# Datasheet

## LWB5+ M.2

*Version 1.3*

# REVISION HISTORY

| Version | Date | Notes | Contributor(s) | Approver |
|---|---|---|---|---|
| 1.0 | 07 Dec 2020 | Initial version | Andrew Chen | Jay White |
| 1.1 | 01 Feb 2021 | Updated Bluetooth v5.0 to v5.2 | Sue White | Jonathan Kaye |
| 1.2 | 03 Mar 2021 | Added two Bluetooth current consumption tables | Maggie Teng | Jonathan Kaye |
| 1.3 | 11 Aug 2021 | Added Peak PHY Calibration Current table (Table 18)<br>Added Power-Up Sequence and Timing Requirements | Andrew Chen | Andy Ross |
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# 1 SCOPE

This document describes key hardware aspects of the Laird LWB5-+ M.2 module providing either SDIO or USB2.0 interface for WLAN connection and UART/PCM, USB2.0/PCM for Bluetooth® connection. This document is intended to assist device manufacturers and related parties with the integration of this radio into their host devices. Data in this document is drawn from several sources and includes information found in the CYPRESS CYW4373EUBGT data sheet issued in July 2020, along with other documents provided from CYPRESS.

**Note that the information in this document is subject to change.** Please contact Laird Connectivity to obtain the most recent version of this document.

# 2 INTRODUCTION

## 2.1 General Description

The LWB5+ M.2 module is an integrated, M.2 2230 E-Key standard factor, 1x1 SISO with T/R diversity, 802.11 a/b/g/n/ac WLAN plus dual-mode Bluetooth 5.2 Low Energy device that is optimized for low-power mobile devices. The integration of all WLAN and *Bluetooth* functionality in M.2 2230 E-Key standard factor supports low cost and simple implementation along with flexibility for platform-specific customization.

This device is pre-calibrated and integrates the complete transmit/receive RF paths including diplexer, switches, reference crystal oscillator and power management units (PMU). There are two MHF4 connectors on the M.2 board, which can use certified antennas to support antenna diversity. For a list of certified antennas, see **Error! Reference source not found.** in the datasheet.

The LWB5+ M.2 module supports IEEE 802.11ac (wave 1) 1x1 SISO with data rates up to MCS9 (433.3 Mbps). Internal Wi-Fi and BT coexistence scheme provides optimized throughput when Wi-Fi and BT are working simultaneously. The device's low power consumption radio architecture and power management unit (PMU) proprietary power save technologies allow for extended battery life.

In addition, its dual 802.11 and Bluetooth radio includes full digital MAC and baseband engines that handle all 802.11 CCK/OFDM® 2.4/5GHz, and Bluetooth 5.2 (Basic Rate, Enhanced Data Rate and Bluetooth Low Energy) baseband and protocol processing.

Please contact our sales/FAE staff for further information. Ordering information is listed in Table 1.

***Table 1: Product ordering information***

| Order Model | Description |
|---|---|
| 453-00048 | 802.11ac + Bluetooth 5.2 LWB5+ M.2 Module, SDIO (WLAN) / UART (Bluetooth) |
| 453-00049 | 802.11ac + Bluetooth 5.2 LWB5+ M.2 Module, USB (WLAN) / USB (Bluetooth) |
| 453-00048-K1 | Development Kit for 1x1 802.11ac + Bluetooth 5.2 SDIO/UART M.2 Module |
| 453-00049-K1 | Development Kit for 1x1 802.11ac + Bluetooth 5.2 USB/USB M.2 Module |



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# 3 LWB5+ M.2 Module Features Summary

The Laird LWB5+ M.2 module features are described in Table 2.

***Table 2: LWB5+ M.2 module features***

| Feature | Description |
|---|---|
| **Radio Front End** | Integrates the complete transmit/receive diversity RF paths including diplexer, switches, reference crystal oscillator, and power management unit (PMU).<br>Supports 20/40/80MHz channel bandwidth.<br>WLAN/Bluetooth share one antenna. |
| The *Bluetooth*® word mark and logos are registered trademarks owned by Bluetooth SIG, Inc. Any use of such marks by Laird is under license. Other trademarks and trade names are those of their respective owners. | |
| **Power Management** | One Buck regulator, multiple LDO regulators, and a power management unit (PMU) are integrated into the CYW4373E. All regulators are programmable via the PMU. These blocks simplify power supply design for Bluetooth, and WLAN functions in embedded designs. |
| **Pre-Calibration** | RF system tested and calibrated in production |
| **Sleep Clock** | An external sleep clock of 32.768 KHz is required |
| **Host Interface Options** | The LWB5+ M.2 card provides two interfaces for customers to choose:<br>**1. SDIO 1.8V/UART**, Wi-Fi section provides support for SDIO v3.0 and also is backward compatible with SDIO v2.0. Bluetooth section supports a high-speed 4-wire UART interface.<br>**2. USB/USB**, an on-chip USB 2.0 hub provides a shared single USB connection to both Wi-Fi and Bluetooth target devices. |
| **Advanced WLAN** | ▪ IEEE 802.11ac compliant.<br>▪ Support for MCS8 VHT20 in 20 MHz channels for up to 86.7 Mbps data.<br>▪ Single-stream spatial multiplexing up to 433.3 Mbps data rate.<br>▪ Supports 20, 40, and 80 MHz channels with optional SGI (256 QAM modulation).<br>▪ Full IEEE 802.11a/b/g/n legacy compatibility with enhanced performance.<br>▪ TX and RX low-density parity check (LDPC) support for improved range and power efficiency.<br>▪ On-chip power amplifiers and low-noise amplifiers for both bands.<br>▪ Support wide variety of WLAN encryption: WEP/WPA/TKIP/WPA2 AES-CCMPs |
| **Advanced Bluetooth** | ▪ Qualified for Bluetooth Core Specification 5.2 with all Bluetooth 4.2 optional features<br>– QDID:<br>– Declaration ID:<br>▪ Bluetooth Class 1 or Class 2 transmitter operation.<br>▪ Support data rate: 1 Mbps (GFSK), 2 Mbps (π/4-DQPSK), 3 Mbps (8-DPSK)<br>▪ Supports extended synchronous connections (eSCO), for enhanced voice quality by allowing for retransmission of dropped packets.<br>▪ Adaptive frequency hopping (AFH) for reducing radio frequency interference.<br>▪ Interface support, host controller interface (HCI) using a highspeed UART interface (or USB interface) and PCM for audio data.<br>▪ Low power consumption improves battery life of IoT and embedded devices.<br>▪ Supports multiple simultaneous Advanced Audio Distribution Profiles (A2DP) for stereo sound.<br>▪ Automatic frequency detection for standard crystal and TCXO values. |



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# 4 SPECIFICATIONS

***Table 3: Specifications***

| Feature | Description |
|---|---|
| **Physical Interface** | M.2 2230 E-Key standard factor |
| **Wi-Fi Interface** | 1-bit or 4-bit Secure Digital I/O; USB 2.0 |
| **Bluetooth/BLE Interface** | Host Controller Interface (HCI) using high speed UART, USB 2.0 |
| **Main Chip** | Cypress CYW4373EUBGT |
| **Input Voltage Requirements** | Typical DC 3.3 V, operating range from DC 3.2V to 3.6V |
| **I/O Signalling Voltage** | Compliant with M.2 standard<br>▪ For the Key-E form factor, the SDIO, PCM, and UART interfaces only support 1.8V |
| **Operating Temperature** | -40° to 85°C (-40° to 185°F) |
| **Operating Humidity** | 10 to 90% (non-condensing) |
| **Storage Temperature** | -40° to 85°C (-40° to 185°F) |
| **Storage Humidity** | 10 to 90% (non-condensing) |
| **Maximum Electrostatic Discharge** | Conductive 4KV; Air coupled 8KV follow EN61000-4-2 |
| **Size** | 30 mm (length) x 22 mm (width) x 3.1 mm (thickness) |
| **Weight** | 3g |
| **Wi-Fi Media** | Direct Sequence-Spread Spectrum (DSSS)<br>Complementary Code Keying (CCK)<br>Orthogonal Frequency Divisional Multiplexing (OFDM) |
| **Bluetooth Media** | Frequency Hopping Spread Spectrum (FHSS) |
| **Wi-Fi Multimedia** | WMM<br>Wi-Fi Multimedia - PowerSave (WMM-PS with U-APSD)<br>WMM-Sequential Access (WMM-SA with PCF) |
| **Network Architecture Types** | Infrastructure and ad-hoc |
| **Wi-Fi Standards** | IEEE 802.11a, 802.11b, 802.11e, 802.11g, 802.11h, 802.11i, 802.11k*, 802.11n, 802.11r, 802.11v*, 802.11ac |
| **Bluetooth Standards** | Bluetooth 5.2 |
| **Wi-Fi Data Rates Supported** | Support 802.11 ac/a/b/g/n 1x1 SISO.<br>802.11b (DSSS, CCK) 1, 2, 5.5, 11 Mbps<br>802.11a/g (OFDM) 6, 9, 12, 18, 24, 36, 48, 54 Mbps<br>802.11n (OFDM, HT20/HT40, MCS0-7)<br>802.11ac (OFDM, VHT20, MCS0-8; OFDM VHT40/VHT80, MCS 0-9) |



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| Feature | Description |
|---|---|

**Modulation Table**

BPSK, QPSK, CCK, 16-QAM, 64-QAM, and 256-QAM.

| 802.11ac / 802.11n HT MCS Index | VHT MCS Index | Spatial Streams | Modulation | Coding | 20 MHz | | 40 MHz | | 80 MHz | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | No SGI | SGI | No SGI | SGI | No SGI | SGI |
| 0 | 0 | 1 | BPSK | 1/2 | 6.5 | 7.2 | 13.5 | 15 | 29.3 | 32.5 |
| 1 | 1 | 1 | QPSK | 1/2 | 13 | 14.4 | 27 | 30 | 58.5 | 65 |
| 2 | 2 | 1 | QPSK | 3/4 | 19.5 | 21.7 | 40.5 | 45 | 87.8 | 97.5 |
| 3 | 3 | 1 | 16-QAM | 1/2 | 26 | 28.9 | 54 | 60 | 117 | 130 |
| 4 | 4 | 1 | 16-QAM | 3/4 | 39 | 43.3 | 81 | 90 | 175.5 | 195 |
| 5 | 5 | 1 | 64-QAM | 2/3 | 52 | 57.8 | 108 | 120 | 234 | 260 |
| 6 | 6 | 1 | 64-QAM | 3/4 | 58.5 | 65 | 121.5 | 135 | 263.3 | 292.5 |
| 7 | 7 | 1 | 64-QAM | 5/6 | 65 | 72.2 | 135 | 150 | 292.5 | 325 |
| | 8 | 1 | 256-QAM | 3/4 | 78 | 86.7 | 162 | 180 | 351 | 390 |
| | 9 | 1 | 256-QAM | 5/6 | N/A | N/A | 180 | 200 | 390 | **433.3** |

| | |
|---|---|
| **802.11ac/n Spatial Streams** | 1 (1x1 SISO) |
| **Bluetooth Data Rates Supported** | 1, 2, 3 Mbps |
| **Bluetooth Modulation** | GFSK@ 1 Mbps<br>Pi/4-DQPSK@ 2 Mbps<br>8-DPSK@ 3 Mbps |
| **Regulatory Certifications** | USA (FCC)<br>EU – members of European Union (ETSI)<br>Canada<br>Australia<br>Japan |
| **2.4 GHz Frequency Bands** | **ETSI:** 2.4 GHz to 2.483 GHz<br>**FCC/IC:** 2.4 GHz to 2.473 GHz<br>**MIC:** 2.4 GHz to 2.495 GHz<br>**RCM**: 2.4 GHz to 2.483 GHz |
| **2.4 GHz Operating Channels (Wi-Fi)** | **ETSI:** 13 (3 non-overlapping)<br>**FCC/IC:** 11 (3 non-overlapping)<br>**MIC:** 14 (4 non-overlapping)<br>**RCM**: 13 (3 non-overlapping) |
| **5 GHz Frequency Bands** | **ETSI**<br>5.15 GHz to 5.35 GHz (Ch 36/40/44/48/52/56/60/64)<br>5.47 GHz to 5.725 GHz (Ch 100/104/108/112/116/120/124/128/132/136/140)<br>5.725 GHz to 5.85 GHz (Ch 149/153/157/161/165)<br>**FCC**<br>5.15 GHz to 5.35 GHz (Ch 36/40/44/48/52/56/60/64)<br>5.47 GHz to 5.725 GHz (Ch 100/104/108/112/116/120/124/128/132/136/140/144<br>5.725 GHz to 5.85 GHz (Ch 149/153/157/161/165)<br>**IC**<br>5.15 GHz to 5.35 GHz (Ch 36/40/44/48/52/56/60/64)<br>5.47 GHz to 5.725 GHz (Ch 100/104/108/112/116/132/136/140/144<br>5.725 GHz to 5.85 GHz (Ch 149/153/157/161/165)<br>**MIC**<br>5.15 GHz to 5.35 GHz (Ch 36/40/44/48/52/56/60/64)<br>5.47 GHz to 5.725 GHz (Ch 100/104/108/112/116/120/124/128/132/136/140) |



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| Feature | Description | |
|---|---|---|
| | **RCM**<br>5.15 GHz to 5.35 GHz (Ch 36/40/44/48/52/56/60/64)<br>5.47 GHz to 5.725 GHz (Ch 100/104/108/112/116/132/136/140<br>5.725 GHz to 5.85 GHz (Ch 149/153/157/161/165) | |
| **5 GHz Operating Channels (Wi-Fi)** | ETSI: 24 non-overlapping; FCC: 25 non-overlapping<br>IC: 22 non-overlapping; MIC: 19 non-overlapping<br>RCM: 21 non-overlapping | |
| **Transmit Power**<br><br>***Note:*** *Transmit power on each channel varies per individual country regulations. All values are nominal with +/-2 dBm tolerance at room temperature.*<br>*Tolerance could be up to +/-2.5 dBm across operating temperature.*<br><br>***Note:***<br>*HT20 – 20 MHz-wide channels*<br>*HT40 – 40 MHz-wide channels*<br>*HT80 – 80 MHz-wide channels* | **802.11a** | |
| | 6 Mbps | 15 dBm (31.6 mW) |
| | 54 Mbps | 13 dBm (20 mW) |
| | **802.11b** | |
| | 1 Mbps | 16 dBm (40 mW) |
| | 11 Mbps | 16 dBm (40 mW) |
| | **802.11g** | |
| | 6 Mbps | 15.5 dBm (35.5 mW) |
| | 48 Mbps, 54 Mbps | 14.5 dBm (28.2 mW) |
| | **802.11n (2.4 GHz)** | |
| | HT20; MCS0-7 | 13.5 dBm (22.4 mW) |
| | HT40; MCS0-7 | 9.5 dBm (8.9 mW) |
| | **802.11n (5 GHz)** | |
| | HT20; MCS0-5 | 15 dBm (31.6 mW) |
| | HT20; MCS6-7 | 13 dBm (20 mW) |
| | HT40; MCS0-7 | 11 dBm (12.6 mW) |
| | **802.11ac (5 GHz)** | |
| | VHT20; MCS0-5 | 15 dBm (31.6 mW) |
| | VHT20; MCS6-7 | 13 dBm (20 mW) |
| | VHT20; MCS8 | 9.5 dBm (10 mW) |
| | VHT40; MCS0-7 | 11 dBm (12.6 mW) |
| | VHT40; MCS8-9 | 9.5 dBm (10 mW) |
| | VHT80; MCS0-7 | 10 dBm (10 mW) |
| | VHT80; MCS8-9 | 9 dBm (7.9 mW) |
| | **Bluetooth** | |
| | 1 Mbps (1DH5) | 7 dBm (5 mW) |
| | 2 Mbps | 3 dBm (1.99 mW) |
| | 3 Mbps | 3 dBm (1.99 mW) |
| | BLE (1 Mbps) | 7 dBm (5 mW) |
| **Typical Receiver Sensitivity**<br>(PER <= 10%)<br>***Note:*** *All values nominal, +/-3 dBm.* | **802.11a:** | |
| | 6 Mbps | -89 dBm |
| | 54 Mbps | -73 dBm |
| | **802.11b:** | |
| | 1 Mbps | -95 dBm (PER < 8%) |
| | 11 Mbps | -88 dBm (PER < 8%) |
| | **802.11g:** | |
| | 6 Mbps | -92 dBm |
| | 54 Mbps | -75 dBm |
| | **802.11n (2.4 GHz)** | |
| | 6.5 Mbps (MCS0; HT20) | -92 dBm |
| | 65 Mbps (MCS7; HT20) | -73 dBm |
| | 13.5 Mbps (MCS0; HT40) | -89 dBm |



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| Feature | Description |
|---|---|
| | 135 Mbps (MCS7; HT40) -70 dBm<br>**802.11n (5 GHz)**<br>6.5 Mbps (MCS0; HT20) -89 dBm<br>65 Mbps (MCS7; HT20) -70 dBm<br>13.5Mbps (MCS0; HT40) -86 dBm<br>135Mbps (MCS7; HT40) -66 dBm<br>**802.11ac (5 GHz)**<br>6.5 Mbps (MCS0; VHT20) -88 dBm<br>78 Mbps (MCS8; VHT20) -66 dBm<br>13.5 Mbps (MCS0; VHT40) -86 dBm<br>180 Mbps (MCS9; VHT40) -62 dBm<br>29.3 Mbps (MCS0; VHT80) -83 dBm<br>390 Mbps (MCS9; VHT80) -59 dBm<br>**Bluetooth:**<br>1 Mbps (1DH5) -90 dBm<br>2 Mbps (2DH5) -92 dBm<br>3 Mbps (3DH5) -86 dBm<br>Bluetooth LE -93 dBm |
| **Operating Systems Supported** | Linux<br>Android |
| **Security** | ▪ WEP<br>▪ WPA and WPA2 (Personal) support for powerful encryption and authentication.<br>▪ AES and TKIP in hardware for faster data encryption and IEEE 802.11i compatibility.<br>▪ Reference WLAN subsystem provides Wi-Fi Protected Setup (WPS).<br>▪ CKIP |
| Compliance | **ETSI Regulatory Do**main<br>EN 300 328<br>EN 301 489-1<br>EN 301 489-17<br>EN 301 893<br>EN 60950-1<br>2011/65/EU (RoHS)<br>**FCC** Regulatory Domain<br>FCC 15.247 DTS – 802.11b/g (Wi-Fi) – 2.4 GHz<br>FCC 15.407 UNII – 802.11a (Wi-Fi) – 5 GHz<br>FCC 15.247 DSS – BT 2.1<br>**Industry Canada**<br>RSS-247 – 802.11a/b/g/n (Wi-Fi) – 2.4 GHz, 5.8 GHz, 5.2 GHz, and 5.4 GHz<br>RSS-247 – BT 2.1<br>**RCM**<br>AS/NZS 4268 :2017<br>AS/NZS 4268 DFS<br>**MIC**<br>Japan ARIB STD-T66/-33/-T71 |
| **Certifications (Pending)** | ***Bluetooth*® SIG Qualification** |
| **Warranty** | One Year Warranty |
| ***All specifications are subject to change without notice*** | |



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# 5 WLAN Functional Description

## 5.1 Overview

The LWB5+ M.2 module is designed based on the CYPRESS CYW4373EUBGT 802.11ac/a/b/g/n chipset. It is optimized for high speed, reliable, and low-power embedded applications. It's integrated with dual-band WLAN (2.4/5GHz) and Bluetooth 5.2. Its functionality includes:

- Improved throughput on the link due to frame aggregation, RIFS (reduced inter-frame spacing), and half guard intervals.
- Support for LDPC (Low Density Parity Check) codes.
- Improved 11n performance due to features such as 11n frame aggregation (TX A-MPDU) and low-overhead host-assisted buffering (RX A-MPDU). These techniques can improve performance and efficiency of applications involving large bulk data transfers such as file transfers or high-resolution video streaming.
- IEEE 802.11ac, 1x1 SISO with data rate up to MCS9 (433.3Mbps).

Additional functionality is listed in the following table (Table 4).

***Table 4: WLAN functions***

| Feature | Description |
|---|---|
| **WLAN MAC** | ▪ Enhanced MAC for supporting IEEE 802.11ac features<br>▪ Transmission and reception of aggregated MPDUs (A-MPDUs) for very high throughput (VHT)<br>▪ Support for power management schemes, including WMM power-save, power-save multi-poll (PSMP) and multiphase PSMP operation<br>▪ Support for immediate ACK and Block-ACK policies<br>▪ Interframe space timing support, including RIFS<br>▪ Support for RTS/CTS and CTS-to-self frame sequences for protecting frame exchanges<br>▪ Back-off counters in hardware for supporting multiple priorities as specified in the WMM specification<br>▪ Timing synchronization function (TSF), network allocation vector (NAV) maintenance, and target beacon transmission time (TBTT)<br>▪ generation in hardware and capturing the TSF timer on an external time synchronization pulse<br>▪ Hardware offload for AES-CCMP, legacy WPA TKIP, legacy WEP ciphers, WAPI, and support for key management<br>▪ Support for coexistence with Bluetooth and other external radios<br>▪ Programmable independent basic service set (IBSS) or infrastructure basic service set functionality<br>▪ Statistics counters for MIB support |
| **WLAN Security** | ▪ WLAN Encryption features supported include:<br>– Temporal Key Integrity Protocol (TKIP)/Wired Equivalent Privacy (WEP)<br>– Advanced Encryption Standard (AES)/Counter-Mode/CBC-MAC Protocol (CCMP)<br>– WLAN Authentication and Private Infrastructure (WPAI) |



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| Feature | Description |
|---|---|
| **WLAN Channel** | Channel frequency supported. |

| 20 MHz | | | | 40 MHz | | 80 MHz | |
|---|---|---|---|---|---|---|---|
| **Channel** | **Freq. (MHz)** | **Channel** | **Freq. (MHz)** | **Channel** | **Freq. (MHz)** | **Channel** | **Freq. (MHz)** |
| 1 | 2412 | 36 | 5180 | 1-5 | 2422 | 42 | 5210 |
| 2 | 2417 | 40 | 5200 | 2-6 | 2427 | 58 | 5290 |
| 3 | 2422 | 44 | 5220 | 3-7 | 2432 | 74 | 5370 |
| 4 | 2427 | 48 | 5240 | 4-8 | 2437 | 90 | 5410 |
| 5 | 2432 | 52 | 5260 | 5-9 | 2422 | 106 | 5530 |
| 6 | 2437 | 56 | 5280 | 6-10 | 2447 | 122 | 5610 |
| 7 | 2422 | 60 | 5300 | 7-11 | 2452 | 138 | 5690 |
| 8 | 2447 | 64 | 5320 | 36-40 | 5190 | 155 | 5775 |
| 9 | 2452 | 100 | 5500 | 44-48 | 5230 | | |
| 10 | 2457 | 104 | 5520 | 52-56 | 5270 | | |
| 11 | 2462 | 108 | 5540 | 60-64 | 5310 | | |
| 12 | 2467 | 112 | 5560 | 68-72 | 5350 | | |
| 13 | 2472 | 116 | 5580 | 76-80 | 5390 | | |
| | | 120 | 5600 | 84-88 | 5430 | | |
| | | 124 | 5620 | 92-96 | 5470 | | |
| | | 128 | 5640 | 100-104 | 5510 | | |
| | | 132 | 5660 | 108-112 | 5550 | | |
| | | 136 | 5680 | 116-120 | 5590 | | |
| | | 140 | 5700 | 124-128 | 5630 | | |
| | | 144 | 5720 | 132-136 | 5670 | | |
| | | 149 | 5745 | 140-144 | 5710 | | |
| | | 153 | 5765 | 149-153 | 5755 | | |
| | | 157 | 5785 | 157-161 | 5795 | | |
| | | 161 | 5805 | | | | |
| | | 165 | 5825 | | | | |



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# 6 BLUETOOTH FUNCTIONAL DESCRIPTION

The LWB5+ M.2 module includes a fully-integrated Bluetooth baseband/radio. Several features and functions are listed in Table 5.

***Table 5: Bluetooth functions***

| Feature | Description |
|---|---|
| **Bluetooth Interface** | ▪ Voice interface:<br>– Hardware support for continual PCM data transmission/reception without processor overhead.<br>– Standard PCM clock rates from 64 kHz to 2.048 MHz with multi-slot handshake and synchronization.<br>– A-law, U-law, and linear voice PCM encoding/decoding.<br>▪ High-Speed UART interface<br>▪ USB 2.0 |
| **Bluetooth Core functionality** | ▪ Bluetooth 5.2 Core Spec (errata)<br>▪ Bluetooth Class 2/Bluetooth class 1<br>▪ WLAN and Bluetooth share same LNA and antenna<br>▪ Digital audio interfaces with TDM interface for voice application<br>▪ Baseband and radio BDR and EDR package type: 1 Mbps, 2 Mbps, 3 Mbps<br>▪ Fully functional Bluetooth baseband: AFH, forward error correction, header error control, access code correction, CRC, encryption bit stream generation, and whitening.<br>▪ Adaptive Frequency Hopping (AFH) using Packet Error Rate (PER)<br>▪ Interlaced scan for faster connection setup<br>▪ Simultaneous active ACL connection setup<br>▪ Automatic ACL package type selection<br>▪ Full master and slave piconet support<br>▪ Scatter net support<br>▪ SCO/eSCO links with hardware accelerated audio signal processing and hardware supported PPEC algorithm for speech quality improvement<br>▪ All standard SCO/eSCO voice coding<br>▪ All standard pairing, authentication, link key, and encryption operations<br>▪ Encryption (AES) support |
| **Bluetooth Low Energy (BLE) Core functionality** | ▪ Bluetooth 5.2 Core Spec (Errata)<br>▪ Bluetooth 4.2 Features:<br>– LE privacy 1.2<br>– LE Secure Connection.<br>– LE Data Length Extension<br>▪ Bluetooth 4.0 Features:<br>– Advertiser, Scanner, Initiator, Master, and Slave roles support (connects to 16 links)<br>– WLAN/Bluetooth Coexistence (BCA) protocol support.<br>– Shared RF with BDR/EDR<br>– Encryption (AES) support.<br>– Intelligent Adaptive Frequency Hopping (AFH) |



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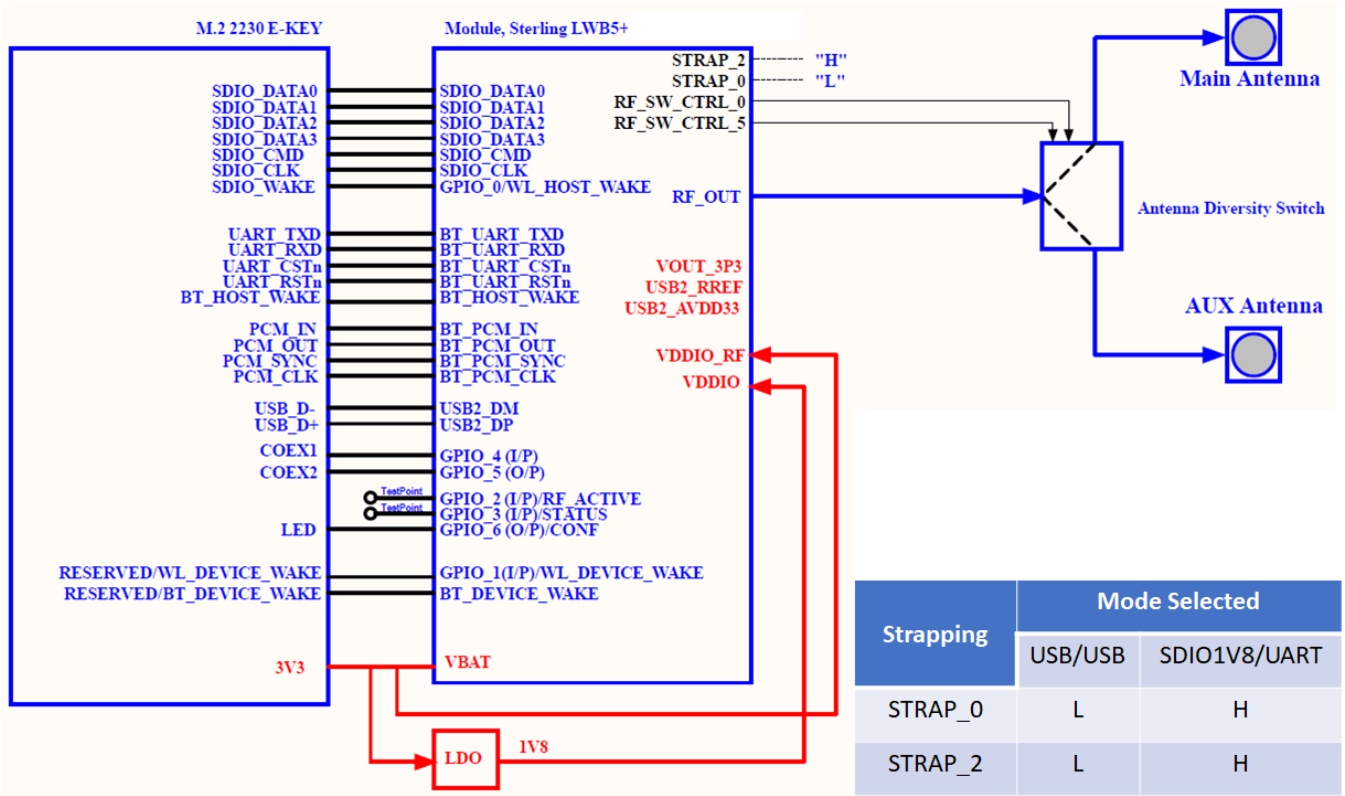
# 7 Block Diagram




| Strapping | Mode Selected | |
|---|---|---|
| | USB/USB | SDIO1V8/UART |
| STRAP_0 | L | H |
| STRAP_2 | L | H |

***Figure 1: Block diagram***

# 8 Electrical Characteristics

## 8.1 Absolute Maximum Ratings

Table 6 summarizes the absolute maximum ratings and Table 7 lists the recommended operating conditions for the LWB5+ M.2 module. Absolute maximum ratings are those values beyond which damage to the device can occur. Functional operation under these conditions, or at any other condition beyond those indicated in the operational sections of this document, is not recommended.

**Note:** Maximum rating for signals follows the supply domain of the signals.

***Table 6: Absolute maximum ratings***

| Symbol (Domain) | Parameter | Max Rating | Unit |
|---|---|---|---|
| 3V3 | External 3.3V power supply | 4.0 | V |
| Storage | Storage Temperature | -40 to +85 | °C |
| Antenna | Maximum RF input (reference to 50-Ω input) | +10 | dBm |
| ESD | Electrostatic discharge tolerance | 2000 | V |



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## 8.2 Recommended Operating Conditions

***Table 7: Recommended Operating Conditions***

| Symbol (Domain) | Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| 3V3 | External 3.3V power supply | 3.2 | 3.30 | 3.6 | V |
| T-ambient | Ambient temperature | -40 | 25 | 85 | °C |

## 8.3 DC Electrical Characteristics

Table 8 list the general DC electrical characteristics over recommended operating conditions (unless otherwise specified).

***Table 8: General DC electrical characteristics (For 1.8V operation VDDIO; VIO_SD)***

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| VIH | High Level Input Voltage | — | 1.17 | — | — | V |
| VIL | Low Level Input Voltage | — | — | — | 0.63 | V |
| VOH | Output high Voltage | — | 1.35 | — | — | V |
| VOL | Output low Voltage | — | — | — | 0.45 | V |

## 8.4 WLAN Radio Receiver Characteristics

Table 9 and Table 10 summarize the LWB5+ M.2 module receiver characteristics.

***Table 9: WLAN receiver characteristics for 2.4 GHz***

| Symbol | Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Frx | Receive input frequency range | 2.412 | — | 2.484 | GHz |
| Srf | | | | | |
| | CCK, 1 Mbps | — | -95 | — | dBm |
| | CCK, 11 Mbps | — | -88 | — | |
| | OFDM, 6 Mbps | — | -92 | — | |
| | OFDM, 54 Mbps | — | -75 | — | |
| | HT20, MCS0 | — | -92 | — | |
| | HT20, MCS7 | — | -73 | — | |
| | HT40, MCS0 | — | -89 | — | |
| | HT40, MCS7 | — | -70 | — | |
| Radj | | | | | |
| | OFDM, 6 Mbps | 16 | 38 | — | dB |
| | OFDM, 54 Mbps | -1 | 20.4 | — | |
| | HT20, MCS0 | 16 | 33.3 | — | |
| | HT20, MCS7 | -2 | 13.7 | — | |

***Table 10: WLAN Receiver Characteristics for 5 GHz***

| Symbol | Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Frx | Receive input frequency range | 5.15 | — | 5.825 | GHz |
| Srf | | | | | |
| | OFDM, 6 Mbps | — | -89 | — | dBm |



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| Symbol | Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| | OFDM, 54 Mbps | — | -73 | — | |
| | HT20, MCS0 | — | -89 | — | |
| | HT20, MCS7 | — | -70 | — | |
| | HT40, MCS0 | — | -86 | — | |
| | HT40, MCS7 | — | -66 | — | |
| | VHT20, MCS0 | — | -88 | — | |
| | VHT20, MCS8 | — | -66 | — | |
| | VHT40, MCS0 | — | -86 | — | |
| | VHT40, MCS9 | — | -62 | — | |
| | VHT80, MCS0 | — | -83 | — | |
| | VHT80, MCS9 | — | -59 | — | |
| Radj (Difference between interfering and desired signal (20 MHz apart)) | OFDM, 6 Mbps | 16 | 31.7 | — | dB |
| | OFDM, 54 Mbps | -1 | 13.8 | — | |
| | OFDM, 65 Mbps | -2 | 8.4 | — | |
| Radj. (Difference between interfering and desired signal (40 MHz apart)) | OFDM, 6 Mbps | 32 | 44.7 | — | dB |
| | OFDM, 54 Mbps | 15 | 26.6 | — | |
| | OFDM, 65 Mbps | 14 | 26.8 | — | |

## 8.5 WLAN Transmitter Characteristics

***Table 11: WLAN transmitter characteristics for 2.4 GHz operation (SDIO=VDIO=1.8V)***

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Ftx | Transmit output frequency range | — | 2.412 | — | 2.484 | GHz |
| Pout | 11b mask compliant | 1-11 Mbps | — | 18 | — | dBm |
| | 11g mask compliant | 6-36 Mbps | — | 17.5 | — | |
| | 11g EVM compliant | 48-54 Mbps | — | 16.5 | — | |
| | 11n HT20 mask compliant | MCS 0-5 | — | 15.5 | — | |
| | 11n HT20 EVM compliant | MCS 6-7 | — | 15.5 | — | |
| | 11n HT40 mask compliant | MCS 0-5 | — | 11.5 | — | |
| | 11n HT40 EVM compliant | MCS 6-7 | — | 11.5 | — | |
| ATx | Transmit power accuracy at 25 ℃ | — | -2.0 | — | +2.0 | dB |

| Freq. | Mode/Rate (Mbps) | Output Power (dBm) | Maximum Current Consumption (mA) |
|---|---|---|---|
| 2412 MHz | 1 Mbps | 18 dBm | 390 |
| | 11 Mbps | 18 dBm | 406 |
| | 6 Mbps | 17.5 dBm | 406 |
| | 54 Mbps | 16.5 dBm | 364 |



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| Freq. | Mode/Rate (Mbps) | Output Power (dBm) | Maximum Current Consumption (mA) |
|---|---|---|---|
| | HT20 MCS 0 | 15.5 dBm | 361 |
| | HT20 MCS 7 | 15.5 dBm | 339 |
| | HT40 MCS 0 | 11.5 dBm | 324 |
| | HT40 MCS 7 | 11.5 dBm | 298 |
| 2442 MHz | 1 Mbps | 18 dBm | 390 |
| | 11 Mbps | 18 dBm | 406 |
| | 6 Mbps | 17.5 dBm | 406 |
| | 54 Mbps | 16.5 dBm | 364 |
| | HT20 MCS 0 | 15.5 dBm | 361 |
| | HT20 MCS 7 | 15.5 dBm | 339 |
| | HT40 MCS 0 | 11.5 dBm | 324 |
| | HT40 MCS 7 | 11.5 dBm | 298 |
| 2472 MHz | 1 Mbps | 18 dBm | 390 |
| | 11 Mbps | 18 dBm | 406 |
| | 6 Mbps | 17.5 dBm | 406 |
| | 54 Mbps | 16.5 dBm | 364 |
| | HT20 MCS 0 | 15.5 dBm | 361 |
| | HT20 MCS 7 | 15.5 dBm | 339 |
| | HT40 MCS 0 | 11.5 dBm | 324 |
| | HT40 MCS 7 | 11.5 dBm | 298 |

***Table 12: WLAN transmitter characteristics for 5 GHz operation (SDIO=VDIO=1.8V)***

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Ftx | Transmit output frequency range | — | 5.15 | — | 5.925 | GHz |
| Pout | Output power | See Note[2] | — | — | — | — |
| | 11a mask compliant | 6-48 Mbps | — | 17 | — | dBm |
| | 11a EVM compliant | 54 Mbps | — | 15 | — | |
| | 11n HT20 mask compliant | MCS 0-5 | — | 17 | — | |
| | 11n HT20 EVM compliant | MCS 6-7 | — | 15 | — | |
| | 11n HT40 mask compliant | MCS 0-5 | — | 13 | — | |
| | 11n HT40 EVM compliant | MCS 6-7 | — | 13 | — | |
| | 11ac VHT20 mask compliant | MCS 0-5 | — | 17 | — | |
| | 11ac VHT20 EVM compliant | MCS 6-7 | — | 15 | — | |
| | 11ac VHT20 EVM compliant | MCS 8 | — | 11.5 | — | |
| | 11ac VHT40 mask compliant | MCS 0-5 | — | 13 | — | |
| | 11ac VHT40 EVM compliant | MCS 6-7 | — | 13 | — | |
| | 11ac VHT40 EVM compliant | MCS 8-9 | — | 11.5 | — | |
| | 11ac VHT80 mask compliant | MCS 0-5 | — | 12 | — | |



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| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| | 11ac VHT80 EVM compliant | MCS 6-7 | — | 12 | — | |
| | 11ac VHT80 EVM compliant | MCS 8-9 | — | 11 | — | |
| ATx | Transmit power accuracy at 25 ℃ | — | -2.0 | — | +2.0 | dB |

***Table 13: WLAN current consumption on 5 GHz (SDIO=VDIO=1.8V)***

| Freq. | Mode/Rate [Mbps] | Output Power Per Chain [dBm] | Maximum Current Consumption (mA) |
|---|---|---|---|
| 5180 MHz | 6 Mbps | 17 dBm | 378 |
| | 54 Mbps | 15 dBm | 341 |
| | HT20 MCS 0 | 17 dBm | 382 |
| | HT20 MCS 7 | 15 dBm | 352 |
| 5190 MHz | HT40 MCS 0 | 13 dBm | 367 |
| | HT40 MCS 7 | 13 dBm | 354 |
| | VHT80 MCS 0 | 12 dBm | 391 |
| 5210 MHz | VHT80 MCS 9 | 11 dBm | 339 |
| 5500 MHz | 6 Mbps | 17 dBm | 378 |
| | 54 Mbps | 15 dBm | 341 |
| | HT20 MCS 0 | 17 dBm | 382 |
| | HT20 MCS 7 | 15 dBm | 352 |
| 5510 MHz | HT40 MCS 0 | 13 dBm | 367 |
| | HT40 MCS 7 | 13 dBm | 354 |
| | VHT80 MCS 0 | 12 dBm | 391 |
| 5530 MHz | VHT80 MCS 9 | 11 dBm | 339 |
| 5825 MHz | 6 Mbps | 17 dBm | 378 |
| | 54 Mbps | 15 dBm | 341 |
| | HT20 MCS 0 | 17 dBm | 382 |
| | HT20 MCS 7 | 15 dBm | 352 |
| 5795 MHz | HT40 MCS 0 | 13 dBm | 367 |
| | HT40 MCS 0 | 13 dBm | 354 |
| 5775 MHz | VHT80 MCS 0 | 12 dBm | 391 |
| | VHT80 MCS 9 | 11 dBm | 339 |

**Note:** Final TX power values on each channel are limited by regulatory requirements



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# 9 Bluetooth Radio Characteristics

Table 14 through Table 16 describe the basic rate transmitter performance, basic rate receiver performance, enhanced rate receiver performance, and current consumption conditions at 25°C.

***Table 14: Basic rate transmitter performance temperature at 25°C (3.3V)***

| Test Parameter | | Min | Typ | Max | BT Spec. | Unit |
|---|---|---|---|---|---|---|
| Maximum RF Output Power | GFSK | — | — | 7 | 0 ~ +20 | dBm |
| | π/4-DQPSK | — | 3 | — | | |
| | 8-DPSK | — | 3 | — | | |
| Frequency Range | | 2.4 | — | 2.4835 | 2.4 ≤ f ≤ 2.4835 | GHz |
| 20 dB Bandwidth | | — | 919.5 | — | ≤ 1000 | KHz |
| Δf1avg Maximum Modulation | | 140 | 155 | 175 | 140 < Δf1avg < 175 | KHz |
| Δf2max Minimum Modulation | | 115 | 135 | — | ≥ 115 | KHz |
| Δf2avg/Δf1avg | | — | 0.9 | — | ≥ 0.80 | — |
| Initial Carrier Frequency | | — | ± 25 | ± 75 | ≤ ± 75 | KHz |
| Frequency Drift (DH1 packet) | | — | ± 10 | ± 25 | ± 25 | KHz |
| Frequency Drift (DH3 packet) | | — | ± 10 | ± 40 | ± 40 | KHz |
| Frequency Drift (DH5 packet) | | — | ± 10 | ± 40 | ± 40 | KHz |
| Drift rate | | — | 8 | 20 | 20 | KHz/50us |
| Adjacent Channel Power | F ≥ ± 3 MHz | — | -50 | — | < -40 | dBm |
| | F = ± 2 MHz | — | -46 | — | ≤ -20 | dBm |
| | F = ± 1 MHz | — | -15 | — | N/A | dBm |

***Table 15: Basic rate receiver performance at 3.3V***

| Test Parameter | | Min | Typ | Max | BT Spec. | Unit |
|---|---|---|---|---|---|---|
| Sensitivity (1DH5) | BER ≤ 0.1% | — | -90 | — | ≤ -70 | dBm |
| Maximum Input | BER ≤ 0.1% | — | — | -20 | ≥ -20 | dBm |
| Interference Performance | Co-Channel | — | 9 | 11 | 11 | dB |
| | C/I 1 MHz adjacent channel | — | -5.5 | 0 | 0 | dB |
| | C/I 2 MHz adjacent channel | — | -38 | -30 | -30 | dB |
| | C/I ≥ 3 MHz adjacent channel | — | -46 | -40 | -40 | dB |
| | C/I image channel | — | -25.5 | -9 | -9 | dB |
| | C/I 1-MHz adjacent to image channel | — | -39 | -20 | -20 | dB |

***Table 16: Enhanced data rate receiver performance (3.3V)***

| Test Parameter | | Min | Typ | Max | BT Spec. | Unit |
|---|---|---|---|---|---|---|
| Sensitivity (BER ≤ 0.01%) | π/4-DQPSK | — | -92 | — | ≤ -70 | dBm |
| | 8-DPSK | — | -86 | — | ≤ -70 | dBm |
| Maximum Input (BER ≤ 0.1%) | π/4-DQPSK | — | — | -20 | ≥ -20 | dBm |
| | 8-DPSK | — | — | -20 | ≥ -20 | dBm |
| C/I Co-Channel (BER ≤ 0.1%) | π/4-DQPSK | — | 10.5 | 13 | ≤ ±13 | dB |
| | 8-DPSK | — | 17.5 | 21 | ≤ ±21 | dB |



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| Test Parameter | | Min | Typ | Max | BT Spec. | Unit |
|---|---|---|---|---|---|---|
| C/I 1 MHz adjacent Channel | π/4-DQPSK | — | -6 | 0 | ≤ 0 | dB |
| | 8-DPSK | — | -3 | 5 | ≤5 | dB |
| C/I 2 MHz adjacent Channel | π/4-DQPSK | — | -38.5 | -30 | ≤ -30 | dB |
| | 8-DPSK | — | -37.5 | -25 | ≤ -25 | dB |
| C/I ≥ 3 MHz adjacent Channel | π/4-DQPSK | — | -47 | -40 | ≤ -40 | dB |
| | 8-DPSK | — | -39.5 | -33 | ≤ -33 | dB |
| C/I image channel | π/4-DQPSK | — | -24.5 | -7 | ≤ -7 | dB |
| | 8-DPSK | — | -17 | 0 | ≤ 0 | dB |
| C/I 1 MHz adjacent to image channel | π/4-DQPSK | — | -43 | -20 | ≤ -20 | dB |
| | 8-DPSK | — | -37 | -13 | ≤ -13 | dB |
| Out-of-Band Blocking Performance (CW) BER ≤ 0.1% | 30-2000MHz | — | -10 | — | — | dBm |
| | 2-2.399GHz | — | -27 | — | — | dBm |
| | 2.484-3GHz | — | -27 | — | — | dBm |
| | 3-12.75GHz | — | -10 | — | — | dBm |

***Table 17: BLE RF Specifications (3.3V)***

| Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Frequency range | — | 2402 | — | 2480 | MHz |
| Rx sensitivity[3] | GFSK, 30.8% PER, 1Mbps | — | -93 | — | dBm |
| Tx power[4] | — | — | — | 7 | dBm |
| Δf1 average | — | 225 | 255 | 275 | KHz |
| Δf2 maximum[5] | — | 185 | 220 | — | KHz |
| $\frac{\Delta f2\ avg}{\Delta f1\ avg}$ ratio | — | 0.8 | 0.95 | — | — |

**Notes**

[3] Dirty Tx is Off.

[4] The BLE TX power cannot exceed 10 dBm EIRP specification limit. The front-end losses and antenna gain/loss must be factored in so as not to exceed the limit.

[5] At least 99.9% of all Δf2 maximum frequency values recorded over 10 packets must be greater than 185 KHz.

***Table 18: Bluetooth current consumption, VBAT=VDDIO=3.3V***

| Operating Mode | Tx | Rx | Unit |
|---|---|---|---|
| DH1 | 24.07 | 24.06 | mA |
| DH3 | 29.23 | 29.03 | mA |
| DH5 | 30.04 | 30.02 | mA |
| 2DH1 | 18.24 | 18.19 | mA |
| 2DH3 | 25.46 | 25.12 | mA |
| 2DH5 | 25.83 | 25.77 | mA |



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| Operating Mode | Tx | Rx | Unit |
|---|---|---|---|
| 3DH1 | 21.47 | 21.43 | mA |
| 3DH3 | 25.21 | 25.26 | mA |
| 3DH5 | 25.84 | 25.79 | mA |
| LE | 30.37 | 14.61 | mA |

***Table 19: Bluetooth current consumption, VBAT=3.3V, VDDIO=1.8V***

| Operating Mode | Tx | Rx | Unit |
|---|---|---|---|
| DH1 | 23.62 | 23.57 | mA |
| DH3 | 28.57 | 28.54 | mA |
| DH5 | 29.62 | 29.62 | mA |
| 2DH1 | 17.65 | 17.77 | mA |
| 2DH3 | 24.06 | 24.07 | mA |
| 2DH5 | 25.11 | 25.12 | mA |
| 3DH1 | 20.91 | 20.87 | mA |
| 3DH3 | 24.42 | 24.72 | mA |
| 3DH5 | 25.34 | 25.29 | mA |
| LE | 30.04 | 14.19 | mA |

***Table 20: Peak PHY Calibration Current***

| Mode | $^{V}$BAT = 3.3V $V_{DDIO}$ = 1.8V $T_A$ = 25°C | |
|---|---|---|
| | $^{V}$BAT, mA | $^{V}$IO, µA |
| Unassociated (2.4 GHz) | 768 | 510 |
| Associated (2.4 GHz) | 748 | 560 |
| Unassociated (5 GHz) | 666 | 410 |
| Associated (5 GHz) | 664 | 390 |



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# 10 Host Interface Specifications

## 10.1 SDIO Specifications

The LWB5+ M.2 module SDIO host interface pins are powered from the VIO_SD voltage supply, which is set internally at 1.8V on the M.2 module. The SDIO electrical specifications are identical for the 1-bit SDIO and 4-bit SDIO modes.

**Note**: The SDIO host signals must be 1.8v at all times as defined by the M.2 standard.

### 10.1.1 Default Speed, High-speed Modes

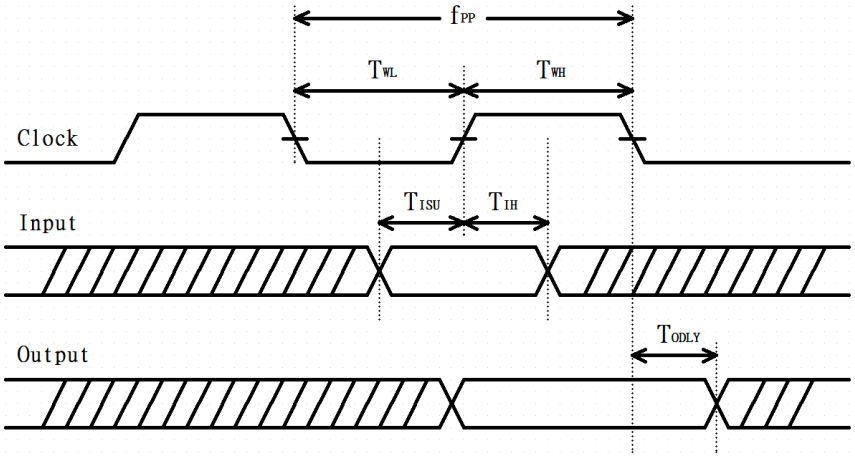


***Figure 2: SDIO protocol timing diagram--- default mode (1.8V)***

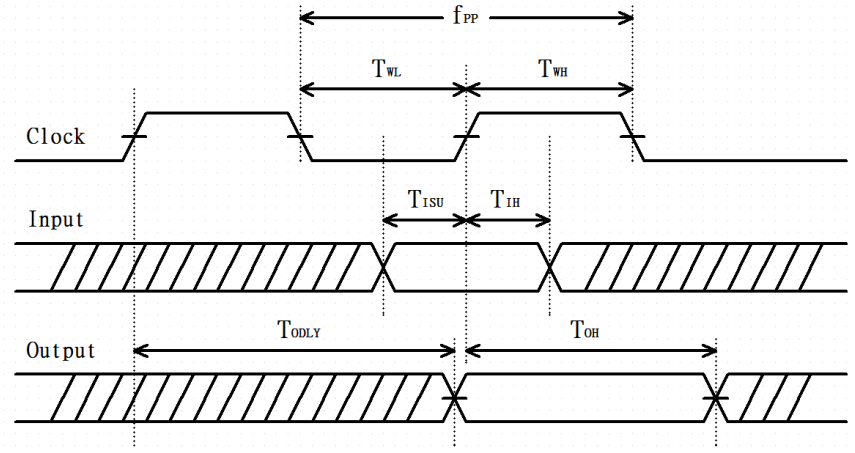


***Figure 3: SDIO protocol timing diagram--- High-Speed mode (1.8V)***

**Note:** Over full range of values specified in the Recommended Operating Conditions unless otherwise specified.

***Table 21: SDIO timing requirements***

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| fPP | Clock Frequency | Default Speed | 0 | - | 25 | MHz |
| | | High-Speed | 0 | - | 50 | |



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| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| TWL | Clock low time | Default Speed<br>High-Speed | 10<br>7 | -<br>- | -<br>- | ns |
| TWH | Clock high time | Default Speed<br>High-Speed | 10<br>7 | -<br>- | -<br>- | ns |
| TISU | Input Setup time | Default Speed<br>High-Speed | 5<br>6 | -<br>- | -<br>- | ns |
| TIH | Input Hold time | Default Speed<br>High-Speed | 5<br>2 | -<br>- | -<br>- | ns |
| TODLY | Output delay time<br>CL≦40pF (1 card) | Default Speed<br>High-Speed | -<br>- | -<br>- | 14<br>14 | ns |
| TOH | Output hold time | High-Speed | 0 | - | - | ns |

## 10.1.2 SDR12, SDR25, SDR50 Mode (up to 100MHz) (1.8V)

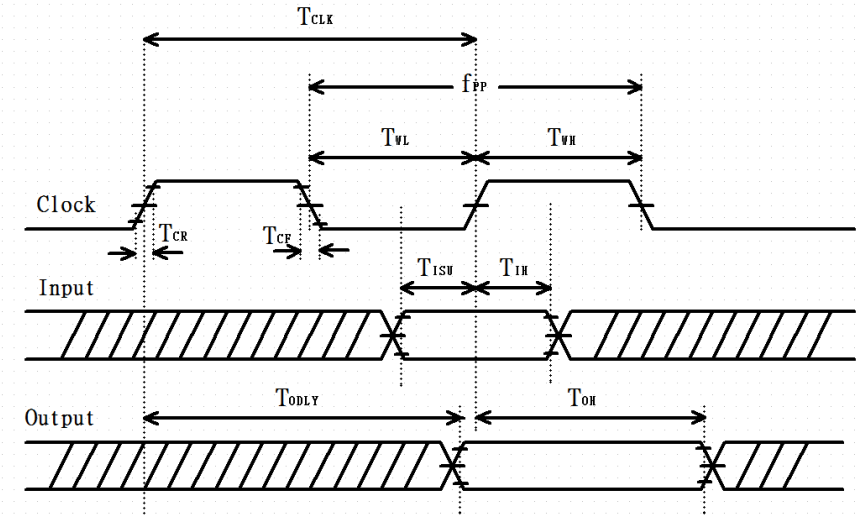


***Figure 4: SDIO protocol timing Diagram--- SDR12, SDR25, SDR50 modes (up to 100 MHz) (1.8V)***

**Note:** Over full range of values specified in the Recommended Operating Conditions unless otherwise specified.

***Table 22: SDIO timing requirements--- SDR12, SDR25, SDR50 modes (up to 100 MHz) (1.8V)***

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| fPP | Clock Frequency | SDR12/25/50 | 25 | - | 100 | MHz |
| TISU | Input setup time | SDR12/25/50 | 3 | -- | - | ns |
| TIH | Input Hold time | SDR12/25/50 | 0.8 | - | - | ns |
| TCLK | Clock Time | SDR12/25/50 | 10 | - | 40 | ns |
| TCR, TCF | Raise time, Fall time<br>TCR, TCF <2ns (max) at 100MHz<br>CCARD=10pF | SDR12/25/50 | - | - | 0.2*TCLK | ns |
| TODLY | Output delay time<br>CL≦30pF | SDR12/25/50 | - | - | 7.5 | ns |



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| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| TOH | Output hold time<br>CL=15pF | SDR12/25/50 | 1.5 | - | - | ns |

## 10.1.3 SDR104 Mode (208 MHz) (1.8V)

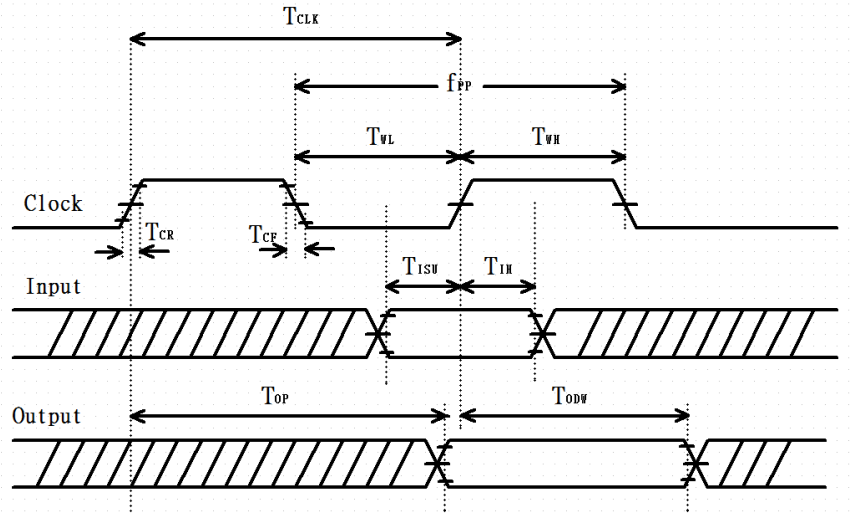


***Figure 5: SDIO protocol timing Diagram--- SDR104 modes (up to 208 MHz) (1.8V)***

**Note:** Over full range of values specified in the Recommended Operating Conditions unless otherwise specified.

***Table 23: SDIO timing requirements--- SDR104 modes (up to 208MHz) (1.8V)***

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| fPP | Clock Frequency | SDR104 | 0 | - | 208 | MHz |
| TISU | Input setup time | SDR104 | 1.4 | -- | - | ns |
| TIH | Input Hold time | SDR104 | 0.8 | - | - | ns |
| TCLK | Clock Time | SDR104 | 4.8 | - | - | ns |
| TCR, TCF | Raise time, Fall time<br>TCR, TCF <0.96ns (max) at 208MHz<br>CCARD=10pF | SDR104 | - | - | 0.2*TCLK | ns |
| TOP | Card Output phase | SDR104 | 0 | - | 10 | ns |
| TODW | Output timing pf variable data window | SDR12/25/50 | 2.88 | - | - | ns |



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## 10.1.4 SDR50 Mode (50MHz) (1.8V)

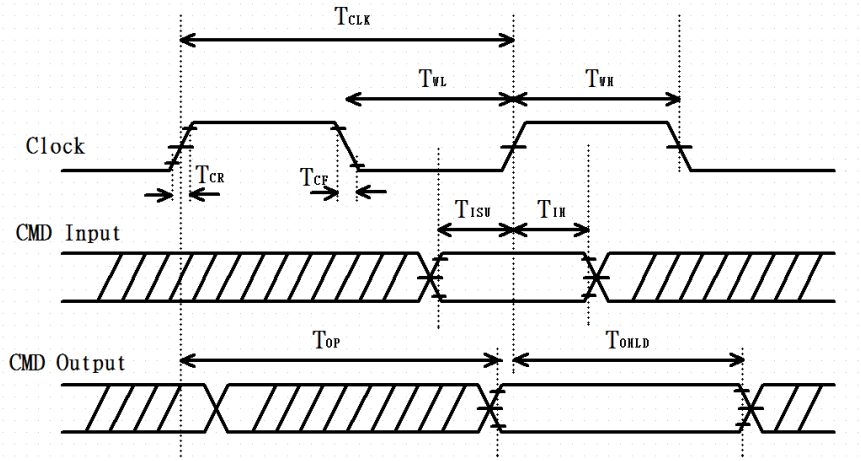


***Figure 6: SDIO CMD timing diagram--- SDR50 modes (50 MHz) (1.8V)***

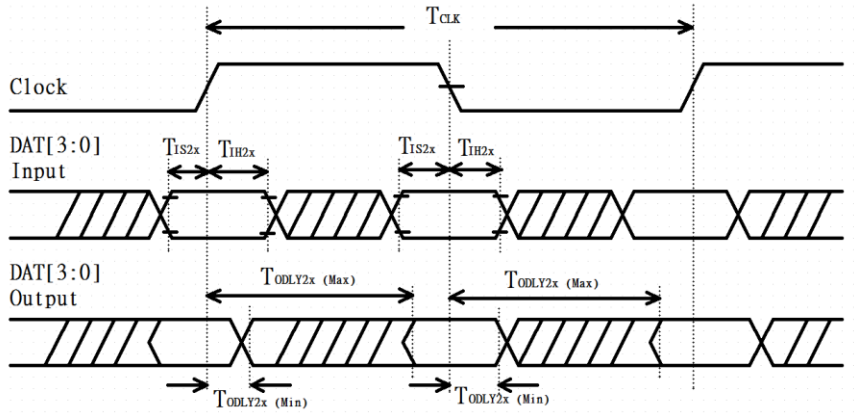


***Figure 7: SDIO DAT[3:0] timing Diagram--- SDR50 modes (50 MHz) (1.8V)***

**Note:** In SDR50 mode, DAT[3:0] lines are samples on both edges pf the clock (not applicable for CMD line)

***Table 24: SDIO timing requirements – SDR50 modes (50 MHz)***

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **Clock** | | | | | | |
| TCLK | Clock time<br>50MHz (max) between rising edge | SDR50 | 20 | -- | -- | ns |
| TCR, TCF | Rise time, fall time<br>TCR, TCF <4.00ns (max) at 50MHz.<br>CCARD=10pF | SDR50 | -- | -- | 0.2*TCLK | ns |
| Clock Duty | -- | SDR50 | 45 | -- | 55 | % |
| **CMD Input (referenced to clock rising edge)** | | | | | | |
| TIS | Input setup time<br>CCARD≦10pF (1 card) | SDR50 | 6 | -- | -- | ns |
| TIH | Input hold time<br>CCARD≦10pF (1 card) | SDR50 | 0.8 | -- | -- | ns |



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| Symbol | Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **CMD Output (referenced to clock rising and failing edge)** | | | | | | |
| TODLY | Output delay time during data transfer mode<br>CL≦30pF (1 card) | SDR50 | -- | -- | 13.7 | ns |
| TOHLD | Output hold time<br>CL≥15pF (1 card) | SDR50 | 1.5 | -- | -- | ns |
| **DAT[3:0] Input (referenced to clock rising and failing edges)** | | | | | | |
| TIS2X | Input setup time<br>CCARD≦10pF (1 card) | SDR50 | 3 | -- | -- | ns |
| TIH2X | Input hold time<br>CCARD≦10pF (1 card) | SDR50 | 0.8 | -- | -- | ns |
| **DAT[3:0] Output (referenced to clock rising and failing edges)** | | | | | | |
| TODLY2X (max) | Output delay time during data transfer mode<br>CL≦25pF (1 card) | SDR50 | -- | -- | 7.0 | ns |
| TODLY2X (min) | Output hold time<br>CL≥15pF (1 card)) | SDR50 | 1.5 | -- | -- | ns |

## 10.2 USB Specifications

The LWB5+ M.2 module can be powered through the USB interface and an external regulator is required to converts a 3.3V voltage for the LWB5+ M.2 module.

The LWB5+ M.2 module shared USB2.0 interface between WLAN and Bluetooth. The data bus DP/DM as USB signaling, the Figure 8 shown the WLAN/Bluetooth shared the USB interface timing

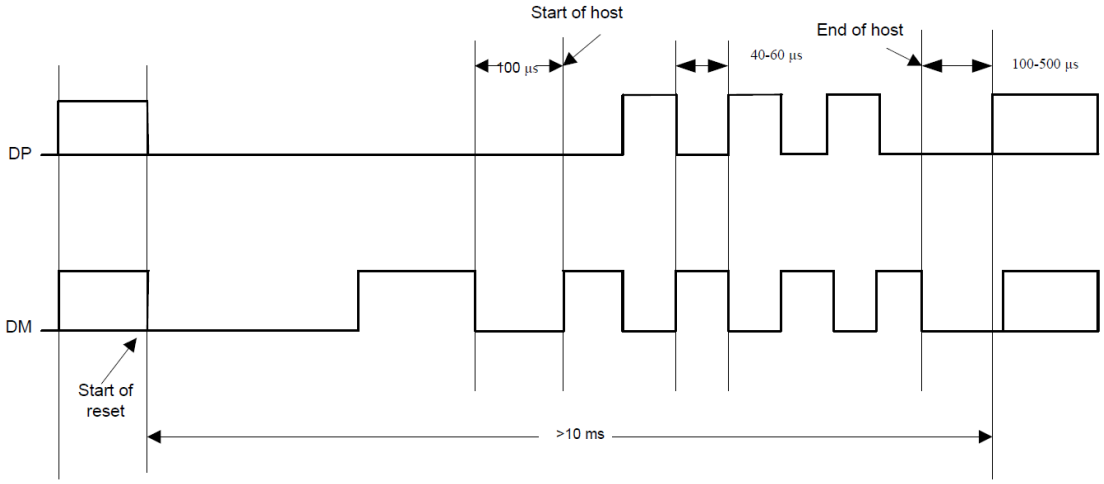


***Figure 8: WLAN/Bluetooth USB Timing***



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## 10.3 PCM Interface Specifications

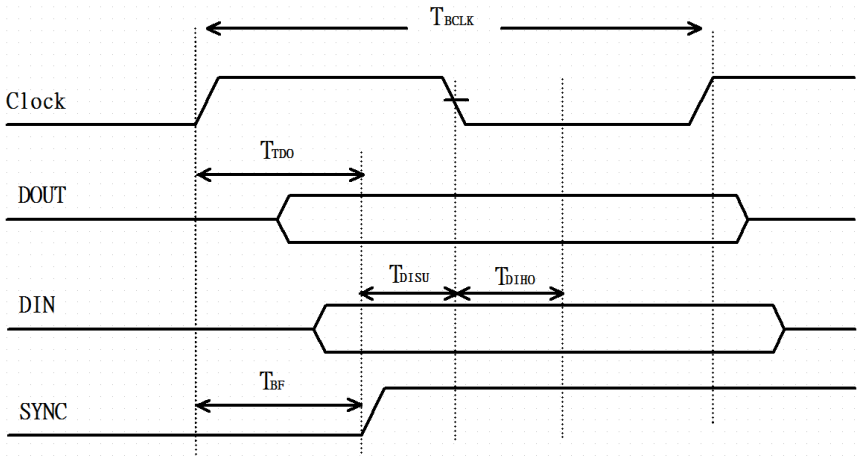


***Figure 9: PCM Timing Specification – Master Mode***

***Table 25: PCM Timing Specification – Master Mode***

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| FBCLK | - | - | 2/2.048 | - | MHz |
| Duty CycleBCLK | - | 0.4 | 0.5 | 0.6 | - |
| TBCLK rise/fall | - | - | 3 | - | ns |
| TDO | - | - | - | 15 | ns |
| TDISU | - | 20 | - | - | ns |
| TDIHO | - | 15 | - | - | ns |
| TBF | - | - | - | 15 | ns |

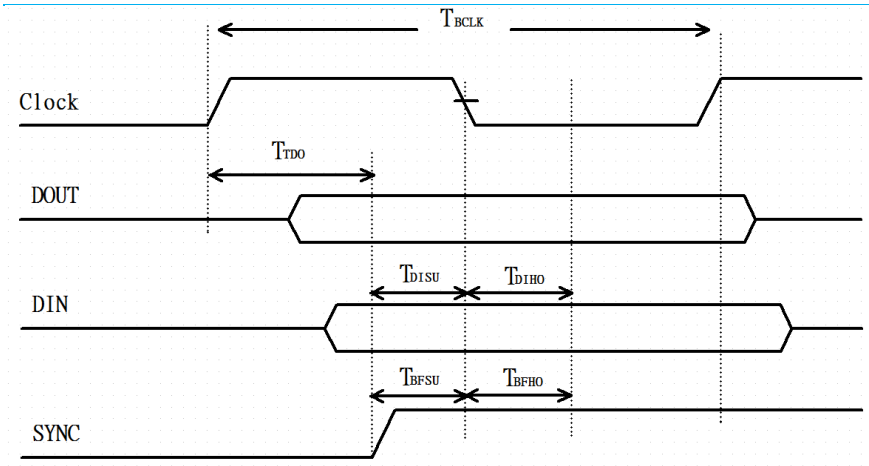


***Figure 8: PCM Timing Specification – Slave Mode***

***Table 26: PCM Timing Specification – Slave Mode***

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| FBCLK | - | - | 2/2.048 | - | MHz |
| Duty CycleBCLK | - | 0.4 | 0.5 | 0.6 | - |
| TBCLK rise/fall | - | - | 3 | - | ns |



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| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| TDO | - | - | - | 30 | ns |
| TDISU | - | 15 | - | - | ns |
| TDIHO | - | 10 | - | - | ns |
| TBFSU | - | 15 | - | - | ns |
| TBFHO | - | 10 | - | - | ns |

# 11 Power-Up Sequence and Timing Requirement

## 11.1 Description on Control Signal

- **WL_REG_ON** – Used by the PMU to power-up the WLAN section. When this pin is high, the regulators are enabled and the WLAN section is out of reset. When this pin is low the WLAN section is in reset. If both the BT_REG_ON and WL_REG_ON pins are low, the regulators are disabled.
- **BT_REG_ON** – Used by the PMU (OR-gated with WL_REG_ON) to power-up the internal regulators. If both the BT_REG_ON and WL_REG_ON pins are low, the regulators are disabled. When this pin is low and WL_REG_ON is high, the BT section is in reset.

**Notes:**

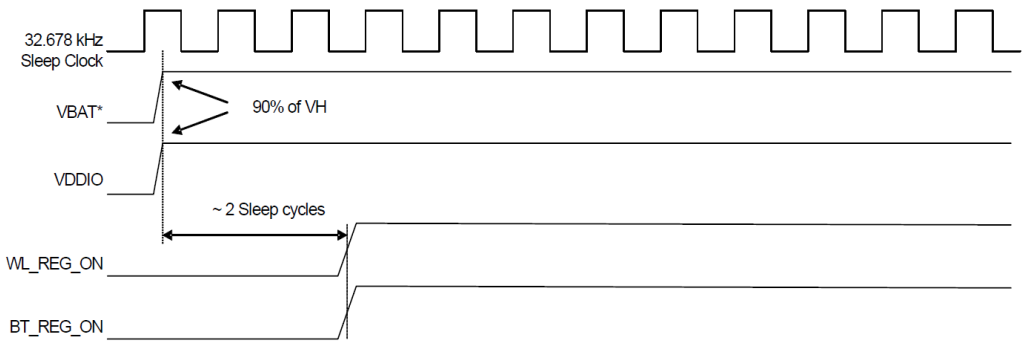
For both the WL_REG_ON and BT_REG_ON pins, there should be at least a 10-millisecond time delay between consecutive toggles (where both signals have been driven low). This allows time for the internal regulator to discharge. If this delay is not followed, there may be a VDDIO in-rush current on the order of 36 mA during the next PMU cold start.

The CYW4373E has an internal power-on reset (POR) circuit. The device is held in reset for a maximum of 110 milliseconds after VDDC and VDDIO have passed the POR threshold. Wait at least 150 milliseconds after VDDC and VDDIO are available before initiating SDIO accesses.

VBAT should not rise 10%–90% faster than 40 microseconds. VBAT should be up before or at the same time as VDDIO. VDDIO should NOT be present first or be held high before VBAT is high.

## 11.2 Control and Timing Diagrams

- **WLAN=ON; Bluetooth=ON**




*Notes:
1. VBAT should not rise 10%–90% faster than 40 microseconds.
2. VBAT should be up before or at the same time as VDDIO. VDDIO should NOT be present first or be held high before VBAT is high.



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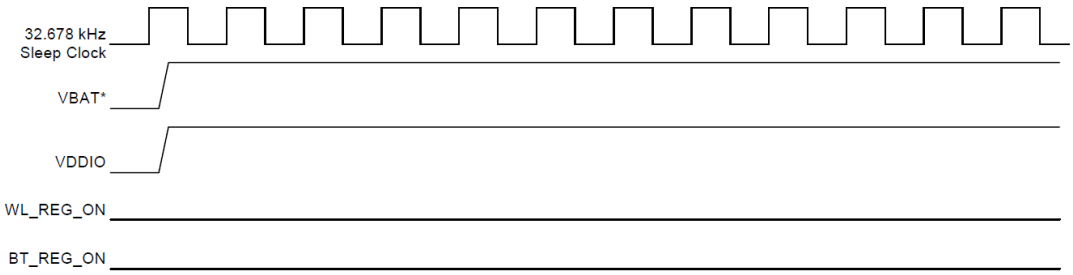
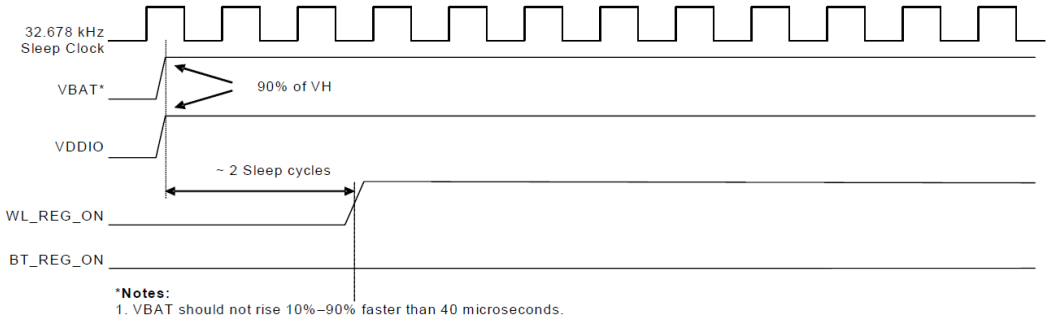
- **WLAN=OFF; Bluetooth=OFF**



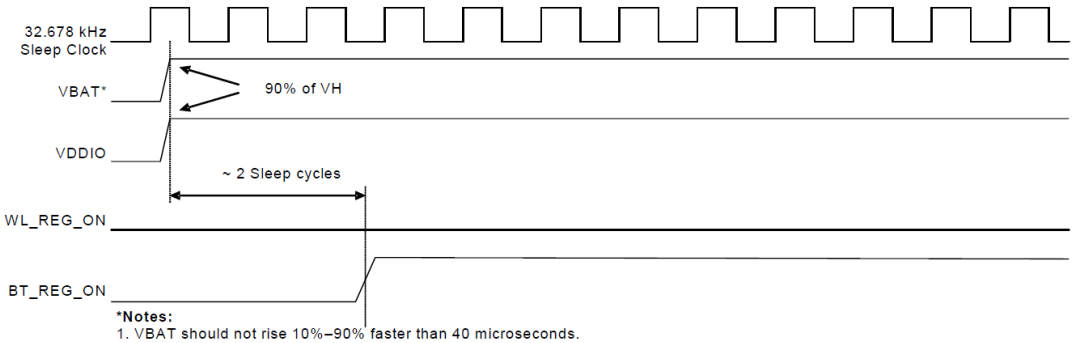

***Notes:**
1. VBAT should not rise 10%–90% faster than 40 microseconds.
2. VBAT should be up before or at the same time as VDDIO. VDDIO should NOT be present first or be held high before VBAT is high.

- **WLAN=ON; Bluetooth=OFF**




***Notes:**
1. VBAT should not rise 10%–90% faster than 40 microseconds.
2. VBAT should be up before or at the same time as VDDIO. VDDIO should NOT be present first or be held high before VBAT is high.

- **WLAN=OFF; Bluetooth=ON**




***Notes:**
1. VBAT should not rise 10%–90% faster than 40 microseconds.
2. VBAT should be up before or at the same time as VDDIO. VDDIO should NOT be present first or be held high before VBAT is high.



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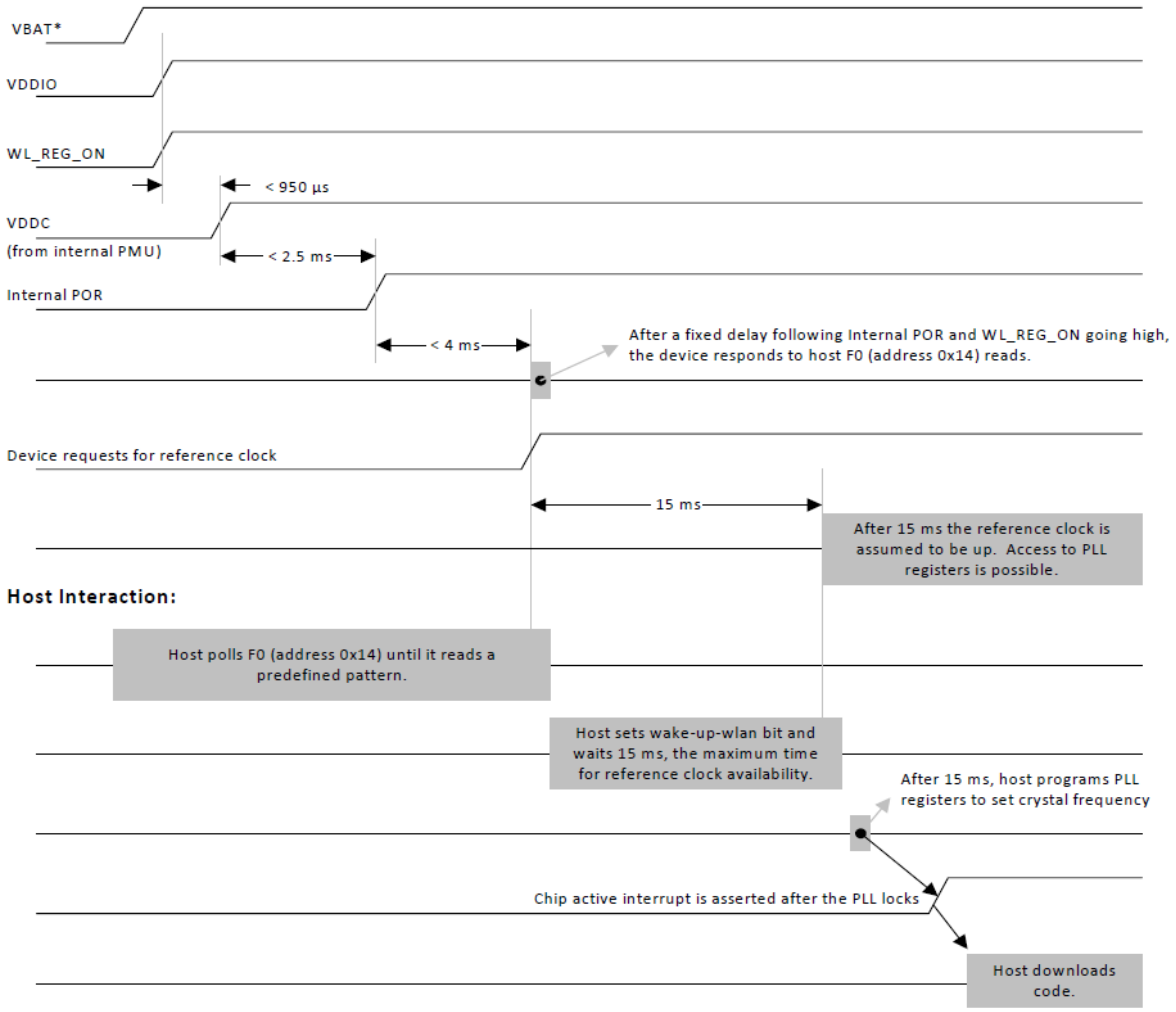
- **WLAN Boot up Sequence for SDIO Host**




***Notes:**
1. VBAT and VDDIO should not rise 10%–90% faster than 40 microseconds.
2. VBAT should be up before or at the same time as VDDIO. VDDIO should NOT be present first or be held high before VBAT is high.



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# 12 PIN DEFINITIONS

***Table 27: Pin definitions of LWB5+ M.2 module***

| Pin # | Name | Type | Voltage Ref. | Function | If Not Used |
|---|---|---|---|---|---|
| 1 | GND | - | - | Ground | GND |
| 2 | 3.3V | PWR I/P | 3.3V | DC supply voltage for module. Operational is 3.2V to 3.6V ( | -- |
| 3 | USB_D+ | I/O | - | Data plus of shared USB 2.0 port | NC |
| 4 | 3.3V | PWR I/P | 3.3V | DC supply voltage for module. Operational is 3.2V to 3.6V | -- |
| 5 | USB_D- | I/O | - | Data minus of shared USB 2.0 port | NC |
| 6 | LED1# | O | 3.3V | Reserved | NC |
| 7 | GND | - | - | Ground | GND |
| 8 | PCM_CLK | I/O | 1.8V | PCM clock. Can be master (Output) or slave (Input) | NC |
| 9 | SDIO CLK | I | 1.8V | SDIO clock input | NC |
| 10 | PCM_SYNC | I/O | 1.8V | PCM Sync. Can be master (Output) or slave (Input); Or SLIM bus data. | NC |
| 11 | SDIO CMD | I/O | 1.8V | SDIO command line | NC |
| 12 | PCM_OUT | O | 1.8V | PCM data output. | NC |
| 13 | SDIO DATA0 | I/O | 1.8V | SDIO data lin0 | NC |
| 14 | PCM_IN | I | 1.8V | PCM data input. | NC |
| 15 | SDIO DATA1 | I/O | 1.8V | SDIO data lin1 | NC |
| 16 | LED2# | O | 3.3V | Reserved | NC |
| 17 | SDIO DATA2 | I/O | 1.8V | SDIO data lin2 | NC |
| 18 | GND | - | - | Ground | GND |
| 19 | SDIO DATA3 | I/O | 1.8V | SDIO data lin3 | NC |
| 20 | UART WAKE# | O | 1.8V | Reserved for feature support BT_HOST_WAKE. Output signal to wake up Host. | NC |
| 21 | SDIO WAKE# | I | 1.8V | Reserved for feature support Reserved for WL_HOST_WAKE. Output signal to wake up host. | NC |
| 22 | UART_TXD | O | 1.8V | Serial data output for the HCI UART interface. | NC |
| 23 | SDIO RESET# | - | - | NC | NC |



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| Pin # | Name | Type | Voltage Ref. | Function | If Not Used |
|---|---|---|---|---|---|
| 32 | UART_RXD | I | 1.8V | Serial data input for the HCI UART interface. | NC |
| 33 | GND | - | - | Ground | GND |
| 34 | UART_RTS | O | 1.8V | Active-Low request-to-send signal for the HCI UART interface. | NC |
| 35 | PERp0 | - | - | NC | NC |
| 36 | UART_CTS | I | 1.8V | Active-Low clear-to-send signal for the HCI UART interface. | NC |
| 37 | PERn0 | - | - | NC | NC |
| 38 | VENDER DEFINED38 | - | - | NC | NC |
| 39 | GND | - | - | Ground | GND |
| 40 | VENDER DEFINED40 | I | 1.8V | Reserved for feature support<br>BT_DEVICE_WAKE. Input signal from Host. | NC |
| 41 | PETp0 | - | - | NC | NC |
| 42 | VENDER DEFINED42 | I/O | 1.8V | Reserved for feature support<br>Reserved for WL_DEVICE_WAKE.<br>Input from Host to wake up WLAN module. | NC |
| 43 | PETn0 | - | - | NC | NC |
| 44 | COEX3 | - | - | NC | NC |
| 45 | GND | - | - | Ground | GND |
| 46 | COEX2 | I/O | 1.8V | Reserved for feature support<br>WCI-2 LTE coexistence Interface | NC |
| 47 | REFCLKp0 | - | - | NC | NC |
| 48 | COEX1 | I/O | 1.8V | Reserved for feature support<br>WCI-2 LTE coexistence Interface | NC |
| 49 | REFCLKn0 | - | - | NC | NC |
| 50 | SUSCLK | I | - | External Sleep Clock input (32.768KHz)<br>The sleep clock is always needed for using this module | -- |
| 51 | GND | - | - | Ground | GND |
| 52 | PERST0# | - | - | NC | NC |
| 53 | CLKREQ0# | - | - | NC | NC |
| 54 | W_DISABLE2# | I | 3.3V | Enables BT regulators. Internal 10K pull-up to enable BT by default. Ground to disable BT. | NC |
| 55 | PEWAKE0# | - | - | NC | NC |
| 56 | W_DISABLE1# | I | 3.3 V | Enables WLAN regulators. Internal 10K pull-up to enable WLAN by default. Ground to disable WLAN. | NC |
| 57 | GND | - | - | Ground | GND |
| 58 | I2C DATA | - | - | NC | NC |
| 59 | RESERVED | - | - | NC | NC |



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| Pin # | Name | Type | Voltage Ref. | Function | If Not Used |
|---|---|---|---|---|---|
| 60 | I2C CLK | - | - | NC | NC |
| 61 | RESERVED | - | - | NC | NC |
| 62 | ALERT# | - | - | NC | NC |
| 63 | GND | - | - | Ground | GND |
| 64 | RESERVED | - | - | NC | NC |
| 65 | RESERVED | - | - | NC | NC |
| 66 | UIM_SWP | - | - | NC | NC |
| 67 | RESERVED | - | - | NC | NC |
| 68 | UIM_POWER_SNK | - | - | NC | NC |
| 69 | GND | - | - | Ground | GND |
| 70 | UIM_POWER_SRC | - | - | NC | NC |
| 71 | RESERVED | - | - | NC | NC |
| 72 | 3.3V | PWR I/P | 3.3V | DC supply voltage for module. Operational is 3.2V to 3.6V | -- |
| 73 | RESERVED | - | - | NC | NC |
| 74 | 3.3V | PWR I/P | 3.3V | DC supply voltage for module. Operational is 3.2V to 3.6V | -- |
| 75 | GND | - | - | Ground | GND |



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# 13 MECHANICAL SPECIFICATIONS

Module dimensions of LWB5+ M.2 module is 17 x 12 x 2.1 mm. Detailed drawings are shown in Figure 11.

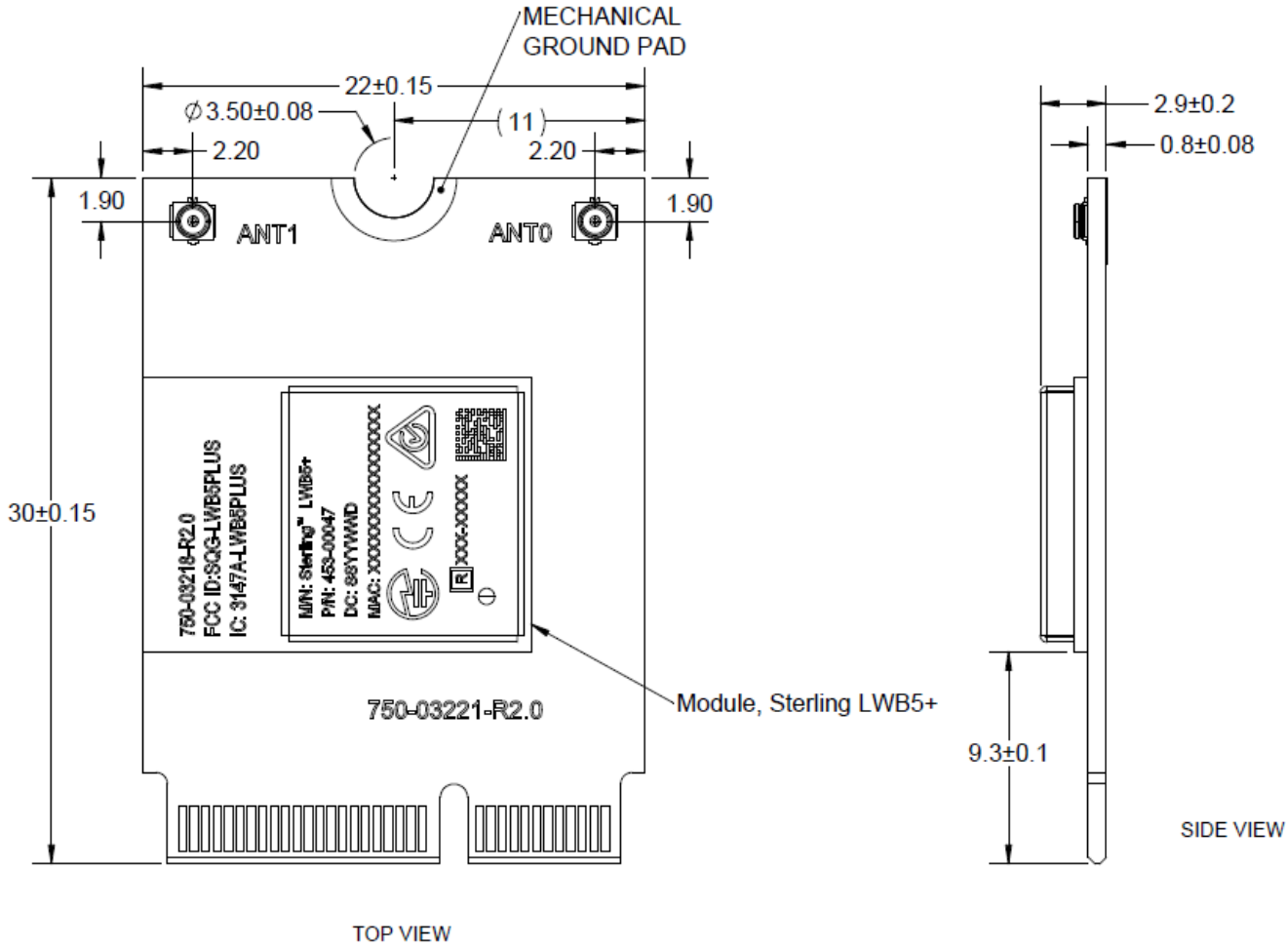


***Figure 11: Mechanical drawing - LWB5+ M.2 module***



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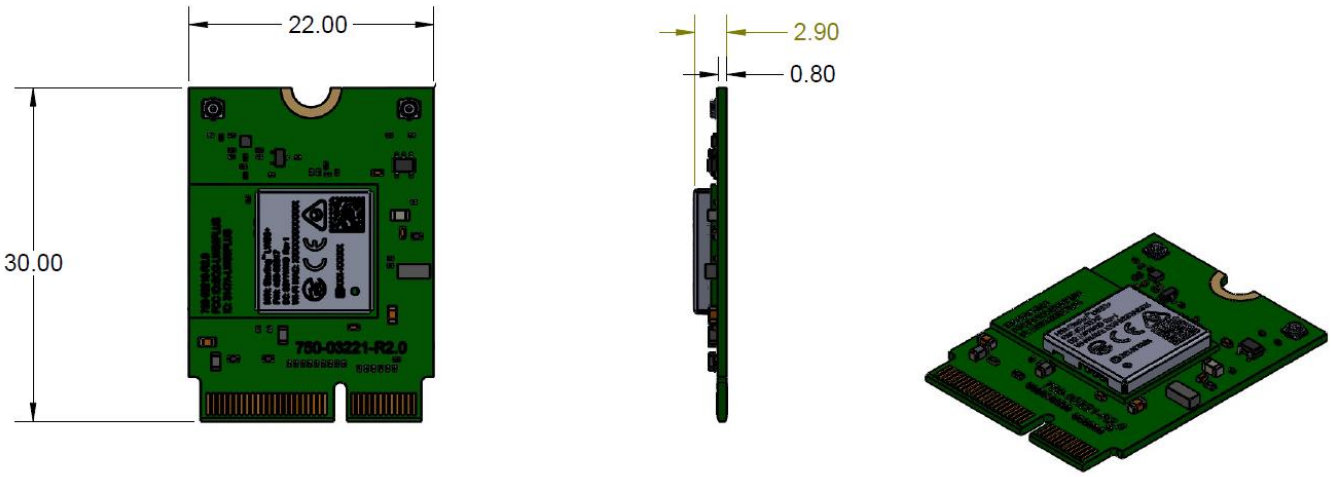


***Figure 12: Module dimension of LWB5+ M.2 module – Top View***

**Note:** The Wi-Fi MAC address is located on the product label.
The last digit of Wi-Fi MAC address is assigned to either *0, 2, 4, 6, 8, A, C, E.*
The BT MAC address is the Wi-Fi MAC address plus 1.

# 14 MOUNTING

The LWB5+ M.2 module connects to the host via a standard PCI EXPRESS M2 connector. The Kyocera's (www.Kyocera-connector.com) 6411 series provide 1.8 mm, 2.3 mm and 3.2 mm connector heights and JAE's (https://www.jae.com/en/) SM3 series provide 1.2 mm, 2.15 mm, 3.1 mm and 4.1 mm connector heights.

Because the LWB5+ M.2 module is a single-side component module, we recommend the following part numbers which have 2.3 mm and 3.1 mm connector height):

| M.2 Key-E Connector | Connector Height |
|---|---|
| KYOCERA 24-6411-067-101-894E | 2.3 mm |
| JAE SM3ZS067U310AERxxxx | 3.1 mm |

The stand-off mating to the recommend 2.3 mm connector from EMI STOP (www.EMISTOP.com) is part number **F50M16-041525P1D4M** and 3.1mm from JAE (https://www.jae.com/en/) is part number **SM3ZS067U310-NUT1-Rxxxx**.

| M.2 Key-E Connector | Stand-off |
|---|---|
| KYOCERA 24-6411-067-101-894E | EMI STOP F50M16-041525P1D4M |
| JAE SM3ZS067U310AERxxxx | JAE SM3ZS067U310-NUT1-Rxxxx |

Detailed layout and stencil opening are show in Figure 13.



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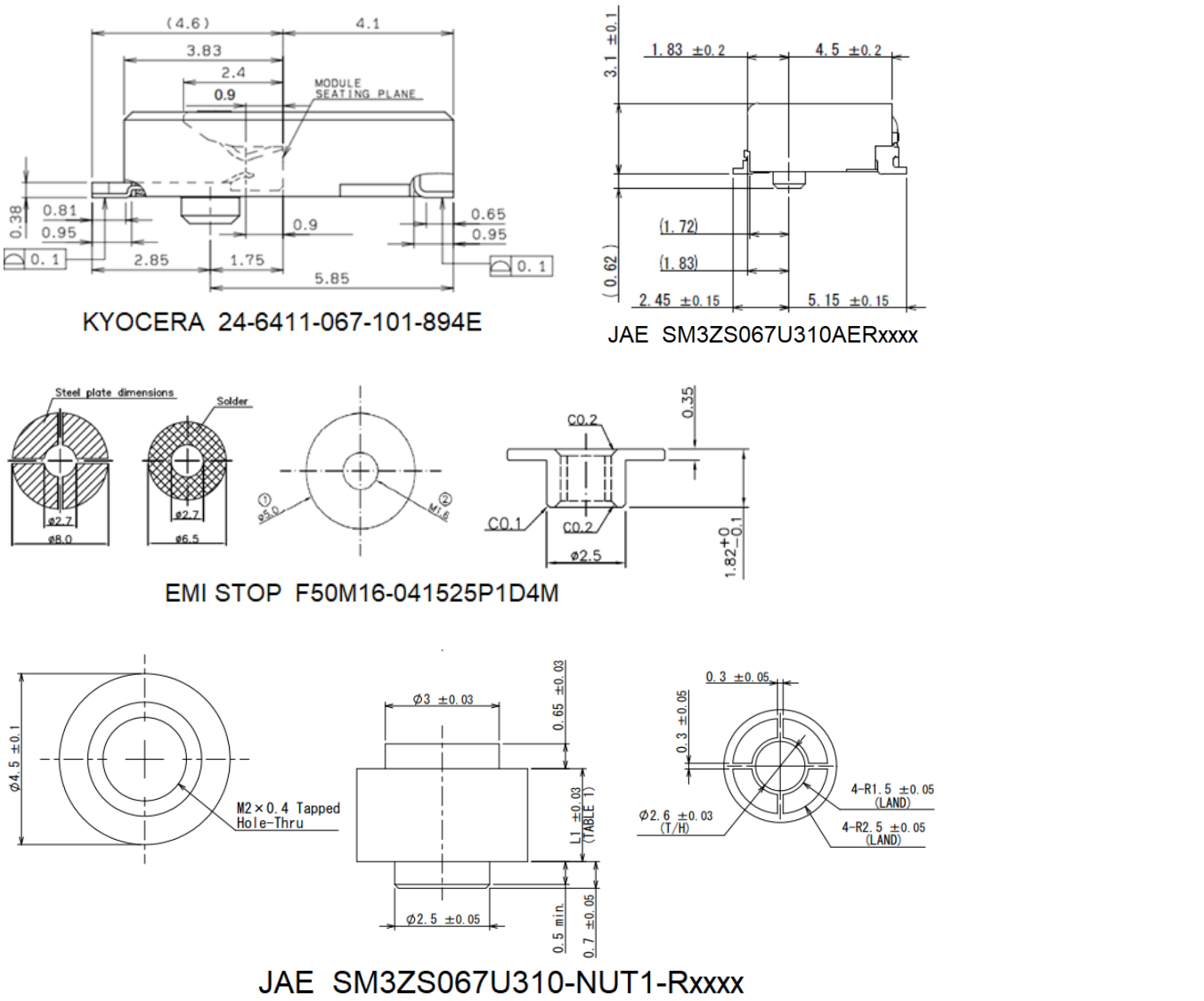


***Figure 13: Mounting information of the LWB5+ M.2 module and recommended layout pattern for the stand-off***

# 15 RF Layout Design Guidelines

The following is a list of RF layout design guidelines and recommendation when installing a Laird radio into your device.

- Do not run antenna cables directly above or directly below the radio.
- Do not place any parts or run any high-speed digital lines below the radio.
- If there are other radios or transmitters located on the device (such as a *Bluetooth* radio), place the devices as far apart from each other as possible. Also, make sure there is at least 25 dB isolation between these two antennas.
- Ensure that there is the maximum allowable spacing separating the antenna connectors on the Laird Connectivity radio from the antenna. In addition, do not place antennas directly above or directly below the radio.
- Laird Connectivity recommends the use of a double-shielded cable for the connection between the radio and the antenna elements.
- Be sure to put a 10uF capacitor on EACH 3.3V power pin. Also, place that capacitor to the pin as close as possible to make sure the internal PMU working correctly.
- Use proper electro-static-discharge (ESD) procedures when installing the Laird Connectivity radio module.
- To avoid negatively impacting Tx power and receiver sensitivity, do not cover the antennas with metallic objects or components.



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## 15.1 Recommended and Required Storage/Handling Conditions

### 15.1.1 Prior to Opening the Dry Packing

The following are required storage conditions ***prior* to opening the dry packing**:

- Normal temperature: 5~40˚C
- Normal humidity: 80% (Relative humidity) or less
- Storage period: One year or less

---

**Note:** Humidity means Relative Humidity.

---

### 15.1.2 After Opening the Dry Packing

The following are required storage conditions ***after* opening the dry packing** (to prevent moisture absorption):

- Storage conditions for one-time soldering:
  - Temperature: 5-25°C
  - Humidity: 60% or less
  - Period: 72 hours or less after opening
- Storage conditions for two-time soldering
  - Storage conditions following opening and prior to performing the 1st reflow:
    - Temperature: 5-25°C
    - Humidity: 60% or less
    - Period: A hours or less after opening
  - Storage conditions following completion of the 1st reflow and prior to performing the 2nd reflow
    - Temperature: 5-25°C
    - Humidity: 60% or less
    - Period: B hours or less after completion of the 1st reflow

---

**Note**: Should keep A+B within 72 hours.

---

### 15.1.3 Precautions for Use

- Opening/handing/removing must be done on an anti-ESD treated workbench.
  All workers must also have undergone anti-ESD treatment.
- The devices should be mounted within one year of the date of delivery.



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# 16 PACKAGE

## 16.1 Shipping

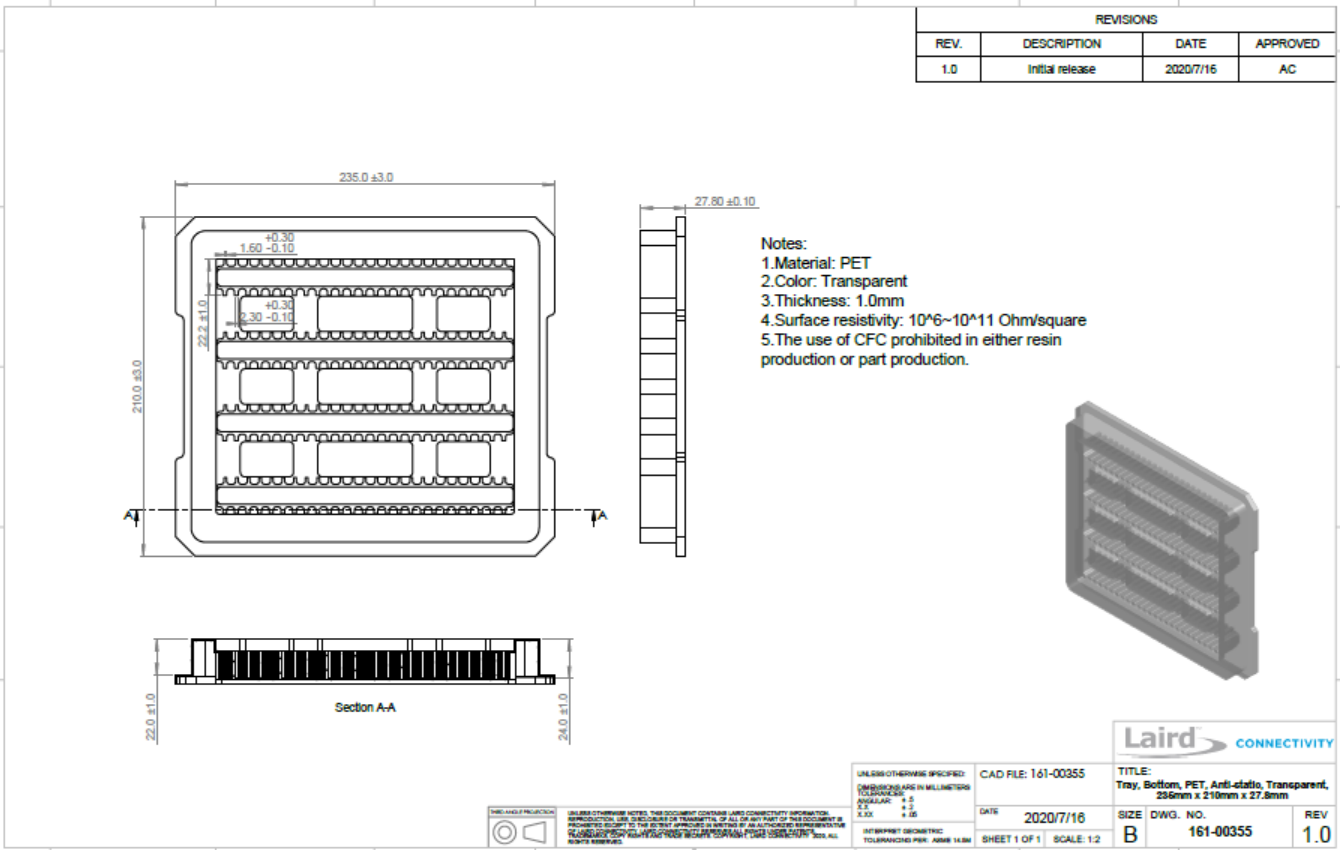


*Figure 9: Shipping Tray, Bottom, 161-00355*



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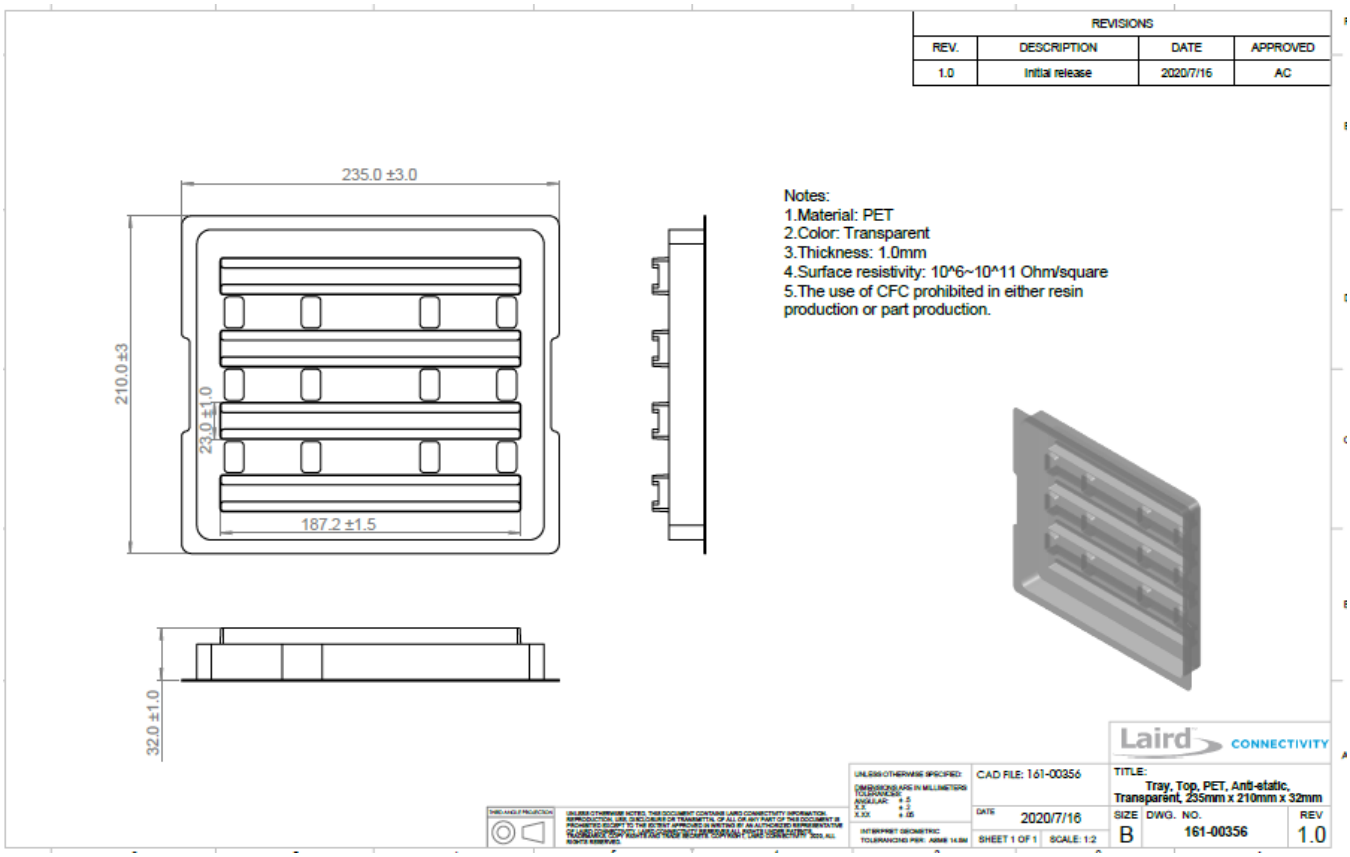


***Figure 10: Shipping Tray, Top, 161-00356***



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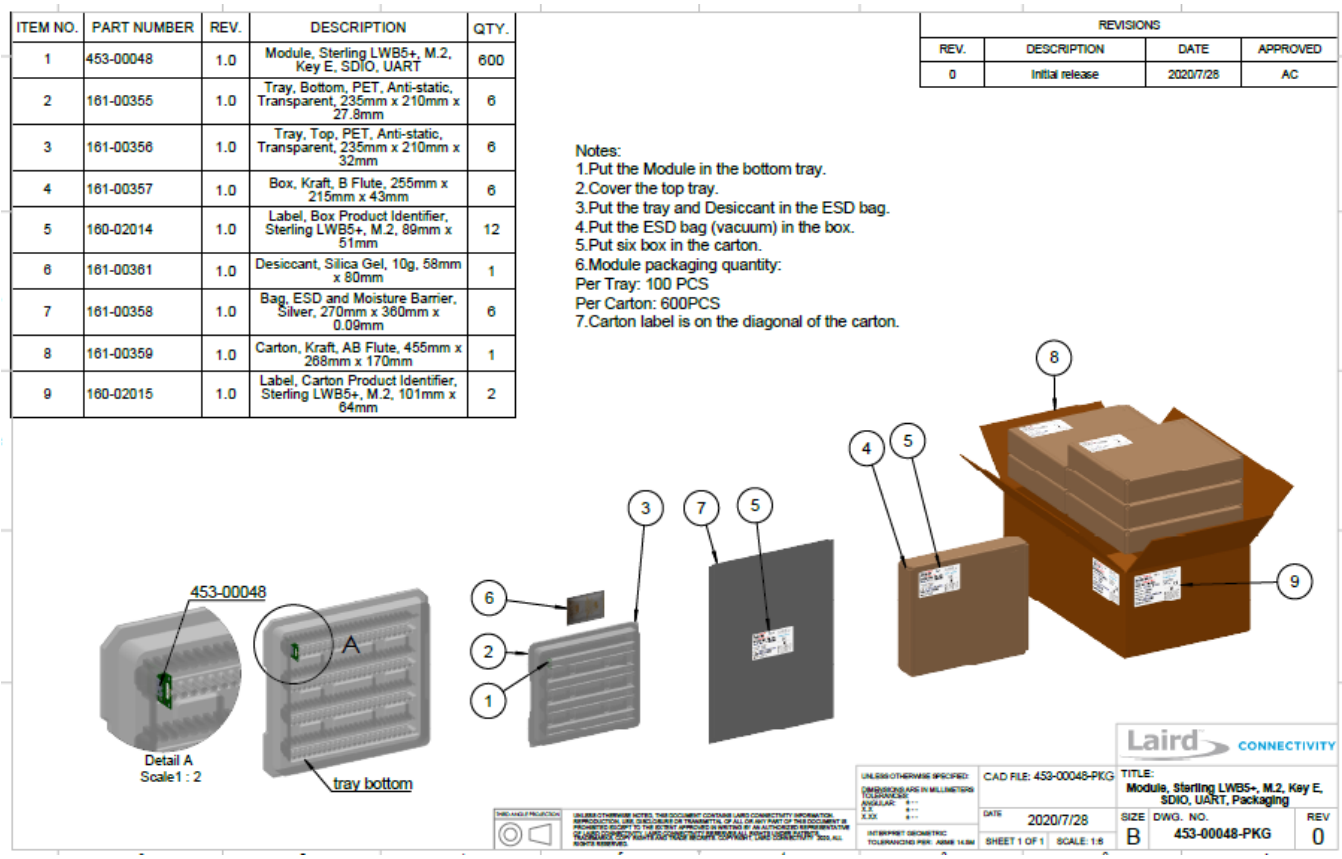

| ITEM NO. | PART NUMBER | REV. | DESCRIPTION | QTY. |
|---|---|---|---|---|
| 1 | 453-00048 | 1.0 | Module, Sterling LWB5+, M.2, Key E, SDIO, UART | 600 |
| 2 | 161-00355 | 1.0 | Tray, Bottom, PET, Anti-static, Transparent, 235mm x 210mm x 27.8mm | 6 |
| 3 | 161-00356 | 1.0 | Tray, Top, PET, Anti-static, Transparent, 235mm x 210mm x 32mm | 6 |
| 4 | 161-00357 | 1.0 | Box, Kraft, B Flute, 255mm x 215mm x 43mm | 6 |
| 5 | 160-02014 | 1.0 | Label, Box Product Identifier, Sterling LWB5+, M.2, 89mm x 51mm | 12 |
| 6 | 161-00361 | 1.0 | Desiccant, Silica Gel, 10g, 58mm x 80mm | 1 |
| 7 | 161-00358 | 1.0 | Bag, ESD and Moisture Barrier, Silver, 270mm x 360mm x 0.09mm | 6 |
| 8 | 161-00359 | 1.0 | Carton, Kraft, AB Flute, 455mm x 268mm x 170mm | 1 |
| 9 | 160-02015 | 1.0 | Label, Carton Product Identifier, Sterling LWB5+, M.2, 101mm x 64mm | 2 |

| REVISIONS | | | |
|---|---|---|---|
| REV. | DESCRIPTION | DATE | APPROVED |
| 0 | Initial release | 2020/7/28 | AC |

Notes:
1.Put the Module in the bottom tray.
2.Cover the top tray.
3.Put the tray and Desiccant in the ESD bag.
4.Put the ESD bag (vacuum) in the box.
5.Put six box in the carton.
6.Module packaging quantity:
Per Tray: 100 PCS
Per Carton: 600PCS
7.Carton label is on the diagonal of the carton.



*Figure 11: Sterling LWB5+ M.2 Packaging Process*

## 16.2 Labelling

The following label is placed on the bag and the inner box.


***Figure 12: Bag and Box Label***



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The following label is located on the adjacent sides of the master carton.


*Figure 13: Master Carton Package Label*

# 17 Regulatory

**Note:** For complete regulatory information, refer to the Sterling LWB5+ Regulatory Information document which is also available from the Sterling LWB5+ product page.

The Sterling LWB5+ holds current certifications in the following countries:

| Country/Region | Regulatory ID |
|---|---|
| USA (FCC) | SQG-LWB5PLUS |
| EU | N/A |
| Canada (ISED) | 3147A-LWB5PLUS |
| Japan (MIC) | 201-200402 |
| Australia | N/A |
| New Zealand | N/A |



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# 18 Ordering Information

| Part Number | Description |
|---|---|
| 453-00048 | 1x1 802.11 a/b/g/n/ac + Bluetooth 5.2 SDIO/UART M.2 Module |
| 453-00049 | 1x1 802.11 a/b/g/n/ac + Bluetooth 5.2 USB/USB M.2 Module |
| 453-00048-K1 | Development Kit for 1x1 802.11 a/b/g/n/ac + Bluetooth 5.2 SDIO/UART M.2 Module |
| 453-00049-K1 | Development Kit for 1x1 802.11 a/b/g/n/ac + Bluetooth 5.2 USB/USB M.2 Module |

# 19 Bluetooth SIG Qualification

## 19.1 Overview

The Sterling LWB5+ Series module is listed on the Bluetooth SIG website as a qualified Controller Subsystem.

| Design Name | Owner | Declaration ID | Link to listing on the SIG website |
|---|---|---|---|
| Sterling LWB5+ | Laird Connectivity | D050832 | https://launchstudio.bluetooth.com/ListingDetails/119009 |

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

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

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

https://www.bluetooth.org/en-us/test-qualification/qualification-overview/fees

For a detailed procedure of how to obtain a new Declaration ID for your design, please refer to the following SIG document, (login is required to views this document):

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

## 19.2 Qualification Steps When Referencing a Laird Controller Subsystem Design

To qualify your product when referencing a Laird Controller Subsystem design, follow these steps:

1. To start a listing, go to: https://www.bluetooth.org/tpg/QLI_SDoc.cfm

   **Note:** A user name and password are required to access this site.

2. In step 1, select the option, New Listing and Reference a Qualified Design.
3. Enter D050382 in the Controller Subsystem table entry.
4. Enter your complimentary Host Subsystem and optional Profile Subsystem QDID in the table entry.
5. Select your pre-paid Declaration ID from the drop-down menu or go to the Purchase Declaration ID page.

   **Note:** Unless the Declaration ID is pre-paid or purchased with a credit card, you cannot proceed until the SIG invoice is paid.

6. Once all the relevant sections of step 1 are finished, complete steps 2, 3, and 4 as described in the help document accessible from the site.

   Your new design will be listed on the SIG website and you can print your Certificate and DoC.



**Americas**: +1-800-492-2320
**Europe**: +44-1628-858-940
**Hong Kong**: +852 2923 0610

For further information please refer to the following training material:

https://www.bluetooth.org/en-us/test-qualification/qualification-overview/listing-process-updates

If you require assistance with the qualification process please contact our recommended Bluetooth Qualification Expert (BQE), Steve Flooks, steve.flooks@eurexuk.com

# 20 Additional Assistance

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

Laird Connectivity
Support Centre: https://www.lairdconnect.com/resources/support
Email: wireless.support@lairdconnectivity.com
Phone: Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852 2923 0610
Web: https://www.lairdconnect.com/products

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