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# BLE Power Consumption Optimization

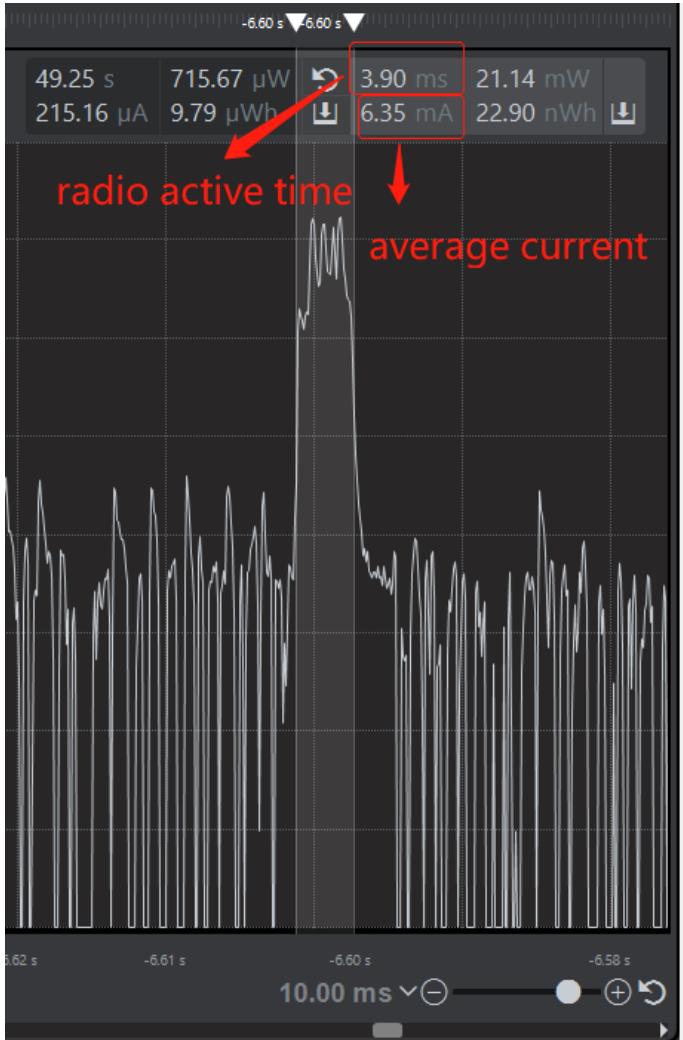
APAC RA | August 2022



# Agenda

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- Optimizing Current Consumption
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# Overview



Current consumption or, more generally, energy usage is a major concern in battery-powered products.

Bluetooth Low Energy has the potential to add wireless connectivity to your device while keeping its energy consumption low.

There are two main factors affecting current consumption.

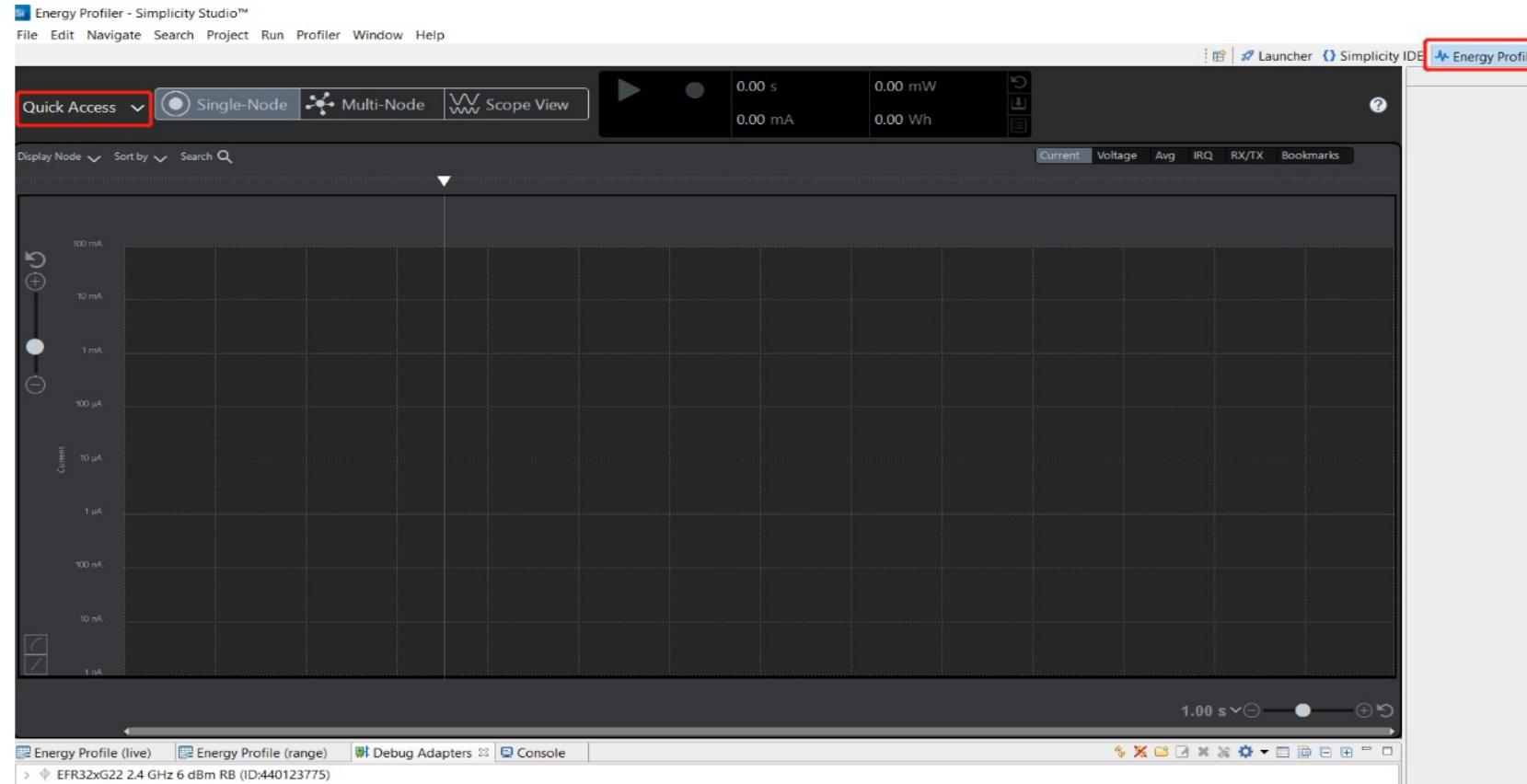
- The amount of power transmitted
- The total amount of time that the radio is active (TX and RX).

# Current Consumption Test Tool

- Energy Profiler in SSV5
- DC power analyzer

# Energy Profiler

The Energy Profiler is a software tool that works together with the Advanced Energy Monitoring (AEM) circuitry built into the WSTK main board.



# Keysight N6705



Keysight N6705 DC power analyzer parameter configuration:

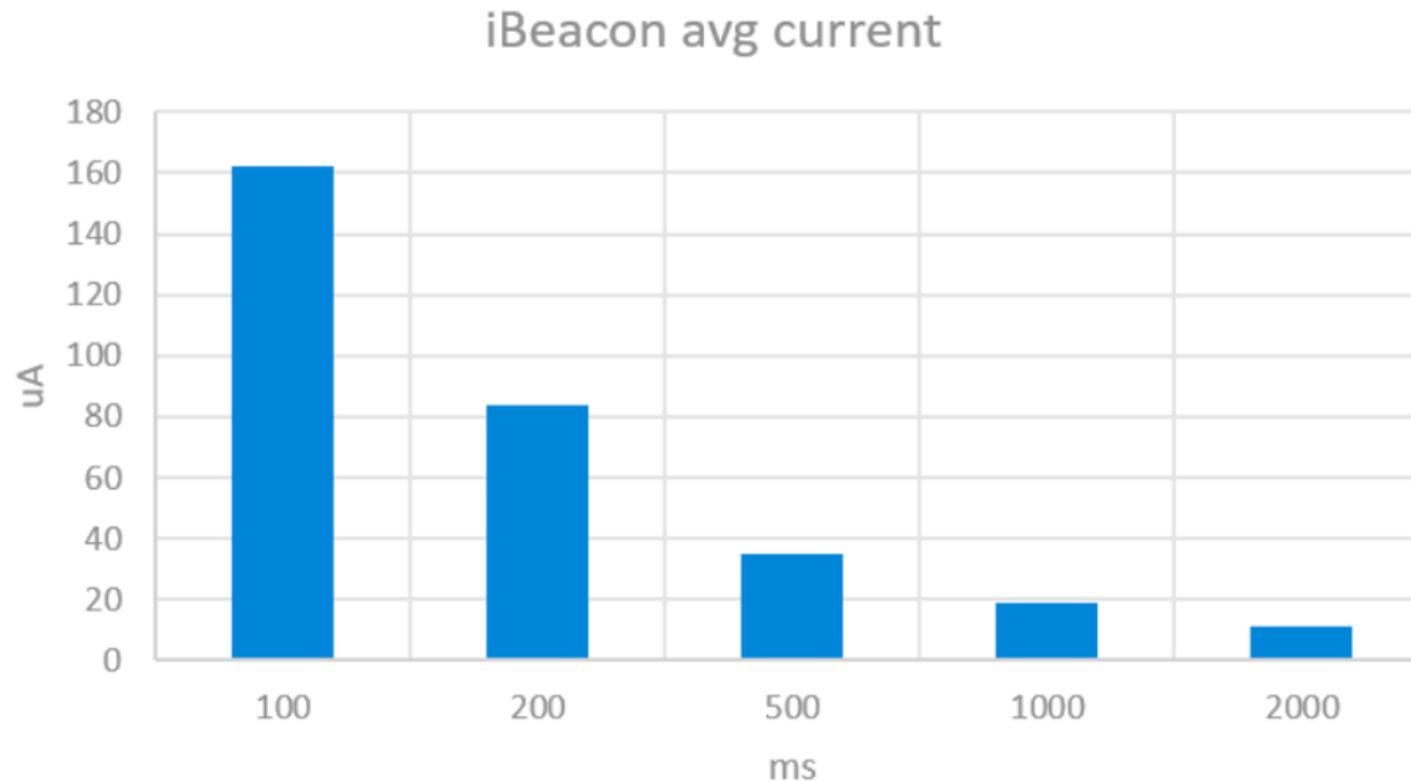
- Set 3.3V supply voltage
- Display Trace: Current
- Data Log Ranges:
  - Voltage:Auto
  - Current:Auto
- Sample Period:0.02048ms

# Optimizing Current Consumption

This section describes a series of optimization methods about current consumption in detail.

- Advertising interval
- TX power
- Connectable/Non-Connectable advertising
- Deep sleep mode
- Connection interval
- Peripheral latency
- 1M/2M PHY
- Command of forcing radio to idle state
- LE power control

# Advertising Interval vs Current Consumption



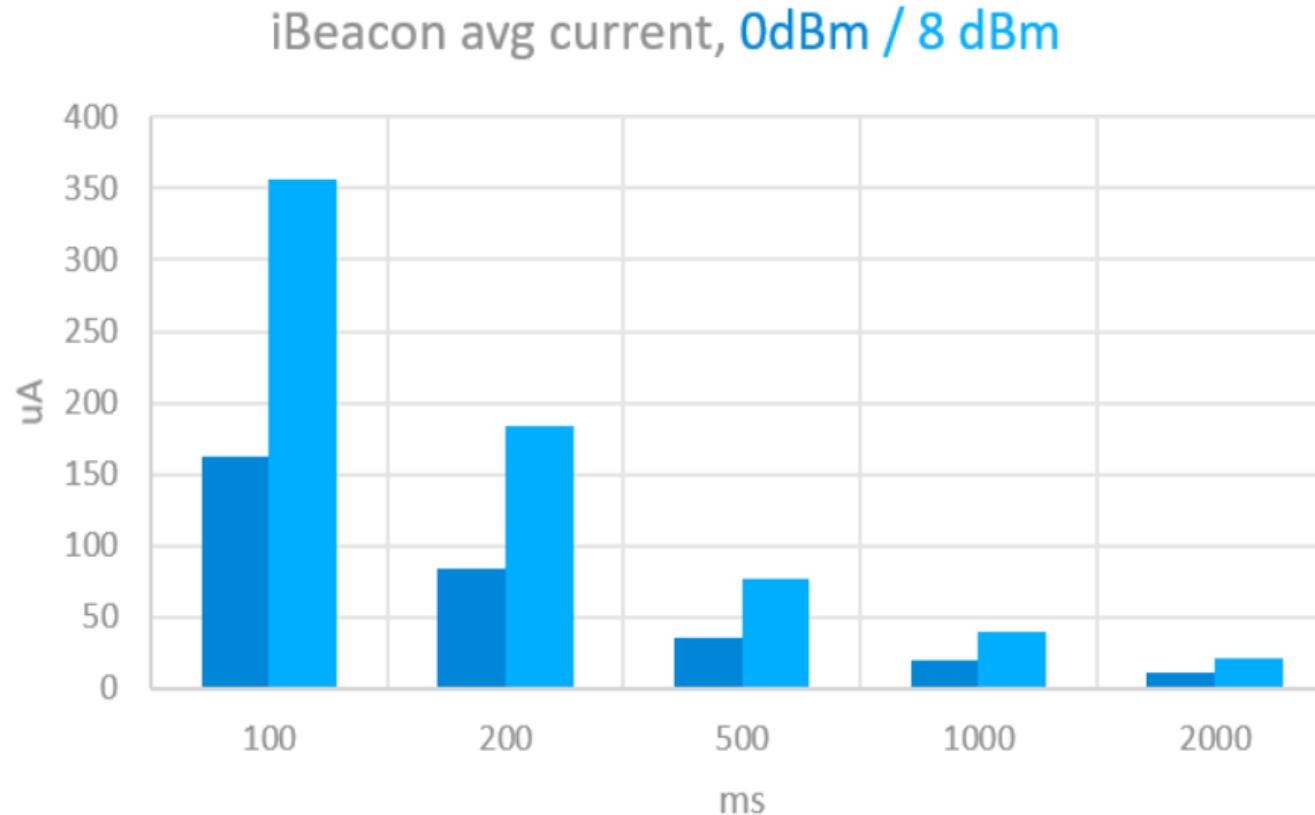
Advertising interval is  
adjustable, from 20 ms  
to 40.96 s .

non-connectable:  
minimum is 100 ms.

## TX power: 0 dBm vs 8 dBm

- The transmit power is adjustable, from -26 dBm to +10 dBm (default is 8 dBm).
- The transmission power can easily be changed in applications using the API call to `sl_bt_system_set_tx_power()`.

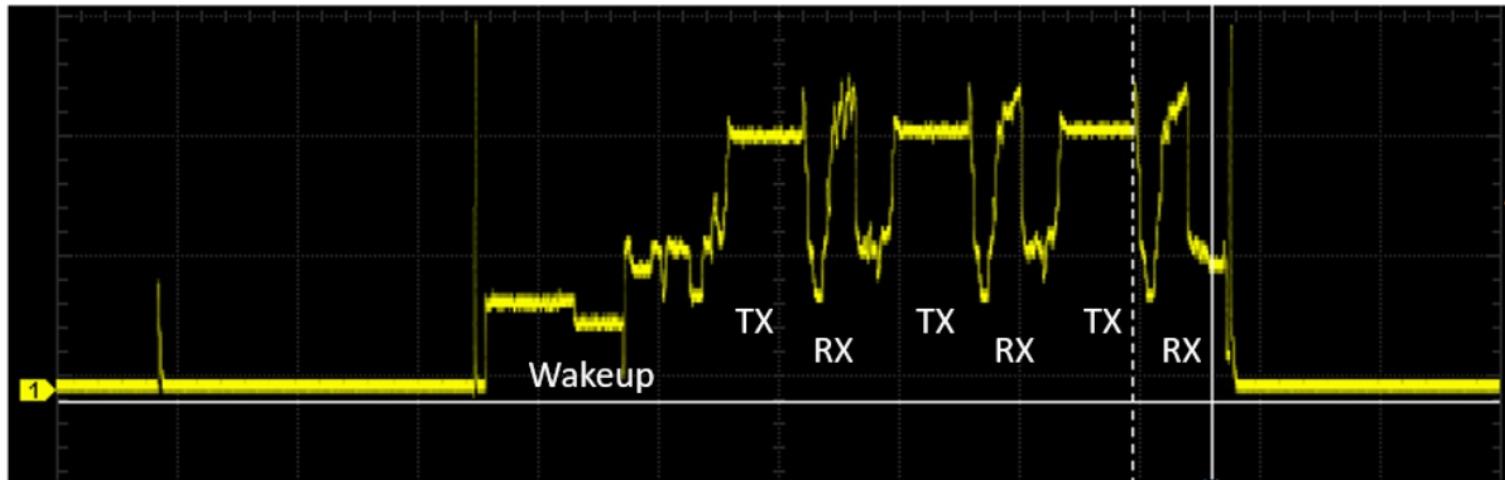
## TX power: 0 dBm vs 8 dBm



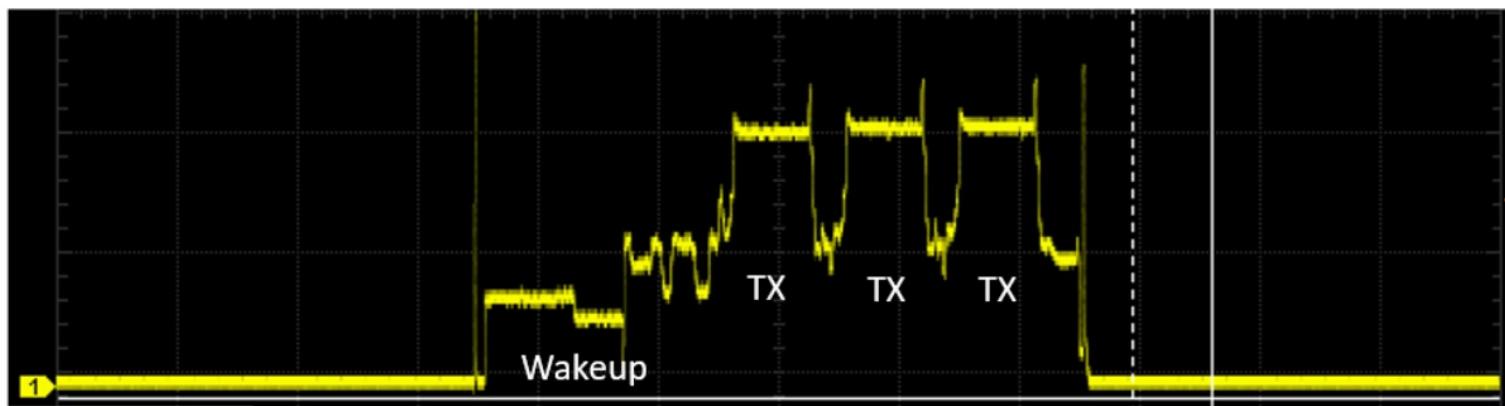
Changing the TX power from 8 dBm to 0 dBm.

# Current Profile: Connectable vs Non-Connectable Advertising Mode

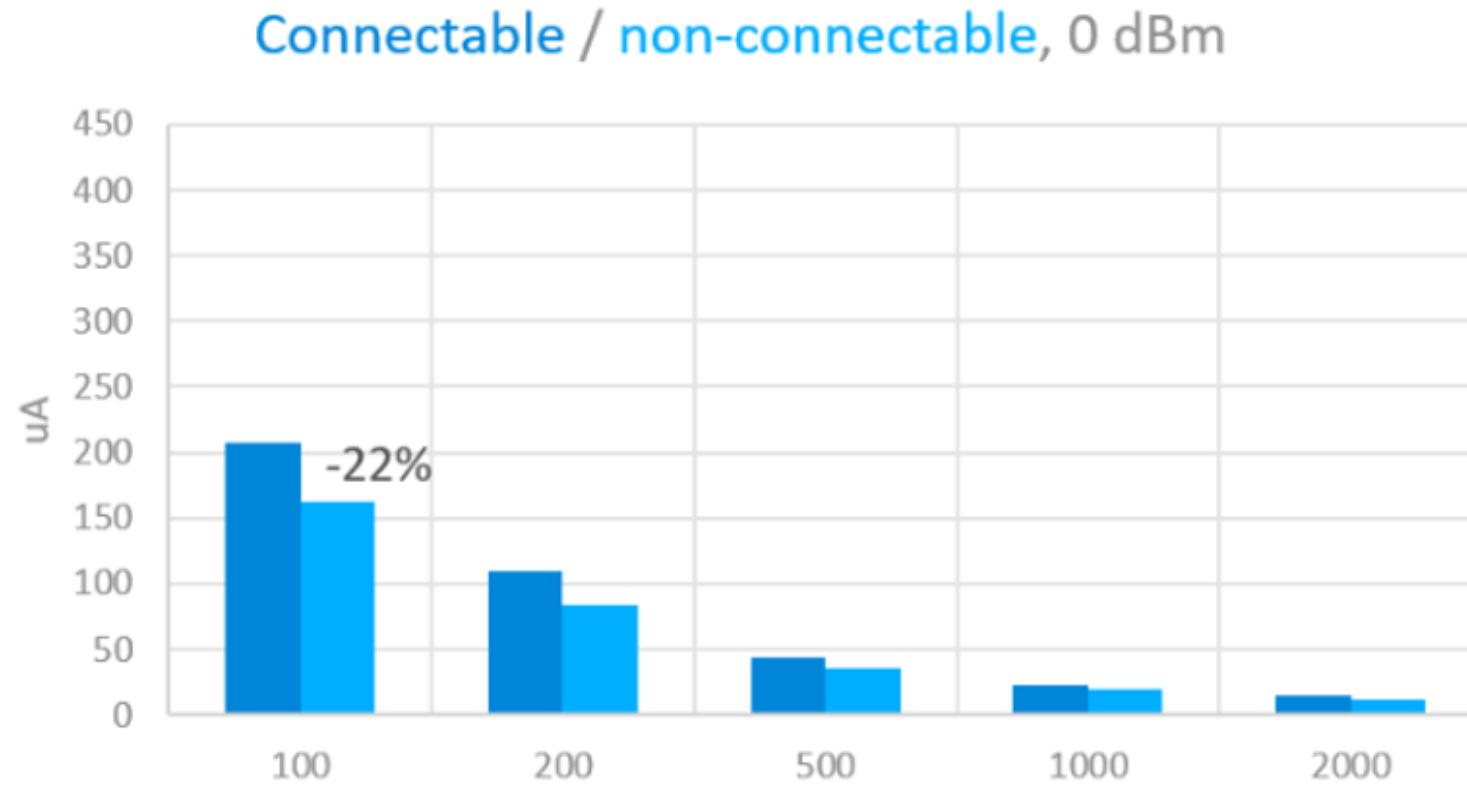
Connectable



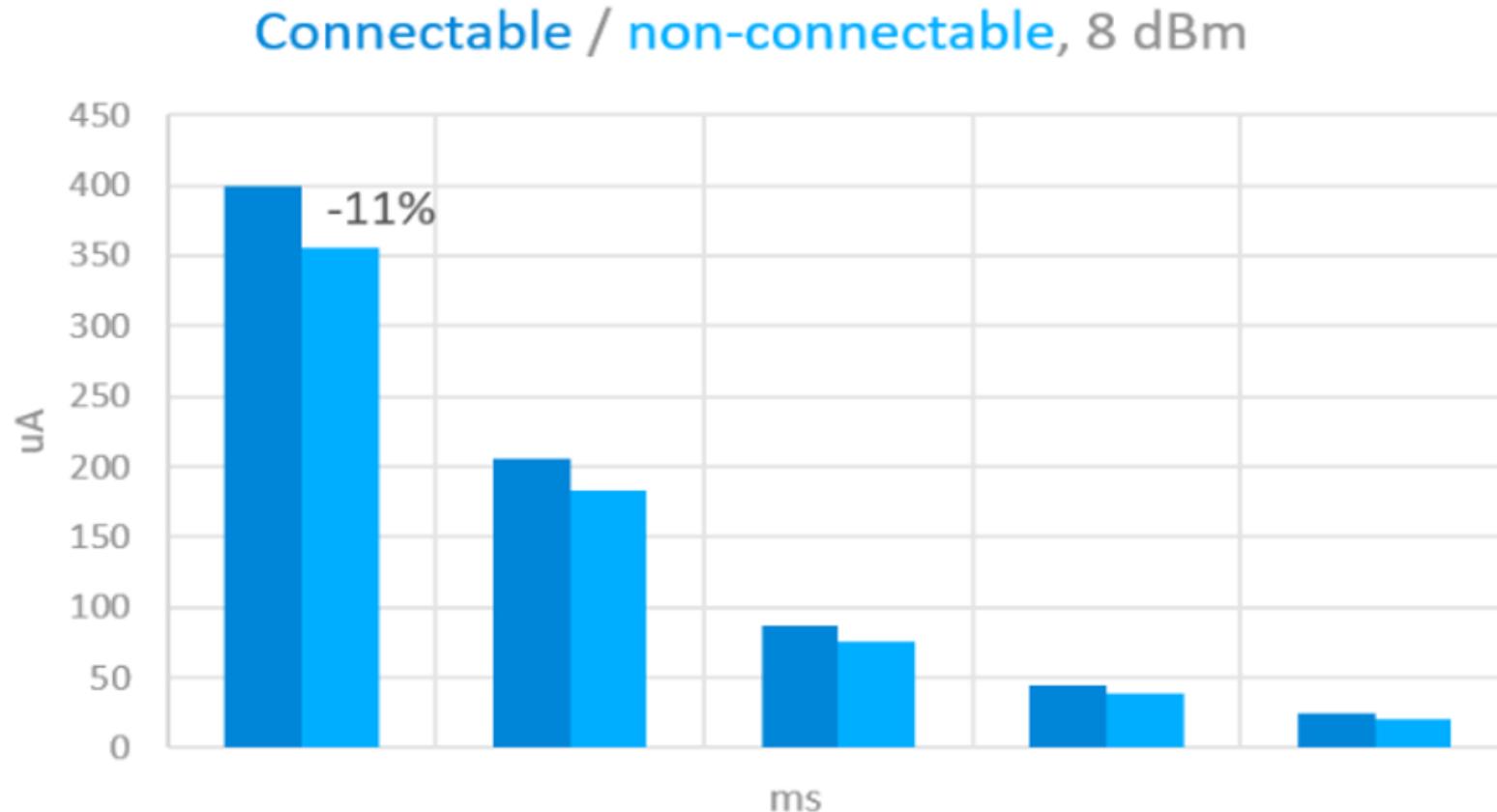
Non-connectable



# Current Profile: Connectable vs Non-Connectable Advertising Mode



# Current Profile: Connectable vs Non-Connectable Advertising Mode

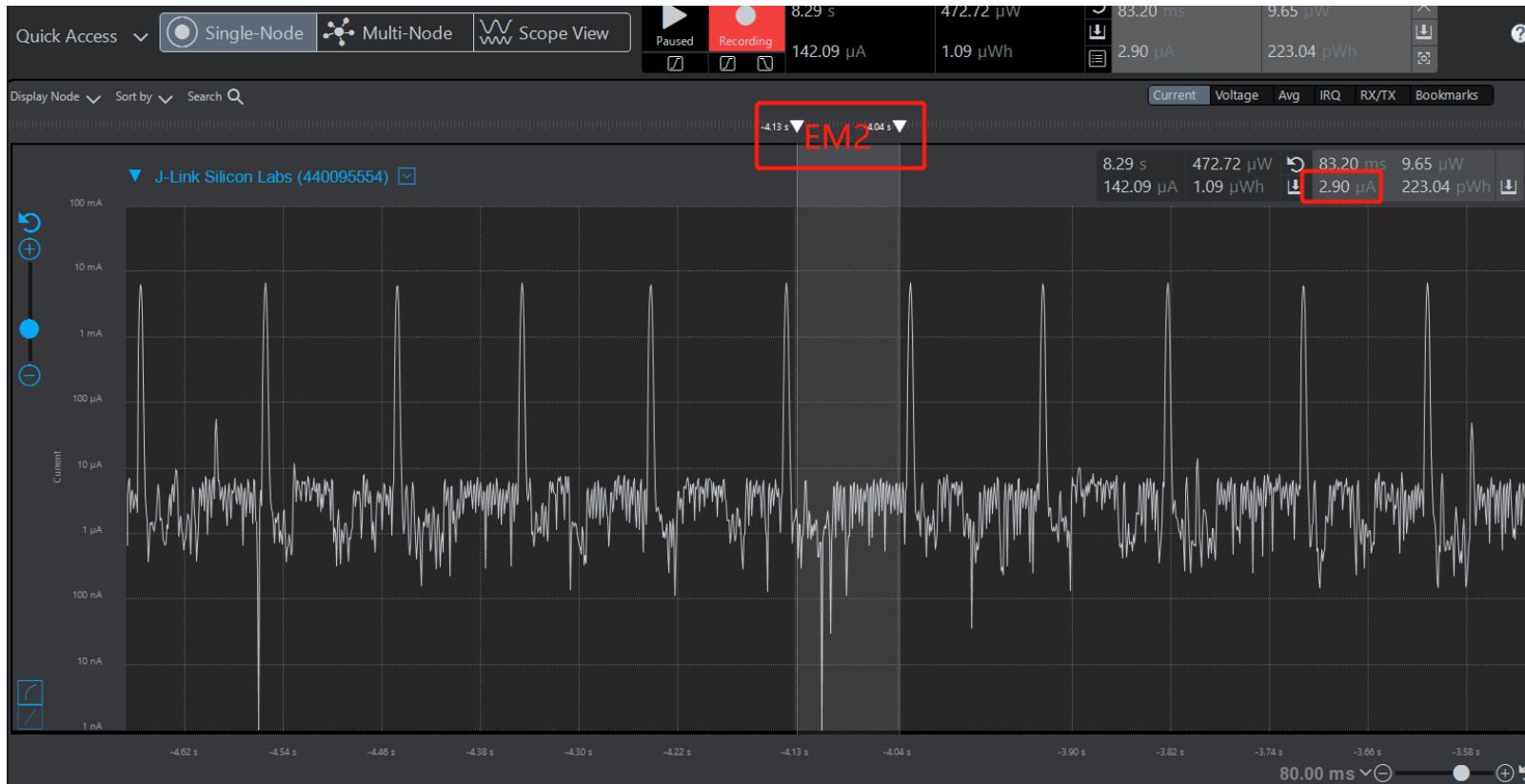


## Current Profile: Deep Sleep Mode

- If deep sleep is enabled (as in most of the examples), the device can enter EM2 mode automatically between advertising events. Deep sleep is only disabled if a peripheral or software component (e.g., UART) disables it.
- In some cases, going to EM3 and EM4 between advertising may be possible to save energy. This, however, only applies to non-connectable advertisements, and should be solved by the application.

# Current Profile: Deep Sleep Mode EM2

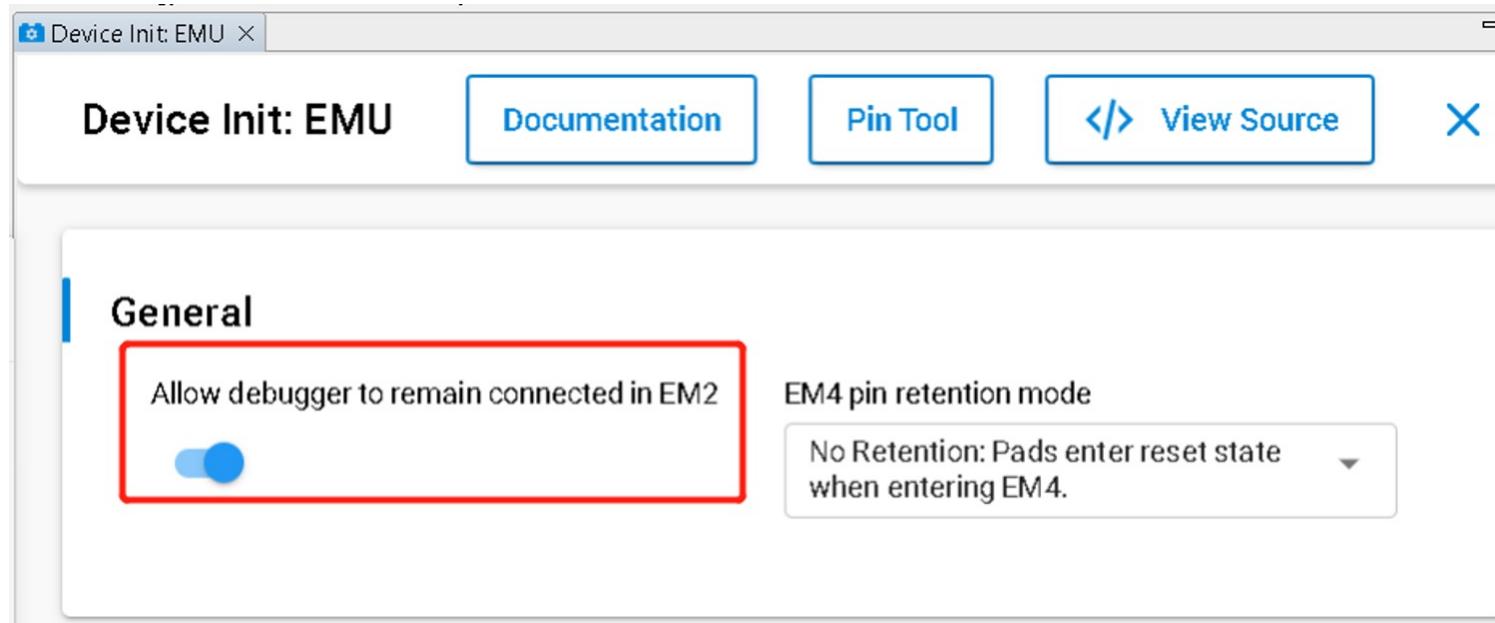
Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Current consumption in EM2 mode, VSCALE0	$I_{EM2\_VS}$	256 kB RAM and full Radio RAM retention, RTC running from LFXO <sup>1</sup>	—	2.9	—	μA
		256 kB RAM and full Radio RAM retention, RTC running from LFRCO <sup>1</sup>	—	2.9	—	μA



Test EFR32xg24 current consumption with energy profiler in EM2 mode, it is 2.90 uA as the EFR32xg24 datasheet said.

# Current Profile: Deep Sleep Mode

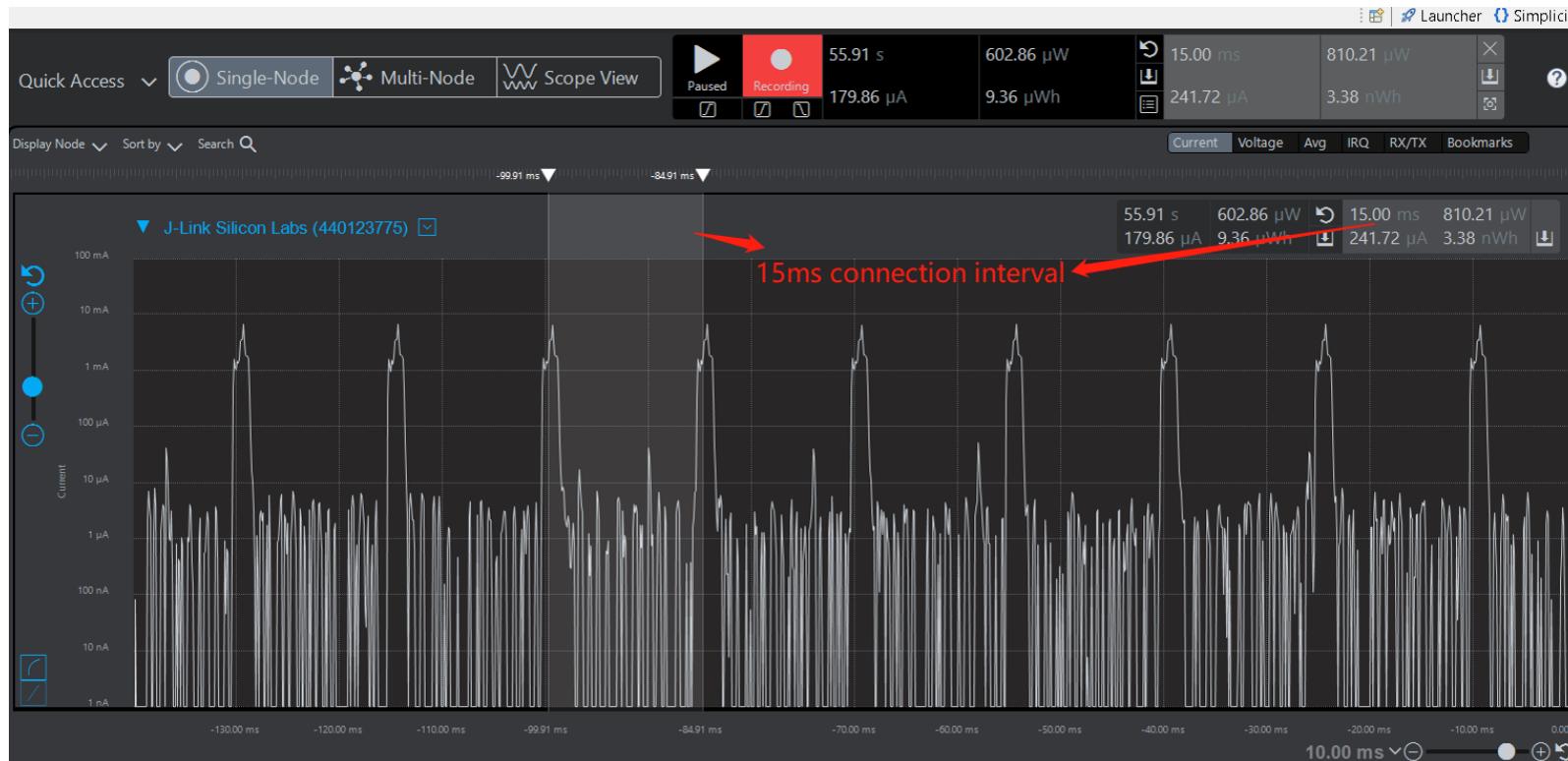
Debug connectivity can be disabled to reduce about 0.5uA current consumption.



# Current Profile: Connection Interval

Connection interval is an easy way to balance between latency/throughput and average current consumption.

- The connection interval : 7.5 ms ~ 4 s
- Connection with Empty Packet Transfer : Active Time 1.5 ms / 15 ms Connection Interval.

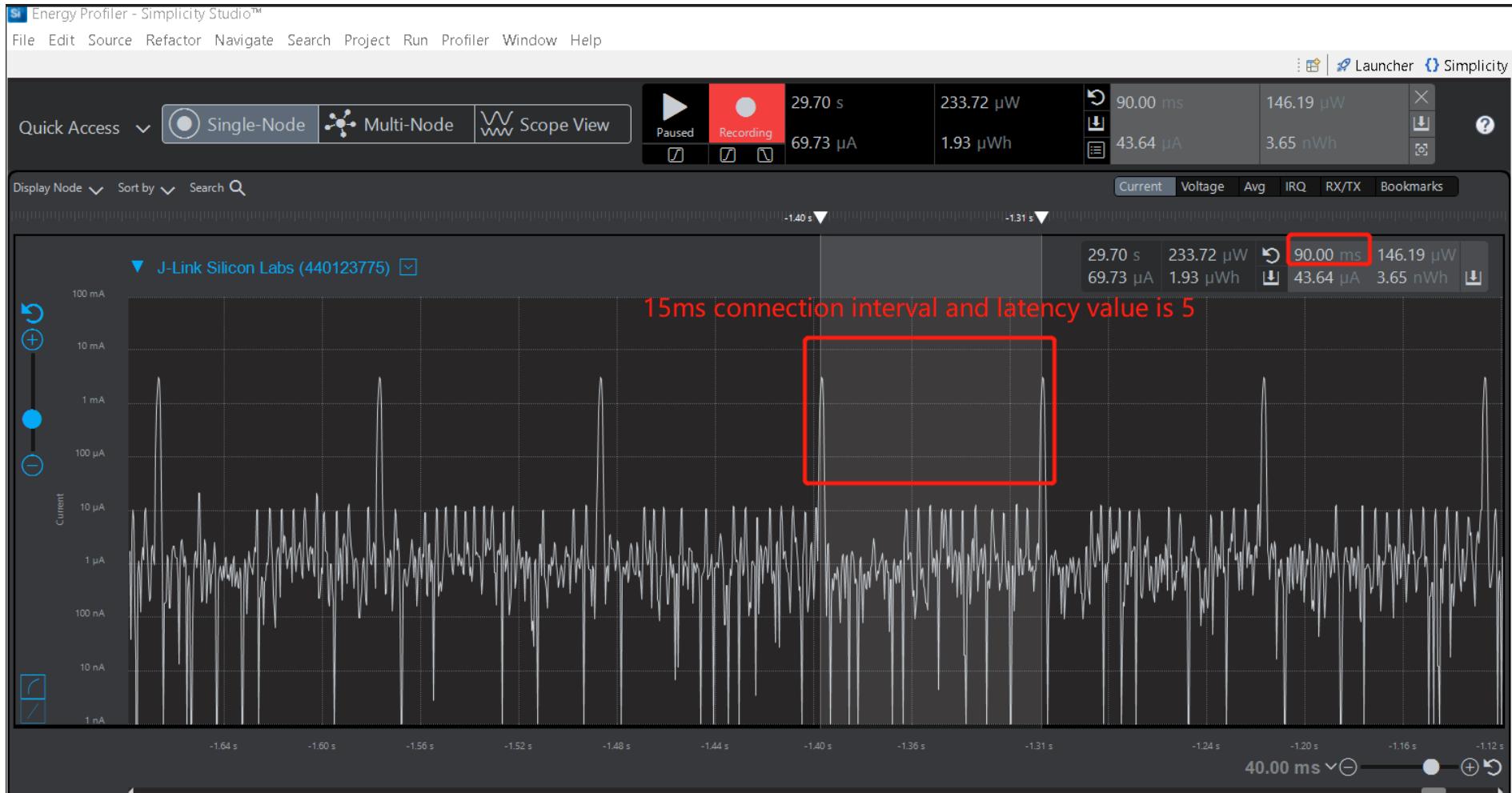


## Current Profile: Peripheral Latency

- Peripheral latency ensures that the peripheral device can skip N connection intervals if it does not have anything to transmit.
- Peripheral latency can be set using “sl\_bt\_connection\_set\_parameters()” API.

# Current Profile: Peripheral Latency

- Peripheral Latency Value of 5



## Current Consumption: 1M vs 2M PHY

Bluetooth 5 introduced 2M PHY for faster throughput and higher energy efficiency. This can lower the average current by reducing the air time of the radio and allowing the MCU to sleep more.

# Current Consumption: 1M vs 2M PHY



- 2M PHYs connections
- 15ms connection interval
- 244byte payload data
- 0dbm tx power
- Send a notification every 200ms

- 1M PHYs connections
  - 15ms connection interval
- 244byte payload data
- 0dbm tx power
- Send a notification every 200ms

Going from 1M to 2M PHY, the energy consumption is reduced by 16%.

## The Command of Forcing Radio to Idle State

There is a command which can force radio to idle state and allow device to sleep. Advertising, scanning, connections, and software timers are halted by this command.

Use this command only for a short time period (a few seconds at maximum). Halting the system for a long time period may have negative consequences on stack's internal

```
sl_status_t sl_bt_system_halt      (uint8_t halt)
```

# LE Power Control

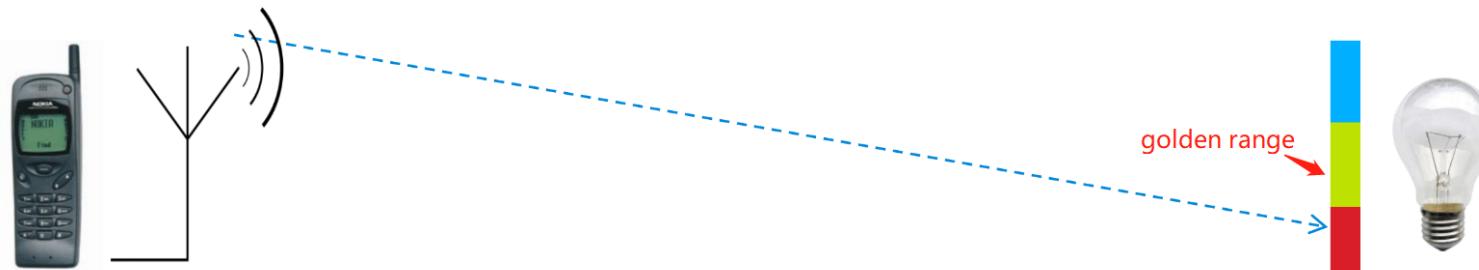
LE Power Control(LEPC) is a new feature introduced in BLE 5.2, which can be used to adjust a connected peer device's transmit power level based on the received signal strength.

## RSSI

- Received Signal Strength Indication
- Can be used to indicate how “good” the signal is
- RSSI decreases when distance increases

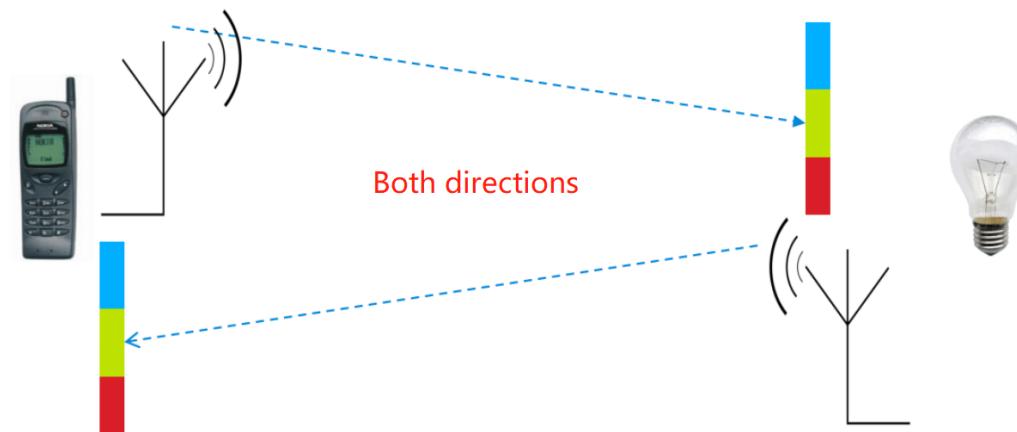
## Golden Range

- Optimum RSSI range for reception
- Can still receive outside this range



# LE Power Control

- If device is far away, local device get bad RSSI and can request to raise TX power of remote device
- It also tells how much more power it needs (dB) to get the RSSI into the "golden range"
- If devices are close to each other, local device get good RSSI and can request to decrease TX power of remote device
- Saves Tx Power on transmitter side
- Tx Power setting is separate for both directions



# LE Power Control

Add LE Power Control component on local and remote devices

The screenshot shows the "bt\_soc\_empty\_xg24" project in the "OVERVIEW" tab. The "SOFTWARE COMPONENTS" tab is selected. A search bar at the top right contains the text "power control". In the "Bluetooth" section, the "LE Power Control" component is listed. It has a red border around its name and a red-bordered "Install" button to its right. Below the component, there is a "Description" field containing the text "Bluetooth LE Power Control feature".

# LE Power Control

By changing the golden range to min = -45 dBm and max = -35 dBm the power level change will become more sensitive and required changes are smaller meaning practically all available power levels will be used.

The screenshot shows the 'LE Power Control' configuration page. At the top, there are tabs for 'bt\_soc\_empty\_xg24.slcp' and 'LE Power Control'. Below the tabs are buttons for 'Pin Tool', 'View Source', and a close button. The main area is titled 'Bluetooth LE Power Control Configuration'. It contains several input fields for setting RSSI golden ranges:

- Activate or deactivate the power control functionality:** A dropdown menu set to '1'.
- The lower bound of RSSI golden range on 1M PHY:** An input field containing '-60'.
- The upper bound of RSSI golden range on 1M PHY:** An input field containing '-40'.
- The lower bound of RSSI golden range on 2M PHY:** An input field containing '-60'.
- The upper bound of RSSI golden range on 2M PHY:** An input field containing '-40'.
- The lower bound of RSSI golden range on Coded PHY with coding scheme S=8:** An input field containing '-60'.
- The upper bound of RSSI golden range on Coded PHY with coding scheme S=8:** An input field containing '-40'.
- The lower bound of RSSI golden range on Coded PHY with coding scheme S=2:** An input field containing '-60'.
- The upper bound of RSSI golden range on Coded PHY with coding scheme S=2:** An input field containing '-40'.

A red box highlights the 'lower bound' and 'upper bound' fields for the 1M PHY configuration.

# Lab

This simple example demonstrates the impact of tx power ,advertising and connection parameters on the power consumption of a BLE device.

Lab requirement:

- Bluetooth-capable radio board(EFR32MG24-BRD2703A)
- Simplicity Studio 5
- WSTK Mainboard(BRD4001A)
- Simplicity Debug Adapter
- 10 Pin Connector Wire

## Summary

Several factors affecting power consumption have been described in this article. In actual product development, the appropriate advertising interval, connection parameters and transmit power should be selected according to the user's application scenario.