Sensor Puck
Mobile App

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RECORD OF REVISIONS

REV	DATE	PAGES AFFECTED	REASON FOR REVISION
1.0	9/24/14	N/A	Created
1.1	10/10/14		
1.2	4/7/15		Describe new ad structures

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Silicon Labs Sensor Puck App

1. Introduction

Silicon Labs developed a project called the Sensor Puck. The purpose of the project is to demonstrate Silicon Lab's sensor ICs. The puck contains sensors for temperature, humidity, ambient light, ultraviolet light and heart rate. The sensor data is broadcast via Bluetooth and is displayed by mobile apps.

This document provides enough detail for a software developer to implement a mobile app.

2. Bluetooth

The Sensor Puck uses a Bluetooth Low Energy (BLE) module. BLE is also known as Bluetooth Smart and Bluetooth 4.0. The puck is a transmit-only broadcaster. The puck sends sensor measurements as manufacturer specific data in advertising packets. The puck sends its device name in scan response packets.

The Sensor Puck mobile app is a receive-only observer. The mobile app is a passive displayer of sensor measurements and it does not connect to the puck. The app simply scans for advertisements from the puck and displays the sensor measurements contained in the advertising packets.

3. Measurement Modes

The Sensor Puck has two measurement modes. If the user's finger is not on the heart rate monitor (HRM), then the puck is in environmental measurement mode. The puck measures temperature, humidity, ambient light and UV light. The puck broadcasts these measurements in environmental advertising packets twice a second.

If the user's finger is on the HRM, then the puck is in biometric measurement mode. The puck measures only the heart rate. Each advertising packet contains the heart rate (in beats per minute) and five raw HRM samples. Biometric advertising packets are sent five times a second. Therefore, the puck sends 25 HRM samples a second.

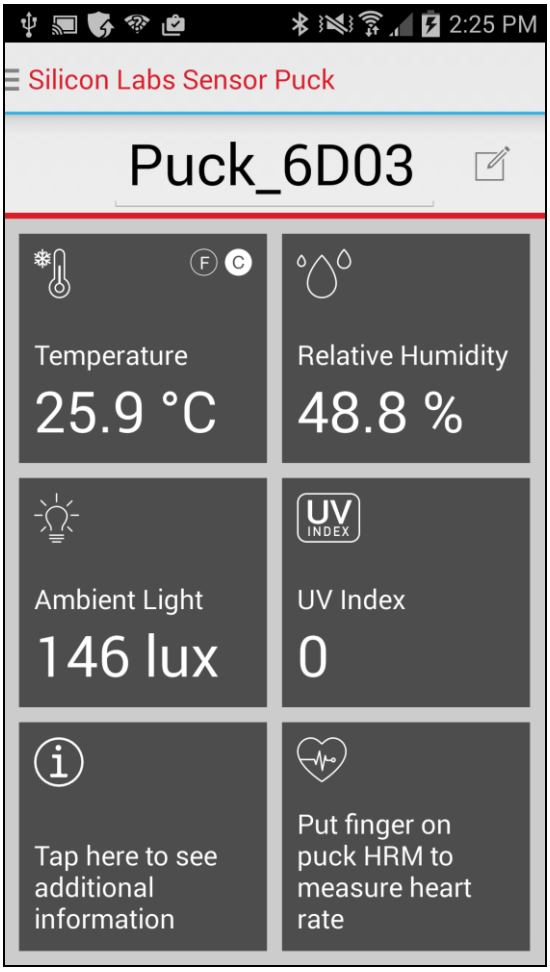
4. Not-Found Screen

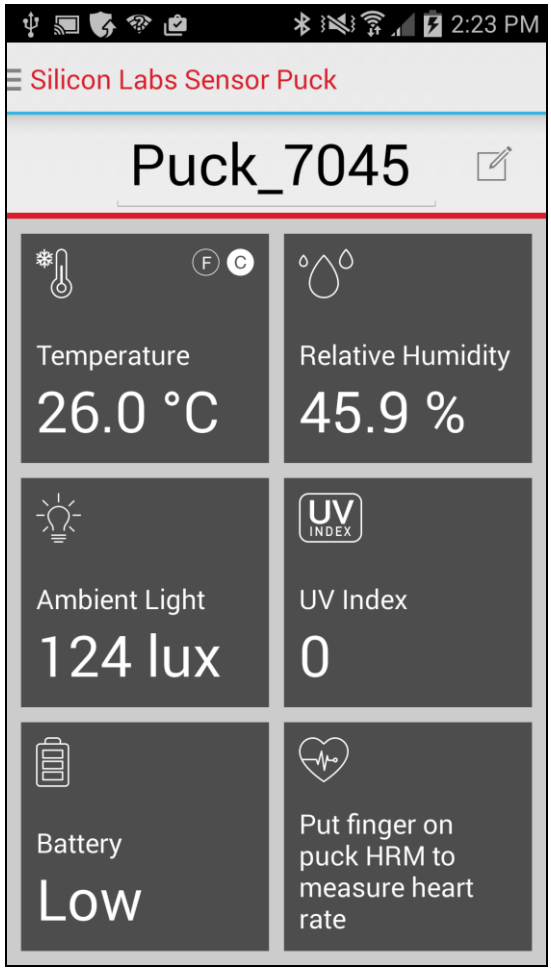
When the mobile app is not receiving any advertising packets, then it displays the not-found screen.

In the not-found screen, the puck name edit field and the edit button (pencil) are disabled.

5. Environmental Screen

When the mobile app receives environmental advertising packets, then it displays the environmental screen.





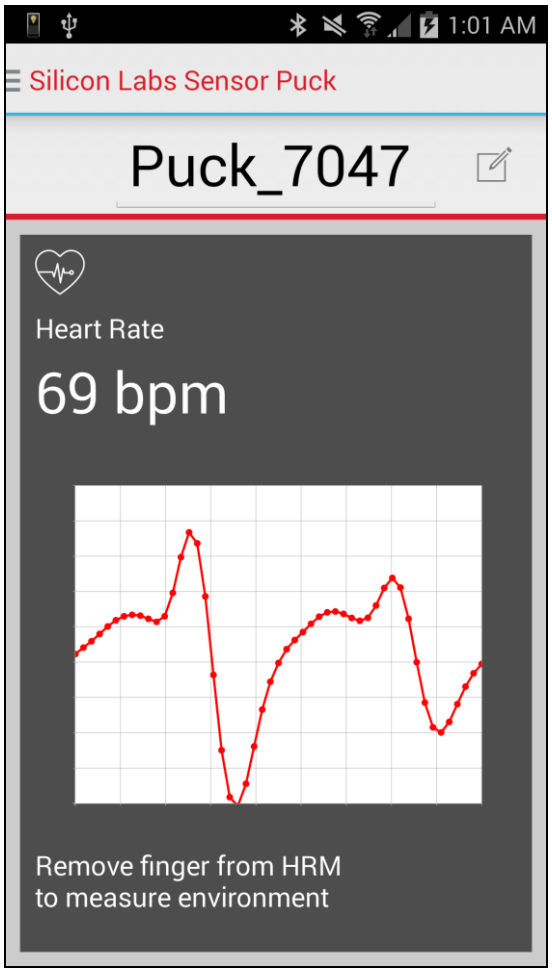
The environmental screen displays the environmental measurements and the battery status.

If the puck's battery voltage is good, then the lower left tile can be tapped to display addition information about the sensors. If the puck's battery voltage is low, then the lower left tile displays low battery status. The word "Low" flashes to draw attention to it.

The user can tap on the “F/C” button to switch the displayed temperature scale between Fahrenheit and Celsius. The temperature measurement, in the advertising packet, is in Celsius.

6. Biometric Screen

When the mobile app receives biometric advertising packets, then it displays the biometric screen.



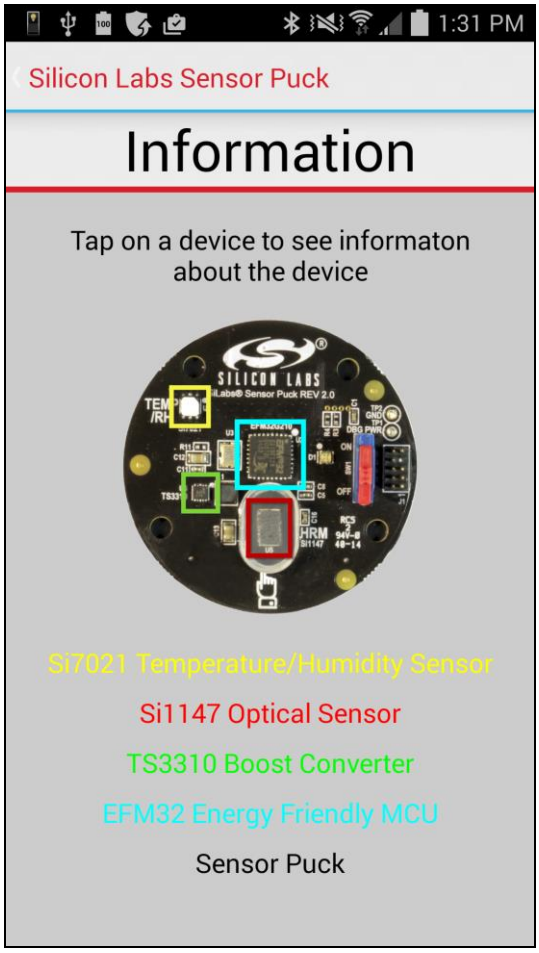
The biometric screen displays the heart rate measurement and graphs the HRM samples. The graph scrolls in real time to display the most recent samples. The graph does not have any labels or legends. The width of the graph is 50 samples (2 seconds). The range of the Y axis is 0 to 30,000.

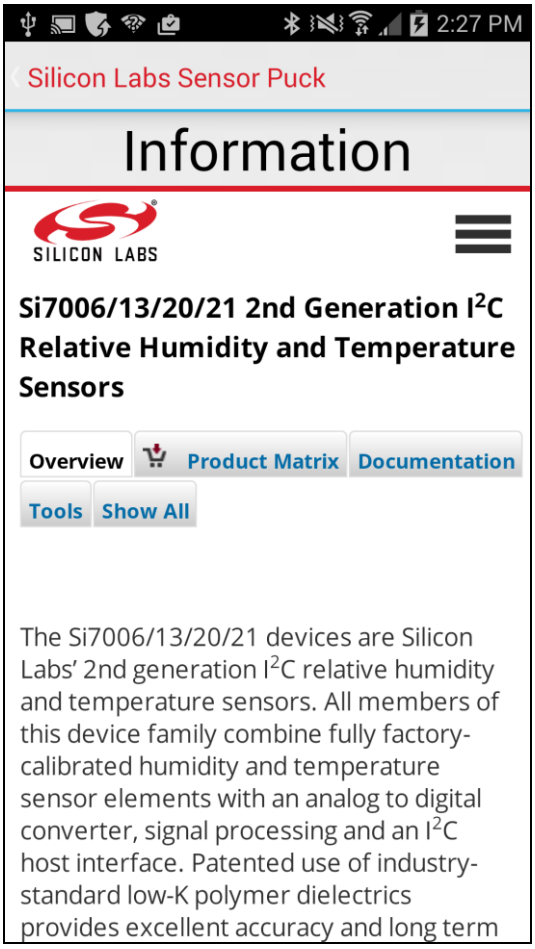
The mobile app processes the raw HRM samples before displaying them. The app applies a band-pass filter to remove DC and noise, and automatically

adjusts the gain of the signal. When advertisements are lost, then app creates interpolated samples to replace for the lost samples.

7. Information Screen

When the user taps in the lower left tile of the environmental screen, then the app displays the information screen.





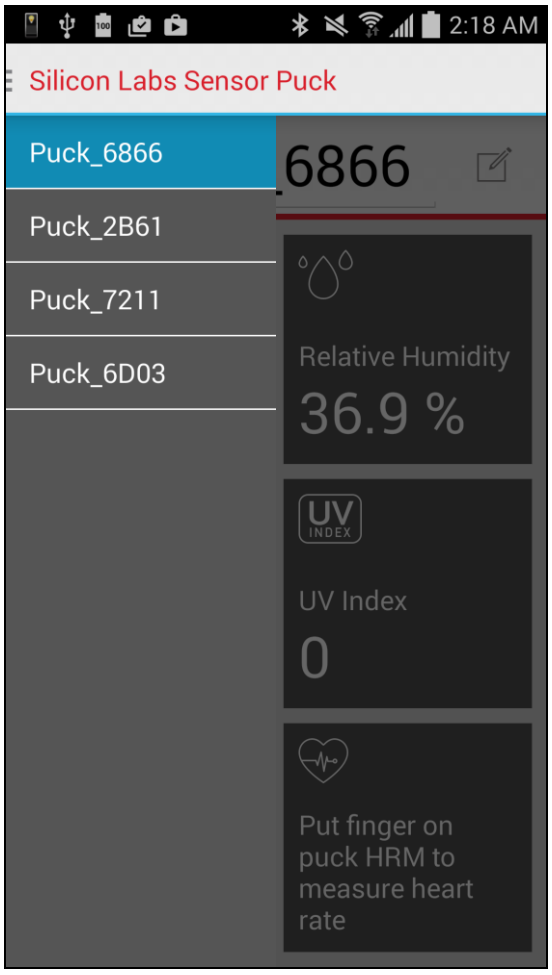
The information screen displays an image of the sensor puck with colored boxes around the sensor ICs and the MCU. Below the puck image is colored text which describes the corresponding colored boxes. The user can tap on a colored box or colored text see detailed information about the IC.

When the user taps on a colored box or colored text, then the information screen displays a web page from the Silicon Labs website. The web page processes JavaScript, but if the user taps on a link then an external web browser is used to

display the linked page. The user can tap the back button or action bar to return to the previous screen.

8. Multiple Pucks

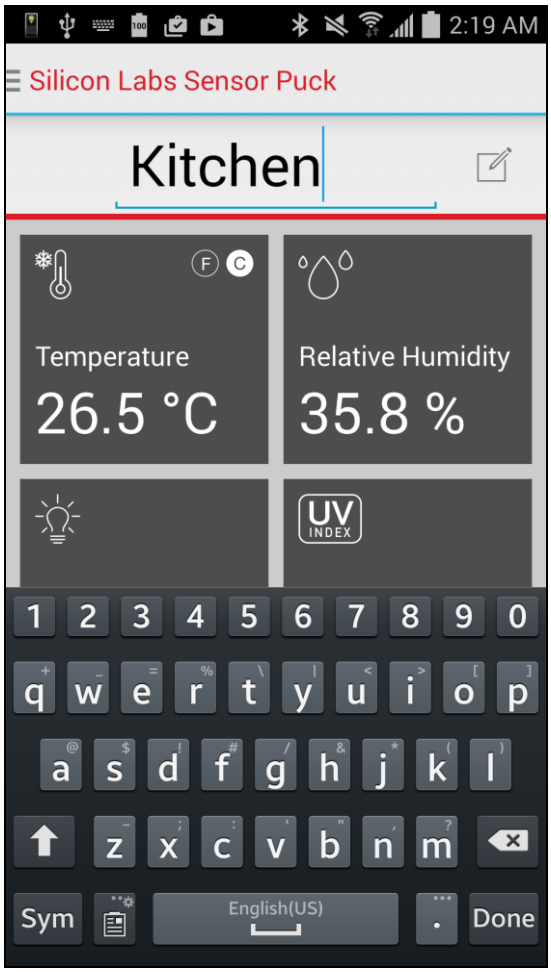
Several pucks may be transmitting advertising packets at the same time. The mobile app maintains a list of all discovered pucks. The user selects a puck from the navigation drawer which slides out from the left side of the screen. The user can open and close the navigation drawer by tapping on the app icon in the action bar. The currently selected puck is highlighted in the navigation drawer.



The mobile app displays measurements from only the selected puck and ignores the advertising packets from the other pucks. The app displays the name of the selected puck in the puck name edit field at the top of the screen.

9. Friendly Names

Pucks are identified by their Bluetooth address. However, a Bluetooth address is not a very friendly name to display to the user. The default name for a puck is "Puck_" followed by the least significant two bytes of the Bluetooth address (in hexadecimal).



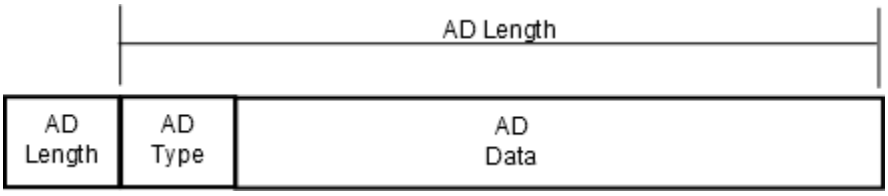
The user can change the name of a puck by tapping on the edit button (pencil) to the right of the puck name edit field. The user can also tap directly in the edit field. The new puck name becomes active when the user taps on the keyboard's done button. If the user completely erases the edit field and then taps on the done button, then the puck name is automatically changed to the default name.

The mobile app saves the friendly name for each puck in persistent storage. This is only necessary if the user has changed the name of the puck from the default name.

When the app is restarted and the puck is discovered again, then the app automatically uses the friendly name from persistent storage to refer to the puck.

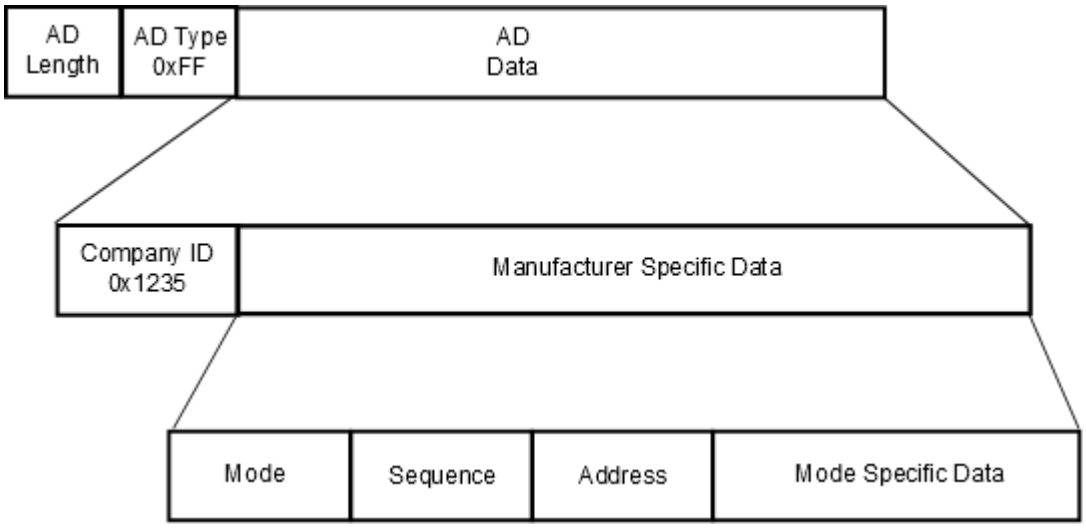
10. Structure of Advertising Data

The payload of an advertisement contains a sequence of advertising data (AD) structures. An AD structure has this format:



10.1 Manufacturer Specific Data

In a puck advertisement, the second AD structure has an AD type of 0xFF (Manufacturer Specific Data) and has this format:



A Silicon Labs Manufacturer Specific Data structure has a company ID of 0x1235. The company ID is followed by a sequence of data fields:

Data Field	Data Type	Units
Mode	uint8	none
Sequence	uint8	none
Address	uint16	none
Mode Specific Data	See next section	See next section

The mode field specifies the measurement mode of the puck. If the mode is 0 then the puck is in environmental measurement mode and this is an environmental advertisement. If the mode is 1 then the puck is in biometric measurement mode and this is a biometric advertisement.

The puck increments the sequence number for each set of new measurements. The sequence number is useful for detecting duplicate and lost advertisements.

The puck takes environmental measurements once a second, but advertisements are sent twice a second. Therefore, the same advertisement is sent twice and the sequence number is the same in both advertisements. The puck increments the sequence number for each unique advertisement (once a second).

In biometric mode, samples are taken 25 times a second, but only 5 advertisements are sent a second. Each advertisement contains 5 samples and the sequence number is incremented in each advertisement.

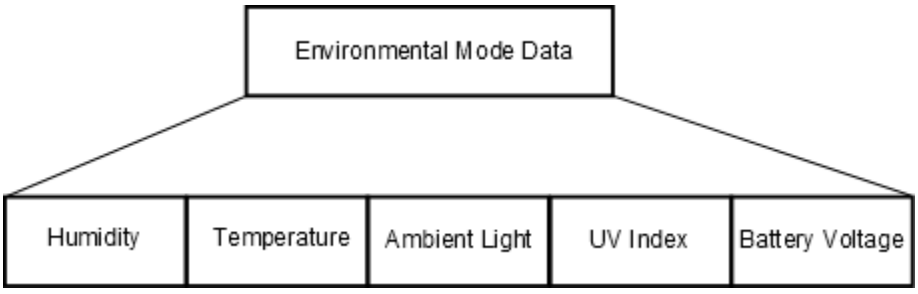
The address field contains the least significant two bytes of the puck's Bluetooth address. The address field is used by the mobile app to identify the puck. This field is particularly useful in the iPhone app, because iOS does not provide the puck's Bluetooth address to the app.

10.2 Mode Specific Data

If the advertisement is an environmental advertisement (mode=0), then the mode specific data is environmental mode data. If the advertisement is a biometric advertisement (mode=1), then the mode specific data is biometric mode data.

10.2.1 Environmental Mode Data

The environmental mode data is a sequence of data fields which contain measurements from the environmental sensors and the battery voltage.

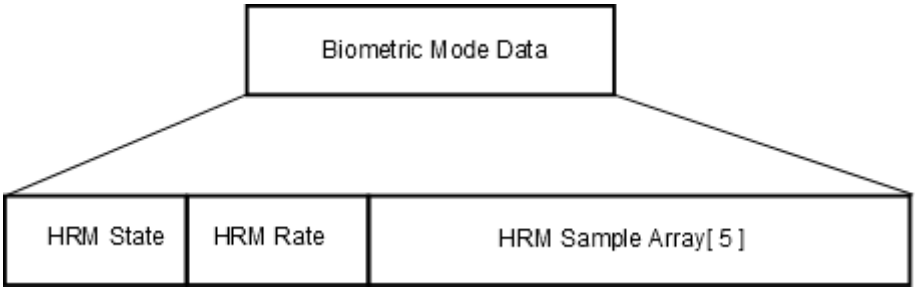


Data Field	Data Type	Units
Humidity	uint16	deciprecent
Temperature	int16	decidegrees
Ambient Light	uint16	lux/2
UV Index	uint8	index
Battery Voltage	uint8	decivolts

A “deci” unit is an integer which is one tenth of a unit. For example, a humidity of 453 decipercent is the same as 45.3 percent. The temperature is in Celsius and can be negative. The ambient light value must be multiplied by 2 to convert to lux.

10.2.2 Biometric Mode Data

The biometric mode data is a sequence of data fields which contain heart rate measurements (HRM) and raw sample data.



Data Field	Data Type	Units
HRM State	uint8	none
HRM Rate	uint8	bpm
HRM Sample Array	uint16[5]	none

The HRM state indicates the status of the puck’s HRM algorithm in determining the heart rate from the raw HRM samples. The HRM states are:

HRM State	Value
Idle	0
No Signal	1
Acquiring	2
Active	3
Invalid	4
Error	5

The HRM heart rate value is only valid when the HRM state is active.

HRM sample data is an array of five uint16 values. The oldest sample is first. The sample values do not have any units and range from 0 to 30,000.

10.3 Puck Firmware Buffers

It may be useful for you to see the buffers that the puck firmware uses to create the advertisements:

```
/* Environmental Advertising Data */
static uint8_t EnvData[ENV_DATA_SIZE] =
{
  /*  0 */ 0x02,               /* AD Length */
  /*  1 */ 0x01,               /* AD Type = Flags */
  /*  2 */ 0x06,         /* Flags  = LE General Discoverable Mode, BR/EDR Not Supported */

  /*  3 */ ENV_DATA_SIZE - 4,  /* AD Length */
  /*  4 */ 0xFF,               /* AD Type = Manufacturer Specific Data */
  /*  5 */ 0x35,               /* Company ID LSB */
  /*  6 */ 0x12,               /* Company ID MSB */

  /*  7 */ ENVIRONMENTAL_MODE, /* Measurement Mode */
  /*  8 */ 0x00,               /* Sequence */
  /*  9 */ 0x00,               /* Address LSB */
  /* 10 */ 0x00,               /* Address MSB */
  /* 11 */ 0x00,               /* Humidity LSB */
  /* 12 */ 0x00,               /* Humidity MSB */
  /* 13 */ 0x00,               /* Temperature LSB */
  /* 14 */ 0x00,               /* Temperature MSB */
  /* 15 */ 0x00,               /* Ambient Light LSB */
  /* 16 */ 0x00,               /* Ambient Light MSB */
  /* 17 */ 0x00,               /* UV Light Index */
  /* 18 */ 0x00,               /* Battery Voltage */
};

/* Biometric Advertising Data */
static uint8_t BioData[BIO_DATA_SIZE] =
{
  /*  0 */ 0x02,              /* AD Length */
  /*  1 */ 0x01,              /* AD Type = Flags */
  /*  2 */ 0x06,         /* Flags  = LE General Discoverable Mode, BR/EDR Not Supported */

  /*  3 */ BIO_DATA_SIZE - 4, /* AD Length */
  /*  4 */ 0xFF,              /* AD Type = Manufacturer Specific Data */
  /*  5 */ 0x35,              /* Company ID LSB */
  /*  6 */ 0x12,              /* Company ID MSB */

  /*  7 */ BIOMETRIC_MODE,    /* Measurement Mode */
  /*  8 */ 0x00,              /* Sequence */
  /*  9 */ 0x00,              /* Address LSB */
  /* 10 */ 0x00,              /* Address MSB */
  /* 11 */ 0x00,              /* HRM State */
  /* 12 */ 0x00,              /* Heart Rate */
  /* 13 */ 0x00,              /* HRM Sample 1 LSB */
  /* 14 */ 0x00,              /* HRM Sample 1 MSB */
  /* 15 */ 0x00,              /* HRM Sample 2 LSB */
  /* 16 */ 0x00,              /* HRM Sample 2 MSB */
  /* 17 */ 0x00,              /* HRM Sample 3 LSB */
  /* 18 */ 0x00,              /* HRM Sample 3 MSB */
  /* 19 */ 0x00,              /* HRM Sample 4 LSB */
  /* 20 */ 0x00,              /* HRM Sample 4 MSB */
  /* 21 */ 0x00,              /* HRM Sample 5 LSB */
  /* 22 */ 0x00,              /* HRM Sample 5 MSB */
};
```