Achieving 10 year battery life with RIOT

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Section 1

Motivation
Use Case

Situation
- IoT Toolbox: Customer specific sensor solutions
- Sensors installed in hard to reach places
- Rugged environments
- No Maintenance

Solution
- battery powered sensors
- radio communication (sub-GHz 802.15.4g)
Disclaimer

- There are differences between platforms
- I’m not an electrical engineer
- Don’t apply changes without measuring the effect!
Section 2

Start with a large battery
Start with a large battery
- D-cell sized
- low self-discharge
- \( \sim 15\text{Ah} \rightarrow \) up to 100 \( \mu \text{A} \) continuous current for 10 years
- with 50 \( \mu \text{A} \) still 2.6V after 10 years
Section 3

Know your components
Get to know your MCU

- read the Data Sheet and the Errata Sheet
- Buck Converter not usable with fast internal clocks (DPLL, DFLL) on sam0
- voltage regulator selection persistent across reﬂashes! (not cold boots)
- use an external Oscillator
- No EXTI in Deep Sleep, only 5 RTC / Tamper pins
- Reset on wake-up

SAM D51
- Cortex-M4 with FPU
- actually not a low power part
- 1.71 V to 3.63 V
- 3.3 μA in BACKUP mode (8k backup RAM retained, RTC)
- 149 μA/MHz in ACTIVE mode with LDO
- 73 μA/MHz in ACTIVE mode with buck converter
Get to know your MCU

- GPIO pins keep their configuration / level in Deep Sleep
  - Reconfigure pins if the connected peripheral does not to avoid voltage differential
  - don’t leave pins with external pull-up LOW or pins with external pull-down HIGH
    \[3.3V / 10 \, k\Omega = 330 \, \mu A\]

- Keep in mind IDLE-HIGH signals like UART

- Don’t measure with Debug UART attached
  - UART adapter draws power via TX line
  - OR board powered via Debug UART
Take a look at other components on the PCB

- Make sure to put peripherals to sleep or cut the power
- don’t wake sleeping peripherals if they are not used
- ~ 25 µA during Deep Sleep (of 50 µA battery budget)
- \[ 25 \mu A \times 10 \times 365 \times 24 \times 60 \times 60 \text{s} = 7884 \text{As} \] left
- \[ 7884 \text{As} / (10 \times 365 \times 60 \text{s}) = 36 \text{mA} \] for a minute each day

**AT86RF215**
- 1.8 V to 3.6 V
- 3 mA in TRXOFF (reset) state
- 30 nA in SLEEP state
- 18.6 mA in RX mode with MR-O-QPSK & Reduced Power Consumption

**LIS2DH12**
- accelerometer / shock sensor
- 6 µA low-power mode

**MTK3333**
- GNSS
- 9 µA backup node
Section 4

Write a low power Application
Stay awake as little as possible

- CPU will reset with each period, keep persistent data in BACKUP_RAM
- Take a measurement
- Only initialize the radio when needed (gnrc_netif_init_devs instead of auto_init_gnrc_netif)
- Wait for GNRC_IPV6_EVENT_ADDR_VALID event (got prefix from border router)
- send the data
- shut down the radio
- shut down the sensors
- sleep till next measuring period
Section 5

Questions?