Smart Pill Bottle

ECE 445 Spring 2016
Mock Design Review

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1. Block Diagram
2. Circuit Schematic

The circuit uses an op-amp as a comparator, with half the battery voltage going into the inverting input, and a constant reference voltage of 2.7V (controlled by a reverse bias zener diode) going into the non-inverting input. When the inverting input voltage drops below 2.7V (battery at 5.4V), the output voltage rises to a level in the operational range of the MCU input’s logical 1. Otherwise, the output voltage of the op-amp is at the MCU input’s logical 0 level.
3. Simulation for Low Battery Detection Block

We are simulating our battery level detection circuit.

<table>
<thead>
<tr>
<th>Battery Voltage</th>
<th>Vout</th>
<th>Battery Voltage</th>
<th>Vout</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.4 V</td>
<td>-0.293 V</td>
<td>5.9 V</td>
<td>-0.288 V</td>
</tr>
<tr>
<td>6.9 V</td>
<td>-0.293 V</td>
<td>5.4 V</td>
<td>2.44 V</td>
</tr>
<tr>
<td>6.4 V</td>
<td>-0.293 V</td>
<td>4.9 V</td>
<td>2.25 V</td>
</tr>
</tbody>
</table>

When the battery level drops below 5.4V, the inverting input voltage of the op-amp (half of the battery voltage) falls below the non-inverting input held at 2.7V by the zener diode and causes the output of the op-amp to rise to a positive voltage. Using resistors we can reduce the output voltage going to the microcontroller to its operational input range.
4. Block Description

The battery level detection block takes one input and one output. The input is the unregulated battery level and the output is an input signal to the microcontroller. The block will sense the output voltage of the battery and, deciding if it is above or below the low voltage threshold, will either output a logical 0 or logical 1 signal to the microcontroller.

![Graph showing battery voltage decline](image)

This figure shows a steep decline in battery voltage at the end of their lifecycle. Thus, our goal is to use a circuit that will detect when the battery output voltage drops before a certain threshold and send a signal to the microcontroller telling it to start the low-battery sequence (unlock pill bottle, transmit message to smartphone, power blinking indicator LED).

5. Requirements and Verification for the Bluetooth LE Module
1. Module must be operational in temperatures of 15 to 30 degrees C. (Based on definition of room temperature for storage of pharmaceuticals set by United States Pharmacopeia)
2. The bluetooth module should be recognizable by and recognize any Bluetooth 4.0 capable smartphone from 0 to 20 meters away.
3. The module should be capable of reliable two-way wireless bluetooth communication with devices from 0 to 20 meters away.
4. The bluetooth module must be capable of two-way wireless communication over the radio frequency range of 2400 Mhz - 2500 Mhz (2.4Ghz ISM band) with any other Bluetooth device operating in the 2.4Ghz ISM band.
5. The module must be fully operational when connected to a power supply of 2.7V +/- 0.9V.
6. The module must support transmission of serial data asynchronously to a microcontroller using UART protocol under a baud rate of 9600 to 9615.
7. The module must be able to receive serial data asynchronously from a microcontroller using UART protocol under a baud rate of 9600 to 9615.

1. Send test signals over bluetooth to probed bluetooth receiver at various temperatures from 15 degrees Celsius to 30 degrees Celsius. Check that signals received match signals transmitted from module. Also check reliable Tx and Rx of data from/to microcontroller over UART by probing Tx and Rx lines while sending test signals.
2. Attempt to pair bluetooth module with Bluetooth 4.0 capable smartphone at various distances from 20 meters to 0 meters. Check that pairing is successful between the two devices.
3. Pair bluetooth module with Bluetooth 4.0 capable smartphone at various distances from 20 meters to 0 meters. Test transmission from bluetooth module to smartphone and vice versa. In each test check that data received at smartphone matches data transmitted from bluetooth module or that data received at bluetooth module matches data transmitted from smartphone.
4. Send test signals from bluetooth module to paired smartphone. Attach antenna to oscilloscope and check that wireless signals fall within 2400Mhz to

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2500Mhz frequency. Do the same procedure sending test signals from smartphone to bluetooth module.
5. Connect bluetooth module to power supply at 1.8V, 2.7V, and 3.6V. Test that reliable wireless communication with paired smartphone is successful and that Tx/Rx with microcontroller over UART is also successful.
6. (and 7.) Transmit 100 packets of serial test data over UART from bluetooth module to microcontroller at a 9600 baud rate. Transmit data back from microcontroller to bluetooth module over UART at 9600 baud rate. Check that packets received at bluetooth module matches original packets. Repeat for 9615 baud rate.

6. Safety Statement

The power source we are using outputs 7.4V DC power which is quickly regulated to at most a voltage of 5V. Even in extreme conditions where resistance of human skin becomes 1000 Ohms, the maximum current delivered to the skin would be 7.4 mA DC, enough to deliver a sensation, but below the threshold for muscle contractions or any serious damage. Under much more likely skin conditions for engineers working with this design of 17,000 Ohms to 100,000
Ohms\textsuperscript{5}, the maximum current delivered to the skin would be 435 microAmps DC, not a perceptible amount to humans\textsuperscript{6}. Since our project delivers little risk for electric shock, and software is generally safe to work with, our project poses no serious safety risks to engineers.

7. Citations


\textsuperscript{6} "Electric shock - Wikipedia, the free encyclopedia." 2011. 18 Feb. 2016