T5-E1 Module Datasheet

Version: 20240816

Contents

T5-E1 is a highly integrated single-antenna single-band 2.4 GHz Wi-Fi 6 (IEEE 802.11b/g/n/ax) and Bluetooth 5.4 Low Energy (LE) combo IoT module. Featuring a multi-peripheral packaging and ultra-low-power chip, the T5-E1 module provides a highly integrated, efficient, secure, and lowest-power environment for IP cameras, HMI applications, smart locks, and other advanced IoT applications.

1. Features

1.1. CPU and on-chip memory

- Built-in with Tuya's custom T5QN88 chip, Armv8-M Star (M33F) processor, with clock frequency of up to 480 MHz
- 8 MB Flash
- 16 MB PSRAM
- 640 KB Share SRAM
- 64 KB ROM

1.2. Wi-Fi

- IEEE 802.11b/g/n/ax compliant
- 20 MHz and 40 MHz channel bandwidth
- Support downlink multi-user multiple input, multiple output (DL MU-MIMO)
- Support orthogonal frequency-division multiple access (OFDMA)
- Support target wake time (TWT)
- Integrated Bluetooth and Wi-Fi coexistence (packet traffic arbitration, PTA)
- Transmit (TX) power up to +20 dBm
- Receive (RX) sensitivity of −99 dBm
- Antenna gain of 3.25 dBi

1.3. Bluetooth

- Support Bluetooth LE 5.4 standard
- Support Bluetooth LE 1 Mbit/s and 2 Mbit/s, long-range mode (125 Kbit/s and 500 Kbit/s)
- TX power +6 dBm
- RX sensitivity of −97 dBm
- Antenna gain of 3.25 dBi

1.4. Peripherals

- 48x GPIOs

- 2x SPIs and 2x QSPIs
- 3x UART interfaces: 1 channel has hardware flow control and supports flash download
- 1x smart card controller
- 1x SDIO interface, 2x I2C interfaces, and 1x CAN controller with CAN FD
- 1x high-speed (HS) USB 2.0 interface
- 1x display controller supporting RGB565 and 8080 interfaces
- 1x segment LCD controller for up to 4 × 32 segments
- 1x 8-bit CIS DVP interface
- 1x 720p H.264 video encoder
- 1x Ethernet MAC interface
- 12x 32-bit PWM channels
- 3x I2S interfaces
- 2x audio ADCs and 1x audio DAC
- 12-bit AUX ADC, up to 11 channels
- 1x touch sensor, up to 16 touch sensing I/Os

1.5. Antenna type

- Onboard antenna

1.6. Operating conditions

- Operating/supply voltage range: 2.0V to 3.6V
- Operating temperature range: −40°C to 85°C

1.7. Module certification

- Wi-Fi & Bluetooth: FCC and CE
- Environmental certification: REACH/RoHS
- Bluetooth certification: BQB

1.8. Reliability test

- High and low temperature, high temperature and high humidity, high temperature, and cold start tests

- Salt spray and electrostatic discharge tests

2. Scope of applications

- Human-machine interaction (HMI) application
- Home appliance
- Air conditioner
- Refrigerator
- Thermostat
- Dishwasher
- Robot vacuum
- Smart socket
- Smart lighting
- Industrial wireless control
- Baby monitor
- IP camera and smart lock
- Smart bus

3. Pin definition

3.1. Pin layout

The pin layout diagram shows the approximate location of the pins on the module. For the actual layout drawn to scale, refer to the module dimensional drawings.

3.2. Pin definition

The module has a total of 70 pins. For a detailed description, refer to the table below.

No.	Name	I/O type	Description
1	GND	P	Ground pin
2	3V3	P	Power pin
3	RST	I	The low-level reset pin, active high, and pulled up internally
4	P20	I/O	• GPIO20 • I2C0_SCL • SWCLK • RGB_R6 • I8080_D9 • SEG10
5	P21	I/O	• I2C0_SDA • SWDIO • ADC6 • RGB_R5 • I8080_D8 • SEG9
6	P22	I/O	• CLK26M • PWMG0_PWM2 • ADC5 • QSPI0_SCK • RGB_R4 • I8080_CSX • SEG8
7	P23	I/O	• PWMG0_PWM3 • ADC3 • QSPI0_CS • RGB_R3 • I8080_RESET • SEG7

No.	Name	I/O type	Description
8	P24	I/O	• LPO_CLK • PWMG0_PWM4 • ADC2 • QSPI0_IO0 • RGB_G7 • I8080_RSX • SEG6
9	P25	I/O	• IRDA • PWMG0_PWM5 • ADC1 • QSPI0_IO1 • RGB_G6 • I8080_WRX • SEG5
10	P26	I/O	• QSPI0_IO2 • RGB_G5 • I8080_RDX • SEG4
11	P28	I/O	• I2S_MCLK • ADC4 • TOUCH2 • CLK_AUXS_CIS • SEG18
12	P1	I/O	• UART1_RX • I2C1_SDA • SWDIO • SC_CLK • ADC13 • LIN_RXD
13	DN	I/O	USB D-
14	DP	I/O	USB D+

No.	Name	I/O type	Description
15	P0	I/O	• UART1_TX • I2C1_SCL • SWCLK • SC_IO • ADC12 • LIN_TXD
16	P9	I/O	• PWMG0_PWM3 • I2S0_DOUT • DMIC_DAT • 32K_XI
17	P8	I/O	• PWMG0_PWM2 • I2S0_DIN • DMIC_CLK • ADC10 • 32K_XO
18	P7	I/O	• PWMG0_PWM1 • I2S0_SYNC • QSPI1_IO3
19	P6	I/O	• PWMG0_PWM0 • I2S0_SCK • QSPI1_IO2
20	P5	I/O	• SPI1_MISO • SDIO_DATA1 • COM7 • QSPI1_IO1 • SEG31
21	P4	I/O	• SPI1_MOSI • SDIO_DATA0 • COM6 • QSPI1_IO0 • SEG30

No.	Name	I/O type	Description
22	P3	I/O	• SPI1_CSN • SDIO_CMD • SC_VCC • QSPI1_CS
23	P2	I/O	• SPI1_SCK • SDIO_CLK • SC_RSTN • LIN_SLEEP • QSPI1_SCK
24	P12	I/O	• UART0_RTS • TOUCH0 • ADC14
25	P13	I/O	• UART0_CTS • TOUCH1 • ADC15
26	P15	I/O	• SDIO_CMD • SPI0_CSN • I2C1_SDA • RGB_DISP • I8080_D14 • SEG15
27	P14	I/O	• SDIO_CLK • SPI0_SCK • I2C1_SCL • RGB_DCLK • I8080_D15 • SEG16
28	P16	I/O	• SDIO_DATA0 • SPI0_MOSI • RGB_DE • I8080_D13 • SEG14

No.	Name	I/O type	Description
29	P17	I/O	• SDIO_DATA1 • SPI0_MISO • RGB_HSYNC • I8080_D12 • SEG13
30	P18	I/O	• SDIO_DATA2 • PWMG0_PWM0 • RGB_VSYNC • I8080_D11 • SEG12
31	P19	I/O	• SDIO_DATA3 • PWMG0_PWM1 • RGB_R7 • I8080_D10 • SEG11
32	P47	I/O	• SPI0_MISO • ENET_MDC • TOUCH15 • RGB_B3 • I8080_D0 • COM0 • I2S2_DOUT
33	P46	I/O	• CAN_STBY • SPI0_MOSI • ENET_PHY_INT • TOUCH14 • RGB_B4 • I8080_D1 • COM1 • I2S2_DIN

No.	Name	I/O type	Description
34	P45	I/O	• CAN_RX • SPI0_CSN • RGB_B5 • I8080_D2 • COM2 • I2S2_SYNC
35	P44	I/O	• CAN_TX • SPI0_SCK • RGB_B6 • I8080_D3 • COM3 • I2S2_SCK
36	RXD	I/O	• DL_UART_RX • SDIO_DATA2 • CLK_AUXS_CIS • UART0_RX • Flash firmware and authorize modules
37	TXD	I/O	• DL_UART_TX • UART0_TX • SDIO_DATA3 • Flash firmware and authorize modules
38	P43	I/O	• I2C1_SDA • I2S1_DOUT • SC_VCC • RGB_B7 • I8080_D4 • SEG0

No.	Name	I/O type	Description
39	P42	I/O	• I2C1_SCL • I2S1_DIN • LIN_SLEEP • SC_RSTN • RGB_G2 • I8080_D5 • SEG1
40	GND	P	Ground pin
41	P27	I/O	• CIS_MCLK • CLK_AUXS_CIS • ENET_PHY_INT • QSPI0_IO3 • SEG17
42	P29	I/O	• CIS_PCLK • ENET_MDC • TOUCH3 • SEG19
43	GND	P	Ground pin
44	GND	P	Ground pin
45	P41	I/O	• UART2_TX • I2S1_SYNC • LIN_TXD • SC_IO • RGB_G3 • I8080_D6 • SEG2
46	P31	I/O	• CIS_VSYNC • UART2_TX • LIN_TXD • TOUCH5 • SC_IO • SEG21

No.	Name	I/O type	Description
47	P30	I/O	• CIS_HSYNC • UART2_RX • LIN_RXD • TOUCH4 • SC_CLK • SEG20
48	P33	I/O	• CIS_PXD1 • PWMG1_PWM1 • ENET_RXD0 • TOUCH7 • TOUCH7 • SEG23
49	P32	I/O	• CIS_PXD0 • PWMG1_PWM0 • ENET_MDIO • TOUCH6 • SC_RSTN • SEG22
50	GND	P	Ground pin
51	P34	I/O	• CIS_PXD2 • PWMG1_PWM2 • ENET_RXD1 • TOUCH8 • SPI0_CSN • SEG24
52	P35	I/O	• CIS_PXD3 • PWMG1_PWM3 • ENET_RXDV • TOUCH9 • SPI0_MOSI • SEG25
53	GND	P	Ground pin

No.	Name	I/O type	Description
54	GND	P	Ground pin
55	GND	P	Ground pin
56	P36	I/O	• CIS_PXD4 • PWMG1_PWM4 • ENET_TXD0 • TOUCH10 • SPI0_MISO • SEG26
57	P37	I/O	• CIS_PXD5 • PWMG1_PWM5 • ENET_TXD1 • TOUCH11 • SEG27
58	GND	P	Ground pin
59	GND	P	Ground pin
60	VIO	AO	GPIO LDO output
61	LN	AO	Audio left channel negative output
62	LP	AO	Audio left channel positive output
63	P38	I/O	• CIS_PXD6 • I2C1_SCL • ENET_TXEN • TOUCH12 • COM4 • SEG28
64	P39	I/O	• CIS_PXD7 • I2C1_SDA • ENET_REF_CLK • TOUCH13 • COM5 • SEG29

No.	Name	I/O type	Description
65	P40	I/O	• UART2_RX • I2S1_SCK • LIN_RXD • SC_CLK • RGB_G4 • I8080_D7 • SEG3
66	MP1	AO	Microphone 1 positive input
67	MN1	AO	Microphone 1 negative input
68	MN2	AO	Microphone 2 negative input
69	MP2	AO	Microphone 2 positive input
70	MBS	AO	Microphone bias output

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- P indicates the power pin.
- I/O indicates the input and output pin.
- AI indicates the analog signal input pin.
- AO indicates the analog signal output pin.

4. Electrical parameters

4.1. Absolute electrical parameters

Parameter	Description	Minimum value	Maximum value	Unit
Ts	Storage temperature	−55	125	°C
VBAT	Supply voltage	−0.3	3.6	V
Electrostatic discharge voltage (human body model)	TAMB −25°C	−4	4	kV
Electrostatic discharge voltage (machine model)	TAMB −25°C	−200	200	V

4.2. Normal operating conditions

Parameter	Description	Minimum value	Typical value	Maximum value	Unit
Ta	Operating temperature	−40	-	85	°C
VBAT	Supply voltage	2.0	3.3	3.6	V
VOL	I/O low-level output	VSS	-	VSS + 0.3	V

Parameter	Description	Minimum value	Typical value	Maximum value	Unit
VOH	I/O high-level output	VBAT − 0.3	-	VBAT	V
Imax	I/O drive current	-	6	20	mA
θ	Supply voltage slope	100	-	-	mV/ms

4.3. Radio frequency (RF) power

Operating status	Mode	Rate	Transmit/Receive power	Average value	Peak (Typical) value	Unit
Transmit	11B	11 Mbit/s	+17 dBm	-	322	mA
Transmit	11G	54 Mbit/s	+15 dBm	-	275	mA
Transmit	11N	HT20 MCS7	+14 dBm	-	265	mA
Transmit	11AX	HE20 MCS7	+14 dBm	-	264	mA
Receive	11B	11 Mbit/s	Continuous reception	-	23	mA
Receive	11G	54 Mbit/s	Continuous reception	-	23	mA
Receive	11N	HT20 MCS7	Continuous reception	-	23	mA
Receive	11AX	HE20 MCS7	Continuous reception	-	23	mA

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In order to test the transmitting operating current, the module is in the state of sending packets at 100% duty cycle.

4.4. Operating current

Operating mode	Status (Ta = 25°C)	Average value	Max (Typical) value	Unit
Quick pairing (Bluetooth)	The module is in EZ mode. The network status indicator blinks quickly.	5.9	290	mA
Quick pairing (AP)	The module is in AP mode. The network status indicator blinks slowly.	18	292	mA
Quick pairing (EZ)	The module is in EZ mode. The network status indicator blinks quickly.	TBD	TBD	mA
Connected	The module is connected to the cloud. The network status indicator is steady on.	5.6	286	mA

Weakly connected	The connection between the module and the hotspot is intermittent. The network status indicator is steady on.	5.8	290	mA
Disconnected	The module is disconnected from the cloud. The network status indicator is steady off.	24	287	mA
Module disabled	The module's clock enable (CEN) pin is pulled down.	133	-	µA

5. RF parameters

5.1. Basic RF features

Parameter	Description
Operating frequency	2.412 to 2.484 GHz
Wi-Fi standard	IEEE 802.11b/g/n/ax (channels 1–14)
Data transmission rate	• 11b：1，2，5.5 and 11 Mbps • 11g：6，9，12，18，24，36，48 and 54 Mbps • 11n：HT20 MCS0-7，HT40 MCS0-7 • 11ax：HE20 MCS0-9，HE40 MCS0-9
Antenna type	PCB antenna with a gain of 3.25 dBi

5.2. Wi-Fi transmitter (TX) performance

Parameter	Minimum value	Typical value	Maximum value	Unit
RF average output power, 802.11b CCK mode, 11 Mit/s	15	17	19	dBm
RF average output power, 802.11g OFDM mode, 54 Mbit/s	13	15	17	dBm
RF average output power, 802.11n OFDM mode, HT20 MCS7	12	14	16	dBm

Parameter	Minimum value	Typical value	Maximum value	Unit
RF average output power, 802.11n OFDM mode, HT40 MCS7	11	13	15	dBm
RF average output power, 802.11ax OFDMA Mode, HE20 MCS7	12	14	16	dBm
RF average output power, 802.11ax OFDMA Mode, HE40 MCS7	11	13	15	dBm
Frequency error	−20	-	20	ppm

5.3. Wi-Fi receiver (RX) performance

Parameter	Minimum value	Typical value	Maximum value	Unit
PER < 8%, RX sensitivity, 802.11b DSSS mode, 11 Mbit/s	-	−88	-	dBm

Parameter	Minimum value	Typical value	Maximum value	Unit
PER < 10%, RX sensitivity, 802.11g OFDM mode, 54 Mbit/s	-	−74	-	dBm
PER < 10%, RX sensitivity, 802.11n OFDM mode, MCS7	-	−73	-	dBm
PER < 10%, RX sensitivity, 802.11ax OFDMA Mode, MCS9	-	−69	-	dBm
PER < 10%, RX sensitivity, Bluetooth LE, 1 Mbit/s	-	−97	-	dBm

5.4. Bluetooth transmitter (TX) performance

Parameter	Minimum value	Typical value	Maximum value	Unit
Operating frequency	2402	-	2480	MHz
Transmission rate over the air	-	-	-	Mbit/s
Transmission power	−20	6	15	dBm

Parameter	Minimum value	Typical value	Maximum value	Unit
Frequency error	−150	-	150	KHz

5.5. Bluetooth receiver (RX) performance

Parameter	Minimum value	Typical value	Maximum value	Unit
RX sensitivity	-	−97	-	dBm
Max RF signal input	−10	-	-	dBm
Intermodulation	-	-	−23	dBm
Adjacent-channel rejection ratio	-	10	-	dB

6. Antenna information

6.1. Antenna type

The T5-E1 module uses an onboard PCB antenna with a gain of 3.25 dBi.

6.2. Antenna interference reduction

When a PCB antenna is used on a Wi-Fi module, we recommend that the module antenna is at least 15 mm away from other metal components. This can optimize the Wi-Fi performance.
Make sure that the enclosure surrounding the antenna is not traced or filled with copper. Otherwise, the RF performance might be degraded. According to the antenna shape of the T5-E1 module, you can choose **Position 3** or **Position 4 (optimal)** when using the module.

7. Development guide

7.1. MCU integration

For more information about MCU integration solutions, see Hardware Design of CBx Series Modules .

8. Packing and production instructions

8.1. Mechanical dimensions

The T5-E1 dimensions are 18.00±0.35 mm (W) × 25.50±0.35 mm (L) × 2.8±0.15 mm (H).

8.3. Production instructions

1. Package the module with the SMT if Tuya's module is designed to be SMT-

   packaged. After being unpacked, the module must be soldered within 24

hours. Otherwise, it needs to be put into a drying cupboard with a relative humidity level no greater than 10%, or pack the module in vacuum again. Then, record the packing time and duration of exposure. The total exposure time cannot exceed 168 hours.

- Instruments or devices required for the SMT process:
- Surface mount system
- SPI
- Reflow soldering machine
- Thermal profiler
- AOI
- Instruments or devices required for the baking process:
- Cabinet oven
- Electro-static discharge (ESD) protection and heat-resistant trays
- ESD protection and heat-resistant gloves

2. A delivered module must meet the following storage requirements:

- The moisture-proof bag must be placed in an environment where the temperature is below 40°C and the relative humidity is lower than 90%.
- The shelf life of a dry-packaged product is 12 months from the date when the product is packaged and sealed.
- A humidity indicator card (HIC) is put in the sealed package.

3. The module needs to be baked in the following cases:

- The vacuum packaging bag is damaged before unpacking.
- After unpacking, no HIC is found in the packaging bag.
- After unpacking, the HIC indicates a humidity level of 10% or higher. In this case, the circle turns pink on the HIC.
- The total exposure time has lasted for over 168 hours since unpacking.
- More than 12 months have passed since the first sealing of the bag.

4. The baking parameter settings are described below:

• Baking temperature: 40°C for reel packaging with relative humidity ≤ 5%. And 125°C for tray packaging with relative humidity ≤ 5% (use a heat-resistant tray, rather than plastic containers).

• Baking time: 168 hours for reel packaging and 12 hours for tray packaging.

• Temperature for triggering an alert: 50°C for reel packaging and 135°C for tray packaging.

• Production can begin after a module has cooled down to below 36°C under natural conditions.

• If a module remains unused for over 168 hours after being baked, it needs to be baked again.

• If a batch of modules is not baked after exposure for more than 168 hours, do not use wave soldering to solder them. Because these modules are level-3 moisture-sensitive devices, they are very likely to get damp when exposed beyond the allowable time. In this case, if they are soldered at high temperatures, device failure or poor soldering performance might occur.

5. In the whole production process, take electrostatic discharge (ESD) protective measures.

6. To guarantee the pass rate, we recommend that you use the SPI and AOI to monitor the quality of solder paste printing and mounting.

8.4. Recommended oven temperature curve

Set the temperature according to the following temperature curve of reflow soldering. The peak temperature is 245°C.

IPC-7530a-3-1-cn
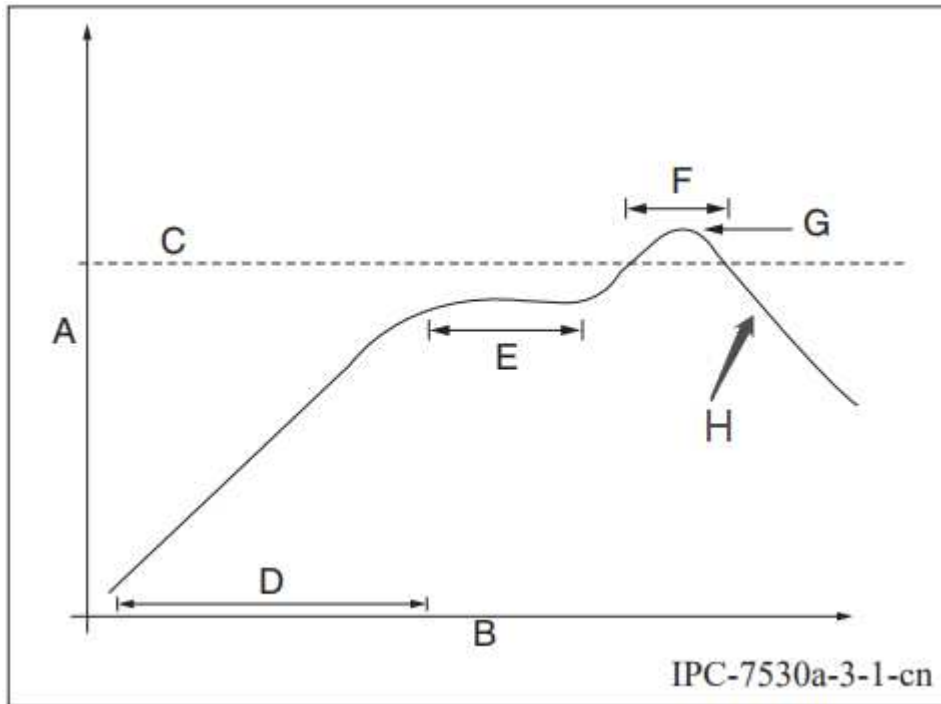
- A: temperature axis
- B: time axis
- C: alloy liquidus temperature from 217°C to 220°C
- D: ramp-up slope from 1°C/s to 3°C/s
- E: keep a constant temperature from 150°C to 200°C for a time period from 60s to 120s
- F: temperature above liquidus temperature for 50s to 70s
- G: peak temperature from 235°C to 245°C
- H: ramp-down slope from 1°C/s to 4°C/s

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> The curve above is based on solder paste SAC305. For more information about other solder pastes, see the recommended oven temperature curve in the specified solder paste specifications.

8.5. Storage conditions

Caution

This bag contains
MOISTURE-SENSITIVE DEVICES

LEVEL

3

If blank, see adjacent
bar code label

1. Calculated shelf life in sealed bag: 12 months at <40°C and <90% relative humidity (RH)

2. Peak package body temperature: _____**260**_____ °C
   If blank, see adjacent bar code label

3. After bag is opened, devices that will be subjected to reflow solder or other high temperature process must be

   a) Mounted within: _____**168**_____ hours of factory conditions
      If blank, see adjacent bar code label
      ≤30°C/60% RH, or

   b) Stored per J-STD-033

4. Devices require bake, before mounting, if:

   a) Humidity Indicator Card reads >10% for level 2a - 5a devices or >60% for level 2 devices when read at 23 ± 5°C

   b) 3a or 3b are not met

5. If baking is required, refer to IPC/JEDEC J-STD-033 for bake procedure

                          See Production Date
Bag Seal Date: _____
                  If blank, see adjacent bar code label

Note: Level and body temperature defined by IPC/JEDEC J-STD-020

9. MOQ and packaging information

Product model	MOQ (pcs)	Shipping packaging	Modules per reel	Reels per carton
T5-E1	3600	Tape and reel	900	4

10. Appendix: Statement

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this device. This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Note: This device has been tested and found to comply with the limits for a Class B digital device, according to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This device generates, uses, and can radiate radio frequency energy and, if not installed and used following the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

If this device does cause harmful interference to radio or television reception, which can be determined by turning the device off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

• Reorient or relocate the receiving antenna.

• Increase the separation between the device and receiver.

• Connect the device into an outlet on a circuit different from that to which the receiver is connected.

• Consult the dealer or an experienced radio/TV technician for help.

Radiation Exposure Statement

This device complies with FCC radiation exposure limits set forth for an uncontrolled rolled environment. This device should be installed and operated with a minimum distance of 20cm between the radiator and your body.

Important Note

This radio module must not be installed to co-locate and operate simultaneously with other radios in the host system except by following FCC multi-transmitter product procedures. Additional testing and device authorization may be required to operate simultaneously with other radios.

The availability of some specific channels and/or operational frequency bands are country-dependent and are firmware programmed at the factory to match the intended destination. The firmware setting is not accessible to the end-user.

The host product manufacturer is responsible for compliance with any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. The final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

The end-user manual shall include all required regulatory information/warnings as shown in this manual, including "This product must be installed and operated with a minimum distance of 20 cm between the radiator and user body".

This device has got an FCC ID: 2ANDL-T5-E1. The end product must be labeled in a visible area with the following: "Contains Transmitter Module FCC ID: 2ANDL-T5-E1".

This device is intended only for OEM integrators under the following conditions: The antenna must be installed such that 20cm is maintained between the antenna and users, and the transmitter module may not be co-located with any other transmitter or antenna.

As long as the 2 conditions above are met, further transmitter tests will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

Declaration of Conformity European Notice

Hereby, Hangzhou Tuya Information Technology Co., Ltd declares that this module product is in compliance with essential requirements and other relevant provisions of Directive 2014/53/EU,2011/65/EU. A copy of the Declaration of Conformity can be found at https://www.tuya.com.

This product must not be disposed of as normal household waste, in accordance with the EU directive for waste electrical and electronic equipment (WEEE-2012/19/EU). Instead, it should be disposed of by returning it to the point of sale, or to a municipal recycling collection point.

The device could be used with a separation distance of 20cm from the human body.