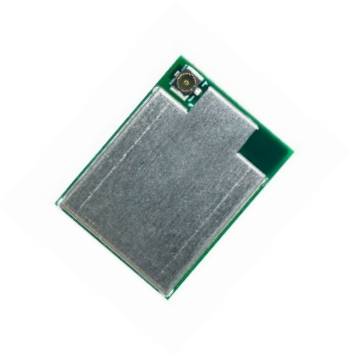


PIXI-IW416

NXP IW416

2.4/5Ghz Dual-Band 1x1 Wi-Fi 4 (802.11n) + Bluetooth 5.2

M.2 LGA Type 1216 Module

REV. A1 – VER. 1.00

October 20, 2023

REVISION HISTORY

Revision	Date	Originator	Notes
1.00	October 20, 2023	TechNexion	Initial Public release

TABLE OF CONTENTS

1. Introduction

1.1 General Introduction

PIXI-IW416 is a high performance 2.4 + 5GHz Wi-Fi 4 (802.11n) and Bluetooth 5.2 combo module based on latest-generation silicon (NXP IW416). With an industrial temperature rating, broad country certifications, and the availability in different package styles, the PIXI-IW416 provides significant flexibility to meet various end user application needs.

The on-module chip antenna package style for the PIXI-IW416 eliminates complexity for design integration, simplifies manufacturing assembly with larger pin outs, and features an advanced chip antenna that offers greater resistance to de-tuning than typical trace or chip antennas.
The module includes the MAC, Baseband and Radio to support WLAN applications and an independent, high-speed UART is provided for the Bluetooth host interface. In addition, the latest Linux and Android drivers are supported directly by TechNexion and NXP.

- Need to get to market quickly?
- Not an expert in 802.11 wireless connectivity?
- Need a custom antenna?
- Would you like a custom design?
- Not quite sure what you need?
- Do you need help with your host board?

TechNexion has a Design Services Team standby that is happy to develop custom hardware or software or assist with integrating the design.

Contact your TechNexion Sales Contact Window or email us at sales@technexion.com.

1.2 Product Key Features

General	Specification
Chipset	NXP IW416
Formfactor	M.2 LGA Type 1216
Antenna	IPEX MHF-4 Connector
Operation Temperature	-40 to +85 Degrees Celsius
Operation Humidity	10 – 90 % non-Condensing

Wi-Fi	Specification	
Chipset	NXP IW416	
Host Interface	SDIO	
Standards	Wi-Fi 4 (802.11n)	
Radio Stream	1T1R	
Frequency Range	2.4Ghz	2412 – 2472Mhz
	5Ghz	5180 – 5825Mhz
Frequency Step	2.4GHz 802.11b/g/n	5Mhz
	5Ghz 802.11a/n	20Mhz
	5Ghz 802.11 n	40Mhz
Link Data Rate	802.11b	1,2, 5.5, 11 Mbps
	802.11a/g	6,9,12,18,24,36,48,54 Mbps
	802.11n	MCS 0,1,2,3,4,5,6,7
Modulation Type	802.11b	DSSS (DBPSK, DQPSK, CCK)
	802.11a/g/n	OFDM (BPSK, QPSK, 16QAM, 64QAM)
Encryption	AES	128 bits
Security	WPA3, WPA2, WPA-WPA mixed modes	

Bluetooth	Specification
Chipset	NXP IW416
Host Interface	UART
Standards	Bluetooth 5.2 (backwards compatible with 5.1, 4.2, 4.1, 4.0 LE, 3.0+HS, 2.1+EDR)
Frequency Range	2402 – 2480Mhz
Channels	0 – 79
Link Data Rate	1 Mbps, 2Mbps and Upto 3Mbps EDR
Modulation Type	FHSS, GFSK, DPSK, DQPSK

1.3 Product Variants

The PIXI-IW416 Base Module is a System in Package (SIP) module, which can be assembled into an OEM end product and is available in the following configurations.

	Partnumber	Description
	PIXI-IW416	PIXI IW416 M.2 SIP Module **Wi-Fi : SDIO** **BT : UART + PCM**

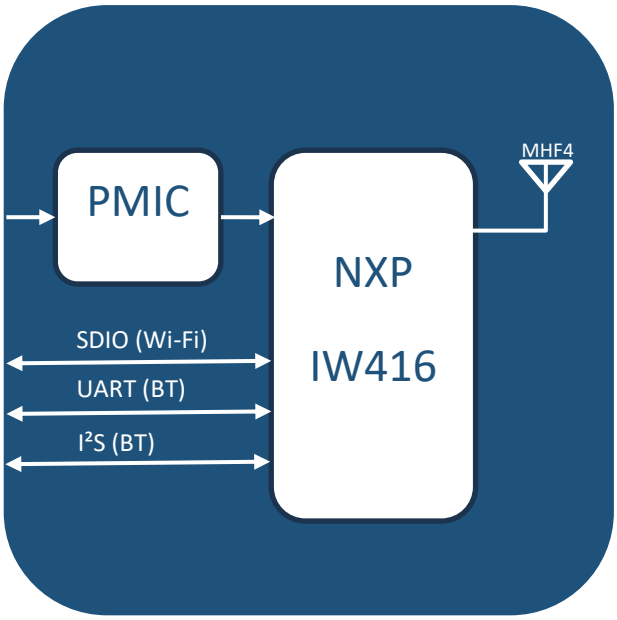
1.4 Add-On Card Variants

TechNexion offers a range of “add-on cards” for customers that want to add the PIXI-IW416 in their OEM project but don’t have the freedom or technical design or manufacturing knowledge to work with SIP packages

	Partnumber	**Description**
	CLIX-IW416	CLIX IW416 Module **Wi-Fi : SDIO** **BT : UART + PCM**

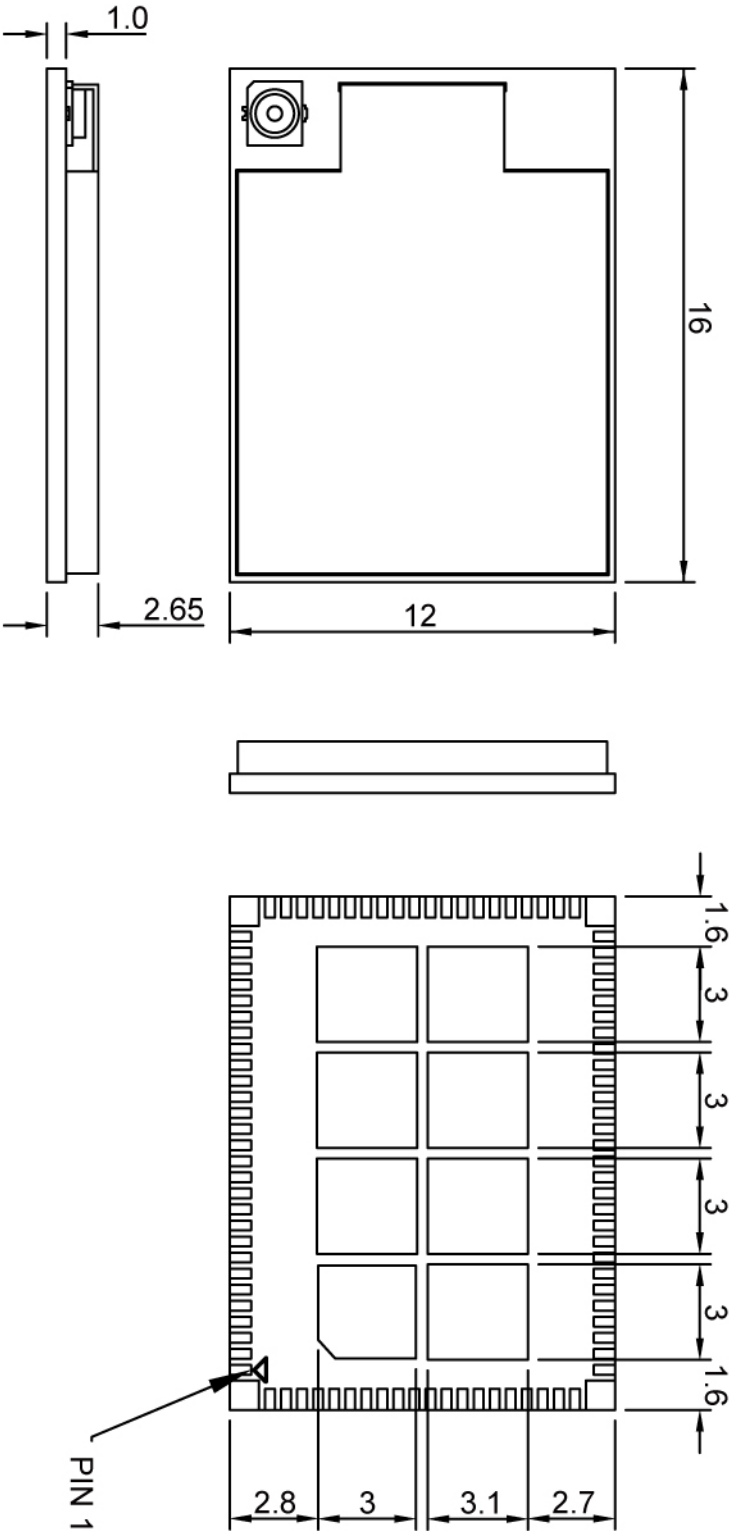
1.5 Block Diagrams

Figure 1 – PIXI-IW416 Block Diagram



1.6 Dimensional Drawing PIXI-IW416

Figure 2 – PIXI-IW416 Dimensional Drawing



2. PIXI-IW416 Signal Pinout

Pin	Name	Type	Description
1	NC		Not Connected
2	NC		Not Connected
3	NC		Not Connected
4	VDD_3P3	P	3.3V
5	VDD_3P3	P	3.3V
6	GND	P	Ground
7	NC		Not Connected
8	NC		Not Connected
9	NC		Not Connected
10	NC		Not Connected
11	NC		Not Connected
12	NC		Not Connected
13	NC		Not Connected
14	NC		Not Connected
15	NC		Not Connected
16	NC		Not Connected
17	GND	P	Ground
18	NC		Not Connected
19	NC		Not Connected
20	GND	P	Ground
21	VENDOR ID		TechNexion Vendor Manufacturing Pin
22	VENDOR ID		TechNexion Vendor Manufacturing Pin
23	GND	P	Ground
24	VENDOR ID		TechNexion Vendor Manufacturing Pin
25	RSVD		Reserved
26	GND	P	Ground
27	NC		Not Connected
28	WL_REG_ON	I	WLAN Enable. (Active High)
29	NC		Not Connected
30	NC		Not Connected
31	NC		Not Connected
32	GND	P	Ground
33	NC		Not Connected
34	NC		Not Connected
35	GND	P	Ground
36	NC		Not Connected
37	NC		Not Connected
38	GND	P	Ground
39	NC		Not Connected
40	NC		Not Connected
41	GND	P	Ground
42	NC		Not Connected
43	NC		Not Connected
44	NC		Not Connected
45	NC		Not Connected
46	SDIO_WAKE_n	O	SDIO Interrupt Signal
47	SDIO_DATA3	I/O	SDIO Data bit 3
48	SDIO_DATA2	I/O	SDIO Data bit 2
49	SDIO_DATA1	I/O	SDIO Data bit 1
50	SDIO_DATA0	I/O	SDIO Data bit 0
51	SDIO_CMD	I	SDIO CMD Line Signal
52	SDIO_CLK	OD	SDIO Clock Signal
53	BT_WAKE_n	I	Bluetooth Host Wake Up Signal (Active High)

Pin	Name	Type	Description
54	UART_CTS	I	UART Clear to Send Signal
55	UART_TX	O	UART Transmit Signal
56	UART_RX	I	UART Receive Signal
57	UART_RTS	O	UART Ready to Send Signal
58	PCM_SYNC	I/O	Bluetooth PCM SYNC Signal
59	PCM_IN	OD	Bluetooth PCM IN Signal
60	PCM_OUT	O	Bluetooth PCM OUT Signal
61	PCM_CLK	I	Bluetooth PCM Clock Signal
62	GND	P	Ground
63	BT_REG_ON	I	Bluetooth enable. Active High
64	NC		Not Connected
65	WL_LED_n	O	Wi-Fi LED Signal
66	WL_HOST_WAKE	I	Host to IW416 Wi-Fi Wake Signal
67	BT_HOST_WAKE	I	Host to IW416 Bluetooth Wake Signal
68	GND	P	Ground
69	NC		Not Connected
70	NC		Not Connected
71	GND	P	Ground
72	VDD_SDIO	P	SDIO Voltage (1.8V or 3.3V)
73	VDD_IO	P	I/O Voltage (1.8V or 3.3V)
74	GND	P	Ground
75	GND	P	Ground
76	GND	P	Ground
77	GND	P	Ground
78	GND	P	Ground
79	NC		Not Connected
80	GND	P	Ground
81	GND	P	Ground
82	GND	P	Ground
83	GND	P	Ground
84	NC		Not Connected
85	GND	P	Ground
86	GND	P	Ground
87	GND	P	Ground
88	GND	P	Ground
89	NC		Not Connected
90	GND	P	Ground
91	GND	P	Ground
92	GND	P	Ground
93	GND	P	Ground
94	NC		Not Connected
95	GND	P	Ground
96	GND	P	Ground
G1	GND	P	Ground
G2	GND	P	Ground
G3	GND	P	Ground
G4	GND	P	Ground
G5	GND	P	Ground
G6	GND	P	Ground
G7	GND	P	Ground
G8	GND	P	Ground
G9	GND	P	Ground
G10	GND	P	Ground
G11	GND	P	Ground
G12	GND	P	Ground

3. RF Characteristics

Table 1 - RX Sensitivity 2.4 Ghz (TA = 25°C VCC = 3.3V)

Parameter	Test condition	Min.	Typ	Max	Unit
802.11b / 20MHz	11Mbps		-87		dBm
802.11g / 20MHz	54Mpbs		-75		dBm
802.11n (MCS7_HT20)	65Mbps		-69		dBm
802.11n (MCS7_HT40)	135Mbps		-70		dBm

Table 2 - RX Sensitivity 5 Ghz (TA = 25°C VCC = 3.3V)

Parameter	Test condition	Min.	Typ	Max	Unit
802.11a / 20MHz	54Mbps		-72		dBm
802.11n (MCS7_HT20)	65Mpbs		-66		dBm
802.11n (MCS7_HT40)	135Mbps		-65		dBm

Table 3 - TX Output Power 2.4 GHz (TA = 25°C VCC = 3.3V)

Parameter	Test condition	Min.	Typ	Max	Unit
802.11b / 20MHz	11Mbps		17		dBm
802.11g / 20MHz	54Mpbs		16		dBm
802.11n (MCS7_HT20)	65Mbps		15		dBm
802.11n (MCS7_HT40)	135Mbps		15		dBm

Table 4 - TX Output Power 5 Ghz (TA = 25°C VCC = 3.3V)

Parameter	Test condition	Min.	Typ	Max	Unit
802.11a / 20MHz	54Mbps		15		dBm
802.11n (MCS7_HT20)	65Mpbs		15		dBm
802.11n (MCS7_HT40)	135Mbps		15		dBm

Table 5 - RX Sensitivity Bluetooth (TA = 25°C VCC = 3.3V)

Parameter	Test condition	Min.	Typ	Max	Unit
Bluetooth Class 1 Device			-80		dBm

Table 6 - TX Output Power Bluetooth (TA = 25°C VCC = 3.3V)

Parameter	Test condition	Min.	Typ	Max	Unit
Bluetooth Class 1 Device			10		dBm

4. Power

4.1. WLAN Power Consumption

Table 7 - RX Sensitivity 2.4 Ghz (TA = 25°C VCC = 3.3V)

Parameter	Test condition	Min.	Typ	Max	Unit
802.11b / 20MHz	11Mbps		50		mA
802.11g / 20MHz	54Mpbs		50		mA
802.11n (MCS7_HT20)	65Mbps		50		mA
802.11n (MCS7_HT40)	135Mbps		50		mA

Table 8 - RX Sensitivity 5 Ghz (TA = 25°C VCC = 3.3V)

Parameter	Test condition	Min.	Typ	Max	Unit
802.11a / 20MHz	54Mbps		62		mA
802.11n (MCS7_HT20)	65Mpbs		62		mA
802.11n (MCS7_HT40)	135Mbps		69		mA

Table 9 - TX Output Power 2.4 GHz (TA = 25°C VCC = 3.3V)

Parameter	Test condition	Min.	Typ	Max	Unit
802.11b / 20MHz	11Mbps		290		mA
802.11g / 20MHz	54Mpbs		270		mA
802.11n (MCS7_HT20)	65Mbps		240		mA
802.11n (MCS7_HT40)	135Mbps		270		mA

Table 10 - TX Output Power 5 Ghz (TA = 25°C VCC = 3.3V)

Parameter	Test condition	Min.	Typ	Max	Unit
802.11a / 20MHz	54Mbps		320		mA
802.11n (MCS7_HT20)	65Mpbs		310		mA
802.11n (MCS7_HT40)	135Mbps		270		mA

4.2. Bluetooth Power Consumption

Table 11 - RX Sensitivity 2.4 Ghz (TA = 25°C VCC = 3.3V)

Parameter	Min.	Typ	Max	Unit
Continuous RX burst		100		mA
Continuous TX 1M (4FSK)		130		mA
Continuous TX 2M (DQDSK)		120		mA
Continuous TX 3M (8PSK)		120		mA

5. Electric Specifications

The PIXI-IW416 can operate at 3.3V operation.

3.3V Operation Mode

Parameter	Min.	Typ	Max	Unit
VDD_3P3	3.135	3.3	3.465	V
VDD_IO	3.135	3.3	3.465	V
VDD_SDIO	3.135	3.3	3.465	V

The PIXI-IW416 can also operate at 1.8V operation as follow.

1.8V Operation Mode

Parameter	Min.	Typ	Max	Unit
VDD_3P3	3.135	3.3	3.465	V
VDD_IO	1.71	1.8	1.89	V
VDD_SDIO	1.71	1.8	1.89	V

5.1 Power domain associated pins

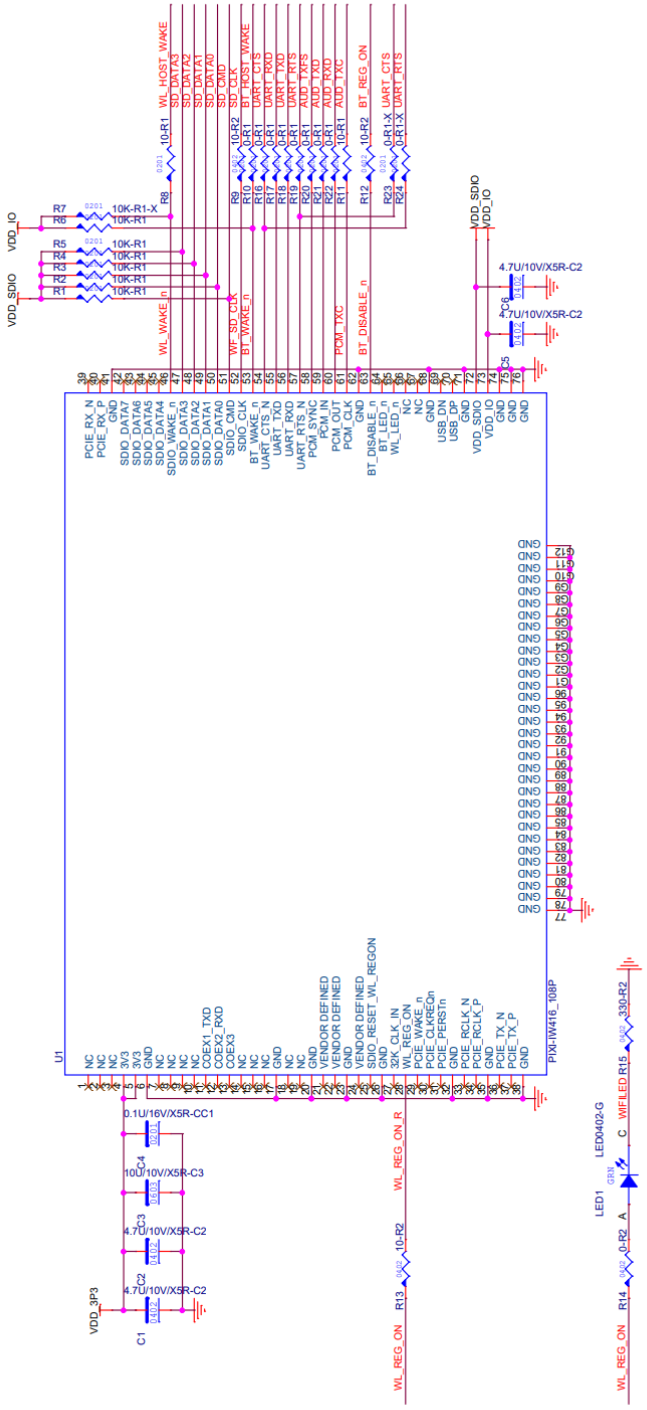
Power Domain	Pins Connected
VDD_3P3	General Power Domain for operation
VDD_IO	28, 46, 53~61, 63, 65, 66, 67
VDD_SDIO	47~52

6. Power Sequence Specifications

The PIXI-IW416 has an integrated Power Management IC (PMIC) that handles all power sequencing. No external specific power sequencing is required.

7 Reference Schematics

7.1 PIXI-IW416



7.2 Signal Connection Checklist while integrating PIXI-IW416

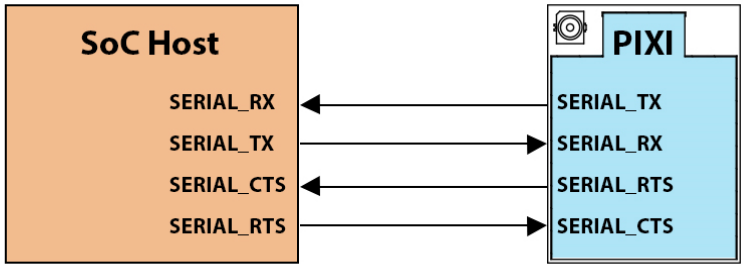
While integrating the PIXI-IW416 in an OEM design is straightforward. The following common design mistakes should be checked against.

7.2.1 Module Integration Considerations - Circuit Implementation

It is recommended that all connection PCB (printed circuit board) traces to the power supply and digital control terminal be as short as possible. Though not necessarily required in all cases, it is a best practice to provide an optional shunt capacitor placement at the module pin on all active and routed power supply and digital control lines. Further, a series damping resistor placement should be incorporated between the module pin/shunt capacitor node and the source/sink of the digital control signals. This provides for effective bypassing and decoupling of digital lines from the radio module, in the event that the application circuit has longer power supply and digital routing.

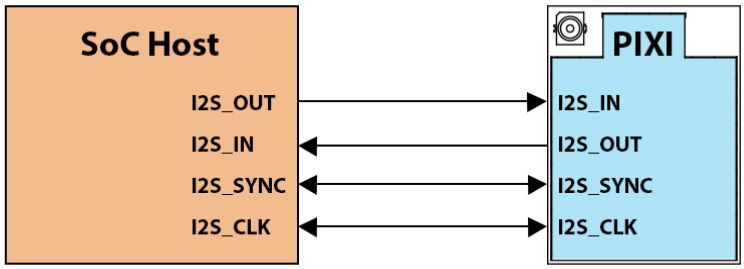
7.2.2 Bluetooth UART Signal Swapping on PIXI-IW416 Designs.

When using the PIXI-IW416. The Bluetooth data signals are connected over the UART. Makes sure that the SOC TX signals connect to the PIXI-IW416 RX signals and vice-versa.



7.2.3 Bluetooth PCM Audio Signal Swapping on PIXI-IW416 Designs.

When using the PIXI-IW416. The Bluetooth audio signals are connected over the PCM. Makes sure that the SOC IN signals connect to the PIXI-IW416 OUT signal and vice-versa.



8. EMC Compliance certification

The PIXI-IW416 module has been tested and approved as a Modular Radio in accordance with the appropriate FCC, IC, ETSI, RED, TELEC and RCM standards. The supporting test data modular test report can be found on our corporate homepage download section at www.technexion.com.

Since this module and its associated set of approved antennas have been certified as a Modular Radio, this allows the end user to integrate this module into an end-product without the requirement of recertifying the radio module. The module-integrator is responsible for the unintentional conducted and radiated emissions and must verify that the integrated product is compliant with the rules associated with unintentional radiators. The module integrator is also required to maintain an engineering record of the verification testing and declare on the product through proper labeling and marking that the device is compliant with these particular rules.

The installed module's FCC ID and IC numbers need to be clearly marked on the product with the following verbiage "Contains FCC ID: 2AKZA-IW416" and "Contains IC: 22364-IW416".

8.1 FCC Testing Requirements for End-Product

Once the module is integrated and the end-product is realized, the end-product must be tested and follow the verification process for Unintentional Conducted and Radiated Emissions in accordance to the FCC and IC guidelines. The module needs to be powered and placed in the receive mode for this test. The receiver must be tuned to its lowest frequency channel, mid-frequency channel, and highest frequency channel. The supporting test data does not need to be submitted to the FCC or IC. The implementation of the module in a specific end-product should also be reviewed to ensure compliance with the FCC and IC requirements for SAR and MPE if applicable.

8.2 FCC Wireless certification: New Filing vs. Permissive Change

Products are continually under revision due to obsolete or unavailable parts, cost cutting, updates for a product release, and so on. The dilemma for most companies is determining the process and requirements for altered products. This section outlines the options available and highlights a few examples for guidance.

Here we focus on changes for unlicensed transmitters that require an FCC Certification or Equipment Authorization. Products require “Document of Compliance” testing if the change could adversely affect the radiating characteristics of the equipment. This procedure is outlined in Title 47 Part 2.1073.

To allow products to be modified without requiring a new filing, the FCC has defined three Permissive Change options listed in Title 47 Part 2.1043.

Class I Permissive Change

Class I Permissive Change includes modifications which do not degrade the characteristics reported by the manufacturer and accepted by the Commission when certification is granted. No filing with the Commission is required for a Class I Permissive Change. [FCC source: 2009 Title 47 CFR 2.1043 ((b)(1))]

Class II Permissive Change

Class II Permissive Change includes modifications which degrade the performance characteristics as reported to the Commission at initial certification. Such degraded performance must still meet the minimum requirements of the applicable rules. When a Class II permissive change is made, the grantee must supply the Commission with complete information and results of tests of characteristics affected by such change. Modified equipment cannot be marketed under the existing grant of certification prior to acknowledgment by the Commission that the change is acceptable. [FCC source: 2009 Title 47 CFR 2.1043 ((b)(2))]

Class III Permissive Change

Class III Permissive Change includes software modifications of a software-defined radio transmitter that change the frequency range, modulation type or maximum output power (either radiated or conducted) outside the parameters previously approved, or that change the circumstances under which the transmitter operates in accordance with Commission rules.

When a Class III Permissive Change is made, the grantee must supply the Commission with a description of the changes and test results showing that the equipment complies with applicable rules with the new software loaded, including compliance with applicable RF exposure requirements. The modified software must not be loaded into the equipment, and the equipment must not be marketed with modified software under the existing grant of certification, prior to acknowledgment by the Commission that the change is acceptable.

Class III changes are permitted only for equipment on which no Class II changes have been made from the originally approved device. [FCC source: 2009 Title 47 CFR 2.1043 ((b)(3))]

Following are examples of three common changes to certified radios.

Example 1: Change of Antenna for a Part 15 Subpart C Unlicensed Radio

Both products and modules are tested and certified with specific antennas. In many cases the end user deviates from the specified antenna due to cost, style or availability. To maintain a Class I Permissive Change, the new antenna must be an equivalent antenna, defined as one of the same type (e.g., yagi or dipole) and must be of equal or less gain than an antenna previously authorized under the same FCC ID, and must have similar in-band and out-of-band characteristics (consult specification sheet for cutoff frequencies).[FCC source: 178919 D01 Permissive Change Policy v04r04]

Therefore, if the antenna is of a different type or higher gain, the product or radio module requires a Class II Permissive Change, and all FCC provisions of Title 47 CFR 15.203 for antenna requirements must be met.

Example 2: Electrical Hardware Changes

The main deciding factor for hardware changes is whether the device is “electrically equivalent.” If the device is electrically equivalent, a Class I or Class II Permissive Change is acceptable, depending on the test result evaluation. Again, it is the manufacturer’s responsibility to ensure that the devices are electrically equivalent and to perform analysis that the device’s performance has not degraded. Some form of testing is generally required to support the claim that the device’s performance has not degraded.

Changes in frequency or output power, or removal or addition of components related to the RF section of the device automatically require a new filing and new FCC ID number.

Example 3: Enclosure Change

Obviously, enclosure changes do not apply to modular radios, but for other products, slight changes are allowed to the enclosure under a permissive change. However, major reorientation of the device inside the enclosure is not acceptable. For example, if the device was originally tested and certified lying flat and the new enclosure has the device mounted vertically, this would require retesting and a new FCC filing.

Summary

Changes to a modular radio or product will result in either a Permissive Change or a new FCC filing and ID number. The degree of change is the determining factor for both the process and the amount of supporting data required to illustrate compliance. TechNexion takes pride in helping customers evaluate and develop the most beneficial test plan to properly address these changes.

9 Antenna Integration Guidelines

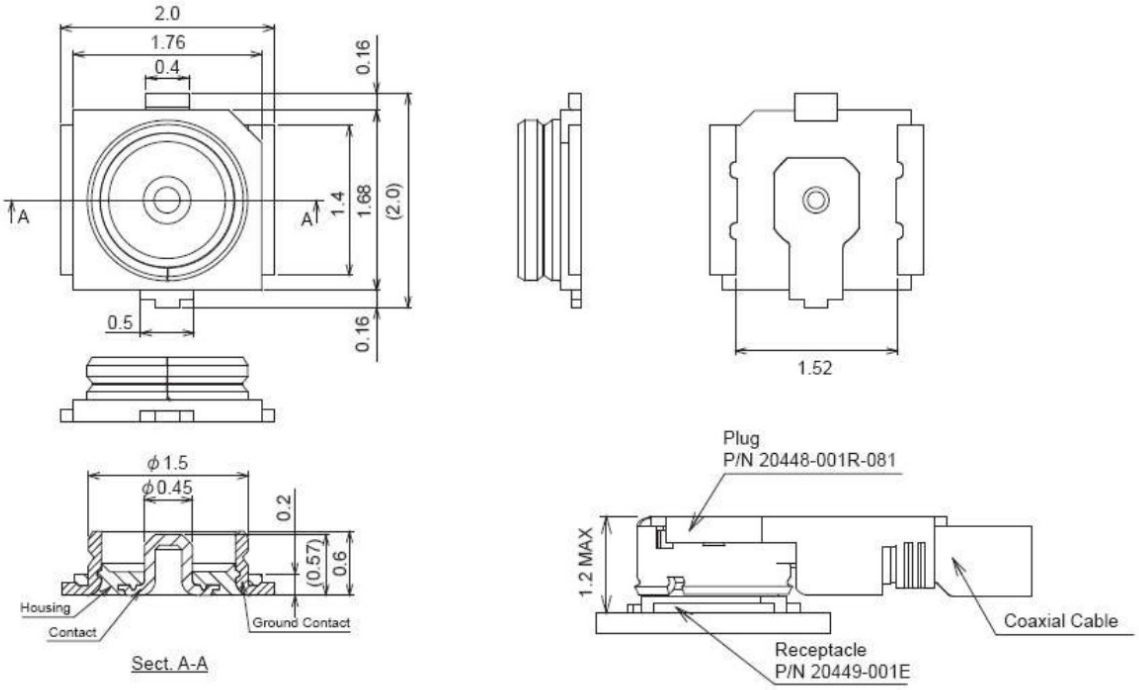
The antenna should be placed such that it is minimally disturbed by the product's packaging material. The incorporation of the largest practical free-space clearance around the antenna is important for maximizing overall performance. Further, the antenna must be placed such that at least a 20 cm separation distance is maintained from the antenna to all other radio transmitters.

In addition to the recommendations given for the antenna systems and the module placement onto a product PCB, it is recommended that all wiring and interconnect systems within the product not be routed anywhere close to the PIXI-IW416 module and its associated circuitry on the PCB, doing so could change the emission characteristics of the module.

9.1 Antenna Connector Specifications

The PIXI-IW416 module has an on-board IPEX MHF4 antenna connector following the specifications below.

When choosing a mating coax patch cable please refer to the following dimensional criteria.



9.2 Certified Antenna Options

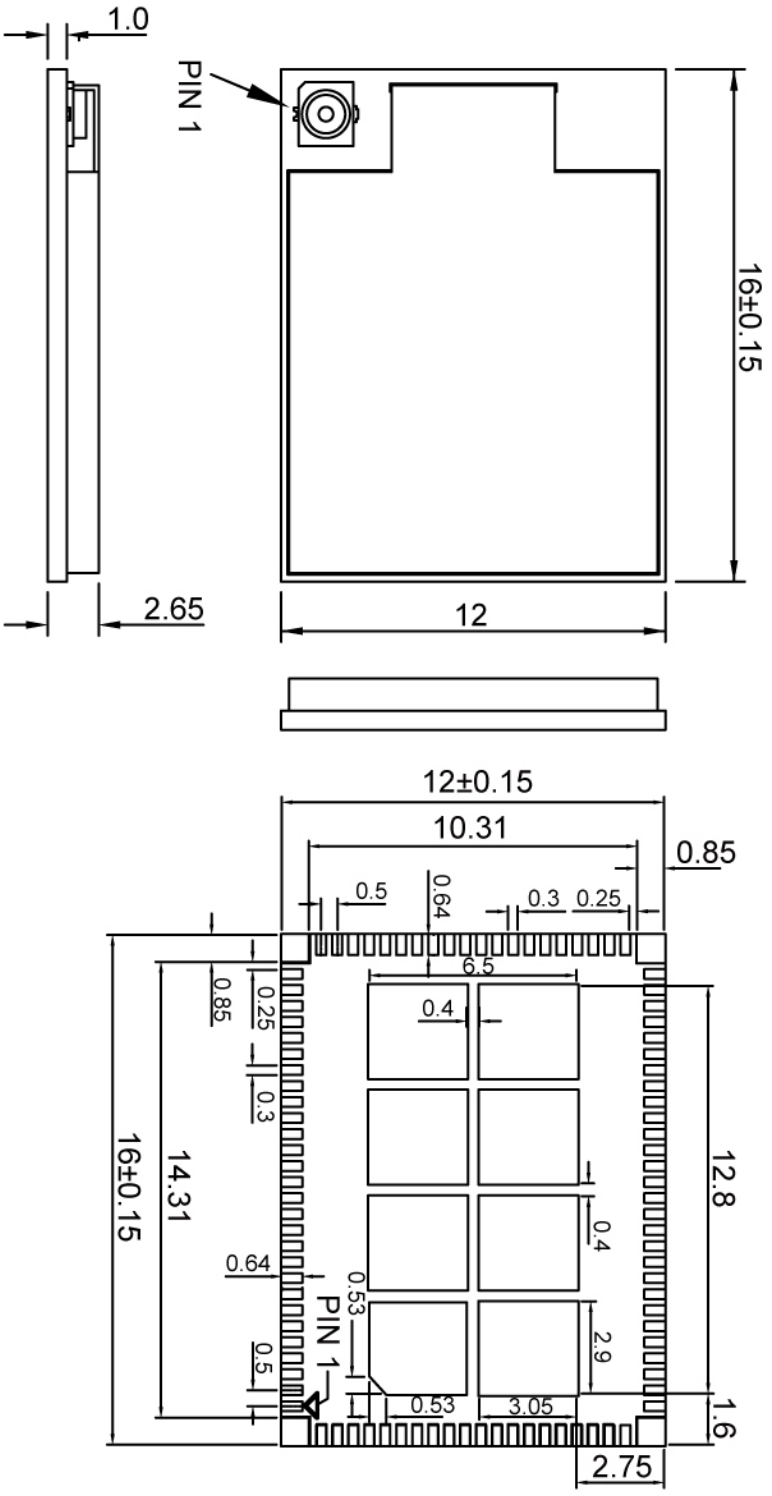
The PIXI-IW416 has been FCC / IC / TELEC certified when used with one of the approved antennas.

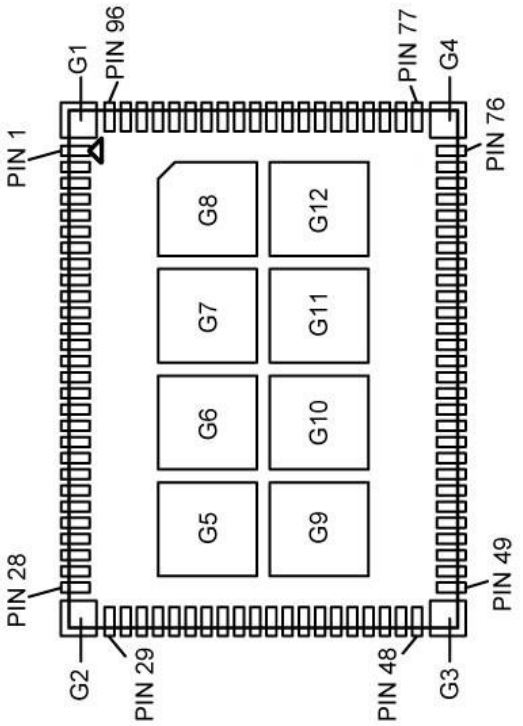
Table 12 – Antenna Options

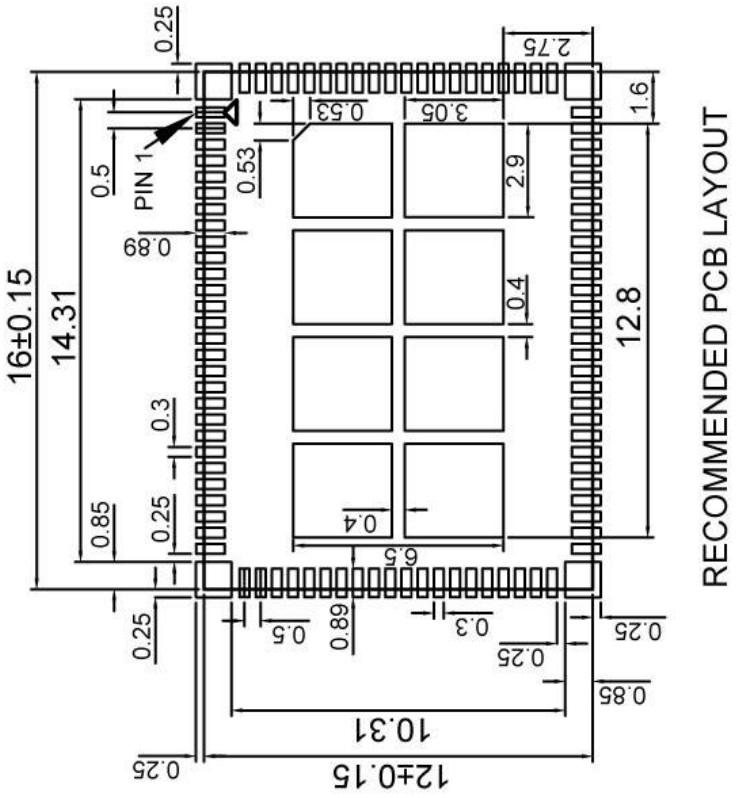
	Partnumber	Description
	ANTP150P232525D2450MHF4	Internal patch antenna (1.5dB)
	ANTP180A138045D2450MHF4	External Dipole antenna (2dB)
	ANTP180A207070D2450MHF4	External Dipole antenna (7dB)

10. SMT and Layout Data.

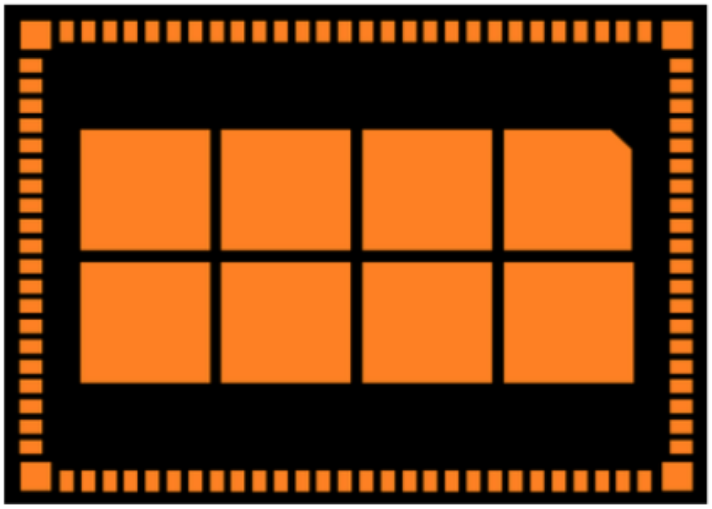
The following data can be retrieved in native file format by contacting your TechNexion sales contact window or emailing sales@technexion.com.




G1
PIN 96
PIN 77
G4
PIN 1
PIN 76
G8
G12
G7
G11
G6
G10
G5
G9
PIN 28
PIN 49
G2
PIN 29
PIN 48
G3


RECOMMENDED PCB LAYOUT
16±0.15
14.31
12.8
12±0.15
10.31
6.5
PIN 1
0.25
0.5
0.89
0.53
0.53
3.05
2.75
1.6
2.9
0.4
0.3
0.85
0.25
0.4
0.5
0.89
0.3
0.25
0.25
0.85
0.25

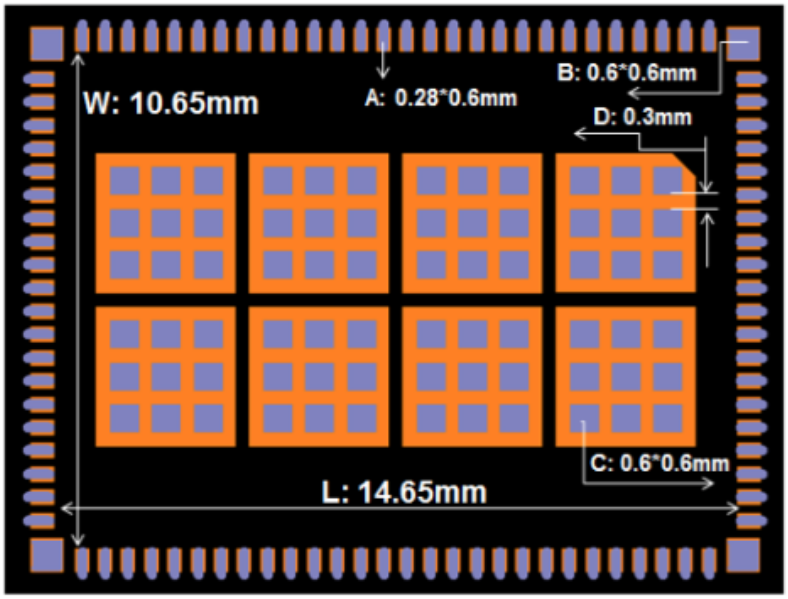
BTC (BOTTOM TERMINAL CHIP) PAD DESIGN



Recommendation:

- Mainboard PAD VS Module PAD = 1 : 1

BTC STENCIL APERTURE (RECOMMENDATION)



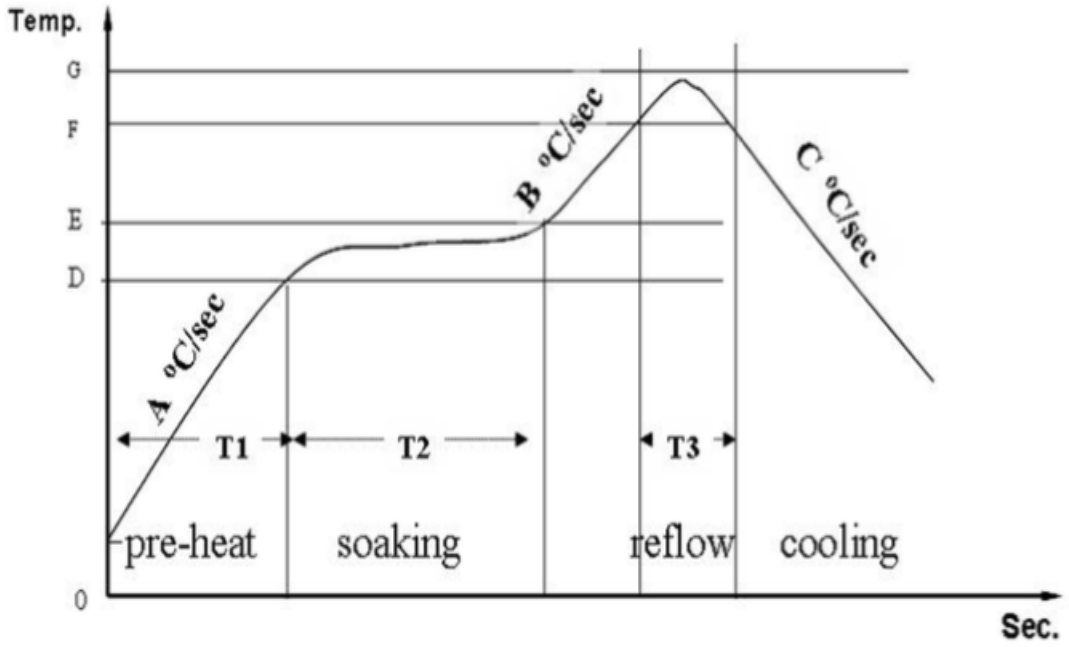
Remark:

- Orange area: PCB PAD
- Light-blue area: Stencil aperture
- Stencil thickness: 0.1~0.12mm

Recommendation:

- 0.5mm pitch functional pin stencil aperture size (A): 0.28*0.6mm,
  the pin hole internal spur: Width (W) =10.65mm, Length (L) =14.65mm.
- Four corners' stencil aperture size (B): 0.6*0.6mm, they should be center located of PAD.
- 9 square apertures on each GND PAD, each size (C): 0.6* 0.6mm, interval(D): 0.3mm

BTC REFLOW SOLDERING PROFILE (RECOMMENDATION)



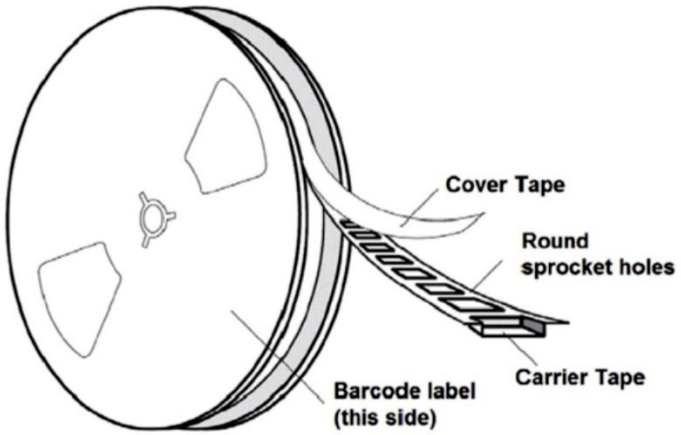
Standard conditions for reflow soldering:

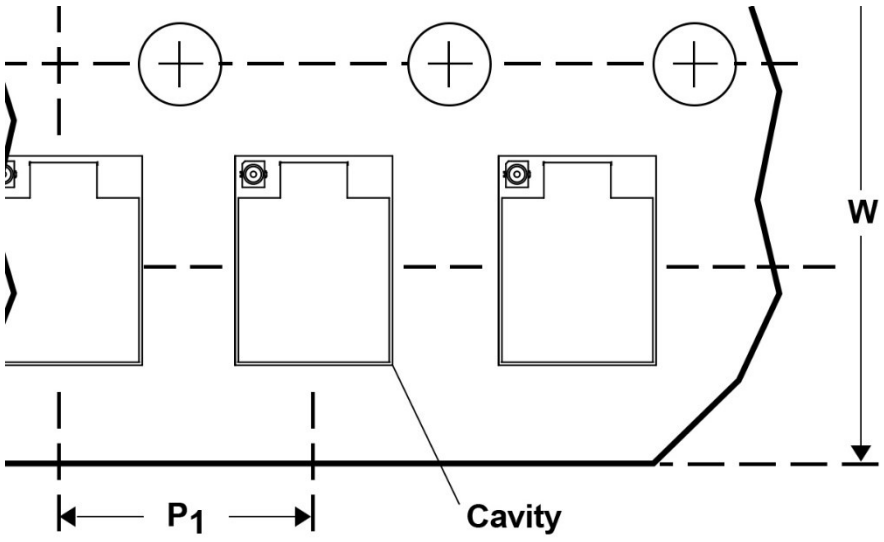
- a. Pre-heating Ramp (A) (Initial temperature: 150℃): 1~2.5℃/sec;
- b. Soaking Time (T2) (150℃~180℃): 60sec~100sec;
- c. Peak Temperature (G): 230~250℃;
- d. Reflow Time (T3) (>220℃): 30~60 sec;
- e. Ramp-up Rate (B): 0~2.5℃/ sec;
- f. Ramp-down Rate (C): 1~3℃/ sec.

11. Packaging Information

TechNexion PIXI-IW416 Modules are packaged either trays or reels.

11.1. Reel Packaging Information



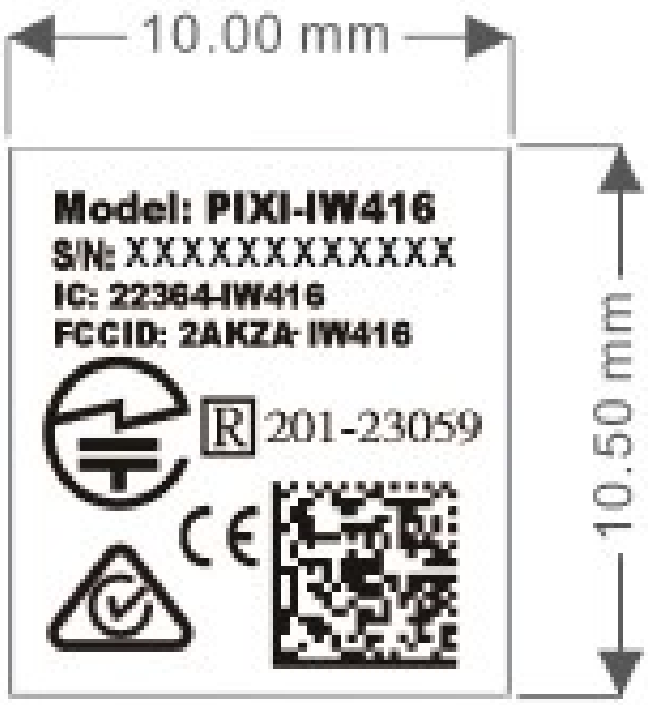


NOTE:

1. Dimensions in mm.
2. 10 Sprocket Hole Pitch Cumulative Tolerance +/- 0.1mm.
3. Pocket Position Relative to Sprocket Hole Measured as True Position of Pocket, not Pocket Hole
4. A full reel contains 1000 modules.

12. Labelling Information

The PIXI-IW416 contains a unique serial label as follow:



13. Ordering Information

The PIXI-IW416 can be ordered in the following configurations.

Partnumber	Description Min	Wi-Fi	Bluetooth
PIXI-IW416	NXP IW416 SDIO 802.11n + UART BT 5.2 MODULE	SDIO	UART

14. Important Notice

TechNexion reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TechNexion terms and conditions of sale supplied at the time of order acknowledgment.

TechNexion warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TechNexion standard warranty. Testing and other quality control techniques are used to the extent TechNexion deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TechNexion assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TechNexion components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

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15. Disclaimer

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