Datasheet

Lyra 24S

Version 1.1

REVISION HISTORY

Version	Date	Notes	Contributors	Approver
1.0	24 May 2023	Initial Release	Robert Gosewehr, Raj Khatri, Dave Drogowski	Jonathan Kaye
1.1	26 Jun 2023	Added content for section 13.2 Maximum Regulatory Certified RF TX Power per Country	Raj Khatri	Jonathan Kaye

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1 INTRODUCTION

The Lyra 24S is a secure, high-performance wireless module optimized for the needs of battery and line-powered IoT devices running on Bluetooth networks.

Based on the **Series 2 EFR32BG24 SoC,** it enables Bluetooth® Low Energy connectivity, delivering exceptional RF performance and energy efficiency, industry-leading Se- cure Vault® technology, and future-proofing capabilities.

The Lyra 24S is a complete System in Package solution offered with robust and fully upgradeable software stacks, global regulatory certifications, advanced development and debugging tools, and documentation that simplifies and minimizes the development cycle of your end-product, helping to accelerate its time-to-market.

The Lyra 24S is targeted for a broad range of applications, including:

- Smart Home Devices
- Lighting
- Gateways and Digital Assistants
- Building Automation and Security

1.1 Key Features

- Bluetooth Low Energy 5.3
- Bluetooth Mesh connectivity
- Built-in antenna or RF pin
- Up to 10 dBm TX output power (see Maximum Regulatory Certified RF TX Power per Country)
- -97 dBm BLE 1M RX sensitivity
- 32-bit ARM® Cortex®-M33 core running up to 78 MHz

- 1536/256 kB of Flash/RAM memory
- Vault High or Vault Mid security
- Rich set of analog and digital peripherals
- 32 GPIO pins
- -40 to 105 °C
- 7mm x 7mm x 1.18mm

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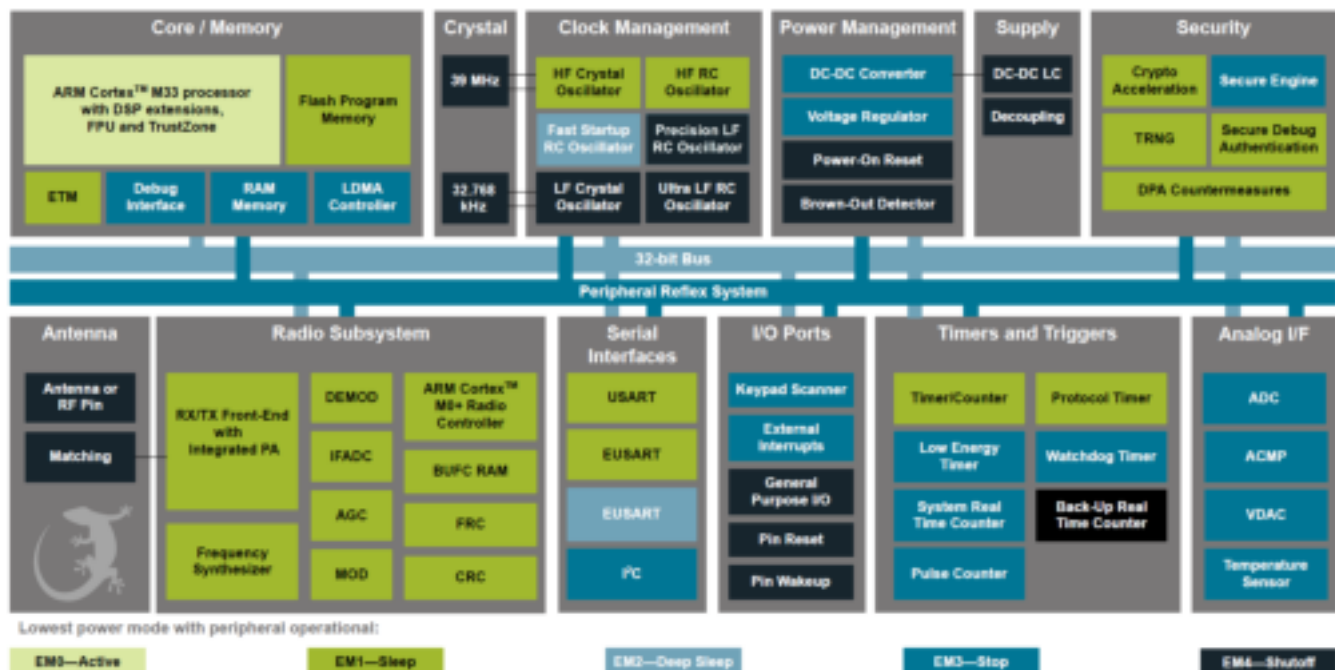
1.2 Hardware Features

- **Supported Protocols**
  - Bluetooth Low Energy (BLE) 5.3
  - Bluetooth Mesh
  - Matter-ready Smart Home Connectivity
- **Wireless System-on-Chip**
  - 2.4 GHz radio
  - TX power up to +10 dBm (see Maximum Regulatory Certified RF TX Power per Country)
  - 32-bit ARM Cortex®-M33 with DSP instruction and floating- point unit for efficient signal processing
  - 1536 kB flash program memory
  - 256 kB RAM data memory
  - Embedded Trace Macrocell (ETM) for advanced debugging
- **Receiver Sensitivity**
  - -105.1 dBm (0.1% BER) at 125 kbps GFSK
  - -100.7 dBm (0.1% BER) at 500 kbps GFSK
  - -97.0 dBm (0.1% BER) at 1 Mbps GFSK
  - -94.3 dBm (0.1% BER) at 2 Mbps GFSK
- **Current Consumption**
  - 5.1 mA RX current at 1 Mbps GFSK
  - 4.6 mA TX current at 0 dBm
  - 23.4 mA TX current at 10 dBm
  - 33.4 µA/MHz in Active Mode (EM0) at 39.0 MHz
  - 1.3 µA EM2 DeepSleep current (16 kB RAM retention and RTC running from LFRCO)
- **Regulatory Certification**
  - CE (EU)
  - UKCA (UK)
  - FCC (USA)
  - ISED (Canada)
  - MIC (Japan)
  - KC (South Korea)
  - RCM (Australia and New Zealand)
- **Operating Range**
  - 1.8 to 3.8 V
  - -40 to +105 °C
- **Dimensions**
  - 7 mm x 7 mm x 1.18 mm

- **Security**
  - Secure Boot with Root of Trust and Secure Loader (RTSL)
  - Hardware Cryptographic Acceleration with DPA counter- measures for AES128/256, SHA-1, SHA-2 (up to 256-bit), ECC (up to 256-bit), ECDSA, and ECDH
  - True Random Number Generator (TRNG) compliant with NIST SP800-90 and AIS-31
  - ARM® TrustZone®
  - Secure Debug Interface lock/unlock
  - Secure Key Management with PUF
  - Anti-Tamper
  - Secure Attestation
- **MCU Peripherals**
  - Analog to Digital Converter (ADC)
    - 12-bit @ 1 Msps
    - 16-bit @ 76.9 ksps
  - 2 × Analog Comparator (ACMP)
  - 2 × Digital to Analog Converter (VDAC)
  - Up to 32 General Purpose I/O pins with output state retention and asynchronous interrupts
  - 8 Channel DMA Controller
  - 16 Channel Peripheral Reflex System (PRS)
  - 3 × 16-bit Timer/Counter with 3 Compare/Capture/PWM channels
  - 2 × 32-bit Timer/Counter with 3 Compare/Capture/PWM channels
  - 2 x 32-bit Real Time Counter (SYSRTC/BURTC)
  - 24-bit Low Energy Timer for waveform generation (LETIMER)
  - 16-bit Pulse Counter with asynchronous operation (PCNT)
  - 2 × Watchdog Timer (WDOG)
  - 1 × Universal Synchronous/Asynchronous Receiver/Transmitter (USART), supporting UART/SPI/SmartCard (ISO 7816)/IrDA/I^{2}S
  - 2 × Enhanced Universal Synchronous/Asynchronous Receiver/Transmitter (EUSART) supporting UART/SPI/DALI/ IrDA
  - 2 × I^{2}C interface with SMBus support
  - Low-Frequency RC Oscillator with precision mode to replace 32 kHz sleep crystal (LFRCO)
  - Keypad scanner supporting up to 6x8 matrix (KEYSCAN)
  - Die temperature sensor with +/- 1.5 °C accuracy after single-point calibration

1.3   Firmware Options

The Lyra 24S series supports two different firmware options for software development:

AT Command Set – fully featured and extensible to suit any developer's needs.

- Proven over 5+ years
- Basic Bluetooth LE cable replacement
- Simplest implementation possible

C Code – Full software development with Silicon Labs SDK and Toolchain

- Native C code development
- Use Simplicity Studio IDE
- Full functionality of Silicon Labs HW / SW

2   ORDERING INFORMATION

Table 1: Ordering Information

Part	Description
453-00170C	Module, SIP, LYRA 24S, Integrated Antenna (Silicon Labs EFR32BG24) – Cut/Tape
453-00170R	Module, SIP, LYRA 24S, Integrated Antenna (Silicon Labs EFR32BG24) – Tape/Reel
453-00170-K1	Development Kit, SIP, LYRA 24S, Integrated Antenna

Note:

1. Lyra 24S series modules operate in the 2.4 GHz ISM frequency band (BLE range: 2402-2480MHz).
2. The maximum RF TX power allowed by different regional regulatory authorities may differ from the maximum output power a module can produce. End-product manufacturers must then verify that the module is configured to meet the regulatory limits for each region in accordance with the local rules and the formal certification test reports.
3. See section Maximum Regulatory Certified RF TX Power per Country.
4. Lyra 24S modules are pre-programmed with **Lyra 24S BGAPI UART/OTA DFU bootloader**. Lyra 24S AT firmware can be loaded by the customer (via SWD interface or via boot loader (UART or OTA)).

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3   SYSTEM OVERVIEW

3.1   Block Diagram

The Lyra 24S module is a highly integrated, high-performance system in package with all the hardware components needed to enable 2.4 GHz wireless connectivity and support robust networking capabilities via multiple wireless protocols.

Built around the **EFR32BG24 Wireless SoC**, the Lyra 24S includes a built-in antenna, an RF matching network (optimized for transmit power efficiency), supply decoupling and filtering components, an LC tank for DC-DC conversion, a 39 MHz reference crystal, and an RF shield. Also, it supports the use of an external 32 kHz crystal as a low frequency reference signal via GPIO pins for use cases demanding maximum energy efficiency.

For designs where an external antenna solution may be beneficial, a module variant with a 50 Ω-matched RF pin instead of the built-in antenna is available.
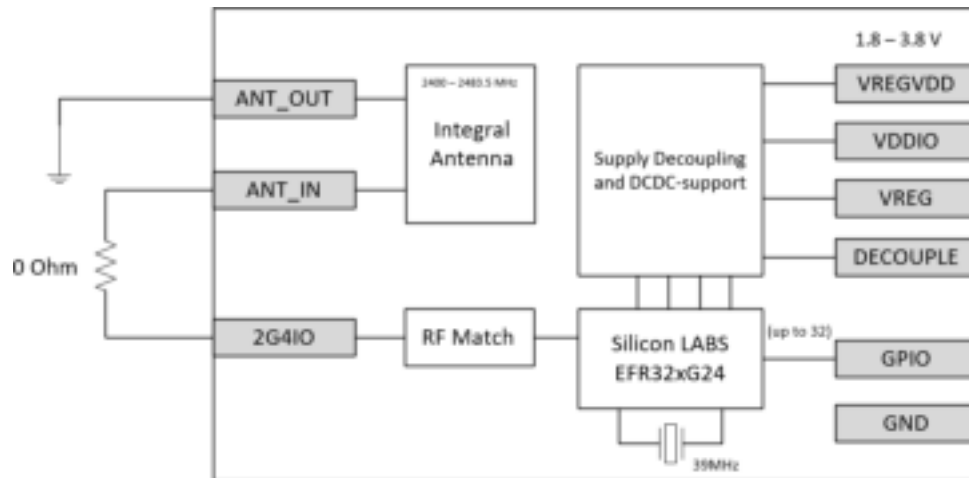
Figure 1: Lyra 24S Block Diagram - Integral Antenna
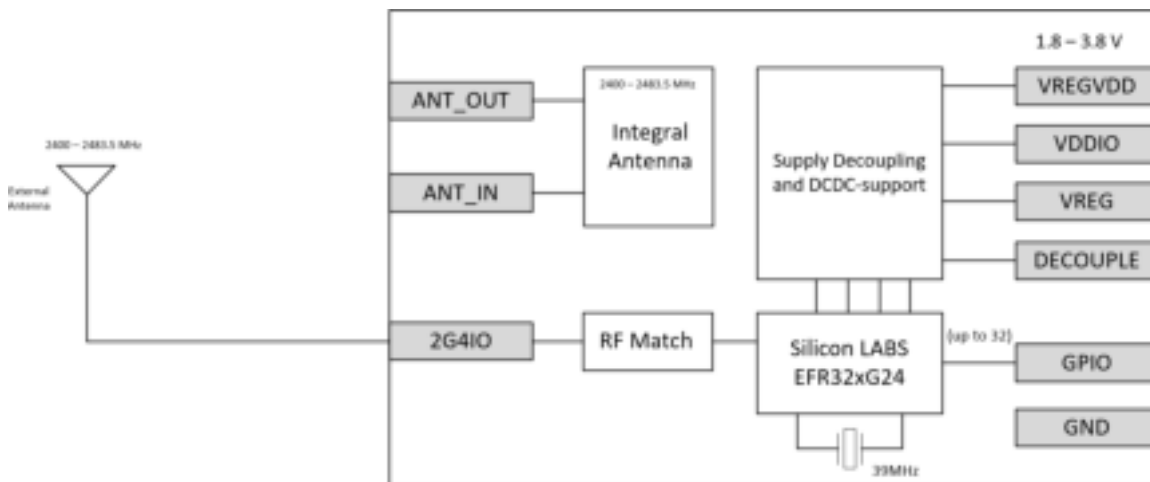
Figure 2: Lyra 24S Block Diagram - External Antenna

Note: There is only one Module, SIP, LYRA 24S, Integrated Antenna (Silicon Labs EFR32BG24) 453-00170, to create the External Antenna connection requires removal of 0R resistor (Figure 1) on customer's board to allow the external antenna to be connected Lyra 24S pin 3 2G4IO (shown in Figure 2). See section Lyra 24S Module 50 Ohms RF Track Design for Connecting External Antenna with the Lyra 24S.

A simplified internal schematic for the Lyra 24S module is shown in Figure 3.
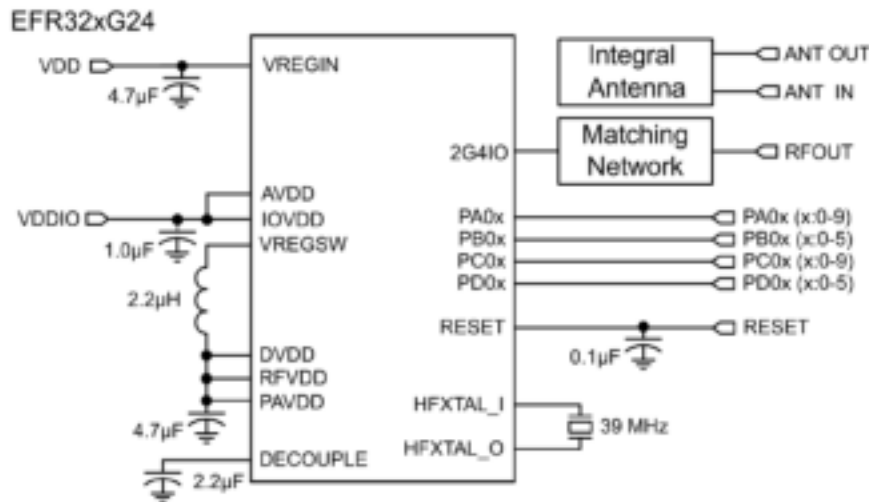
Figure 3: Lyra 24S Module Schematic

3.2   EFR32BG24 SoC

The **EFR32BG24 SoC** features a 32-bit ARM Cortex M33 core, a 2.4 GHz high-performance radio, 1536 kB of Flash memory, 256 kB of RAM, a dedicated core for security, a rich set of MCU peripherals, and various clock management and serial interfacing options. See the EFR32xG24 Reference Manual for details.

3.3   Integrated Antenna

Lyra 24S modules come with two antenna solution variants: a built-in integral ground loop type antenna realized by a PCB trace design, or a 50Ω-matched RF pin to support an external antenna. Typical performance characteristics for the built-in antenna are detailed in the table below. See Antenna Radiation and Efficiency for Lyra 24S Integrated Antenna and External Antenna Integration with the Lyra 24S Module 453-00170 for other relevant details.

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Antenna frequency range	F_{RANGE}		2400	—	2483.5	MHz
Antenna Gain	G_{MAX}	Maximum relative to isotropic	—	—	1.48	dBi
Antenna Efficiency	Efficiency		-2.5	—	-1.36	dB
Reference impedance	Z		—	50	—	Ω
Dielectric Constant Host Board	DI_{CONST}		—	4.3	—	
Trace Thickness	$T_{THICKNESS}$		—	47	—	um
VSWR	VSWR	Maximum	—	—	2:1	

Antenna efficiency, gain, and radiation pattern are dependent on the application PCB layout and mechanical design. Antenna specification is based on the assumption that the host board design guidelines in section are followed.

3.4   External Antenna

Lyra 24S module can be used with external antennas (certified by Laird Connectivity) and requires a RF 50 Ohm track (Ground Coplanar Waveguide) to be designed to run from Lyra 24S module 2G4IO (pin 6) to an RF antenna connector (IPEX MHF 4) on the host PCB. The 50Ohm RF track design and length **MUST** be copied as defined in section Lyra 24S Module 50 Ohms RF Track Design for Connecting External Antenna with the Lyra 24S.

The list of supported external antennas (certified by Laird Connectivity) are listed in section External Antenna Integration with the Lyra 24S Module.

3.5   Power Supply

The Lyra 24S requires a primary supply (VDD) and IO supply (VDDIO) voltage to operate. All necessary decoupling, filtering and DC-DC-related components are included in the module.

3.6   General Purpose Input/Output (GPIO)

The Lyra 24S has up to 32 General Purpose Input/Output pins. Each GPIO pin can be individually configured as either an output or input. More advanced configurations including open-drain, open-source, and glitch-filtering can be configured for each individual GPIO pin. The GPIO pins can be overridden by peripheral connections, like SPI communication. Each peripheral connection can be routed to several GPIO pins on the device. The input value of a GPIO pin can be routed through the Peripheral Reflex System to other peripherals. The GPIO subsystem supports asynchronous external pin interrupts.

All of the pins on ports A and port B are EM2 capable. These pins may be used by Low-Energy peripherals in EM2/3 and may also be used as EM2/3 pin wake-ups. Pins on ports C and D are latched/retained in their current state when entering EM2 until EM2 exit upon which internal peripherals could once again drive those pads.

A few GPIOs also have EM4 wake functionality. These pins are listed in Alternate Pin Functions.

3.7   Security

Lyra 24S modules support one of two levels in the Security Portfolio offered by Silicon Labs: **Secure Vault Mid** or **Secure Vault High.**   Lyra 24S modules support Secure Vault High.

Secure Vault is a collection of technologies that deliver state-of-the-art security and upgradability features to protect and future proof IoT devices against costly threats, attacks, and tampering. A dedicated security CPU enables the Secure Vault functions and isolates cryptographic functions and data from the Cortex-M33 core. Lyra 24S support Secure Vault High.

Table 2: Secure Vault Features

Feature	Secure Vault Mid	Secure Vault High
True Random Number Generator (TRNG)	Yes	Yes
Secure Boot with Root of Trust and Secure Loader (RTSL)	Yes	Yes
Secure Debug with Lock/Unlock	Yes	Yes
DPA Countermeasures	Yes	Yes
Anti-Tamper		Yes
Secure Attestation		Yes
Secure Key Management		Yes

Symmetric Encryption	▪ AES 128 / 192 / 256 bit
	  – ECB, CTR, CBC, CFB, CCM, GCM, CBC-MAC, and GMAC
		▪ AES 128 / 192 / 256 bit
		  – ECB, CTR, CBC, CFB, CCM, GCM, CBC-MAC, and GMAC
		▪ ChaCha20

Public Key Encryption - ECDSA / ECDH / EdDSA	▪ p192 and p256	▪ p192, p256, p384 and p521 ▪ Curve25519 (ECDH) ▪ Ed25519 (EdDSA)
Key Derivation	▪ ECJ-PAKE p192 and p256	▪ ECJ-PAKE p192, p256, p384, and p521 ▪ PBKDF2 ▪ HKDF
Hashes	▪ SHA-1 ▪ SHA-2/256	▪ SHA-1 ▪ SHA-2 256, 384, and 512 ▪ Poly1305

3.7.1 Secure Boot with Root of Trust and Secure Loader (RTSL)

The Secure Boot with RTSL authenticates a chain of trusted firmware that begins from an immutable memory (ROM).

It prevents malware injection, prevents rollback, ensures that only authentic firmware is executed, and protects Over The Air updates. For more information about this feature, see Silicon Labs' AN1218: Series 2 Secure Boot with RTSL.

3.7.2 Cryptographic Accelerator

The Cryptographic Accelerator is an autonomous hardware accelerator with Differential Power Analysis (DPA) countermeasures to protect keys.

It supports AES encryption and decryption with 128/192/256-bit keys, ChaCha20 encryption, and Elliptic Curve Cryptography (ECC) to support public key operations, and hashes.

Supported block cipher modes of operation for AES include:

- ECB (Electronic Code Book)
- CTR (Counter Mode)
- CBC (Cipher Block Chaining)
- CFB (Cipher Feedback)
- GCM (Galois Counter Mode)
- CCM (Counter with CBC-MAC)
- CBC-MAC (Cipher Block Chaining Message Authentication Code)
- GMAC (Galois Message Authentication Code)

The Cryptographic Accelerator accelerates Elliptical Curve Cryptography and supports the NIST (National Institute of Standards and Technology) recommended curves including P-192, P-256, P-384, and P-521 for ECDH (Elliptic Curve Diffie-Hellman) key derivation, and ECDSA (Elliptic Curve Digital Signature Algorithm) sign and verify operations. Also supported is the non-NIST Curve25519 for ECDH and Ed25519 for EdDSA (Edwards-curve Digital Signature Algorithm) sign and verify operations.

Secure Vault also supports ECJ-PAKE (Elliptic Curve variant of Password Authenticated Key Exchange by Juggling) and PBKDF2 (Password-Based Key Derivation Function 2).

Supported hashes include SHA-1, SHA-2/256/384/512 and Poly1305.

This implementation provides a fast and energy efficient solution to state of the art cryptographic needs.

3.7.3 True Random Number Generator

The True Random Number Generator module is a non-deterministic random number generator that harvests entropy from a thermal energy source. It includes start-up health tests for the entropy source as required by NIST SP800-90B and AIS-31 as well as online health tests required for NIST SP800-90C.

The TRNG is suitable for periodically generating entropy to seed an approved pseudo random number generator.

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3.7.4   Secure Debug with Lock/Unlock

For obvious security reasons, it is critical for a product to have its debug interface locked before being released in the field.

In addition, Secure Vault High also provides a secure debug unlock function that allows authenticated access based on public key cryptography. This functionality is particularly useful for supporting failure analysis while maintaining confidentiality of IP and sensitive end-user data.

For more information about this feature, see Silicon Labs' AN1190: Series 2 Secure Debug.

3.7.5   DPA Countermeasures

The AES and ECC accelerators have Differential Power Analysis (DPA) countermeasures support. This makes it very expensive from a time and effort standpoint to use DPA to recover secret keys.

3.7.6   Secure Key Management with PUF

Key material in Secure Vault High products is protected by "key wrapping" with a standardized symmetric encryption mechanism. This method has the advantage of protecting a virtually unlimited number of keys, limited only by the storage that is accessible by the Cortex-M33, which includes off-chip storage as well. The symmetric key used for this wrapping and unwrapping must be highly secure because it can expose all other key materials in the system. The Secure Vault Key Management system uses a Physically Unclonable Function (PUF) to generate a persistent device-unique seed key on power up to dynamically generate this critical wrapping/unwrapping key which is only visible to the AES encryption engine and is not retained when the device loses power.

3.7.7   Anti-Tamper

Secure Vault High devices provide internal tamper protection which monitors parameters such as voltage, temperature, and electro- magnetic pulses as well as detecting tamper of the security sub-system itself. Additionally, 8 external configurable tamper pins support external tamper sources, such as enclosure tamper switches.

For each tamper event, the user is able to select the severity of the tamper response ranging from an interrupt, to a reset, to destroying the PUF reconstruction data which will make all protected key materials un-recoverable and effectively render the device inoperable. The tamper system also has an internal resettable event counter with programmable trigger threshold and refresh periods to mitigate false positive tamper events.

For more information about this feature, see Silicon Labs' AN1247: Anti-Tamper Protection Configuration and Use.

3.7.8   Secure Attestation

Secure Vault High products support Secure Attestation, which begins with a secure identity that is created during the Silicon Labs manufacturing process. During device production, each device generates its own public/private keypair and securely stores the wrapped private key into immutable OTP memory and this key never leaves the device. The corresponding public key is extracted from the device and inserted into a binary DER-encoded X.509 device certificate, which is signed into a Silicon Labs CA chain and then programmed back into the chip into an immutable OTP memory.

The secure identity can be used to authenticate the chip at any time in the life of the product. The production certification chain can be requested remotely from the product. This certification chain can be used to verify that the device was authentically produced by Silicon Labs. The device unique public key is also bound to the device certificate in the certification chain. A challenge can be sent to the chip at any point in time to be signed by the device private key. The public key in the device certificate can then be used to verify the challenge response, proving that the device has access to the securely stored private key, which prevents counterfeit products or impersonation attacks.

For more information about this feature, see Silicon Labs' AN1268: Authenticating Silicon Labs Devices Using Device Certificates.

4   ELECTRICAL SPECIFICATIONS

All electrical parameters in all tables are specified under the following conditions, unless stated otherwise:

- Typical values are based on **T$_A$=25 °C** and **VDD = VDDIO = 3.0 V**, by production test and/or technology characterization.
- Radio performance numbers are measured in conducted mode, based on Silicon Laboratories reference designs using output power-specific external RF impedance-matching networks for interfacing to a 50 Ω antenna.
- Minimum and maximum values represent the worst conditions across supply voltage, process variation, and operating temperature, unless stated otherwise.

4.1   Absolute Maximum Ratings

Table 3: Absolute Maximum Ratings

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Storage temperature range	T$_{STG}$		-40	—	+105	°C
Voltage on any supply pin	V$_{DDMAX}$		-0.3	—	3.8	V
Voltage ramp rate on any supply pin	V$_{DDRAMPMAX}$		—	—	1.0	V/µs
DC voltage on any GPIO pin	V$_{DIGPIN}$		-0.3	—	V$_{VDDIO}$+0.3	V
DC voltage on RESETn pin[1]	V$_{RESETn}$		-0.3	—	3.8	V
Absolute voltage on RFOUT pin	V$_{MAX2G4}$		-0.3	—	V$_{VDD}$+0.3	V
Total current into VDD pin	I$_{VDDMAX}$	Source	—	—	200	mA
Total current into GND pin	I$_{VSSMAX}$	Sink	—	—	200	mA
Current per I/O pin	I$_{IOMAX}$	Sink	—	—	50	mA
		Source	—	—	50	mA
Current for all I/O pins	I$_{IOALLMAX}$	Sink	—	—	200	mA
		Source	—	—	200	mA

Note:

1. The RESETn pin has a pull-up device to the internal DVDD supply. For minimum leakage, RESETn should not exceed the voltage at DVDD, which is generated by the DC-DC converter. DVDD is equal to 1.8 V when DC-DC is active and bypassed to VDD when DC-DC is inactive.

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4.2   General Operating Conditions

Table 4: General Operating Conditions

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Operating ambient temperature range	T_A		-40	—	+105	°C
VDD operating supply voltage	V_{VDD}	DC-DC in regulation	2.2	3.0	3.8	V
		DC-DC in bypass	1.8	3.0	3.8	V
VDDIO operating supply voltage	V_{VDDIO}	AVDDBODEN=0, IOVDDxBODEN=0[1]	1.71	3.0	3.8	V
HCLK and SYSCLK frequency	f_{HCLK}	VSCALE2, MODE = WS1	—	—	78	MHz
		VSCALE2, MODE = WS0	—	—	40	MHz
		VSCALE1, MODE = WS0	—	—	40	MHz
EM01 Group A clock frequency	$f_{EM01GRPACLK}$	VSCALE2	—	—	78	MHz
		VSCALE1	—	—	40	MHz
EM01 Group C clock frequency	$f_{EM01GRPCCLK}$	VSCALE2	—	—	78	MHz
		VSCALE1	—	—	40	MHz
Radio HCLK frequency	f_{RHCLK}	VSCALE2 or VSCALE1	—	39.0	—	MHz

Note:

1. The AVDD and IOVDD BOD enable bits are in the EMU_BOD3SENSE register. These BODs are disabled on reset.

4.3   MCU Current Consumption at 3.0V

Unless otherwise indicated, typical conditions are: **VDD = VDDIO = 3.0 V**, **DC-DC in regulation**. **Voltage scaling level = VSCALE1**. T_A **= 25 °C**. Minimum and maximum values in this table represent the worst conditions across process variation at T_A **= 25 °C**.

Table 5: MCU Current Consumption at 3.0V

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Current consumption in EM0 mode with all peripherals disabled	I_{ACTIVE}	78 MHz HFRCO w/ DPLL referenced to 39 MHz crystal, CPU running Prime from flash, VSCALE2	—	33.3	—	µA/MHz
		78 MHz HFRCO w/ DPLL referenced to 39 MHz crystal, CPU running while loop from flash, VSCALE2	—	32.8	—	µA/MHz
		78 MHz HFRCO w/ DPLL referenced to 39 MHz crystal, CPU running CoreMark loop from flash, VSCALE2	—	49.1	—	µA/MHz
		39 MHz crystal, CPU running Prime from flash	—	33.9	—	µA/MHz
		39 MHz crystal, CPU running while loop from flash	—	33.4	—	µA/MHz
		39 MHz crystal, CPU running CoreMark loop from flash	—	49.4	—	µA/MHz
		38 MHz HFRCO, CPU running while loop from flash	—	28.1	—	µA/MHz

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Current consumption in EM1 mode with all peripherals disabled	I_{EM1}	78 MHz HFRCO w/ DPLL referenced to 39 MHz crystal, VSCALE2	—	22.6	—	µA/MHz
		39 MHz crystal	—	24.4	—	µA/MHz
		38 MHz HFRCO	—	19.0	—	µA/MHz
Current consumption in EM2 mode, VSCALE0	I_{EM2_VS}	256 kB RAM and full Radio RAM retention, RTC running from LFXO[1]	—	3.1	—	µA
		256 kB RAM and full Radio RAM retention, RTC running from LFRCO[1]	—	3.1	—	µA
		16 kB RAM and full Radio RAM retention, RTC running from LFXO[1]	—	1.3	—	µA
		16 kB RAM and full Radio RAM retention, RTC running from LFRCO[1]	—	1.3	—	µA
		16 kB RAM and full Radio RAM retention, RTC running from LFRCO in precision mode[1]	—	1.9	—	µA
Current consumption in EM3 mode, VSCALE0	I_{EM3_VS}	256 kB RAM and full Radio RAM retention, RTC running from ULFRCO[1]	—	2.9	—	µA
		16 kB RAM and full Radio RAM retention, RTC running from ULFRCO[1]	—	1.1	—	µA
Current consumption in EM4 mode	I_{EM4}	No BURTC, no LF oscillator	—	0.31	—	µA
		BURTC with LFXO	—	0.64	—	µA
Current consumption during reset	I_{RST}	Hard pin reset held	—	467	—	µA

Note:

1. CPU cache retained, EM0/1 peripheral states retained

4.4 Radio Current Consumption with 3.0 V Supply

RF current consumption measured with MCU in EM1 and all MCU peripherals disabled. Unless otherwise indicated, typical conditions are: **VDD = VDDIO = 3.0 V**, **DC-DC in regulation**. T_A = 25 °C.

Table 6: Radio Current Consumption with 3.0 V Supply

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Current consumption in receive mode, active packet reception, VSCALE1, EM1P	I_{RX_ACTIVE}	125 kbit/s, 2GFSK, f = 2.4 GHz	—	5.4	—	mA
		500 kbit/s, 2GFSK, f = 2.4 GHz	—	5.5	—	mA
		1 Mbit/s, 2GFSK, f = 2.4 GHz	—	5.1	—	mA
		2 Mbit/s, 2GFSK, f = 2.4 GHz	—	5.8	—	mA
Current consumption in receive mode, listening for packet, VSCALE1, EM1P	I_{RX_LISTEN}	125 kbit/s, 2GFSK, f = 2.4 GHz	—	5.4	—	mA
		500 kbit/s, 2GFSK, f = 2.4 GHz	—	5.4	—	mA
		1 Mbit/s, 2GFSK, f = 2.4 GHz	—	5.0	—	mA
		2 Mbit/s, 2GFSK, f = 2.4 GHz	—	5.8	—	mA
Current consumption in transmit mode	I_{TX}	f = 2.4 GHz, CW, 10 dBm output power	—	23.4	—	mA

4.5 RF Transmitter General Characteristics for the 2.4 GHz Band

Unless otherwise indicated, typical conditions are: **VDD = VDDIO = 3.0 V**, **DC-DC in regulation**. RF center frequency **2.45 GHz. T_A = 25°C**.

Table 7: RF Transmitter General Characteristics for the 2.4 GHz Band

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
RF tuning frequency range	F_{RANGE}		2402	—	2480	MHz
Maximum TX power (see Maximum Regulatory Certified RF TX Power per Country)	$POUT_{MAX}$	10 dBm	—	10.0	—	dBm
		0 dBm	—	-1.4	—	dBm
Minimum active TX power	$POUT_{MIN}$	10 dBm	—	-29.1	—	dBm
		0 dBm	—	-24.9	—	dBm
Output power step size	$POUT_{STEP}$	0 dBm	0.1	0.6	10	dB
		10 dBm, -5 dBm < Output power < 0 dBm	0.2	0.7	1.7	dB
		10 dBm, 0 dBm < Output power < 10 dBm	0.04	0.2	0.8	dB
Output power variation vs supply voltage variation, frequency = 2450 MHz	$POUT_{VAR\_V}$	10 dBm output power with VDD voltage swept from 1.8 V to 3.8 V	—	0.02	—	dB
		0 dBm output power with VDD voltage swept from 1.8 V to 3.8 V	—	0.06	—	dB
Output power variation vs temperature, Frequency = 2450 MHz	$POUT_{VAR\_T}$	0 dBm, (-40 to +105 °C)	—	1.1	—	dB
Output power variation over the RF tuning frequency range	$POUT_{VAR\_F}$	10 dBm	—	0.6	—	dB
		0 dBm	—	0.07	—	dB

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4.6   RF Receiver General Characteristics for the 2.4 GHz Band

Unless otherwise indicated, typical conditions are: **VDD = VDDIO = 3.0 V**, **DC-DC in regulation**. RF center frequency **2.45 GHz. T_A = 25°C**.

Table 8: RF Receiver General Characteristics for the 2.4 GHz Band

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
RF tuning frequency range	F_{RANGE}		2402	—	2480	MHz

4.7   RF Receiver Characteristics for Bluetooth Low Energy in the 2.4 GHz Band 1 Mbps Data Rate

Unless otherwise indicated, typical conditions are: **VDD = VDDIO = 3.0 V**, **DC-DC in regulation**. RF center frequency **2.45 GHz. T_A = 25°C**.

Table 9: RF Receiver Characteristics for Bluetooth Low Energy in the 2.4 GHz Band 1 Mbps Data Rate

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Rx Max Strong Signal Input Level for 0.1% BER	RX_{SAT}	Signal is reference signal[1]	—	10	—	dBm
Sensitivity	SENS	Signal is reference signal, 37 byte payload[1]	—	-97	—	dBm
		Signal is reference signal, 255 byte payload[1]	—	-95.4	—	dBm
		With non-ideal signals[2][1]	—	-95.0	—	dBm
Signal to co-channel interferer	C/I_{CC}	(see notes)[1][3]	—	8.7	—	dB
N ± 1 Adjacent channel selectivity	C/I_1	Interferer is reference signal at +1 MHz offset[1][4][3][5]	—	-5.4	—	dB
		Interferer is reference signal at -1 MHz offset[1][4][3][5]	—	-5.3	—	dB
N ± 2 Alternate channel selectivity	C/I_2	Interferer is reference signal at +2 MHz offset[1][4][3][5]	—	-40.9	—	dB
		Interferer is reference signal at -2 MHz offset[1][4][3][5]	—	-39.7	—	dB
N ± 3 Alternate channel selectivity	C/I_3	Interferer is reference signal at +3 MHz offset[1][4][3][5]	—	-45.5	—	dB
		Interferer is reference signal at -3 MHz offset[1][4][3][5]	—	-45.7	—	dB
Selectivity to image frequency	C/I_{IM}	Interferer is reference signal at image frequency with 1 MHz precision[1][5]	—	-23.3	—	dB
Selectivity to image frequency ± 1 MHz	C/I_{IM_1}	Interferer is reference signal at image frequency +1 MHz with 1 MHz precision[1][5]	—	-40.9	—	dB
		Interferer is reference signal at image frequency -1 MHz with 1 MHz precision[1][5]	—	-5.4	—	dB
Intermodulation performance	IM	n = 3 (see note[6])	—	-17.3	—	dBm

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Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Note:						

1. 0.017% Bit Error Rate.
2. With non-ideal signals as specified in Bluetooth Test Specification RF-PHY.TS.5.0.1 section 4.7.1
3. Desired signal -67 dBm.
4. Desired frequency 2402 MHz ≤ Fc ≤ 2480 MHz.
5. With allowed exceptions.
6. As specified in Bluetooth Core specification version 5.1, Vol 6, Part A, Section 4.4

4.8 RF Receiver Characteristics for Bluetooth Low Energy in the 2.4 GHz Band 2 Mbps Data Rate

Unless otherwise indicated, typical conditions are: **VDD = VDDIO = 3.0 V**, **DC-DC in regulation**. RF center frequency **2.45 GHz. T_A = 25°C**.

Table 10: RF Receiver Characteristics for Bluetooth Low Energy in the 2.4 GHz Band 2 Mbps Data Rate

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Rx Max Strong Signal Input Level for 0.1% BER	RX_{SAT}	Signal is reference signal[1]	—	10	—	dBm
Sensitivity	SENS	Signal is reference signal, 37 byte payload[1]	—	-94.3	—	dBm
		Signal is reference signal, 255 byte payload[1]	—	-92.7	—	dBm
		With non-ideal signals[2][1]	—	-92.5	—	dBm
Signal to co-channel interferer	C/I_{CC}	(see notes)[1][3]	—	8.6	—	dB
N ± 1 Adjacent channel selectivity	C/I_1	Interferer is reference signal at +2 MHz offset[1][4][3][5]	—	-5.3	—	dB
		Interferer is reference signal at -2 MHz offset[1][4][3][5]	—	-5.8	—	dB
N ± 2 Alternate channel selectivity	C/I_2	Interferer is reference signal at +4 MHz offset[1][4][3][5]	—	-42.2	—	dB
		Interferer is reference signal at -4 MHz offset[1][4][3][5]	—	-44.2	—	dB
N ± 3 Alternate channel selectivity	C/I_3	Interferer is reference signal at +6 MHz offset[1][4][3][5]	—	-48.1	—	dB
		Interferer is reference signal at -6 MHz offset[1][4][3][5]	—	-50.2	—	dB
Selectivity to image frequency	C/I_{IM}	Interferer is reference signal at image frequency with 1 MHz precision[1][5]	—	-22.8	—	dB
Selectivity to image frequency ± 2 MHz	C/I_{IM_1}	Interferer is reference signal at image frequency +2 MHz with 1 MHz precision[1][5]	—	-42.2	—	dB
		Interferer is reference signal at image frequency -2 MHz with 1 MHz precision[1][5]	—	-5.3	—	dB
Intermodulation performance	IM	n = 3 (see note[6])	—	-18.3	—	dBm

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Note:						

1. 0.017% Bit Error Rate.
2. With non-ideal signals as specified in Bluetooth Test Specification RF-PHY.TS.5.0.1 section 4.7.1
3. Desired signal -64 dBm.
4. Desired frequency 2402 MHz ≤ Fc ≤ 2480 MHz.
5. With allowed exceptions.
6. As specified in Bluetooth Core specification version 5.1, Vol 6, Part A, Section 4.4

4.9 RF Receiver Characteristics for Bluetooth Low Energy in the 2.4 GHz Band 500 kbps Data Rate

Unless otherwise indicated, typical conditions are: **VDD = VDDIO = 3.0 V**, **DC-DC in regulation**. RF center frequency **2.45 GHz. T_A = 25°C**.

Table 11: RF Receiver Characteristics for Bluetooth Low Energy in the 2.4 GHz Band 500 kbps Data Rate

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Rx Max Strong Signal Input Level for 0.1% BER	RX_{SAT}	Signal is reference signal[1]	—	10	—	dBm
Sensitivity	SENS	Signal is reference signal, 37 byte payload[1]	—	-100.7	—	dBm
		Signal is reference signal, 255 byte payload[1]	—	-99.4	—	dBm
		With non-ideal signals[2][1]	—	-98.4	—	dBm
Signal to co-channel interferer	C/I_{CC}	(see notes)[1][3]	—	2.7	—	dB
N ± 1 Adjacent channel selectivity	C/I_1	Interferer is reference signal at +1 MHz offset[1][4][3][5]	—	-7.1	—	dB
		Interferer is reference signal at -1 MHz offset[1][4][3][5]	—	-7.4	—	dB
N ± 2 Alternate channel selectivity	C/I_2	Interferer is reference signal at +2 MHz offset[1][4][3][5]	—	-46.8	—	dB
		Interferer is reference signal at -2 MHz offset[1][4][3][5]	—	-49.7	—	dB
N ± 3 Alternate channel selectivity	C/I_3	Interferer is reference signal at +3 MHz offset[1][4][3][5]	—	-49.4	—	dB
		Interferer is reference signal at -3 MHz offset[1][4][3][5]	—	-54.5	—	dB
Selectivity to image frequency	C/I_{IM}	Interferer is reference signal at image frequency with 1 MHz precision[1][5]	—	-49	—	dB
Selectivity to image frequency ± 1 MHz	C/I_{IM_1}	Interferer is reference signal at image frequency +1 MHz with 1 MHz precision[1][5]	—	-49.4	—	dB
		Interferer is reference signal at image frequency -1 MHz with 1 MHz precision[1][5]	—	-46.8	—	dB

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Parameter	Symbol	Test Condition	Min	Typ	Max	Unit

Note:

1. 0.017% Bit Error Rate.
2. With non-ideal signals as specified in Bluetooth Test Specification RF-PHY.TS.5.0.1 section 4.7.1
3. Desired signal -72 dBm.
4. Desired frequency 2402 MHz ≤ Fc ≤ 2480 MHz.
5. With allowed exceptions.

4.10   RF Receiver Characteristics for Bluetooth Low Energy in the 2.4 GHz Band 125 kbps Data Rate

Unless otherwise indicated, typical conditions are: **VDD = VDDIO = 3.0 V**, **DC-DC in regulation**. RF center frequency **2.45 GHz. T$_A$ = 25°C**.

Table 12: RF Receiver Characteristics for Bluetooth Low Energy in the 2.4 GHz Band 125 kbps Data Rate

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Rx Max Strong Signal Input Level for 0.1% BER	RX$_{SAT}$	Signal is reference signal[1]	—	10	—	dBm
Sensitivity	SENS	Signal is reference signal, 37 byte payload[1]	—	-105.1	—	dBm
		Signal is reference signal, 255 byte payload[1]	—	-104.7	—	dBm
		With non-ideal signals[2,1]	—	-104.3	—	dBm
Signal to co-channel interferer	C/I$_{CC}$	(see notes)[1,3]	—	0.9	—	dB
N ± 1 Adjacent channel selectivity	C/I$_1$	Interferer is reference signal at +1 MHz offset[1,4,3,5]	—	-12.4	—	dB
		Interferer is reference signal at -1 MHz offset[1,4,3,5]	—	-12.8	—	dB
N ± 2 Alternate channel selectivity	C/I$_2$	Interferer is reference signal at +2 MHz offset[1,4,3,5]	—	-52.6	—	dB
		Interferer is reference signal at -2 MHz offset[1,4,3,5]	—	-55.5	—	dB
N ± 3 Alternate channel selectivity	C/I$_3$	Interferer is reference signal at +3 MHz offset[1,4,3,5]	—	-53.8	—	dB
		Interferer is reference signal at -3 MHz offset[1,4,3,5]	—	-60	—	dB
Selectivity to image frequency	C/I$_{IM}$	Interferer is reference signal at image frequency with 1 MHz precision[1,5]	—	-53	—	dB
Selectivity to image frequency ± 1 MHz	C/I$_{IM\_1}$	Interferer is reference signal at image frequency +1 MHz with 1 MHz precision[1,5]	—	-53.8	—	dB
		Interferer is reference signal at image frequency -1 MHz with 1 MHz precision[1,5]	—	-52.6	—	dB

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Parameter	Symbol	Test Condition	Min	Typ	Max	Unit

Note:

1. 0.017% Bit Error Rate.
2. With non-ideal signals as specified in Bluetooth Test Specification RF-PHY.TS.5.0.1 section 4.7.1
3. Desired signal -79 dBm.
4. Desired frequency 2402 MHz ≤ Fc ≤ 2480 MHz.
5. With allowed exceptions.

4.11 High-Frequency Crystal

Table 13: High-Frequency Crystal

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Crystal frequency	f_{HFXTAL}		—	39	—	MHz
Initial calibrated accuracy	ACC_{HFXTAL}		-5	—	+5	ppm
Temperature drift	$DRIFT_{HFXTAL}$	Across specified temperature range	-30	—	30	ppm

4.12 Low-Frequency Crystal Oscillator

Table 14: Low Frequency Crystal Oscillator

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Crystal Frequency	F_{LFXO}		—	32.768	—	kHz
Supported Crystal equivalent series resistance (ESR)	ESR_{LFXO}	GAIN = 0	—	—	80	kΩ
		GAIN = 1 to 3	—	—	100	kΩ
Supported range of crystal load capacitance [1]	C_{L_LFXO}	GAIN = 0	4	—	6	pF
		GAIN = 1	6	—	10	pF
		GAIN = 2 (see note[2])	10	—	12.5	pF
		GAIN = 3 (see note[2])	12.5	—	18	pF
Current consumption	I_{CL12p5}	ESR=70 kΩ, C_L=12.5pF, GAIN[3] = 2, AGC[4] = 1	—	294	—	nA
Startup Time	$T_{STARTUP}$	ESR=70 kΩ, C_L=7pF, GAIN[3] = 1, AGC[4] = 1	—	52	—	ms
On-chip tuning cap step size	SS_{LFXO}		—	0.26	—	pF
On-chip tuning capacitor value at minimum setting[5]	C_{LFXO_MIN}	CAPTUNE = 0	—	5.2	—	pF
On-chip tuning capacitor value at maximum setting[5]	C_{LFXO_MAX}	CAPTUNE = 0x4F	—	26.2	—	pF

Note:

1. Total load capacitance seen by the crystal
2. Crystals with a load capacitance of greater than 12 pF require external load capacitors.
3. In LFXO_CAL Register
4. In LFXO_CFG Register
5. The effective load capacitance seen by the crystal will be C_{LFXO}/2. This is because each XTAL pin has a tuning cap and the two caps will be seen in series by the crystal

4.13 Precision Low Frequency RC Oscillator (LFRCO)

Table 15: Precision Low Frequency RC Oscillator (LFRCO)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Nominal oscillation frequency	F_{LFRCO}		—	32.768	—	kHz
Frequency accuracy	F_{LFRCO_ACC}	Normal mode	-3	—	3	%
		Precision mode[1], across operating temperature range[2]	-500	—	500	ppm
Startup time	$t_{STARTUP}$	Normal mode	—	204	—	µs
		Precision mode[1]	—	11.7	—	ms
Current consumption	I_{LFRCO}	Normal mode	—	189.9	—	nA
		Precision mode[1], T = stable at 25 °C [3]	—	649.8	—	nA

Note:

1. The LFRCO operates in high-precision mode when CFG_HIGHPRECEN is set to 1. High-precision mode is not available in EM4.
2. Includes ± 40 ppm frequency tolerance of the HFXO crystal.
3. Includes periodic re-calibration against HFXO crystal oscillator.

4.14 GPIO Pins

Table 16: GPIO Pins

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Leakage current	I_{LEAK_IO}	MODEx = DISABLED, VDD = VDDIO = 3.0 V	—	2.5	—	nA
Input low voltage[1]	V_{IL}	Any GPIO pin	—	—	0.3*VDDIO	V
		RESETn	—	—	0.3*DVDD	V
Input high voltage[1]	V_{IH}	Any GPIO pin	0.7*VDDIO	—	—	V
		RESETn	0.7*DVDD	—	—	V
Hysteresis of input voltage	V_{HYS}	Any GPIO pin	0.05*VDDIO	—	—	V
		RESETn	0.05*DVDD	—	—	V
Output high voltage	V_{OH}	Sourcing 20 mA, VDDIO = 3.0 V	0.8*VDDIO	—	—	V
Output low voltage	V_{OL}	Sinking 20 mA, VDDIO = 3.0 V	—	—	0.2*VDDIO	V
GPIO rise time	T_{GPIO_RISE}	VDDIO = 3.0 V, C_{load} = 50pF, SLEWRATE = 4, 10% to 90%	—	8.4	—	ns
GPIO fall time	T_{GPIO_FALL}	VDDIO = 3.0 V, C_{load} = 50pF, SLEWRATE = 4, 90% to 10%	—	7.1	—	ns
Pull up/down resistance[2]	R_{PULL}	Any GPIO pin. Pull-up to VDDIO: MODEn = DISABLE DOUT=1. Pull-down to GND: MODEn = WIREDORPULLDOWN DOUT = 0.	35	44	55	kΩ
		RESETn pin. Pull-up to DVDD	35	44	55	kΩ

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
Maximum filtered glitch width	T_{GF}	MODE = INPUT, DOUT = 1	—	27	—	ns

Note:

1. GPIO input thresholds are proportional to the VDDIO pin. RESETn input thresholds are proportional to the internal DVDD supply, which is generated by the DC-DC converter. DVDD is equal to 1.8 V when DC-DC is active and bypassed to VDD when DC-DC is inactive.

2. GPIO pull-ups connect to VDDIO supply, pull-downs connect to GND. RESETn pull-up connects to internal DVDD supply, which is generated by the DC-DC converter. DVDD is equal to 1.8 V when DC-DC is active and bypassed to VDD when DC-DC is inactive.

4.15 Microcontroller Peripherals

The set of peripherals available in Lyra 24S modules includes:

- 12-bit 1 Msps ADC
- Analog Comparators
- 16-bit and 32-bit Timers/Counters
- 24-bit Low Energy Timer for waveform generation
- 32-bit Real Time Counter
- USART (UART/SPI/SmartCards/IrDA/I2S)
- I^2C peripheral interfaces
- 12 Channel Peripheral Reflex System

Details on their electrical performance can be found in the relevant portions of Section 4 of the EFR32BG24 SoC datasheet.

To learn which GPIO ports provide access to every peripheral, consult the Digital Peripheral Connectivity and Analog Peripheral Connectivity tables.

4.16 Antenna Radiation and Efficiency for Lyra 24S Integrated Antenna

Typical Lyra 24S radiation patterns for the built-in antenna under optimal operating conditions are plotted in the figures that follow. Antenna gain and radiation patterns have a strong dependence on the size and shape of the application PCB the module is mounted on, as well as on the proximity of any mechanical design to the antenna.
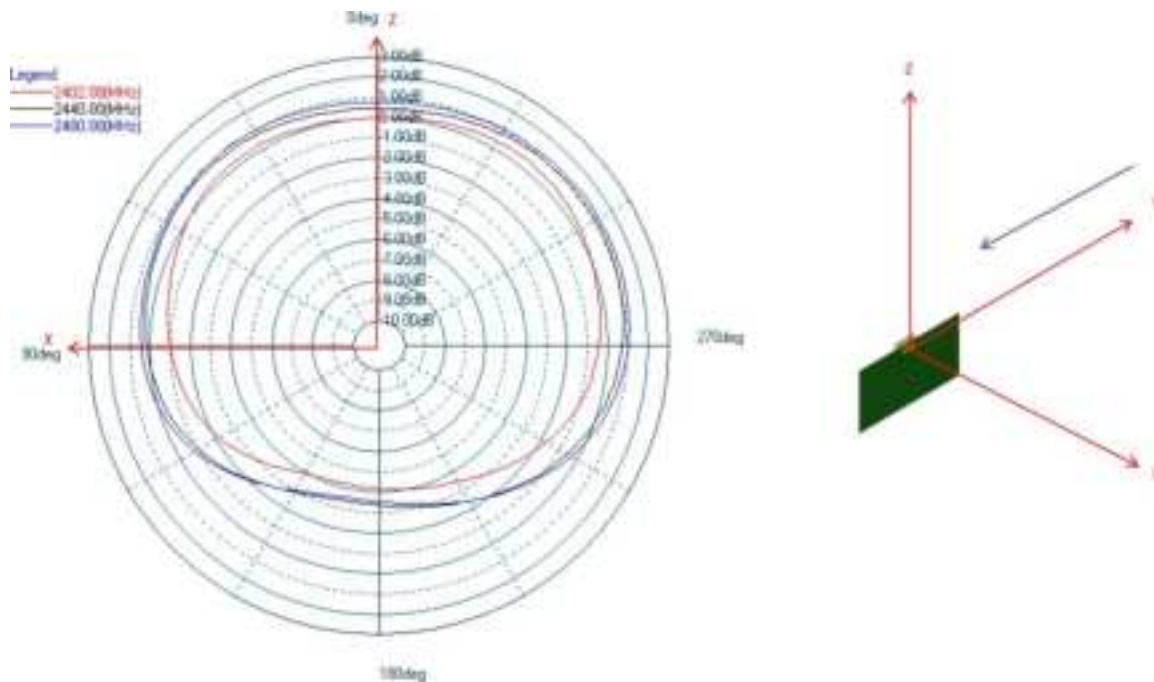
Figure 4: Typical 2D Antenna Radiation Patterns - Phi 0º (Side View) Gain (dBi)

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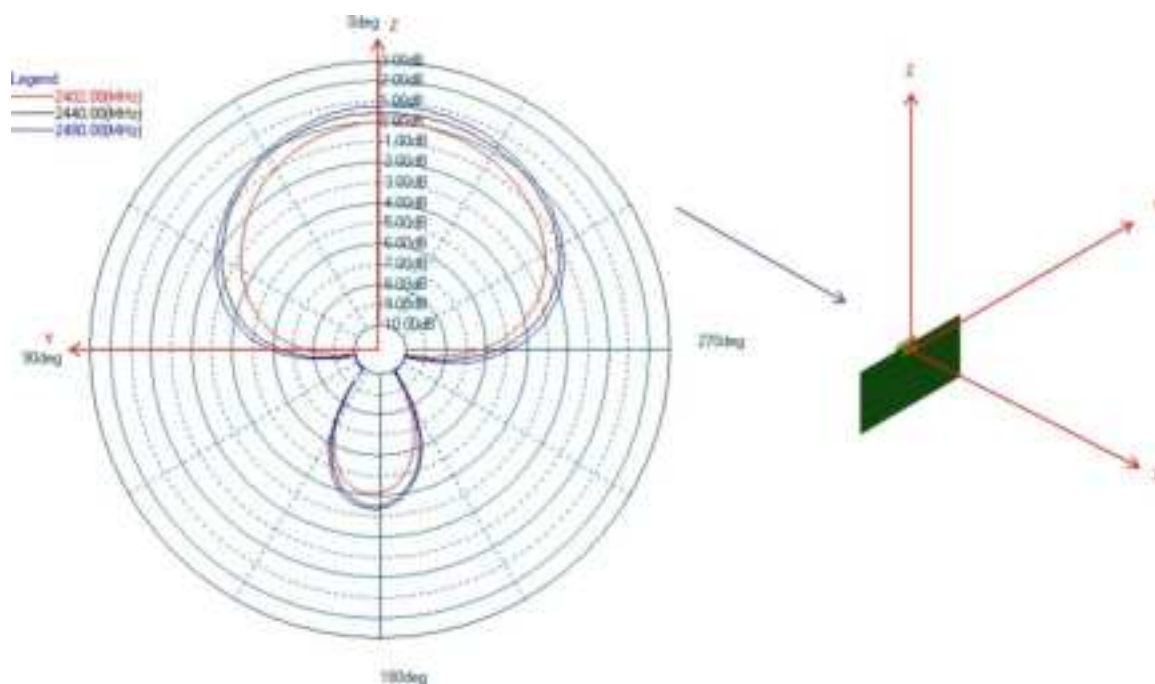
Figure 5: Typical 2D Antenna Radiation Patterns - Phi 90º (Top View) Gain (dBi)
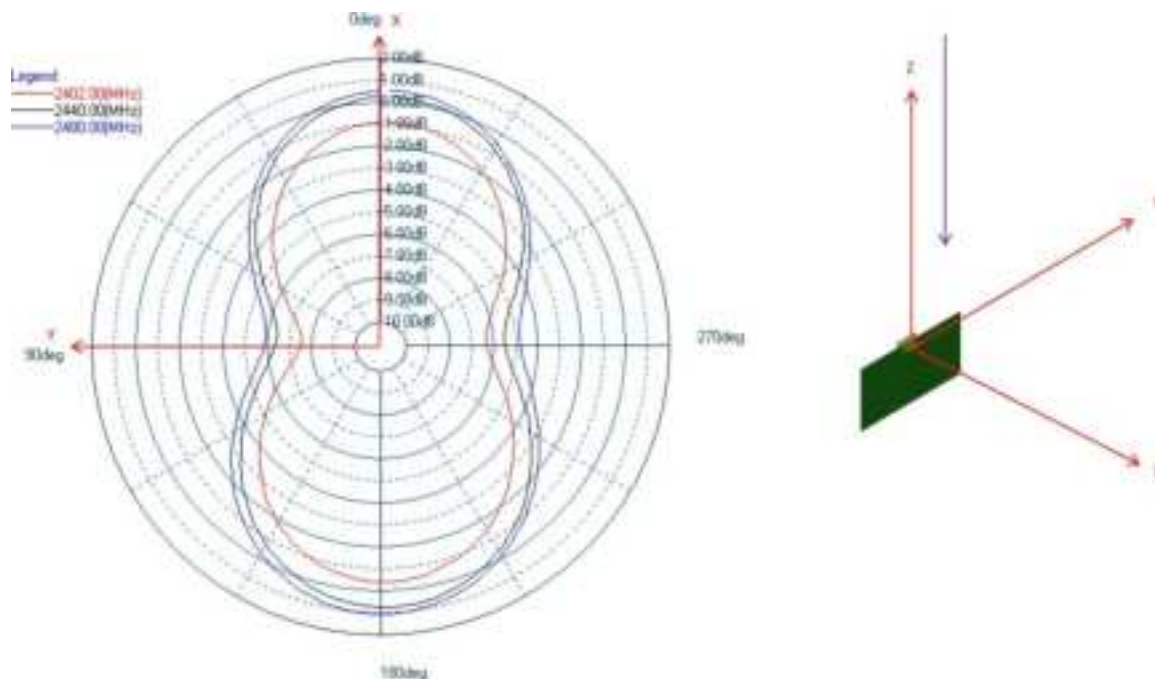
Figure 6: Typical 2D Antenna Radiation Patterns - Theta 90º (Front View) Gain (dBi)
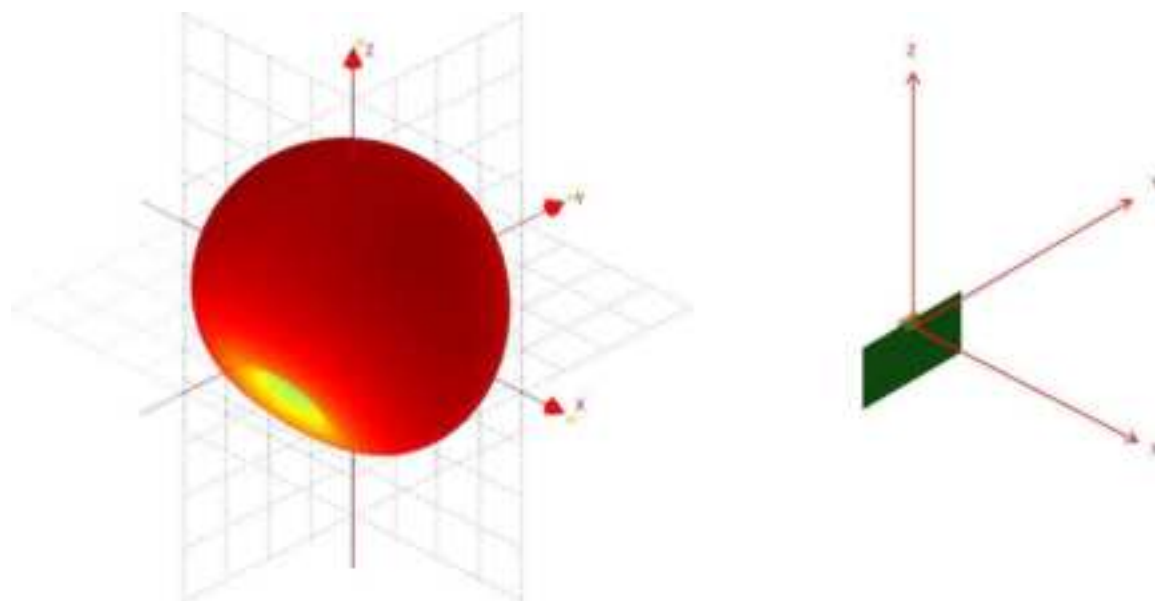
Figure 7: 3D Radiation Pattern at 2440 MHz

5 REFERENCE DIAGRAMS

5.1 Network Co-Processor (NCP) Application with UART Host

The Lyra 24S can be controlled via the UART interface as a peripheral to an external host processor. Typical power supply, programming/debug interface, and host interface connections are shown in the figure below. For more details, see AN958: Debugging and Programming Interfaces for Custom Designs.

Note: For boot pin, see section 5.3 Boot.

Figure 8: UART NCP Configuration

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5.2 SoC Application

The Lyra 24S can be used in a stand-alone SoC configuration without an external host processor. Typical power supply and programming/debug interface connections are shown in the figure below. For more details, see AN958: Debugging and Programming Interfaces for Custom Designs.

Figure 9: Standalone SoC Configuration

5.3 Boot

The **BOOT pin is used to determine when execution of the bootloader is required**. Upon reset, execution of the bootloader begins. The **state of the BOOT pin is read immediately upon start-up of the bootloader**. If LOW, execution of the bootloader continues, facilitating firmware update via the UART. If the BOOT pin is HIGH, the bootloader will stop execution and pass control to the main application firmware.

6 PIN DEFINITIONS

6.1 Module Pinout

Figure 10: Lyra 24S Module Pinout (Top View)

For GPIO pin to peripheral assignment in AT firmware, see User Guide – AT Interface Application – Lyra 24 Series.

The next table shows the Lyra 24S pinout and general descriptions for each pin. Refer to Alternate Pin Functions, Analog Peripheral Connectivity, and Digital Peripheral Connectivity for details on functions and peripherals supported by each GPIO pin.

Table 17: Module Pinout

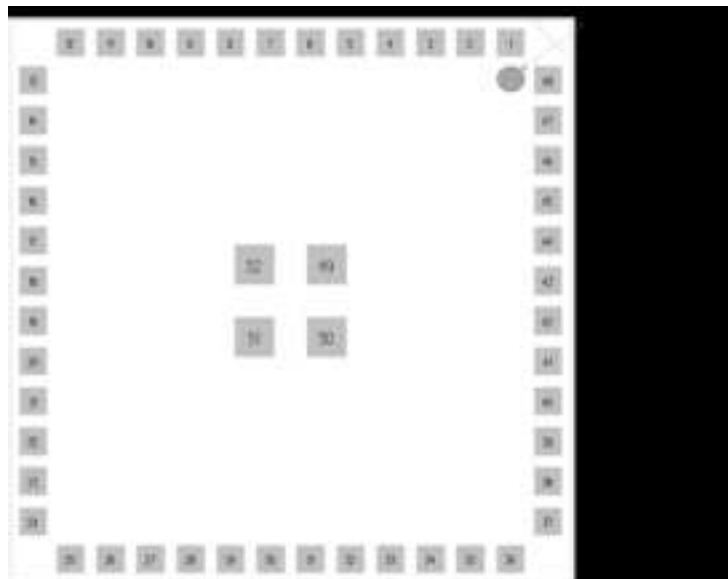| Pin Name	No.	Description	Pin Name	No.	Description
DNC	1	Do not connect	GND	52	GROUND
ANT OUT	2	Integral Ant Out	GND	51	GROUND
DNC	3	Do not connect	GND	50	GROUND
DNC	4	Do not connect	GND	49	GROUND
ANT IN	5	Integral Ant In	GND	48	GROUND
2G4IO	6	RF IN/OUT	RESETn[1]	47	RESET
GND	7	GROUND	PC09	46	GPIO
PB05	8	GPIO	PC08	45	GPIO
PB04	9	GPIO	PC07	44	GPIO
PB03	10	GPIO	PC06	43	GPIO
PB02	11	GPIO	PC05	42	GPIO
GND	12	GROUND	PC04	41	GPIO
PB01	13	GPIO	PC03	40	GPIO
PB00	14	GPIO	PC02	39	GPIO
PA00	15	GPIO	PC01	38	GPIO
PA01	16	GPIO	PC00	37	GPIO
PA02	17	GPIO	PD00	36	GPIO LF XTAL Output (Optional)

Pin Name	No.	Description	Pin Name	No.	Description
PA03	18	GPIO	PD01	35	GPIO LF XTAL Input (Optional)
PA04	19	GPIO	PD02	34	GPIO
PA05	20	GPIO	PD03	33	GPIO
PA06	21	GPIO	PD04	32	GPIO
PA07	22	GPIO	PD05	31	GPIO
PA08	23	GPIO	VDDIO	30	I/O power supply
PA09	24	GPIO	GND	29	GROUND
GND	25	GROUND	VDD	28	Power supply
VDCDC	26	Test pin (internal test usage)	DECOUPLE	27	Test pin (internal test usage)

6.2   Alternate Pin Functions

Some GPIOs support alternate functions like debugging, wake-up from EM4, external low frequency crystal access, etc. The following table shows both which module pins have alternate capabilities and the functions they support. Refer to the SoCs reference manual for more details.

Table 18: Alternate Pin Functions

GPIO	Alternate Functions		
PA00	IADC0.VREFP		
PA01	GPIO.SWCLK		
PA02	GPIO.SWDIO		
PA03	GPIO.SWV GPIO.TDO GPIO.TRACEDATA0		
PA04	GPIO.TDI GPIO.TRACECLK		
PA05	GPIO.TRACEDATA1 GPIO.EM4WU0		
PA06	GPIO.TRACEDATA2		
PA07	GPIO.TRACEDATA3		
PB00	VDAC0.VDAC_CH0_MAIN_OU TPUT		
PB01	GPIO.EM4WU3	VDAC0.VDAC_CH1_MAIN_OU TPUT	
PB02	VDAC1.VDAC_CH0_MAIN_OU TPUT		
PB03	GPIO.EM4WU4	VDAC1.VDAC_CH1_MAIN_OU TPUT	
PC00	GPIO.EM4WU6		
PC01	GPIO.EFP_TX_SDA		
PC02	GPIO.EFP_TX_SCL		
PC05	GPIO.EFP_INT GPIO.EM4WU7		
PC07	GPIO.EM4WU8	GPIO.THMSW_EN	GPIO.THMSW_HALFSWITCH
PD00	LFXO.LFXTAL_O		
PD01	LFXO.LFXTAL_I LFXO.LF_EXTCLK		
PD02	GPIO.EM4WU9		

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6.3   Analog Peripheral Connectivity

Many analog resources are routable and can be connected to numerous GPIO's. The table below indicates which peripherals are available on each GPIO port. **When a differential connection is being used, positive inputs are restricted to the EVEN pins and negative inputs are restricted to the ODD pins**. When a single ended connection is being used positive input is available on all pins. See the SoC's Reference Manual for more details on the ABUS and analog peripherals.

Table 19: Analog Peripheral Connectivity

Peripheral	Signal	PA		PB		PC		PD	
		EVEN	ODD	EVEN	ODD	EVEN	ODD	EVEN	ODD
ACMP0	ANA_NEG	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	ANA_POS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ACMP1	ANA_NEG	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	ANA_POS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
IADC0	ANA_NEG	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	ANA_POS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
VDAC0	VDAC_CH0_ABUS_OUT- PUT	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	VDAC_CH1_ABUS_OUT	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
VDAC1	VDAC_CH0_ABUS_OUT- PUT	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	VDAC_CH1_ABUS_OUT	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

6.4   Digital Peripheral Connectivity

Many digital resources are routable and can be connected to numerous GPIOs. The table below indicates which peripherals are available on each GPIO port.

Table 20: DBUS Routing Table

Peripheral.Resource	PORT			
	PA	PB	PC	PD
ACMP0.DIGOUT	Available	Available	Available	Available
ACMP1.DIGOUT	Available	Available	Available	Available
CMU.CLKIN0			Available	Available
CMU.CLKOUT0			Available	Available
CMU.CLKOUT1			Available	Available
CMU.CLKOUT2	Available	Available		
EUSART0.CS	Available	Available		
EUSART0.CTS	Available	Available		
EUSART0.RTS	Available	Available		
EUSART0.RX	Available	Available		
EUSART0.SCLK	Available	Available		
EUSART0.TX	Available	Available		
EUSART1.CS	Available	Available	Available	Available
EUSART1.CTS	Available	Available	Available	Available
EUSART1.RTS	Available	Available	Available	Available
EUSART1.RX	Available	Available	Available	Available
EUSART1.SCLK	Available	Available	Available	Available
EUSART1.TX	Available	Available	Available	Available
FRC.DCLK			Available	Available

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Peripheral.Resource	PORT			
FRC.DFRAME			Available	Available
FRC.DOUT			Available	Available
HFXO0.BUFOUT_REQ_IN_ASYNC	Available	Available		
I2C0.SCL	Available	Available	Available	Available
I2C0.SDA	Available	Available	Available	Available
I2C1.SCL			Available	Available
I2C1.SDA			Available	Available
KEYSCAN.COL_OUT_0	Available	Available	Available	Available
KEYSCAN.COL_OUT_1	Available	Available	Available	Available
KEYSCAN.COL_OUT_2	Available	Available	Available	Available
KEYSCAN.COL_OUT_3	Available	Available	Available	Available
KEYSCAN.COL_OUT_4	Available	Available	Available	Available
KEYSCAN.COL_OUT_5	Available	Available	Available	Available
KEYSCAN.COL_OUT_6	Available	Available	Available	Available
KEYSCAN.COL_OUT_7	Available	Available	Available	Available
KEYSCAN.ROW_SENSE_0	Available	Available		
KEYSCAN.ROW_SENSE_1	Available	Available		
KEYSCAN.ROW_SENSE_2	Available	Available		
KEYSCAN.ROW_SENSE_3	Available	Available		
KEYSCAN.ROW_SENSE_4	Available	Available		
KEYSCAN.ROW_SENSE_5	Available	Available		
LETIMER0.OUT0	Available	Available		
LETIMER0.OUT1	Available	Available		
MODEM.ANT0	Available	Available	Available	Available
MODEM.ANT1	Available	Available	Available	Available
MODEM.ANT_ROLL_OVER			Available	Available
MODEM.ANT_RR0			Available	Available
MODEM.ANT_RR1			Available	Available
MODEM.ANT_RR2			Available	Available
MODEM.ANT_RR3			Available	Available
MODEM.ANT_RR4			Available	Available
MODEM.ANT_RR5			Available	Available
MODEM.ANT_SW_EN			Available	Available
MODEM.ANT_SW_US			Available	Available
MODEM.ANT_TRIG			Available	Available
MODEM.ANT_TRIG_STOP			Available	Available
MODEM.DCLK	Available	Available		
MODEM.DIN	Available	Available		
MODEM.DOUT	Available	Available		
PCNT0.S0IN	Available	Available		
PCNT0.S1IN	Available	Available		
PRS.ASYNCH0	Available	Available		
PRS.ASYNCH1	Available	Available		
PRS.ASYNCH2	Available	Available		

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Peripheral.Resource	PORT			
PRS.ASYNCH3	Available	Available		
PRS.ASYNCH4	Available	Available		
PRS.ASYNCH5	Available	Available		
PRS.ASYNCH6			Available	Available
PRS.ASYNCH7			Available	Available
PRS.ASYNCH8			Available	Available
PRS.ASYNCH9			Available	Available
PRS.ASYNCH10			Available	Available
PRS.ASYNCH11			Available	Available
PRS.ASYNCH12	Available	Available		
PRS.ASYNCH13	Available	Available		
PRS.ASYNCH14	Available	Available		
PRS.ASYNCH15	Available	Available		
PRS.SYNCH0	Available	Available	Available	Available
PRS.SYNCH1	Available	Available	Available	Available
PRS.SYNCH2	Available	Available	Available	Available
PRS.SYNCH3	Available	Available	Available	Available
RAC.LNAEN	Available	Available	Available	Available
RAC.PAEN	Available	Available	Available	Available
TIMER0.CC0	Available	Available	Available	Available
TIMER0.CC1	Available	Available	Available	Available
TIMER0.CC2	Available	Available	Available	Available
TIMER0.CDTI0	Available	Available	Available	Available
TIMER0.CDTI1	Available	Available	Available	Available
TIMER0.CDTI2	Available	Available	Available	Available
TIMER1.CC0	Available	Available	Available	Available
TIMER1.CC1	Available	Available	Available	Available
TIMER1.CC2	Available	Available	Available	Available
TIMER1.CDTI0	Available	Available	Available	Available
TIMER1.CDTI1	Available	Available	Available	Available
TIMER1.CDTI2	Available	Available	Available	Available
TIMER2.CC0	Available	Available		
TIMER2.CC1	Available	Available		
TIMER2.CC2	Available	Available		
TIMER2.CDTI0	Available	Available		
TIMER2.CDTI1	Available	Available		
TIMER2.CDTI2	Available	Available		
TIMER3.CC0			Available	Available
TIMER3.CC1			Available	Available
TIMER3.CC2			Available	Available
TIMER3.CDTI0			Available	Available
TIMER3.CDTI1			Available	Available
TIMER3.CDTI2			Available	Available
TIMER4.CC0	Available	Available		

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Peripheral.Resource	PORT			
TIMER4.CC1	Available	Available		
TIMER4.CC2	Available	Available		
TIMER4.CDTI0	Available	Available		
TIMER4.CDTI1	Available	Available		
TIMER4.CDTI2	Available	Available		
USART0.CLK	Available	Available	Available	Available
USART0.CS	Available	Available	Available	Available
USART0.CTS	Available	Available	Available	Available
USART0.RTS	Available	Available	Available	Available
USART0.RX	Available	Available	Available	Available
USART0.TX	Available	Available	Available	Available

7 DESIGN GUIDELINES

7.1 Layout and Placement

For optimal performance of the Lyra 24S the following guidelines are recommended:

- Place the module 1.50 mm from the edge of the copper "keep-in" area at the middle of the long edge of the application PCB, as illustrated in Figure 11: Recommended Layout for Lyra 24S (Integrated Antenna).
- Copy the exact design from Figure 12: TOP Layer Antenna Layout with Coordinates with the values for coordinates A to L given in Table 21: Antenna Polygon Coordinates, Referenced to Center of Lyra 24S.
- Make a cutout in all lower layers aligned with the right edge and the bottom edge of the integral loop antenna as indicated by the red box in Figure 13: Antenna Clearance in Inner and Bottom Layers.
- Connect all ground pads directly to a solid ground plane in the top layer.
- Connect 2G4IO to ANT_IN through a 0-ohm resistor.
- The 0-ohm gives the ability to test conducted and to evaluate the antenna impedance in the design.
- Place ground vias as close to the ground pads of the Lyra 24S as possible.
- Place ground vias along the antenna loop right and bottom side.
- Place ground vias along the edges of the application board.
- Do not place plastic or any other dielectric material in contact with the antenna.
- A minimum clearance of 0.5 mm is advised.
- Solder mask, conformal coating and other thin dielectric layers are acceptable directly on top of the antenna region.
- Proper module placement and electrical connection should be ensured by measuring radiated output power from antenna.
- Impedance of the antenna can be verified by measuring S11 at ANT_IN pin that is corresponding antenna specification.
- With an external antenna, use a 50Ω trace to connect RF signal to the antenna, as it is illustrated in section Lyra 24S Module 50 Ohms RF Track Design for Connecting External Antenna with the Lyra 24S.

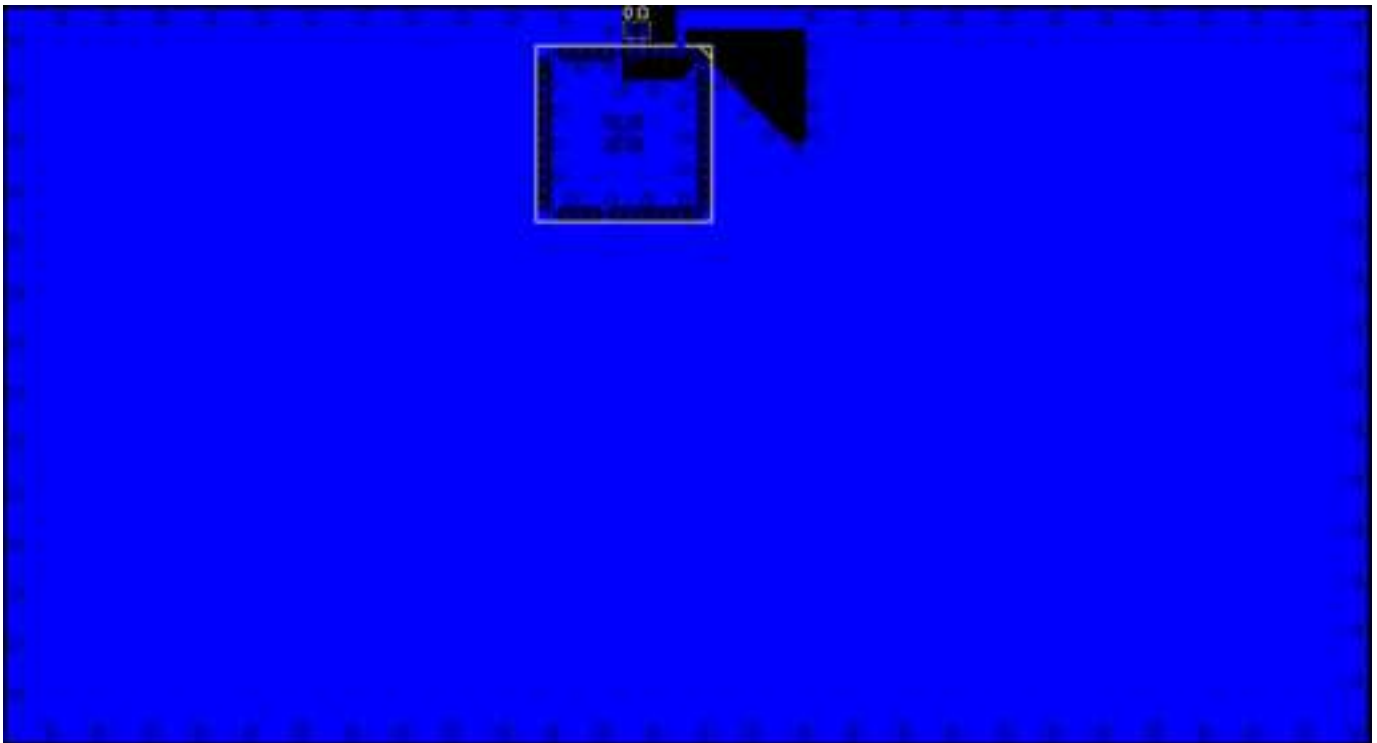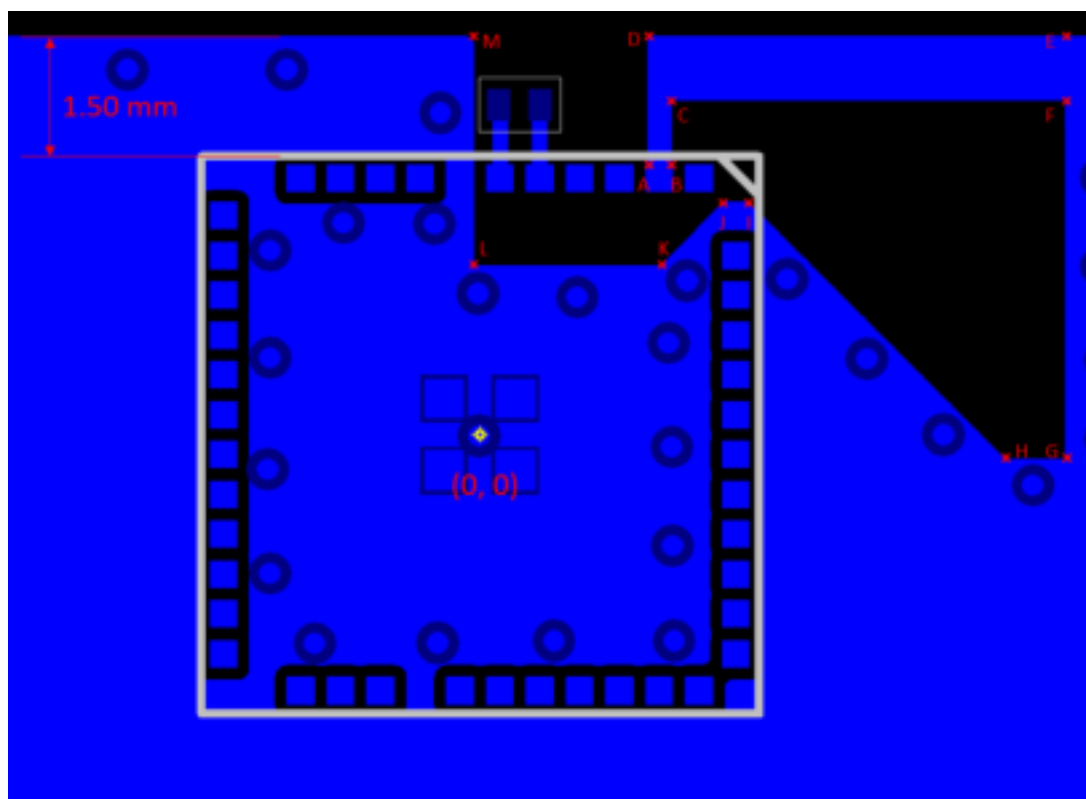*Figure 11: Recommended Layout for Lyra 24S (Integrated Antenna)*

Figure 12: TOP Layer Antenna Layout with Coordinates

Table 21: Antenna Polygon Coordinates, Referenced to Center of Lyra 24S

Point	Coordinate
A	(2.10, 3.30)
B	(2.40, 3.30
C	(2.40, 4.20)
D	(2.10, 5.00)
E	(7.35, 5.00)
F	(7.35, 4.20)
G	(7.35, -0.03)
H	(6.59, -0.30)
I	(3.39, 2.90)
J	(3.05, 2.90)
K	(2.27, 2.13)
L	(-0.08, 2.13)
M	(-0.08, 5.00)

Tolerance for the coordinates is +/- 0.05 mm.

Figure 13: Antenna Clearance in Inner and Bottom Layers

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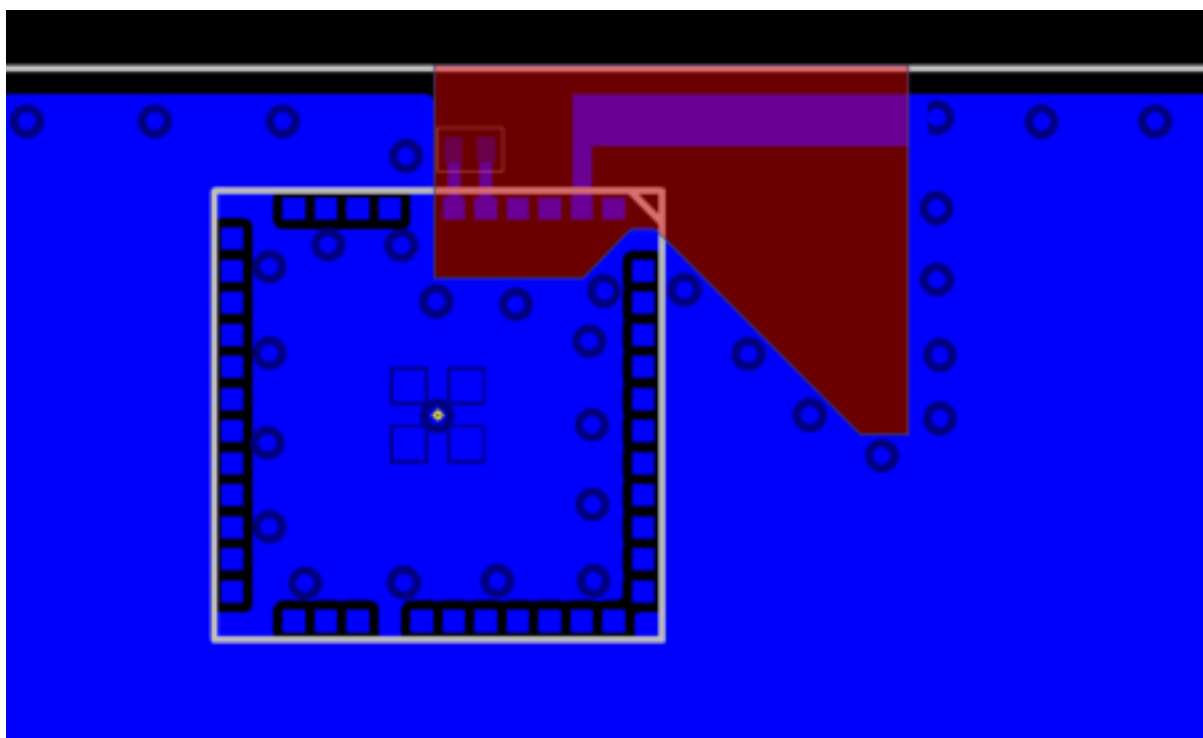
7.2   Best Design Practices

The design of a good RF system relies on thoughtful placement and routing of the RF signals. The following guidelines are recommended:

- Place the Lyra 24S and antenna close to the center of the longest edge of the application board.
- Do not place any circuitry between the board edge and the antenna.
- Make sure to tie all GND planes in the application board together with as many vias as can be fitted.
- Generally, ground planes are recommended in all areas of the application board except in the antenna keep-out area shown in Figure 13: Antenna Clearance in Inner and Bottom Layers.
- Open-ended stubs of copper in the outer layer ground planes must be removed if they are more than 5 mm long to avoid radiation of spurious emissions.
- The width of the GND plane to the sides of the Lyra 24S will impact the efficiency of the on-board integral loop antenna.
- To achieve optimal performance, a GND plane width of 55 mm is recommended as seen on Figure 14: Illustration of Recommended Board Width.
- See Antenna Radiation and Efficiency for Lyra 24S Integrated Antenna for reference. Figure 15: Non-Recommended Layout Examples illustrates layout scenarios that will lead to severely degraded RF performance for the application board.

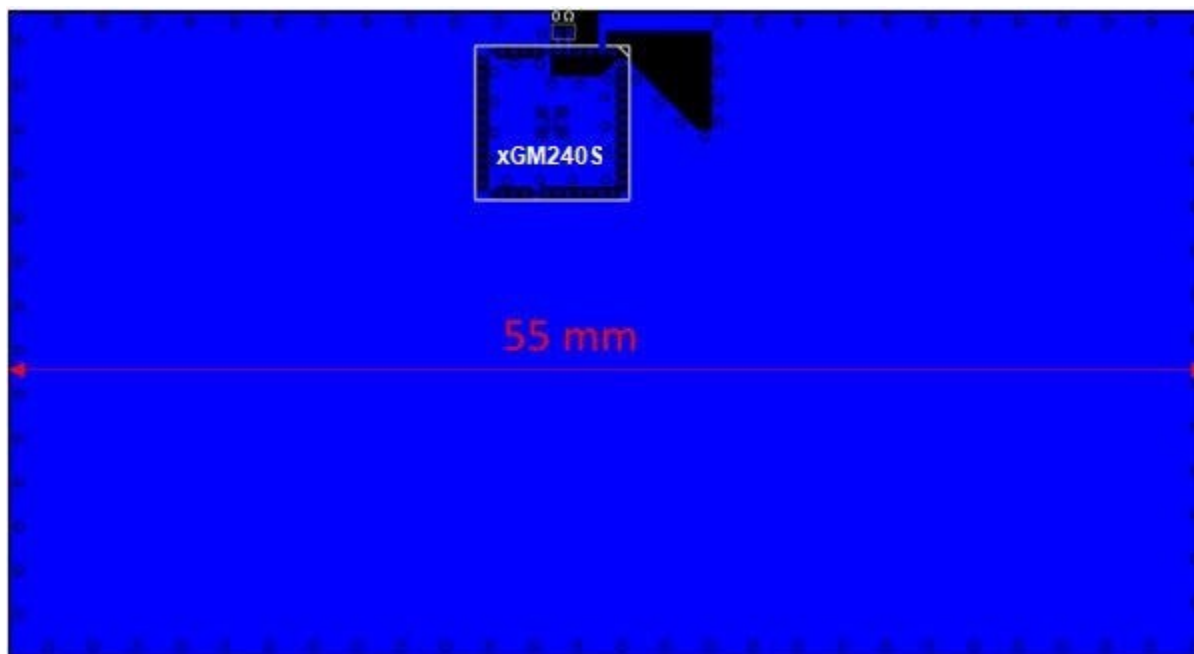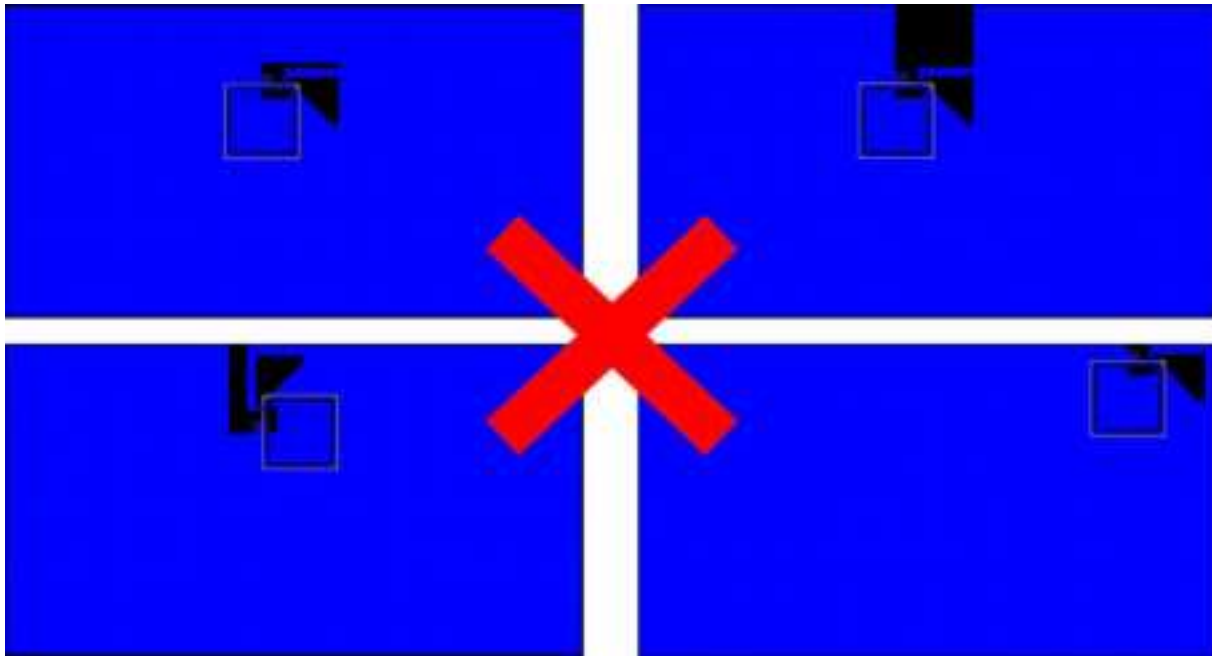*Figure 14: Illustration of Recommended Board Width*

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Figure 15: Non-Recommended Layout Examples

7.3   Radio Performance vs. Carrier Board Size

As with most applications, the **carrier board size is determined by the overall form factor or size of the additional circuitry**. The recommended carrier board width of 55 mm is thus not always possible in the end-application. If another form factor is required, the antenna performance of the integrated antenna will likely be compromised, but it may still be sufficiently good for providing the required link quality and range of the end-application. As can be seen in Figure 16: Efficiency of the Integrated Antenna as Function of the Carrier Board Size for Lyra 24S, the **best performance is achieved for a carrier board size of 55 mm x 30 mm**, with relatively constant performance for larger boards and rapidly declining performance for smaller boards.

WARNING: Any antenna tuning, and/or change of the loop dimensions, is likely to invalidate a modular certification, unless it is done to compensate for the degradation caused by a host board deviating in size from the manufacturer's best-case reference. Separate guidance might be provided by the manufacturer to address this particular kind of degradation, in which case a Permissive Change to the modular approval might not even become necessary: however, since this is evaluated on a case-by-case basis, please consult your certification house on the best approach.
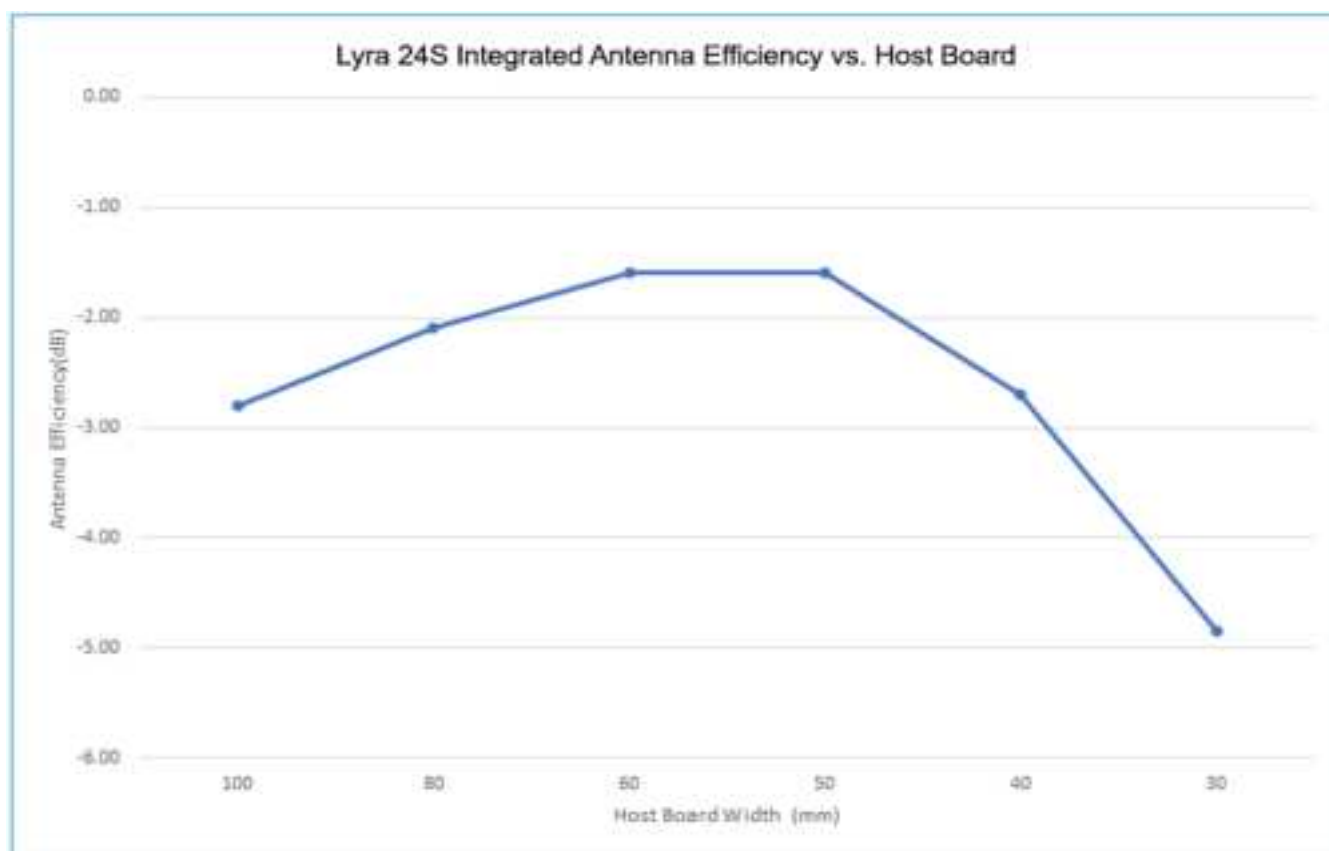
Lyra 24S
Datasheet

Figure 16: Efficiency of the Integrated Antenna as Function of the Carrier Board Size for Lyra 24S

7.4   Impact of Human Body and Other Materials in Close Proximity

Placing the module in contact with or very close to the human body will negatively impact antenna efficiency and reduce range.

Avoid placing plastic or any other dielectric material in close proximity to the antenna. Conformal coating and other thin dielectric layers are acceptable directly on top of the antenna region, but this will also negatively impact antenna efficiency and reduce range.

Any metallic objects in close proximity to the antenna will prevent the antenna from radiating freely. The minimum recommended distance of metallic and/or conductive objects is 10 mm in any direction from the antenna except in the directions of the application PCB ground planes.

7.5   Reset

The Lyra 24S can be reset by pulling the RESET line low, by the internal watchdog timer, or by software command. The reset state does not provide power saving functionality and it is not recommended as a means to conserve power.

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7.6   Debug

See Silicon Labs' AN958: Debugging and Programming Interfaces for Custom Designs.

The Lyra 24S supports hardware debugging via 4-pin JTAG or 2-pin serial-wire debug (SWD) interfaces. It is recommended to expose the debug pins in your own hardware design for firmware update and debug purposes. The table below lists the required pins for JTAG and SWD debug interfacing, which are also presented in Alternate Pin Functions.

If JTAG interfacing is enabled, the module must be power cycled to return to a SWD debug configuration if necessary.

Table 22: Debug Pins

Pin Name	JTAG Signal	SWD Signal	Comments
PA04	TDI	N/A	This pin is disabled after reset. Once enabled the pin has a built-in pull-up.
PA03	TDO	N/A	This pin is disabled after reset.
PA02	TMS	SWDIO	Pin is enabled after reset and has a built-in pull-up.
PA01	TCK	SWCLK	Pin is enabled after reset and has a built-in pull-down.

7.7   Packet Trace Interface (PTI)

The Lyra 24S integrates a true PHY-level packet trace interface (PTI) peripheral that can capture packets non-intrusively to monitor and log device and network traffic without burdening processing resources in the module's SoC. The PTI generates two output signals that can serve as a powerful debugging tool, especially in conjunction with other hardware and software development tools available from Silicon Labs. The **PTI_DATA** and **PTI_FRAME** signals can be accessed through any GPIO on ports C and D (see **FRC.DOUT** and **FRC.DFRAME** peripheral resources in Pin Definitions).

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7.8 Lyra 24S Module 50 Ohms RF Track Design for Connecting External Antenna with the Lyra 24S

Lyra 24S module can be used with external antennas (certified by Laird Connectivity), and requires a 50 Ohm RF trace (GCPW, that Grounded Coplanar Waveguide) to be designed to run from Lyra 24S module 2G4IO (pin6) to a RF antenna connector (IPEX MHF4) on host PCB. **The 50 Ohms RF track design and length MUST be copied** (as specified in this section). Lyra 24SP module GND pin7 used to support GCPW 50Ohm RF trace.

Checklist for SCH

Lyra 24S External antenna connection	Lyra 24S Internal antenna connection
1. Fit IPEX MHF4 RF connector (20449-001E), J3.	1. Fit 0R resistor (position R939 in below SCH) between Lyra 24S module pin6 (2G4IO) and pin5 (ANT_IN).
2. Fit 0R resistor (position R940 in below SCH) between Lyra 24S module pin6 (2G4IO) and IPEX MHF4 RF connector (20449-001E).	2. Do not Fit R940 and J3 (positions in below SCH).
3. Leave Lyra 24S module pin5 (ANT_IN) open circuited.	3. Lyra 24S pin5 (ANT_IN internal antenna PCB layout MUST be followed.
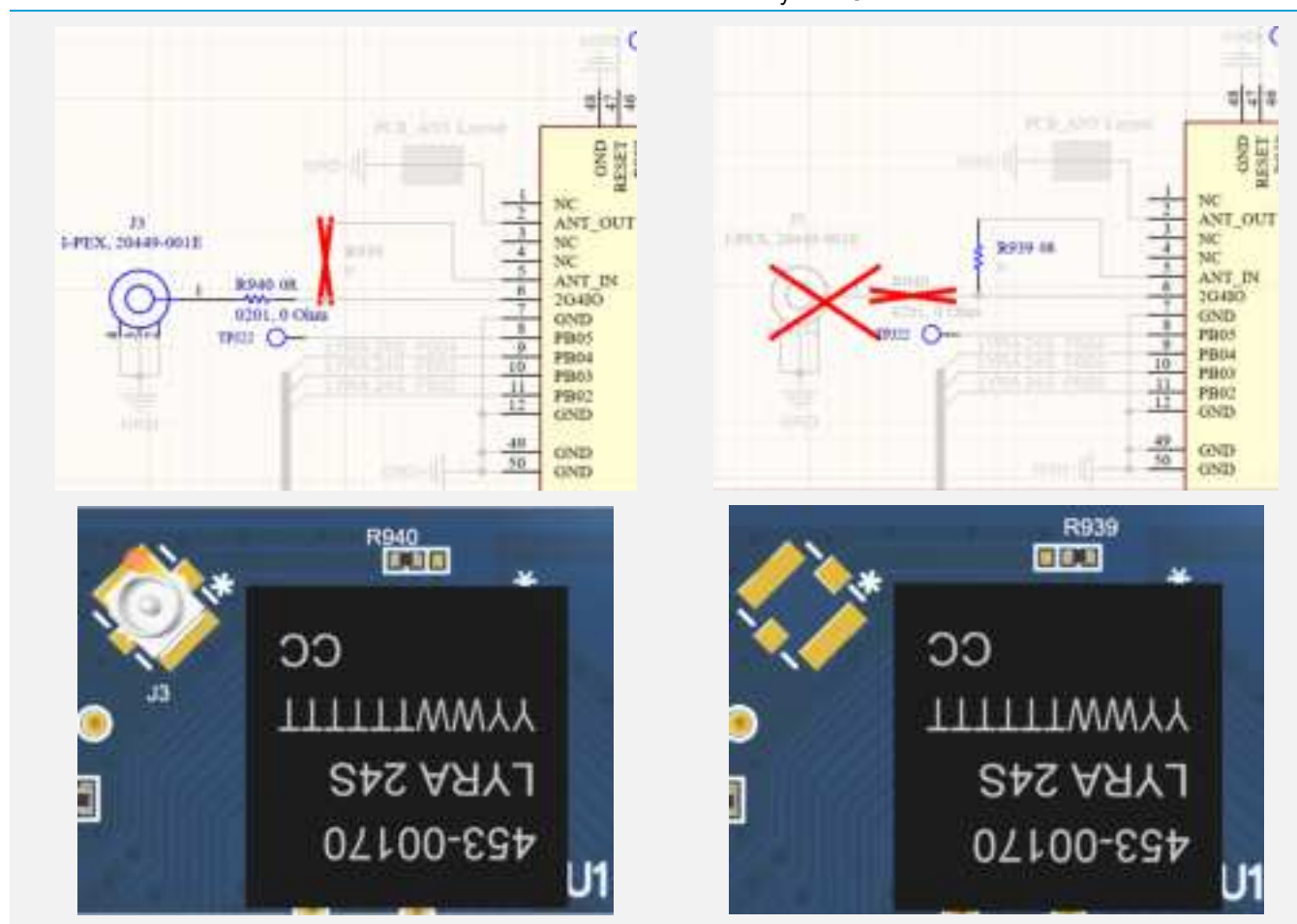
Figure 17: Lyra 24S for External antenna connection host PCB 50-Ohm RF trace schematic with MHF4 RF connector

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Layer1 (RF Track and RF GND)
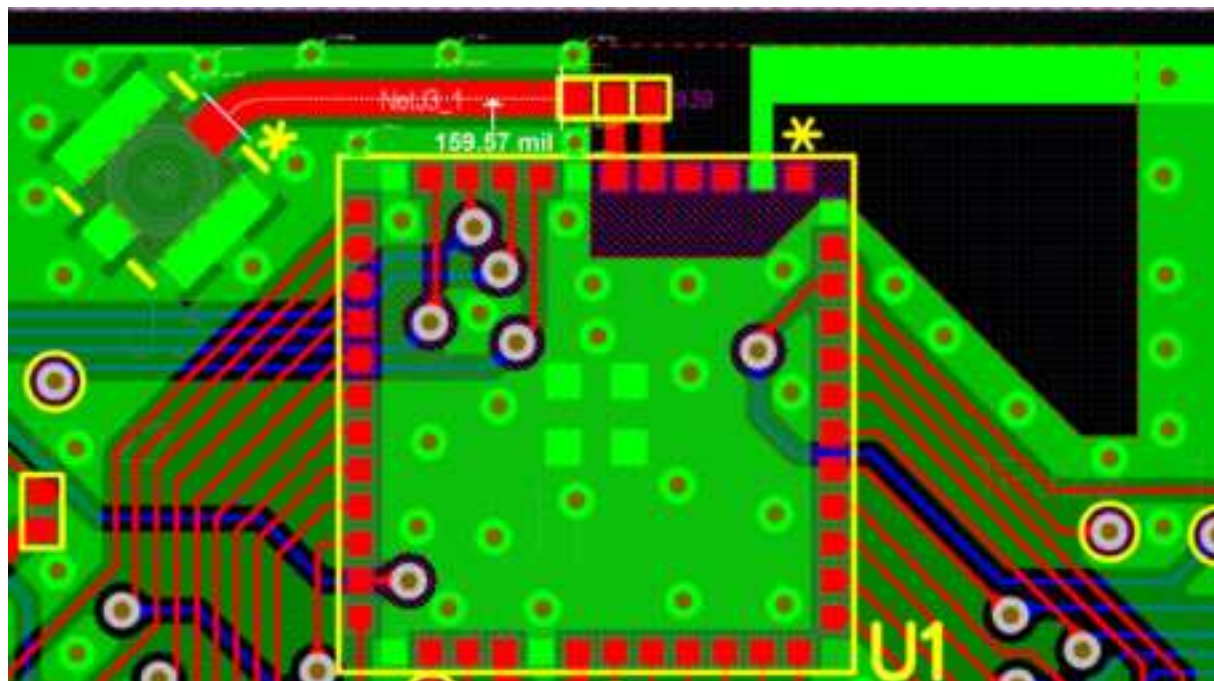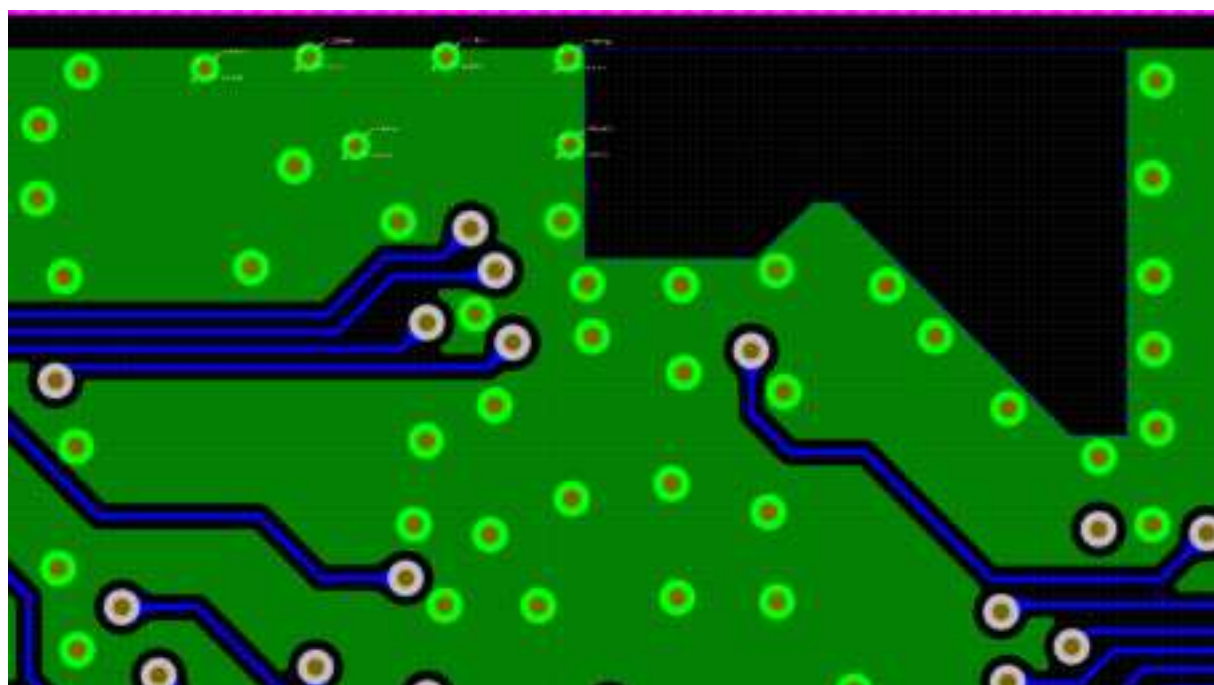

Layer2 (RF GND)

Figure 18: 50-Ohm RF trace design (Layer1 and Layer2) on DVK-Lyra 24S development board 453-00170-K1 (or host PCB) for use with Lyra 24S (453-00170) module

Checklist for PCB:

▪ MUST use a 50-Ohm RF trace (GCPW, that is Grounded Coplanar Waveguide) from 2F4IO (pin6) of the Lyra 24S module (453-00170) to RF antenna connector (IPEX MHF4 Receptable (MPN: 20449-001E)) on host PCB.

▪ To ensure regulatory compliance, MUST follow exactly the following considerations for 50-Ohms RF trace design and test verification:
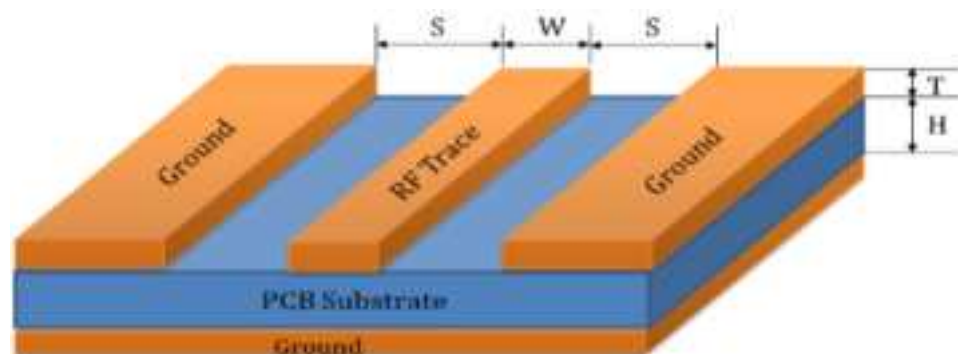
	Thickness		Dielectric	
	mil	mm	Constant Er	
Solder Mask	1.0	0.025	3.5	
Layer1 Copper 1oz+plating	1.5	0.038		Stack up for 50 Ohms GCPW RF Track.
Core	57.60	1.463	4.2	
Layer2 Copper 1oz+plating	1.5	0.038		
Solder Mask	1.0	0.025	3.5	
Total	62.6	1.59		

Figure 19: Lyra 24P development board PCB stack-up and 50-Ohms Grounded CPW RF trace design using GND on L1 and L2

Note 1: The plating (ENIG) above base 1ounce copper is not listed, but plating expected to be ENIG.

▪ The 50-Ohms RF trace design MUST be Grounded Coplanar Waveguide (GCPW) with
  – Layer1 RF track width (W) of 20 mil and
  – Layer1 gap (S) to GND of 5 mil and where the
  – Layer1 to Layer 2 dielectric thickness (H) MUST be 57.6 mil (dielectric constant Er 4.2).
  – Further the Layer1 base copper must be 1-ounce base copper (that is 1.5 mil) plus the plating and
  – Layer1 MUST be covered by solder mask of 1.0 mil thickness (dielectric constant Er 3.5).
▪ The 50-Ohms RF trace design MUST follow the PCB stack-up shown in Figure 19. (Layer1 to Layer2 thickness MUST be identical to the Lyra 24S development board).
▪ The 50-Ohms RF track should be a controlled-impedance trace e.g., ±10%.
▪ The 50-Ohms RF trace length MUST be identical (as seen in Figure 18) (159.57mil) to that on the Lyra 24S development board from Lyra 24S module 2G4IO RF pad (pin6) to the RF connector IPEX MHF4 Receptable (MPN: 20449-001E).
▪ Place GND vias regularly spaced either side of 50-Ohms RF trace to form GCPW (Grounded coplanar waveguide) transmission line as shown in Figure 18 and use Lyra 24S module GND pin7.
▪ Use spectrum analyzer to confirm the radiated (and conducted) signal is within the certification limit.

7.9 External Antenna Integration with the Lyra 24S Module 453-00170

Please refer to the Lyra 24S Regulatory Information Guide for details on using Lyra 24S module with external antennas in each regulatory region. The Lyra 24S has been designed to operate with the below external antennas (with a maximum gain of 2.0dBi). The required antenna impedance is 50 ohms. See Table 23. External antennas improve radiation efficiency.

Table 23: External antennas for the Lyra 24S

Manufacturer	Model	Laird Connectivity Part Number	Weight (g)	Dimensions (mm)	Type	Connector	Peak Gain	
							2400-2500 MHz	2400-2480 MHz
Laird Connectivity	NanoBlue	EBL2400A1-10MH4L	2	44.45 x 12.7 x 0.81	PCB Dipole	IPEX MHF4	2 dBi	-
Laird Connectivity	FlexPIFA	001-0022	1.13	40.1 x 11.0 x 2.5	PIFA	IPEX MHF4	-	2 dBi
Mag Layers	EDA-8709-2G4C1-B27-CY	0600-00057	NA	NA	Dipole	IPEX MHF4	2 dBi	-
Laird Connectivity	mFlexPIFA	EFA2400A3S-10MH4L	1.8	25.4 × 23.4 × 2.5	PIFA	IPEX MHF4	-	2 dBi

8 PACKAGE SPECIFICATIONS

8.1 Package Outline

Figure 20: Top, Bottom and side views

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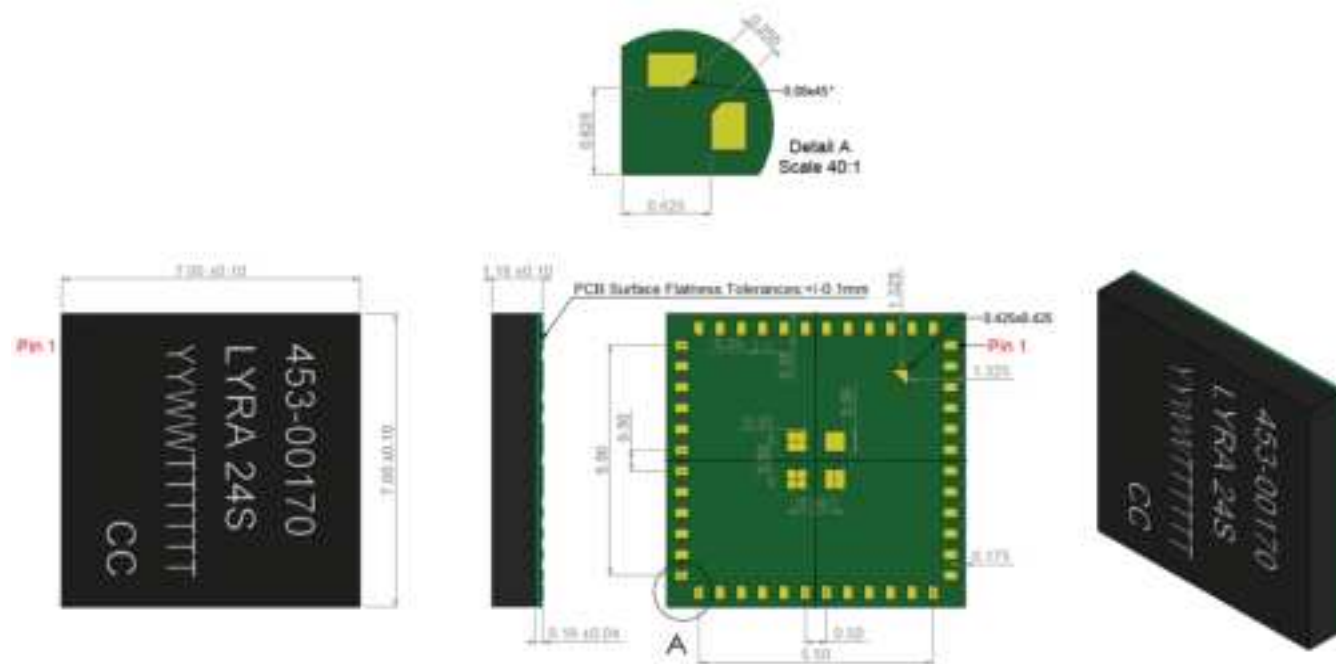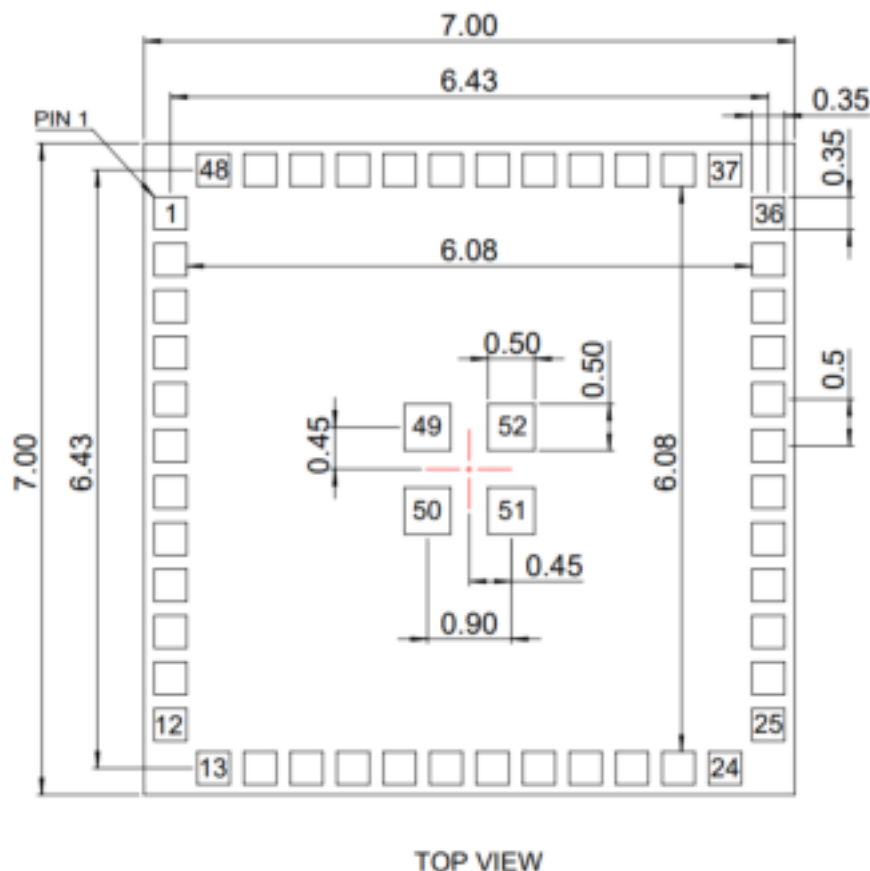
8.2   PCB Land Pattern

Figure 21: Recommended Land Pattern for Modules with a Built-in Antenna

Note:

4. All dimensions shown are in millimeters (mm) unless otherwise noted.

5. Dimensioning and Tolerancing is per the ANSI Y14.5M-1994 specification.

6. This Land Pattern Design is based on IPC-SM-782 guidelines.

7. All dimensions shown are at Maximum Material Condition (MMC). Least Material Condition (LMC) is calculated based on a Fabrication Allowance of 0.05mm.

8. All pads are to be non-solder mask defined (NSMD). Clearance between the solder mask and the metal pad is to be 60um minimum, all the way around the pad.

9. A stainless steel, laser-cut and electro-polished stencil with trapezoidal walls should be used to assure good solder paste release.

10. The stencil thickness should be 0.125mm (5 mils).

11. The ratio of stencil aperture to land pad size should be 1:1 for all perimeter pads.

12. A No-Clean, Type-3 solder paste is recommended.

13. The recommended card reflow profile is per the JEDEC/IPC J-STD-020 specification for Small Body Components.

Above notes and stencil design are shared as recommendations only. A customer or user may find it necessary to use different parameters and fine tune their SMT process as required for their application and tooling.

8.3   Package Marking

Figure 22: Lyra 24S Top Marking

Table 24: Top Marking Definition

Part Number	Line 1 Marking	Line 2 Marking	Line 3 Marking	Line 4 Marking
453-00170	453-00170	LYRA 24S	YYWWTTTTTTT **See Note 1**	CC **See Note 2**

Note:
  1. YY = Year. WW = Work Week, TTTTTTT = Trace Code
  2. Country of Origin ISO Code Abbreviation.

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9 SOLDERING RECOMMENDATIONS

9.1 Reflow for lead Free Solder Paste

- Optimal solder reflow profile depends on solder paste properties and should be optimized as part of an overall process development.
- It is important to provide a solder reflow profile that matches the solder paste supplier's recommendations.
- Temperature ranges beyond that of the solder paste supplier's recommendation could result in poor solderability.
- All solder paste suppliers recommend an ideal reflow profile to give the best solderability.

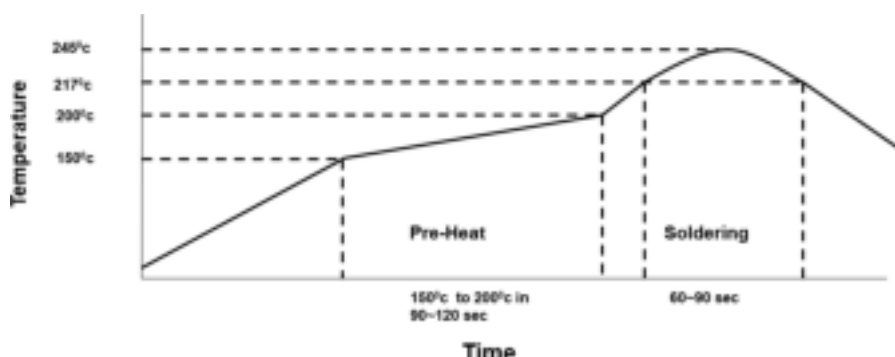## 9.2 Recommended Reflow Profile for lead Free Solder Paste

Figure 23: Recommended Reflow Profile

10 MISCELLANEOUS

10.1 Cleaning

In general, cleaning the populated modules is strongly discouraged. Residuals under the module cannot be easily removed with any cleaning process.

- Cleaning with water can lead to capillary effects where water is absorbed into the gap between the host board and the module. The combination of soldering flux residuals and encapsulated water could lead to short circuits between neighboring pads. Water could also damage any stickers or labels.
- Cleaning with alcohol or a similar organic solvent will likely flood soldering flux residuals into the RF shield, which is not accessible for post-washing inspection. The solvent could also damage any stickers or labels.
- Ultrasonic cleaning could damage the module permanently.

10.2 Rework

The Lyra 24P module can be unsoldered from the host board if the Moisture Sensitivity Level (MSL) requirements are met as described in this datasheet.

Never attempt a rework on the module itself, i.e. replacing individual components. Such actions terminate warranty coverage.

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10.3   Handling and Storage

10.3.1 Handling

The Lyra 24P module contain a highly sensitive electronic circuitry. Handling without proper ESD protection may damage the module permanently.

10.3.2 Moisture Sensitivity Level (MSL)

Per J-STD-020, devices rated as MSL 4 and not stored in a sealed bag with desiccant pack should be baked prior to use.

Devices are packaged in a Moisture Barrier Bag with a desiccant pack and Humidity Indicator Card (HIC). Devices that will be subjected to reflow should reference the HIC and J-STD-033 to determine if baking is required.

If baking is required, refer to J-STD-033 for bake procedure.

10.3.3 Storage

Per J-STD-033, the shelf life of devices in a Moisture Barrier Bag is 12 months at <40C and <90% room humidity (RH).

Do not store in salty air or in an environment with a high concentration of corrosive gas, such as Cl2, H2S, NH3, SO2, or NOX. Do not store in direct sunlight.

The product should not be subject to excessive mechanical shock.

10.3.4 Repeated Reflow Soldering

Only a single reflow soldering process is encouraged for host boards.

11 TRAY AND REEL

Lyra 24S modules are delivered to the customer in Tray or reel. Find the packaging dimensions below. All dimensions are given in mm unless otherwise indicated.

NOTES
1. 10 sprocket hole pitch cumulative tolerance ±0.2
2. Camber not to exceed 1mm in 100mm
3. Material: Black conductive Polystyrene
4. A₀ and B₀ measured on a plane 0.3mm above the bottom of the pocket
5. K₀ measured from a plane on the inside bottom of the pocket to the top surface of the carrier.
6. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole
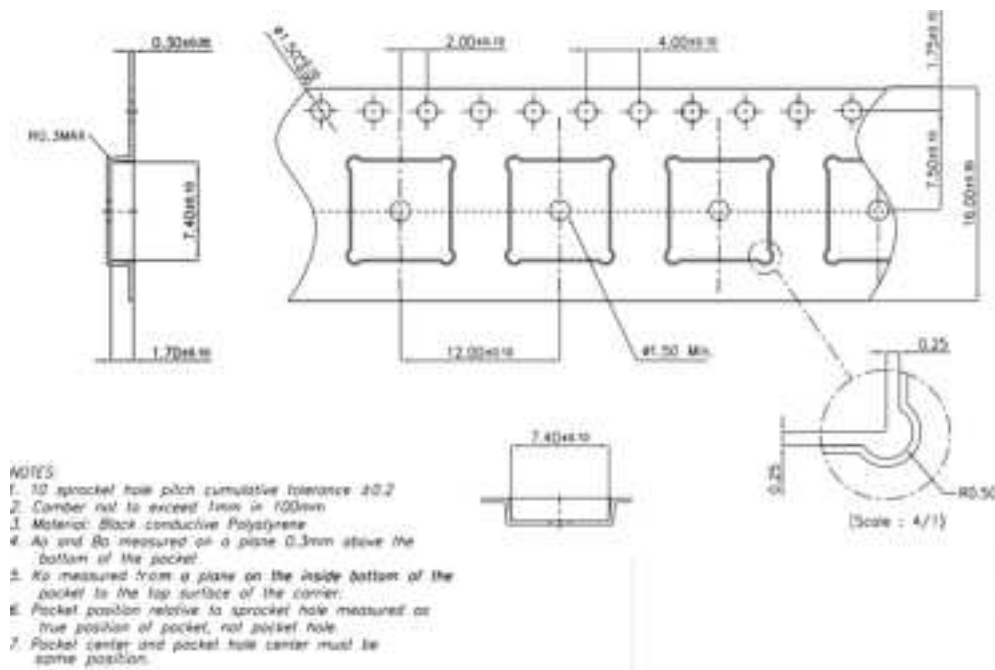7. Pocket center and pocket hole carrier must be same position.
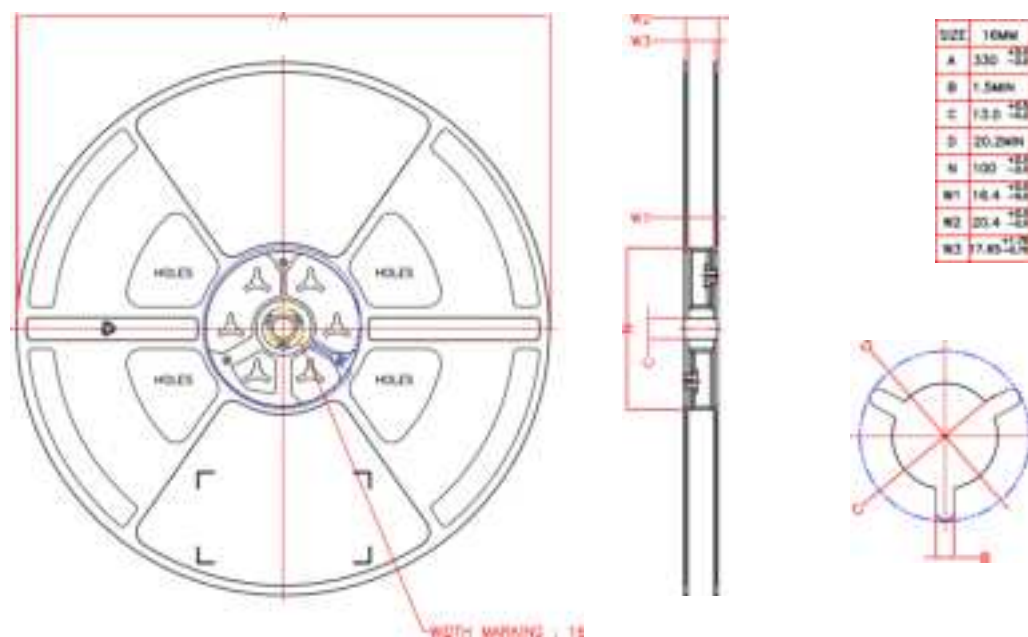
Figure 24: Carrier Tape Dimensions

Figure 25: Reel Dimensions

The following label will be applied on the outer packaging to show regulatory compliance.

Figure 26: Regulatory Compliance Label

12 RELIABILITY TEST

12.1 Climatic And Dynamic

Table 25: Climatic and Dynamic Tests and Results

Test Name	Test Condition	Qualification	LoT ID or Start	Fail/Pass or End	Notes	Summary	Status
Test Group A – Accelerated Environment Stress Tests							
THB	JA101 85°C, 85%RH Vcc=3.8V, 1000 hours	3 lots, N=>25	Q048531 Q048715 Q048533	0/25 0/33 0/25	1 1 1	3 lots 0/83	Pass
Temp Cycle	JA104 Cond C: -65°C to 150°C 500 cycles	3 lots, N=>25	Q048534 Q048535 Q048526	0/25 0/25 0/25	1 1 1	3 lots 0/75	Pass
HTSL	JA103 150°C, 1000hr	3 lots, N=>25	Q048444 Q048529 Q048530	0/25 0/25 0/25	1 1 1	3 lots 0/75	Pass
Test Group B – Accelerated Lifetime Simulation Tests							
HTOL	JA108 TJ ≥ 125°C, Dynamic Vcc=3.8V, 1000 hours	3 lots, N=>77	Q048618 Q049010 Q048287 Q049006 Q048200 Q049005	0/55 0/32 0/58 0/20 0/49 0/55	2 2 2 2 2 2	6 lots 0/269	Pass
LTOL	JA108 TA = -10°C, Dynamic Vcc=3.8V, 1000 hours	1 lot, N=>32	Q042871	0/59	2	1 lot 0/59	Pass
ELFR	JA108 TJ ≥ 125°C, Dynamic Vcc=3.8V, 48 hours	3 lots, N=>500	Q048286 Q049476 Q048085 Q049007	0/494 0/6 0/504 0/534	2 2 2 2	4 lots 0/1538	Pass
NVM Endurance, Retention and Operating Life	JESD22-A117 25°C 500 hours	3 lots, N=>39	Q048257 Q048332 Q048620	0/44 0/44 0/44	2 2 2	3 lots 0/132	Pass
NVM Endurance, Retention and Operating Life	JESD22-A117 + JESD22-A103 150°C, 1000 hours	3 lots, N=>39	Q048331 Q048262 Q048621	0/44 0/44 0/44	2 2 2	3 lots 0/132	Pass
Test Group E – Electrical Verification							
ESD-HMB	JS-001	1 lot, N=>3	Q048512			2.5 kV	Class 2
ESD-CDM	JS-002	1 lot, N=>3	Q049478		3	TC 250	Class C1
Latch Up	JESD78 ±100mA; Overvoltage=3.8V	1 lot, N=>3	Q048513 Q048509	25 °C 105 °C			Pass

Notes:
1. Parts are Pre-conditioned at MSL 3 / 260°C
2. Leverage on die family qualification data (EFR32xG24 series)
3. Device passed at 400 V

12.2 Reliability MTBF Prediction

Reliability Prediction Approach

- Apply Telcordia SR-232 Issue 3 Parts Count calculation
- Confidence Level 90%
- Quality Level II

Table 26: MTBF Prediction

Lyra 24S	40C	105C
FIT (10^{-9})	58	1092
MTBF (Mhours)	17	0.9

13 REGULATORY

13.1 Regulatory information

Note: For complete regulatory information, refer to the Lyra 24S Regulatory Information document which is also available from the Lyra 24 Series Bluetooth 5.3 Solutions Product Page.

The Lyra 24S holds current certifications in the following countries:

Table 27: Lyra 24S Regulatory Information

Country/Region	Regulatory ID
USA (FCC)	SQG-LYRA24S
Canada (ISED)	3147A-LYRA24S
UK (UKCA)	N/A
EU	N/A
Japan (MIC)	201-230070
Korea (KC)	R-C-L8C-LYRA24S
Australia (AS)	N/A
New Zealand (NZS)	N/A

13.2 Maximum Regulatory Certified RF TX Power per Country

13.2.1 For shipped AT firmware

Laird Connectivity AT firmware implements maximum RF TX power settings per country highlighted below.

Table 28: AT Firmware Maximum RF TX Power Settings

	Country and implementation	Global	EU	UK	USA	Canada	Australia	New Zealand	Japan	South Korea
AT FW	Region code	GL	EU	UK	US	CA	AU	NZ	JP	SK
AFH	Turned on or off?	on	on	on	on	on	on	on	on	on
10dBm mode	Target TX power conducted	7dBm	7dBm	7dBm	10dBm	10dBm	7dBm	7dBm	9dBm	10dBm
	Antenna Gain setting	0dBi	0dBi	0dBi	0dBi	0dBi	0dBi	0dBi	0dBi	0dBi
	TX power setting	7dBm	7dBm	7dBm	10dBm	10dBm	7dBm	7dBm	9dBm	10dBm

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852-2762-4823

453-00170 Lyra 24P – Bluetooth v5.3 PCB Module (10dBm) with Integrated Antenna is shipped AT firmware where the radio regulatory region "global" is set which is lowest common settings across RF TX power across certified countries. To switch to the specific radio regulatory region country of USA, Canada, Europe, UK, Australia, New Zealand, Japan and South Korea, customer can use appropriate AT command for setting the radio regulatory region per country.

13.2.2 For customers C code development -

Customers developing with **C Code –** Full software development with Silicon Labs SDK and Toolchain, MUST implement the maximum RF TX power settings per country and other parameters mentioned in this section.

13.2.3 AFH firmware module description

See Silabs AFH firmware module (in Silabs BLE stack) operation description
https://docs.silabs.com/bluetooth/5.0/general/system-and-performance/adaptive-frequency-hopping

This was enabled for CE Adaptivity requirements (since Lyra 24S declared as Adaptive for CE), so left enabled for all certified countries.

13.2.4 Europe (CE), UK (UKCA), Australia (RCM, New Zealand (RCM) Radio RF TX power Table

Table 29: Europe (CE), UK (UKCA), Australia (RCM), New Zealand (RCM) Radio TX power table

Module Laird Part number	453-000170							
Description	Module, SIP, Lyra 24S, Integrated Antenna (Silicon Labs EFR32BG24)							
Antenna Gain (dBi)	1.48dBi peak for Integrated antenna. 2.0dBi peak external antenna.							
Radio Regulatory country:	**Europe (CE), CANADA (ISED), Australia (RCM), New Zealand (RCM)**							
Declared as FHSS or DTS?	DTS							
AFH FW module?	AFH firmware module turned ON (so CE Adaptivity met).							
Silabs BLE SDK:	5.0.0.0 GA (December 14, 2022).							
Silabs Gecko SDK Suite:	4.2 (December 14, 2022).							
10dBm mode	**CERTIFIED maximum conducted RF TX power per BLE PHY** (below is for when Lyra 24S is connected to an external antenna of 2dBi peak gain, use this RF TX power setting for Integrated antenna (1.48dBi) as well).				**CERTIFIED LOWEST COMMON RF TX power setting across BLE PHY's, other restrict…**	**IMPLEMENTED in Laird Connectivity AT FW or customer MUST implement in customers own developed C-code. AFH firmware module turned ON.**		
	NOTE1				**NOTE2**	**NOTE3**	**NOTE4A**	**NOTE4B**
BLE PHY	Physical channel (channel Index)	Frequency (MHz) channel centre.	Certified conducted Maximum TX Power setting dBm	Measured Conducted Peak POWER (dBm)	Certified Lowest common conducted certified RF TX power setting across all 4 BLE data rates.	Target RF TX power conducted to implement in FW. Other restrictions (if any).	Antenna Gain **setting** in FW	TX power **setting** in FW
BLE 1Mbps	CH0 (CH37)	2402 MHz	7dBm	7.45dBm	7dBm	7dBm	0dBi	7dBm
	CH39 (CH39)	2480 MHz	7dBm	7.16dBm	7dBm	7dBm	0dBi	7dBm
BLE 2Mbps	CH1 (CH0)	2404 MHz	7dBm	7.46dBm	7dBm	7dBm	0dBi	7dBm
	CH38 (CH36)	2478 MHz	7dBm	7.16dBm	7dBm	7dBm	0dBi	7dBm
BLE 125kbps	CH0 (CH37)	2402 MHz	7dBm	7.45dBm	7dBm	7dBm	0dBi	7dBm
	CH39 (CH39)	2480 MHz	7dBm	7.17dBm	7dBm	7dBm	0dBi	7dBm
BLE 500kbps	CH0 (CH37)	2402 MHz	7dBm	7.45dBm	7dBm	7dBm	0dBi	7dBm
	CH39 (CH39)	2480 MHz	7dBm	7.17dBm	7dBm	7dBm	0dBi	7dBm

NOTE1: CERTIFIED maximum conducted RF TX power per BLE PHY. This is not what is implemented in AT firmware, this is what was certified only.

NOTE2: Certified Lowest common TX power setting across BLE PHY's.   This lowest common TX power setting is stated since we do <u>not</u> use per BLE RF TX power setting in AT firmware, but same TX power setting across all 4 BLE PHY's.

NOTE3: IMPLEMENT in AT firmware target RF TX power conducted. This target actual implemented in AT firmware. So for CE, UKCA, RCM (Australia and New Zealand), this is actual target 7dBm conducted).
To implement that, NOTE4A defines what Antenna Gain setting MUST be used and NOTE4B defines what TX power setting MUST be used.

NOTE4: IMPLEMENTED in AT firmware (or MUST implement in customers own developed C-code) the Actual target RF TX power conducted:
NOTE4A: the Antenna Gain **setting** of 0dBi and
NOTE4B: the TX power **setting** to 7dBm
which results in:
Target Actual RF TX power (dBm) = TX power **setting** (dBm) - Antenna Gain **setting**(dBi)
7dBm   = 7dBm – 0dBi

13.2.5 USA (FCC), Canada (ISED) Radio RF TX power Table

Table 30: Usa (FCC), Canada (ISED) Radio TX power table

Module Laird Part number	453-000170
Description	Module, SIP, Lyra 24S, Integrated Antenna (Silicon Labs EFR32BG24)
Antenna Gain (dBi)	1.48dBi peak for Integrated antenna. 2.0dBi peak external antenna.
Radio Regulatory country:	**USA (FCC) and CANADA (ISED)**
Declared as FHSS or DTS?	DTS
AFH FW module?	AFH firmware module turned ON.
Silabs BLE SDK: **Silabs Gecko SDK Suite:**	5.0.0.0 GA (December 14, 2022). 4.2 (December 14, 2022).

10dBm mode	CERTIFIED maximum conducted RF TX power per BLE PHY				CERTIFIED LOWEST COMMON RF TX power setting across BLE PHY's, other restrict…	Implemented in Laird Connectivity AT FW or customer MUST implement in customers own developed C-code. AFH firmware module turned ON.		
	NOTE1				NOTE2	NOTE3	NOTE4A	NOTE4B
BLE PHY	Physical channel (channel Index)	Frequency (MHz) channel centre.	Certified conducted Maximum TX Power setting dBm	Measured Conducted Peak POWER (dBm)	Certified Lowest common conducted certified RF TX power setting across all 4 BLE data rates.	Target RF TX power conducted to implement in FW. Other restrictions (if any).	Antenna Gain **setting** in FW	TX power **setting** in FW
BLE 1Mbps	CH0 (CH37)	2402 MHz	10dBm	10.27dBm	10dBm	10dBm	0dBi	10dBm
	CH39 (CH39)	2480 MHz	10dBm	9.72dBm	10dBm	10dBm	0dBi	10dBm
BLE 2Mbps	CH1 (CH0)	2404 MHz	10dBm	10.26dBm	10dBm	10dBm	0dBi	10dBm
	CH38 (CH36)	2478 MHz	10dBm	9.71dBm	10dBm	10dBm	0dBi	10dBm
BLE 125kbps	CH0 (CH37)	2402 MHz	10dBm	10.25dBm	10dBm	10dBm	0dBi	10dBm
	CH39 (CH39)	2480 MHz	10dBm	9.70dBm	10dBm	10dBm	0dBi	10dBm
BLE 500kbps	CH0 (CH37)	2402 MHz	10dBm	10.24dBm	10dBm	10dBm	0dBi	10dBm
	CH39 (CH39)	2480 MHz	10dBm	9.69dBm	10dBm	10dBm	0dBi	10dBm

NOTE1:   CERTIFIED maximum conducted RF TX power per BLE PHY.   This is not what is implemented in AT firmware, this is what was certified only.

NOTE2:   Certified Lowest common TX power setting across BLE PHY's.   This lowest common TX power setting is stated since we do not use per BLE RF TX power setting in AT firmware, but same TX power setting across all 4 BLE PHY's.

NOTE3:   IMPLEMENT in AT firmware target RF TX power conducted. This target actual implemented in AT firmware. So for Usa(FCC), Canada (ISED) this is actual target 10dBm conducted).
To implement that, NOTE4A defines what Antenna Gain setting MUST be used and NOTE4B defines what TX power setting MUST be used.

NOTE4:   IMPLEMENTED in AT firmware (or MUST implement in customers own developed C-code) the Actual target RF TX power conducted:-
NOTE4A: the Antenna Gain **setting** of 0dBi and
NOTE4B: the TX power **setting** to 10dBm
which results in:
Target Actual RF TX power (dBm) = TX power **setting** (dBm) - Antenna Gain **setting**(dBi)
10dBm   = 10dBm – 0dBi

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852-2762-4823

13.2.6 Japan (MIC) Radio RF TX power Table

Table 31: Japan (MIC) Radio TX power table

Module Laird Part number	453-000170
Description	Module, SIP, Lyra 24S, Integrated Antenna (Silicon Labs EFR32BG24)
Antenna Gain (dBi)	1.48dBi peak for Integrated antenna. 2.0dBi peak external antenna.
Radio Regulatory country:	**Japan (MIC)**
Declared as FHSS or DTS?	DTS
AFH FW module?	AFH firmware module turned ON.
Silabs BLE SDK:	5.0.0.0 GA (December 14, 2022).
Silabs Gecko SDK Suite:	4.2 (December 14, 2022).

10dBm mode	CERTIFIED maximum conducted RF TX power per BLE PHY				CERTIFIED LOWEST COMMON RF TX power setting across BLE PHY's, other restrict…	IMPLEMENTED in Laird Connectivity AT FW or customer MUST implement in customers own developed C-code. AFH firmware module turned ON.		
	NOTE1				NOTE2	NOTE3	NOTE4A	NOTE4B
BLE PHY	Physical channel (channel Index)	Frequency (MHz) channel centre.	Certified conducted Maximum TX Power setting dBm	Measured Conducted Peak POWER (dBm)	Certified Lowest common conducted certified RF TX power setting across all 4 BLE data rates.	Target RF TX power conducted to implement in FW. Other restrictions (if any).	Antenna Gain **setting** in FW	TX power **setting** in FW
BLE 1Mbps	CH0 (CH37)	2402 MHz	9dBm	9.01dBm	9dBm	9dBm	0dBi	9dBm
	CH39 (CH39)	2480 MHz	9dBm	8.67dBm	9dBm	9dBm	0dBi	9dBm
BLE 2Mbps	CH1 (CH0)	2404 MHz	9dBm	8.99dBm	9dBm	9dBm	0dBi	9dBm
	CH38 (CH36)	2478 MHz	9dBm	8.67dBm	9dBm	9dBm	0dBi	9dBm
BLE 125kbps	CH0 (CH37)	2402 MHz	9dBm	8.97dBm	9dBm	9dBm	0dBi	9dBm
	CH39 (CH39)	2480 MHz	9dBm	8.64dBm	9dBm	9dBm	0dBi	9dBm
BLE 500kbps	CH0 (CH37)	2402 MHz	9dBm	8.99dBm	9dBm	9dBm	0dBi	9dBm
	CH39 (CH39)	2480 MHz	9dBm	8.65dBm	9dBm	9dBm	0dBi	9dBm

NOTE1: CERTIFIED maximum conducted RF TX power per BLE PHY. This is not what is implemented in AT firmware, this is what was certified only.

NOTE2: Certified Lowest common TX power setting across BLE PHY's. This lowest common TX power setting is stated since we do <u>not</u> use per BLE RF TX power setting in AT firmware, but same TX power setting across all 4 BLE PHY's.

NOTE3: IMPLEMENT in AT firmware target RF TX power conducted. This target actual implemented in AT firmware. So for Japan (MIC), this is actual target 9dBm conducted).
To implement that, NOTE4A defines what Antenna Gain setting MUST be used and NOTE4B defines what TX power setting MUST be used.

NOTE4: IMPLEMENTED in AT firmware (or MUST implement in customers own developed C-code) the Actual target RF TX power conducted:-
NOTE4A: the Antenna Gain **setting** of 0dBi and
NOTE4B: the TX power **setting** to 9dBm
which results in:
Target Actual RF TX power (dBm) = TX power **setting** (dBm) - Antenna Gain **setting**(dBi)
9dBm = 9dBm – 0dBi

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13.2.7 South Korea Radio RF TX power Table

Table 32: South Korea TX power table

Module Laird Part number	453-000170
Description	Module, SIP, Lyra 24S, Integrated Antenna (Silicon Labs EFR32BG24)
Antenna Gain (dBi)	1.48dBi peak for Integrated antenna. 2.0dBi peak external antenna.
Radio Regulatory country:	**South Korea**
Declared as FHSS or DTS?	FHSS (uses Silabs AFH FW module ON)
AFH FW module?	AFH firmware module turned ON.
Silabs BLE SDK: Silabs Gecko SDK Suite:	5.0.0.0 GA (December 14, 2022). 4.2 (December 14, 2022).

10dBm mode	CERTIFIED maximum conducted RF TX power per BLE PHY				CERTIFIED LOWEST COMMON RF TX power setting across BLE PHY's, other restrict…	IMPLEMENTED in Laird Connectivity AT FW or customer MUST implement in customers own developed C-code. AFH firmware module turned ON.		
	NOTE1				NOTE2	NOTE3	NOTE4A	NOTE4B
BLE PHY	Physical channel (channel Index)	Frequency (MHz) channel centre.	Certified conducted Maximum TX Power setting dBm	Certified Measured Conducted Peak POWER (dBm)	Certified Lowest common conducted certified RF TX power setting across all 4 BLE data rates.	Target RF TX power conducted to implement in FW. Other restrictions (if any).	Antenna Gain **setting** in FW	TX power **setting** in FW
BLE 1Mbps	CH0 (CH37)	2402	10dBm		10dBm	10dBm	0dBi	10dBm
	CH39 (CH39)	2480	10dBm		10dBm	10dBm	0dBi	10dBm
BLE 2Mbps	CH1 (CH0)	2404	10dBm		10dBm	10dBm	0dBi	10dBm
	CH38 (CH36)	2478	10dBm		10dBm	10dBm	0dBi	10dBm
BLE 125kbps	CH0 (CH37)	2402	10dBm		10dBm	10dBm	0dBi	10dBm
	CH39 (CH39)	2480	10dBm		10dBm	10dBm	0dBi	10dBm
BLE 500kbps	CH0 (CH37)	2402	10dBm		10dBm	10dBm	0dBi	10dBm
	CH39 (CH39)	2480	10dBm		10dBm	10dBm	0dBi	10dBm

NOTE1:   CERTIFIED maximum conducted RF TX power per BLE PHY in 20dBm mode or 10dBm mode tables.   This is not what is implemented in AT firmware, this is what was certified only.

NOTE2:   Certified Lowest common TX power setting across BLE PHY's.   This lowest common TX power setting is stated since we do not use per BLE RF TX power setting in AT firmware, but same TX power setting across all 4 BLE PHY's.

NOTE3:   IMPLEMENT in AT firmware target RF TX power conducted. This target actual implemented in AT firmware. So for South Korea, this is actual target 10dBm conducted).   To implement that, NOTE4A defines what Antenna Gain setting MUST be used and NOTE4B defines what TX power setting MUST be used.

NOTE4:   IMPLEMENTED in AT firmware (or MUST implement in customers own developed C-code) the Actual target RF TX power conducted:-
NOTE4A: the Antenna Gain **setting** of 0dBi and
NOTE4B: the TX power **setting** to 10dBm
which results in:
Target Actual RF TX power (dBm) = TX power **setting** (dBm) - Antenna Gain **setting**(dBi)
10dBm   = 10dBm – 0dBi

13.2.8 Global (lowest common across certified countries) Radio RF TX power Table

Table 33: Global (lowest common across certified countries) Radio TX power table

Module Laird Part number	453-000170
Description	Module, SIP, Lyra 24S, Integrated Antenna (Silicon Labs EFR32BG24)
Antenna Gain (dBi)	1.48dBi peak for Integrated antenna. 2.0dBi peak external antenna.
Radio Regulatory country:	**Global (lowest common across certified countries)**
Declared as FHSS or DTS?	FHSS
AFH FW module?	AFH firmware module turned ON.
Silabs BLE SDK:	5.0.0.0 GA (December 14, 2022).
Silabs Gecko SDK Suite:	4.2 (December 14, 2022).

10dBm mode	CERTIFIED maximum conducted RF TX power per BLE PHY				CERTIFIED LOWEST COMMON RF TX power setting across BLE PHY's, other restrict…	IMPLEMENTED in Laird Connectivity AT FW or customer MUST implement in customers own developed C-code. AFH firmware module turned ON.		
	NOTE1				NOTE2	NOTE3	NOTE4A	NOTE4B
BLE PHY	Physical channel (channel Index)	Frequency (MHz) channel centre.	Certified conducted Maximum TX Power setting dBm	Certified Measured Conducted Peak POWER (dBm)	Certified Lowest common conducted certified RF TX power setting across all 4 BLE data rates.	Target RF TX power conducted to implement in FW. Other restrictions (if any).	Antenna Gain **setting** in FW	TX power **setting** in FW
BLE 1Mbps	CH0 (CH37)	2402	7dBm	7.45dBm	7dBm	7dBm	0dBi	7dBm
	CH39 (CH39)	2480	7dBm	7.16dBm	7dBm	7dBm	0dBi	7dBm
BLE 2Mbps	CH1 (CH0)	2404	7dBm	7.46dBm	7dBm	7dBm	0dBi	7dBm
	CH38 (CH36)	2478	7dBm	7.16dBm	7dBm	7dBm	0dBi	7dBm
BLE 125kbps	CH0 (CH37)	2402	7dBm	7.45dBm	7dBm	7dBm	0dBi	7dBm
	CH39 (CH39)	2480	7dBm	7.17dBm	7dBm	7dBm	0dBi	7dBm
BLE 500kbps	CH0 (CH37)	2402	7dBm	7.45dBm	7dBm	7dBm	0dBi	7dBm
	CH39 (CH39)	2480	7dBm	7.17dBm	7dBm	7dBm	0dBi	7dBm

NOTE1:   CERTIFIED maximum conducted RF TX power per BLE PHY in 20dBm mode or 10dBm mode tables.   This is not what is implemented in AT firmware, this is what was certified only.

NOTE2:   Certified Lowest common TX power setting across BLE PHY's.   This lowest common TX power setting is stated since we do not use per BLE RF TX power setting in AT firmware, but same TX power setting across all 4 BLE PHY's.

NOTE3:   IMPLEMENT in AT firmware target RF TX power conducted. This target actual implemented in AT firmware. So for Global (lowest common across certified countries), this is actual target 7dBm conducted).
To implement that, NOTE4A defines what Antenna Gain setting MUST be used and NOTE4B defines what TX power setting MUST be used.

NOTE4:   IMPLEMENTED in AT firmware (or MUST implement in customers own developed C-code) the Actual target RF TX power conducted:-
NOTE4A: the Antenna Gain **setting** of 0dBi and
NOTE4B: the TX power **setting** to 7dBm
which results in:
Target Actual RF TX power (dBm) = TX power **setting** (dBm) - Antenna Gain **setting**(dBi)
7dBm   = 7dBm – 0dBi

14 BLUETOOTH SIG QUALIFICATION

14.1 Overview

The Lyra 24P Series module is listed on the Bluetooth SIG website as a qualified End Product, using the combination of a RF-PHY, LL and Host Stack Components.

Table 34: Bluetooth SIG Qualification

Design Name	Owner	Declaration ID	Reference QDID	Link to listing on the SIG website
Lyra 24P	Laird Connectivity	TBD	TBD	TBD

14.1.1 Referenced Qualified Components

Table 35: Referenced Qualified Components

Design Name	Owner	Reference QDID	Link to listing on the SIG website
EFR32BG24 and EFR32MG24 RF-PHY	Silicon Laboratories	TBD	TBD
Wireless Gecko Link Layer	Silicon Laboratories	TBD	TBD
Wireless Gecko Host	Silicon Laboratories	TBD	TBD

It is a mandatory requirement of the Bluetooth Special Interest Group (SIG) that every product implementing Bluetooth technology has a Declaration ID. Every Bluetooth design is required to go through the qualification process, even when referencing a Bluetooth Design that already has its own Declaration ID. The Qualification Process requires each company to registered as a member of the Bluetooth SIG – https://www.bluetooth.com/

The following link provides a link to the Bluetooth Registration page: https://www.bluetooth.org/login/register/

For each Bluetooth Design, it is necessary to purchase a Declaration ID. This can be done before starting the new qualification, either through invoicing or credit card payment. The fees for the Declaration ID will depend on your membership status, please refer to the following webpage:

https://www.bluetooth.com/develop-with-bluetooth/qualification-listing/qualification-listing-fees/

For a detailed procedure of how to obtain a new Declaration ID for your design, please refer to the following SIG document:

https://www.bluetooth.org/DocMan/handlers/DownloadDoc.ashx?doc_id=283698&vId=317486

15 ADDITIONAL INFORMATION

Please contact your local sales representative or our support team for further assistance:

Headquarters	Laird Connectivity 50 S. Main St. Suite 1100 Akron, OH 44308 USA
Phone	Americas: +1-800-492-2320 Europe: +44-1628-858-940 Hong Kong: +852-2762-4823
Website	www.lairdconnect.com/
Technical Support	www.lairdconnect.com/resources/support
Sales Contact	www.lairdconnect.com/contact

Note: Information contained in this document is subject to change.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.

- Increase the separation between the equipment and receiver.

- Connect the equipment into an outlet on a circuit different from that

   to which the receiver is connected.

- Consult the dealer or an experienced radio/TV technician for help.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the

following two conditions: (1) This device may not cause harmful interference, and (2)

this device must accept any interference received, including interference that may

cause undesired operation.

IMPORTANT NOTE:

Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Country Code selection feature to be disabled for products marketed to the US/CANADA

Integration instructions for host product manufacturers

Applicable FCC rules to module

FCC Part 15.247

Summarize the specific operational use conditions

The module is must be installed in mobile device.

This device is intended only for OEM integrators under the following conditions:

1)   The antenna must be installed such that 20 cm is maintained between the antenna and users, and

2)   The transmitter module may not be co-located with any other transmitter or antenna

As long as 2 conditions above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

IMPORTANT NOTE: In the event that these conditions can not be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID can not be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization. The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.

The end user manual shall include all required regulatory information/warning as show in this manual.

Limited module procedures

Not applicable

Trace antenna designs

Not applicable

RF exposure considerations

Co-located issue shall be met as mentioned in "Summarize the specific operational use conditions".

Product manufacturer shall provide below text in end-product manual

"Radiation Exposure Statement:

The product comply with the US portable RF exposure limit set forth for an uncontrolled environment and are safe for intended operation as described in this manual. The further RF exposure reduction can be achieved if the product can be kept as far as possible from the user body or set the device to lower output power if such function is available.."

Antennas

Ant. No.	Brand	Model	Type	Connector	2400-2500MHz	2400-2480MHz	Cable loss (dB)
					Gain (dBi)		
1	Laird	NanoBlue	PCB Dipole	IPEX MHF4	2	---	N/A
2	Laird	FlexPIFA	PCB Dipole	IPEX MHF4	---	2	N/A
3	Mag.Layers	EDA-8709-2G4C1-B27-CY	Dipole	IPEX MHF4	2.32	---	0.7
4	Laird	mFlexPIFA	PIFA	IPEX MHF4	---	2	N/A
5	Laird	Lyra 24S PCB Trace Antenna	Internal PCB	---	---	1.48	N/A

Label and Compliance Information

Product manufacturers need to provide a physical or e-label stating

"Contains FCC ID: SQG-LYRA24S" with finished product

Information on Test Modes and Additional Testing Requirements

Test tool: Uwterminal shall be used to set the module to transmit continuously.

Additional Testing, Part 15 Subpart B Disclaimer

The module is only FCC authorized for the specific rule parts listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. The final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

(1) This device may not cause interference

(2) This device must accept any interference, including interference that may cause undesired operation of the device

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

(1) L'appareil ne doit pas produire de brouillage;

(2) L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

This radio transmitter [IC: 3147A-LYRA24S] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Le présent émetteur radio [IC: 3147A-LYRA24S] a été approuvé par Innovation, Sciences et Développement économique Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué pour tout type figurant sur la liste, sont strictement interdits pour l'exploitation de l'émetteur.

Ant. No.	Brand	Model	Type	Connector	2400-2500MHz	2400-2480MHz	Cable loss (dB)
					Gain (dBi)		
1	Laird	NanoBlue	PCB Dipole	IPEX MHF4	2	---	N/A
2	Laird	FlexPIFA	PCB Dipole	IPEX MHF4	---	2	N/A
3	Mag.Layers	EDA-8709-2G4C1-B27-CY	Dipole	IPEX MHF4	2.32	---	0.7
4	Laird	mFlexPIFA	PIFA	IPEX MHF4	---	2	N/A
5	Laird	Lyra 24S PCB Trace Antenna	Internal PCB	---	---	1.48	N/A

Radiation Exposure Statement:

This equipment complies with Canada radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

Déclaration   d'exposition   aux   radiations:
Cet équipement est conforme Canada limites d'exposition aux radiations dans un environnement non contrôlé. Cet équipement doit être installé et utilisé à distance minimum de 20cm entre le radiateur et votre corps.

1) The transmitter module may not be co-located with any other transmitter or antenna.

As long as 1 condition above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

1) Le module émetteur peut ne pas être coïmplanté avec un autre émetteur ou antenne.

Tant que les 1 condition ci-dessus sont remplies, des essais supplémentaires sur l'émetteur ne seront pas nécessaires. Toutefois, l'intégrateur OEM est toujours responsable des essais sur son produit final pour toutes exigences de conformité supplémentaires requis pour ce module installé.

IMPORTANT NOTE:

In the event that these conditions can not be met (for example certain laptop configurations or co-location with another transmitter), then the Canada authorization is no longer considered valid and the IC ID can not be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate Canada authorization.

NOTE IMPORTANTE:

Dans le cas où ces conditions ne peuvent être satisfaites (par exemple pour certaines configurations d'ordinateur portable ou de certaines co-localisation avec un autre émetteur), l'autorisation du Canada n'est plus considéré comme valide et l'ID IC ne peut pas être utilisé sur le produit final. Dans ces circonstances, l'intégrateur OEM sera chargé de réévaluer le produit final (y compris l'émetteur) et l'obtention d'une autorisation distincte au Canada.

End Product Labeling

The final end product must be labeled in a visible area with the following: "Contains IC: 3147A-LYRA24S".

Plaque signalétique du produit final

Le produit final doit être étiqueté dans un endroit visible avec l'inscription suivante: "Contient des IC: 3147A-LYRA24S".

Manual Information To the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.

The end user manual shall include all required regulatory information/warning as show in this manual.

Manuel d'information à l'utilisateur final

L'intégrateur OEM doit être conscient de ne pas fournir des informations à l'utilisateur final quant à la façon d'installer ou de supprimer ce module RF dans le manuel de l'utilisateur du produit final qui intègre ce module. Le manuel de l'utilisateur final doit inclure toutes les informations réglementaires requises et avertissements comme indiqué dans ce manuel.

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