Tech Talks LIVE Schedule – Presentation will begin shortly

tech talks

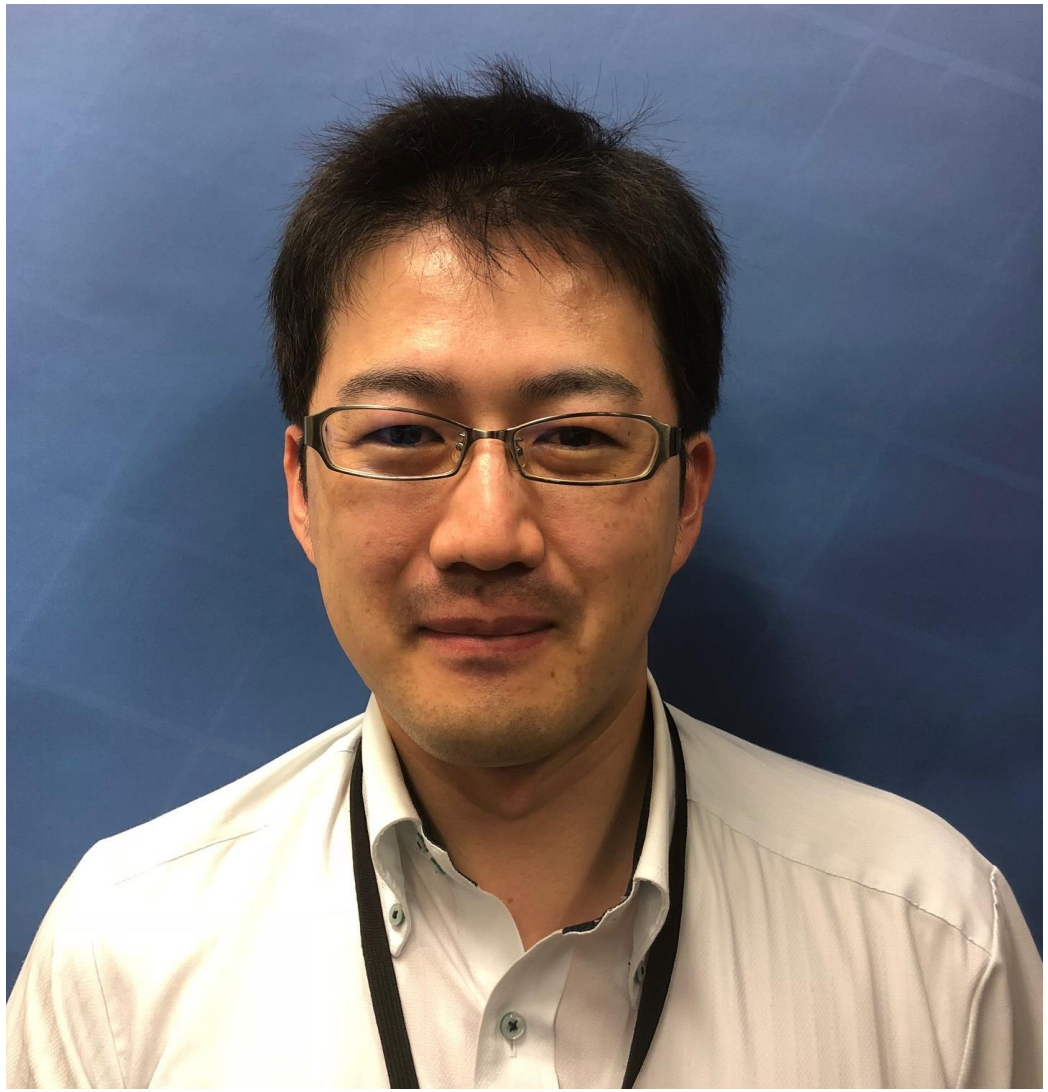
Wireless Connectivity Tech Talks

Wednesday, April 7th	**Unboxing the BGM220 Explorer Kit**
Wednesday, May 26th	**Optimize Your Battery Power with BG22**

Recording and slides will be posted to:
www.silabs.com/training

We will begin in 0:00

Speaker



岡田靖章（Yas Okada）

FAE, Japan

SILICON LABS

tech talks

WELCOME

Optimize Your Battery Power with BG22

Yas Okada

Agenda

- EFR32BG22 overview
- Optimizing power consumption
  - RF parameters
  - Device specific parameters
- What's new?
  - Power Manager
  - BT 5.2 LE Power Control
- Going further: EFP PMIC

BG22 Overview

EFR32BG22: Optimized Battery Powered Bluetooth LE

Optimized

Secure Bluetooth 5.2 SoCs for High-Volume Products

Radio
Bluetooth 5.2
TX: -27 to +6 dBm
RX: -96 to -107 dBm
1M, 2M and LE Coded PHYs
AoA & AoD

Ultra-Low Power
3.5 mA TX (radio)
2.6 mA RX (radio)
1.4 µA EM2 with 32 kB RAM
0.5 µA w/ RTC in EM4

World Class Software
Bluetooth 5.2
Bluetooth mesh LPN
Direction Finding

Compact Size
5x5 QFN40 (26 GPIO)
4x4 QFN32 (18 GPIO)
4x4 TQFN32 (18 GPIO)

ARM Cortex-M33 with TrustZone
38.4/76.8 MHz
352/512 kB of flash
32kB RAM

Peripherals Fit for Purpose
2x USART, 2x I2C, 2x PDM and GPIO
12-bit ADC (16 channels)
Built-in temperature sensor with +/- 1.5 °C
Built-in 32 kHz, 500ppm sleep clock

Security
AES128/256,SHA-1, SHA-2 (256-bit)
ECC (up to 256-bit), ECDSA and ECDH
True Random Number Generator (TRNG)
Secure boot with RTSL
Secure debug with lock/unlock

Extending Battery Life in Bluetooth Applications

Location Services	Data Transfer
Advertising 10 bytes every 1000ms	Connected to a phone at 2000ms interval
TX at 0dBm and using 1 channel	Using 2M PHY and transmitting 10 Byte / packet
Average current: 3.7µA	**Average current: 4.0µA**

5+ years on CR2032
10+ years on a CR2354

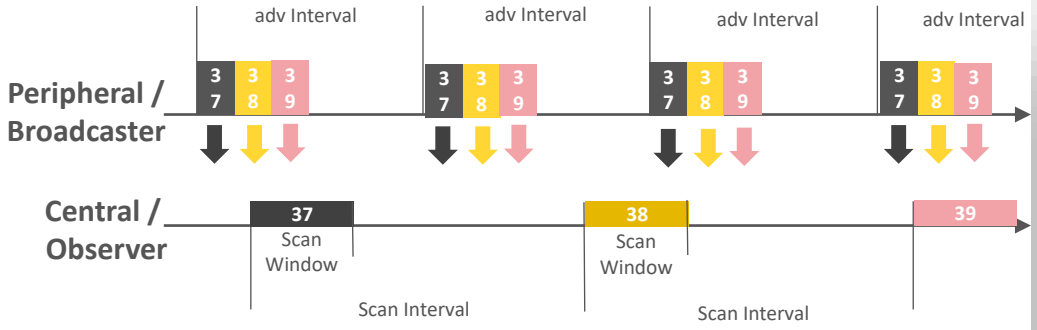
Optimizing Battery Life

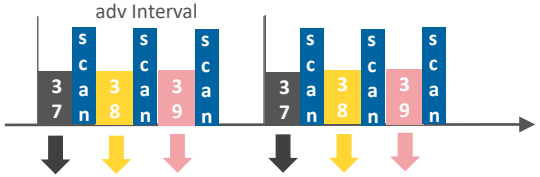
- RF Parameters that affect average current consumption
  - TX power
  - Advertising/connection intervals
  - Number of advertising channels
  - Connectable mode configuration
  - Payload
  - Choice of PHY
- Device-specific parameters
  - PA mode
  - Crystal settings
  - Voltage scaling
  - Debug configuration

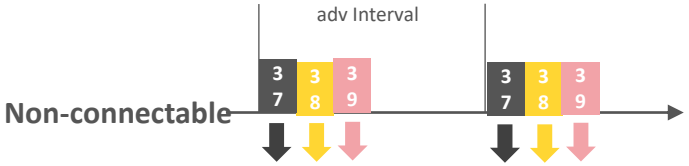
RF Parameters

Advertisement Specific Parameters

- Advertising interval
  - The longer the interval, the lower the power consumption
  - Tradeoff: Latency
- Channel count
  - Energy can be spared when sending the packets on only 1 or 2 channels
  - Tradeoff: Discoverability is limited
- Payload
  - If the packet contains less payload, the radio can be switched off faster
  - Tradeoff: Data
- Connectivity
  - If the advertiser is connectable, the radio will switch to RX mode to listen for connection requests
  - If it is not connectable, the radio will be switched off immediately after advertising

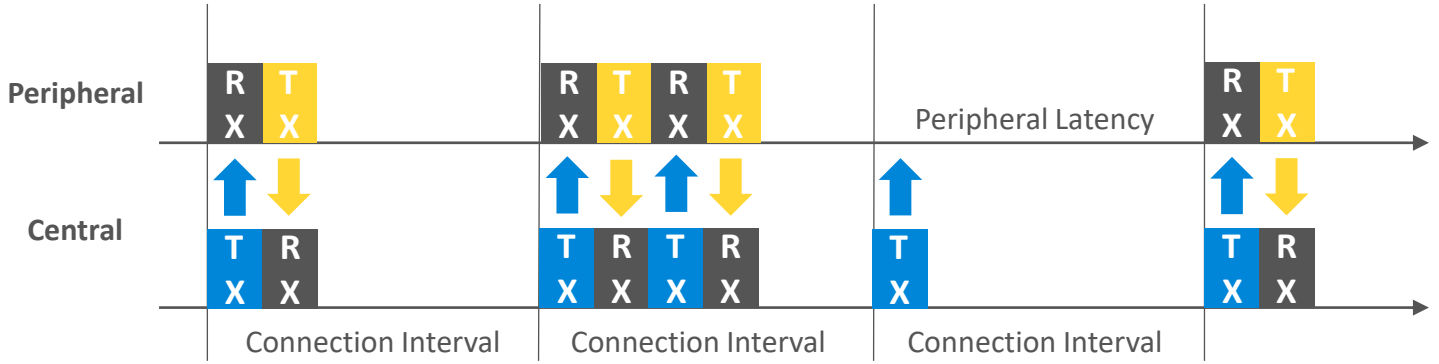






Connection Specific Parameters

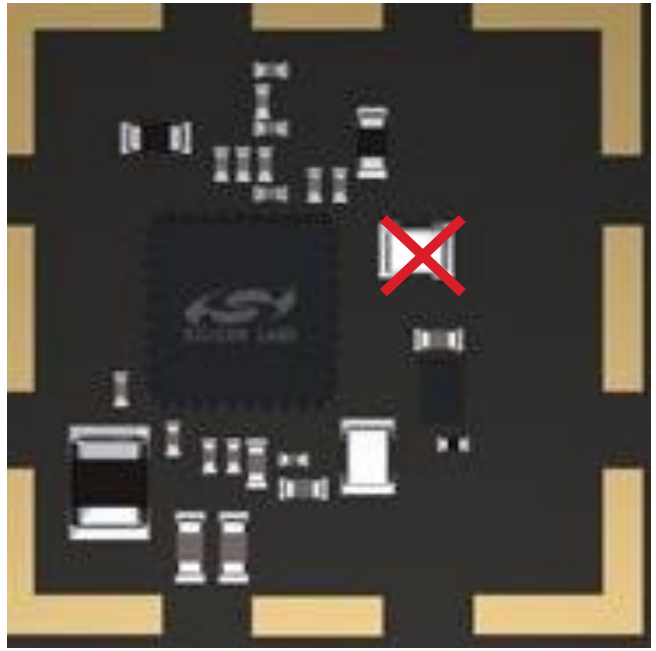
- Connection interval
  - The longer the interval, the lower the power consumption
  - Tradeoff: Latency
- PHY (2M, 1M, LE Coded PHY)
  - 2M PHY = shorter TX time
  - LE Coded PHY = longer range
  - Tradeoff: Compatibility and range
- Peripheral Latency
  - Allows the peripheral to skip connection intervals without dropping the connection
  - Tradeoff: Latency



Device Specific Parameters

PLFRCO – Precision Low Frequency RC Oscillator

- Using a precision 32k crystal can reduce overall current consumption.
  - EM2 state with an external crystal consumes 1.4uA
- Precision LF RC Oscillator can be used in place of an external 32k crystal
  - 500 ppm accuracy achieved with temperature sensing and calibration
- EM2 current consumption in precision mode
  - EM2 state with LFRCO consumes 1.7uA in stable temperature



Battery Optimization – Power Amplifier

- The BG22 has a 0dBm PA optimized for extended battery life in personal area network devices.
  - Such as Wearables, heart rate monitors, and blood glucose monitors.
- The PA of the BG22 has different operating modes: High Power and Low Power.
  - With High power mode a TX of 0dBm will require more power than if it is configured for Low Power mode.
  - High Power Mode TX at 0dBm consumes 5.2mA
  - Low Power Mode TX at 0dBm consumes 4.2mA

```
/* Bluetooth stack configuration parameters (see "UG136: Silicon Labs Bluetooth C Applica
static gecko_configuration_t config = {
  .config_flags = 0,                                  /* Check flag options from UG136 *
  .sleep.flags = SLEEP_FLAGS_DEEP_SLEEP_ENABLE,       /* Sleep is enabled */
//  .......
  .pa.config_enable = 1,                              /* Set this to be a valid PA confi
  .pa.input = GECKO_RADIO_PA_INPUT_DCDC,              /* Configure PA input to DCDC */
  .pa.pa_mode = RAIL_TX_POWER_MODE_2P4GIG_LP,         /* RAIL_TX_POWER_MODE_2P4GIG_LP  ,
//  .......
};
```

Save Power by using the DC/DC – Energy Management Unit

- The EFR32BG22 can consume
  - 2mA while in EM0
  - 2uA while in EM2
- Utilize the internal DC/DC for better power efficiency.
- Using the DC/DC can reduce the EM0 current consumption to
  - 1.32mA while in EM0 (30% energy savings)
  - 1.5uA in EM2 (25% energy savings).
- DC/DC converter operates down to 2.2V
- Utilize the VDD Comparator
  - The EMU contains a VDD Comparator to help monitor the main supply voltage level.
  - The comparator will trigger an interrupt if the voltage drops below a configured value to allow the user to bypass the DC/DC converter.
- DC/DC requires an extra inductor and capacitor for operation.

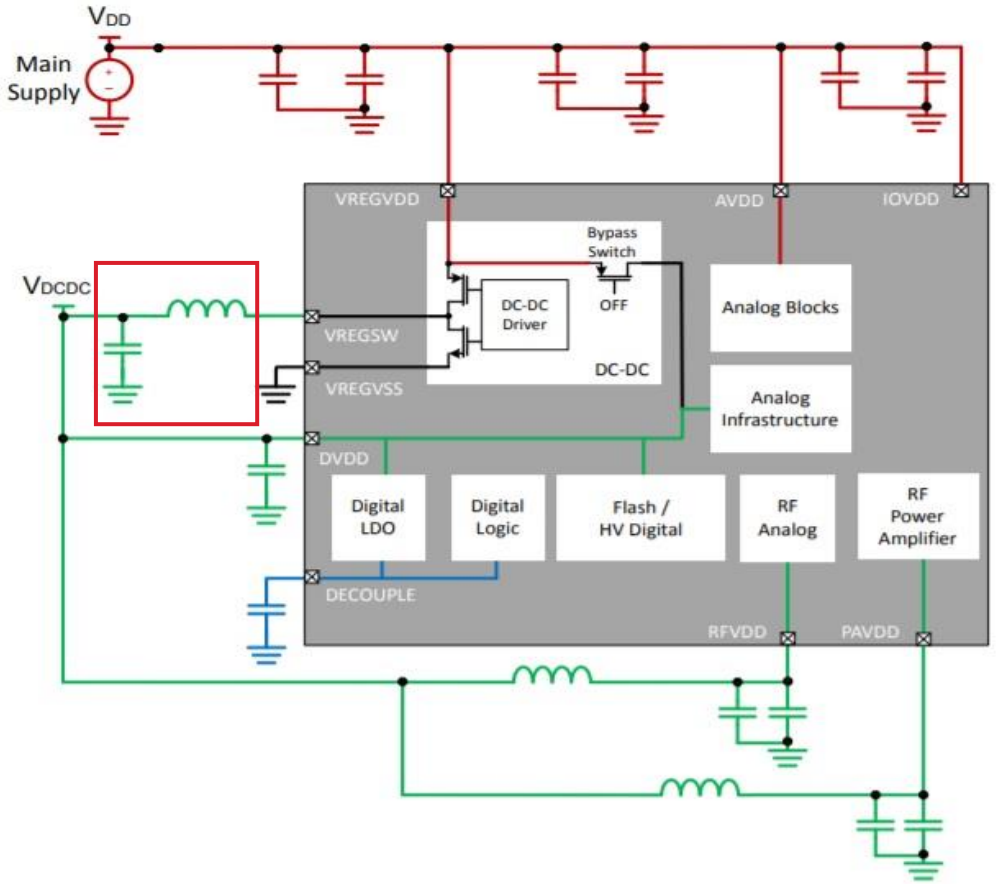


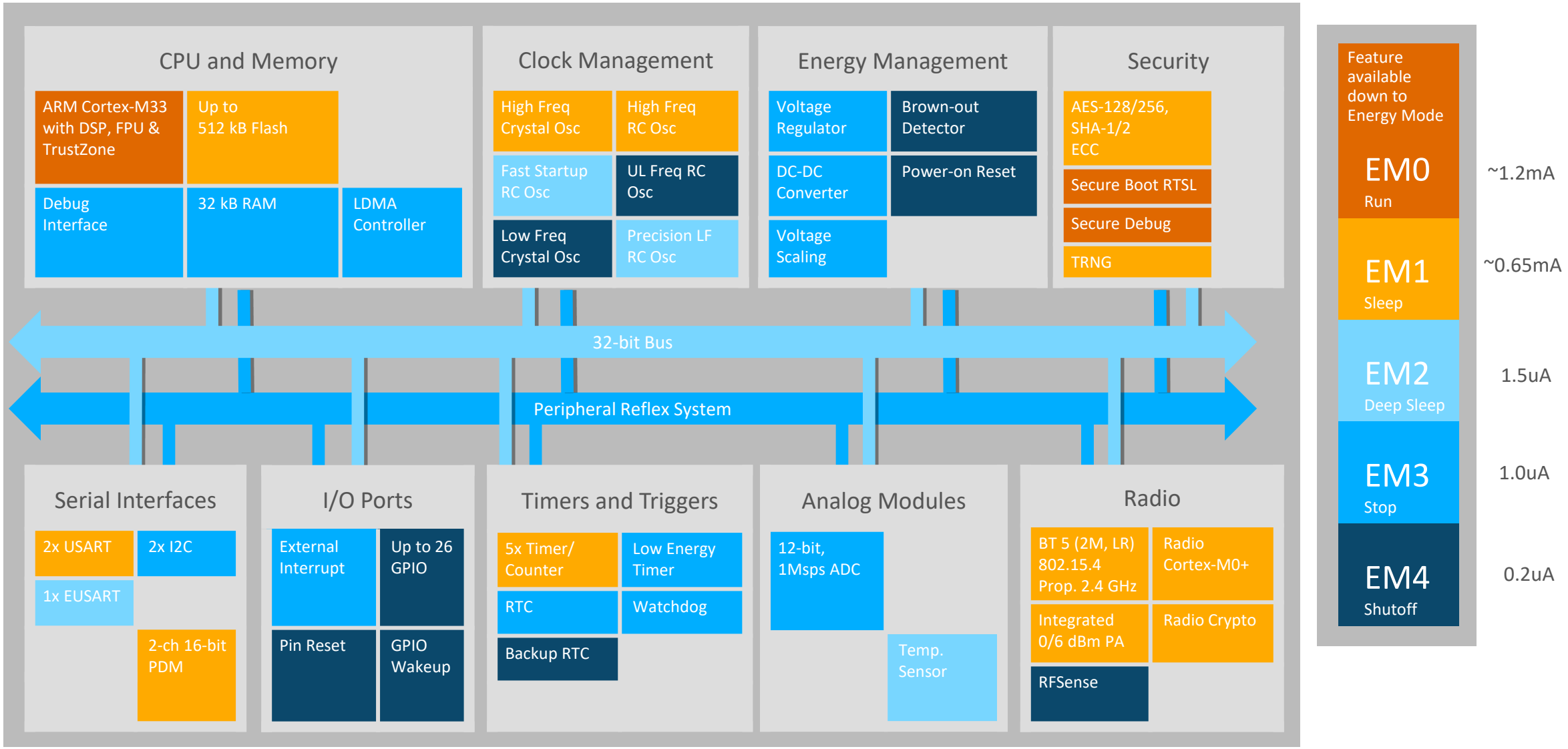
Figure 12.4. DC-DC Power Configuration

Additional Optimizations

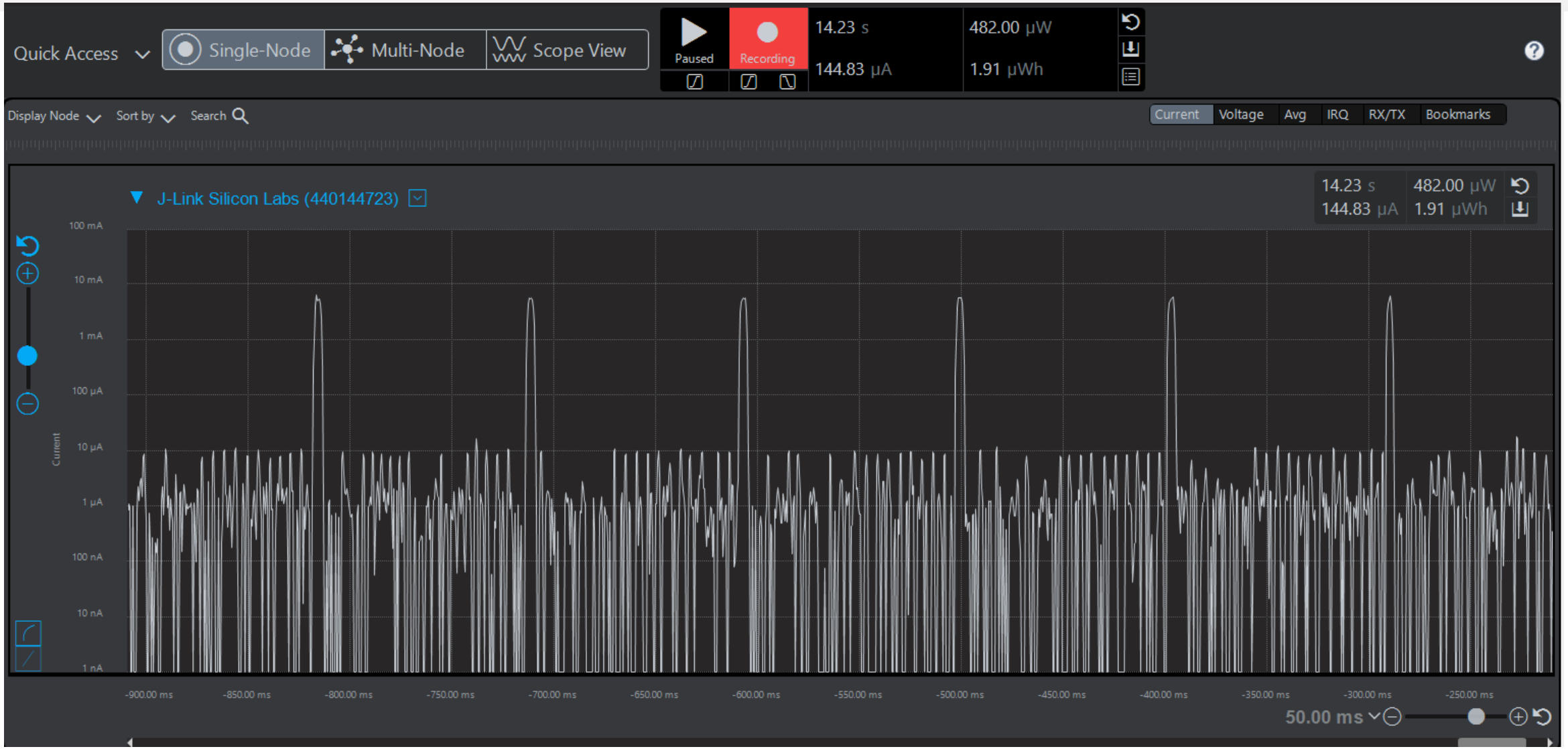
- The ARM debug unit can be shut down in EM2
  - As default it is enabled in the projects
  - After it is switched off, it can only be enabled again via Simplicity Commander
- Switch off VCOM/ debug log
  - Disable the usage of VCOM port and any debug prints in order to save energy

What’s New? Power Manager and LE Power Control

EFR32BG22 Peripheral Set and Energy Modes

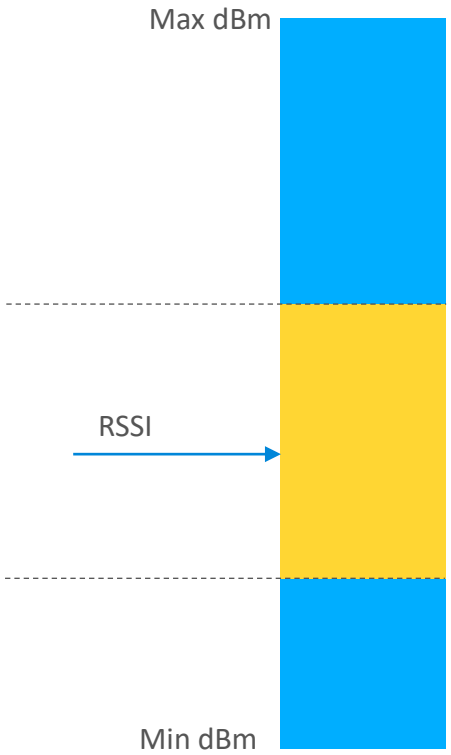


Power Manager and Energy Modes



LE Power Control

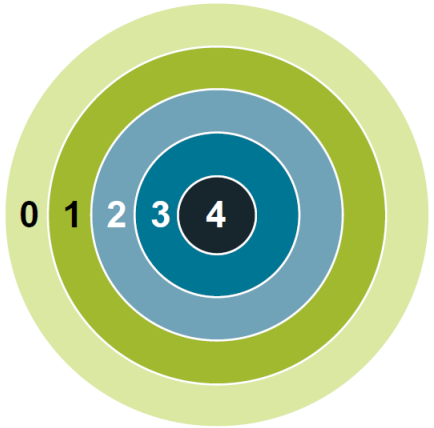
- New Feature in Bluetooth 5.2
- Allows master/slave to indicate whether they can change their TX power
  - Connection oriented – not supported for advertising
- Golden Range – optimal RSSI range for reception
  - RSSI is too low – request to increase TX power
  - RSSI is in the optimal range – no need to change
  - RSSI is too high – request to decrease TX power

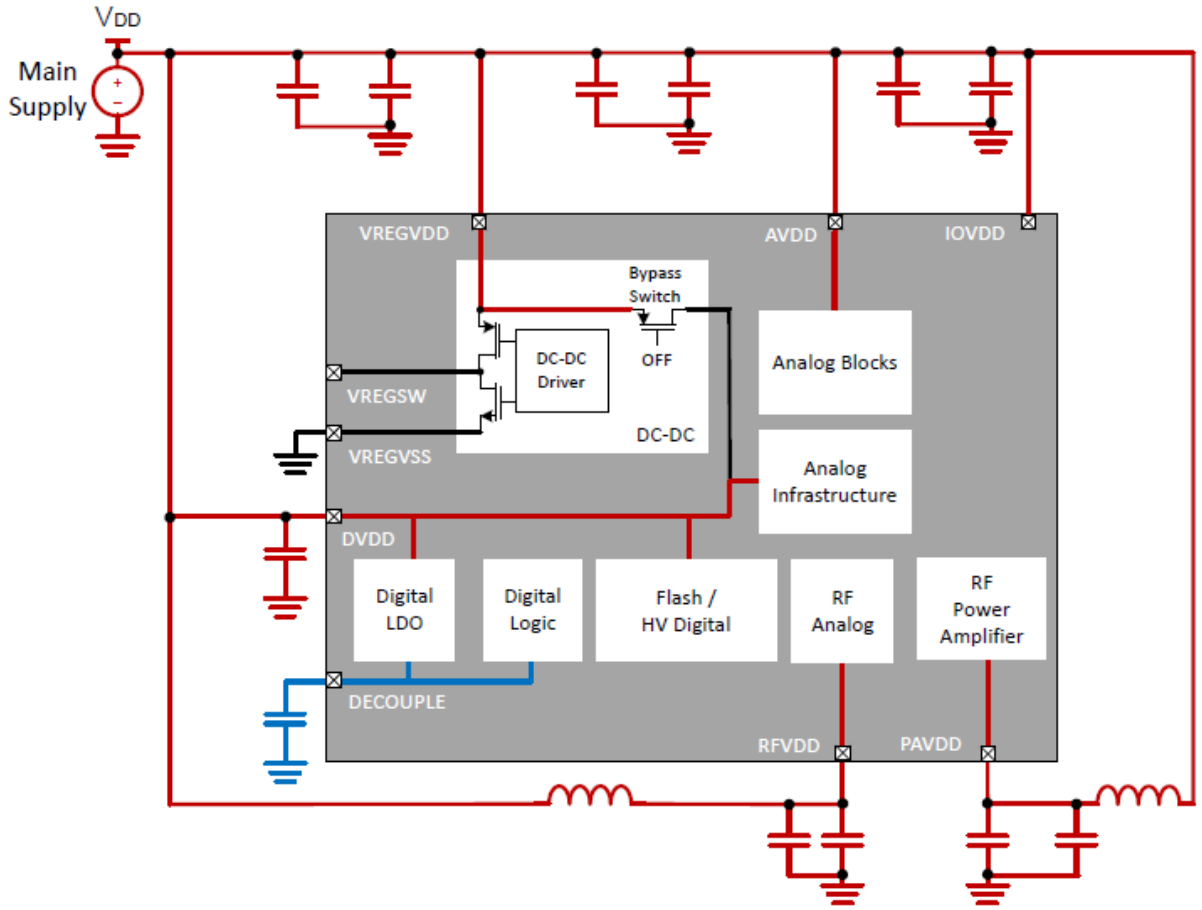


Going Further – EFP PMIC

EFR32BG22: Energy Management Unit (EMU)

- Energy Management Unit (EMU)
  - Manages energy modes
  - Power domains and routing
  - DC/DC control
  - Reset management
  - Brown Out Detectors
  - **Supply Voltage scaling**
  - **Internal LDO control**





Feature available down to Energy Mode

EM0 Run

EM1 Sleep

EM2 Deep Sleep

EM3 Stop

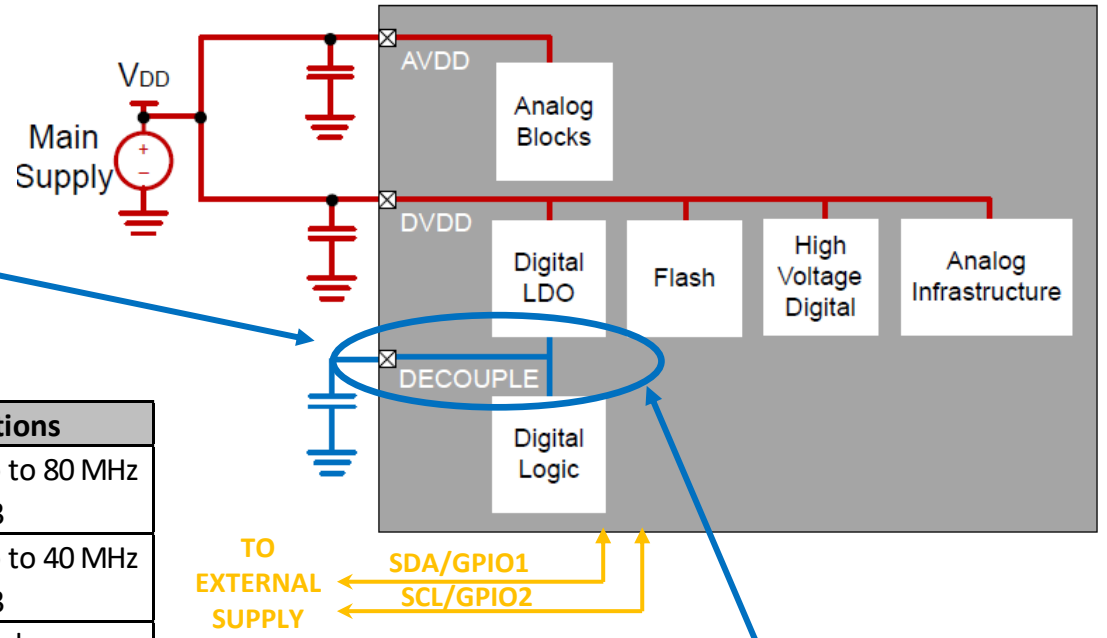
EM4 Shutoff

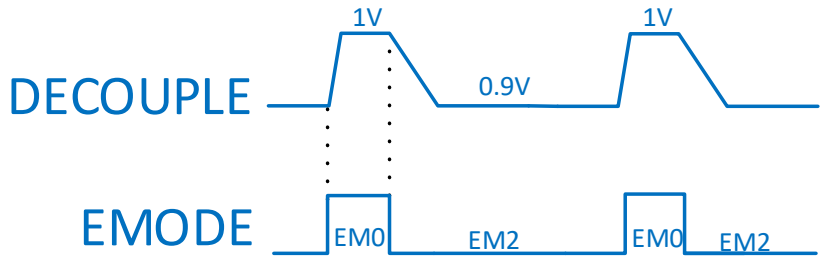
EFR32BG22: Dynamic Voltage Scaling

- Reduce current consumption
  - $P_{dynamic}$ = alpha*C*V^2*Freq
- Control Digital logic voltage
  - Clock frequency dependent
  - Energy mode dependent

VSCALE Setting	DECOUPLE Voltage	Operating Conditions
VSCALE2	1.1 V	EM0/EM1 Operation up to 80 MHz EM2 and EM3
VSCALE1	1.0 V	EM0/EM1 Operation up to 40 MHz EM2 and EM3
VSCALE0	0.9V	EM2 and EM3 Only

- Internal LDO
- External supply
  - I2C
  - Direct Mode
    - I2C pins become push-pull
    - EMU controls the pin directly



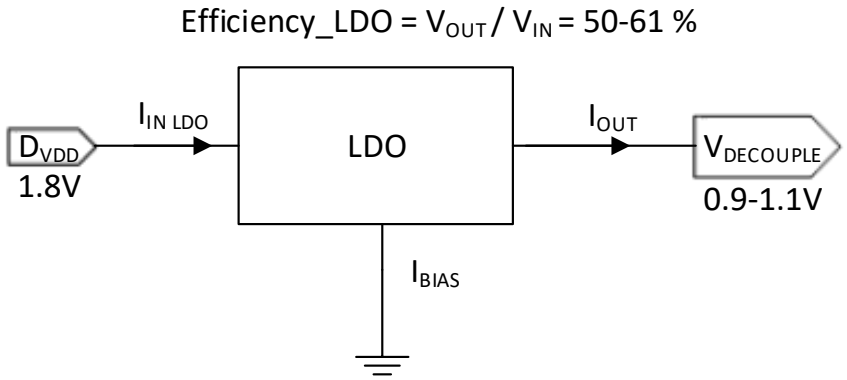


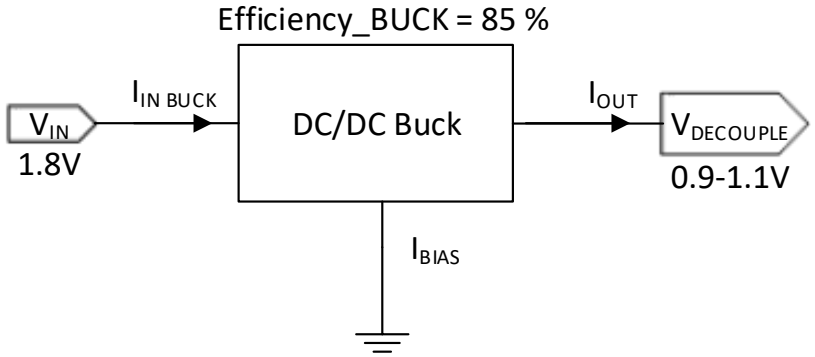
Feature available down to Energy Mode

- EM0 Run
- EM1 Sleep
- EM2 Deep Sleep
- EM3 Stop
- EM4 Shutoff

EFR32BG22: Internal LDO Control

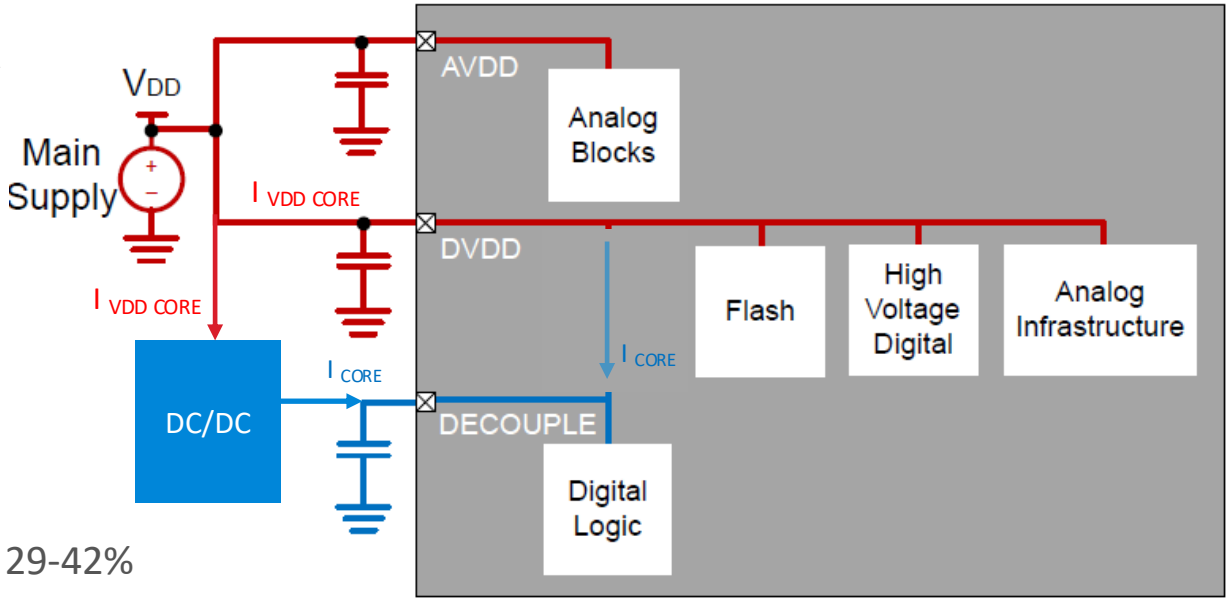
- Disable internal Digital LDO





$I_{IN\ BUCK} = I_{IN\ LDO} * Efficiency\_LDO / Efficiency\_BUCK$

$I_{IN\ BUCK} = (58 - 71\%) * I_{IN\ LDO}$



- Supply DECOUPLE from external supply
  - DC/DC buck converter
  - Reduce core supply current ($I_{VDD\ CORE}$) by 29-42%

Feature available down to Energy Mode

EM0 Run

EM1 Sleep

EM2 Deep Sleep

EM3 Stop

EM4 Shutoff

Energy Friendly Power PMIC

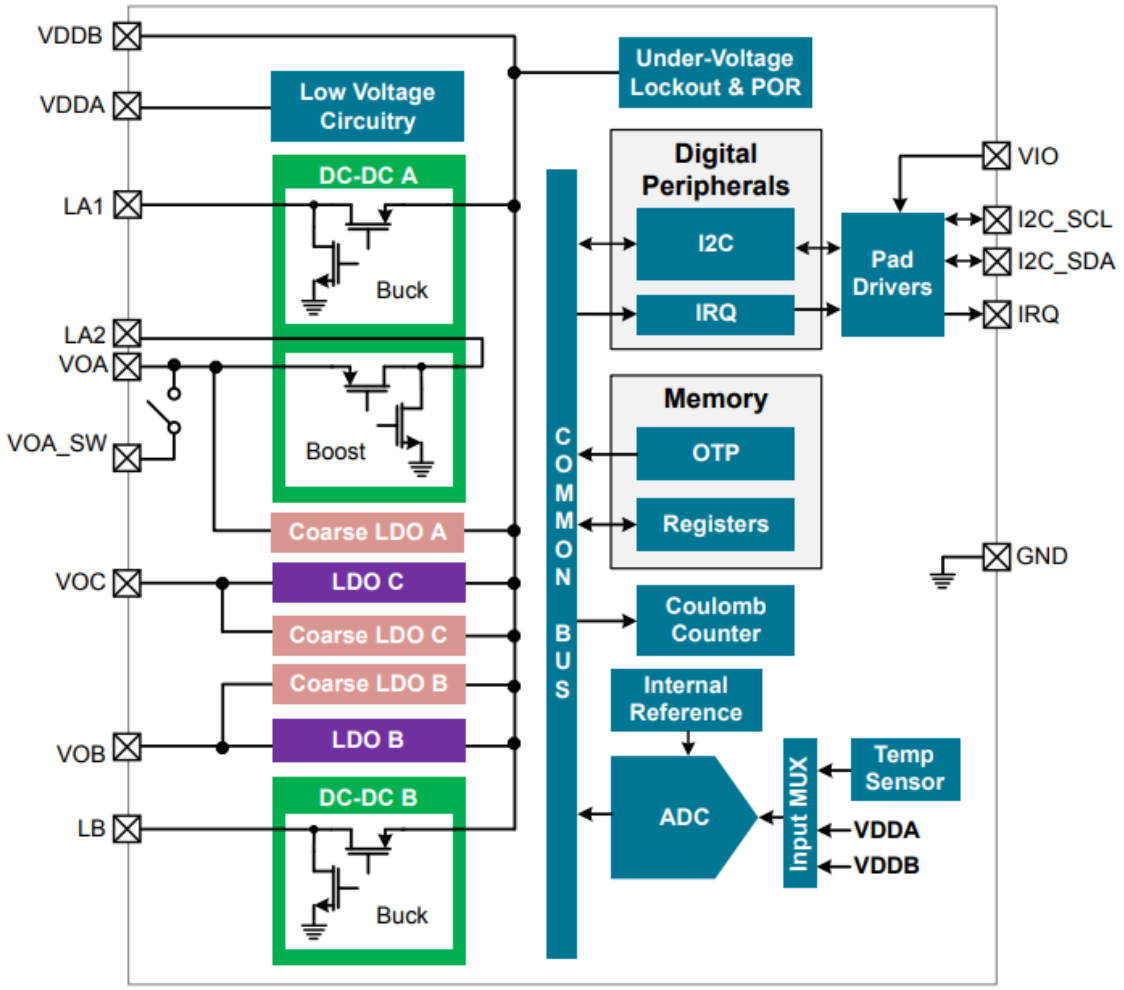


Figure 3.1. EFP01 Block Diagram

- Multiple output voltage rails (3)
  - 150mA/rail max load with up to 94% efficiency
- Supports broad range of input voltage and battery chemistry
  - 0.8-1.8 volts and 1.8-5.5 volts
  - Extends EFR/EFM support below 1.7v and above 3.8v
- Optimized for battery operation
  - Integrated, loss-less coulomb counter
  - Prevents primary cell corrosion - no leakage under 1.4 v
  - Inrush current control for batteries with high internal resistance
- Software configurable
  - OTP configuration for stored startup configurations
  - I2C command/control interface for dynamic configuration changes
- Low current
  - 250 nA quiescent current with one output enabled
  - Low as 30nA in EM4
- 3x3 mm QFN20 package

Summary

- RF Parameters that affect average current consumption
  - TX power
  - Advertising/connection intervals
  - Number of advertising channels
  - Connectable mode configuration
  - Payload
  - Choice of PHY
- Device-specific parameters
  - PA mode
  - Crystal settings
  - Voltage scaling
  - Debug configuration
- Power manager and LE Power Control
- EFP PMIC

IoT Hardware Development Tools – Feature Comparison

	Explorer Kit	Dev Kit	Pro Kit
Debug Speed	1.6MHz	1.6MHz	8MHz
Debug USB	Full Speed	Full Speed	High Speed
Packet Trace Interface (PTI)	✓	✓	✓ 2x
Breakout Pads	✓	✓	✓
Pushbutton s & User LEDs	✓	✓	✓
Virtual COM	✓	✓	✓
Coin cell battery holder	–	✓	✓
On-board Sensors	–	✓	✓
Battery Pack Connector	–	✓	✓
Radio Board Connectors	–	–	✓
EXP Connector	–	–	✓
Display	–	–	✓
Debug OUT	–	–	EFM8/32, EFR32, EZR32
Debug Ethernet	–	–	100 Mbit/s
Energy Monitor (AEM)	–	–	✓
3rd Party Hardware addons	✓	–	–

Explorer Kit

- Lowest price point
- On-board debugger and signal breakouts
- Minimal on-board features
- 3rd part hardware support
- New Category

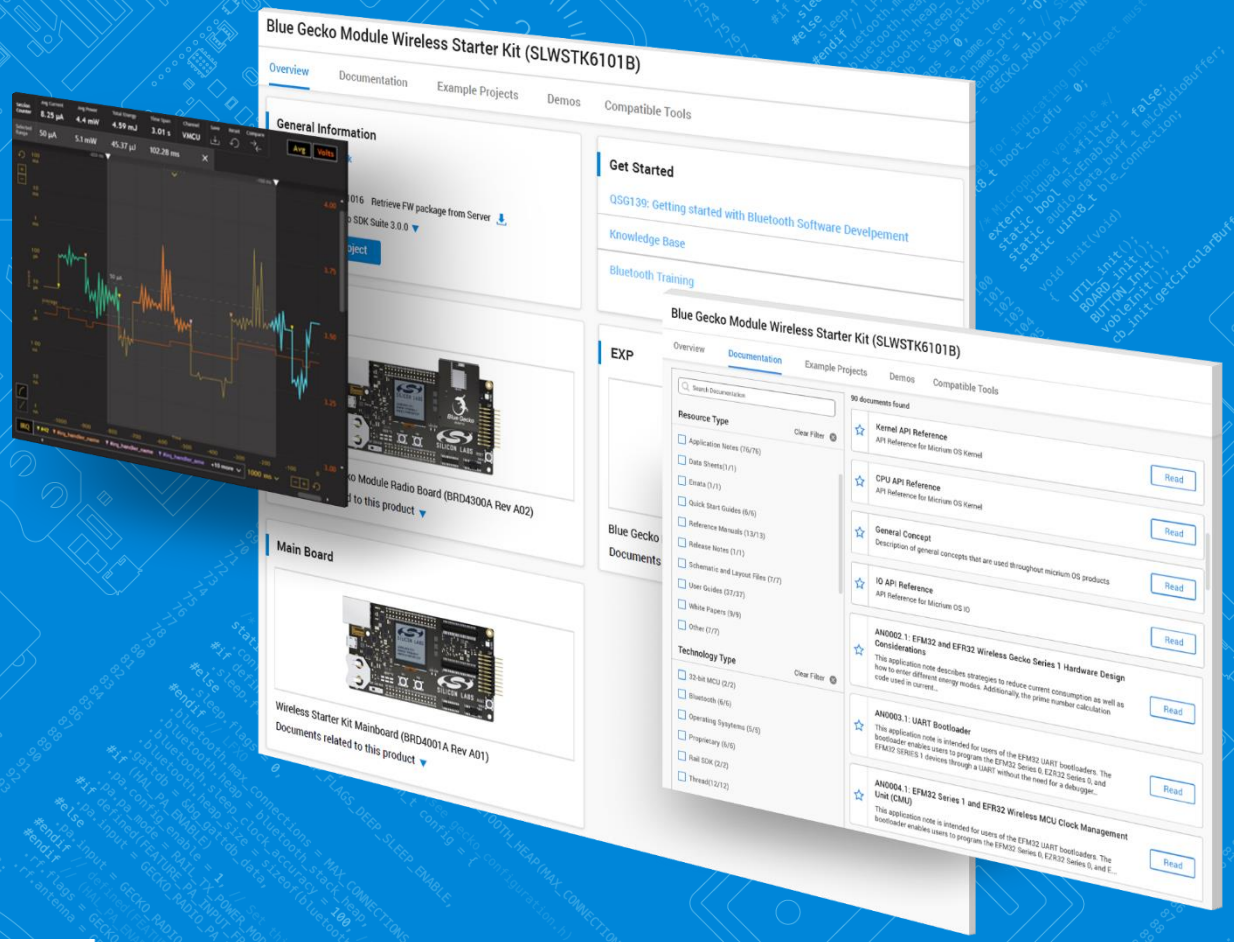
Dev Kit

- Single device development board
- On-board debugger and signal breakouts
- On-board sensors
- Impressive out-of-the-box demos
- Evolution from Thunderboard

Pro Kit

- Modular development platform
- Advanced development use cases
- Energy profiling and external device debug
- Ethernet for large network test
- Designed to maximize reuse of EFR32 devices
- Evolution from WSTK

✓ Supported ✓ Optional or not mounted – Not Supported



14 Silicon Labs Simplicity Studio 5

Simplified Developer Experience

- Simplicity Studio 5
  - **Interface**
    - Fresh, new & simplified
    - Intuitive out-of-the-box experience
    - Fast access to developer resources
    - Linux, Mac & Windows
  - **Tools**
    - Configuration utilities
    - Compiler
    - Error & validation
    - IDE & command line support
    - Graphical hardware configurator
    - Energy Profiler – visual energy analysis
    - Network Analyzer – packet capture & decode

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Q&A

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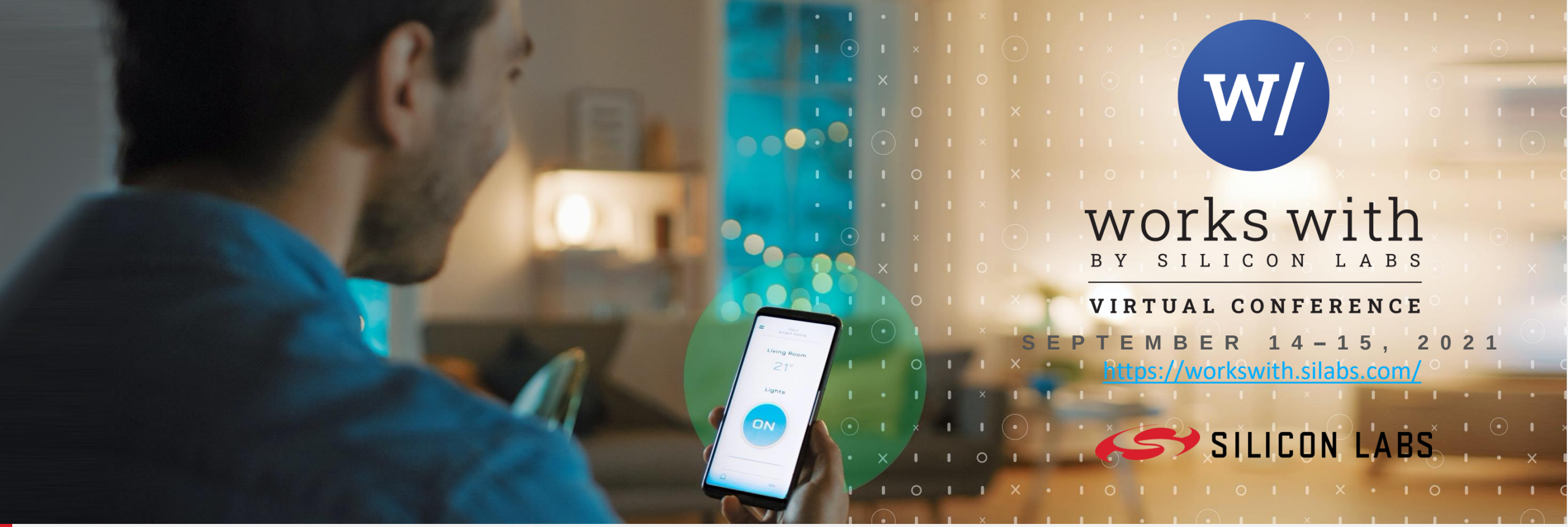

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