



# **E18-MS1PA2-PCB User Manual**

**CC2530 2.4GHz 100mW ZigBee Wireless Module**



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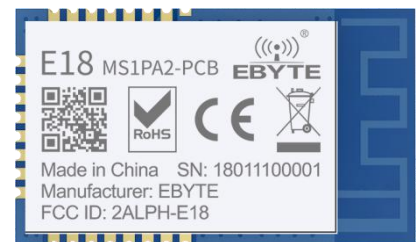
## 1. General introduction

### 1.1 Brief introduction

E18-MS1PA2-PCB is small-sized 2.4GHz ZigBee wireless module, which is designed and produced by Chengdu Ebyte. SMD type with pcb antenna, with a transmission power of 100mW and the pin pitch is 1.27mm. It is applicable for various applications (especially smart home).

E18-MS1PA2-PCB adopts the original CC2530 RF chip of TI, the chip is integrated with 8051 MCU and wireless transceiver, and built-in PA+LNA, greatly expanding communication distance and improving communication stability. The module is applicable for ZigBee design and 2.4GHz IEEE 802.15.4 protocol.

All IO ports of the MCU have been pinned out for multiple development.



### 1.2 Features

- Built-in PA+LNA, maximum transmission power of 100Mw for long distance ZigBee transmission;
- Communication distance is up to 800m under ideal conditions;

- Built-in ZigBee protocol stack;
- Support peripherals such as ADC、 PWM、 GPIO;
- Built-in 32.768kHz clock crystal oscillator;
- Global license-free ISM 2.4GHz band;
- Rich resources, 256KB FLASH, 8KB RAM;
- High performance and low power 8051 micro-controller core with code acquisition;
- 2.0~3.6V power supply, power supply over 3.3V guarantees the best performance;
- Industrial grade standard design, support -40 ~ 85 °C for working over a long time;
- PCB antenna, no need for external antenna.

## 1.3 Application

- Smart home and industrial sensors;
- Security system, positioning system;
- Wireless remote control, drone;
- Wireless game remote control;
- Health care products;
- Wireless voice, wireless headset;
- Automotive industry applications.

## 2. Specification and parameter

### 2.1 Limit parameter

Main parameter	Performance		Remark
	Min	Max	
Power supply (V)	0	3.6	Voltage over 3.6V will cause permanent damage to the module
Blocking power (dBm)	-	10	Chance of is slim when modules are used in short distance
Operating temperature (°C)	-40	+85	Industrial grade

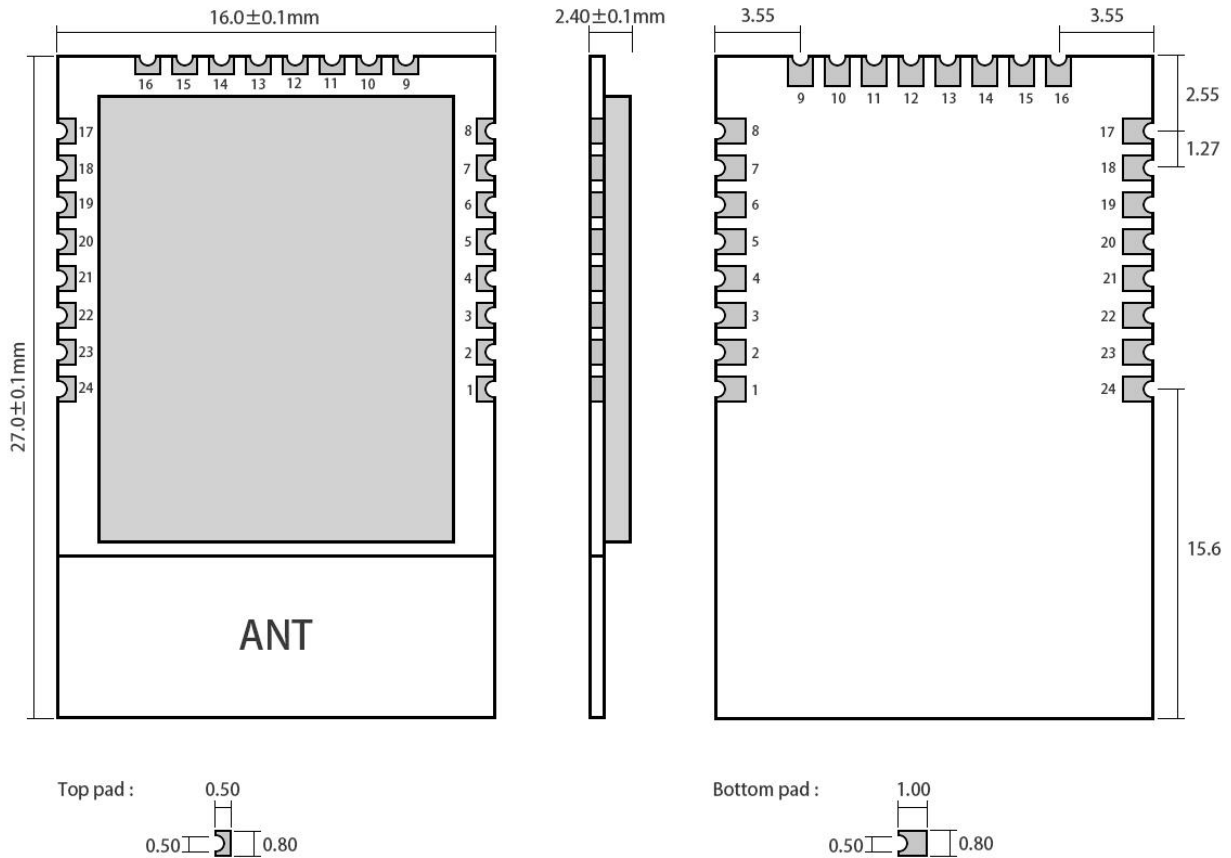
### 2.2 Operating parameter

Main parameter	Performance			Remark
	Min	Type	Max	
Operating voltage (V)	2.0	3.3	3.6	≥3.3 V ensures output power
Communication level (V)		3.3		For 5V TTL, it may be at risk of burning down

Operating temperature (°C)		-40	-	+85	Industrial grade
Operating frequency (GHz)		2.400	-	2.480	ISM band
Power Consumption	TX current (mA)		98		Instant power consumption
	RX current (mA)		36		-
	Sleep current (μA)		2		Shut down by software
Max TX power (dBm)		19.6	20	20.5	-
Receiving sensitivity (dBm)		-99	-98	-97	Air data rate is 250 kbps

Main parameter	Description	Remark
Reference distance	800m	Test condition: clear and open area, antenna gain: 5dBi, antenna height: 2.5m, air data rate: 250kbps
Protocol	ZigBee	
Communication interface	I/O	All IO ports lead out
Package	SMD	
Interface	1.27mm	
IC	CC2530F256RHAT/QFN40	Built-in PA+LNA
FLASH	256KB	
RAM	8KB	
Core	8051	
Size	16*27mm	
Antenna	PCB	50 ohm impedance

### 3. Size and pin definition



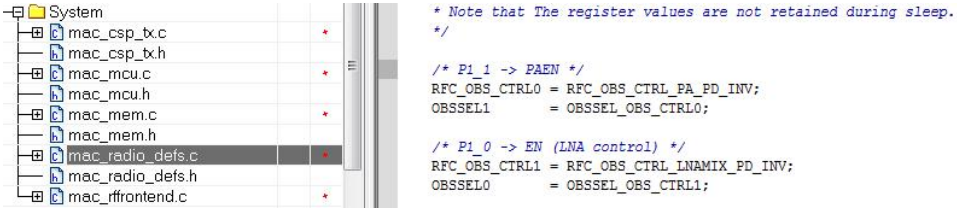

Pad quantity : 24  
Unit: mm

Pin No.	Pin item	Pin direction	Application
1	GND	Input	Ground, connecting to power supply reference ground
2	VCC	Input	Power supply, must be 2.0-3.6V
3	P2.2	Input /Output	MCU GPIO
4	P2.1	Input /Output	MCU GPIO
5	P2.0	Input /Output	MCU GPIO
6	P1.7	Input /Output	MCU GPIO
7	P1.6	Input /Output	MCU GPIO
8	NC		N.C.
9	NC		N.C.
10	P1.5	Input /Output	MCU GPIO
11	P1.4	Input /Output	MCU GPIO
12	P1.3	Input /Output	MCU GPIO
13	P1.2	Input /Output	MCU GPIO
14	P1.1	Output	MCU GPIO, PA transmission control pin
15	P1.0	Output	MCU GPIO, PA receiving control pin

16	P0.7	Input /Output	MCU GPIO
17	P0.6	Input /Output	MCU GPIO
18	P0.5	Input /Output	MCU GPIO
19	P0.4	Input /Output	MCU GPIO
20	P0.3	Input /Output	MCU GPIO
21	P0.2	Input /Output	MCU GPIO
22	P0.1	Input /Output	MCU GPIO
23	P0.0	Input /Output	MCU GPIO
24	RESET	Input	Reset port

## 4. Usage

No.	Keyword	Remark
1	Burn firmware	<p>The module is built-in 8051 MCU, to download programme please use CC Debugger;</p>
use2	Initiate PA	<p>Initiate PA , modify it in file hal_board_cfg.h.</p> <pre> #include "hal_mcu.h" #include "hal_defs.h" #include "hal_types.h"  /* -----  *  *                               CC25:  *  *                               Define HAL_PA_LNA C  *                               Define HAL_PA_LNA i  *                               Note that only one  * -----  */ #define HAL_PA_LNA //去掉xHAL_PA_LNA #define xHAL_PA_LNA_CC2590 </pre>

<p>3</p>	<p>Parameter setting</p>	<p>This product can modify the settings of PA in zstack directly in the previous program;                  In this example, the pins P1.1 and P1.0 of the CC2530 are connected to the PA_EN, LNA_EN of the internal PA;                  At the same time, it can be seen that LNA_EN is always in the high level and the receiving mode.</p> <table border="1" data-bbox="451 443 1023 573"> <thead> <tr> <th>Working mode</th> <th>PA_EN</th> <th>LAN_EN</th> </tr> </thead> <tbody> <tr> <td>TX mode</td> <td>1</td> <td>0</td> </tr> <tr> <td>RX mode</td> <td>0</td> <td>1</td> </tr> <tr> <td>Sleep mode</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Working mode	PA_EN	LAN_EN	TX mode	1	0	RX mode	0	1	Sleep mode	0	0
Working mode	PA_EN	LAN_EN												
TX mode	1	0												
RX mode	0	1												
Sleep mode	0	0												
<p>4</p>	<p>Program modification</p>	<p>Find macRadioTurnOnPower() from file mac_radio_defs.c, and modify.</p>  <pre>                 /* Note that The register values are not retained during sleep.                 */                 /* P1_1 -&gt; PAEN */                 RFC_OBS_CTRL0 = RFC_OBS_CTRL_PA_PD_INV;                 OBSSEL1      = OBSSEL_OBS_CTRL0;                  /* P1_0 -&gt; EN (LNA control) */                 RFC_OBS_CTRL1 = RFC_OBS_CTRL_LNAMIX_PD_INV;                 OBSSEL0      = OBSSEL_OBS_CTRL1;             </pre>												
<p>5</p>	<p>Power modification</p>	<p>Find static CODE const macPib_t macPibDefaults from file mac_pib.c, modify in the red signed below.</p>  <pre>                 TRUE,                 FALSE,                  /* Proprietary */                 #if defined (HAL_PA_LNA)                 20,                 #elif defined (HAL_PA_LNA_CC2590)                 11,                 #else                 3,             </pre>												

## 5. Programming

### 5.1 TI ZigBee FAQ

① Differences between different versions of TI's ZigBee protocol stack, how to choose the right protocol stack for product development?

From the Z-Stack 0.1 to Z-Stack 2.5.1a and the current Z-Stack Home 1.2.1, Z-Stack Lighting 1.0.2, Z-Stack Energy 1.0.1, Z-Stack Mesh 1.0.0, TI mainly upgraded the protocol stack through: 1) adding some new features according to ZigBee Specification of the ZigBee Alliance, for example, ZigBee2007 tree-shape route, adding Mesh route in ZigBee Pro, and raising MTO and Source Routing algorithms so TI added some new functions to the protocol stack, also did some correction of bugs in Spec such as some unclear descriptions; 2) Correction of bugs of TI ZigBee protocol itself.



You can find the differences between one protocol stack and the previous version in the Release Note of the installation directory.

After the Z-Stack 2.5.1a, TI did not publish the protocol stack in the form of Z-Stack 2.6.x but in Application Profile form, because TI hopes the developers could select proper protocol stack based on actual applications. The protocol stacks like Z-Stack Home 1.2.1 includes two parts: 1) Core Stack, it is the follow-up versions of Z-Stack 2.5.1a, it can be found from the Z-Stack Core Release Notes.txt, Version 2.6.2. 2) Profile-related part, this part is related to the actual application, Home Automation stack is about the realization of ZigBee Home Automation Profile. Meanwhile, Z-Stack Lighting 1.0.2 and Z-Stack Energy 1.0.1 are Core Stack with Profile for application.

- 1) Z-Stack Home 1.2.2a is specific for smart home products development.
- 2) Z-Stack Lighting 1.0.2 is specific for ZLL products development.
- 3) Z-Stack Energy 1.0.1 is specific for intelligent energy, meter, In Home Display, and so on.
- 4) Z-Stack Mesh 1.0.0 is specific for private applications, it only utilizes the function of standard ZigBee protocol, Mesh route and so on, the application layer shall be defined by the developer.

After the publish of ZigBee 3.0 protocol, the latest ZigBee protocol stack is Z-Stack 3.0, it supports CC2530 and CC2538.

## ② How to apply for standard ZigBee test certification?

Take standard ZigBee Home Automation products as example, developers must develop according to the description in the ZigBee Home Automation Profile Specification, this document can be found from [www.zigbee.or](http://www.zigbee.or). After developing the product, developers need to learn the ZigBee Home Automation Profile Test Specification, this document described the items to be tested by the Test House, it can be downloaded from [www.zigbee.org](http://www.zigbee.org) also, in addition, there is another PICS document, it is specific for describing the functions supported, developers confirm the functions by checking the boxes according to the actual functions and the required functions in the Specification, as below are the testing procedure:

- 1) Join the ZigBee alliance, generally assisted by testing labs;
- 2) Send samples to testing lab, complete the PICS file;
- 3) First round pre-testing, the testing lab feedback the testing results, developers modify the sample codes.
- 4) The testing lab verify the modified sample, and starts formal test;
- 5) The testing lab assists developers to complete the ZigBee alliance online certification application;
- 6) The testing lab submits the test report to ZigBee alliance. The alliance will review and issue certificate.

Currently, there are two testing labs in China who can complete standard ZigBee test:

- 1) CESI in Beijing;
- 2) Element Shenzhen Office (headquartered in England)

Please refer to below wiki link for details:

[http://processors.wiki.ti.com/index.php/ZigBee\\_Product\\_Certification\\_Guide](http://processors.wiki.ti.com/index.php/ZigBee_Product_Certification_Guide)

## ③ How to select the 64-bit MAC address of the device?

There are two IEEE addresses in CC2530, one is Primary IEEE address, the other is Secondary address. Primary IEEE address is stored in Information Page of the chip, this address is bought by TI from IEEE, each chip has one unique address. Users could only Read this value and cannot modify or erase it. By reading the address in the protocol stack, users can obtain `osal_memcpy (aExtendedAddress, (uint8 *) (P_INFOPAGE+HAL_INFOP_IEEE_OSET), Z_EXTADDR_LEN)`. Secondary address is stored in the last Page of the Flash of CC2530, users can Read/Write with the function `HalFlashRead (HAL_FLASH_IEEE_PAGE, HAL_FLASH_IEEE_OSET, aExtendedAddress, Z_EXTADDR_LEN)`.

When the protocol stack is operating, how to select Primary IEEE address or Secondary address as MAC address? Please operate in the function `zmain_ext_addr(void)`.

- 1) Read IEEE address from NV, if it already exists (not 0xFF), use this address as MAC address;
- 2) If not in 1), read from the Secondary IEEE address storage place, if it exists (not 0xFF), write the address into NV, and use this address as MAC address;
- 3) If not in 2), read from the Primary IEEE address storage place, if it exists (not 0xFF), write the address into NV, and use this address as MAC address;
- 4) If not in 3), generate one 64-bit variable randomly, write it into NV, use it as MAC address.

#### ④ How to forbid node from searching network, or extend the interval for sending Beacon Request?

End Device is low power consumption device powered by battery, after cutting from network, how to forbid the node from searching network, or how to extend the interval for sending Beacon Request.

1) Start searching network `uint8 ZDApp_StartJoiningCycle( void )`

Stop searching network `uint8 ZDApp_StopJoiningCycle( void )`

2) Change the Beacon Request sending period

Modify the variable `zgDefaultStartingScanDuration`

// Beacon Order Values

```
#define BEACON_ORDER_NO_BEACONS      15
#define BEACON_ORDER_4_MINUTES      14 // 245760 milliseconds
#define BEACON_ORDER_2_MINUTES      13 // 122880 milliseconds
#define BEACON_ORDER_1_MINUTE      12 // 61440 milliseconds
#define BEACON_ORDER_31_SECONDS    11 // 30720 milliseconds
#define BEACON_ORDER_15_SECONDS    10 // 15360 MSecs
#define BEACON_ORDER_7_5_SECONDS   9 // 7680 MSecs
#define BEACON_ORDER_4_SECONDS     8 // 3840 MSecs
#define BEACON_ORDER_2_SECONDS     7 // 1920 MSecs
#define BEACON_ORDER_1_SECOND      6 // 960 MSecs
#define BEACON_ORDER_480_MSEC      5
#define BEACON_ORDER_240_MSEC      4
#define BEACON_ORDER_120_MSEC     3
#define BEACON_ORDER_60_MSEC      2
#define BEACON_ORDER_30_MSEC      1
#define BEACON_ORDER_15_MSEC      0
```

#### ⑤ How to put End Device into low power consumption mode, how to set up sleep time?

After the `POWER_SAVING` is enabled in the protocol stack macro definition, put `DRFD_RCVC_ALWAYS_ON=FALSE` in `f8wConfig.cfg` file, then the End Device will enter sleep mode.

The sleep time is decided by the OSAL operating system, the latest Event Timeout to occur will be set as sleep time. There is description in the protocol stack `hal_sleep` function.

There are two kinds of timeout: one is the timeout of application layer event, the other is the timeout of MAC layer event.

1) Timeout of application layer, can be obtained through `osal_next_timeout()` of `osal_pwrmgr_powerconserve(void)` function;

2) Timeout of MAC layer, can be obtained through `MAC_PwrNextTimeout()` of `halSleep(uint16 osal_timeout)` function.

## ⑥ What new features does ZigBee 3.0 stack have?

Please refer to below link, it describes the new features of the ZigBee 3.0 stack as compared with the previous ZigBee Home Automation/ZigBee Light Link.

[http://processors.wiki.ti.com/index.php/What%27s\\_New\\_in\\_ZigBee\\_3.0](http://processors.wiki.ti.com/index.php/What%27s_New_in_ZigBee_3.0)

About the status switch in the TI ZigBee protocol stack

[http://www.deyisupport.com/question\\_answer/wireless\\_connectivity/zigbee/f/104/t/104629.aspx](http://www.deyisupport.com/question_answer/wireless_connectivity/zigbee/f/104/t/104629.aspx)

## ⑦ About the difference between OAD and OTA in TI protocol stack?

OAD is short for Over the Air Download, OTA is short for Over the Air. The functions of these two are the same, they can be called the software upgrade on air. In the earlier ZigBee protocol standard, there was no standard for node software upgrading on air, but many customers have such requirements, thus TI developed their own protocol stack for software upgrading on air, and named it as OAD. After that, ZigBee alliance noticed the more and more requirements for upgrading on air, so they developed the upgrading on air standard and named it as OTA, this standard has taken the TI OAD method as reference and has made some modification. The upgrading on air in TI's earlier protocol stack, it is called OAD, and in the later stack, it is called OTA as following the ZigBee alliance stack.

## ⑧ Which protocol stack shall be selected for developing private application based on ZigBee Mesh?

Many customers only need to apply the function of ZigBee Mesh network in their system or products, and do not need to do according to the application layer as defined by the ZigBee, especially for some industrial applications, as for such requirements, how to select proper TI protocol stack for developing products?

[http://www.deyisupport.com/question\\_answer/wireless\\_connectivity/zigbee/f/104/t/132197.aspx](http://www.deyisupport.com/question_answer/wireless_connectivity/zigbee/f/104/t/132197.aspx)

# 6. Basic operation

## 6.1 Hardware design

- It is recommended to use a DC stabilized power supply. The power supply ripple factor is as small as possible and the module needs to be reliably grounded;
- Please pay attention to the correct connection of the positive and negative poles of the power supply, reverse connection may cause permanent damage to the module;
- Please check the power supply to ensure that between the recommended supply voltage, if exceeding the maximum,

the module will be permanently damaged;

- Please check the stability of the power supply. Voltage can not fluctuate greatly and frequently;
- When designing the power supply circuit for the module, it is often recommended to reserve more than 30% of the margin, so the whole machine is beneficial for long-term stable operation;
- The module should be as far away as possible from the power supply, transformers, high-frequency wiring and other parts with large electromagnetic interference;
- Bottom Layer High-frequency digital routing, high-frequency analog routing, and power routing must be avoided under the module. If it is necessary to pass through the module, assume that the module is soldered to the Top Layer, and the copper is spread on the Top Layer of the module contact part(well grounded), it must be close to the digital part of the module and routed in the Bottom Layer;
- Assuming the module is soldered or placed over the Top Layer, it is wrong to randomly route over the Bottom Layer or other layers, which will affect the module's spurs and receiving sensitivity to varying degrees;
- It is assumed that there are devices with large electromagnetic interference around the module that will greatly affect the performance. It is recommended to keep them away from the module according to the strength of the interference. If necessary, appropriate isolation and shielding can be done;
- Assume that there are traces with large electromagnetic interference (high-frequency digital, high-frequency analog, power traces) around the module that will greatly affect the performance of the module. It is recommended to stay away from the module according to the strength of the interference. If necessary, appropriate isolation and shielding can be done;
- If the communication line uses a 5V level, a 1k-5.1k resistor must be connected in series (not recommended, there is still a risk of damage);
- Try to stay away from some physical layers such as TTL protocol at 2.4GHz , for example: USB3.0;
- The mounting structure of antenna has a great influence on the performance of the module. It is necessary to ensure that the antenna is exposed, preferably vertically upward. When the module is mounted inside the case, use a good antenna extension cable to extend the antenna to the outside;
- The antenna must not be installed inside the metal case, which will cause the transmission distance to be greatly weakened.

## 7. FAQ

### 7.1 Communication distance is too short

- The communication distance will be affected when obstacle exists;
- Data lose rate will be affected by temperature, humidity and co-channel interference;
- The ground will absorb and reflect wireless radio wave, so the performance will be poor when testing near ground;
- Sea water has great ability in absorbing wireless radio wave, so performance will be poor when testing near the sea;
- The signal will be affected when the antenna is near metal object or put in a metal case;
- Power register was set incorrectly, air data rate is set as too high (the higher the air data rate, the shorter the distance);
- The power supply low voltage under room temperature is lower than recommended value, the lower the voltage, the

lower the transmitting power;

- Due to antenna quality or poor matching between antenna and module.

## 7.2 Module is easy to damage

- Please check the power supply source, ensure it is between the recommended supply voltage, voltage higher than the maximum will damage the module.
- Please check the stability of power source, the voltage cannot fluctuate too much;
- Please make sure antistatic measure are taken when installing and using, high frequency devices have electrostatic susceptibility;
- Please ensure the humidity is within limited range, some parts are sensitive to humidity;
- Please avoid using modules under too high or too low temperature.

## 7.3 BER(Bit Error Rate) is high

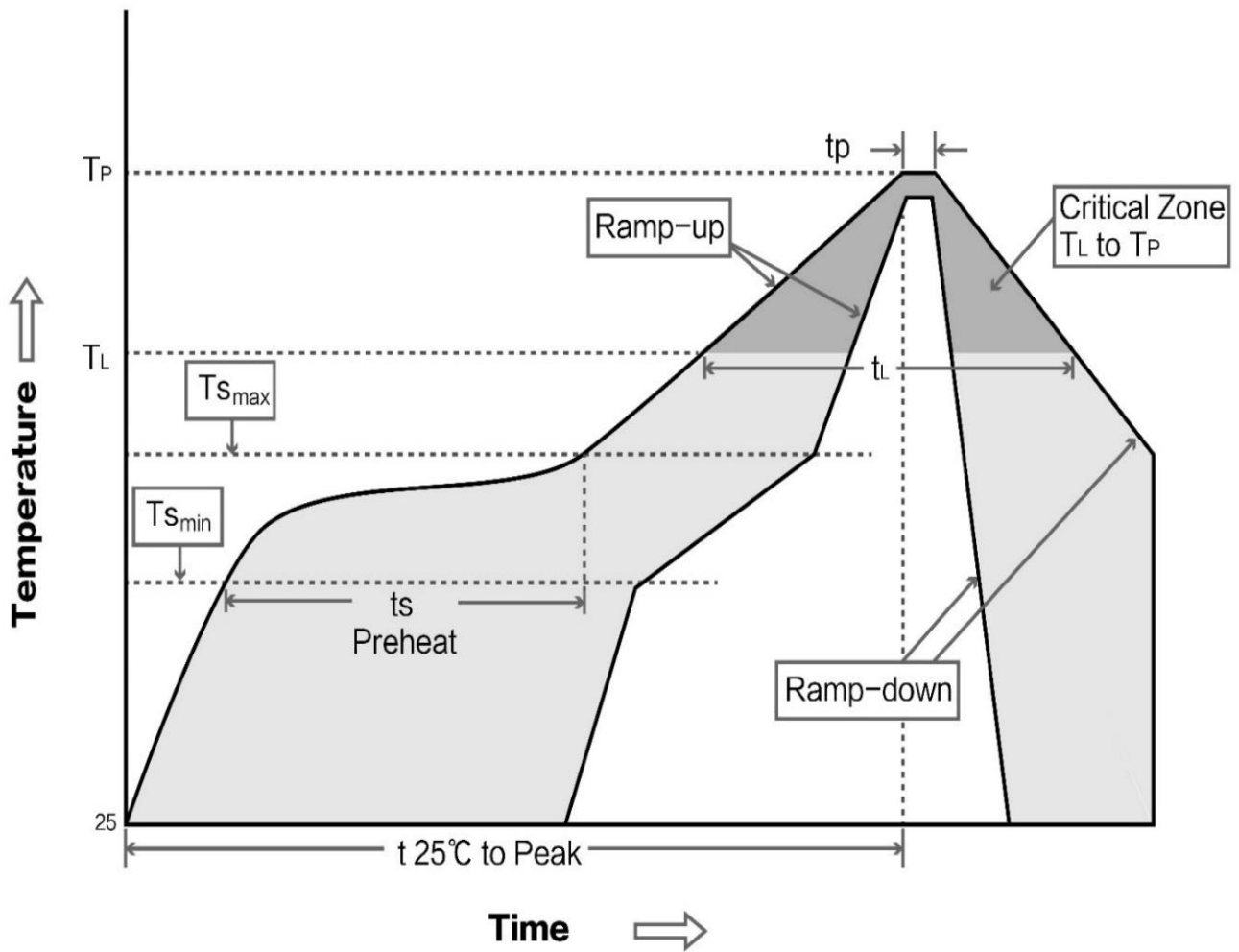
- There are co-channel signal interference nearby, please be away from interference sources or modify frequency and channel to avoid interference;
- Poor power supply may cause messy code. Make sure that the power supply is reliable;
- The extension line and feeder quality are poor or too long, so the bit error rate is high.

# 8. Welding instruction

## 8.1 Reflow soldering temperature

Profile Feature	Curve characteristics	Sn-Pb Assembly	Pb-Free Assembly
Solder Paste	Solder paste	Sn63/Pb37	Sn96.5/Ag3/Cu0.5
Preheat Temperature min (T <sub>smin</sub> )	Min preheating temp.	100°C	150°C
Preheat temperature max (T <sub>smax</sub> )	Max preheating temp.	150°C	200°C
Preheat Time (T <sub>smin</sub> to T <sub>smax</sub> )(ts)	Preheating time	60-120 sec	60-120 sec
Average ramp-up rate(T <sub>smax</sub> to T <sub>p</sub> )	Average ramp-up rate	3°C/second max	3°C/second max
Liquidous Temperature (TL)	Liquid phase temp.	183°C	217°C
Time (t <sub>L</sub> ) Maintained Above (TL)	Time below liquid phase line	60-90 sec	30-90 sec
Peak temperature (T <sub>p</sub> )	Peak temp	220-235°C	230-250°C
Average ramp-down rate (T <sub>p</sub> to T <sub>smax</sub> )	Average ramp-down rate	6°C/second max	6°C/second max
Time 25°C to peak temperature	Time to peak temperature for 25°C	6 minutes max	8 minutes max

## 8.2 Reflow soldering curve



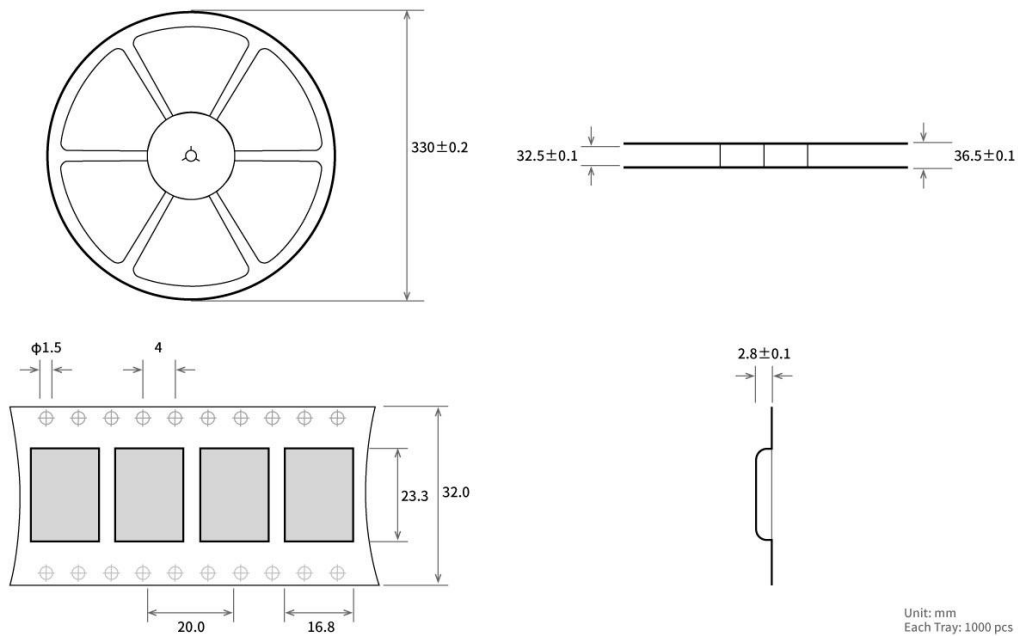
## 9. E18 series

Model	IC	Frequency	Tx power	Distance	Size	Package	Antenna
		Hz	dBm	m	mm		
E18-MS1-PCB	CC2530	2.4G	4	200	14.1*23	SMD	PCB
E18-MS1-IPX	CC2530	2.4G	4	240	14.1*20.8	SMD	IPEX
E18-MS1PA1-PCB	CC2530	2.4G	20	800	16*27	SMD	PCB
E18-MS1PA2-IPX	CC2530	2.4G	20	1200	16*22.5	SMD	IPEX
E18-2G4Z27SI	CC2530	2.4G	27	2500	16*22.5	SMD	IPEX
E18-2G4U04B	CC2531	2.4G	4	200	18*59	USB	PCB

## 10. Antenna recommendation

Model No.	Type	Frequency	Gain	Size	Cable	Interface	Function feature
		Hz	dBi	mm	cm		
TX2400-NP-5010	Flexible Antenna	2.4G	2.0	10x50	-	IPEX	Flexible FPC soft antenna
TX2400-JZ-3	Rubber antenna	2.4G	2.0	30	-	SMA-J	Short straight & omnidirectional antenna
TX2400-JZ-5	Rubber antenna	2.4G	2.0	50	-	SMA-J	Short straight & omnidirectional antenna
TX2400-JW-5	Rubber antenna	2.4G	2.0	50	-	SMA-J	Fixed bending & omnidirectional antenna
TX2400-JK-11	Rubber antenna	2.4G	2.5	110	-	SMA-J	Flexible & omnidirectional antenna
TX2400-JK-20	Rubber antenna	2.4G	3.0	200	-	SMA-J	Flexible & omnidirectional antenna
TX2400-XPL-150	Sucker antenna	2.4G	3.5	150	150	SMA-J	small-size sucker antenna, cost-effective

## 11. Package



## Revision history

Version	Date	Description	Issued by
1.0	2020-4-22	Initial version	Ken

## About us

Technical support: [support@cdebyte.com](mailto:support@cdebyte.com)

Documents and RF Setting download link: [www.ebyte.com](http://www.ebyte.com)

Thank you for using Ebyte products! Please contact us with any questions or suggestions: [info@cdebyte.com](mailto:info@cdebyte.com)

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**Chengdu Ebyte Electronic Technology Co.,Ltd.**