



深圳大夏龙雀科技有限公司
Shenzhen DX-SMART Technology Co Ltd.

DX-BT20 5.0蓝牙模块
DX-BT20 5.0 Bluetooth Module

Note: English instructions go to page 15
(英文说明书请跳转到第15页)

技 术 手 册

v 1.1



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一. 概述

DX-BT20 5.0蓝牙模块是深圳大夏龙雀科技有限公司专为智能无线数据传输而打造,采用美国TI公司CC2640芯片,支持高速传输,超低功耗,遵循V5.0 BLE蓝牙规范。支持AT 指令,用户可根据需要更改串口波特率、设备名称等参数,使用灵活。

本模块支持 UART 接口,并支持蓝牙串口透传,具有成本低、体积小、功耗低、收发灵敏性高等优点,只需配备少许的外围元件就能实现其强大功能。



二. 模块默认参数:

蓝牙协议	Bluetooth Specification V5.0 BLE
工作频率	2.4GHz ISM band
通信接口	UART
供电电源	3.3V
通信距离	30-40M (空旷环境)
外观尺寸	27(L)mm x 13(W)mm x 2(H) mm
蓝牙认证	FCC CE ROHS REACH
蓝牙名称	BT20
串口参数	9600、8数据位、1停止位、无校验、无流控
Service UUID	FFE0
Notify\Write UUID	FFE1
Write UUID	FFE2
Storage temperature	MIN:-55℃ - MAX:+125℃
Work temperature	MIN:-20℃ - MAX:+70℃
定制需求	如有其它特殊功能要求,可以联系我司,对模块进行定制

三. 应用领域:

DX-BT20 模块支持 BT 5.0 BLE 协议,可以同具备 BLE 蓝牙功能的 iOS 设备直接连接,支持后台程序常驻运行。主要用于短距离的数据无线传输领域。避免繁琐的线缆连接,能直接替代串口线。BT20 模块成功应用领域:

- ※ 蓝牙无线数据传输;
- ※ 手机、电脑周边设备;



- ※ 手持 POS 设备;
- ※ 医疗设备无线数据传输;
- ※ 智能家居控制;
- ※ 汽车检测 OBD 设备;
- ※ 蓝牙打印机
- ※ 蓝牙遥控玩具
- ※ 共享沙发、共享充电宝

四. 功耗参数

模式	状态	电流	Unit
低功耗模式	Discoverable	200	uA
	Connected	2.9	mA
正常工作模式	Discoverable	1.6	mA
	Connected	2.9	mA

五. 射频特性

Rating	Value	Unit
BLE 发射功率	5	dBm
BLE 灵敏度	-97	dBm

六. 透传参数

数据吞吐量:

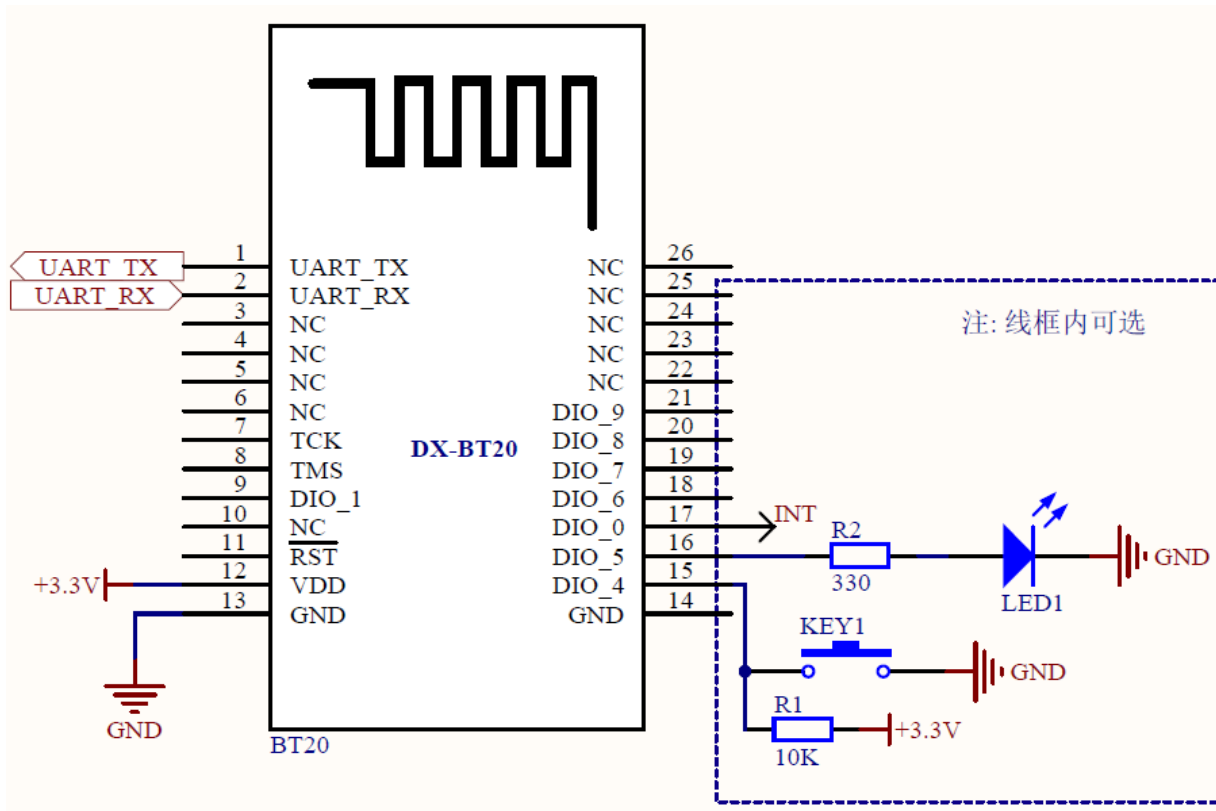
Android -> BT20 -> UART		UART -> BT20 -> Android	
波特率	115200	波特率	115200
连接间隔时间(ms)	20	连接间隔时间(ms)	20
APP 数据包大小(bytes)	200	串口数据包大小(bytes)	200
发送间隔(ms)	60	发送间隔(ms)	50
吞吐量(bytes/s)	3400	吞吐量(bytes/s)	4000
Characteristic 写方式	Write without Response	Characteristic 通知方式	Notify
iPhone -> BT20 -> UART		UART -> BT20 -> iPhone	
波特率	115200	波特率	115200
连接间隔时间(ms)	30	连接间隔时间(ms)	30
APP 数据包大小(bytes)	100	串口数据包大小(bytes)	200
发送间隔(ms)	50	发送间隔(ms)	100



吞吐量(bytes/s)	2000	吞吐量(bytes/s)	2000
Characteristic 写方式	Write without Response	Characteristic 通知方式	Notify

注：此表格参数仅做参考，不代表模组能支持的最大数据吞吐量。

七. 模块引脚说明及最小电路图:



八. 管脚功能描述:

管脚序号	管脚名称	管脚说明
1	UART_TX	串口数据输出
2	UART_RX	串口数据输入
3	NC	悬空
4	NC	悬空
5	NC	悬空
6	NC	悬空
7	TCK	调试时钟口
8	TMS	调试数据口



9	DIO_1	可编程输入输出口
10	NC	悬空
11	RESETB	低电平复位，至少5ms
12	VDD	电源 V3.3
13	GND	地
14	GND	地
15	DIO_4	断开连接引脚(见详细说明)
16	DIO_5	LED灯管脚(见详细说明)
17	DIO_0	蓝牙连接指示口(见详细说明)
18	DIO_6	可编程输入输出口
19	DIO_7	可编程输入输出口
20	DIO_8	可编程输入输出口
21	DIO_9	可编程输入输出口
22	NC	NC
23	NC	NC
24	NC	NC
25	NC	NC
26	NC	NC

九. 功能引脚详细说明

1、P16 脚 (DIO_5): LED 灯指示引脚

LED 显示	模块状态
慢闪	待机状态
快闪	已连接通道未建立
长亮	已连接通道已建立

2、P17 脚 (DIO_0): 连接状态指示脚

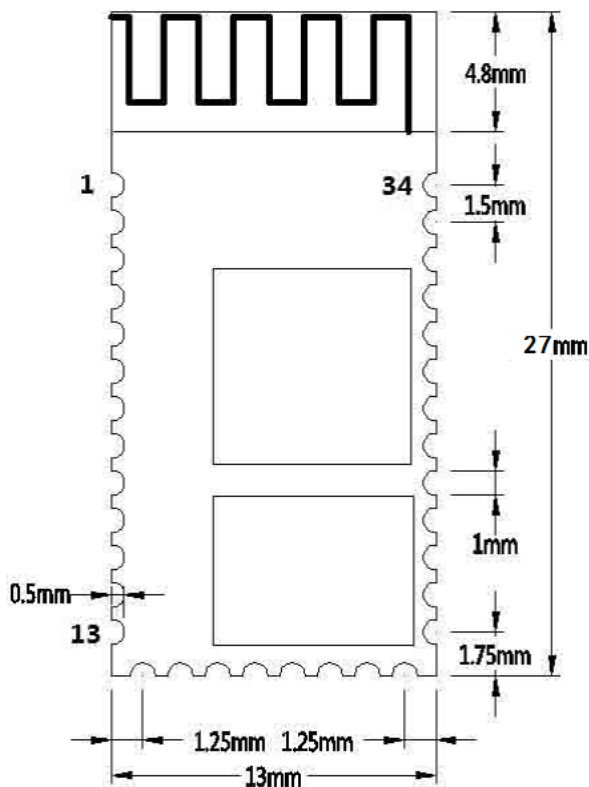
引脚状态	模块状态
输出低电平	待机状态
输出高电平	已连接通道已建立

3、P15 脚 (DIO_4): 连接中断脚 (模块处于连接状态有效)

引脚状态	模块状态
无动作	连接状态
输入 200ms 低电平脉冲	中断连接，模块进入待机状态



十. 外形尺寸:



十一. LAYOUT 注意事项

DX-BT20 蓝牙模块工作在2.4G无线频段，应尽量避免各种因素对无线收发的影响，注意以下几点：

- 1、包围蓝牙模块的产品外壳避免使用金属，当使用部分金属外壳时，应尽量让模块天线部分远离金属部分。
- 2、产品内部金属连接线或者金属螺钉，应尽量远离模块天线部分。
- 3、模块天线部分应靠载板PCB 四围放置，不允许放置于板中，且天线下方载板铣空，与天线平行的方向，不允许铺铜或走线。直接把天线部分直接露出载板，也是比较好的选择。
- 4、建议在基板上的模块贴装位置使用绝缘材料进行隔离，例如在该位置放一个整块的丝印（TopOverLay）

十二. AT 指令集

指令集详细说明(注：模块未连接时即为 AT 指令模式)

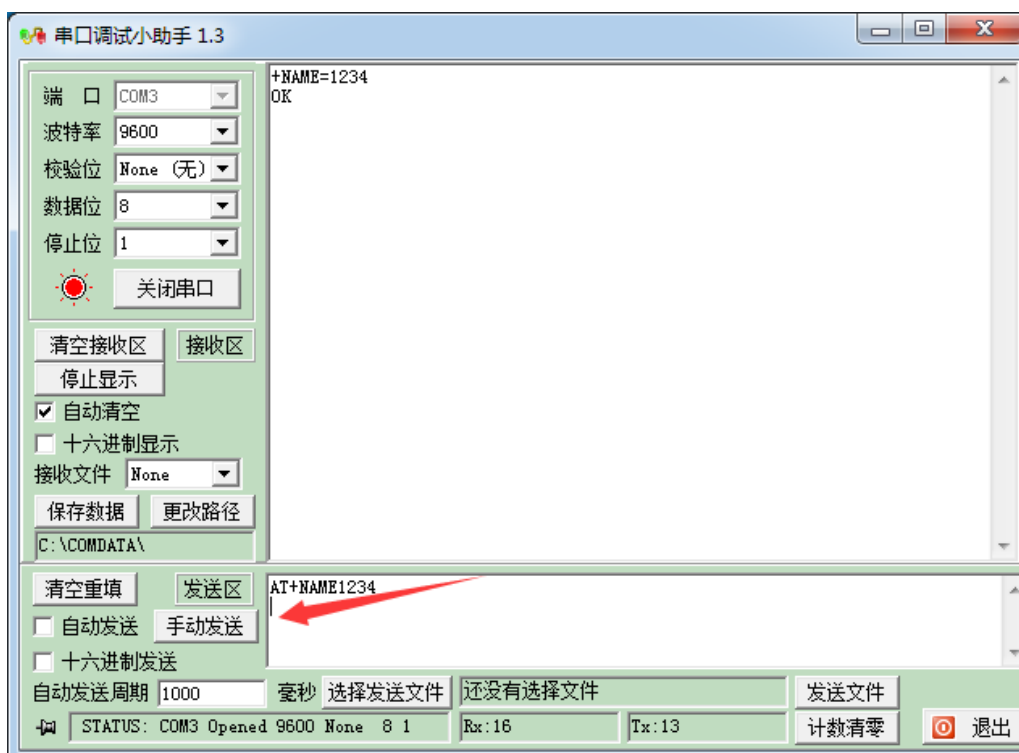
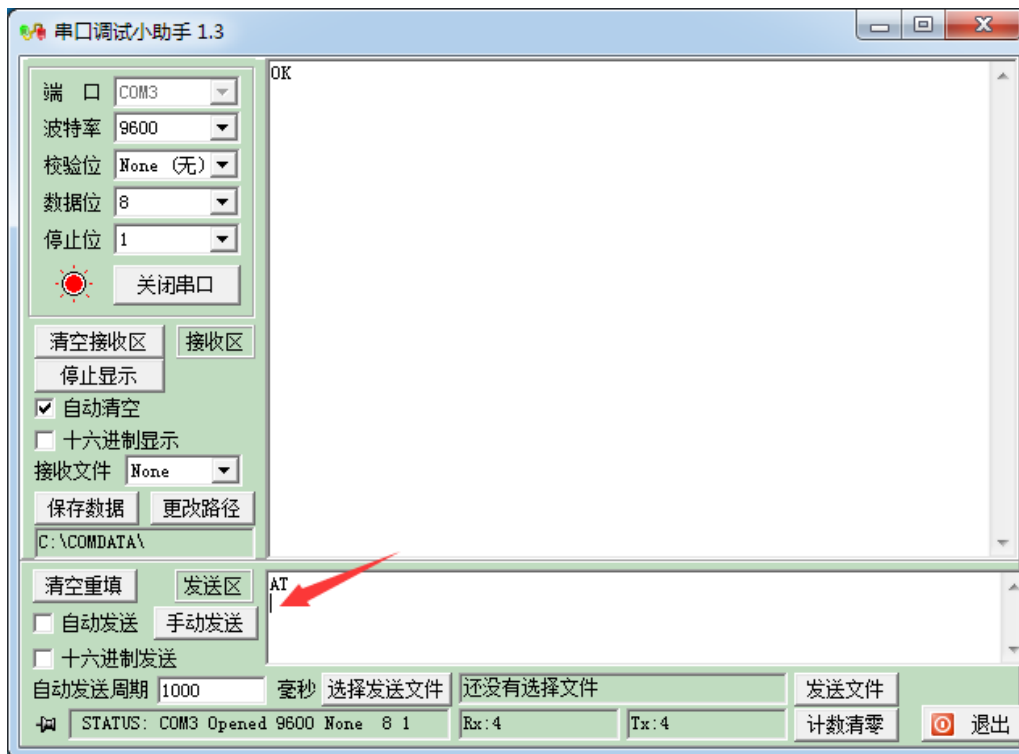
- 1、AT 指令，属于字符行指令，按行解析（即发 AT 指令时必须以回车换行或者\r\n、16 进制为 0D0A 结尾）
- 3、AT 指令只支持大写，指令前缀为 AT+，可分为参数设置指令和读取指令。
- 4、设置指令格式：AT+<CMD><PARAM>操作成功返回：+<CMD>=<PARAM>\r\n OK\r\n



失败不返回字符。

5、读取指令格式：AT+<CMD>操作成功返回：+<CMD>=<PARAM>\r\n 失败不返回字符。

AT 命令格式举例(图一为 AT 测试命令，图二为将蓝牙名称改为 1234)：





1、测试指令：

功能	指令	响应	说明
测试指令	AT\r\n	OK\r\n	

2、获取软件版本号：

功能	指令	响应	说明
查询版本号	AT+VERSION\r\n	+VERSION=<version>\r\n OK\r\n	<version>软件版本号

注：依据不同的模块与定制需求，版本会有区别。

3、设置/查询模块蓝牙地址码：

功能	指令	响应	说明
查询模块 MAC 地址	AT+LADDR\r\n	+LADDR=<laddr>\r\n	<laddr>蓝牙 12 位 MAC 地址码

4、设置/查询设备名称：

功能	指令	响应	说明
查询模块蓝牙名	AT+NAME\r\n	+NAME=<name>\r\n	<name>蓝牙名，最长为 20 个字节 默认名称：BT20
设置模块蓝牙名	AT+NAME<name>\r\n	+NAME=<name>\r\n OK	

示例：

1. 发送设置：

AT+NAMEDX-BT20\r\n

——设置模块设备名为：“DX-BT20”

返回：

+NAME=DX-BT20\r\n
OK

——设置模块设备名为：“DX-BT20” 成功

2. 发送查询：

AT+NAME\r\n

——查询模块名

返回：

+NAME=DX-BT20\r\n

——返回模块设备名为：“DX-BT20”



5、设置/查询一串口波特率：

功能	指令	响应	说明
查询模块波特率	AT+BAUD\r\n	+BAUD=<baud>\r\n	<baud>波特率对应序号
设置模块波特率	AT+BAUD<baud>\r\n	+BAUD<baud>\r\n OK\r\n	
			1:1200
			2:2400
			3:4800
			4:9600
			5:19200
			6:38400
			7:57600
			8:115200
			默认值：4 (9600)

注：模块设置波特率后需重新上电，启用新波特率进行数据通信和 AT 指令解析。

示例：设置串口波特率：38400

1. 发送设置：

AT+BAUD6\r\n

返回：

+BAUD=6\r\n

OK\r\n

2. 发送查询：

AT+BAUD\r\n

返回：

+BAUD=6\r\n

6、设置/查询一串口停止位：

功能	指令	响应	说明
查询模块串口停止位	AT+STOP\r\n	+STOP=<Param>\r\n	<Param>停止位
设置模块串口停止位	AT+STOP<Param>\r\n	+STOP=<Param>\r\n OK	0-1 停止位 1-2 停止位 默认值：0



7、设置/查询一串口校验位：

功能	指令	响应	说明
查询模块串口校验位	AT+PARI\r\n	+PARI=<Param>\r\n	<Param>校验位 0-1 无校验 1-2 奇校验 2-2 偶校验 默认值：0
设置模块串口校验位	AT+PARI<Param>\r\n n	+PARI=<Param>\r\n OK	

8、设置\查询一服务 SERVICE UUID：（修改完之后要重启手机蓝牙，手机才生效）

功能	指令	响应	说明
查询模块服务 UUID	AT+UUID\r\n	+UUID =<service>\r\n	<service>服务 UUID 默认服务 UUID： FFE0
设置模块服务 UUID	AT+UUID<service>\r\n	+UUID =<service>\r\n OK	

示例：设置服务 UUID 为：FE00

1. 发送设置：

AT+UUID0XFF00\r\n

返回：

+UUID=0XFF00\r\n

OK

9、设置\查询一通知 NOTIFY UUID\写入 WRITE UUID ：（修改完之后要重启手机蓝牙，手机才生效）

功能	指令	响应	说明
查询模块通知\写入 UUID	AT+CHAR\r\n	+CHAR=<UUID>\r\n	<UUID>通知\写入 UUID 默认值：FFE1
设置模块通知\写入 UUID	AT+CHAR<UUID>\r\n	+CHAR=<UUID>\r\n OK	

注：此通道是为可读写通道（即可以读也可写）

示例：设置通知\写入 UUID 为：FE01

1. 发送设置：

AT+CHAR0XFE01\r\n



返回：

+CHAR= FE01r\n

OK\r\n

10、设置\查询—写入 WRITE UUID ：（修改完之后要重启手机蓝牙，手机才生效）

功能	指令	响应	说明
查询模块写入 UUID	AT+WRITE\r\n	+WRITE =<UUID >\r\n	<UUID>写入 UUID 默认值： FFE2
设置模块写入 UUID	AT+WRITE<UUID>\r\n	+ WRITE =<UUID>\r\n OK	

示例：设置写入 UUID 为： FE02

1. 发送设置：

AT+WRITE0XFE02\r\n

返回：

+WRITE= FE02r\n

OK\r\n

11、设置\查询—低功耗模式：

功能	指令	响应	说明
查询模块低功耗模式	AT+PWRM\r\n	+PWRM=<Param>\r\n	< Param > (0、1) 0：低功耗模式 1：正常工作模式 默认值： 1
设置模块低功耗模式	AT+PWRM<Param>\r\n	+PWRM=<Param>\r\n OK	

12、软件重启：

功能	指令	响应	说明
软件重启	AT+RESET\r\n	+RESET OK\r\n	

13、恢复出厂设置：

功能	指令	响应	说明
恢复出厂设置	AT+DEFAULT \r\n	+DEFAULT OK\r\n	



14、设置/查询—广播时间间隔：

功能	指令	响应	说明
查询模块广播时间间隔	AT+ ADVI \r\n	+ ADVI =<Param>\r\n	Param: 0~F 0—100ms
设置模块广播时间间隔	AT+ADVI<Param>\r\n	+ ADVI =<Param>\r\n OK	1—152.5ms 2—211.25ms 3—318.75ms 4—417.5ms 5—546.25ms 6—760ms 7—852.5ms 8—1022.5ms 9—1285ms A—2000ms B—3000ms C—4000ms D—5000ms E—6000ms F—7000ms 默认设置：0

注：此指令可以用于降低功耗

十三．联系我们

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电话：0755-2997 8125

传真：0755-2997 8369

网址：<http://www.szdx-smart.com/>



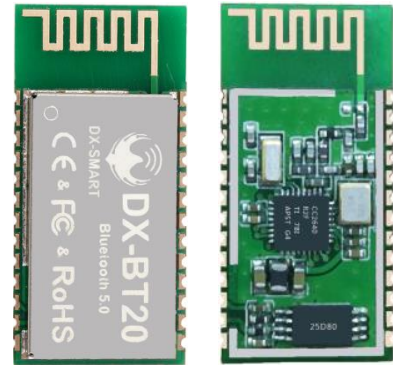
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1. Overview

DX-BT20 4.0 Bluetooth module is built by Shenzhen DX-SMART Technology Co., Ltd. for intelligent wireless data transmission. It adopts CC2541 chip of American TI Company, configures 256Kb space, and follows V4.0 BLE Bluetooth specification. Support AT command, users can change the serial port baud rate, device name, pairing password and other parameters as needed, flexible use.

This module supports UART interface and supports Bluetooth serial port transparent transmission. It has the advantages of low cost, small size, low power consumption, high sensitivity of sending and receiving, etc. It can realize its powerful functions with only a few peripheral components simple operation, high cost performance and technology leading edge.



2. Module default parameters:

Bluetooth Protocol	Bluetooth Specification V4.0 BLE
Working Frequency	2.4GHz ISM band
Communication Interface	UART
Power Supply	3.3V
Communication distance	30-40M (Open and unobstructed environment)
Physical Dimension	27(L)mm x 13(W)mm x 2(H) mm
Bluetooth Authentication	FCC CE ROHS REACH
Bluetooth Name	BT20
Serial Port Parameters	9600、8 data bits、1 stop bit、No check、No flow control
Service UUID	FFE0
Notify\Write UUID	FFE1
Write UUID	FFE2
Storage temperature	MIN:-55℃ - MAX:+125℃
Work temperature	MIN:-20℃ - MAX:+70℃
Customized requirements	If you have other special function requirements, you can contact us to customize the module.



3. Application area:

DX-BT20 module supports BT4 .2 BLE protocol, which can be directly connected to iOS devices that have BLE Bluetooth function, and supports background program resident operation.

Successful application of BT20 module:

- ※ Bluetooth wireless data transmission;
- ※ Mobile phones, computer peripherals;
- ※ Handheld POS device;
- ※ Medical equipment wireless data transmission;
- ※ Smart Home Control;
- ※ Automotive Inspection OBD Equipment;
- ※ Bluetooth printer;
- ※ Bluetooth remote control toy;
- ※ Anti-lost device, LED light control;

4. Power consumption parameters:

Mode	Status	Current	Unit
Low power mode	Discoverable	200	uA
	Connected	2.9	mA
Normal working mode	Discoverable	1.6	mA
	Connected	2.9	mA

5. Radio frequency characteristics:

Rating	Value	Unit
BLE Transmit power	5	dBm
BLE Sensitivity	-97	dBm

6. Transparent transmission parameters:

Data throughput:

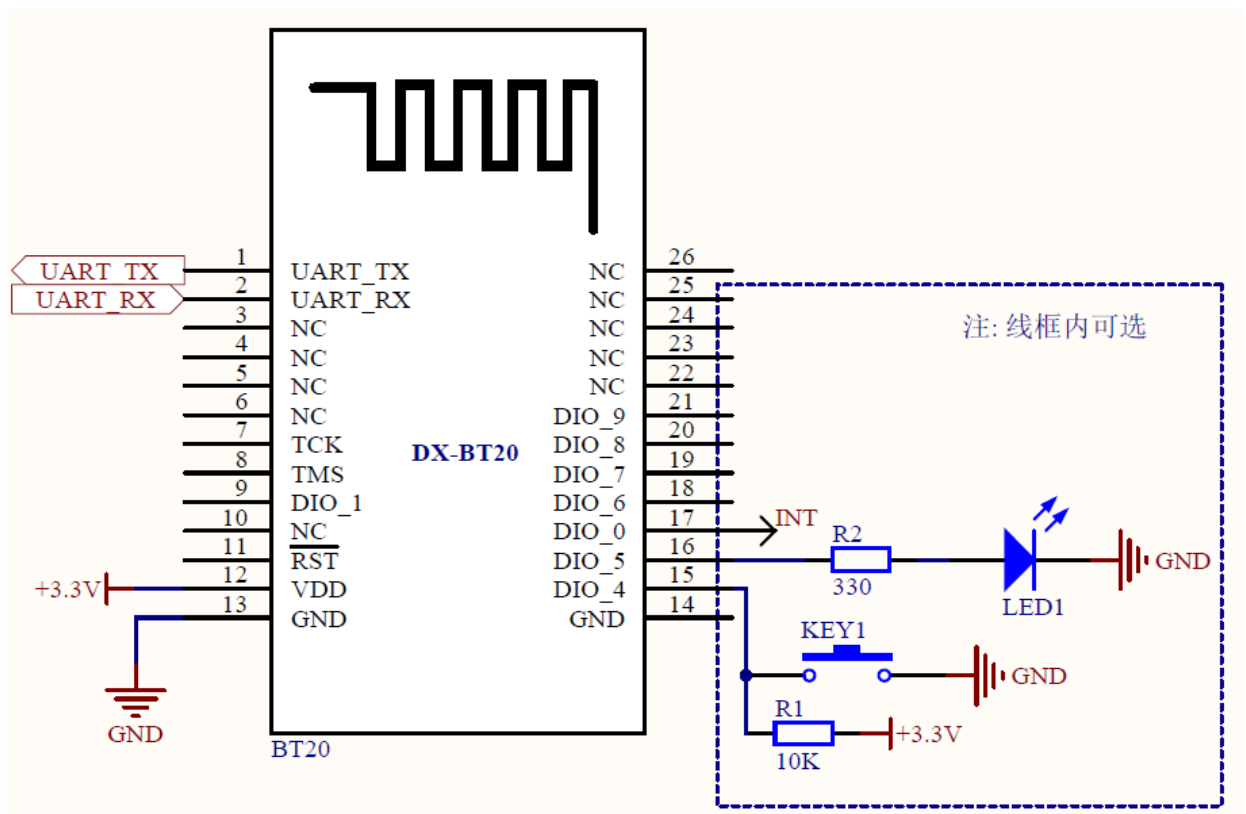
Android ->BT20 -> UART		UART ->BT20 -> Android	
Baud rate	115200	Baud rate	115200
Connection interval (ms)	20	Connection interval (ms)	20
Serial packet size (bytes)	200	Serial packet size (bytes)	200



Transmission interval (ms)	60	Transmission interval (ms)	50
Throughput (bytes/s)	3400	Throughput (bytes/s)	4000
Characteristic Write	Write without Response	Characteristic Notify	Notify
iPhone 6 ->BT20 -> UART		UART ->BT20 -> iPhone 6	
Baud rate	115200	Baud rate	115200
Connection interval (ms)	30	Connection interval (ms)	30
Serial packet size (bytes)	100	Serial packet size (bytes)	200
Transmission interval (ms)	50	Transmission interval (ms)	100
Throughput (bytes/s)	2000	Throughput (bytes/s)	2000
Characteristic Write	Write without Response	Characteristic Notify	Notify

Note: This table parameter is for reference only and does not represent the maximum data throughput that the module can support.

7. Module pin description and minimum circuit diagram:





8. Pin function description:

Pin number	Pin name	Pin description
1	UART_TX	Serial data output
2	UART_RX	Serial data input
3	NC	NC
4	NC	NC
5	NC	NC
6	NC	NC
7	TCK	Debug clock port
8	TMS	Debug data port
9	DIO_1	Programmable input and output port
10	NC	NC
11	RESETB	Low level reset, at least 5ms
12	VCC	3.3 V
13	GND	GND
14	GND	GND
15	DIO_4	Disconnect pin
16	DIO_5	LED lamp pin
17	DIO_0	Bluetooth connection indicator
18	DIO_6	Programmable input and output port
19	DIO_7	Programmable input and output port
20	DIO_8	Programmable input and output port
21	DIO_9	Programmable input and output port
22	NC	NC
23	NC	NC
24	NC	NC
25	NC	NC
26	NC	NC



9. Detailed description of function pins:

1. P16 pin (DIO_5): LED indicator pin

LED Display	Module Status
slow flashing	standby mode
Fast flashing	Connected, channel not established
Long bright	Connected, channel established

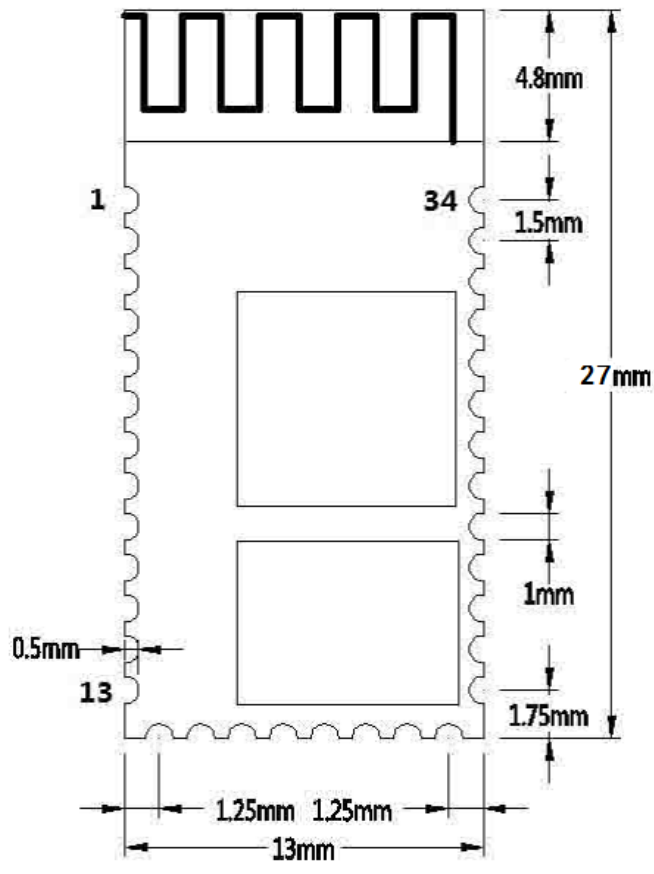
2. P17 pin (DIO_0): connection status indicator

Pin state	Module status
Output low level	standby mode
Output high level	Connected, channel established

3. P15 pin (DIO_4): connection interrupt pin (module is in the connected state)

Pin state	Module status
No action	Connection Status
Input 200ms low pulse	Interrupt connection, module enters standby

10. Dimensions:



11. LAYOUT Precautions:

The DX-BT20 Bluetooth module works in the 2.4G wireless band. It should try to avoid the influence of various factors on the wireless transceiver. Pay attention to the following points:

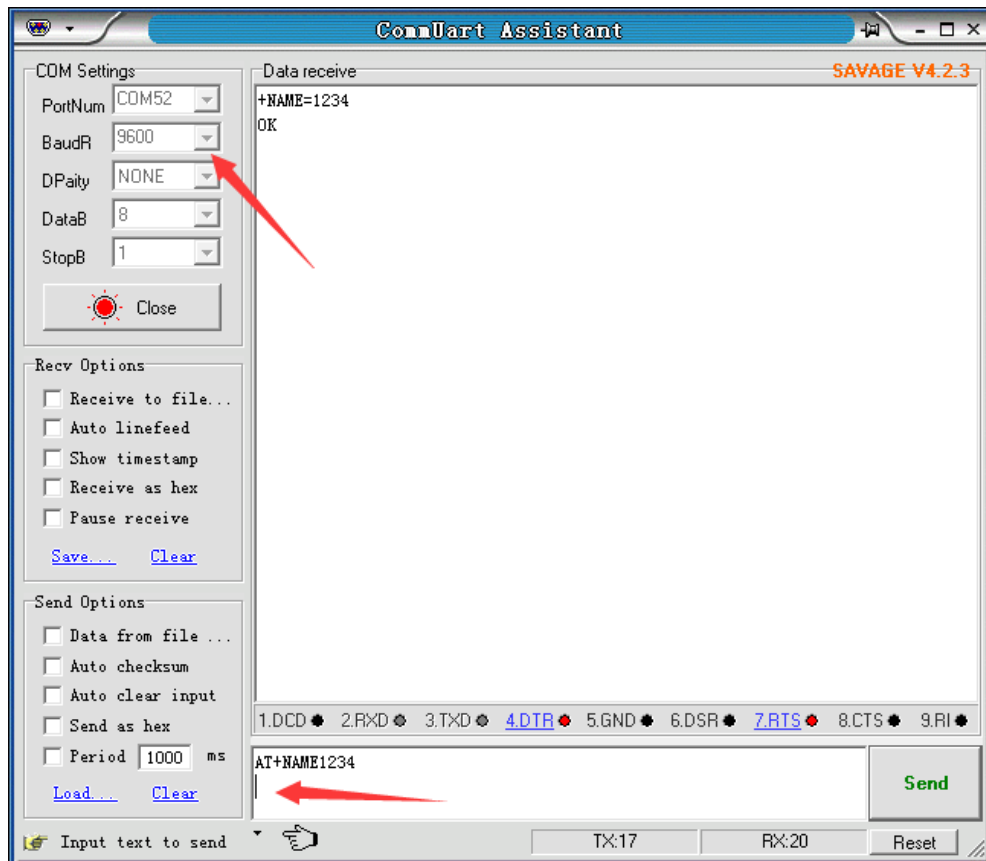
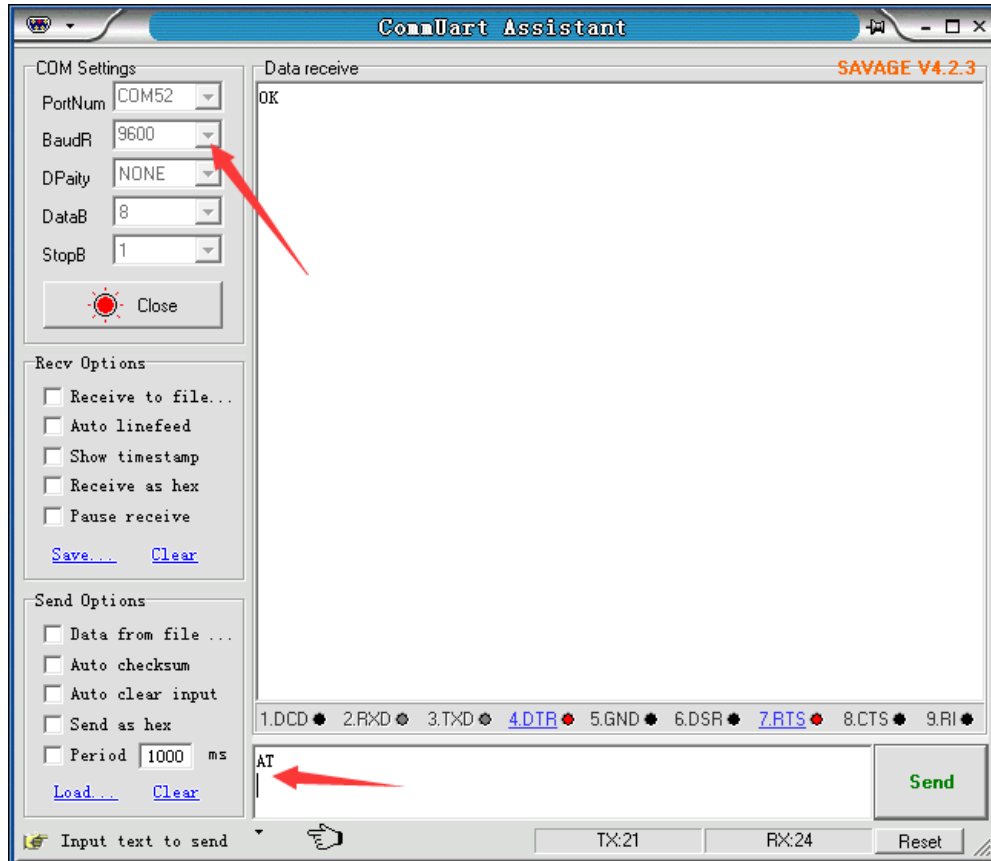
1. the product shell surrounding the Bluetooth module to avoid the use of metal, when using part of the metal shell, should try to make the module antenna part away from the metal part.
2. The internal metal connecting wires or metal screws of the product should be far away from the antenna part of the module.
3. The antenna part of the module should be placed around the PCB of the carrier board. It is not allowed to be placed in the board, and the carrier board under the antenna is slotted. The direction parallel to the antenna is not allowed to be copper or traced. It is also a good choice to directly expose the antenna part out of the carrier board.
4. It is recommended to use insulating material for isolation at the module mounting position on the substrate. For example, put a block of screen printing (TopOverLay) at this position.

12. AT COMMAND

(Note: AT command mode when the module is not connected)

1. AT command, which belongs to the character line instruction, is parsed according to the line (that is, AT command must be returned by carriage return or \r\n, hexadecimal number is 0D0A)
2. The AT command supports case and the instruction prefix is AT+, which can be divided into parameter setting instructions and read instructions.
3. Set the instruction format: AT+<CMD><PARAM> Operation returns successfully: +<CMD>=<PARAM>\r\n OK\r\n Failure does not return characters.
4. Read instruction format: AT+<CMD>Operation succeeds: +<CMD>=<PARAM>\r\n Failure does not return a return character.

AT command format example (Figure 1 is AT test command, Figure 2 is to change the Bluetooth name to 1234):





1、Test Command:

Function	Command	Response	Description
Test instructions	AT\r\n	OK\r\n	

2、Get The Software Version:

Function	Command	Response	Description
Query version number	AT+VERSION\r\n	+VERSION=<version>\r\n OK\r\n	<version> Software version number

Note: The version will be different depending on different modules and customization requirements.

3、Set/Query Module Bluetooth MAC:

Function	Command	Response	Description
Query module MAC address	AT+LADDR\r\n	+LADDR=<laddr>\r\n	<laddr> Bluetooth 12-bit MAC Address Code

4、Set/Query Device Name:

Function	Command	Response	Description
Query module Bluetooth name	AT+NAME\r\n	+NAME=<name>\r\n	<name> Bluetooth name, up to 20 bytes
Set the module Bluetooth name	AT+NAME<name> >\r\n	+NAME=<name>\r\n OK	Default name: BT20

Example:

1. Send Settings:

AT+NAME=DX-BT20\r\n ——Set module device name: “DX-BT20”

return:

+NAME=DX-BT20\r\n ——Set module device name: “DX-BT20” succeeded

OK\r\n

2. Send inquiry:

AT+NAME\r\n ——Query module name

return:

+NAME=DX-BT20\r\n ——Return module device name: “DX-BT20”



5、Set/Query - Serial Port Baud Rate:

Function	Command	Response	Description
Query module baud	AT+BAUD\r\n	+BAUD=<baud>\r\n	<baud> Baud rate
Set the module baud	AT+BAUD<baud>\r\n	+BAUD=<baud>\r\n OK\r\n	corresponding serial number 1:1200 2:2400 3:4800 4:9600 5:19200 6:38400 7:57600 8:115200 Default: 4 (9600)

Note: The module must be re-powered after setting the baud rate, enabling the new baud rate for data communication and AT command resolution.

Example: Setting the Serial Port Baud Rate: 38400

1. Send Settings:

AT+BAUD6\r\n

return:

+BAUD=6\r\n

OK\r\n

2. Send inquiry:

AT+BAUD\r\n

return:

+BAUD=6\r\n

6、Set/Query - Serial Port Stop Bit:

Function	Command	Response	Description
Query module serial port stop bit	AT+STOP\r\n	+STOP=<Param>\r\n	< Param> Stop bit 0 -1 Stop bit



Set module serial port stop bit	AT+STOP<Param> >\r\n	+STOP=<Param>\r\n OK	1 -2 Stop bit Default: 0
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7、Set / Query - Serial Parity Bit:

Function	Command	Response	Description
Query module serial parity bit	AT+PARI\r\n	+PARI=<Param>\r\n	< Param> Check Digit 0 -1 No check
Set the module serial parity bit	AT+PARI<Param >\r\n n	+PARI=<Param>\r\n OK	1 -2 Odd parity 2 -2 Even parity Default: 0

8、Settings\Query—SERVICE UUID: (Requires restarting the phone Bluetooth, the phone will take effect)

Function	Command	Response	Description
Query module service UUID	AT+UUID\r\n	+UUID =<service>\r\n	<service> Service UUID
Set module service UUID	AT+UUID<service> >\r\n	+UUID =<service>\r\n OK	Default service UUID:FFE0

Example: Set the service UUID to: FE00

1. Send Settings:

AT+UUID0XFF00\r\n

return:

+UUID=0XFF00 r\n

OK

9、Settings\Query—NOTIFY UUID\ WRITE UUID: (Requires restarting the phone Bluetooth, the phone will take effect)

Function	Command	Response	Description
Query module notify\write UUID	AT+CHAR\r\n	+CHAR=<UUID >\r\n	<UUID> notify\write UUID
Set module notify \write UUID	AT+CHAR<UUID> \r\n	+CHAR =<UUID>\r\n OK	Default: FFE1

Note: This channel is a readable and writable channel (ie it can be read or written)



Example: Set the notify \write UUID to: FE01

1. Send settings:

`AT+CHAR0xFE01\r\n`

return:

`+CHAR= FE01\r\n`

`OK\r\n`

10、Settings\Query—WRITE UUID: (Requires restarting the phone Bluetooth, the phone will take effect)

Function	Command	Response	Description
Query module write UUID	<code>AT+WRITE\r\n</code>	<code>+ WRITE =<UUID >\r\n</code>	<UUID> write UUID Default: FFE2
Set module write UUID	<code>AT+WRITE<UUID >\r\n</code>	<code>+ WRITE =<UUID>\r\n OK</code>	

Example: write UUID to: FE02

1. Send settings:

`AT+WRITE0xFE02\r\n`

return:

`+ WRITE = FE02\r\n`

`OK\r\n`

11、Settings\Query - Low Power Mode:

Function	Command	Response	Description
Query module low power mode	<code>AT+PWRM\r\n</code>	<code>+PWRM=<Param>\r\n</code>	< Param >(0、 1) 0: Low power mode 1: working mode Default: 1
Set module low power mode	<code>AT+PWRM=<Par am>\r\n</code>	<code>+PWRM=<Param>\r\n OK</code>	

12、Software restart:

Function	Command	Response	Description
Software restart	<code>AT+RESET\r\n</code>	<code>+RESET OK\r\n</code>	

13、Restore default settings:

Function	Command	Response	Description
Restore default settings	<code>AT+DEFAULT \r\n</code>	<code>+DEFAULT</code>	



		OK\r\n	
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14、Settings / Query - Broadcast Interval:

Function	Command	Response	Description
Query Broadcast Interval	AT+ ADVI \r\n	+ ADVI =<Param>\r\n	Param: 0~F
Set Broadcast Interval	AT+ADVI<Param>\r\n	+ ADVI =<Param>\r\n OK	0—100ms 1—152.5ms 2—211.25ms 3—318.75ms 4—417.5ms 5—546.25ms 6—760ms 7—852.5ms 8—1022.5ms 9—1285ms A—2000ms B—3000ms C—4000ms D—5000ms E—6000ms F—7000ms Default: 0

Note: This instruction can be used to reduce power consumption

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