

# Datasheet

ST60-2230C-P/ST60-2230C-PU

*Version 2.2*

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## Revision History

Version	Date	Notes	Contributor(s)	Approver
1.0	06 Apr 2018	Initial version	Andrew Chen	Jay White
1.1	15 Jun 2018	Updated block diagram. Changed pin type and description to NC on pin 54	Kai Wei	Jay White
1.2	07 Nov 2018	Removed 802.11s reference		Jay White
1.3	14 Nov 2018	Fixed channels for KC		Andrew Chen
1.4	07 Feb 2019	Revised FCC and IC ID numbers	Tom Smith	Jay White
1.5	13 Feb 2019	Updated logos and URLs; corrected Korea ID #	Connie Linn	Sue White
1.6	17 Apr 2019	Removed DFS Radar Detection references		Jay White
1.7	23 July 2019	Corrected Table 20: Pin Definitions. Pin 76, 77 do not exist. Updated Peak Current consumption Corrected I/O Signalling Voltage	Kai Wei	Jay White
1.8	26 Sept 2019	Removed AoA/DoA references		Jay White
1.9	11 Oct 2019	Removed Android version numbers	Joe Conley	Jay White
1.10	14 Oct 2019	Removed advertising extension references... LE Advertising Length Extension Updated warranty information (one year vs. three)	Jonathan Kaye	Jay White
1.11	12 Dec 2019	Corrected Table 20: Pin Definitions. Pin12 from PCM_IN to PCM_OUT Pin14 from PCM_OUT to PCM_IN	Kai Wei	Jay White
1.12	20 Jan 2020	Corrected Table 21: Pin Definitions. Pin53 should be N/C.if not used.	Kai Wei	Jay White
1.13	25 Feb 2020	Added ST to all part numbers	Derek Wong	Jay White
1.14	24 Aug 2020	Update block diagram (antenna description) Updated Figure 5 (Stand-off Dimension)	Kai Wei	Jay White
1.15	10 Sep 2020	Add second source for M.2 connector and stand-off	Kai Wei	Jay White
1.16	18 Nov 2020	Updated all regulatory information	Ryan Urness	Jay White
1.17	16 Dec 2020	Updated certified antenna and other regulatory info	Bob Monroe	Jonathan Kaye
1.18	22 July 2021	Updated Bluetooth version number to 5.1	Miles Chung	Dan Kephart
1.19	23 Aug 2021	Added EN 300 440 support	Maggie Teng	Dave Drogowski
1.20	24 Aug 2021	Updated supported security types	Dan Kephart	Dave Drogowski
1.21	16 Nov 2021	Removed CCX / WFA Certifications info	Dan Kephart	Dave Drogowski
1.22	12 Jan 2022	Added note of .1µF capacitor on pins 41 and 43 in <a href="#">Pin Definitions</a>	Andrew Chen	Dave Drogowski
1.23	2 May 2022	Updated to latest Wi-Fi/BT specifications	Dave Drogowski	Dan Kephart
1.24	12 May 2022	EU supported 5GHz U-NII-3 band EU and JP do not support CH144	Kai Wei	Andrew Chen
1.25	1 June 2022	Updated weight in <a href="#">Specifications</a>	Dave Drogowski	Andrew Chen
1.26	3 Aug 2022	Updated dimensions of module in <a href="#">Mechanical Specifications</a> Added recommendation for <a href="#">Mounting Screw</a>	Dan Kephart	Andrew Chen
2.0	7 May 2024	Ezurio rebranding	Sue White	Dave Drogowski
2.1	18 Sep 2025	Replaced 802.11 channel information with reference to regulatory release notes	John Nosky	
2.2	17 June 2026	Removed SRRC certification.	Dave Drogowski	Andy Ross

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# 1 Scope

This document describes key hardware aspects of the Ezurio ST60-2230C-P/ ST60-2230C-PU M.2 module providing either PCIe bus interface for WLAN connection and UART (ST60-2230C-P)/USB (ST60-2230C-PU) for Bluetooth® (including Low Energy or LE) connection. This document is intended to assist device manufacturers and related parties with the integration of this module into their host devices. Data in this document is drawn from the Marvell 88W8997 datasheet issued in April 25, 2016.

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

# 2 Introduction

## 2.1 General Description

The ST60-2230C-P/ST60-2230C-PU module is a dual band 2x2 802.11ac WLAN plus Bluetooth 5.1 dual mode adapter; it complies with M.2 2230 E-Key standard. The module provides both simultaneous and independent operation of the following:

- IEEE 802.11ac, 2x2 MIMO spatial stream multiplexing with data rates up to MCS9 (866.7 Mbps)
- Bluetooth (Class 1)
- Bluetooth 5.1 (with Low Energy or LE)
- Bluetooth *Smart Ready* operation
- Three-way coexistence for WLAN and Bluetooth



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

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

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

WLAN interface:

- PCIe – Supports PCIe V2.0 Gen 1/Gen 2 rate (2.5/5 Gbps) interface

Bluetooth Interfaces:

- USB 2.0 – ST60-2230C-PU only
- High-Speed UART – ST60-2230C-P only

The ST60-2230C-P/ST60-2230C-PU modules also provide a PCM interface for master or slave mode – with the option of an 8-bit or 16-bit width size. Pins CON[0], CON[1], and CON[2] are used to configure the operation interface.

- ST60-2230C-P – The interfaces are PCIe/UART (WLAN/Bluetooth) with configuration setting to 011.
- ST60-2230C-PU – The interfaces are PCIe/USB (WLAN/Bluetooth) with configuration setting to 010.

# 3 Features Summary

The Ezurio ST60-2230C-P/ST60-2230C-PU device features are described in [Table 1](#).

**Table 1: ST60-2230C-P/ST60-2230C-PU features**

Feature	Description
	<ul style="list-style-type: none"> <li>• Integrates the complete transmit/receive RF paths including band pass filter, diplexer, switches, reference crystal oscillator, and power manage unit (PMU)</li> <li>• Supports 20/40/80 MHz channel bandwidth</li> <li>• WLAN/Bluetooth share one antenna</li> </ul>
	Coexistence arbitration for WLAN, Bluetooth, and LTE operation

Feature	Description												
	Dynamic Voltage Scaling (DVS) and Adaptive Voltage Scaling (AVS) feature supports the latest Marvell SoC and processor power control scheme.												
	RF system-tested and calibrated in production.												
	An external sleep clock of 32.768 KHz is required during power save mode.												
	<ul style="list-style-type: none"> <li>• PCIe V2.0 Gen 1/Gen 2 for WLAN</li> <li>• 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>												
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010	PCIe	USB 2.0	-										
011	PCIe	UART	-										
	<ul style="list-style-type: none"> <li>• Incorporates a 40 MHz reference frequency source in package</li> <li>• An external sleep clock is recommended for minimal current consumption. If no sleep clock input is provided, an internal sleep clock (derived from the reference clock) is used. An approximate 50 uA current increase on the 3.3V rail.</li> </ul>												
	<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): <ul style="list-style-type: none"> <li>- 802.11ac—MCS0-9 Nsts=1 and 2</li> <li>- 802.11n—MCS0-15</li> </ul> </li> <li>• 20/40/80 MHz channel bandwidths support</li> <li>• On-chip gain selectable LNA with optimized noise figure and power consumption</li> <li>• Internal PA with optimized gain distribution for linearity and noise performance</li> <li>• Support Wild variety of WLAN encryption: TKIP/WEP/AES</li> </ul>												
	<ul style="list-style-type: none"> <li>• Bluetooth 5.1 (BDR/EDR/LE), Bluetooth Class 1</li> <li>• Bluetooth 5 ready</li> <li>• Supports the following data rates: 1 Mbps (GFSK), 2 Mbps (<math>\pi/4</math>-DQPSK), 3 Mbps (8-DPSK)</li> <li>• Digital audio interface with PCM/TDM interface for voice application</li> <li>• Adaptive Frequency Hopping (AFH) using Package Error Rate (PER)</li> <li>• Standard SDIO or UART HCI transport layer</li> <li>• WLAN/Bluetooth coexistence protocol support</li> <li>• Shared LNA with WLAN/Bluetooth</li> <li>• Encryption (AES) support</li> </ul>												

## 4 Specifications

**Table 2: 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 v2.0 Gen1/Gen2 (2.5/5 Gbps); USB 2.0												
Bluetooth/ BLE Interface	Host Controller Interface (HCI) using High Speed UART, USB 2.0												
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010	PCIe	USB 2.0	-										
011	PCIe	UART	-										
Main Chip	Marvell 88W8997 (WLAN/BT); Marvell 88PG823 (PMU)												
Input Voltage Requirements	DC 3.3 V $\pm$ 10%												
I/O Signalling Voltage	DC 1.8 V $\pm$ 10%												

Feature	Description
Peak Current consumption, VCC= 3.3 volts VIO= 1.8 volts (At maximum transmit power setting) <i>(Measured transmit current under 99% duty cycle)</i> <i>Note: Reset refers to the radio are in reset, both Wi-fi and BT reset are asserted.</i>	<b>MIMO 2x 2 operations.</b> <b>802.11b (with BT in standby) @ 18 dBm 1 Mbps</b> Transmit: 1050 mA Receive: 520 mA <b>802.11g (with BT in standby) @ 18 dBm 6 Mbps</b> Transmit: 980 mA Receive: 520 mA <b>802.11a (with BT in standby) @ 18 dBm 6 Mbps</b> Transmit: 1100 mA Receive: 580 mA <b>802.11n (2.4 GHz/40 MHz) (with BT in standby) @ 16 dBm MCS0</b> Transmit: 850 mA Receive: 520 mA <b>802.11n (5.0 GHz/40 MHz) (with BT in standby) @ 16 dBm MCS0</b> Transmit: 900 mA Receive: 600 mA <b>802.11ac (5.0 GHz/80 MHz) (with BT in standby) @ 14 dBm MCS0</b> Transmit: 850 mA Receive: 600 mA Bluetooth (with Wi-Fi in standby) Transmit: 120 mA Receive: 100 mA Reset: <b>90 mA</b>
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	22 mm (length) x 30 mm (width) x 3.3 mm (thickness)
Weight	2.5 g
Wi-Fi Media	Direct Sequence-Spread Spectrum (DSSS) Complementary Code Keying (CCK) 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) A-MPDU Rx (De-aggregation) and Tx (aggregation) (802.11ac single-MPDU A-MPDU)
Network Architecture Types	Infrastructure and ad-hoc
Wi-Fi Standards	IEEE 802.11a, 802.11b, 802.11d*, 802.11e, 802.11g, 802.11h, 802.11i, 802.11k*, 802.11n, 802.11r, 802.11v*, 802.11ac * Summit version only
Bluetooth Standards	Bluetooth version 2.1 with Enhanced Data Rate Bluetooth 5.1 (Bluetooth Low Energy or BLE)
Wi-Fi Data Rates Supported	Support 802.11 ac/a/b/g/n 2X2 MIMO MIMO/802.11ac 802.11b (DSSS, CCK) 1, 2, 5.5, 11 Mbps

Feature	Description																																																																																																																																																																																																																																																																		
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	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>																																																																																																																																																																																																																																																								
802.11ac/n Spatial Streams	2 (2x2 MIMO)																																																																																																																																																																																																																																																																		
Bluetooth Data Rates Supported	1, 2, 3 Mbps																																																																																																																																																																																																																																																																		
Bluetooth Modulation	GFSK@ 1 Mbps PI/4-DQPSK@ 2 Mbps 8-DPSK@ 3 Mbps																																																																																																																																																																																																																																																																		
Wi-Fi Channels and Regulatory Domains	Supported Wi-Fi channels and regulatory domains change over time, see the Regulatory Release Notes (RRN) posted with each software release for the latest information.																																																																																																																																																																																																																																																																		
Transmit Power	802.11a 6 Mbps 18 dBm (63 mW)  802.11n 54 Mbps 16 dBm (40 mW)																																																																																																																																																																																																																																																																		
<i>Note: Transmit power on each channel</i>																																																																																																																																																																																																																																																																			

Feature	Description			
<i>varies according to individual country regulations. All values are nominal with +/-2 dBm tolerance at room temperature. Tolerance could be up to +/-2.5 dBm across operating temperature.</i>	802.11b			
	1 Mbps		18 dBm (63 mW)	
	11 Mbps		18 dBm (63 mW)	
	802.11g			
	6 Mbps		18 dBm (63 mW)	
	54 Mbps		16 dBm (40 mW)	
	802.11n (2.4/5 GHz)			
	6.5 Mbps (MCS0-5/MCS8-13;HT20)		18 dBm (63 mW)	
	65 Mbps (MCS6-7/MCS14-15;HT20)		16 dBm (40 mW)	
	13.5Mbps(MCS0-5/MCS8-13;HT40)		16 dBm (40 mW)	
<b>Note:</b> <i>HT20 – 20 MHz-wide channels</i>	135Mbps (MCS6-7/MCS14-15;HT40)		14 dBm (25 mW)	
	802.11ac (5 GHz)			
	<i>HT40 – 40 Mhz-wide channels</i>	6.5/13 Mbps (MCS0-6;Ntst=1,2;HT20)		18 dBm (63 mW)
		78/156 Mbps (MCS7-8;Ntst=1,2;HT20)		16 dBm (40 mW)
	<i>HT80 – 80 MHz-wide channels</i>	13.5/27Mbps (MCS0-6;Ntst=1,2;HT40)		16 dBm (40 mW)
		180/360Mbps (MCS7-9;Ntst=1,2;HT40)		14 dBm (25 mW)
		29.3/58.5 Mbps (MCS0-5;Ntst=1,2;HT80)		14 dBm (25 mW)
		263.3/526.5 Mbps (MCS6-8;Ntst=1,2;HT80)		12 dBm (15.8 mW)
		390/780 Mbps (MCS9;Ntst=1,2;HT80)		10 dBm (10 mW)
		Bluetooth		
	1 Mbps (1DH5)		10 dBm (12.5 mW)	
	2 Mbps		7 dBm (6.3 mW)	
	3 Mbps		7 dBm (6.3 mW)	
	BLE (1 Mbps)		7 dBm (6.3 mW)	
Typical Receiver Sensitivity	6 Mbps		-89 dBm	
(PER <= 10%)	54 Mbps		-74 dBm	
<b>Note:</b> <i>All values nominal, +/-3 dBm. Sensitivity on CH13 (WLAN)/CH78 (BT) will degrade up to 4-6dB.</i>	802.11b:			
	1 Mbps		-95 dBm	
	11 Mbps		-90 dBm	(PER < 8%)
	6 Mbps		-91 dBm	
	54 Mbps		-75 dBm	
	802.11n (2.4 GHz)			
	6.5 Mbps (MCS0;HT20)		-91 dBm	
	65 Mbps (MCS7;HT20)		-73 dBm	
	13.5Mbps(MCS0;HT40)		-85 dBm	
	135Mbps (MCS7;HT40)		-70 dBm	
802.11n (5 GHz)				
6.5 Mbps (MCS0;HT20)		-89 dBm		
65 Mbps (MCS7;HT20)		-70 dBm		
13.5Mbps(MCS0;HT40)		-86 dBm		
135Mbps (MCS7;HT40)		-69 dBm		
802.11ac (5 GHz)				
6.5 Mbps (MCS0;HT20)		-89 dBm		



Feature	Description
	AS/NZS 4268:2017 KC (Korea)
	ARIB STD-T71 (5 GHz)
Certifications	Bluetooth® SIG Qualification 
Warranty	One Year Warranty

*All specifications are subject to change without notice*

## 5 WLAN Functional Description

The ST60-2230C-P/ST60-2230C-PU M.2 module is designed based on the 60-SIPT SIP. It is optimized for high-speed, reliable, and low-power embedded applications. It is integrated with dual-band WLAN (2.4 GHz/5 GHz) and Bluetooth 5.1. Its functionality includes the following:

- Improved throughput on the link due to frame aggregation, RIFS (reduced inter-frame spacing), and half-guard intervals.
- Support for STBC (Space Time Block Codes) and LDPC (Low Density Parity Check) codes.
- Improved 11n performance due to features such as 11n frame aggregation (A-MPDU and A-MSDU) and low-overhead host-assisted buffering (RX A-MSDU and RX A-MPDU). These techniques can improve performance and efficiency of applications involving large bulk data transfers such as file transfers or high-resolution video streaming.
- IEEE 802.11 ac, 2X2 MIMO spatial stream multiplexing with data rate up to MCS9 (866.7 Mbps).

Additional functionality is listed in [Table 3](#).

**Table 3: 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 MIMO</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>
WLAN Base Band	<ul style="list-style-type: none"> <li>• 802.11ac 2x2 MIMO (with on-chip Marvell RF radio)</li> <li>• Backward compatibility with legacy 802.11 n/a/b/g technology</li> <li>• WLAN/Bluetooth LNA sharing</li> <li>• PHY rate up to 866.7Mbps</li> <li>• 20MHz bandwidth/channel, 40MHz bandwidth/channel, upper/lower 20MHz packets in 40MHz channel, 20MHz duplicate legacy packets in 40MHz channel operation</li> <li>• 80MHz bandwidth/channel, 4 positions of 20MHz packets in 80MHz channel, upper/lower 40MHz packets in 80MHz channel, 20MHz quadruplicate legacy packets in 80MHz channel mode operation</li> <li>• Modulation and Coding Scheme (MCS): 802.11 ac (MCS0-9. Nsts=1/2); 802.11n (MCS0-15)</li> <li>• 802.11 K Radio Resource Measurement</li> <li>• 802.11ac /802.11n optional MIMO features: <ul style="list-style-type: none"> <li>- 20/40/80 MHz Coexistence with middle-packaged detection (GI detection) for enhanced CCA.</li> <li>- 1 spatial stream STBC reception and transmission</li> <li>- LDPC transmission and reception for 802.11ac and 802.11n</li> <li>- 256 QAM (MCS8-9) modulations supported</li> <li>- Short guard interval</li> <li>- RIFS on receive path for 802.11n packets</li> <li>- 802.11n Greenfield TX/RX</li> </ul> </li> <li>• Power Save Feature</li> </ul>
WLAN Security	<p>WLAN Encryption features supported include:</p> <ul style="list-style-type: none"> <li>• Temporal Key Integrity Protocol (TKIP)/Wired Equivalent Privacy (WEP)</li> <li>• Advanced Encryption Standard (AES)/Counter-Mode/CBC-MAC Protocol (CCMP)</li> <li>• Advanced Encryption Standard (AES)/Cipher-Based Message Authentication Code (CMAC)</li> <li>• Advanced Encryption Standard (AES)/Galois/Counter Mode Protocol (GCMP)</li> <li>• WLAN Authentication and Private Infrastructure (WPAI)</li> </ul>



## 6 Bluetooth Functional Description

The ST60-2230C-P/ST60-2230C-PU Bluetooth (BT) block is based on the 60-SIPT SiP that already has fully-integrated Bluetooth baseband and radio. Several features and functions are listed in [Table 4](#).

**Table 4: Bluetooth functions**

Feature	Description
Bluetooth Interface	Voice interface: <ul style="list-style-type: none"> <li>• Hardware support for continual PCM data transmission/reception without processor overhead.</li> <li>• Standard PCM clock rates from 64 kHz to 2.048 MHz with multi-slot handshake and synchronization.</li> <li>• A-law, U-law, and linear voice PCM encoding/decoding.</li> <li>• High-Speed UART interface – ST60-2230C-P only</li> <li>• USB 2.0 – ST60-2230C-PU only</li> </ul>
Bluetooth Core functionality	<ul style="list-style-type: none"> <li>• Bluetooth 5.1</li> <li>• Bluetooth Class 1</li> <li>• WLAN and Bluetooth share same LNA and antenna</li> <li>• Digital audio interfaces with PCM/TDM interface for voice application</li> <li>• Baseband and radio BDR and EDR package type: 1Mbps, 2Mbps, 3Mbps</li> <li>• Fully functional Bluetooth baseband: AFH, forward error correction, header error control, access code correction, CRC, encryption bit stream generation, and whitening</li> <li>• Adaptive Frequency Hopping (AFH) using Packet Error Rate (PER)</li> <li>• Interlaced scan for faster connection setup</li> <li>• Simultaneous active ACL connection setup</li> <li>• Automatic ACL package type selection</li> <li>• Full master and slave piconet support</li> <li>• Scatter net support</li> <li>• SCO/eSCO links with hardware accelerated audio signal processing and hardware supported PPEC algorithm for speech quality improvement</li> <li>• All standard SCO/eSCO voice coding</li> <li>• All standard pairing, authentication, link key, and encryption operations</li> <li>• Encryption (AES) support</li> </ul>
Bluetooth Low Energy (BLE) Core functionality	<ul style="list-style-type: none"> <li>• Advertiser, Scanner, Initiator, Master, and Slave roles support (connects up to 16 links)</li> <li>• WLAN/Bluetooth Coexistence (BCA) protocol support</li> <li>• Shared RF with BDR/EDR</li> <li>• Encryption (AES) support</li> <li>• Intelligent Adaptive Frequency Hopping (AFH)</li> <li>• LE privacy 1.2</li> <li>• LE Secure Connection</li> <li>• LE Data Length Extension</li> <li>• 2 Mbps LE</li> </ul>

7 Block Diagram

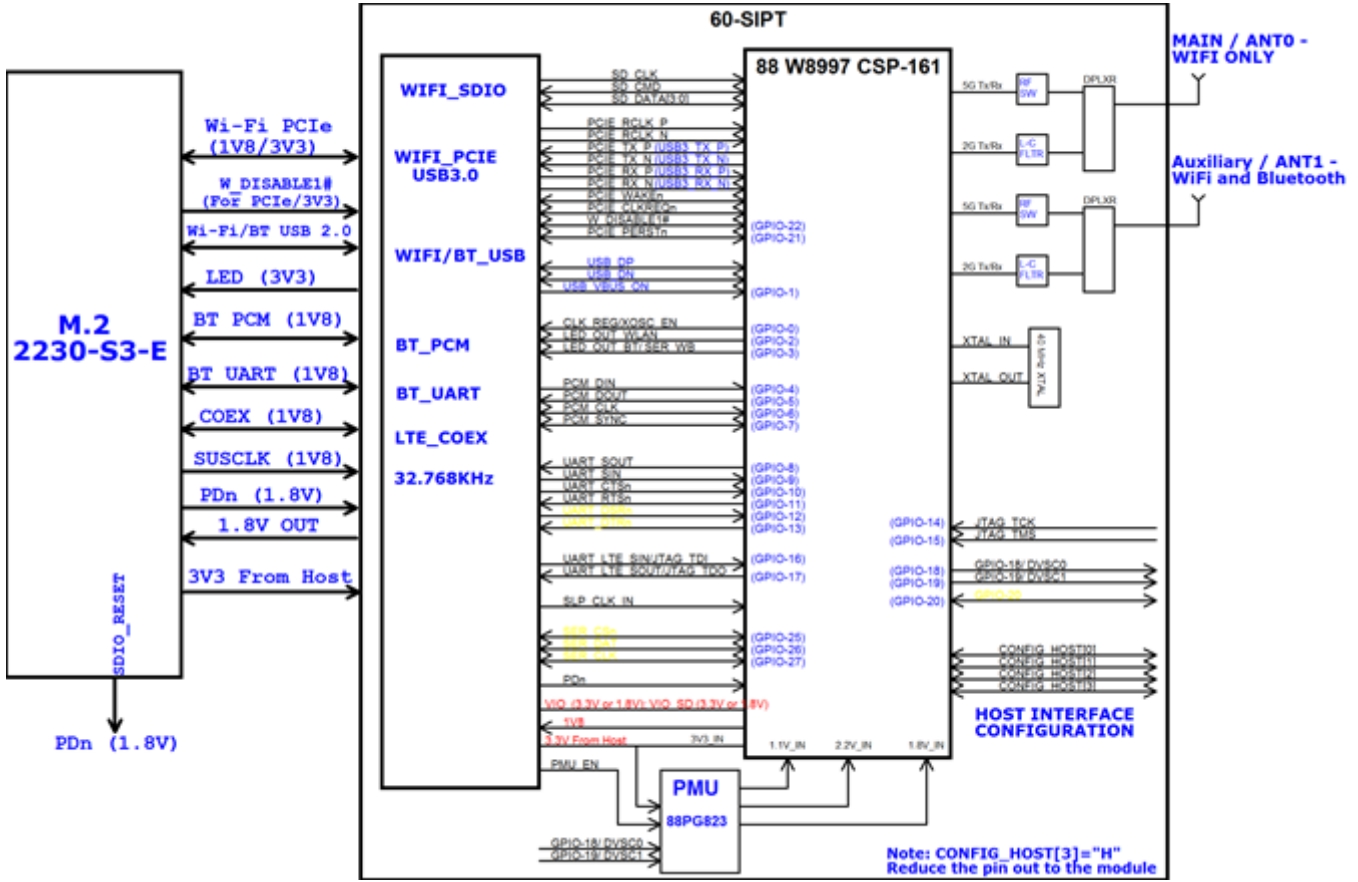


Figure 1: Block Diagram of ST60-2230C-P/ST60-2230C-PU

## 8 Electrical Characteristics

### 8.1 Absolute Maximum Ratings

Table 5 summarizes the absolute maximum ratings and Table 6 lists the recommended operating conditions for the ST60-2230C-P/ST60-2230C-PU. 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 5: Absolute maximum ratings**

Symbol (Domain)	Parameter	Max Rating	Unit
VIO	I/O configuration power supply (1.8V system)	2.2	V
3V3	External 3.3V power supply	4.0	V
Storage	Storage Temperature	-40 to +85	°C
ANT0; ANT1	Maximum RF input (reference to 50-Ω input)	+10	dBm
ESD	Electrostatic discharge tolerance	2000	V

### 8.2 Recommended Operating Conditions

**Table 6: Recommended Operating Conditions**

Symbol (Domain)	Parameter	Min	Typ	Max	Unit
VIO	WLAN and BT GPIO I/O power supply	1.62	1.8	1.98	V
3V3	External 3.3V power supply	2.97	3.30	3.63	V
T-ambient	Ambient temperature	-30	25	85	°C

### 8.3 DC Electrical Characteristics

Table 7 list the general DC electrical characteristics over recommended operating conditions (unless otherwise specified).

**Table 7: General DC electrical characteristics (For 1.8V operation VIO)**

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

## 8.4 WLAN Radio Receiver Characteristics

Table 8 and Table 9 summarize the WLAN ST60-2230C-P/ST60-2230C-PU receiver characteristics.

**Table 8: WLAN receiver characteristics for 2.4 GHz signal chain operation**

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

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

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

**Table 9: WLAN receiver characteristics for 5 GHz dual chain operation**

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

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

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

## 8.5 WLAN Transmitter Characteristics

Table 10: 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>				dBm
	11b mask compliant	1-11Mbps		18		
	11g mask compliant	6-36Mbps		18		
	11g EVM compliant	48-54Mbps		16		
	11n HT20 mask compliant	MCS0-5/MCS8-13		18		
	11n HT20 EVM compliant	MCS6-7/MCS14-15		16		
	11n HT40 mask compliant	MCS0-5/MCS8-13		16		
	11n HT40 EVM compliant	MCS6-7/MCS14-15		14		
ATx	Transmit power accuracy at 25 °C	-	-	+ 2.0		dB

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

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Ftx	Transmit output frequency range		5.15		5.925	GHz
Pout	Output power	See Note <sup>3</sup>				dBm
	11a mask compliant	6-36Mbps		18		
	11a EVM compliant	48-54Mbps		16		
	11n HT20 mask compliant	MCS0-5/MCS8-13		18		
	11n HT20 EVM compliant	MCS6-7/MCS14-15		16		
	11n HT40 mask compliant	MCS0-5/MCS8-13		16		
	11n HT40 EVM compliant	MCS6-7/MCS14-15		16		
	11ac HT20 mask compliant	MCS0-6 (Ntst=1,2)		18		
	11ac HT20 EVM compliant	MCS7-8(Ntst=1,2)		16		
	11ac HT40 mask compliant	MCS0-5 (Ntst=1,2)		16		
	11ac HT40 EVM compliant	MCS6-9(Ntst=1,2)		14		
	11ac HT80 mask compliant	MCS0-5 (Ntst=1,2)		14		
	11ac HT80 EVM compliant	MCS6-8(Ntst=1,2)		12		
	11ac HT80 EVM compliant	MCS9(Ntst=1,2)		10		
	ATx	Transmit power accuracy at 25 °C	-	-	+ 2.0	

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

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

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

## 9 Bluetooth Radio Characteristics

Table 11 through Table 14 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 11: Basic rate transmitter performance temperature at 25°C (1.8V)**

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

**Table 12: Enhanced data rate transmitter performance 25°C (1.8V)**

Test Parameter	Min	Typ	Max	BT Spec.	Unit	
Relative Transmit Power	5	7	9		dBm	
Max Carrier Frequency Stability Iw0I	2-DH5	–	1	–	$\leq \pm 10$	KHz
	3-DH5	–	1	–		
Max Carrier Frequency Stability Iw1I	2-DH5	–	4	–	$\leq \pm 75$	KHz
	3-DH5	–	4	–		
Max Carrier Frequency Stability Iw0+w1I	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 13: Basic rate receiver performance at 1.8V**

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

Test Parameter		Min	Typ	Max	BT Spec.	Unit
Carrier-to-Interferer Ratio (C/I)	Co-Channel	–	10	11	11	
	C/I ( $\pm 1$ MHz)	–	-4	0	0	dB
	C/I ( $\pm 2$ MHz)	–	-45	–	-30	dB
	C/I ( $\pm 3$ MHz)	–	-49	–	-40	dB
Maximum Level of Intermodulation Interferers		-39	-30	-	$\geq -39$	dBm

**Table 14: Enhanced data rate receiver performance 1.8V**

Test Parameter		Min	Typ	Max	Bluetooth Specification	Unit
Sensitivity (BER $\leq 0.01\%$ )	$\pi/4$ DQPSK	–	-94	-91	$\leq -70$	dBm
	8 DPSK	–	-88	-85	$\leq -70$	dBm
Maximum Input (BER $\leq 0.1\%$ )	$\pi/4$ DQPSK	-20	–	–	$\geq -20$	dBm
	8 DPSK	-20	–	–	$\geq -20$	dBm
Co-Channel C/I (BER $\leq 0.1\%$ )	$\pi/4$ DQPSK	–	10	13	$\leq \pm 13$	dB
	8 DPSK	–	16	20	$\leq \pm 20$	dB
Adjacent Channel C/I (1 MHz)	$\pi/4$ DQPSK	–	-9	0	$\leq 0$	dB
	8 DPSK	–	-6	5	$\leq 5$	dB
Second Adjacent Channel C/I (2 MHz)	$\pi/4$ DQPSK	–	-47	-30	$\leq -30$	dB
	8 DPSK	–	-42	-25	$\leq -25$	dB
Third Adjacent Channel C/I (3 MHz)	$\pi/4$ DQPSK	–	-51	-40	$\leq -40$	dB
	8 DPSK	–	-48	-33	$\leq -33$	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 PCIE Specifications

The ST60-2230C-P/ST60-2230C-PU PCIe host interface pins are powered from the AVDD18 voltage supply. The PCI Express interface supports a x1 PCI Express interface (one Lane). A Lane consists of an input and an output high-speed differential pair. Also supported is a PCI Express reference clock. Refer to the PCI Express Base Specification for more details on the functional requirements for the PCI Express interface signals.

### 10.1 Differential Tx Output Electricals

**NOTE:** In accordance with PCI Express Base Specification, Revision 2.1 March 4, 2009.

**Table 15: PCI Express Tx Output Specifications—2.5 GT/s**

Symbol	Parameter	Min	Typ	Max	Units
UI	Unit interval (UI) The specified UI is equivalent to a tolerance of $\pm 300$ ppm 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 $V_{Tx-DIFFpp} = 2 * IV_{TXD+} - V_{TXD-I}$	0.8	--	1.2	V
$V_{Tx-DIFF-PP-LOW}$	Low power differential peak-to-peak Tx voltage swing $V_{Tx-DIFFpp} = 2 * IV_{TXD+} - V_{TXD-I}$	0.4	--	1.2	V
$V_{Tx-DE-RATIO-3.5dB}$	Tx de-emphasis level ratio (3.5 dB)	3.0	--	4.0	dB
$T_{Tx-EYE}$	Tx eye including all jitter sources	0.75	--	--	UI
$T_{Tx-EYE-MEDIAN-to-MAX-JITTER}$	Maximum time between jitter median and maximum deviation from median	--	--	0.125	UI
$T_{Tx-RISE-FALL}$	Tx rise/fall time Measured differentially from 20% to 80% of swing.	0.125	--	--	UI
$RL_{Tx-DIFF}$	Tx package plus Si differential return loss	10	--	--	dB
$RL_{Tx-CM}$	Tx package plus Si common mode return loss	6	--	--	dB
$V_{Tx-CM-AC-P}$	Tx AC common mode voltage	--	20	--	mV
$I_{Tx-SHORT}$	Tx short circuit current limit	--	--	90	mA
$V_{Tx-DC-CM}$	Tx DC common mode voltage	0	--	3.6	V
$V_{Tx-CM-DC-ACTIVE-IDLE-DELTA}$	Absolute delta of DC common mode voltage during L0 and electrical idle	0	--	100	mV
$V_{Tx-IDLE-DIFF-AC-p}$	Electrical idle differential peak output voltage	0	--	20	mV
$V_{Tx-RCV-DETECT}$	Voltage change allowed during receiver detection	--	--	600	mV
$T_{Tx-IDLE-MIN}$	Minimum time spent in electrical idle	20	--	--	ns
$T_{Tx-IDLE-SET-TO-IDLE}$	Maximum time to transition to a valid electrical idle after sending an electrical idle ordered set	--	--	8	ns
$T_{Tx-IDLE-TO-DIFF-DATA}$	Maximum time to transition to valid diff signaling after leaving electrical idle	--	--	8	ns
$T_{CROSSLINK}$	Crosslink random timeout	--	--	1.0	ms
$C_{Tx}$	AC coupling capacitor	75	--	200	nF

**Table 16: PCI Express Tx Output Specifications—5 GT/s**

Symbol	Parameter	Min	Typ	Max	Units
UI	Unit interval (UI) The specified UI is equivalent to a tolerance of $\pm 300$ ppm for each Refclk source. Period does not account for SSC induced variations.	199.94	--	200.06	Ps
$V_{Tx-DIFFpp}$	Differential peak-to-peak Tx voltage swing $V_{Tx-DIFFpp} = 2 * IV_{TXD+} - V_{TXD-I}$	0.8	--	1.2	V

Symbol	Parameter	Min	Typ	Max	Units
$V_{TX-DIFFpp-LOW}$	Low power differential peak-to-peak Tx voltage swing $V_{TX-DIFFpp} = 2 \cdot IV_{TXD+} - V_{TXD-I}$	0.4	--	1.2	V
$V_{TX-DE-RATIO-3.5dB}$	Tx de-emphasis level ratio (3.5 dB)	3.0	--	4.0	dB
$V_{TX-DE-RATIO-6dB}$	Tx de-emphasis level ratio (6 dB)	5.5	--	6.5	dB
$T_{MIN-PULSE}$	Instantaneous lone pulse width Measured relative to rising/falling pulse.	0.9	--	--	UI
$T_{TX-EYE}$	Tx eye including all jitter sources	0.75	--	--	UI
$T_{TX-HF-DJ-DD}$	Tx deterministic jitter > 1.5 MHz Deterministic jitter only.	--	--	0.15	UI
$T_{TX-LF-RMS}$	Tx RMS jitter < 1.5 MHz Total energy measured over a 10 kHz-1.5 MHz range.	--	3.0	--	Ps RMS
$T_{TX-RISE-FALL}$	Tx rise/fall time Measured differentially from 20% to 80% of swing.	0.15	--	--	UI
$RL_{TX-DIFF}$	Tx package plus Si differential return loss (0.05-1.25 GHz)	10	--	--	dB
	Tx package plus Si differential return loss (1.25-2.5 GHz)	8	--	--	
$RL_{TX-CM}$	Tx package plus Si common mode return loss				dB
$V_{TX-CM-AC-PP}$	Tx AC common mode voltage				mVPP
$I_{TX-SHORT}$	Tx short circuit current limit				mA
$V_{TX-DC-CM}$	Tx DC common mode voltage				V
$V_{TX-CM-DC-ACTIVE-IDLE-DELTA}$	Absolute delta of DC common mode voltage during L0 and electrical idle				mV
$V_{TX-IDLE-DIFF-AC-p}$	Electrical idle differential peak output voltage $V_{TX-IDLE-DIFF-DC} = IV_{TX-IDLE-D+} - V_{TX-IDLE-D-I} \leq 20$ mV				mV
$V_{TX-IDLE-DIFF-DC}$	DC electrical idle differential output voltage $V_{TX-IDLE-DIFF-DC} = IV_{TX-IDLE-D+} - V_{TX-IDLE-D-I} \leq 5$ mV				mV
$V_{TX-RCV-DETECT}$	Voltage change allowed during receiver detection				mV
$T_{TX-IDLE-MIN}$	Minimum time spent in electrical idle				ns
$T_{TX-IDLE-SET-TO-IDLE}$	Maximum time to transition to a valid electrical idle after sending an electrical idle ordered set	--	--	8	ns
$T_{TX-IDLE-TO-DIFF-DATA}$	Maximum time to transition to valid differential signaling after leaving electrical idle	--	--	8	ns
$T_{CROSSLINK}$	Crosslink random timeout	--	--	1.0	ms
$C_{TX}$	AC coupling capacitor	75	--	200	nF

## 10.2 Differential Rx Input Electricals

**NOTE:** In accordance with PCI Express Base Specification, Revision 2.1 March 4, 2009.

**Table 17: PCI Express Rx Input Specifications—2.5 GT/s**

Symbol	Parameter	Min	Typ	Max	Units
UI	Unit Interval (UI) UI does not account for SSC induced variations.	399.88	--	400.12	ps
$V_{RX-DIFF-PP-CC}$	Differential Rx peak-to-peak voltage for common Refclk Rx architecture	0.175	--	1.2	V
$V_{RX-DIFF-PP-DC}$	Differential Rx peak-to-peak voltage for data clocked Rx architecture	0.175	--	1.2	V
$T_{RX-EYE}$	Rx eye time opening Minimum eye time at Rx pins to yield a 10-12 BER.	0.40	--	--	UI

Symbol	Parameter	Min	Typ	Max	Units
$T_{RX-EYE-MEDIAN-to-MAX-JITTER}$	Maximum time delta between median and deviation from median	--	--	0.3	UI
$V_{RX-CM-ACp}$	AC peak common mode input voltage	--	--	150	mV
$RL_{RX-DIFF}$	Differential return loss	15	--	--	dB
$RL_{RX-CM}$	Common mode return loss	0	--	3.6	dB
$Z_{RX-DIFF-DC}$	DC differential input impedance	80	100	120	W
$Z_{RX-DC}$	DC input impedance	40	50	60	W
$Z_{RX-HIGH-IMP-DC}$	Powered down DC input impedance	200	--	--	k $\Omega$
$V_{RX-IDLE-DET-DIFF-p-p}$	Electrical idle detect threshold	65	--	175	mV
$T_{RX-IDLE-DET-DIFF-ENTERTIME}$	Unexpected electrical idle enter detect threshold integration time	--	--	10	ms
$L_{RX-SKEW}$	Total skew	--	--	20	ns

**Table 18: PCI Express Rx Input Specifications—5 GT/s**

Symbol	Parameter	Min	Typ	Max	Units
UI	Unit Interval (UI) UI does not account for SSC induced variations.	199.94	--	200.06	ps
$V_{RX-DIFF-PP-CC}$	Differential Rx peak-to-peak voltage for common Refclk Rx architecture	0.120	--	1.2	V
$V_{RX-DIFF-PP-DC}$	Differential Rx peak-to-peak voltage for data clocked Rx architecture	0.100	--	1.2	V
$T_{RX-TJ-CC}$	Maximum Rx inherent total timing error for common Refclk Rx architecture	--	--	0.40	UI
$T_{RX-TJ-DC}$	Maximum Rx inherent total timing error for data clocked Rx architecture	--	--	0.34	UI
$T_{RX-DJ-DD-CC}$	Maximum Rx inherent deterministic timing error for common Refclk Rx architecture	--	--	0.30	UI
$T_{RX-DJ-DD-DC}$	Maximum Rx inherent deterministic timing error for data clocked Rx architecture	--	--	0.24	UI
$T_{RX-MIN-PULSE}$	Minimum width pulse at Rx Measured to account for worst Tj at 10 <sup>-12</sup> BER.	0.6	--	--	UI
$V_{RX-CM-ACp}$	AC peak common mode input voltage	--	--	150	mV
$RL_{RX-DIFF}$	Differential return loss	15	--	--	dB
$RL_{RX-CM}$	Common mode return loss	0	--	3.6	dB
$Z_{RX-DIFF-DC}$	DC differential input impedance	80	100	120	W
$Z_{RX-DC}$	DC input impedance	40	50	60	W
$Z_{RX-HIGH-IMP-DC}$	Powered down DC input impedance	200	--	--	k $\Omega$
$V_{RX-IDLE-DET-DIFF-p-p}$	Electrical idle detect threshold	65	--	175	mV
$T_{RX-IDLE-DET-DIFF-ENTERTIME}$	Unexpected electrical idle enter detect threshold integration time	--	--	10	ms
$L_{RX-SKEW}$	Total skew	--	--	20	ns

# 11 USB Specifications

## 11.1 USB LS Driver and Receiver Parameters

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

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

**Table 15: 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 Defined with 1.425KΩ pull-up resistor to 3.6V	2.8	-	3.6	V
VOL	Output signal ended low 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 Defined from 10% to 90% for raise time and 90% to 10% for fall time	75.0	-	300.0	ns
TLF	Data rise time 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 *Including frequency tolerance. Timing difference between the differential data signals. *Defined at crossover point of differential signals	-95	-	95	ns
TUDJ2	Source jitter total: for paired transitions *Including frequency tolerance. Timing difference between the differential data signals. *Defined at crossover point of differential signals	-150	-	150	ns
<b>Receiver Specifications</b>					
VIH	Input signal ended high	2.0	-	-	V
VIL	Input signal ended low	-	-	0.8	V
VDI	Differential input sensitivity	0.2	-	-	V

## 11.2 USB FS Driver and Receiver Parameters

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

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

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

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

### 11.3 USB HS Driver and Receiver Parameters

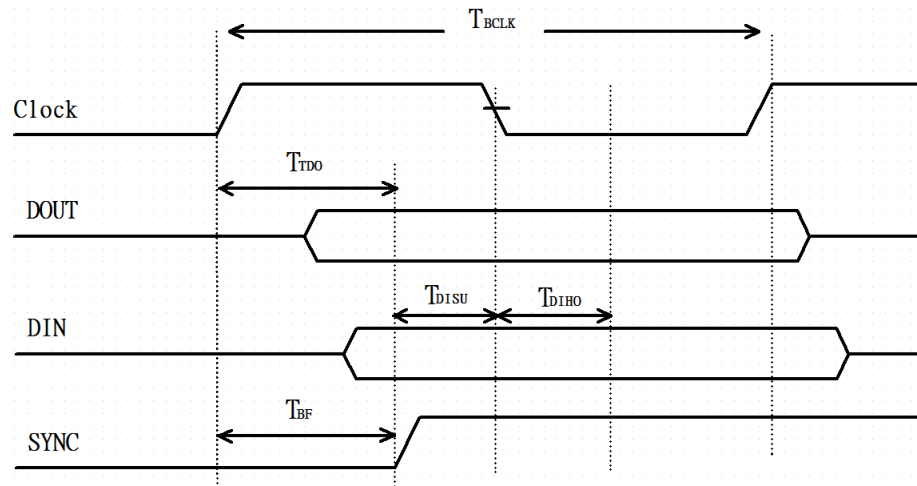
**Notes:** Over full range of values specified in the Recommended Operating Conditions unless otherwise specified.

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

**Table 17: 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 Defined from 10% to 90% for raise time and 90% to 10% for fall time	500	-	-	ns
THSF	Data fall time 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

### 12 PCM Interface Specifications



**Figure 2: PCM Timing Specification - Master Mode**

**Table 18: 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>DO</sub>	-	-	-	15	ns
T <sub>DISU</sub>	-	20	-	-	ns
T <sub>DIHO</sub>	-	15	-	-	ns

Symbol	Parameter	Min.	Typ.	Max.	Unit
TBF	-	-	-	15	ns

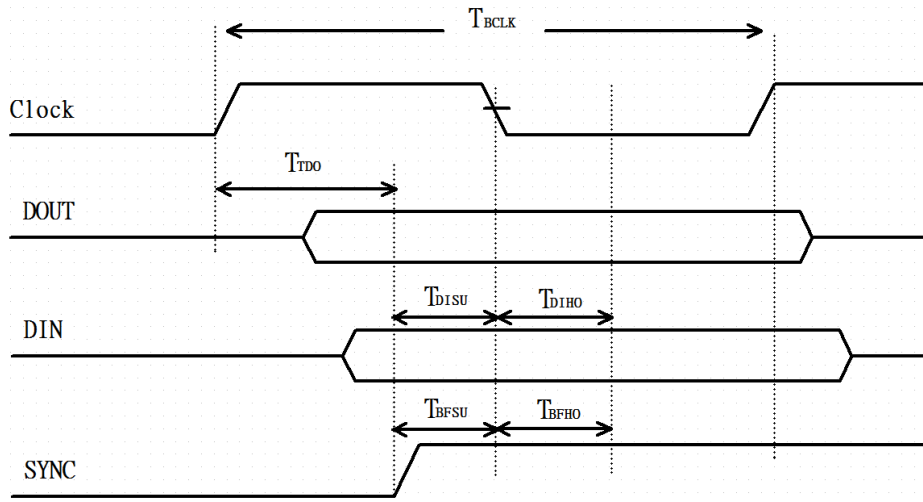


Figure 3: PCM Timing Specification - Slave Mode

Table 19: 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
T <sub>D0</sub>	-	-	-	30	ns
T <sub>DISU</sub>	-	15	-	-	ns
T <sub>DIHO</sub>	-	10	-	-	ns
T <sub>BFSU</sub>	-	15	-	-	ns
T <sub>BFHO</sub>	-	10	-	-	ns

## 13 Pin Definitions

Table 20: Pin definitions

Pin #	Name	Type	Voltage Ref.	Description	If Not Used
1	GND	-	-	Ground	GND
2	3.3V	Power	-	3.3V module power supply	-
3	USB_D+	I/O	3.3V	USB Differential Data-Positive <i>ST60-2230C-PU only</i>	N/C
4	3.3V	Power	-	3.3V module power supply	-
5	USB_D-	I/O	3.3V	USB Differential Data-Negative <i>ST60-2230C-PU only</i>	N/C
6	LED1#	O,PU	3.3V	LED indicator for WLAN with 10mA drive capability	N/C
7	GND	-	-	Ground	GND
8	PCM_CLK	I/O	1.8V	PCM Clock Signal (Optional) Optimal clock used for some codecs. Output if Master mode; Input if Slave mode.	N/C

Pin #	Name	Type	Voltage Ref.	Description	If Not Used
9	SDIO CLK	N/C	1.8V	SDIO 4-bit Mode Clock Input	N/C
10	PCM_SYNC	I/O	1.8V	PCM Sync Pulse Signal Output if Master mode; Input if Slave mode.	N/C
11	SDIO CMD	N/C	1.8V	SDIO 4-bit Mode Command/Response	N/C
12	PCM_OUT	O	1.8V	PCM Data	N/C
13	SDIO DATA0	N/C	1.8V	SDIO 4-bit Mode DATA line Bit[0]	N/C
14	PCM_IN	I	1.8V	PCM Data	N/C
15	SDIO DATA1	N/C	1.8V	SDIO 4-bit Mode DATA line Bit[1]	N/C
16	LED2#	N/C	N/C	N/C	N/C
17	SDIO DATA2	N/C	1.8V	SDIO 4-bit Mode DATA line Bit[2]	N/C
18	GND	-	-	Ground	GND
19	SDIO DATA3	N/C	1.8V	SDIO 4-bit Mode DATA line Bit[3]	N/C
20	UART WAKE#	O	3.3V	Reserved for BT to wakeup Host	N/C
21	SDIO WAKE#	O	1.8V	Reserved for Wake-On-WLAN	N/C
22	UART TXD	O	1.8V	UART Serial Data Output <b>ST60-2230C-P only</b>	N/C
23	SDIO RESET#	N/C	N/C	N/C	N/C
32	UART RXD	I	1.8V	UART Serial Data Input <b>ST60-2230C-P only</b>	N/C
33	GND	-	-	Ground	GND
34	UART RTS	O,WPU	1.8V	UART Request To Send (Active low) <b>ST60-2230C-P only</b>	N/C
35	PERp0	I	1.8V	PCIe Receive Data-Positive	N/C
36	UART CTS	I,PU	1.8V	UART Clear To Send (Active low) <b>ST60-2230C-P only</b>	N/C
37	PERn0	I	1.8V	PCIe Receive Data-Negative	N/C
38	VENDOR DEFINED38	N/C	N/C	N/C	N/C
39	GND	-	-	Ground	GND
40	VENDOR DEFINED40	N/C	N/C	N/C	N/C
41	PETp0	O	1.8V	PCIe Transmit Data-Positive; 0.1µF capacitor included in module	N/C
42	VENDOR DEFINED42	N/C	N/C	N/C	N/C
43	PETn0	O	1.8V	PCIe Transmit Data-Negative; 0.1µF capacitor included in module	N/C
44	COEX3	N/C	1.8V	General purpose I/O pin.	N/C
45	GND	-	-	Ground	GND
46	COEX2	O,PD	1.8V	Serial data to external LTE device/	N/C
47	REFCLKp0	I	1.8V	PCIe Differential Clock input-Positive	N/C
48	COEX1	I,PD	1.8V	Serial data from external LTE device/	N/C
49	REFCLKn0	I	1.8V	PCIe Differential Clock input-Negative	N/C
50	SUSCLK(32KHz)	I,PU	3.3V	Sleep Clock Input	-

Pin #	Name	Type	Voltage Ref.	Description	If Not Used
				An external sleep clock of 32.768KHz with minimum +/- 250ppm is required for power saving mode	
51	GND	-	-	Ground	GND
52	PERST0#	I,PD	3.3V	PCIe host indication to reset the device (input) (active low)	N/C
53	CLKREQ0#	I/O	3.3V	PCIe clock request (input/output) (active low)	N/C
54	W_DISABLE2#	N/C	N/C	N/C	N/C
55	PEWAKE0#	I/O	3.3V	PCIe wake signal (input/output) (active low)	N/C
56	W_DISABLE1#	I,PU	3.3V	Reserved	N/C
57	GND	-	-	Ground	GND
58	I2C DATA (I/O) (0/3.3V)	N/C	N/C	N/C	N/C
59	RESERVED/PETp1	N/C	N/C	N/C	N/C
60	I2C CLK (0/3.3V)	N/C	N/C	N/C	N/C
61	RESERVED/PETn1	N/C	N/C	N/C	N/C
62	ALERT# (0/3.3V)	O	3.3V	N/C	N/C
63	GND	-	-	Ground	GND
64	RESERVED	N/C	N/C	N/C	N/C
65	RESERVED/PERp1	N/C	N/C	N/C	N/C
66	UIM_SWP/PERST1#	N/C	N/C	N/C	N/C
67	RESERVED/PERn1	N/C	N/C	N/C	N/C
68	UIM_POWER_SNK/C LKREQ1#	N/C	N/C	N/C	N/C
69	GND	-	-	Ground	GND
70	UIM_POWER_SRC/G PIO1/PEWAKE1#	N/C	N/C	N/C	N/C
71	RESERVED/REFCLKp1	N/C	N/C	N/C	N/C
72	3.3V	Power	-	3.3V module power supply	-
73	RESERVED/REFCLKn1	N/C	N/C	N/C	N/C
74	3.3V	Power	-	3.3V module power supply	-
75	GND	-	-	Ground	GND

## 14 Mechanical Specifications

Module dimensions of ST60-2230C-P/ST60-2230C-PU are 22 mm x 30 mm x 2.66 mm. Detail drawings are shown in Figure 4.

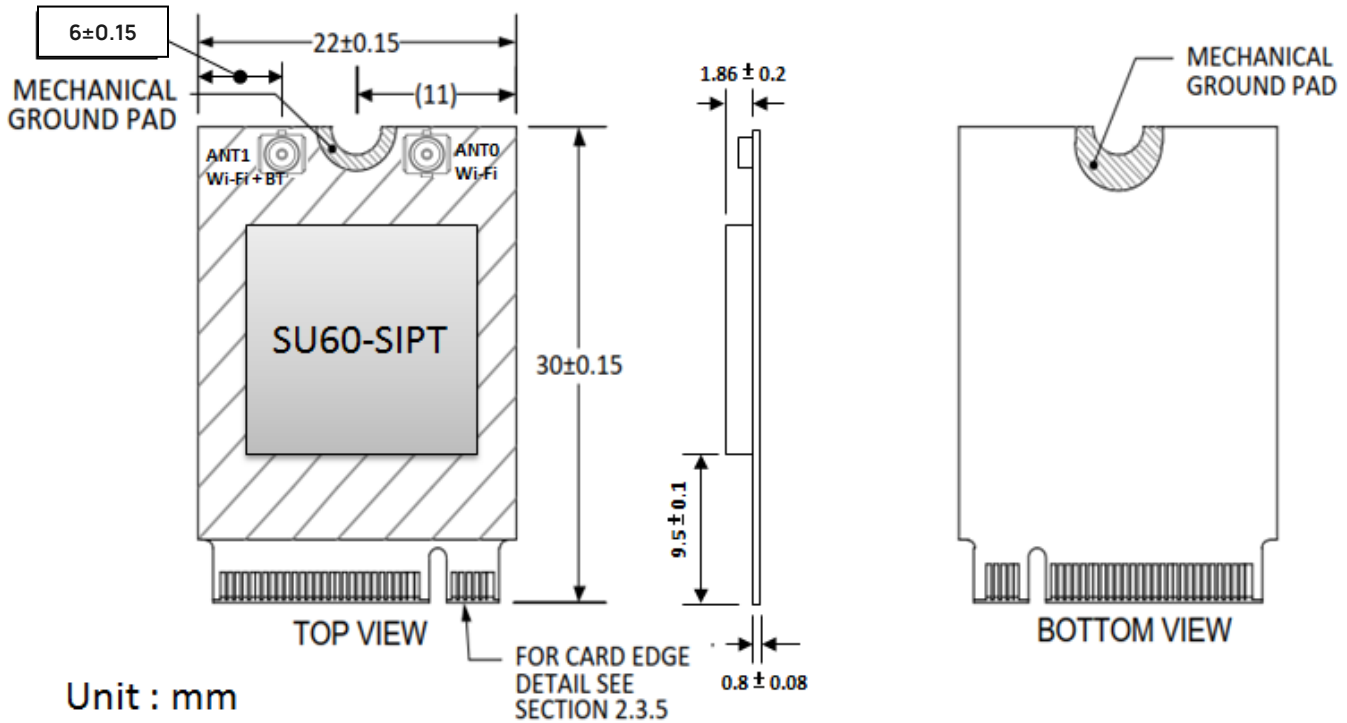


Figure 4: Module dimension of ST60-2230C-P/ST60-2230C-PU

**Note:** The Wi-Fi MAC address is located on the product label.

The last digit of Wi-Fi MAC address will be assigned to either "0", "4", "8", or "C".

The BT MAC address will be the Wi-Fi MAC on the label plus 3.

## 15 Mounting

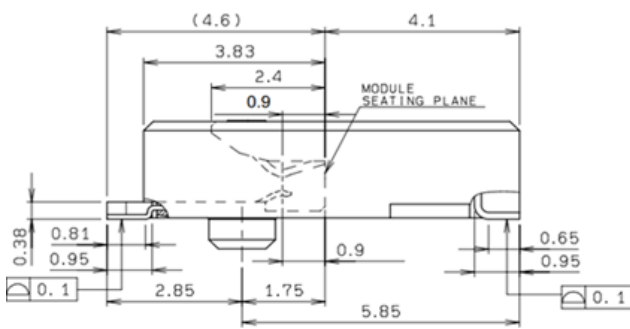
The ST60-2230C-P/ST60-2230C-PU connects to the host via a standard PCI EXPRESS M2 connector. The Kyocera's ([www.Kyocera-connector.com](http://www.Kyocera-connector.com)) 6411 series provide 1.8 mm, 2.3 mm and 3.2 mm connector heights and JAE's (<https://www.jae.com/en/>) SM3 series provide 1.2 mm, 2.15 mm, 3.1 mm and 4.1 mm connector heights.

Because the ST60-2230C-P/ST60-2230C-PU is a single-side component module, we recommend the following part numbers which have 2.3 mm and 3.1 mm connector height):

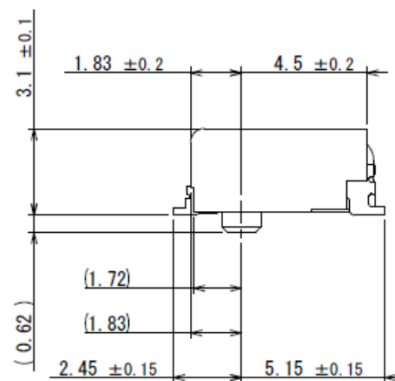
M.2 Key-E Connector	Connector Height
KYOCERA 24-6411-067-101-894E	2.3 mm
JAE SM3ZS067U310AERxxxx	3.1 mm

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

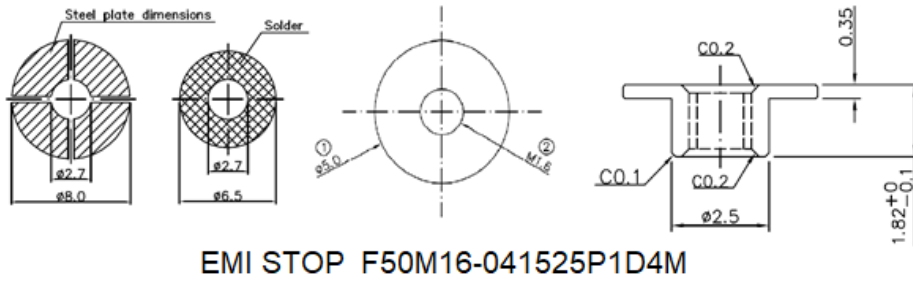
M.2 Key-E Connector	Stand-off
KYOCERA 24-6411-067-101-894E	EMI STOP F50M16-041525P1D4M
JAE SM3ZS067U310AERxxxx	JAE SM3ZS067U310-NUT1-Rxxxx.



KYOCERA 24-6411-067-101-894E



JAE SM3ZS067U310AERxxxx



JAE SM3ZS067U310-NUT1-Rxxxx

Figure 5: Mounting information of the ST60-2230C-P/ST60-2230C-PU and recommended layout pattern for the stand-off

### 15.1 Mounting Screw

The ST60-2230C modules are secured in their mounting position with a mounting screw. Ezurio recommends the use of the Hama Naka Shoukin Industry Co. FPHM1.6-0.35x3.5(5,0.5)CR3-Zn screw. Contact [peggy@hnsco.com.tw](mailto:peggy@hnsco.com.tw) for more information.

浜中松琴工業有限公司 HAMA NAKA SHOUKIN INDUSTRY CO., LTD.

料號: \_\_\_\_\_ 規格: \_\_\_\_\_ FPHM1.6-0.35x3.5(5,0.5)  
材質: \_\_\_\_\_ AISI-1018 熱處理: \_\_\_\_\_ Hardening 電鍍: \_\_\_\_\_ CR3/Zn

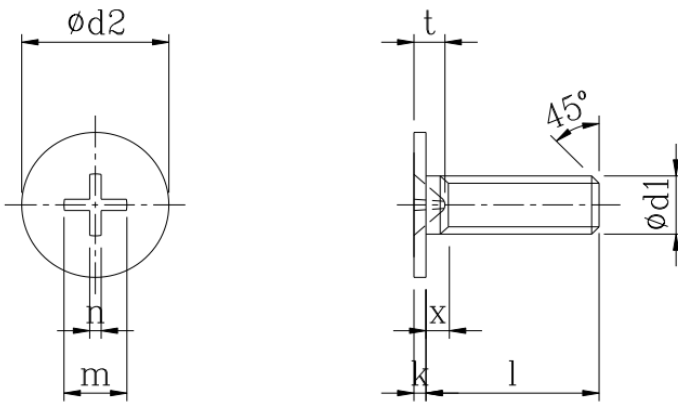


Figure 6: Mechanical drawing of FPH M1.6-0.35x3.5(5,0.5)CR3-Zn

## 16 RF Layout Design Guidelines / Precautions

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

- Do not run antenna cables directly above or directly below the radio.
- Do not place any parts or run any high-speed digital lines below the radio.
- If there are other radios or transmitters located on the device (such as a Bluetooth radio), place the devices as far apart from each other as possible. Also, make sure there is at least 25 dB isolation between the Bluetooth antenna and the Wi-Fi antenna.

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

## 17 Regulatory

Information on certified antennas and regulatory certifications can be found in the [60-2230 Regulatory Information Guide](#).

## 18 Ordering Information

Part Number	Description
ST60-2230C-P	2X2 802.11 a/b/g/n with Bluetooth 5.1 dual mode module with PCIe bus interface for WLAN connection and UART for Bluetooth (including Low Energy) connection
ST60-2230C-PU	2X2 802.11 a/b/g/n with Bluetooth 5.1 dual mode module with PCIe bus interface for WLAN connection and USB for Bluetooth (including Low Energy) connection
DVK-ST60-2230C	Development kit for the ST60-2230C

## 19 Additional Information

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

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

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

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