HAC-UBee

2.4G Low Power Data Radio Module

(Based on ZigBee protocol)

V3.X

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Catalogue

I Features of HAC-Ubee Wireless Module

HAC-Ubee is a kind of low power wireless module based on Zigbee protocol stack. The features are shown as follow:

1. Low power transmission with 2.5mW（4dBm）, and receiving sensitivity is -105dBm （BER=10-2）.
2. ISM frequency band with no require of applying frequency. The carrier frequency is 2.4GHz.
3. High anti-interference and Low BER (Bit error Rate)

   Based on the Quadrature Phase Shift Keying (QPSK) modulation, the high-efficiency forward error correction channel encoding technology is used to enhance data's resistance to both transient interference and random interference. Narrowband interference of the same frequency can be suppressed by Direct Sequence Spread Spectrum. The 16 CRC verify bits can be used to check mistake.
4. The transmitting speed in the air can reach up to 250kbps.
5. Transmission Distance

   Within the visible range, the reliable transmission distance is 300m.
6. Multi-channels

   HAC-Ubee offers 16 channels. It will select the suitable and reliable communication channel automatically according to the user's environment.
7. UART interface

   HAC-Ubee provides a UART interface of TTL level. The default interface baud rate is 38400bps ex-factory , and the parity is no-parity (8N1).
8. Low power consumption

   The receiving current is less than or equal to 27mA, and the transmitting current is less than or equal to 40mA.
9. Small size and light weight
10. By using SoC , the transceivers have less peripheral circuits, higher reliability,and lower failure rate.
11. Offering many kinds of antenna connecting methods, such as PCB antenna, Chip antenna, IPX antenna connecting base and so on.
12. It can meet for the protocol of IEEE 802.15.4 for 2.4GHz and the application of ZigBee， it can make network automatically.
13. This device complies with part 15 of the FCC rules. Operation is subject to the following two

conditions:

(1) This device may not cause harmful interference, and

(2) This device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

RF Exposure warning statement:

The device has been evaluated to meet general RF exposure requirement. The device can be used in portable exposure condition without restriction.

II. Applications of HAC-Ubee Wireless Module

HAC-Ubee low power wireless 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 equipment of computer room, door's security, personnel orientation.
* Traffic and the control for street lamp.
* Logistics, active RFID, POS system and wireless handheld terminal.

III. Using Methods of HAC-Ubee **Wireless Module**

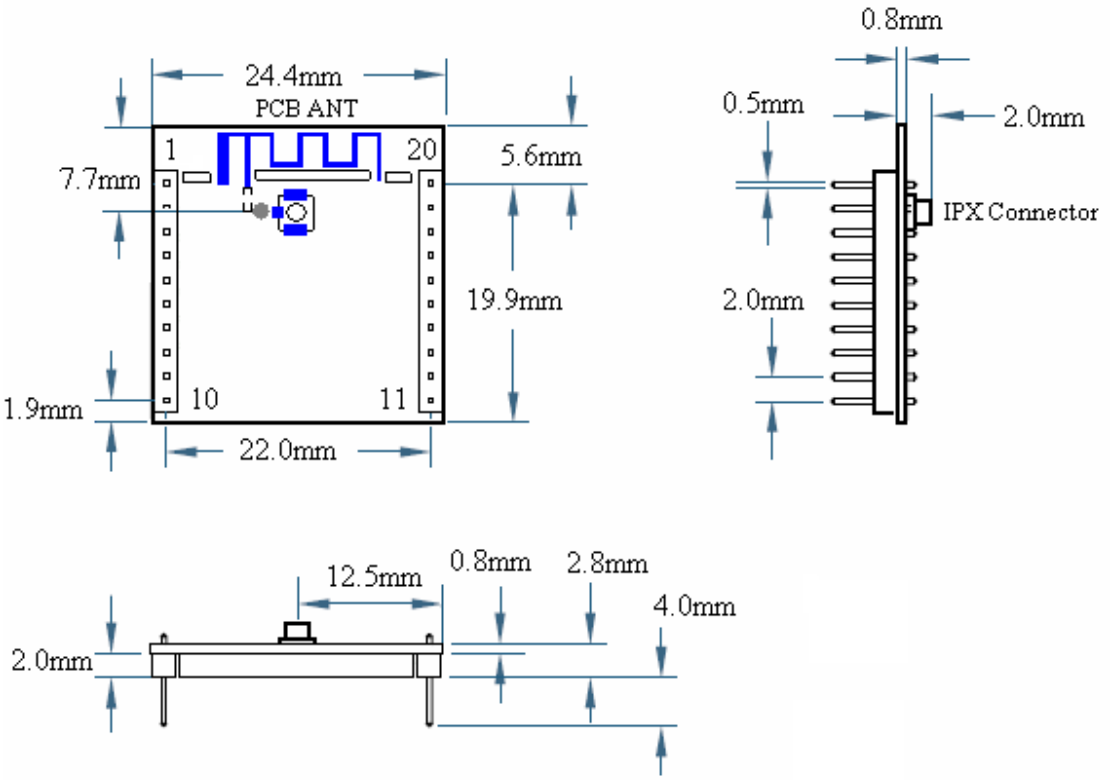
3.1 Technical Parameter of HAC-Ubee

Name	Parameter			Unit
	Minimum	Typical Value	Maximum	
Electric Performance （25℃）				
Power Supply	**3.0**	**3.3**	**3.6**	V
Interface Level	**-0.3**		**VCC + 0.3≤3.6**	**V**
Transmitting Current	**36**	**38**	**40**	**mA**
Receiving Current	**25**	**26**	**27**	**mA**
Sleeping Current		**3**		**μA**
Wireless Performance（25℃）				

Working Frequency	**2.405**		**2.480**	GHz
Transmitting Power	**3.8**	**4.0**	**4..2**	dBm
Receiving Sensitivity		**-97**		dBm
Transmitting Rate		**250**		Kbps
General Performance				
Interface baud rate	**2400**	**38400**	**115200**	bps
Working Temperature	**-40**		**80**	℃
Size	**25.5** X **24.4** X **4**			mm

Table 1 Technical Parameter of HAC-Ubee

3.2 The Size of HAC-Ubee



Picture 1 The Size of HAC-Ubee

3.3 Pin Definition of HAC-Ubee

Pin	Definition	Input/Output	Function Instruction
1	VCC	IN	Power Supply, +3.0~3.6V
2	TXD	OUT	Output serial data
3	RXD	IN	Input serial data

4	DIO1	IN/OUT	Data I/O1
5	RESET	IN	Low level reset
6	DIO2	IN/OUT	Data I/O2
7	DIO3	IN/OUT	Data I/O3
8	DIO4/DD	IN/OUT	Data I/O4 / Program data
9	DIO5/DC	IN/OUT	Data I/O5 / Program clock
10	GND		Power supply (Negative),Ground
11	DIO6	IN/OUT	Data I/O6
12	DIO7	IN/OUT	Data I/O7
13	DIO8	IN/OUT	Data I/O8
14	DIO9	IN/OUT	Data I/O9
15	DIO10	IN/OUT	Data I/O10
16	DIO11	IN/OUT	Data I/O11
17	DIO12/ADC3	IN/OUT	Data I/O12/Analog Input 3
18	DIO13/ADC2	IN/OUT	Data I/O13/Analog Input 2
19	DIO14/ADC1	IN/OUT	Data I/O14/Analog Input 1
20	DIO15/ADC0	IN/OUT	Data I/O15/Analog Input 0

Table 2 Pin Definition of HAC-Ubee

3. 1 HAC-Ubee Optional fittings

1）Standard fittings

Standard Ubee V3.0 always goes with PCB antenna, excluding IPX antenna base.

2）There is an optional Chip antenna called HAC-Antenna-CH2400 for customers。

When using Chip antenna, it needs to cut down the PCB antenna connection and connect with pad of Chip antenna. In such fittings, it doesn't include antenna base.

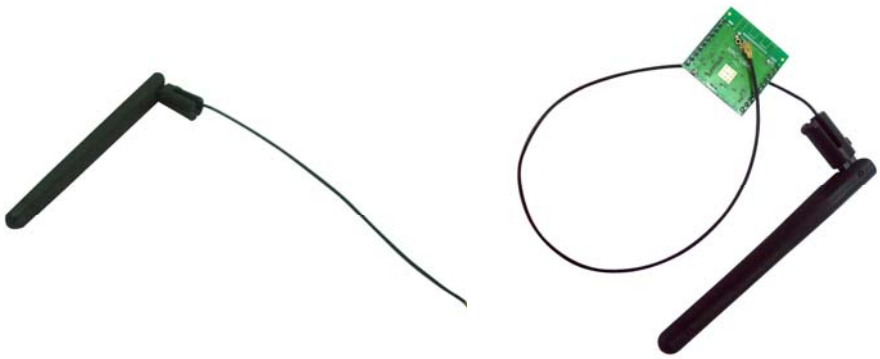
3）Using antenna cable to connect with external antenna

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.

A 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-LX2400-10-ZSMA-M。

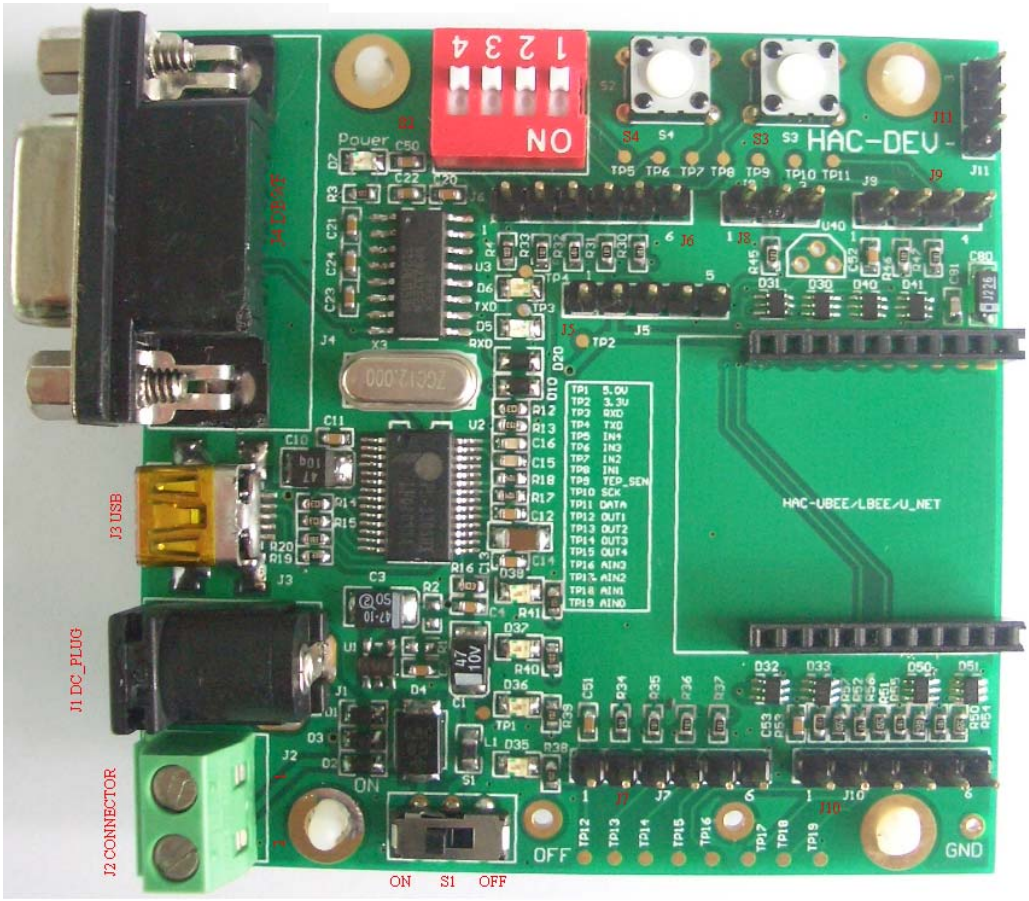
HAC-KX-IPEX-10G1-SMA-F HAC-Antenna-LX2400-10-ZSMA-M

B Using antenna called LX2400Z-10-KX-10G1-IPEX to connect with the HAC-Ubee module directly.



IV. Development Kit for HAC-Ubee Wireless Module

4.1 General Information for HAC-DEV Development Kit



Picture 2 HAC-DEV

Connector Definition:

a. J1 (DC_PLUG ） 5V power supply input

b. J2 (DC_CONNECTOR) 5V power supply input

Pin Name	Definition
Pin1	GND
Pin2	5V

c. J3 (USB_ PLUG) USB port, USB to Serial port. Please refer to the Appendix 2 for the installation for USB Driver.

d. J4 (DB9/F) RS232 data port

Pin Name	Definition
Pin2	TXD
Pin3	RXD

Pin5	**GND**
Other pins	**No Definition**

e. J5 (Programming) CC2530F256 Program Port

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

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

f. J6 (DA_IN) Digital Level Input

Pin Name	**Definition**
Pin1	**3.3V input**
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**

g. 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**

h. J8 (DS18B20) Temperature Sensor DS18B20 port

Pin Name	**Definition**
Pin1	**GND**
Pin2	**TEP_SEN**
Pin3	**GND**

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

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

j. 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

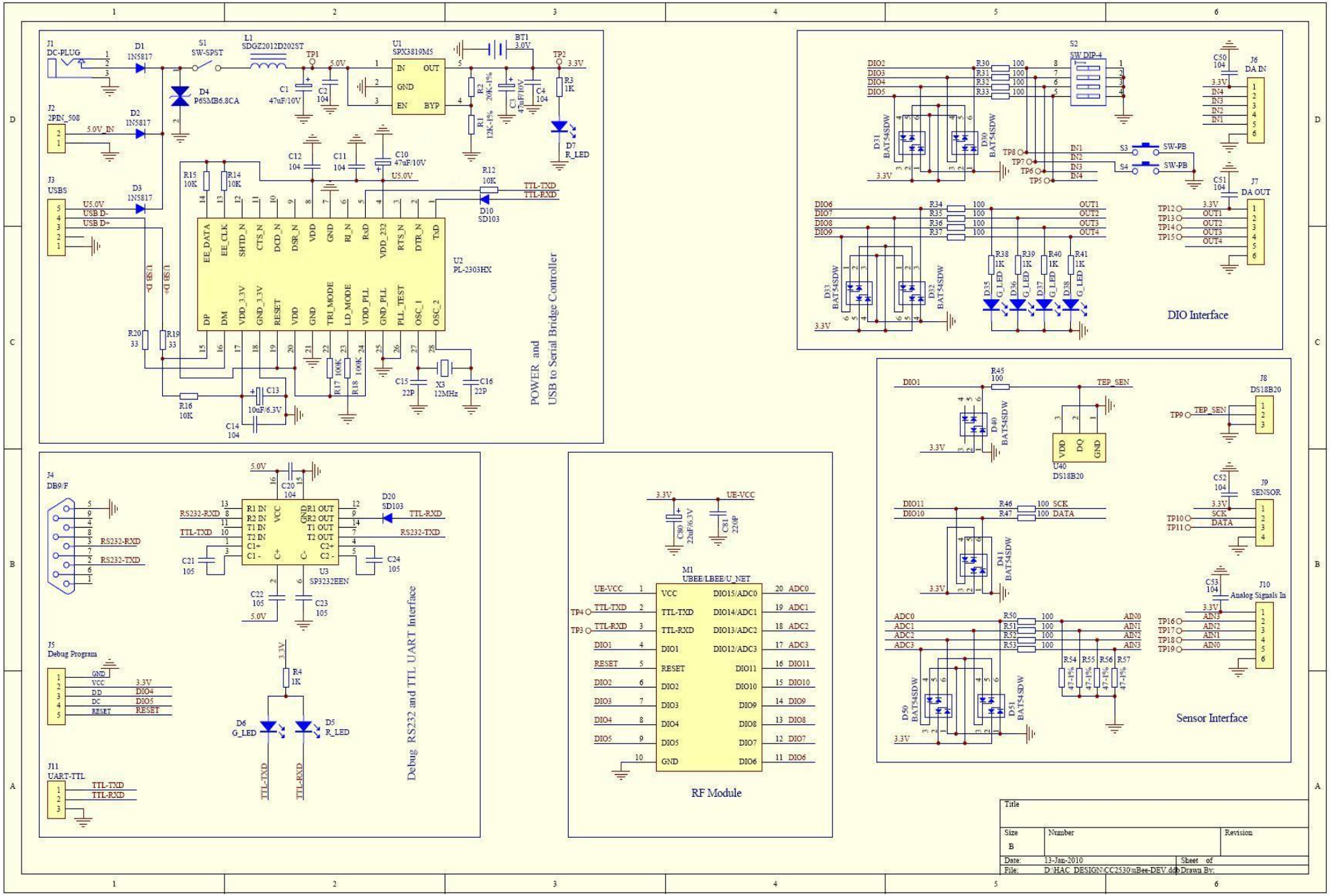
k. J11 (UART_TTL) Serial Port for TTL Level

Pin Name	Definition
Pin1	TXD
Pin2	RXD
Pin3	GND

4.2 Connecting Methods between HAC-Ubee and HAC-DEV

Picture 3 Connecting Methods between HAC-Ubee and HAC-DEV

4.3 Schematic Diagram for HAC-DEV


POWER and USB to Serial Bridge Controller
DIO Interface
Sensor Interface
Debug RS232 and TTL UART Interface
RF Module
Title
Size B
Number
Revision
Date: 13-Jan-2010
Sheet of
File: D:\HAC_DESIGN\CC2530\uBee-DEV.ddb
Drawn By:

V. Working Mode of HAC-Ubee Wireless Module

5.1. Working Mode of HAC-Ubee Wireless Module

There are three working modes for HAC-Ubee. They are: Transparent Mode, API Mode, AT Command Mode.

5.1.1 Transparent Mode

By default, Modules operate in Transparent Mode. When operating in this mode, the modules act as a serial line replacement - all UART data received through the RXD pin is queued up for RF transmission. When RF data is received, the data is sent out the TXD pin.

- No serial characters are received for the amount of time determined.
- The maximum number of characters that will fit in an RF packet (85) is received.

Serial-to-RF Packetization

Data is buffered in the RXD buffer until one of the following causes the data to be packetized and transmitted: If the module cannot immediately transmit (for instance, if it is already receiving RF data), the serial data is stored in the RXD Buffer. The data is packetized and sent at timeout or when 85 bytes (maximum packet size) are received.

5.1.2 API Mode

API (Application Programming Interface) Operation is an alternative to the default Transparent Operation. The frame-based API extends the level to which a host application can interact with the networking capabilities of the module.

When in API mode, all data entering and leaving the module is contained in frames that define operations or events within the module.

Transmit Data Frames (received through the RXD pin (pin 3)) include:

• RF Transmit Data Frame

• Command Frame (equivalent to AT commands)

Receive Data Frames (sent out the TXD pin (pin 2)) include:

• RF-received data frame

• Command response

• Event notifications such as reset, associate, disassociate, etc.

The API provides alternative means of configuring modules and routing data at the host application layer. A host application can send data frames to the module that contain address and payload information instead of using command mode to modify addresses. The module will send data frames to the application containing status packets; as well as source, RSSI and payload information from received data packets. The API operation option facilitates many operations such as the examples cited below:

• Transmitting data to multiple destinations without entering Command Mode

• Receive success/failure status of each transmitted RF packet

• Identify the source address of each received packet

*** How to let the module work under the API mode after power up?**

User can use AT command to enter the API mode. The setup steps are shown as follow:

Enter the AT Command page

Input the 3-character command sequence "+++" and wait for the reply "OK" from module.

Input "ATAP 1<CR>" command, the module will reply "OK". It is used to set the module working under API mode.

Input "ATWR<CR>" command, the module will reply "OK". It is used to save the setting. So the module will enter API mode automatically when restart the module next time.

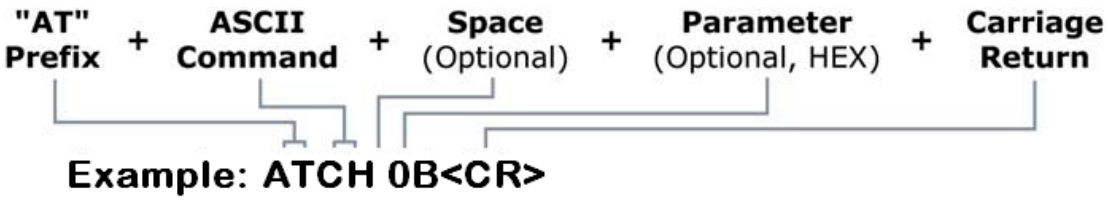
Input "ATCN<CR>" command to exit from the AT Command mode. Now, the module works under the API mode. Even power up the module again, it still enters the API mode directly.

5.1.3 AT Command Mode

To modify or read RF Module parameters, the module must first enter into Command Mode - a state in which incoming characters are interpreted as commands. Two Command Mode options are supported: AT Command Mode [refer to section below] and API Command Mode

Send the 3-character command sequence "+++" and observe guard times before and after the command characters.

NOTE: Failure to enter AT Command Mode is most commonly due to baud rate mismatch. Ensure the 'Baud' setting on the "PC Settings" tab matches the interface data rate of the RF module. By default, the BD parameter = 5 (38400 bps).



To read a parameter value stored in the RF module's register, omit the parameter field.

The preceding example would change the RF module Channel to "0x0B". To store the new value to non-volatile (long term) memory, subsequently send the WR (Write) command.

For modified parameter values to persist in the module's registry after a reset, changes must be saved to non-volatile memory using the WR (Write) Command. Otherwise, parameters are restored to previously saved values after the module is reset.

System Response: When a command is sent to the module, the module will parse and execute the

command. Upon successful execution of a command, the module returns an “OK” message. If execution of a command results in an error, the module returns an “ERROR” message.

NOTE: Some parameters will validate at once after setting, but some parameters will validate after restart the module. So please read every AT command very carefully.

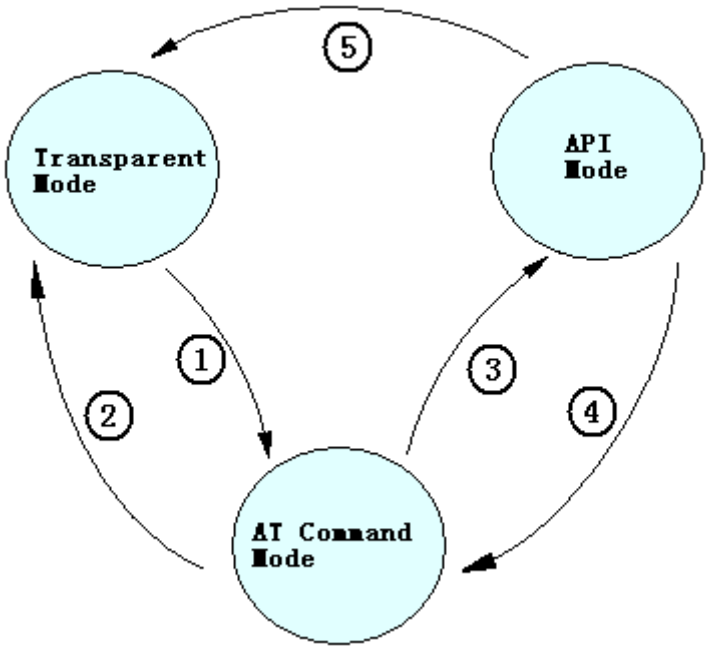
To Exit AT Command Mode:

Send the ATCN (Exit Command Mode) command (followed by a carriage return). [OR]

If no valid AT Commands are received within 10 seconds.

5.1.4 How to select the working mode

The default setting in the factory is transparent working mode.



1. Under the transparent mode, input 3-character command sequence “+++” from serial port, it will change for the AT Command mode.

2. When you select the transparent working mode (ATAP 0), inputting “ATCN” command can exit from the AT Command mode and enter the transparent mode. Or when you select the transparent working mode (ATAP 0), if there is no input in 10 seconds, the module will exit from the AT Command mode and enter the transparent mode.

3. When you select the API working mode (ATAP 1), inputting “ATCN” command can exit from the AT Command mode and enter the API mode. Or when you select the API working mode (ATAP 1), if there is no input in 10 seconds, the module will exit from the AT Command mode and enter the API mode.

4. Under the API mode, input 3-character command sequence “+++” will let the module switch to AT Command mode.

5. Under API mode, when using AT Command to setup transparent mode (ATAP 0), the module will

switch to transparent mode.

5.2 AT Command

AT Command	Command Category	Name and Description	Parameter Range	Default	**Firmware Version**
WR	Special	Write. Write all configurable parameter values to non-volatile memory so that parameter modifications persist through subsequent power-up or reset.	-	-	>=0x19
RE	Special	Restore Defaults. Restore module parameters to factory defaults.	-	-	>=0x19
FR	Special	Software Reset. Immediately performs a hard reset.	-	-	>=0x19
MT	Networking	Module Mode. Read the device type of module.	0-2 0-Coordinator 1-Router 2-EndDevice	-	>=0x19
CH	Networking	Channel. Set/Read the channel number used for transmitting and receiving data between RF modules (uses 802.15.4 protocol channel numbers).	0x0B - 0x1A	0x0B	>=0x19
ID	Networking	PAN ID. Set/Read the setup PAN (Personal Area Network) ID.	0 - 0xFFFF	0x19AC	>=0x19
PI	Networking	PAN ID. Read the PANID in the network.	0 - FFFF (Read only)	-	>=0x19
DH	Networking	64-bit Destination Address High. Set/Read the upper 32 bits of the 64-bit destination address. When combined with DL, it defines the destination address used for transmission. 0x000000000000FFFF is the broadcast address for the PAN.	0 - 0xFFFFFFFF	0x00	>=0x19
DL	Networking	64-bit Destination Address Low. Set/Read the lower 32 bits of the 64-bit destination address. When combined with DH, DL defines the destination address used for transmission. 0x000000000000FFFF is the broadcast address for the PAN.	0 - 0xFFFFFFFF	0xFFFF	>=0x19
MY	Networking	16-bit Source Address. Read the RF module 16-bit source address.	0-0xFFFF (Read only)	-	>=0x19
SH	Networking	Serial Number High. Set/Read high 32 bits of the RF module's unique IEEE 64-bit address.	0 - 0xFFFFFFFF	-	>=0x19
SL	Networking	Serial Number Low. Set/Read low 32 bits of the RF module's unique IEEE 64-bit address.	0 - 0xFFFFFFFF	-	>=0x19
DS	Networking	16-bit Destination Address. Set/Read the lower 16 bits destination address. 0xFFFF is the broadcast address for the PAN.	0 - 0xFFFF	0xFFFF	>=0x19
DT	Networking	Destination Address Type. Set/Read the destination address type.	0-1 0- 64bit 1-16bit	1	>=0x19
RN	Networking	Reset Network. Reset network, search the network again after restart the module. Note: after reset network and search network again, the 16-bit address may change.	0-1 0 = Disabled 1 = Enabled	0	>=0x19
AP	Serial Interfacing	API Enable. Disable/Enable API Mode.	0 - 1 0 = Disabled 1 = API enabled	0	>=0x19
BD	Serial Interfacing	Interface Data Rate. Set/Read the serial interface data rate for communications between the RF module serial port and host.	1 = 2400 2 = 4800 3 = 9600 4 = 19200 5 = 38400	5	>=0x19

			6 = 57600 7 = 115200		
CN	AT Command Mode Options	Exit Command Mode. Explicitly exit the module from AT Command Mode.	-	-	>=0x19
HV	Diagnostics	Hardware Version. Read hardware version of the RF module.	0 - 0xFFFF (Read only)	-	>=0x19
VR	Diagnostics	Firmware Version. Read firmware version of the RF module.	0 - 0xFF (Read only)	-	>=0x19

5.2.1 AP

<Serial Interfacing> The AP command is used to enable the RF module to operate using a frame-based API instead of using the default Transparent (UART) mode.

Command	ATAP (**API Enable**)	
Parameter	Range	0-1
	Default Value	0
	Value	0: Disabled (Transparent operation) 1: API enabled
Effective Conditions	Validate at once after the command	
Minimum Firmware Version Required：0x19		

The examples for changing the working mode:

Input 3-character command sequence “+++” and switch to the AT Command mode.

Using ATAP command to setup the working mode you want, such as ATAP 0<CR> or ATAP 1<CR>.

If the setting is still needed to be validated after restart the module next time, using ATWR<CR> command to write the setting into Non-volatile memory.

Input “ATCN<CR> command to exit from AT Command mode, the module will enter the setting working mode.

5.2.2 BD

<Serial Interfacing> The BD command is used to set and read the serial interface data rate used between the RF module and host. This parameter determines the rate at which serial data is sent to the module from the host. To validate the setting parameters，it needs to write the data to non-volatile memory after modifying interface data rates. And Modified interface data rates do not take effect until restart the module next time. When parameters 1-7 are sent to the module, the respective interface data rates are used (as shown in the table on the right). The RF data rate is not affected by the BD parameter. We recommend that users don’t select too low interface data rate, or it will cause the serial port data communication overflow.

Command	ATBD **(Interface Data Rate)**

Parameter	Range	1-7
	Default Value	5
	Value	1 = 2400 2 = 4800 3 = 9600 4 = 19200 5 = 38400 6 = 57600 7 = 115200
Effective Conditions	Use WR command to save setting, it will be effective after restart the module again.	
Minimum Firmware Version Required：0x19		

The examples for changing the serial port baud rate:

Input 3-character command sequence “+++” and switch to the AT Command mode.

Using ATBD command to setup the serial port baud rate you want, such as ATBD 6<CR>.

Using ATWR command to write the setting into Non-volatile memory

Input “ATFR<CR> command, the module will restart at once.

5.2.3 CH

<Networking {Addressing}> The CH command is used to set/read the operating channel on which RF connections are made between RF modules. The channel is one of three addressing options available to the module. The other options are the PAN ID (ID command) and destination addresses (DL, DH & DS commands). In order for modules to communicate with each other, the modules must share the same channel number. Different channels can be used to prevent modules in one network from listening to trans-missions of another. Adjacent channel rejection is 23 dB. The module uses channel numbers of the 802.15.4 standard. Center Frequency = 2.405 + (CH - 11d) * 5 MHz (d = decimal)

To validate setting parameters, when setting the channel, at the same time, using the RN command to setup the module as that reset the network after restart next time, then write the settings to the non-volatile memory. In this way, the module will work on the new channel after restart the module next time.

Command	ATCH (**Channel**)	
Parameter	Range	0x0B - 0x1A
	Default Value	0x0B
Effective Conditions	RN=1, Use WR command to save setting, it will be effective after restart the module again.	
Minimum Firmware Version Required：0x19		

The examples for changing the channel:

Input 3-character command sequence “+++” and switch to the AT Command mode.

Using ATCH command to setup the channel you want, such as ATCH 0E<CR>.

Using ATRN command to setup the module reset the network after restart the module next time, ATRN 1<CR>.

Using ATWR command to write the setting into Non-volatile memory

Input “ATFR<CR> command, the module will restart at once.

5.2.4 CN

<AT Command Mode Options> The CN command is used to explicitly exit the RF module from AT Command Mode.

Command	ATCN(**Exit Command Mode**)
Parameter	None
Effective Conditions	Validate at once
Minimum Firmware Version Required：0x19	

5.2.5 DH

<Networking {Addressing}> The DH command is used to set and read the upper 32 bits of the RF module's 64-bit destination address. When combined with the DL (Destination Address Low) parameter, it defines the destination address used for transmission. An module will only communicate with other modules having the same channel (CH parameter), PAN ID (ID parameter) and destination address (DH + DL parameters). 0x000000000000FFFF (DL concatenated to DH) is the broadcast address for the PAN.

Only under the transparent mode, and DT=0, the setting will be effective.

Command	ATDH (**Destination Address High**)	
Parameter	Range	0x00 - 0xFFFFFFFF
	Default Value	0x00
Effective Conditions	Validate at once	
Minimum Firmware Version Required：0x19		

The examples for changing the upper 32-bit of destination address:

Input 3-character command sequence “+++” and switch to the AT Command mode.

Using ATDH command to setup the upper 32-bit of destination address you want, such as ATDH 0<CR>.

Using ATWR command to write the setting into Non-volatile memory

Input “ATCN<CR> command to exit from the AT Command mode.

5.2.6 DL

<Networking {Addressing}> The DL command is used to set and read the lower 32 bits of the RF module's 64-bit destination address. When combined with the DH (Destination Address High) parameter, it defines the destination address used for transmission. A module will only communicate with other mod-ules having the same channel (CH parameter), PAN ID (ID parameter) and destination address (DH + DL parameters). 0x000000000000FFFF (DL concatenated to DH) is the broadcast address for the PAN.

Only under the transparent mode, and DT=0, the setting will be effective.

Command	ATDL (**Destination Address Low**)	
Parameter	Range	0x00 - 0xFFFFFFFF
	Default Value	0xFFFF
Effective Conditions	Validate at once	
Minimum Firmware Version Required：0x19		

The examples for changing the lower 32-bit of destination address:

Input 3-character command sequence “+++” and switch to the AT Command mode.

Using ATDL command to setup the lower 32-bit of destination address you want, such as ATDL FFFF<CR>.

Using ATWR command to write the setting into Non-volatile memory

Input “ATCN<CR> command to exit from the AT Command mode.

5.2.7 DS

<Networking {Addressing}> The DS command is used to set and read the RF module's 16-bit destination address. A module will only communicate with other modules having the same channel (CH parameter), PAN ID (ID parameter) and destination address (64bit or 16bit). 0xFFFF is the broadcast address for the PAN.

Only under the transparent mode, and DT=1, the setting will be effective.

Command	ATDS (**Short Destination Address/ 16bit Destination Address**)	
Parameter	Range	0x00 - 0xFFFF
	Default Value	0xFFFF
Effective Conditions	Validate at once	
Minimum Firmware Version Required：0x19		

The examples for changing the 16-bit of destination address:

Input 3-character command sequence “+++” and switch to the AT Command mode.

Using ATDS command to setup the 16-bit of destination address you want, such as ATDS FFFF<CR>.

Using ATWR command to write the setting into Non-volatile memory

Input “ATCN<CR> command to exit from the AT Command mode.

5.2.8 DT

<Networking {Addressing}> The DT command is used to set and read the RF module's destination address type，64-bit or 16-bit. A module will only communicate with other modules having the same channel (CH parameter), PAN ID (ID parameter) and destination address (64bit or 16bit).

This parameter only validates under the transparent mode. Under the transparent mode, all UART data received through the RXD pin is queued up for RF transmission， when DT is equal to 0, the destination address for transmitting is 64-bit address which is the combination of DH and DL. When DT is equal to 1, the destination address for transmitting is 16-bit address assigned by DS.

Command	ATDT(**Destination Address Type 64-bit or 16bit**)	
Parameter	Range	0-1
	Default Value	1
	Value	0 = 64-bit Destination Address 1 = 16-bit Destination Address
Effective Conditions	Validate at once	
Minimum Firmware Version Required：0x19		

The examples for changing the type of destination address:

Input 3-character command sequence “+++” and switch to the AT Command mode.

Using ATDT command to setup the destination address you want, such as ATDT 1<CR>.

Using ATWR command to write the setting into Non-volatile memory

Input “ATCN<CR> command to exit from the AT Command mode.

5.2.9 FR

<Special> The FR command is used to force a software reset on the RF module. The reset simulates powering off and then on again the module.

Command	ATFR(**Software Reset**)
Parameter	None
Effective Conditions	Validate at once

Minimum Firmware Version Required：0x19

5.2.10 HV

<Diagnostics> The HV command is used to read the hardware version of the RF module.

Command	ATHV(**Hardware Version**)	
Parameter	Range	0-0xFFFF[Read-only]
Minimum Firmware Version Required：0x19		

5.2.11 ID

<Networking {Addressing}> The ID command is used to set and read the PAN (Personal Area Network) ID of the RF module. Only modules with matching PAN IDs can communicate with each other. Unique PAN IDs enable control of which RF packets are received by a module.

To validate the setting PAN ID, when setting the PAN ID, at the same time, using the RN command to setup the module as that reset the network after restart next time, then write the settings to the non-volatile memory. In this way, the PAN ID will be effective after restart the module next time.

Command	ATID (**PAN ID**)	
Parameter	Range	0x00 - 0xFFFF
	Default Value	0x19AC
Effective Conditions	RN=1, Use WR command to save setting, it will be effective after restart the module again.	
Minimum Firmware Version Required：0x19		

The PAN ID of all the modules in a network should be the same. If users want to assign PAN ID for a module, it can be set as 0x00-0xFFFE. If the PAN ID of module is 0xFFFF, and there will be different results according to different module types. If it is Coordinator, when power up, it will select one value from 0x00-0xFFFE as its PAN ID in random. If it is Router or EndDevice, when power up, they will search the PAN ID of Zigbee network that is nearby, assign the same value for PAN ID and try to enter the Zigbee network. When there are some Zigbee networks around, they will select the network with best RSSI value.

When the PAN ID is 0xFFFF, the actual PAN ID value after enter the network can be read by ATPI command. When assign PAN ID value (0x00-0xFFFE) for the module, the PAN ID value read by ATPI command is the same as the value read by ATID command.

The examples for changing the PAN ID of module:

Input 3-character command sequence “+++” and switch to the AT Command mode.

Using ATID command to setup the PAN ID you want, such as ATID 12AB<CR>.

Using ATRN command to setup the module reset the network after restart the module next time, i.e. ATRN 1<CR>.

Using ATWR command to write the setting into Non-volatile memory

Input “ATFR<CR>” command to restart the module at once.

5.2.12 MT

<Networking > The MT command is used to read the type of RF modules.

Command	ATMT(**Type**)	
Parameter	Range	0-2
	Value	0 = Coordinator 1 = Router 2 = EndDevice
Minimum Firmware Version Required：0x19		

5.2.13 MY

<Networking {Addressing}> The MY command is used to read the 16-bit source address of the RF module.

Command	ATMY (**16-bit Source Address**)	
Parameter	Range	0x00 - 0xFFFE
Minimum Firmware Version Required：0x19		

If the 16-bit Source Address of module is 0xFFFE, it means that the module doesn’t enter any Zigbee network. Whereas, if the 16-bit Source Address is less than 0xFFFE, it means it has been in a Zigbee network.

5.2.14 PI

<Networking {Addressing}> The PI command is used to read the PAN ID of module after enter the network. Only when the PAN ID is set as 0xFFFF, the PAN ID in the network is different from the PAN ID value read by “ATID” command. About this, please read “ATID” command for more information.

Command	ATPI (**PAN ID**)	
Parameter	Range	0x00 - 0xFFFE
Minimum Firmware Version Required：0x19		

5.2.15 PL

<RF Interfacing> The PL command is used to select and read the power level at which the RF

module transmits conducted power.

If the parameter is not 4 (maximum power), it will take effect to the module communication. So we don't recommend the users to change this parameter.

Command	ATPL(**Power Level**)	
Parameter	Range	0-4
	Default Value	4
	Value	0 = Min Power 4 = Max Power
Effective Conditions	Use WR command to save setting, it will be effective after restart the module again.	
Minimum Firmware Version Required：0x19		

The examples for changing the power level:

Input 3-character command sequence "+++" and switch to the AT Command mode.

Using ATPL command to setup the power level you want, such as ATPL 4<CR>.

Using ATWR command to write the setting into Non-volatile memory

Input "ATFR<CR>" command to restart the module at once.

5.2.16 RE

<(Special)> The RE command is used to restore all configurable parameters to their factory default settings. The RE command will write restored values to non-volatile (persistent) memory and force a software reset on the RF module.

This command will make the module drop out of the network and may change some settings like PAN ID, 16-bit address and so on.

Command	ATRE(**Restore**d defaults)
Parameter	None
Effective Conditions	Validate at once
Minimum Firmware Version Required：0x19	

The examples for changing the power level:

Input 3-character command sequence "+++" and switch to the AT Command mode.

Using ATRE command to restore the factory default setting, ATRE<CR>

5.2.17 RN

<Networking > The RN command is used to read and setup whether reset the network when restart

the module next time. If yes, when restart the module next time, the module will search the Zigbee network again and try to enter. It means if the module has entered a Zigbee network, it will lose the network. After restart, the settings such as PAN ID, channel, 16-bit address and so on may change.

Command	ATRN(**reset network when restart the module next time**)	
Parameter	Range	0-1
	Default Value	0
	Value	0 = Disable 1 = Enable
Effective Conditions	Use WR command to save setting, it will be effective after restart the module again.	
Minimum Firmware Version Required：0x19		

The examples for changing whether reset the network when restart the module next time:
Input 3-character command sequence “+++” and switch to the AT Command mode.

Using ATRN command to setup whether reset the network when restart the module next time, such as ATRN 1<CR>.
Using ATWR command to write the setting into Non-volatile memory
Input “ATFR<CR>” command to restart the module at once.

5.2.18 SH

<Diagnostics> The SH command is used to set and read the high 32 bits of the RF module's unique IEEE 64-bit address.

Note: The 64-bit address has been set by the chip manufactory of the module in the factory. The chip manufacture ensures the unique 64-bit address for each chip. In a Zigbee network, the 64-bit address of each module is unique, otherwise, it will cause communication chaos. So we don’t recommend the users to change the 64-bit address (Serial Number).

If the high 32-bit and low 32-bit are set as 0xFFFFFFFF, it can make the 64-bit address (Serial Number) restore to the factory default setting.

To validate the 64-bit address, when setting the 64-bit address, at the same time, using the RN command to setup the module as that reset the network after restart next time, then write the settings to the non-volatile memory. In this way, the new 64-bit address will be effective after restart the module next time.

Command	ATSH(**Serial Number High**)	
Parameter	Range	0-0xFFFFFFFF

	Default Value	0
Effective Conditions	RN=1, Use WR command to save setting, it will be effective after restart the module again.	
Minimum Firmware Version Required：0x19		

The examples for changing the high 32-bit address:

Input 3-character command sequence "+++" and switch to the AT Command mode.

Using ATSH command to setup the high 32-bit address, such as ATSH 0<CR>

Using ATRN command to setup whether reset the network when restart the module next time, such as ATRN 1<CR>.

Using ATWR command to write the setting into Non-volatile memory

Input "ATFR<CR>" command to restart the module at once.

5.2.19 SL

<Diagnostics> The SL command is used to set and read the low 32 bits of the RF module's unique IEEE 64-bit address.

Note: The 64-bit address has been set by the chip manufactory of the module in the factory. The chip manufacture ensures the unique 64-bit address for each chip. In a Zigbee network, the 64-bit address of each module is unique, otherwise, it will cause communication chaos. So we don't recommend the users to change the 64-bit address (Serial Number).

If the high 32-bit and low 32-bit are set as 0xFFFFFFFF, it can make the 64-bit address (Serial Number) restore to the factory default setting.

To validate the 64-bit address, when setting the 64-bit address, at the same time, using the RN command to setup the module as that reset the network after restart next time, then write the settings to the non-volatile memory. In this way, the new 64-bit address will be effective after restart the module next time.

Command	ATSL(**Serial Number Low**)	
Parameter	Range	0-0xFFFFFFFF
	Default Value	0
Effective Conditions	RN=1, Use WR command to save setting, it will be effective after restart the module again.	
Minimum Firmware Version Required：0x19		

The examples for changing the low 32-bit address:

Input 3-character command sequence "+++" and switch to the AT Command mode.

Using ATSL command to setup the low 32-bit address, such as ATSL 0<CR>

Using ATRN command to setup whether reset the network when restart the module next time, such as ATRN 1<CR>.

Using ATWR command to write the setting into Non-volatile memory

Input “ATFR<CR>” command to restart the module at once.

5.2.20 VR

<Diagnostics> The VR command is used to read which firmware version is stored in the module.

Command	ATVR (**Firmware Version**)	
Parameter	Range	0x00 - 0xFF
Minimum Firmware Version Required：0x19		

5.2.21 WR

<(Special)> The WR command is used to write all configurable parameters to the RF module's non-volatile memory. Parameter values remain in the module's memory until overwritten by subsequent use of the WR Command. If changes are made without writing them to non-volatile memory, the module reverts back to previously saved parameters the next time the module is powered-on.

Command	ATWR (**Write**)
Parameter	None
Minimum Firmware Version Required：0x19	

5.3 API Operation

By default, RF Modules act as a serial line replacement (Transparent Operation) - all UART data received through the RXD pin is queued up for RF transmission. When the module receives an RF packet, the data is sent out the TXD pin with no additional information.

Inherent to Transparent Operation are the following behaviors:

• If module parameter registers are to be set or queried, a special operation is required for transitioning the module into Command Mode.

• In point-to-multipoint systems, the application must send extra information so that the receiving module(s) can distinguish between data coming from different remotes.

As an alternative to the default Transparent Operation, API (Application Programming Interface) Operations are available. API operation requires that communication with the module be done

through a structured interface (data is communicated in frames in a defined order). The API specifies how commands, command responses and module status messages are sent and received from the module using a UART Data Frame.

5.3.1 API Frame Specifications

API mode can be enabled using the AP (API Enable) command. Use the following AP parameter values to configure the module to operate in a particular mode:

• AP = 0 (default): Transparent Operation (UART Serial line replacement) API modes are disabled.

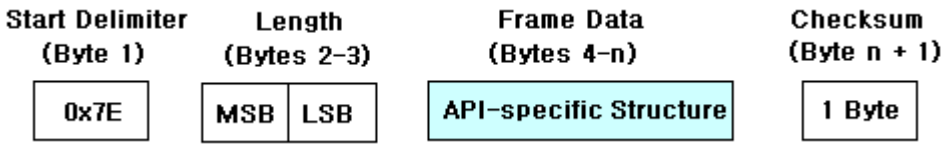
• AP = 1: API Operation

Any data received prior to the start delimiter is silently discarded. If the frame is not received correctly or if the checksum fails, the data is silently discarded.

API Operation (AP parameter = 1)

When this API mode is enabled (AP = 1), the UART data frame structure is defined as follows:

Figure UART Data Frame Structure:



MSB = Most Significant Byte, LSB = Least Significant Byte

Checksum

To test data integrity, a checksum is calculated and verified.

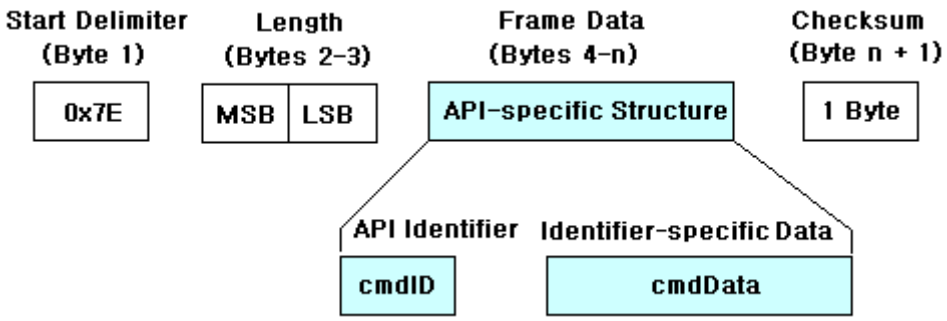
To calculate: Not including frame delimiters and length, add all bytes keeping only the lowest 8 bits of the result and subtract from 0xFF.

To verify: Add all bytes (include checksum, but not the delimiter and length). If the checksum is correct, the sum will equal 0xFF.

5.3.2 API Types

Frame data of the UART data frame forms an API-specific structure as follows:

Figure. UART Data Frame & API - Specific Structure:



The cmdID frame (API-identifier) indicates which API messages will be contained in the cmdData frame (Identifier-specific data). Refer to the sections that follow for more information regarding the supported API types. Note that multi-byte values are sent big endian.

AT Command

API Identifier Value: 0x08

The "AT Command" API type allows for module parameters to be queried or set. When using this command ID, whether the new parameter values validate at once or restart next time, it is up to the different AT Commands. Register queries (reading parameter values) are returned immediately.

Figure. AT Command Frames
(Note that frames are identical to the "AT Command" API type except for the API identifier.)

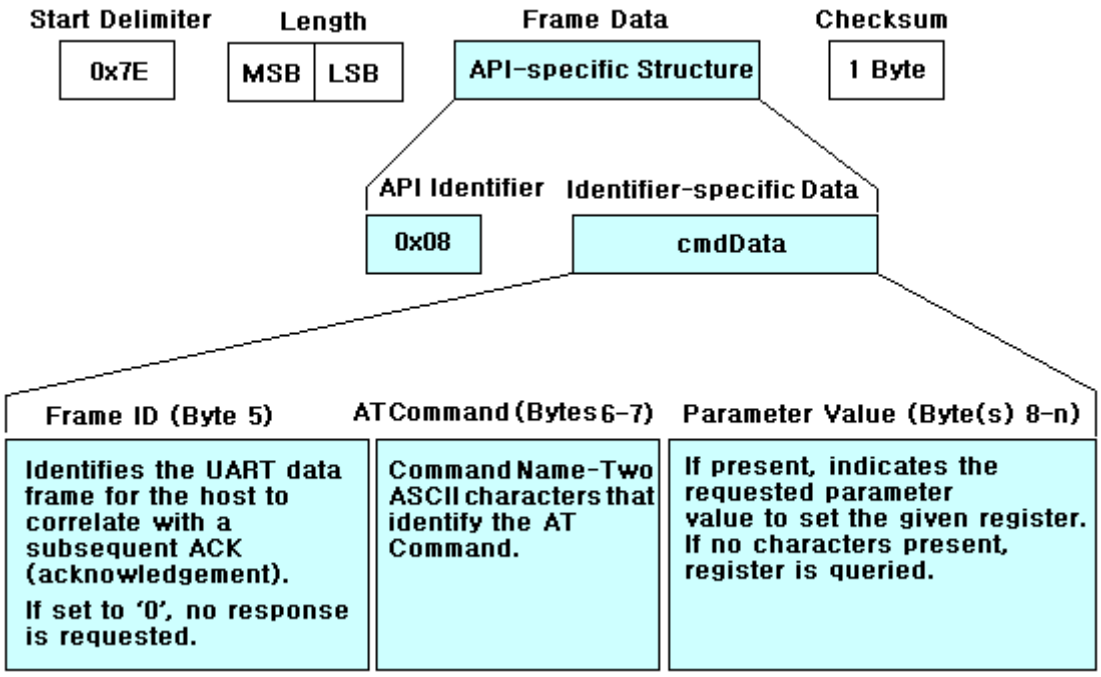
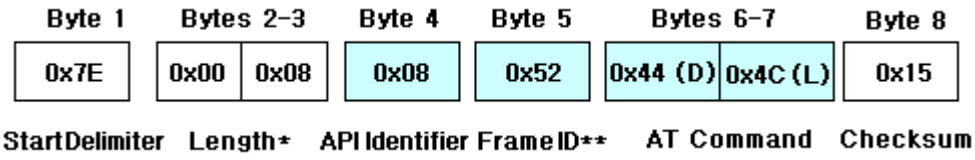


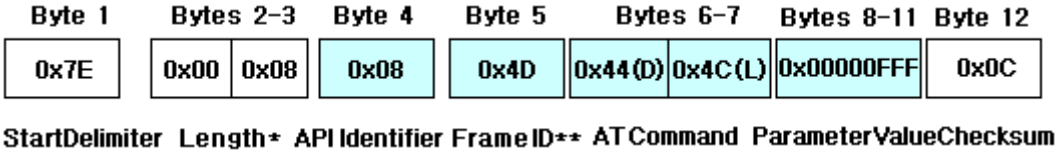
Figure. Example: API frames when reading the DL parameter value of the module.



* *Length [Bytes] = API Identifier + Frame ID + AT Command*

*** "R" value was arbitrarily selected.*

Figure . Example: API frames when modifying the DL parameter value of the module.



* *Length [Bytes] = API Identifier + Frame ID + AT Command + Parameter Value*

*** "M" value was arbitrarily selected.*

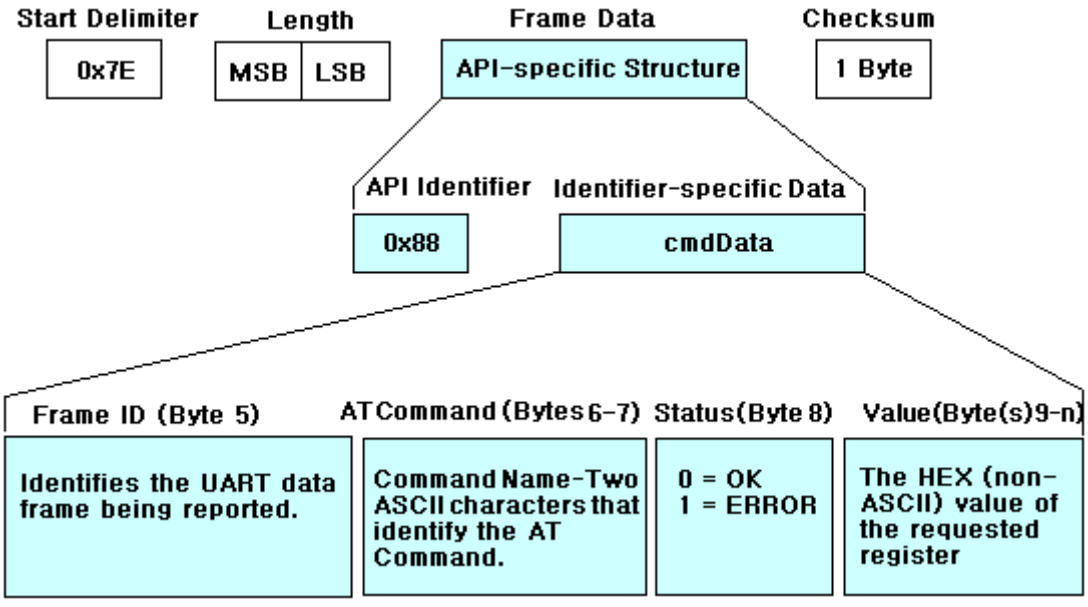
AT Command Response

API Identifier Value: 0x88

Response to previous command

In response to an AT Command message, the module will send an AT Command Response mes-sage. Some commands will send back multiple frames. These commands will end by sending a frame with a status of ATCMD_OK and no cmdData.

Figure . AT Command Response Frames.

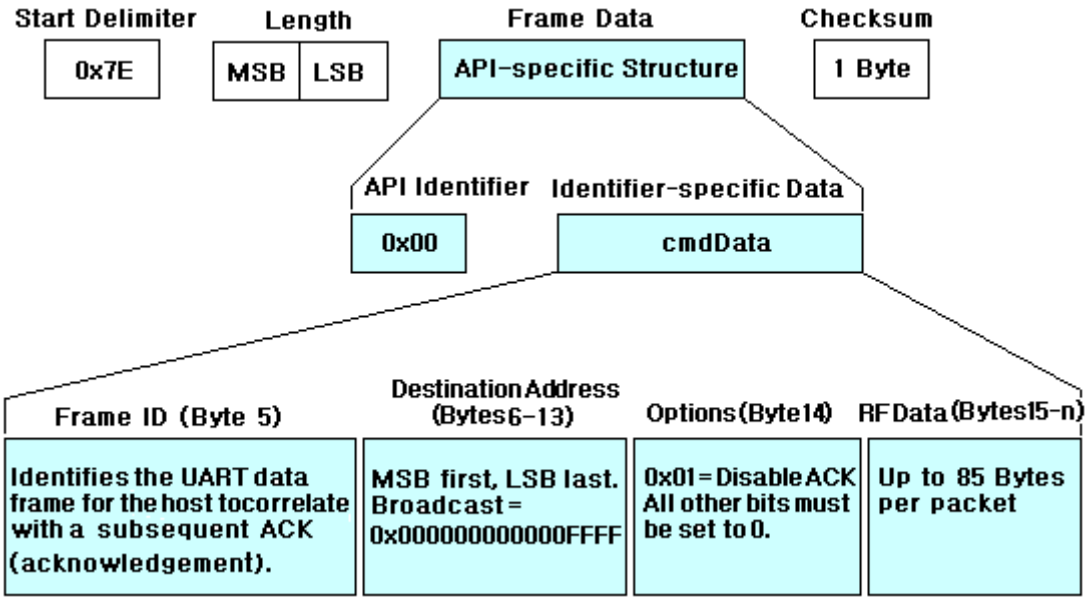


TX (Transmit) Request: 64-bit address

API Identifier Value: 0x00

A TX Request message will cause the module to send RF Data as an RF Packet.

Figure. TX Packet (64‐bit address) Frames

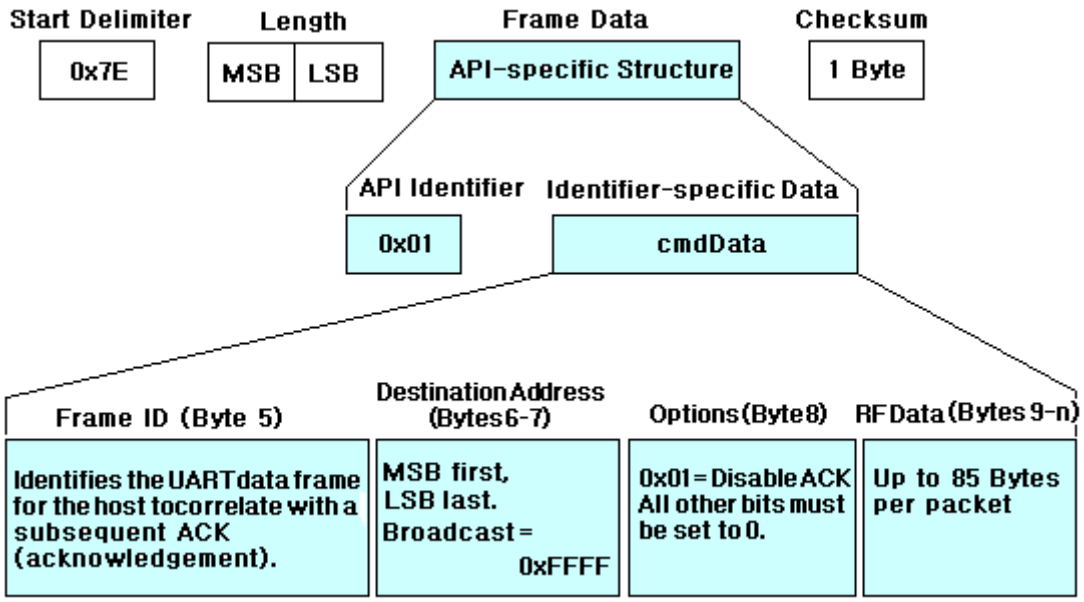


TX (Transmit) Request: 16-bit address

API Identifier Value: 0x01

A TX Request message will cause the module to send RF Data as an RF Packet.

Figure . TX Packet (16‐bit address) Frames

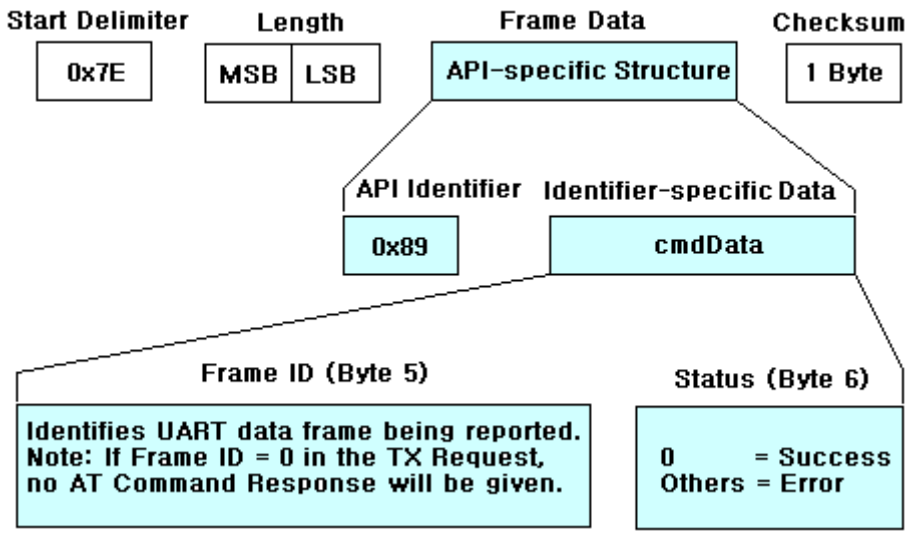


TX (Transmit) Status

API Identifier Value: 0x89

When a TX Request is completed, the module sends a TX Status message. This message will indicate if the packet was transmitted successfully or if there was a failure.

Figure . TX Status Frames

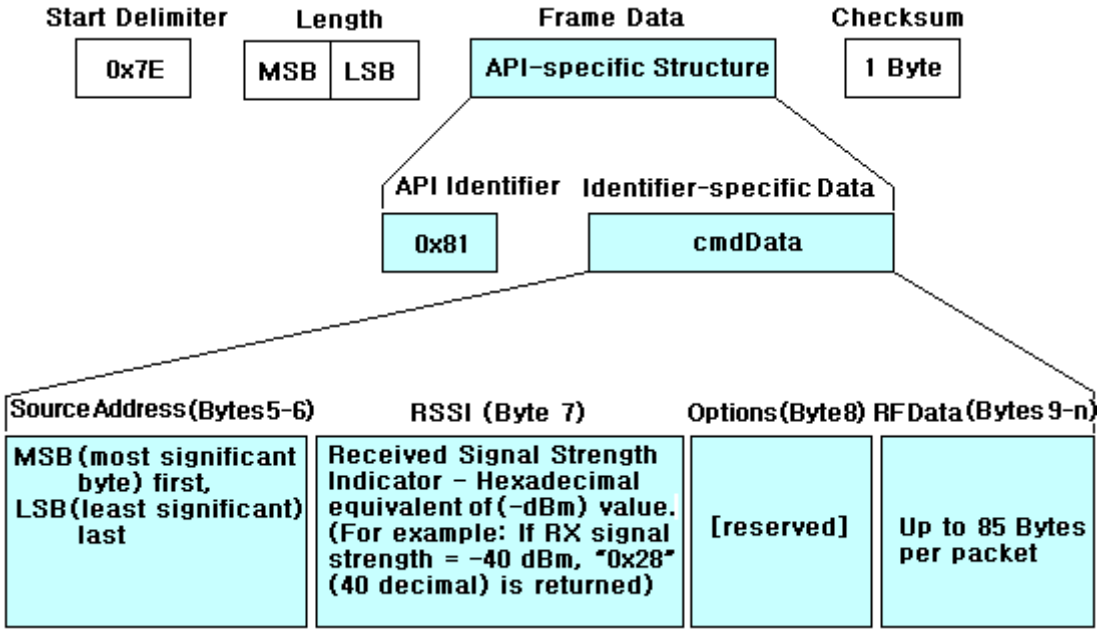


RX (Receive) Packet: 16-bit Address

API Identifier Value: 0x81

When the module receives an RF packet, it is sent out the UART using this message type.

Figure . RX Packet (16 - bit address) Frames



5.4 Frequently Asked Questions.

5.4.1 How to broadcast transmission?

First users need to note that the broadcast is restricted to avoid the broadcast storm in the network. In a Zigbee network, all the broadcast items for all the nodes should not be more than 9 items (default value) in 3 seconds. If it exceeds the default value, the network will shield broadcast automatically.

Broadcast under transparent mode

Under the transparent mode, if the type of destination address which can be set by ATDT command is 16-bit address, set the 16-bit destination address as 0xFFFF which can be set by ATDS command,. If the type of destination address is 64-bit address, set the high 32-bit destination address as 0x00000000 which can be set by ATDH command. And set the low 32-bit destination address as 0x0000FFFF which can be set by ATDL. In this way, under the transparent mode, all the data input from the serial port of module can be transmitted by broadcast.

Broadcast under the API mode

Under the API mode, if users want to send data by 64-bit destination address, users only need to set the address as 0x000000000000FFFF. If by 16-bit destination address, users need to set the address as 0xFFFF. In this way, under the API mode, data can be transmitted by broadcast.

When the module transmits data by broadcast, all the other online modules in the network can receive the data.

5.4.2 How to know a module that has been in the network?

Read the short address or 16-bit address (AT Command is ATMY.) can confirm the module whether it is in the network. If its short address is 0xFFFE, it means it is not in the network. If its short address is less than 0xFFFE, it means it is in the network.

Need to know that the Coordinator is always in the network. For one module, if the module has been in a network, it will always be in the network, even the module has been restarted again, and the short address can not be changed. Only when using the ATRN command to initialize the network, the module will lose the network.

5.4.3 How to make the module work under the API mode after power up?

Users can use AT command to make the module enter API mode:

Enter the AT Command page of HAC Studio.

Input 3-character command sequence “+++” and wait the module returns “OK”

Input “ATAP 1<CR>” command, the module returns “OK”, it is used to setup the module work under the API mode.

Input “ATWR <CR>” command, the module returns “OK”, it is used to save the setting to keep the

working mode as API mode after restart the module.

Input “ATCN <CR>” to exit from the AT Command mode. Now, the module is working on the API mode. Even restart the module, it also enters the API mode directly.

5.4.4 Keep the 64-bit address of every module in the network has a unique address

In a Zigbee network, the 64-bit address of every module should be unique to ensure that every module works normally in the network. If there are two modules which have the same 64-bit address in the Zigbee network, it will cause some communication chaos. This is very important.

The 64-bit address has been set by the chip manufactory of the module in the factory. The chip manufacture ensures the unique 64-bit address for each chip. So, we don’t recommend change the 64-bit address.

Except change 64-bit address intentionally can make that two modules have the same 64-bit address, there are some other involuntary operations that can cause this phenomena. For example, when you are using “Setup (API)” page of HAC-Studio setting software to setup, you read the setting of one module, after change the module, you don’t read the 64-bit address again and setup the module directly. In this way, the 64-bit address of last module is still in the page, so it will be written into the new module. So it will cause two modules have the same 64-bit address.

VI. Assistant Software

We offer a upper software called HAC Studio to help users to test, evaluate and setup the HAC-Ubee module. There are 5 parts in total.

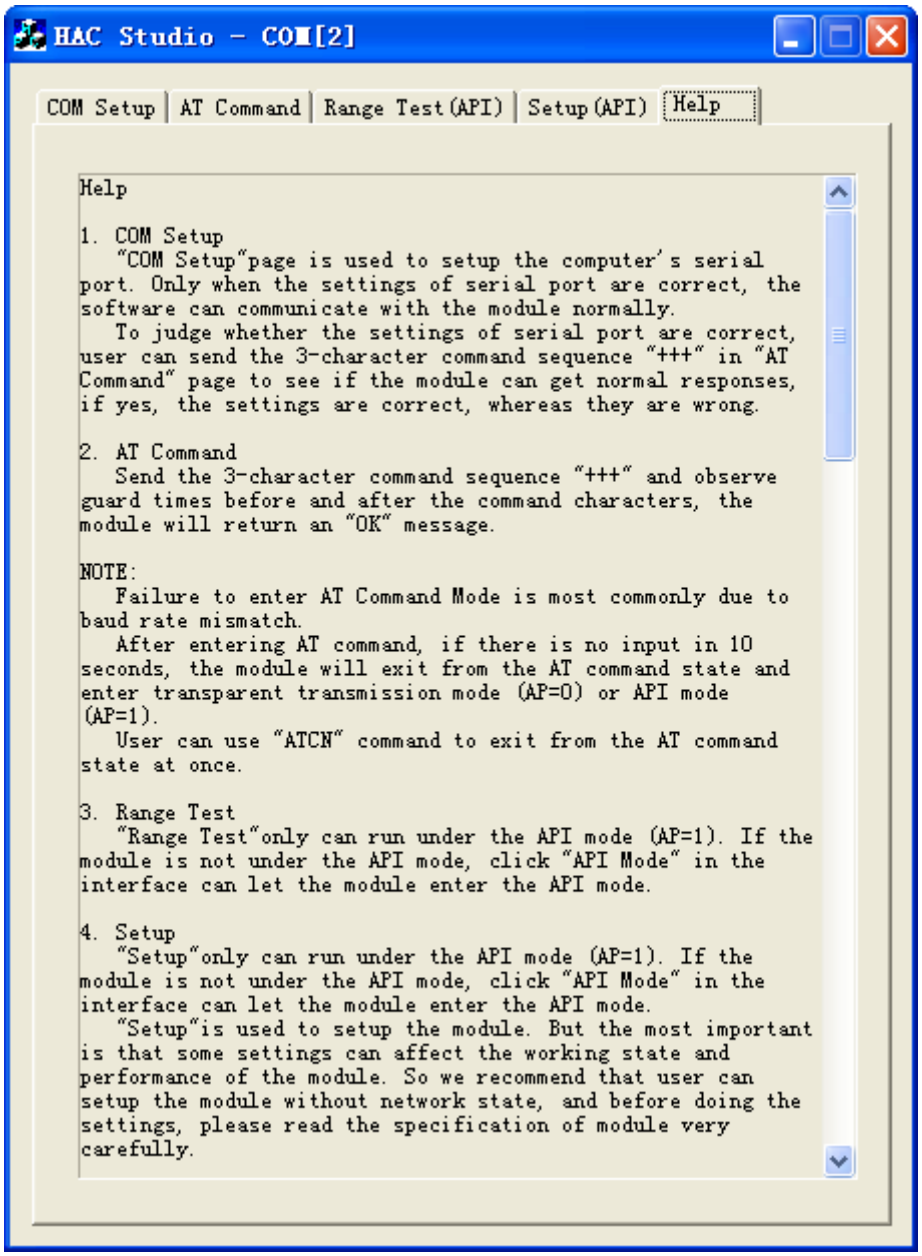
"COM Setup" page is used to setup the computer’s serial port. Only when the settings of serial port are correct, the software can communicate with the module normally.

"AT Command" page is used to input and output AT Command.

"Range Test" is used for the communication test of module, it only can run under the API mode (AP=1).

"Setup" is used to setup the module. But the most important is that some settings can affect the working state and performance of the module. "Setup" only can run under the API mode (AP=1).

"Help" is the help for software. Before using the software, please read the “Help” at first.



VII. Appendix

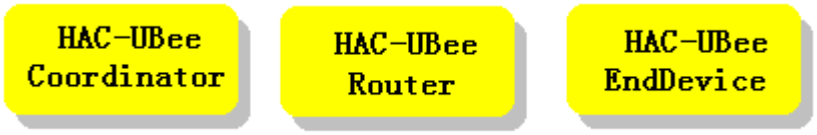
Appendix 1:

1. What is Zigbee?

The ZigBee Alliance based on an open global standard is an association of companies working together to enable reliable, cost-effective and low-power Wireless communications solutions. ZigBee launched by ZigBee Alliance is a short-distance, low-power and low-cost wireless communication technology. Some International well-known companies are members of ZigBee Alliance, such as TI, Motorola, Siemens, Philips.

2. The sort of Zigbee module

Our ZigBee module is based on ZigBee protocol stack of TI company. According to different functions in the network, module can be divided into three types, one is Coordinator, another one is Router, the rest one is end device. The appearance and interface of three types are the same. Users can distinguish them by label or by the upper software.



Picture Module Label

3. Zigbee Network

One Zigbee network only have one Coordinator, it is useed for the establishment of the network. Only after Coordinator has been electrified for a few seconds, the network can be startup. Coordinator is the first node in the network. Then Router can connect with Coordinator and enter into the network. At the same time, Router in the network allows the other Router enter the network by connecting with it. Any two nodes in the network can do point-to-point communication. At the same time, any node can broadcast to the other nodes.

Whether a module can enter the network depends on whether it has node that has enter network in its communication distance. If the distance between the module and its nearest node in the network is more than its communication distance (seen in the module specification), and the node will not communicate with any nodes in the network.

The establishment of ZigBee network can finish automatically after the module has been electrified, User doesn't need to operate. The order for the module's power doesn't seem particularly important. After Coordinator has been electrified, ZigBee network can be built. Once a Router has entered the network, even if the Coordinator's power is off, the network can also work normally.

The networking for Coordinator needs to search the suitable channel. And Router enter the network also need to search channel and network and connect. It needs some time to deal with these processes. For Coordinator and Router, once the module enters the network, except initializing the network, or the module will still in the network.

All modules in one network should have the same PAN ID and channel.

4. The 64-bit address and 16-bit address of module

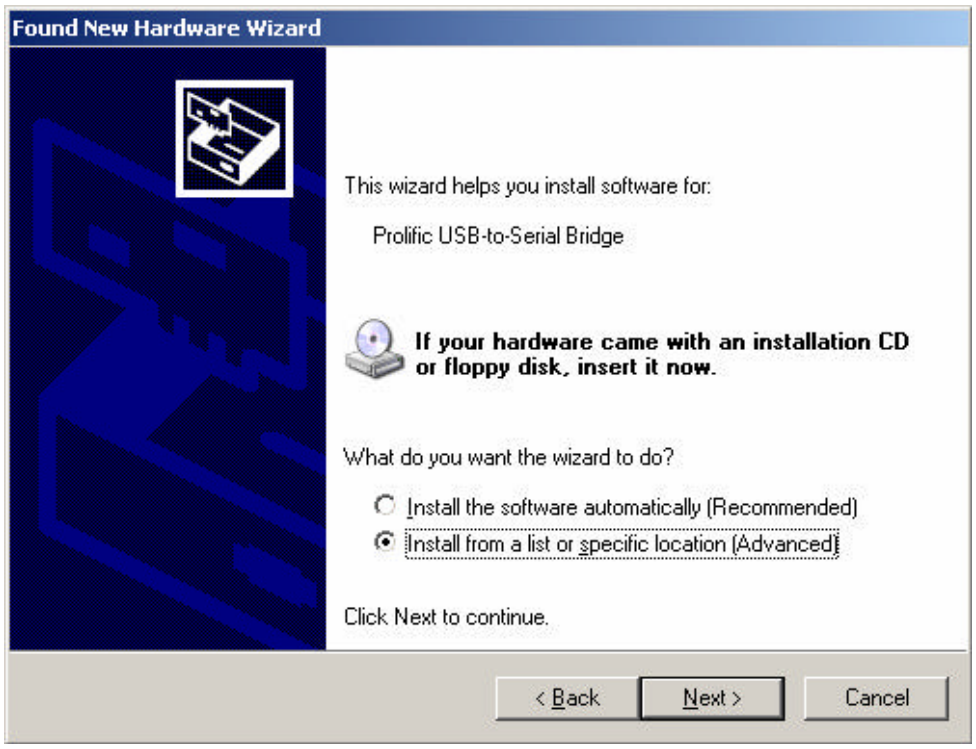
The 64-bit address has been set by the chip manufactory of the module in the factory. The chip manufacture ensures the unique 64-bit address for each chip. Before entering one Zigbee network, its 16-bit address is 0xFFFE, it is unmeaning. Once the module enters the Zigbee network, it will get a 16-bit address that is less than 0xFFFE. In this network, the 16-bit address is unique, except reset the network, or 16-bit address will always belong to this module. The 16-bit address of Coordinator in the network is fixed, it is always 0x0000.

Appendix 2:

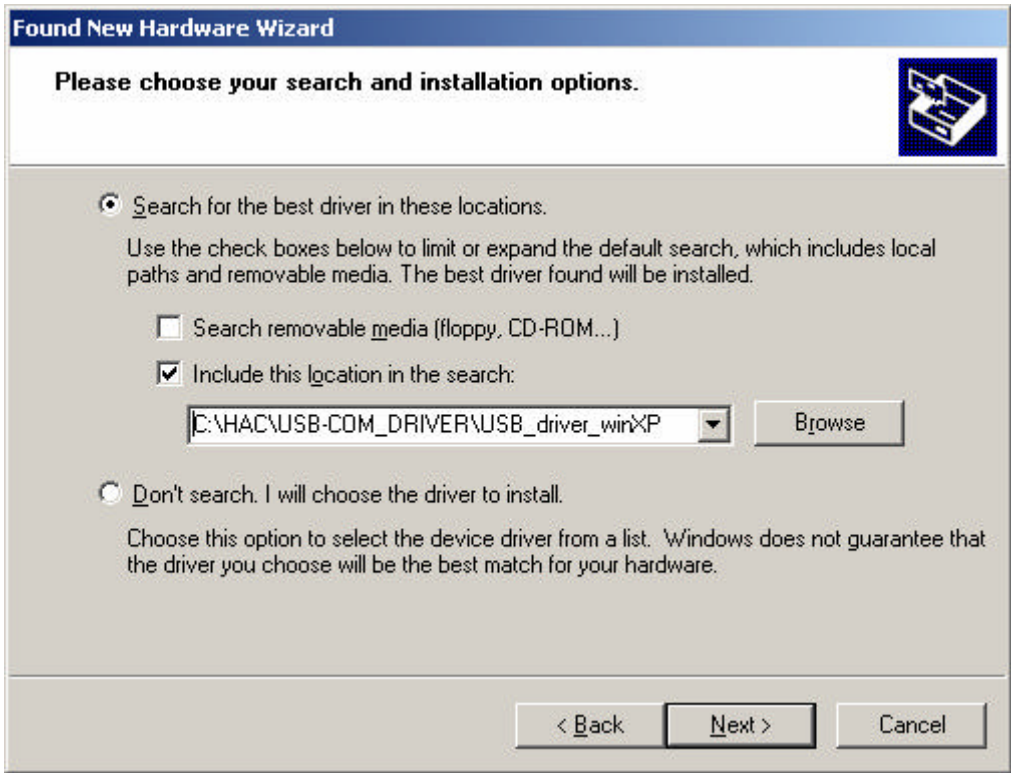
Installation instruction for USB driver
MU series (USB to RS232)

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'.

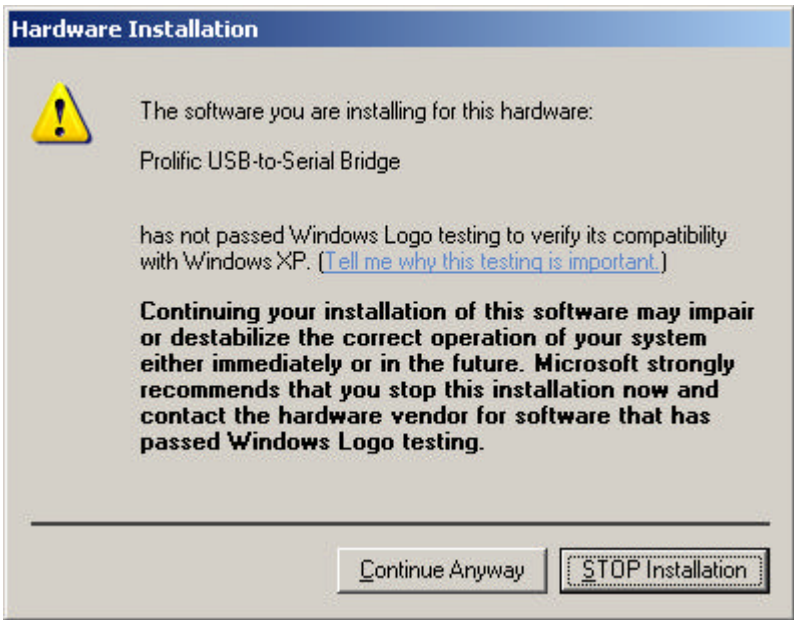
2. The next wizard box will show as below. Select 'Advanced' installation and click on 'Next' button.

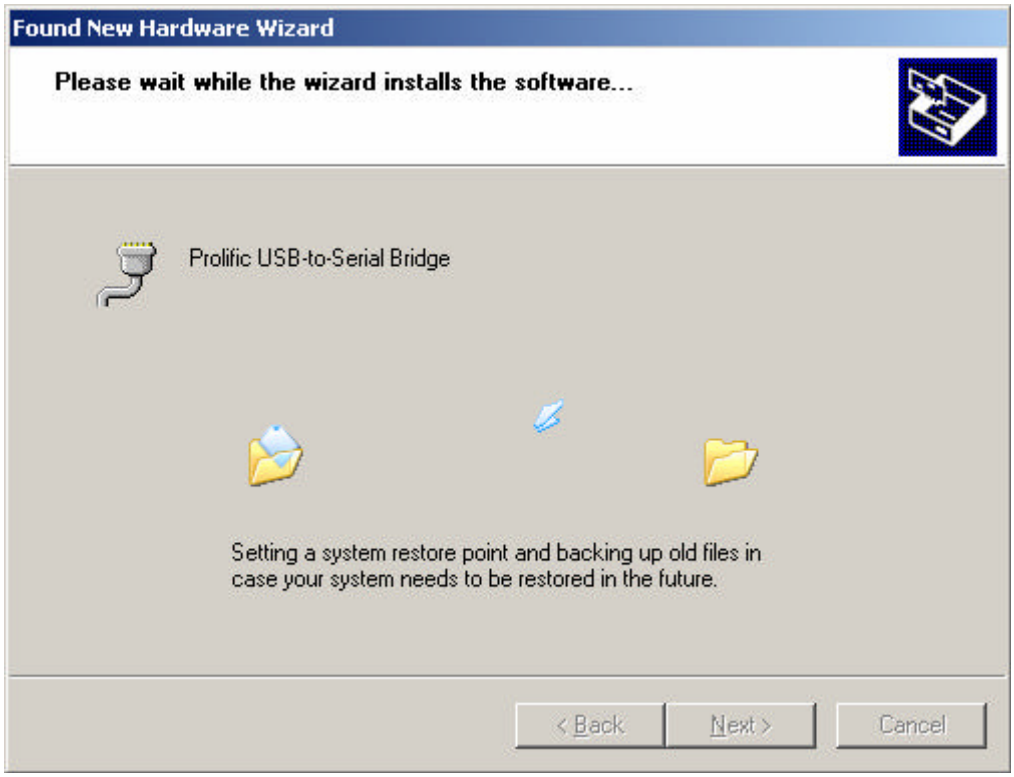


3. In the next dialog box, please specify the path where your Windows XP driver located, and click next after the correct path is selected.

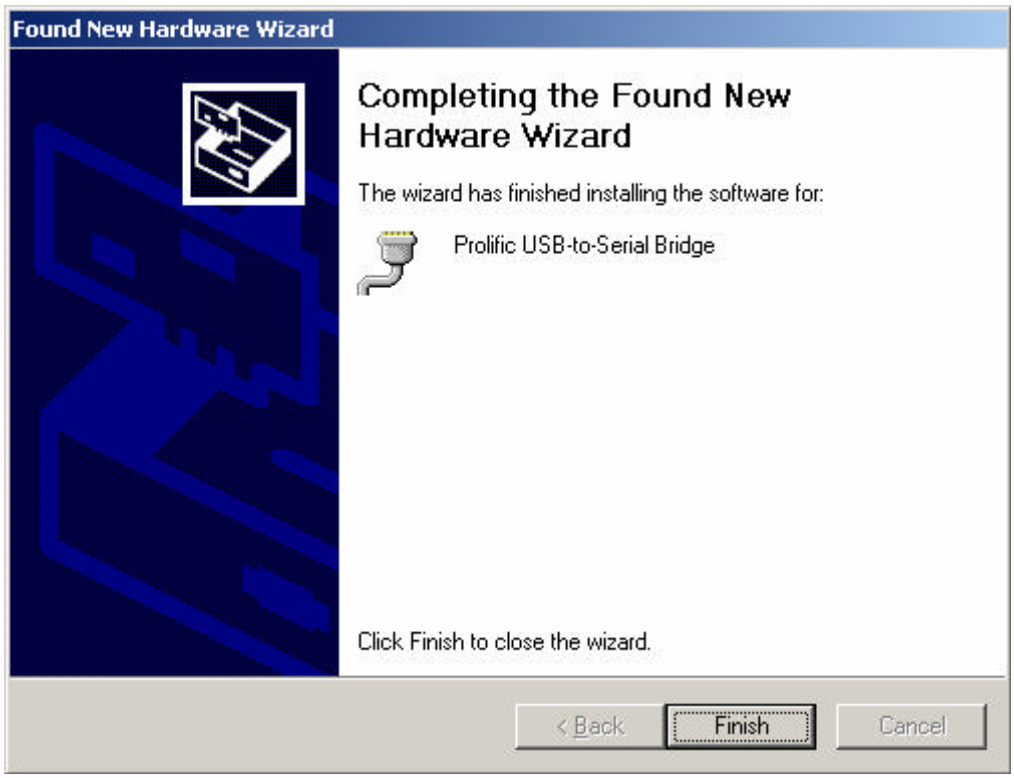


4. A warning message dialog box will appeared as below. Click 'Continue Anyway' button to start the installation.

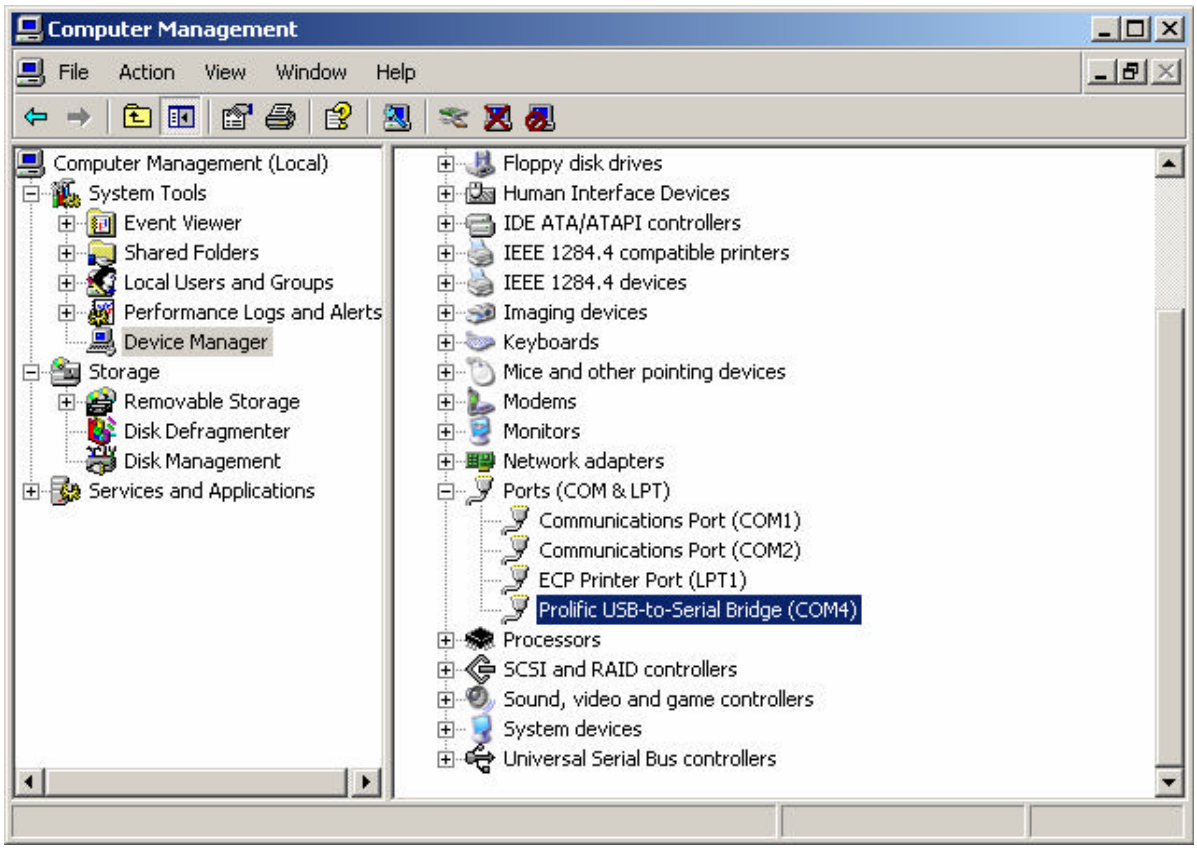




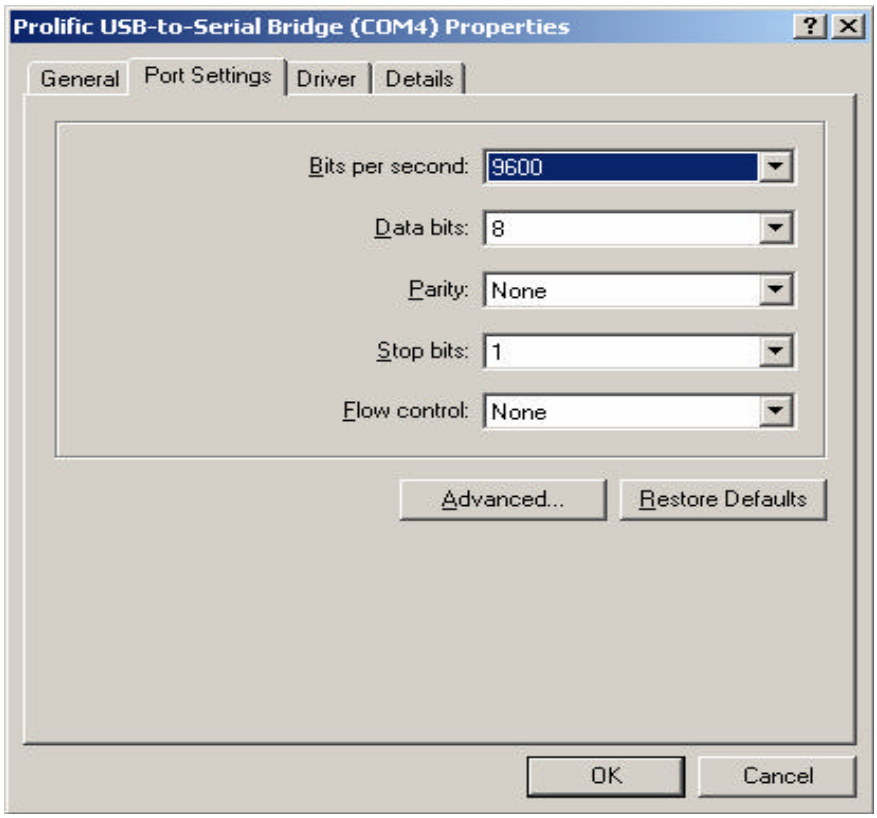
5. After the installation is completed, the following dialog box will appear. Click on the 'Finish' button to complete the installation.



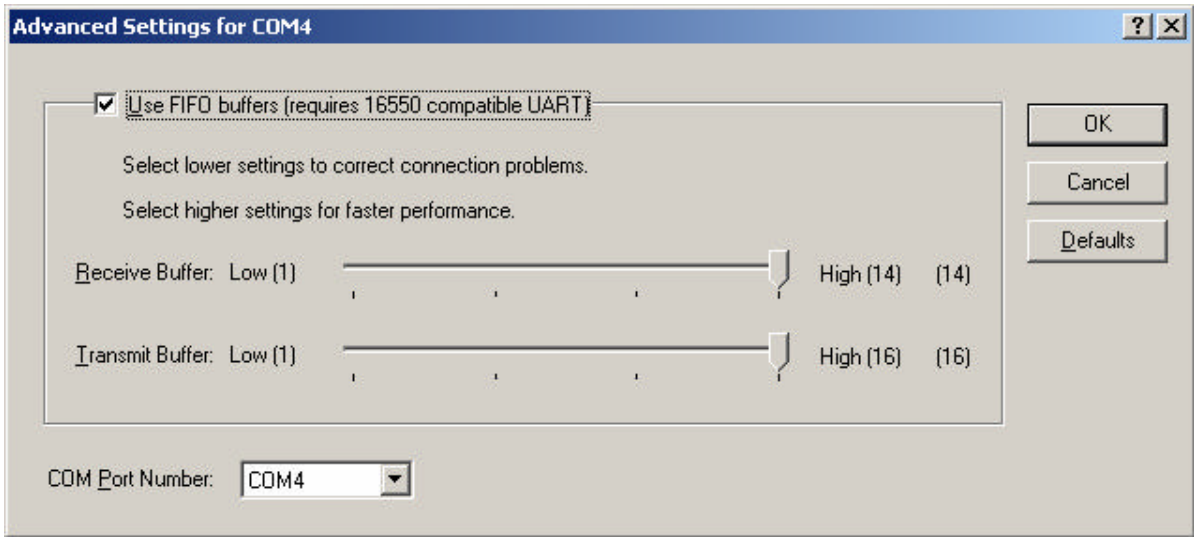
6. To verify and set the parameters of the serial port, open the Computer Manager window and select on Device Manager on the left window. Open the COM port field in the right window.



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.