



CYALKIT-E04

## S6AE102A and S6AE103A Evaluation Kit Guide

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Cypress Semiconductor  
198 Champion Court  
San Jose, CA 95134-1709  
Phone (USA): 800.858.1810  
Phone (Intl): 408.943.2600  
<http://www.cypress.com>

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# 1. Safety Information



## 1.1 Regulatory Compliance

CYALKIT-E04 S6AE102A and S6AE103A EVK is intended for use as a development platform for hardware or software in a laboratory environment. The board has an open system design, which does not include a shielded enclosure. This may cause interference with other electrical or electronic devices in close proximity. In a domestic environment, this product may cause radio interference. In this case, the user may be required to take adequate preventive measures. Also, the board should not be used near any medical equipment or RF devices.

Attaching additional wiring to this product or modifying the product operation from the factory default may affect its performance and cause interference with other apparatus in the immediate vicinity. If such interference is detected, suitable mitigating measures should be taken.



CYALKIT-E04 S6AE102A and S6AE103A EVK contains electrostatic discharge (ESD)-sensitive devices. Electrostatic charges readily accumulate on the human body and any equipment, and can discharge without detection. Permanent damage may occur to devices subjected to high-energy discharges. Proper ESD precautions are recommended to avoid performance degradation or loss of functionality. Store unused CYALKIT-E04 boards in the protective shipping package.



End of Life/Product Recycling

The end of life of this kit is five years after the date of manufacture mentioned on the back of the box. Contact your nearest recycler to discard the kit.

## 1.2 General Safety Instructions

### 1.2.1 ESD Protection

ESD can damage boards and their associated components. Cypress recommends that you perform procedures only at an ESD workstation. If one is not available, use appropriate ESD protection by wearing an antistatic wrist strap attached to chassis ground (any unpainted metal surface) on your board when handling parts.

### 1.2.2 Handling Boards

CYALKIT-E04 boards are sensitive to ESD. Hold the board only by its edges. After removing the board from its box, place it on a grounded, static-free surface. Use a conductive foam pad, if available. Do not slide the board over any surface.

## 2. Introduction



Thank you for your interest in the CYALKIT-E04 S6AE102A and S6AE103A EVK. It provides an easy-to-use platform to develop battery-free applications with an energy-harvesting device. This kit consists of an S6AE102A board, an S6AE103A board, and a sensor board along with a solar module, wires, and a battery for testing different configurations. Table 2-1 shows the features of S6AE102A and S6AE103A. This kit can be used stand-alone or it can be used in conjunction with the CY8CKIT-042-BLE Bluetooth Low Energy Pioneer kit to demonstrate and develop applications that power a BLE device using harvested energy.

This kit guide explains how to set up and use the Evaluation Kit (EVK). Be sure to read it before using the product. Consult with sales or support representatives for more information.

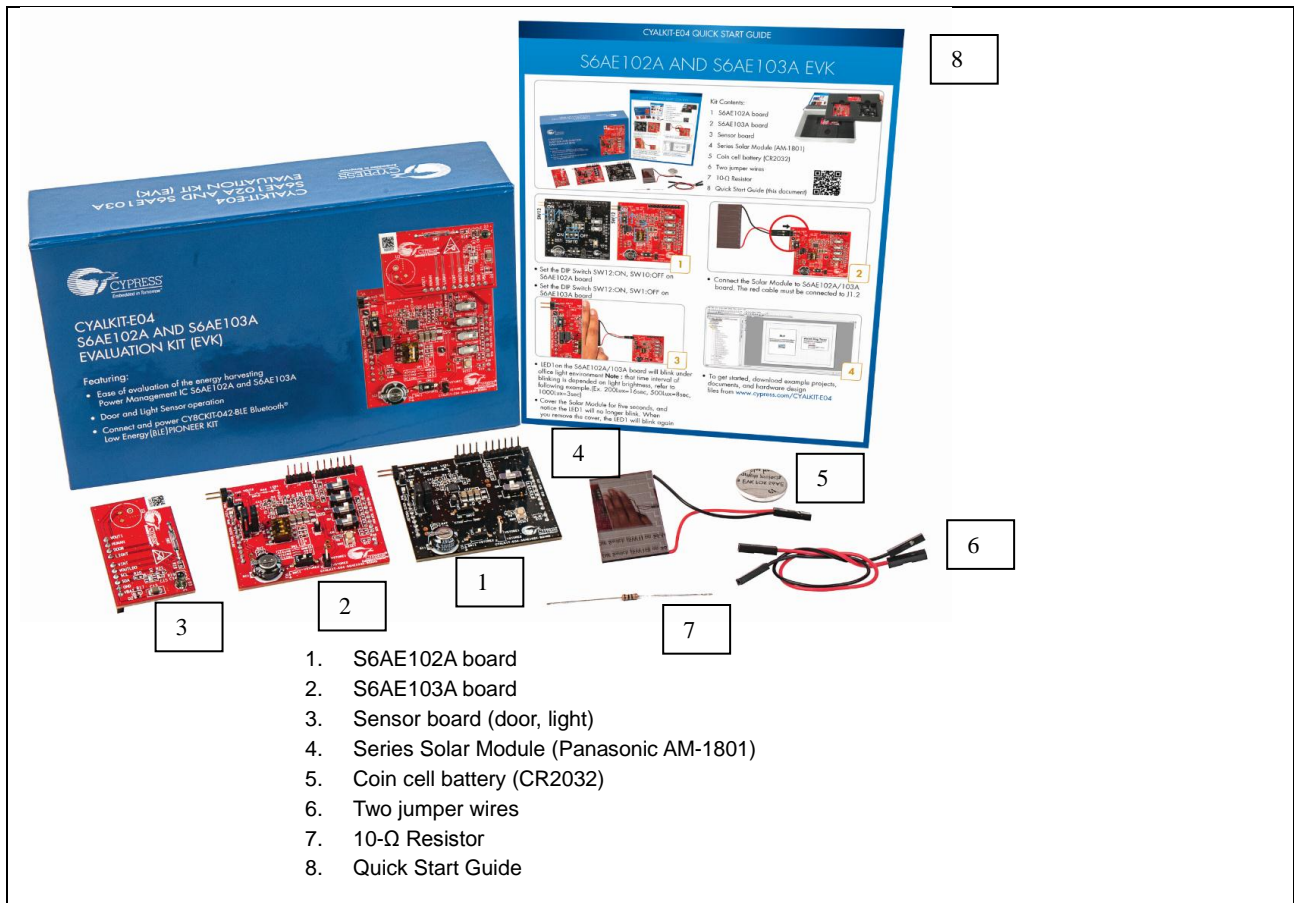
**Note:** All information included in this document is current as of the date it was issued. Such information is subject to change without any prior notice. Please confirm the latest relevant information with the sales representatives.

Table 2-1. Features of S6AE102A and S6AE103A

Feature	S6AE102A	S6AE103A
LDO	Yes	Yes
CR Timer	-	Yes
Comparator	-	Yes
Package	20-pin QFN (4 x 4 mm)	24-pin QFN (4 x 4 mm)

## 2.1 Kit Introduction

Figure 2-1. Kit Contents



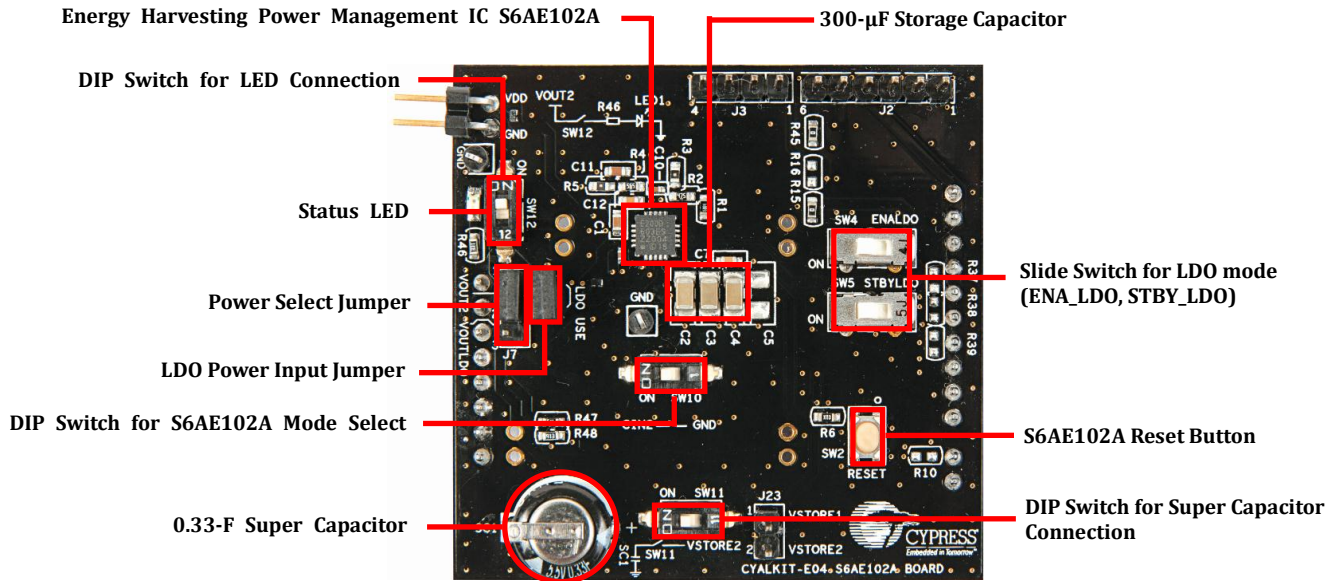


## 2.2 Board Details

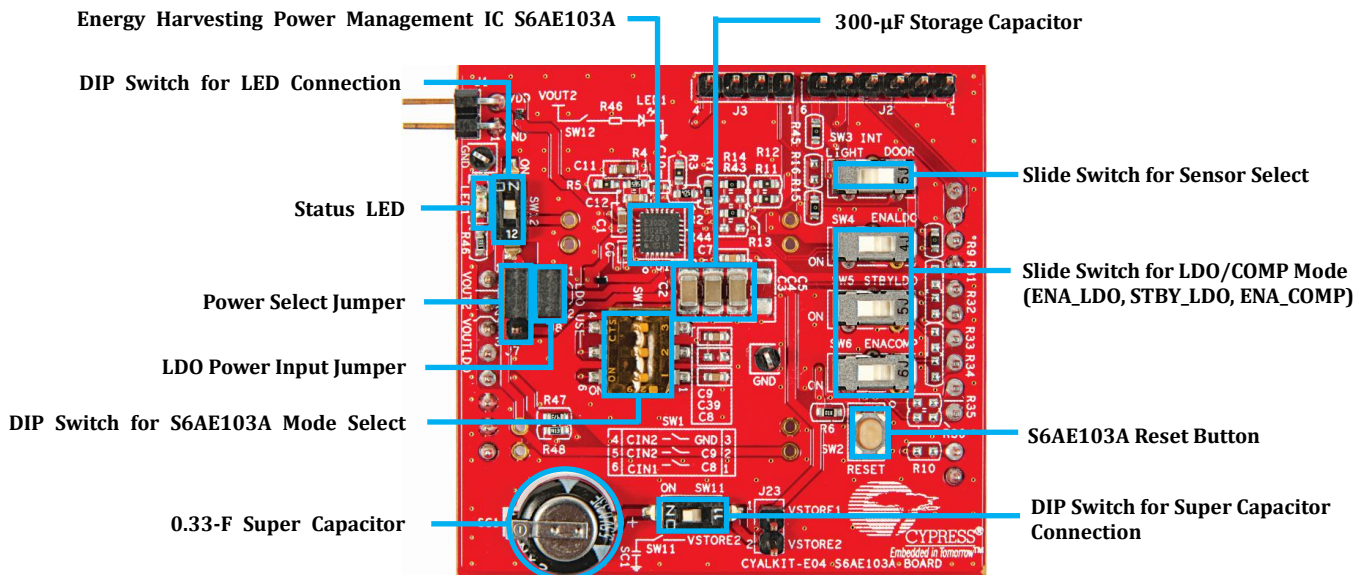
CYALKIT-E04 S6AE102A and S6AE103A EVK consists of the blocks shown below.

Figure 2-2. Board Details

### S6AE102A Board Details



### S6AE103A Board Details





The following figure shows a markup of the onboard connectors and switches of the S6AE102A board (in black) and the S6AE103A board (in red).

Figure 2-3. Onboard Connectors and Switches

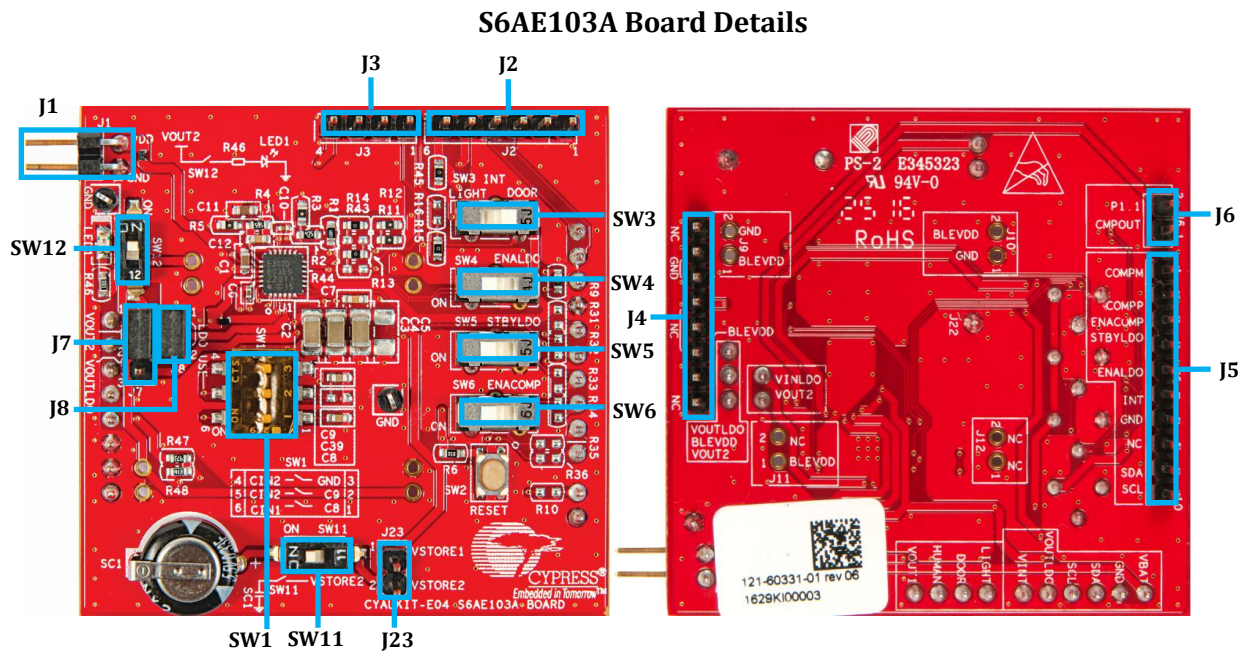
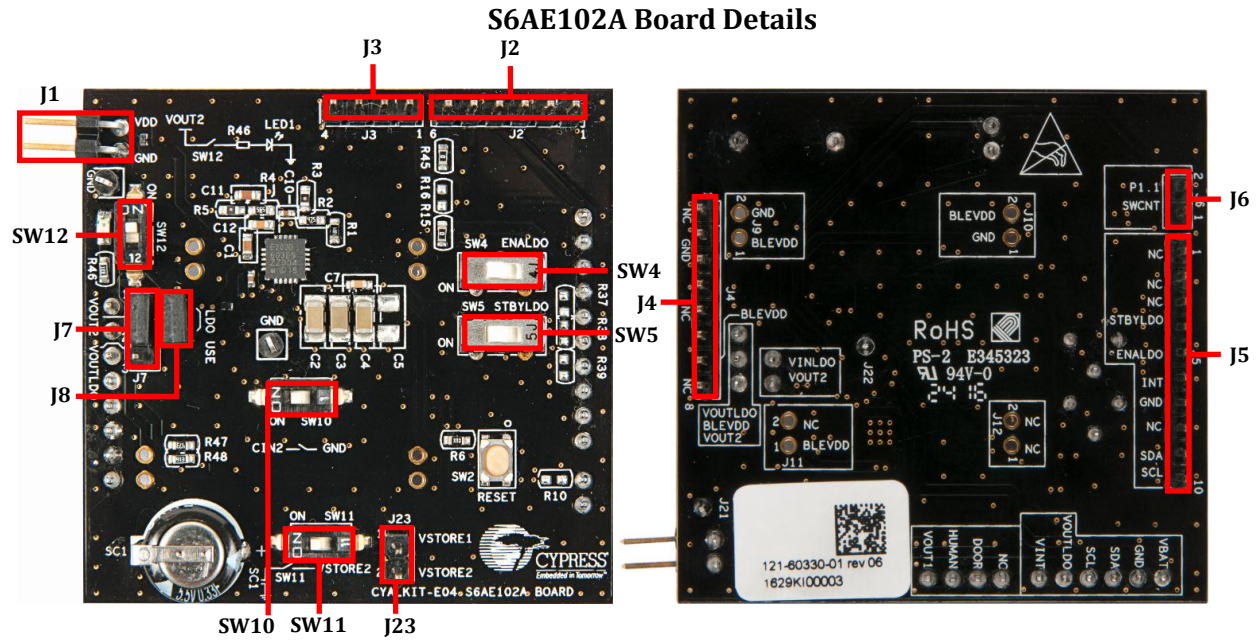


Table 2-2. S6AE102A and S6AE103A Board Pinout

Header	Pin#	S6AE102A board	S6AE103A board
J1	1	GND	GND
J1	2	VDD	VDD
J2	1	VBAT	VBAT
J2	2	GND	GND
J2	3	SDA	SDA
J2	4	SCL	SCL
J2	5	VOUT_LDO	VOUT_LDO
J2	6	VINT	VINT
J3	1	NC	LIGHT
J3	2	DOOR	DOOR
J3	3	PIR	PIR
J3	4	VOUT1	VOUT1
J4	1	NC	NC
J4	2	GND	GND
J4	3	GND	GND
J4	4	V5.0	V5.0
J4	5	NC	NC
J4	6	NC	NC
J4	7	BLE_VDD *	BLE_VDD *
J4	8	NC	NC
J5	1	NC	COMPM
J5	2	NC	COMPP
J5	3	NC	ENA_COMP
J5	4	STBY_LDO	STBY_LDO
J5	5	ENA_LDO	ENA_LDO
J5	6	INT	INT
J5	7	GND	GND
J5	8	NC	NC
J5	9	SDA	SDA
J5	10	SCL	SCL
J6	1	SW_CNT	COMPOUT
J6	2	P1.1	P1.1
J23	1	VSTORE1	VSTORE1
J23	2	VSTORE2	VSTORE2

\* The BLE\_VDD terminal is mainly intended to supply power to Cypress Pioneer series kits when CYALKIT-E04 is connected via Arduino-compatible headers. Jumper J7 sets the connection to BLE\_VDD from VOUT2 or VOUT\_LDO. See [Using CYALKIT-E04 with the CY8CKIT-042-BLE Bluetooth Low Energy Kit](#) for an example of using CYALKIT-E04 with a CY8CKIT-042-BLE Pioneer kit.

Table 2-3. Switch/Jumper Default Position of S6AE102A Board

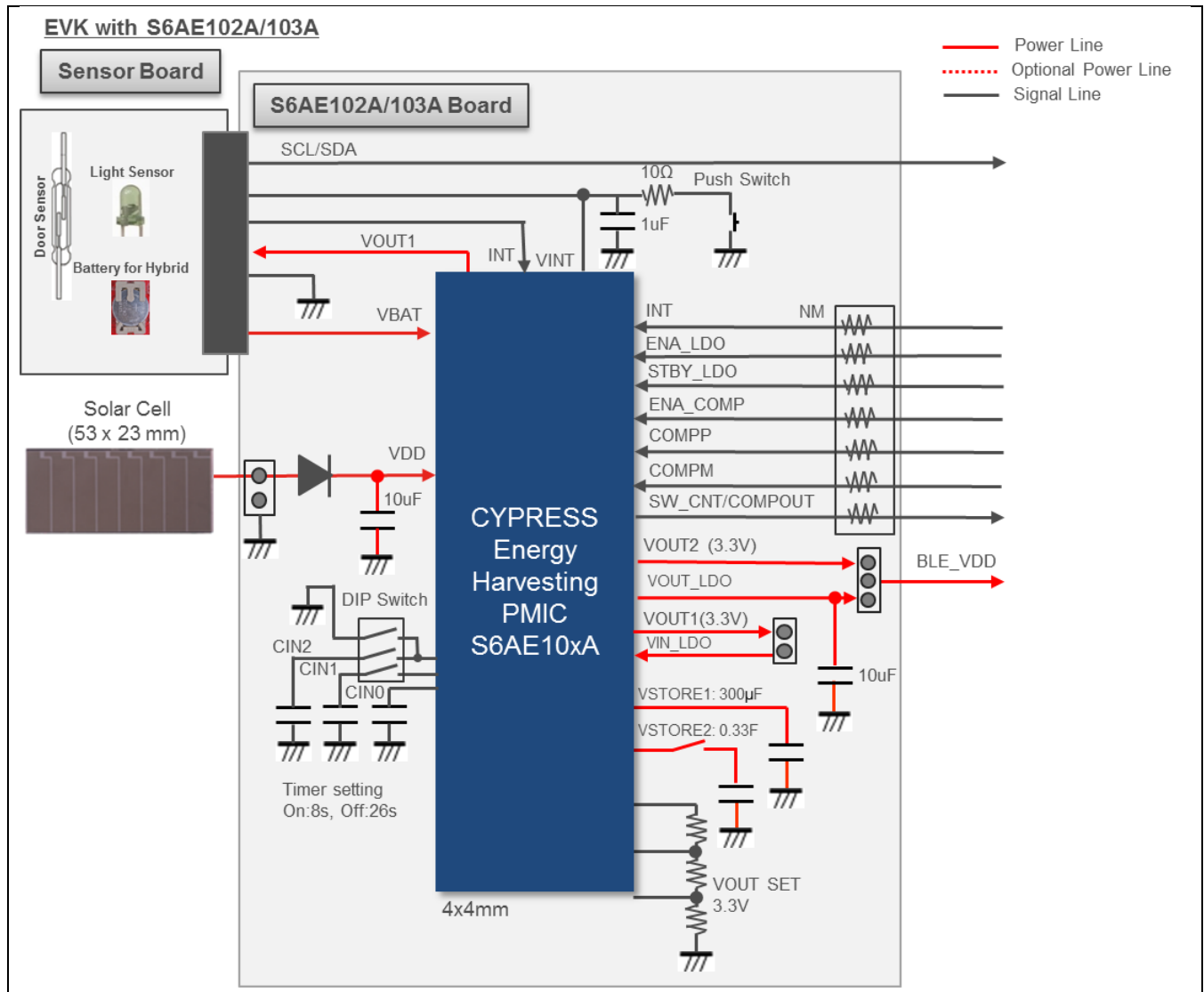
Switch/Jumper	Purpose	Default Position
SW10	Operation mode	OFF: Energy driven mode
SW4	ENA_LDO	ON: LDO enabled
SW5	STBY_LDO	ON: LDO normal mode
SW11	Switch for super capacitor connection	ON: super capacitor connected
SW12	Switch for LED connection	ON: LED connected
J7	Power select jumper	Short 1-2: VOUT2-BLE_VDD connected
J8	LDO Power input jumper	Short 1-2: VIN_LDO-VOUT1 connected

Table 2-4. Switch/Jumper Default Position of S6AE103A Board

Switch/Jumper	Purpose	Default Position
SW1	Operation mode	1: OFF; 2: OFF; 3: OFF: Energy driven mode
SW3	INT	DOOR: INT is connected door sensor output
SW4	ENA_LDO	ON: LDO enabled
SW5	STBY_LDO	ON: LDO normal mode
SW6	ENA_COMP	ON: Comparator connected
SW11	Switch for super capacitor connection	ON: super capacitor connected
SW12	Switch for LED connection	ON: LED connected
J7	Power select jumper	Short 1-2: VOUT2-BLE_VDD connected
J8	LDO Power input jumper	Short 1-2: VIN_LDO-VOUT1 connected

## 2.3 Block Diagram

Figure 2-4. Block Diagram of S6AE102A and S6AE103A EVK



## 2.4 Features

CYALKIT-E04 S6AE102A and S6AE103A EVK makes it easy to evaluate the ultra-low-power, energy harvesting S6AE102A and S6AE103A PMICs. This evaluation kit consists of three independent boards: the S6AE102A board, S6AE103A board, and sensor board. This kit is capable of supporting the life extension of a primary battery or becoming a battery-less solution, and can be used for evaluation of diverse power management functions used for wireless sensor networks. Magnetic door sensor operation and ambient light sensor operation can be evaluated by connecting the sensor board to the S6AE102A/S6AE103A board.

- The S6AE102A/103A boards support the following:
  - Selecting the mode (Energy-driven mode / Event-driven mode 1 / Event-driven mode 2, Timer-driven mode) using a switch
  - Charging the surplus solar energy to a 0.33-F super capacitor
  - Reset button for S6AE102A/S6AE103A
  - LEDs for status
  - Test pin header for ground
- The sensor board supports the following:
  - Expansion board for sensor/battery input
  - Magnetic door sensor (reed switch)
  - Ambient light sensor
- Reference schematic, BOM list, and layout for easy design.
- Sample firmware for CY8CKIT-042-BLE to work with EVK

The kit uses the S6AE102A/S6AE103A ultra-low-power Energy Harvesting Power Management IC (PMIC) and is Arduino pin header-compatible.

# 3. Software Installation



This section describes how to install the software.

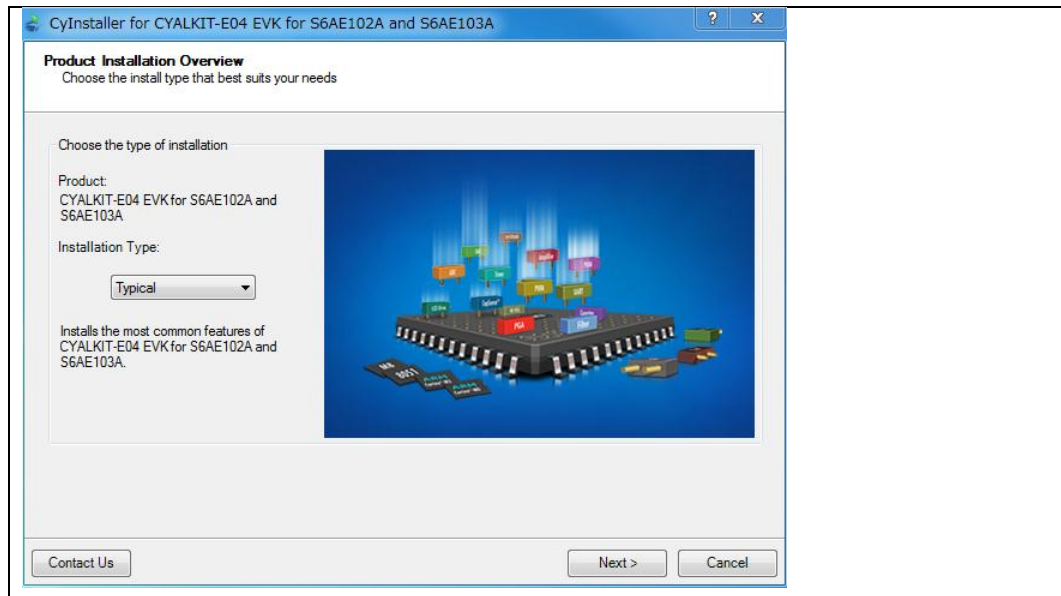
## 3.1 Install Software

Follow these steps to install the CYALKIT-E04 S6AE102A and S6AE103A EVK software:

1. Download the CYALKIT-E04 S6AE102A and S6AE103A EVK software from [www.cypress.com/CYALKIT-E04](http://www.cypress.com/CYALKIT-E04).  
It is available in three formats for download:
  - **CYALKIT-E04 Complete Setup:** This installation package contains the files related to the kit. However, it does not include the Windows Installer or Microsoft .NET framework packages. If these packages are not already installed on your computer, the installer directs you to download and install them from the Internet.
  - **CYALKIT-E04 Only Package:** This executable file installs only the kit contents, which include code examples, hardware files, and user documents. This package can be used if all the software prerequisites are installed on your computer.
  - **CYALKIT-E04 CD ISO:** This file is a complete package, stored in a CD-ROM image format that can be used to create a CD, or extract using ISO extraction programs such as WinZip or WinRAR. This file includes all the required software, utilities, drivers, hardware files, and user documents.
2. Run **Install S6AE102A and S6AE103A EVK** to start the installation.
3. Select the folder to install the files related to CYALKIT-E04 S6AE102A and S6AE103A EVK. Choose the directory and click **Next**.  
The CYALKIT-E04 CD ISO installer automatically installs the required software if it is not present on your computer. The CYALKIT-E04 Complete Setup installer directs you to download the required software from the Internet.
4. Choose the **Typical/Custom/Complete** installation type in the **Product Installation Overview** window. Click **Next** after you select the installation type.

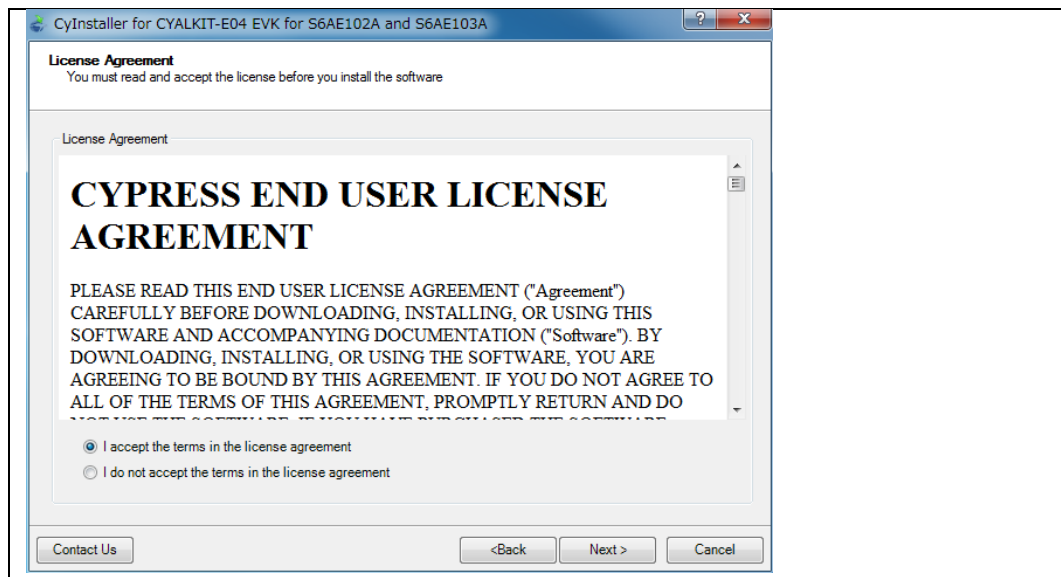


Figure 3-1. Select Installation Type



5. Read the **Cypress End User License Agreement** and make a selection based on the terms of the license agreement. Click **Next** to continue the installation.

Figure 3-2. Accept End User License Agreement



6. When the installation begins, a list of packages appears on the installation page. A green check mark appears next to each package after successful installation.
7. Click **Finish** to complete the installation.
8. Enter your contact information or select the **Continue Without Contact Information** check box. Click **Finish** to complete the installation.
9. After the installation is complete, the kit contents are available at the following location:

*<Install directory>\S6AE102A and S6AE103A Kit*

Default location (Example: Windows 7):



64-bit: C:\Program Files (x86)\Cypress\ CYALKIT-E04 S6AE102A and S6AE103A Kit

32-bit: C:\Program Files\Cypress\ CYALKIT-E04 S6AE102A and S6AE103A Kit

## 3.2 Uninstall Software

You can uninstall the CYALKIT-E04 S6AE102A and S6AE103A EVK software using one of the following methods:

Example: Windows 7

- Go to **Start > All Programs > Cypress > Cypress Update Manager**; click the **Uninstall** button.
- Go to **Start > Control Panel > Programs and Features**. Select the **S6AE102A and S6AE103A EVK** program from the list and click the **Uninstall/Change** button.

## 3.3 PSoC Creator

PSoC<sup>®</sup> Creator<sup>™</sup> is a state-of-the-art, easy-to-use integrated design environment (IDE). It is a revolutionary hardware and software co-design environment, powered by a library of pre-verified and pre-characterized PSoC Components<sup>™</sup>. With PSoC Creator, you can:

- Drag and drop PSoC Components to build a schematic of your custom design
- Automatically place and route Components and configure GPIOs
- Develop and debug firmware using the included Component APIs

PSoC Creator also enables you to tap into an entire tool ecosystem with integrated compiler chains and production programmers for PSoC devices.

To develop firmware for the BLE pioneer kit which can be used in conjunction with this kit in order to demonstrate powering wireless BLE solutions from an energy harvesting device, PSoC Creator 3.3 CP3 or newer is required. Download the latest version from [www.cypress.com/psoccreator](http://www.cypress.com/psoccreator).

# 4. Getting Started



You can become familiar with the CYALKIT-E04 by checking each sensor operation. This activity will also confirm that the S6AE102A board, S6AE103A board, and sensor board are operating properly.

In this section, you will confirm the basic operation of the Energy Harvesting PMIC and the sensor by using the provided kit to detect light and door open/close conditions.

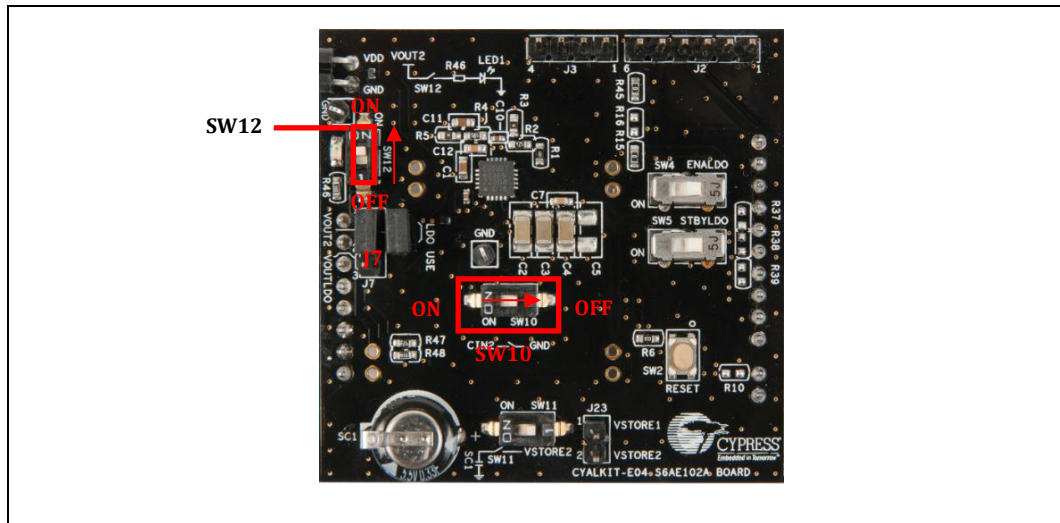
The door sensor operation uses Event-Driven mode 1 of S6AE102A/103A. Refer to the [datasheet](#) for details on the mode's function.

## 4.1 Solar and Battery Power Options

### 4.1.1 Operation with the Solar Module

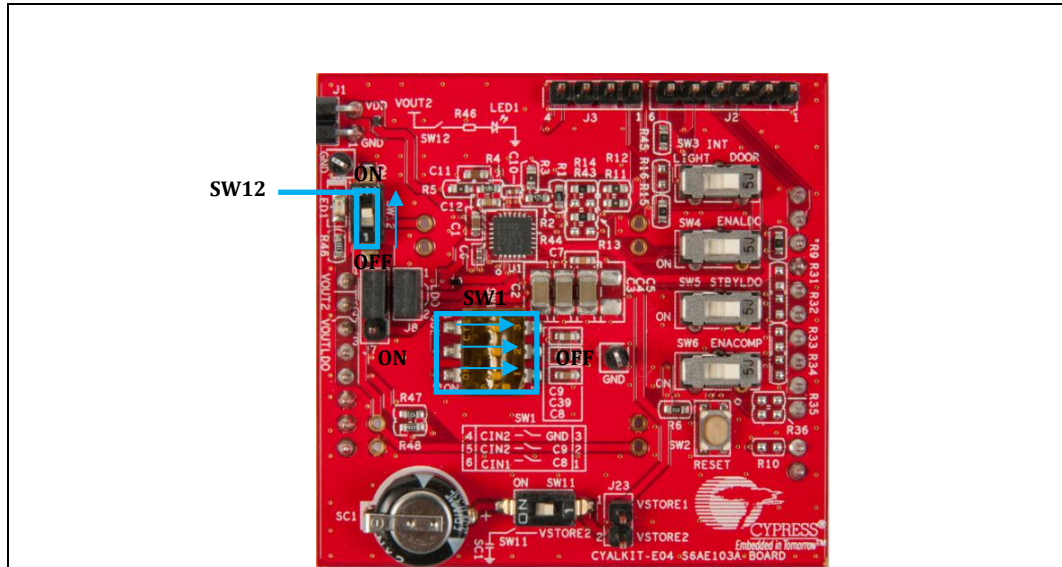
1. Set switch SW12 to ON to enable the LED.
2. For the S6AE102A board: set switch SW10 to OFF for Energy-driven mode.

Figure 4-1. S6AE102A Board Settings for Operation with Solar Module



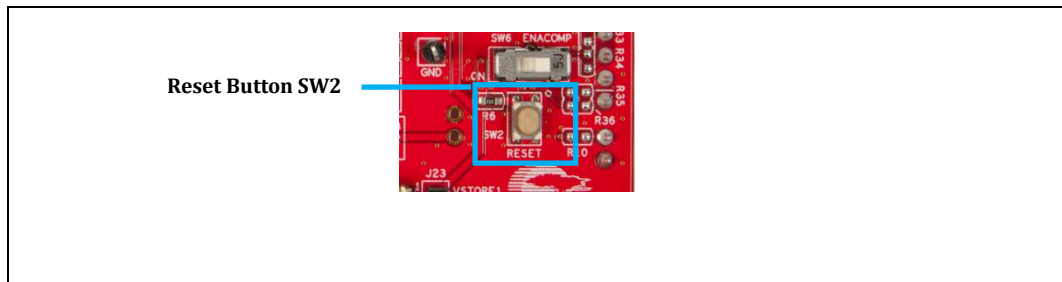
- For the S6AE103A board: set switch SW1 as follows for Energy driven mode: 1: OFF, 2: OFF, 3: OFF.

Figure 4-2. S6AE103A Board Settings for Operation with the Solar Module



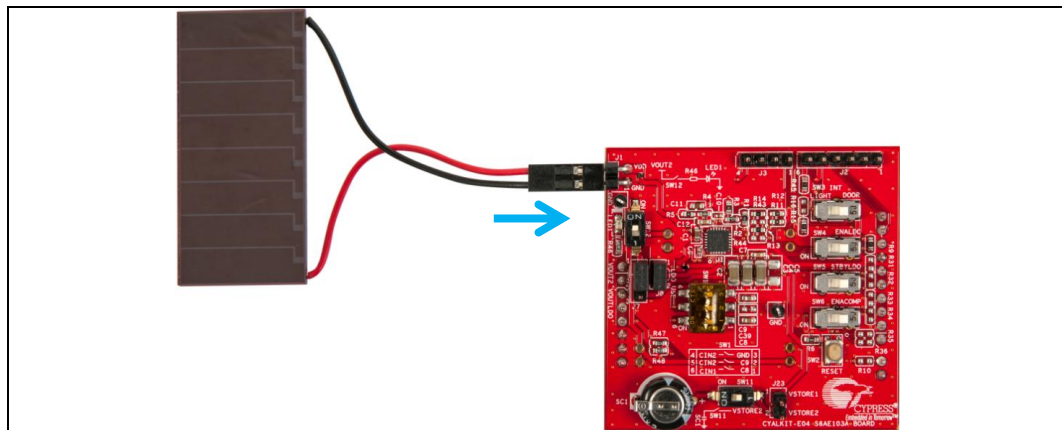
- Push the reset button SW2.

Figure 4-3. S6AE102A/103A Reset Button



- Connect the solar module to the S6AE102A/103A board. The red cable is connected to J1 pin 2.

Figure 4-4. Connecting the Solar Module



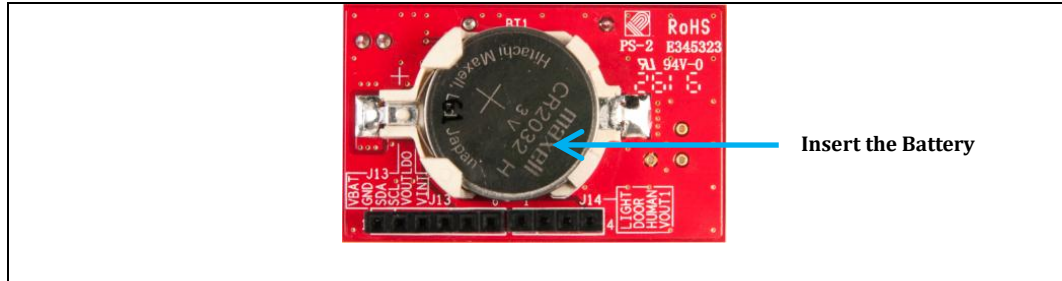
- LED1 on the S6AE102A/103A board will blink under an office light environment.

**Note:** The interval of blinking will depend on light brightness. For example, at 200 Lux, the interval is 16 seconds; at 500 Lux, 8 seconds; and at 1000 Lux, 3 seconds.

### 4.1.2 Solar and Battery Operation with the Solar Module and Sensor Board

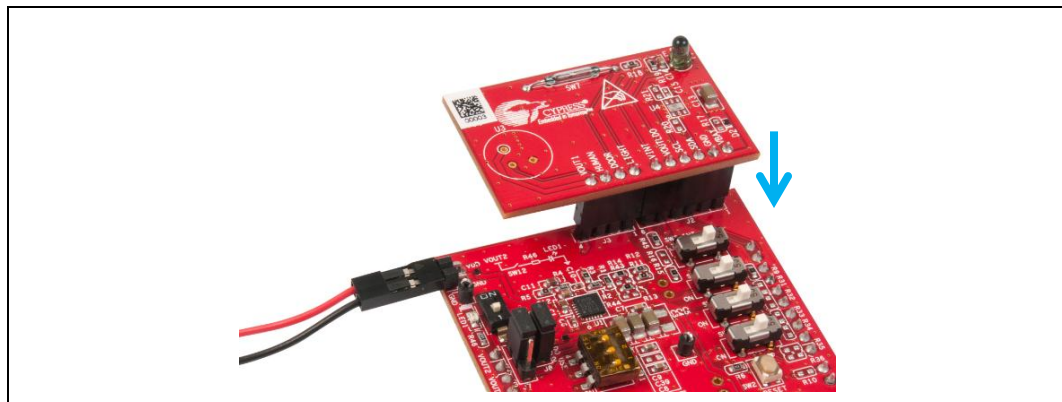
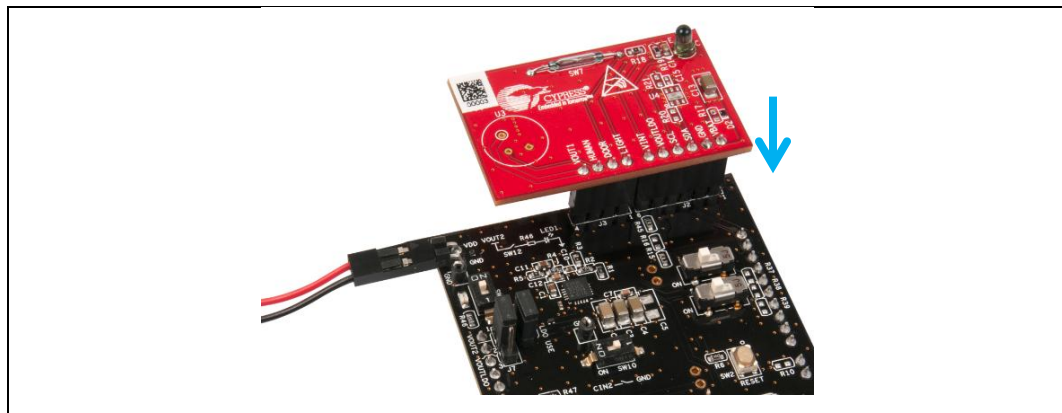
1. Leave all jumpers and switches set as in the previous example.
2. Insert the coin cell battery (CR2032) into the battery holder on the sensor board.

Figure 4-5. Inserting the Coin Cell Battery



3. Connect the sensor board to the S6AE102A/103A board.

Figure 4-6. Connecting the Sensor Board to S6AE102A/103A Board



5. LED1 on the S6AE102A/103A board will stay ON irrespective of whether the solar module is connected.

**Note:** Remove the coin cell battery (CR2032) from the battery holder of the sensor board to prevent battery leakage when not using this kit.

### 4.1.3 Super Capacitor Charging Operation with Solar Module

1. Set SW12 to OFF. This disables the LED.

2. Set switch SW11 to ON. This connects the super capacitor.
3. Connect the solar module to the S6AE102A/103A board. The red cable is connected to J1 pin 2.
4. Monitor the voltage of VSTORE2 (J23 2). The voltage of the super capacitor will increase gradually. See [Waveforms of Charging and Discharging Operation](#) for more information on the charging operation of the super capacitor.

Figure 4-7. S6AE102A Board Settings for Checking Super Capacitor Charging with Solar Module

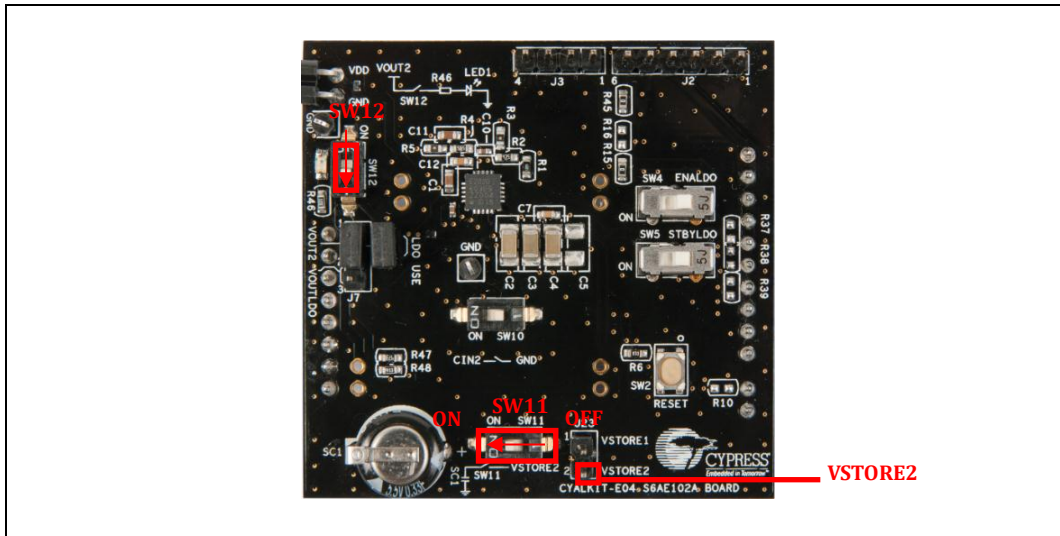
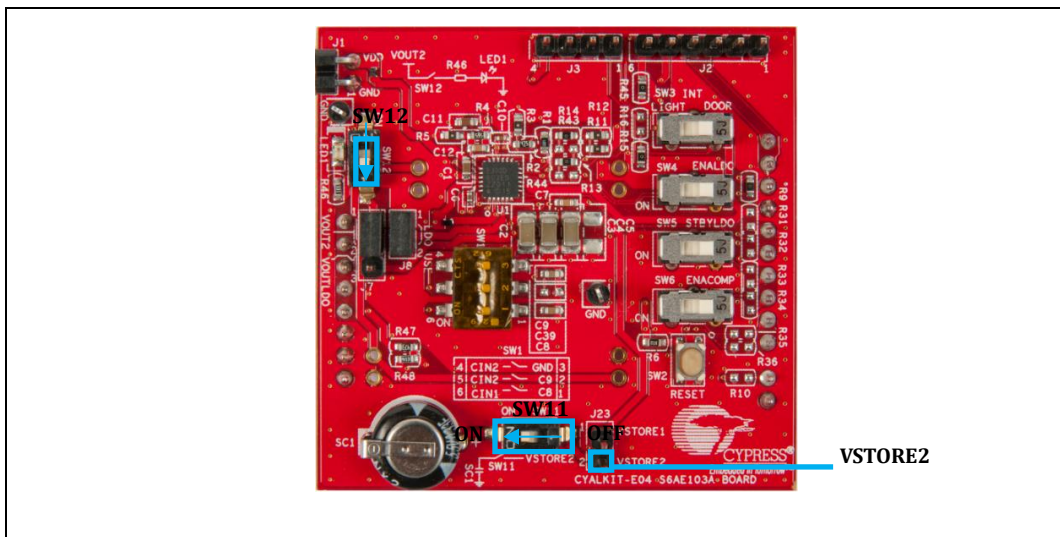


Figure 4-8. S6AE103A Board Settings for Checking Super Capacitor Charging with Solar Module



#### 4.1.4 LDO Operation with the Solar Module and Battery

1. Connect VOUT1 and VIN\_LDO (J8 1-2). This provides power to the LDO.
2. Connect BLE\_VDD and VOUT\_LDO (J7 2-3). This connects the LDO output to BLE\_VDD.
3. Set switch SW12 to OFF. This disables the LED.
4. Set switch SW4 to ON and SW5 to ON. This enables LDO with normal mode.
5. Set switch SW11 to ON. This enables the super capacitor.
6. Connect the solar module to the S6AE102A/103A board. The red cable is connected to J1 pin 2.



7. Connect the sensor board with battery to the S6AE102A/103A board.
8. Monitor that BLE\_VDD becomes 1.8 V.

Figure 4-9. S6AE102A Board Settings for Checking LDO Operation

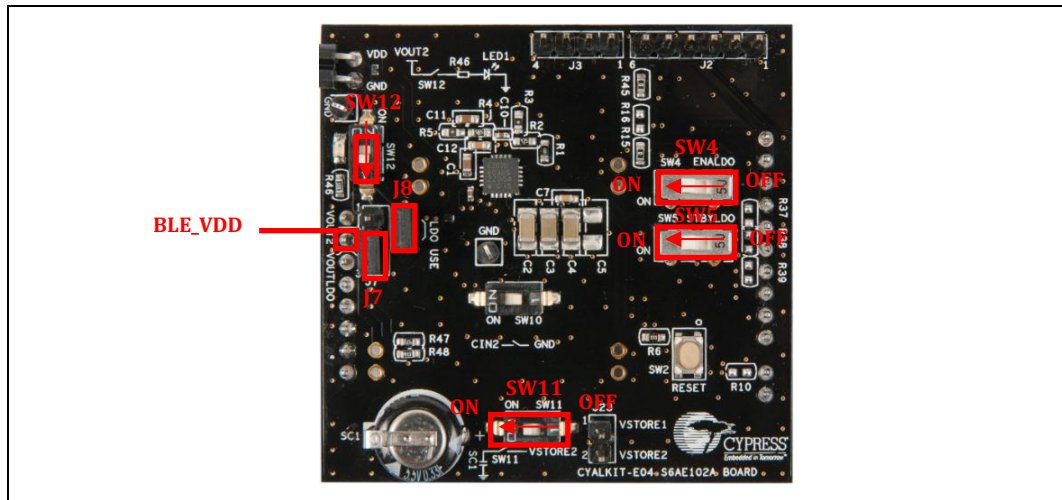
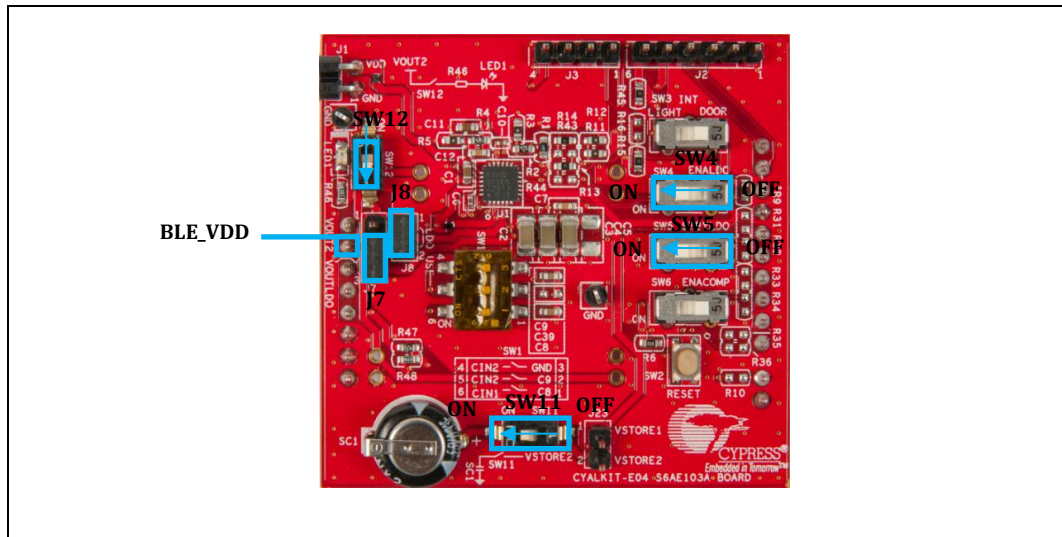
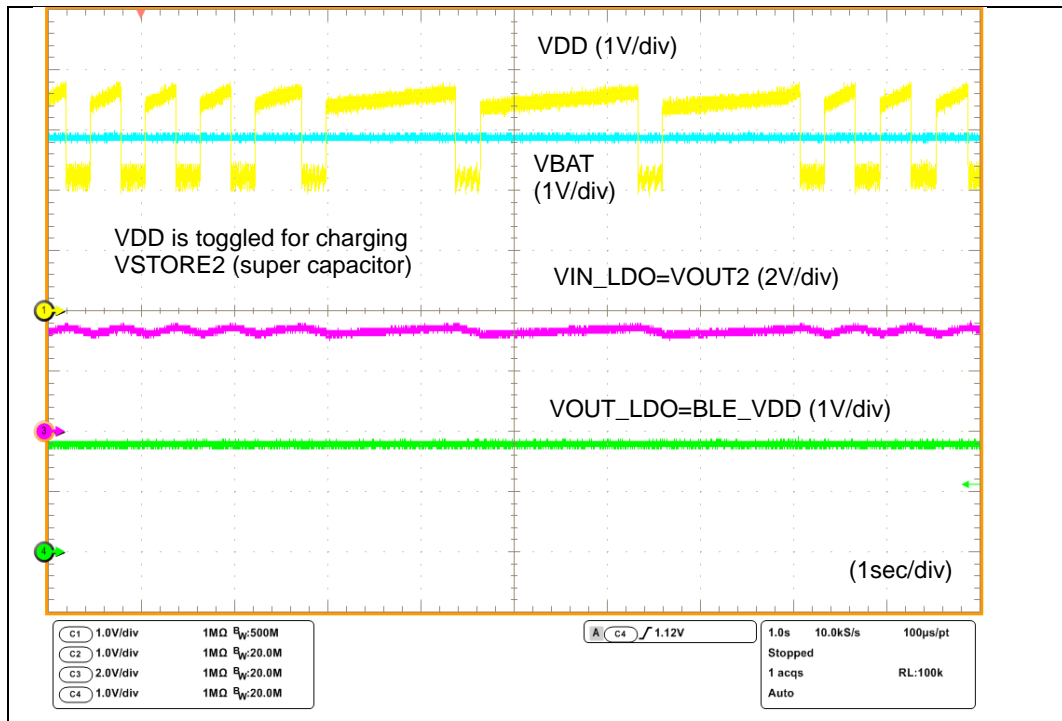


Figure 4-10. S6AE103A Board Settings for Checking LDO Operation



Note that VOUT\_LDO can output a stable voltage even if VOUT2 has ripple or if a dual input (solar and battery) is connected as the power source.

Figure 4-11. LDO with Solar + Battery Input

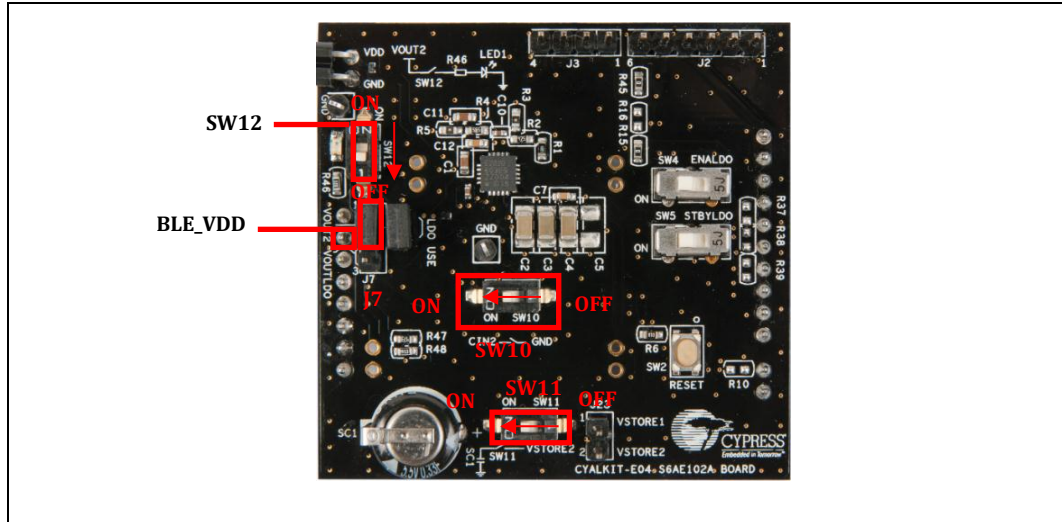




## 4.2 Door Sensor Operation with S6AE102A/S6AE103A/Sensor Board and Solar Module

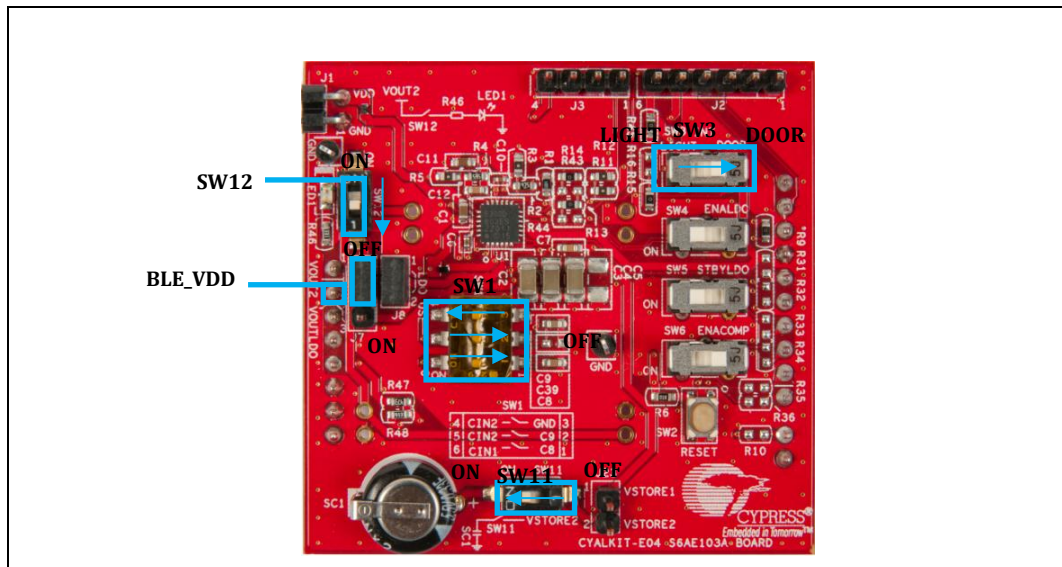
1. Set switch SW11 to ON. This enables the super capacitor.
2. Set switch SW12 to OFF. This disables the LED.
3. Connect BLE\_VDD and VOUT2 (J7 1-2).
4. For the S6AE102A board: set switch SW10 to ON for setting Event-driven mode 1.

Figure 4-12. S6AE102A Board Settings for Checking Door Sensor Operation



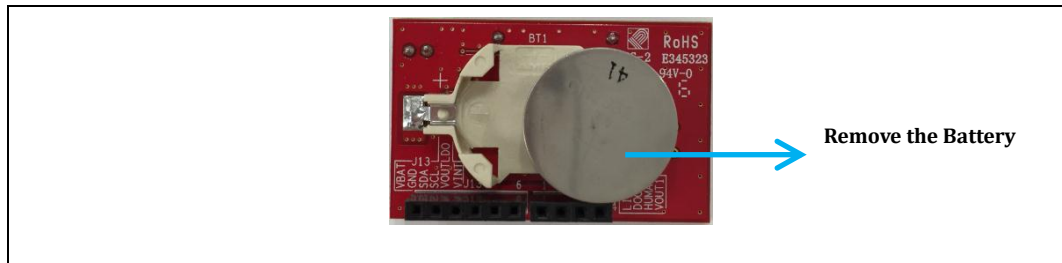
3. For the S6AE103A board: set switch SW1 as follows for setting Event-driven mode 1. 1: OFF, 2: OFF, 3: ON.
4. For the S6AE103A board: set switch SW3 to DOOR for inputting the door sensor signal to INT.

Figure 4-13. S6AE103A Board Settings for Checking Door Sensor Operation



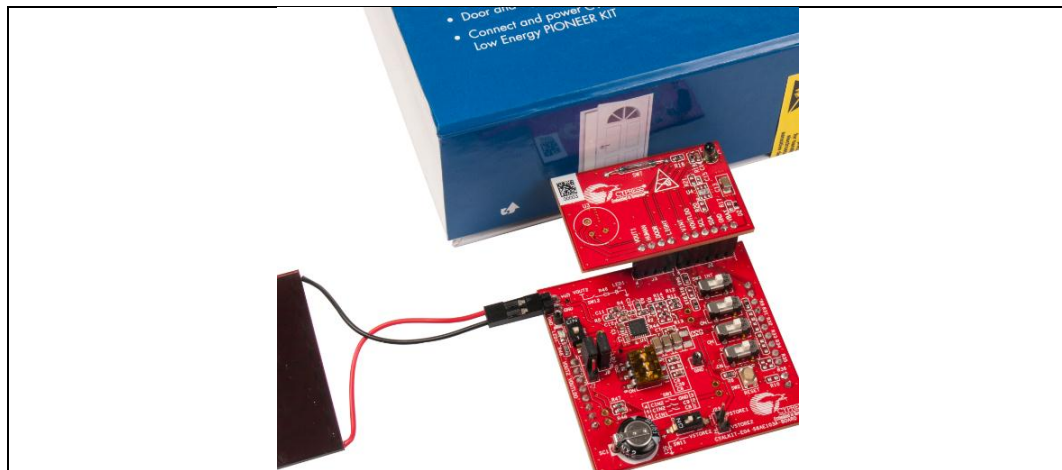
5. Push the reset button SW2.
6. Connect the sensor board to the S6AE102A/103A board without the CR2032 battery.

Figure 4-14. Removing the Coin Cell Battery



7. Connect the solar module to the S6AE102A/103A board. The red cable is connected to J1 pin 2.
8. Monitor that BLE\_VDD is low when the magnetic sensor SW7 is placed against the doorknob picture on the kit box. There are magnets at those two positions in the kit box. BLE\_VDD goes above 3 V when the magnetic sensor SW7 is separated by more than 10 mm from the doorknob picture. This functionality allows a subsystem (for example a BLE signaling device) to be powered whenever the door is open. When the door is closed, the subsystem is powered down and energy is stored in the super capacitor.

Figure 4-15. Checking the Door Sensor Operation



9. The following waveforms illustrate the electrical signals on the kit during the operation as a door sensor.

Figure 4-16. Door Sensor with Solar Input

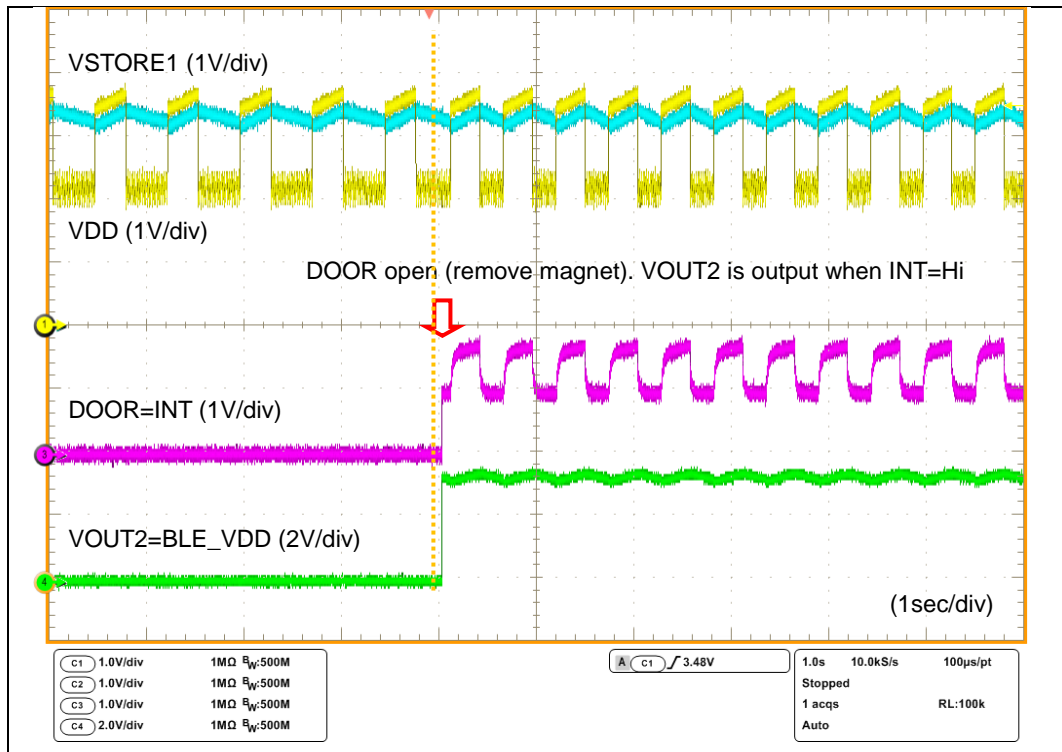
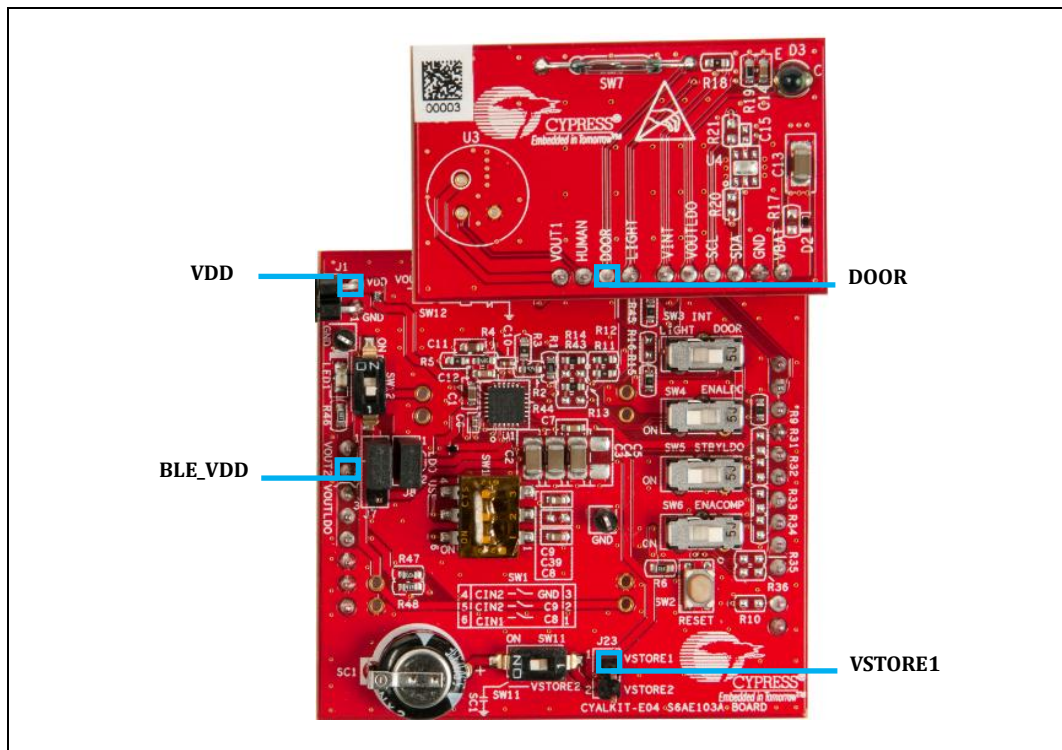


Figure 4-17. S6AE103A Board Measurement Points



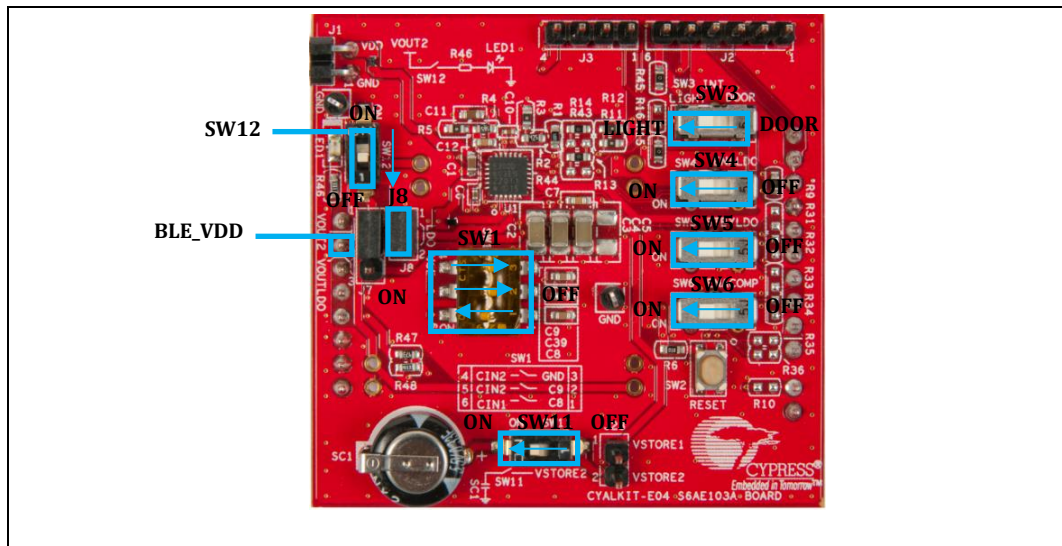
### 4.3 Light Sensor Operation with the S6AE103A/Sensor Board

In this section, you will confirm the light sensor operation of the Energy Harvesting PMIC by using the S6AE103A board and Sensor board. The light sensor operation uses an internal LDO and the comparator function. The light sensor signal and the divided LDO reference voltage are inputs to the comparator. The comparator outputs to the INT pin to control the PMIC operation mode.

The light sensor operation uses Event-driven mode 2 of the S6AE103A. Refer to the [datasheet](#) for details on the mode's function.

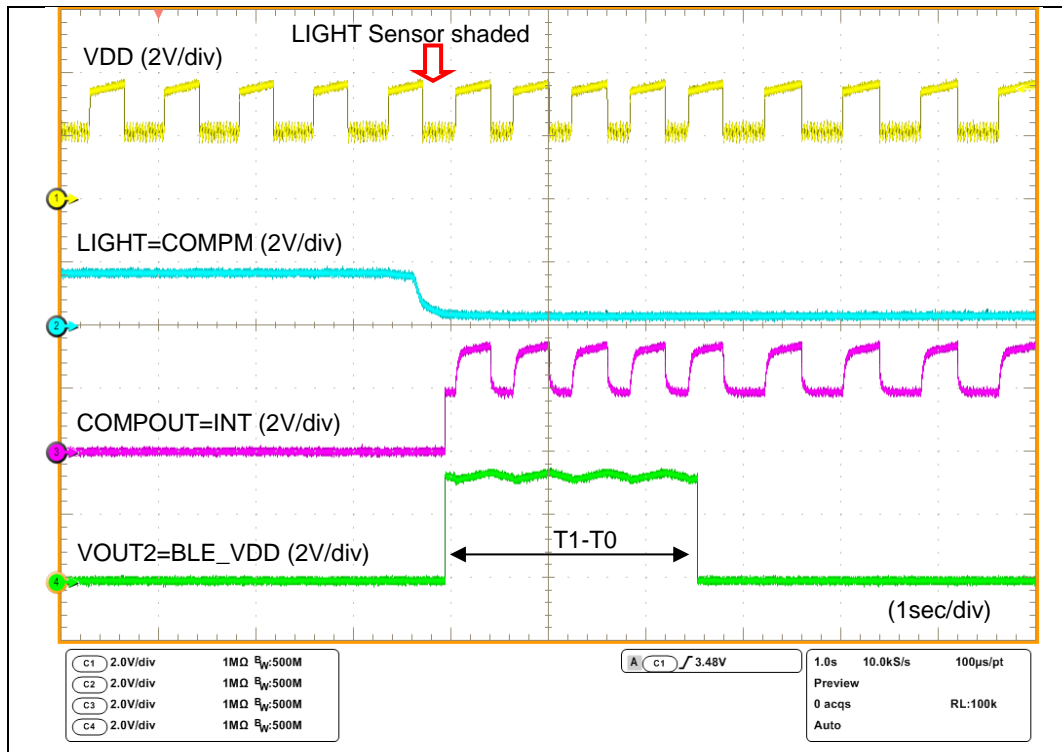
1. Disconnect the solar module.
2. Connect VOUT1 and VIN\_LDO (J8 1-2) for using VOUT1 as the LOD input source.
3. Set SW12 OFF. This disables the LED.
4. Set SW11 ON. This enables the super capacitor.
5. Set SW1 as follows for setting Event-driven mode 2. 1: ON, 2: OFF, 3: OFF
4. Set switch SW3 to LIGHT, SW4 to ON, SW5 to ON, SW6 to ON. This enables the light sensor, LDO normal mode, and comparator.

Figure 4-18. S6AE103A Board Settings for Checking Light Sensor Operation



5. Connect the sensor board without the coin cell battery to the S6AE103A board.
6. Push the reset button SW2.
7. Connect the solar module.
8. Monitor the voltage of BLE\_VDD (J4 7). It will start out in a low state. Then, cover the light sensor; BLE\_VDD will go high for approximately three seconds.

Figure 4-19. Light Sensor Operation with Solar Input





## 4.4 Timer Operation with the S6AE103A Board

In this section, you will confirm the timer operation of the Energy Harvesting PMIC by using the S6AE103A board.

The timer operation uses the Timer-Driven mode of S6AE103A. Refer to the [datasheet](#) for details on the mode's function.

1. Disconnect the solar module and sensor board.
2. Set SW12 to OFF. This disables the LED.
3. Set SW1 as follows for setting Timer-driven mode. 1: ON, 2: ON, 3: OFF
4. Push reset button SW2.
5. Connect the solar module.
6. Monitor the voltage of BLE\_VDD (J4 7).

The BLE\_VDD will be high for about three seconds and then low for approximately eight seconds.

Figure 4-20. S6AE103A Board Settings for Checking Timer Operation

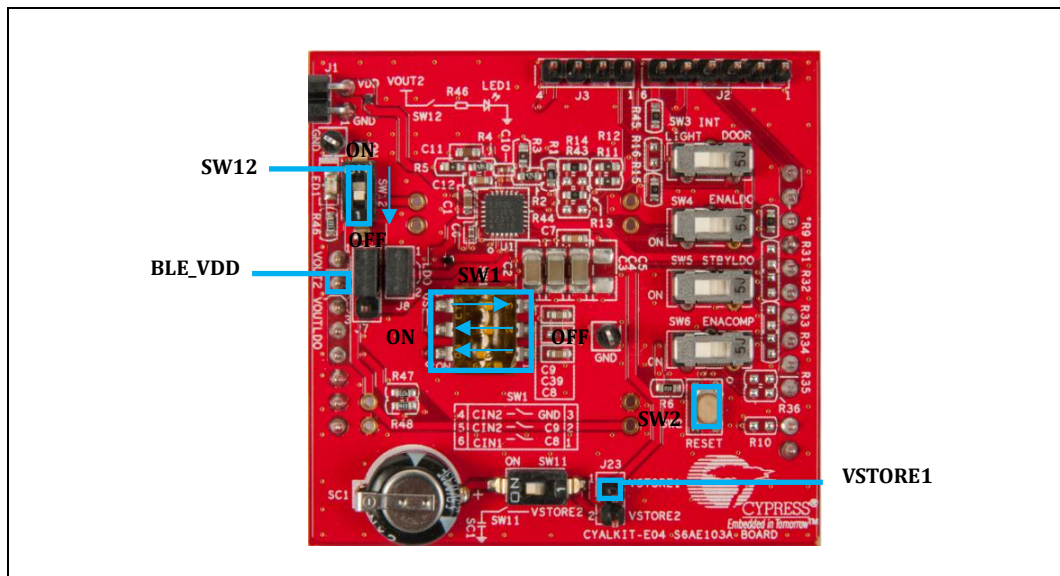
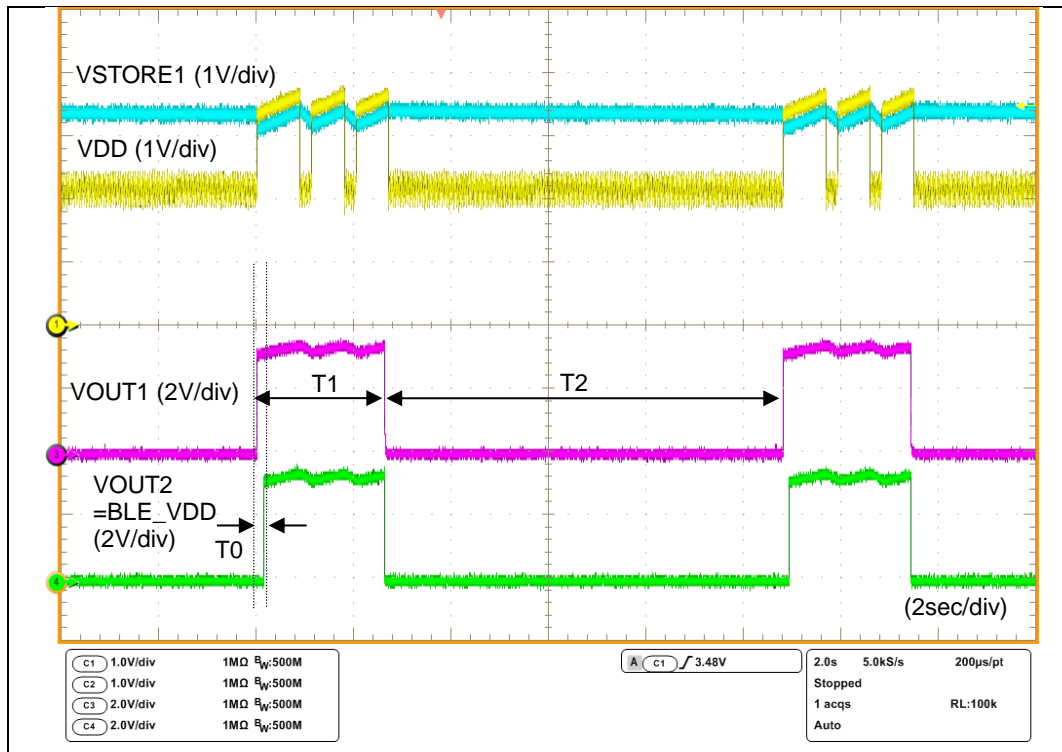


Figure 4-21. Timer Operation with Solar Input





# 5. Hardware



This chapter describes the EVK hardware.

## 5.1 S6AE102A and S6AE103A Boards

Figure 5-1 shows the circuit of the S6AE102A/103A Energy Harvesting PMIC. There are five main blocks to perform energy harvesting. Refer to the [S6AE102A/S6AE103A datasheet](#) for detailed specifications. The kit schematic and board layouts are available at the following location:

<Install directory>\S6AE102A and S6AE103A Kit<version>\Hardware

1. Power input block
2. VOUT setting block
3. Storage and VOUT control block
4. Internal timer setting block
5. LDO setting block

Figure 5-1. S6AE102A Board Circuits

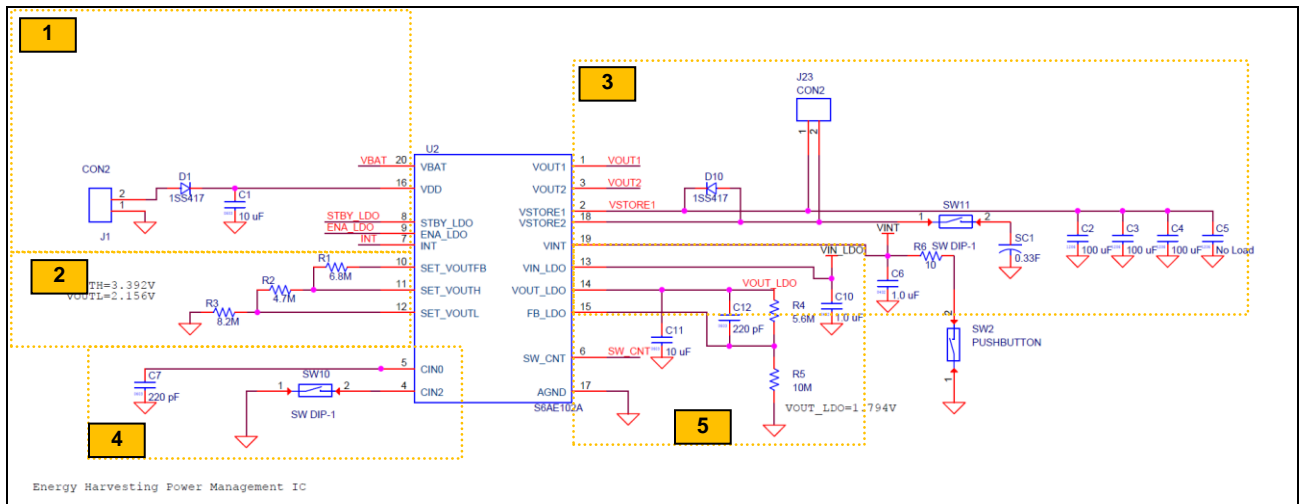
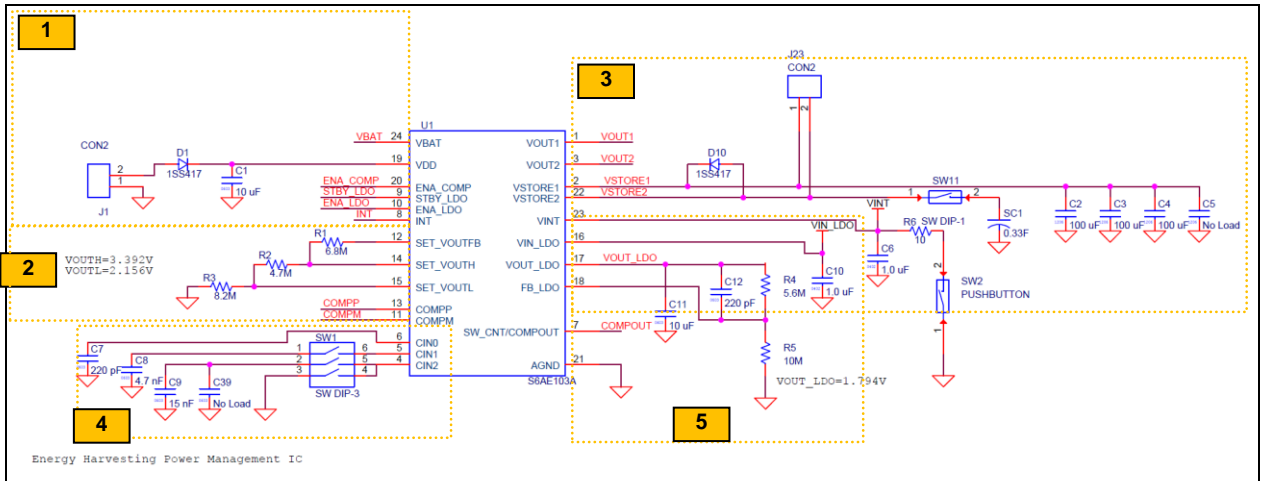


Figure 5-2. S6AE103A Board Circuits



### 5.1.1 Power Input Block

This section describes the S6AE102A/103A power input block as shown in the following diagram. There are power inputs for solar energy (VDD) and a primary battery input (VBAT), and control pins for the internal LDO, comparator, and interrupt input.

Figure 5-3. Power Input Block of S6AE102A and S6AE103A Boards

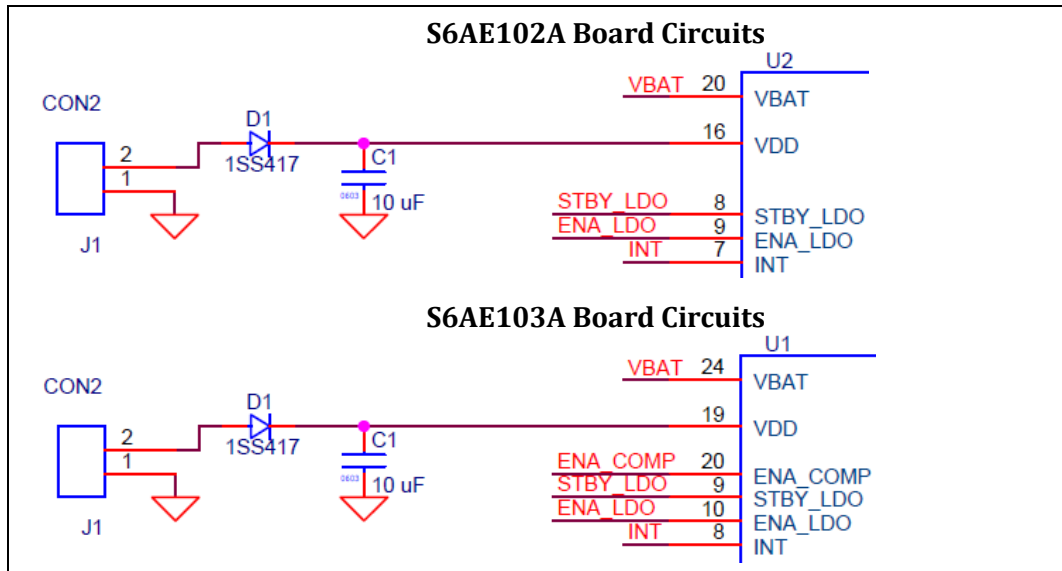


Table 5-1..Pin Description of Power Input Block

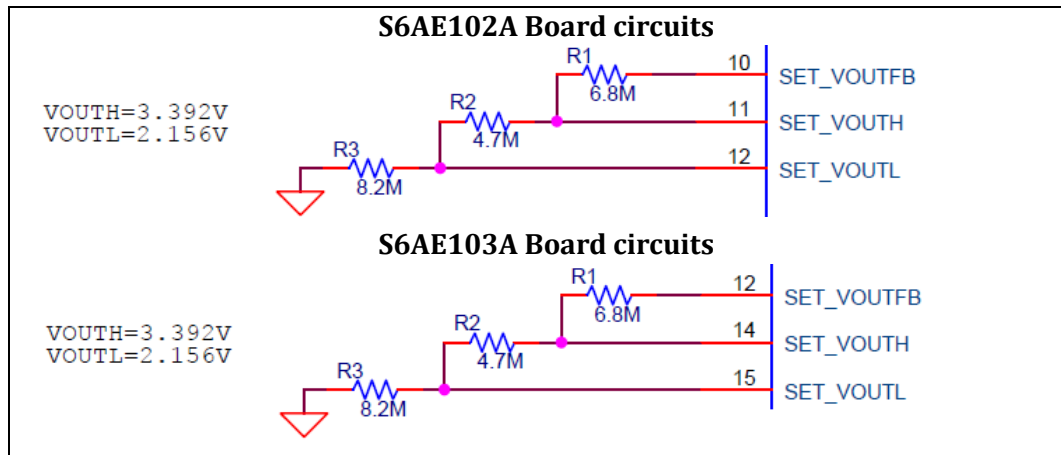
Pin Name	Description
VBAT	Connects to J2.1 Primary battery input pin Extra battery input
VDD	Connects to the solar cell (AM-1801) Solar cell input pin Diode (D1) for reverse current protection Capacitor (C1) for charging input energy

Pin Name	Description
ENA_COMP (S6AE103A)	Connects to SW6 (H: Enable, L: Disable) Comparator control pin
STBY_LDO	Connects to SW5 (H: Normal, L: Standby) LDO operation mode setting pin
ENA_LDO	Connects to SW4 (H: Enable, L: Disable) LDO output control pin
INT	Connects to SW3 <input type="checkbox"/> DOOR: Controlled by door sensor <input type="checkbox"/> LIGHT: Controlled by light sensor Event-driven mode control pin

### 5.1.2 VOUT Setting Block

This section describes the S6AE102A/103A VOUT settings as shown in the following diagram. The VOUT1 and VOUT2 output voltage of S6AE103A can be set by changing the resistors connected to the SET\_VOUTH and SET\_VOUTL pins. This is because the VOUT upper limit voltage (VVOUTH) and VOUT lower limit voltage (VVOUTL) are set based on the connected resistors. The SET\_VOUTFB pin outputs a reference voltage for setting the VOUT upper limit voltage and VOUT lower limit voltage. Voltages applied to the SET\_VOUTH and SET\_VOUTL pins are produced by dividing this reference voltage outside the IC.

Figure 5-4. VOUT Setting Block on S6AE102A and S6AE103A Boards



The VOUT upper limit voltage (VVOUTH) and VOUT lower limit voltage (VVOUTL) can be calculated using the following formulas:

VOUT upper limit voltage

$$V_{VOUTH} [V] = \frac{57.5 \times (R2 + R3)}{11.1 \times (R1 + R2 + R3)} = \frac{57.5 \times (4.7M + 8.2M)}{11.1 \times (6.8M + 4.7M + 8.2M)} = 3.392V$$

VOUT lower limit voltage

$$V_{VOUTL} [V] = \frac{57.5 \times (R3)}{11.1 \times (R1 + R2 + R3)} = \frac{57.5 \times (8.2M)}{11.1 \times (6.8M + 4.7M + 8.2M)} = 2.156V$$

### 5.1.3 Storage and VOUT Control Block

This section describes the S6AE102A/S6AE103A storage and VOUT control block as shown in the following diagram. There are two storage pins and two VOUT pins. The solar energy charges both a small capacitor (300 μF) and a large capacitor (330 mF). The large capacitor can be connected or disconnected using SW11.

Figure 5-5. Storage and VOUT Control Block Circuits on S6AE102A and S6AE103A Boards

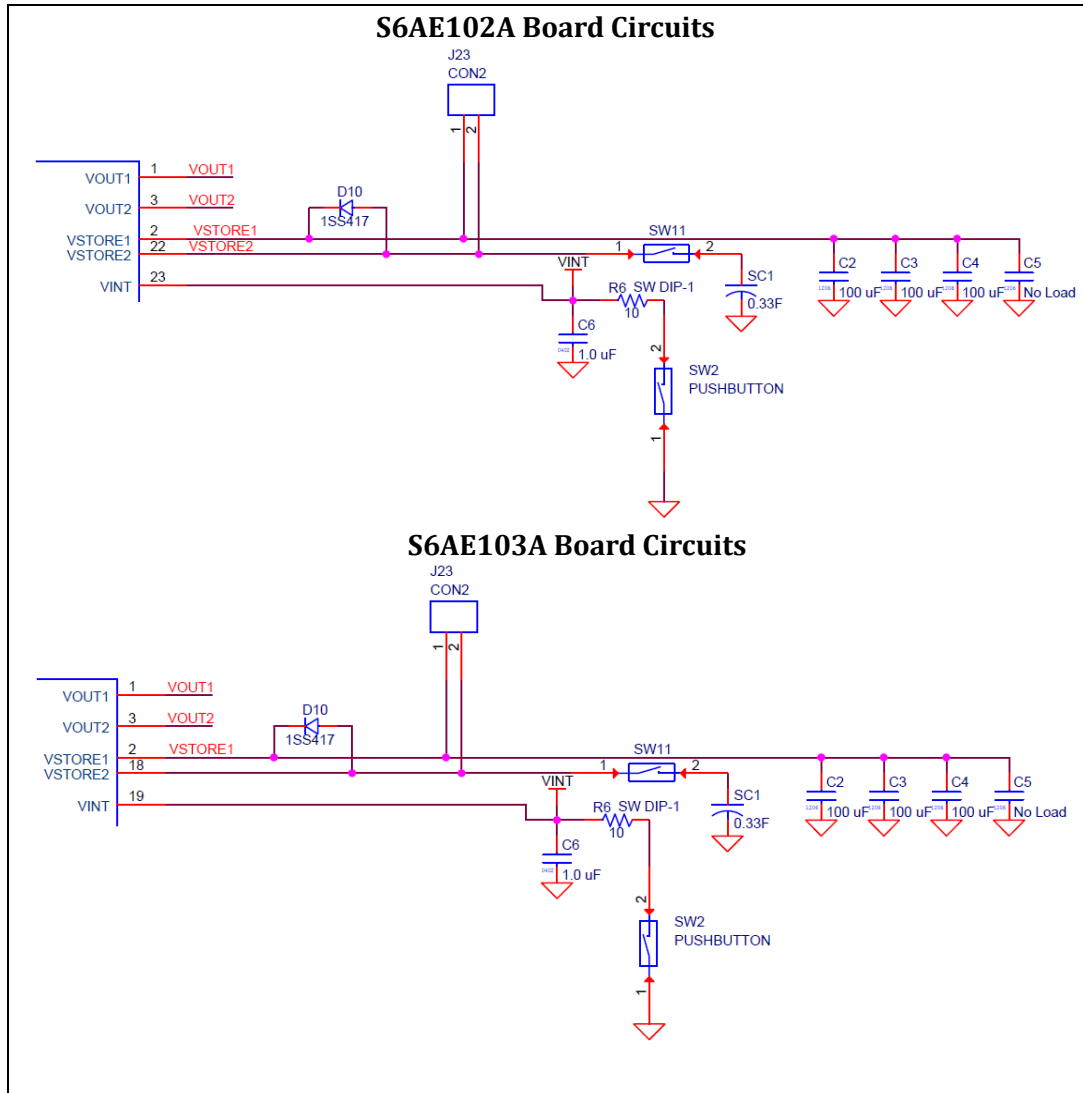


Table 5-2..Pin Description of Storage and VOUT Control Block

Pin Name	Description
VOUT1	Connects to J3.4 and J8.1 Output voltage pin 1 Supplies energy to sensor
VOUT2	Connects to J7.1 Output voltage pin 2 Supplies energy to BLE Supplies energy to VIN_LDO
VSTORE1	Connects to 300- $\mu$ F capacitor Storage output pin 1 For startup storage

Pin Name	Description
VSTORE2	Connects to 330-mF super capacitor Storage output pin 2 For surplus energy storage
VINT	Connects to 1.0- $\mu$ F capacitor Internal circuit storage output pin

### 5.1.4 Internal Timer Setting Block

This section describes the S6AE102A/103A internal timer setting block as shown in the following diagram. There are three pins (CIN0/1/2) to control the VOUT pins.

Figure 5-6. Internal Timer Setting Block Circuits of S6AE102A and S6AE103A Boards

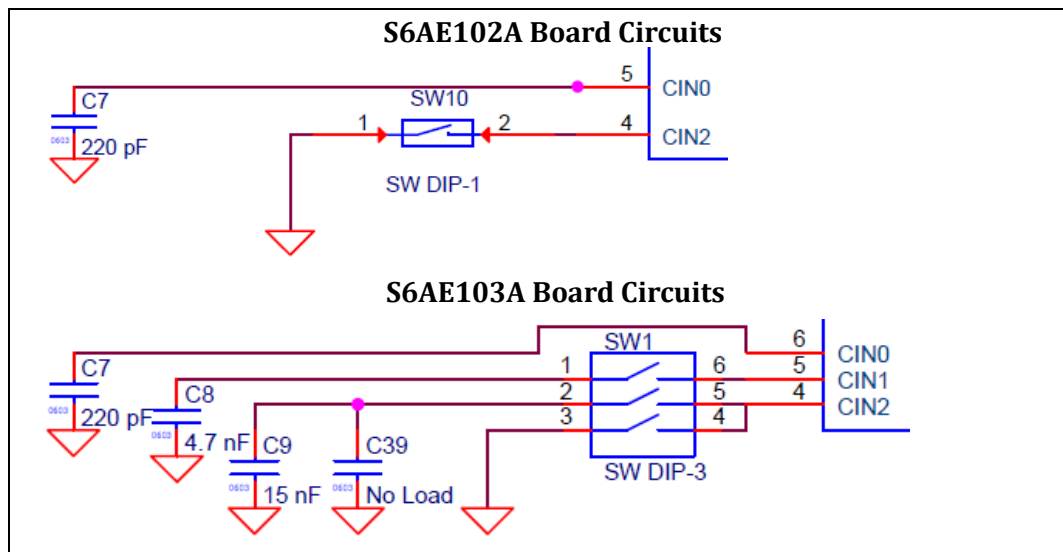


Table 5-3..Pin Description of Internal Timer Setting Block

Pin Name	Description
CIN0 (fixed)	Connects to 220-pF capacitor C7 Timer time 0 (T0) setting pin $T0 = 0.13 \text{ seconds}^1$
CIN1 (103A only)	Connects to 4700-pF capacitor C8 when SW1.1:ON Timer time 1 (T1) setting pin $T1 = 2.58 \text{ seconds}^1$
CIN2 (102A)	Connects to GND when using T1 ( Event Driven mode 1) Open when not using timer ( Energy Driven mode)
CIN2 (103A)	Connects to 15000-pF capacitor C9 and capacitor C39, when SW1.2:ON, SW1.3:OFF Timer time 2 (T2) setting pin $T1 = 8.20 \text{ seconds}^1$

<sup>1</sup> Refer to section 5.1.4.2 Setting the Timer for S6AE103A for detailed calculation formulas.

### 5.1.4.1 Setting the Timer for S6AE102A

The timer times 0 (T0) is set according to the capacitance value at CIN0. The timer function is disabled/enabled by turning SW10 ON/OFF. Timer time 0 (T0) can be calculated using the following formulas:

$$T0[s] = 0.5455 \times C[F] \times 10^9 + 0.01327[s] = 0.5455 \times 220 \times 10^{-12} \times 10^9 + 0.01327[s] = 0.13 [s]$$

### 5.1.4.2 Setting the Timer for S6AE103A

The timer times 0, 1, and 2 (T0, T1, and T2) are set according to the capacitance value at the connections between the CIN0, CIN1, and CIN2 pins and the AGND pin. The timer functions are disabled/enabled by turning the appropriate switches ON/OFF.

Timer time 0 (T0), timer time 1 (T1), and timer time 2 (T2) can be calculated using the following formulas:

$$T0[s] = 0.5455 \times C[F] \times 10^9 + 0.01327[s] = 0.5455 \times 220 \times 10^{-12} \times 10^9 + 0.01327[s] = 0.13 [s]$$

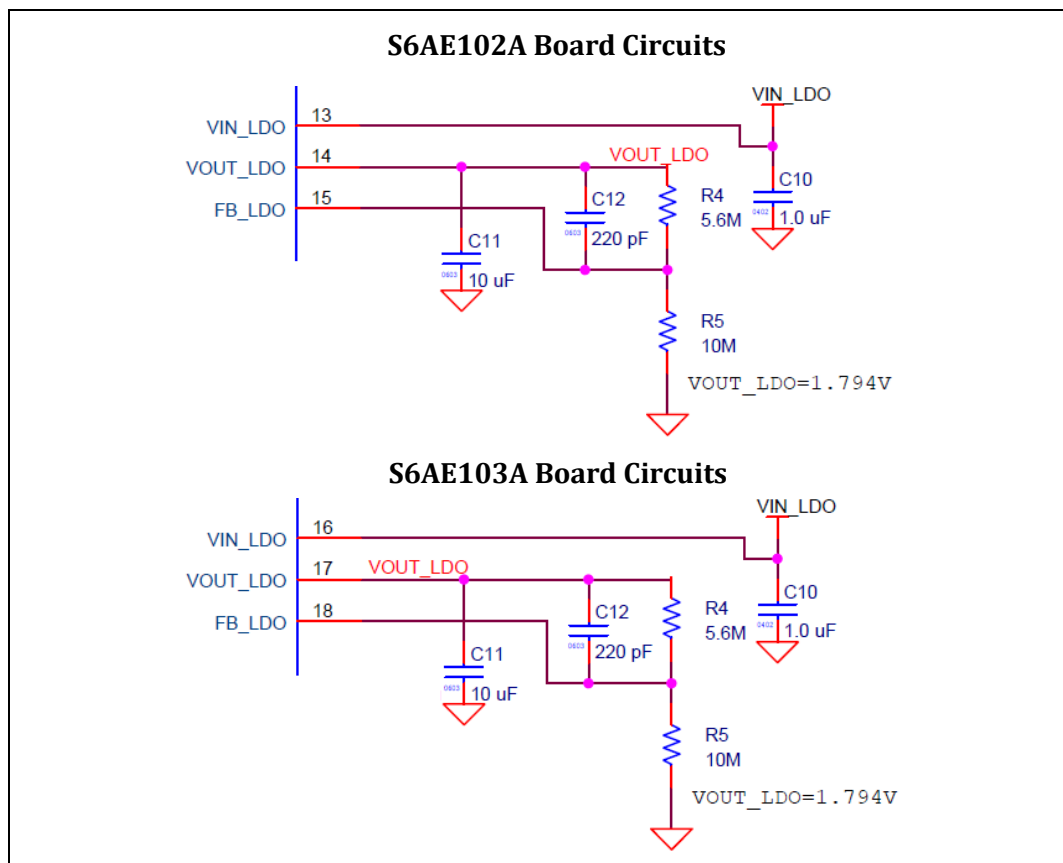
$$T1[s] = 0.5455 \times 4.7 \times 10^{-9} \times 10^9 + 0.01327[s] = 2.58 [s]$$

$$T2[s] = 0.5455 \times 15 \times 10^{-9} \times 10^9 + 0.01327[s] = 8.20 [s]$$

## 5.1.5 LDO Setting Block

This section describes the S6AE102A/103A LDO output settings as shown in the following diagram. The LDO output voltage of S6AE102A/103A can be set by changing the resistors connected to the FB\_LDO pins.

Figure 5-7. LDO Setting Block Circuits of S6AE102A S6AE103A Boards



The LDO output voltage (V<sub>VOUTLD</sub>) can be calculated using the following formula:

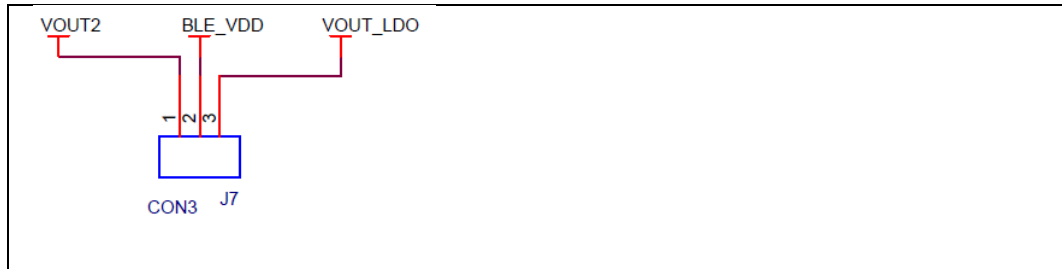
LDO output voltage

$$V_{VOUTLD}[V] = \frac{1.15 \times (R4 + R5)}{R5} = \frac{1.15 \times (5.6M + 10M)}{10M} = 1.794V$$

### 5.1.6 Output Power Selector

This section describes the power source selector for BLE\_VDD. BLE\_VDD is used for supplying power from the EVK to a connected CY8CKIT-042-BLE. VOUT2 is the EVK output, whose high voltage is set to 3.3 V. VOUT\_LDO is the LDO output, which is set to 1.8 V. VOUT2 is output to BLE\_VDD when J7 1-2 are shorted. LDO is output to BLE\_VDD when J7 2-3 are shorted.

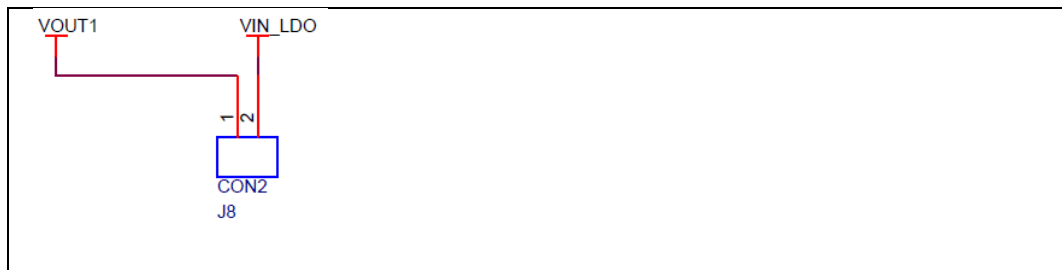
Figure 5-8. Output Power Selector



### 5.1.7 LDO Input Power Selector

Connect J8 1-2 when you use the LDO. The LDO input is supplied from VOUT1 of the S6AE102A/103A.

Figure 5-9. LDO Input Power Selector

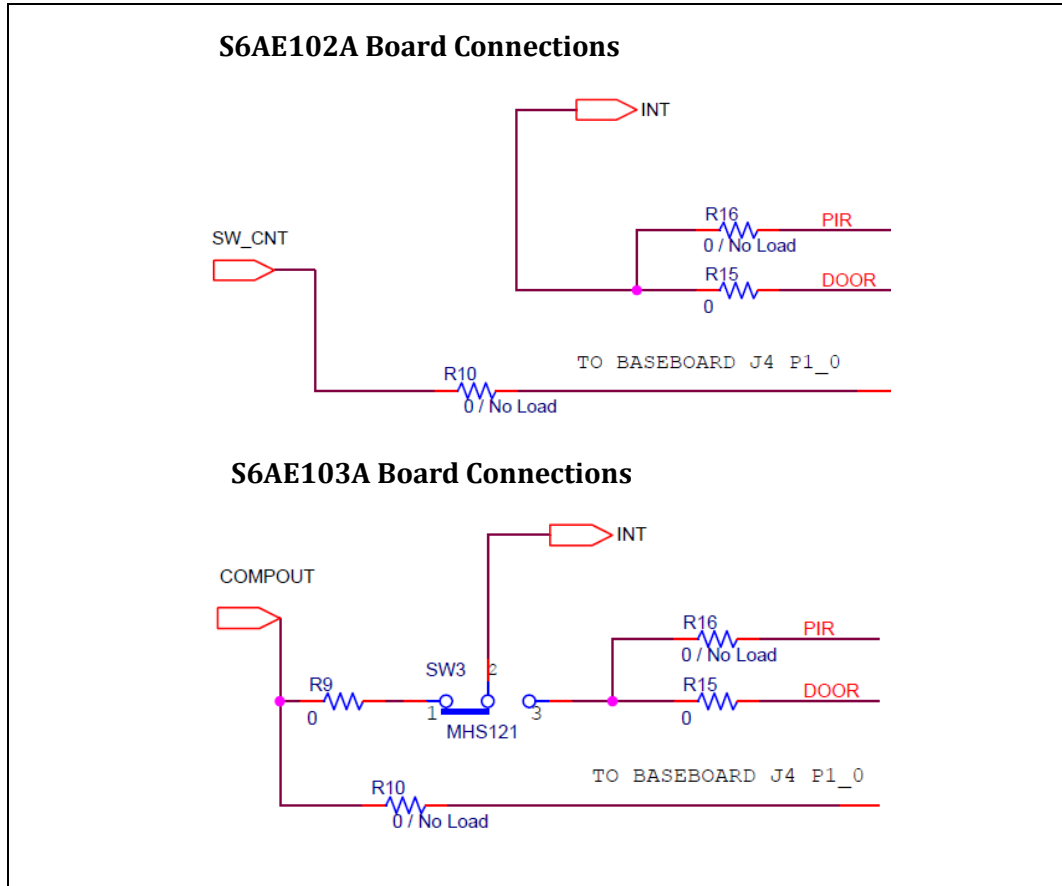




### 5.1.8 INT Selector

The S6AE102A INT pin is connected to the door sensor output. The S6AE103A INT pin is connected to switch SW3. It selects the connection of the INT pin to either DOOR or PIR (Light Sensor).

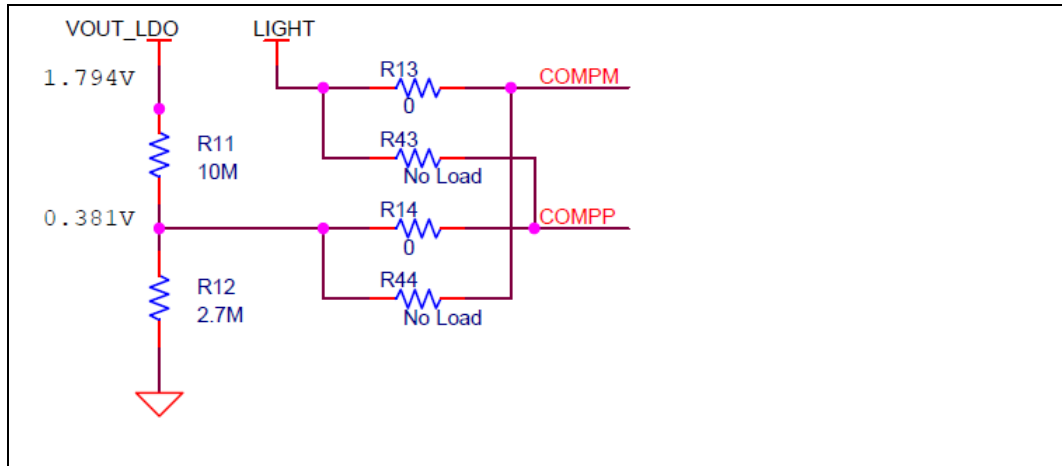
Figure 5-10. INT Selection



### 5.1.9 Comparator

Only S6AE103A includes a comparator, which can set the flexible comparison signal level. The light sensor is connected to the negative input of the comparator, and the divided LDO output is connected to the positive input of the comparator as the reference voltage. At the initial board settings, the comparator outputs a high value to SW\_CNT/COMPOUT when the light sensor output LIGHT is higher than 0.381 V.

Figure 5-11. Comparator Circuit

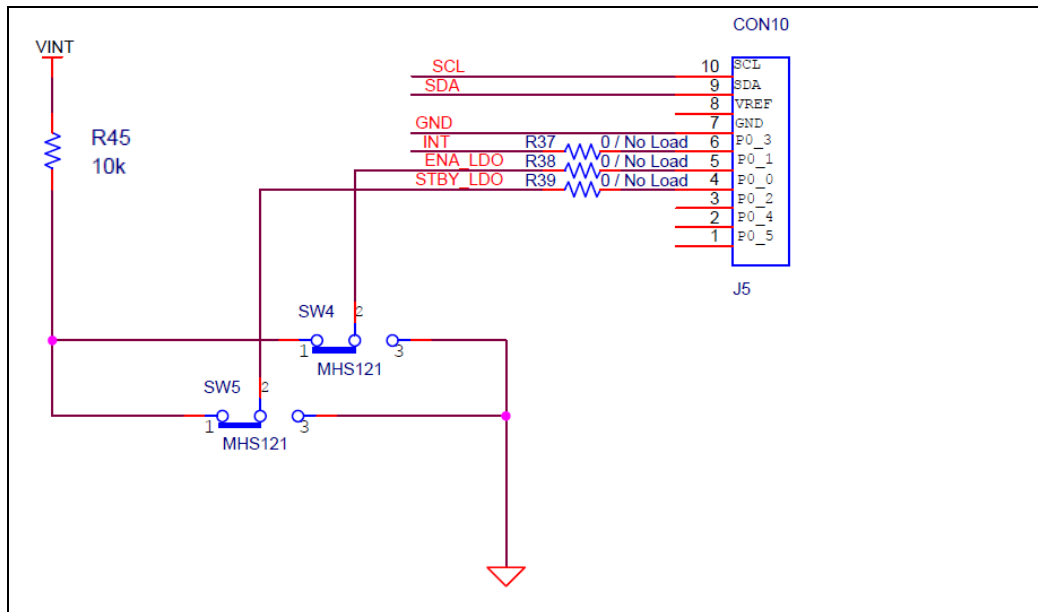


### 5.1.10 Control Block

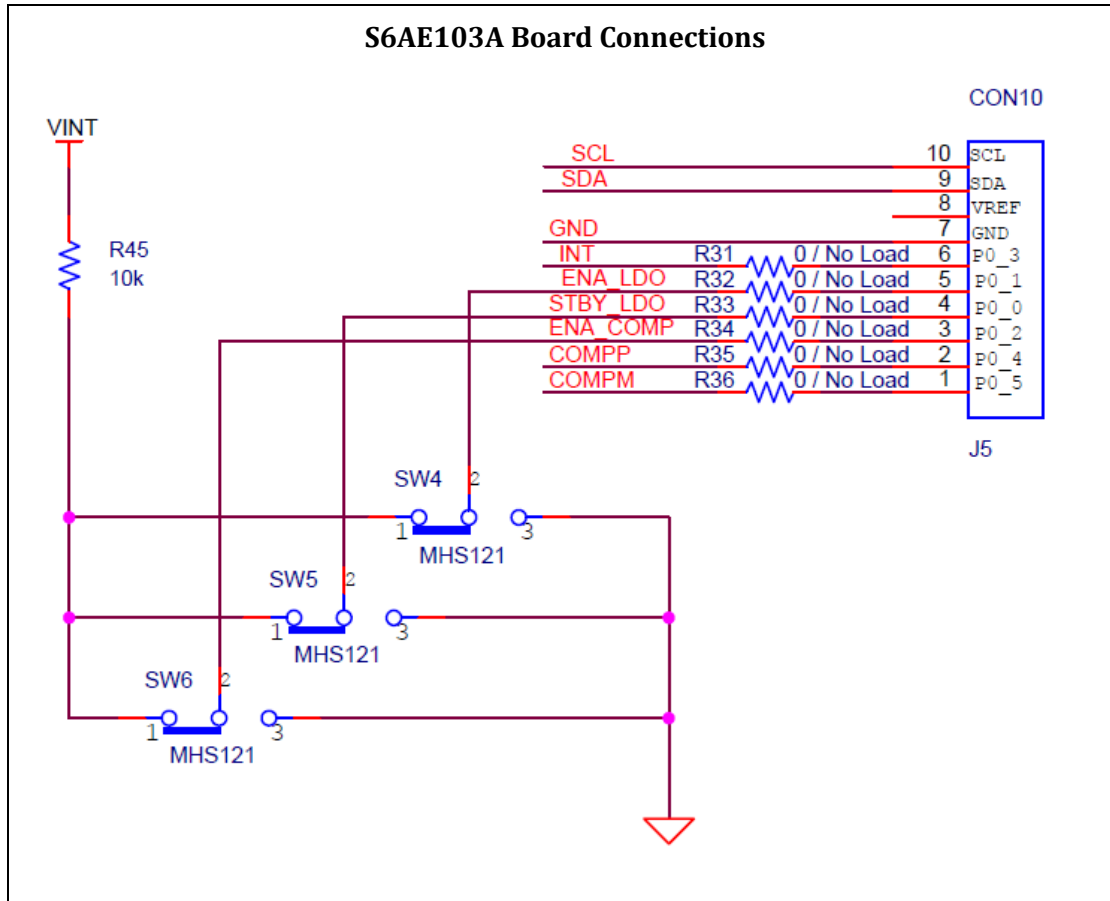
This energy harvesting PMIC includes an LDO. There are two operating modes: standby mode for operating at low power consumption, and normal mode in which the maximum output current is 10 mA, which are set at the STBY\_LDO pin. Refer to the table below for the LDO output mode.

Only S6AE103A includes a comparator. It compares the voltage at the COMPP pin and the COMPM pin when the ENA\_COMP pin is high, and outputs the results to the SW\_CNT/COMPOUT pin.

Figure 5-12. S6AE102A Board Connections



MODE	SW4 ENA_LDO	SW5 STBY_LDO	Notes
LDO not used	Lo	NA	-
LDO used (standby mode)	High	Low	$I_{OUTLD2}=0.1\text{mA}$ , $I_{INLD2}=0.4\mu\text{A}$
LDO used (normal mode)	High	High	$I_{OUTLD1}=10\text{mA}$ , $I_{INLD2}=6\mu\text{A}$



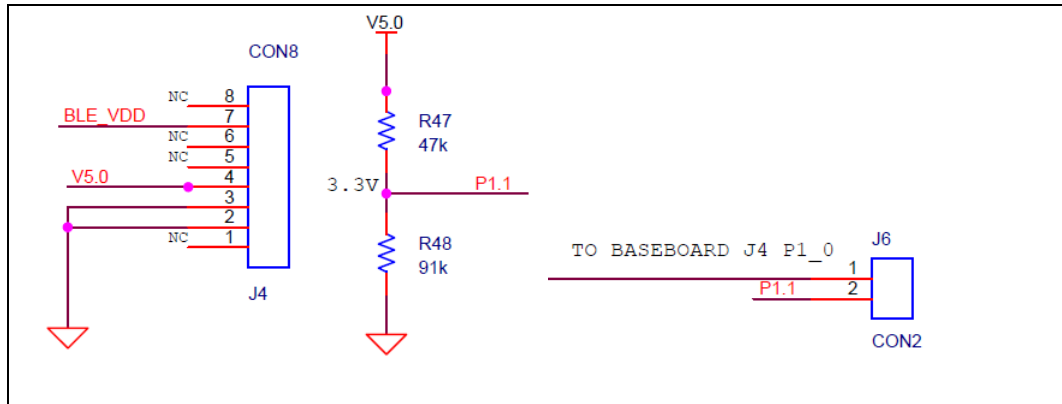
MODE	SW4 ENA_LDO	SW5 STBY_LDO	Notes
LDO not used	Lo	NA	-
LDO used (standby mode)	High	Low	$I_{OUTLD2}=0.1\text{ mA}$ , $I_{INLD2}=0.4\ \mu\text{A}$
LDO used (normal mode)	High	High	$I_{OUTLD1}=10\text{ mA}$ , $I_{INLD2}=6\ \mu\text{A}$

MODE	SW6 ENA_COMP	Notes
Comparator not used	Lo	-
Comparator used	High	$I_{INCP} = 20\text{ nA}$

### 5.1.11 VBUS Detector

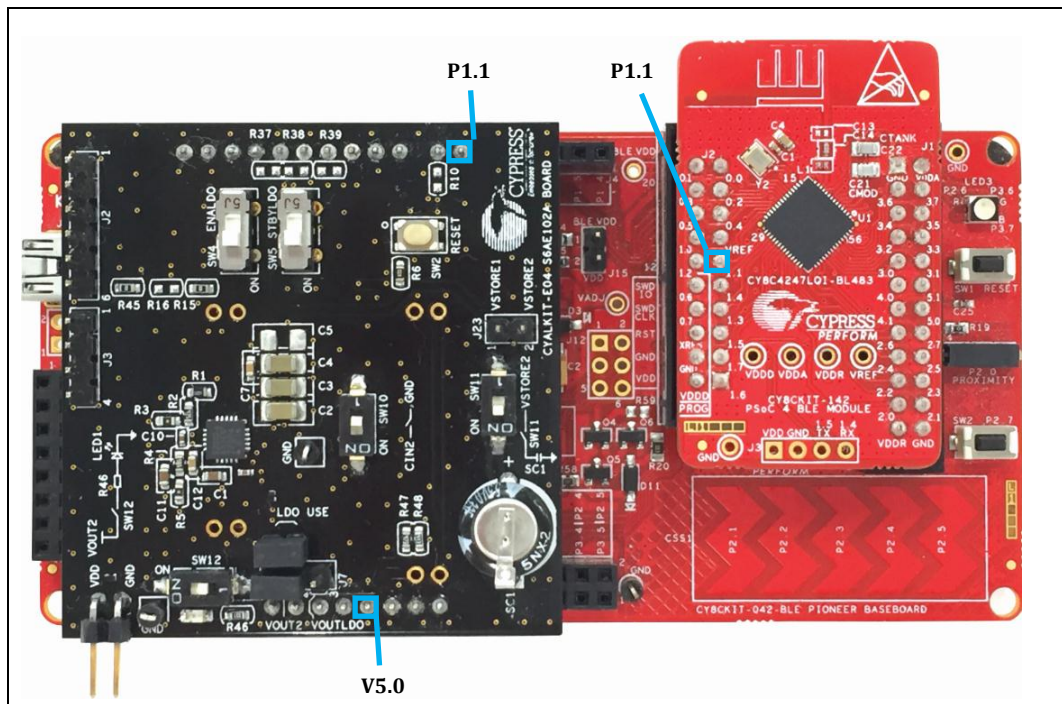
When 5 V is input to J4.4, this circuit outputs 3.3 V to J6.2. This function is used for debugging the PSoC 4 / PRoC BLE module.

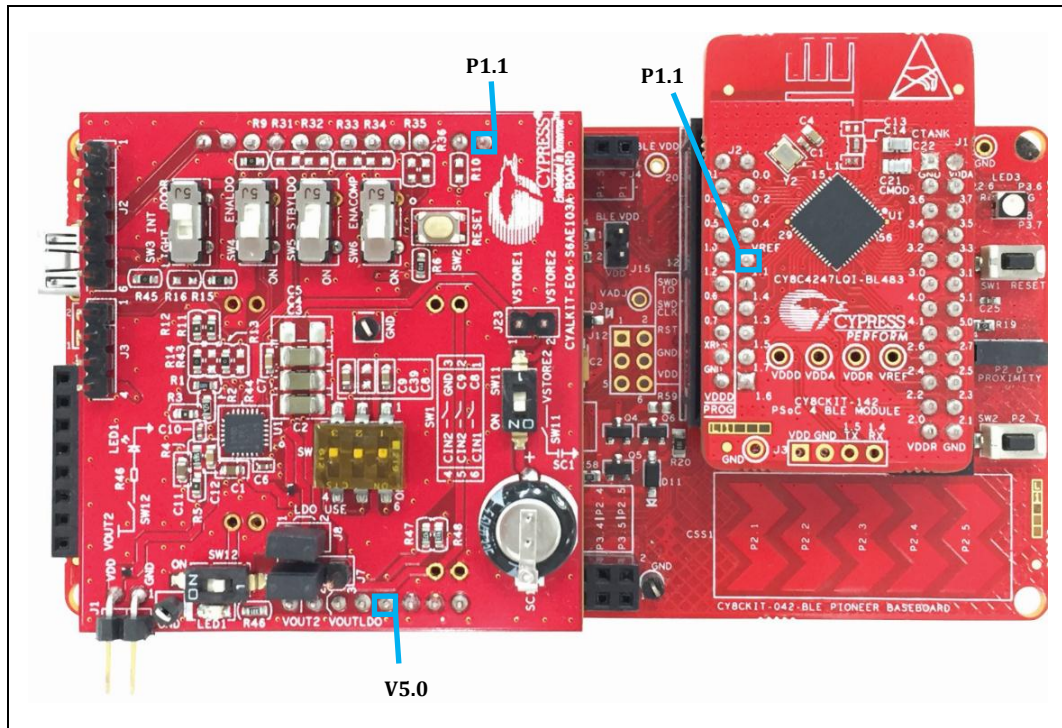
When USB is connected to a CY8CKIT-042-BLE, the VBUS voltage is output to V5.0 through a diode. The PSoC 4 / PRoC BLE module can then detect whether USB is connected by monitoring the voltage on J2.11.



CY8CKIT-042-BLE	CYALKIT-E04
J1.4 V5.0	J4.4 V5.0

CY8ALKIT-E04	CY8CKIT-042-BLE	PSOC 4 BLE MODULE PRoC BLE MODULE
J6.2 P1.1	J4.7 P1_1   J11.11 P1_1	J2.11 P1.1





### 5.1.12 Mode Switches

Table 5-4, Table 5-4 lists the switch positions for each operation mode. For the light sensor operation, SW4/SW5/SW6 should be ON because the light sensor is powered by the LDO and the comparator compares the light sensor signal.

Table 5-4. Switch Description of S6AE102A Board

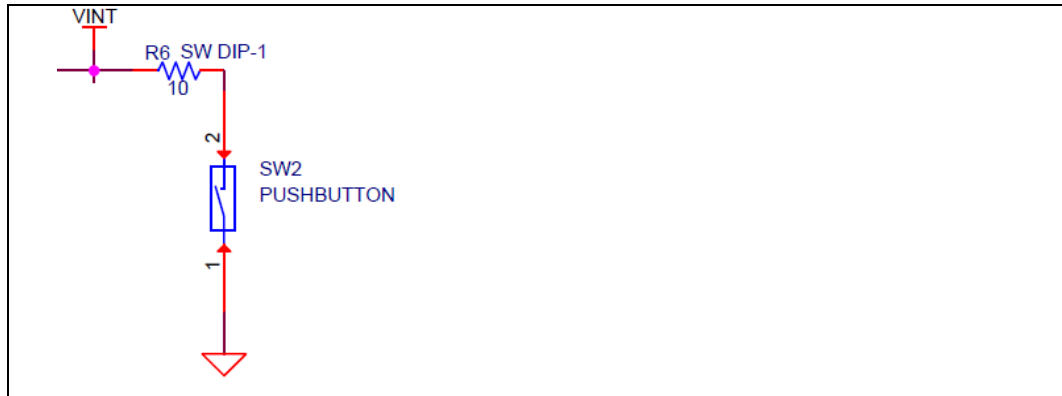
MODE	SW10	SW4	SW5
Normal	OFF	NA	NA
DOOR	ON	NA	NA

Table 5-5. Switch Description of S6AE103A Board

MODE	SW1-1	SW1-2	SW1-3	SW3	SW4	SW5	SW6
Normal	OFF	OFF	OFF	DOOR	NA	NA	NA
DOOR	OFF	OFF	ON	DOOR	NA	NA	NA
LIGHT	ON	OFF	OFF	LIGHT	ON	ON	ON
TIMER	ON	ON	OFF	DOOR	NA	NA	NA

### 5.1.13 Reset Switch

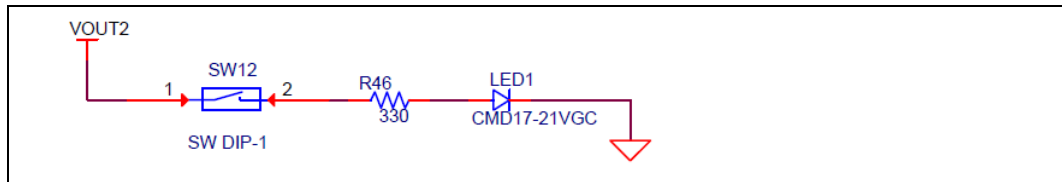
Push the reset switch SW2 when changing the IC operation mode. Ensure that VDD = OPEN, VBAT = OPEN, and SW11 = OFF before pushing the reset switch SW2.



### 5.1.14 Switch for Status LED

SW12 is used to enable or disable the status LED. Turn OFF SW12 to reduce current consumption. The current is roughly estimated by the following equation.

$$I = V_{OUT12}/R_{46} = 3.3 \text{ V}/330 \text{ ohm} = 10 \text{ mA}$$

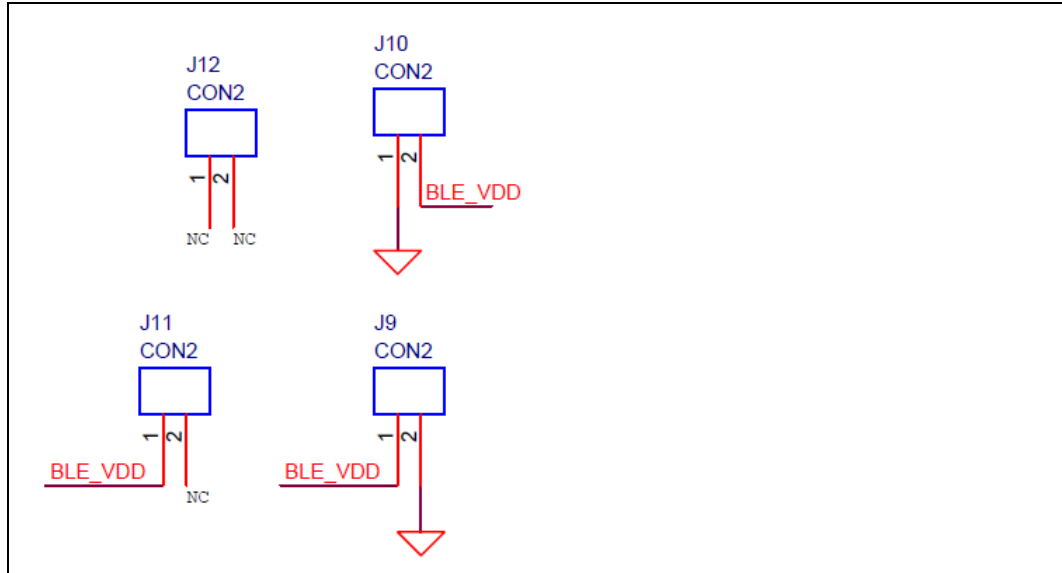


### 5.1.15 Unimplemented Pins

Table 5-6 lists the expansion pins that are not implemented.

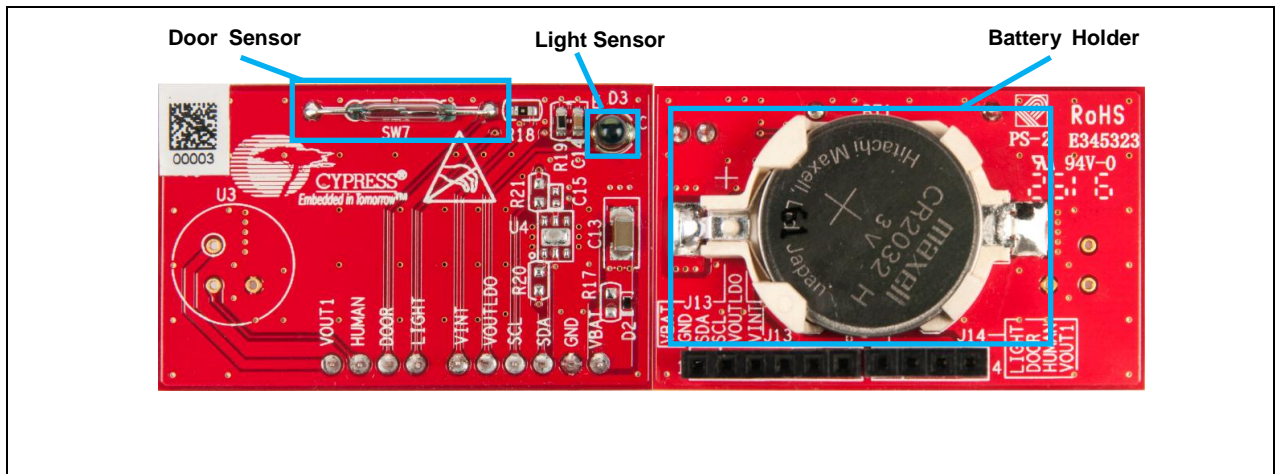
Table 5-6. Description of Unimplemented Pins

Pin Number	Description
J9 1	BLE_VDD (J4 7)
J9 2	GND
J10 1	GND
J10 2	BLE_VDD (J4 7)
J11 1	BLE_VDD (J4 7)
J11 2	NC
J12 1	NC
J12 2	NC



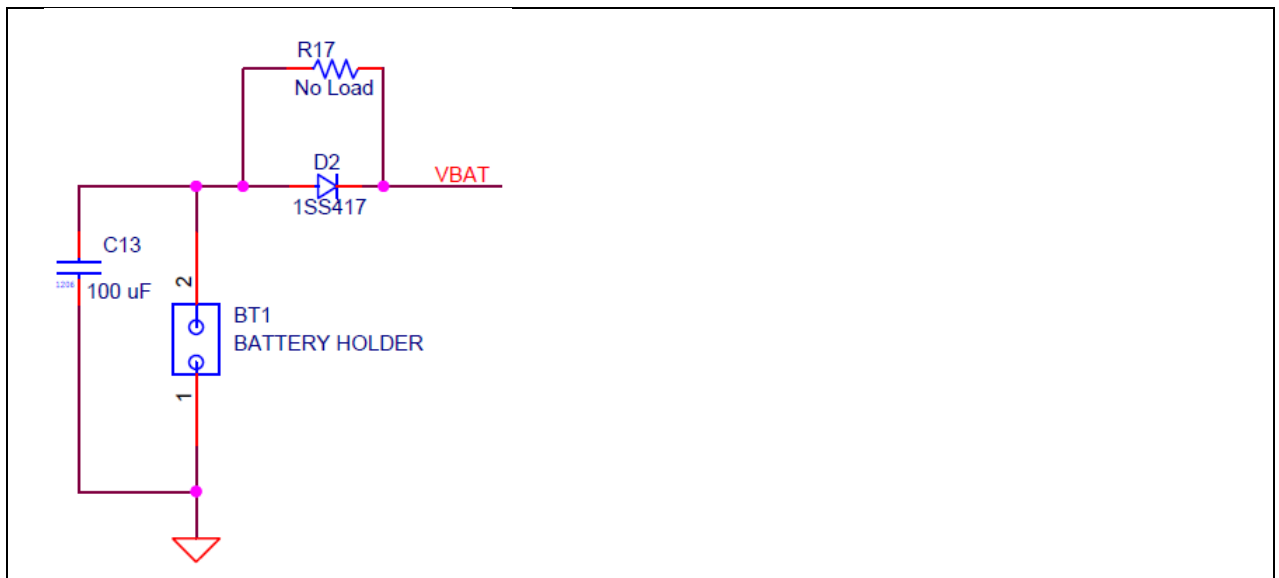
## 5.2 Sensor Board

The sensor board consists of the blocks shown in the following diagram.



### 5.2.1 Battery Holder

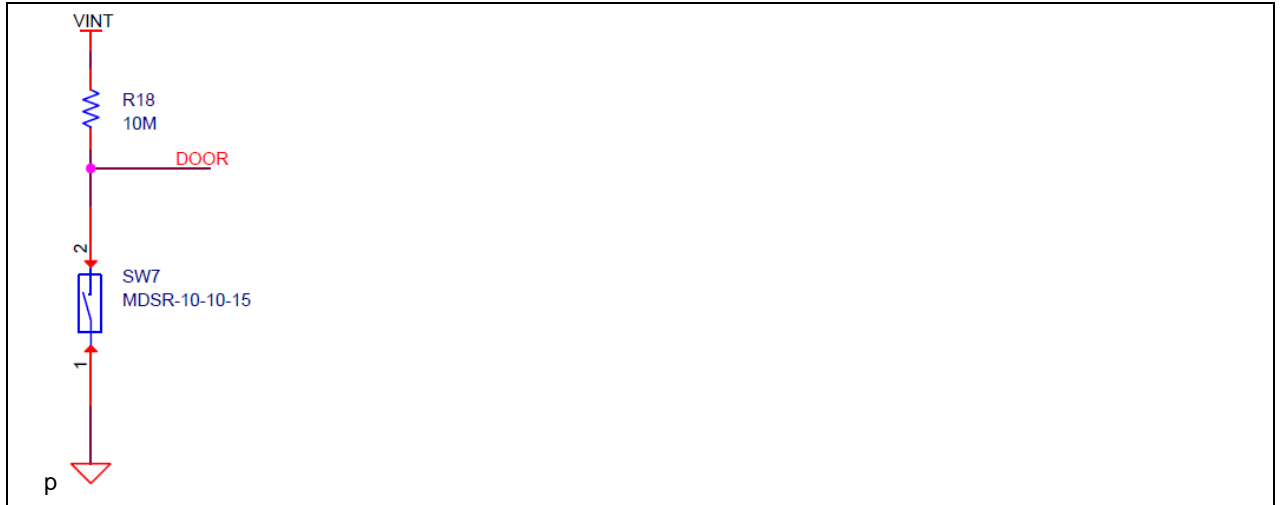
The sensor board has a battery holder for primary battery input as shown below. It can connect a primary battery such as a CR2032 3-V coin cell.



### 5.2.2 Magnetic Door Sensor

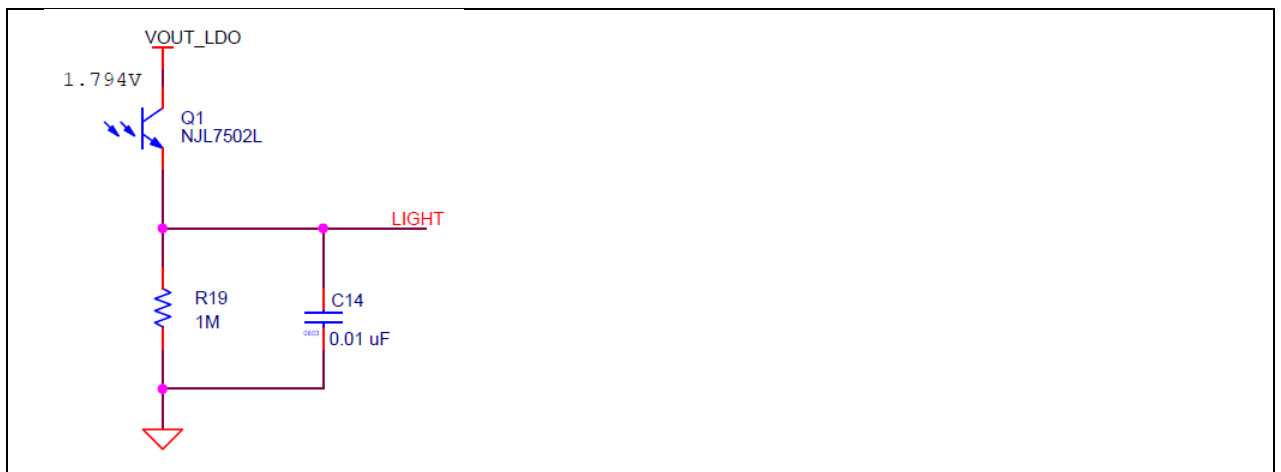
The door sensor is a subminiature, normally open switch with a 10.16-mm long x 1.80-mm diameter (0.400-inch x 0.071-inch) glass envelope, capable of switching 200 Vdc at 10 W. It has a high insulation resistance of  $10^{12}$  ohms minimum and a low contact resistance of less than 120 milliohms.





### 5.2.3 Ambient Light Sensor

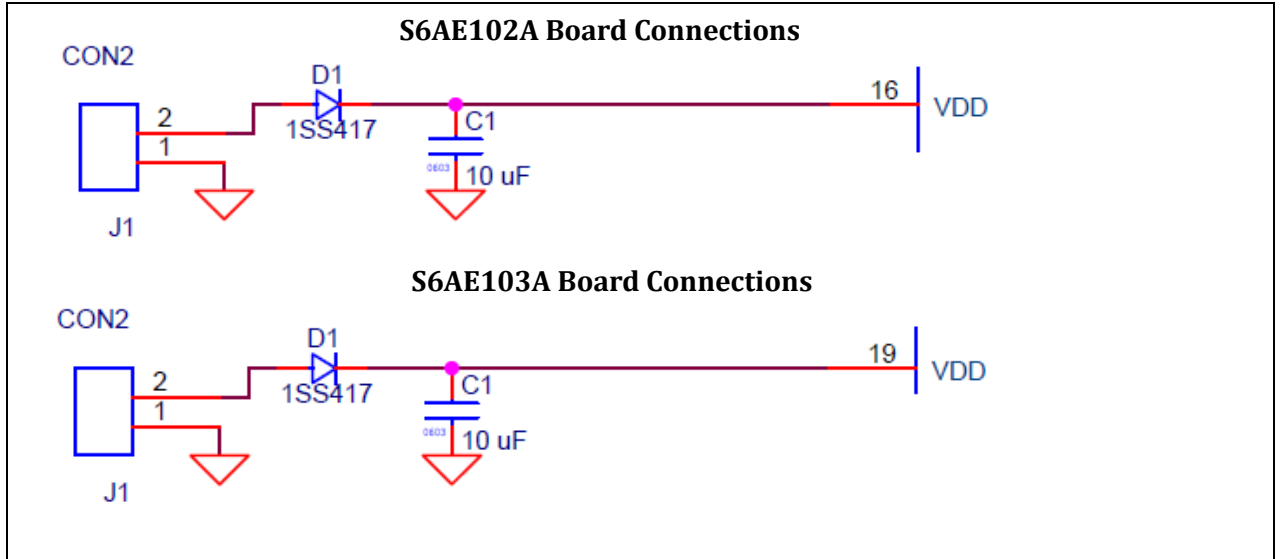
The light sensor is a phototransistor whose spectral response is similar to that of the human eye. The LIGHT outputs high when the ambient light sensor is placed under office light. The LIGHT outputs low when it falls under about 100 lux.



### 5.3 53 x 23 mm Solar Cell

The solar cell (AM-1801) connects to the S6AE102A/103A VDD pin via a diode for reverse current protection and a 10- $\mu$ F capacitor, as shown in the following diagram.

Figure 5-13. Solar Cell Connections



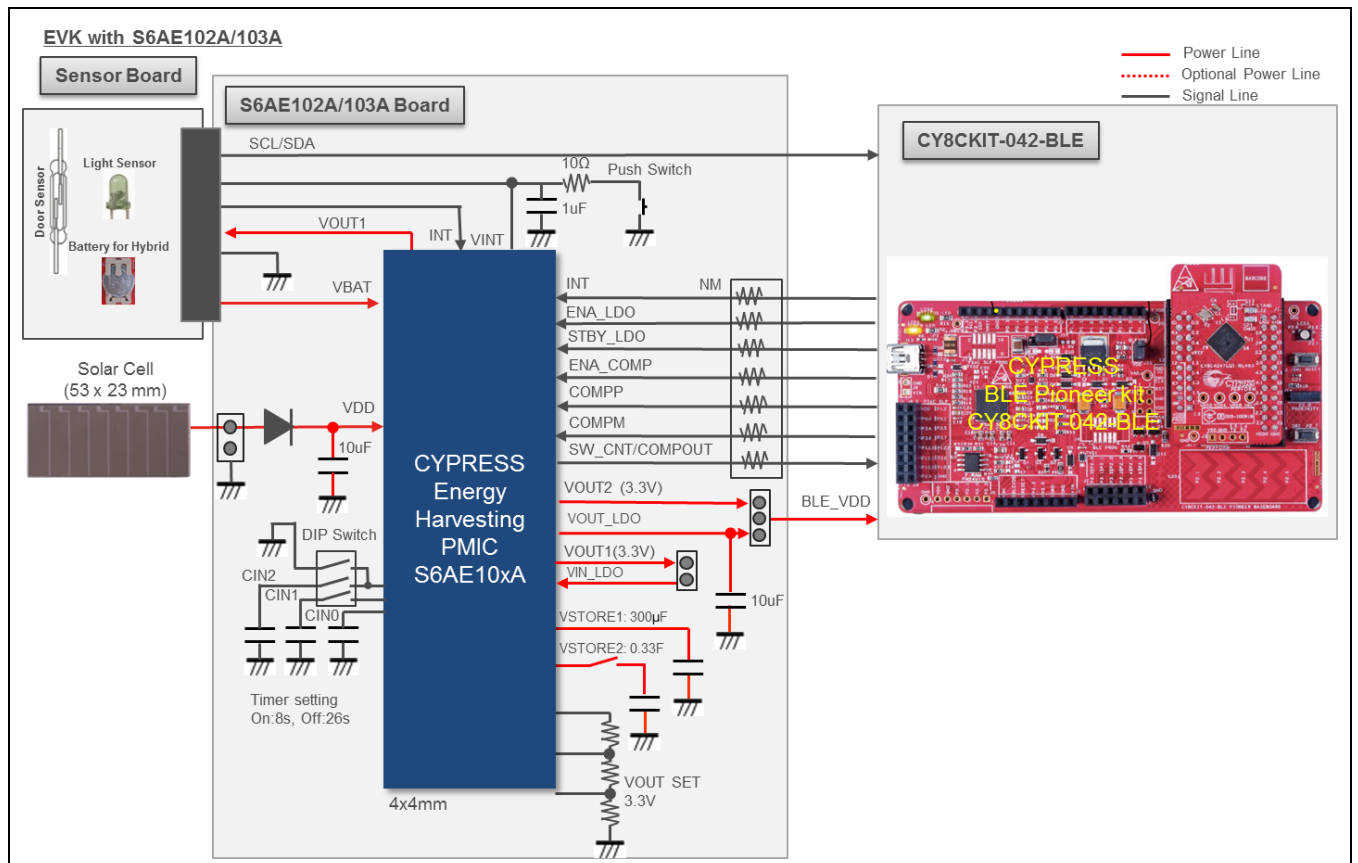
# A. Advanced Topics



## A.1 Using CYALKIT-E04 with the CY8CKIT-042-BLE Bluetooth Low Energy Kit

CYALKIT-E04 can be used to get started with S6AE102A and S6AE103A along with a CY8CKIT-042-BLE Bluetooth Low Energy kit. When this kit is connected to CY8CKIT-042-BLE, the BLE Module can operate with the energy from the energy harvesting device.

Figure 5-14. Connecting CYALKIT-E04 with the CY8CKIT-042-BLE Bluetooth Low Energy Kit



## A.2 Arduino Uno-Compatible Headers

The CYALKIT-E04 S6AE102A/103A board is Arduino Uno-compatible.

Table A-1. J4 Arduino-Compatible Header Pin Map

Pin No.	Arduino Pin	CY8CKIT-042-BLE	CYALKIT-E04 S6AE102A Board	CYALKIT-E04 S6AE103A Board
1	VIN	VIN	NC	NC
2	GND	GND	GND	GND
3	GND	GND	GND	GND
4	5V	5V	5V	5V
5	3.3V	3.3V	NC	NC
6	RESET	RESET	NC	NC
7	IOREF	BLE.VDD	BLE.VDD	BLE_VDD
8	NC	NC	NC	NC

Table A-2. J5 Arduino-Compatible Header Pin Map

Pin No.	Arduino Pin	CY8CKIT-042-BLE	CYALKIT-E04 S6AE102A Board	CYALKIT-E04 S6AE103A Board
1	D8	P0[5]	NC	COMPM
2	D9	P0[4]	NC	COMPP
3	D10	P0[2]	NC	ENA_COMP
4	D11	P0[0]	STBY_LDO	STBY_LDO
5	D12	P0[1]	ENA_LDO	ENA_LDO
6	D13	P0[3]	INT	INT
7	GND	GND	GND	GND
8	AREF	VREF	NC	NC
9	SDA	P3[4]	SDA	SDA
10	SCL	P3[5]	SCL	SCL

Table A-3. J6 Arduino-Compatible Header Pin Map

Pin No.	Arduino Pin	CY8CKIT-042-BLE	CYALKIT-E04 S6AE102A Board	CYALKIT-E04 S6AE103A Board
1	D7	P1[0]	SW_CNT	COMPOUT
2	D6	P1[1]	P1.1	P1.1

### A.3 Programming Using PSoC programmer

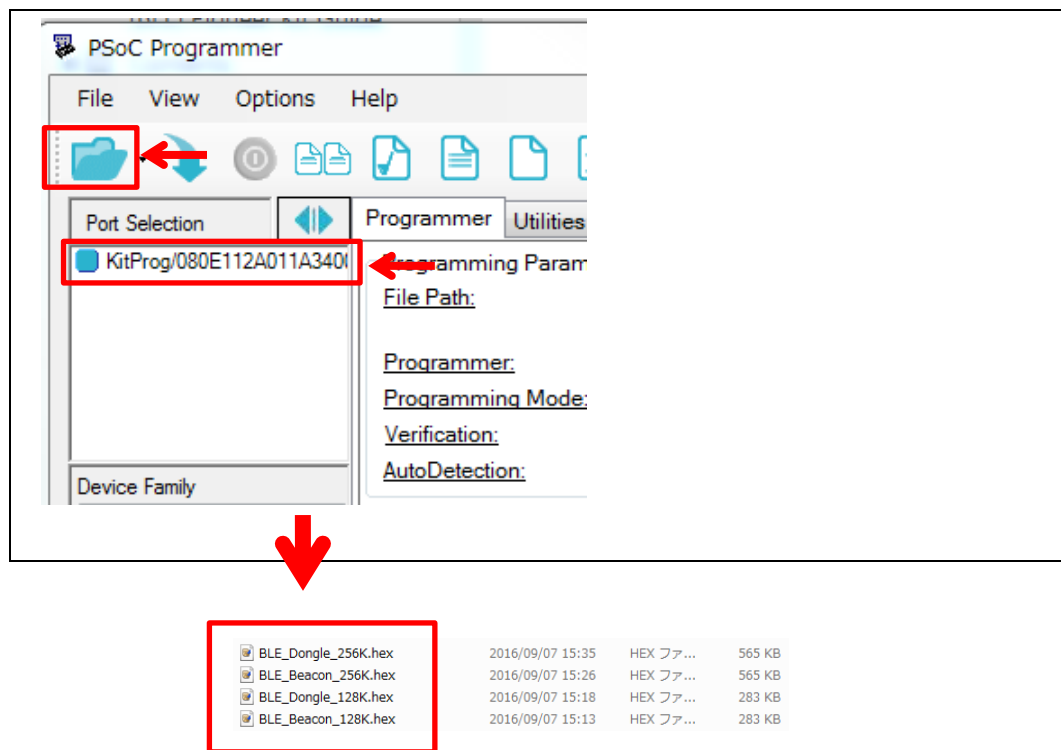
This kit provides an example project to use the CY8CKIT-042-BLE Bluetooth Low energy kit as a solar-powered beacon. CY8CKIT-042-BLE comes with both a development kit and a separate dongle. The kit connects to CY8CKIT-E04 while the dongle optionally connects to your computer to act as a receiver for the beacon. Any smartphone beacon app can also be used instead of the dongle if desired.

PSoC Programmer (3.24 or later) can be used to program the hex files provided with the software into both the BLE module and BLE dongle. To do so, follow these steps.

1. Connect CY8CKIT-042-BLE or the dongle to your computer's USB port and open PSoC Programmer from **Start > All Programs > Cypress > PSoC Programmer <version> > PSoC Programmer <version>**.
2. Click the **File Load** button at the top-left corner of the window. Browse for the required hex file and click **Open**. The example hex files are located in the Hex Files folder.

<Install directory>\CYALKIT-E04 S6AE102A and S6AE103A Kit<version>\Firmware\Hex Files

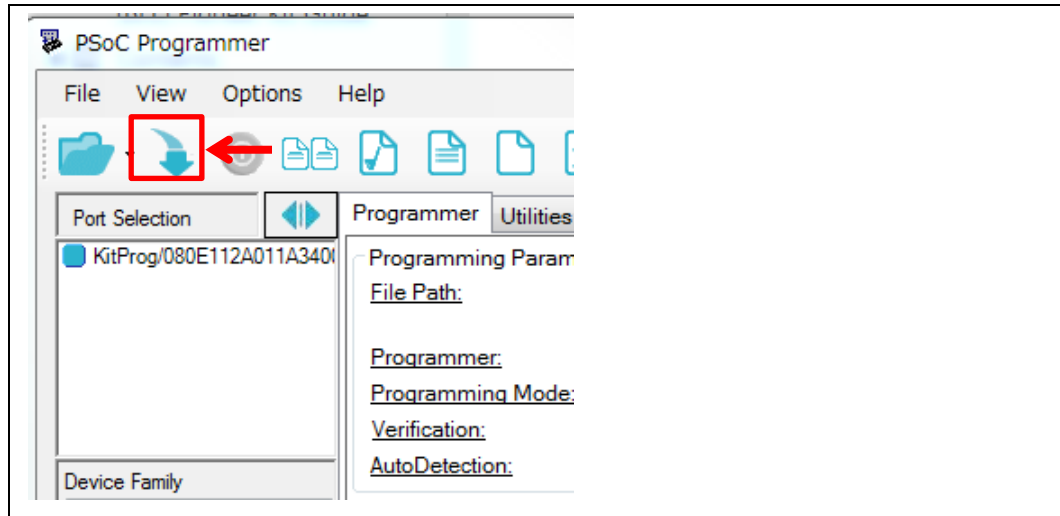
Figure 5-15. Selecting the HEX Files



- Click the **Program** button to start programming the kit with the selected file.

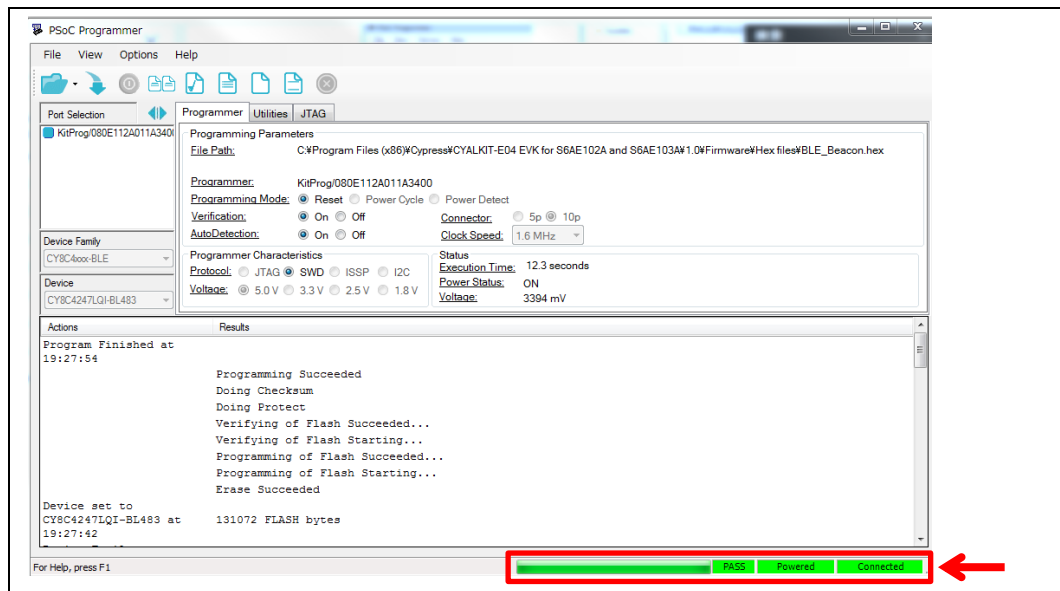
**Note:** If the hex file does not match the device selected, then PSoC Programmer will throw an error of device mismatch and terminate programming. The beacon hex file is intended for the red PSoC BLE module that comes with CY8CKIT-042-BLE, not the black PSoC BLE module.

Figure 5-16. Programming the Kit



- When programming is finished successfully, indicated by a PASS message on the status bar, the BLE Module or BLE Dongle is ready for use. Close PSoC Programmer.

Figure 5-17. Programming Successful Message



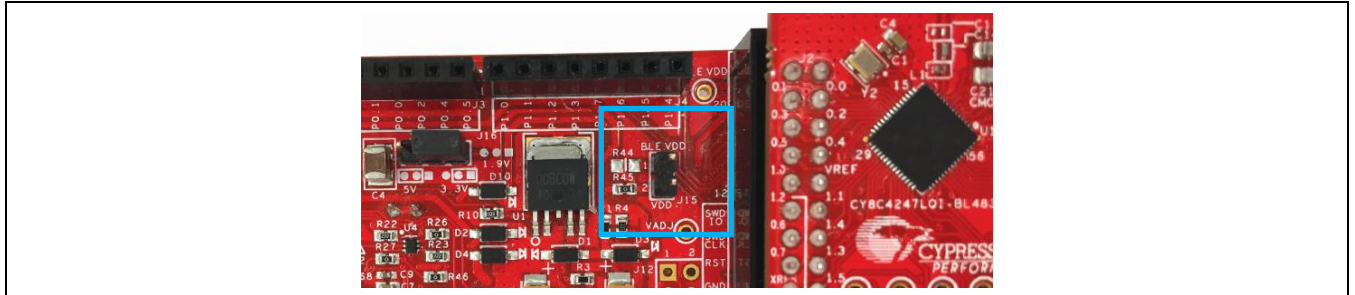
**Note:** This kit also provides the firmware projects for programming and debugging using PSoC Creator. For details of how to use PSoC Creator and the associated projects, see the CY8CKIT-042-BLE kit guide. The PSoC Creator projects can be found in:

*<Install directory>\CYALKIT-E04 S6AE102A and S6AE103A Kit\<version>\Firmware*

### A.4 Solar-Powered Beacon Operation with CY8CKIT-042-BLE

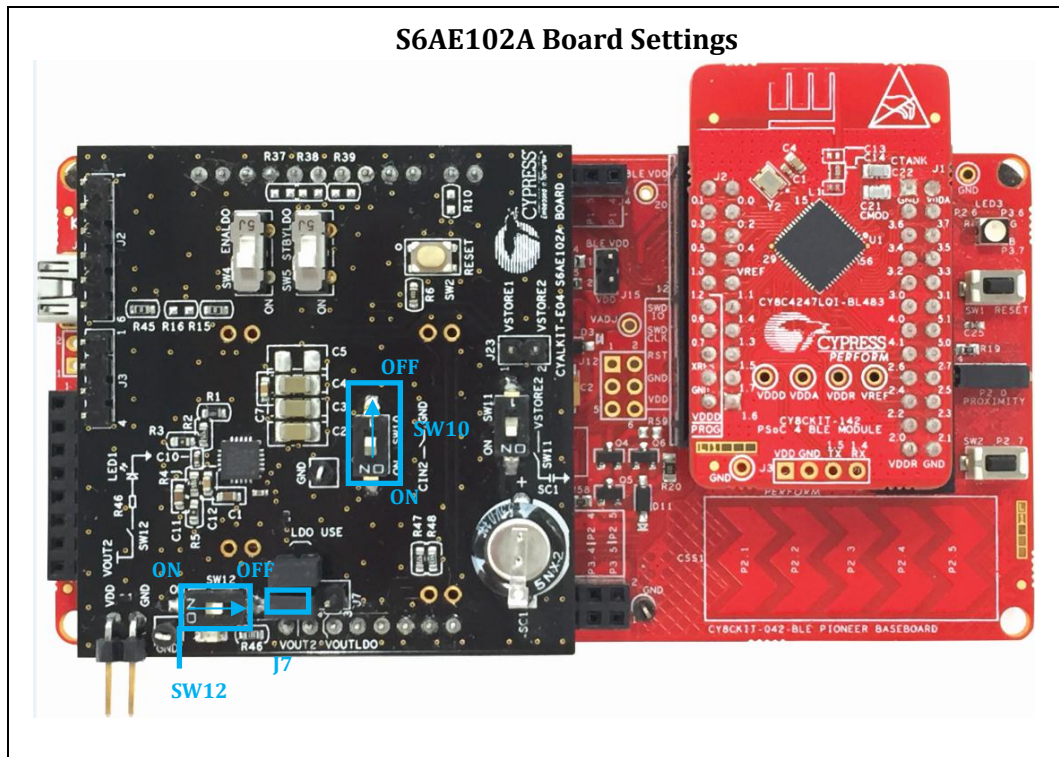
1. Program CY8CKIT-042-BLE using the instructions in the previous section.
2. Disconnect the kit from the USB port.
3. Set the CY8CKIT-042-BLE Pioneer baseboard J15 to OPEN. This will allow CY8CKIT-E04 to power just the BLE module rather than the entire baseboard.

Figure 5-18. Setting the CY8CKIT-042-BLE Pioneer Baseboard to Power Only the BLE Module



4. Connect the S6AE102A/103A board to the BLE Pioneer Kit.
5. For the S6AE102A board: set switch SW10 to OFF. Set SW12 to OFF.
6. Set J7 to pins 1 and 2.

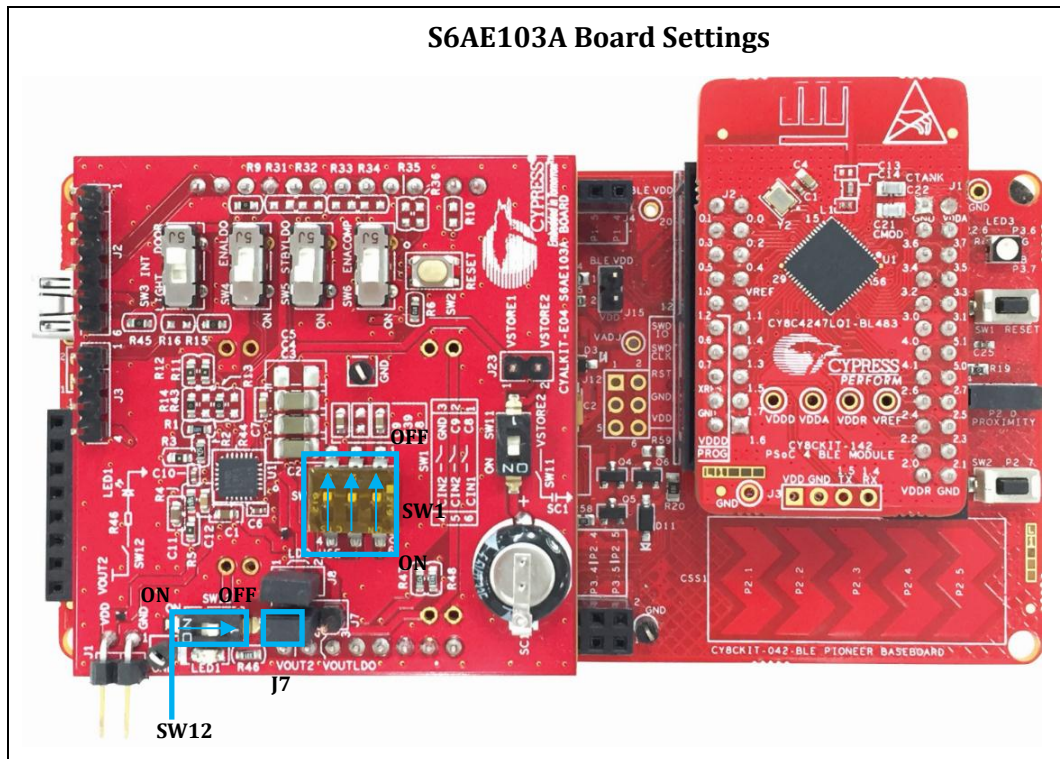
Figure 5-19. Settings on the S6AE102A Board



4. For the S6AE103A board: set switch SW1 as follows: 1: OFF, 2: OFF, 3: OFF. Set SW12 to OFF.
5. Connect J7 to pins 1 and 2.



Figure 5-20. Settings on the S6AE103A Board



6. Connect the solar module to the S6AE102A/103A board. The red cable is connected to J1.2.
7. If you have already reprogrammed the BLE dongle, connect it to a USB port on your computer. You can alternatively use a smartphone beacon application to locate the beacon instead of the dongle. If so, you can skip the remaining steps.

Figure 5-21. Connecting the USB Dongle to a PC USB Port

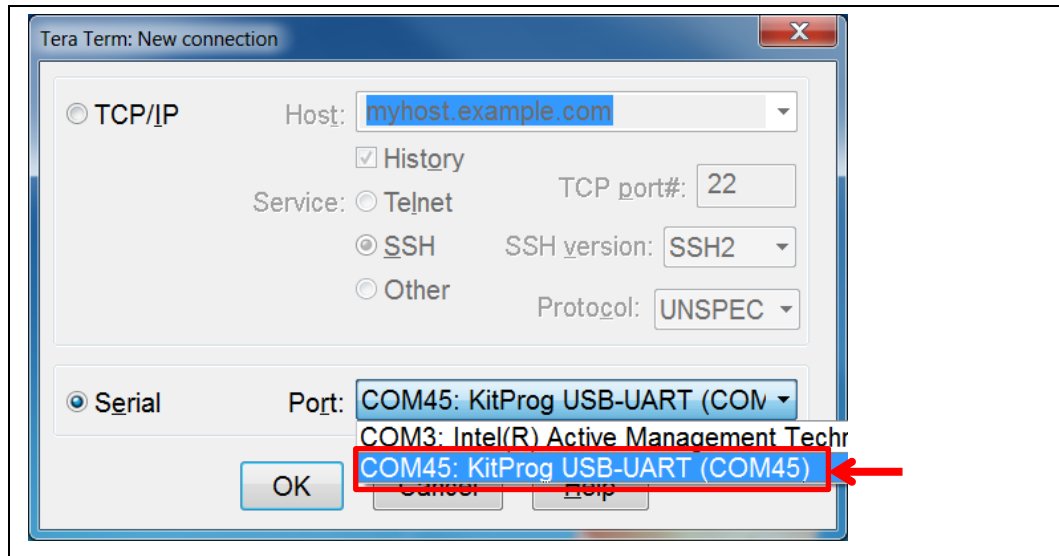


8. User LED1 on the BLE dongle will blink at intervals of transmitting from the BLE Module.
9. Confirm that a COM port (KitProg USB-UART) was added in the **Device Manager**:
  - Open Device Manager.
  - Under **Ports (COM & LPT)**, confirm that a KitProg USB-UART was added. Note the COM number (COMxxx).
10. Download and install Tera Term from the following web page (you may alternatively use any other serial terminal program):
 

<https://ttssh2.osdn.jp/index.html.en>

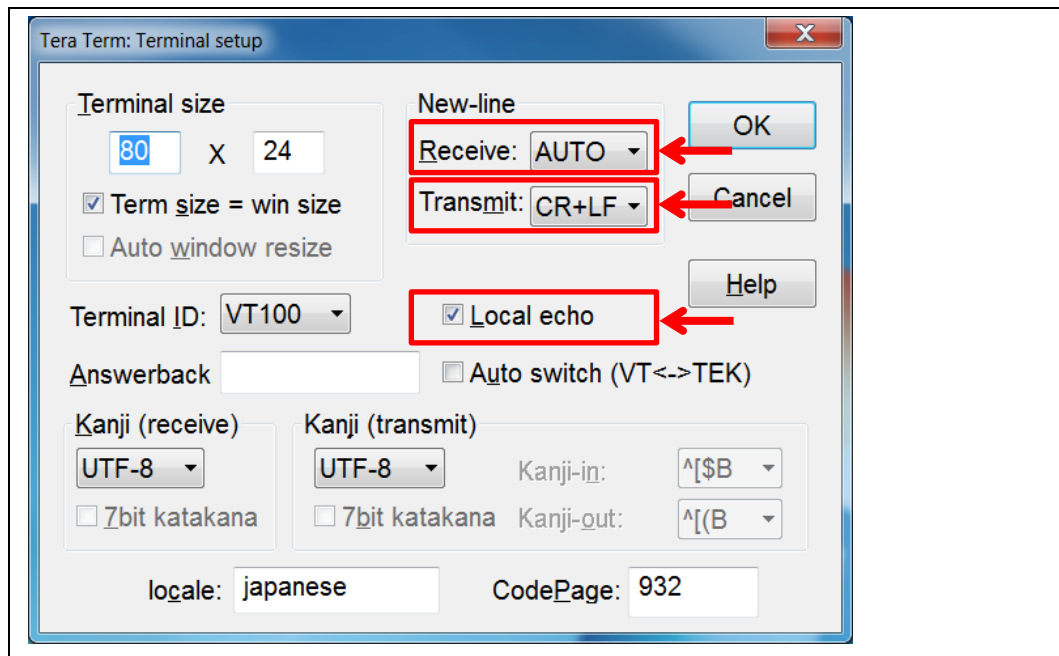
Note that the kit guide is using Tera Term 4.92 version.
11. After it is installed, run Tera Term:
  - Windows 7: **Start > All Programs > Tera Term**
  - Windows 8/8.1: **[Ctrl] [Tab] > All Apps > Tera Term**

- Windows 10: Start button > **All Apps** > **Tera Term**
- 12. In Tera Term, select **File** > **New Connection**. On the New Connection window, click **Serial** and select “COMxxx: KitProg USB-UART (COMxxx)”, and then click **OK**.



- 13. Configure the terminal setting (**Setup** > **Terminal**) as follows, and then click **OK**.

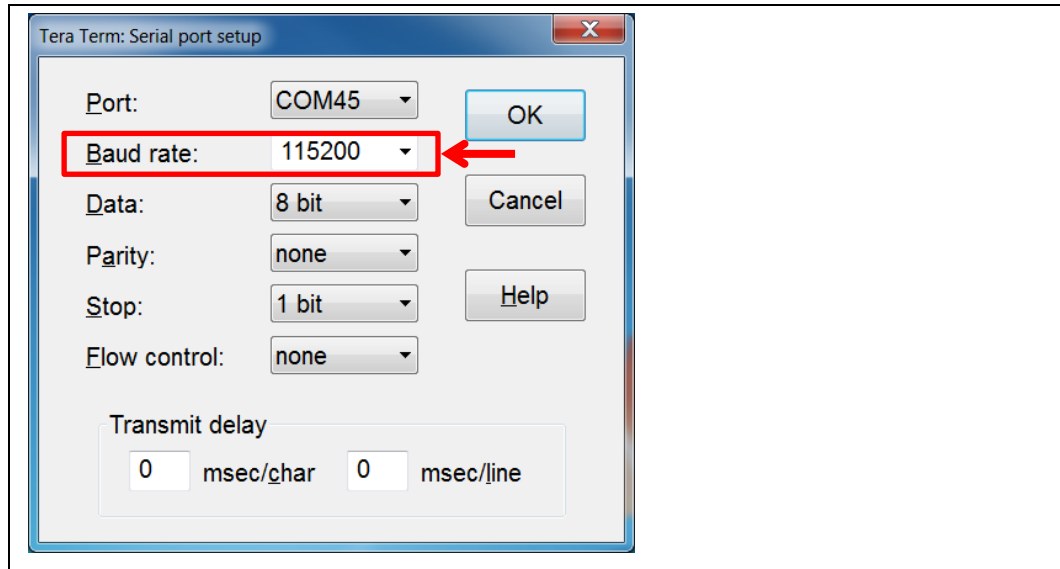
- **Receive: AUTO**
- **Transmit: CR+LF**
- **Local echo: Select**
- Other settings: Default



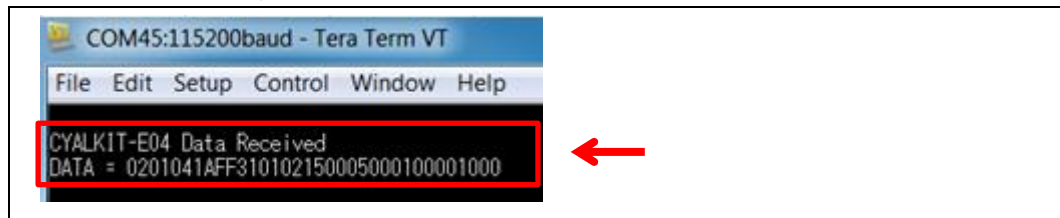
- 14. Configure the serial port setting (**Setup** > **Serial Port**) as follows, and then click **OK**.

- **Baud rate: 115200**

□ Other settings: Default

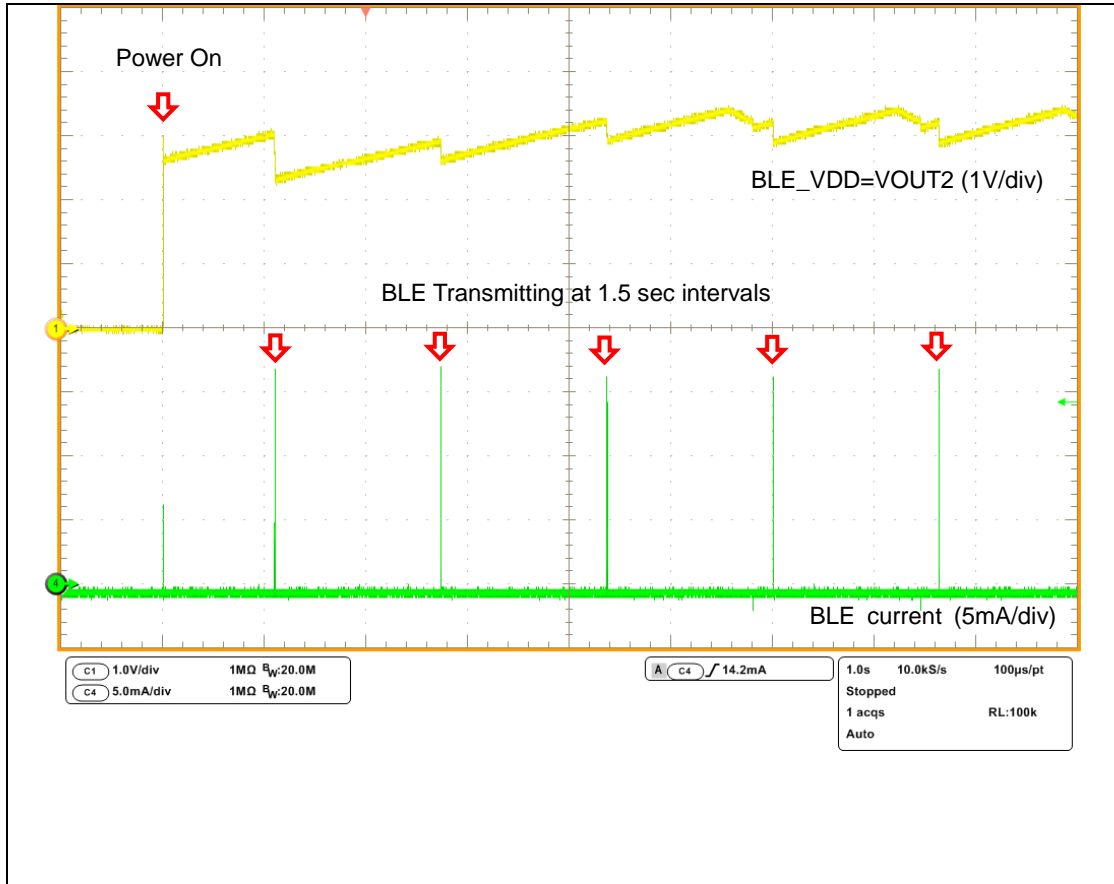


15. Confirm that the BLE dongle is receiving the data by observing that the “CYALKIT-E04 Data Received DATA = ....” Appears on Tera Term, repeatedly.



The following waveform shows the BLE Module transmitting states.

Figure 5-22. BLE Module Transmitting States



## A.5 Waveforms of Charging and Discharging Operation

Figure 5-23 shows the charging operation waveform. Note the following:

1. Solar energy is the input.
2. Charging starts at VSTORE1.
3. When the VSTORE1 voltage achieves the VOUTH setting voltage (3.392 V), the VOUT1/VOUT2 voltage turns ON and charging starts at the surplus energy to VSTORE2.
4. Repeat to charge both VSTORE1 and VSTORE2.

Figure 5-23. Charging Operation Waveform

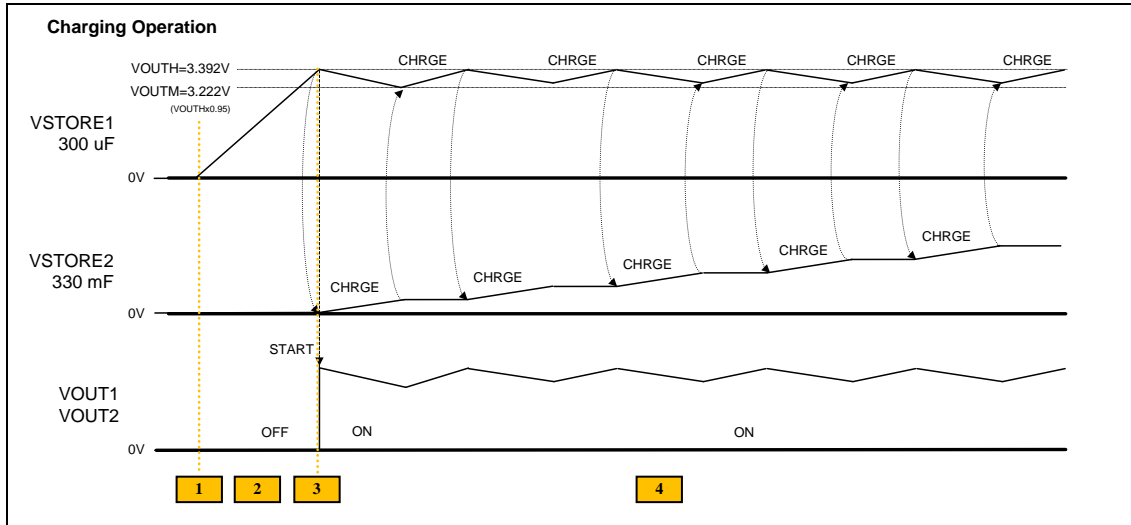
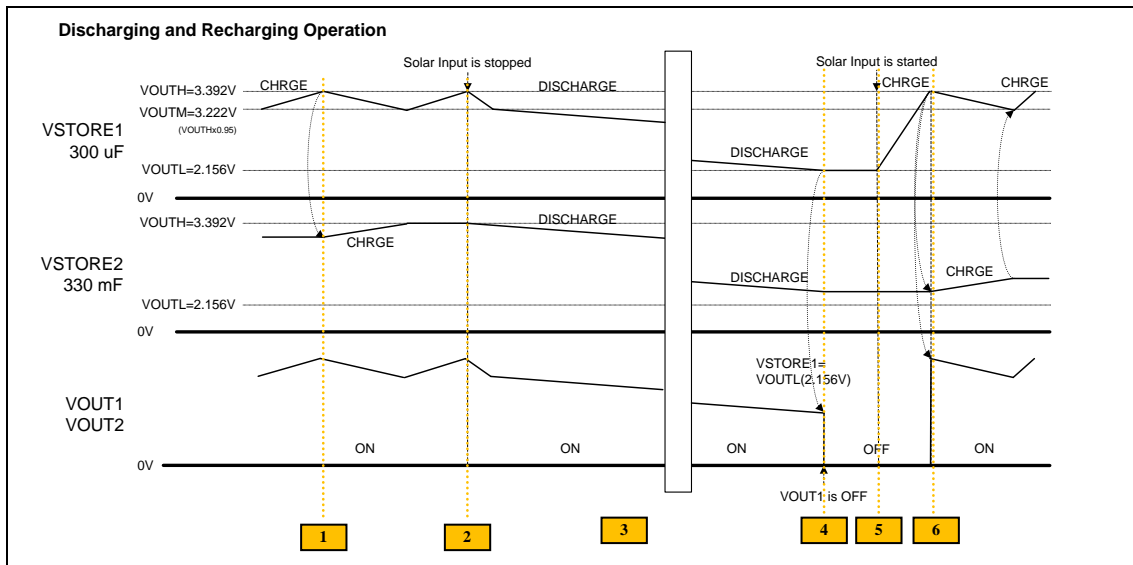


Figure 5-24 shows the discharging and recharging operation waveform. Note the following:

1. When the VSTORE1 voltage achieves the VOUTH setting voltage (3.392 V), the surplus energy charges to VSTORE2.
2. Solar input is stopped.
3. The voltage decreases slowly due to the load current.
4. When the VSTORE1 voltage achieves VOUTL (2.156 V), VOUT1 turns OFF.
5. The solar input is started.
6. When the VSTORE1 voltage achieves the VOUTH setting voltage (3.392 V), the VOUT1/VOUT2 voltage turns ON and charging starts at the surplus energy to VSTORE2.

Figure 5-24. Discharging and Recharging Operation Waveform



## A.6 How to Use Extra Components

### A.1.1 10-Ω Resistor for Current Measurement

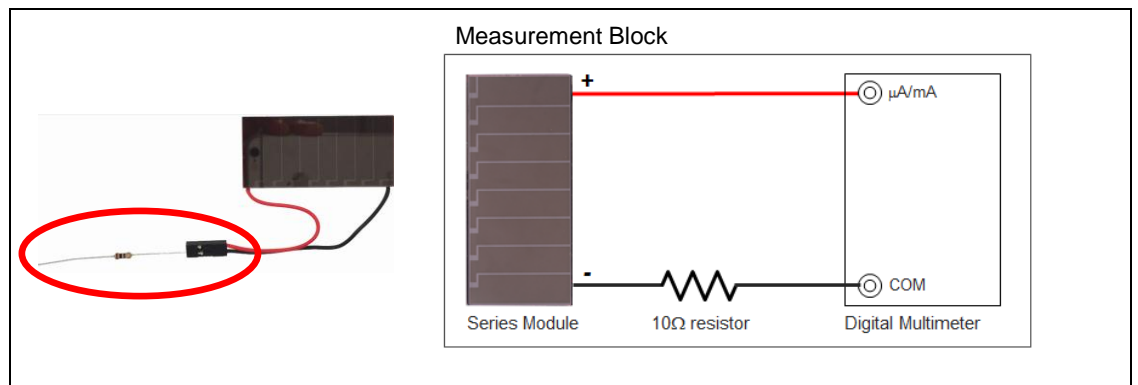
This section describes how to use the solar module and a multimeter (MASTECH: MS8268, not included in this kit.) to measure the current produced by the solar module using the 10-Ω Resistor that is included in the CYALKIT-E04 EVK. First, you will take measurements under constant ambient light. Then, you will vary the available light and observe how the energy output of the solar module changes.

Figure 5-25. Components Required for Current Measurement



1. Now, you will measure the current produced by the solar module. Connect a 10-Ω resistor to the black wire on the solar module as shown in Figure 5-26.

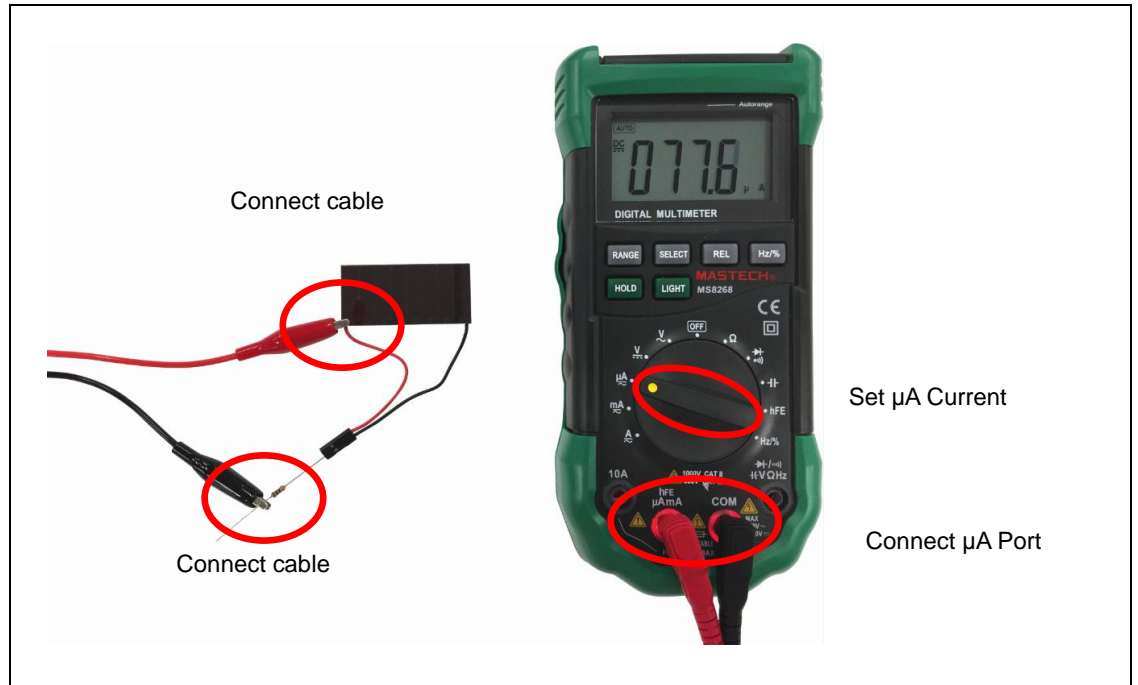
Figure 5-26. Connecting the 10-Ohm Resistor





2. Set the multimeter to measure current in the microamp range. Connect the positive cable of the multimeter to the positive lead of the solar module, and the negative cable to the 10- $\Omega$  resistor. Observe the current ( $I_1$ ).
3. Next, cover the solar module with your hand and observe the reduction in current produced.

Figure 5-27. Measuring the Current



# Revision History



## Document Revision History

Document Title: CYALKIT-E04 S6AE102A and S6AE103A Evaluation Kit Guide Document Number: 002-12768			
Revision	Issue Date	Origin of Change	Description of Change
**	05/23/2016	ATTS	New kit guide
*A	06/29/2016	ATTS	Changed the board picture Changed the description of door sensor operation Added the waveforms in 4.1 and 4.2 Added A. Advanced Topics
*B	08/01/2016	ATTS	Changed the board picture
*C	09/15/2016	ATTS	Changed the board picture Added 2.2 Board Details Updated 2.3 Block Diagram Updated 4 Getting Started Updated 5 Hardware Updated Copyright
*D	09/26/2016	EIFU	Updated Tera Term information
*E	10/06/2016	ATTS	Added Features of S6AE102A and S6AE103A in 1 Changed the pin name : HUMAN to PIR
*F	11/11/2016	ATTS	Updated 5.1.11 VBUS Detector Changed the description of board picture