

How to power optimize with the latest features in the nRF9160 SiP

A part of Mobile World Congress experience



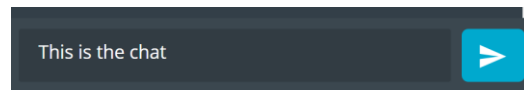
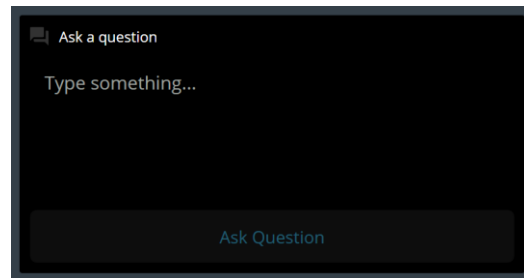
NORDIC
SEMICONDUCTOR

Agenda

- Practicalities
- Introduction of the host
- nRF9160 SiP Overview
- Cellular network complexities
- How our modem makes it easy and how it compares
- Optimizing for low power
- New features to consider in your design
- Real time testing and what to look for
- Further help and technical support
- Program for Mobile World Congress 2021
- Q&A

Practicalities

- Duration: ~45 mins + Q&A
- Questions are encouraged!
 - Please type questions in the top of the right sidebar
 - All questions are anonymous
 - Try to keep them relevant to the topic
 - We will answer towards the end
- The chat is not anonymous, and do not use for questions
- Go to DevZone if you have more questions
- A recording of the webinar will be available together with the presentation at webinars.nordicsemi.com



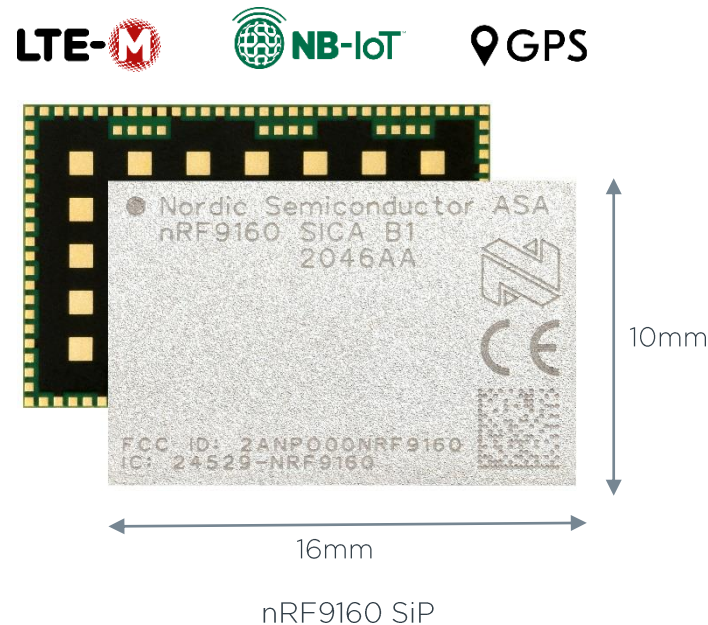
Martin Lesund- Technical Marketing Manager



- Master of Science in Electronics (NTNU)
 - Thesis: Ultra-low power serial communication for IoT
- Joined Nordic in 2017, based in Trondheim, Norway
- Previous 3 years in the Tech. support
 - Focus on cellular IoT and nRF9160
- 1 dog, a fiancée and is moving into his new house this fall
- Tech. geek, love the outdoors and biking

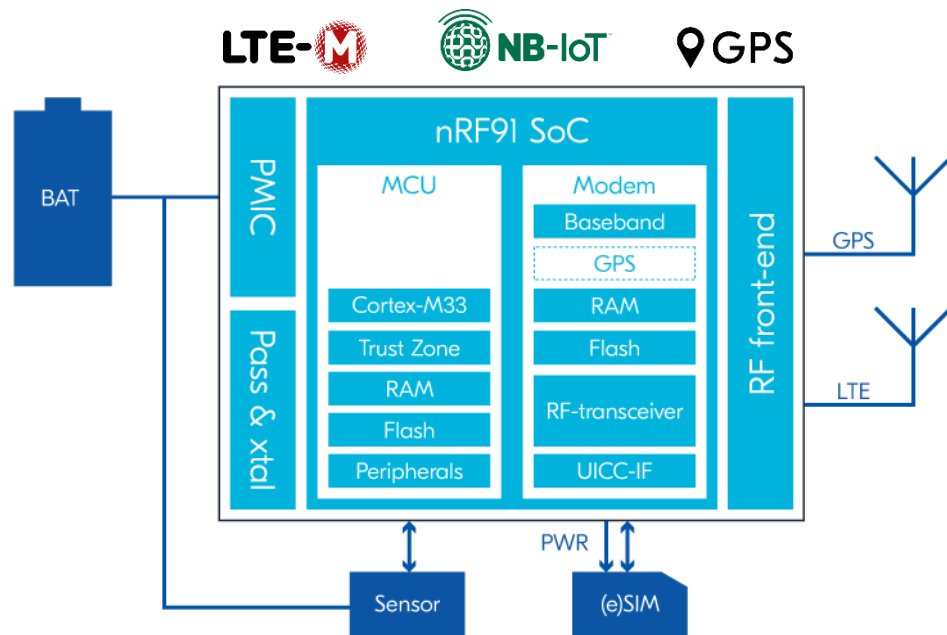
nRF9160 – Voids Cellular Modules

- Based on Nordic Dual Core SoC:
 - Arm® Cortex® M33 MCU for the application
 - Multiband LTE-M/NB-IoT modem with GPS
- Small form factor - includes PMIC, RF FEM, passives and crystals
- Ultra Low Power – Avg. 18μA @ 81.92s eDRX
 - Power saving mode (PSM) floor current: 2.7 μA
- Multiband support for global coverage
- Pre-certified System-in-Package (SiP)



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nRF9160 SiP rev 2 - available now

- Significant improvement in an already best in class low power solution
- No changes on pin-out nor form factor
 - Existing REV1 designs only need to change an external cap (*DECO*) from 47 μ F to 4.7 μ F



Description	nRF9160 REV2	Compared to REV1
CPU running CoreMark @64MHz from flash, HFXO + cache	2.2mA	-24%
PSM floor current	2.7 μ A	-33%
Avg. current eDRX (655s, one PO/PTW, PTW=2,56s)	6 μ A / 9 μ A [LTE-M / NB-IoT]	-33% / -18% [LTE-M / NB-IoT]

LTE Connection Modes

RRC Connected

Transfer user data

High power consumption

Synchronized with the
network

RRC Idle

Listening to on the network

Sleep for shorter intervals to save power
(eDRX)

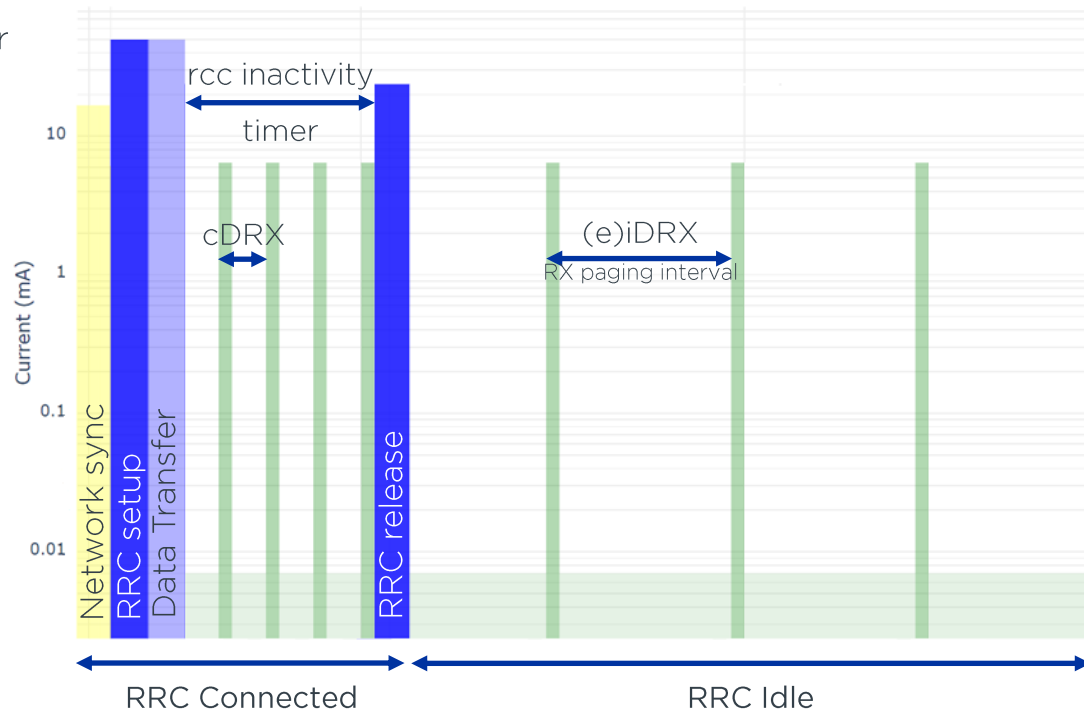
Shorter DL latency

PSM

Sleep for **longer** intervals to save power
Longer DL latency

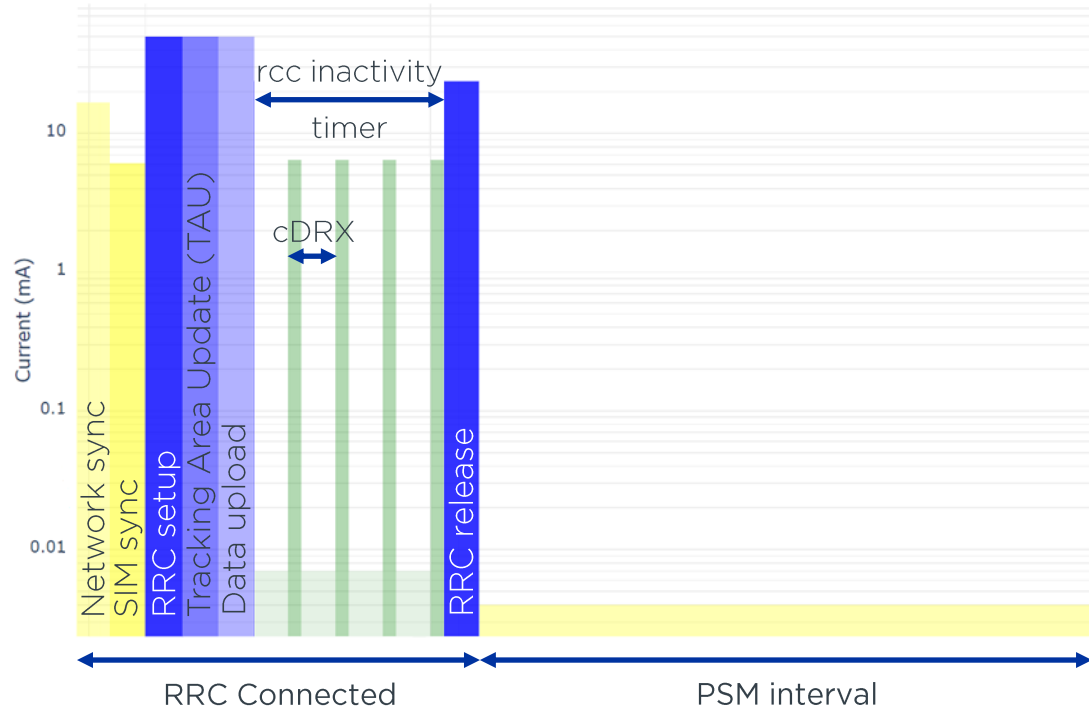
RRC Connected and RRC Idle Mode

- Sleep in eDRX intervals to save power
 - cDRX: 0.01s to 10.24s
 - iDRX: 0.16s to ~44 min
 - We support all timers
- Device can wake up any time to send data
- Network can store data for device
- Device listens for data at the end of each DRX interval
- Longer DRX intervals results in longer download latency, but lower power



Power Save Mode (PSM)

- Sleep in PSM intervals to save power
 - 10 min to 413 days
- Device can wake up at any time to send data
- After the end of each PSM interval, the modem switch back to RRC Connected
- Longer PSM intervals results in longer downlink latency, but lower avg. power consumption
- Lower floor current compared to iDRX intervals RRC Idle



Cellular network complexities

- Do not trust and rely on a few spec points – **cellular is complex**
- RCC connected mode, cDRX intervals, cDRX inactivity timer, RRC inactivity timer, RCC idle mode, T3324 timer, iDRX intervals, iDRX PDCCH, PTW, Default paging cycle, PSM, T3412 timer, SIM current, Band, Signal Conditions (TX Output Power), CE levels, Repetitions, QPSK, BPSK, Data upload size, Data upload interval, ...



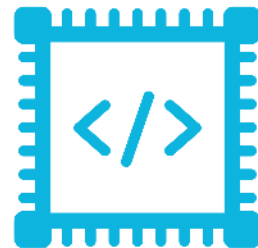
Example:

Most modules seemingly have low PSM floor current numbers in specifications/marketing collaterals

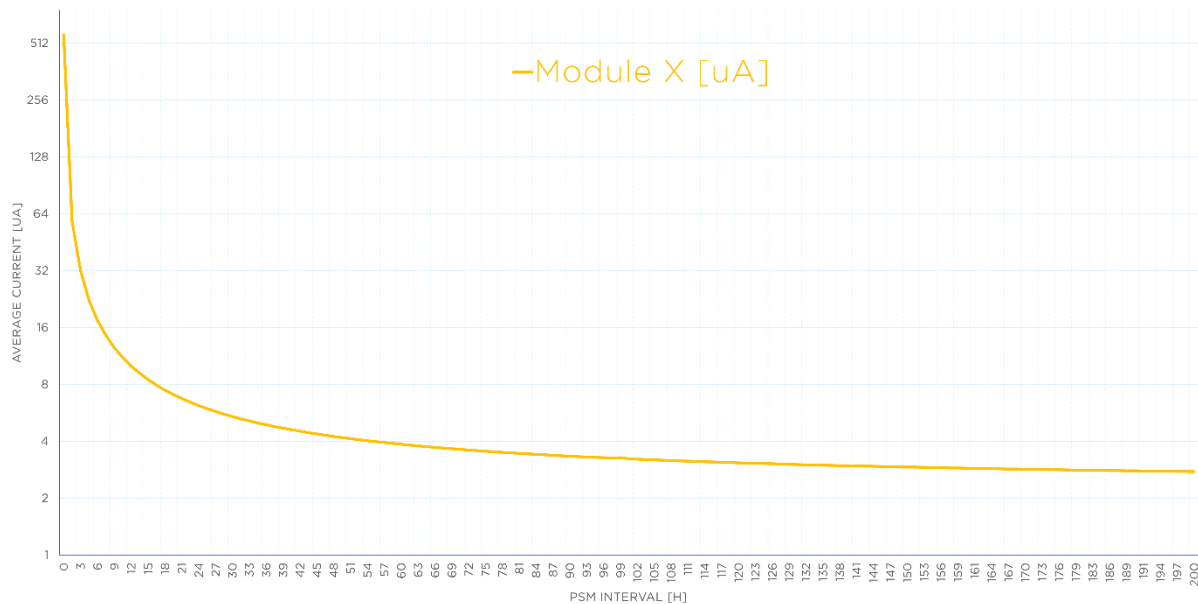
- But ..these are more like a «system OFF» current, ...
..since they are without RAM retention, sometimes not even GPIO retention
- This means the module must re-negotiate with network for every wake-up
- SIM current and external MCU currents are also not included in these numbers ...

How nRF9160 makes it easy

- Intelligent modem algorithms
- Modem handles the complex parts automatically
- Modem firmware updates releases
 - Optimizations and improvements
 - Bug fixes
 - New features (For “Major” mfw updates) [e.g. 1.2.x -> 1.3.x]
- Provide a full open-source and scalable software development kit, nRF Connect SDK



Module X - “1.8 μ A PSM floor...”

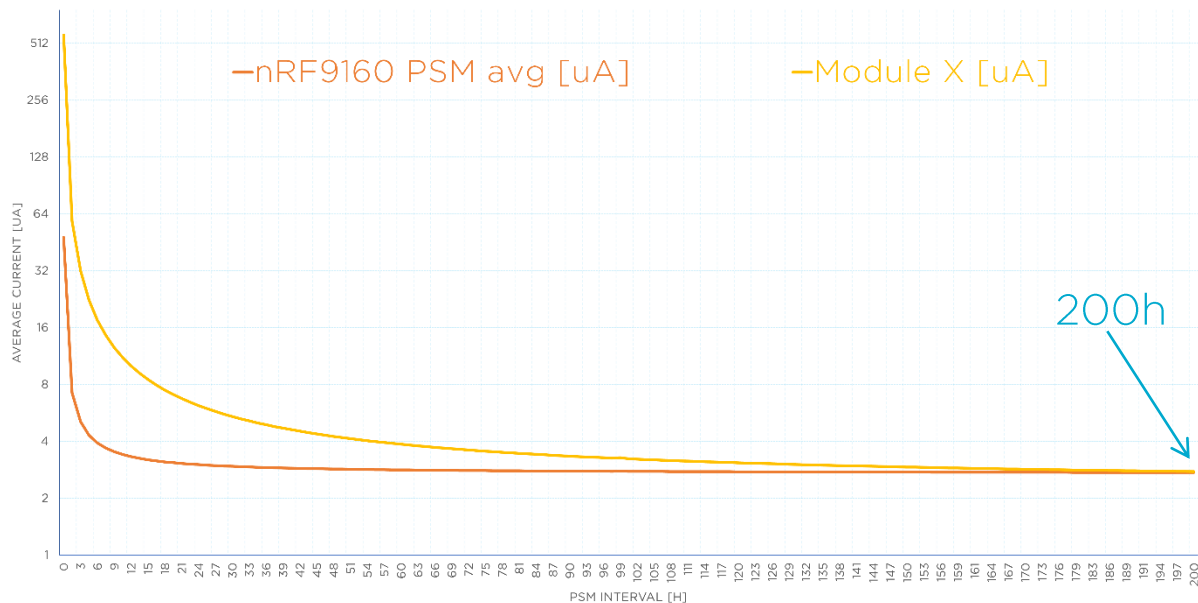


- Comparing average PSM current
 - Module X “PSM” + reconnect
- Module X “PSM” + reconnect
 - Claims 1.8 μ A PSM floor current
 - However, the avg. current after ~51 hours is ~4 μ A

* Calculations with external MCU sleep at 500 nA for Module X

** Module X excludes SIM currents

nRF9160 vs. Module X



- Comparing average PSM current

- Module X "PSM" + reconnect
- nRF9160 in PSM + reconnect

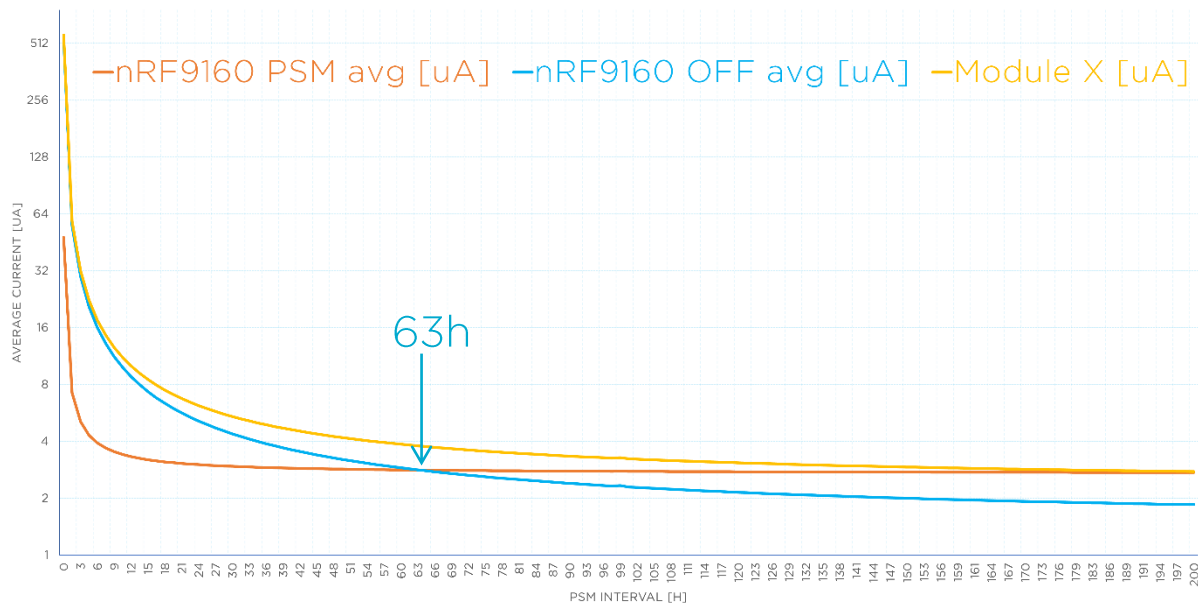
- nRF9160 PSM + reconnect

- Is more power efficient the entire time until around 200h vs. Module X

* Calculations with external MCU sleep at 500 nA for Module X.

** Module X excludes SIM currents

nRF9160 vs. Module X



Comparing average PSM current

- Module X "PSM" + reconnect
- nRF9160 in PSM + reconnect
- nRF9160 OFF + network attach

nRF9160 OFF + network attach

- RAM retention included
- Is even more efficient than nRF9160 PSM from the 63rd hour

* Calculations with external MCU sleep at 500 nA for Module X.

** Module X excludes SIM currents

How to optimize for low power

- Radio ON uses most power – reduce use time

- Interval sending/receiving

- › eDRX, PSM

- Send information – not data

- › Utilize the M33 to process the data

- First LTE search time

- › First LTE search optimization*

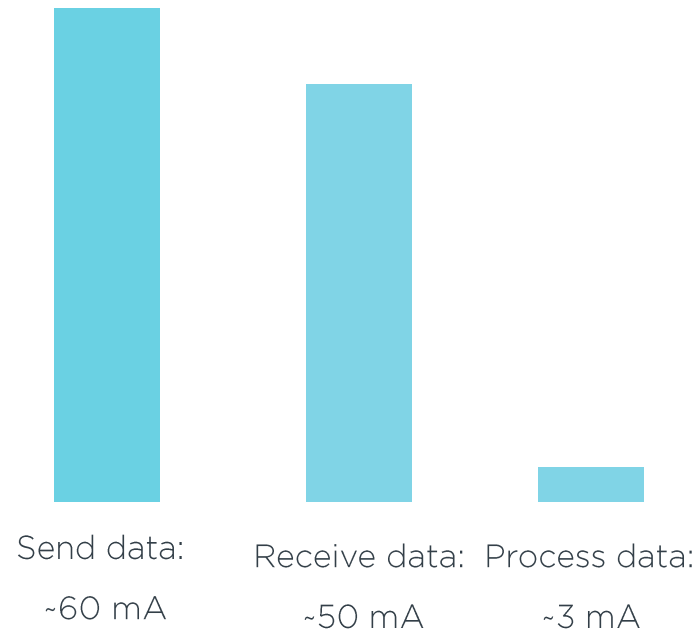
- › Modem domain events*

- Send data when good conditions

- › Pre-evaluation of connection*

- Avoid “rrc inactivity timer”

- › AS-RAI feature*



First LTE search optimization

- Speed up network selection when moving to a new area or first-time deployment
- Modem will go over to full searches if needed
- Store *Mobile Country Code, Bands, Radio Frequency Channel Number, LTE-M/NB-IoT* in a prioritized list
- AT Command : AT%COUNTRYDATA



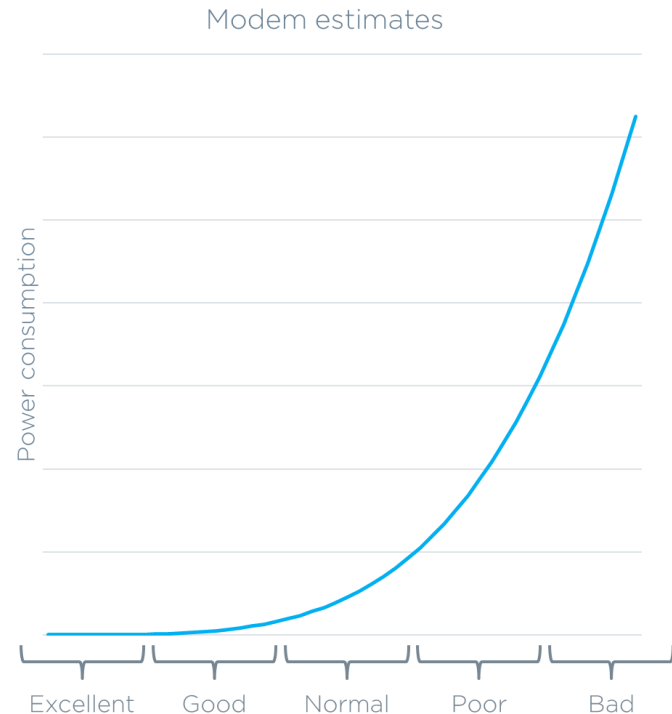
Modem domain events

- Get notified of “SEARCH STATUS 1”, “SEARCH STATUS 2”, “RESET LOOP”, “ME OVERHEADED”, “ME BATTERY LOW”
- The search statuses are very helpful to decide to stop the LTE search to save power after a “Light search” (SEARCH STATUS 1)
- “Light search” is the most modems most intelligent guesses to select the network
- AT Command : [AT%MDMEV](#)



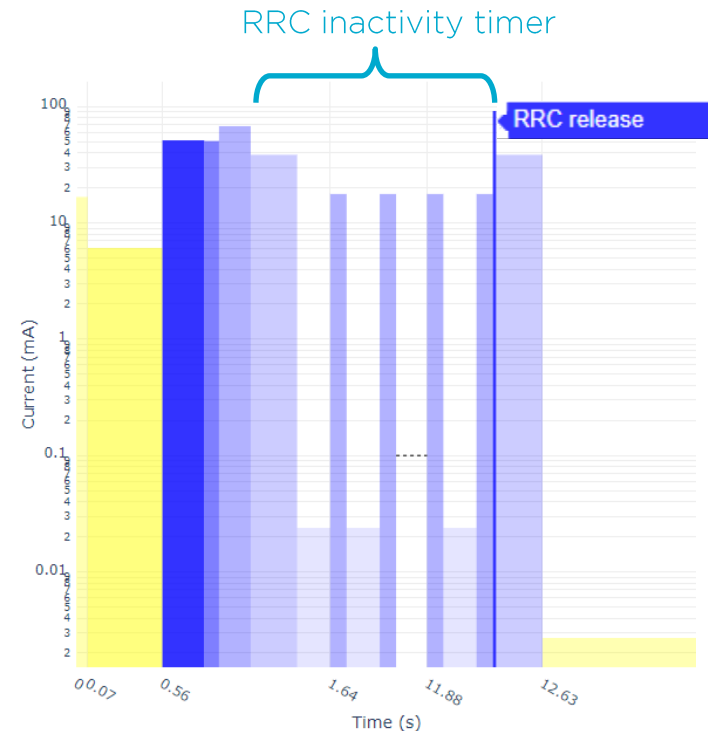
Pre-Evaluation of connection

- Evaluate the power consumption **before** connecting and sending data
- Returns both estimate category and raw parameters:
 - Estimate categories: Excellent, Good, Normal, Poor or Bad
 - Raw parameters: Radio link quality, RSRP, RSRQ, SNR, CE level, TX Power, repetitions, pathloss ++
- Perform a short measurement and analyze the radio environment on downlink on a cell
- AT Command : AT%CONEVAL



AS Release Assistance Indication

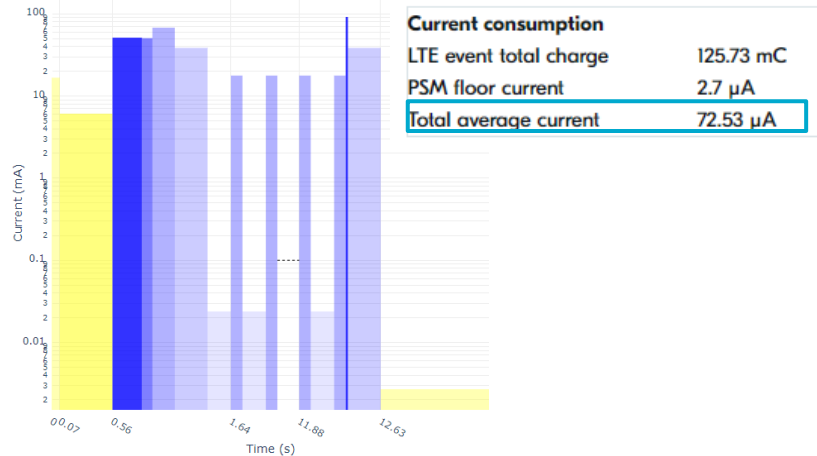
- Skip the network dependent “RRC inactivity timer”
- Switch quickly from RRC connected mode to IDLE/PSM if there is no more data to send or receive.
- A lot of power to be saved since radio needs to stay ON after each send/recv. in this RRC inactivity timer.
- AT Command : [AT%RAI](#)



AS Release Assistance Indication

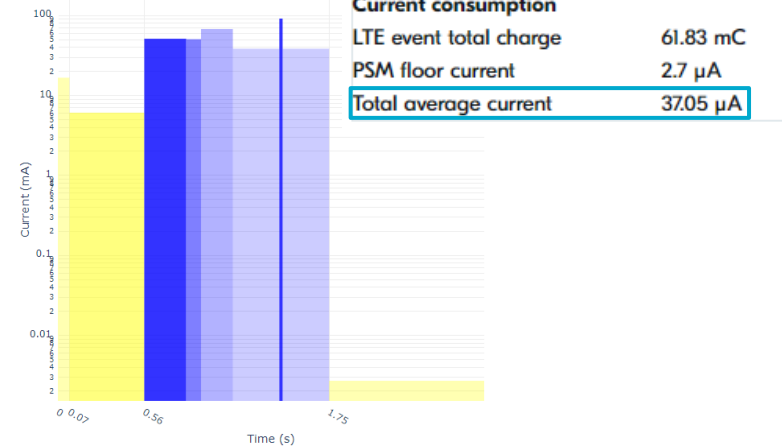
- *Example:* Sending data UDP (1kB) each 30min, rest of time in PSM
- Using AS RAI, we see a 50% improvement = double the battery life!

RRC Inactivity timer: 11 sec



2 years 1 month of battery life*

Using AS RAI

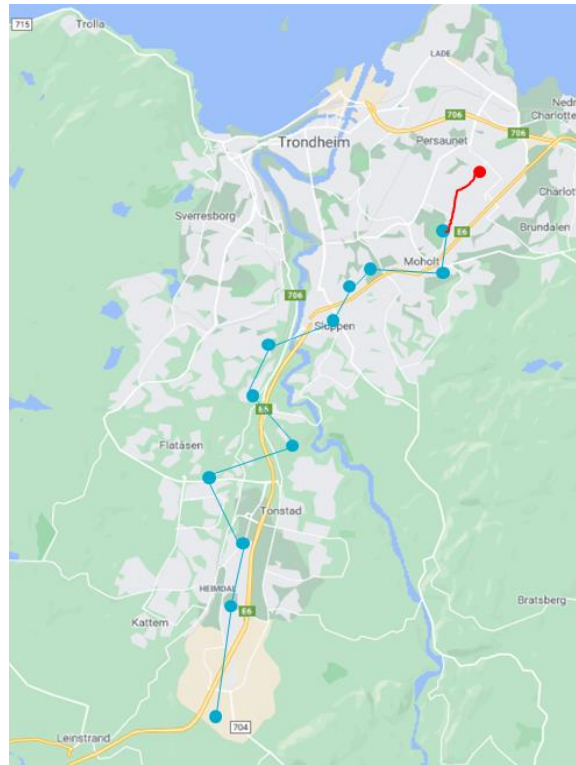


4 years 3 months of battery life*

*1400mAh battery based on estimates on the [Online Power Profiler](#)

How to optimize for low power - Location

- Cellular Positioning – Fast and Ultra Low Power
 - Save power when accuracy is not needed
 - Works indoor
 - Single- and multi-cell measurement support
- Integrated GPS – Great for accurate tracking
 - Down to 3m accuracy
 - Assisted GPS and Predicted GPS supported
 - Continues, interval and single-show mode
- Sign up for [“How cloud helps your IoT devices to get location data”](#) for more info



nRF Connect SDK v1.6.0 – Just released!

Support for all major protocols

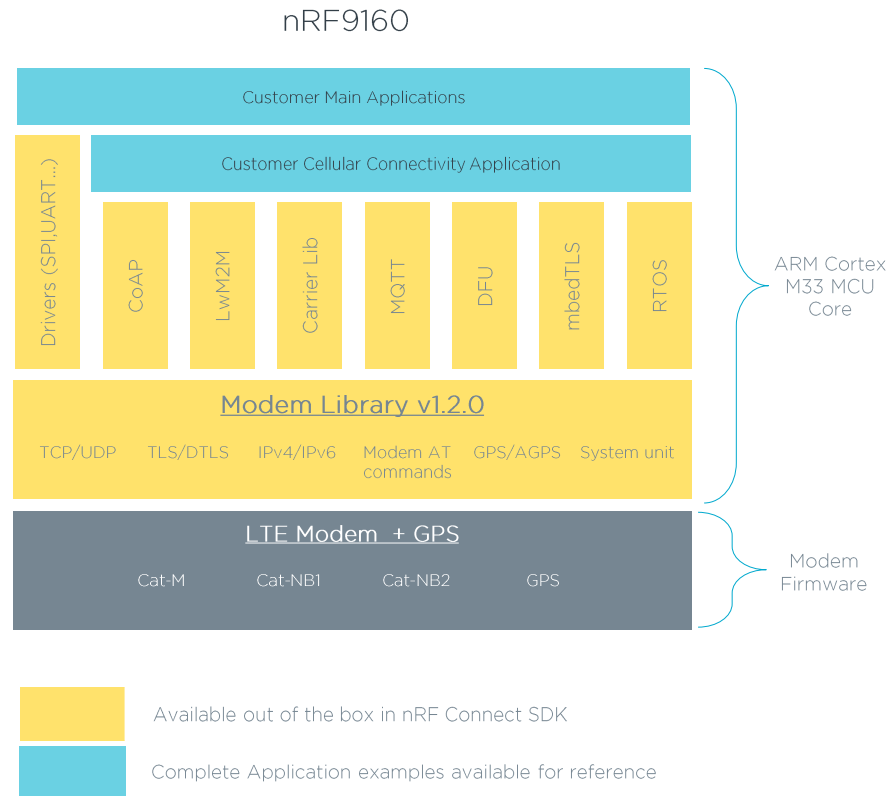
- e.g. MQTT, CoAP, LWM2M, HTTP(S), etc

Native in nRF Connect SDK

- All open source and free of charge
- Flexible sockets: connect to multiple Clouds and services
- Robust and flexible FOTA
- RTOS for a modular approach
- Full application and cloud examples

Connectivity protocols seamlessly integrated with modem

- Nordic owns of the entire solution – simple support
- Focus on on your own application



Online Power Profiler for cellular IoT



Made to also fit cellular "dummies"

- Extensive User Guide available

No expensive LTE call box needed anymore

- Control and set network parameters

Re-configure, test and learn quickly

- See what parameters affects power consumption and how

Export settings to nRF Connect SDK project

- Unified solution with the Power Profiler Kit 2

- Available on [Nordic Semiconductor Devzone page](#)



Search the DevZone

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Support +

Nordic content

Online power profiler > opp

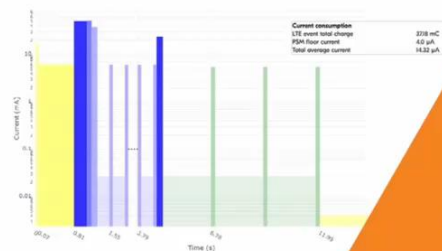
Online Power Profiler

Click below for either the nRF52 series version which calculates the current consumption when using the Bluetooth LE Softdevice, or the nRF91 version for LTE-M and NB-IoT current consumption

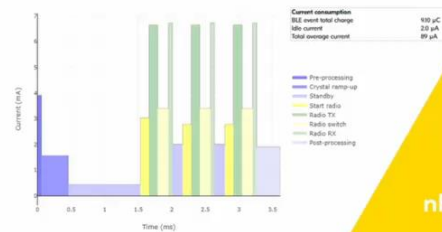
For more information on how to use the Online Power Profiler, click [here](#)

Contents

Online Power Profiler

[Online Power Profiler for LTE](#)[User guide \(LTE\)](#)[Online Power Profiler for BLE](#)**nRF91**
SERIES

Online Power
Profiler Tool for
nRF91 Series SiP

**nRF52**
SERIES

Online Power
Profiler Tool for
nRF52 Series SoCs

Power Profiler Kit II

First-of-its-kind tool for cellular developers

Perfect to track and measure power consumption

- Simple, accurate and powerful

Easy to estimate battery life

- Auto-calculates energy consumption

Spot and debug unwanted current drains

- Continuously during engineering cycle
- Compare with the Online Power Profiler
- Simple and cost-efficient (\$89 retail price)



nRF Connect v3.6.1 - Power Profiler: FEAT7B0E3B18



PPK2

FEAT7B0E3B18



DATA LOGGER

REAL-TIME

ABOUT

MODE

Source meter **Ampere meter**

Set supply voltage to 3700 mV

Enable power output ☒

SAMPLING PARAMETERS

100,000 samples per second

Sample for 432 seconds

Estimated RAM required 172.8 MB
10 us period

Start

DISPLAY OPTIONS

Timestamps ☒Digital channels ☒

0 1 2 3 4 5 6 7

Save / Export

Screenshot

☒ LOCK Y-AXIS

10ms

100ms

1s

3s

10s

1min

LIVE VIEW ☒

150 mA

100 mA

50 mA

0 μ A $\Delta 21.36s$ $\Delta 21.36s$

WINDOW

0.00 μ A
average0.00 μ A
max21.36s
time0.00 μ C
charge

SELECTION

Hold SHIFT+LEFT CLICK and DRAG to make a selection

CLEAR

☒ SHOW SIDE PANEL

CLEAR LOG

OPEN LOG FILE

☒ AUTOSCROLL LOG☐ SHOW LOG

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Webinars



**Technology intros
and trainings**

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Nordic Developer Zone



**Nordic tech support center
& online community**

29k+ users, 60k+ Posts Q&A
3 million page visits last 6 months

devzone.nordicsemi.com

Nordic GitHub



121 Repos, C/C++
Python, Javascript

github.com/NordicSemiconductor

Program for Mobile World Congress 2021

Date	Topic
June 28, 10:00 CEST	How to power optimize with the latest features in the nRF9160 SiP
June 29, 09:00 CEST June 29, 18:00 CEST	Expand cellular IoT coverage with iBasis IoT connectivity
June 30, 10:00 CEST	How cloud helps your IoT devices to get location data
July 1, 09:00 CEST July 1, 20:00 CEST	Exciting new features in nRF Connect SDK v1.6.0

All webinars are available on demand at webinars.nordicsemi.com

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Q&A