XBee®/XBee-PRO® 900 OEM RF Modules

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RF Module Operation

RF Module Configuration

Appendices

OEM RF Modules by Digi International

D R A F T

Digi International Inc.
11001 Bren Road East
Minnetonka, MN 55343
877 912-3444 or 952 912-3444
http://www.digi.com

90000903-A
3/30/2008

Technical Support: Phone: (801) 765-9885

Live Chat: www.digi.com

E-support: http://www.digi.com/support/eservice/eservicelogin.jsp

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1. XBee®/XBee-PRO® 900 OEM RF Modules

The XBee®/XBee-PRO® 900 OEM RF Modules were engineered to support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between remote devices.

The modules operate within the ISM 900 MHz frequency band.

1.1. Key Features

High Performance, Low Cost

- Indoor/Urban: up to up to 1000ft (300m)
- Outdoor line-of-sight: up to 1.8 miles (3 km)
- Transmit Power Output: 45 mW (+16.7 dBm) EIRP
- Receiver Sensitivity: -100 dBm
- RF Data Rate: 156.25 kbps

Advanced Networking & Security

- Retries and Acknowledgements
- DSSS (Direct Sequence Spread Spectrum)
- Each direct sequence channel has over 65,000 unique network addresses available
- Point-to-point, point-to-multipoint and peer-to-peer topologies supported
- Self-routing, self-healing and fault-tolerant mesh networking

Low Power

XBee 900

- TX Current: 210 mA (@3.3 V)
- RX Current: 80mA (@3.3 V)
- Power-down Current: 60 uA typical pin sleep
- 80 uA typical cyclic sleep.

Easy-to-Use

- No configuration necessary for out-of bo RF communications
- AT and API Command Modes for configuring module parameters
- Small form factor
- Extensive command set
- Free X-CTU Software (Testing and configuration software)

1.1.1. Worldwide Acceptance

FCC Approval (USA) Refer to Appendix A for FCC Requirements.
Systems that contain XBee®/XBee-PRO® 900 RF Modules inherit Digi Certifications.

ISM (Industrial, Scientific & Medical) **900 MHz frequency band**

Manufactured under **ISO 9001:2000** registered standards

XBee®/XBee-PRO® 900 RF Modules are optimized for use in **US**, **Canada**, (contact Digi for complete list of agency approvals).

1.2. Specifications

Table 1-01. Specifications of the XBee®/XBee-PRO® 900 OEM RF Module

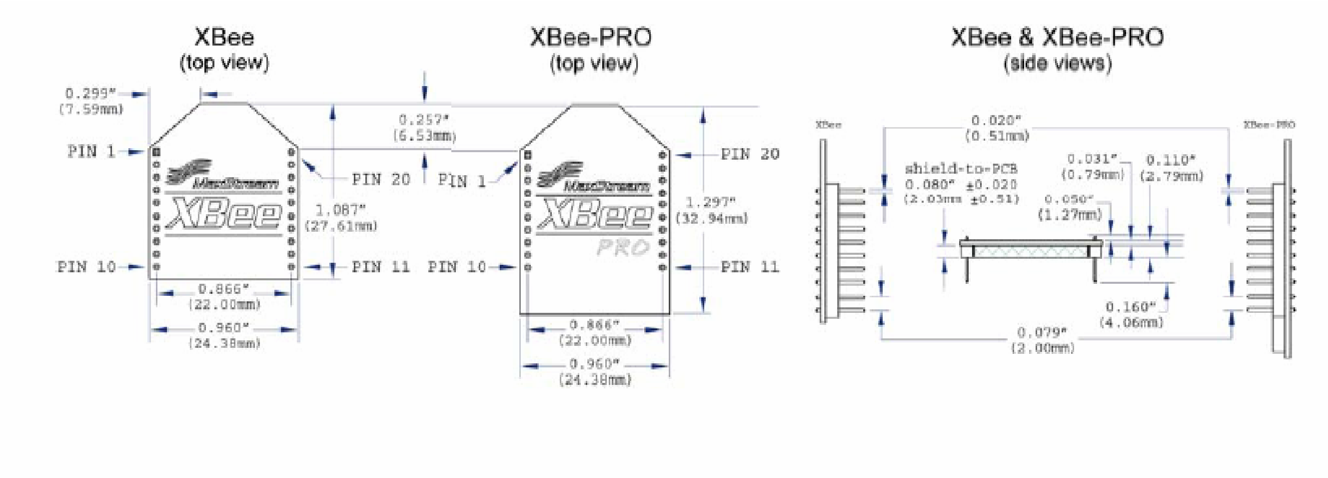
Specification	XBee 900
Performance	
Indoor/Urban Range	up to 1000ft (300m)

Table 1-01.   Specifications of the XBee®/XBee-PRO® 900 OEM RF Module

Specification	XBee 900
Outdoor RF line-of-sight Range	up to 1.8 miles (3 km) w/2.1dB dipole antenna up to 6 miles (10 km) w/high gain antenna
Transmit Power Output	+17 dBm (50 mW)
RF Data Rate	156.25 kbps
Serial Interface Data Rate (software selectable)	3.3V CMOS Serial UART (5V tolerant inputs)
Receiver Sensitivity	-100dBm
Power Requirements	
Supply Voltage	3.0 to 3.6 VDC
Operating Current	210mA, (180 mA typical)
Operating Current (Receive))	80mA
Idle Current (Receiver off)	
Power-down Current	
General	
Operating Frequency Band	902-928 MHz (ISM)
Dimensions	0.962 in x 1.312 in (2.443 cm x 3.332 cm)
Operating Temperature	-40 to 85 ?C (Industrial), 0 to 95% non-condensing
Connector Options	1/4 wave wire antenna, RPSMA RF connector, U.Fl RF connector
Networking & Security	
Supported Network Topologies	Mesh, point-to-point, point-to-multipoint, peer-to-peer
Number of Channels (software selectable)	8 hopping patterns on 12 channels or single channel
Addressing Options	PAN ID, Channel, 64-bit addresses
Agency Approvals	
United States (FCC Part 15.247)	FCC ID: MCQ-XBEE09P
Industry Canada (IC)	IC: 1846A-XBEE09P
Europe (CE)	N/A

1.3. Mechanical Drawings

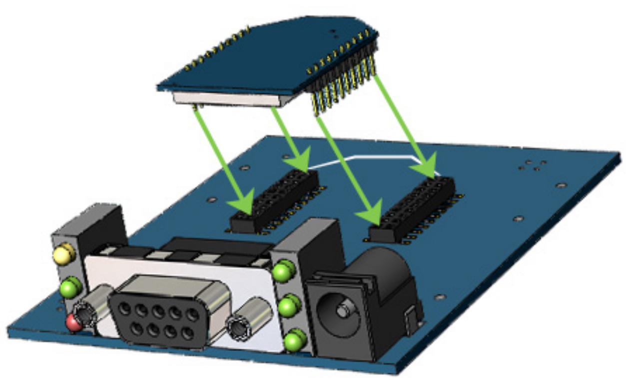
Figure 1-01. Mechanical drawings of the XBee®/XBee-PRO® 900 OEM RF Modules (antenna options not shown)



1.4. Mounting Considerations

The XBee®/XBee-PRO® 900 RF Module (through-hole) was designed to mount into a receptacle (socket) and therefore does not require any soldering when mounting it to a board. The Development Kits contain RS-232 and USB interface boards which use two 20-pin receptacles to receive modules.

Figure 1-02. XBee Series 2 PRO Module Mounting to an RS-232 Interface Board.



The receptacles used on Digi development boards are manufactured by Century Interconnect. Several other manufacturers provide comparable mounting solutions; however, Digi currently uses the following receptacles:

- Through-hole single-row receptacles -
  Samtec P/N: MMS-110-01-L-SV (or equivalent)
- Surface-mount double-row receptacles -
  Century Interconnect P/N: CPRMSL20-D-0-1 (or equivalent)
- Surface-mount single-row receptacles -
  Samtec P/N: SMM-110-02-SM-S

Digi also recommends printing an outline of the module on the board to indicate the orientation the module should be mounted.

1.5. Pin Signals

Figure 1-03. XBee®/XBee-PRO® 900 RF Module Pin Number
(top sides shown - shields on bottom)

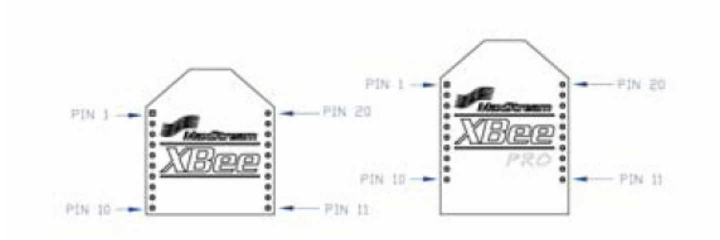


Table 1-02. Pin Assignments for the XBee®/XBee-PRO® 900 Modules
(Low-asserted signals are distinguished with a horizontal line above signal name.)

Pin #	Name	Direction	Description
1	VCC	-	Power supply
2	DOUT	Output	UART Data Out
3	DIN / **CONFIG**	Input	UART Data In
4	DIO12	Either	Digital I/O 12
5	**RESET**	Input	Module Reset (reset pulse must be at least 200 ns)
6	PWM0 / RSSI / DIO10	Either	PWM Output 0 / RX Signal Strength Indicator / Digital IO
7	PWM / DIO11	Either	Digital I/O 11
8	[reserved]	-	Do not connect
9	DTR / SLEEP_RQ/ DIO8	Either	Pin Sleep Control Line or Digital IO 8
10	GND	-	Ground
11	DIO4	Either	Digital I/O 4
12	**CTS** / DIO7	Either	Clear-to-Send Flow Control or Digital I/O 7
13	ON / **SLEEP / DIO9**	Output	Module Status Indicator or Digital I/O 9
14	[reserved]	-	Do not connect
15	Associate / DIO5	Either	Associated Indicator, Digital I/O 5
16	**RTS** / DIO6	Either	Request-to-Send Flow Control, Digital I/O
17	AD3 / DIO3	Either	Analog Input 3 or Digital I/O 3
18	AD2 / DIO2	Either	Analog Input 2 or Digital I/O 2
19	AD1 / DIO1	Either	Analog Input 1 or Digital I/O 1
20	AD0 / DIO0 / ID Button	Either	Analog Input 0, Digital I/O 0, or Node Identification

Design Notes:

- Minimum connections: VCC, GND, DOUT & DIN
- Minimum connections to support serial firmware upgrades: VCC, GND, DIN, DOUT, RTS & DTR
- Signal Direction is specified with respect to the module
- Module includes a 30k Ohm resistor attached to **RESET**
- Several of the input pull-ups can be configured using the PR command
- Unused pins should be left disconnected

1.6. Electrical Characteristics

Table 1-03. DC Characteristics of the XBee®/XBee-PRO® 900 (VCC = 2.8 - 3.4 VDC)

Symbol	Parameter	Condition	Min	Typical	Max	Units
VIL	Input Low Voltage	All Digital Inputs	-	-	0.2 * VCC	V
V_{IH}	Input High Voltage	All Digital Inputs	0.8 * VCC	-	-	V
V_{OL}	Output Low Voltage	I_{OL} = 2 mA, VCC >= 2.7 V	-	-	0.18*VCC	V
V_{OH}	Output High Voltage	I_{OH} = 2 mA, VCC >= 2.7 V	0.82*VCC	-	-	V
II_{IN}	Input Leakage Current	V_{IN} = VCC or GND, all inputs, per pin	-	-	0.5uA	uA

2. RF Module Operation

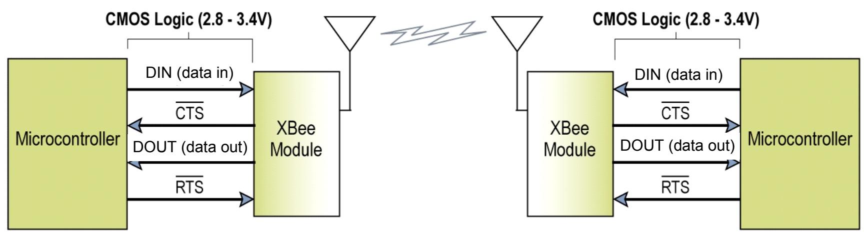
2.1. Serial Communications

The XBee®/XBee-PRO®OEM RF Modules interface to a host device through a logic-level asynchronous serial port. Through its serial port, the module can communicate with any logic and voltage compatible UART; or through a level translator to any serial device (For example: Through a Digi proprietary RS-232 or USB interface board).

2.1.1. UART Data Flow

Devices that have a UART interface can connect directly to the pins of the RF module as shown in the figure below.

Figure 2-01. System Data Flow Diagram in a UART-interfaced environment
(Low-asserted signals distinguished with horizontal line over signal name.)

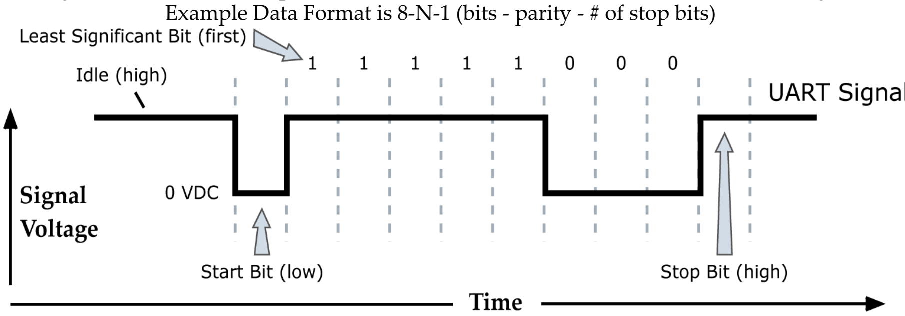


Serial Data

Data enters the module UART through the DIN (pin 3) as an asynchronous serial signal. The signal should idle high when no data is being transmitted.

Each data byte consists of a start bit (low), 8 data bits (least significant bit first) and a stop bit (high). The following figure illustrates the serial bit pattern of data passing through the module.

Figure 2-02. UART data packet 0x1F (decimal number "31") as transmitted through the RF module
Example Data Format is 8-N-1 (bits - parity - # of stop bits)

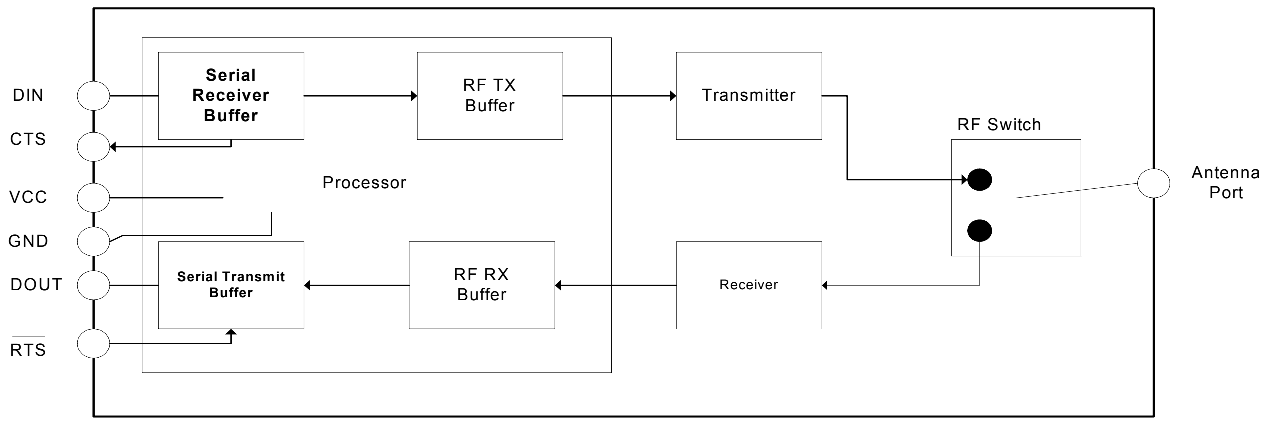


The module UART performs tasks, such as timing and parity checking, that are needed for data communications. Serial communications depend on the two UARTs to be configured with compatible settings (baud rate, parity, start bits, stop bits, data bits).

2.1.2. Serial Buffers

The XBee modules maintain buffers to collect received serial and RF data, which is illustrated in the figure below. The serial receive buffer collects incoming serial characters and holds them until they can be processed. The serial transmit buffer collects data that is received via the RF link that will be transmitted out the UART.

Figure 2-03. Internal Data Flow Diagram



Serial Receive Buffer

When serial data enters the RF module through the DIN Pin (pin 3), the data is stored in the serial receive buffer until it can be processed. Under certain conditions, the module may not be able to process data in the serial receive buffer immediately. If large amounts of serial data are sent to the module, CTS flow control may be required to avoid overflowing the serial receive buffer.

Cases in which the serial receive buffer may become full and possibly overflow:
1. If the module is receiving a continuous stream of RF data, the data in the serial receive buffer will not be transmitted until the module is no longer receiving RF data.

2. If the module is transmitting an RF data packet, the module may need to discover the destination address or establish a route to the destination. After transmitting the data, the module may need to retransmit the data if an acknowledgment is not received, or if the transmission is a broadcast. These issues could delay the processing of data in the serial receive buffer.

Serial Transmit Buffer

When RF data is received, the data is moved into the serial transmit buffer and is sent out the serial port. If the serial transmit buffer becomes full enough such that all data in a received RF packet won't fit in the serial transmit buffer, the entire RF data packet is dropped.

Cases in which the serial transmit buffer may become full resulting in dropped RF packets
If the RF data rate is set higher than the interface data rate of the module, the module could receive data faster than it can send the data to the host.

If the host does not allow the module to transmit data out from the serial transmit buffer because of being held off by hardware flow control.

2.1.3. Serial Flow Control

The $\overline{\text{RTS}}$ and $\overline{\text{CTS}}$ module pins can be used to provide $\overline{\text{RTS}}$ and/or $\overline{\text{CTS}}$ flow control. $\overline{\text{CTS}}$ flow control provides an indication to the host to stop sending serial data to the module. RTS flow control allows the host to signal the module to not send data in the serial transmit buffer out the uart. $\overline{\text{RTS}}$ and $\overline{\text{CTS}}$ flow control are enabled using the D6 and D7 commands.

$\overline{\text{CTS}}$ Flow Control

If $\overline{\text{CTS}}$ flow control is enabled (D7 command), when the serial receive buffer is 17 bytes away from being full, the module de-asserts $\overline{\text{CTS}}$ (sets it high) to signal to the host device to stop sending serial data. $\overline{\text{CTS}}$ is re-asserted after the serial receive buffer has 34 bytes of space.

RTS Flow Control

If flow RTS control is enabled (D6 command), data in the serial transmit buffer will not be sent out the DOUT pin as long as RTS is de-asserted (set high). The host device should not de-assert RTS for long periods of time to avoid filling the serial transmit buffer. If an RF data packet is received, and the serial transmit buffer does not have enough space for all of the data bytes, the entire RF data packet will be discarded.Transparent Operation

When operating in Transparent Mode, the modules act as a serial line replacement. All UART data received through the DIN pin is queued up for RF transmission. When RF data is received, the data is sent out the DOUT pin. The module configuration parameters are configured using the AT command mode interface. (See RF Module Operation --> Command Mode.)

When RF data is received by a module, the data is sent out the DOUT pin.

Serial-to-RF Packetization

Data is buffered in the serial receive buffer until one of the following causes the data to be packetized and transmitted:

No serial characters are received for the amount of time determined by the RO (Packetization Timeout) parameter. If RO = 0, packetization begins when a character is received.

Maximum number of characters that will fit (72) in an RF packet is received.

The Command Mode Sequence (GT + CC + GT) is received. Any character buffered in the serial receive buffer before the sequence is transmitted.

2.1.4. API Operation

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 DIN pin (pin 3)) include:

- RF Transmit Data Frame
- Command Frame (equivalent to AT commands)

Receive Data Frames (sent out the DOUT 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, 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

To implement API operations, refer to the API Operation chapter 6.

2.2. Modes of Operation

2.2.1. Idle Mode

When not receiving or transmitting data, the RF module is in Idle Mode. During Idle Mode, the RF module is also checking for valid RF data. The module shifts into the other modes of operation under the following conditions:

- Transmit Mode (Serial data in the serial receive buffer is ready to be packetized)
- Receive Mode (Valid RF data is received through the antenna)
- Command Mode (Command Mode Sequence is issued)

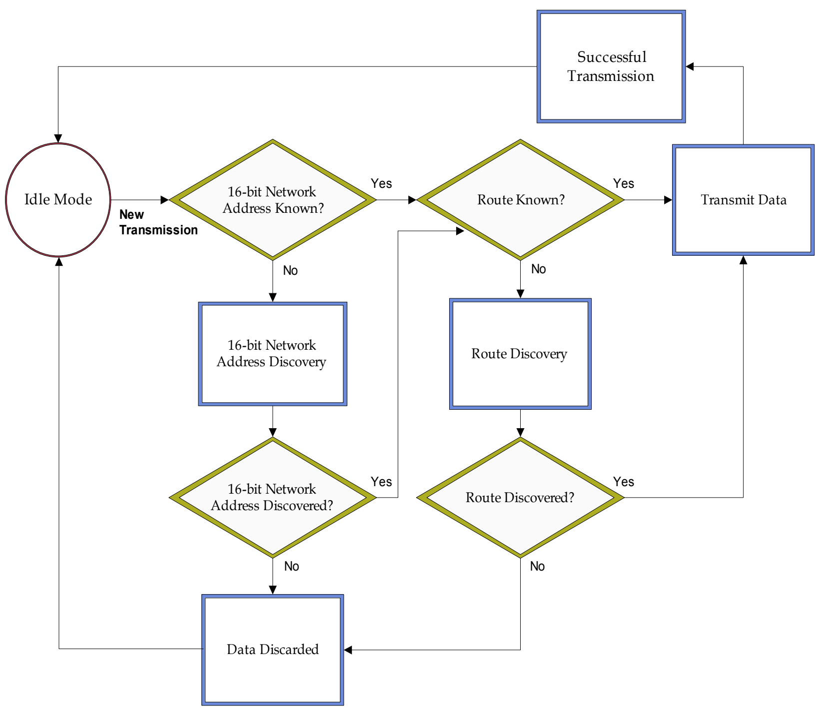
2.2.2. Transmit Mode

When serial data is received and is ready for packetization, the RF module will exit Idle Mode and attempt to transmit the data. The destination address determines which node(s) will receive the data.

Prior to transmitting the data, the module ensures that a 16-bit network address and route to the destination node have been established.

If a route is not known, route discovery will take place for the purpose of establishing a route to the destination node. If a module with a matching network address is not discovered, the packet is discarded. The data will be transmitted once a route is established. If route discovery fails to establish a route, the packet will be discarded.

Figure 2-04. Transmit Mode Sequence



When data is transmitted from one node to another, a network-level acknowledgement is transmitted back across the established route to the source node. This acknowledgement packet indicates to the source node that the data packet was received by the destination node. If a network acknowledgement is not received, the source node will re-transmit the data. See Data Transmission and Routing in chapter 3 for more information.

2.2.3. Receive Mode

If a valid RF packet is received, the data is transferred to the serial transmit buffer

2.2.4. Command Mode

To modify or read RF Module parameters, the module must first enter into Command Mode - a state in which incoming serial characters are interpreted as commands. Refer to the API Mode section for an alternate means of configuring modules.

AT Command Mode

To Enter AT Command Mode:
Send the 3-character command sequence "+++" and observe guard times before and after the command characters. [Refer to the "Default AT Command Mode Sequence" below.]

Default AT Command Mode Sequence (for transition to Command Mode):

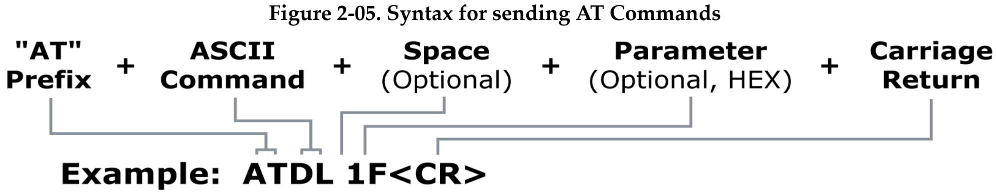
- No characters sent for one second [GT (Guard Times) parameter = 0x3E8]
- Input three plus characters ("+++") within one second [CC (Command Sequence Character) parameter = 0x2B.]
- No characters sent for one second [GT (Guard Times) parameter = 0x3E8]

All of the parameter values in the sequence can be modified to reflect user preferences.

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).

To Send AT Commands:
Send AT commands and parameters using the syntax shown below.

Figure 2-05. Syntax for sending AT Commands



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

The preceding example would change the RF module Destination Address (Low) to "0x1F". 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.

To Exit AT Command Mode:

1. Send the ATCN (Exit Command Mode) command (followed by a carriage return).

   [OR]

2. If no valid AT Commands are received within the time specified by CT (Command Mode Timeout) Command, the RF module automatically returns to Idle Mode.

For an example of programming the RF module using AT Commands and descriptions of each configurable parameter, refer to the "Examples" and "Command Reference Tables" chapters.

3. XBee 900 DigiMesh

3.1. Digi Mesh Networking

Mesh networking allows message to be routed through several different nodes to a final destination. The MeshX firmware allows OEMs and system integrators to bolster their networks with the self-healing attributes of mesh networking. In the event that one RFconnection between nodes is lost (due to power-loss, environmental obstructions, etc.) critical data can still reach its destination due to the mesh networking capabilities embedded inside the modules.

3.2. Digi Mesh Feature Set

Digi Mesh contains the following features

- **Self-healing**
  Any node may enter or leave the network at any time without causing the network as a whole to fail.
- **Peer-to-peer architecture**
  No hierarchy and no parent-child relationships are needed.
- **Quiet Protocol**
  Routing overhead will be reduced by using a reactive protocol similar to AODV.
- **Route Discovery**
  Rather than maintaining a network map, routes will be discovered and created only when needed.
- **Selective acknowledgements**
  Only the destination node will reply to route requests
- **Reliable delivery**
  Reliable delivery of data is accomplished by means of acknowledgements.
- **Unicast and Broadcast addressing supported**

Note that Sleep (low power) modes are not currently supported.

3.3. Data Transmission and Routing

3.3.1. Unicast Addressing

When transmitting while using Unicast communications, reliable delivery of data is accomplished using retries and acknowledgements. The number of retries isdetermined by the NR (Network Retries) parameter.RF data packets are sent up to NR + 1 times and ACKs (acknowledgements) are transmitted by the receiving module upon receipt.

Refer to the DL (Destination Address Low) and DH (Destination Address High) parameters forinformation on how to configure a module to operate using Unicast addresses.

All transmissions are addressed at the MAC layer.

When a new Unicast is given to the MAC layer for transmission, the following will occur:

- The MAC header is pre-pended.
- If incomplete transmissions precede it with the same destination address, the RF data packet is placed on a pending queue.

3.3.2. Random Exponential Back off

The back-off is random because the number of delay slots (RN parameter) between retries (RR parameter) is random. The backoff is exponential because the range of the number of the random number of delay slots doubles with each retry. Note that the randomness allows the backoff time to decrease from one retry to the next. However, because of the exponent, the backoff can quickly grow very large.

The number of time slots when the transmission can occur doubles with each retry; but the actual time between retries may be more or less than double the previous retry.

3.3.3. Broadcast Addressing

When operating in Broadcast Mode, reliable delivery of RF data packets is accomplished using multiple transmissions. When transmitting in Broadcast mode, ACKs are not returned upon receipt of an RF data packet. Retries don't apply to broadcasts because no acknowledgements will be used.

The delay between retransmissions is a random number of delay slots in the range between 0 and RN ("Delay Slots" parameter). After a Broadcast is sent RR + 1 times, a function will be called to indicate a successful transmission.

3.3.4. Routing

A module within a Mesh network is able to determine reliable routes using a routing algorithm and table. The routing algorithm uses a reactive method derived from AODV (Ad-hoc On-demand Distance Vector). An associative routing table is used to map a destination node address with its next hop. By sending a message to the next hop address, either the message will reach its destination or be forwarded to an intermediate node which will route the message on to its destination. A message with a Broadcast address is broadcast to all neighbors. All receiving neighbors will rebroadcast the message and eventually the message will reach all corners of the network. Packet tracking prevents a node from resending a broadcast message twice.

A message with a Unicast destination node address is looked up in an associative routing table. If the destination address is not found and the message came here from a neighboring node; then a routing error has occurred and the undeliverable message is dropped. An ACK timeout will eventually occur at the source node and route discovery (RD) will be launched to re-establish the route.

If the message originated with this node and RD is already underway to discover a route to the destination; then the message is saved until RD is completed. If no route discovery is underway and the route to the destination is unavailable, then the message is saved and RD is launched to establish a route to the destination. When route discovery is over, the routing table will be updated and the message relayed.

3.3.5. Route Discovery

If the source node doesn't have a route to the requested destination, the packet is queued to await a route discovery (RD) process.

RD begins by the source node broadcasting a route request (RREQ). Any node that receives the RREQ that is not the ultimate destination is called an intermediate node.

Intermediate nodes may either drop or forward a RREQ, depending on whether the new RREQ has a better route back to the source node. If so, information from the RREQ is saved and the RREQ is updated and broadcast. When the ultimate destination receives the RREQ, it unicasts a route reply (RREP) back to the source node along the path of the RREQ. This is done regardless of route quality and regardless of how many times an RREQ has been seen before.

This allows the source node to receive multiple route replies. After a calculated wait time, the source node selects the route with the best round trip route quality, which it will use for the queued packet and for subsequent packets with the same destination address.

4. XBee 900

5. XBee Command Reference Tables

Special

Table 5-01. Special Commands

AT Command	Name and Description	Parameter Range	Default
WR	**Write**. Write parameter values to non-volatile memory so that parameter modifications persist through subsequent resets. Note: Once WR is issued, no additional characters should be sent to the module until after the "OK\r" response is received.	--	--
RE	**Restore Defaults**. Restore module parameters to factory defaults. RE command does not reset the ID parameter.	--	--
FR	**Software Reset**. Reset module. Responds immediately with an "OK" then performs a reset ~2 seconds later. Use of the FR command will cause a network layer restart on the node if SC or ID were modified since the last reset.	--	--
AC	**Apply Changes**. Immediately applies new settings without exiting command mode.	--	--
R1	**Restore Compiled**. Restore module parameters to compiled defaults.	--	--
VL	**Version Long**. Shows detailed version information including application build date and time.	--	--

Addressing

Table 5-02. Addressing Commands)

AT Command	Name and Description	Parameter Range	Default
DH	**Destination Address High**. Set/Get the upper 32 bits of the 64-bit destination address. When combined with DL, it defines the destination address used for transmission.	0 to 0xFFFFFFFF	0x01010101
DL	**Destination Address Low**. Set/Get the lower 32 bits of the 64-bit destination address. When combined with DH, DL defines the destination address used for transmission. DL is not supported in API Mode.	0 to 0xFFFFFFFF	0x00000000
SH	**Serial Number High**. Read high 32 bits of the RF module's unique IEEE 64-bit address. 64-bit source address is always enabled. This value is read-only and it never changes	0x01010101	0x01010101
SL	**Serial Number Low**. Read low 32 bits of the RF module's unique IEEE 64-bit address. 64-bit source address is always enabled . This is read only and it is also the serial number of the node. .	0 to 0xFFFFFFFF	--
NI	**Node Identifier.** Stores a string identifier. The register only accepts printable ASCII data. In AT Command Mode, a string can not start with a space. A carriage return ends the command. Command will automatically end when maximum bytes for the string have been entered. This string is returned as part of the ND (Node Discover) command. This identifier is also used with the DN (Destination Node) command.	20-Byte printable ASCII string	--
ZA	**ZigBee Application Layer Addressing**. Set/read the Zigbee application layer addressing enabled attribute. If enabled, data packets will use the SE, DE, and CI commands to address Zigbee application layer source and destination endpoints, and the cluster ID fields in all data transmissions. ZA is only supported in the AT firmware.	0 - 1	0
SE	**Source Endpoint**. Set/read the ZigBee application layer source endpoint value. If ZigBee application layer addressing is enabled (ZA command), this value will be used as the source endpoint for all data transmissions. SE is only supported in AT firmware.The default value 0xE8 (Data endpoint) is the Digi data endpoint	1 - 0xEF	0xE8
DE	**Destination Endpoint**. Set/read Zigbee application layer destination ID value. If ZigBee application layer addressing is enabled (ZA command), this value will be used as the destination endpoint all data transmissions. DE is only supported in AT firmware.The default value (0xE8) is the Digi data endpoint.	1-0xF0	0xE8
CI	**Cluster Identifier**. Set/read Zigbee application layer cluster ID value. If ZigBee application layer addressing is enabled (ZA command), this value will be used as the cluster ID for all data transmissions. CI is only supported in AT firmware.The default value0x11 (Transparent data cluster ID).	0-0xFFFF	0x0011

Serial Interfacing (I/O)

Table 5-03. Serial Interfacing Commands

AT Command	Name and Description	Parameter Range	Default
AP	**API mode**. Set or read the API mode of the radio. The following settings are allowed: **0** API mode is off. All UART input and output is raw data and packets are delineated using the RO and RB parameters. **1** API mode is on. All UART input and output data is packetized in the API format, without escape sequences. **2** API mode is on with escaped sequences inserted to allow for control characters (XON, XOFF, escape, and the 0x7e delimiter to be passed as data.	0, 1, or 2	0
AO	**API Output Format**. Enables different API output frames. Options include: **0** ZigBee Standard Data Frames (0x90 for RF rx) **1** ZigBee Explicit Addressing Data Frames (0x91 for RF rx)	0, 1	0
BD	**Baud rate**. Set or read serial interface rate (speed for data transfer between radio modem and host). Values from 0-8 select preset standard rates. Values at 0x39 and above select the actual baud rate. Providing the host supports it. Baud rates can go as high as 1.875Mbps. The values from 0 to 8 are interpreted as follows: **0** - 1,200bps **3** - 9,600bps **6** - 57,600bps **1** - 2,400bps **4** - 19,200bps **7** - 115,200bps **2** - 4,800bps **5** - 38,400bps **8** - 230,400bps	0 to 8, and 0x39 to 0x1c9c38	0x03 (9600 bps)
RO	**Packetization Timeout**. Set/Read number of character times of inter-character silence required before packetization. Set (RO=0) to transmit characters as they arrive instead of buffering them into one RF packet.	0 - 0xFF [x character times]	3
FT	**Flow Control Threshhold**. Set or read flow control threshhold. De-assert CTS and/or send XOFF when FT bytes are in the UART receive buffer. Re-assert CTS when less than FT - 16 bytes are in the UART receive buffer.	17 to 382	0x016D = 365
GT	**Command Guard Time**. Set required period of silence before and after the Command Mode Characters of the Command Mode Sequence (GT + CC + GT). The period of silence is used to prevent inadvertent entrance into AT Command Mode. If the GT time is less than RO time at the baud rate, then RO time will be used for GT time.	0 to 0xFFFF	0x3E8
ME	**Mesh Enable**. Enable Digi Mesh network layer. Otherwise the application bypasses the Mesh layer and goes directly to the mac layer. All radios that wish to communicate must have the same setting.	0 to 1	0
NB	**Parity**. Set or read parity settings for UART communications. The values from 0 to 4 are interpreted as follows: **0** No parity **3** Forced high parity **1** Even parity **4** Forced low parity **2** Odd parity	0 to 4	0 (No parity)
SB	**Stop Bits**. Set or read number of stop bits used for UART communications. The values from 0 to 4 are interpreted as follows: 0 - 1 stop bit 1 - 2 stop bits	0 to 1	0 (1 stop bit)
D7	**DIO7 Configuration**. Configure options for the DIO7 line of the module. Options include: 0 = Input, unmonitored 1 = CTS flow control 3 = Digital input, monitored 4 = Digital output low 5 = Digital output high 6 = RS-485 Tx enable, low TX (0V on transmit, high when idle) 7 = RS-485 Tx enable, high TX (high on transmit, 0V when idle)	0-1, 3-7	0
D6	**DIO6 Configuration**. Configure options for the DIO6 line of the module. Options include: 0 = Input, unmonitored 1 = RTS flow control 3 = Digital input, monitored 4 = Digital output low 5 = Digital output high	0-1, 3-5	0
D5	**AD5/DIO5 Configuration**. Configure options for the AD5/DIO5 line of the module. Options include: 0 = Input, unmonitored 1 = Power LED output 3 = Digital input, monitored 4 = Digital output low 5 = Digital output high	0-1, 3-5	1

I/O Commands

Table 5-04. I/O Commands

AT Command	Name and Description	Parameter Range	Default
P0	**DIO10/PWM0 Configuration**. Configure options for the DIO10/PWM0 line of the module. Options include: 0 = Input, unmonitored 1 = RSSI 2 = PWM0 3 = Digital input, monitored 4 = Digital output low 5 = Digital output high	0-5	1
P1	**DIO11/PWM1 Configuration**. Configure options for the DIO11/PWM1 line of the module. Options include: 0 = Input, unmonitored 2 = PWM1 3 = Digital input, monitored 4 = Digital output low 5 = Digital output high	0, 2-5	0
P2	**DIO12 Configuration**. Configure options for the DIO12 line of the module. Options include: 0 = Input, unmonitored 3 = Digital input, monitored 4 = Digital output low 5 = Digital output high	0, 3-5	0
???RP	**RSSI PWM Timer.** Time RSSI signal will be output after last transmission. When RP = 0xFF, output will always be on.	0 - 0xFF [x 100 ms]	0x28 (40d)
D0	**AD0/DIO0 Configuration**. Configure options for the AD0/DIO0 line of the module. Options include: 0 = Input, unmonitored 3 = Digital input, monitored 4 = Digital output low 5 = Digital output high	0, 3-5	0
D1	**AD1/DIO1 Configuration**. Configure options for the AD1/DIO1 line of the module. Options include: 0 = Input, unmonitored 3 = Digital input, monitored 4 = Digital output low 5 = Digital output high	0, 3-5	0
D2	**AD2/DIO2 Configuration**. Configure options for the AD2/DIO2 line of the module. Options include: 0 = Input, unmonitored 3 = Digital input, monitored 4 = Digital output low 5 = Digital output high	0, 3-5	0
D3	**AD3/DIO3 Configuration**. Configure options for the AD3/DIO3 line of the module. Options include: 0 = Input, unmonitored 3 = Digital input, monitored 4 = Digital output low 5 = Digital output high	0, 3-5	0
D4	**AD4/DIO4 Configuration**. Configure options for the AD4/DIO4 line of the module. Options include: 0 = Input, unmonitored 3 = Digital input, monitored 4 = Digital output low 5 = Digital output high	0, 3-5	0

Table 5-04. I/O Commands

AT Command	Name and Description	Parameter Range	Default
PR	Set/read the bit field that configures the internal pull-up resistor status for the I/O lines. "1" specifies the pull-up resistor is enabled. "0" specifies no pullup. Bits:" 0 - DIO4 (Pin 11) 1 - AD3 / DIO3 (Pin 17) 2 - AD2 / DIO2 (Pin 18) 3 - AD1 / DIO1 (Pin 19) 4 - AD0 / DIO0 (Pin 20) 5 - RTS / DIO6 (Pin 16) 6 - DTR / Sleep Request / DIO8 (Pin 9) 7 - DIN / Config (Pin 3) 8 - Associate / DIO5 (Pin 15) 9 - On/Sleep / DIO9 (Pin 13) 10 - DIO12 (Pin 4) 11 - PWM0 / RSSI / DIO10 (Pin 6) 12 - PWM1 / DIO11 (Pin 7)	0 - 0x1FFF	0 - 0x1FFF

Diagnostics

Table 5-05. Diagnostics Commands

AT Command	Name and Description	Parameter Range	Default
VR	**Firmware Version**. Read firmware version of the module.	0 - 0xFFFF [read-only]	Factory-set
HV	**Hardware Version**. Read hardware version of the module.	0 - 0xFFFF [read-only]	Factory-set
%V	**Supply Voltage.** Reads the voltage on the Vcc pin. To convert the reading to a mV reading, divide the read value by 1023 and multiply by 1200. A %V reading of 0x8FE (2302 decimal) represents 2700mV or 2.70V.	-	-

AT Command Options

Table 5-06. AT Command Options Commands

AT Command	Name and Description	Parameter Range	Default
CT	**Command Mode Timeout.** Set/Read the period of inactivity (no valid commands received) after which the RF module automatically exits AT Command Mode and returns to Idle Mode.	2 - 0x028F [x 100 ms]	0x64 (100d)
CN	**Exit Command Mode.** Explicitly exit the module from AT Command Mode.	--	--
GT	**Guard Times**. Set required period of silence before and after the Command Sequence Characters of the AT Command Mode Sequence (GT + CC + GT). The period of silence is used to prevent inadvertent entrance into AT Command Mode.	1 - 0x0CE4 [x 1 ms] (max of 3.3 decimal sec)	0x3E8 (1000d)
CC	**Command Character**. Set or read the character to be used between guard times of the AT Command Mode Sequence. The AT Command Mode Sequence causes the radio modem to enter Command Mode (from Idle Mode).	0 - 0xFF	0x2B

Digi Mesh: Networking & Security

Table 5-07. Networking Commands

AT Command	Name and Description	Parameter Range	Default
ID	**Network Identifier**. Set or read the user network address. Nodes must have the same network address to communicate. Changes to ID should be written to non-volatile memory using the WR command.	0x0000 to 0x7FFF	0x7FFF
NT	**Node Discover Timeout.** Set/Read the amount of time a node will spend discovering other nodes when ND or DN is issued.	0 - 0xFC [x 100 msec]	0x3C (60d)
ND	**Node Identifier**. Stores a string identifier. The string accepts only printable ASCII data In AT Command Mode, the string can not start with a space. A Carriage return ends the command. Command will automatically end when maximum bytes for the string have been entered. This string is returned as part of the ATND (Network Discover) command. This identifier is also used with the ATDN (Destination Node) command. .	20 byte ASCII string	a space character

Table 5-07. Networking Commands

AT Command	Name and Description	Parameter Range	Default
DN	**Destination Node.** Resolves an NI (Node Identifier) string to a physical address (case-sensitive). The following events occur after the destination node is discovered: <AT Firmware> 1. DL & DH are set to the extended (64-bit) address of the module with the matching NI (Node Identifier) string. 2. OK (or ERROR)\r is returned. 3. Command Mode is exited to allow immediate communication If there is no response from a module within (NT * 100) milliseconds or a parameter is not specified (left blank), the command is terminated and an “ERROR” message is returned. In the case of an ERROR, Command Mode is not exited.	up to 20-Byte printable ASCII string	a space character

6. Antennas: 900 MHz Antenna Listings

900 MHz Antenna Listings				
Omni-directional antennas				
Part Number	**Type**	**Connector**	**Gain**	**Application**
A09-F0	Fiberglass Base	RPN	0 dBi	Fixed
A09-F1	Fiberglass Base	RPN	1.0 dBi	Fixed
A09-F2	Fiberglass Base	RPN	2.1 dBi	Fixed
A09-F3	Fiberglass Base	RPN	3.1 dBi	Fixed
A09-F4	Fiberglass Base	RPN	4.1 dBi	Fixed
A09-F5	Fiberglass Base	RPN	5.1 dBi	Fixed
A09-F6	Fiberglass Base	RPN	6.1 dBi	Fixed
A09-F7	Fiberglass Base	RPN	7.1 dBi	Fixed
A09-F8	Fiberglass Base	RPN	8.1 dBi	Fixed
A09-F9	Base Station	RPSMAF	9.2dBi	Fixed
A09-W7	Wire Base Station	RPN	7.1 dBi	Fixed
A09-F0	Fiberglass Base	RPSMA	0 dBi	Fixed
A09-F1	Fiberglass Base	RPSMA	1.0 dBi	Fixed
A09-F2	Fiberglass Base	RPSMA	2.1 dBi	Fixed
A09-F3	Fiberglass Base	RPSMA	3.1 dBi	Fixed
A09-F4	Fiberglass Base	RPSMA	4.1 dBi	Fixed
A09-F5	Fiberglass Base	RPSMA	5.1 dBi	Fixed
A09-F6	Fiberglass Base	RPSMA	6.1 dBi	Fixed
A09-F7	Fiberglass Base	RPSMA	7.1 dBi	Fixed
A09-F8	Fiberglass Base	RPSMA	8.1 dBi	Fixed
A09-M7	Base Station	RPSMAF	7.2dBi	Fixed
A09-W7SM	Wire Base Station	RPSMA	7.1 dBi	Fixed
A09-F0TM	Fiberglass Base	RPTNC	0 dBi	Fixed
A09-F1TM	Fiberglass Base	RPTNC	1.0 dBi	Fixed
A09-F2TM	Fiberglass Base	RPTNC	2.1 dBi	Fixed
A09-F3TM	Fiberglass Base	RPTNC	3.1 dBi	Fixed
A09-F4TM	Fiberglass Base	RPTNC	4.1 dBi	Fixed
A09-F5TM	Fiberglass Base	RPTNC	5.1 dBi	Fixed
A09-F6TM	Fiberglass Base	RPTNC	6.1 dBi	Fixed
A09-F7TM	Fiberglass Base	RPTNC	7.1 dBi	Fixed
A09-F8TM	Fiberglass Base	RPTNC	8.1 dBi	Fixed
A09-W7TM	Wire Base Station	RPTNC	7.1 dBi	Fixed
A09-HSM-7	Straight half-wave	RPSMA	3.0 dBi	Fixed / Mobile
A09-HASM-675	Articulated half-wave	RPSMA	2.1 dBi	Fixed / Mobile
A09-HABMM-P6I	Articulated half-wave	MMCX	2.1 dBi	Fixed / Mobile
A09-HABMM-6-P6I	Articulated half-wave	MMCX	2.1 dBi	Fixed / Mobile
A09-HBMM-P6I	Straight half-wave w/	MMCX	2.1 dBi	Fixed / Mobile
A09-HRSM	Right angle half-wave	RPSMA	2.1 dBi	Fixed
A09-HASM-7	Articulated half-wave	RPSMA	2.1 dBi	Fixed

A09-HG	Glass mounted half-	RPSMA	2.1 dBi	Fixed
A09-HATM	Articulated half-wave	RPTNC	2.1 dBi	Fixed
A09-H	Half-wave dipole	RPSMA	2.1 dBi	Fixed
A09-HBMMP6I	1/2 wave antenna	MMCX	2.1dBi	Mobile
A09-QBMMP6I	1/4 wave antenna	MMCX	1.9 dBi	Mobile
A09-QI	1/4 wave integrated wire antenna	Integrated	1.9 dBi	Mobile
29000187	Helical	Integrated	-2.0 dBi	Fixed/Mobile
A09-QW	Quarter-wave wire	Permanent	1.9 dBi	Fixed / Mobile
A09-QRAMM	3 " Quarter-wave wire	MMCX	2.1 dBi	Fixed / Mobile
A09-QSM-3	Quarter-wave straight	RPSMA	1.9 dBi	Fixed / Mobile
A09-QSM-3H	Heavy duty quarter-	RPSMA	1.9 dBi	Fixed / Mobile
A09-QBMM-P6I	Quarter-wave w/ 6"	MMCX	1.9 dBi	Fixed / Mobile
A09-QHRN	Miniature Helical Right	Permanent	-1 dBi	Fixed / Mobile
A09-QHSN	Miniature Helical Right	Permanent	-1 dBi	Fixed / Mobile
A09-QHSM-2	2" Straight	RPSMA	1.9 dBi	Fixed / Mobile
A09-QHRSM-2	2" Right angle	RPSMA	1.9 dBi	Fixed / Mobile
A09-QHRSM-170	1.7" Right angle	RPSMA	1.9 dBi	Fixed / Mobile
A09-QRSM-380	3.8" Right angle	RPSMA	1.9 dBi	Fixed / Mobile
A09-QAPM-520	5.2" Articulated Screw	Permanent	1.9 dBi	Fixed / Mobile
A09-QSPM-3	3" Straight screw	Permanent	1.9 dBi	Fixed / Mobile
A09-QAPM-3	3" Articulated screw	Permanent	1.9 dBi	Fixed / Mobile
A09-QAPM-3H	3" Articulated screw	Permanent	1.9 dBi	Fixed / Mobile
A09-DPSM-P12F	omni directional	RPSMA	3.0 dBi	Fixed
A09-D3NF-P12F	omni directional	RPN	3.0 dBi	Fixed
A09-D3SM-P12F	omni directional w/ 12ft	RPSMA	3.0 dBi	Fixed
A09-D3PNF	omni directional	RPN	3.0 dBi	Fixed
A09-D3TM-P12F	omni directional w/ 12ft	RPTNC	3.0 dBi	Fixed
A09-D3PTM	omni directional	RPTNC	3.0 dBi	Fixed
A09-M0SM	Mag Mount	RPSMA	0 dBi	Fixed
A09-M2SM	Mag Mount	RPSMA	2.1 dBi	Fixed
A09-M3SM	Mag Mount	RPSMA	3.1 dBi	Fixed
A09-M5SM	Mag Mount	RPSMA	5.1 dBi	Fixed
A09-M7SM	Mag Mount	RPSMA	7.1 dBi	Fixed
A09-M8SM	Mag Mount	RPSMA	8.1 dBi	Fixed
A09-M0TM	Mag Mount	RPTNC	0 dBi	Fixed
A09-M2TM	Mag Mount	RPTNC	2.1 dBi	Fixed
A09-M3TM	Mag Mount	RPTNC	3.1 dBi	Fixed
A09-M5TM	Mag Mount	RPTNC	5.1 dBi	Fixed
A09-M7TM	Mag Mount	RPTNC	7.1 dBi	Fixed
A09-M8TM	Mag Mount	RPTNC	8.1 dBi	Fixed

Table Yagi antennas

Part Number	**Type**	**Connector**	**Gain**	**Application**
A09-Y6	2 Element Yagi	RPN	6.1 dBi	Fixed / Mobile
A09-Y7	3 Element Yagi	RPN	7.1 dBi	Fixed / Mobile
A09-Y8	4 Element Yagi	RPN	8.1 dBi	Fixed / Mobile
A09-Y9	4 Element Yagi	RPN	9.1 dBi	Fixed / Mobile
A09-Y10	5 Element Yagi	RPN	10.1 dBi	Fixed / Mobile

A09-Y11	6 Element Yagi	RPN	11.1 dBi	Fixed / Mobile
A09-Y12	7 Element Yagi	RPN	12.1 dBi	Fixed / Mobile
A09-Y13	9 Element Yagi	RPN	13.1 dBi	Fixed / Mobile
A09-Y14	10 Element Yagi	RPN	14.1 dBi	Fixed / Mobile
A09-Y14	12 Element Yagi	RPN	14.1 dBi	Fixed / Mobile
A09-Y15	13 Element Yagi	RPN	15.1 dBi	Fixed / Mobile
A09-Y15	15 Element Yagi	RPN	15.1 dBi	Fixed / Mobile
A09-Y6TM	2 Element Yagi	RPTNC	6.1 dBi	Fixed / Mobile
A09-Y7TM	3 Element Yagi	RPTNC	7.1 dBi	Fixed / Mobile
A09-Y8TM	4 Element Yagi	RPTNC	8.1 dBi	Fixed / Mobile
A09-Y9TM	4 Element Yagi	RPTNC	9.1 dBi	Fixed / Mobile
A09-Y10TM	5 Element Yagi	RPTNC	10.1 dBi	Fixed / Mobile
A09-Y11TM	6 Element Yagi	RPTNC	11.1 dBi	Fixed / Mobile
A09-Y12TM	7 Element Yagi	RPTNC	12.1 dBi	Fixed / Mobile
A09-Y13TM	9 Element Yagi	RPTNC	13.1 dBi	Fixed / Mobile
A09-Y14TM	10 Element Yagi	RPTNC	14.1 dBi	Fixed / Mobile
A09-Y14TM	12 Element Yagi	RPTNC	14.1 dBi	Fixed / Mobile
A09-Y15TM	13 Element Yagi	RPTNC	15.1 dBi	Fixed / Mobile
A09-Y15TM	15 Element Yagi	RPTNC	15.1 dBi	Fixed / Mobile

7. API Operation

As an alternative to 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.

7.0.1. API Frame Specifications

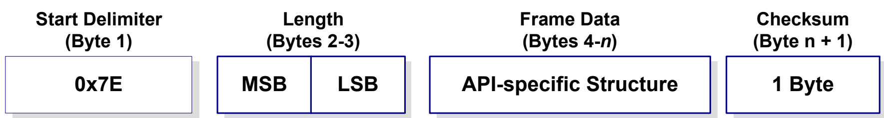
Two API modes are supported and both can be enabled using the AP (API Enable) command. Use the following AP parameter values to configure the module to operate in a particular mode:

- AP = 1: API Operation
- AP = 2: API Operation (with escaped characters)

API Operation (AP parameter = 1)

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

Figure 7-01. UART Data Frame Structure:



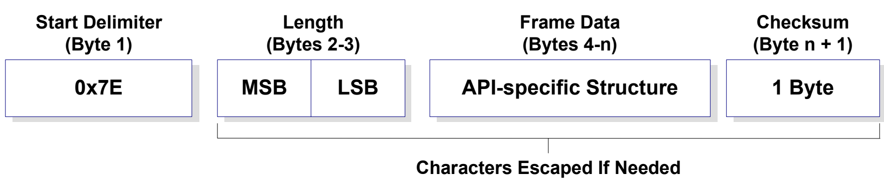
MSB = Most Significant Byte, LSB = Least Significant Byte

Any data received prior to the start delimiter is silently discarded. If the frame is not received correctly or if the checksum fails, the module will reply with a module status frame indicating the nature of the failure.

API Operation - with Escape Characters (AP parameter = 2)

When this API mode is enabled (AP = 2), the UART data frame structure is defined as follows:

Figure 7-02. UART Data Frame Structure - with escape control characters:



MSB = Most Significant Byte, LSB = Least Significant Byte

Escape characters. When sending or receiving a UART data frame, specific data values must be escaped (flagged) so they do not interfere with the data frame sequencing. To escape an interfering data byte, insert 0x7D and follow it with the byte to be escaped XOR’d with 0x20.

Data bytes that need to be escaped:

- 0x7E – Frame Delimiter
- 0x7D – Escape
- 0x11 – XON
- 0x13 – XOFF

Example - Raw UART Data Frame (before escaping interfering bytes):
0x7E 0x00 0x02 0x23 0x11 0xCB

0x11 needs to be escaped which results in the following frame:
0x7E 0x00 0x02 0x23 0x7D 0x31 0xCB

Note: In the above example, the length of the raw data (excluding the checksum) is 0x0002 and the checksum of the non-escaped data (excluding frame delimiter and length) is calculated as: 0xFF - (0x23 + 0x11) = (0xFF - 0x34) = 0xCB.

Checksum

To test data integrity, a checksum is calculated and verified on non-escaped data.

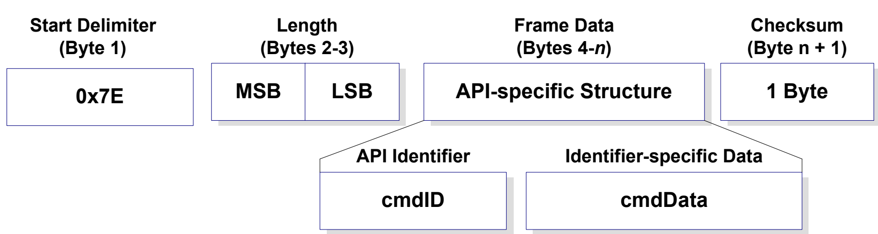
To calculate: Not including frame delimiters and length, add all bytes keeping only the lowest 8 bits of the result and subtract the result from 0xFF.

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

7.0.2. API Frames

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

Figure 7-03. 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). Note that multi-byte values are sent big endian. The modules support the following API frames:

Table 7-08. API Frame Names and Values

API Frame Names	Values
Modem Status	0x8A
Advanced Modem Status	0x8C
AT Command	0x08
AT Command - Queue Parameter Value	0x09
AT Command Response	0x88
Remote Command Request	0x17
Remote Command Response	0x97
Transmit Request	0x10
Explicit Addressing Command Frame	0x11
Transmit Status	0x8B
Receive Packet (AO=0)	0x90

Table 7-08. API Frame Names and Values

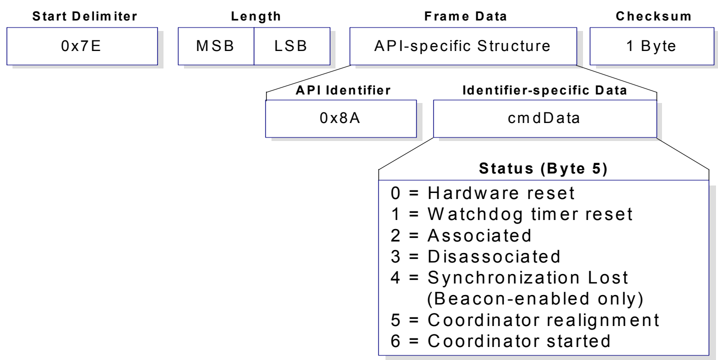
API Frame Names	Values
Explicit Rx Indicator (AO=1)	0x91
XBee Sensor Read Indicator (AO=0)	0x94
Node Identification Indicator (AO=0)	0x95

Modem Status

API Identifier Value: (0x8A)

RF module status messages are sent from the module in response to specific conditions.

Figure 7-04. Modem Status Frames



AT Command

API Identifier Value: (0x08)

Allows for module parameter registers to be queried or set.

Figure 7-5. AT Command Frames

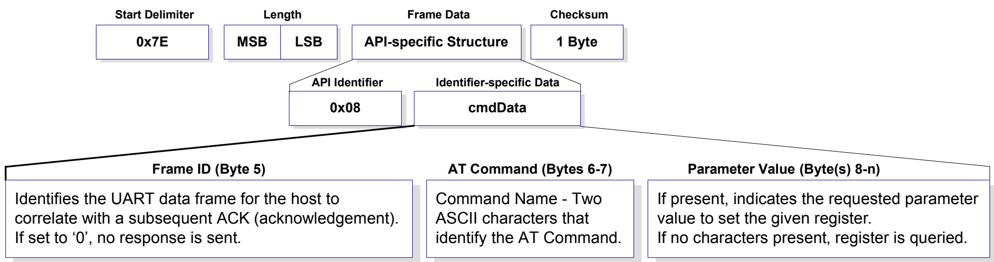


Figure 7-6. Example: API frames when reading the NJ parameter value of the module.

Byte 1	Bytes 2-3		Byte 4	Byte 5	Bytes 6-7		Byte 8
0x7E	0x00	0x04	0x08	0x52 (R)	0x4E (N)	0x4A (J)	0x0D
Start Delimiter	Length*		API Identifier	Frame ID**	AT Command		Checksum

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

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

Figure 7-7. Example: API frames when modifying the NJ parameter value of the module.

Byte 1	Bytes 2-3		Byte 4	Byte 5	Bytes 6-7		Bytes 8	Byte 9
0x7E	0x00	0x05	0x08	0x4D (M)	0x4E (N)	0x4A (J)	0x40	0xD2
Start Delimiter	Length*		API Identifier	Frame ID**	AT Command		Parameter Value	Checksum

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

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

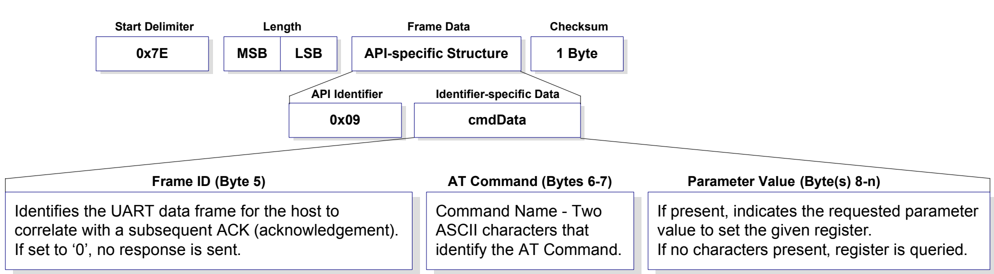
A string parameter used with the NI (Node Identifier), ND (Node Discover) and DH (Destination Address High) command is terminated with a 0x00 character.

AT Command - Queue Parameter Value

API Identifier Value: (0x09)

This API type allows module parameters to be queried or set. In contrast to the "AT Command" API type, new parameter values are queued and not applied until either the "AT Command" (0x08) API type or the AC (Apply Changes) command is issued. Register queries (reading parameter values) are returned immediately.

Figure 7-8. AT Command Frames
(Note that frames are identical to the "AT Command" API type except for the API identifier.)

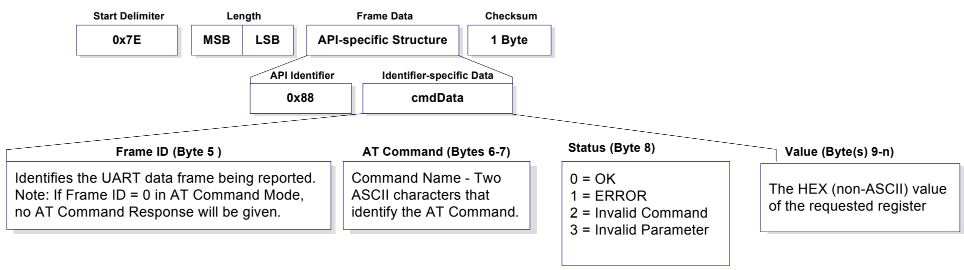


AT Command Response

API Identifier Value: (0x88)
Response to previous command.

In response to an AT Command message, the module will send an AT Command Response message. Some commands will send back multiple frames (for example, the ND (Node Discover) command).

Figure 7-9. AT Command Response Frames.

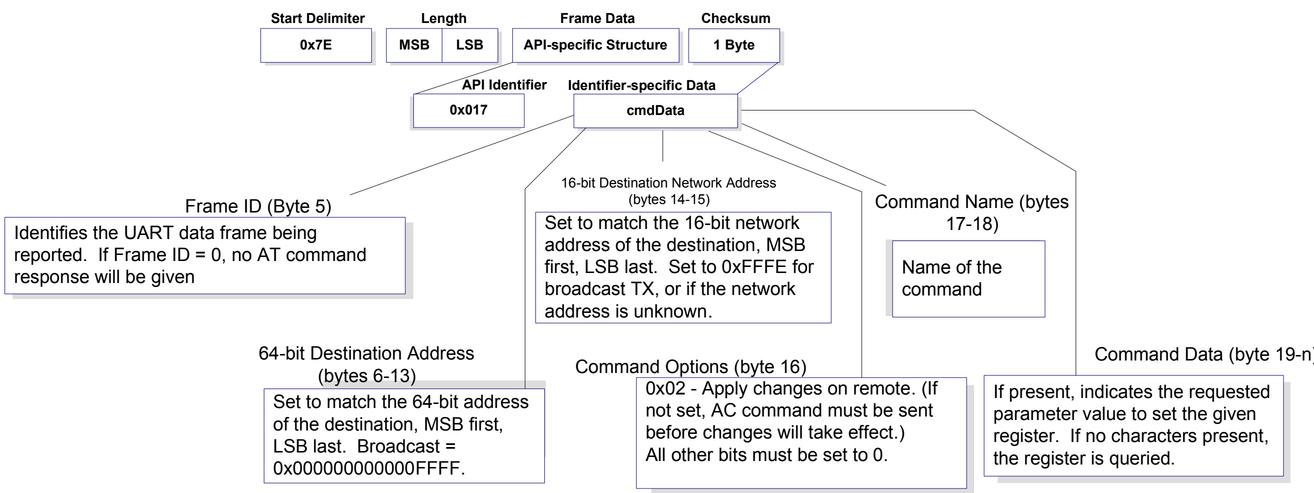


Remote AT Command Request

API Identifier Value: (0x17)

Allows for module parameter registers on a remote device to be queried or set

Figure 7-10. Remote AT Command Request

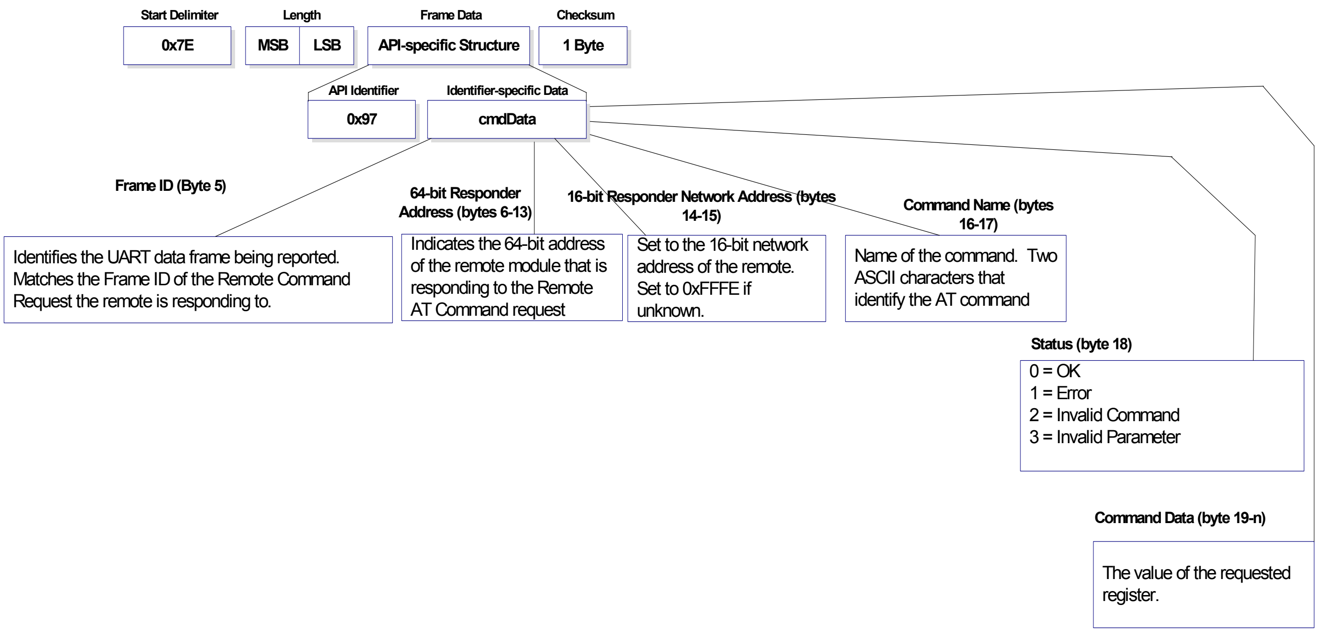


Remote Command Response

API Identifier Value: (0x97)

If a module receives a remote command response RF data frame in response to a Remote AT Command Request, the module will send a Remote AT Command Response message out the UART. Some commands may send back multiple frames--for example, Node Discover (ND) command.

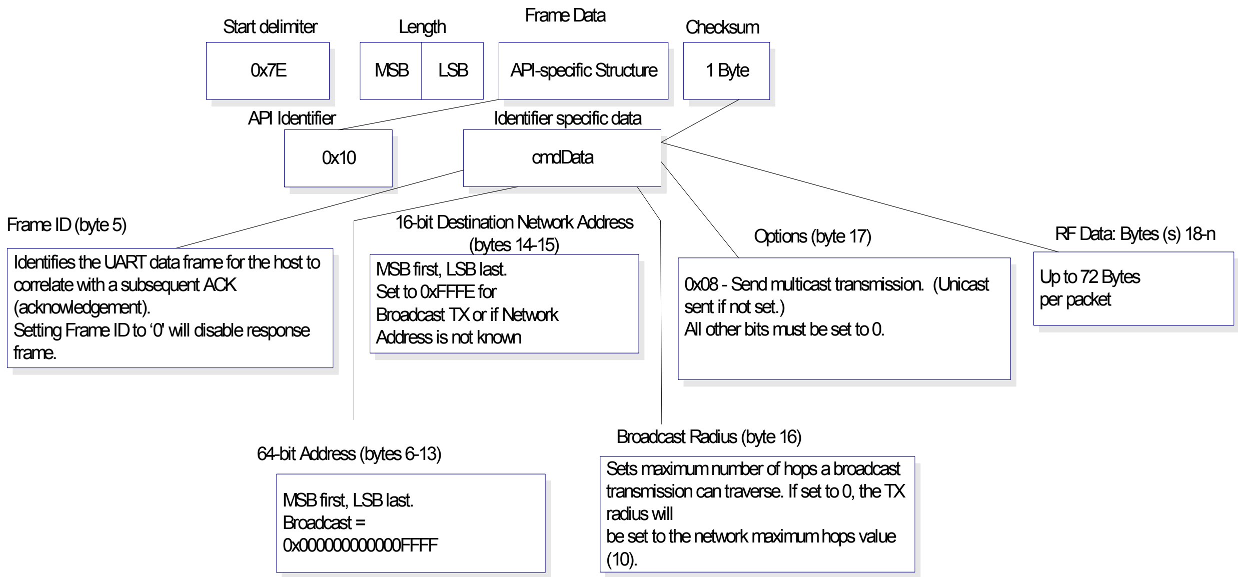
Figure 7-11. Remote AT Command Response.



Transmit Request

API Identifier Value: (0x10) A TX Request message will cause the module to send RF Data as an RF Packet.TX Packet Frames

Figure 7-12. Transmit Request.

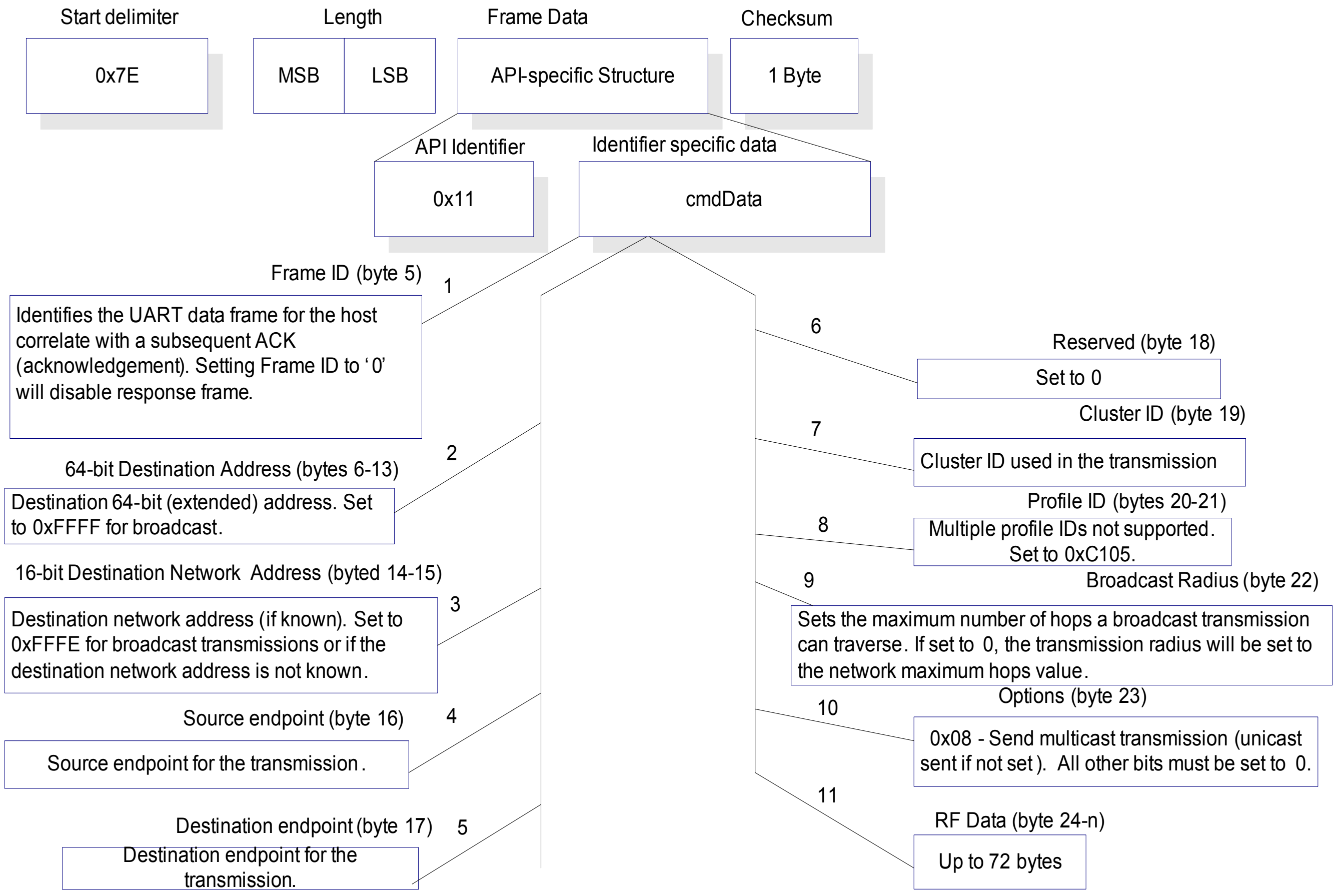


Explicit Addressing ZigBee Command Frame

API Identifier Value: (0x11)

Allows ZigBee application layer fields (endpoint and cluster ID) to be specified for a data transmission.

Figure 7-13. Explicit Addressing ZigBee Command Frame.

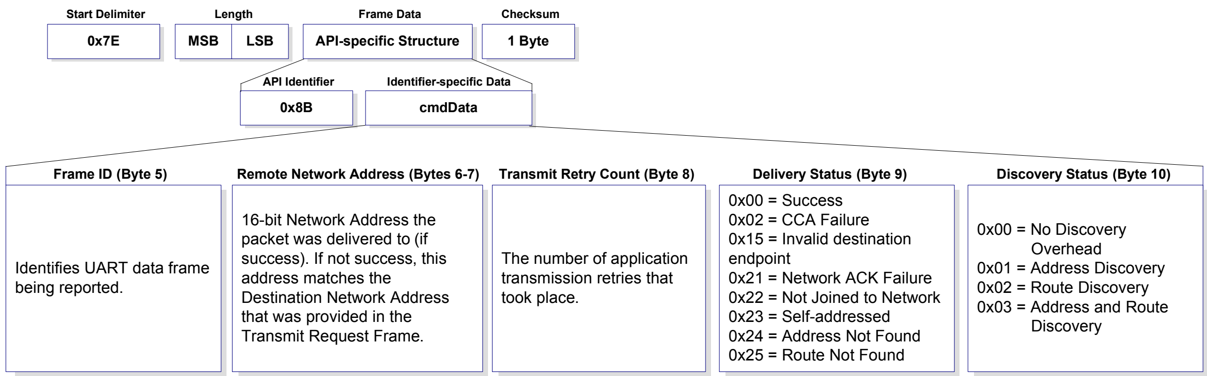


Transmit Status

API Identifier Value: 0x8B

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 7-14. TX Status Frames

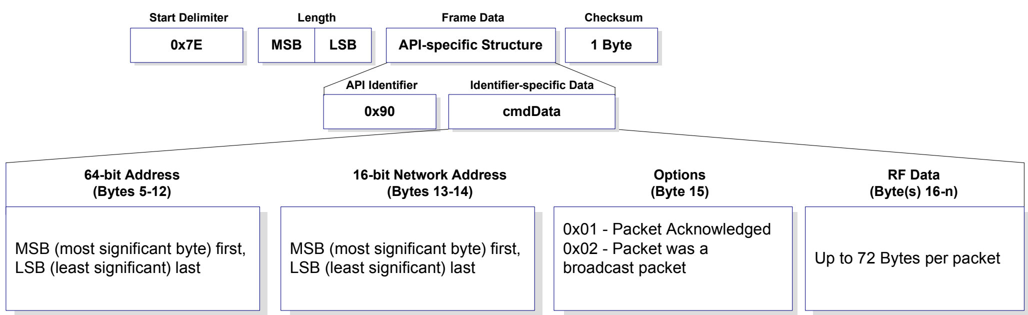


Receive Packet

API Identifier Value: (0x90)

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

Figure 7-15. RX Packet Frames

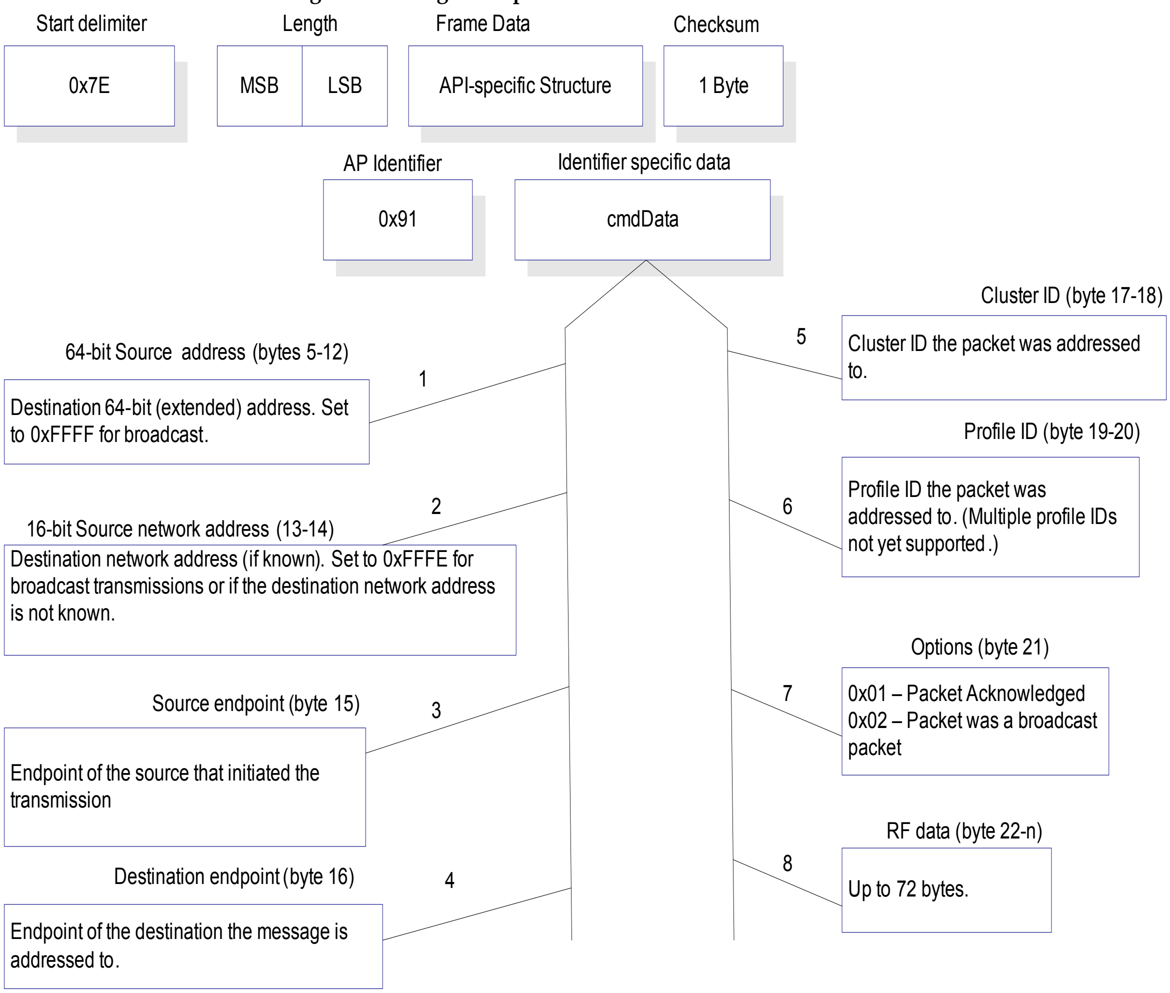


Explicit Rx Indicator

API Identifier Value:(0x91)

When the modem receives a RF packet it is sent out the UART using this message type (when AO=1).

Figure 7-16. ZigBee Explicit Rx Indicators

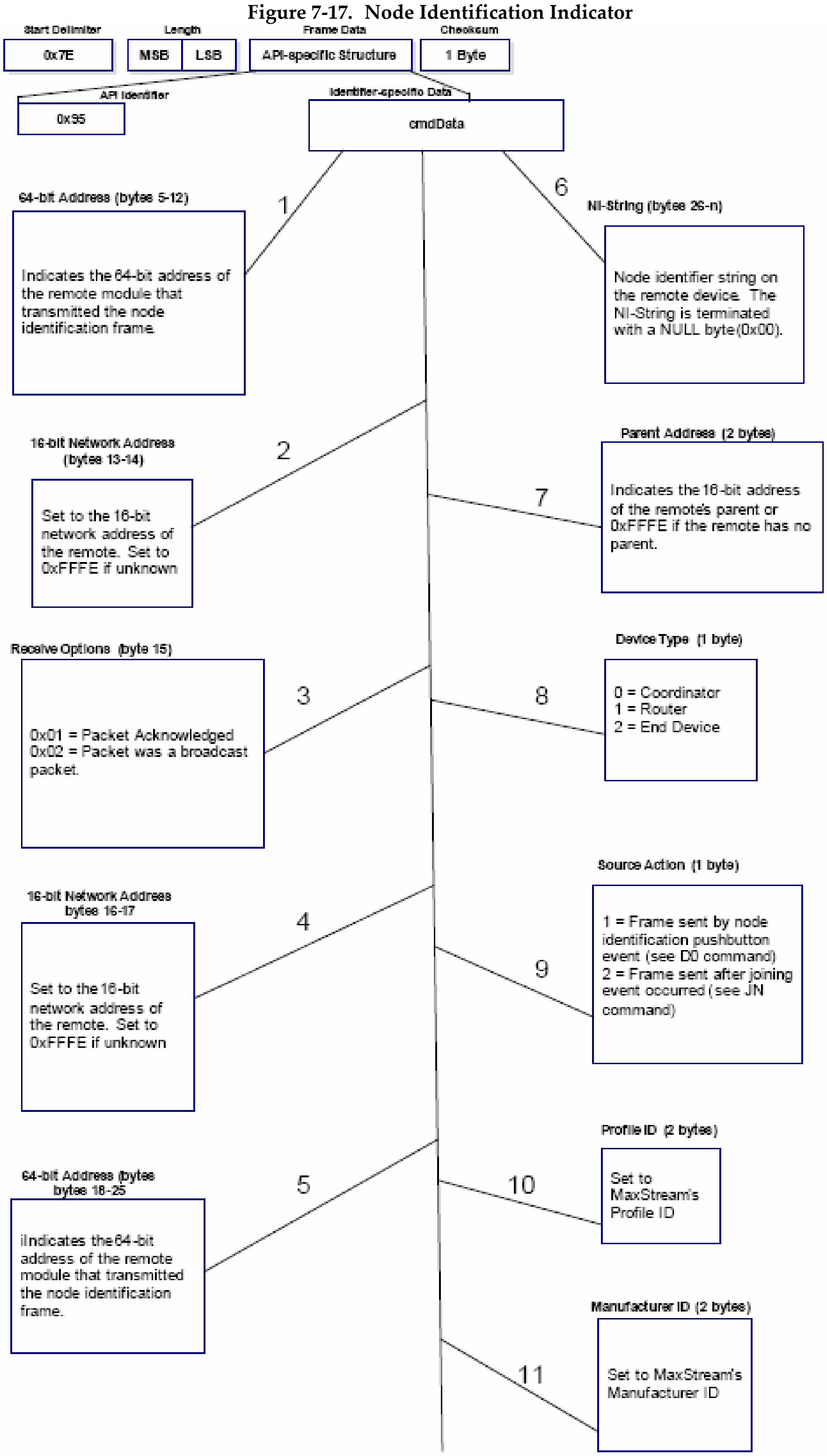


Node Identification Indicator

API Identifier Value: 0x95

This frame is received on the coordinator when a module transmits a node identification message to identify itself to the coordinator (when AO=0). The data portion of this frame is similar to a Node Discovery response frame (see ND command).

Figure 7-17. Node Identification Indicator



Appendix A: Definitions

Definitions

Table A-01. Terms and Definitions

ZigBee Protocol	
PAN	Personal Area Network - A data communication network that includes a coordinator and one or more routers/end devices.
Network Address	The 16-bit address assigned to a node after it has joined to another node. The coordinator always has a network address of 0.
Route Request	Broadcast transmission sent by a coordinator or router throughout the network in attempt to establish a route to a destination node.
Route Reply	Unicast transmission sent back to the originator of the route request. It is initiated by a node when it receives a route request packet and its address matches the Destination Address in the route request packet.
Route Discovery	The process of establishing a route to a destination node when one does not exist in the Routing Table. It is based on the AODV (Ad-hoc On-demand Distance Vector routing) protocol.
ZigBee Stack	ZigBee is a published specification set of high-level communication protocols for use with small, low-power modules. The ZigBee stack provides a layer of network functionality on top of the 802.15.4 specification. For example, the mesh and routing capabilities available to ZigBee solutions are absent in the 802.15.4 protocol.

Digi Mesh Protocol	
Hopping	One direct host-to-host connection forming part of the route between hosts
Network Identifier	
Network Address	The 64-bit address assigned to a node after it has joined to another node.
Route Request	Broadcast transmission sent by a coordinator or router throughout the network in attempt to establish a route to a destination node.
Route Reply	Unicast transmission sent back to the originator of the route request. It is initiated by a node when it receives a route request packet and its address matches the Destination Address in the route request packet.
Route Discovery	The process of establishing a route to a destination node when one does not exist in the Routing Table. It is based on the AODV (Ad-hoc On-demand Distance Vector routing) protocol.

ZigBee Stack	ZigBee is a published specification set of high-level communication protocols for use with small, low-power modules. The ZigBee stack provides a layer of network functionality on top of the 802.15.4 specification. For example, the mesh and routing capabilities available to ZigBee solutions are absent in the 802.15.4 protocol.

Appendix B: Agency Certifications

United States FCC

The XBee®/XBee-PRO® 900 RF Module complies with Part 15 of the FCC rules and regulations. Compliance with the labeling requirements, FCC notices and antenna usage guidelines is required.

To fufill FCC Certification, the OEM must comply with the following regulations:

1. The system integrator must ensure that the text on the external label provided with this device is placed on the outside of the final product. [Figure A-01]
2. XBee®/XBee-PRO® 900 RF Module may only be used with antennas that have been tested and approved for use with this module [refer to the antenna tables in this section].

OEM Labeling Requirements

WARNING: The Original Equipment Manufacturer (OEM) must ensure that FCC labeling requirements are met. This includes a clearly visible label on the outside of the final product enclosure that displays the contents shown in the figure below.

Required FCC Label for OEM products containing the XBee®/XBee-PRO® 900 RF Module

Contains FCC ID:MCQ-XBEE09P

The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (*i.*) this device may not cause harmful interference and (*ii.*) this device must accept any interference received, including interference that may cause undesired operation.

FCC Notices

IMPORTANT: The XBee®/XBee-PRO® 900 OEM RF Module has been certified by the FCC for use with other products without any further certification (as per FCC section 2.1091). Modifications not expressly approved by Digi could void the user's authority to operate the equipment.

IMPORTANT: OEMs must test final product to comply with unintentional radiators (FCC section 15.107 & 15.109) before declaring compliance of their final product to Part 15 of the FCC Rules.

IMPORTANT: The RF module has been certified for remote and base radio applications. If the module will be used for portable applications, the device must undergo SAR testing.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.

If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: Re-orient or relocate the receiving antenna, Increase the separation between the equipment and receiver, Connect equipment and receiver to outlets on different circuits, or Consult the dealer or an experienced radio/TV technician for help.

FCC-Approved Antennas (900 MHz)

The XBee®/XBee-PRO® 900 RF Module can be installed utilizing antennas and cables constructed with standard connectors (Type-N, SMA, TNC, etc.) if the installation is performed professionally and according to FCC guidelines. For installations not performed by a professional, non-standard connectors (RPSMA, RPTNC, etc.) must be used.

The modules are FCC approved for fixed base station and mobile applications on channels 0x0B-0x1A for XBee®/XBee-PRO® 900 and on channels 0x0B - 0x18 for Xbee Series2 Pro. If the antenna is mounted at least 20cm (8 in.) from nearby persons, the application is considered a mobile application. Antennas not listed in the table must be tested to comply with FCC Section 15.203 (Unique Antenna Connectors) and Section 15.247 (Emissions).

XBee®/XBee-PRO® 900 have been tested and approved for use with all the antennas listed in the tables below. (Cable-loss IS required when using gain antennas as shown below.)

*** If using the RF module in a portable application** (For example - If the module is used in a handheld device and the antenna is less than 20cm from the human body when the device is in operation): The integrator is responsible for passing additional SAR (Specific Absorption Rate) testing based on FCC rules 2.1091 and FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, OET Bulletin and Supplement C. The testing results will be submitted to the FCC for approval prior to selling the integrated unit. The required SAR testing measures emissions from the module and how they affect the person.

RF Exposure

WARNING: To satisfy FCC RF exposure requirements for mobile transmitting devices, a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during device operation. To ensure compliance, operations at closer than this distance are not recommended. The antenna used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.

The preceding statement must be included as a CAUTION statement in OEM product manuals in order to alert users of FCC RF Exposure compliance.

Canada (IC)

Labeling requirements for Industry Canada are similar to those of the FCC. A clearly visible label on the outside of the final product enclosure must display the following text:

Contains Model: XBEE09P, IC: 1846A-XBEE09P

Integrator is responsible for its product to comply with IC ICES-003 & FCC Part 15, Sub. B - Unintentional Radiators. ICES-003 is the same as FCC Part 15 Sub. B and Industry Canada accepts FCC test report or CISPR 22 test report for compliance with ICES-003.

Transmitter Antennas

This device has been designed to operate with the antennas listed below, and having a maximum gain of 15.1 dB. Antennas not included in this list or having a gain greater than 15.1 dB are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.