

# Datasheet

## 60-SIPT series

*Version 1.1*

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## REVISION HISTORY

| Version | Date         | Notes                                                  | Approver    |
|---------|--------------|--------------------------------------------------------|-------------|
| 1.0     | 29 Aug 2017  | Initial version                                        | Jay White   |
| 1.1     | 08 Sept 2017 | Updated Max. Current Consumption table/column headings | Andrew Chen |
|         |              |                                                        |             |
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## 1 SCOPE

This document describes key hardware aspects of the Laird 60-SIPT series system-in-package (SiP) modules providing either SDIO, USB2.0, or PCIe bus interface for WLAN connection and UART/PCM, SDIO/PCM, USB2.0/PCM for Bluetooth® connection. This document is intended to assist device manufacturers and related parties with the integration of this radio into their host devices. Data in this document is drawn from several sources and includes information found in the Marvell 88W8997/88PG823 data sheets issued in April 2016, along with other documents provided from Marvell.

**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-SIPT series SiP modules are an integrated, small form factor 2x2 MIMO 802.11 a/b/g/n/ac WLAN plus *Bluetooth* 4.2 dual mode device that is optimized for low-power mobile devices. The integration of all WLAN and *Bluetooth* functionality in a single package supports low cost and simple implementation along with flexibility for platform-specific customization.

This device is pre-calibrated and integrates the complete transmit/receive RF paths including band pass filter, diplexer, switches, reference crystal oscillator, and power manage units (PMU).

The 60-SIPT series device supports IEEE 802.11 ac (wave 2) 2X2 receive multi-user MIMO (MU-MIMO) spatial stream multiplexing with data rates up to MCS9 (866.7 Mbps). It also supports Bluetooth 2.1 + EDR and Bluetooth 4.2 (Bluetooth Low Energy or BLE). Internal Wi-Fi and BT coexistence scheme provides optimized throughput when Wi-Fi and BT working simultaneously. The device's low power consumption radio architecture and power manage unit (PMU) proprietary power save technologies allow for extended battery life.

In addition, its dual 802.11 and Bluetooth radio includes full digital MAC and baseband engines that handle all 802.11 CCK/OFDM® 2.4/5GHz, and Bluetooth basic rate and EDR baseband and protocol processing.

Dual embedded low-power CPU cores minimize host loading and maximize flexibility to support customer-specific use cases.

The 60-SIPT series SiP modules include two product SKUs which is have different supported software features. Please check Laird Sales/FAE for further information. Order information is listed in [Table 1](#).



**Table 1: Product ordering information**

| Order Model | Description                                                                             |
|-------------|-----------------------------------------------------------------------------------------|
| SU60-SIPT   | 802.11ac + BT4.2 60 Series hardware combined with Summit Series Enterprise software     |
| ST60-SIPT   | 802.11ac + BT4.2 60 Series hardware combined with Sterling Series Professional software |

### 3 60-SIPT SERIES FEATURES SUMMARY

The Laird 60-SIPT series device features are described in [Table 2](#).

**Table 2: 60-SIPT series features**

| Feature                | Description                                                                                                                                                                                                                                  |
|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Radio Front End</b> | Integrates the complete transmit/receive RF paths including band pass filter, diplexer, switches, reference crystal oscillator, and power manage unit (PMU).<br>Supports 20/40/80MHz channel bandwidth.<br>WLAN/Bluetooth share one antenna. |

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|                            |                                                                                                                                                                                                                                                                                                                                                                                                      |             |                      |                                              |
|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------------|----------------------------------------------|
| <b>Coexistence</b>         | Coexistence arbitration for WLAN, Bluetooth, and LTE operation                                                                                                                                                                                                                                                                                                                                       |             |                      |                                              |
| <b>Power Management</b>    | Dynamic Voltage Scaling (DVS) and Adaptive Voltage Scaling (AVS) features support 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 100 MHz), USB2.0 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/BLE</b> | <b>ROM Notes</b>                             |
|                            | 000                                                                                                                                                                                                                                                                                                                                                                                                  | SDIO        | UART                 | -                                            |
|                            | 001                                                                                                                                                                                                                                                                                                                                                                                                  | SDIO        | SDIO                 | -                                            |
|                            | 010                                                                                                                                                                                                                                                                                                                                                                                                  | PCIe        | USB 2.0              | Initial USB 2.0 PHY and COM PHY PCIe portion |
|                            | 011                                                                                                                                                                                                                                                                                                                                                                                                  | PCIe        | UART                 | Initial only COM PHY PCIe portion            |
|                            | 100                                                                                                                                                                                                                                                                                                                                                                                                  | USB 2.0     | UART                 | Initial COM PHY USB 2.0                      |
|                            | 101                                                                                                                                                                                                                                                                                                                                                                                                  | USB 2.0     | USB 2.0              | Initial only USB 2.0 PHY                     |
| <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 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> <li>Modulation and coding scheme (MCS): 802.11ac—MCS0-9 Nsts=1 and 2.<br/>802.11n—MCS0-15</li> </ul>                                                                            |             |                      |                                              |
|                            | <ul style="list-style-type: none"> <li>Dynamic frequency selection (radar detection) DFS</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 wide variety of WLAN encryption: TKIP/WEP/AES</li> </ul> |             |                      |                                              |

| Feature            | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Advanced Bluetooth | <ul style="list-style-type: none"> <li>Bluetooth 4.2 (BDR/EDR/LE), Bluetooth class 1</li> <li>Support data rate: 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/BLE Interface         | Host Controller Interface (HCI) using high speed UART, SDIO, USB 2.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                  |                          |                                              |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
|                                 | <table><tr><th>Strap Value<br/>CONFIG_HOST [2-0]</th><th>WLAN</th><th>Bluetooth/<br/>BLE</th><th>ROM Notes</th></tr><tr><td>000</td><td>SDIO</td><td>UART</td><td>-</td></tr><tr><td>001</td><td>SDIO</td><td>SDIO</td><td>-</td></tr><tr><td>010</td><td>PCIe</td><td>USB 2.0</td><td>Initial USB 2.0 PHY and COM PHY PCIe portion</td></tr><tr><td>011</td><td>PCIe</td><td>UART</td><td>Initial only COM PHY PCIe portion</td></tr><tr><td>100</td><td>USB 2.0</td><td>UART</td><td>Initial COM PHY USB 2.0</td></tr><tr><td>101</td><td>USB 2.0</td><td>USB 2.0</td><td>Initial only USB 2.0 PHY</td></tr></table> | Strap Value<br>CONFIG_HOST [2-0] | WLAN                     | Bluetooth/<br>BLE                            | ROM Notes | 000 | SDIO | UART | - | 001 | SDIO | SDIO | - | 010 | PCIe | USB 2.0 | Initial USB 2.0 PHY and COM PHY PCIe portion | 011 | PCIe | UART | Initial only COM PHY PCIe portion | 100 | USB 2.0 | UART | Initial COM PHY USB 2.0 | 101 | USB 2.0 | USB 2.0 | Initial only USB 2.0 PHY |
|                                 | Strap Value<br>CONFIG_HOST [2-0]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | WLAN                             | Bluetooth/<br>BLE        | ROM Notes                                    |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
|                                 | 000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | SDIO                             | UART                     | -                                            |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
|                                 | 001                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | SDIO                             | SDIO                     | -                                            |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
|                                 | 010                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | PCIe                             | USB 2.0                  | Initial USB 2.0 PHY and COM PHY PCIe portion |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
|                                 | 011                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | PCIe                             | UART                     | Initial only COM PHY PCIe portion            |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
|                                 | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | USB 2.0                          | UART                     | Initial COM PHY USB 2.0                      |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
| 101                             | USB 2.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | USB 2.0                          | Initial only USB 2.0 PHY |                                              |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
| 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%                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                  |                          |                                              |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
| Operating Temperature           | -30° to 85°C (-22° to 185°F)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                  |                          |                                              |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
| Operating Humidity              | 10 to 90% (non-condensing)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                  |                          |                                              |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
| Storage Temperature             | -40° to 85°C (-40° to 185°F)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                  |                          |                                              |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
| Storage Humidity                | 10 to 90% (non-condensing)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                  |                          |                                              |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
| Maximum Electrostatic Discharge | Conductive 4KV; Air coupled 8KV follow EN61000-4-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                  |                          |                                              |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
| Size                            | 13 mm (length) x 14 mm (width) x 1.87 mm (thickness)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                  |                          |                                              |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
| Weight                          | TBD g                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                  |                          |                                              |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
| Wi-Fi Media                     | Direct Sequence-Spread Spectrum (DSSS)<br>Complementary Code Keying (CCK)<br>Orthogonal Frequency Divisional Multiplexing (OFDM)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                  |                          |                                              |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
| Bluetooth Media                 | Frequency Hopping Spread Spectrum (FHSS)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                  |                          |                                              |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
| Wi-Fi Media Access Protocol     | Carrier sense multiple access with collision avoidance (CSMA/CA)<br>A-MPDU Rx (De-aggregation) and Tx (aggregation) (802.11ac single-MPDU A-MPDU)                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                  |                          |                                              |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |
| Network Architecture Types      | Infrastructure and ad-hoc                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                  |                          |                                              |           |     |      |      |   |     |      |      |   |     |      |         |                                              |     |      |      |                                   |     |         |      |                         |     |         |         |                          |

| Feature                           | Description                                                                                                                                                                                                                          |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <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, 802.11s*, 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)                                                                                                                                         |
| <b>Wi-Fi Data Rates Supported</b> | Support 802.11 ac/a/b/g/n 2X2 MIMO.<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) |
| <b>Modulation Table</b>           | BPSK, QPSK, CCK, 16-QAM, 64-QAM, and 256-QAM.                                                                                                                                                                                        |

| 802.11ac<br>802.11n                   | HT<br>MCS<br>Index | VHT<br>MCS<br>Index | Spatial<br>Streams                                                                                                                                                                                             | Modulation | Coding | 20 MHz |       | 40 MHz |     | 80 MHz |              |
|---------------------------------------|--------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|--------|--------|-------|--------|-----|--------|--------------|
|                                       |                    |                     |                                                                                                                                                                                                                |            |        | No SGI | SGI   | No SGI | SGI | No SGI | SGI          |
|                                       | 0                  | 0                   | 1                                                                                                                                                                                                              | BPSK       | 1/2    | 6.5    | 7.2   | 13.5   | 15  | 29.3   | 32.5         |
|                                       | 1                  | 1                   | 1                                                                                                                                                                                                              | QPSK       | 1/2    | 13     | 14.4  | 27     | 30  | 58.5   | 65           |
|                                       | 2                  | 2                   | 1                                                                                                                                                                                                              | QPSK       | 3/4    | 19.5   | 21.7  | 40.5   | 45  | 87.8   | 97.5         |
|                                       | 3                  | 3                   | 1                                                                                                                                                                                                              | 16-QAM     | 1/2    | 26     | 28.9  | 54     | 60  | 117    | 130          |
|                                       | 4                  | 4                   | 1                                                                                                                                                                                                              | 16-QAM     | 3/4    | 39     | 43.3  | 81     | 90  | 175.5  | 195          |
|                                       | 5                  | 5                   | 1                                                                                                                                                                                                              | 64-QAM     | 2/3    | 52     | 57.8  | 108    | 120 | 234    | 260          |
|                                       | 6                  | 6                   | 1                                                                                                                                                                                                              | 64-QAM     | 3/4    | 58.5   | 65    | 121.5  | 135 | 263.3  | 292.5        |
|                                       | 7                  | 7                   | 1                                                                                                                                                                                                              | 64-QAM     | 5/6    | 65     | 72.2  | 135    | 150 | 292.5  | 325          |
|                                       |                    | 8                   | 1                                                                                                                                                                                                              | 256-QAM    | 3/4    | 78     | 86.7  | 162    | 180 | 351    | 390          |
|                                       |                    | 9                   | 1                                                                                                                                                                                                              | 256-QAM    | 5/6    | N/A    | N/A   | 180    | 200 | 390    | <b>433.3</b> |
|                                       | 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    | <b>866.7</b> |
| <b>802.11ac/n Spatial Streams</b>     |                    |                     | 2 (2x2 MIMO)                                                                                                                                                                                                   |            |        |        |       |        |     |        |              |
| <b>Bluetooth Data Rates Supported</b> |                    |                     | 1, 2, 3 Mbps                                                                                                                                                                                                   |            |        |        |       |        |     |        |              |
| <b>Bluetooth Modulation</b>           |                    |                     | GFSK@ 1 Mbps<br>Pi/4-DQPSK@ 2 Mbps<br>8-DPSK@ 3 Mbps                                                                                                                                                           |            |        |        |       |        |     |        |              |
| <b>Regulatory Domain Support</b>      |                    |                     | 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 |            |        |        |       |        |     |        |              |

| Feature                                                                                                                                                                                                                                                                        | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>2.4 GHz Frequency Bands</b>                                                                                                                                                                                                                                                 | <b>ETSI:</b> 2.4 GHz to 2.483 GHz<br><b>FCC:</b> 2.4 GHz to 2.473 GHz<br><b>MIC:</b> 2.4 GHz to 2.495 GHz<br><b>KC:</b> 2.4 GHz to 2.483 GHz                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>2.4 GHz Operating Channels (Wi-Fi)</b>                                                                                                                                                                                                                                      | <b>ETSI:</b> 13 (3 non-overlapping)<br><b>FCC:</b> 11 (3 non-overlapping)<br><b>MIC:</b> 14 (4 non-overlapping)<br><b>KC:</b> 13 (3 non-overlapping)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <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 5.85 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)                                                                                                                                                                                                                                                                                                                   |
| <b>5 GHz Operating Channels (Wi-Fi)</b>                                                                                                                                                                                                                                        | <b>ETSI:</b> 19 non-overlapping; <b>FCC:</b> 24 non-overlapping<br><b>MIC:</b> (Japan): 19 non-overlapping; <b>KC:</b> 19 non-overlapping                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Transmit Power</b><br><br><i><b>Note:</b> Transmit power on each channel varies per individual country regulations. All values are nominal with +/-2 dBm tolerance at room temperature.</i><br><br><i>Tolerance could be up to +/-2.5 dBm across operating temperature.</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>13.5 Mbps (MCS0-5/MCS8-13; HT40) 16 dBm (40 mW)<br>135 Mbps (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>13.5/27 Mbps (MCS0-5; Ntst=1,2; HT40) 16 dBm (40 mW)<br>180/360 Mbps (MCS6-8; Ntst=1,2; HT40) 14 dBm (25 mW)<br>200/400 Mbps (MCS9; Ntst=1,2; HT40) 12 dBm (15.8mW)<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) |



| Feature                                                                                                                                                                                               | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                       | <div>2 Mbps7 dBm (6.3 mW)</div> <div>3 Mbps7 dBm (6.3 mW)</div> <div>BLE (1 Mbps)7 dBm (6.3 mW)</div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Typical Receiver Sensitivity</b><br>(PER <= 10%)<br><i><b>Note:</b> All values nominal, +/-3 dBm.<br/>           Sensitivity on CH13 (WLAN)/CH78<br/>           (BT) will degrade up to 4-6dB.</i> | <b>802.11a:</b><br><div>6 Mbps-89 dBm</div> <div>54 Mbps-74 dBm</div> <b>802.11b:</b><br><div>1 Mbps-95 dBm</div> <div>11 Mbps-90 dBm (PER&lt;8%)</div> <b>802.11g:</b><br><div>6 Mbps-91 dBm</div> <div>54 Mbps-75 dBm</div> <b>802.11n (2.4 GHz)</b><br><div>6.5 Mbps (MCS0; HT20)-91 dBm</div> <div>65 Mbps (MCS7; HT20)-73 dBm</div> <div>13.5 Mbps (MCS0; HT40)-85 dBm</div> <div>135 Mbps (MCS7; HT40)-70 dBm</div> <b>802.11n (5 GHz)</b><br><div>6.5 Mbps (MCS0; HT20)-89 dBm</div> <div>65 Mbps (MCS7; HT20)-70 dBm</div> <div>13.5Mbps (MCS0; HT40)-86 dBm</div> <div>135Mbps (MCS7; HT40)-69 dBm</div> <b>802.11ac (5 GHz)</b><br><div>6.5 Mbps (MCS0; HT20)-89 dBm</div> <div>78 Mbps (MCS8; HT20)-67 dBm</div> <div>13.5 Mbps (MCS0; HT40)-86 dBm</div> <div>180 Mbps (MCS9; HT40)-63 dBm</div> <div>29.3 Mbps (MCS0; HT80)-81 dBm</div> <div>390/780 Mbps (MCS9; HT80)-55 dBm</div> <b>Bluetooth:</b><br><div>1 Mbps (1DH5)-95 dBm</div> <div>2Mbps (2DH5)-94 dBm</div> <div>3 Mbps (3DH5)-88 dBm</div> <div>BLE-95 dBm</div> |
| <b>Operating Systems Supported</b>                                                                                                                                                                    | Linux 3.x to 4.9.x kernel.<br>Android 5.0-5.1.1 (Lollipop) Nov. 2014 supported.<br>Android 6.0-6.01 (Marshmallow) Oct 2015 supported<br>Android 7.0-7.1.1 (Nougat) Aug. 2016 supported                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

| 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> | 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                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |          |               |         |          |          |      |          |  |
| <p><b>Compliance</b></p> <p><i>Note: These regulatory certifications are pending.</i></p>     | <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/>2011/65/EU (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>                                                                                                                                                                                                                                                     |          |               |         |          |          |      |          |  |
| <p><b>Certifications</b></p> <p><i>Note: These regulatory certifications are pending.</i></p> | <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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |          |               |         |          |          |      |          |  |
| <i>All specifications are subject to change without notice</i>                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |          |               |         |          |          |      |          |  |

## 5 WLAN FUNCTIONAL DESCRIPTION

### 5.1 Overview

The 60-SIPT series SiP module is designed based on the Marvell 88W8997 802.11ac/a/b/g/n chipset. It is optimized for high speed, reliable, and low-power embedded applications. It's integrated with dual-band WLAN (2.4/5GHz) and Bluetooth 4.2. Its functionality includes:

- 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 (866.7Mbps).

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

**Table 4: WLAN functions**

| Feature  | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| WLAN MAC | <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 866.7 Mbps</li> <li>20 MHz bandwidth/channel, 40 MHz bandwidth/channel, upper/lower 20 MHz packets in 40 MHz channel, 20 MHz duplicate legacy packets in 40 MHz channel operation.</li> <li>80 MHz bandwidth/channel, 4 positions of 20 MHz packets in 80 MHz channel, upper/lower 40 MHz packets in 80 MHz channel, 20 MHz quadruplicate legacy packets in 80 MHz channel mode operation.</li> <li>Modulation and Coding Scheme (MCS): 802.11ac (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>One 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>  | <ul style="list-style-type: none"> <li>WLAN Encryption features supported include: <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> </li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

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

## 6 BLUETOOTH FUNCTIONAL DESCRIPTION

The 60-SIPT series includes a fully-integrated Bluetooth baseband/radio. Several features and functions are listed in [Table 5](#).

**Table 5: Bluetooth functions**

| Feature                                              | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Bluetooth Interface</b>                           | <ul style="list-style-type: none"> <li>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> </ul> </li> <li>SDIO interface</li> <li>High-Speed UART interface</li> <li>USB 2.0</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Bluetooth Core functionality</b>                  | <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: 1 Mbps, 2 Mbps, 3 Mbps</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> |
| <b>Bluetooth Low Energy (BLE) Core functionality</b> | <ul style="list-style-type: none"> <li>Advertiser, Scanner, Initiator, Master, and Slave roles support (connects 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>2Mbps LE</li> <li>Direction Finding –connectionless Angle of Departure (AoD)</li> <li>Direction Finding –connectionless Angle of Arrival (AoA)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

## 7 BLOCK DIAGRAM

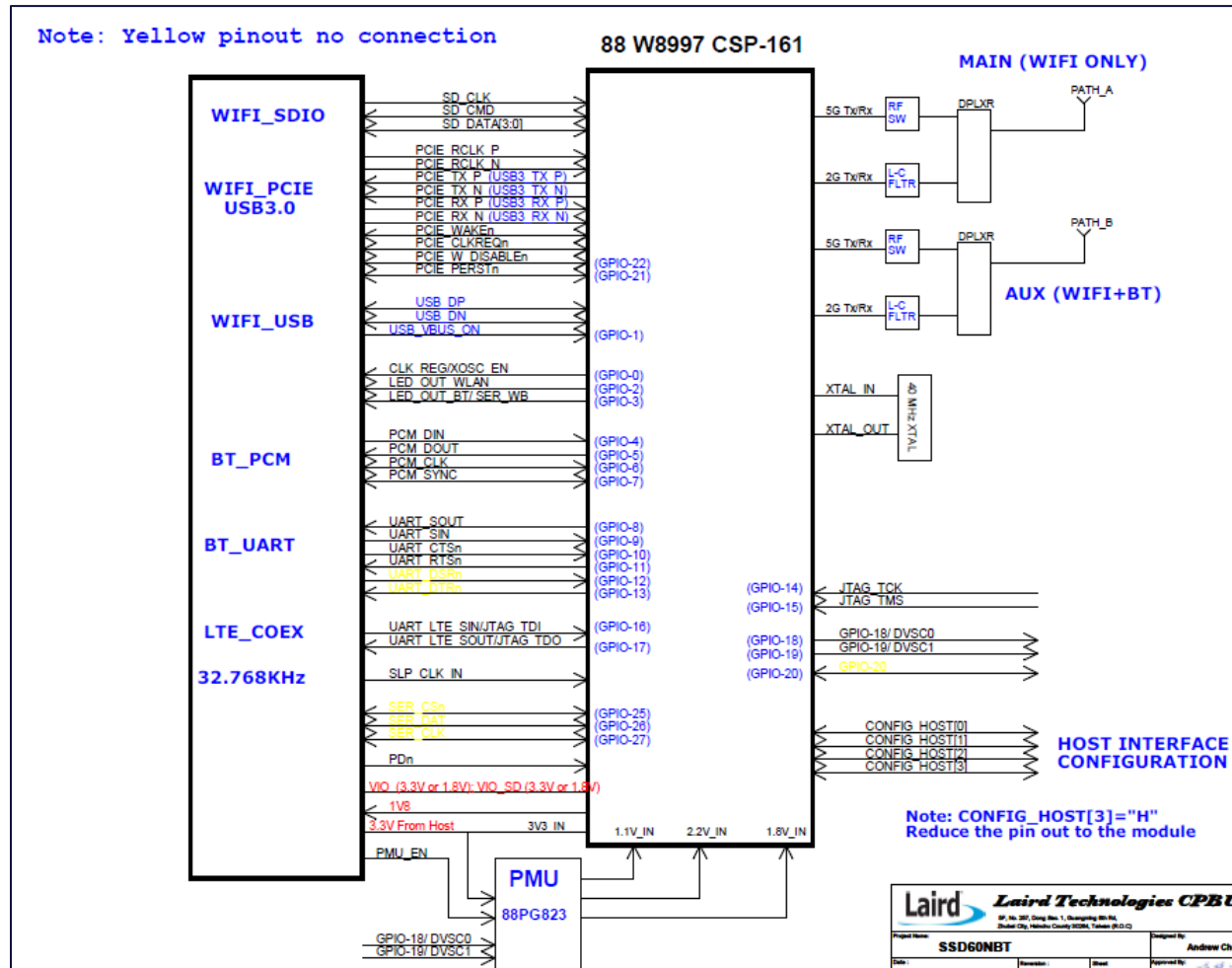


Figure 1: Block diagram

## 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-SIPT Series. 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 (for 1.8V system)<br>(for 3.3V system) | 2.2<br>4.0 | V    |

| Symbol (Domain) | Parameter                                                             | Max Rating | Unit |
|-----------------|-----------------------------------------------------------------------|------------|------|
| VIO             | I/O configuration power supply (for 1.8V system)<br>(for 3.3V system) | 2.2<br>4.0 | 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    | 1.62/2.97 | 1.8/3.3 | 1.98/3.63 | V    |
| VIO             | WLAN and BT GPIO I/O power supply | 1.62/2.97 | 1.8/3.3 | 1.98/3.63 | 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 and Table 9 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 | --         | 1.26 |     | 2.2  | V    |
| VIL    | Low Level Input Voltage  | --         | -0.4 |     | 0.54 | V    |
| VHYS   | Input Hysteresis         | --         | 100  |     |      | mV   |
| VOH    | Output high Voltage      | --         | 1.4  |     |      | V    |
| VOL    | Output low Voltage       | --         |      |     | 0.4  | V    |

Table 9: General DC electrical characteristics (For 3.3V operation VIO\_SD; VIO)

| Symbol | Parameter                | Conditions | Min  | Typ | Max | Unit |
|--------|--------------------------|------------|------|-----|-----|------|
| VIH    | High Level Input Voltage | --         | 2.4  |     | 3.6 | V    |
| VIL    | Low Level Input Voltage  | --         | -0.4 |     | 0.9 | V    |
| VHYS   | Input Hysteresis         | --         | 100  |     |     | mV   |
| VOH    | Output high Voltage      | --         | 2.9  |     |     | V    |
| VOL    | Output low Voltage       | --         |      |     | 0.4 | V    |

Table 10: DC electrical characteristics for 1.8V or 3.3V operation on special pads (PCIE\_WAKEn, PCIE\_CLKREQn)

| Symbol | Parameter                | Conditions | Min  | Typ | Max | Unit |
|--------|--------------------------|------------|------|-----|-----|------|
| VIH    | High Level Input Voltage | --         | 1.4  |     | 3.6 | V    |
| VIL    | Low Level Input Voltage  | --         | -0.4 |     | 0.8 | V    |



| Symbol | Parameter          | Conditions | Min | Typ | Max | Unit |
|--------|--------------------|------------|-----|-----|-----|------|
| VHYS   | Input Hysteresis   | --         | 150 |     |     | mV   |
| VOL    | Output low Voltage | --         |     |     | 0.4 | V    |

## 8.4 WLAN Radio Receiver Characteristics

Table 11 and Table 12 summarize the WLAN 60-SIPT series receiver characteristics.

**Table 11: 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  |
| S <sub>r</sub> f  | Sensitivity                   |                       |       |     |       |      |
|                   | CCK, 1 Mbps                   | See Note <sup>1</sup> |       | -95 |       | dBm  |
|                   | CCK, 11 Mbps                  |                       |       | -90 |       |      |
|                   | OFDM, 6 Mbps                  |                       |       | -91 |       |      |
|                   | OFDM, 54 Mbps                 |                       |       | -75 |       |      |
|                   | HT20, MCS0                    |                       |       | -91 |       |      |
|                   | HT20, MCS7                    |                       |       | -73 |       |      |
| R <sub>a</sub> dj | Adjacent channel rejection    |                       |       |     |       |      |
|                   | OFDM, 6 Mbps                  | See Note <sup>1</sup> |       | TBD |       | dB   |
|                   | OFDM, 54 Mbps                 |                       |       | TBD |       |      |
|                   | HT20, MCS0                    |                       |       | TBD |       |      |
|                   | HT20, MCS7                    |                       |       | TBD |       |      |

**Table 12: 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  |
| S <sub>r</sub> f  | Sensitivity                   |                       |      |     |       |      |
|                   | OFDM, 6 Mbps                  | See Note <sup>1</sup> |      | -89 |       | dBm  |
|                   | OFDM, 54 Mbps                 |                       |      | -74 |       |      |
|                   | HT20, MCS0                    |                       |      | -89 |       |      |
|                   | HT20, MCS7                    |                       |      | -70 |       |      |
|                   | HT40, MCS0                    |                       |      | -86 |       |      |
|                   | HT40, MCS7                    |                       |      | -69 |       |      |
| R <sub>a</sub> dj | Adjacent channel rejection    |                       |      |     |       |      |
|                   | OFDM, 6 Mbps                  | See Note <sup>1</sup> |      | TBD |       | dB   |
|                   | OFDM, 54 Mbps                 |                       |      | TBD |       |      |
|                   | HT20, MCS0                    |                       |      | TBD |       |      |
|                   | HT20, MCS7                    |                       |      | TBD |       |      |

Note<sup>1</sup>: Performance data are measured under single chain operation.

## 8.5 WLAN Transmitter Characteristics

Table 13: 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  | -   | +2.0  | dB   |

| Freq.   | Mode/Rate (Mbps) | Output Power Per Chain (dBm) | Maximum Current Consumption    |                               |
|---------|------------------|------------------------------|--------------------------------|-------------------------------|
|         |                  |                              | Single Chain (mA) <sup>8</sup> | Dual Chains (mA) <sup>8</sup> |
| 2412MHz | 1 Mbps           | 18dBm                        | 340                            | 620                           |
|         | 54 Mbps          | 16dBm                        | 280                            | 500                           |
|         | HT20 MCS7        | 16dBm                        | 280                            | 510                           |
| 2422MHz | 1 Mbps           | 18dBm                        | 340                            | 620                           |
|         | 54 Mbps          | 16dBm                        | 280                            | 500                           |
|         | HT20 MCS7        | 16dBm                        | 280                            | 510                           |
| 2472MHz | 1 Mbps           | 18dBm                        | 340                            | 620                           |
|         | 54 Mbps          | 16dBm                        | 280                            | 500                           |
|         | HT20 MCS7        | 16dBm                        | 280                            | 510                           |

Table 14: 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       |      | 14  |       |      |
|        | 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         | MCS6-8(Ntst=1,2)      |      | 14  |       |      |
|        | 11ac HT40 EVM compliant         | MCS9(Ntst=1,2)        |      | 12  |       |      |

| Symbol | Parameter                        | Conditions        | Min  | Typ | Max  | Unit |
|--------|----------------------------------|-------------------|------|-----|------|------|
| ATx    | 11ac HT80 mask compliant         | MCS0-5 (Ntst=1,2) |      | 14  |      |      |
|        | 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 | -   | +2.0 | dB   |

**Table 15: WLAN current consumption on 5 GHz**

| Freq.    | Mode/Rate [Mbps] | Output Power Per Chain [dBm] | Maximum Current Consumption |                  |
|----------|------------------|------------------------------|-----------------------------|------------------|
|          |                  |                              | Single Chain (mA)           | Dual Chains (mA) |
| 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              |

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

## 9 BLUETOOTH RADIO CHARACTERISTICS

Table 16 through Table 17 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 16: Basic rate transmitter performance temperature at 25°C (3.3V)**

| 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   | —      | $\geq 0.80$                   | —    |

| Test Parameter            |                          | Min | Typ  | Max | BT Spec.      | Unit           |
|---------------------------|--------------------------|-----|------|-----|---------------|----------------|
| 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 17: Enhanced data rate transmitter performance 25°C (3.3V)**

| Test Parameter                         |                          | Min | Typ | Max | BT Spec.      | Unit |
|----------------------------------------|--------------------------|-----|-----|-----|---------------|------|
| Relative Transmit Power                |                          | 5   | 7   | 9   |               | dBm  |
| Max Carrier Frequency Stability  wo    | 2-DH5                    | —   | 1   | —   | $\leq \pm 10$ | KHz  |
|                                        | 3-DH5                    | —   | 1   | —   |               |      |
| Max Carrier Frequency Stability  wi    | 2-DH5                    | —   | 4   | —   | $\leq \pm 75$ | KHz  |
|                                        | 3-DH5                    | —   | 4   | —   |               |      |
| Max Carrier Frequency Stability  w0+wi | 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 18: Basic rate receiver performance at 3.3V**

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

Table 19: Enhanced data rate receiver performance 3.3V

| 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 (1MHz)        | $\pi/4$ DQPSK | —   | -9    | 0   | ≤ 0                     | dB   |
|                                    | 8 DPSK        | —   | -6    | 5   | ≤ 5                     | dB   |
| Second Adjacent Channel C/I (2MHz) | $\pi/4$ DQPSK | —   | -47   | -30 | ≤ -30                   | dB   |
|                                    | 8 DPSK        | —   | -42   | -25 | ≤ -25                   | dB   |
| Third Adjacent Channel C/I (3MHz)  | $\pi/4$ 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 HOST INTERFACE SPECIFICATIONS

### 10.1 SDIO Specifications

The 60-SIPT series 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.

#### 10.1.1 Default Speed, High-speed Modes

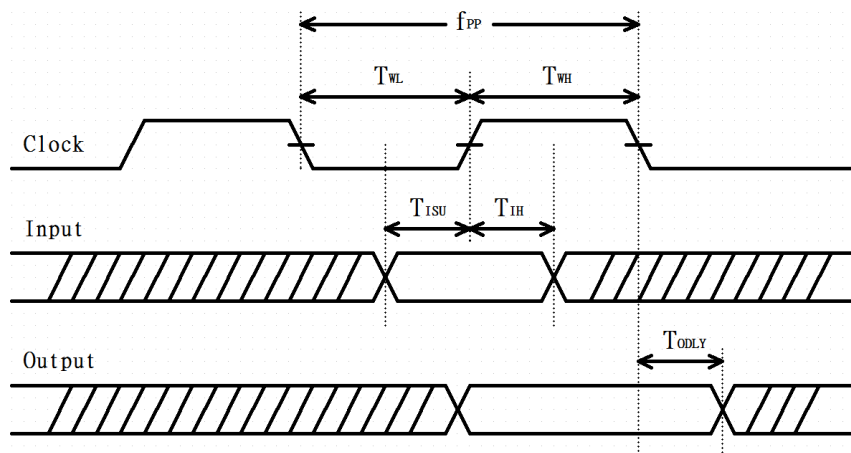


Figure 2: SDIO protocol timing diagram--- default mode (3.3V)

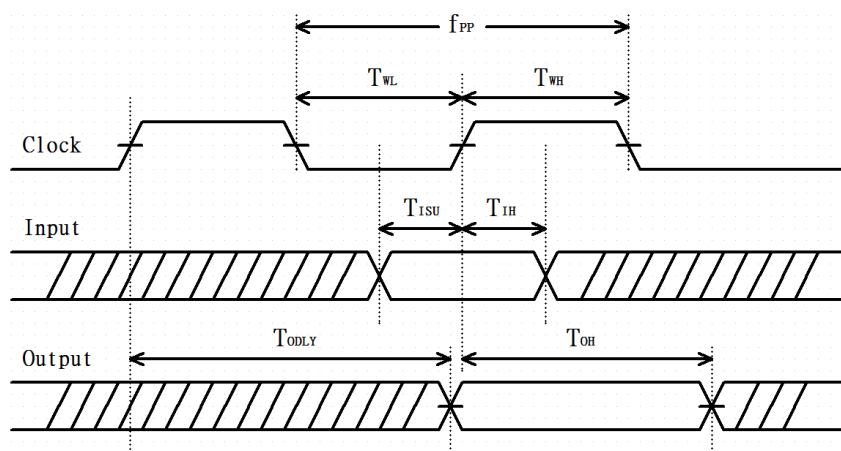


Figure 3: SDIO protocol timing diagram--- High-Speed mode (3.3V)

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

Table 20: SDIO timing requirements

| Symbol          | Parameter       | Condition     | Min. | Typ. | Max. | Unit |
|-----------------|-----------------|---------------|------|------|------|------|
| f <sub>PP</sub> | Clock Frequency | Default Speed | 0    | -    | 25   | MHz  |
|                 |                 | High-Speed    | 0    | -    | 50   |      |

| Symbol            | Parameter                               | Condition     | Min. | Typ. | Max. | Unit |
|-------------------|-----------------------------------------|---------------|------|------|------|------|
| T <sub>WL</sub>   | Clock low time                          | Default Speed | 10   | -    | -    | ns   |
|                   |                                         | High-Speed    | 7    | -    | -    |      |
| T <sub>WH</sub>   | Clock high time                         | Default Speed | 10   | -    | -    | ns   |
|                   |                                         | High-Speed    | 7    | -    | -    |      |
| T <sub>ISU</sub>  | Input Setup time                        | Default Speed | 5    | -    | -    | ns   |
|                   |                                         | High-Speed    | 6    | -    | -    |      |
| T <sub>IH</sub>   | Input Hold time                         | Default Speed | 5    | -    | -    | ns   |
|                   |                                         | High-Speed    | 2    | -    | -    |      |
| T <sub>ODLY</sub> | Output delay time<br>CL ≤ 40pF (1 card) | Default Speed | -    | -    | 14   | ns   |
|                   |                                         | High-Speed    | -    | -    | 14   |      |
| T <sub>OH</sub>   | Output hold time                        | High-Speed    | 0    | -    | -    | ns   |

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

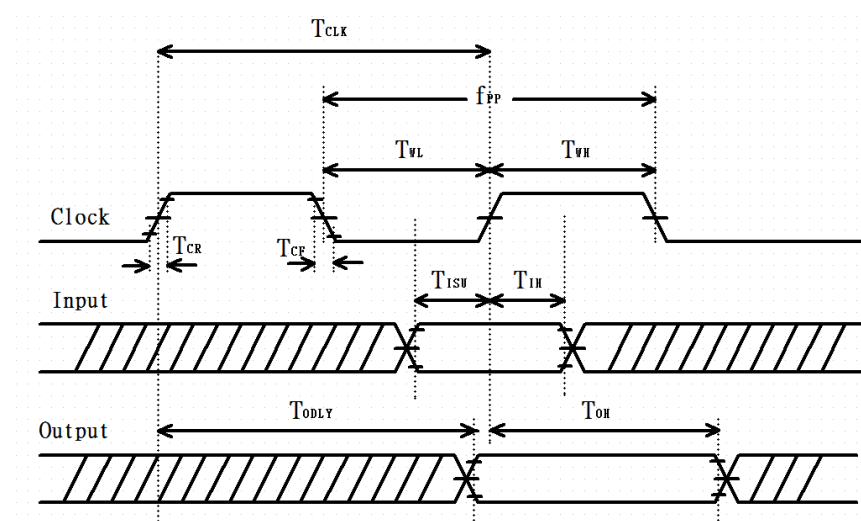


Figure 4: SDIO protocol timing Diagram--- SDR12, SDR25, SDR50 modes (up to 100 MHz) (1.8V)

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

Table 21: SDIO timing requirements--- SDR12, SDR25, SDR50 modes (up to 100 MHz) (1.8V)

| 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 100MHz<br>C <sub>CARD</sub> = 10pF | SDR12/25/50 | -    | -    | 0.2 * T <sub>CLK</sub> | ns   |

| Symbol            | Parameter                                  | Condition   | Min. | Typ. | Max. | Unit |
|-------------------|--------------------------------------------|-------------|------|------|------|------|
| 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   |

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

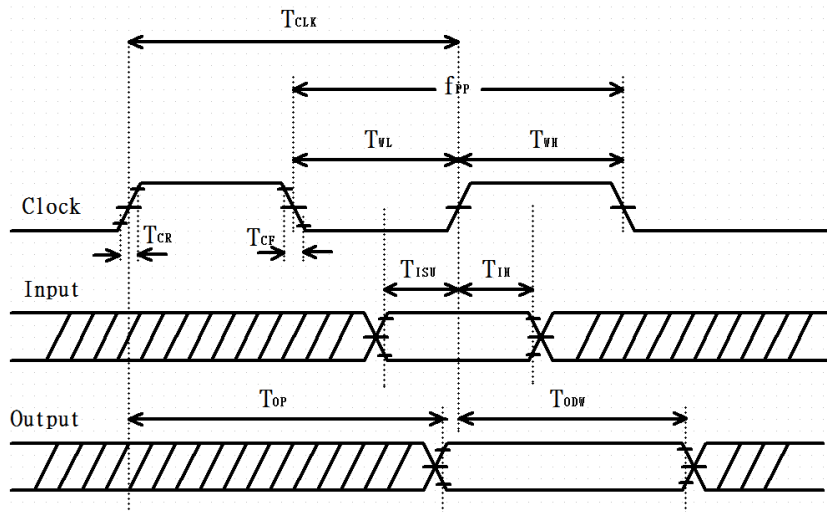


Figure 5: SDIO protocol timing Diagram--- SDR104 modes (up to 208 MHz) (1.8V)

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

Table 22: SDIO timing requirements--- SDR104 modes (up to 208MHz) (1.8V)

| 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 208MHz<br>C <sub>CARD</sub> = 10pF | 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   |



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

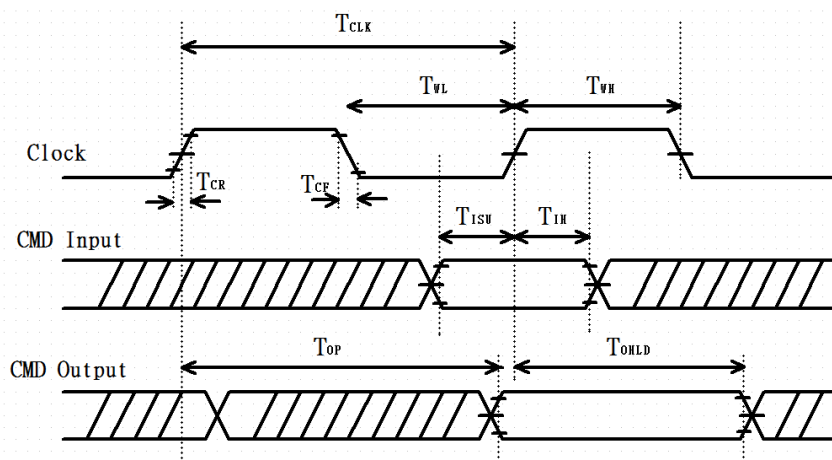


Figure 6: SDIO CMD timing diagram--- DDR50 modes (50 MHz) (1.8V)

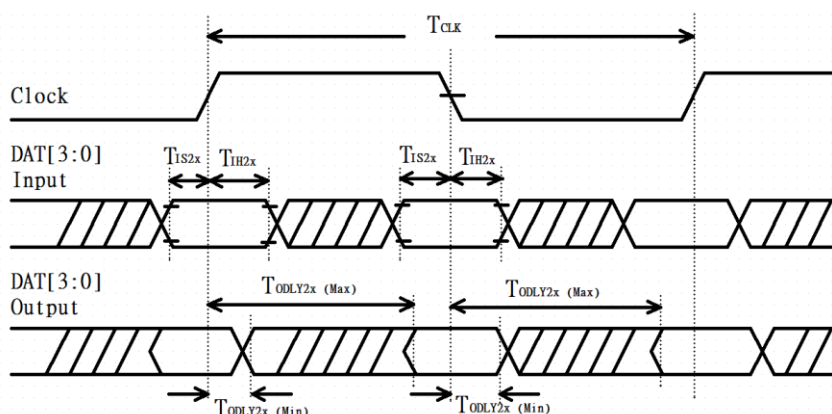


Figure 7: SDIO DAT[3:0] timing Diagram--- DDR50 modes (50 MHz) (1.8V)

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

Table 23: SDIO timing requirements – DDR50 modes (50 MHz)

| 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>C <sub>CARD</sub> = 10pF | DDR50     | --   | --   | 0.2 * T <sub>CLK</sub> | ns   |
| Clock Duty                                  | --                                                                                                             | DDR50     | 45   | --   | 55                     | %    |
| CMD Input (referenced to clock rising edge) |                                                                                                                |           |      |      |                        |      |
| T <sub>IS</sub>                             | Input setup time<br>C <sub>CARD</sub> ≤ 10pF (1 card)                                                          | DDR50     | 6    | --   | --                     | ns   |

| Symbol                                                         | Parameter                                                                      | Condition | Min. | Typ. | Max. | Unit |
|----------------------------------------------------------------|--------------------------------------------------------------------------------|-----------|------|------|------|------|
| $T_{IH}$                                                       | 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)       |                                                                                |           |      |      |      |      |
| $T_{ODLY}$                                                     | Output delay time during data transfer mode<br>$C_L \leq 30\text{pF}$ (1 card) | DDR50     | --   | --   | 13.7 | ns   |
| $T_{OHL D}$                                                    | 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)  |                                                                                |           |      |      |      |      |
| $T_{IS2X}$                                                     | Input setup time<br>$C_{CARD} \leq 10\text{pF}$ (1 card)                       | DDR50     | 3    | --   | --   | ns   |
| $T_{IH2X}$                                                     | 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) |                                                                                |           |      |      |      |      |
| $T_{ODLY2X} \text{ (max)}$                                     | Output delay time during data transfer mode<br>$C_L \leq 25\text{pF}$ (1 card) | DDR50     | --   | --   | 7.0  | ns   |
| $T_{ODLY2X} \text{ (min)}$                                     | Output hold time<br>$C_L \geq 15\text{pF}$ (1 card))                           | DDR50     | 1.5  | --   | --   | ns   |

## 10.2 PCI Express Specifications

The PCI Express host interface pins are powered from the 1.8V generated by the PMU inside the 60-SIPT series.

### 10.2.1 Differential TX Output Electricals

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

Table 24: PCI Express TX Output Specifications – 2.5GT/s

| Symbol                  | Parameter                                                                                                                                                     | Min.   | Typ. | Max.   | Unit |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------|--------|------|
| UI                      | Unit interval (UI)<br>The specified UI is equivalent to a tolerance of +/- 300ppm for each Refclk source. Period does not account for SSC induced variations. | 399.88 | -    | 400.12 | Ps   |
| $V_{TX-DIFF-PP}$        | Differential peak-to-peak TX voltage swing<br>$V_{TX-DIFF-PP} = 2 *  V_{TXD+} - V_{TXD-} $                                                                    | 0.8    | -    | 1.2    | V    |
| $V_{TX-DIFF-PP-LOW}$    | Low power differential peak-to-peak TX voltage swing<br>$V_{TX-DIFF-PP} = 2 *  V_{TXD+} - V_{TXD-} $                                                          | 0.4    | -    | 1.2    | V    |
| $V_{TX-DE-RATIO-3.5dB}$ | Tx de-emphasis level ratio (3.5dB)                                                                                                                            | 3.0    | -    | 4.0    | V    |
| $T_{TX-EYE}$            | Tx eye including all jitter sources                                                                                                                           | 0.75   | -    | -      | UI   |

| Symbol                       | Parameter                                                                                          | Min.  | Typ. | Max.  | Unit |
|------------------------------|----------------------------------------------------------------------------------------------------|-------|------|-------|------|
| TTX-EYE-MEDIAN-to-MAX-JITTER | Maximum time between jitter median and maximum deviation from median                               | -     | -    | 0.125 | UI   |
| TTX-RISE-FALL                | Tx rise/fall time<br>Measured differentially from 20% to 80%                                       | 0.125 | -    | -     | UI   |
| RLTX-DIFF                    | Tx package plus Si differential return loss                                                        | 10    | -    | -     | dB   |
| RLTX-CM                      | Tx package plus Si common mode return loss                                                         | 6     | -    | -     | dB   |
| VTX-CM-AC-P                  | Tx AC common mode voltage                                                                          | -     | 20   | -     | mV   |
| ITX-SHORT                    | Tx short circuit current limit                                                                     | -     | -    | 90    | mA   |
| VTX-DC-CM                    | Tx DC common mode voltage                                                                          | -     | -    | 3.6   | V    |
| VTX-CM-DC-ACTIVE-IDLE-DELTA  | Absolute delta of DC common mode voltage during L0 and electrical idle.                            | 0     | -    | 100   | mV   |
| VTX-IDLE-DIFF-AC-p           | Electrical idle differential peak output voltage                                                   | 0     | -    | 20    | mV   |
| TTX-IDLE-MIN                 | Minimum time spent in electrical idle                                                              | 20    | -    | -     | ns   |
| TTX-IDLE-SET-TO-IDLE         | Maximum time to transition to a valid electrical idle after sending an electrical idle ordered set | -     | -    | 8     | ns   |
| TTX-IDLE-TO-DIFF-DATA        | Maximum time to transition to valid diff signalling after leaving electrical idle                  | -     | -    | 8     | ns   |
| TCROSLINK                    | Crosslink random timeout                                                                           | -     | -    | 1.0   | ms   |
| CTX                          | AC coupling capacitor                                                                              | 75    | -    | 200   | nF   |

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

**Table 25: PCI Express TX Output Specifications - 5GT/s**

| Symbol             | Parameter                                                                                                                                                     | Min.   | Typ. | Max.   | Unit |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------|--------|------|
| UI                 | Unit interval (UI)<br>The specified UI is equivalent to a tolerance of +/- 300ppm for each Refclk source. Period does not account for SSC induced variations. | 199.94 | -    | 200.06 | Ps   |
| VTX-DIFF-PP        | Differential peak-to-peak TX voltage swing<br>$V_{TX-DIFF-PP}=2* V_{TXD+} - V_{TXD-} $                                                                        | 0.8    | -    | 1.2    | V    |
| VTX-DIFF-PP-LOW    | Low power differential peak-to-peak TX voltage swing<br>$V_{TX-DIFF-PP}=2* V_{TXD+} - V_{TXD-} $                                                              | 0.4    | -    | 1.2    | V    |
| VTX-DE-RATIO-3.5dB | Tx de-emphasis level ratio (3.5dB)                                                                                                                            | 3.0    | -    | 4.0    | V    |
| VTX-DE-RATIO-6dB   | Tx de-emphasis level ratio (6dB)                                                                                                                              | 5.5    | -    | 6.5    | V    |
| TMIN-PULSE         | Instantaneous lone pulse width<br>Measured relative to rising/failing pulse                                                                                   | 0.9    | -    | -      | UI   |
| TTX-EYE            | Tx eye including all jitter sources                                                                                                                           | 0.75   | -    | -      | UI   |
| TTX-HF-DJ-DD       | Tx deterministic jitter > 1.5MHz<br>Deterministic jitter only                                                                                                 | -      | -    | 0.15   | UI   |

| Symbol                                  | Parameter                                                                                                                      | Min.    | Typ. | Max. | Unit   |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|---------|------|------|--------|
| T <sub>TX-LF-RMS</sub>                  | Tx RMS jitter<1.5MHz<br>Total energy measured over a 10KHz-1.5MHz range                                                        | -       | 3.0  | -    | Ps RMS |
| T <sub>TX-RISE-FALL</sub>               | Tx rise/fall time<br>Measured differentially from 20% to 80%                                                                   | 0.15    | -    | -    | UI     |
| R <sub>LTX-DIFF</sub>                   | Tx package plus Si differential return loss<br>(0.05-1.25GHz)<br>(1.25-2.5GHz)                                                 | 10<br>8 | -    | -    | dB     |
| R <sub>LTX-CM</sub>                     | Tx package plus Si common mode return loss                                                                                     | 6       | -    | -    | dB     |
| V <sub>TX-CM-AC-PP</sub>                | Tx AC common mode voltage                                                                                                      | -       | -    | 100  | mV     |
| I <sub>TX-SHORT</sub>                   | Tx short circuit current limit                                                                                                 | -       | -    | 90   | mA     |
| V <sub>TX-DC-CM</sub>                   | Tx DC common mode voltage                                                                                                      | -       | -    | 3.6  | V      |
| V <sub>TX-CM-DC-ACTIVE-IDLE-DELTA</sub> | Absolute delta of DC common mode voltage during L0 and electrical idle.                                                        | 0       | -    | 100  | mV     |
| V <sub>TX-IDLE-DIFF-AC-p</sub>          | Electrical idle differential peak output voltage<br>$V_{TX-IDLE-DIFF-DC} =  V_{TX-IDLE-D+} - V_{TX-IDLE-D-}  \leq 20\text{mV}$ | 0       | -    | 20   | mV     |
| V <sub>TX-IDLE-DIFF-DC</sub>            | DC Electrical idle differential output voltage<br>$V_{TX-IDLE-DIFF-DC} =  V_{TX-IDLE-D+} - V_{TX-IDLE-D-}  \leq 5\text{mV}$    | 0       | -    | 5    | mV     |
| V <sub>TX-RCVDTECT</sub>                | Voltage change allowed during receiver detection                                                                               | 0       | -    | 600  | mV     |
| T <sub>TX-IDLE-MIN</sub>                | Minimum time spent in electrical idle                                                                                          | 20      | -    | -    | ns     |
| T <sub>TX-IDLE-SET-TO-IDLE</sub>        | Maximum time to transition to a valid electrical idle after sending an electrical idle ordered set                             | -       | -    | 8    | ns     |
| T <sub>TX-IDLE-TO-DIFF-DATA</sub>       | Maximum time to transition to valid diff signalling after leaving electrical idle                                              | -       | -    | 8    | ns     |
| T <sub>CROSLINK</sub>                   | Crosslink random timeout                                                                                                       | -       | -    | 1.0  | ms     |
| C <sub>TX</sub>                         | AC coupling capacitor                                                                                                          | 75      | -    | 200  | nF     |

### 10.2.2 Differential RX input Electricals

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

**Table 26: PCI Express RX Output Specifications – 2.5GT/s**

| Symbol                     | Parameter                                                                                                                                                     | Min.   | Typ. | Max.   | Unit |
|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------|--------|------|
| UI                         | Unit interval (UI)<br>The specified UI is equivalent to a tolerance of +/- 300ppm for each Refclk source. Period does not account for SSC induced variations. | 399.88 | -    | 400.12 | Ps   |
| V <sub>RX-DIFF-PP-CC</sub> | Differential RX peak-to-peak voltage for common Refclk RX architecture                                                                                        | 0.175  | -    | 1.2    | V    |
| V <sub>RX-DIFF-PP-DC</sub> | Differential RX peak-to-peak voltage for data clocked Refclk RX architecture                                                                                  | 0.175  | -    | 1.2    | V    |

| Symbol                       | Parameter                                                                    | Min. | Typ. | Max. | Unit       |
|------------------------------|------------------------------------------------------------------------------|------|------|------|------------|
| TRX-EYE                      | Rx eye time opening<br>Minimum eye time at Rx pins to yield a $10^{-12}$ BER | 0.4  | -    | -    | UI         |
| TRX-EYE-MEDIAN-to-MAX-JITTER | Maximum time delta between median and deviation from median                  | -    | -    | 0.3  | UI         |
| VRX-CM-ACp                   | AC peak common mode input voltage                                            | -    | -    | 150  | mV         |
| RLRX-DIFF                    | Differential return loss                                                     | 15   | -    | -    | dB         |
| RLRX-CM                      | Common mode return loss                                                      | 0    | -    | 3.6  | dB         |
| ZRX-DIFF-DC                  | DC differential input impedance                                              | 80   | 100  | 120  | $\Omega$   |
| ZRX-DC                       | DC input impedance                                                           | 40   | 50   | 60   | $\Omega$   |
| ZRX-HIGH-IMP-DC              | Powered down DC input impedance                                              | 200  | -    | -    | K $\Omega$ |
| VRX-IDLE-DET-DIFF-p-p        | Electrical idle detect threshold                                             | 65   | -    | 175  | mV         |
| TRX-IDLE-DIFF-ENTERTIME      | Unexpected electrical idle enter detect threshold integration time           | -    | -    | 10   | ms         |
| LRX-SKEW                     | Total Skew                                                                   | -    | -    | 20   | ns         |

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

**Table 27: PCI Express RX Output Specifications – 5GT/s**

| Symbol         | Parameter                                                                                                                                                     | Min.   | Typ. | Max.   | Unit     |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------|--------|----------|
| UI             | Unit interval (UI)<br>The specified UI is equivalent to a tolerance of +/- 300ppm for each Refclk source. Period does not account for SSC induced variations. | 199.94 | -    | 200.06 | ps       |
| VRX-DIFF-PP-CC | Differential RX peak-to-peak voltage for common Refclk RX architecture                                                                                        | 0.12   | -    | 1.2    | V        |
| VRX-DIFF-PP-DC | Differential RX peak-to-peak voltage for data clocked Refclk RX architecture                                                                                  | 0.1    | -    | 1.2    | V        |
| TRX-TJ-CC      | Maximum Rx inherent total timing error for common Refclk RX architecture                                                                                      | -      | -    | 0.4    | UI       |
| TRX-TJ-DC      | Maximum Rx inherent total timing error for data clocked RX architecture                                                                                       | -      | -    | 0.34   | UI       |
| TRX-DJ-DD-CC   | Maximum Rx inherent deterministic timing error for common Refclk RX architecture                                                                              | -      | -    | 0.3    | UI       |
| TRX-DJ-DD-DC   | Maximum Rx inherent deterministic timing error for data clocked RX architecture                                                                               | -      | -    | 0.24   | UI       |
| TRX-MIN-PULSE  | Minimum width pulse at Rx                                                                                                                                     | 0.6    | -    | -      | UI       |
| VRX-CM-ACp     | AC peak common mode input voltage                                                                                                                             | -      | -    | 150    | mV       |
| RLRX-DIFF      | Differential return loss                                                                                                                                      | 15     | -    | -      | dB       |
| RLRX-CM        | Common mode return loss                                                                                                                                       | 1-     | -    | 3.6    | dB       |
| ZRX-DIFF-DC    | DC differential input impedance                                                                                                                               | 80     | 100  | 120    | $\Omega$ |
| ZRX-DC         | DC input impedance                                                                                                                                            | 40     | 50   | 60     | $\Omega$ |

| Symbol                  | Parameter                                                          | Min. | Typ. | Max. | Unit |
|-------------------------|--------------------------------------------------------------------|------|------|------|------|
| ZRX-HIGH-IMP-DC         | Powered down DC input impedance                                    | 200  | -    | -    | KΩ   |
| VRX-IDLE-DET-DIFF-p-p   | Electrical idle detect threshold                                   | 65   | -    | 175  | mV   |
| TRX-IDLE-DIFF-ENTERTIME | Unexpected electrical idle enter detect threshold integration time | -    | -    | 10   | ms   |
| LRX-SKEW                | Total Skew                                                         | -    | -    | 20   | ns   |

## 10.3 USB Specifications

### 10.3.1 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 28: 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<br>Defined from 10% to 90% for raise time and 90% to 10% for fall time                                                                                                          | 75.0   | -    | 300.0 | ns   |
| TLF                            | Data rise 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> |                                                                                                                                                                                                |        |      |       |      |

|                 |                                |     |   |     |   |
|-----------------|--------------------------------|-----|---|-----|---|
| V <sub>IH</sub> | Input signal ended high        | 2.0 | - | -   | V |
| V <sub>IL</sub> | Input signal ended low         | -   | - | 0.8 | V |
| V <sub>DI</sub> | Differential input sensitivity | 0.2 | - | -   | V |

### 10.3.2 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 29: 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>   |                                                                                                                                                                                                |       |      |      |      |
| V <sub>OH</sub>                | Output signal ended high<br>Defined with 1.425KΩ pull-up resistor to 3.6V                                                                                                                      | 2.8   | -    | 3.6  | V    |
| V <sub>OL</sub>                | Output signal ended low<br>Defined with 1.425KΩ pull-up resistor to ground                                                                                                                     | 0.0   | -    | 0.3  | V    |
| V <sub>CRS</sub>               | Output signal crossover voltage                                                                                                                                                                | 1.3   |      | 2.0  | V    |
| T <sub>FR</sub>                | Output raise time<br>Defined from 10% to 90% for raise time and 90% to 10% for fall time                                                                                                       | -4.0  | -    | 20.0 | ns   |
| T <sub>FL</sub>                | Output fall time<br>Defined from 10% to 90% for raise time and 90% to 10% for fall time                                                                                                        | -4.0  | -    | 20.0 | ns   |
| T <sub>DJ1</sub>               | 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   |
| T <sub>DJ2</sub>               | 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   |
| T <sub>FDEOP</sub>             | Source jitter for differential transition to SE0 transition. Defined at crossover point of differential signals                                                                                | -2.0  | -    | 5.0  | ns   |
| <b>Receiver Specifications</b> |                                                                                                                                                                                                |       |      |      |      |
| V <sub>IH</sub>                | Input signal ended high                                                                                                                                                                        | 2.0   | -    | -    | V    |
| V <sub>IL</sub>                | Input signal ended low                                                                                                                                                                         | -     | -    | 0.8  | V    |
| V <sub>DI</sub>                | Differential input sensitivity                                                                                                                                                                 | 0.2   | -    | -    | V    |
| T <sub>JR1</sub>               | Receiver jitter: to next transition                                                                                                                                                            | -18.5 | -    | 18.5 | ns   |

| Symbol | Parameter                                                                                          | Min. | Typ. | Max. | Unit |
|--------|----------------------------------------------------------------------------------------------------|------|------|------|------|
|        | Defined at crossover point of differential data signals                                            |      |      |      |      |
| TJR2   | Receiver jitter: for paired transitions<br>Defined at crossover point of differential data signals | -9.0 | -    | 9.0  | ns   |

### 10.3.3 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 30: USB HS Driver and Receiver Specifications**

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



## 10.4 PCM Interface Specifications

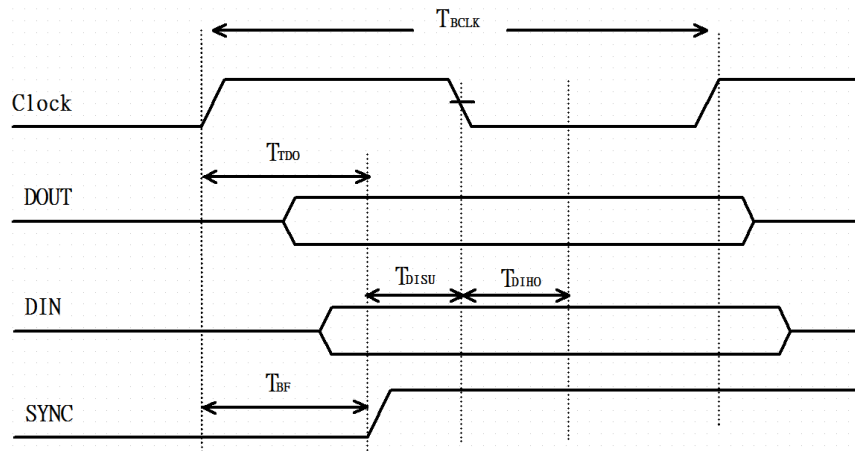


Figure 8: PCM Timing Specification – Master Mode

Table 31: PCM Timing Specification – Master Mode

| Symbol                      | Parameter | Min. | Typ.    | Max. | Unit |
|-----------------------------|-----------|------|---------|------|------|
| FBCLK                       | -         | -    | 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   |

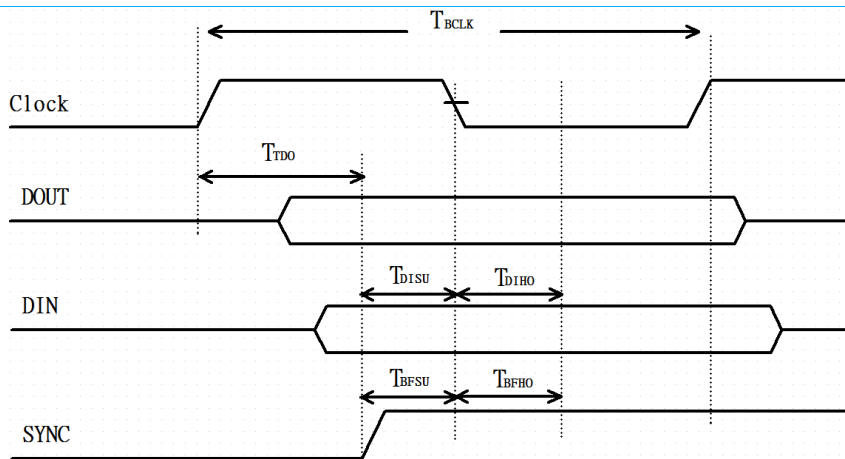


Figure 9: PCM Timing Specification – Slave Mode

Table 32: PCM Timing Specification – Slave Mode

| Symbol                      | Parameter | Min. | Typ.    | Max. | Unit |
|-----------------------------|-----------|------|---------|------|------|
| FBCLK                       | -         | -    | 2/2.048 | -    | MHz  |
| Duty Cycle <sub>BCLK</sub>  | -         | 0.4  | 0.5     | 0.6  | -    |
| T <sub>BCLK</sub> rise/fall | -         | -    | 3       | -    | ns   |

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

## 11 PIN DEFINITIONS

**Note:** AVDD18 is generated by PMU internally. No need to power from outside the SIP.

Table 33: Pin definitions of 60-SIPT series

| Pin # | Name              | Type  | Voltage Ref. | Description                                                                                                                                                                                                                                             | If Not Used |
|-------|-------------------|-------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| 1     | PDn               | I     | -            | Full Power-Down (input) (Active low)<br>0=full power-down mode; 1=normal mode<br>PDn can accept an input range from 1.8V to 3.6V<br><b>PDn must be high for normal operation. Please connect to pin-32 (1.8V_OUT) through 49.9KΩ.</b>                   | --          |
| 2     | GND               | -     | -            | Ground                                                                                                                                                                                                                                                  | GND         |
| 3     | GND               | -     | -            | Ground                                                                                                                                                                                                                                                  | GND         |
| 4     | ANT0 (Wi-Fi/BT)   | A,I/O | -            | RF Transmit/Receive<br>Wi-Fi and BT share the same path.                                                                                                                                                                                                | 50Ω Load    |
| 5     | GND               | -     | -            | Ground                                                                                                                                                                                                                                                  | GND         |
| 6     | GND               | -     | -            | Ground                                                                                                                                                                                                                                                  | GND         |
| 7     | GND               | -     | -            | Ground                                                                                                                                                                                                                                                  | GND         |
| 8     | GND               | -     | -            | Ground                                                                                                                                                                                                                                                  | GND         |
| 9     | GND               | -     | -            | Ground                                                                                                                                                                                                                                                  | GND         |
| 10    | GND               | -     | -            | Ground                                                                                                                                                                                                                                                  | GND         |
| 11    | GND               | -     | -            | Ground                                                                                                                                                                                                                                                  | GND         |
| 12    | ANT1 (Wi-Fi only) | A,I/O | -            | RF Transmit/Receive<br>Wi-Fi only                                                                                                                                                                                                                       | 50Ω Load    |
| 13    | GND               | -     | -            | Ground                                                                                                                                                                                                                                                  | GND         |
| 14    | GND               | -     | -            | Ground                                                                                                                                                                                                                                                  | GND         |
| 15    | CONFIG_HOST2      | I, PU | AVDD18       | Host interface configuration setting.<br>Detail configuration table are shown in Table 32<br>To set a configuration bit to "0", attach a 100kΩ resistor from the pin to ground.<br>No external circuitry is required to set a configuration bit to "1". | -           |

| Pin # | Name                  | Type           | Voltage Ref. | Description                                                                                                                                                                                                                                             | If Not Used |
|-------|-----------------------|----------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| 16    | CONFIG_HOST1          | I, PU          | AVDD18       | Host interface configuration setting.<br>Detail configuration table are shown in Table 32<br>To set a configuration bit to “0”, attach a 100kΩ resistor from the pin to ground.<br>No external circuitry is required to set a configuration bit to “1”. | -           |
| 17    | CONFIG_HOST0          | I, PU          | AVDD18       | Host interface configuration setting.<br>Detail configuration table are shown in Table 32<br>To set a configuration bit to “0”, attach a 100kΩ resistor from the pin to ground.<br>No external circuitry is required to set a configuration bit to “1”. | -           |
| 18    | GND                   | -              | -            | Ground                                                                                                                                                                                                                                                  | GND         |
| 19    | PCM_CLK               | I/O            | VIO          | PCM Clock Signal (Optimal)<br>Optimal clock used for some codecs.<br>Output if Master mode; Input if Slave mode.                                                                                                                                        | N/C         |
| 20    | PCM_DOUT              | O              | VIO          | PCM Data                                                                                                                                                                                                                                                | N/C         |
| 21    | PCM_SYNC              | I/O            | VIO          | PCM Sync Pulse Signal<br>Output if Master mode; Input if Slave mode.                                                                                                                                                                                    | N/C         |
| 22    | PCM_DIN               | I              | VIO          | PCM Data                                                                                                                                                                                                                                                | N/C         |
| 23    | GPIO0                 | I/O            | VIO          | General purpose I/O pin.<br>Reserved for WoW (Wake on WLAN) feature.                                                                                                                                                                                    | N/C         |
| 24    | GND                   | -              | -            | Ground                                                                                                                                                                                                                                                  | GND         |
| 25    | PCIE_WAKEn            | I/O            | VIO          | PCIE wake signal (input/output) (active low)                                                                                                                                                                                                            | N/C         |
| 26    | PCIE_CLKREQn          | I/O            | VIO          | PCIE clock request (input/output) (active low)                                                                                                                                                                                                          | GND         |
| 27    | PCIE_PERSTn           | I, PD          | VIO          | PCIE host indication to reset the device (input) (active low)                                                                                                                                                                                           | N/C         |
| 28    | PCIE_W_DISABLEn       | I, PU          | VIO          | PCIE host indication to disable the WLAN function of the device (input) (active low)                                                                                                                                                                    | N/C         |
| 29    | LTE_SOUT/<br>JTAG_TDO | O, PD<br>O, PD | VIO          | Serial data to external LTE device/<br>JTAG Test Data Out (TDO)                                                                                                                                                                                         | N/C         |
| 30    | LTE_SIN/<br>JTAG_TDI  | I, PD<br>I, PD | VIO          | Serial data from external LTE device/<br>JTAG Test Data Input (TDI)                                                                                                                                                                                     | N/C         |
| 31    | VIO                   | Power          | -            | 1.8V/2.5V/3.3V Digital I/O Power Supply                                                                                                                                                                                                                 | -           |
| 32    | 1.8V_OUT              | Power          | -            | 1.8V output from 60-SIPT series.<br>Used to pull-up the PDn pin for POR.<br>Note:<br>Do NOT used as power source for other circuits.                                                                                                                    | N/C         |
| 33    | GND                   | -              | -            | Ground                                                                                                                                                                                                                                                  | GND         |
| 34    | 32KHz                 | I, PU          | VIO          | Sleep Clock Input<br>An external sleep clock of 32.768KHz with minimum +/-250ppm is required for power saving mode                                                                                                                                      | -           |

| Pin # | Name        | Type    | Voltage Ref. | Description                                                                                                                                                                                                   | If Not Used |
|-------|-------------|---------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
| 35    | GND         | -       | -            | Ground                                                                                                                                                                                                        | GND         |
| 36    | PCIE_RCLK_N | I       | AVDD18       | PCIE Differential Clock Input-Negative                                                                                                                                                                        | N/C         |
| 37    | PCIE_RCLK_P | I       | AVDD18       | PCIE Differential Clock Input-Positive                                                                                                                                                                        | N/C         |
| 38    | GND         | -       | -            | Ground                                                                                                                                                                                                        | GND         |
| 39    | PCIE_TX_P   | O       | AVDD18       | PCIE Transmit Data-Positive                                                                                                                                                                                   | N/C         |
| 40    | PCIE_TX_N   | O       | AVDD18       | PCIE Transmit Data-Negative                                                                                                                                                                                   | N/C         |
| 41    | GND         | -       | -            | Ground                                                                                                                                                                                                        | GND         |
| 42    | PCIE_RX_N   | I       | AVDD18       | PCIE Receive Data-Negative                                                                                                                                                                                    | N/C         |
| 43    | PCIE_RX_P   | I       | AVDD18       | PCIE Receive Data-Positive                                                                                                                                                                                    | N/C         |
| 44    | GND         | -       | -            | Ground                                                                                                                                                                                                        | GND         |
| 45    | USB_DN      | I/O     | 3V3          | USB Differential Data-Negative                                                                                                                                                                                | N/C         |
| 46    | USB_DP      | I/O     | 3V3          | USB Differential Data-Positive                                                                                                                                                                                | N/C         |
| 47    | GND         | -       | -            | Ground                                                                                                                                                                                                        | GND         |
| 48    | 3V3         | Power   | -            | 3.3V module power supply<br><b>Note:</b> A 10u MLCC is needed for this pin. Place the capacitor close to this pin as possible.<br>Ref. parts: GRM188R60J106ME47D (MURATA)<br>or CC0805KKX7R6BB106 (YAGO)      | -           |
| 49    | 3V3         | Power   | -            | 3.3V module power supply<br><b>Note:</b> A 10u MLCC is needed for this pin. Place the capacitor close to this pin as possible.<br>Ref. parts: GRM188R60J106ME47D (MURATA)<br>or CC0805KKX7R6BB106 (YAGO)      | -           |
| 50    | GND         | -       | -            | Ground                                                                                                                                                                                                        | GND         |
| 51    | PMU_EN      | I       |              | Enable input for all Regulators inside the 60-SIPT series when it is "H" state. The 60-SIPT will be off when it is "L" state.<br>Note: DO NOT float this pin. Pull-up to 3.3V with 100K for normal operation. | 100K, PU    |
| 52    | VIO_SD      | Power   | -            | 1.8V/3.3V Digital I/O SDIO Power Supply                                                                                                                                                                       | -           |
| 53    | SDIO_DATA0  | I/O, PU | VIO_SD       | SDIO 4-bit Mode DATA line Bit[0]                                                                                                                                                                              | N/C         |
| 54    | SDIO_DATA1  | I/O, PU | VIO_SD       | SDIO 4-bit Mode DATA line Bit[1]                                                                                                                                                                              | N/C         |
| 55    | SDIO_DATA2  | I/O, PU | VIO_SD       | SDIO 4-bit Mode DATA line Bit[2]                                                                                                                                                                              | N/C         |
| 56    | SDIO_DATA3  | I/O, PU | VIO_SD       | SDIO 4-bit Mode DATA line Bit[3]                                                                                                                                                                              | N/C         |
| 57    | SDIO_CMD    | I/O, PU | VIO_SD       | SDIO 4-bit Mode Command/Response                                                                                                                                                                              | N/C         |
| 58    | SDIO_CLK    | I, PU   | VIO_SD       | SDIO 4-bit Mode Clock Input                                                                                                                                                                                   | N/C         |
| 59    | GND         | -       | -            | Ground                                                                                                                                                                                                        | GND         |
| 60    | UART_TXD    | O, WPU  | VIO          | UART Serial Data Output                                                                                                                                                                                       | N/C         |
| 61    | UART_RXD    | I, WPU  | VIO          | UART Serial Data Input                                                                                                                                                                                        | N/C         |
| 62    | UART_CTSn   | I, PU   | VIO          | UART Clear to Send (Active low)                                                                                                                                                                               | N/C         |

| Pin # | Name         | Type   | Voltage Ref. | Description                                                                                                           | If Not Used |
|-------|--------------|--------|--------------|-----------------------------------------------------------------------------------------------------------------------|-------------|
| 63    | UART_RTSn    | O, WPU | VIO          | UART Request to Send (Active low)                                                                                     | N/C         |
| 64    | GND          | -      | -            | Ground                                                                                                                | GND         |
| 65    | JTAG_TCK     | I, PU  | VIO          | JTAG Test Clock (input)                                                                                               | N/C         |
| 66    | JTAG_TMS     | I, PU  | VIO          | JTAG Test Controller Select (input)                                                                                   | N/C         |
| 67    | LED_OUT_BT   | O, PU  | VIO          | LED indicator for BT with 10 mA drive capability. Reserved for BT wake up Host feature.                               | N/C         |
| 68    | LED_OUT_WLAN | O, PU  | VIO          | LED indicator for WLAN with 10mA drive capability                                                                     | N/C         |
| 69-84 | GND          | -      | -            | Thermal Ground Pad<br><b>(Important for RF performance and thermal dissipation; please flow the reference design)</b> | GND         |

## 12 HOST CONFIGURATION OPTIONS

60-SIPT series support various host configurations for WLAN and BT. Its detail configurations are shown in following table ([Error! Reference source not found.](#)).

**Table 34: Wi-Fi host interface configuration table**

| CONFIG_HOST [2-0] | WLAN    | BT/BLE  | Note                                         |
|-------------------|---------|---------|----------------------------------------------|
| 000               | SDIO    | UART    | -                                            |
| 001               | SDIO    | SDIO    | -                                            |
| 010               | PCIe    | USB 2.0 | Initial USB 2.0 PHY and COM PHY PCIe portion |
| 011               | PCIe    | UART    | Initial only COM PHY PCIe portion            |
| 100               | USB 2.0 | UART    | Initial USB 2.0 PHY                          |
| 101               | USB 2.0 | USB 2.0 | Initial only USB 2.0 PHY                     |

Module dimensions of 60-SIPT series is 13 x 14 x 1.87 mm. Detail drawings are shown in [Figure 10](#).



**Note:** The Wi-Fi MAC address is located on the product label. The BT MAC address always immediately follows the Wi-Fi MAC address. Therefore, the BT MAC address is the Wi-Fi MAC address plus one.

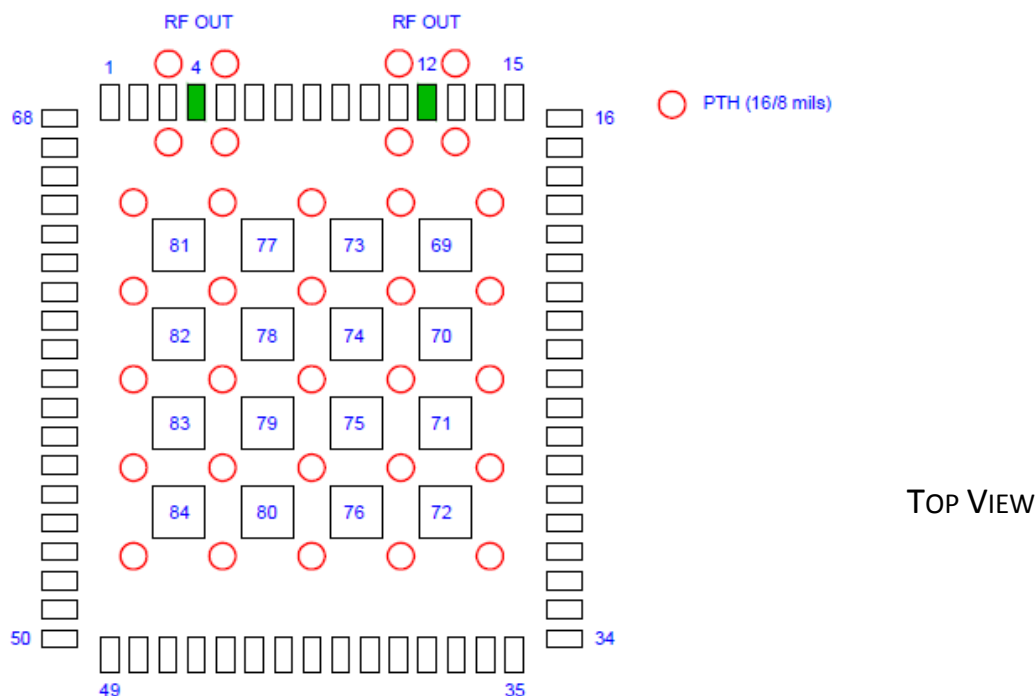


Figure 12: Recommended ground via

Recommend minimal via size and placement for grounding and thermal dissipation. Please double the ground via number when using laser via on HID process. More ground via and the use of 1-oz copper is recommended in our design to get better thermal dissipation.

**Note:** When soldering, the stencil thickness should be  $\geq 0.1$  mm.

## 14 RF LAYOUT DESIGN GUIDELINES

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

- Do not run antenna cables directly above or directly below the radio.
- Do not place any parts or run any high speed digital lines below the radio.
- If there are other radios or transmitters located on the device (such as a *Bluetooth* radio), place the devices as far apart from each other as possible. Also, make sure there is at least 25 dB isolation between these two antennas.
- Ensure that there is the maximum allowable spacing separating the antenna connectors on the Laird 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 a 10uF capacitor on EACH 3.3V power pin. Also, place that capacitor to the pin as close as possible to make sure the internal PMU working correctly.
- Use proper electro-static-discharge (ESD) procedures when installing the Laird radio module.
- To get maximum throughput when operate at MIMO 2x2, two antennas with at least 25 dB isolation is recommended.

- To avoid negatively impacting Tx power and receiver sensitivity, do not cover the antennas with metallic objects or components.

## 15 RECOMMENDED STORAGE, HANDLING, BAKING, AND REFLOW PROFILE

### 15.1 Required Storage Conditions

#### 15.1.1 Prior to Opening the Dry Packing

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

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

---

**Note:** Humidity means Relative Humidity.

---

#### 15.1.2 After Opening the Dry Packing

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

- Storage conditions for one-time soldering:
  - Temperature: 5~25°C
  - Humidity: 60% or less
  - Period: 48 hours or less after opening
- Storage conditions for two-time soldering

Storage conditions following opening and prior to performing the 1<sup>st</sup> reflow:

- Temperature: 5~25°C
- Humidity: 60% or less
- Period: 48 hours or less after opening

Storage conditions following completion of the 1<sup>st</sup> reflow and prior to performing the 2<sup>nd</sup> reflow

- Temperature: 5~25°C
- Humidity: 60% or less
- Period: 48 hours or less after completion of the 1<sup>st</sup> reflow

#### 15.1.3 Temporary Storage Requirements after Opening

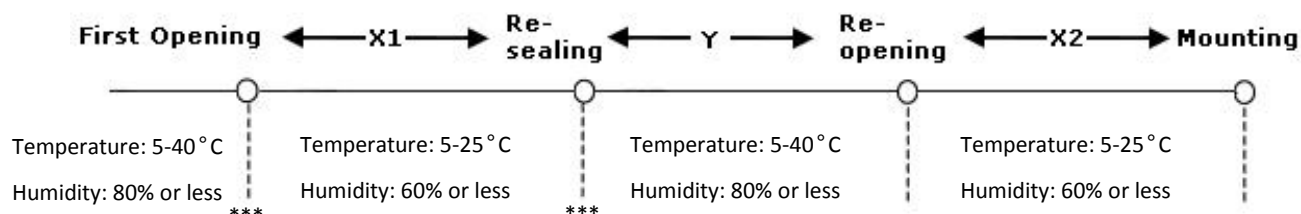
The following are temporary storage requirements after opening:

- Only re-store the devices *once* prior to soldering.
- Use a dry box or place desiccant (with a blue humidity indicator) with the devices and perform dry packing again using heat-sealing.



The following indicate the required storage period, temperature, and humidity for this temporary storage:

1. Storage temperature and humidity



2. Storage period

- X1+X2 – Refer to [After Opening the Dry Packing](#) storage requirements.
- Y – Two weeks or less.

## 15.2 Baking Conditions

Baking conditions and processes for the SSD50NBT follow the J-STD-033 standard which includes the following:

- The calculated shelf life in a sealed bag is 12 months at <40°C and <90% relative humidity.
- Once the packaging is opened, the SiP must be mounted (per MSL3/Moisture Sensitivity Level 3) within 168 hours at <30°C and <60% relative humidity.
- If the SiP is not mounted within 168 hours or if, when the packaging is opened, the humidity indicator card displays >10% humidity, then the product must be baked for 48 hours at 125°C (±5°C).

## 15.3 Surface Mount Conditions

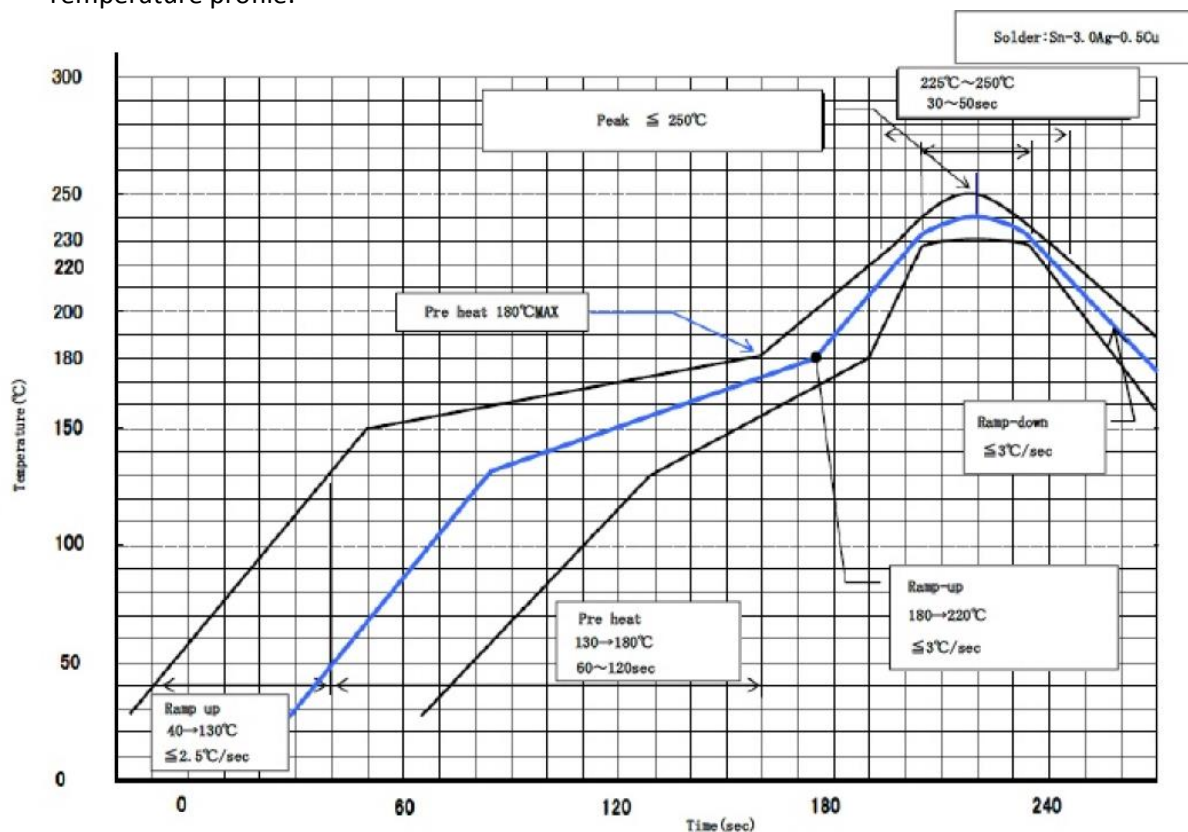
The following soldering conditions are recommended to ensure device quality.

### 15.3.1 Soldering

**Note:** When soldering, the stencil thickness should be  $\geq 0.1$  mm.

Convection reflow or IR/Convection reflow (one-time soldering or two-time soldering in air or nitrogen environment)

- Measuring point – IC package surface
- Temperature profile:



Ramp-up : 40 - 130 deg. Less than 2.5 deg./sec

Pre heat : 130 - 180 deg. 60 - 120 sec , 180 deg. MAX

Ramp-up : 180 - 220 deg. Less than 3 deg./sec

Peak Temperature : MAX 250 deg.

225 deg. ~ 250 deg. , 30 ~ 50 sec

Ramp-down : Less than 3 deg./sec

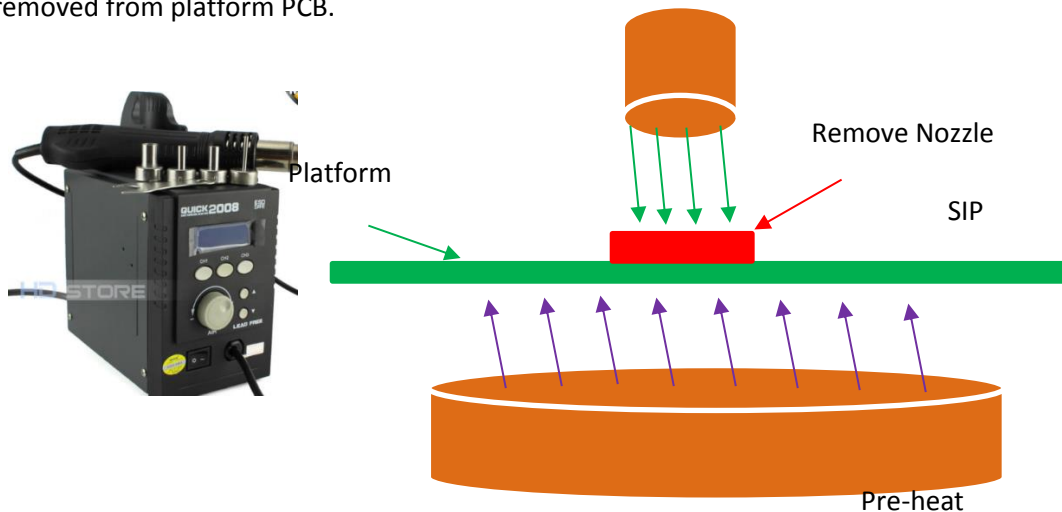
**Figure 13 Temperature profile**

### 15.3.2 Cautions When Removing the SIP from the Platform for RMA

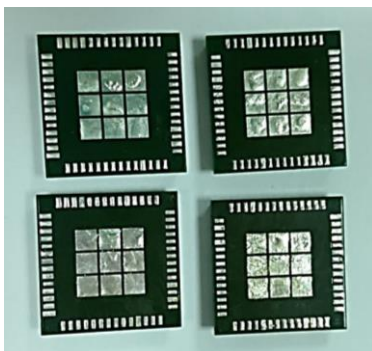
- Bake the platform before removing the SIP from the platform. Reference baking conditions.
- Remove the SIP by using a hot air gun. This process should be carried out by a skilled technician.

Suggestion conditions:

- One-side component platform:
  - Set the hot plate at 280 °C.
  - Put the platform on the hot plate for 8~10 seconds.
  - Remove the SIP from platform.
- Two-side components platform:
  - Use two hot air guns
  - On the bottom side, use a pre-heated nozzle (temperature setting of 200~250 °C) at a suitable distance from the platform PCB.
  - On the top side, apply a remove nozzle (temperature setting of 330 °C). Heat the SIP until it can be removed from platform PCB.

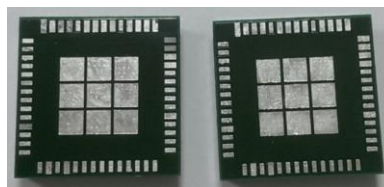


- Remove the residue solder under the bottom side of SIP.



(Not accepted for RMA)

*SIP with residue solder on the bottom*



(Accepted for RMA analysis)

*SIP without residue solder on the bottom*

- Remove and clean the residue flux is needed.

### 15.3.3 Precautions for Use

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

## 16 REGULATORY

### 16.1 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), 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 | 2.5dBi (2.390-2.490),3.5 dBi (4.900-5.100),3.5 dBi (5.150-5.350),3.5 dBi (5.70-5.900) |
| LSR/FlexPIFA 001-0016              | PIFA            | IPEX U.FL | 2.5dBi@2.4GHz, 3dBi@5GHz                                                              |
| LSR/001-0009                       | Dipole          | IPEX U.FL | 2dBi@2.4GHz, 2dBi@5GHz                                                                |

## 17 FCC AND IC REGULATORY

| Model          | US/FCC       | CANADA/IC      |
|----------------|--------------|----------------|
| 60-SIPT series | SQG-SU60SIPT | 3147A-SU60SIPT |

The 60-SIPT is designed to pass certification with the antenna listed below. The required antenna impedance is 50 ohms.

| Model                              | Type            | Connector | Peak gain (dBi) |               |               |               |              |
|------------------------------------|-----------------|-----------|-----------------|---------------|---------------|---------------|--------------|
|                                    |                 |           | 2400~2483.5 MHz | 5150~5250 MHz | 5250~5350 MHz | 5470~5725 MHz | 5725~5850MHz |
| 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         | 3.38dBi       |               |               |              |
| Ethertronics/WLAN_1000146          | Magnetic Dipole | IPEX U.FL | 2.5 dBi         | 3.5 dBi       |               |               |              |
| LSR/FlexPIFA 001-0016              | PIFA            | IPEX U.FL | 2.5dBi          | 3.0dBi        |               |               |              |
| LSR/001-0009                       | Dipole          | IPEX U.FL | 2.0dBi          | 2.0 dBi       |               |               |              |

## 17.1 FCC

### 17.1.1 Federal Communication Commission Interference Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in an 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 must 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.

If the three conditions above are met, further **transmitter** testing is not 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*

If 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 is responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

### 17.1.2 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 end product must be labeled in a visible area with the following: **Contains FCC ID: SQG-SSD50NBT.**

### 17.1.3 Manual Information to the End User

The OEM integrator must 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

### 17.2.1 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-SSD50NBT) 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-SSD50NBT) 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.

### 17.2.2 Antenna Information

| Model                | Type       | Connector | Peak gain (dBi) |               |               |               |              |
|----------------------|------------|-----------|-----------------|---------------|---------------|---------------|--------------|
|                      |            |           | 2400~2483.5 MHz | 5150~5250 MHz | 5250~5350 MHz | 5470~5725 MHz | 5725~5850MHz |
| Laird/NanoBlade-IP04 | PCB Dipole | IPEX U.FL | 2.0 dBi         | 3.9 dBi       | 3.9 dBi       | 4.0 dBi       |              |

| Model                              | Type            | Connector | Peak gain (dBi) |          |
|------------------------------------|-----------------|-----------|-----------------|----------|
| Laird/MAF95310 Mini NanoBlade Flex | PCB Dipole      | IPEX U.FL | 2.79 dBi        | 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 limitées 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.

If the condition above is met, further transmitter test is not 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:*

If 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 Importante:*

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

**End Product Labeling**

The end product must be labeled in a visible area with the following: **Contains IC: 3147A-SSD50NBT.**

**Plaque signalétique du produit final**

Le produit final doit être étiqueté dans un endroit visible avec l'inscription suivante: **Contient des IC: 3147A-SSD50NBT.**

**Manual Information to the End User**

The OEM integrator must 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 SU60-SIPT has been tested for compliance with relevant standards for the EU market. The SU60-SIPT module was tested with antennas listed below.

| 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), 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 | 2.5dBi (2.390-2.490), 3.5 dBi (4.900-5.100), 3.5 dBi (5.150-5.350), 3.5 dBi (5.70-5.900) |
| LSR/FlexPIFA 001-0016              | PIFA            | IPEX U.FL | 2.5dBi@2.4GHz, 3dBi@5GHz                                                                 |
| LSR/001-0009                       | Dipole          | IPEX U.FL | 2dBi@2.4GHz, 2dBi@5GHz                                                                   |

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-SIPT series                               |
| EU Directives: | 2014/53/EU – Radio Equipment Directive (RED) |

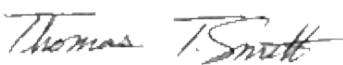
#### Reference standards used for presumption of conformity:

| 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 Directive 1999/5/EC, when used for its intended purpose.

|                 |                                                          |
|-----------------|----------------------------------------------------------|
| Place of Issue: | Laird<br>W66N220 Commerce Court, Cedarburg, WI 53012 USA |
|-----------------|----------------------------------------------------------|

|                                 |                                                                                   |
|---------------------------------|-----------------------------------------------------------------------------------|
|                                 | 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

|     |                          |
|-----|--------------------------|
| TBD | 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

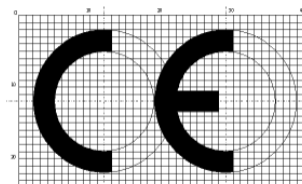
SW version: P95

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                                        |
|----------------------------|----------------------------------------------------|
| ST60-SIPT/SU60-SIPT series | 2X2 802.11 a/b/g/n/ac with BT4.2 dual mode 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</b><br><b>[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 1999/5/ES.                                                                   |
|  <b>Dansk</b><br><b>[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 1999/5/EF.                                           |
|  <b>Deutsch</b><br><b>[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 1999/5/EG befindet.          |
|  <b>Eesti</b><br><b>[Estonian]</b>  | Käesolevaga kinnitab <i>[tootja nimi = name of manufacturer]</i> seadme <i>[seadme tüüp = type of equipment]</i> vastavust direktiivi 1999/5/EÜ 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 1999/5/EC.                                         |
|  <b>Español</b><br><b>[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 1999/5/CE.            |

|                                                                                                                             |                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <b>Ελληνική</b><br><b>[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 1999/5/ΕΚ.                                            |
|  <b>Français</b><br><b>[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 1999/5/CE.                                 |
|  <b>Italiano</b><br><b>[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 1999/5/CE.                        |
| <b>Latviski</b><br><b>[Latvian]</b>                                                                                         | Aršo <i>[name of manufacturer /izgatavotājanosaukums]</i> deklarē, ka <i>[type of equipment / iekārtas tips]</i> atbilst Direktīvas 1999/5/EK būtiskajām prasībām un citiemar to saistītajiem noteikumiem.                          |
| <b>Lietuvių</b><br><b>[Lithuanian]</b>                                                                                      | Šiuo <i>[manufacturer name]</i> deklaruoja, kad šis <i>[equipment type]</i> atitinka esminius reikalavimus ir kitas 1999/5/EB Direktyvos nuostatas.                                                                                 |
|  <b>Nederlands</b><br><b>[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 1999/5/EG.                                 |
|  <b>Malti</b><br><b>[Maltese]</b>          | Hawnhekk, <i>[isem tal-manifattur]</i> , jiddikjara li dan <i>[il-mudel tal-prodott]</i> jikkonforma mal-htigijiet essenzjali u ma provvedimenti oħrajn rilevanti li hemm fid-Dirrettiva 1999/5/EC.                                 |
|  <b>Magyar</b><br><b>[Hungarian]</b>       | Alulírott, <i>[gyártó neve]</i> nyilatkozom, hogy a <i>[... típus]</i> megfelel a vonatkozó alapvető követelményeknek és az 1999/5/EC irányelv egyéb előírásainak.                                                                  |
|  <b>Polski</b><br><b>[Polish]</b>          | Niniejszym <i>[nazwa producenta]</i> oświadczam, że <i>[nazwa wyrobu]</i> jest zgodny z zasadniczymi wymogami oraz pozostałymi stosownymi postanowieniami Dyrektywy 1999/5/EC.                                                      |
|  <b>Português</b><br><b>[Portuguese]</b> | <i>[Nome do fabricante]</i> declara que este <i>[tipo de equipamento]</i> está conforme com os requisitos essenciais e outras disposições da Directiva 1999/5/CE.                                                                   |
|  <b>Slovensko</b><br><b>[Slovenian]</b>  | <i>[Ime proizvajalca]</i> izjavlja, da je ta <i>[tip opreme]</i> v skladu z bistvenimi zahtevami in ostalimi relevantnimi določili direktive 1999/5/ES.                                                                             |
| <b>Slovensky</b><br><b>[Slovak]</b>                                                                                         | <i>[Menovýrobcu]</i> týmto vyhlasuje, že <i>[typzariadenia]</i> spĺňa základné požiadavky a všetky príslušné ustanovenia Smernice 1999/5/ES.                                                                                        |
|  <b>Suomi</b><br><b>[Finnish]</b>        | <i>[Valmistaja = manufacturer]</i> vakuuttaa täten että <i>[type of equipment = laitteen tyyppimerkintä]</i> tyypinen laite on direktiivin 1999/5/EY oleellisten vaatimusten ja sitä koskevien direktiivin muiden ehtojen mukainen. |
|  <b>Svenska</b><br><b>[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 1999/5/EG.                                      |

## 20 BLUETOOTH SIG QUALIFICATION

### 20.1 Overview

The 60 Series module is listed on the Bluetooth SIG website as a qualified Controller Subsystem.

| Design Name | Owner | Declaration ID | Link to listing on the SIG website |
|-------------|-------|----------------|------------------------------------|
| SU60-SIPT   | Laird | D035149        | 60 Series Summit SIP               |
| ST60-SIPT   | Laird | D035149        | 60 Series Sterling SIP             |

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

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

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

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

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

[https://www.bluetooth.org/DocMan/handlers/DownloadDoc.ashx?doc\\_id=283698&vId=317486](https://www.bluetooth.org/DocMan/handlers/DownloadDoc.ashx?doc_id=283698&vId=317486)

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

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

1. To start a listing, go to: [https://www.bluetooth.org/tpg/QLI\\_SDoc.cfm](https://www.bluetooth.org/tpg/QLI_SDoc.cfm)

---

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

---

2. In step 1, select the option, New Listing and Reference a Qualified Design.
3. Enter 99404 in the Controller Subsystem table entry.
4. Enter your complimentary Host Subsystem and optional Profile Subsystem QDID in the table entry.
5. Select your pre-paid Declaration ID from the drop-down menu or go to the Purchase Declaration ID page.

---

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

---

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

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

For further information please refer to the following training material:

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

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

## 21 ADDITIONAL ASSISTANCE

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

Laird Technologies Connectivity Products Business Unit

Support Centre: <http://ews-support.lairdtech.com>

Email: [wireless.support@lairdtech.com](mailto:wireless.support@lairdtech.com)

Phone: Americas: +1-800-492-2320

Europe: +44-1628-858-940

Hong Kong: +852 2923 0610

Web: <http://www.lairdtech.com/wireless>

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