WIT608B

WMTS Spread Spectrum Medical Telemetry Transceiver

Integration Guide

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Important Regulatory Information

Murata Product FCC ID: HSW-608B

FCC Warnings

Note: Operation of this equipment requires the prior coordination with a frequency coordinator designated by the FCC for the Wireless Medical Telemetry Services. Changes or modification not expressly approved by the party responsible for certification could void the user's authority to operate this product. This product is for professional installation. Only persons specifically trained by Murata for installation of this device into healthcare facilities may install this product.

Modular Approval Additional User Manual Instructions

The WIT608B Module is not intended for OEM integrators and/or end-users. The module must be integrated by grantee authorized professional installers. Installers must be provided with antenna installation instructions and transmitter operating conditions for satisfying RF exposure compliance.

The host product shall be properly labeled to identify the modules within the host product.

The host product must be labeled to display the FCC ID certification number for the module, preceded by the word "Contains" or similar wording expressing the same meaning, as follows:
Contains FCC ID: HSW-608B

FCC s MPE Requirements

Notice to users/installers using the following mobile antennas with this Murata RF product:	
Cushcraft 2 dBi Patch antenna, Nearson 2dBi dipole,	*The field strength radiated by any one of these antennas, when connected to Murata RF products, may exceed FCC mandated RF exposure limits. FCC rules require professional installation of these antennas in such a way that the general public will not be closer than 20 cm from the radiating aperture of any of these antennas. End users of these systems must also be informed that RF exposure limits may be exceeded if personnel come closer than 20 cm to the apertures of any of these antennas.*

. INTRODUCTION

The WIT608B radio transceiver provides reliable wireless connectivity for either point-to-point or multipoint applications. Frequency hopping spread spectrum technology ensures maximum resistance to noise and multipath fading and robustness in the presence of interfering signals, while operation in the 611 MHz WMTS band allows protected operation in the US. A simple serial interface supports asynchronous data up to 115200 bps. An on-board 3 KB buffer and an error-correcting over-the-air protocol provide smooth data flow and simplify the task of integration with existing applications.

Radio Features include:

- Multipath fading impervious frequency hopping technology with 39 frequency channels (608-614 MHz).
- Supports point-to-point or multipoint applications.
- Meets Part 95 FCC rules
- Superior range to 802.11 wireless LAN devices.
- Transparent ARQ protocol w/3KB buffer ensures data integrity.
- Low power 3.0v CMOS control signals

- Simple serial interface handles both data and control at up to 115200 bps.
- Fast acquisition typically locks to hopping pattern in 4 seconds or less.
- ~10 mW transmit power.
- Support for diversity antenna.
- Built-in data scrambling reduces possibility of eavesdropping.
- Nonvolatile memory stores configuration when powered off.
- Smart power management features for low current consumption.
- Dynamic TDMA slot assignment that maximizes throughput.

2. RADIO OPERATION

2.1. Synchronization and Registration

As discussed above, frequency hopping radios periodically change the frequency at which they transmit. In order for the other radios in the network to receive the transmission, they must be listening to the frequency over which the current transmission is being sent. To do this, all the radios in the net must be synchronized and must be set to the same hopping pattern.

In point-to-point or point-to-multipoint arrangements, one radio module is designated as the base station. All other radios are designated remotes. One of the responsibilities of the base station is to transmit a synchronization signal to the remotes to allow them to synchronize with the base station. Since the remotes know the hopping pattern, once they are synchronized with the base station, they know which frequency to hop to and when. Every time the base station hops to a different frequency, it immediately transmits a synchronizing signal.

When a remote is powered on, it rapidly scans the frequency band for the synchronizing signal. Since the base station is transmitting over 39 frequencies and the remote is scanning 39 frequencies, it can take several seconds for a remote to synch up with the base station.

Once a remote has synchronized with the base station, it must request registration from the base station. The registration process identifies to the base station the remotes from which transmissions will be received and not discarded. Registration also allows tracking of remotes entering and leaving the network. The base station builds a table of serial numbers of registered remotes. To improve efficiency, the 24-bit remote serial number is assigned a 6-bit “handle” number. Two of these are reserved for system use, thus each base station can register 62 separate remotes. This handle is how user applications will know the remotes. Note that if a remote leaves the coverage area and then re-enters, it may be assigned a different handle.

To detect if a remote has gone offline or out of range, the registration must be “renewed” once every 256 hops. Registration is completely automatic and requires no user application intervention. When the remote is registered, it will receive several network parameters from the base. This allows the base to automatically update these network parameters in the remotes over the air. Once a parameter has been changed in the base, it is automatically changed in the remotes. The parameters automatically changed are *hop duration* and the duty cycle.

At the beginning of each hop, the base station transmits a synchronizing signal. After the synchronizing signal has been sent, the base will transmit any data in its buffer unless *data transmit delay* has been set. The *data transmit delay* parameter allows for the transmission of groups of continuous data in transparent mode (protocol mode 0). The amount of data that the base station can transmit per hop is determined by the *base slot size* parameter. The maximum amount of data sent by a base station per hop is 208 bytes. If there is no data to be sent, the base station will not transmit until the next frequency.

The operation for remotes is similar to the base station without the synchronizing signal. The amount of data a remote can send on one hop is dependent upon the *hop duration,* the *base slot size* and the number of registered remotes. 212 bytes per hop is the maximum data length a remote can transmit per hop, subject to limitations imposed by the *hop duration*, the *base slot* size and the number of registered remotes. A detailed explanation of this relationship is provided in Section 2.2.3. *Minimum data length* and *data transmit delay* operate the same as with the base station.

Except for the registration process which occurs only when a remote logs onto the network, the whole procedure is repeated on every frequency hop. Refer to the section on *Modem Commands* for complete details on parameters affecting the transmission of data.

2.2. Data Transmission

The WIT608B supports point-to-multipoint operation. In a point-to-multipoint network, a star topology is used with the radio set up as a base station acting as the central communications point and all other radios in the network set up as remotes. In this configuration, all communications take place between the base station and any one of the remotes. Remotes cannot communicate directly with each other. It should be noted that point-to-point mode is a subset of point-to-multipoint mode and therefore there is no need to specify one mode or the other.

2.2.2. Point-to-Multipoint

In point-to-multipoint mode, data sent from the user application to the base station must be packetized by the user application unless the remote device can distinguish between transmissions intended for it and transmissions intended for other remote devices. This is necessary to identify the remote to which the base station should send data. When the user packet is received by the remote, if the remote is in transparent mode (protocol mode 0), the packetization bytes are stripped by the remote. In this instance the remote host receives just data. If the remote is not in transparent mode, the remote host will receive the appropriate packet header as specified by the remote's protocol mode. Refer to the section *Protocol Modes* for details on the various packet formats.

When a remote sends data to a base station in point-to-multipoint mode, the remote host does not need to perform any packetization of the data. Remotes can operate in transparent mode even though the base is operating in a packet mode. The remote will add address, sequence and CRC bytes as in the point-to-point mode. When the base station receives the data, the base station will add packetization header bytes according to its *protocol mode* setting.

2.2.3. Handle Assignment

Handles are used to reduce overhead by not sending the unique 24-bit serial number ID of a remote when sending or receiving data. The use of the various protocol modes causes the base radio to issue CONNECT packets when a new remote registers with the base. In addition to indicating the presence of a new remote, the CONNECT packets provide the current relationship between remote serial numbers and handles.

When a remote links to a base and requests registration, it requests by default that it be assigned handle 30H. This default request can be changed by the Set Default Handle command. If that handle is not currently in use by another remote, the base will assign that handle to the remote. If the requested handle is already in use by another remote, the base will assign the next higher handle that is available. Thus, if a remote requests handle 30H and that handle is already assigned, the base will assign the remote handle 31H if that is available. If 31H is already assigned, the base will assign handle 32H is that is available and so on.

When a remote leaves the coverage area of the base or otherwise loses link, e.g. the remote was turned off or put into sleep mode, the base detects this event when the remote does not renew its registration within 255 hops. With the default setting of 10msec per hop, this could be as along as 2.55 seconds. If within this time the remote re-establishes link with the base, the previous handle assigned to this remote will still be marked active in the base radio. Thus the remote will be assigned a new handle. If the base radio is in one of the protocol modes, a new CONNECT packet will be issued indicating the current handle assigned to the remote. The remote is identified by the serial number that is contained in the CONNECT packet.

If the radio is to be used in a point-to-point mode where there is only one base and one remote, using the point-to-point mode command of the radios will override this handle mechanism and always assign the remote the same handle.

2.2.4. TDMA Operation

For applications needing guaranteed bandwidth availability, the TDMA operation of the WIT608B can meet this requirement. In the WIT608B TDMA scheme, each remote has an assigned time slot during which it can transmit. The base station time slot is set independently of the remote time slots through the *Set Base Slot Size* command. The base station assigns each remote a time slot and informs the remotes of the size of the time slot. All remote time slots are the same size that is determined by the number of remotes registered with the base station. The slot size is a dynamic variable that changes as the number of registered remotes changes. The remotes are continually updated with the time slot size. This approach continually maximizes the data throughput. The base station divides the amount of time available per hop by the number of registered remotes up to a maximum of 16 times slots per hop. If the number of registered remotes is greater than 16, the time slots will be spread across the required number of hops. For networks with more than 16 possible remotes, the *Set Duty Cycle* command must be used to specify a duty cycle -- the number of hops over which the time slots must be spread. For 1 to 16 remotes, no duty cycle is required; for 17 to 32 remotes a duty cycle of at least ½ is required; and for 33 to 62 remotes a duty cycle of ¼ or more is necessary. An added benefit of using the power save mode to set a duty cycle is improved average current consumption efficiency. Refer to the *Status Commands* section for details of this command.

2.2.5. Full Duplex Communication

From an application perspective, the WIT608B communicates in full duplex. That is, both the user application and the remote terminal can be transmitting data without waiting for the other to finish. At the radio level, the base station and remotes do not actually transmit at the same time. If they did, the transmissions would collide. As discussed earlier, the base station transmits a synchronization signal at the beginning of each hop followed by a packet of data. After the base station transmission, the remotes will transmit. Each base station and remote transmission may be just part of a complete transmission from the user application or the remote terminal. Thus, from an application perspective, the radios are communicating in full duplex mode since the base station will receive data from a remote before completing a transmission to the remote.

2.2.6. Error-free Packet Transmission Using ARQ

The radio medium is a hostile environment for data transmission. In a typical office or factory environment, 1% - 2% of the 611 MHz frequency band may be unusable at any given time at any given station due to noise, interference or multipath fading. For narrowband radio systems (and also many spread spectrum radio systems which use direct sequence spreading), this would imply a loss of contact on average of over 30 seconds per hour per station. The WIT608B overcomes this problem by hopping rapidly throughout the band in a pseudo-random pattern. If a message fails to get through on a particular channel, the WIT608B simply tries again on the next channel. Even if two thirds of the band is unusable, the WIT608B can still communicate reliably.

Data input to the WIT608B is broken up by the radio into packets. A 24-bit checksum is attached to each packet to verify that it was correctly received. If the packet is received correctly, the receiving station sends an acknowledgment, or **`ACK`**, back to the transmitting station. If the transmitter doesn't receive an **`ACK`**, at the next frequency hop it will attempt to send the packet again. When ARQ is enabled, the transmitting radio will attempt to send a packet *packet attempts limit* times before discarding the packet. A value of **`00H`** disables ARQ. When it is disabled, any transmission received with errors is discarded. It is the responsibility of the user application to track missing packets. A second parameter, *ARQ Mode,* allows the choice between using ARQ to resend unsuccessful transmissions or always sending a transmission *packet attempts limit* times regardless of the success or failure of any given transmission.

All of this error detection and correction is transparent to the user application. All the user application sees is error-free data from the modem. However, if the ARQ mode is disabled, transmissions with errors are discarded, and missing data detection will be the responsibility of the user application. Refer to the *Protocol Commands* section for complete details.

2.3. Modes of Operation

2.3.1. Control and Data Modes

The WIT608B has two modes of operation: Control mode and Data mode. When in Control Mode, the various radio and modem parameters can be modified. When in Data Mode, only data can be transmitted. The default mode is Data Mode. There are two ways to enter Control Mode. The first way is to assert the Configure (CFG) pin on the modem. Upon entering Control Mode, the modem will respond with a **>** prompt. After each command is entered, the modem will again respond with a **>** prompt. As long as the CFG pin is asserted, data sent to the modem will be interpreted as command data. Once the CFG pin is deasserted, the modem will return to Data Mode.

The second method for entering Control Mode is to send the escape sequence **`:WIT608B`** (all lower case) followed by a carriage return. In the default mode, the escape sequence is only valid immediately after power up or after deassertion of the Sleep pin on the modem. The modem will respond in the same way with a **>** prompt. To return to Data Mode, enter the *Exit Modem Control Mode* command, **`z>`**, or assert and deassert the Sleep pin. There are three modes for the escape sequence, controlled by the *Set Escape Sequence Mode* command, **`zc`**:

`zc = 0`	Escape sequence disabled
`zc = 1`	Escape sequence available once at startup (default setting)
`zc = 2`	Escape sequence available at any time

The **`zc2`** mode setting is useful if the user application has a need to change the modem settings "on the fly". In this mode the escape sequence is always enabled and may be sent at any time after a pause of at least 20ms. The modem will respond in the same way as when in the default mode. It is necessary to issue the *Exit Modem Control Mode* command, **`z>`**, before resuming data transmission. The escape sequence must be interpreted as data until the last character is received and as such may be transmitted by the modem to any listening modems.

2.3.2. Sleep Mode

To save power consumption for intermittent transmit applications, the WIT608B supports a Sleep Mode. Sleep Mode is entered by asserting the Sleep pin on the modem interface. While in Sleep Mode, the modem consumes less than 50µA. This mode allows the radio to be powered off while the terminal device remains powered. After leaving Sleep Mode, the radio must re-synchronize with the base station and re-register.

2.3.3. Low Power Mode and Duty Cycling

To conserve power, WIT608B remotes power down the receiver and transmitter between hops when not in use. Base stations must remain active all the time to handle any transmission from any remote. Remotes can save even more power by enabling the duty cycle feature. This feature causes a remote to power down for 2^N frequency hops where $1/2^N$ is the duty cycle. Rather than attempting to transmit on every frequency hop when data is in the transmit buffer, a remote will attempt to transmit only every 2^N hops. Roughly speaking, this will proportionately reduce the average power consumption while increasing average latency. When there are more than 16 remotes being operated, duty cycling must be enabled since a maximum of 16 time slots is available per hop.

When a remote radio is powered up but is out of range of a base station, it will continuous scan the frequency bands for the presence of a base radio. During this scanning the radio can consume up to 50mA of current. A low power seek mode is available in which the remote radios seek base stations only 50% of the time. This will reduce current consumption by about 50% but will double the time it can take a remote to link with a base up to 4 seconds.

2.3.4. RF Flow Control Mode

Because of slight differences in baud rates between transmitting and receiving hosts, when sending large amounts of data (100’s of KB) in one direction in a point-to-point application, it is possible to overrun the receive buffer of the receiving radio. For example a nominal 115.2Kbaud at the transmitting radio’s host might really be 115,201 and at the receiving radio’s host it might be 115,199. This is similar to a situation where the transmitting radio is sent data at a higher baud rate than the baud rate at which data is received by the receiving host. To compensate for the variations in nominal baud rates, the WIT608B supports an RF flow control mode for point-to-point operation. In this mode, when the receive buffer of the receiving WIT608B is close to full, the receiving WIT608B stops acknowledging transmissions. The transmitting radio is set to infinite retries which invokes the RF flow control mode (See *Set Packet Attempts Limit* in Section 5.3). The receiving radio will not begin acknowledging transmissions from the transmitting radio until more room in the receive buffer has become available. This will cause data in the transmit buffer of the transmitting radio to back up. If it backs up to the point where the transmit buffer fills up, the transmitting radio will deassert CTS stopping data from the transmitting radio’s host device. Once room is available in the receiving radio’s buffer, the receiving radio will begin acknowledging transmissions from the transmitting radio allowing the transmitting radio’s buffer to begin to empty which will cause the transmitting radio to reassert CTS. Either one or both of the radios in a point-to-point installation can be configured for the RF flow control. If this mode is invoked in a point-to-multipoint installation, communications with all radios will be stopped when any one radio’s receive buffer becomes full.

3. PROTOCOL MODES

In point-to-point applications, it is generally desired that the radios operate in a transparent mode. That is, raw unformatted data is sent from the host to the radio and is received as raw data from the receiving end. The addressing and error detection and correction are still performed by the radios, but it is transparent to the user application. To set up a point-to-point network, one radio has to be set up as a base station. When the radios are powered on, the base station will send out the synchronization signal at the beginning of each hop. The remote will synchronize with the base and automatically request registration. Once the remote is registered, the radios can transmit data. Protocol mode operation is available in point-to-point mode if desired.

If the base station is to be responsible for directing data to a specific remote in point-to-multipoint mode, the data sent to the base station by the user application must adhere to a packet format. This allows transmissions from the base station to be directed to a specific remote. Data received by a base station from a remote is similarly formatted to identify to the user application the remote that sent the transmission. The remotes may still use transparent mode without formatting to send data to the base, if desired. The WIT608B supports 10 protocol formats that are described in detail below. The protocol format is selected through the *Set Protocol Mode* command.

Base and remote radios can use protocol modes to insure that a packet is transmitted to the base without being broken up over multiple hops. The *data length* value in the data packet becomes the effective *minimum packet length* and *maximum packet length* for that packet. Note that if the remote *data length* is set to a number of bytes that is longer than the number of bytes that can be transmitted by a remote on a single hop, the packet will be discarded. For the base, this value is set by the *Set Base Slot Size* command. For remotes this value is dynamically available through the *Get Maximum Data Length* command or may be calculated based on the maximum number of remotes that can ever be registered at one time. See Sections 5.3 and 2.2.3 respectively. Also note that using protocol modes effectively disables *Data Transmit Delay*. This means that a packet will not be transmitted until the entire packet has been sent to the radio, regardless of the amount of time it takes.

If the remote hosts can determine what data is directed to them in point-to-multipoint mode, the data can be sent to the base station without using a packet format. In this situation, broadcast mode is selected at the base station by using the *Set Default Handle* and selecting **3FH** as the default handle. In this mode, the automatic retransmission of unsuccessful transmissions is disabled. This is required since all of the remote modems will attempt to acknowledge each base transmission when ARQ is enabled. Transmissions that are received with errors are discarded by the radio. The remote devices must be able to detect a missing packet and request a retransmission by the base device.

Protocol Modes Definitions

mode 00 — Transparent mode used for point-to-point networks or multipoint remotes; does not support any packet types.

mode 01 — This is the simplest protocol mode supporting Data packets only. This mode is not recommended for base radios. No CONNECT or DISCONNECT packets are supported and no sequence numbers are provided.

packet types supported: Data

mode 02 — This mode includes notification when remotes are registered or dropped through CONNECT and DISCONNECT packets that are sent to the user application at the base station and at the remote. No sequence numbers are provided.

packet types supported: Data
CONNECT
DISCONNECT

mode 04 — This is the packet format used by the WIT2400. This allows legacy software to operate the WIT608B with a minimum of changes. Note however, that since different air data rates are used, WIT608Bs and WIT2400s cannot be mixed in a network.

packet types supported: 2400 data format
(addresses must be limited to 1..62)

modes 05 – 08 — *reserved for future use.*

mode 09 — This mode sends the protocol mode 01 packets during transmit but receives data transparently.

mode 0A — This mode sends the protocol mode 02 packets during transmit but receives data transparently.

mode 0C — This mode sends the protocol mode 04 packet during transmit but receives data transparently.

modes 0D – 0F — *reserved for future use.*

mode 11 — This mode sends data transparently but supports protocol mode 1 during reception.

mode 12 This mode sends data transparently but supports protocol mode 2 during reception.

mode 14 This mode sends data transparently but supports protocol mode 4 during reception.

3.1.1. Data Packet

Modes 01 & 02:

Base `1110 1001 00HH HHHH LLLL LLLL` <0-208 bytes data>

Remote `1110 1001 0000 0000 LLLL LLLL` <0-212 bytes data>

Mode 04 (WIT2400):

Base `0000 0010 00HH HHHH LLLL LLLL` <0-208 bytes data> `0000 0011`

Remote `0000 0010 0000 0000 LLLL LLLL` <0-212 bytes data> `0000 0011`

`H` : handle number (0-63)
`L` : data length (0-208 for base, 0-212 for remote)

This packet carries user data. The handle number is the handle of the receiving remote. When data is being sent from a remote to the base, no handle number is required. Up to 212 bytes (208 for base radios) of user data may be carried per data packet but no more than is specified by the *maximum data length* parameter. The radio will not break up a packet over multiple hops. Packets with a data length greater than *maximum data length* will not be sent and will be discarded. This parameter is variable and depends on the number of remotes currently registered.
Handle 63 is reserved for broadcast packets from the base to all remotes. Acknowledgment requests are not supported for broadcasts. For this reason, it is a good idea to send broadcast messages several times to increase the odds of reaching all remotes.

3.1.3. Connect Packet

`1110 1001 10HH HHHH RRRR TTTT 00NN NNNN` <3-byte remote ID> (base, receive only)

`H` : handle number (0-62)
`R` : receive sequence number (from previous cell)
`T` : transmit sequence number (from previous cell)
`N` : network number of the previous base (if roamed)

`1110 1001 10HH HHHH RRRR TTTT 00NN NNNN` <3-byte base ID> (remote, receive only)

`H` : handle number (0-62)
`R` : receive sequence number
`T` : transmit sequence number
`N` : network number of base

Remotes must go through an automatic registration process when roaming from one base to another, after loss of contact, or when acquiring a base signal for the first time after power up. The base then assigns the remote a handle value, may or may not assign it a dedicated time slice depending on the user settings, and notifies the user application of the new remote with a connect packet.

The network number of the last base the remote was connected to is given to aid user software in resending orphan packets that may have been sent to the remote's previous cell. If the remote has been powered up for the first time and this is the first base contacted, the last base ID will be reported as **80H**.

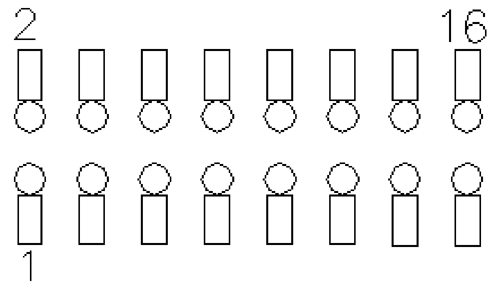
3.1.4. Disconnect Packet (base only, receive only)

```
1110 1001   11HH HHHH   0111 1111
```

`H` : handle number (1-62)

When a remote goes out of range or roams to another cell, the base issues a disconnect packet to indicate that the remote is no longer available.

4. MODEM INTERFACE



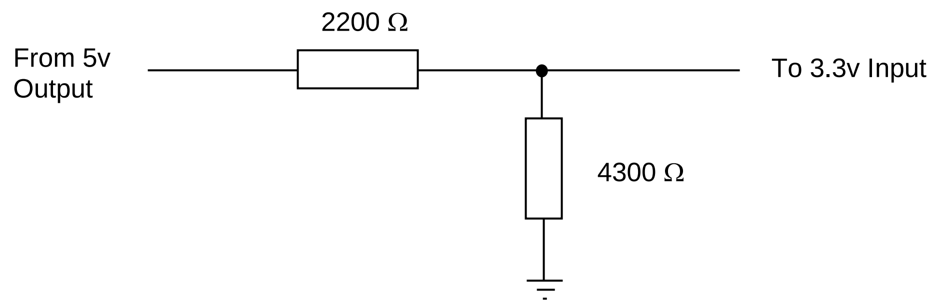
Electrical connection to the WIT608B is made through a 16-pin male header on the modem module. The signals are 3.3 volt signals and form an RS-232 style asynchronous serial interface.

The table below provides the connector pinout.

Pin	Signal	Type	Description
1	GND	-	Signal and chassis ground
2	TXD	Input	Transmit data. Input for serial data to be transmitted. In Control Mode also used to transmit modem commands to the modem.
3	RXD	Output	Receive data. Output for received serial data. In Control Mode, also carries receive modem status from the modem.
4	$\overline{\text{CFG}}$	Input	Configuration selector. Used to switch between Control and Data Modes. Normally, CFG will be set for Data Mode. An internal 10K pull-up enables Data Mode if this signal is left unconnected. Control Mode is also accessible by transmitting an escape sequence immediately after wake up or power up. (0v) 1 = Control Mode (3.3v) 0 = Data Mode
5	$\overline{\text{RTS}}$	Input	Request to send. Gates the flow of receive data from the radio to the user on or off. In normal operation this signal should be asserted. When negated, the WIT608B buffers receive data until RTS is asserted. (0v) 1 = Receive data (RxD) enabled (3.3v) 0 = Receive data (RxD) disabled.
6	SLEEP	Input	Sleeps/wakes radio transceiver. In sleep mode all radio functions are disabled consuming less than 50µA. At wake up, any user programmed configuration settings are refreshed from non-volatile memory, clearing any temporary settings that may have been set. (3.3v) 1 = Sleep Radio (0v) 0 = Wake Radio
7	$\overline{\text{DCD}}$	Output	Data carrier detect. For remotes, indicates the remote has successfully acquired the hopping pattern of the base station. (0v) 1 = Carrier detected (synchronized) (3.3v) 0 = No carrier detected (not synchronized)
8	$\overline{\text{CTS}}$	Output	Clear to send. Used to control transmit flow from the user to the radio. (0v) 1 = Transmit buffer not full, continue transmitting (3.3v) 0 = Transmit buffer full, stop transmitting
9	-	-	Reserved for future use. Do not connect.
10	$\overline{\text{Reset}}$	Input	Resets the radio.
11-15	-	-	Reserved for future use. Do not connect.
16	VCC	-	Positive supply. Min 3.3 v, 5.0 v nominal, 10.0 v max.

4.1. Interfacing to 5 Volt Systems

The modem interface signals on the WIT608B are 3.3 volt signals. To interface to 5 volt signals, the resistor divider network shown below must be placed between the 5 volt signal outputs and the WIT608B signal inputs. The output voltage swing of the WIT608B 3.3 volt signals is sufficient to drive 5 volt logic inputs.



4.2. Evaluation Unit and OEM Module Differences

The evaluation unit has an RS-232 transceiver that translates RS-232 level signals to 3.3 volt signals for input into the OEM module inside the evaluation unit. A typical schematic is shown in Appendix 7.5. The OEM module does not have any type of RS-232 transceiver and cannot handle the RS-232 voltages. This allows the OEM module to be easily integrated into any 3.3 volt system without any logic signal translation. In order for the OEM module to function properly several pins need to be driven low or tied to ground. Pin 5 (RTS) and pin 6 (SLEEP) need to be pulled to ground on the 16-pin male header. If you have the OEM module interfaced to an RS-232 transceiver, RTS and DTR need to be pulled high on the transceiver side. In the evaluation unit, RTS and DTR are pulled high on the transceiver side so the evaluation unit will work with these signals not connected.

4.3. Three Wire Operation

The WIT608B can be operated in a three wire configuration using just TxD, RxD and Ground. To operate the WIT608B in this configuration, the Sleep and RTS signals must be tied to ground. These signals are pulled up on the WIT608B module and if left disconnected will put the radio into sleep mode and RTS will be deasserted.

The WIT608B does not support software flow control (XON/XOFF). Thus when using a three wire configuration, there is no flow control. The radio configuration and/or the application must insure the transmit and receive buffers do not overflow. The WIT608B has a 2048-byte transmit buffer and a 1024-byte receive buffer. For example, the default settings for the *base slot size* and *hop duration* are **08H** and **90H** respectively. The 08H base slot size allows the base to send 32 bytes of data per hop. The **90H** hop duration provides a 10ms hop dwell time. These default settings provide a base throughput of

40kbps (Since the over the air transmission is synchronous, the 32kbps synchronous over the air rate is equivalent to 40kbps asynchronous into the radio serial port). If the base transmits continuously at a higher rate than this, unless the default settings are changed, the transmit buffer will eventually overflow. To allow a higher base throughput, either increase the base slot size or the hop duration or both. A similar analysis needs to be performed for the remote radios. Refer to *Section 2.2.3 TDMA Mode* for the remote throughput calculation.

4.4. Power-On Reset Requirements

The WIT608B has an internal reset circuit that provides a reset signal to the microprocessor if the supply voltage to the WIT608B falls below 2.7 volts. Operation of the microprocessor at voltages below this voltage is unspecified and can result in corruption of the program memory. When the radio is first powered on, there is an inrush current in excess of 250mA. The power supply in the host must be capable of sourcing this current without the voltage falling below 2.7 volts at the radio. Failure of the power supply to meet this requirement can result in “motorboating” of the radio where the inrush current of the radio pulls the supply voltage below 2.7 volts causing the reset circuit to fire which resets the radio removing the current requirement. Once the voltage recovers to a level above 2.7 volts, the reset signal is removed from the radio which causes the inrush current which causes the voltage to drop causing the reset circuit to fire and so on.

If the host circuitry has a reset circuit that generates a reset signal to the radio anytime the power supply voltage falls below 2.7 volts, the on-board reset circuit can be disabled. Murata recommends leaving the reset circuit enabled unless it causes a problem due to a soft turn-on of the power supply voltage by the host. Please contact Murata Technical Support for details on disabling the reset circuit.

5. MODEM COMMANDS

The WIT608B is configured and controlled through a series of commands. These commands are sent to the modem directly when the modem is in Control Mode when the modem is in Data Mode if the escape sequence is enabled. The command syntax is the same for either method, a one- or two-letter command followed by one or more parameters. The modem will respond with a two-byte message that indicates the new modem parameter value. The commands are loosely grouped into five different categories: Serial commands, Network commands, Protocol commands, Status commands and Memory commands. Each command is described in detail below. In the descriptions, brackets ([,]) are used to denote a set of optional arguments. Vertical slashes (|) separate selections. For example, given the string **wn[?|0..3f]**, some legal commands are **wn?**, **wn0**, **wn3** and **wna**. Most commands which set a parameter also have a **?** option which causes the modem to respond with the current parameter setting, e.g., **wn?** Each modem command must be followed by either a carriage return or a line feed.

5.1. Serial Commands

These commands affect the serial interface between the modem and the host. The default settings are 9600 bps and protocol mode 0.

Command	Description
sd[?|00..FF]	Set Data Rate Divisor Data Rate Divisor (hex) 1200 bps = BF 2400 bps = 5F 9600 bps = 17 14400 bps = 0F 19200 bps = 0B 28800 bps = 07 38400 bps = 05 57600 bps = 03 115200 bps = 01 230400 bps = 00
sp[?|00..14]	Set Protocol Mode 00 = point-to-point transparent mode 01 = basic command and data only 02 = command, data and connection notification 04 = WIT2400 protocol mode 05 – 08 = *reserved for future use* 09 = mode 01 during transmit, transparent receive 0A = mode 02 during transmit, transparent receive 0C = mode 04 during transmit, transparent receive 0D – 10 = *reserved for future use* 11 = transparent transmit, mode 01 during receive 12 = transparent transmit, mode 02 during receive 14 = transparent transmit, mode 04 during receive

Set Data Rate Divisor
Sets the serial bit rate between the modem and the host. This command takes effect immediately and will require adjusting the host serial rate to agree. Nonstandard rates may be programmed by entering a data rate divisor computed with the following formula:

```
DIVISOR = (230400/RATE)-1
```

Round all non-integer values down.

Set Protocol Mode
Enables the base station to operate in a multipoint network. Depending on the user application, more or less acknowledgment may be desired by the application. Remotes can operate in transparent mode even though the base station is operating in one of the nontransparent modes.

When using a protocol mode, make sure to count in packet overhead when calculating network performance. Refer to the section on *Protocol Modes* for details on each format.

5.2. Network Commands

Network commands are used to set up a WIT608B network and to set radio addressing and configuration.

Command	Description
`wb[?|0|1]`	Set Transceiver Mode `0` = remote (default) `1` = base station
`wd[?|1-3f]`	Set Default Handle Used to override automatic handle assignment by the base station `30` = default
`wg[?|0|1]`	Enable Global Network Mode `0` = Link only to hop pattern specified by `wn` parameter (default) `1` = Link to any hop pattern, regardless of `wn` parameter
`wl[?|0-ff]`	Set lockout key allowing network segregation beyond network number 0 = default
`wn[?|0-3f]`	Set Hopping Pattern (Network Number) `0` = default
`wp[?|0|1]`	Set Transmit Power `0` = 10mW `1` = 100mW (default)
`wr?`	Read Receive Signal Strength
`wu[?|0|1]`	Set Point-to-Point Direct Mode 0 = Multipoint mode (default) 1 = Point-to-point direct mode
`ww[?|0|1}`	Base DCD Enable 0 = DCD always asserted (default) 1 = Base asserts DVD when pn=1 remote registered
`dx[?|0-ff]` (remote only)	Set Range optimization `0` = default

Set Transceiver Mode
Sets modem operation as either base station or remote. Default is remote.

Set Default Handle
Sets handle number between 1 and 62 inclusive for a remote. This handle will override the automatic handle assignment by the base station. This command can be used in applications where it is desired to have specific modems have specific handles. When specified for the base, the default handle determines which remote it will address when transparent protocol mode is in effect. When **`3FH`** is specified for the base, broadcast mode is entered.

Enable Global Network Mode
For networks with multiple base stations, remotes are ordinarily only able to link to one base station, set by the hopping pattern. Mode 1 enables the global mode that allows remotes to link to any base station they can hear, acquiring whatever hop pattern is required. In this mode a remote can only change base stations once it is no longer registered with a base station.

Set Lockout Key
Allows further network segregation beyond the network number. This feature allows multiple co-located networks in which global roaming is enabled. In global roaming, a remote is allowed to link to any base regardless of the network number as long as the lockout key agrees. By using different lockout keys, the bases to which remotes link can be limited or segregated.

Set Hopping Pattern
The WIT608B has 39 preprogrammed hopping patterns (also referred to as network numbers). By using different hopping patterns, nearby or co-located networks can avoid interfering with each other's transmissions. Even if both networks tried to use the same frequency, on the next hop they would be at different frequencies.

Set Transmit Power
The WIT608B has one preset transmit power levels of ~ 10mW (10dBm).

Read Receive Signal Strength Indicator (RSSI)
This command reports the relative signal strength averaged over the last 10 hops. This command returns a one byte value that is proportional to received signal strength and can range from **00H** to **FFH**. Typical values range from **30H** to **80H** where the lower the number the lower the received signal strength and the higher the number the higher the received signal strength. This is a relative indication and does not directly correspond to a field strength number. This is available only at the remotes as the base station is the only source that transmits on a regular basis. Plus, in a point-to-multipoint network the base will receive different signal strengths from each remote.

Base DCD Mode Enable
Since the most general application for WIT radios is in a multipoint network, normally DCD is always asserted at the base. There is an optional mode that may be enabled for point-to-point networks by setting 'ww1'. This will assert DCD whenever one or more remotes are registered. For point-to-point use, 'pn' should be set to 1. The default is 'ww0'.

5.3. Protocol Commands

These commands can be used to tune the transceiver for optimum transmission of data across the RF link. For most applications, the default values are adequate.

Command	Description
ph[?|00-fe] (base only)	Set Hop Duration 90H = default (=10ms)
pk[?|00-d0]	Set Minimum Data Length 01 = default
pl? (remote only)	Get Maximum Data Length (read only) D4 = default (=212 bytes)
pn[?|01-3e] (base only)	Set Maximum Number of Remotes 3e = default (=62 remotes)
pr[?|00-ff]	Set Packet Attempts Limit 10H = default FFH = Infinite retry (RF flow control point-to-point only)
pt[?|00-ff]	Set Data Transmit Delay 00H = default
pv[?|0|1] (base only)	Set Slot Assignment Mode 0 = default (dynamic slot assignment) 1 = static slot assignment
pw[?|00-34] (base only)	Set Base Slot Size 08H = default (=32 bytes)
px[?|0|1]	Set ARQ mode. 0 = ARQ enabled (default) 1 = ARQ disabled (redundant transmission)

Note: Incorrect setting of these parameters may result in reduced throughput or loss of data packets.

Set Hop Duration
Sets the length of time the transceiver spends on each frequency channel. A smaller value will allow the remote to lock on to the base signal faster at system startup, and will generally decrease packet latency. A larger value increases network capacity, due to decreased overhead in channel switching. The hop duration is specified in 69.4µs increments. The default value of **90H** corresponds to a duration of 10ms. The maximum value of **FEH** is 17.627ms. For best results, do not specify a duration of less than 3 ms. This value only needs to be set in the base which broadcasts the parameter to all remotes. However, link time can be reduced if this value is also programmed into the remotes, which use it as a starting value when scanning for the base.

Set Minimum Data Length

This sets the minimum threshold number of bytes required to form a packet in transparent mode. The radio will wait until the *data transmit delay* elapses before sending a data packet with less than this number of bytes. Can be used to keep short, intermittent transmissions contiguous. In packet modes, the length parameter in the data packet will override this value (See Section 3.1). This value is subject to the *maximum data length* even in packet mode. See *Get Maximum Data Length* below.

Get Maximum Data Length (remote only, read only)
This parameter indicates the largest number of bytes that a remote will transmit per hop, based on the size of the slot it has been allocated by the base. In general more remotes mean less data can be transmitted per remote. By reading this parameter and dividing by the hop duration, the remote's data rate capacity can be determined. Attempting to send protocol mode packets longer than *maximum data length* will result in the packet being discarded without being sent. See Section 2.3.3 on the tradeoffs between *hop duration* and data length.

Set Maximum Number of Remotes (base only)
This parameter limits the number of remotes that can register with a given base. The default is 62 remotes which is the maximum number of remotes that can be registered with a base at one time. This command is useful when used in conjunction with global roaming for load balancing when base stations are collocated. It is also useful to assure a minimum remote throughput.

Set Packet Attempts Limit
If *ARQ Mode* is set to `0`, sets the number of times the radio will attempt to send an unsuccessful transmission before discarding it. If *ARQ Mode* is set to `1`, it is the number of times every transmission will be sent, regardless of success or failure of a given attempt. When this parameter is set to **FFH**, RF flow control mode is entered for transmissions from the radio (See Section 2.3.4). This mode can be entered for one or both radios in a point-to-point system. When used in a point-to-point system the **wu** parameter should be set to 1. Using this mode in a point-to-multipoint system will stop transmissions to all radios when any one radio has a full buffer or if the base radio attempts to send data to a remote that has recently (<2.5 seconds) left the range of the base.

Set Data Transmit Delay
When used in conjunction with the *minimum data length* parameter, this sets the amount of time from the receipt of a first byte of data from the host until the radio will transmit in transparent mode. Default is `00H` which causes transmission to occur without any delay. When a host is sending a group of data that needs to be sent together, setting this parameter will provide time for the group of data to be sent by the host before the radio transmits. If the length of data to be sent together is longer than the time slot can send, the data will not be sent together but will be broken up over multiple hops. The length of time the radio will wait is equal to the specified value times the hop duration.

Set Slot Assignment Mode (base station only)

Sets whether the base station will assign remote transmit slots dynamically, based on the number of remotes currently registered or whether the base station will assign remote transmit slots statically, based on the *maximum number of remotes* parameter. If static slot assignment is selected, make sure *maximum number of remotes* is correctly set. Otherwise remote transmit performance will suffer as transmit time will be reserved for remotes that may not exist. The dynamic assignment mode will generally be preferred; however, the static assignment mode will result in a static *maximum data length* parameter.

Set Base Slot Size (base station only)
Sets the amount of time allocated for transmission on each hop for the base station time slot in 69.4µs increments, corresponding to 4 bytes per unit. Maximum value is **34H** which corresponds to 208 bytes. If using a protocol mode, attempting to send a packet with a length longer than this setting will cause the packet to be discarded.

Set ARQ Mode
Sets ARQ mode when set to 0 which is the default. In this mode the radio will resend an unsuccessful transmission until either successful or *packet attempt limit* attempts have been made. When set to 1 selects redundant transmit mode that will send every transmission *packet attempt limit* times regardless of success or failure of any given attempt. When redundant transmit mode is used, receiving radios will discard all subsequent retransmissions once the transmission has been successfully received. Thus the receiving host will receive just one copy of the transmission.

5.4. Status Commands

These commands deal with general interface aspects of the operation of the WIT608B.

Command	Description
`zb[?|0|1]`	Banner Display Disable `0` = disabled `1` = enabled (default)
`zc[?|0..2]`	Set Escape Sequence Mode `0` = disabled `1` = once after reset (default) 2 = unlimited times
`zh?`	Read factory serial number high byte.
`zm?`	Read factory serial number middle byte.
`zl?`	Read factory serial number low byte.
`zp[?|0-4]`	Set the duty cycle at which the modem will wake up to send and receive data. Duty cycle equals $1/2^N$ where the argument of the command equals N.
`zq[?|0|1]` (remote only)	Low Power Acquisition Mode Enable `0` = Disabled (default) `1` = Enabled
`z>`	Exit Modem Control Mode

Banner Display Disable
Enables or disables display of the banner string and revision code automatically at power-up. May be disabled to avoid being mistaken for data by the host.

Set Escape Sequence Mode
Enables or disables the ability to use the in-data-stream escape sequence method of accessing Control Mode by transmitting the string "`:WIT608B`". When this mode is set to `1`, the escape sequence only works immediately after reset (this is the default). When set to `2`, the escape sequence may be used at any time in the data stream when preceded by a pause of 20 ms. Note that the escape sequence must be interpreted as data by the radio until the last character is received, and as such will be generally be transmitted to a receiving radio station, if any.

Read Factory Serial Number High, Middle and Low Bytes.
These read only commands return one of the three bytes of the unique factory-set serial number, which are also visible in the startup banner.

Set Duty Cycle
Allows reduced power consumption by having a remote wake up only every 2^N hops to receive and transmit. Power consumption is roughly proportional to the duty cycle selected. For example, if N=2, the remote will wake up every fourth hop. Power

consumption will be roughly ¼ the consumption as when N=0. This parameter must be set to the appropriate value when more than 16 remotes are in use.

Enable Low Power Acquisition Mode. When a remote is searching for a base to acquire and register with, it scans the frequency band very rapidly. This mode consumes about 80mA of current during this mode. To reduce the frequency consumption when a remote is in acquisition mode, a low power acquisition mode is provided. In this mode, the remote only scans the frequency band every other hop. This will reduce the average current consumption during acquisition to about 40mA. The tradeoff is it can take twice as long to acquire and register with a base, or up to 4 seconds.

5.5. Memory Commands

The WIT608B allows the user to store a configuration in nonvolatile memory, which is loaded during the initialization period every time the radio is powered up. Note that changes to the serial port baud rate from recalling the factory defaults or recalling memory will not take effect until DTR is toggled or power to the radio is cycled.

Command	Description
`m0`	Recall Factory Defaults
`m<`	Recall Memory
`m>`	Store Memory
m!	Display Modified Parameters

Recall Factory Defaults
Resets the WIT608B to its factory default state. This is useful for testing purposes or if there is a problem in operation of the system and the configuration is suspect. Use the *Store Memory* command afterwards if you wish the factory default settings to be remembered the next time you cycle power or reset the radio.

Recall Memory
Useful for restoring the power-on settings after experimenting with temporary changes to data rate, protocol or network parameters, etc.

Store Memory
This command is necessary after any command to change the data rate, transceiver address, or other radio setting that you wish to make permanent.

Display Modified Parameters
This command lists all parameter settings that are different from the factory default settings. This will list changed parameters whether or not they have been stored with the m> command. Note that issuing this command will cause the radio to lose link with the base and will cause all remotes to lose link when issued to the base radio.

5.6. Modem Command Summary

Serial Commands

sd[?|00..ff]	Set Data Rate Divisor	
sp[?|00..14]	Set Protocol Mode	

Network Commands

wb[?|0|1]	Set Transceiver Mode	
wd[?|1..3f]	Set Default Handle	
wl[?|0..ff]	Set Lockout Key	
wn[?|00..3f]	Set Hopping Pattern	
wg[?|0|1]	Enable Global Network Modes	
wp[?|0|1]	Set Transmit Power	
wr?	Read Receive Signal Strength	(remote only)
wu[?|0|1]	Set Point-to-Point Direct Mode	
dx[?|0..62]	Set Range Optimization	(base only)

Protocol Commands

pe[?|0..4]	Set Alternative Frequency Band	
ph[?|00..fe]	Set Hop Duration	(base only)
pl?	Get Maximum Data Length	(remote only, read only)
pn[?|01..3e]	Set Maximum Number of Remotes	(base only)
pk[?|00..d4]	Set Minimum Data Length	
pr[?|00..ff]	Set Packet Attempts Limit	
pt[?|00..ff]	Set Data Transmit Delay	(remote only)
pv[?|0|1]	Set Slot Assignment Mode	(base only)
pw[?|00..34]	Set Base Slot Size	(base only)
px[?|0|1]	Set ARQ Mode	

Status Commands

zb[?|0|1]	Banner Display Disable	
zc[?|0..2]	Set Escape Sequence Mode	
zh?	Read Factory Serial Number High Byte	
zm?	Read Factory Serial Number Middle Byte	
zl?	Read Factory Serial Number Low Byte	
zp[?|0..4]	Set Duty Cycle	
zq[?|0|1]	Enable Low Power Acquisition	(remote only)
z>	Exit Modem Control Mode	

Memory Commands

m0	Recall Factory Defaults	
m<	Recall Memory	
m>	Store Memory	
m!	Display Changed Parameters	

Note: Brackets ([,]) as used here denote a set of optional arguments. Vertical slashes separate selections. For example, given the string `wn[?|00..3f]`, legal commands would be `wn?`, `wn0`, `wn3`, and `wn2a`.

Most commands which set a parameter also have a `?` option which displays the current parameter setting; e.g., `wn?`.

9. APPENDICES

9.1. Technical Specifications

9.1.1 Ordering Information

WIT608B	OEM Module, Serial connector pins down - Standard
WIT608BS4	OEM Module, Serial connector pins up

9.1.2. Power Specifications

Vcc Input Range:	3.0v to 5.0v
Operating Temperature Range:	+10°C to +50°C

Current Consumption (Max transmit power, 230.4Kbps I/O)

Mode	Remote	Base Station
Sleep	50µA	N/A
Standby	20mA	N/A
Typical Average	12mA	50mA
Peak (Tx)	75mA	75mA

9.1.3. RF Specifications

FCC Certification	Part 95
Rated RF Power	+10 dBm
Line-of-site Range	30-40 meters indoor hospital environment
Frequency Range	608-614 MHz WMTS Band
Number of Channels	39
Receiver Sensitivity	-92 dBm
Channel Data Rate	230.4 Kbps
IF Adjacent Channel Rejection	>55dB

9.1.4. Mechanical Specifications

Weight		35g
Dimensions (including shield)		80.2 x 46.5 x 8.6mm (refer to section 7.6 for mechanical drawing)
RF Connector:		
	WIT	Huber/Suhner: 85 MMCX 50-0-1
	Mating	Huber/Suhner: 11 MMCX-50-2-3 (straight)
		Huber/Suhner: 16 MMCX-50-2-2 (rt. angle)
Data/Power Connector:		
	WIT	Samtec: DIS5-108-51-L-D
	Mating	Samtec: CLP-108-02-G-D (PCB mount)
		Samtec: FFSD-08 (IDC cable)

9.2. Serial Connector Pinouts

Signal	WIT608B OEM Pinout	
GND	1	
TXD	2	
RXD	3	
CFG	4	
RTS	5	
SLEEP	6	
DCD	7	
CTS	8	

Note: The WIT608B is the standard part number and has the serial connector pins pointing down allowing connection to a mother board without using a cable. WIT608B has the serial connector pins pointing up.

The HN-510 is wired as a DCE device and as such can be connected to DTE devices such as PCs with a straight-through cable. When connecting a HN-510 to a DTE device, a "null modem" cable is required. To effect a null modem cable, cross-wire TXD and RXD and connect ground. The HN-510 can operate with just these three wires connected. However, as the WIT608B does not support software flow control, there will be no flow control in this mode. If the DTE device fails to respond, connect DCD from the HN-510 to the DTR and RTS inputs to activate the DCE device whenever the WIT608B asserts carrier.

When connecting to the WIT608B, make sure that all of the inputs (TXD, CFG, RTS and SLEEP) are terminated for proper operation.

9.3. Approved Antennas

The WIT608B is designed to ensure that no antenna other than the one fitted shall be used with the device. The table below lists the antennas which can be purchased directly from Murata. Contact Murata Technical Support with any questions.

Description	Gain	Part Number	Coupling
2 dBi Cushcraft Patch	2 dBi		MMCX
2 dBi Nearson Dipole	2 dBi		MMCX

9.4. Technical Support

For technical support call Murata at (678) 684-2000 between the hours of 8:30AM and 5:30PM Eastern Time.