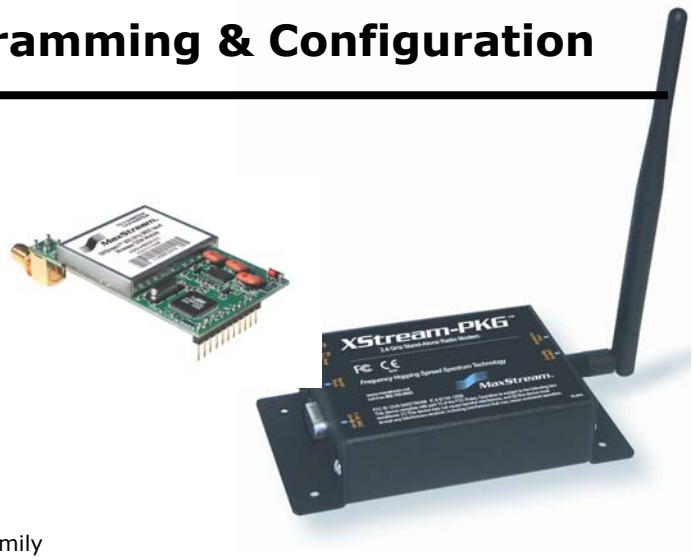
XStream™ Advanced Programming & Configuration



Advanced Manual v4.2A

Advanced Development for the XStream Product Family

XStream Product Family Radio Modems:
XStream OEM RF Modules (900 MHz & 2.4 GHz)
XStream-PKG-R RS-232/485 RF Modems (900 MHz & 2.4 GHz)
XStream-PKG-U USB RF Modems (900 MHz & 2.4 GHz)

MaxStream

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Contents

XStream Product Family

The XStream Product Family consists of the following radio modems:

- 9XStream (900 MHz) & 24XStream (2.4 GHz) **OEM RF Modules**
- 9XStream-PKG-R & 24XStream-PKG-R **RS-232/485 RF Modems**
- 9XStream-PKG-E & 24XStream-PKG-E **Ethernet RF Modems**
- 9XStream-PKG-U & 24XStream-PKG-U **USB RF Modems**

9XStream (900 MHz) and 24XStream (2.4 GHz) Radio Modems are form-factor and electrically compatible with each other and with XCite™ (900 MHz) radio modems.

Features

Long Range at a Low Cost

9XStream (900 MHz) Range:

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

24XStream (2.4 GHz) Range:

- Indoor/Urban: **up to 600'** (180 m)
- Outdoor line-of-sight: **up to 3 miles** (5 km) w/ 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) [-93 dBm is industry average]

Advanced Networking & Security

True Peer-to-Peer (no "master" required), Point-to-Point, Point-to-Multipoint & Multidrop

Retries and Acknowledgements (ACK)

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

Easy-to-Use

FCC & international agency approved

No configuration required

Advanced configurations using standard AT Commands

Transparent Operation (replaces serial wires)

Portable (small form factor & low power)

Software-selectable serial interfacing

MODBUS, $\overline{\text{CTS}}$, $\overline{\text{RTS}}$, $\overline{\text{DCD}}$ & $\overline{\text{DTR}}$ I/O Support

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

XII™ Interference Immunity

Power-saving Sleep Modes

FHSS (Frequency Hopping Spread Spectrum)

Worldwide Acceptance

FCC Certified (USA) [Go to Appendix A for FCC Requirements]
Systems that contain XStream RF Modems can inherit MaxStream's FCC Certification

ISM (Industrial, Scientific & Medical) frequency band

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

9XStream-PKG-E (900 MHz) RF Modems approved for use in **US**, **Canada**, **Australia**, **Israel** (and more). 24XStream-PKG-E (2.4 GHz) adds **EU** (Europe) and other approvals.

XStream OEM RF Module Signal Pinouts

Signal Pinouts in this section refer to OEM RF Modules, not the pins coming out of the DB-9 connector of PKG-R (RS-232/485) RF Modems and XIB-R interface boards. Signal Pinouts are available through an 11-pin header. All pins operate on 5V CMOS levels. The following five J1 Signal Pinouts are most commonly used in MaxStream product applications:

- DI (pin 4 – Data In)
- DO (pin 3 – Data Out)
- VCC (pin 10 – Power)
- GND (pin 11 – Ground)
- DO2 (pin 1 – Data Out 2)

Application Circuit

Figure 1. Application Circuit – connection to host processor

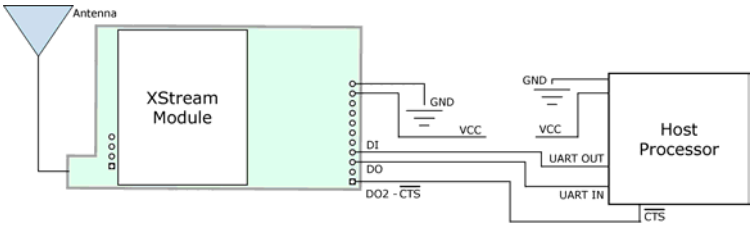


Table 1. J1 Pin Descriptions – XStream Module Signal Pinouts and their Functions
(Low-asserted signals distinguished with a horizontal line over signal name.)

Module Pin	Signal Name	I/O	When Active	Description
1	DO2	O*	low	Clear-to-Send ($\overline{\text{CTS}}$) Flow Control
2	DI3 (Power-down)	I*	high	Can be used to enter Sleep Modes that require less power.
3	DO (Data Out)	O*	n/a	Serial Data leaving the data radio modem (to the host)
4	DI (Data In)	I	n/a	Serial data entering the data radio modem (from the host)
5	DI2	I**	low	Request-to-Send ($\overline{\text{RTS}}$) / Enable Binary Commands
6	$\overline{\text{RESET}}$	I*	low	Re-boot data radio modem
7	DO3	O	high	Receive (RX) LED
8	$\overline{\text{TX}}$ / PWR	O	low	$\overline{\text{TX}}$ - Asserted during transmission
			high	PWR – Indicates power is on
9	$\overline{\text{CONFIG}}$	I***	low	Backup method for entering Command Mode. Primary method is with "+++" [See CC Command]
10	VCC	I	-	5 VDC Regulated (± 0.25)
11	GND	-	-	Ground

* Pin utilizes 10K Ω Pull-Up resistor (already installed in the module)

** Pin utilizes 10K Ω Pull-Down resistor (already installed in the module)

*** Pin utilizes 100K Ω Pull-Up resistor (already installed in the module)

Note: When integrating XStream Modules onto host boards, all lines that are not used should be left disconnected (floating).

Table 2. J2 Signal Pinout 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.

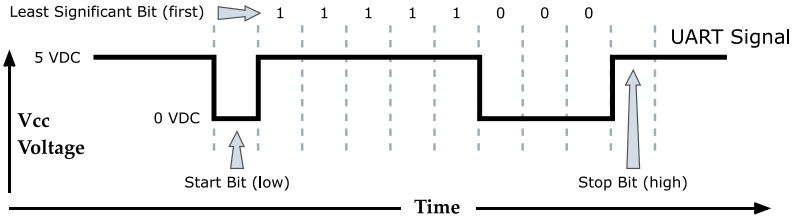
DI/DO Signal Pinouts

❹ Pin 4 = DI (Data In)

<Input> Data enters the XStream Module through the DI Pin as an asynchronous serial signal. The signal should idle high when no data is being transmitted.

Each data packet consists of a start bit (low), 8 data bits (least significant bit first) and a stop bit (high). The figure of a UART data packet [below] illustrates the serial bit pattern of data shifting into the module. The start and stop bits from the UART signal are not transmitted, but are regenerated on the receiving module.

Figure 2. 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)



→ DI Buffer

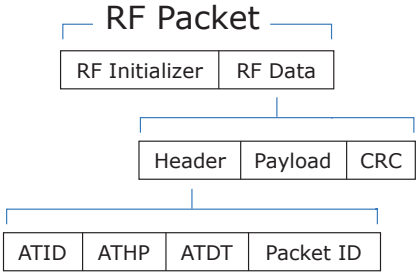
Once serial data has entered the XStream Module through the DI Pin, the data is stored in the DI Buffer until it can be transmitted.

Once the first byte of data enters the DI Buffer, the module begins to initialize the RF channel unless RF data is already being received. In the case where the module is receiving RF data, serial data is stored in the DI Buffer. When the DI Buffer is 17 bytes away from being full, the XStream Module de-asserts (high) $\overline{\text{CTS}}$ to signal to the host device to stop sending data. $\overline{\text{CTS}}$ re-asserts once the DI Buffer has at least 35 bytes available.

In addition to $\overline{\text{CTS}}$ hardware flow control, XON/XOFF software flow control can also be implemented [See the FL (Software Flow Control) Command]. In this case, the XStream Module sends XON and XOFF signals in addition to asserting/de-asserting $\overline{\text{CTS}}$.

After the serial data enters through the DI pin from the host, the data is packetized for RF transmission. The RF packet structure is as follows:

Figure 3. RF Packet Structure



❹ Pin 3 = DO (Data Out)

<Output> Data from RF (over-the-air) transmission is received through the DO Pin. Received data is checked for errors and addressing, then sent to the DO Buffer before being sent to the host device. This pin utilizes a 10K Ω Pull-Up resistor that is already installed in the module.

DO Buffer →

Once incoming RF data is received into the DO Buffer, data is sent out the serial port to a host device. If $\overline{\text{RTS}}$ is enabled for flow control, data will not be sent out the DO Buffer as long as the $\overline{\text{RTS}}$ pin is de-asserted (high). In such a scenario, data could be lost if $\overline{\text{RTS}}$ is de-asserted long enough to allow the DO Buffer to become full.

Flow Control Signal Pinouts

Pin 1 = DO2 (Data Out 2)

<Output> The DO2 pin informs the host device whether or not serial data can be sent to the XStream Module from the host device. When Pin 1 is asserted (low), serial data is permitted to be sent to the XStream Module. In RS-232 applications, Pin 1 is directly associated with the DI Buffer. In RS-485/422 applications, the Pin 1 signal controls the transmit driver (TX enable) on the RS-485 and RS-422 logic converters (on the MaxStream Interface Board or equivalent). Pin 1 utilizes a 10KΩ Pull-Up resistor that is already installed in the module. In some applications, Pin 1 may not need to be observed.

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

If the DI Buffer reaches its capacity, either the $\overline{\text{CTS}}$ line or XON / XOFF flow control must be observed to prevent loss of data between the host device and the XStream Module. There are two cases in which the DI Buffer may become full:

1. If the serial interface rate is set higher than the default baud rate for the module, the module will receive serial data faster than it is transmitted.
2. If the XStream Module is receiving a continuous stream of data or if it is monitoring data on a network, any serial data that arrives on the DI pin is placed in the DI Buffer. This data will be transmitted when the module no longer detects RF data in the network.

XON Software Flow Control

XON/XOFF software flow control can be used (on Pin 3) instead of $\overline{\text{CTS}}$ hardware flow control. [See FL (Software Flow Control) Command for more information]

Pin 5 = DI2 (Data In 2)

<Input> The Pin 5 signal can be configured to enable $\overline{\text{RTS}}$ flow control recognition or binary command programming. Use RT (DI2 Configuration) Command to adjust the parameters that control Pin 5 flow control and binary programming options. By default, $\overline{\text{RTS}}$ flow control is not enabled. This pin utilizes a 10KΩ Pull-Down resistor already installed in the module.

$\overline{\text{RTS}}$ Hardware Flow Control

If $\overline{\text{RTS}}$ flow control is enabled, no data is sent out the DO pin when $\overline{\text{RTS}}$ is de-asserted (high). If $\overline{\text{RTS}}$ flow control is implemented on the host device, RT Parameter must be set on the XStream Module in order to recognize the $\overline{\text{RTS}}$ signal as a flow control line.

If $\overline{\text{RTS}}$ is asserted (low), all received RF data is placed in the DO Buffer until the line is de-asserted. Once the DO Buffer reaches capacity, any additional received RF data is lost.

XOFF Software Flow Control

XON/XOFF software flow control can be used (on Pin 4) to simulate $\overline{\text{RTS}}$ hardware flow control. [See FL (Software Flow Control) Command for more information]

Remaining Signal Pinouts

Pin 2 = DI3 (Data In 3)

<Input> Pin 2 can be used to transition the XStream Module into a low power-consuming Sleep Mode. If SM = 1 [SM (Sleep Mode) Command], allowing Pin 2 to float high causes the module to enter into a state of minimal power-consumption (until awakened by driving Pin 2 low). [Go to the "Sleep Modes" section for more information.] This pin utilizes a 10K Ω Pull-Up resistor already installed in the module.

Pin 6 = $\overline{\text{RESET}}$

<Input> Pin 6 is almost always high and only low when the radio is reset. Since the OEM module has an onboard reset monitor, this pin can be left disconnected. Pin 6 utilizes a 10KΩ Pull-Up resistor already installed in the module.

Pin 7 = DO3 (Data Out 3)

<Output> Pin 7 is normally driven low, but is driven high briefly by the radio to indicate RF data reception. This pin can be tied through a resistor to an LED for visual indication (RX LED).

Pin 8 = $\overline{\text{TX}}$ / PWR

<Output> Pin 8 is normally driven high and can be tied through a resistor to an LED to indicate the following:

- The module has power
- The module is not is sleep mode
- RF transmission (Pin 8 pulses off briefly during RF Transmission)

Pin 9 = $\overline{\text{CONFIG}}$

<Input> When Command Mode cannot be entered using normal procedure [See "AT Command Mode" section], the $\overline{\text{CONFIG}}$ pin is used to manually enter the module into AT Command Mode. If Pin 9 is asserted during reset or power-up, the module immediately enters into AT Command Mode at the module's default baud rate (serial port baud rate is temporarily set to match the default baud rate of the XStream Module in use). Upon entering into AT Command Mode, all configured parameters (including baud rate) remain in their saved state unless modified as is described in the "Modem Configurations" chapter of this manual. This pin utilizes a 100K Ω Pull-Up resistor already installed in the module.

IMPORTANT: The $\overline{\text{CONFIG}}$ pin is intended as a secondary method for entering Command Mode. The primary method uses the command break sequence. MaxStream reserves the right to change the functionality of the $\overline{\text{CONFIG}}$ pin and recommends using the command break sequence [See "AT Command Mode" section] for entering Command Mode.

Pin 10 = VCC (power)

<Input> Pin 10 accepts regulated 5V signals.

Pin 11 = GND (Ground)

Pin 11 is used for grounding.

Interfacing Hardware

MaxStream, Inc. developed proprietary interface boards (Product numbers: XIB-R for RS-232/485 & XIB-U for USB) to facilitate connections between XStream OEM RF Modules and serial devices. Many integrators of MaxStream products have developed their own interfacing circuitry. Other integrators use MaxStream Interface Boards. In either case, the following sections illustrate how to interface with the XStream OEM RF Module by illustrating XIB-R Interface Board functions.

XStream Development Kit (RS-232/485)

The XStream Development Kit includes all the hardware and software needed for a basic RF link.

Table 3. XStream Development Kit (RS-232/485) contents

Item	Qty.	Description	Part Number
Quick Start Guide	1	Quickly familiarizes users with some of the XStream Module's most important functions. The guide provides step-by-step instructions on how to make an RF link and test its ability to transport data over varying ranges and conditions.	MD0009
CD	1	CD includes documentation and configuration software	MD0010
XStream OEM RF Module (w/ attached wire antenna)	1	Module comes with fixed RF Data (baud) rates up to 19200 bps	Varies according to frequency usage
XStream OEM RF Module (w/ RPSMA antenna port)	1	Module comes with fixed RF Data (baud) rates up to 19200 bps	Varies according to frequency usage
Antenna (RPSMA)	1	RPSMA half-wave dipole antenna	Varies according to frequency usage
MaxStream Interface Board	2	Supplies regulated 5V DC power to module and provides signal-level conversion for interfacing with PC RS-232 serial ports or RS-485/422 devices	XIB-R
Serial Loopback Adapter	1	Connects to the female RS-232 (DB-9) serial connector of the MaxStream Interface Board and can be used to configure the radio modem to function as a repeater (for range testing)	JD2D3-CDL-A
NULL Modem Adapter (male-to-male)	1	Connects to the female RS-232 (DB-9) serial connector of the MaxStream Interface Board and can be used to connect the radio modem to another DCE (female DB9) device	JD2D2-CDN-A
NULL Modem Adapter (female-to-female)	1	Used to bypass radios to verify serial cabling is functioning properly	JD3D3-CDN-A
Male DB-9 to RJ-45 Adapter	1	Facilitates adapting the DB-9 Connector of the MaxStream Interface Board to a CAT5 cable (male DB9 to female RJ45)	JE1D2-CDA-A
Female DB-9 to RJ-45 Adapter	1	Facilitates adapting the DB-9 Connector of the MaxStream Interface Board to a CAT5 cable (female DB9 to female RJ45)	JE1D3-CDA-A
9V AC Power Adapter	2	Wall-based transformer with US 2-prong plug	JP4P2-9V4-6F
9V Battery Clip (6")	1	Allows Interface Board to be remotely powered by a 9V battery	JP2P3-C2C-4I
RS-232 Cable (6')	2	Straight-through serial cable that connects interface board (DCE) to a PC (DTE)	JD2D3-CDS-6F

MaxStream RS-232/485 Interface Board & RF Modem

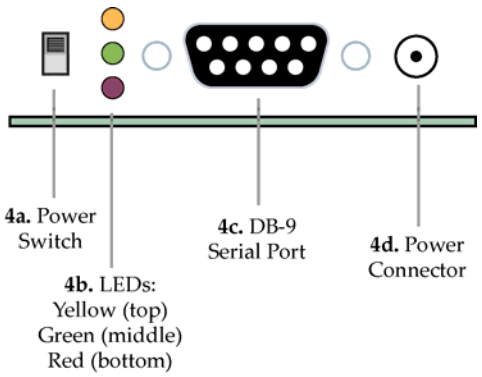
The MaxStream XIB-R Interface board was developed as a means of connecting XStream Modules to any system having RS-232/485/422 connections. XStream Modules require signals to enter at CMOS voltages. One of the main functions of the interface board is to convert interface signals between CMOS levels (5 VDC regulated) and RS-232 levels (-12 to +12V). The MaxStream Interface Board (and the XStream-PKG-R RF Modem) includes the following built-in features:

- DIP Switch
- Configuration Switch
- Power Switch
- LEDs
- DB-9 Connector
- Power Connector

MaxStream also supplies USB interfacing. See the "XStream-PKG-U USB RF Modem" product manual or call MaxStream for more information.

RS-232/485 Interface Board Components & Features

Figure 4. Front View



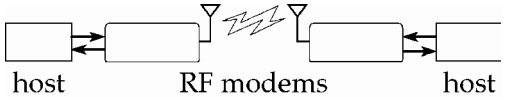
4a. Power Switch

Move the Power Switch to the on (up) position to power the Interface Board. DIP Switch [5a] settings are only read during a power-up sequence.

4b. LEDs

The LED indicators visualize diagnostic status information. The radio 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)



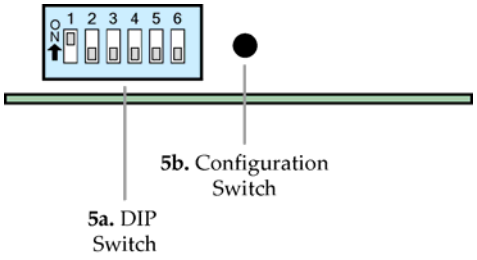
4c. DB-9 Serial Port

Standard female DB-9 (RS-232) DCE connector – This connector can be also used for RS-485 and RS-422 connections.

4d. Power Connector

7-18 VDC Power Connector (Center positive, 5.5/2.1mm) – Power can also be supplied through Pin 9 of the DB-9 Connector.

Figure 5. Back View



5a. DIP Switch

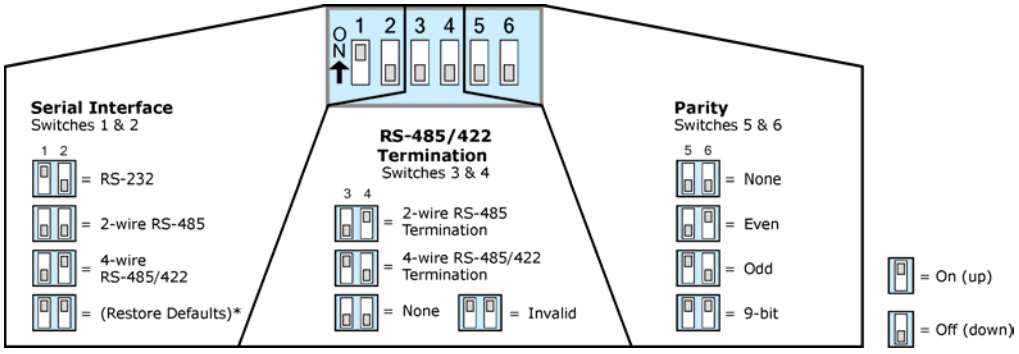
The DIP Switch automatically configures the XStream OEM RF Module to operate in different modes. Each time the module assembly (interface board + the RF Module) is powered-on, intelligence on the XIB-R interface board programs the module according to the positions of the DIP Switch. [See figure below for DIP Switch settings]

NOTE: In cases where AT Commands should not be sent each time the module assembly is powered-on, the processor must be disabled by populating J7 on the interface board.

5b. Configuration Switch

The Configuration Switch provides an alternate way to enter "AT Command Mode". To enter "AT Command Mode" at the radio modem's default baud rate, hold the Configuration Switch down while powering on the module using the Power Switch [4a].

Figure 6. MaxStream XIB-R (RS-232/485) Interface Board DIP Switch Settings



* The "(Restore Defaults)" setting, for switches 1 & 2, can be used to restore modem parameters to their default values. Once switches are in position, restore occurs during next power-up.

Adapters

The XStream Development Kit and XStream-PKG-R RF Modems (with the "-RA" suffix) come with several adapters. The connectors and adapters facilitate basic functions, such as the following:

- Performing Range Tests
- Testing Cables
- Connecting to other RS-232 DCE and DTE devices
- Connecting to terminal blocks or RJ-45 (for RS-485/422 devices)

NULL Modem Adapter (male-to-male)

Part Number: JD2D2-CDN-A (Black, DB-9 M-M) The male-to-male NULL modem adapter can be used to connect two DCE devices. A DCE device is one that connects with a straight-through cable to the male serial port of a computer (DTE).

Figure 7. Male NULL modem adapter and pinouts

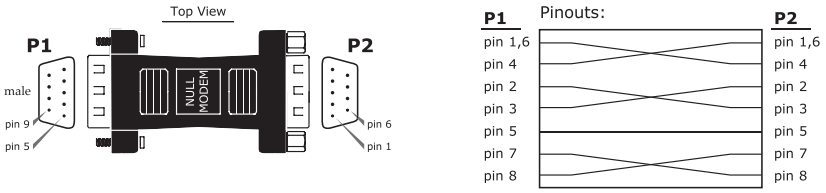
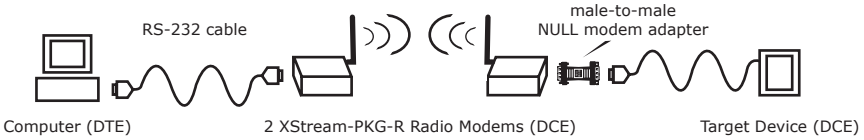


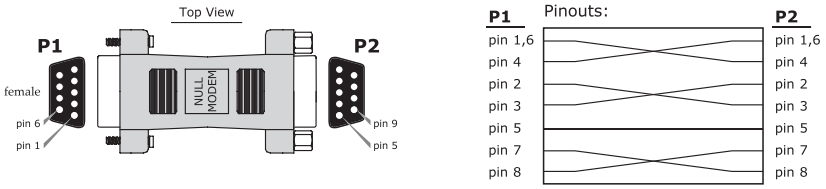
Figure 8. Example of a MaxStream Radio Modem (DCE Device) connecting to another DCE device)



NULL Modem Adapter (female-to-female)

Part Number: JD3D3-CDN-A (Gray, DB-9 F-F) The female-to-female NULL modem adapter can be used to verify serial cabling is functioning properly. To test cables, insert the female-to-female NULL modem adapter in place of a pair of radio modems and test the connection without radio modules in the connection.

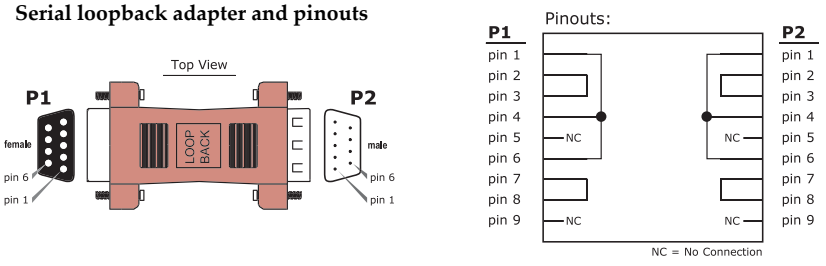
Figure 9. Female NULL modem adapter and pinouts



Serial Loopback Adapter

Part Number: JD2D3-CDL-A (Red, DB-9 M-F) The serial loopback adapter is used for range testing. During a range test, the serial loopback adapter configures the radio modem to function as a repeater by looping serial data back into the radio for retransmission.

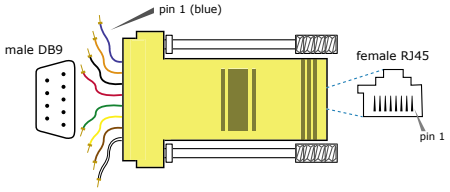
Figure 10. Serial loopback adapter and pinouts



Male DB-9 to RJ-45 Adapter

Part Number: JE1D2-CDA-A (Yellow, RJ-45 female to DB-9 male) This adapter facilitates adapting a DB-9 connector to a CAT5 cable.

Figure 11. Male RS-485/422 Adapter and pin specifications



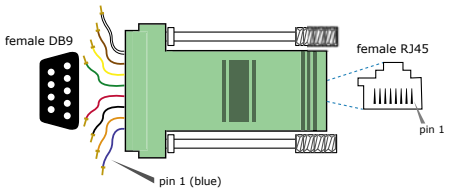
RJ45 Pin Specifications

RJ45 Pin	Wire Color
1	blue
2	orange
3	black
4	red
5	green
6	yellow
7	brown
8	white

Female DB-9 to RJ-45 Adapter

Part Number: JE1D3-CDA-A (Green, RJ-45 female to DB-9 female) This adapter facilitates adapting a DB-9 connector to a CAT5 cable.

Figure 12. Female RS-485/422 Adapter and pin specifications



RJ45 Pin Specifications

RJ45 Pin	Wire Color
1	blue
2	orange
3	black
4	red
5	green
6	yellow
7	brown
8	white

RS-485/422 Connection Guidelines

The RS-485/422 protocol provides a solution for wired communications that can tolerate high noise and push signals over long distances. RS-485/422 signals can communicate as far as 4000 feet (1200 meters). RS-232 signals are only suitable for cable distances up to 100 feet (30.5 meters).

RS-485 offers multi-drop capability in which up to 32 nodes can be connected. The RS-422 protocol is used for point-to-point communications.

Suggestions for integrating the XStream Module with the RS-485/422 protocol:

1. When using Ethernet twisted pair cabling: Select wires so that T+ and T- are connected to each wire in a twisted pair. Likewise, select wires so that R+ and R- are connected to a twisted pair. (For example, tie the green and white/green wires to T+ and T-.)
2. For straight-through Ethernet cable (not cross-over cable) – The following wiring pattern works well: Pin 3 to T+, Pin 4 to R+, Pin 5 to R-, Pin 6 to T-
3. Note that the connecting cable only requires 4 wires (even though there are 8 wires).
4. When using phone cabling (RJ-11) – Pin 2 in the cable maps to Pin 3 on opposite end of cable and Pin 1 maps to Pin 4 respectively.

Antennas

[See Appendix A for a list of FCC-Approved Antennas]

Factors that determine RF link range:

- Ambient RF noise (interference)
- Line–of–sight obstructions
- Transmit power
- Receive sensitivity
- Antenna configuration

Factors that affect antenna performance:

- RF cable length
- Height of antennas off the ground
- Obstructions
- Radiation pattern
- Antenna Gain

XStream Antenna Connector Options

In order to comply with the FCC rules and obtain a "modular" certification, it is required that the XStream Modules utilize a "non standard" connector. This is to ensure that the radios are used only with approved antennas. The XStream radio modules have two connector options:

- RPSMA
- MMCX
- N-Connector

RPSMA

[Available for OEM Modules & RF Modems] The Reverse Polarity SMA (RPSMA) connector uses the same body as a regular SMA connector. In order to be a "non standard" connector, the gender of the center conductor is changed. The female RPSMA actually has a male center conductor.

MMCX

[Available for OEM Modules only] The Micro-Miniature connector (MMCX) is a good solution for high volume, price-sensitive applications. The small size and snap on connection make it suitable for attaching an external mounted antenna to a radio module inside an enclosure.

N-Connector

[Available for OEM Modules & RF Modems] An N-Connector does not come installed on the XStream Modules, but is a common connector used with higher gain antennas such as the Yagi. MaxStream can supply "RPSMA to N-Connector" cables in various lengths.

Antenna Cables

RF cables are typically used to connect a radio installed in a cabinet to an antenna mounted externally. As a general rule, it is best to keep the RF cable as short as possible. All cables have losses which are usually measured in dB loss per 100 ft. MaxStream has cables available made with LMR-195. Some common cables and dB losses are included in this table:

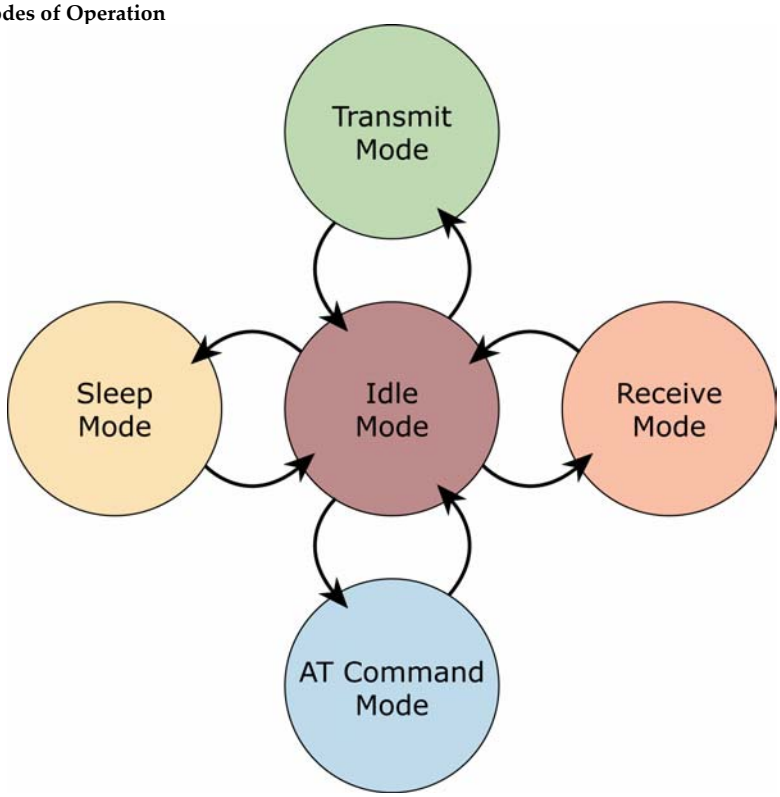
Table 4. Potential Signal Strength Loss due to Antenna Cable Length

Cable Type	Loss at 900 MHz per 100' (loss per 100m)	Loss at 2.4 GHz per 100' (loss per 100m)	Diameter Inches (mm)
RG-58	14.5 (47.4) dB	25.3 (83.2) dB	0.195 (4.95)
RG-174	25.9 (85.0) dB	44.4 (145.84) dB	0.100 (2.54)
RG-316	24.7 (81.0) dB	42.4 (139.0) dB	0.102 (2.59)
LMR-195	11.1 (36.5) dB	19.0 (62.4) dB	0.195 (4.95)
LMR-240	7.6 (24.8) dB	12.9 (42.4) dB	0.240 (6.10)
LMR-600	2.5 (8.2) dB	4.4 (14.5) dB	0.590 (14.99)

Modes of Operation

XStream OEM RF Modules and XStream-PKG-R RF Modems operate in five modes and can only operate in one mode at a time.

Figure 13. MaxStream Modes of Operation



Idle Mode

XStream Modules operate in Idle Mode when data is not being transmitted nor received. While in Idle Mode, modules use the same amount of power as they do in RX mode. Modules transition into another mode under any of the following conditions:

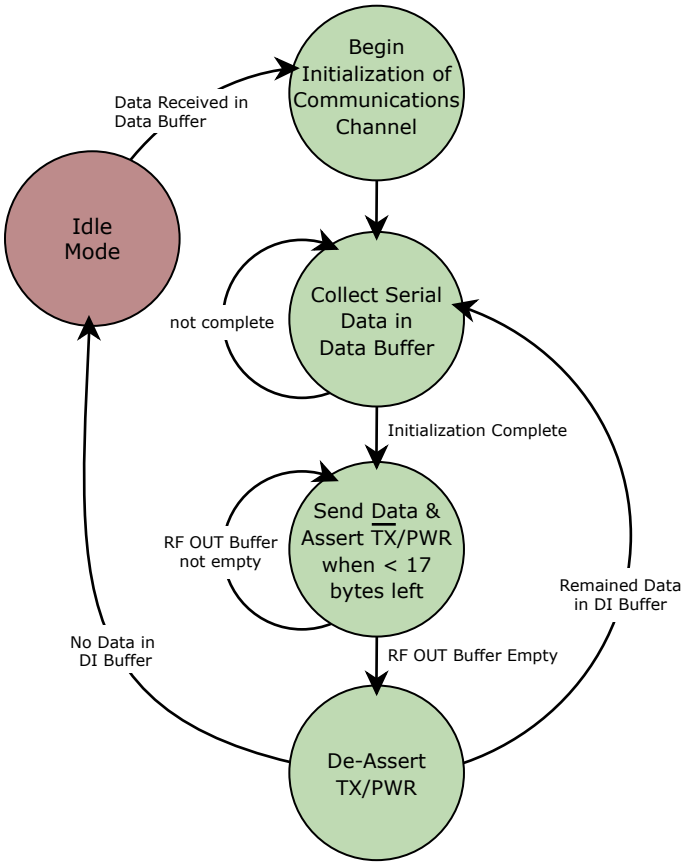
1. Serial data is received in the DI Buffer (Module transitions into Transmit Mode)
2. Valid data is received by the antenna (Module transitions into Receive Mode)
3. AT Command Mode Sequence is issued (Module transitions into AT Command Mode)
4. Sleep Mode condition is met (Module transitions into Sleep Mode)

Modules automatically transition back to Idle Mode once finished responding to these conditions.

Transmit Mode

When the first byte of serial data comes through the DI Pin and arrives in the DI Buffer, the module transitions into Transmit Mode. Once in Transmit Mode, the module initializes a communications channel. During channel initialization, incoming serial data accumulates in the DI buffer. Once the channel is initialized, data in the DI buffer is grouped into packets (up to 64 bytes in each packet) and is transmitted. The module continues to transmit data packets until the DI buffer is empty. Once transmission is finished, the module returns to Idle Mode. This progression is shown below.

Figure 14. Transmission of data



[Also refer to the block diagram of the XStream OEM RF Module located in the "XStream OEM RF Module" Product Manual]

Cyclic Redundancy Check (CRC)

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 data packet before transmission. On the receiving end, the receiver computes the CRC on all incoming data. Received data that has an invalid CRC is discarded [See "Receive Mode" section on next page].

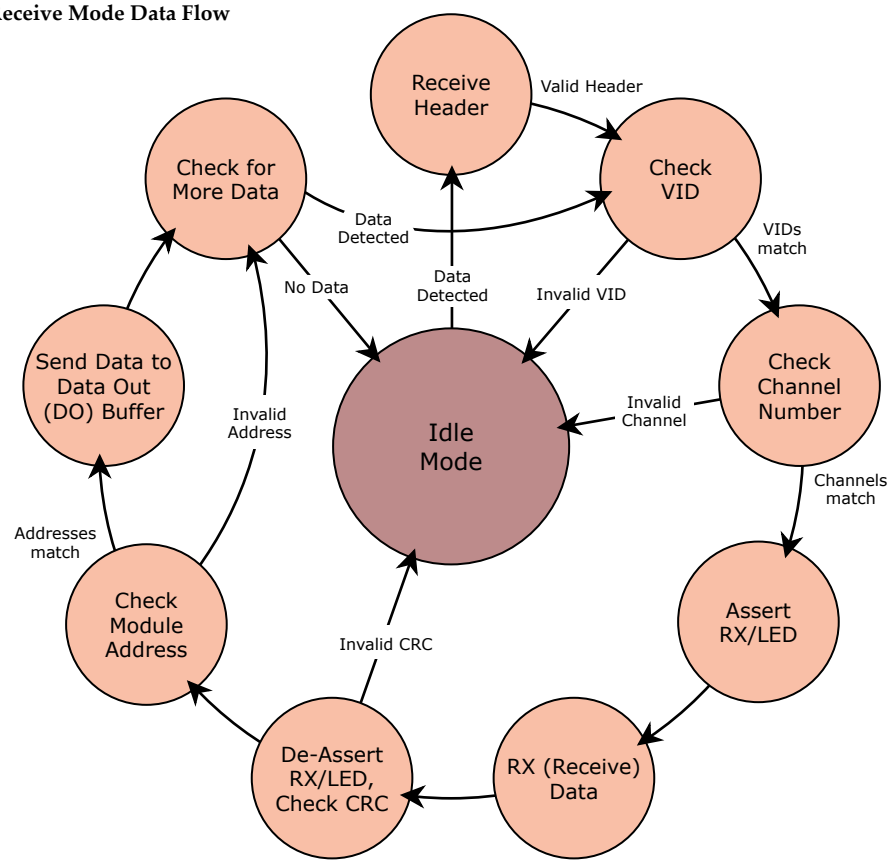
Transmission Latency

Transmission latency is dependent on the number of bytes contained in a packet and the baud rate of the XStream Module. A wake-up initializer is sent every time a new transmission sequence begins. In some applications, SY Command can be used to reduce the length of the wake-up initializer (contains channel information used to initialize listening receivers to the transmitter's hopping pattern) sent at the beginning of a transmission and thus reduce latency.

Receive Mode

If a module detects over-the-air transmitted data while operating in Idle Mode, it transitions into Receive Mode to start receiving packets. Once a packet is received, it goes through the receiving-end of a CRC (cyclic redundancy check) to ensure that the data was transmitted without error. If the CRC data bits on the incoming packet are invalid, the packet is discarded. If the CRC is valid, the packet is placed the DO Buffer. This process is shown in the figure below:

Figure 15. Receive Mode Data Flow



The module returns to Idle Mode after valid data is no longer detected or once an error is detected in the received data. If serial data-to-transmit is stored in the DI buffer while the module is giving precedence to Receive Mode, the data will be transmitted after the module finishes receiving data and returns to Idle Mode.

Sleep Modes

Sleep Modes enable the XStream Radio Modem to go into states of low power-consumption when not in use. Any of three Sleep Modes configurations can be used:

1. Host Controlled
2. Wake on RF activity
3. Wake on Serial Port activity

To enter Sleep Mode, one of the following must occur (In addition to SM (Sleep Mode) Command having a non-zero value):

- The module must be idle (no data transmission or reception) for a user-defined period of time [See ST (Time before Sleep) Command]
- The DI3-SLEEP Pin (Pin 2) is de-asserted

Once in Sleep Mode, the radio modem does not transmit or receive data until it first returns to Idle Mode. The return into Idle Mode is triggered by the de-assertion of Pin 2 or the arrival of a serial byte through Pin 4 (Data In). Sleep Mode is enabled and disabled using SM Command.

The following table lists MaxStream's Sleep Mode configurations and the requirements needed to transition into and out of Sleep Mode:

Table 5. Sleep Mode Configurations

Sleep Mode Setting	Transition into Sleep Mode	Transition out of Sleep Mode	Related Commands	Power Consumption
Pin Sleep (SM=1)	Microcontroller can shut down and Wake-up modules. Assert (high) DI3-SLEEP Pin (Pin 2)	De-Assert (low) DI3-SLEEP pin (Pin 2)	SM	26 µA
Serial Port Sleep (SM=2)	Automatic transition into Sleep Mode after user-defined period of inactivity (no transmitting or receiving). Period of inactivity set using ST Command.	When serial byte is received on the DI pin (Pin 4)	SM, ST	1 mA
Cyclic Sleep (SM=3-8)	Transitions into and out of Sleep Mode in cycles (user-selectable wake-up interval of time (½ second to 16 seconds) set by SM Command). The Cyclic Sleep interval time must be shorter than "Wake-up Initializer Timer" (set by LH Command). (Can be forced into Idle Mode using Sleep Pin if PW (Pin Wake-up) Command is issued.)		HT, LH, PW, SM, ST	typically 76 µA (when sleeping)

Pin Sleep (SM = 1)

Pin Sleep requires the least amount of power. In order to achieve this low-power state, Pin 2 (DI3-SLEEP) must be asserted (high). The module remains in Pin Sleep until the Sleep pin is de-asserted.

After enabling Pin Sleep (SM (Sleep Mode) Parameter = 1), Pin 2 controls whether the XStream Module is active or in Sleep Mode. When Pin 2 is de-asserted (low), the module is fully operational. When Pin 2 is asserted (high), the module transitions to Sleep Mode and remains in its lowest power-consuming state until the Sleep pin is de-asserted. The XStream Module requires 40 ms to transition from Sleep Mode to Idle Mode. Pin 2 is only active if the module is setup to operate in this mode; otherwise the pin is ignored. Once in Pin Sleep Mode, DO2-$\overline{\text{CTS}}$ (pin 1) 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.

Serial Port Sleep (SM = 2)

Serial Port Sleep is a Sleep Mode setting in which the 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 setting 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 Command. [See ST (Time before Sleep) Command]

While the module is in this low-power state, Pin 1 (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, Pin 1 (DO2-$\overline{\text{CTS}}$) is asserted and any data received on the DI Pin is transmitted. Pin 8 (PWR) is also de-asserted (low) when the module is in Cyclic Sleep Mode. Pins 1 and 8 are asserted each time the module cycles into Idle Mode to listen for valid data packets and de-asserts when the module returns to 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 the incoming 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-up from cyclic sleep when Pin 2 (DI3-SLEEP) is de-asserted (low). To configure a module to operate in this manner, PW (Pin Wake-up) Command must be issued. Once the Pin 2 (DI3-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 0xB ("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-up during the wake-up initializer portion of data transmission in order to be synchronized with the transmitter and receive the data.

Figure 16. Correct Configuration (LH > SM):

The 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.

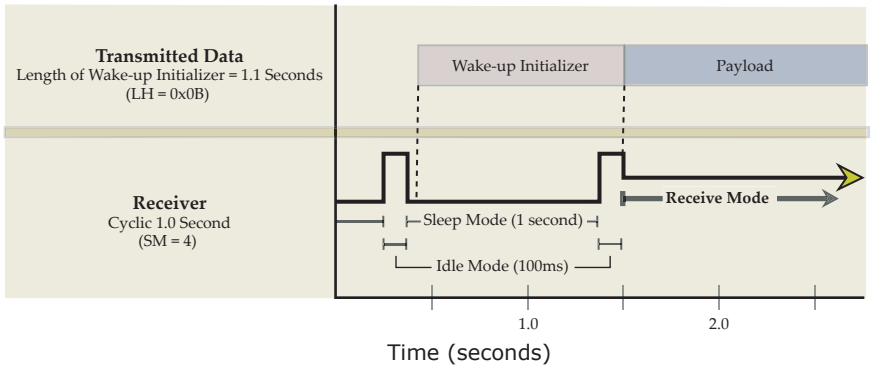
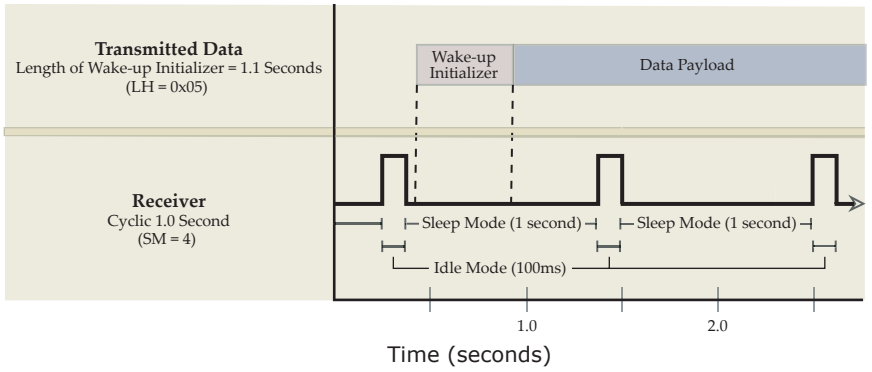


Figure 17. Incorrect Configuration (LH < SM):

The length of the 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).



The wake-up initializer is sent with the initial transmitted packet after a user-defined period of inactivity (no serial or RF data is sent or received). This period of inactivity is adjusted using HT Command. [See HT (Time before Wake-up Initializer) Command] Sending a wake-up initializer (length slightly exceeds the cyclic sleep time interval) assures that the receiver will detect the new transmission and will be able to receive the accompanying data. If the sleeping module misses the wake-up initializer due to interference and does not respond as expected, a new wake-up initializer can be sent using FH (Force Wake-up Initializer) Command.

AT Command Mode

AT Command Mode provides a state in which adjustable parameters of the XStream Module can be modified. These parameters extend flexibility in configuring modules to fit specific design criteria such as advanced functionality in networking modules in a data system.

AT Commands

AT Commands are a set of commands that allow users to customize and configure the XStream Module to meet specific needs.

In order to utilize the AT Commands, users must enter into "AT Command Mode". AT Commands can then be sent to the module using ASCII commands and parameters. Commands can be sent using the X-CTU Software (MaxStream-provided) or via a serial communications software programs such as "HyperTerminal".

When using serial communications software, a special break sequence is used so that the module can transition into "AT Command Mode". This sequence is described in the "Enter AT Command Mode" section.

Enter AT Command Mode

To enter AT Command Mode, use any of the following methods:

1. When using serial communications software, send the 3-character command sequence "+++" while observing times of silence before [BT (Guard Time Before) Command] and after [AT (Guard Time After) Command] the command character. The command character '+' can be changed to another ASCII value using CC (Command Sequence Character) Command. [See "Default AT Command Mode Sequence" below.]
2. Assert (low) the $\overline{\text{CONFIG}}$ pin* and turn the power switch off and back on. (If using the MaxStream Interface Board, the same result can be achieved by keeping the configuration button pressed while turning off and then on again the power switch.)

Important: * Do not tie the $\overline{\text{CONFIG}}$ pin to the microprocessor.

Default AT Command Mode Sequence (for entering into AT Command Mode)**:**

1. No characters sent for 1 second. [Time can be modified using BT (Guard Time Before) Command]
2. Input three (3) plus characters ("+++") within one (1) second. [Character can be modified using CC (Command Sequence Character) Command.]
3. No characters sent for one (1) second. [Time can be modified using the AT (Guard Time After) Command.]

The parameter values listed in the AT Command Mode Sequence represent OEM RF Module defaults. All three can be modified using XStream AT Commands.

Configure and Read Modem Parameters

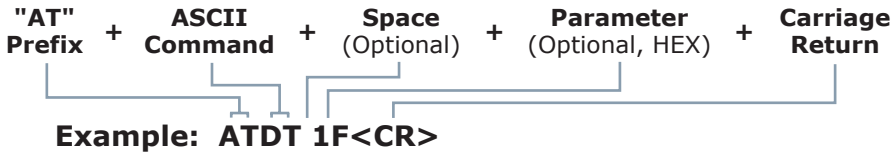
Once in AT Command Mode, parameters can be configured and read using AT Commands. Parameters changed while in AT Command Mode must be saved to non-volatile memory using WR (Write) Command or the parameters will be reset to their previously stored value the next time the module is powered-up.

The "Modem Configuration" chapter is dedicated to explaining the methods needed to configure and read module parameters. The following page explains the protocols and syntax required to configure and read module parameters.

Syntax

When using serial communications software, ASCII commands and parameters are not case sensitive. The optional space can be any non-alpha-numeric character and XStream Modules require parameter values be hexadecimal.

Figure 18. Syntax for sending AT Commands
(Sequence must be sent within 20 seconds of entering into AT Command Mode)



NOTE: To read current parameter values, leave the parameter field blank.

In example above, the "ATDT 1F" sequence would change the module's networking address to a hexadecimal value of "1F" (decimal 31).

ASCII commands and parameters are not case sensitive. The optional space can be any no-alpha-numeric character and the XStream Module expects numeric values to be hexadecimal.

Queries

To query the current value of a particular parameter, send the corresponding AT command without any parameters (followed by a carriage return).

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 (and an optional space). The "AT" prefix is only sent before the first command and should not be included with subsequent commands in a line.

System Response

After executing a recognized AT command, the module responds with "OK<CR>". If an unrecognized command or a command with a bad parameter is received, the module responds with "ERROR<CR>." Modified AT values are reset to previous stored values upon module power-down unless the WR (Write) Command was issued to save parameters to non-volatile memory.

Basic methods for sending AT Commands.

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

Method 1 (One line per command)

Issue AT Command	System Response
+++	OK<CR> (Enter into AT Command Mode)
ATDT 1A0D<CR>	OK<CR> (Change Destination Address)
ATWR<CR>	OK<CR> (Write to non-volatile memory)
ATCN<CR>	OK<CR> (Exit AT Command Mode)

Method 2 (Multiple commands on one line)

Issue AT Command	System Response
+++	OK<CR>
ATDT 1A0D, WR, CN<CR>	OK<CR>- OK<CR> (Write to non-volatile memory) OK<CR> (Exit AT Command Mode)

<CR> = Carriage Return

Exit AT Command Mode

To exit AT Command Mode:

1. If no valid AT Commands are received within the time specified by CT (Time before Exit AT Command Mode) Command, the module automatically returns to Idle Mode.
2. AT Command Mode can be exited explicitly by issuing CN (Exit AT Command Mode) Command.

Binary Commands

The DI2-$\overline{\text{RTS}}$/CMD pin (Pin 5) must be asserted in order to send binary commands to an XStream Module. The $\overline{\text{RTS}}$/CMD pin can be asserted and sent a command anytime during transmission or reception of data. There is a minimum time delay of 100 microseconds (after the stop bit of the command byte has been sent) before which $\overline{\text{RTS}}$/CMD can be de-asserted. The command executes when all parameters associated with the command have been sent. If all parameters are not received within 0.5 seconds, the module returns to Idle Mode. Note that when parameters are sent, they are always two bytes long with the least significant byte sent first.

Binary Command Mode also allows multiple commands to be sent in sequence. When the $\overline{\text{RTS}}$/CMD pin is asserted, all incoming serial data will be interpreted as commands. Commands can be sent in sequences of commands and their associated parameters. If $\overline{\text{RTS}}$/CMD remains asserted, all received commands will be executed by the XStream Module. All modified parameters must be stored in non-volatile memory by sending WR (Write) Command (0x8 with no parameters) before powering down or resetting the module or the changes will be lost.

Commands can be queried for their current value by sending the command logically ORed with the value 0x80 (hexadecimal) with $\overline{\text{RTS}}$/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.

IMPORTANT: For the XStream Module to recognize a binary command, RT Command must be issued. If binary programming is not enabled, the module will not recognize when the $\overline{\text{RTS}}$/CMD pin is asserted and will therefore not recognize binary commands.

Radio Modem Configuration

XStream AT Commands are organized into the following command categories:

- AT Command Mode Options
- Diagnostic
- Networking
- Serial Interfacing
- Sleep (Low Power)

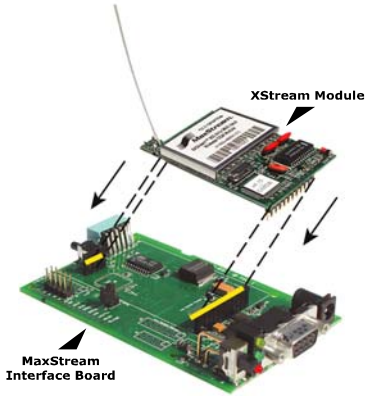
Configuration Software

X-CTU Software

X-CTU is MaxStream-provided software used to interface with and configure XStream OEM RF Modules. The software application is organized into the following four tabs:

- **PC Settings** tab - Setup PC serial ports to interface with an XStream Module assembly
- **Range Test** tab – Test XStream Radio Modem range
- **Terminal** tab – Configure and read XStream Modem parameters using AT Commands
- **Modem Configuration** tab – Configure and read XStream Radio Modem parameters

Figure 19. Module Assembly



Install X-CTU software

Double-click the "setup_X-CTU.exe" file and follow prompts of the installation screens. The file is located in the 'software' folder of the MaxStream CD and under the 'Downloads' section of the following web page: www.maxstream.net/helpdesk/

Using X-CTU software

In order to use the X-CTU software, a module assembly (an XStream Module mounted to a MaxStream Interface Board) must be connected to the serial port of a PC. The baud rate of the serial port ("PC Settings" tab) must match the baud rate of the module (BD (Baud Rate) Command on the "Modem Configuration" tab).

Serial Communications Software

A terminal program has been built into the X-CTU software. Use the syntax illustrated in Figure 18 when issuing AT Commands using terminal software. This example sets the destination address of the module to "0x1F". WR (Write) Command would also have to be used in order to save the new value to the module's non-volatile (long term) memory.

AT Commands (Short Reference)

Table 6. XStream AT Commands

(Modules expect numerical values in hexadecimal. "d" denotes decimal equivalents)

AT Command	Binary Command	AT Command Name	Range	Command Category	# Bytes Returned	Factory Default
AT	0x05 (5d)	Guard Time After	0x02 – 0xFFFF (x 100 ms)	AT Command Mode Options	2	0x0A (10d)
BD	0x15 (21d)	Baud Rate	0 – 6	Serial Interfacing	1	RF data rate
BT	0x04 (4d)	Guard Time Before	0 – 0xFFFF (x 100 ms)	AT Command Mode Options	2	0x0A (10d)
CC	0x13 (19d)	Command Sequence Character	0x20 – 0x7F	AT Command Mode Options	1	0x2B ("+")
CD v 4.29D*	0x28 (40d)	DO3 Configuration	0 - 3	Serial Interfacing	1	0
CN	0x09 (9d)	Exit AT Command Mode	none	AT Command Mode Options	n/a	none
CS v 4.27D*	0x1F (31d)	DO2 Configuration	0 – 4	Serial Interfacing	1	0
CT	0x06 (6d)	AT Command Mode Timeout	0x02 – 0xFFFF (x 100 ms)	AT Command Mode Options	2	0xC8 (200d)
DT	0x00 (0d)	Destination Address	0 – 0xFFFF	Networking	2	0
E0	0x0A (10d)	Echo Off	none	AT Command Mode Options	n/a	none
E1	0x0B (11d)	Echo On	none	AT Command Mode Options	n/a	none
ER	0x0F (15d)	Receive Error Count.	0 – 0xFFFF	Diagnostic	2	0
FH	0x0D (13d)	Force Wake-up Initializer	none	Sleep (Low Power)	n/a	none
FL	0x07 (7d)	Software Flow Control	0 – 1	Serial Interfacing	1	0
FT v 4.27B*	0x24 (36d)	Flow Control Threshold	0x0 – 0xFF (bytes)	Serial Interfacing	2	varies
GD	0x10 (16d)	Receive Good Count	0 – 0xFFFF	Diagnostic	2	0
HP	0x11 (17d)	Hopping Channel	0 – 6	Networking	1	0
HT	0x03 (3d)	Time before Wake-up Initializer	0 – 0xFFFF (x 100 ms)	Sleep (Low Power)	2	0xFFFF
ID v 4.27C*	0x27 (39d)	Modem VID	0 – 0xFFFF (Read-only)	Networking	2	none
LH	0x0C (12d)	Wake-up Initializer Timer	0 – 0xFF (x 100 ms)	Sleep (Low Power)	1	1
MK	0x12 (18d)	Address Mask	0 – 0xFFFF	Networking	2	0xFFFF
NB v 4.27B*	0x23 (35d)	Parity	0 – 4	Serial Interfacing	1	0
PC v 4.22*	0x1E (30d)	Power-up Mode	0 – 1	AT Command Mode Options	1	0
PW v 4.22*	0x1D (29d)	Pin Wake-up	0 – 1	Sleep (Low Power)	1	0
RE	0x0E (14d)	Restore Defaults	None	(Special)	n/a	none
RN v 4.22*	0x19 (25d)	Delay Slots	0 – 0xFF (slots)	Networking	1	0
RO v 4.2AA*	0x21 (33d)	Time before Transmission	0 – 0xFFFF (x 0.2 ms)	Serial Interfacing	2	0x20 (32d)
RP v 4.2AA*	0x22 (34d)	RSSI PWM Timer	0 - 0x7F (x 100 ms)	Diagnostic	1	0
RR v 4.22*	0x18 (24d)	Retries	0 – 0xFF	Networking	1	0
RS v 4.22*	0x1C (28d)	RSSI	0x06 – 0x36 (Read-only)	Diagnostic	1	none
RT	0x16 (22d)	DI2 Configuration	0 - 2	Serial Interfacing	1	0
SH v 4.27C*	0x25 (37d)	Serial Number High	0 – 0xFFFF (Read-only)	Diagnostic	2	none
SL v 4.27C*	0x26 (38d)	Serial Number Low	0 – 0xFFFF (Read-only)	Diagnostic	2	none
SM	0x01 (1d)	Sleep Mode	0 – 8	Sleep (Low Power)	1	0
ST	0x02 (2d)	Time before Sleep	0x10 – 0xFFFF (x 100 ms)	Sleep (Low Power)	2	0x64 (100d)
SY	0x17 (23d)	Time before Initialization	0 – 0xFF (x 100 ms)	Networking	1	0 (disabled)
TR v 4.22*	0x1B (27d)	Transmit Error Count	0 – 0xFFFF	Diagnostic	2	0
TT v 4.22*	0x1A (26d)	Streaming Limit	0 – 0xFFFF [0 = disabled]	Networking	2	0xFFFF
VR	0x14 (20d)	Firmware Version	0 x 0xFFFF (Read-only)	Diagnostic	2	none
WR	0x08 (8d)	Write	none	(Special)	n/a	none

* Firmware version in which the command was introduced. All subsequent firmware versions also support the command.

AT Command (Long Descriptions)

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

AT (Guard Time After) Command

<AT Command Mode Options> AT Command is used to set the time-of-silence that follows the command sequence character (CC Command). By default, 1 second must elapse before entering another character. The AT Command Mode Sequence used to enter AT Command Mode is as follows:

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

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

AT Command: AT

Binary Command: 0x05 (5 decimal)

Parameter Range: 0x02 - 0xFFFF (x 100 ms)

# of bytes returned: 2

Default Parameter Value: 0x0A (10 decimal)

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

BD (Baud Rate) Command

<Serial Interfacing> BD Command allows the user to adjust the UART baud rate and thus modify the rate at which serial data is sent to the module. Baud rates range from 1200 to 57600 baud (bps). The new baud rate does not take effect until CN (Exit AT Command Mode) Command is issued.

Note: If the serial data rate is set to exceed the fixed RF data rate of the XStream radio modem, $\overline{\text{CTS}}$ flow control may need to be implemented as described in the "Signal Pinouts" section of this Manual.

AT Command: BD

Binary Command: 0x15 (21 decimal)

Parameter Range: 0 – 6

# of bytes returned: 1

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

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

BT (Guard Time Before) Command

<AT Command Mode Options> BT Command is used to set the DI pin silence time that precedes the command sequence character (CC Command). By default, 1 second must elapse before entering another character. The default sequence used to enter AT Command Mode is as follows:

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

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

AT Command: BT

Binary Command: 0x04 (4 decimal)

Parameter Range: 0 - 0xFFFF (x 100 ms)

# of bytes returned: 2

Default Parameter Value: 0x0A (10 decimal)

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

CC (Command Sequence Character) Command

<AT 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 enters the radio modem to 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: CC

Binary Command: 0x13 (19 decimal)

Parameter Range: 0x20 – 0x7F

# of bytes returned: 1

Default Parameter Value: 0x2B (ASCII "+" sign)

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

CD (DO3 Configuration) Command

<AT Command Mode Options> CD Command is used to redefine the RX LED I/O line (OEM RF Module Pin 7).

AT Command: CD

Binary Command: 0x28 (40 decimal)

Parameter Range: 0 – 2

# of bytes returned: 1

Default Parameter Value: 0

Minimum Firmware Version Required: 4.29D

Parameter Values	Configuration
0	RX LED
1	high
2	low

CN (Exit AT Command Mode) Command

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

AT Command: CN

Binary Command: 0x09 (9 decimal)

CS (DO2 Configuration) Command

<Serial Interfacing> CS Command is used to modify the behavior of the $\overline{CTS}$ signal such that it either provides RS-232 flow control, enables RS-485 transmission / reception or determines RS-422 transmit enable. By default, $\overline{CTS}$ provides RS-232 flow control. CS Parameter must be adjusted for the module to operate in RS-485/422 environments.

AT Command: CS

Binary Command: 0x1F (31 decimal)

Parameter Range: 0 – 4

# of bytes returned: 1

Default Parameter Value: 0

Minimum Firmware Version Required: 4.27D

Parameter Values	Configuration
0	Normal
1	RS-485 enable low
2	high
3	RS-485 enable high
4	low

CT (AT Command Mode Timeout) Command

<AT Command Mode Options> CT Command sets the amount of time before AT Command Mode is exited automatically. AT Command Mode can be exited manually using CN (Exit AT Command Mode) Command or, after a "CT" time of inactivity, the module exits AT Command Mode on its own and returns to Idle Mode.

AT Command: CT

Binary Command: 0x06 (6 decimal)

Parameter Range: 0x02 - 0xFFFF (x 100 ms)

# of bytes returned: 2

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

DT (Destination Address) Command

<Networking> DT Command is used to set 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. This is similar in nature to interconnecting several PCs under a common hub. 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: DT

Binary Command: 0

Parameter Range: 0 - 0xFFFF

# of bytes returned: 2

Default Parameter Value: 0

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. All typed characters will not show up on the terminal unless the communications terminal has been configured to display characters.

AT Command: E0

Binary Command: 0x0A (10 decimal)

E1 (Echo On) Command

<AT Command Mode Options> E1 Command turns on the echo in AT Command Mode. All typed characters will show up on the terminal when the communications terminal has been configured to display characters.

AT Command: E1

Binary Command: 0x0B (11 decimal)

ER (Receive Error Count) Command

<Diagnostic> ER Command can be used to set the receive-error count to a particular value. This value is reset to 0 after every 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: ER

Binary Command: 0x0F (15 decimal)

Parameter Range: 0 - 0xFFFF

# of bytes returned: 2

Default Parameter Value: 0

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: FH

Binary Command: 0x0D (13 decimal)

FL (Software Flow Control) Command

<Serial Interfacing> FL Command is used to adjust serial flow control. Hardware flow control is implemented with the XStream Module as the $\overline{\text{CTS}}$ pin (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 to use is 0x11 (17 decimal). XOFF character to use is 0x13 (19 decimal)

AT Command: FL

Binary Command: 0x07 (7 decimal)

Parameter Range: 0 – 1

# of bytes returned: 1

Default Parameter Value: 0

Parameter Values	Configuration
0	Disable software flow control
1	Enable software flow control

FT (Flow Control Threshold) Command

<Serial Interfacing> FT Command is used to assert $\overline{CTS}$ or XOFF software flow control when FT bytes are in the receiver DO buffer.

AT Command: FT

Binary Command: 0x24 (36 decimal)

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

# of bytes returned: 2

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

Minimum Firmware Version required: 4.27B

GD (Receive Good Count) Command

<Diagnostic> GD Command can be used to set the count of good received RF packets. This value is reset to "0x00" 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: GD

Binary Command: 0x10 (16 decimal)

Parameter Range: 0 - 0xFFFF

# of bytes returned: 2

Default Parameter Value: 0

Related Commands: ER (Receive Error Count)

HP (Hopping Channel) Command

<Networking> HP Command is used to set the module's hopping channel number. A channel is one of three layers of addressing available to the XStream radio modem. 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: HP

Binary Command: 0x11 (17 decimal)

Parameter Range: 0 – 6

# of bytes returned: 1

Default Parameter Value: 0

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

HT (Time before Wake-up Initializer) Command

<Sleep (Low Power)> If any radio modems within range are running in a "Cyclic Sleep" setting, a wake-up initializer must be used by the transmitter for the other modules to synchronize to the transmitter [see LH ("Wake-up Initializer Timer") Command]. When a receiving module in Cyclic Sleep wakes, it must detect the wake-up initializer portion of the RF packet in order to synchronize to the transmitter and receive data. The value of HT Parameter tells the transmitter, "After a period of inactivity (no transmitting or receiving) lasting "HT" amount of time, send a long wake-up initializer". HT Parameter should be set to match the inactivity timeout [specified by ST (Time before Sleep) Command] used by the receiver(s).

From the receiver perspective, after "HT" time elapses and the inactivity timeout [ST (Time before Sleep) Command] is met, the receiver goes into cyclic sleep. Once it enters cyclic sleep, the only way for the module to be able to receive data from a transmitter is to first detect the wake-up initializer and synchronize to the transmitter. A long wake-up initializer must be used to ensure quick synchronization from all receivers in cyclic sleep. Thus, when time "HT" time elapses (matching the inactivity timeout); the transmitter then knows that it needs to send a long Wake-up Initializer for all receivers to be able to synchronize to its next transmission. Matching "HT" to the time specified by ST Command on the receiver(s) guarantees that all receivers will detect the next transmission.

AT Command: HT

Binary Command: 0x03 (3 decimal)

Parameter Range: 0 - 0xFFFF (x 100 ms)

# of bytes returned: 2

Default Parameter Value: 0xFFFF (means no long Wake-up Initializer will be sent)

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

ID (Modem VID) Command

<Networking> ID Command reads and reports the module's VID. VID is a MaxStream-specific acronym that stands for "Vendor Identification Number". This number is factory-set and allows modules with matching VIDs to communicate. Modules with non-matching VIDs will not receive unintended data transmission.

AT Command: ID

Binary Command: 0x27 (39 decimal)

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

# of bytes returned: 2

Minimum Firmware Version required: 4.27C

LH (Wake-up Initializer Timer)

<Sleep (Low Power)> LH Command adjusts the duration of time in which the RF 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 synchronize with the transmitter, they must detect ~35ms of the wake-up initializer (which contains synchronization information).

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.

AT Command: LH

Binary Command: 0x0C (12 decimal)

Parameter Range: 0 - 0xFF (x 100 ms)

# of bytes returned: 1

Default Parameter Value: 1

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

Figure 20. Correct Configuration (LH > SM):

The 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.

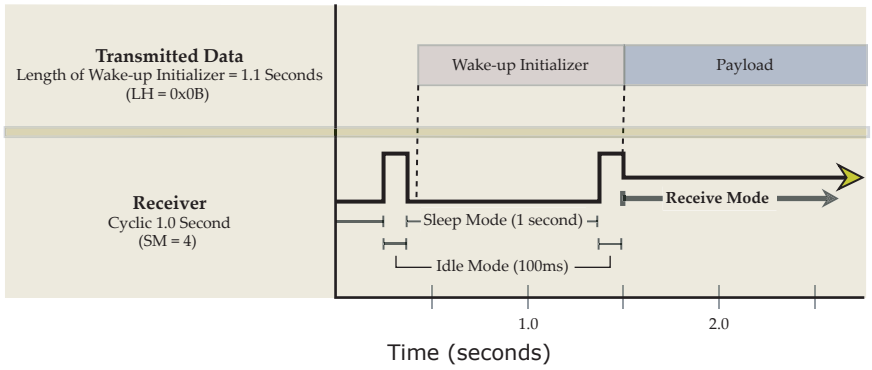
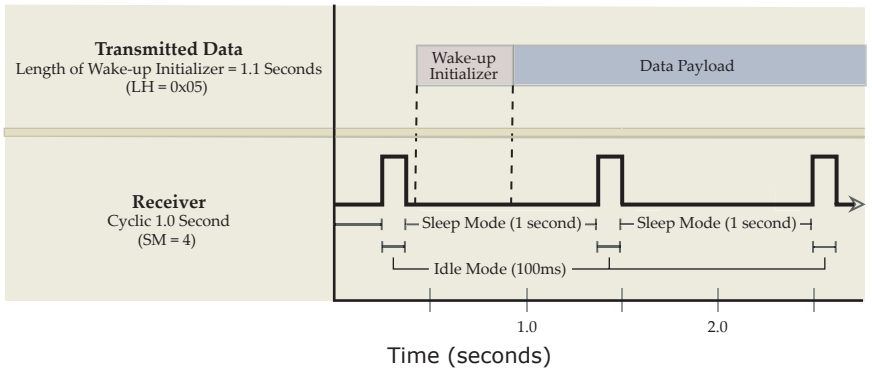


Figure 21. Incorrect Configuration (LH < SM):

The length of the 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).



MK (Address Mask) Command

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

AT Command: MK

Binary Command: 0x12 (18 decimal)

Parameter Range: 0 - 0xFFFF

# of bytes returned: 2

Default Parameter Value: 0xFFFF (When set to this value, the Destination Address of the transmitter must exactly match the Destination Address of the receiver.)

Related Commands: DT (Destination Address), HP (Hopping Channel)

NB (Parity) Command

<Serial Interfacing> NB Command allows parity for the module to be changed.

AT Command: NB

Binary Command: 0x23 (35 decimal)

Parameter Range: 0 - 4

# of bytes returned: 1

Default Parameter Value: 0

Minimum Firmware Version required: 4.27B

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

PC (Power-up to AT 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: PC

Binary Command: 0x1E (30 decimal)

Parameter Range: 0 – 1

# of bytes returned: 1

Default Parameter Value: 0

Minimum Firmware Version required: 4.22

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

NOTE: If using the XStream-PKG-R (RS-232/485) RF Modem or XIB-R (RS-232/485) Interface Board, the J7 jumper must be populated in order to use PC Command.

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: PW

Parameter Range: 0 – 1

# of bytes returned: 1

Default Parameter Value: 0

Parameter Values	Configuration
0	Disabled
1	Enabled

Binary Command: 0x1D (29 decimal)

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

Minimum Firmware Version required: 4.22

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: RE

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.

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.

AT Command: RN

Binary Command: 0x19 (25 decimal)

Parameter Range: 0 - 0xFF

# of bytes returned: 1

Default Parameter Value: 0 (No delay slots inserted)

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

Minimum Firmware Version required: 4.22

RO (Time before Transmission) 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" parameter is "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.

AT Command: RO

Binary Command: 0x21 (33 decimal)

Parameter Range: 0 – 0xFFFF (x 0.2 ms)

# of bytes returned: 2

Default Parameter Value: 0x20 (32 decimal)

Minimum Firmware Version required: 4.2AA

RP (RSSI PWN Timer) Command

<Diagnostic> RP Command is used to enable a PWM ("Pulse Width Modulation") output on the config pin (pin 9 of the OEM 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 a 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: RP

Binary Command: 0x22 (34 decimal)

Parameter Range: 0 - 0x7F (x 100 ms)

# of bytes returned: 1

Default Parameter Value: 0 (disabled)

Minimum Firmware Version required: 4.2AA

RR (Retries) Command

<Networking> RR Command specifies 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 radio modems in the system must have retries enabled.

AT Command: RR

Binary Command: 0x18 (24 decimal)

Parameter Range: 0 - 0xFF

# of bytes returned: 1

Default Parameter Value: 0 (disabled)

Minimum Firmware Version required: 4.22

RS (RSSI) Command

<Diagnostic> RS Command returns the signal level of the last packet received. This command 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: RS

Binary Command: 0x1C (28 decimal)

# of bytes returned: 1

Minimum Firmware Version required: 4.22

RT (DI2 Configuration) Command

<Serial Interfacing> RT Command must be issued to enable binary programming and $\overline{\text{RTS}}$ flow control. RT command dictates how pin 5 (DI2-$\overline{\text{RTS}}$/CMD) of the XStream OEM RF Module is used.

AT Command: RT

Binary Command: 0x16 (22 decimal)

Parameter Range: 0 – 2

# of bytes returned: 1

Default Parameter Value: 0

Parameter Values	Configuration
0	Disabled
1	Enable Binary Commands
2	Enable $\overline{\text{RTS}}$ flow control

SH (Serial Number High) Command

<Diagnostic> SH Command reads and returns the module serial number high word.

AT Command: SH

Binary Command: 0x25 (37 decimal)

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

# of bytes returned: 2

Related Commands: SL (Serial Number Low Word)

Minimum Firmware Version required: 4.27C

SL Command (Serial Number Low Word)

<Diagnostic> The SH Command reads and reports the module serial number low word.

AT Command: SL

Binary Command: 0x26 (38 decimal)

Parameter Range: 0 x 0xFFFF (Read-only)

# of bytes returned: 2

Related Commands: SH (Serial Number High Word)

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.

Parameter Values	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

AT Command: SM

Binary Command: 0x01 (1 decimal)

Parameter Range: 0 – 8

# of bytes returned: 1

Default Parameter Value: 0

Related Commands: Pin Sleep – PC, PW
Serial Port Sleep – ST
Cyclic Sleep – ST, LH, HT, PW

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 either Cyclic Sleep or Serial Port Sleep Mode settings have been selected using SM (Sleep Mode) Command.

AT Command: ST

Binary Command: 2

Parameter Range: 0x10 – 0xFFFF [x 100 ms]

# of bytes returned: 2

Default Parameter Value: 0x64 (100 decimal)

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.

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.

AT Command: SY

Binary Command: 0x17 (23 decimal)

Parameter Range: 0 - 0xFF (tenths of seconds)

# of bytes returned: 1

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

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 '0x0' when the module is reset.

AT Command: TR

Binary Command: 0x1B (27 decimal)

Parameter Range: 0 - 0xFFFF

# of bytes returned: 2

Default Parameter Value: 0

Related Command: RR (Retries)

Minimum Firmware Version required: 4.22

TT (Streaming Limit) Command

<Networking> TT Command is used to simulate full-duplex behavior. TT Command defines a limit on the number of bytes that can be sent out before a random delay is issued. If a modem is sending a continuous stream of RF data, a delay is inserted which stops its transmission and allows other 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: TT

Binary Command: 0x1A (26 decimal)

Parameter Range: 0 - 0xFFFF

# of bytes returned: 2

Default Parameter Value: 0xFFFF (65535 decimal)

Related Commands: RN (Delay Slots)

Minimum Firmware Version required: 4.22

VR (Firmware Version) Command

<Diagnostic> VR Command returns the Firmware Version of the XStream Module.

AT Command: VR

Binary Command: 0x14 (20 decimal)

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

# 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: WR

Binary Command: 0x08 (8 decimal)

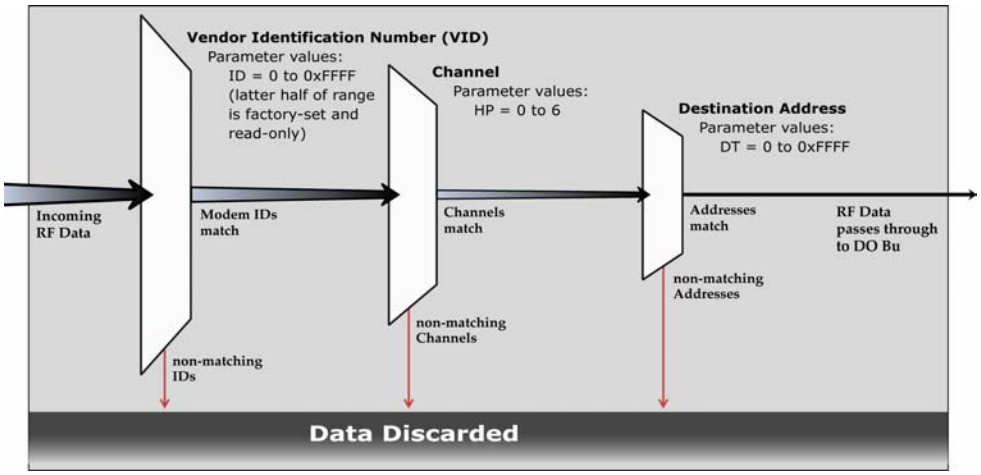
Advanced Networking and Security

Network Layers

The XStream Modules utilize three layers of addressing to communicate between radio modems. The network layers are depicted below. Only radio modems with the matching addresses are able to communicate. The three main network layers are:

- Vendor Identification Number (ATID)
- Channel (ATHP)
- Destination Address (ATDT)

Figure 22. Network Security Layers



Each network layer provides a separate layer of filtration. The Vendor Identification Number (VID) provides the first layer of filtration through the ID (Modem ID) Parameter. If the incoming RF data carries a matching VID number, the data continues through to the subsequent Channel and Destination Address layers. The Destination Address is the last network layer and provides the most granular form of filtration. If at any point during the incoming RF data flow the numbers in question do not match, the data is discarded.

XStream Modules and RF Modems are built around a peer-to-peer protocol that inherently supports a multidrop type network (similar to RS-485). In their default state, any XStream radio modem will communicate with any other XStream radio modem in its default state.

Vendor Identification Number (ATID)

The value contained in the ID Command register is called the Vendor Identification Number (VID). A unique VID is available upon special request. The VID is programmed to the XStream Module at the factory and is stored in the module's permanent memory. Only modules with matching VIDs can communicate with each other.

VID addressing ensures that radio modems ignore transmissions and receptions of XStream Radio Modems having a different VID in the same vicinity. To request a unique VID, contact MaxStream to obtain the VID Request Form.

Hopping Channel (ATHP)

Channels provide a network layer from which channels can be used for isolation. HP Command is used to define channel values.

XStream radio modems operate in FHSS Hopping Mode. HP Parameter values range from 0 through 6 (7 unique hopping patterns).

Each channel utilizes a different pseudo-random hopping sequence to navigate through shared hopping channels. In the event that two modules from different networks collide on a channel, the two modules will jump to separate channels on the next hop without loss of data. Using channel numbers enables multiple module pairs to operate in the same vicinity with minimal interference from each other.

Destination Address (ATDT) and Address Mask (ATMK)

XStream Destination Addresses and Masks provide the means to set up global or local addresses for establishing module groups, subnets, etc. The Destination Address network layer provides for more granular isolation of modules. The XStream Destination Addresses and Masks can be used to:

- Set up point-to-point and point-to-multipoint network configurations
- Provide greater flexibility in establishing module groups, subnets, etc.

Each module in a network can be configured with a 16-bit Destination Address to establish selective communications within a network. This address is set to one of 65535 values using DT (Destination Address) Command. The default Destination Address is 0.

All modules with the same Destination Address can transmit and receive data among themselves. Modules having different Destination Addresses still detect and listen to the data (in order to maintain network synchronization); however, the data is discarded data rather than passing on.

Packet-based Radio Modems

XStream modules are packet based. This means all data shifted into one module is packetized and sent out the antenna port. Because XStream modules use a peer-to-peer architecture, all modules on the same channel (ATHP) will receive the packet and decide whether to pass it to the host or to throw it away. Each transmitted packet contains information about the transmitting module.

Any module that receives a packet will check the address values and decide what to do with the packet. The options are as follows:

- Receive the packet as a global packet
- Receive the packet as a local packet
- Discard the packet

Address Mask

The mask parameter can be used to allow a base module to receive data from a range of addresses. It may also be used to configure "subnets" of modules that communicate in a group together.

The Pseudo Code uses the bit-wise "AND" operation, "&". This operation is performed bit by bit on each of the 16 bits in the TXDT, RXDT and RXMK parameters.

Table 7. Bit-wise AND Truth

Bit-wise AND Operation ("&")		
Operand 1	& Operand 2	= Result
0	0	0
0	1	0
1	0	0
1	1	1

For example: Hexadecimal: 0x3 & 0x9 = 0x1

The Address Mask can be used as an additional method of facilitating communications between modules. The Address Mask can be set to one of 65535 possible values using MK (Address Mask) Command. The default value of the MK Parameter is 0xFFFF.

All transmitted data packets contain the Destination Address of the transmitting module. When a transmitted packet is received by a module, the Destination Address of the transmitter (contained in the packet) is logically "ANDed" (bitwise) with the Address Mask of the Receiver. If the resulting value matches the Destination Address of the Receiver, or if it matches the Receiver Address Mask, the packet is accepted. Otherwise, the packet is discarded.

Note:	When performing this comparison, any "0" values in the Receiver Address Mask are treated as irrelevant and are ignored.

Pseudo code for receiving

```
/* ********************************************************
*  Function: Receive_Data()                                *
*                                                          *
*  Description: Algorithm used by XStream modules          *
*               to qualify incoming data packets.          *
*                                                          *
*  Variables:                                              *
*  (parameter types: short = 16 bits, char = 8 bits)       *
*                                                          *
*    short TXDT = Transmitter's Module Address   (ATDT)    *
*    short RXDT = Receiver's Module Address      (ATDT)    *
*    short RXMK = Receiver's Module Address Mask (ATMK)    *
*                                                          *
********************************************************/

Function Receive_Data (TXDT, RXDT, RXMK, RXRR)
{
  if((TXDT & RXMK) == RXMK) /* Is incoming address a global address? */
  {
    Send_data_out_port(); /* Call to function that Sends data out port */
  }

  else if((TXDT & RXMK) == (RXDT & RXMK)) /* Is TXDT a local address? */
  {
    Send_data_out_port(); /* Call to function that Sends data out port */

  }

  else     /* neither global nor local address */
  {
    Purge_buffer();  /* Call to some function that throws data away */
  }

}  /* End Function Receive_Data() */
```

Pseudo code for transmitting

```
/* ********************************************************
*  Function: RF_Transmit_Control()                         *
*                                                          *
*  Description: Algorithm used by XStream modules          *
*               to packetize and transmit data packets.    *
*               This procedure only runs if there is       *
*               data in the data buffer and the            *
*               communication channel is clear.            *
*                                                          *
*  Variables:                                              *
*  (parameter types: short = 16 bits, char = 8 bits)       *
*                                                          *
*    char  DINC = Number of bytes in Data In Buffer        *
*                                                          *
********************************************************/

Function RF_Transmit_Control (DINC)
{

  Initialize_RF_Channel(); /* This process takes 35ms */
  while(DINC > 0)    /* Data In Buffer is not empty */
  {
    Assemble_RF_Packet(); /* Packet contains TXDT, TXVD and TXHP params*/

    {
      Transmit_Data(); /* Call function that shifts data out antenna */
    }                  /* Global packets not subject to TXRR */


  }  /* End while Data In Buffer is not empty */

  Close_RF_Channel();   /* Allows other modules to communicate */

}  /* End Function RF_Transmit_Control() */
```

Appendix A: Agency Certifications

FCC Compliance

The MaxStream XStream OEM RF Module complies with Part 15 of the FCC Rules. Compliance requires the following be stated:

FCC ID: **OUR9XSTREAM** (for 900 MHz) or **OUR-24XSTREAM** (for 2.4 GHz)
This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

OEM Labeling Requirements

Label Warning

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

Figure 23. Required FCC Label for OEM products containing 9XStream (900 MHz) OEM RF Module

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.

Figure 24. Required FCC Label for OEM products containing 24XStream (2.4 GHz)OEM RF Module

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.

FCC Notices

Adherence to the following is required:

IMPORTANT: The 9XStream (900 MHz) and 24XStream (2.4 GHz) OEM Modules have been certified by the FCC for use with other products without any further certification (as per FCC section 2.1091). Changes or modifications not expressly approved by 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 OEM RF Modules have been certified for remote and base radio applications. If the XStream will be used for portable applications, the device must undergo SAR testing.

NOTE:

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

- 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.

Antenna Warning

WARNING: This device has been tested with Reverse Polarity SMA connectors with the antennas listed in Tables 8 & 9 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).

FCC 9XStream (900 MHz) Approved Antenna List

Table 8. Antennas approved for use with 9XStream (900 MHz) OEM RF Modules.

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

* FCC-approved antennas not inventoried by MaxStream – Contact MaxStream (1-866-765-9885) for information.

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

Over 100 additional antennas that 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. Contact MaxStream at (801) 765-9885.

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.

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 ≥ 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.

In order to fulfill the FCC Certification requirements, the OEM must comply with 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 23].
2. The 9XStream OEM RF Module (900 MHz) may be used only with Approved Antennas that have been tested with this module. [Table 8]

FCC 24XStream (2.4 GHz) Approved Antenna List

Table 9. Antennas approved for use with 24XStream (2.4 GHz) OEM RF Modules by the FCC

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

* FCC-approved antennas not inventoried by MaxStream – Contact MaxStream (1-866-765-9885) for information.

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

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 ≥ 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.

In order to fulfill the FCC Certification requirements, the OEM must comply with 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 24].
2. The 24XStream (2.4 GHz) OEM RF Module may be used only with Approved Antennas that have been tested with this module. [Table 9]

European Compliance (2.4 GHz only)

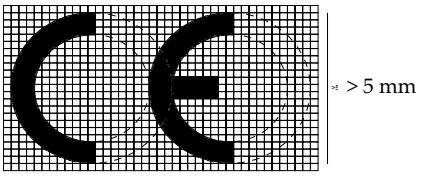
The 24XStream has been certified for several European countries. For a complete list, see http://www.maxstream.net.

If the 24XStream modules are incorporated into a product, the manufacturer must ensure compliance of the final product to the European harmonized EMC and low-voltage/safety standards. A Declaration of Conformity must be issued for each of these standards and kept on file as described in Annex II of the R&TTE Directive. Furthermore, the manufacturer must maintain a copy of the XStream user manual documentation and ensure the final product does not exceed the specified power ratings, antenna specifications, and/or installation requirements as specified in the user manual. If any of these specifications are exceeded in the final product, a submission must be made to a notified body for compliance testing to all required standards.

OEM Labeling Requirements

The 'CE' marking must be affixed to a visible location on the OEM product.

Figure 25. CE Label Requirements



The CE mark shall consist of the initials "CE" taking the following form:

- If the CE marking is reduced or enlarged, the proportions given in the above graduated drawing must be respected.
- The CE marking must have a height of at least 5mm except where this is not possible on account of the nature of the apparatus.
- The CE marking must be affixed visibly, legibly, and indelibly.

Furthermore, since the usage of the 2400 – 2483.5 MHz band is not harmonized throughout Europe, the Restriction sign must be placed to the right of the 'CE' marking as shown below. See the R&TTE Directive, Article 12 and Annex VII for more information

Figure 26. CE Label Required on OEM Equipment

Restrictions

France – France imposes restrictions on the 2.4 GHz band. Go to www.art-telecom.Fr or contact MaxStream for more information.

Norway – Norway prohibits operation near Ny-Alesund in Svalbard. More information can be found at the Norway Posts and Telecommunications site (www.npt.no).

24XStream Declarations of Conformity

MaxStream has issued Declarations of Conformity for the 24XStream modules concerning emissions, EMC and safety. These files are located in the 'documentation' folder of the MaxStream CD.

Important Note

MaxStream does not list the entire set of standards that must be met for each country. MaxStream customers assume full responsibility for learning and meeting the required guidelines for each country in their distribution market. For more information relating to European compliance of an OEM product incorporating the 24XStream module, contact MaxStream, or refer to the following web sites:

CEPT ERC 70-03E – Technical Requirements, European restrictions and general requirements: Available at www.ero.dk/

R&TTE Directive – Equipment requirements, placement on market: Available at www.ero.dk/

Notifications and Required Information

Since the 2.4 GHz band is not harmonized throughout Europe, a notification must be sent to each country prior to shipping product according to Article 6.4 of the R&TTE Directive. A list of national contacts for most European countries may be found at www.ero.dk/.

The following technical data (relating to the 24XStream) is often required in filling out a notification form.

- Frequency Band: 2400 – 2483.5 MHz
- Modulation: Frequency Shift Keying
- Channel Spacing: 400 kHz
- ITU Classification: 400KF1D
- Output Power: 100 mW EIRP
- Notified Body Number: 0891

Contact MaxStream (801) 765-9885 if additional information is required.

Europe 24XStream (2.4 GHz) Approved Antenna List

Table 10. Antennas approved for use with 24XStream (2.4 GHz) OEM RF Modules in Europe

Manufacturer	Part Number	Type	Gain	Application	Minimum Separation Distance
MaxStream	A24-HABMM-P6I	Dipole	2.1 dBi	Fixed/Mobile *	20cm
MaxStream	A24-HBMM-P6I	Dipole	2.1 dBi	Fixed/Mobile *	20cm
MaxStream	A24-HABSM	Dipole	2.1 dBi	Fixed/Mobile *	20cm
MaxStream	A24-QABMM-P6I	Monopole	1.9 dBi	Fixed/Mobile *	20cm
MaxStream	A24-QBMM-P6I	Monopole	1.9 dBi	Fixed/Mobile *	20cm
MaxStream	A24-Q1	Monopole	1.9 dBi	Fixed/Mobile *	20cm

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

Appendix B: Additional Information

1-Year Warranty

XStream OEM RF Modules & XStream-PKG-R 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.

XStream OEM RF Module Specifications

Table 11. XStream OEM RF Module Specifications

(XStream-PKG-R RF Modem carries the same specifications except for physical properties)

Specification	9XStream (900 MHz) Module		24XStream (2.4 GHz) Module	
Performance				
Indoor/Urban Range	Up to 1500' (450 m)		Up to 600' (180 m)	
Outdoor LOS 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	
Serial Data Throughput	9600 bps	19200 bps	9600 bps	19200 bps
RF Data Rate (Baud)	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
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			
Serial Data Interface	RS-232/422/485			
I/O Data Rate	Software selectable 1200 - 57600 bps			
Power Requirements				
Supply Voltage	5 VDC (± 0.25 V) regulated			
Transmit Current	150 mA			
Receive Current	50 mA			
Power Down Current	< 26 µA			
Physical Properties				
Module Board Size	1.600" x 2.825" x 0.350" (4.06 cm x 6.86 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	

Appendix C: Troubleshooting & FAQs

Contact MaxStream

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

Documentation:	www.maxstream.net/helpdesk/	
Technical Support:	Phone.	(866) 765-9885 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]