

DWM1001 Battery Lifetime Estimation

Version 0.1

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1 PURPOSE

The DWM1001 is a UWB module consisting of an MCU with Bluetooth functionality and accelerometer as well as the DW1000 UWB transceiver. An analysis of battery lifetime expectations for the module and description of our battery lifetime estimator tool is presented in this document.

2 BATTERY LIFETIME ESTIMATOR TOOL

2.1 Typical Hardware

A diagram of the main blocks within the DWM1001 is shown in Figure 1. The module requires a 3.3 V nominal supply voltage. This is routed to the MCU, accelerometer and DW1000 transceiver. The DW1000 is also supplied with a 1.8 V voltage, generated by a DCDC buck converter.

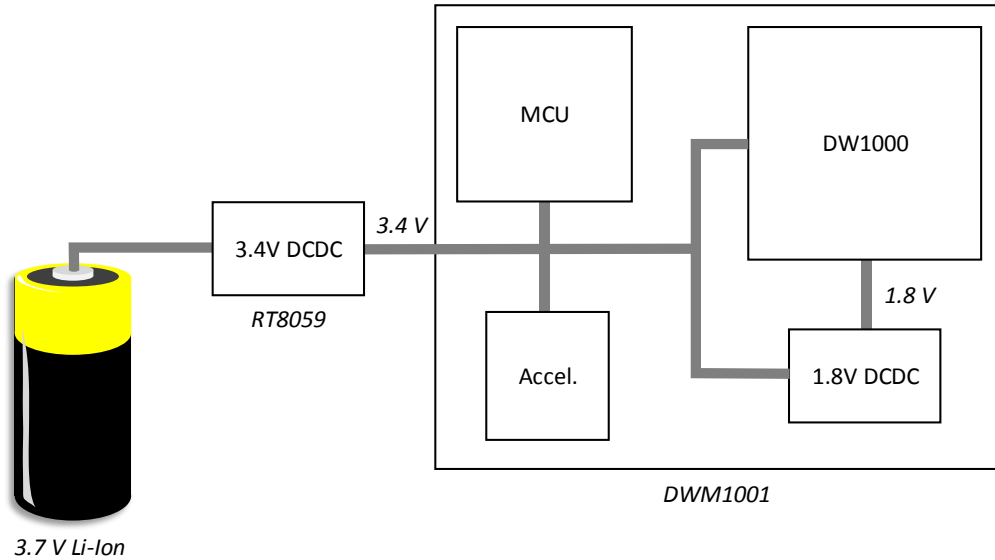
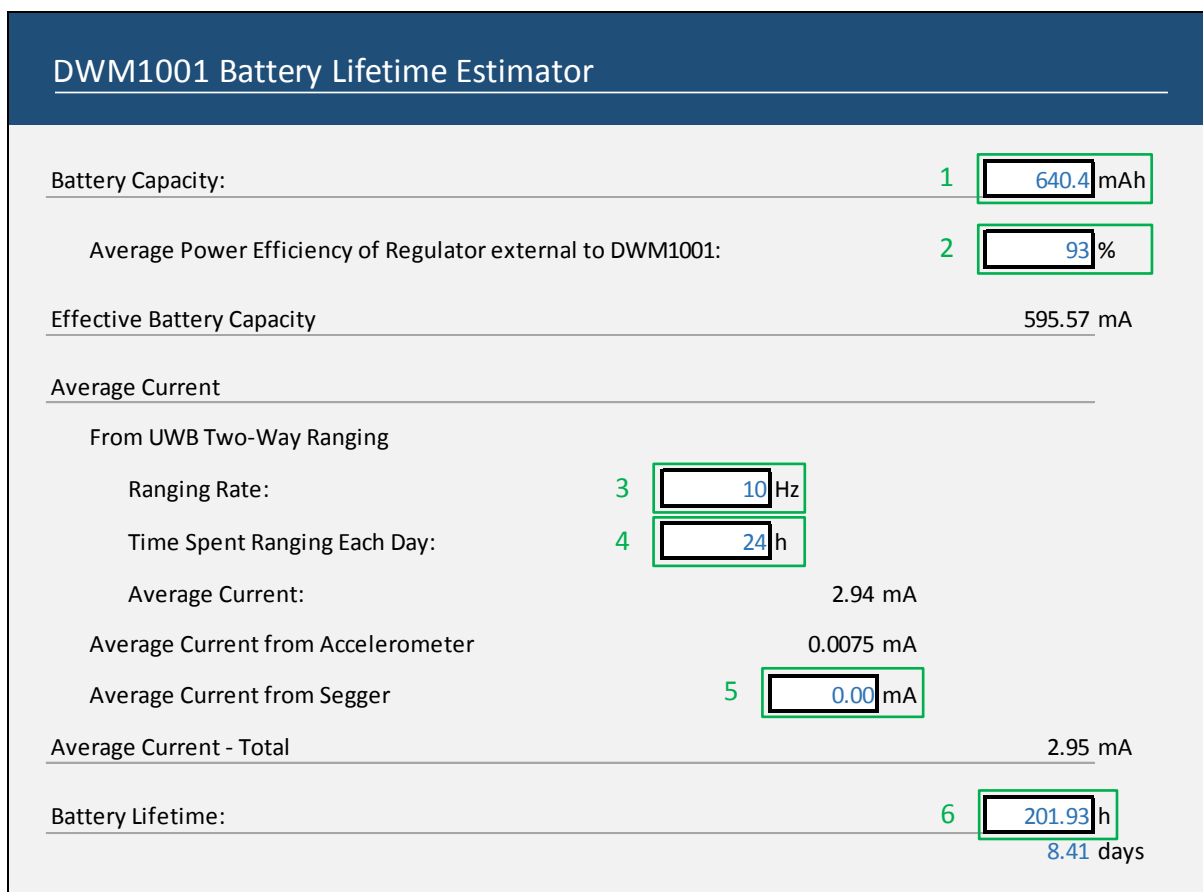


Figure 1. DWM1001 Block Diagram

2.2 Using the Estimator

There is a spreadsheet tool for estimating the lifetime of a battery used to power a DWM1001 module. The user interface is shown in Figure 2. Here is how it is used:

1. Enter the capacity of the battery (mAh).
2. Enter the average efficiency of the external regulator IC that supplies the DWM1001 module. For the DWM1001-Dev board, the Richtek RT8059 buck converter has roughly 93% average efficiency.
3. Enter the two-way ranging rate (Hz).
4. Consider the typical amount of time that the module will spend doing two-way ranging per day (hrs).
5. If the module is mounted on the DWM1001-Dev board and the J-Link Segger IC is powered (solder bridge shorted), this draws an additional 12 mA constant current which needs to be included in the budget.
6. The battery lifetime is calculated (hrs, days).



DWM1001 Battery Lifetime Estimator	
Battery Capacity:	1 <input type="text" value="640.4"/> mAh
Average Power Efficiency of Regulator external to DWM1001:	2 <input type="text" value="93"/> %
Effective Battery Capacity	595.57 mAh
Average Current	
From UWB Two-Way Ranging	
Ranging Rate:	3 <input type="text" value="10"/> Hz
Time Spent Ranging Each Day:	4 <input type="text" value="24"/> h
Average Current:	2.94 mA
Average Current from Accelerometer	0.0075 mA
Average Current from Segger	5 <input type="text" value="0.00"/> mA
Average Current - Total	2.95 mA
Battery Lifetime:	6 <input type="text" value="201.93"/> h 8.41 days

Figure 2. Battery Lifetime Estimator User Interface

2.3 Assumptions

The following assumptions apply.

- The estimator is based on the DWM1001-Dev board. The accuracy of the estimator has been compared to measured data taken using the DWM1001-Dev board in a real RTLS network.
- Variation in the efficiency of the external regulator supplying the DWM1001 as the battery voltage decreases is not considered. Instead a single equivalent percentage is used for the efficiency.
- Battery capacity derating due to pulse current draw is not included. The presence of on-board power regulation and capacitance minimise current spikes seen by the battery.
- The purpose of the tool is just to provide an **estimation** of battery lifetime, with a goal of being within 10 % of the actual lifetime.

2.4 Calculation

The approach has been to consider the power profile of the module and resolve this into an average current figure. By scaling by the UWB ranging rate and number of hours active over one day, the figure for battery lifetime can be calculated by dividing the capacity by the average current.

2.4.1 UWB Two-Way Ranging

The two-way ranging power profile, as can be found in the DWM1001 datasheet, is shown in Figure 3.

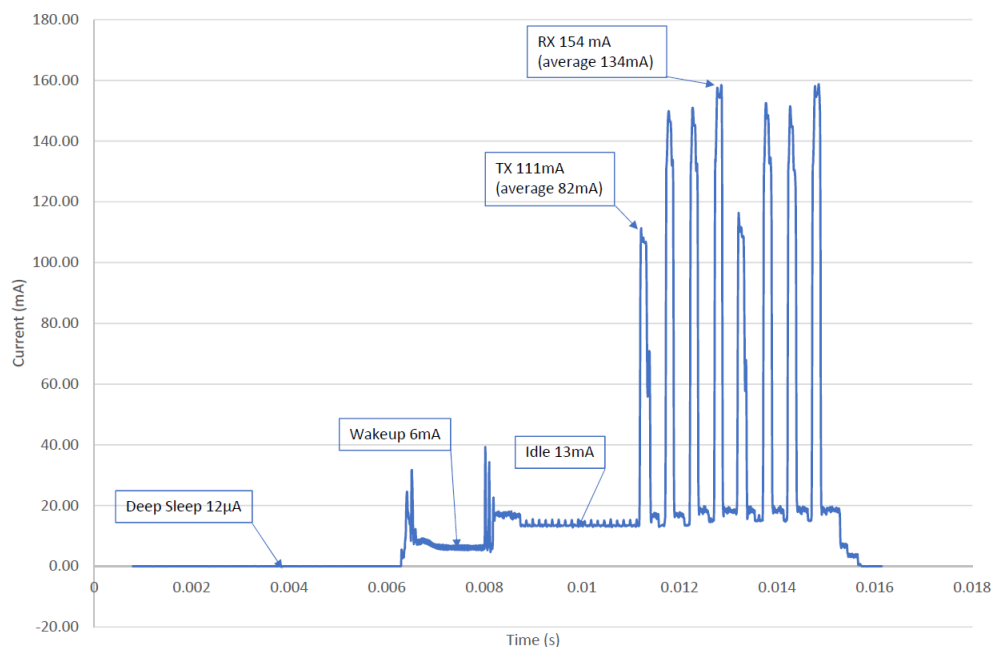


Figure 3. DWM1001 TWR Power Profile

The estimator uses the following approximation to the measured profile. It begins with entry into the wakeup state and takes account of the IDLE, TX and RX states, ending with an IDLE state at the end of the two-way ranging exchange.

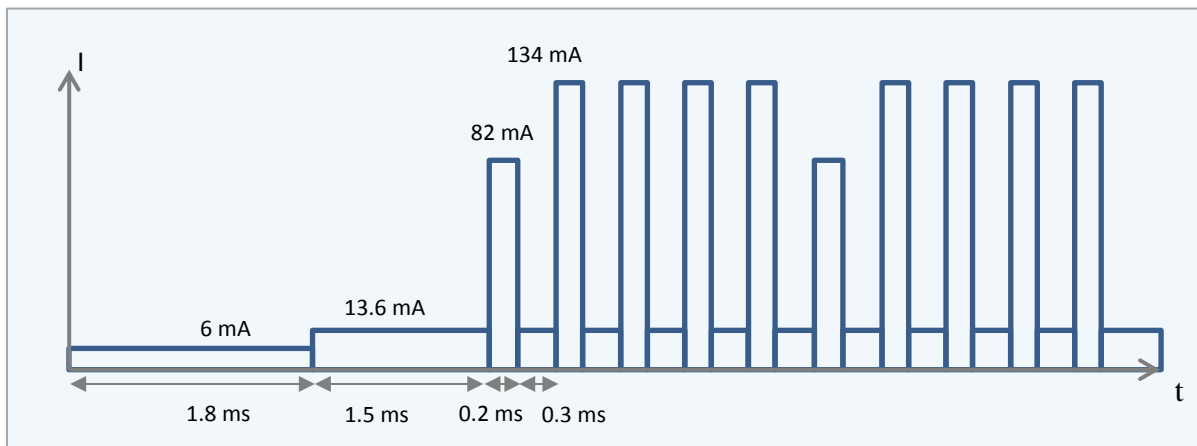


Figure 4. Estimator TWR Approximation

2.4.2 Sleep Mode

When the module is not involved in a two-way ranging exchange, it is in DEEPSLEEP mode. After a TWR exchange there's a fixed current draw of 200 uA for 23 ms, followed by a constant 13 uA current level. The estimator scales the time spent at this level according to the ranging rate and number of hours spent ranging per day.

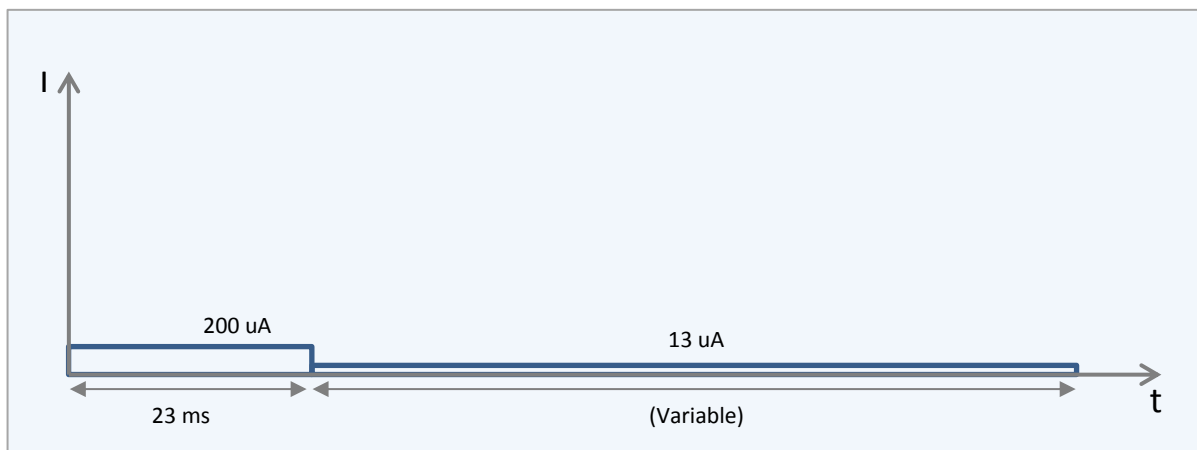


Figure 5. Estimator DEEPSLEEP Approximation

2.4.3 Accelerometer Power Profile

Not included in the TWR power profile is the accelerometer power consumption. The accelerometer turns on for 1.5 ms every 20 ms and consumes 100 μA whilst on. The approximation is illustrated in Figure 6.

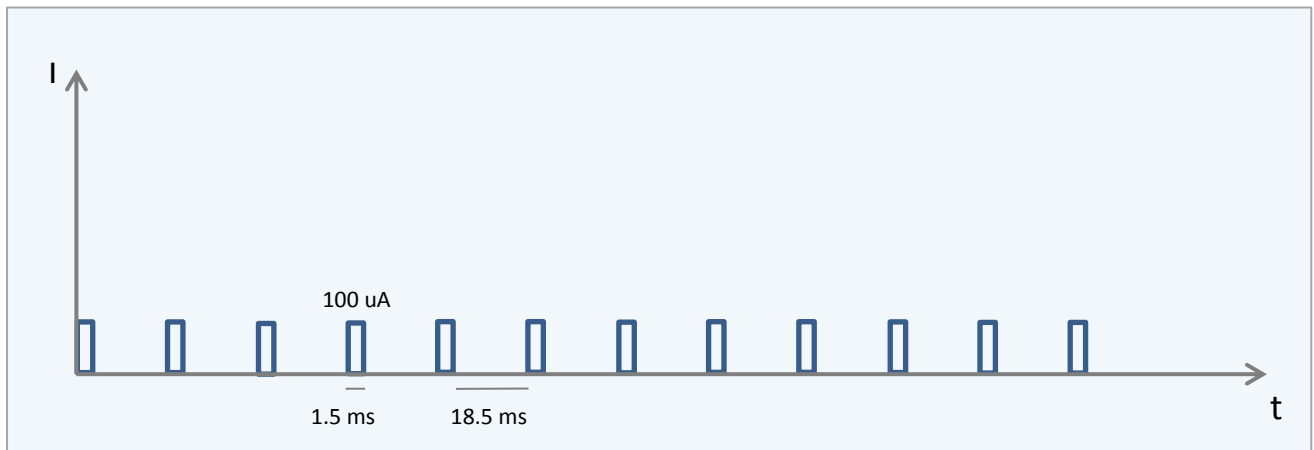


Figure 6. Accelerometer Power Consumption Approximation

3 CORRELATION WITH MEASURED RESULTS

To test the accuracy of the estimator tool, an experiment was performed to measure the battery lifetime of a tag in a typical PANS RTLS network. To avoid very long test times, the most active module ranging scenario was chosen. This was with a constant ranging rate of 10 Hz, i.e. ranging at this rate for 24 hours per day.

3.1 Experiment Setup

Figure 7 shows the battery lifetime measurement setup. The tag is in an RTLS network, ranging with four anchors. In the DRTLs Android app, the update rate is set to 10 Hz, and LEDs, BLE (responsive mode) and accelerometer are turned off.

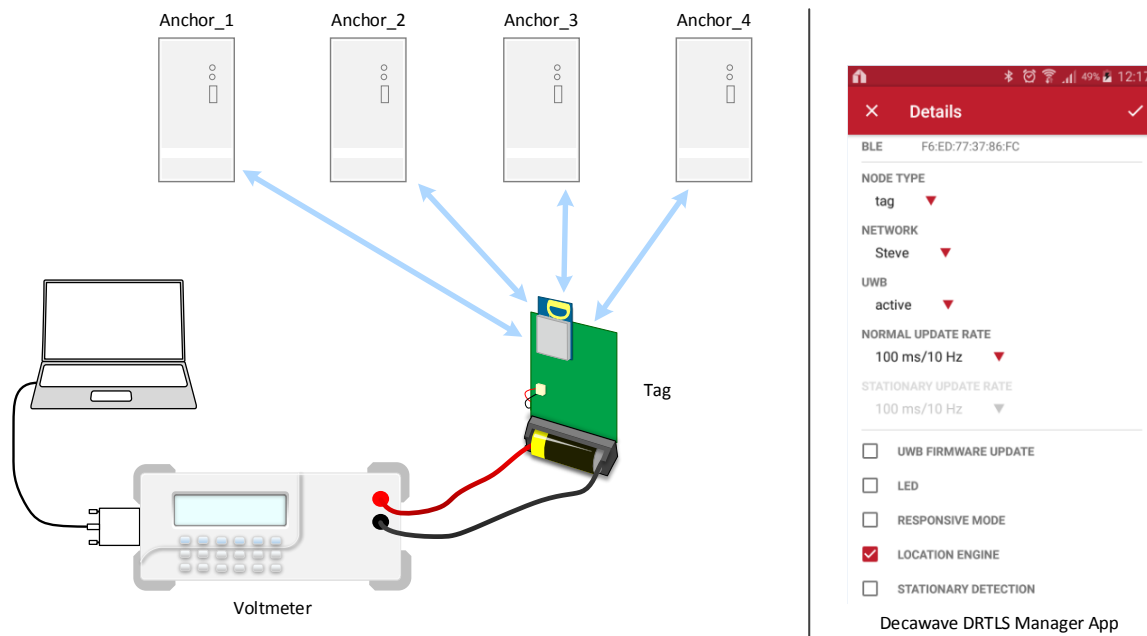
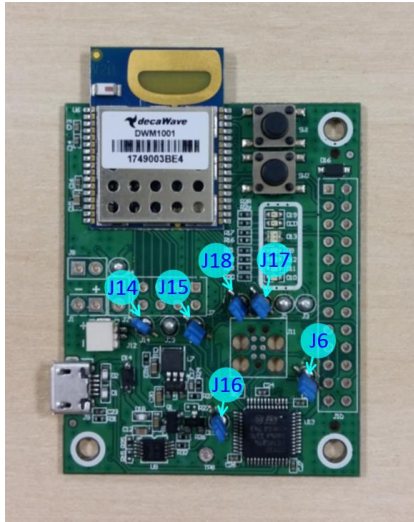


Figure 7. Tag Battery Lifetime Measurement Setup

The DWM1001 module is mounted on a DWM1001-Dev board. To minimise leakage current, the solder bridges indicated in Figure 8 are disconnected. Soldered-on headers can be seen at the jumper connections, which allowed the electrical connections to be broken once the module was configured.



Jumper	Signal
J6	RESET
J14	UART_TXD
J15	UART_RXD
J16	SEGGER_VBAT
J17	SWD_IO
J18	SWD_CLK

Figure 8. Minimising Leakage Current on DWM1001-Dev

The battery used in the experiment was the RCR123A (16340) Nitecore NL166. This is labelled as having a nominal capacity of 650 mAh but a measured capacity of 640.4 mAh. See Appendix A for the capacity characterisation of the battery used.

Controlled remotely via a laptop, a digital multimeter measures the battery voltage once per minute as it decays from fully charged to 2.6 V. The results are logged.

3.2 Measured Battery Profile in RTLS

The measured data is plotted and shown in Figure 9. The battery lifetime is taken as the amount of time for the battery voltage to reduce to 2.8 V, the lower supply voltage limit of the DWM1001.

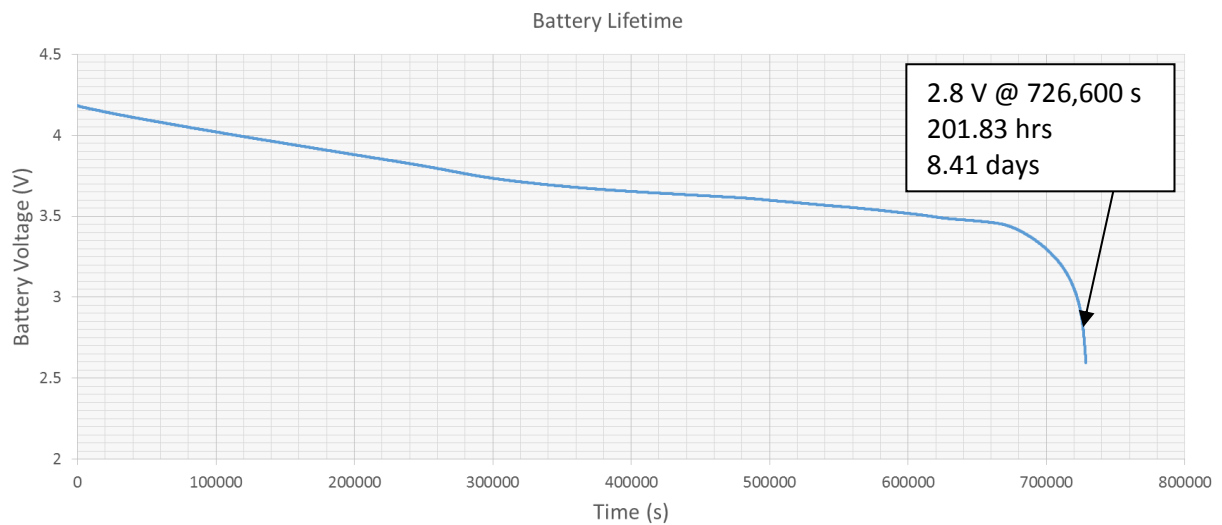


Figure 9. Measured Battery Lifetime Profile in RTLS

The battery lifetime estimation for this experiment was also 8.41 days.

DWM1001 Battery Lifetime Estimator

Battery Capacity:	640.4 mAh
Average Power Efficiency of Regulator external to DWM1001:	93%
Effective Battery Capacity	595.57 mAh
Average Current	
From UWB Two-Way Ranging	
Ranging Rate:	10 Hz
Time Spent Ranging Each Day:	24 h
Average Current:	2.94 mA
Average Current from Accelerometer	0.0075 mA
Average Current from Segger	0.00 mA
Average Current - Total	2.95 mA
Battery Lifetime:	201.93 h 8.41 days

4 CONCLUSION

The estimator is an easy to use tool for determining the battery lifetime of tags in the PANS Release 1 RTLS system. It is shown to be accurate, with the estimation matching the measured result with a standard RCR123A (16340) battery.

5 APPENDIX A: RCR123A BATTERY CHARACTERISATION

According to its label, the Nitecore NL166 RCR123A battery has a nominal capacity of 650 mAh. To more accurately establish what the actual capacity of the battery is, the circuit in Figure 10 can be used.

A load is provided to the battery which allows a constant current to be drained from the battery as its voltage decays. The circuit is based on the On-Semi CAT4101 constant-current LED driver. The constant current setting is tuned using a 0 – 200 k Ω potentiometer. An ammeter can be connected at the header to check the current drain from the battery as the potentiometer is tuned. The CAT4101 is powered via the 5 V rail from a USB connection.

Battery capacity is usually derated for pulsed current draw. Although the current drawn by DWM1001 varies during two-way ranging exchanges, the power regulator and capacitance present on the DWM1001-Dev board have the effect of smoothing out the current pulses seen by the battery. For this reason, it is assumed that there is no pulsed current derating.

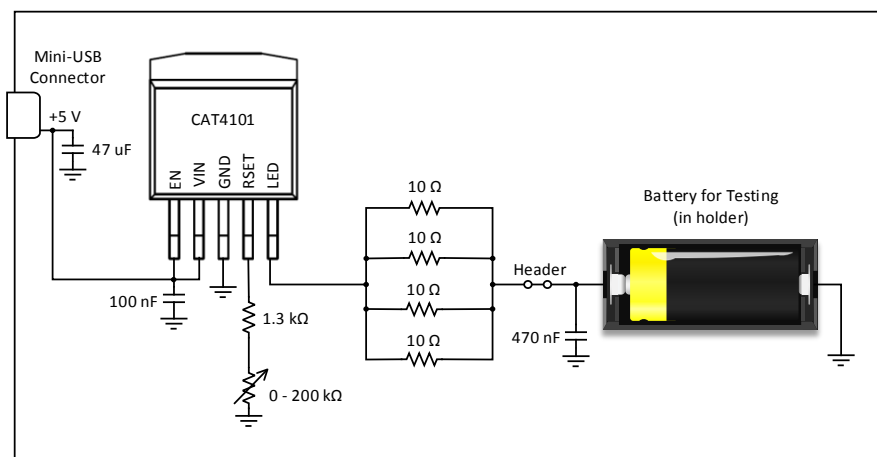


Figure 10. Battery Capacity Measurement Circuit

The battery capacity can be found by recording the time taken to drain the battery at a constant current. A current of 3 mA was chosen as this is close to the average current drawn by the DWM1001-Dev board, as calculated by the DWM1001 battery lifetime estimator tool.

From the measured voltage decaying profile in Figure 11, the time to reduce to 2.8 V was 213.47 hrs, which, at 3 mA constant current, gives a capacity of 640.4 mAh.

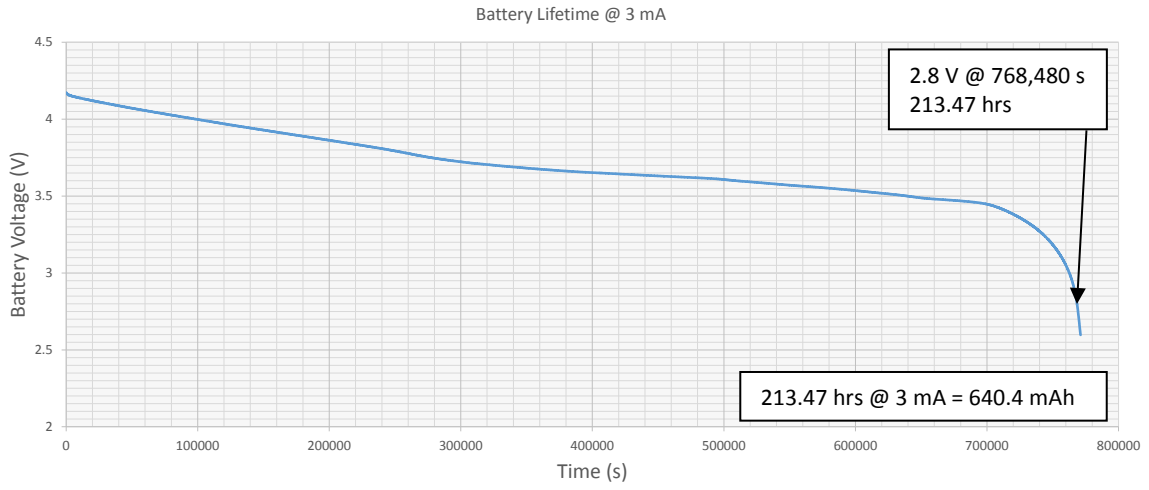


Figure 11. Battery Lifetime Measurement Result

6 REVISION HISTORY

Revision	Date	Description	Revised By
0.1	22-Jan-2019	Initial release	SC

7 FURTHER INFORMATION

Decawave develops semiconductors solutions, software, modules, reference designs - that enable real-time, ultra-accurate, ultra-reliable local area micro-location services. Decawave's technology enables an entirely new class of easy to implement, highly secure, intelligent location functionality and services for IoT and smart consumer products and applications.

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