

## RSL10 Solar Cell Multi-Sensor Platform User's Guide



ON Semiconductor®

[www.onsemi.com](http://www.onsemi.com)

### EVAL BOARD USER'S MANUAL

#### Introduction

The RSL10 Solar Cell Multi-Sensor Platform (RSL10-SOLARSENS-GEVK) is a comprehensive development platform for battery-free IoT applications for smart building, smart home, and Industry 4.0 verticals. Based on the industry's lowest power Bluetooth® Low Energy radio ([RSL10](#)), the board features sensors for environmental and motion sensing ([BMA400](#)—a smart 3-axis accelerometer, [BME280](#)— a smart environmental sensor, and the [NCT203](#) wide-range digital temperature sensor).

The board also features a low weight, low profile 47 µF storage capacitor of; a programming and debug interface; and a connected solar cell.

Since the device harvests energy from a low current source, it is important to minimize leakage of the overall system during operation and standby. Along with other energy efficient devices, an ultra-low quiescent current LDO ([NCP170](#)) on the board significantly minimize leakage.

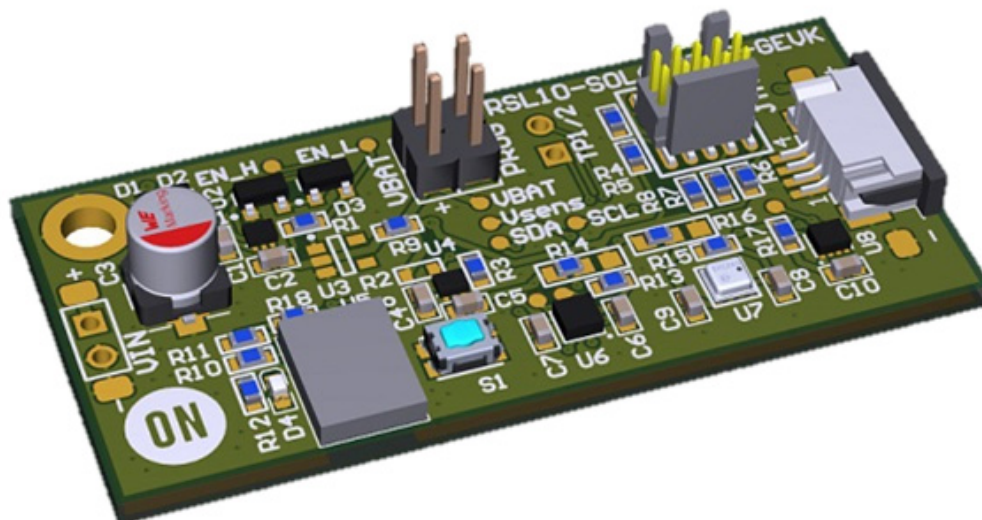


Figure 1. RSL10 Solar Cell Multi-Sensor Platform

**Hardware Description**

*Default Configuration*

The development platform includes a solar multi-sensor board hardware and a connected solar cell. If you need to reconnect the solar cell or would like to work with another solar cell than the one provided out of the box, follow the guidelines in section ‘Powering the Board’.

In addition to the [RSL10 SIP](#) (System-in-Package), the following sensors are present on the board.

- [BMA400](#), 3-Axis Smart Accelerometer
- [BME280](#), Environmental Sensor (temperature, humidity, pressure)
- [NCT203](#), Wide-range (-40 to 125°C) Temperature Sensor

The platform also features an ultra-low quiescent LDO ([NCP170](#)) and a 100 µF capacitor to store energy.

*Powering the Board*

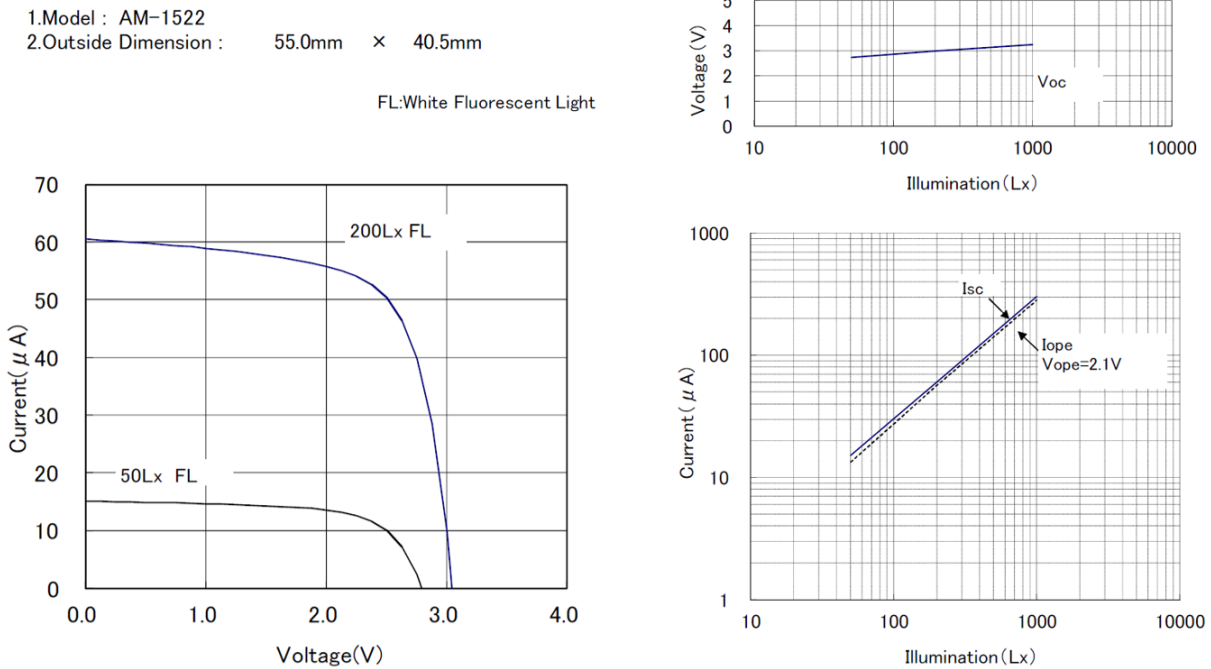
The board is powered by a solar cell. The default solar cell used is [Panasonic Amorton AM-1522](#), which has a typical operating voltage of 3 V.

The circuitry is protected by a clamp at 3 V, and the operating domain is 1.6 V to 2.65 V.

Below 1.6 V, no transmission is allowed and the device is harvesting energy; Above 2.65 V, the device starts to operate and depletes energy buffering down to 1.6 V.

For more information about the power regulation section, refer to Continuous Harvesters and ON Semiconductor’s Low-Power RF Technology Close the Gap in Environmental and Accelerometer Sensors for IoT ([TND6285/D](#)). The powering cell or its equivalent can be mounted either by soldering both terminals or with the ZIF interface.

**WARNING:** ENSURE THE POLARITY OF THE PCB IS CORRECT WITH RESPECT TO THE ONE OF THE CELL.



**Figure 2. Electrical Specifications of the Panasonic Amorton AM-1522 Solar Cell**

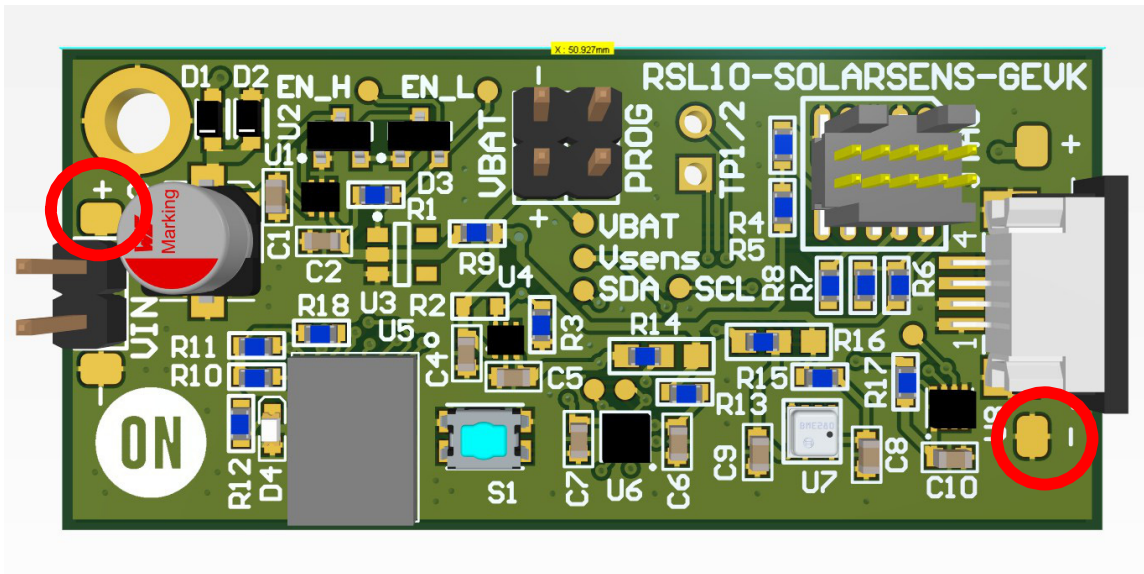


Figure 3. Connecting Cables to the Solder Pads

*Normal Operations*

Every transmission is signed with a LED pulse (**LED D4** located just at the Left of RSL10).

In case no transmission is seen or if the device looks to be hooked in out-of-operation, hit the **Reset** button (S1) and wait for a few seconds.

In normal lighting conditions, the LED will blink faster than once per second.

*Operating Conditions*

The device has been tested under the following lighting conditions:

**Table 1. COMMON LIGHTING OPERATING CONDITIONS**

	Light Source	Time	Solar Cell Facing	Sensor Location	Lux Level (Note 1)
<b>Cloudy Winter</b>	Natural	11:00am	Sky	Office, Near Window	415
"	"	"	Indoor	Office, Near Window	230
"	"	"	Outdoor	Office, Near Window	630
"	"	3:40pm	Indoor	Office desk	200
"	Ceiling Neon	11:00am	Ceiling	Office Corridor	340
"	"	"	White wall	Office Corridor	220
"	"	"	Ground	Office Corridor	140 (Note 2)
"	"	4:30pm	Ceiling	Office desk	250
"	Natural	9:00am	Window	Automotive Dashboard	700
"	"	"	Ground	"	350
"	"	"	Front seat	"	400

1. Lux levels are measure with uncalibrated iOS® App from Velux on iPhone® 6.  
 2. Under similar lighting conditions, the device should automatically start up and begin transmitting sensor data. For more information on sensor operations, refer to section 'Firmware Implementation'.

**Firmware Implementation**

*Default Configuration*

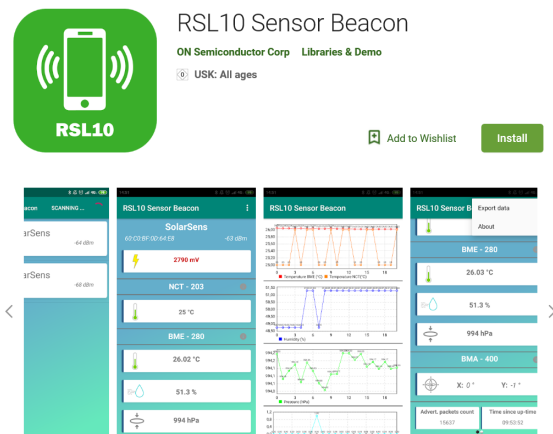
The development platform is loaded with a preconfigured operating setting where both on-board temperature sensors are polled once at a time alternatively, and temperature information loss is sent via a default Eddystone beacon format.

*Using the RSL10 Sensor Beacon App*

The RSL10 Sensor Beacon application enables monitoring of the telemetry data of various RSL10-based platforms and it is available on iOS and Google Play. When connected to the RSL10 Solar Cell Multi-Sensor Platform, the app allows you to view the following telemetry and environment parameters:

- Temperature (via two different inputs)
- Pressure
- Humidity
- Acceleration in 3-axis
- Advertised packages count
- Time since up-time

Aside from displaying the real-time values of these variables, the app plots as well the values over time in several charts. All the logged data is exportable in csv format.



**Figure 4. RSL10 Sensor Beacon Mobile App**

Other freely-available beacon scanning apps such as BLE Scanner can also connect with RSL10 Solar Cell Multi-Sensor Platform to display the received packages, but will not support all the functionalities of RSL10 Sensor Beacon.

*Customizing the Firmware*

In order to customize the firmware, ensure you have downloaded the following from onsemi.com:

- RSL10 Software Development Kit (SDK), an Eclipse-based environment for software development for all RSL10-based platforms
- Bluetooth IoT Development Kit CMSIS Pack

The RSL10 SDK contains fully integrated development environment with a powerful editor, toolchain, documentation, a wide range of example code, and a CMSIS-Pack based software packages. For more information on the RSL10 SDK, refer to the [RSL10 SDK Getting Started Guide](#) (AND9697).

*Installing the RSL10 Software Development Kit and CMSIS-Packs*

The B-IDK software allows for rapid development of various use cases. For This section details the prerequisites and provides detailed steps for downloading the firmware onto the RSL10-SOLARSENS-GEVK.

**Prerequisites**

1. Install 64-bit version of Java from <https://www.java.com/en/download/>
2. Install J-Link Version 6.32i or later from <https://www.segger.com/downloads/jlink> (select J-Link software and documentation pack)
3. Download and install “ON Semiconductor IDE Installer” from <https://www.onsemi.com/PowerSolutions/product.do?id=RSL10>
  - a.) Download the “RSL10 SDK Getting Started Guide” and RSL10 CMSIS pack under “RSL10 Software Package” from the above site. All of these are highlighted in the picture below. Save the CMSIS pack in a folder, for example, C:\cmsis\_packs



**Figure 5.**

4. Download the B-IDK CMSIS pack from <https://www.onsemi.com/B-IDK> and save it in the same folder as the RSL10 CMSIS pack (see 3.a above)
5. CMSIS pack at item 4. is dependent on ARM CMSIS pack 5.5.1 or higher after download from: [https://github.com/ARM-software/CMSIS\\_5/releases](https://github.com/ARM-software/CMSIS_5/releases)
6. CMSIS pack at item 4. is also dependent on ARM CMSIS – FreeRTOS version 10.2.0 or higher for users exposed to design the code under FreeRTOS with RSL10: <https://github.com/ARM-software/CMSIS-FreeRTOS/releases>

Importing the CMSIS–Packs

1. Launch the RSL10 ON Semiconductor IDE

NOTE: Please import the RSL10 CMSIS pack first as the B–IDK CMSIS pack (step 4 in the Prerequisites section) depends on the RSL10 CMSIS pack (step 3a in the Prerequisites section).

2. Refer to Chapter 3 of RSL10 SDK Getting Started Guide (step 3a) for step–by–step instruction on importing the CMSIS packs.
3. Once all packs are successfully imported, they can be viewed in the CMSIS pack manager perspective as shown below.

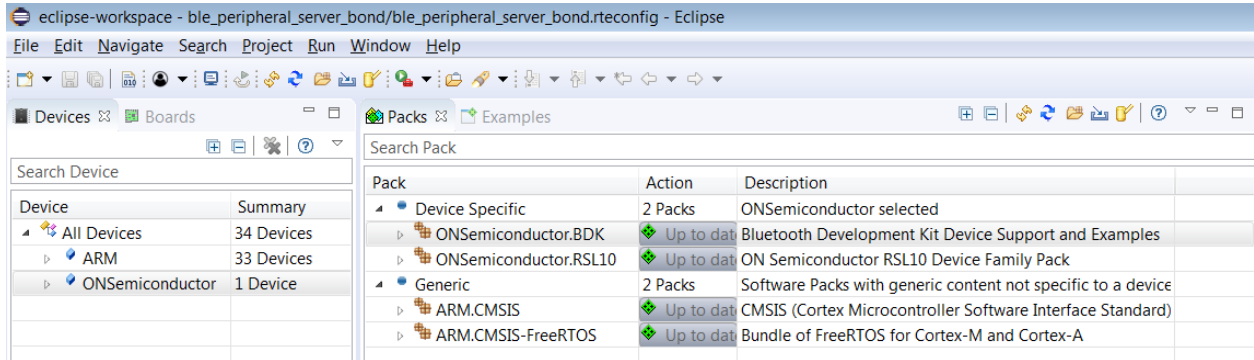


Figure 6. CMSIS Pack Manager Perspective

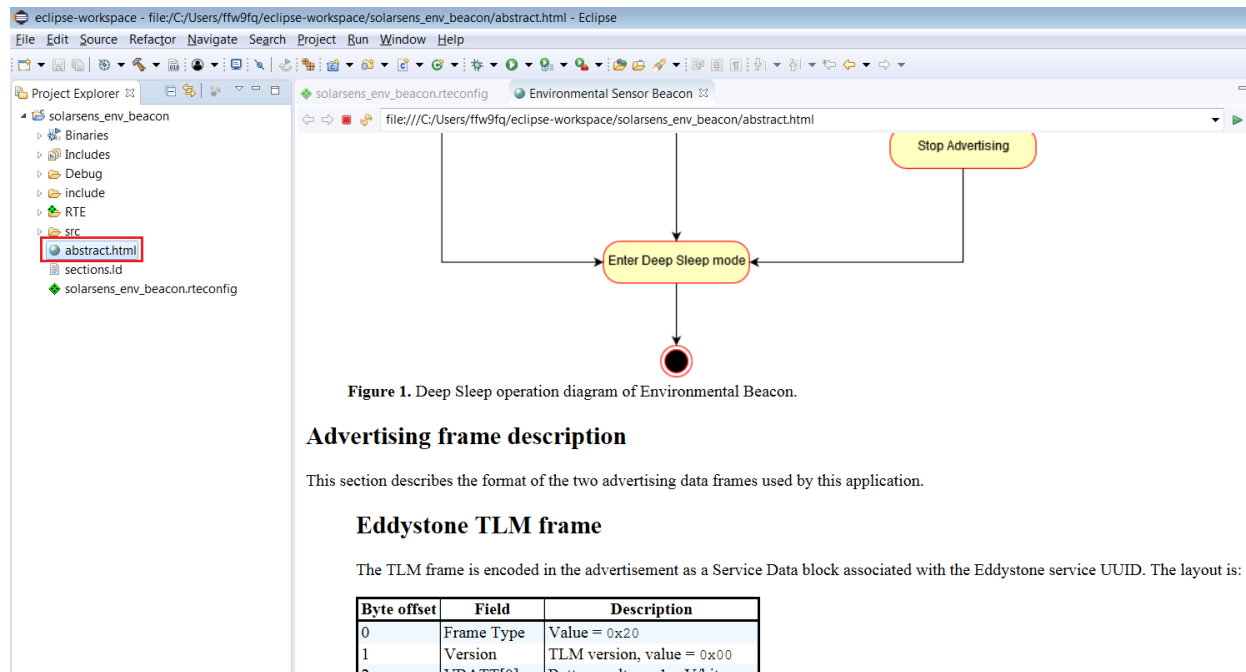


Figure 1. Deep Sleep operation diagram of Environmental Beacon.

Advertising frame description

This section describes the format of the two advertising data frames used by this application.

Eddystone TLM frame

The TLM frame is encoded in the advertisement as a Service Data block associated with the Eddystone service UUID. The layout is:

Byte offset	Field	Description
0	Frame Type	Value = 0x20
1	Version	TLM version, value = 0x00
2	VBATT01	Battery voltage, 1 mV/bit

Figure 7. Advertising Frame Description

## EVBUM2623/D

Since the board does not provide a debugging probe, a compatible standalone debugging probe is required. This can be any SEGGER J-Jink debug probe with 10-pin Cortex® Debug connector adapter.

The board comes with a [Ribes Tech](#) solar cell attached. **For the purposes of debugging and re-flashing of the board**, it is required to disconnect the solar cell from the board. External power source needs to be connected to either of the VIN connectors. Power source can be alternatively

connected to VBAT header for the purpose of detailed power consumption analysis of RSL10 and associated sensors.

Example setup for debugging is shown in Figure 9 where the board is powered by 3.3 V from an UART to USB convertor and also uses the PROG header as UART TX line. For power measurements the converter should be replaced by appropriate power consumption meter and both debug probe and UART should be disconnected.

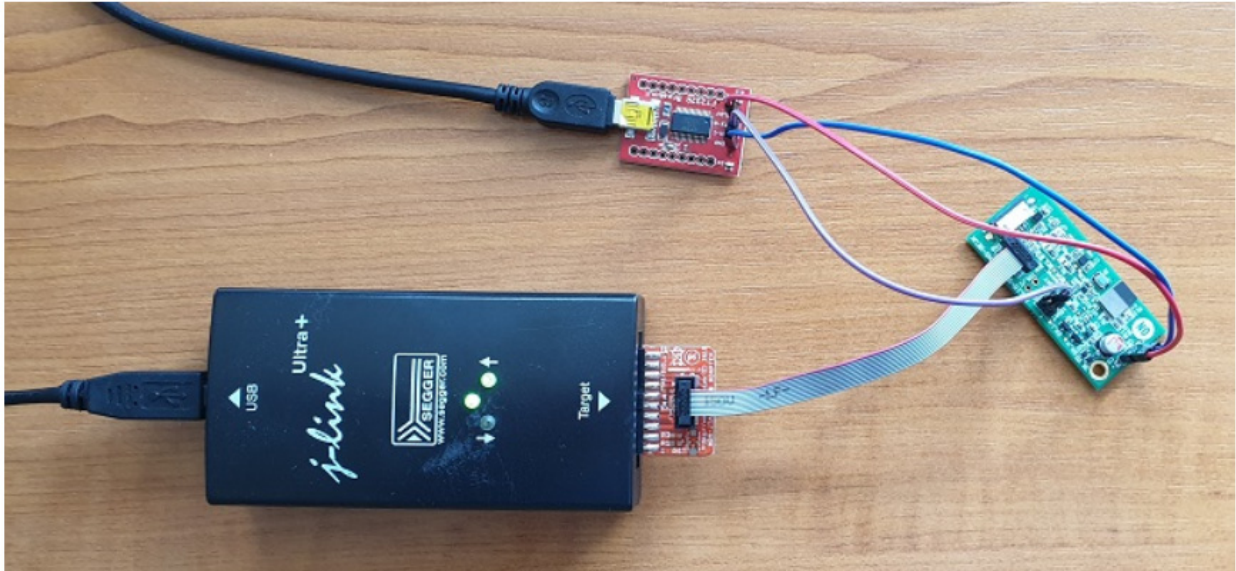


Figure 8. Sample Debugging Set-up

### Build Configurations

The project provides two build configurations that can be selected and build using the **Build Selector** in the Toolbar.

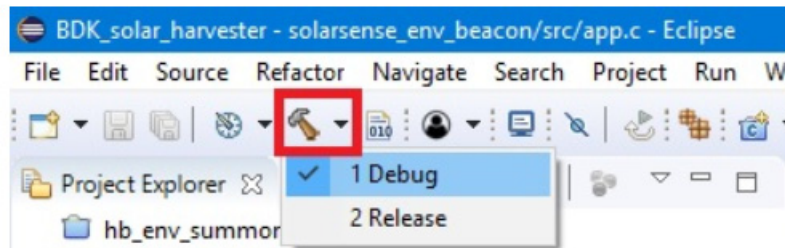


Figure 9. Build Configuration Selection Button in the RSL10 SDK

### Debug

This configuration should be used for debugging purposes only.

- Binary with debugging symbols ( `-O0 -g3` ).
- Trace messages printed over UART peripheral using PROG DIO pad (Header J8, DIO12). Configuration for this port is: 230400 bps, 8N1, no flow control

Sending of trace messages over UART slows down the execution of the program which might impact performance in some cases.

Release

This configuration should be used for power consumption measurements and production builds.

- Optimized for speed, no debug symbols ( `-O2` ).
- Trace messages disabled.

*CMSIS Configuration Header*

The project provides configuration header `app_config.h` located in the include folder of

project. This header can be opened by using CMSIS Configuration wizard editor as shown in Figure 10. The Configuration Wizard allows some predefined program parameters to be changed without changing the code directly. All options provide short descriptions and check for valid setting value range.

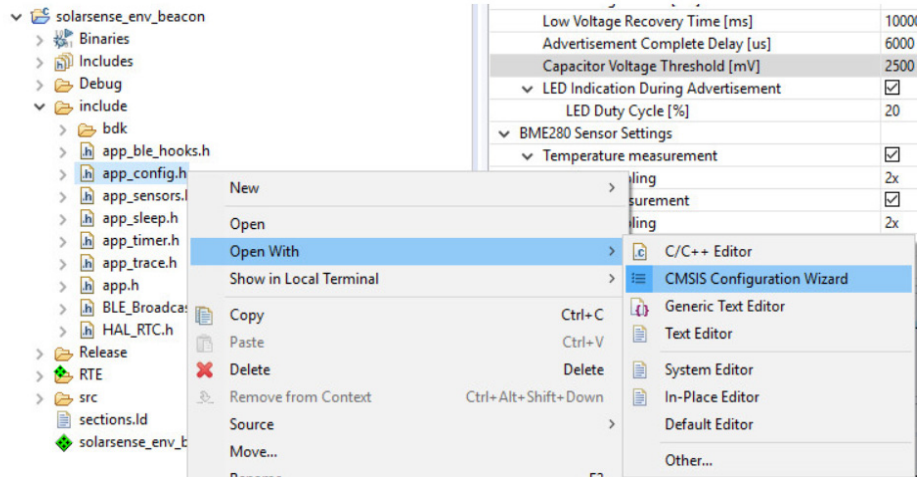


Figure 10. Selecting CMSIS Configuration Wizard as the Default Editor for `app_config.h` File

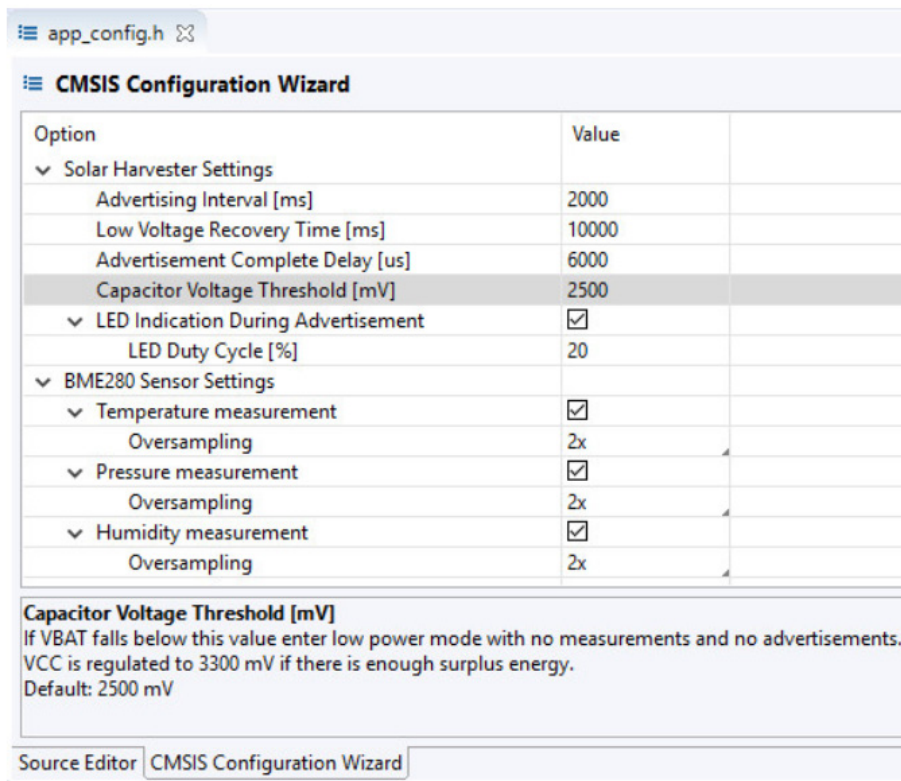
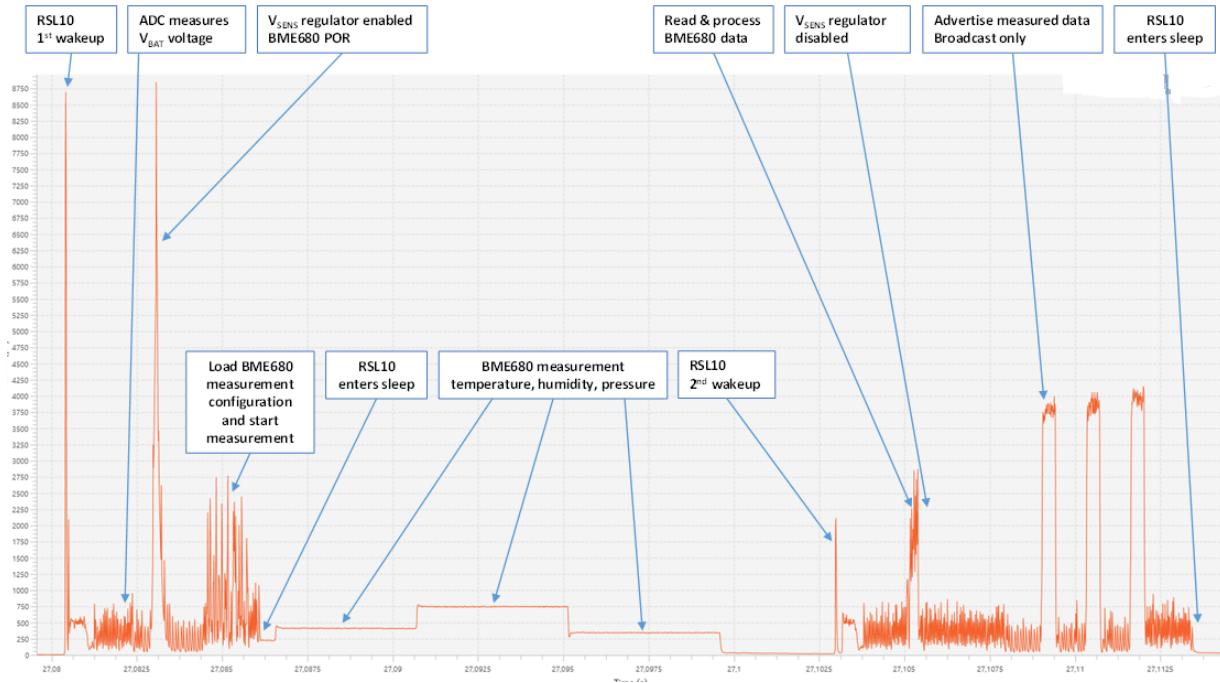


Figure 11. CMSIS Configuration Wizard with Available Program Settings

Figure 12 shows the current consumption of the board during a sensor measurement event, followed by advertisement of measured data. During this event, a total of 60  $\mu\text{J}$  of energy was used to both measure sensor data and

advertise the results. If sensor measurement is not scheduled and the board only advertises, the energy consumption is reduced to 20  $\mu\text{J}$ .



**Figure 12. Typical Operation Cycle with Sensor Measurement and Advertising (3 V power supply, advertising interval set to 1 s, and sensor measurement during every advertising interval)**

*Debugging/Flashing*

Refer to the [RSL10 SDK Getting Started Guide Section 4.4](#) for instructions on how to create debugging configurations and flash the program onto RSL10.

Bluetooth is a registered trademark of Bluetooth SIG.  
 Cortex is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.  
 Google is a registered trademark of Google, Inc.  
 iOS and iPhone are registered trademarks of Apple, Inc.  
 All other brand names and product names appearing in this document are registered trademarks or trademarks of their respective holders.



**onsemi**, **Onsemi**, and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi**'s product/patent coverage may be accessed at [www.onsemi.com/site/pdf/Patent-Marking.pdf](http://www.onsemi.com/site/pdf/Patent-Marking.pdf). **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

The evaluation board/kit (research and development board/kit) (hereinafter the "board") is not a finished product and is not available for sale to consumers. The board is only intended for research, development, demonstration and evaluation purposes and will only be used in laboratory/development areas by persons with an engineering/technical training and familiar with the risks associated with handling electrical/mechanical components, systems and subsystems. This person assumes full responsibility/liability for proper and safe handling. Any other use, resale or redistribution for any other purpose is strictly prohibited.

**THE BOARD IS PROVIDED BY ONSEMI TO YOU "AS IS" AND WITHOUT ANY REPRESENTATIONS OR WARRANTIES WHATSOEVER. WITHOUT LIMITING THE FOREGOING, ONSEMI (AND ITS LICENSORS/SUPPLIERS) HEREBY DISCLAIMS ANY AND ALL REPRESENTATIONS AND WARRANTIES IN RELATION TO THE BOARD, ANY MODIFICATIONS, OR THIS AGREEMENT, WHETHER EXPRESS, IMPLIED, STATUTORY OR OTHERWISE, INCLUDING WITHOUT LIMITATION ANY AND ALL REPRESENTATIONS AND WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE, NON-INFRINGEMENT, AND THOSE ARISING FROM A COURSE OF DEALING, TRADE USAGE, TRADE CUSTOM OR TRADE PRACTICE.**

**onsemi** reserves the right to make changes without further notice to any board.

You are responsible for determining whether the board will be suitable for your intended use or application or will achieve your intended results. Prior to using or distributing any systems that have been evaluated, designed or tested using the board, you agree to test and validate your design to confirm the functionality for your application. Any technical, applications or design information or advice, quality characterization, reliability data or other services provided by **onsemi** shall not constitute any representation or warranty by **onsemi**, and no additional obligations or liabilities shall arise from **onsemi** having provided such information or services.

**onsemi** products including the boards are not designed, intended, or authorized for use in life support systems, or any FDA Class 3 medical devices or medical devices with a similar or equivalent classification in a foreign jurisdiction, or any devices intended for implantation in the human body. You agree to indemnify, defend and hold harmless **onsemi**, its directors, officers, employees, representatives, agents, subsidiaries, affiliates, distributors, and assigns, against any and all liabilities, losses, costs, damages, judgments, and expenses, arising out of any claim, demand, investigation, lawsuit, regulatory action or cause of action arising out of or associated with any unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of any products and/or the board.

This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and may not meet the technical requirements of these or other related directives.

FCC WARNING – This evaluation board/kit is intended for use for engineering development, demonstration, or evaluation purposes only and is not considered by **onsemi** to be a finished end product fit for general consumer use. It may generate, use, or radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment may cause interference with radio communications, in which case the user shall be responsible, at its expense, to take whatever measures may be required to correct this interference.

**onsemi** does not convey any license under its patent rights nor the rights of others.

LIMITATIONS OF LIABILITY: **onsemi** shall not be liable for any special, consequential, incidental, indirect or punitive damages, including, but not limited to the costs of requalification, delay, loss of profits or goodwill, arising out of or in connection with the board, even if **onsemi** is advised of the possibility of such damages. In no event shall **onsemi**'s aggregate liability from any obligation arising out of or in connection with the board, under any theory of liability, exceed the purchase price paid for the board, if any.

The board is provided to you subject to the license and other terms per **onsemi**'s standard terms and conditions of sale. For more information and documentation, please visit [www.onsemi.com](http://www.onsemi.com).

## PUBLICATION ORDERING INFORMATION

### LITERATURE FULFILLMENT:

Email Requests to: [orderlit@onsemi.com](mailto:orderlit@onsemi.com)

**onsemi Website:** [www.onsemi.com](http://www.onsemi.com)

### TECHNICAL SUPPORT

**North American Technical Support:**

Voice Mail: 1 800-282-9855 Toll Free USA/Canada

Phone: 011 421 33 790 2910

**Europe, Middle East and Africa Technical Support:**

Phone: 00421 33 790 2910

For additional information, please contact your local Sales Representative