

## SENSOR PUCK USER'S GUIDE

### 1. Introduction

The sensor puck demonstrates Silicon Laboratories optical sensor (Si1147-M01) RH and temperature sensor (Si7021) and low power MCU (EFM32G210 "Gecko"). The data is broadcast using a Bluetooth Low Energy (BLE) module and can be displayed on a mobile device (Apple iOS or Android) that supports the BLE protocol.

By using broadcast mode, a connection does not have to be established, making it possible to display the data from several modules at the same time.

### 2. Evaluation Kit Description

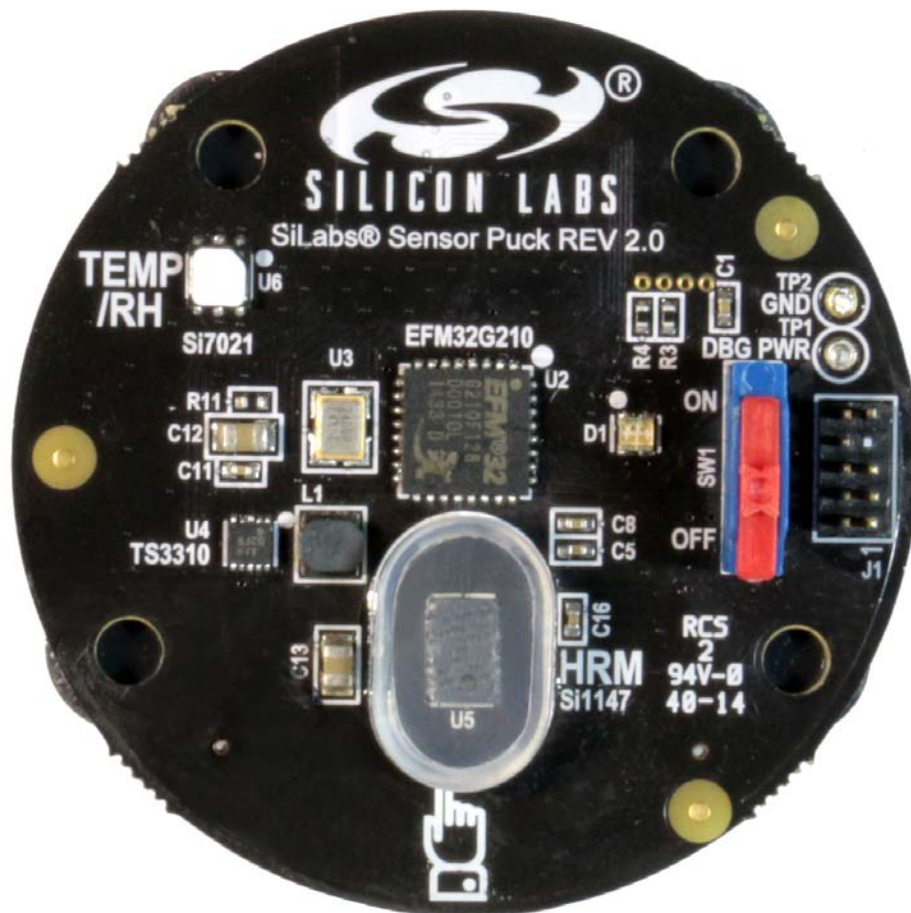


Figure 1. Silicon Labs Sensor Puck

The evaluation kit consists of a sensor puck with a battery and the on/off switch in the off position. Install the battery if it is not installed. The + terminal of the battery faces away from the board towards the + terminal of the battery holder. Remove the pull tab separating the battery from the battery holder if needed. When the switch is turned on, the puck will automatically start taking and broadcasting data. For the puck itself, there is no installation required.

# Sensor Puck

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The data that is broadcast is generally displayed on a mobile device. To display the data the Silicon Labs Sensor Puck app must be installed on the mobile device. The application is available for no charge from the Apple App Store or the Google Play Store. (Search for Silicon Labs Sensor Puck.)

## 3. Operation

### ■ Environmental mode

- Measures ambient light, UV index, ambient temperature, and ambient humidity.
- This is the default mode of operation and the lowest power.
- In this mode of operation measurements are taken and broadcast (once per second).
- The LED flashes green once per measurement cycle.
- The battery current consumption in this mode is approximately 1.5 mA average, which means that a standard CR2032 battery will last about five days. The battery for this demo is not rechargeable so it must be replaced if it is depleted.

### ■ Biometric mode

- At the once per second interval for environmental monitoring, the puck checks for the presence of an object over the Si1147-M01 (under the acrylic cover).
- If an object is detected the puck will go into biometric mode and attempt to measure heart rate.
- Heart rate is measured by the reflection of IR light from an LED inside the Si1147-M01.
- The light is reflected from a finger-tip to measure the heart rate.
- In biometric mode the power consumption goes up to 7 mA, so battery life will decrease to about one day in this mode.
- In biometric mode, the LED will flash red while it is acquiring the heartbeat and then switches to continuous green once the heartbeat has been acquired.
- To avoid excessive power drain in case the puck is left on and covered with an object, the puck will exit biometric mode after 90 seconds. In this case, the object must be removed and a finger should be placed over the acrylic cover to start biometric monitoring again.
- The data from the puck is broadcast over a BLE “advertisement” packet. The mobile device that displays the data does not need to make a connection to the puck. For this reason, it possible that a single mobile device (i.e. a phone) can display data from multiple pucks.

## 4. Sensor Puck Applications

There is a Sensor Puck app for iOS devices and another Sensor Puck app for Android devices. Both apps are named "Silicon Labs Sensor Puck".

The iOS Sensor Puck app can be installed from the Apple App Store. The iOS app runs on devices with iOS 7 and higher, and has Bluetooth 4.0 hardware. Silicon Labs has verified that the iOS app runs on iPhone 4S, 5, 5S, 6 and 6 Plus. The iOS app also runs on iPad 3 and 4.

The Android Sensor Puck app can be installed from the Google Play Store. The Android app runs on devices with Android version 4.3 and higher, and has Bluetooth 4.0 hardware. Silicon Labs has verified that the Android app runs on the following devices: Samsung Galaxy S4, Samsung Galasy S5, Samsung Galaxy Tab 3, Motorola Moto E, Motorola Moto G, HTC Desire, HTC One Max, LG Nexus 5, LG G Flex, Sony Z1, Sony T2 Ultra, and Asus Nexus 7.

When the puck is in environmental mode, the Silicon Labs Sensor Puck app displays the environmental screen:

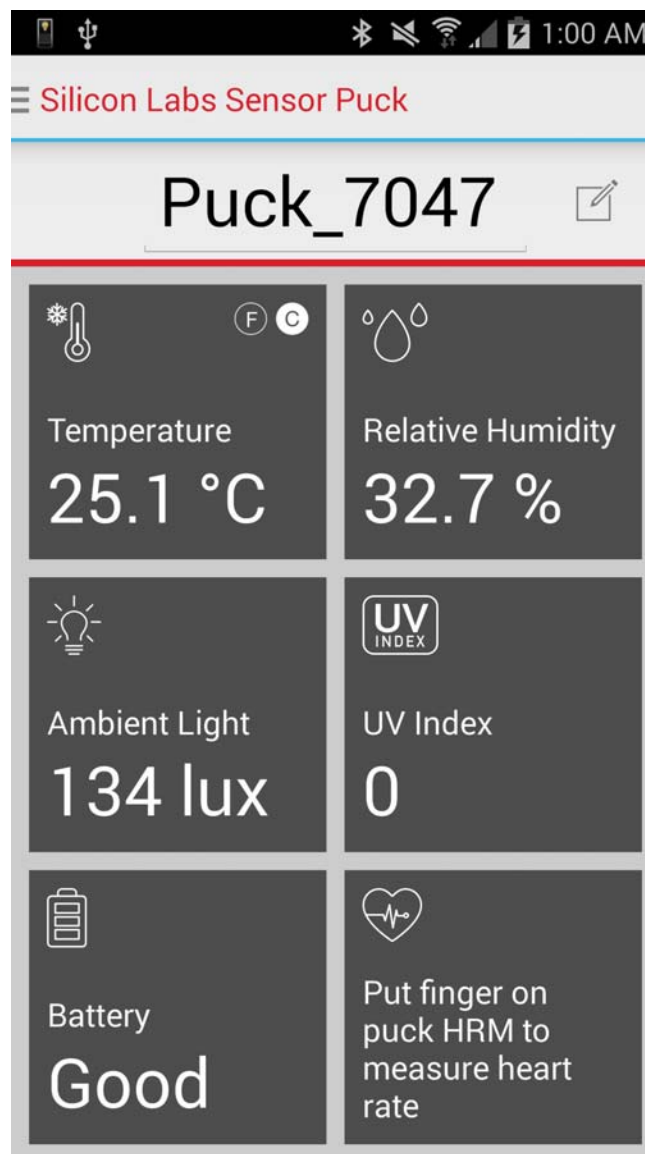


Figure 2. Android Environmental Screen

# Sensor Puck

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The environmental screen displays the environmental sensor measurements and the battery status. The puck name is displayed at the top of the screen. The temperature scale can be changed between Celsius and Fahrenheit by tapping the small C and F buttons.

When the puck is in biometric mode, the Android Sensor Puck displays the biometric screen.

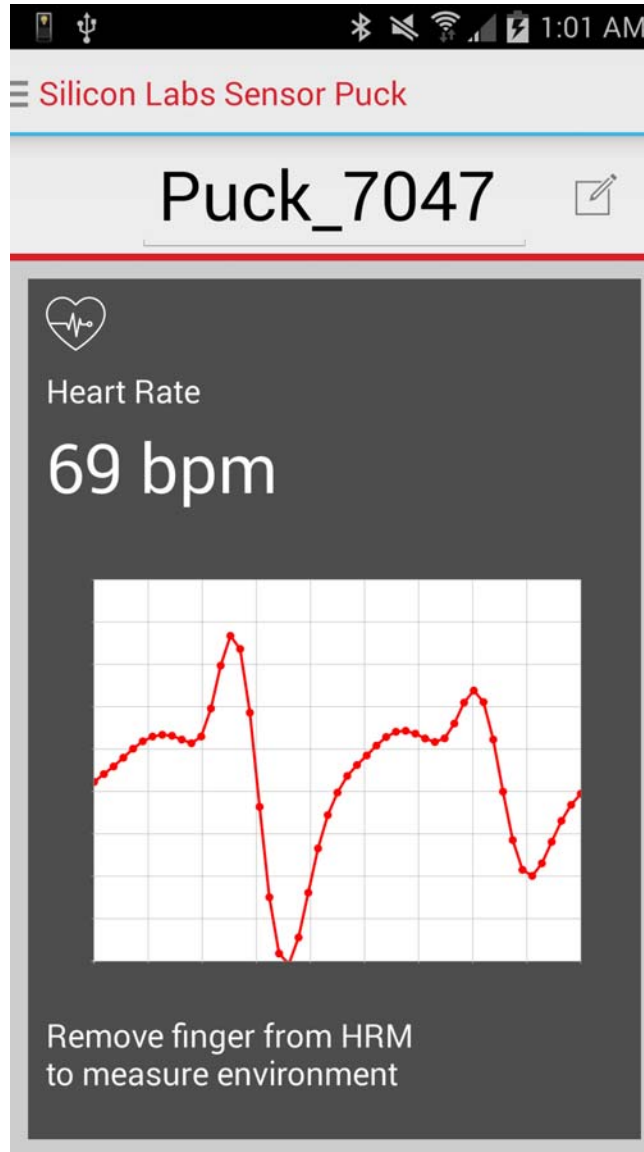


Figure 3. Android Biometric Screen

The iOS Sensor Puck app does not have a biometric screen. The iOS app displays the heart rate in the lower right corner of the environmental screen:

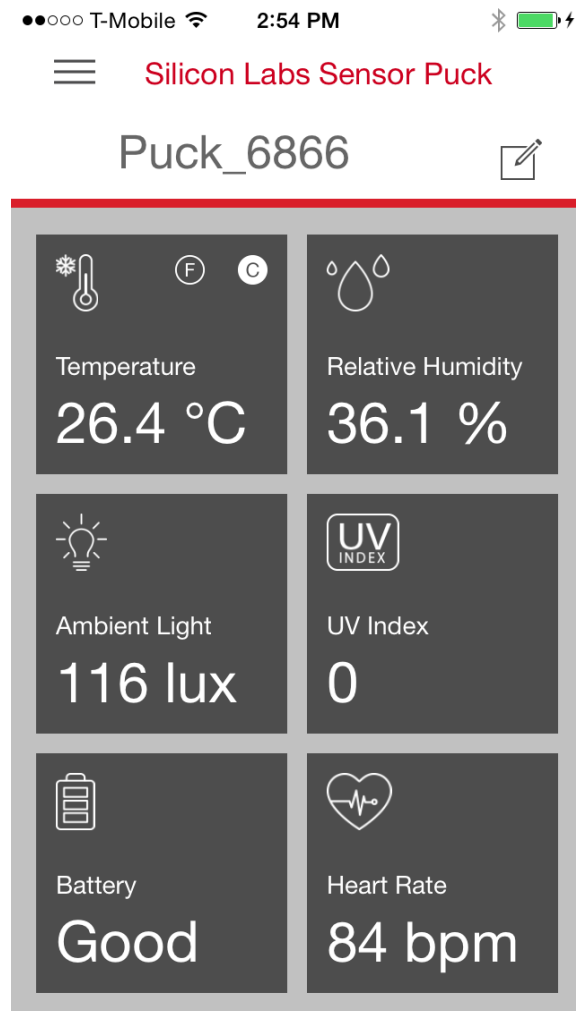


Figure 4. iOS Environmental Screen

# Sensor Puck

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If there are several sensor pucks, you can use the navigation drawer to select a different puck. To open the navigation drawer, tap on the three-line icon in the upper left corner of the screen or swipe from the left edge of the screen.

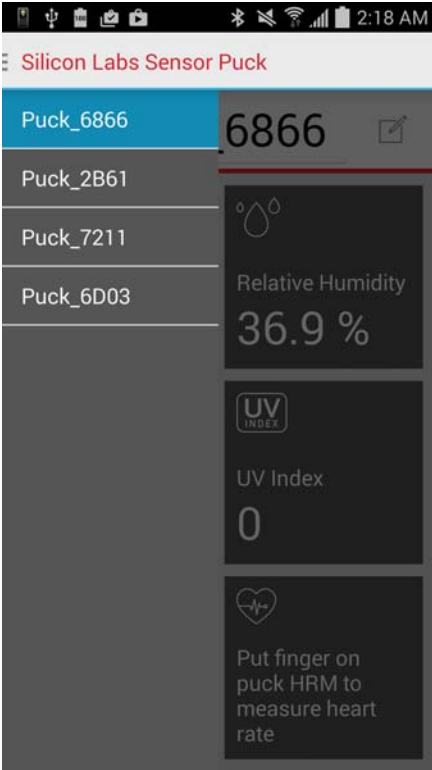


Figure 5. Navigation Drawer

You can change the name of a puck by tapping on the edit icon to the right of the puck name.



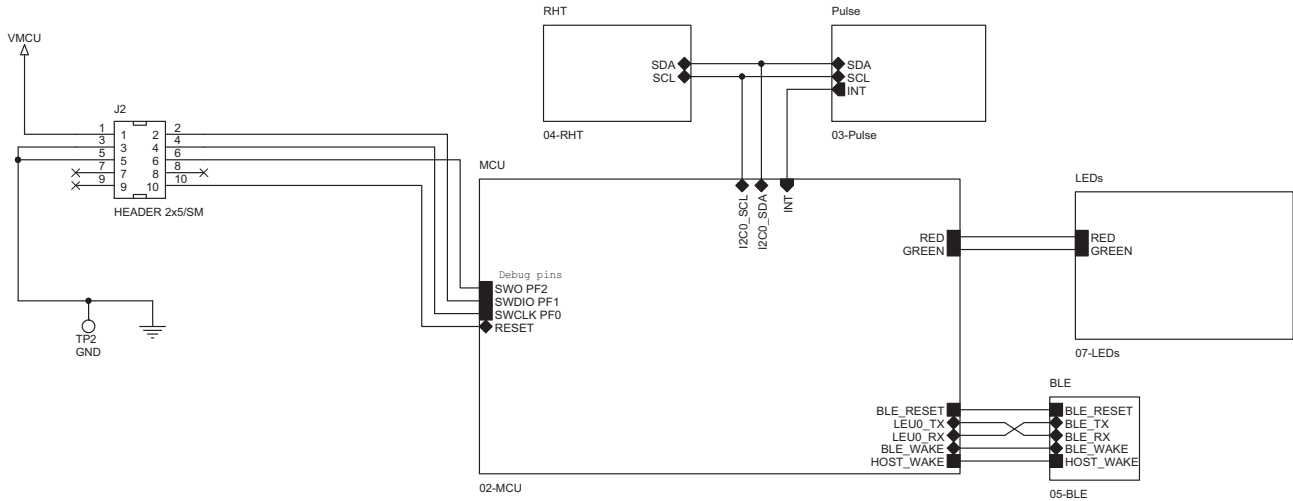
Figure 6. Puck Name

# Sensor Puck

## 5. Sensor Puck Hardware Description

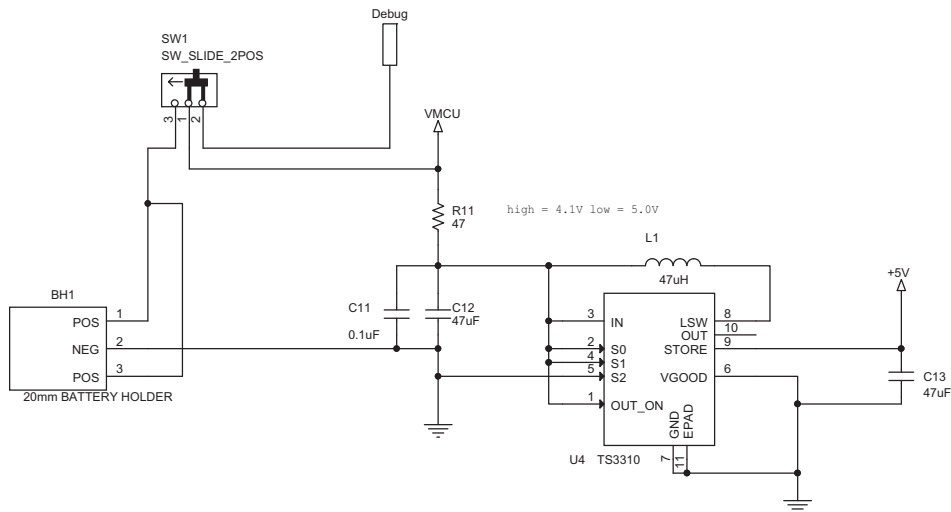
### 5.1. Schematics

Figure 7 shows the block diagram of the puck with debug header MCU, the sensors, and the Bluetooth module.



**Figure 7. Block Diagram**

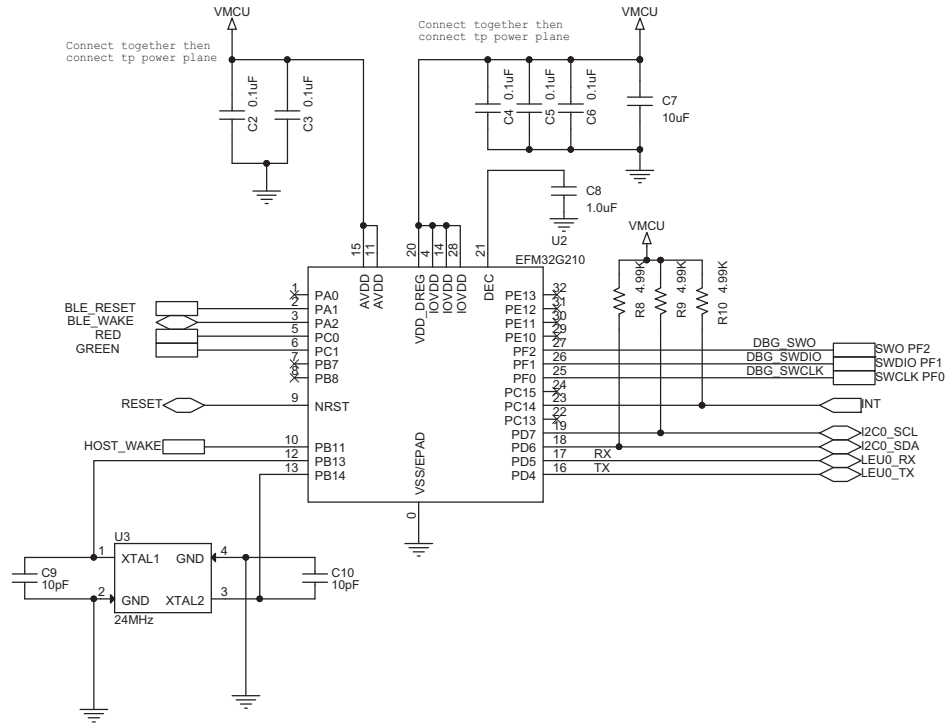
Figure 8 shows the power section. The CR2032 battery is used to power most of the ICs. A boost converter is used to produce 4.1 V which is used to power the LED of the Si1147 so it can be driven at higher current than is possible with a coin cell battery.



**Figure 8. Power Section**

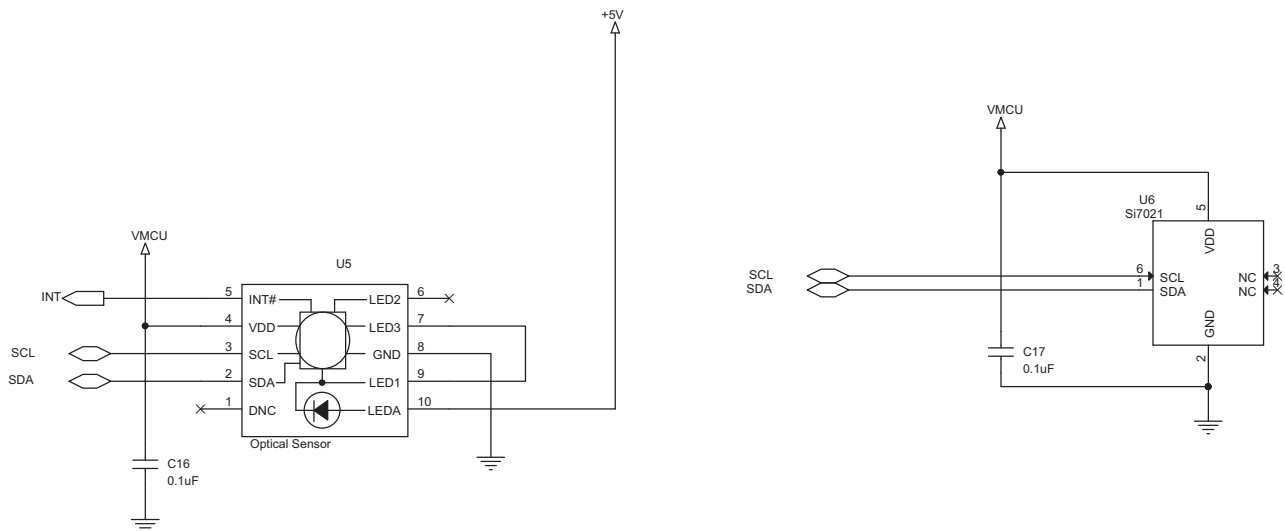
Figure 9 shows the EFM32G210 “Gecko” MCU. The 24 MHz clock is only used in active periods. For lower power consumption, the internal 32 KHz R-C clock is used as much as possible. A special calibration routine is used to calibrate the 32 KHz clock against the 24 MHz crystal for accuracy in the UART communication speed while in low power mode.





**Figure 9. EFM32G210 MCU**

Figure 10 shows the Si7021 RH and temperature sensor as well as the Si1147-M01 optical sensor.



**Figure 10. Sensors**

Figure 11 shows the BLE module and LEDs.

# Sensor Puck

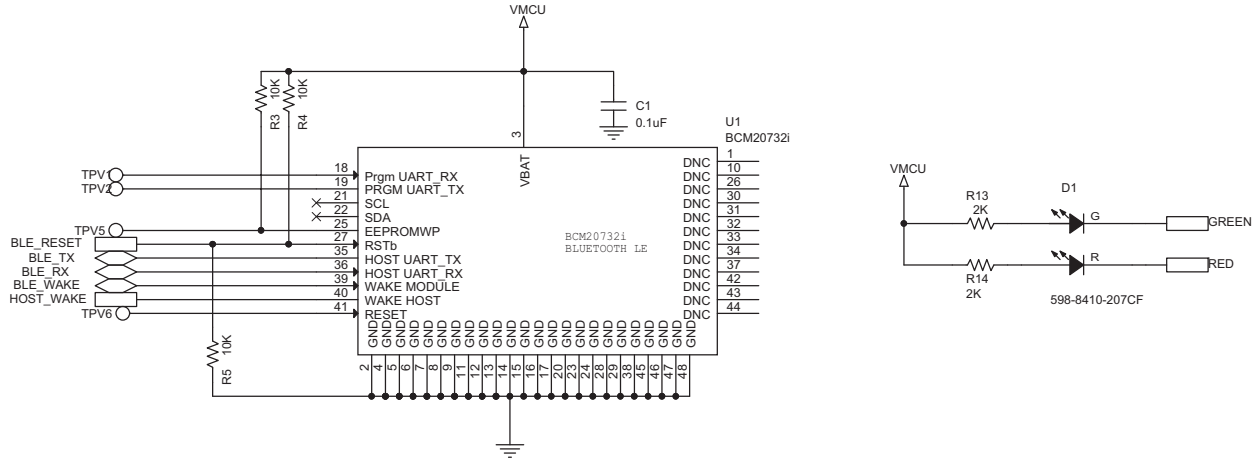


Figure 11. BLE Module and LEDs

## 5.2. Bill of Materials

Table 1. Sensor Puck BOM

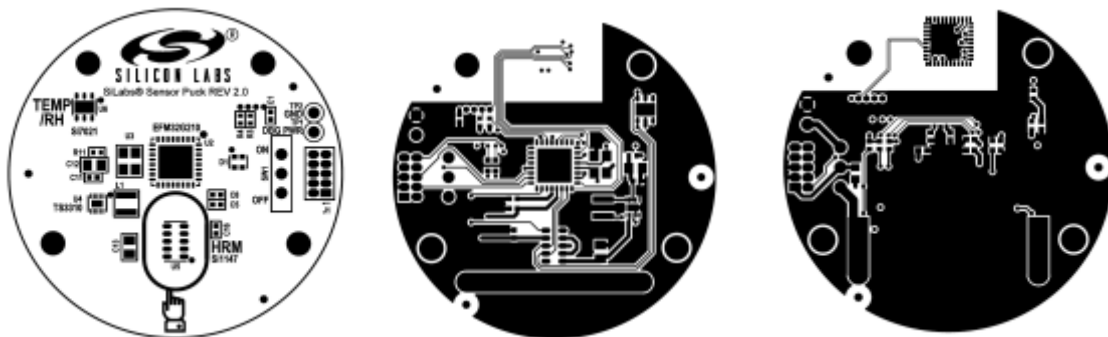
Quantity	Reference	Value	Voltage	Tol	Manufacturer Part Number	Manufacturer
1	BH1	20 mm BATTERY HOLDER			BAT-HLD-001	LINX TECHNOLOGIES INC.
1	C1	0.1 $\mu$ F	16 V	$\pm 10\%$	C0402X7R160-104K	Venkel
8	C2,C3,C4,C5,C6,C11, C16,C17	0.1 $\mu$ F	10 V	$\pm 10\%$	C0402X7R100-104K	Venkel
1	C7	10 $\mu$ F	6.3 V	$\pm 20\%$	C0603X5R6R3-106M	Venkel
1	C8	1.0 $\mu$ F	6.3 V	$\pm 10\%$	C0402X5R6R3-105K	Venkel
2	C9,C10	10 pF	50 V	$\pm 5\%$	C0402C0G500-100J	Venkel
2	C12,C13	47 $\mu$ F	6.3 V	$\pm 20\%$	C0805X5R6R3-476M	Venkel
1	D1	598-8410-207CF			598-8410-207CF	Dialight
1	J1	Header 2x5 TH			M50-3500542	Harwin
1	L1	47 $\mu$ H		$\pm 20\%$	NR 3012T 470M	Taiyo Yuden
3	R3,R4,R5	10 K		$\pm 1\%$	CR0402-16W-1002F	Venkel
3	R8,R9,R10	4.99 K		$\pm 1\%$	CR0402-16W-4991F	Venkel

**Table 1. Sensor Puck BOM (Continued)**

Quantity	Reference	Value	Voltage	Tol	Manufacturer Part Number	Manufacturer
1	R11	47		±1%	CR0402-16W-47R0F	Venkel
2	R13,R14	2 K		±1%	CR0402-16W-2001F	Venkel
4	SF4,SF5,SF6,SF7	BUMPER			SJ61A6	3M
1	SW1	SW_SLIDE_2POS			NK236H	Apem Inc.
4	TPV1,TPV2,TPV5,TPV6	TPV			N/A	N/A
2	TP1,TP2	RED			151-207-RC	Kobiconn
1	U1	BCM20732i	3.3 V		BCM20732i	iDevices
1	U2	EFM32G210	3.3 V		EFM32G210F128-QFN32	SiLabs
1	U3	24 MHz			FA-238 24.0000MB	Epson
1	U4	TS3310	5 V		TS3310ITD1022	SiLabs
1	U5	Optical Sensor			Si1147-M01-GM	SiLabs
1	U6	Si7021			Si7021-A10-GM1	SiLabs

### 5.3. Layout

Figure 12 shows the layout of the puck. The Bluetooth module has a keep and area and is placed on the backside to avoid antenna detuning. The inner power and ground layers are not shown.



**Figure 12. Silkscreen, Front and Back Metal**

# Sensor Puck

## 6. Sensor Puck Firmware

No firmware download is necessary to use the puck as it comes preprogrammed with firmware, but the capability to view and modify the firmware source code is available in Simplicity Studio.

It is possible to download, debug, and even modify this code within Simplicity Studio, however, to connect the puck to Studio you will need two additional pieces of hardware. First, a standard 9-pin Arm Cortex debug cable is required (not supplied). This cable can be ordered from Segger (see the link below).

<http://segger.com/jlink-adapters-9pin-cortexm.html>

Secondly, an EFM32 development kit with a 20-pin debug out header, such as the Zero Gecko STK, is required (also not supplied). The cable connects the 20-pin debug out header on the EFM32 development kit to the 9-pin debug header on the puck (J1).

Steps to program the firmware of the Sensor Puck:

- Install and launch the latest version of Simplicity Studio ([www.silabs.com/simplicity](http://www.silabs.com/simplicity)).
- Connect the 20-pin header of the programming/debug cable to the EFM32 development kit.
- Connect the 9-pin header of the programming debug cable to the Sensor Puck.
- Slide Sensor Puck power switch to 'ON'.
- Select DBG mode on the power switch of the EFM32 development kit.
- Connect a USB cable from PC to EFM32 Development kit J-Link connector.
- If the EFM32 development kit is not connected automatically, select 'Detect Connected Device'.
- Once the kit is recognized, select the tile 'Kit Manager' shown below to configure the development kit to debug out mode.

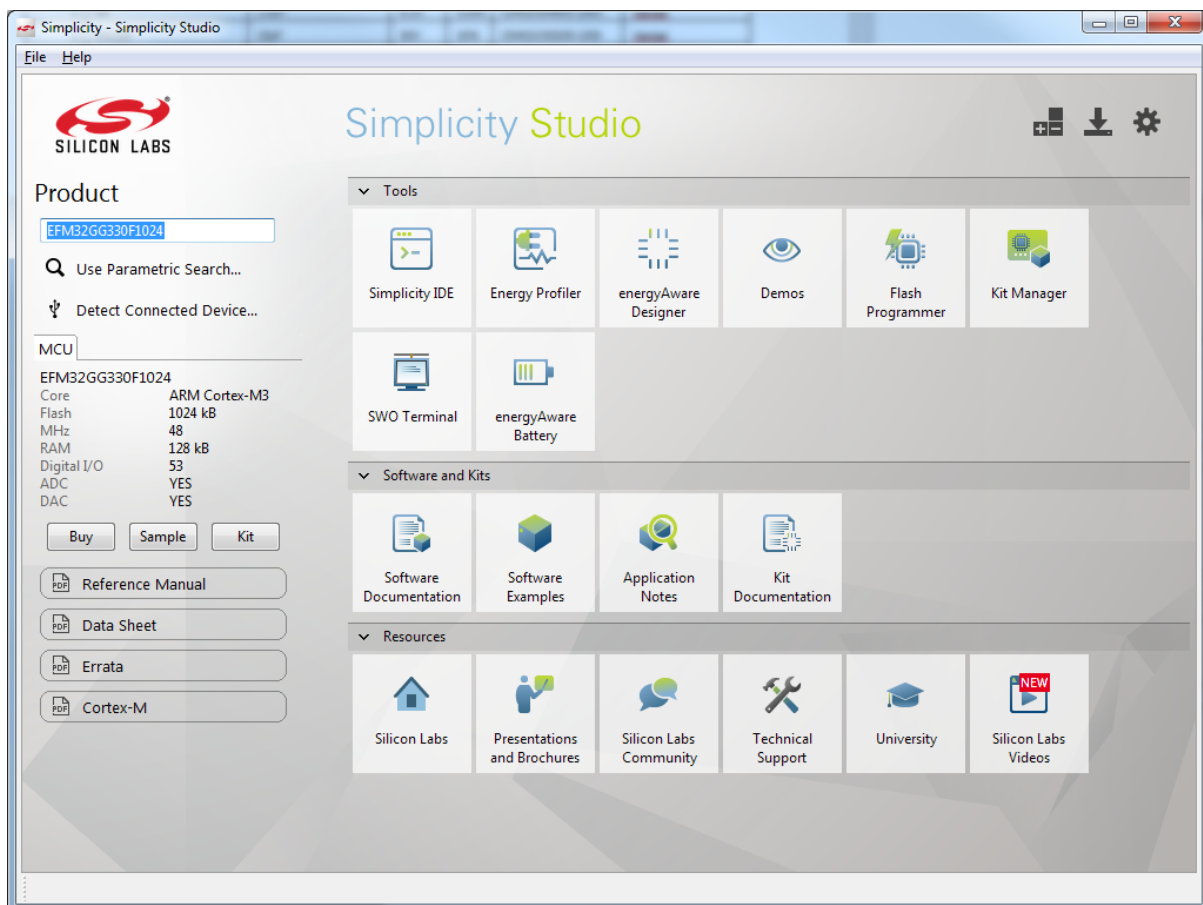


Figure 13. Simplicity Studio Launch Screen

Next, set the debug mode to 'Out' in the dialog shown below.

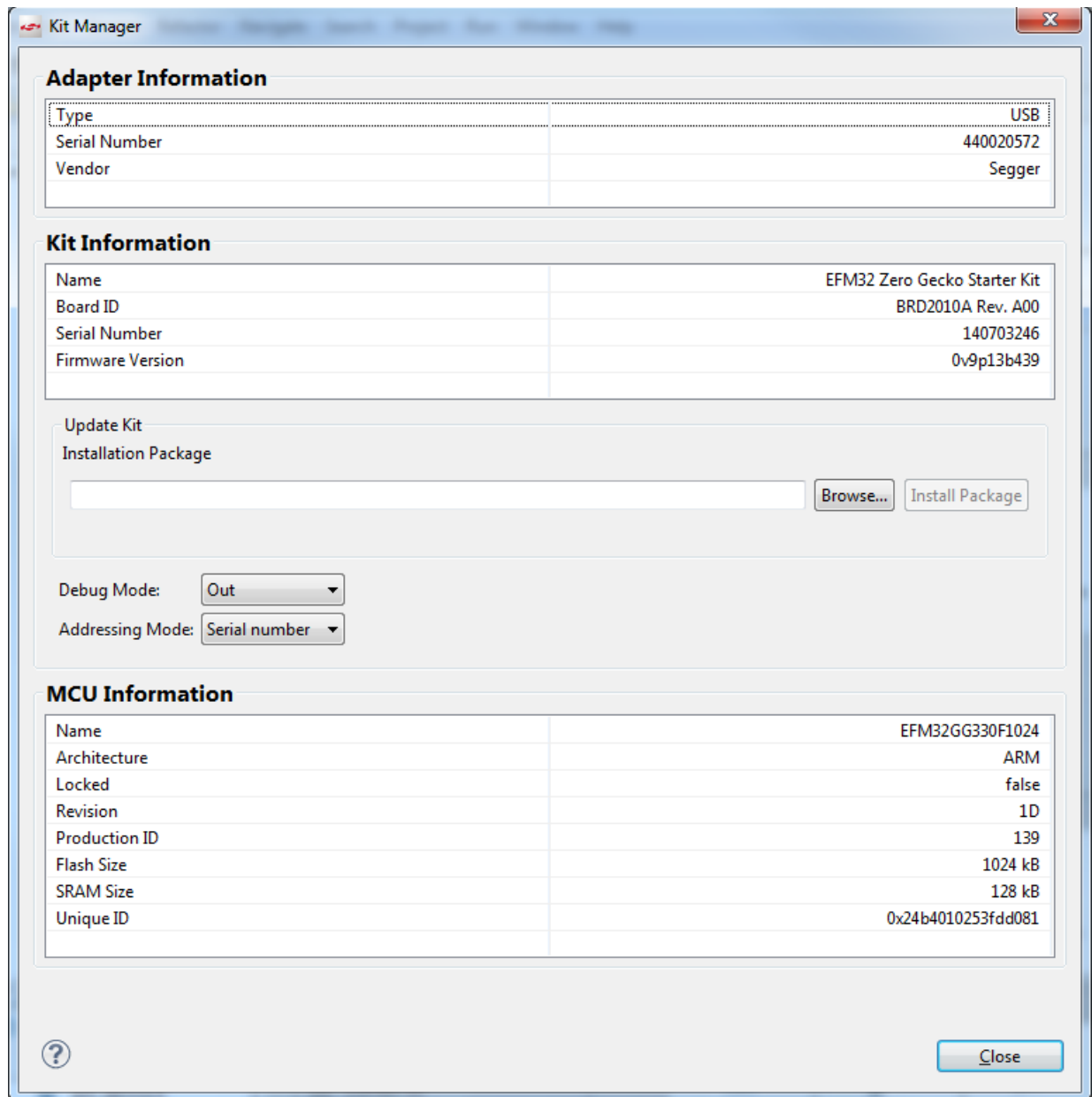


Figure 14. Kit Manager Dialog

To use the development kit subsequently without the puck, it is necessary to revert this setting before disconnecting the puck.

To open the source code in Simplicity Studio, launch the Software Examples wizard by clicking on the Software Examples tile (see Figure 13). Then select Sensor\_Puck as the kit. Click 'Next' and select the sensor\_puck source code.

This will load the source code in the Silicon Labs IDE where it can then be viewed, edited, compiled, and downloaded from within Simplicity Studio. The details of doing this are beyond the scope of this document.

**Note:** Sensor Puck is planned to be supported in V3.0 of Simplicity Studio. Prior to V3.0, the source code will be provided at [www.silabs.com/sensor-puck](http://www.silabs.com/sensor-puck). To load the project into Simplicity Studio, use the steps in the readme document in this link instead of the Software Examples wizard.

# Sensor Puck

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## CONTACT INFORMATION

Silicon Laboratories Inc.  
400 West Cesar Chavez  
Austin, TX 78701  
Tel: 1+(512) 416-8500  
Fax: 1+(512) 416-9669  
Toll Free: 1+(877) 444-3032

Please visit the Silicon Labs Technical Support web page:  
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#### Как с нами связаться

**Телефон:** 8 (812) 309 58 32 (многоканальный)

**Факс:** 8 (812) 320-02-42

**Электронная почта:** [org@eplast1.ru](mailto:org@eplast1.ru)

**Адрес:** 198099, г. Санкт-Петербург, ул. Калинина, дом 2, корпус 4, литера А.