# Application Note : Suggestions for Application Design with Coin Cell Battery

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**Brief:**

This document presents some suggestions on hardware and software design with Telink RF SoC for applications using coin cell battery.

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## Revision History

| Version | Major Changes | Date | Author |
|---|---|---|---|
| 1.0.0 | Initial release | 2016/12 | L.X., W.J.Z., W.S.H., G.Z.Q., Cynthia |

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# 1 Overview

This document mainly presents some suggestions on hardware and software design with Telink RF SoC for applications using coin cell battery.

When an application product uses coin cell battery to supply power, battery specifications (e.g. capacity, pulse drain current) will limit the time to supply power continuously, and directly influence hardware and software design. To optimize product design and ensure system stability, it's highly recommended for user to read this guide.

## 2 Coin Cell Battery Characterization

Coin cell battery has different usage characteristics compared to other type of batteries. For example, if there are large current draws for the battery continuously, the battery capacity can drop very fast leading to very short life time; while on the other hand, if the duty cycle is low enough and the battery has enough time to recover during the active cycles, the battery life can be considerably longer.

In this document, the coin cell battery model "CR2032" commonly used in 2.4G wireless applications (such as RF4CE, ZigBee, BLE) is taken as an example. The battery specifications are shown as below:

- Nominal voltage: 3V
- Nominal capacity (2.5V cutoff): 220mAh
- Recommended continuous drain current: 0.3mA
- Recommended pulse drain current: 12mA

As shown above, the recommended pulse drain current is 12mA. However, the actual transient current may exceed 12mA, for example, at the maximum Tx power; since the coin cell battery can't bear the strong transient current, the voltage will drop sharply. If the battery voltage drops below the operating voltage range of the actual product, it will power cycle the product, even power off the product.

To characterize the performance of cell battery, a number of tests are done with firmware simulating various usage scenarios:

Case 1: 300ms Active mode with high current draw + 2s suspend with low current, this simulates the key processing and RF transmission activities in some applications.

Case 2: 1s RF mode + 5s MCU active without RF + 10s suspend mod, this simulates prolonged user interactions in some applications.

In both cases, for RF active mode, the average current is kept over 30mA; in normal mode without RF packet transfer, the current is kept to 20mA.

Figure 1 and Figure 2 shows current in simulation test of case 1 and case 2.

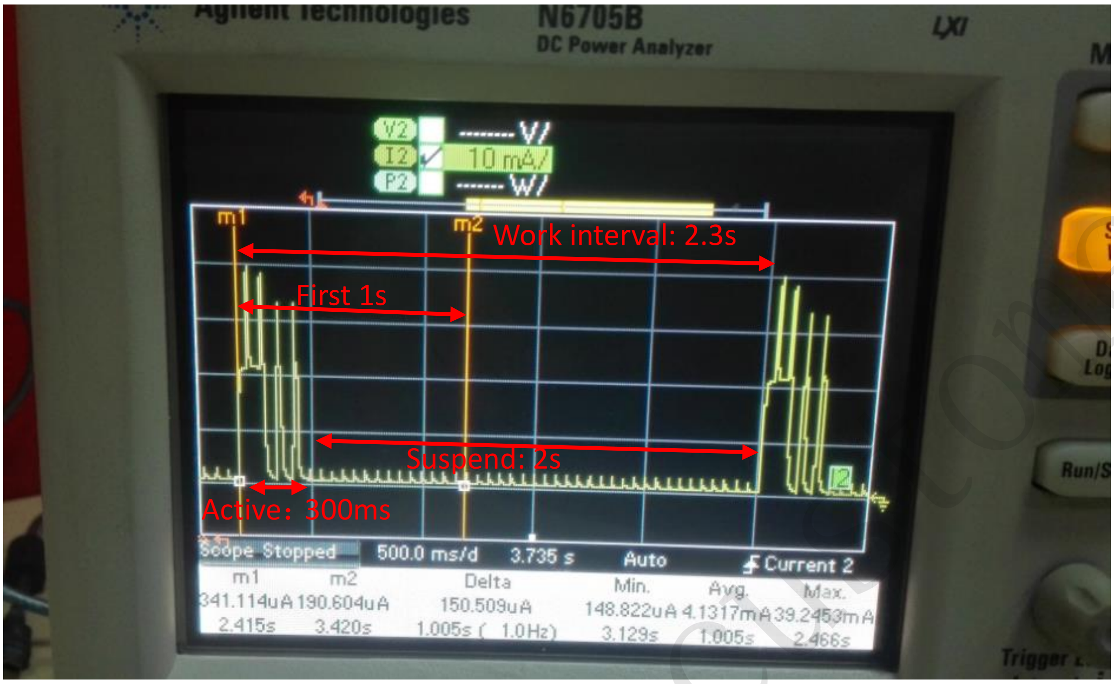
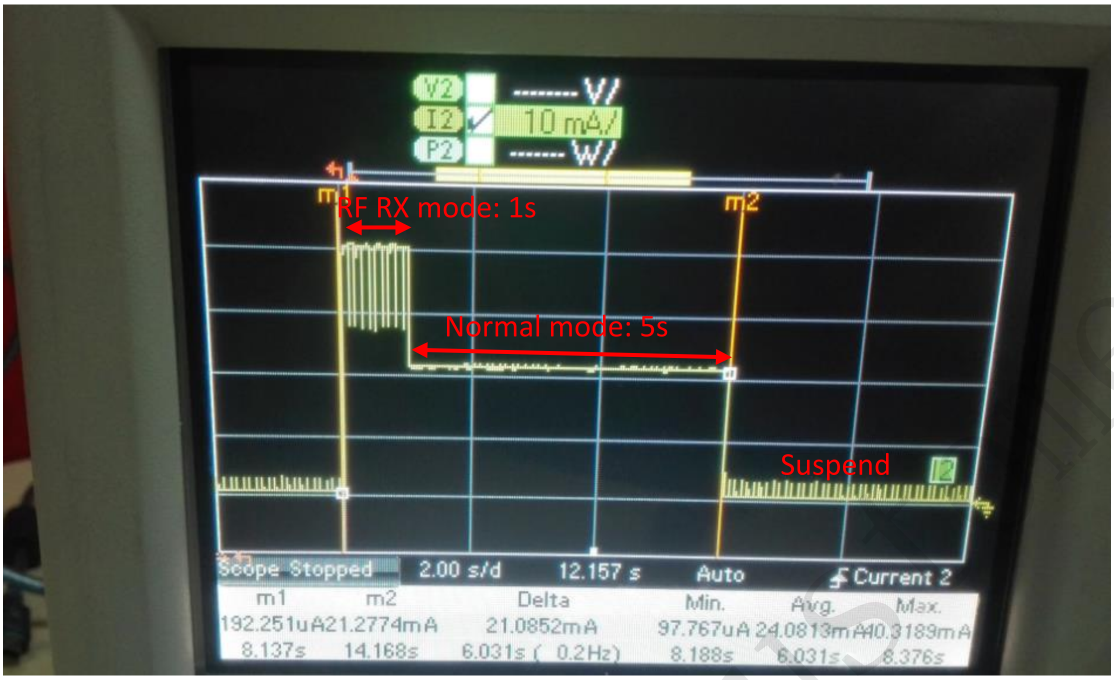



Figure 1　　Current test sample in Case 1

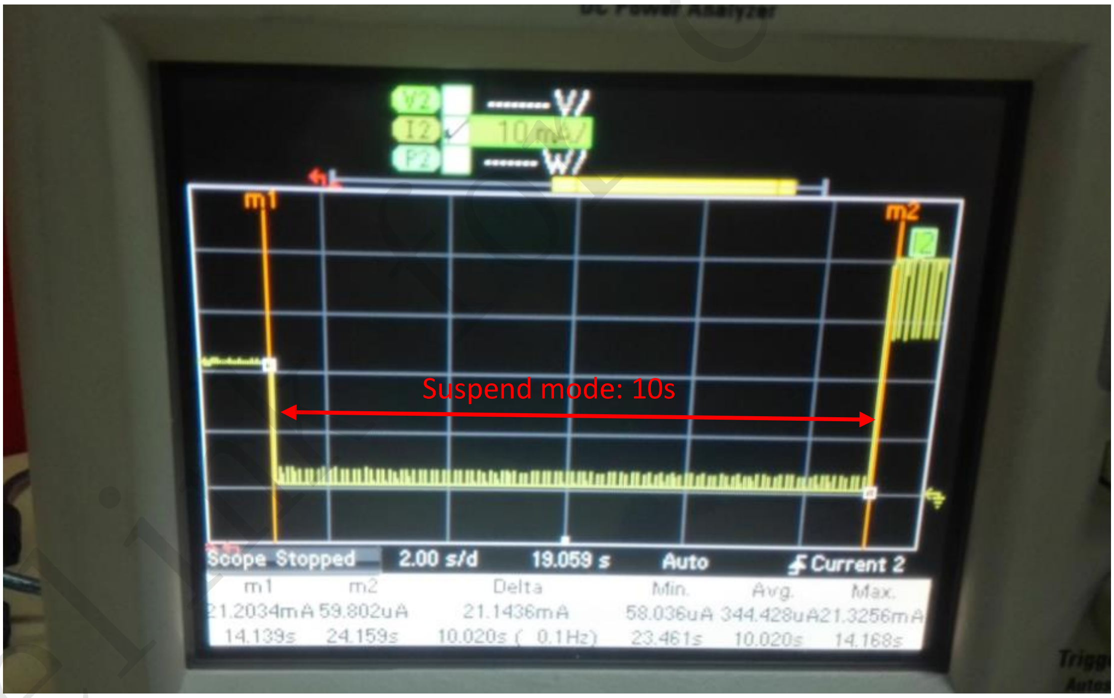
For Case 1 test, after 40 hours of repeated test, the maximum voltage drops below 2V and the software on chip performs voltage shutoff.

If each case 1 cycle is considered as one key press event, then the total count of simulated key presses is 40h/2.3s≈62600; suppose daily key press count is 200, the battery lifetime should be 62600/200=313 days.

Since short sleep duration (2s suspend) is configured to simplify and speed up simulation test, the battery does not get enough recovery time during the tests and the lifetime was decreased. If the suspend time is longer, it can be expected that the cell battery life time will increase as well.




1s RX mode + 5s normal mode




10s suspend mode

Figure 2　　Current test sample in Case 2

**For Case 2 test, multiple runs with different parameter settings are performed as follows.**

**Test run 1 for a new cell:**

- ✧ After the first simulation test of two hours, the minimum voltage drops to 1.98V. The chip can still work normally, but the voltage is supposed to be unreliable.
- ✧ Turn off DUT and wait for 12 hours.
- ✧ Restart the test. After the second simulation test of less than 1.5 hours, the chip cannot work normally due to low voltage.
- ✧ Turn off the DUT and wait for 10 minutes.
- ✧ Restart the test. After the third simulation test of less than 10 minutes, the chip cannot work normally.
- ✧ Power down the DUT and wait for 30 minutes.
- ✧ Restart the test. After the fourth simulation test of about 20 minutes, the chip cannot work normally.

It can be seen that without resting, the battery will last around 2 hours, but with recovery time, the total test time is 4 hours.

Shortened interval between two adjacent tests will have more influence on the current test.

**Test Run2:**

If suspend time is changed to 2s (shorter recovery time for battery), after simulation test of less than 20 minutes (0.33h) for a new cell, the minimum voltage drops below 2V.

**Test Run 3:**

If suspend time is changed to 5s, after simulation test of about 50 minutes (0.8h) for a new cell, the minimum voltage drops below 2V.

**Summary:** Depending on how much rest time the battery gets between repeated tests, the coin cell can last between 20 minutes to 2 hours. Shortened suspend time will have more influence on battery lifetime.

# 3 Hardware Design Suggestions

User can try to select coin cell battery model which can bear higher transient current, or follow the suggestions below on hardware design:

1) It's recommended to use several coin cell batteries in parallel, and the number depends on maximum system current.

2) Whether system adopts single or multiple coin cell batteries, in order to maximize power usage, it's recommended to place a capacitor with large capacitance (e.g. 220uF or higher) close to the battery/batteries. When load current is high, this capacitor can share the load on the battery; when load current is low, this capacitor will be charged by the batteries.

**Following test shows the actual effect of the capacitor for one RC (Remote Control) sample using the coin cell battery model "CR2032":**

When no capacitor with large capacitance value is placed next to the battery, press keys to transfer RF packets, sharp voltage drop can be detected, as shown in the figure below.

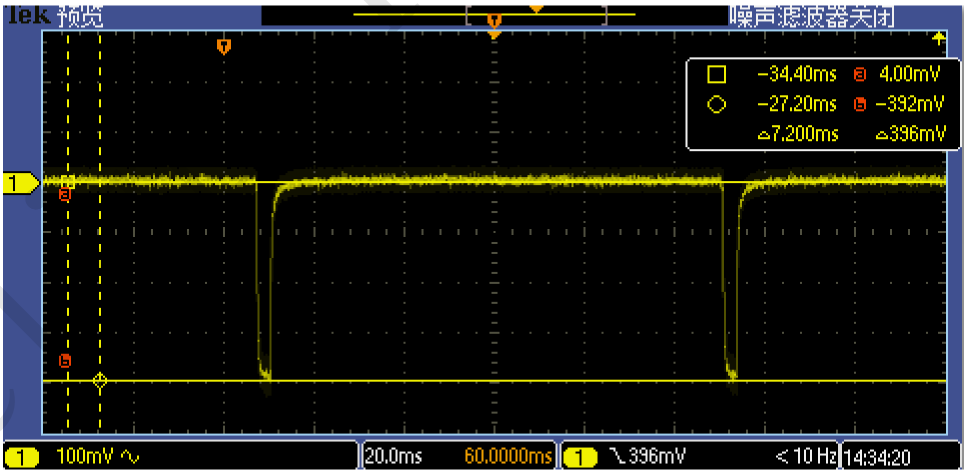



Figure 3 Large voltage drop before placing capacitor

If the battery used is not new, capacity would be lower, the voltage drop would be more obvious.

By placing a capacitor with large capacitance value (e.g. 220uF), the detected voltage drop is decreased obviously, as shown in the figure below.

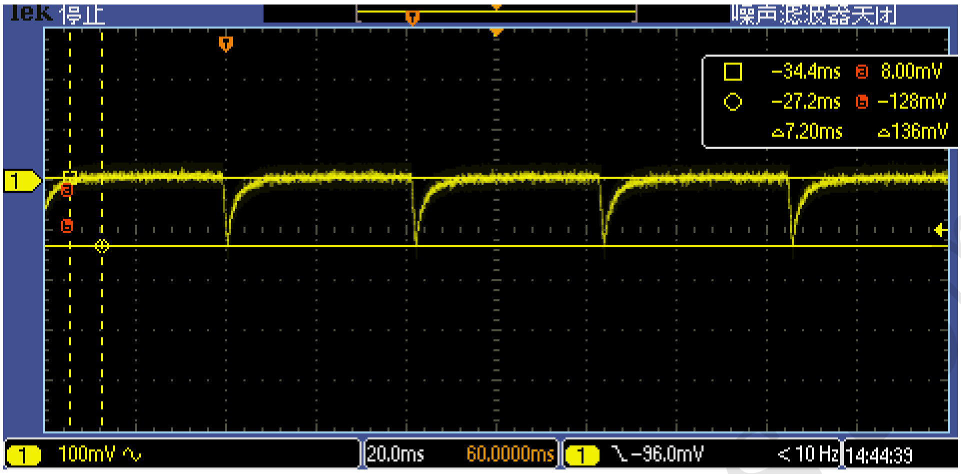



Figure 4 Decreased voltage drop after placing capacitor

# 4 Software Design Suggestions

1) When battery voltage drops below specific threshold, low-voltage alarm signal (e.g. LED blinking) should be generated to inform user to charge or change battery. Then the whole system should be shut down and enter low power mode.

2) In low voltage state, try not to carry out any operations so as to avoid risk, for example, do no write or erase flash. Flash operations such as erasing can drop large current for a prolonged time. The operation can be particularly risky when the voltage level is low.

3) After flash writing operation, read the written contents and check if there's error. If the check result shows error, just restart a writing operation. It's recommended that rewriting should not exceed three times.

4) When certain GPIO is enabled as wakeup source for low-power mode, make sure its level before entering low-power mode differs from the wakeup level, otherwise the product will fail to enter low-power mode.
   For 8626, it's recommended to use PWM0/GP3/GP16/GP24 as wakeup pin, since wakeup level can be configured independently for these pins.

5) Try not to continuously process tasks with high power consumption and long execution time in firmware. Break tasks into small atomic operations and spread them out over duty cycles to avoid continuously high current operation.