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XStream™ OEM RF Module

XStream OEM RF Module

RF Module Operation

RF Module Configuration

RF Communication Modes

Appendices

Product Manual v5.x00

For XStream OEM RF Module Part Numbers:

X09-001…	X24-009…	XH9-001…
X09-009…	X24-019…	XH9-009…
X09-019…		XH9-019…

Reliable 900 MHz & 2.4 GHz OEM RF Modules by MaxStream, Inc.

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M100018

2006.02.24

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Contents

1. XStream OEM RF Module

The XStream OEM RF Module is a drop-in wireless data solution that transfers a standard asynchronous serial data stream over-the-air between devices. The module was engineered to provide OEMs and integrators with an easy-to-use wireless solution that yields reliable, long range and low cost wireless links.

1.1. Features

Long Range

9XStream (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 (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

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

FHSS (Frequency Hopping Spread Spectrum)

Fast network synchronization (~ 35 ms)

Streaming, Repeater, Multi-Streaming & Acknowledged Modes supported

Easy-to-Use

No configuration required

Advanced configurations supported through standard AT & binary Commands

5 VDC (± 0.25 V) power supply

Continuous RF data stream up to 19.2 kbps

Portable (small form factor easily designed into a wide range of data radio systems)

Software-selectable serial interfacing rates

MODBUS, CTS, RTS, DTR, DCD (& more) I/O Support

Support for multiple data formats (parity, start and stop bits, etc.)

XII™ Interference Immunity

Power-saving Sleep Modes

Free & Unlimited
World Class Technical Support

1.1.1. Worldwide Acceptance

FCC Certified (USA) – Refer to Appendix A for FCC Requirements.
Systems that include XStream Modules automatically inherit MaxStream Certifications

ISM (Industrial, Scientific & Medical) frequency band

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

9XStream (900 MHz) OEM RF Modules are approved for use in **US**, **Canada**, **Australia**, **Israel** (and more). 24XStream (2.4 GHz) Modules add **Europe** (EU) and other approvals.

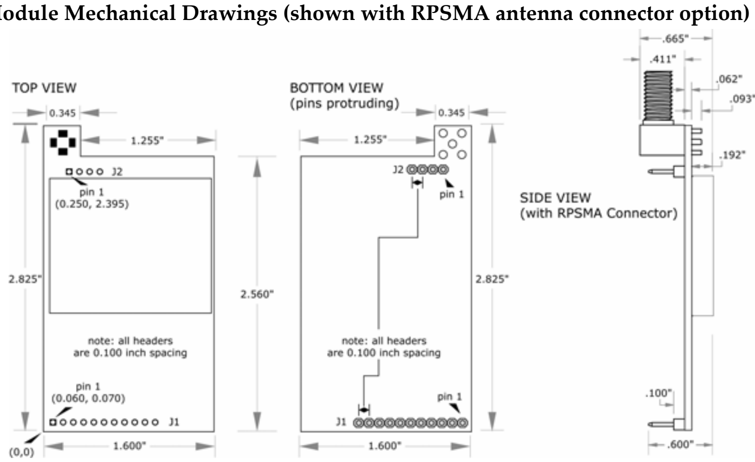
1.2. Specifications

Table 1-01. XStream OEM RF Module Specifications

Specification	9XStream (900 MHz) OEM RF Module		24XStream (2.4 GHz) OEM RF Module	
Performance				
Indoor/Urban Range	up to 1500' (450 m)		up to 600' (180 m)	
Outdoor 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 – 57,600 bps (non-standard baud rates also supported)		1200 – 57,600 bps (non-standard baud rates also supported)	
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	5 VDC (± 0.25 V) regulated		5 VDC (± 0.25 V) regulated	
Receive Current	50 mA		80 mA	
Transmit Current	140 mA		150 mA	
Power Down Current	< 26 μA		< 26 μA	
General				
Frequency Range	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			
Serial Data Interface	CMOS UART			
Physical Properties				
Module Board Size	1.600" x 2.825" x 0.350" (4.06 cm x 7.18 cm x 0.89 cm)			
Weight	0.8 oz (24 g)			
Connector	11-pin & 4-pin, 0.1" spaced male Berg-type headers			
Operating Temperature	0 to 70º C (commercial), -40 to 85º C (industrial)			
Antenna				
Integrated Wire (optional)	¼ wave monopole, 3" (7.62 cm) length, 1.9 dBi Gain			
Connector (optional)	Reverse-polarity SMA or MMCX			
Impedance	50 ohms unbalanced			
Certifications (visit www.maxstream.net for complete list)				
FCC Part 15.247	OUR9XSTREAM		OUR-24XSTREAM	
Industry Canada (IC)	4214A-9XSTREAM		4214A 12008	
Europe	N/A		ETSI, CE	

1.3. Mechanical Drawings

Figure 1-01. XStream Module Mechanical Drawings (shown with RPSMA antenna connector option)



1.4. Pin Signals

Figure 1-02. XStream OEM RF Module Pin Numbers (bottom view, pins protruding)

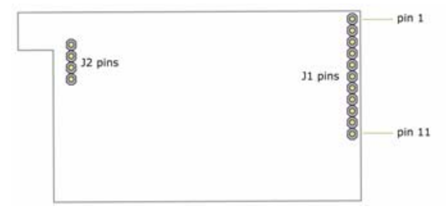


Table 1-02. J1 Pin Signal Descriptions
(Low-asserted signals distinguished with a horizontal line over signal name.)

Module Pin	Signal Name	I/O	When Active	Function
1	DO2 / $\overline{CTS}$ / RS-485 Enable	O*	low	$\overline{CTS}$ (clear-to-send) flow control – When pin is driven low, UART host is permitted to send serial data to the module. Refer to the Serial Communications [p9] and CS Command [p23] sections for more information.
				RS-485 Enable – To configure this pin to enable RS-485 (2-wire or 4--wire) communications, refer to the Serial Communications [p9] and CS Command [p23] sections.
2	DI3 / SLEEP	I*	high	By default, DI3 pin is not used. To configure this pin to support Sleep Modes, refer to the Sleep Mode [p13], SM Command [p32] and PW Command [p29] sections.
3	DO (data out)	O*	n/a	Serial data exiting the module (to the UART host). Refer to the Serial Communications [p9] section for more information.
4	DI (data in)	I	n/a	Serial data entering the module (from UART host). Refer to the Serial Communications [p9] section for more information.
5	DI2 / $\overline{RTS}$ / CMD	I**	low	$\overline{RTS}$ (request-to-send) flow control – By default, this pin is not used. To configure this pin to regulate the flow of serial data exiting the module, refer to the Serial Communications [p9] and RT Command [p31] sections.
				CMD –Refer to Binary Commands [p17] and RT Command [p31] sections to enable binary command programming.
6	$\overline{RESET}$	I*	low	Re-boot module.
7	DO3 / RX LED	O	high	Pin is driven high during RF data reception; otherwise, the pin is driven low. Refer to the CD Command [p22] to enable.
8	$\overline{TX}$ / PWR	O	low	$\overline{TX}$ - Pin pulses low during RF transmission.
			high	PWR – Indicates power is on and module is not in Sleep Mode.
9	$\overline{CONFIG}$	I***	low	Pin can be used as a backup method for entering Command Mode during power-up. Primary method is with "+++". Refer to the Command Mode [p16] section for more information.
10	VCC	I	-	5 VDC regulated (± 0.25)
11	GND	-	-	Ground

* Module has 10K Ω internal pull-up resistor
** Module has 10K Ω internal pull-down resistor
*** Module has 100K Ω internal pull-up resistor

Note: When integrating the XStream Module with a Host PC Board, all lines that are not used should be left disconnected (floating).

Table 1-03. J2 Pin Signal Descriptions

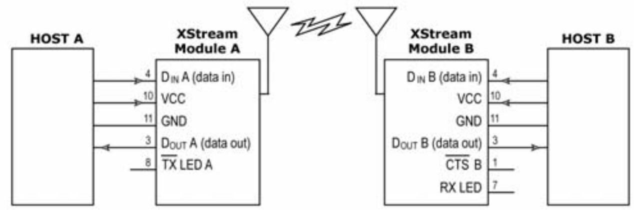
Module Pin	Signal Name
1	reserved
2	GND
3	GND
4	GND

J2 Pins are used primarily for mechanical stability and may be left disconnected.

1.5. Electrical Characteristics

Figure 1-03. System Block Diagram

Basic wireless link between hosts



The data flow sequence is initiated when the first byte of data is received in the DI Buffer of the transmitting module (XStream Module A). As long as XStream Module A is not already receiving RF data, data in the DI Buffer is packetized, then transmitted over-the-air to XStream Module B-0

1.5.1. Timing Specifications

Figure 1-04. Timing Specifications ("A" and "B" refer to Figure 1-03.)

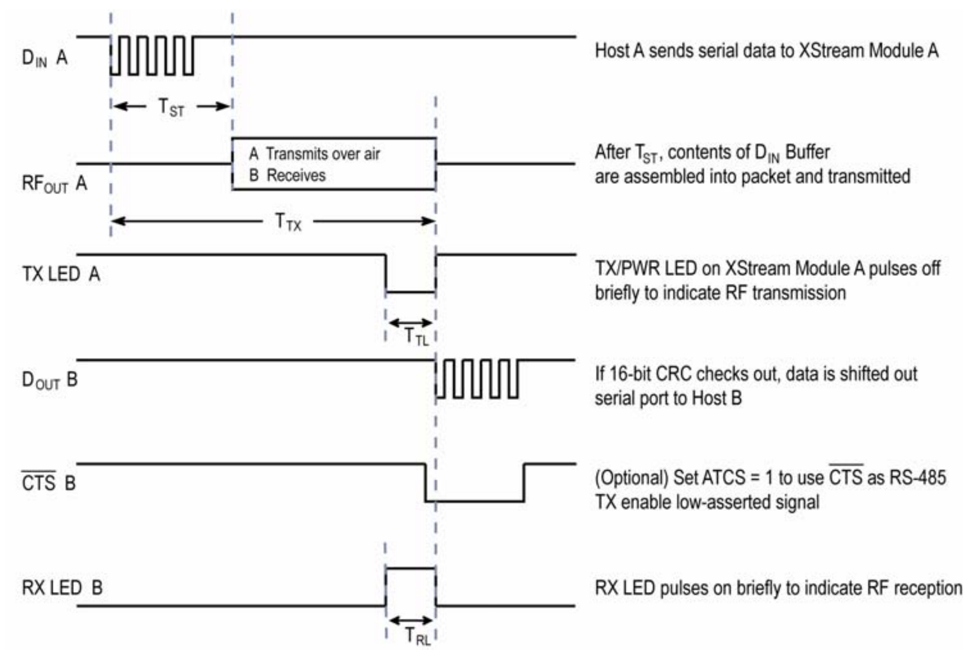


Table 1-04. AC Characteristics (SY parameter = 0, symbols correspond to Figure 1-03 and Figure 1-04.)

Symbol	Description	19200 baud rate (32 byte packet)	19200 timing (B=number of bytes)	9600 baud rate (32 byte packet)	9600 timing (B=number of bytes)
T_{TX}	Latency from the time data is transmitted until received	54.0 ms	For 0 < B < 64, T = 41.6 + (0.4 * B) ms For B > 63, T = 66.8 ms	72.0 ms	For 0 < B < 40, T = 46.27 + (0.73 * B) ms For B >= 39 bytes, T = 74.80 ms
T_{TL}	Time that $\overline{TX}$/PWR pin is driven low	8.4 ms	For 0 < B < 14, T = 3.24 + (0.4 * B) ms For B > 13, T = 8.48 ms	16.8 ms	For 0 < B < 14, T = 6.50 + (0.8 * B) ms For B > 13, T = 16.80 ms
T_{RL}	Time that RX LED pin is driven high	13.6 ms	For 0 < B < 65, T = 0.79 + (0.408 * B) For B > 64, T = 26.9 ms	25.6 ms	For 0 < B < 37, T = 1.63 + (0.794 * B) For B > 36, T = 30.2 ms
T_{ST}	Channel Initialization Time	35.0 ms	35.0 ms	35.0 ms	35.0 ms

Table 1-05. DC Characteristics (Vcc = 4.75 – 5.25 VDC)

Symbol	Parameter	Condition	Min	Typical	Max	Units
VIL	Input Low Voltage	All input signals	-0.5		0.3 * Vcc	V
VIH	Input High Voltage	All except RESET pin	0.6 * Vcc		Vcc + 0.5	V
VIH2	Input High Voltage	pin *	0.9 * Vcc		Vcc + 0.5	V
VOL	Output Low Voltage	IOL = 20 mA, Vcc = 5V			0.7 0.5	V
VOH	Output High Voltage	IOH = -20 mA, Vcc = 5V	4.0 2.0			V
IIL	Input Leakage Current I/O Pin	Vcc = 5.5V, pin low (absolute value)			3	µA
IIH	Input Leakage Current I/O Pin	Vcc = 5.5V, pin high (absolute value)			3	µA
IIL2		CTS, RESET, DO		(Vcc – VI) / 10 **		mA
IIL3		CONFIG		(Vcc – VI) / 47 **		mA
IIH2		RTS		(Vcc – VI) / 10 **		mA

* Reset pulse must last at least 250 nanoseconds

** VI = the input voltage on the pin

2. RF Module Operation

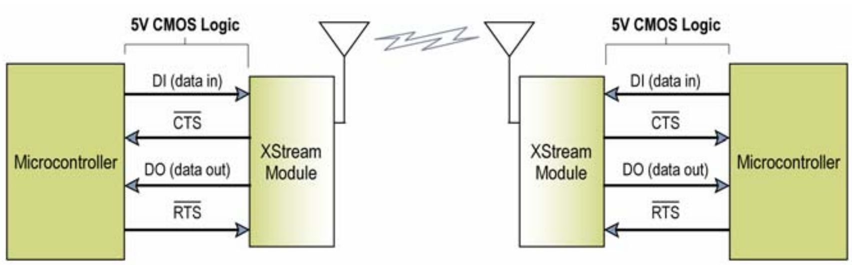
2.1. Serial Communications

The XStream OEM RF Module interfaces to a host device through a CMOS-level asynchronous serial port. Through its serial port, the module can communicate with any UART voltage compatible device or through a level translator to any RS-232/485/422 device.

2.1.1. UART-Interfaced Data Flow

Devices that have a UART interface can connect directly through the pins of the XStream Module as is shown in the figure below.

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

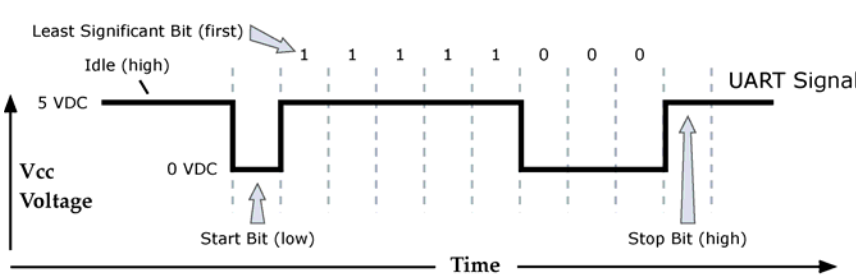


Serial Data

Data enters the XStream Module through the DI pin (pin 4) as an asynchronous serial signal. The signal should idle high when no data is being transmitted.

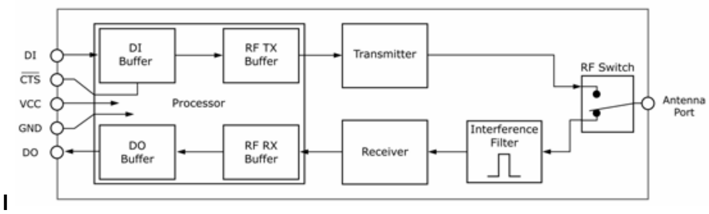
The UART performs tasks, such as timing and parity checking, that are needed for data communications. Serial communication consists of two UARTs configured with compatible parameters (baud rate, parity, start bits, stop bits, data bits) to have successful communication. Each data packet consists of a start bit (low), 8 data bits (least significant bit first) and a stop bit (high). The following figure illustrates the serial bit pattern of data passing through the module.

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



2.1.2. Flow Control

Figure 2-03. Internal Data Flow Diagram (The five most commonly-used pin signals shown.)



DI (Data In) Buffer and Flow Control

When serial data enters the XStream Module through the DI Pin (pin 4), then the data is stored in the DI Buffer until it can be transmitted.

When the RB and RO parameter thresholds are satisfied (refer to Transmit Mode section [p11] and command descriptions for more information), the module attempts to initialize an RF connection. If the module is already receiving RF data, the serial data is stored in the DI Buffer. The size of the DI Buffer can be determined by issuing the RZ (DI Buffer Size) Command. If the DI buffer becomes full, hardware or software flow control must be implemented in order to prevent overflow (loss of data between the host and XStream Module).

How to eliminate the need for flow control:

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

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

1. If the serial interface data rate is set higher than the RF data rate of the module, the module will receive data from the host faster than it can transmit the data over-the-air.
2. If the module is receiving a continuous stream of RF data or monitoring data on a network, any serial data that arrives on the DI pin is placed in the DI Buffer. The data in the DI buffer will be transmitted over-the-air when the module no longer detects RF data in the network.

Hardware Flow Control (**$\overline{\text{CTS}}$**). When the DI buffer is 17 bytes away from being full; by default, the module de-asserts (high) $\overline{\text{CTS}}$ to signal to the host device to stop sending data [refer to FT (Flow Control Threshold) and CS (DO2 Configuration) Commands]. $\overline{\text{CTS}}$ is re-asserted after the DI Buffer has 34 bytes of memory available.

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

DO (Data Out) Buffer and Flow Control

When RF data is received, the data enters the DO buffer and is then sent out the serial port to a host device. Once the DO Buffer reaches capacity, any additional incoming RF data is lost. The size of the DO Buffer can be determined by issuing the RZ (DI Buffer Size) Command, then multiplying the result by 1.5.

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

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

Hardware Flow Control (**$\overline{\text{RTS}}$**). If $\overline{\text{RTS}}$ is enabled for flow control (RT Parameter = 2), data will not be sent out the DO Buffer as long as $\overline{\text{RTS}}$ (pin 5) is de-asserted.

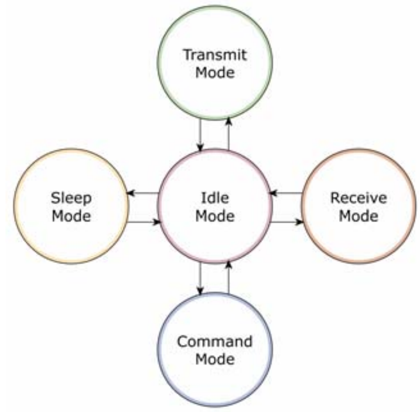
Software Flow Control (XOFF). XON/XOFF software flow control can be enabled using the FL (Software Flow Control) Command. This option only works with ASCII data.

2.2. Modes of Operation

XStream OEM RF Modules operate in five modes.

Figure 2-04. XStream Modes of Operation

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



2.2.1. 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 module 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 module automatically transitions back into Idle Mode.

2.2.2. Transmit Mode

After the first byte of serial data is received in the DI buffer (from the UART), the module attempts to shift to Transmit Mode and initiate RF connections with other modules. After transmission is complete, the module returns to Idle Mode.

Note: RF reception must complete before the module is able to enter into Transmit Mode.

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

1. RB bytes have been received in the DI buffer and are pending for RF transmission [refer to RB (Packetization Threshold) Command, p29].

   The RB parameter may be set to any value between 1 and the RF packet size (PK), inclusive. When RB = 0, the packetization threshold is ignored.
2. At least one character has been received in the DI buffer (pending for RF transmission) and RO time has been observed on the UART [refer to RO (Packetization Timeout) Command].

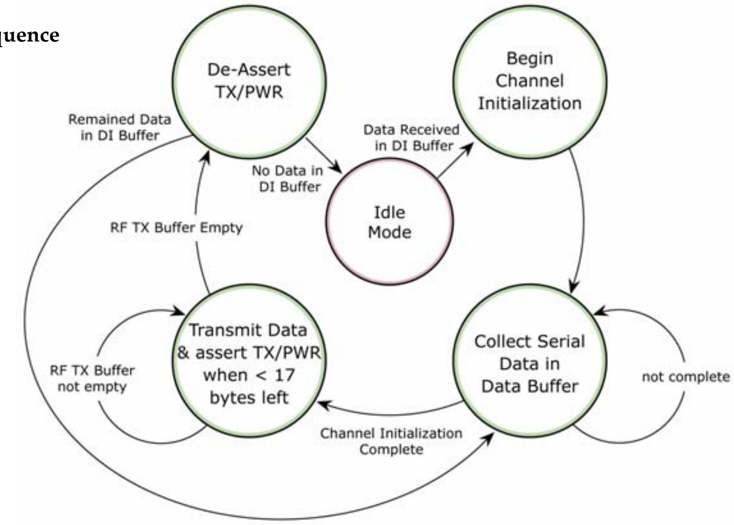
   The timeout can be disabled by setting RO to zero. In this case, transmission will begin after RB bytes have been received in the DI buffer.

After either RB or RO conditions are met, the module then initializes a communications channel. [Channel Initialization is the process of sending an RF initializer that synchronizes receiving modules with the transmitting module. During channel initialization, incoming serial data accumulates in the DI buffer.]

Serial data in the DI buffer is grouped into RF packets [refer to PK (RF Packet Size)]; converted to RF data; then transmitted over-the-air until the DI buffer is empty.

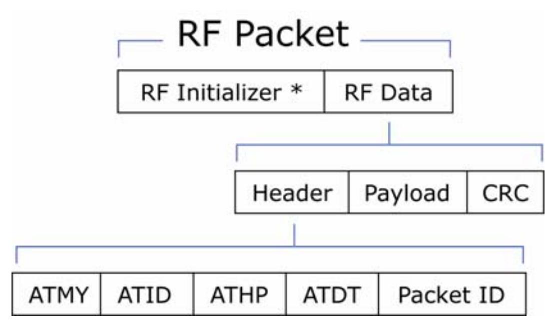
RF data, which includes the payload data, follows the RF initializer. The payload includes up to the maximum packet size (PK Command) bytes. As the transmitting module nears the end of the transmission, it inspects the DI buffer to see if more data exists to be transmitted. This could be the case if more than PK bytes were originally pending in the DI buffer or if more bytes arrived from the UART after the transmission began. If more data is pending, the transmitting module assembles a subsequent packet for transmission.

Figure 2-05. Data Transmission Sequence



RF Data Packet

Figure 2-06. RF Data Packet



* 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 modules of information such as the hopping pattern used by the transmitting module. 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 module. For example, a wake-up initializer is a type of RF initializer used to wake remote modules 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 modules are in cyclic sleep.

Header

The header contains network addressing information that filters incoming RF data. The receiving module checks for a matching Hopping Channel (HP parameter), Vendor Identification Number (ID parameter) and Destination Address (DT parameter). Data that does not pass through all three network filter layers is discarded.

CRC (Cyclic Redundancy Check)

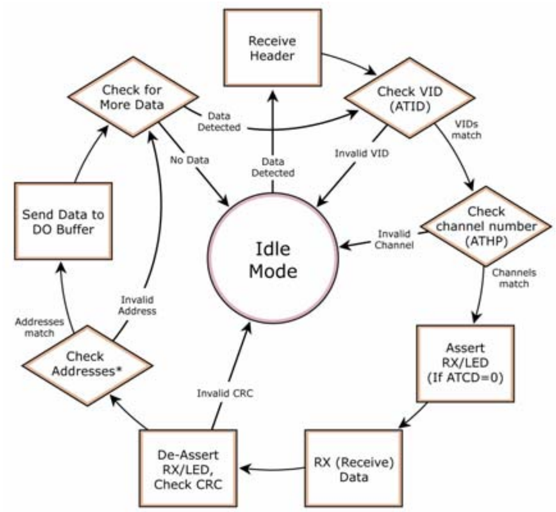
To verify data integrity and provide built-in error checking, a 16-bit CRC (Cyclic Redundancy Check) is computed for the transmitted data and attached to the end of each RF packet. On the receiving end, the receiving module computes the CRC on all incoming RF data. Received data that has an invalid CRC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

2.2.3. Receive Mode

If the module detects RF data while in Idle Mode, the module transitions into Receive Mode to receive RF packets. Once a packet is received, the module checks the CRC 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 module returns to Idle Mode when valid RF data is no longer detected or after an error is detected in the received RF data.

Figure 2-07. Data Reception Sequence →



* Refer to the Addressing section [p36] of the RF Communication Modes chapter for more information regarding address recognition.

> Note: If serial data exists in the DI buffer while the module is in Receive Mode, the UART data will be transmitted after the module is finished receiving the RF data and has returned to Idle Mode.

2.2.4. Sleep Mode

Sleep Modes enable the XStream Module 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 module to transition into Sleep Mode, the module must have a non-zero SM (Sleep Mode) Parameter and one of the following must occur:

1. The module is idle (no data transmission or reception) for a user-defined period of time [See ST (Time before Sleep) Command]
2. DI3 (pin 2) is asserted (only for Pin Sleep option)

In Sleep Mode, the module will not transmit or receive data until the module 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.

Table 2-01. Summary of Sleep Mode Configurations

Sleep Mode Setting	Transition into Sleep Mode	Transition out of Sleep Mode	Related Commands	Typical Power Consumption
Pin Sleep (SM = 1)	Microcontroller can shut down and wake modules by asserting (high) SLEEP (pin 2). Note: Module will complete transmission / reception before activating Pin Sleep.	De-assert (low) SLEEP (pin 2).	SM	26 µA
Serial Port Sleep (SM = 2)	Automatic transition to Sleep Mode occurs after a user-defined period of inactivity (no transmitting or receiving of data). The period of activity is defined using the ST (Time before Sleep) Command.	When serial byte is received on the DI pin (pin 4).	SM, ST	1 mA
Cyclic Sleep (SM = 3-8)	Automatic transition to Sleep Mode occurs in cycles as defined by the SM (Sleep Mode) Command. Note: The cyclic sleep time interval must be shorter than the "Wake-up Initializer Timer" (set by LH Command).	After the cyclic sleep time interval elapses. Note: Module can be forced into Idle Mode if PW (Pin Wake-up) Command is issued.	SM, ST, HT, LH, PW	76 µA when sleeping

For more information about Sleep Modes, refer to the individual commands listed in "Related Commands" column of the table. The SM command is central to all Sleep Mode configurations.

Pin Sleep (SM = 1)

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

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

Once in Pin Sleep Mode, $\overline{CTS}$ is de-asserted (high), indicating that data should not be sent to the module. The PWR pin 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, $\overline{CTS}$ 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, $\overline{CTS}$ is asserted and any data received on the DI Pin is transmitted. The PWR pin 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 SLEEP (pin 2) is de-asserted (low). To configure a module to operate in this manner, PW (Pin Wake-up) Command must be issued. Once SLEEP 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 2-08. 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.

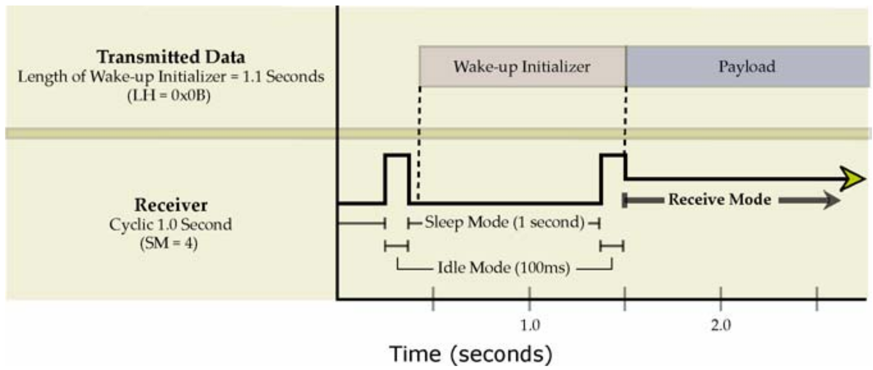
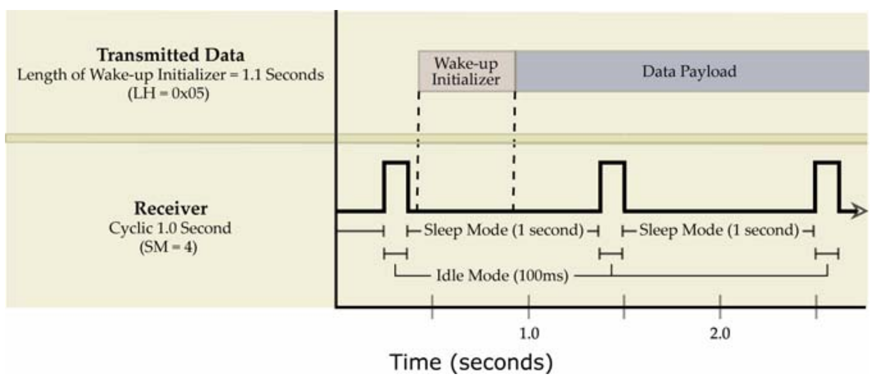


Figure 2-09. Incorrect Configuration (LH < SM)

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).



2.2.5. Command Mode

To modify or read module parameters, the module must first enter into Command Mode (a state in which incoming characters are interpreted as commands). Two command types are supported:

- AT Commands
- Binary Commands

AT Commands

To Enter AT Command Mode:

1. Send the 3-character command sequence "+++" and observe guard times before and after the command characters. [Refer to the "Default AT Command Mode Sequence" below.] The "Terminal" tab (or other serial communications software) of the X-CTU Software can be used to enter the sequence.

   [OR]

2. Assert (low) the CONFIG pin and either turn the power going to the module off and back on. (If using a MaxStream XIB-R Interface Board, the same result can be achieved by keeping the configuration switch pressed while turning off, then on again the power supplying the module assembly (module assembly = module mounted to an interface board))

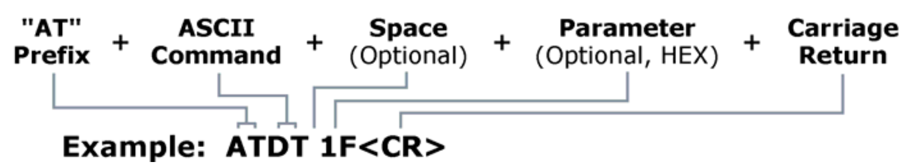
Default AT Command Mode Sequence (for transitioning to Command Mode):

- No characters sent for one second [BT (Guard Time Before) parameter = 0x0A]
- Input three plus characters ("+++") within one second [CC (Command Sequence Character) Command = 0x2B-0]
- No characters sent for one second [AT (Guard Time After) parameter = 0x0A]

To Send AT Commands:

Send AT commands and parameters using the syntax shown below.

Figure 2-10. Syntax for sending AT Commands



The preceding example would change the module Destination Address to "0x1F". For modified parameter values to persist in the module registry, changes must be saved to non-volatile memory using WR (Write) Command. Otherwise, parameters are restored to previously saved values after the module is powered off and then on again.

NOTE: To read the current value of a module parameter, leave the parameter field blank. For example, the following command will return the current destination address: ATDT<CR>

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

To Exit AT Command Mode:

1. Send ATCN (Exit Command Mode) Command.

   [OR]

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

For an example that illustrates programming the module using AT Commands, refer to the Module Configuration chapter [p18].

Binary Commands

Sending and receiving parameter values using binary commands is the fastest way to change operating parameters of the module. Binary commands are used most often to sample signal strength (RS parameter) and/or error counts; or to change module addresses and channels for polling systems when a quick response is necessary. Since the sending and receiving of parameter 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 time 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 [pin 5] must be asserted in order to send binary commands to the module. 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.

CMD (pin 5) must be asserted in order to send binary commands to an XStream Module. CMD can be asserted to recognize commands anytime during transmission or reception of data. A minimum time delay of 100 µs (after the stop bit of the command byte has been sent) must be observed before pin 5 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 module aborts the command and returns to Idle Mode. Note: When parameters are sent, they are always two bytes long with the least significant byte sent first.

Commands can be queried for their current value by sending the command logically ORed with the value 0x80 (hexadecimal) with 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 2-11. Binary Command Write then Read

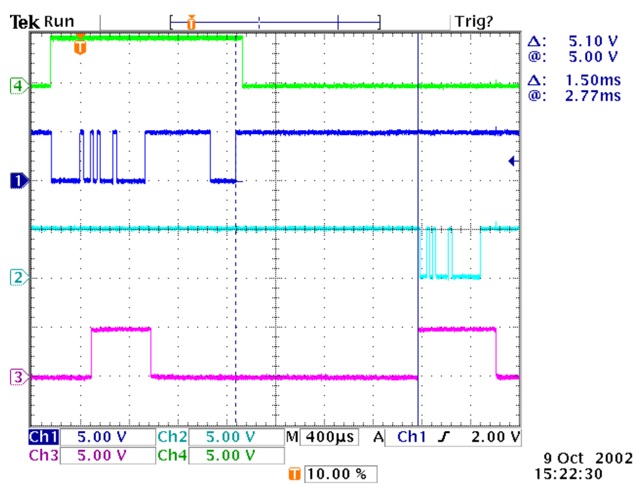
Signal #4 is CMD (pin 5)

Signal #1 is the DIN (pin 4) signal to the radio

Signal #2 is the DOUT (pin 3) signal from the radio

Signal #3 is $\overline{CTS}$ (pin 1)

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 module.



IMPORTANT: For the XStream Module to recognize a binary command, RT (DI2 Configuration) Command must be issued. If binary programming is not enabled (RT ≠ 1), the module will not recognize that the CMD pin (Pin 5) is asserted and therefore will not recognize the data as binary commands.

3. RF Module Configuration

3.1. Hands-on Programming Examples

For information about entering and exiting AT and Binary Command Modes, refer to the Command Mode section [p16].

3.1.1. AT Command Example

MaxStream's X-CTU Software facilitates module programming.

To install, double-click the "setup_X-CTU.exe" file that is located on the MaxStream CD & on the Internet. (www.maxstream.net)

To Send AT Commands (Using the Terminal tab of MaxStream's X-CTU Software)

Example: Both of the following examples change the module's destination address to 0x1A0D and save the new address to non-volatile memory.

Method 1 (One line per command)

Send AT Command	System Response
+++	OK <CR> (Enter into Command Mode)
ATDT <Enter>	current Destination Address <CR> (Read)
ATDT1A0D <Enter>	OK <CR> (Change destination address)
ATWR <Enter>	OK <CR> (Write to non-volatile memory)
ATCN <Enter>	OK <CR> (Exit Command Mode)

Method 2 (Multiple commands on one line)

Send AT Command	System Response
+++	OK <CR> (Enter into Command Mode)
ATDT <Enter>	current Destination Address <CR> (Read)
ATDT1A0D,WR,CN <Enter>	OK <CR> (Execute commands)

Note: In order to use a host PC and the X-CTU Software Terminal tab to send data to the module, PC com port settings must match the baud, parity & stop bit parameters stored in the module.

Use the "PC Settings" tab to configure PC com port settings to match module parameter values.

3.1.2. Binary Command Example

To Send Binary Commands:

Example: Use binary commands to change the XStream 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 5 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 5 is driven low) (Exit Binary Command Mode)

Note: $\overline{\text{CTS}}$ (pin 1) is de-asserted high when commands are being executed. Hardware flow control must be disabled as $\overline{\text{CTS}}$ will hold off parameter bytes.

3.2. Command Reference Table

Table 3-01. XStream Commands (The module expects numerical values in hexadecimal. "d" denotes decimal equivalent.)

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 command and parameter options were first supported.

NOTE: AT Commands issued without a parameter value will return the currently stored parameter.

3.3. XStream Command Descriptions

Command descriptions in this section are listed alphabetically. Command categories are designated within "< >" symbols that follow each command title. XStream Modules expect parameter numerical values in hexadecimal (designated by the "0x" prefix).

AM (Auto-set MY) Command

<Networking & Security> 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).

AT Command: ATAM
Binary Command: 0x3A (58 decimal)
Minimum firmware version required: 4.40

AT (Guard Time After) Command

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

Refer to the AT Commands section [p16] to view the default AT Command Mode Sequence.

AT Command: ATAT
Binary Command: 0x05 (5 decimal)
Parameter Range: 0x02 – 0xFFFF [x 100 milliseconds]
Number of bytes returned: 2
Default Parameter Value: 0x0A (10 decimal)
Related Commands: BT (Guard Time Before), CC (Command Sequence Character)

BD (Interface Data Rate) Command

<Serial Interfacing> BD Command allows the user to adjust the UART interface data rate and thus modify the rate at which serial data is sent to the RF module. The new baud rate does not take effect until the CN command is issued. The RF data rate is unaffected by the BD parameter.

Most applications will require one of the seven standard baud rates; however, non-standard baud rates are also supported.

Note: If the interface data rate is set to exceed the fixed RF data rate of the module, $\overline{CTS}$ flow control may need to be implemented as described in the Pin Signals [p6], Flow Control [p10] and CS (DO2 Configuration) sections.

AT Command: ATBD
Binary Command: 0x15 (21 decimal)
Parameter Range (Standard baud rates): 0 – 6 (Non-standard baud rates): 0x7D – 0xFFFF

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

Number of bytes returned: 2
Default Parameter Value: Set to equal module's factory-set RF data rate.
Related Commands: CN (Exit Command Mode)
Minimum firmware version required: 4.2B (Custom baud rates not previously supported.)

Non-standard Interface Data Rates: When parameter values outside the range of standard interface data rates are sent, the closest 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.

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 in the BD register.

Table 3-02. 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 module.

AT Command: ATBK	
Binary Command: 0x2E (46 decimal)	
Parameter Range: 0 – 1	
Parameter	Configuration
0	disable
1	enable
Default Parameter Value: 0	
Number of bytes returned: 1	
Related Commands: BO (Serial Break Timeout)	
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 parameter = 1.

AT Command: ATBO
Binary Command: 0x30 (48 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

<Command Mode Options> BT Command is used to set the DI pin silence time that must precede the command sequence character (CC Command) of the AT Command Mode Sequence.

Refer to the AT Commands section [p16] to view the default AT Command Mode sequence.

AT Command: ATBT
Binary Command: 0x04 (4 decimal)
Parameter Range: 0 – 0xFFFF [x 100 milliseconds]
Default Parameter Value: 0x0A (10 decimal)
Number of bytes returned: 2
Related Commands: AT (Guard Time After), CC (Command Sequence Character)

CB (Connection Duration Timeout) Command

<Networking & Security> Set/Read the maximum amount of time an exclusive connection between a base and remote module in a point-to-multipoint network is sustained. The remote module will disconnect when this timeout expires.

AT Command: ATCB
Binary Command: 0x33 (51 decimal)
Parameter Range: 0x01 – 0xFFFF [x 100 milliseconds]
Default Parameter Value: 0x28 (4d 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

<Command Mode Options> CC Command is used to set 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).

Refer to the AT Commands section [p16] to view the default AT Command Mode sequence.

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

CD (DO3 Configuration) Command

<Serial Interfacing> CD Command is used to redefine the behavior of the DO3 (Data Output 3)/RX LED line.

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: 4.2B	

CE (Connection Inactivity Timeout) Command

<Networking & Security> Set/Read the duration of inactivity that will cause a break in a connection between modules. The base module will disconnect when no payload has been transferred for the time specified by the CE parameter.

AT Command: ATCE
Binary Command: 0x34 (52 decimal)
Parameter Range: 0 – 0xFFFF [x 10 milliseconds]
Default Parameter Value: 0x64 (1d 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

<Diagnostics> 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: 0x35 (53 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

<Diagnostics/Networking & Security> 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 & Security> 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

<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 (Data Output 3) output will return to default after no DI3 (Data Input 3) status information is received during the timeout period.

Use with CD = 1 or 2, DR = 1.

AT Command: ATCO
Binary Command: 0x2F (47 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 the behavior of the DO2 (Data Output 2) pin signal. 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

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

AT Command: ATCT
Binary Command: 0x06 (6 decimal)
Parameter Range: 2 – 0xFFFF [x 100 milliseconds]
Default Parameter Value: 0xC8 (200 decimal, 20 seconds)
Number of bytes returned: 2

DC (Disconnect) Command

<Networking & Security> DC Command is used (when in Multi-Streaming Mode (MD = 1 or 2)) to explicitly force the disconnection of an active exclusive connection. If MD = 1, the base module will force the disconnection 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> DR Command is used to 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: 0x2D (45 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), MD (RF Mode)	
Minimum Firmware Version Required: 4.30	

DT (Destination Address) Command

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 (Module VID), MK (Address Mask)

<Networking & Security> DT Command is used to set the networking address of an XStream Module. XStream Modules use three filtration layers: Channels (ATHP), Vendor Identification Number (ATID) and Destination Addresses (ATDT). DT Command assigns an address to a module that enables it to communicate only with other modules having the same addresses. All modules that share the same Destination Address can communicate freely with each other. Modules 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.

E0 (Echo Off) Command

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

AT Command: ATE0
Binary Command: 0x0A (10 decimal)

E1 (Echo On) Command

<Command Mode Options> E1 Command turns on the 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

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)

<Diagnostics> Set/Read the receive error count. The error-count records the number of packets partially received then aborted on reception error. This value returns to 0 after a reset and is not non-volatile (value does not persist in the module'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 module is reset.

FH (Force Wake-up Initializer) Command

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

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 of module with software flow control. Hardware flow control is implemented with the XStream Module as the DO2 pin ($\overline{CTS}$), which regulates when serial data can be transferred to the module. FL Command is used to allow software flow control. 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, $\overline{CTS}$ is de-asserted or the XOFF software flow control character is transmitted.

AT Command: ATFT
Binary Command: 0x24 (36 decimal)
Parameter Range: 0 – 0xFF [bytes] (Maximum value equals the 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

<Diagnostics> Set/Read the count of good received RF packets. Parameter value is reset to 0 after every reset and is not non-volatile (value does not persist in the 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 & Security> HP Command is used to set the module hopping channel number. A channel is one of three layers of addressing available to the module. In order for modules to communicate with each other, the modules must have the same channel number since each network 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 (Module VID), MK (Address Mask)