UtiliCom

SPREAD SPECTRUM COMMUNICATIONS

LongRanger 2050

Operator's Manual

PRELIMINARY

18 October 1999

FCC Notice

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

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Changes or modifications not expressly approved in writing by Utilicom Inc. may void the user's authority to operate this equipment. Utilicom can not accept any financial or other responsibilities that may be the result of your use of this information, including direct, indirect, special, or consequential damages. There are no warranties extended or granted by this document. Refer to separate warranty documents for product warranty coverage and specifics.

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1   INTRODUCTION

The *LongRanger 2050* is a Spread Spectrum radio operating in the "Industrial Scientific and Medical" (ISM) band from 2.400GHz to 2.4835 GHz. It provide a wireless, synchronous full duplex, point to point communications at a variety of speeds up to 768 Kbps. Spread Spectrum technology allows operation without a license with output power of up to 28 dBm.

The *LongRanger 2050* architecture separates the radio into two distinct sections: an Indoor Unit that interfaces with the user equipment, and a watertight Outdoor Unit, which is typically mounted in close proximity to the antenna. The two units are connected with a single coaxial cable, carrying the following signals:

1. DC voltage to power up the Outdoor Unit.
2. Reference frequency for the Outdoor Unit frequency synthesizer.
3. Encoded control signals to select the transmit/receive channels, calibration and built in test functions of the outdoor unit.
4. Intermediate Frequency (transmit and receive))

The cable connecting the Indoor and Outdoor unit can be an inexpensive coaxial cable since the Intermediate Frequency in the cable operates at 325 MHz.

2   SPECIFICATIONS

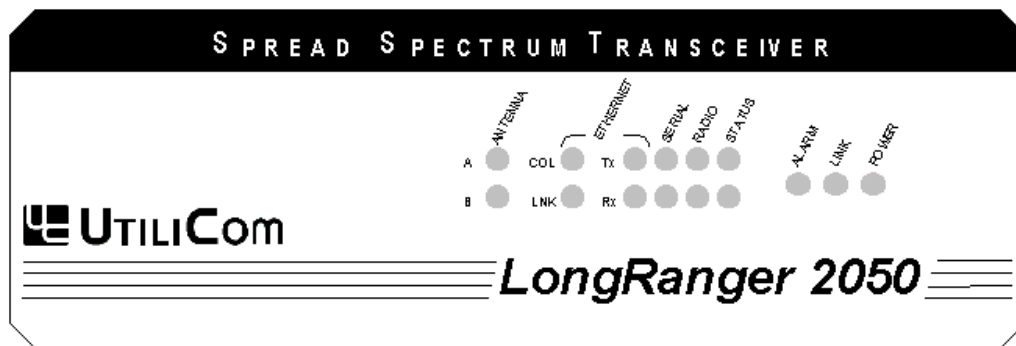| RF Specifications	
RF Frequency Band	2.400GHz to 2.4835 GHz
RF Signal Bandwidth	13.8 MHz
RF Channels	Center frequency programmable in 512 KHz steps
Transmitter Output Power	Up to 28 dBm (programmable)
Modulation Type	BPSK or QPSK (programmable), direct sequence spread spectrum
PN Code rate	9.216 Mchip/sec
PN Code Lengths	11, 15, 31 or 63 (programmable)
RF Data Rates (one way)	146 Kbps to 1676 Kbps (see table below)
Receiver Sensitivity (10^{-6} BER)	-95 dBm (@ 146 Kpbs) -84 dBm (@ 1676 Kbps)
Transmit/Receive Turnaround	< 150 us
Data Interfaces	
Command Port	RS-232 (DE9 connector)
Primary Serial Data Port	RS-232/EIA530/V.35 (DB25 connector)
Ethernet Port	10 BaseT
Echelon LONWORKS	RJ-45 Connector
Diagnostic Port	RS-232 (DE9 internal connector)
Power Requirements	
Input Voltage	+9 to +16 Volts DC (External AC adapter available)
Power Consumption	15 Watts maximum
Operating Temperature	-40 to +70 Degrees C
Mechanical:	
Indoor Unit Dimensions	6.8" wide x 2.3" high x 8.3" deep
Indoor Unit Weight	40 oz.
Up/Down Converter Dimensions	5.9" diameter x 1.75" high
Up/Down Converter Weight	48 oz.

One Way RF Data Rates (Kbps)

	PN Code Length			
	11	**15**	**31**	**63**
BPSK	838	614	297	146
QPSK	1676	1229		

3 INDOOR UNIT

3.1 Front Panel

The *LongRanger 2050* front panel is shown in the figure below. The front panel includes fifteen Light Emitting Diodes (LED's) described in the following table.
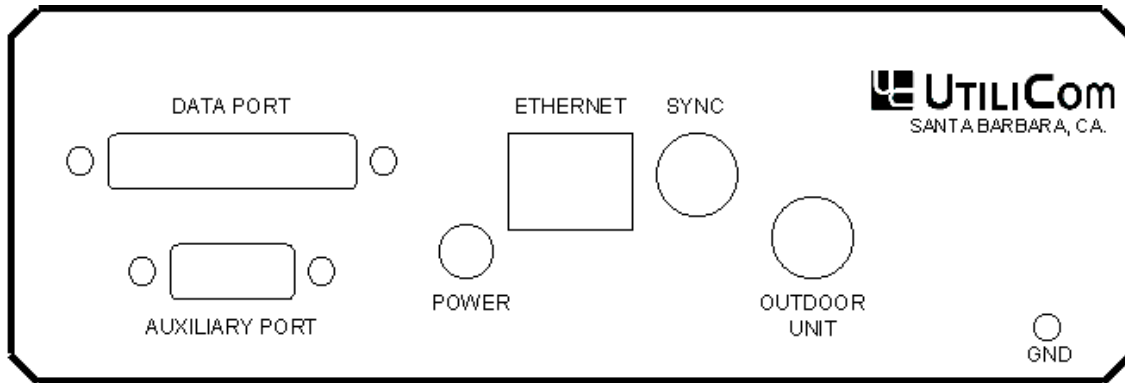

Front Panel LED's

LED	Color	Function
POWER	Green	Lights up when the unit power is applied to the power connector
LINK	Green	Indicates that the RF link and data link to the user Data Terminal Equipment is active and operational.
ALARM	Red	When lit indicates that an alarm condition (link dropped) has occurred. It can be cleared with a console command.
RADIO Tx	Amber	Lights up when the radio is transmitting over RF
RADIO Rx	Green	Lights up when the radio is receiving over RF
SERIAL Tx	Amber	Lights up when data is being output by the radio over the Data port in the radio rear panel
SERIAL Rx	Green	Lights up when data is being received by the radio over the Data port in the radio rear panel
ANTENNA A	Green	Indicates that the radio is currently utilizing the antenna A port in the Outdoor Unit
ANTENNA B	Green	Indicates that the radio is currently utilizing the antenna B port in the Outdoor Unit

3.2 Rear Panel

The *LongRanger 2050* rear panel is shown in the figure below. It includes seven connectors described in the following table

Indoor Unit Rear Panel Connectors

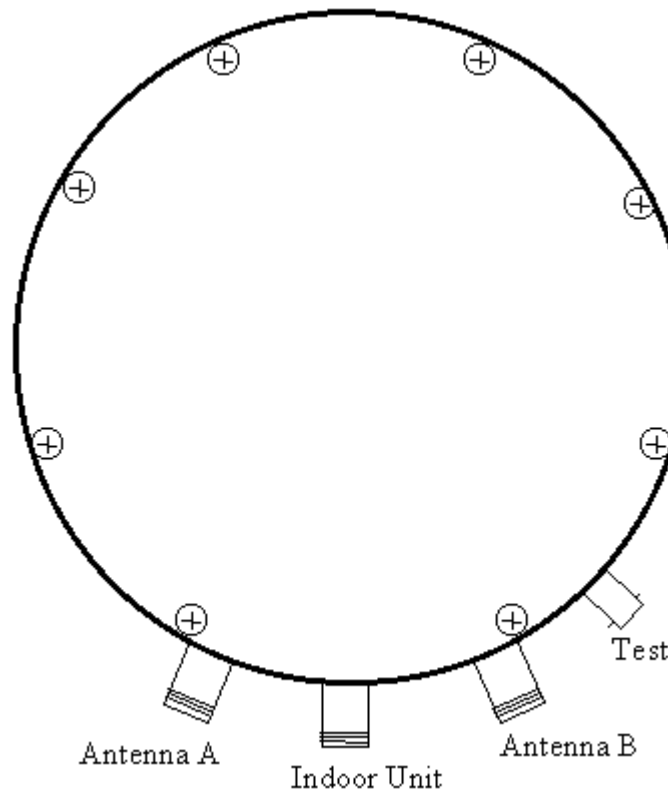| Connector	Type	Function
DATA PORT	DB25 Female	Data port to be connected to the Data Terminal Equipment. This port can be software configured to operate in RS-232, EIA-530 or V.35 modes. The pin assignments are standard Data Communication Equipment (DCE) shown in the following table.
AUXILIARY PORT	DE9 Female	The auxiliary port is used to configure and monitor the radio operation. It operates in RS-232 mode and is wired as a standard DCE. This port should be connected to a terminal or a PC running a terminal emulation mode. The baud rate defaults to 9600 baud.
POWER		Power jack to be connected to the external power supply.
ETHERNET	RJ45 10 Base T	Connection to an Ethernet LAN used for network management purposes.
SYNC	BNC	Synchronization signal to synchronize the RF transmissions of collocated units.
OUTDOOR UNIT	TNC	Intermediate Frequency and control signals to the Outdoor Unit. It must be connected through a coaxial cable to the corresponding connector in the Outdoor Unit.
GND		Chassis ground to be wired to the Earth ground.

The Data Port connector pin assignments, for each of the programmable modes, is sjhown in the following table:

Data Port Connector (DB25) Pin Assignments

Signal Name	Abbr.	Pin Assignment			Direction
		RS-232	EIA 530	V.35	
Protective Ground	GND	1	1	1	
Transmitted Data	TD	2	(A) 2 (B) 14	(A) 2 (B) 14	DTE to radio
Received Data	RD	3	(A) 3 (B) 16	(A) 3 (B) 16	radio to DTE
Request to Send	RTS	4	(A) 4 (B) 19	4	DTE to radio
Clear to Send	CTS	5	(A) 5 (B) 13	5	radio to DTE
Data Set Ready	DSR	6	(A) 6 (B) 22	6	radio to DTE
Signal Ground	SG	7	7	7	
Carrier Detect	CD	8	(A) 8 (B) 10	8	radio to DTE
Synchronous Transmit Clock	STC	15	(A) 15 (B) 12	(A) 15 (B) 12	radio to DTE
Synchronous Receive Clock	SRC	17	(A) 17 (B) 9	(A) 17 (B) 9	radio to DTE
Data Terminal Ready	DTR	20	(A) 20 (B) 23	20	DTE to radio
Synchronous External Clock		24	(A) 24 (B) 11	(A) 24 (B) 11	DTE to radio

4   OUTDOOR UNIT

The Outdoor Unit is a 6 inch diameter round unit with four connectors along its side. The unit is environmentally sealed and it is intended to be mounted in close proximity to the antenna. Figure 2 shows the outline of the outdoor unit and identifies the four connectors. The unit is typically mounted with the TNC connector pointing down as shown in the figure.

Outdoor Unit Connectors

Connector	Type	Use
Antenna A	N	2.4 GHz RF connection to the primary antenna. When a single antenna is used, antenna A is the default.
Indoor Unit	TNC	Intermediate Frequency and control signals. This must be connected to an indoor unit using a coaxial cable
Antenna B	N	2.4 GHz RF connection to an alternate antenna.
Test	BNC	Test connector to be used as an antenna alignment aid

5   INITIAL INSTALLATION

The *LongRanger 2050* units are shipped pre-configured to operate in synchronous mode at 384 Kbps with internal timing (clocks supplied by the radios). It is recommended to perform the initial check out on the bench before a field installation. For initial check out perform the following steps:
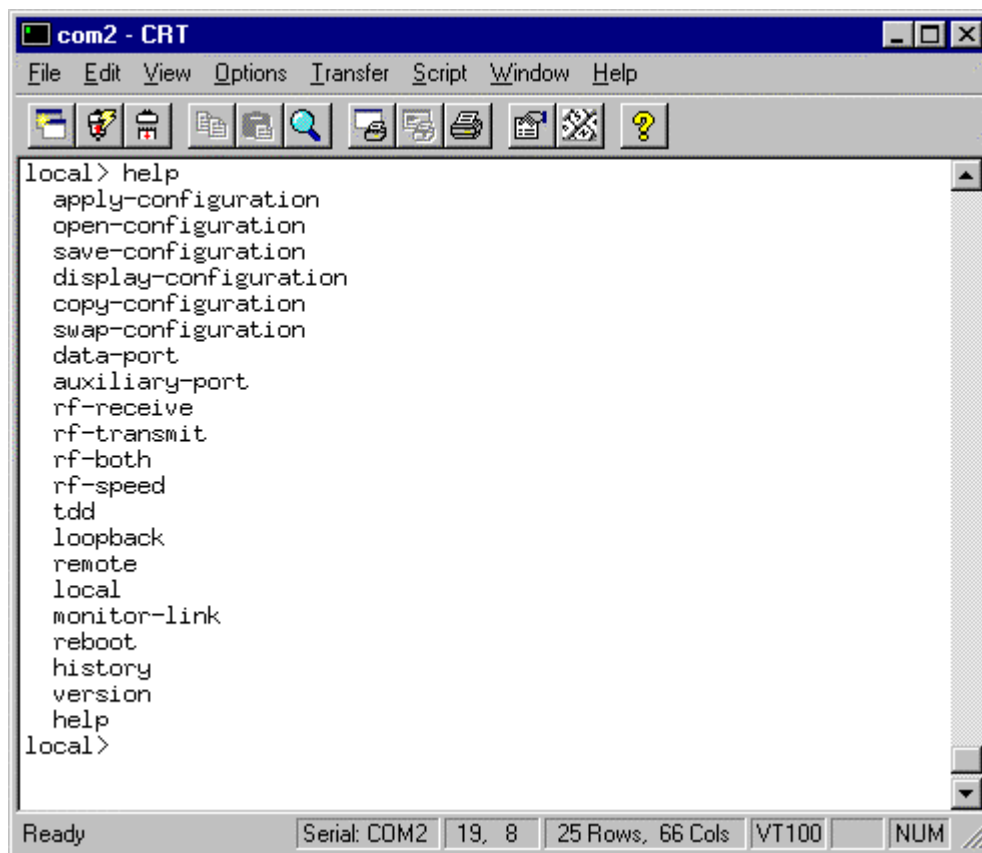
1. Connect the Indoor units Auxiliary Port to a terminal, or a PC running a terminal emulation program. Configure the terminal settings as follows:
    Baud rate: 9600
    Parity: none
    Word length: 8 bits

2. Connect each indoor unit Data Port to the appropriate Data Terminal Equipment.

3. Connect each Indoor Unit to the respective Outdoor Unit using a coaxial cable with male TNC connectors at both ends.

4. Connect the Outdoor Units Antenna A port (N type connector) to an appropriate 2.4 GHz band antenna using a coaxial cable.

5. Connect the Indoor Unit power connector to the external power supply. Make sure that the power supply is rated for the appropriate voltage (110 or 220 Vac).

6. Connect the power supplies to the power outlet.

7. After initial power up, the units output the prompt "local>" to the respective terminals. Set one radio to the default "factory-master" configuration by typing the following command:
       local> **apply fm**

8. Set the second radio to the default "factory-slave" configuration by typing the following command:
       local> **apply fs**

9. If there is an RF path between the two units, the RADIO LED's in both indoor units will light up indicating that they have established an RF link.

10. The terminal at each end can be used to further modify the radios operating parameters and monitor the link performance. The following section describes the command language used to perform those functions.

6 COMMANDS

The auxiliary port in the back panel (asynchronous RS-232) is used for issuing configuration commands and monitor the radio status and performance.

Both the local radio and the remote radio may be configured or monitored. The prompt will read "local>" or "remote>" to indicate which unit is being configured. Of course, configuring the remote unit is only possible if an RF link is established.

The "help" command provides a list of all the commands available. To get more detailed help for a specific command, type "help command-name". A sample output of the help command, listing all commands, is shown in the figure below:

The radio keeps a history of several of the previously issued commands. Those commands can be viewed by pressing the up-arrow and down-arrow keys on the keyboard. Any of those previously issued commands can then be edited and reentered by pressing the <Carriage Return> key.

6.1   Command syntax

The command interpreter in the *LongRanger 2050* is designed to accommodate both a novice as well as an expert operator. All commands and parameters have descriptive names so that they are easily remembered and their meaning is clear. In order to be descriptive however, those commands are sometimes long. As the operator becomes familiar with the command language, typing the complete words could become cumbersome. The *LongRanger* command interpreter recognizes any abbreviations to commands and parameter names, as long as they are unambiguous. If an ambiguous command is entered, the radio will output all possible choices.

Commands have the following generic form:

> *command   parameter=value   parameter=value*

Following is a brief list of syntax rules:

- Words (for commands, parameters, or values) can be abbreviated to a point where they are unambiguous.

- Some commands or parameters consist of compound words separated by an hyphen. With compound words, the hyphen is optional. Additionally each word in a compound word can be abbreviated separately. For example, the following are all valid abbreviations for the command "data-port": "data", "datap" d-p" "dp".

- The parameter and value lists are context sensitive, i.e., in order to solve ambiguities the command interpreter only considers parameters valid for current command, or values valid for the current parameter.

- Arguments (parameter/value pairs) can be listed in any order.

- Even though parameters can be listed in any order, there is a "natural" order known by the command interpreter. This allows the user to specify parameter values without having to type the parameter names. For example the command
    >copy-configuration source=factory-master dest=current
  can be entered as (using abbreviation rules as well):
    >copy fm cur

- Using the preceding rule, for commands that have a single argument, the "parameter name" part of the argument is always optional, i.e., you can enter:
    >*command value*

- Not all parameters associated with a command need to be specified. Depending on the command, when a parameter is omitted it either assumes a default value or keeps the last value assigned to that parameter.

6.2   Radio Configurations

A "radio configuration" consists of a set of programmable parameters that define the radio operation with regard to a variety of operating modes. The radio holds five configuration sets at all times, identified as "current", alternate", "working-copy", "factory-master", and "factory-slave".

The "current" configuration is the set of parameters currently being used. This configuration can be modified by the operator and is stored in non-volatile memory. On power up the radio reverts to this configuration.

The "alternate" configuration is a second set of configuration parameters also stored in non-volatile memory. It is useful for trying out different parameters in the current configuration but still keeping a known working configuration intact.

The "factory-master" and "factory-slave" are preset configurations that can not be modified by the operator. They configure two radios in a compatible mode, one as a master and the other as a slave. They are often useful as a starting point to create a customized configuration.

The "working-copy" configuration is a temporary copy where all the edits are performed. This configuration is not in non-volatile memory. On power up the working-copy configuration is set to the "current" configuration.

In order to modify the radio operating parameters, the desired configuration must first be copied into the "working copy" area. All the edits are performed on this working copy. When the edit is complete, the working copy can be written to the "current" or "alternate" configurations. When this is executed, the software performs a number of consistency checks to verify that the configuration is "legal."

The commands to manipulate the different configurations are described below

copy-configuration source=xxx destination=xxx

> Copies the configuration specified as the source into the one specified as the destination.
> Examples:
> > local> **copy-configuration source=factory-master destination=alternate**
> > local> **copy fm alt**

swap-configuration source=xxx destination=xxx

> Swaps the configurations specified as the source and the destination.
> Example:
> > local> **swap current alternate**
> > local> **sw c a**

open-configuration source=xxx

Copies the specified configuration into the "working-copy" so that it can be edited. If the source parameter is not specified it defaults to "current"
Example:
> local> **open alternate**

save-configuration destination=xxx

Copies the "working-copy" parameters into the specified configuration
Example:
> local> **save alternate**

apply-configuration source=xxx

Copies the specified configuration into the "current" configuration. If the parameter is not specified it defaults to the "working-copy"
Example:
> local> **apply fm**

display-configuration source=xxx

Displays all the parameters of the specified configuration
Example:
> local> **display fac-slave**
> local> **dis fs**

6.3   Edit configuration commands

This set of commands modifies the parameters in the "working copy" configuration set. For this set of commands, when a parameter is omitted, it keeps the last value assigned to that parameter.

data-port

speed=value

Sets the data rate of the synchronous data port in bits per second. Valid values are: 64000, 128000, 192000, 256000, 384000, 512000, 768000.

physical-interface=rs-232 or *eia-530* or *v.35*

Sets the electrical interface of the DB25 data port. The possible values are: rs-232, eia-530 or v.35

clock-source=value

Specifies the clock source to be used to clock in the transmit data line (pins 2,14), and to clock out the receive data line (pins 3, 16). It can be specified as one of four values:

internal: The transmit and receive clocks are generated by the local radio. The transmit clock is output on pins 15 and 12, and the receive clock on pins 17 and 9.

external: The transmit and receive clocks are supplied by the DTE on pins 24 and 11. The radio drives the transmit and receive clock lines (pins 15,12 and 17,9), with a clock signal locked to the externally supplied clock.

remote: The transmit and receive clocks are locked to the clock in the remote radio. The transmit clock is output on pins 15 and 12, and the receive clock on pins 17 and 9.

hybrid: The transmit clock is supplied by the DTE on pins 24 and 11. The receive clock is locked to the transmit clock of the remote radio.

In a typical link, one radio will have the clock source set to remote and the other radio to either internal or external. This guarantees that there is a single clock source providing the timing reference for the links in both directions, therefore avoiding clock slippage.

transmit-clock-polarity=non-invert or *invert*

Allows to invert the polarity of the transmit clock being output on pins 15 and 12.

receive-clock-polarity=non-invert or *invert*

Allows to invert the polarity of the receive clock being output on pins 17 and 9.

auxiliary-port

speed=valuer

Sets the data rate of the asynchronous auxiliary port in bits per second. Valid values are all the common baud rates from 300 to 115200.

data-bits=7 or *8*

Sets the number of data bits per character. Valid values are 7 or 8.

parity= none, *even* or *odd*

Sets the parity mode in the auxiliary port to none, even or odd.

stop-bits=1 or *2*

Sets the number of stop bits to 1 or 2.

rf-receive

channel=number

Sets the radio frequency channel for RF receive. The valid channel numbers range from 5 to 50. Channel 5 corresponds to 2407.78 MHz and channel 50 to 2476.90 MHz. Channels are spaced 1536 KHz apar (see table below).

pn-code=number

Selects one of the pre-programmed pseudo-noise spreading codes from 1 to 6. The number of different spreading codes available depends on the spreading code length specified with the rf-speed command as follows:

PN code length	63	31	15	11
Number of codes	6	6	2	1

antenna=a or b

Selects the antenna port in the Outdoor Unit to be used during RF receive.

address=number

Specifies the radio local address for the RF link. Its value can range from 0 to 65536. The address value can be entered in hexadecimal format by preceding it with 0x. If the address is specified as all ones (0xFFFF), the radio will accept all RF packets irrespective of the packet address.

rf-transmit

channel=number

Sets the radio frequency channel for RF receive. The valid channel numbers range from 5 to 50. Channel 5 corresponds to 2407.78 MHz and channel 50 to 2476.90 MHz. Channels are spaced 1536 KHz apar (see table below).

pn-code=number

Selects one of the pre-programmed pseudo-noise spreading codes from 1 to 6. The number of different spreading codes available depends on the spreading code length specified with the rf-speed command as follows:

PN code length	63	31	15	11
Number of codes	6	6	2	1

antenna=a or b

Selects the antenna port in the Outdoor Unit to be used during RF transmissions

address=number

Specifies the destination address inserted in each packet. Its value can range from 0 to 65536. The address value can be entered in hexadecimal format by preceding it with 0x. The address value of all ones (0xFFFF) is interpreted as a broadcast address and will be accepted by all radios.

power=number

Specifies the transmit output power in dBm. The number entered can range from 0 to 28 dBm in steps of two (if an odd value is specified, it will be accepted but the power level will be 1 dB less than specified).

rf-both

This command allows to modify the parameters that are common to the RF transmit and receive with a single command. The valid parameters are: channel, pn-code, antenna, and address. Refer to the previous two commands for a description of each parameter.

rf-speed

There is normally no need for the user to change the rf-speed parameters. As long as the automatic rf-speed mode is turned ON, the radio will adjust the spreading code length and the modulation values to provide adequate RF bandwidth for the desired user data rate.

pn-length=number

Specifies the spreading code length to be used in the spreading process. The valid numbers are 11, 15, 31 or 63.

modulation=bpsk or qpsk

Specifies the modulation type to be used in the RF process. The combination of the PN code length and the modulation type result in specific data rates over RF.

secondary-speed=value

Reserves the specified data rate for the secondary data transmitted over RF. The secondary data is used to monitor and configure the remote unit. The default value of 1200 bits per second is adequate for that purpose.

automatic=1 or 0 (on or off)

When turned on, the RF speed parameters (pn code length and modulation) are automatically adjusted by the radio to provide enough RF throughput for the full duplex data rate specified for the data port.

tdd

synchronization=master or *slave*

For a radio link to work in Time Division Duplex, one radio needs to be configured as a master and the other radio as a slave.   The slave radio synchronizes its RF transmissions to the timing of the master radio.

cycle-time=value

Specifies the length of the time division duplex cycle in milliseconds. A cycle consists of a transmission of a packet followed by a reception. The end to end delay of the synchronous data is approximately ¾ of the cycle time. Valid values range from 8 to 40.

loopback

mode=value

Specifies a loopback mode used for testing. Valid values are the following:

off: loopback is turned off. This is the normal operation

input-data: the Transmit Data input in pins 2 and 14 is looped back out as receive data (pins 3, 16).

base-unit: The transmit data is looped back internally in the indoor unit, after the spreading operation. The data is output as the receive data (pins 3 and 16).

output-data: The receive data output in pins 3, 16 is looped back as input transmit data. The data driven by the DTE into pins 2 and 14 is ignored.

6.4   Console Redirection Commands

In an operating radio link, it is possible to monitor and configure the remote radio from the other end of the link. The command prompt indicates which radio the commands will be directed to ("local>" or "remote>"). The commands "local" and "remote" can be used to change that status:

remote

This command can be issued when the current prompt reads "local>".   If there is a link established with the remote radio the prompt will change to "remote>" and any subsequent commands will be directed to the remote radio. If there is no link established to the remote radio, the command will timeout and the "local>" prompt reappears.

local

This command can be issued when the current prompt reads "remote>". The prompt will change to "local>", and any subsequent commands will be interpreted by the local radio.

When changing radio operating parameters that break the link, you must always "apply" the changes to the remote radio first. For example, changing the link to another channel, can be performed with the following sequence:

local> **remote**

remote> **open**   (opens the "current" configuration)
remote> **rf-both channel=30**
remote> **apply**

(The "apply" command above breaks the link. The local radio will now timeout and revert to the local mode).

local> **open**
local> **rf-both channel=30**
local> **apply**

The link is now reestablished on channel 30. Note that the three commands issued to the local radio are identical to the ones issued to the remote. Those commands can be accessed through the up-arrow key as an alternative to retyping them.

6.5   Radio Test and Monitoring Commands

rssi channel=number

This command monitors and reports, twice a second, the Received Signal Strength on the specified channel. If the channel is not specified, it defaults to the current receive channel. Press any key to revert back to normal operation. While monitoring the RSSI, the RF link to the remote radio is not maintained. In order to monitor the RSSI on the current channel, without breaking the link, use the command "monitor-link"

monitor-link

This command reports, twice a second, the current transmit power and receive signal strength for each of the Outbound and Inbound links.

spectrum-analysis

display=graph or *table*

test-oscillator=0 or *1 (off* or *on)*

dwell-time=0..1000

This command performs a scan of all the channels in the band, dwelling on each channel for the specified amount of time (defaults to 20 milliseconds). While on each channel it

measures the RSSI for that channel and stores its peak valuel. It then displays the data collected in a graphical or table formats (defaults to "graph").

The Outdoor Unit contains a test oscillator that may be turned on during this test. Running the spectrum analysis with the test oscillator on is useful to check the health of the local radio.

ber-test

This command performs two functions:

1. The data from the DTE being input at the data port is replaced with a 511 Bit Error Rate pattern which is transmitted over RF.

2. The data being received over RF and output to the DTE through the data port is checked to match the 511 Bit Error Rate pattern. The radio outputs a line, twice a second, with the results of this check.

In order to test a two way link using this command, you must first set the remote radio in loopback mode by performing the following steps:

local> **remote**

remote> **open**
remote> **loopback output-data**
remote> **apply**
remote> **local**

local> **ber-test**

At the end of the test, remember to turn off the loopback mode in the remote radio.

6.6   Miscellaneous commands

version

Displays the radio model and software version.

history

Displays the previous commands entered through the console port.

help [command-name]

If no command is specified, displays the complete list of commands. If a command is specified it displays the valid parameter and corresponding values for that specific command.

Channel Frequency Correspondence

Channel	Frequency (KHz)	Channel	Frequency (KHz)	Channel	Frequency (KHz)
5	2,407,780	21	2,432,356	37	2,456,932
6	2,409,316	22	2,433,892	38	2,458,468
7	2,410,852	23	2,435,428	39	2,460,004
8	2,412,388	24	2,436,964	40	2,461,540
9	2,413,924	25	2,438,500	41	2,463,076
10	2,415,460	26	2,440,036	42	2,464,612
11	2,416,996	27	2,441,572	43	2,466,148
12	2,418,532	28	2,443,108	44	2,467,684
13	2,420,068	29	2,444,644	45	2,469,220
14	2,421,604	30	2,446,180	46	2,470,756
15	2,423,140	31	2,447,716	47	2,472,292
16	2,424,676	32	2,449,252	48	2,473,828
17	2,426,212	33	2,450,788	49	2,475,364
18	2,427,748	34	2,452,324	50	2,476,900
19	2,429,284	35	2,453,860		
20	2,430,820	36	2,455,396		

Number of Non-Overlapping Channels	Suggested Channel Allocation	Frequency Separation
3	5, 27, 49	33,792
4	5, 20, 35, 50	23,040
5	5, 16, 27, 38, 49	16, 896
6	5, 14, 23, 32, 41, 50	13,824