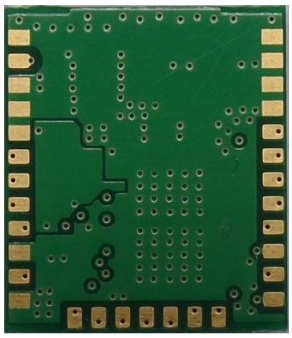
SEONG JI / SFM10R1

P/N: WSSFM10R1AT

DATA SHEET Rev.18



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18423, Korea

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1. Approval Revision Record

NO	REASON	RECORD OF REVISION	Date	Remark
1	REV00	WSSFM100A00 Approval Releases	2016-07-13	-
2	REV01	PCB Design changed - PCB Size - PIN-map	2016-08-22	-
3	REV02	PCB Design changed - PIN-map	2016-08-25	-
4	REV03	Model name changed	2016-10-05	-
5	REV04	Package Spec. added	2016-10-17	-
6	REV05	PIN function & Reflow profile added	2016-10-30	-
7	REV06	RF spec.(Harmonics, Sensitivity) changed	2016-10-31	-
8	REV07	Sentence added.	2016-11-15	-
9	REV08	RF spec. changed & Power mode added.	2016-12-02	-
10	REV09	Power mode Test method changed.	2016-12-20	-
11	REV10	Add VCC condition for VIL and VIH	2016-12-22	-
12	REV11	Add Soldering footprint	2017-01-15	-
13	REV12	PIN27 note. Removed.	2017-03-20	-
14	REV13	Module picture changed(R0->R1)	2017-04-01	-
15	REV14	Box label dimension added.	2017-05-17	-
16	REV15	DC characteristics changed.	2017-09-11	-
17	REV16	‘ESD Warning’ added.	2018-07-02	-
18	REV17	POR requirement added	2019-04-25	-
19	REV18	Manufacture changed(Seong JI)	2019-08-20	-

2. Scope

Description : Sigfox Module RCZ1

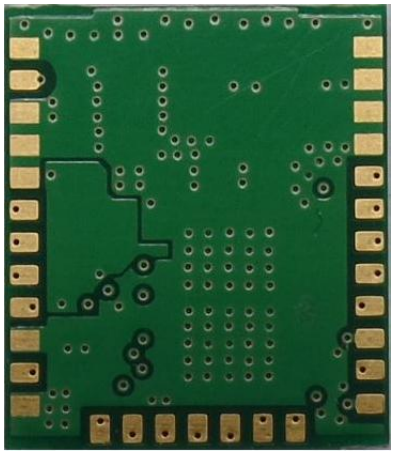
Type : SMD Type

PCBA Size : 13mm(W) x 15mm(L) x 2.21mm(H)

This module is SIGFOX verified and that the ETSI are completed.

3. Numbering of product

3-1. Product



3-2. Part No.

W	S	**S**	**F**	**M**	**1**	**0**	**R**	**1**	A	T
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)

No.	EXPLANATION
(1),(2)	Wireless Solution
(3),(4)	Application (SF:Sigfox)
(5)	Type (M:Module)
(6),(7)	Group model numbering
(8), (9)	Region Code
(10),(11)	Application Type(Firm Ware Type) AT(AT command version) AP(API version)

3-3. Lot. No.

S	A	C	J	A	1	0	0	1
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

①	Sigfox Module
②	Manufacture Area Packing Lot / A / B / C Area / Korea / China / Vietnam
③	Year Year: 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 Mark: W X Y Z A B C D E F
④	Month Month: 1 2 3 4 5 6 7 8 9 10 11 12 Mark: A B C D E F G H I J K L
⑤	Day Day: 1 2 3 4 5 6 7 8 9 10 Mark: 1 2 3 4 5 6 7 8 9 A Day: 11 12 13 14 15 16 17 18 19 20 Mark: B C D E F G H I J K Day: 21 22 23 24 25 26 27 28 29 30 31 Mark: L M N O P Q R S T U V
⑥⑦	Model Serial Number (10,11,12,13…)
⑧⑨	A Serial Number (1serial: 900ea)

4. Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
VCC	Module input voltage	-0.5 to 5.5	V
OT	Operating Temperature	-30 to +85	℃
ST	Storage Temperature	-40 to +125	℃

5. DC Characteristics

Symbol	Parameter	Min	Typ.	Max	Unit
VCC	Module input voltage	2.1	3.3	3.6	V
Current	Tx Current(@+14.0dBm,MOD)	-	57	-	mA
	Tx Current(@+13.0dBm,MOD)		47	-	mA
	Rx Current	-	13.5	-	mA
	Sleep Current Deep Sleep Current		1.7 0.13	-	uA

6. I/O Specifications

Symbol	Parameter	Min	Typ.	Max	Unit
VIH	High level input voltage @VCC=3.3V	2.0			V
VIL	Low level input voltage @CC=3.3V			0.8	V

7. RF Specifications

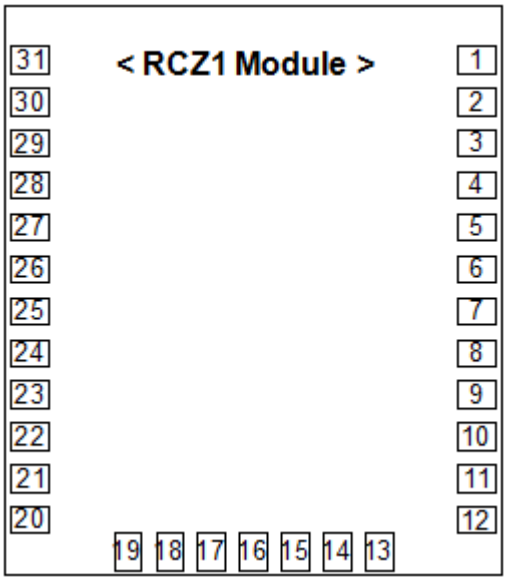
Conditions: VCC=3.3V, Temp=25℃

Parameter		Min	Typ.	Max	Unit
RF Characteristics					
RF Frequency	Tx		868.130		MHz
	Rx		869.525		MHz
Tx output power(at “15” setting)			14.0		dBm
Tx output power(at “14” setting)			13.0		dBm
Frequency Error Tolerance(+25℃)		-2.5	-	+2.5	ppm
2nd Harmonics(conducted)		-	-37	-35	dBm
3nd Harmonics(conducted)		-	-41	-35	dBm
Rx Sensitivity(@600bps, GFSK)		-127	-		dBm
Rx Spurious Emission(30MHz~12.75GHz)				-54	dBm

* Because of output power variation of modules the maximum output power can be over 14dBm, so we recommend to set 14 as default output setting.

8. Pin Description

8-1. Interface PIN(SMD Type : 31 Pin)_Bottom view



1	GND	9	GPIO5	17	TXLED/ DBG_CLK	25	GPIO2
2	GND	10	GPIO4	18	NC4/DBG_EN	26	GPIO3
3	GND	11	CPU_LED	19	RST_N	27	GND
4	GND	12	RADIO_LED	20	GND	28	GND
5	NC3/ SYSCLK	13	GPIO9	21	VDD_IO	29	GND
6	GPIO8	14	UARTTX	22	GND	30	RF_IO
7	GPIO7	15	UARTRX	23	GPIO0	31	GND
8	GPIO6	16	RXLED/ DBG_DATA	24	GPIO1		

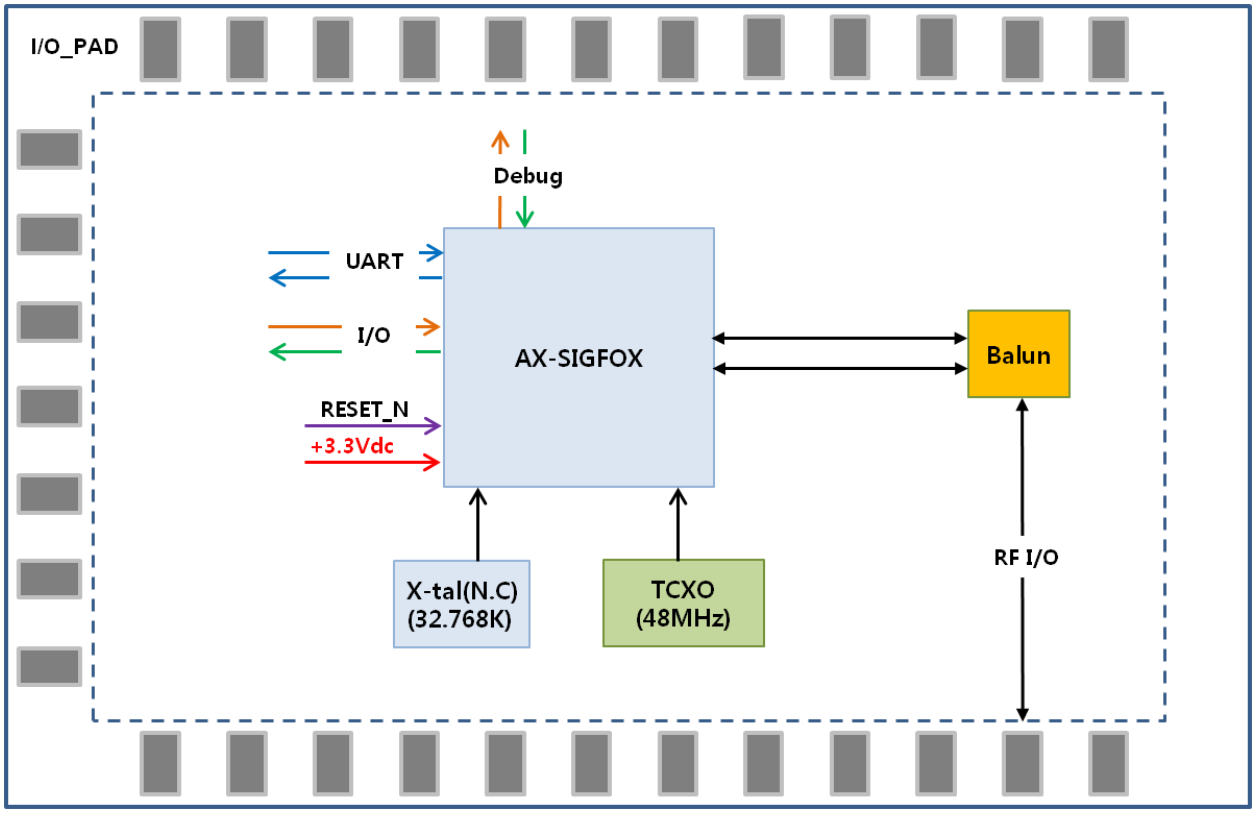
Pin-map of RCZ1, RCZ2, RCZ3 and RCZ4 module is compatible (Pin to Pin)

8-2. Interface PIN description

PIN(s)	NAME	TYPE	Description
1~4	GND	P	Ground
5	NC3/SYSCLK	N	Do not connect
6	GPIO8	I/O/PU	General purpose IO
7	GPIO7	I/O/PU	General purpose IO, selectable SPI functionality (MISO)
8	GPIO6	I/O/PU	General purpose IO, selectable SPI functionality (MOSI)
9	GPIO5	I/O/PU	General purpose IO, selectable SPI functionality (SCK)
10	GPIO4	I/O/PU	General purpose IO, selectable ∑Δ DAC functionality, selectable dock functionality
11	CPU_LED	O	CPU activity indicator
12	RADIO_LED	O	Radio activity indicator
13	GPIO9	I/O/PU	General purpose IO, wakeup from deep sleep
14	UARTTX	O	UART transmit
15	UARTRX	I/PU	UART receive
16	RXLED/DBG_DATA	O	Receive activity indicator
17	TXLED/DBG_CLK	O	Transmit activity indicator
18	NC4/DBG_EN	PD	Do not connect
19	RST_N	I/PU	Optional reset pin
20	GND	P	Ground
21	VDD_IO	P	Power supply
22	GND	P	Ground
23	GPIO0	I/O/A/PU	General purpose IO, selectable ADC functionality, selectable ∑Δ DAC functionality, selectable clock functionality
24	GPIO1	I/O/A/PU	General purpose IO, selectable ADC functionality
25	GPIO2*	I/O/A/PU	General purpose IO, selectable ADC functionality
26	GPIO3*	I/O/A/PU	General purpose IO, selectable ADC functionality
27	GND	P	Ground
28~29	GND	P	Ground
30	RF_IO	A	RF input/output
31	GND	P	Ground

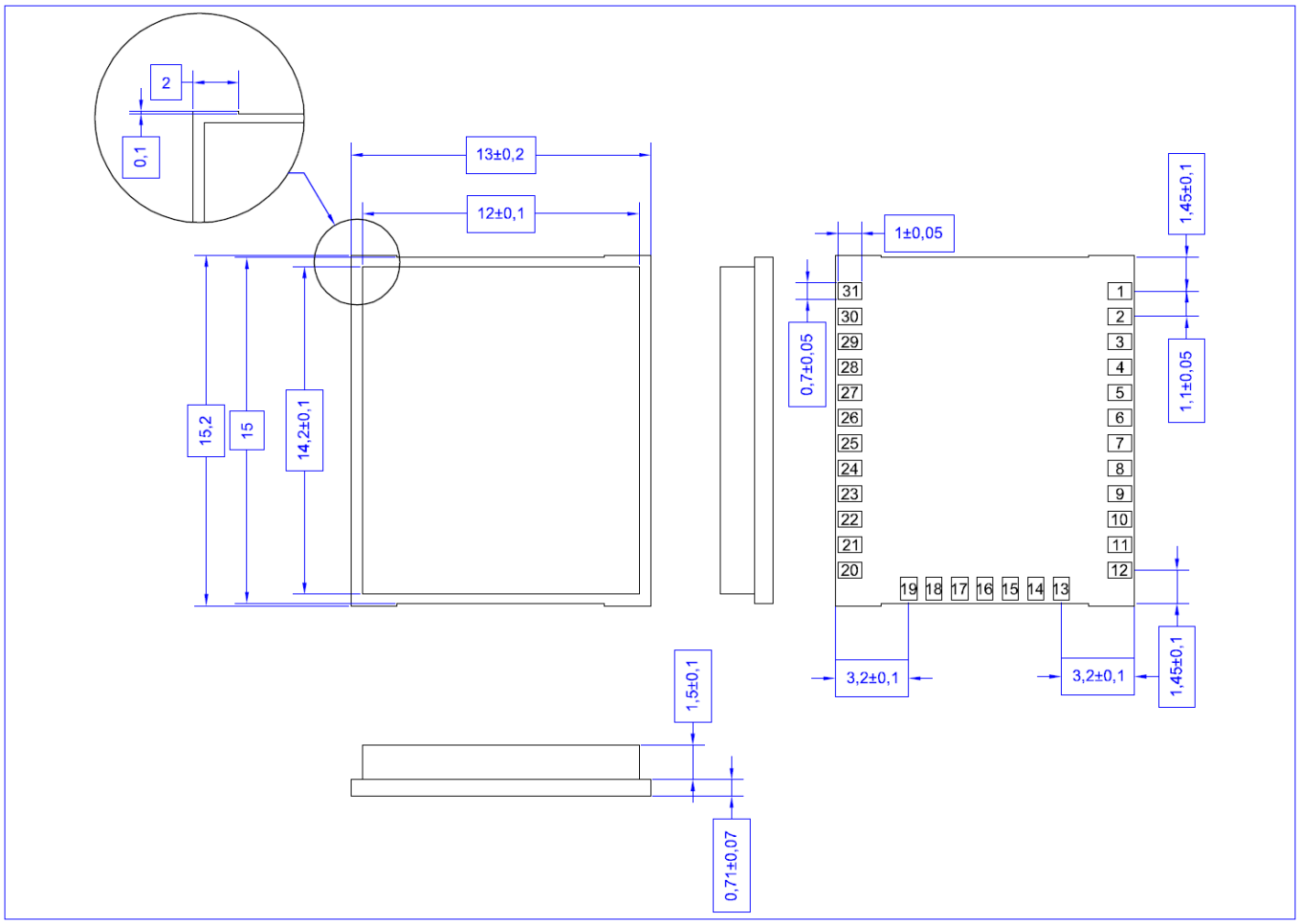
* The GPIO2 and GPIO3 pin as “Not connected” state if the product is designed to be compatible with RCZ2 and RCZ4 module.

9. Block Diagram



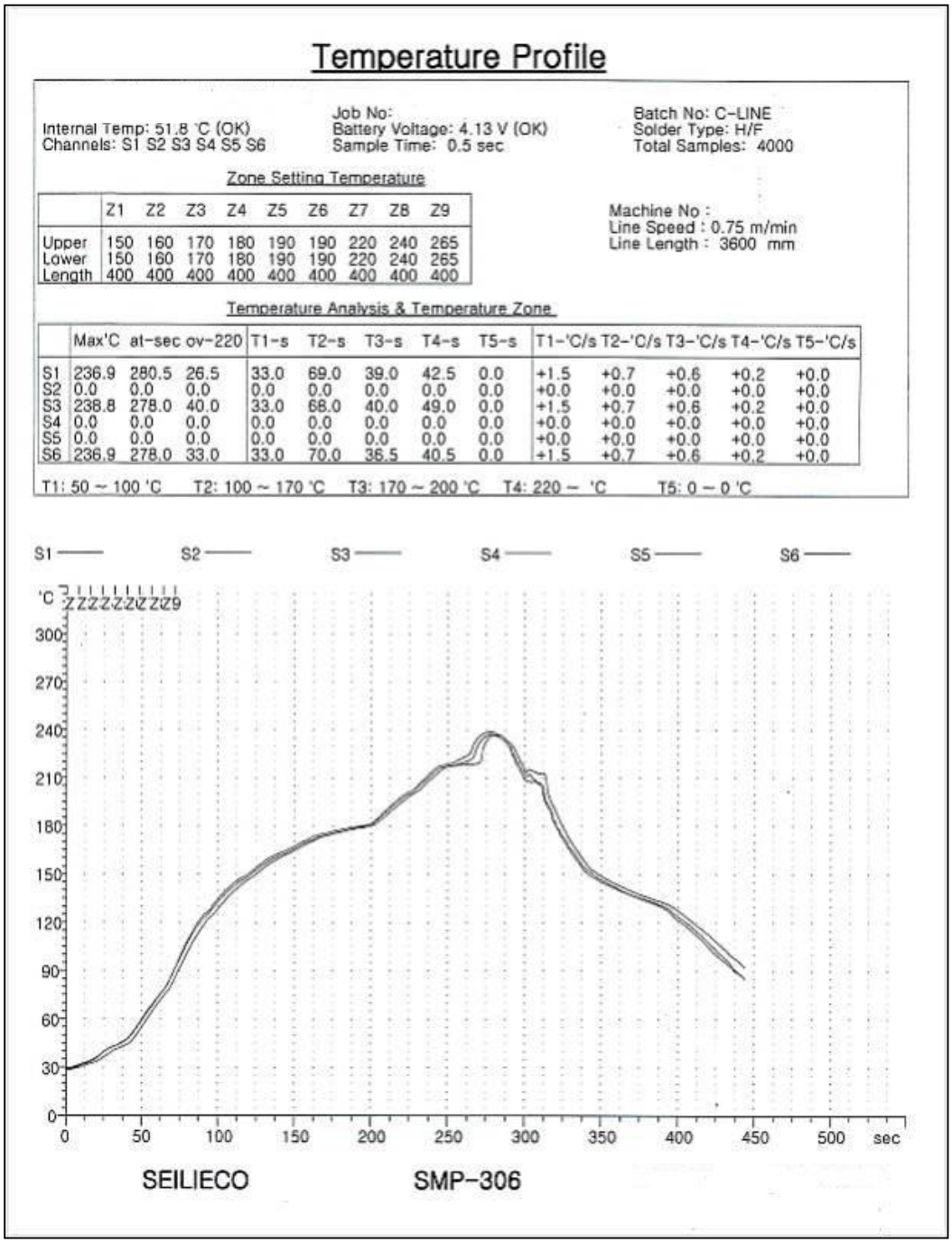
10. Dimensions & drawing

10-1. Design dimension



11. Reflow profile

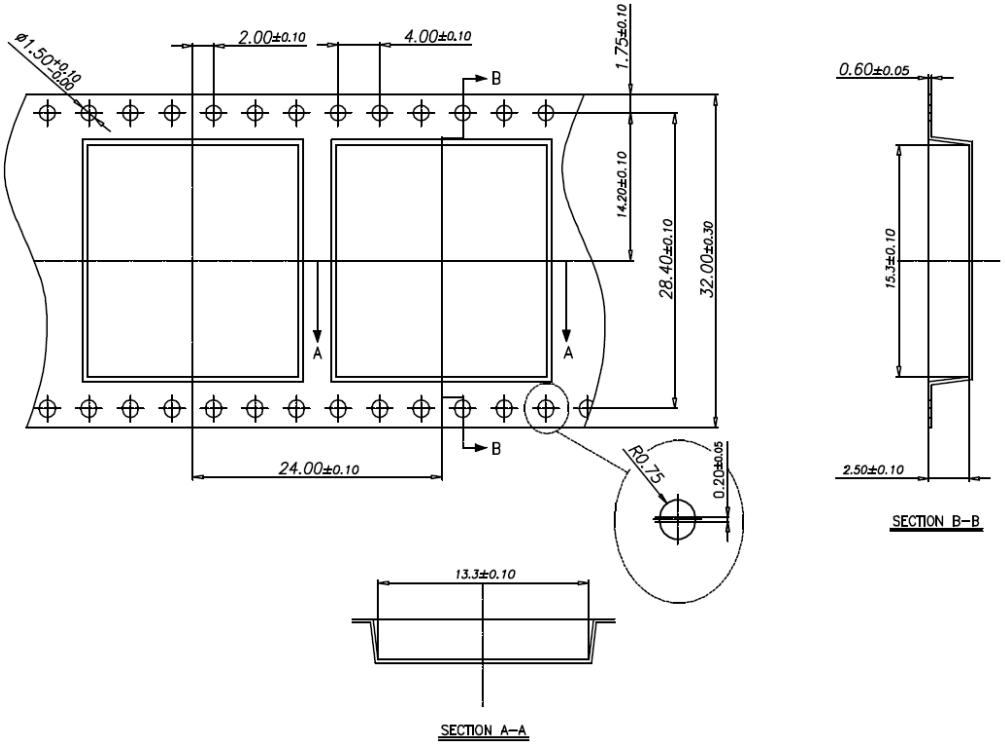
<Reflow profile of Module>



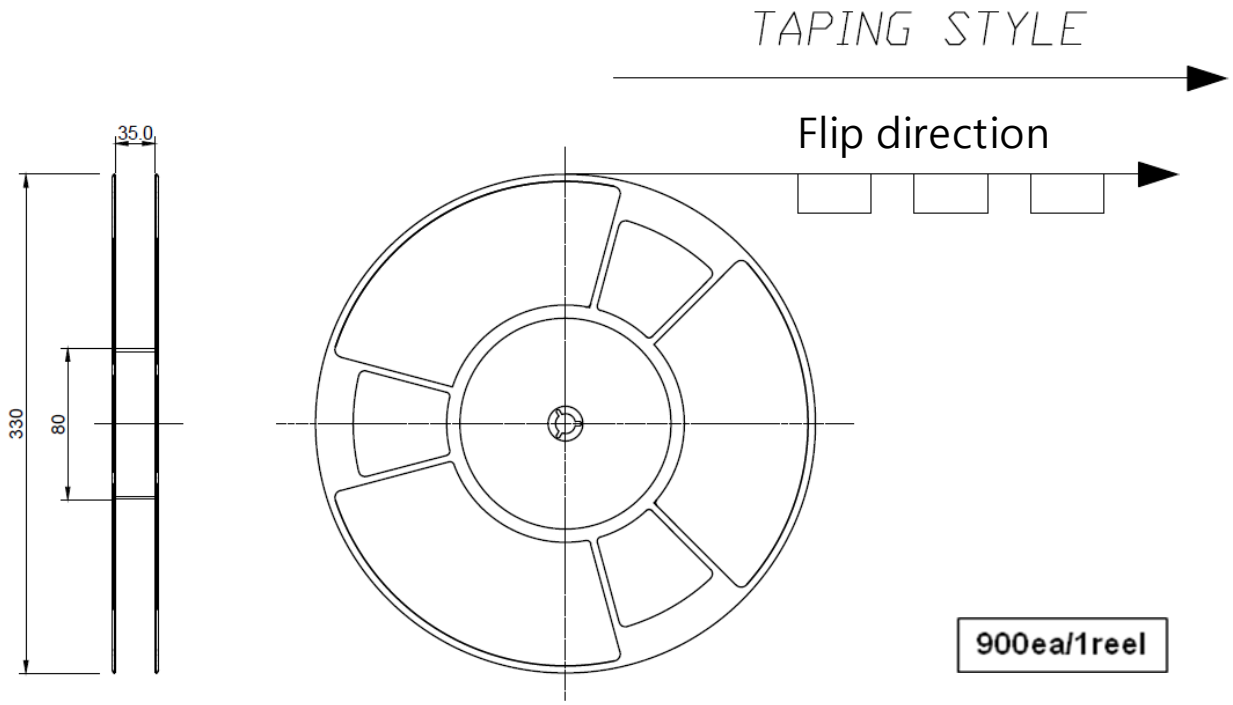
	Preheat	Soak	Ramp	PEAK
SPEC	50~100℃	100~170℃	220℃ ↑	240℃
	1~2℃/sec	60~100sec	30~50sec	±5℃
result of measurement	1.5	69	44	237.5
	OK	OK	OK	OK

12. Package

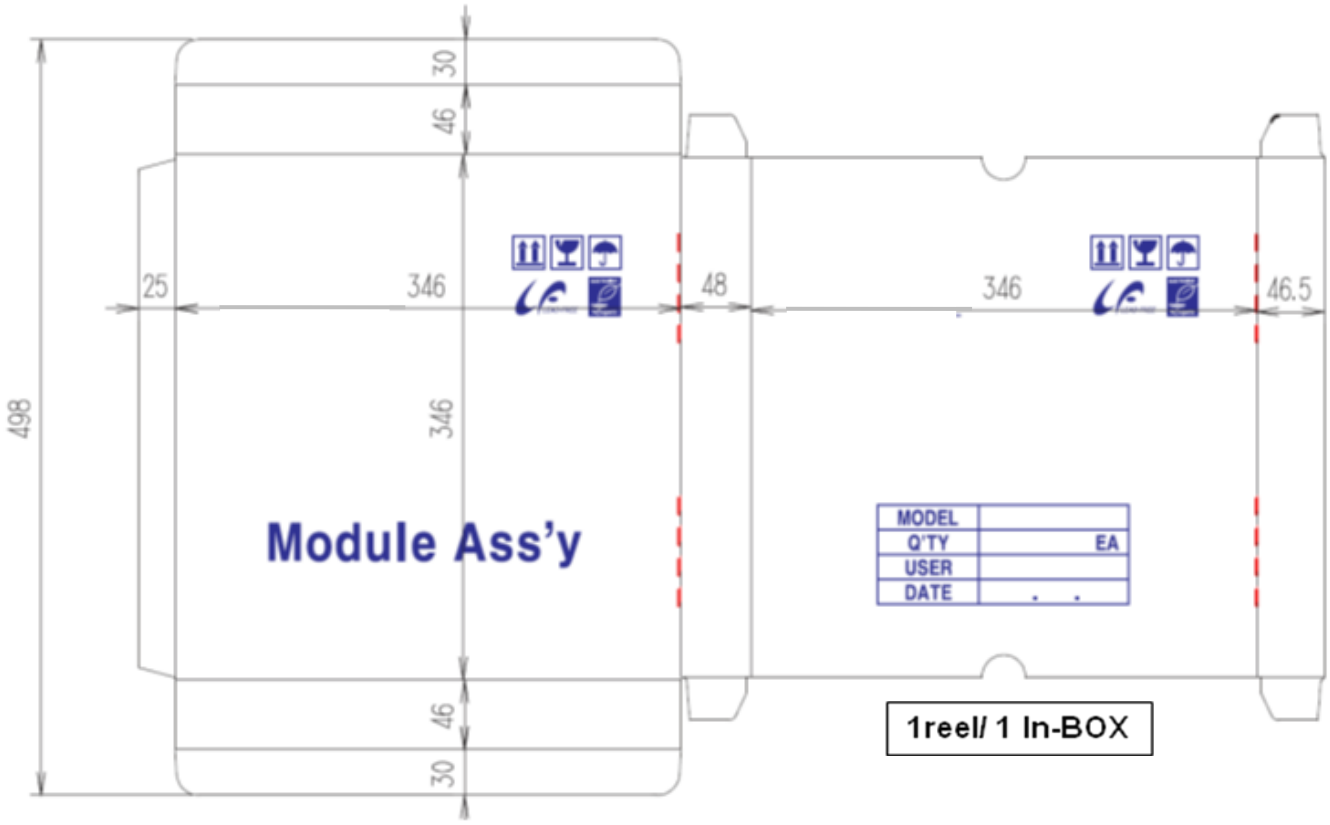
12-1. Dimension of Tape



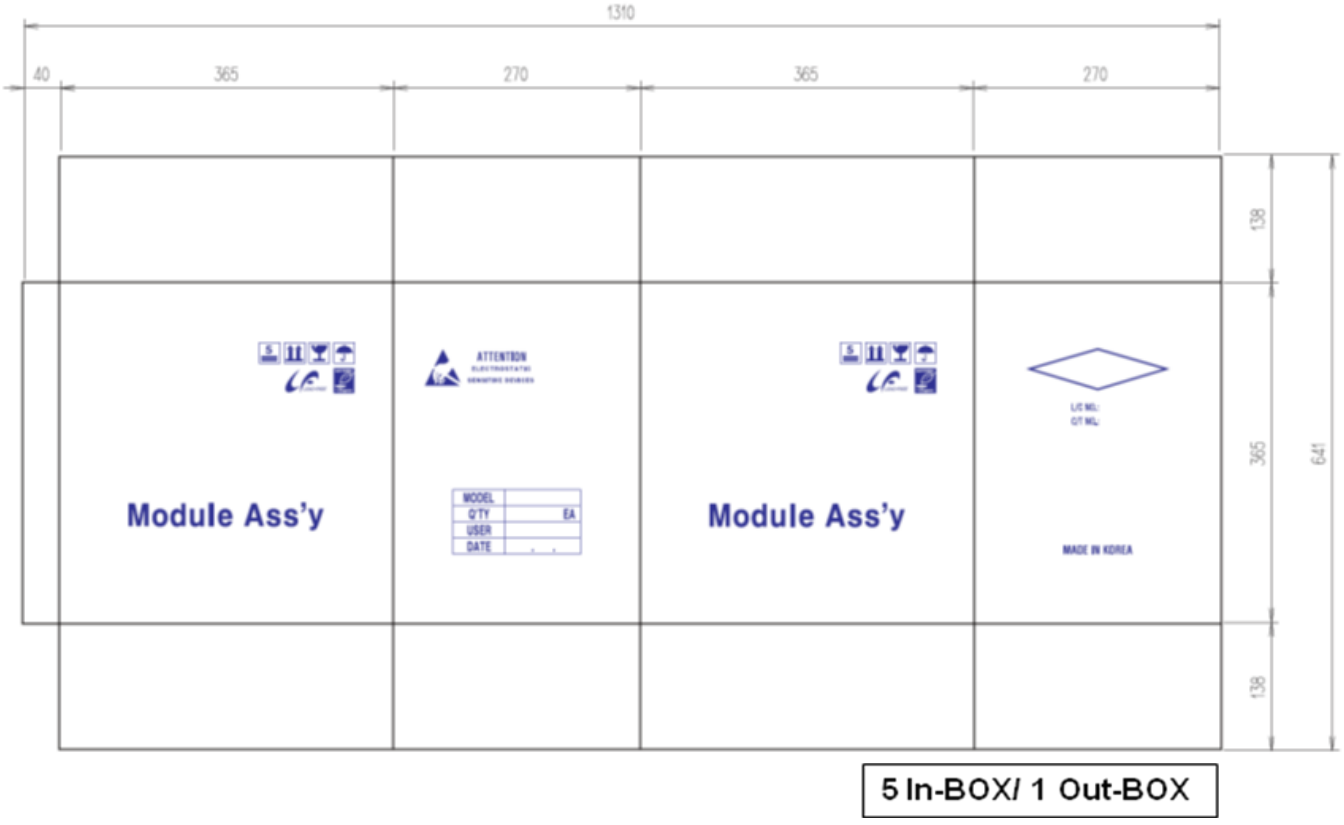
12-2. Dimension of Reel



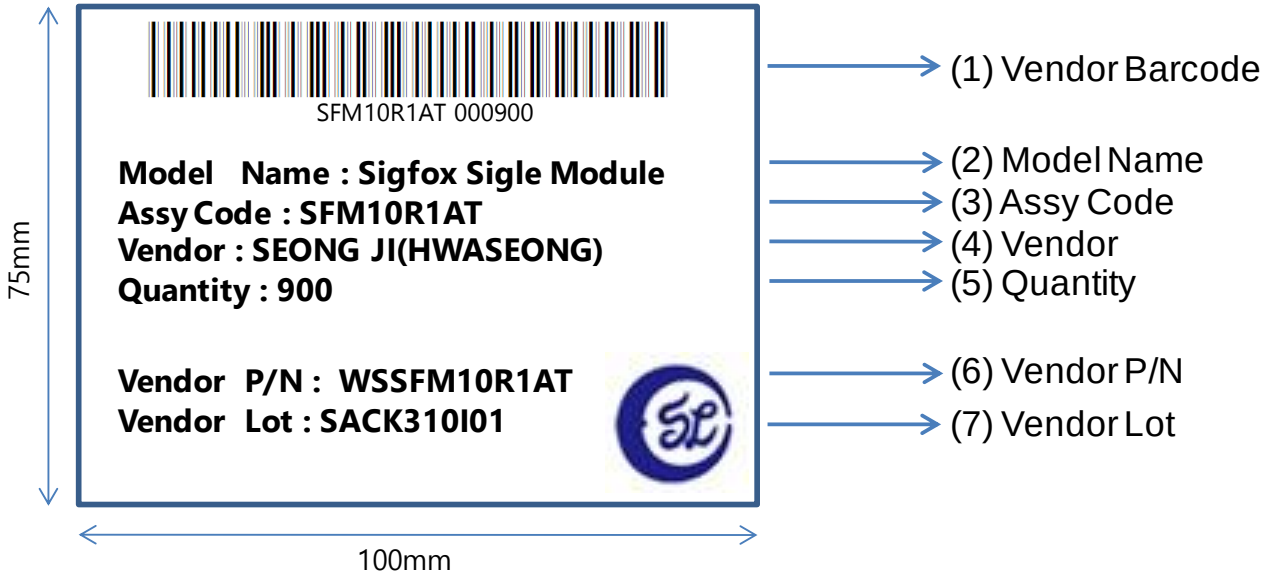
12-3. IN BOX



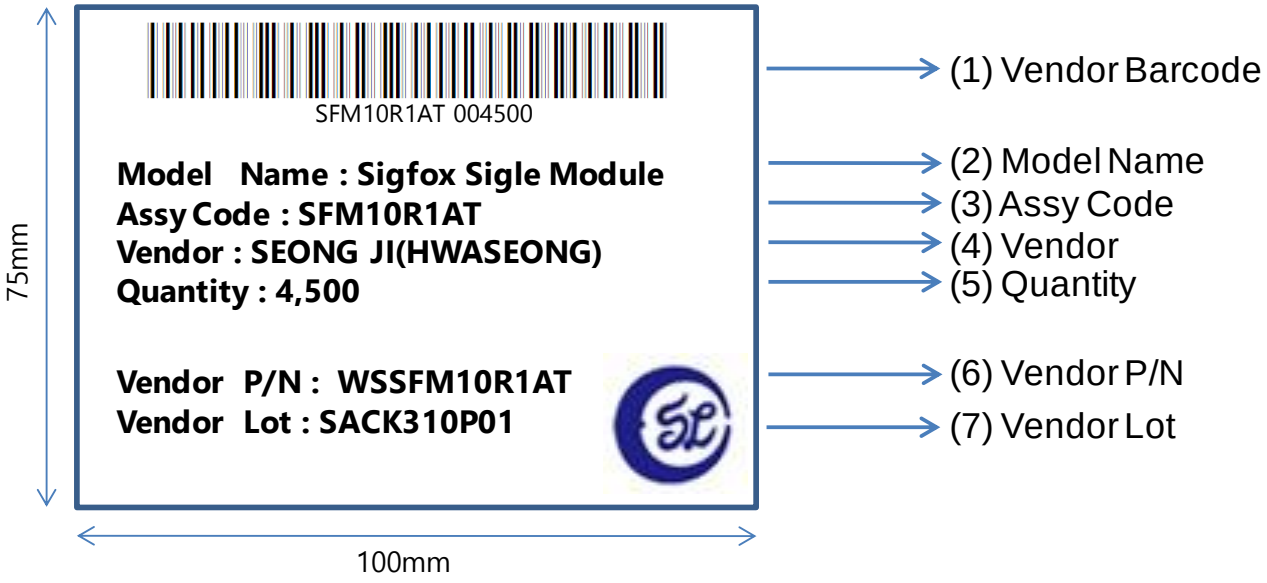
12-4. OUT BOX



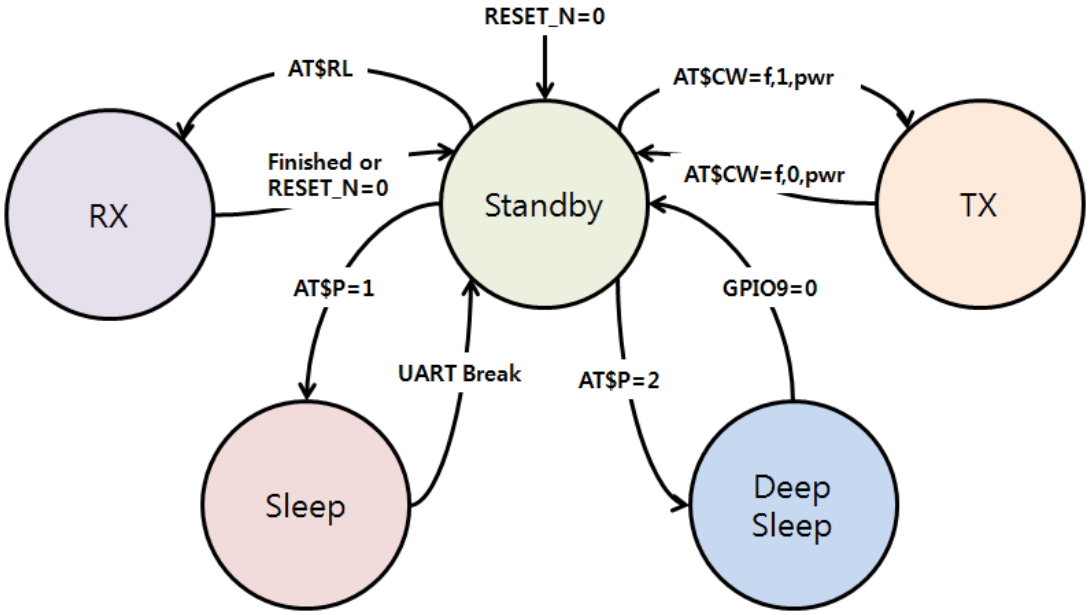
12-5. IN BOX Label



12-6. OUT BOX Label



13. Power Modes



13-1. TX current test

1. Disconnect Debug Switch(SW5~SW9) on EVB
2. Connect UART Switch(SW10~SW11) on EVB
3. Power switch ON(SW4) on EVB
4. Push the RESET Switch(SW1) on EVB
5. Initial mode=Standby mode (@500uA/ Remove J2-CPULED jumper)
6. TX current test method
   1) Input AT command 'AT' (UART condition checking)
   2) Click the Quick command (MOD EU ON : default power table '15') or
      Input AT command 'AT$IF=868130000 click 'Send' icon, then 'ATS302=15', click 'Send' Icon, 'AT$CB=-1,1' and then click 'Send' icon.
      For changing RF power, use 'ATS302=XX' and then click 'Send' icon instead of using 'ATD302=15'
   3) Disconnect UART Switch(SW10~SW11) on EVB
   4) And then, Check TX current

13-2. RX current test

1. Disconnect Debug Switch(SW5~SW9) on EVB
2. Connect UART Switch(SW10~SW11) on EVB
3. Power switch ON(SW4) on EVB
4. Push the RESET Switch(SW1) on EVB
5. Initial mode=Standby mode (@500uA/ Remove J4-CPULED jumper)
3. RX current test method
   1) Input AT command 'AT' (UART condition checking)
   2) Input AT command 'AT$RL' and then click 'Send' icon.
   3) Disconnect UART Switch(SW10~SW11) on EVB
   4) And then, Check TX current.

13-3. Sleep current test

1. Disconnect Debug Switch(SW5~SW9) on EVB
2. Connect UART Switch(SW10~SW11) on EVB
3. Power switch ON(SW4) on EVB
4. Push the RESET Switch(SW1) on EVB
5. Initial mode=idle mode (@500uA/ Remove J2-CPULED jumper)
6. Sleep current test method
   1) Input AT command‘AT’(UART condition checking)
   2) Input AT command‘AT$P=1’(sleep mode command)
   3) Disconnect UART Switch(SW10~SW11) on EVB
   4) And then, Check Sleep current

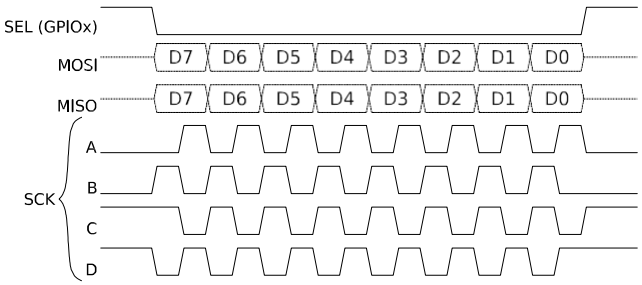
13-4. Deep sleep current test

1. Disconnect Debug Switch(SW5~SW9) on EVB
2. Connect UART Switch(SW10~SW11) on EVB
3. Power switch ON(SW4) on EVB
4. Push the RESET Switch(SW1) on EVB
5. Initial mode=idle mode (@500uA/ Remove J2-CPULED jumper)
6. Sleep current test method
   1) Input AT command‘AT’(UART condition checking)
   2) Input AT command‘AT$P=2’(sleep mode command)
   3) Disconnect UART Switch(SW10~SW11) on EVB
   4) And then, Check Sleep current
   5) If the module wakes up, Push the tact switch(SW2: wakeup PIN) on EVB

14. AT commands

Command	Name	Description
AT	Dummy Command	Just returns 'OK' and does nothing else. Can be used to check communication.
AT$SB=bit[,bit]	Send Bit	Send a bit status (0 or 1). Optional bit flag indicates if AX-SFJK should receive a downlink frame.
AT$SF=frame[,bit]	Send Frame	Send payload data, 1 to 12 bytes. Optional bit flag indicates if AX-SFJK should receive a downlink frame.
AT$SO	Manually send out of band message	Send the out-of-band message.
AT$TR?	Get the transmit repeat	Returns the number of transmit repeats. Default: 2
AT$TR=?	Get transmit range	Returns the allowed range of transmit repeats.
AT$TR=uint	Get transmit repeat	Sets the transmit repeat.
ATSuint?	Get Register	Query a specific configuration register's value. See chapter "Registers" for a list of registers.
ATSuint=uint	Set Register	Change a configuration register.
ATSuint=?	Get Register Range	Returns the allowed range of transmit repeats.
AT$IF=uint	Set TX Frequency	Set the output carrier macro channel for Sigfox frames.
AT$IF?	Get TX Frequency	Get the currently chosen TX frequency.
AT$DR=uint	Set RX Frequency	Set the reception carrier macro channel for Sigfox frames.
AT$DR?	Get RX Frequency	Get the currently chosen RX frequency.
AT$CW=uint,bit[,uint_opt]	Continuous Wave	To run emission tests for Sigfox certification it is necessary to send a continuous wave, i.e. just the base frequency without any modulation. Parameters: **Name** / **Range** / **Description** Frequency / 800000000-999999999, 0 / Continuous wave frequency in Hz. Use 923200000 for Sigfox Mode / 0, 1 / Enable or disable carrier wave. Power / 14 / dBm of signal | Default: 14
AT$CB=uint_opt,bit	Test Mode: TX constant byte	For emission testing it is useful to send a specific bit pattern. The first parameter specifies the byte to send. Use '-1' for a (pseudo-)random pattern. Parameters: **Name** / **Range** / **Decsription** Pattern / 0-255, -1 / Byte to send. Use '-1' for a (pseudo-)random pattern. Mode / 0, 1 / Enable or disable pattern test mode.
AT$T?	Get Temperature	Measure internal temperature and return it in 1/10th of a degree Celsius.
AT$V?	Get Voltages	Return current voltage and voltage measured during the last transmission in mV.

Command	Name	Description
AT$I=uint	Information	Display various product information: 0: Software Name & Version Example Response: AX-Sigfox 1.1 RCZ3 1: Contact Details Example Response: support@axsem.com 2: Silicon revision lower byte Example Response: 8F 3: Silicon revision upper byte Example Response: 51 4: Major Firmware Version Example Response: 1 5: Minor Firmware Version Example Response: 1 7: Firmware Variant (Frequency Band etc. (EU/US)) Example Response: RCZ3 9: SIGFOX Library Version Example Response: UDL1-1.8.9 10: Device ID Example Response: 00012345 11: PAC Example Response: 0123456789ABCDEF
AT$P=uint	Set Power Mode	To conserve power, the AX-SFJK can be put to sleep manually. Depending on power mode, you will be responsible for waking up the AX-SFJK again! 0: software reset (settings will be reset to values in flash) 1: sleep (send a break to wake up) 2: deep sleep (toggle GPIO9 or RESET_N pin to wake up; the AX-SFJK is not running and all settings will be reset!)
AT$WR	Save Config	Write all settings to flash (RX/TX frequencies, registers) so they survive reset/deep sleep or loss of power. Use AT$P=0 to reset the AX-SFJK and load settings from flash.
AT:Pn?	Get GPIO Pin	Return the setting of the GPIO Pin *n*; *n* can range from 0 to 9. A character string is returned describing the mode of the pin, followed by the actual value. If the pin is configured as analog pin, then the voltage (range 0…1 V) is returned. The mode characters have the following meaning: **Mode** **Description** 0 Pin drives low 1 Pin drives high Z Pin is high impedance input U Pin is input with pull-up A Pin is analog input (GPIO pin 0…3 only) T Pin is driven by clock or DAC (GPIO pin 0 and 4 only) The default mode after exiting reset is U on all GPIO pins.
AT:Pn=?	Get GPIO Pin Range	Print a list of possible modes for a pin. The table below lists the response. **Pin** **Modes** P0 0, 1, Z, U, A, T P1 0, 1, Z, U, A P4 0, 1, Z, U, T P5 0, 1, Z, U P6 0, 1, Z, U P7 0, 1, Z, U P8 0, 1, Z, U P9 0, 1, Z, U
AT:Pn=mode	Set GPIO Pin	Set the GPIO pin mode. For a list of the modes see the command AT:Pn?

Command	Name	Description
AT:ADC Pn[-Pn[(1V|10V)]]?	Get GPIO Pin Analog Voltage	Measure the voltage applied to a GPIO pin. The command also allows measurement of the voltage difference across two GPIO pins. In differential mode, the full scale range may also be specified as 1 V or 10 V. Note however that the pin input voltages must not exceed the range 0..VDD_IO. The command returns the result as fraction of the full scale range (1 V if none is specified). The GPIO pins referenced should be initialized to analog mode before issuing this command.
AT:SPI[(A|B|C|D)]=bytes	SPI Transaction	This command clocks out *bytes* on the SPI port. The clock frequency is 312.5 kHz. The command returns the bytes read on MISO during output. Optionally the clocking mode may be specified (default is A): **Mode** **Clock Inversion** **Clock Phase** A normal normal B normal alternate C inverted normal D inverted alternate  Note that SEL, if needed, is not generated by this command, and must instead be driven using standard GPIO commands (AT:Pn=0|1).
AT:CLK=freq,reffreq	Set Clock Generator	Output a square wave on the pin(s) set to T mode. The frequency of the square wave is (freq / 2^{16}) × reffreq. Possible values for reffreq are 20000000, 10000000, 5000000, 2500000, 1250000, 625000, 312500, 156250. Possible values if freq are 0…65535.
AT:CLK=OFF	Turn off Clock Generator	Switch off the clock generator
AT:CLK?	Get Clock Generator	Return the settings of the clock generator. Two numbers are returned, freq and reffreq.
AT:DAC=value	Set ΣΔ DAC	Output a ΣΔ DAC value on the pin(s) set to T mode. Parameter value may be in the range −32768…32767. The average output voltage is (1/2 + value / 2^{17}) × VDD. An external low pass filter is needed to get smooth output voltages. The modulation frequency is 20 MHz. A possible low pass filter choice is a simple RC low pass filter with R = 10 kΩ and C = 1 µF.
AT:DAC=OFF	Turn off ΣΔ DAC	Switch off the DAC
AT:DAC?	Get ΣΔ DAC	Return the DAC value

Command	Name	Description
AT$TM=mode,config	Activates the Sigfox Testmode	Available test modes: 1. TX BPSK Send only BPSK with Synchro Bit + Synchro frame + PN sequence: No hopping centered on the TX_frequency. Config bits 0 to 6 define the number of repetitions. Bit 7 of config defines if a delay is applied of not in the loop 2. TX Protocol: Tx mode with full protocol with Sigfox key: Send Sigfox protocol frames with initiate downlink flag = True. Config defines the number of repetitions. 3. RX Protocol: This mode tests the complete downlink protocol in Downlink only. Config defines the number of repetitions. 4. RX GFSK: RX mode with known pattern with SB + SF + Pattern on RX_frequency (internal comparison with received frame ⇔ known pattern = AA AA B2 27 1F 20 41 84 32 68 C5 BA AE 79 E7 F6 DD 9B. Config defines the number of repetitions. Config defines the number of repetitions. 5. RX Sensitivity: Does uplink + downlink frame with Sigfox key and specific timings. This test is specific to SIGFOX's test equipments & softwares. 6. TX Synthesis: Does one uplink frame on each Sigfox channel to measure frequency synthesis step
AT$SE	Starts AT$TM=3,255 indefinitely	Convenience command for sensitivity tests
AT$SL[=frame]	Send local loop	Sends a local loop frame with optional payload of 1 to 12 bytes. Default payload: 0x84, 0x32, 0x68, 0xC5, 0xBA, 0x53, 0xAE, 0x79, 0xE7, 0xF6, 0xDD, 0x9B.
AT$RL	Receive local loop	Starts listening for a local loop.
AT$I=195	Information	F/W CRC check

15. Registers

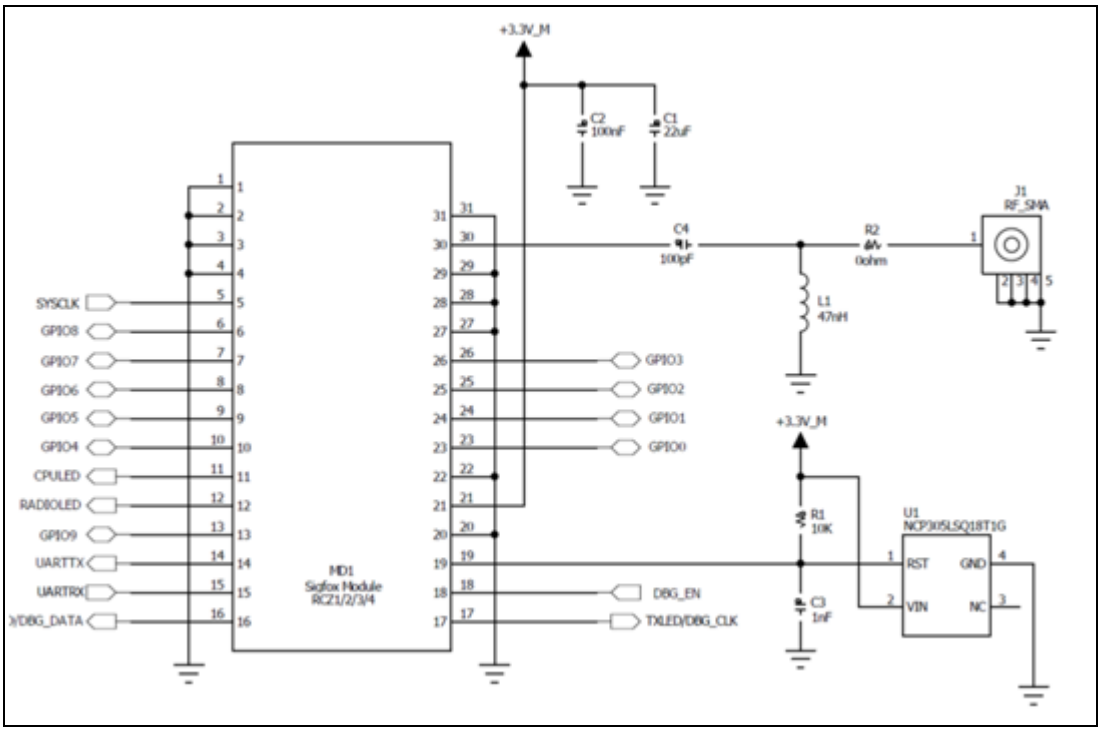
Number	Name	Description	Default	Range	Units
300	Out Of Band Period	AX-SFJK sends periodic static messages to indicate that they are alive. Set to 0 to disable.	24	0–24	hours
410	Encryption Key Configuration	Set to zero for normal operation. Set to one for use with the SIGFOX Network Emulator Kit (SNEK)	0	0–1	0: private key 1: public key

16. Specific recommendation

1. Default output power is set to 12.5dBm.
   To set the output power to 14dBm, use <ATS302=15> before sending a SIGFOX frame.
2. To send a frame the following procedure should be followed
   AT$SF= xxxxxxxxxxxx

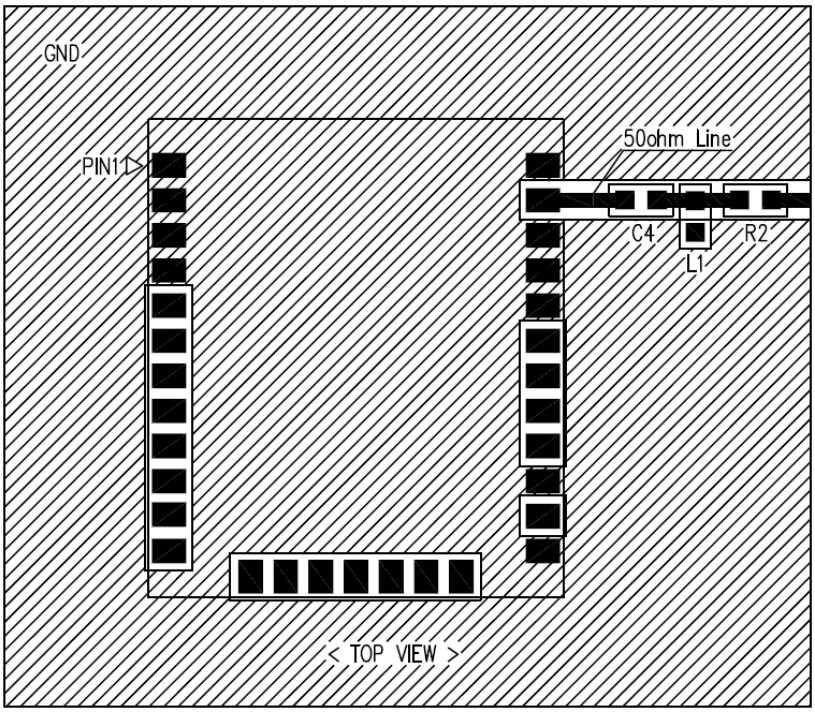
17. Design Guide

17-1. Circuit Design

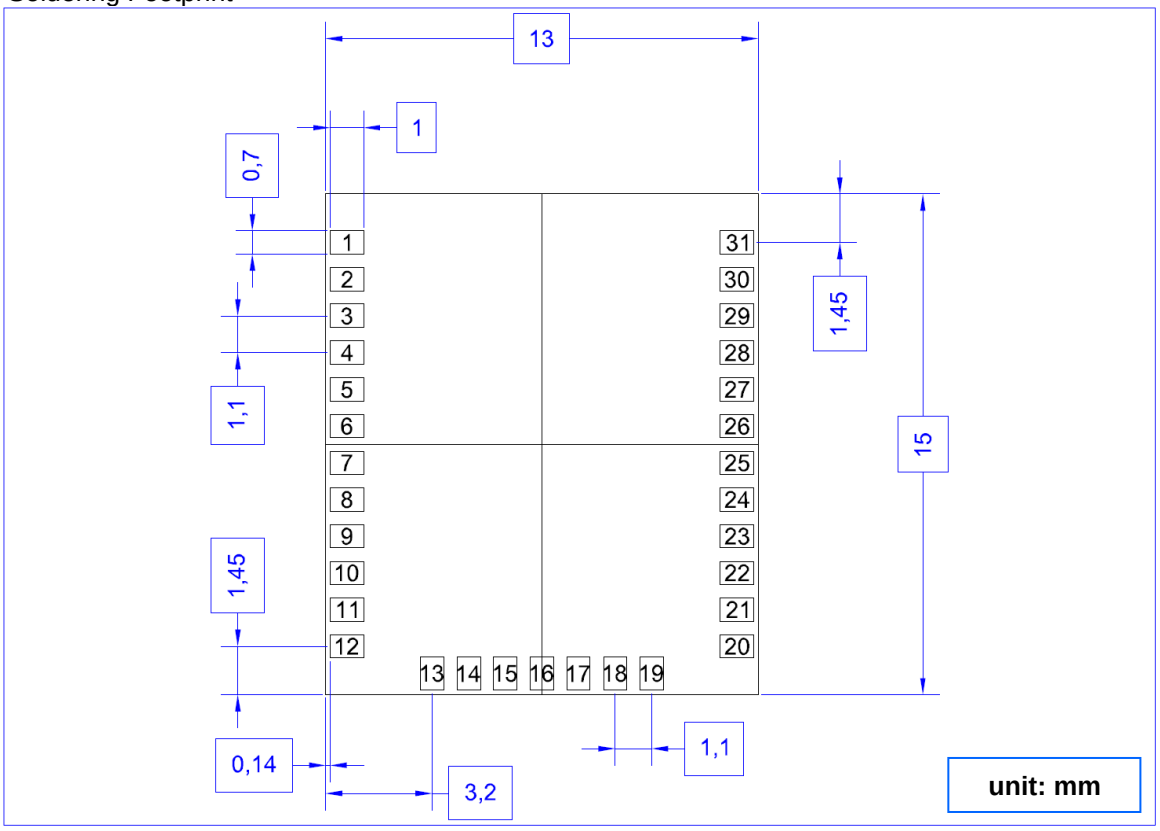


NAME	Description
MD1	Sigfox Module(RC1~RC4)
+3.3V_M	Module Power supply, Typically 3.3V
J1	RF In-Output, Impedance=50Ω
C1	22uF
C2	100nF
C3	1nF
C4*	100pF
R1	10KΩ
R2	0Ω
L1*	47nH
U1	Reset IC

17-2. PCB Layout Design



17-3. Soldering Footprint



[TOP View]

18. POR requirement

This module features a built-in Power-On Reset (POR) circuit. The internal POR circuitry is edge sensitive, so certain rise and fall time of VDD_IO (supply voltage) are required to trigger the internal POR.

18-1. Normal Start-up

VDD_IO should start at lower than 0.1V and rise with the slope of faster than 0.1V/ms.

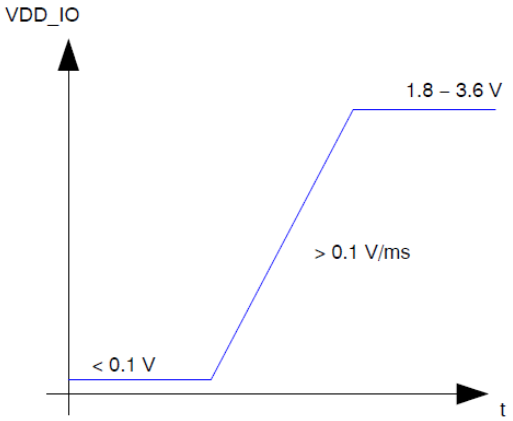


Figure 1 Normal Startup

18-2. Temporary Loss of Power

Figure 2 shows a loss of power waveform. In this scenario, if the VDD_IO voltage does not return to below 0.1 V before reapplying power again, but lingers in the range of approximately 0.45 V to 0.7 V and the rise time is lower than 3.3 V/ms then external reset circuitry or an external reset device should be used.

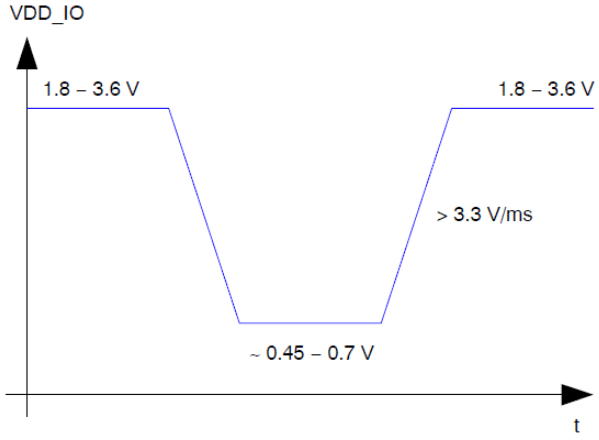
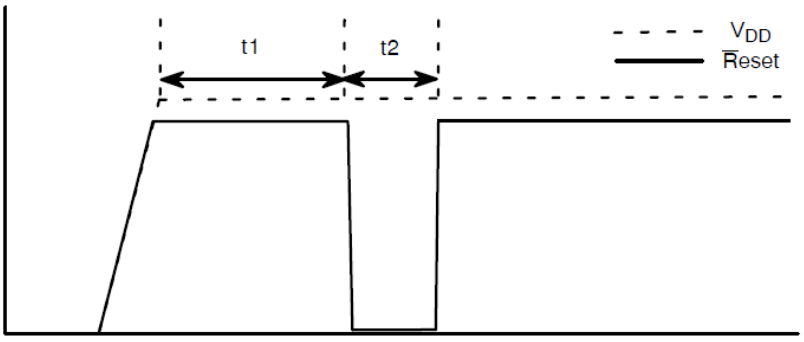


Figure 2 Temporary Loss of Power

18-3. Suggested External Reset Sequence

The followings show the suggested external reset sequences which should apply to the RESET_N pin of the Module



	Suggested Minimum Requirement
t1	600 μs
t2	1 μs

19. Reset

19-1. External reset IC(case1)

Recommended reset IC with open drain output is NCP305LSQ18T1G with 1.8V of detect voltage. Output pin of the reset IC requires external pull-up resistor and is connected with reset pin of module.

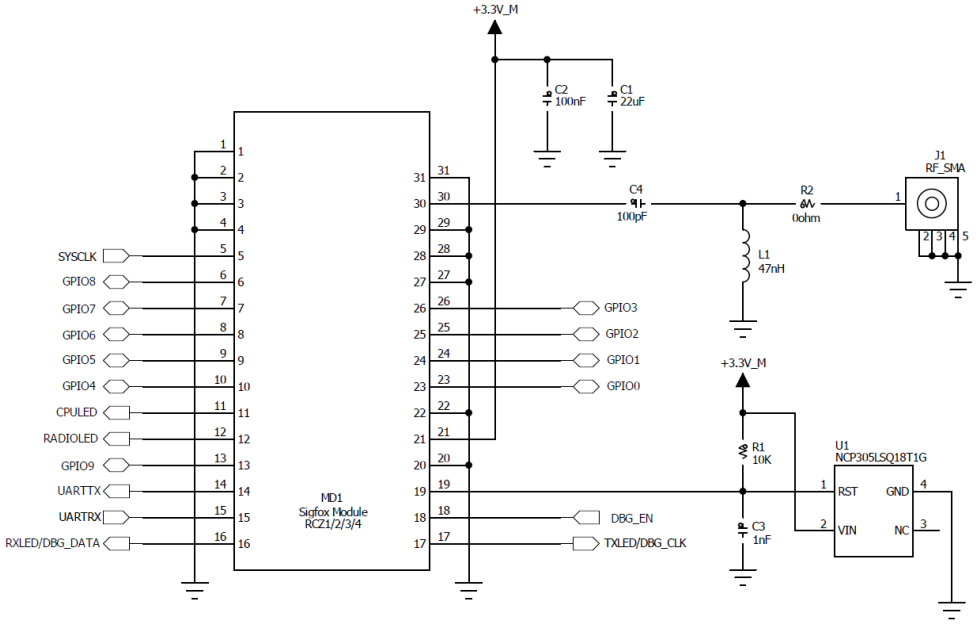


Figure 3 External reset IC

19-2. Reset control from Host MCU(case2)

Host MCU can control RST_N(#19) pin. It can reset the module to be power on in stable power condition or force reset it when the module doesn't respond to the AT command.

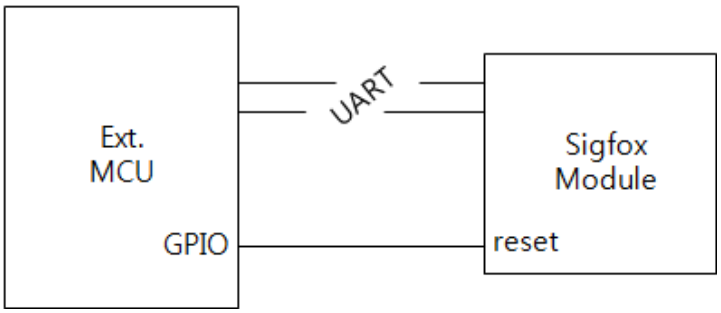
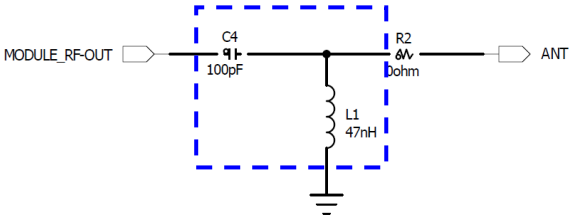


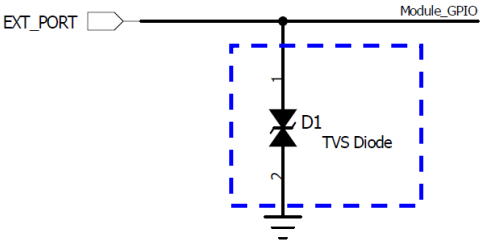
Figure 4 Reset control from Host MCU

20. ESD protection guide

To increase ESD protection on RF path over +/-2KV, we strongly recommend to add C4, L1 on that line.



To increase ESD protection on GPIO over +/-2KV, if a device using this module has an external interface, apply the TVS diode to the interface line.



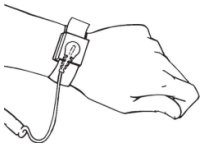
ESD Warning

This modules are ESD sensitive devices, appropriate precautions should be taken during the module assembly in the final product.
Mechanical impact and harsh tools must be avoided during the module assembly in the final product.

Product ESD specification:
• HBM ±2kV

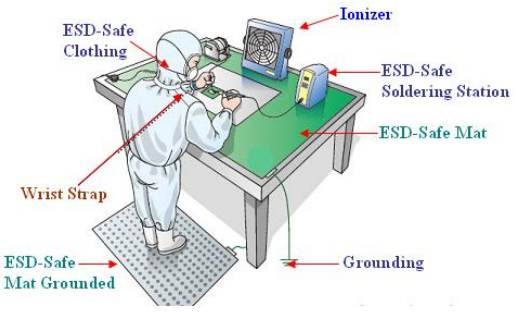
The following precautions must be taken:

• Do not open the protective conductive packaging until you have use the following, and are at an approved anti-static work station.



• Use a conductive wrist strap attached to a good earth ground.

• If working on a prototyping board, use a soldering iron or station that is marked as ESD-safe.
• If possible, use SMT equipment(reflow) when making prototype boards.
• Use an approved anti-static mat to cover your work surface.



• Always discharge yourself by touching a grounded bare metal surface or approved anti-static mat before picking up an ESD - sensitive electronic component.