

WIT2410

2.4GHz Spread Spectrum Wireless Industrial Transceiver

Integration Guide

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One Meca Way
Norcross, Georgia 30093
www.digital-wireless.com
(770) 564-5540

Note: This device has not been authorized as required by the rules of the Federal Communications Commission. This device is not, and may not be, offered for sale or lease, or sold or leased, until authorization is obtained.

About This Manual

This manual is designed to allow integration of the Digital Wireless Corporation WIT2410 OEM module into complete products. Care has been taken to try and make sure all of the information in this manual is accurate. However, specifications can change over time and Digital Wireless cannot guarantee the accuracy of this information. If you have any questions on any information in this manual, please contact Digital Wireless Technical Support at (770) 564-5540.

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1. INTRODUCTION

The WIT2410 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 2.4 GHz ISM band allows license-free use and worldwide compliance. A simple serial interface supports asynchronous data up to 230400 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.

- Multipath fading impervious frequency hopping technology with 75 frequency channels (2401-2475 MHz).
- Supports point-to-point or multipoint applications.
- Meets FCC rules 15.247 and ETS 300.328 for worldwide license-free operation.
- Superior range to 802.11 wireless LAN devices.
- Transparent ARQ protocol w/3KB buffer ensures data integrity.
- Digital addressing supports up to 32 networks, with 62 remotes per network.
- Low power 3.3v CMOS signals
- Simple serial interface handles both data and control at up to 230400 bps.
- Fast acquisition typically locks to hopping pattern in 5 seconds or less.
- Selectable 10 mW or 100 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.

1.1 Why Spread Spectrum?

The radio transmission channel is very hostile, corrupted by noise, path loss and interfering transmissions from other radios. Even in a pure interference-free environment, radio performance faces serious degradation through a phenomenon known as multipath fading. Multipath fading results when two or more reflected rays of the transmitted signal arrive at the receiving antenna with opposing phase, thereby partially or completely canceling the desired signal. This is a problem particularly prevalent in indoor installations. In the frequency domain, a multipath fade can be described as a frequency-selective notch that shifts in location and intensity over time as reflections change due to motion of the radio or objects within its range. At any given time, multipath fades will typically occupy 1% - 2% of the 2.4 GHz band. This means that from a probabilistic viewpoint, a conventional radio system faces a 1% - 2% chance of signal impairment at any given time due to multipath.

Spread spectrum reduces the vulnerability of a radio system to both interference from jammers and multipath fading by distributing the transmitted signal over a larger region of the frequency band than would otherwise be necessary to send the information. This allows the signal to be reconstructed even though part of it may be lost or corrupted in transit.

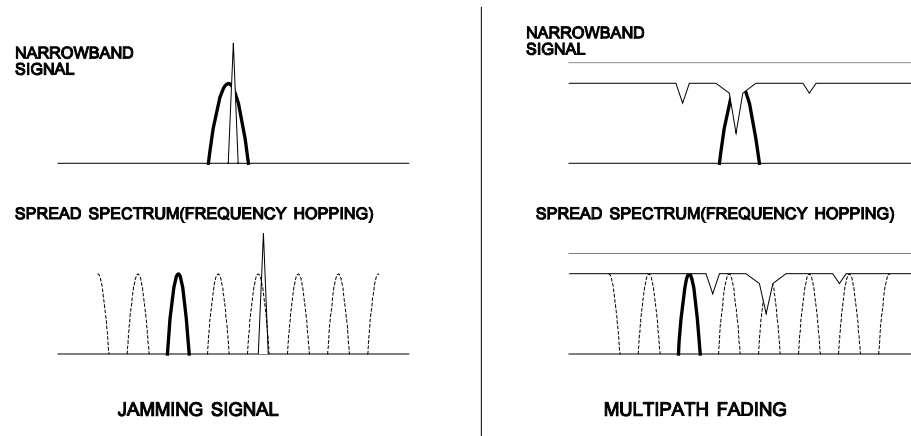


Figure 1

Narrowband vs. spread spectrum in the presence of interference

1.2 Frequency Hopping vs. Direct Sequence

The two primary approaches to spread spectrum are direct sequence (DS) and frequency hopping (FH), either of which can generally be adapted to a given application. Direct sequence spread spectrum is produced by multiplying the transmitted data stream by a much faster, noise-like repeating pattern. The ratio by which this modulating pattern exceeds the bit rate of the baseband data is called the processing gain, and is equal to the amount of rejection the system affords against narrowband interference from multipath and jammers. Transmitting the data signal as usual, but varying the carrier frequency rapidly according to a pseudo-random pattern over a broad range of channels produces a frequency hopping spectrum system.

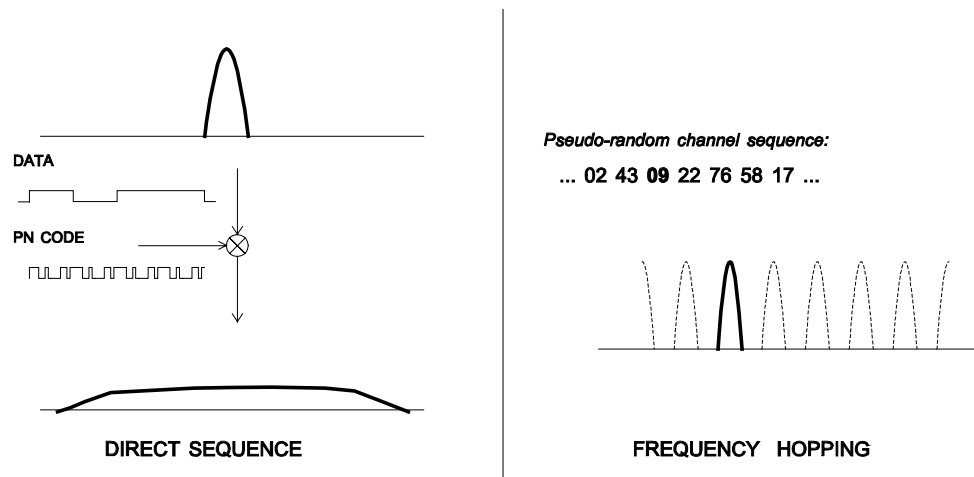


Figure 2
Forms of spread spectrum

One disadvantage of direct sequence systems is that due to spectrum constraints and the design difficulties of broadband receivers, they generally employ only a minimal amount of spreading (typically no more than the minimum required by the regulating agencies). For this reason, the ability of DS systems to overcome fading and in-band jammers is relatively weak. By contrast, FH systems are capable of probing the entire band if necessary to find a channel free of interference. Essentially, this means that a FH system will degrade gracefully as the channel gets noisier while a DS system may exhibit uneven coverage or work well until a certain point and then give out completely.

Because it offers greater immunity to interfering signals, FH is often the preferred choice for co-located systems. Since direct sequence signals are very wide, they tend to offer few non-overlapping channels, whereas multiple hoppers may interleave with less interference. Frequency hopping does carry some disadvantage in that as the transmitter cycles through the hopping pattern it is nearly certain to visit a few blocked channels where no data can be sent. If these channels are the same from trip to trip, they can be memorized and avoided; unfortunately, this is generally not the case, as it may take several seconds to completely cover the hop sequence during which time the multipath delay profile may have changed substantially. To ensure seamless operation throughout these outages, a hopping radio must be capable of buffering its data until a clear channel can be found. A second consideration of frequency hopping systems is that they require an initial acquisition period during which the receiver must lock on to the moving carrier of the transmitter before any data can be sent, which typically takes several seconds. In summary, frequency hopping systems generally feature greater coverage and channel utilization than comparable direct sequence systems. Of course, other implementation factors such as size, cost, power consumption and ease of implementation must also be considered before a final radio design choice can be made.

As an additional benefit, RF spectrum has been set aside at 2.4 GHz in most countries (including the U.S.) for the purpose of allowing compliant spread spectrum systems to operate freely without the requirement of a site license. This regulatory convenience alone has been a large motivation for the industry-wide move toward spread spectrum.

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. All radios in a net must be set to the same hopping pattern before attempting to communicate.

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 75 frequencies and the remote is scanning 75 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. If necessary, the automatic handle assignment can be overridden to explicitly tie certain handles to certain remotes. See the section on *Network Commands* for details on the *Set Default Handle* command.

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*, the duty cycle and the multiple access mode, i.e., TDMA or CSMA.

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 *packet transmit delay* has been set. The *packet transmit delay* parameter allows for the transmission of groups of continuous data in transparent mode (protocol mode 0). In TDMA mode the

amount of data that the base station can transmit per hop is determined by the hop duration and the number of remotes registered with the base. In CSMA mode, the maximum amount of data sent is determined by *maximum data length*. In any event, the maximum amount of data sent by a base station or remote per hop is 127 bytes. If there is no data to be sent, the base station will not transmit until the next frequency.

The operation of the remotes depends on whether the remote is set up for TDMA mode or CSMA mode. In TDMA mode, the operation of the remotes is the same as the base station without the synchronization signal.

In CSMA mode, remotes compete on an *ad hoc* basis for transmission time. The likelihood that a remote will attempt to transmit immediately is affected by the *persistence* parameter. If a collision is detected with another radio, the remote will wait a random period of time before trying to retransmit. The *backoff* parameter controls the maximum time a remote will wait before attempting to retransmit. Unregistered remotes can request registration any time after the base station transmission. Refer to the section *Protocol Commands* for details on the *persistence* and *backoff* parameters.

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 WIT2410 supports two network configurations: point-to-point and point-to-multipoint. In a point-to-point network, one radio is set up as the base station and the other radio is set up as a remote. 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.

2.2.1. Point-to-Point

In point-to-point mode, unless *packet transmit delay* has been set, the base station will transmit whatever data is in its buffer limited to 127 bytes or by the length of the *base slot size*. If the base station has more data than can be sent on one hop, the remaining data will be sent on subsequent hops. In addition to the data, the base station adds some information to the transmission over the RF link. It adds the address of the remote to which it is transmitting, even though in a point-to-point mode there is only one remote. It also adds a sequence number to identify the transmission to the remote. This is needed in the case of acknowledging successful packets and retransmitting errored packets. Also added is a 24-bit CRC to allow the base to check the received transmission for errors. When the remote receives the transmission, it will acknowledge the transmission if it was received without

errors. If no acknowledgment is received, the base station will retransmit the same packet on the next frequency hop.

In point-to-point mode, a remote will transmit whatever data is in its buffer up to the limit of its *maximum packet length*. If desired, a *minimum packet length* can also be set, which forces the remote to wait until a certain amount of data is available or the specified *packet transmit delay* is exceeded before transmitting. If the remote has more data than can be sent on one hop, it will send as much data as possible as a packet, adding its own address, a packet sequence number and 24-bit CRC. These additional bytes are transparent to the user application if the protocol mode is 00 (which is the default). In the event a remote has more data to send, the data will be sent on subsequent hops. If the packet is received by the base station without errors, the base station will acknowledge the packet. If the remote does not receive an acknowledgment, it will retransmit the packet on the next frequency hop. To the user application, acknowledgments and retransmissions all take place behind the scenes without the need for user intervention.

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. 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. 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. TDMA Mode

For applications needing guaranteed bandwidth availability, the TDMA mode of the WIT2410 can meet this requirement. This is the default mode of the WIT2410. In TDMA mode, 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 which 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 time 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.

When setting up a TDMA network, keep in mind that time slot length, maximum packet size and hop duration are all interrelated. The *hop duration* parameter will determine the time slot size and the maximum amount of data that can be transmitted per hop by the remotes. There is a hard limit of the absolute maximum amount of data that can be sent on any given hop of 212 bytes regardless of any parameters. The base station requires 1.7 ms overhead for tuning, the synchronization signal and parameter updating, as well as a guard time of 500 us between each remote slot. Thus the amount of time allocated per remote slot is roughly:

$$\frac{\text{hop duration} - \text{base slot} - 1.7\text{ms} - (\# \text{ of registered remotes} - 1) \cdot 500\text{us}}{(\# \text{ of registered remotes})}$$

Take for example a network comprised of a base station and 10 remotes. A hop duration of 15 ms is chosen. We decide that the base station needs to be able to send up to 32 bytes each hop (equivalent to a capacity for the base of ~ 21 kbps). Counting the 1.7 ms overhead for the base packet and making use of the fact that our RF rate is 460.8 kbps, we determine that the base slot requires approximately:

$$\frac{32 \cdot 8}{460.8\text{kbps}} + 1.7 \text{ ms} = 2.3 \text{ ms}$$

Each remote time slot will be:

$$\frac{15 \text{ ms} - 2.3 \text{ ms} - (9) \cdot 0.5 \text{ ms}}{10} = 0.82 \text{ ms}$$

From our RF data rate of 460.8 kbps we see that it takes 17.36 µs to send a byte of data, so each remote will be able to send up to

$$\frac{0.82 \text{ ms}}{17.36\text{us}} = 47 \text{ bytes of data per hop.}$$

Note that the 47 bytes is the actual number of data bytes that can be sent. If the WIT2410 is using a protocol mode, the packet overhead does not need to be considered. So in this example, the total capacity per remote would be:

$$\frac{47 \text{ bytes}}{15 \text{ ms}} = 25 \text{ kbps}$$

If we figure a minimum margin of safety for lost packets and retransmissions of about 20%, we see that this would be more than sufficient to support 19.2 kbps of continuous data per remote. It is also useful to remember that the asynchronous data input to the WIT2410 is

stripped of its start and stop bits during transmission by the radio, yielding a "bonus" of 10/8 or 25% in additional capacity.

The above calculations are provided as a means of estimating the capacity of a multipoint WIT2410 network. To determine the precise amount of capacity, you can actually set up the radio system and then query the *maximum packet length* from one of the remotes in control mode to discover its exact setting. Divide this number by the hop duration as above to get the remote's exact capacity.

2.2.4. CSMA Mode

CSMA mode is not currently available for the WIT2410.

2.2.5. Full Duplex Communication

From an application perspective, the WIT2410 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 up to three packets 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 2.4 GHz 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 WIT2410 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 WIT2410 simply tries again on the next channel. Even if two thirds of the band are unusable, the WIT2410 can still communicate reliably.

Data input to the WIT2410 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, it is the responsibility of the user application to track errored or missing packets. A second parameter, *ARQ Mode*, allows the choice between using ARQ to resend errored packets or always sending a packet *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 non-errored data from the modem. However, if the ARQ mode is disabled, error detection and correction 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 WIT2410 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 **:wit2410** (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 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 WIT2410 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 50 μ A. 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, WIT2410 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 in TDMA mode, duty cycling must be enabled since a maximum of 16 time slots are available per hop.

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 is 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.

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 WIT2410 supports 12 protocol formats which are described in detail below. The protocol format is selected through the *Set Protocol Mode* command.

- | | |
|---------|---|
| 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 and Command packets only. 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
<div style="text-align: center;">CONNECT
DISCONNECT</div> |
| mode 04 | This is the packet format used by the WIT2400. This allows legacy software to operate the WIT2410. Note however, that since different air data rates are used, WIT2410s and WIT2400s cannot be mixed in a network.

packet types supported: 2400 data format
(addresses must be limited to 0..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. Packet Formats

The byte formats for each packet type are shown in the table below. Packet fields are organized to fall on byte boundaries. In the case of bit-level fields, most-significant bits are on the left.

WIT2400 packet type (mode 04):

DATA	0000 0010	00HH HHHH	0LLL LLLL	<0-127 bytes data>	0000 0011
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MRTP (WIT2410) packet types (modes 01-03):

Transmit and Receive:

DATA	1110 1001	00HH HHHH	0LLL LLLL	<0-127 bytes data>
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Receive only:

CONNECT	1110 1001	10HH HHHH	RRRR TTTT	00NN NNNN	<3 byte remote ID>
DISCONNECT	1110 1001	11HH HHHH	0111 1111		

H	: handle number (0-63)
L	: data length (0-127)
N	: remote's previous network number (if roamed)
R	: receive sequence number (from previous cell)
T	: transmit sequence number (from previous cell)

3.1.1. Data Packet

Modes 01 & 02: 1110 1001 00HH HHHH 0LLL LLLL <0-127 bytes data>
Mode 04 (WIT2400): 0000 0010 00HH HHHH 0LLL LLLL <0-127 bytes data> 0000 0011
 H : handle number (0-63)
 L : data length (0-127)

This packet carries user data. The handle number is the handle of the sending or receiving remote, depending on whether the data is going to or coming from the base. Up to 127 bytes of user data may be carried per data packet.

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 **FFH**.

3.1.4. Disconnect Packet (base only, receive only)

1110 1001 10HH 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.

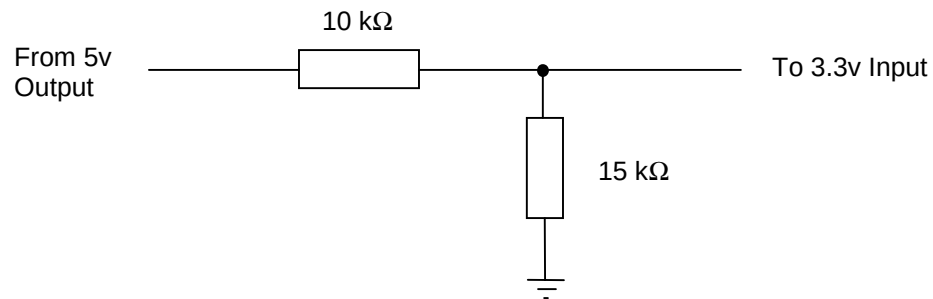
4. MODEM INTERFACE

Electrical connection to the WIT2410 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 WIT2410 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 50 μ A. 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
9-15	-	-	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 WIT2410 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 WIT2410 signal inputs. The output voltage swing of the WIT2410 3.3 volt signals is sufficient to drive 5 volt logic inputs.



5. MODEM COMMANDS

The WIT2410 is configured and controlled through a series of commands. These commands are sent to the modem directly when the modem is in Control Mode or through Command Packets when the modem is in Data Mode. 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?**

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 = <i>reserved for future use</i> 09 = mode 01 during transmit, transparent receive 0A = mode 02 during transmit, transparent receive 0C = mode 04 during transmit, transparent receive 0D – 10 = <i>reserved for future use</i> 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:

$$\text{DIVISOR} = (230400/\text{RATE}) - 1$$

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 WIT2410 network and to set radio addressing and configuration.

Command	Description
wb[? 0 1]	Set Transceiver Mode 0 = remote (default) 1 = base station
wd[? 0-3f]	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
wn[? 0-1f]	Set Hopping Pattern (Network Number) 0 = default
wp[? 0 1]	Set Transmit Power 0 = 10mW 1 = 100mW (default)
wr?	Read Receive Signal Strength

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.

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. Enable the global mode if you wish to allow remotes to link to any base station it can hear, acquiring whatever hop pattern is required.

Set Hopping Pattern

The WIT2410 has 32 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 WIT2410 has two preset transmit power levels, 10mW (10dBm) and 100mW (20dBm). Control of the transmit power is provided through this command. Default is 100mW.

Read Receive Signal Strength Indicator (RSSI)

This command reports the relative signal strength averaged over the last 10 hops. This command returns a two-digit hexadecimal value and can range from 00 to FF. 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 a different signal strength from each remote.

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
pe[? 0-3]	Set Alternative Frequency Band 0 = FCC operation. (default) 1 = France (ETSI) 2 = Spain 3 = Japan
ph[? 00-ff] (base only)	Set Hop Duration 90H = default
pk[? 00-d0]	Set Minimum Data Length 0 = default
pl?	Get Maximum Data Length D4 = default
pr[? 00-ff]	Set Packet Attempts Limit 10H = default
pt[? 00-ff]	Set Packet Transmit Delay 00H = default
pw[? 00-30] (base only)	Set Base Slot Size 04H = default
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 Alternative Frequency Band

When set to 1, limits the operating RF channel set to the 2448 to 2480 MHz frequency band for compliance with European ETSI or French regulatory standards. When set to 2, sets appropriate operation for Spain. When set to 3, sets appropriate operation for Japan. This setting should be set to 0, for FCC-compliant operation in the US (this is the default).

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 **FFH** is 17.7ms. 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.

Get Maximum Data Length (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.

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 *packet transmit delay* elapses before sending a data packet with less than this number of bytes. Can be used to keep short, intermittent transmissions contiguous.

Set Packet Attempts Limit

Sets the number of times the radio will attempt to send an errored packet before discarding it if *ARQ Mode* is set to 0. If *ARQ Mode* is set to 1, it is the number of times every packet will be sent, regardless of success or failure of a given attempt.

Set Packet 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. Incremented in 69.4µs steps with a maximum value FFH or 17.7ms.

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 30H which corresponds to 192 bytes.

Set ARQ Mode

Sets ARQ mode when set to 0 which is the default. In this mode the radio will resend an errored packet until either successful or *packet attempt limit* attempts have been made. When set to 1 selects redundant transmit mode that will send every packet *packet attempt limit* times regardless of success or failure of any given attempt.

5.4. Status Commands

These commands deal with general interface aspects of the operation of the WIT2410.

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[? 0-5]	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.
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 ":wit2410". 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. For backwards compatibility with the WIT2400, the string ":wit2410" is also accepted for entering Control Mode. 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 $1/4$ the consumption as when $N=0$. This parameter must be set to the appropriate value when TDMA mode is being used with more than 16 remotes.

5.5. Memory Commands

The WIT2410 allows the user to store a configuration in nonvolatile memory, which is loaded during the initialization period every time the radio is powered up.

Command	Description
m0	Recall Factory Defaults
m<	Recall Memory
m>	Store Memory

Recall Factory Defaults

Resets the WIT2400 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.

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[? 0..3f]	Set Default Handle	
wn[? 00..3f]	Set Hopping Pattern	
wg[? 0 1]	Enable Global Network Mode	
wp[? 0 1]	Set Transmit Power	
wr?	Read Receive Signal Strength	(remote only)

Protocol Commands

pe[? 0..3]	Set Alternative Frequency Band	
ph[? 00..ff]	Set Hop Duration	(base only)
pl?	Get Maximum Data Length	
pk[? 00..d4]	Set Minimum Data Length	
pr[? 00..ff]	Set Packet Attempts Limit	
pt[? 00..ff]	Set Packet Transmit Delay	(remote only)
pw[? 00..20]	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
z>	Exit Modem Control Mode

Memory Commands

m0	Recall Factory Defaults
m<	Recall Memory
m>	Store Memory

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?`.

6. WIT2410 DEVELOPER'S KIT

The WIT2410 Developer's Kit contains two self-contained wireless modems built around the WIT2410M OEM module. In addition, two WIT2410 OEM modules are included in the kit. The self-contained units allow developers to get up and running quickly using standard RS-232 interfaces without having to build a CMOS level serial interface. In addition, the self-contained modems include status LEDs to provide modem status information visually. The built-in battery pack allows the developer to use the modems without being tethered to a power source. This provides a simple way to test the range of the radios. Other than the true RS-232 signals of the serial interface, the self-contained modems operate exactly as the OEM modules.

Connection is made to the modems through a standard DB-9 connector. The modems are set up as DCE devices requiring the use of a straight-through cable to connect to DTE devices. The pinout is provided in Section 7.3. The modems can be used with just a three wire connection. Transmit data, receive data and ground are the three required connections. Note that in this configuration, no flow control is available as the WIT2410 does not support software flow control.

When the developer's kit is shipped from the factory, one modem is set up as a base station and the other is set up as a remote. The interface rate for both modems is set at 9600 bps. The default setting for the network key allows the modems to communicate without changing any settings. The modems are set up to operate in TDMA mode. As a quick test, separate the two modems by about 5 feet, plug in the power and turn the modems on. Do not connect the modems to any device. The Carrier Detect (CD) LED on the base station will come on immediately. After a few seconds, the CD LED on the remote will come on. This indicates that the modems have synchronized and have established a communications link.

An important point to remember is that if the base station is in Sleep mode, no communications can take place until (1) the base station is taken out of sleep mode and (2) the remote has synchronized with the base station. As the Sleep signal is brought out on the pin usually occupied by DTR, connecting the base station to a PC serial port with DTR de-asserted will put the modem into sleep mode. Some communications programs will attempt to communicate immediately after asserting DTR. The base station will transmit this data, but the remote will not be synchronized with the base station and will not receive the transmission. In this instance, do not connect the Sleep signal to DTR of the serial port.

6.1. COM24

Provided with the developer's kit is a simple communications program designed especially for the WIT2410. This program provides a simple command interface to the modems along with function key control for manipulating the serial port control lines and baud rates. This program is designed to run under DOS although it will also work in the DOS box under most versions of Windows. However, due to the limitations Windows puts on programs interfacing directly to hardware, COM24 may not work under Windows 98 without booting directly to DOS.

COM24 defaults to com1: and 9600 bps. The port and baud rate can be changed through the invocation of the program. The invocation syntax is shown below:

COM24 <data rate> <port number>

Note that the data rate applies to the serial port of the computer. This parameter has no effect on the modem. If the modem is set for 9600bps but COM24 is invoked to run at 19.2kbps, the computer and the modem will be unable to communicate. When the modems are used for the first time, if they are connected to serial port 1, the program can be invoked without data rate or port number parameters.

The following function keys on the PC have the following functions in COM24:

- F1** Toggles state of DTR (Sleep). State is shown in status line.
- F2** Toggles state of RTS. State is shown in status line.
- F3** Transmits “:wit2400”. Used to enter control mode.
- F5** Toggles local echo. If you are transmitting characters through one modem to another WIT2410, this allows you to see what you are typing.
- F6** Toggles stream mode. Causes COM24 to transmit a repeating pattern of characters. Useful for testing.
- F8** Toggles binary mode. Displays extended ASCII and control characters. Useful for testing.
- PgUp** Sets data rate of PC serial port to next higher value. Value is displayed in status line. Useful when COM24 is used to change the WIT2410 interface data rate. COM24 can communicate at new data rate without having to exit and re-enter COM24.
- PgDn** Sets data rate of PC serial port to next lower value. Value is displayed in status line.

The values of DTR (Sleep), RTS, DSR, CTS, DCD and the PC serial port rate are displayed in the status line at the bottom of the display.

6.2. Demonstration Procedure

The procedure below provides a quick demonstration of the WIT2410.

1. Attach a transceiver to each computer, preferably between 5' and 30' apart for convenience.
2. Start COM24 running on both computers by typing "COM24". If you are connected to a serial port other than COM1:, use "COM24 9600 <port number>" to start the program; e.g., for COM2:, use "COM24 9600 2". If you prefer, almost any other serial communications program such as Procomm or QModem set for 9600 bps will also work.
3. Turn the radios on and use the function keys to set DTR and RTS to 1 (if you are using a terminal program other than COM24, these are typically set automatically). The radio should respond by setting both DSR and CTS to 1, and transmit a short sign-on message

including the firmware version and whether the unit is configured as a base or remote. Watch the states of the hardware control lines on the status bar as you do this. The DCD indicator should be lit on the base station. After a few seconds, the remote unit will acquire the base station's signal and also assert its DCD signal.

4. Access modem control mode for each unit. To access modem control mode, use the F1 key to toggle DTR to 0 and back to 1 and then press the F3 key, which sends the ":wit2400" escape sequence. If you are not using COM24, simply turn the radio off and back on and then type ":wit2400" (must be lower case, no backspace characters). The transceiver should echo back ">" to indicate that you have entered modem control mode. Check the remote unit's hopping pattern by entering "wn?" at the prompt. The remote should respond with "0", the default setting. Check that the base station's hopping pattern matches this by entering "wn?" at the base station.
5. Exit control mode by entering "z>". Do this for both radios. At this point, you should be able to type characters into either radio and see them appear at the other side. If you are using COM24, you can press the F6 key to transmit a repeating test pattern.
6. For a range test, disconnect the remote station from the computer and power supply. The DCD indicator should remain lit as long as the base station is in range..
7. Exit COM24 by pressing the ESC key.

6.3. Troubleshooting

Radio is not responding.

Make sure DTR is asserted to bring the radio out of sleep mode. DSR should be on to indicate the radio is ready.

Can't enter modem control mode.

Make sure the host data rate is correct. The WIT2410 defaults to 9600 bps asynchronous. Evaluation units do not have external access to the CFG_SEL signal; you must use the :wit2410 power-on escape sequence to access modem control mode. The first characters typed after the radio wakes up should be the escape sequence. Make sure you type the colon (:) and enter the letters in lower case; the characters following the colon echo to show you have typed them correctly. If using the "on-the-fly" escape sequence command, make sure a pause of at least 20ms precedes the escape sequence.

Remote never detects carrier.

Check that the base station is running, and that the remote is programmed to the same hopping pattern. Also check that the hop duration for base and remote are the same, and that the remote has a non-zero link margin.

Carrier is detected, but no data appears to be received.

Make sure that RTS is asserted to enable receive character flow. In a point-to-point application, if a remote is not receiving data, check that the base's default handle is the same as the remote's. In a multipoint application, check that the remote is not configured for protocol mode and that the base is using the correct protocol format and destination handle.

Radio is interfering with other nearby circuits.

It is possible for the RF energy envelope to be rectified by nearby circuits that are not shielded for RFI, manifesting as a lower frequency noise signal. If possible, place the antenna at least 1 foot away from the transceiver module, and 3 feet from other circuit boards and obstructions. Place sensitive circuits in a grounded metal casing to keep out RFI.

Sign-on banner or modem control mode prompt is unreadable.

If the problem is repeatable, check whether the data rates between host and transceiver match.

Range is extremely limited.

This is usually a sign of poor antenna coupling. Check that the antenna is firmly connected. If possible, remove any obstructions in the near field of the antenna (~3' radius).

Transmitting terminal flashes CTS occasionally.

This indicates that the transmitter is unable to reliably get its data across. This may be the result of an interfering signal, but most often is caused by overloading of the network. Adjusting the protocol parameters may increase the network efficiency.

Receiving terminal drops characters periodically.

Set the number of retries to a high number and send a few characters. Check that the transmitted data can get through under these conditions. Sometimes this symptom is caused by an application that is explicitly dependent on the timing of the received data stream. The nature of the packetized RF channel imposes a degree of unpredictability in the end-to-end transmission delay.

7. APPENDICES

7.1. Technical Specifications

7.1.1. Power Specifications

Vcc Input Range: 3.3v to 10.0v
Vcc Ripple: <1%
Operating Temperature Range: -20C to +70C

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

Mode	Remote	Base Station
Sleep	50µA	N/A
Standby	20mA	N/A
Typical	50mA	120mA
Peak (Tx)	200mA	200mA

7.1.2. RF Specifications

FCC Certification	Part 15.247, no license required
ETSI (European) Certification	brETSI 300.328, no license required
Rated RF Power	+18 dBm (+20 dBm effective radiated)
Line-of-site Range	approx. 6/10 of a mile
Frequency Range	2401 – 2480MHz
Number of Channels	75 (France: 33, Spain & Japan: 25)
Receiver Sensitivity	-93dBm
Channel Data Rate	460Kbps
IF Adjacent Channel Rejection	>55dB

7.2.2. 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: FFSD-08 (IDC cable) Samtec: CLP-108-02-G-D (PCB mount)

7.3. Serial Connector Pinouts

Signal	WIT2410M OEM Pinout	WIT2410E DB9 Pinout
GND	1	5
TXD	2	3
RXD	3	2
CFG	4	-
RTS	5	7
SLEEP	6	4
DCD	7	1
CTS	8	8

The WIT2410E is wired as a DTE device and as such can be connected to DTE devices such as PCs with a straight-through cable. When connecting a WIT2410E to a DCE device, a “null modem” cable is required. To effect a null modem cable, cross-wire TXD and RXD and connect ground. The WIT2410E can operate with just these three wires connected. However, as the WIT2410 does not support software flow control, there will be no flow control in this mode. If the DCE device fails to respond, connect DCD from the WIT2410E to the DTR and RTS inputs to activate the DCE device whenever the WIT2410 asserts carrier.

When connecting to the WIT2410M, make sure that all of the inputs (TXD, CFG, RTS and SLEEP) are terminated for proper operation.

7.4. Approved Antennas

The WIT2410M is designed to ensure that no antenna other than the one fitted shall be used with the device. The end user must permanently affix the antenna by using an adhesive on the coupling such as *Loctite*, or ensure the antenna has a unique coupling. The table below lists the antennas which can be purchased directly from Digital Wireless Corporation. Contact DWC Technical Support with any questions.

Description	Gain	Part Number	Coupling
YD24/15 Yagi Directional	14 dB	YAGI2415	N
Om24/9 Omnidirectional	9 dB	OMNI249	N
DWC Patch	6 dB	PA2400	MMCX
Dipole	2 dB	RWA249R	Reverse SMA

7.5. Technical Support

For technical support call Digital Wireless Corporation at (770) 564-5540 between the hours of 8:30AM and 5:30PM Eastern Time.

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7.7. Warranty

Seller warrants solely to Buyer that the goods delivered hereunder shall be free from defects in materials and workmanship, when given normal, proper and intended usage, for twelve (12) months from the date of delivery to Buyer. Seller agrees to repair or replace at its option and without cost to Buyer all defective goods sold hereunder, provided that Buyer has given Seller written notice of such warranty claim within such warranty period. All goods returned to Seller for repair or replacement must be sent freight prepaid to Seller's plant, provided that Buyer first obtain from Seller a Return Goods Authorization before any such return. Seller shall have no obligation to make repairs or replacements which are required by normal wear and tear, or which result, in whole or in part, from catastrophe, fault or negligence of Buyer, or from improper or unauthorized use of the goods, or use of the goods in a manner for which they are not designed, or by causes external to the goods such as, but not limited to, power failure. No suit or action shall be brought against Seller more than twelve (12) months after the related cause of action has occurred. Buyer has not relied and shall not rely on any oral representation regarding the goods sold hereunder, and any oral representation shall not bind Seller and shall not be a part of any warranty.

THE PROVISIONS OF THE FOREGOING WARRANTY ARE IN LIEU OF ANY OTHER WARRANTY, WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL (INCLUDING ANY WARRANTY OR MERCHANT ABILITY OR FITNESS FOR A PARTICULAR PURPOSE). SELLER'S LIABILITY ARISING OUT OF THE MANUFACTURE, SALE OR SUPPLYING OF THE GOODS OR THEIR USE OR DISPOSITION, WHETHER BASED UPON WARRANTY, CONTRACT, TORT OR OTHERWISE, SHALL NOT EXCEED THE ACTUAL PURCHASE PRICE PAID BY BUYER FOR THE GOODS. IN NO EVENT SHALL SELLER BE LIABLE TO BUYER OR ANY OTHER PERSON OR ENTITY FOR SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING, BUT NOT LIMITED TO, LOSS OF PROFITS, LOSS OF DATA OR LOSS OF USE DAMAGES ARISING OUT OF THE MANUFACTURE, SALE OR SUPPLYING OF THE GOODS. THE FOREGOING WARRANTY EXTENDS TO BUYER ONLY AND SHALL NOT BE APPLICABLE TO ANY OTHER PERSON OR ENTITY INCLUDING, WITHOUT LIMITATION, CUSTOMERS OF BUYERS.