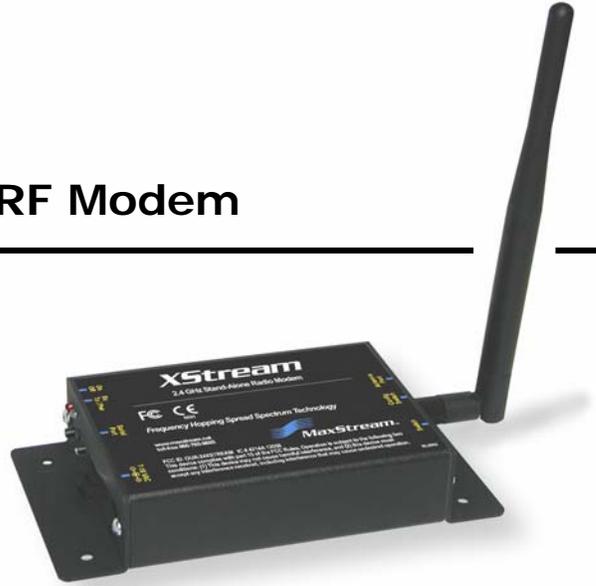


XStream-PKG-T™ Telephone RF Modem

XStream Telephone RF Modem
RF Module Operation
Telephone Module Operation
RF Communication Modes
Appendices



Product Manual v5.x00

XStream RF Modem Part Numbers:

X09-001PK...-T...

X24-009PK...-T...

XH9-001PK...-T...

X09-009PK...-T...

X24-019PK...-T...

XH9-009PK...-T...

X09-019PK...-T...

XH9-019PK...-T...

Reliable 900 MHz & 2.4 GHz Stand-alone RF Modems by MaxStream, Inc.



355 South 520 West, Suite 180
Lindon, UT 84042
Phone: (801) 765-9885
Fax: (801) 765-9895

rf-xperts@maxstream.net
www.maxstream.net (live chat support)

M100111
2006.02.24

© 2006 MaxStream, Inc. All rights reserved

No part of the contents of this manual may be transmitted or reproduced in any form or by any means without the written permission of MaxStream, Inc.

XStream™, XStream-PKG-R™ and XStream-PKG-T™ are registered trademarks of MaxStream, Inc.

Technical Support:

Phone: (801) 765-9885

Live Chat: www.maxstream.net

E-Mail: rf-xperts@maxstream.net

Contents

1. XStream Telephone RF Modem	4	Appendix A: Agency Certifications	38
1.1. Key Features	4	FCC Certification	38
1.1.1. Worldwide Acceptance	4	OEM Labeling Requirements	39
1.2. Product Overview	5	Antenna Usage	40
1.2.1. Specifications	5	FCC-Approved Antennas	41
1.3. External Interface	6	IC (Industry Canada) Certification	42
1.3.1. Front and Back Views	6	Appendix B: Development Guide	43
1.4. Block Diagram	7	Mechanical Drawings	43
1.5. Pin Signals	8	RF Module Configuration	44
1.5.1. RJ-11 Connector Pin Signals	8	X-CTU Software	44
1.5.2. DB-9 Connector Pin Signals	8	RF Module Commands (Long Descriptions)	45
2. RF Module Operation	9	Appendix C: Additional Information	61
2.1. Modes of Operation	9	1-Year Warranty	61
2.1.1. Idle Mode	9	Ordering Information	61
2.1.2. Transmit Mode	10	Contact MaxStream	62
2.1.3. Receive Mode	11		
2.1.4. Sleep Mode	12		
2.1.5. Command Mode	14		
2.2. RF Module Configuration	15		
2.2.1. Command Reference Table	15		
2.2.2. AT Command Mode	16		
2.2.3. Binary Command Mode	18		
3. Telephone Module Operation	20		
3.1. Telephone Module Configuration	20		
3.1.1. Command Reference Tables	22		
3.1.2. Telephone Module Configuration Example	25		
4. RF Communication Modes	26		
4.1. Addressing	27		
4.1.1. Address Recognition	27		
4.2. Basic Communications	28		
4.2.1. Streaming Mode (Default)	28		
4.2.2. Repeater Mode	29		
4.3. Acknowledged Communications	32		
4.3.1. Acknowledged Mode	32		
4.3.2. Multi-Streaming Mode	34		

1. XStream Telephone RF Modem

The XStream-PKG-T RF Modem provides long range data communications and advanced networking for the expanding RFd2d (Radio Frequency Device-to-Device) segment of the wireless market. Out-of-box, the modem comes configured to sustain long range wireless communications between devices.

The modem transfers a standard asynchronous serial data stream between two or more modems. Its built-in telephone interfacing allows for rapid integration into existing data systems.



1.1. Key Features

Long Range at a Low Cost

9XStream-PKG-T (900 MHz) Range:

- Indoor/Urban: **up to 1500'** (450 m)
- Outdoor line-of-sight: **up to 7 miles** (11 km) w/ 2.1 dBm dipole antenna
- Outdoor line-of-sight: **up to 20 miles** (32 km) w/ high gain antenna

24XStream-PKG-T (2.4 GHz) Range:

- Indoor/Urban: **up to 600'** (180 m)
- Outdoor line-of-sight: **up to 3 miles** (5 km) w/ 2.1 dBm dipole antenna
- Outdoor line-of-sight: **up to 10 miles** (16 km) w/ high gain antenna

Receiver sensitivity: **-110 dBm** (@ 900 MHz),
-105 dBm (@ 2.4 GHz)

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)

7 hopping channels, each with over 65,000 unique network addresses available

Easy-to-Use

Out-of-Box RF Experience
(no configuration required)

No Master/Slave setup dependencies

External DIP Switch configurations

Advanced configurations using simple AT & binary commands

7-28 VDC power supply

Transparent Operation

Portable
(small form factor & low power)

Software-selectable interfacing rates

Support for multiple data formats

XII™ Interference Immunity

I/O line passing RF communication options available

Unlimited Technical Support is included

1.1.1. Worldwide Acceptance

FCC Certified (USA) Refer to Appendix A for FCC Requirements.

Devices that contain XStream RF Modems inherit MaxStream's FCC Certification

ISM (Industrial, Scientific & Medical) frequency band

Manufactured under ISO 9001:2000 registered standards

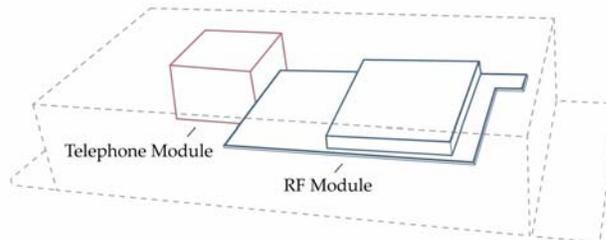
9XStream-PKG-T (900 MHz) RF Modems approved for use in **US, Canada, Australia, Israel** (and more).



1.2. Product Overview

When networked with other MaxStream Radio Modems (RS-232/485, Ethernet, USB, etc.), the XStream PKG Telephone Modem provides a transparent wireless link between serial devices and telephone modems. The telephone interface extends MaxStream's over-the-air range with the reach of any PSTN (Public Switched Telephone Network).

Figure 1-01. On-board Telephone & RF Modules Inside the XStream-PKG-T Telephone RF Modem



The XStream-PKG-T RF Modem comes configured to provide an immediate wireless link between devices; however, both the on-board RF and Telephone Modules can be configured for additional functionality through the use of a simple AT command interface [Refer to the RF Module Configuration [p15] & Telephone Module Configuration [p20] sections for programming options].

1.2.1. Specifications

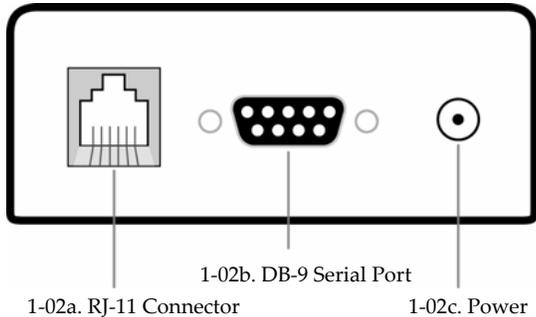
Table 1-01. Specifications of the XStream-PKG-T Telephone RF Modem

Specification	9XStream-PKG-T (900 MHz)		24XStream-PKG-T (2.4 GHz)	
Performance				
Indoor/Urban Range	Up to 1500' (450 m)		Up to 600' (180 m)	
Outdoor RF line-of-sight Range	Up to 7 miles (11 km) w/ dipole antenna Up to 20 miles (32 km) w/ high-gain antenna		Up to 3 miles (5 km) w/ dipole antenna Up to 10 miles (16 km) w/ high-gain antenna	
Interface Data Rate	1200 - 57600 bps (software selectable)		1200 - 57600 bps (software selectable)	
Throughput Data Rate	9,600 bps	19,200 bps	9,600 bps	19,200 bps
RF Data Rate	10,000 bps	20,000 bps	10,000 bps	20,000 bps
Transmit Power Output	100 mW (20 dBm)	100 mW (20 dBm)	50 mW (17 dBm)	50 mW (17 dBm)
Receiver Sensitivity	-110 dBm	-107 dBm	-105 dBm	-102 dBm
Power Requirements				
Supply Voltage	7-28 VDC (optional jumpers allow the PKG-T to be powered with a 5V supply)			
Receive (RX) Current	140 mA		160 mA	
Transmit (TX) Current	220 mA		230 mA	
General				
Frequency	902-928 MHz		2.4000-2.4835 GHz	
Spread Spectrum	Frequency Hopping, Wide band FM modulator			
Network Topology	Peer-to-Peer, Point-to-multipoint, Point-to-Point, Multidrop			
Channel Capacity	7 hop sequences share 25 frequencies			
Physical Properties				
Enclosure	Extruded aluminum, black anodized			
Enclosure Size	2.750" x 6.500" x 1.124" (7.90 cm x 16.51 cm x 3.80 cm)			
Operating Temperature	0 to 70° C (commercial), -40 to 85° C (industrial)			
Antenna				
Type	½ wave dipole whip, 6.75" (17.1 cm), 2.1 dBi Gain			
Connector	Reverse-polarity SMA (RPSMA)			
Impedance	50 ohms unbalanced			
Certifications				
FCC Part 15.247	OUR9XSTREAM		OUR-24XSTREAM	
Industry Canada (IC)	4214A-9XSTREAM		4214A 12008	

1.3. External Interface

1.3.1. Front and Back Views

Figure 1-02. Front View



1-02a. RJ-11 Connector

Standard RJ-11 connector is used to connect to telephone lines. [Pin descriptions are on page 8]

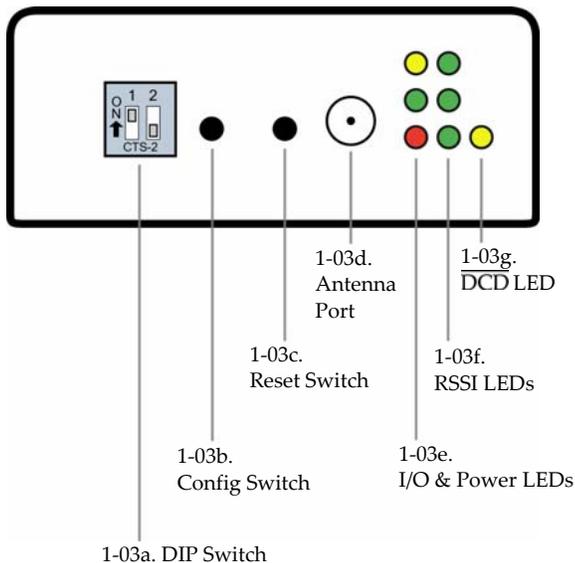
1-02b. DB-9 Serial Port

Standard female DB-9 (RS-232) DCE connector is primarily used as a medium to configure RF module and Telephone module parameter values.

1-02c. Power Connector

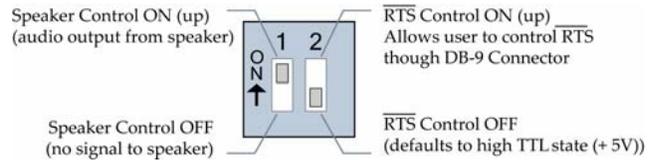
7-28 VDC Power, Center positive, 5.5/2.1 mm Connector – Installing internal jumpers J1 & J5 allows the unit to be powered with a regulated 5V supply.

Figure 1-03. Back View



1-03a. DIP Switch

DIP Switch provides external control of speaker and $\overline{\text{RTS}}$ functions.



1-03b. Config (Configuration) Switch

Configuration Switch provides an alternate way to enter AT Command Mode. To enter AT Command Mode at the RF Modem's default baud rate, read the Reset Switch entry [Figure 1-03c].

1-03c. Reset Switch

Reset Switch forces both the Telephone Module and the RF Module into reset (or re-boot).

This switch can also be used in conjunction with the Config Switch [Figure 1-03b] to enter the RF Module into AT Command Mode.

To enter the RF module into AT Command Mode:

- (i.) Simultaneously press the Reset and Config switches,
- (ii.) release the Reset Switch,
- (iii.) then after 1 sec. release the Config Switch. The RF modem then enters AT Command Mode at the module's default baud rate.

1-03d. Antenna Port

50Ω RF signal connector for connecting to external antenna - Antenna connector type is RPSMA (Reverse Polarity SMA).

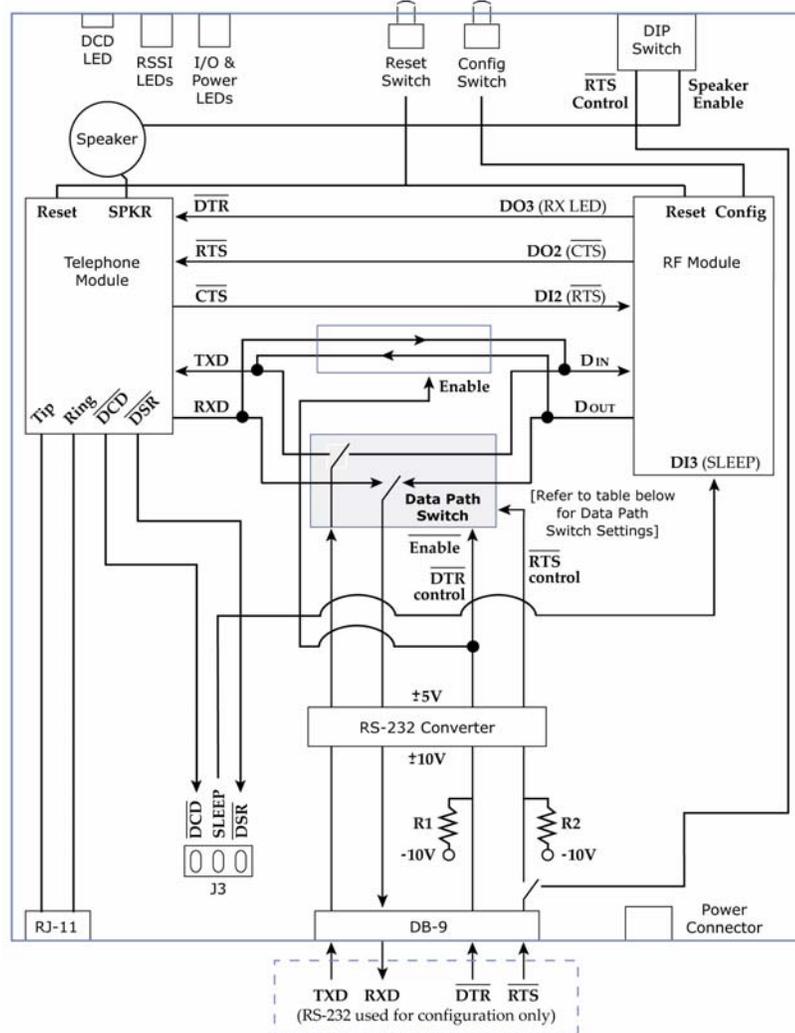
1-03e, 1-03f, & 1-03g. LED Indicators

Table 1-02. LED indicators and their meanings

1-03e. I/O & Power LEDs	1-03f. RSSI LEDs	1-03g. DCD (Data Carrier Detect) LED
LED indicators visualize diagnostic status information. The RF Modem's status is represented as follows: Yellow (top LED) = Serial Data Out (to host) Green (middle) = Serial Data In (from host) Red (bottom) = Power/TX Indicator (Red light is on when powered, off briefly during RF transmission)	Used to determine RSSI (Received Signal Strength Indicator) and fade margin available in the wireless link: 3 Green LEDs ON = Very Strong (> 30 dB fade margin) 2 Green LEDs ON = Strong (> 20 dB fade margin) 1 Green LED ON = Moderate (> 10 dB fade margin) 0 Green LED ON = Weak (< 10 dB fade margin) Fade Margin = The difference between the incoming signal strength and the modem's receiver sensitivity.	Illuminated yellow LED indicates telephone connection is established and DCD (Data Carrier Detect) is asserted. This signal is controlled by the Telephone Module.

1.4. Block Diagram

Figure 1-04. PKG-T RF Modem Internal Block Diagram
(Low-asserted signals distinguished by horizontal line over pin name.)



The PKG-T RF Modem provides a wireless link between devices out-of-box and without configuration. If more advanced features are needed, the XStream RF Module and Telephone Module can be configured via the DB-9 connector or a wireless link.

The Data Path Switch is controlled by the $\overline{\text{DTR}}$ and $\overline{\text{RTS}}$ lines of the DB-9 connector. In the PKG-T's RF Modem's default state (when nothing is attached to the DB-9 connector), data is routed between the RF module and the telephone module. In this case, the Telephone Module communicates directly with a remote RF Modem and receives commands through a wireless link.

Table 1-03. Data Path Switch Settings - Signal Routing between RS-232 DB-9 connector, RF Module & Telephone Module (Low-asserted signals distinguished by horizontal line over pin name.)

DTR	RTS	Result
+10V	+10V	DB-9 connects to RF Module for configuration.
+10V	-10V	DB-9 connects to Telephone Module for configuration.
-10V (default state)	-10V / +10V (default state)	RF Module and Telephone Module are connected to each other and not to the DB-9 connector. This is the default state of the RF Modem (when DB-9 is not connected).

Refer to the RF Module Configuration [p15] and Telephone Module Configuration [p20] sections for more information about configurations of the on-board Telephone and RF Modules.

1.5. Pin Signals

1.5.1. RJ-11 Connector Pin Signals

Figure 1-05. Tip and Ring Pins of the RJ-11 Connector

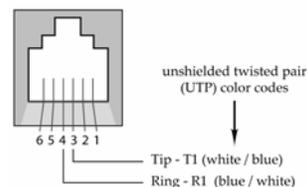


Table 1-04. RJ-11 Signals and their implementations on the XStream-PKG-T RF Modem

Pin	Pin Name	Description	Implementation
3	T1	Tip	Dial-tone and talk circuit
4	R1	Ring	Dial-tone and talk circuit
2, 5		not used	
1, 6		not connected	

1.5.2. DB-9 Connector Pin Signals

Figure 1-06. Pins of the Female DB-9 (RS-232) Connector

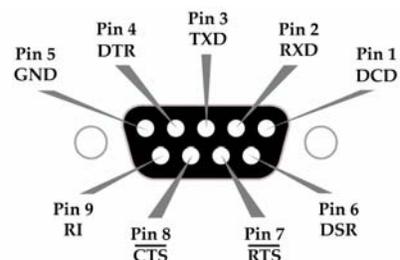


Table 1-05. DB-9 (RS-232) Signals and their implementations on the XStream-PKG-T RF Modem (Low-asserted signals are distinguished by horizontal line over pin name.)

Pin	Pin Name	Description	Implementation
1	$\overline{\text{DCD}}$	Data-Carrier-Detect	Set to +5V
2	RXD	Received Data	Serial Data OUT of the RF Modem (to host, from over-the-air)
3	TXD	Transmitted Data	Serial Data IN to the RF Modem (from host, to be transmitted over-the-air)
4	$\overline{\text{DTR}}$	Data-Terminal-Ready	Enables configuration (Serial Port Method) of XStream OEM RF Module or Telephone Module
5	GND	Ground	Ground
6	$\overline{\text{DSR}}$	Data-Set-Ready	Set to +5V
7	$\overline{\text{RTS}}$	Request-to-Send	Connects DB-9 data lines to XStream RF Module or Telephone Module when $\overline{\text{DTR}}$ asserted (+10V)
8	$\overline{\text{CTS}}$	Clear-to-Send	Set to +5V
9	RI	Ring Indicator	not used

Jumpers

Table 1-06. Jumpers on the XIB-T Interface Board

Jumper	Description
J3	Connects either $\overline{\text{DCD}}$ or $\overline{\text{DSR}}$ of the Telephone Modem to DI3 (SLEEP) of the on-board RF Module.

Non-populated J1 and J5 jumpers are also available for bypassing the high input voltage regulators. This would allow the RF modem to be powered with a 5 volt supply. Contact MaxStream Technical Support for more information.

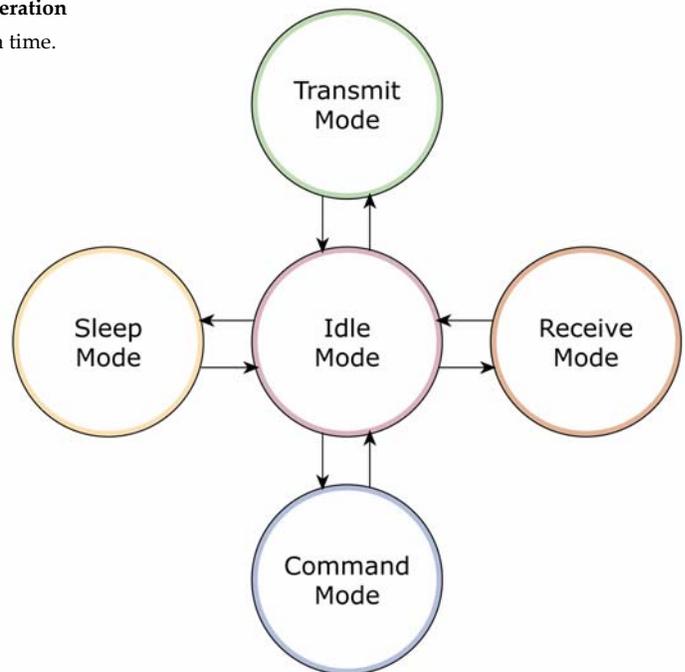
2. RF Module Operation

2.1. Modes of Operation

An on-board RF module enables the XStream-PKG-T RF Modem to send and receive data over-the-air. The RF module operates in five modes.

Figure 2-01. RF Module's Modes of Operation

The modem can only be in one mode at a time.



2.1.1. Idle Mode

When not receiving or transmitting data, the module is in Idle Mode. The module 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:

- Serial 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)

After responding to any of the preceding conditions, the modem automatically transitions back into Idle Mode.

2.1.2. Transmit Mode

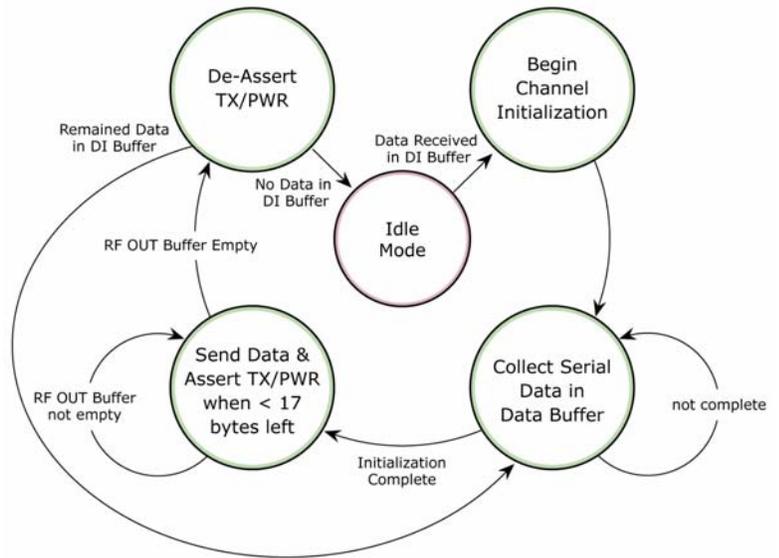
When the first byte of serial data is received from the UART in the DI buffer, the modem attempts to shift to Transmit Mode and initiate an RF connection with other modems.

Figure 2-02. Transmission of Data

Once in Transmit Mode, the modem initializes a communications channel. Channel initialization is the process of sending an RF initializer that synchronizes receiving modems with the transmitting modem. When streaming multiple RF packets, the RF Initializer is only sent in front of the first packet. During channel initialization, incoming serial data accumulates in the DI buffer.

After the channel is initialized, data in the DI buffer is grouped into packets (up to 64 bytes in each packet) and is transmitted. The modem continues to transmit data packets until the DI buffer is empty. Once transmission is finished, the modem returns to Idle Mode. This progression is shown above.

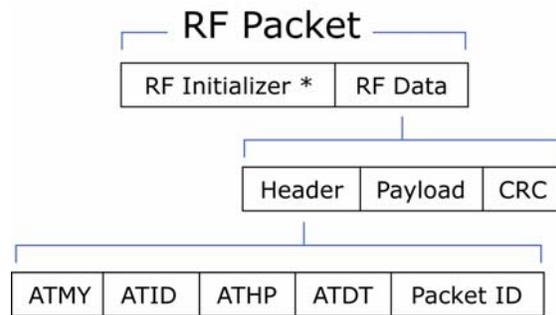
As the transmitting modem nears the end of the transmission, it inspects the DI buffer to see if more data exists to be transmitted. This could be the case if more bytes arrived from the host after the transmission began. If more data is pending, the transmitting modem assembles a subsequent packet for transmission.



RF Packet

The RF packet is the sequence of data used for communicating information between MaxStream Modems. An RF Packet consists of an RF Initializer and RF Data.

Figure 2-03. RF Packet Components



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

RF Initializer

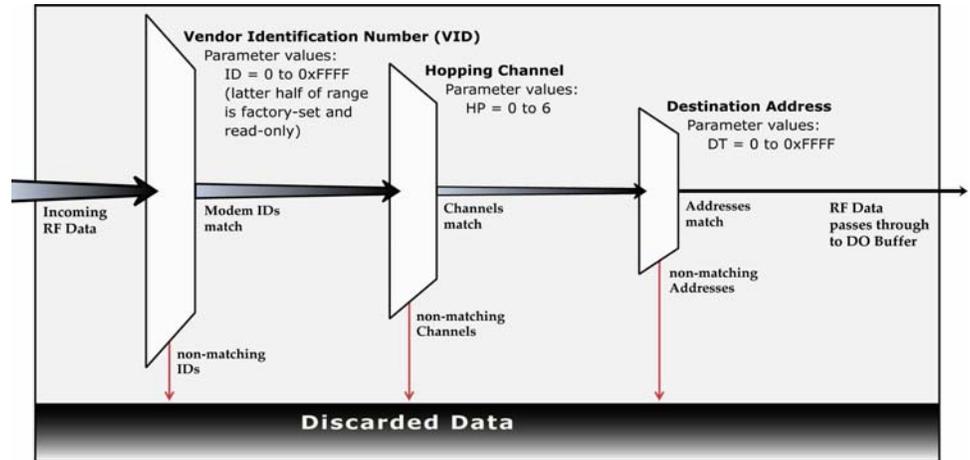
An RF initializer is sent each time a new connection sequence begins. The RF initializer contains channel information that notifies receiving modems of information such as the hopping pattern used by the transmitting modem. The first transmission always sends an RF initializer.

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 is used to filter 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 filter layers is discarded.

Figure 2-04. Filtration 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. On the receiving end, the receiving modem computes the CRC on all incoming RF data. Received data that has an invalid CRC is discarded [Refer to Receive Mode section].

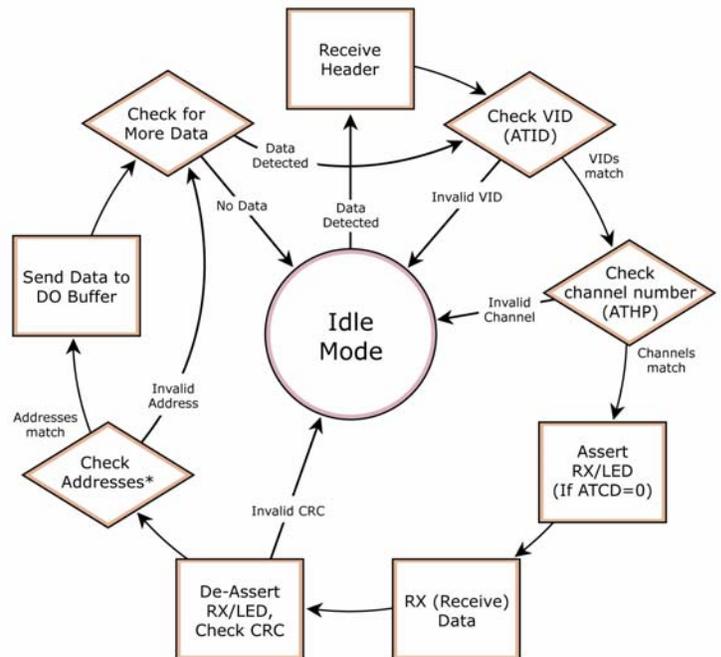
2.1.3. Receive Mode

If a modem detects RF data while operating in Idle Mode, the modem transitions into Receive Mode to start receiving RF packets.

Figure 2-05. Reception of RF Data →

After a packet is received, the modem checks the 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 proceeds to the DO Buffer.

The modem returns to Idle Mode after valid RF data is no longer detected or after an error is detected in 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.



2.1.4. Sleep Mode

Sleep Modes are not supported by the XStream-PKG-T Telephone RF Modem; however, Sleep Modes can be implemented on remote modems connected to the telephone RF modem host.

Sleep Modes enable the XStream Modem to operate at minimal power consumption when not in use. Three Sleep Mode options are available:

- Pin Sleep (Host Controlled)
- Serial Port Sleep (Wake on Serial Port activity)
- Cyclic Sleep (Wake on RF activity)

For the modem to transition into Sleep Mode, the modem must have a non-zero SM (Sleep Mode) Parameter and one of the following must occur:

1. The modem is idle (no data transmission or reception) for a user-defined period of time [Refer to ST (Time before Sleep) Command].
2. SLEEP pin is asserted (only for Pin Sleep option).

In Sleep Mode, the modem will not transmit or receive data until the modem first transitions to Idle Mode. All Sleep Modes are enabled and disabled using SM Command. Transitions into and out of Sleep Modes are triggered by various mechanisms as shown in the table below.

For more information about Sleep Modes, refer to the individual commands listed in "Related Commands" column of the table. SM Command is the best starting point for implementing sleep mode configurations.

Pin Sleep (SM = 1)

Pin Sleep requires the least amount of power. In order to achieve this state, Pin 2 (SLEEP) must be asserted (high). The module remains in Pin Sleep until the Sleep pin is de-asserted.

After enabling Pin Sleep, DI3 controls whether the XStream Module is active or in Sleep Mode. When DI3 is de-asserted (low), the module is fully operational. When DI3 is asserted (high), the module transitions to Sleep Mode and remains in its lowest power-consuming state until the Sleep pin is de-asserted. DI3 is only active if the module is setup to operate in this mode; otherwise the pin is ignored.

Once in Pin Sleep Mode, DO2 (pin 1, $\overline{\text{CTS}}$) is de-asserted (high), indicating that data should not be sent to the module. Pin 8 (PWR) is also de-asserted (low) when the module is in Pin Sleep Mode.

Note: The module will complete a transmission or reception before activating Pin Sleep.

Serial Port Sleep (SM = 2)

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

When Serial Port Sleep is enabled, the module 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 module returns to Idle Mode and is fully operational.

Cyclic Sleep (SM = 3-8)

Cyclic Sleep is the Sleep Mode in which the XStream Module enters into a low-power state and awakens periodically to determine if any transmissions are being sent.

When Cyclic Sleep settings are enabled, the XStream Module 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 module is in Cyclic Sleep Mode, DO2 ($\overline{\text{CTS}}$) is de-asserted (high) to indicate that data should not be sent to the module during this time. When the module awakens to listen for data, DO2 is asserted and any data received on the DI Pin is transmitted. PWR is also de-asserted (low) when the module is in Cyclic Sleep Mode.

The module 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 module returns to Idle Mode and listens for a valid data packet for 100 ms. If the module does not detect valid data (on any frequency), the module returns to Sleep Mode. If valid data is detected, the module transitions into Receive Mode and receives incoming RF packets. The module then returns to Sleep Mode after a Period of inactivity that is determined by ST "Time before Sleep" Command.

The module can also be configured to wake from cyclic sleep when DI3 (SLEEP) is de-asserted (low). To configure a module to operate in this manner, PW (Pin Wake-up) Command must be issued. Once DI3 is de-asserted, the module 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 0x0B ("1.1" seconds). With these parameters set, there is no risk of the receiving module 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 modules must wake during the wake-up initializer portion of data transmission in order to be synchronized with the transmitting module and receive the data.

Figure 2-06. 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.

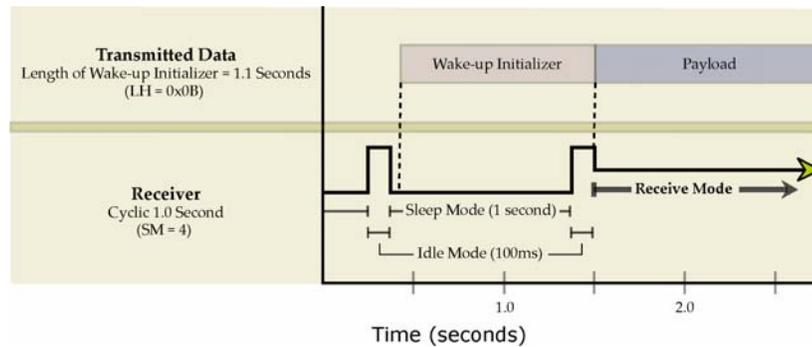
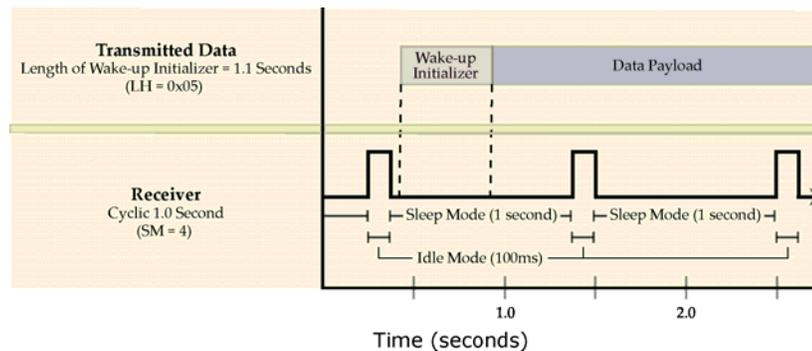


Figure 2-07. Incorrect Configuration (LH < SM):

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).



2.1.5. Command Mode

To modify or read RF module parameters, the module must first enter into Command Mode - the state in which incoming characters are interpreted as commands. Two command types are available for programming the on-board RF module:

- AT Commands
- Binary Commands

Refer to the RF Module Configuration sections [beginning on the next page] for more information.

For information about programming the on-board telephone module, refer to the Telephone Module Configuration [p20] section.

NOTE: The XStream-PKG-T RF Modem automatically powers up to a Command Mode for the on-board telephone module, the on-board RF Module does not. To enter RF Module into Command Mode for the purpose of programming the module, follow the refer to the RF Module Configuration section [next page].

2.2. RF Module Configuration

2.2.1. Command Reference Table

Table 2-01. Commands Unique to the on-board RF Module (For detailed command descriptions, refer to Appendix B)

AT Command	Binary Command	AT Command Name	Range	Command Category	# Bytes Returned	Factory Default
AM v4.30*	0x3A (58d)	Auto-set MY	-	Networking & Security	-	-
AT	0x05 (5d)	Guard Time After	0x02 – 0xFFFF [x 100 msec]	Command Mode Options	2	0x0A (10d)
BD v4.2B*	0x15 (21d)	Baud Rate	Standard baud rates: 0 – 6 (custom rates also supported)	Serial Interfacing	2	factory-set RF data rate
BK v4.30*	0x2E (46d)	Serial Break Passing	0 – 1	Serial Interfacing	1	0
BO v4.30*	0x30 (48d)	Serial Break Timeout	0 – 0xFFFF [x 1 second]	Serial Interfacing	2	0
BT	0x04 (4d)	Guard Time Before	0 – 0xFFFF [x 100 msec]	Command Mode Options	2	0x0A (10d)
CB v4.30*	0x33 (51d)	Connection Duration Timeout	0x01 – 0xFFFF [x 100 msec]	Networking & Security	2	0x28 (4d sec)
CC	0x13 (19d)	Command Sequence Character	0x20 – 0x7F	Command Mode Options	1	0x2B (“+”)
CD v4.2B*	0x28 (40d)	DO3 Configuration	0 – 4	Serial Interfacing	1	0
CE v4.30*	0x34 (52d)	Connection Inactivity Timeout	0 – 0xFFFF [x 10 msec]	Networking & Security	2	0x64 (1d sec)
CF v4.30*	0x35 (53d)	Connection Failure Count	0 – 0xFFFF	Networking & Security	2	0
CL v4.30*	0x39 (57d)	Last Connection Address	[read-only]	Diagnostics	2	-
CM v4.30*	0x38 (56d)	Connection Message	0 – 1	Networking & Security	1	0
CN	0x09 (9d)	Exit AT Command Mode	-	Command Mode Options	-	-
CO v4.30*	0x2F (47d)	DO3 Timeout	0 – 0xFFFF [x 1 second]	Serial Interfacing	2	0x03
CS v4.27D*	0x1F (31d)	DO2 Configuration	0 – 4	Serial Interfacing	1	0
CT	0x06 (6d)	Command Mode Timeout	0x02 – 0xFFFF [x 100 msec]	Command Mode Options	2	0xC8 (200d)
DC v4.30*	0x37 (55d)	Disconnect	-	Networking & Security	-	-
DR v4.30*	0x2D (45d)	DI3 Configuration	0 – 4	Serial Interfacing	1	0
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
FT v4.27B*	0x24 (36d)	Flow Control Threshold	0 – 0xFF [bytes]	Serial Interfacing	2	varies
GD	0x10 (16d)	Receive Good Count	0 – 0xFFFF	Diagnostics	2	0
HP	0x11 (17d)	Hopping Channel	0 – 6	Networking & Security	1	0
HT	0x03 (3d)	Time before Wake-up Initializer	0 – 0xFFFF [x 100 msec]	Sleep (Low Power)	2	0xFFFF
ID v4.2B*	0x27 (39d)	Modem VID	User-settable: 0x10 - 0x7FFF Read-only: 0x8000 – 0xFFFF	Networking & Security	2	-
IU v4.30*	0x3B (59d)	DI2, DI3 Update Timer	0 – 0xFFFF [x 100 msec]	Serial Interfacing	2	0x0A (10d)
LH	0x0C (12d)	Wake-up Initializer Timer	0 – 0xFF [x 100 msec]	Sleep (Low Power)	1	0x01
MD v4.30*	0x32 (50d)	RF Mode	0 – 4	Networking & Security	1	0
MK	0x12 (18d)	Address Mask	0 – 0xFFFF	Networking & Security	2	0xFFFF
MY v4.30*	0x2A (42d)	Source Address	0 – 0xFFFF	Networking & Security	2	0xFFFF
NB v4.30*	0x23 (35d)	Parity	0 – 5	Serial Interfacing	1	0
PC v4.22*	0x1E (30d)	Power-up Mode	0 – 1	Command Mode Options	1	0
PK v4.30*	0x29 (41d)	RF Packet Size	0 – 0x100 [bytes]	Serial Interfacing	2	0x40 (64d)
PW v4.22*	0x1D (29d)	Pin Wake-up	0 – 1	Sleep (Low Power)	1	0
RB v4.30*	0x20 (32d)	Packetization Threshold	0 – 0x100 [bytes]	Serial Interfacing	2	0x01
RE	0x0E (14d)	Restore Defaults	-	(Special)	-	-
RN v4.22*	0x19 (25d)	Delay Slots	0 – 0xFF [slots]	Networking & Security	1	0
RO v4.2A*	0x21 (33d)	Packetization Timeout	0 – 0xFFFF [x 200 µsec]	Serial Interfacing	2	0
RP v4.2A*	0x22 (34d)	RSSI PWM Timer	0 – 0x7F [x 100 msec]	Diagnostics	1	0
RR v4.22*	0x18 (24d)	Retries	0 – 0xFF	Networking & Security	1	0
RS v4.22*	0x1C (28d)	RSSI	0x06 – 0x36 [read-only]	Diagnostics	1	-
RT	0x16 (22d)	DI2 Configuration	0 – 2	Serial Interfacing	1	0
RZ v4.30*	0x2C (44d)	DI Buffer Size	[read-only]	Diagnostics	-	-
SB v4.2B*	0x36 (54d)	Stop Bits	0 – 1	Serial Interfacing	1	0
SH v4.27C*	0x25 (37d)	Serial Number High	0 – 0xFFFF [read-only]	Diagnostics	2	-
SL v4.27C*	0x26 (38d)	Serial Number Low	0 – 0xFFFF [read-only]	Diagnostics	2	-
SM	0x01 (1d)	Sleep Mode	0 – 8	Sleep (Low Power)	1	0
ST	0x02 (2d)	Time before Sleep	0x10 – 0xFFFF [x 100 msec]	Sleep (Low Power)	2	0x64 (100d)
SY	0x17 (23d)	Time before Initialization	0 – 0xFF [x 100 msec]	Networking & Security	1	0 (disabled)
TO v4.30*	0x31 (49d)	DO2 Timeout	0 – 0xFFFF (x 1 sec)	Serial Interfacing	2	0x03
TR v4.22*	0x1B (27d)	Transmit Error Count	0 – 0xFFFF	Diagnostics	2	0
TT v4.22*	0x1A (26d)	Streaming Limit	0 – 0xFFFF [0 = disabled]	Networking & Security	2	0xFFFF
VR	0x14 (20d)	Firmware Version	0 x 0xFFFF [read-only]	Diagnostics	2	-
WR	0x08 (8d)	Write	-	(Special)	-	-

* Firmware Version in which the command was first introduced. All subsequent versions also support the command.

2.2.2. AT Command Mode

This section illustrates how to configure the on-board RF Module using standard AT Commands. Refer to p17 for programming examples that implement the instructions on this page.

Hardware Setup:

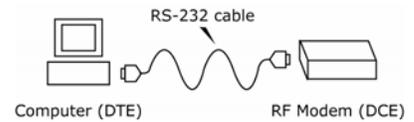
The on-board RF Module is configured through the DB-9 connector of the PKG-T RF Modem. To configure the on-board RF Module, DIP Switch 2 must be ON (up) and both \overline{DTR} and \overline{RTS} must be asserted (+10V RS-232 logic). Most serial communications software (including MaxStream's X-CTU Software) will assert \overline{DTR} and \overline{RTS} when the serial com port is opened.

1. Attach an RS-232 cable to the DB-9 connectors of the XStream-PKG-T RF Modem and a PC.
2. Move DIP Switch 2 (\overline{RTS} Control) to the ON (up) position.
3. Launch MaxStream's X-CTU™ Software and select the "PC Settings" Tab.
[Refer to the X-CTU section of Appendix B for information about X-CTU.]



In the 'Com Port Setup' section, match the Baud, Parity and Stop Bit settings of the PC com port with those of the RF Module. [Refer to BD & NB commands.]

Figure 2-08. Hardware Setup for Configuring the RF Module



Enter AT Command Mode:

Enter the AT Command Mode Sequence using the "Terminal" tab* of the X-CTU Software.

[OR]

Assert (low) the \overline{CONFIG} pin and turn the power going to the modem off and back on. This can be achieved by (i.) simultaneously pressing the Reset and Config switches [Figures 1-03b & 1-03c], (ii.) releasing the Reset Switch, (iii.) then after 1 sec. releasing the Config Switch. The RF Module then enters AT Command Mode at the module's default baud rate.

* The "Modem Configuration" tab can also be used to send AT commands to the RF module. When using this tab, make sure the settings under the 'AT Command Setup' sub-section of the "PC Settings" tab match the AT Command Mode Sequence parameters stored in the RF Module.

The **AT Command Mode Sequence** (default parameter values are shown in parenthesis):

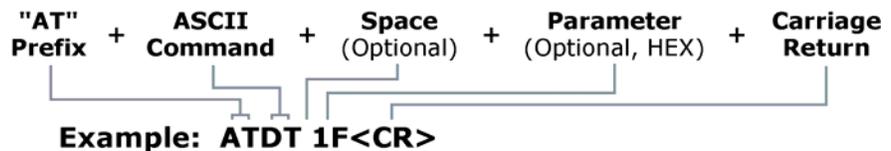
- Observe Guard Time Before (ATBT = 0x0A, no characters sent for one second)
- Enter three copies of the Command Sequence Character (ATCC = 0x2D, ASCII "---")
- Observe Guard Time After (ATAT = 0x0A, no characters sent for one second)

IMPORTANT: The default Command Sequence Character ("-") is unique to the XStream-PKG-T Telephone RF Modem. All other MaxStream Radio Modems use the "+" character as their default.

Send AT Commands:

When using the "Terminal" tab of the X-CTU Software, send AT Commands and parameters using the syntax shown below:

Table 2-02. Syntax for sending RF Module AT Commands:



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

The preceding example would change destination address of the RF Module to "1F". To store the new value to non-volatile (long-term) memory, the WR (Write) Command must follow.

System Response. When a command is sent to the module, the module parses and executes the command. Upon successful execution of a command, the module returns an "OK" message. If execution of command results in an error, the module returns an "ERROR" message.

Multiple AT Commands. Multiple AT commands can be entered on one line with one carriage return at the end of the line. Each command must be delimited by a comma (spaces in between are optional). The "AT" prefix is only sent before the first command and should not be included with subsequent commands in a line.

Exit AT Command Mode:

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

AT Command Examples

EXAMPLE #1: Modify DT (Destination Address) parameter using the Terminal tab

The following steps show how to read & modify the destination address of a PKG-T RF modem.

1. Follow the "Hardware Setup" steps outlined on p14; then open the X-CTU program (Start --> Programs --> MaxStream --> X-CTU).
2. Under the 'Com Port Setup' section of the "PC Settings" tab, select the Com Port that will be used to connect the RF module; then select the 'Baud' setting that matches the module's baud rate. Use RF Module default values for all other fields.
3. Select the "Terminal" tab; then send the following AT commands:

Method 1 (One line per command)

Issue AT Command	System Response
---	OK<CR> (Enters RF module into AT Command Mode)
ATDT <Enter>	(reads & displays current destination address)<CR>
ATDT1A0D<Enter>	OK<CR> (Changes DT address to 0x1A0d)
ATWR <Enter>	OK<CR> (Writes new value to non-volatile memory)
ATCN <Enter>	OK<CR> (Exits RF Module from AT Command Mode)

Method 2 (Multiple commands on one line)

Issue AT Command	System Response
---	OK<CR> (Enters into AT Command Mode)
ATDT <Enter>	(reads & displays current destination address)<CR>
ATDT1A0D, WR, CN <Enter>	OK<CR> (Send multiple AT Commands)

EXAMPLE #2: Restore Defaults using the Modem Configuration tab

The following steps show how to read currently stored RF module parameter values; then restore the RF module parameters to their factory-default states.

1. Follow the "Hardware Setup" steps outlined on p14; then open the X-CTU program (Start --> Programs --> MaxStream --> X-CTU).
2. Under the 'Com Port Setup' section of the "PC Settings" tab, select the Com Port that will be used to connect the RF module; then select the 'Baud' setting that matches the module's baud rate. Use RF Module default values for all other fields.
3. Under the 'Host Setup' sub-tab, enter "-" in the ASCII text box to match the RF module's CC (Command Sequence Character) parameter.
4. Select the "Modem Configuration" tab; then select the Read' button to read currently stored parameter values of the RF module.
5. Select the 'Load' button, then navigate to and open the appropriate profile. Profiles carry a ".pro" file extension and are located in the 'Profiles' folder of the MaxStream CD.
6. Select the 'Write' button to save RF module default values to non-volatile memory.

2.2.3. Binary Command Mode

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

Common questions about using binary commands:

- What are the implications of asserting CMD while live data is being sent or received?
- After sending serial data, is there a minimum time delay before CMD can be asserted?
- Is a delay required after CMD is de-asserted before payload data can be sent?
- How does one discern between live data and data received in response to a command?

The CMD pin must be asserted in order to send binary commands to the RF modem. The CMD pin can be asserted to recognize binary commands anytime during the transmission or reception of data. 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. The application does not allow control over when data is received, except by waiting for dead time between bursts of communication.

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{CTS} signal will frame the response coming from the binary command request [refer to Figure below].

A minimum time delay of 100 μ s (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.

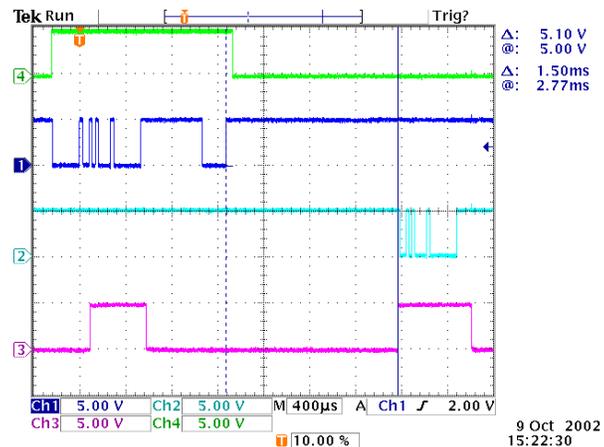
Note: When parameters are sent, they are two bytes long with the least significant byte sent first. Binary commands that return one parameter byte must be written with two parameter bytes.

Commands can be queried for their current value by sending the command logically ORed (bit-wise) with the value 0x80 (hexadecimal) with CMD 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 2-09. Binary Command Write then Read

- Signal #4 is CMD
- Signal #1 is the DIN signal to the radio
- Signal #2 is the DOOUT signal from the radio
- Signal #3 is \overline{CTS}

In this 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 outlines the data response out of the modem



9 Oct 2002
15:22:30

IMPORTANT: For the RF Module to recognize a binary command, the RT (DI2 Configuration) parameter must be set to one. If binary programming is not enabled (RT \neq 1), the RF module will not recognize that the CMD pin is asserted and therefore will not recognize the data as binary commands.

Binary Command Example

The following example steps through an RF module configuration process using binary commands.

To Send Binary Commands:

Example: Use binary commands to change the RF Module's destination address to 0x1A0D and save the new address to non-volatile memory.

1. RT Command must be set to "1" in AT Command Mode to enable binary programming.
2. Assert CMD (Pin is driven high). (Enter Binary Command Mode)
3. Send Bytes [Parameter bytes must be 2 bytes long]:
 - 00 (Send DT (Destination Address) Command)
 - 0D (Least significant byte of parameter bytes)
 - 1A (Most significant byte of parameter bytes)
 - 08 (Send WR (Write) Command)
4. De-assert CMD (Pin is driven low). (Exit Binary Command Mode)

Note: $\overline{\text{CTS}}$ is high when command is being executed. Hardware flow control must be disabled as $\overline{\text{CTS}}$ will hold off parameter bytes.

3. Telephone Module Operation

3.1. Telephone Module Configuration

The Telephone Module features a rich set of AT commands that allow flexibility in operations. On power-up or reset, the Telephone Module operates in command mode and will accept AT commands either from an RS-232 serial cable or from another MaxStream RF Modem (PKG-R, PKG-U, etc.) over a wireless link.

Refer to the Telephone Module Configuration Example section [p25] for programming examples.

Hardware Setup Option 1 – Serial Port Method:

Configurations made through the serial line [Figure 3-01]

1. Connect an RS-232 cable to the DB-9 connector of the PKG-T RF Modem.
2. Move DIP Switch 1 (Speaker Control) to the ON (up) position and DIP Switch 2 ($\overline{\text{RTS}}$ control) to the OFF (down) position. This will configure the Data Path Switch to connect the DB-9 and Telephone Module.
3. Assert $\overline{\text{DTR}}$ (+10V). Most serial communications software (including MaxStream's X-CTU Software) will assert $\overline{\text{DTR}}$ when the serial com port is opened.

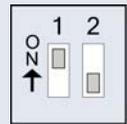
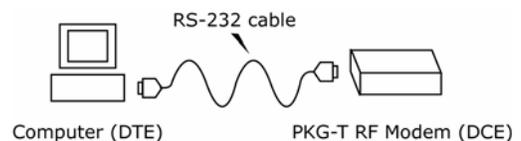


Figure 3-01. Hardware Setup - Serial Port Method



Hardware Setup Option 2 – Wireless Link Method

Configurations made via a remote PKG RF Modem [Figure 3-02]

1. Detach cable from the DB-9 connector (Absence of the cable will automatically de-assert $\overline{\text{DTR}}$ (-10V RS-232 level)).
2. Connect wirelessly to the RF Modem (AT Commands are sent from a PC to a device such as the PKG-R RS-232/485 RF Modem via a serial port. The PKG-R Modem then relays commands over-the-air to the PKG-T Telephone RF Modem.)

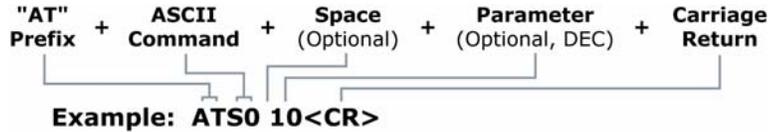
Figure 3-02. Hardware Setup - Wireless Link Method



Send AT Commands:

When using the "Terminal" tab of the X-CTU Software, send AT Commands and parameters using the syntax shown below:

Figure 3-03. Syntax for sending Telephone Module AT Commands:



The Telephone Modem ignores spaces, parenthesis and quotation marks in a command string.

To read a parameter value stored in a register, type a question mark "?" after the command line.

Aborting Commands. Some commands that require time to execute may be aborted during operation. A single character may be sent to the module to abort the currently executing command.

Disconnecting a Call. Below are four methods that can be used to disconnect a call:

1. Resetting the Telephone Module's power (by pressing the "Reset Switch" of the RF Modem [Figure 1-03c]) will disconnect and put the module back to the OFF line state.
2. A remote device can also cause the telephone module to disconnect. If the remote RF modem disconnects, the local telephone module will automatically sense the loss of the carrier signal, then return to the OFF line state.
3. "ATH" or "ATZ" commands can also be used to disconnect a call. In order to issue a command to the Telephone Module when it is On line, the module must be placed into the "On Line Command State".

This is accomplished by issuing a special escape sequence. The default value of this three digit escape sequence is the "+" character [S-Parameter "S2"]. The "+++" is guarded by a 1-second delay before and after it is sent [S-Parameter "S12"]. When the module detects the escape sequence, the "OK" result will be displayed and the module will enter the On Line Command State. The "ATH" or "ATZ" commands can now be issued to disconnect the call.
4. If I/O line passing is enabled, a DTR drop will cause the modem to disconnect.

System Response

Command Echo. The Telephone Module may echo characters (default state). The echo can be turned off or on using the "E" command as described in Table 3-02.

The modem will issue basic codes in response to processing an AT Command. Result codes may be displayed either in word (V1) or numeric (V0) format using the Vn command. The Qn command controls if result codes are issued (Q0) or not issued (Q1).

Table 3-01. Basic Result Codes

Numeric	Word	Description
0	OK	Modem has received and acknowledged the command
1	CONNECT	Connection made at 300 bps or extended result codes are off (X0)
2	RING	An incoming ring signal has been detected
3	NO CARRIER	Reflects that either an intended disconnect or a failure to complete a connection
4	ERROR	Indicates an invalid command was issued to the modem
5	CONNECT 1200	Indicates 1200 bps line or DTE connection (see Wn command)
6	NO DIALTONE	Modem cannot detect a dial tone
7	BUSY	Modem has detected a busy tone
8	NO ANSWER	After S7 time has elapsed, the remote device did not answer
10	CONNECT 2400	Line speed or DTE connection at 2400 bps
12	CONNECT 9600	Line speed or DTE connection at 9600 bps
15	CONNECT 14400	Line speed or DTE connection at 14400 bps
16	CONNECT 19200	Line speed or DTE connection at 19200 bps
17	CONNECT 38400	Line speed or DTE connection at 38400 bps
18	CONNECT 57600	Line speed or DTE connection at 57600 bps

3.1.1. Command Reference Tables

Tables 3-02, 3-03 and 3-04 contain the commands available for configuring the on-board telephone module.

Table 3-02. Telephone Module AT Commands

AT Command	Parameters
General Commands	
A	Module will go off-hook and attempt to answer an incoming call
A/	Repeat Previous Command
Bn	n = 0 CCITT operation at 300 or 1200 bps n = 1 Bell operation at 300 or 1200 bps (default)
Dn (Dial Commands)	n = 0-9 DTMF Digits
	n = A-D DTMF Digits
	n = * Star Digit. (tone dialing only)
	n = # Gate Digit. (tone dialing only)
	n = T Tone Dialing.
	n = P Pulse Dialing.
	n = R (Command is accepted but not acted on)
	n = S Dial Stored Number. Dial the number stored in the directory (n = 0-3). See "&Z" Command.
	n = , Pause. Wait for S8 time
	n = ; Remain. Remain in AT Command Mode after Dialing
	n = " (Ignored – may be used to format dial string)
	n = <space> (Ignored)
	n = () (Ignored – may be used to format dial string)
n = W Wait for Dial Tone. Waits for dial tone until timeout specified by "S7" expires. If no dial tone is detected, module returns on-hook and generates error message.	
n = @ Wait for Silence. Waits for at least 5 x 1 second of silence before continuing with next dial string parameter. If silence is not detected before the "S7" timeout expires, the module will terminate the call with NO ANSWER message.	
n = ! Flash. Module goes on-hook according to time specified in "S29".	
En	n = 0 Disable Command Echo n = 1 Enable Command Echo (default)
Hn	n = 0 Module will hang up. n = 1 If on-hook, module will go off-hook and enter command mode
Ln	n = 0 Low volume on speaker line n = 1 Low volume on speaker line (default) n = 2 Medium volume n = 3 High Volume
Mn	n = 0 Speaker is always off n = 1 Speaker is on while establishing connection, but off when receiving carrier (default) n = 2 Speaker always on n = 3 Speaker on while answering, off when receiving carrier and when dialing
On	n = 0 Enter on-line data mode without a retrain n = 1 Enter on-line data mode with a retrain
Qn	n = 0 Enable results codes to DTE (default) n = 1 Disable results codes to DTE
Sr	r Establishes S-register "r" as the default register r = n Sets S-register "r" to the value "n" r? Reports the value of S-register
Vn	n = 0 Enables short form (terse) result codes n = 1 Enables long form (verbose) result codes (default)
Wn	n = 0 Upon connect, module reports only DTE speed (i.e. CONNECT 9600) (default) n = 1 Upon connect, module reports modulation, line speed, error correction protocol, and DTE speed n = 2 Upon connect, module reports DCE speed
Xn	n = 0 Ignores dial & busy tone. Sends CONNECT message when a connection is established by blind dialing.
	n = 1 Disables monitoring of busy tones; sends only OK, CONNECT, RING, NO CARRIER, ERROR. If busy tone detection is enforced and busy tone is detected, NO CARRIER will be reported instead of NO DIALTONE.
	n = 2 Disables monitoring of busy tones. Sends only OK, CONNECT, RING, NO CARRIER, ERROR, NO DIALTONE and CONNECT or CARRIER XXXX. If busy tone detection is enforced and busy tone is detected, NO CARRIER will be reported instead of BUSY. If dial tone detection is enforced or selected and dial tone is not detected, NO CARRIER will be reported instead of NO DIAL TONE.
	n = 3 Enables monitoring of busy tones; sends only OK, CONNECT, RING, NO CARRIER, ERROR, NO DIALTONE and CONNECT or CARRIER XXXX. If dial tone detection is enforced and dial tone is not detected, NO CARRIER will be reported.
	n = 4 Enables monitoring of busy tones; sends all messages. (default)
Zn	n = 0 Soft reset and restore profile 0 n = 1 Soft reset and restore profile 1

Table 3-03. Telephone Module AT Commands – Ampersand Commands
(Low-asserted signals are distinguished by horizontal line over pin name.)

AT Command	Parameters
Ampersand (&) Commands	
&Cn	n = 0 <u>DCD</u> Always On n = 1 Module Controls <u>DCD</u> (default)
&Dn	n = 0 Ignore <u>DTR</u> n = 1 <u>DTR</u> drop puts module in command mode without disconnecting n = 2 <u>DTR</u> drop causes the module to hang up (default) n = 3 <u>DTR</u> drop causes module to perform a soft reset as if the Z command were received
&Fn	n = 0 Restore Factory Configuration 0 n = 1 Restore Factory Configuration 1
&Gn	n = 0 No Guard Tone (default) n = 2 1800 Hz Guard Tone
&Kn	n = 0 Disables flow control n = 3 Enables <u>RTS</u> / <u>CTS</u> hardware flow control (default) n = 4 Enables XON/XOFF software flow control n = 5 Enables transparent XON/XOFF software flow control
&Rn	n = 0 <u>CTS</u> follows <u>RTS</u> . <u>RTS</u> - <u>CTS</u> delay set by "S26" S-Parameter. n = 1 <u>CTS</u> always asserted.
&Sn	n = 0 <u>DSR</u> Always On (default) n = 1 Module Controls <u>DSR</u>
&Tn	n = 0 Terminates test in progress n = 1 Begin Analog Loopback Test
&V	Diagnostic command - Reports current configuration, stored user profiles and first 4 stored telephone numbers
&V1	Diagnostic command - Shows statistics for most recent connection
&Wn	n = 0 Store configuration as profile 0 n = 1 Store configuration as profile 1
&Yn	n = 0 Hard reset restores profile 0 n = 1 Hard reset restores profile 1
&Zn	Stores telephone number dial string (to 31 digits) into n (n = 0 - 3)

S-Parameters

Reading and Setting S-Parameters

Commands that begin with the letter "S" are called S-Parameters. The number following the "S" indicates the parameter number. The Telephone Module can select an active S-Parameter and (where applicable) perform read/write operations. Commands can be performed on an S-Parameter as follows:

ATSn – Makes S-Parameter n active
ATSn=v – Sets S-Parameter n to value v
ATSn? – Reads current value of S-Parameter n

Once a register is made active (the last register accessed), the register name is optional and can be omitted from subsequent read/write commands that reference the same register. This is show in the table below.

Table 3-04. Sample read and write commands using active register

Command	System Response
ATS7	Make "S7" Parameter Active
AT=51 or ATS7=51	Set "S7" to 51 (decimal)
AT?	Read Value of "S7"

If the number n (or the value v on a write) is out of range or invalid, the module will return the "ERROR" message. All S-Parameter values and responses are in decimal format. All S-Parameters can be read using "&V" command [Table 3-03].

Table 3-05. Telephone Module AT Commands – S-Parameters

AT Command	Description	Parameter Range	Default
S-Parameters			
S0	Number of Rings before Auto-Answer. The number of rings before module will automatically answer.	0 - 255	0 (no Auto-Answer)
S1	Ring Counter. Counts Number of Rings, clears count after 8 seconds of no ring.	0 - 255	n/a
S2	Command Sequence Char. Holds ASCII value of escape character.	0 - 255	43 ("+" char)
S3	Carriage Return Char. Holds ASCII value of carriage return character.	0 - 127	13 (carriage return)
S4	Line Feed Char. Holds ASCII value of line feed character.	0 - 127 [ASCII decimal]	10 (line feed)
S5	Backspace Char. Holds ASCII value of backspace character.	0 - 32 [ASCII decimal]	8 (backspace)
S6	Wait Time/Dial Tone. The length of time module will wait for dial tone when encountering a "W" dial modifier before returning "NO DIAL TONE" message.	2 - 255 [x 1 second]	2
S7	Wait Time/Carrier. The length of time module will wait: - for carrier before hanging up - for silence when encountering the "@" dial modifier before continuing with the next dial string parameter - for dial tone when encountering a "W" dial modifier before continuing with the next dial string parameter.	1 - 255 [x 1 second]	50
S8	Pause Time. Sets time that module must pause when the ";" character is encountered in the dial string.	2 - 255 [x 1 second]	2
S9	Carrier Detect Time. No value can be written.	Not configurable [x 1 ms]	600
S10	Carrier Loss Time. Time that module waits before hanging up after losing carrier. The actual wait time is (S10 - S9), so "S10" must be set to a value greater than "S9".	6 - 255 [x 100 ms]	14
S11	Dial Tone Duration. Sets tone duration for DTMF dialing.	50 - 255 [x 1 ms]	95
S12	Guard Times. Required maximum time period of silence between receipt of the last character of the three escape character sequence and sending of the "OK" result code. If any characters are detected during this time, "OK" will not be sent.	0 - 255 [x 20 ms]	50 (1 second)
S26	RTS / CTS Delay Time. The time delay before the module turns on CTS after detecting OFF to ON RTS transition (when "&R0" command is set).	0 - 255 [x 10 ms]	1
S29	On-hook Time. Sets length of time that the module will go on-hook when it encounters Flash ("P") dial modifier in dial string.	Not configurable [x 10 ms]	70 (country-dependent, not configurable)
S30	Disconnect Inactivity Timer. The length of time that the module will stay online before disconnecting when no data is sent or received.	0 - 255 [x 10 seconds]	0 (disabled)

3.1.2. Telephone Module Configuration Example

The following programming example illustrates telephone module configurations using “Serial” and “Wireless Link” configuration methods. This example requires: 1 PKG-T Telephone RF Modem, 1 PKG-R RS-232/485 RF Modem, 1 PC (or laptop), 2 power supplies and 1 RS-232 cable.

Serial Configuration Method

Setup and Telephone Configuration (Using the Serial Configuration Method)

1. Attach RS-232 cable to DB-9 ports of the PKG-T Modem and PC [as shown in Figure 3-01].
2. Move DIP Switch 1 to the ON (up) position and switch 2 of the PKG-T Modem to the OFF (down) position [As is shown in the illustration to the right]. NOTE: When configuring the on-board RF Module rather than the on-board Telephone Module, DIP Switch 2 must be in the ON (up) position.
3. Connect power to the XStream-PKG-T RF Modem.
4. On the laptop (or PC) launch the X-CTU Software (or HyperTerminal Software).
5. Click on the “PC Settings” tab and make sure the serial com port’s baud rate and parity settings match values currently stored in the PKG-T Modem.
6. Click the “Terminal” tab of the X-CTU Software and type in any character.
 - The Telephone Modem in the PKG-T will automatically detect the initial character (blue font) and echo the character back (red font), verifying a connection is established.
 - If no character is echoed back, try the following:
 - 1) Make sure the PKG-T Modem is connected to the same serial com port that is selected on the “PC Settings” tab of the X-CTU Software.
 - 2) Reset PKG-T RF Modem.
7. Type the following AT Command in the “Terminal” tab of the X-CTU Software:



Send Command*	System Response
ATL2 <CR>	OK (Turns speaker to medium volume)

Wireless Link Configuration Method

Telephone Module Configuration (Using the Wireless Link Configuration Method)

In this section of the example, AT Commands will first be sent to a PKG-R (RS-232/485) RF Modem from a PC via a serial connection. The PKG-R Modem will then relay the commands over-the-air to a receiving PKG-T Telephone RF Modem [as shown in Figure 3-02].

8. Configure the RS-232 RF Modem to RS-232 mode by moving DIP Switch 1 of the PKG-R Modem to the ON (up) position and the remaining switches to the OFF (down) position.
9. Remove RS-232 cable from XStream-PKG-T Telephone RF Modem’s DB-9 connector and connect it to the DB-9 connector of the PKG-R Modem. Verify both the PKG-R and PKG-T Modems are powered [as indicated by the red LEDs].
10. Click the “Terminal” tab of the X-CTU Software and enter any character.
 - The Telephone Modem in the PKG-T will automatically detect the initial character (blue font) and echo the character back (red font), thus verifying a wireless link is established.
11. Type the following AT Commands
(Echo is on by default so all characters will appear in duplicate):



Send Command*	System Response
AT&S1 <CR>	OK (Enables Telephone Module control of \overline{DSR})
ATS30=20 <CR>	OK (Sets 200 sec. timeout - time of inactivity before disconnect)
AT&W0 <CR>	OK (Stores current settings as Profile “0”)
AT&Y0 <CR>	OK (Hard reset then restores Profile “0”)
AT&V <CR>	(... Lists active & stored profile values) OK
At&F0 <CR>	OK (Restores factory default configuration “0”)

* <CR> Each command line is concluded with a carriage return (<CR> or “Enter” key)

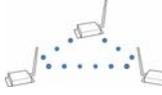
4. RF Communication Modes

Network configurations covered in this chapter are described in terms of the following:

- Network Topology (Point-to-Point, Point-to-Multipoint or Peer-to-Peer)
- RF Communication Type (Basic or Acknowledged)
- RF Mode (Streaming, Repeater, Acknowledged or Multi-Streaming)

The following table provides a summary of the network configurations supported.

Table 4-01. Summary of network configurations supported by the XStream RF Modem

Point-to-Point		
	Definition	An RF data link between two modems.
	Sample Network Profile * (Broadcast Communications)	Use default values for all modems.
	Sample Network Profile * (Acknowledged Communications)	All Modems: ATAM [auto-set MY (Source Address) parameter] ** ATDT FFFF [set Destination Address to 0xFFFF]
	Basic Communication RF Modes	Streaming Mode [p28], Repeater Mode [p29]
	Acknowledged Communication RF Mode	Acknowledged Mode [p32]
Point-to-Multipoint		
	Definition	RF data links between one base and multiple remotes.
	Sample Network Profile * (Basic Communications)	Base: ATMY 0 [set Source Address to 0x00] ATDT FFFF [set Destination Address to 0xFFFF]
		Remotes: ATAM [auto-set MY (Source Address) parameter] ** ATDT 0 [set Destination Address to 0x00]
	Sample Network Profile * (Acknowledged Communications)	Base: ATMY 0 [set Source Address to 0x00] ATDT FFFF [set Destination Address to 0xFFFF] ATRR 3 [set number of Retries to 3]
		Remotes: ATAM [auto-set MY (Source Address) parameter] ** ATDT 0 [set Destination Address to 0x00] ATRR 3 [set number of Retries to 3]
	Basic Communication RF Modes	Streaming Mode [p28], Repeater Mode [p29]
Acknowledged Communication RF Modes	Acknowledged Mode [p32], Multi-Streaming Mode [p34]	
Peer-to-Peer		
	Definition	Modems remain synchronized without use of a master/server. Each modem shares the roles of master and slave. MaxStream's peer-to-peer architecture features fast synch times (35ms to synchronize modems) and fast cold start times (50ms before transmission).
	Sample Network Profile * (Basic Communications)	Use default values for all modems.
	Sample Network Profile * (Acknowledged Communications)	All Modems: ATAM [auto-set MY (Source Address) parameter] ** ATDT FFFF [set Destination Address to 0xFFFF] ATRR 3 [set number of Retries to 3]
	Basic Communication RF Mode	Streaming Mode [p28]
	Acknowledged Communication RF Mode	Acknowledged Mode [p32]

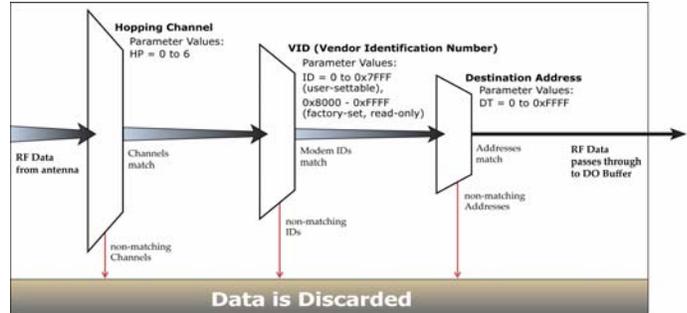
* Assume default values for parameters not listed. Profiles do not reflect addressing implementations.

** AM (Auto-set MY) Command must be issued through a terminal program such as the one incorporated in the X-CTU 'Terminal' tab.

4.1. Addressing

Each RF packet contains addressing information that is used to filter incoming RF data. Receiving modems inspect the Hopping Channel (HP parameter), Vendor Identification Number (ID parameter) and Destination Address (DT parameter) contained in each RF packet. Data that does not pass through all three network security layers is discarded.

Figure 4-01. Filtration layers contained in the RF packet header



4.1.1. Address Recognition

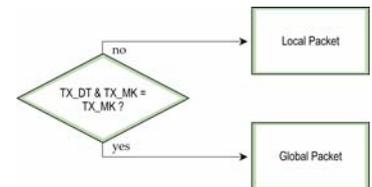
Transmissions can be addressed to a specific modem or group of modems using the DT (Destination Address) and MK (Address Mask) parameters. The transmitting modem dictates whether the packet is intended for a specific modem (local address) or multiple modems (global address) by comparing the packet's DT parameter to its own MK parameter.

Figure 4-02. Local Packets vs. Global Packets (Transmitting Modem)

TX_DT = Transmitter Destination Address

TX_MK = Transmitter Address Mask

Note: When TX_DT = 0xFFFF (default), RF packets are global and are received by all modems within range. (Receivers do not send ACKs.)



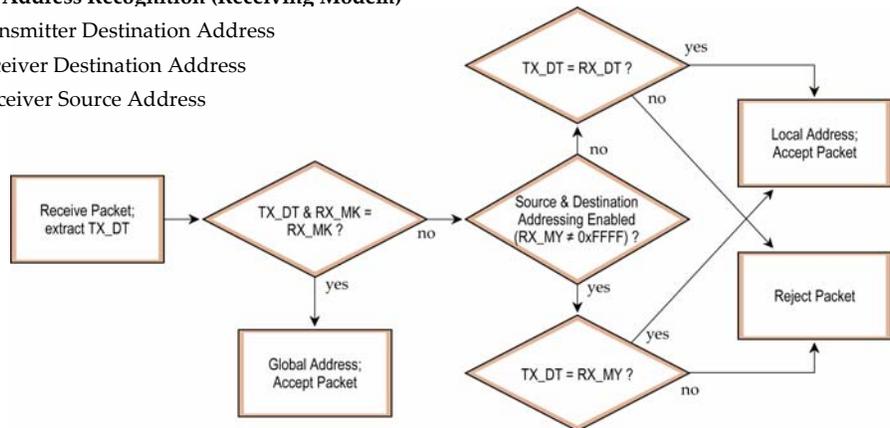
A receiving modem will only accept a packet if a packet is addressed to it (either as a global or local packet). The RX modem makes this determination by inspecting the destination address of the RF packet and comparing it to its own address and mask. The Destination Address of the TX modem is logically "ANDed" with the Address Mask of the RX modem.

Figure 4-03. Address Recognition (Receiving Modem)

TX_DT = Transmitter Destination Address

RX_DT = Receiver Destination Address

RX_MY = Receiver Source Address



NOTE: For more information regarding addressing and masks, refer to Application Note 'XST-AN004b'. (Located on the MaxStream CD and on the web: www.maxstream.net)

4.2. Basic Communications

Basic Communications are accomplished through two sub-types:

- Broadcast - By default, XStream Modems communicate through Broadcast communications and within a peer-to-peer network topology. When any modem transmits, all other modems within range will receive the data and pass it directly to their host device.
- Addressed - If addressing parameters match, received RF data is forwarded to the DO (Data Out) buffer; otherwise, the RF data is discarded.

When using Basic Communications, any functions such as acknowledgements are handled at the application layer by the OEM/integrator. The Broadcast Modes provide transparent communications, meaning that the RF link simply replaces a wired link.

4.2.1. Streaming Mode (Default)

Characteristics: Highest data throughput
 Lowest latency and jitter
 Reduced immunity to interference
 Transmissions never acknowledged (ACK) 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 systems more sensitive to latency and/or jitter than to occasional packet loss. For example: streaming audio or video.

Streaming Mode Data Flow

Figure 4-04. Streaming Mode State Diagram (TX Modem)

Events and processes in this mode are common to all of the other RF Communication Modes.

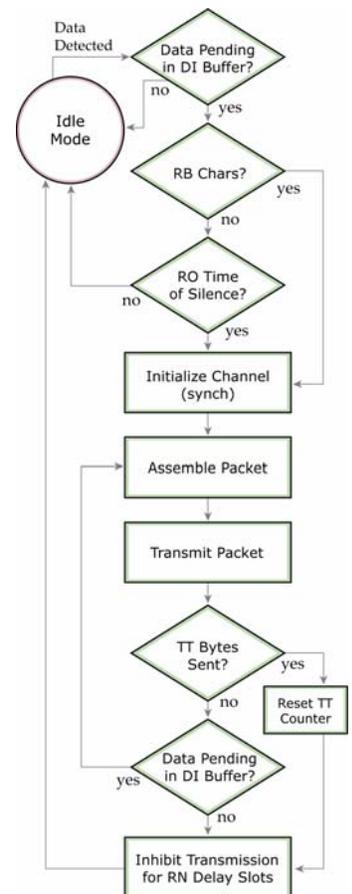
NOTE: When streaming data, RB and RO parameters are only observed on the first packet.

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 (TT Command) is specified by the transmitting modem as the maximum number of bytes the transmitting modem can send in one transmission event. After the TT parameter threshold 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.



4.2.2. Repeater Mode

- Characteristics:** Self-organizing - No route configuration is necessary
 Self-healing / Fault-tolerant
 Low power consumption and Minimized interference
 Network throughput is determined by number of hops, not by number of repeaters. Multiple repeaters within range of source node count as one hop.
 Supports "transparent" multi-drop mode or addressed data filtering mode.
 Duplicate RF packets are automatically filtered out.
 All packets propagate to every node in the network (filtering rules apply).
 Broadcast communications - each packet comes out every node exactly once.
 Addressed communications - all radios see every packet. Only the modem with a matching address will forward it to the DO buffer (UART IN).
 Data entering the network on any modem is transmitted and forwarded through every repeater modem until it reaches the ends of the network.
 Each repeater will repeat a packet only once.
- Constraints:** Requires that each modem have a unique MY (Source Address) parameter.
 System must introduce just one packet at a time to the network for transmission (256 bytes max).
 Each hop (H) decreases network throughput by a factor of $1/(H+1)$.
 Additional repeaters add network redundancy without decreasing throughput.
- Required Parameter Values (TX Modem):** MD = 3 or 4, MY = unique value (can be accomplished by issuing the AM (Auto-set MY) and WR (Write) commands to all modems in the network)
- Related Commands:** Networking (MD, DT, MY, AM), Serial Interfacing (RN, PK, RO, RB)
- Recommended Use:** Use in networks where intermediary nodes are needed to relay data to modems that are beyond the transmission range of the base modem.

Theory of Operation

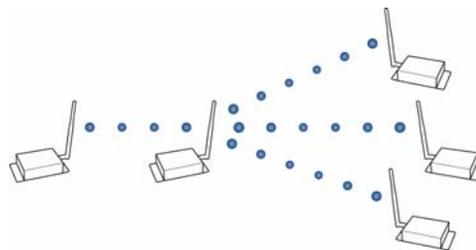
OEMs and integrators can extend the effective range and reliability of a data radio system by forwarding traffic through one or more repeaters.

Instead of using routing tables and path discovery to establish dynamic paths through a network, the repeater system uses a sophisticated algorithm to propagate each RF packet through the entire network.

The network supports RF packets up to 256 bytes. The repeater network can operate using broadcast or addressed communications for multi-drop networks and works well in many systems with no special configuration.

When in Repeater Mode, the network repeats each message among all available nodes exactly one time. This mechanism eliminates the need for configuring specific routes. The network is self-organizing and self-healing so that the system is able to receive transmissions in the event of a modem going down.

Figure 4-05. Sample Repeater Network Topology



Repeater Network Configuration

A network may consist of End Nodes (EN), End/Repeater Nodes (ERN) and a Base Node (BN). The base node initiates all communications.

The repeater network can be configured to operate using Basic Broadcast or Basic Addressed communications. The addressing capabilities of the modems allow integrators to send a packet as a global packet (DT = 0xFFFF) and shift out of every radio in the network (Basic Broadcast). Alternatively, the packet can be sent with a specific DT (Destination Address) parameter so that it is only accepted by a specific remote node (Basic Addressed).

Configuration Instruction (Basic Broadcast Communications)

Assign each radio modem a unique MY (source) address. (The AM (Auto-set MY) command will configure a unique source address that is based on modem serial number.)

Enable Basic Broadcast Communications (DT = 0xFFFF) or Addressed Broadcast Communications (ATDT specifies a specific destination)

Configure PK, RO and RB to ensure that RF packet aligns with protocol packet. (ex. PK=0x100, RB=0x100, RO depends on baud rate).

Configure one or more repeaters in the system (ATMD = 3).

Configure remote nodes as destinations (MD = 4). This will ensure that the remote node waits for the repeater traffic to subside before it transmits a response.

The configuration instructions above reflect configuration for a Basic Broadcast Repeater system. To configure a Basic Addressed Repeater system, use the DT (Destination Address) parameter to assign unique addresses to each modem in the network.

Algorithm details

- Packet ID (PID) is composed of transmitting modem MY address and packet serial number.
- Incoming packets with a PID already found in the PID buffer will be ignored.
- Each modem maintains a PID buffer 8 deep of previously received packets (managed as FIFO).

Packets may be shifted out the serial port and/or repeated depending on the DT parameter contained in the RF packet.

Table 4-02. DT (Destination Address) parameter truth table

Address Match	Send out serial port?	Repeat?
Global	Yes	Yes
Local	Yes	No
None	No	Yes

Repeat delay based on RSSI

A transmitted packet may be received by more than one repeater at the same time. In order to reduce the probability that the repeaters will transmit at the same instant, resulting in a collision and possible data loss; an algorithm has been developed that will allow a variable back-off prior to retransmission of the packet by a repeater. The algorithm allows radios that receive the packet with a stronger RF signal (RSSI) to have the first opportunity to retransmit the packet.

The RN (Delay Slots) parameter is used to configure this delay. Set RN=0 (no delays) for small networks with few repeaters or repeaters that are not within range of each other. Set RN=1 for systems with 2 to 5 repeaters that may be within range of each other.

The actual length of the delay is computed by the formula:

$$\text{Delay (ms)} = L * DS$$

$$DS = (-41 - \text{RSSI}) / 10 * RN + \text{RandomInt}(0, RN)$$

Where L is the length of the transmitted packet in milliseconds, DS is the number of delay slots to wait, RSSI is the received signal strength in dBm, RN is the value of the RN register and RandomInt(A,B) is a function that returns a random integer from A to B-0

Response packet delay

As a packet propagates through the repeater network, if any node receives the data and generates a quick response, the response needs to be delayed so as not to collide with subsequent retransmissions of the original packet. To reduce collisions, both repeater and end node radios in a repeater network will delay transmission of data shifted in the serial port to allow any repeaters within range to complete their retransmissions.

The time for this delay is computed by the formula:

$$\text{Maximum Delay (ms)} = L * DS$$

$$DS = ((-41 - (-100)) / 10) * RN + RN + 1$$

Where L is the length of the transmitted packet in milliseconds, DS is the number of delay slots to wait, RSSI is the received signal strength in dBm, and RN is the value of the RN register.

Use Case - Broadcast Repeater Network

Consider modems R1 through R10 each communicating to a PLC using the ModBus protocol and spaced evenly in a line. All ten nodes are configured as 'destinations & repeaters' within the scope of Basic Broadcast Communications (MD=3, AM, DT=0xFFFF, PK=0x100, RO=0x03, RB=0x100, RN=1). The Base Host (BH) shifts payload that is destined for R10 to R1. R1 initializes RF communication and transmits payload to nodes R2 through R5 which are all within range of R1. Modems R2 through R5 receive the RF packet and retransmit the packet simultaneously. They also send the data out the serial ports, to the PLC's.

Table 4-03. Commands used to configure repeater functions

AT Command	Binary Command	AT Command Name	Range	# Bytes Returned	Factory Default
AM	0x3A (58d)	Auto-set MY	-	-	-
DT	0x00 (0d)	Destination Address	0 - 0xFFFF	2	0
MD	0x3C (60d)	RF Mode	3 - 4	1	0
MY	0x2A (42d)	Source Address	0 - 0xFFFF	2	0xFFFF
RN	0x19 (25d)	Delay Slots	0 - 0xFF [slots]	1	0
WR	0x08 (8d)	Write	-	-	-

Bandwidth Considerations

Using broadcast repeaters in a network reduces the overall network data throughput as each repeater must buffer an entire packet before retransmitting it. For example: if the destination is within range of the transmitter and the packet is 32 bytes long, the transmission will take 72ms on a 9600 baud XStream modem (much faster modems are available). If that same packet has to propagate through two repeaters, it will take 72ms to arrive at the first repeater, another 72ms to get to the second and a final 72ms to get to the destination for a total of 216ms. Taking into account UART transfer times (~1ms/byte at 9600 baud), a server to send a 32 byte query and receive a 32 byte response is ~200ms, allowing for 5 polls per second. With the two repeaters in the path, the same query/response sequence would take about 500ms for 2 polls per second.

To summarize, this system is sending and receiving 64 bytes 5 times per second for a throughput of 320 bytes per second with no repeaters and 128 bytes per second with 2 repeaters. Generally, the network throughput will decrease by a factor of 1/(R+1), with R representing the number of repeaters between the source and destination.

Note that these numbers are absolutely worst case to illustrate how the system would perform in a typical, low bandwidth system. As a counter example the 115kbps 9XTend radio can transfer the same 32 byte packet in 12 ms for a round trip with UART transfer times of ~30ms or 33 polls per second (1066 bytes per second) with no repeaters. With two repeaters the time would be ~100ms round trip time for 10 polls per second or 320 bytes per second network throughput with two repeaters.

4.3. Acknowledged Communications

4.3.1. Acknowledged Mode

Characteristics: 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.

Recommended Use: Acknowledge Mode configuration is appropriate when reliable delivery is required between modems. If messages are smaller than 256 bytes, use RB and RO commands to align RF packets with application packets.

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

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

Table 4-04. Sample Network Profile

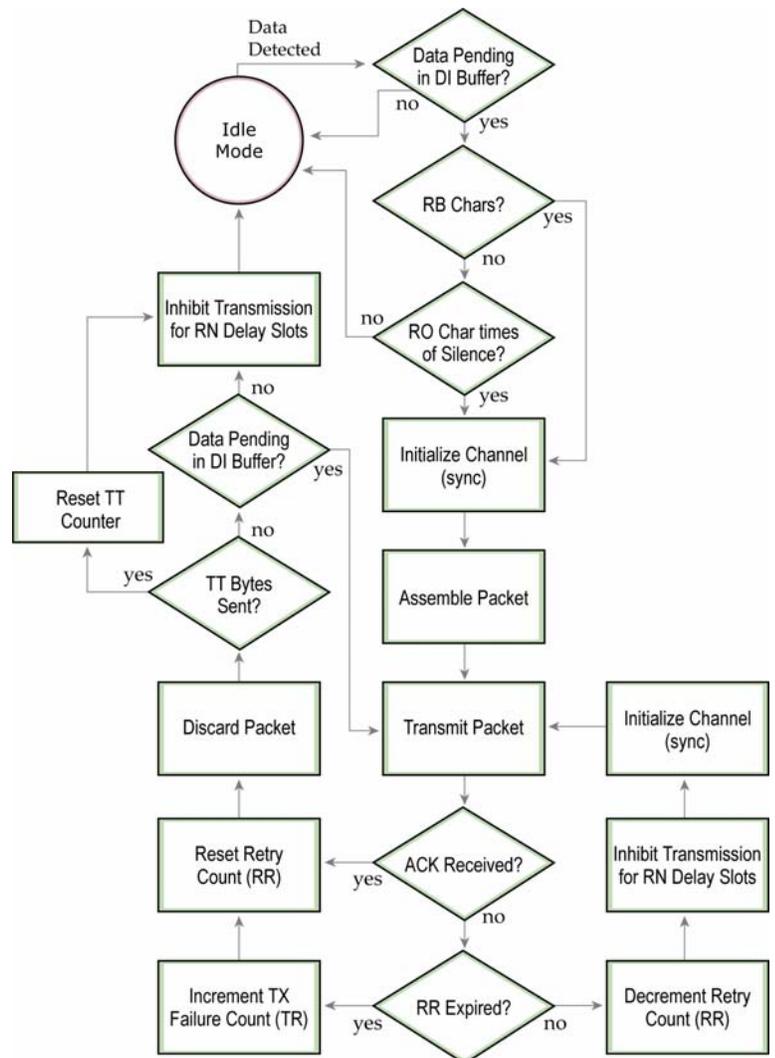
Modem	Parameter Settings (assume default values for parameters not listed)
All	ATTR A [set number of Retries to 0x0A] ATRN 5 [set number of Delay Slots to 5]

Connection Sequence

Figure 4-06. Acknowledged Mode State Diagram →

After sending a packet while in Acknowledged Mode, the transmitting modem listens for an ACK (acknowledgement). If it receives the ACK, it will either send 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 for transmission).

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.



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 it may retransmit the packet (potentially 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. This means 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 parameter). The transmitting modem checks for more pending data near the end of each packet.

The streaming limit (TT parameter) 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.

4.3.2. Multi-Streaming Mode

Characteristics: Enables exclusive connections [Definition is in Theory of Operation section.] Supports the passing of large data streams (> 256 bytes) from multiple remote modems to a base modem (If a complete data stream from a remote modem is less than 256 bytes, data can be sent from several remotes to a base location without enabling this mode and latencies will be much less.)
 Transmissions never acknowledged (ACK) by receiving modem(s)

Required Parameter Values (TX Modem): MD = 1 (Base), MD = 2 (Remote), RN > 0, RR > 0, MY ≠ 0xFFFF

Recommended Use: Use this mode in point-to-multipoint networks where remote modems initiate communications and require exclusive (uninterrupted) connections to the base modem.

Table 4-05. Sample Network Profile

Modem	Parameter Settings (assume default values for parameters not listed)
Base	ATMD 1 [configure modem as Multi-Stream Base] *
Remotes	ATMD 2 [configure modem as Multi-Stream Remote] *

* When Multi-Streaming is enabled, the following parameters are consequently modified (if they have not already been modified from their default states): RR, RN, MY, CD, AT and BT. [refer to Table 4-06]

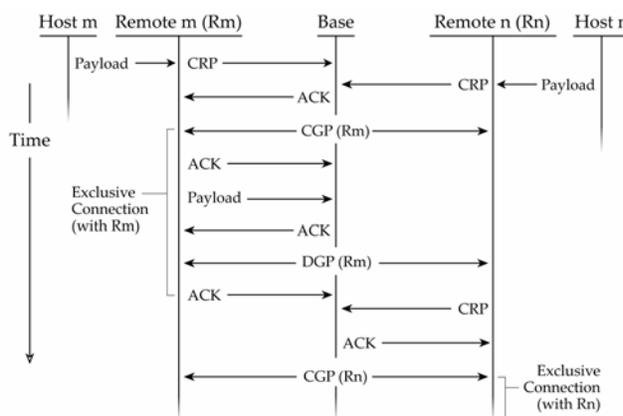
Theory of Operation

When in Multi-Streaming Mode, all remote modems can initiate communications with the base modem at the same time, but only one remote is granted an exclusive connection. After an exclusive connection begins, data is transferred exclusively between two modems without interruption from any other modems in the network.

An exclusive connection is a bi-directional connection that can only be established when in Multi-Streaming Mode. An exclusive connection is immune to other remote modems interrupting the connection and interleaving data (The interleaved data potentially renders the base modem unable to discern from which remote modem the data was transmitted).

When an exclusive connection is granted to a single remote, the other remotes are notified that the connection exists. The notification causes the remote modems to postpone transmissions until the base modem sends notification that the exclusive connection has ended.

Figure 4-07. Sample Connection Sequence Diagram



CRP = Connection Request Packet
CGP = Connection Grant Packet
DRP = Disconnect Request Packet (not shown in diagram – applicable when remote connection is disconnected using the pin sleep I/O line).
DGP = Disconnect Grant Packet
ACK = Acknowledgement of reception.
Base modem = The central transmitting/receiving modem in a network of modems that maintains communications with remote modems.
Remote modem = An modem in a network of modems that sends data to and receives data from a base modem.
Payload = Data contained inside the RF Data of the RF Packet that originates from a host to be transmitted over the air.

In the connection sequence above, an exclusive connection is first granted to "Remote m". The CGP (Connection Grant Packet) is broadcast to all remote modems in the network to communicate the base in engaged in an exclusive connection. Upon receipt of the CGP notification, remote modems will wait for a DGP (Disconnect Grant Packet) before attempting again to send data to the base modem.

Initiating a Connection

Connection Guidelines:

- A remote modem can only request a connection with the base modem.
- The base modem may hold off or grant a connection request to another modem.
- A remote modem will not try to establish a connection if one already exists.
- A connection fails if no response is received after RR (Retries) CRP packets. After a failure, whatever condition was causing a connection to be established is cleared. If the condition was data to be sent, all data in the DI buffer will be flushed. If the condition was DI3 transition, then no connection will be attempted until another correct DI3 transition.
- A global connection cannot fail. [Definition is on next page.]

Once in Multi-Streaming Mode (MD > 0), several events can initiate an exclusive connection:

1. Remote modem has payload to transmit. After a remote modem receives data from its host, the modem will attempt to establish a connection with the base modem. The connection is defined by the remote's DT (Destination Address) parameter. If another remote has a connection with the base, no connection will be established until the connection runs its course. Any remotes requesting a connection will then arbitrate for the next connection. RR (Retries) and RN (Random back-off) parameters control this arbitration.
2. Base sets the DT (Destination Address) parameter. When the base modem sets the DT (Destination Address) parameter, an exclusive connection is immediately initiated with the remote modem that has a matching DT parameter. After the DT command is sent (If ATCM=1), the base modem indicates a successful connection with a "CONNECT XXXX" string where "XXXX" is the remote's address. An unsuccessful connection is indicated with an "ERROR" string. If the connection is successful, the modem immediately exits AT Command Mode and data can be sent to and received from the connected remote modem. If an error is returned, the modem stays in AT Command Mode. If a base is connected to a remote when the DT command is executed, the current connection is disconnected before a new connection is created.
3. DI3 pin (pin 2, SLEEP) is asserted (set low). Both base and remote modems can create a connection (defined by the current DT (Destination Address) parameter) when the DI3 pin is asserted (driven high). DR (DI3 Configuration) Command is used to establish this mode. If a remote asserts DI3, a connection request will be sent when no connection is active. If the base asserts DI3, a connection will immediately be established with the remote after any connection.

Initiating a Disconnection

To disconnect, the base modem sends a DGP (disconnect grant packet). A remote modem can only request a disconnect. The following conditions cause a disconnect:

1. No over-the-air data sent or received for CE (Connection Inactivity Timeout) time. If no over-the-air data is successfully sent (no acknowledgement received) or received (any good packet) for CE time, the connection will be dropped. Only a base modem can detect this condition. Refer to CE Command.
2. Absolute CB (Connection Duration Timeout). The CB parameter defines an absolute timeout. A timer is started on the remote units when a connection is established. When the connection has been active for CB time, the base will close the connection. A remote that detects this condition will automatically disconnect (it will not send a DRP (disconnect request packet)). Remotes that monitor a connection between the base and another remote will disregard any connection after the CB time. Refer to CB Command.
3. DI3 pin (pin 2, SLEEP) is de-asserted (set high). A base or remote modem can cause a disconnect by setting the DI3 line high. If no connection is active, the de-assertion is ignored. A remote will request a disconnect if DI3 is de-asserted and the remote is currently connected the base. Refer to DR (DI3 Configuration) Command.
4. A remote or a base modem receives the ATDC (Disconnect) Command.

Configuration

AT Command Mode

AT command mode is used for all commands on base and remote modems. Binary command mode is not available when MD = 1 or 2.

The base is in AT command mode when not engaged in an exclusive connection with a remote. No AT Command Mode sequence is needed. When a base modem is connected to a remote modem, the AT Command Mode sequence is used to enter AT command mode. The connection with the remote is maintained. Care should be taken that the CE (Connection Inactivity) timeout does not occur while in AT Command Mode.

The remote must use the AT command sequence to enter AT Command Mode. When a connection exists with a base modem, the connection is maintained. Care must be taken that the CB (Connection Duration) timeout does not occur while in AT Command Mode.

As of firmware version, 4.30, a faster method is available for entering AT Command Mode. If the BT and AT parameters are set to 0, BT (Guard Time Before) and AT (Guard Time After) times are set to 6 milliseconds.

Beware that this will also mean that AT Command Mode cannot be entered by manually typing the AT command sequence (usually “+++”), because the AT time will occur faster than the characters can be typed.

Auto Configuration

When enabling Multi-Streaming Modes (by setting the MD (RF Mode) parameter to 1 or 2), other parameter values are automatically modified to support the mode. For example, when the MD parameter is changed to 1 or 2, the RR parameter is changed to 0x0A (hex). The modification only occurs if the RR parameter is 0 (its default) before the MD command was executed. If any other value is found for the RR parameter, the RR parameter will not be changed. Auto configuration occurs every time the modem is powered-up.

Table 4-06. Auto Configurations

Parameter changed when MD = 1 or 2	Condition for modification to take place (default values)	Resulting Parameter Value
RR (Retries)	If RR = 0	RR = 0x0A (10 decimal)
RN (Delay Slots)	If RN = 0	RN = 5
MY (Source Address)	If MY = 0xFFFF (& MD = 2)	Unique value based on serial number *
CD (DO3 Configuration)	If CD = 0	CD = 3
BT (Guard Time Before)	If BT = 0x0A	BT = 0
AT (Guard Time After)	If AT = 0x0A	AT = 0

* The system requires that each remote have a unique address. The automatic address is based on the serial number and is not guaranteed unique, although the chances for a duplicate address are 1 in 16,000. No method currently exists for detecting & reassigning duplicate remote addresses.

Global Connection

The base modem can connect to all remote modems (to send a broadcast message) by connecting with a DT address of 0xFFFF (hex). There will be no acknowledgements from the remote radios and each packet from the base will be sent RR times. A remote cannot send messages to a base during a global connect.

The CGP and DGP packets will be sent RR times to begin and end the global connection respectively. The connection can be terminated by CE, CB timers, D13 or ATDC Command as any other connections.

Sleep Modes and Connections

Cyclic sleep can be used with the remote modems to conserve power. ST “Time before Sleep” Parameter defines how long after a disconnect a remote will stay awake. A modem is not allowed to enter sleep mode when it is engaged in a connection. A modem will wake as defined by SM parameter and check for an RF message. If a message is detected, the modem will stay awake only if the message is a connect message from the base for this modem. DI3 (pin 2) wake-up can be used to wake a remote modem. Usually the connection on DI3 should also be enabled so that a connection is established on wake-up.

NOTE: The ST (Time Before Sleep) time must be set long enough to account for the time it could take to make a connection if several remote modems get a connection before a remote’s ST times out.

Pin sleep can also be used with a remote modem. A modem will not be allowed into pin sleep while a connection is active. Usually the connection on DI3 (DR = 4) should also be enabled so that a connection is established on wakeup. Pin wake-up could also be used to scan for a connection at an interval not defined by the cyclic sleep modes.

I/O Passing and Connections

I/O lines can be passed between a remote and base modem by enabling I/O line passing (see the RT, DR, CD, CO, CS, BK, BO commands). When a connection is not active, the output lines on the base and remote modems will be in their default state. When a connection is established, the base and remote output line will be set to reflect the corresponding input lines.

Monitoring Connections

The DO3 pin (RX LED) can be used to show when a connection is active on both remote and base modems. This is the default condition. This line will be asserted (high) during a connection and de-asserted (low) when there is no connection.

A base modem can also be set to send the “CONNECT XXXX” string (where “XXXX” is the connecting modem’s MY (Source Address) parameter) anytime a connection is established. Refer to CM (Connection Message) Command.

Appendix A: Agency Certifications

FCC Certification

The XStream RF Modem complies with Part 15 of the FCC rules and regulations. Compliance with the labeling requirements, FCC notices and antenna usage guidelines is required.

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

1. The system integrator must ensure that the text on the external label provided with this device is placed on the outside of the final product [Figure A-01 for 900 MHz operations or Figure A-02 for 2.4 GHz operations].
2. The finished product must display also the information illustrated in Figure A-03.
3. The XStream RF Modem may be used only with Approved Antennas that have been tested with this modem. [Tables A-01 and A-02]

FCC Notices:

IMPORTANT: The 9XStream (900 MHz) and 24XStream (2.4 GHz) OEM Modems 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 MaxStream 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 XStream RF Modems have been certified for remote and base radio applications. If the XStream will be used for portable applications, the device must undergo SAR testing.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

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

OEM Labeling Requirements

	<p>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.</p>
---	---

Figure A-01. Required FCC Label for OEM products containing the 9XStream (900 MHz) RF Modem

<p>Contains FCC ID: OUR9XSTREAM 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.</p>

Figure A-02. Required FCC Label for OEM products containing the 24XStream (2.4 GHz) RF Modem

<p>Contains FCC ID: OUR-24XSTREAM 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.</p>

FCC Part 68 Labeling and User Information

The finished product must display the following information:

Figure A-03. FCC Part 68 Labeling Requirements →

The Federal Communication Commission (FCC) has established rules, which permits this device to be directly connected to the telephone network. If this device is malfunctioning, it may also be causing harm to the telephone network; this device should be disconnected until the source of the problem can be determined and until repair has been made. If this is not done, the telephone company may temporarily disconnect service. The telephone company may make changes in its technical operations and procedures; if such changes affect the compatibility or use of this device, the telephone company is required to give adequate notice of the changes. If the telephone company request information on what equipment is connected to their lines, inform them of the following:

<p>Complies with FCC Part 68 Rules Registration Number: 3A4M500BHM-T-W Ringer Equivalence: 0.0B</p>

- The telephone number the device it connected to
- The ringer equivalence number (REN)
- The device uses an RJ11 type jack
- The FCC Registration Number

The REN (Ringer Equivalence Number) is used to determine the number of devices that may be connected to the telephone line. Excessive RENs on a telephone line may result in devices not ringing in response to an incoming call. In most, but not all areas, the sum of the REN should not exceed five (5.0). To be certain of the number of devices that may be connected to a line, as determined by the total RENs, contact the local telephone company.

The Telephone Consumer Protection Act of 1991 makes it unlawful for any person to use a computer or any other electronic device, including fax machines, to send any message unless such message clearly contains in a margin at the top or bottom of each transmitted page or on the first page of the transmission, the date and time, it is sent and an identification of the business or other entity, or other individual sending the message and the telephone number of the sending machine or such business, other entity, or individual. (The telephone number provided may not be a 900 number or any number for which charges exceed local or long distance transmission charges.)

This equipment must not be used on party lines. Connection to party line service is subject to state tariffs. Contact state public utility commission for information.

Antenna Usage

Antenna Warning

 **WARNING:** This device has been tested with Reverse Polarity SMA connectors with the antennas listed in Tables A-01 & A-02 of Appendix A. When integrated in 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).

RF Exposure

 **WARNING:** This equipment is approved only for mobile and base station transmitting devices, separation distances of (i) 20 centimeters or more for antennas with gains < 6 dBi or (ii) 2 meters or more for antennas with gains \geq 6 dBi should be maintained between the antenna of this device and nearby persons during operation. To ensure compliance, operation at distances closer than this is not recommended.

The preceding statement must be included as a CAUTION statement in manuals for OEM products to alert users on FCC RF Exposure compliance.

MaxStream radio modems are pre-FCC approved for use in fixed base station and mobile applications. As long as the antenna is mounted at least 20 cm (8 in) from nearby persons, the application is considered a mobile application. If the antenna will be mounted closer than 20 cm to nearby persons, then the application is considered "portable" and requires an additional test performed on the final product. This test is called the Specific Absorption Rate (SAR) testing and measures the emissions from the radio modem and how they affect the person.

Over 100 additional antennas have been tested and are approved for use with MaxStream 900 MHz Radio Modems (including "Mag Mount", "Dome", "Multi-path" and "Panel" antennas). Because of the large number of approved antennas, MaxStream requests that you send specific information about an antenna you would like to use with the modem and MaxStream will evaluate whether the antenna is covered under our FCC filing.

FCC-Approved Antennas

Table A-01. Antennas approved for use with 9XStream (900 MHz) RF Modems.

Manufacturer	Part Number	Type	Gain	Application	Min. Separation Distance
*	*	Yagi	6.2 dBi	Fixed/Mobile **	20 cm
*	*	Yagi	7.2 dBi	Fixed/Mobile **	20 cm
MaxStream	A09-Y8	Yagi	8.2 dBi	Fixed/Mobile **	20 cm
*	*	Yagi	9.2 dBi	Fixed/Mobile **	20 cm
*	*	Yagi	10.2 dBi	Fixed/Mobile **	20 cm
MaxStream	A09-Y11 (FCC pending)	Yagi	11.2 dBi	Fixed/Mobile **	20 cm
MaxStream	A09-F2	Omni Direct.	2.2 dBi	Fixed **	20 cm
MaxStream	A09-F5	Omni Direct.	5.2 dBi	Fixed **	20 cm
MaxStream	A09-F8	Omni Direct.	8.2 dBi	Fixed **	20 cm
*	*	Omni Direct.	9.2 dBi	Fixed **	20 cm
*	*	Omni Direct.	7.2 dBi	Fixed **	20 cm
MaxStream	A09-M7	Omni Direct.	7.2 dBi	Fixed **	20 cm
MaxStream	A09-H	1/2 wave antenna	2.1 dBi	Fixed/Mobile **	20 cm
MaxStream	A09-HBMM-P5I	1/2 wave antenna	2.1 dBi	Fixed/Mobile **	1 cm
MaxStream	A09-QBMM-P5I	1/4 wave antenna	1.9 dBi	Fixed/Mobile **	1 cm
*	*	1/4 wave integrated wire antenna	1.9 dBi	Fixed/Mobile **	1 cm

Table A-02. Antennas approved for use with 24XStream (2.4 GHz) RF Modems.

Manufacturer	Part Number	Type	Gain	Application	Min. Separation Distance
*	*	Yagi	6 dBi	Fixed **	2 m
*	*	Yagi	8.8 dBi	Fixed **	2 m
*	*	Yagi	9 dBi	Fixed **	2 m
*	*	Yagi	10 dBi	Fixed **	2 m
*	*	Yagi	11 dBi	Fixed **	2 m
*	*	Yagi	12 dBi	Fixed **	2 m
*	*	Yagi	12.5 dBi	Fixed **	2 m
*	*	Yagi	13.5 dBi	Fixed **	2 m
*	*	Yagi	15 dBi	Fixed **	2 m
*	*	Omni Direct	2.1 dBi	Fixed/Mobile **	20 cm
*	*	Omni Direct	3 dBi	Fixed/Mobile **	20 cm
*	*	Omni Direct	5 dBi	Fixed/Mobile **	20 cm
*	*	Omni Direct	7.2 dBi	Fixed **	2 m
*	*	Omni Direct	8 dBi	Fixed **	2 m
*	*	Omni Direct	9.5 dBi	Fixed **	2 m
*	*	Omni Direct	10 dBi	Fixed **	2 m
*	*	Omni Direct	12 dBi	Fixed **	2 m
*	*	Omni Direct	15 dBi	Fixed **	2 m
MaxStream	A24-P8	Panel	8.5 dBi	Fixed **	2 m
MaxStream	A24-P13	Panel	13 dBi	Fixed **	2 m
*	*	Panel	14 dBi	Fixed **	2 m
*	*	Panel	15 dBi	Fixed **	2 m
*	*	Panel	16 dBi	Fixed **	2 m
MaxStream	A24-P19	Panel	19 dBi	Fixed **	2 m
MaxStream	A24-HABMM-P6I	Dipole	2.1 dBi	Fixed/Mobile **	20 cm
MaxStream	A24-HBMM-P6I	Dipole	2.1 dBi	Fixed/Mobile **	20 cm
MaxStream	A24-HABSM	Dipole	2.1 dBi	Fixed/Mobile **	20 cm
MaxStream	A24-QABMM-P6I	Monopole	1.9 dBi	Fixed/Mobile **	20 cm
*	A24-Q1	Monopole	1.9 dBi	Fixed/Mobile **	20 cm
*	*	Monopole	1.9 dBi	Fixed/Mobile **	20cm

* FCC-approved antennas not inventoried by MaxStream – Contact MaxStream (866) 765-9885 for information.

** Can be approved for portable applications if integrator gains approval through SAR testing

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 9XStream Radio (900 MHz), IC: 4214A-9XSTREAM

Contains Model 24XStream Radio (2.4 GHz), IC: 4214A 12008

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: Development Guide

Mechanical Drawings

Figure B-01. XStream-PKG-T (Telephone) RF Modem (RJ-11 and DB-9 Connectors)

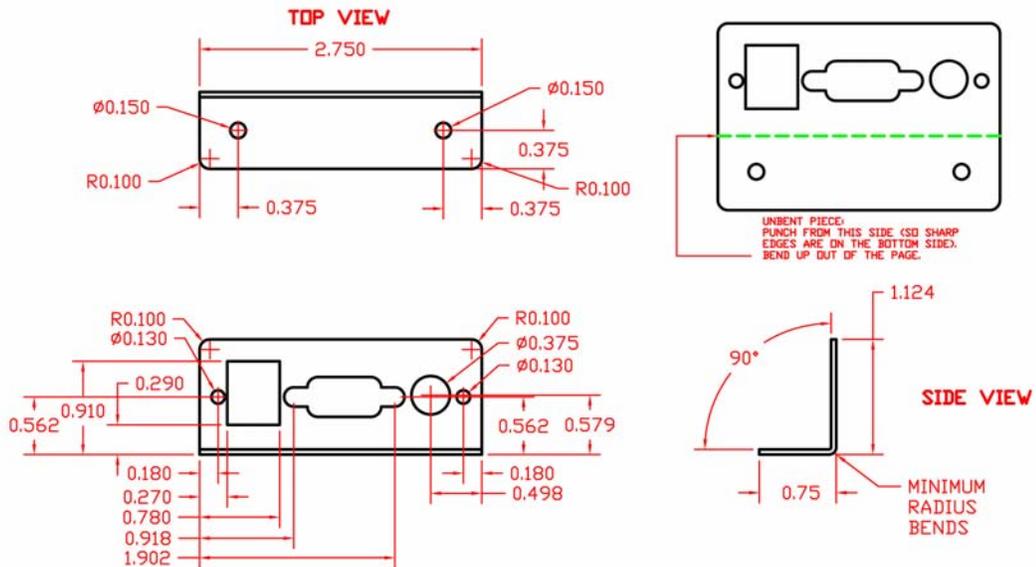
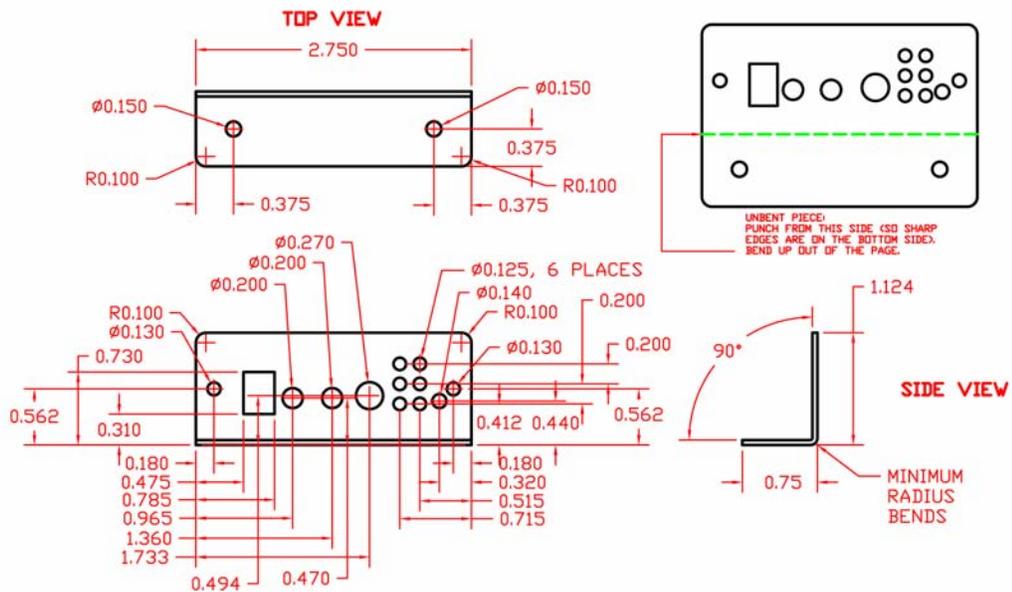


Figure B-02. XStream-PKG-T (Telephone) RF Modem (LEDs)



RF Module Configuration

X-CTU Software

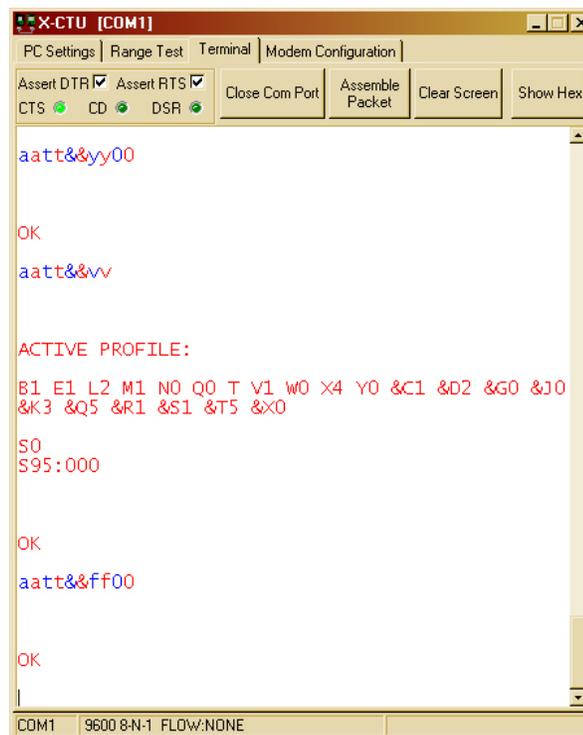
X-CTU software can be used to setup and monitor XStream-PKG-T RF Modems communications. The software provides an easy-to-use interface that is divided into four tabs.

- PC Settings tab - Setup PC serial com ports to interface with XStream RF Modem
- Range Test tab – Test Modem Range
- Terminal tab – Configure and read XStream RF Module & Telephone Module parameters
- Modem Configuration tab – DO NOT USE when configuring the XStream-PKG-T RF Modem. The “Modem Configuration” tab is used to configure XStream RF Modules that are mounted to the XIB-R (RS-232/485) and XIB-U (USB) Interface Boards.

To Install X-CTU Software:

1. Double-click the “setup_X-CTU.exe” file then follow prompts of the installation screens. This file is located in the “software” folder of the MaxStream CD and under the ‘Downloads’ section of the following web page: www.maxstream.net/support/

Figure B-03. Terminal tab of the X-CTU Software (Used to configure the Telephone and RF Modules)



RF Module Commands (Long Descriptions)

Commands in this section are listed alphabetically. Command categories are designated between the "< >" symbols that follow each command title. XStream Modules expect numerical values in hexadecimal. Hexadecimal values are designated by a "0x" prefix.

AM (Auto-set MY) Command

<Networking> AM Command is used to automatically set the MY (Source Address) parameter from the factory-set module 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: 0x3A (58 decimal)

Parameter Range: 0 – 0xFFFF

Minimum Firmware Version Required: 4.30

AT (Guard Time After) Command

<AT Command Mode Options> AT Command is used to set/read the time-of-silence that follows the command sequence character (CC Command). By default, AT Command Mode will activate after one second of silence.

AT Command: ATAT

Binary Command: 0x05 (5 decimal)

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

Number of bytes returned: 2

Default Parameter Value: 0x0A (10 decimal)

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

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

- 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 is used to adjust the period of silence that follows the command sequence character.

Fast AT Command Mode Entry. Set AT and BT parameters to 0 for 0.6 second guard times. Beware that this will also mean that AT Command Mode cannot be entered by manually typing the AT command sequence characters ("+++" by default) because the BT timeout will occur faster than the characters can be typed.

BD (Interface Data Rate) Command

<Serial Interfacing> BD Command is used to set/read the UART I/O serial data rate (the rate at which serial data is sent to the module). The new baud rate does not take effect until the CN (Exit AT Command Mode) Command is issued.

AT Command: ATBD

Binary Command: 0x15 (21 decimal)

Parameter Range: 0 – 6

The RF data rate is not affected by the BD Command.

Note: If the serial data rate is set to exceed the fixed RF data rate of the XStream module, CTS flow control may need to be implemented as described in the "Pin Signals" and "Flow Control" sections of this manual.

Parameter	BAUD (bps) Configuration
0	1200
1	2400
2	4800
3	9600
4	19200
5	38400
6	57600

Number of bytes returned: 1

Default Parameter Value: Equal to module's fixed RF data rate.

Non-standard Interface Data Rates: When parameter values outside the range of standard baud rates are sent, the closest interface data rate represented by the number is stored in the BD register. For example, a rate of 19200 bps can be set by sending the following command line "ATBD4B00". NOTE: When using MaxStream's X-CTU Software, non-standard interface data rates can only be set and read using the X-CTU 'Terminal' tab. Non-standard rates are not accessible through the 'Modem Configuration' tab.

When the BD command is sent with a non-standard interface data rate, the UART will adjust to accommodate the requested interface rate. In most cases, the clock resolution will cause the stored BD parameter to vary from the parameter that was sent (refer to the table below). Reading the BD command (send "ATBD" command without an associated parameter value) will return the value that was actually stored to the BD register.

Parameter Sent vs. Parameter Stored

BD Parameter Sent (HEX)	Interface Data Rate (bps)	BD Parameter Stored (HEX)
0	1200	0
4	19,200	4
7	115,200	7
12C	300	12B
1C200	115,200	1B207

BK (Serial Break Passing) Command

<Serial Interfacing> Pass a serial break condition on the DI pin to the DO pin of another modem.

AT Command: ATBK

Binary Command: 0x2D (45 decimal)

Parameter Range: 0 - 1

Parameter	Configuration
0	disable
1	enable

Default Parameter Value: 0

Number of bytes returned: 1

Minimum Firmware Version Required: 4.30

BO (Serial Break Timeout) Command

<Serial Interfacing> DO pin will return to default after no serial break status information is received during the timeout period.

Use with BK = 1.

AT Command: ATBO

Binary Command: 0x2F (47 decimal)

Parameter Range: 0 - 0xFFFF [x 1 second]

Default Parameter Value: 0

Number of bytes returned: 2

Related Commands: BK (Serial Break Passing)

Minimum Firmware Version Required: 4.30

BT (Guard Time Before) Command

<AT Command Mode Options> BT Command is used to set/read the DI pin silence time that must precede 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 of the values in this sequence can be adjusted.

Fast AT Command Mode Entry. Set AT and BT parameters to 0 for 0.6 second guard times. Beware that this will also mean that AT Command Mode cannot be entered by manually typing the AT command sequence characters ("---" by default) because the BT timeout will occur faster than the characters can be typed.

AT Command: ATBT

Binary Command: 0x04 (4 decimal)

Parameter Range: 2 - 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)

CB (Connection Duration Timeout) Command

<Networking> Set/Read the maximum duration of an exclusive connection between a base and remote module of a point-to-multipoint network. The remote module will disconnect when this timeout expires.

AT Command: ATCB

Binary Command: 0x32 (50 decimal)

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

Default Parameter Value: 0x28 (4 seconds)

Number of bytes returned: 2

Related Commands: CE (Connection Inactivity Timeout), DC (Disconnect), MD (RF Mode)

Minimum Firmware Version Required: 4.30

CC (Command Sequence Character) Command

<AT Command Mode Options> CC Command is used to set/read the ASCII character to be 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. CC Command is used to change the command sequence character.

AT Command: ATCC

Binary Command: 0x13 (19 decimal)

Parameter Range: 0x20 – 0x7F

Default Parameter Value: 0x2D (ASCII “-” sign)

Number of bytes returned: 1

Related Commands: AT (Guard Time After), BT (Guard Time Before)

CD (DO3 Configuration) Command

<Serial Interfacing> CD Command is used to select/read the behavior of the DO3 line (pin 7).

AT Command: ATCD

Binary Command: 0x28 (40 decimal)

Parameter Range: 0 – 4

Parameter	Configuration
0	RX LED
1	Default high
2	Default low
3	[reserved]
4	Assert only when packet addressed to module sent

Default Parameter Value: 0

Number of bytes returned: 1

Minimum Firmware Version Required: 4.29D

CE (Connection Inactivity Timeout) Command

<Networking> Set/Read the duration of inactivity that breaks the connection. The base module will disconnect when no payload has been transferred for the time specified.

AT Command: ATCE

Binary Command: 0x33 (51 decimal)

Parameter Range: 0 – 0xFFFF
[x 10 milliseconds]

Default Parameter Value: 0x64 (1 decimal second)

Number of bytes returned: 2

Related Commands: CB (Connection Duration Timeout), DC (Disconnect), MD (RF Mode)

Minimum Firmware Version Required: 4.30

CF (Connection Failure Count) Command

<Diagnostic> Set/Read the number of times the base module expired retries attempting to send a Connection Grant Packet. Set to zero to clear the register.

AT Command: ATCF
 Binary Command: 0x34 (52 decimal)
 Parameter Range: 0 – 0xFFFF
 Default Parameter Value: 0
 Number of bytes returned: 2
 Minimum Firmware Version Required: 4.30

CL (Last Connection Address) Command

<Diagnostic> Read the address of the remote module that last connected to the base module. A remote module will return its DT (Destination Address) parameter.

AT Command: ATCL
 Binary Command: 0x39 (57 decimal)
 Parameter Range: 0 – 0xFFFF [read-only]
 Number of bytes returned: 2
 Minimum Firmware Version Required: 4.30

CM (Connection Message) Command

<Networking> Select whether base sends connect messages to the host when a connection is established. When enabled, a "CONNECTXXXX" string is sent to the host of the base module. "XXXX" is the MY (Source Address) of the connected remote module.

AT Command: ATCM
 Binary Command: 0x38 (56 decimal)
 Parameter Range: 0 – 1

Parameter	Configuration
0	enable
1	disable

Default Parameter Value: 0
 Number of bytes returned: 1
 Minimum Firmware Version Required: 4.30

CN (Exit AT Command Mode) Command

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

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

CO (DO3 Timeout) Command

<Serial Interfacing> DO3 output will return to default after no DI3 status information is received during the timeout period.
 Use with CD = 1 or 2. DR =1.

AT Command: ATCO
 Binary Command: 0x2E (46 decimal)
 Parameter Range: 0 – 0xFFFF [x 1 second]
 Default Parameter Value: 3
 Number of bytes returned: 2
 Related Commands: CD (DO3 Configuration), DR (DI3 Configuration)
 Minimum Firmware Version Required: 4.30

CS (DO2 Configuration) Command

<Serial Interfacing> CS Command is used to select/read the behavior of the DO2 pin signal (pin 1). 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, DO2 provides RS-232 $\overline{\text{CTS}}$ (Clear-to-Send) flow control.

AT Command: ATCS

Binary Command: 0x1F (31 decimal)

Parameter Range: 0 – 4

Parameter	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 (DI2 Configuration), TO (DO2 Timeout)

Minimum Firmware Version Required: 4.27D

CT (Command Mode Timeout) Command

<AT Command Mode Options> CT Command is used to set/read the amount of time before AT Command Mode terminates automatically. After CT time of inactivity, the module exits AT Command Mode and returns to Idle Mode. AT Command Mode can also be exited manually using CN (Exit AT Command Mode) Command.

AT Command: ATCT

Binary Command: 0x06 (6 decimal)

Parameter Range: 0x02 – 0xFFFF
[x 100 milliseconds]

Default Parameter Value: 0xC8 (200 decimal, 20 seconds)

Number of bytes returned: 2

DC (Disconnect) Command

<Networking> Use DC Command (when in Multi-Streaming Mode, MD > 0) to explicitly force a disconnect of an active exclusive connection. If MD = 1, the base module will force the disconnect of an exclusive connection. If MD = 2, the remote module will send a "Disconnect Request Packet" to the base module.

AT Command: ATDC

Binary Command: 0x37 (55 decimal)

Related Commands: CB (Connection Duration Timeout), CE (Connection Inactivity Timeout), MD (RF Mode)

Minimum Firmware Version Required: 4.30

DR (DI3 Configuration) Command

<Serial Interfacing> Configure DI3 (pin 2, SLEEP) for I/O line passing (use with CD=1 or 2 and CO) or controlling connection status (use with MD=1 or 2).

AT Command: ATDR

Binary Command: 0x2C (44 decimal)

Parameter Range: 0 – 4

Parameter	Configuration
0	Disabled
1	DI3 I/O passing enabled
2	Connect on low
3	Disconnect on high
4	Connect and Disconnect

Default Parameter Value: 0

Number of bytes returned: 1

Related Commands: CD (DO3 Configuration), CO (DO3 Timeout)

Minimum Firmware Version Required: 4.30

DT (Destination Address) Command

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

<AT 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

<AT Command Mode Options> E1 Command turns on the 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

<Diagnostic> Set/Read the receive-error. 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 radio 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 radio modem is reset.

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 transmit. WR (Write) Command does not need to be issued with FH Command.

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

Use only with cyclic sleep modes active on remote modules.

FL (Software Flow Control) Command

<Serial Interfacing> FL Command is used to configure software flow control. Hardware flow control is implemented with the XStream Module as the DO2 pin (pin 1, \overline{CTS}), which regulates when serial data can be transferred to the module. 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	Configuration
0	Disable software flow control
1	Enable software flow control

Default Parameter Value: 0
 Number of bytes returned: 1

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 – (Receiving module DO buffer size minus 0x11 bytes)

Default Parameter Value: Receiving module DO buffer size minus 0x11

Number of bytes returned: 2

Minimum Firmware Version Required: 4.27B

GD (Receive Good Count) Command

<Diagnostic> 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 module'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 module 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)

HP (Hopping Channel) Command

<Networking> Set/Read the channel on which a modem communicates. A channel is one of three layers of addressing available to the radio modem. In order for modules to communicate with each other, the modules must have the same channel number since each channel uses a different hopping sequence. Different channels can be used to prevent modules in one network from listening to transmissions of another.

AT Command: ATHP

Binary Command: 0x11 (17 decimal)

Parameter Range: 0 – 6

Default Parameter Value: 0

Number of bytes returned: 1

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

HT (Time before Wake-up Initializer) Command

<Sleep (Low Power)> Set time of inactivity (no serial or RF data is sent or received) before a wake-up initializer is sent. This allows a base station to track the awake-status of remotes.

AT Command: ATHT

Binary Command: 0x03 (3 decimal)

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

Default Parameter Value: 0xFFFF (means that 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)

If any radio modems within range are running in a "Cyclic Sleep" setting, a wake-up initializer is used by the transmitting module to notify sleeping modules that data is coming and they should wake from cyclic sleep [refer to the LH ("Wake-up Initializer Timer") Command]. When

a receiving module in Cyclic Sleep wakes, it must detect the wake-up initializer in order to remain awake and receive data. The value of HT parameter tells the transmitter, "After a period of inactivity (no transmitting or receiving) lasting HT time, send a wake-up initializer".

NOTE: HT of the base radio should be set shorter than ST of remote radios.

From the receiving module perspective: After HT time elapses and the inactivity timeout [ST Command] is met, the receiver goes into cyclic sleep. In cyclic sleep, the receiver wakes once per sleep interval to check for a wake-up initializer. When a wake-up initializer is detected, the module will stay awake to receive data. The wake-up initializer must be longer than the cyclic sleep interval to ensure that sleeping modules detect incoming data. When HT time elapses, the transmitter then knows that it needs to send a wake-up initializer for all receivers to be able to remain awake and receive the next transmission. Matching HT to the time specified by ST on the receiving module guarantees that all receivers will detect the next transmission.

HV (Hardware Version) Command

<Diagnostic> Read modem hardware version number.

AT Command: ATHV

Parameter Range: 0 – 0xFFFF [read-only]

Number of bytes returned: 2

Minimum Firmware Version Required: 4.30

ID (Modem VID) Command

<Networking> Set/Read the “Vendor Identification Number”. Only modems with matching IDs can communicate with each other. Modules with non-matching VIDs will not receive unintended data transmission.

AT Command: ATID

Binary Command: 0x27 (39 decimal)

Parameter Range: 0x10 – 0x7FFF
(user-settable)
0x8000 – 0xFFFF [read-only]

Number of bytes returned: 2

Minimum Firmware Version Required: 4.30

IU (DI2, DI3 Update Timer) Command

<Serial Interfacing> The status of DI2, DI3 and Break is transmitted at the interval specified by IU - and whenever there is a transition as well. A setting of Zero disables periodic update. DI2 or DI3 passing must be enabled for the update to take place.

AT Command: ATIU

Binary Command: 0x3B (59 decimal)

Parameter Range: 0 – 0xFFFF [x 100 ms]

Default Parameter Value: 0x0A (10 decimal)

Number of bytes returned: 2

Related Commands: BK (Serial Break Passing), BO (Serial Break Timeout), CO (DO3 Timeout), DR (Disconnect), RT (DI2 Configuration), TO (DO2 Timeout)

Minimum Firmware Version Required: 4.30

LH (Wake-up Initializer Timer) Command

<Sleep (Low Power)> LH Command adjusts the duration of time for which the wake-up initializer is sent. When receiving modules 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 modules 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.

MD (RF Mode) Command

<Networking & Security> The MD command is used to select/read the setting that enables Multi-Stream and Repeater Modes.

Multi-Streaming Mode enables exclusive connections in point-to-multipoint networks. Refer to the Multi-Streaming Mode section [p34] for more information regarding how these parameter values affect other parameter values.

Repeater Mode enables longer range via an intermediary modem. When MD=3, the modem will act as a “store and forward” repeater. Any packets not addressed to this node will be repeated. A Repeater End Node (MD=4) handles repeated messages, but will not forward the data over-the-air. Refer to the Repeater Mode section [p29] for more information.

AT Command: ATMD

Binary Command: 0x32 (50 decimal)

Parameter Range: 0 – 2

Parameter	Configuration
0	Peer-to-Peer (Transparent)
1	Multi-Stream Base
2	Multi-Stream Remote
3	Repeater
4	Repeater End Node

Default Parameter Value: 0

Number of bytes returned: 1

Related Commands: CB (Connection Duration Timeout), CE (Connection Inactivity Timeout), CM (Connection Message), DC (Disconnect)

Minimum Firmware Version Required: 4.30

MK (Address Mask) Command

<Networking> MK Command is used to set/read the address mask. All data packets contain the Destination Address (ATDT) of the transmitting module. When an RF data packet is received, the transmitter DT Address is logically “ANDed” (bitwise) with the Address Mask (ATMK) 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 module’s DO serial port. If the “ANDed” value does not match the DT Address or the MT Address of the receiver, the packet is discarded.

AT Command: ATMK

Binary Command: 0x12 (18 decimal)

Parameter Range: 0 – 0xFFFF

Default Parameter Value: 0xFFFF
(Destination address (DT parameter) of the transmitting module must exactly match the destination address of the receiving module.)

Number of bytes returned: 2

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

MY (Source Address) Command

<Networking> Set/Read the source address of the module.

AT Command: ATMY

Binary Command: 0x2A (42 decimal)

Parameter Range: 0 – 0xFFFF

Default Parameter Value: 0xFFFF (Disabled – DT 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)

Minimum Firmware Version Required: 4.30

NB (Parity) Command

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

AT Command: ATNB

Binary Command: 0x23 (35 decimal)

Parameter Range: 0 – 5

Parameter	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
5	9-bit

Default Parameter Value: 0

Number of bytes returned: 1

Minimum Firmware Version Required: 4.30

PC (Power-up Mode) Command

<AT Command Mode Options> PC Command allows the module to power-up directly into AT Command Mode from reset or power-on. If PC Command is enabled with SM Parameter set to 1, the SLEEP Pin (DI3-Pin 2) can be used to enter the module into AT Command Mode. When the SLEEP pin is de-asserted (low), the module will Wake-up into AT Command Mode. This behavior allows modem DTR emulation.

AT Command: ATPC

Binary Command: 0x1E (30 decimal)

Parameter Range: 0 – 1

Parameter	Configuration
0	Power-up to Idle Mode
1	Power-up to AT Command Mode

Default Parameter Value: 0

Number of bytes returned: 1

Minimum Firmware Version Required: 4.22

PK (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.

AT Command: ATPK

Binary Command: 0x29 (41 decimal)

Parameter Range: 0 – 0x100 [Bytes]

Default Parameter Value: 0x40 (64 decimal)

Number of bytes returned: 2

Related Commands: RB (Packetization Threshold), RO (Packetization Timeout)

Minimum Firmware Version Required: 4.30

PW (Pin Wake-up) Command

<Sleep (Low Power)> Under normal operation, a module 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 DI3-SLEEP Pin (Pin 2) can be used to awaken the module from Cyclic Sleep. If the SLEEP Pin is de-asserted (low), the module will be fully operational and will not go into Cyclic Sleep. Once SLEEP is asserted, the module 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	Configuration
0	Disabled
1	Enabled

Default Parameter Value: 0

Number of bytes returned: 1

Related Commands: SM (Sleep Mode), ST (Time before Sleep)

Minimum Firmware Version Required: 4.22

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 times out 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 that the 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 0x100 HEX (800 decimal))

Default Parameter Value: 1

Number of bytes returned: 2

Related Commands: BR (RF Data Rate), PK (RF Packet Size), RO (Packetization Timeout)

Minimum Firmware Version Required: 4.30

RE (Restore Defaults) Command

<Diagnostic> RE Command restores 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 default settings will not be saved in the event of module reset or power-down.

AT Command: ATRE

Binary Command: 0x0E (14 decimal)

RN (Delay Slots) Command

<Networking> RN Command is only applicable if retries have been enabled [RR (Retries) Command], or if forced delays will be inserted into a transmission [see TT (Streaming Limit) Command]. RN Command is used to adjust the time delay that the transmitter inserts before attempting to resend a packet. If the transmitter fails to receive an acknowledgement after sending a packet, it will insert 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 38ms.

AT Command: ATRN

Binary Command: 0x19 (25 decimal)

Parameter Range: 0 – 0xFF

Default Parameter Value: 0 (no delay slots inserted)

Number of bytes returned: 1

Related Commands: RR (Retries), TT (Streaming Limit)

Minimum Firmware Version Required: 4.22

If two modules attempted to transmit at the same time, the random time delay after packet failure would allow one of the two modules to transmit the packet successfully, while the other would wait until the channel opens up to begin transmission.

RO (Packetization Timeout) Command

<Serial Interfacing> RO Command is used to specify the timeout value (in 0.2 ms increments) when transmission starts after receiving serial data. If the RB = 0, this command has no effect. After a serial byte is received and if no other byte is received before the RO timeout, the transmission will start.

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

- RO times out 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 200 µs]
 Default Parameter Value: 0x32 (50 decimal)
 Number of bytes returned: 2
 Related Commands: RB (Packetization Threshold)
 Minimum Firmware Version Required: 4.2AA

RP (RSSI PWM Timer) Command

<Diagnostic> RP Command is used to enable a PWM ("Pulse Width Modulation") output on the Config pin (pin 9 of the RF Module) which is calibrated to show the level the received RF signal is above the sensitivity level of the radio modem. The 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 radio modem. The following table shows levels above sensitivity and PWM values.

The total period of the PWM output is 8.32 ms. There are 40 steps in the PWM output 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 the PWM output will be active with the RSSI value of the last received RF packet. After the set time when no RF packets are received, the PWM output will be set low (0 percent PWM) until another RF packet is received. The PWM output will also be set low at power-up. A parameter value of 0xFF permanently enables the PWM output and it will always reflect the value of the last received RF packet.

PWM output shares the Config input pin. When the radio modem is powered, the Config pin will be an input. During the power-up sequence, the Config pin will be read to determine whether the radio modem is going into AT Command Mode. After this, if RP parameter is a non-zero value, the Config pin will be configured as an output and set low until the first RF packet is received. With a non-zero RP parameter, the Config pin will be an input for RP ms after power up.

AT Command: ATRP
 Binary Command: 0x22 (34 decimal)
 Parameter Range: 0 – 0x7F [x 100 milliseconds]
 Default Parameter Value: 0 (disabled)
 Number of bytes returned: 1
 Minimum Firmware Version Required: 4.2AA

RR (Retries) Command

<Networking> RR Command reads/sets the number of retries that can be sent for a given RF packet. Once RR Command is enabled (set to a non-zero value), RF packet acknowledgements and retries are enabled. After transmitting a packet, the transmitter will wait to receive an acknowledgement from a receiver. If the acknowledgement is not received in the period of time specified by the RN (Delay Slots) Command, the transmitter will transmit the original packet again. The packet will be transmitted repeatedly until an acknowledgement is received or until the packet has been sent RR times.

Note: For retries to work correctly, all modules in the system must have retries enabled.

AT Command: ATRR
 Binary Command: 0x18 (24 decimal)
 Parameter Range: 0 – 0xFF
 Default Parameter Value: 0 (disabled)
 Number of bytes returned: 1
 Minimum Firmware Version Required: 4.22

RS (RSSI) Command

<Diagnostic> RS Command returns the signal level of the last packet received. This reading is useful for determining range characteristics of the XStream Modules under various conditions of noise and distance.

Once the command is issued, the module will return a value between 0x6 and 0x36 where 0x36 represents a very strong signal level and 0x4 indicates a low signal level.

AT Command: ATRS

Binary Command: 0x1C (28 decimal)

Parameter Range: 6 – 0x36 [Read-only]

Number of bytes returned: 1

Minimum Firmware Version Required: 4.22

RT (DI2 Configuration) Command

<Serial Interfacing> RT command is used to dictate the behavior of the DI2 (RTS/CMD) line. RT Command must be issued to enable RTS flow control or binary programming.

AT Command: ATRT

Binary Command: 0x16 (22 decimal)

Parameter Range: 0 – 2

Parameter	Configuration
0	disabled
1	Enable Binary Programming
2	Enable RTS Flow Control

Default Parameter Value: 0

Number of bytes returned: 1

RZ (RX Buffer) Command

<Diagnostic> Read DI Buffer Size. The DO Buffer size can be determined by multiplying the result of the RZ Command by 1.5.

AT Command: ATRZ

Binary Command: 0x2B (43 decimal)

Parameter Range: Read-only

Number of bytes returned: 2

Minimum Firmware Version Required: 4.30

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: 0x36 (54 decimal)

Parameter Range: 0 – 1

Parameter	Configuration
0	1 stop bits
1	2 stop bits

Default Parameter Value: 0

Number of bytes returned: 1

Minimum Firmware Version Required: 4.30

SH (Serial Number High) Command

<Diagnostic> Set/Read the serial number high word of the module.

AT Command: ATSH

Binary Command: 0x25 (37 decimal)

Parameter Range: 0 – 0xFFFF [Read-only]

Number of bytes returned: 2

Related Commands: SL (Serial Number Low)

Minimum Firmware Version Required: 4.27C

SL (Serial Number Low) Command

<Diagnostic> Set/Read the serial number low word of the module.

AT Command: ATSH

Binary Command: 0x26 (38 decimal)

Parameter Range: 0 – 0xFFFF [Read-only]

Number of bytes returned: 2

Related Commands: SH (Serial Number High)

Minimum Firmware Version Required: 4.27C

SM (Sleep Mode) Command

<Sleep Mode (Low Power)> SM Command is used to adjust Sleep Mode settings. By default, Sleep Mode is disabled and the module remains continually active. SM Command allows the module to run in a lower-power state and be configured in one of eight settings.

Cyclic Sleep settings wake the module after the amount of time designated by SM Command. If the module detects a wake-up initializer during the time it is awake, it will synchronize with the transmitter and start receiving data after the wake-up initializer runs its duration. Otherwise, it returns to Sleep Mode and continue to cycle in and out of inactivity until the 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.

AT Command: ATSM

Binary Command: 0x01

Parameter Range: 0 – 8

Parameter	Configuration
0	Disabled
1	Pin Sleep
2	Serial Port Sleep
3	Cyclic 0.5 second sleep (Module wakes every 0.5 seconds)
4	Cyclic 1.0 second sleep
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)

ST (Time before Sleep) Command

<Sleep Mode (Low Power)> ST Command sets the period of time (in tenths of seconds) in which the module remains inactive before entering into Sleep Mode. For example, if the ST Parameter is set to 0x64 (100 decimal), the module 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

Parameter Range: 0x10 – 0xFFFF
[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)

SY (Time before Initialization) Command

<Networking> SY Command keeps a communication channel open as long as module transmits or receives before the active connection expires. It can be used to reduce latency in a query/response sequence and should be set 100 ms longer than the delay between transmissions.

This command allows multiple XStream Modules to share a hopping channel for a given amount of time after receiving data. By default, all packets include an RF initializer that contains channel information used to synchronize any listening receivers to the transmitter's hopping pattern. Once a new module comes within range or is powered on within range, it is able to instantly synchronize to the transmitter and start receiving data. If no new modules are introduced into the system, the synchronization information becomes redundant once modules have become synchronized.

SY Command allows the modules to remove this information from the RF Initializer after the initial synchronization. For example, changing the SY Parameter to 0x14 (20 decimal) allows all modules to remain in sync for 2 seconds after the last data packet was received. Synchronization information is not re-sent unless transmission stops for more than 2 seconds. This command allows significant savings in packet transmission time.

AT Command: ATSY

Binary Command: 0x17 (23 decimal)

Parameter Range: 0 – 0xFF
[x 100 milliseconds]

Default Parameter Value: 0 (Channel initialization information is sent with each RF packet.)

Number of bytes returned: 1

Warning: Not recommended for use in an interference-prone environment. Interference can break up the session and the communications channel will not be available again until SY time expires.

With SY set to zero, the channel session is opened and closed with each transmission - resulting in a more robust link with more latency.

TO (DO2 Timeout) Command

<Serial Interfacing> DO2 output will return to default after no DI2 status information is received during the timeout period.

Use with CS = 2 or 4.

AT Command: ATTO

Binary Command: 0x30 (48 decimal)

Parameter Range: 0 – 0xFFFF [x 1 second]

Default Parameter Value: 3

Number of bytes returned: 2

Minimum Firmware Version Required: 4.30

TR (Transmit Error Count) Command

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

The TR Parameter is not non-volatile and will therefore be reset to zero each time the module 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)

Minimum Firmware Version Required: 4.22

TT (Streaming Limit) Command

<Networking> TT Command defines a limit on the number of bytes that can be sent out before a random delay is issued. TT Command is used to simulate full-duplex behavior.

If a modem is sending a continuous stream of RF data, a delay is inserted which stops its transmission and allows other modules time to transmit (once it sends number of bytes specified by TT Command). Inserted random delay lasts between 1 & 'RN + 1' delay slots, where each delay slot lasts 38ms.

AT Command: ATTT

Binary Command: 0x1A (26 decimal)

Parameter Range: 0 – 0xFFFF

Default Parameter Value: 0xFFFF (65535 decimal)

Number of bytes returned: 2

Related Commands: RN (Delay Slots)

Minimum Firmware Version Required: 4.22

VR (Firmware Version) Command

<Diagnostic> Read the Firmware Version of the XStream Module.

AT Command: ATVR

Binary Command: 0x14 (20 decimal)

Parameter Range: 0 – 0xFFFF [Read-only]

Number of bytes returned: 2

WR (Write) Command

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

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

AT Command: ATWR

Binary Command: 0x08

Appendix C: Additional Information

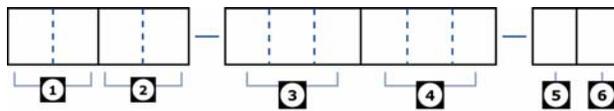
1-Year Warranty

XStream RF Modems from MaxStream, Inc. (the "Product") are warranted against defects in materials and workmanship under normal use, for a period of 1-year from the date of purchase. In the event of a product failure due to materials or workmanship, MaxStream will repair or replace the defective product. For warranty service, return the defective product to MaxStream, shipping prepaid, for prompt repair or replacement.

The foregoing sets forth the full extent of MaxStream's warranties regarding the Product. Repair or replacement at MaxStream's option is the exclusive remedy. THIS WARRANTY IS GIVEN IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, AND MAXSTREAM SPECIFICALLY DISCLAIMS ALL WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL MAXSTREAM, ITS SUPPLIERS OR LICENSORS BE LIABLE FOR DAMAGES IN EXCESS OF THE PURCHASE PRICE OF THE PRODUCT, FOR ANY LOSS OF USE, LOSS OF TIME, INCONVENIENCE, COMMERCIAL LOSS, LOST PROFITS OR SAVINGS, OR OTHER INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PRODUCT, TO THE FULL EXTENT SUCH MAY BE DISCLAIMED BY LAW. SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES. THEREFOR, THE FOREGOING EXCLUSIONS MAY NOT APPLY IN ALL CASES. This warranty provides specific legal rights. Other rights which vary from state to state may also apply.

Ordering Information

Figure C-01. MaxStream RF Modem Part Numbers Key



Divisions of the MaxStream PKG RF Modem part numbers:

1 MaxStream Product Family

XC = XCite
X = XStream
XT = XTend

2 Operating Frequency

09 = 902-928 MHz
24 = 2.4000 - 2.4835 GHz (XStream only)
H9 = 923 MHz (XStream only)

3 Throughput Data Rate

001 = 1200 bps (XStream only)
009 = 9600 bps
019 = 19200 bps (XStream only)
038 = 38400 bps (XCite Only)
(blank) All XTend RF Modems support 9600 & 115200 bps (software selectable)

4 Operating Temperature

PKC = Commercial: 0 to 70° C
PKI = Industrial: -40 to 85° C. Embedded RF Module is Conformal Coated
PKT = Tested Industrial: -40 to 85° C. Embedded RF Module is Conformal Coated & 100% tested

5 Interface

R = RS-232, RS-485/422
U = USB
E = Ethernet
T = Telephone

6 Accessories Package

A = Accessories Package (specific to the Interface) Included
(blank) means the accessories package is not included

Contact MaxStream

Free and unlimited technical support is included with every MaxStream Radio Modem sold.

Please use the following resources for additional support:

Documentation: www.maxstream.net/support/downloads.php

Technical Support: Phone. (866) 765-9885 toll-free U.S. & Canada
(801) 765-9885 Worldwide

Live Chat. www.maxstream.net

E-Mail. rf-xperts@maxstream.net

MaxStream office hours are 8:00 am – 5:00 pm [U.S. Mountain Standard Time]