

# ITM-6394N

IEEE 802.11ah Wireless LAN Module



## Specification For ITM-6394N

**V1.0**

# Revision History

Date	Revision Content	Revised By	Version
2024/10/4	- Initial released	Colin Tseng	1.0
	-		
	-		
	-		
	-		

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# 1. Features

## General

- Supports 902 ~ 928MHz frequency band
- Supports single-stream 150kbps ~ 15Mbps data rate
- Supports AP and STA mode

## Host interface

- UART and HSPI support for host interface

## Standards Supported

- IEEE Std 802.11ah standard
- Security: OPEN, WPA2-PSK(AES), WPA3- OWE, WPA3-SAE

## MAC Features

- S1G Beacon, NDP Control frame, TIM compression, unified scaling factor for max Idle period/listen interval/WNM-sleep interval, STA Type, S1G baseline functions (DCF, HCF, multi-rate support, A-MPDU), and S1G BSS operation
- Network efficiency enhancements: NDP PS- Poll/PS-Poll Ack/Probe Req./Probe Resp., RAW avoidance, TSBTT, and differentiated EDCA Parameter
- Power saving: Non-TIM operation, dynamic AID assignment and TWT
- BSS scalability (up to 8192 STAs): Multicast AID, and authentication control
- Low-cost STA/AP: EL operation, Flow Control
- Supports transmission of Standby Radio frame

## Peripheral Interfaces

- I2C, SPI and UART
- A Wi-Fi dedicated HSPI for data transfer to Host

## Peripheral Interfaces

- Full IEEE 802.11ah compatibility with enhanced performance
- Single-stream up to 15Mbps data rate
- Supports 1/2/4 MHz channel with optional SGI
- Supports S1G\_1M, Short/Long format
- Modulation: OFDM with BPSK, QPSK, 16QAM, 64QAM

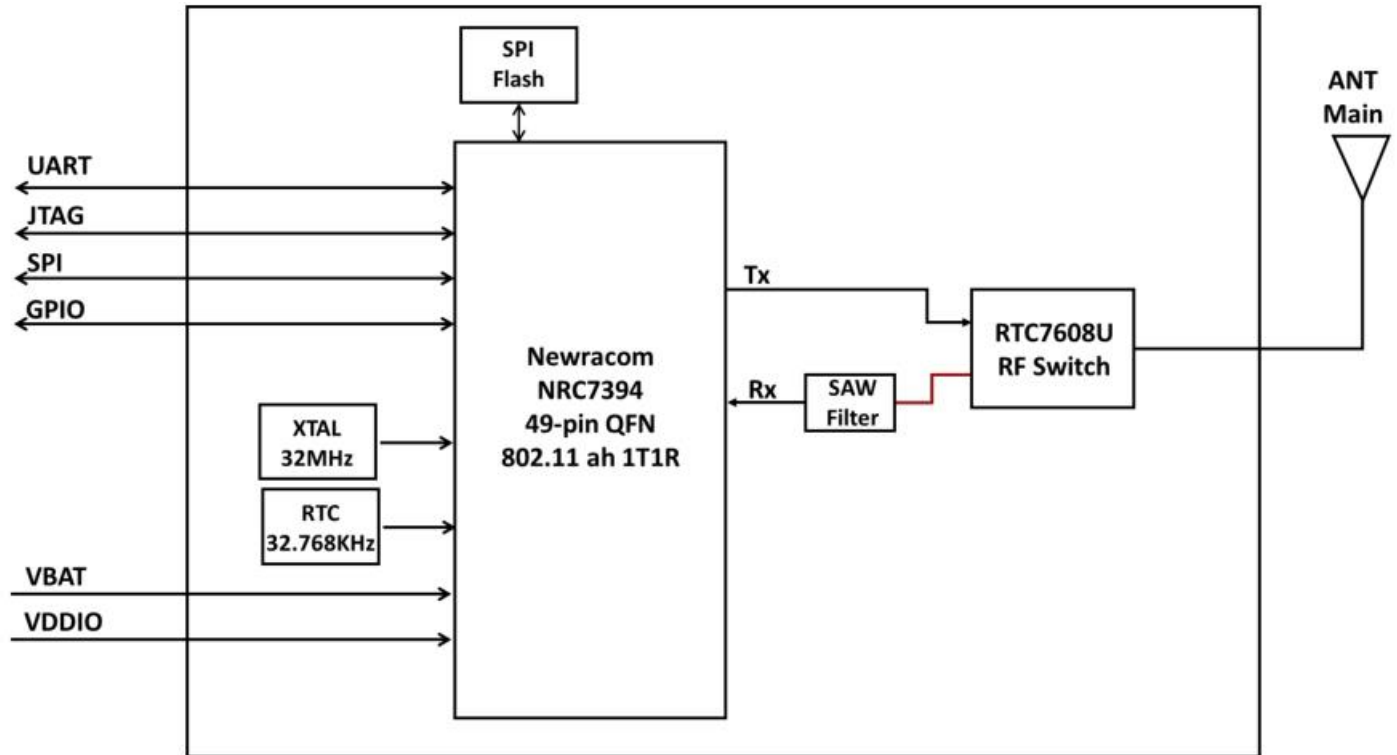
## 2. Introduction

### 2.1 Product Overview

The ITM-6394N is the smallest IEEE 802.11ah Wi-Fi module that operates in the Sub 1GHz license exempt band, offering longer range and higher data rate for internet of things (IoT) applications. The ITM-6394N supports 1/2/4 MHz channel bandwidth which yields 150 Kbps to 15 Mbps PHY rate that can handle low rate sensors to high rate surveillance camera applications. The self-contained Wi-Fi networking with huge range of data throughput offers the ideal solution to add Wi-Fi connectivity to IoT products with low power consumption requirements.

The ITM-6394N integrated Newracom NRC7394 which is a complete radio front end that is optimized for Sub 1 GHz band. It has a fully integrated PA and fractional N synthesizer. An embedded Cortex M3 ARM<sup>®</sup> processor in the NRC7394 offers enough processing power to accommodate Wi-Fi subsystem as well as user application in a single Wi-Fi SoC. NRC7394 also includes two host interfaces, HSPI and UART, and rich peripherals such as general SPI, I2C, UART, PWM, auxiliary ADC, and GPIOs. The low leakage retention memory inside NRC7394 can be used to store code and data necessary for fast wake up from deep sleep mode.

## 2.2 Block Diagram



## 2.3 Specifications Table

### 2.3.1 General

Features	Description
Product Description	IEEE 802.11ah Wireless LAN Module
Major Chipset	Newracom NRC7394 (49-pin QFN)
Host Interface	SPI
Dimension	12mm x 12mm x 1.91mm (Tolerance remarked in mechanical drawing)
Form Factor	LGA module, 44 pins
Antenna	<ul style="list-style-type: none"> <li>For LGA, "1T1R, external" ANT Main : TX/RX</li> </ul>
Weight	0.7g

### 2.3.2 WLAN

Features	Description															
WLAN Standard	IEEE 802.11ah															
Frequency Range	(US/CA): Unit MHz 1MHz Bandwidth: 902.5, 903.5, 904.5, 905.5, 906.5, 907.5, 908.5, 909.5, 910.5, 911.5, 912.5, 913.5, 914.5, 915.5, 916.5, 917.5, 918.5, 919.5, 920.5, 921.5, 922.5, 923.5, 924.5, 925.5, 926.5, 927.5  2MHz Bandwidth: 903, 905, 907, 909, 911, 913, 915, 917, 919, 921, 923, 925, 927  4MHz Bandwidth: 906, 910, 914, 918, 922, 926															
Modulation	OFDM, BPSK, QPSK, 16-QAM, 64-QAM															
Channel Bandwidth	1/2/4 MHz															
Output Power (Board Level Limit)*	<table border="1"> <thead> <tr> <th></th> <th>Min</th> <th>Typ</th> <th>Max</th> <th>Unit</th> </tr> </thead> <tbody> <tr> <td>MCS0 (1/2/4 MHz) @EVM ≤ -5dB</td> <td></td> <td>15</td> <td>16.5</td> <td>dBm</td> </tr> <tr> <td>MCS7 (1/2/4 MHz) @EVM ≤ -27dB</td> <td></td> <td>12</td> <td>13.5</td> <td>dBm</td> </tr> </tbody> </table>		Min	Typ	Max	Unit	MCS0 (1/2/4 MHz) @EVM ≤ -5dB		15	16.5	dBm	MCS7 (1/2/4 MHz) @EVM ≤ -27dB		12	13.5	dBm
		Min	Typ	Max	Unit											
	MCS0 (1/2/4 MHz) @EVM ≤ -5dB		15	16.5	dBm											
MCS7 (1/2/4 MHz) @EVM ≤ -27dB		12	13.5	dBm												

<b>Receiver Sensitivity</b>	Min	Typ	Max	Unit
	MCS0 (1 MHz)	-101	-98	dBm
	MCS0 (2 MHz)	-98	-95	dBm
	MCS0 (4 MHz)	-96	-93	dBm
	MCS7 (1 MHz)	-84	-81	dBm
	MCS7 (2 MHz)	-80	-77	dBm
<b>Data Rate</b>	<ul style="list-style-type: none"> <li>■ 1 MHz Bandwidth: up to 3Mbps</li> <li>■ 2 MHz Bandwidth: up to 6.5Mbps</li> <li>■ 4 MHz Bandwidth: up to 13.5Mbps</li> </ul>			
	<ul style="list-style-type: none"> <li>■ OPEN, WPA2-PSK(AES), WPA3-OWE, WPA3-SAE standard</li> </ul>			
	<b>Security</b>			

**\* If you have any certification questions about output power please contact FAE directly. \* Output power and receiver sensitivity is based on VBAT with +/- 5% of typical value.**

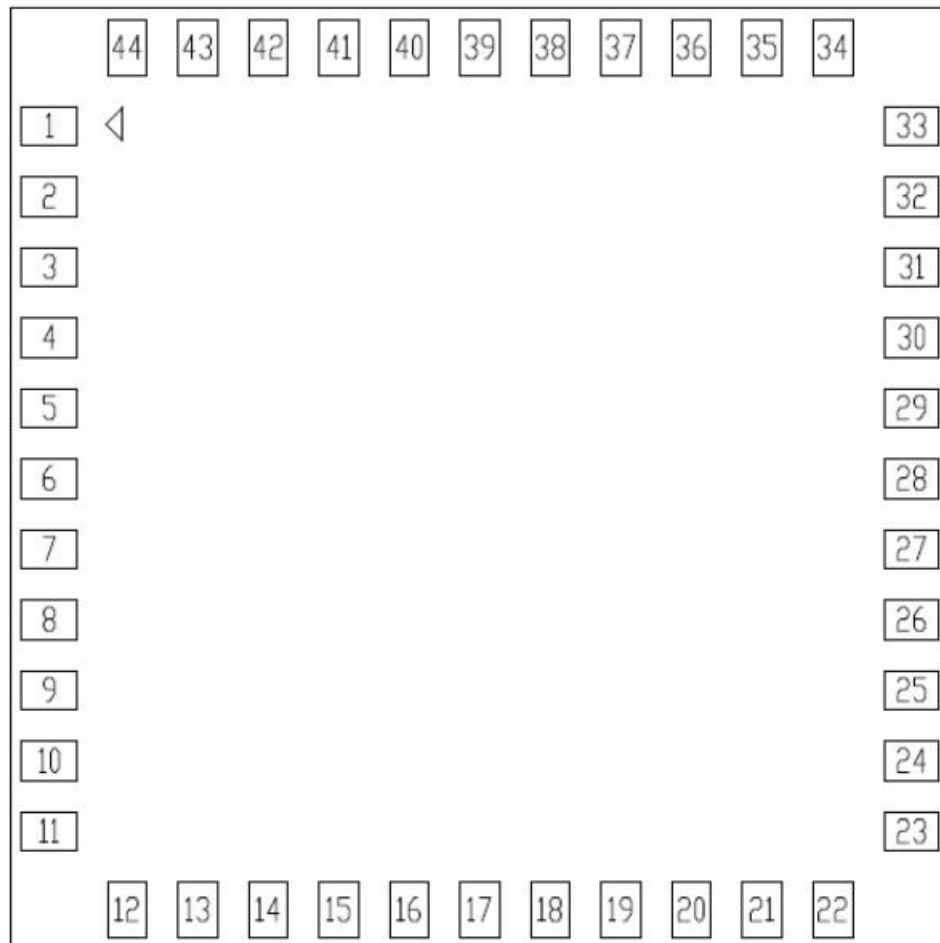
### 2.3.3 Operating Conditions

Features	Description
	<b>Operating Conditions</b>
<b>Voltage</b>	VBAT: 3.3V VDDIO:
<b>Operating Temperature</b>	-40°C ~85 °C
<b>Operating Humidity</b>	less than 85%R.H
<b>Storage Temperature</b>	-40°C ~85 °C
<b>Storage Humidity</b>	less than 60%R.H
	<b>ESD Protection</b>
<b>Human Body Model</b>	TBD
<b>Changed Device Model</b>	TBD



# 3. Pin Definition

## 3.1 Pin Map



**ITM-6394N Pin Map (Top View)**

### 3.2 Pin Table

Pin No.	Definition	Basic Description	Voltage	Type
1	GND	GROUND		GND
2	ANT	RF IN/OUT		I/O
3	GND	GROUND		GND
4	NC	No Connection		
5	NC	No Connection		
6	GP25	General IO port 25		I/O
7	NC	No Connection		
8	NC	No Connection		
9	VBAT	3.3V power supply	3.3V	Power
10	GND	GROUND		GND
11	GND	GROUND		GND
12	RSTn / PMS_POR_O	Hardware reset input and POR reset output. (active low)		I/O
13	NC	No Connection		
14	NC	No Connection		
15	HSPI_nCS	HSPI chip select		I/O
16	HSPI_MOSI	HSPI MOSI		I/O
17	HSPI_CLK	HSPI clock		I/O
18	HSPI_MISO	HSPI MISO		I/O
19	NC	No Connection		
20	GND	GROUND		GND
21	NC	No Connection		
22	VDDIO	I/O supply Input		Power
23	NC	No Connection		
24	NC	No Connection		

25	MODE	Chip boot mode For XIP boot, connect to VDD For ROM boot, connect to GND		I
26	HSPI_EIRQ	HSPI external IRQ EIRQ will be Hi-z by every reset condition External pull-up or pull-down may be required depends on system application		I/O
27	GP20	General IO port 20		I/O
28	GP8 / UART0_TXD	If MODE is connected to GND, default serial TXD. General IO port 8.		I/O
29	GP9 / UART0_RXD	If MODE is connected to GND, default serial RXD. General IO port 9.		I/O
30	GP14 / JTAG_nTRST	JTAG nTRST input General IO port 14		I/O
31	GND	GROUND		GND
32	NC	No Connection		
33	GND	GROUND		GND
34	GP18 / AUXADCIN1	AUX ADC input 1 General IO port 18		I/O
35	GP17 / AUXADCIN0	AUX ADC input 0 General IO port 17		I/O
36	GND	GROUND		GND
37	NC	No Connection		
38	GP24	General IO port 24		I/O
39	GP12 / JTAG_TDO	JTAG data output General IO port 12		I/O
40	NC	No Connection		
41	GP10 / JTAG_TMS	JTAG mode selection General IO port 10		I/O
42	GP13 / JTAG_TDI	JTAG data input. General IO port 13		I/O
43	NC	No Connection		
44	GP11 / JTAG_TCK	JTAG clock General IO port 11		I/O

# 4. Electrical Characteristics

## 4.1 Absolute Maximum Ratings

Symbol	Parameter	Minimum	Typical	Maximum	Unit
V <sub>BAT</sub>	3.3V power supply	-0.5		3.8	
V <sub>DDIO</sub>	I/O supply Input	-0.5		3.8	
T <sub>stg</sub>	Storage temperature	-40	-	85	°C

## 4.2 Recommended Operating Conditions

Symbol	Parameter	Minimum	Typical	Maximum	Unit
V <sub>BAT</sub>	3.3V power supply	3.135	3.3	3.465	V
V <sub>DDIO</sub>	3.3V I/O supply Input	3.0	3.3	3.6	V
V <sub>DDIO</sub>	1.8V I/O supply Input	1.68	1.8	1.92	V

## 4.3 Digital IO Pin DC Characteristics

V<sub>DDIO</sub> = 3.3V

Symbol	Parameter	Minimum	Typical	Maximum	Unit
V <sub>IH</sub>	Input high voltage	2	-	3.6	V
V <sub>IL</sub>	Input low voltage	-0.3	-	0.8	V
V <sub>OH</sub>	Output high voltage	2.4	-		V
V <sub>OL</sub>	Output low voltage		-	0.4	V

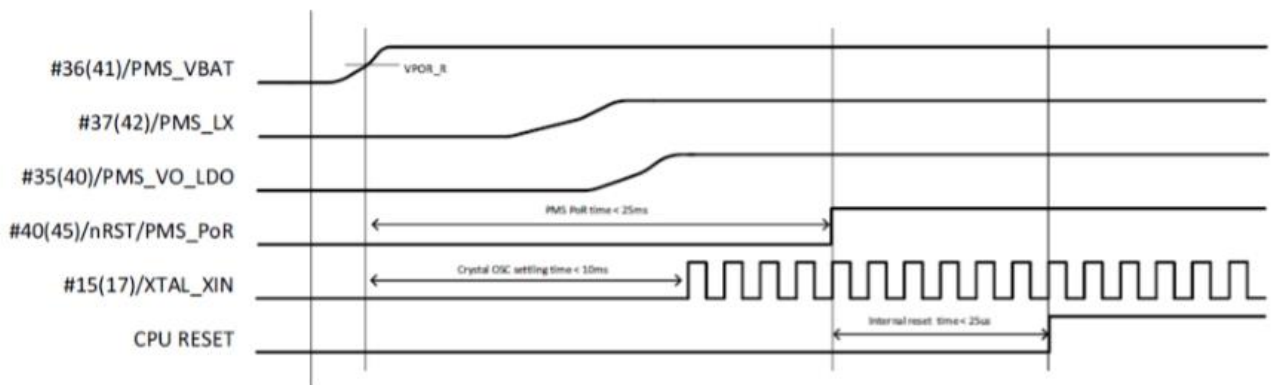
V<sub>DDIO</sub> = 1.8V

Symbol	Parameter	Minimum	Typical	Maximum	Unit
V <sub>IH</sub>	Input high voltage	1.17	-	1.8	V
V <sub>IL</sub>	Input low voltage	-0.3	-	0.63	V
V <sub>OH</sub>	Output high voltage	1.35	-		V
V <sub>OL</sub>	Output low voltage		-	0.45	V

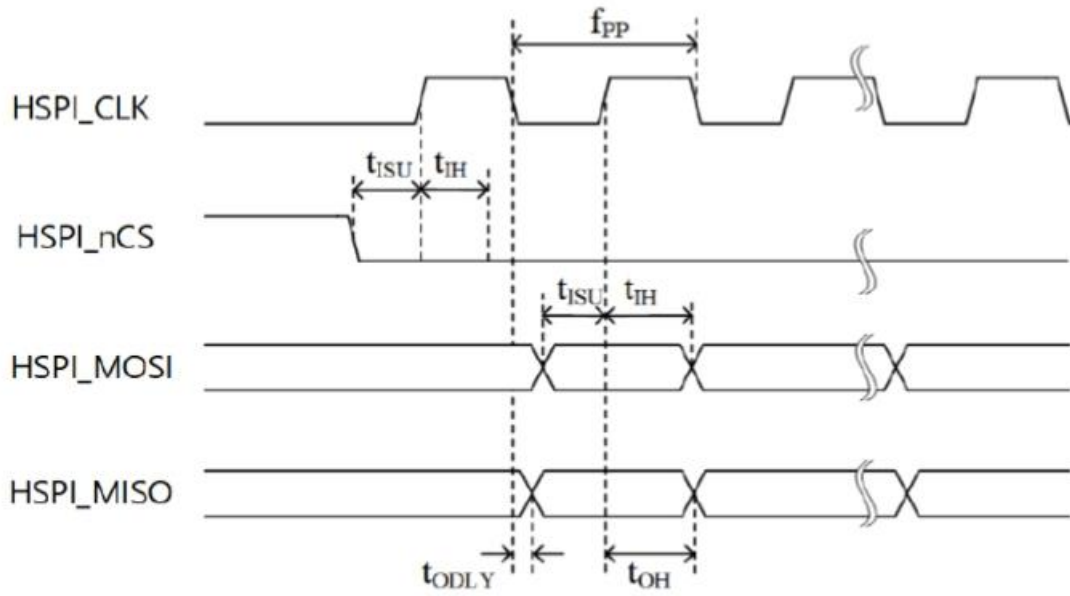
## 4.4 Timing Sequence

### 4.4.1 Power on sequence

The figure below shows the module power on sequence. The start of the POR circuit in the PMS block and BUCK oscillator are triggered by VBAT when the level exceeds a predefined voltage level. The main 32 MHz crystal oscillator starts to run when the internal power supply is stable. The PMS\_PoR (active low) is de-asserted after a pre-defined settling time for stable crystal oscillation to ensure reliable SoC operation. PMS\_PoR is open-drain circuit with internal pull-up resistor and connected with external RSTn pin. When the PMS\_PoR releases RSTn pin to HIGH, the power-on sequence is completed and the SoC can control the entire system after the internal 25usec reset time.

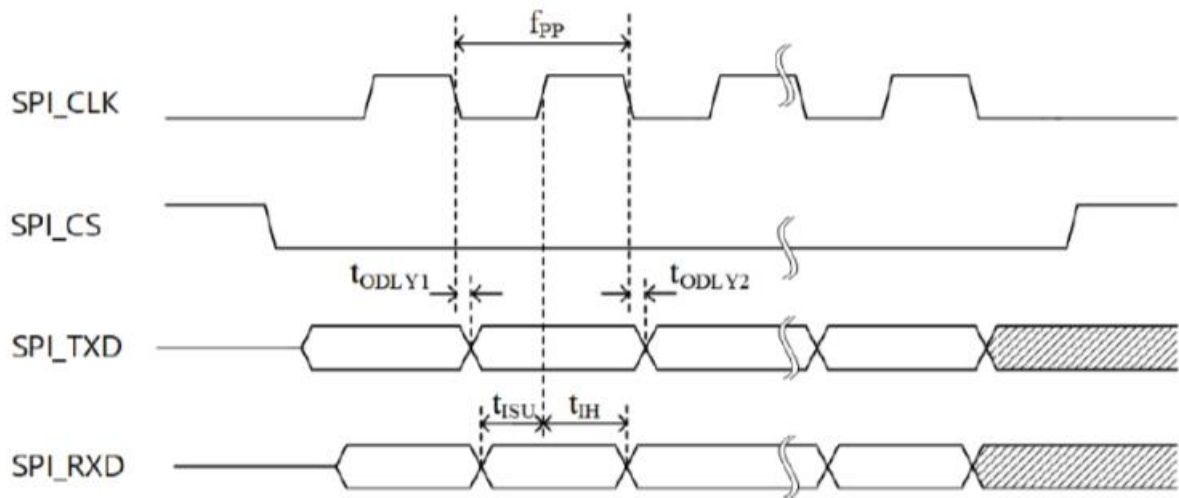


## 4.4.2 HSPI Timing



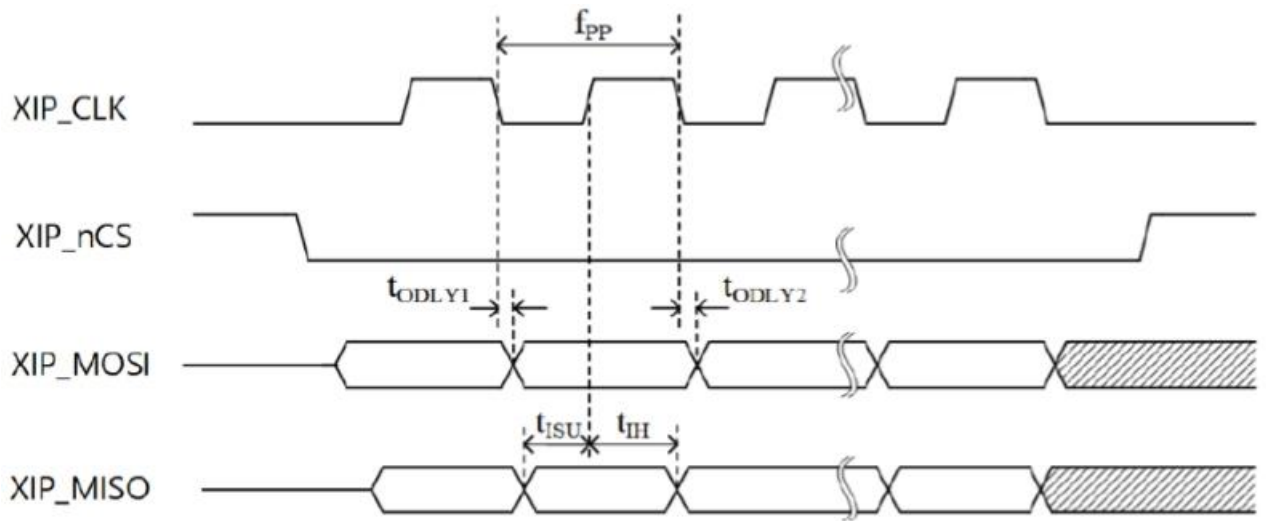
Symbol	Parameter	Min	Typ	Max	Unit
$f_{PP}$	Frequency	-	-	20	MHz
$t_{ODLY}$	Output delay time	2.7	-	20.2	ns
$t_{OH}$	Output hold time	25	-	-	ns
$t_{ISU}$	Input setup time	-	-	21.6	ns
$t_{IH}$	Input hold time	5.8	-	-	ns

### 4.4.3 SPI Timing



Symbol	Parameter		Min	Typ	Max	Unit
$f_{pp}$	Frequency	master	-	-	16	MHz
		slave	-	-	2	MHz
$t_{ODLY1}$	Output delay time1		0	-	23	ns
$t_{ODLY2}$	Output delay time2		0	-	23	ns
$t_{ISU}$	Input setup time		18	-	-	ns
$t_{IH}$	Input hold time		20	-	-	ns

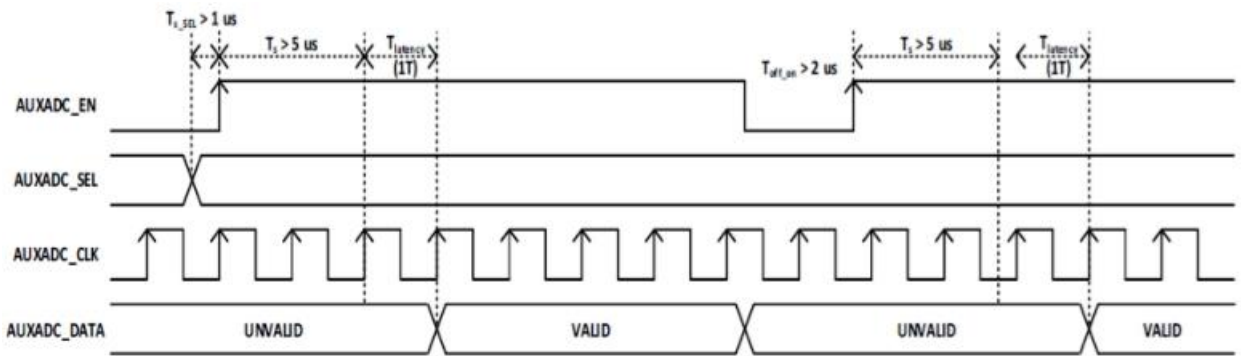
#### 4.4.4 XIP(eXecute In Place) Timing



Symbol	Parameter	Min	Typ	Max	Unit
$f_{PP}$	Frequency	-	-	32	MHz
$t_{ODLY1}$	Output delay time1	0	-	15	ns
$t_{ODLY2}$	Output delay time2	0	-	15	ns
$t_{ISU}$	Input setup time	-	-	5.1	ns
$t_{IH}$	Input hold time	7.7	-	-	ns



## 4.4.5 AUXADC Timing



Symbol	Parameter	Min	Typ	Max	Unit
Input Range	Input signal range	0.1		0.9	V
Output Range	Output Code Range (After s/w compensation)	100		900	10-bit
FS	Sampling Clock	-	2	-	MHz
Latency	Conversion latency (1 cycle = T)	-	1	-	cycle
N	Resolution	-	10	-	Bit
RIN	Input impedance	-	4	-	Mohms
Ts	Settling time after enable	5			us
Ts_sel	Setup time of AUXADC_SEL	1			us
Toff_on	Reset time	2			us
I_active	Current consumption (1.1 V)	-	-	150	uA
I_down	Power-down current (1.1 V)	-	-	2	uA

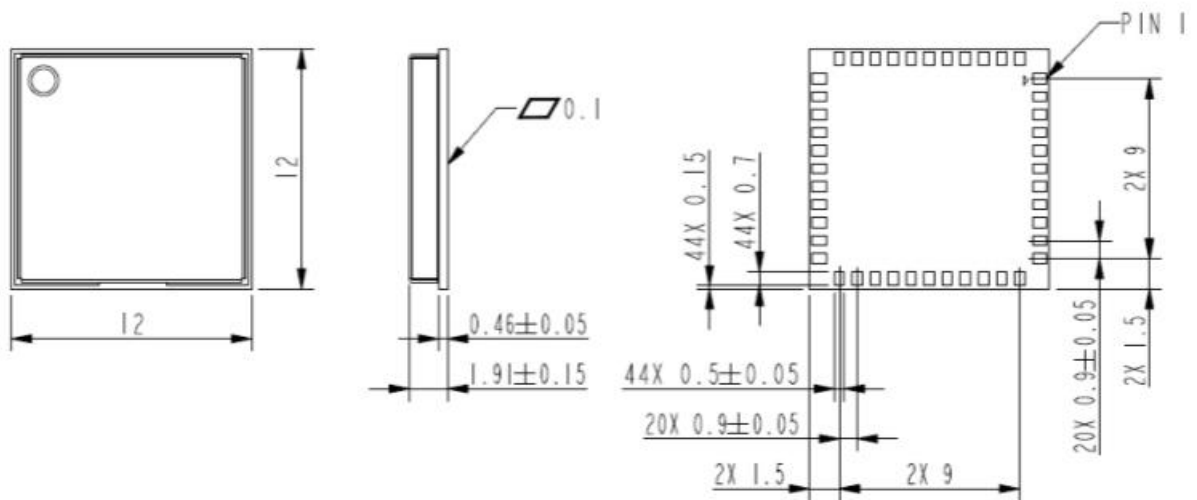
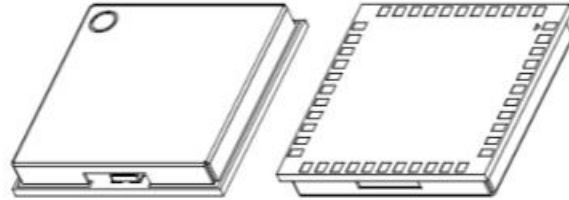
## 4.5 Power Consumption

### 4.5.1 Current Consumption Results

MODE	DUT Status	VDDIO (mA) 3.3V	VBAT (mA) 3.3V
802.11ah (1/2/4MHz BW)	Tx@10dBm	1.9mA	164mA
	Tx@13dBm	1.93mA	174mA
	Tx@15dBm	1.95mA	186mA
	Continuous Rx @ -85 dBm	1.61mA	21mA
	Deep Sleep mode	0.0001mA	0.0035mA

# 5. Mechanical Information

## 5.1 Mechanical Drawing



TOLERANCE UNLESS OTHERWISE SPECIFIED:  $\pm 0.1$ mm

# 6. Packing Information

<p>Example of carton label</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td colspan="2" style="text-align: center;"><b>Brickcom</b></td> </tr> <tr> <td>BRICKCOM P/N</td> <td>ITM-6394N</td> </tr> <tr> <td>Customer</td> <td>由業務提供</td> </tr> <tr> <td>Customer P/N</td> <td>由業務提供</td> </tr> <tr> <td>Customer PO</td> <td>由業務提供</td> </tr> <tr> <td>Description</td> <td>AW-XXXXXX</td> </tr> <tr> <td>QTY</td> <td>1200 pcs</td> </tr> <tr> <td>C/N</td> <td></td> </tr> <tr> <td>N.W.</td> <td>G.W.</td> </tr> <tr> <td colspan="2" style="text-align: center;">  </td> </tr> </table>	<b>Brickcom</b>		BRICKCOM P/N	ITM-6394N	Customer	由業務提供	Customer P/N	由業務提供	Customer PO	由業務提供	Description	AW-XXXXXX	QTY	1200 pcs	C/N		N.W.	G.W.		
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<p>Example of production label</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>P/N:  ITM-6394N </td> </tr> <tr> <td>D/C: 1309 </td> </tr> <tr> <td>PCK NO.: PCKNO0069097 </td> </tr> <tr> <td>QTY: 294 </td> </tr> <tr> <td style="text-align: right;">BAG SEAL DATE: _____</td> </tr> </table>	P/N:  ITM-6394N 	D/C: 1309 	PCK NO.: PCKNO0069097 	QTY: 294 	BAG SEAL DATE: _____															
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