RP2040-BLE User Manual

Contents

1. PRODUCT INTRODUCTION

The RP2040-BLE is a mini dual-mode Bluetooth 5. 1 expansion module designed for RP2040 development board, which is controlled via UART AT commands, and can be used for Bluetooth wireless communication applications.

1.1 PARAMETERS

Category	Parameter
Bluetooth Module	RP2040-BLE
Dimensions (mm)	33.49 x 21
Transmission Distance	30m (open air)
Communication	UART
Antenna	Onboard PCB antenna
Input Voltage	5V/3.3V
Operating Current	Startup transient current : about 22mA for about 300ms When not connected, it alternates between 11 and 15mA, and after connection, the stable current is 11mA. Low power mode current : refer to user manual
Transmission Cache	1K bytes UART cache, it is recommended to transmit less than 512 bytes per transmission for SPP
UART Baudrate	13 different baudrate configuration, 115200 bp s by default
Operating Temperature	-40℃ ~ 80℃

1.2 INTERFACE DESCRIPTION

Function PIN	Description
VSYS	3.3V/5V Power
GND	GND
GP20	UART Tx pin (default)
GP21	UART Rx pin (default)
GP15	Bluetooth connection status detection pin (high level means Bluetooth is connected)

2. PRODUCT USAGE

2.1 COMMUNICATION FORMAT

Support asynchronous serial communication mode, accept commands sent by the host computer through the serial port Communication Standard: 115200 bps (Configurable through serial commands) see: Module Baudrate Setting and Query Data bit: 8, stop bit: 1, Parity bit: none, Stream control: none Note: the design of all instructions are regular, not randomly divided, you can find the rules by comparing the following.
Control command format : At+<CMD>[<param>]\r\n ---- all are characters, not hex numbers
Data feedback format: <IND>[<param>]\r\n

Data characteristics	Details
AT+	The control command is given by the control host to the module, starting with “AT+”
<CMD>	Followed by <CMD> control, usually 2 characters
[<param>]	If there is a parameter after CMD, it is followed by [<param>]

Brief Introduction to commands		
Function	Command	Remark
Common Command Features	AT+C?	The public command starts with AT+C, followed by “?” is the detailed function command
Bluetooth Command Features	AT+B?	The public command starts with AT+B, followed by “?” is the detailed function command
Public Inquiry	AT+Q?	The public command starts with AT+Q, followed by “?” is the detailed function command
Bluetooth Query	AT+T?	The Bluetooth query command starts with AT+T, followed by “?” is the detailed function command

2.2 COMMUNICATION COMMAND EXAMPLE

Common Part--Control Instructions--Description		
CMD	Corresponding function	Detailed description
AT+CT	Set baud rate	For detail see： Module baud rate setting and query
AT+CZ	Chip reset	Chip soft reset, see: Reset and restore factory
AT+CW	Chip reset to factory settings	Restore factory settings, clear all previously memorized parameters, see:Module reset and restore factory settings
AT+CL	Chip low power settings	See：Chip low-power command description., the default is normal working mode
AT+CR	Chip power-on callback information settings	See: Chip power-on callback information setting., the default is open
AT+BM	Set BLE bluetooth name	See：Set the name and address of bluetooth
AT+BN	Set the MAC address of BLE	See：Set the name and address of bluetooth
AT+BD	Set SPP bluetooth name	See：Set the name and address of bluetooth
AT+QT	Query the baud rate of the system	See：Module baud rate setting and query
AT+QL	Query the low-power state	See：Set the name and address of bluetooth
AT+TM	Query BLE Bluetooth name	See：Set the name and address of bluetooth
AT+TN	Query BLE Bluetooth address	See：Set the name and address of bluetooth
AT+TD	Query SPP Bluetooth name	See：Set the name and address of bluetooth

2.3 MODULE BAUDRATE SETTING AND QUERY

AT+CT??\r\n	Baud rate setting command, ?? represents the serial number of the baud rate
AT+QT\r\n	Baud rate query command, return QT+?? ?? represents the serial number of the baud rate

Baud rate serial number						
01	02	03	04	05	06	07
9600	19200	38400	57600	115200	256000	512000
08	09	10	11	12	13	
230400	460800	1000000	31250	2400	4800	

1. Once the baud rate is set, the chip will memorize it. The next time you turn it on, the baud rate will be the one you set.

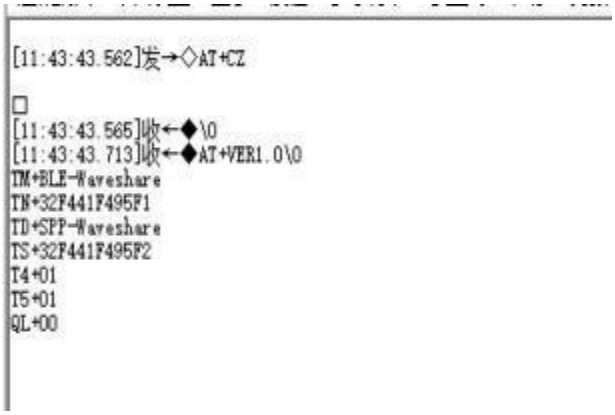
2. After setting the baud rate, please wait for 1 second, then send the reset [AT+CZ], or power off.

3. If you want to restore the default baud rate, please send the command to restore the factory settings, then the chip will automatically erase all configurations.

2.3 MODULE RESET AND FACTORY RESET

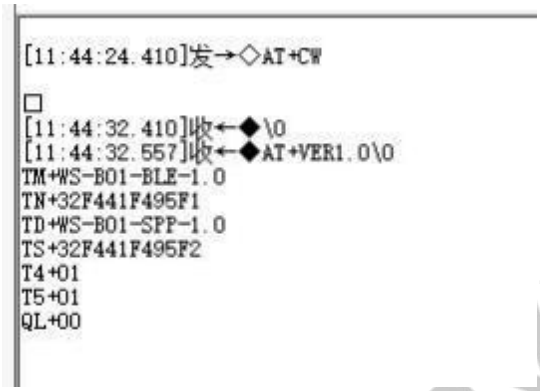
Reset Command: AT+CZ\r\n

Please wait one second after entering the reset command.



Factory reset command: AT+CW\r\n

Please wait five seconds after entering the factory reset command.



2.4 SET THE NAME AND ADDRESS OF BLUETOOTH

AT+BMBLE-Waveshare\r\n	**Set BLE Bluetooth name to "BLE-Waveshare"**
AT+BN112233445566\r\n	**Set the address of BLE. The address displayed on the mobile phone is: 66 55 44 33 22 11**
AT+BDSPP-Waveshare\r\n	**Set the SPP Bluetooth name to "SPP-Waveshare"**

1. After setting the bluetooth name, please reset the module, and use the mobile phone to search again after reset.

2. The maximum length of the Bluetooth name is 30 bytes.

3. After modifying the Bluetooth name, if the device name displayed on the mobile phone does not change, the main reason may be that you have not modified the Bluetooth address, resulting in the mobile phone not being updated synchronously. At this time, what you need to do is to change the pairing information on the mobile phone. Delete and search again, or search with another device.

2.5 SET THE NAME AND ADDRESS OF BLUETOOTH

AT+TM\r\n	Return TM+BLE-Waveshare\r\n for Bluetooth name BLE-Waveshare
AT+TN\r\n	Returns the Bluetooth address of TN+12345678AABB\r\n BLE: 0xBB, 0xAA, 0x78, 0x56, 0x34, 0x12
AT+TD\r\n	Return to TD+SPP-Waveshare\r\n for Bluetooth name SPP-Waveshare

There is no SPP address whether it is set or queried, because the SPP address is obtained by +1 on the highest byte of the BLE MAC address, for example:

The address of BLE is returned as: TN+32F441F495F1,

This means the address of BLE is: 0xF1 , 0x95 , 0xF4 , 0x 41 , 0xF4 , 0x32

Then the address of SPP is: 0xF2 , 0x95 , 0xF4 , 0x 41 , 0xF4 , 0x32

2.6 CHIP LOW-POWER COMMAND DESCRIPTION

AT+CL00\r\n	Do not enter low power mode. It will be valid at the next power-on. Be careful to restart the power after setting
AT+CL01\r\n	Enter low power mode. It is valid at the next power-on. After setting, pay attention to power on again — the chip enters this state by default, no need to set
AT+QL\r\n	Low-power query command. The return value is QL+01\r\n, indicating that the current working state is low power consumption mode

1. After setting, you need to power on again to update the configuration.
2. This command is memorized. After the command is sent successfully, the chip will save it.
3. After starting the low-power mode, there are many restrictions, which are generally turned off by default.
4. After the setting, the chip will return to the device information normally when it is powered on. AT commands can be set within 5 seconds, and after 5 seconds, any AT commands will be ignored before the Bluetooth connection.
5. The difference between low power consumption and normal operation is mainly due to the difference in the way of Bluetooth broadcasting when Bluetooth is not connected. During normal

operation, Bluetooth is always in the broadcasting state. During low power consumption, it broadcasts every 0.5 seconds, once every 0.1 seconds, and the rest of the time is in a sleep state. When connected to Bluetooth, the power consumption of the two working modes is similar (of course, the low power consumption will be a little lower), If it is not particularly sensitive to power consumption or it will be in a disconnected state for a long time after power-on, it is better to keep the module in normal working state.

6. The following table is the current under each working state, which is measured in the experimental environment, and the results are for reference only.

	Serial number	Current	Description
Bluetooth, Low power, RP2040, sleep mode	Boot moment	22mA	When the chip is powered on, the peripherals need to be initialized. The instantaneous current is relatively large, and this time is maintained for 300ms, and it enters a low-power state.
	Working Status - Not Connected	1mA, 5mA alternately	The chip is in normal working state, broadcasts normally, and is in a periodic state of sleep, wake-up broadcast, and sleep. The purpose is to save power consumption, the cycle is 500ms. 100ms broadcast once, 400ms sleep
	Working status - connected	11mA	When the connection is successful, the chip will no longer go to sleep. but at work
Bluetooth, low-power, RP2040, normal working mode	Boot moment	22mA	When the chip is powered on, the peripherals need to be initialized. The instantaneous current is relatively large, this time is maintained for 300ms, and it enters the 5mA working state
	Working status - not connected	14mA, 18mA alternately	The Bluetooth chip operates in a normal working state, continuously broadcasting externally in a cyclic pattern of sleep, wake-up broadcasting,

			and sleep. The purpose is to conserve power, with a cycle of 500ms: broadcasting every 100ms, followed by a 400ms sleep period.
	Working status - connected	14mA	After connection, the chip will not enter the sleep mode, and it keeps in working mode
Bluetooth, normal, RP2040, Sleep	Boot moment	25mA	Upon startup, peripheral initialization is required. The transient current is relatively high, lasting around 300ms, during which the Bluetooth chip enters its working status.
	Working status - not connected	13mA, 17mA alternately	The Bluetooth chip always in working status
	Working status - connected	14mA	The Bluetooth chip always in working status
Bluetooth, normal, RP2040, Sleep	Boot moment	26mA	The startup require to initialize the peripherals, and the transient current is relatively high, lasting around 300ms, during which the Bluetooth chip enters its working status.
	Working status - not connecte	16mA, 20mA alternately	The Bluetooth chip always in working status
	Working status - connected	17mA	The Bluetooth chip always in working status

2.7 CHIP BLE ENABLE AND SPP ENABLE

AT+B401\r\n	Enable BLE function. Of course AT+B400\r\n is closed
AT+B500\r\n	Disable the function of SPP. Of course AT+B501\r\n is turned on
AT+T4\r\n	Check whether the BLE function is enabled. The chip will return T4+01 or T4+00
AT+T5\r\n	Check whether the SPP function is enabled. The chip will return T5+01 or T5+00

1. After the BLE/SPP function is turned off, it must be powered on again for this function to take effect. Of course it's the same.

2. You only need to set it once, the chip automatically saves the parameters, and you don't need to set it next time.

3. After the BLE/SPP function is turned off, the mobile phone cannot search for the name of BLE.

2.8 DESCRIPTION OF THE ERROR MESSAGE RETURNED BY THE CHIP

ER+1\r\n	The received data frame is incorrect
ER+2\r\n	The received command does not exist, that is, the string like AT+KK you sent cannot be found
ER+3\r\n	The received AT command did not receive a carriage return and line feed, that is, \r\n
ER+4\r\n	The parameter sent by the command is out of range, or the command format is incorrect. Please check your AT commands
ER+7\r\n	The MCU sends data to the mobile phone, but the mobile phone does not open notify. In the successful state of BLE connection

Focus on the description of notify [monitoring]. After the test APP on the mobile phone is connected to the Bluetooth chip, notify must be turned on. The bluetooth chip can send data to the mobile phone. When the mobile phone sends data to the Bluetooth chip, it is enough to use the write feature.

2.9 CHIP POWER-ON CALLBACK INFORMATION SETTINGS

AT+CR00\r\n	Turn off postback messages for power-on. Be careful to restart the power after setting
AT+CR01\r\n	Enable the return message of chip power-on. It is valid at the next power-on. Be careful to restart the power after setting

Note: After this function is turned off, it will also turn off the OK or ER+X return information that is actively returned after the AT command is executed. It is recommended to keep it turned on here.

2.10 TRANSPARENT TRANSMISSION DESCRIPTION

1. After the Bluetooth connection, the module automatically enters the transparent transmission mode. Except for the completely correct AT command, the rest of the data will be transparently transmitted.

2. The maximum amount of data that can be handled in a single time is 1024 bytes. SPP recommends that it should not exceed 512 bytes at a time.

3. The MTU (maximum communication packet length) of the mobile phone APP generally defaults to 20 bytes for 1 data packet; when the data packet sent by the module exceeds 20 bytes, the module will automatically divide the packet according to the set MTU; you can Modify the MTU to modify the data interaction speed (the larger the MTU, the faster the data interaction speed).

3. NEW FUNCTIONS (PURCHASED AFTER 2023/02/20)

3.1 BLUETOOTH STATUS DETECTION PIN

AT+CF00\r\n	Output low level when the Bluetooth is not connected
AT+CF01\r\n	When the Bluetooth is not connected, high and low level changes at a frequency of 1 Hz

After the Bluetooth is connected, it is in high-level.

After setting, it takes effect after resetting/rebooting.

3.2 SPP PASSWORD SETTING

AT+B100\r\n	Closed pairing password, the next time you connect without having to enter the password to connect
AT+B101\r\n	Turn on the pairing password, the next time you connect you need to enter the password to connect
AT+BE1234\r\n	Set the Bluetooth connection password to "1234", which can only be a number but not a letter.

Note:

1. Connection passwords must consist only of digits; letters are not allowed.
2. The length of the connection password must be exactly 4 bytes.
3. Enabling a password will occur automatically after setting it.
4. After setting a password, it will not affect previously configured devices unless the Bluetooth address is changed.
5. All settings take effect after a restart.

3.3 RF BLUETOOTH TRANSMITTING POWER SETTING

AT+BR01\r\n	Set the transmitting power of the Bluetooth is level 1.
AT+BR09\r\n	Set the transmitting power of the Bluetooth is level 9.

Note:

1. Changes take effect immediately after being sent.
2. The valid range for values is [0 to 9].
3. Values are automatically saved when power is disconnected, and the next power-up will use the saved value.
4. The chip defaults to the maximum power of 9.
5. Higher transmission power results in a broader broadcast range but relatively higher power consumption.

3.4 BLE BROADCAST INTERVAL SETTING

Command	Broadcast Interval	Reference Working Current
AT+UT00\r\n	250ms	The average current is 300uA.
AT+UT01\r\n	500ms	The average current is 180uA.
AT+UT02\r\n	750ms	The average current is 140uA.
AT+UT03\r\n	1000ms	The average current is 100uA.
AT+UT04\r\n	1500ms	The average current is 70uA.
AT+UT05\r\n	2000ms	The average current is 62uA.
AT+UT06\r\n	3000ms	The average current is 40uA.
AT+UT07\r\n	4000ms	The average current is 30uA.

Note:

1. Once the broadcast interval is set, the chip automatically records it and retains the setting even after power loss.
2. Currently, querying the current broadcast settings is not supported. However, each power-up will return the current broadcast interval parameters.
3. To restore the default broadcast interval, please use the factory reset command.

4. The longer the broadcast interval, the longer it takes for mobile devices to detect the broadcast.

3.5 UUID SETTING

AT+U0F000\r\n	Specify the service UUID as F
AT+U1F001\r\n	Designate feature code 1 as F001 with the properties "Write Without Response" and "Listen":
AT+U2F002\r\n	Designate feature code 2 as F002 with the properties "Read" and "Listen":
AT+U3F003\r\n	Designate feature code 3 as F001 with the properties "Write Without Response"

Note:

1. The functionality of each position cannot be changed; only the characteristic code is modified.
2. Changes take effect after rebooting and configurations are automatically saved after power loss.
3. If characteristic codes are set to be the same, one will be randomly changed to a non-conflicting characteristic code.
4. It's advisable to set all characteristics once during setup (although it's generally recommended to avoid altering them).
5. For designing an app, it's suggested to only modify the characteristics that will be utilized.
6. Default characteristic codes are as follows: U0-fff0, U1-fff1, U2-fff2, U3-fff3. Restoration to factory settings can be achieved by using the factory reset command.