

# Datasheet

60-2230C/60-2230C-SS

60-2230C-U/60-2230C-UU

*Version 2.1*

---

## REVISION HISTORY

| Version | Date         | Notes                                                                                                                                                                                                                       | Contributors | Approver      |
|---------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|---------------|
| 1.0     | 29 Aug 2017  | Initial version                                                                                                                                                                                                             |              | Jay White     |
| 1.1     | 06 Sept 2017 | Updated module size to 22 mm (length) x 30 mm (width) x 3.3 mm (thickness)<br>Updated <i>Figure 8: Module dimension of 60-2230C</i> .<br>Changed $6.7\pm0.15$ to $6\pm0.15$ .<br>Changed pin definitions for pins 54 and 56 |              | Jay White     |
| 1.2     | 08 Sept 2017 | Updated Max. Current Consumption table/column headings                                                                                                                                                                      |              | Andrew Chen   |
| 1.3     | 10 Oct 2017  | Added mFlexPIFA antenna info                                                                                                                                                                                                |              | Bill Steinike |
| 1.4     | 05 Dec 2017  | Added Korea regulatory ID information                                                                                                                                                                                       |              | Connie Lin    |
| 1.5     | 26 Mar 2018  | Updated block diagram                                                                                                                                                                                                       | Kai Wei      | Jay White     |
| 1.6     | 30 Mar 2018  | Update Wi-Fi and BT MAC rule; added part numbers and associated supported interfaces                                                                                                                                        | Andrew Chen  | Jay White     |
| 1.7     | 09 Apr 2018  | Updated operation interface for 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU; added China (SRRC) certification information                                                                                                   | Kai Wei      | Jay White     |
| 1.8     | 18 Oct 2018  | Updated to clarify PCIe USB 2.0 supported                                                                                                                                                                                   | John Nosky   | Sue White     |
| 1.9     | 07 Nov 2018  | Removed 802.11s reference                                                                                                                                                                                                   |              | Jay White     |
| 2.0     | 14 Nov 2018  | Updated KC channel list                                                                                                                                                                                                     |              | Andrew Chen   |
| 2.1     | 11 Feb 2019  | Corrected the FCC, KC, and IC regulatory IDs                                                                                                                                                                                | Connie Lin   | Jay White     |

## CONTENTS

|      |                                                |    |
|------|------------------------------------------------|----|
| 1    | Scope.....                                     | 4  |
| 2    | Introduction .....                             | 4  |
| 2.1  | General Description .....                      | 4  |
| 2.2  | Part Numbers and Supported Interfaces.....     | 5  |
| 3    | Features Summary .....                         | 5  |
| 4    | Specifications .....                           | 6  |
| 5    | WLAN Functional Description .....              | 12 |
| 6    | Bluetooth Functional Description .....         | 15 |
| 7    | Block Diagram .....                            | 16 |
| 8    | Electrical Characteristics .....               | 17 |
| 8.1  | Absolute Maximum Ratings.....                  | 17 |
| 8.2  | Recommended Operating Conditions .....         | 17 |
| 8.3  | DC Electrical Characteristics .....            | 17 |
| 8.4  | WLAN Radio Receiver Characteristics.....       | 18 |
| 8.5  | WLAN Transmitter Characteristics.....          | 19 |
| 9    | Bluetooth Radio Characteristics.....           | 21 |
| 10   | SDIO Timing Requirements .....                 | 23 |
| 11   | USB Specifications.....                        | 26 |
| 12   | PCM interface specifications.....              | 30 |
| 2.   | Pin Definitions.....                           | 31 |
| 13   | Mechanical Specifications.....                 | 34 |
| 14   | Mounting .....                                 | 35 |
| 15   | RF Layout Design Guidelines / Precautions..... | 36 |
| 16   | Regulatory.....                                | 36 |
| 16.1 | Regulatory IDs Summary .....                   | 36 |
| 16.2 | Certified Antennas .....                       | 36 |
| 17   | FCC and IC Regulatory.....                     | 37 |
| 17.1 | FCC.....                                       | 37 |
| 17.2 | Industry Canada.....                           | 38 |
| 18   | European Union Regulatory.....                 | 41 |
| 18.1 | EU Declarations of Conformity .....            | 42 |
| 19   | Ordering Information .....                     | 43 |
| 19.1 | General Comments .....                         | 43 |

# 1 SCOPE

This document describes key hardware aspects of the Laird 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU M.2 module providing either SDIO or USB2.0 bus interface for WLAN connection and UART/SDIO/USB2.0 for Bluetooth® (including Low Energy or LE) connection. This document is intended to assist device manufacturers and related parties with the integration of this module into their host devices

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

# 2 INTRODUCTION

## 2.1 General Description

The 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU module is a dual band 2x2 802.11ac WLAN plus Bluetooth 4.2 dual mode adapter; it complies with M.2 2230 E-Key standard. The module provides both simultaneous and independent operation of the following:

- IEEE 802.11ac (Wave 2), 2x2 receive Multi-User MIMO spatial stream multiplexing with data rates up to MCS9 (866.7 Mbps)
- Bluetooth (Class 1 and Class 2)
- Bluetooth 4.2 (with Low Energy or LE)
- Bluetooth 5 Ready
- Bluetooth *Smart Ready* operation
- Three-way coexistence for WLAN and Bluetooth




---

**Note:** The *Bluetooth*® word mark and logos are registered trademarks owned by Bluetooth SIG, Inc. and any use of such marks by Laird is under license. Other trademarks and trade names are those of their respective owners.

---

Internal coexistence arbitration and a Mobile Wireless System (MWS) serial transport interface provide the functionality for connecting an external Long Term Evolution (LTE).

The module integrates all WLAN and Bluetooth functionality into a single package which supports low-cost and simple implementation along with flexibility for platform-specific customization. In addition, it has low power consumption radio architecture and proprietary power save technologies to extended battery life.

On the DFS engine, the module supports 802.11h Dynamic Frequency Selection to detect the presence of radar signals; support is extended to 80 MHz mode under the 802.11ac channelization modes. In addition, the E-DFS (Enhanced DFS) scheme is designed to increase pulse detection rates for shorter (0.5 us, 0.8 us, 1 us), in-band DFS pulses. The scheme is designed to minimize the false-alarm rate for out-of-band DFS pulse.

There are two interfaces for WLAN function:

- SDIO 3.0 – Supports both 1-bit SDIO and 4-bit SDIO transfer modes at full clock range up to 208 MHz
- USB 2.0

In addition, there are three interfaces for Bluetooth function:

- SDIO
- USB 2.0
- High-Speed UART

The 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU module also provides a PCM interface for master or slave mode; with the option of an 8-bit or 16-bit width size.

Pins CON[0], CON[1], and CON[2] are used to configure the operation interface.

- 60-2230C – The interfaces are SDIO/UART (WLAN/Bluetooth) with the configuration setting 000.
- 60-2230C-SS – The interfaces are SDIO/SDIO (WLAN/Bluetooth) with the configuration setting 001.
- 60-2230C-U – The interfaces are USB/UART (WLAN/Bluetooth) with the configuration setting 100.
- 60-2230C-UU – The interfaces are USB/USB (WLAN/Bluetooth) with the configuration setting 101.

## 2.2 Part Numbers and Supported Interfaces

The following (Table 1) are the 60-2230C part numbers and the interfaces each supports.

**Table 1: Part numbers and supported interfaces**

| Part Number   | Supported Interfaces |           |
|---------------|----------------------|-----------|
|               | WLAN                 | Bluetooth |
| ST60-2230C    | UART                 | UART      |
| ST60-2230C-SS | SDIO                 | SDIO      |
| ST60-2230C-UU | USB                  | USB       |
| ST60-2230C-U  | UART                 | UART      |

## 3 FEATURES SUMMARY

The Laird 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU device features are described in Table 2.

**Table 2: 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU of features**

| Feature                    | Description                                                                                                                                                                                                                                                                                                                                                         |             |                           |                                              |
|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------------------|----------------------------------------------|
| <b>Radio Front End</b>     | <ul style="list-style-type: none"> <li>▪ Integrates the complete transmit/receive RF paths including band pass filter, diplexer, switches, reference crystal oscillator, and power manage unit (PMU)</li> <li>▪ Supports 20/40/80 MHz channel bandwidth</li> <li>▪ WLAN/Bluetooth share one antenna</li> </ul>                                                      |             |                           |                                              |
| <b>Coexistence</b>         | Coexistence arbitration for WLAN, Bluetooth, and LTE operation                                                                                                                                                                                                                                                                                                      |             |                           |                                              |
| <b>Power Management</b>    | Dynamic Voltage Scaling (DVS) and Adaptive Voltage Scaling (AVS) feature supports the latest Marvell SoC and processor power control scheme.                                                                                                                                                                                                                        |             |                           |                                              |
| <b>Pre-Calibration</b>     | RF system-tested and calibrated in production.                                                                                                                                                                                                                                                                                                                      |             |                           |                                              |
| <b>Sleep Clock</b>         | An external sleep clock of 32.768 KHz is required during power save mode.                                                                                                                                                                                                                                                                                           |             |                           |                                              |
| <b>Host Interface</b>      | <ul style="list-style-type: none"> <li>▪ SDIO 3.0 (4-bit and 1-bit), SDR 12/25/50 mode (up to 100MHz), USB 2.0 or PCIe for WLAN</li> <li>▪ SDIO 3.0, USB 2.0, HS-UART for Bluetooth HCI (compatible with any upper layer Bluetooth stack)</li> <li>▪ PCM digital audio interface for Bluetooth audio application.</li> </ul>                                        |             |                           |                                              |
|                            | <b>Strap Value<br/>CONFIG_HOST[2-0]</b>                                                                                                                                                                                                                                                                                                                             | <b>WLAN</b> | <b>Bluetooth/<br/>BLE</b> | <b>ROM Notes</b>                             |
|                            | 000                                                                                                                                                                                                                                                                                                                                                                 | SDIO        | UART                      | -                                            |
|                            | 001                                                                                                                                                                                                                                                                                                                                                                 | SDIO        | SDIO                      | -                                            |
|                            | 100                                                                                                                                                                                                                                                                                                                                                                 | USB 2.0     | UART                      | Initial USB 2.0 PHY and COM PHY PCIe USB 2.0 |
|                            | 101                                                                                                                                                                                                                                                                                                                                                                 | USB 2.0     | USB 2.0                   | Initial USB 2.0 PHY only                     |
| <b>Reference Frequency</b> | <ul style="list-style-type: none"> <li>▪ Incorporates a 40 MHz reference frequency source in package</li> <li>▪ An external sleep clock is recommended for minimal current consumption. If no sleep clock input is provided, an internal sleep clock (derived from the reference clock) is used. An approximate 50 uA current increase on the 3.3V rail.</li> </ul> |             |                           |                                              |
| <b>Advanced WLAN</b>       | <ul style="list-style-type: none"> <li>▪ A-MPDU RX (de-aggregation) and TX (aggregation) supports 802.11ac single-MPDU A-MPDU</li> <li>▪ Multi-BSS/Station</li> <li>▪ Transmit rate adaption, transmit power control</li> </ul>                                                                                                                                     |             |                           |                                              |

| Feature                   | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                           | <ul style="list-style-type: none"> <li>Modulation and coding scheme (MCS): <ul style="list-style-type: none"> <li>802.11ac—MCS0-9 Nsts=1 and 2</li> <li>802.11n—MCS0-15</li> </ul> </li> <li>Dynamic frequency selection (DFS) – Radar detection</li> <li>20/40/80 MHz channel bandwidths support</li> <li>On-chip gain selectable LNA with optimized noise figure and power consumption</li> <li>Internal PA with optimized gain distribution for linearity and noise performance</li> <li>Support Wild variety of WLAN encryption: TKIP/WEP/AES</li> </ul>                      |
| <b>Advanced Bluetooth</b> | <ul style="list-style-type: none"> <li>Bluetooth 4.2 (BDR/EDR/LE), Bluetooth Class 1</li> <li>Bluetooth 5 ready</li> <li>Supports the following data rates: 1 Mbps (GFSK), 2 Mbps (<math>\pi/4</math>-DQPSK), 3 Mbps (8-DPSK)</li> <li>Digital audio interface with PCM/TDM interface for voice application</li> <li>Adaptive Frequency Hopping (AFH) using Package Error Rate (PER)</li> <li>Standard SDIO or UART HCI transport layer</li> <li>WLAN/Bluetooth coexistence protocol support</li> <li>Shared LNA with WLAN/Bluetooth</li> <li>Encryption (AES) support</li> </ul> |

## 4 SPECIFICATIONS

Table 3: Specifications

| Feature                                                                                 | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |         |                   |                                                     |
|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-------------------|-----------------------------------------------------|
| Physical Interface                                                                      | 84-pin LGA package (including 16 thermal ground pad under the package)                                                                                                                                                                                                                                                                                                                                                                                                             |         |                   |                                                     |
| Wi-Fi Interface                                                                         | 1-bit or 4-bit Secure Digital I/O; PCIe v3.0 Gen1/Gen2 (2.5/5 Gbps); USB 2.0                                                                                                                                                                                                                                                                                                                                                                                                       |         |                   |                                                     |
| Bluetooth/<br>BLE Interface                                                             | Host Controller Interface (HCI) using High Speed UART, SDIO, USB 2.0                                                                                                                                                                                                                                                                                                                                                                                                               |         |                   |                                                     |
|                                                                                         | Strap Value<br>CONFIG_HOST[2-0]                                                                                                                                                                                                                                                                                                                                                                                                                                                    | WLAN    | Bluetooth<br>/BLE | ROM Notes                                           |
|                                                                                         | 000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | SDIO    | UART              | -                                                   |
|                                                                                         | 001                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | SDIO    | SDIO              | -                                                   |
|                                                                                         | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | USB 2.0 | UART              | Initial USB 2.0 PHY <i>and</i> COM PHY PCIe USB 2.0 |
|                                                                                         | 101                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | USB 2.0 | USB 2.0           | Initial USB 2.0 PHY only                            |
| Main Chip                                                                               | Marvell 88W8997 (WLAN/BT); Marvell 88PG823 (PMU)                                                                                                                                                                                                                                                                                                                                                                                                                                   |         |                   |                                                     |
| Input Voltage Requirements                                                              | DC 3.3 V ±10%                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |         |                   |                                                     |
| I/O Signalling Voltage                                                                  | DC 3.3 V ± 10% or DC 1.8 V ± 10%                                                                                                                                                                                                                                                                                                                                                                                                                                                   |         |                   |                                                     |
| Peak Current consumption, VCC=VIO = 3.3 volts (At maximum transmit power setting)       | <b>MIMO 2x 2 operations.</b><br><b>802.11b (with BT in standby) @ 18 dBm 1 Mbps</b><br>Transmit: XX mA Receive: XX mA<br><b>802.11g (with BT in standby) @ 18 dBm 6 Mbps</b><br>Transmit: XX mA Receive: XX mA<br><b>802.11a (with BT in standby) @ 18 dBm 6 Mbps</b><br>Transmit: XX mA Receive: XX mA<br><b>802.11n (2.4 GHz/40MHz) (with BT in standby) @ 16 dBm MCS0</b><br>Transmit: XX mA Receive: XX mA<br><b>802.11n (5.0 GH/40MHz) (with BT in standby) @ 16 dBm MCS0</b> |         |                   |                                                     |
| <i><b>Note:</b> Reset refers to the radio are in reset, both Wi-fi and BT reset are</i> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |         |                   |                                                     |

| Feature                                | Description                                                                                                                                                                                                                                                    |
|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>asserted.</i>                       | Transmit: XX mA Receive: XX mA<br><b>802.11ac (5.0 GH/80MHz) (with BT in standby) @ 14 dBm MCS0</b><br>Transmit: XX mA Receive: XX mA<br><b>Bluetooth (with Wi-Fi in standby)</b><br>Transmit: XX mA Receive: XX mA<br><b>Reset:</b><br>XXX mA                 |
| <b>Operating Temperature</b>           | -30° to 85°C (-22° to 185°F)                                                                                                                                                                                                                                   |
| <b>Operating Humidity</b>              | 10 to 90% (non-condensing)                                                                                                                                                                                                                                     |
| <b>Storage Temperature</b>             | -40° to 85°C (-40° to 185°F)                                                                                                                                                                                                                                   |
| <b>Storage Humidity</b>                | 10 to 90% (non-condensing)                                                                                                                                                                                                                                     |
| <b>Maximum Electrostatic Discharge</b> | Conductive 4KV; Air coupled 8KV follow EN61000-4-2                                                                                                                                                                                                             |
| <b>Size</b>                            | 22 mm (length) x 30 mm (width) x 3.3 mm (thickness)                                                                                                                                                                                                            |
| <b>Weight</b>                          | TBD g                                                                                                                                                                                                                                                          |
| <b>Wi-Fi Media</b>                     | Direct Sequence-Spread Spectrum (DSSS)<br>Complementary Code Keying (CCK)<br>Orthogonal Frequency Divisional Multiplexing (OFDM)                                                                                                                               |
| <b>Bluetooth Media</b>                 | Frequency Hopping Spread Spectrum (FHSS)                                                                                                                                                                                                                       |
| <b>Wi-Fi Media Access Protocol</b>     | Carrier sense multiple access with collision avoidance (CSMA/CA)<br>A-MPDU Rx (De-aggregation) and Tx (aggregation) (802.11ac single-MPDU A-MPDU)                                                                                                              |
| <b>Network Architecture Types</b>      | Infrastructure and ad-hoc                                                                                                                                                                                                                                      |
| <b>Wi-Fi Standards</b>                 | IEEE 802.11a, 802.11b, 802.11d*, 802.11e, 802.11g, 802.11h, 802.11i, 802.11k*, 802.11n, 802.11r, 802.11v*, 802.11ac<br>* Summit version only                                                                                                                   |
| <b>Bluetooth Standards</b>             | Bluetooth version 2.1 with Enhanced Data Rate<br>Bluetooth 4.2 (Bluetooth Low Energy or BLE)<br>Bluetooth 5 (coming soon)                                                                                                                                      |
| <b>Wi-Fi Data Rates Supported</b>      | Support 802.11 ac/a/b/g/n 2X2 MIMO<br>MU-MIMO/802.11ac Wave 2<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, MCS 0-15)<br>802.11ac (OFDM, HT20, MCS0-8; OFDM HT40/HT80, MCS 0-9) |

| Feature                            |          | Description                                                                                                                                                                                                    |               |                 |            |        |        |       |        |     |        |       |
|------------------------------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-----------------|------------|--------|--------|-------|--------|-----|--------|-------|
| Modulation Table                   |          | BPSK, QPSK, CCK, 16-QAM, 64-QAM, and 256-QAM.                                                                                                                                                                  |               |                 |            |        |        |       |        |     |        |       |
|                                    | 802.11ac | HT MCS Index                                                                                                                                                                                                   | VHT MCS Index | Spatial Streams | Modulation | Coding | 20 MHz |       | 40 MHz |     | 80 MHz |       |
|                                    | 802.11n  |                                                                                                                                                                                                                |               |                 |            |        | 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 |
|                                    |          | 8                                                                                                                                                                                                              | 0             | 2               | BPSK       | 1/2    | 13     | 14.4  | 27     | 30  | 58.5   | 65    |
|                                    |          | 9                                                                                                                                                                                                              | 1             | 2               | QPSK       | 1/2    | 26     | 28.9  | 54     | 60  | 117    | 130   |
|                                    |          | 10                                                                                                                                                                                                             | 2             | 2               | QPSK       | 3/4    | 39     | 43.3  | 81     | 90  | 175.5  | 195   |
|                                    |          | 11                                                                                                                                                                                                             | 3             | 2               | 16-QAM     | 1/2    | 52     | 57.8  | 108    | 120 | 234    | 260   |
|                                    |          | 12                                                                                                                                                                                                             | 4             | 2               | 16-QAM     | 3/4    | 78     | 86.7  | 162    | 180 | 351    | 390   |
|                                    |          | 13                                                                                                                                                                                                             | 5             | 2               | 64-QAM     | 2/3    | 104    | 115.6 | 216    | 240 | 468    | 520   |
|                                    |          | 14                                                                                                                                                                                                             | 6             | 2               | 64-QAM     | 3/4    | 117    | 130.3 | 243    | 270 | 526.5  | 585   |
|                                    |          | 15                                                                                                                                                                                                             | 7             | 2               | 64-QAM     | 5/6    | 130    | 144.4 | 270    | 300 | 585    | 650   |
|                                    |          |                                                                                                                                                                                                                | 8             | 2               | 256-QAM    | 3/4    | 156    | 173.3 | 324    | 360 | 702    | 180   |
|                                    |          |                                                                                                                                                                                                                | 9             | 2               | 256-QAM    | 5/6    | N/A    | N/A   | 360    | 400 | 780    | 866.7 |
| 802.11ac/n Spatial Streams         |          | 2 (2x2 MIMO)                                                                                                                                                                                                   |               |                 |            |        |        |       |        |     |        |       |
| 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 Domain Support          |          | FCC (Americas, Parts of Asia, and Middle East)<br>ETSI (Europe, Middle East, Africa, and Parts of Asia)<br>IC (Industry Canada)<br>MIC (Japan) (formerly TELEC) – Option<br>KC (Korea) (formerly KCC) – Option |               |                 |            |        |        |       |        |     |        |       |
| 2.4 GHz Frequency Bands            |          | ETSI: 2.4 GHz to 2.483 GHz<br>FCC: 2.4 GHz to 2.473 GHz<br>MIC: 2.4 GHz to 2.495 GHz<br>KC: 2.4 GHz to 2.483 GHz                                                                                               |               |                 |            |        |        |       |        |     |        |       |
| 2.4 GHz Operating Channels (Wi-Fi) |          | ETSI: 13 (3 non-overlapping)<br>FCC: 11 (3 non-overlapping)<br>MIC: 14 (4 non-overlapping)<br>KC: 13 (3 non-overlapping)                                                                                       |               |                 |            |        |        |       |        |     |        |       |

| Feature                                                                                                                                                                                                                                                                                                                                                                                          | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>5 GHz Frequency Bands</b>                                                                                                                                                                                                                                                                                                                                                                     | <b>ETSI</b><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><b>FCC</b><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 5.825 GHz (Ch 149/153/157/161/165)<br><b>MIC (Japan)</b><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><b>KC</b><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)<br>5.725 GHz to 5.825 GHz (Ch 149/153/157/161/165)                                                                                                                                                                                                                                                                                                                 |
| <b>5 GHz Operating Channels (Wi-Fi)</b>                                                                                                                                                                                                                                                                                                                                                          | <b>ETSI:</b> 19 non-overlapping; <b>FCC:</b> 24 non-overlapping<br><b>MIC (Japan):</b> 19 non-overlapping; <b>KC:</b> 20 non-overlapping                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Transmit Power</b><br><br><i><b>Note:</b> Transmit power on each channel varies according to individual country regulations. All values are nominal with +/-2 dBm tolerance at room temperature. Tolerance could be up to +/-2.5 dBm across operating temperature.</i><br><br><i><b>Note:</b> HT20 – 20 MHz-wide channels<br/>HT40 – 40 Mhz-wide channels<br/>HT80 – 80 MHz-wide channels</i> | <b>802.11a</b><br>6 Mbps 18 dBm (63 mW)<br>54 Mbps 16 dBm (40 mW)<br><b>802.11b</b><br>1 Mbps 18 dBm (63 mW)<br>11 Mbps 18 dBm (63 mW)<br><b>802.11g</b><br>6 Mbps 18 dBm (63 mW)<br>54 Mbps 16 dBm (40 mW)<br><b>802.11n (2.4/5 GHz)</b><br>6.5 Mbps (MCS0-5/MCS8-13;HT20) 18 dBm (63 mW)<br>65 Mbps (MCS6-7/MCS14-15;HT20) 16 dBm (40 mW)<br>13.5Mbps(MCS0-5/MCS8-13;HT40) 16 dBm (40 mW)<br>135Mbps (MCS6-7/MCS14-15;HT40) 14 dBm (25 mW)<br><b>802.11ac (5 GHz)</b><br>6.5/13 Mbps (MCS0-6;Ntst=1,2;HT20) 18 dBm (63 mW)<br>78/156 Mbps (MCS7-8;Ntst=1,2;HT20) 16 dBm (40 mW)<br>13.5/27Mbps (MCS0-6;Ntst=1,2;HT40) 16 dBm (40 mW)<br>180/360Mbps (MCS7-9;Ntst=1,2;HT40) 14 dBm (25 mW)<br>29.3/58.5 Mbps (MCS0-5;Ntst=1,2;HT80) 14 dBm (25 mW)<br>263.3/526.5 Mbps (MCS6-8;Ntst=1,2;HT80) 12 dBm (15.8 mW)<br>390/780 Mbps (MCS9;Ntst=1,2;HT80) 10 dBm (10 mW)<br><b>Bluetooth</b><br>1 Mbps (1DH5) 10 dBm (12.5 mW)<br>2 Mbps 7 dBm (6.3 mW)<br>3 Mbps 7 dBm (6.3 mW)<br>BLE (1 Mbps) 7 dBm (6.3 mW) |

| Feature                                                                                                      | Description                                                                                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Typical Receiver Sensitivity</b><br>(PER <= 10%)                                                          | <b>802.11a:</b><br>6 Mbps -89 dBm<br>54 Mbps -74 dBm                                                                                                                                                                         |
| <b>Note:</b> All values nominal, +/-3 dBm.<br>Sensitivity on CH13 (WLAN)/CH78 (BT) will degrade up to 4-6dB. | <b>802.11b:</b><br>1 Mbps -95 dBm<br>11 Mbps -90 dBm (PER<8%)                                                                                                                                                                |
|                                                                                                              | <b>802.11g:</b><br>6 Mbps -91 dBm<br>54 Mbps -75 dBm                                                                                                                                                                         |
|                                                                                                              | <b>802.11n (2.4 GHz)</b><br>6.5 Mbps (MCS0;HT20) -91 dBm<br>65 Mbps (MCS7;HT20) -73 dBm<br>13.5Mbps(MCS0;HT40) -85 dBm<br>135Mbps (MCS7;HT40) -70 dBm                                                                        |
|                                                                                                              | <b>802.11n (5 GHz)</b><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) -69 dBm                                                                          |
|                                                                                                              | <b>802.11ac (5 GHz)</b><br>6.5 Mbps (MCS0;HT20) -89 dBm<br>78 Mbps (MCS8;HT20) -67 dBm<br>13.5 Mbps (MCS0;HT40) -86 dBm<br>180 Mbps (MCS9;HT40) -63 dBm<br>29.3 Mbps (MCS0;HT80) -81 dBm<br>390/780 Mbps (MCS9;HT80) -60 dBm |
|                                                                                                              | <b>Bluetooth:</b><br>1 Mbps (1DH5) -95 dBm<br>2Mbps (2DH5) -94 dBm<br>3 Mbps (3DH5) -88 dBm<br>BLE -95 dBm                                                                                                                   |
| <b>Operating Systems Supported</b>                                                                           | Linux Kernel 3x or newer<br>Android 5x and newer                                                                                                                                                                             |

| Feature                                                        | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |               |         |          |          |      |          |  |
|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---------------|---------|----------|----------|------|----------|--|
| <b>Security</b>                                                | <p><b>Standards</b></p> <p>Wireless Equivalent Privacy (WEP)<br/>Wi-Fi Protected Access (WPA)<br/>IEEE 802.11i (WPA2)</p> <p><b>Encryption</b></p> <p>Wireless Equivalent Privacy (WEP, RC4 Algorithm)<br/>Temporal Key Integrity Protocol (TKIP, RC4 Algorithm)<br/>Advanced Encryption Standard (AES, Rijndael Algorithm)<br/>Encryption Key Provisioning<br/>Static (40-bit and 128-bit lengths)<br/>Pre-Shared (PSK)</p> <p><b>Dynamic</b></p> <p>802.1X Extensible Authentication Protocol Types</p> <table> <tr> <td>EAP-FAST</td><td>PEAP-MSCHAPv2</td></tr> <tr> <td>EAP-TLS</td><td>PEAP-TLS</td></tr> <tr> <td>EAP-TTLS</td><td>LEAP</td></tr> <tr> <td>PEAP-GTC</td><td></td></tr> </table> <p><b>Note:</b> EAP types are supplicant software dependent.</p> | EAP-FAST | PEAP-MSCHAPv2 | EAP-TLS | PEAP-TLS | EAP-TTLS | LEAP | PEAP-GTC |  |
| EAP-FAST                                                       | PEAP-MSCHAPv2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |          |               |         |          |          |      |          |  |
| EAP-TLS                                                        | PEAP-TLS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |          |               |         |          |          |      |          |  |
| EAP-TTLS                                                       | LEAP                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |          |               |         |          |          |      |          |  |
| PEAP-GTC                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |          |               |         |          |          |      |          |  |
| <b>Compliance</b>                                              | <p><b>ETSI Regulatory Domain</b></p> <p>EN 300 328<br/>EN 301 489-1<br/>EN 301 489-17<br/>EN 301 893<br/>EN 60950-1<br/>EU 2002/95/EC (RoHS)</p> <p><b>FCC Regulatory Domain</b></p> <p>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</p> <p><b>Industry Canada</b></p> <p>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</p>                                                                                                                                                                                                                                                                                                                   |          |               |         |          |          |      |          |  |
| <b>Certifications</b>                                          | <p><b>Wi-Fi Alliance</b> (Summit version only)<br/>802.11a, 802.11b, 802.11g , 802.11n, 802.11ac<br/>WPA Enterprise<br/>WPA2 Enterprise</p> <p><b>Cisco Compatible Extensions</b> (Version 4) (Summit version only)</p> <p><b>Bluetooth® SIG Qualification</b></p> <div>    </div>                                                                                                                                                                                                                       |          |               |         |          |          |      |          |  |
| <b>Warranty</b>                                                | Three Year Warranty                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |               |         |          |          |      |          |  |
| <b>All specifications are subject to change without notice</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |          |               |         |          |          |      |          |  |

## 5 WLAN FUNCTIONAL DESCRIPTION

The 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU M2 module is designed based on the 60-SIPT SiP. It is optimized for high-speed, reliable, and low-power embedded applications. It is integrated with dual-band WLAN (2.4 GHz/5 GHz) and Bluetooth 4.2. Its functionality includes the following:

- Improved throughput on the link due to frame aggregation, RIFS (reduced inter-frame spacing), and half-guard intervals.
- Support for STBC (Space Time Block Codes) and LDPC (Low Density Parity Check) codes.
- Improved 11n performance due to features such as 11n frame aggregation (A-MPDU and A-MSDU) and low-overhead host-assisted buffering (RX A-MSDU and 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 802.11 ac (Wave 2), 2X2 receive Multi-User MIMO (MU-MIMO) spatial stream multiplexing with data rate up to MCS9 (866.7 Mbps).

Additional functionality is listed in [Table 4](#).

**Table 4: WLAN functions**

| Feature         | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>WLAN MAC</b> | <ul style="list-style-type: none"> <li>▪ Frame Exchange at the MAC level to deliver data</li> <li>▪ Received frame filtering and validation (Cyclic Redundancy Check (CRC))</li> <li>▪ Generation of MAC header and trailer information (MAC protocol Data Units (MPDUs))</li> <li>▪ Fragmentation of data frames (MAC Service Data Units (MSDUs))</li> <li>▪ Access Mechanism support for fair access to shared wireless medium through (DCF and EDCA)</li> <li>▪ A-MPDU Aggregation/Deaggregation (support 802.11ac single –MPDU A-MPDU)</li> <li>▪ 20/40/80 MHz channel Coexistence</li> <li>▪ RIFS Burst Receive</li> <li>▪ Management Information Base</li> <li>▪ Radio Resource Measurement</li> <li>▪ Quality of Service</li> <li>▪ Block Acknowledgement</li> <li>▪ 802.11ac Downlink MU-MIMO (receive)</li> <li>▪ Dynamic Frequency Selection</li> <li>▪ Beamforming</li> <li>▪ TIM Frame TX and RX</li> <li>▪ Multi-BSS/Station</li> <li>▪ Transmit Rate Adaptation.</li> <li>▪ Transmit Power Control</li> </ul> |

| Feature               | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>WLAN Base Band</b> | <ul style="list-style-type: none"> <li>802.11ac 2x2 MU-MIMO (with on-chip Marvell RF radio)</li> <li>Backward compatibility with legacy 802.11 n/a/b/g technology</li> <li>WLAN/Bluetooth LNA sharing</li> <li>PHY rate up to 866.7Mbps</li> <li>20MHz bandwidth/channel, 40MHz bandwidth/channel, upper/lower 20MHz packets in 40MHz channel, 20MHz duplicate legacy packets in 40MHz channel operation</li> <li>80MHz bandwidth/channel, 4 positions of 20MHz packets in 80MHz channel, upper/lower 40MHz packets in 80MHz channel, 20MHz quadruplicate legacy packets in 80MHz channel mode operation</li> <li>Modulation and Coding Scheme (MCS): 802.11 ac (MCS0-9. Nsts=1/2); 802.11n (MCS0-15)</li> <li>Dynamic Frequency Selection (DFS) (Radar detection) <ul style="list-style-type: none"> <li>Enhanced radar detection for long and short pulse radar</li> <li>Enhanced AGC scheme for DFS channel</li> <li>Japan DFS requirements for W53 and W56</li> </ul> </li> <li>802.11 K Radio Resource Measurement</li> <li>802.11ac /802.11n optional MIMO features: <ul style="list-style-type: none"> <li>20/40/80 MHz Coexistence with middle-packaged detection (GI detection) for enhanced CCA.</li> <li>1 spatial stream STBC reception and transmission</li> <li>LDPC transmission and reception for 802.11ac and 802.11n</li> <li>256 QAM (MCS8-9) modulations supported</li> <li>Short guard interval</li> <li>RIFS on receive path for 802.11n packets</li> <li>802.11n Greenfield TX/RX</li> </ul> </li> <li>Power Save Feature</li> </ul> |
| <b>WLAN Security</b>  | <p>WLAN Encryption features supported include:</p> <ul style="list-style-type: none"> <li>Temporal Key Integrity Protocol (TKIP)/Wired Equivalent Privacy (WEP)</li> <li>Advanced Encryption Standard (AES)/Counter-Mode/CBC-MAC Protocol (CCMP)</li> <li>Advanced Encryption Standard (AES)/Cipher-Based Message Authentication Code (CMAC)</li> <li>Advanced Encryption Standard (AES)/Galois/Counter Mode Protocol (GCMP)</li> <li>WLAN Authentication and Private Infrastructure (WPAI)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

| Feature      | Description                  |             |         |             |         |             |          |
|--------------|------------------------------|-------------|---------|-------------|---------|-------------|----------|
| WLAN Channel | Channel frequency supported. |             |         |             |         |             |          |
|              | 20 MHz                       |             |         | 40 MHz      |         | 80 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     | 2442        | 106 5530 |
|              | 6                            | 2437        | 56      | 5280        | 6-10    | 2447        | 122 5610 |
|              | 7                            | 2442        | 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        |         |             |          |

## 6 BLUETOOTH FUNCTIONAL DESCRIPTION

The 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU Bluetooth (BT) block is based on the 60-SIPT SiP that already has fully-integrated Bluetooth baseband and radio. Several features and functions are listed in [Table 5](#).

**Table 5: Bluetooth functions**

| Feature                                       | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bluetooth Interface                           | Voice interface: <ul style="list-style-type: none"> <li>▪ Hardware support for continual PCM data transmission/reception without processor overhead.</li> <li>▪ Standard PCM clock rates from 64 kHz to 2.048 MHz with multi-slot handshake and synchronization.</li> <li>▪ A-law, U-law, and linear voice PCM encoding/decoding.</li> <li>▪ SDIO interface</li> <li>▪ High-Speed UART interface</li> <li>▪ USB 2.0</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|                                               | <ul style="list-style-type: none"> <li>▪ Bluetooth 4.2</li> <li>▪ Bluetooth Class 2/Bluetooth class 1</li> <li>▪ WLAN and Bluetooth share same LNA and antenna</li> <li>▪ Digital audio interfaces with PCM/TDM interface for voice application</li> <li>▪ Baseband and radio BDR and EDR package type: 1Mbps, 2Mbps, 3Mbps</li> <li>▪ Fully functional Bluetooth baseband: AFH, forward error correction, header error control, access code correction, CRC, encryption bit stream generation, and whitening</li> <li>▪ Adaptive Frequency Hopping (AFH) using Packet Error Rate (PER)</li> <li>▪ Interlaced scan for faster connection setup</li> <li>▪ Simultaneous active ACL connection setup</li> <li>▪ Automatic ACL package type selection</li> <li>▪ Full master and slave piconet support</li> <li>▪ Scatter net support</li> <li>▪ SCO/eSCO links with hardware accelerated audio signal processing and hardware supported PPEC algorithm for speech quality improvement</li> <li>▪ All standard SCO/eSCO voice coding</li> <li>▪ All standard pairing, authentication, link key, and encryption operations</li> <li>▪ Encryption (AES) support</li> </ul> |
| Bluetooth Core functionality                  | <ul style="list-style-type: none"> <li>▪ Advertiser, Scanner, Initiator, Master, and Slave roles support (connects up to 16 links)</li> <li>▪ WLAN/Bluetooth Coexistence (BCA) protocol support</li> <li>▪ Shared RF with BDR/EDR</li> <li>▪ Encryption (AES) support</li> <li>▪ Intelligent Adaptive Frequency Hopping (AFH)</li> <li>▪ LE privacy 1.2</li> <li>▪ LE Secure Connection</li> <li>▪ LE Data Length Extension</li> <li>▪ LE Advertising Length Extension</li> <li>▪ 2 Mbps LE</li> <li>▪ Direction Finding – Connectionless Angle of Departure (AoD)</li> <li>▪ Direction Finding – Connectionless Angle of Arrival (AoA)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Bluetooth Low Energy (BLE) Core functionality | <ul style="list-style-type: none"> <li>▪ Advertiser, Scanner, Initiator, Master, and Slave roles support (connects up to 16 links)</li> <li>▪ WLAN/Bluetooth Coexistence (BCA) protocol support</li> <li>▪ Shared RF with BDR/EDR</li> <li>▪ Encryption (AES) support</li> <li>▪ Intelligent Adaptive Frequency Hopping (AFH)</li> <li>▪ LE privacy 1.2</li> <li>▪ LE Secure Connection</li> <li>▪ LE Data Length Extension</li> <li>▪ LE Advertising Length Extension</li> <li>▪ 2 Mbps LE</li> <li>▪ Direction Finding – Connectionless Angle of Departure (AoD)</li> <li>▪ Direction Finding – Connectionless Angle of Arrival (AoA)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

## 7 BLOCK DIAGRAM

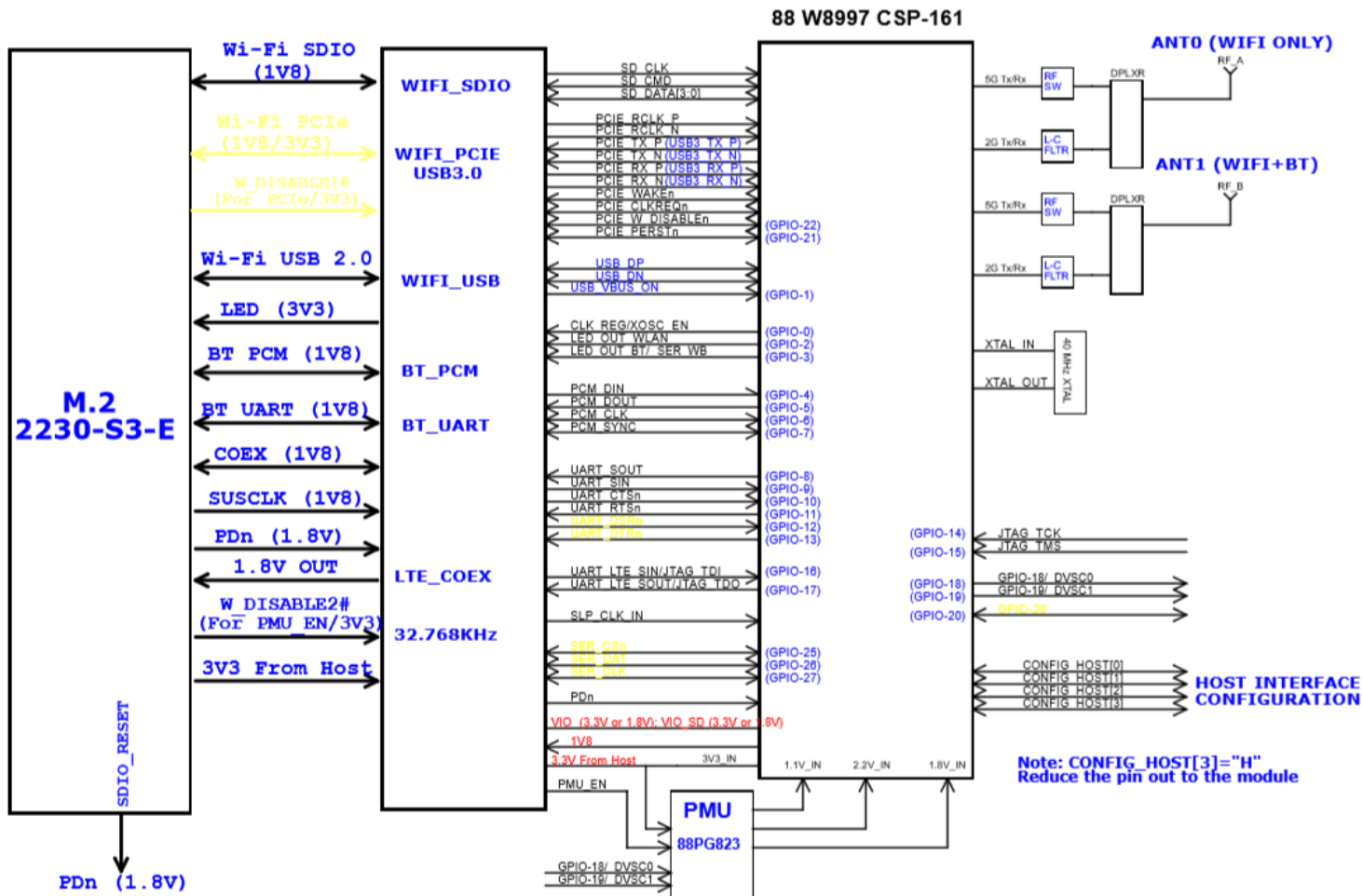


Figure 1: Block Diagram of 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU

## 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 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU. 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 |
|-----------------|---------------------------------------------------|------------|------|
| VIO_SD          | WLAN host SDIO interface I/O supply (1.8V system) | 2.2        | V    |
| VIO             | I/O configuration power supply (1.8V system)      | 2.2        | V    |
| 3V3             | External 3.3V power supply                        | 4.0        | V    |
| Storage         | Storage Temperature                               | -40 to +85 | °C   |
| ANT0; ANT1      | Maximum RF input (reference to 50-Ω input)        | +10        | dBm  |
| ESD             | Electrostatic discharge tolerance                 | 2000       | V    |

### 8.2 Recommended Operating Conditions

**Table 7: Recommended Operating Conditions**

| Symbol (Domain) | Parameter                         | Min  | Typ  | Max  | Unit |
|-----------------|-----------------------------------|------|------|------|------|
| VIO_SD          | WLAN host interface I/O supply    | 1.62 | 1.8  | 1.98 | V    |
| VIO             | WLAN and BT GPIO I/O power supply | 1.62 | 1.8  | 1.98 | V    |
| 3V3             | External 3.3V power supply        | 2.97 | 3.30 | 3.63 | V    |
| T-ambient       | Ambient temperature               | -30  | 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 VIO\_SD;VIO)**

| Symbol | Parameter                | Conditions | Min       | Typ | Max       | Unit |
|--------|--------------------------|------------|-----------|-----|-----------|------|
| VIH    | High Level Input Voltage | --         | 0.7 x 1V8 |     | 1V8+0.4   | V    |
| VIL    | Low Level Input Voltage  | --         | -0.4      |     | 0.3 x 1V8 | V    |
| VHYS   | Input Hysteresis         | --         | 100       |     |           | mV   |
| VOH    | Output high Voltage      | --         | 1V8-0.4   |     |           | V    |
| VOL    | Output low Voltage       | --         |           |     | 0.4       | V    |

## 8.4 WLAN Radio Receiver Characteristics

Table 9 and Table 10 summarize the WLAN 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU receiver characteristics.

**Table 9: WLAN receiver characteristics for 2.4 GHz signal chain operation**

| Symbol          | Parameter                     | Conditions            | Min   | Typ | Max   | Unit |
|-----------------|-------------------------------|-----------------------|-------|-----|-------|------|
| Fr <sub>x</sub> | Receive input frequency range |                       | 2.412 |     | 2.484 | GHz  |
| Sr <sub>f</sub> | Sensitivity                   |                       |       |     |       |      |
|                 | CCK, 1 Mbps                   | See Note <sup>3</sup> |       | -95 |       | dBm  |
|                 | CCK, 11 Mbps                  |                       |       | -90 |       |      |
|                 | OFDM, 6 Mbps                  |                       |       | -91 |       |      |
|                 | OFDM, 54 Mbps                 |                       |       | -75 |       |      |
|                 | HT20, MCS0                    |                       |       | -91 |       |      |
|                 | HT20, MCS7                    |                       |       | -73 |       |      |
| Radj            | Adjacent channel rejection    |                       |       |     |       |      |
|                 | OFDM, 6 Mbps                  | See Note <sup>4</sup> |       | TBD |       | dB   |
|                 | OFDM, 54 Mbps                 |                       |       | TBD |       |      |
|                 | HT20, MCS0                    |                       |       | TBD |       |      |
|                 | HT20, MCS7                    |                       |       | TBD |       |      |

<sup>3</sup>Performance data are measured under signal chain operation.

<sup>4</sup>Performance data are measured under signal chain operation.

**Table 10: WLAN receiver characteristics for 5 GHz dual chain operation**

| Symbol          | Parameter                     | Conditions            | Min  | Typ | Max   | Unit |
|-----------------|-------------------------------|-----------------------|------|-----|-------|------|
| Fr <sub>x</sub> | Receive input frequency range |                       | 5.15 |     | 5.825 | GHz  |
| Sr <sub>f</sub> | Sensitivity                   |                       |      |     |       |      |
|                 | OFDM, 6 Mbps                  | See Note <sup>5</sup> |      | -89 |       | dBm  |
|                 | OFDM, 54 Mbps                 |                       |      | -74 |       |      |
|                 | HT20, MCS0                    |                       |      | -89 |       |      |
|                 | HT20, MCS7                    |                       |      | -70 |       |      |
|                 | HT40, MCS0                    |                       |      | -86 |       |      |
|                 | HT40, MCS7                    |                       |      | -69 |       |      |
| Radj            | Adjacent channel rejection    |                       |      |     |       |      |
|                 | OFDM, 6 Mbps                  | See Note <sup>6</sup> |      | TBD |       | dB   |
|                 | OFDM, 54 Mbps                 |                       |      | TBD |       |      |
|                 | HT20, MCS0                    |                       |      | TBD |       |      |
|                 | HT20, MCS7                    |                       |      | TBD |       |      |

<sup>5</sup>Performance data are measured under signal chain operation

<sup>6</sup>Performance data are measured under signal chain operation.

## 8.5 WLAN Transmitter Characteristics

**Table 11: WLAN transmitter characteristics for 2.4 GHz per chain operation**

| Symbol | Parameter                        | Conditions            | Min   | Typ   | Max   | Unit |
|--------|----------------------------------|-----------------------|-------|-------|-------|------|
| Ftx    | Transmit output frequency range  |                       | 2.412 |       | 2.484 | GHz  |
| Pout   | Output power                     | See Note <sup>7</sup> |       |       |       |      |
|        | 11b mask compliant               | 1-11Mbps              |       | 18    |       | dBm  |
|        | 11g mask compliant               | 6-36Mbps              |       | 18    |       |      |
|        | 11g EVM compliant                | 48-54Mbps             |       | 16    |       |      |
|        | 11n HT20 mask compliant          | MCS0-5/MCS8-13        |       | 18    |       |      |
|        | 11n HT20 EVM compliant           | MCS6-7/MCS14-15       |       | 16    |       |      |
|        | 11n HT40 mask compliant          | MCS0-5/MCS8-13        |       | 16    |       |      |
|        | 11n HT40 EVM compliant           | MCS6-7/MCS14-15       |       | 14    |       |      |
| ATx    | Transmit power accuracy at 25 °C | -                     | -     | + 2.0 |       | dB   |

| Freq.    | Mode/Rate (Mbps) | Output Power Per Chain (dBm) | Max. Current Consumption       |                               |
|----------|------------------|------------------------------|--------------------------------|-------------------------------|
|          |                  |                              | Single Chain (mA) <sup>8</sup> | Dual Chains (mA) <sup>8</sup> |
| 2412 MHz | 1 Mbps           | 18dBm                        | 340                            | 620                           |
|          | 54 Mbps          | 16dBm                        | 280                            | 500                           |
|          | HT20 MCS7        | 16dBm                        | 280                            | 510                           |
| 2442 MHz | 1 Mbps           | 18dBm                        | 340                            | 620                           |
|          | 54 Mbps          | 16dBm                        | 280                            | 500                           |
|          | HT20 MCS7        | 16dBm                        | 280                            | 510                           |
| 2472 MHz | 1 Mbps           | 18dBm                        | 340                            | 620                           |
|          | 54 Mbps          | 16dBm                        | 280                            | 500                           |
|          | HT20 MCS7        | 16dBm                        | 280                            | 510                           |

**Table 11: WLAN transmitter characteristics for 5 GHz per chain operation**

| Symbol | Parameter                       | Conditions            | Min  | Typ | Max   | Unit |
|--------|---------------------------------|-----------------------|------|-----|-------|------|
| Ftx    | Transmit output frequency range |                       | 5.15 |     | 5.925 | GHz  |
| Pout   | Output power                    | See Note <sup>3</sup> |      |     |       |      |
|        | 11a mask compliant              | 6-36Mbps              |      | 18  |       | dBm  |
|        | 11a EVM compliant               | 48-54Mbps             |      | 16  |       |      |
|        | 11n HT20 mask compliant         | MCS0-5/MCS8-13        |      | 18  |       |      |
|        | 11n HT20 EVM compliant          | MCS6-7/MCS14-15       |      | 16  |       |      |
|        | 11n HT40 mask compliant         | MCS0-5/MCS8-13        |      | 16  |       |      |
|        | 11n HT40 EVM compliant          | MCS6-7/MCS14-15       |      | 16  |       |      |
|        | 11ac HT20 mask compliant        | MCS0-6 (Ntst=1,2)     |      | 18  |       |      |
|        | 11ac HT20 EVM compliant         | MCS7-8(Ntst=1,2)      |      | 16  |       |      |
|        | 11ac HT40 mask compliant        | MCS0-5 (Ntst=1,2)     |      | 16  |       |      |
|        | 11ac HT40 EVM compliant         | MCS6-9(Ntst=1,2)      |      | 14  |       |      |
|        | 11ac HT80 mask compliant        | MCS0-5 (Ntst=1,2)     |      | 14  |       |      |

| Symbol | Parameter                        | Conditions       | Min | Typ   | Max | Unit |
|--------|----------------------------------|------------------|-----|-------|-----|------|
| ATx    | 11ac HT80 EVM compliant          | MCS6-8(Ntst=1,2) |     | 12    |     |      |
|        | 11ac HT80 EVM compliant          | MCS9(Ntst=1,2)   |     | 10    |     |      |
|        | Transmit power accuracy at 25 °C | -                | -   | + 2.0 |     | dB   |

| Freq.    | Mode/Rate [Mbps] | Output Power Per Chain [dBm] | Max. Current Consumption       |                               |
|----------|------------------|------------------------------|--------------------------------|-------------------------------|
|          |                  |                              | Single Chain (mA) <sup>8</sup> | Dual Chains (mA) <sup>8</sup> |
| 5180 MHz | 6 Mbps           | 18 dBm                       | 400                            | 710                           |
|          | 54 Mbps          | 16 dBm                       | 330                            | 610                           |
|          | HT20 MCS0        | 18 dBm                       | 400                            | 720                           |
|          | HT20 MCS7        | 16 dBm                       | 360                            | 620                           |
| 5190 MHz | HT40 MCS7        | 14 dBm                       | 320                            | 550                           |
| 5500 MHz | 6 Mbps           | 18 dBm                       | 380                            | 680                           |
|          | 54 Mbps          | 16 dBm                       | 330                            | 600                           |
|          | HT20 MCS0        | 18 dBm                       | 370                            | 690                           |
|          | HT20 MCS7        | 16 dBm                       | 320                            | 600                           |
| 5510 MHz | HT40 MCS7        | 14 dBm                       | 300                            | 530                           |
| 5825 MHz | 6 Mbps           | 18 dBm                       | 380                            | 690                           |
|          | 54 Mbps          | 16 dBm                       | 310                            | 600                           |
|          | HT20 MCS0        | 18 dBm                       | 360                            | 710                           |
|          | HT20 MCS7        | 16 dBm                       | 340                            | 550                           |
| 5795 MHz | HT40 MCS7        | 14 dBm                       | 300                            | 530                           |

<sup>7</sup>Performance data are measured under single chain operation.

**Note:** Final TX power values on each channel are limited by the regulatory certification test limit.

## 9 BLUETOOTH RADIO CHARACTERISTICS

Table 12 through Table 15 describe the basic rate transmitter performance, enhanced data transmitter performance, basic rate receiver performance, enhanced rate receiver performance, and current consumption conditions at 25°C.

**Table 12: Basic rate transmitter performance temperature at 25°C (1.8V)**

| Test Parameter                       | Min                      | Typ   | Max    | BT Spec.                      | Unit           |
|--------------------------------------|--------------------------|-------|--------|-------------------------------|----------------|
| Maximum RF Output Power              | 8                        | 10    | 11     | 0 ~ +20                       | dBm            |
| Frequency Range                      | 2.4                      | —     | 2.4835 | $2.4 \leq f \leq 2.4835$      | GHz            |
| 20 dB Bandwidth                      | —                        | 919.5 | —      | $\leq 1000$                   | KHz            |
| $\Delta f_{1avg}$ Maximum Modulation | 140                      | 165   | 175    | $140 < \Delta f_{1avg} < 175$ | KHz            |
| $\Delta f_{2max}$ Minimum Modulation | —                        | 135   | —      | $\geq 115$                    | KHz            |
| $\Delta f_{2avg}/\Delta f_{1avg}$    | —                        | 0.9   | —      | $\geq 0.80$                   | —              |
| Initial Carrier Frequency            | —                        | +/-5  | —      | $\leq \pm 75$                 | KHz            |
| Drift Rate (DH1 package)             | —                        | 4     | —      | $\leq 20$                     | KHz/50 $\mu$ s |
| Drift (DH3 packet)                   | —                        | 8     | —      | $\leq 25$                     | KHz            |
| Drift (DH5 packet)                   | —                        | 7     | —      | $\leq 40$                     | KHz            |
| Adjacent Channel Power               | $F \geq \pm 3\text{MHz}$ | —     | -50    | $< -40$                       | dBm            |
|                                      | $F = \pm 2\text{MHz}$    | —     | -46    | $\leq -20$                    | dBm            |
|                                      | $F = \pm 1\text{MHz}$    | —     | -15    | N/A                           | dBm            |

**Table 13: Enhanced data rate transmitter performance 25°C (1.8V)**

| Test Parameter                                                  | Min                      | Typ | Max | BT Spec.      | Unit |
|-----------------------------------------------------------------|--------------------------|-----|-----|---------------|------|
| Relative Transmit Power                                         | 5                        | 7   | 9   |               | dBm  |
| Max Carrier Frequency Stability  w <sub>o</sub>                 | 2-DH5                    | —   | 1   | $\leq \pm 10$ | KHz  |
|                                                                 | 3-DH5                    | —   | 1   |               |      |
| Max Carrier Frequency Stability  w <sub>i</sub>                 | 2-DH5                    | —   | 4   | $\leq \pm 75$ | KHz  |
|                                                                 | 3-DH5                    | —   | 4   |               |      |
| Max Carrier Frequency Stability  w <sub>o</sub> +w <sub>i</sub> | 2-DH5                    | —   | 5   | $\leq \pm 75$ | KHz  |
|                                                                 | 3-DH5                    | —   | 5   |               |      |
| RMS DEVM                                                        | 2-DH5                    | —   | 4   | $\leq 20$     | %    |
|                                                                 | 3-DH5                    | —   | 4   | $\leq 13$     | %    |
| Peak DEVM                                                       | 2-DH5                    | —   | 9   | $\leq 35$     | %    |
|                                                                 | 3-DH5                    | —   | 9   | $\leq 25$     | %    |
| 99% DEVM                                                        | 2-DH5                    | —   | 12  | $\leq 30$     | %    |
|                                                                 | 3-DH5                    | —   | 12  | $\leq 20$     | %    |
| EDR Differential Phase Encoding                                 | —                        | 99  | —   | $\geq 99$     | %    |
| Adjacent Channel Power                                          | $F \geq \pm 3\text{MHz}$ | —   | TBD | $< -40$       | dBm  |
|                                                                 | $F = \pm 2\text{MHz}$    | —   | TBD | $\leq -20$    | dBm  |

**Table 14: Basic rate receiver performance at 1.8V**

| Test Parameter                               |               | Min | Typ | Max | BT Spec. | Unit |
|----------------------------------------------|---------------|-----|-----|-----|----------|------|
| Sensitivity (1DH5)                           | BER ≤ 0.1%    | —   | -95 | -92 | ≤ -70    | dBm  |
| Maximum Input                                | BER ≤ 0.1%    | -20 | -10 | —   | ≥ -20    | dBm  |
| Carrier-to-Interferer Ratio (C/I)            | Co-Channel    | —   | 10  | 11  | 11       |      |
|                                              | C/I (± 1 MHz) | —   | -4  | 0   | 0        | dB   |
|                                              | C/I (± 2 MHz) | —   | -45 | —   | -30      | dB   |
|                                              | C/I (± 3 MHz) | —   | -49 | —   | -40      | dB   |
| Maximum Level of Intermodulation Interferers |               | -39 | -30 | -   | ≥ -39    | dBm  |

**Table 15: Enhanced data rate receiver performance 1.8V**

| Test Parameter                      |               | Min | Typ   | Max | Bluetooth Specification | Unit |
|-------------------------------------|---------------|-----|-------|-----|-------------------------|------|
| Sensitivity (BER ≤ 0.01%)           | $\pi/4$ DQPSK | —   | -94   | -91 | ≤ -70                   | dBm  |
|                                     | 8 DPSK        | —   | -88   | -85 | ≤ -70                   | dBm  |
| Maximum Input (BER ≤ 0.1%)          | $\pi/4$ DQPSK | -20 | —     | —   | ≥ -20                   | dBm  |
|                                     | 8 DPSK        | -20 | —     | —   | ≥ -20                   | dBm  |
| Co-Channel C/I (BER ≤ 0.1%)         | $\pi/4$ DQPSK | —   | 10    | 13  | ≤ ±13                   | dB   |
|                                     | 8 DPSK        | —   | 16    | 20  | ≤ ±20                   | dB   |
| Adjacent Channel C/I (1 MHz)        | $\pi/4$ DQPSK | —   | -9    | 0   | ≤ 0                     | dB   |
|                                     | 8 DPSK        | —   | -6    | 5   | ≤ 5                     | dB   |
| Second Adjacent Channel C/I (2 MHz) | $\pi/4$ DQPSK | —   | -47   | -30 | ≤ -30                   | dB   |
|                                     | 8 DPSK        | —   | -42   | -25 | ≤ -25                   | dB   |
| Third Adjacent Channel C/I (3 MHz)  | $\pi/4$ DQPSK | —   | -51   | -40 | ≤ -40                   | dB   |
|                                     | 8 DPSK        | —   | -48   | -33 | ≤ -33                   | dB   |
| Out-of-band blocking                | 30-2000MHz    | —   | -12.5 | —   | —                       | dBm  |
|                                     | 2-2.399GHz    | —   | -12.4 | —   | —                       | dBm  |
|                                     | 2.484-3GHz    | —   | -18   | —   | —                       | dBm  |
|                                     | 3-12.75GHz    | —   | -2.6  | —   | —                       | dBm  |

## 10 SDIO TIMING REQUIREMENTS

The 60-2230C/60-2230C-SS SDIO host interface pins are powered from the VIO\_SD voltage supply. The SDIO electrical specifications are identical for the 1-bit SDIO and 4-bit SDIO modes.

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

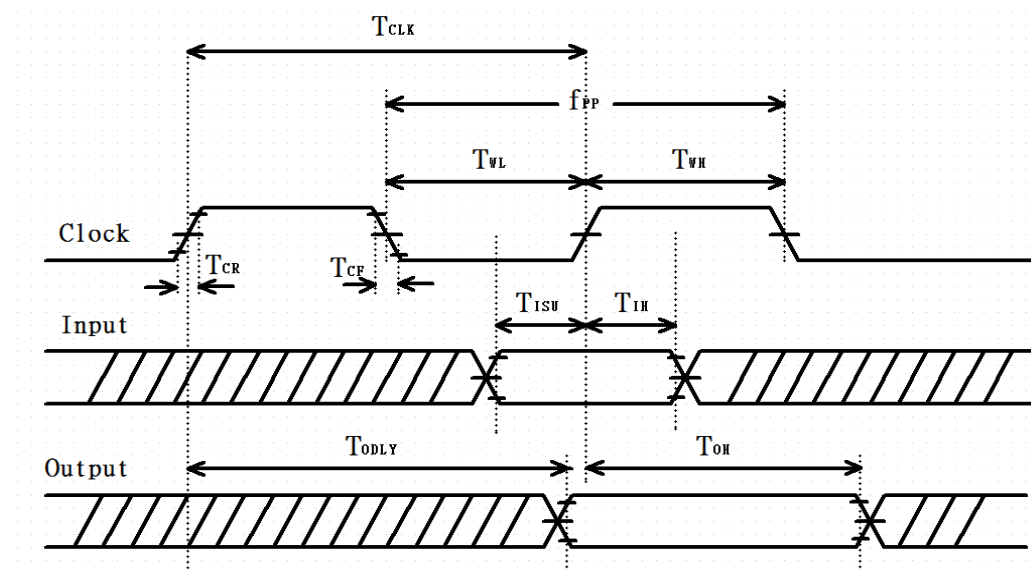


Figure 2:SDIO protocol timing Diagram--- SDR12, SDR25, SDR50 modes (up to 100 MHz) (1.8V)

Table 16: SDIO timing requirements--- 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.

| Symbol                            | Parameter                                                                                                     | Condition   | Min. | Typ. | Max.                   | Unit |
|-----------------------------------|---------------------------------------------------------------------------------------------------------------|-------------|------|------|------------------------|------|
| f <sub>PP</sub>                   | Clock Frequency                                                                                               | SDR12/25/50 | 25   | -    | 100                    | MHz  |
| T <sub>ISU</sub>                  | Input setup time                                                                                              | SDR12/25/50 | 3    | --   | -                      | ns   |
| T <sub>IH</sub>                   | Input Hold time                                                                                               | SDR12/25/50 | 0.8  | -    | -                      | ns   |
| T <sub>CLK</sub>                  | Clock Time                                                                                                    | SDR12/25/50 | 10   | -    | 40                     | ns   |
| T <sub>CR</sub> , T <sub>CF</sub> | Raise time, Fall time<br>T <sub>CR</sub> , T <sub>CF</sub> < 2ns (max) at 100 MHz<br>C <sub>CARD</sub> = 10pF | SDR12/25/50 | -    | -    | 0.2 * T <sub>CLK</sub> | ns   |
| T <sub>ODLY</sub>                 | Output delay time<br>C <sub>L</sub> ≤ 30pF                                                                    | SDR12/25/50 | -    | -    | 7.5                    | ns   |
| T <sub>OH</sub>                   | Output hold time<br>C <sub>L</sub> = 15pF                                                                     | SDR12/25/50 | 1.5  | -    | -                      | ns   |

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

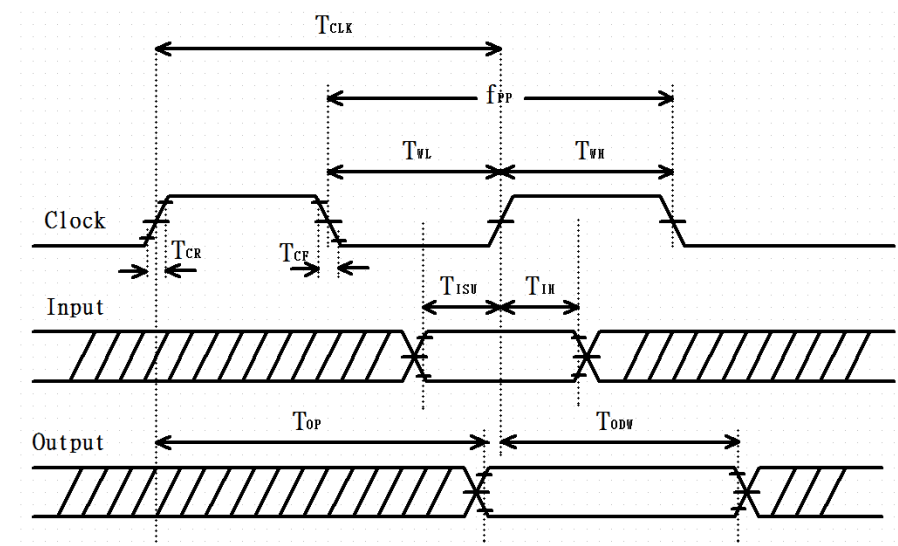


Figure 3: SDIO protocol timing Diagram--- SDR104 modes (up to 208 MHz) (1.8V)

Table 17: SDIO timing requirements--- SDR104 modes (up to 208MHz) (1.8V)

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

| Symbol                            | Parameter                                                                                                         | Condition   | Min. | Typ. | Max.                   | Unit |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------------|-------------|------|------|------------------------|------|
| f <sub>PP</sub>                   | Clock Frequency                                                                                                   | SDR104      | 0    | -    | 208                    | MHz  |
| T <sub>ISU</sub>                  | Input setup time                                                                                                  | SDR104      | 1.4  | --   | -                      | ns   |
| T <sub>IH</sub>                   | Input Hold time                                                                                                   | SDR104      | 0.8  | -    | -                      | ns   |
| T <sub>CLK</sub>                  | Clock Time                                                                                                        | SDR104      | 4.8  | -    | -                      | ns   |
| T <sub>CR</sub> , T <sub>CF</sub> | Raise time, Fall time<br>T <sub>CR</sub> , T <sub>CF</sub> < 0.96ns (max) at 208 MHz<br>C <sub>CARD</sub> = 10 pF | SDR104      | -    | -    | 0.2 * T <sub>CLK</sub> | ns   |
| T <sub>OP</sub>                   | Card Output phase                                                                                                 | SDR104      | 0    | -    | 10                     | ns   |
| T <sub>ODW</sub>                  | Output timing pf variable data window                                                                             | SDR12/25/50 | 2.88 | -    | -                      | ns   |

### 10.3 DDR50 Mode (50MHz) (1.8V)

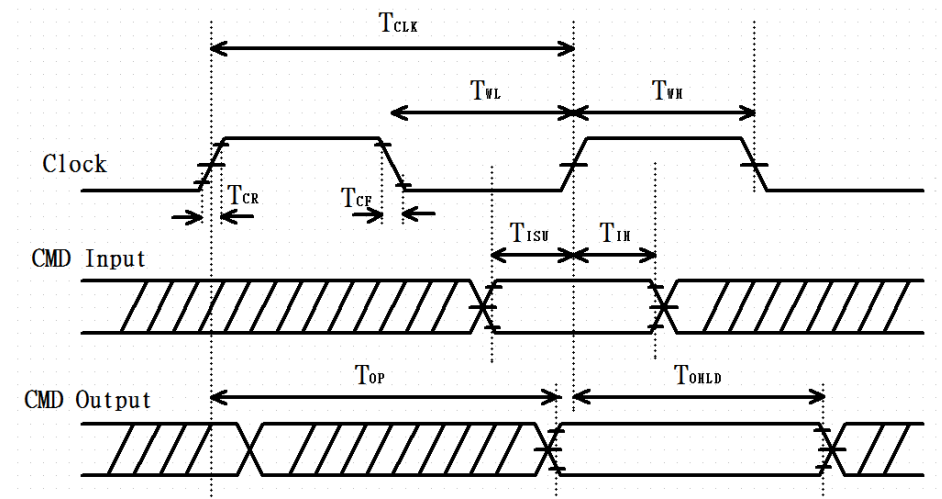


Figure 4: SDIO CMD timing Diagram--- DDR50 modes (50 MHz) (1.8V)

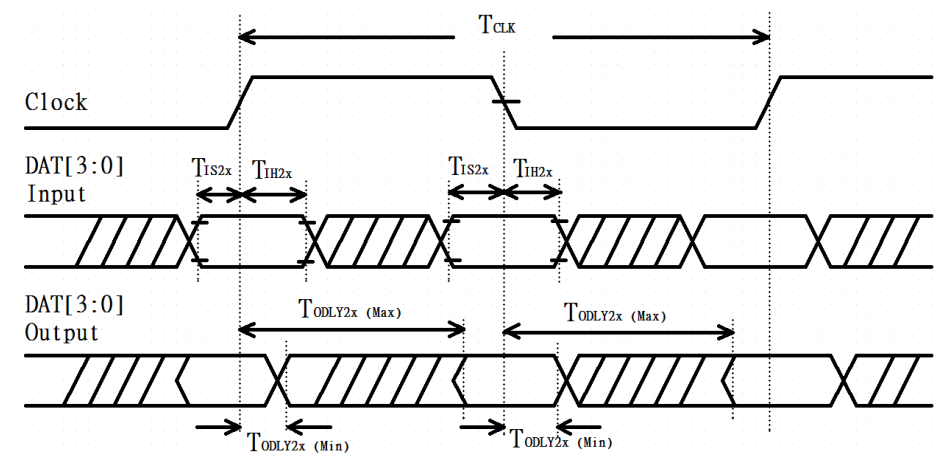


Figure 5: SDIO DAT[3:0] timing Diagram--- DDR50 modes (50 MHz) (1.8V)

**Note:** In DDR50 mode, DAT[3:0] lines are samples on both edges pF the clock (not applicable for CMD line)

Table 18: SDIO timing requirements--- DDR50 modes (50MHz)

| Symbol                                      | Parameter                                                                                       | Condition | Min. | Typ. | Max.                 | Unit |
|---------------------------------------------|-------------------------------------------------------------------------------------------------|-----------|------|------|----------------------|------|
| Clock                                       |                                                                                                 |           |      |      |                      |      |
| T <sub>CLK</sub>                            | Clock time<br>50MHz (max) between rising edge                                                   | DDR50     | 20   | --   | --                   | ns   |
| T <sub>CR</sub> , T <sub>CF</sub>           | Rise time, fall time<br>T <sub>CR</sub> , T <sub>CF</sub> <4.00ns (max) at 50MHz.<br>CCARD=10pF | DDR50     | --   | --   | 0.2*T <sub>CLK</sub> | ns   |
| Clock Duty                                  | --                                                                                              | DDR50     | 45   | --   | 55                   | %    |
| CMD Input (referenced to clock rising edge) |                                                                                                 |           |      |      |                      |      |

| Symbol                                                         | Parameter                                                                     | Condition | Min. | Typ. | Max. | Unit |
|----------------------------------------------------------------|-------------------------------------------------------------------------------|-----------|------|------|------|------|
| TIS                                                            | Input setup time<br>$C_{CARD} \leq 10\text{pF}$ (1 card)                      | DDR50     | 6    | --   | --   | ns   |
| TIH                                                            | Input hold time<br>$C_{CARD} \leq 10\text{pF}$ (1 card)                       | DDR50     | 0.8  | --   | --   | ns   |
| CMD Output (referenced to clock rising and failing edge)       |                                                                               |           |      |      |      |      |
| TODLY                                                          | Output delay time during data transfer mode<br>$C_L \leq 30\text{pF}$ (1card) | DDR50     | --   | --   | 13.7 | ns   |
| TOHLD                                                          | Output hold time<br>$C_L \geq 15\text{pF}$ (1 card)                           | DDR50     | 1.5  | --   | --   | ns   |
| DAT[3:0] Input (referenced to clock rising and failing edges)  |                                                                               |           |      |      |      |      |
| TIS2X                                                          | Input setup time<br>$C_{CARD} \leq 10\text{pF}$ (1 card)                      | DDR50     | 3    | --   | --   | ns   |
| TIH2X                                                          | Input hold time<br>$C_{CARD} \leq 10\text{pF}$ (1 card)                       | DDR50     | 0.8  | --   | --   | ns   |
| DAT[3:0] Output (referenced to clock rising and failing edges) |                                                                               |           |      |      |      |      |
| TODLY2X (max)                                                  | Output delay time during data transfer mode<br>$C_L \leq 25\text{pF}$ (1card) | DDR50     | --   | --   | 7.0  | ns   |
| TODLY2X (min)                                                  | Output hold time<br>$C_L \geq 15\text{pF}$ (1 card))                          | DDR50     | 1.5  | --   | --   | ns   |

## 11 USB SPECIFICATIONS

### 11.1 USB LS Driver and Receiver Parameters

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

The load is 100Ω differential for these parameters, unless other specified.

**Table 16: USB LS Driver and Receiver Specifications**

| Symbol                       | Parameter                                                                  | Min.   | Typ. | Max.  | Unit |
|------------------------------|----------------------------------------------------------------------------|--------|------|-------|------|
| BR                           | Baud rate                                                                  | -      | 1.5  | -     | Mbps |
| BRPPM                        | Baud rate tolerance                                                        | -15000 | -    | 15000 | ppm  |
| <b>Driver Specifications</b> |                                                                            |        |      |       |      |
| VOH                          | Output signal ended high<br>Defined with 1.425KΩ pull-up resistor to 3.6V  | 2.8    | -    | 3.6   | V    |
| VOL                          | Output signal ended low<br>Defined with 1.425KΩ pull-up resistor to ground | 0.0    | -    | 0.3   | V    |
| VCRS                         | Output signal crossover voltage                                            | 1.3    |      | 2.0   | V    |
| TLR                          | Data fall time                                                             | 75.0   | -    | 300.0 | ns   |

| Symbol                         | Parameter                                                                                                                                                                                      | Min. | Typ. | Max.  | Unit |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|-------|------|
|                                | Defined from 10% to 90% for raise time and 90% to 10% for fall time                                                                                                                            |      |      |       |      |
| TLF                            | Data risel time<br>Defined from 10% to 90% for raise time and 90% to 10% for fall time                                                                                                         | 75.0 | -    | 300.0 | ns   |
| TLRFM                          | Rise and fall time matching                                                                                                                                                                    | 80.0 | -    | 125.0 | %    |
| TUDJ1                          | Source jitter total: to next transition<br>*Including frequency tolerance. Timing difference between the differential data signals.<br>*Defined at crossover point of differential signals     | -95  | -    | 95    | ns   |
| TUDJ2                          | Source jitter total: for paired transitions<br>*Including frequency tolerance. Timing difference between the differential data signals.<br>*Defined at crossover point of differential signals | -150 | -    | 150   | ns   |
| <b>Receiver Specifications</b> |                                                                                                                                                                                                |      |      |       |      |
| VIH                            | Input signal ended high                                                                                                                                                                        | 2.0  | -    | -     | V    |
| VIL                            | Input signal ended low                                                                                                                                                                         | -    | -    | 0.8   | V    |
| VDI                            | Differential input sensitivity                                                                                                                                                                 | 0.2  | -    | -     | V    |

## 11.2 USB FS Driver and Receiver Parameters

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

The load is 100Ω differential for these parameters, unless other specified.

**Table 17: USB FS Driver and Receiver Specifications**

| Symbol                         | Parameter                                                                                                                                                                                      | Min.  | Typ. | Max. | Unit |
|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|------|------|
| BR                             | Baud rate                                                                                                                                                                                      | -     | 12.0 | -    | Mbps |
| BRPPM                          | Baud rate tolerance                                                                                                                                                                            | -2500 | -    | 2500 | ppm  |
| <b>Driver Specifications</b>   |                                                                                                                                                                                                |       |      |      |      |
| VOH                            | Output signal ended high<br>Defined with 1.425KΩ pull-up resistor to 3.6V                                                                                                                      | 2.8   | -    | 3.6  | V    |
| VOL                            | Output signal ended low<br>Defined with 1.425KΩ pull-up resistor to ground                                                                                                                     | 0.0   | -    | 0.3  | V    |
| VCRS                           | Output signal crossover voltage                                                                                                                                                                | 1.3   | -    | 2.0  | V    |
| TFR                            | Output raise time<br>Defined from 10% to 90% for raise time and 90% to 10% for fall time                                                                                                       | -4.0  | -    | 20.0 | ns   |
| TFL                            | Output fall time<br>Defined from 10% to 90% for raise time and 90% to 10% for fall time                                                                                                        | -4.0  | -    | 20.0 | ns   |
| TDJ1                           | Source jitter total: to next transition<br>*Including frequency tolerance. Timing difference between the differential data signals.<br>*Defined at crossover point of differential signals     | -3.5  | -    | 3.5  | ns   |
| TDJ2                           | Source jitter total: for paired transitions<br>*Including frequency tolerance. Timing difference between the differential data signals.<br>*Defined at crossover point of differential signals | -4.0  | -    | 4.0  | ns   |
| TFDEOP                         | Source jitter for differential transition to SE0 transition.<br>Defined at crossover point of differential signals                                                                             | -2.0  | -    | 5.0  | ns   |
| <b>Receiver Specifications</b> |                                                                                                                                                                                                |       |      |      |      |
| VIH                            | Input signal ended high                                                                                                                                                                        | 2.0   | -    | -    | V    |
| VIL                            | Input signal ended low                                                                                                                                                                         | -     | -    | 0.8  | V    |
| VDI                            | Differential input sensitivity                                                                                                                                                                 | 0.2   | -    | -    | V    |
| TJR1                           | Receiver jitter: to next transition<br>Defined at crossover point of differential data signals                                                                                                 | -18.5 | -    | 18.5 | ns   |
| TJR2                           | Receiver jitter: for paired transitions<br>Defined at crossover point of differential data signals                                                                                             | -9.0  | -    | 9.0  | ns   |

## 11.3 USB HS Driver and Receiver Parameters

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

The load is 100Ω differential for these parameters, unless other specified.

**Table 18: USB HS Driver and Receiver Specifications**

| Symbol                  | Parameter                                                           | Min. | Typ. | Max. | Unit |
|-------------------------|---------------------------------------------------------------------|------|------|------|------|
| BR                      | Baud rate                                                           | -    | 480  | -    | Mbps |
| BRPPM                   | Baud rate tolerance                                                 | -500 | -    | 500  | ppm  |
| Driver Specifications   |                                                                     |      |      |      |      |
| VHSOH                   | Data signal high                                                    | 360  | -    | 440  | mV   |
| VHSOL                   | Data signal low                                                     | -10  | -    | 10   | mV   |
| THSR                    | Data rise time                                                      | 500  | -    | -    | ns   |
|                         | Defined from 10% to 90% for raise time and 90% to 10% for fall time |      |      |      |      |
| THSF                    | Data fall time                                                      | -500 | -    | -    | ns   |
|                         | Defined from 10% to 90% for raise time and 90% to 10% for fall time |      |      |      |      |
| Receiver Specifications |                                                                     |      |      |      |      |
| VHSCM                   | Input signal ended low                                              | -50  | -    | 500  | mV   |

## 12 PCM INTERFACE SPECIFICATIONS

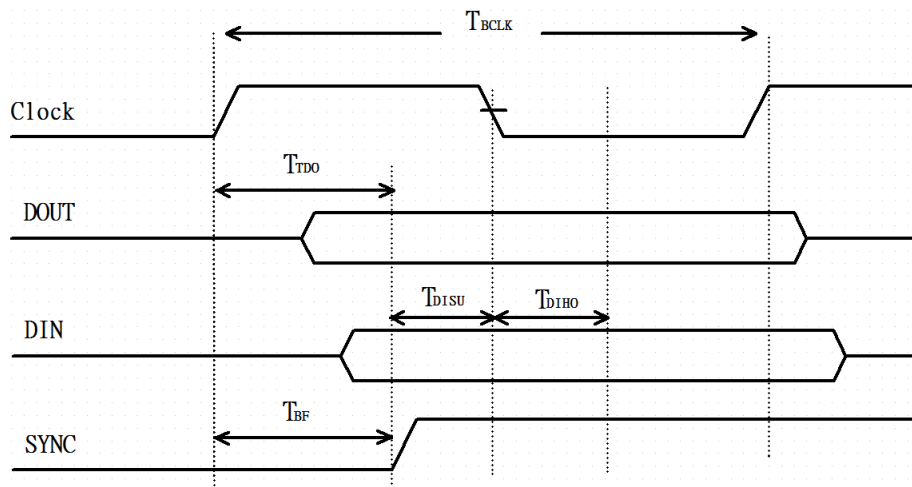


Figure 6: PCM Timing Specification – Master Mode

Table 19: PCM Timing Specification – Master Mode

| Symbol                      | Parameter | Min. | Typ.    | Max. | Unit |
|-----------------------------|-----------|------|---------|------|------|
| F <sub>BCLK</sub>           | -         | -    | 2/2.048 | -    | MHz  |
| Duty Cycle <sub>BCLK</sub>  | -         | 0.4  | 0.5     | 0.6  | -    |
| T <sub>BCLK</sub> rise/fall | -         | -    | 3       | -    | ns   |
| T <sub>D0</sub>             | -         | -    | -       | 15   | ns   |
| T <sub>DISU</sub>           | -         | 20   | -       | -    | ns   |
| T <sub>DIHO</sub>           | -         | 15   | -       | -    | ns   |
| T <sub>BF</sub>             | -         | -    | -       | 15   | ns   |

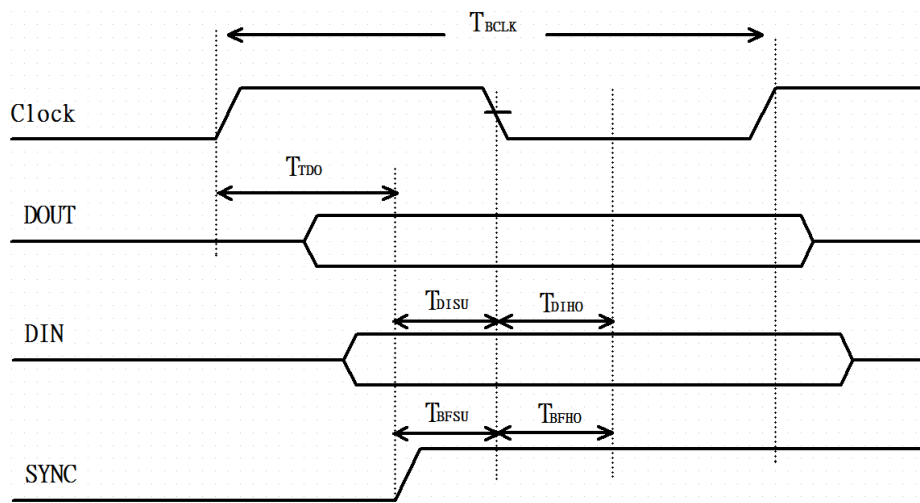


Figure 7: PCM Timing Specification – Slave Mode

Table 20: PCM Timing Specification – Slave Mode

| Symbol                      | Parameter | Min. | Typ.    | Max. | Unit |
|-----------------------------|-----------|------|---------|------|------|
| F <sub>CLK</sub>            | -         | -    | 2/2.048 | -    | MHz  |
| Duty Cycle <sub>BCLK</sub>  | -         | 0.4  | 0.5     | 0.6  | -    |
| T <sub>BCLK rise/fall</sub> | -         | -    | 3       | -    | ns   |
| T <sub>DO</sub>             | -         | -    | -       | 30   | ns   |
| T <sub>DISU</sub>           | -         | 15   | -       | -    | ns   |
| T <sub>DIHO</sub>           | -         | 10   | -       | -    | ns   |
| T <sub>BFSU</sub>           | -         | 15   | -       | -    | ns   |
| T <sub>BFHO</sub>           | -         | 10   | -       | -    | ns   |

## 2. PIN DEFINITIONS

Table 21: Pin definitions

| Pin # | Name       | Type   | Voltage Ref. | Description                                                                                                       | If Not Used |
|-------|------------|--------|--------------|-------------------------------------------------------------------------------------------------------------------|-------------|
| 1     | GND        | -      | -            | Ground                                                                                                            | GND         |
| 2     | 3.3V       | Power  | -            | 3.3V module power supply                                                                                          | -           |
| 3     | USB_D+     | I/O    | 3.3V         | USB Differential Data-Positive                                                                                    | N/C         |
| 4     | 3.3V       | Power  | -            | 3.3V module power supply                                                                                          | -           |
| 5     | USB_D-     | I/O    | 3.3V         | USB Differential Data-Negative                                                                                    | N/C         |
| 6     | LED1#      | O,PU   | 3.3V         | LED indicator for WLAN with 10mA drive capability                                                                 | N/C         |
| 7     | GND        | -      | -            | Ground                                                                                                            | GND         |
| 8     | PCM_CLK    | I/O    | 1.8V         | PCM Clock Signal (Optional)<br>Optimal clock used for some codecs.<br>Output if Master mode; Input if Slave mode. | N/C         |
| 9     | SDIO CLK   | I,PU   | 1.8V         | SDIO 4-bit Mode Clock Input                                                                                       | N/C         |
| 10    | PCM_SYNC   | I/O    | 1.8V         | PCM Sync Pulse Signal<br>Output if Master mode; Input if Slave mode.                                              | N/C         |
| 11    | SDIO CMD   | I/O    | 1.8V         | SDIO 4-bit Mode Command/Response                                                                                  | N/C         |
| 12    | PCM_IN     | I      | 1.8V         | PCM Data                                                                                                          | N/C         |
| 13    | SDIO DATA0 | I/O,PU | 1.8V         | SDIO 4-bit Mode DATA line Bit[0]                                                                                  | N/C         |
| 14    | PCM_OUT    | O      | 1.8V         | PCM Data                                                                                                          | N/C         |
| 15    | SDIO DATA1 | I/O,PU | 1.8V         | SDIO 4-bit Mode DATA line Bit[1]                                                                                  | N/C         |
| 16    | LED2#      | N/C    | N/C          | N/C                                                                                                               | N/C         |
| 17    | SDIO DATA2 | I/O,PU | 1.8V         | SDIO 4-bit Mode DATA line Bit[2]                                                                                  | N/C         |
| 18    | GND        | -      | -            | Ground                                                                                                            | GND         |
| 19    | SDIO DATA3 | I/O,PU | 1.8V         | SDIO 4-bit Mode DATA line Bit[3]                                                                                  | N/C         |
| 20    | UART WAKE# | O      | 3.3V         | Reserved for BT to wakeup Host                                                                                    | N/C         |
| 21    | SDIO WAKE# | O      | 1.8V         | Reserved for Wake-On-WLAN                                                                                         | N/C         |
| 22    | UART TXD   | O      | 1.8V         | UART Serial Data Output                                                                                           | N/C         |

| Pin # | Name                    | Type  | Voltage Ref. | Description                                                                                                                         | If Not Used |
|-------|-------------------------|-------|--------------|-------------------------------------------------------------------------------------------------------------------------------------|-------------|
| 23    | SDIO RESET#             | N/C   | N/C          | N/C                                                                                                                                 | N/C         |
| 32    | UART RXD                | I     | 1.8V         | UART Serial Data Input                                                                                                              | N/C         |
| 33    | GND                     | -     | -            | Ground                                                                                                                              | GND         |
| 34    | UART RTS                | O,WPU | 1.8V         | UART Request To Send (Active low)                                                                                                   | N/C         |
| 35    | PERp0                   | N/C   | 1.8V         | PCIe Receive Data-Positive                                                                                                          | N/C         |
| 36    | UART CTS                | I, PU | 1.8V         | UART Clear To Send (Active low)                                                                                                     | N/C         |
| 37    | PERn0                   | N/C   | 1.8V         | PCIe Receive Data-Negative                                                                                                          | N/C         |
| 38    | VENDOR DEFINED38        | N/C   | N/C          | N/C                                                                                                                                 | N/C         |
| 39    | GND                     | -     | -            | Ground                                                                                                                              | GND         |
| 40    | VENDOR DEFINED40        | N/C   | N/C          | N/C                                                                                                                                 | N/C         |
| 41    | PETp0                   | N/C   | 1.8V         | PCIe Transmit Data-Positive                                                                                                         | N/C         |
| 42    | VENDOR DEFINED42        | N/C   | N/C          | N/C                                                                                                                                 | N/C         |
| 43    | PETn0                   | N/C   | 1.8V         | PCIe Transmit Data-Negative                                                                                                         | N/C         |
| 44    | COEX3                   | I/O   | 1.8V         | General purpose I/O pin.                                                                                                            | N/C         |
| 45    | GND                     | -     | -            | Ground                                                                                                                              | GND         |
| 46    | COEX2                   | O,PD  | 1.8V         | Serial data to external LTE device/                                                                                                 | N/C         |
| 47    | REFCLKp0                | N/C   | 1.8V         | PCIe Differential Clock input-Positive                                                                                              | N/C         |
| 48    | COEX1                   | I,PD  | 1.8V         | Serial data from external LTE device/                                                                                               | N/C         |
| 49    | REFCLKn0                | N/C   | 1.8V         | PCIe Differential Clock input-Negative                                                                                              | N/C         |
| 50    | SUSCLK(32KHz)           | I,PU  | 3.3V         | Sleep Clock Input<br>An external sleep clock of 32.768KHz with minimum +/- 250ppm is required for power saving mode                 | -           |
| 51    | GND                     | -     | -            | Ground                                                                                                                              | GND         |
| 52    | PERST0#                 | N/C   | 3.3V         | PCIe host indication to reset the device (input) (active low)                                                                       | N/C         |
| 53    | CLKREQ0#                | N/C   | 3.3V         | PCIe clock request (input/output) (active low)                                                                                      | GND         |
| 54    | W_DISABLE2#             | N/C   | 3.3V         | N/C                                                                                                                                 | N/C         |
| 55    | PEWAKE0#                | N/C   | 3.3V         | PCIe wake signal (input/output) (active low)                                                                                        | N/C         |
| 56    | W_DISABLE1# (O)(0/3.3V) | I,PU  | 3.3V         | Enable input for all Regulators inside the 60-SIPT.<br>Note: DO NOT float this pin. Pull-up to 3.3V with 100K for normal operation. | N/C         |
| 57    | GND                     | -     | -            | Ground                                                                                                                              | GND         |
| 58    | I2C DATA (I/O)(0/3.3V)  | N/C   | N/C          | N/C                                                                                                                                 | N/C         |
| 59    | RESERVED/PETp1          | N/C   | N/C          | N/C                                                                                                                                 | N/C         |
| 60    | I2C CLK (O)(0/3.3V)     | N/C   | N/C          | N/C                                                                                                                                 | N/C         |
| 61    | RESERVED/PETn1          | N/C   | N/C          | N/C                                                                                                                                 | N/C         |
| 62    | ALERT# (I)(0/3.3V)      | N/C   | N/C          | N/C                                                                                                                                 | N/C         |

| Pin # | Name                             | Type  | Voltage Ref. | Description              | If Not Used |
|-------|----------------------------------|-------|--------------|--------------------------|-------------|
| 63    | GND                              | -     | -            | Ground                   | GND         |
| 64    | RESERVED                         | N/C   | N/C          | N/C                      | N/C         |
| 65    | RESERVED/PERp1                   | N/C   | N/C          | N/C                      | N/C         |
| 66    | UIM_SWP/PERST1#                  | N/C   | N/C          | N/C                      | N/C         |
| 67    | RESERVED/PERn1                   | N/C   | N/C          | N/C                      | N/C         |
| 68    | UIM_POWER_SNK/<br>CLKREQ1#       | N/C   | N/C          | N/C                      | N/C         |
| 69    | GND                              | -     | -            | Ground                   | GND         |
| 70    | UIM_POWER_SRC/<br>GPIO1/PEWAKE1# | N/C   | N/C          | N/C                      | N/C         |
| 71    | RESERVED/REFCLKp<br>1            | N/C   | N/C          | N/C                      | N/C         |
| 72    | 3.3V                             | Power | -            | 3.3V module power supply | -           |
| 73    | RESERVED/REFCLKn<br>1            | N/C   | N/C          | N/C                      | N/C         |
| 74    | 3.3V                             | Power | -            | 3.3V module power supply | -           |
| 75    | GND                              | -     | -            | Ground                   | GND         |
| 76    | GND                              | -     | -            | Ground                   | GND         |
| 77    | GND                              | -     | -            | Ground                   | GND         |

## 13 MECHANICAL SPECIFICATIONS

Module dimensions of 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU are 22 mm x 30 mm x 3.3 mm. Detail drawings are shown in Figure 8.

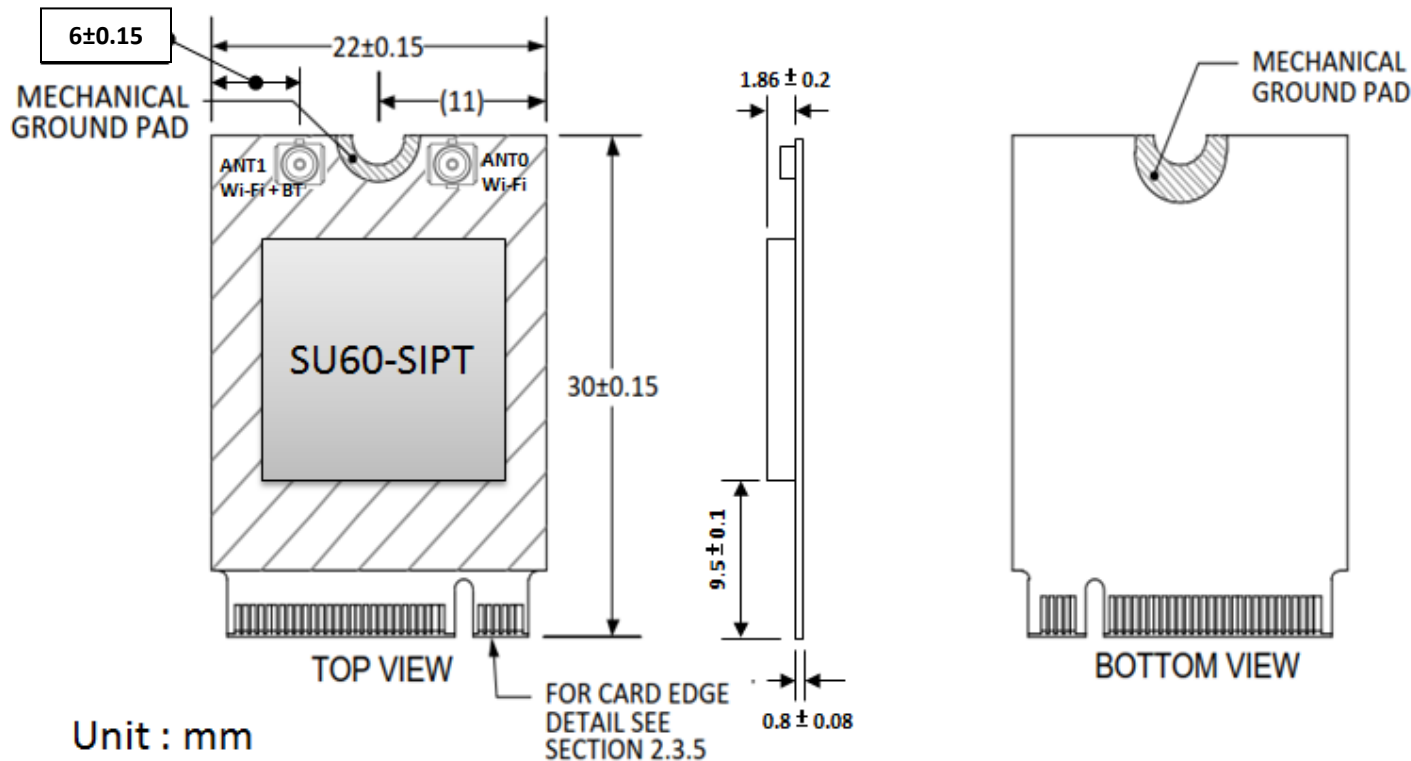


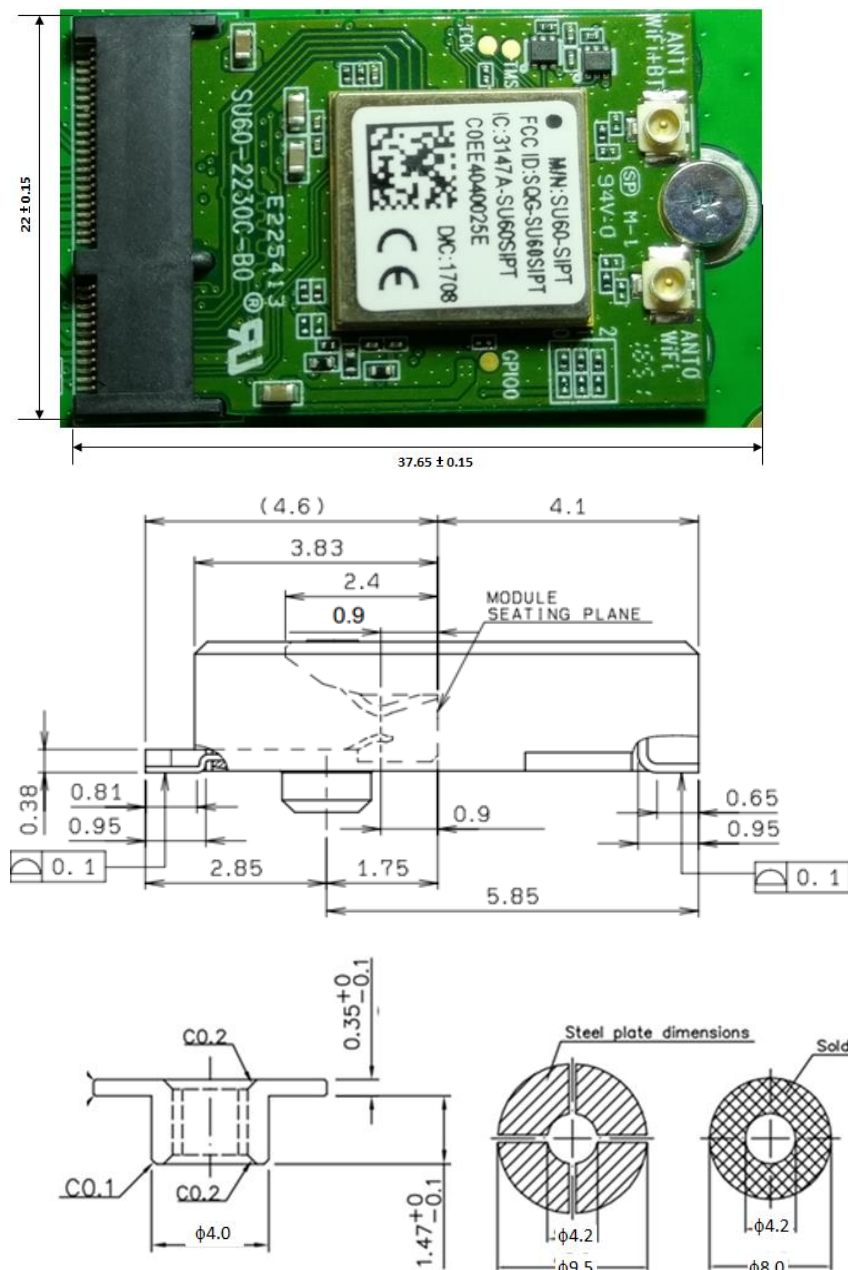
Figure 8: Module dimension of 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU

**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, 4, 8 or C.  
The BT MAC address is the Wi-Fi MAC address plus 3.

The 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU connects to the host via a standard PCI EXPRESS M2 connector. The Kyocera's ([www.Kyocera-connector.com](http://www.Kyocera-connector.com)) 6411 series provide 1.8 mm, 2.3 mm and 3.2 mm connector heights.

24-6411-067-101-894E

The stand-off mating to the recommend 2.3 mm connector from EMI STOP ([www.EMISTOP.com](http://www.EMISTOP.com)) is part number **F50M16-041525P1D4M**. Detail layout and stencil opening are show in [Figure 9](#).



**Figure 9: Mounting information of the 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU and recommended layout pattern for the stand-off**

## 15 RF LAYOUT DESIGN GUIDELINES / PRECAUTIONS

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 the Bluetooth antenna and the Wi-Fi antenna.
- Ensure that there is the maximum allowable spacing separating the antenna connectors on the Laird radio from the antenna. In addition, do not place antennas directly above or directly below the radio.
- Laird recommends the use of a double-shielded cable for the connection between the radio and the antenna elements.
- Be sure to put the capacitor on the power pin as close as possible to reduce the radiation issue.
- Use proper electro-static-discharge (ESD) procedures when installing the Laird radio module.
- To get maximum throughput when operate at MIMO 2x2, two antennas with at least 25 dB isolation are recommended.
- To avoid negatively impacting Tx power and receiver sensitivity, do not cover the antennas with metallic objects or components.
- Opening/handling/removing must be done on an anti-ESD treated workbench. All workers must be also have undergone anti-ESD treatment.
- The devices should be mounted within one year of the date of delivery.

## 16 REGULATORY

### 16.1 Regulatory IDs Summary

| Model    | US/FCC     | Canada/IC     | Korea                | China          |
|----------|------------|---------------|----------------------|----------------|
| 60-2230C | SQG-60SIPT | 3147A-602230C | MSIP-CRM-LAI-60-SIPT | 2017AJ7897 (M) |

### 16.2 Certified Antennas

| Model                              | Type            | Connector | 2400~2483.5MHz                                                                               |
|------------------------------------|-----------------|-----------|----------------------------------------------------------------------------------------------|
|                                    |                 |           | 5150~5250MHz 5250~5350MHz<br>5470~5725MHz 5725~5850MHz                                       |
| Laird/NanoBlade-IP04               | PCB Dipole      | IPEX U.FL | 2 dBi (2.4-2.5 GHz), 3.9 dBi (5.15-5.35 GHz),<br>4 dBi (5.6 GHz)                             |
| Laird/MAF95310 Mini NanoBlade Flex | PCB Dipole      | IPEX U.FL | 2.79 dBi @ 2.4 GHz, 3.38 dBi @ 5 GHz                                                         |
| Ethertronics/WLAN_1000146          | Magnetic Dipole | IPEX U.FL | 2.5 dBi (2.390-2.490), 3.5 dBi (4.900-5.100),<br>3.5 dBi (5.150-5.350), 3.5 dBi (5.70-5.900) |
| LSR/FlexPIFA 001-0016              | PIFA            | IPEX U.FL | 2.5 dBi@2.4 GHz, 3 dBi@5 GHz                                                                 |
| mFlexPIFA 001-0030                 | PIFA            | IPEX U.FL | 2 dBi (2.4-2.5 GHz)                                                                          |
| LSR/001-0009                       | Dipole          | IPEX U.FL | 2 dBi@2.4 GHz, 2 dBi@5 GHz                                                                   |

## 17 FCC AND IC REGULATORY

| Model    | US/FCC     | CANADA/IC     |
|----------|------------|---------------|
| 60-2230C | SQG-60SIPT | 3147A-602230C |

The 60-2230C has been designed to pass certification with the antenna listed below. The required antenna impedance is 50 ohms.

**Table 22: FCC antenna information**

| Model                              | Type            | Connector | Peak gain ( dBi ) |               |               |               |               |
|------------------------------------|-----------------|-----------|-------------------|---------------|---------------|---------------|---------------|
|                                    |                 |           | 2400~2483.5 MHz   | 5150~5250 MHz | 5250~5350 MHz | 5470~5725 MHz | 5725~5850 MHz |
| Laird/NanoBlade-IP04               | PCB Dipole      | IPEX U.FL | 2.0 dBi           | 3.9 dBi       | 3.9 dBi       | 4.0dBi        |               |
| Laird/MAF95310 Mini NanoBlade Flex | PCB Dipole      | IPEX U.FL | 2.79 dB           | 3.38 dBi      |               |               |               |
| Ethertronics/ WLAN_1000146         | Magnetic Dipole | IPEX U.FL | 2.5 dBi           | 3.5 dBi       |               |               |               |
| LSR/FlexPIFA 001-0016              | PIFA            | IPEX U.FL | 2.5dBi            | 3.0 dBi       |               |               |               |
| LSR/001-0009                       | Dipole          | IPEX U.FL | 2.0dBi            | 2.0 dBi       |               |               |               |

### 17.1 FCC

#### 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

### Radiation Exposure Statement

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

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

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

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

1. The antenna must be installed such that 20 cm is maintained between the antenna and users, and
2. The transmitter module may not be co-located with any other transmitter or antenna,
3. For all products market in US, OEM has to limit the operation channels in CH1 to CH11 for 2.4G band by supplied firmware programming tool. OEM shall not supply any tool or info to the end-user regarding to Regulatory Domain change.

As long as the three conditions above are met, further **transmitter** testing 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 **cannot 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 **cannot** 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.

## End Product Labeling

This transmitter module is authorized only for use in device where the antenna may be installed such that 20 cm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following:

**Contains FCC ID: SQG-60SIPT .**

## 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.

## 17.2 Industry Canada

### Industry Canada Statement

This device complies with Industry Canada's license-exempt RSSs. Operation is subject to the following two conditions:

- This device may not cause interference; and
- This device must accept any interference, including interference that may cause undesired operation of the device.

*Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence.*

*L'exploitation est autorisée aux deux conditions suivantes:*

- l'appareil ne doit pas produire de brouillage;
- l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

*This radio transmitter (IC: 3147A-602230C) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.*

*Le présent émetteur radio (IC: 3147A-602230C) a été approuvé par Industrie 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, sont strictement interdits pour l'exploitation de l'émetteur.*

## Antenna Information

**Table 23: Antenna information**

| Model                              | Type            | Connector | Peak gain (dBi) |               |               |               |               |
|------------------------------------|-----------------|-----------|-----------------|---------------|---------------|---------------|---------------|
|                                    |                 |           | 2400~2483.5 MHz | 5150~5250 MHz | 5250~5350 MHz | 5470~5725 MHz | 5725~5850 MHz |
| Laird/NanoBlade-IP04               | PCB Dipole      | IPEX U.FL | 2.0 dBi         | 3.9 dBi       | 3.9 dBi       | 4.0 dBi       |               |
| Laird/MAF95310 Mini NanoBlade Flex | PCB Dipole      | IPEX U.FL | 2.79 dB         | 3.38 dBi      |               |               |               |
| Ethertronics/WLAN_1000146          | Magnetic Dipole | IPEX U.FL | 2.5 dBi         | 3.5 dBi       |               |               |               |
| LSR/FlexPIFA 001-0016              | PIFA            | IPEX U.FL | 2.5 dBi         | 3.0 dBi       |               |               |               |
| LSR/001-0009                       | Dipole          | IPEX U.FL | 2.0 dBi         | 2.0 dBi       |               |               |               |

## Caution:

(i) The device for operation in the band 5150–5250 MHz is only for indoor use to reduce the potential for harmful interference to co-channel mobile satellite systems;

(ii) For devices with detachable antenna(s), the maximum antenna gain permitted for devices in the bands 5250-5350 MHz and 5470-5725 MHz shall be such that the equipment still complies with EIRP limit;

(iii) For devices with detachable antenna(s), the maximum antenna gain permitted for devices in the band 5725-5850 MHz shall be such that the equipment still complies with the EIRP limits specified for point-to-point and non-point-to-point operation as appropriate; and

Operations in the 5.25-5.35GHz band are restricted to indoor usage only.

## Avertissement:

(i) les dispositifs fonctionnant dans la bande de 5150 à 5250MHz sont réservés uniquement pour une utilisation à l'intérieur afin de réduire les risques de brouillage préjudiciable aux systèmes de satellites mobiles utilisant les mêmes canaux;

(ii) pour les dispositifs munis d'antennes amovibles, le gain maximal d'antenne permis pour les dispositifs utilisant les bandes de 5250 à 5350MHz et de 5470 à 5725 MHz doit être conforme à la limite de la p.i.r.e;

(iii) pour les dispositifs munis d'antennes amovibles, le gain maximal d'antenne permis (pour les dispositifs utilisant la bande de 5725 à 5850 MHz) doit être conforme à la limite de la p.i.r.e. spécifiée pour l'exploitation point à point et l'exploitation non point à point, selon le cas;

Les opérations dans la bande de 5.25-5.35GHz sont limités à un usage intérieur seulement.

## Radiation Exposure Statement

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

## Déclaration d'exposition aux radiations

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

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

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

As long as the condition above is 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:**

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

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

## Important Note

In the event that these conditions cannot 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 cannot 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 Important

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-602230C.**

## laque signalétique du produit final

Le produit final doit être étiqueté dans un endroit visible avec l'inscription suivante: **Contient des IC: 3147A-602230C.**

## 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.

## 18 EUROPEAN UNION REGULATORY

The 60-2230C has been tested for compliance with relevant standards for the EU market. 60-2230C module was tested with antennas listed below.

**Table 24: EU antenna information**

| Model                               | Type                           | Connector | 2400~2483.5MHz                                                                      |
|-------------------------------------|--------------------------------|-----------|-------------------------------------------------------------------------------------|
|                                     |                                |           | 5150~5250MHz 5250~5350MHz<br>5470~5725MHz 5725~5850MHz                              |
| Laird MAF94051                      | Dipole                         | RP-SMA    | 2.1 dBi (2.4-2.5 GHz), 2.4 dBi (4.9 GHz)<br>2.6 dBi (5.25 GHz), 3.4 dBi (5.875 GHz) |
| Laird/NanoBlade-IP04                | PCB Dipole                     | IPEX MHF  | 2 dBi (2.4-2.5 GHz),<br>3.9 dBi (5.15-5.35 GHz), 4 dBi (5.6 GHz)                    |
| Laird/MAF95310 Mini Nano Blade Flex | PCB Dipole                     | IPEX MHF  | 2.79 dBi (2.4 GHz), 3.38 dBi (5 GHz)                                                |
| Laird/NanoBlue-IP04                 | PCB Dipole                     | IPEX MHF  | 2 dBi (2.4 GHz only)                                                                |
| Ethertronics/WLAN_1000146           | Isolated<br>Magnetic<br>Dipole | IPEX MHF  | 2.5 dBi (2.390-2.490 GHz),<br>3.5 dBi (4.900-5.100, 5.150-5.350,<br>5.70-5.900 GHz) |

The OEM should consult with a qualified test house before entering their device into an EU member country to make sure all regulatory requirements have been met for their complete device.

Reference the Declaration of Conformities listed below for a full list of the standards that the modules were tested to. Test reports are available upon request.

## 18.1 EU Declarations of Conformity

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

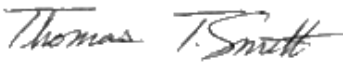
|                |                                              |
|----------------|----------------------------------------------|
| Manufacturer:  | Laird                                        |
| Products:      | 60-2230C                                     |
| EU Directives: | 2014/53/EU – Radio Equipment Directive (RED) |

### Reference standards used for presumption of conformity:

| Article Number | Requirement                                                           | Reference standard(s)                                          |
|----------------|-----------------------------------------------------------------------|----------------------------------------------------------------|
| 3.1a           | Low voltage equipment safety                                          | EN 60950-1:2006+A11+A1:2010+A12:2011+A2 2013                   |
|                | RF Exposure                                                           | EN 62311:2008                                                  |
|                |                                                                       | EN 50385:2002                                                  |
| 3.1b           | Protection requirements with respect to electromagnetic compatibility | EN 301 489-1 v2.2.0 (Draft)<br>EN 301 489-17 v3.2.0 (Draft)    |
| 3.2            | Means of the efficient use of the radio frequency spectrum            | EN 300 328 v2.1.1 (2015-02)<br>EN 301 893 v2.1.0 (Final Draft) |

### Declaration:

We, Laird, declare under our sole responsibility that the essential radio test suites have been carried out and that the above product to which this declaration relates is in conformity with all the applicable essential requirements of Article 3 of the EU Radio Equipment directive 2014/53/EU, when used for its intended purpose.

|                                 |                                                                                                       |
|---------------------------------|-------------------------------------------------------------------------------------------------------|
| Place of Issue:                 | Laird<br>W66N220 Commerce Court, Cedarburg, WI 53012 USA<br>tel: +1-262-375-4400 fax: +1-262-364-2649 |
| Date of Issue:                  | May 2017                                                                                              |
| Name of Authorized Person:      | Thomas T Smith, Director of EMC Compliance                                                            |
| Signature of Authorized Person: |                    |

### Maximum Output Power for Each Frequency

|            |                          |
|------------|--------------------------|
| <b>TBD</b> | 20.5 dBm, 5.15-5.25 GHz  |
|            | 20.5 dBm, 5.25-5.35 GHz  |
|            | 20.5 dBm, 5.47-5.725 GHz |

### Software Version for Testing

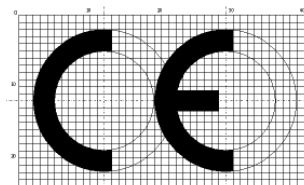
SW version: P95

The minimum distance between the user and/or any bystander and the radiating structure of the transmitter is 20 cm.

5150 ~ 5350 MHz is limited to indoor used in the following countries:



|    |    |    |    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|----|----|----|
| BE | DK | IE | FR | CY | LU | NL | PT | SK | UK | NO |
| BG | DE | EL | HR | LV | HU | AT | RO | FI | LI | TR |
| CZ | EE | ES | IT | LT | MT | PL | SI | SE | IS | CH |



## 19 ORDERING INFORMATION

| Part Number | Description                                |
|-------------|--------------------------------------------|
| 60-2230C    | 2X2 802.11 ac + BT4.2 SDIO/UART M.2 module |
| 60-2230C-SS | 2X2 802.11 ac + BT4.2 SDIO/SDIO M.2 module |
| 60-2230C-U  | 2X2 802.11 ac + BT4.2 USB/UART M.2 module  |
| 60-2230C-UU | 2X2 802.11 ac + BT4.2 USB/USB M.2 module   |

### 19.1 General Comments

This is a preliminary datasheet. Please check with Laird for the latest information before commencing a design. If in doubt, ask.

|                                                                                                               |                                                                                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>Česky [Czech]</b>        | <i>[Jméno výrobce]</i> tímto prohlašuje, že tento <i>[typ zařízení]</i> je ve shodě se základními požadavky a dalšími příslušnými ustanoveními směrnice 2014/53/EU.                                                                   |
|  <b>Dansk [Danish]</b>       | Undertegnede <i>[fabrikantens navn]</i> erklærer herved, at følgende udstyr <i>[udstyrets typebetegnelse]</i> overholder de væsentlige krav og øvrige relevante krav i direktiv 2014/53/EU.                                           |
|  <b>Deutsch [German]</b>     | Hiermit erkläre <i>[Name des Herstellers]</i> , dass sich das Gerät <i>[Gerätetyp]</i> in Übereinstimmung mit den grundlegenden Anforderungen und den übrigen einschlägigen Bestimmungen der Richtlinie 2014/53/EU befindet.          |
|  <b>Eesti [Estonian]</b>     | Käesolevaga kinnitab <i>[tootja nimi = name of manufacturer]</i> seadme <i>[seadme tüüp = type of equipment]</i> vastavust direktiivi 2014/53/EU põhinõuetele ja nimetatud direktiivist tulenevatele teistele asjakohastele sätetele. |
|  <b>English</b>             | Hereby, <i>[name of manufacturer]</i> , declares that this <i>[type of equipment]</i> is in compliance with the essential requirements and other relevant provisions of Directive 2014/53/EU.                                         |
|  <b>Español [Spanish]</b>  | Por medio de la presente <i>[nombre del fabricante]</i> declara que el <i>[clase de equipo]</i> cumple con los requisitos esenciales y cualesquiera otras disposiciones aplicables o exigibles de la Directiva 2014/53/EU.            |
|  <b>Ελληνική [Greek]</b>   | ΜΕ ΤΗΝ ΠΑΡΟΥΣΑ <i>[name of manufacturer]</i> ΔΗΛΩΝΕΙ ΟΤΙ <i>[type of equipment]</i> ΣΥΜΜΟΡΦΩΝΕΤΑΙ ΠΡΟΣ ΤΙΣ ΟΥΣΙΩΔΕΙΣ ΑΠΑΙΤΗΣΕΙΣ ΚΑΙ ΤΙΣ ΛΟΙΠΕΣ ΣΧΕΤΙΚΕΣ ΔΙΑΤΑΞΕΙΣ ΤΗΣ ΟΔΗΓΙΑΣ 2014/53/EU.                                             |
|  <b>Français [French]</b>  | Par la présente <i>[nom du fabricant]</i> déclare que l'appareil <i>[type d'appareil]</i> est conforme aux exigences essentielles et aux autres dispositions pertinentes de la directive 2014/53/EU.                                  |
|  <b>Italiano [Italian]</b> | Con la presente <i>[nome del costruttore]</i> dichiara che questo <i>[tipo di apparecchio]</i> è conforme ai requisiti essenziali ed alle altre disposizioni pertinenti stabilite dalla direttiva 2014/53/EU.                         |
| <b>Latviski [Latvian]</b>                                                                                     | Aršo <i>[name of manufacturer / izgatavotājanosaukums]</i> deklarē, ka <i>[type of equipment / iekārtas tips]</i> atbilst Direktīvas 2014/53/EU būtiskajām prasībām un citiemar to saistītajiem noteikumiem.                          |
| <b>Lietuvių [Lithuanian]</b>                                                                                  | Šiuo <i>[manufacturer name]</i> deklaruojama, kad šis <i>[equipment type]</i> atitinka esminius reikalavimus ir kitas 2014/53/EU Direktyvos nuostatas.                                                                                |
|  <b>Nederlands [Dutch]</b> | Hierbij verklaart <i>[naam van de fabrikant]</i> dat het toestel <i>[type van toestel]</i> in overeenstemming is met de essentiële eisen en de andere relevante bepalingen van richtlijn 2014/53/EU.                                  |
|  <b>Malti [Maltese]</b>    | Hawnhekk, <i>[isem tal-manifattur]</i> , jiddikjara li dan <i>[il-mudel tal-prodott]</i> jikkonforma mal-ħtiġijiet essenzjali u ma provviedimenti oħrajn rilevanti li hemm fid-Dirrettiva 2014/53/EU.                                 |
|  <b>Magyar [Hungarian]</b> | Alulírott, <i>[gyártó neve]</i> nyilatkozom, hogy a <i>[... típus]</i> megfelel a vonatkozó alapvető követelményeknek és az 2014/53/EU irányelv egyéb előírásainak.                                                                   |
|  <b>Polski [Polish]</b>    | Niniejszym <i>[nazwa producenta]</i> oświadczam, że <i>[nazwa wyrobu]</i> jest zgodny z zasadniczymi wymogami oraz pozostałymi stosownymi postanowieniami Dyrektywy 2014/53/EU.                                                       |
|  <b>Português</b>          | <i>[Nome do fabricante]</i> declara que este <i>[tipo de equipamento]</i> está conforme com os requisitos essenciais e outras                                                                                                         |

|                                   |                                                                                                                                                                                                                                       |
|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>[Portuguese]</b>               | disposições da Directiva 2014/53/EU.                                                                                                                                                                                                  |
| <b>[Slovensko<br/>Slovenian]</b>  | <i>[Ime proizvajalca]</i> izjavlja, da je ta <i>[tip opreme]</i> v skladu z bistvenimi zahtevami in ostalimi relevantnimi določili direktive 2014/53/EU.                                                                              |
| <b>Slovensky<br/>[Slovak]</b>     | <i>[Menovýrobcu]</i> týmtovyhlasuje, že <i>[typzariadenia]</i> spĺňa základné požiadavky a všetky príslušné ustanovenia Smernice 2014/53/EU.                                                                                          |
| <b>[fi] Suomi<br/>[Finnish]</b>   | <i>[Valmistaja = manufacturer]</i> vakuuttaa täten että <i>[type of equipment = laitteen tyyppimerkintä]</i> tyyppinen laite on direktiivin 2014/53/EU oleellisten vaatimusten ja sitä koskevien direktiivin muiden ehtojen mukainen. |
| <b>[sv] Svenska<br/>[Swedish]</b> | Härmed intygar <i>[företag]</i> att denna <i>[utrustningstyp]</i> står i överensstämmelse med de väsentliga egenskapskrav och övriga relevanta bestämmelser som framgår av direktiv 2014/53/EU.                                       |

© Copyright 2018 Laird. All Rights Reserved. Any information furnished by Laird and its agents is believed to be accurate and reliable. All specifications are subject to change without notice. Responsibility for the use and application of Laird materials or products rests with the end user since Laird and its agents cannot be aware of all potential uses. Laird makes no warranties as to non-infringement nor as to the fitness, merchantability, or sustainability of any Laird materials or products for any specific or general uses. Laird, Laird Technologies, Inc., or any of its affiliates or agents shall not be liable for incidental or consequential damages of any kind. All Laird products are sold pursuant to the Laird Terms and Conditions of Sale in effect from time to time, a copy of which will be furnished upon request. When used as a tradename herein, *Laird* means Laird PLC or one or more subsidiaries of Laird PLC. *Laird™*, *Laird Technologies™*, corresponding logos, and other marks are trademarks or registered trademarks of Laird. Other marks may be the property of third parties. Nothing herein provides a license under any Laird or any third party intellectual property right.