9XStream™

Wireless OEM Module

Operation Manual v 2.8

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FCC Compliance

FCC Notice

WARNING: 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.

Labeling Requirements

WARNING: The Original Equipment Manufacturer (OEM) must ensure that FCC labeling requirements are met. This includes a clearly visible label on the outside of the OEM enclosure specifying "Contains Transmitter Module, FCC ID: OUR9XSTREAM as well as the FCC Notice above.

Antenna Warning

WARNING: This device has been tested with Reverse Polarity SMA and MMCX connectors with the antennas listed below. When integrated in the OEMs product, these fixed antennas require installation preventing end-users from replacing them with non-approved antennas. Any antenna not in the following table must be tested to comply with FCC Section 15.203 for unique antenna connectors and Section 15.247 for emissions.

FCC Qualifications

IMPORTANT: The 9XSTREAM module has been certified by the FCC for integration into OEM 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.

In order to fulfill the certification requirements, however, the OEM must comply with FCC regulations:

1. The system integrator must ensure that the external label provided with this device is placed on the outside of the final product.

2. The 9XStream may be used only with **Approved Antennas** that have been tested with this module.

Approved Antenna List

Manufacturer	Part Number	Type	Gain	Application	Connector Type	Minimum Separation Distance
MaxStream	A09-Y6	Yagi	6.2dBi	Fixed/Mobile	RPSMAF	20cm
MaxStream	A09-Y7	Yagi	7.2dBi	Fixed/Mobile	RPSMAF	20cm
MaxStream	A09-Y8	Yagi	8.2dBi	Fixed/Mobile	RPSMAF	20cm
MaxStream	A09-Y9	Yagi	9.2dBi	Fixed/Mobile	RPSMAF	20cm
MaxStream	A09-Y10	Yagi	10.2dBi	Fixed/Mobile	RPSMAF	20cm
MaxStream	A09-Y11	Yagi	11.2dBi	Fixed/Mobile	RPSMAF	20cm
MaxStream	A09-Y12	Yagi	12.2dBi	Fixed/Mobile	RPSMAF	20cm
MaxStream	A09-Y13	Yagi	13.2dBi	Fixed/Mobile	RPSMAF	20cm
MaxStream	A09-Y14	Yagi	14.2dBi	Fixed/Mobile	RPSMAF	20cm
MaxStream	A09-Y15	Yagi	15.2dBi	Fixed/Mobile	RPSMAF	20cm
MaxStream	A09-F2	Base Station	2.2dBi	Fixed	RPSMAF	20cm
MaxStream	A09-F5	Base Station	5.2dBi	Fixed	RPSMAF	20cm
MaxStream	A09-F8	Base Station	8.2dBi	Fixed	RPSMAF	20cm
MaxStream	A09-F9	Base Station	9.2dBi	Fixed	RPSMAF	20cm
MaxStream	A09-W7	Base Station	7.2dBi	Fixed	RPSMAF	20cm
MaxStream	A09-M7	Base Station	7.2dBi	Fixed	RPSMAF	20cm
MaxStream	A09-H	1/2 wave antenna	2.1dBi	Fixed/Mobile	RPSMAF	20cm
MaxStream	A09-HBMM-P6I	1/2 wave antenna	2.1dBi	Mobile	MMCX	20cm
MaxStream	A09-QBMM-P6I	1/4 wave antenna	1.9 dBi	Mobile	MMCX	20cm
MaxStream	A09-QI	1/4 wave integrated wire antenna	1.9 dBi	Mobile	Integrated	20cm

RF EXPOSURE

⚠ **WARNING: This equipment is approved for mobile / base station applications**
When using the 9Xstream with mobile or base station antennas, a minimum separation distances of 20 centimeters or more must be maintained. 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.

Warranty

The 9XStream module from MaxStream (the "Product") is warranted against defects in materials and manufacturing under normal use in accordance with instructions and specifications published by MaxStream in connection with its Development Kits or as otherwise published by MaxStream from time to time, for a period of 90 days from the date of purchase from MaxStream. 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.

Overview

The 9XStream 12, 96, and 192 modules are 100-milliwatt, frequency-hopping wireless modules that allow wireless communication between equipment using a standard asynchronous serial data stream. The half-duplex transmission of the 9XStream can sustain a continuous data stream at the specified data rate. The 9XStream has been engineered for use with the following applications (among others):

- Supervisory Control and Data Acquisition (SCADA)
- Remote meter reading
- Home Automation
- Security
- Instrument monitoring
- Point of Sale Systems (POS)

The 9XStream operates within the 900 MHz ISM Band and is approved by the FCC under Part 15 of FCC Rules and Regulations. A regulated 5-volt supply is required for operation.

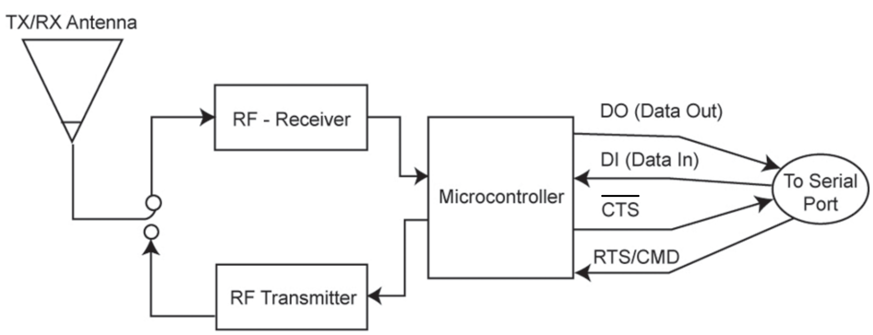


Figure 1a - Block diagram demonstrating basic module operation and data flow for both transmit and receive.

Features

- Frequency-Hopping Spread Spectrum (FHSS) technology
- Noise and interference resistance
- Enhanced sensitivity and range
- Multiple Low-power modes (down to 1 Microamp)
- Standard serial digital interface connection
- Built-in Networking and addressing
- Simple AT command interface

Simple Product Integration

The 9XStream doesn't require previous knowledge of RF operation. It interfaces to any UART or PC Serial Port using the MaxStream interface board and has been developed with a small form-factor for ease of integration. The data transfer performance of the 9XStream has been enhanced with proprietary technology from MaxStream and requires no additional licensing or FCC approval.

Serial Port Operation

The 9XStream modules come equipped with a CMOS-level asynchronous serial port, which provides direct communication with any device having a UART interface (Universal Asynchronous Receiver-Transmitter). The serial port can also communicate with a COM port on a personal computer, or other RS-232 port via the MaxStream interface board. By connecting the 9XStream to the serial port on a host device, the host becomes a wireless communication device. To transmit, the host device simply sends data from its serial port to the 9XStream and the 9XStream converts the data into spread spectrum, FCC-approved wireless data. The data is then detected by a receiving 9XStream module, checked for integrity, and sent to a receiving device via the serial port (Figure 2a).

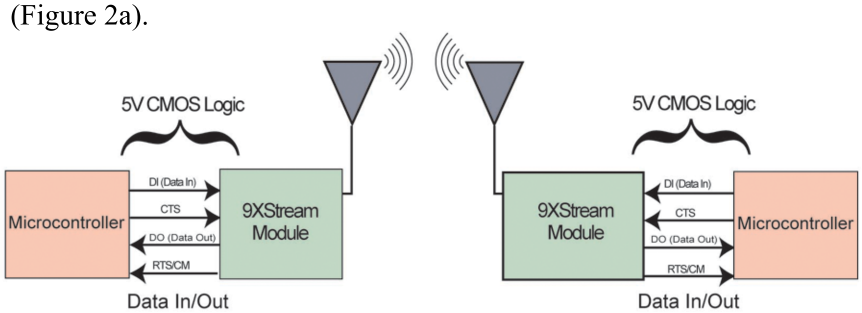


Figure 2a

Serial Pins

Figure 2a above shows 4 data lines needed to interface from a microcontroller or RS-232 device to the 9XStream modules. These four lines represent DI (Data In), DO (Data Out), $\overline{\text{CTS}}$, and RTS/CMD (request to send/command mode). (All low-asserted pins are distinguished with a line over the top of the pin name, or a '*' symbol prefacing the pin name.) While the DI and DO pins are indispensable in almost all cases, the $\overline{\text{CTS}}$ and RTS/CMD may not be needed under certain conditions. The following includes a brief description of each of these pins and under what conditions the pins must be used. A brief explanation of the $\overline{\text{CONFIG}}$ pin is also provided.

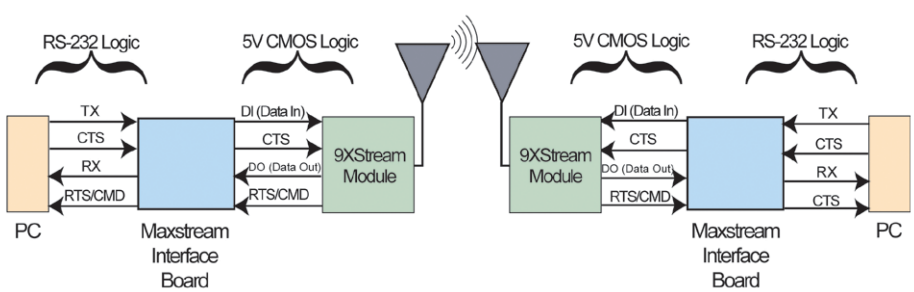


Figure 2b

DI (Data In) – Pin 4 (Input)

Data enters the 9XStream on the DI pin as an asynchronous serial signal. The serial signal is idle (high) when no data is being transmitted. Each data packet consists of a start bit (low), 8 data bits, and a stop bit (high) as shown below in Figure 3.

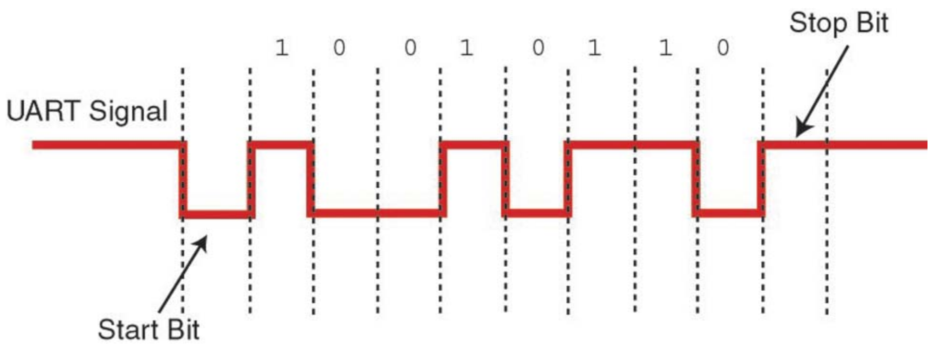


Figure 3

The 9XStream modules transfer exactly 8-bits over the air. The start and stop bits from the UART signal are not actually transmitted, but are regenerated on the receiving module before they are sent out the serial port. This allows for the following data configurations to be sent:

- 8-bit, no parity, 1 stop bit
- 7-bit, even parity, 1 stop bit
- 7-bit, odd parity, 1 stop bit
- 7-bit, no parity, 2 stop bits

Since the 9XStream is half-duplex, it can only transmit or receive at a given time. Thus, once the first byte is detected on the DI pin, the 9XStream immediately begins transmitting the incoming data unless over-the-air data is already being received. In this case, the data on the DI pin is stored in the data buffer until data is no longer being received at the antenna. If the 9XStream receives a lengthy sequence of serial data (while receiving over-the-air data), the data buffer could reach its capacity (132 bytes) in which case the $\overline{\text{CTS}}$ signal will need to be implemented (see $\overline{\text{CTS}}$ section below).

Note: The 9600 and 19200-baud modules allow incoming serial data to be transferred at a rate of 2400-57600 bits/second. Serial data can be transferred to the module at a rate equal to or less than the module's over-the-air baud rate without any problems. However, if the serial interface rate is set to exceed the module's baud rate (9600 or 19200 bps respectively), $\overline{\text{CTS}}$ must be implemented since the data buffer may become full.

DO (Data Out) – Pin 3 (Output)

Data received from over-the-air transmissions is checked for errors and then sent to the DO pin.

$\overline{\text{CTS}}$ – Pin 1 (Output)

The $\overline{\text{CTS}}$ pin (clear to send) informs the host device whether or not serial data can be sent to the 9XStream module. When CTS registers as ***low***, serial data can be sent to the 9XStream module. All incoming serial data is stored in a data buffer until the next data packet is transmitted (over-the-air). The data buffer can hold up to 132 bytes of data. At 115 bytes, the 9XStream module de-asserts the CTS signal (sets it high) to alert the host device to stop sending serial data. The CTS remains de-asserted until the number of bytes in the buffer drops below 98.

There are three cases in which the data buffer may become full:

1. When the 9600 and 19200-baud modules are configured at a higher serial data rate than the module's over-the-air baud rate causing the data buffer to become momentarily full and CTS to de-assert.

2. The 9XStream module is a half-duplex transmitter/receiver. If the module is receiving a long, continuous string of over-the-air data, any serial data that arrives at the buffer will not be transmitted until the module no longer detects over-the-air data.

3. If any module in a network (see **Networking and Addressing**) is transmitting data, all other modules in the network will not transmit until they finish receiving data. If the network modules receive lengthy serial data, their data buffers may become full.

Note: In applications where none of these conditions occur, the CTS signal need not be monitored.

RTS/CMD – Pin 5 (Input)

RTS The RTS signal (request to send) is not implemented for flow control with the 9XStream modules. All received data (over-the-air) is sent out the serial port regardless of the RTS signal.

CMD The 9XStream comes with a variety of configurable settings including power-saving modes and network addressing options. This pin may be used as a way to manually configure the 9XStream module. When this pin is asserted (high), incoming serial data (on the DI pin) is interpreted as commands instead of data. (See the ***Command Mode*** section of this manual.)

CONFIG – Pin 9 (Input)

The $\overline{\text{CONFIG}}$ pin (low-asserted) is used to force the module to enter AT Command Mode. When asserted (low), the serial port baud rate is temporarily set to match the default baud rate of the 9XStream module. This ensures that the module will transition into AT Command Mode at a known baud rate. Upon entering AT Command Mode, all configured parameters, including the baud rate, remain in their saved state and can be modified as described in the ***AT Command Mode*** section.

IMPORTANT:DO NOT tie the $\overline{\text{CONFIG}}$ pin to an external device as it may cause problems with module operation. The CONFIG pin should be tied to an external switch and used manually to enter AT Command Mode only when the AT Command Mode cannot be entered under the normal procedure (see the *AT Command Mode* section).

Modes of Operation

The 9XStream wireless module features several modes of operation that allow the module to be responsive to data and yet utilize minimum power. The figure below shows these modes, followed by a comprehensive look into each and the necessary conditions for the 9XStream module to transition from one mode to another.

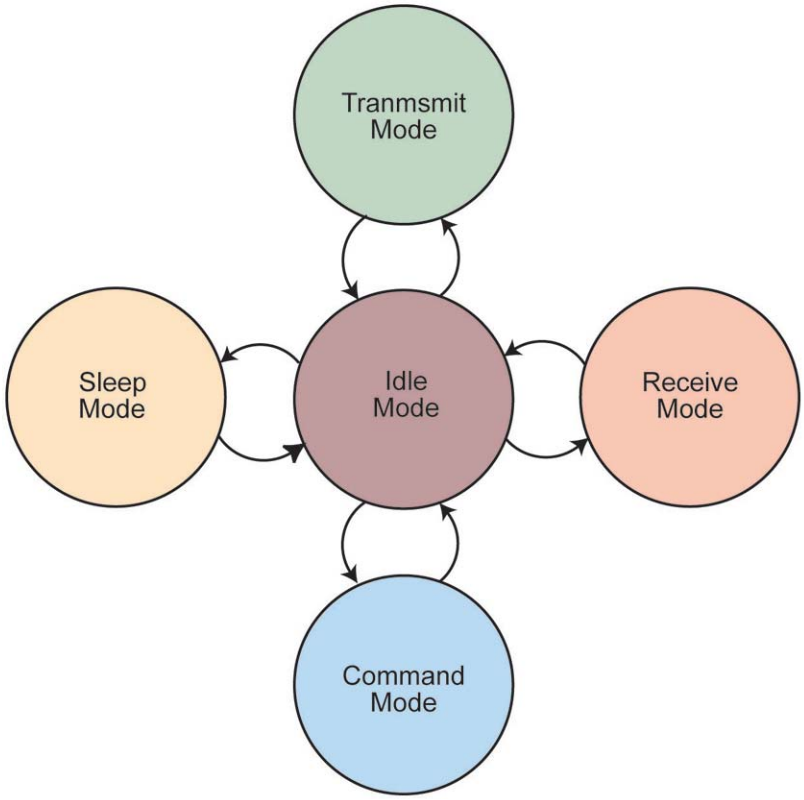


Figure 4

Idle Mode

The 9XStream module operates in **Idle Mode** when there is no data being transmitted or received. The module transitions to **Transmit Mode** once data is presented on the DI pin. If valid data is detected at the antenna, the module will switch from Idle Mode to **Receive Mode**. When no longer transmitting or receiving, the module returns to Idle Mode.

Transmit Mode

When the first byte arrives in the data buffer through the DI pin, the module leaves Idle Mode and transitions to **Transmit Mode**. This transition happens instantaneously from the moment the first byte of data arrives in the data buffer. In Transmit Mode, a header is sent out and is followed by the first data packet, which has a CRC (Cyclic Redundancy Check) attached (see the

***Transmit Mode** (cont.)*

Data Validity section for more information). The first data packet contains all bytes that accumulated in the data buffer while the header was being sent. After the first data packet is sent, another header will be sent if data is available in the buffer. The header is followed by another data packet. The second data packet (and all subsequent data packets) will consist of data that accumulated in the buffer while the previous data packet and header were being sent (see Figure 5a). The size of each data packet can vary up to 64 bytes. This progression is shown in Figure 5b.

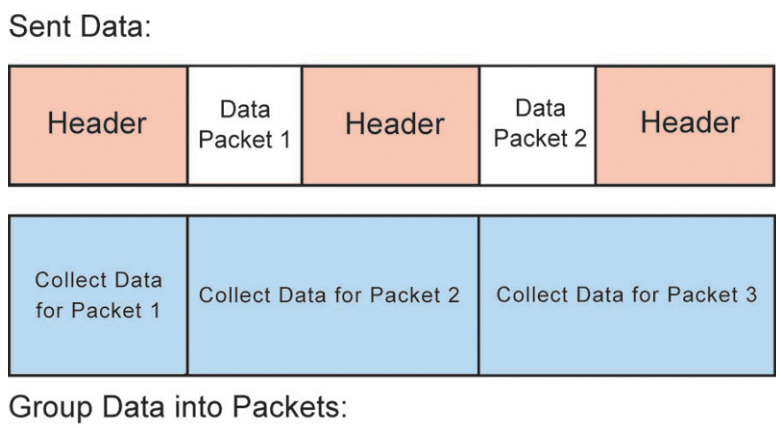


Figure 5a – Generation of data packets

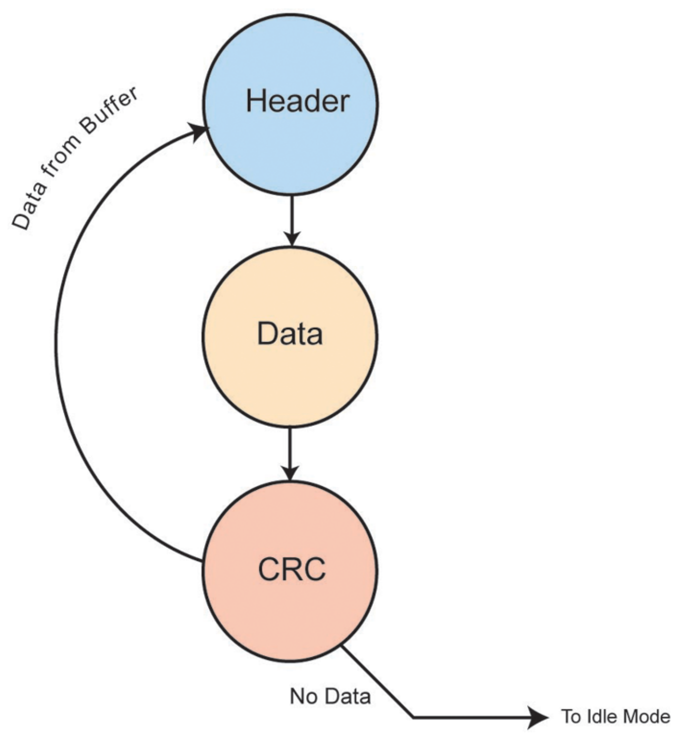


Figure 5b – Transmit Mode description

Data Validity

To verify data integrity, a 16-bit cyclic redundancy check (CRC) is computed for the transmitted data and attached to the end of each data packet before transmission. The receiver will then compute the CRC on all incoming data. Any received data that has an invalid CRC is discarded.

Transmission Latency

The length of time required to send a packet of data depends on the number of bytes being sent and the baud rate. In addition, modules have a Synchronization Timer option that can be manually configured using the **SY** command as discussed in the **9XStream Commands Table** (Appendix E). Modifying this parameter can significantly change the transmission latency. See the **Timing Diagrams** section for more information on transmission latencies.

Note: As outlined in Figure 5a, a header always prefaces a data packet. The header contains information that is used by all receivers (within range) to synchronize their hopping patterns to the transmitter. The length of the header can be reduced in some applications by eliminating the synchronization information. See *Timing Diagrams* for more information.

Receive Mode

If over-the-air data is present at the RF receiver when the module is in Idle Mode, it will transition to Receive Mode and start receiving packets. Once a packet is received, it goes through a CRC (cyclic redundancy check) to ensure that the data was transmitted correctly. If the CRC data bits on the incoming packet are invalid, the packet is discarded. If the CRC is valid, the packet is sent to the serial port via the DO pin. This process is shown in Figure 6 below.

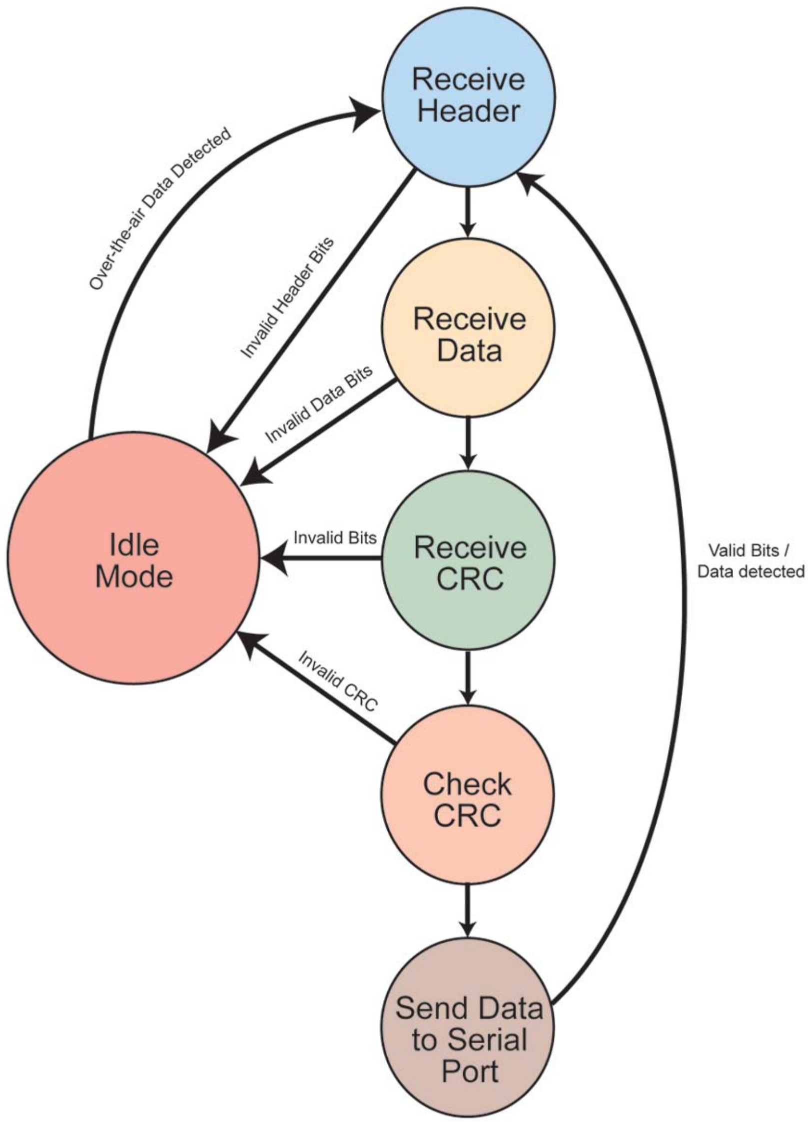


Figure 6 – Receive Mode description

Receive Mode *(cont.)*

The module will remain in Receive Mode until an error is detected in the received data, or data is no longer transmitted, at which point, the module transitions to Idle Mode. If serial data was stored in the data buffer while the module was in Receive Mode, the data will be transmitted after the module returns to Idle Mode.

Sleep Mode

Sleep Mode enables the 9XStream module to go into a low-power state in which minimal power is consumed when the module is not in use. Once in Sleep Mode, the module will not transmit or receive data until it first returns to Idle Mode. To enter Sleep Mode, the module must be inactive (no data transmission or reception) for a user-defined period of time (specified by the ST command). After this time elapses, the module transitions to Sleep Mode. By default, Sleep Mode is disabled and must be enabled using the SM command.

The 9XStream features several Sleep Mode settings, each of which makes use of different mechanisms to enter or leave Sleep Mode. The table in **Appendix H** lists the various Sleep Mode settings and the requirements to transition to and from Sleep Mode for each setting.

Pin Sleep (SM=1)

After enabling the **Pin Sleep** setting, the Sleep pin (Pin 2) controls whether the 9XStream is active or in Sleep Mode. If Sleep is de-asserted, the module is fully operational. Once Sleep is asserted, the module transitions to Sleep Mode and remains in its lowest power consuming state until the Sleep pin is de-asserted. The 9XStream requires 85 ms to transition from Sleep Mode to Idle Mode. The Sleep pin is only active if the module is set up to operate in this mode; otherwise the pin is ignored. (See the **SM** command in the **9XStream Commands Table** (Appendix E), for more information.) Once in Pin Sleep Mode, the $\overline{\text{CTS}}$ pin (Pin 1) is de-asserted (high) to indicate that data should not be sent to the module during this time. The TX/PWR pin (Pin 8) is also de-asserted (low) when the module is in Pin Sleep Mode.

Serial Port Sleep (SM=2)

If this state 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 can be changed by modifying the ST command. When the module is in Serial Port Sleep Mode, the TX/PWR pin (Pin 8) is de-asserted (low). The module will return to Idle Mode once a character is received on the DI pin.

Cyclic Sleep (SM=3-7)

If the **Cyclic Sleep** setting is enabled, the 9XStream module goes into Sleep Mode after a user-defined period of inactivity (no transmission or reception on the RF channel). The user-defined period may be set by adjusting the ST parameter (see the **ST** command in the **9XStream Commands Table** – Appendix E).

The module remains in Sleep Mode for a user-defined period of time ranging from 0.5 seconds to 8 seconds (adjustable using **SM** command). After this period of time, the module returns to Idle Mode and listens for a valid data packet. If no valid data packet is found (on any channel), the module returns to Sleep Mode. If a data packet is found, the module transitions into **Receive Mode** and receives the incoming packets until another ST inactivity time out occurs. When the module is awake, it requires 100 milliseconds to search for a valid data packet.

While the module is in a low-power state, the $\overline{\text{CTS}}$ pin (Pin 1) 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, the $\overline{\text{CTS}}$ pin is asserted, and any data received on the **DI** pin will be transmitted. The TX/PWR pin (Pin 8) is also de-asserted (low) when the module is in Cyclic Sleep Mode. It is asserted each time the module cycles into Idle Mode to listen for valid data packets, and then de-asserts if the module returns to Sleep Mode.

Cyclic Scanning

Each RF packet consists of a header and data as shown previously in **Figure 5a**. Since the header contains the channel synchronization information, the module must wake up during the header portion of a packet in order to synchronize with the transmitter and receive the data. To ensure that the 9XStream module can detect the header, a long header can be sent periodically during a transmission. This long header repeats the synchronization information for a period of time defined by the **LH** command.

By default, the long header is turned off and must be enabled in order to communicate with a module operating in Cyclic Sleep Mode. To enable the long header, the LH parameter must be set to a value greater than the time of cyclic sleep to ensure accurate detection by the receiver(s). For example, if the 9XStream is set to wake up from Sleep Mode every four seconds and check for a packet, a transmitter would need to send a long header that is just over four seconds in length to guarantee that the receiving module will detect the packet. (Exact timing requirements can be found in the **Timing Diagrams** section.) This concept of long header length versus Sleep Mode timing is displayed in **Figure 7a** and **b**.

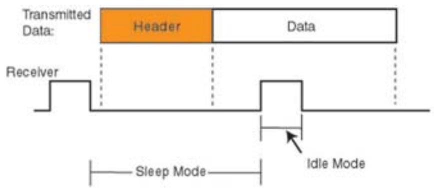


Figure 7a – The length of the long header is not as long as the period of Cyclic Sleep. It is possible for the receiver to wake and miss the header (and the data packet) in this scenario.

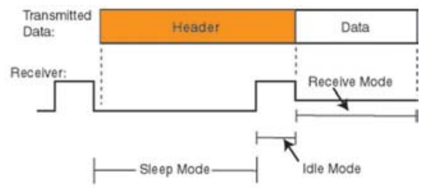


Figure 7b – The length of the long header exceeds the period of Cyclic Sleep. The receiver is guaranteed to detect and receive the data packet.

The long header is only sent with the initial transmitted packet after a user-defined period of inactivity (no serial data received and no over-the-air transmitting or receiving). This period of inactivity must be adjusted using the **HT** command as described in the **9XStream Commands Table** (Appendix E). Sending a long header assures that the receiver will detect the new transmission and will be able to receive the data (as long as the header length slightly exceeds the cyclic sleep time).

Command Mode

Command Mode allows several features, including the power-down and addressing options, to be configured. These adjustable parameters offer greater flexibility to designers in configuring the module to fit specific design criteria. There are three ways to enter Command Mode:

1. Assert RTS/CMD and send a binary command.
2. Send the sequence "+++" to send AT commands.
3. Assert (low) the CONFIG pin and turn the power switch off and back on.

Important: Do not tie CONFIG pin to microprocessor. (See the *Serial Port Operation* section for more information.)

Once in Command Mode, the configurable parameters can be adjusted using either AT commands or Binary commands, as explained below. Any parameters that are changed while in Command Mode must be saved to non-volatile memory using the **WR** command, or they will reset to their stored value upon **reset** or **power-up**.

Command Mode *(cont.)*

In these examples, sent or received ASCII characters are marked in quotations. Quotation marks should not be included when sending commands to the 9XStream modules. Carriage Returns (ASCII character 13) will be denoted as <CR>. Binary values are represented in this document with < and >. These characters are also not sent as part of the actual command. All binary values are represented as hexadecimal values (HEX) in these examples, and are denoted by an H after the number. The actual Binary Command values must all be sent in binary with the Least Significant Byte (LSB) sent first followed by the Most Significant Byte (MSB) if the value is larger than one byte.

AT Commands

The following sections contain a description of the AT and Binary Command Modes along with some examples. In these examples, sent or received ASCII characters are marked in quotations.

AT commands can be sent to the module using ASCII commands and parameters. A special break sequence is used so that the module will transition into AT Command Mode. The default sequence for entering AT Command Mode is as follows:

- No characters sent for one (1) second.
  *(Time modified by **BT** command.)*
- Three (3) plus characters (**+++**) sent within one (1) second.
  *(Character modified by **CC** command.)*
- No characters sent for one (1) second.
  *(Time modified by **AT** command.)*

The 9XStream module responds by sending an **OK<CR>**.

All AT commands are sent as follows:

AT	**+**	**Two (2) Character ASCII Command**	**+**	**Optional Space**	**+**	**Parameter (HEX)**	**+**	**Carriage Return**

The ASCII command consists of **AT** followed by two alphanumeric bytes, and the parameter is a number represented as ASCII hexadecimal characters (0-9, A-F). The ASCII commands and parameters are not case-sensitive. The optional space can be any non-alpha-numeric character

After executing a recognized AT command, the module responds with an **OK<CR>**. If an unrecognized command or a command with a bad parameter is received, the module will respond with an **ERROR<CR>.**

AT Commands (cont.)

A modified AT value is reset upon module power-down unless the **WR** command is issued to save the parameter to non-volatile memory.

To query the current value of a particular command, send the corresponding **AT** command without any parameters (carriage return, however, is still sent). The response will be the current value of that command reported as a hexadecimal number.

The following example demonstrates basic AT Command functionality in the 9XStream module.

Example: This example will change the user-defined Module Address to 1A0D (HEX) and check the current value of the SM command. It will also write the new Module Address to non-volatile memory.

SEND	**RESPONSE**
+++	**OK<CR>**
ATDT 1A0D<CR>	**OK<CR>**
ATSM<CR>	**0 <CR>**
ATWR<CR> *(write to non-volatile memory)*	**OK<CR>**
ATCN<CR> *(exit AT Command Mode)*	**OK<CR>**

Exiting AT Command Mode

There are two ways to exit the AT command mode and return to Idle Mode. If no valid AT commands are received within the time specified by the AT Command Timeout parameter (CT command), the module will return to Idle Mode automatically. Alternatively, the AT command mode can be exited by sending the CN command.

Binary Commands

Binary command bytes are organized as follows:

<Command><Parameters>
1 byte *2 bytes*

When sending a Binary command to the 9XStream, the **Command byte** must be sent while the RTS/CMD pin (Pin 5) is asserted. RTS/CMD can be de-asserted 100 microseconds after the stop bit from the Command byte has been sent. It does not matter whether RTS/CMD is asserted when the **Parameter bytes** are sent. The command will execute when all the parameters associated with the command have been sent. If all parameters aren't received within 0.5 seconds the module will return to Idle Mode.

Binary Commands (cont.)

Note: When parameters are sent, they are always two bytes long with the Least Significant Byte sent first. When they are read, they are 1 or 2 bytes long as indicated in the *9XStream Command Table* (Appendix E).

Binary Command Mode allows multiple commands to be sent in sequence. When the 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 RTS/CMD remains asserted, all received commands will be executed by the 9XStream module. All modified parameters must be stored in non-volatile memory by sending the WR command (08H 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 80H (hexadecimal) with RTS/CMD asserted. When this binary value is sent (with no parameters) the current value of the command will be sent back, through the DO pin.

Note: For the 9XStream module to recognize a Binary command, the RT command must be issued from AT Command Mode to enable binary programming. If binary programming is not enabled, the module will not recognize when the RTS/CMD pin is asserted and will therefore not recognize Binary Commands.

Example: This example will set Sleep Mode to the Pin Sleep setting and store the new Sleep Mode value to non-volatile memory. (Again, the RT command must be issued in AT Command Mode to enable binary programming before Binary Command Mode will work.)

Assert RTS/CMD	**(Enter command mode.)**
Send bytes:	**(Send SM1 command)**
<01H>	**(Command Byte - SM)**
<01H>	**(Least significant bit of the Parameter Bytes - 01H)**
<00H>	**(Most significant bit of the Parameter Bytes – 00H)**
Send bytes:	**(Send WR command)**
<08H>	**(Command Byte - WR)**
	De-assert RTS/CMD

Networking and Addressing

The 9XStream modules utilize three levels of addressing to communicate between modules. This networking hierarchy is depicted in Figure 8 below. Only modules with the matching addresses are able to communicate. The three methods of addressing are: Vendor Identification number, Networks, and Module Addresses.

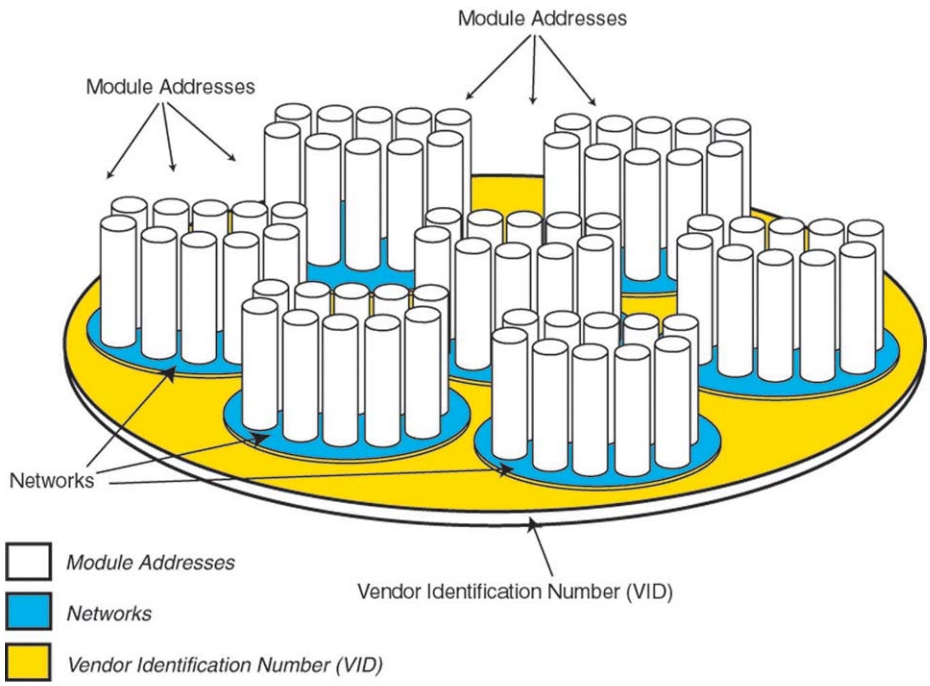


Figure 8 – Layout of a typical network configuration. The 9XStream features a powerful set of networking and addressing options allowing the functionality of complex networking systems.

Vendor Identification Number (VID)

For network security, a unique **Vendor Identification Number (VID)** can be requested. The VID is programmed into the 9XStream module at the factory and is stored in permanent memory. This number can only be changed at the factory. Only modules with matching VID numbers can communicate together. VID addressing ensures that modules with a given VID are immune to either transmissions or receptions with 9XStream modules of a different VID in the same vicinity. To request a unique VID number, contact MaxStream to obtain a **VID Request Form**.

Networks

Within each VID, there are seven available **networks**. Each network utilizes a different pseudo-random hopping sequence to navigate through the shared hopping channels. In the event that two modules from different networks collide on a channel (because they hop in a different sequence) the two modules will jump to separate channels on the next hop. Using networks, multiple module pairs can operate in the same vicinity with minimal interference from each other. The network parameter is user-definable using the **HP** command as described in the **9XStream Command Table** (Appendix E).

Module Address

Module Addresses and **Module Address Masks** provide another level of addressing among 9XStream modules. Each module in a network can be configured with a 16-bit Module Address to establish selective communications within a network. This address is set to one of 65535 values using the "DT" command. The default Module Address is 0000H.

All modules with the same Module Address can transmit and receive data among themselves. Any modules on a network with different Module Addresses will still detect and listen to the data in order to maintain network synchronization. However, they will not send the data out to their serial ports if their Module Addresses don't match the Module Address of the transmitter. (The Module Address Mask can be used to provide exceptions to this rule as described in the following section.)

Module Address Mask

The Module Address Mask can be used as an additional method to facilitate communication among modules. The Module Address Mask can also be set to one of 65535 possible values using the **MK** command. The default value is FFFFH.

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

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

Module Address Mask *(cont.)*

Packets with a Transmitter Module Address of FFFFH are received by all modules (as shown below in Figure 9). A Transmitter Module Address that matches the Module Address Mask is called a Global Address.

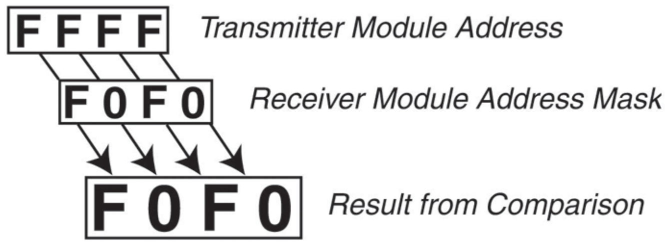


Figure 9 – Demonstration of Module Address comparison at receiver. FFFFH logically "ANDed" with any Module Address Mask will equal the Module Address Mask.

Example: Consider Module A with Module Address of 00FFH and Module Address Mask F0F0H (Figure 10).

Figure 10

Module A can receive packets from other modules in three ways:

1. **From modules with a Transmitter Module Address of 00FFH.**
2. **By logically "ANDing" a F0F0H Mask with the Receiver Module Address to receive *0XFX* (HEX).**
3. **From an address that matches the Module Address Mask of the module (F0F0H), or packets from a module having a Transmitter Module Address (Global Address) of *FXFX* (since the two *0* values in FOFOH are *insignificant*).**

Glossary

AT commands – A set of commands that can be used to customize and configure the 9XStream module to meet specific needs. AT commands are sent via a serial communications program such as HyperTerminal.

Binary commands – A set of commands used to configure the 9XStream module. Binary commands are sent with RTS/CMD asserted. The RT command must be used to enable binary programming prior to using binary commands. Multiple Binary commands can be issued sequentially while RTS/CMD is asserted.

Clear to send – See **CTS pin**.

CMOS logic – Logic levels used by the 9XStream module (0-5V).

Command Mode – A mode of operation, which manually modifies the configurable parameters of the 9XStream module. Both Binary and AT command modes are available.

Command table – Table containing 23 currently implemented commands. This table lists all of the adjustable parameters along with a brief description of each.

CRC – See **Cyclic Redundancy Check**.

CTS pin – The low-asserted **Clear To Send** pin (Pin 1) provides flow control for the 9XStream module. When CTS is asserted (low), serial data can be sent to the module for transmission. If the module is unable to transmit the data, CTS may de-assert (high) once the data buffer nears capacity to prevent buffer overflow.

Cyclic redundancy check (CRC) – Used by the 9XStream module to ensure data integrity during transmission. A CRC is computed on the bits to be transmitted over-the-air and sent with each data packet. The CRC is recomputed by the receiver and compared with the original CRC bits. The packet is valid if the receiver CRC matches the CRC computed by the transmitter.

Cyclic sleep – Sleep Mode setting in which the module enters a low-power state and awakens periodically to determine if any transmissions are being sent.

Data buffer – Collects incoming serial data prior to over-the-air data transmission. The data buffer can hold up to 132 bytes at a given time. When the buffer fills to 115 bytes, the Clear To Send (CTS) pin is de-asserted to stop the flow of incoming serial data.

Data packets – A grouping of data to be sent over-the-air. Each data packet contains a header and data that is collected from the data buffer. The size of the packets varies up to 64 bytes depending on how many bytes of data are in the data buffer.

Glossary *(cont.)*

Data validity – Act of comparing received data with transmitted data to ensure accurate transmission. Data validity is verified by performing a CRC check.

DI pin – All incoming serial data enters the 9XStream module on the Data In (DI) pin (Pin 4).

DO pin – All received over-the-air data leaves the 9XStream module through the Data Out (DO) pin (Pin 3). The data can then be sent to a microcontroller or RS-232 device.

FCC – The Federal Communications Commission is the US government agency responsible for regulating radio communications standards in the United States.

Flow control – Method of determining when serial data can be sent to the module for over-the-air transmission. Flow control is used to prevent buffer overflow. This can be implemented in hardware and/or software. Hardware flow control is implemented in the 9XStream module using the $\overline{CTS}$ pin.

Frequency Hopping Spread Spectrum (FHSS) – Method employed by the 9XStream module which involves transmitting data over several different channels in a specific channel hopping sequence known by the transmitter and the receiver(s).

Half-duplex – A mode for radio operations. Radios that operate in half-duplex are able to either transmit data or receive data at a given time, but cannot do both simultaneously. When one module is transmitting, all modules (of the same VID) within range listen to the transmission and will only transmit once the transmission is complete.

Hardware flow control – See **Flow Control**.

Headers – Information that prefaces the data bits in transmitted data packets. The header contains information used by the receiver(s) to synchronize to the transmitter.

HyperTerminal – A serial communications program useful for communicating with the 9XStream module and configuring user-defined operating parameters through AT commands.

Idle Mode – A mode of operation in which the module is neither transmitting nor receiving.

Industrial Temperature – Temperature tested version of 9XStream modules extending beyond normal operating specifications (0ºC to 70ºC). These modules are tested for a temperature range from -40ºC to 85ºC.

Glossary *(cont.)*

Integration – The process of incorporating the 9XStream module into an application in place of a serial cable.

Interface board – An optional board available with the 9XStream module that converts RS-232-level data into CMOS logic levels.

Long header – A lengthy header (length determined by LH command – see Appendix E) sent out to ensure that modules running in a cyclic sleep mode detect the header when they awake and synchronize to the transmission.

Low-power modes – See **Sleep Mode**.

Module Addresses – Provides a layer of addressing among modules. Modules with the same Module Addresses can communicate together.

Module Address Masks – Provide a layer of filtering to over-the-air data packets that are received by the module. The address (of the transmitting module) is logically "ANDed" with the Module Address Mask of the receiver. The resulting value must match the Module Address of the receiver for the packet to be received. All **"0"** values are not compared.

Networks – Provides a layer above Module Addresses for communicating between modules. Each network has a unique hopping sequence that allows modules on the same network to remain synchronized together.

Pin layout – Describes the layout and functionality of all pins on the 9XStream module.

Pin sleep – A Sleep Mode setting which puts the 9XStream into a minimal power state when the SLEEP pin is asserted. It remains in Pin sleep until the SLEEP pin is de-asserted. This setting must be enabled using the SM command.

Power-saving modes – See **Sleep Mode**.

Receive Mode – A mode of operation that receives over-the-air data and transmits all valid data packets out to the serial port. The module must be in Idle Mode to transition to Receive Mode.

RS-232 logic – Standard logic levels implemented in devices using the RS-232 communication protocol.

RTS/CMD (Request to Send/Command) – The RTS/CMD pin (Pin 5) is used primarily to configure Binary commands (CMD). RTS flow control is not implemented in the 9XStream module.

Sensitivity – A measurement specification that describes how weak a signal can be (in dBm) and still be detected by the receiver.

Glossary *(cont.)*

Serial data – Data that enters the 9XStream module through its serial port.

Serial port sleep – A Sleep Mode setting in which module runs in a low power state until data is detected on the DI pin. This setting must be enabled using the SM command.

Sleep Mode – A mode of operation in which the 9XStream enters a low power consuming state. Several Sleep Mode settings are available and can be configured using the SM command.

SLEEP pin – If Pin Sleep is enabled, the SLEEP pin (Pin 2) determines if the module is in Sleep Mode or Idle Mode. See **Pin sleep**.

Standby Mode – See **Idle Mode**.

Start bit – A low UART signal sent to signify the beginning of an eight-bit data sequence.

Stop bit – The last bit in a UART data sequence. The stop bit is high and indicates the end of an eight-bit data sequence.

Synchronization – Synchronization is used to ensure that the transmitter and receiver are communicating properly with each other and following the same channel hopping sequence.

Transmission Latency – Time required to send a packet of data. This value is dependent on the number of bytes being sent and the baud rate of the module.

Transmit Mode – Mode of operation in which over-the-air data can be transmitted from a module to other modules.

TTL (Transistor-transistor logic)

UART (Universal Asynchronous Receiver-Transmitter) – See **Serial port**.

VID (**Vendor Identification number) –** This number allows modules with the same VID to communicate. Any module with a different VID will not receive their data transmissions.

Application Notes

Why does Sensitivity Matter?

Receiver sensitivity is the lowest power level at which the receiver can detect a wave and demodulate data. Sensitivity is purely a receiver specification and is independent of the transmitter. As the wave propagates away from the transmitter, it attenuates as the distance increases. Lowering the sensitivity on the receiver (making it more negative) will allow the radio to detect weaker signals, and can thus increase the transmission range. Sensitivity is vitally important since even slight differences in receiver sensitivity can account for large discrepancies in the range. To better understand this relationship, the following example is provided.

Example: **Compare the MaxStream 9XStream module (with-110 dBm sensitivity) to a commercial radio receiver with a sensitivity of –90 dBm. The Friis transmission formula can be used to calculate received power (or signal strength) at any receiver location under line-of-sight conditions. This formula is given by**

$$P(r) = \frac{P(t) \times G(t) \times G(r) \times \lambda^2}{F(s) \times 4\pi r^2}$$

P(r) = received power (mW)
P(t) = transmitted power (mW)
G(t) = gain of transmit antenna (linear)
G(r) = gain of receive antenna (linear)
F(s) = fading margin (linear)
λ = wavelength (meters)
r = distance between Transmitter and Receiver (meters)

The following values were used to compare the range limitations of these modules:

P(t) = 100mW
G(t) and G(r) = 2dB, or 1.585 linear
λ = 0.333 meters
F(s) = 21 dB, or 125.89 (experimentally determined)

The table below demonstrates the power received at the receiver over the specified range between the TX and RX antennas, assuming line-of-sight conditions.

Range (meters)	Received Power	Detectable by 9XStream module	Detectable by commercial radio
100	-68.526 dBm	YES	YES
500	-82.506 dBm	YES	YES
1000	-88.526 dBm	YES	YES
3000	-92.048 dBm	YES	NO
5000	-102.506 dBm	YES	NO
8000	-106.588 dBm	YES	NO
10000	-108.526 dBm	YES	NO
11265 (7 miles)	-109.559 dBm	YES	NO
12000	-110.805 dBm	NO	NO

Since the range doubles every 6dB, the 20dB sensitivity difference in radios corresponds to 2^(20/6) = 10.08 times the range using the MaxStream radio!

In a similar fashion, MaxStream radios offer 32 times the range of –80 dBm radios and over 100 times the range of –70 dBm radios.

How Does the 'SY' Command Affect Packet Transmission?

Experiment 1 – Byte Transmission

Two 19200-baud 9XStream wireless modules were configured with the sync timer command (SY) set to 20 ms (2 seconds) and the transmission times were observed. One byte was sent when the modules were out of sync and was followed (within 2 seconds) by a second byte. Figure A1 shows the observed results from the oscilloscope. (The pulse on the transmitter is shown in yellow and the pulse on the receiver in blue.)

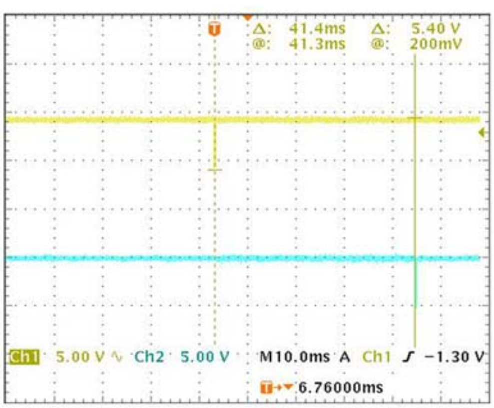


Figure A1 – Oscilloscope output of first byte on transmit and receive ends.

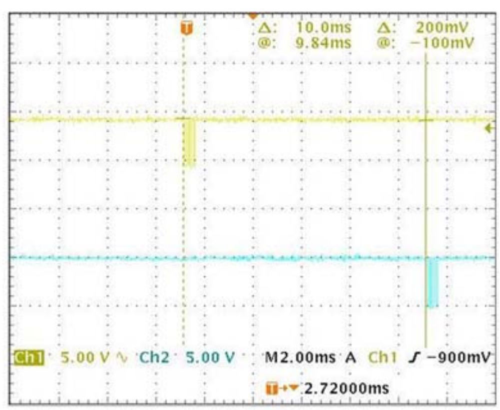


Figure A2 – Oscilloscope output of second byte with SY set to 20.

Experiment 1 – Byte Transmission (cont.)

From Figures A1 and A2, it is evident that the sync timer parameter can save significant amounts of time by reducing the header length.

As shown in Figure A1, the first byte, which included synchronization information in the header, was sent and received in 41.4 ms. Once the modules were synchronized, the second byte transmission did not have the synchronization information included in the header. This transmission occurred in only 10.0 ms – a savings of about 75%. This is shown on similar testing on the 9600-baud modules showed 48.4 ms to transmit the first byte and synchronize the modules, and 16.2 ms to transmit the second byte without synchronization information. This experiment was followed by a second test to note the effect of the sync timer command on transmitting a continuous data stream.

Experiment 2 – Data Transmission

A continuous stream of 32 byte packets was sent to the 9XStream transmitter through a serial connection and then transmitted to a 9XStream receiver located several feet away. This experiment was performed using 19200-baud modules. The transmission time was first measured with the modules in their default condition, and then measured again after setting the sync timer (SY command) to 20. The following output plots were obtained from an oscilloscope. (Again, the signal at the transmitter is shown in yellow, while the receiver's signal is shown in blue.)

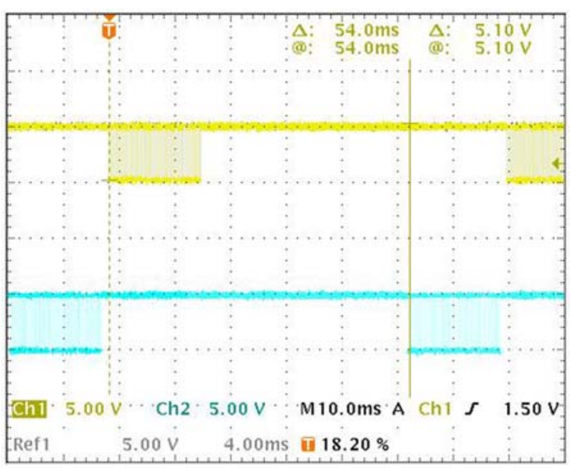


Figure B1 – Oscilloscope output of transmitted and received data under normal conditions.

Experiment 2 – Data Transmission

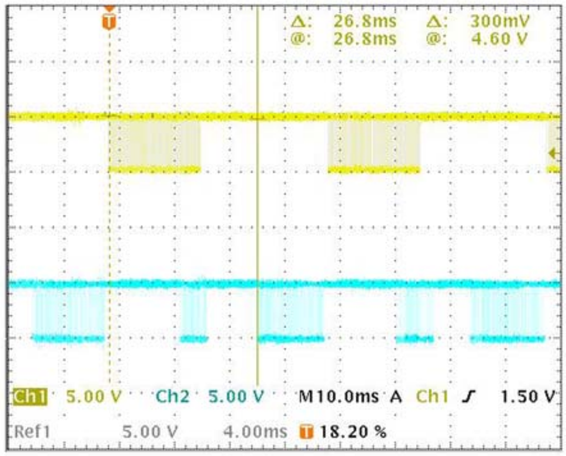
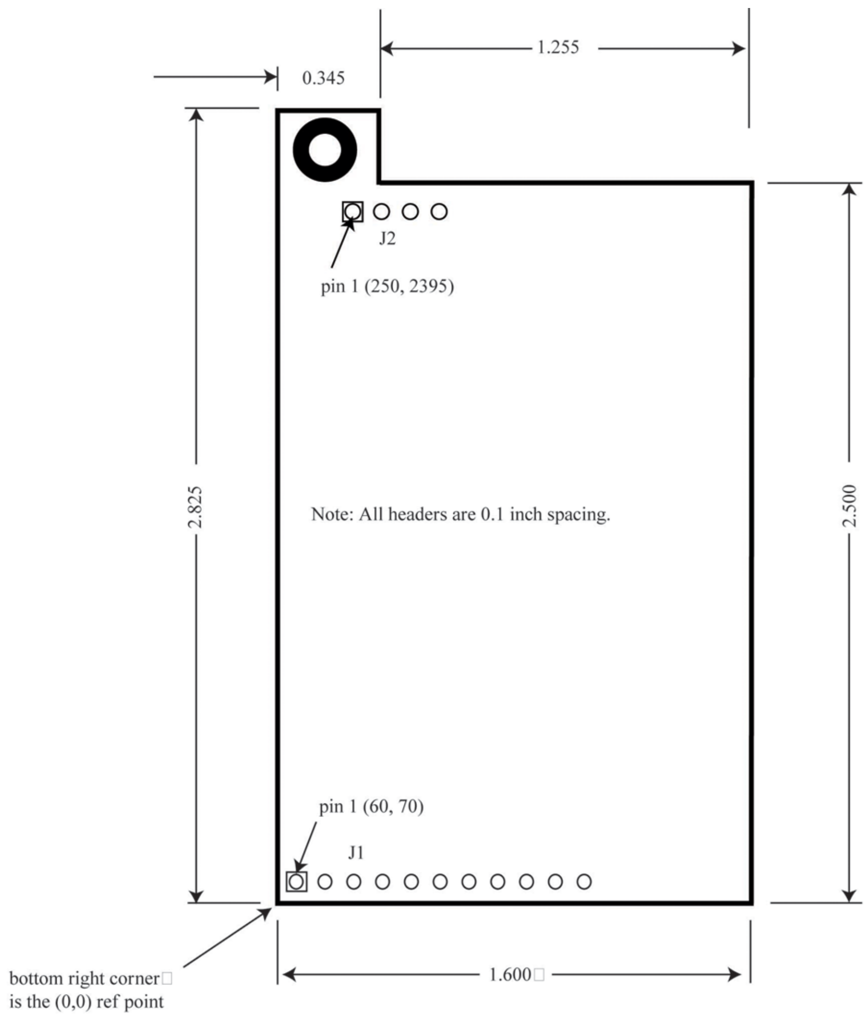


Figure B2 – Plot of transmitted and received data after setting the SY parameter to 20.

In Figure B1, where synchronization information was transmitted with the data, 54.0 ms was required to transmit each packet to the receiver. After adjusting the SY parameter to stop sending synchronization information in the preamble, Figure B2 shows that the same data transmission occurred in only 26.8 ms.

Appendix A – Packaging Information



Top view diagram of the 9XStream module with pin layout and dimensions.

Appendix B – J1/J2 Pin Descriptions

Pin No.	Pin Name	I/O Type	Description	Active
1	$\overline{\text{CTS}}$	O PU	Clear to Send flow control	low
2	SLEEP (PWRDN)	I PU	Can be used to enter Sleep Mode (See “Modes of Operation” section for details.)	high
3	DO (Data Out)	O PU	Data leaving the module that is sent to the host	high
4	DI (Data In)	I	Data entering the 9XStream module to be transmitted over the air	high
5	RTS/CMD	I PD	Command mode enable (See “Binary Command Mode” section for details.)	high
6	$\overline{\text{RESET}}$	I PU	Reset module	low
7	RXLED	O	Indicates good RF data reception	high
8	$\overline{\text{TX}}$/PWR	O	PWR - Indicates module powered on	high
			$\overline{\text{TX}}$ - Asserted during transmission	↓ low
9	$\overline{\text{CONFIG}}$	I PU*	Hold low during power up or reset - forces ASCII command mode. DO NOT TIE TO MICROPROCESSOR! (See “Serial Port Operation” section for details.)	low
10	VCC	I	+5 VDC	-
11	GND	-	Signal ground	-

PU – 10kΩ Pull-Up Resistor
PD – 10kΩ Pull-Down Resistor

* $\overline{\text{CONFIG}}$ signal has a 47kΩ Pull-Up Resistor

J2 Pin Descriptions

Pin	Signal
1	GND
2	GND
3	GND
4	GND

Appendix C – Specifications

	X09-009	X09-019
General		
Frequency Range	902 to 928 MHz, unlicensed ISM Band	
Type	Frequency Hopping Spread Spectrum Transceiver	
Frequency Control	Direct FM	
Transport Protocol	Various Monitoring and Addressing Modes – *see "Networking and Addressing" section*	
Channel Capacity	Hops through 25 channels. Features 7 different hop sequences.	
Serial Data Interface	Asynchronous CMOS (TTL) signals, 5V levels	
Serial Interface Baud Rate	Configurable from 2400-57600 bps **1200 bps available*	Configurable from 2400-57600 bps
Data Throughput	9600 bps	19200 bps
Performance		
Channel Data Rate	10k	20k
Transmit Power Output	100mW	100mW
Rx Sensitivity	-110 dBm	–107 dBm
Range*	Indoor: 600' to 1500' Outdoor: 7mi. with dipole, over 20 mi. with high gain antenna	Indoor: 425'to 1060' Outdoor: 5 miles with dipole, over 14 miles with high gain antenna
Interference Rejection	70 dB at pager and cellular phone frequencies	
Power Requirements		
Supply Voltage	5 VDC +/-0.25V	
Current Consumption	Tx – 150 mA nominal, Rx – 50 mA nominal Power Down mode – less than 1 microamp Other cyclic power-down modes available – *see "Low Power Modes" section*	
Physical Properties		
Board Size	1.6" x 2.85" x .35" (4.06 x 6.86 x .89) cm	
Weight	0.8oz (24g)	
Connectors	11 pin and 4 pin 0.1" spaced male Berg type headers	
Operating Temperature	Standard: 0ºC to 70ºC Industrial version: -40ºC to 85ºC available	
Antennas		
Antenna Connector	MMCX Female or Reverse Polarity SMA Male	
Approved Antennas	Integral wire antenna (factory installed) 1/4 wave flexible monopole 1/2 wave flexible dipole, SMA	

Appendix D – Product Listing

MMCX – No Antenna
X09-009NM, X09-019NM

MMCX – Wire Antenna
X09-009WM, X09-019WM

SMA – No Antenna
X09-009NS, X09-019NS

¼ Wave Antenna MMCX
A09-QBMM-3-P6I

½ Wave Antenna MMCX
A09-HBMM-7-P6I

½ Wave Antenna SMA
A09-HASM-675

900 MHz Modules

Product Code	Description
X09-009NM	9600-baud, no wire mount antenna, MMCX connector
X09-009WM	9600-baud, wire mount antenna, MMCX connector
X09-009NS	9600-baud, no wire mount antenna, SMA connector
X09-009WS	9600-baud, wire mount antenna, SMA connector
X09-019NM	19200-baud, no wire mount antenna, MMCX connector
X09-019WM	19200-baud, wire mount antenna, MMCX connector
X09-019NS	19200-baud, no wire mount antenna, SMA connector
X09-019WS	19200-baud, wire mount antenna, SMA connector
Package Kits	
X09-009PK	9600-baud, Package
X09-019PK	19200-baud, Package
Development Kits	
X09-009DK	9600-baud, Development Kit
X09-019DK	19200-baud, Development Kit

Appendix D – Product Listing (cont.)

Antennas

Product Code	Gain (dBi)	Frequency Range (MHz)	Feed Connector		Description
Yagi Antennas					
A09-Y6	6.2	896 – 980	RPSMAF		Yagi
A09-Y7	7.2	902 – 928	RPSMAF		Yagi
A09-Y8	8.2	902 – 928	RPSMAF		Yagi
A09-Y9	9.2	902 – 928	RPSMAF		Yagi
A09-Y10	10.2	902 – 928	RPSMAF		Yagi
A09-Y11	11.2	902 – 928	RPSMAF		Yagi
A09-Y12	12.2	902 – 928	RPSMAF		Yagi
A09-Y13	13.2	902 – 928	RPSMAF		Yagi
A09-Y14	14.2	902 – 928	RPSMAF		Yagi
A09-Y15	15.2	902 – 928	RPSMAF		Yagi
A09-W7	7.2	902 – 928	RPSMA		Base Station
A09-M7	7.2	902 – 928	RPSMA		Base Station
A09-F2	2.2	902 – 928	RPSMA		Base Station
A09-F5	5.2	902 – 928	RPSMA		Base Station
A09-F8	8.2	902 – 928	RPSMA		Base Station
A09-F9	9.2	902 – 928	RPSMA		Base Station
Whip Antennas					
A09-HASM-675	2.1	902 – 928	RPSMA		½ wave Whip
A09-HBMM-7-P6I	2.1	902 – 928	MMCX		½ wave Whip
A09-QBMM-3-P6I	1.9	902 – 928	MMCX		¼ wave Whip
A09-QI	1.5	902 – 928	Integrated		¼ wave wire
NOTE: If using an external antenna, the wire antenna should be removed from the 9XStream module.					

Appendix E – 9XStream Commands

AT Command	Binary Command Number	Version	Description	Parameters	# Bytes Returned	Factory Default
DT	0	4.08	Set the Module Address. (Only modules with the same address can communicate.)	Range: 0 – FFFFH	2	0
SM	1	4.08	Adjust Sleep Mode Setting	0 - No Sleep 1 – Pin Sleep 2 – Serial Port Sleep 3 – Cyclic 0.5 second 4 – Cyclic 1.0 second 5 – Cyclic 2.0 second 6 – Cyclic 4.0 second 7 – Cyclic 8.0 second	1	0
ST	2	4.08	Set time to Sleep. Time of inactivity before entering Sleep Mode (This number is only valid in Cyclic and Serial Port Sleep settings).	Range: 10 – FFFFH (tenths of a second)	2	64H
HT	3	4.08	Set time before long header. Time of inactivity (no serial or over-the-air data is transmitted or received) before a long header is used. The default value (FFFFH) means no long header will be sent.	Range: 0 – FFFFH (tenths of a second)	2	FFFFH
BT	4	4.08	Set silence time before command sequence.	Range: 0 – FFFFH (tenths of a second)	2	AH
AT	5	4.08	Set silence time after command sequence.	Range: 0 – FFFFH (tenths of a second)	2	AH
CT	6	4.08	Set time out from AT Command Mode. Returns to Idle Mode from AT Command Mode if no valid commands have been received within this time period.	Range: 0 – FFFFH (tenths of a second)	2	C8H
FL	7	4.08	Set serial software flow control. (Hardware flow control ($\overline{CTS}$) is always on.)	1- No software flow control 1- use software flow control	1	0
WR	8	4.08	Write all configurable parameters to non-volatile memory. All settable parameters are stored.	NA	NA	NA

Appendix E – 9XStream Commands (cont.)

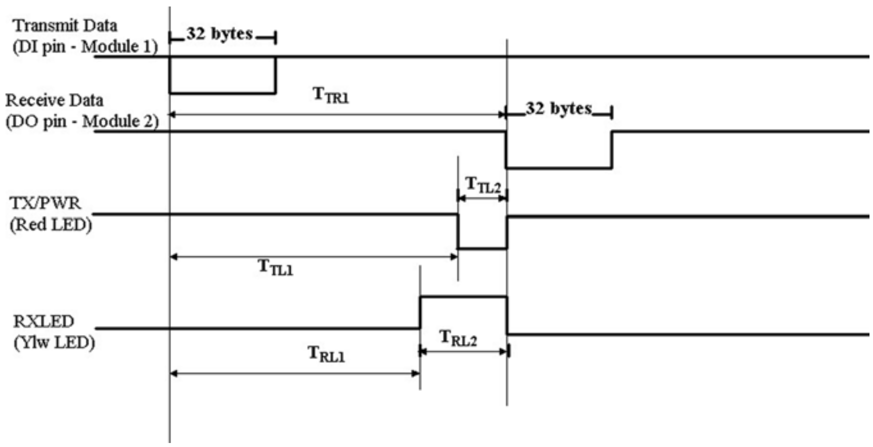
AT Command	Binary Command Number	Version	Description	Parameters	# Bytes Returned	Factory Default
CN	9	4.08	Exit AT Command Mode.	NA	NA	NA
E1	11	4.08	Enable character echo in AT command mode.	NA	NA	NA
LH	12	4.08	Transmit header time. Used to adjust the length of the long header.	Range: 0 – FFH (tenths of a second)	1	1H
FH	13	4.08	Force header on next transmit.	NA	NA	NA
RE	14	4.08	Restore defaults configuration.	NA	NA	NA
ER	15	4.08	Set Receive Error Count. This value is reset to 0 after every reset. It is not non-volatile. Once this counter reaches FFFFH, it remains there until reset.	Range: 0 – FFFFH	2	0
GD	16	4.08	Set Receive Good Count. This value is reset to 0 after every reset. It is not non-volatile. Once this counter reaches FFFFH, it remains there until reset.	Range: 0 – FFFFH	2	0
HP	17	4.08	Set Network number. Each Network uses a different hop sequence. Seven different Network numbers are available. This can be used to operate independent networks of 9XStream modules in the same vicinity.	Range: 0 – 6	1	0
MK	18	4.08	Set Module Address Mask. Only bits set to '1' are used in the address comparison between the transmitter's address and that of the receiver. A global address is an address that has the same bits set as the Address Mask.	Range: 0 – FFFFH	2	FFFFH
CC	19	4.08	Set command sequence character. The parameters determine the ASCII command sequence character used to enter AT Command Mode.	Range: 20H – 7FH	1	2BH ('+')

Appendix E – 9XStream Commands *(cont.)*

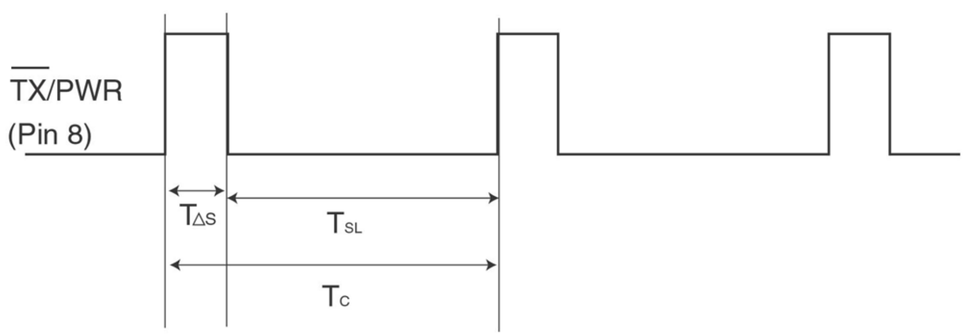
AT Command	Binary Command Number	Version	Description	Parameters	# Bytes Returned	Factory Default
VR	20	4.08	Firmware version	NA	2	NA
BD	21	4.08	Set Serial Baud Rate (bps). Use to adjust the serial port baud rate. The new baud rate will not take effect until the ATCN command is issued. If the BD command is issued in Binary Command Mode, it must be stored using the WR command, and the new baud rate will take affect after resetting the module.	Range: 1 - 6 1 - 2400 2 - 4800 3 - 9600 4 - 19200 5 - 38400 6 - 57600	1	
RT	22	4.10	RTS/CMD Control. This command must be used to turn on binary programming if Binary Command Mode will be used. (By default, binary programming is disabled, so any commands sent in Binary Command Mode will not be understood until binary programming is enabled.)	0 – Disable binary programming. 1 – Enable binary programming.	1	0
SY	23	4.12	Set Sync Timer. This time represents the time that the transmitter and receiver stay in sync after receiving or sending data. Setting this parameter to 20 (14H) will allow any module to transmit within the next 2 seconds utilizing a header of 8ms instead of 35ms. Use this parameter to speed up communication latency and turn-around time.	Range: 0 –FFH (tenths of a second)	1	0

Appendix F – Timing Diagrams

Pin Timings



Sleep Mode Timings



Appendix G – Electrical Characteristics

DC Characteristics
(Vcc=4.75V to 5.25V)

Symbol	Parameter	Condition	Min	Typical	Max	Units
V_{IL}	Input Low Voltage	All input signals	-0.5		0.3*Vcc	V
V_{IH}	Input High Voltage	(Except $\overline{\text{RESET}}$)	0.6*Vcc		Vcc+0.5	V
V_{IH2}	Input High Voltage	($\overline{\text{RESET}}$)	0.9*Vcc		Vcc+0.5	V
V_{OL}	Output Low Voltage	I_{OL}=20mA Vcc=5V			0.6	V
V_{OH}	Output High Voltage	I_{OH}=-3mA Vcc=5V	4.2			V
I_{IL}	Input Leakage Current I/O Pin	Vcc=5V, pin low (abs. value) (Except CTS, DO, RESET, CONFIG)			8.0	uA
I_{IH}	Input Leakage Current I/O Pin	Vcc=5V, pin high (abs. value) (Except RTS/CMD)			980	nA
I_{IL2}		$\overline{\text{CTS}}$, DO, $\overline{\text{RESET}}$		$(Vcc-V_I)/10$		mA
I_{IL3}		$\overline{\text{CONFIG}}$		$(Vcc-V_I)/47$		mA
I_{IH2}		RTS/CMD		$V_I/10$		mA

Appendix G – Electrical Characteristics (cont.)

AC Characteristics
Pin Timings (SY=0)

Symbol	Description	X09-019	19200 Timing* (B = Number of Bytes)	X09-009	9600 Timing* (B = Number of Bytes) (T measured in ms)
T_{R1}	Latency from the time data is transmitted until received.	54 ms	For 0<B<64, T=41.6+(0.4*B) For B>63, T=66.8 ms	72.0 ms	For 0<B<40, T=46.27+(0.73*B) For B>=39 bytes, T=74.8 ms
T_{TA1}	Latency from when serial data enters the DI pin to when it is actually transmitted over-the-air.	1.6 ms	For all B, T=1.6 ms	2.0 ms	For all B, T=2.0 ms
T_{TA2}	Latency of over-the-air data transmission.	52.4 ms	For all B, T=38.8 + (0.4*B) + 0.8	70 ms	For all B, T=41.8+(0.8*B) + 1.6
T_{P1}	Time duration of header bits in data packet.	31.04 ms	For all B, T=38.8 ms	41.8 ms	For all B, T=41.8 ms
T_{P2}	Time duration of data bits in data packet.	12.8 ms	For all B, T=0.4B ms	25.6 ms	For all B, T=0.8B ms
T_{P3}	Time duration of CRC bits in data packet.	0.83 ms	For all B, T=0.8 ms	1.6 ms	For all B, T=1.6 ms
T_{TL1}	Time from when data packet is transmitted until TX/PWR first pulses low.	46.4 ms	For 0<B<12, T=37.8 ms For 11<B<65, T=33.3+(0.39*B) ms For B>64, T=58.4 ms	55.6 ms	For 0<B<12, T=39.8 ms For 11<B<35, T=30.52+(0.77*B) For B>34 bytes, T=56.8 ms
T_{TL2}	Time that TX/PWR pin is driven low (when red LED flashes).	8.4 ms	For 0<B<14, T=3.24+(0.4B) For B>13, T=8.48 ms	16.8 ms	For 0<B<14, T=6.5+(0.8*B) ms For B>13, T=16.8 ms

AC Characteristics
Pin Timings (SY=0) *(cont.)*

Symbol	Description	X09-019	19200 Timing* (B = Number of Bytes)	X09-009	9600 Timing* (B = Number of Bytes) (T measured in ms)
T_{RL1}	Time from when data packet is transmitted until RXLED pin first goes high on receiver.	40.6 ms	For all B, T=39.6 ms	44.5 ms	For all B, T=44.5 ms
T_{RL2}	Time that RXLED pin is driven low (when yellow LED flashes).	13.6 ms	For 0<B<65, T=0.79+(0.408*B) For B>64, T=26.9 ms	25.6 ms	For 0<B<37, T=1.63+(0.794*B) For B>36, T=30.2 ms
* Note: The timing formulas are approximations over a specified range of bytes. They are accurate to within 1 – 2 milliseconds.					

Pin Timings (SY = 10)

Symbol	Description	X09-019	19200 Timing Formulas* (B = Number of Bytes)	X09-009	9600 Timing Formulas* (B = Number of Bytes) (T measured in ms)
T_{R1}	Latency from the time data is transmitted until received.	12.2 ms	For 0<B<9, T=9.0+(0.4*B) For B>8, T=12.2 ms	19.4 ms	For 0<B<6, T=15.5+(0.775*B) For B>5 bytes, T=19.4 ms
T_{TA1}	Latency from when serial data enters the DI pin to when it is actually transmitted over-the-air.	1.6 ms	For all B, T=1.6 ms	2.0 ms	For all B, T=2.0 ms
T_{TA2}	Latency of over-the-air data transmission.	32.8 ms	For all B, T=T_{P1}+ (0.4*B) + 0.8	61.7 ms	For all B, T=T_{P1}+(0.8*B) + 1.6
T_{P1}	Time duration of header bits in data packet.	19.2 ms	For B<9, T=6.9 ms For 8<B<29,	34.5 ms	For B<6, T=11.8 ms For 5<B<22,

			T=13.2 ms For 28<B<54, T=19.2 ms		T=23.2 ms For 21<B<45, T=34.5 ms

AC Characteristics
Pin Timings (SY=10) *(cont.)*

Symbol	Description	X09-019	19200 Timing Formulas* (B = Number of Bytes)	X09-009	9600 Timing Formulas* (B = Number of Bytes) (T measured in ms)
T_{P2}	Time duration of data bits in data packet.	12.8 ms	For all B, T=0.4B ms	25.6 ms	For all B, T=0.8B ms
T_{P3}	Time duration of CRC bits in data packet.	0.83 ms	For all B, T=0.8 ms	1.6 ms	For all B, T=1.6 ms
T_{TL1}	Time from when data packet is transmitted until TX/PWR first pulses low.	6.04 ms	For all B, T=6.04 ms	9.08 ms	For all B, T=9.08 ms
T_{TL2}	Time that TX/PWR pin is driven low (when red LED flashes).	6.44 ms	For 0<B<9, T=3.24+(0.4*B) For B>8, T=6.44 ms	11.3 ms	For 0<B<6, T= 6.5+(0.8*B) ms For B>5, T=11.3 ms
T_{RL1}	Time from when data packet is transmitted until RXLED pin first goes high on receiver.	8.44 ms	For all B, T=8.44 ms	14 ms	For all B, T=14 ms
T_{RL2}	Time that RXLED pin is driven low (when yellow LED flashes).	4.28 ms	For 0<B<10, T 0.8+(0.4*B) For B>9, T=4.28 ms	5.68 ms	For 0<B<6, T=1.6+(0.82*B) For B>5, T=5.68 ms

* Note: The timing formulas are approximations over a specified range of bytes. They are accurate to within 1 – 2 milliseconds.

Cyclic Sleep Mode Timings

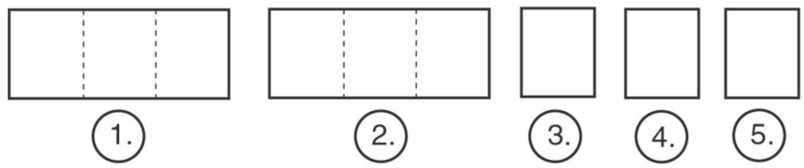
Symbol	Description	19200-baud	9600-baud
$T_{\Delta S}$	Time when module is listening for a valid header to start receiving data.	100 ms	100 ms
T_{SL}	Time where the 9XStream is in its low power cyclic sleep. This time is adjustable using the SM command.	0.5 seconds 1.0 seconds 2.0 seconds 4.0 seconds 8.0 seconds (depends on SM)	0.5 seconds 1.0 seconds 2.0 seconds 4.0 seconds 8.0 seconds (depends on SM)
T_C	Total period between successive pulses of the module awakening from Sleep Mode. This value is dependent on the setting of the SM command.	0.6 seconds 1.1 seconds 2.1 seconds 4.1 seconds 8.1 seconds (depends on SM)	0.6 seconds 1.1 seconds 2.1 seconds 4.1 seconds 8.1 seconds (depends on SM)

Appendix H – Sleep Mode Settings

Sleep Settings	**Transition to Sleep Mode**	**Return to Idle Mode**	**Sleep Current**		**Configure Commands**
No Sleep Mode	None. The module remains in Idle Mode. (Default Setting)	-	50 mA		-
Pin Sleep	High on SLEEP pin (pin 2).	Low on SLEEP pin.	<2 uA		SM
Serial Port Sleep	Automatic transition after a user-defined period of module inactivity (no transmitting or receiving of data). Set by ST command.	Any serial byte received on DI pin.	1 mA		SM, ST
Cyclic Sleep	Automatic transition after a user-defined period of module inactivity (no transmitting or receiving of data). Set by ST command.	Periodically returns to Idle Mode	**0.5 Cyclic:** Min: 60µA Max: 40mA Avg: 7.4mA **2.0 Cyclic:** Min: 60µA Max: 35.7mA Avg: 2.07mA **8.0 Cyclic:** Min: 60µA Max: 35.56mA Avg: 630 µA	**1.0 Cyclic:** Min: 60µA Max: 35.7mA Avg: 4mA **4.0 Cyclic:** Min: 60µA Max: 35.7mA Avg: 1.1mA	SM, ST, LH, HT

Appendix I – Module Part Numbers

Module Part Numbers Key



1. Operating Frequency
   - ***X09*** *- 900 MHz*
   - ***X24*** *- 2.4 GHz*
2. Over-Air Baud Rate
   - ***009*** *- 9600-baud*
   - ***019*** *- 19200-baud*
3. Wire Antenna
   - ***W*** *- Wire Antenna*
   - ***N*** *- No Wire Antenna*
4. Connector
   - ***M*** *- MMCX Connector*
   - ***S*** *- SMA Connector*
5. Temperature Rating
   - ***C*** *- Commercial. Certified for operation from 0° to 70° C.*
   - ***I*** *- Industrial. Conformal coated. Certified for operation from -40° to 85° C.*
   - ***T*** *- 100% Tested. Conformal coated. Certified for operation from -40° to 85° C.*

Using the 9XStream Development Kit

Introduction:

Use this development kit to experience the extended range and ease of use of the MaxStream 9XStream module. This module transmits data at either 9600 or 19200 bits per second (see FCC label on module shield) in the license-free 900MHz ISM band. See how simple it is to communicate with the module using asynchronous serial communications by following the instructions below.

Contents:

2	9XStream Frequency Hopping modules
2	Interface Boards
2	9 VDC power supplies
2	DB-9 straight through serial cables
1	Null modem adapter
1	3.5" floppy disk containing file RAT.TXT

Requirements:

Two (2) computers with an available COM port and Windows 95/98 or NT.

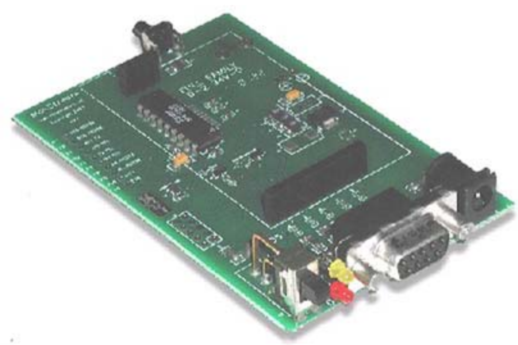


Figure 1 – MaxStream PC Interface Board

Instructions:

1. Assemble and Connect Interface Boards to computers.
    a. Connect the modules to the Interface Boards by fitting the 4 and 11-pin connectors into their respective female headers.
    b. Attach the male sides of one of the DB-9 Connecting Cables to the female DB-9 jacks on the Interface Boards.
    c. Attach the female side of a DB-9 connecting cable to an available RS-232 port on the back of Computer 1. Connect Module 2 to Computer 2 in the same fashion.
    d. Plug power supplies into the Interface Boards. Turn the switch on. The red LEDs on the Interface Boards will illuminate to show the boards are powered.
    e. Refer to figure 1 for completed assembly.

2. Run and configure HyperTrm.exe on both computers
    a. Open the folder on the Start Menu found under Programs -> Accessories -> Communications -> HyperTerminal.
    b. Double-click on the application HyperTrm.exe and choose a name and an icon for the new connection in the **Connection Description** dialogue box.
    c. In the **Connect To** dialogue box on each computer, select *Connect using: Direct to Com1* or *Direct to Com2* to correspond with the COM port used on the respective computers (see figure 2) . Click *OK*.
    d. In the **COM Properties** dialogue box, set the following: *Bits per second: 19200; Data bits: 8; Parity: None; Stop Bits: 1* and *Flow Control: Hardware* (See figure 3). Click *OK.* (Set the *Bits per second* to *9600* if you are using 9XStream-96 modules)
    e. Both computers are now set up and ready to communicate.

Figure 2 –Connect To Dialogue Box

Instructions (cont.)

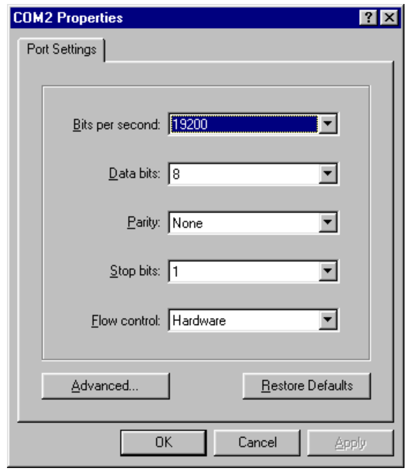


Figure 3 – COM Properties Dialogue Box

3. Test Connection
   a. Place cursor in HyperTerminal window of Computer 1 and type a message. Notice that text appears only in the window of Computer 2 and text typed on Computer 2 appears only on Computer 1. This text is being transferred over the air by the 9XStream modules.
   b. Transfer the file RAT.TXT
      i. On Computer 1: Select *Transfer* menu -> *Send File*(or try right-clicking in the HyperTerminal window). Insert the disk into the A: drive and enter *Filename: A:\RAT.TXT* Select *Protocol: Ymodem* (See figure 4). Press *Send*.

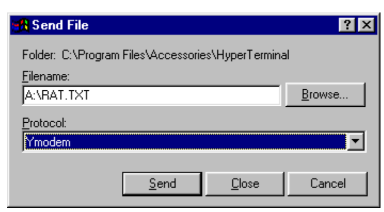


Figure 4 – Send File Dialogue Box

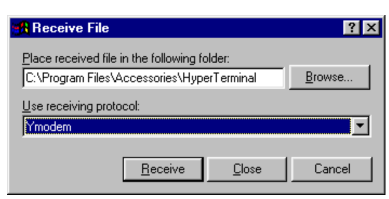


Figure 5 – Receive File Dialogue Box

Instructions (cont.)

   ii. On Computer 2: Select *Transfer* menu -> *Receive File.* Select a folder in which to place the file and select *Protocol: Ymodem* (see figure 5). Press *Receive*.
   iii. The file will begin to transfer and any errors or retries will be accounted for. Touch the antennas and move the modules around to notice that errors or retries do occur under certain circumstances.
   iv. When the transfer completes, open RAT.TXT on Computer 2 and observe the pattern of text, it will be easy to see if any characters were lost or corrupted.
   v. Any file can be transferred this way. Use either Xmodem or Ymodem protocol. Both computers must have the same settings.
  c. Try range testing by distancing the two computers from each other. The modules can send and receive data up to 10 miles line of sight using gain antennas.

4. Problems (Trouble Shooting)
  a. Can't find the HyperTerminal on your computer?
   i. Search your hard drive for HyperTrm.exe
   ii. Download a free version from http://www.hilgraeve.com
  b. Power LED doesn't illuminate when battery clip is attached?
   i. Replace the battery.
  c. Cannot connect to the comm port or communication not working?
   i. Try selecting another comm port by selecting *Properties* under the *File* menu.
   ii. If necessary test the comm ports with a null modem cable (cross RX and TX) between the two computers to verify operation of comm ports.
  d. Characters are getting scrambled?
   i. Verify that both comm ports are set match the baud rate of the modules being tested. Probably 9600 baud or 19200 bits per second. Look for the baud rate on the FCC sticker, 96 or 192 respectively.

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