Datasheet

Sona™ IF513

Version 0.1

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Revision History

Version	Date	Notes	Contributors	Approver
0.1	27 May 2024	Preliminary release	Jacky Kuo	Andy Ross

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1 Scope

This document describes key hardware aspects of the Ezurio Sona™ IF513 series wireless modules providing a SDIO 3.0 interface for WLAN connection and high-speed 4-wire UART interface for Bluetooth® connection. This document is intended to assist device manufacturers and related parties with the integration of this radio into their host devices. Data in this document is drawn from several sources and includes information found in the Infineon CYW55513IUBGT data sheet issued on March 23, 2023, along with other documents provided by Infineon.

Note: **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 Sona IF513 series wireless module is an integrated, small form factor Wi-Fi/Bluetooth module that is optimized for low-power mobile devices, featuring:

- Wi-Fi 6E: Tri-band 1x1 MIMO IEEE 802.11a/b/g/n/ac/ac/ax WLAN
- Bluetooth® 5.4: Dual Mode

The integration of all WLAN and Bluetooth functionality in a single package supports a low cost and simple implementation along with flexibility for platform-specific customization. The radio is pre-calibrated and integrates the complete transmit/receive RF paths including bandpass filter, diplexer, switches, reference crystal oscillator, and power management units (PMU). It is available in both M.2 2230 E-Key and M.2 1216 solder-down form factors with an MHF4 antenna connector and optional antenna diversity. The M.2 1216 module is also available with an RF trace pin for use with external antenna solutions. For a list of certified antennas see Certified Antennas.

The Sona IF513 series device supports IEEE 802.11ax tri-band (2.4/5/6 GHz) 1x1 MIMO with data rates up to MCS11 (143 Mbps PHY data rate for 2.4/5/6 GHz). The device's low power consumption, radio architecture and power management unit (PMU) proprietary power save technologies allow for extended battery life.

In addition, its tri-band IEEE 802.11ax and Bluetooth radio includes full digital MAC and baseband engines that handle all 802.11 CCK/OFDM/OFDMA® 2.4/5/6 GHz and Bluetooth 5.4 (Basic Rate, Enhanced Data Rate, and Bluetooth Low Energy) baseband and protocol processing.

Ordering information is listed in Table 1. Please contact Ezurio Sales/FAE for further information.

Table 1: Product ordering information

Part Number	Description
453-00184R	Module, Sona IF513, MHF4L, Tape and Reel
453-00184C	Module, Sona IF513, MHF4L, Cut Tape
453-00185R	Module, Sona IF513, Trace Pin, Tape and Reel
453-00185C	Module, Sona IF513, Trace Pin, Cut Tape
453-00186	Module, Sona IF513, M.2, Key E, SDIO, UART
453-00186-K1	Development Kit, Module, Sona IF513, M.2, Key E, SDIO, UART
453-00193R	Module, Sona IF513, Antenna Diversity, MHF4L, Tape and Reel
453-00193C	Module, Sona IF513, Antenna Diversity, MHF4L, Cut Tape
453-00194R	Module, Sona IF513, Antenna Diversity, Trace Pin, Tape and Reel
453-00194C	Module, Sona IF513, Antenna Diversity, Trace Pin, Cut Tape
453-00195	Module, Sona IF513, Antenna Diversity, M.2, Key E, SDIO, UART
453-00195-K1	Development Kit, Module, Sona IF513, Antenna Diversity, M.2, Key E, SDIO, UART

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3 Sona IF513 Series Feature Summary

The Ezurio Sona IF513 series device features are described in Table 2.

Table 2: Sona IF513 series wireless module feature

Feature	Description
Radio Front End	• Integrates the complete transmit/receive RF paths including bandpass filter, diplexer, switches, reference crystal oscillator, and power manage unit (PMU) • Supports tri-band (2.4/5/6 GHz) • Supports 20MHz channel bandwidth • Supports 1x1 WLAN/Bluetooth antenna configuration • Supports 1x1 WLAN antenna diversity configuration, the Bluetooth shared main antenna
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	One buck regulator, multiple LDO regulators, and a power management unit (PMU) are integrated into the CYW55513IUBGT. All regulators are programmable via the PMU. These blocks simplify power supply design for Bluetooth and WLAN functions in embedded designs.
Pre-Calibration	RF system tested and calibrated in production
Sleep Clock	The Sona IF513 series requires a 32.768 KHz sleep clock. There is an internal 32.768 KHz option on the Sona IF513 M.2 2230 card. The 32.768 kHz precision oscillator which meets the requirements listed following table must be used.

Parameter	LPO Clock	Unit
Nominal input frequency	32.768	kHz
Frequency accuracy	±250	ppm
Duty cycle	30 – 70	%
Input signal amplitude	200 – 3300	mV, p-p
Signal type	Square-wave or sine-wave	-
Input impedance	› 100k	Ω
	‹ 5	pF
Clock jitter (during initial startup)	‹ 10,000	ppm

Host Interface	The Sona IF513 M.2 card support the "SDIO/UART" interfaces: • **SDIO/UART**, Wi-Fi section provides support for SDIO v3.0 and is backward compatible with SDIO v2.0. Bluetooth section supports a high-speed 4-wire UART interface.
Advanced WLAN	• IEEE 802.11a/b/g/n/ac/ac/ax compliant, tri-band capable (2.4/5/6 GHz) • 1x1 MIMO providing up to 143 Mbps PHY data rate for 2.4/5/6 GHz (1024-QAM modulation) • Supports 20 MHz bandwidth with optional SGI (1024-QAM modulation) • On-chip power amplifiers and low-noise amplifiers for both bands • Support wide variety of WLAN encryption: WEP, WPA/WPA2/WPA3, AES and IEEE 802.11i compatibility • Support TKIP (Hardware accelerator) and CKIP (Software accelerator)
Advanced Bluetooth	• Bluetooth 5.4 (BDR + EDR + Bluetooth LE) • Bluetooth Class 1 or Class 2 transmitter operation • Support data rate: 1 Mbps (GFSK), 2 Mbps (π/4-DQPSK), 3 Mbps (8-DPSK), LE-1 Mbps, LE-2 Mbps, LE-LR-500K (S=2) and LE-LR-125K (S=8) • Supports extended synchronous connections (eSCO) for enhanced voice quality by allowing for retransmission of dropped packets • Adaptive frequency hopping (AFH) for reducing radio frequency interference • Host controller interface (HCI) using a highspeed UART and PCM/I2S for audio data • Low power consumption improves battery life of IoT and embedded devices • Supports multiple simultaneous Advanced Audio Distribution Profiles (A2DP) for stereo sound • On-chip memory includes 768 KB SRAM and 2 MB ROM

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4 Specifications

Table 3: Specifications

Feature	Description
Physical Interface	M.2 2230 E-Key standard form factor M.2 1216 108-pin LGA package (including 8 thermal ground pads under the package)
Wi-Fi Interface	Secure Digital I/O 2.0/3.0
Bluetooth/BLE Interface	Host Controller Interface (HCI) using high speed UART
Main Chipset	Infineon AIROC™ CYW55513IUBGT
Input Voltage Requirements	Typical DC 3.3 V, operating range from DC 3.13V to 3.5V
I/O Signalling Voltage	Compliant with M.2 standard Typical DC 1.8 V ± 5%
Operating Temperature	-40° to +85°C (-40° 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)
MSL (Moisture Sensitivity Level)	4
Maximum Electrostatic Discharge	Conductive 8KV; Air coupled 12KV (follows EN61000-4-2)
Size	M.2 1216 • Length: 16 mm • Width: 12 mm • Thickness: 0.43 mm M.2 E-Key • Length: 30 mm • Width: 22 mm Thickness: 3.1 mm
Weight – g (oz.)	M.2 1216 • ~0.7 M.2 E-Key • 3
Wi-Fi Media	Direct Sequence-Spread Spectrum (DSSS) Complementary Code Keying (CCK) Orthogonal Frequency Division Multiplexing (OFDM) Orthogonal Frequency Division Multiple Access (OFDMA)
Bluetooth Media	Frequency Hopping Spread Spectrum (FHSS)
Wi-Fi Multimedia	WMM Wi-Fi Multimedia - PowerSave (WMM-PS with U-APSD) WMM-Sequential Access (WMM-SA)
Network Architecture Types	Infrastructure (client operation)
Wi-Fi Standards	IEEE 802.11ax, 11ac, 11ac, 11a/b/g/n, 11d/h, 11i, 11r, 11w, 11e, 11k, 11ai, 11v
Bluetooth Standards	Bluetooth 2.1 + EDR, 3.0, 4.2, 5.0, 5.1, 5.2, 5.3, 5.4
Wi-Fi Data Rates Supported	Support 802.11 ax/ac/a/b/g/n 1x1 MU-MIMO. 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, MCS0-7) 802.11ac (OFDM, VHT20, MCS0-8) 802.11ax (2.4 GHz / OFDM / HE20 / MCS0-11; 2.4 GHz / OFDMA / HE20 / MCS0-11) 802.11ax (5 GHz, 6 GHz / OFDM / HE20 / MCS0-11; 5 GHz, 6 GHz / OFDMA / HE20 / MCS0-11)

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Feature	Description
Modulation Table	BPSK, QPSK, CCK, 16-QAM, 64-QAM, 256-QAM, 1024-QAM

Modulation Type						OFDM (IEEE 802.11n/ac)		OFDM (IEEE 802.11ax)		
MCS Index			Spatial Stream	Modulation	Coding	20MHz		20MHz		
HT	VHT	HE				0.8us GI	0.4us GI	0.8us GI	1.6us GI	3.2us GI
0	0	0	1	BPSK	1/2	6.5	7.2	8.6	8.1	7.3
1	1	1	1	QPSK	1/2	13	14.4	17.2	16.3	14.6
2	2	2	1	QPSK	3/4	19.5	21.7	25.8	24.4	21.9
3	3	3	1	16-QAM	1/2	26	28.9	34.4	32.5	29.3
4	4	4	1	16-QAM	3/4	39	43.3	51.6	48.8	43.9
5	5	5	1	64-QAM	2/3	52	57.8	68.8	65	58.5
6	6	6	1	64-QAM	3/4	58.5	65	77.4	73.1	65.8
7	7	7	1	64-QAM	5/6	65	72.2	86	81.3	73.1
	8	8	1	256-QAM	3/4	78	86.7	103.2	97.5	87.8
	9	9	1	256-QAM	5/6	N/A	N/A	114.7	108.3	97.5
		10	1	1024-QAM	3/4			129	121.9	109.7
		11	1	1024-QAM	5/6			143.4	135.4	121.9

OFDMA (IEEE 802.11ax)														
MCS Index	Spatial Stream	Modualtion	Coding	26-tone RU			52-tone RU			106-tone RU			242-tone RU		
HE				0.8us GI	1.6us GI	3.2us GI	0.8us GI	1.6us GI	3.2us GI	0.8us GI	1.6us GI	3.2us GI	0.8us GI	1.6us GI	3.2us GI
0	1	BPSK	1/2	0.9	0.8	0.8	1.8	1.7	1.5	3.8	3.5	3.2	8.6	8.1	7.3
1	1	QPSK	1/2	1.8	1.7	1.5	3.5	3.3	3	7.5	7.1	6.4	17.2	16.3	14.6
2	1	QPSK	3/4	2.6	2.5	2.3	5.3	5	4.5	11.3	10.6	9.6	25.8	24.4	21.9
3	1	16-QAM	1/2	3.5	3.3	3	7.1	6.7	6	15	14.2	12.8	34.4	32.5	29.3
4	1	16-QAM	3/4	5.3	5	4.5	10.6	10	9	22.5	21.3	19.1	51.6	48.8	43.9
5	1	64-QAM	2/3	7.1	6.7	6	14.1	13.3	12	30	8.3	25.5	68.8	65	58.5
6	1	64-QAM	3/4	7.9	7.5	6.8	15.9	15	13.5	33.8	31.9	28.7	77.4	73.1	65.8
7	1	64-QAM	5/6	8.8	8.3	7.5	17.6	16.7	15	37.5	35.4	31.9	86	81.3	73.1
8	1	256-QAM	3/4	10.6	10	9	21.2	20	18	45	42.5	38.3	103.2	97.5	87.8
9	1	256-QAM	5/6	11.8	11.1	10	3.5	22.2	20	50	47.2	42.5	114.7	108.3	97.5
10	1	1024-QAM	3/4	13.2	12.5	11.3	26.5	25	22.5	56.3	53.1	47.8	129	121.9	1097
11	1	1024-QAM	5/6	14.7	13.9	12.5	29.4	27.8	25	62.5	59	53.1	143.4	135.4	121.9

802.11ax/ac/n Spatial Streams	1 (1x1 MU-MIMO)
Bluetooth Data Rates Supported	1, 2, 3 Mbps
Bluetooth Modulation	GFSK @ 1 Mbps Pi/4-DQPSK @ 2 Mbps 8-DPSK @ 3 Mbps
Bluetooth LE Data Rates Supported	1, 2 Mbps, 500 Kbps (S=2), 125 Kbps (S=8)
Bluetooth LE Modulation	GFSK @ 1, 2 Mbps GFSK @ 125, 500 Kbps
Regulatory Certifications	United States (FCC) EU - Member countries of European Union (ETSI) Great Britain (UKCA) Canada (ISED) Australia/New Zealand (RCM) Japan (MIC)
2.4 GHz Frequency Bands	**EU:** 2.4 GHz to 2.483 GHz **FCC/ISED:** 2.4 GHz to 2.473 GHz **UKCA**: 2.4 GHz to 2.483 GHz **MIC:** 2.4 GHz to 2.483 GHz **RCM**: 2.4 GHz to 2.483 GHz

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Feature	Description	
5 GHz Frequency Bands	**EU** 5.15 GHz to 5.35 GHz 5.47 GHz to 5.725 GHz 5.725 GHz to 5.85 GHz **FCC** 5.15 GHz to 5.35 GHz 5.47 GHz to 5.725 GHz 5.725 GHz to 5.85 GHz **ISED** 5.15 GHz to 5.35 GHz 5.47 GHz to 5.725 GHz 5.725 GHz to 5.85 GHz **UKCA** 5.15 GHz to 5.35 GHz 5.47 GHz to 5.730 GHz 5.725 GHz to 5.850 GHz **MIC** 5.15 GHz to 5.35 GHz 5.47 GHz to 5.725 GHz **RCM** 5.15 GHz to 5.35 GHz 5.47 GHz to 5.725 GHz 5.725 GHz to 5.85 GHz	
6 GHz Frequency Bands	**FCC / ISED** UNII-5, 5.925 GHz to 6.415 GHz UNII-6, 6.435 GHz to 6.515 GHz UNII-7, 6.535 GHz to 6.875 GHz UNII-8, 6.895 GHz to 7.115 GHz **EU** UNII-5, 5.945 GHz to 6.425 GHz	**UKCA** UNII-5, 5.945 GHz to 6.425 GHz **MIC** UNII-5, 5.945 GHz to 6.425 GHz **RCM** UNII-5, 5.945 GHz to 6.425 GHz
Transmit Power ***Note:*** *Transmit power on each channel varies per 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.* ***Note:*** *HT20/VHT20/HE20 – 20 MHz-wide channels*	**802.11a** 6 Mbps 54 Mbps **802.11b** 1 Mbps 11 Mbps **802.11g** 6 Mbps 54 Mbps **802.11n (2.4 GHz)** HT20; MCS0-4 HT20; MCS5-7 **802.11ax (2.4 GHz)** HE20; MCS0-4 HE20; MCS5-7 HE20; MCS8-9 HE20; MCS13 **802.11n (5 GHz)** HT20; MCS0-4 HT20; MCS5-7	 17 dBm (50.11 mW) 16.5 dBm (44.66 mW) 18 dBm (63.09 mW) 18 dBm (63.09 mW) 18 dBm (63.09 mW) 17 dBm (50.11 mW) 18 dBm (63.09 mW) 16 dBm (39.81 mW) 18 dBm (63.09 mW) 16 dBm (39.81 mW) 14 dBm (25.11 mW) 10.5 dBm (19.95 mW) 17 dBm (50.11 mW) 16.5 dBm (44.66 mW)

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Feature	Description	
	802.11ac (5 GHz)	
	VHT20; MCS0-4	17 dBm (50.11 mW)
	VHT20; MCS5-7	16.5 dBm (44.66 mW)
	VHT20; MCS8	14 dBm (25.12 mW)
	802.11ax (5 GHz)	
	HE20; MCS0-4	17 dBm (50.11 mW)
	HE20; MCS5-7	16.5 dBm (44.66 mW)
	HE20; MCS8-9	14 dBm (25.12 mW)
	HE20; MC10-11	13 dBm (19.95 mW)
	802.11ax (6 Hz, UNII-5 / 6)	
	11a; 6M-24M	15.5 dBm (35.48 mW)
	HE20; MCS0-4	15.5 dBm (35.48 mW
	HE20; MCS5-7	15 dBm (31.62 mW)
	HE20; MCS8-9	13.5 dBm (22.38 mW)
	HE20; MCS10-11	12 dBm (15.85 mW)
	802.11ax (6 Hz, UNII-7 / 8)	
	11a; 6M-24M	15 dBm (31.62 mW)
	HE20; MCS0-4	15 dBm (31.62 mW)
	HE20; MCS5-7	13 dBm (19.95 mW)
	HE20; MCS8-9	12 dBm (15.85 mW)
	HE20; MCS10-11	10.5 dBm (11.22 mW)
	Bluetooth	
	1 Mbps (1DH1 3, 5)	7 dBm (5.01 mW), Maximum
	2 Mbps (2DH1, 3, 5)	3 dBm (2.51 mW), Maximum
	3 Mbps (3DH1, 3, 5)	3 dBm (2.51 mW), Maximum
	LE (1 Mbps, 2 Mbps)	7 dBm (5.01 mW), Maximum
	LE-LR (S=2, S=8)	7 dBm (5.01 mW), Maximum
Typical Receiver Sensitivity (PER < = 10%) *__Note:__ All values nominal, +/-2 dBm.*	**802.11a:**	
	6 Mbps	-90 dBm
	54 Mbps	-74 dBm
	802.11b:	
	1 Mbps	-97 dBm (PER < 8%)
	11 Mbps	-90 dBm (PER < 8%)
	802.11g:	
	6 Mbps	-93 dBm
	54 Mbps	-76 dBm
	802.11n (2.4 GHz)	
	6.5 Mbps (MCS0; HT20)	-93 dBm
	65 Mbps (MCS7; HT20)	-75 dBm
	802.11ax (2.4 GHz)	
	7.3 Mbps (MCS0; HE20)	-93 dBm
	121.9 Mbps (MCS11; HE20)	-62 dBm
	7.3 Mbps (MCS0; HE20/RU242)	-93 dBm
	802.11n (5 GHz)	
	6.5 Mbps (MCS0; HT20)	-90 dBm
	65 Mbps (MCS7; HT20)	-73 dBm
	802.11ac (5 GHz)	
	6.5 Mbps (MCS0; VHT20)	-90 dBm
	78 Mbps (MCS8; VHT20)	-70 dBm
	802.11ax (5 GHz)	
	7.3 Mbps (MCS0; HE20)	-90 dBm
	121.9 Mbps (MCS11; HE20)	-60 dBm
	7.3 Mbps (MCS0; HE20/RU242)	-90 dBm

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Feature	Description	
	802.11ax (6 GHz, UNII-5)	
	6 Mbps	-90 dBm
	24 Mbps	-83 dBm
	7.3 Mbps (MCS0; HE20)	-90 dBm
	121.9 Mbps (MCS11; HE20)	-59 dBm
	7.3 Mbps (MCS0; HE20/RU242)	-90 dBm
	802.11ax (6 GHz, UNII-6)	
	6 Mbps	-90 dBm
	24 Mbps	-82 dBm
	7.3 Mbps (MCS0; HE20)	-90 dBm
	121.9 Mbps (MCS11; HE20)	-59 dBm
	7.3 Mbps (MCS0; HE20/RU242)	-90 dBm
	802.11ax (6GHz, UNII-7)	
	6 Mbps	-89 dBm
	24 Mbps	-81 dBm
	7.3 Mbps (MCS0; HE20)	-89 dBm
	121.9 Mbps (MCS11; HE20)	-58 dBm
	7.3 Mbps (MCS0; HE20/RU242)	-89 dBm
	802.11ax (6 GHz, UNII-8)	
	6 Mbps	-88 dBm
	24 Mbps	-80 dBm
	7.3 Mbps (MCS0; HE20)	-88 dBm
	121.9 Mbps (MCS11; HE20)	-56 dBm
	7.3 Mbps (MCS0; HE20/RU242)	-88 dBm
	Bluetooth:	
	1 Mbps (1DH5)	-91 dBm
	2Mbps (2DH5)	-93 dBm
	3 Mbps (3DH5)	-87 dBm
	LE-1 Mbps	-95 dBm
	LE-2 Mbps	-92 dBm
	LE-LR (S=2)	-102 dBm
	LE-LR (S=8)	-107 dBm
Operating Systems Supported	Linux Android	
Security	• WPA, WPA2 (Enterprise) and WPA3 (Enterprise) support for powerful encryption and authentication • AES and TKIP in hardware for faster data encryption and IEEE 802.11i compatibility • Reference WLAN subsystem provides Wi-Fi Protected Setup (WPS)	
Compliance	**EU**	
	EN 300 328	EN 62368-1:2014
	EN 301 489-1	EN 300 440
	EN 301 489-17	EN 303 687
	EN 301 893	2011/65/EU (RoHS)
	FCC	**ISED Canada**
	47 CFR FCC Part 15.247	RSS-247
	47 CFR FCC Part 15.407	RSS-248
	47 CFR FCC Part 2.1091	
	AS/NZS	**MIC**
	AS/NZS 4268:2017	ARIB STD-T66/RCR STD-33 (2.4 GHz) ARIB STD-T71 (5 GHz) Article 2 Paragraph 1 of Item 80 : LPI (ZR), 6 GHz

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Feature	Description
Certifications	*Bluetooth*® SIG Qualification D063147
Warranty	One Year Warranty
All specifications are subject to change without notice	

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5 WLAN Functional Description

5.1 Overview

The Sona IF513 series wireless module is designed based on the Infineon AIROC CYW55513I Wi-Fi 6E chipset. It is optimized for high speed, reliability, and low-power embedded applications. It is integrated with tri-band WLAN (2.4/5/6 GHz) and Bluetooth 5.4. Its functionality is listed in Table 4.

Table 4: WLAN functions

Feature	Description
WLAN MAC	▪ Enhanced MAC for supporting IEEE 802.11 a/b/g/n/ac/ac/ax features. ▪ Transmission and reception of HE-SU and HE-ER-SU PPDU. ▪ Reception of HE-MU PPDU -OFDMA/MU-MIMO Frame. ▪ Transmission of HE-TB PPDU (Uplink MU OFDMA). ▪ Trigger frame reception. ▪ QoS null transmission in triggered/non-triggered data. ▪ MU RTS and MU BA reception. ▪ Dual NAV. ▪ Target wake time. ▪ Transmission and reception of A-MPDUs/AMSDUs. ▪ Support for power management schemes, including WMM power-save. ▪ Support for all ACK and Block-ACK policies as per standard. ▪ Interframe space timing support, including RIFS. ▪ Support for RTS/CTS and CTS-to-nowhere frame sequences for protecting frame exchanges. ▪ Timing synchronization function (TSF), network allocation vector (NAV) maintenance, and target beacon transmission time (TBTT) generation in hardware and capturing the TSF timer on an external time synchronization pulse. ▪ Hardware offload for cipher suites/encryption types WEP, TKIP(WPA), AES(WPA2), support for WPA3-SAE and key management. ▪ Support for MBSS, P2P Wi-Fi Direct ▪ Support for coexistence with Bluetooth ▪ RTS-CTS based BW signaling mechanism support
WLAN Security	▪ WLAN Encryption features supported include: - Temporal Key integrity Protocol (TKIP)/Wired Equivalent Privacy (WEP) - WPA2 (Personal/Enterprise) - WPA3 (Personal/Enterprise/192b)
WLAN Channel	Channel frequency supported.

2.4 GHz / 20 MHz		5 GHz / 20 MHz	
Channel	**Frequency (MHz)**	**Channel**	**Frequency (MHz)**
1	2412	36	5180
2	2417	40	5200
3	2422	44	5220
4	2427	48	5240
5	2432	52	5260
6	2437	56	5280
7	2442	60	5300
8	2447	64	5320
9	2452	100	5500
10	2457	104	5520
11	2462	108	5540
12	2467	112	5560
13	2472	116	5580
		120	5600
		124	5620
		128	5640
		132	5660
		136	5680

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Feature	Description

	140	5700
	144	5720
	149	5745
	153	5765
	157	5785
	161	5805
	165	5825

6 GHz / UNII-5 / 20 MHz	
Channel	**Frequency (MHz)**
1	5955
5	5975
9	5995
13	6015
17	6035
21	6055
25	6075
29	6095
33	6115
37	6135
41	6155
45	6175
49	6195
53	6215
57	6235
61	6255
65	6275
69	6295
73	6315
77	6335
81	6355
85	6375
89	6395
93	6415

6 GHz / UNII-6 / 20 MHz	
Channel	**Frequency (MHz)**
97	6435
101	6455
105	6475
109	6495
113	6515

6 GHz / UNII-7 / 20 MHz	
Channel	**Frequency (MHz)**
117	6535
121	6555
125	6575
129	6595
133	6615
137	6635
141	6655
145	6675
149	6695
153	6715
157	6735
161	6755
165	6775
169	6795
173	6815
177	6835
181	6855
185	6875

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Feature	Description

6 GHz / UNII-8 / 20 MHz	
Channel	**Frequency (MHz)**
189	6895
193	6915
197	6935
201	6955
205	6975
209	6995
213	7015
217	7035
221	7055
225	7075
229	7095
233	7115

6 Bluetooth Functional Description

The Sona IF513 series wireless module includes a fully integrated Bluetooth baseband/radio. Several features and functions are listed in Table 5.

Table 5: Bluetooth functions

Feature	Description
Bluetooth Interface	• Voice interface: – Supported by PCM and I2S transports and bi-directional operations. • PCM ➢ Sample rates 8k for NBS and 16k for WBS supported. ➢ Sample width is limited to 16-bits. ➢ Synchronization clock width of 1 or 3 (short or long). ➢ Bit clocks of 128k, 256k, 512k, 1024k and 2024k, the only difference being the number of 16bit slots. ➢ HFP samples can be taken from any available slot. Slot 0 is the default slot. • I2S ➢ Supports bit clocks of 256k (NBS) and 512k (WBS). ➢ HFP samples can be taken from either left or right. Left is the default. • A2DP codec controller ➢ Supported by I2S transport in a single direction, either in or out but not both. ➢ Two channels, left and right. Mono is not supported. ➢ Sample rates: 44.1k or 48k. ➢ Sample width is limited to 16-bits. ➢ Supports bit clocks of 32 times the sample rate, 1411200 (44.1k) or 1536000 (48k) and not adjustable. • High-Speed UART interface
Bluetooth Core functionality	• Supports all Bluetooth 5.3 and 4.2 features. ▪ Dual-mode Bluetooth low energy. • Bluetooth LE LE-2Mbps mode, LE-Long Range mode, Advertising Extensions, Slot Availability Masks. • Extended inquiry response (EIR): Shortens the time to retrieve the device name, specific profile, and operating mode. • Encryption pause resume (EPR): Enables the use of Bluetooth technology in a much more secure environment. • Sniff subrating (SSR): Optimizes power consumption for low duty cycle asymmetric data flow, which subsequently extends battery life. • Secure simple pairing (SSP): Reduces the number of steps for connecting two devices, with minimal or no user interaction required. • Link supervision time out (LSTO): Additional commands added to HCI and link management protocol (LMP) for improved link time-out supervision.

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Feature	Description
	• QoS enhancements: Changes to data traffic control, which results in better link performance. Audio, human interface device (HID), bulk traffic. SCO, and enhanced SCO (eSCO) are improved with the erroneous data (ED) and packet boundary flag (PBF) enhancements.
Bluetooth Features	• Supports features of Bluetooth Core Specification version 5.3 • Supports features of Bluetooth Core Specification version 5.2: – LE Isochronous Channels – LE Power Control – eATT – ISOC – GATT Caching • Supports features of Bluetooth Core Specification version 5.1: – Control length extension – Periodic Advertising Sync Transfer (PAST) • Supports features of Bluetooth Core Specification version 5.0: – LE 2Mbps – LE Long Range (LE-LR) – Stable Modulation Index for LE – LE Advertising Extension – Slot Availability Masks (SAM) – Channel Selection Algorithm – High Duty Cycle Non-Connectable Advertising • Supports features of Bluetooth Core Specification version 4.0 + EDR – Adaptive frequency hopping (AFH) – Quality of service (QoS) – Extended synchronous connections (eSCO) – Voice Connections – Fast connect (interlaced page and inquiry scans) – Secure simple pairing (SSP) – Sniff subrating (SSR) – Encryption pause resume (EPR) – Extended inquiry response (EIR) – Link supervision timeout (LST) ▪ UART baud rates up to 4 Mbps ▪ Supports Bluetooth 4.2, 5.0, 5.1, 5.2, and 5.3 packet types ▪ Supports maximum Bluetooth data rates over HCI UART • Multipoint operation with up to seven active slaves – Maximum of seven simultaneous active ACL links – Maximum of three simultaneous active SCO and eSCO connections with scatternet support ▪ Narrowband and wideband packet loss concealment ▪ Scatternet operation with up to four active piconets with background scan and support for scatter mode • High-speed HCI UART transport support with low-power out-of-band BT_DEV_WAKE and BT_HOST_WAKE signaling. • Channel quality driven data rate and packet type selection • Standard Bluetooth test modes • Extended radio and production test mode features ▪ Full support for power saving modes – Bluetooth clock request – Bluetooth standard sniff – Deep-sleep modes and software regulator shutdown

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7 Block Diagrams

7.1 M.2 1216 Solder-Down type

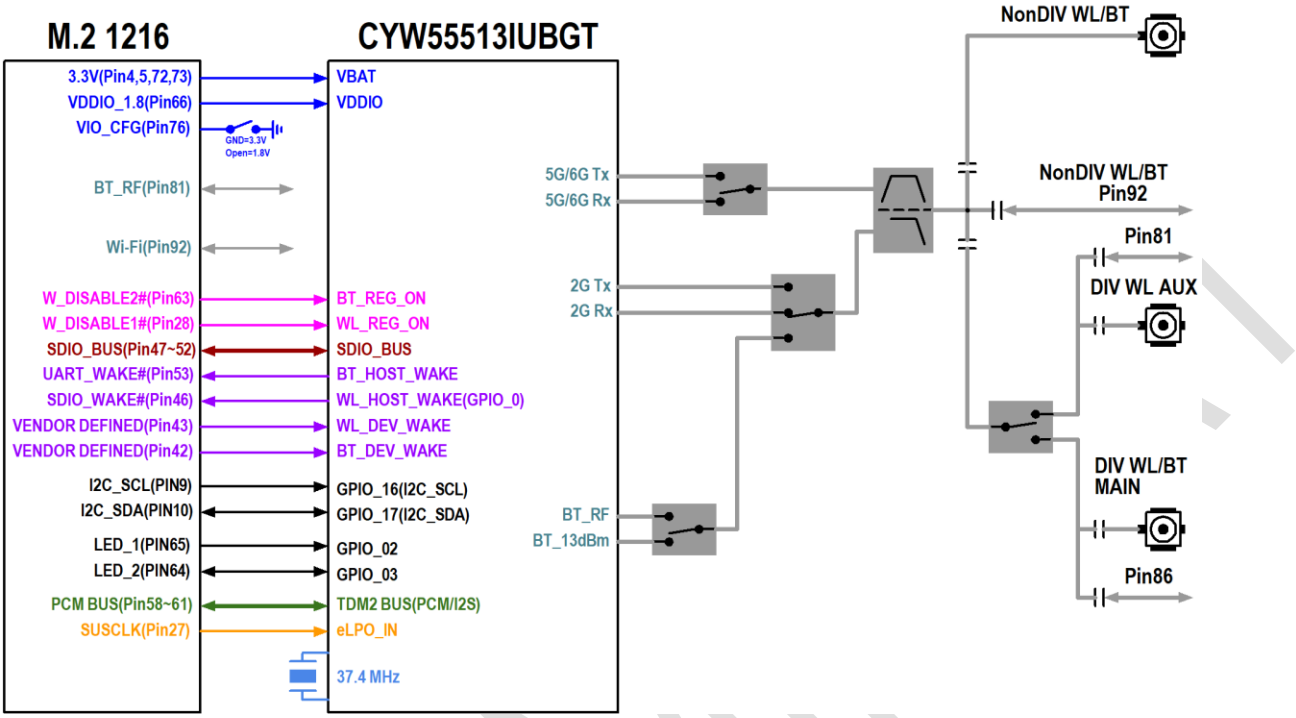


Figure 1: M.2 1216 Solder-Down type block diagram

7.2 M.2 2230 Key-E card

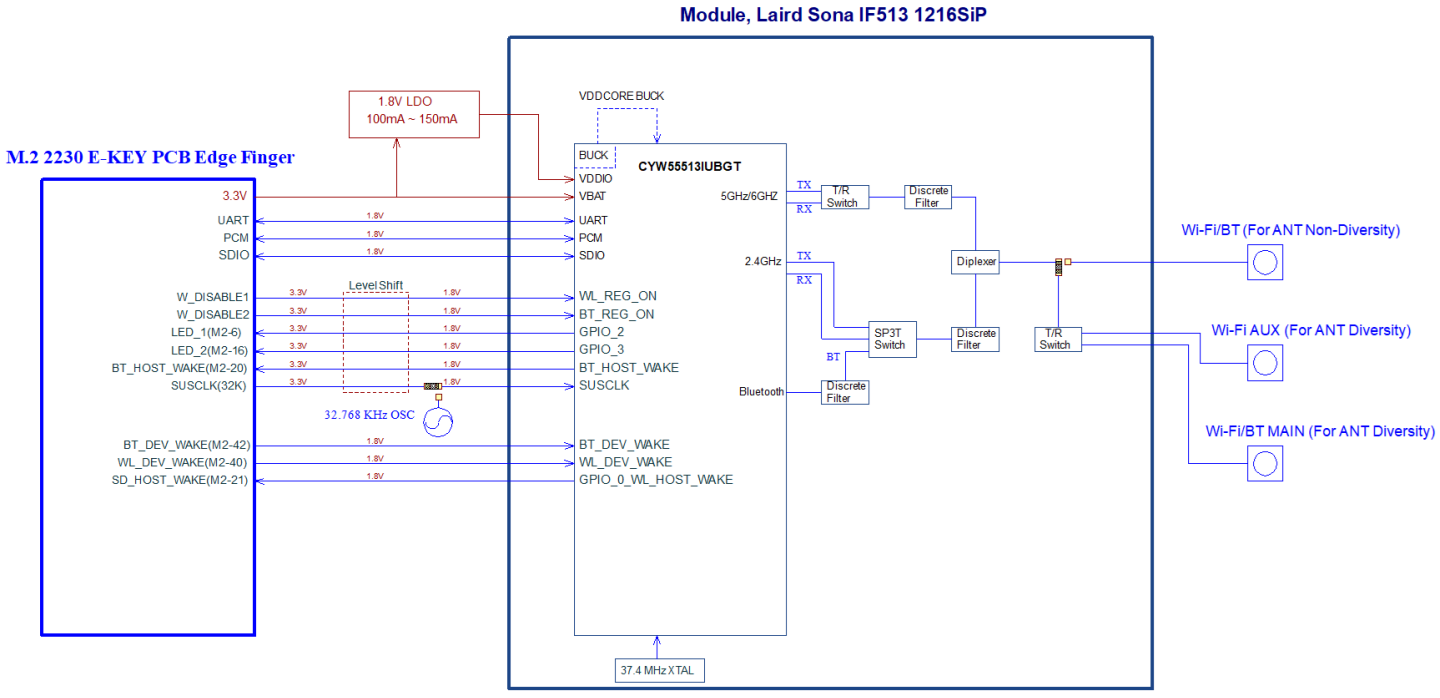


Figure 2: M.2 2230 Key-E card block diagram

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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 Sona IF513 series wireless module. 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)	Description	Max Rating	Unit
VBAT	External DC power supply (M.2 1216)	+6.0	V
VDDIO	DC supply voltage for digital I/O (M.2 1216)	2.2	V
3V3	External 3.3V power supply (M.2 2230 E-Key)	3.6	V
Storage	Storage temperature	-40 to +125	°C
Antenna	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
VBAT	External DC power supply	3.13	3.3	3.5	V
VDDIO	DC supply voltage for digital I/O	1.71	1.8	1.89	V
T-ambient	Ambient temperature	-40	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 VDDIO)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
VIH	High Level Input Voltage	—	0.65 x VDDIO	—	—	V
VIL	Low Level Input Voltage	—	—	—	0.35 x VDDIO	V
VOH	Output high Voltage	—	VDDIO – 0.4	—	—	V
VOL	Output low Voltage	—	—	—	0.45	V

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8.4 WLAN Radio Receiver Characteristics

Table 9, Table 10, and Table 11 summarize the Sona IF513 series wireless module receiver characteristics.

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

Item	Parameter	Conditions	Min	Typ	Max	Unit
Frequency Range	Receive input frequency range	–	2.412	–	2.484	GHz
Modulation Type	Sensitivity					
	CCK, 1 Mbps	See Note[1]	–	-97	–	dBm
	CCK, 11 Mbps		–	-90	–	
	OFDM, 6 Mbps		–	-93	–	
	OFDM, 54 Mbps		–	-76	–	
	HT20, MCS0		–	-93	–	
	HT20, MCS7		–	-75	–	
	HE20, MCS0		–	-93	–	
	HE20, MCS11		–	-62	–	
ACI – CCK [Difference between interfering and desired signal (20 MHz apart)]	Desired and interfering signal 30 MHz apart					
	1 Mbps (-74 dBm)		–	>48	–	dB
	Desired and interfering signal 25 MHz apart					
	11 Mbps (-70 dBm)		–	>46	–	dB
ACI - OFDM [Difference between interfering and desired signal (20 MHz apart)]	6 Mbps (-79 dBm)		–	42.5	–	
	54 Mbps (-62 dBm)	See Note[1]	–	25.5	–	dB
ACI – MCS0-11 [Difference between interfering and desired signal (20 MHz apart)]	MCS0 (-79dBm)		–	35.5	–	dB
	MCS7 (-61 dBm)		–	15	–	
	HE9 (-54 dBm)		–	10.3	–	dB
	HE11 (-49 dBm)		–	5.3	–	

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

Item	Parameter	Conditions	Min	Typ	Max	Unit
Frequency Range	Receive input frequency range	–	5.15	–	5.825	GHz
Modulation Type	Sensitivity					
	OFDM, 6 Mbps	See Note[1]	–	-90	–	dBm
	OFDM, 54 Mbps		–	-74	–	
	HT20, MCS0		–	-90	–	
	HT20, MCS7		–	-73	–	
	VHT20, MCS0		–	-90	–	
	VHT20, MCS8		–	-70	–	
	HE20, MCS0		–	-90	–	
	HE20, MCS11		–	-60	–	
ACI - OFDM [Difference between interfering and desired signal (20 MHz apart)]	Adjacent channel rejection					
	6 Mbps (-79 dBm)	See Note[1]	–	29.5	–	dB
	54 Mbps (-62 dBm)		–	13	–	
ACI – MCS0-11	MCS0 (-79 dBm)	See Note[1]	–	26	–	dB
	MCS7 (-61 dBm)		–	8.5	–	

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Item	Parameter	Conditions	Min	Typ	Max	Unit
[Difference between interfering and desired signal (20 MHz apart)]	HE9 (-54 dBm)		–	0.4	–	
	HE11 (-49 dBm)		–	-5.3	–	
ACI – MCS0-11 [Difference between interfering and desired signal (40 MHz apart)]	MCS0, N_{SS} = 1 (-76 dBm)	See Note[1]	–	29.5	–	dB
	MCS7, N_{SS} = 1 (-58 dBm)		–	9	–	
	MCS9, N_{SS} = 1 (-51 dBm)		–	4	–	
	MCS11, N_{SS} = 1 (-46 dBm)		–	-3	–	
ACI – MCS0-11 [Difference between interfering and desired signal (80 MHz apart)]	MCS0, N_{SS} = 1 (-73 dBm)	See Note[1]	–	35.5	–	dB
	MCS7, N_{SS} = 1 (-55 dBm)		–	8.5	–	
	MCS9, N_{SS} = 1 (-48 dBm)		–	4.5	–	
	MCS11, N_{SS} = 1 (-43 dBm)		–	-1.5	–	

Table 11: WLAN receiver characteristics for 6 GHz single chain operation

Item	Parameter	Conditions	Typical (Sensitivity)				Unit
			UNII-5	UNII-6	UNII-7	UNII-8	
Frequency Range	Receive input frequency range	–	5950 - 6415	6435 - 6515	6535 - 6875	6895 - 7115	MHz
Modulation Type	OFDM, 6Mbps	See Note[1]	-90	-90	-89	-88	dBm
	OFDM, 24Mbps		-83	-82	-81	-80	
	HE20, MCS0		-90	-90	-89	-88	
	HE20, MCS7		-74	-73	-72	-71	
	HE20, MCS8		-69	-69	-69	-68	
	HE20, MCS9		-68	-68	-68	-67	
	HE20, MCS11		-59	-59	-58	-56	
ACI - OFDM [Difference between interfering and desired signal (20 MHz apart)]	6 Mbps (-79 dBm)	See Note[1]	25	25	25	25	dB
ACI – MCS0-11 [Difference between interfering and desired signal (20 MHz apart)]	MCS0 (-79 dBm)	See Note[1]	25	25	25	25	
	MCS7 (-61 dBm)		5	5	5	5	
	MCS9 (-54 dBm)		4	3.5	5	4	
	MCS11 (-49 dBm)		-1.5	-2.5	-0.5	-2	

Note 1: Performance data are measured in single chain operation.

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8.5 WLAN Transmitter Characteristics

Table 12 through Table 21 summarize the Sona IF513 series wireless module transmitter characteristics.

Table 12: WLAN transmitter characteristics for 2.4 GHz operation (VBAT = 3.3V, VDDIO = 1.8V)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Ftx	Transmit output frequency range	—	2.402	—	2.484	GHz
Pout	Output power	See Note[2]	—	—	—	—
	11b mask compliant	1-11Mbps	—	18	—	dBm
	11g mask compliant	6-36Mbps	—	18	—	
	11g EVM compliant	48-54Mbps	—	17	—	
	11n HT20 mask compliant	MCS0-4	—	18	—	
	11n HT20 EVM compliant	MCS5-7	—	16	—	
	11ax HE20 mask compliant	MCS0-4	—	18	—	
	11ax HE20 EVM compliant	MCS5-7	—	16	—	
	11ax HE20 EVM compliant	MCS8-9	—	14	—	
	11ax HE20 EVM compliant	MCS10-11	—	13	—	
ATx	Transmit power accuracy at 25 ℃	—	-2.0	—	+2.0	dB

Table 13: WLAN current consumption on 2.4 GHz (VBAT = 3.3V, VDDIO = 1.8V, BT_REG_ON = Low)

Modulation	Data Rate	Bandwidth (MHz)	Spatial Stream	RF Power Level (dBm)	VBAT Current Consumption (mA)	VIO Current Consumption (mA)
CCK	1 Mbps	20	1	20	255.8	4.6
CCK	11 Mbps	20	1	20	264.8	2.4
BPSK	6 Mbps	20	1	20	244.4	2.9
QPSK	MCS2	20	1	20	252.6	3.5
16-QAM	MCS4	20	1	20	211.8	2.8
64-QAM	MCS7	20	1	18	215.7	2.4
256-QAM	MCS9	20	1	16	197.7	2.1
1024-QAM	MCS11	20	1	15	190.5	1.8

Table 14: WLAN transmitter characteristics for 5 GHz operation (VBAT=3.3V, VDDIO=1.8V)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Ftx	Transmit output frequency range	—	5.15	—	5.925	GHz
Pout	Output power	See Note[2]	—	—	—	—
	11a mask compliant	6-36Mbps	—	17	—	dBm
	11a EVM compliant	48-54Mbps	—	16.5	—	
	11n HT20 mask compliant	MCS0-4	—	17	—	
	11n HT20 EVM compliant	MCS5-7	—	16.5	—	
	11ac VHT20 mask compliant	MCS0-4	—	17	—	
	11ac VHT20 EVM compliant	MCS5-7	—	16.5	—	
	11ac VHT20 EVM compliant	MCS8	—	14	—	
	11ax HE20 mask compliant	MCS0-4	—	17	—	
	11ax HE20 EVM compliant	MCS5-7	—	16.5	—	
	11ax HE20 EVM compliant	MCS8-9	—	14	—	
	11ax HE20 EVM compliant	MCS10-11	—	13	—	
ATx	Transmit power accuracy at 25 ℃	—	-2.0	—	+2.0	dB

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Table 15: WLAN current consumption on 5 GHz (VBAT = 3.3V, VDDIO = 1.8V, BT_REG_ON = Low)

Modulation	Data Rate	Bandwidth (MHz)	Spatial Stream	RF Power Level (dBm)	VBAT Current Consumption (mA)	VIO Current Consumption (mA)
BPSK	6 Mbps	20	1	19	307.2	3.1
QPSK	MCS2	20	1	19	310.9	3.1
16-QAM	MCS4	20	1	19	315.8	3
64-QAM	MCS7	20	1	18.5	297.5	2.5
256-QAM	MCS9	20	1	16	274.8	2.2
1024-QAM	MCS11	20	1	15	257.7	2.1

Table 16: WLAN transmitter characteristics for UNII-5 and UNII-6 operation (VBAT = 3.3V, VDDIO = 1.8V)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Ftx	Transmit output frequency range	—	5.925	—	6.53	GHz
Pout	Output power	See Note[2]	—	—	—	—
	11a mask compliant	6-24Mbps	—	15.5	—	dBm
	11ax HE20 mask compliant	MCS0-4	—	15.5	—	
	11ax HE20 EVM compliant	MCS5-7	—	15	—	
	11ax HE20 EVM compliant	MCS8-9	—	13.5	—	
	11ax HE20 EVM compliant	MCS10-11	—	12	—	
ATx	Transmit power accuracy at 25 ℃	—	-2.0	—	+2.0	dB

Table 17: WLAN current consumption on UNII-5 band (VBAT = 3.3V, VDDIO = 1.8V, BT_REG_ON = Low)

Modulation	Data Rate	Bandwidth (MHz)	Spatial Stream	RF Power Level (dBm)	VBAT Current Consumption (mA)	VIO Current Consumption (mA)
BPSK	6 Mbps	20	1	17.5	332	3.1
BPSK	MCS0	20	1	17.5	327	2.7
QPSK	MCS2	20	1	17.5	325.4	3
16-QAM	MCS4	20	1	17.5	338.6	3
64-QAM	MCS7	20	1	17	317.4	2.4
256-QAM	MCS9	20	1	15.5	288.2	2.2
1024-QAM	MCS11	20	1	14	264.7	2

Table 18: WLAN current consumption on UNII-6 band (VBAT = 3.3V, VDDIO = 1.8V, BT_REG_ON = Low)

Modulation	Data Rate	Bandwidth (MHz)	Spatial Stream	RF Power Level (dBm)	VBAT Current Consumption (mA)	VIO Current Consumption (mA)
BPSK	6 Mbps	20	1	17.5	279.3	3.1
BPSK	MCS0	20	1	17.5	283.6	2.7
QPSK	MCS2	20	1	17.5	292.9	3
16-QAM	MCS4	20	1	17.5	298.1	3
64-QAM	MCS7	20	1	17	282	2.4
256-QAM	MCS9	20	1	15.5	266.1	2.2
1024-QAM	MCS11	20	1	14	251	2

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Table 19: WLAN transmitter characteristics for UNII-7 and UNII-8 operation (VBAT = 3.3V, VDDIO = 1.8V)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Ftx	Transmit output frequency range	—	6.53	—	7.125	GHz
Pout	Output power	See Note[2]	—	—	—	—
	11a mask compliant	6-24Mbps	—	15	—	dBm
	11ax HE20 mask compliant	MCS0-4	—	15	—	
	11ax HE20 EVM compliant	MCS5-7	—	13	—	
	11ax HE20 EVM compliant	MCS8-9	—	12	—	
	11ax HE20 EVM compliant	MCS10-11	—	10.5	—	
ATx	Transmit power accuracy at 25 ℃	—	-2.0	—	+2.0	dB

Table 20: WLAN current consumption on UNII-7 band (VBAT = 3.3V, VDDIO = 1.8V, BT_REG_ON = Low)

Modulation	Data Rate	Bandwidth (MHz)	Spatial Stream	RF Power Level (dBm)	VBAT Current Consumption (mA)	VIO Current Consumption (mA)
BPSK	6 Mbps	20	1	17	286.4	3.1
BPSK	MCS0	20	1	17	289.4	2.7
QPSK	MCS2	20	1	17	290.1	3
16-QAM	MCS4	20	1	17	296.3	3
64-QAM	MCS7	20	1	15	265.4	2.4
256-QAM	MCS9	20	1	14	252.7	2.2
1024-QAM	MCS11	20	1	12.5	238.3	2

Table 21: WLAN current consumption on UNII-8 band (VBAT = 3.3V, VDDIO = 1.8V, BT_REG_ON = Low)

Modulation	Data Rate	Bandwidth (MHz)	Spatial Stream	RF Power Level (dBm)	VBAT Current Consumption (mA)	VIO Current Consumption (mA)
BPSK	6 Mbps	20	1	17	310.9	3.1
BPSK	MCS0	20	1	17	306.1	2.7
QPSK	MCS2	20	1	17	314.1	3
16-QAM	MCS4	20	1	17	318.6	3
64-QAM	MCS7	20	1	15	290.5	2.4
256-QAM	MCS9	20	1	14	270.4	2.2
1024-QAM	MCS11	20	1	12.5	253.5	2

Note 2: Final TX power values on each channel are limited by regulatory requirements.

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9 Bluetooth Radio Characteristics

Table 22 through Table 26 describe the performance of the Bluetooth transmitter and receiver and the current consumption at 25°C.

Table 22: BR / EDR transmitter performance (VBAT = 3.3V, VDDIO = 1.8V)

Test Parameter		Min	Typ	Max	BT Spec.	Unit
Maximum RF Output Power	GFSK	—	—	7	0 ~ +20	dBm
	π/4-DQPSK	—	—	4		
	8-DPSK	—	—	4		
Frequency Range		2.4	—	2.4835	2.4 ≤ f ≤ 2.4835	GHz
20 dB Bandwidth		—	930	—	≤ 1000	KHz
Δf1avg Maximum Modulation		140	154	175	140 < Δf1avg < 175	KHz
Δf2max Minimum Modulation		115	147	—	≥ 115	KHz
Δf2avg/Δf1avg		—	0.95	—	≥ 0.80	—
Initial Carrier Frequency		—	± 25	± 75	≤ ± 75	KHz
Frequency Drift (DH1 packet)		—	± 8	± 25	± 25	KHz
Frequency Drift (DH3 packet)		—	± 8	± 40	± 40	KHz
Frequency Drift (DH5 packet)		—	± 8	± 40	± 40	KHz
Drift rate		—	5	20	20	KHz/50us
EDR ωi		—	—	± 75	≤ ± 75	KHz
EDR ω0		—	—	± 10	≤ ± 10	KHz
EDR (ωi + ω0)		—	—	± 75	≤ ± 75	KHz
RMS DEVM for π/4-DQPSK		—	—	≤ 0.2	≤ 0.2	—
RMS DEVM for 8-DPSK		—	—	≤ 0.13	≤ 0.13	—
Peak DEVM for π/4-DQPSK		—	—	≤ 0.35	≤ 0.35	—
Peak DEVM for 8-DPSK		—	—	≤ 0.25	≤ 0.25	—
99% DEVM for π/4-DQPSK		—	—	≤ 0.30	≤ 0.30	—
99% DEVM for 8-DPSK		—	—	≤ 0.20	≤ 0.20	—
EDR In-Band Spurious Emission	IM-NI ≥ 2.5 MHz	—	-43	-40	< -40	dBm
	1.5 MHz < IM-NI < 2.5 MHz	—	-31	-20	≤ -20	dBm
	1.0 MHz < IM-NI < 1.5 MHz	—	-38	-26	≤ -26	dBm

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Table 23: Basic Rate receiver performance (VBAT = 3.3V, VDDIO = 1.8V)

Test Parameter		Min	Typ	Max	Bluetooth Spec.	Unit
Sensitivity (1DH5)	BER ≤ 0.1%	—	-91	—	≤ -70	dBm
Maximum Input	BER ≤ 0.1%	—	—	-20	≥ -20	dBm
Interference Performance	Co-Channel	—	8.5	11	11	dB
	C/I 1 MHz adjacent channel	—	-1.4	0	0	dB
	C/I 2 MHz adjacent channel	—	-41	-30	-30	dB
	C/I ≥ 3 MHz adjacent channel	—	-42.5	-40	-40	dB
	C/I image channel	—	-31.5	-9	-9	dB
	C/I 1-MHz adjacent to image channel	—	-44.5	-20	-20	dB

Table 24: Enhanced Data Rate receiver performance (VBAT = 3.3V, VDDIO = 1.8V)

Test Parameter		Min	Typ	Max	Bluetooth Spec.	Unit
Sensitivity (BER ≤ 0.01%)	π/4-DQPSK	—	-93	—	≤ -70	dBm
	8-DPSK	—	-87	—	≤ -70	dBm
Maximum Input (BER ≤ 0.1%)	π/4-DQPSK	—	—	-20	≥ -20	dBm
	8-DPSK	—	—	-20	≥ -20	dBm
C/I Co-Channel (BER ≤ 0.1%)	π/4-DQPSK	—	10.5	13	≤ ±13	dB
	8-DPSK	—	18	21	≤ ±21	dB
C/I 1 MHz adjacent Channel	π/4-DQPSK	—	-6.5	0	≤ 0	dB
	8-DPSK	—	-1	5	≤5	dB
C/I 2 MHz adjacent Channel	π/4-DQPSK	—	-38.5	-30	≤ -30	dB
	8-DPSK	—	-36.5	-25	≤ -25	dB
C/I ≥ 3 MHz adjacent Channel	π/4-DQPSK	—	-42.5	-40	≤ -40	dB
	8-DPSK	—	-41.5	-33	≤ -33	dB
C/I image channel	π/4-DQPSK	—	-30	-7	≤ -7	dB
	8-DPSK	—	-22.5	0	≤ 0	dB
C/I 1 MHz adjacent to image channel	π/4-DQPSK	—	-47.5	-20	≤ -20	dB
	8-DPSK	—	-41.5	-13	≤ -13	dB
Out-of-Band Blocking Performance (CW) BER ≤ 0.1%	30-2000MHz	—	-10	—	—	dBm
	2-2.399GHz	—	-27	—	—	dBm
	2.484-3GHz	—	-27	—	—	dBm
	3-12.75GHz	—	-10	—	—	dBm

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Table 25: BLE RF Specifications (VBAT = 3.3V, VDDIO = 1.8V)

Parameter	Conditions		Min	Typ	Max	Unit
Frequency range	–		2402	–	2480	MHz
Rx sensitivity[3]	GFSK, PER ≤ 30.8%	1 Mbps	–	-95	–	dBm
		2 Mbps	–	-92	–	dBm
		500 Kbps	–	-102	–	dBm
		125 Kbps	–	-107	–	dBm
Tx power[4]	–		–	–	7	dBm
Δf1 average	1 Mbps		225	255	275.5	KHz
	2 Mbps		450	500	550	KHz
	125 Kbps		225	255	275	KHz
Δf2 average	1 Mbps		185	230	–	KHz
Δf2 maximum[5]	2 Mbps		370	450	–	KHz
Δf1 average (Stable Modulation)	1 Mbps		247.5	250	252.5	KHz
	2 Mbps		495	500	550	KHz
	125 Kbps		247.5	250	252.5	KHz
$\frac{\Delta f2\ avg}{\Delta f1\ avg}$ ratio	1 Mbps		0.8	1.0	–	%
	2 Mbps		0.8	1.0	–	%

Table 26: Bluetooth transmitter current consumption (VBAT = 3.3V, VDDIO = 1.8V, WL_REG_ON = OFF)

Operation Band	Operating Mode		VBAT Current Consumption (mA)	VIO Current Consumption (mA)
	Data Rate	RF Power Level (dBm)		
Basic Rate	1DH5	6.8	18.8	0.4
Enhanced Data Rate	2DH5	3.4	18.7	0.4
	3DH5	3.4	18.24	0.4
Low-Energy	1 Mbps	6.81	19.86	0.4
	2 Mbps	6.6	13.21	0.4
	500 Kbps	6.73	17.32	0.4
	125 Kbps	6.64	23.13	0.4

Notes:

[3] Dirty Tx is Off.

[4] The Bluetooth LE TX power cannot exceed 10 dBm EIRP specification limit. The front-end losses and antenna gain/loss must be factored in so as not to exceed the limit.

[5] At least 99.9% of all Δf2 maximum frequency values recorded over 10 packets must be greater than 185 KHz.

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10 Crystal Oscillator Requirements

Table 27: Crystal Oscillator Specification

32.768 KHz Oscillator	
Frequency Accuracy	200 ppm
Duty Cycle	30% – 70%
Input Signal Amplitude	200-3300 mV, peak-peak
Signal Type	Square or Sine Wave
Clock Jitter	<10,000 ppm

IMPORTANT: A 32.768 KHz crystal is required for the module to be functional. The module will not boot without this crystal.

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11 Host Interface Specifications

11.1 SDIO Specifications

The Sona IF513 series provides support for SDIO 2.0/3.0, including the new UHS-I[6] modes:

- DS: Default speed (DS) up to 25 MHz, including 1- and 4-bit modes (1.8 V signaling)
- HS: High speed up to 50 MHz (1.8 V signaling)
- SDR12: SDR up to 25 MHz (1.8V signaling)
- SDR25: SDR up to 50 MHz (1.8V signaling)
- SDR50: SDR up to 100 MHz (1.8V signaling)
- DDR50: DDR up to 500 MHz (1.8V signaling)

The Sona IF513 series wireless module SDIO host interface pins are powered from the VDDIO voltage supply, which is set internally at 1.8V[7] on the M.2 module.

Note:

[6] The UHS-I rate SDR104, that is part of the SDIO 3.0 specification is not supported.

[7] The SDIO host signals must be 1.8V at all times as defined by the M.2 standard.

11.1.1 Default mode and High-Speed mode

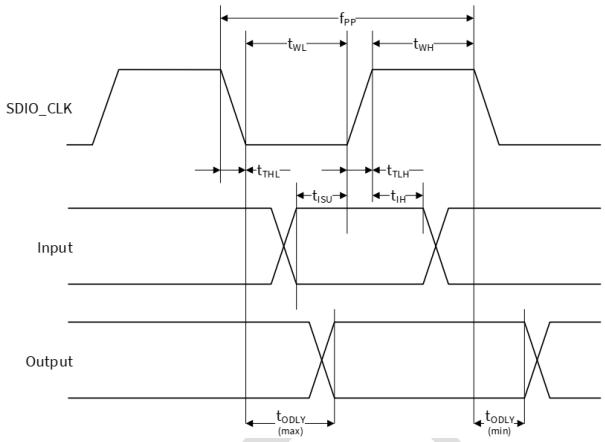


Figure 3: SDIO bus timing- Default mode (1.8V)

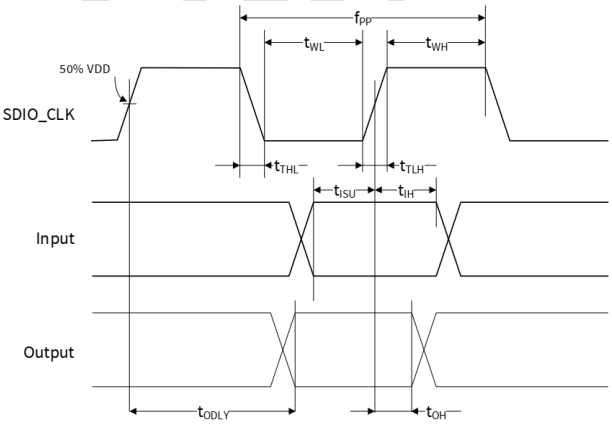


Figure 4: SDIO bus timing- High-Speed mode (1.8V)

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

Table 28: SDIO timing requirements

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
f_{PP}	Clock Frequency	**Default mode**	0	-	25	MHz
		High-Speed mode	0	-	50	
t_{WL}	Clock low time	**Default mode**	10	-	-	ns
		High-Speed mode	7	-	-	
t_{WH}	Clock high time	**Default mode**	10	-	-	ns
		High-Speed mode	7	-	-	
t_{TLH}	Clock rise time	**Default mode**	-	-	10	ns
		High-Speed mode	-	-	3	
t_{THL}	Clock low time	**Default mode**	-	-	10	ns
		High-Speed mode	-	-	3	
t_{ISU}	Input Setup time	**Default mode**	5	-	-	ns
		High-Speed mode	6	-	-	

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Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
t_{IH}	Input Hold time	**Default Speed**	5	-	-	ns
		High-Speed mode	2	-	-	
t_{ODLY}	Output delay time – Data Transfer mode	**Default mode**	0	-	14	ns
		High-Speed mode	-	-	14	
	Output delay time – Identification mode	**Default mode**	0	-	50	ns
t_{OH}	Output hold time	**High-Speed mode**	2.5	-	-	ns
CL	Total system capacitance (each line)	**High-Speed mode**	-	-	40	pF

11.1.2 SDIO bus clock timing specifications in SDR mode

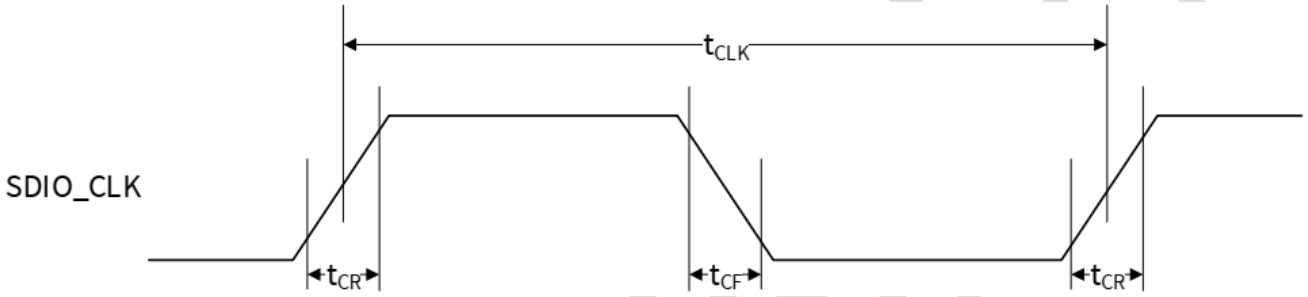


Figure 5: SDIO clock timing (SDR modes)

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

Table 29: SDIO clock timing parameters (SDR modes)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
t_{CLK}		**SDR12**	40	-	-	ns
		SDR25	20	-	-	
		SDR50	10	-	-	
t_{CR}, t_{CF}	t_{CR}, t_{CF} < 2ns (max) at 100MHz C_{CARD}=10pF		-	-	0.2*t_{CLK}	ns
-	Clock duty cycle	**SDR12/25/50/104**	30	-	70	%

11.1.3 SDIO Bus Input Timing

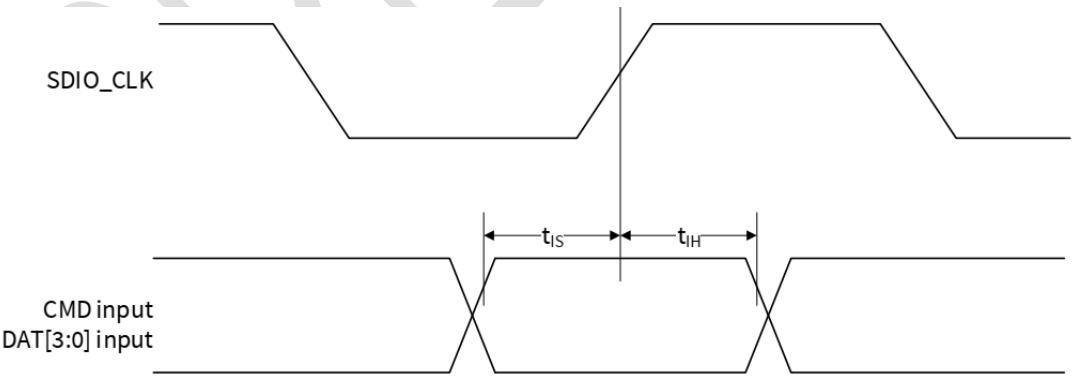


Figure 6: SDIO bus input timing (SDR mode)

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

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Table 30: SDIO bus input timing requirements (SDR mode)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
t_{IS}	Input setup time, C_{CARD}=10pF, V_{CT}=0.975V	**SDR50**	3	-	-	ns
t_{IH}	Input Hold time, C_{CARD}=5pF, V_{CT}=0.975V	**SDR50**	0.8	-	-	ns

11.1.4 SDIO Bus Output Timing

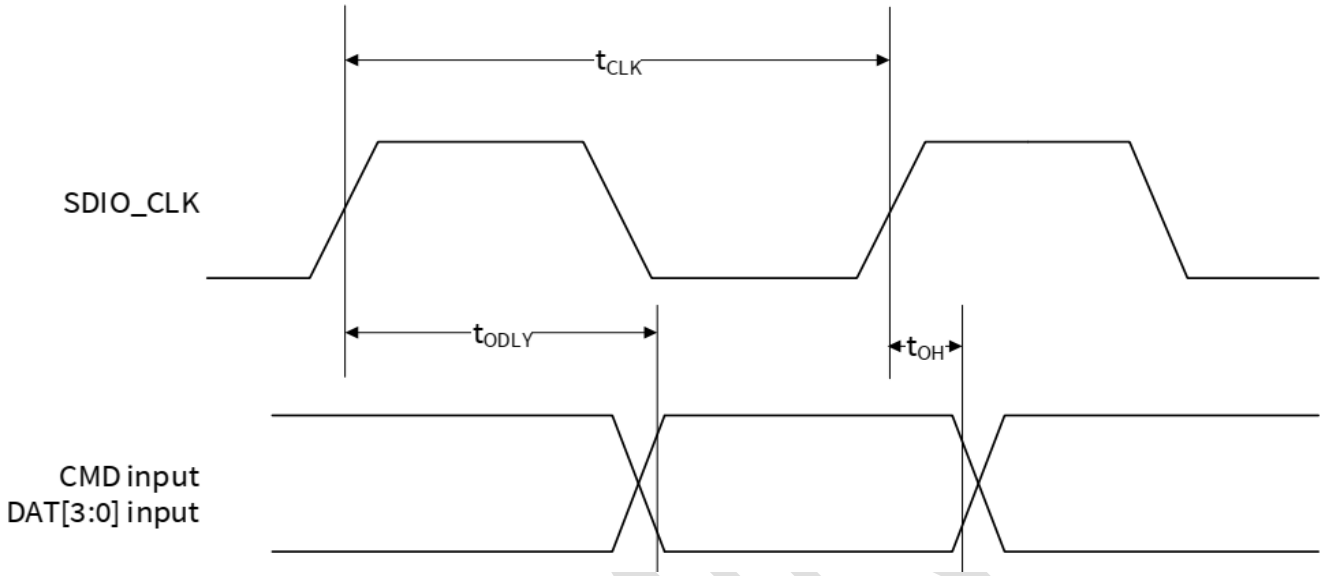


Figure 7: SDIO bus output timing (SDR modes)

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

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Table 31: SDIO bus output timing requirements (SDR modes)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
t_{ODLY}	Delay time, $t_{CLK} \geq 20ns$, $C_L = 40pF$	**SDR12/SDR25**	-	-	14	ns
	Delay time, $t_{CLK} \geq 10ns$, $C_L = 30pF$	**SDR50**	-	-	7.5	
t_{OH}	Hold time, $C_L = 15pF$	**SDR12/SDR25/SDR50**	1.5	-	-	ns

11.1.5 SDIO Bus Timing Specifications in DDR50 mode

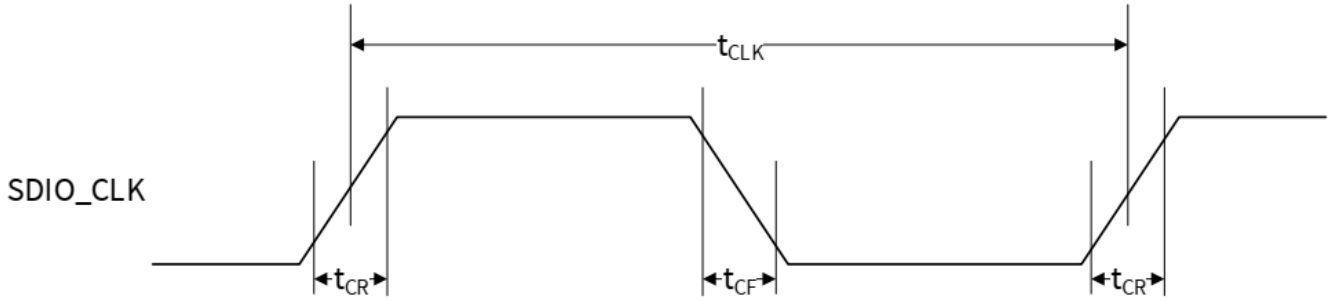


Figure 8: SDIO clock timing (DDR50 mode)

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

Table 32: SDIO bus clock timing requirements (DDR50 mode)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
t_{CLK}	-	**DDR50**	25	-	-	ns
t_{CR}, t_{CF}	t_{CR}, t_{CF} < 4ns (max) at 50MHz C_{CARD}=10pF		-	-	0.2*t_{CLK}	ns
-	Clock duty cycle	**DDR50**	45	-	55	%

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11.1.5.1 SDIO Bus Data Timing Specifications

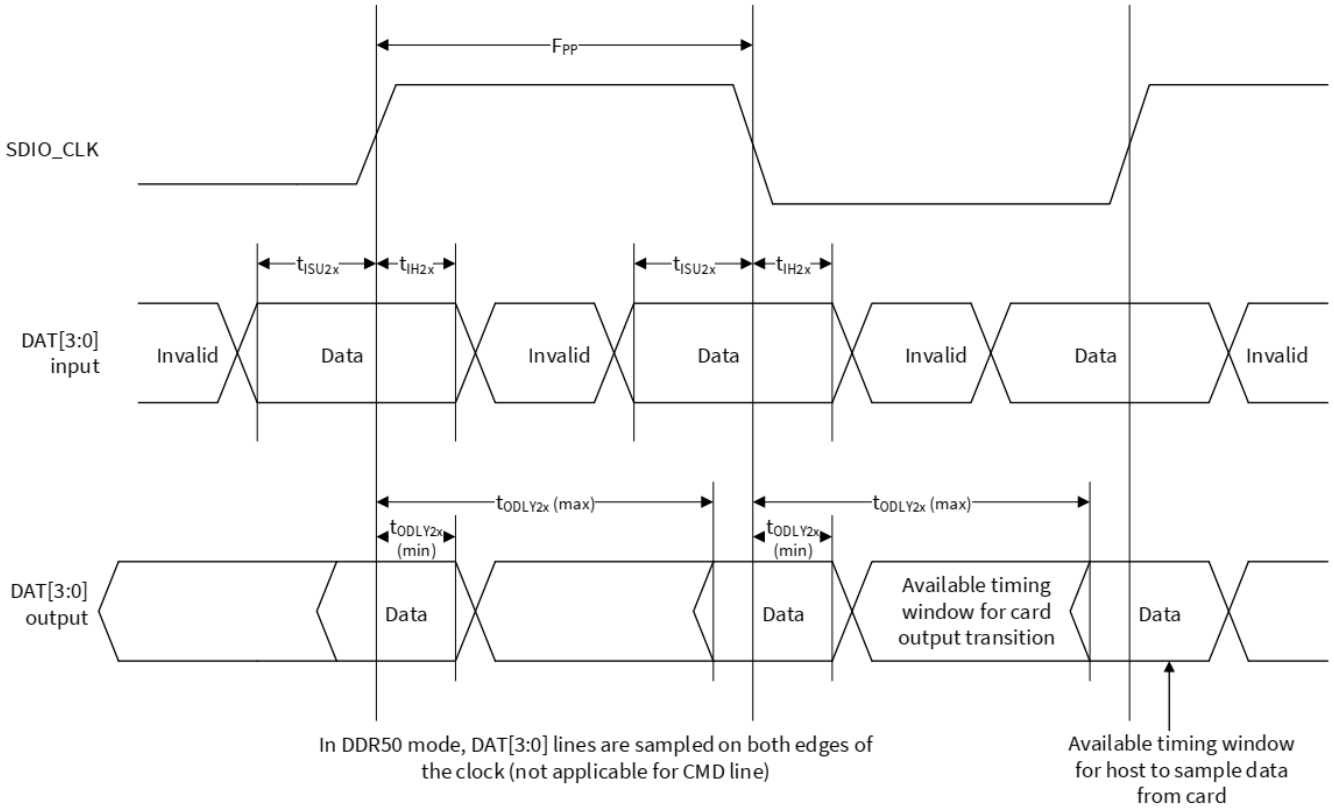


Figure 9: SDIO data timing (DDR50 mode)

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

Table 33: SDIO bus data timing requirements (DDR50 mode)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
Input CMD						
t_{ISU}	Input setup time	C_{CARD} < 10pF	6	-	-	ns
tIH	Input hold time		0.8	-	-	
Output CMD						
t_{ODLY}	Output delay time		-	-	13.7	ns
t_{OH}	Output hold time	C_{CARD} < 15pF	1.5	-	-	
Input DAT						
t_{ISU2x}	Input setup time	C_{CARD} < 10pF	3	-	-	ns
t_{IH2x}	Input hold time		0.8	-	-	
Output DAT						
t_{ODLY2x}	Output delay time		-	-	7.5	ns
t_{ODLY2x}	Output hold time	C_{CARD} < 15pF	1.5	-	-	

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11.2 PCM Interface Specifications

11.2.1 PCM Interface

The Sona IF513 series wireless module supports a PCM interface. The PCM interface on the Sona IF513 series wireless module can connect to linear PCM codec devices in Master/Slave mode. In Master mode, the Sona IF513 generates the BT_PCM_CLK and BT_PCM_SYNC signals, and in Slave mode, these signals are provided by another master on the PCM interface and are input to the Sona IF513 module.

The configuration of the PCM interface may be adjusted by the host through the use of vendor-specific HCI commands.

11.2.2 Burst PCM mode

In this mode of operation, the PCM bus runs at a significantly higher rate of operation to allow the host to duty cycle its operation and save current. In this mode of operation, the PCM bus can operate at a rate of up to 24 MHz. This mode of operation is initiated with an HCI command from the host.

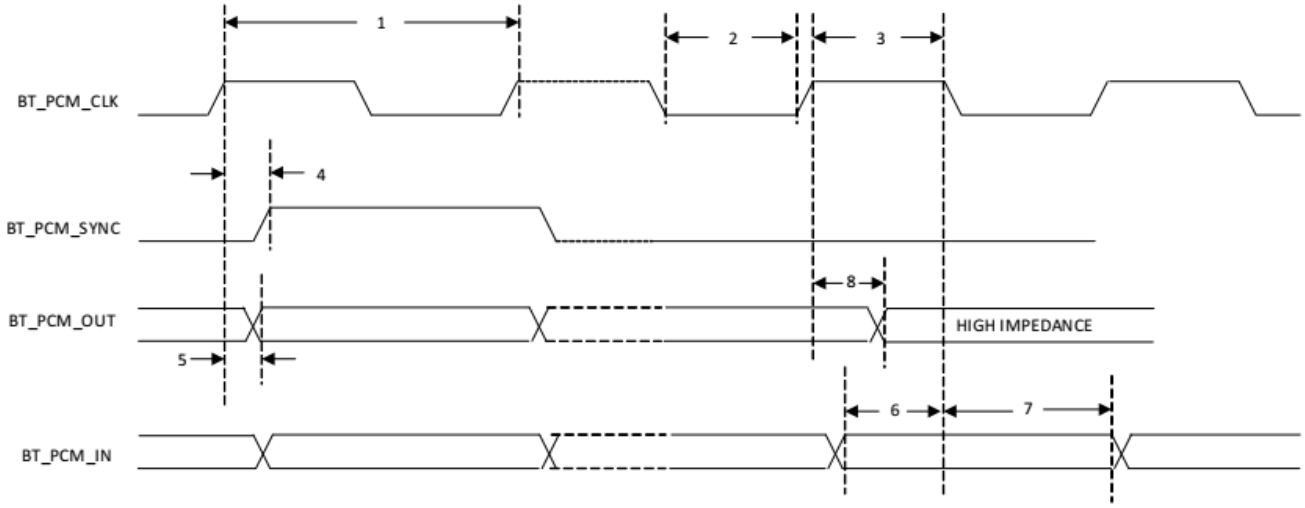


Figure 10: PCM timing diagram – Short Frames Sync, Master Mode

Table 34: PCM timing specification – Short Frames Sync, Master Mode

Reference	Characteristics	Min.	Typ.	Max.	Unit
1	PCM bit clock frequency	-	-	12.0	MHz
2	PCM bit clock LOW	41.0	-	-	ns
3	PCM bit clock HIGH	41.0	-	-	ns
4	BT_PCM_SYNC delay	0	-	25.0	ns
5	BT_PCM_OUT delay	0	-	25.0	ns
6	BT_PCM_IN setup	8.0	-	-	ns
7	BT_PCM_IN hold	8.0	-	-	ns
8	Delay from rising edge of BT_PCM_CLK during last bit period to BT_PCM_OUT becoming high impedance	0	-	25.0	ns

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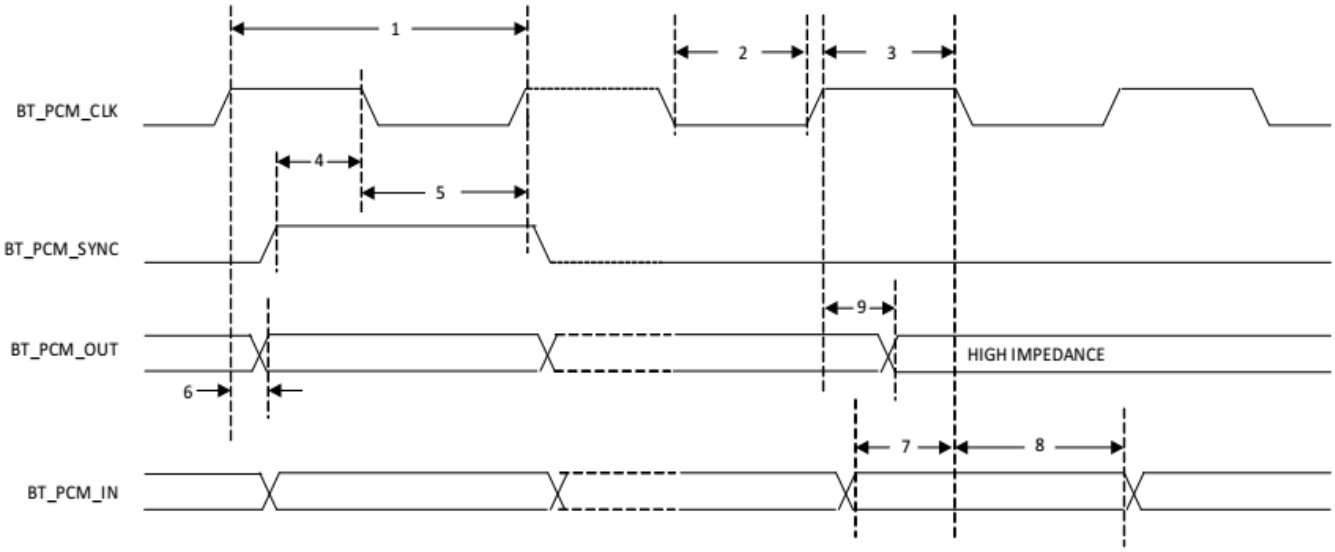


Figure 11: PCM timing diagram- Short Frame Sync, Slave Mode

Table 35: PCM timing specification – Short Frame Sync, Slave Mode

Reference	Characteristics	Min.	Typ.	Max.	Unit
1	PCM bit clock frequency	-	-	12.0	MHz
2	PCM bit clock LOW	41.0	-	-	ns
3	PCM bit clock HIGH	41.0	-	-	ns
4	BT_PCM_SYNC setup	8.0	-	-	ns
5	BT_PCM_SYNC hold	8.0	-	-	ns
6	BT_PCM_OUT delay	0	-	25.0	ns
7	BT_PCM_IN setup	8.0	-	-	ns
8	BT_PCM_IN hold	8.0	-	-	ns
9	Delay from rising edge of BT_PCM_CLK during last bit period to BT_PCM_OUT becoming high impedance	0	-	25.0	ns

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11.3 UART Interface

The Sona IF513 series Bluetooth access through the UART interface that it is a standard 4-wire interface (RX, TX, RTS, and CTS) with adjustable rates from 9600 bps to 4.0 Mbps. The baud rate may be selected through a vendor-specific UART HCI command. The default baud rate is 115.2 K baud.

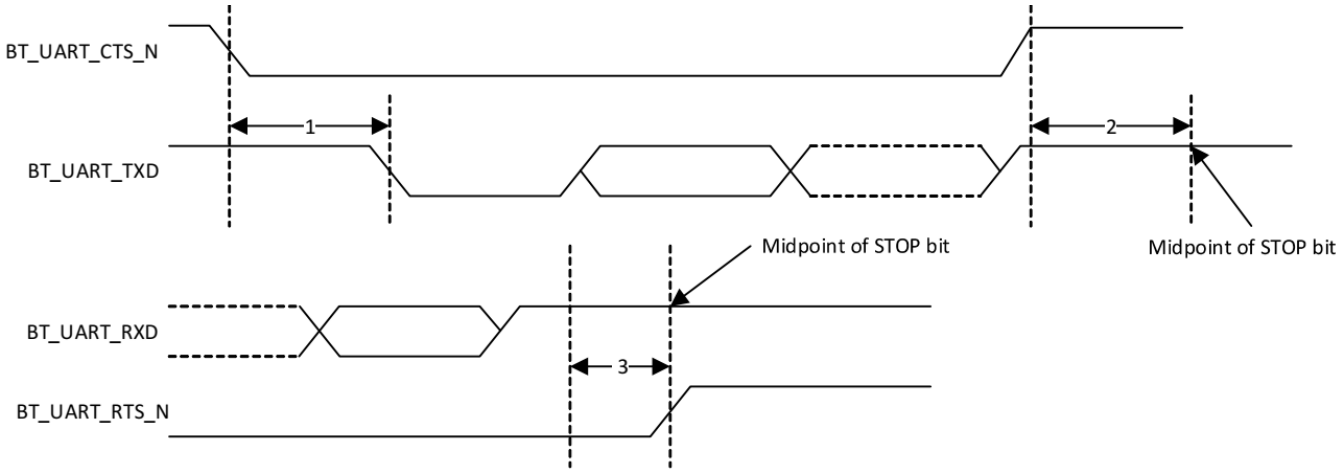


Figure 12: UART timing diagram

Table 36: UART timing specifications

Reference	Characteristics	Min.	Typ.	Max.	Unit
1	Delay time, BT_UART_CTS_N low to BT_UART_TXD valid	-	-	1.5	Bit periods
2	Setup time, BT_UART_CTS_N high before midpoint of stop bit	-	-	0.5	Bit periods
3	Delay time, midpoint of stop bit to BT_UART_RTS_N high	-	-	0.5	Bit periods

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12 Power-Up Sequence and Timing

Sona IF513 has two signals that allow the host to control power consumption by enabling or disabling the Bluetooth, WLAN, and internal regulator block.

12.1 Description of Control Signals

- WL_REG_ON: Used to power up the WLAN. When this pin is high, the internal regulators are enabled, and the WLAN section is out of reset. When this pin is low the WLAN section is in reset. This signal is connected to the W_DISABLE1# pin on the M.2 interface.
- BT_REG_ON: Used to power up the Bluetooth section. If both the BT_REG_ON and WL_REG_ON pins are low, the regulators are disabled. When this pin is low and WL_REG_ON is high, the Bluetooth section is in reset. This signal is connected to the W_DISABLE2# pin on the M.2 interface.

12.2 Control Signal Timing Diagram

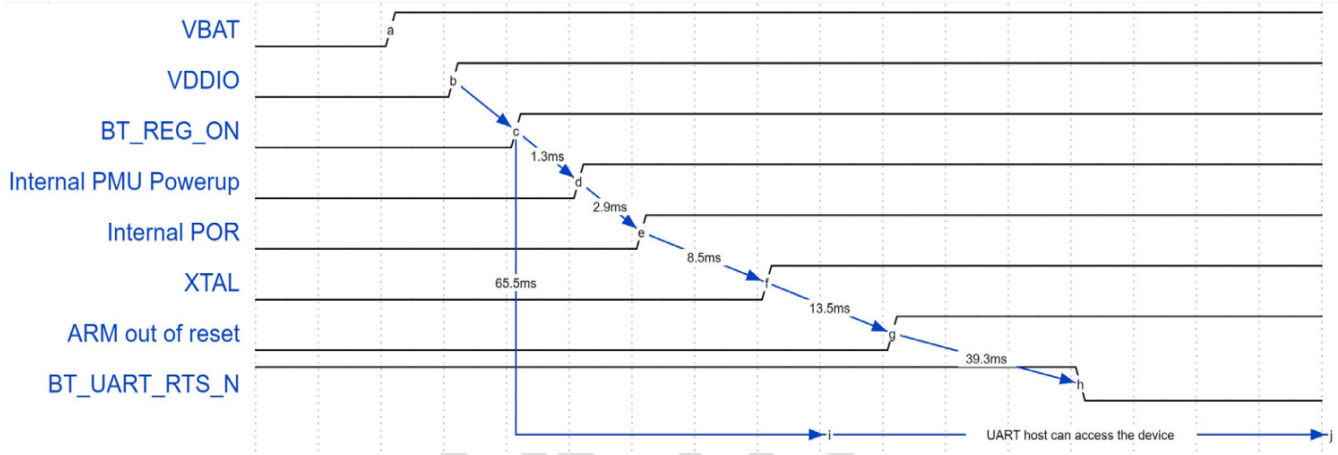


Figure 13: Bluetooth subsystem bootup sequence

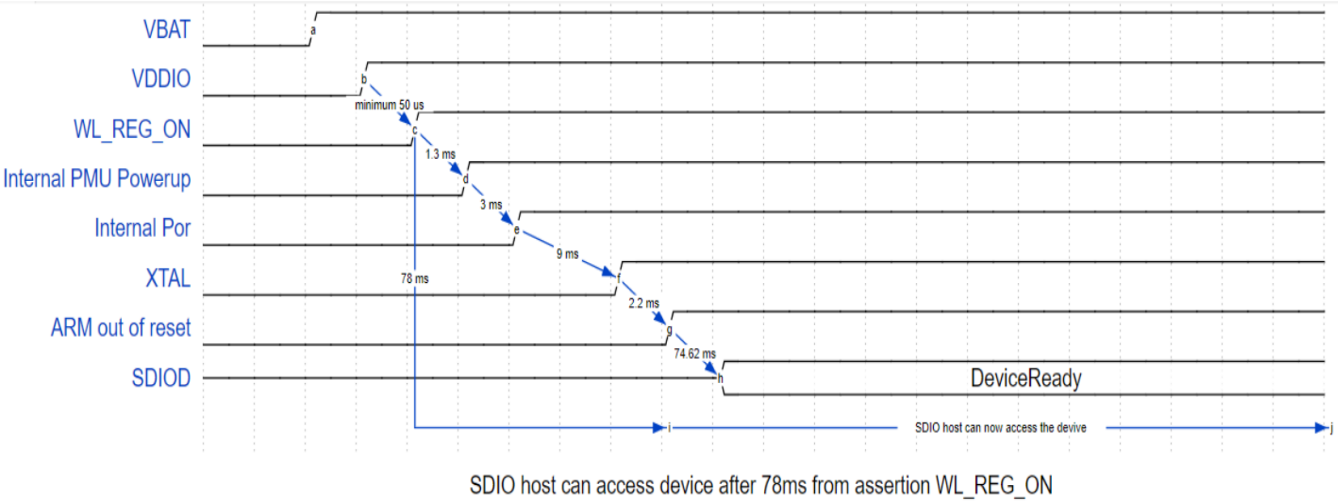


Figure 14: WLAN boot-up sequence for SDIO host

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13 Pin Definitions

13.1 M.2 1216 Solder-Down

Table 37: M.2 1216 pin definitions

Pin #	Name	Type	Voltage Ref.	Function	If Not Used
1	-	-	-	-	Unused
2	-	-	-	-	Unused
3	-	-	-	-	Unused
4	VBAT	PWR	3.3V	DC supply voltage for module. Operational: VBAT is 3.0V to 4.8V ** VBAT at 3.13V to 3.5V has the same TX power but a better EVM/harmonic emissions margin	-
5	VBAT	PWR	3.3V	DC supply voltage for module. Operational: VBAT is 3.0V to 4.8V ** VBAT at 3.13V to 3.5V has the same TX power but a better EVM/harmonic emissions margin	-
6	GND	-	-	Ground	GND
7	-	-	-	-	Unused
8	-	-	-	-	Unused
9	I2C_CLK	I	1.8V	I2C clock signal input	NC
10	I2C_SDA	I/O	1.8V	I2C signal data input/output	NC
11	-	-	-	-	Unused
12	-	-	-	-	Unused
13	-	-	-	-	Unused
14	-	-	-	-	Unused
15	-	-	-	-	Unused
16	-	-	-	-	Unused
17	GND	-	-	Ground	GND
18	-	-	-	-	Unused
19	-	-	-	-	Unused
20	GND	-	-	Ground	GND
21	-	-	-	-	Unused

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Pin #	Name	Type	Voltage Ref.	Function	If Not Used
22	-	-	-	-	Unused
23	GND	-	-	Ground	GND
24	-	-	-	-	Unused
25	-	-	-	-	Unused
26	GND	-	-	Ground	GND
27	LPO_IN	I	VDDIO	External sleep clock input (32.768 KHz)	
28	WL_REG_ON	I	VDDIO	Enables WLAN regulators. There is an internal 50K pull down resistor on this signal.	-
29	-	-	-	-	Unused
30	-	-	-	-	Unused
31	-	-	-	-	Unused
32	GND	-	-	Ground	GND
33	-	-	-	-	Unused
34	-	-	-	-	Unused
35	GND	-	-	Ground	GND
36	-	-	-	-	Unused
37	-	-	-	-	Unused
38	GND	-	-	Ground	GND
39	-	-	-	-	Unused
40	-	-	-	-	Unused
41	GND	-	-	Ground	GND
42	BT_DEV_WAKE	I	VDDIO	Bluetooth Device Wake-up: Signal from host to Sona IF513.	NC
43	WL_DEV_WAKE	I	VDDIO	WLAN Device Wake-up: Signal from host to Sona IF513.	NC
44	-	-	-	-	Unused
45	-	-	-	-	Unused
46	GPIO_0_WL_HOST_WAKE	O	VDDIO	Host wake up. Signal from the Sona IF513.	NC
47	SDIO_DATA_3	I/O	VDDIO	SDIO Data line 3	NC
48	SDIO_DATA_2	I/O	VDDIO	SDIO Data line 2	NC

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Pin #	Name	Type	Voltage Ref.	Function	If Not Used
49	SDIO_DATA_1	I/O	VDDIO	SDIO Data line 1	NC
50	SDIO_DATA_0	I/O	VDDIO	SDIO Data line 0	NC
51	SDIO_CMD	I/O	VDDIO	SDIO Command Line	NC
52	SDIO_CLK	I	VDDIO	SDIO Clock Input	NC
53	BT_HOST_WAKE	O	VDDIO	Host wake up. Signal from the Sona IF513.	NC
54	BT_UART_CTS_N	I	VDDIO	UART clear-to-send. Active-low clear-to-send signal for the HCI UART interface.	NC
55	BT_UART_TXD	O	VDDIO	UART Serial Output. Serial data output for the HCI UART interface.	NC
56	BT_UART_RXD	I	VDDIO	UART Serial Input. Serial data input for the HCI UART interface.	NC
57	BT_UART_RTS_N	O	VDDIO	UART request-to-send. Active-low request-to-send signal for the HCI UART interface.	NC
58	BT_PCM_SYNC	I/O	VDDIO	PCM Sync. Supported - Master (Output) or Slave (Input).	NC
59	BT_PCM_IN	I	VDDIO	PCM data input.	NC
60	BT_PCM_OUT	O	VDDIO	PCM data output	NC
61	BT_PCN_CLK	I/O	VDDIO	PCM clock. Supported – Master (Output) or Slave (Input).	NC
62	GND	-	-	Ground	GND
63	BT_REG_ON	I	VDDIO	Enables Bluetooth regulators. There is an internal 50K pull down resistor on this signal.	-
64	GPIO_3	I/O	VDDIO	Reserved for feature support	NC
65	GPIO_2	I/O	VDDIO	Reserved for feature support	NC
66	VDDIO	PWR	1.8V	IO supply for IF513	NC
67	-	-	-	-	Unused
68	GND	-	-	Ground	GND
69	-	-	-	-	Unused
70	-	-	-	-	Unused
71	GND	-	-	Ground	GND
72	VBAT	PWR	3.3V	DC supply voltage for module. Operational: VBAT is 3.0V to 4.8V ** VBAT at 3.13V to 3.5V has the same TX power but a better EVM/harmonic emissions margin	-
73	VBAT	PWR	3.3V	DC supply voltage for module. Operational: VBAT is 3.0V to 4.8V	-

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Pin #	Name	Type	Voltage Ref.	Function	If Not Used
				** VBAT at 3.13V to 3.5V has the same TX power but a better EVM/harmonic emissions margin	
74~75	GND	-	-	Ground	GND
76	VIO_CFG	O	-	Sideband IO voltage indication. Connected to ground for 3.3V on the sideband IO signals. Otherwise, it must be left unconnected.	GND
77~80	GND	-	-	Ground	GND
81	WL_C2	I/O	-	For the Sona IF513 Trace type module – Antenna diversity_WLAN port (AUX antenna port)	-
82~85	GND	-	-	Ground	GND
86	WL_C0	I/O	-	For the Sona IF513 Trace type module – Antenna diversity_WLAN/Bluetooth port (Main antenna port)	-
87~91	GND	-	-	Ground	GND
92	WL_C1	I/O	-	For the Sona IF513 Trace type module – Non-Antenna diversity_WLAN/Bluetooth port	-
93~96	GND	-	-	Ground	GND
G1~G12	GND	-	-	Ground	GND

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13.2 M.2 2230 Key-E

Table 38: M.2 2230 Key-E pin definitions

Pin #	Name	Type	Voltage Ref.	Function	If Not Used
1	GND	-	-	Ground	GND
2	3.3V	PWR I/P	3.3V	DC supply voltage for module. ** VBAT at 3.13V to 3.5V has the same TX power but a better EVM/harmonic emissions margin	-
3	USB_D+	-	-	NC	Unused
4	3.3 V	PWR I/P	3.3 V	DC supply voltage for module. ** VBAT at 3.13V to 3.5V has the same TX power but a better EVM/harmonic emissions margin	-
5	USB_D-	-	-	NC	Unused
6	LED1#	O	3.3V	Reserved for the GPIO2	NC
7	GND	-	-	Ground	GND
8	PCM_CLK	I/O	1.8V	PCM clock. Can be master (Output) or slave (Input)	NC
9	SDIO CLK	I	1.8V	SDIO clock input	NC
10	PCM_SYNC	I/O	1.8V	PCM Sync. Can be master (Output) or slave (Input)	NC
11	SDIO CMD	I/O	1.8V	SDIO command line	NC
12	PCM_OUT	O	1.8V	PCM data output.	NC
13	SDIO DATA0	I/O	1.8V	SDIO data line0	NC
14	PCM_IN	I	1.8V	PCM data input.	NC
15	SDIO DATA1	I/O	1.8V	SDIO data line1	NC
16	LED2#	O	3.3V	Reserved for the GPIO3	NC
17	SDIO DATA2	I/O	1.8V	SDIO data line2	NC
18	GND/VIO_CFG	O	-	Sideband IO voltage indication. This pin of the Sona IF513 M.2 card is grounded by default.	GND
19	SDIO DATA3	I/O	1.8V	SDIO data line3	NC
20	UART WAKE#	O	3.3 V	Reserved for BT_HOST_WAKE- Output signal to wake up Host.	NC
21	SDIO WAKE#	I	1.8V	Reserved for WL_HOST_WAKE- Output signal to wake up host.	NC
22	UART_TXD	O	1.8V	Serial data output for the HCI UART interface.	NC
23	SDIO RESET#	-	-	NC	Unused
32	UART_RXD	I	1.8V	Serial data input for the HCI UART interface.	NC
33	GND	-	-	Ground	GND
34	UART_RTS	O	1.8V	Active-Low request-to-send signal for the HCI UART interface.	NC
35	PERp0	-	-	-	Unused
36	UART_CTS	I	1.8V	Active-Low clear-to-send signal for the HCI UART interface.	NC
37	PERn0	-	-	-	Unused
38	VENDOR DEFINED38	-	-	-	Unused
39	GND	-	-	Ground	GND

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Pin #	Name	Type	Voltage Ref.	Function	If Not Used
40	VENDOR DEFINED40	I	1.8V	Reserved for WL_DEVICE_WAKE- Input signal from host to wake up WLAN module.	NC
41	PETp0	-	-	-	Unused
42	VENDOR DEFINED42	I/O	1.8V	Reserved for BT_DEVICE_WAKE- Input signal from host to wake up Bluetooth.	NC
43	PETn0	-	-	-	Unused
44	COEX3	-	-	-	Unused
45	GND	-	-	Ground	GND
46	COEX2	-	-	-	Unused
47	REFCLKp0	-	-	-	Unused
48	COEX1	-	-	-	Unused
49	REFCLKn0	-	-	-	Unused
50	SUSCLK	I	3.3 V	External Sleep Clock input (32.768KHz) The sleep clock is always needed for using this module. If the 32.768 KHz signal is not available externally, a 32.768 KHz circuit has been reserved in the M.2 module.	Required
51	GND	-	-	Ground	GND
52	PERST0#	-	-	-	Unused
53	CLKREQ0#	-	-	-	Unused
54	W_DISABLE2#	I	3.3 V	Enables Bluetooth regulators. Ground to disable Bluetooth.	—
55	PEWAKE0#	-	-	-	Unused
56	W_DISABLE1#	I	3.3 V	Enables WLAN regulators. Ground to disable WLAN.	—
57	GND	-	-	Ground	GND
58	I2C DATA	I/O	-	I2C signal data input/output	NC
59	RESERVED	-	-	NC	NC
60	I2C CLK	I	-	I2C clock signal input	NC
61	RESERVED	-	-	NC	NC
62	ALERT#	-	-	NC	NC
63	GND	-	-	Ground	GND
64	RESERVED	-	-	NC	NC
65	RESERVED	-	-	NC	NC
66	UIM_SWP	-	-	NC	NC
67	RESERVED	-	-	NC	NC
68	UIM_POWER_SNK	-	-	NC	NC
69	GND	-	-	Ground	GND
70	UIM_POWER_SRC	-	-	NC	NC
71	RESERVED	-	-	NC	NC
72	3.3V	PWR I/P	3.3V	DC supply voltage for module. ** VBAT at 3.13V to 3.5V has the same TX power but a better EVM/harmonic emissions margin	--

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Pin #	Name	Type	Voltage Ref.	Function	If Not Used
73	RESERVED	-	-	NC	NC
74	3.3V	PWR I/P	3.3V	DC supply voltage for module. ** VBAT at 3.13V to 3.5V has the same TX power but a better EVM/harmonic emissions margin	--
75	GND	-	-	Ground	GND

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14 Mechanical Specifications

14.1 M.2 1216

Module dimensions of Sona IF513 M.2 1216 package is 12 x 16 x 1.9 mm. Detailed drawings are shown in Figure 15.

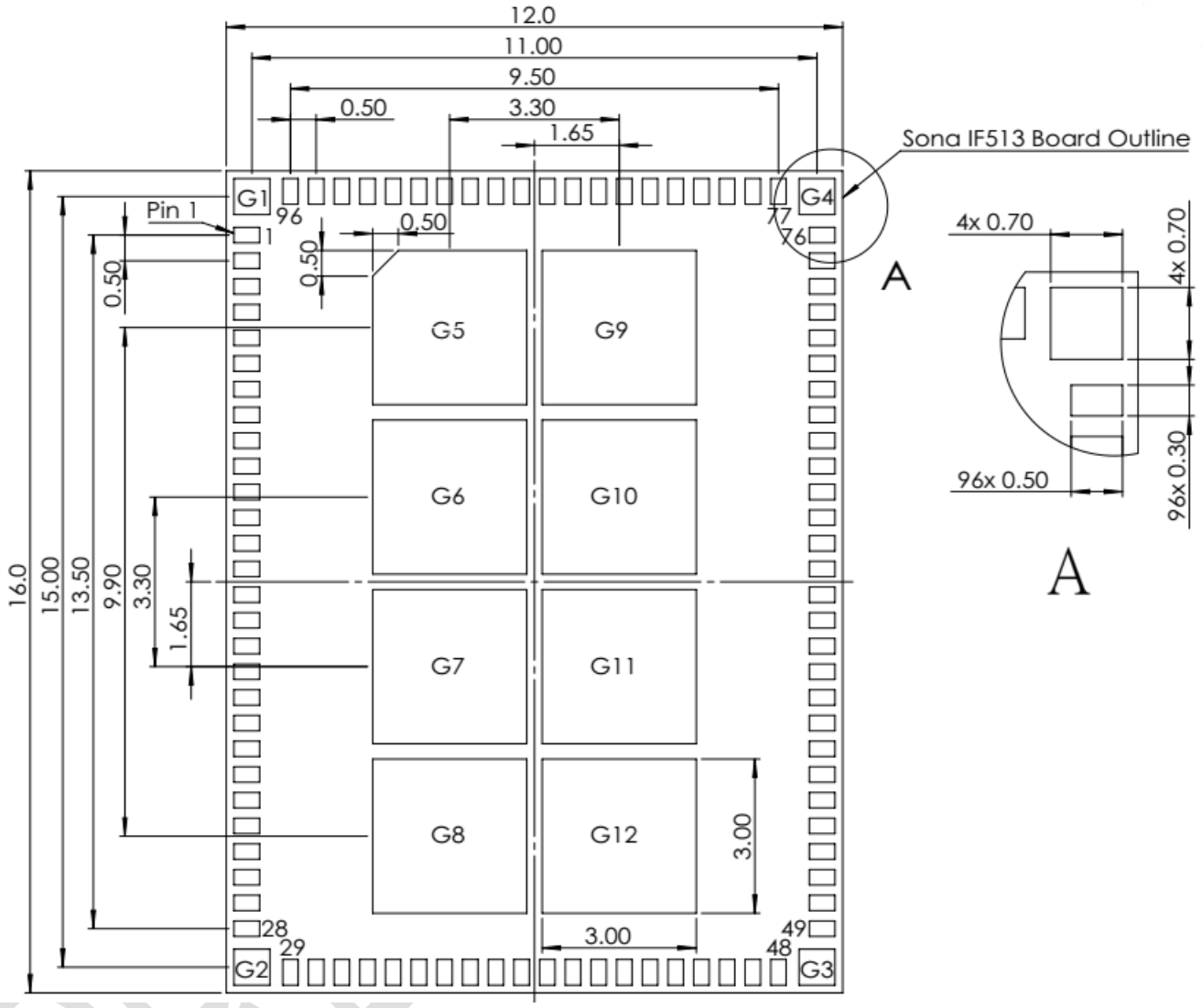


Figure 15: M.2 1216 PCB footprint (Top view)

Note: Dimensions are in millimeters tolerances:

Angular:	± 0.5
X.X:	± 0.1
X.XX:	± 0.05

There are 4 variants for the Sona IF513 solder-down type, and the detailed drawings are shown in Figure 16, Figure 17, Figure 18, and Figure 19.

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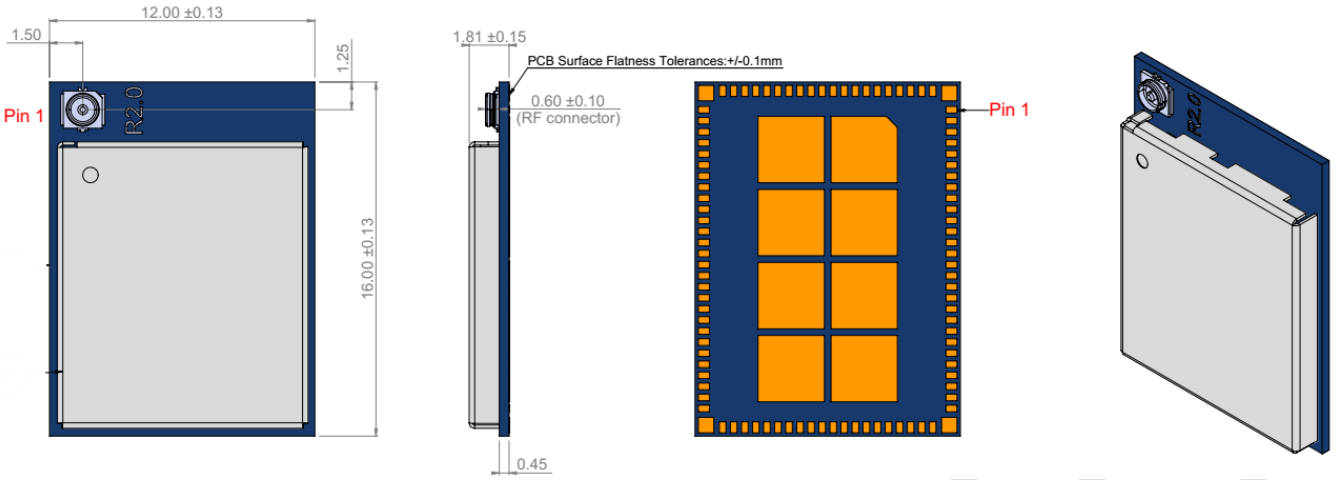


Figure 16: M.2 1216 (MHF4 variant) Non-Antenna Diversity type

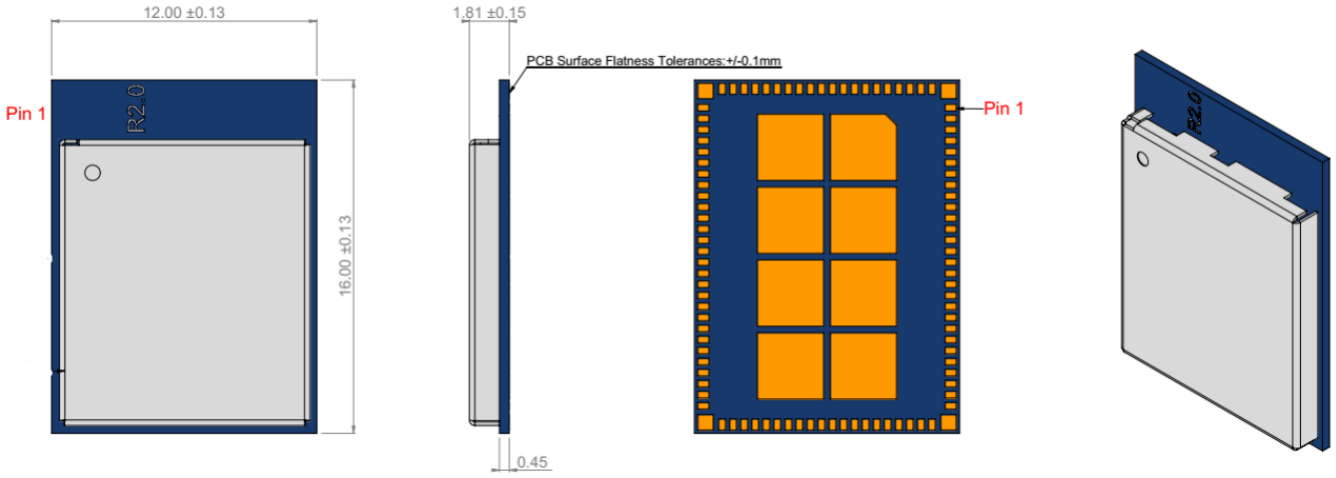


Figure 17: M.2 1216 (Trace variant) Non-Antenna Diversity type

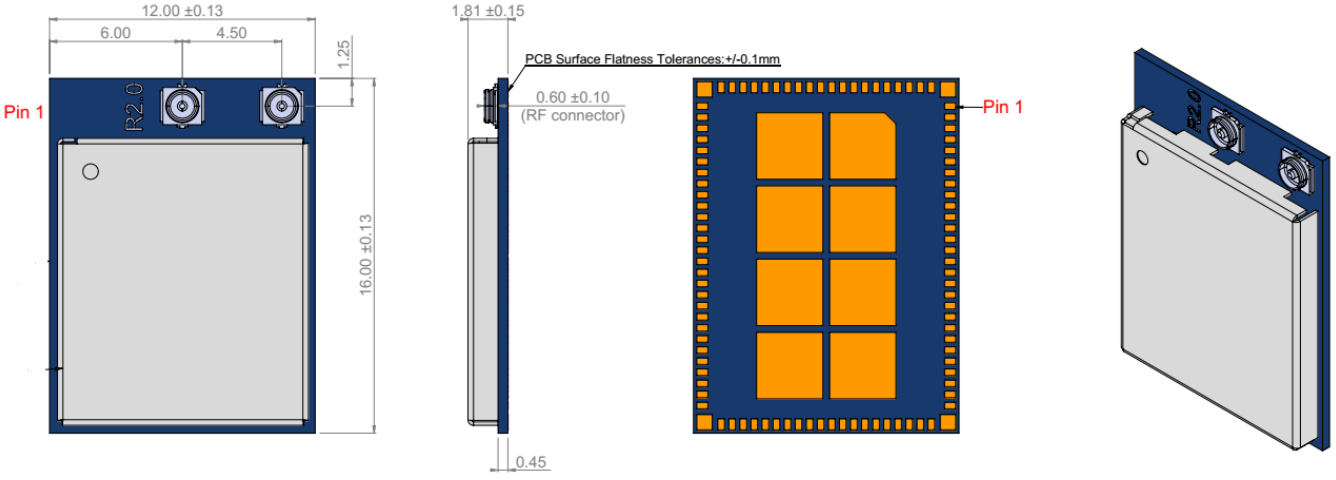


Figure 18: M.2 1216 (MHF4 variant) Antenna Diversity type

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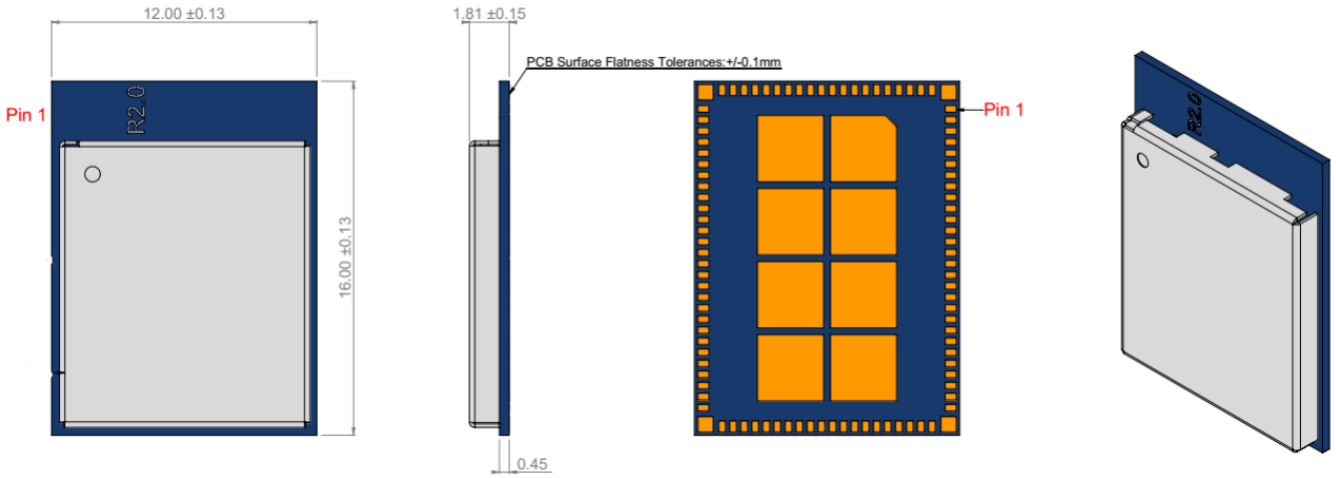


Figure 19: M.2 1216 (Trace variant) Antenna Diversity type

14.2 M.2 2230 Key-E

Module dimensions of Sona IF513 M.2 2230 E-Key module is 22 x 30 x 2.7 mm. Detailed drawings are shown in Figure 20 and Figure 21.

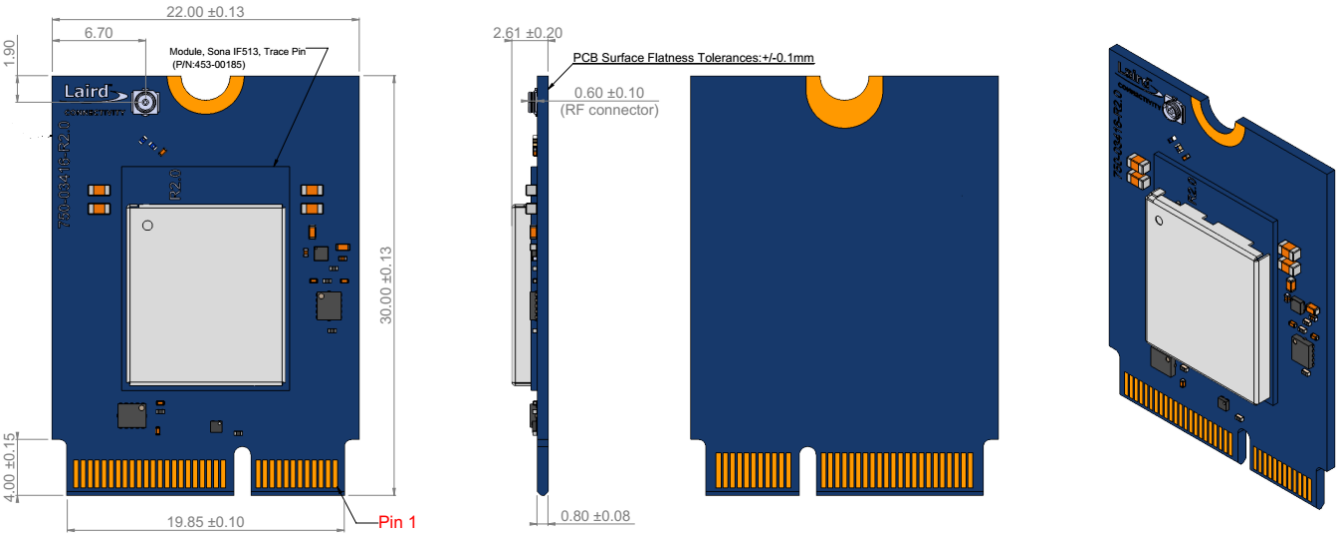


Figure 20: Sona IF513 M.2 2230 Non-Antenna Diversity type

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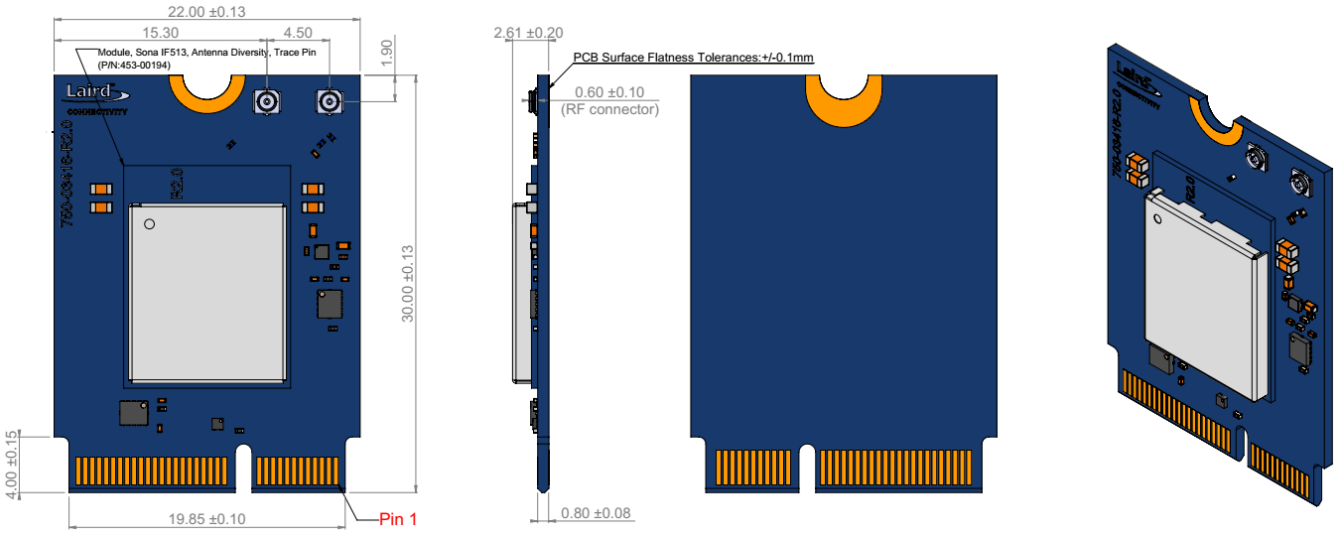


Figure 21: Sona IF513 M.2 2230 Antenna Diversity type

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, 2, 4, 6, 8, A, C, E.*
The BT MAC address is the Wi-Fi MAC address plus 1.

14.3 M.2 2230 Key-E Mounting

The Sona IF513 M.2 2230 E-Key module connects to the host via a standard PCI EXPRESS M2 connector.

Kyocera's 6411 series provides 1.8mm, 2.3mm and 3.2mm connector heights. JAE's SM3 series provides 1.2mm, 2.15mm, 3.1mm and 4.1mm connector heights.

The Sona IF513 M.2 2230 E-Key module is a single-sided component module, so we recommend the connectors listed in Table 39.

Table 39: Recommended M.2 2230 E-Key Connectors

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

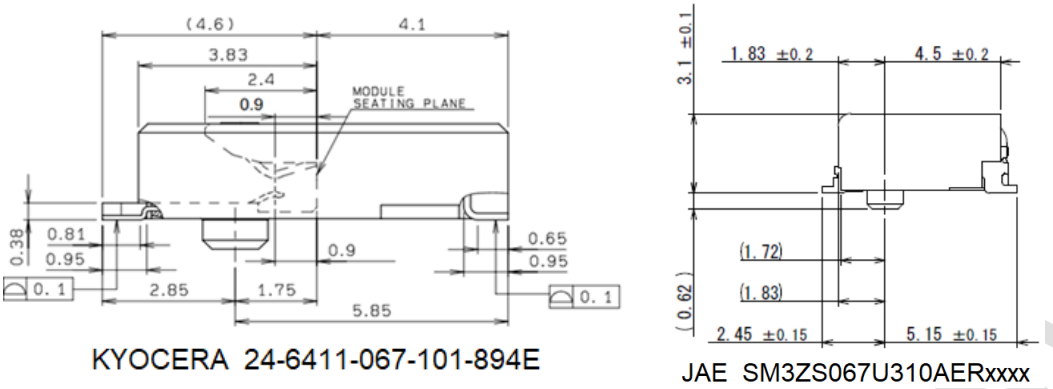
The corresponding standoffs are listed in Table 40.

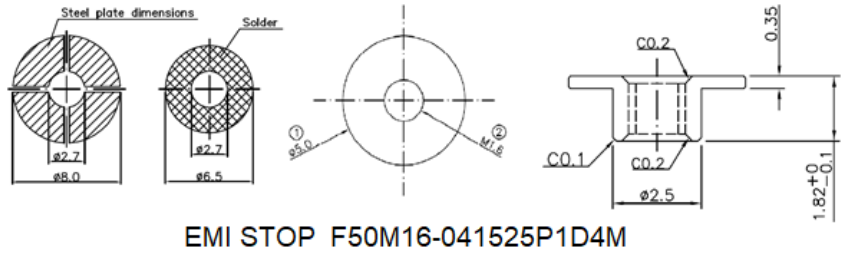
Table 40: Recommended M.2 E-Key Standoffs

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

Detailed layout and stencil opening are show in Figure 22.

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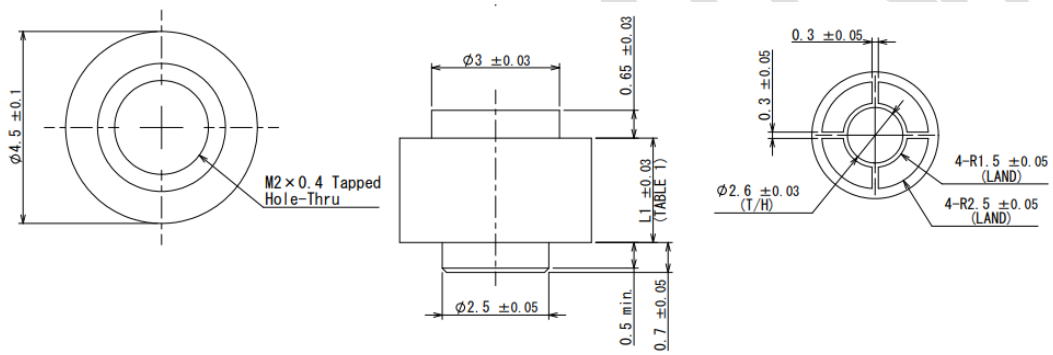


Figure 22: M.2 2230 Key-E connector/standoff mounting

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15 RF Layout Design Guidelines

The following is a list of RF layout design guidelines and recommendations 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.
- 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 a 10uF/16V/0603 capacitor on EACH 3.3V power pin. Place the capacitor as close as possible to the pin to ensure correct PMU operation.
- Use proper electro-static-discharge (ESD) procedures when installing the Ezurio radio module. To avoid negatively impacting Tx power and receiver sensitivity, do not cover the antennas with metallic objects or components.

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16 Application Notes

16.1 Introduction

Ezurio's surface mount modules are designed to conform to all major manufacturing guidelines. This application note is intended to provide additional guidance beyond the information that is presented in the user manual. This application note is considered a living document and will be updated as new information is presented.

The modules are designed to meet the needs of several commercial and industrial applications. They are easy to manufacture and conform to current automated manufacturing processes.

16.2 Shipping and Labeling

16.2.1 M.2 1216 Solder-Down

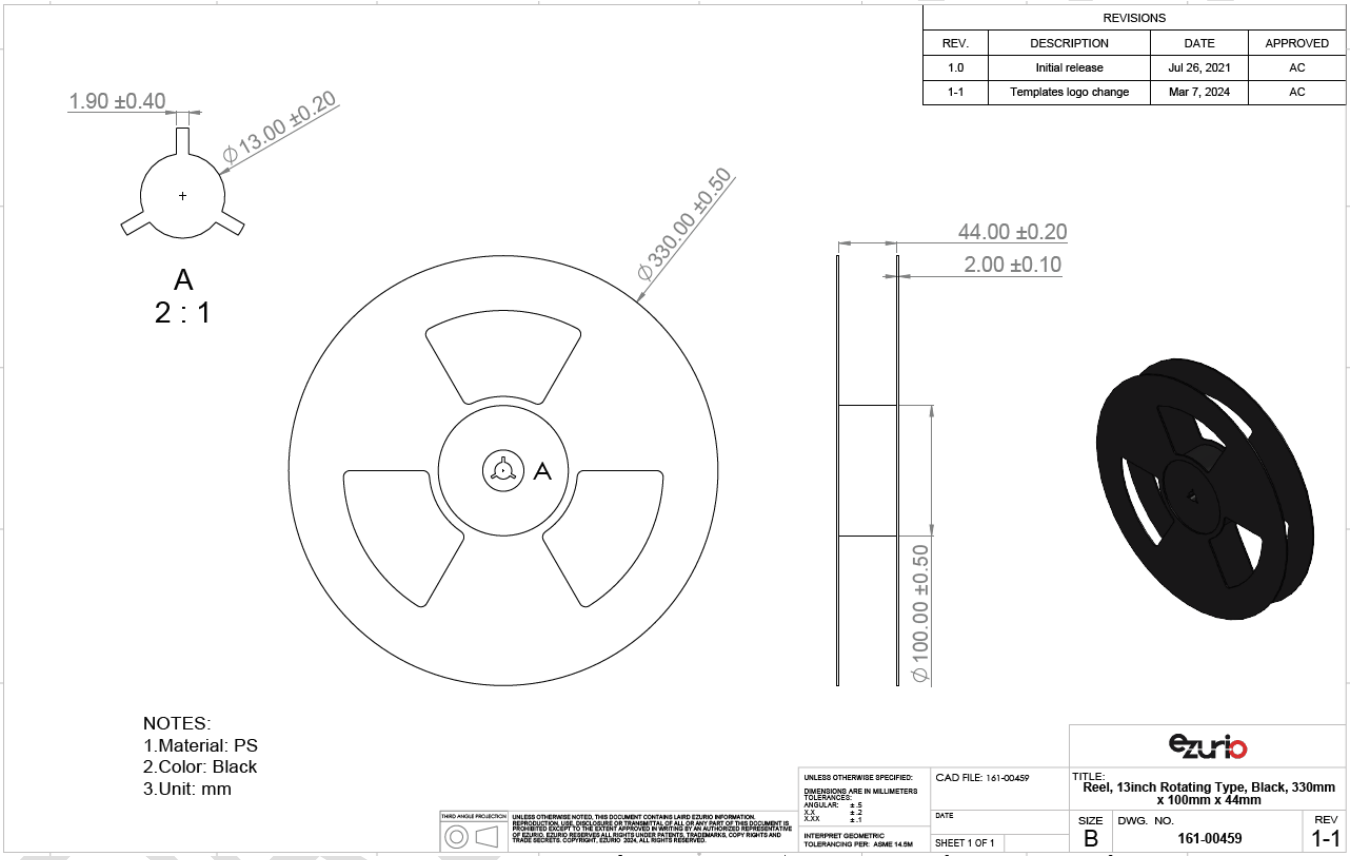


Figure 23: Sona IF513 Reel specifications, 161-00459

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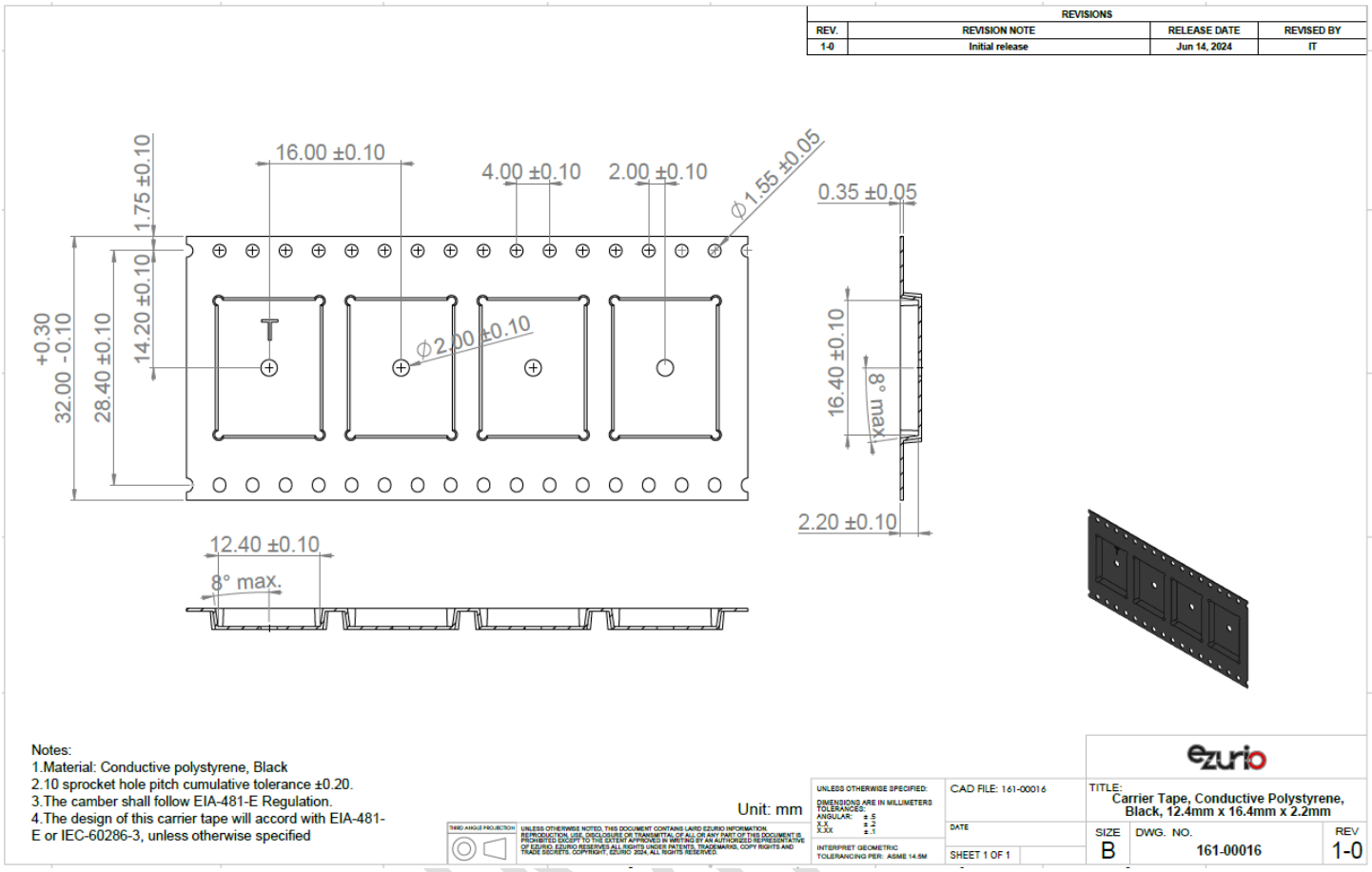


Figure 24: Sona IF513 Tape specifications, 161-00016

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There are 1,000 Sona IF513 modules taped in a reel (and packaged in a pizza box) and two boxes per carton (2,000 modules per carton). Reel, boxes, and carton are labeled with the appropriate labels. See Figure 25 for more information.

NO.	ITEM NUMBER	REV.	DESCRIPTION	QTY.
1	161-00016	1-0	Carrier Tape, Conductive Polystyrene, Black, 12.4mm x 16.4mm x 2.2mm	1
2	453-00184	1-1	Module, Sona IF513, MHF4L	1000
3	161-00352	1-1	Cover Tape, Anti-static Polyester, 25.5mm x 0.05mm	1
4	160-02008	1-2	Label, Blank Moisture Sensitivity Level, 4in x 4in	1
5	160-00040	1-0	Label, Product Identifier, Sona IF513, 89mm x 51mm	3
6	160-00041	1-0	Label, Carton Product Identifier, Sona IF513, 101mm x 64mm	2
7	161-00459	1-1	Reel, 13inch Rotating Type, Black, 330mm x 100mm x 44mm	1
8	161-00506	1-1	Desiccant, Silica Gel, 66g, 110mm x 120mm	1
9	161-00507	1-1	Box, Single-Wall Corrugated E Flute, 362mm x 344mm x 83mm	1
10	161-00508	1-1	Carton, AB Flute, 365mm x 383mm x 279mm	1
11	161-00510	1-1	Humidity Indicator Card, Minimum 60% RH, Three Spot Indication, 75mm x 50mm, J-STD-033 Rev D	1
12	161-00544	1-1	Bag, ESD and Moisture Barrier, Silver, 420mm x 475mm x 0.15mm	1

REVISIONS			
REV.	REVISION NOTE	RELEASED DATE	REVISED BY
1-0	Initial release	Jun 18, 2024	IT

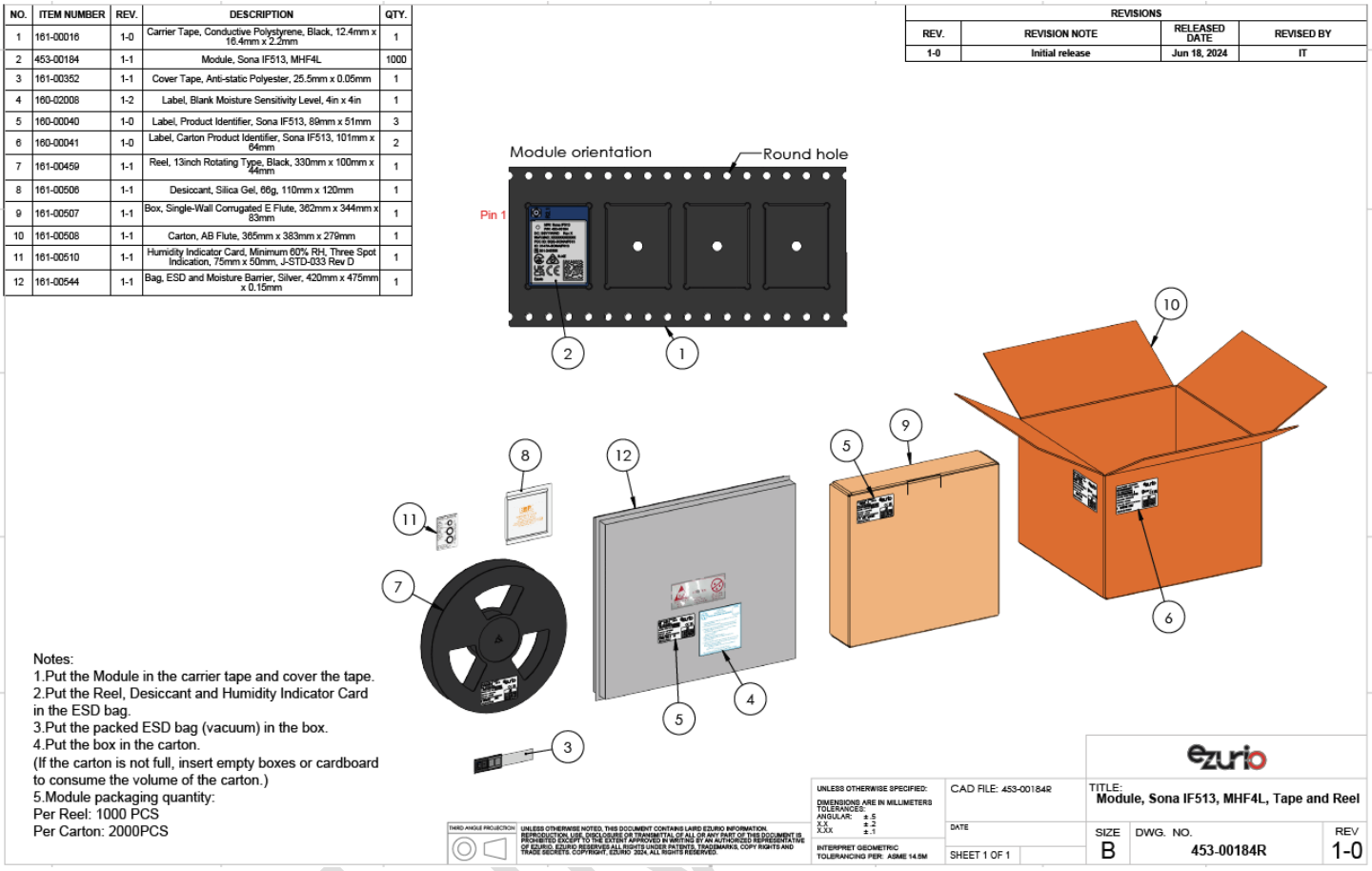


Figure 25: Sona IF513 packaging processes, 453-00184R

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The following labels are located on the antistatic bag.

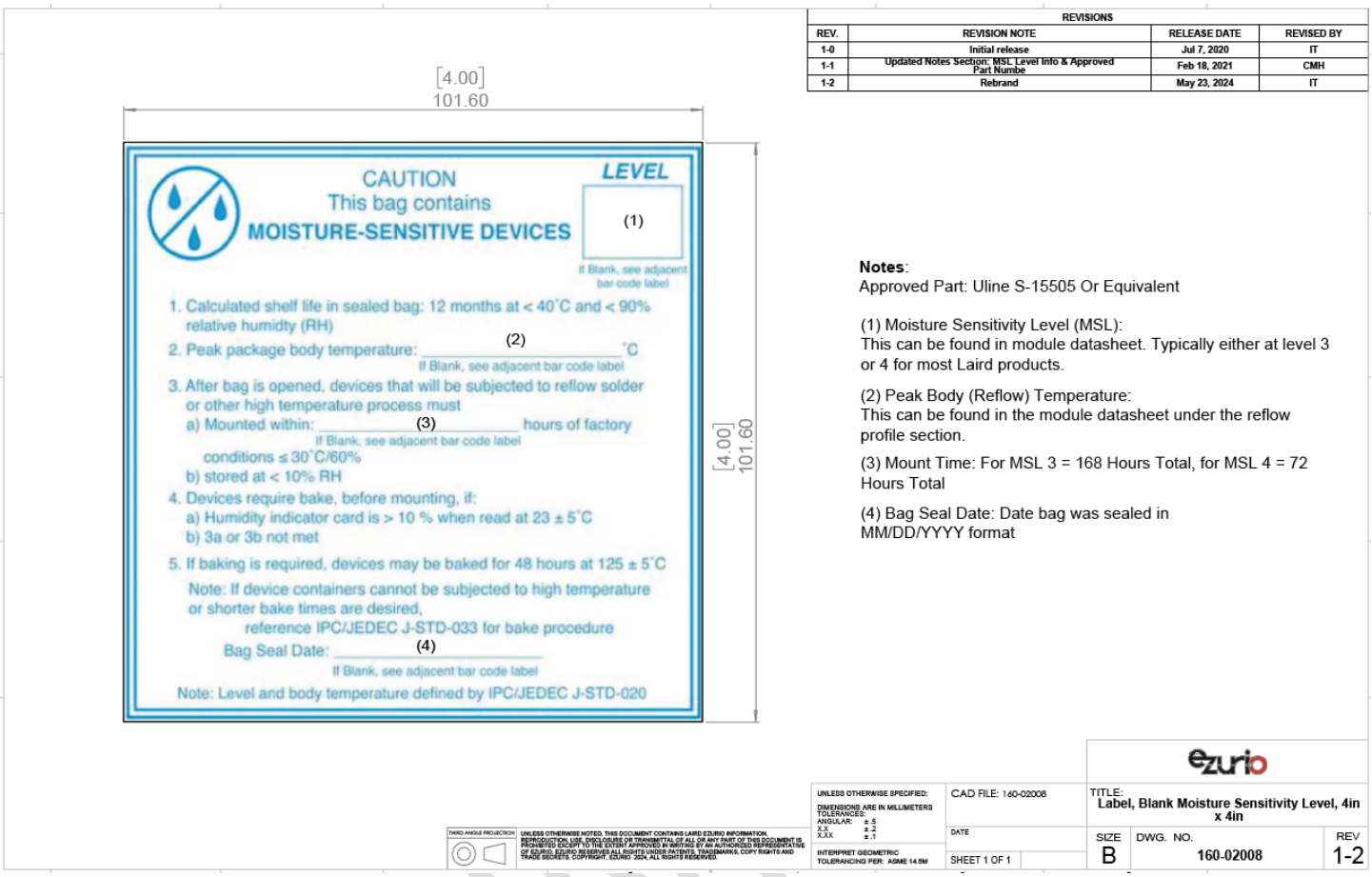


Figure 26: Sona IF513 Moisture Sensitivity Level Label, 160-02008

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The following label is placed on the reel, bag and pizza box.

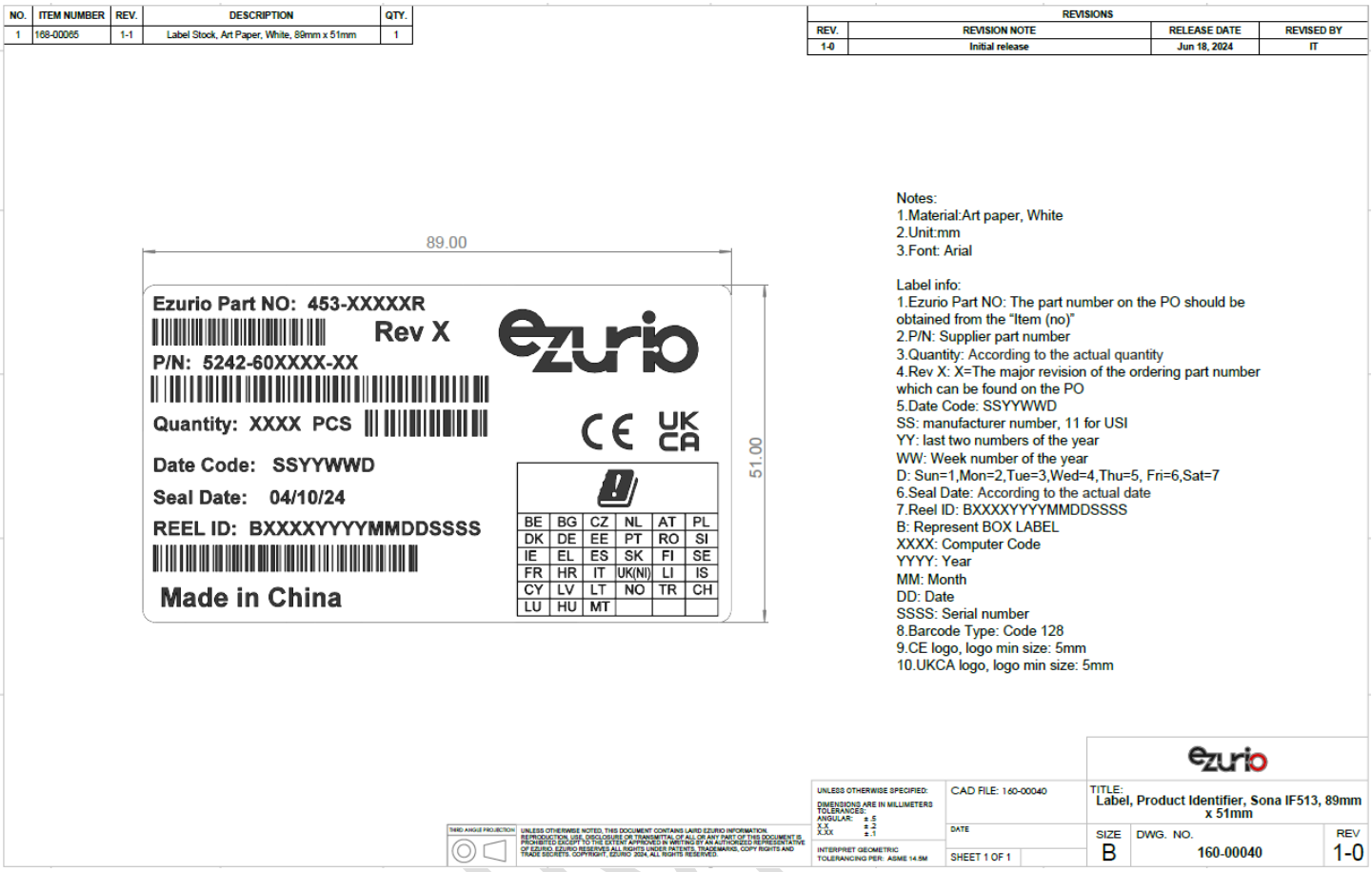


Figure 27: Sona IF513 Reel, Bag, and Box Product Identifier Label, 160-00040

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The following package label is located on adjacent sides of the master carton.

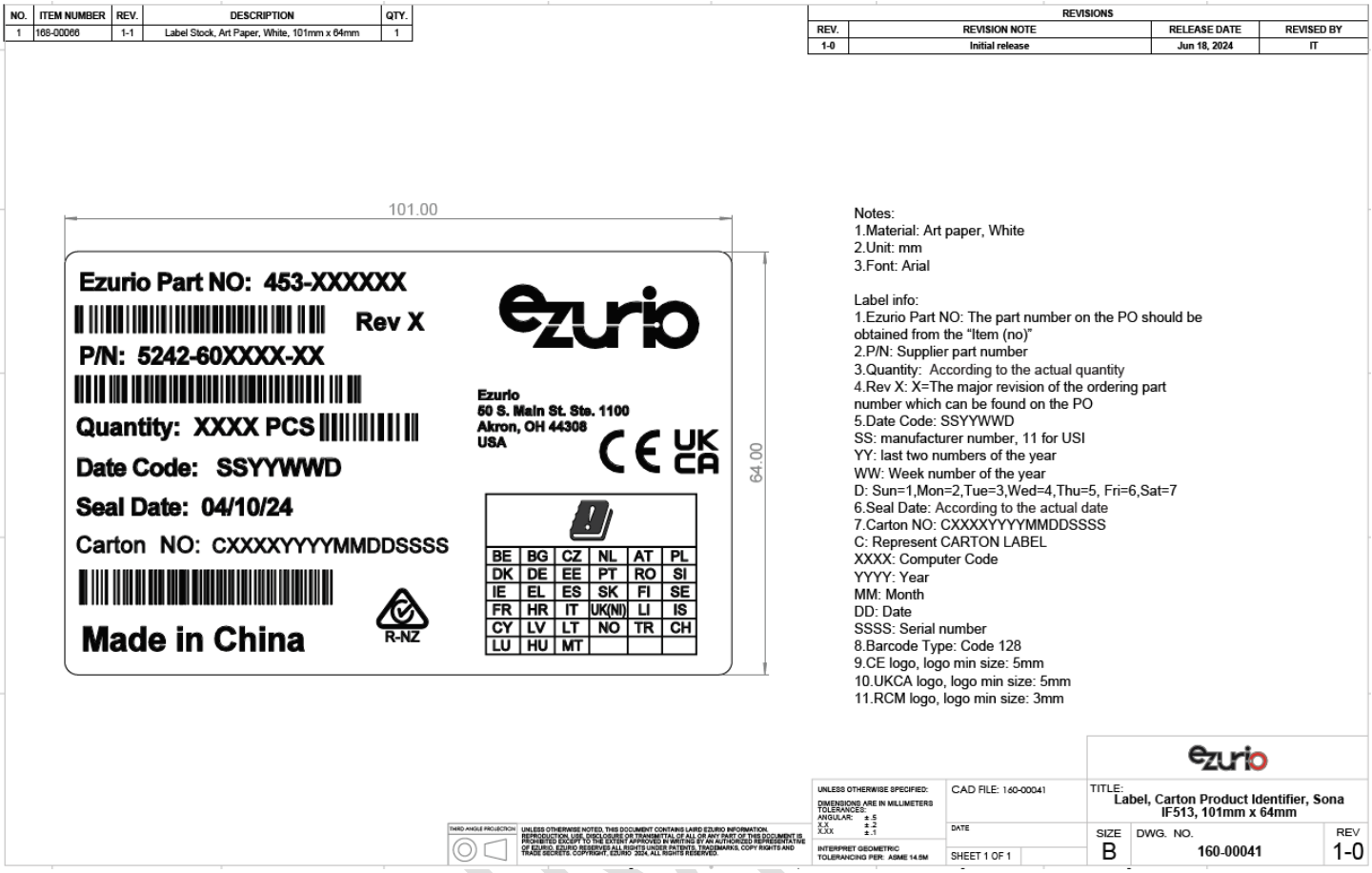


Figure 28: Sona IF513 Carton Product Identifier Label, 160-00041

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16.2.2 M.2 2230 Key-E Card

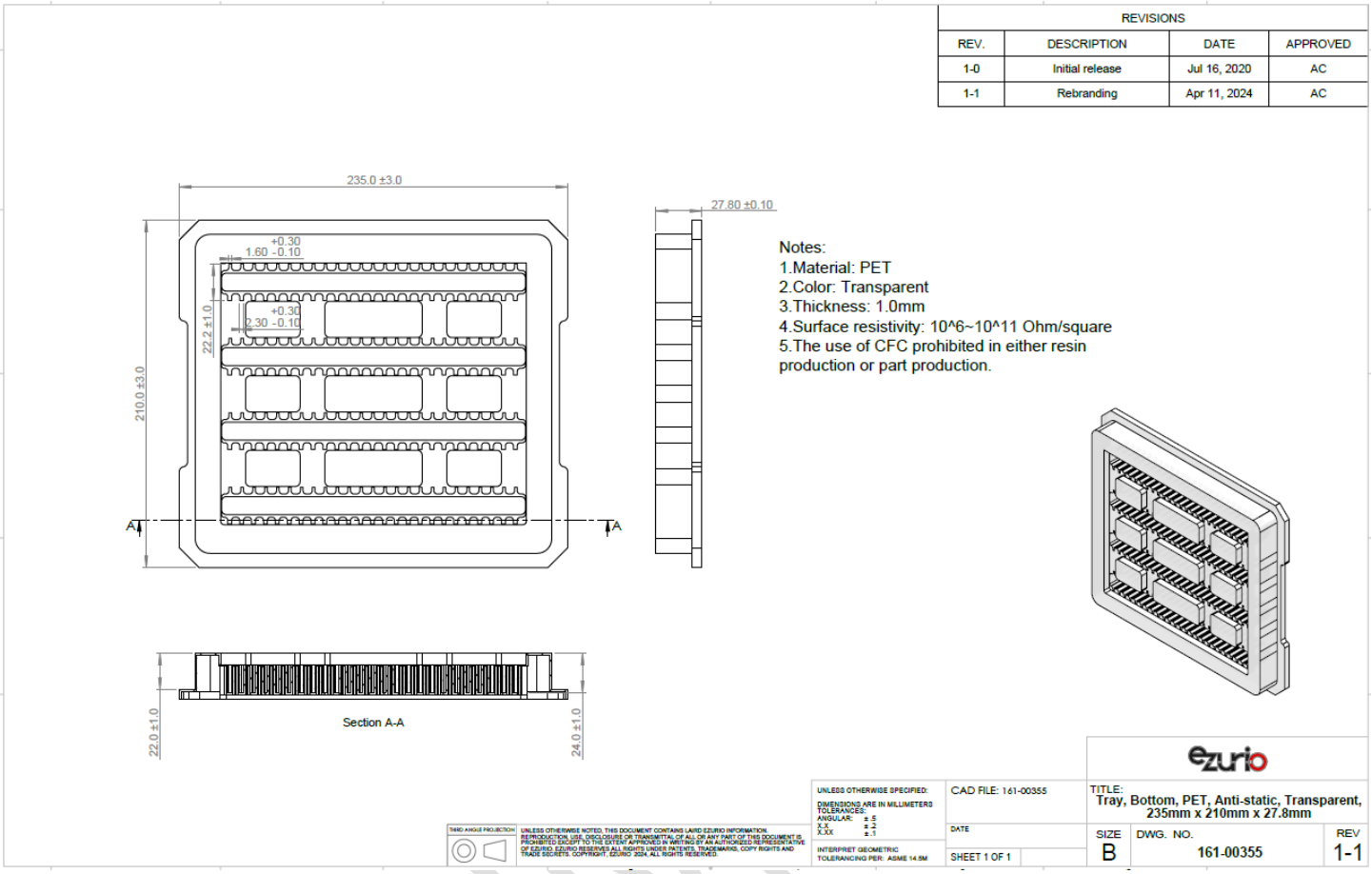


Figure 29: Sona IF513 M.2 2230 Shipping Tray, Bottom, 161-00355

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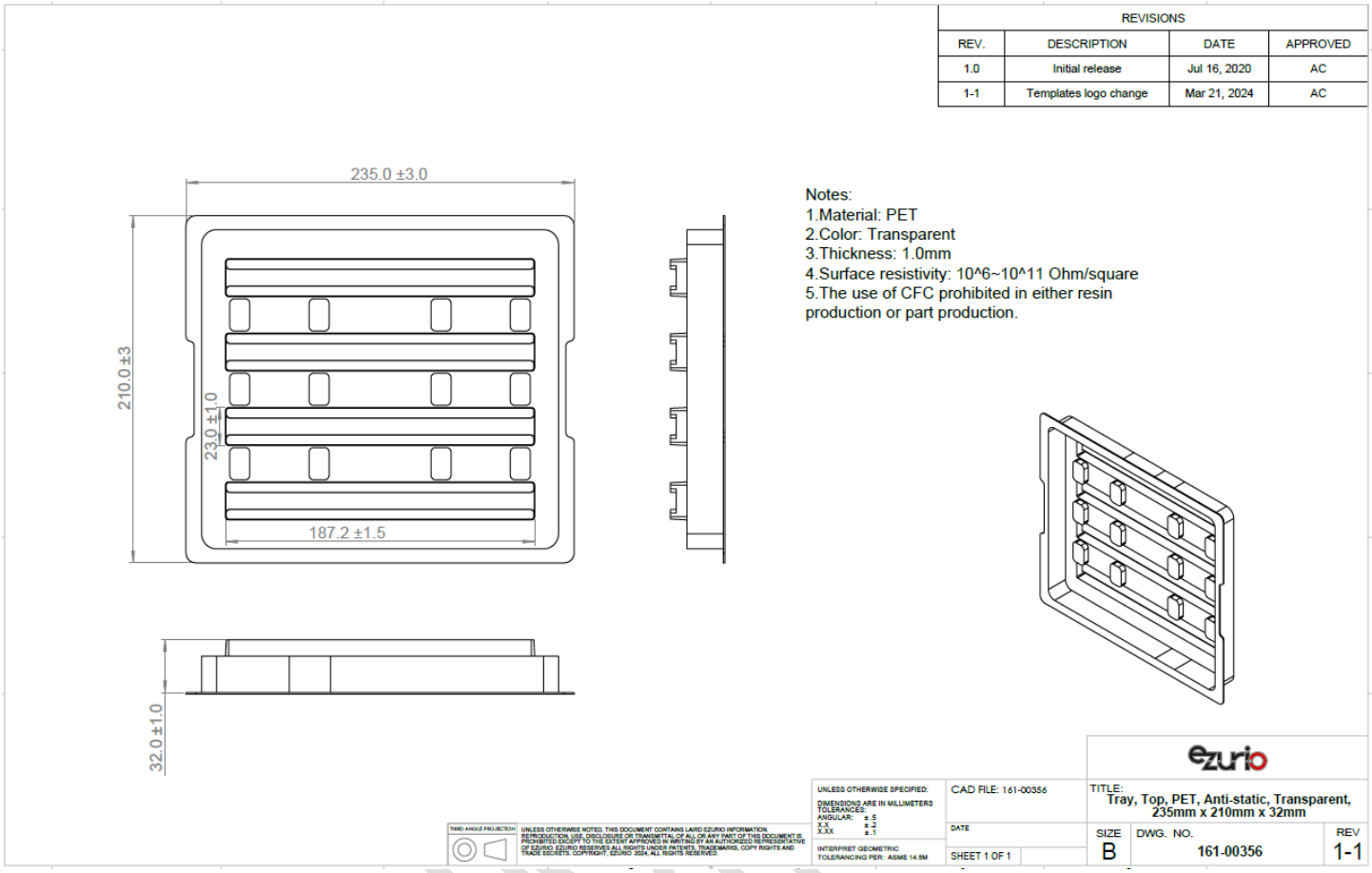


Figure 30: Sona IF513 M.2 2230 Shipping Tray, Top, 161-00356

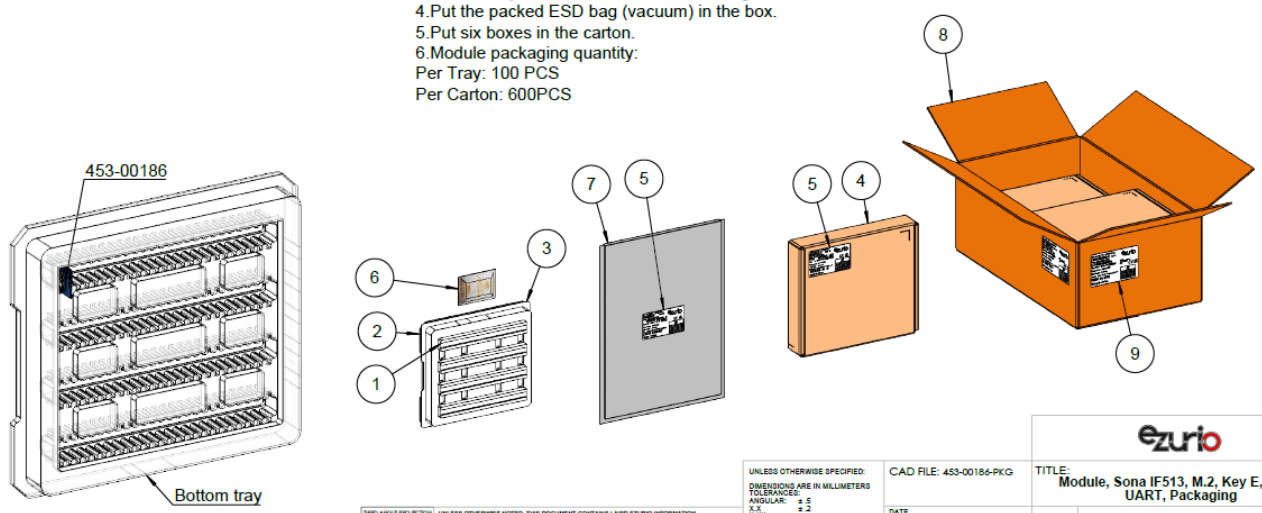
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NO.	ITEM NUMBER	REV.	DESCRIPTION	QTY.
1	453-00186	1-1	Module, Sona IF513, M.2, Key E, SDIO, UART	600
2	161-00355	1-1	Tray, Bottom, PET, Anti-static, Transparent, 235mm x 210mm x 27.8mm	6
3	161-00356	1-1	Tray, Top, PET, Anti-static, Transparent, 235mm x 210mm x 32mm	6
4	161-00357	1-1	Box, Kraft, B Flute, 252mm x 217mm x 41mm	6
5	160-00040	1-0	Label, Product Identifier, Sona IF513, 89mm x 51mm	12
6	161-00361	1-1	Desiccant, Silica Gel, 10g, 58mm x 80mm	6
7	161-00358	1-1	Bag, ESD and Moisture Barrier, Silver, 270mm x 380mm x 0.09mm	6
8	161-00359	1-1	Carton, Kraft, AB Flute, 455mm x 268mm x 170mm	1
9	160-00041	1-0	Label, Carton Product Identifier, Sona IF513, 101mm x 64mm	2

REVISIONS			
REV.	REVISION NOTE	RELEASE DATE	REVISED BY
0-1	Initial release	Jun 19, 2024	IT

Notes:
1.Put the Module in the bottom tray.
2.Cover the top tray.
3.Put the tray and Desiccant in the ESD bag.
4.Put the packed ESD bag (vacuum) in the box.
5.Put six boxes in the carton.
6.Module packaging quantity:
Per Tray: 100 PCS
Per Carton: 600PCS



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
TOLERANCES:
ANGULAR: ± .5
X.X ± .2
X.XX ± .1
INTERPRET GEOMETRIC TOLERANCING PER: ASME 14.5M

CAD FILE: 453-00186-PKG
DATE
SHEET 1 OF 1

TITLE: Module, Sona IF513, M.2, Key E, SDIO, UART, Packaging
SIZE B | DWG. NO. 453-00186-PKG | REV 0-1

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Figure 31: Sona IF513 M.2 2230 Packaging Process, 453-00186-PKG

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The following label is placed on the bag and the inner box.

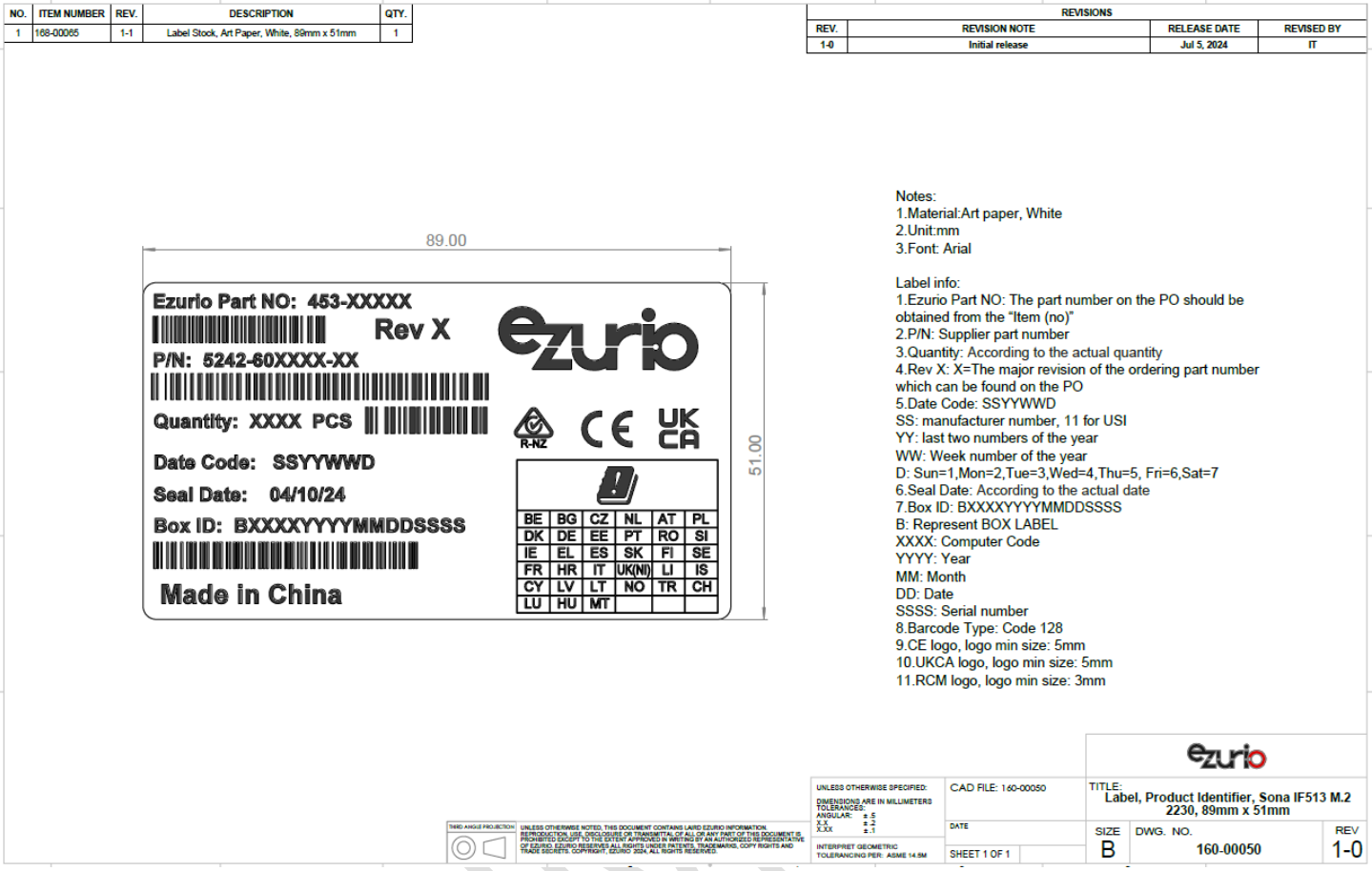


Figure 32: Sona IF513 M.2 2230 Bag and Box Product Identifier Label, 160-00050

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The following label is located on the adjacent sides of the master carton.

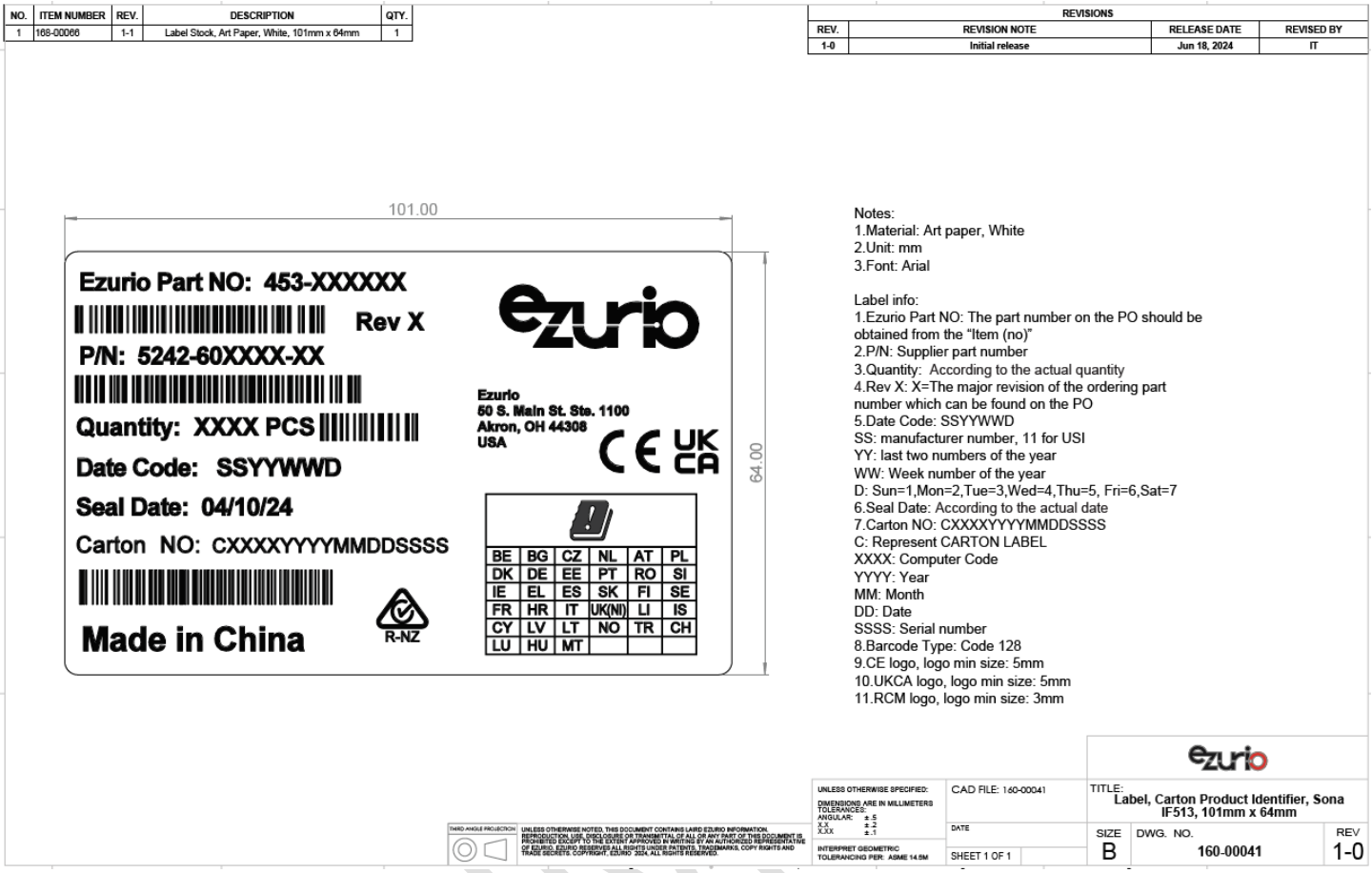


Figure 33: Sona IF513 Carton Product Identifier Label, 160-000041

16.3 Required Storage Conditions

16.3.1 Prior to Opening the Dry Packing

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

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

Note: Humidity means relative humidity.

16.3.2 After Opening the Dry Packing

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

- Storage conditions for one-time soldering:
  - Temperature: 5-25°C
  - Humidity: 60% or less
  - Period: 72 hours or less after opening
- Storage conditions for two-time soldering
  - Storage conditions following opening and prior to performing the 1st reflow:
    - Temperature: 5-25°C
    - Humidity: 60% or less
    - Period: A hours or less after opening

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- Storage conditions following completion of the 1st reflow and prior to performing the 2nd reflow
  - Temperature: 5-25°C
  - Humidity: 60% or less
  - Period: B hours or less after completion of the 1st reflow

Note: Should keep A+B within 72 hours.

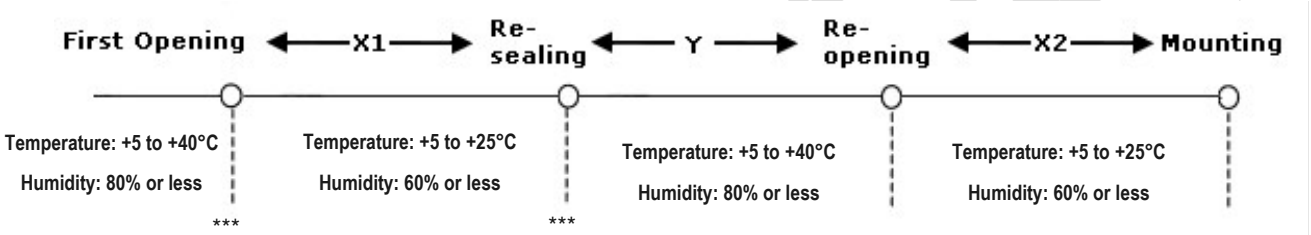
16.3.3 Temporary Storage Requirements after Opening

The following are temporary storage requirements after opening:

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

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

- Storage temperature and humidity:



*** - External atmosphere temperature and humidity of the dry packing

- Storage period:
  - X1+X2 – Refer to Required Storage Conditions. Keep is X1+X2 within 72 hours.
  - Y – Keep within two weeks or less.

16.4 Baking Conditions

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

- The calculated shelf life in a sealed bag is 12 months at <40°C and <80% relative humidity.
- Once the packaging is opened, the SiP must be mounted (per MSL4/Moisture Sensitivity Level 4) within 72 hours at <30°C and <60% relative humidity.

If the SiP is not mounted within 72 hours or if, when the dry pack is opened, the humidity indicator card displays >10% humidity, then the product must be baked for 48 hours at 125°C (±5°C).

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17 Surface Mount Conditions

The following soldering conditions are recommended to ensure device quality.

17.1 Recommended Stencil Aperture

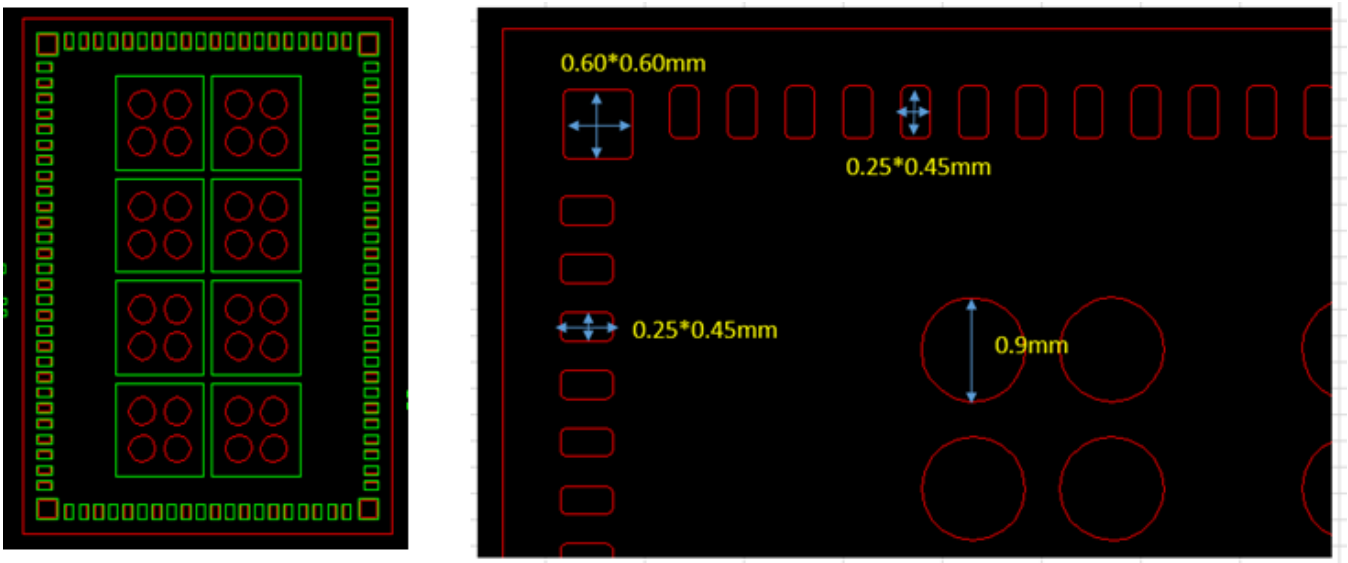


Figure 34: Sona IF513 M.2 1216 stencil aperture

Note: The stencil thickness is 0.12mm.

17.2 Soldering

Note: When soldering, the stencil thickness should be 0.12 mm.

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

Measuring point – IC package surface
Temperature profile:

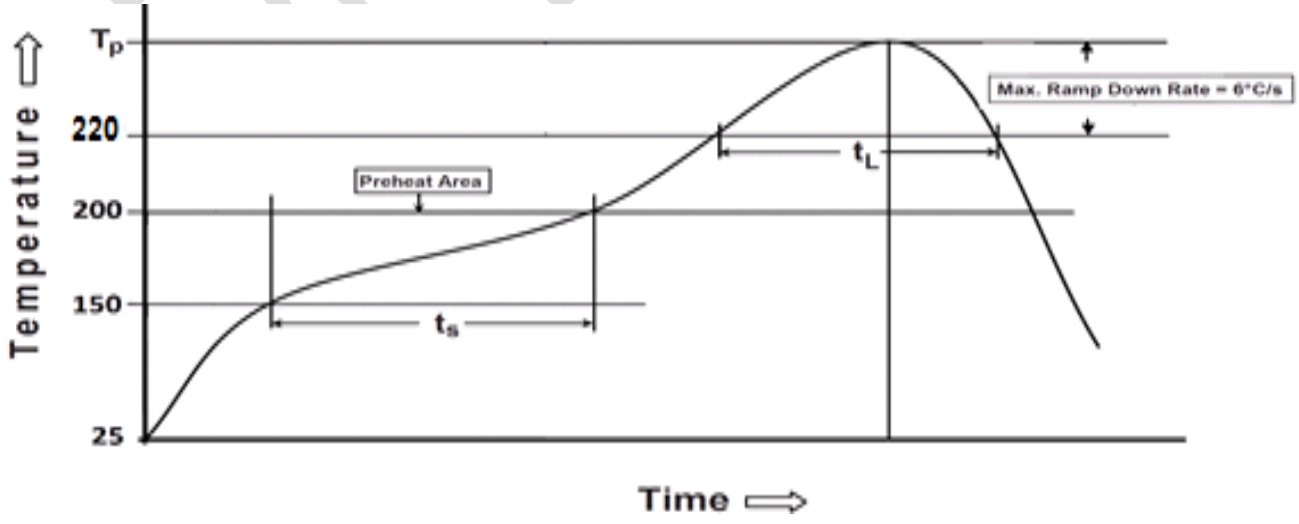


Figure 35: Temperature profile

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- Solder paste alloy: SAC305(Sn96.5 / Ag3.0 / Cu 0.5)
- Pre-heat temperature: 150℃ ~ 200℃; Soak time: 60 second ~ 120 second
- Peak temperature: 235℃ ~ 250℃
- Time above 220℃: 40 second ~ 90 second
- Optimal cooling rate < 3℃/second
- The oxygen concentration < 2000 ppm

17.2.1 Cautions When Removing the M.2 1216 from the Platform for RMA

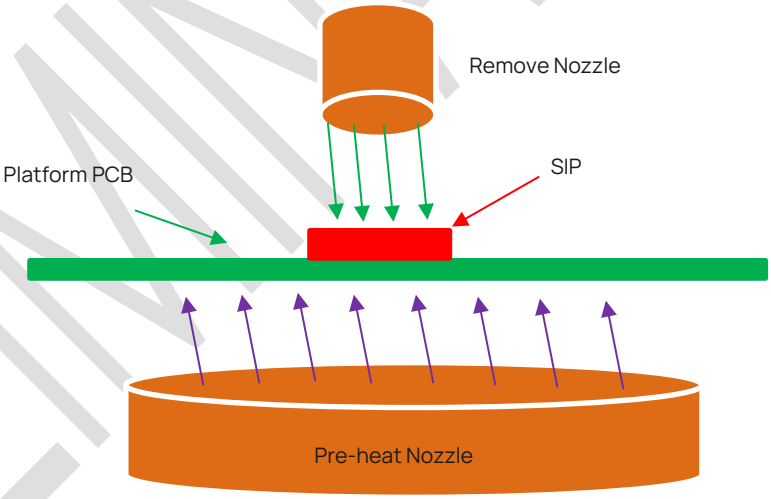
- Bake the platform before removing the Sona IF513 module from the platform. Reference **Error! Reference source not found.**.
- Remove the Sona IF513 module by using a hot air gun. This process should be carried out by a skilled technician.

Recommended conditions:

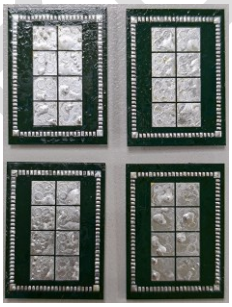


- One-side component platform:
  - Set the hot plate at 280°C.
  - Put the platform on the hot plate for 8~10 seconds.
  - Remove the device from platform.
- Two-side components platform:
  - Use two hot air guns.
  - On the bottom, use a pre-heated nozzle (temp setting of 200~250°C) at a suitable distance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



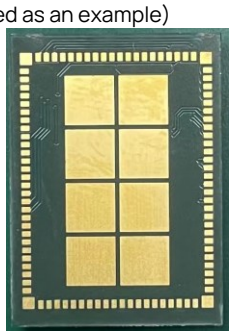


- Remove the residue solder under the bottom side of device. (Note: Alternate module pictured as an example)



(Not accepted for RMA)

Figure 36: Example M.2 1216 with residue solder on the bottom



(Accepted for RMA analysis)

Figure 37: Sona IF513 module without residue solder

- Remove and clean the residue flux as needed.

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17.2.2 Precautions for Use

- Opening/handling/removing must be done on an anti-ESD treated workbench. All workers must also have undergone anti-ESD treatment.
- The devices should be mounted within one year of the date of delivery.
- The Sona IF513 modules are MSL level 4 rated.

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18 Reliability Test

The Sona IF513 modules were tested for reliability. Test items and the corresponding standards are shown in **Error! Reference source not found.**.

18.1 Environmental and Mechanical

The following are the followed reliability test procedures.

Table 41: Sona IF513 M.2 1216 Solder-down Module Reliability Test Items and Standards

Test Item	Specification	Standard	Test Result
Step 1: Pre-conditioning	**Pre-check:** 1. Function check (Tools and SOP supplied by customers). 2. Mechanical check. **Pre-conditioning:** 1. Bake: 125°C for 24 hours. 2. Moisture Soak: 30°C/60% RH for 192 hours 3. Not shorter than 15 minutes and not longer than 4 hours after removal from the temperature/humidity chamber, subject the sample to 3 cycles of the reflow. **Post-check:** 1. Function check (Tools and SOP supplied by customers). 2. Mechanical check. 3. Perform inspections of short, open, delamination of DUTs by Optical Microscope (under 40X optical magnification). 4. X-RAY / CSAM (SAT) on any failed samples (Notify customers). 5. Cross-sections analysis based on X-RAY and CSAM results.	JESD22-A113	Pass
Step 2: Temperature Cycling Non-operating	1. Dwell on -40°C for 15 minutes 2. Shock to 85°C with in ramp rate 15 °C/minute 3. Dwell on 85°C for 15 minutes 4. Shock to -40°C with in ramp rate 15 degree C/minute 5. Repeat step 1-4 and stop to check functions at 500/ 700 cycles	JESD22-A113	Pass
Vibration Non-operating Unpackaged device	1. Vibration Wave Form: Sine Waveform 2. Vibration frequency / Displacement: 20-80 Hz/1.5mm 3. Vibration frequency / Acceleration: 80-2000 Hz/20g 4. Cycle Time: 4 min/cycle 5. Number of Cycles: 4 cycle/axis 6. Vibration Axes: X, Y and Z (Rotate each axis on vertical vibration table)	JEDEC 22-B103B (2016)	Pass
Mechanical Shock Non-operating Unpackaged device	1. Pulse shape: Half-sine waveform 2. Impact acceleration: 1500 g 3. Pulse duration: 0.5 ms 4. Number of shocks: 30 shocks (5 shocks for each face) 5. Orientation: Bottom, top, left, right, front and rear faces	JEDEC 22-B110B.01 (2019)	Pass

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Table 42: Sona IF513 M.2 2230 E-Key Module Reliability Test Item and Standards

Test Item	Specification	Standard	Test Result
Thermal Shock	1. Temperature: -40 ~ 85℃ 2. Ramp time: Less than 10 seconds. 3. Dwell Time: 10 minutes 4. Number of Cycles: 500 times	*JESD22-A106 *IEC 60068-2-14 for dwell time and number of cycles	Pass
Vibration Non-operating Unpackaged device	1. Vibration Wave Form: Sine Waveform 2. Vibration frequency / Displacement: 20-80 Hz/1.5mm 3. Vibration frequency / Acceleration: 80-2000 Hz/20g 4. Cycle Time: 4 min/cycle 5. Number of Cycles: 4 cycle/axis 6. Vibration Axes：X, Y and Z (Rotate each axis on vertical vibration table)	JEDEC 22-B103B (2016)	Pass
Mechanical Shock Non-operating Unpackaged device	1. Pulse shape: Half-sine waveform 2. Impact acceleration: 1500 g 3. Pulse duration: 0.5 ms 4. Number of shocks: 30 shocks (5 shocks for each face) 5. Orientation: Bottom, top, left, right, front and rear faces	JEDEC 22-B110B.01 (2019)	Pass

18.2 Reliability Prediction

Test Item	Specification	Standard
Mean Time Between Failure (MTBF)	1. Normal Operating Temperature:45 ℃ Ground Fixed Ground Mobile 2. High Temperature: 85 ℃ Ground Fixed Ground Mobile	Telcordia SR-332 Issue 4 (2016)

Ezurio Part Number	Environment	Test Result 45 ℃ (Hours)
453-00184R 453-00184C 453-00185R 453-00185C 453-00193R 453-00193C 453-00194R 453-00194C	Ground, Fixed, Uncontrolled Ground, Mobile	1,221,4794.22 9,280,713.28

Ezurio Part Number	Environment	Test Result 85 ℃ (Hours)
453-00184R 453-00184C 453-00185R 453-00185C 453-00193R 453-00193C 453-00194R 453-00194C	Ground, Fixed, Uncontrolled Ground, Mobile	2,944,966.86 2,244,523.16

Ezurio Part Number	Environment	Test Result 45 ℃ (Hours)
453-00186 453-00195	Ground, Fixed, Uncontrolled Ground, Mobile	3,880,182.6 2,921,415.1

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Ezurio Part Number	Environment	Test Result 85 ℃ (Hours)
453-00186	Ground, Fixed, Uncontrolled	787,914.3
453-00195	Ground, Mobile	593,306.2

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19 Regulatory

Note: For complete regulatory information, refer to the Sona IF513 Regulatory Information document which is also available from the Sona IF513 product page.

The Sona IF513 holds current certifications in the following countries:

Country/Region	Regulatory ID
USA (FCC)	SQG-SONAIF513
EU	N/A
UKCA	N/A
Canada (ISED)	3147A-SONAIF513
Japan (MIC)	201-240308
Australia	N/A
New Zealand	N/A

19.1 Certified Antennas

The Sona IF513 module was tested with antennas listed in the following table. The OEM can choose a different manufacturer's antenna but must make sure it is of same type and that the gain is lesser than or equal to the antenna that is approved for use.

Manufacturer	Model	Ezurio Part Number	Type	Connector	Peak Gain (dBi)		
					2.4GHz	5GHz	6GHz
Ezurio	FlexMIMO 6E	EFD2471A3S-10MH4L	PIFA	MHF4L	2.2	3.8	3.3
Ezurio	FlexPIFA 6E	EFB2471A3S-10MH4L	PIFA	MHF4L	2.2	3.9	3.8
Ezurio	Mini NanoBlade Flex 6 GHz	EMF2471A3S-10MH4L	PCB Dipole	MHF4L	2.4	4.4	5.2
Joymax Electronics	Dipole 6E	TWX-100BRSAX-2001 / TWX-100BRS3B	Dipole	RP-SMA	2	4.0	4.0

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20 Bluetooth SIG Qualification

20.1 Overview

The Sona IF513 Series module is listed on the Bluetooth SIG website as a qualified Controller Subsystem.

Design Name	Owner	Declaration ID	Link to listing on the SIG website
Sona IF513	Ezurio	D057578	https://launchstudio.bluetooth.com/ListingDetails/158180

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

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

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

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

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

https://www.bluetooth.org/DocMan/handlers/DownloadDoc.ashx?doc_id=283698&vId=317486

20.2 Qualification Steps When Referencing a Ezurio Controller Subsystem Design

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

1. To start a listing, go to: https://www.bluetooth.org/tpg/QLI_SDoc.cfm

   Note: A username and password are required to access this site.

2. In step 1, select the option, New Listing and Reference a Qualified Design.
3. Enter D057578 in the Controller Subsystem table entry.
4. Enter your complimentary Host Subsystem and optional Profile Subsystem QDID in the table entry.
5. Select your pre-paid Declaration ID from the drop-down menu or go to the Purchase Declaration ID page.

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

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

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

For further information please refer to the following training material:

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

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

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