SuRG Low Power Use Cases - Examined

SuRG Power showcase

Summary:

The SuRG42-CP is engineered to solve the "power vs sunlight readability" trade-off common in outdoor and portable electronics. By utilizing **reflective LCD technology**, which leverages ambient light instead of a power-hungry backlight, and the ultra-low-power **STM32U585 architecture**, the SuRG module consumes **95% less power** than traditional transmissive TFT displays.

This document analyzes three real-world Use Cases using a standard **10,000mAh battery pack**. The results demonstrate that while a typical backlit display lasts just **~2 days**, the SuRG42-CP provides **2 year or longer lifetimes** under identical conditions.

Key Use Case Highlights:

- **Use Case 1, Industrial Shift Use:**
  Over **2 years** of runtime for instruments used 8 hours a day.
- **Use Case 2, 24/7 Continuous Monitoring:**
  Over **250 days** of uninterrupted operation with a visible static image.
- **Use Case 3, Optimized IoT Duty-Cycling:**
  Up to **6.14 years** for systems updating once every 10 minutes.
- **Typical Backlight TFT Displays:**
  Up to **1.19 days** of uninterrupted operation with a visible static image.

In addition to our standard Use Cases, this document includes a deep-dive empirical power analysis for Use Case 3. For full microsecond-level current captures and measured transition data, please refer to the Appendix.

Core Advantage: The SuRG42-CP maintains a sunlight-readable image while consuming only **1.4mA @ 3V** in its Idle state, outperforming traditional systems by a factor of more than **240x**.

The SuRG42-CP published power specifications are:

- Active Mode Power 24mA @ 3V (typ)
- Idle Mode Power 1.4mA @ 3V (typ)
- Power Down 30uA @ 3V (typ)

Use Case Scenario	**Operating Profile**	**Projected Battery Life**
Use Case 1: Single Shift	8-hr work shift (1% Active, 99% Idle); 6 hours Power Down	**2.03 Years** *(741.40 days)*
Use Case 2: Continuous 24/7	24-hr workday (1% Active, 99% Idle); no Power Down	**0.70 Years** *(256.25 days)*
Use Case 3: Duty-Cycled 24/7	Triggered every 10 mins (500ms Active, 59.9s Idle, 9m Power Down)	**6.14 Years** *(2243.16 days)*
Typical Backlight TFT Display	24-hr continuous operation (350mA @ 5V, no Idle mode or Power Down)	**1.19 Days** *(28.57 hours)*

All calculations based on a standard 10,000mAh battery

Contents

1. *Use Case 1 – Instrument used for one shift per day:*

a. Requirements:

   i. An 8-hour work shift per day during which the sunlight readable display is visible 100% of the shift.

   ii. During the 8-hour work shift, the system is active taking readings and updating the display 1% of the time.

   iii. During off time (16-hours per day), the system is in Power Down.

b. Power Analysis

$$\text{8 working hours:} \begin{cases} 8\ Hours * 0.99 *\ 1.4\ mA = 11.088\ mAh\ (Idle\ Mode) \\ 8\ Hours * 0.01 * 24mA = 1.920\ mAh\ (Active\ Mode) \end{cases}$$

$$\text{16 off hours: } 16\ Hours * 1.00 *\ 0.030\ mA = 0.480\ mAh\ \ (Power\ Down\ Mode)$$

$$mAh\ per\ 24Hours = (11.088mAh + 1.920mAh + 0.480mAh)/day = 13.488\ mAh/day$$

$$Battery\ life = \frac{10{,}000mAh}{13.488\ mAh/day} = \mathbf{741.40\ days\ or\ 2.03\ Years}$$

2. *Use Case 2 – Instrument used continuously all day:*

a. Requirements

   i. 24 Hour workday where the sunlight readable display is visible 100% of the time.

   ii. During the entire 24 Hour Day, the system is actively taking readings and updating the display 1% of the time.

   iii. There is no Power Down.

b. Power Analysis

$$\text{24 working hours:} \begin{cases} 24\ Hours * 0.99 *\ 1.4\ mA = 33.264\ mAh\ (Idle\ Mode) \\ 24\ Hours * 0.01 * 24mA = 5.760\ mAh\ (Active\ Mode) \end{cases}$$

$$mAh\ per\ 24Hours = (33.264 + 5.760)/day = 39.024\ mAh/day$$

$$Battery\ life = \frac{10{,}000mAh}{39.024\ mAh/day} = \mathbf{256.25\ days\ or\ 0.70\ Years}$$

3. *Use Case 3 – Instrument used continuously all day but only showing updated readings every 10 minutes:*

a. Requirements
   i. 24 Hour workday; updating the sunlight readable display every 10 minutes.
   ii. Use the Power Button (or external RTC Board) once every 10 minutes to wake up from Power Down mode.
   iii. Active mode then uses 500 ms to take readings, make calculations, and update the display.
   iv. We then transition to Idle Mode for 59,500 ms to show updated data for the remainer of one minute.
   v. Finally, transition to Power Down Mode for the last 9 minutes of the 10-minute cycle.

b. Power analysis

$$Idle\ duty\ cycle: \frac{59{,}500ms}{600{,}000ms} = 9.917\%$$

$$Active\ duty\ cycle: \frac{500ms}{600{,}000ms} = 0.083\%$$

$$Power\ Down\ duty\ cycle: \frac{540{,}000ms}{600{,}000ms} = 90\%$$

$$\text{24 hour work day: } \begin{cases} 24\ Hours * 0.09917 * \ 1.4\ mA = \ 3.332mAh\ (Idle\ Mode) \\ 24\ Hours * 0.00083 * 24mA = \ 0.478mAh\ (Active\ Mode) \\ 24\ Hours * 0.90 * 0.030mA = \ 0.648mAh\ (Power\ Down\ Mode) \end{cases}$$

$$mAh\ per\ 24Hours = (3.332mAh + 0.478mAh + 0.648mAh)/day = 4.458\ mAh/day$$

$$Battery\ life = \frac{10000mAh}{4.458\ mAh/day} = \mathbf{2243.16\ days\ or\ 6.14\ Years}$$

Please note that the initial model presented above was a theoretical estimate. For an in-depth empirical power analysis capturing exact startup transients and dynamic state transitions, see the following sections in the Appendix.

Hardware set ~200ms Delay During Boot Time
Use Case 3, Using Measured Current values to Determine Battery lifetime

4. *Typical Backlight TFT Display Use Case:*

For a Backlight TFT like Future Designs, Inc. uEZGUI-4088-43WQN

Typical Backlight TFTs have a required mandatory backlight for display visibility, meaning the high current draw will always be present when showing an image on the display. With the SuRG42-CP, which utilizes Reflective LCD technology, it provides readability with ambient light sources with zero additional power draw from a backlight. This is why you will see in the analysis below that the battery life of typical TFT displays is much lower than what is possible with the SuRG42-CP.

Active mode Power 350mA @ 5V (5V standard requirement for typical TFT display units)

No Idle or Power Down Mode

(Compare to Use Case 2 above)

a. Requirements
    a. 24-hour workday where display is visible 100% of the time.
    b. With the uEZGUI, there is no Idle mode, so it will be full current draw to run the backlight and keep an image on the display during the 24-Hour workday.
    c. There is no Power Down.
    d. Requires a 5V battery.

b. Power Analysis

$$\text{24 working hours: } 24\ Hours * \ 350\ mA = 8{,}400\ mAh$$

$$mAh\ per\ 24Hours = 8{,}400\ mAh/day$$

$$Battery\ life = \frac{10{,}000mAh}{8{,}400\ mAh/day} = 1.19\ \boldsymbol{days\ \ or\ 28.57\ hours}$$

Note: Raw mAh comparisons across differing voltages assume single-cell nominal baselines. Evaluating total energy in Watt-hours (Wh) favors the SuRG module even more. Furthermore, with the SuRG42-CP operating at 3V, it yields lower current draw at the supply rail when stepped down from standard 5V inputs via a buck regulator, maximizing real-world efficiency even more.

5. *Appendix*

a. Hardware Set ~200ms Delay During Boot Time

When booting the SuRG42-CP from a complete Power-Down state (VDD turned off), there is an inherent hardware-enforced delay of approximately 200 ms before any software execution can begin.

During this 200 ms window:

- The VDD power rail is fully powered and stable.
- The MCU's master reset pin is held low, keeping the processor in a hardware reset state. No code execution occurs (including low-level assembly startup or bootloader code) until this reset pin is physically released.
- The current draw during this interval is ~1.7mA at 3V.

Why the Delay Exists

This delay is enforced by the onboard pushbutton controller, which manages system power and reset signaling. The controller features a hardcoded internal safety timer that holds the reset line low for a minimum of 200 ms after power-up.

For most general-purpose designs, a 200 ms power saturation and stabilization window is highly acceptable and ensures robust, glitch-free startups. Because of this, it is configured as the standard behavior shipped on our production boards.

Is there an alternative?

For specialized, time-critical applications where this 200 ms physical delay must be eliminated, FDI can provide custom hardware modifications and board spins to implement a bypassed reset architecture, but since this delay is during a lower power state, it will barely affect battery lifetimes, as seen below:

For a quick summary of the comparison for with and without the delay:

Accounting for lower current draw during delay: $\mathbf{2335.90}\ \boldsymbol{days}$

Completely removing the 200ms power draw: $\mathbf{2336.99}\ \boldsymbol{days}$

If we do not modify the board but perform an experiment where the 200ms delay is eliminated, we would only increase usability by 26.16 hours (0.0467%). So, it is NOT worth making the changes to remove this 200ms delay for power saving purposes. However, if your application requires an extremely fast boot time (under 300ms), then this re-work may be useful.

i. *Use Case 3 with 200ms Hardware Delay current draw accounted for.*

During this 200ms delay, the device is not pulling the full 24mA of active current. The MCU is being held in a reset state due to the NRST pin being held low. From our measurements, during this time, input current is ~1.7mA @3V. This 200ms was previously included in the active mode duty cycle, so now it is broken up into a 200ms delay, and the remaining 300ms in active mode. If we take this into account for our Use Case 3 measurements, we get a more accurate reduced value.

$$Idle\ duty\ cycle: \frac{59{,}500ms}{600{,}000ms} = 9.917\%$$

$$Active\ duty\ cycle: \frac{300ms}{600{,}000ms} = 0.050\%$$

$$Hardware\ Delay\ duty\ cycle: \frac{200ms}{600{,}000ms} = 0.033\%$$

$$Power\ Down\ duty\ cycle: \frac{540{,}000ms}{600{,}000ms} = 90\%$$

24 hour work day: $$\begin{cases} 24\ Hours * 0.09917 * \ 1.4\ mA = \ 3.332mAh\ (Idle\ Mode) \\ 24\ Hours * 0.00050 * 24mA = \ 0.288mAh\ (Active\ Mode) \\ 24\ Hours * 0.00033 * 1.7mA = \ 0.013mAh\ (Hardware\ Delay) \\ 24\ Hours * 0.90 * 0.030mA = \ 0.648mAh\ (Power\ Down\ Mode) \end{cases}$$

$$mAh\ per\ 24Hours =$$

$$(3.332mAh + 0.288mAh + 0.013mAh + 0.648mAh)/day = 4.281\ mAh/day$$

$$Battery\ life = \frac{10000mAh}{4.281\ mAh/day} = \mathbf{2335.90\ days\ or\ 6.40\ Years}$$

ii. *Use Case 3 with Removed 200ms Hardware Delay.*

To show the power saving of removing the 200ms Hardware delay, we can look at the altered Use case 3 with this 200ms delay removed:

$$Idle\ duty\ cycle: \frac{59{,}700ms}{600{,}000ms} = 9.950\%$$

$$Active\ duty\ cycle: \frac{300ms}{600{,}000ms} = 0.050\%$$

$$Power\ Down\ duty\ cycle: \frac{540{,}000ms}{600{,}000ms} = 90\%$$

24 hour work day: $\begin{cases} 24\ Hours * 0.09950 * 1.4\ mA = 3.343mAh\ (Idle\ Mode) \\ 24\ Hours * 0.00050 * 24mA = 0.288mAh\ (Active\ Mode) \\ 24\ Hours * 0.90 * 0.030mA = 0.648mAh\ (Power\ Down\ Mode) \end{cases}$

$$mAh\ per\ 24Hours = (3.343mAh + 0.288mAh + 0.648mAh)/day = 4.279\ mAh/day$$

$$Battery\ life = \frac{10000mAh}{4.279\ mAh/day} = \mathbf{2336.99\ days\ or\ 6.40\ Years}$$

b. Use Case 3, Using Measured Current values to Determine Battery Lifetime

While previous sections of this document rely on our measured static current draws for Power Down, Idle, and Active mode, the transitions between these modes were not accounted for. In embedded system applications, it's typical for the current draw to fluctuate during transitioning stages, which accounts for part of the overall current consumption. In this section, we document the current draw during these transitions and take them into account when calculating total battery life.

To eliminate ambiguity and establish an absolute empirical baseline for system battery life, we have conducted a deep-dive power analysis of our low-power application using the **Nordic Power Profiler Kit II (PPK2)**.

Why Empirical PPK2 Measurement Is Required

Standard multimeters and static duty-cycle equations are insufficient for capturing microsecond level transients. By leveraging the PPK2's high-speed sampling capabilities (100,000 samples/second, 10us intervals) with real-time dynamic auto ranging, we can:

- **Capture Transition & Inrush Phases:** Precisely measure the peak and duration of transient currents during wakeups, reset delays, and peripheral initializations.
- **Calculate True Dynamic Charge (Q):** Integrate instantaneous current over variable-length active windows, capturing exact energy consumption in millicoulombs(mC) and milliamp-hours(mAh) without relying on ideal rectangular pulse assumptions.
- **Eliminate Estimations:** Replace datasheet "typical" mode assumptions with statistical averages derived across real operational cycles.

Transitioning from Theory to Empirical Data

In the following sub-sections, we re-evaluate our low-power operational use cases by substituting theoretical active and startup calculations with empirically measured values.

If looking to acquire a Power Profiler Kit II of your own, please check out NORDIC’s website for more information:

https://www.nordicsemi.com/Products/Development-hardware/Power-Profiler-Kit-2

i. Defining Operation stages and Transitions of Use Case 3

The reported values represent the overall average across **5 independent test runs** for each Stage.

During each test, high-frequency current measurements were recorded at 10us intervals.

Average Current (mA): Derived from the mean operating current of each test.

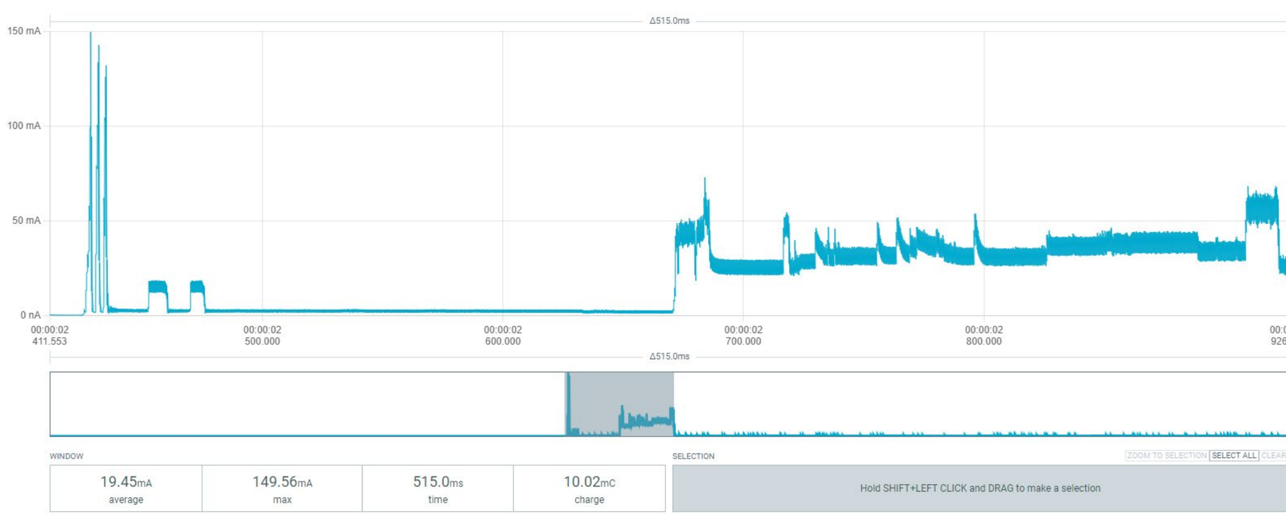
Average Duration (ms): The measured time between the start and stop timestamps of each test.

Average Charge (mC): Calculated per test by summing the instantaneous current(mA) readings across the sample's duration(ms) and multiplying it by the 10us sample interval.

The Measured Numbers used below reflect the combined arithmetic mean of all 5 trials to ensure statistical repeatability and eliminate single-run anomalies.

Timestamps and graph plots are provided as visual representations of sample trials, while the bulleted Charge, Duration and Current values represent the full 5-test run averages for each stage.

1. Wake from Power Down, Update Display, Transition into IDLE mode
   - **Behavior:** The system wakes from Power Down, initializes the micro-controller and display, processes the screen update, and transitions into Idle mode.
   - **Average Duration**: 509.8800ms
   - **Average current**: 19.7906mA
   - **Average Charge**: 10.0908mC



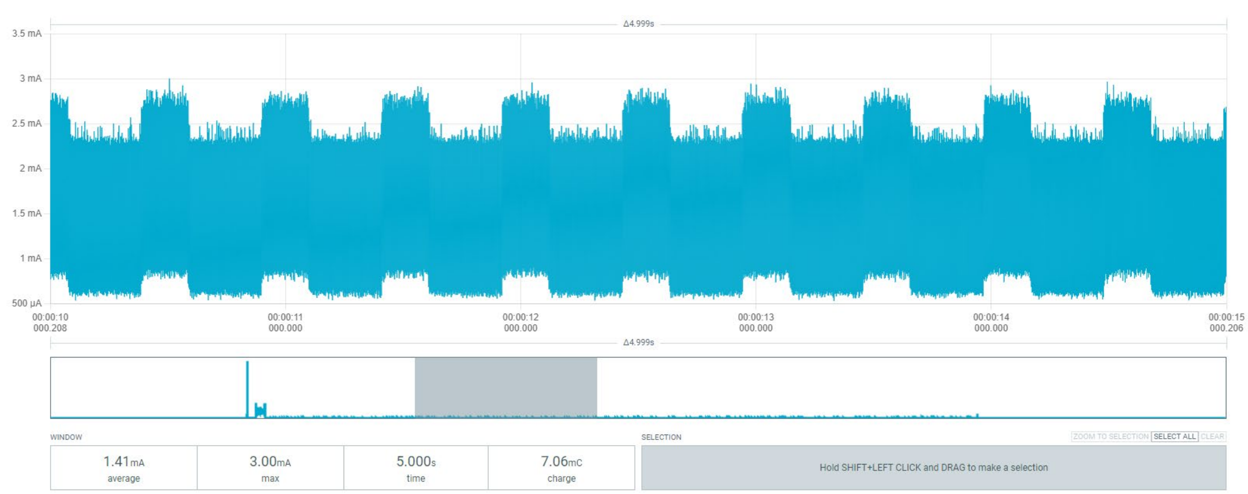
WINDOW

19.45mA average	149.56mA max	515.0ms time	10.02mC charge

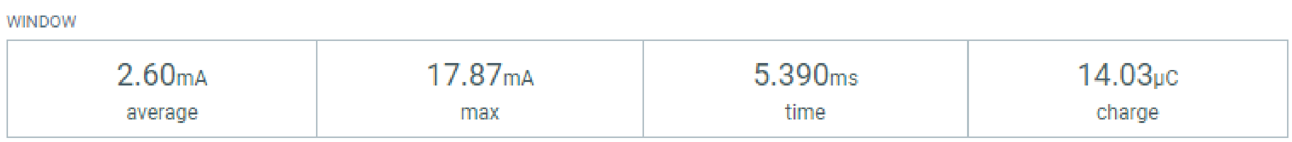
2. Unit remains in IDLE mode with updated display visible
   - **Behavior:** The display maintains the visible static image in Idle mode for the remainder of the 1-minute active window.
   - **Estimated Duration**: 60000ms – Stage 1 – Stage 3 = 59485.4280ms
     i. **Test Average Duration:** 5000.6260ms
   - **Average current**: 1.4158mA
   - **Estimated Average Charge**: 84.2195mC
     i. **Test Average Charge**: 7.0799mC

Notes about Stages 2 & 4 methodology:

Sampling continuous data across the full duration of Stages 2 and 4 generates large dataset sizes. To optimize profiling efficiency without losing accuracy, charge is derived by scaling empirical baseline data. Average current was measured over a representative 5-second sample window and multiplied by the stage's total expected duration Average Current(mA) times Estimated Duration (ms). This scaled approach is valid for these static phases, as the current draw remains virtually flat throughout, and any minor transient fluctuations have a negligible impact on total charge.



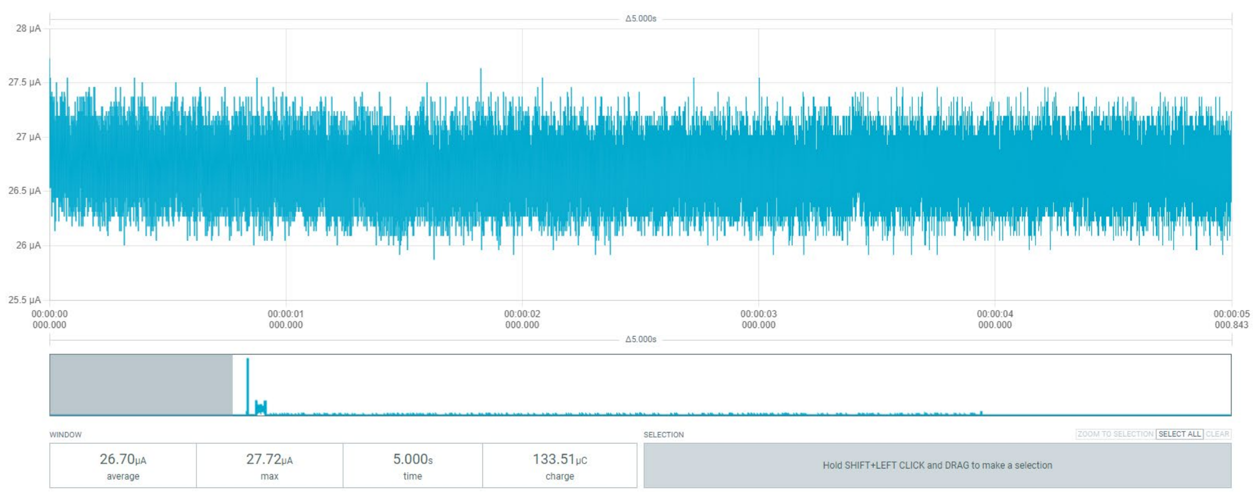
3. Unit wakes up from IDLE mode to turn off VDD rail to enter power Down
    - **Behavior:** The unit briefly wakes from Idle execution to power down peripherals and turn off the internal VDD rail before entering Power Down.
    - **Average Duration**: 4.6920ms
    - **Average current**: 2.9574mA
    - **Average Charge**: 0.0139mC



4. Remain in Power Down mode for remainder of time
    - **Behavior:** The device remains in PowerDown for the remaining 9 minutes of the 10-minute cycle.
    - **Estimated Duration**: 540000ms
        i. **Test Average Duration:** 5000.2560ms
    - **Average current**: 0.0267mA
    - **Estimated Average Charge**: 14.4180mC
        i. **Test Average Charge**: 0.1334mC

Notes about Stages 2 & 4 methodology:

Sampling continuous data across the full duration of Stages 2 and 4 generates large dataset sizes. To optimize profiling efficiency without losing accuracy, charge is derived by scaling empirical baseline data. Average current was measured over a representative 5-second sample window and multiplied by the stage's total expected duration Average Current(mA) times Estimated Duration (ms). This scaled approach is valid for these static phases, as the current draw remains virtually flat throughout, and any minor transient fluctuations have a negligible impact on total charge.



WINDOW

26.70µA	27.72µA	5.000s	133.51µC
average	max	time	charge

ii. Calculating Battery life consumption of Use Case 3

Based on the 4 operational stages defined above, we can determine the exact charge consumed per cycle and project the system's overall battery life. The target application profile executes a repeating 10-minute cycle across a 24-hour workday.

Step 1: Total Charge Consumed per Cycle

$$Q_{Total\ Cycle} = Q_{stage\ 1} + Q_{stage\ 2} + Q_{stage\ 3} + Q_{stage\ 4}$$

$$Q_{Total\ Cycle} = 10.0908\text{mC} + 84.2195\text{mC} + 0.0139\text{mC} + 14.4180\text{mC}$$

$$Q_{Total\ Cycle} = 108.7422mC$$

Step 2: Convert Cycle Charge to mAh

$$\frac{108.7422mC}{3600s/h} = 0.0302mAh$$

Step 3: Calculate the daily charge consumption in mAh.

$$Cycles\ per\ Day = \frac{24\ hours * 60\ minutes}{10\ minutes} = 144\ cycles/day$$

$$Daily\ Consumption = 0.0302mAh * 144 = 4.3488mAh/day$$

Step4: Using a 10,000mAh battery from the use cases before, we can calculate the accurately measured Battery life.

$$Battery\ life = \frac{10000mAh}{4.3488mAh/day} = \mathbf{2299.48\ days\ or\ 6.30\ Years}$$

Now that we have the accurate battery life measurement of the measured model, we can compare the previous Use Case 3 measurements in a table below, showing the differences.

Use Case 3 Analysis	Theoretical Model	Theoretical Model (with Boot delay)	Theoretical Model (Empirically Measured)
Analysis Method	Measured Static Currents using duty cycle Calculations	Measured Static Currents & boot time delay using duty cycle Calculations	Measured Dynamic Current Draw during runtime
Boot/Active Stage	500ms @ 24.00mA	300ms @24.00mA + 200ms @1.70mA	509.8800ms @19.7906mA Or 10.0908mC
Idle Stage	59500ms @ 1.40mA	59500ms @ 1.40mA	59485.4280ms @ 1.4158mA or 84.2195mC + 4.6920ms @ 2.9574mA or 0.0139mC
Power Down Stage	540000ms @ 30.00uA	540000ms @ 30.00uA	540000ms @ 26.70uA Or 14.4180mC
Daily Battery Drain	4.458mAh	4.281mAh	4.3488mAh
Projected Battery Life (10,000 mAh)	**6.14 Years (2243.16 Days)**	**6.40 Years (2335.90 Days)**	**6.30 Years (2299.48 Days)**
Variance from Empirical	**-56.32 Days (-2.45%)**	**+36.42 Days (+1.58%)**	**N/A**

Key Takeaways

- **Theoretical Model (6.14 Years):** Underestimates lifespan because it assumes a full 500ms at maximum active mode current (24mA) and uses a conservative 30uA Power Down current.
- **Theoretical Model with Boot Delay (6.40 Years):** Slightly overestimates lifespan by assuming the MCU immediately drops to low current during the reset delay and not considering runtime transitions and dynamic startup transient spikes.
- **Empirical Model (6.30 Years):** Provides the true real-world baseline. By measuring dynamic transient spikes and accounting for state transition periods with the PPK2, this model confirms a **6.30-year operational life** on a standard 10,000mAh battery.

Website and Support

Support:

- FDI Support home page:.. https://www.teamfdi.com/support
- FDI Forums: .... https://www.teamfdi.com/forum
- FDI SuRG Page: ....https://www.teamfdi.com/products/surg/
- FDI SuRG42-CP Page: https://www.teamfdi.com/product/surg42-cp/