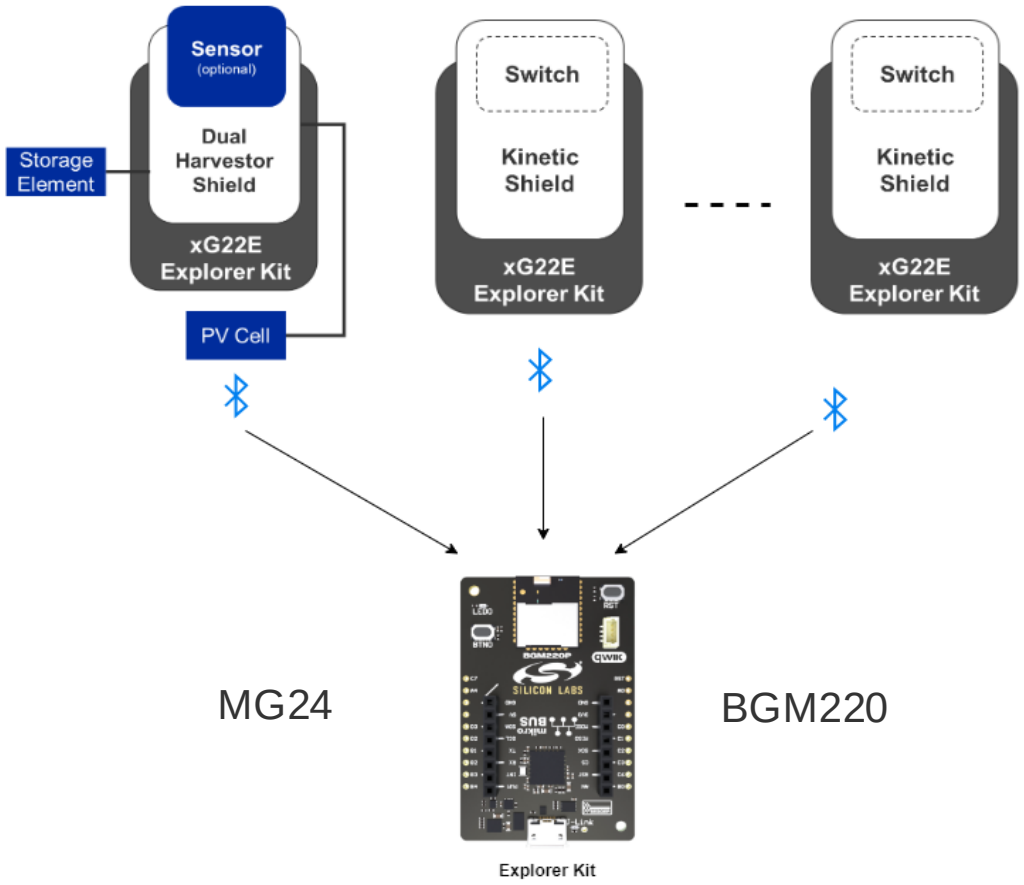
SOFTWARE – MG24/BGM220 Explorer – Bluetooth RAIL Observer

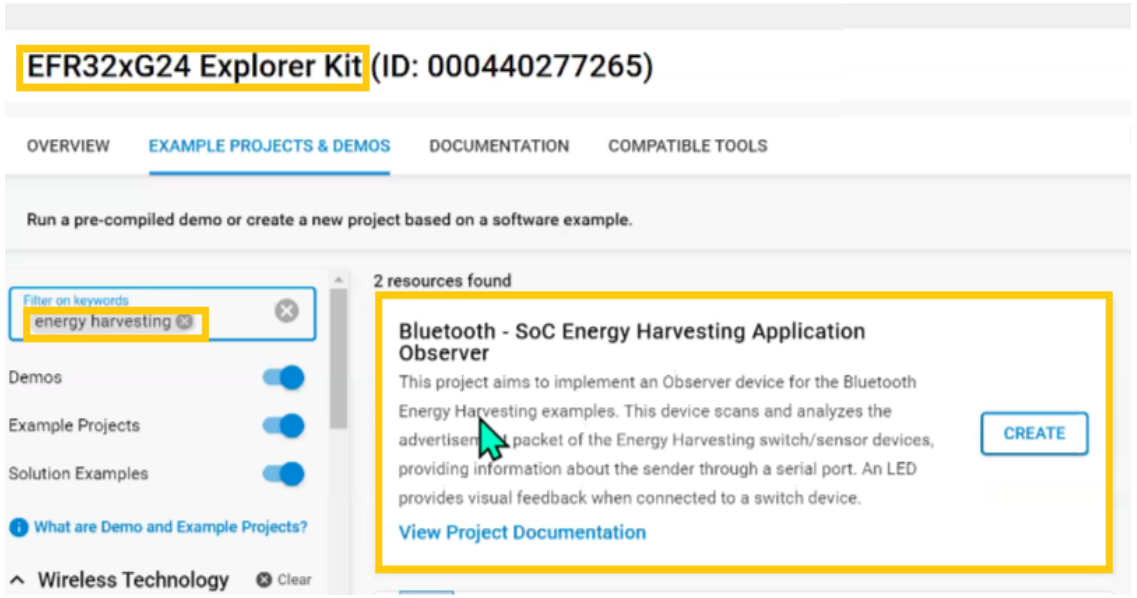


- 'Observer' App used on external Silicon Labs Kit can be used to detect Bluetooth LE and BLE RAIL packets (MG24 or BGM220 Explorer) (not incl.)
- 'Observer' App used for both Sensor and Switch BLE/RAIL application

```
>>> [601084] Found an EH Sensor device: 0C:2A:6F:76:F7:8D, channel: 37, rssi: -59, read storage voltage: 3825 mV
--------------------------------
                                                    From Sensor
>>> [805413] Found an EH Sensor device: 0C:2A:6F:76:F7:8D, channel: 37, rssi: -48, read storage voltage: 3825 mV
--------------------------------

>>> [932576] Found an EH Sensor device: 0C:2A:6F:76:F7:8D, channel: 37, rssi: -75, read storage voltage: 3825 mV
--------------------------------
```

- Device ID, Channel, RSSI and Storage Voltage in Command Prompt – Simplicity Studio



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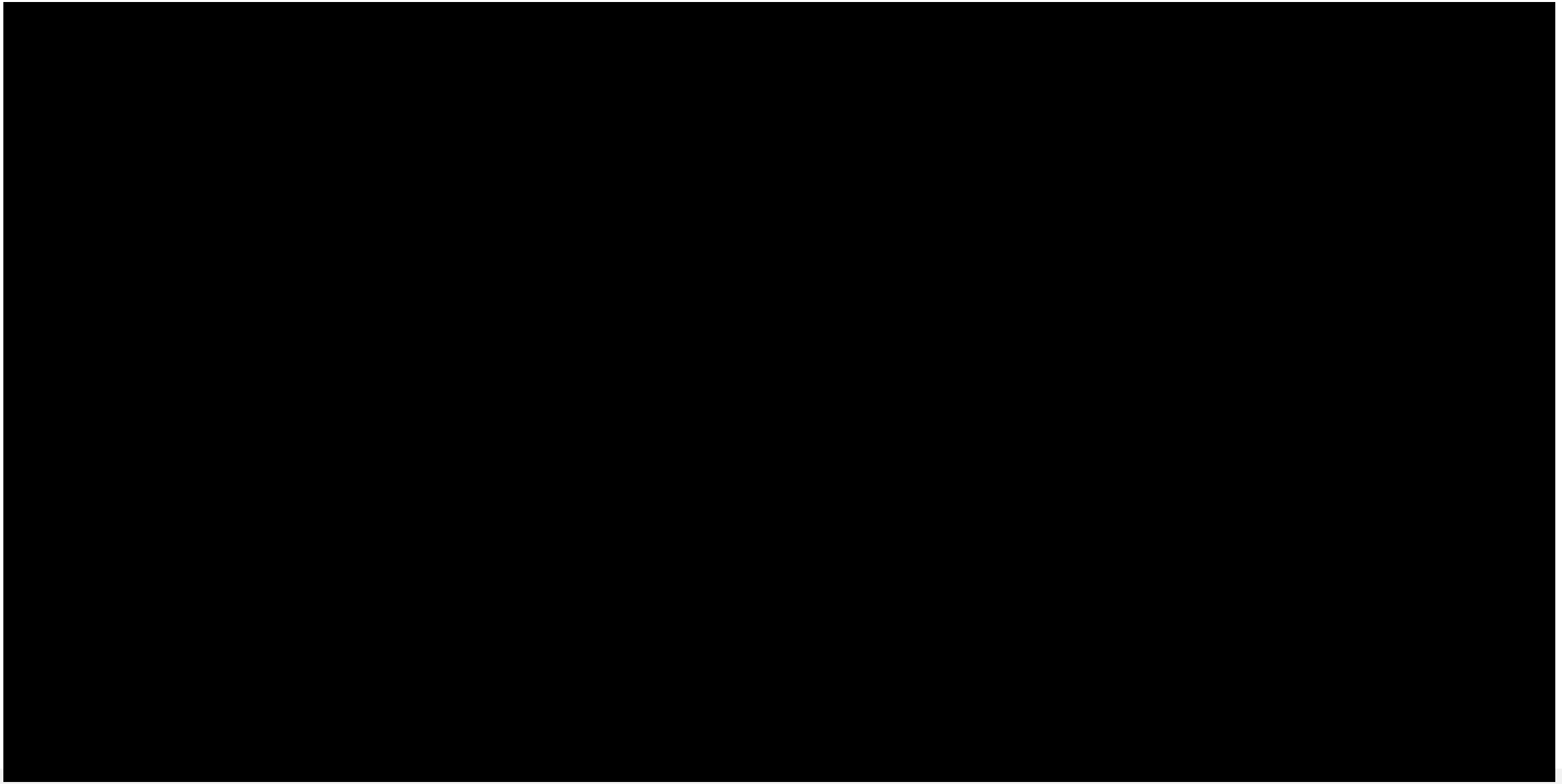
SOFTWARE – EK8200A – Bluetooth RAIL Sensor



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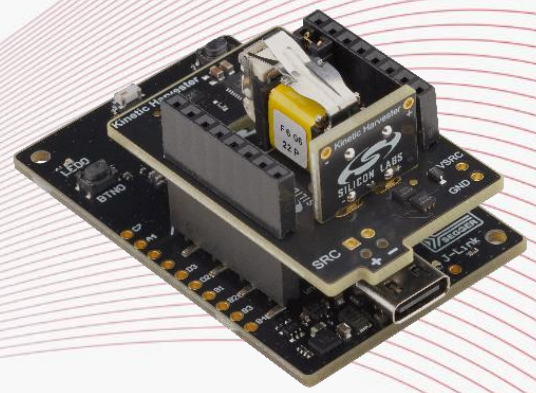
EK8200A – Energy Harvesting Shields
Example Setup DEMO



- Energy Harvesting SDK Extension installation
- Zigbee Green Power Kinetic Switch & Observer
  - Compiling and Flashing
  - Commissioning DEMO
  - Light DEMO

Energy Harvesting SDK Extension

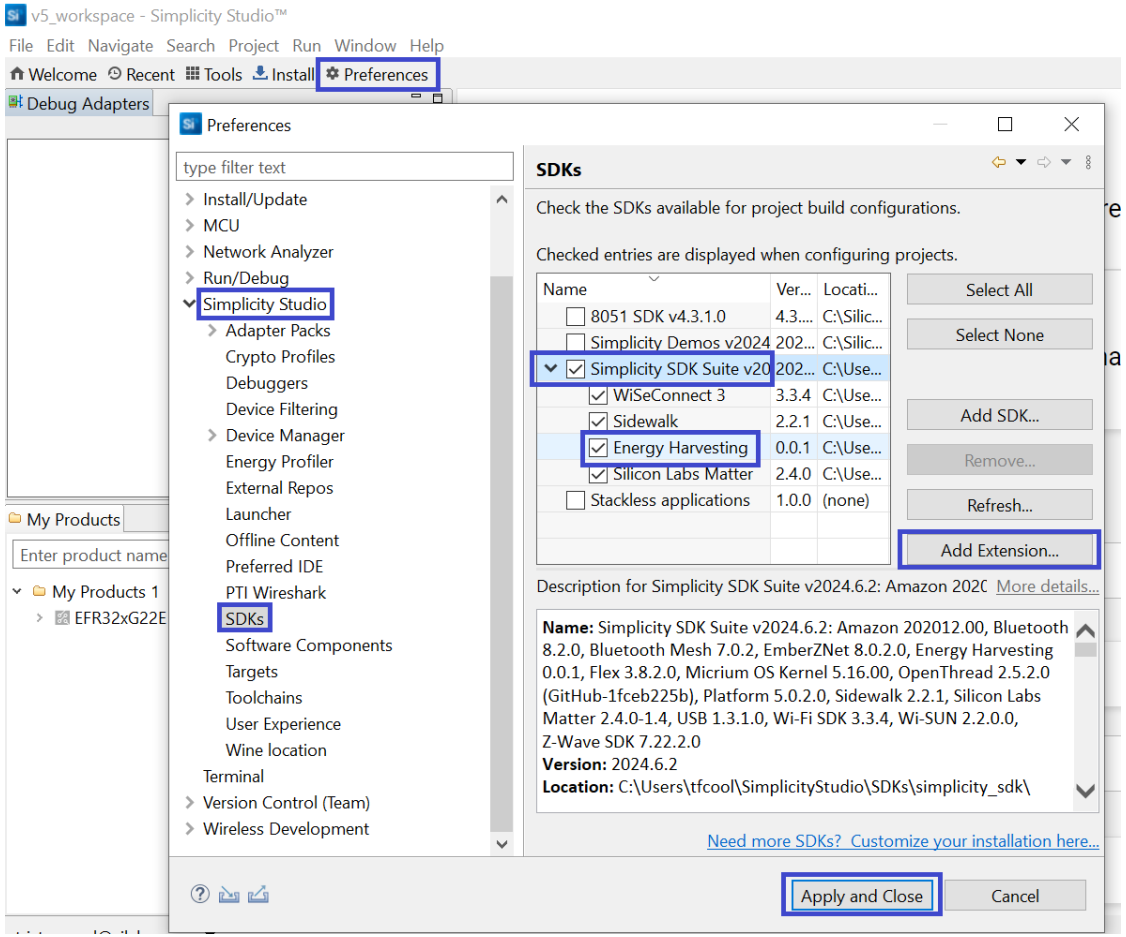
EXAMPLES AND SDK EXTENSTION

- Clone the repository to your PC:
- `git clone https://github.com/SiliconLabs/energy_harvesting_applications.git`

INSTALL SDK EXTENSION

- **Simplicity Studio Launcher -** Add the SDK extension to the SiSDK:
  - ***Preferences*** → ***Simplicity Studio*** → ***SDKs*** and select the Simplicity SDK Suite to add extension to
  - ***Browse*** → navigate to root folder where we cloned repos → ***Select Folder***
  - Click **OK** and then **Trust** and **Apply and Close**
  - Restart Simplicity Studio

ENERGY HARVEST SDK EXTENSION



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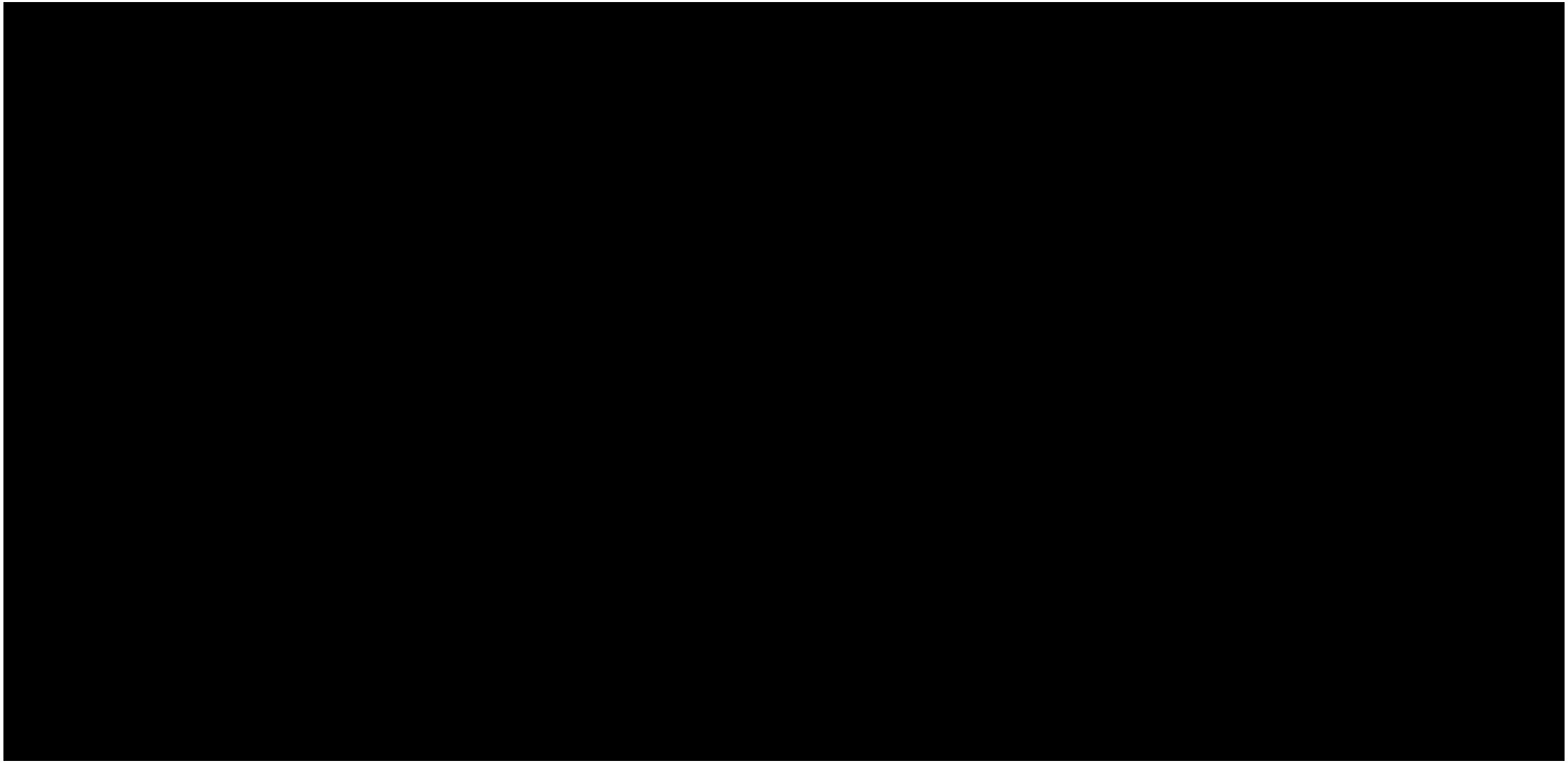
Energy Harvesting SDK Extension installation



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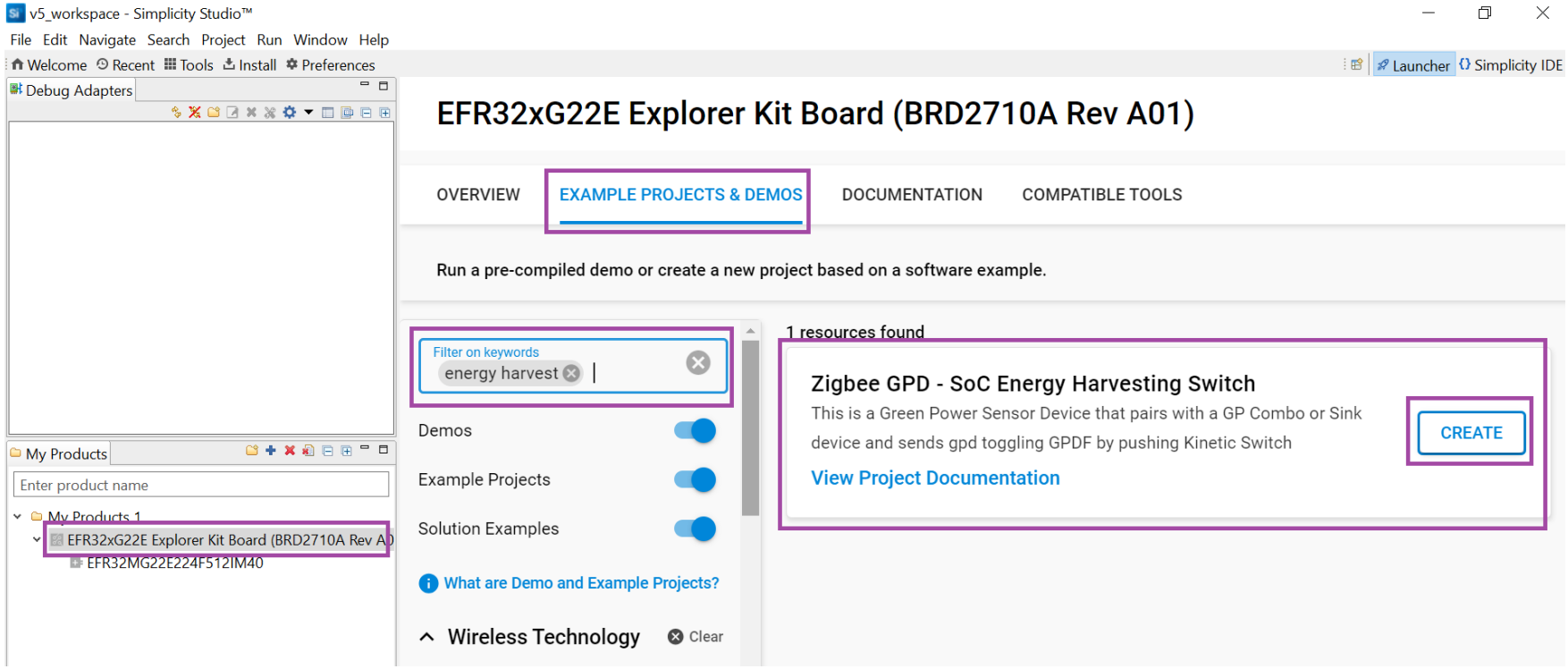
Zigbee GPD – SoC Energy Harvesting Switch



- Attach BRD8202 Kinetic Shield to MG22E Explorer BRD2710
- Connect to computer – open Simplicity Studio

- ***EXAMPLES PROJECTS & DEMOS*** → search for 'energy harvest'
- ***CREATE*** → Build Project → Flash Project

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Zigbee GPD – SoC Energy Harvesting Switch & Observer

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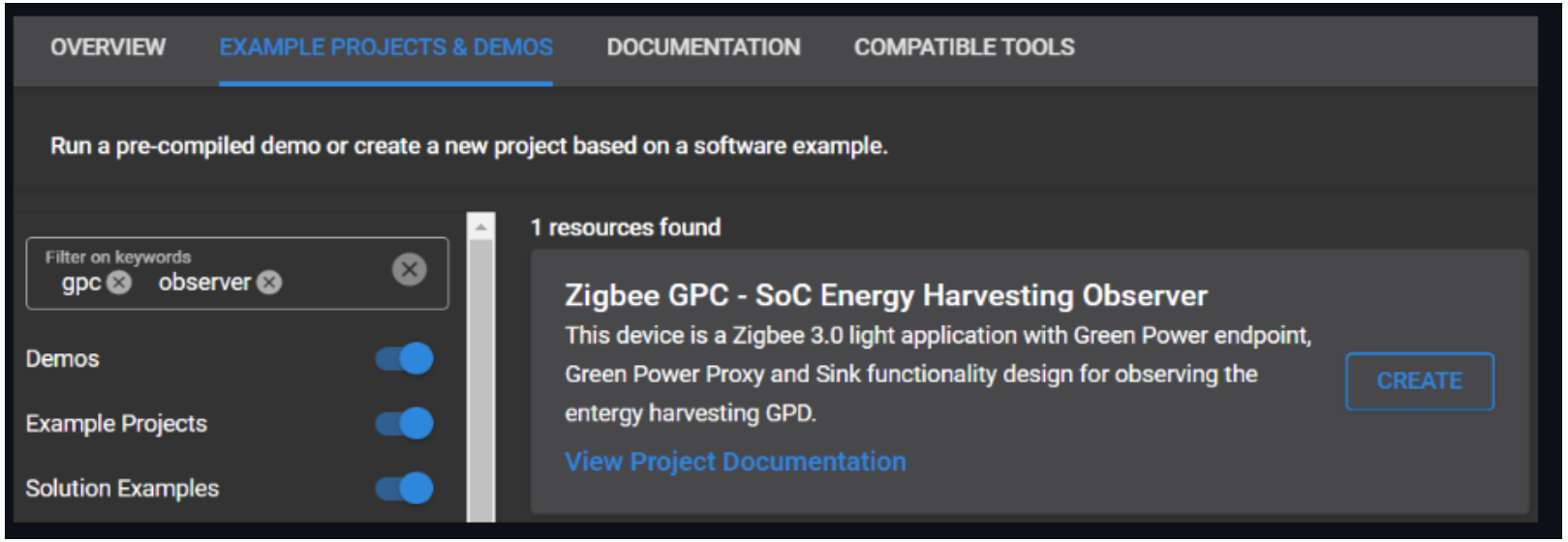
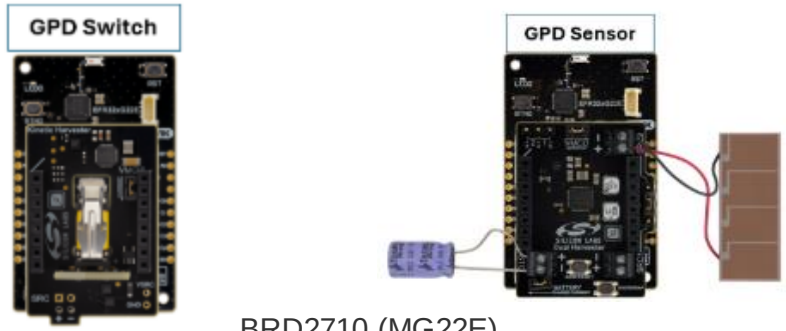
Zigbee Green Power SoC Energy Harvesting GPC Observer (MG24)

BRD2703 (MG24)





BRD2710 (MG22E)

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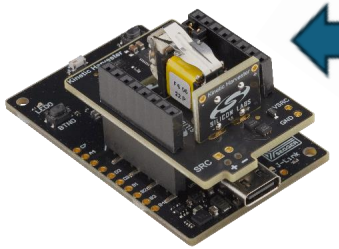
Zigbee Green Power - Energy Harvesting Switch – Commissioning & Light



Green Power

Explorer Kit

MG22E Explorer
BRD2710 + BRD8202

MG24 Explorer
BRD2703
(not incl.)

SWITCH
Zigbee Energy Harvesting

LIGHT
Z3LightGPCombo

Commission:

- MG24: Connect to computer - Open console log
- MG24: LED0 is *blinking* – Zigbee network not ready
- MG24: Press **BTN1** to bring up network
- MG24: LED0 *ON* – network made – ready
- MG24: Press **BTN0** to commission mode

- MG22E: Hold **BTN0** and Press Kinetic Button (6x+)
  MG24: Console messages confirm commission
- MG22E: Push Kinetic Button to toggle LED
- MG24: **LED1** toggle state

Decommission:

- MG22E: Hold **BTN0** while pressing Kinetic (~6x)
- MG24: Hold **BTN1** to leave network --> restart

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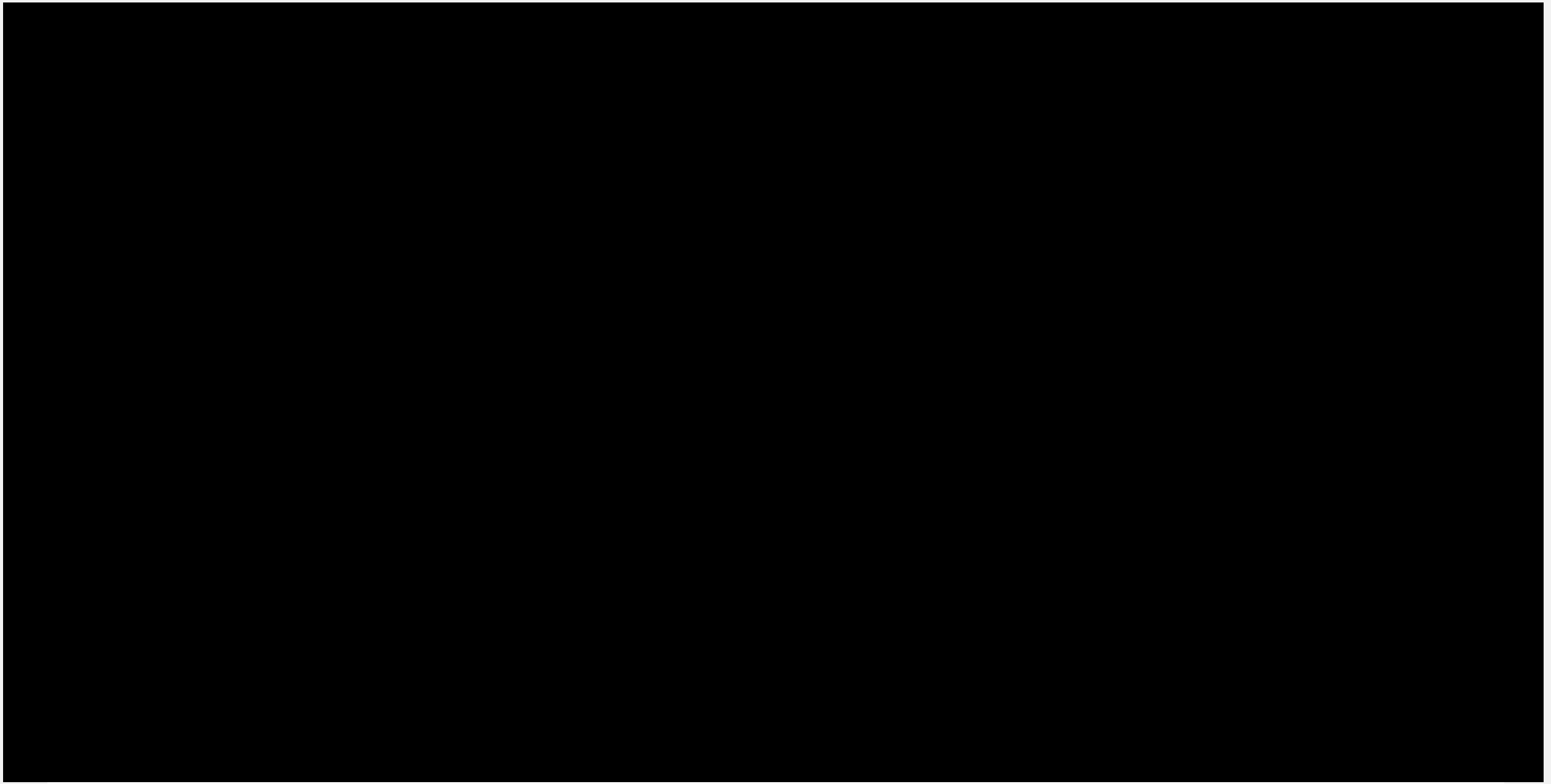

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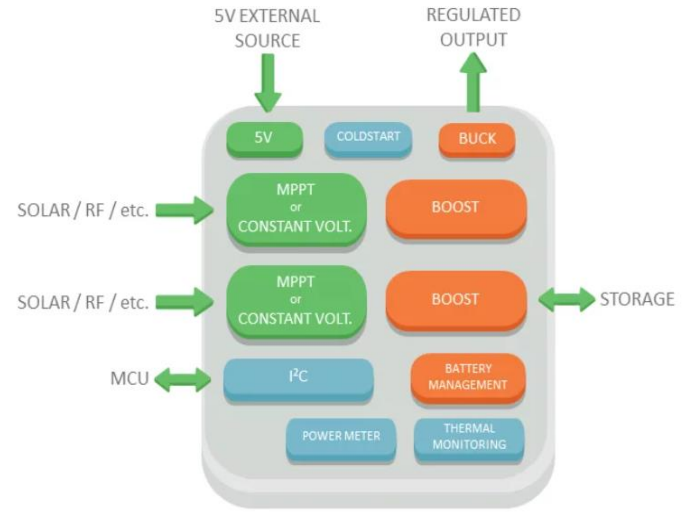
SILICON LABS

e-peas -
Key Design Consideration

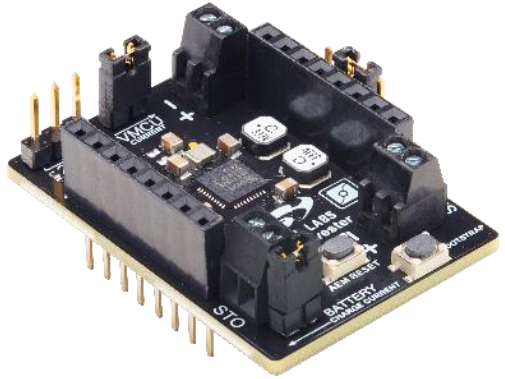
- Bruno DAMIEN
- Ecosystem and Partners Marketing Director

AEM13920 Shield Concept (BRD8201)

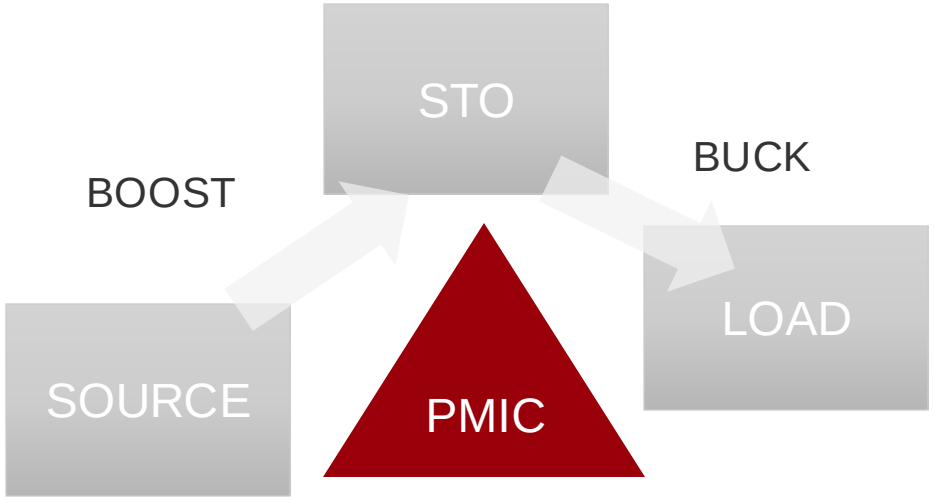
- 2 independent energy harvesting input sources
- 1 high capacity storage element (1 Joule to ...1000 Joules)
  - With protection
- 1 programmable regulated output to supply EFR32xG22E application
- Default configuration with GPIO
- I2C bus to EFR32xG22E to over-ride or fine tune settings
- Optional 5V input source
- Average Power Monitoring with registers



AEM13920 simplified Block diagram

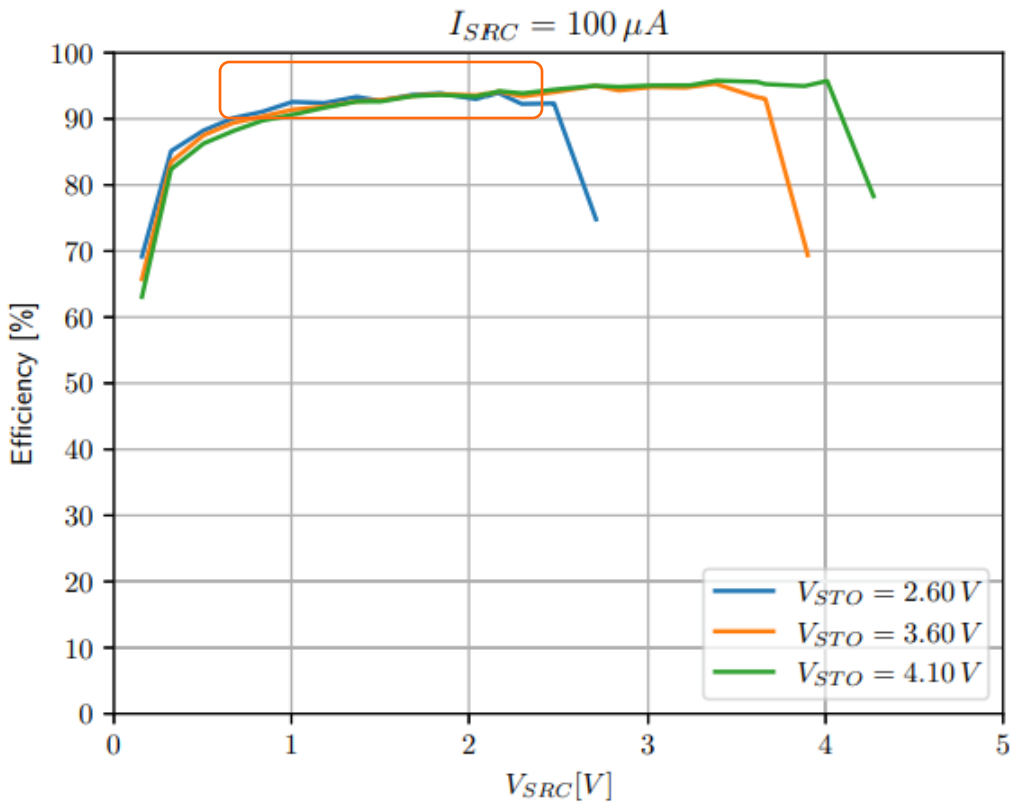


On-board extra features
Current sense jumper
PMIC test points
Full set of GPIO configuration pins

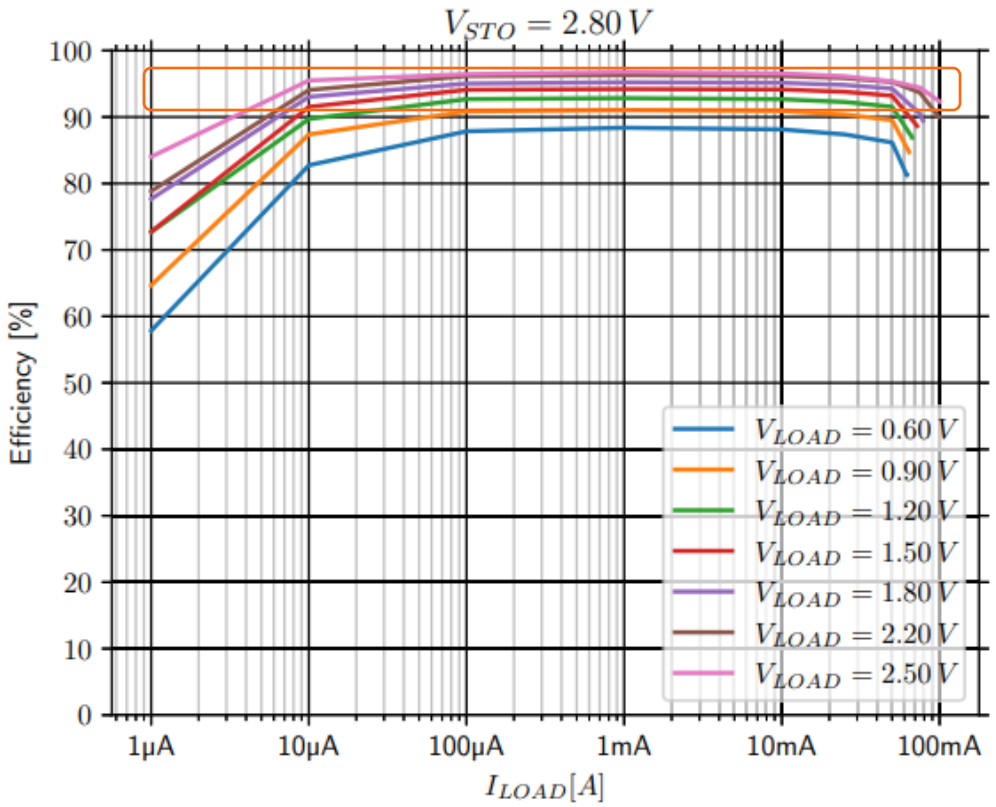


Highest efficiency Boost and Buck converters for best outcome

Energy conversion efficiency
higher than 90%
from source to Storage element



Energy conversion efficiency
higher than 90%
from Storage element to application



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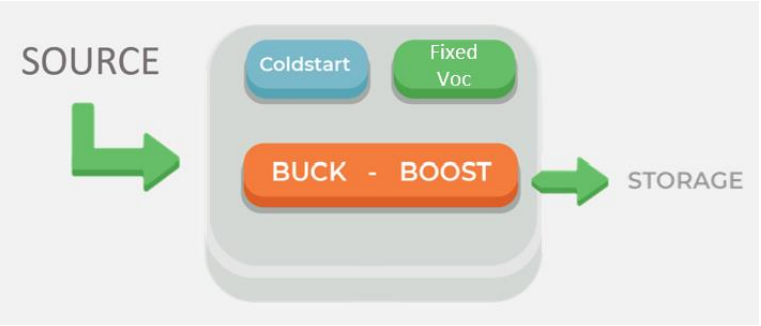
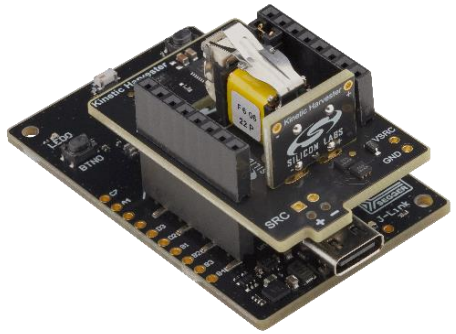
AEM00300 Shield Concept (BRD8202)

- **Pulse energy Harvester input**
- **Miniature SMD Storage Capacitor with few 10µF for ~1mJ energy**
- **Output voltage control via over voltage configuration**
- **Unique configuration to exhaust energy from source down to last 10µJoules**
- **Optimized for Kinetic harvester**
  - **Compliant with various harvester types**



AEM00300 Simple Block diagram



linptech

ZF

e-peas semiconductors

Kinetic harvesters

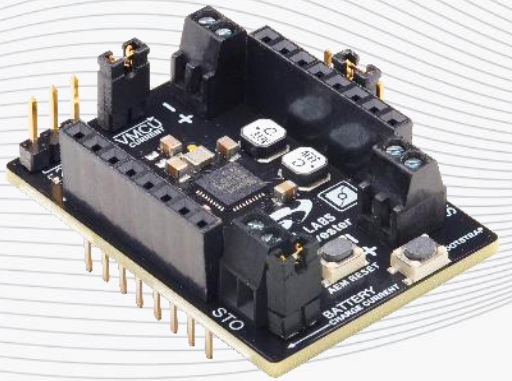
Please contact e-peas for support of your pulse harvester source

e-peas -
Taking Measurements

- **AEM13920 + PV shield** (BRD8201)
- **AEM00300 + Kinetic Shield** (BRD8202)

AEM13920 Shield with Dual PV

- BRD8201



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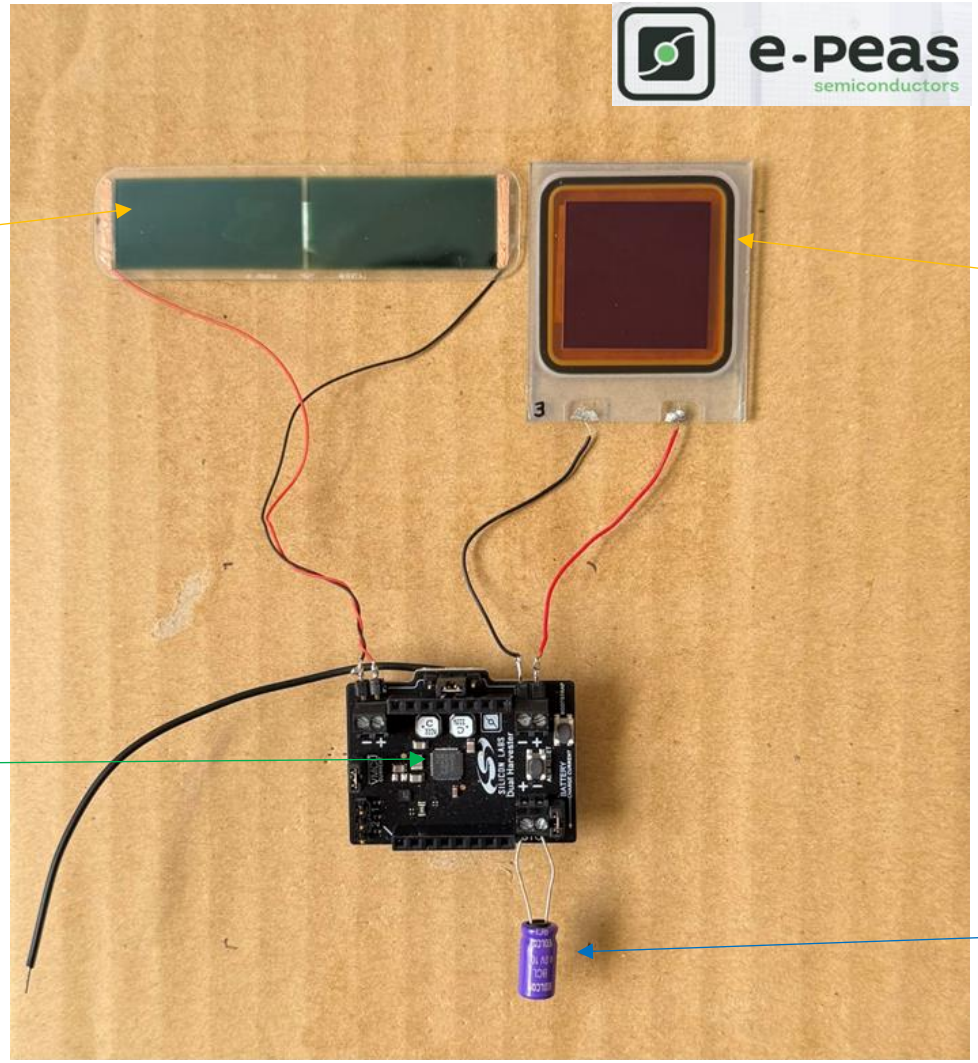
Dual PV harvesting set-up example : BRD8201 AEM13920

Organic
Multi element PV
1V with Vmpp=75%



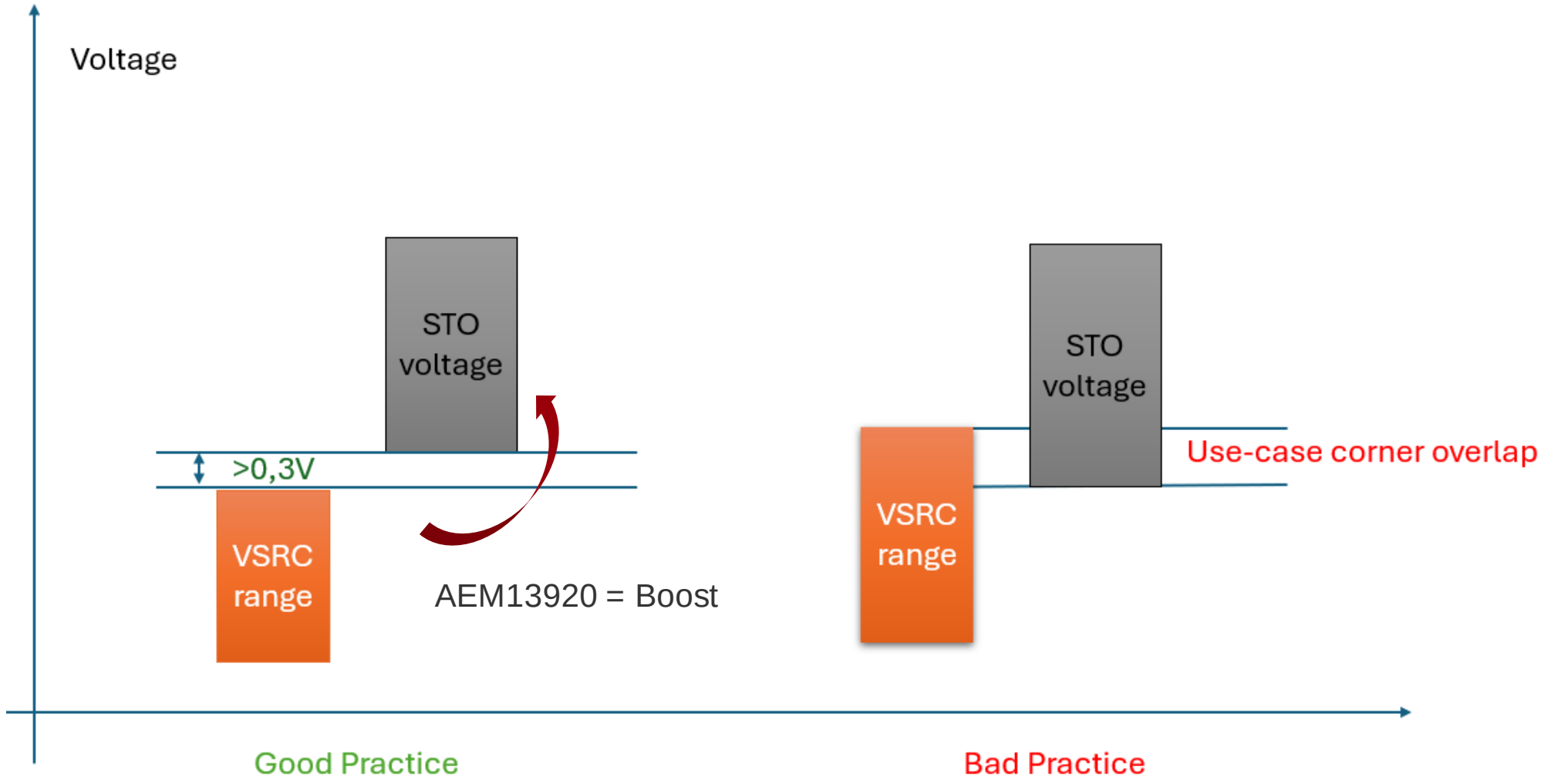
DSSC PV
Single element
0,75V
Constant V behavior

AEM13920 EH Power Management IC

Ground Probe

10F Lithium Capacitor
2.5-3.8V protection

Good practice to select Source and Storage combinations



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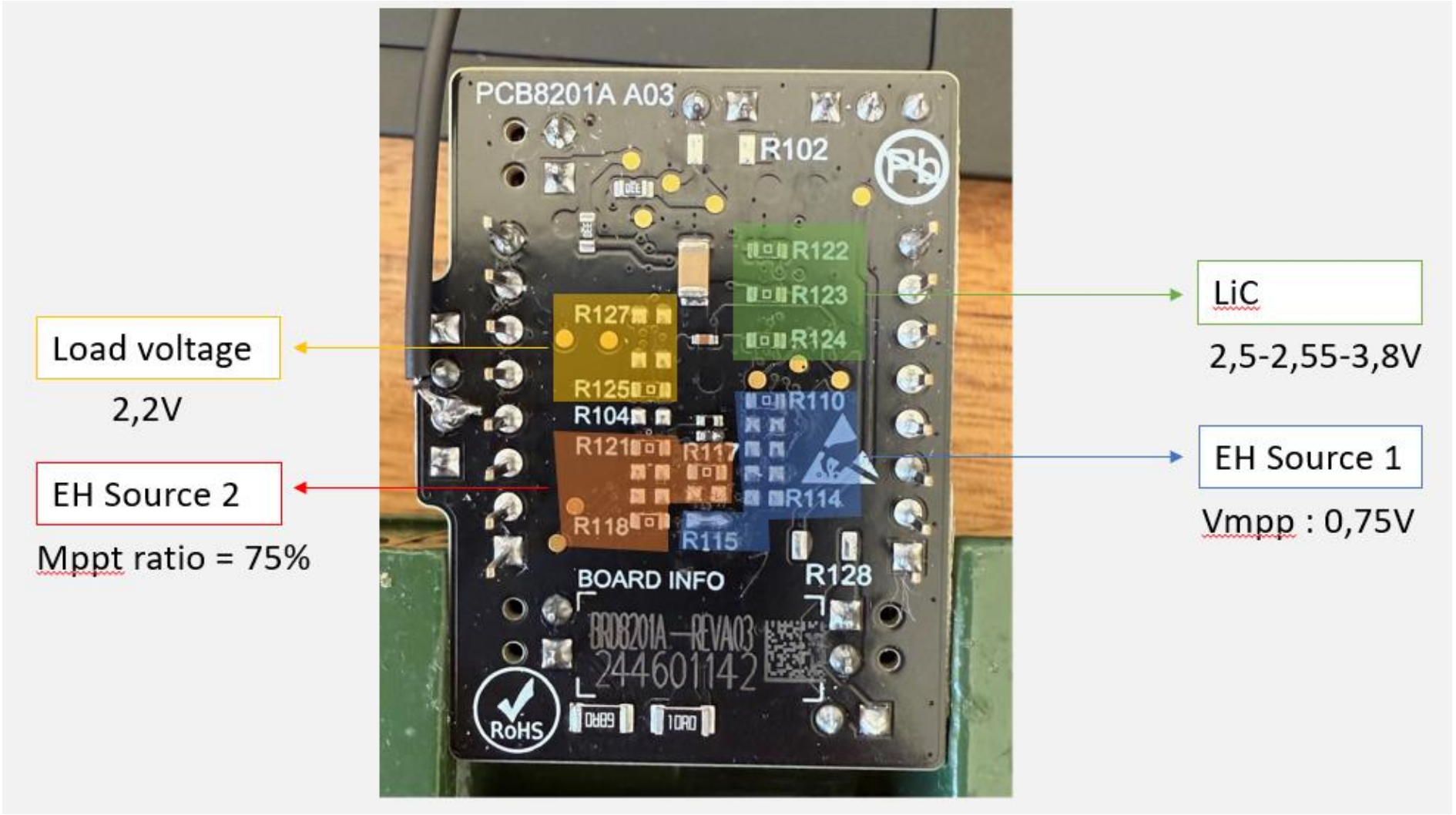
BRD8201 Shield Hardware setting : convert settings with GPIO



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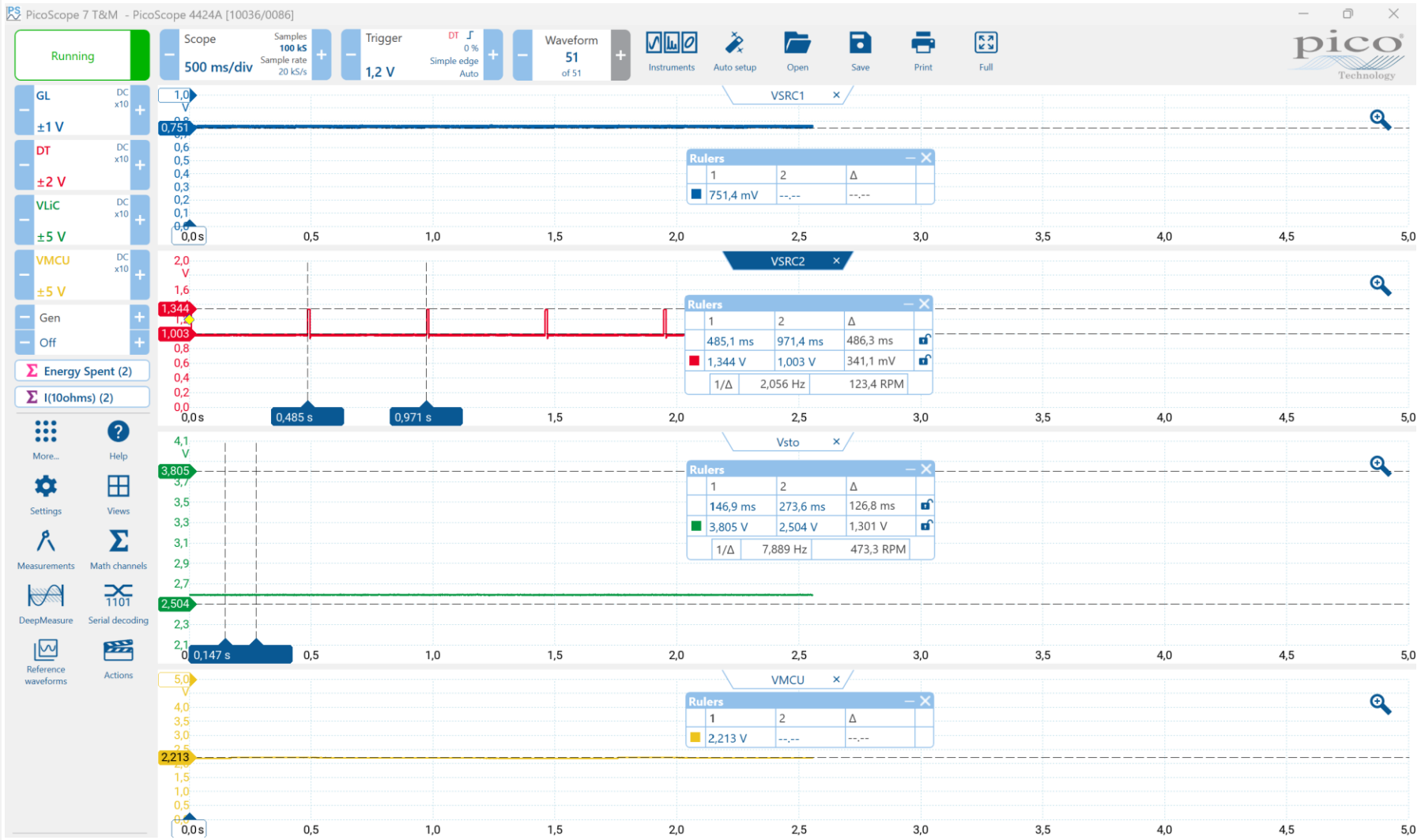
Whatever happens on STO and Source, EFR32xB22E remains powered safely



Source 1 : constant voltage extraction

Source 2 : Mpp ratio extraction ½ period 75% ratio

VLiC 2,6V => charging

VMCU =2,2V

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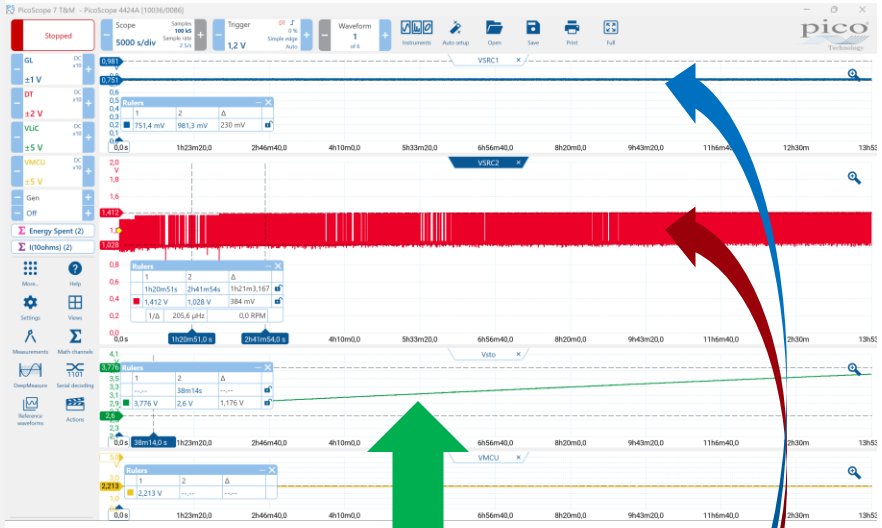
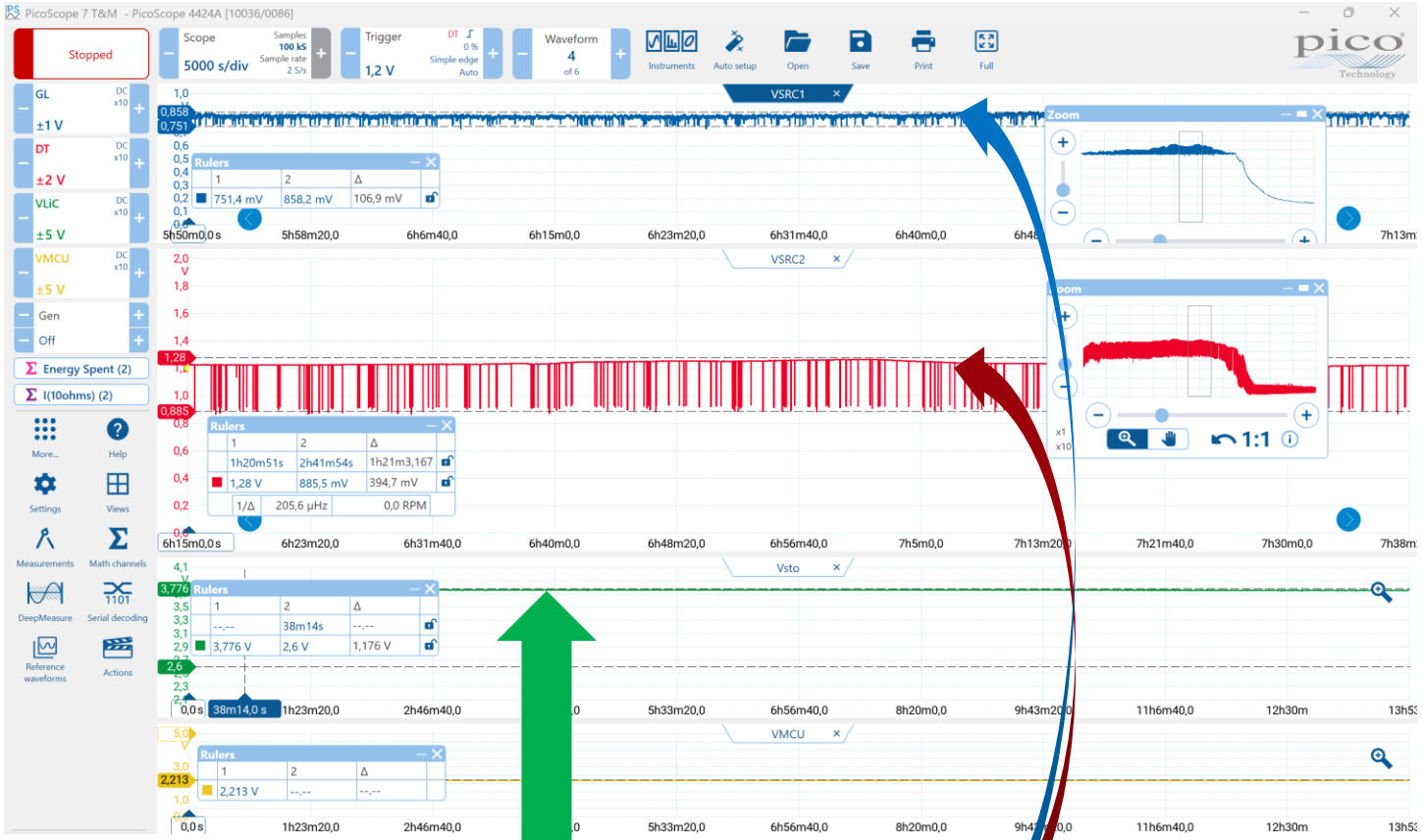
What happens when LiC is fully charged ?



STO is not fully charged
=> PV regulation is active



STO is fully charged
=> PV regulation is off => Vpv tends to run in open circuit

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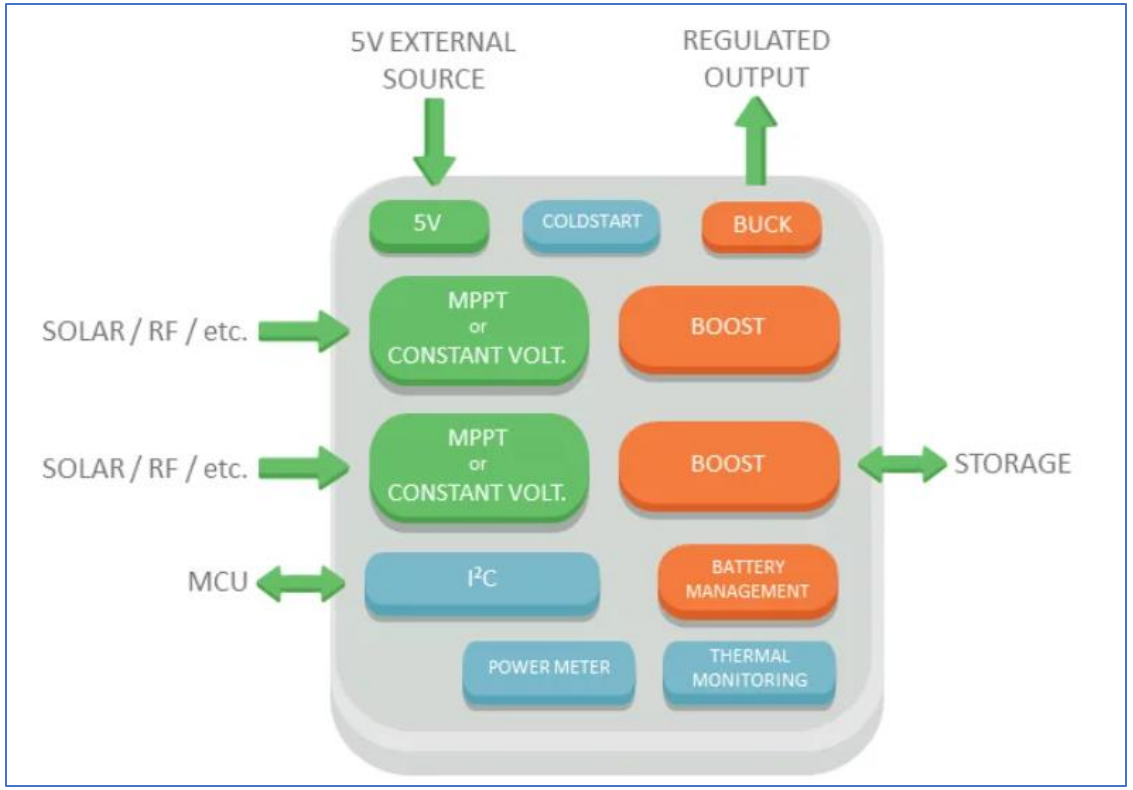
Other configurations

- **AEM13920 I2C bus interaction with EFR32xG22E**
- **Allows full (re)configuration of PMIC register map (38 registers)**
- **Allows readout of alarm registers / APM / Voltages**

8. Register Map

Please note that the AEM13920 device address is 0x41.

Address	Name	Bit	Field Name	Access	Reset	Description
0x00	VERSION	[3:0]	MINOR	R	-	Minor version number.
		[7:4]	MAJOR	R	-	Major version number.
0x01	SRC1REGU0	[0:0]	MODE	R/W	0x01	SRC1 regulation mode.
		[3:1]	CFG0	R/W	0x00	SRC1 regulation mechanism configuration.
0x02	SRC1REGU1	[2:0]	CFG1	R/W	0x00	
		[5:3]	CFG2	R/W	0x00	
0x03	SRC2REGU0	[0:0]	MODE	R/W	0x01	SRC2 regulation mode.
		[3:1]	CFG0	R/W	0x00	SRC2 regulation mechanism configuration.
0x04	SRC2REGU1	[2:0]	CFG1	R/W	0x00	
		[5:3]	CFG2	R/W	0x00	
0x05	VOVDIS	[5:0]	THRESH	R/W	0x06	Storage element overdischarge threshold.
0x06	VCHRDY	[5:0]	THRESH	R/W	0x05	Storage element ready threshold.
0x07	VOVCH	[6:0]	THRESH	R/W	0x3A	Storage element overcharge threshold.
0x08	BST1CFG	[0:0]	EN	R/W	0x01	Boost SRC1 enable.
		[1:1]	HPEN	R/W	0x01	Boost SRC1 high-power mode enable.
		[4:2]	TMULT	R/W	0x01	Boost SRC1 current configuration.
0x09	BST2CFG	[0:0]	EN	R/W	0x01	Boost SRC2 enable.
		[1:1]	HPEN	R/W	0x01	Boost SRC2 high-power mode enable.
		[4:2]	TMULT	R/W	0x01	Boost SRC2 current configuration.
0x0A	BUCKCFG	[2:0]	VOUT	R/W	0x00	Buck voltage configuration.
		[5:3]	TMULT	R/W	0x03	Buck current configuration.
0x0B	TEMPCOLDCH	[7:0]	THRESH	R/W	0xD1	Cold temperature threshold for storage element charging.
0x0C	TEMPHOTCH	[7:0]	THRESH	R/W	0x18	Hot temperature threshold for storage element charging.
0x0D	TEMPCOLDDIS	[7:0]	THRESH	R/W	0xD1	Cold temperature threshold for storage element discharging.
0x0E	TEMPHOTDIS	[7:0]	THRESH	R/W	0x18	Hot temperature threshold for storage element discharging.
0x0F	TMON	[0:0]	EN	R/W	0x01	Temperature monitoring enable.



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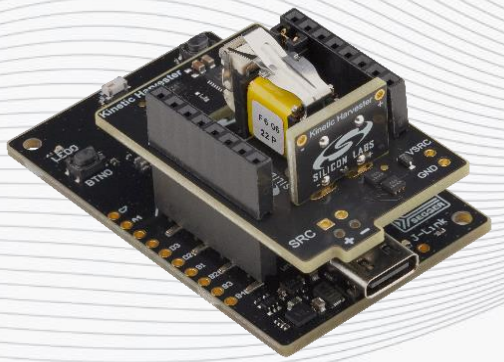
AEM00300 Kinetic Shield

- BRD8202



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Kinetic Harvesting with AEM00300 set-up

- We want to measure actual operating energy .
- We insert a 10 ohms series resistor in the MCU voltage path

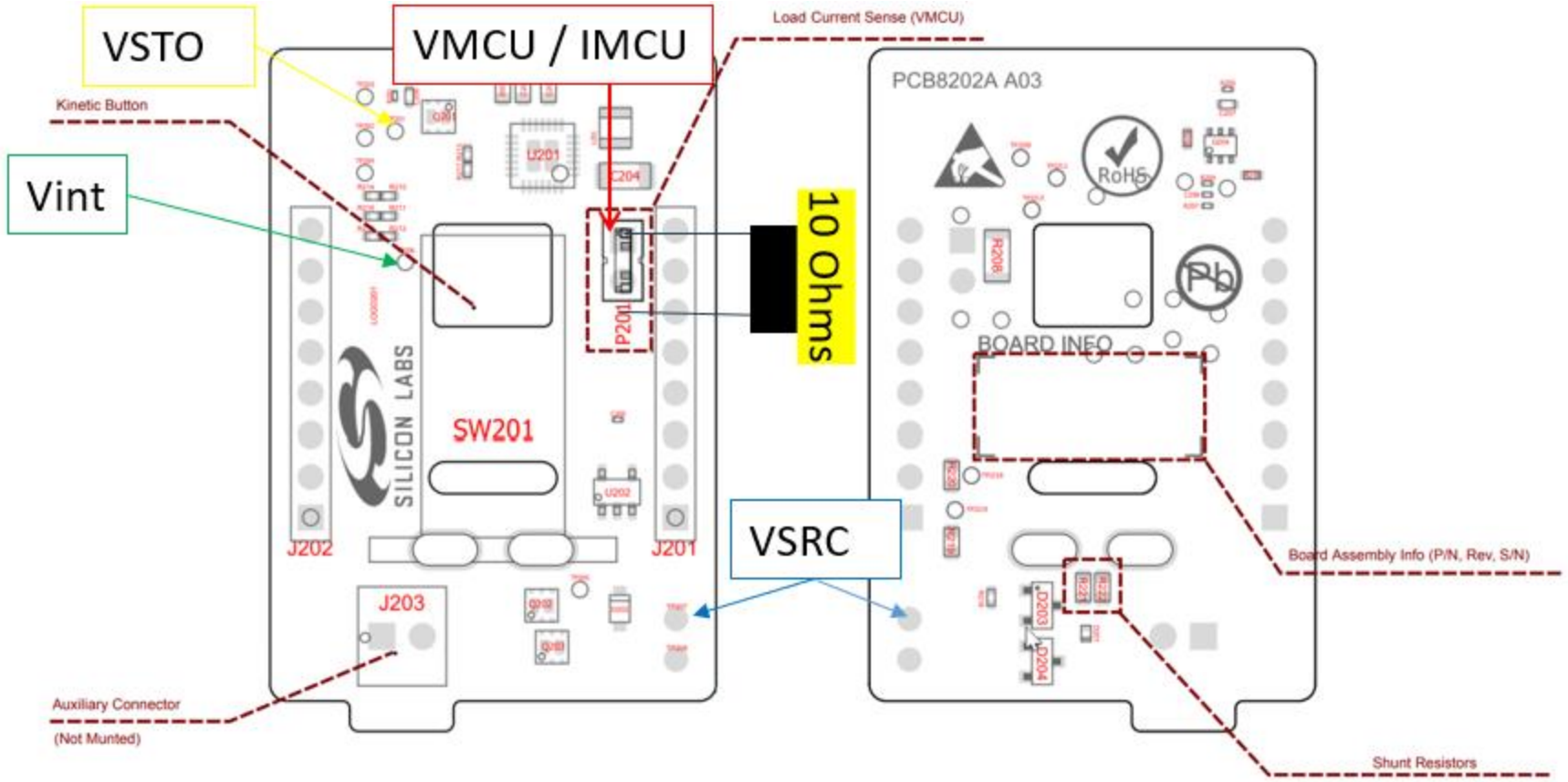

Figure 3.10. BRD8202A Kinetic Button Shield Assembly Drawings, Top Side to the Left and Bottom Side to the Right

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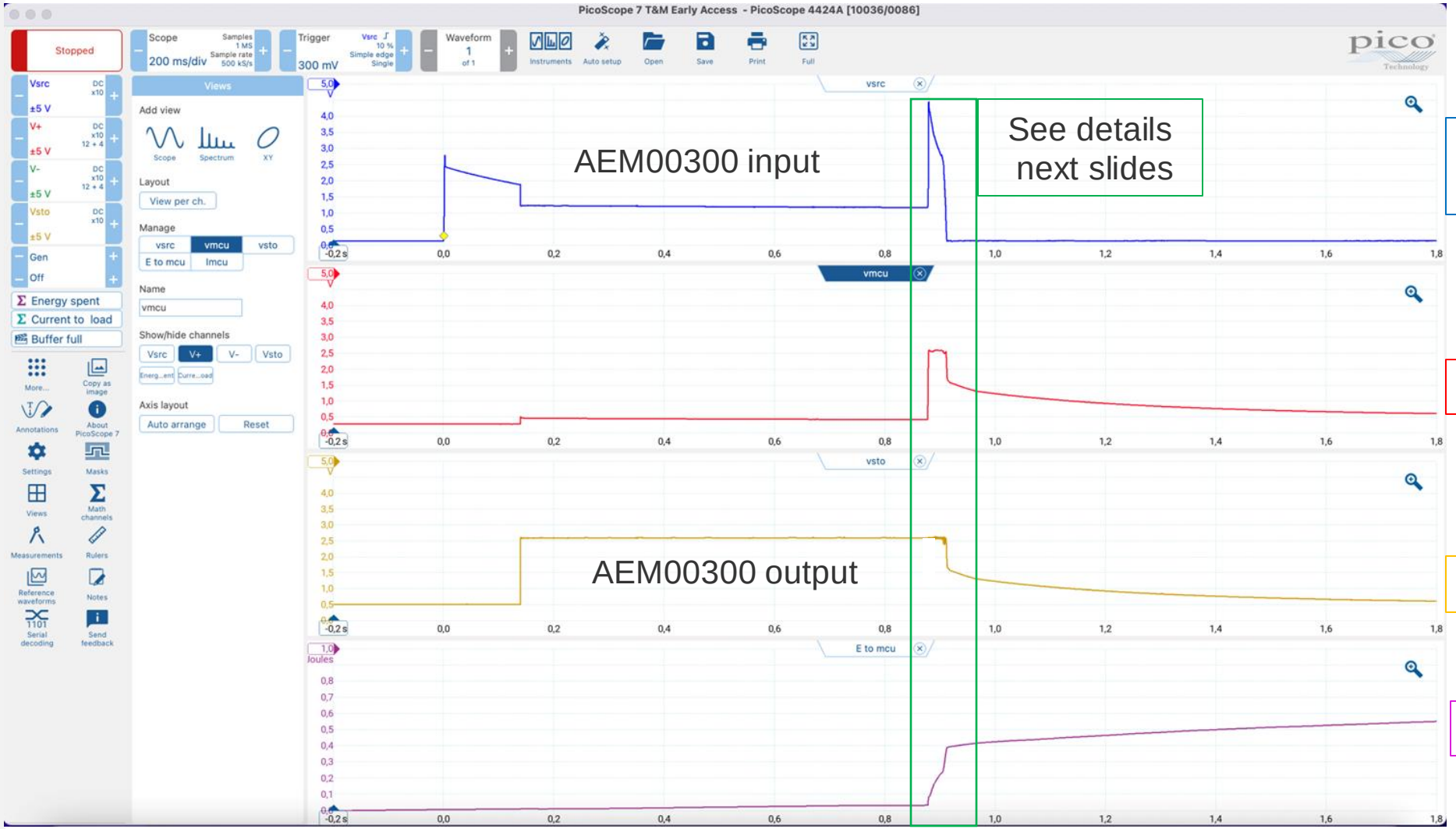
Behavior on push/release operations BLE use case



SRC : Harvester rectified voltage

MCU supply voltage

STO buffer voltage

Energy to EFR32

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Zooming on BLE TX part : Ultra-fast boot-time

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What about energy ? (BLE use case)

Full Source energy depletion

MCU supply maximization

350µJ spent during activity

13 beacons sent

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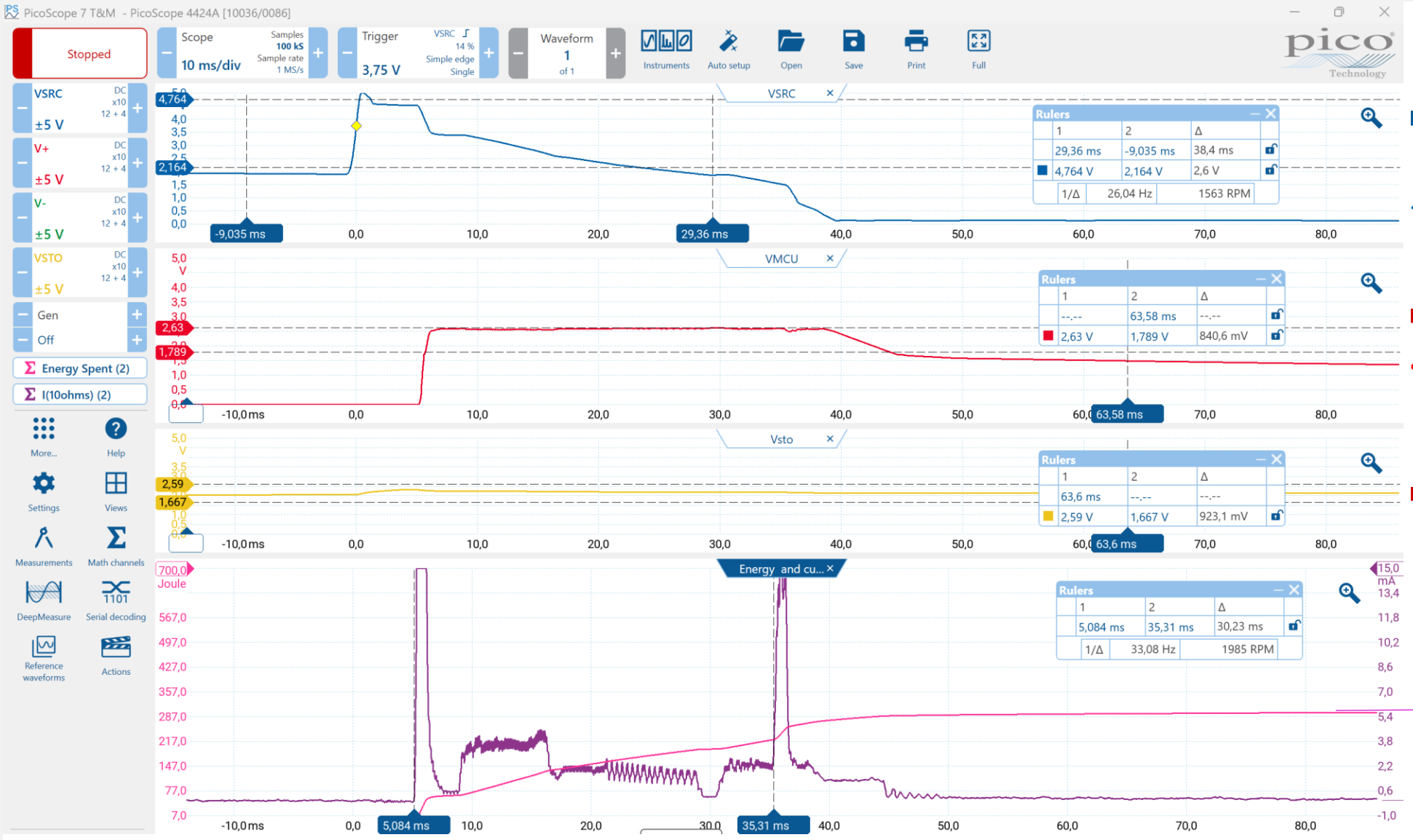
Zigbee use case (Green Power switch)



Full Source energy depletion

MCU supply maximization

300µJ spent during activity

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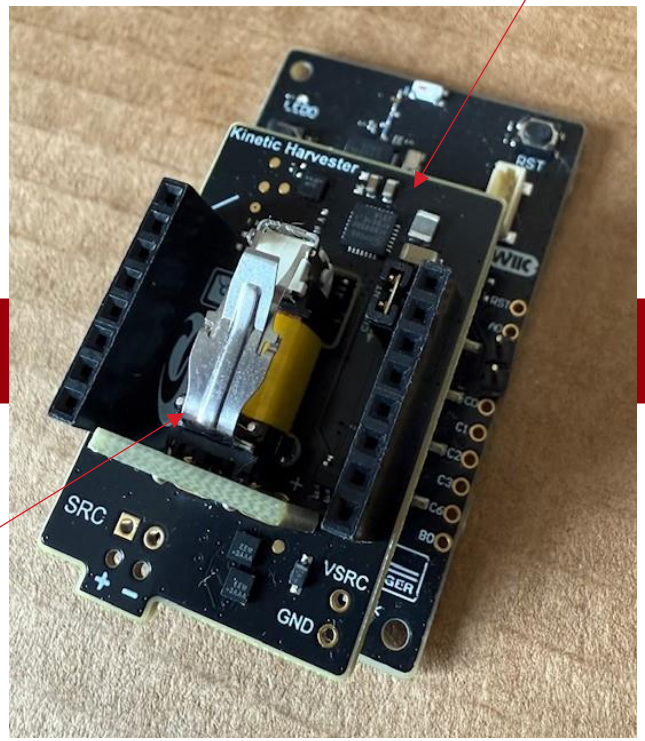
My ZGP lamp is toggling thanks to a battery-free button.

ON

AEM00300 PMIC Section



Kinetic raw harvester

OFF

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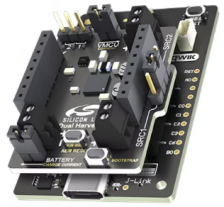
ORDERING – EK8200A – Energy Harvesting Shields for Explorer Kit



xG22-EK8200A

EFR32xG22E Energy Harvesting Explorer Kit

Buy Now

The EFR32xG22E Energy Harvesting Explorer Kit is an excellent starting point for exploring and evaluating various energy harvesting solutions with Silicon Labs' Multiprotocol Wireless Systems on Chip (SoC). It enables the evaluation of the functionality and performance of energy-harvesting-powered devices with Bluetooth LE and Zigbee Green Power. This comprehensive kit includes the EFR32xG22E Explorer Kit and multiple energy harvesting shield boards, enabling the evaluation of various energy sources such as photovoltaic cells, inductive or piezoelectric systems, and thermoelectric generators (TEG). It supports
Read More

LAUNCH DATE: 2/19/2025

PURCHASE LINK: http://www.silabs.com/development-tools/wireless/efr32xg22e-energy-harvesting-explorer-kit.html

WEB-PAGE: https://www.silabs.com/wireless/energy-harvesting

RESOURES – UG, QSG, AN: https://docs.silabs.com/energy-harvester/latest/

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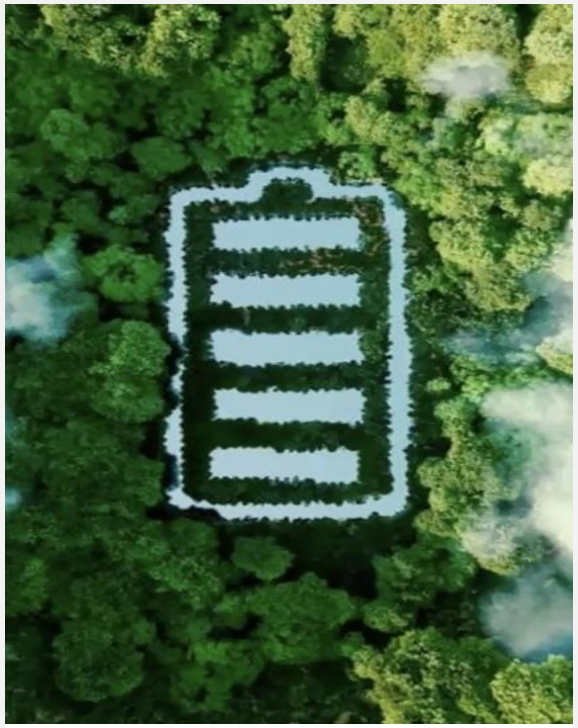
Additional Resources



TECH TALK

“Unboxing Silicon Labs' Latest Bluetooth SoC for Energy Harvesting“

Visit Site

BLOGS

“Ambient IoT – The Future of Sustainable IoT”

“Building a More Sustainable, Connected World with xG22E”

SiLabs xG22E | Ambient IoT

WORKSWITH

“**WW23:** Harnessing Ambient IoT: A Leap Towards Sustainable Connectivity “

“WW24: IoT Trends”

WW23 | WW24

OTHER

e-peas AEM datasheets

AEM13920v1.7 | AEM00300v1.4

e-peas AEM Selector Guide

Selector Guide

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Q&A

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Thank you