HAC-LN Series Low Power Data Radio Module

Version 3.0

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Catalogue

I.   Features of HAC-LN Series

1.   Low power transmission with 300mW, 600mW available for special need.

2.   With 868/915MHz carrier frequency optional.

3.   High anti-interference and Low BER (Bit error Rate)

Based on the Gaussian Frequency Shift Keying (GFSK) modulation, the high-efficiency forward error correction channel encoding technology is used to enhance data's resistance to both transient interference 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 distances respectively is 2500m @1200bps, and is more than 1500m@9600bps.

5.   Transparent data transmission

Transparent data interface used in transceivers 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-channels

HAC-LN transceivers offer 8 channels, if needed, 16 or 32 channels available to satisfy various configuration of communication under user's demand at the same time

7.   2 ports with three connection methods

HAC-LN transceivers provide 2 ports with three connections, ports: a UART interface of TTL level, a non-standard RS-232 port and a non-standard RS-485 port, which both are defined by user software (define it just by plugging out and in one short circuit device and then power on).

Note: LN384 (i.e. the baud rate is 38400bps) is without any non-standard RS-232/485 port.

8.   Big data buffer area

With optional interface baud rate: 1200/4800/9600/19200/38400bps and 8N1/8E1 data format (set by user), the transceiver can transmit unlimited data frames with flexible user program.

Note: the data rate is only settled down before delivery, please inform our sales when placing your orders.

9.   Intelligent data control and no any extra programs required

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-LN transceivers automatically.

10. Lower power consumption & Sleep function

With +5V power, the receive current is less than 50mA, the transmit current is less than 400mA, and the sleep current is less than 5μA.

11. High reliability, small and light

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

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

II.   Applications of HAC-LN Series

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

 * Auto Meter Reading system.

 * Remote control and monitoring.

 * Automatic data collection.

 * Building automatization, security, machine-house equipment wireless monitoring

 * Traffic, Personnel positioning and alarm in the well

III.   How to use HAC-LN Series

HAC-LN is a member of HAC series 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.

1. **Power supply**

The factory default setting is +5.0, ±0.25V DC. By using better ripple factor, HAC-LN 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.

2. Connection Definition with terminal

HAC-LN transceivers supply one 9-pin connector (JP1), their definitions and connection methods with terminals are shown in Table 1.

Table 1: JP1 Pin Definitions and connection methods

Pin	Signal Name	Function	Level	Connection with terminal	Remarks
1	GND	Power Ground		Power Ground	
2	VCC	Power supply DC	+4.75~5.25V		
3	RxD/TTL	Serial data for receiving terminal	TTL	TxD	
4	TxD/TTL	Serial data for transmitting terminal	TTL	RxD	
5	SGND	Signal Ground			
6	A(TxD)	A of RS-485 (TxD of RS-232)		A(RxD)	
7	B(RxD)	B of RS-485 (RxD of RS-232)		B(TxD)	
8	SLEEP	Sleep control (input)	TTL	Sleep signal	High level sleep
9	RESET	Reset signal (Input)	TTL		Negative pulse reset

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

CONNECT SKETCH MAP
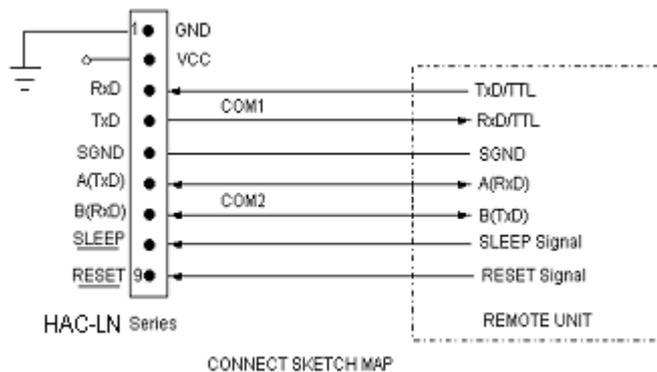
4. Setting of channel, interface and data format:

Before using HAC-LN, the user needs to make simple configuration based on its own needs to determine the channel, interface mode and data format.

There is one group of 5-bit short-circuit jumper wire (JP2) on the upper right corner of HAC-LN, defined as ABCDE respectively. Assuming the open circuit of jumper wire (without short circuiter) is mode 1 and short circuit of jumper wire (with short circuiter) is mode 0, then the configuration is as follows:

a.   Channel configuration:

ABC jumper wires of JP2 provide 8 options, and the user can choose to use 0-7 channels through ABC jumper wires. Within one small communication network, as long as ABC jumper wire mode is same, there can be mutual communication.

Table 2: Corresponding frequency points @868MHz of 0~7 channels

Channel No.	Frequency	Channel No.	Frequency
CBA=000(0)	868.050 MHz	CBA=100(4)	869.350 MHz
CBA=001(1)	868.350 MHz	CBA=101(5)	869.675 MHz
CBA=010(2)	868.575 MHz	CBA=110(6)	869.500 MHz
CBA=011(3)	869.225 MHz	CBA=111(7)	869.926MHz

Table 3: Corresponding frequency points @915MHz of 0~7 channels

Channel No.	Frequency	Channel No.	Frequency
0	915.2000 MHz	4	915.6940 MHz
1	915.4288 MHz	5	915.2332 MHz
2	915.7360 MHz	6	915.1580 MHz
3	915.5072 MHz	7	915.9260MHz

Note: The frequency points corresponding to each channel can be adjusted based on the user's needs.

1=Unplugging short circuiter (unconnected)

0 =Plugging in short circuiter

b. Selection of interface mode:

HAC-LN provides 2 serial ports. COM1 (Pin3 and Pin4 of JP1) is fixed as UART serial port of TTL level; COM2 (Pin6 and Pin7 of JP1) can choose non-standard RS232/485 interface mode through D of JP2:

D=1 (Unplugging short circuiter)　COM2 = RS-485

D=0 (Plugging in short circuiter)　COM2 = RS-232
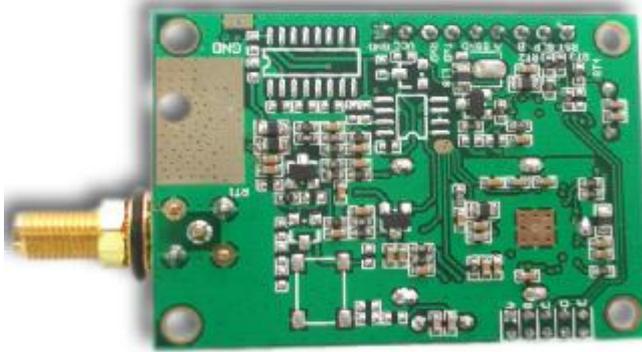
The following attention should be paid for the two serial ports provided by HAC-LN:

i.　For the data received from the air, when HAC-LN transmits it to the terminal equipment through serial port, COM1 and COM2 output simultaneously, i.e. if the user connects one device at COM1 and COM2 respectively, they both can receive the data simultaneously.

ii.　For the data transmitted from the terminal equipment and ready to transmit to the air, HAC-LN can only receive the data sent from either COM1 or COM2 but not simultaneously.

Suggestion: The user only use one serial port of COM1 and COM2.

NOTE: A standard interface of RS232 or RS485 is available if needed, but please inform our sales when placing your orders. All HAC-LN series can have standard RS232 or RS485 as COM2, but only one option is available once, here non-standard RS232 or RS485 is invalidated.

c. Parity mode selection:

HAC-LN can support no-parity or even parity modes of the serial communication UART, i.e. 8N1/8E1, which can be chosen through E of JP2:

E=1 (Unplugging short circuiter)　Parity: 8E1 (even parity)

E=0 (Plugging in short circuiter)   Parity: 8N1 (no parity)

NOTE: The communication data rate can not be set by user, it should be confirmed when placing orders and set before delivery. The short circuiter will be validated by re-powering on if its method of plugging is changed.

5.   The Function-indicator light

a.   The LED indicator light glitters for 0.5S once after switched on.

b.   The LED indicator light glitters continually while receiving data from air.

c.   The LED indicator light will light on continuously when the transceiver transmits data into air after receiving from COM.

d.   If the module enables the sleep function, LED indicator light is always dark.

6. Supported protocol and Transmit capability

HAC-LN 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.

As using FIFO mode, HAC-LN is able to satisfy user big data package transmission.

7. Sleep function instruction:

Due to reducing more consumption, HAC-LN transceivers support Sleep function. In sleep mode, the current consumption is less than 5µA.

The sleep function is usually closed in default status to ensure the reliability of preventing transceivers from getting in wrong sleep mode.

The sleep function can be only opened by HAC after informed by the customer when they put order.

a. How to use the Sleep function:

The Pin8 'SLP' in JP1 is the signal of sleep control. In high power level, when the transceiver stays in sleep mode, the conversion from idle mode to sleep will be finished in 1ms. The SLP signal can convert transceiver from idle to sleep mode in 1ms after rising edge. If the Sleep signal arrives when the transceiver is transmitting data, the module will enter sleep mode after finishing transmission. From sleep mode to idle, it takes the transceiver 10ms after falling edge.

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

b. Attentions about use of sleep function:

When the sleep function enabled, any supply glitches, such as switch dithering, fire striking or 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. But such a condition seldom occurs.
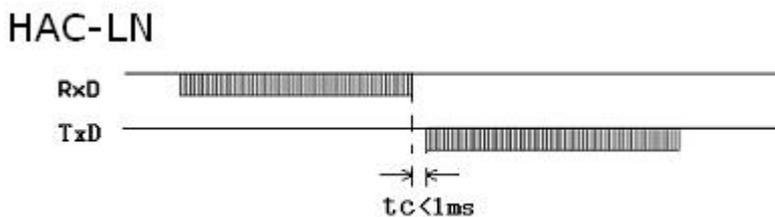
 Sleep Timing Diagram:
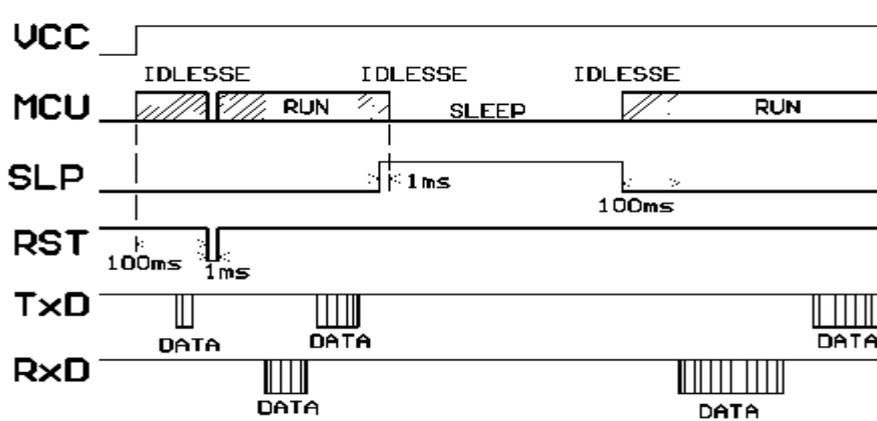
8. The attentions of data transmission

a.   The delay time (tc) of conversion between transmitting and receiving is less than 1ms.

 Timing diagram:

b.   The delay time of transceivers between the first bit sent by TxD to the first bit received by RxD.

Due to a data processing will be made on user's data by HAC-LN transceiver using FEC (Forward Error Correction) or other correction algorithm, when RxD of a HAC-LN 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	90	9600	12
2400	48	19200	6
4800	24	38400	3

Timing diagram:
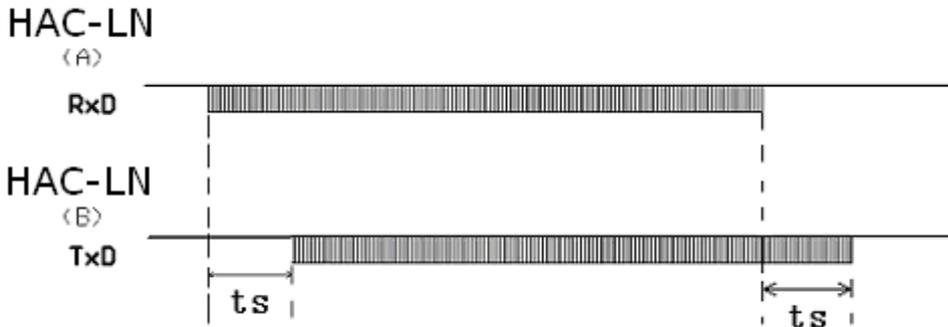
c. Error dealing procedure:

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

d. Large-number data transmission

In theory, when the interface data rate is faster than the RF data rate, HAC-LN 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. Dimension diagram (Unit: mm):

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

10.   Antenna configuration:

Many appropriative antennas for 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.

a. Helical SMA antennas

LX868/915-10-SMA: 100mm helical SMA antennas with high gain and low cost, reach a long distance.

LX868/915-3-SMA: 35mm SMA helical antenna with magnetic core, small size, beautiful appearance (like the mobile phone antenna)

LX868/915-10-ZSMA: 100mm SMA helical antenna with folding joint, easy for adjusting the direction and fixing.

b. Magnetic vehicle antenna

XP868/915-300H-SMA: include magnetic antenna base, suitable for equipment with metal shell, easy for fixing, effective to enhance the transmission distance.

If the user has special demands on antennas, we can design and produce for them specially.

IV. Networking Application of series HAC-LN Series

The communication channel of HAC-LN is half duplex, which is most 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. A unique address is given to each station. The coordination of communication is controlled by master station that uses data frames containing address code to transmit data or command. Slave station will receive all of the data and command and compare the received address code with local address code. If they are different, the data will be deserted without any response. If those address codes are the 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 back the data of response. All these jobs must be performed by upper protocol, and it is assured that there is only one transmitter-receiver in the state of transmission in the communication network at any instant moment so as to avoid the cross-interference.

HAC-LN 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 semi duplex while always observing the time sequence of come-and-go for receiving and transmitting.

V. Technical specification of HAC-LN Series

Modulation mode: GFSK

Working frequency: 868.00~869.95MHz (804~900MHz available for special needs)

912.200~917.690MHz (900~940MHz available for special needs)

Transmission power: 300mW@5V (600mW@7.2~9V available if needed)

Interface data rate: 1200/2400/4800/9600/19200/38400bps, set before delivery.

Receiving sensitivity -123dBm~-116dBm, (-118dBm@9600bps)

Interface data format: 8E1/8N1

Transmit current: <400mA (300mW), <450mA(600mW)

Receive current: <50mA

Sleep current: 5μA

Working humidity: 10%~90% relative humidity without condensation

Working temperature: -20℃~60℃ (Commercial) , -40℃~80℃(Industrial)

 Dimension: 53×38×10mm

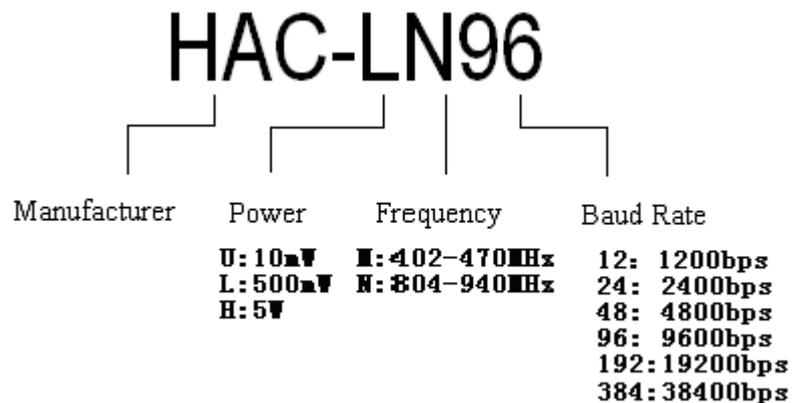 Power supply: 4.75 ~ 5.25VDC (300mW)

            7.2~9VDC (600mW)

VI.   Description of type

or product type HAC LN96, "HAC-"indicates the name of manufacturer ShenZhen HAC Technology Co., Ltd., "L" low power, i.e. transmission power is 300mW, "N" indicates carrier frequency 868/915MHz, the factory default is 869.926MHz, and 96 indicates that interface baud rate is 9600bps. 38400bps type is HAC-LN384.

HAC-UNet

470MHz Micro Power Wireless Self-organized Module

(Based on VBee protocol)

V2.0

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1. Features of HAC-UNet

HAC-UNet is an ultra low power data radio module which based on wireless self-organized technology VBee protocol. Its features are as follow:

1. Standard transmitting power is 100mW（20dBm）, it can be customized as 50mW(17dBm). The working frequency is from 470MHz to 475MHz.

2. High anti-interference and Low BER (Bit error Rate)

   Based on the GFSK modulation, the high-efficiency forward error correction channel encoding technology is used to enhance data's resistance to both transient interference and random interference. The 16 CRC verify bits can be used to check mistake.

3. The transmitting speed in the air is fixed on 9600bps. The reliable transmitting distance is 1500m within the visible range.

4. HAC-UNet offers 8 channels.

5. HAC-UNet offers a UART interface of TTL level. The standard RS232/RS485 port can be optional. The baud rate and parity can be setup.

6. Low power consumption (100mW), the receiving current is no more than 50mA, and the transmitting current is no more than 100mA.

7. Small size and light weight

8. By using monolithic SoC radio-frequency integrated circuit and single-chip MCU, the transceiver needs less peripheral circuits, and it is higher reliability and lower failure rate.

II. Applications of HAC-UNet

HAC-UNet ultra low power data radio module is suitable for:

 * Home appliances intelligent control.

 * Auto Meter Reading system.

 * Industry telemetry and automatic data collection system.

 * Security and alarm.

 * Wireless monitor for hotel and machine room, access control system, personnel orientation.

 * Traffic and the control for street lamp.

 * Logistics, active RFID, POS system and wireless handheld terminal.

III. How to use HAC-UNet

3.1 Power supply

HAC-UNet power supply is +4.75~5.25V DC. By using better ripple factor (the peak value of ripple is less than 10mV), HAC-UNet can also share power supply with other equipment. If possible, a voltage-stabilizing chip with +5V DC voltage is recommended as the only power supply. But if only switch power supply available, the jam by switch pulse to the transceivers should be avoided. In additional, if there are any other equipments in the system, the module should be connected to ground reliably.

3.2 Dimension diagram (Unit: mm):
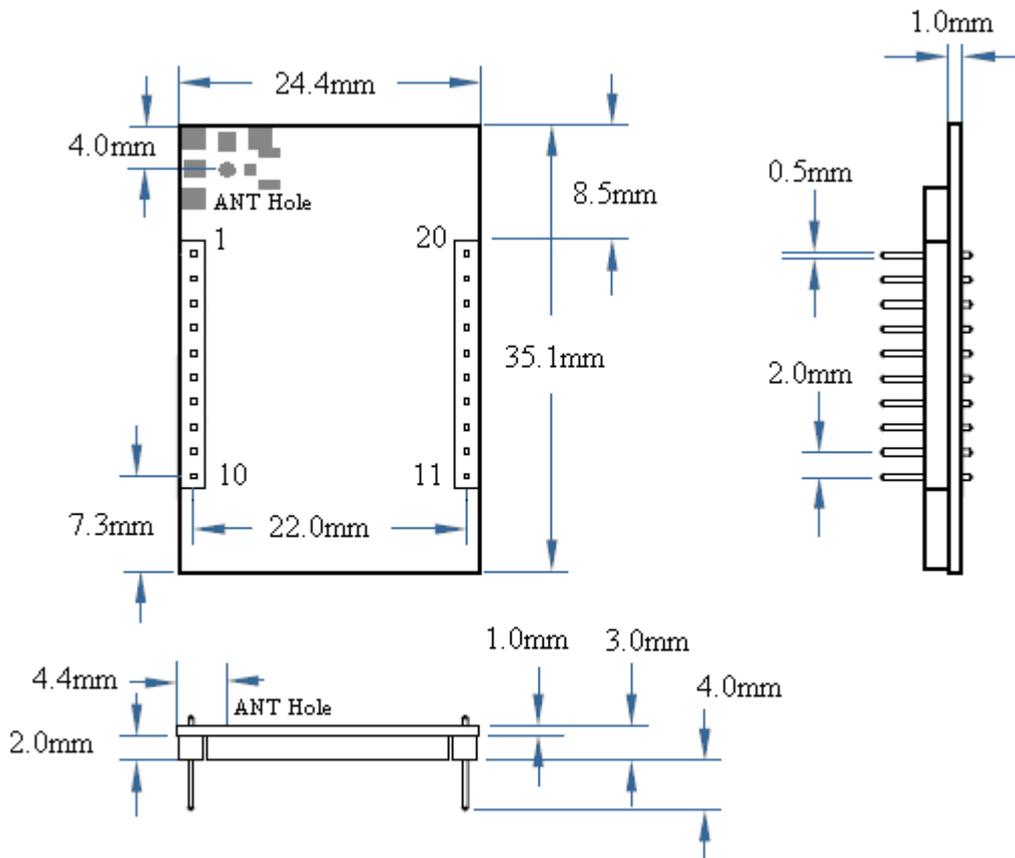
Dimension Diagram of HAC-UNet

3.3 Connection Definition with terminal

HAC-UNet supply two 10-pin connectors, their definitions and connection methods with terminals are shown in Table 1.

Pin	Definition	Input/Output	Description
1	VCC	Input	Power supply, +4.75~5.25V
2	TXD	Output	TTL level serial data output, can be extended as RS232 (TxD) or RS485 (A)
3	RXD	Input	TTL level serial data input, can be extended as RS232 (TxD) or RS485 (A)
4	DIO1	Input/Output	Digital I/O 1
5	RESET	Input	Low level reset
6	DIO2	Input/Output	Digital I/O 2
7	DIO3	Input/Output	Digital I/O 3
8	DIO4/DD	Input/Output	Digital I/O 4 Program data
9	DIO5/DC	Input/Output	Digital I/O 5 Program clock
10	GND		Ground
11	DIO6	Input/Output	Digital I/O 6
12	DIO7	Input/Output	Digital I/O 7
13	DIO8	Input/Output	Digital I/O 8
14	DIO9	Input/Output	Digital I/O 9
15	DIO10	Input/Output	Digital I/O 10
16	DIO11	Input/Output	Digital I/O 11
17	DIO12/ADC3	Input/Output	Digital I/O 12 Analog input 3
18	DIO13/ADC2	Input/Output	Digital I/O 13 Analog input 2
19	DIO14/ADC1	Input/Output	Digital I/O 14 Analog input 1
20	DIO15/ADC0	Input/Output	Digital I/O 15 Analog input 0

Table 1: Pin Definitions and connection methods of connector

3.4 HAC-UNet Channel Frequency

Channel	Frequency	Channel	Frequency
0	470.000MHz	4	472.000MHz
1	470.500MHz	5	472.500MHz
2	471.000MHz	6	473.000MHz
3	471.500MHz	7	473.500MHz

Table 2 Channel Frequency of HAC-UNet

3.5 HAC-UNet Optional Accessories

1. Spring antenna

The picture as follow is the module goes with spring antenna called TH480-B.

2. HAC480-10-SMA Helical antenna

By using helical antenna, it requires SMA antenna base, standard or lengthen antenna base can be selected to solder on the module.

3. Using antenna cable to connect with external antenna

Such a connecting method is suitable for the products with the enclosure that has strong shield for wireless signal. The module has been soldered with IPX antenna base, at the same time, it needs to cut down the PCB antenna and lead the signal to IPX antenna base. If the IPX antenna base isn't needed, it can solder antenna cable directly. In this way, the connecting method is much firmer, but it is not suitable for transportation and assembly, because the pad for soldering antenna cable is easy to fall off if there is a force during the process of transportation and assembly.

Using antenna cable with two ends connector called KX-IPEX-10G1-SMA-F to connect with an 10cm external folding helical antenna called HAC-Antenna-LX480-10-WSMA-M。

HAC-KX-IPEX-10G1-SMA-F   HAC-Antenna-LX480-10-WSMA-M

IV. Technical specification of HAC-UNet

l   Modulation mode: GFSK

l   Working frequency: 470~475GHz

l   Transmission power: 17/20dBm

l   Data format: 8E1/8N1

l   Receiving sensitivity -110dBm@9600bps (1%BER)

l   Channel bandwidth: 100K@9600bps

l   Interface baud rate: 1200~38400bps

l   Working temperature: -20℃~70℃   (Industrial)

l   Power supply: +4.75 ~ 5.25VDC

l   Dimension: $43\times24\times7.2$mm (excluding the antenna base)

l   Transmitting current: ≤100mA

l   Receiving current: ≤50mA

l   Working humidity: 10%~90% relative humidity without condensation

V. Testing and development kit of HAC-UNet

5.1 Brief introduction of testing board called HAC-DEV
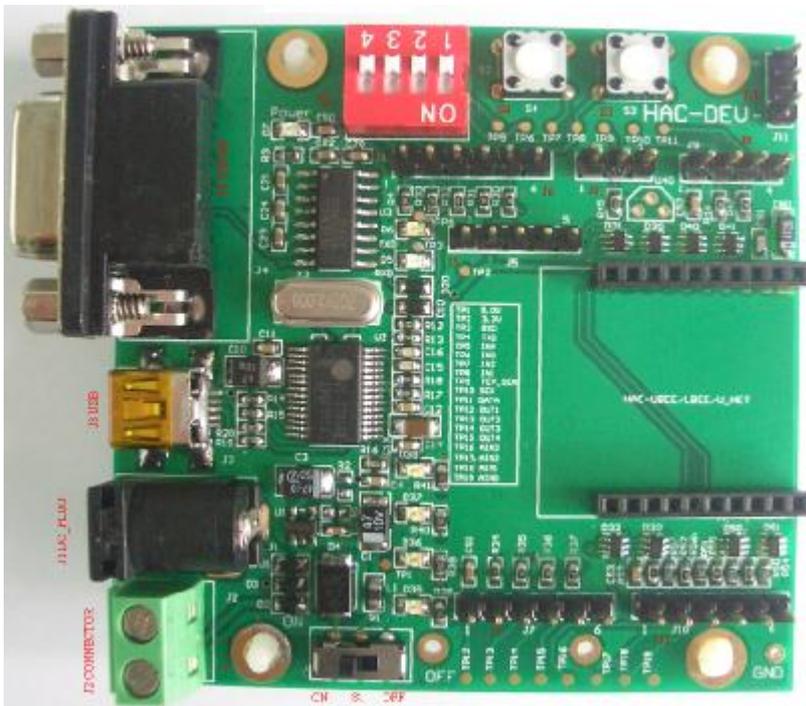
Connector Definition:

1. J1 (DC_PLUG), 5V power supply input

2. J2 (DC_CONNECTOR) , 5V power supply input

Pin Name	Definition
Pin1	GND
Pin2	5V

3. J3 (USB_ PLUG) USB port, USB port to serial port, please refer to the Appendix 1 for the driver installation method.

4. J4 (DB9/F) RS232 data port

Pin Name	Definition
Pin2	TXD
Pin3	RXD
Pin5	GND
Other Pins	No definition

5. J5 (Programming) CC2530F256 program interface

Pin Name	Definition
Pin1	GND
Pin2	3.3V Input
Pin3	DC
Pin4	DD
Pin5	RESET

Note: If there is external power supply, don't connect the Pin2:3.3V.

6. J6 (DA_IN) Digital Level Input

Pin Name	Definition
Pin1	3.3V Output
Pin2	IN4 Digital Input 4th way
Pin3	IN3 Digital Input 3rd way
Pin4	IN2 Digital Input 2nd way
Pin5	IN1 Digital Input 1st way
Pin6	GND

7. J7 (DA_OUT) Digital Level Output

Pin Name	Definition

Pin1	3.3V Output
Pin2	OUT1 Digital Output 1st way
Pin3	OUT2 Digital Output 2nd way
Pin4	OUT3 Digital Output 3rd way
Pin5	OUT4 Digital Output 4th way
Pin6	GND

8. J8 (DS18B20) Temperature Sensor DS18B20 port

Pin Name	Definition
Pin1	GND
Pin2	TEP_SEN
Pin3	GND

9. J9 (SENSOR) I^2C port, connect with sensor

Pin Name	Definition
Pin1	3.3V
Pin2	SCK
Pin3	DATA
Pin4	GND

10. J10（Analog Signals IN）4~20mA current signal input

Pin Name	Definition
Pin1	3.3V Output
Pin2	AIN3 Current Signal Input 3rd way
Pin3	AIN2 Current Signal Input 2nd way
Pin4	AIN1 Current Signal Input 1st way
Pin5	AIN0 Current Signal Input 0 way
Pin6	GND

11. J11 (UART_TTL)   Serial Port for TTL Level

Pin Name	Definition
Pin1	TXD
Pin2	RXD
Pin3	GND

5.2 Connecting Methods between HAC-LBee and HAC-DEV

5.3 Schematic Diagram of HAC-DEV

POWER and USB to Serial Bridge Controller

Debug RS232 and TTL UART Interface

RF Module

DIO Interface

Sensor Interface
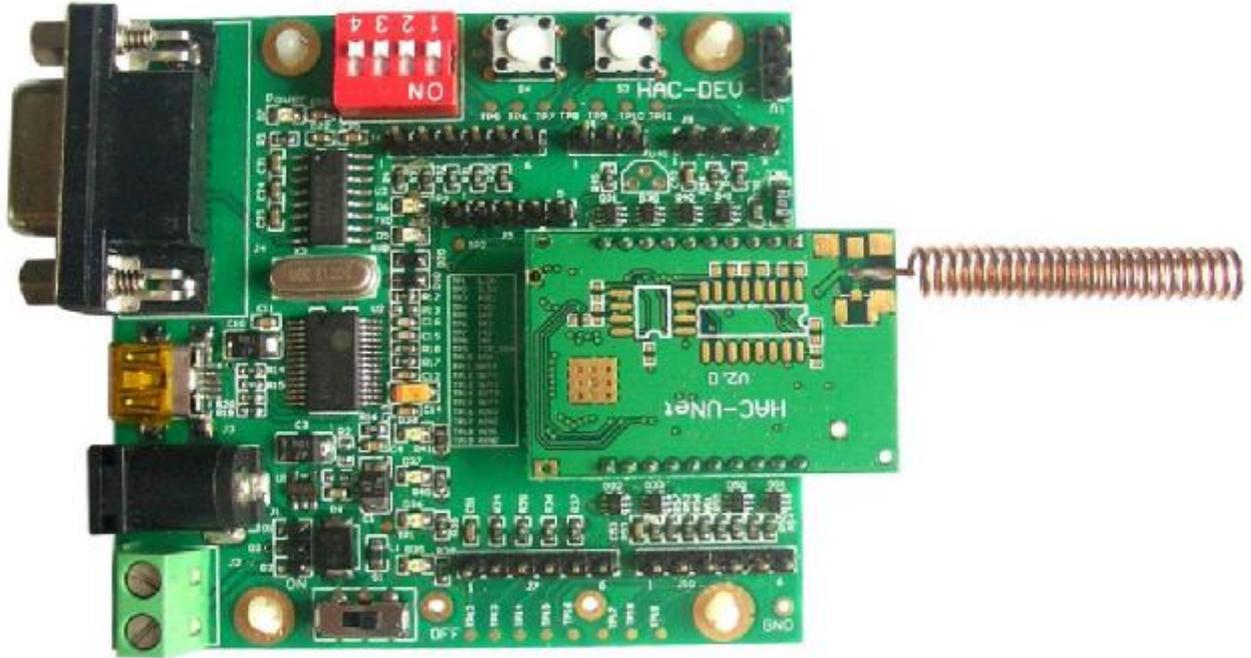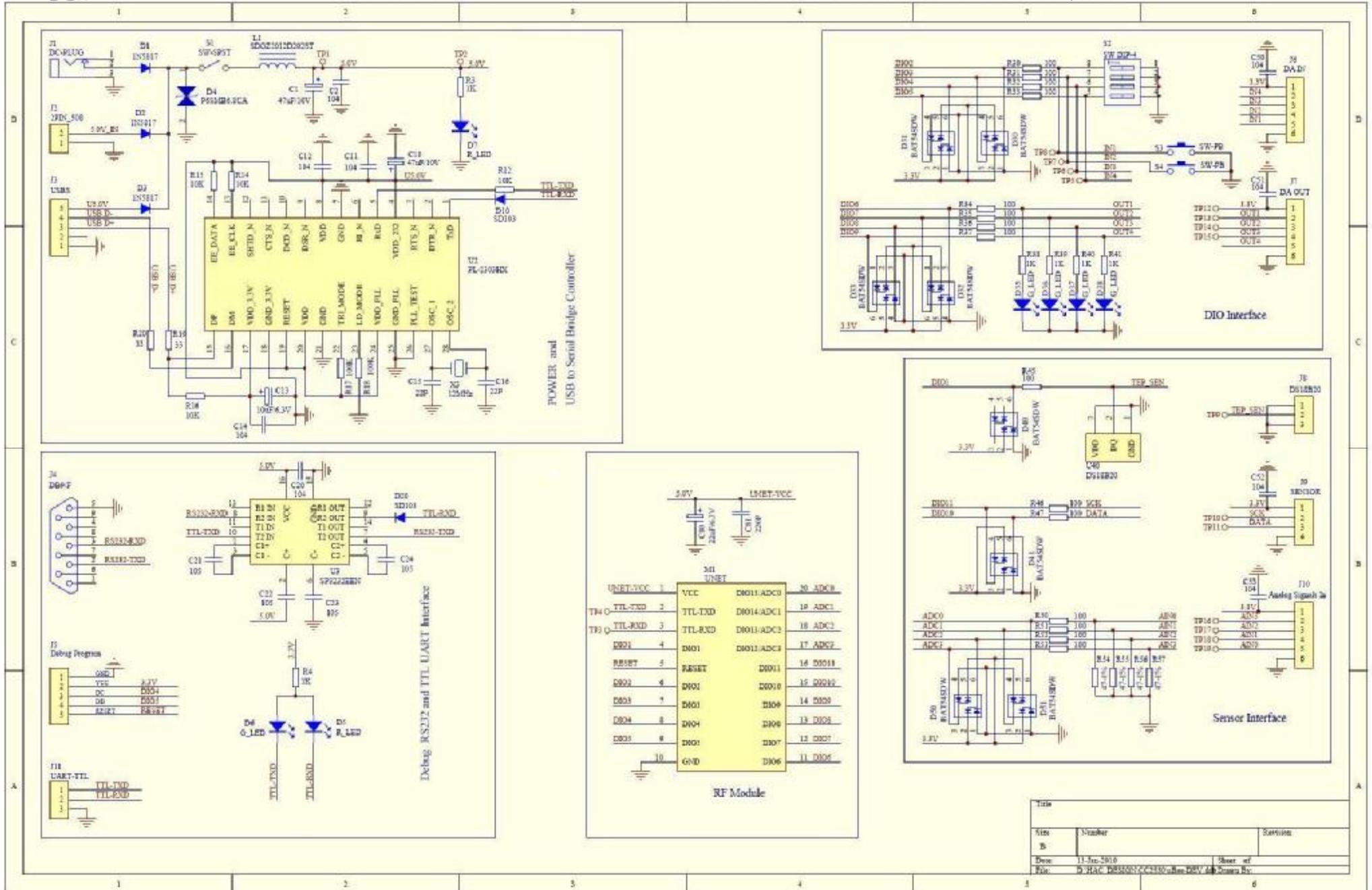
VI. The VBee Network of HAC-UNet

6.1 Brief Introduction of VBee

Our company Shenzhen HAC Telecom Technology Co., Ltd started the development of wireless self-organized module in 2006. Now, we have developed two kinds of wireless self-organized module. One is 2.4GHz wireless module based on Zigbee technology. The other one is 470MHz wireless module HAC-UNet based on VBee self-organized technology.

After more than two years' development, Our company has our own intellectual property of self-organized technology. VBee can fetch up the weak penetrability of 2.4GHz rf module, it is more suitable for the environment with obstacles (like AMR system or other industrial control system). And VBee module is using exoteric communal frequency band (470MHz).

6.2 The features of VBee

VBee is used Mesh network structure. Every VBee network will have a main node (called AP), child node with router function (called NP) and terminal sleeping node with router function (called EP). The data that transmits from AP to NP or from AP to EP is called download, and the data that transmits from NP and EP to AP is called upload.

The features of VBee network

a. Self-organized network, self-organized router
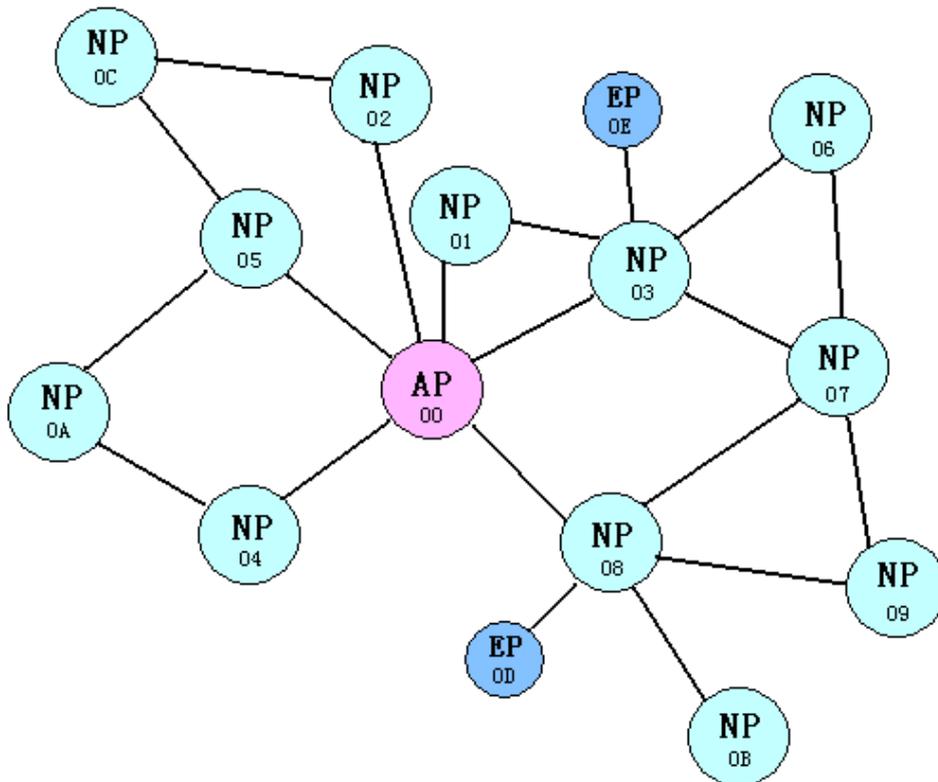
Picture 3 VBee network structure

Every VBee network starts from AP. It doesn't need any helps to make the network. When the nodes are powered up, they will join the network automatically.

The nodes in the network can know its own hops in the network according to its position and the position of adjacent nodes. For example, in the picture 3, the node 02 is further than node 01, but the node 02 can communicate with AP directly, so the hops of the node 02 and the node 01 are the same, it is one hop. The node 02 doesn't need the help of node 01 to communicate AP, they can communicate with each other directly.

Except self-organized network, the data transmission in the network is self-organized router, and it can choose the best transmitting path intelligently.

Choosing the shortest path automatically is another feature of VBee. For example, in the picture 3, when the node 09 uploads the data to AP, it can reach AP through node 07 and node 03, it also can reach AP through node 08. The path of former needs three hops, and the latter only needs two hops. So it will choose node 08 to upload the data to AP automatically.

b. Large network capacity and large coverage

One VBee network has 1000 nodes. And the network hops is big (the maximum hops is 8), so communication coverage is larger than the coverage of traditional point-to-point or point-to-multipoint network.

c. Network ID design to avoid the mutual interference

Network ID includes the channel number of RF module. It can ensure that even all RF modules are using the same channel in the same VBee network, it also can avoid the mutual interference of RF modules in different VBee network which are working in the same area.

d. Data transmission is using collision backoff algorithms and data resending design, which enhance the successful probability of network data transmission. According to the calculation and testing, if we don't use collision backoff and data resending technology, the successful probability of one hop will be 90%, and the successful probability of eight hops will be 43%. Even the successful probability of one hop is 99%, and the successful probability of eight hops will be 92%.

By using the collision backoff and data resending technology, it enhances the successful probability of data transmission in the VBee network.

e. Suitable for installing in locale

Based on some smart designs, users don't need to setup network static or dynamic router according to the local environment for all the nodes and setup the nodes.

Changing the broken module or adding new nodes doesn't need to restart the whole system or

setup the nodes.

Because of the reasons, even the worker can finish the work of installation, changing and so on.

6.3 Network performance of VBee

Topology structure	MESH Network
Maximum nodes' number	1001 （1pcs AP and 1000pcs NPs）
Maximum hops	8 （AP is 0 hop.）
Length of node ID	2 Bytes
Data transmission	Upload (from NP to AP）, download（from AP to NP）, broadcasting, or others (customize)
Networking	Automatic （it doesn't need locale or manual setup.）
Data transmitting mode	Automatic, optimize（it doesn't need locale setup or manual designation）
Note ID setup	Setup in the factory
Changes of broken node	When changing AP or NP, users don't need to reset the system or do some setting.
Adding node	When adding node to the network, users don't need to reset the system or do some setting.
Interface	Default: AP formatted protocol, NP transparent protocol (customized)
Single download data package length of AP	Default: 128 bytes, including 116 bytes payload (customized)
Single upload data package length of NP	Default: 112 bytes, including 100 bytes payload (customized)

Table 3 Network performance of VBee

6.4 The comparing between VBee module and Zigbee module.

Attribute	VBee Module	ZigBee Module
Main products	HAC-UNet(50mW-100mW)	HAC-UBee(2.5mW) 、 HAC-LBee(100mW)
Network structure	MESH	MESH
Maximum nodes' number	1001	65530 (Theory value)
Networking and Router	Automatic	Automatic
Network default hops	8	5
Data transmitting mode	Upload, Download, Broadcasting, Point-to-Point	Point-to-Point, Broadcasting
Communication protocol	AT command, ModBUs, Transparent transmission, Special protocol (Customized)	AT command, ModBUs, Transparent transmission, Special protocol (Customized)
Carrier frequency	400M-500M	2.4G
RF transmitting rate	9600bps	250Kbps
Data net load for	About 100 bytes	About 80 bytes

every package		
Average transmission delay	s	ms

Table 4 The comparing between VBee module and Zigbee module

From the Table 4, we can see the difference between VBee module and Zigbee module. The main differences are the carrier frequency and the transmitting rate. Zigbee is using 2.4GHz, and VBee is using 400~500MHz. It means that the penetrability of VBee module is better than Zigbee module. So in some hard and complex environments, the transmitting distance of VBee module is further than Zigbee module, and the reliability is also better. But the transmitting rate of Zigbee module is faster than VBee module. In some real time systems, the Zigbee module is more suitable for using.

VII. The data interface protocol of VBee network

7.1 AP protocol

When the HAC-UNet module acts as an AP, its default data protocol is formatted protocol. For the data coming from serial port, HAC-UNet module just deals with the data which can meet the formatted requirements. And after receiving the data from the network, it will send the data with some formats to serial port. It means that when the module (AP) receives the data from serial port, it will compare the data package and judge whether the data can meet the protocol requirements. If yes, it will make the corresponding responses. If not, it will discard the package and continue to search the package until find the package that can meet the formatted requirements. After receiving the data from the network, it will pack the data according to the formatted protocol and output to serial port.

Please refer to the VIII chapter for the default formatted protocol of AP.

Users can customize the special protocol according to their requirements, such as AT command, ModBus and so on.

7.2. NP/EP Protocol

When the HAC-UNet module acts as a NP or EP, its default data protocol is transparent protocol. For the data coming from serial port, HAC-UNet module will send the data to AP by transparent mode (without any explains or changes) through the VBee network, and AP will output the data from serial port of AP according to the formatted protocol. For the package receiving from the network, NP or EP will output the net data of package from the serial port.

Users can customize the special protocol for NP or EP according to their requirements, such as AT command, ModBus and so on.

VIII. VBee Network Formatted Protocol Text of HAC-UNet

8.1. Data Format

Serial Number	Field	Length	Instructions
1	Command Word	One byte	
2	Serial number of Command	One byte	
3	Source ID	Two bytes（LSB first）	
4	Reservation 1	Two bytes	The field for VBee internal using
5	Destination ID	Two bytes（LSB first）	
6	Reservation 2	One byte	The field for VBee internal using
7	Data Length	One byte	The effective length of the data content of Serial number 10.
8	Reservation 3	One byte	The field for VBee internal using.
9	Parity	One byte	The parity of serial number 1~10, before calculating, the value is 0.
10	Data Content		The field length depends on various commands.

8.2. Data Download

The data download command is sent to the AP by peripheral equipment which connects with the AP. Its purpose is that send the data content to NP or EP or to the peripheral equipments by NP or EP.

Serial Number	Field	Length	Instructions
1	Command Word	One byte	'D'
2	Serial number of Command	One byte	Created by AP automatically, 0xFF
3	Source ID	Two bytes	ID of AP, created by AP automatically, 0xFFFF.
4	Reservation 1	Two bytes	The field for VBee internal using, 0xFFFF.
5	Destination ID	Two bytes	The Destination ID for the command, LSB first.
6	Reservation 2	One byte	The field for VBee internal using, 0xFF.
7	Data length	One byte	The effective length of the data content of Serial number 10.
8	Reservation 3	One byte	The field for VBee internal using, 0xFF.
9	Parity	One byte	The parity of serial number 1~10, before calculating, the value should be set as 0.
10	Data Content	Less than or equal to 100 bytes	The length of field is indefinite, but it should be less than or equal to 100 bytes.

8.3. Data Upload

The data upload command is that make the NP or EP sends the data package to AP, then AP will output the data to peripheral equipments through serial port.

Serial Number	Field	Length	Instructions
1	Command Word	One byte	'U'
2	Serial number of Command	One byte	The command serial number created by source NP or EP.
3	Source ID	Two bytes	ID of source NP or EP, LSB first.
4	Reservation 1	Two bytes	The field for VBee internal using, meaningless.
5	Destination ID	Two bytes	The field for VBee internal using, meaningless.
6	Reservation 2	One byte	The field for VBee internal using, meaningless.
7	Data length	One byte	The effective length of the data content of Serial number 10.
8	Reservation 3	One byte	The field for VBee internal using, meaningless.
9	Parity	One byte	The parity of serial number 1~10, before calculating, the value should be set as 0.
10	Data Content	Less than or equal to 116 bytes	The length of field is indefinite, but it should be less than or equal to 116 bytes.

4. Checkout Arithmetic
const uint8   crc8_table[] =

```
{
      0, 94,188,226, 97, 63,221,131,194,156,126, 32,163,253, 31, 65,
   157,195, 33,127,252,162, 64, 30, 95,   1,227,189, 62, 96,130,220,
    35,125,159,193, 66, 28,254,160,225,191, 93,   3,128,222, 60, 98,
   190,224,   2, 92,223,129, 99, 61,124, 34,192,158, 29, 67,161,255,
    70, 24,250,164, 39,121,155,197,132,218, 56,102,229,187, 89,   7,
   219,133,103, 57,186,228,   6, 88, 25, 71,165,251,120, 38,196,154,
   101, 59,217,135,   4, 90,184,230,167,249, 27, 69,198,152,122, 36,
   248,166, 68, 26,153,199, 37,123, 58,100,134,216, 91,   5,231,185,
   140,210, 48,110,237,179, 81, 15, 78, 16,242,172, 47,113,147,205,
    17, 79,173,243,112, 46,204,146,211,141,111, 49,178,236, 14, 80,
   175,241, 19, 77,206,144,114, 44,109, 51,209,143, 12, 82,176,238,
    50,108,142,208, 83, 13,239,177,240,174, 76, 18,145,207, 45,115,
   202,148,118, 40,171,245, 23, 73,   8, 86,180,234,105, 55,213,139,
    87,   9,235,181, 54,104,138,212,149,203, 41,119,244,170, 72, 22,
   233,183, 85, 11,136,214, 52,106, 43,117,151,201, 74, 20,246,168,
   116, 42,200,150, 21, 75,169,247,182,232, 10, 84,215,137,107, 53
};

uint8 crc8_update(uint8 crc,uint8 data)
{
    return crc8_table[crc ^ data];
}
```

```
uint8 crc8_check(void *data,uint8 size)
{
    uint8 i,crc = 0;

    for (i = 0; i < size; i++)
     {
         crc = crc8_update(crc, ((uint8 *)data)[i]);
     }

     return crc;
 }
```

The checkout arithmetic is using one byte CRC. Adding checkout field into the command is for ensuring the command's preciseness. When calculating the checkout field of command, please pay attention to the following information.

1. When sending command is just for parity calculation, before calculating, it is needed to set the parity value as 0, and then calculate the parity value. After calculating, add the value into the parity field of command package. When calculating, the field of data content should be calculated.

2. If it is for checking the received command, before calculating, please save the content of parity field in the command package first, and then set it as 0, after that calculate the parity value. After calculating, compare the calculated parity value with saved parity value, if there are the same, it means the received command package is right. If not, it means the received command package has some errors. When calculating, the field of data content should be calculated.

IX. Parameter setting of HAC-UNet

The default settings of HAC-UNet in the factory are shown as follow: 0 channel, 38400bps, 8 data bits, no parity, 1 stop bit.

Users can set the working channel and serial port of HAC-UNet by the setting software. The selection of channel is from 0 to 7 channel, the baud rate is from 2400bps to 38400bps, and the parity can be no-parity or even-parity.

Users can customize other special setting according to their requirements. If the setting protocol of HAC-UNet is needed, please ask our sales for it.

## X. The function indicator of HAC-UNet

When power up, the Red LED and Green LED will light for one time, it will last about 3 seconds.

The Red LED is the indicator of network state of HAC-UNet. When HAC-UNet is not in the network, it will flicker every 6 seconds, and the duration is about 300ms. When HAC-UNet is in the network, it will flicker every 3 seconds, and the duration is about 50ms.

The Green LED is the indicator of wireless communication state of HAC-UNet. When receiving data, it will flicker one time, and the duration is about 50ms.

XI.   The testing, evaluation and demo instruction for HAC-UNet

11.1. Schematic diagram for testing, evaluation and demo
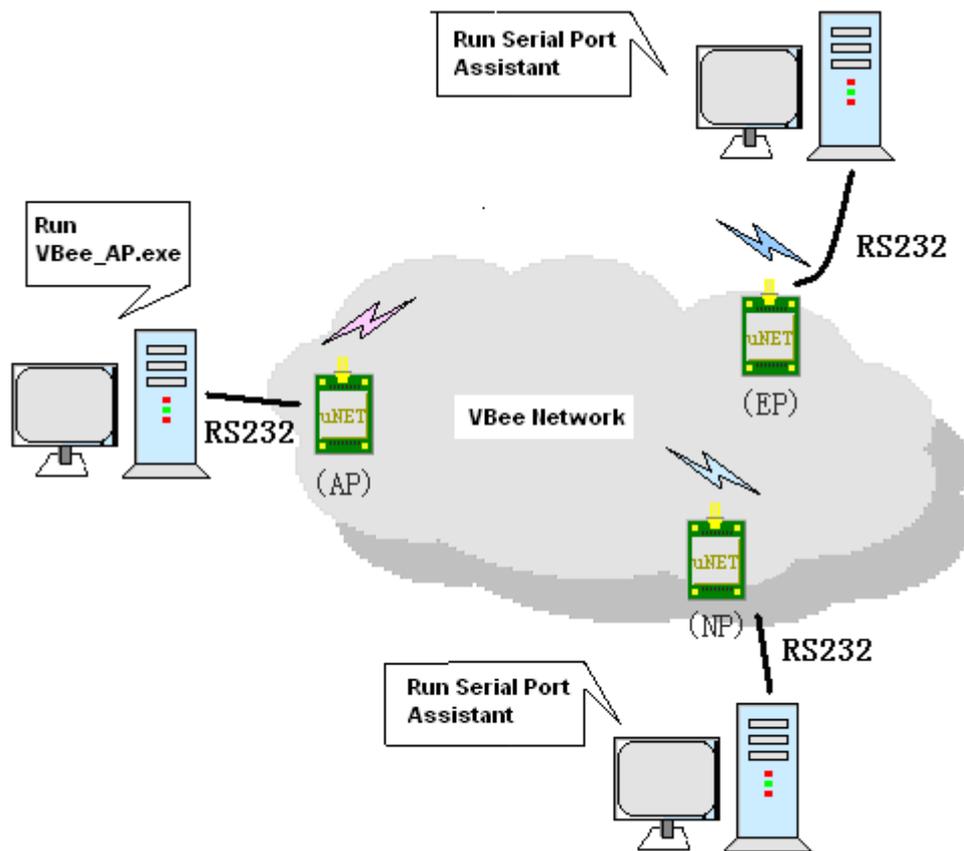
Picture 4 Schematic diagram for evaluation and demo

11.2. The module for testing, evaluation and demo

Take some modules for testing and demo, 1pcs AP, the others are NP or EP. Please make a record for the testing module ID.

11.3. The interface of testing, evaluation and demo

The baud rate is 38400bps, 1 start bit, 8 data bit, no-parity, 1 stop bit.

11.4. The upper machine software for testing, evaluation and demo

The VBee_AP.exe is the upper machine software for the testing and demo of HAC-UNet. It can communicate with AP through serial port and control the download for any NP and upload from any NP. It also can get network node ID in the network and its own hops.

11.5. The steps for testing, evaluation and demo

a. Connect AP with PC through RS232 serial port (or RS485), power up the AP.

b. Run VBee_AP.exe on the PC that is connected with the AP, and open the serial port of PC that is connected with AP.

c. To test the network speciality, user can place the NP with appropriate distance according to the testing condition, for example place 1 or 2 NP on every floor.

d. Connect the NP with PC through RS232 or RS485 port, and power up the NP according the power supply requirements.

e. Because of the transparent protocol, user can run either a serial port debugging software on the PC that is connected with NP, choose the suitable baud rate and open the serial port.

f. Click 'Read Network Node' on the software VBee_AP, then the network node can be seen from the list of the software.

h. Input 'Download ID' (for example input 1003) and input download data, and click 'Download', then you can see the download data from the software interface.

i. Input upload data from serial port debugging software that is connected with NP, and you can see the upload data from the VBee_AP software that is connected with AP and the ID of NP.

j. If there are some problems during the testing, please save the LOG file of VBee_AP.

XII. The type explanation of HAC-UNet

HAC-UNet AP   Coordinator   Standard

HAC-UNet AP/2   Coordinator with RS232

HAC-UNet AP/4   Coordinator with RS485

HAC-UNet NP   Router

HAC-UNet EP   End Device

Appendix 1: Installation instruction for USB driver
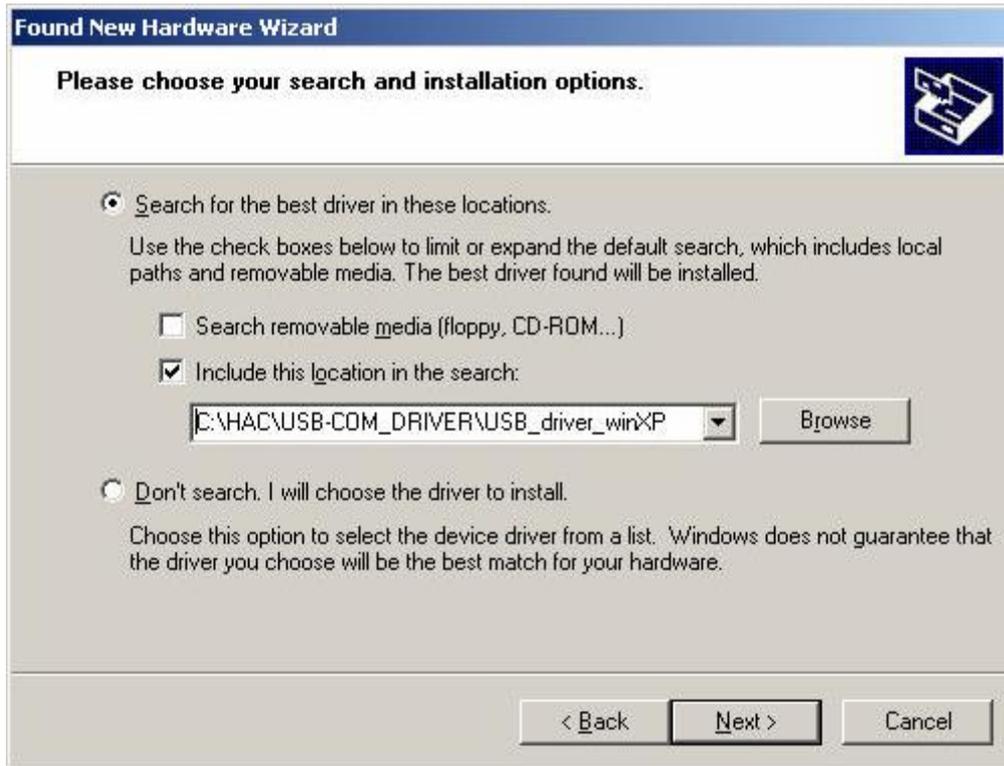
1. **Connect MU USB port to the USB port of your computer. A dialog box popups as follow. Select 'No, not this time' and click 'Next'.**

2. **The next wizard box will show as below. Select 'Advanced' installation and click on 'Next' button.**

3. **In the next dialog box, please specify the path where your Windows XP driver located, and click next after the correct path is selected.**

Found New Hardware Wizard

Please choose your search and installation options.

    ◉ Search for the best driver in these locations.

        Use the check boxes below to limit or expand the default search, which includes local paths and removable media. The best driver found will be installed.

        ☐ Search removable media (floppy, CD-ROM...)

        ☑ Include this location in the search:

           [C:\HAC\USB-COM_DRIVER\USB_driver_winXP ▼]   [Browse]

    ○ Don't search. I will choose the driver to install.

        Choose this option to select the device driver from a list. Windows does not guarantee that the driver you choose will be the best match for your hardware.

                                         [< Back] [Next >] [Cancel]

4. A warning message dialog box will appeared as below. Click **'Continue Anyway'** button to start the installation.

Hardware Installation

⚠ The software you are installing for this hardware:

    Prolific USB-to-Serial Bridge

    has not passed Windows Logo testing to verify its compatibility with Windows XP. ([Tell me why this testing is important.])

    Continuing your installation of this software may impair or destabilize the correct operation of your system either immediately or in the future. Microsoft strongly recommends that you stop this installation now and contact the hardware vendor for software that has passed Windows Logo testing.

                        [Continue Anyway]   [STOP Installation]

Found New Hardware Wizard

Please wait while the wizard installs the software...

Prolific USB-to-Serial Bridge

Setting a system restore point and backing up old files in case your system needs to be restored in the future.

< Back   Next >   Cancel

5. After the installation is completed, the following dialog box will appear. Click on the 'Finish' button to complete the installation.

Found New Hardware Wizard

Completing the Found New Hardware Wizard

The wizard has finished installing the software for:

Prolific USB-to-Serial Bridge

Click Finish to close the wizard.

< Back   Finish   Cancel

6. To verify and set the parameters of the serial port, open the Computer Manager window and select on Device Manager on the left window. Open the COM port field in the right window.
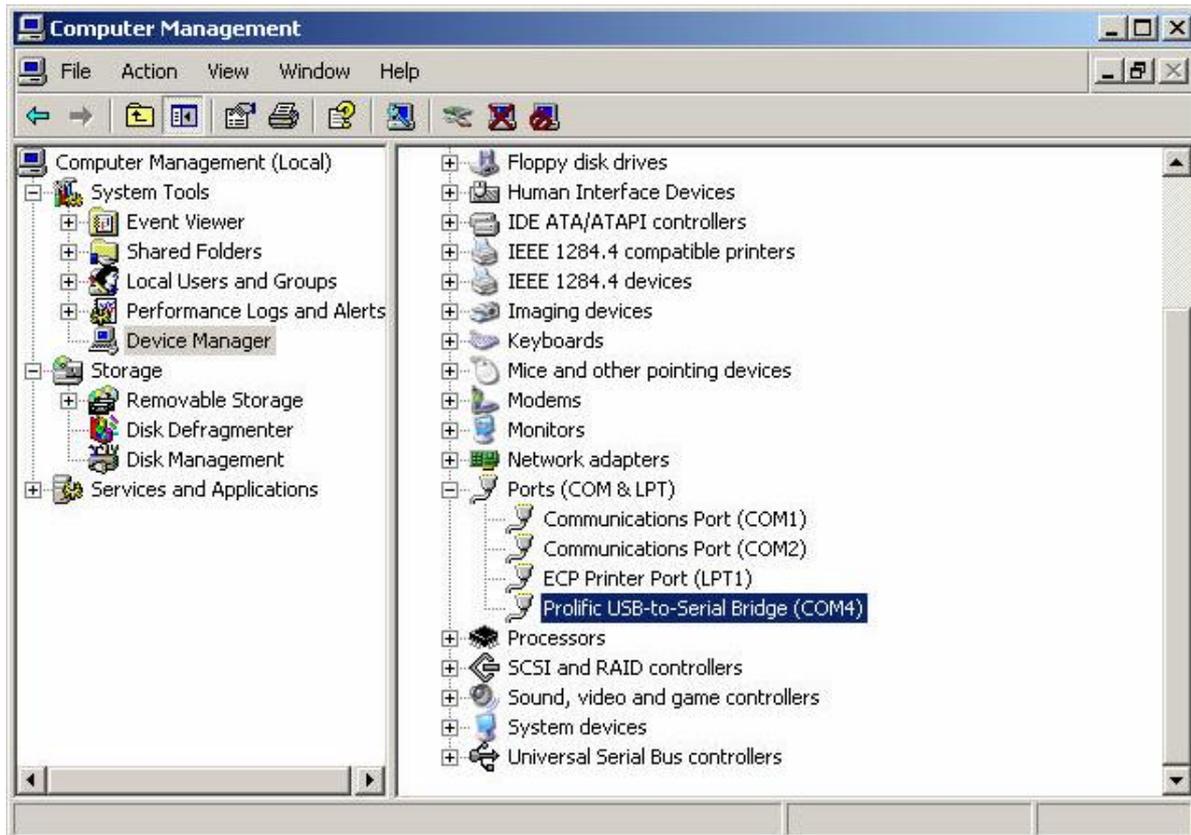
7. Right click on 'Prolific USB-to-Serial Bridge (COMx)' and select on Properties. Make sure that the parameters of the properties dialog box has all the fields set as below.
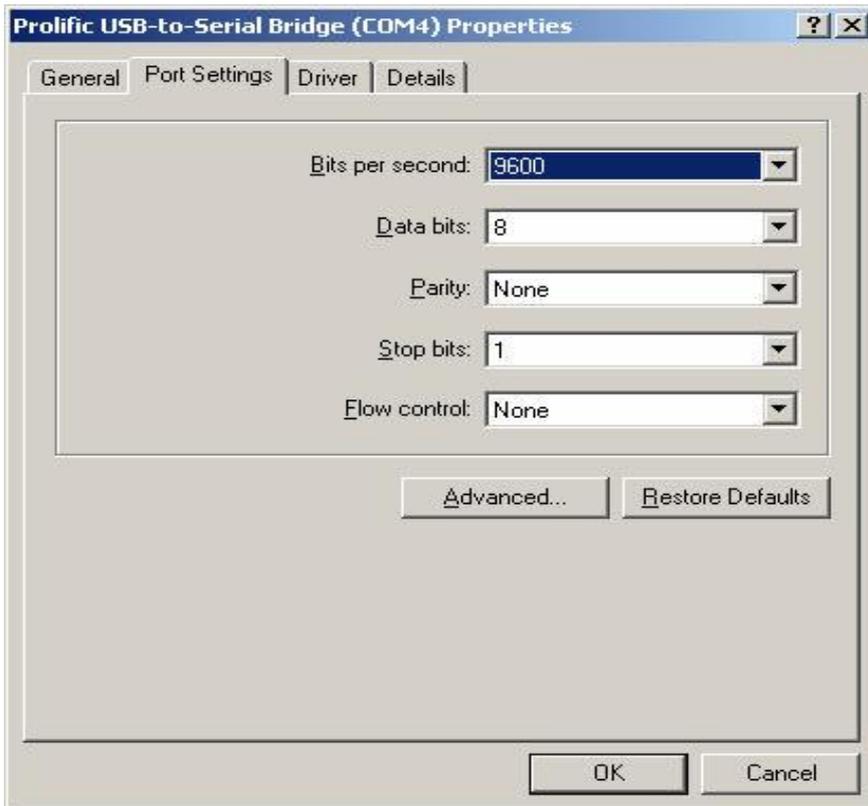
8. Open additional setting by click on 'Advanced' button on the properties dialog box. Double check and make sure that the advanced setting for selected COM ports has the following settings. Click OK when it's done.
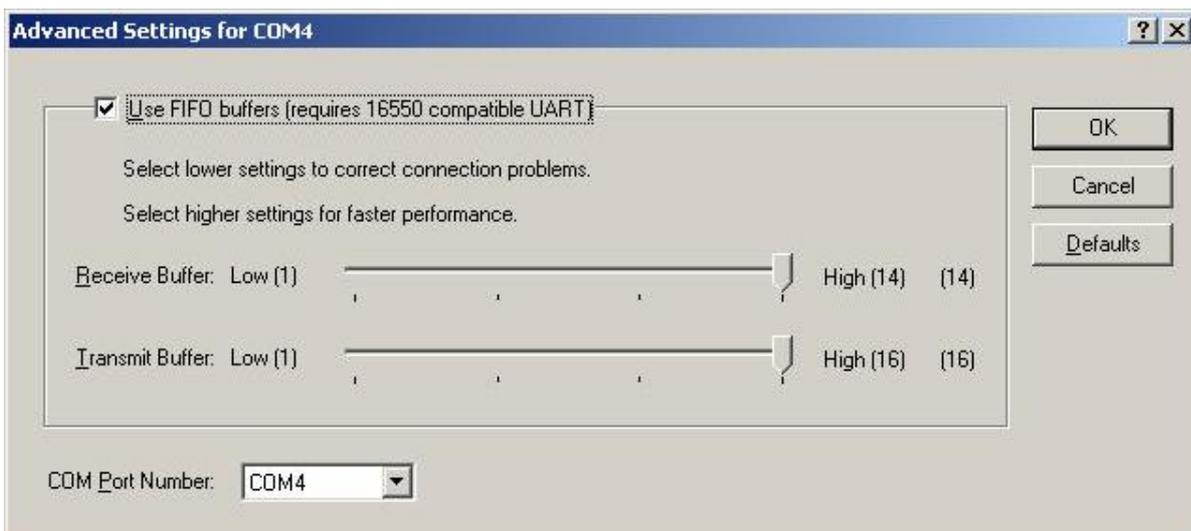
Now, the configuration of the serial port has been done. You may use the COM4 or whatever the COM port you have installed to transmit data. One last thing for using the radio modem is that, remember to check the baud rate and parity bit of COM port must be the same as the Smart device.