SECTION 6

USER'S MANUAL

Hornet Transceiver Operator's Guide

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Hornet Transceiver
Operator's Guide

Revised February 8, 2000

Compliance Notice

FCC Compliance

Warning

Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. Government regulations prohibit the use of an antenna other than the antenna provided by the manufacturer.

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 when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy, and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.
However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the 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.

Document Revision History

Listed below is the history log for this document. This log shall be updated each time changes are made and the next revision number shall be assigned.

Revision	Date	Author	Reason
Pre-release	2/09/00	L. Ochs	Draft manual for FCC

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Preface
About This Guide

About Your Hornet Transceiver Operator's Guide

The *Hornet Transceiver Operator's Guide* is your source for installing, configuring, and operating the Hornet Transceiver. The guide is designed to provide you with step-by-step instructions for connecting the transceiver to your computer and configuring it for use with OEM products. The guide includes all electrical, mechanical, and protocol information that is required to integrate a Hornet transceiver with your Host equipment.

How to Use This Guide

The *Hornet Transceiver Operator's Guide* is organized by the following major sections:

- **Compliance Notice**
  This section has the necessary Federal Communication Commissions (FCC) Compliance Statement.
- **Preface – About this Guide**
  This section gives a brief overview of the manual layout.
- **Chapter 1 – Introduction**
  This section describes the Hornet radio features and provides general information and comparisons to other radio types.
- **Chapter 2 – Getting Started**
  This section assumes the user has purchased evaluation units and provides the information required to unpack, install, configure, and operate the Hornet radios.
- **Chapter 3 –Interface**
  This section provides the physical interface specifications of the Hornet radio.
- **Chapter 4 – Protocol**
  This section provides detailed information related to the Hornet radio protocol.
- **Appendix A – Specifications**
  This section provides the Hornet radio specifications.

Chapter 1
Introduction

Chapter Overview

This chapter provides a general overview of the Hornet Transceiver. It includes the following information:

- A description of the Hornet Transceiver
- A list of Hornet Transceiver features
- An explanation of the differences between Frequency Agile, Fixed Frequency, and Spread Spectrum
- A description of the two types of protocols that the Hornet Transceiver supports: Transparent or Message

Product Description

The Hornet Transceiver provides secure, reliable, wireless communications for point-to-point and point-to-multi-point data links requiring a high degree of portability. Such applications could include point of sale, medical, mobile computing, data collection, remote monitoring, and data entry systems.
The Hornet Transceiver offers high performance with low power consumption. The transceiver operates in the 2.4 GHz International frequency band and can be approved for use in most areas of the world. It is a frequency agile design in that four discrete frequencies (channels) are used for data transmission. These multiple frequencies and the use of Carrier Sense Multiple Access (CSMA) enables the unit to have excellent performance in congested environments. Prior to data transmission, the radio searches to find a free channel for transmission and then proceeds to establish a link with the destination device. If a channel is not free the radio waits a random period of time before searching again for a free channel.

Hornet Transceiver Features

The Hornet Transceiver provides advanced features to ensure reliable communications. Listed below are some of these features:

- Four channel selectivity
- Carrier Sense Multiple Access to enable reliable communications in a congested environment
- Error detection and correction protocols to provide performance similar to that of a wire
- Point to Point, Point to Multi-Point, and Broadcast capability
- Automatic channel switching to avoid signal nulls
- License free operation

Frequency Agile vs. Fixed Frequency (Narrow Band)

The Hornet Transceiver employs a Frequency Agile design that provides significant benefits over fixed frequency transceivers. Unlike Frequency Agile communications, typical Narrow Band radio technology is based on sending information on a single, fixed frequency. As a result, Narrow Band communications can be blocked or jammed by other sources transmitting on the same frequency. Frequency Agility provides a level of performance above that which can be achieved with a fixed frequency link. The Hornet transceiver employs intelligent channel switching to achieve the following:

- Interference avoidance by automatically switching to another channel
- Avoidance of signal nulls and destructive multi-path by switching to a channel with superior propagation characteristics.

Fixed frequency transceivers are very prone to interference and even more prone to the affects of destructive multi-path. Destructive multi-path results in received signal strengths that can fluctuate by 30 dB or more as a receiver moves about a very small area. With a fixed frequency design, if the receive signal level falls below the receiver sensitivity the radio link will be lost. In the case of the Hornet, the radio simply identifies this situation and switches to a channel that has superior signal propagation characteristics in order to avoid the destructive multi-path effects. Due to multi-path, each of the four channels will result in different received signal levels that may vary by 30 dB or more as the transceiver is moved about an area and as people or objects move about the area. The radio intelligently selects a frequency that enables adequate signal levels to achieve a valid communication link.

Frequency Agile vs. Spread Spectrum

The Hornet Transceiver employs a Frequency Agile design that is different than spread spectrum in various ways

Hornet Operating Modes

The Hornet radio has two basic modes of operation, namely Transparent and Message.

Chapter 2
Getting Started

Unpacking

The Hornet Evaluation kit comes with the following items:

- 2 ea – Hornet RS232 Adapter boards
- 2 ea – Ribbon flex cable connecting the Hornet radio to the RS232 Adapter board
- 2 ea – Power Supply, 120VAC to 5VDC
- 2 ea – 9VDC battery
- 2 ea – Hornet radio (Xetron part number 360029G01)
- 2 ea – Computer cable, 9 pin male to 9 pin female
- 1 ea – 1.5" diskette containing documentation and evaluation software

The Hornet evaluation kit includes everything to enable a quick and thorough assessment of the Hornet radio's performance and its suitability for the intended application. The items included will enable the designer to quickly evaluate the radio's performance and progressively move forward toward integration.

Initially the Hornet can be connected between computers to perform range tests, communication tests, coverage tests, etc. A connector is also provided on the Adapter board to enable a direct CMOS connection to the radio for the second step in the integration process. For the final phase of integration, the radio can be disconnected from the interface board and integrated with the intended target system.

Setup

Unpack the radios and place them on a flat bench or desk. Connect the computer cable between the Adapter board 9 pin DSUB connector and the computer serial port. Power the Adapter board with the supplied wall mount power supply or battery. The battery works best for mobile tests. Care should be taken to monitor the battery voltage level and replace it when it falls below 8 volts to prevent erratic operation.

Set up the computer as follows:
In Windows 95/98 perform the following to ensure proper flow control and operation:

- Select START, SETTINGS, CONTROL PANEL
- From the Control Panel, select SYSTEM, DEVICE MANAGER
- Double click on the COM port to be used
- Set Flow Control to HARDWARE
- Select ADVANCED and set the TRANSMIT BUFFER to the Lowest setting **(required to prevent Hornet buffer overrun)**
- Repeat the above steps for each COM port used (i.e. COM1, COM2, COM3, etc.)

Perform the above for the second radio and computer.

Software Installation

Unzip the files from the supplied diskette and install them in a directory on the C: drive. Double click on the "*HornetEval.exe*" file to run the Evaluation Software. The following initial screen should be seen.

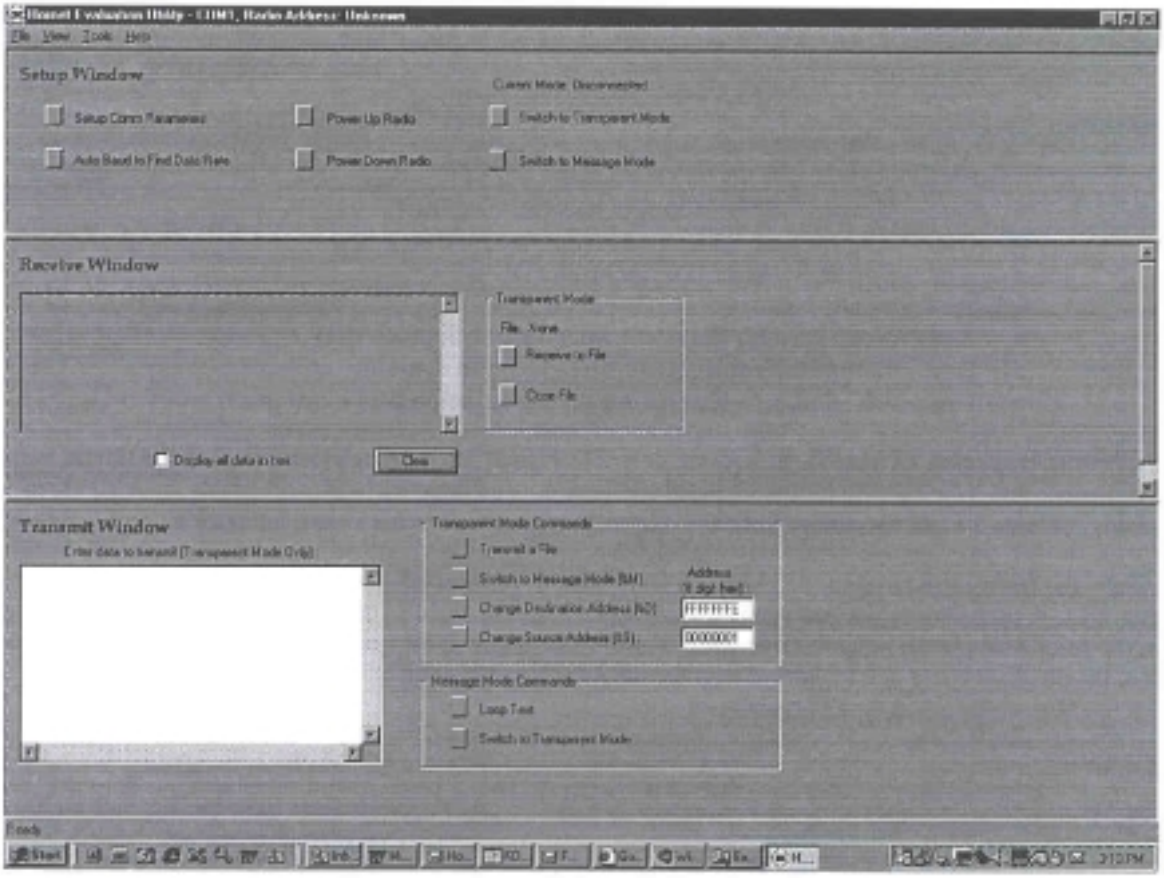


Figure 1 Hornet Eval main screen

The HornetEval program has three basic windows, *Setup Window, Transmit Window, and Receive Window*. The *Setup* Window provides a method of configuring and initializing the radio. The *Transmit Window* is used to initiate data transmission and the *Receive Window* to view or capture received data. The functions of each are described in more detail in this document.

Overview

Much of the functionality of the HORNET is controlled via the EEPROM settings in the microcontroller. These settings are written using a utility called HornetEval.exe which is a WIN32 GUI program that manages the settings in files and uploads and downloads the values to the Hornet radio. This utility also has many other features which may or may not be used by the operator such as calibration, command test, and a raw serial interface. At the time of this writing some of these features are still under development and this utility will continue to be enhanced as new features are needed.

Concept of Operation

The HORNET has 512 bytes of EEPROM space which are used to hold operating parameters, a Transparent Mode Address List, and Identification Fields. These values are stored in Intel-Hex formatted files which can be loaded into the HORNET EEPROM in two ways. The first way is to use the serial connection to the microcontroller. The second way is to load directly using an Atmel AVR Evaluation Board (not supplied). Either way, this utility can be used to build the EEPROM Hex file. This utility is also the means for loading the EEPROM using the serial connection by sending special "XE" commands to the target. "XE" commands are explained in the "Host Interface Specification".

In addition to managing the EEPROM settings, this utility also has built-in functions for issuing other commands to the target via the serial interface, such as Calibration commands, soft reset, and a simple command interface test.

It should be noted that many of these settings only take effect after the device has been reset either via a power cycle or via the software reset (see 'Issue Soft Reset' button). The Radio's EEPROM map is shown in Appendix A.

Radio Configuration

With the HornetEval running and power supplied to both radios, the user is now ready to configure the radios. From the SETUP WINDOW select "Setup Comm parameters" and set the parameters to the intended baud rate, comm port, and Hardware flow control.

Select the "Power Up Radio" function to apply power to the radio. The DTR signal controls the Hornet on board power FET switch. To verify power is applied to the radio, ensure the DTR LED is on.

To establish communication with the radio, select "Auto baud to find data rate". The software will sequentially select each baud rate and mode of operation until the correct settings are found.

The radio can be configured now that communications have been established. From the top toolbar select the "View" pull down menu and then select "Configure radio dialog". If the "Configure radio dialog" is grayed and unavailable for selection, then select "Switch to Message Mode" in the *SETUP WINDOW*. Go back and select "Configure radio dialog". The following screen should appear:

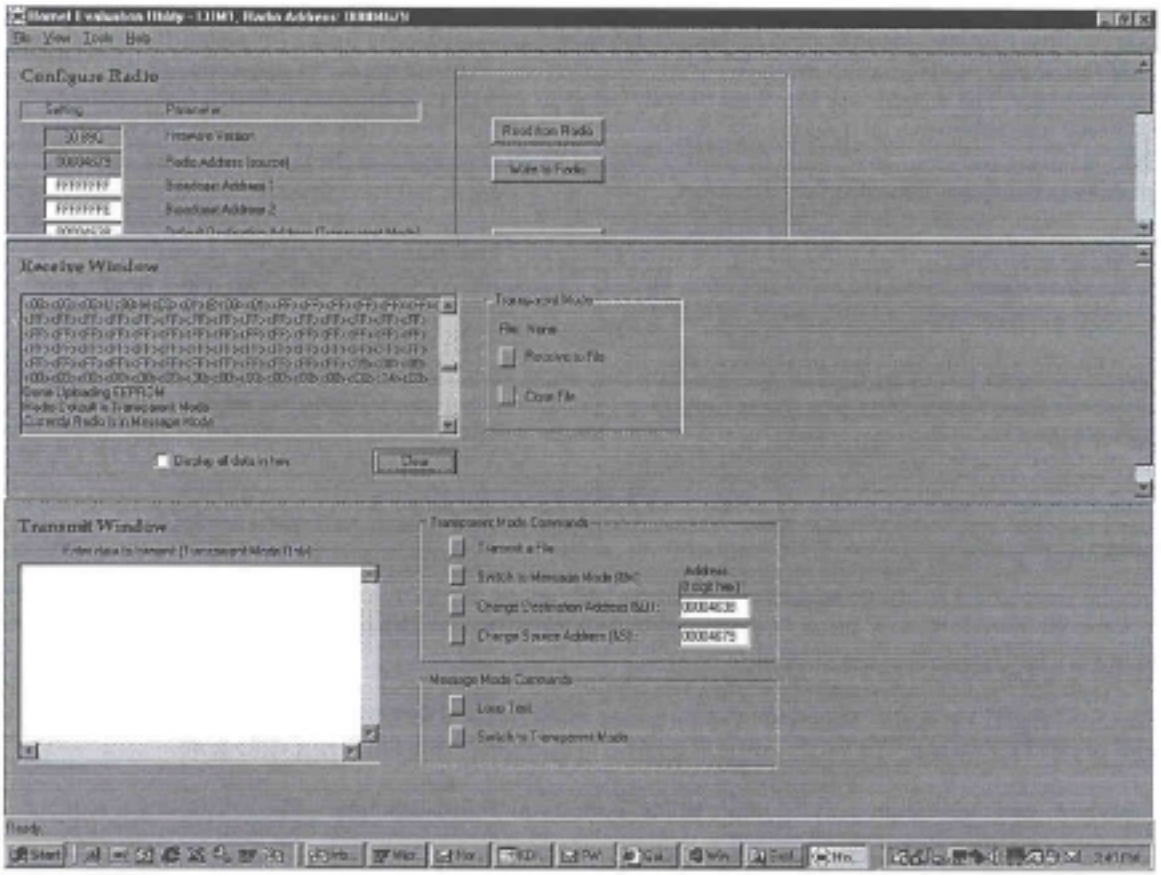


Figure 2 Configure radio dialog

Position the cursor on the bottom boundary of the *Radio Configure Window* and drag the cursor to resize to full screen such that the following screen can be seen

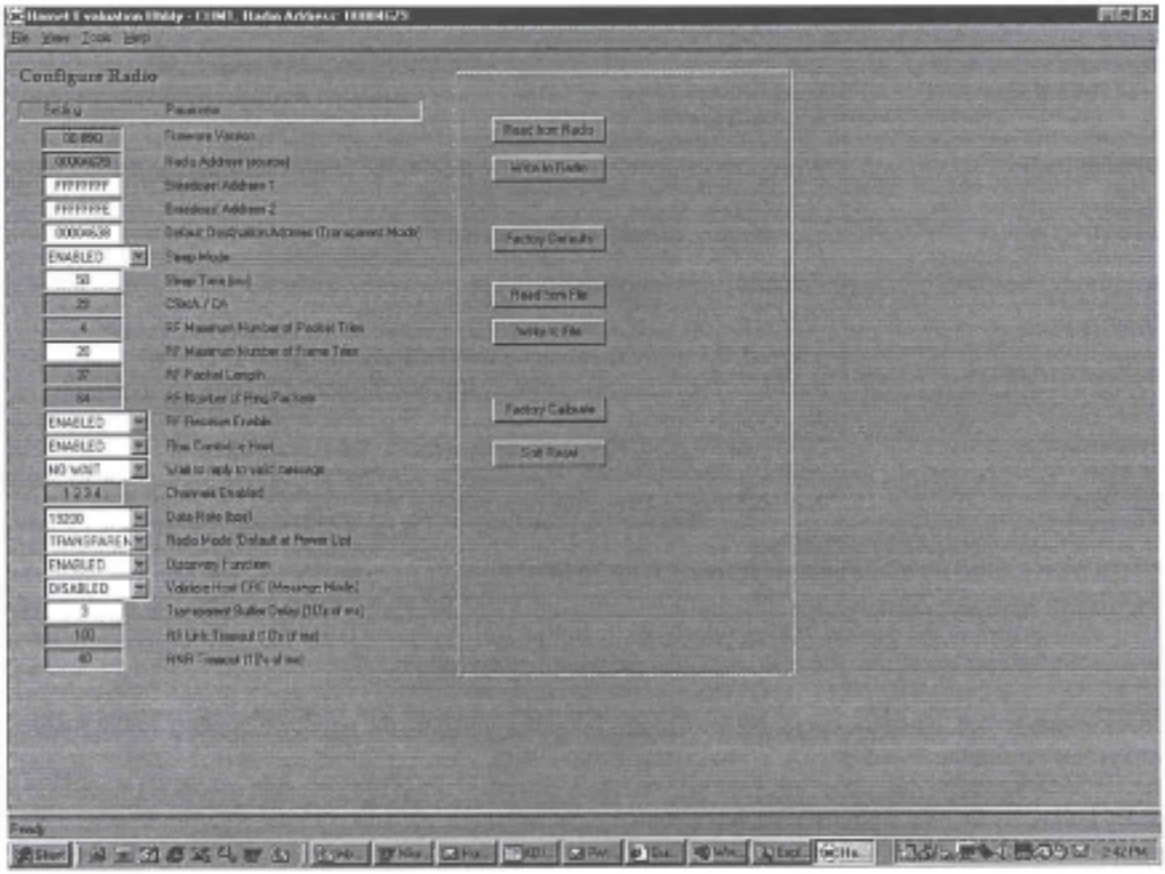


Figure 3 Configure Radio full screen

The following functions are available from this window:

Function	Description
Read from Radio	Reads the values stored in the radio's EEPROM settings and displays them on screen
Write to Radio	Writes the values displayed on screen to the radio's no volatile EEPROM locations
Factory Defaults	Sets the parameters on screen to the factory defaults
Read from File	Uploads parameters from a file that was previously stored
Write to File	Writes the on screen parameters to a file in Intel Hex format for later retrieval. As many files can be written and maintained as desired. The Intel-Hex format is compatible with most device programmers including the AVR evaluation board.
Factory Calibrate	Used by the factory for calibration of the radio
Soft Reset	Resets the radio to use the new settings

"Read from Radio" all of the parameters and "Write to File" for later recovery should you decide to re-install the original settings. After reading the parameters from the radio, the on-screen parameters can be changed. After setting them to the desired values, select "Write to Radio" to program the radio with the new settings. Issue a "Soft Reset" to ensure the radio is initialized with the new values.

To leave this screen, place the cursor on the window boundary and drag the window boundary to the smaller screen size. From the toolbar select "View" then "Setup Dialog".

Listed below are the descriptions of each parameter.

Firmware Revision

This field reflects the current revision level of the firmware in the radio. It is a six digit string formatted as XX.YYZ where XX is the revision level, YY is the release level. Z is a product code to differentiate firmware targeted for different applications which may enable different feature sets. This field does not need to be filled in and downloaded to the radio because the radio writes the firmware revision into EEPROM when it comes up and sees that the string location in EEPROM differs from the revision in the firmware. Thus this value will always reflect the correct revision level of the firmware when it is uploaded and read.

Radio Address (Source)

This is the 32 bit hex value that is the address of this HORNET device. This address is factory set to the serial number of the radio. This utility does not provide the capability to change this address, however it can be changed using an "XE" command as described in the Host Interface Specification.

Broadcast Address 1

This is the 32 bit broadcast address. Normally this is set to FFFFFFFF.

Broadcast Address 2

This is the 32 Transparent Mode or secondary broadcast address. Normally this is set to FFFFFFFE. It collects all message frames sent by units who have their Default Destination address set to this address. Units will filter out any messages received where the sender is not in the Transparent Mode Address List if this feature is present in the firmware.

Default Destination Address

This is the 32 bit address that is loaded into the destination address registers when a Transparent Mode frame is being sent. If it is desired that all Transparent Mode frames be broadcast then this should always match Broadcast Address 2. If, however, it is desired that two Transparent Mode devices be dedicated to each other in a point to point communication scheme, then this address should match the Radio Address(Source) of the other unit. Setting the Destination Address to the Source Address of another unit and vice versa will cause all communication to occur as if there is simply a wire between the hosts.

Sleep Mode

When enabled, the radio automatically duty cycles based on the sleep time. The radio is designed to typically operate in this mode.

Sleep Time

This is the idle time in milliseconds between scanning for Rings while in low power mode.

CSMA/CA

Carrier Sense Multiple Access/Collision Avoidance setting. This factory set parameter identifies the number of times the threshold setting is incremented when determining if a channel is free. Prior to transmission the HORNET searches all channels to find one that is clear. If activity is on all 4 channels the HORNET waits a random period of time before rescanning the channels. With each successive rescan the HORNET increases the allowable threshold setting by 6 dB to determine if the channel is clear. Eventually the interfering signal goes away or the HORNET increments the threshold setting above the interferer and proceeds to transmit. If the parameter is set low such that the threshold setting is below the interferer, the radio increments the frame retry count by one when the maximum number of CSMA/CA increments are reached. If the maximum number of frame retries are reached, the radio sends a NAK (in message mode) to the Host indicating that all channels are busy. In effect, this setting determines politeness of the radio when other radios are in close proximity. The default setting ensures the radio eventually attempts transmission.

RF Maximum Number of Packet Tries

This is the number of times to try to send the same packet if an error occurs.

RF Maximum Number of Frame Tries

This is the number of times to try to send the entire frame if an error occurs. This includes re-ringing the destination and sending all packets over again in an attempt to get the entire frame across and a good status back from the remote HORNET.

RF Packet Length

This is the size of the packet over the RF link including overhead bytes. Leave this set to 37 (32+5 overhead).

RF Number of Ring Packets

Number of ring packets to send out waiting for ACK from target or, in the case of broadcasting, the total number to send out before starting to send the data. This is tied to the ASIC Sleep Time in that the sleep time should not be too long to where it could sleep through an entire ring cycle.

RF Receive Enable

Enabling this function allows the RF to respond to Ring packets at its address and accept data packets. Disabling this function prevents a radio from receiving data.

Flow Control to Host

Enabling this function causes the HORNET to read the RTS line from the Host when deciding whether to send data to the host. The HORNET will still toggle CTS and RI at the appropriate times.

Wait to Reply to Valid Message

After receiving data over the air, the HORNET needs to send back a response with status codes. These codes can be sent at one of 3 different times:

1. **No Wait** – As soon as the CRC is verified and the data is buffered, the status
2. **Until RTS** – As soon as the Host raises RTS, the status codes are sent back.
3. **Until Flush** – The status codes are not sent back until all of the data has been flushed to the Host.

For modes #2 and 3, if RTS is not ready, then the Ring Indicate (RI) line is asserted until RTS is seen. The timeout for this is the RNR Timeout (see below).

It should be noted that the operation of an exchange can be altered significantly depending on this setting. For a message that requires a response (for example a Discovery Request), if "No Wait" is specified then the Discovery Reply will come back in a separate exchange where the remote HORNET will ring back and send the Reply. However, with "Until Flush" set, the Reply will be sent back as part of the same exchange.

Enable Channels

The channels that are enabled for radio use. Up to four channels can be selected. Prior to transmission the radio will automatically scan all enabled channels to find a clear channel. Similarly, the radio will automatically scan all enabled channels for incoming messages.

Data Rate Select

This drop down box is used to select the HORNET's serial data rate. The Hornet radio can be set from 1200 to 19.2 Kbps. Rates above 19.2 Kbps require a different configuration to enable the host to wake the unit by asserting RTS prior to sending serial data.

Radio Mode (Default at Power Up)

This setting programs the EEPROM Mode setting to Transparent or Message mode. This configuration will be used on power up.

Discovery Function

Enables or disables the Discovery function. See the Host Interface Specification for additional information.

Validate Host CRC (Message Mode)

When this function is enabled the HORNET, when in Message Mode, verifies all CRC's within a message from the host device. When disabled, all CRC's are ignored.

Transparent Buffer Delay

Determines how long data will sit in a receive buffer coming from the Host before the HORNET decides it is time to send the data to a remote target. The 'Transparent Buffer Delay' is a timer that is reloaded upon the receipt of each incoming character from the host. The radio sends the data in its buffer when the timer expires. This timer is set in **1 ms** increments. An example of the usage of this timer at a 19.2 Kbps host interface is to set the timer to 2 milliseconds (approximately 4 character times) to ensure the radio transmits the data in the

buffer 2 milliseconds after receipt of a host packet. At 19.2 Kbps, each character is received approximately every 500 us and after the receipt of each character the timer is reloaded to 2 milliseconds. After a complete packet is received and no additional characters are sent the timer expires after 2 milliseconds and the over-the-air transfer is initiated. If the timer is set too short, a longer delay than usual between characters will initiate a transfer. On the other hand, if very long strings of data are sent to the radio without any delays between characters (i.e. continuous file transfer), then over-the-air transmission will begin when the buffer becomes full.

RF Link Timeout

Determines how long a HORNET will sit patiently waiting for a response from the other device over the air before giving up and shutting down its end of the link. This value should always be set *higher* than the 'RNR Timeout' since RNR timeout is a valid response to return while waiting for a response.

RNR Timeout

Determines how long a HORNET is willing to wait for a host device to accept data. This delay only comes into play if Flow Control is enabled (see 'Disable Flow Control') and if the 'Withhold Reply' is not set to 'No Wait.' This value should always be set lower than the 'RF Link Timeout' (see above).

Identification Fields

This list, as described in the Host Interface Specification, is for managing a list of ID fields for this device. There are 256 bytes set aside for this list which can be formatted as one sees fit.

Default Settings

Parameter	Transparent Mode Defaults	Message Mode Defaults
Local Address	Serial no.	Serial no.
Broadcast Address 1	FFFFFFFF	FFFFFFFF
Broadcast Address 2	FFFFFFFE	FFFFFFFE
Destination Address [1]	Local addr. of mating radio	Local addr. of mating radio
Sleep time (ms)	50	50
CSMA/CA	20	20
Packet Tries	4	4
Frame Tries	20	6
RF Packet Length	37	37
RF Number of Ring Pkts	64	64
RF Receive	Enable	Enable
Flow Control to Host	Enable	Enable
Sleep Mode	Enable	Enable
Withhold Reply	No Wait	No Wait
Channel Enable	1,2,3,4	1,2,3,4
Baud rate (Kbps)	19.2	19.2
Discovery	Enable	Enable
CRC	Disable	Disable
Non intelligent Delay (1's of ms)	3	3
RF Link timeout (10's of ms)	10	10
RNR timeout (10's of ms)	5	5

Communication Tests

The HornetEval software has been designed to enable communication testing of the radio in both the Transparent Mode and Message Mode. These modes are further described in Chapter 4: Protocol.

Transparent Mode Tests

In the Transparent Mode of Operation the radio can be tested by performing file transfers and transmitting typed text. Before performing these tests set the radio to the Transparent mode by selecting "Switch to Transparent Mode" in the Setup Window.

To transfer a file perform the following:

- At the receiving end select "Receive to File" in the *Receive Window* and enter a directory path and filename.
- At the Transmit end enter the "8 digit Address" of the receiving radio in the *Transparent Mode Command Window* and then select "Change Destination Address" to program the radio with the proper address.
- Select "Transmit a File" and enter the filename of the file to transfer. Select Open to initiate the file transfer.
- After completion, select "Close File" to close the receiving file.

To transfer typed text perform the following:

- Ensure the destination address is set to the source address of the receiving radio. If not, enter the "8 digit Address" of the receiving radio in the *Transparent Mode Command Window* and then select "Change Destination Address" to program the radio with the proper address.

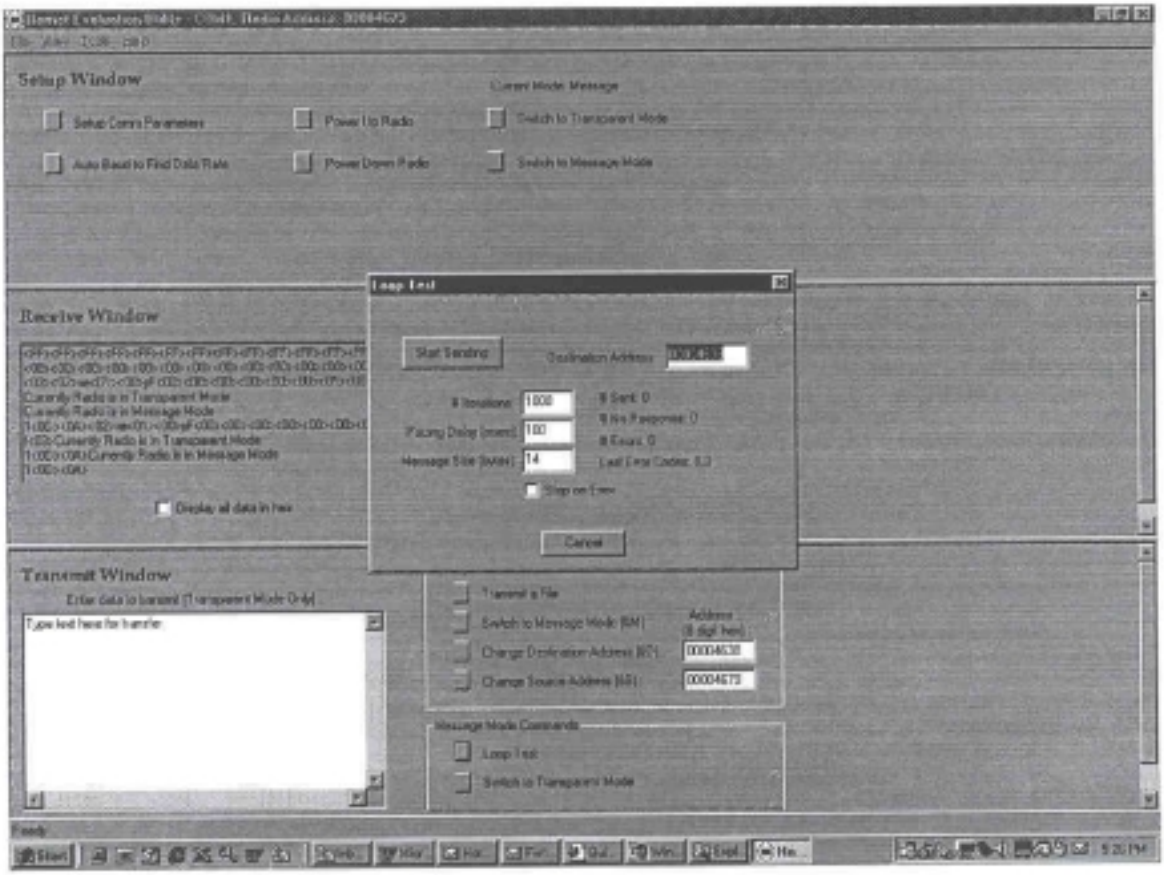
Place the cursor in the Transmit Window area and begin typing text.

Message Mode Tests

The program uses the Message Mode of operation for performing Loop Tests. To initiate the Loop Test perform the following:

- Select "Loop Test". The window shown below should appear.
- Ensure the destination address is set to the source address of the receiving radio.
- Set the "# iterations" to set the duration of the test.
- Set the "Pacing Delay (ms)". This value is the number of milliseconds that the program waits between sent packets.
- Set "Message Size (bytes)" to the number of bytes in each packet. **This setting should not be set greater than 96.**
- Select "Start Sending" to initiate the test.

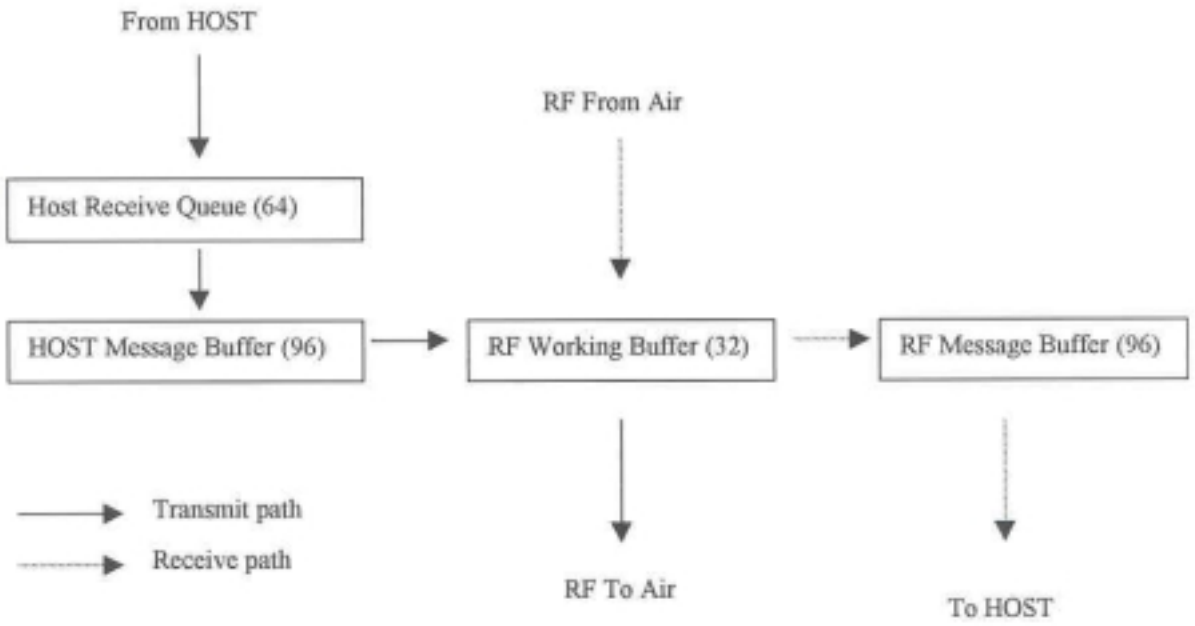
The program will display the number of packets sent, the number of no responses, and the number of errors.



Description of the *HORNET* data buffers

Four buffers handle data being sent and received in the Hornet Radio Modem. Two are used for receiving and storing data frames from a local host, one is used to store data frames received over the air and one is used as a temporary buffer for data packets to be sent or received over the air. Listed below are the data buffers and a description of each follows:

- Host Receive Queue
- Host Message Buffer
- RF Message Buffer
- RF Working Buffer



Flow of send and receive data in the Hornet buffers

Host Receive Queue

All data bytes received from the host are put into the Host Receive Queue. This is a First-In-First-Out (FIFO) buffer. The buffer is arranged as a ring of 64 bytes (as the data pointers reach the end of the memory space, they are reset to the beginning of the buffer). An interrupt routine handles the reception of bytes. Flow control is handled as bytes are received. The amount of available space in the queue is compared to a threshold value of 12 bytes. The available space is based on the read and write pointer locations. Locations that have already been read are considered available for new bytes. When the available space falls below the threshold (11 or fewer free bytes), the CTS signal is de-asserted to prevent the host from sending more bytes. When the space is equal to or greater than the threshold, CTS is asserted again.

Due to the Hornet's limited buffer space it is necessary to adjust the PC's FIFO size for proper operation with a Personal Computer. In Windows 95/98 perform the following to ensure proper flow control and operation:

- Select START, SETTINGS, CONTROL PANEL
- From the Control Panel, select SYSTEM, DEVICE MANAGER
- Double click on the COM port to be used
- Set Flow Control to HARDWARE
- Select ADVANCED and set the TRANSMIT BUFFER to the Lowest setting
- Repeat the above steps for each COM port used (i.e. COM1, COM2, COM3, etc.)

Host Message Buffer

As a lower priority, when the controller is not busy with more important tasks, any data accumulated in the Host Receive Queue is copied to the Host Message buffer. This buffer has 96 bytes. In Transparent mode, data in the Message Buffer is considered to be a complete frame when either of the two conditions occur:

1. The Message Buffer is close to full;
2. The Transparent Buffer Delay timer expires.

The Transparent Buffer Delay timer is restarted every time bytes are copied to the Message Buffer. When the time expires (due to a pause in the data), the current bytes in the Message Buffer are considered a frame to be transmitted. The frame is then packetized for over-the-air transmission. Each payload packet is assembled in the RF Working Buffer, and then sent to the ASIC for transmission.

RF Working Buffer

This 32-byte buffer is used to hold a packet received over the air, or in preparation for sending over the air. For receiving data, the ASIC is polled to see if a new RF packet was received. If so, the processor saves the bytes to this buffer. If a packet was received, it will be processed to determine the type of packet (i.e. Virtual Circuit, Payload or Status). Payload packets are copied to the RF Message Buffer to reassemble the frame. For sending data, bytes are copied from the Host Message Buffer into the RF Working Buffer to be sent as smaller payload packets.

RF Message Buffer

When Payload packets received off the air are processed, they are copied from the RF Working Buffer to the RF Message Buffer until a complete frame is received. This buffer has 96 bytes. In Transparent Mode these bytes are then passed to the host. The transfer to the host can be set to one of the following three different flow control modes:

1. No Wait
2. Until RTS
3. Until flush to host

In No Wait mode, an acknowledgement is sent back to the sender immediately upon verification of the received frame's CRC, without regard to the host's ability to receive the message. In "Until RTS" mode, the radio confirms the presence of the host before sending the acknowledgment, but does not wait for the data to be transferred. In "Until flush to host" mode, the data must be completely transferred to the host before the acknowledgment is sent.