



User Manual for
HE-XRC9

Wireless Communication

900MHZ MODEM COM Module

PREFACE

This manual explains how to install and use the 900MHz Modem COM Module (HE-XRC9).

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ABOUT PROGRAMMING EXAMPLES

Any example programs and program segments in this manual or provided on accompanying diskettes are included solely for illustrative purposes. Due to the many variables and requirements associated with any particular installation, Horner APG cannot assume responsibility or liability for actual use based on the examples and diagrams. It is the sole responsibility of the system designer utilizing the XRC9 module to appropriately design the end system, to appropriately integrate the XRC9 module and to make safety provisions for the end equipment as is usual and customary in industrial applications as defined in any codes or standards which apply.

Note: The programming examples shown in this manual are for illustrative purposes only. Proper machine operation is the sole responsibility of the system integrator.

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NOTES

1. 900MHz Modem COM Module

The XLe OCS plug in accessory 900MHz Modem COM Module is our longest range wireless solution. Out-of-box, the modem is equipped to sustain long range wireless links between devices. Simply enter serial data into one modem and the data surfaces on the other side of the wireless link.

The modem transfers a standard asynchronous serial data stream



Features

Long Range Performance

1 Watt Power Output (1 mW – 1 W, selectable)

Range (@ 9600 bps throughput data rate):

- Indoor/Urban: **up to 3000'** (900 m)
- Outdoor line-of-sight:
up to **14 miles** (22 km) w/ dipole antenna
- Outdoor line-of-sight:
up to **40 miles** (64 km) w/ high gain antenna

Range (@ 115200 bps throughput data rate):

- Indoor/Urban: **up to 1500'** (450 m)
- Outdoor line-of-sight:
up to **7 miles** (11 km) w/ dipole antenna
- Outdoor line-of-sight:
up to **20 miles** (32 km) w/ high gain antenna

Receiver Sensitivity: -110 dBm (@ 9600 baud),
-100 dBm (@ 115200 baud)

Advanced Networking & Security

- True Peer-to-Peer (no "master" required), Point-to-Point, Point-to-Multipoint & Multidrop Retries and Acknowledgements
- FHSS (Frequency Hopping Spread Spectrum)
- 10 hopping channels - each with over 65,000 network addresses available
- **256-bit AES Encryption** (See KY Command [p35] for implementation)

Easy-to-Use

- No configuration required
- Advanced configurations available through AT & binary Commands
- Continuous RF data stream of up to 115.2 kbps
- Transparent Operation – Wireless links replace serial wires
- Serial interfacing
- MODBUS, \overline{CTS} , \overline{RTS} , \overline{DCD} & \overline{DTR} I/O Support
- XII™ Interference Immunity
- Power-saving Sleep Modes
- Streaming, Acknowledged & Multi-Send RF Communication Options
- **Free & Unlimited Technical Support**

Worldwide Acceptance

FCC Approved (USA - Go to Appendix A [p47] for FCC Requirements)

Systems that contain 900MHz Modem COM Modules can inherit FCC Certification

IC Approved (Canada)

ISM (Industrial, Scientific & Medical) **license-free** 902-928 MHz frequency band

Manufactured under ISO 9001:2000 registered standards



Specifications and Overview

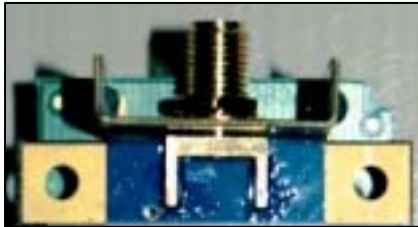
Table 1.1. 900MHz Modem COM Module Specifications

| Performance | | @ 9600 bps Throughput Data Rate | @ 115200 bps Throughput Data Rate |
|--|----------------------------|---|--|
| Transmit Power Output | | 1 mW - 1 W (software selectable) | 1 mW - 1 W (software selectable) |
| Indoor/Urban Range | | Up to 3000' (900 m) | Up to 1500' (450 m) |
| Outdoor RF line-of-sight Range | | Up to 14 miles (22 km) w/ dipole antenna Up to 40 miles (64 km) w/ high-gain antenna | Up to 7 miles (11 km) w/ dipole antenna Up to 20 miles (32 km) w/ high-gain antenna |
| Interface Data Rate (selectable using BD Command) | | 1200 - 230400 bps | 1200 - 230400 bps |
| RF Data Rate | | 10000 bps | 125000 bps |
| Receiver Sensitivity | | -110 dBm | -100 dBm |
| Power Requirements (refer also to Table 1. 2) | | | |
| Receive Current | | 110 mA | 110 mA |
| Idle Currents | 16 sec cyclic sleep (SM=8) | 20 mA | 19 mA |
| | 8 sec cyclic sleep (SM=7) | 21 mA | 19 mA |
| | 4 sec cyclic sleep (SM=6) | 24 mA | 20 mA |
| | 2 sec cyclic sleep (SM=5) | 30 mA | 22 mA |
| | 1 sec cyclic sleep (SM=4) | 39 mA | 25 mA |
| Pin Sleep Power Down | | 17 mA | 17 mA |
| Serial Port Sleep Power Down | | 45 mA | 45 mA |
| General | | | |
| Frequency | | 902-928 MHz ISM Band | |
| Spread Spectrum | | FHSS (Frequency Hopping Spread Spectrum) | |
| Modulation | | FSK (Frequency Shift Keying) | |
| Supported Network Topologies | | Peer-to-Peer, Point-to-Point, Point-to-Multipoint & Multidrop | |
| Channel Capacity | | 10 hop sequences share 50 frequencies | |
| Operating Temperature | | -40 to 85° C | |
| Antenna | | | |
| Connector | | RPSMA (Reverse-polarity SMA) | |
| Type | | ½ wave dipole whip, 6.75" (17.1 cm), 2.1 dBi Gain | |
| Impedance | | 50 ohms unbalanced | |
| Certifications | | | |
| FCC Part 15.247 | | OUR-9XTEND | |
| Industry Canada (IC) | | 4214A-9XTEND | |

Table 1.2. COM Module Specifications – Relative to user-selected TX Power Output

| Power Requirements (TX Currents Relative To Each TX Power Output Option) | | | | | |
|---|-------------|--------------|---------------|---------------|------------|
| Transmit Power Output | 1 mW | 10 mW | 100 mW | 500 mW | 1 W |
| Transmit Current @9600 baud (9 VDC supply voltage, typical) | 110 mA | 145 mA | 250 mA | 510 mA | 900 mA |
| Transmit Current @115K baud (9 VDC supply voltage, typical) | 110 mA | 140 mA | 245 mA | 500 mA | 800 mA |

Figure 1.1. – Antenna Port XRC9



1.2a. Antenna Port

Port is a 50Ω RF signal connector for connecting to an external antenna. The connector type is RPSMA (Reverse Polarity SMA) female. The connector has threads on the outside of a barrel and a male center conductor.

1.3: Overview

To supplement the built-in MJ1 and MJ2 serial ports on the XLe, the 900MHz modem optional COM module (HE-XRC9) can be installed internal to the XLe to provide 900MHz spread spectrum communications.

The HE-XRC9 has the following features:

- Topology – Spread spectrum (HSFF)
- Frequency – ISM 908–928 MHz
- Encryption – 256bit AES
- Power – 1 mW to 1 watt (adjustable to match antenna to maximum EIRP)
- Indoor range – up to 3000 feet
- Outdoor range – up to 40 miles (line-of-sight)
- Transfer rate – 9.6k or 115.2k (range reduced at higher baud rate)

The HE-XRC9 allows spread spectrum communications through ladder communication function blocks when the MJ1/Com Option port is opened in *Radio 900MHz* mode via the OPEN function block. The SEND function block may then be used to initialize the operating parameters utilizing Hayes AT style commands (such as source and destination IDs). Once the HE-XRC9 is initialized and an AT style command to exit command mode is issued; thereafter, either the SEND/RECV or MODBUS function blocks may be then used to transfer data.

The HE-XRC9 utilizes the same internal communications channel (UART) as the MJ1 serial port; thus, enabling the HE-XRC9 deactivates the MJ1 serial port. However, support is provided to select which device is currently active through ladder control.

The HE-XRC9 is provided connection to the internal handshake lines of RTS and CTS. As such, the OPEN function block handshake parameter of hardware is functional if the HE-XRC9 is programmed appropriately. Additionally, software handshaking (XON/XOFF) is also available if both the OPEN function block and the HE-XRC9 is programmed appropriately.

Included with the HE-XRC9 is an articulated 1/2-wave dipole RPSMA antenna (2.1 db gain).

1.4: INSTALLATION PROCEDURE

1. Disconnect all power from the XLe unit including I/O power.
2. Remove the four screws on the back of the XLe unit and remove the back cover. The back cover can be discarded or saved, but it will be replaced with the extended back cover that ships with the communication add-on. Screws are re-used (Figure 1).

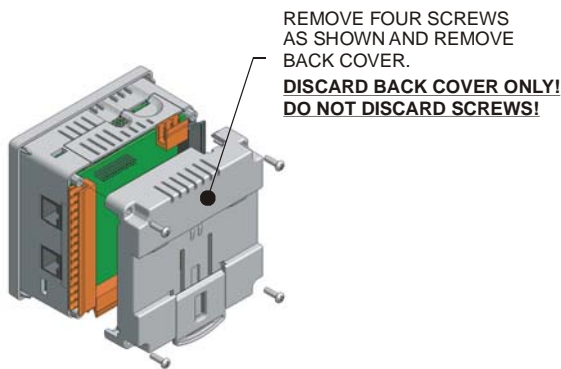


Figure 1.2. - Removing Back Cover of the XLE

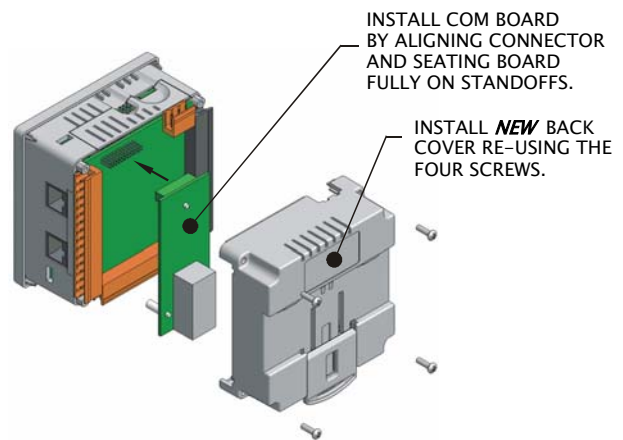


Figure 1.3. - Installing the COM Board in the XLE

3. Plug the communication board onto the 24-pin connector. Make sure all the pins are properly aligned.
4. Place the extended back cover onto the unit. It can be helpful to tip it at an angle so the connector on the COM board passes through the opening on the back cover.
5. Place the screw back into the hole and turn the screw slowly counter clockwise until it clicks into the threads. This prevents the screw from being cross-threaded. Now, turn the screw clock-wise until the cover is firmly secured. Repeat this process for all four (4) screws.
6. Install the included antenna. Note: In most applications, the XLe will be mounted inside an enclosure. The antenna should be mounted on the outside of the enclosure with an appropriate antenna extension cable. Horner APG offers two optional kits that include these cables, the one foot (0.304 meter) **HE200ANT906** and the four foot (1.219 meter) **HE200ANT908**.

1.5: Configuration

Once the HE-XRC9 is installed, the corresponding CSCAPE application must be made aware of the optional COM module. This is accomplished through the CSCAPE: Controller -> I/O Configuration menu as shown below:

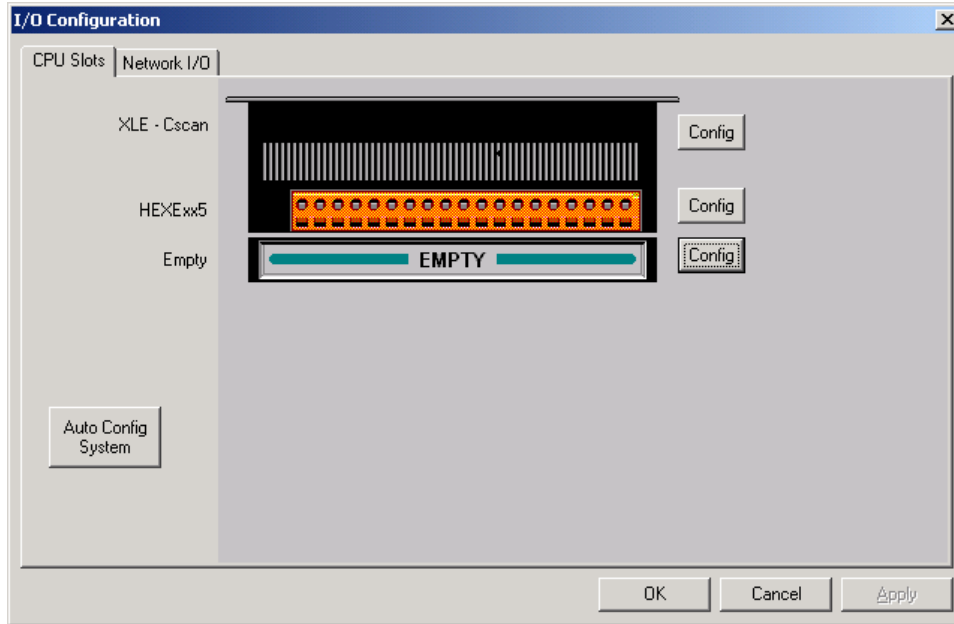


Figure 1.4. –
 Pre Configuration

If the target XLe (with the HE-XRC9 installed) is available and connected to CSCAPE, the Auto Config System will fill the EMPTY slot with HEXRC9 information. If the target XLe is NOT available, the user may manually configure by clicking the Config button adjacent to the EMPTY slot and selecting HEXRC9 – radio modem option card (this assumes that XLE has previously been selected as the Controller). Thereafter, on exiting the I/O Configuration dialog by clicking the OK button, the application is configured for the HE-XRC9.

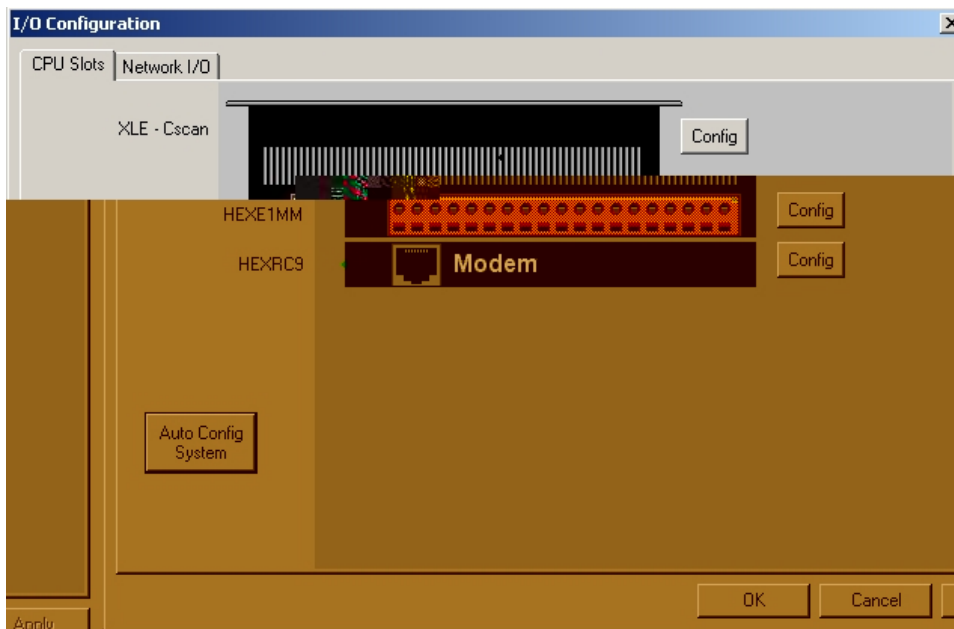


Figure 1.5. –
 Post Configuration

Failure to set HEXRC9 in the I/O Configuration when attempting to download an application that uses an OPEN function block set to Radio 900 generates a download error. Even if the HE-XRC 9 is not used by the application, the HEXRC9 must still be set in the I/O Configuration to prevent an I/O Configuration error on the XLe

1.6: Ladder communications

To access the HE-XRC9 optional COM module from ladder, the application must first execute an OPEN function block for MJ1/Option port with Mode set to **Radio 900**. This function block accomplishes three tasks:

- Serial port is disconnected from the CSCAPE command interpreter and made available to ladder communications function blocks.
- Serial port is internally connected to the HE-XRC9.
- Serial port transfer rate and frame protocol set to match HE-XRC9

The OPEN function block Baud rate and frame parameters (Parity, Data bits, etc...) must be set to match that of the HE-XRC9. The factory default setting of these parameters are **9600, 8, N, and 1**. It is possible to program the HE-XRC9 for a different baud rate and frame protocol and save those values to non-volatile memory; however, it is left to the user to record those values and set the OPEN function block appropriately.

Once the MJ1/Option port is opened in Radio 900 mode, it is ready to start transmitting data; however, it may be desired to change modes of operation, source and destination addresses, or add encryption. This requires entering command mode through the sending of a "+++" sequence to the HE-XRC9 followed by the appropriate "AT" commands by using SEND function blocks. The "AT" commands and corresponding transmit modes are covered in detail in the Command and Control section ([Chapter 4](#)) of this manual and at:

http://www.maxstream.net/products/xtend/product-manual_XTend_OEM_RF-Module.pdf .

When transferring data, handshaking is generally not required for messages less than 2K bytes. The HE-XRC9 breaks larger messages into smaller packets for transfer between HE-XRC9 modems. Note that Modbus RTU communications may be unreliable if the HE-XRC9 packet size or transfer method is not configured for complete RTU message transfer without breaking into individual transfer packets.

Once the HE-XRC9 is properly *Opened*, SEND/RECV or MODBUS function blocks may be used to transfer data.

User access to SLEEP and CONFIG pins on the MaxStream 9Xtend OEM RF Module are not supported on the HE-XRC9. Likewise CMD mode is not supported since CSCAPE applications cannot directly access the RTS handshake line.

2. Drawings and Photographs

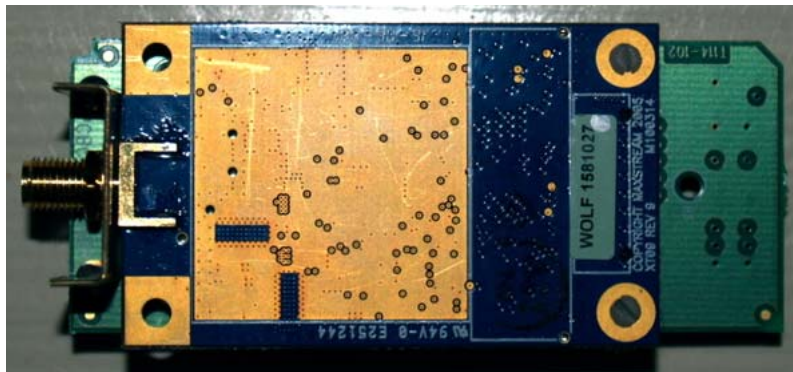


Figure 2.2. – XRC9 Top View

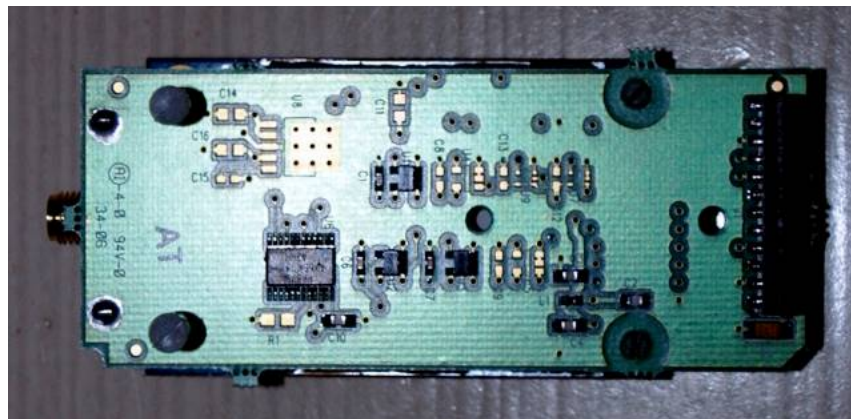


Figure 2.3. – XRC9 Bottom View



Figure 2.4. – XRC9 with Antenna Attached



Figure 2.5. – XRC9 mounted in XLe

3. RF Module Operation

⚠ WARNING: When operating at 1 Watt power output, observe a minimum separation distance of 2' (0.6 m) between modems. Transmitting in close proximity of other modems can damage modem front ends.

Host and COM Module I/O Settings

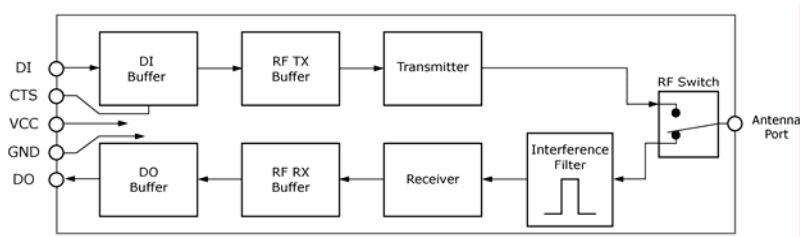
Serial communications between a host and the 900MHz Modem COM Module are dependent upon having matching baud rate, parity, stop bit & number of data bits settings. Refer to the table below to ensure host serial port settings match those of the 900MHz Modem COM Module.

Table 3.1. Parameter values critical to serial communications between the COM Module and host

| Parameter Setting | 900MHz Modem COM Module Default Parameter Value | |
|-------------------------|---|--------------------|
| Baud (Serial Data Rate) | 9600 bps | (BR parameter = 3) |
| Number of Data Bits | 8 | (NB parameter = 0) |
| Parity | None | (NB parameter = 0) |
| Number of Stop Bits | 1 | (NB parameter = 0) |

Flow Control

Figure 3.1. Internal Data Flow Diagram



DI (Data In) Buffer and Flow Control

When data enters the 900MHZ MODEM through the DI Pin, the data is stored in the DI Buffer until it can be transmitted.

When the RB and RO parameter thresholds are satisfied (refer to Transmit Mode section for more information), the modem attempts to initialize an RF connection. If the modem is already receiving RF data, the serial data is stored in the modem’s DI Buffer. The DI buffer stores at least 2.1 KB. If the DI buffer becomes full, hardware or software flow control must be implemented in order to prevent overflow (loss of data between the host and 900MHZ MODEM).

How to eliminate the need for flow control:

1. Send messages that are smaller than the DI buffer size. The size of the DI buffer varies according to the packet size (PK parameter) and the parity setting (NB parameter) used.
2. Interface at a lower baud rate (BD parameter) than the RF data rate (BR parameter).

Case in which the DI Buffer may become full and possibly overflow:

1. If the modem is receiving a continuous stream of RF data or if the modem is monitoring data on a network, any serial data that arrives on the DI pin is placed in the DI Buffer. The data in the DI buffer will be transmitted over-the-air when the modem no longer detects RF data in the network.

Hardware Flow Control ($\overline{\text{CTS}}$). When the DI buffer is 17 bytes away from being full; by default, the modem de-asserts (high) $\overline{\text{CTS}}$ to signal to the host device to stop sending data [refer to FT (Flow Control Threshold, p34) and CS (GPO1 Configuration, p32) Commands.]. $\overline{\text{CTS}}$ is re-asserted after the DI Buffer has 34 bytes of memory available.

Software Flow Control (XON). XON/XOFF software flow control can be enabled using the FL (Software Flow Control) Command [p33]. This option only works with ASCII data.

DO (Data Out) Buffer & Flow Control

When RF data is received, the data enters the DO buffer. Once the DO Buffer reaches capacity, any additional incoming RF data is lost. The DO buffer stores at least 2.1 KB.

Two cases in which the DO Buffer may become full and possibly overflow:

1. If the RF data rate is set higher than the interface data rate of the modem, the modem will receive data from the transmitting modem faster than it can send the data to the host.
2. If the host does not allow the modem to transmit data out from the DO buffer because of being held off by hardware or software flow control.

Hardware Flow Control ($\overline{\text{RTS}}$). If $\overline{\text{RTS}}$ is enabled for flow control (RT Parameter = 2, p41), data will not be sent out the DO Buffer as long as $\overline{\text{RTS}}$ is de-asserted.

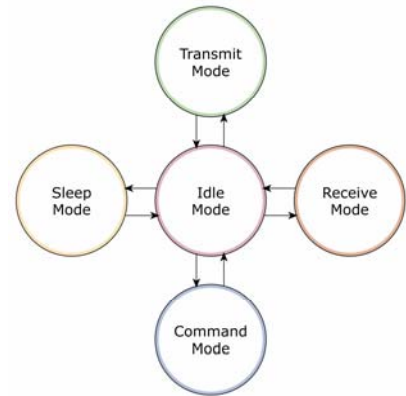
Software Flow Control (XOFF). XON/XOFF software flow control can be enabled using the FL (Software Flow Control) Command [p33]. This option only works with ASCII data.

Modes of Operation

900MHz Modem COM Modules operate in five modes.

Figure 3.2. Modes of Operation

The COM Module can only be in one mode at a time.



Idle Mode

When not receiving or transmitting data, the modem is in Idle Mode. The modem uses the same amount of power in Idle Mode as it does in Receive Mode.

The modem shifts into the other modes of operation under the following conditions:

- Data is received in the DI Buffer (Transmit Mode)
- Valid RF data is received through the antenna (Receive Mode)
- Command Mode Sequence is issued (Command Mode)
- Sleep Mode condition is met (Sleep Mode)

The modem automatically transitions to Idle Mode after finished responding to these conditions.

Transmit Mode

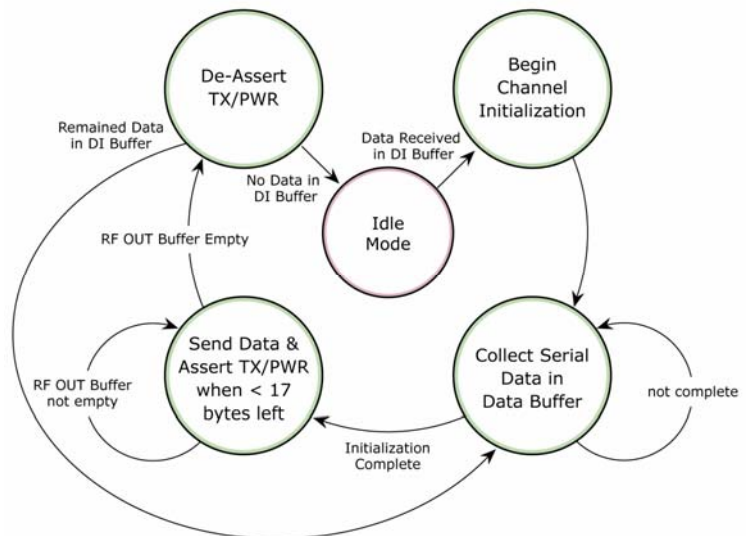
When the first byte of serial data is received from the host in the DI buffer, the modem attempts to shift to Transmit Mode and initiate an RF connection with other modems. After transmission is finished, the modem returns to Idle Mode.

RF transmission begins after either of the following criteria is met:

1. RB bytes have been received by the host and are pending for RF transmission.
[RB (Packetization Threshold) Command]
2. At least one character has been received by the host and is pending for RF transmission, and RO character times of silence have been observed on the host.
[RO (Packetization Timeout) Command]

Figure 3.3. Transmit Mode Data Flow

The character timeout trigger can be disabled by setting RO to zero. In this case, transmission will not begin until RB bytes have been received and are pending for RF transmission. The RB parameter may be set to any value between 1 and the RF packet size (PK), inclusive. Note that transition to Transmit Mode cannot take place during RF reception; the RF reception must complete before the modem can transition into Transmit Mode.



After either of the RB and RO conditions are met, the modem then initializes a communications channel. Data in the DI buffer is grouped into RF packets (up to 2048 bytes in each packet - refer to PK (Maximum RF Packet Size) Command), converted to RF data and then is transmitted over-the-air until the DI buffer is empty.

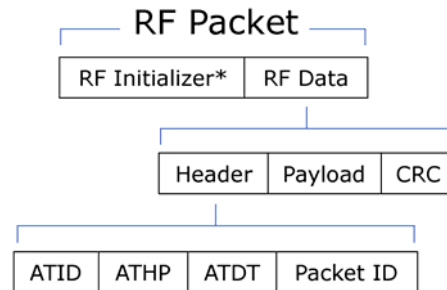
Channel initialization is the process of sending an RF initializer that synchronizes receiving modems with the transmitting modem. During channel initialization, incoming serial data accumulates in the DI buffer.

RF data, which includes the payload data, follows the RF initializer. The payload includes up to the maximum packet size (PK Command) bytes. As the TX modem nears the end of the transmission, it inspects the DI buffer to see if more data exists to be transmitted. This could be the case if more than PK bytes were originally pending in the DI buffer or if more bytes arrived from the host during transmission. If more data is pending, the transmitting modem instructs all listening modems that a subsequent packet is coming. Receiving modems move to the new frequency and listen for the subsequent packet.

Refer to the RF Communication Options [p22] section for information and state diagrams that illustrate channel initialization and the sequence of events that follow.

RF Packet

Figure 3.4. RF Packet Components



* When streaming multiple RF packets, the RF Initializer is only sent in front of the first packet.

RF Initializer

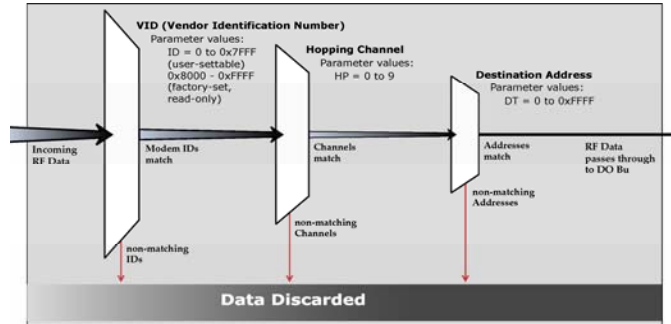
An RF initializer is sent each time a new connection sequence begins. The RF initializer contains channel information that notifies receiving modems of information such as the hopping pattern used by the transmitting modem. Channel initialization takes 5 ms at the 115k RF data rate and 54 ms at the 9600 RF data rate. The first transmission always sends an RF initializer.

An RF initializer can be of various lengths depending on the amount of time determined to be required to prepare a receiving modem. For example, a wake-up initializer is a type of RF initializer used to wake remote modems from Sleep Mode (Refer to the FH, LH, HT and SM Commands for more information). The length of the wake-up initializer should be longer than the length of time remote modems are in cyclic sleep.

Header

The header contains network addressing information that filters incoming RF data. The receiving modem checks for matching a VID, Hopping Channel and Destination Address. Data that does not pass through all three network security layers is discarded.

Figure 3.5. Network Layers Contained in the Header



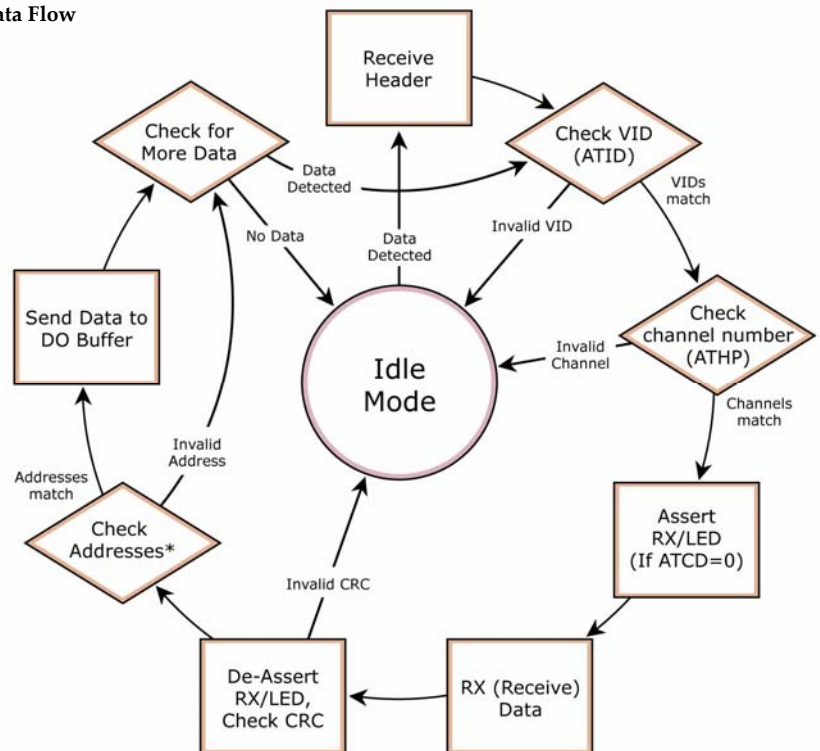
CRC (Cyclic Redundancy Check)

To verify data integrity and provide built-in error checking, a 16-bit CRC (Cyclic Redundancy Check) is computed for the transmitted data and attached to the end of each RF packet before transmission. On the receiving end, the receiving modem computes the CRC on all incoming RF data. Received data that has an invalid CRC is discarded. [See Receive Mode section.]

Receive Mode

If a modem detects RF data while in Idle Mode, the modem transitions into Receive Mode to start receiving RF packets. Once a packet is received, it goes through the receiving end of a CRC (cyclic redundancy check) to ensure that the data was transmitted without error. If the CRC data bits on the incoming packet are invalid, the packet is discarded. If the CRC is valid, the packet is placed the DO Buffer. Refer to the Addressing Options section (under RF Communication Options) for more information about address recognition.

Figure 3.6. Receive Mode Data Flow



The modem returns to Idle Mode after valid RF data is no longer detected or after an error is detected within the received RF data. If serial data is stored in the DI buffer while the modem is in Receive Mode, the serial data will be transmitted after the modem is finished receiving data and returns to Idle Mode.

Shutdown Mode

Hardware Sleep

Shutdown Mode offers the lowest power mode available to Horner modem users (< 1 μ A). This mode is available through the XRC9.

Contact Horner Technical Support for more information.

Command Mode

To set or read modem parameters; the modem must first enter Command Mode (a state in which incoming characters are interpreted as commands). Two command types are available:

- AT Commands
- Binary Commands

For modified parameter values to persist in the modem's registry, changes must be saved to non-volatile memory using WR (Write) Command. Otherwise, parameters are reset to previously stored values after the modem is powered off and then on again.

AT Commands

To enter AT Command Mode:

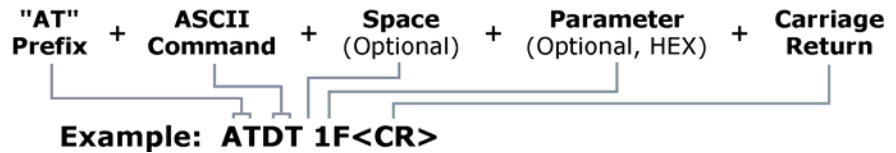
1. Send the 3-character command sequence "+++" and observe guard times before and after the command characters. [See "Default AT Command Mode Sequence" below.]
Use the "Terminal" tab (or other serial communications software) of the RadioSet Software to enter the sequence.
[OR]
2. Force entrance into AT Command Mode by keeping the configuration switch [Figure 1.1a, p **Error! Bookmark not defined.**] pressed while turning off, then on again the power supplying the COM Module.

Default AT Command Mode Sequence:

- No characters sent for one second [see BT (Guard Time Before) Command]
- Input three plus characters ("+++") within one second [see CC (Command Sequence Character) Command.]
- No characters sent for one second [see AT (Guard Time After) Command.]

To Send AT Commands to the COM Module:

Figure 3.7. Syntax for sending 900MHZ MODEM AT Commands



NOTE: To read a current parameter value stored in a register, leave the parameter field blank.

The preceding example would change the modem Destination Address "1F". To store the new value to the modem's non-volatile (long term) memory, use the WR (Write) Command.

To Exit Command Mode:

1. If no valid AT Commands are received within the time specified by CT (Command Mode Timeout) Command, the modem automatically returns to Idle Mode.
[OR]
2. Send ATCN (Exit Command Mode) Command.

Binary Commands

Sending and receiving register values using binary commands is the fastest way to change the operating parameters of the 900MHz Modem COM Module. Binary commands are used most often to sample signal strength (RS register) and/or error counts; or change modem addresses and channels for polling systems. Since the sending and receiving register values takes place through the same serial data path as 'live' data (received RF payload), interference between the two can be a concern.

Common questions about using binary command mode:

- What are the implications of asserting CMD in any of the various states while live data is being sent or received?
- Specifically, is there a minimum time delay after serial data is sent before which we can assert CMD and send a command?
- Is a delay required after CMD is de-asserted before we can send normal data?
- How can we know if data being received is the return from a command or live data?
- The application does not allow control over when data is received, except by waiting for dead time between bursts of communication.

Answers: The CMD line (GPI1) can be asserted to send a command to the radio anytime during transmission or reception of data. Note that the status of the CMD signal is only checked at the end of the stop bit as the byte is shifted into the serial port. If the command is sent in the middle of a stream of payload data to be transmitted, the command will essentially be executed in the order it is received. If the radio is continuously receiving data, the radio will wait for a break in the received data before executing the command. The $\overline{\text{CTS}}$ signal will frame the response coming from the binary command request [see graphic below].

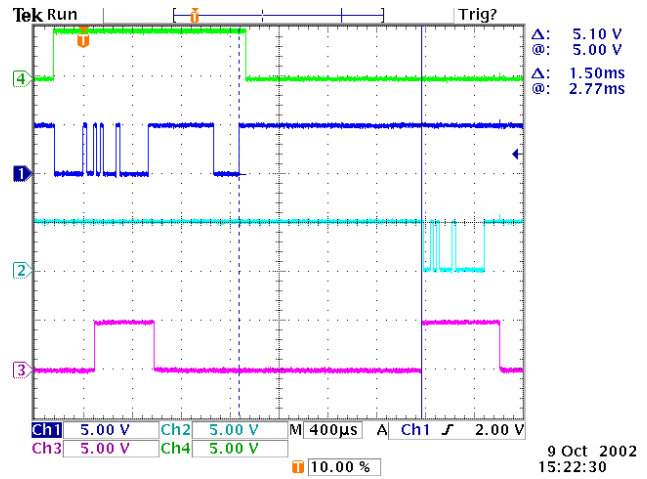
The CMD pin must be asserted in order to send binary commands to an 900MHZ MODEM . The CMD pin can be asserted to recognize commands anytime during transmission or reception of data. A minimum time delay of 100 μs (after the stop bit of the command byte has been sent) must be observed before the CMD pin can be de-asserted. The command executes after all parameters associated with the command have been sent. If all parameters are not received within 0.5 seconds, the modem returns to Idle Mode. Note: When parameters are sent, they are always two bytes long with the least significant byte sent first.

Commands can be queried for their current value by sending the command logically ORed with the value 0x80 (hexadecimal) with the CMD pin asserted. When the binary value is sent (with no parameters), the current value of the command parameter is sent back through the DO pin.

Figure 3.8. Binary Command Write then Read

Signal #1 is the DIN signal to the modem
 Signal #2 is the DOUT signal from the modem
 Signal #3 is \overline{CTS}
 Signal #4 is CMD

In this particular graph, a value was written to a register and then read out to verify it. While not in the middle of other received data, note that the \overline{CTS} signal (GPO1) outlines the data response out of the modem.



IMPORTANT: For the 900MHZ MODEM to recognize a binary command, RT (GPI1 Configuration) Command must be issued. If binary programming is not enabled (RT != 1), the modem will not recognize the data as binary commands.

RF Communication Options

The 900MHz Modem COM Module can be configured to operate in any of three RF communication modes:

- Streaming
- Acknowledged
- Multi-Transmit

The mode is defined by parameters stored in the transmitting modem [see table below].

Receiving modems automatically adapt to the correct mode on a per-packet basis, based on the contents of each received packet.

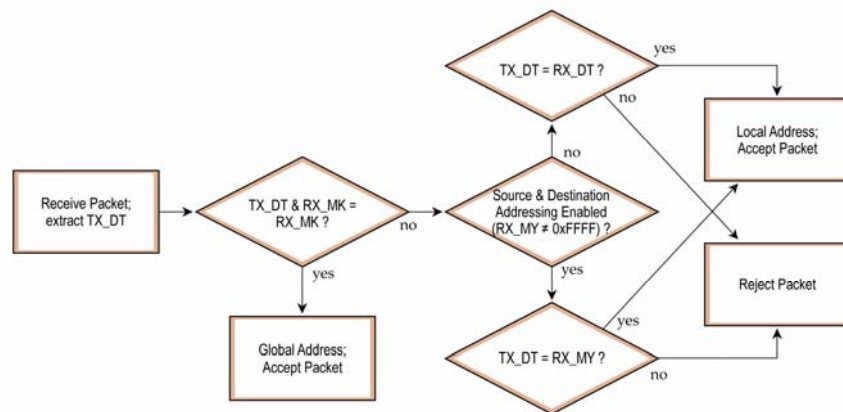
Table 3.2. Mode in Relation to Transmitting Modem Parameter Values

| RF Communication Mode | RR Parameter Value | MT Parameter Value |
|-----------------------|--------------------|--------------------|
| Streaming | 0 | 0 |
| Acknowledged | >= 1 | 0 |
| Multi-Transmit | ignored | >=1 |

Addressing Options

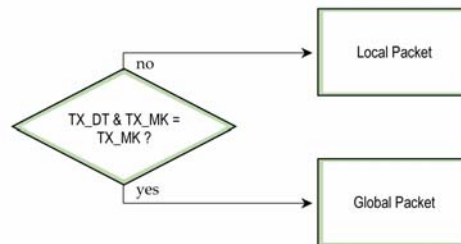
Transmissions can be addressed to a specific modem or group of modems using the DT (Destination Address) and MK (Address Mask) commands. A receiving modem will only accept a packet if it determines the packet is addressed to it, either as a global or local packet. The receiving modem makes this determination by inspecting the destination address of the packet and comparing it to its own address and address mask [Figure 3.10].

Figure 3.9. Address Recognition (@ RX Modem)



The transmitting modem determines whether the packet is intended for a specific node (local address) or multiple nodes (global address) by comparing the packet’s destination address (DT) and its own address mask (MK) [Figure 3.11]. It is assumed that the address masks on the transmitting modem and receiving modem have been programmed to the same value for proper operation in each RF Communication Mode.

Figure 3.10. Address Recognition (@ TX Modem)



Streaming Mode

- Attributes:** Highest data throughput
 Lowest latency and jitter
 Reduced immunity to interference
 Streaming mode transmissions never acknowledged by receiving modem(s)

Required Parameter Values (TX Modem): RR (Retries) = 0

Related Commands: Networking (DT, MK, MY), Serial Interfacing (PK, RB, RO, TT)

Recommended Use: Mode is most appropriate for data that is more sensitive to latency and/or jitter than it is to occasional packet loss. For example: streaming audio or video.

Streaming Mode Connection Sequence

Events up through the 'Transmit Packet' process are common to all three RF Communication Options. Refer to the Transmit Mode section [p 18] for more information.

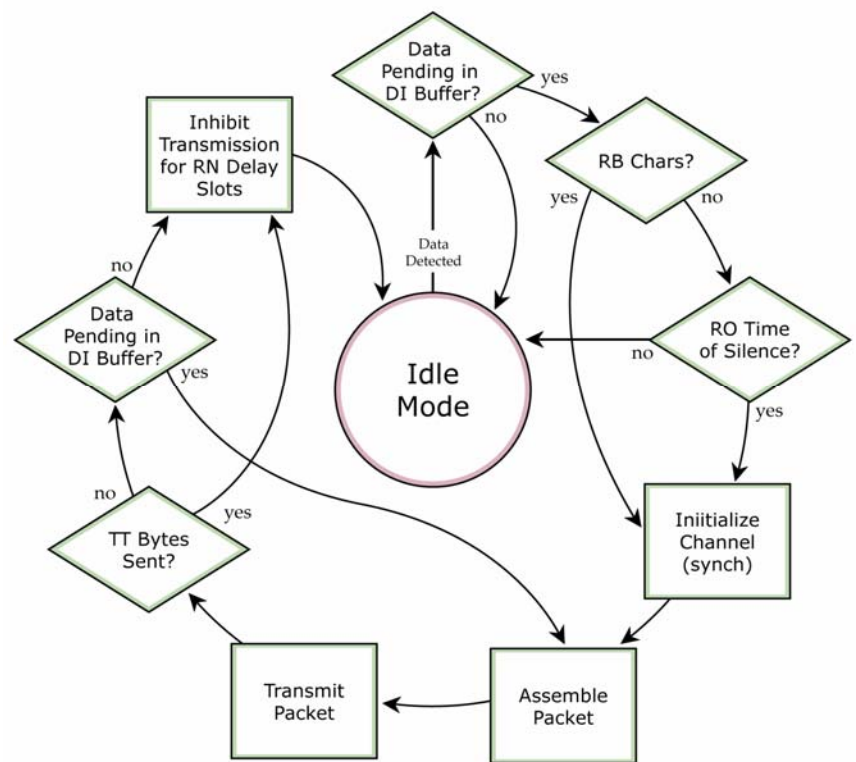
When streaming data, RB and RO parameters are used only on the first packet. After transmission begins, the TX event will continue uninterrupted until the DI buffer is empty or the streaming limit (TT Command) is reached. As with the first packet, the payload of each subsequent packet includes up to the maximum packet size (PK Command).

The streaming limit is specified by the transmitting modem as the maximum number of bytes the transmitting modem can send in one transmission event. If the TT parameter is reached, the transmitting modem will force a random delay of 1 to RN delay slots (exactly 1 delay slot if RN=0).

Subsequent packets are sent without an RF initializer since receiving modems stay synchronized with the transmitting modem for the duration of the transmission event (from preceding packet information). However, due to interference, some receiving modems may lose data (and synchronization to the transmitting modem), particularly during long transmission events.

Once the transmitting modem has sent all pending data or has reached the TT limit, the transmission event ends. The transmitting modem will not transmit again for exactly RN delay slots if the local (i.e. transmitting modem's) RN parameter is set to a non-zero value. The receiving modem(s) will not transmit for a random number of delay slots between 0 and (RN-1) if the local (i.e. receiving modem's) RN parameter is set to a non-zero value. These delays are intended to lessen congestion following long bursts of packets from a single transmitting modem, during which several receiving modems may have become ready to transmit.

Figure 3.11. Streaming Mode State Diagram



Acknowledged Mode

Attributes: Reliable delivery through positive acknowledgements for each packet
Throughput, latency and jitter vary depending on the quality of the channel and the strength of the signal.

Required Parameter Values (TX Modem): RR (Retries) >= 1

Related Commands: Networking (DT, MK, RR), Serial Interfacing (PK, RN, RO, RB, TT)

Recommended Use: Use for applications that require Reliable Delivery. If messages are smaller than 256 bytes, use RB and RO commands to align RF packets to application packets.

Acknowledged Mode Connection Sequence

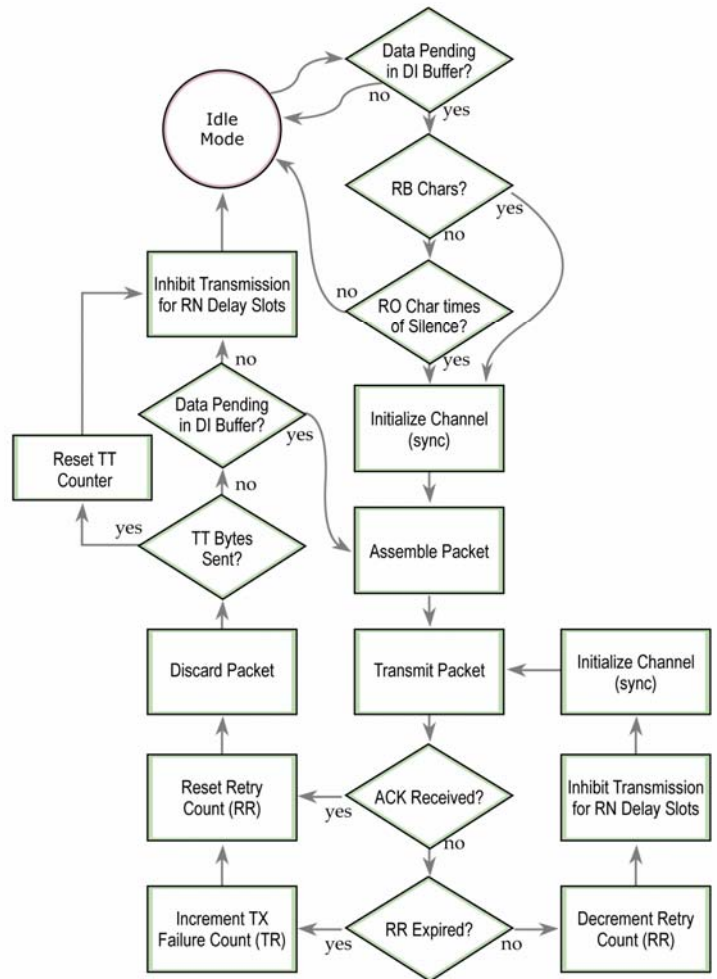
Events up through the 'Transmit Packet' process are common to all three RF Communication Options. Refer to the Transmit Mode section [p 18] for more information.

After sending a packet while in acknowledged mode, the transmitting modem listens for an acknowledgement. If it receives the ACK, it will either move on to sending a subsequent packet (if more transmit data is pending), or will wait for exactly RN random delay slots before allowing another transmission (if no more data is pending to be transmitted).

If the transmitting modem does not receive the ACK within the allotted time, it will retransmit the packet with a new RF initializer following the ACK slot. There is no delay between the first ACK slot and the first retransmission. Subsequent retransmissions incur a delay of a random number of delay slots, between 0 and RN. If RN is set to 0 on the transmitting modem, there are never any back-off delays between retransmissions.

Note that during back-off delays, the transmitting modem will go into Idle Mode and may receive RF data. This can have the effect of increasing the back-off delay, as the radio cannot return to RF transmit (or retransmit) mode as long as it is receiving RF data.

Figure 3.12. Acknowledged Mode State Diagram



After receiving and acknowledging a packet, the receiving modem will move to the next frequency and listen for either a retransmission or new data, for a specific period of time. Even if the transmitting modem has indicated that it has no more pending transmit data, it may have not received the previous ACK, and so may retransmit the packet, possibly with no delay after the ACK slot. In this case, the receiving modem will always detect the immediate retransmission, which will hold off the communications channel and thereby reduce collisions. Receiving modems acknowledge each retransmission they receive, but they only pass the first copy of a packet they receive out the UART.

RB and RO parameters are not applied to subsequent packets, meaning that once transmission has begun, it will continue uninterrupted until the DI buffer is empty or the streaming limit (TT) has been reached. As with the first packet, the payload of each subsequent packet includes up to the maximum packet size (PK), and the transmitting modem checks for more pending data near the end of each packet.

The streaming limit (TT) specifies the maximum number of bytes that the transmitting modem will send in one transmission event, which may consist of many packets and retries. If the TT parameter is reached, the transmitting modem will force a random delay of 1 to RN delay slots (exactly 1 delay slot if RN is zero). Each packet is counted only once toward TT, no matter how many times the packet is retransmitted.

Subsequent packets in acknowledged mode are similar to those in streaming mode, with the addition of an acknowledgement between each packet, and the possibility of retransmissions. Subsequent packets are sent without an RF initializer, as the receiving modems are already synchronized to the transmitting modem from the preceding packet(s) and they remain synchronized for the duration of the transmission event. Each retransmission of a packet includes an RF initializer.

Once the transmitting modem has sent all pending data or has reached the TT limit, the acknowledged transmission event is completed. The transmitting modem will not transmit again for exactly RN delay slots, if the local RN parameter is set to a nonzero value. The receiving modem will not transmit for a random number of delay slots between 0 and (RN-1), if the local RN parameter is set to a nonzero value. These delays are intended to lessen congestion following long bursts of packets from a single transmitting modem, during which several receiving modems may have themselves become ready to transmit.

Multi-Transmit Mode

Attributes: Reliable Delivery through forced transmission of every RF packet
Every RF packet is sent exactly (MT + 1) times with no delays between packets
Diminished throughput and increased latency

Required Parameter Values (TX Modem): MT (Multi-Transmit) ≥ 1

Other Related Commands: Networking (DT, MK, MY, RN, TT), Serial Interfacing (BR, PK, RB, RO), RF Interfacing (FS)

Recommended Use: Use for applications that require Reliable Delivery without using retries and acknowledgements.

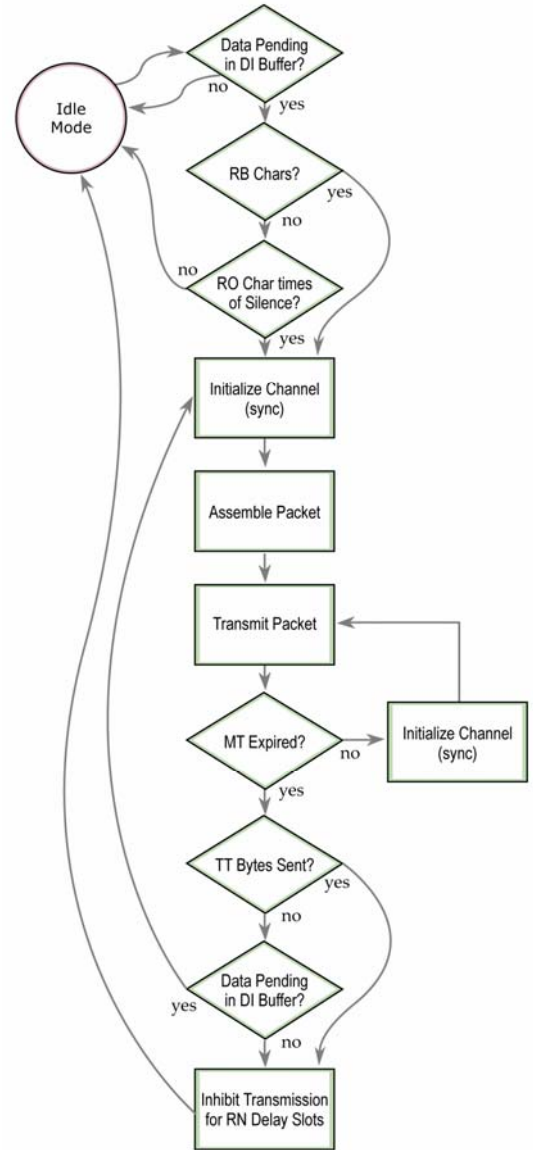
Multi-Transmit Mode Connection Sequence

Events up through the 'Transmit Packet' process are common to all three RF Communication Options. Refer to the Transmit Mode section [p 18] for more information.

In Multi-Transmit mode, each packet is retransmitted MT times, for a total of (MT+1) transmissions. There is no delay between retransmissions, and the transmitting modem will never receive RF data between retransmissions. Each retransmission includes an RF initializer. A transmission event may include follow-on packets, each of which will be retransmitted MT times. The Forced Sync (FS) parameter is ignored in multiple-transmission mode. The RB and RO parameters are not applied to follow-on packets, meaning that once transmission has begun, it will continue uninterrupted until the DI buffer is empty or the streaming limit (TT) has been reached. As with the first packet, the payload of each follow-on packet includes up to the maximum packet size (PK) bytes, and the transmitting modem checks for more pending data near the end of each packet. Follow-on packets are not sent until all retransmissions of the previous packet are finished. The streaming limit (TT) is specified at the transmitting modem as the maximum number of bytes that the transmitting modem can send in one transmission event, which may consist of many packets. If the TT parameter is reached, the transmitting modem will force a random delay of 1 to RN delay slots (exactly 1 delay slot if RN is zero). In Multi-Transmit mode, each packet is counted only once when tracking the streaming limit (TT), no matter how many times it is retransmitted.

When a receiving modem receives a Multi-Transmit packet, it calculates the amount of time remaining in the Multi-Transmit event, and inhibits its own transmissions for the duration of the Multi-Transmit event, plus a random number of delay slots between 0 and (RN-1). If the local RN parameter is zero, the delay is only for the calculated duration of the Multi-Transmit event. Thus, a receiving modem need only receive one of the transmissions, and it will keep off the channel until the transmitting modem is done. If follow-on packets are coming, the receiving modems will move to the new frequency and listen for the follow-on packet for a specific period of time.

Figure 3.13. – Multi-Transmit Mode State Diagram



4. Command and Control

Command Descriptions (Short)

Table 4.1. 900MHZ MODEM Commands (“d” denotes decimal equivalent)

| AT Command | Binary Command | AT Command Name | Parameter Range | Command Category | # Bytes Returned | Factory Default |
|------------|----------------|---------------------------------|---|-----------------------|------------------|------------------|
| %V | 0x3B (59d) | Board Voltage | 0x2CCCA – 0x5BFFA [read-only] | Diagnostics | 2 | - |
| AM | 0x40 (64d) | Auto-set MY | 0 – 0xFFFF | Networking & Security | 2 | - |
| AT | 0x05 (5d) | Guard Time After | 2 - (ATST-3) [x 100 msec] | Command Mode Options | 2 | 0x0A (10d) |
| BD | 0x15 (21d) | Baud Rate (Serial Data Rate) | 0 - 8 | Serial Interfacing | 1 | 3 |
| BR | 0x39 (57d) | RF Data Rate | 0 - 1 | RF Interfacing | 1 | 1 |
| BT | 0x04 (4d) | Guard Time Before | 0 – 0xFFFF [x 100 msec] | Command Mode Options | 2 | 0x0A (10d) |
| CC | 0x13 (19d) | Command Sequence Character | 0x20 - 0x7F | Command Mode Options | 1 | 0x2B [“+”] (43d) |
| CD | 0x28 (40d) | GPO2 Configuration | 0 - 2 | Serial Interfacing | 1 | 2 |
| CF | - | Number Base | 0 - 2 | Command Mode Options | 1 | 1 |
| CN | 0x09 (9d) | Exit Command Mode | - | Command Mode Options | - | - |
| CS | 0x1F (31d) | GPO1 Configuration | 0 - 4 | Serial Interfacing | 1 | 0 |
| CT | 0x06 (6d) | Command Mode Timeout | 2 – 0xFFFF [x 100 ms] | Command Mode Options | 2 | 0xC8 (200d) |
| DB | 0x36 (54d) | Received Signal Strength | 0x6E to 0x28 [read-only] | Diagnostics | 1 | - |
| DT | 0x00 (0d) | Destination Address | 0 - 0xFFFF | Networking & Security | 2 | 0 |
| E0 | 0x0A (10d) | Echo Off | - | Command Mode Options | - | - |
| E1 | 0x0B (11d) | Echo On | - | Command Mode Options | - | - |
| ER | 0x0F (15d) | Receive Error Count | 0 – 0xFFFF | Diagnostics | 2 | 0 |
| FH | 0x0D (13d) | Force Wake-up Initializer | - | Sleep (Low Power) | - | - |
| FL | 0x07 (7d) | Software Flow Control | 0 - 1 | Serial Interfacing | 1 | 0 |
| FS | 0x3E (62d) | Forced Sync Time | 1 – 0xFFFF [x 10 msec] | RF Interfacing | 2 | 0 |
| FT | 0x24 (36d) | Flow Control Threshold | 0 – DI Buffer size (bytes) | Serial Interfacing | 2 | varies |
| GD | 0x10 (16d) | Receive Good Count | 0 – 0xFFFF | Diagnostics | 2 | 0 |
| HP | 0x11 (17d) | Hopping Channel | 0 - 9 | Networking & Security | 1 | 0 |
| HT | 0x03 (3d) | Time before Wake-up Initializer | 0 – 0xFFFF [x 100 msec] | Sleep (Low Power) | 2 | 0xFFFF (65535d) |
| HV | - | Hardware Version | 0 – 0xFFFF [read-only] | Diagnostics | 2 | 0x14FF (5375d) |
| ID | 0x27 (39d) | Modem VID | 0 - 0x7FFF (user-settable) 0x8000 - 0xFFFF [factory-set] | Networking & Security | 2 | 0x3332 (13106d) |
| KY | 0x3C (60d) | AES Encryption Key | 0 – (Any other 64-digit hex valid key) | Networking & Security | 2 | 0 |
| LH | 0x0C (12d) | Wake-up Initializer Timer | 0 – 0xFF [x 100 msec] | Sleep (Low Power) | 2 | 1 |
| MK | 0x12 (18d) | Address Mask | 0 - 0xFFFF | Networking & Security | 2 | 0xFFFF (65535d) |
| MT | 0x3D (61d) | Multi-Transmit | 0 – 0xFF | Networking & Security | 1 | 0 |
| MY | 0x2A (42d) | Source Address | 0 - 0xFFFF | Networking & Security | 2 | 0xFFFF (65535d) |
| NB | 0x23 (35d) | Parity | 0 - 4 | Serial Interfacing | 1 | 0 |
| PK | 0x29 (41d) | Maximum RF Packet Size | 1 – 0x800 [Bytes] | RF Interfacing | 2 | 0x800 (2048d) |
| PL | 0x3A (58d) | TX Power Level | 0 - 4 | RF Interfacing | 1 | 4 [1 Watt] |
| PW | 0x1D (29d) | Pin Wake-up | 0 - 1 | Sleep (Low Power) | 1 | 0 |
| RB | 0x20 (32d) | Packetization Threshold | 1 - Current value of PK | Serial Interfacing | 2 | 0x800 (2048d) |
| RC | - | Ambient Power - Single Channel | 0 – 0x31 [dBm, read-only] | Diagnostics | 1 | - |
| RE | 0x0E (14d) | Restore Defaults | - | (Special) | - | - |
| RM | - | Ambient Power - All Channels | No parameter – 0x7D0 [read-only] | Diagnostics | 2 | - |
| RN | 0x19 (25d) | Delay Slots | 0 – 0xFF (slots) | Networking & Security | 1 | 0 |
| RO | 0x21 (33d) | Packetization Timeout | 0 – 0xFFFF [x UART character time] | Serial Interfacing | 2 | 3 |
| RP | 0x22 (34d) | RSSI PWM Timer | 0 – 0xFF [x 100 msec] | Diagnostics | 1 | 0x20 (32d) |
| RR | 0x18 (24d) | Retries | 0 – 0xFF | Networking & Security | 1 | 0x0A (10d) |
| RT | 0x16 (22d) | GPI1 Configuration | 0 - 2 | Serial Interfacing | 1 | 0 |
| SB | 0x37 (55d) | Stop Bits | 0 - 1 | Serial Interfacing | 1 | 0 |
| SH | 0x25 (37d) | Serial Number High | 0 – 0xFFFF [read-only] | Diagnostics | 2 | varies |

| | | | | | | |
|----|------------|----------------------------|--------------------------------|-----------------------|---|-------------|
| SL | 0x26 (38d) | Serial Number Low | 0 - 0xFFFF [read-only] | Diagnostics | 2 | varies |
| SM | 0x01 (1d) | Sleep Mode | 0 - 2, 4 - 8; 3 reserved | Sleep (Low Power) | 1 | 0 |
| ST | 0x02 (2d) | Time before Sleep | (ATAT+3) - 0x7FFF [x 100 msec] | Sleep (Low Power) | 2 | 0x64 (100d) |
| TP | 0x38 (56d) | Board Temperature | 0 - 0x7F [read-only] | Diagnostics | 1 | - |
| TR | 0x1B (27d) | Delivery Failure Count | 0 - 0xFFFF [read-only] | Diagnostics | 2 | 0 |
| TT | 0x1A (26d) | Streaming Limit | 0 - 0xFFFF [0 = disabled] | Networking & Security | 2 | 0 |
| TX | 0x3F (63d) | Transmit Only | 0 - 1 | RF Interfacing | 1 | 0 |
| VL | - | Firmware Version - verbose | Returns string | Diagnostics | - | - |
| VR | 0x14 (20d) | Firmware Version | 0 - 0xFFFF [read-only] | Diagnostics | 2 | - |
| WA | - | Active Warning Numbers | Returns string | Diagnostics | - | - |
| WN | - | Warning Data | Returns string | Diagnostics | - | - |
| WR | 0x08 (8d) | Write | - | (Special) | - | - |
| WS | - | Sticky Warning Numbers | Returns string | Diagnostics | - | - |

* Firmware version in which the command and parameter options were first supported.

Command Descriptions (long)

Commands in this section are listed alphabetically. Command categories are designated between the "< >" symbols that follow each command title. By default, 232-485 COM Modules expect numerical values in hexadecimal since the default value of the CF (Number Base) Parameter is '1'. Hexadecimal values are designated by the "0x" prefix and decimal values by the "d" suffix.

%V (Board Voltage) Command

<Diagnostics> %V Command is used to read the current voltage of the RS232-485 Module circuit board.

Sample Output: 5.02 V (when ATCF = 0)
5051F (when ATCF = 1) *
5.02 (when ATCF = 2)

AT Command: AT%V

Binary Command: 0x3B (59 decimal)

Parameter Range (read-only):
0x2CCCA - 0x5BFFA
(2.80 - 5.75 decimal)

Number of bytes returned: 2

* When CF = 1 (default), a hex integer is shown that is equal to (voltage * 65536d).

AM (Auto-set MY) Command

<Networking & Security> AM Command is used to automatically set the MY (Source Address) parameter from the factory-set modem serial number. The address is formed with bits 29, 28 and 13-0 of the serial number (in that order). The value is displayed as a result of this command.

AT Command: ATAM

Binary Command: 0x40 (64 decimal)

Parameter Range: 0 - 0xFFFF

AT (Guard Time After) Command

<Command Mode Options> AT Command is used to set/read the time-of-silence that follows the command sequence character (CC Command). By default, 1 second must elapse before and after the command sequence character.

The default sequence used to enter AT Command Mode is as follows:

- No characters sent for 1 second [BT (Guard Time Before) Command]
- Send three plus characters "+++" [CC (Command Sequence Character) Command]
- No characters sent for 1 second [AT (Guard Time After) Command]

AT Command: ATAT

Binary Command: 0x05 (5 decimal)

Parameter Range: 2 - (ATST-3), up to 0x7FFC
[x 100 milliseconds]

Default Parameter Value: 0x0A (10 decimal)

Number of bytes returned: 2

Related Commands: BT (Guard Time Before),
CC (Command Sequence Character)

All of the values in this sequence can be adjusted. AT Command is used to adjust the period of silence that follows the command sequence character.

BD (Baud Rate) Command

<Serial Interfacing> BD Command is used to set/read the interface data rate (the rate at which serial data is sent to the modem from a host). Newly modified serial data rates do not take effect until the modem exits Command Mode [refer to CN (Exit Command Mode) and CT (Command Mode Timeout) Commands].

The BR (RF Data Rate) Parameter is not affected by the BD Command.

Note: If the serial data rate is set to exceed the fixed RF data rate of the 900MHZ MODEM, \overline{CTS} flow control may need to be implemented. Refer to the Flow Control [p15] and CS (GPO1 Configuration Command [p32] sections for more information.

AT Command: ATBD

Binary Command: 0x15 (21 decimal)

Parameter Range: 0 - 8

| Parameter Value | BAUD (bps) Configuration |
|-----------------|--------------------------|
| 0 | 1200 |
| 1 | 2400 |
| 2 | 4800 |
| 3 | 9600 |
| 4 | 19200 |
| 5 | 38400 |
| 6 | 57600 |
| 7 | 115200 |
| 8 | 230400 |

Default Parameter Value: 3

Number of bytes returned: 1

BR (RF Data Rate) Command

<RF Interfacing> BR Command is used to set/read the RF data rate (rate that RF data is transmitted over-the-air) of the modem.

AT Command: ATBR

Binary Command: 0x39 (57 decimal)

Parameter Range: 0 - 1

| Parameter Value | BAUD (bps) Configuration |
|-----------------|--------------------------|
| 0 | 9600 |
| 1 | 115200 |

Default Parameter Value: 1

Number of bytes returned: 1

BT (Guard Time Before) Command

<Command Mode Options> BT Command is used to set/read the time-of-silence that precedes the command sequence character (CC Command) of the AT Command Mode Sequence.

The default sequence used to enter AT Command Mode is as follows:

- No characters sent for 1 second [BT (Guard Time Before) Command]
- Send three plus characters "+++" [CC (Command Sequence Character) Command]
- No characters sent for 1 second [AT (Guard Time After) Command]

All values in the sequence can be modified.

AT Command: ATBT

Binary Command: 0x04 (4 decimal)

Parameter Range: 0 - 0xFFFF
[x 100 milliseconds]

Default Parameter Value: 0x0A (10 decimal)

Number of bytes returned: 2

Related Commands: AT (Guard Time After), CC (Command Sequence Character)

CC (Command Sequence Character) Command

<Command Mode Options> CC Command is used to set/read the ASCII character used between Guard Times of the AT Command Mode Sequence (BT+ CC + AT). The AT Command Mode Sequence activates AT Command Mode (from Idle Mode).

The default sequence used to enter AT Command Mode is as follows:

- No characters sent for 1 second [BT (Guard Time Before) Command]
- Send three plus characters "+++" [CC (Command Sequence Character) Command]
- No characters sent for 1 second [AT (Guard Time After) Command]

All of the values in this sequence can be adjusted.

| |
|---|
| AT Command: ATCC |
| Binary Command: 0x13 (19 decimal) |
| Parameter Range: 0x20 - 0x7F |
| Default Parameter Value: 0x2B (ASCII "+" sign) |
| Number of bytes returned: 1 |
| Related Commands: AT (Guard Time After), BT (Guard Time Before) |

CD (GPO2 Configuration) Command

<Serial Interfacing> CD Command is used to select/read the behavior of the GPO2 line.

| AT Command: ATCD | | | | | | | | |
|---|-----------------|---------------|---|--------|---|--------------|---|-------------|
| Binary Command: 0x28 (40 decimal) | | | | | | | | |
| Parameter Range: 0 - 2 | | | | | | | | |
| <table border="1"> <thead> <tr> <th>Parameter Value</th> <th>Configuration</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>RX LED</td> </tr> <tr> <td>1</td> <td>Default high</td> </tr> <tr> <td>2</td> <td>Default low</td> </tr> </tbody> </table> | Parameter Value | Configuration | 0 | RX LED | 1 | Default high | 2 | Default low |
| Parameter Value | Configuration | | | | | | | |
| 0 | RX LED | | | | | | | |
| 1 | Default high | | | | | | | |
| 2 | Default low | | | | | | | |
| Default Parameter Value: 2 | | | | | | | | |
| Number of bytes returned: 1 | | | | | | | | |

CF (Number Base) Command

<Command Mode Options> CF command is used to set/read command formatting setting.

The following commands are always entered and read in hex, no matter the CF setting:

VR (Firmware Version), HV (Hardware Version), KY (AES Encryption Key).

| AT Command: ATCF | | | | | | | | |
|--|---|---------------|---|---|---|--|---|---|
| Binary Command: 0x1F (31 decimal) | | | | | | | | |
| Parameter Range: 0 - 2 | | | | | | | | |
| <table border="1"> <thead> <tr> <th>Parameter Value</th> <th>Configuration</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>Commands utilize default number base; decimal commands may output units</td> </tr> <tr> <td>1</td> <td>All commands are forced to unsigned, unit-less hex</td> </tr> <tr> <td>2</td> <td>Commands utilize their default number base; no units are output</td> </tr> </tbody> </table> | Parameter Value | Configuration | 0 | Commands utilize default number base; decimal commands may output units | 1 | All commands are forced to unsigned, unit-less hex | 2 | Commands utilize their default number base; no units are output |
| Parameter Value | Configuration | | | | | | | |
| 0 | Commands utilize default number base; decimal commands may output units | | | | | | | |
| 1 | All commands are forced to unsigned, unit-less hex | | | | | | | |
| 2 | Commands utilize their default number base; no units are output | | | | | | | |
| Default Parameter Value: 1 | | | | | | | | |
| Number of bytes returned: 1 | | | | | | | | |

CN (Exit Command Mode) Command

<Command Mode Options> CN Command is used to explicitly exit AT Command Mode.

| |
|----------------------------------|
| AT Command: ATCN |
| Binary Command: 0x09 (9 decimal) |

CS (GP01 Configuration) Command

<Serial Interfacing> CS Command is used to select the behavior of the GP01 pin. This output can provide RS-232 flow control, control the TX enable signal (for RS-485 or RS-422 operations), or set the default level for the I/O line passing function.

By default, GP01 provides RS-232 $\overline{\text{CTS}}$ (Clear-to-Send) flow control.

AT Command: ATCS

Binary Command: 0x1F (31 decimal)

Parameter Range: 0 – 4

| Parameter Value | Configuration |
|-----------------|---|
| 0 | RS-232 $\overline{\text{CTS}}$ flow control |
| 1 | RS-485 TX enable low |
| 2 | high |
| 3 | RS-485 TX enable high |
| 4 | low |

Default Parameter Value: 0

Number of bytes returned: 1

Related Commands: RT (GPI1 Configuration), TO (GP01 Timeout)

DB (Received Signal Strength) Command

<Diagnostics> DB Command is used to read the receive signal strength (in decibels relative to milliWatts) of the last received packet. This parameter is useful in determining range characteristics of 900MHZ MODEM s under various conditions.

In default mode, this command shows the power level in signed decimal format, with the units (dBm). If CF is set to 1, the magnitude of the value is presented in unsigned hex. If CF is set to 2, the value is presented in decimal, but without the units.

Sample Output: -88 dBm (when ATCF = 0)
 58 (when ATCF = 1)
 -88 (when ATCF = 2)

AT Command: ATDB

Binary Command: 0x36 (54 decimal)

Parameter Range (read-only):
0x6E – 0x28
(-110 to -40 Decimal)

Number of bytes returned: 1

Related Command: CN (Exit Command Mode)

DT (Destination Address) Command

<Networking & Security> DT Command is used to set/read the networking address of the 900MHZ MODEM . 900MHZ MODEM s uses three network layers –Vendor Identification Number (ATID), Channels (ATHP), and Destination Addresses (ATDT). DT Command assigns an address to a modem that enables it to communicate only with other modems having the same addresses. All modems that share the same Destination Address can communicate freely with each other.

Modems in the same network with a different Destination Address (than that of the transmitter) will listen to all transmissions to stay synchronized, but will not send any of the data out their serial ports.

AT Command: ATDT

Binary Command: 0x00

Parameter Range: 0 – 0xFFFF

Default Parameter Value: 0

Number of bytes returned: 2

Related Commands: HP (Hopping Channel), ID (Modem VID), MK (Address Mask)

E0 (Echo Off) Command

<Command Mode Options> E0 Command turns off character echo in AT Command Mode. By default, echo is off.

AT Command: ATE0

Binary Command: 0x0A (10 decimal)

E1 (Echo On) Command

<Command Mode Options> E1 Command turns on the character echo in AT Command Mode. Each typed character will be echoed back to the terminal when ATE1 is active. E0 is the default.

AT Command: ATE1
Binary Command: 0x0B (11 decimal)

ER (Receive Error Count) Command

<Diagnostics> Set/Read the number of receive-errors. The error count records the number of packets partially received then aborted on a reception error. This value returns to 0 after a reset and is not non-volatile (Value does not persist in the modem’s memory after a power-up sequence). Once the Receive Error Count reaches its maximum value (up to 0xFFFF), it remains at its maximum count value until the maximum count value is explicitly changed or the modem is reset.

The ER parameter is not reset by pin, serial port or cyclic sleep modes.

AT Command: ATER
Binary Command: 0x0F (15 decimal)
Parameter Range: 0 – 0xFFFF
Default Parameter Value: 0
Number of bytes returned: 2
Related Commands: GD (Receive Good Count)

FH (Force Wake-up Initializer) Command

<Sleep (Low Power)> FH Command is used to force a Wake-up Initializer to be sent on the next transmission. WR (Write) Command does not need to be issued with FH Command.

Use only with cyclic sleep modes active on remote modems.

AT Command: ATFH
Binary Command: 0x0D (13 decimal)

FL (Software Flow Control) Command

<Serial Interfacing> FL Command is used to configure software flow control. Hardware flow control is implemented with the 900MHZ MODEM as the GP01 pin (\overline{CTS}), which regulates when serial data can be transferred to the modem.

FL Command can be used to allow software flow control to also be enabled. XON character used is 0x11 (17 decimal). XOFF character used is 0x13 (19 decimal).

AT Command: ATFL
Binary Command: 0x07 (7 decimal)
Parameter Range: 0 – 1

| Parameter Value | Configuration |
|-----------------|-------------------------------|
| 0 | Disable software flow control |
| 1 | Enable software flow control |

Default Parameter Value: 0
Number of bytes returned: 1

FS (Forced Synch Time) Command

<RF Interfacing> FS Command only applies to streaming data. Normally, only the first packet of a continuous stream has the full RF initializer. The modems then remain synchronized for subsequent packets of the stream. This parameter can be used to periodically force an RF initializer during such streaming. Any break in UART character reception long enough to drain the DI Buffer (UART receive buffer) and cause a pause in RF data transmission will also cause an RF initializer to be inserted on the next transmission.

AT Command: ATFS
Binary Command: 0x3E (62 decimal)
Parameter Range: 0 – 0xFFFF
[x 10 milliseconds]
Default Parameter Value: 0
Number of bytes returned: 2

FT (Flow Control Threshold) Command

<Serial Interfacing> Set/Read the flow control threshold. When FT bytes have accumulated in the DI buffer, $\overline{\text{CTS}}$ is de-asserted or the XOFF software flow control character is transmitted.

AT Command: ATFT

Binary Command: 0x24 (36 decimal)

Parameter Range: 0 - (Receive buffer size minus 0x11 bytes)

Default Parameter Value: DO Buffer size minus 0x11 (decimal 17)

Number of bytes returned: 2

GD (Receive Good Count) Command

<Diagnostics> Set/Read the count of good received RF packets. Parameter value is reset to 0 after every reset and is not non-volatile (Value does not persist in the modem's memory after a power-up sequence). Once the "Receive Good Count" reaches its maximum value (up to 0xFFFF), it remains at its maximum count value until the maximum count value is manually changed or the modem is reset.

AT Command: ATGD

Binary Command: 0x10 (16 decimal)

Parameter Range: 0 - 0xFFFF

Default Parameter Value: 0

Number of bytes returned: 2

Related Commands: ER (Receive Error Count)

The GD parameter is not reset by pin, serial port or cyclic sleep modes.

HP (Hopping Channel) Command

<Networking & Security> HP Command is used to set/read the modem's hopping channel number. A channel is one of three layers of addressing available to the 900MHZ MODEM .

AT Command: ATHP

Binary Command: 0x11 (17 decimal)

Parameter Range: 0 - 9

Default Parameter Value: 0

Number of bytes returned: 1

Related Commands: ID (Modem VID), DT (Destination Address), MK (Address Mask)

In order for modems to communicate with each other, the modems must have the same channel number since each channel uses a different hopping sequence. Different channels can be used to prevent modems in one network from listening to transmissions of another.

HT (Time before Wake-up Initializer) Command

<Sleep (Low Power)> Set/read time of inactivity (no serial or RF data is sent or received) before a wake-up initializer is sent by a TX modem. HT should be set shorter than inactivity timeout [ST Command] time of any RX modems operating in Cyclic Sleep (SM=4-8). The wake-up initializer sent by the TX modem instructs all RX modems to remain awake to receive RF data.

AT Command: ATHT

Binary Command: 0x03 (3 decimal)

Parameter Range: 0 - 0xFFFF
[x 100 milliseconds]

Default Parameter Value: 0xFFFF (wake-up initializer will not be sent)

Number of bytes returned: 2

Related Commands: LH (Wake-up Initializer Timer), SM (Sleep Mode), ST (Time before Sleep)

From the RX modem perspective: After HT time elapses and the inactivity timeout [ST Command] is met, the RX modem goes into cyclic sleep. In cyclic sleep, the RX modem wakes once per sleep interval [SM Command] to check for a wake-up initializer. When a wake-up initializer is detected, the modem stays awake to receive data. The wake-up initializer must be longer than the cyclic sleep interval to ensure that sleeping modems detect incoming data.

When HT time elapses, the TX modem knows it needs to send a wake-up Initializer for all RX modems to remain awake and receive the next transmission.

HV (Hardware Version) Command

<Diagnostics> HV Command is used to read the hardware version of the modem.

AT Command: ATHV

Parameter Range (read-only): 0 – 0xFFFF

Default Parameter Value: 0x14FF (5375d)

Number of bytes returned: 2

ID (Modem VID) Command

<Networking & Security> ID Command is used to set/read the VID (Vendor Identification Number) of the modem. Modems must have matching VIDs in order to communicate.

AT Command: ATID

Binary Command: 0x27 (39 decimal)

Parameter Range:

0 – 0x7FFF (user-settable)

0x8000 – 0xFFFF (factory-set)

Default Parameter Value: 0x3332 (13106d)

Number of bytes returned: 2

KY (AES Encryption Key) Command

<Networking & Security> KY Command is used to set the 256-bit AES (Advanced Encryption Standard) key for encryption/decryption of data. Once set, the key cannot be read out of the modem by any means. The entire payload of the packet is encrypted using the key and the CRC is computed across the ciphertext. When encryption is turned on, each packet carries an additional 16 bytes to convey the random CBC Initialization Vector (IV) to the receiver(s).

AT Command: ATKY

Binary Command: 0x3C (60 decimal)

Parameter Range:

0 – (any other 64-digit hex valid key)

Default Parameter Value: 0 (disabled)

Number of bytes returned: 2

Number Base: Always Hexadecimal

A modem with the wrong key (or no key) will still receive encrypted data, but the resultant data driven out the serial port will be meaningless. Likewise, a modem with a key will still receive unencrypted data sent from a modem without a key, but the output will be meaningless.

Because CBC mode is utilized, repetitive data appears different in different transmissions due to the randomly-generated IV.

LH (Wake-up Initializer Timer) Command

<Sleep (Low Power)> LH Command is used to set/read the duration of time for which the wake-up initializer is sent. When receiving modems are put into Cyclic Sleep Mode, they power-down after a period of inactivity [specified by ST (Time before Sleep) Command] and will periodically awaken and listen for transmitted data. In order for the receiving modems to remain awake, they must detect ~35ms of the wake-up initializer.

AT Command: ATLH

Binary Command: 0x0C (12 decimal)

Parameter Range: 0 – 0xFF

[x 100 milliseconds]

Default Parameter Value: 1

Number of bytes returned: 1

Related Commands: HT (Time before Wake-up Initializer), SM (Sleep Mode), ST (Time before Sleep)

LH Command must be used whenever a receiver is operating in Cyclic Sleep Mode. This lengthens the Wake-up Initializer to a specific amount of time (in tenths of a second). The Wake-up Initializer Time must be longer than the cyclic sleep time that is determined by SM (Sleep Mode) Command. If the wake-up initializer time were less than the Cyclic Sleep interval, the connection would be at risk of missing the wake-up initializer transmission.

Refer to Figures 4.3 & 4.4 of the SM Command description to view diagrams of correct and incorrect configurations. The images help visualize the importance that the value of LH be greater than the value of SM.

MK (Address Mask) Command

<Networking & Security> MK Command is used to set/read the "Address Mask". All data packets contain the Destination Address of the transmitting modem.

When an RF data packet is received, the transmitter's Destination Address is logically "ANDed" (bitwise) with the Address Mask of the receiver. The resulting value must match the Destination Address or the Address Mask of the receiver for the packet to be received and sent out the modem's DO serial port. If the "ANDed" value does not match either the Destination Address or the Address Mask of the receiver, the packet is discarded. (All "0" values are treated as "irrelevant" values and are ignored.)

AT Command: ATMK

Binary Command: 0x12 (18 decimal)

Parameter Range: 0 - 0xFFFF

Default Parameter Value: 0xFFFF (65535d)

Destination address (DT parameter) of the transmitting modem must exactly match the destination address of the receiving modem.

Number of bytes returned: 2

Related Commands: DT (Destination Address), HP (Hopping Channel), ID (Modem VID), MY (Source Address)

MT (Multi-Transmit) Command

<Networking & Security> MT packets do not request an acknowledgement from the receiving modem(s). MT takes precedence over RR, so if both MT and RR are non-zero, then MT+1 packets will be sent, with no ACK requests.

When a receiving modem receives a packet with remaining forced retransmissions, it calculates the length of the packet and inhibits transmission for the amount of time required for all retransmissions. Thereafter, a random number of delay slots are inserted between 0 and RN before transmission is allowed from the receiving modem(s). This prevents all listening modems from transmitting at once upon conclusion of a multiple transmission event, as long as RN is non-zero.

Comment: Actual number of forced transmissions is the parameter value plus one. For example, if MT=1, two transmissions of each packet will be sent.

AT Command: ATMT

Binary Command: 0x3D (61 decimal)

Parameter Range: 0 - 0xFF

Default Parameter Value: 0 (no forced retransmissions)

Number of bytes returned: 1

Related Commands: Networking (DT, MK, MY, RN, TT), Serial Interfacing (BR, PK, RB, RO), RF Interfacing (FS)

MY (Source Address) Command

<Networking & Security> Set/Read the source address of the modem.

AT Command: ATMY

Binary Command: 0x2A (42 decimal)

Parameter Range: 0 - 0xFFFF

Default Parameter Value: 0xFFFF (Disabled - DT (Destination Address) parameter serves as both source and destination address.)

Number of bytes returned: 2

Related Commands: DT (Destination Address), HP (Hopping Channel), ID (Modem VID), MK (Address Mask)

NB (Parity) Command

<Serial Interfacing> Select/Read parity settings for UART communications.

AT Command: ATNB

Binary Command: 0x23 (35 decimal)

Parameter Range: 0 - 4

| Parameter Value | Configuration |
|-----------------|---|
| 0 | 8-bit (no parity or 7-bit (any parity)) |
| 1 | 8-bit even |
| 2 | 8-bit odd |
| 3 | 8-bit mark |
| 4 | 8-bit space |

Default Parameter Value: 0

Number of bytes returned: 1

PK (Maximum RF Packet Size) Command

<RF Interfacing> PK Command is used to set/read the maximum size of RF packets. The maximum packet size can be used along with RB/RO to implicitly set the channel dwell time.

If PK is set above 256 and BR is subsequently changed to 0, then PK will automatically be lowered to 256 and a warning will be raised (see BR (RD Data Rate) and WN (Warning Data) Commands for details).

Changes to this parameter may have a secondary effect on the RB (Packet Control Characters) Parameter. RB must always be less than or equal to PK. If PK is changed to a value less than the current value of RB, RB is automatically lowered to be equal to PK.

* When BR = 0, the maximum PK value is 0x100 (256d). When BR = 1, the maximum PK value is 0x800 (2048d).

AT Command: ATPK

Binary Command: 0x29 (41 decimal)

Parameter Range: 0 - 0x800 [Bytes]

Default Parameter Value: 0x800*
(2048 decimal)

Number of bytes returned: 2

Related Commands: BR (RF Data Rate) RB (Packetization Threshold), RO (Packetization Timeout), WN (Warning Data)

PL (Power Level) Command

<RF Interfacing> PL Command is used to set/read the power level at which the modem transmits.

AT Command: ATPL

Binary Command: 0x3A (58 decimal)

Parameter Range: 0 - 4

| Parameter Value | Configuration |
|-----------------|------------------|
| 0 | 1 mW |
| 1 | 10 mW |
| 2 | 100 mW |
| 3 | 500 mW |
| 4 | 1000 mW (1 Watt) |

Default Parameter Value: 4

Number of bytes returned: 1

PW (Pin Wake-up) Command

<Sleep (Low Power)> Under normal operation, a modem in Cyclic Sleep Mode cycles from an active state to a low-power state at regular intervals until data is ready to be received. If the PW Parameter is set to 1, the SLEEP Pin can be used to awaken the modem from Cyclic Sleep. If the SLEEP Pin is de-asserted (low), the modem will be fully operational and will not go into Cyclic Sleep.

Once SLEEP is asserted, the modem will remain active for the period of time specified by ST (Time before Sleep) Command, and will return to Cyclic Sleep Mode (if no data is ready to be transmitted). PW Command is only valid if Cyclic Sleep has been enabled.

| AT Command: ATPW | |
|---|---------------|
| Binary Command: 0x1D (29 decimal) | |
| Parameter Range: 0 - 1 | |
| Parameter Value | Configuration |
| 0 | Disabled |
| 1 | Enabled |
| Default Parameter Value: 0 | |
| Number of bytes returned: 1 | |
| Related Commands: SM (Sleep Mode), ST (Time before Sleep) | |

RB (Packetization Threshold) Command

<Serial Interfacing> RF transmission will commence when data is in the DI Buffer and either of the following criteria are met:

- RO character times of silence on the UART receive lines (ignored if RO = 0)
- RB characters have been received by the UART (ignored if RB = 0)

If PK is lowered below the value of RB, RB is automatically lowered to match PK.

Note: RB and RO criteria only apply to the first packet of a multi-packet transmission. If data remains in the DI Buffer after the first packet, transmissions will continue in streaming manner until there is no data left in the DI Buffer (UART receive buffer).

| | |
|--|--|
| AT Command: ATRB | |
| Binary Command: 0x20 (32 decimal) | |
| Parameter Range: 0 - Current value of PK Parameter (up to 0x800 Bytes) | |
| Default Parameter Value: 0x800 | |
| Number of bytes returned: 2 | |
| Related Commands: BR (RF Data Rate), PK (RF Packet Size), RO (Packetization Timeout) | |

RC (Ambient Power – Single Channel) Command

<Diagnostics> RC Command is used to examine and report the power level on a given channel.

Sample output: -78 dBm [when CF = 0]
4e [when CF = 1]
-78 [when CF = 2]

| | |
|---|--|
| AT Command: ATRC | |
| Parameter Range (read-only): 0 - 0x31 [dBm] | |
| Number of bytes returned: 1 | |
| Related Commands: RM (Ambient Power - All channels) | |

RE (Restore Defaults) Command

<Diagnostics> RE Command is used to restore all configurable parameters to factory default settings. However, RE Command will not write the default values to non-volatile (persistent) memory. Unless the WR (Write) Command is issued after the RE command, the restored default settings will not be saved in the event of modem reset or power-down.

| | |
|-----------------------------------|--|
| AT Command: ATRE | |
| Binary Command: 0x0E (14 decimal) | |

RM (Ambient Power – All Channels) Command

<Diagnostics> RM Command is used to examine and report the power levels on all channels. If no parameter is given, then the channels will be scanned once. If a parameter is given, the channels will be repeatedly scanned for that number of seconds (up to 2000d), and the maximum power level seen for each channel is reported (i.e. peak hold).

AT Command: ATRM
 Parameter Range (read-only): no parameter - 0x7D0 (2000d)
 Number of bytes returned: 2
 Related Commands: RC (Ambient Power - Single channel)

A graphical spectrum analyzer application can be implemented by repeatedly calling ATRM with no arguments and reading the resultant 50 power levels (easiest to do when CF = 1 or 2).

Sample output [when CF = 0]: Ch 0: -100 dBm
 Ch 1: -103 dBm
 ...
 Ch 49: -99 dBm

Sample output [when CF = 1]: 64
 67
 ...
 63

Sample output [when CF = 2]: -100
 -103
 ...
 -99

RN (Delay Slots) Command

<Networking & Security> RN Command is used to set/read the time delay that the transmitting modem inserts before attempting to resend a packet. If the transmitting modem fails to receive an acknowledgement after sending a packet, it inserts a random number of delay slots (ranging from 0 to (RN minus 1)) before attempting to resend the packet. Each delay slot lasts for a period of 38 ms.

AT Command: ATRN
 Binary Command: 0x19 (25 decimal)
 Parameter Range: 0 - 0xFF [38 ms slots]
 Default Parameter Value: 0 (no delay slots inserted)
 Number of bytes returned: 1
 Related Commands: RR (Retries), TT (Streaming Limit)

If two modems attempt to transmit at the same time, the random time delay after packet failure allows only one modem to transmit the packet successfully; while the other modem waits until the channel available for RF transmission.

RN Command is only applicable if retries have been enabled [RR (Retries) Command] or if forced delays will be inserted into a transmission [TT (Streaming Limit) Command].

RO (Packetization Timeout) Command

<Serial Interfacing> RO Command is used to set/read the Packetization Timeout setting. RF transmission commences when data is in the DI buffer and either of the following criteria are met:

- RO character times of silence on the UART receive lines (ignored if RO = 0)
- RB characters have been received by the UART (ignored if (RB = 0)

AT Command: ATRO
 Binary Command: 0x21 (33 decimal)
 Parameter Range: 0 - 0xFFFF
 [x UART character times]
 Default Parameter Value: 0x03 (3 decimal)
 Number of bytes returned: 2
 Related Commands: RB (Packetization Threshold)

RB and RO criteria only apply to the first packet of a multi-packet transmission. If data remains in the DI Buffer (UART receive) after the first packet, transmissions will continue in streaming manner until there is no data left in the DI Buffer (UART receive).

RO Command (continued)

When RO is the transmission-beginning criteria: The actual time between the reception of the last character from the UART and the beginning of RF transmission will be at least 800 µsec longer than the actual RO time to allow for transmission setup. Additionally, it is subject to 100 - 200 µsec of additional uncertainty, which could be significant for small values of RO at high UART bit rates.

The RO timer calculates the correct UART character time (10, 11, or 12 bits) based on the following criteria:

- 1 start bit
- 8 data bits
- 0 or 1 parity bit (as set by ATNB)
- 1 or 2 stop bits (as set by ATSB)

RP (RSSI PWM Timer) Command

RP Command is used to enable a PWM ("Pulse Width Modulation"). The pin is calibrated to show the difference between received signal strength and the sensitivity level of the modem. PWM pulses vary from zero to 95 percent. Zero percent means the received RF signal is at or below the published sensitivity level of the modem. The following table shows dB levels above sensitivity and PWM values:

| |
|---|
| AT Command: ATRP |
| Binary Command: 0x22 (34 decimal) |
| Parameter Range: 0 – 0xFF [x 100 milliseconds] |
| Default Parameter Value: 0x20 (32 decimal) |
| Number of bytes returned: 1 |

The total time period of the PWM output is 8.32 ms. PWM output consists of 40 steps and therefore the minimum step size is 0.208 ms.

| dBm above Sensitivity | PWM percentage (high period / total period) |
|------------------------------|--|
| 10 | 47.5 |
| 20 | 62.5 |
| 30 | 77.5 |

A non-zero value defines the time that PWM output is active with the RSSI value of the last received RF packet. After the set time when no RF packets are received, PWM output is set low (0 percent PWM) until another RF packet is received. PWM output is also set low at power-up. A parameter value of 0xFF permanently enables PWM output and always reflects the value of the last received RF packet.

Pin 11 of the encased OEM RF module is shared between PWM output and Config input. When the modem is powered, the Config pin is an input. During the power-up sequence, if RP parameter is a non-zero value, the Config pin is configured as an output and set low until the first RF packet is received. With a non-zero RP parameter, the Config pin is an input for RP ms after power up.

RR (Retries) Command

<Networking & Security> RR Command is used to set/read the number of retries that can be sent for a given RF packet. When RR Command is enabled (non-zero value) and when MT Command equals zero, RF packet acknowledgements and retries are enabled.

| |
|--|
| AT Command: ATRR |
| Binary Command: 0x18 (24 decimal) |
| Parameter Range: 0 – 0xFF |
| Default Parameter Value: 0x0A (10 decimal) |
| Number of bytes returned: 1 |

After transmitting a packet, the transmitting modem waits to receive an acknowledgement from a receiving modem. If the acknowledgement is not received in the period of time specified by RN (Delay Slots) Command, the original packet is transmitted again. The RF packet is transmitted repeatedly until an acknowledgement is received or until the packet is sent RR times.

RT (GPI1 Configuration) Command

RT Command is used to set/read the behavior of the GPI1 pin. The pin can be configured to enable binary programming or RTS flow control.

AT Command: ATRT

Binary Command: 0x16 (22 decimal)

Parameter Range: 0 - 2

| Parameter Value | Configuration |
|-----------------|--------------------------------|
| 0 | disabled |
| 1 | Enable Binary Programming |
| 2 | Enable <u>RTS</u> Flow Control |

Default Parameter Value: 0

Number of bytes returned: 1

SB (Stop Bits) Command

<Serial Interfacing> SB Command is used to set/read the number of stop bits in the data packets.

AT Command: ATSB

Binary Command: 0x37 (55 decimal)

Parameter Range: 0 - 1

| Parameter Value | Configuration |
|-----------------|---------------|
| 0 | 1 stop bit |
| 1 | 2 stop bits |

Default Parameter Value: 0

Number of bytes returned: 1

SH (Serial Number High) Command

<Diagnostics> SH Command is used to set/read the serial number high word of the modem.

AT Command: ATSH

Binary Command: 0x25 (37 decimal)

Parameter Range (read-only): 0 - 0xFFFF

Number of bytes returned: 2

Related Commands: SL (Serial Number Low)

SL (Serial Number Low) Command

<Diagnostics> SL Command is used to set/read the serial number low word of the modem.

AT Command: ATSL

Binary Command: 0x26 (38 decimal)

Parameter Range (read-only): 0 - 0xFFFF

Number of bytes returned: 2

Related Commands: SH (Serial Number High)

SM (Sleep Mode) Command

<Sleep Mode (Low Power)> SM Command is used to set/read the modem's Sleep Mode settings that configure the modem to run in states that require minimal power consumption.

Pin Sleep (SM = 1)

Next to Shutdown Mode, Pin Sleep requires the least amount of power. In order to achieve this state, SLEEP must be asserted (high). The modem remains in Pin Sleep until the SLEEP pin is de-asserted.

After enabling Pin Sleep (SM=1), GPI2 controls whether the 900MHZ MODEM is active or in Sleep Mode. When GPI2 is de-asserted (low), the modem is fully operational. When GPI2 is asserted (high), the modem transitions to Sleep Mode and remains in its lowest power-consuming state until the Sleep pin is de-asserted. GPI2 is only active if the modem is setup to operate in this mode; otherwise the pin is ignored.

Once in Pin Sleep Mode, GP01 (\overline{CTS}) is de-asserted (high), indicating that data should not be sent to the modem. PWR is also de-asserted (low) when the modem is in Pin Sleep Mode.

Serial Port Sleep (SM = 2)

Serial Port Sleep is a Sleep Mode in which the 900MHZ MODEM runs in a low power state until serial data is detected on the DI pin.

When Serial Port Sleep is enabled, the modem goes into Sleep Mode after a user-defined period of inactivity (no transmitting or receiving of data). This period of time is determined by ST (Time before Sleep) Command. Once a character is received through the DI pin, the modem returns to Idle Mode and is fully operational.

Cyclic Sleep (SM = 4-8)

Cyclic Sleep is the Sleep Mode in which the 900MHZ MODEM enters into a low-power state and awakens periodically to determine if any transmissions are being sent. Cyclic sleep settings wake the modem after the amount of time designated by the associated SM parameter values. If the modem detects a wake-up initializer during the time it is awake, the modem synchronizes with the transmitting modem and starts receiving data after the wake-up initializer runs its duration. Otherwise, the modem returns to Sleep Mode and continues to cycle in and out of activity until a wake-up initializer is detected. If a Cyclic Sleep setting is chosen, the ST, LH and HT parameters must also be set as described in the "Sleep Mode" section of this manual.

When Cyclic Sleep settings are enabled, the 900MHZ MODEM goes into Sleep Mode after a user-defined period of inactivity (no transmission or reception on the RF channel). The user-defined period is determined by ST (Time before Sleep) Command.

While the modem is in Cyclic Sleep Mode, GP01 (\overline{CTS}) is de-asserted (high) to indicate that data should not be sent to the modem during this time. When the modem awakens to listen for data, GP01 is asserted and any data received on the DI Pin is transmitted. The PWR pin is also de-asserted (low) when the modem is in Cyclic Sleep Mode.

AT Command: ATSM

Binary Command: 0x01

Parameter Range: 0 - 8

| Parameter Value | Configuration |
|-----------------|--|
| 0 | Disabled |
| 1 | Pin Sleep |
| 2 | Serial Port Sleep |
| 3 | reserved |
| 4 | Cyclic 1.0 second sleep (Modem wakes every 1.0 second) |
| 5 | Cyclic 2.0 second sleep |
| 6 | Cyclic 4.0 second sleep |
| 7 | Cyclic 8.0 second sleep |
| 8 | Cyclic 16.0 second sleep |

Default Parameter Value: 0

Number of bytes returned: 1

Related Commands:

Pin Sleep - PC (Power-up Mode), PW (Pin Wake-up)

Serial Port Sleep - ST (Time before Sleep)

Cyclic Sleep - ST (Time before Sleep), LH (Wake-up Initializer Timer), HT (Time Before Wake-up Initializer), PW (Pin Wake-up)

SM Command (continued)

The modem remains in Sleep Mode for a user-defined period of time ranging from 0.5 seconds to 16 seconds (SM Parameters 3 through 8). After this interval of time, the modem returns to Idle Mode and listens for a valid data packet for 100 ms. If the modem does not detect valid data (on any frequency), the modem returns to Sleep Mode. If valid data is detected, the modem transitions into Receive Mode and receives incoming RF packets. The modem then returns to Sleep Mode after a Period of inactivity that is determined by ST "Time before Sleep" Command.

The modem can also be configured to wake from cyclic sleep when GPI2 (SLEEP) is de-asserted (low). To configure a modem to operate in this manner, PW (Pin Wake-up) Command must be issued. Once GPI2 is de-asserted, the modem is forced into Idle Mode and can begin transmitting or receiving data. It remains active until no data is detected for the period of time specified by the ST Command, at which point it resumes its low-power cyclic state.

Note: The cyclic interval time defined by SM (Sleep Mode) Command must be shorter than the interval time defined by LH (Wake-up Initializer Timer).

For example: If SM=4 (Cyclic 1.0 second sleep), the LH Parameter should equal 0xB ("1.1" seconds). With these parameters set, there is no risk of the receiving modem being asleep for the duration of wake-up initializer transmission. "Cyclic Scanning" explains in further detail the relationship between "Cyclic Sleep" and "Wake-up Initializer Timer"

Cyclic Scanning. Each RF transmission consists of an RF Initializer and payload. The wake-up initializer contains initialization information and all receiving modems must wake during the wake-up initializer portion of data transmission in order to be synchronized with the transmitting modem and receive the data.

Figure 4.1. Correct Configuration (LH > SM):

Length of the wake-up initializer exceeds the time interval of Cyclic Sleep. The receiver is guaranteed to detect the wake-up initializer and receive the accompanying payload data.

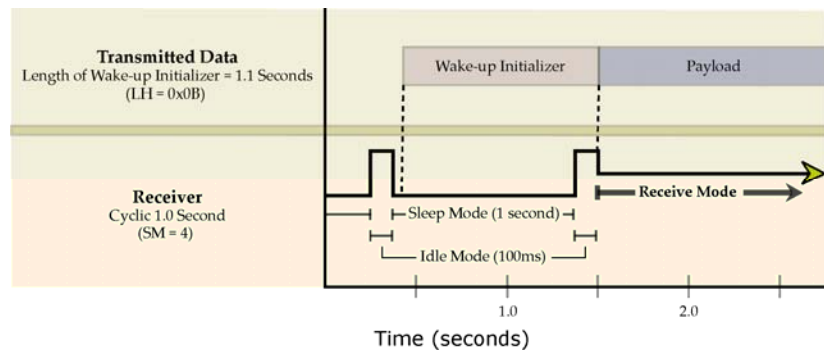
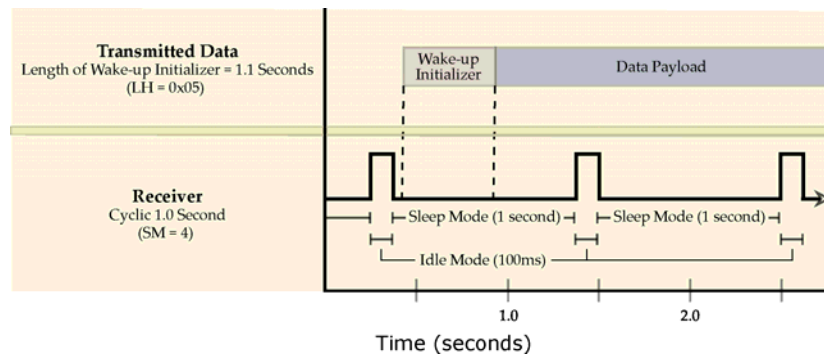


Figure 4.2. Incorrect Configuration (LH < SM):

Length of wake-up initializer is shorter than the time interval of Cyclic Sleep. This configuration is vulnerable to the receiver waking and missing the wake-up initializer (and therefore also the accompanying payload data).



ST (Time before Sleep) Command

<Sleep Mode (Low Power)> ST Command is used to set/read the period of time (milliseconds) in which the modem remains inactive before entering Sleep Mode.

For example, if the ST Parameter is set to 0x64 (100 decimal), the modem will enter into Sleep mode after 10 seconds of inactivity (no transmitting or receiving).

This command can only be used if Cyclic Sleep or Serial Port Sleep Mode settings have been selected using SM (Sleep Mode) Command.

| |
|---|
| AT Command: ATST |
| Binary Command: 0x02 (2 decimal) |
| Parameter Range: (ATAT+3) - 0x7FFF [x 100 milliseconds] |
| Default Parameter Value: 0x64 (100 decimal) |
| Number of bytes returned: 2 |
| Related Commands: SM (Sleep Mode), LH (Wake-up Initializer Timer), HT (Time before Wake-up Initializer) |

TP (Board Temperature) Command

<Diagnostics> TP Command is used to read the current temperature of the board.

Sample Output: 26 C [when ATCF = 0]
1A [when ATCF = 1]
26 [when ATCF = 2]

| |
|--------------------------------------|
| AT Command: ATTP |
| Binary Command: 0x38 (56 decimal) |
| Parameter Range (read-only): 0- 0x7F |
| Number of bytes returned: 1 |
| Related Commands: WN (Warning Data) |

TR (Transmit Error Count) Command

<Diagnostics> TR Command is used to report the number of retransmit failures. This number is incremented each time a packet is not acknowledged within the number of retransmits specified by RR (Retries) Command. It therefore counts the number of packets that were not successfully received and were subsequently dropped.

TR Parameter is not non-volatile and will therefore be reset to zero when the modem is reset.

| |
|-----------------------------------|
| AT Command: ATTR |
| Binary Command: 0x1B (27 decimal) |
| Parameter Range: 0 - 0xFFFF |
| Default Parameter Value: 0 |
| Number of bytes returned: 2 |
| Related Commands: RR (Retries) |

TT (Streaming Limit) Command

<Networking & Security> TT Command is used to set/read the limit on the number of bytes that can be sent out before a random delay is issued.

If a modem is sending a continuous stream of RF data, a delay is inserted which stops its transmission and allows other modems time to transmit (once it sends TT bytes of data).

Inserted random delay lasts between 1 & 'RN + 1' delay slots, where each delay slot lasts 38 ms.

TT command can be used to simulate full-duplex behavior.

| |
|---------------------------------------|
| AT Command: ATTT |
| Binary Command: 0x1A (26 decimal) |
| Parameter Range: 0 - 0xFFFF |
| Default Parameter Value: 0 (disabled) |
| Number of bytes returned: 2 |
| Related Commands: RN (Delay Slots) |

TX (Transmit Only) Command

<RF Interfacing> TX Command is used to set/read the transmit/receive behaviors of the modem. Setting a modem to TX-only may reduce latency because the transmitting modem will never be "stuck" receiving data from other modems.

| AT Command: ATTX | | | | | | |
|--|-----------------|---------------|---|-----------|---|---------|
| Binary Command: 0x3F (63 decimal) | | | | | | |
| Parameter Range: 0 - 1 | | | | | | |
| <table border="1"> <thead> <tr> <th>Parameter Value</th> <th>Configuration</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>TX and RX</td> </tr> <tr> <td>1</td> <td>TX only</td> </tr> </tbody> </table> | Parameter Value | Configuration | 0 | TX and RX | 1 | TX only |
| Parameter Value | Configuration | | | | | |
| 0 | TX and RX | | | | | |
| 1 | TX only | | | | | |
| Default Parameter Value: 0 | | | | | | |
| Number of bytes returned: 1 | | | | | | |

VL (Firmware Version - verbose) Command

<Diagnostics> VL Command is used to read the verbose firmware version of the 900MHZ MODEM .

Sample output: Firmware version 0.8, Apr 16
2004 10:46:57

AT Command: ATVL

Parameter Range: Returns string

Number of bytes returned: 2

VR (Firmware Version) Command

<Diagnostics> VR Command is used to read the firmware version of the 900MHZ MODEM .

AT Command: ATVR

Binary Command: 0x14 (20 decimal)

Parameter Range (read-only): 0 - 0xFFFF

Number of bytes returned: 2

WA (Active Warning Numbers) Command

<Diagnostics> WA Command reports the warning numbers of all active warnings - one warning number per line. No further information is shown and warning counts are not reset.

AT Command: ATWA

Parameter Range: Returns string - one warning number per line.

Sample Output (indicates warnings 1 and 3 are currently active):
1
3
OK

WN (Active Warning Numbers) Command

<Diagnostics> WN Command is used to report detailed data for all active and sticky warnings.

AT Command: ATWN

Parameter Range: Returns string

- Warning number & description
- Number of occurrences since the last WN or WS command
- Whether the warning is currently active

Warnings which are not currently active, and have not been active since the last WN or WS command, are not displayed. WN Command also resets all non-zero warning counts, except for warnings that are presently active, which are set to 1.

Sample output: Warning 1: Under-voltage
3 occurrences; presently active
Warning 4: Over-temperature
5 occurrences; presently inactive.

| Warning Number | Description |
|----------------|---|
| 1 | Under-voltage. This is caused if the supply voltage falls below the minimum threshold for the lowest power level (2.8 V). If/when the voltage rises above the threshold, the warning is deactivated. The module will not transmit below this voltage threshold. |
| 2 | Over-voltage. This is caused if the supply voltage exceeds 5.75 V. Transmission is not allowed while this warning is active. |
| 3 | Under-temperature. This is caused if the temperature sensed by the module is less than -40 C. The module does not artificially limit operation while this warning is active, but module functionality is not guaranteed. |
| 4 | Over-temperature. This is caused if the temperature sensed by the module is greater than 105 C. The module does not allow transmission nor reception while this warning is active. The warning is deactivated when the temperature falls to 100 C. |
| 5 | Power reduced. This is caused if the transmit power has to be reduced from the level programmed by PL Command due to insufficient supply voltage. The 1 W power level requires 4.75 V or higher; 500 mW requires 3.0 V or higher; 100 mW, 10 mW and 1 mW require 2.8 V or higher. |
| 6 | Default calibration data in flash. This is caused if the module-specific power calibration data is either not present or is invalid, or if none of the parameters have been modified from their default values. Power levels may be incorrect. |
| 7 | Default configuration parameters in flash. This is caused if the user-modifiable parameters (i.e. those stored by a 'WR' command) in flash are all the compiled-in default values. This is caused if the user configuration is found to be not present or invalid at power-up and there is no user custom configuration, or if no user-modifiable parameters have been modified from the compiled-in defaults. Note that modification of one or more parameters without the subsequent ATWR to commit the changes to flash will not deactivate this warning, since it reflects the status of the parameters in flash. Note as well that this warning does not reflect usage of the custom configuration defaults, only usage of the compiled-in defaults. |
| 8 | Default factory configuration parameters in flash. This is caused if the factory parameters (i.e. those stored by a 'WP' command) in flash are all the default values. This is caused if the factory configuration is found to be not present or invalid at power-up, or if no factory parameters have been modified. Note that modification of one or more parameters without the subsequent ATWP to commit the changes to flash will not deactivate this warning, since it reflects the status of the parameters in flash. |

WR (Write) Command

<(Special)> WR Command writes configurable parameters to the modem's non-volatile memory (Parameter values remain in the modem's memory until overwritten by future use of WR Command).

AT Command: ATWR

Binary Command: 0x08

If changes are made without writing them to non-volatile memory, the modem reverts back to previously saved parameters the next time the modem is powered-on.

WS (Sticky Warning Numbers) Command

<Diagnostics> WS Command reports the warning numbers of all warnings which have been active since the last use of WS or WN command, including any warnings which are currently active. No further information is shown.

AT Command: ATWS

Parameter Range (read-only): 1 - 8

Number of bytes returned: 1

This command also resets all non-zero warning counts, except for warnings that are presently active, which are set to 1.

Appendix A: Agency Certifications

FCC Certification

The 900MHz Modem COM Module complies with Part 15 of the FCC rules and regulations. Compliance with labeling requirements, FCC notices and antenna regulations is required.

Labeling Requirements

In order to inherit Horner's FCC Certification, compliance requires the following be stated on the device and within its operation manual:

FCC ID: OUR-9XTEND

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

Label Warning



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.

Figure A.1. Required FCC Label for OEM products containing the 900MHZ MODEM (900 MHz) OEM COM Module

Contains FCC ID: OUR-9XTEND

The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

FCC Notices

Adherence to the following is required:

IMPORTANT: The 900MHz Modem COM Modules have been certified by the FCC for use with other products without any further certification (as per FCC section 2.1091). Changes or modifications not expressly approved by Horner could void the user's authority to operate the equipment.

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

IMPORTANT: The 900MHz Modem COM Modules have been certified for fixed base station and mobile applications. If modems will be used for portable applications, the device must undergo SAR testing.

NOTE:

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:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiving modem.
- Connect the equipment into an outlet on a circuit different from that to which the receiving modem is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Antenna Warning



WARNING: This device has been tested with Reverse Polarity SMA connectors with the antennas listed in Tables A.1 – A.7 of Appendix A. When integrated into OEM products, fixed antennas require installation preventing end-users from replacing them with non-approved antennas. Antennas not listed in the tables must be tested to comply with FCC Section 15.203 (unique antenna connectors) and Section 15.247 (emissions).

FCC-Approved Antennas (900 MHz)

Fixed Base Station and Mobile Applications

Horner Modems are pre-FCC approved for use in fixed base station and mobile applications. When the antenna is mounted at least 20 cm (8") from nearby persons, the application is considered a mobile application.

Portable Applications and SAR Testing

When the antenna is mounted closer than 20 cm to nearby persons, then the application is considered "portable" and requires an additional test be performed on the final product. This test is called the Specific Absorption Rate (SAR) testing and measures the emissions from the modem and how they affect the person.

RF Exposure

(This statement must be included as a CAUTION statement in OEM product manuals.)

⚠ WARNING: This equipment is approved only for mobile and base station transmitting devices. Antenna(s) used for this transmitter must be installed to provide a separation distance of at least 30 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

NOTE: The separation distance indicated in the above is 30 cm, but any distance greater than or equal to 23 cm can be used (per MPE evaluation).

To fulfill FCC Certification requirements:

1. Integrator must ensure required text [Figure A.1] is clearly placed on the outside of the final product.
2. 900MHZ MODEM may be used only with Approved Antennas that have been tested with this modem. [Refer to Tables A.1 – A.7]

1 Watt Transmit Power Output or Lower

Table A.1. Half-wave antennas (approved when operating at 1 Watt power output or lower.)

| Part Number | Type | Connector | Gain | Application |
|-----------------|-------------------------------------|-----------|---------|----------------|
| 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 w/ 6" pigtail | MMCX | 2.1 dBi | Fixed / Mobile |
| A09-HABMM-6-P6I | Articulated half-wave w/ 6" pigtail | MMCX | 2.1 dBi | Fixed / Mobile |
| A09-HBMM-P6I | Straight half-wave w/ 6" pigtail | 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-wave | 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 |

Table A.2. Yagi antennas (approved when operating at 1 Watt power output or lower.)

| Part Number | Type | Connector | Gain | Required Antenna Cable Loss | Application |
|-------------|----------------|-----------|---------|-----------------------------|----------------|
| A09-Y6 | 2 Element Yagi | RPN | 6.1 dBi | - 0.1 dB* | Fixed / Mobile |
| A09-Y7 | 3 Element Yagi | RPN | 7.1 dBi | - 1.1 dB* | Fixed / Mobile |
| A09-Y8 | 4 Element Yagi | RPN | 8.1 dBi | - 2.1 dB* | Fixed / Mobile |
| A09-Y6TM | 2 Element Yagi | RPTNC | 6.1 dBi | - 0.1 dB* | Fixed / Mobile |
| A09-Y7TM | 3 Element Yagi | RPTNC | 7.1 dBi | - 1.1 dB* | Fixed / Mobile |
| A09-Y8TM | 4 Element Yagi | RPTNC | 8.1 dBi | - 2.1 dB* | Fixed / Mobile |

* FCC regulations stipulate a 36 dBm EIRP power requirement. Users implementing antenna gain greater than 6.0 dB must compensate for the added gain with cable loss. When operating at 1 W power output, the sum (in dB) of cable loss and antenna gain shall not exceed 6.0 dB.

Omni-directional base station antennas (approved when operating at 1 Watt power output or lower.)

| Part Number | Type | Connector | Gain | Required Antenna Cable Loss | Application |
|-------------|-------------------------|-----------|---------|-----------------------------|-------------|
| A09-F0 | Fiberglass Base Station | RPN | 0 dBi | - | Fixed |
| A09-F1 | Fiberglass Base Station | RPN | 1.0 dBi | - | Fixed |
| A09-F2 | Fiberglass Base Station | RPN | 2.1 dBi | - | Fixed |
| A09-F3 | Fiberglass Base Station | RPN | 3.1 dBi | - | Fixed |
| A09-F4 | Fiberglass Base Station | RPN | 4.1 dBi | - | Fixed |
| A09-F5 | Fiberglass Base Station | RPN | 5.1 dBi | - | Fixed |
| A09-F6 | Fiberglass Base Station | RPN | 6.1 dBi | - 0.1 dB* | Fixed |
| A09-F7 | Fiberglass Base Station | RPN | 7.1 dBi | - 1.1 dB* | Fixed |
| A09-F8 | Fiberglass Base Station | RPN | 8.1 dBi | - 2.1 dB* | Fixed |
| A09-W7 | Wire Base Station | RPN | 7.1 dBi | - 1.1 dB* | Fixed |
| A09-F0 | Fiberglass Base Station | RPSMA | 0 dBi | - | Fixed |
| A09-F1 | Fiberglass Base Station | RPSMA | 1.0 dBi | - | Fixed |
| A09-F2 | Fiberglass Base Station | RPSMA | 2.1 dBi | - | Fixed |
| A09-F3 | Fiberglass Base Station | RPSMA | 3.1 dBi | - | Fixed |
| A09-F4 | Fiberglass Base Station | RPSMA | 4.1 dBi | - | Fixed |
| A09-F5 | Fiberglass Base Station | RPSMA | 5.1 dBi | - | Fixed |
| A09-F6 | Fiberglass Base Station | RPSMA | 6.1 dBi | - 0.1 dB* | Fixed |
| A09-F7 | Fiberglass Base Station | RPSMA | 7.1 dBi | - 1.1 dB* | Fixed |
| A09-F8 | Fiberglass Base Station | RPSMA | 8.1 dBi | - 2.1 dB* | Fixed |
| A09-W7SM | Wire Base Station | RPSMA | 7.1 dBi | - 1.1 dB* | Fixed |
| A09-F0TM | Fiberglass Base Station | RPTNC | 0 dBi | - | Fixed |
| A09-F1TM | Fiberglass Base Station | RPTNC | 1.0 dBi | - | Fixed |
| A09-F2TM | Fiberglass Base Station | RPTNC | 2.1 dBi | - | Fixed |
| A09-F3TM | Fiberglass Base Station | RPTNC | 3.1 dBi | - | Fixed |
| A09-F4TM | Fiberglass Base Station | RPTNC | 4.1 dBi | - | Fixed |
| A09-F5TM | Fiberglass Base Station | RPTNC | 5.1 dBi | - | Fixed |
| A09-F6TM | Fiberglass Base Station | RPTNC | 6.1 dBi | - 0.1 dB* | Fixed |
| A09-F7TM | Fiberglass Base Station | RPTNC | 7.1 dBi | - 1.1 dB* | Fixed |
| A09-F8TM | Fiberglass Base Station | RPTNC | 8.1 dBi | - 2.1 dB* | Fixed |
| A09-W7TM | Wire Base Station | RPTNC | 7.1 dBi | - 1.1 dB* | Fixed |

Table A.3. Mag Mount antennas (approved when operating at 1 Watt power output or lower.)

| Part Number | Type | Connector | Gain | Required Antenna Cable Loss | Application |
|-------------|-----------|-----------|---------|-----------------------------|-------------|
| 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 | -1.1 dB* | Fixed |
| A09-M8SM | Mag Mount | RPSMA | 8.1 dBi | -2.1 dB* | 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 | -1.1 dB* | Fixed |
| A09-M8TM | Mag Mount | RPTNC | 8.1 dBi | -2.1 dB* | Fixed |

Table A.4. Multi-path antennas (approved when operating at 1 Watt power output or lower.)

| Part Number | Type | Connector | Gain | Application |
|---------------|--|-----------|---------|-------------|
| A09-DPSM-P12F | omni directional permanent mount w/ 12ft pigtail | RPSMA | 3.0 dBi | Fixed |
| A09-D3NF-P12F | omni directional magnetic mount w/ 12ft pigtail | RPN | 3.0 dBi | Fixed |
| A09-D3SM-P12F | omni directional w/ 12ft pigtail | RPSMA | 3.0 dBi | Fixed |
| A09-D3PNF | omni directional permanent mount | RPN | 3.0 dBi | Fixed |
| A09-D3TM-P12F | omni directional w/ 12ft pigtail | RPTNC | 3.0 dBi | Fixed |
| A09-D3PTM | omni directional permanent mount | RPTNC | 3.0 dBi | Fixed |
| A92-D4PNF | 900 MHz / 2.4GHz permanent mount | RPN | 2.1 dBi | Fixed |
| A92-D4P | 900 MHz / 2.4GHz permanent mount | RPSMA | 2.1 dBi | Fixed |
| A92-D4PTM | 900 MHz / 2.4GHz permanent mount | RPTNC | 2.1 dBi | Fixed |

* FCC regulations stipulate a 36 dBm EIRP power requirement. Users implementing antenna gain greater than 6.0 dB must compensate for the added gain with cable loss. When operating at 1 W power output, the sum (in dB) of cable loss and antenna gain shall not exceed 6.0 dB.

100 milliWatt Transmit Power Output or Lower

Table A.5. Monopole antennas (approved when operating at 100 mW power output or lower.)

| Part Number | Type | Connector | Gain | Application |
|---------------|--------------------------------------|-----------|---------|----------------|
| 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-wave straight | RPSMA | 1.9 dBi | Fixed / Mobile |
| A09-QBMM-P6l | Quarter-wave w/ 6" pigtail | MMCX | 1.9 dBi | Fixed / Mobile |
| A09-QHRN | Miniature Helical Right Angle solder | Permanent | -1 dBi | Fixed / Mobile |
| A09-QHSN | Miniature Helical Right Angle solder | 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 mount | Permanent | 1.9 dBi | Fixed / Mobile |
| A09-QSPM-3 | 3" Straight screw mount | Permanent | 1.9 dBi | Fixed / Mobile |
| A09-QAPM-3 | 3" Articulated screw mount | Permanent | 1.9 dBi | Fixed / Mobile |
| A09-QAPM-3H | 3" Articulated screw mount | Permanent | 1.9 dBi | Fixed / Mobile |

Table A.6. Yagi antennas (approved when operating at 100 mW power output or lower.)

| 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 |

IC (Industry Canada) Certification

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 9XTend Radio, IC: 4214A-9XTEND

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.

Appendix B: Additional Information

Technical Support

For user manual updates and assistance, contact Technical Support:

North America:

(317) 916-4274

www.heapg.com

Europe:

(+) 353-21-4321-266

www.horner-apg.com

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