

Datasheet

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

Version 1.26

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 Pin Definitions	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 Specifications	Dave Drogowski	Andrew Chen
1.26	3 Aug 2022	Updated dimensions of module in Mechanical Specifications Added recommendation for Mounting screw	Dan Kephart	Andrew Chen

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1 SCOPE

This document describes key hardware aspects of the Laird Connectivity 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 Laird Connectivity 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



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

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

Feature	Description				
Radio Front End	- 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				
Coexistence	Coexistence arbitration for WLAN, Bluetooth, and LTE operation				
Power Management	Dynamic Voltage Scaling (DVS) and Adaptive Voltage Scaling (AVS) feature supports the latest Marvell SoC and processor power control scheme.				
Pre-Calibration	RF system-tested and calibrated in production.				
Sleep Clock	An external sleep clock of 32.768 KHz is required during power save mode.				
Host Interface	- PCIe V2.0 Gen 1/Gen 2 for WLAN - USB 2.0, HS-UART for Bluetooth HCI (compatible with any upper layer Bluetooth stack) - PCM digital audio interface for Bluetooth audio application.				
	Strap Value CONFIG_HOST[2-0]		WLAN	Bluetooth/BLE	ROM Notes
	010		PCIe	USB 2.0	-
	011		PCIe	UART	-
Reference Frequency	- 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.				
Advanced WLAN	- 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				
Advanced Bluetooth	- Bluetooth 5.1 (BDR/EDR/LE), Bluetooth Class 1 - Bluetooth 5 ready - Supports the following data rates: 1 Mbps (GFSK), 2 Mbps (π/4-DQPSK), 3 Mbps (8-DPSK) - Digital audio interface with PCM/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				

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			
	Strap Value CONFIG_HOST[2-0]	WLAN	Bluetooth/ BLE	ROM Notes
	010	PCIe	USB 2.0	-
	011	PCIe	UART	-
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%			
Peak Current consumption, VCC= 3.3 volts VIO= 1.8 volts (At maximum transmit power setting) (Measured transmit current under 99% duty cycle) <i>Note: Reset refers to the radio are in reset, both Wi-fi and BT reset are asserted.</i>	MIMO 2x 2 operations. 802.11b (with BT in standby) @ 18 dBm 1 Mbps Transmit: 1050 mA Receive: 520 mA 802.11g (with BT in standby) @ 18 dBm 6 Mbps Transmit: 980 mA Receive: 520 mA 802.11a (with BT in standby) @ 18 dBm 6 Mbps Transmit: 1100 mA Receive: 580 mA 802.11n (2.4 GHz/40 MHz) (with BT in standby) @ 16 dBm MCS0 Transmit: 850 mA Receive: 520 mA 802.11n (5.0 GH/40 MHz) (with BT in standby) @ 16 dBm MCS0 Transmit: 900 mA Receive: 600 mA 802.11ac (5.0 GH/80 MHz) (with BT in standby) @ 14 dBm MCS0 Transmit: 850 mA Receive: 600 mA Bluetooth (with Wi-Fi in standby) Transmit: 120 mA Receive: 100 mA Reset: 90 mA			
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)			

Feature	Description											
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 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	
	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										

Feature	Description
Bluetooth Modulation	GFSK@ 1 Mbps Pi/4-DQPSK@ 2 Mbps 8-DPSK@ 3 Mbps
Regulatory Domain Support	FCC EU ISED (Canada) MIC (Japan) KC (Korea)
2.4 GHz Frequency Bands	EU: 2.4 GHz to 2.483 GHz FCC: 2.4 GHz to 2.473 GHz MIC: 2.4 GHz to 2.495 GHz KC: 2.4 GHz to 2.483 GHz
2.4 GHz Operating Channels (Wi-Fi)	EU: 13 (3 non-overlapping) FCC: 11 (3 non-overlapping) MIC: 14 (4 non-overlapping) KC: 13 (3 non-overlapping)
5 GHz Frequency Bands	EU 5.15 GHz to 5.35 GHz (Ch 36/40/44/48/52/56/60/64) 5.47 GHz to 5.725 GHz (Ch 100/104/108/112/116/120/124/128/132/136/140) 5.725 GHz to 5.825 GHz(Ch 149/153/157/161/165) FCC 5.15 GHz to 5.35 GHz (Ch 36/40/44/48/52/56/60/64) 5.47 GHz to 5.725 GHz (Ch 100/104/108/112/116/120/124/128/132/136/140/144) 5.725 GHz to 5.825 GHz(Ch 149/153/157/161/165) MIC 5.15 GHz to 5.35 GHz (Ch 36/40/44/48/52/56/60/64) 5.47 GHz to 5.725 GHz (Ch 100/104/108/112/116/120/124/128/132/136/140) KC 5.15 GHz to 5.35 GHz (Ch 36/40/44/48/52/56/60/64) 5.47 GHz to 5.725 GHz (Ch 100/104/108/112/116/120/124) 5.725 GHz to 5.825 GHz (Ch 149/153/157/161/165)
5 GHz Operating Channels (Wi-Fi)	EU: 24 non-overlapping; FCC: 25 non-overlapping MIC: 19 non-overlapping; KC: 20 non-overlapping
Transmit Power	802.11a 6 Mbps 18 dBm (63 mW) 54 Mbps 16 dBm (40 mW) 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) 135Mbps (MCS6-7/MCS14-15;HT40) 14 dBm (25 mW) 802.11ac (5 GHz) 6.5/13 Mbps (MCS0-6;Ntst=1,2;HT20) 18 dBm (63 mW)

Feature	Description	
HT40 – 40 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)
HT80 – 80 MHz-wide channels	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 (PER <= 10%)	802.11a: 6 Mbps 54 Mbps	-89 dBm -74 dBm
Note: All values nominal, +/-3 dBm.	802.11b: 1 Mbps 11 Mbps	-95 dBm -90 dBm
Sensitivity on CH13 (WLAN)/CH78 (BT) will degrade up to 4-6dB.	802.11g: 6 Mbps 54 Mbps	-91 dBm -75 dBm
	802.11n (2.4 GHz) 6.5 Mbps (MCS0;HT20) 65 Mbps (MCS7;HT20) 13.5Mbps(MCS0;HT40) 135Mbps (MCS7;HT40)	-91 dBm -73 dBm -85 dBm -70 dBm
	802.11n (5 GHz) 6.5 Mbps (MCS0;HT20) 65 Mbps (MCS7;HT20) 13.5Mbps(MCS0;HT40) 135Mbps (MCS7;HT40)	-89 dBm -70 dBm -86 dBm -69 dBm
	802.11ac (5 GHz) 6.5 Mbps (MCS0;HT20) 78 Mbps (MCS8;HT20) 13.5 Mbps (MCS0;HT40) 180 Mbps (MCS9;HT40) 29.3 Mbps (MCS0;HT80) 390/780 Mbps (MCS9;HT80)	-89 dBm -67 dBm -86 dBm -63 dBm -81 dBm -60 dBm
	Bluetooth: 1 Mbps (1DH5) 2Mbps (2DH5) 3 Mbps (3DH5) BLE	-95 dBm -94 dBm -88 dBm -95 dBm
Operating Systems Supported	Linux Kernel 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 <table> <tr> <td>EAP-FAST</td><td>PEAP-MSCHAPv2</td></tr> <tr> <td>EAP-TLS</td><td>PEAP-TLS</td></tr> <tr> <td>EAP-TTLS</td><td>LEAP</td></tr> <tr> <td>PEAP-GTC</td><td></td></tr> </table> Note: EAP types are supplicant software dependent.	EAP-FAST	PEAP-MSCHAPv2	EAP-TLS	PEAP-TLS	EAP-TTLS	LEAP	PEAP-GTC	
EAP-FAST	PEAP-MSCHAPv2								
EAP-TLS	PEAP-TLS								
EAP-TTLS	LEAP								
PEAP-GTC									
Compliance	<table> <tr> <td> EU EN 300 328 EN 300 440 EN 301 489-1 EN 301 489-17 EN 301 893 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 AS/NZS AS/NZS 2772.2:2011 AS/NZS 4268:2017 KC (Korea) </td><td> 62311:2008 EN 50665:2017 EN 50385:2017 EU 2015/863 (RoHS 3) ISED Canada ICES-003 ANSI C63.4:2014 RSS-247 MIC ARIB STD-T66/RCR STD-33 (2.4 GHz) ARIB STD-T71 (5 GHz) SRRC (China) </td></tr> </table>	EU EN 300 328 EN 300 440 EN 301 489-1 EN 301 489-17 EN 301 893 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 AS/NZS AS/NZS 2772.2:2011 AS/NZS 4268:2017 KC (Korea)	62311:2008 EN 50665:2017 EN 50385:2017 EU 2015/863 (RoHS 3) ISED Canada ICES-003 ANSI C63.4:2014 RSS-247 MIC ARIB STD-T66/RCR STD-33 (2.4 GHz) ARIB STD-T71 (5 GHz) SRRC (China)						
EU EN 300 328 EN 300 440 EN 301 489-1 EN 301 489-17 EN 301 893 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 AS/NZS AS/NZS 2772.2:2011 AS/NZS 4268:2017 KC (Korea)	62311:2008 EN 50665:2017 EN 50385:2017 EU 2015/863 (RoHS 3) ISED Canada ICES-003 ANSI C63.4:2014 RSS-247 MIC ARIB STD-T66/RCR STD-33 (2.4 GHz) ARIB STD-T71 (5 GHz) 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-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	▪ 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 ▪ Beamforming ▪ TIM Frame TX and RX ▪ Multi-BSS/Station ▪ Transmit Rate Adaptation. ▪ Transmit Power Control

Feature	Description
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)

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

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:
	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.
	- High-Speed UART interface – ST60-2230C-P only - USB 2.0 – ST60-2230C-PU only
Bluetooth Core functionality	- Bluetooth 5.1 - Bluetooth Class 1 - WLAN and Bluetooth share same LNA and antenna - Digital audio interfaces with PCM/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 2 Mbps LE

7 BLOCK DIAGRAM

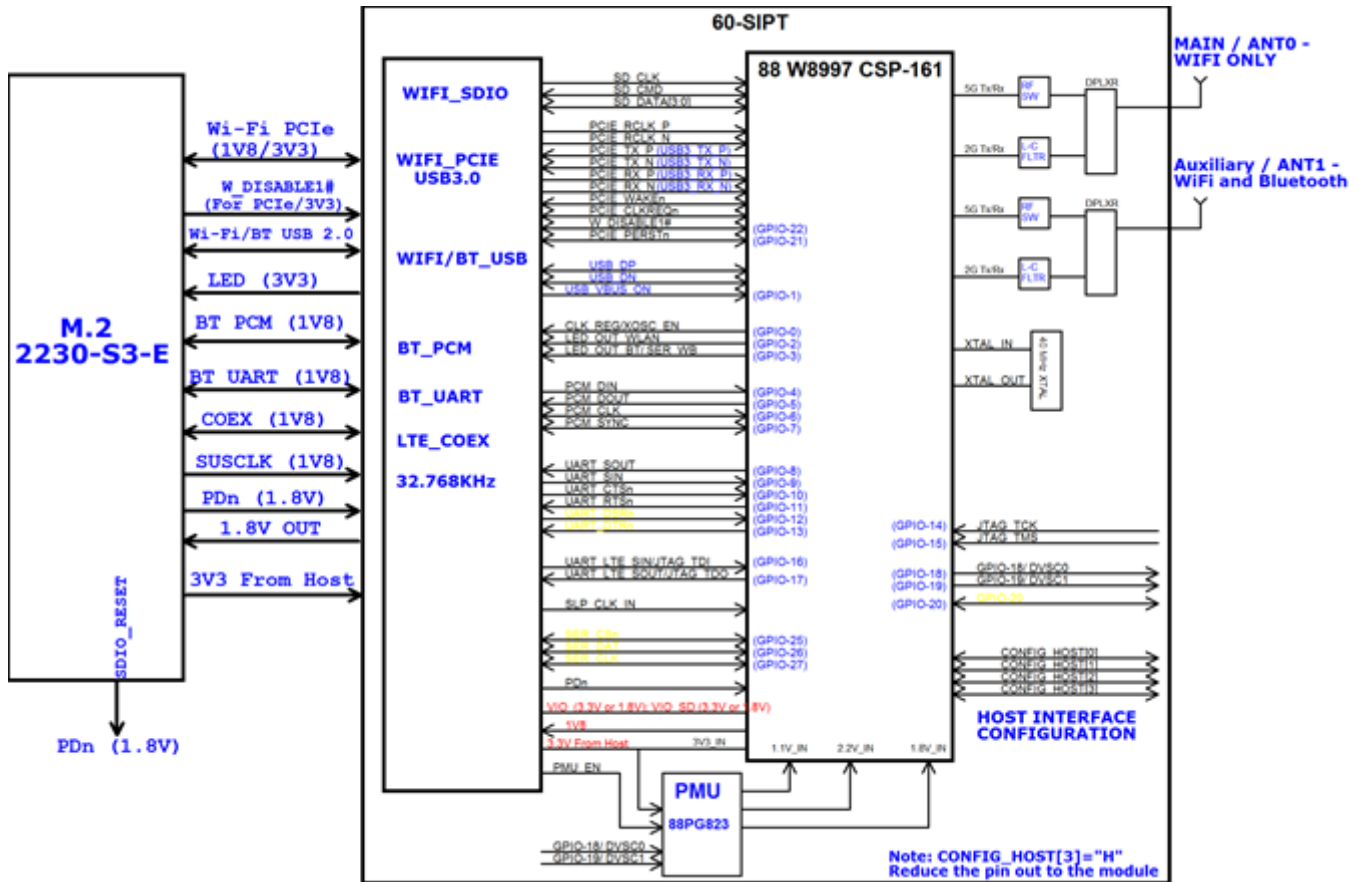


Figure 1: Block Diagram of ST60-2230C-P/ST60-2230C-PU

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 _x	Receive input frequency range		2.412		2.484	GHz
Sr _f	Sensitivity					
	CCK, 1 Mbps	See Note ³		-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 ⁴		TBD		dB
	OFDM, 54 Mbps			TBD		
	HT20, MCS0			TBD		
	HT20, MCS7			TBD		

³Performance data are measured under signal chain operation.

⁴Performance 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 _x	Receive input frequency range		5.15		5.825	GHz
Sr _f	Sensitivity					
	OFDM, 6 Mbps	See Note ⁵		-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 ⁶		TBD		dB
	OFDM, 54 Mbps			TBD		
	HT20, MCS0			TBD		
	HT20, MCS7			TBD		

⁵Performance data are measured under signal chain operation

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

Freq.	Mode/Rate (Mbps)	Output Power Per Chain (dBm)	Max. Current Consumption	
			Single Chain (mA) ⁸	Dual Chains (mA) ⁸
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 ³				
	11a mask compliant	6-36Mbps		18		dBm
	11a EVM compliant	48-54Mbps		16		
	11n HT20 mask compliant	MCS0-5/MCS8-13		18		
	11n HT20 EVM compliant	MCS6-7/MCS14-15		16		
	11n HT40 mask compliant	MCS0-5/MCS8-13		16		
	11n HT40 EVM compliant	MCS6-7/MCS14-15		16		
	11ac HT20 mask compliant	MCS0-6 (Ntst=1,2)		18		
	11ac HT20 EVM compliant	MCS7-8(Ntst=1,2)		16		
	11ac HT40 mask compliant	MCS0-5 (Ntst=1,2)		16		
	11ac HT40 EVM compliant	MCS6-9(Ntst=1,2)		14		
	11ac HT80 mask compliant	MCS0-5 (Ntst=1,2)		14		

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

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

⁷Performance 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	—	≤ 1000	KHz
Δf_{1avg} Maximum Modulation	140	165	175	$140 < \Delta f_{1avg} < 175$	KHz
Δf_{2max} Minimum Modulation	—	135	—	≥ 115	KHz
$\Delta f_{2avg}/\Delta f_{1avg}$	—	0.9	—	≥ 0.80	—
Initial Carrier Frequency	—	+/-5	—	$\leq \pm 75$	KHz
Drift Rate (DH1 package)	—	4	—	≤ 20	KHz/50 μ s
Drift (DH3 packet)	—	8	—	≤ 25	KHz
Drift (DH5 packet)	—	7	—	≤ 40	KHz
Adjacent Channel Power	$F \geq \pm 3\text{MHz}$	—	-50	< -40	dBm
	$F = \pm 2\text{MHz}$	—	-46	≤ -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 wo	2-DH5	—	1	$\leq \pm 10$	KHz
	3-DH5	—	1		
Max Carrier Frequency Stability wi	2-DH5	—	4	$\leq \pm 75$	KHz
	3-DH5	—	4		
Max Carrier Frequency Stability w0+wi	2-DH5	—	5	$\leq \pm 75$	KHz
	3-DH5	—	5		
RMS DEVN	2-DH5	—	4	≤ 20	%
	3-DH5	—	4	≤ 13	%
Peak DEVN	2-DH5	—	9	≤ 35	%
	3-DH5	—	9	≤ 25	%
99% DEVN	2-DH5	—	12	≤ 30	%
	3-DH5	—	12	≤ 20	%
EDR Differential Phase Encoding	—	99	—	≥ 99	%
Adjacent Channel Power	$F \geq \pm 3\text{MHz}$	—	TBD	< -40	dBm
	$F = \pm 2\text{MHz}$	—	TBD	≤ -20	dBm

Table 13: Basic rate receiver performance at 1.8V

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

Table 14: Enhanced data rate receiver performance 1.8V

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

10 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 ± 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 * VTXD+ - VTXD- $	0.8	--	1.2	V
V _{TX-DIFF-PP-LOW}	Low power differential peak-to-peak Tx voltage swing V _{TX-DIFFpp} = $2 * VTXD+ - VTXD- $	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 ± 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 * V_{TXD+} - V_{TXD-} $	0.8	--	1.2	V
$V_{Tx-DIFFpp-LOW}$	Low power differential peak-to-peak Tx voltage swing $V_{Tx-DIFFpp} = 2 * V_{TXD+} - V_{TXD-} $	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 LO and electrical idle				mV
$V_{Tx-IDLE-DIFF-AC-p}$	Electrical idle differential peak output voltage $V_{Tx-IDLE-DIFF-DC} = V_{Tx-Idle-D+} - V_{Tx-Idle-D-} \leq 20$ mV				mV
$V_{Tx-IDLE-DIFF-DC}$	DC electrical idle differential output voltage $V_{Tx-IDLE-DIFF-DC} = V_{Tx-Idle-D+} - V_{Tx-Idle-D-} \leq 5$ 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
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 Ω
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	0.6	--	--	UI

Symbol	Parameter	Min	Typ	Max	Units
Measured to account for worst Tj at 10 ⁻¹² BER.					
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 Ω
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 100 Ω 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
Driver Specifications					
VOH	Output signal ended high Defined with 1.425K Ω pull-up resistor to 3.6V	2.8	-	3.6	V
VOL	Output signal ended low Defined with 1.425K Ω 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

Symbol	Parameter	Min.	Typ.	Max.	Unit
TUDJ2	Source jitter total: for paired transitions				
	*Including frequency tolerance. Timing difference between the differential data signals.	-150	-	150	ns
	*Defined at crossover point of differential signals				
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 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
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.	-3.5	-	3.5	ns
	*Defined at crossover point of differential signals				
TDJ2	Source jitter total: for paired transitions				
	*Including frequency tolerance. Timing difference between the differential data signals.	-4.0	-	4.0	ns
	*Defined at crossover point of differential signals				
TFDEOP	Source jitter for differential transition to SEO transition. Defined at crossover point of differential signals	-2.0	-	5.0	ns
Receiver Specifications					

Symbol	Parameter	Min.	Typ.	Max.	Unit
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
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

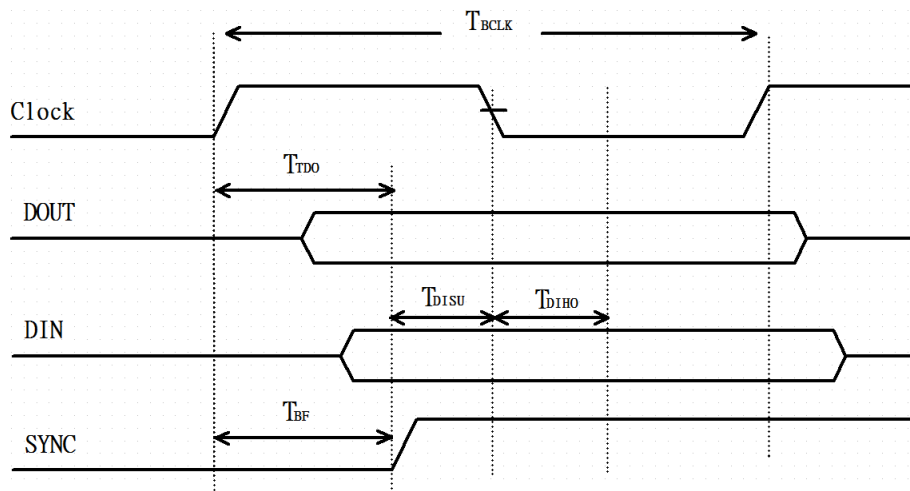


Figure 2: PCM Timing Specification – Master Mode

Table 18: PCM Timing Specification – Master Mode

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

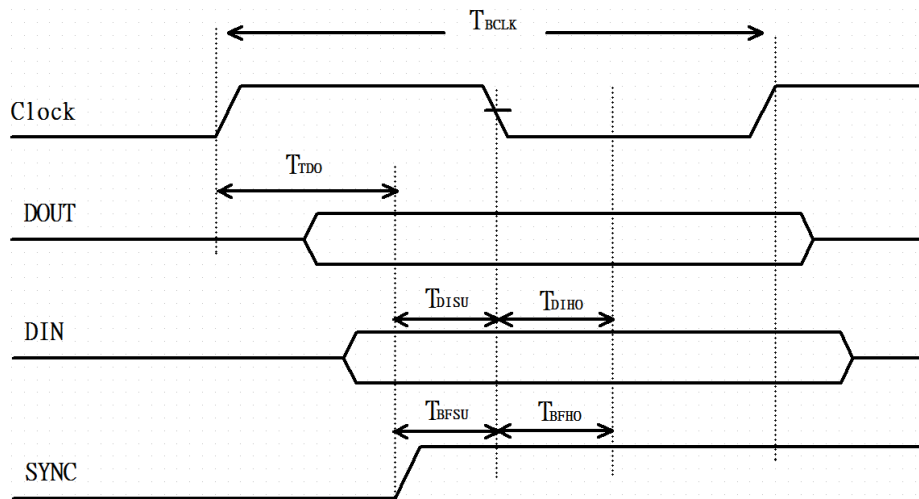


Figure 3: PCM Timing Specification – Slave Mode

Table 19: PCM Timing Specification – Slave Mode

Symbol	Parameter	Min.	Typ.	Max.	Unit
FBCLK	-	-	2/2.048	-	MHz
Duty Cycle _{BCLK}	-	0.4	0.5	0.6	-
T _{BCLK rise/fall}	-	-	3	-	ns
TDO	-	-	-	30	ns
TDISU	-	15	-	-	ns
TDIHO	-	10	-	-	ns
TBFSU	-	15	-	-	ns
TBFHO	-	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 ST60-2230C-PU only	N/C
4	3.3V	Power	-	3.3V module power supply	-
5	USB_D-	I/O	3.3V	USB Differential Data-Negative ST60-2230C-PU only	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	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

Pin #	Name	Type	Voltage Ref.	Description	If Not Used
22	UART TXD	O	1.8V	UART Serial Data Output ST60-2230C-P only	N/C
23	SDIO RESET#	N/C	N/C	N/C	N/C
32	UART RXD	I	1.8V	UART Serial Data Input ST60-2230C-P only	N/C
33	GND	-	-	Ground	GND
34	UART RTS	O,WPU	1.8V	UART Request To Send (Active low) ST60-2230C-P only	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) ST60-2230C-P only	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 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

Pin #	Name	Type	Voltage Ref.	Description	If Not Used
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/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
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.

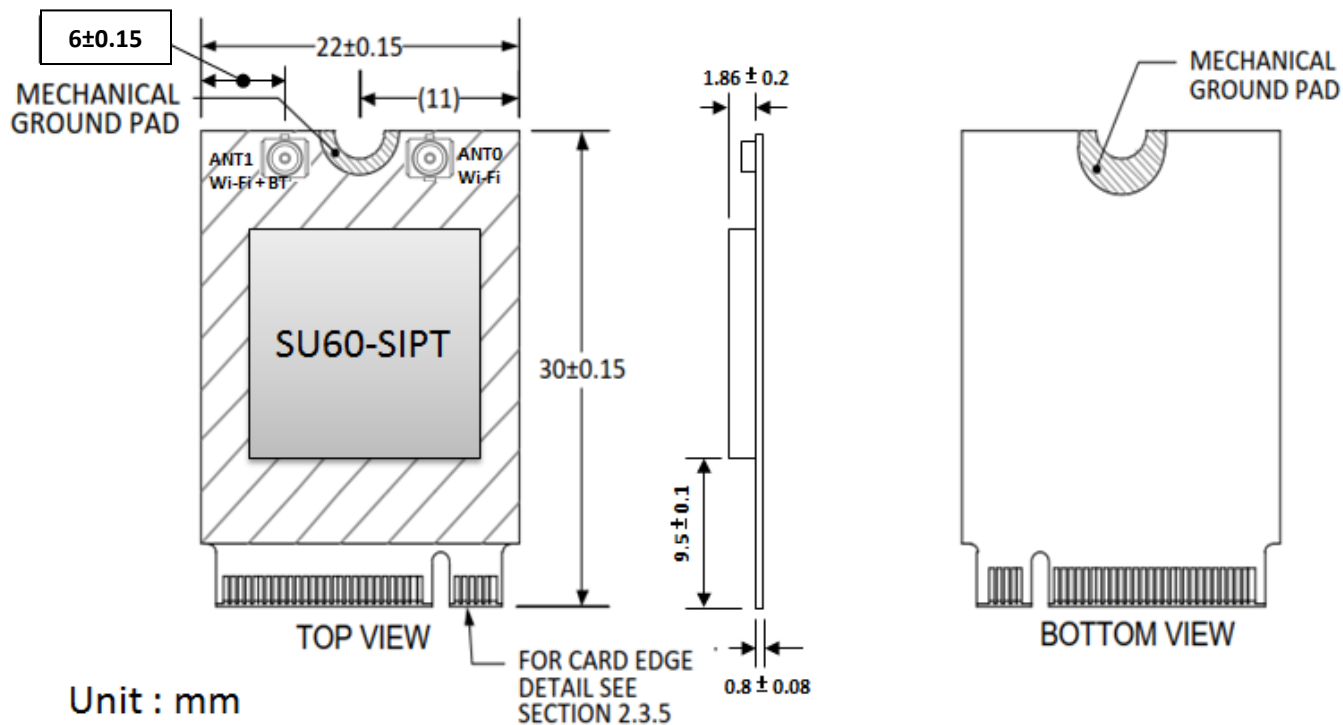


Figure 4: Module dimension of ST60-2230C-P/ST60-2230C-PU

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

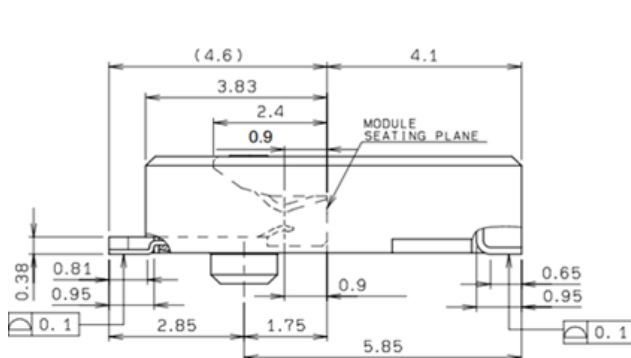
The ST60-2230C-P/ST60-2230C-PU connects to the host via a standard PCI EXPRESS M2 connector. The Kyocera's (www.kyocera-connector.com) 6411 series provide 1.8 mm, 2.3 mm and 3.2 mm connector heights and JAE's (<https://www.jae.com/en/>) SM3 series provide 1.2 mm, 2.15 mm, 3.1 mm and 4.1 mm connector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

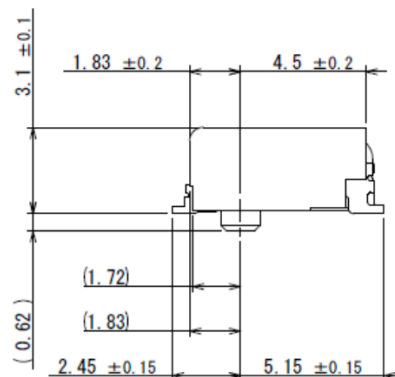
M.2 Key-E Connector	Connector Height
KYOCERA 24-6411-067-101-894E	2.3 mm
JAE SM3ZS067U310AERxxxx	3.1 mm

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

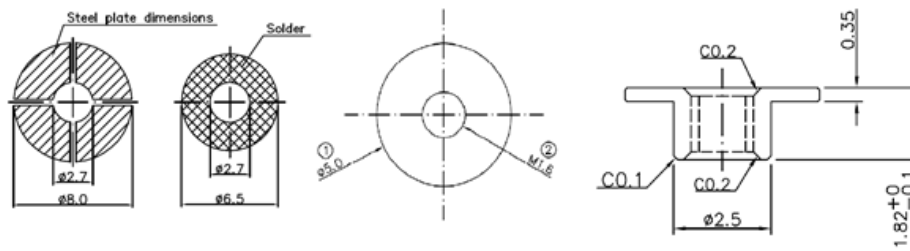
M.2 Key-E Connector	Stand-off
KYOCERA 24-6411-067-101-894E	EMI STOP F50M16-041525P1D4M
JAE SM3ZS067U310AERxxxx	JAE SM3ZS067U310-NUT1-Rxxxx



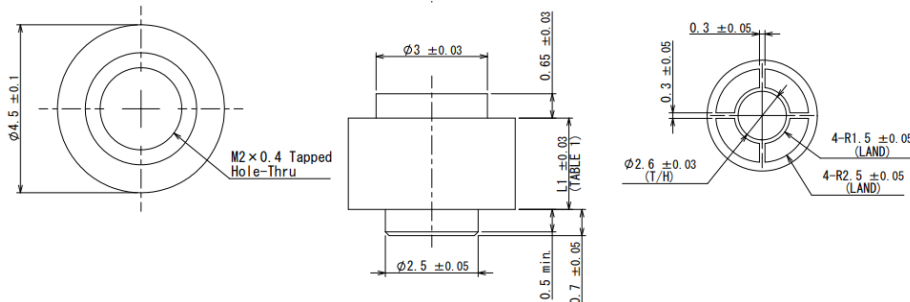
KYOCERA 24-6411-067-101-894E



JAE SM3ZS067U310AERxxxx



EMI STOP F50M16-041525P1D4M



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. Laird Connectivity 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.

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

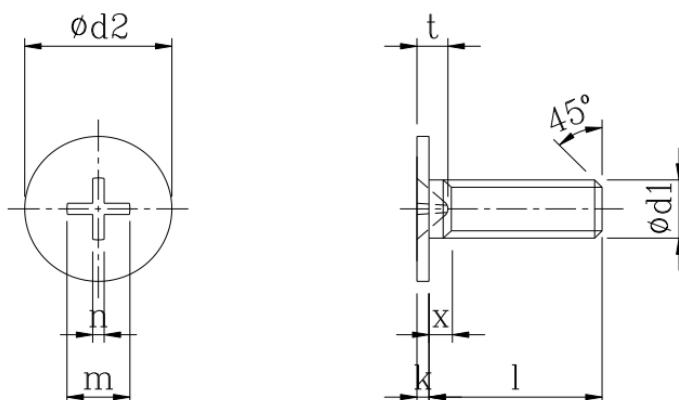


Figure 6: Mechanical drawing of FPH M1.6-0.35x3.5(5,0.5)CR3-Zn

16 RF LAYOUT DESIGN GUIDELINES / PRECAUTIONS

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

- Do not run antenna cables directly above or directly below the radio.
- Do not place any parts or run any high speed digital lines below the radio.
- If there are other radios or transmitters located on the device (such as a *Bluetooth* radio), place the devices as far apart from each other as possible. Also, make sure there is at least 25 dB isolation between the Bluetooth antenna and the Wi-Fi antenna.
- Ensure that there is the maximum allowable spacing separating the antenna connectors on the Laird Connectivity radio from the antenna. In addition, do not place antennas directly above or directly below the radio.
- Laird Connectivity recommends the use of a double-shielded cable for the connection between the radio and the antenna elements.
- Be sure to put the capacitor on the power pin as close as possible to reduce the radiation issue.
- Use proper electro-static-discharge (ESD) procedures when installing the Laird Connectivity 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

17.1 Current Regulatory Certifications

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
Korea (KC)	MSIP-CRM-LAI-60-2230C
Australia	N/A
New Zealand	N/A
China (SRRC)	2017DJ2473

17.2 Certified Antennas

The antennas listed below were tested for use with the ST60-2230C. The OEM can choose a different manufacturer's antenna but must make sure it is of same type and that the gain is less than or equal to the antenna that is approved for use.*

***Note:** Japan (MIC) lists applicable antennas on its certificates. If your antenna is not on the approved list, regardless of whether it is comparative, it must be added to the certificate before it can be used in Japan.

Model	Type	Connector	Maximum Gain				
			2400-2483.5	5150-5250	5250-5350	5470-5725	5725-5850
Laird Connectivity (LSR) 001-0009	Dipole	IPEX U.FL	2.0	2.0	2.0	2.0	2.0
Laird Connectivity NanoBlade-IP04	PCB dipole	IPEX U.FL	2.0	3.9	3.9	4.0	4.0
Laird Connectivity MAF95310 Mini NanoBlade Flex	PCB Dipole	IPEX U.FL	2.79	3.38	3.38	3.38	3.38
Laird Connectivity (LSR) FlexPIFA	PIFA	IPEX U.FL	2.5	3.0	3.0	3.0	3.0
Ethertronics WLAN_1000146	Magnetic dipole	IPEX U.FL	2.5	3.5	3.5	3.5	3.5
Laird Connectivity MIMO FlexPIFA	PIFA	IPEX U.FL	2.0	3.0	3.0	3.0	3.0

17.3 FCC Regulatory

To ensure regulatory compliance, when integrating the ST60-2230C into a host device, it is necessary to meet the documentation requirements set forth by the applicable regulatory agencies. The following sections (FCC, ISED Canada, European Union, and others) outline the information that may be included in the user's guide and external labels for the host devices into which the ST60-2230C is integrated.

17.3.1 Antenna Information

The ST60-2230C family has been designed to operate with the antennas listed below.

Model	Type	Connector	Maximum Gain				
			2400-2483.5	5150-5250	5250-5350	5470-5725	5725-5850
Laird Connectivity (LSR) 001-0009	Dipole	IPEX U.FL	2.0	2.0	2.0	2.0	2.0
Laird Connectivity NanoBlade-IP04	PCB dipole	IPEX U.FL	2.0	3.9	3.9	4.0	4.0
Laird Connectivity MAF95310 Mini NanoBlade Flex	PCB Dipole	IPEX U.FL	2.79	3.38	3.38	3.38	3.38
Laird Connectivity (LSR) FlexPIFA	PIFA	IPEX U.FL	2.5	3.0	3.0	3.0	3.0
Ethertronics WLAN_1000146	Magnetic dipole	IPEX U.FL	2.5	3.5	3.5	3.5	3.5
Laird Connectivity MIMO FlexPIFA	PIFA	IPEX U.FL	2.0	3.0	3.0	3.0	3.0

Note: The OEM is free to choose another vendor's antenna of like type and equal or lesser gain as an antenna appearing in the table and still maintain compliance. Reference FCC Part 15.204(c)(4) for further information on this topic.

17.3.2 FCC Documentation Requirements

Federal Communication Commission Interference Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

However, there is no guarantee that interference will not occur in an installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference; and
2. This device must accept any interference received, including interference that may cause undesired operation.

FCC Radiation Exposure Statement

This product complies with the US portable RF exposure limit set forth for an uncontrolled environment and is safe for intended operation as described in this manual. Further RF exposure reduction can be achieved if the product is kept as far as possible from the user body or is set to a lower output power if such function is available.

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

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

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

If the condition above is met, further transmitter testing is not required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this installed module.

IMPORTANT NOTE:

If this condition cannot be met (for example, certain laptop configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID **cannot** be used on the final product. In these circumstances, the OEM integrator is responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

End-Product Labeling

The end product must be labeled in a visible area with the following: **Contains FCC ID: SQG-60SIPT**

Manual Information to the End User

The OEM integrator must be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.

The end user manual shall include all required regulatory information/warning as show in this manual.

17.4 ISED Canada

Model	MIC ID
ST60-2230C	3147A-602230C

17.4.1 Antenna Information

This radio transmitter (IC: 3147A-602230C) was approved by Innovation, Science and Economic Development (ISED) Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Le présent émetteur radio (IC: 3147A-602230C) a été approuvé par Innovation, Sciences et Développement économique Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué pour tout type figurant sur la liste, sont strictement interdits pour l'exploitation de l'émetteur.

Model	Type	Connector	Maximum Gain				
			2400-2483.5	5150-5250	5250-5350	5470-5725	5725-5850
Laird Connectivity (LSR) 001-0009	Dipole	IPEX U.FL	2.0	2.0	2.0	2.0	2.0
Laird Connectivity NanoBlade-IP04	PCB dipole	IPEX U.FL	2.0	3.9	3.9	4.0	4.0
Laird Connectivity MAF95310 Mini NanoBlade Flex	PCB Dipole	IPEX U.FL	2.79	3.38	3.38	3.38	3.38
Laird Connectivity (LSR) FlexPIFA	PIFA	IPEX U.FL	2.5	3.0	3.0	3.0	3.0
Ethertronics WLAN_1000146	Magnetic dipole	IPEX U.FL	2.5	3.5	3.5	3.5	3.5
Laird Connectivity MIMO FlexPIFA	PIFA	IPEX U.FL	2.0	3.0	3.0	3.0	3.0

17.4.2 ISED (Canada) Statement

The end user manual shall include all required regulatory information/warning as shown in this manual.

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

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

*Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence.
L'exploitation est autorisée aux deux conditions suivantes:*

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

Radiation Exposure Statement

The product complies with the Canada portable RF exposure limit set forth for an uncontrolled environment and are safe for intended operation as described in this manual. The minimum separation distance for portable use is limited to 15mm assuming use of antenna with 2 dBi of gain. The further RF exposure reduction can be achieved if the product can be kept as far as possible from the user body or set the device to lower output power if such function is available.

Déclaration d'exposition aux radiations:

Le produit est conforme aux limites d'exposition pour les appareils portables RF pour les Etats-Unis et le Canada établies pour un environnement non contrôlé. La distance de séparation minimale pour l'utilisation portative est limitée à 15mm en supposant l'utilisation de l'antenne avec 2 dBi de gain. Le produit est sûr pour un fonctionnement tel que décrit dans ce manuel. La réduction aux expositions RF peut être augmentée si l'appareil peut être conservé aussi loin que possible du corps de l'utilisateur ou que le dispositif est réglé sur la puissance de sortie la plus faible si une telle fonction est disponible.

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

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

If the condition above is met, further transmitter testing is not required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

Cet appareil est conçu uniquement pour les intégrateurs OEM dans les conditions suivantes:

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

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

IMPORTANT NOTE:

If this condition cannot be met (for example, certain laptop configurations or co-location with another transmitter), then the Canada authorization is no longer considered valid and the IC ID **cannot** be used on the final product. In these circumstances, the OEM integrator is responsible for re-evaluating the end product (including the transmitter) and obtaining a separate Canada authorization.

NOTE IMPORTANTE:

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

End-Product Labeling

The final end product must be labeled in a visible area with the following: **Contains IC: xxx**

Plaque signalétique du produit final

*Le produit final doit être étiqueté dans un endroit visible avec l'inscription suivante: **Contient des IC: xxx***

Manual Information to the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.

The end user manual shall include all required regulatory information/warning as show in this manual.

Manuel d'information à l'utilisateur final

L'intégrateur OEM doit être conscient de ne pas fournir des informations à l'utilisateur final quant à la façon d'installer ou de supprimer ce module RF dans le manuel de l'utilisateur du produit final qui intègre ce module.

Le manuel de l'utilisateur final doit inclure toutes les informations réglementaires requises et avertissements comme indiqué dans ce manuel.

Japan (MIC) Regulatory

The ST60-2230C is approved for use in the Japanese market. The part numbers listed below hold WW type certification. Refer to ARIB-STD-T66 for further guidance on OEM's responsibilities.

Model	MIC ID
ST60-2230C	003-170090

17.4.3 Antenna Information

The ST60-2230C was tested with antennas listed below.

Note: Japan (MIC) lists applicable antennas on its certificates. If your antenna is not on the approved list, regardless of whether it is comparative, it must be added to the certificate before it can be used in Japan.

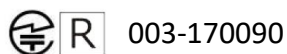
Model	Type	Connector	Maximum Gain				
			2400-2483.5	5150-5250	5250-5350	5470-5725	5725-5850
Laird Connectivity (LSR) 001-0009	Dipole	IPEX U.FL	2.0	2.0	2.0	2.0	2.0
Laird Connectivity NanoBlade-IP04	PCB dipole	IPEX U.FL	2.0	3.9	3.9	4.0	4.0
Laird Connectivity MAF95310 Mini NanoBlade Flex	PCB Dipole	IPEX U.FL	2.79	3.38	3.38	3.38	3.38
Laird Connectivity (LSR) FlexPIFA	PIFA	IPEX U.FL	2.5	3.0	3.0	3.0	3.0
Ethertronics WLAN_1000146	Magnetic dipole	IPEX U.FL	2.5	3.5	3.5	3.5	3.5

17.4.4 Labeling Requirements

It is recommended that the host device bears a label showing the Japanese “GITEKI” mark and the certification number accompanied by the following statement:

当該機器には電波法に基づく、技術基準適合証明等を受けた特定無線設備を装着している

Translation: “This equipment contains specified radio equipment that has been certified to the Technical Regulation Conformity Certification under the Radio Law.”



17.5 Korea (KC) Regulatory

The 60-2230C is approved for use in the Korean market.

Model	Certificate Number
60-2230C	MSIP-CRM-LAI-60-2230C

17.6 Australia and New Zealand Regulatory

RCM: Pending Compliant to standards EN 300 328 V1.9.1, AS/NZS 4268: 2012-A1:2013, and EN 55022:2010/AC:2011

If this device is used in a product, the OEM has responsibility to verify compliance of the final end product to the Australia/New Zealand (RCM) Standards. All end-products require their own certification (SDoc). You will not be able to leverage the module certification and ship product into the country.

17.7 China (SRRC) Regulatory

The 60-SOM is approved for use in the China market.

Model	CMIIT ID
60-2230C	2017DJ2473

17.8 European Union

17.8.1 Antenna Information

Model	Type	Connector	Maximum Gain				
			2400-2483.5	5150-5250	5250-5350	5470-5725	5725-5850
Laird Connectivity (LSR) 001-0009	Dipole	IPEX U.FL	2.0	2.0	2.0	2.0	2.0
Laird Connectivity NanoBlade-IP04	PCB dipole	IPEX U.FL	2.0	3.9	3.9	4.0	4.0
Laird Connectivity MAF95310 Mini NanoBlade Flex	PCB Dipole	IPEX U.FL	2.79	3.38	3.38	3.38	3.38
Laird Connectivity (LSR) FlexPIFA	PIFA	IPEX U.FL	2.5	3.0	3.0	3.0	3.0
Ethertronics WLAN_1000146	Magnetic dipole	IPEX U.FL	2.5	3.5	3.5	3.5	3.5
Laird Connectivity MIMO FlexPIFA	PIFA	IPEX U.FL	2.0	3.0	3.0	3.0	3.0

17.8.2 User's Guide Requirements

The integrator must include specific information in the user's guide for the device into which the ST60-2230C is integrated. In addition to the required FCC and IC statements outlined above, the following Radio Equipment Directive (RED) statements must be added in their entirety and without modification into a prominent place in the user's guide for the device into which the ST60-2230C is integrated:

This device complies with the essential requirements of the 2014/53/EU – Radio Equipment Directive (RED). The following test methods have been applied in order to prove presumption of conformity with the essential requirements of the 2014/53/EU – Radio Equipment Directive (RED):

- **EN 62368-1:2014/A11:2017**
Safety requirements for audio/video, information, and technology equipment
- **EN 300 328 v2.2.2 (2019-07)**
Electromagnetic compatibility and Radio Spectrum Matters (ERM); Wideband Transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and using spread spectrum modulation techniques; Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive
- **EN 62311:2008 | EN 50665:2017 | EN 50385:2017**
RF exposure
- **EN 301 489-1 v2.2.0 (2017-03)**
Electromagnetic compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements
- **EN 301 489-17 V3.2.0 (2017-03)**
Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 17: Specific conditions for 2,4 GHz wideband transmission systems and 5 GHz high performance RLAN equipment
- **EN 301 893 V2.1.1 (2017-05)**
Electromagnetic compatibility and Radio spectrum Matters (ERM); Broadband Radio Access Networks (BRAN); Specific conditions for 5 GHz high performance RLAN equipment
- **EU 2015/863 (RoHS 3)**
Declaration of Compliance – EU Directive 2015/863; Reduction of Hazardous Substances (RoHS)

This device is a 2.4 GHz wideband transmission system (transceiver), intended for use in all EU member states and EFTA countries, except in France and Italy where restrictive use applies.

In Italy the end-user should apply for a license at the national spectrum authorities in order to obtain authorization to use the device for setting up outdoor radio links and/or for supplying public access to telecommunications and/or network services.

This device may not be used for setting up outdoor radio links in France and in some areas the RF output power may be limited to 10 mW EIRP in the frequency range of 2454 – 2483.5 MHz. For detailed information the end-user should contact the national spectrum authority in France.

Български [Bulgarian]	С настоящото [име на производителя] декларира, че това устройство [вид оборудване] е в съответствие със съществените изисквания и други приложими разпоредби на Директиви 2014/53/EU
Hrvatski [Croatian]	[naziv proizvođača] ovim putem izjavljuje da je ovaj uređaj [vrsta opreme] sukladan osnovnim zahtjevima i ostalim bitnim odredbama Direktiva 2014/53/EU
Česky [Czech]	[Jméno výrobce] tímto prohlašuje, že tento [typ zařízení] je ve shodě se základními požadavky a dalšími příslušnými ustanoveními směrnice 2014/53/EU.
Dansk [Danish]	Undertegnede [fabrikantens navn] erklærer herved, at følgende udstyr [udstyrets typebetegnelse] overholder de væsentlige krav og øvrige relevante krav i direktiv 2014/53/EU.
Deutsch [German]	Hiermit erkläre [Name des Herstellers], dass sich das Gerät [Gerätetyp] in Übereinstimmung mit den grundlegenden Anforderungen und den übrigen einschlägigen Bestimmungen der Richtlinie 2014/53/EU befindet.
Eesti [Estonian]	Käesolevaga kinnitab [tootja nimi] seadme [seadme tüüp] vastavust direktiivi 2014/53/EL põhinõuetele ja nimetatud direktiivist tulenevatele teistele asjakohastele sätetele.
English	Hereby, [name of manufacturer], declares that this [type of equipment] is in compliance with the essential requirements and other relevant provisions of Directive 2014/53/EU.
Español [Spanish]	Por medio de la presente [nombre del fabricante] declara que el [clase de equipo] cumple con los requisitos esenciales y cualesquiera otras disposiciones aplicables o exigibles de la Directiva 2014/53/EU.
Ελληνική [Greek]	ΜΕ ΤΗΝ ΠΑΡΟΥΣΑ [όνομα του κατασκευαστή] ΔΗΛΩΝΕΙ ΟΤΙ [εξοπλισμού] ΣΥΜΜΟΡΦΩΝΕΤΑΙ ΠΡΟΣ ΤΙΣ ΟΥΣΙΩΔΕΙΣ ΑΠΑΙΤΗΣΕΙΣ ΚΑΙ ΤΙΣ ΛΟΙΠΕΣ ΣΧΕΤΙΚΕΣ ΔΙΑΤΑΞΕΙΣ ΤΗΣ ΟΔΗΓΙΑΣ 2014/53/ΕΕ.
Français [French]	Par la présente [nom du fabricant] déclare que l'appareil [type d'appareil] est conforme aux exigences essentielles et aux autres dispositions pertinentes de la directive 2014/53/EU.
Íslenska [Icelandic]	Hér, [Nafn framleiðanda], því yfir að þetta [gerð búnaðar] tæki er í samræmi við grunnkröfur og önnur viðeigandi ákvæði tilskipana 2014/53/ESB
Italiano [Italian]	Con la presente [nome del costruttore] dichiara che questo [tipo di apparecchio] è conforme ai requisiti essenziali ed alle altre disposizioni pertinenti stabilite dalla direttiva 2014/53/EU.
Latviešu valoda [Latvian]	Ar šo [izgatavojotānosaukums] deklarē, ka [iekārtas tips] atbilst Direktīvas 2014/53/ES būtiskajām prasībām un citiemar to saistītajiem noteikumiem.
Lietuvių kalba [Lithuanian]	Šiuo [gamintojo pavadinimas] deklaruojama, kad šis [rangos tipas] atitinka esminius reikalavimus ir kitas 2014/53/ES Direktyvos nuostatas.
Nederlands [Dutch]	Hierbij verklaart [naam van de fabrikant] dat het toestel [type van toestel] in overeenstemming is met de essentiële eisen en de andere relevante bepalingen van richtlijn 2014/53/EU.
Malti [Maltese]	Hawnhekk, [isem tal-manifattur], jiddikjara li dan [il-mudell tal-prodott] jikkonforma mal-htigijiet essenzjali u ma provviedimenti oħrajn relevanti li hemm fid-Dirrettiva 2014/53/EU.
Magyar [Hungarian]	Alulírott, [gyártó neve] nyilatkozom, hogy a [...] típus] megfelel a vonatkozó alapvető követelményeknek és az 2014/53/EU irányelv egyéb előírásainak.
Norsk [Norwegian]	Herved [navnet på produsenten], erklærer at denne [type utstyr] enheten, er i samsvar med de grunnleggende kravene og andre relevante bestemmelser i direktivene 2014/53/EU
Polski [Polish]	Niniejszym [nazwa producenta] oświadczam, że [nazwa wyrobu] jest zgodny z zasadniczymi wymogami oraz pozostałymi stosownymi postanowieniami Dyrektywy 2014/53/EU.
Português [Portuguese]	[Nome do fabricante] declara que este [tipo de equipamento] está conforme com os requisitos essenciais e outras disposições da Directiva 2014/53/EU.
Română [Romanian]	Prin prezenta, [numele producătorului] declară că acest dispozitiv [tipul de echipament] este în conformitate cu cerințele esențiale și alte prevederi relevante ale Directivei 2014/53/EU
Slovenščina [Slovenian]	[Ime proizvajalca] izjavlja, da je ta [tip opreme] v skladu z bistvenimi zahtevami in ostalimi relevantnimi določili direktive 2014/53/EU.
Slovenčina [Slovak]	[Menovýrobcu] týmto vyhlasuje, že [typzariadenia] spĺňazákladnépožiadavky a všetkypríslušnéustanovenia Smernice 2014/53/EU.
Suomi [Finnish]	[Valmistaja] vakuuttaa täten että [laitteen tyyppimerkintä] tyyppinen laite on direktiivin 2014/53/EU oleellisten vaatimusten ja sitä koskevien direktiivin muiden ehtojen mukainen.

Svenska [Swedish]

Härmed intygar [företag] att denna [utrustningstyp] står i överensstämmelse med de väsentliga egenskapskrav och övriga relevanta bestämmelser som framgår av direktiv 2014/53/EU.

17.8.3 EU Declaration of Conformity

Manufacturer	Laird Connectivity
Products	ST60-2230C
Product Description	Dual band 2x2 802.11ac WLAN plus Bluetooth 5.1 dual mode adapter
EU Directives	2014/53/EU – Radio Equipment Directive (RED)



Reference standards used for presumption of conformity:

Article Number	Requirement	Reference standard(s)
3.1a	Safety requirements for audio/video, information, and technology equipment	EN 62368-1:2014/A11:2017
	RF Exposure	EN 62311:2008
		EN 50665:2017 EN 50385:2017
3.1b	Protection requirements with respect to electromagnetic compatibility	EN 301 489-1 v2.2.0 (2017-03) EN 301 489-17 v3.2.0 (2017-03)
3.2	Protection requirements – Electromagnetic compatibility	EN 300 328 v2.2.2 (2019-07) EN 301 893 v2.1.1 (2017-05)

Declaration:

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

Place of Issue:	Laird Connectivity W66N220 Commerce Court, Cedarburg, WI 53012 USA tel: +1-262-375-4400 fax: +1-262-364-2649
Date of Issue:	August 2020
Name of Authorized Person:	Ryan Urness, Director of Test Services
Signature of Authorized Person:	

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 ASSISTANCE

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

Laird Connectivity

Support Centre: <https://www.lairdconnect.com/resources/support>

Email: wireless.support@lairdconnectivity.com

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

Europe: +44-1628-858-940

Hong Kong: +852 2762 4823

Web: <https://www.lairdconnect.com/products>

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