Datasheet

ST60-2230C/ST60-2230C-Q/ST60-2230C-SS

ST60-2230C-U/ST60-2230C-UU

Version 5.4

Revision History

Version	Date	Notes	Contributors	Approver
1.0	29 Aug 2017	Initial version		Jay White
1.1	06 Sept 2017	Updated module size to 22 mm (length) x 30 mm (width) x 3.3 mm (thickness) Updated *Figure 8: Module dimension of 60-2230C.* Changed *6.7±0.15* to *6±0.15*. Changed pin definitions for pins 54 and 56		Jay White
1.2	08 Sept 2017	Updated Max. Current Consumption table/column headings		Andrew Chen
1.3	10 Oct 2017	Added mFlexPIFA antenna info		Bill Steinike
1.4	05 Dec 2017	Added Korea regulatory ID information		Connie Lin
1.5	26 Mar 2018	Updated block diagram	Kai Wei	Jay White
1.6	30 Mar 2018	Update Wi-Fi and BT MAC rule; added part numbers and associated supported interfaces	Andrew Chen	Jay White
1.7	09 Apr 2018	Updated operation interface for 60-2230C/60-2230C-SS/60-2230C-U/60-2230C-UU; added China (SRRC) certification information	Kai Wei	Jay White
1.8	18 Oct 2018	Updated to clarify PCIe USB 2.0 supported	John Nosky	Sue White
1.9	07 Nov 2018	Removed 802.11s reference		Jay White
2.0	14 Nov 2018	Updated KC channel list		Andrew Chen
2.1	11 Feb 2019	Corrected the FCC, KC, and IC regulatory IDs	Connie Lin	Jay White
2.2	07 Mar 2019	Corrected Table 1: Part numbers and supported interfaces	Kai Wei	Jay White
2.3	17 Apr 2019	Removed DFS Radar Detection section		Jay White
2.4	23 July 2019	Corrected Table 21: Pin Definitions. Pin 76,77 do not exist; Updated Peak Current consumption; Corrected I/O Signalling Voltage	Kai Wei	Jay White
2.5	28 Aug 2019	Updated to BT5.1		Jay White
2.6	26 Sept 2019	Removed AoA/DoA references		Jay White
2.7	11 Oct 2019	Removed Android version numbers	Joe Conley	Jay White
2.8	14 Oct 2019	Removed advertising extension references… *LE Advertising Length Extension* Updated warranty information (one year vs. three)	Jonathan Kaye	Jay White
2.9	28 Nov 2019	Corrected Table 21: Pin Definitions: Pin12 from PCM_IN to PCM_OUT; Pin14 from PCM_OUT to PCM_IN	Kai Wei	Jay White
2.10	17 Dec 2019	Added the weight of the module (replaced the TBD)	Andrew Dobbing	Jay White
2.11	20 Jan 2020	Corrected Table 21: Pin Definitions. Pin53 should be N/C.if not used.	Kai Wei	Jay White
2.12	04 Feb 2020	Added NCC to Regulatory section	Connie Lin	Jay White
2.13	25 Feb 2020	Added *ST* to all part numbers	Derek Wong	Jay White
2.14	13 May 2020	Updated Certified Antennas tables		Jay White
2.15	06 May 2020	Updated block diagram (antenna description)	Kai Wei	Jay White
2.16	23 Jun 2020	Corrected Table 21: Pin Definitions – Pin12 from PCM_IN to PCM_OUT; Pin14 from PCM_OUT to PCM_IN	Kai Wei	Jay White
2.17	24 Aug 2020	Updated EN certifications Updated Figure 9 (Stand-off Dimension)	Kai Wei	Jay White
2.18	10 Sep 2020	Add second source for M.2 connector and stand-off	Kai Wei	Jay White
2.19	18 Nov 2020	Updated all regulatory information	Ryan Urness	Jay White
2.20	16 Dec 2020	Updated certified antenna list and additional regulatory info	Bob Monroe	Jonathan Kaye
3.0	22 Jan 2021	Transferred regulatory information to separate document	Maggie Teng	Jonathan Kaye

Version	Date	Notes	Contributors	Approver
3.1	28 Jan 2021	Removed beamforming references	Dan Kephart	Andrew Dobbing
3.2	30 Mar 2021	Fixed note error	Jonathan Kaye	Andrew Chen
3.3	05 May 2021	Updated 5 GHz operating channel numbers for EU, FCC, and MIC	Miles Chung	Andrew Chen
3.4	23 Aug 2021	Added EN 300 440 support	Maggie Teng	Dave Drogowski
3.5	24 Aug 2021	Updated supported security types	Dan Kephart	Dave Drogowski
3.6	16 Nov 2021	Removed CCX / WFA Certifications info	Dan Kephart	Dave Drogowski
3.7	2 May 2022	Updated to latest Wi-Fi/BT specifications	Dave Drogowski	Dan Kephart
3.8	12 May 2022	EU supported 5GHz U-NII-3 band EU and JP do not support CH144	Kai Wei	Andrew Chen
3.9	1 June 2022	Updated weight of module in Specifications	Dave Drogowski	Andrew Chen
4.0	3 Aug 2022	Updated dimensions of module in Mechanical Specifications Added recommendation for Mounting Screw	Dan Kephart Maggie Teng	Andrew Chen
4.1	29 Oct 2024	Added -Q variant	Dave Drogowski	Dan Kephart
5.0	15 Apr 2025	Ezurio rebranding	Sue White	Dave Drogowski
5.1	13 May 2025	Added DVK-ST60-2230C development kit to ordering information	Dan Kephart	Dave Drogowski
5.2	13 Jun 2025	Added NCC to Regulatory	Alexander Mohr	Andy Ross
5.3	18 Sept 2025	Replaced 802.11 channel information with reference to regulatory release notes	John Nosky	Dave Drogowski
5.4	10 Apr 2026	Updated SUSCLK voltage to 3V3 in Block Diagram	Dave Drogowski	Andrew Chen

Contents

1 Scope

This document describes key hardware aspects of the Ezurio ST60-2230C/ST60-2230C-Q/ST60-2230C-SS/ST60-2230C-U/ST60-2230C-UU M.2 module providing either SDIO or USB2.0 bus interface for WLAN connection and UART/SDIO/USB2.0 for Bluetooth® (including Low Energy or LE) connection. This document is intended to assist device manufacturers and related parties with the integration of this module into their host devices

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

2 Introduction

2.1 General Description

The ST60-2230C/ST60-2230-Q/ST60-2230C-SS/ST60-2230C-U/ST60-2230C-UU 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
- 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.

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.

There are two interfaces for WLAN function:

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

In addition, there are three interfaces for Bluetooth function:

- SDIO
- USB 2.0
- High-Speed UART

The ST60-2230C/ST60-2230C-Q/ST60-2230C-SS/ST60-2230C-U/ST60-2230C-UU module also provides a PCM interface for master or slave mode; with the option of an 8-bit or 16-bit width size.

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

- ST60-2230C – The interfaces are SDIO/UART (WLAN/Bluetooth) with the configuration setting 000.
- ST60-2230C-SS – The interfaces are SDIO/SDIO (WLAN/Bluetooth) with the configuration setting 001.
- ST60-2230C-U – The interfaces are USB/UART (WLAN/Bluetooth) with the configuration setting 100.
- ST60-2230C-UU – The interfaces are USB/USB (WLAN/Bluetooth) with the configuration setting 101.

2.2 Part Numbers and Supported Interfaces

The following (Table 1) are the ST60-2230C part numbers and the interfaces each supports.

Table 1: Part numbers and supported interfaces

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

3 Features Summary

The Ezurio ST60-2230C/ST60-2230C-Q/ST60-2230C-SS/ST60-2230C-U/ST60-2230C-UU device features are described in Table 2.

Table 2: ST60-2230C/ST60-2230C-Q/ST60-2230C-SS/ST60-2230C-U/ST60-2230C-UU of features

<table>
<tr><th>Feature</th><th>Description</th></tr>
<tr><td>Radio Front End</td><td>• Integrates the complete transmit/receive RF paths including band pass filter, diplexer, switches, reference crystal oscillator, and power manage unit (PMU)
• Supports 20/40/80 MHz channel bandwidth
• WLAN/Bluetooth share one antenna</td></tr>
<tr><td>Power Management</td><td>Dynamic Voltage Scaling (DVS) and Adaptive Voltage Scaling (AVS) feature supports the latest Marvell SoC and processor power control scheme.</td></tr>
<tr><td>Pre-Calibration</td><td>RF system-tested and calibrated in production.</td></tr>
<tr><td>Sleep Clock</td><td>An external sleep clock of 32.768 KHz is required during power save mode.</td></tr>
<tr><td>Host Interface</td><td>• SDIO 3.0 (4-bit and 1-bit), SDR 12/25/50 mode (up to 100MHz), USB 2.0 or PCIe for WLAN
• SDIO 3.0, USB 2.0, HS-UART for Bluetooth HCI (compatible with any upper layer Bluetooth stack)
• PCM digital audio interface for Bluetooth audio application.
<table>
<tr><th>Strap Value CONFIG_HOST[2-0]</th><th>WLAN</th><th>Bluetooth/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>100</td><td>USB 2.0</td><td>UART</td><td>Initial USB 2.0 PHY and COM PHY PCIe USB 2.0</td></tr>
<tr><td>101</td><td>USB 2.0</td><td>USB 2.0</td><td>Initial USB 2.0 PHY only</td></tr>
</table></td></tr>
<tr><td>Reference Frequency</td><td>• Incorporates a 40 MHz reference frequency source in package
• 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.</td></tr>
<tr><td>Advanced WLAN</td><td>• A-MPDU RX (de-aggregation) and TX (aggregation) supports 802.11ac single-MPDU A-MPDU
• Multi-BSS/Station
• Transmit rate adaption, transmit power control
• Modulation and coding scheme (MCS):
– 802.11ac—MCS0-9 Nsts=1 and 2
– 802.11n—MCS0-15
• 20/40/80 MHz channel bandwidths support
• On-chip gain selectable LNA with optimized noise figure and power consumption
• Internal PA with optimized gain distribution for linearity and noise performance
• Support Wild variety of WLAN encryption: TKIP/WEP/AES</td></tr>
<tr><td>Advanced Bluetooth</td><td>• Bluetooth 5.1
• Supports the following data rates: 1 Mbps (GFSK), 2 Mbps (π/4-DQPSK), 3 Mbps (8-DPSK)
• Digital audio interface with TDM interface for voice application
• Adaptive Frequency Hopping (AFH) using Package Error Rate (PER)
• Standard SDIO or UART HCI transport layer
• WLAN/Bluetooth coexistence protocol support
• Shared LNA with WLAN/Bluetooth
• Encryption (AES) support</td></tr>
</table>

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

Strap Value CONFIG_HOST[2-0]	WLAN	Bluetooth /BLE	ROM Notes
000	SDIO	UART	-
001	SDIO	SDIO	-
100	USB 2.0	UART	Initial USB 2.0 PHY *and* COM PHY PCIe USB 2.0
101	USB 2.0	USB 2.0	Initial USB 2.0 PHY only

Main Chip	Marvell 88W8997 (WLAN/BT); Marvell 88PG823 (PMU)
Input Voltage Requirements	DC 3.3 V ±10%
I/O Signalling Voltage	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	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 5.1
Wi-Fi Data Rates Supported	Support 802.11 ac/a/b/g/n 2X2 MIMO MMO/802.11ac 802.11b (DSSS, CCK) 1, 2, 5.5, 11 Mbps 802.11a/g (OFDM) 6, 9, 12, 18, 24, 36, 48, 54 Mbps 802.11n (OFDM, HT20/HT40, MCS 0-15) 802.11ac (OFDM, HT20, MCS0-8; OFDM HT40/HT80, MCS 0-9)
Modulation Table	BPSK, QPSK, CCK, 16-QAM, 64-QAM, and 256-QAM.

802.11ac / 802.11n	HT MCS Index	VHT MCS Index	Spatial Streams	Modulation	Coding	20 MHz		40 MHz		80 MHz	
						No SGI	SGI	No SGI	SGI	No SGI	SGI
	0	0	1	BPSK	1/2	6.5	7.2	13.5	15	29.3	32.5

Feature	Description										
	1	1	1	QPSK	1/2	13	14.4	27	30	58.5	65
	2	2	1	QPSK	3/4	19.5	21.7	40.5	45	87.8	97.5
	3	3	1	16-QAM	1/2	26	28.9	54	60	117	130
	4	4	1	16-QAM	3/4	39	43.3	81	90	175.5	195
	5	5	1	64-QAM	2/3	52	57.8	108	120	234	260
	6	6	1	64-QAM	3/4	58.5	65	121.5	135	263.3	292.5
	7	7	1	64-QAM	5/6	65	72.2	135	150	292.5	325
		8	1	256-QAM	3/4	78	86.7	162	180	351	390
		9	1	256-QAM	5/6	N/A	N/A	180	200	390	**433.3**
	8	0	2	BPSK	1/2	13	14.4	27	30	58.5	65
	9	1	2	QPSK	1/2	26	28.9	54	60	117	130
	10	2	2	QPSK	3/4	39	43.3	81	90	175.5	195
	11	3	2	16-QAM	1/2	52	57.8	108	120	234	260
	12	4	2	16-QAM	3/4	78	86.7	162	180	351	390
	13	5	2	64-QAM	2/3	104	115.6	216	240	468	520
	14	6	2	64-QAM	3/4	117	130.3	243	270	526.5	585
	15	7	2	64-QAM	5/6	130	144.4	270	300	585	650
		8	2	256-QAM	3/4	156	173.3	324	360	702	180
		9	2	256-QAM	5/6	N/A	N/A	360	400	780	**866.7**

802.11ac/n Spatial Streams	2 (2x2 MIMO)
Bluetooth Data Rates Supported	1, 2, 3 Mbps
Bluetooth Modulation	GFSK@ 1 Mbps 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		
Note: *Transmit power on each channel varies according to individual country regulations. All values are nominal with +/-2 dBm tolerance at room temperature.* *Tolerance could be up to +/-2.5 dBm across operating temperature.*	6 Mbps 54 Mbps	18 dBm (63 mW) 16 dBm (40 mW)
	1 Mbps 11 Mbps	18 dBm (63 mW) 18 dBm (63 mW)
	6 Mbps 54 Mbps	18 dBm (63 mW) 16 dBm (40 mW)
Note: *HT20 – 20 MHz-wide channels* *HT40 – 40 Mhz-wide channels*	6.5 Mbps (MCS0-5/MCS8-13;HT20) 65 Mbps (MCS6-7/MCS14-15;HT20) 13.5Mbps(MCS0-5/MCS8-13;HT40) 135Mbps (MCS6-7/MCS14-15;HT40)	18 dBm (63 mW) 16 dBm (40 mW) 16 dBm (40 mW) 14 dBm (25 mW)
	6.5/13 Mbps (MCS0-6;Ntst=1,2;HT20)	18 dBm (63 mW)

Feature	Description		
HT80 – 80 MHz-wide channels	78/156 Mbps (MCS7-8;Ntst=1,2;HT20)		16 dBm (40 mW)
	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)
	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 (PER < = 10%) ***Note:*** *All values nominal, +/-3 dBm. Sensitivity on CH13 (WLAN)/CH78 (BT) will decade up to 4-6dB.*	802.11a:		
	6 Mbps	-89 dBm	
	54 Mbps	-74 dBm	
	802.11b:		
	1 Mbps	-95 dBm	
	11 Mbps	-90 dBm	(PER < 8%)
	802.11g:		
	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	
	78 Mbps (MCS8;HT20)	-67 dBm	
	13.5 Mbps (MCS0;HT40)	-86 dBm	
	180 Mbps (MCS9;HT40)	-63 dBm	
	29.3 Mbps (MCS0;HT80)	-81 dBm	
	390/780 Mbps (MCS9;HT80)	-60 dBm	
	Bluetooth:		
	1 Mbps (1DH5)	-95 dBm	
	2Mbps (2DH5)	-94 dBm	
	3 Mbps (3DH5)	-88 dBm	
	BLE	-95 dBm	
Operating Systems Supported	Ezurio Linux		
	Android		

Feature	Description
Security	Standards Wireless Equivalent Privacy (WEP) Wi-Fi Protected Access (WPA) WPA2-Personal WPA2-Enterprise WPA3-Personal WPA3-Enterprise Encryption Wireless Equivalent Privacy (WEP, RC4 Algorithm) Temporal Key Integrity Protocol (TKIP, RC4 Algorithm) Advanced Encryption Standard (AES, Rijndael Algorithm) Encryption Key Provisioning Static (40-bit and 128-bit lengths) Pre-Shared (PSK) Dynamic 802.1X Extensible Authentication Protocol Types EAP-FAST, EAP-TLS, EAP-TTLS, PEAP-GTC, PEAP-MSCHAPv2, PEAP-TLS, LEAP **Note:** EAP types are supplicant software dependent.
Compliance	**EU** EN 300 328, EN 300 440, EN 301 489-1, EN 301 489-17, EN 301 893, 62311:2008, EN 50665:2017, EN 50385:2017, EU 2015/863 (RoHS 3) **FCC** 47 CFR FCC Part 15.247, 47 CFR FCC Part 15.407, 47 CFR FCC Part 2.1091, FCC Part 15 Subpart B Class B **ISED Canada** ICES-003, ANSI C63.4:2014, RSS-247 **AS/NZS** AS/NZS 2772.2:2011, AS/NZS 4268:2017 **MIC** ARIB STD-T66/RCR STD-33 (2.4 GHz), ARIB STD-T71 (5 GHz) **KC (Korea)** **SRRC (China)**
Certifications	*Bluetooth*® SIG Qualification
Warranty	One Year Warranty

All specifications are subject to change without notice

5 WLAN Functional Description

The ST60-2230C/ST60-2230C-Q/ST60-2230C-SS/ST60-2230C-U/ST60-2230C-UU M2 module is designed based on the 60-SIPT SiP. It is optimized for high-speed, reliable, and low-power embedded applications. It is integrated with dual-band WLAN (2.4 GHz/5 GHz) and Bluetooth 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 4.

Table 4: WLAN functions

Feature	Description
WLAN MAC	• Frame Exchange at the MAC level to deliver data • Received frame filtering and validation (Cyclic Redundancy Check (CRC)) • Generation of MAC header and trailer information (MAC protocol Data Units (MPDUs)) • Fragmentation of data frames (MAC Service Data Units (MSDUs) • Access Mechanism support for fair access to shared wireless medium through (DCF and EDCA) • A-MPDU Aggregation/Deaggregation (support 802.11ac single –MPDU A-MPDU) • 20/40/80 MHz channel Coexistence • RIFS Burst Receive • Management Information Base • Radio Resource Measurement • Quality of Service • Block Acknowledgement • 802.11ac MIMO • Dynamic Frequency Selection • TIM Frame TX and RX • Multi-BSS/Station • Transmit Rate Adaptation. • Transmit Power Control
WLAN Base Band	• 802.11ac 2x2 MIMO (with on-chip Marvell RF radio) • Backward compatibility with legacy 802.11 n/a/b/g technology • WLAN/Bluetooth LNA sharing • PHY rate up to 866.7Mbps • 20MHz bandwidth/channel, 40MHz bandwidth/channel, upper/lower 20MHz packets in 40MHz channel, 20MHz duplicate legacy packets in 40MHz channel operation • 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 • Modulation and Coding Scheme (MCS): 802.11 ac (MCS0-9. Nsts=1/2); 802.11n (MCS0-15) • 802.11 K Radio Resource Measurement • 802.11ac /802.11n optional MIMO features: – 20/40/80 MHz Coexistence with middle-packaged detection (GI detection) for enhanced CCA. – 1 spatial stream STBC reception and transmission – LDPC transmission and reception for 802.11ac and 802.11n – 256 QAM (MCS8-9) modulations supported – Short guard interval – RIFS on receive path for 802.11n packets – 802.11n Greenfield TX/RX • Power Save Feature
WLAN Security	WLAN Encryption features supported include: • Temporal Key Integrity Protocol (TKIP)/Wired Equivalent Privacy (WEP) • Advanced Encryption Standard (AES)/Counter-Mode/CBC-MAC Protocol (CCMP) • Advanced Encryption Standard (AES)/Cipher-Based Message Authentication Code (CMAC) • Advanced Encryption Standard (AES)/Galois/Counter Mode Protocol (GCMP) • WLAN Authentication and Private Infrastructure (WPAI)

6 Bluetooth Functional Description

The ST60-2230C/ST60-2230C-Q/ST60-2230C-SS/ST60-2230C-U/ST60-2230C-UU Bluetooth (BT) block is based on the 60-SIPT SiP that already has fully integrated Bluetooth baseband and radio. Several features and functions are listed in Table 5.

Table 5: Bluetooth functions

Feature	Description
Bluetooth Interface	Voice interface: • Hardware support for continual PCM data transmission/reception without processor overhead. • Standard PCM clock rates from 64 kHz to 2.048 MHz with multi-slot handshake and synchronization. • A-law, U-law, and linear voice PCM encoding/decoding. • SDIO interface • High-Speed UART interface • USB 2.0
Bluetooth Core functionality	• Bluetooth 5.1 • Bluetooth Class 1 • WLAN and Bluetooth share same LNA and antenna • Digital audio interfaces with TDM interface for voice application • Baseband and radio BDR and EDR package type: 1Mbps, 2Mbps, 3Mbps • Fully functional Bluetooth baseband: AFH, forward error correction, header error control, access code correction, CRC, encryption bit stream generation, and whitening • Adaptive Frequency Hopping (AFH) using Packet Error Rate (PER) • Interlaced scan for faster connection setup • Simultaneous active ACL connection setup • Automatic ACL package type selection • Full master and slave piconet support • Scatter net support • SCO/eSCO links with hardware accelerated audio signal processing and hardware supported PPEC algorithm for speech quality improvement • All standard SCO/eSCO voice coding • All standard pairing, authentication, link key, and encryption operations • Encryption (AES) support
Bluetooth Low Energy (BLE) Core functionality	• Advertiser, Scanner, Initiator, Master, and Slave roles support (connects up to 16 links) • WLAN/Bluetooth Coexistence (BCA) protocol support • Shared RF with BDR/EDR • Encryption (AES) support • Intelligent Adaptive Frequency Hopping (AFH) • LE privacy 1.2 • LE Secure Connection • LE Data Length Extension • LE Advertising Length Extension • 2 Mbps LE

7 Block Diagram

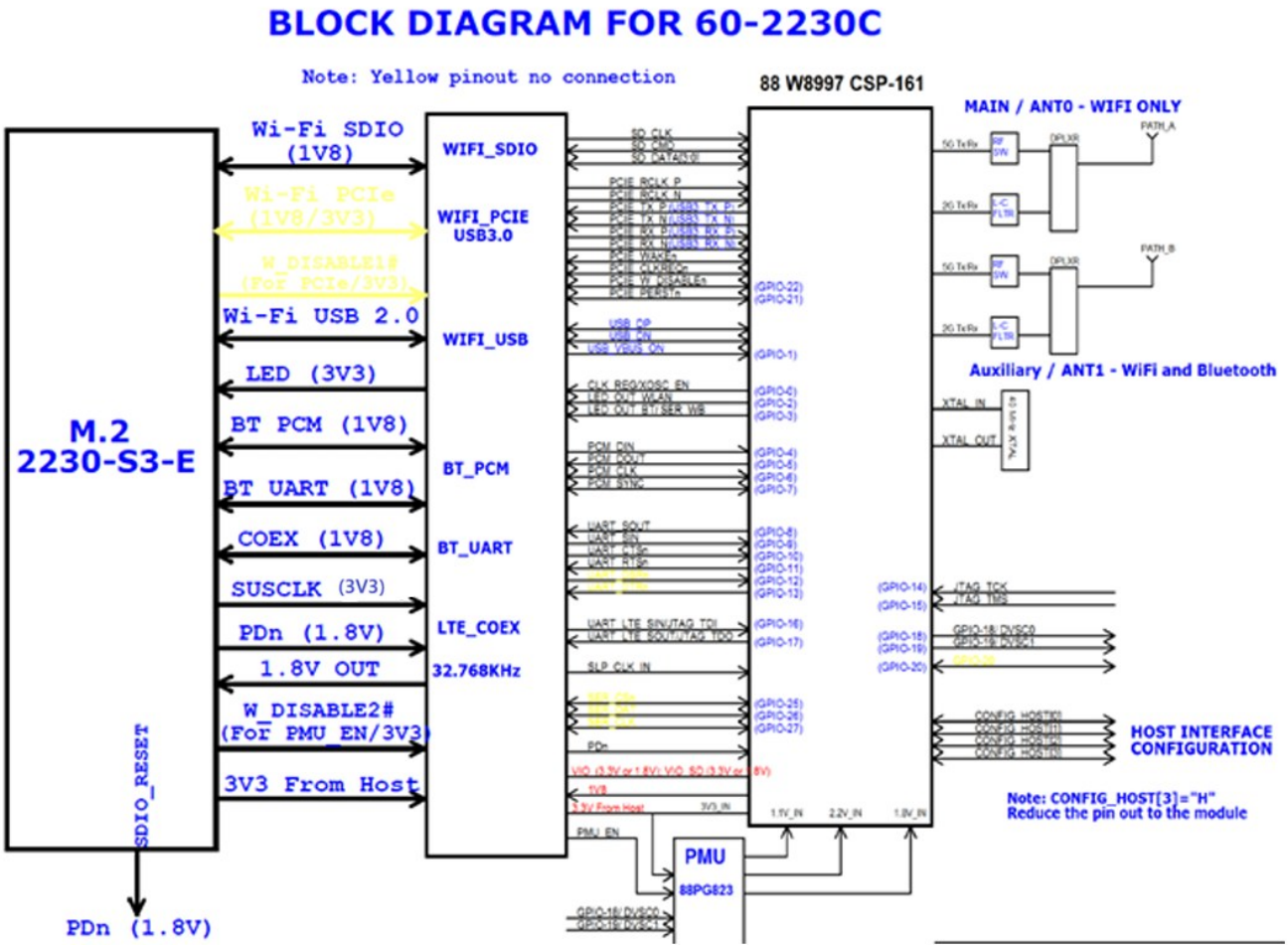


Figure 1: Block Diagram of ST60-2230C/ST60-2230C-Q/ST60-2230C-SS/ST60-2230C-U/ST60-2230C-UU

8 Electrical Characteristics

8.1 Absolute Maximum Ratings

Table 6 summarizes the absolute maximum ratings and Table 7 lists the recommended operating conditions for the ST60-2230C/ST60-2230C-Q/ST60-2230C-SS/ST60-2230C-U/ST60-2230C-UU. Absolute maximum ratings are those values beyond which damage to the device can occur. Functional operation under these conditions, or at any other condition beyond those indicated in the operational sections of this document, is not recommended.

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

Table 6: Absolute maximum ratings

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

8.2 Recommended Operating Conditions

Table 7: Recommended Operating Conditions

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

8.3 DC Electrical Characteristics

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

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

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

8.4 WLAN Radio Receiver Characteristics

Table 9 and Table 10 summarize the WLAN ST60-2230C/ST60-2230C-Q/ST60-2230C-SS/ST60-2230C-U/ST60-2230C-UU receiver characteristics.

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Frx	Receive input frequency range		2.412		2.484	GHz
Srf	Sensitivity					
	CCK, 1 Mbps	See Note 1		-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 1		TBD		dB
	OFDM, 54 Mbps			TBD		
	HT20, MCS0			TBD		
	HT20, MCS7			TBD		

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Frx	Receive input frequency range		5.15		5.825	GHz
Srf	Sensitivity					
	OFDM, 6 Mbps	See Note 1		-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 1		TBD		dB
	OFDM, 54 Mbps			TBD		
	HT20, MCS0			TBD		
	HT20, MCS7			TBD		

Note 1: Performance data are measured under signal chain operation.

8.5 WLAN Transmitter Characteristics

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Ftx	Transmit output frequency range		2.412		2.484	GHz
Pout	Output power	See Note 1				
	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 ℃	-	-	+ 2.0		dB

Freq.	Mode/Rate (Mbps)	Output Power Per Chain (dBm)	Max. Current Consumption	
			Single Chain (mA)[8]	Dual Chains (mA)[8]
2412 MHz	1 Mbps	18 dBm	340	620
	54 Mbps	16 dBm	280	500
	HT20 MCS7	16 dBm	280	510
2442 MHz	1 Mbps	18 dBm	340	620
	54 Mbps	16 dBm	280	500
	HT20 MCS7	16 dBm	280	510
2472 MHz	1 Mbps	18 dBm	340	620
	54 Mbps	16 dBm	280	500
	HT20 MCS7	16 dBm	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
P_{out}	Output power	See Note 2			2.5 (MIMO) 1.5 (SISO)	Watts
	11a mask compliant	6-36Mbps		18		dBm
	11a EVM compliant	48-54Mbps		16		
	11n HT20 mask compliant	MCS0-5/MCS8-13		18		
	11n HT20 EVM compliant	MCS6-7/MCS14-15		16		
	11n HT40 mask compliant	MCS0-5/MCS8-13		16		
	11n HT40 EVM compliant	MCS6-7/MCS14-15		16		
	11ac HT20 mask compliant	MCS0-6 (Ntst=1,2)		18		
	11ac HT20 EVM compliant	MCS7-8(Ntst=1,2)		16		
	11ac HT40 mask compliant	MCS0-5 (Ntst=1,2)		16		
	11ac HT40 EVM compliant	MCS6-9(Ntst=1,2)		14		
	11ac HT80 mask compliant	MCS0-5 (Ntst=1,2)		14		
	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 ℃	-	-	+ 2.0		dB

Note 2 Final TX power values on each channel are limited by the regulatory certification test limit.

Freq.	Mode/Rate [Mbps]	Output Power Per Chain [dBm]	Max. Current Consumption	
			Single Chain (mA)[8]	Dual Chains (mA)[8]
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

9 Bluetooth Radio Characteristics

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

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

Test Parameter		Min	Typ	Max	BT Spec.	Unit
Maximum RF Output Power		8	10	11	0 ~ +20	dBm
Frequency Range		2.4	—	2.4835	2.4 ≤ f ≤ 2.4835	GHz
20 dB Bandwidth		—	919.5	—	≤ 1000	KHz
Δf1avg Maximum Modulation		140	165	175	140 < Δf1avg < 175	KHz
Δf2max Minimum Modulation		—	135	—	≥ 115	KHz
Δf2avg/Δf1avg		—	0.9	—	≥ 0.80	—
Initial Carrier Frequency		—	+/-5	—	≤±75	KHz
Drift Rate (DH1 package)		—	4	—	≤ 20	KHz/50 µs
Drift (DH3 packet)		—	8	—	≤25	KHz
Drift (DH5 packet)		—	7	—	≤ 40	KHz
Adjacent Channel Power	F≥ ± 3MHz	—	-50	—	< -40	dBm
	F = ± 2MHz	—	-46	—	≤ -20	dBm
	F = ± 1MHz	—	-15	—	N/A	dBm

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

Test Parameter		Min	Typ	Max	BT Spec.	Unit
Relative Transmit Power		5	7	9		dBm
Max Carrier Frequency Stability Iwol	2-DH5	—	1	—	≤ ±10	KHz
	3-DH5	—	1	—		
Max Carrier Frequency Stability Iwil	2-DH5	—	4	—	≤ ±75	KHz
	3-DH5	—	4	—		
Max Carrier Frequency Stability Iw0+wil	2-DH5	—	5	—	≤ ±75	KHz
	3-DH5	—	5	—		
RMS DEVM	2-DH5	—	4	—	≤ 20	%
	3-DH5	—	4	—	≤13	%
Peak DEVM	2-DH5	—	9	—	≤ 35	%
	3-DH5	—	9	—	≤ 25	%
99% DEVM	2-DH5	—	12	—	≤ 30	%
	3-DH5	—	12	—	≤ 20	%
EDR Differential Phase Encoding		—	99	—	≥ 99	%
Adjacent Channel Power	F≥ ± 3MHz	—	TBD	—	< -40	dBm
	F = ± 2MHz	—	TBD	—	≤ -20	dBm

Table 14: Basic rate receiver performance at 1.8V

Test Parameter		Min	Typ	Max	BT Spec.	Unit
Sensitivity (1DH5)	BER ≤ 0.1%	—	-95	-92	≤ -70	dBm
Maximum Input	BER ≤ 0.1%	-20	-10	—	≥ -20	dBm

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

Table 15: Enhanced data rate receiver performance 1.8V

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

10 SDIO Timing Requirements

The ST60-2230C/ST60-2230C-Q/ST60-2230C-SS SDIO host interface pins are powered from the VIO_SD voltage supply. The SDIO electrical specifications are identical for the 1-bit SDIO and 4-bit SDIO modes.

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

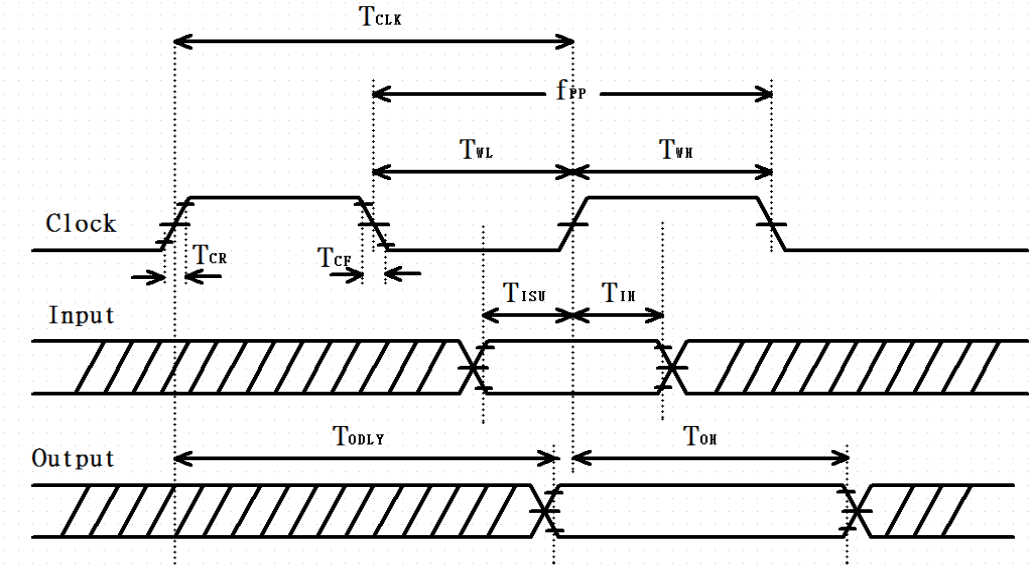


Figure 2:SDIO protocol timing Diagram--- SDR12, SDR25, SDR50 modes (up to 100 MHz) (1.8V)

Table 16: SDIO timing requirements--- SDR12, SDR25, SDR50 modes (up to 100 MHz) (1.8V)

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

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
fPP	Clock Frequency		25	-	100	MHz
TISU	Input setup time	SDR12/25/50	3	--	-	ns
TIH	Input Hold time		0.8	-	-	ns
TCLK	Clock Time	SDR12/25/50	10	-	40	ns
TCR,TCF	Raise time, Fall time TCR,TCF＜2ns (max) at 100 MHz CCARD=10pF		-	-	0.2*TCLK	ns
TODLY	Output delay time CL≦30pF	SDR12/25/50	-	-	7.5	ns
TOH	Output hold time CL=15pF		1.5	-	-	ns

10.2 SDR104 Mode (208 MHz) (1.8V)

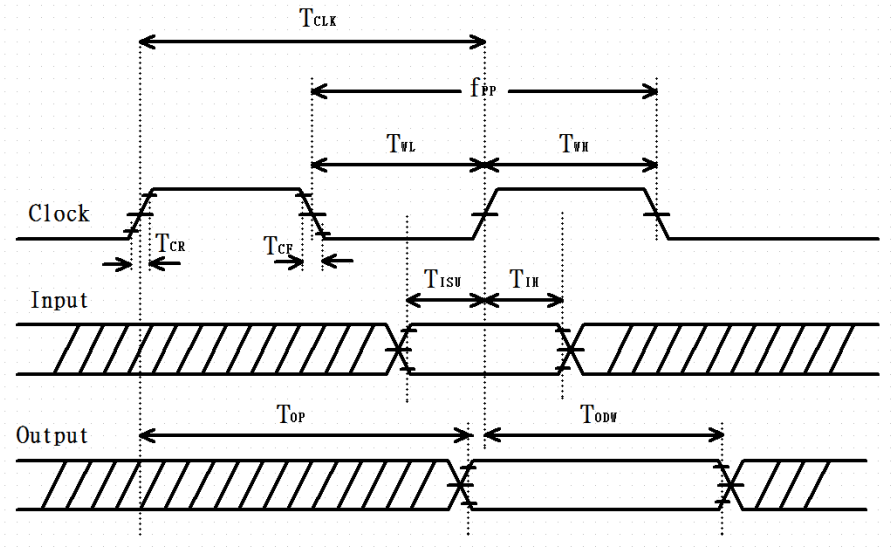


Figure 3: SDIO protocol timing Diagram--- SDR104 modes (up to 208 MHz) (1.8V)

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

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

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

10.3 DDR50 Mode (50 MHz) (1.8V)

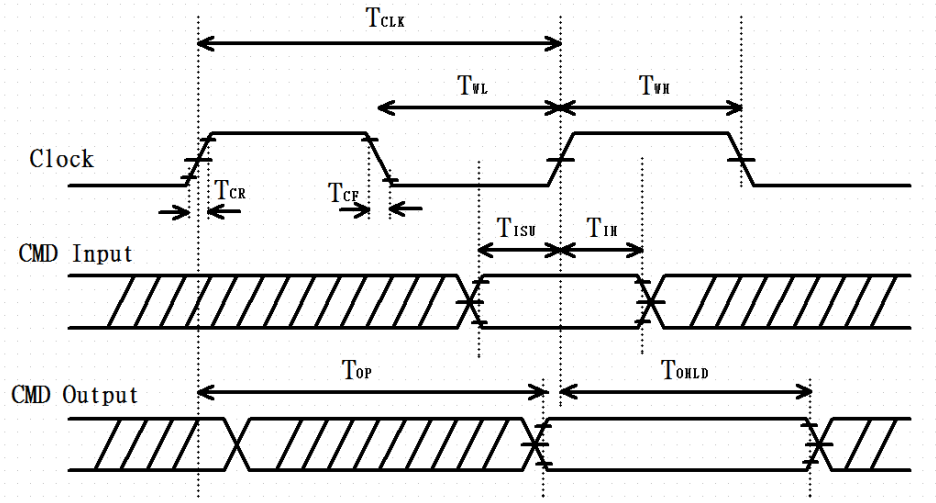


Figure 4: SDIO CMD timing Diagram--- DDR50 modes (50 MHz) (1.8V)

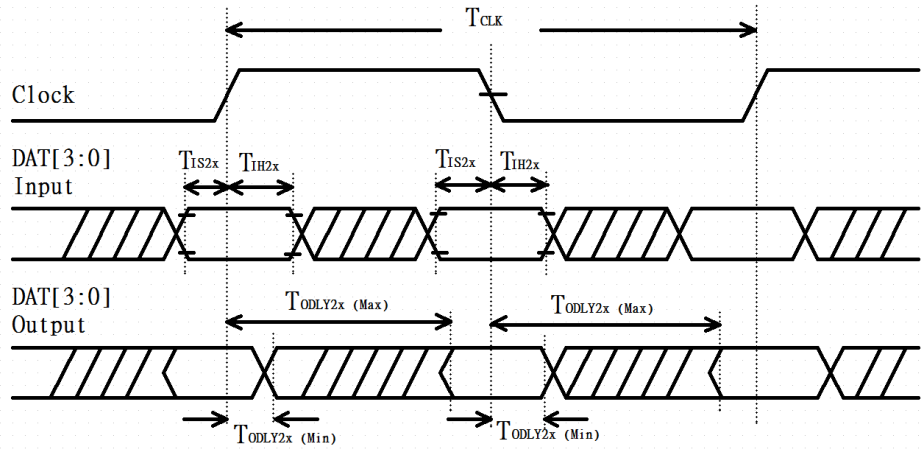


Figure 5: SDIO DAT[3:0] timing Diagram--- DDR50 modes (50 MHz) (1.8V)

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

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

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
Clock						
TCLK	Clock time 50MHz (max) between rising edge	DDR50	20	--	--	ns
TCR, TCF	Rise time, fall time TCR, TCF ‹4.00ns (max) at 50MHz. CCARD=10pF		--	--	0.2*TCLK	ns
Clock Duty	--	DDR50	45	--	55	%
CMD Input (referenced to clock rising edge)						
TIS	Input setup time CCARD≦10pF (1 card)	DDR50	6	--	--	ns

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
TIH	Input hold time CCARD≦10pF (1 card)		0.8	--	--	ns
CMD Output (referenced to clock rising and failing edge)						
TODLY	Output delay time during data transfer mode CL≦30pF (1card)		--	--	13.7	ns
TOHLD	Output hold time CL≥15pF (1 card)	DDR50	1.5	--	--	ns
DAT[3:0] Input (referenced to clock rising and failing edges)						
TIS2X	Input setup time CCARD≦10pF (1 card)	DDR50	3	--	--	ns
TIH2X	Input hold time CCARD≦10pF (1 card)		0.8	--	--	ns
DAT[3:0] Output (referenced to clock rising and failing edges)						
TODLY2X (max)	Output delay time during data transfer mode CL≦25pF (1card)		--	--	7.0	ns
TODLY2X (min)	Output hold time CL≥15pF (1 card))	DDR50	1.5	--	--	ns

11 USB Specifications

11.1 USB LS Driver and Receiver Parameters

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

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

Table 16: USB LS Driver and Receiver Specifications

Symbol	Parameter	Min.	Typ.	Max.	Unit
BR	Baud rate	-	1.5	-	Mbps
BRPPM	Baud rate tolerance	-15000	-	15000	ppm
Driver Specifications					
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 raise 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	%

Symbol	Parameter	Min.	Typ.	Max.	Unit
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
Receiver Specifications					
VIH	Input signal ended high	2.0	-	-	V
VIL	Input signal ended low	-	-	0.8	V
VDI	Differential input sensitivity	0.2	-	-	V

11.2 USB FS Driver and Receiver Parameters

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

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

Table 17: USB FS Driver and Receiver Specifications

Symbol	Parameter	Min.	Typ.	Max.	Unit
BR	Baud rate	-	12.0	-	Mbps
BRPPM	Baud rate tolerance	-2500	-	2500	ppm
Driver Specifications					
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

Symbol	Parameter	Min.	Typ.	Max.	Unit
Receiver Specifications					
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 18: USB HS Driver and Receiver Specifications

Symbol	Parameter	Min.	Typ.	Max.	Unit
BR	Baud rate	-	480	-	Mbps
BRPPM	Baud rate tolerance	-500	-	500	ppm
Driver Specifications					
VHSOH	Data signal high	360	-	440	mV
VHSOL	Data signal low	-10	-	10	mV
THSR	Data rise time 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
Receiver Specifications					
VHSCM	Input signal ended low	-50	-	500	mV

12 PCM Interface Specifications

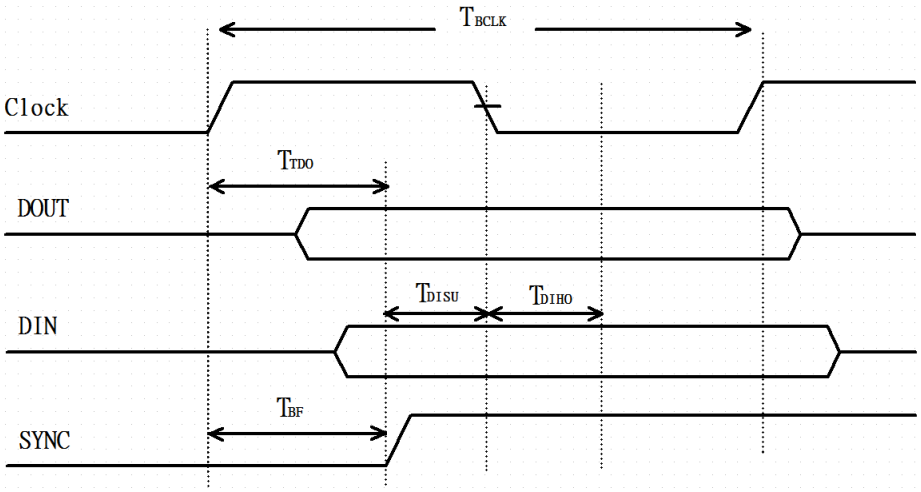


Figure 6: PCM Timing Specification – Master Mode

Table 19:PCM Timing Specification – Master Mode

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

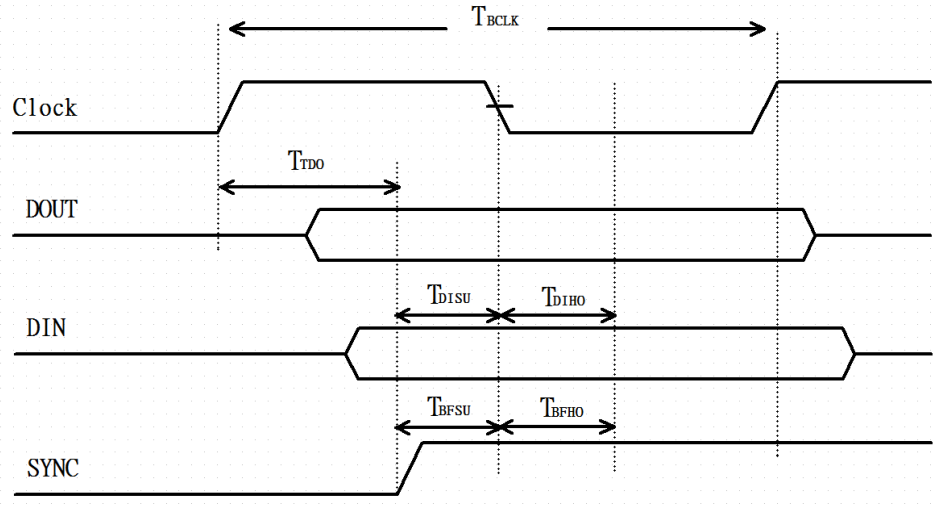


Figure 7: PCM timing specification – slave mode

Table 20: PCM timing specification – slave mode

Symbol	Parameter	Min.	Typ.	Max.	Unit
FBCLK	-	-	2/2.048	-	MHz
Duty CycleBCLK	-	0.4	0.5	0.6	-

Symbol	Parameter	Min.	Typ.	Max.	Unit
TBCLK rise/fall	-	-	3	-	ns
TDO	-	-	-	30	ns
TDISU	-	15	-	-	ns
TDIHO	-	10	-	-	ns
TBFSU	-	15	-	-	ns
TBFHO	-	10	-	-	ns

13 Pin Definitions

Table 21: Pin definitions

Pin #	Name	Type	Voltage Ref.	Description	If Not Used
1	GND	-	-	Ground	GND
2	3.3V	Power	-	3.3V module power supply	-
3	USB_D+	I/O	3.3V	USB Differential Data-Positive	N/C
4	3.3V	Power	-	3.3V module power supply	-
5	USB_D-	I/O	3.3V	USB Differential Data-Negative	N/C
6	LED1#	O,PU	3.3V	LED indicator for WLAN with 10mA drive capability	N/C
7	GND	-	-	Ground	GND
8	PCM_CLK	I/O	1.8V	PCM Clock Signal (Optimal) Optimal clock used for some codecs. Output if Master mode; Input if Slave mode.	N/C
9	SDIO CLK	I,PU	1.8V	SDIO 4-bit Mode Clock Input	N/C
10	PCM_SYNC	I/O	1.8V	PCM Sync Pulse Signal Output if Master mode; Input if Slave mode.	N/C
11	SDIO CMD	I/O	1.8V	SDIO 4-bit Mode Command/Response	N/C
12	PCM_OUT	O	1.8V	PCM Data	N/C
13	SDIO DATA0	I/O,PU	1.8V	SDIO 4-bit Mode DATA line Bit[0]	N/C
14	PCM_IN	I	1.8V	PCM Data	N/C
15	SDIO DATA1	I/O,PU	1.8V	SDIO 4-bit Mode DATA line Bit[1]	N/C
16	LED2#	N/C	N/C	N/C	N/C
17	SDIO DATA2	I/O,PU	1.8V	SDIO 4-bit Mode DATA line Bit[2]	N/C
18	GND	-	-	Ground	GND
19	SDIO DATA3	I/O,PU	1.8V	SDIO 4-bit Mode DATA line Bit[3]	N/C
20	UART WAKE#	O	3.3V	Reserved for BT to wakeup Host	N/C
21	SDIO WAKE#	O	1.8V	Reserved for Wake-On-WLAN	N/C
22	UART TXD	O	1.8V	UART Serial Data Output	N/C
23	SDIO RESET#	N/C	N/C	N/C	N/C
32	UART RXD	I	1.8V	UART Serial Data Input	N/C
33	GND	-	-	Ground	GND
34	UART RTS	O,WPU	1.8V	UART Request To Send (Active low)	N/C
35	PERp0	N/C	1.8V	PCIe Receive Data-Positive	N/C

Pin #	Name	Type	Voltage Ref.	Description	If Not Used
36	UART CTS	I, PU	1.8V	UART Clear To Send (Active low)	N/C
37	PERn0	N/C	1.8V	PCIe Receive Data-Negative	N/C
38	VENDOR DEFINED38	N/C	N/C	N/C	N/C
39	GND	-	-	Ground	GND
40	VENDOR DEFINED40	N/C	N/C	N/C	N/C
41	PETp0	N/C	1.8V	PCIe Transmit Data-Positive	N/C
42	VENDOR DEFINED42	N/C	N/C	N/C	N/C
43	PETn0	N/C	1.8V	PCIe Transmit Data-Negative	N/C
44	COEX3	I/O	1.8V	General purpose I/O pin.	N/C
45	GND	-	-	Ground	GND
46	COEX2	O,PD	1.8V	Serial data to external LTE device/	N/C
47	REFCLKp0	N/C	1.8V	PCIe Differential Clock input-Positive	N/C
48	COEX1	I,PD	1.8V	Serial data from external LTE device/	N/C
49	REFCLKn0	N/C	1.8V	PCIe Differential Clock input-Negative	N/C
50	SUSCLK(32KHz)	I,PU	3.3V	Sleep Clock Input An external sleep clock of 32.768KHz with minimum +/-250ppm is required for power saving mode	-
51	GND	-	-	Ground	GND
52	PERST0#	N/C	3.3V	PCIe host indication to reset the device (input) (active low)	N/C
53	CLKREQ0#	N/C	3.3V	PCIe clock request (input/output) (active low)	N/C
54	W_DISABLE2#	N/C	3.3V	N/C	N/C
55	PEWAKE0#	N/C	3.3V	PCIe wake signal (input/output) (active low)	N/C
56	W_DISABLE1# (0/3.3V)	I,PU	3.3V	Enable input for all Regulators inside the 60-SIPT. Note: This pin should be connected to a system GPIO to allow the module to be reset under software control.	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)	I	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/CLKREQ1#	N/C	N/C	N/C	N/C
69	GND	-	-	Ground	GND
70	UIM_POWER_SRC/GPIO1/PEWAKE1#	N/C	N/C	N/C	N/C

Pin #	Name	Type	Voltage Ref.	Description	If Not Used
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/ST60-2230C-Q/ST60-2230C-SS/ST60-2230C-U/ST60-2230C-UU are 22 mm x 30 mm x 2.66 mm. Detail drawings are shown in Figure 8.

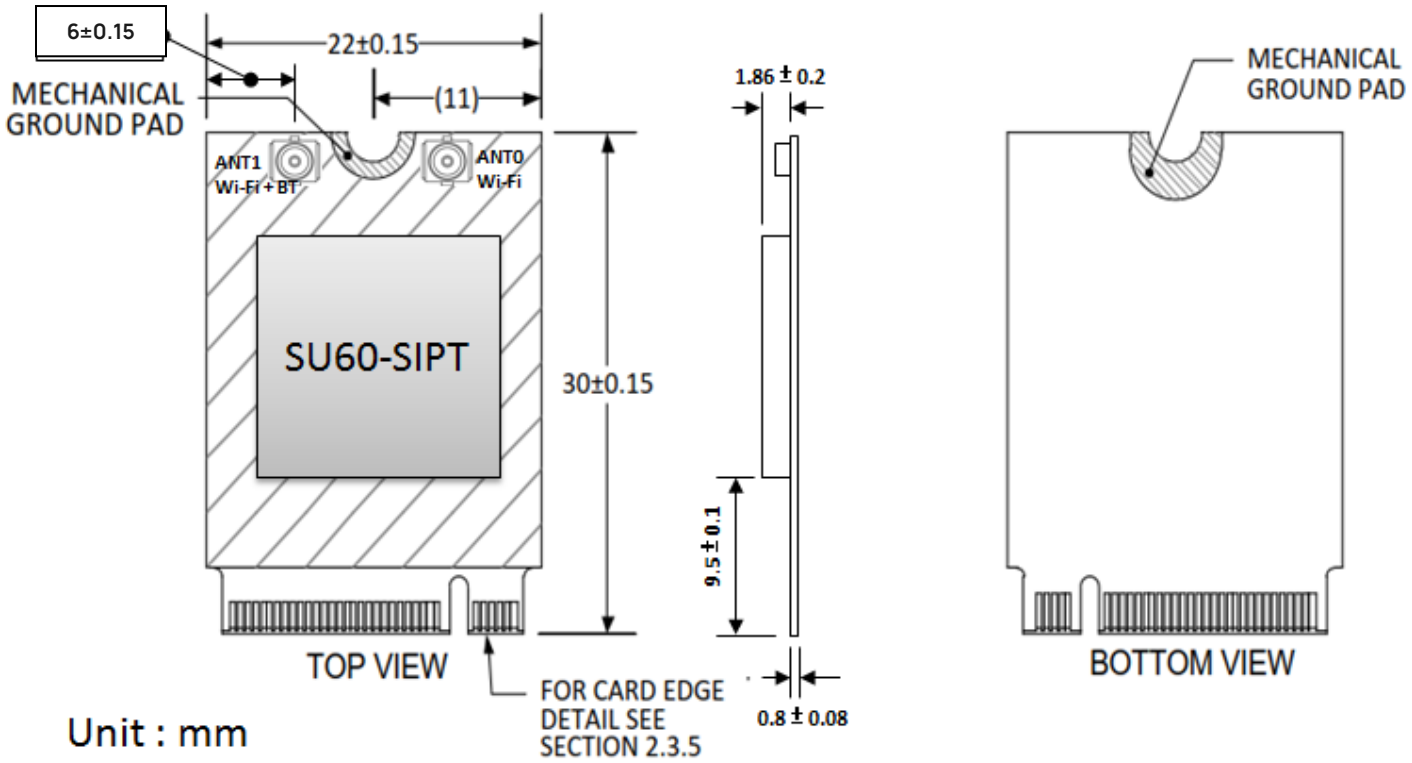


Figure 8: Module dimension of ST60-2230C/ST60-2230C-Q/ST60-2230C-SS/ST60-2230C-U/ST60-2230C-UU

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

The last digit of Wi-Fi MAC address is assigned to either *0*, *4*, *8*, or *C*.

The BT MAC address is the Wi-Fi MAC address plus 3.

15 Mounting

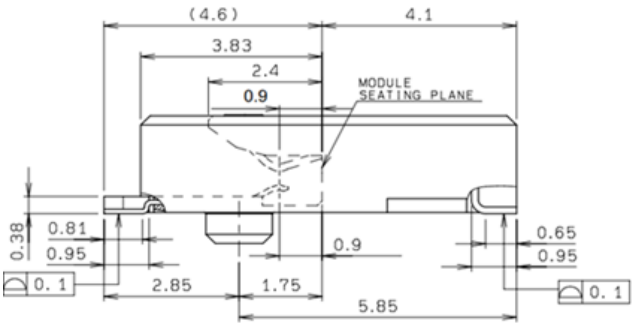
The ST60-2230C/ST60-2230C-Q/ST60-2230C-SS/ST60-2230C-U/ST60-2230C-UU connects to the host via a standard PCI EXPRESS M2 connector. The Kyocera's (www.Kyocera-connector.com) 6411 series provide 1.8 mm, 2.3 mm, and 3.2 mm connector heights and JAE's (https://www.jae.com/en/) SM3 series provide 1.2 mm,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

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

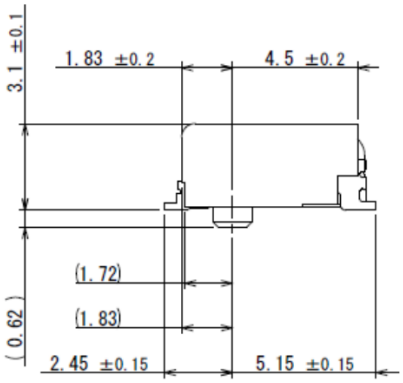
M.2 Key-E Connector	Connector Height
KYOCERA 24-6411-067-101-894E	2.3 mm
JAE SM3ZS067U310AERxxxx	3.1 mm

The stand-off mating to the recommend 2.3 mm connector from EMI STOP (www.EMISTOP.com) is part number **F50M16-041525P1D4M** and 3.1 mm 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

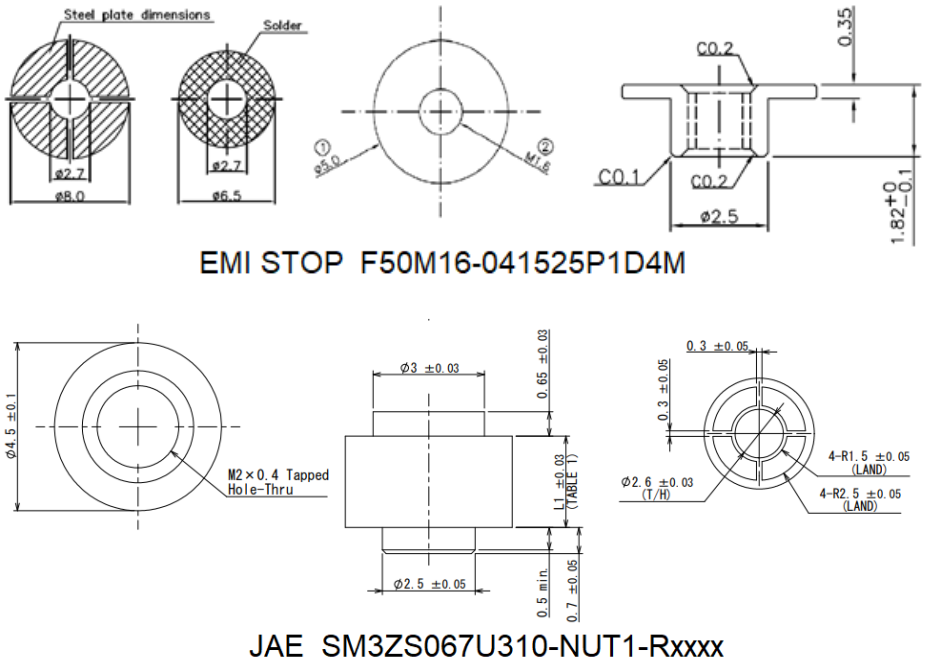


Figure 9: Mounting information of the ST60-2230C/ST60-2230C-Q/ST60-2230C-SS/ST60-2230C-U/ST60-2230C-UU and recommended layout pattern for the stand-off

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 for more information.

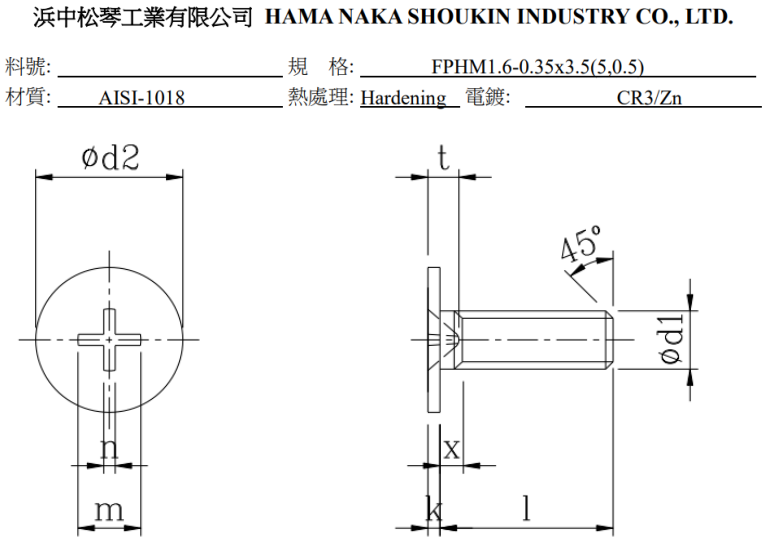


Figure 10: Mechanical drawing of FPH M1.6-0.35x3.5(5,0.5)CR3-Zn

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/handing/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

Note: For complete regulatory information, refer to the 60-2230C Regulatory Information document which is also available from the 60-2230C product page.

The ST60-2230C holds current certifications in the following countries:

Country/Region	Regulatory ID
USA (FCC)	SQG-60SIPT
EU	N/A
Canada (ISED)	3147A-602230C
Japan (MIC)	003-170090
Taiwan (NCC)	CCAF23Y10200T7
Korea (KC)	MSIP-CRM-LAI-60-2230C
Australia	N/A
New Zealand	N/A
China (SRRC)	2017DJ2473

18 Ordering Information

Part Number	Description
ST60-2230C	2X2 802.11 ac + Bluetooth 5.1 SDIO/UART M.2 module
ST60-2230C	2X2 802.11 ac + Bluetooth 5.1 SDIO/UART M.2 module, Q variant
ST60-2230C-SS	2X2 802.11 ac + Bluetooth 5.1 SDIO/SDIO M.2 module
ST60-2230C-U	2X2 802.11 ac + Bluetooth 5.1 USB/UART M.2 module
ST60-2230C-UU	2X2 802.11 ac + Bluetooth 5.1 USB/USB M.2 module
DVK-ST60-2230C	Development Board, ST60-2230C

19 Additional Information

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

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

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

Ezurio's products are subject to standard Terms & Conditions.