



# Datasheet

## BL54L15 Series

*Version 1.1*

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## Revision History

| Version | Date         | Notes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Contributor(s) | Approver      |
|---------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|---------------|
| 0.1     | 10 June 2024 | Initial PRELIMINARY release.                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Raj Khatri     | Jonathan Kaye |
| 0.2     | 2 Oct 2024   | Updated pin list names and notes below table1.<br>Added section <b>External Antenna Integration with BL54L15 MHF4 variant (453-00044)</b><br>Added section on Programmability.                                                                                                                                                                                                                                                                                                                          | Raj Khatri     | Jonathan Kaye |
| 0.3     | 24 Oct 2024  | Removed Medium voltage mode (VDDM_nRF) from <b>Specification Summary</b> table and updated Normal voltage mode (VDD_nRF) operating range from 1.7V-2.6V to 1.7V-3.6V.<br>Updated <b>Block Diagram and Pin-out</b> for 39 connection pins.<br>Updated SCH symbol to remove pin40.<br>Updated pin list in <b>Table 1</b> (removed pin 40 VDDM_nRF).<br>Updated <b>BL54L15 Power Supply</b><br>Updated <b>Table 4</b> external antenna Mag Layers EDA-8709-2G4C1-B27-CY antenna gain from 2dBi to 2.32dBi. | Raj Khatri     | Jonathan Kaye |
| 0.4     | 6 Dec 2024   | Updated maximum Tx power to +7 dBm.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Dave Drogowski | Jonathan Kaye |
| 0.5     | 11 Dec 2024  | Updated <b>sensitivity value</b><br>Added trace antenna performance                                                                                                                                                                                                                                                                                                                                                                                                                                     | Louis Chang    | Jonathan Kaye |
| 0.6     | 16 Dec 2024  | Updated maximum Tx power to +6 dBm.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Louis Chang    | Jonathan Kaye |
| 1.0     | 16 Dec 2024  | Initial release                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Dave Drogowski | Jonathan Kaye |
| 1.1     | 19 Dec 2024  | Updated maximum Tx power to +7 dBm.                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Louis Chang    | Jonathan Kaye |
| 1.2     | 13 Jan 2025  | Updated title of <b>7.4</b><br>Updated some typo                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Louis Chang    |               |

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## 1 Overview and Key Features

Experience a new pinnacle of performance, efficiency, and security with our new BL54L15 series, built on Nordic Semiconductor's powerful **nRF54** silicon. Elevating what you know and love from the nRF52 series, this next generation redefines Bluetooth LE and 802.15.4 solutions. Unleashing enhanced processing power, expanded memory, and innovative peripherals, the BL54L15 is the ultimate choice for low power connectivity.

Powered by **Nordic's nRF54L15 SoC**, our compact BL54L15 modules deliver secure and robust Bluetooth LE and 802.15.4 with flexible programming via Nordic's nRF Connect SDK or Ezurio Canvas Software Suite.

Featuring a **128MHz ARM Cortex M33** and **128MHz RISC-V coprocessor**, supported by 1.5 MB non-volatile memory and 256 KB RAM, the BL54L15 modules offer double the processing power (vs prior BL654 – nRF52840). The BL54L15 series brings out all nRF54L15 hardware features and capabilities including up to **+7 dBm** transmit power, **1.7V – 3.6V** supply considerations, and **NFC A-Tag** implementation.

It's further enhanced with state-of-the-art security and is designed for PSA Certified level 3 and supports services such as Secure Boot, Secure Firmware Update, Secure Storage plus protection from physical attacks.

**Note:** BL54L15 hardware provides all functionality of the nRF54L15 chipset used in the module design. This is a hardware datasheet only – it does not cover the software aspects of the BL54L15. This is to acknowledge that information in this datasheet is referenced from the nRF54L15 datasheet.



### 1.1 Features and Benefits

- **Nordic nRF54L15** – 6x6 mm QFN48 with 31 GPIOs utilized.
- **Multi-protocol support:** Bluetooth 5.4 LE, 802.15.4 (Thread/Matter)
- **Cortex M33** processor core: 128 MHz ARM Cortex M33
- **RISC-V** co-processor core: 128 MHz VPR
- **Memory:** 1.5MB non-volatile memory, 256 KB RAM
- **High Speed Peripherals:** - HS-SPI/UART, software defined peripherals on 128 MHz VPR, GPIO - 1x 64 MHz Port, 1.7 – 3.6V, 11 GPIOs
- **Low Leakage Peripherals:** 2x QDEC, 7x Timer, Global RTC, 2x WDT, NFC A-Tag, TEMP, I2S, COMP, 3x PWM, LPCOMP, 14-bit 8CH ADC, 5x TWI/SPI/UART, GPIO (2x 16 MHz Port (P0, P1), 20 GPIO's, 1.7-3.6V, 31 GPIO)
- **Antenna choice** – integrated pre-certified **PCB Trace antenna** or external antenna support via **MHF4 connector**
- **Ultra-small footprint** (14 mm x 10 mm x 1.6 mm)
- **Extended Industrial Temperature Rating** (-40° to +105 °C)
- **Bluetooth LE:** Peripheral/Central, 2 Mbps (high throughput), LE Coded (long range), AoA/AoD, Mesh
- **Firmware Over the Air (FOTA)** via MCUboot and nRF Connect SDK
- **Hostless operation** – Multi Core MCU reduces BOM
- **Fully featured development kits** to jump start Bluetooth LE development
- Mechanically same form factor as **BL652 Series**

### 1.2 Application Areas

- Building Automation
- Security
- Medical Peripherals
- Industrial Sensors

## 2 Specification

### 2.1 Specification Summary

| Categories/Feature                                           | Implementation                                                                                                                                                                                                                                                                                                                                                                                                          |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
|--------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|--------------------------------------|------------|----------------------------------------|--------------|------------------|--------------|-----------------|----------------------------|-----------------|
| <b>Wireless Specification</b>                                |                                                                                                                                                                                                                                                                                                                                                                                                                         |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| Bluetooth®                                                   | Bluetooth 5.4 – Single mode <ul style="list-style-type: none"> <li>GATT client/server – Any adopted/custom services</li> <li>Central/Peripheral roles</li> <li>Bluetooth LE mesh</li> <li>2M PHY</li> <li>LE Coded PHY</li> <li>LE Advertising Extensions</li> <li>LE secure connections</li> <li>Data packet length extensions</li> <li>LE privacy v1.2</li> <li>LE ping</li> <li>DTM Firmware (Test Modes)</li> </ul> |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| IEEE 802.15.4-2006 PHY                                       | 2405–2480 MHz IEEE 802.15.4-2006 radio transceiver, implementing IEEE 802.15.4-2006 compliant <ul style="list-style-type: none"> <li>250kbps, 2450MHz, O-QPSK PHY</li> <li>Channels 11-26. Channel 11 2405MHz and CH26 2480MHz.</li> <li>Clear channel assessment (CCA)</li> <li>Energy detection (ED) scan</li> <li>CRC generation</li> </ul>                                                                          |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| Nordic proprietary 1Mbps, 2Mbps, 4Mbps modes radio           | 2402–2480 MHz Nordic proprietary 1Mbps and 2Mbps modes radio transceiver <ul style="list-style-type: none"> <li>1Mbps nRF proprietary mode (ideal transmitter)</li> <li>2Mbps nRF proprietary mode (ideal transmitter)</li> <li>4Mbps nRF proprietary mode (ideal transmitter)</li> </ul>                                                                                                                               |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| Frequency                                                    | 2.402 - 2.480 GHz for BLE (CH0 to CH39)<br>2.405 - 2.480 GHz for IEEE 802.15.4-2006 PHY (CH11 to CH26)                                                                                                                                                                                                                                                                                                                  |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| Raw Data Rates                                               | 1 Mbps BLE (over-the-air)<br>2 Mbps BLE (over-the-air)<br>125 kbps BLE (over-the-air)<br>500 kbps BLE (over-the-air)<br>250 kbps IEEE 802.15.4-2006 (over-the-air)<br>Nordic proprietary 1Mbps, 2Mbps and 4Mbps modes (over-the-air)                                                                                                                                                                                    |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| Maximum Transmit Power Setting                               | +7 dBm Conducted 453-00001 (Integrated antenna) (Exclude antenna gain)<br>+7 dBm Conducted 453-00044 (External antenna) (Test at MHF4 connector)                                                                                                                                                                                                                                                                        |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| Minimum Transmit Power Setting                               | -8 dBm (to +7dBm in <1dB steps)                                                                                                                                                                                                                                                                                                                                                                                         |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| Receive Sensitivity <sup>1</sup><br>(≤37byte packet for BLE) | <table> <tr><td>BLE 1 Mbps (BER=1E-3)</td><td>-94 dBm typical</td></tr> <tr><td>BLE 2 Mbps</td><td>-92 dBm typical</td></tr> <tr><td>BLE 125 kbps</td><td>-102 dBm typical</td></tr> <tr><td>BLE 500 kbps</td><td>-98 dBm typical</td></tr> <tr><td>IEEE 802.15.4-2006 250kbps</td><td>TBD dBm typical</td></tr> </table>                                                                                               | BLE 1 Mbps (BER=1E-3) | -94 dBm typical                      | BLE 2 Mbps | -92 dBm typical                        | BLE 125 kbps | -102 dBm typical | BLE 500 kbps | -98 dBm typical | IEEE 802.15.4-2006 250kbps | TBD dBm typical |
| BLE 1 Mbps (BER=1E-3)                                        | -94 dBm typical                                                                                                                                                                                                                                                                                                                                                                                                         |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| BLE 2 Mbps                                                   | -92 dBm typical                                                                                                                                                                                                                                                                                                                                                                                                         |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| BLE 125 kbps                                                 | -102 dBm typical                                                                                                                                                                                                                                                                                                                                                                                                        |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| BLE 500 kbps                                                 | -98 dBm typical                                                                                                                                                                                                                                                                                                                                                                                                         |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| IEEE 802.15.4-2006 250kbps                                   | TBD dBm typical                                                                                                                                                                                                                                                                                                                                                                                                         |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| Link Budget (conducted)                                      | <table> <tr><td>101 dB</td><td>@ BLE 1 Mbps (TX power used is 7dBm)</td></tr> <tr><td>109 dB</td><td>@ BLE 125 kbps (TX power used is 7dBm)</td></tr> </table>                                                                                                                                                                                                                                                          | 101 dB                | @ BLE 1 Mbps (TX power used is 7dBm) | 109 dB     | @ BLE 125 kbps (TX power used is 7dBm) |              |                  |              |                 |                            |                 |
| 101 dB                                                       | @ BLE 1 Mbps (TX power used is 7dBm)                                                                                                                                                                                                                                                                                                                                                                                    |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| 109 dB                                                       | @ BLE 125 kbps (TX power used is 7dBm)                                                                                                                                                                                                                                                                                                                                                                                  |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| <b>NFC</b>                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                         |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |
| NFC-Type A Listen mode compliant                             | <b>Based on NFC forum specification:</b> 13.56 MHz, Data rate 106 kbps, NFC Type2 and Type 4 emulation<br><b>Modes of Operation:</b> Disable, Sense, Activated<br><b>Use Cases:</b> Touch-to-Pair with NFC, NFC enabled Out-of-Band Pairing                                                                                                                                                                             |                       |                                      |            |                                        |              |                  |              |                 |                            |                 |

*Note<sup>1</sup> Known Noise on channels 2432MHz and 2464MHz degrades receiver sensitivity, in which sensitivity are not within the typical value*

| Security                             | Designed for PSA Certified Level 3 with Secure Boot, Secure Firmware Update, and Secure Storage. Integrated tamper sensors detect attacks and take action, and cryptographic accelerators are hardened against side-channel attacks. |                                                                                                                                                                                                                                                                                              |
|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Host Interfaces and Peripherals      | Application Core (High Performance)                                                                                                                                                                                                  | Software defined peripheral Core (ultra-low power)                                                                                                                                                                                                                                           |
| Total                                |                                                                                                                                                                                                                                      | 31 x multifunction I/O lines                                                                                                                                                                                                                                                                 |
| Two co-processors                    | Arm Cortex-M33 with DSP, FPU, TrustZone support.<br>1524KB non-volatile RRAM<br>256KB RAM<br>L1 cache<br>128MHz clock<br>Uses voltage and clock frequency scaling                                                                    | RISC-V CPU (VPR) fast lightweight peripheral processor (FLPR) dedicated for software defined peripherals<br><br><br><br><br>16MHz clock                                                                                                                                                      |
| GPIO                                 |                                                                                                                                                                                                                                      | Up to 31 multifunction GPIO's                                                                                                                                                                                                                                                                |
|                                      | 64MHz 1.7-3.6V GPIO port<br>P2.00-P2.10                                                                                                                                                                                              | 16MHz 1.7-3.6V GPIO port<br>P1.00-P1.14;<br>P0.00-P0.04                                                                                                                                                                                                                                      |
| ADC (14-bit)                         | 14-bit 20KS/s with oversampling<br>12-bit 250KS/s<br>10-bit 2MS/s<br>AINO-AIN7 pins upto 8 programmable gain channels                                                                                                                |                                                                                                                                                                                                                                                                                              |
| Global RTC (GRTC)                    |                                                                                                                                                                                                                                      | Implements full real time clock and calendar as shared system time. Can run in System OFF mode.<br><br>Ultra low power, 1us resolution, 52bits wide, uses 16MHz clock, 32.76kHz when other power modes.                                                                                      |
| RTC                                  |                                                                                                                                                                                                                                      | 2x low power runs off LFCLK                                                                                                                                                                                                                                                                  |
| High Speed SPI/UART                  | 1 x                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                              |
| SPI/UART/TWI                         |                                                                                                                                                                                                                                      | 4x                                                                                                                                                                                                                                                                                           |
| PWM                                  |                                                                                                                                                                                                                                      | 3x 4channel PWM                                                                                                                                                                                                                                                                              |
| I2S                                  |                                                                                                                                                                                                                                      | 1x I2S (Inter-IC sound interface)                                                                                                                                                                                                                                                            |
| PDM                                  |                                                                                                                                                                                                                                      | 1x PDM (Pulse code modulation interface) for digital microphones                                                                                                                                                                                                                             |
| TIMER                                |                                                                                                                                                                                                                                      | 7x Timer (32bit)                                                                                                                                                                                                                                                                             |
| QDEC                                 |                                                                                                                                                                                                                                      | 2x QDEC (Quadrature decoder)                                                                                                                                                                                                                                                                 |
| COMP                                 |                                                                                                                                                                                                                                      | 1x COMP (comparator)                                                                                                                                                                                                                                                                         |
| LPCOMP                               |                                                                                                                                                                                                                                      | 1x LPCOMP (low power comparator)                                                                                                                                                                                                                                                             |
| TEMP                                 |                                                                                                                                                                                                                                      | 1x Temperature sensor<br>Temperature range equal to operating temperature range                                                                                                                                                                                                              |
| WDT                                  |                                                                                                                                                                                                                                      | 2x WDT (Watchdog timer)                                                                                                                                                                                                                                                                      |
| NFC A-Tag                            |                                                                                                                                                                                                                                      | 1x                                                                                                                                                                                                                                                                                           |
| Wakeup pins                          |                                                                                                                                                                                                                                      | 20x                                                                                                                                                                                                                                                                                          |
| External optional 32.768 kHz crystal |                                                                                                                                                                                                                                      | Not needed for normal radio operation.<br><br>Optionally, connect +/-20ppm accuracy crystal for more accurate protocol timing. Fit associated load capacitor for crystal or use nRF54L15 internal load capacitor, which is configurable as TBD pF to TBD pF in TBDpF steps on pins XL1, XL2. |
| Security                             | Designed for PSA Certified Level 3 with Secure Boot, Secure Firmware Update, and Secure Storage. Integrated tamper sensors detect attacks and take action, and cryptographic accelerators are hardened against side-channel attacks. |                                                                                                                                                                                                                                                                                              |

| Programmability                                                        |                                                                                                                                                                                                                                                                                                                   | Via SWD (JTAG) 2 wire interface |  |
|------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|--|
| Options                                                                | Nordic nRFConnect SDK: Software/Support available from Nordic directly <a href="https://devzone.nordicsemi.com/">https://devzone.nordicsemi.com/</a><br>Canvas SW Suite: Software/ Support available from <a href="https://www.ezurio.com/canvas/software-suite">https://www.ezurio.com/canvas/software-suite</a> |                                 |  |
| FW upgrade                                                             | Via SWD (JTAG) 2 wire interface or UART                                                                                                                                                                                                                                                                           |                                 |  |
| Supply Voltage                                                         | Normal Voltage Mode (VDD, VDDM_nRF): 1.7V-3.6V (Internal DCDC convertor or LDO)                                                                                                                                                                                                                                   |                                 |  |
| Power Consumption                                                      |                                                                                                                                                                                                                                                                                                                   |                                 |  |
| Active Modes Peak Current (for maximum Tx power +7dBm)<br>– Radio only | TBD mA peak Tx (with DCDC)                                                                                                                                                                                                                                                                                        |                                 |  |
| Active Modes Peak Current (for Tx power -8dBm) – Radio only            | TBD mA peak Tx (with DCDC)                                                                                                                                                                                                                                                                                        |                                 |  |
| Active Modes Average Current                                           | Depends on many factors.                                                                                                                                                                                                                                                                                          |                                 |  |
| Ultra-low Power Modes                                                  | System ON Idle                                                                                                                                                                                                                                                                                                    | TBD uA (wake on any event)      |  |
|                                                                        | System OFF                                                                                                                                                                                                                                                                                                        | TBD uA (wake on reset)          |  |
| Antenna Options                                                        |                                                                                                                                                                                                                                                                                                                   |                                 |  |
| Internal                                                               | PCB Trace antenna – on-board (453-00001 variant)                                                                                                                                                                                                                                                                  |                                 |  |
| External                                                               | Connection via on module IPEX MHF4 (453-00044 variant)                                                                                                                                                                                                                                                            |                                 |  |
| Physical                                                               |                                                                                                                                                                                                                                                                                                                   |                                 |  |
| Dimensions                                                             | 14mm x 10mm x 1.6mm<br>Pad Pitch – 0.75 mm<br>Pad Type – Three rows of pads (LGA - Land Grid Array).                                                                                                                                                                                                              |                                 |  |
| Weight                                                                 | <1 gram                                                                                                                                                                                                                                                                                                           |                                 |  |
| Environmental                                                          |                                                                                                                                                                                                                                                                                                                   |                                 |  |
| Operating                                                              | -40 °C to +105 °C                                                                                                                                                                                                                                                                                                 |                                 |  |
| Storage                                                                | -40 °C to +105 °C                                                                                                                                                                                                                                                                                                 |                                 |  |
| Miscellaneous                                                          |                                                                                                                                                                                                                                                                                                                   |                                 |  |
| Lead Free                                                              | Lead-free and RoHS compliant                                                                                                                                                                                                                                                                                      |                                 |  |
| Warranty                                                               | One-Year Warranty                                                                                                                                                                                                                                                                                                 |                                 |  |
| Development Tools                                                      |                                                                                                                                                                                                                                                                                                                   |                                 |  |
| Development Kit                                                        | Development kit per module SKU (453-00001-K1 and 453-00044-K1 respectively)                                                                                                                                                                                                                                       |                                 |  |
| Development Tools                                                      | Nordic nRFConnect - Android and iOS applications<br>UART firmware upgrade<br>Xbit Tools and utilities                                                                                                                                                                                                             |                                 |  |
| Bluetooth®                                                             | Full Bluetooth SIG Declaration ID                                                                                                                                                                                                                                                                                 |                                 |  |
| FCC/ISED/CE/MIC/RCM/UKCA                                               | All BL54L15 Series                                                                                                                                                                                                                                                                                                |                                 |  |

## 3 Hardware Specifications

### 3.1 Block Diagram and Pin-out

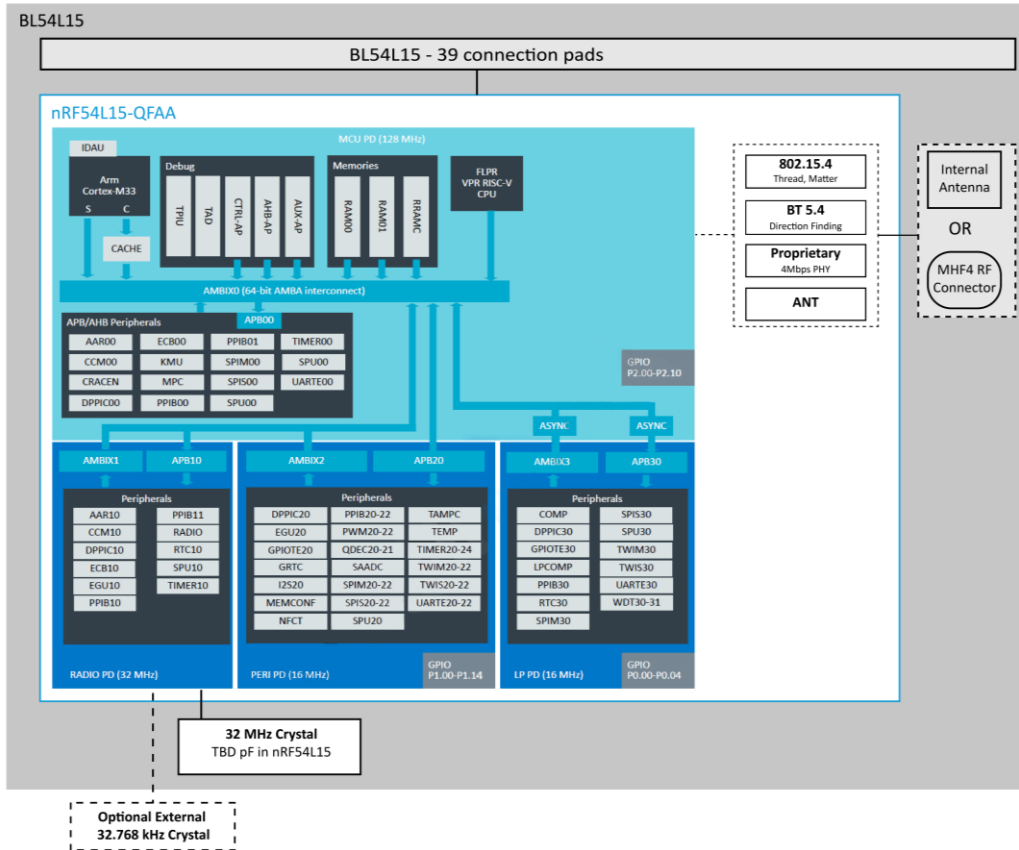


Figure 1: BL54L15 HW block diagram

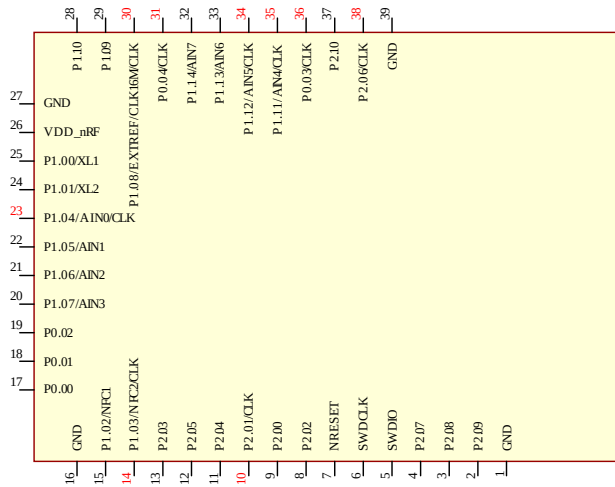


Figure 2: Top view - Schematic symbol for 453-00001 BL54L15 Module (Nordic nRF54L15) - Integrated PCB Trace Antenna variant or 453-00044 MHF4 RF connector variant

### 3.2 Pin Definitions

Table 1: Pin definitions

| Pin # | Pin Name (red coloured pins for clock for interfaces, trace) | nRF54L15 QFN48 Pin | nRF54L15 QFN48 Name            | Description                                                                            | Example usage                                              |
|-------|--------------------------------------------------------------|--------------------|--------------------------------|----------------------------------------------------------------------------------------|------------------------------------------------------------|
| 1     | GND                                                          | -                  | VSS                            |                                                                                        |                                                            |
| 2     | P2.09                                                        | 20                 | P2.09/TRACEDATA[2]/SPI.SDI/SDO | General purpose I/O<br>Trace data<br>SPIM SDI<br>SPIS SDI<br>UARTE CTS                 | Trace<br>SPIM00/SPIM21<br>SPIS00/SPIS21<br>UARTE00/UARTE21 |
| 3     | P2.08                                                        | 19                 | P2.08/TRACEDATA[1]/SPI.SDI/SDO | General purpose I/O<br>Trace data<br>SPIM SDO<br>SPIS SDO<br>UARTE TXD                 | Trace<br>SPIM00/SPIM21<br>SPIS00/SPIS21<br>UARTE00/UARTE21 |
| 4     | P2.07                                                        | 18                 | P2.07/TRACEDATA[0]/SWO/SPI.DCX | General purpose I/O<br>Trace data<br>Serial wire output (SWO)<br>SPIM DCX<br>UARTE RXD | Trace<br>Trace<br>SPIM00/SPIM21<br>UARTE00/UARTE21         |
| 5     | SWDIO                                                        | 25                 | SWDIO                          | Serial Wire Debug IO for debug and programming                                         |                                                            |
| 6     | SWDCLK                                                       | 26                 | SWDCLK                         | Serial Wire Debug clock input for debug and programming                                |                                                            |
| 7     | NRESET                                                       | 30                 | nRESET                         | Pin RESET with internal pull-up resistor (13k Ohms).<br>System Reset (Active Low).     |                                                            |

| Pin # | Pin Name (red coloured pins for clock for interfaces, trace) | nRF54L15 QFN48 Pin | nRF54L15 QFN48 Name | Description                                                                                     | Example usage                                                      |
|-------|--------------------------------------------------------------|--------------------|---------------------|-------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| 8     | P2.02                                                        | 13                 | P2.02/SPI.SDI/SDO   | General purpose I/O<br>SPIM SDO<br>SPIS SDO<br>UARTE TXD<br>QSPI D0<br>Serial wire output (SWO) | SPIM00/SPIM20<br>SPIS00/SPIS20<br>UARTE00/UARTE20<br>FLPR<br>Trace |
| 9     | P2.00                                                        | 11                 | P2.00/SPI.DCX       | General purpose I/O<br>SPIM DCX<br>UARTE RXD<br>QSPI D3                                         | SPIM00/SPIM20<br>UARTE00/UARTE20<br>FLPR (QSPI)                    |
| 10    | P2.01/CLK                                                    | 12                 | P2.01/SPI.SCK       | General purpose I/O<br>SPIM SCK<br>SPIS SCK<br>QSPI SCK                                         | <b>Clock pin</b><br>SPIM00/SPIM20<br>SPIS00/SPIS20<br>FLPR         |
| 11    | P2.04                                                        | 15                 | P2.04/SPI.SDI/SDO   | General purpose I/O<br>SPIM SDI<br>SPIS SDI<br>UARTE CTS<br>QSPI D1                             | SPIM00/SPIM20<br>SPIS00/SPIS20<br>UARTE00/UARTE20<br>FLPR          |
| 12    | P2.05                                                        | 16                 | P2.05/SPI.CS        | General purpose I/O<br>SPIM CS<br>UARTE RTS<br>QSPI CS                                          | SPIM00/SPIM20<br>UARTE00/UARTE20<br>FLPR                           |
| 13    | P2.03                                                        | 14                 | P2.03               | General purpose I/O<br>QSPI D2                                                                  | FLPR                                                               |
| 14    | P1.03/NFC2/CLK                                               | 4                  | P1.03/NFC2          | General purpose I/O<br>Dedicated pin for NFC input                                              | <b>Clock pin</b>                                                   |
| 15    | P1.02/NFC1                                                   | 3                  | P1.02/NFC1          | General purpose I/O<br>Dedicated pin for NFC input                                              |                                                                    |
| 16    | GND                                                          |                    |                     |                                                                                                 |                                                                    |
| 17    | P0.00                                                        | 23                 | P0.00               | General purpose I/O                                                                             |                                                                    |
| 18    | P0.01                                                        | 24                 | P0.01               | General purpose I/O                                                                             |                                                                    |
| 19    | P0.02                                                        | 27                 | P0.02               | General purpose I/O                                                                             |                                                                    |
| 20    | P1.07/AIN3                                                   | 8                  | P1.07/AIN3/TAMPC    | General purpose I/O<br>TAMPC active shield 1 input<br>Analog input                              | TAMPC                                                              |
| 21    | P1.06/AIN2                                                   | 7                  | P1.06/AIN2/TAMPC    | General purpose I/O<br>TAMPC active shield 1 output<br>Analog input                             | TAMPC                                                              |
| 22    | P1.05/AIN1                                                   | 6                  | P1.05/AIN1/TAMPC    | General purpose I/O<br>TAMPC active shield 0 input<br>RADIO DFEGPIO<br>Analog input             | TAMPC<br>RADIO                                                     |
| 23    | P1.04/AIN0/CLK                                               | 5                  | P1.04/AIN0/TAMPC    | General purpose I/O<br>TAMPC active shield 0 output<br>Analog input                             | <b>Clock pin</b><br>TAMPC                                          |
| 24    | P1.01/XL2                                                    | 2                  | P1.01/XL2           | General purpose I/O                                                                             | Ezurio Devkit: Optional 32.768kHz crystal pad XL2, XL1 and         |

| Pin # | Pin Name (red coloured pins for clock for interfaces, trace) | nRF54L15 QFN48 Pin | nRF54L15 QFN48 Name        | Description                                                                                                              | Example usage                                                                                                     |
|-------|--------------------------------------------------------------|--------------------|----------------------------|--------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
|       |                                                              |                    |                            | General purpose I/O<br>Connection for 32.768kHz crystal                                                                  | associated 9pF load capacitor inside nRF54L15 chipset.                                                            |
| 25    | P1.00/XL1                                                    | 1                  | P1.00/XL1                  | General purpose I/O<br>Connection for 32.768kHz crystal                                                                  | Ezurio Devkit: Optional 32.768kHz crystal pad XL2, XL1 and associated 9pF load capacitor inside nRF54L15 chipset. |
| 26    | VDD_nRF                                                      | 48                 | VDD                        | 1.7V-3.6V input for Normal Voltage Mode where connect external supply to VDD_nRF(pin26).<br>See 3.5 BL54L15 Power Supply |                                                                                                                   |
| 27    | GND                                                          |                    |                            |                                                                                                                          |                                                                                                                   |
| 28    | P1.10                                                        | 38                 | P1.10/TAMPC                | General purpose I/O<br>TAMPC active shield 2 input<br>RADIO DFEGPIO                                                      | TAMPC<br>RADIO                                                                                                    |
| 29    | P1.09                                                        | 37                 | P1.09/TAMPC                | General purpose I/O<br>TAMPC active shield 2 output<br>RADIO DFEGPIO                                                     | TAMPC<br>RADIO                                                                                                    |
| 30    | P1.08/EXTREF/CLK16M/CLK                                      | 9                  | P1.08/CLK16M/TAMPC         | General purpose I/O<br>GRTC HF clock output<br>External reference for SAADC                                              | Clock pin                                                                                                         |
| 31    | P0.04/CLK                                                    | 29                 | P0.04/GRTC_CLKOUT32K       | General purpose I/O<br>GRTC LF clock output                                                                              | Clock pin<br>GRTC                                                                                                 |
| 32    | P1.14/AIN7                                                   | 42                 | P1.14/AIN7                 | General purpose I/O<br>RADIO DFEGPIO<br>Analog input                                                                     | RADIO                                                                                                             |
| 33    | P1.13/AIN6                                                   | 41                 | P1.13/AIN6                 | General purpose I/O<br>RADIO DFEGPIO<br>Analog input                                                                     | RADIO                                                                                                             |
| 34    | P1.12/AIN5/CLK                                               | 40                 | P1.12/AIN5                 | General purpose I/O<br>TAMPC active shield 3 input<br>RADIO DFEGPIO<br>Analog input                                      | Clock pin<br>TAMPC<br>RADIO                                                                                       |
| 35    | P1.11/AIN4/CLK                                               | 39                 | P1.11/AIN4                 | General purpose I/O<br>TAMPC active shield 3 output<br>RADIO DFEGPIO<br>Analog input                                     | Clock pin<br>TAMPC<br>RADIO                                                                                       |
| 36    | P0.03/CLK                                                    | 28                 | P0.03/GRTC_PWMOUT          | General purpose I/O<br>GRTC PWM output                                                                                   | Clock pin<br>GRTC                                                                                                 |
| 37    | P2.10                                                        | 21                 | P2.10/TRACEDATA[3]/SPIM.CS | General purpose I/O<br>Trace<br>SPIM CS<br>UARTE RTS                                                                     | Trace<br>SPIM00/SPIM21<br>UARTE00/UARTE21                                                                         |
| 38    | P2.06/CLK                                                    | 17                 | P2.06/TRACECLK/SPI.SCK     | General purpose I/O<br>SPIM SCK<br>SPIS SCK<br>Trace clock                                                               | Clock pin<br>SPIM00/SPIM21<br>SPIS00/SPIS21<br>Trace                                                              |
| 39    | GND                                                          |                    |                            |                                                                                                                          |                                                                                                                   |

Pin Definition Notes:

| Pin #                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Pin Name (red coloured pins for clock for interfaces, trace) | nRF54L15 QFN48 Pin | nRF54L15 QFN48 Name | Description | Example usage |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|--------------------|---------------------|-------------|---------------|
| <p><b>Note 1</b> <b>GPIO</b> = General Input or Output (GPIO level voltage tracks VDD pin). AIN =Analog input.</p> <p>If GPIO is selected as an input, ensure the input is not floating (which can cause current consumption to drive with time in low power modes (such as System ON Idle), by selecting the internal pull up or pull down.</p> <p><b>Must connect all GND pads to host board PCB GND plane.</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                              |                    |                     |             |               |
| <p><b>Note2</b> <b>Clock for serial interfaces or trace</b></p> <p>Some peripherals (SPI, TWI, PDM, I2S, TRACE, GRTC) have clock signals. Dedicated clock pins have been optimized to ensure correct timing relationship between clock and data signal for these peripherals. Pins that can be used as clock signals are shown with pin name in red colour.</p> <p>The peripheral data signal must be configured to use pins close to the clock pin. This ensures that the internal paths from the peripheral to the pin have the same delay, so that the data and clock signals reach the pins at the same time.</p> <p>For high-speed signals, the printed circuit board (PCB) layout must use short PCB traces of identical length. This makes sure any delays are kept to a minimum and it assures close to identical delay and clock path.</p>                                                                                                                                                                                                                                                                                                                             |                                                              |                    |                     |             |               |
| <p><b>Note 3</b> <b>Dedicated pins</b></p> <p><b>UARTE20/21:</b> Can use any pin son GPIO port P1. Can be connected across power domains to dedicated pin on P2.</p> <p><b>SPIM00:</b> Has dedicated pins on GPIO port P2. For 32MHz operation, the pins must be configured using extra high drive E0/E1 configuration.</p> <p><b>SPIM20/21:</b> Can use any pin son GPIO port P1. Can be connected across power domains to dedicated pin on P2.</p> <p><b>SPI520/21:</b> Can use any pin son GPIO port P1. Can be connected across power domains to dedicated pin on P2.</p> <p><b>TRACE:</b> Has dedicated pins on GPIO port P2. For 32MHz operation, the pins must be configured using extra high drive E0/E1 configuration.</p> <p><b>GRTC:</b> Has dedicated pins for clock and PWM output.</p> <p><b>TAMPC:</b> Has dedicated pins for active shield inputs and outputs.</p> <p><b>FLPR:</b> Uses dedicated pins on GPIO port P2 for emulated peripherals such as QSPI.</p> <p><b>RADIO:</b> Uses dedicated pins on GPIO port P1 for antenna switch control (DFEGPIO for direction finding).</p> <p><b>NFC:</b> Uses dedicated pins listed in pin definitions table1.</p> |                                                              |                    |                     |             |               |
| <p><b>Note 4</b> <b>SWDIO / SWCLK / nRESET / VDD / GND</b></p> <p>Customer MUST bring out SWDIO, SWCLK, nRESET, VDD, GND for programming purposes.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                              |                    |                     |             |               |

### 3.3 Electrical Specifications

#### 3.3.1 Absolute Maximum Ratings

Absolute maximum ratings are the extreme limits for supply voltage and voltages on digital and analogue pins of the module are listed below; exceeding these values causes permanent damage.

Table 2: Absolute maximum ratings

| Parameter                         | Min                 | Max  | Unit               |
|-----------------------------------|---------------------|------|--------------------|
| <b>Supply Voltages</b>            |                     |      |                    |
| VDD_nRF                           | TBD                 | TBD  | V                  |
| Voltage at GND pin                | TBD                 | 0    | V                  |
| <b>I/O pin voltage</b>            |                     |      |                    |
| Voltage at GPIO pin (at VDD≤3.6V) | TDB                 | TBD  | V                  |
| NFC antenna pin current (NFC1/2)  | -                   | TBD  | mA                 |
| Radio RF input level              | -                   | TBD  | dBm                |
| <b>Environmental</b>              |                     |      |                    |
| Storage temperature               | -40                 | +105 | °C                 |
| MSL (Moisture Sensitivity Level)  | -                   | 4    | -                  |
| <b>ESD (as per EN301-489)</b>     |                     |      |                    |
| Conductive                        |                     | 4    | kV                 |
| Air Coupling                      |                     | 8    | kV                 |
| Flash Memory (Endurance) (Note 2) | TBD                 |      | Write/erase cycles |
| Flash Memory (Retention)          | TBD years at TBD °C |      | years at TBD °C    |

**Absolute maximum Ratings Notes:**

**Note 1** The absolute maximum rating for VDD pin (max) is TBD V for the BL54L15.

**Note 2** Wear levelling can be implemented by customer.

### 3.3.2 Recommended Operating Parameters

**Table 3: Power supply operating parameters**

| Parameter                                                                                          | Min | Typ | Max  | Unit |
|----------------------------------------------------------------------------------------------------|-----|-----|------|------|
| VDD_nRF (independent of DCDC) supply range                                                         | 1.7 |     | 3.6  | V    |
| VDD Maximum ripple or noise (See <a href="#">Note 1</a> )                                          | -   | -   | 10   | mV   |
| Time in Power-on reset after supply reaches minimum operating voltage, depend on supply rise time. |     |     |      |      |
| VDD supply rise time (0V to 1.7V) <sup>2</sup> 10uS                                                | -   | TBD | TBD  | mS   |
| VDD supply rise time (0V to 1.7V) <sup>2</sup> >10mS                                               | -   | TBD | TBD  | mS   |
| Operating Temperature Range                                                                        | -40 | +25 | +105 | °C   |

**Recommended Operating Parameters Notes:**

**Note 1** This is the maximum VDD\_nRF ripple or noise (at any frequency) that does not disturb the radio.

**Note 2** The on-board power-on reset circuitry may not function properly for rise times longer than the specified maximum.

## 3.4 Clocks

### 3.4.1 HFXO - 32MHz crystal oscillator and nRF54L15 internal load capacitor TBD pF mandatory setting

The BL54L15 module contains the 32 MHz crystal, but the load capacitors to create 32MHz crystal oscillator circuit are inside the nRF54L15 chipset. Customer **MUST** set the internal nRF54L15 capacitors to TBD pF (for proper operation of the 32 MHz crystal circuit).

The 32 MHz crystal inside the BL54L15 module is a high accuracy crystal ( $\pm 15$  ppm at room temperature) that helps with radio operation and reducing power consumption in the active modes.

### 3.4.2 LFCLK – Low Frequency clock source

There are four possibilities (see figure 5) for the low frequency clock (LFCLK) and options are:

**LFRC (32.768kHz RC oscillator):** The internal 32.768 kHz RC oscillator (LFRC) is fully embedded in nRF54L15 (and does not require additional external components) with an accuracy  $\pm 250$  ppm (after calibration of LFRC at least every eight seconds using the HFXO as a reference oscillator).

**LFXO (32.768kHz crystal oscillator):** For higher LFCLK accuracy (greater than  $\pm 250$ ppm accuracy is required), the low frequency crystal oscillator (LFXO) must be used. To use LFXO, a 32.768kHz crystal must be connected between the XL1 and XL2 pins and the load capacitance between each crystal terminal and ground. Optionally internal (to nRF54L15) capacitor of maximum TBDpF in TBDpF steps are provided on pins XL1 and XL2.

**Low frequency (32.768 kHz) external source:** The 32.768 kHz oscillator (LFXO) is designed to work with external sources

**LFSYNTH (32.768kHz Synthesised clock) from HFCLK (LFSYNTH):** The LFCLK can be synthesised from the HFCLK source. LFSYNTH depends on the HFCLK to run. The accuracy of the LFCLK clock with LFSYNTH as a source assumes the accuracy of the HFCLK. If high accuracy is required, the HFCLK must generated from the HFXO. Using the LFSYNTH clock removes the requirement for an external 32.768kHz crystal but the increases the average power consumption as the HFCLK will turned on in the system.

### 3.4.3 Other Internal Clocks

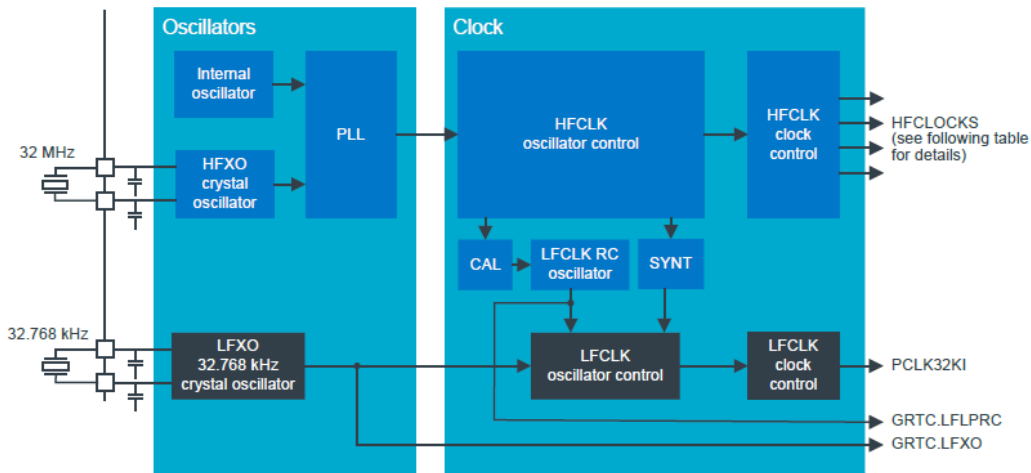


Figure 3: nRF54L15 Clock System Overview (adapted from Nordic)

### 3.5 BL54L15 Power Supply

Normal voltage mode power supply mode is entered when the external supply voltage (1.7V-3.6V) is connected to both VDD\_nRF pin (pin26). See Figure 4.

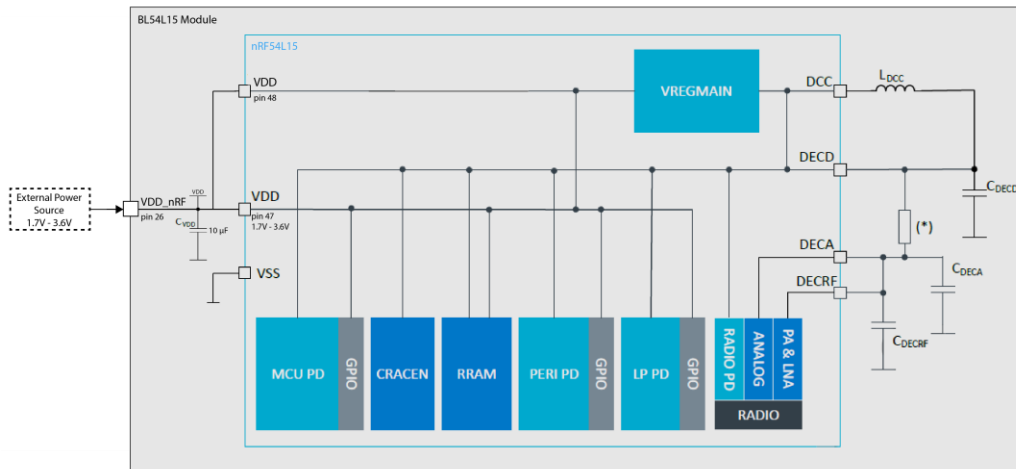


Figure 4: Normal Voltage Mode

## 4 Programmability

### 4.1 BL54L15 Default Firmware

The BL54L15 module is shipped from Ezurio manufacturing facilities with no firmware programmed.

### 4.2 BL54L15 Firmware Options

Firmware for use with the BL54L15 can be divided into the following types.

- **Bootloader** – This is the application that resides on the Application Core used to perform firmware updates of the Application and FLPR cores.

The MCU Boot or Trusted Firmware M Bootloaders are recommended to be used as the basis for the BL54L15 Bootloader functionality.

- **Application** – This is the main application running on the Application core. It interfaces with the integrated radio stack(s) and provides supplementary functionality in addition to the time critical activities performed for radio activity.
- **Software Defined Peripheral** – This is the application running on the RISC-V FLPR core.

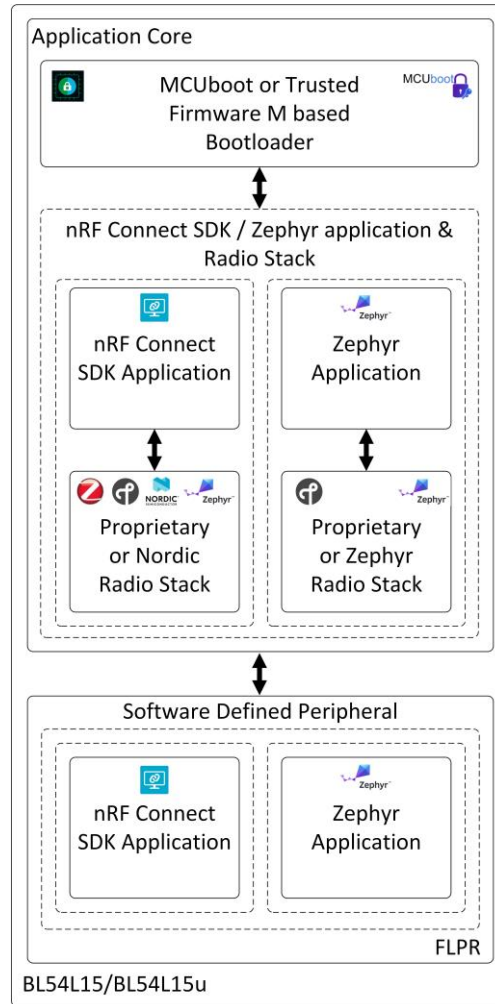


Figure 5: Functional SW block diagram for BL54L15 series module

## 5 Peripherals

| Feature     |                                                       | Module          |               |
|-------------|-------------------------------------------------------|-----------------|---------------|
|             |                                                       | BL54L15         | BL54L15u      |
|             |                                                       | nRF54L15-QFAA   | nRF54L15-CAAA |
| Memory      | Non-volatile memory (RRAM)                            | 1524 KB         |               |
|             | Random access memory (RAM)                            | 256 KB          |               |
| Radio       | Bluetooth Low Energy                                  | Yes             |               |
|             | Bluetooth Low Energy Coded PHY (Long range)           | Yes             |               |
|             | Bluetooth Constant Tone Extension (Direction-finding) | Yes             |               |
|             | IEEE 802.15.4                                         | Yes             |               |
| GPIO pins   | GPIO pins                                             | 31              | 32            |
|             | Wakeup-pins                                           | 20              | 21            |
|             | Analog input pins                                     | 8               |               |
|             | GPIO voltage                                          | VDD (1.7V-3.6V) |               |
| Peripherals | Timers (TIMER)                                        | 7               |               |
|             | Real-time counter (RTC)                               | 2               |               |
|             | Global real-time counter (GRTC)                       | Yes             |               |
|             | Serial interfaces (UART, SPI, TWI)                    | 5               |               |
|             | Temperature sensor                                    | Yes             |               |
|             | Comparator (COMP)                                     | Yes             |               |
|             | Analog-to-digital converter (ADC)                     | Yes             |               |
|             | Quadrature decoder (QDEC)                             | 2               |               |
|             | Inter-IC sound interface (I2S)                        | 2               |               |
|             | Near-field communication (NFC)                        | Yes             |               |
|             | Pulse density modulation interface (PDM)              | 2               |               |
|             | Pulse-width modulator (PWM)                           | 3               |               |
|             | Watchdog timer (WDT)                                  | 2               |               |
| Security    | Active tamper shield pin pairs (in/out)               | 4               |               |
|             | Glitch detectors                                      | Yes             |               |
|             | Key management unit                                   | Yes             |               |
|             | Encryption accelerator                                | Yes             |               |
| Debug       | ITM parallel trace                                    | Yes             | No            |

## 6 Mandatory SW requirements related to hardware

### 6.1 32MHz crystal internal load capacitor setting of TBD pF

MANDATORY. BL54L15 module contains the 32 MHz crystal but the load capacitors to create 32 MHz crystal oscillator circuit are inside the nRF54L15 chipset. Customer MUST set the internal nRF54L15 capacitors to TBD pF (for proper operation of the 32 MHz crystal circuit in the BL54L15 module).

## 7 Hardware Integration Suggestions

### 7.1 Circuit

The BL54L15 is easy to integrate, requiring one mandatory external 10uF capacitor on customers board and apart from that those components which customer require for development and in your end application.

The following are suggestions for your design for the best performance and functionality.

Checklist (for Schematic):

- **BL54L15 power supply:**

Normal voltage mode power supply mode is entered when the external supply voltage (1.7V-3.6V) is connected to both VDD\_nRF pin (pin26).

External power source should be within the operating range, rise time and noise/ripple specification of the BL54L15. Add decoupling capacitors for filtering the external source. Power-on reset circuitry within BL54L15 series module incorporates brown-out detector, thus simplifying your power supply design. Upon application of power, the internal power-on reset ensures that the module starts correctly.

- **AIN (ADC) and GPIO pin IO voltage levels**

BL54L15 GPIO voltage levels are at VDD. Ensure input voltage levels into GPIO pins are at VDD also (if VDD source is a battery whose voltage drops). Ensure ADC pin maximum input voltage for damage is not violated.

- **AIN (ADC) impedance and external voltage divider setup**

If you need to measure with ADC a voltage higher than 3.6V, you can connect a high impedance voltage divider to lower the voltage to the ADC input pin.

- **SWD**

This is REQUIRED for loading firmware. MUST wire out the SWD two wire interface on host design. Five lines should be wired out, namely SWDIO, SWDCLK, nRESET, GND and VDD.

- **UART and flow control (CTS, RTS)**

Required if customer requires UART.

- **I2C**

It is essential to remember that pull-up resistors on both SCL and SDA lines are required, the value as per I2C standard. nRF54L15 can provide 13K Ohms typical pull up values internally. For other values, fit external pull-up resistor on both SCL and SDA as per I2C specification to set speed. The I2C specification allows a line capacitance of 400pF.

- **QSPI, High Speed SPI, High speed TWI (I2C, 1Mbps) and Trace**

High-Speed SPI, TWI and Trace come on dedicated GPIO pins only. Other lower speed SPI and TWI can come out on any GPIO pins.

For all high-speed signal, the printed circuit board (PCB) layout must ensure that connections are made using short PCB traces.

- **GPIO pins**

If GPIO is selected as an input, ensure the input is not floating (which can cause current consumption to drive with time in low power modes (such as System ON Idle), by selecting the internal pull up or pull down.

- **NFC antenna connector**

To make use of the Ezurio flexi-PCB NFC antenna (part # 0600-00061), fit connector:

- Description – FFC/FPC Connector, Right Angle, SMD/90d, Dual Contact, 1.2 mm Mated Height
- Manufacturer – Molex
- Manufacturers Part number – 512810594

Add tuning capacitors of 300 pF on NFC1 pin to GND and 300 pF on NFC2 pins to GND if the PCB track length is similar as development board.

- **nRESET pin (active low)**

Hardware reset. Wire out to push button or drive by host.

By default module is out of reset when power applied to VDD pins (13K pull-up inside BL54L15 (nRF54L15-QFAA)).

- **Optional External 32.768kHz crystal**

If the optional external 32.768kHz crystal is needed, then use a crystal that meets specification and add load capacitors (either inside nRF54L15-QFAA or discrete capacitors outside BL54L15 (nRF54L15-QFAA) whose values should be tuned to meet all specification for frequency and oscillation margin.

已註解 [RK1]: @Dave Drozowski updated this datasheet, this text was wrong, now placed correct text, please clean.

## 7.2 PCB Layout on Host PCB - General

### Checklist (for PCB):

- MUST locate BL54L15 module close to the edge of PCB (mandatory for the 453-00001 for on-board PCB trace antenna to radiate properly).
- Use solid GND plane on inner layer (for best EMC and RF performance).
- All module GND pins MUST be connected to host PCB GND.
- Place GND vias close to module GND pads as possible.
- Unused PCB area on surface layer can be flooded with copper but place GND vias regularly to connect the copper flood to the inner GND plane. If GND flood copper is on the bottom of the module, then connect it with GND vias to the inner GND plane.
- Route traces to avoid noise being picked up on VDD, VDDM supply and AIN (analogue), GPIO (digital) traces and high-speed traces.
- Ensure no exposed copper is on the underside of the module (refer to land pattern of BL54L15 development board).

## 7.3 PCB Layout on Host PCB for the 453-00001

### 7.3.1 Antenna Keep-out on Host PCB

The 453-00001 has an integrated PCB trace antenna and its performance is sensitive to host PCB. It is critical to locate the 453-00001 on the edge of the host PCB (or corner) to allow the antenna to radiate properly. Refer to guidelines in section **PCB land pattern and antenna keep-out area for the 453-00001**. Some of those guidelines repeated below.

- Ensure there is no copper in the antenna keep-out area on any layers of the host PCB. Keep all mounting hardware and metal clear of the area to allow proper antenna radiation.
- For best antenna performance, place the 453-00001 module on the edge of the host PCB, preferably in the edge center.
- The BL54L15 development board (453-00001-K1) has the 453-00001 module on the edge of the board (not in the corner). The antenna keep-out area is defined by the BL54L15 development board which was used for module development and antenna performance evaluation is shown in **Figure 6**, where the antenna keep-out area is ~5mm wide, ~28.6mm long; with PCB dielectric (no copper) height ~1.57mm sitting under the 453-00001 PCB trace antenna module.
- The 453-00001 PCB trace antenna is tuned when the 453-00001 is sitting on development board (host PCB) with size of 113 mm x 63.5 mm x 1.6mm.
- A different host PCB thickness dielectric will have small effect on antenna.
- The antenna-keep-out defined in the **6.2 Host PCB Land Pattern and Antenna Keep-out for the 453-00001** section.
- Host PCB land pattern and antenna keep-out for the BL54L15 applies when the 453-00001 is placed in the edge of the host PCB preferably in the edge center.

**Figure 6** shows an example.

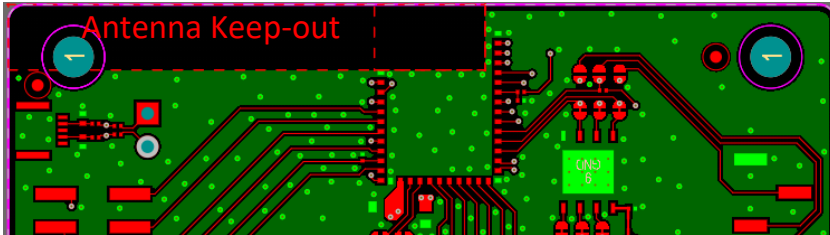


Figure 6: PCB trace Antenna keep-out area (shown in red), corner of the BL54L15 development board for the 453-00001 module.

### Antenna Keep-out Notes:

- Note 1** The BL54L15 module is placed on the edge, preferably edge centre of the host PCB.
- Note 2** Copper cut-away on all layers in the *Antenna Keep-out* area under the 453-00001 on host PCB.

### 7.3.2 Antenna Keep-out and Proximity to Metal or Plastic

#### Checklist (for metal /plastic enclosure):

- Minimum safe distance for metals without seriously compromising the antenna (tuning) is 40 mm top/bottom and 30 mm left or right.
- Metal close to the 453-00001 PCB trace monopole antenna (bottom, top, left, right, any direction) will have degradation on the antenna performance. The amount of that degradation is entirely system dependent, meaning you will need to perform some testing with your host application.
- Any metal closer than 20 mm will begin to significantly degrade performance (S11, gain, radiation efficiency).
- It is best that you test the range with a mock-up (or actual prototype) of the product to assess effects of enclosure height (and materials, whether metal or plastic) and host PCB ground (GND plane size).

## 7.4 External Antenna Integration with BL54L15 MHF4 variant (453-00044)

Please refer to the regulatory sections for FCC, ISED, CE, MIC, UKCA and RCM details of use of BL54L15 with external antennas in each regulatory region.

The BL54L15 family has been designed to operate with the below external antennas (with a maximum gain of 2.32 dBi). The required antenna impedance is 50 ohms. See Table 4. External antennas improve radiation efficiency.

Table 4: External antennas for the BL54L15 MHF4 module variant module (453-00044)

| Manufacturer | Model                    | Ezurio Part Number | Type       | Connector  | Peak Gain     |               |
|--------------|--------------------------|--------------------|------------|------------|---------------|---------------|
|              |                          |                    |            |            | 2400-2500 MHz | 2400-2480 MHz |
| Ezurio       | NanoBlue                 | EBL2400A1-10MH4L   | PCB Dipole | IPEX MHF4  | 2 dBi         | -             |
| Ezurio       | FlexPIFA                 | 001-0022           | PIFA       | IPEX MHF4L | -             | 2 dBi         |
| Mag.Layers   | EDA-8709-2G4C1-B27-CY    | 0600-00057         | Dipole     | IPEX MHF4  | 2.32 dBi      | -             |
| Ezurio       | mFlexPIFA                | EFA2400A3S-10MH4L  | PIFA       | IPEX MHF4L | -             | 2 dBi         |
| Ezurio       | i-FlexPIFATM Mini Series | EFG2401A3S-10MH4L  | i-FlexPIFA | IPEX MHF4L | -             | 2 dBi         |
| Ezurio       | Ezurio NFC               | 0600-00061         | NFC        | N/A        | -             | -             |

已註解 [RK2]: To be checked with JK.

## 8 Mechanical Details

### 8.1 BL54L15 Mechanical Details

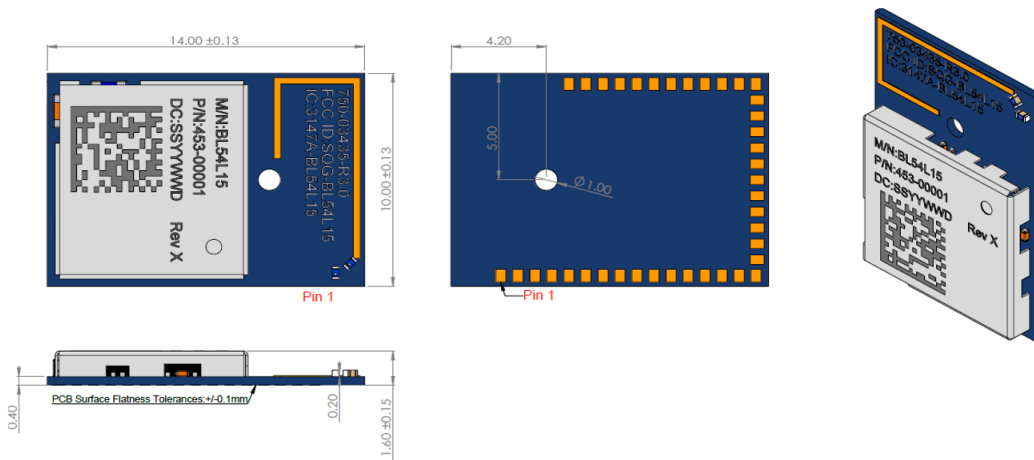


Figure 7: Mechanical Details – Internal Antenna variant module (453-00001)

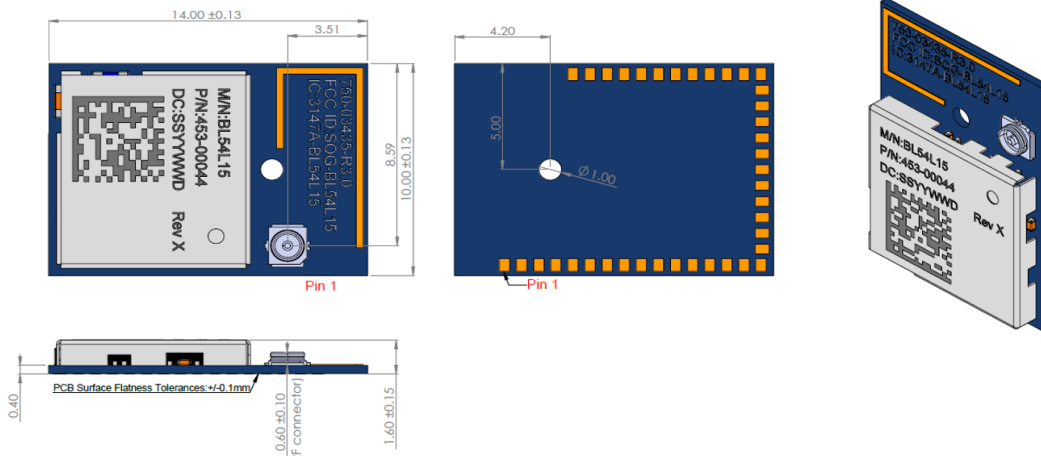


Figure 8: Mechanical Details – MHF4 RF connector variant module (453-00044)

3D models for BL54L15 Module, MHF4 (453-00044) and BL54L15 Module, PCB printed (453-00001) on the BL54L15 product page – <https://www.ezurio.com/product/bl54l15-series-bluetooth-le-80215-4-nfc>

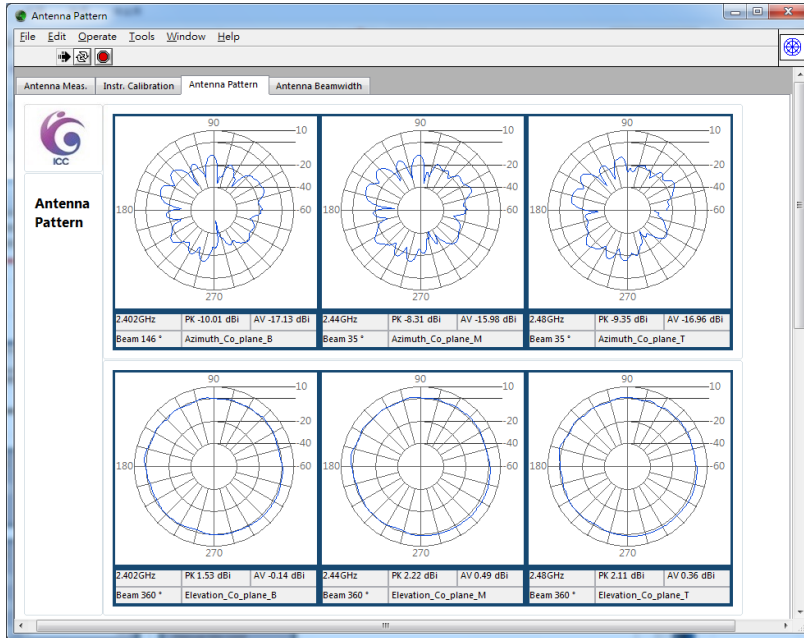


## 9 On-Board PCB Trace Antenna Characteristics

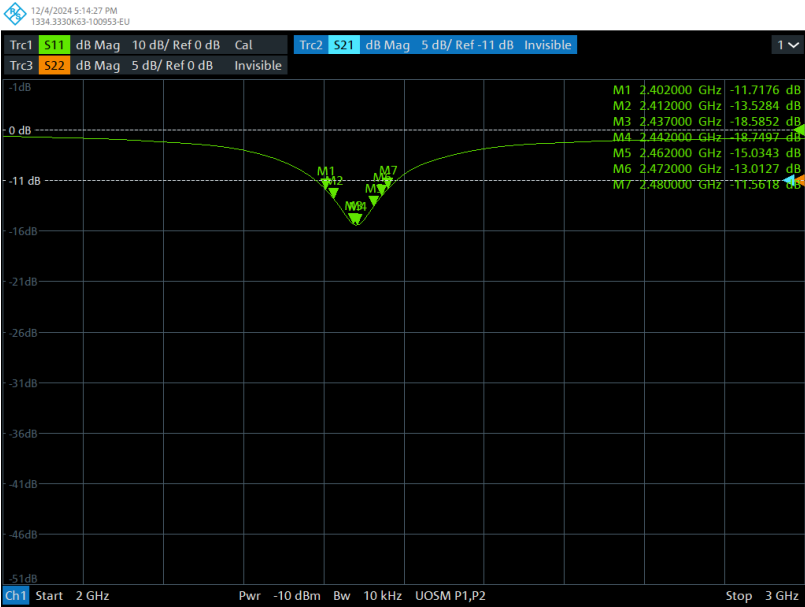
### 9.1 Summary of Antenna Performance

|                             | 2402MHz |          | 2440MHz  |          | 2480MHz  |          |
|-----------------------------|---------|----------|----------|----------|----------|----------|
|                             | Peak    | Avg      | Peak     | Avg      | Peak     | Avg      |
| 453-00001 PCB trace antenna | +0.2dBi | -4.24dBi | +1.49dBi | -3.19dBi | +1.39dBi | -3.27dBi |

### 9.2 2.4GHz Radiated Performance



9.3 Antenna S11 measuring data



## 10 Regulatory

### 10.1 Federal Communication Commission Interference Statement

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:

##### FCC 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.

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

#### Integration instructions for host product manufacturers

##### Applicable FCC rules to module

FCC Part 15.247

##### Summarize the specific operational use conditions

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

- 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.  
**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

"FCC 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

| Manufacture / Part Number            | Type            | Connector         | Gain(dBi) |
|--------------------------------------|-----------------|-------------------|-----------|
| Ezurio / EBL2400A1-10MH4L            | PCB Dipole      | IPEX MHF4         | 2         |
| Ezurio / 001-0022                    | FlexPIFA        | IPEX MHF4L        | 2         |
| Mag.Layers / 0600-00057              | Dipole          | IPEX MHF4         | 2.32      |
| Ezurio / EFA2400A3S-10MH4L           | FlexPIFA        | IPEX MHF4L        | 2         |
| Ezurio / EFG2401A3S-10MH4L           | i-FlexPIFA      | IPEX MHF4L        | 2         |
| Ezurio / 0600-00061 (NFC)            | Coiled Inductor | FFC/FPC Connector | -         |
| Ezurio / BL54L15 Printed PCB Antenna | Printed PCB     | NA                | 0         |

**Label and Compliance Information**

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

"Contains FCC ID: [SQG-BL54L15](#)" with finished product

**Information on Test Modes and Additional Testing Requirements**

Test tool: [PuTTY](#), Version:0.60 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

## 10.2 Industry Canada statement:

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.

Radiation Exposure Statement:

The product comply with the Canada 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.

### Déclaration d'exposition aux radiations:

Le produit est conforme aux limites d'exposition pour les appareils portables RF pour les Etats-Unis et le Canada établies pour un environnement non contrôlé. Le produit est sûr pour un fonctionnement tel que décrit dans ce manuel. La réduction aux expositions RF peut être augmentée si l'appareil peut être conservé aussi loin que possible du corps de l'utilisateur ou que le dispositif est réglé sur la puissance de sortie la plus faible si une telle fonction est disponible.

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

- 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.

Cet appareil est conçu uniquement pour les intégrateurs OEM dans les conditions suivantes:

- 1) Le module émetteur peut ne pas être coimplanté 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-BL54L15".

### Plaque signalétique du produit final

Le produit final doit être étiqueté dans un endroit visible avec l'inscription suivante: "Contient des IC: 3147A-BL54L15".

### 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.

This radio transmitter [IC: 3147A-BL54L15 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-BL54L15] 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.

| Manufacture / Part Number            | Type            | Connector         | Gain(dBi) |
|--------------------------------------|-----------------|-------------------|-----------|
| Ezurio / EBL2400A1-10MH4L            | PCB Dipole      | IPEX MHF4         | 2         |
| Ezurio / 001-0022                    | FlexPIFA        | IPEX MHF4L        | 2         |
| Mag.Layers / 0600-00057              | Dipole          | IPEX MHF4         | 2.32      |
| Ezurio / EFA2400A3S-10MH4L           | FlexPIFA        | IPEX MHF4L        | 2         |
| Ezurio / EFG2401A3S-10MH4L           | i-FlexPIFA      | IPEX MHF4L        | 2         |
| Ezurio / 0600-00061 (NFC)            | Coiled Inductor | FFC/FPC Connector | -         |
| Ezurio / BL54L15 Printed PCB Antenna | Printed PCB     | NA                | 0         |

### 10.3 Europe – EU Declaration of Conformity

This device complies with the essential requirements of the Radio Equipment directive: 2014 / 53 / EU. The following test methods have been applied in order to prove presumption of conformity with the essential requirements of the Radio Equipment directive: 2014 / 53 / EU:

EN 300 328 V2.2.2

(BS)EN 62497:2010

(BS)EN 50663 2017

EN 300 330 V2.1.1

EN 301 489-1 V2.2.3

EN 301 489-3 V2.3.2

EN 301 489-17 V3.3.1

IEC 62368-1:2018; and/or

(BS) EN IEC 62368-1:2020+A11:2020

2400-2483.5GHz: 9.55dbm

BT LE: 9.58dbm

SW version: V0.5.6

#### RF exposure statement

The product comply with the RF exposure limit and is 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.

## 11 Ordering Information

| Part Number  | Product Description                                                |
|--------------|--------------------------------------------------------------------|
| 453-00001R   | Module, BL54L15, (Nordic nRF54L15), Trace antenna, Tape/Reel       |
| 453-00044R   | Module, BL54L15, (Nordic nRF54L15), MHF4 Connector, Tape/Reel      |
| 453-00001C   | Module, BL54L15, (Nordic nRF54L15), Trace antenna, Cut Tape        |
| 453-00044C   | Module, BL54L15, (Nordic nRF54L15), MHF4 Connector, Cut Tape       |
| 453-00001-K1 | Development kit, Module, BL54L15 (Nordic nRF54L15), Trace antenna  |
| 453-00044-K1 | Development kit, Module, BL54L15 (Nordic nRF54L15), MHF4 Connector |



## 12 Additional Information

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

|                   |                                                                                               |
|-------------------|-----------------------------------------------------------------------------------------------|
| Headquarters      | Ezurio<br>50 S. Main St. Suite 1100<br>Akron, OH 44308 USA                                    |
| Website           | <a href="http://www.ezurio.com">http://www.ezurio.com</a>                                     |
| Technical Support | <a href="http://www.ezurio.com/resources/support">http://www.ezurio.com/resources/support</a> |
| Sales Contact     | <a href="http://www.ezurio.com/contact">http://www.ezurio.com/contact</a>                     |

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