TSLM

Synthesized Wireless Radio Modem

242-22*w*0-XYZ

User Manual
001-2200-000 pdf | 001-2200-101 print
Last updated January 2008

2006 Aug	FCC Release
2006 Dec	Preliminary User Release
2007 Jan	Manual Release
2007 Jan	Revision 1: added TSLM dimension diagram
2007 Mar	Revision 2: corrected drawings for Figures 4-4 & 4-5, added ID number incrementing info to Section 7.2.3
2008 Jan	Revision 3: Added Channel Selection information, Section 5.2.9.1

SECTION 1 – PREFACE

1.1 COPYRIGHT NOTICE

This manual covers the operation of the TSLM Synthesized Radio Modems. Specifications described are typical only and are subject to normal manufacturing and service tolerances.

CalAmp DataCom reserves the right to modify the equipment, its specification or this manual without prior notice, in the interest of improving performance, reliability or servicing. At the time of publication all data is correct for the operation of the equipment at the voltage and/or temperature referred to. Performance data indicates typical values related to the particular product.

Products offered may contain software which is proprietary to CalAmp DataCom. The offer of supply of these products and services does not include or infer any transfer of ownership.

1.2 WARNING RF EXPOSURE

The radio equipment described in this user manual emits low level radio frequency energy. Professional installation is required. The concentrated energy may pose a health hazard.

This device is intended for Fixed installation conditions. Do not allow persons to come within 6.6 feet of non-directional antenna and 20 feet from the front of directional antennas when the transmitter is operating.

SECTION 2 – PRODUCT OVERVIEW

2.1 MODULE IDENTIFICATION

The module identification number is a random, unique serial number (SN) printed on the shipping box and the model label on the side of the module.

Figure 2.1 - Module Identification Label

2.2 GENERAL DESCRIPTION

The Dataradio TSLM is a transparent, real-time wireless modem designed to replace wire lines in SCADA, telemetry, and any other information and control applications that utilize RS-232 serial data messaging. The TSLM uses advanced digital modulation and signal processing techniques to achieve exceptionally high throughput efficiency using licensed narrow band radio channels.

The TSLM is available in many frequency bands and regulatory formats, to suit spectrum band requirements in various continental regions. The range is designed for both fixed point to point, and multiple address or point to multipoint systems.

2.2.1 Physical Description

The TSLM consists of a logic printed circuit board (PCB) that includes the modem circuitry and a separate radio module. The unit is housed in a nickel-plated, formed steel case. The front panel includes the DE-15 data connector and a BNC antenna connector, as well as two multi-colored LED indicators. Power connections are made through the DE-15 data connector. The unit is not hermetically sealed and should be mounted in a suitable enclosure where dust and/or a corrosive atmosphere are anticipated. There are no external switches or adjustments. Operating parameters are set using TSLM Programming Software.

2.2.2 Features and Benefits

- Data speeds of 4800 to 9600 bps in 12.5 kHz channels
- Standard RS-232 interface with RTS/CTS or Data Operated Transmit (DOX) operation
- Built-in 8 channel synthesized radio transceiver for VHF and UHF bands
- Power output 1-5 W (software controlled)
- Half duplex or simplex operation
- Online diagnostics monitoring
- Offline local and remote diagnostics

2.2.3 Product Range

The TSLM is available in UHF and VHF frequency bands. For a break down of available part numbers and their frequency ranges, see Table 2.3.

2.3 PART NUMBER BREAKDOWN

242-22*w*0-XY0(M)

Table 2.3
Description of Part Number (reference part number equation above)

W	X	Y	(M)
1 VHF	2 406-422 MHz	1 12.5 kHz	Mounting Bracket
4 UHF	3 414-430 MHz		
	5 450-470 MHz		
	6 150-174 MHz		
	7 137-162 MHz		

2.4 RELATED PRODUCTS AND STANDARD ACCESSORIES

2.4.1 TSLM Programming Kit

Table 2.3
Programming Kit Descrption: 250-2200-001

Programming Kit	250-2200-001 *(includes the following):*
Start Up Disc	002-2200-100
Programming Software	039-2200-210
Manual(s)	001-2200-000 pdf 001-2200-101 print
Programming Cable	697-4006-406

2.4.2 Miscellaneous Accessories

Table 2.4
Accessories

Description	Part Number
Mounting Bracket Kit	250-2000-005
Unterminated Application Cable	023-3276-007
Terminated Application Cable	697-0000-001

2.4.3 Infrastructure

The TSLM is based on the Dataradio T-96SR platform giving user's the versatility to design systems with the T-96SR functioning as a Master, T-Base and Repeater and TSLM units providing economical remote monitoring and high availability system operation. The TSLM and T-96SR share radio modulation scheme, on-line and offline diagnostics, and data connector pin-out compatibility.

Table 2.5
T-96SR Infrastructure

T-96SR Model Number Breakdown 242-40W6-XYZ(F)				
W	X	Y	Z (UHF Units)	F (optional)
1 VHF	0 406 – 430 MHz	1 12.5 kHz	0 406 – 422 MHz	Fan Option
4 UHF	4 132 – 150 MHz		1 414 – 430 MHz	
	5 450 - 470 MHz			
	6 150 – 174 MHz			

2.4.4 Antenna

Yagi Antenna Kit Description	Part Number
* 138-143 MHz, 6.5 dB	250-0211-007
* 138-143 MHz, 9.5 dB	250-0211-010
* 143-148 MHz, 6.5 dB	250-0211-107
* 143-148 MHz, 9.5 dB	250-0211-110
* 148-152 MHz, 6.5 dB	250-0211-207
* 148-152 MHz, 9.5 dB	250-0211-210
* 152-157 MHz, 6.5 dB	250-0211-307
* 152-157 MHz, 9.5 dB	250-0211-310
* 157-163 MHz, 6.5 dB	250-0211-407
* 157-163 MHz, 9.5 dB	250-0211-410
* 163-169 MHz, 6.5 dB	250-0211-507
* 163-169 MHz, 9.5 dB	250-0211-510
* 169-174 MHz, 6.5 dB	250-0211-607
* 169-174 MHz, 9.5 dB	250-0211-610
450-470 MHz, 7 dB	250-0241-507
450-470 MHz, 10 dB	250-0241-510
*Antenna Kit Feedline	
25 feet antenna feedline, (LMR400), N Male)	250-0200-025
50 feet antenna feedline, (LMR400, N Male)	250-0200-055

*Requires antenna feedline

SECTION 3 – APPLICATIONS AND ARCHITECTURE

3.1 APPLICATION DETAILS

The TSLM is designed to replace wire lines in SCADA, telemetry and control applications. The RS-232 serial port allows direct connection to Programmable Logic Controllers (PLCs) or Remote Terminal Units (RTUs).

3.1.1 Generic Connectivity

The TSLM is designed for SCADA and telemetry applications, and any other applications that use ASCII or HEX communications protocols, and which connect physically using the RS232 interface standard. Converters may be used to adapt interface standards such as RS422/485 and others.

An ASCII protocol is any that consists of message strings formed from ASCII characters, that being defined as a 10 or 11 bit block including start and stop bits, 7 or 8 data bits and optional parity bits.

Many telemetry vendors utilize proprietary ASCII and HEX protocols, and also common 'open standard' industry protocols such as DNP, MODBUS, BSAP, Seimens and DF1 half duplex or DF1 radio.

3.1.2 SCADA Systems

A SCADA system is defined as one or more centralized control sites used to monitor and control remote field devices over wide areas. Examples include regional utilities monitoring and controlling networks over entire metropolitan areas. Industry sectors include energy utilities, water and wastewater utilities, and environmental groups.

3.1.3 Telemetry Systems

Dedicated telemetry control systems interconnect sequential devices either where cabling is not practical or distances make cable connections impractical.

3.1.4 Information Systems

Public Information systems include monitoring applications such as vehicle flow, travel time, and meteorological stations.

3.2 NETWORK ARCHITECTURE

This section briefly discusses network design, including basic network types, interfacing modems and DTE, data protocols for efficient channel operation, addressing and repeaters.

3.2.1 Point-to-Point

A point-to-point network is the simplest of all networks, and may be used for connecting a pair of PC's, a host computer and a terminal, a SCADA master and one remote, mobile applications like in-vehicle GPS receivers to base stations, or a wide variety of other networking applications.

3.2.2 Point-to-Multipoint

A Point-to-Multipoint network is a common network type used in SCADA or other polling systems. The single master station communicates with any number of remotes and controls the network by issuing polls and waiting for remote responses. Individual remotes (DTE) manage addressing and respond when their individual addresses are queried. The DTE unit addresses are maintained in a scanning list stored in the host program or master terminal device at the SCADA host site. The communications equipment is transparent and does not interact with specific remotes; all data is coupled to the host on a single data line (such a network is commonly used with synchronous radio modems and asynchronous radio modems).

3.2.3 Multiple Point-to-Point

A multiple point-to-point is similar to the point-to-multipoint system except the SCADA host has multiple serial ports that are directed to different geographic areas in the SCADA system.

3.2.4 Peer-to-peer

A Peer-to-Peer network is generally used for device to device communications among a number of stations. This network requires full addressing capability on the part of the data equipment (DTE). If the distances involved for any link or links are too great for a single radio hop, they can be extended by means of repeaters without affecting the basic network design.

3.2.5 Store and Forward

Store and Forward is a common technique where a data transmission is sent from one device to a receiving device but first passes through a relaying device. The device is typically an RTU or PLC used by the message service to store the received message then it transmits the message to the intended recipient.

SECTION 4 – SYSTEM PLANNING AND DESIGN

4.1 UNDERSTANDING RF PATH REQUIREMENTS

Radio waves are propagated when electrical energy produced by a radio transmitter is converted into magnetic energy by an antenna. Magnetic waves travel through space. The receiving antenna intercepts a very small amount of this magnetic energy and converts it back into electrical energy that is amplified by the radio receiver.

A radio modem requires a minimum amount of received RF signal to operate reliably and provide adequate data throughput. In most cases, spectrum regulators will define or limit the amount of signal that can be transmitted. Transmitted power decays with distance and other factors as it moves away from the transmitting antenna.

Other factors that will decay a signal include obstructions such as hills, buildings and foliage, and the horizon – i.e. the bulge between two points of earth. Minimal signal degradation may occur as a result of environmental conditions such as fog, rain, dust storms or other similar factors.

There are several methods to ascertain the available RF coverage from a transmitting station. This can be accomplished by:

A. Using basic formulas to calculate the theoretically available signal – allowing for free space path loss due to distance and equipment signal loss

B. Using sophisticated software to build earth terrain models and apply other correction factors such as earth curvature and the effects of obstructions

C. Actual in-field signal strength testing

As good design practice, CalAmp DataCom recommends the results of at least two of these modes be considered to design a radio path with one of the results being the actual in-field signal strength test.

4.2 SELECTING ANTENNAS

Antennas come in a variety of shapes and sizes, but fall into two basic categories: directional and omni-directional. Directional antennas are designed to focus and radiate the RF energy in one specific direction. Generally, in a point-to-point network, directional antennas will be used. In a point-multipoint network, with a base station and a several remotes, the base station will use an omni-directional antenna and the remotes will use directional antennas. Figure 4.1 shows some antenna variations.

Omni directional antennas are designed to radiate the RF signal in a 360 degree pattern around the antenna. Short range antennas such as folded dipoles and ground independent whips are used to radiate the signal in a ball shaped pattern while high a gain omni such as a co-linear compress the RF radiation sphere into the horizontal plane to provide a relatively flat disc shaped pattern that travels further because more of the energy is radiated in the horizontal plane.

Vertical dipoles are often mounted in pairs, or sometimes groups of 3 or 4, to achieve even coverage and to increase gain. The vertical collinear usually consists of several elements stacked one above the other to achieve similar results.

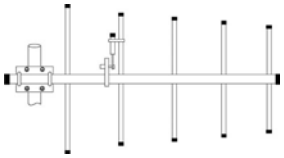
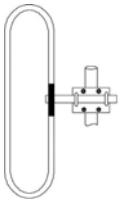
Omni (Vertical collinear)	Yagi	Vertical Dipole
		

Figure 4.1- Antenna Types

4.2.1 Antenna Gain

Antenna gain is usually measured in comparison to a dipole. A dipole behaves much like the filament of a flashlight bulb: it radiates energy in almost all directions. One bulb like this would provide very dim room lighting. Add a reflector capable of concentrating all the energy into a narrow angle of radiation and you have a flashlight. Within that bright spot on the wall, the light might be a thousand times greater than it would be without the reflector. The resulting bulb-reflector combination has a gain of 1000, or 30 dB, compared to the bulb alone. Gain can be achieved by concentrating the energy both vertically and horizontally, as in the case of the flashlight and Yagi antenna, or by reducing the vertical angle of radiation, leaving the horizontal alone. In this case the antenna will radiate equally in all horizontal directions, but will take the energy that otherwise would have gone skywards and use it to increase the horizontal radiation.

NETWORK CONFIGURATIONS

4.2.2 Basic Network Configuration

A Basic Network configuration has the following characteristics:

- Master station may be half duplex or simplex
- Online diagnostics are not available in real time
- Remote/local diagnostics and Online Diagnostics are available by disconnecting the master PLC and substituting a PC running the TSLM Field Programming Software utility or utilizing a monitor radio

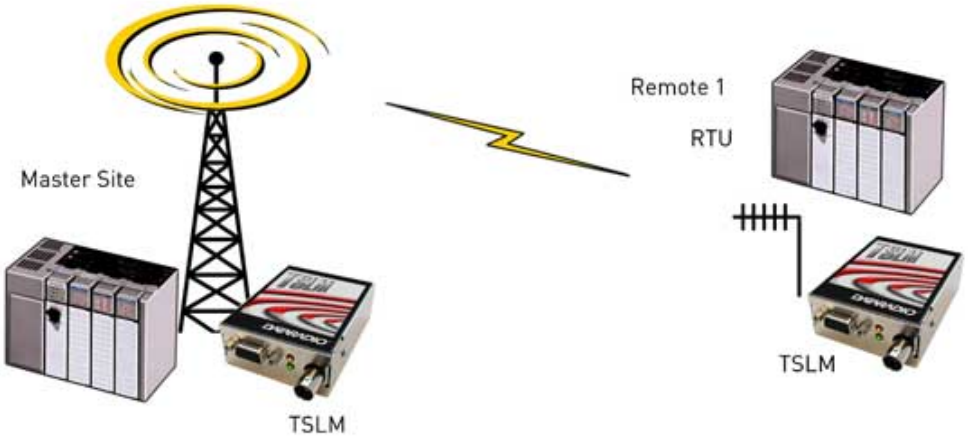


Figure 4.2 Basic Network Configuration

4.2.3 T-96SR Master Network Configuration for Higher Duty Cycle Applications

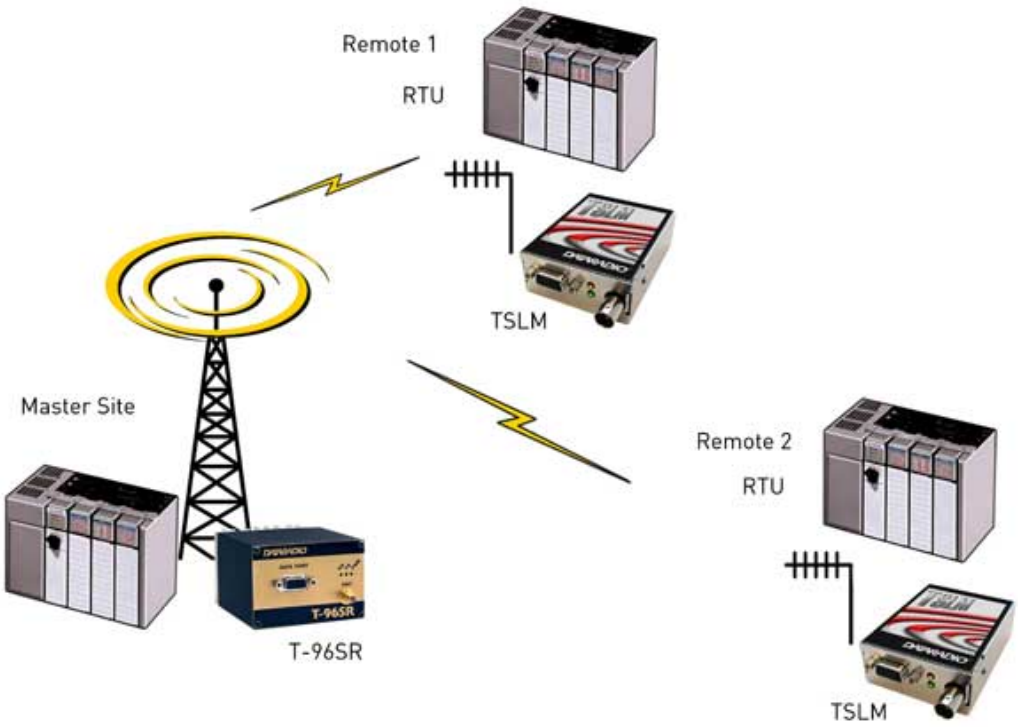


Figure 4.3 T-96SR Master Network Configuration

A Network Using a T-96SR as Master configuration has the following characteristics:

- Recommended for higher duty cycle applications
- Master station may be simplex or half duplex
- The T-96SR will receive RTS/CTS or DOX mode communications from a TSLM (The T-96SR will not transmit in DOX mode, only when RTS is raised)

4.2.4 T-Base Network Configuration

A Network Using a T-Base configuration has the following characteristics:

- Master station may be full duplex[1], half duplex or simplex
- The Online Diagnostics utility does not disrupt network activity
- Remote/local diagnostics and statistics/control are available using the Offline Diagnostics utility when connected to the Tx module
- The T-Base outputs Online Diagnostic information that can be processed by the Online Diagnostics utility or a user-supplied network management program
- The T-96SR provides high availability for systems requiring system redundancy

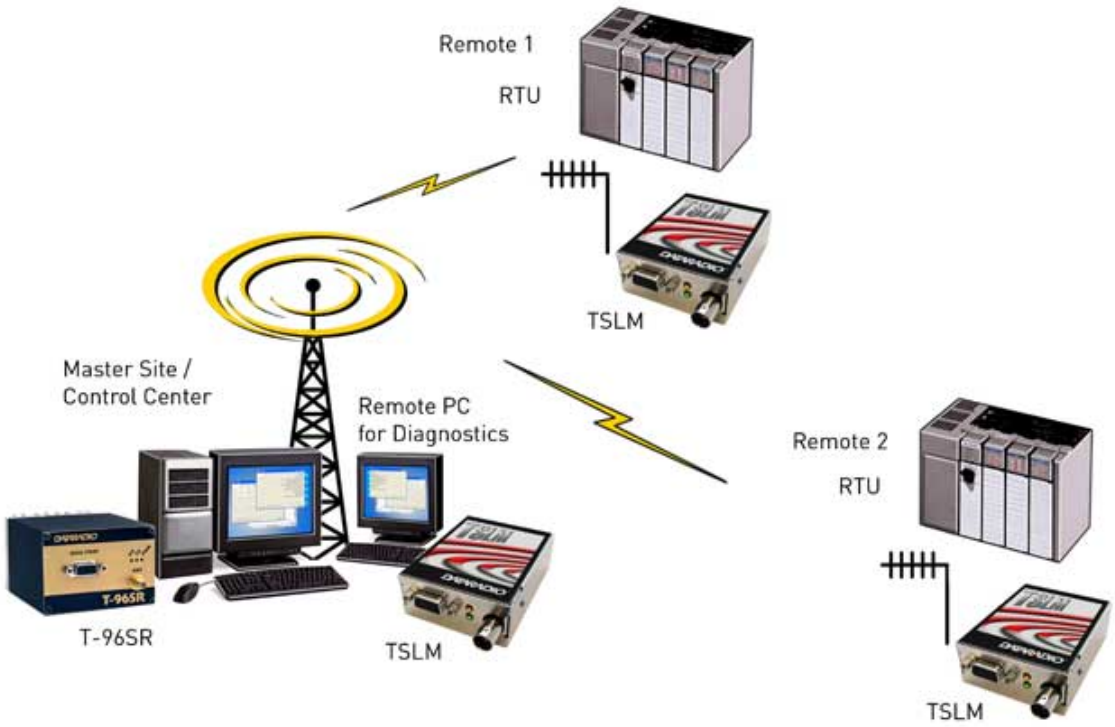


Figure 4.4 T-Base Network Configuration with Diagnostics

[1] Requires duplexer or dual antennas

4.2.5 Network Configuration Using a T-Base Repeater

A Network Using a T-Base Repeater has the following characteristics:

- Master station and all remotes must be half duplex
- The RTS/CTS delays for each TSLM in the system must be extended as shown in Table 5.3

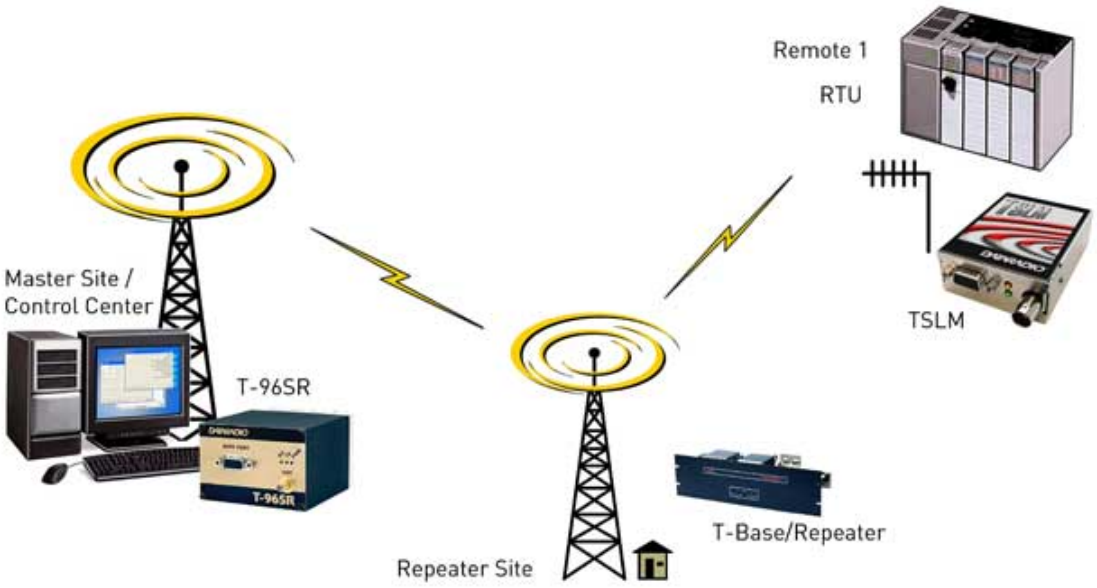


Figure 4.5 Network Using a T-Base Repeater

4.2.6 Network Configuration Using a TSLM for Monitoring Online Diagnostics

A Network Using a TSLM for Online Diagnostics configuration has the following characteristics:

- Master station may be half duplex or simplex
- Accumulated online diagnostics are stored for a maximum of 10 stations are available at a monitoring site (monitoring site must be in range of all remotes)
- Online Diagnostics are available in real time at the monitoring site
- Remote Offline Diagnostics, statistics, and control are available from the monitoring site by temporarily disabling network activity (best if using a Master Station Antenna System)

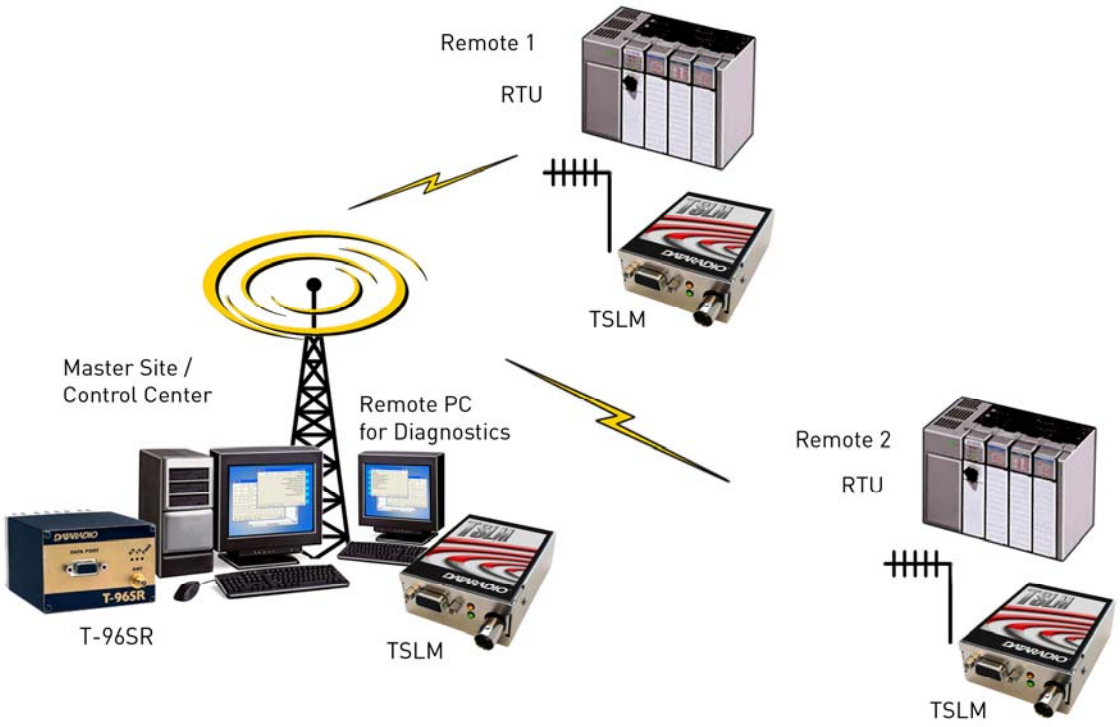


Figure 4.6 Network Using a TSLM for Online Diagnostics

SECTION 5 – GETTING STARTED

5.1 UNPACKING

When ready for installation, carefully unpack your TSLM shipping carton and identify each item as listed below:

- One TSLM radio modem (with mounting plate if “M” option is ordered)
- Quick Start Guide

5.2 QUICK START GUIDE

The Quick Start Guide is included in print with the TSLM.

5.2.1 General

The TSLM is a transparent, real-time wireless modem designed for use in VHF and UHF telemetry and SCADA systems. Power output is 1-5 W programmable. Data rates are 4800 - 9600 bps (12.5 kHz channels). It contains an 8 channel, synthesized radio transceiver.

5.2.2 Compatibility

The TSLM is based on the Dataradio T-96SR platform giving users the versatility to design systems with the T-96SR functioning as a Master or Base and repeater and TSLM units providing economical remote monitoring stations. The TSLM and T-96SR share radio modulation, on-line diagnostics, and data connector pin-out compatibility.

5.2.3 Installation

The TSLM should be mounted in a clean, dry location. The unit is not hermetically sealed and must be protected against moisture, corrosive chemicals and high dust levels.

5.2.4 Antenna

The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 141 cm (55.5 inches) for VHF models or 121 cm (47.6 inches) for UHF models from all persons. The antenna must be designed for the frequency of operation and mounted at an elevation sufficient to cover the distance required. The antenna feedline should have a male BNC connection and requires an impedance of 50 ohms.

5.2.5 Power Requirements

The TSLM requires a filtered power source of 7.2 - 15 V with a 3 A rating. Power connection is via the data connector as shown on the next page.

5.2.6 RS-232 Port

The TSLM is equipped with an RS-232 data port configured as DCE. It should be connected, using a suitable shielded cable, to equipment configured as DTE.

5.2.7 RS-232 Interface Signal

Table 5.1
RS-232 Interface Signal

Term	Data	Alternate	Voltage
On	Space	Asserted	+3 to +15V
Off	Mark	Dropped	-3 to -15V

5.2.8 Connector Pin out

DTE connector is a DE-15 female

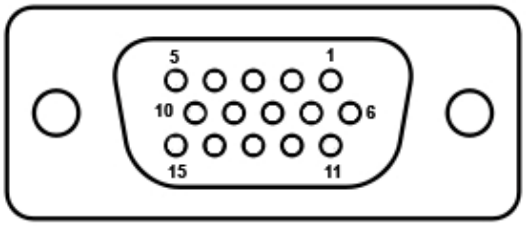


Figure 5.1 DE-15 Connector Pin-out

Table 5.2
DE-15 Pin Descriptions

DE-15 Pin	Description
1	GND (Ground)
2	RxD (Receive Data)
3	TxD (Transmit Data)
4	Rx_TP (Receive baseband data test point)
5	RAW_BATT (12.5 Vdc nominal power supply)
6	GND (Ground)
7	CTS (Clear To Send)
8	RTS (Request To Send)
9	DCD (Data Carrier Detect)
10	RAW_BATT (12.5 Vdc nominal power supply)
11	CSO (Channel Select 0)
12	CS1 (Channel Select 1)
13	CS2 (Channel Select 2)
14	RSSI_OUT (Receive Signal Strength Indicator)
15	DTR_PGM (Program Mode Select)

5.2.9 Field Programming Software

The TSLM is configured by means of the Field Programming Software (FPS) (Part No. 039-2200-210). Channel frequencies for 8 channels are also selected using the FPS.

The following parameters may be adjusted with the FPS:

- Channel 1 - 8 TX and RX frequencies
- Baud rate, word length, parity
- Timing parameters
- Diagnostics on/off
- Carrier detect threshold level
- Power output

In addition, the FPS provides the tools for test transmissions and allows test statistics to be obtained and displayed. See the Programming Software on-line help file for details.

5.2.9.1 Channel Selection

Channel frequencies are programmed for 8 channels using the TSLM FPS. The current operating channel is selected in one of two ways:

1. Utilizing hardware jumpers by strapping connection on the Data Port Connector. There is a 10k ohm pull-up resistor on each line (CS0 to CS2) (refer to Table 5.3).
2. By making changes with the TSLM FPS. Select the channel from the TSLM Offline Diagnostics or User Test interface.

Table 5.3
Channel Selection

Channel	CS2	CS1	CS0
1	gnd	gnd	gnd
2	gnd	gnd	open
3	gnd	open	gnd
4	gnd	open	open
5	open	gnd	gnd
6	open	gnd	open
7	open	open	gnd
8	open	open	open

5.2.10 RTS/CTS or DOX Operation

The unit operates transparently at the data speed selected by the Field Programming Software.

In DOX mode, the TSLM will begin transmitting when data is ready to send (no RTS signal required) and terminate when no data remains to be sent.

If RTS/CTS operation is selected, the DTE starts a data transfer by asserting RTS. A CTS response is returned after the transmitter has been keyed and the remote modem has had sufficient time to synchronize.

Data is transmitted as long as RTS is asserted and the PTT Watchdog timer has not expired. The DTE should not drop RTS until the last data character is completely sent to the TSLM. A CTS response is dropped when the last character has been transmitted on the radio network.

In the idle mode, i.e. no transmission or reception, RXD will be held in the idle condition. When a radio carrier is received, the TSLM will assert DCD and data will be delivered via RXD. When the radio carrier is dropped, the TSLM will clamp RXD off and drop DCD. It is possible that a few extraneous bits may be delivered at the end of a transmission, and user software should take this possibility into account.

5.2.11 RTS/CTS delays

Table 5.4
RTS/CTS Delays

Bit/sec	Normal Delay		Repeater		Extended T2
	Diag off	Diag on	Diag off	Diag on	
4800	30 mS	52 mS	60 mS	82 mS	24.4
9600	20 mS	32 mS	40 mS	52 mS	13.8

5.2.12 Duty Cycle

The TSLM is designed for intermittent duty at its full power rating (50% duty cycle, 30 seconds maximum transmit). 5W units may be used for longer duty cycles if RF output power is reduced to 2W. A built-in timer limits transmission times to protect the unit (may be disabled via the FPS). Systems requiring a greater Duty Cycle should utilize the Dataradio T-96SR as the Master station.

5.2.13 LED Indicators

Operating status of the TSLM is indicated by two front panel LEDs

Table 5.5
LED Indica*tor Descriptions*

	LED	Indicates	Description
Bottom LED	Green solid	Power	DC power applied
	Green flashing	Setup	Setup mode
Top LED	Red	Transmit	Transmitting signal
	Amber	Carrier Detect	Receiving signal
	Green	Rx data	Receiving data

5.2.14 Setup Mode

The TSLM Field Programming Software will automatically enable set-up mode when a setup cable is connected. In set-up mode, the unit will accept user-desired configuration commands. Setup mode is indicated by the green PWR LED flashing.

Note: The setup cable (697-4006-406) is a separate cable from the application cable (697-0000-001).

5.2.15 Default Data Settings

Enabled = Box checked
Disabled = Box unchecked

Table 5.6
Default Data Settings

Parameter	Setting
On Line Diagnostics	Enabled
Repeater Mode (Extended T1 RTS-CTS)	Disabled
Extended Turn Off T2	Disabled
Output Raw Diagnostic Data Only	Disabled
Rx-Only Radio	Disabled
Baud Rate	9600
Data Format	8 Bits/1 Stop/Parity None
PTT Watchdog	Enabled@30 Sec.
Dynamic Carrier Detect Off Threshold	Enabled
Carrier Detect	On: -110 dBm OFF: -115 dBm
Tx Control	RTS

5.2.16 Diagnostics

5.2.16.1 Online Diagnostics

The TSLM gathers Online Diagnostics during normal operation. If enabled, these values will be sent automatically at the beginning of each transmission.

5.2.16.2 Offline Diagnostics

Network statistics are available via the Offline Diagnostics utility and are available by disconnecting the TSLM from the DTE and utilizing the TSLM Field Programming Software. In normal operation, a TSLM retains Network statistics for up to 10 of the last unique Short ID's heard. This allows real-time viewing of network statistics.

Table 5.7 TSLM Diagnostics

Online	Supply voltage
	Internal temperature
	Received signal strength (in dBm) RSSI
Offline	Supply voltage
	Internal temperature
	Received signal strength (in dBm) RSSI

5.2.17 TSLM Product Warranty Information

CalAmp DataCom guarantees that every Dataradio TSLM Radio Modem will be free from physical defects in material and workmanship for two (2) years from the date of purchase when used within the limits set forth in the Specifications section of the User Manual.

The manufacturer's warranty statement is available in Appendix 1 of this User Manual. If the product proves defective during the warranty period, contact CalAmp DataCom Customer Service to obtain a Return Material Authorization (RMA).

This product is designed for quick field service by replacement with a complete unit.

5.2.18 Factory Technical Support

M-F 7:30 AM to 4:30 PM CDT
CalAmp DataCom
299 Johnson Ave.
Ste 110, Waseca, MN 56093

Tel 507.833.8819 or 800.992.7774
Fax 507.833.6758
Email supportimc@calamp.com

For application assistance, consult the Technical Support Application Notes (TSAN) at: http://www.calamp.com/imc_tslm.shtml

SECTION 6 – USAGE AND MAINTENANCE

6.1 USAGE

Check DC power connector for correct voltage (7.2 - 15 VDC) and polarity before plugging in the power connector. Refer to Section 7 for FPS setup.

6.2 TSLM MOUNTING DIMENSIONS

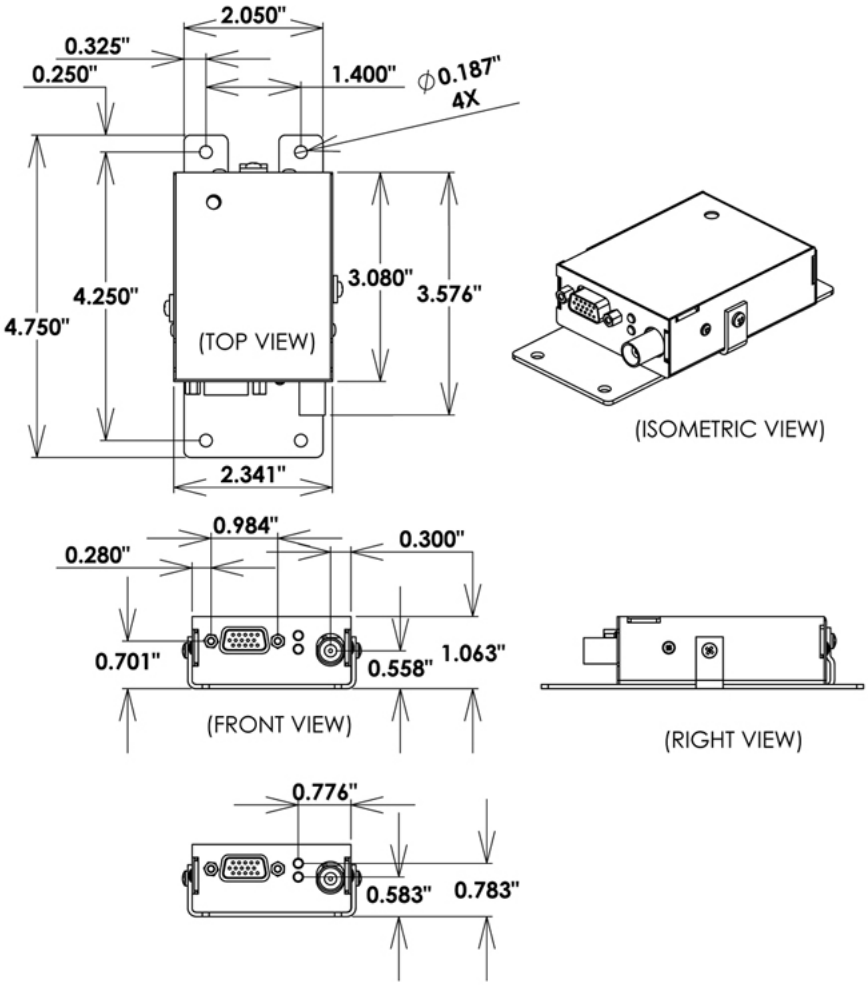


Figure 6.1 TSLM Dimensions

6.2.1 Connector Pinout

The TSLM is equipped with a DE-15 female data port configured as DCE. It should be connected, using a suitable shielded cable, to equipment configured as DTE.

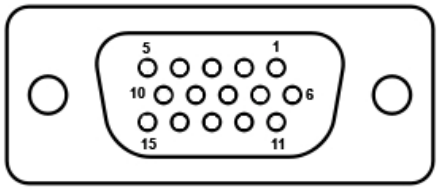


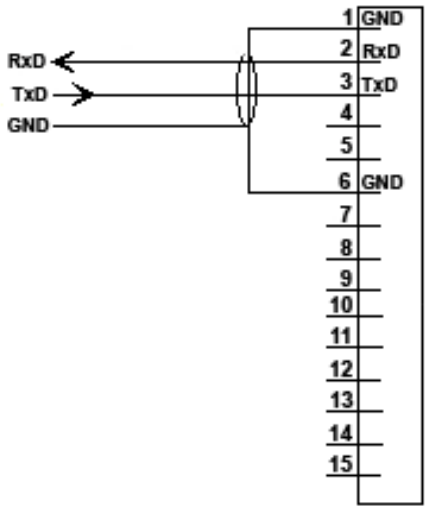
Figure 6.2 DE-15 Connector Pinout

Table 6.1
LED Indicators/Descriptions

DE-15 Pin	Description
1	GND (Ground)
2	RxD (Receive Data)
3	TxD (Transmit Data)
4	Rx_TP (Receive baseband data test point)
5	RAW_BATT (12.5 Vdc nominal power supply)
6	GND Ground
7	CTS (Clear To Send)
8	RTS (Request To Send)
9	DCD (Data Carrier Detect)
10	RAW_BATT (12.5 Vdc nominal power supply)
11	CSO (Channel Select 0)
12	CS1 (Channel Select 1)
13	CS2 (Channel Select 2)
14	RSSI_OUT (Receive Signal Strength Indicator)
15	DTR_PGM (Program Mode Select)

6.2.2 Wire Connection (DOX)

For DTE that lack RTS control, the TSLM can operate in DOX mode (Data Operated Transmit) with only Transmit Data, Receive Data and Ground ("3-wire interface").



The 3rd wire connection for GND may be from Pin 1 or Pin 6 Ground

Figure 6.3 3-Wire Connection for DOX Mode

6.2.3 Power up

Upon power up, the radio will self-test. Once complete, the green power LED will be displayed. Failure of the power LED to light indicates no power, or failure of the unit due to incorrect polarity or over voltage.

6.2.4 LED Indicators

Table 6.2
LED Indicators/Descriptions

	LED	Indicates	Description
Bottom LED	Green (Solid)	Power	DC Power is applied
	Green (Flashing)	Setup	Unit is in setup mode
Top LED	Red	Transmit	Unit is transmitting signal
	Amber	Carrier Detect	Unit is receiving signal
	Green	Receive Data	Unit is receiving data

6.2.5 Default Data Settings

Table 6.3
Default Data Settings

Parameter	Setting
On Line Diagnostics	Enabled
Repeater Mode (Extended T1 RTS-CTS)	Disabled
Extended Turn Off T2	Disabled
Output Raw Diagnostic Data Only	Disabled
Rx Only Radio	Disabled
PTT Watchdog	Enabled@30 Sec.
Dynamic Carrier Detect Off Threshold	Enabled
Carrier Detect	On: -110 dBm OFF: -115 dBm
Baud Rate	9600
Data Bits	8 Bits
Stop Bits	1 Bits
Parity	None
RTS	Enabled
Extended Tx	Disabled
DOX	Disabled
Unkey Delay	3 mS

6.2.6 Link Establishment and BER Testing

The primary function of the TSLM is to transmit data created by the DTE or application software. CalAmp DataCom modems and modulation types typically permit an overall raw error rate of better than 1 error in 10^{-6} as long as signal strengths are adequate. Depending on the speed and the radio being used this error rate can be obtained with signal levels of approximately -107 dBm, but be sure to allow a sufficient signal fade margin.

Using a Dataradio TSLM at 9600 bits per second transmission, an error rate of 1 in 10^{-6} means that you can expect 1 bit error every 107 seconds (in use, errors will likely be much less frequent, but consider designing for the worst case).

6.3 MAINTENANCE AND DIAGNOSTICS

6.3.1 Online diagnostics

Online diagnostics provide three types of information:

- Supply voltage
- Internal temperature
- Received signal strength (in dBm) (RSSI)

Online diagnostics do not interfere with normal network operation. The diagnostic stream is preceded by the unit short ID. The accumulated values can be dynamically monitored using the Online Diagnostics utility or displayed using the Offline Diagnostics utility. Diagnostic online is stored according to the unit's Short ID.

Online Diagnostics are accumulated in the monitoring TSLM for the last 10 unique Short ID's heard. This information may be viewed using the Online Diagnostics utility. For larger networks, the TSLM can output raw diagnostic data only which may be interpreted for network management by the Dataradio Field Programming Software Online Diagnostics utility or by a user-supplied software program. Contact your sales representatives for more information.

6.3.2 Offline Diagnostics

Offline diagnostics and Network statistics are returned in response to a specific request to a particular station. The use of this feature requires temporary suspension of user network operation. Offline diagnostics provide information that is displayed via the Offline Diagnostics utility. Each TSLM can accumulate Network Statistics for up to 10 unique modems heard.

Offline Diagnostics gather and display three types of information:

- Supply voltage
- Internal temperature
- Received signal strength (in dBm) RSSI)

Note: Fwd and Rev power are available if the remote modem is a T-96SR.

6.3.3 Remote Commands

Remote commands are sent and responses received with the host application offline. Remote commands include:

- Begin test transmission (several types are available)
- Get statistics (diagnostics)
- Sample network statistics (monitoring online diagnostics)

SECTION 7 – FIELD PROGRAMMING SOFTWARE

7.1 INTRODUCTION

The TSLM requires Programming Software for configuration, adjustment and diagnostics. Operating characteristics are configured using the Programming Software. Offline Diagnostics and Online Diagnostics give access to Offline Diagnostics and commands (local and remote) and online diagnostics monitoring.

7.2 INSTALLATION

The TSLM Field Programming Software provides programming and diagnostics for the TSLM wireless modem. The Field Programming Software allows the user to edit and program user programmable settings, interactively tune modem and RF parameters, and monitor diagnostic data. This manual assumes the Field Programming Software has been installed on the user's PC with at least one operational serial COM Port available. USB to serial converters are available if the user's PC does not have a DB-9 serial connector. Contact CalAmp DataCom for more information.

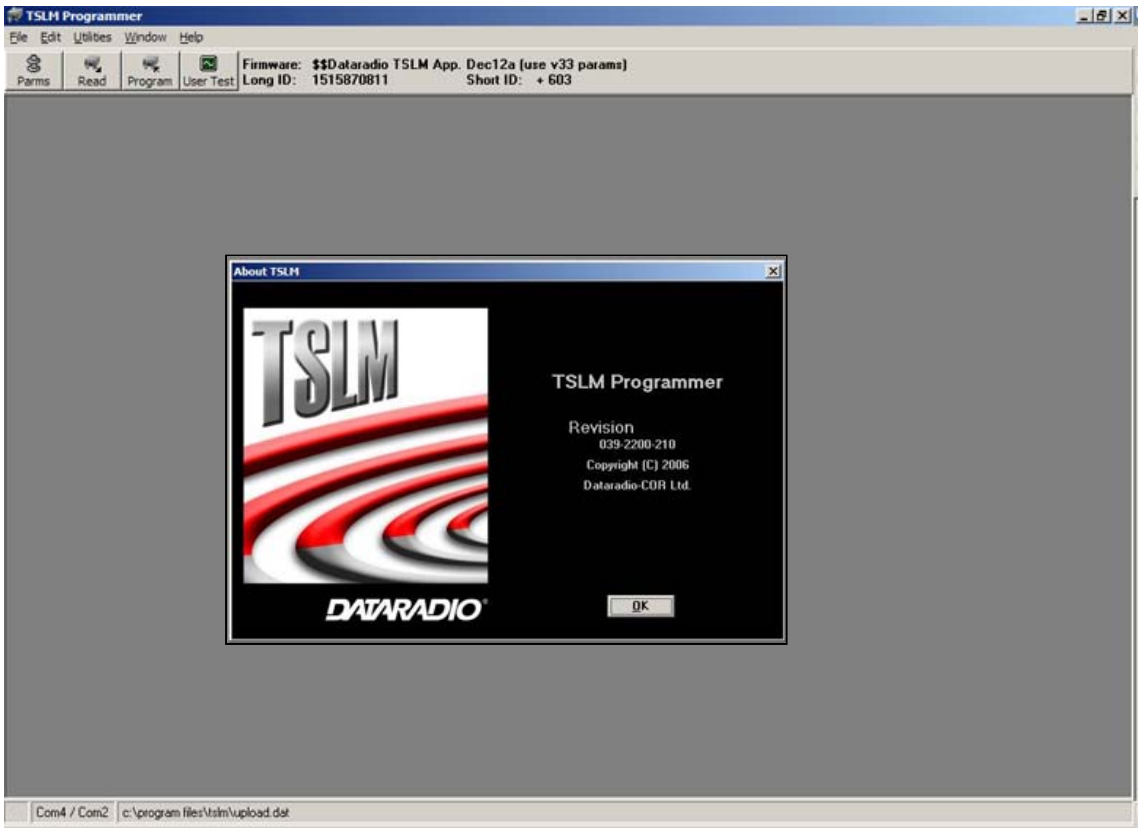


Figure 7.1 TSLM Field Programming Software Screen

7.2.1 Setup TSLM Parameters

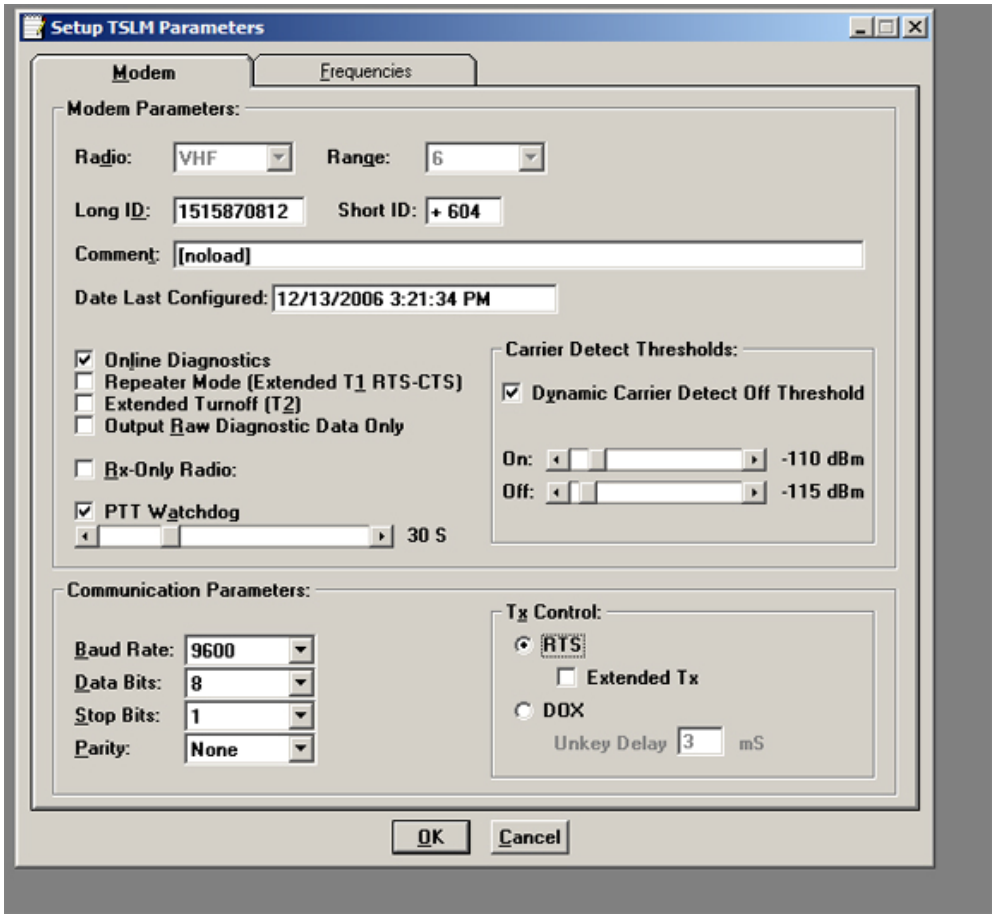


Figure 7.2 Setup TSLM Parameters/Modem Screen

7.2.1.1 Modem Tab

The Setup Modem/Radio Parameters allows the user to view and edit TSLM programmable parameters. The Setup Modem/Radio Parameters screen is accessed from the Edit menu pull-down or from the Parms icon when the tool bar is visible. Programming parameters can be stored in a data file with the .DAT file extension. Programmable parameters are used by the Read/Write Parameters screen for programming into nonvolatile memory.

Parameter settings are modified from two screen tabs: the Modem tab and Frequencies tab. When desired parameters in each tab window have been adjusted, select the OK button to store the parameter information into local PC memory and exit the parameter screen. Clicking the Default Parms button sets certain parameters back to factory default settings. Clicking Cancel exits the parameter screen without modifying any parameters currently stored in local PC memory. To send parameters to the connected TSLM, the Program icon must be selected.

Modem parameters include:

Radio

Radio lists unit type and range. These fields are not user-changeable and are for reference.

Long ID

The Long ID ID Number is a unique number assigned at the factory. This number may be changed in the case of a duplication. The ID Number is used by the programmer for remote addressing and diagnostics. The range of this field is 1 to 4294967295 but multiples of 1024 should not be used. A multiple of 1024 results in a Short ID of 0. If the ID Number is within the range of 1 to 1023, the Short ID will be the same. This ID is not the same as the printed serial number. Use the printed serial number to verify if the unit is under warranty.

Short ID

The Short ID is derived from the longer ID Number. It is used to identify units and minimizes the time required to transmit Online Diagnostics. The Short ID of each unit in a network must be unique if Online or Offline Diagnostics will be used. Since the Short ID is derived from the ID Number, no entry is allowed in this field. The range of the Short ID is 1 to 1023.

Comment

The Comment field can be used as a notepad (i.e., customer name, location, technical info...etc can be entered in this field). Comments are text up to 80 characters including spaces.

Date Last Configured

The Date Last Configured field shows the date the unit was last programmed. The date is from the PC operating system. No entry is allowed in this field.

Online Diagnostics

If enabled, diagnostics information is sent at the beginning of each transmission. Diagnostics information is invisible to user data except for the increase in RTS/CTS delay of 11ms (at 9600 b/s). The default value is “Enabled” (checked). All units in a network must use the same setting. Diagnostics from the last 10 stations received are stored in each unit. These values are read using the Offline or Online Diagnostics screen.

Transmitted information includes:

- Short ID
- Supply Voltage (in Volts)
- Internal Temperature (in Celsius)
- Received Signal Strength (in dBm) (RSSI)

Repeater Mode (Extended T1 RTS-CTS)

The Repeater Mode option extends transmitter turn-on time to allow use in a repeater network. The default value is “Disabled” (unchecked). RTS/CTS delays are important in system design including a T-96SR/T-Base configuration.

Table 7.1
RTS/CTS Delays

	Normal Delay		**Repeater**		**Extended T2**
	Diag off	Diag on	Diag off	Diag on	
4800	30 mS	52 mS	60 mS	82 mS	24.4
9600	20 mS	32 mS	40 mS	52 mS	13.8

Extended Turn-off (T2)

An end-of-transmission quiet period approximately 8 characters long can be invoked on the TSLM by holding its transmitter on briefly after RTS is dropped. This quiet period (which occurs between the last valid data character and any possible extraneous “noise” bits) may be of benefit to some DTE that would otherwise be adversely affected by the extraneous bits.

The Extended Turn-off option extends transmitter turn-off time to enforce a quiet period at the end of each transmission. Select “Enabled” if data equipment does not clearly terminate each data frame and is susceptible to extraneous bits (dribble bits) at the end of data transmission. The default value is “Disabled” (unchecked).

Values are: 4800 b/s = 16 ms; 9600 b/s = 9 ms

Output Raw Diagnostic Data Only

The Output Raw Diagnostic Data Only option instructs the modem to receive diagnostic information received from other modems only. Enabling this option disables user data delivery. This function is provided to simulate or provide a diagnostic unit such as the one incorporated in a T-Base or T-Base Repeater. The default value for this option is “Disabled” (unchecked).

Rx–Only Radio

The Rx Only Radio option disables the radio’s transmitter and any ability for the modem to transmit data.

PTT Watchdog

The PTT Watchdog allows the user to set the maximum transmit time. This is used to protect against a ‘stuck’ transmitter. The time is selected by a slider bar. The range is 0 to 120 seconds with a default of 30 seconds. Warning: Transmissions longer than 30 seconds may exceed the duty cycle rating of the transmitter and lead to shortened life or transmitter failure.

Communication Parameters include:

Baud Rate

This field selects the RS-232 Interface and Network (over the air) baud rate. Baud rate is user-selectable for either 4800 or 9600 bps.

Table 7.2
RS-232 Interface and Network Baud Rates

Configuration	Baud Rates
Half-channel TSLM	4800, 9600

Data Bits/Stop Bits/Parity

The Data Format field selects the word length and number of stop bits for the data stream. The following options are available:

a. 8 Data Bits, 1 Stop Bit
b. 8 Data Bits, 2 Stop Bits
c. 7 Data Bits, 1 Stop Bit
d. 7 Data Bits, 2 Stop Bits

Carrier Detect Thresholds:

Dynamic Carrier Detect Off Threshold

The Dynamic Carrier Detect Off Threshold allows the modem to automatically adjust the Carrier Detect Off Threshold based on the RSSI while receiving data. If selected, the Carrier Detect Off level will automatically adjust to approximately 15 dB below the actual signal strength. This provides rapid detection of loss-of-carrier and minimizes or eliminates 'bit dribble' at the end of transmissions. Recommendation: Keep Dynamic Carrier Detect Off Threshold enabled (checked) unless interference or variable signal strength causes problems.

Carrier Detect On Threshold

Carrier Detect On Threshold indicates RSSI level when a carrier is detected. This level should be more than the Carrier Detect Off Threshold. The default value for Carrier Detect On Threshold is -110 dBm. CalAmp DataCom recommends keeping On/Off values separated by 5 dBm to prevent CD "popping".

Carrier Detect Off Threshold

Carrier Detect Off Threshold indicates the RSSI level when a carrier is no longer detected. This level should be less than the Carrier Detect On. The default value for Carrier Detect Off Threshold is -115 dBm.

Tx Control:

RTS

RTS configures the TSLM for RTS/CTS operation. The default for this field is enabled.

Extended Tx

Extended Tx will cause the modem to continue transmitting any remaining data after RTS is lowered. This is for use with devices whose RTS vs data timing may be inconsistent. Extended Tx configures the TSLM for systems including T-96SR or T-Base infrastructure. The default for this field is disabled.

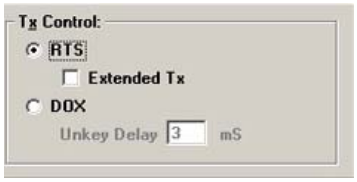


Figure 7.3 Setup Modem/Tx Control Screen

DOX

DOX configures the TSLM for Data Activated Transmit operation. The default for this field is disabled.

DOX Unkey Delay

The DOX Unkey Delay parameter enforces a maximum data gap time for data as it arrives at the transmitting modem. It is the amount of time a transmitting modem will wait for additional data before terminating a DOX transmission. If it is desirable to minimize gaps in the data at the receiving modem, this parameter should be set to 0.

7.2.1.2 Frequencies Tab

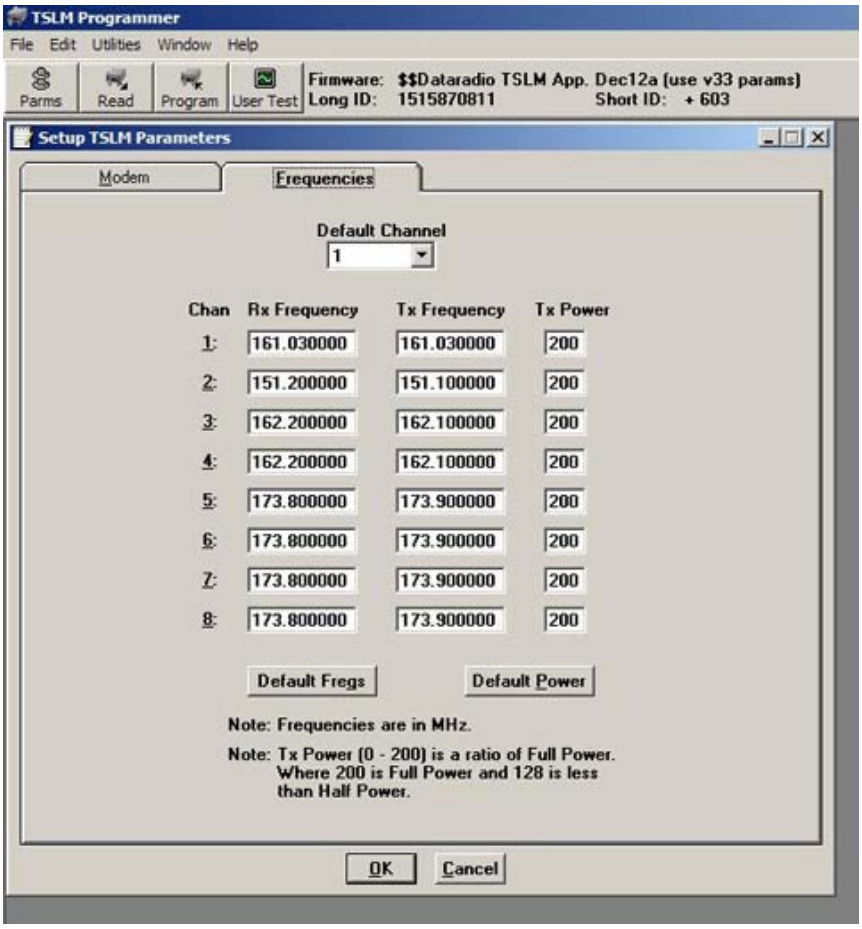


Figure 7.4 Setup TSLM Parameters/Modem Screen

Default Channel

Default Channel allows the user to set a default channel selection.

Chan

Chan displays the frequency channel pair.

Rx Frequency

Rx Frequency displays the receive frequency for the channel pair. Frequencies are in MHz.

Tx Frequency

Tx Frequency displays the transmit frequency for the channel pair. Frequencies are in MHz.

Tx Power

Power displays the Power Output Adjust value for the channel pair. The default value is 200 (5 watts). This value should be left at the default value unless:

- a lower power is required to meet regulatory requirements or
- the user's application requires an increase in the transmit duty cycle

Default Freqs

The Default Freqs button forces the Rx and Tx Frequencies to their factory default values, based on radio type and range.

Default Power

Default Power returns to TSLM to factory set power levels.

Tx Power (0-220) is a ratio of full-power where 220 is full power and 128 is less than half-power.

7.2.2 Version Request

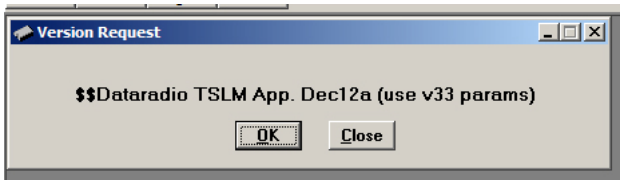


Figure 7.5 Version Request Screen

Selecting Version Request causes the TSLM Field Programming Software to display information about the version of the TSLM hardware and firmware.

7.2.3 READ / Copy / Program TSLM PARAMETERS

Read/Program TSLM parameters is performed when the TSLM is offline and connected the programming cable.

After radio parameters are selected, click the OK button to store the information into the PC's memory. To load parameters into the TSLM, initiate a Program from the Edit menu or select the Program icon from the Tool Bar. After the programmable parameters are loaded into the TSLM, save the parameter information using the Save Data As option in the File pull-down menu. The name and location of the file (*.dat extension) will appear on the status bar at the bottom of the screen. The ID number of the radio will automatically increment by one when the connected radio has completed its programming in order to facilitate programming multiple radios. Take care to avoid multiple clicks on the "OK" button during the programming operation. Clicking "Cancel" and re-clicking the "Program" icon will allow another programming operation without changing the ID of the radio.

7.2.4 Read Programmable Settings Settings

The Read Programmable Settings command will read parameters from the current TSLM and store the information in local memory. The parameters can be viewed and/or edited with the Setup TSLM Parameters screens.

Note: CalAmp DataCom recommends a Read be done anytime an initial connection is made to the TSLM Setup Port before accessing the Setup TSLM Parameters screen. This will help the user avoid writing erroneous parameters to the connected unit. Take note of the unit ID number being programmed. This ID number will be used to create a diagnostic ID List.

7.2.5 Port Settings

TSLM programming is completed through the PC's Primary COM Port. Primary and secondary COM ports are configured with the Field Programming Software. The programming cable (included in the Programming Kit - DRL part number 250-2200-001) is connected from the Setup Port on the TSLM to the PC's COM port configured as the Primary Port. The Port Settings screen of the Field Programming Software is accessed via the Utilities pull-down menu. Port Settings screens are used to configure the PC's serial COM Ports. COM Port assignments are displayed in the bottom status bar of the TSLM Field Programming Software screen. Verify availability of user COM Port by viewing user-PC System Properties/Hardware/Device Manager/Ports. Confirm the TSLM unit is connected to the primary COM port of the PC by selecting Port Settings from the Utilities drop-down menu. Perform a Read to verify communications. A USB to serial converter is required if the programming PC does not have a DB-9 serial port.

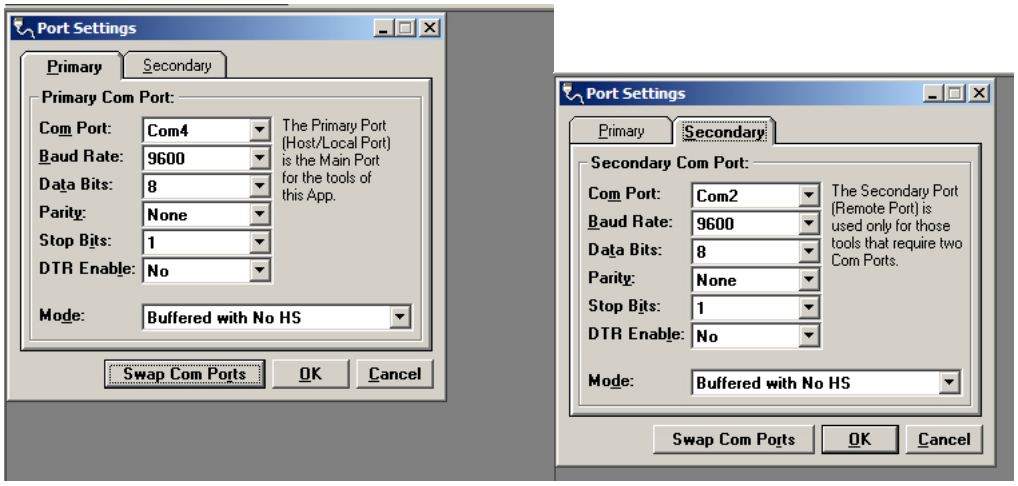


Figure 7.7 Port Settings Primary and Secondary Screens

7.2.5.1 COM Port Parameters

COM Port

Selects COM Port number (COM 1-32) for Primary and Secondary COM Ports.

Baud Rate

Selects the communication speed for Primary and Secondary COM Ports.

Data Bits

Selects the number of data bits (7-8) transmitted or received for the Primary and Secondary COM Ports.

Parity

Selects transmission or reception of any Parity Bits for the Primary and Secondary COM Ports.

Stop Bits

Selects number of Stop Bits (1 or 2) transmitted or received for the Primary and Secondary COM Ports.

DTR Enable

Used to assert DTR (Data Terminal Ready) line of the RS232 Port when the port is open for the Primary and Secondary COM Ports.

Swap COM Ports

Selecting the Swap Com Ports button moves the Secondary COM Port settings to the Primary COM Port (and moves the Primary COM Port to the Secondary settings). Since TSLM programming is done through the Primary COM Port, this is useful when two units are connected to the Primary and Secondary COM Ports. A Swap COM Ports allows the second unit to be programmed without switching programming cables.

7.2.5.2 Primary and Secondary Port Settings Communications Modes

The Mode drop down menu configures the communications mode for the Primary and Secondary PC Port. Table 7.1 lists TSLM Communication Mode configurations.

Table 7.5
Communication Modes

Mode	Description
Sync/Esc with No HS	Sends data using Sync/byte-stuffing protocol without handshaking
Buffered with No HS	Sends buffered data without handshaking. This mode required for DOX operation.
Sync/Esc with RTS/CTS HS	Sends data using the Sync/Esc byte-stuffing protocol with RTS/CTS hardware handshaking.
Buffered with RTS/CTS HS	Sends buffered data with RTS/CTS hardware handshaking.
Sync/Esc with Flow Control HS	Sends data using the Sync/Esc byte-stuffing protocol with flow control handshaking.
Buffered with Flow Control HS	Sends buffered data with flow control hardware handshaking.

7.2.6 Port Statistics

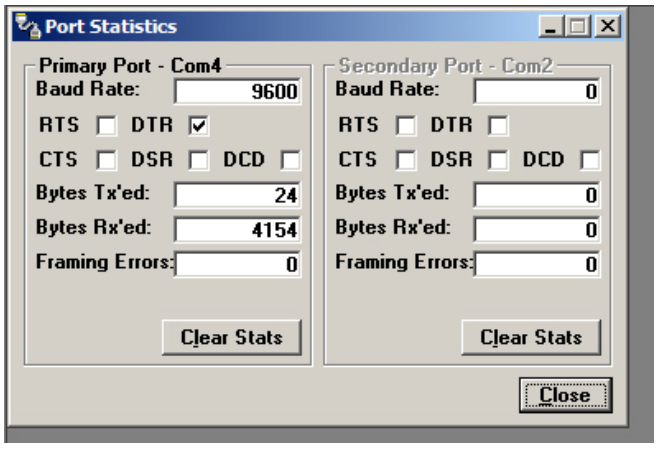


Figure 7.8 Port Statistics Screen

Port Statistics show current parameters of the PC's Primary and Secondary COM Ports.

Baud Rate

Baud Rate shows the current baud rate setting for the Primary and Secondary COM ports.

RTS

RTS shows the current state of the RTS (request to send) line. RTS is an output from the PC.

DTR

DTR shows the current state of the DTR (data terminal ready) line. DTR is an output from the PC.

CTS

CTS shows the current state of the CTS (clear to send) line. CTS is an input to the PC.

DSR

DSR shows the current state of the DSR (data set ready) line. DSR is an input to the PC.

DCD

DCD shows the current state of the DCD (data carrier detect) line. DCD is an input to the PC.

Bytes Tx'ed

Bytes Transmitted shows the number of bytes (characters) transmitted since the port was last opened or cleared.

Bytes Rx'ed
Bytes Received shows the number of bytes (characters) received since the port was last opened or cleared.

Framing Errors

Framing Errors shows the number of Framing Errors received since the port was last opened or cleared.

7.2.7 Offline Link Test

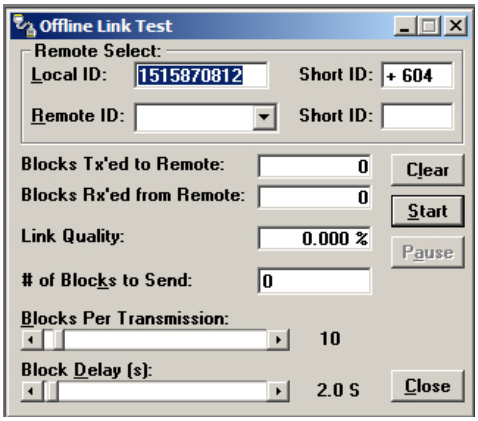


Figure 7.9 Offline Link Test Screen

The Offline Link Test is used to test the link between two units: the local unit interfaced to the computer and a remote unit. Blocks of data are transmitted to the remote unit and the remote unit decodes and returns them. The transmitted and received blocks of data are compared and the ratio of the results are calculated. An Offline Link Test requires suspension of user network operation.

Remote Select:

Local ID

The Local ID is the Long ID of the unit connected to the computer. The Short ID is displayed.

Remote ID

The Remote ID combo box allows selection of the unit (by choosing its Remote ID) from which the Link Test information is gathered. Remote IDs are set up in the Diagnostic IDs and Alarms Screen. The Short ID is displayed.

An Offline Link Test returns the following statistics:

Blocks Tx'ed to Remote

Blocks Tx'ed to Remote displays the number of data blocks transmitted to the remote unit.

Blocks Rx'ed from Remote

Blocks Rx'ed from Remote displays the number of data blocks received from the remote unit.

Link Quality

Link Quality displays the ratio of data blocks received to data blocks transmitted (in %).

# of Blocks to Send

# of Blocks to Send allows the user to determine the number of blocks to send before stopping (with 0 being disabled).

Blocks Per Transmission

Allows the selection of the number of blocks per transmission (1 to 200 blocks).

Block Delay (s)

Block Delay(s) allows the user to determine the delay between data transmission blocks in 0.05 second intervals (0.00 to 120.00 seconds).

Clear

Clear allows the user to clear the display (blocks transmitted, blocks received and link quality).

Start

Start is used to begin the test.

Pause

Pause is used to stop the test and allows the user to resume the test at a later time.

7.2.8 Offline Diagnostics

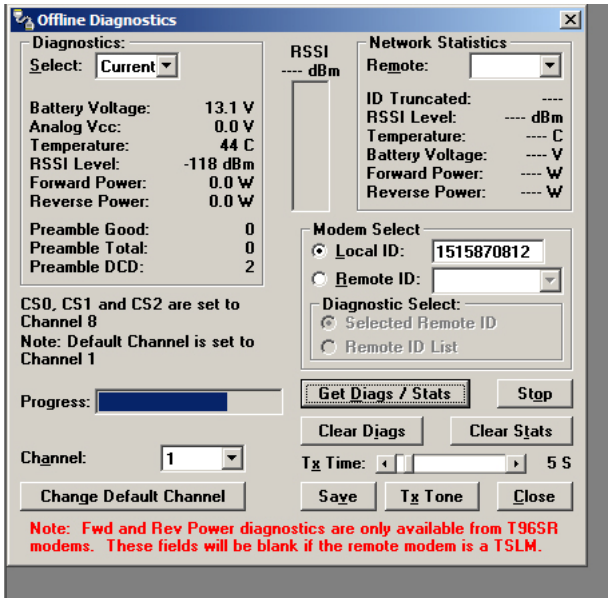


Figure 7.10 Offline Diagnostics Screen

Offline Diagnostics are returned from a local or remote unit in response to a Get Diags Request. *An Offline Diagnostics request requires suspension of user network operation.*

Diagnostics:

Select

Select allows the user to choose Current, Low or High Diagnostics. Current shows the value of the last requested parameters. Low or High displays the lowest or highest value of the parameters since the last Clear was performed or the last time power was removed.

Offline Diagnostics parameters include the following:

- Battery Voltage: supply voltage
- Analog Vcc: Analog Circuits Regulated 5V line
- Temperature: internal case temperature (in Celsius)
- RSSI Level: Received Signal Strength Indication (in dBm)
- Forward Power: Forward Power (in watts)*
- Reverse Power: Reverse Power (in watts)*
- Preamble Good: the number of correctly decoded transmissions received since power up. Used with Preamble Total, this serves as an indication of how well the unit is receiving data
- Preamble Total: the number of total transmissions detected since power up. Used with Preamble Good, this serves as an indication of how well the unit is receiving data
- Preamble DCD: this number shows a count of all received Carrier Detects

**Forward and Reverse Power diagnostics are available only from T-96SR modems. These fields are included to support T-96SR infrastructure and will be blank if the local or remote modem is a TSLM.*

Network Statistics

Offline Network Statistics are only available when the 'Online Diagnostics' option is enabled for the network. Online Diagnostics are located on the Setup Modem/Radio Parameters screen. When enabled, diagnostic information is inserted at the beginning of each transmission from each unit in the network. While the network may remain online, the monitoring unit is in 'Setup' mode (flashing green LED).

Network Statistics:

Remote

The Remote drop down allows the user to select (from the list Remotes) which network statistics to display.

ID Truncated

ID Truncated shows the user the Long and Short ID are not the same.

RSSI Level

The RSSI level shows the current RSSI level (in dBm) while the Local unit is receiving.

Temperature

Temperature shows the internal case temperature (in Celsius).
Battery Voltage

Battery Voltage shows the supply voltage (in Volts).

Forward Power

Forward Power shows forward power (in Watts). This parameter is available only when remote modem is a T-96SR

Reverse Power

Reverse Power shows reverse power (in Watts). This parameter is available only when remote modem is a T-96SR.

RSSI Panel

The RSSI panel shows the current RSSI level (in dBm) while the local unit is receiving.

Modem Select:

Local ID

The Local ID button allows the user to send commands to the local unit (the unit interfaced to the computer). The Short ID for this unit is shown.

Remote ID

The Remote ID button allows the user to send diagnostic commands to any specific remote unit and obtain its diagnostic information. The Remote ID is selected from the list of Remote IDs set up in the Diagnostic IDs and Alarms screen.

Diagnostic Select / Selected Remote ID

This button allows the user to gather Offline Diagnostics from the selected Remote ID only.

Diagnostic Select / Remote ID List

This button allows the user to gather Offline Diagnostics from all the IDs in the list of Remote IDs (including the local unit).

Progress

The Progress panel displays the progress of obtaining Remote Diagnostics.

Channel

Channel allows the user to change the default channel of operation. Changing the default channel takes effect after pressing the Change Default Channel button.

Change Default Channel

Change Default Channel allows the user to redirect the default Channel to another programmed channel.

Get Diags / Stats

The Get Diags button allows the user to send the command for Offline Diagnostics. The command is sent to the unit connected to the computer if the Local ID button is selected. The command is sent to the selected Remote ID if the Remote ID and Selected Remote ID buttons are selected. The command is sent to the list of Remote IDs if the Remote ID and Remote ID List buttons are selected.

Stop

The Stop button allows the user to stop any commands for Offline Diagnostics from being sent.

Clear Diags

Clear Diags clears the unit's online network statistics.

Tx Time

Tx Time allows the user to select the length of time the unit will transmit a tone (in seconds) when the Tx Tone button is pressed (1 to 60 seconds).

Save

The Save button allows the user to save the current Offline Diagnostics to a file.

Tx Tone

The Tx Tone button instructs the unit to transmit a tone for modulation on the programmed transmit frequency for a duration of Tx Time.

7.2.9 Online Diagnostics

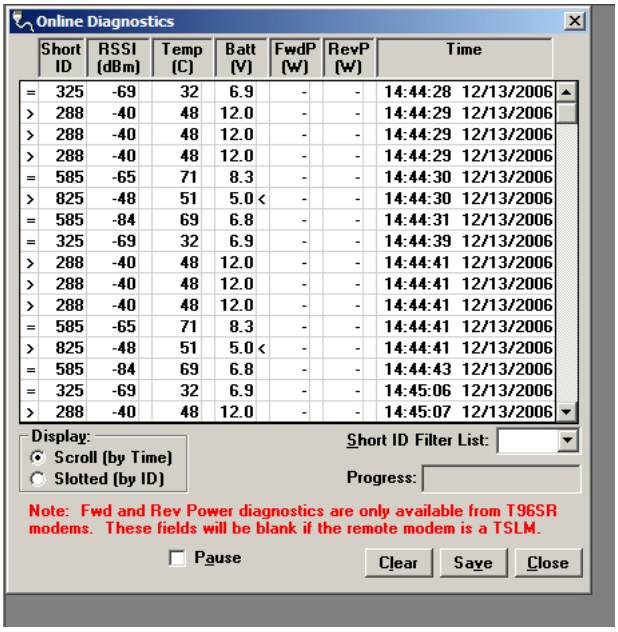


Figure 7.11 Online Diagnostics Screen

Online Diagnostics are transmitted by each unit in a network before the user's data is transmitted. Online Diagnostics must be enabled in all units of a telemetry system to prevent corruption of user data by diagnostic data. All units must be programmed with the Online Diagnostics parameter found on the Setup TSLM Parameters screen to receive Diagnostics from a system. The unit the computer is interfaced with will output Online Diagnostics as they are received. This unit must have the Output Raw Diagnostic Data Only parameter programmed (found on the Setup TSLM Parameters Screen). Using Online Diagnostics does not require suspension of network operation. Online Diagnostics are subject to alarm and filter conditions defined in the Diagnostic IDs, Alarms and Filters parameters. When Online Diagnostics are received and a diagnostic field falls outside the alarm limits, a "<" character will designate a value less than the low alarm and a ">" character will designate a value greater than the high alarm. If Online Diagnostics are received and a diagnostic field falls outside the filter limits, the diagnostic information will be considered invalid and will not be displayed.

The following Online Diagnostics are gathered:

Short ID

The Short ID displays the Short ID of the unit transmitting the diagnostics.

RSSI

RSSI (Received Signal Strength Indicator) displays the RSSI (in dBm) of the unit transmitting the diagnostics. This is the RSSI sampled during the last transmission received.

Temp

Temp displays the internal case temperature (in Celsius) of the unit transmitting the diagnostics.

Batt

Batt displays the supply voltage (in volts) of the unit transmitting the diagnostics.

FwdP*

FwdP displays the forward power (in watts) of the unit transmitting the diagnostics.

RevP*

RevP displays the reverse (reflected) power (in watts) of the unit transmitting the diagnostics.

**Forward and Reverse Power diagnostics are available only from T-96SR modems. These fields are included to support TSLM infrastructure and will be blank if the remote modem is a TSLM.*

Time

Time is the time stamp when the diagnostics were received.

Short ID Filter List

The Short ID Filter list allows the user to filter Short IDs.

Display

Display allows the user to format on screen data. The following options are available:

- Scroll (by time): displays the diagnostics as they are received
- Slotted (by ID): sorts the diagnostics by Short ID. Using this option, each Short ID will have one row of diagnostics, showing the most recent Short ID

Progress

The Progress panel shows the sorting progress of the diagnostics if a filter was changed.

Pause

The Pause check box allows the user to pause the reception of the diagnostics for scrolling through the grid.

Clear

The Clear button allows the user to clear the display and current Online Diagnostics.

Save

The Save button allows the user to save the current Online Diagnostics to a file. A maximum of 4096 lines of data can be saved.

7.2.10 Diagnostic IDs, Alarms and Filters

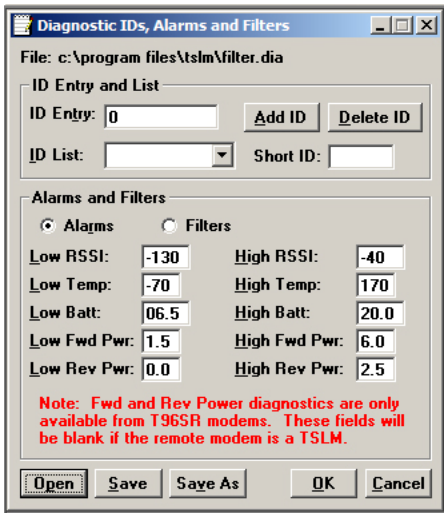


Figure 7.12 Diagnostic IDs, Alarms and Filters Screen

The Diagnostics IDs and Alarms utility allows the user to set up the ID List for use with the Offline Link Test and Offline and Online Diagnostics as well as the Alarms for use with Online Diagnostics.

ID Entry and List:

ID Entry and ADD ID

ID Entry allows the entry of a Long ID to be added to the ID List. The range of this field is 1 to 4294967295 but multiples of 1024 should not be used. A multiple of 1024 results in a Short ID of 0. If the Long ID is within the range of 1 to 1023, the Short ID will be the same or the resulting Short ID will be smaller than the Long ID and will be represented by a '+' character in front of the ID. A Long ID is added to the ID List by an 'Enter' or by clicking the Add ID button.

ID List and Delete ID

ID List allows the user to select a Long ID from the list to delete. A Long ID is deleted from the list by pressing the Delete ID button.

Short ID

Short ID shows the converted Short ID from the selected Long ID of the ID List.

Alarms and Filters:

Alarms and Filters

Alarms and Filters are used with Online Diagnostics. When Online Diagnostics are received and a diagnostic field falls outside the Alarm limits, a "<"character will designate a value less than the low Alarm and a ">" character will designate a value greater than the High Alarm. When Online Diagnostics are received and a diagnostic field falls outside the Filter Limits, the diagnostic information is considered invalid and is not displayed.

Low/High RSSI

Low/High RSSI represent the low and high RSSI limits for the RSSI Diagnostics.

Low/High Temp

The Low/High Temp represents the low and high limits for the temperature diagnostics (in degrees C).

Low/High Batt

Low/High Batt represents the low and high limits for the battery voltage diagnostics (in volts).

*Low/High Fwd Pwr

Low/High Fwd Pwr represents the low and high limits for the forward power diagnostics (in watts).

*Low/High Rev Pwr

Low/High Rev Pwr represents the low and high limits for the Reverse Power diagnostics (in watts).

**Forward and Reverse Power diagnostics are available only from T-96SR modems. These fields are included to support TSLM infrastructure and will be blank if the remote modem is a TSLM.*

Open

The Open button allows the user to restore Diagnostic IDs and Alarms from a previously saved file.

Save

The Save button allows the user to save the current Diagnostic IDs and Alarms to the current file.

Save As

The Save As button allows the user to save the current Diagnostic IDs and Alarms to a name different than the current file.

7.2.11 User Test

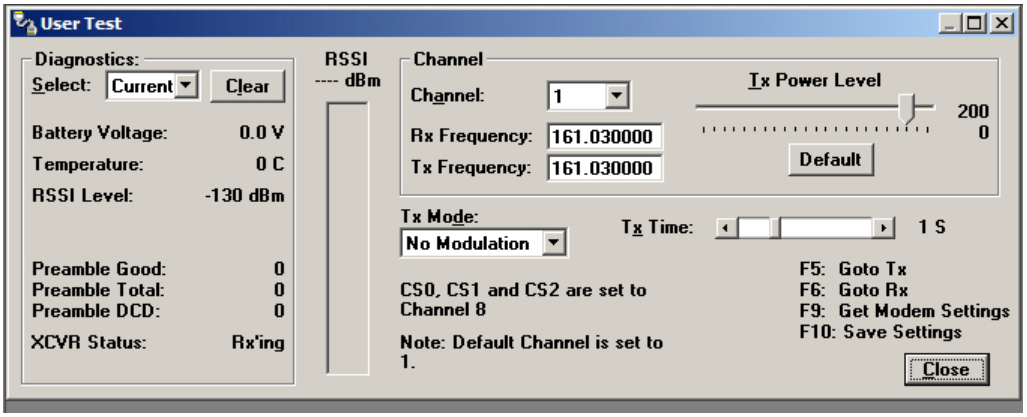


Figure 7.13 User Test Utility Screen

The User Test utility is an Offline function and requires suspension of network operation.

Diagnostics:

User Test diagnostic parameters include:

Select

Select allows the user to choose Current, Low or High Diagnostics. Current shows the value of the last requested parameters. Low or High displays the lowest or highest value of the parameters since the last Clear was performed or the last time power was removed

Battery Voltage

Battery Voltage shows the supply voltage (in Volts).

Temperature

Internal temperature (in degrees Celsius)

RSSI Level

Received Signal Strength Indication (in dBm).

Preamble Good

The number of correctly decoded transmissions received since power up. Used with Preamble Total, this serves as an indication of how well the unit is receiving data.

Preamble Total

The number of total transmissions detected since power up. Used with Preamble Good, this serves as an indication of how well the unit is receiving data.

XCVR Status

XCVR Status shows if the TSLM is transmitting or receiving.

RSSI Panel

This panel shows the current RSSI level (in dBm) while the local unit is receiving.

Channel:

Channel

Channel allows the user to select the User Test Channel. Channels 1-8 and Disabled are available. If disabled is selected, the unit will read the Channel select lines in the external connector.

Rx / Tx Frequency

Rx / Tx Frequency shows the current receive and transmit frequencies.

TX Power Level

Tx Power Level allows the user to configure the Transmit Power Level for the User Test. Clicking Default will return the Tx Power Level to the default value of 200.

Tx Mode

Tx Mode allows the user to select the transmit mode for the User Test. The following modes are available:

- No Modulation
- Random Data
- 100 Hz Tone
- 1200 Hz Tone

Tx Time

Tx Time allows the user to choose the transmit time for the User Test. The Tx Time range is from 0 to 120 seconds.

F5

Pressing the F5 key will cause the unit to transmit on the programmed transmit frequency.

F6

Pressing the F6 key will cause the unit to go to receive on the programmed receive Frequency.

F10

Pressing F10 will save the User Test Settings.

7.2.12 Packet Test

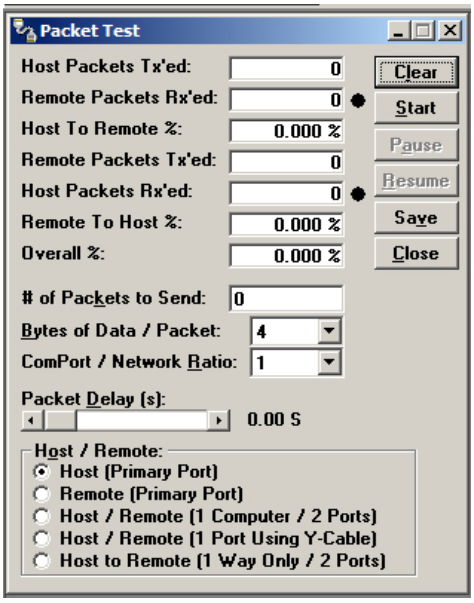


Figure 7.14 Packet Test Screen

The Packet Test utility is used to simulate a Host/Remote polling environment. The Master unit will send out a packet to the Remote and the Remote will reply to the Master with the same packet information. This is a useful utility for testing modem communication.

Host Packets Tx'ed

Host Packets transmitted shows the number of data packets the Master has sent to the Remote.

Remote Packets Rx'ed

Host Packets received shows the number of data packets the Remote device has received from the Master.

Host to Remote %

Host to Remote percentage shows the percentage of packets the Host device has successfully sent to the Remote.

Remote Packets Tx'ed

Remote Packets transmitted shows the number of data packets that the Remote device has returned to the Host.

Host Packets Rx'ed

Host Packets received shows the number of data packets the Host device has received from the Remote.

Remote to Host %

Remote to Host percentage shows the number of packets the Remote device successfully sent to the Host.

Overall %

Overall percentage shows the percentage of Host received packets versus Host transmitted packets.

# of Packets to Send

Number of Packets to Send programs the number of packets the Host should send to the Remote before stopping.

Bytes of Data / Packet

Bytes of Data / Packet is the programmable number of data bytes in each packet the Host sends. The Remote will respond with the same number of packets.

COMPort/Network Ratio

COMPort/Network Ratio is the ratio of the COM port baud rate to network (over the air) baud rate of a modem. This is used if the network baud rate is slower than the COM port baud rate. If the COM port baud rate is 9600 and the network baud rate is 4800, set the ratio to 2. If the two are the same, set this field to 1.

Packet Delay (s)

Packet Delay (s) is the number of seconds for the Host to delay between sending each packet. This field ranges from 0.00 to 10.00 seconds (in 0.25 second intervals).

Host/Remote:

Host/Remote is used to configure COM port options. (See Table 7.6)

- Host (Primary Port) - Configures the primary COM port as the Host device (the device initiating packets to the Remote device.
- Remote (Primary Port) - Configures the primary COM port as the Remote device (the device responding to the packets from the Host device).
- Host/Remote (1 computer / 2 ports) - Configures the primary COM port as the Host device and the secondary COM port as the Remote device. This option requires a computer with 2 COM ports.
- Host/Remote (1 Port using a Y-cable and CalAmp DataCom 697-0000-001 application cable) - Configures the primary COM port as the Host and Remote device. A Y-cable is required for this option (with transmit connections split to the transmitting device and receive connections split to the receiving device). A computer with 1 COM port is utilized for this option

Table 7.6
Y-Cable Connections

Pin Name	DB-9	Computer	Rx TSLM	Tx TSLM
DCD	1	X	X	-
RxD	2	X	X	-
TxD	3	X	-	X
DTR	4	-	-	-
GND	5	X	X	X
DSR	6	-	-	-
RTS	7	X	-	X
CTS	8	X	-	X
RI	9	-	-	-
X = Requires connection - = No connection				

7.2.13 Array Test

The Array Test screen is used to send programmable length test packets.

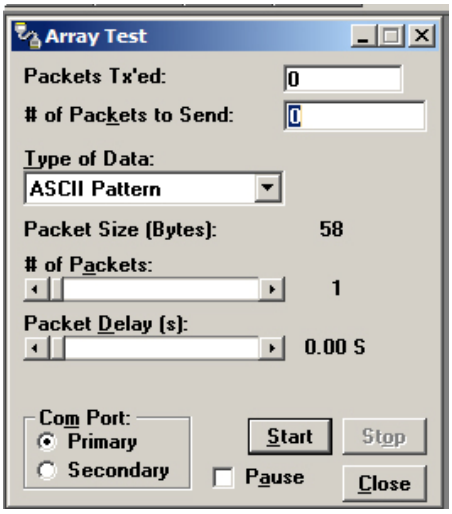


Figure 7.15 Packet Test Screen

Packets Tx'ed

Packets Tx'ed shows the total number of packets transmitted.

# of Packets to Send

# of Packets to Send allows the user to set the total number of packets to send before stopping (field range is 0 to unlimited)

Type of data

Type of Data allows the user to select the data pattern for each packet. The size for each data pattern is listed in the pattern format explanations (packets are built using one of four possible patterns).

- ASCII Pattern - Packets are 58 characters in length and have a sequence number at the beginning of each string starting with 000, incrementing to 999 then wrapping around to 000 again

  The pattern used to build the packets will have the following format (in ASCII):
  000 ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz
  001 ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz
  ---

  998 ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz
  999 ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz
  000 ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz
  001 ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz

- ASCII Number Pattern - The packets will be 58 characters in length and have a sequence number at the beginning of each string, starting at 000 and incrementing to 999, then wrapping around to 000 again.

  The pattern used to build the packets will have the following format (in ASCII):
  000 00 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF
  001 00 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF
  ---

  998 00 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF
  999 00 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF
  000 00 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF
  001 00 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF

- Binary Pattern - The packets will be 16 characters in length and have a sequence number every 16 characters, starting at 0x00 and incrementing to 0xFF, then wrapping around to 0x00 again.

  The pattern used to build the packets will have the following format (in Hex):

  00 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF

  01 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF

  02 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF

  -- 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF

  FE 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF

  FF 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF

  00 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF

01 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF

02 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF

-- 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF

- Random Binary Pattern - The packets will be 16 characters in length and contain random binary data.

  # of Packets

  # of Packets allows the user to set the number of packets in each transmission.

  Packet Delay

  Packet Delay allows the user to set the amount of time (in seconds) to delay between each packet transmission, ranging from 0.00 to 30.00 seconds (in 0.25 second intervals).

  Com Port

  Com Port allows the user to select the COM port (primary or secondary) for data transmission.

7.2.14 Program Firmware

The Program Firmware utility allows the user to update the TSLM firmware. Contact Technical Services for more information.

7.2.15 ASCII / HEX TERMINAL

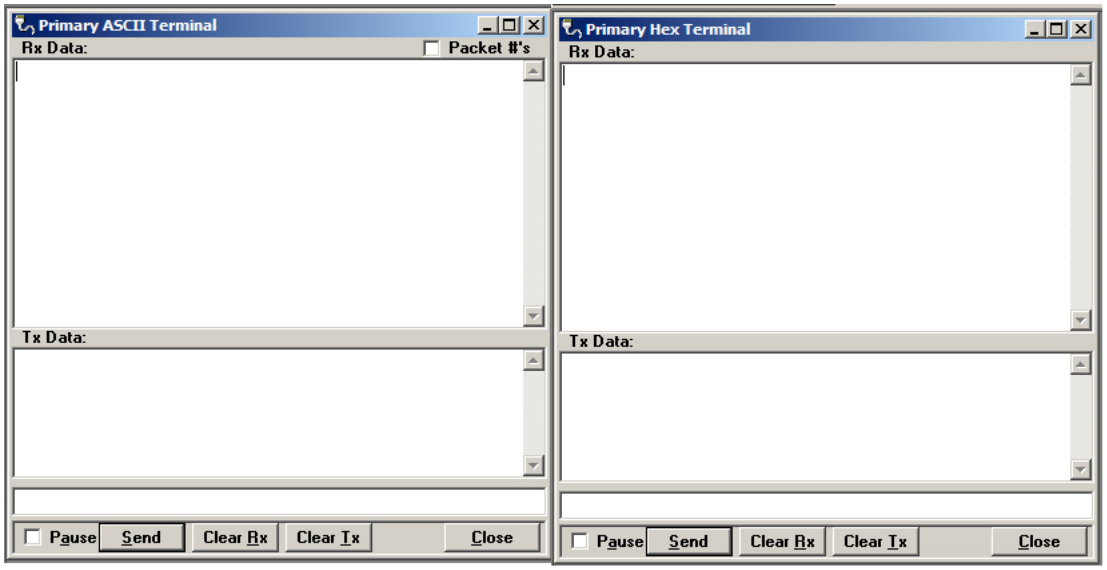


Figure 7.16 ASCII / Hex Terminal Screens

Terminal Screens allow the user to select an ASCII or Hexadecimal Terminal Screen for the Primary and Secondary COM Ports (configured in the Port Settings Utility). Data is sent according to the port configuration set up in the Port Settings screen.

ASCII / HEX TERMINAL:

ASCII Terminal configurations include:

Primary

The Primary ASCII Terminal screen sends and receives ASCII data on the Primary COM Port (set up in the Port Settings screen).

Secondary

The Secondary ASCII Terminal screen sends and receives ASCII data on the Secondary COM Port (set up in the Port Settings screen).

HEX Terminal:

Hex Terminal configurations include:

Primary

The Primary Hex Terminal screen selects a Hexadecimal Terminal screen to send and receive Hexadecimal data on the Primary COM Port (set up in the Port Settings screen).

Secondary

The Secondary Hex Terminal screen selects a Hexadecimal Terminal screen to send and Receive Hexadecimal data on the Secondary COM Port (set up in the Port Settings utility).

SECTION 8 – SPECIFICATIONS

Product specifications are subject to change without notice.

8.1 GENERAL SPECIFICATIONS

<table>
<tr><td>Frequency Range</td><td colspan="5">UHF 406-470 MHz VHF 137-174 MHz</td></tr>
<tr><td>Defined Frequency Bands</td><td colspan="5">UHF 406-422 MHz [2] VHF 150-174 MHz [6]
UHF 414-433 MHz [3] VHF 137-162 MHz [7]
UHF 450-470 MHz [5]</td></tr>
<tr><td>RF Input Impedance</td><td colspan="5">50 Ohm</td></tr>
<tr><td>Frequency Control</td><td colspan="5">Synthesized software programmable or
Hardware controlled through the DE-15 pin connector</td></tr>
<tr><td>Channel Steps</td><td colspan="5">12.5 kHz</td></tr>
<tr><td>Frequency Resolution</td><td colspan="5">6.25 kHz 2.5 kHz</td></tr>
<tr><td>Carrier Frequency Stability</td><td colspan="5">1.0 PPM (-30°C to +75°C)</td></tr>
<tr><td>System Deviation</td><td colspan="5">3.0 kHz maximum @ 9600 Baud
4.0 kHz maximum @ 4800 Baud</td></tr>
<tr><td>Operating Mode</td><td colspan="5">Simplex or Half Duplex</td></tr>
<tr><td>Front Panel Indicators</td><td colspan="5">PWR, TX and RX</td></tr>
<tr><td>Time-out-Timer</td><td colspan="5">Variable 0-120 seconds switchable on/off</td></tr>
<tr><td>Diagnostics</td><td colspan="5">Configuration, test, performance statistics</td></tr>
<tr><td>Data Rate</td><td colspan="5">4800 and 9600 bps</td></tr>
<tr><td>Signal Levels</td><td colspan="5">EIA RS-232</td></tr>
<tr><td>Data Format</td><td colspan="5">Asynchronous, serial, transparent</td></tr>
<tr><td>Word Length</td><td colspan="5">7 or 8 bit words, 1 or 2 stop bits</td></tr>
<tr><td>Parity</td><td colspan="5">Even, odd, or none</td></tr>
<tr><td>Transmit Control</td><td colspan="5">RTS-CTS or Data Activation Transmit (DOX)</td></tr>
<tr><td rowspan="4">Turnaround Time</td><td colspan="5">RTS-CTS delay</td></tr>
<tr><td>Baud</td><td colspan="2">Normal Delay</td><td colspan="2">Repeater</td><td>Extended T2</td></tr>
<tr><td></td><td>Diag off</td><td>Diag on</td><td>Diag off</td><td>Diag on</td><td></td></tr>
<tr><td>4800
9600</td><td>30 mS
30 mS</td><td>52 mS
32 mS</td><td>60 mS
40 mS</td><td>82 mS
52 mS</td><td>24.4
13.8</td></tr>
<tr><td>Modulation</td><td colspan="5">DRCMSK</td></tr>
<tr><td>Communication Mode</td><td colspan="5">Serial synchronous</td></tr>
<tr><td>BER</td><td colspan="5">Better than $1x10^{-6}$ at –107dBm for 9600 bps</td></tr>
<tr><td>RSSI Description
@ .22 uV (-120 dBm)
@ 220 uV (-60 dBm)</td><td colspan="5">Unit Min Max Conditions
V 0.31 2.00 MID @ -120dBm 1.0kHz 1.5kHz deviation
V 1.18 3.70 MID @ -60dBm 1.0kHz 1.5kHz deviation</td></tr>
</table>

8.2 TRANSMITTER SPECIFICATIONS

Conducted Carrier Output Power	Adjustable 1 Watt to 5 Watts ±10% at 12.5 VDC and 25°C Adjustable 0.10 Watt to 2 Watts ±20% at 7.20 VDC and 25°C ±3dB from +10.0 to +15.0 VDC at 25°C ±3dB from +6.0 to +9.0 VDC at 25°C ±3dB from -30° to +60°C
Bandwidth (without tuning)	406-422 MHz 16 MHz 137-162 MHz 25 MHz 414-430 MHz 16 MHz 150-174 MHz 24 MHz 450-470 MHz 20 MHz
Radiated Spurious Emissions	< -20dBm
Tx Cold Start	≤ 100 mS from power on to Transmit Data
Transmitter Stability into VSWR	No failure or instability up to 10:1
Intermodulation Attenuation	> 40 dB

8.3 RECEIVER SPECIFICATIONS

Bandwidth (without tuning)	406-422 MHz 16 MHz 137-162 MHz 25 MHz 414-430 MHz 16 MHz 150-174 MHz 24 MHz 450-470 MHz 20 MHz
Reference Sensitivity	≤ -116dBm at 12dB SINAD and 1 kHz tone
Adjacent Channel Rejection	≥ 60dB
Spurious and Image Rejection	≥ 70dB per TIA/EIA
Intermodulation Rejection	≥ 70dB
Rx Cold Start	≤ 100 mS from power on to Receive Data
Audio Level	445 mVrms +180/-145 mVrms over voltage and temperature at standard deviation w/ a 1 kHz tone
Audio Distortion	< 3%
Blocking Rejection	≥ 84dB
Conducted Spurious Emissions	≤ -57dBm
RSSI	> -120 to –50dBm

8.4 INTERFACE SPECIFICATIONS

Power/Data Connector	15 Pin Female DE-15 Female Connector
RF Connector	BNC female

8.5 ENVIRONMENTAL SPECIFICATIONS

Dimensions	1.02 x 2.45 x 3.63 in.
Weight	8.0 oz
Temperature	-30° to +60°C
Humidity	0-95% (40°C non-condensing)

8.6 REGULATORY AND INDUSTRY SPECIFICATIONS

TIA/EIA	All specifications per TIA/EIA–603 unless otherwise noted
FCC	UHF NP4-2422240510: 9K60F1D and 10K0F1D VHF NP4-2422210610: 9K60F1D and 10K0F1D
IC	UHF 773B-2240510: 9K60F1D and 10K0F1D VHF 773B-2210610: 9K60F1D and 10K0F1D

SECTION 9 – SERVICE AND SUPPORT

9.1 PRODUCT WARRANTY, RMA AND CONTACT INFORMATION

CalAmp DataCom guarantees that every Dataradio TSLM Synthesized Radio Modem will be free from physical defects in material and workmanship for two (2) years from the date of purchase when used within the limits set forth in the Specifications section of this manual.

The manufacturer's warranty statement is available in Appendix 1. If the product proves defective during the warranty period, contact CalAmp DataCom Customer Service to obtain a Return Material Authorization (RMA).

9.2 RMA REQUEST

Contact Customer Service:
299 Johnson Ave., Ste 110, Waseca, MN 56093
Tel 1.507.833.8819 Email rma@dataradio.com

BE SURE TO HAVE THE EQUIPMENT MODEL AND SERIAL NUMBER, AND BILLING AND SHIPPING ADDRESSES ON HAND WHEN CALLING. You may also request an RMA online at www.dataradio.com/rma.

When returning a product, mark the RMA clearly on the outside of the package. Include a complete description of the problem and the name and telephone number of a contact person. RETURN REQUESTS WILL NOT BE PROCESSED WITHOUT THIS INFORMATION.

For units in warranty, customers are responsible for shipping charges to CalAmp DataCom. For units returned out of warranty, customers are responsible for all shipping charges. Return shipping instructions are the responsibility of the customer.

9.3 PRODUCT DOCUMENTATION

CalAmp DataCom reserves the right to update its products, software, or documentation without obligation to notify any individual or entity. Product updates may result in differences between the information provided in this manual and the product shipped. For the most current product documentation, visit www.calamp.com for datasheets, programming software and user manuals.

9.4 TECHNICAL SUPPORT

M-F 7:30 AM to 4:30 PM CDT

CalAmp DataCom
299 Johnson Ave.
Ste 110, Waseca, MN 56093

Tel 507.833.8819 Fax 507.833.6758 Email supportimc@calamp.com

SECTION 10 – Data Telemetry Warranty

Dataradio COR Ltd. ("DRL") warrants to the original purchaser for use ("Buyer") that data telemetry products manufactured by DRL ("Products") are free from defects in material and workmanship and will conform to DRL's published technical specifications for a period of, except as noted below, two (2) years from the date of shipment to Buyer. DRL makes no warranty with respect to any equipment not manufactured by DRL, and any such equipment shall carry the original equipment manufacturer's warranty only. DRL further makes no warranty as to and specifically disclaims liability for, availability, range, coverage, grade of service or operation of the repeater system provided by the carrier or repeater operator. Any return shipping charges for third party equipment to their respective repair facilities are chargeable and will be passed on to the Buyer.

If any Product fails to meet the warranty set forth above during the applicable warranty period and is returned to a location designated by DRL. DRL, at its option, shall either repair or replace such defective Product, directly or through an authorized service agent, within thirty (30) days of receipt of same. No Products may be returned without prior authorization from DRL. Any repaired or replaced Products shall be warranted for the remainder of the original warranty period. Buyer shall pay all shipping charges, handling charges, fees and duties for returning defective Products to DRL or DRL's authorized service agent. DRL will pay the return shipping charges if the Product is repaired or replaced under warranty, exclusive of fees and duties. Repair or replacement of defective Products as set forth in this paragraph fulfills any and all warranty obligations on the part of DRL.

This warranty is void and DRL shall not be obligated to replace or repair any Products if (i) the Product has been used in other than its normal and customary manner; (ii) the Product has been subject to misuse, accident, neglect or damage or has been used other than with DRL approved accessories and equipment; (iii) unauthorized alteration or repairs have been made or unapproved parts have been used in or with the Product; or (iv) Buyer failed to notify DRL or DRL's authorized service agent of the defect during the applicable warranty period. DRL is the final arbiter of such claims.
THE AFORESAID WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED AND IMPLIED, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. DRL AND BUYER AGREE THAT BUYER'S EXCLUSIVE REMEDY FOR ANY BREACH OF ANY OF SAID WARRANTIES IT AS SET FORTH ABOVE. BUYER AGREES THAT IN NO EVENT SHALL DRL BE LIABLE FOR INCIDENTAL, CONSEQUENTIAL, SPECIAL, INDIRECT OR EXEMPLARY DAMAGES WHETHER ON THE BASIS OF NEGLIGENCE, STRICT LIABILITY OR OTHERWISE. The purpose of the exclusive remedies set forth above shall be to provide Buyer with repair or replacement of non-complying Products in the manner provided above. These exclusive remedies shall not be deemed to have failed of their essential purpose so long as DRL is willing and able to repair or replace non-complying Products in the manner set forth above.

This warranty applies to all Products sold worldwide.

Some states do not allow limitations on implied warranties so the above limitations may not be applicable. You may also have other rights which vary from state to state.

EXCEPTIONS

ONE YEAR:	Labor to replace defective parts in repeaters or base stations
THIRTY DAY:	Tuning and adjustment of telemetry radios
NO WARRANTY:	Fuses, lamps and other expendable parts