Smart Bandage Communications Module

Datasheet

1 Features

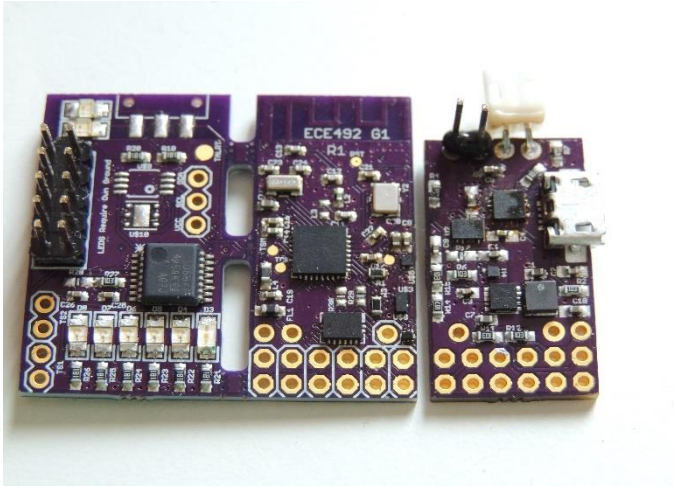
- **TI CC2650 Bluetooth Capable MCU**
- **Lithium Ion Battery Management System**
- **Lithium Ion Gas Gauge for Battery Life**
- **JTAG header unit for easy programming of MCU**
- **Detachable development board for prototyping**
- **Temperature, humidity sensors on the dev board**
- **LEDs indicators, micro USB charger with smart shutoff**
- **PCB antenna for communication**
- **Moisture Sensing grid**

2 Applications

- **Medical Sensor device for wound monitoring**

3 General Description

The Smart Bandage device provides remote monitoring of wounds by placing sensors inside of a bandage and relaying the resulting data over Bluetooth Low Energy (BLE). By knowing what is occurring inside the bandage through temperature, humidity and moisture sensors, the amount of attention required to optimize the healing process can be monitored without introducing sources of infection to the wound.



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4.1 Description of Operation

The Smart Bandage device is designed to be powered off of a single cell Lithium Ion battery, and charged from a standard USB port. In regular operation, the device spends the majority of its time in a low power sleep state, with all optional peripherals disabled. The device then awakes at a predefined interval, reads all sensor data, and resumes sleeping. Every 1-6 hours the device enables its Bluetooth antenna and relays all measurements taken to a smartphone for further processing and monitoring.

The Bandage Module, which is the Flexible Printed Circuit (FPC) with all of the sensors is designed to be attached to the 2x6 pin header located on the Communications Module. The Bandage Module then hosts 3xMCP9808 Temperature sensor, 1xHDC1050 Humidity + Temperature sensor, and 5x moisture sensing lines. The Bandage Module has two grounds: digital and analog, which are join on the Communications Module.

4.2 Board Layout

Significant components of the Smart Bandage PCBs are laid out below, and described in Table 1.

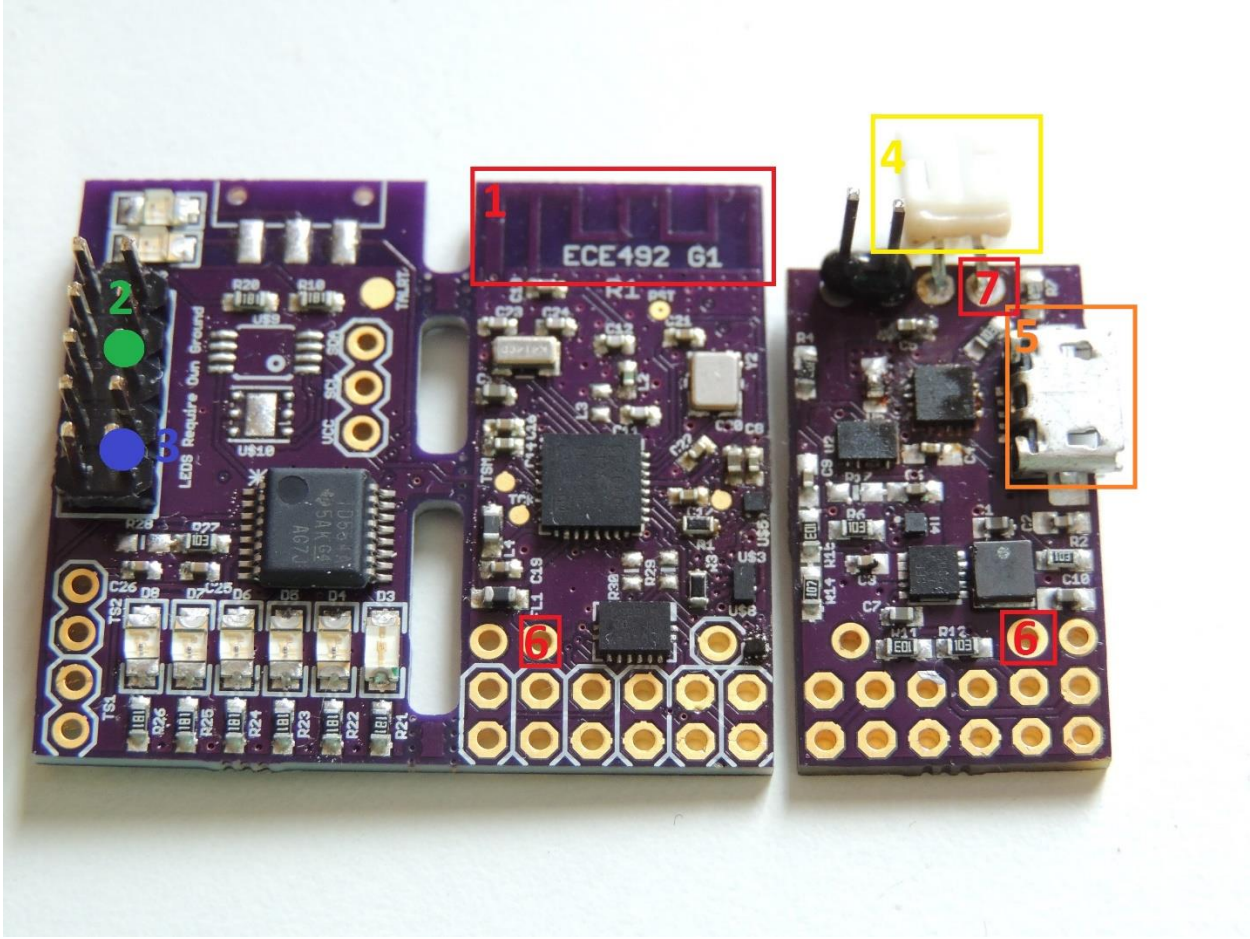

Figure 1: Communications Module Details

Important I/O	Number	Value
PCB ANTENNA	1	nil
JTAG_TSMC	2	0-3.3 Volts
JTAG_TCKC	3	0-3.3 Volts
3.3V Regulator Test Point	6	3.3 Volts
Battery Test Point	7	0-4.2 Volts
Micro USB	5	0-5.5 Volts
Battery Connector (JST type connector)	4	Nominal: 3.7 Volts

Table 1: Board Features

The bottom board on the communication module is mounted to the top board be placing it component side down, and populating the 6x2, 1x2, and 1x1 0.1" pin headers. The top board is then placed on top, with space for the battery in the middle, and the headers soldered in place. The result is shown in Figure 2.

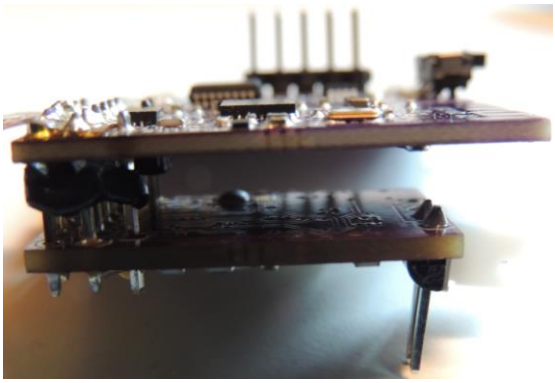

Figure 2: Mounted Communications and Bandage Modules

5 Bill of Materials

Table 2 shows the required parts list to construct two copies of the device.

Part	Digikey PN	QTY
TI CC2640	296-41981-1-ND	2
Flexible Printed Circuit Board (10 Copies)		1
Main board PCB (10 Copies)		1
Shipping from China for PCBs		1
MCP9808 Temperature Sensor	MCP9808T-E/MSCT-ND	4
HDC1050DMBR Humidity + Temperature Sensor	296-42616-1-ND	2
Solder Stencils (oshstencils.com)		1
BQ24075 Li-Ion Charge/PWR MGMT IC	296-25609-1-ND	2
STC3115 IC Gas Gauge	497-15077-1-ND	2
TPS63031 Buck/Boost Converter	296-39461-1-ND	2
74LV4051BQ 8ch Analog Multiplexer	568-9269-1-ND	2
74LVC2G53 2ch Analog Multiplexer	568-5476-1-ND	2
TLV71713PDQNR IC Reg LDO 1.3V	296-36773-1-ND	2
RES SMD 4.32KOHM 0.1% 1/10W 0603	P4.32KDBCT-ND	10
Assorted 0603 Passives		1

110mAh E-Textiles Battery (Sparkfun)		1
1.5uH 55mOhm Chip Inductor	490-5343-1-ND	2
DMC2990UDJ P/N MOSFET Pair	DMC2990UDJ-7DICT-ND	6
Ferrite Bead Filter	490-5216-1-ND	2
Crystal Oscillator 32.768kHz	535-9543-1-ND	2
Crystal Oscillator 24MHz	SER3635CT-ND	2
Inductor 2nH 0402	490-6569-1-ND	4
Inductor 15nH 0402	490-6559-1-ND	4
TCA9554A IO Expander (Testing)	296-43004-1-ND	2
Total		

Table 2: Bill of Materials

6 ELECTRICAL CHARACTERISTICS

Max Input Voltage	5.5V
Min Input Voltage	2.5V
Peak Current Draw	130.5mA
Average Current Draw	0.594mA

Table 3: Electrical Characteristics

6.1 POWER CHARACTERISTICS IN OPERATING MODES

The Smart Bandage has three main modes: Check, Transmit, and Sleep. The check state occurs roughly every 30 seconds (with production settings) and enables all sensors, reads all values, saves values in flash, and then returns to sleep. Transmit mode is enabled every 1-6 hours and enables the BLE functionality of the device for transmitting of data to the smartphone. Once data transmission is complete, the device will return to sleep mode where it spends most of its time. Power consumption for each of these modes is show in Table 3. The seconds per hour column indicates the estimated amount of time (per hour) spent in each state.

State	Seconds/Hour (S)	Current Draw (uA)
Check	12	130,367
Transmit	10	8,400
Sleep	3588	2.7
All Modes (Passive Consumption)	3600	133

Table 4: State Power Consumptions

7 BLUETOOTH CHARACTERISTICS

The device exposes a single “Smart Bandage” Bluetooth service, containing 14 distinct Bluetooth characteristics, which are detailed in Table 5.

Name	ID	Size (B)	Properties	Description
Current Temperature*	0xF0F1	8	R	Current (latest) temperature readings from the device. 4x16bit values.
Current Humidity*	0xF0F2	2	R	Current (latest) humidity readings from the device. 4x16bit values.
Bandage ID	0xF0F3	2	R	A numerical unique identifier for the bandage.
Battery Charge*	0xF0F5	2	R	The charge status of the battery.
External Power	0xF0F6	1	R	Whether the device has external power.
Current Moisture Map*	0xF0F7	10	R	Current (latest) moisture readings from the device. 5x16bit values.
Current System Time	0xF0F8	4	R, W	Current system time in seconds since Unix epoch.
Historical Readings	0xF0F9	70	R, N/I	A 4byte timestamp followed by 3x<Readings Size>byte readings. See below on Readings.
Historical Readings Size	0xF0FA	2	R	The size (in bytes) of an individual reading.
Historical Readings Count	0xF0FB	4	R, W	The number of historical readings available.
Historical Readings Data Offsets	0xF0FC	4	R	Data offsets of fields within a reading.
Extra Pointer	0xF0FD	1	R, W	Extra data control pointer.
Extra Data	0xF0FE	2	R, W	Extra data read/write.

Table 5: Bluetooth Characteristics

**All values representing numerical readings such as Temperature, Humidity, Moisture, and Battery State are sent as integers 16x their actual size. Therefore, to display the value convert it to a floating point number, and divide by 16.0.*

7.1 READINGS

In the Smart Bandage a `Reading` is the set of all sensor values for a given time. An example reading definition is shown in Figure 3.

```
typedef struct {
      SB_READING_T  temperatures[SB_NUM_TEMPERATURE];
      SB_READING_T  humidities[SB_NUM_HUMIDITY];
      SB_READING_T  moistures[SB_NUM_MOISTURE];
      SB_TIMEDIFF_T timeDiff;
} SB_PeripheralReadings;
```

Figure 3: C Definition of a Reading

Due to C structure packing, and the fact that the number of sensors may change the size of a reading (in bytes) is given in the `Historical Readings Size` characteristic, will the byte offsets of the start of each field (temperatures, humidities, moistures, and timeDiff, respectively) appear in the `Historical Readings Data Offsets` with each byte indicating the byte offset of the relevant field. The `timeDiff` field of the reading refers to the number of seconds since the reference time which is stored in the first 4 bytes of the `Historical Readings` characteristic. The same reference time is used for the three readings retrieved in a single notification of the characteristic, but may change between reads.

The optimal way to read all of the historical readings is to enable Indications on the `Historical Readings` characteristic, which will cause the device to send an Indication containing reading data, and will update the readings and send a new value when the indication response is received. The secondary way to read the values is to read the `Historical Readings` characteristic and then write any value to the `Historical Readings Count` characteristic, which will cause the values to be updated. This is called the `Write back` method and is significantly slower than the indication method.

7.2 EXTRA DATA

The extra data parameters (`Extra Data Pointer`, and `Extra Data`) allow the following functional aspects of the device to be controlled:

Property	PTR Value	Description
CheckSleepIntervalMS	1	Milliseconds between check states.
BLECheckInterval	2	Number of check states before the device enters Transmit mode.
CheckReadDelayMS	3	The time the device allows sensors to initialize after enabling them in milliseconds.
MaxTransmitStateTimeS	4	The maximum amount of time in the Transmit state before a return to sleep is forced in seconds.

Table 6: Extra Data Parameters

Reading and writing an Extra Data property is done as follows: First the PTR value from Table 6 should be written to the `Extra Data Pointer` characteristic. Subsequent read or write operations on the `Extra Data` characteristic will then read or write that property.