HAC-LBee/S

2.4G Low Power Data Radio Module

(Based on 802.15.4 protocol)
V3.X

SHENZHEN HAC TELECOM TECHNOLOGY CO., LTD

Catalogue

I Features of HAC-LBee/S Wireless Module

HAC-LBee/S is a kind of low power wireless module based on 802.15.4 protocol stack. The features are shown as follow:

1. Low power transmission with 100mW（20dBm）, 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 1000m.

6. Multi-channels

   HAC-LBee/S offers 16 channels. It will select the suitable and reliable communication channel automatically according to the user's environment.

7. UART interface

   HAC-LBee/S provides a UART interface of TTL level. The parity is no-parity (8N1), and the baud rate can be set by users.

8. Low power consumption

   The receiving current is less than or equal to 50mA, and the transmitting current is less than or equal to 160mA.

9. Small size and light weight

10. By using monolithic radio-frequency integrated circuit and single-chip MCU, 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.

II. Applications of HAC-LBee/S Wireless Module

HAC-LBee/S 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-LBee/S Wireless Module

3.1 Technical Parameter of HAC-LBee/S

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	**140**	**150**	**160**	**mA**
Receiving Current	**29**	**30**	**31**	**mA**
Sleeping Current		**3**		**μA**
Wireless Performance（-25℃）				
Working Frequency	**2.405**		**2.485**	GHz
Transmitting Power	**19.0**	**19.5**	**20.2**	dBm
Receiving Sensitivity		**-105**		dBm
Transmitting Rate		**250**		Kbps
General Performance				
Interface baud rate	**1200**		**115200**	bps
Working Temperature	**-40**		**80**	℃
Size	**35.1 Ⅹ 24.4 Ⅹ 4**			mm
Antenna	**PCB antenna, chip antenna, IPX antenna base**			

Table 1 Technical Parameter of HAC-LBee/S

3.2 The Size of HAC-LBee/S (35.1x24.4x4mm)
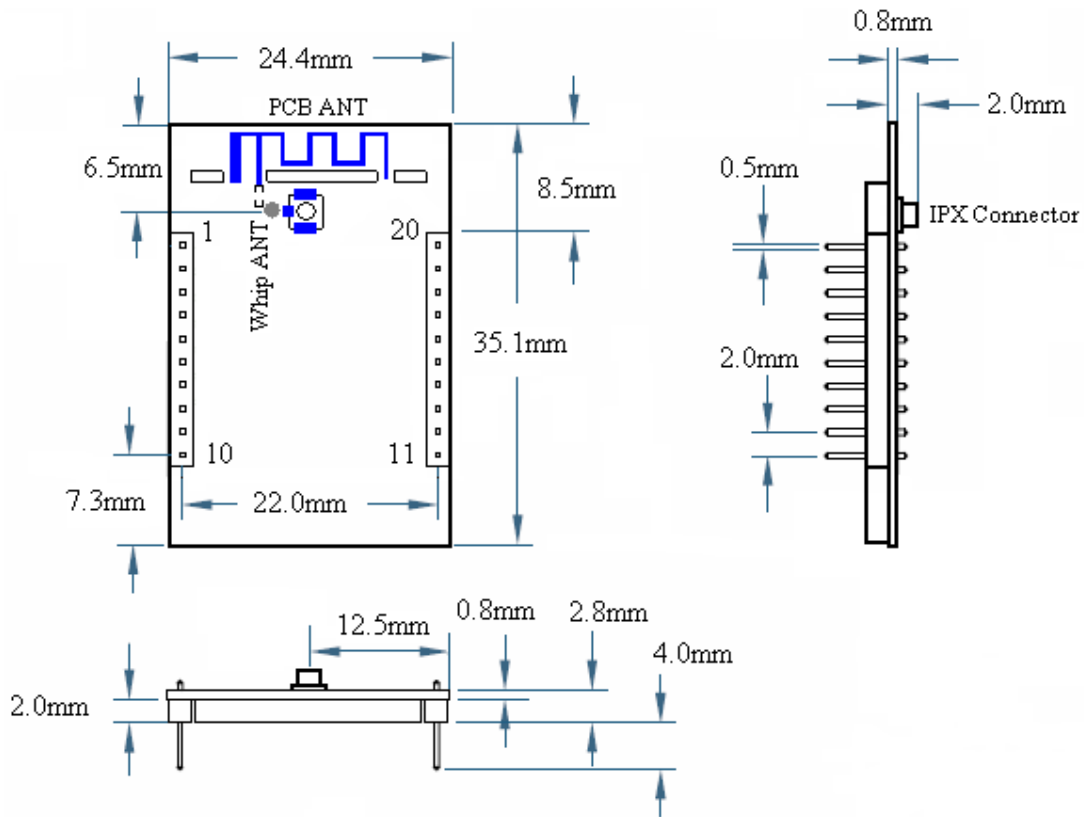
**Picture 1 The Size of HAC-LBee/S**

3.3 Pin Definition of HAC-LBee/S

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/SLEEP	IN/OUT	Data I/O5 / Program clock/Sleep enable

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-LBee/S

IV.　Development Kit for HAC-LBee/S Wireless Module

4.1 General Information for HAC-DEV Development Kit
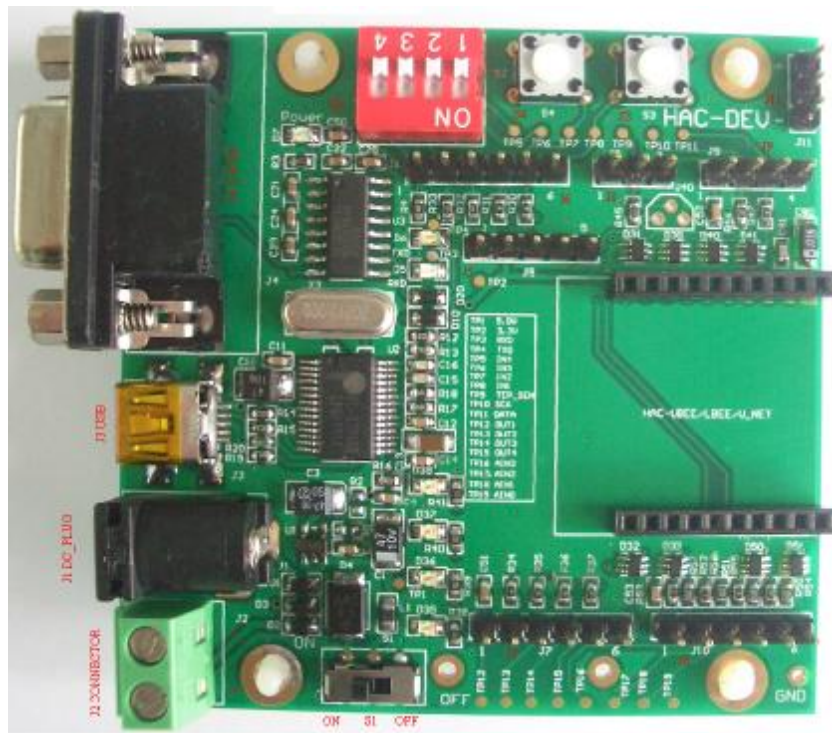
Picture 2 HAC-DEV

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

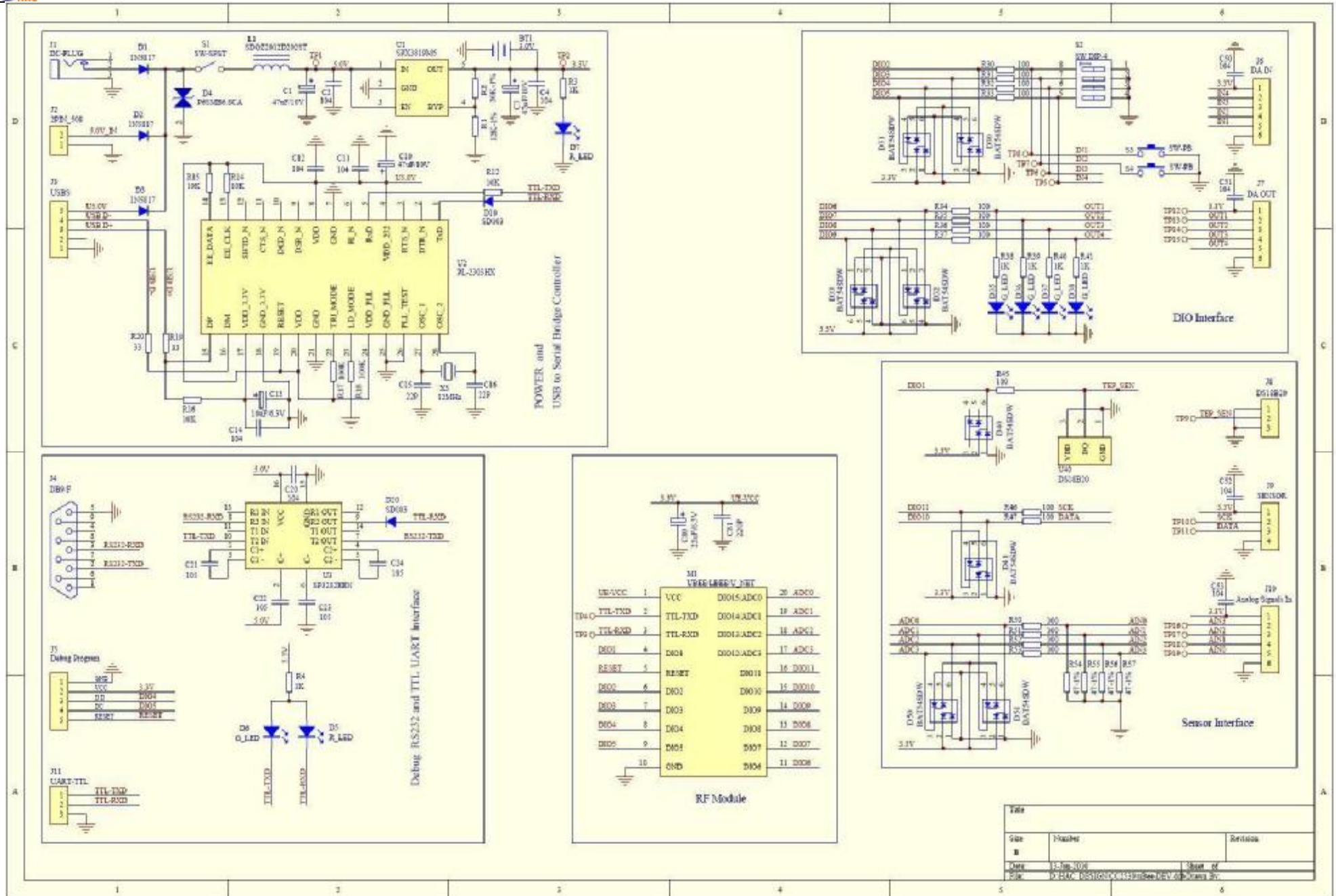k. J11 (UART_TTL)   Serial Port for TTL Level

Pin Name	Definition
Pin1	TXD
Pin2	RXD
Pin3	GND

4.2 Connecting Methods between HAC-LBee/S and HAC-DEV

Picture 3 Connecting Methods between HAC-LBee/S and HAC-DEV

4.3 Schematic Diagram for HAC-DEV

POWER and USB to Serial Bridge Controller

Debug RS232 and TTL UART Interface

RF Module

DIO Interface

Sensor Interface

V.   Working Mode of HAC-LBee/S Wireless Module

5.1. Working Mode of HAC-LBee/S Wireless Module

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

5.1.1   Transparent Mode

By default, Modules operate under transparent working Mode. When operating under transparent 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 (100) 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 100 bytes (maximum packet size) are received.

The destination address under the transparent mode composes of DH and DL. If DH is 0, and DL is less than 0xFFFF, the data will be sent by 16-bit destination address. Or it will use 64-bit destination address.

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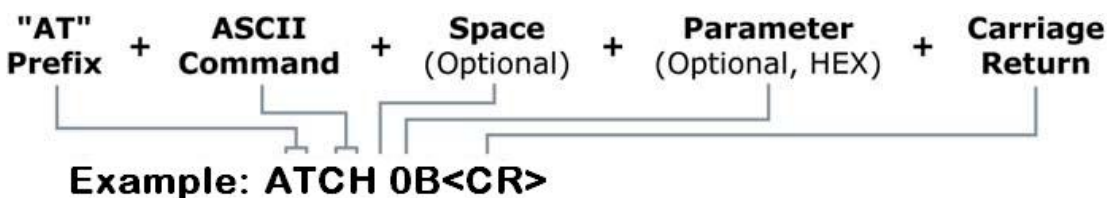
Input "ATCN<CR>" command to exit from the AT Command mode. Now, the module works under the API mode. Even power up the module again, it still enters the API mode directly.

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 = 3 (9600 bps).

"AT" Prefix + ASCII Command + Space (Optional) + Parameter (Optional, HEX) + Carriage Return

Example: ATCH 0B<CR>

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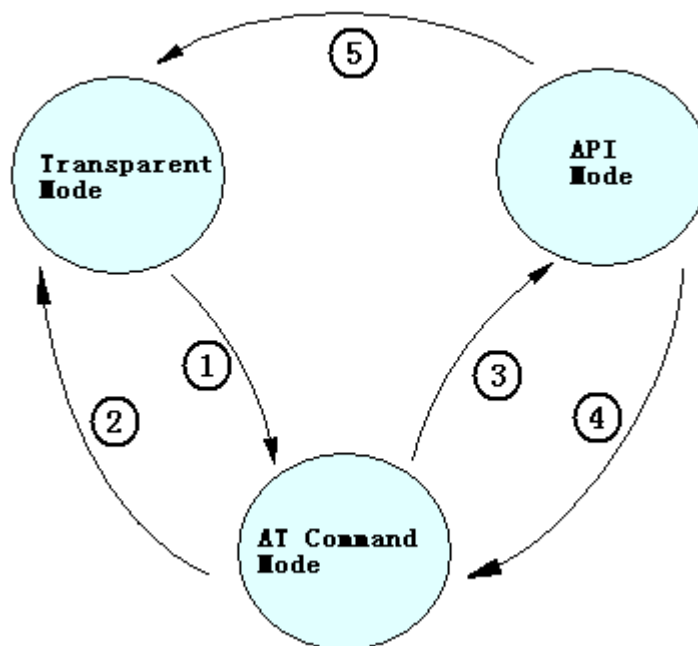
1. Under the transparent mode, input 3-character command sequence "+++" from serial port, it will change for the AT Command mode.

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.	-	-	>=0x1000
RE	Special	Restore Defaults. Restore module parameters to factory defaults.	-	-	>=0x1000
FR	Special	Software Reset. Immediately performs a hard reset.	-	-	>=0x1000
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	>=0x1000
ID	Networking	PAN ID. Set/Read the setup PAN (Personal Area Network) ID.	0 - 0xFFFF	0x234	>=0x1000
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	>=0x1000
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	>=0x1000
MY	Networking	16-bit Source Address. Read the RF module 16-bit source address.	0-0xFFFF	0x0001	>=0x1000
SH	Networking	Serial Number High. Set/Read high 32 bits of the RF module's unique IEEE 64-bit address.	0 - 0xFFFFFFFF	-	>=0x1000
SL	Networking	Serial Number Low. Set/Read low 32 bits of the RF module's unique IEEE 64-bit address.	0 - 0xFFFFFFFF	-	>=0x1000
SM	Sleep	Sleep state. Set/read the sleep state of module	0-5	0	>=0x1000
AP	Serial Interfacing	API Enable. Disable/Enable API Mode.	0 - 1 0 = Transparent 1 = API enabled	0	>=0x1000
BD	Serial Interfacing	Interface Data Rate. Set/Read the serial interface data rate for communications between the RF module serial port and host.	1-7 1 = 2400 2 = 4800 3 = 9600 4 = 19200 5 = 38400 6 = 57600 7 = 115200	3	>=0x1001
CN	AT Command Mode Options	Exit Command Mode. Explicitly exit the module from AT Command Mode.	-	-	>=0x1000
HV	Diagnostics	Hardware Version. Read hardware version of the RF module.	0 - 0xFFFF (Read only)	-	>=0x1000

VR	Diagnostics	Firmware Version. Read firmware version of the RF module.	0 - 0xFF (Read only)	-	>=0x1000

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：0x1000		

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. When parameters 1-7 are sent to the module, the respective interface data rates are used (as shown in the table on the below). The RF data rate is not affected by the BD parameter (it is fixed to 250kbps). We recommend that users don't select too low interface data rate, or it will cause the serial port data communication overflow. We only offer the AT command to change the serial port data rate, no command for changing data rate under API mode.

Command	ATBD (**Interface Data Rate**)	
Parameter	Range	1-7
	Default Value	3

	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：0x1001		

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 5<CR>.

Using ATWR command (ATWR<CR>)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. HAC-LBee/S provides 16 channels (0x0B-0x1A). 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. The module uses channel numbers of the 802.15.4 standard. Center Frequency = 2.405 + (CH - 11d) * 5 MHz (d = decimal)

Command	ATCH (**Channel**)	
Parameter	Range	0x0B - 0x1A
	Default Value	0x0B
Effective Conditions	Validate immediately	
Minimum Firmware Version Required：0x1000		

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 ATWR command (ATWR<CR>) to write the setting into Non-volatile memory

Input "ATCN<CR> command to exit the AT command mode

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 immediately
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.

Under transparent mode, HAC-LBee/S sends data with this destination address. When the destination address (DH + DL parameters) is **0x000000000000FFFF**, HAC-LBee/S will send the data through broadcasting. When the 64-bit destination address is less than 0x000000000000FFFF, HAC-LBee/S will send the data according to the 16-bit destination address.

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 immediately	
Minimum Firmware Version Required：0x1000		

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.

Under transparent mode, HAC-LBee/S sends data with this destination address. When the destination address (DH + DL parameters) is **0x000000000000FFFF**, HAC-LBee/S will send the data through broadcasting. When the 64-bit destination address is less than 0x000000000000FFFF,

HAC-LBee/S will send the data according to the 16-bit destination address.

Command	ATDL (**Destination Address Low**)	
Parameter	Range	0x00 - 0xFFFFFFFF
	Default Value	0xFFFF
Effective Conditions	Validate immediately	
Minimum Firmware Version Required：0x1000		

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 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 immediately
Minimum Firmware Version Required：0x1000	

5.2.8 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：0x1000		

5.2.9 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.

Command	ATID (**PAN ID**)	
Parameter	Range	0x00 - 0xFFFF
	Default Value	0x234
Effective Conditions	Validate immediately	
Minimum Firmware Version Required：0x1000		

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 ATWR command to write the setting into Non-volatile memory

Input "ATCN<CR>" command to exit the AT command mode.

5.2.10 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
	Default Value	0x0001
Effective Conditions	Validate immediately	
Minimum Firmware Version Required：0x1000		

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

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

Using ATMY command to setup the 16-bit address you want, such as ATMY 1<CR>.

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

Input "ATCN<CR>" command to exit the AT command mode.

5.2.11 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：0x1000		

With different transmitting power, the corresponding current is shown as the following table.

Power level	Transmitting power	Transmitting current
0	0 dBm	70mA
1	5 dBm	75mA
2	10 dBm	85mA
3	15 dBm	108mA
4	20 dBm	160mA

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 "ATCN<CR>" command to exit the AT command mode.

5.2.12 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 immediately
Minimum Firmware Version Required：0x1000	

The examples for restoring the factory default setting:

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

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

5.2.13 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).

Command	ATSH(**Serial Number High**)	
Parameter	Range	0-0xFFFFFFFF
	Default Value	-
Minimum Firmware Version Required：0x1000		

5.2.14 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).

Command	ATSL(**Serial Number Low**)	
Parameter	Range	0-0xFFFFFFFF
	Default Value	-
Minimum Firmware Version Required：0x1000		

5.2.15 SM

The SM command is used to set and read the sleep state of the module. The parameter is 0-5, 0 means working state, 1-5 means the sleep state.

When setting the sleep enable, it is controlled by the pin 9 (DIO5/SLEEP). When it is high level, it is sleeping. When it is low level, it is working.

Under the sleep state, the sleep current is less than 1μA.

Command	ATSM(**Sleep Mode**)	
Parameter	Range	0-5
	Default	0
	Value	0 = Disable 1 = Sleep Enable 2 = Sleep Enable 3 = Sleep Enable 4 = Sleep Enable 5 = Sleep Enable
Effective Conditions	Validate immediately after finishing the AT command state	
Minimum Firmware Version Required：0x1000		

The examples for changing the sleep state:

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

Using ATPL command to setup the sleep state you want, such as ATSM 1<CR>.

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

Input "ATCN<CR>" command to exit the AT command mode.

5.2.16 VR

<Diagnostics> The VR command is used to read which firmware version is stored in the module. Some AT command may be based on different firmware version.

Command	ATVR (**Firmware Version**)	
Parameter	Range	0x00 - 0xFF
Minimum Firmware Version Required：0x1000		

5.2.17 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：0x1000	

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:
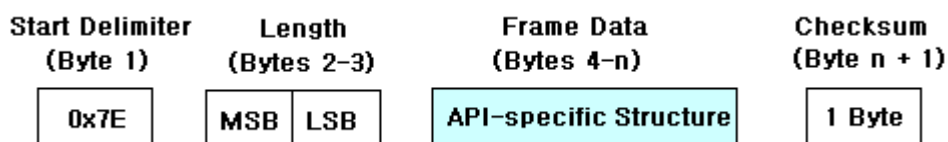
MSB = Most Significant Byte, LSB = Least Significant Byte
Start Delimiter
Start Delimiter is frame header, the frame header is fixed to 0x7E under the API mode.
Length
Length is the effective data length, it is the length of Frame Data, MSB=high byte, LSB=low byte.
Checksum

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

To calculate: Not including frame delimiters and length (1-3 bytes), 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:
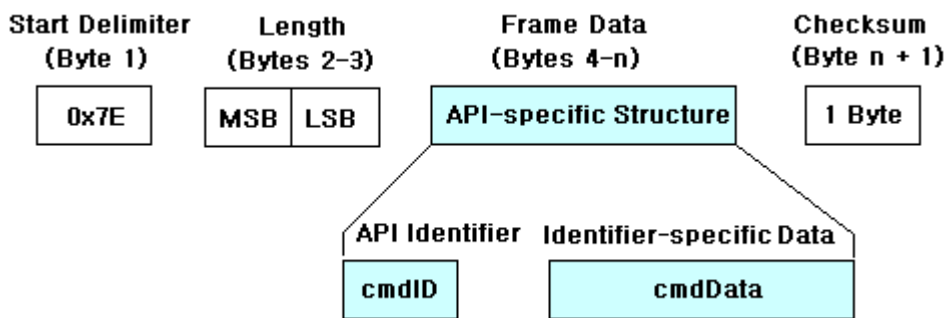
The cmdID frame (API-identifier) indicates which API messages will be contained in the cmdData frame (Identifier-specific data). Refer to the sections that follow for more information regarding the supported API types. Note that multi-byte values are sent big endian.

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.)
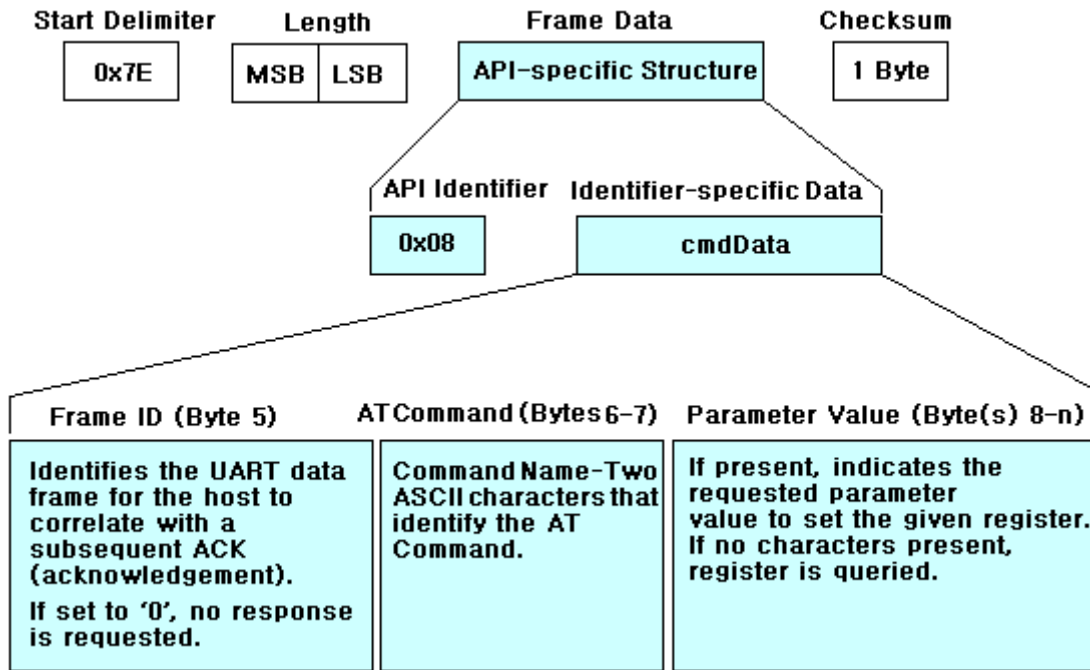
Figure. Example: API frames when reading the DL parameter value of the module.
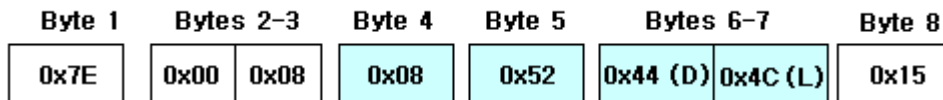
    *   Length [Bytes] = API Identifier + Frame ID + AT Command*
    *** "R" value was arbitrarily selected.*

Figure . Example: API frames when modifying the DL parameter value of the module.
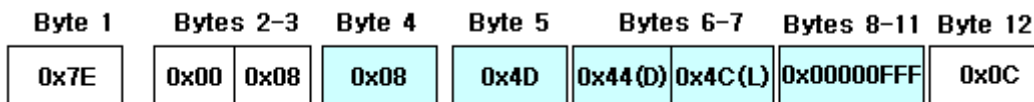
  Length [Bytes] = API Identifier + Frame ID + AT Command + Parameter Value

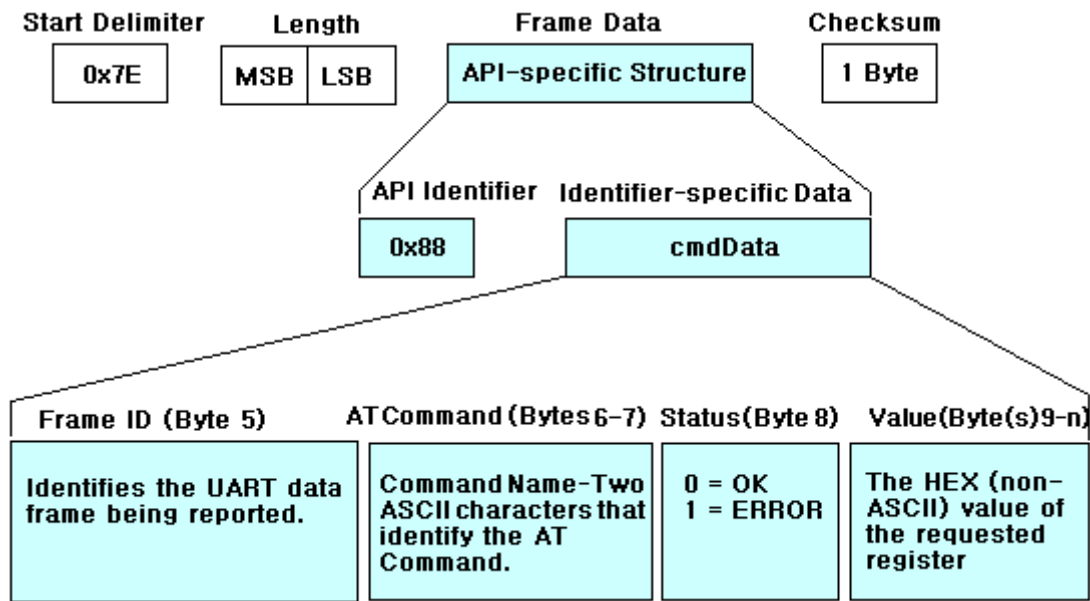 *** "M" value was arbitrarily selected.*

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
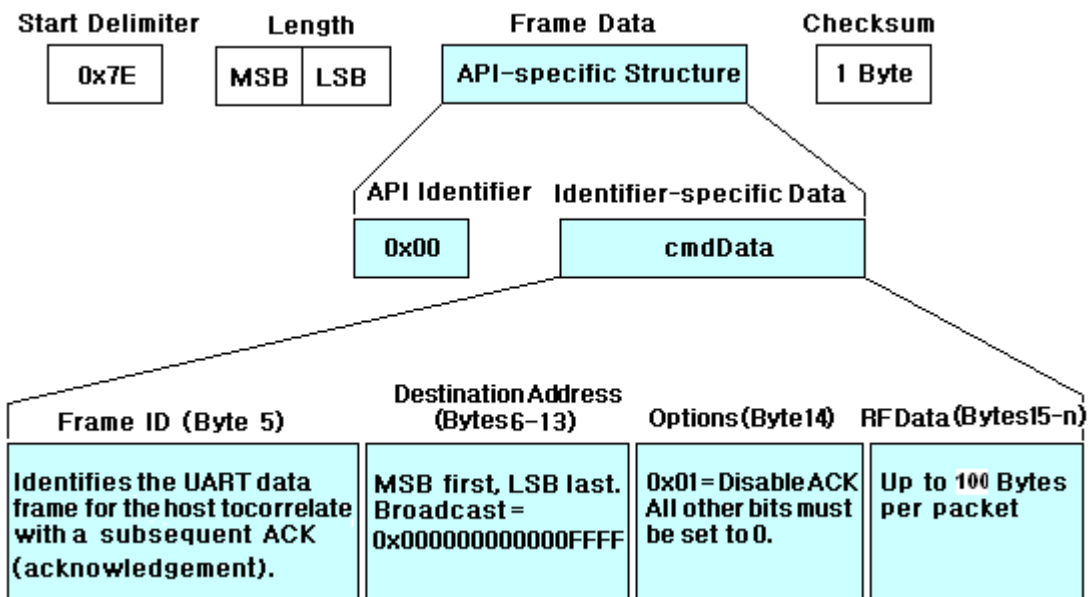
TX (Transmit) Request: 16-bit address

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
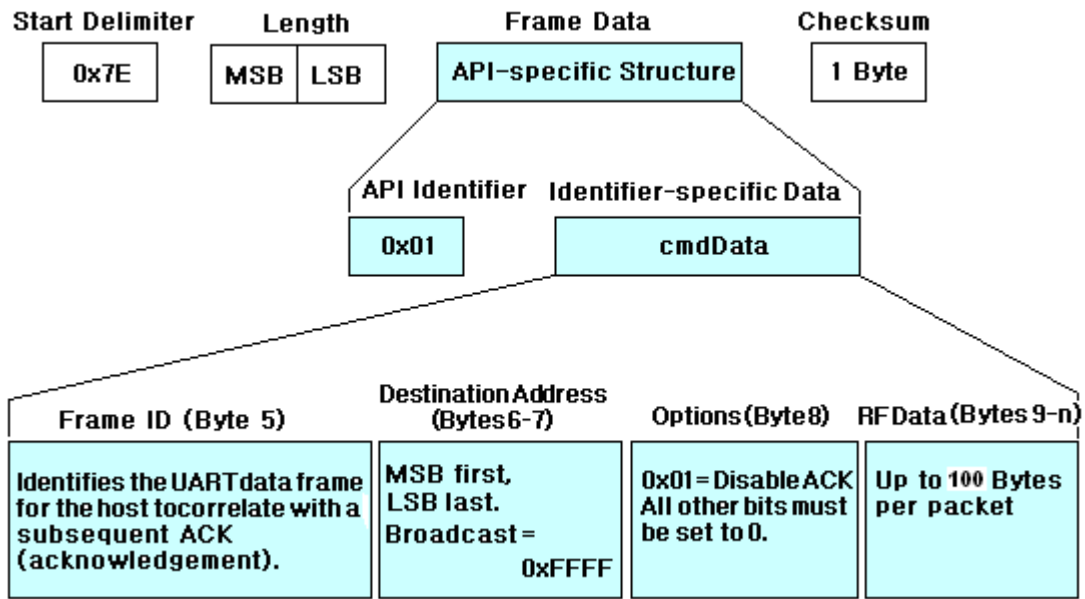
TX (Transmit) Status

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
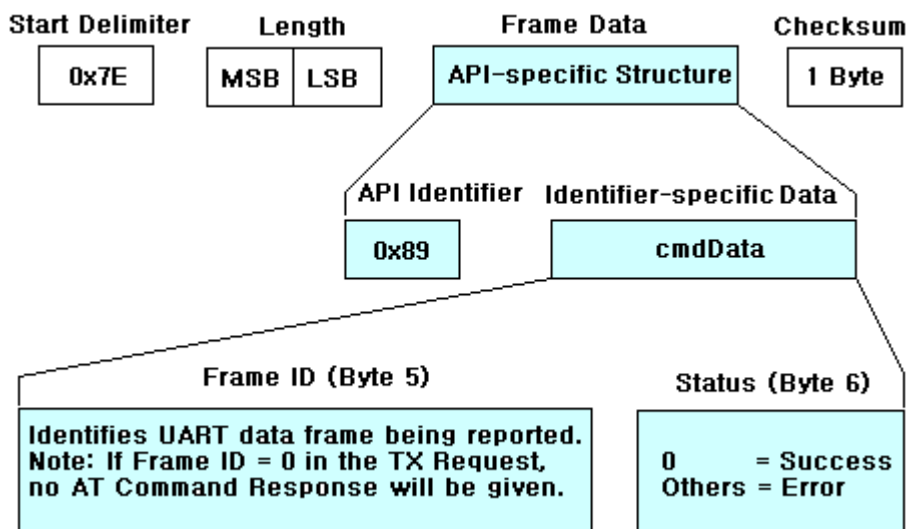
RX (Receive) Packet: 16-bit Address

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
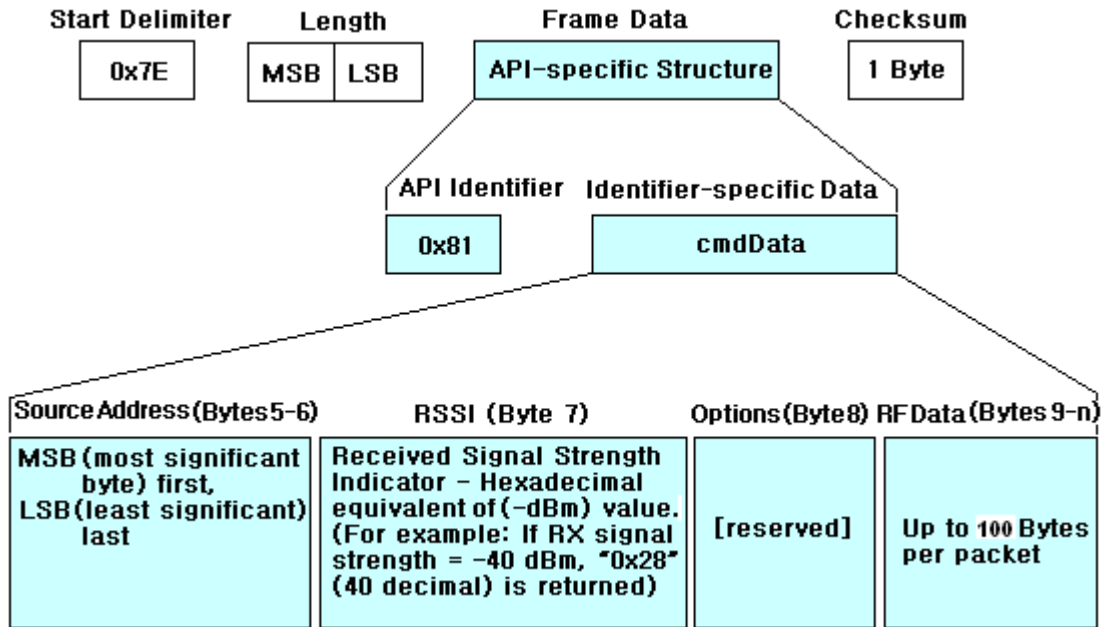
5.4 Frequently Asked Questions.

5.4.1 How to broadcast transmission?

When one module broadcast data, the other modules in the same network (Same PAN ID and same channel) will receive the broadcasting data.

Broadcast under transparent mode

Under the transparent mode, set the upper 32-bit of 64-bit destination address as 0x00000000 by ATDH command, set the lower 32-bit of 64-bit destination address as 0x0000FFFF by ATDL command. 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 (the command word is 0x00), users only need to set the address as 0x000000000000FFFF. If by 16-bit destination address (the command word is 0x01), users need to set the address as 0xFFFF. In this way, under the API mode, data can be transmitted by broadcast.

5.4.2 How to send data to the appointed module under the transparent mode?

When one module works under the transparent mode, except broadcast, it also can send the data to the appointed module. There are two ways, one is using 64-bit destination address. Before using this method, users need to set the 64-bit destination address by ATDH and ATDL command, for example:

ATDH 7F130301

ATDL 004B1200

In this way, under the transparent mode, all the data receive from serial port will send to the module with the 64-bit destination address of 0x7F130301004B1200. The other way is using 16-bit destination address. Before using this method, users need to set the 16-bit destination address by ATDH and ATDL command. Using ATDH command to set the upper 32-bit destination address as 0x00000000, Using ATDL command to make the lower 32-bit destination address less than 0x0000FFFF, for example:

ATDH 0

ATDL A

In this way, under the transparent mode, all the data receive from serial port will send to the module with the 16-bit destination address of 0x000A.

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 How to control the sleep function?

Users can use ATSM command to set the sleep mode. When the parameter is 0, it is under the working mode. When the parameter is 1-5, it enables sleep. When it enables sleep, whether the module is sleep, it is controlled by the pin 9 (DIO5/SLEEP). When the pin 9 is high level, it is sleep, or it is working.

When it enables sleep, the pin 9 (DIO5/SLEEP) is high level, after exiting AT command, the module will enter the sleep mode. Enter the sleep mode, the working current is less than 1μA, the module can not send or receive the air data and serial port data. So, to awake the sleep module, the pin 9 (DIO5/SLEEP) should stay low level until the data has been finishing sending and receiving.

Setting methods of sleep enable:

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

Input "ATSM 1<CR>" command, the module returns "OK", it is used for enabling sleep.

Input "ATWR <CR>" command, the module returns "OK", it is used to save the setting to keep enabling sleep after restart the module.

Input "ATCN <CR>" to exit from the AT Command mode. Now, if the pin 9 (DIO5/SLEEP) of module is high level, it will enter sleep mode, will not response for sending or receiving data.

Setting methods of awaking and canceling the sleep enable:

Keep the pin 9 (DIO5/SLEEP) as low level, the module can be awaken from the sleep mode.

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

Input "ATSM 0<CR>" command, the module returns "OK", it is used to disable sleep.

Input "ATWR <CR>" command, the module returns "OK", it is used to save the setting to keep disabling sleep after restart the module.

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

Note: when plugging HAC-LBee/S into the testing board HAC-DEV, the pin 9 (DIO5/SLEEP) is high level. So when the module with sleep enable function plugs into the testing board, or set the module work for sleep mode, the module will keep sleeping and will not response for any commands.

5.4.5 How to change the baud rate?

Using ATBD command, users can change the baud rate. For example change the baud rate to 38400bps (the corresponding parameter is 5):

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

Input "ATBD 5<CR>" command, the module returns "OK", it is used to set the baud rate as 38400bps.

Input "ATWR <CR>" command, the module returns "OK", it is used to save the setting to keep 38400bps after restart the module.

Input "ATFR<CR>" command, it is used to restart the module. After restart the module, the serial port baud rate is 38400bps.

Note: the baud rate of HAC Studio should be same with the serial port baud rate of module. After changing the baud rate of module, the baud rate of HAC Studio is also needed to be changed for the same baud rate.

VI.   Assistant Software

We offer a upper software called HAC Studio to help users to test, evaluate and setup the HAC-LBee/S 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.
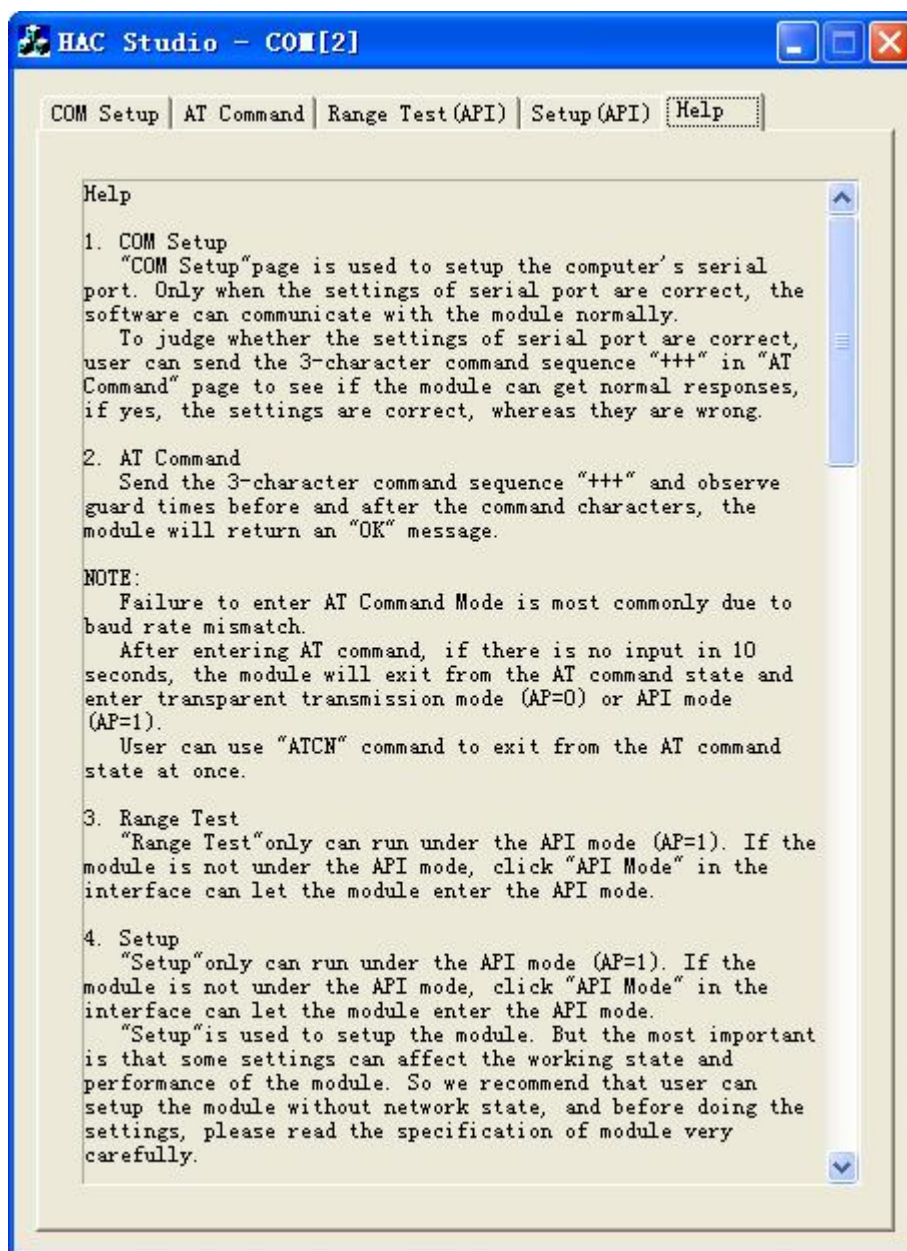
VII. Appendix

Appendix:

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'.
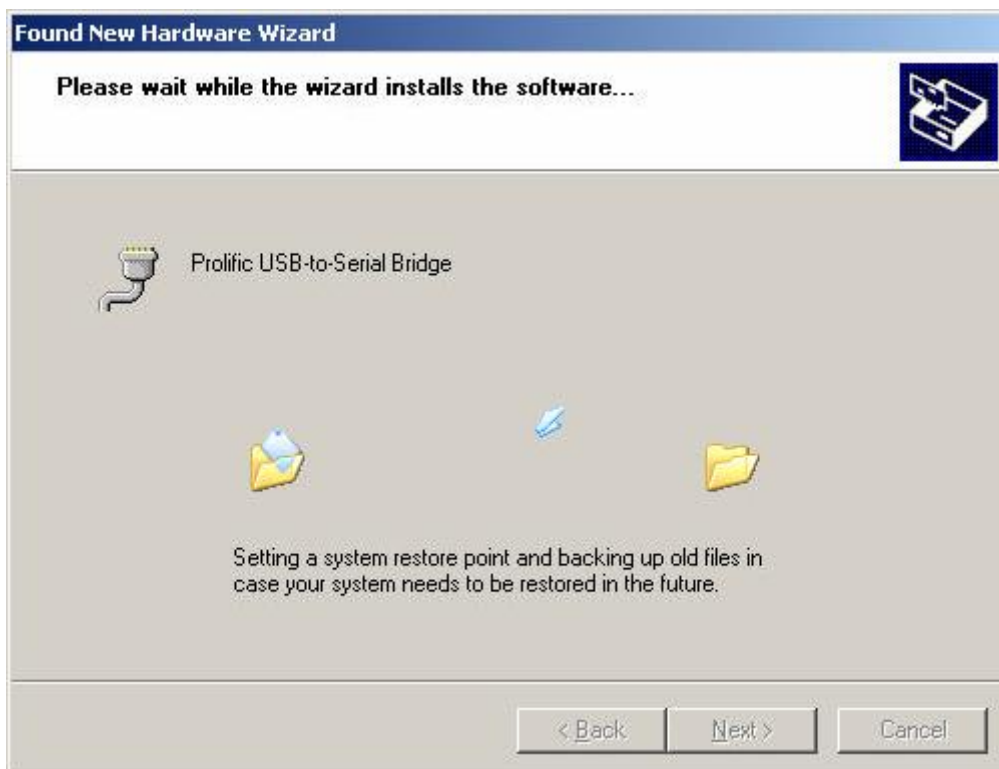

2. The next wizard box will show as below. Select 'Advanced' installation and click on 'Next' button.
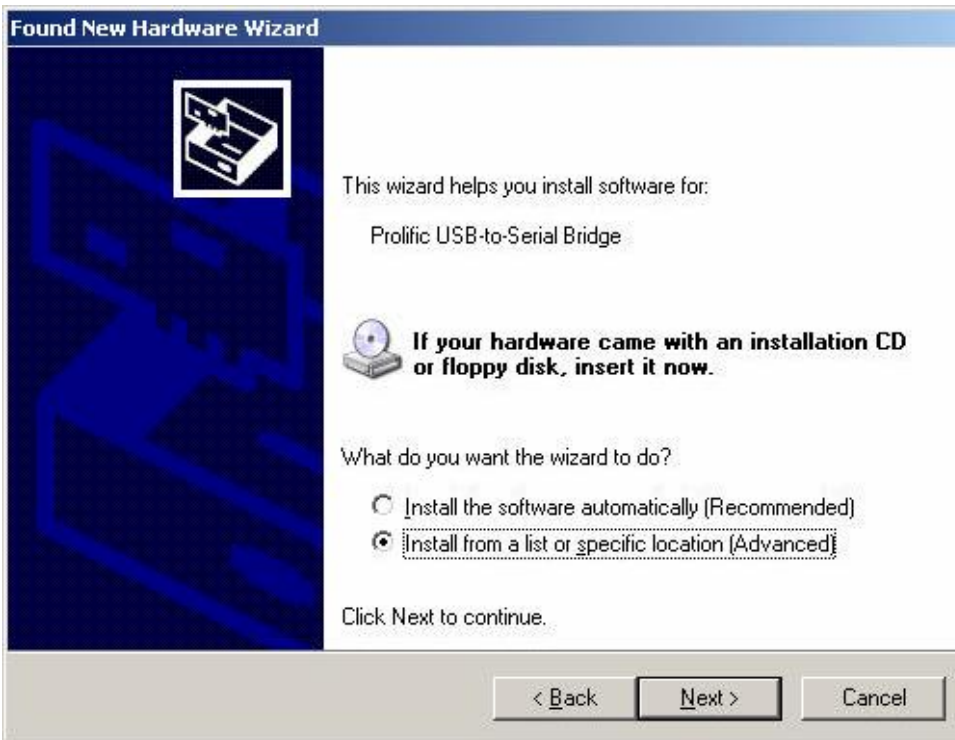
3. In the next dialog box, please specify the path where your Windows XP driver located, and click next after the correct path is selected.
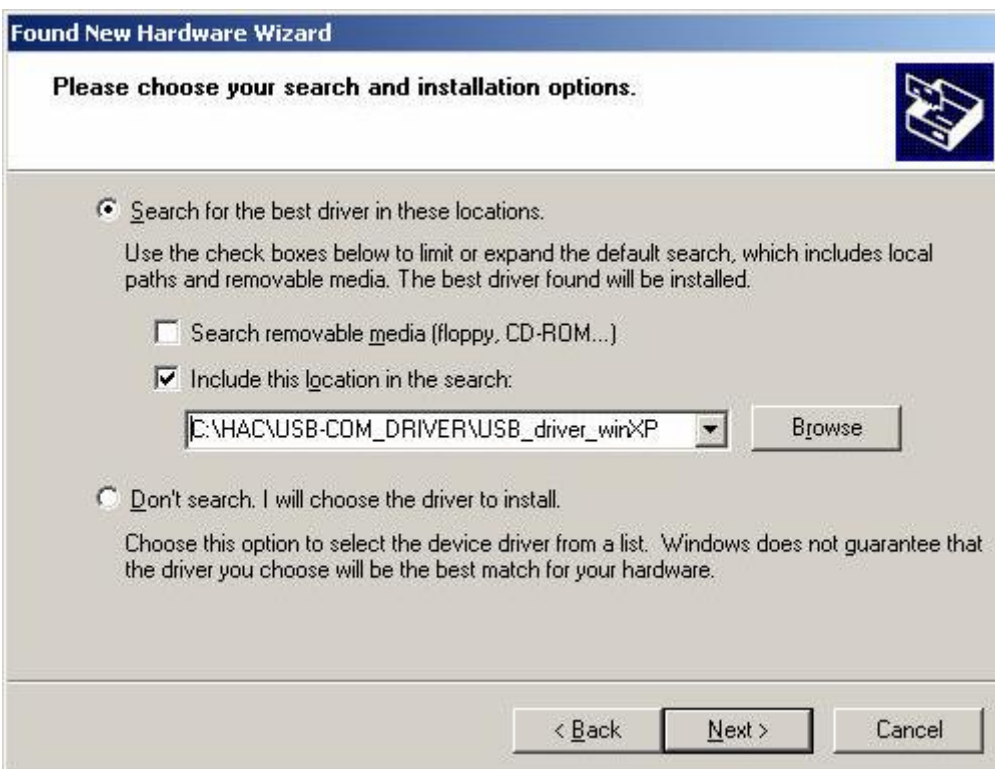

4. A warning message dialog box will appeared as below. Click 'Continue Anyway' button to start the installation.

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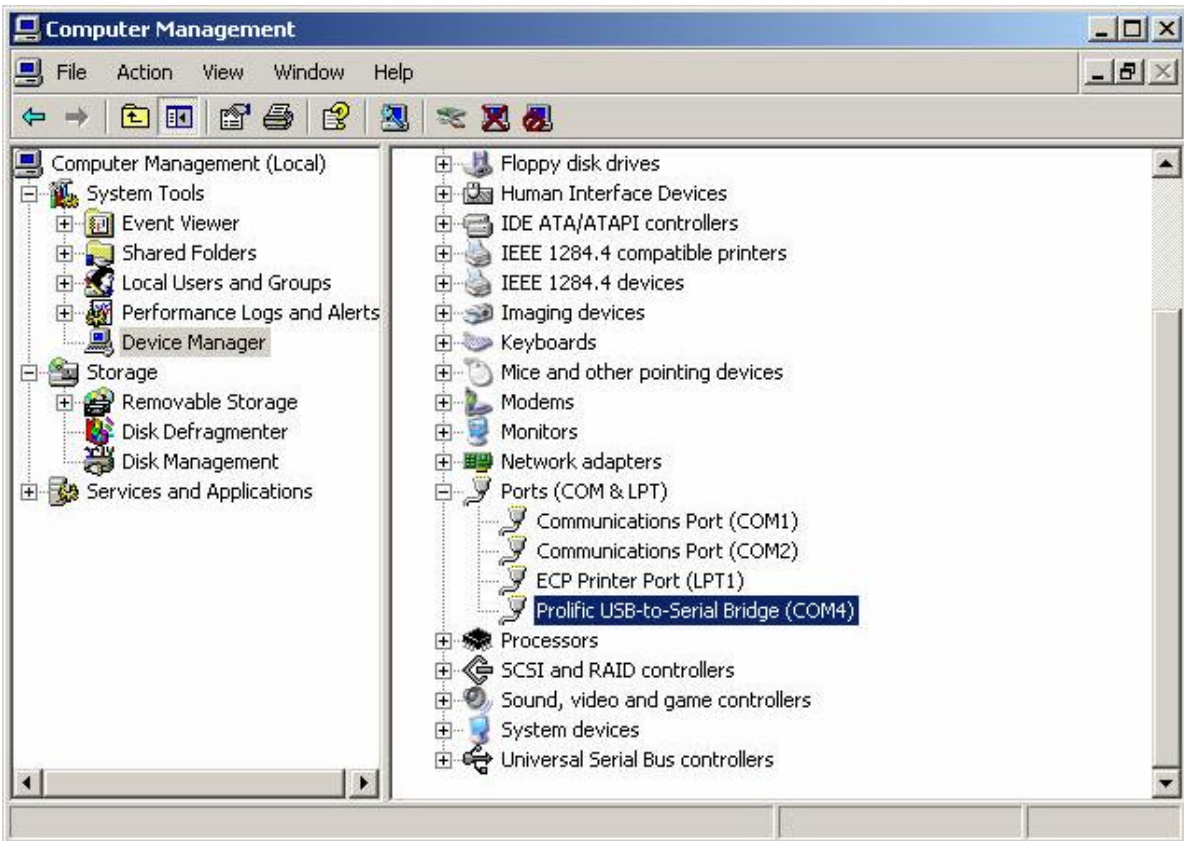
7. Right click on ' Prolific USB-to-Serial Bridge (COMx)' and select on Properties. Make sure that the parameters of the properties dialog box has all the fields set as below.
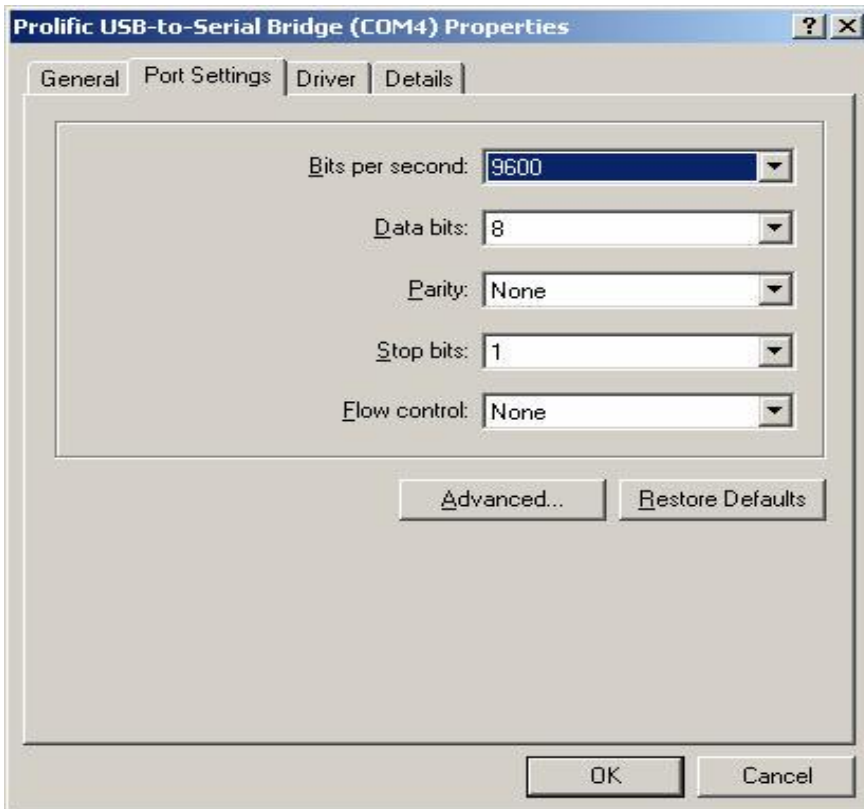
8. Open additional setting by click on 'Advanced' button on the properties dialog box. Double check and make sure that the advanced setting for selected COM ports has the following settings. Click OK when it's done.
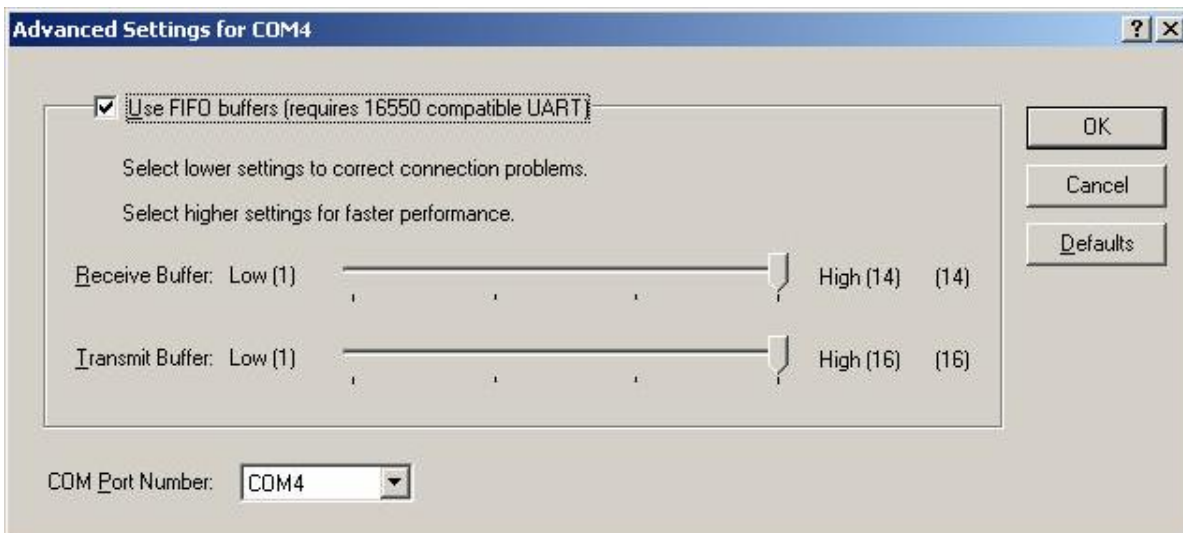
Now, the configuration of the serial port has been done. You may use the COM4 or whatever the COM port you have installed to transmit data. One last thing for using the radio modem is that, remember to check the baud rate and parity bit of COM port must be the same as the Smart device.