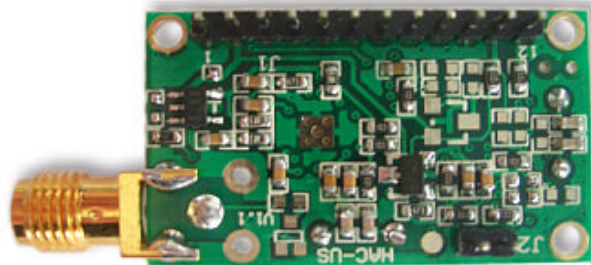
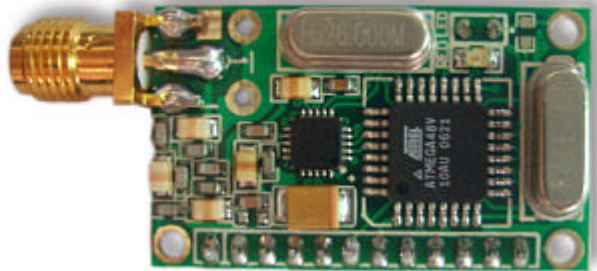


HAC-US Ultra Low Power Data Radio Module

Version 1.1



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I. Features of HAC-US ultra Low Power Data Radio Module

1. Ultra low power transmission with 10mW maximal transmission power.
2. Requiring no any frequency, HAC-US transceivers work on ISM frequency band and carrier frequencies of 315MHz, 433MHz, 868MHz and 915MHz, only one available once.
3. High anti-interference and low BER (Bit error Rate)

Based on the Gaussian Frequency Shift Keying (GFSK) modulation mode, the high-efficiency forward error correction channel encoding technology is used to enhance data's resistance to both transient and random interference and the actual bit error rate of $10^{-5} \sim 10^{-6}$ can be achieved when channel bit error rate is 10^{-2} .

4. Long transmission distance

Within the visible range, when the height of antenna is higher than 2m and the bit Error Rate (BER) is 10^{-3} , the reliable transmission distance respectively is more than 800m@1200bps, >500m @9600bps and >300m @ 38400bps.

5. Transparent data transmission

Transparent data interface used in transceiver is for meeting many standard or nonstandard user protocols. Any false data generated in air can be filtrated automatically (What has been received is exactly what has been transmitted).

6. Multi-channel

HAC-US transceivers offer Multi-channels in one ISM frequency band satisfying various configuration of communication under users' demand at the same time and avoiding the interference by other devices in the same locale. (Channels setting is set via serial port's order, please see the concrete method in Page6)

7. 3 serial ports with 3 connection methods

HAC-US provides 3 serial ports and 3 connection methods, with COM1 as the TTL level UART interface, COM2 as the nonstandard RS-232 port and Com3 as the nonstandard RS-485 port (using software analogy as the logic of RS232 and RS485, the level of COM 2 is $-0.7\sim 5.7V$ having the same use method with the standard RS232/485 and the efficient drive distance is 2m.)

Note: when the baud rate is more than 9600bps,only TTL interface available.

8. Large data buffer zone

The interface data rate is same with the RF baud rate: 1200, 2400, 4800, 9600, 19200, 38400, 56700bps. With format of 8N1/8E1/8O1, users can define by themselves. HAC-US can

transmit unlimited long data frames supporting flexible programming.

9. Intelligent data control requiring no any complicated transmission programs

Even for half duplex communication, no any excessive programs required. All RF system data transmission/reception and other On-the-Fly conversion and control are performed by HAC-US transceivers automatically.

10. Low power consumption & sleep function

The receiving current is <25mA, the transmitting current is <40mA, and the sleeping current is <25uA.

11. High reliability, light and small

By using monolithic radio-frequency integrated circuit and single-chip MCU, the transceivers have little peripheral circuits, high reliability, and low failure rate.

12. More options of configurable antennas for user different applications..

II. Applications of series HAC-US ultra low power data radio module

HAC-US Series Ultra low power data radio module is suitable for:

Wireless meter reading

Industrial remote control and remote test

Automatic data collecting system

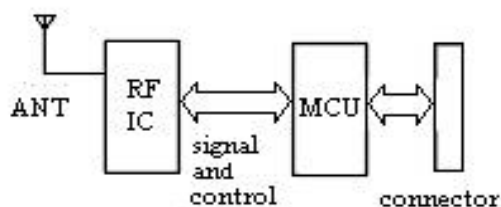
Building automatization, security, machine-house equipment wireless monitoring

POS system

Positioning and alarm in the well

III. How to use HAC-US series ultra low power data radio module

HAC-US is a member of HAC series ultra low power data radio modules, which provides RS-232, RS-485 and UART/TTL level interface port for direct connection with PC, RS485 devices, monolithic processors and other UART components kind of applications. The schematic diagram is shown below:



HAC-US series principle map

1. Power supply

The factory default setting is +4.75~5.25V DC. By using better ripple factor (the ripple peak should be <10mV), HAC-US transceivers can also share power supply with other equipment.

If possible, a voltage-stabilizing chip with 5V voltage is more recommended as the only power supply than Switch power supply. But if only switch power supply available, the jam by switch pulse to the transceivers should be avoided. In addition, the reliable grounding must be used if there is other device in the system equipment. In case of failing to connect with the ground, it can form its own grounding but must be absolutely separated from the municipal electric supply.

Note: If the transceivers with lower power and lower consumption are required, we can lower the power supply into 2.5~3V product.

2. Connection Definition with terminal

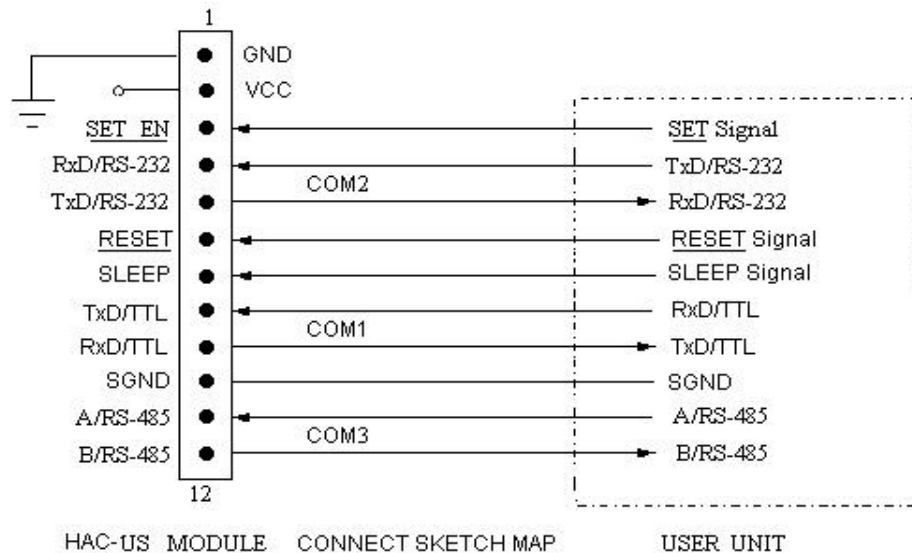
HAC-US transceivers supply one 12-pin connector (JP1), their definitions and connection method with terminals are shown in Table 1.

Table 1: Pin Definitions and connection methods

Pin	Signal Name	Function	Level	Connected to terminal	Remark
1	GND	Ground		Ground	
2	VCC	Power supply DC	+3.3~5.5V		
3	SET_EN	Enable setting	TTL		
4	RxD/RS-232	Serial data input to the transceiver	RS-232	TxD	COM2
5	TxD/RS-232	Transmitted data out of the transceiver	RS-232	RxD	COM2
6	<u>RESET</u>	Reset (input)	TTL		Negative pulse reset
7	SLEEP	Sleep control (input)	TTL	Sleep signal	High level sleep
8	TxD/TTL	Serial data transmitting	TTL	RxD	COM1
9	RxD/TTL	Serial data receiving	TTL	TxD	COM1

10	SGND	Signal grounding			Connected with Grounding
11	A/RS-485	Port A of RS 485	RS-485	A/RS-485	COM3
12	B/RS-485	Port B of RS 458	RS-485	B/RS-485	COM3

3. The connection schematic diagram of HAC-US transceivers with terminal



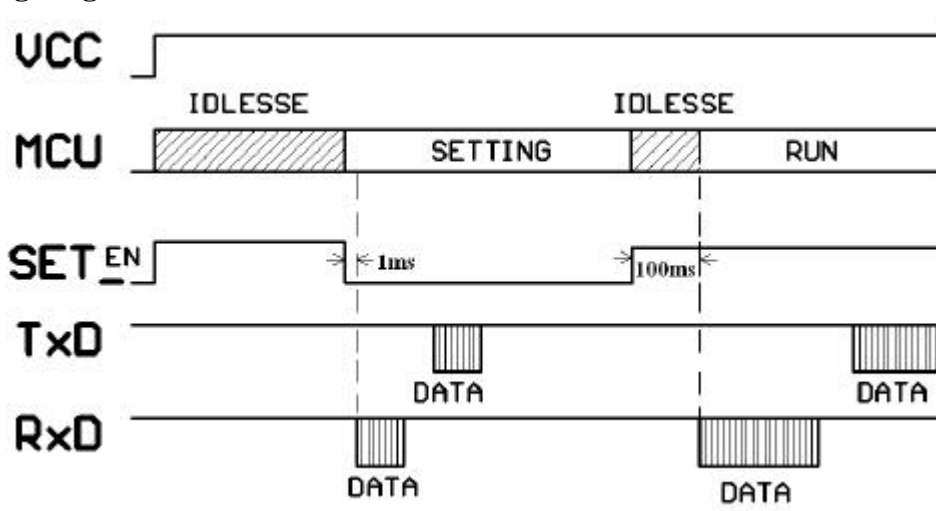
4. The function-indicator light

- The LED indicator light glitters for 2S once after switched on.
- The LED indicator light glitters continually while receiving data from air.
- The LED indicator light will light on continuously when the transceiver transmits data into air after receiving from COM
- The LED indicator light glitters continually but darker, when the transceiver is in setting mode.

5. HAC-US function setting

A simple configuration based on user's needs should be made to validate the channel frequency, interface data rate, data format, sleep function and transmission power. The US_studio software and the setting board provided by HAC can be used.

Also, users can program setting software by themselves, but the control of setting enabling (SET_EN) should be a strong consideration while programming. When being idle and SET_EN set in low level, 1ms later HAC-US transceivers will be in setting mode; When SET_EN set in high level, 100ms later the transceivers will turn into work mode.

Timing Diagram:

HAC-US's default setting is as following:

Channel: 0 Baud rata: 1200bps Data format: 8E1 Sleeping function: Closed

Note: The user's other specific requirement will be set before leaving factory.

The concrete Setting methods are following:

a. Interface and data format

Via 3 COM ports, the basic parameter can be set using ASCII code or Hex. (**Note: when getting in setting mode, the baud rate - 9600bps and the data format - 8N1 are both fixed).**

b. Command format:

	Identifier	Read-write sign	Command word	Parameter	End code
ASCII	\$	R / W	1byte	n byte	(Enter)
Hex	0x24	0x52/0x57	1byte	n byte	0x0D

Identifier: \$- Command starts

Read-write sign: R-read parameter, W-write parameter

Command word: C-channel Number, V-verifying code, B-baud rate, S-sleep function

Parameter: Refer to command paraphrase

End code: Enter –ending sign command (0x0D)

There is no distinction between capitals and small letters in entire commands. If wrong input occurs, by pressing 'Backspace' (0x08) the last byte can be deleted and the command can be input again.

C. Command paraphrase

Read the current parameter :

ASCII	\$R
Hex	24 52 0D

Return :

ASCII	Channel : 0 (Channel No. : 0~31) Verifying : 8E1 (Parity bit : 8E1/8O1/8N1) Baud rate : 1200 (Baud rate : 1200~57600) Sleep : Close (Sleeping function : Close/Open)
Hex	20 20 43 68 61 6E 6E 65 6C 3A 20 30 0D 0A 20 20 20 56 65 72 69 66 79 3A 20 38 65 31 0D 0A 42 61 75 64 20 72 61 74 65 3A 20 31 32 30 30 20 0D 0A 20 20 20 20 53 6C 65 65 70 3A 20 43 6C 6F 73 65 0D 0A

To write the Channel parameter :

Input the command :

ASCII	\$WC08
Hex	24 57 43 30 38 0D

Return :

ASCII	Channel : 8 (Channel No. : 0~31)
Hex	20 20 43 68 61 6E 6E 65 6C 3A 20 38 0D 0A

Note: The new channel No. is 8. '\$WC' is the command for writing channels with parameter 00~31.

When the channel number is less than 10, the anterior '0' cannot be omitted.

To write the parity bit parameter :

Input command :

ASCII	\$WVE
Hex	24 57 56 45 0D

Return :

ASCII	Verify : 8E1
Hex	20 20 20 56 65 72 69 66 79 3A 20 38 65 31 0D 0A



Note: The parity bit set as 8E1. '\$WV' is the command for writing channels with parameter **N, O, E**, which respectively represent 8N1, 8O1, 8E1. 8 and 1 mean there are 8 efficient data bits and one start bit one stop bit.

To write the baud rate parameter :

Input command :

ASCII	\$W D
Hex	24 57 42 44 0D

Return :

ASCII	Baud rate : 9600
Hex	42 61 75 64 20 72 61 74 65 3A 20 39 36 30 30 20 0D 0A

Note :The baud rate set as 9600bps. '\$WB' is the command for writing channels with parameter **A, B, C, D, E, F, G**, which respectively mean: 1200bps, 2400bps, 4800bps, 9600bps, 19200bps, 38400bps, 57600bps.

To write the sleep parameter :

Input command :

ASCII	\$W S O
Hex	24 57 42 44 0D

Return :

ASCII	Sleep : Open
Hex	20 20 20 20 53 6C 65 65 70 3A 20 4F 70 65 6E 20 0D 0A

Note : Open the sleep function. '\$WS' is the command for writing channels with parameter **O, C** and other characters, which respectively represent opening the sleep function (O) and closing the sleep function(C).

To write the command of error :

When any error occur in identifier、read-write sign、command word, please press

'Backspace' :

ASCII	Error!
Hex	45 72 72 6F 72 21 20 0D 0A

When nothing wrong with identifier, read-write sign, but command sign wrong, return :

ASCII	Error!
Hex	(command sign :) 45 72 72 6F 72 21 20 0D 0A



Note: Red words are setting parameter, different setting leads to different return character.

6. Channel Frequency:

Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)
00	430.1498	08	435.5578	16	440.9658	24	446.3738
01	430.8258	09	436.2338	17	441.6418	25	447.0498
02	431.5018	10	436.9098	18	442.3178	26	447.7258
03	432.1778	11	437.5858	19	442.9938	27	448.4018
04	432.8538	12	438.2618	20	443.6698	28	449.0778
05	433.5298	13	438.9378	21	444.3458	29	449.7538
06	434.205	14	439.6138	22	445.0288	30	450.4298
07	434.8818	15	440.2898	23	445.6978	31	451.1058

Note: Each channel frequency can be modified freely before leaving factory to meet user's needs.

7. Interface ports use:

- i. HAC-US transmits the data received from air to terminal unit via serial ports, COM1, COM2 and COM3 output synchronously. Likewise, if COM1, COM2 and COM3 are respectively connected with one device, they can receive the data synchronously.
- ii. For the data sent by terminal units and ready to be transmitted into the air, HAC-US transceivers can only receive the data sent by one port of COM1, COM2 and COM3, but not two or three simultaneously.

Note: Only one port of COM1, COM2, COM3 can be connected to use.

8. Attentions about data transmission:

- i. Due to e a data processing will be made on users' data by HAC-US transceiver using FEC (Forward Error Correction) or other correction algorithm, when RxD of a HAC-US transceiver 'A' receives the data, then transmits it, the other one transceiver 'B' will have a delay (ts) to receive and transmit by TxD. Different RF data rate causes different delay time. Please see the specific delay time below:

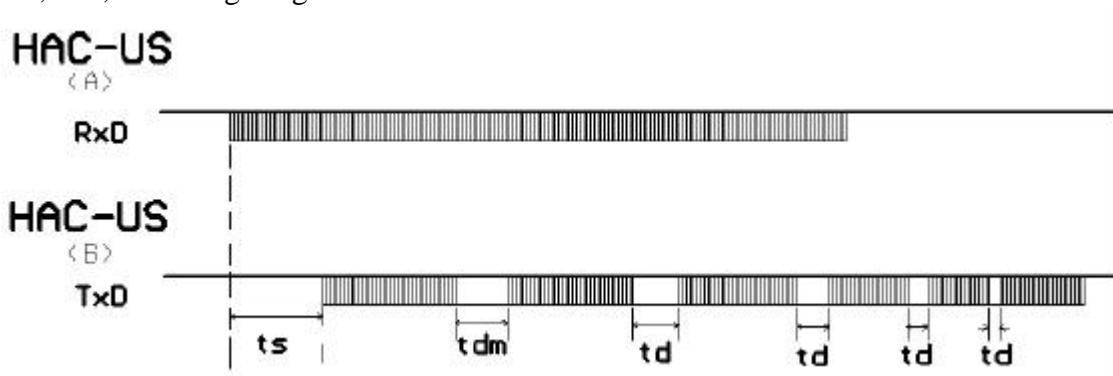
RF data rate (bps)	Delay ts (ms)	RF data rate (bps)	Delay ts (ms)
1200	115	19200	8
2400	58	38400	5

4800	30	57600	3
9600	16		

- ii. When HAC-US is transmitting the data, there is a certain intervening time between the data sent by TxD (tdm). Different baud rate leads to different intervening time (td). When the 'time-out' is set for TxD receiving, it should be more than maximal intervening time (tdm). The specific maximal intervening times (tdm) is following:

Baud rate (bps)	Max-delay tdm (ms)	Baud rate (bps)	Max-delay tdm (ms)
1200	65	19200	5
2400	33	38400	3
4800	17	57600	2
9600	9		

- iii. Ts, tdm, td Timing Diagram:



- iv. Error dealing procedure:

To enhance the reliability and stability of user's system, a verify bit or a Cyclic Redundancy Check (CRC) mode is highly recommended to resent the wrong information while using HAC-US series modules.

- v. Large-number data transmission

In theory, when the interface data rate is faster than the RF data rate, HAC-US transceivers can sent unlimited-long data package, but any long packages more than 120B are not recommended. The length of each package should be between 60~100B. We also recommend user to resent the wrong information using Automatic Error Request Equipment (ARQ).

The analyzing as below:

What if the actual transmission BER (Bit Error Rate) is 10^{-4} , 1 packet with 1KB data, which is about 10-thousand bits, is sent, theoretically, at least 1 bit will be received wrongly, then the 1KB information will never be received correctly.



But if we package the data into 10 packets with 100B for each, when all 10 packets are sent, there will be only 1 packet wrong according to this probability. After that, resend this wrong packet using ARQ mode. So by resending one more packet and the efficiency rate is reduced 10%, all data will be absolutely received correctly.

9. Supported protocol and Transmit capability

HAC-US standard transceivers offer transparent protocol to support various applications and protocols of users. If the user needs to decrease his cost or ease the workload of terminal CPU, we can add other specific functions based on the transparent protocol, such as addressing, data acquisition, command interpretation, etc.

10. Low Power Consumption (Sleep) function instruction:

Due to reducing more consumption, HAC-US transceivers support Sleep function. In sleep mode, the current consumption is $< 25\mu\text{A}$.

i. How to use the Sleep function:

The Pin7 'SLP' in JP1 is the signal of sleep control. In high power level, when the transceiver stays in sleep state, the conversion from idle mode to sleep will be finished in 1ms. The SLP signal can convert transceiver from idle mode to sleep in 1 ms after rising edge. If the Sleep signal arrives when the transceiver is receiving or transmitting data into air, the module will enter sleep state after finishing transmission.

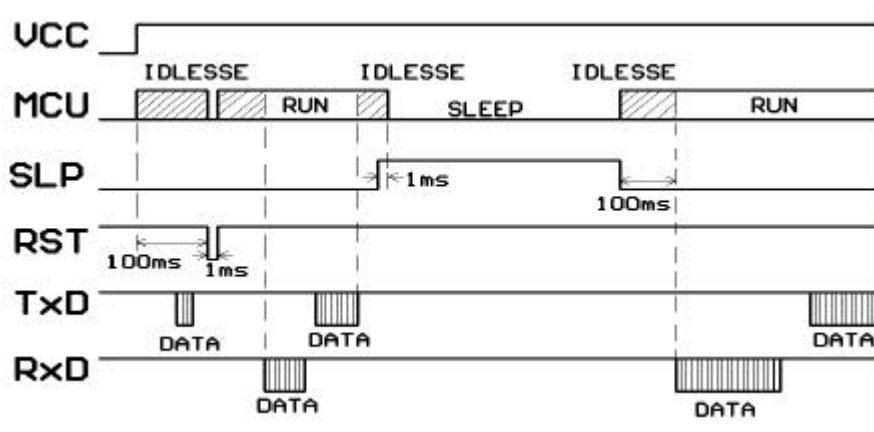
Likewise, when the SLP (SLEEP) keeps in low power level, the transceiver will work continuously. It takes $< 100\text{ms}$ to convert it from sleep to work mode after falling edge.

To disable the opened sleep function of HAC-US, the SLP (SLEEP) pin should be definitely connected with 0 or ground.

ii. Attentions for use sleep function:

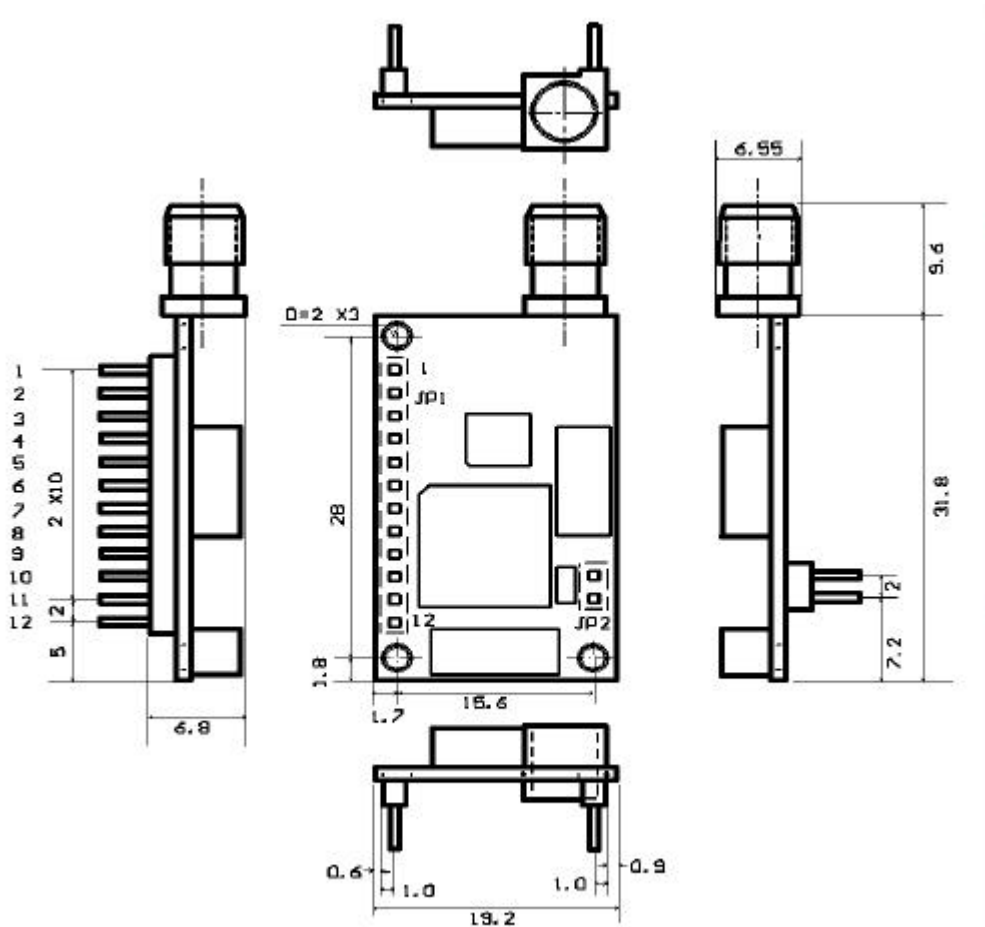
When the sleep function enabled, any glitches, such as switch dithering, fire striking, quick switching on and off, could cause the transceiver to be switched to the wrong sleep mode. After switching on, users can avoid this error by making a compulsive restoration once after the CPU delays 100ms.

iii. Sleep timing Diagram



10. Dimension diagram (Unit: mm):

The dimension diagram below is the factory set default of HAC-US transceiver. Other required smaller sizes and different shapes can also be provided.



12. Antenna configuration:

Many appropriate antennas for ultra low power RF modules are selected for meeting different user antenna configurations. Please ask our Sales office for further information about



the antenna's dimension and performance. The main options of antennas are exterior flagelliform rubber antenna with helical SMA joint, spring antennas and PCB antennas.

- i. Helical SMA (SMA connector) antennas:
80mm helical SMA antennas with high gain and low cost, reach a long distance
35mm magnetic helical SMA antennas with high gain are small and good-looking (similar with mobile phone's antenna).
- ii. Spring antennas:
Spring antennas with a small dimension of 30mm×7mm, can be welded on the PCB of HAC-US. By using this antenna inserted in plastic shell, the cost will be lower.
- iii. PCB antennas:
PCB antennas with a small dimension of 30mm×7mm, can be welded on the PCB board. The total length of modules is only increased 25mm by welding PCB antenna and PCB with a 5mm superposition. But the product's configuration will be simplified to be smaller and thinner via using PCB antennas.
- iv. Antenna customization:
If the user has special demands on antennas, we can design and produce for them specially.

IV. Application of HAC-US series networking

The communication channel of HAC-US is half duplex, which is mostly suitable for the communication mode of point to multi-point. Under this mode, one master station must be set, and all of the rest are slave stations with a unique address. The coordination of communication is controlled by master station that uses data frames containing address code to transmit data or command. All of slave stations will receive the data and command and compare the received address code with local address code. If they are different, the data will be dismissed with no response. If they are same, it means the data is sent to the local. Slave station will make different responses according to the transmitted data or command and send the data back as response. All these jobs must be performed by upper level protocol, which will assure that there is only one transmitter-receiver in transmission mode in the communication network at any transient moment so as to avoid the cross-interference.

HAC-US transceivers can also be used for point-to-point communication with easier operation. For the programming of serial port, all you have to do is to remember that its communication mode is half duplex and always to observe the time sequence of come-and-go for receiving and transmitting.



V. Technical index of HAC-US

Modulation mode:	GFSK(Gaussian Frequency Shift Keying)
Working frequency:	315MHz, 433 MHz, 868 MHz, 915 MHz
Transmission power:	10dBm
Interface data format:	8E1/8N1/8O1
Receiving sensitivity:	-110dBm@1200bps
Interface baud rate:	1200、2400、4800、9600、19200、38400、57600bps
Working temperature:	-20 ~70
Power supply:	+3.3 ~ 5.5VDC
Dimension:	31.8mm×19.2mm×6.8mm
Transmitting current:	40mA
Receiving current:	25mA
Sleeping current :	25uA
Working humidity:	10%~90% relative humidity without condensation

VI. Explanation of type

For HAC-US433 product type, 'HAC-' indicates the name of manufacturer Shenzhen HAC Telecom Technology Co., Ltd., 'US' is the name of type, '433' is the carrier frequency.

HAC—US 433				
manufacturer	type	frequency range:	315	300-348MHz
			433	400-464MHz
			868	800-900MHz
			915	900-928MHz