BW20-12F Specification

Version V1.0.0

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Document resume

Version	Date	Develop/revise content	Edition	Approve
V1.0.0	2024.06.13	First Edition	Xihuan Lu	Ning Guang

Content

1. Product overview

BW20-12F is a dual-band Wi-Fi + BLE SoC module developed by Ai-Thinker based on RTL8711 series chips, which supports dual-frequency (2.4 GHz or 5 GHz)802.11a/b/g/n WLAN protocol and Bluetooth 5.0 protocol. The BW 20-12F integrates dual-core MCU, a ARM V8.1 (Cortex-M4F compatible) high-performance MCU with a maximum frequency of 330 MHz; a ARM V8M (Cortex-M0 compatible) low-power MCU.

The BW20-12F module has rich peripheral interfaces, including UART / GPIO / ADC / PWM / IIC / SPI / SDIO / IR / SWD / USB etc. It can be widely used in the Internet of Things (IoT), mobile devices, wearable electronic devices, smart home and other fields.

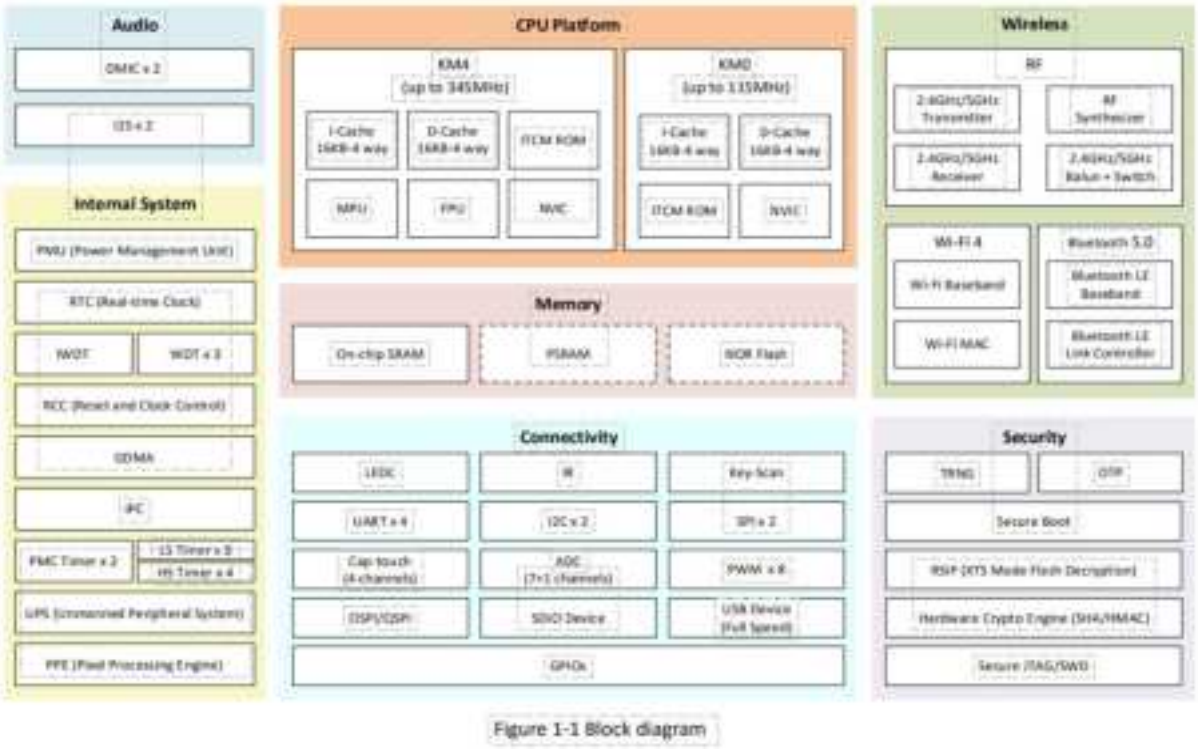


Figure 1 Chip Block Diagram

1.1. Characteristic

- Support for the 802.11a/b/g/n protocol
- Support for dual-frequency 2.4GHz or 5GHz
- Supports the HT20 / HT40 mode
- Support for Bluetooth 5.0
- Support for BLE Long Range
- The Bluetooth supports a high-power mode LE data length extension
- Support for link layer privacy
- Support for the hardware encryption engine Integrated dual-core MCU, up to 330 MHz
- Abundant interfaces, with 17 flexible IO ports
- Wi-Fi and Bluetooth share the same antenna
- Support secondary development, support programming in Linux and Windows environments
- Support for Arduino development

2. Main parameters

Table 1 Description of the main parameters

Model	BW20-12F
Package	SMD-22
Size	24*16*3.2(±0.2)MM
Antenna	on-board PCB antenna、IPEX connector（1st generation）
Frequency range	2400~2483.5MHz and 5180~5825MHz
Operating temperature	-40 ℃~85 ℃
Storage temperature	-40 ℃~125 ℃，<90%RH
Power supply	Voltage supply 3.0V~3.6V，Current supply>500mA
Support interface	UART/GPIO/ADC/PWM/IIC/SPI/SDIO/IR/SWD/USB
Available IO	Default 17
UART rate	Default 115200bps
Bluetooth	BLE 5.0
SPI flash	Default 4MByte

2.1. Static electricity requirement

BW 20-12F module is electrostatic sensitive equipment, which requires special ESD precautions, and usually ESD protective devices should be added in use. Proper ESD handling and packaging must be used during the transportation, operation, and use of the BW 20-12F module. Do not touch the module by hand or use non-antistatic iron to damage the module.

Figure 2 ESD Anti-static diagram

2.2. Electrical characteristics

Table 2 Electrical characteristics table

Parameters		Condition	Min.	Typical value	Max.	Unit
Voltage supply		3V3	3.0	3.3	3.6	V
I/O	VIL	-	-	-	0.3*VDD	V
	VIH	-	0.65*VDD	-	-	V
	VOL	-	-	0.15*VDD	-	V
	VOH	-	-	0.85*VDD	-	V

2.3. Wi-Fi RF performance

Table 3 BLE RF performance

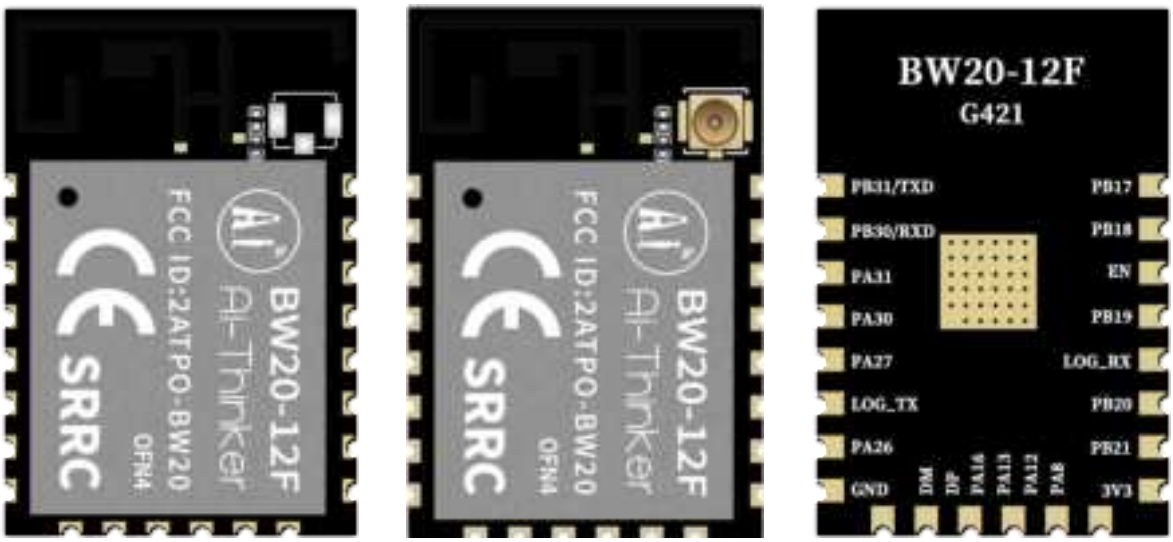
Description	Typical value			Unit
Frequency range	2400~2483.5 and 5180~5825			MHz
Output power				
Mode	**Min. value**	**Typical value**	**Max.**	**Unit**
11a mode，PA output power	-	24.083	-	dBm
11b mode，PA output power	-	23.908	-	dBm
11g mode，PA output power	-	23.981	-	dBm
11n mode，PA output power	-	23.918	-	dBm
Receiving sensitivity				
Mode	**Min.value**	**Typical value**	**Max.**	**Unit**
11b，1Mbps	-	-99	-	dBm
11b，11Mbps	-	-90	-	dBm
11a/g，6Mbps	-	-94	-	dBm
11a/g，54Mbps	-	-76	-	dBm
HT20（MCS0）	-	-93	-	dBm
HT20（MCS7）	-	-74	-	dBm
HT40（MCS0）	-	-91	-	dBm
HT40（MCS7）	-	-71	-	dBm

2.4. BLE RF performance

Table 4 BLE RF performance

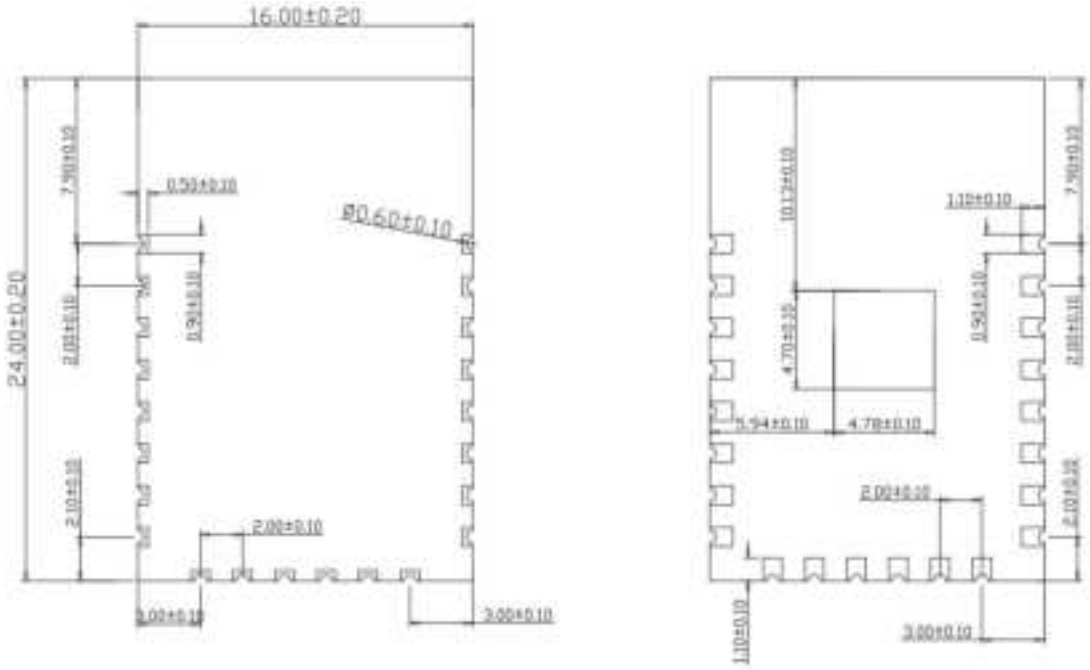
Description	Typical value			Unit
Frequency range	2400 ~ 2480MHz			MHz
Output power				
Rate mode	**Min.value**	**Typical value**	**Max.value**	**Unit**
1Mbps	-	8.153	-	dBm
2Mbps	-	8.139	-	dBm
Receiving sensitivity				
Rate mode	**Min.value**	**Typical value**	**Max.value**	**Unit**
1Mbps @30.8%PER	-	-99	-	dBm
2Mbps @30.8%PER	-	-97	-	dBm

3. Appearance dimensions



Front Front Back

Figure 3 Appearance diagram (Rendering figure is for reference only,subject to physical objects)



Front Back

Figure 4 Size diagram

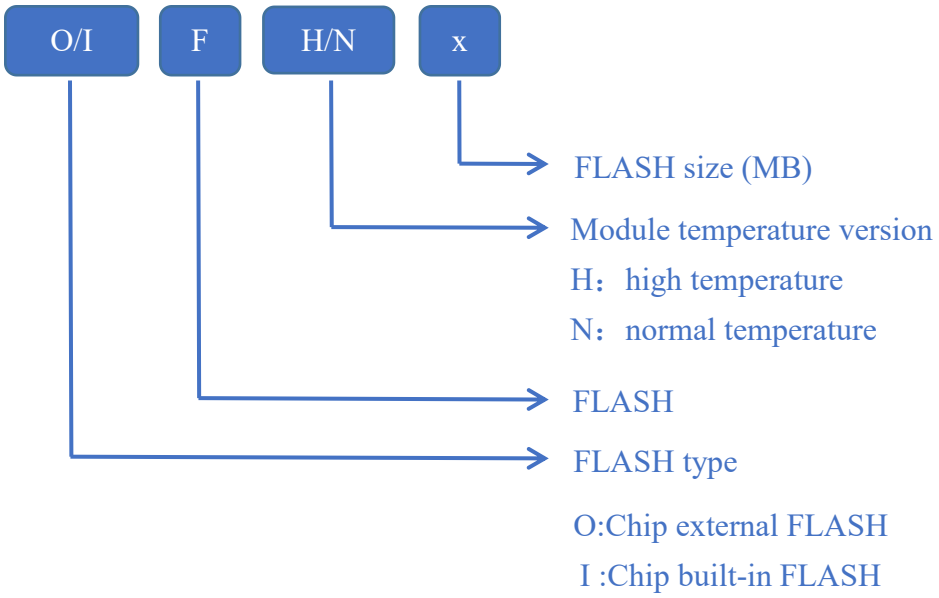
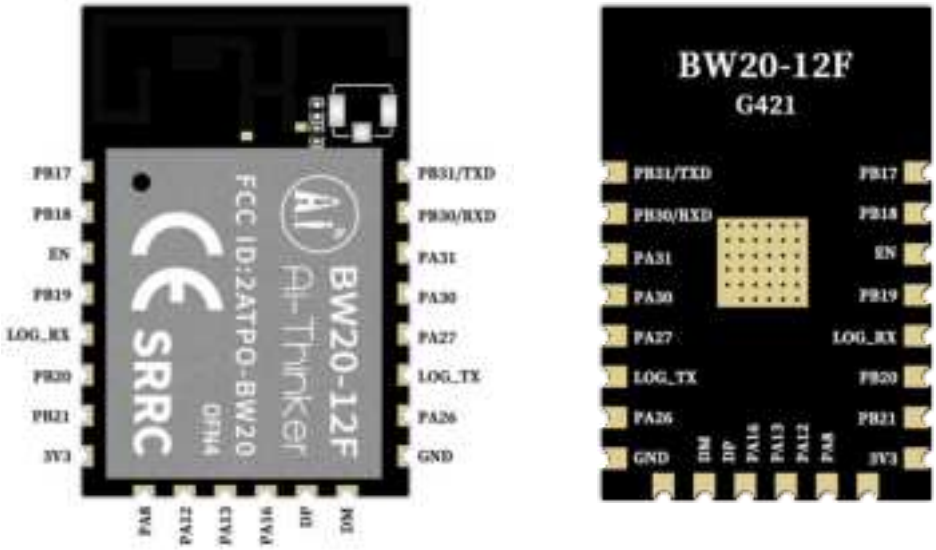


Figure 5 The screen cover information

4. Pin definition

BW20-12F is connected a total of 22 pins, as in the pin schematic diagram, and the definition of the pin function is shown in the following table.



Front Back

Figure 6 Pin diagram

Table 5 Pin function definition table

No.	Name	Function description
1	PB17	TOUCH2_ADC2/SPI1_CS/SD_D3
2	PB18	TOUCH1_ADC1/SPI1_CLK/SD_CMD
3	EN	Chips enable pin and pull up effectively
4	PB19	TOUCH0_ADC0/SPI1_MOSI/SD_CLK
5	LOG_RX	UART_LOG_RXD，Firmware download RX pin
6	PB20	SPI1_MISO/SWD_CLK/SD_D0
7	PB21	SPI1_CS/SWD_DAT/SD_D1
8	3V3	3.3V power supply（VDD），the external power supply output current is recommended in above 500mA
9	PA8	PSRAM_DQ5/TIM8_TRIG
10	PA12	SPI0_CS/SD_D2/TIM9_TRIG
11	PA13	The default is not available and the IO is occupied by Flash inside the module. Please contact Ai-Thinker if need to use. SD_D2/external Flash this pin is NC

12	PA16	The default is not available and the IO is occupied by Flash inside the module. Please contact Ai-Thinker if need to use. SPI0_MISO/SD_CLK/external Flash this pin is NC
13	DP	PA29/SPI1_CLK/SD_CLK/FSDP
14	DM	PA28/SPI0_MISO/SD_CMD/FSDM
15	GND	Ground
16	PA26	SPI0_CLK/SD_D2
17	LOG_TX	UART _ LOG _ TXD, TX pin for download firmware, do not external pull down will enter Flash download mode
18	PA27	SPI0_MOSI/SD_D3
19	PA30	SPI1_MOSI/SWD_CLK/SD_D0，default function is SWD DATA，IC can be configured as PA31
20	PA31	SPI1_MISO/SWD_DAT/SD_D1，fefault function is SWD DATA，IC can be configured as PA31
21	PB30/RXD	UART 1 _ RXD, do not external pull down, external pull down will enter Load OTP settings
22	PB31/TXD	UART 1 _ TXD, do not external pull down, external pull down will enter the chip test mode

Note: 1. When LOG_TX is low level at the moment of power-on, the module enters the burning mode; when it is high level at the moment of power-on, the module starts normally and defaults is pull-up.
2. PA13 and PA16 are internally occupied in the external Flash version. At this time, these two IOs are unavailable and the pins are left floating.
3. PB30 / RXD Do not external pull down, external pull down will enter the Load OTP settings.
4. PB31 / TXD do not external down, external down will enter the chip test mode.

5. Schematic diagram

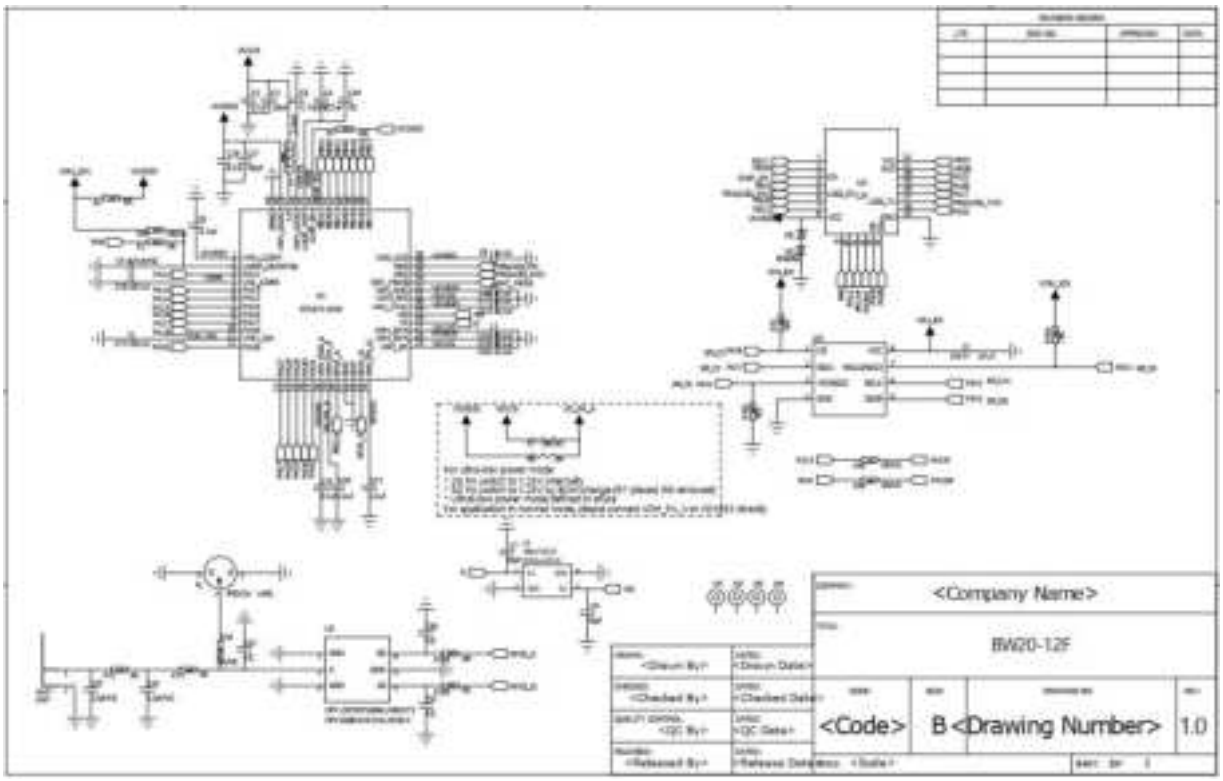


Figure 7 Schematic diagram

6. Design guide

6.1. Circuit guidance of application

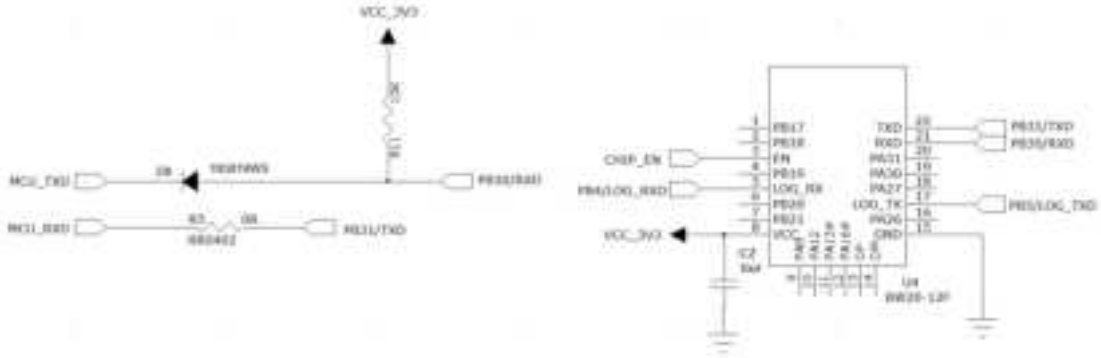


Figure 8 Circuit guidance of application

Note：

- LOG _ TX is the starting control pin in normal operating mode at high level and burning firmware mode at low level. Internal chip default high level.

6.2. Recommend PCB package size

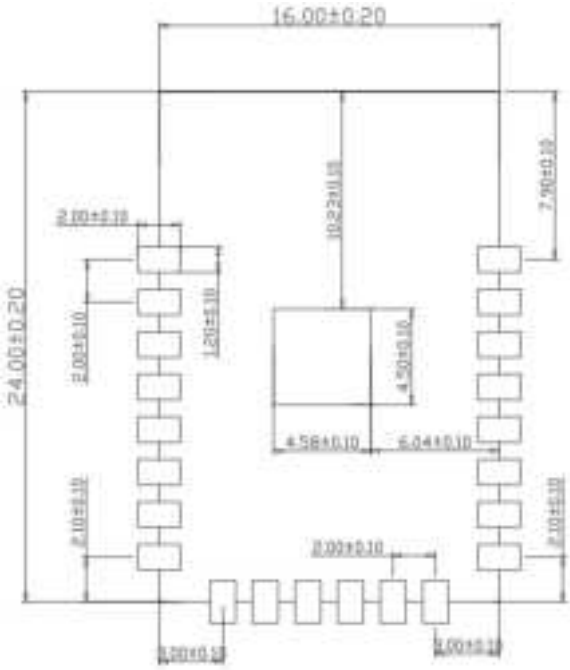


Figure 9 Recommend PCB package size（TOP view）

6.3. Antenna layout requirements

- In the installation position on the motherboard, the following two ways are recommended:

Scheme 1: put the module on the edge of the motherboard, and the antenna area extends of the edge of the motherboard.

Scheme two: put the module on the edge of the motherboard, which hollowed an area in the antenna position.

- In order to meet the performance of on-board antenna, metal parts are prohibited around the antenna, away from high-frequency devices.

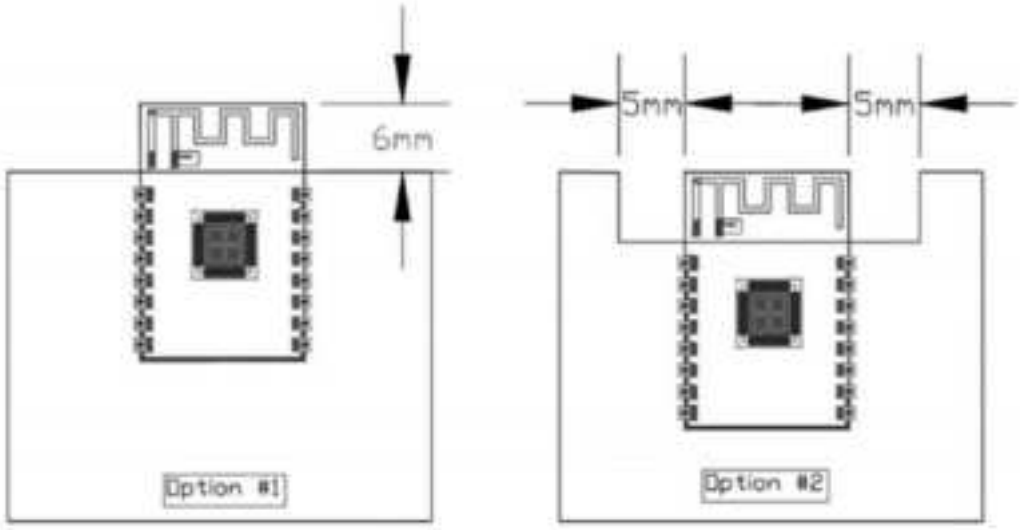


Figure 10 Schematic diagram of the antenna layout

6.4. Power supply

- Recommended 3.3V voltage, peak current above 500 mA.
- It is recommended to use LDO; if DC-DC, ripple control within 30 mV.
- The DC-DC power supply circuit suggests to reserve the position of the dynamic response capacitor, which can optimize the output ripple when the load change is large.
- 3.3V power interface, it is recommended to add ESD devices.
- If the power supply is boosted from 1.5V to 3.0V for more than 15 ms, add the voltage reset IC or use the wide voltage version Flash.
- During the repeated up and down process, if the voltage cannot be less than 0.3V, the voltage reset IC must be increased.

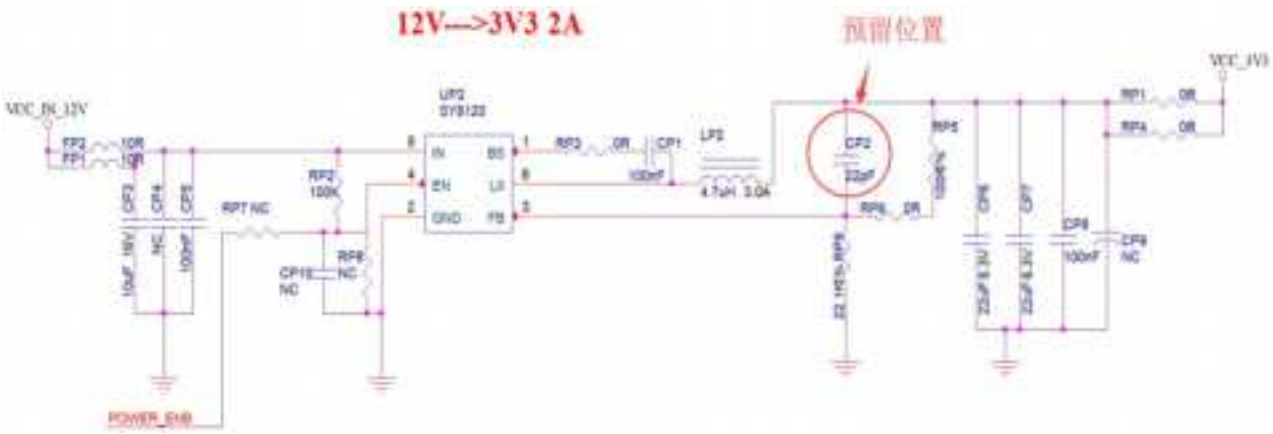


Figure 11 The DC-DC step-down circuit diagram

6.5. GPIO

- There are some IO ports on the periphery of the module. If you need to use it, it is recommended to connect a 10-100 ohm resistor in series with the IO port. This inhibits overshoot and makes both sides level more stable. It is helpful for EMI and ESD.
- For special I/O ports to be pulled up and down, refer to the usage instructions in the specifications, which may affect the module startup configuration.
- The IO port of the module is 3.3V. If the IO level of the main control and the module do not match, a level conversion circuit needs to be added.
- If the I/O port is directly connected to a peripheral port or terminals, for example, a pin row, reserve an ESD device near the terminal of the I/O cable.

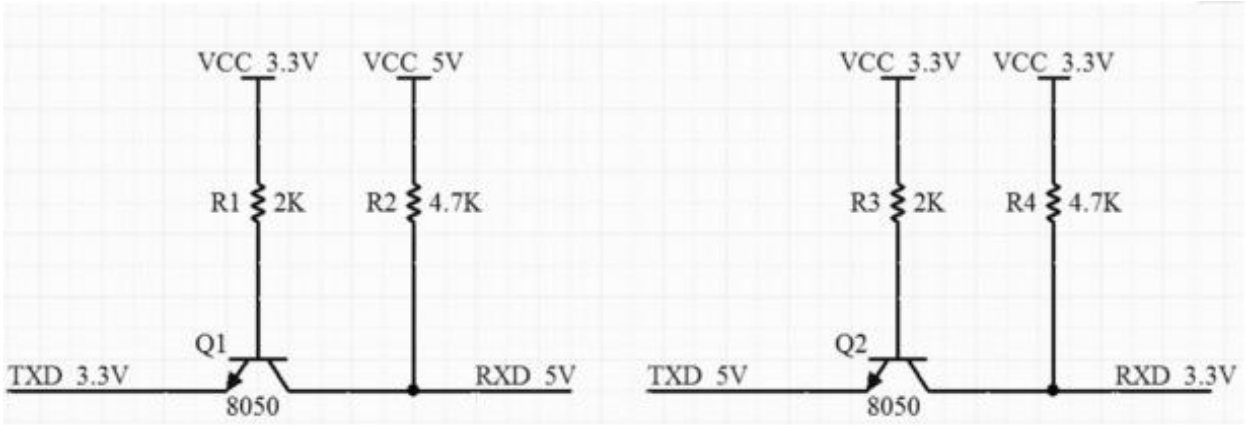


Figure 12 The level conversion circuit

7. Storage conditions

Products sealed in moisture-proof bags should be stored in a non-condensing atmosphere of <40 ° C /90%RH.

The module has a moisture sensitivity rating of MSL 3.

After the vacuum bag is opened, it must be used within 168 hours at 25±5℃/60%RH, otherwise it needs to be baked before it can be put on line again.

8. Reflow welding curve diagram

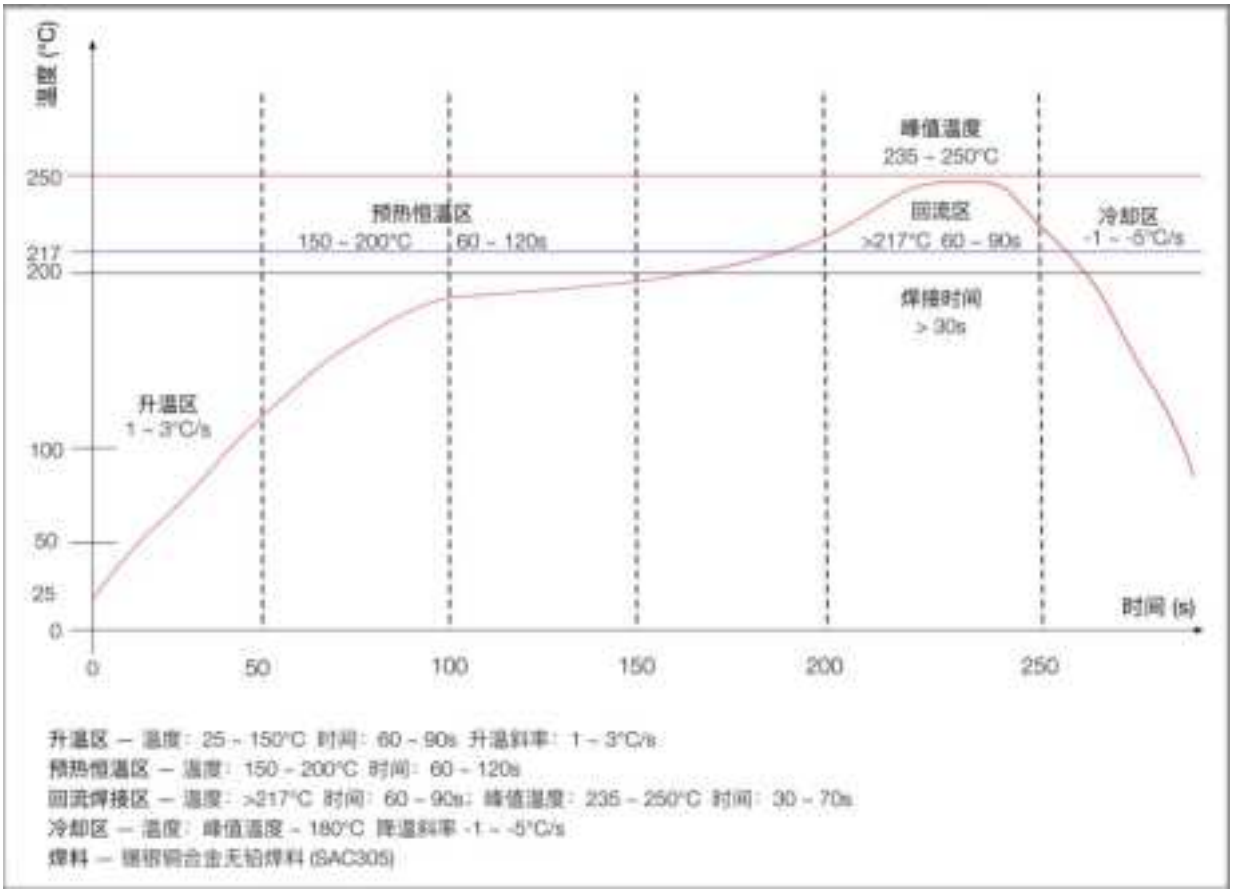


Figure 13 Reflow welding diagram

9. Product Packaging Information

BW20-12F module module was packaged in a tape, 800pcs/reel.As shown in the below image:

Figure 14 Package and packing diagram

10.Contact us

Ai-Thinker official website　　Office forum　　Develop DOCS

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WeChat mini program　　WeChat official account

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FCC WARNING

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

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.

This device and its antenna(s) must not be co-located or operating in conjunction with any other antenna or transmitter.

15.105 Information to the user.

(b) For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with 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 equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment 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 equipment and receiver.

—Connect the equipment 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.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator and your body. Radiation Exposure Statement: This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment.

This transmitter must not be co-located or operating in conjunction with any other

antenna or transmitter.
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 by the end user.
The final end product must be labelled in a visible area with the following:
“Contains Transmitter Module “FCC ID: 2ATPO-BW20”

Requirement per KDB996369 D03

2.2 List of applicable FCC rules

List the FCC rules that are applicable to the modular transmitter. These are the rules that specifically establish the bands of operation, the power,spurious emissions, and operating fundamental frequencies. DO NOT list compliance to unintentional-radiator rules (Part 15 Subpart B) since that is not a condition of a module grant that is extended to a host manufacturer. See also Section 2.10 below concerning the need to notify host manufacturers that further testing is required.3

Explanation: This module meets the requirements of FCC part 15C (15.247).it Specifically identified AC Power Line Conducted Emission, Radiated Spurious emissions, Band edge and RF Conducted Spurious Emissions, Conducted Peak Output Power, Bandwidth, Power Spectral Density, Antenna Requirement.

2.3 Summarize the specific operational use conditions

Describe use conditions that are applicable to the modular transmitter, including for example any limits on antennas, etc. For example, if point-to-point antennas are used that require reduction in power or compensation for cable loss, then this information must be in the instructions. If the use condition limitations extend to professional users, then instructions must state that this information also extends to the host manufacturer’s instruction manual. In addition, certain information may also be needed, such as peak gain per frequency band and minimum gain, specifically for master devices in 5 GHz DFS bands.

Explanation: The product antenna uses an irreplaceable antenna with a gain of 2.4GWIFI:2.33dBi, BT : 2.33dBi, WiFi (5.2G) : 2.91dBi, WiFi (5.3G) : 3dBi, WiFi (5.6G) : 3.79dBi WiFi, (5.8G) : 5.33dBi

2.4 Single Modular

If a modular transmitter is approved as a “Single Modular,” then the module manufacturer is responsible for approving the host environment that the Single Modular is used with. The manufacturer of a Single Modular must describe, both in the filing and in the installation instructions, the alternative means that the Single Modular manufacturer uses to verify that the host

meets the necessary requirements to satisfy the module limiting conditions. A Single Modular manufacturer has the flexibility to define its alternative method to address the conditions that limit the initial approval, such as: shielding, minimum signaling amplitude, buffered modulation/data inputs, or power supply regulation. The alternative method could include that the limited module manufacturer reviews detailed test data or host designs prior to giving the host manufacturer approval.

This Single Modular procedure is also applicable for RF exposure evaluation when it is necessary to demonstrate compliance in a specific host. The module manufacturer must state how control of the product into which the modular transmitter will be installed will be maintained such that full compliance of the product is always ensured. For additional hosts other than the specific host originally granted with a limited
module, a Class II permissive change is required on the module grant to register the additional host as a specific host also approved with the module.

Explanation: The module is a single module.

2.5 Trace antenna designs

For a modular transmitter with trace antenna designs, see the guidance in Question 11 of KDB Publication 996369 D02 FAQ – Modules for Micro-Strip Antennas and traces. The integration information shall include for the TCB review the integration instructions for the following aspects: layout of trace design, parts list (BOM), antenna, connectors, and isolation requirements.

a) Information that includes permitted variances (e.g., trace boundary limits, thickness, length, width, shape(s), dielectric constant, and impedance as applicable for each type of antenna); b) Each design shall be considered a different type (e.g., antenna length in multiple(s) of frequency, the wavelength, and antenna shape (traces in phase) can affect antenna gain and must be considered); c) The parameters shall be provided in a manner permitting host manufacturers to design the printed circuit (PC) board layout; d) Appropriate parts by manufacturer and specifications; e) Test procedures for design verification; and f) Production test procedures for ensuring compliance

The module grantee shall provide a notice that any deviation(s) from the defined parameters of the antenna trace, as described by the instructions, require that the host product manufacturer must notify the module grantee that they wish to change the antenna trace design. In this case, a Class II permissive change application is required to be filed by the grantee, or the host manufacturer can take responsibility through the change in FCC ID (new application) procedure followed by a Class II permissive change application

2.6 **RF exposure considerations**

It is essential for module grantees to clearly and explicitly state the RF exposure conditions that permit a host product manufacturer to use the

module. Two types of instructions are required for RF exposure information: (1) to the host product manufacturer, to define the application conditions (mobile, portable – xx cm from a person's body); and (2) additional text needed for the host product manufacturer to provide to end users in their end-product manuals. If RF exposure statements and use conditions are not provided, then the host product manufacturer is required to take responsibility of the module through a change in FCC ID (new application).

Explanation: The module complies with FCC radiofrequency radiation exposure limits for uncontrolled environments. The device is installed and operated with a distance of more than 20 cm between the radiator and your body." This module follows FCC statement design, FCC ID: 2ATPO-BW20

2.7 Antennas

A list of antennas included in the application for certification must be provided in the instructions. For modular transmitters approved as limited modules, all applicable professional installer instructions must be included as part of the information to the host product manufacturer. The antenna list shall also identify the antenna types (monopole, PIFA, dipole, etc. (note that for example an "omni-directional antenna" is not considered to be a specific "antenna type").

For situations where the host product manufacturer is responsible for an external connector, for example with an RF pin and antenna trace design, the integration instructions shall inform the installer that unique antenna connector must be used on the Part 15 authorized transmitters used in the host product.

The module manufacturers shall provide a list of acceptable unique connectors.

Explanation: The product antenna uses an irreplaceable antenna with a gain of **2.4GWIFI:2.33dBi, BT : 2.33dBi, WiFi (5.2G) : 2.91dBi, WiFi (5.3G) : 3dBi, WiFi (5.6G) : 3.79dBi WiFi, (5.8G) : 5.33dBi**

2.8 Label and compliance information

Grantees are responsible for the continued compliance of their modules to the FCC rules. This
includes advising host product manufacturers that they need to provide a physical or e-label stating “Contains FCC ID” with their finished product. See Guidelines for Labeling and User Information for RF Devices – KDB Publication 784748.

Explanation: The host system using this module, should have label in a visible area indicated the following texts: "Contains FCC ID: 2ATPO-BW20

2.9 Information on test modes and additional testing requirements5

Additional guidance for testing host products is given in KDB Publication 996369 D04 Module Integration Guide. Test modes should take into consideration different operational conditions for a stand-alone modular transmitter in a host, as well as for multiple simultaneously transmitting modules or other transmitters in a host product.

The grantee should provide information on how to configure test modes for host product evaluation for different operational conditions for a stand-alone modular transmitter in a host, versus with multiple, simultaneously transmitting modules or other transmitters in a host.

Grantees can increase the utility of their modular transmitters by providing special means, modes, or instructions that simulates or characterizes a connection by enabling a transmitter. This can greatly simplify a host manufacturer’s determination that a module as installed in a host complies with FCC requirements.

Explanation: Shenzhen Ai-Thinker Technology Co., Ltd can increase the utility of our modular transmitters by providing instructions that simulates or characterizes a connection by enabling a transmitter.

2.10 Additional testing, Part 15 Subpart B disclaimer

The grantee should include a statement that the modular transmitter is only FCC authorized for the specific rule parts (i.e., FCC transmitter rules) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. If the grantee markets their product

as being Part 15
Subpart B compliant (when it also contains unintentional-radiator digital circuity), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

Explanation: The module without unintentional-radiator digital circuity, so the module does not require an evaluation by FCC Part 15 Subpart B. The host shoule be evaluated by the FCC Subpart B.