TAS 4500
RF Channel Emulator
Operations Manual

Telecom Analysis Systems, Inc.
34 Industrial Way East
Eatontown, NJ 07724

Phone: (732) 544-8700

Fax: (732) 544-8347

This manual applies to the TAS 4500, Version 4.3 and higher

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1.0. INTRODUCTION

1.1. Overview

The TAS 4500 FLEX RF Channel Emulator provides a convenient, thorough approach for testing wireless communications equipment by emulating the delay, fast and slow fading, and path loss characteristics of RF mobile communication channels. The 4500 FLEX allows thorough testing in a laboratory setting and drastically reduces the time required for product tests. The 4500 FLEX can be used to test a wide range of wireless voice and data communication equipment, including cellular telephones, cellular modems, personal communication terminals, wireless LANs, pagers, wireless network equipment, and much more.

TAS 4500 FLEX provides advanced signal processing features to address a wide range of wireless communications technologies. The 4500 FLEX delivers these features in a modular format, so your test system can evolve to meet your testing needs for years to come. The TAS 4500 FLEX has the following features:

- Plug-In RF Front End Modules
- Plug-In Local Oscillator Modules
- Plug-In, Wide Bandwidth Signal Processing Modules
- Plug-In System Software PCMCIA Card

A single TAS 4500 emulates two independent wide bandwidth RF channels, each with up to six transmission paths, see Figure 1-1. Delay, path loss, Rayleigh fading, and log-normal fading characteristics can be programmed for each path. Two six-path channels can be combined to make one 12-path channel, and two TAS 4500s can be combined and synchronized for multi-channel applications.

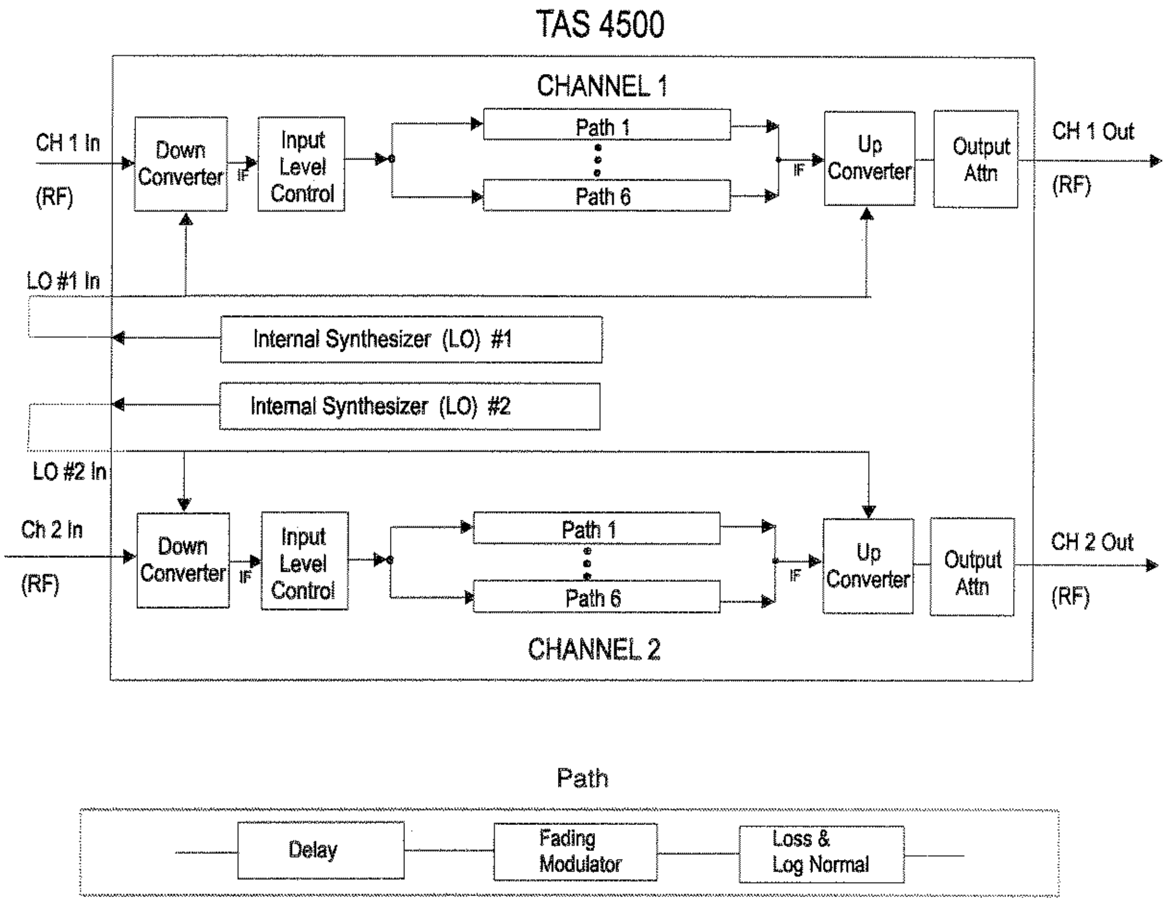

Figure 1-1. TAS 4500 Block Diagram

TAS 4500 provides powerful features that are new for an instrument of this type. Built-in calculation of fading coefficients and the built-in user interface eliminate the need for an external computer and greatly enhance testing speed and convenience. Built-in GPIB and RS-232 control ports make it easy to include the TAS 4500 in automatic test systems.

1.1.1. Product Highlights

- Wideband channel emulation capability meets or exceeds requirements of most wireless communications standards, including AMPS, IS-95 (CDMA), IS-54 (TDMA), GSM, CT2, TETRA, DCS-1800 and JDC.
- Emulates important radio channel characteristics, including Rayleigh fading, Rician fading, Suzuki fading, Nakagami fading, log-normal shadowing, delay spread/multi-path distortion, and path loss. See feature summary in Table 1-1.
- TAS 4500's modular architecture lets your test system capabilities grow as your testing requirements grow. The modular 4500 FLEX architecture lets you select the number of RF channels and frequency synthesizers required to fit both existing and future testing applications.
- The FLEX-IF™ allows you to select the IF bandwidth that is best for your application. Bandwidths of 6 MHz, 15 MHz, and 26 MHz are available to meet all your testing needs.
- The FLEX-RF™ front end offers a host of high-performance features, including excellent rejection of the local oscillator signal and a built-in RF attenuator. These features greatly enhance dynamic range and improve testing performance at low RF receive levels.
- The FLEX-LO™ modules completely address the testing needs of both cordless phone, paging, cellular and PCS applications, eliminating the need for external signal generators.
- Built-in digital signal processors and user interface provide generation and control of fading signals in real time: no external PC required, no long signal processing delays.
- Advanced Fading Features such as selectable fading method, fading repetition rate and fading power spectrum allow comprehensive testing using multiple fading models.
- The Dynamic Parameter Emulation with Power Delay Profile feature allows the user an advanced method to enter and play back data emulating dynamic channel models.
- Fine delay resolution makes TAS 4500 suitable for testing mobile, wireless LAN, and PBX applications.
- Built-in configurations for industry-standard test procedures.
- GPIB and RS-232 control ports make it easy to include TAS 4500 in automatic test systems.
- Field-upgradeable PCMCIA System Software Card allows quick and easy access to the latest firmware revisions and features.
- Flexible architecture provides easy configuration of test setups for 2, 4, or 8 branch diversity receivers.

RF FRONT END MODULE*	800-3000 MHz	25-3000 MHz
Double Conversion	●	●
RF Image and LO Feedthrough Suppression	○	○
Programmable Output Attenuator	○	○
RF Channel Bypass	○	○

IF SIGNAL PROCESSING MODULE	6 MHz	15 MHz	26 MHz
Rayleigh Fading	●	●	●
Advanced Fading Features	●	●	●
Dynamic Parameter Emulation	●	●	N/A
Rician Fading	●	●	●
Suzuki Fading	●	●	●
Nakagami Fading	●	●	●
Frequency Shift	●	●	●
Phase Shift	●	●	●
Rayleigh Fading with Freq. Shift	●	●	●
Log Normal Fading	●	●	●
Relative Path Loss	●	●	●
Relative Path Delay	●	●	●
Extended Relative Path Delay	○	○	○

OPTIONAL INTERNAL LO MODULE NUMBER	CARRIER FREQUENCY RANGE SUPPORTED
LO Number 3	60-260 MHz 340-540 MHz
LO Number 4	800-3000MHz

● - Standard Feature ○ - Optional Feature

* Consult factory for additional carrier frequency ranges

Table 1-1. Feature Summary for TAS 4500 FLEX System Configurations

1.1.2. TAS 4500 Applications

The TAS 4500 provides many emulation features for testing wireless telecommunications equipment for product development, manufacturing and evaluation applications.

Product Development and Engineering Test

Product development and engineering test organizations can use the TAS 4500 to test and evaluate the performance of wireless communications equipment in the presence of real world conditions such as Rayleigh fading, and delay spread. Repeatable and realistic testing is crucial to the successful development of wireless systems because they typically require complex signal processing techniques to mitigate the effects of RF channel impairments.

Quality Assurance (QA) Testing

The QA organization of a wireless equipment manufacturer can use the TAS 4500 to monitor product quality by testing if the manufactured product is consistently meeting the targeted performance levels. This can be a major issue particularly for high volume products such as cellular telephone and modems.

Evaluation and Acceptance Testing

Communications equipment users often need to evaluate the performance of wireless telecommunication equipment as part of their procurement process for such equipment. This typically requires the equipment from candidate suppliers to be tested against an established set of performance specifications. These types of tests require test equipment that is very flexible, accurate and easy to use. The TAS 4500 possesses these characteristics and provides the functionality for the user to evaluate wireless communication equipment against a wide variety of domestic and international testing specifications.

1.2. Guided Tour

The front panel keys and display provide access to all the features of the TAS 4500. The front panel enables the definition of channel characteristics, control of the input signal level, measurement of peak signal levels, set up of general system configuration parameters, and saving and recalling configuration files.

1.2.1. Front Panel Description

Figure 1-2 shows the TAS 4500 front panel. The following sections describe each front panel feature.

The buttons and displays on the front panel of the TAS 4500 are partitioned into logical groups to provide a user friendly interface. This consists of menu group select keys (CH 1 and CH 2, MEASURE, CONFIG, and FILE) that are located at the lower right side of the front panel. The menu navigation keys (up, down, left and right arrows), value editing (+ and -), ENTER and ESC (ESCAPE) as well as the CURSOR control keys are located just below the two row by forty column main display. The REMOTE control enable/disable key is at the lower right corner of the panel. The input level RANGE keys are grouped near the lower center portion of the front panel.

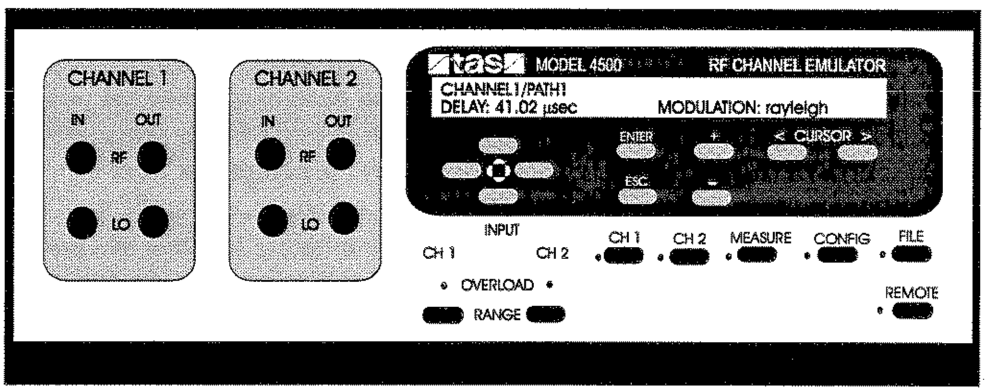

Figure 1-2. TAS 4500 Front Panel

Front Panel Buttons and Displays

CH 1 Key

The channel 1 menu group controls the simulated unidirectional RF channel that consists of up to six independently programmable transmission paths. This menu group allows I/O parameters (carrier frequency, LO frequency, input reference level, and output attenuation) as well as RF channel parameters (number of paths in the channel model, relative path delay, fast and slow fading, frequency shift, phase shift, and relative path attenuation) to be viewed and controlled. The LED to the left of the button is lit when this menu group is selected.

CH 2 Key
The channel 2 menu group controls the second simulated unidirectional RF channel that consists of up to six independently programmable transmission paths. This menu group allows I/O parameters (carrier frequency, LO frequency, input reference level and output attenuation) as well as RF channel parameters (number of paths in the channel model, relative path delay, fast and slow fading, frequency shift, phase shift, and relative path attenuation) to be viewed and controlled. The LED to the left of the button is lit when this menu group is selected.

MEASURE Key
The measure menu group controls the instrument's measurement function. The measure menu allows the measurement of peak signal levels. The LED to the left of the button is lit when this menu group is selected.

CONFIG Key
The configure menu group allows the configuration of the remote control interface, selects the displayed units for the path characteristics, sets the fading parameters and sets the LCD contrast. The system summary displays the instrument's software version, diagnostic status and hardware configuration. The LED to the left of the button is lit when this menu group is selected.

FILE Key
The file menu group allows you to load both user and TAS defined parameter profiles and to save user define parameter configurations. The LED to the left of the button is lit when this menu group is selected.

Menu Navigation Up & Down Arrow Keys
To move between screens of the same menu, the Menu Navigation Up & Down Arrow keys are used. They are located together with the Menu Navigation Left & Right Arrow keys as a group under the left hand side of the front panel display.

Menu Navigation Left & Right Arrow Keys
The Menu Navigation Left and Right Arrow Keys move the cursor between parameter fields of the same menu screen. They are located together with the Menu Navigation Up & Down Arrow keys as a group under the left hand side of the front panel display.

Cursor Left & Right Arrow Keys
The Cursor Left and Right Arrow Keys move the cursor between digits within a parameter field.

ENTER Key
The ENTER key accesses a submenu. A carriage return symbol (↵) appears at the right side of each menu item that has a submenu.

ESC Key
The ESC key allows you to exit a submenu, or clear an error condition.

Value + & - Keys
The Value + and - keys are used to modify the value of the parameter field that is currently active. The Value + key increments the value of the field while the Value - key decrements the value of the field.

CH 1 and CH 2 Range Keys
These keys are located near the lower center of the front panel to provide direct access to the input level control function for both channels. The invoked button causes the channel emulator to measure the peak level of the transmit signal that is present at the input (RF IN) of the associated channel. The results of this measurement are then used to configure the channel's input level control circuit. The 4500 automatically forces the present INPUT REFERENCE LEVEL to the appropriate value to adjust the level of the input signal to approximately 3 dB below the full scale dynamic range of the channel. This provides the signal processing circuitry of the 4500 with the optimum conditions to emulate channel characteristics. When performing an input range, the overload LED will light momentarily, indicating that the TAS 4500 is optimizing the signal level.

REMOTE Key
The remote key enables/disables remote control operation. When remote operation is enabled, menu parameters cannot be changed from the front panel. However, the menu navigation keys can still be used to view parameter values. The LED to the left of the button is lit when the 4500 is in remote control mode.

Main Display
The main display located in the center of the front panel, shows all control menus and level measurement results.

OVERLOAD LEDs
The overload LEDs are located under the left hand side of the display. These two LEDs should be monitored to be sure the signal applied at the RF Channel input is within the specified range. When lit, the LED indicates the RF input signal has peak levels above the permitted range and will be clipped by the instruments input circuitry. If an overload condition occurs, the input reference level parameter should be increased and/or the input signal level should be reduced.

Signal Input/Output Connectors

RF Input/Output N-Connectors

There are two N-type connectors per channel located on the upper left hand side of the TAS 4500 front panel for RF input and output.

LO Input/Output N-Connectors

There are two N-type connectors per channel located on the lower left half side of the TAS 4500 front panel for LO (Local Oscillator) input and output. An LO signal must be present at the LO IN for that channel to operate. The LO is used by the channel's down converter to translate the RF input signal to an internal IF signal, and by the channel's up converter to translate the IF signal back to a RF output signal.

1.2.2. Rear Panel Description

Figure 1-3 shows the rear panel of a standard 4500.

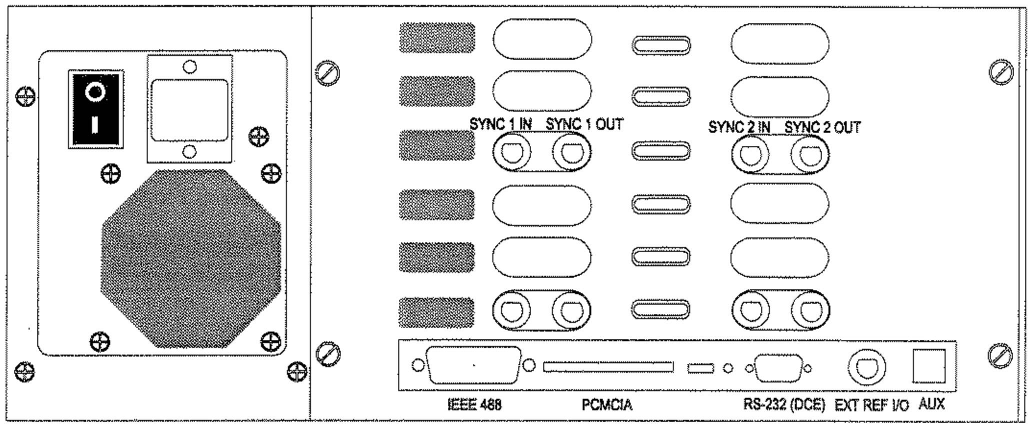

Figure 1-3. Rear Panel of the TAS 4500

PCMCIA System Software Interface
The system software for the TAS 4500 is resident on a PCMCIA memory card which plugs into the PCMCIA System Software Interface on the lower portion of the instrument's rear panel. This PCMCIA card makes it easy to upgrade to the latest firmware version.

IEEE-488 Remote Control Port
The CONTROL (IEEE-488) port is a 24 pin IEEE-488 receptacle which supports the IEEE-488 (GPIB) protocol. This port must be connected to an IEEE-488 controller to control the TAS 4500 via IEEE-488. This connection may be either direct or via multi-point bus which contains other IEEE-488 controlled equipment.

The IEEE-488 controller can be a generic PC with an embedded IEEE-488 control card installed, a IEEE-488 computer, an RS-232 to IEEE-488 converter, or some other IEEE-488 controller.

RS-232 (DCE) Remote Control Port
The CONTROL (DCE) port is a 9 pin D-sub connector which supports RS-232C. The control port is wired as a Data Communications Equipment (DCE). All RS-232C remote control of the TAS 4500 must be done via this port. An RS-232C terminal or a PC (IBM compatible) can control the TAS 4500 through this via a regular RS-232 cable. It is important to note that a null modem cable is not required. Two protocols are supported in RS-232 control mode, ACK/NAK (ACKnowledge/Negative ACKnowledge), and CR/LF (Carriage Return/Line Feed). Both of these protocols are explained in full detail in the REMOTE OPERATION section of this manual.

AUX Port
The AUX (auxiliary) port is a RJ-45 connector that is currently not used.

SYNC 1(2) IN(OUT) Connectors
The SYNC 1(2) input(output) connectors shown in Figure 1-3 are BNC type connectors. The TTL digital signal on this connector is used to provide synchronization of the digital signal processing between two 4500 units that are configured in a 4 branch diversity test setup.

EXTernal REFerence I/O Connector
The External Reference Input/Output connector is a BNC type connector that provides a 10 MHz sine wave reference signal as an output when the TAS 4500 is using its own internal reference. This connector can also accept an externally supplied 10 MHz sine wave reference signal which can be used to drive the internal signal processing circuitry of the TAS 4500 as a software selectable option.

AC Power Receptacle
The AC universal power receptacle is located on the upper left corner of the rear panel. This receptacle also contains the AC on/off switch and the fuse for the unit.

Fan Vent Areas
The rear panel of the TAS 4500 contains two fan vent areas. One vent area is below the AC power receptacle, the other to the right of this vent. The area behind these vents should be unobstructed for proper air flow to cool the TAS 4500.

1.3. Installation

This section describes a simple and straightforward procedure for installing TAS 4500.

1.3.1. Quick Start Procedure

To prepare the TAS 4500 for initial operation, perform the following steps:

1. Unpack the TAS 4500 shipping carton. The carton should contain a packing list as well as all the items shown on the list.

2. Please make sure that all parts listed on the packing list are contained in your TAS 4500 shipping carton. Save the shipping carton and packing materials until you have completed the system installation and initial check. If you must return equipment, please use the original box and packing material.

3. Check each item for physical damage. If any part appears to be damaged, contact the TAS Customer Service department immediately.

4. Read Section 1.2 of this manual.

5. Follow the installation instructions in Section 1.3.2.

6. Read Sections 2.1 and 2.2 and perform the exercise described in Section 2.2.

1.3.2. Installation Guide

The following information describes the basic steps that should be followed to install the TAS 4500.

1. Plug one end of the AC power cord into the TAS 4500, then plug the other end into the AC source.

2. Setup the TAS 4500 for one of the standard test configurations described in Sections 1.3.3. through 1.3.5. or in a user defined configuration. See Section 1.3.6. for setup instructions for 4 branch diversity configurations, and Section 1.3.7. for 8 branch diversity configurations.

3. Set the AC power switch at the upper right corner (when viewed from the front of the 4500) of the rear panel to the "1" position. The TAS 4500 now executes its power-up self test and calibration sequence for a few seconds, while it displays the following message on the MAIN DISPLAY:

```
TAS 4500
System diagnostics & initialization...
```

If the TAS 4500 detects an error, it shows the appropriate error message on the main display. If the TAS 4500 detects no errors it will display the first line of the CH 1 (Channel 1) menu.

Consult Section 2.0. "Local Operation", for further information. If you intend to use a computer or data terminal to control the TAS 4500, consult Section 4.0. "Remote Operation".

NOTE: If the TAS 4500 encounters a failure during its initial diagnostic operation, record the error code displayed on the front panel, and refer Section 6.0. "Error Codes" of this manual.

1.3.3. Single Channel 3 or 6 Path Configuration Test Setup

The TAS 4500 may be easily used in a single channel 3 or 6 path configuration in which an RF transmitter is connected to the emulator's channel input with a compatible receiver connected to the channel output. This unidirectional setup requires all the paths being used to be equipped in Channel 1. This setup is illustrated in Figure 1-4.

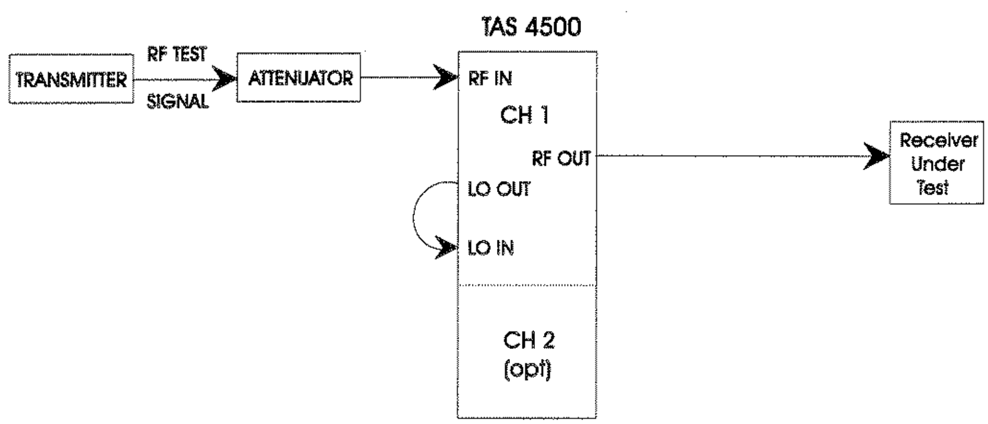

Figure 1-4. Single Channel 3 or 6 Path Configuration

Signal Interconnect:

1. Install a cable from the antenna jack of the RF transmitter to the input of a 50 dB RF attenuator.

   The attenuator is required if the transmit power is greater than the specified input signal level range of the 4500 (-10 dBm is the nominal, see technical specifications for limits). The loss required by the RF attenuator depends on the transmitter's output power. A 6 watt (38 dBm) transmitter with a 50 dB attenuator would present an input power of -12 dBm (38 dBm - 50 dB).

2. Install a cable from the output of the RF attenuator to the N type connector on the front panel of the TAS 4500 labeled "CHANNEL 1 RF IN".

3. Install a short cable from the N type connector labeled "CHANNEL 1 LO OUT" to the "CHANNEL 1 LO IN" connector on the front panel of the TAS 4500. If no internal synthesizer is configured then the LO IN port must be connected to an external user supplied RF frequency synthesizer.

   An LO (Local Oscillator) signal must be present at the LO IN for that channel to operate. The LO is used by the channel's down converter to translate the RF input signal to an internal IF signal, and by the channel's up converter to translate the IF signal back to a RF output signal. Refer to section 7.0. Technical Specifications for the required LO frequency and level.

4. Install a cable from the N type connector on the front panel of the TAS 4500 labeled "RF OUT" to the input of the RF receiver.

Parameter Settings:

5. Basic installation is complete once the equipment has been setup as described in steps 1 to 4 above. You are now ready to set the parameters of the TAS 4500 to the values that are needed to conduct the test.

NOTE: Be sure the Type 1 Channel Correlation is selected as described in Section 2.4. and that the input level control circuit is properly configured (see Section 3.4.). Typically the most convenient method to configure the input level control is to press the CH 1 RANGE button on the front panel of the TAS 4500 after the transmit signal is present at the RF IN port.

1.3.4. Single Channel 12 Path Configuration Test Setup

The TAS 4500 may be easily used in a twelve path single channel configuration in which a RF transmitter is connected to both the emulator's channel inputs through a power divider with a compatible receiver connected to a power combiner that sums the channel outputs. For the 12 path configuration, two 6-path channels must be combined. This unidirectional setup is illustrated in Figure 1-5.

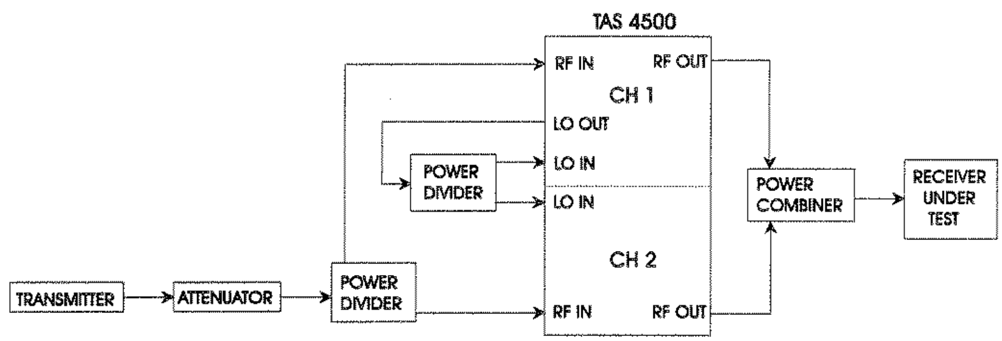

Figure 1-5. Single Channel 12 Path Configuration

Signal Interconnect:

1. Install a cable from the antenna jack of the RF transmitter to the input of a 50 dB RF attenuator.

   The attenuator is required if the transmit power is greater than the specified input signal level range of the 4500 (-10 dBm is the nominal; see technical specifications for limits). The loss required by the RF attenuator depends on the transmitter's output power. A 6 watt (38 dBm) transmitter with a 50 dB attenuator would present the power divider with -12 dBm (38 dBm - 50 dB).

2. Install a cable from the output of the RF attenuator to the input of a 1 to 2 power divider.

   The power divider is needed to split the transmit signal to drive both channel inputs of the TAS 4500.

3. Install a cable from one of the two divider outputs to the N type connector on the front panel of the TAS 4500 labeled "CHANNEL 1 RF IN".

4. Install a cable from the second of the two divider outputs to the N type connector on the front panel labeled "CHANNEL 2 RF IN".

5. Install a cable from the output of the N type connector labeled "CHANNEL 1 LO OUT" to the input of a 1 to 2 power divider.

   The power divider is needed to allow the use of a single LO instead of requiring two Local Oscillators.

6. Install a cable from one of the two divider outputs to the N type connector on the front panel of the TAS 4500 labeled "CHANNEL 1 LO IN".

7. Install a cable from the second of the two divider outputs to the N type connector on the front panel labeled "CHANNEL 2 LO IN". (Note that a power divider is not required if the TAS 4500 is equipped with two LOs. In this case a short cable should be installed from each LO OUT to LO IN connector). If no internal synthesizer is configured then the LO OUT connector will be blanked and the LO IN port must be connected to an external user supplied RF frequency synthesizer.

   An LO (Local Oscillator) signal must be present at the LO IN for that channel to operate. The LO is used by the channel's down converter to translate the RF input signal to an internal IF signal, and by the channel's up converter to translate the IF signal back to a RF output signal. Refer to section 7.0. Technical Specifications for the required LO frequency and level.

8. Install a cable from the N type connector on the front panel of the TAS 4500 labeled "CHANNEL 1 RF OUT" to one of the two inputs of the 2 to 1 power combiner. Install a cable from the N type connector on the front panel labeled "CHANNEL 2 RF OUT" to the second of the two inputs of the power combiner.

9. Install a cable from the output of the power combiner to the input of the RF receiver.

Parameter Settings:

10. Basic installation is complete once the equipment has been setup as described in steps 1 to 9 above. You are now ready to set the parameters of the TAS 4500 to the values that are needed to conduct the test.

NOTE: Be sure that the Type 1 Channel Correlation is selected as described in section 2.4.1. and that the input level control circuit is properly configured (see section 3.4.). Typically the most convenient method to configure the input level control is to press the CH 1 and CH 2 RANGE buttons on the front panel of the TAS 4500 after the transmit signal is present at both the RF IN ports.

1.3.5. Duplex Channel Configuration Test Setup

The TAS 4500 may be easily used in a duplex channel configuration with 3 or 6 paths in each direction in which transmitter A communicates with receiver B through Channel 1 and transmitter B and receiver A through Channel 2 of the TAS 4500. This setup is illustrated in Figure 1-6.

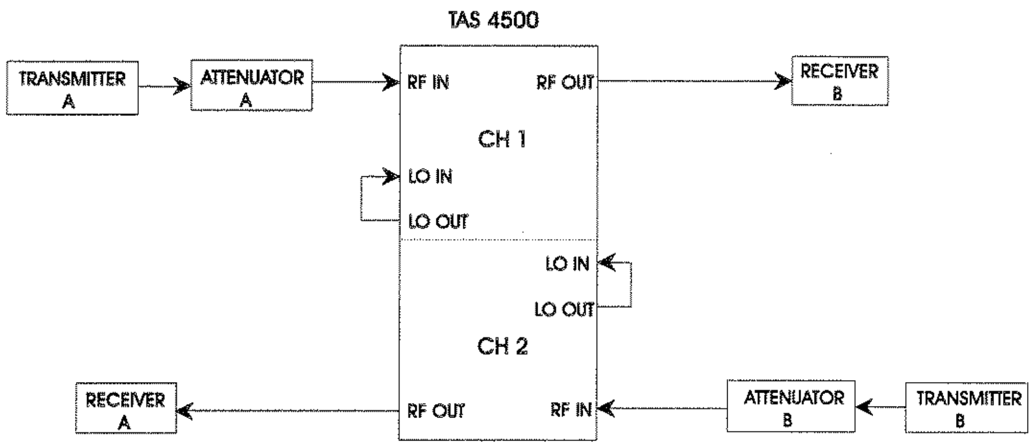

Figure 1-6. Duplex Channel Configuration

Signal Interconnect:

1. Install a cable from the antenna jack of RF transmitter A to the input of a 50 dB RF attenuator A.

   The attenuator is required if the transmit power is greater than the specified input signal level range of the 4500 (-10 dBm is the nominal; see technical specifications for limits). The loss required by the RF attenuator depends on the transmitter's output power. A 6 watt (38 dBm) transmitter with a 50 dB attenuator would present an input power of -12 dBm (38 dBm - 50 dB).

2. Install a cable from the output of the RF attenuator A to the N type connector on the front panel of the TAS 4500 labeled "CHANNEL 1 RF IN".

3. Repeat steps 1 and 2 above for transmitter B, attenuator B and channel 2 of the TAS 4500.

4. Install a short cable from the N type connector labeled "CHANNEL 1 LO OUT" to the "CHANNEL 1 LO IN" connector on the front panel of the TAS 4500. If no internal synthesizer is configured then the LO OUT connector will be blanked and the LO IN port must be connected to an external user supplied RF frequency synthesizer.

   An LO (Local Oscillator) signal must be present at the LO IN for that channel to operate. The LO is used by the channel's down converter to translate the RF input signal to an internal IF signal, and by the channel's up converter to translate the IF signal back to a RF output signal. Consult the technical specifications of your model 4500 for the required LO frequency and level.

5. Repeat steps 4 above for the channel 2 LO of the TAS 4500.

6. Install a cable from the N type connector on the front panel of the TAS 4500 labeled "CHANNEL 1 RF OUT" to the input of the RF receiver B.

7. Repeat steps 6 above for the "CHANNEL 2 RF OUT" of the TAS 4500 and RF receiver A.

Parameter Settings:

8. Basic installation is complete once the equipment has been setup as described in steps 1 to 7 above. You are now ready to set the parameters of the TAS 4500 to the values that are needed to conduct the test.

NOTE: Be sure that the Type 1 Channel Correlation is selected as described in section 2.4. and that the input level control circuit is properly configured (see section 3.4.). Typically the most convenient method to configure the input level control is to press the CH 1 and CH 2 RANGE buttons on the front panel of the TAS 4500 after the transmit signal is present at both the RF IN ports.

1.3.6. 4 Branch Diversity Test Setup for 4500

TAS 4500 units that are equipped with the factory installed 4 Branch Diversity test feature may be easily used in a 12 or 24 path single channel setup that is configured as 4 branches (with up to 6 paths in each branch). In this configuration a RF transmitter is connected to the 4 channel (branch) inputs provided by the two 4500 units with a 1 to 4 power splitter as shown in Figure 1-7. Each one of the outputs from these channels provide the input signal to one of the 4 available ports of a 4 branch diversity receiver. The top 4500 unit shown in Figure 1-7 is to be configured as the primary unit and provides branches 1 and 2. While the lower 4500 unit is configured as the secondary unit and provides branches 3 and 4. The typical configuration requirements for the primary and secondary units are defined below.

Control of the 4 branch diversity test configuration is provided by TASKIT/4500 Diversity software and is not available from the front panel of the 4500. The typical configuration requirements for providing TASKIT control are provided below.

The following operations are required for the proper installation of a 4 branch diversity test setup:

1. Primary unit (channels 1 and 2) configuration requirements
2. Secondary unit (channels 3 and 4) configuration requirements
3. Interconnect of the synchronization signals
4. Configuration of the Local Oscillator (LO)
5. Interconnect of the RF transmit and receive signals
6. Configuration of the test system control interfaces

See the information that follows for details.

Primary Unit (Channels 1 and 2) Configuration Requirements

The TAS 4500 unit that is designated as the primary unit will provide channels 1 and 2 of the 4 channel (branch) setup. This unit must provide the SYNC 1 and SYNC 2 signals to the secondary unit.

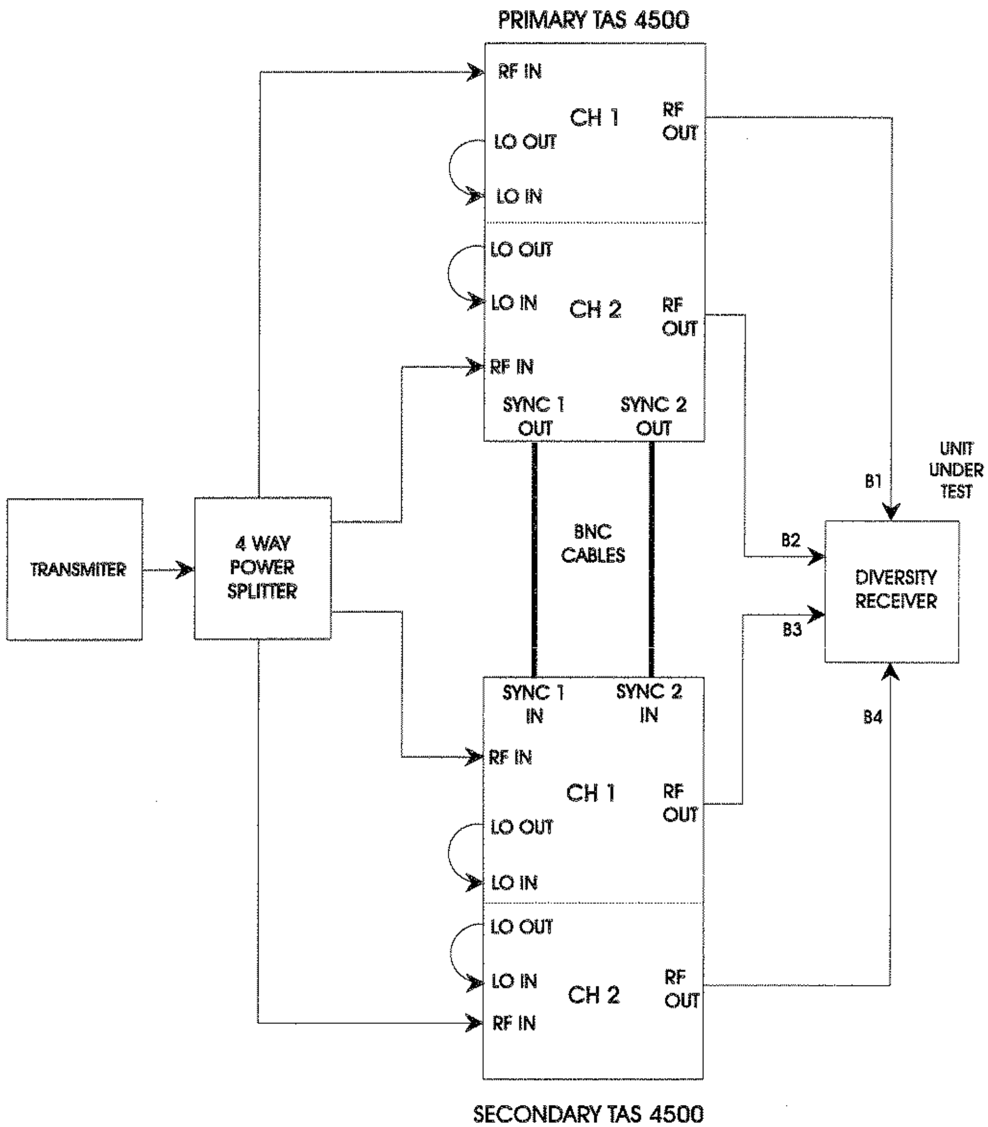

Figure 1-7. 4 Branch Diversity Configuration

Secondary Unit (Channels 3 and 4) Configuration Requirements

The TAS 4500 unit that is designated as the secondary unit will provide channels 3 and 4 of the 4 channel (branch) setup. This unit must input the SYNC 1 and SYNC 2 signals from the primary unit.

Interconnect of the Synchronization Signals

Install a BNC cable from the SYNC 1 OUT connector shown in Figure 1-3 on the rear panel of the primary unit to the SYNC 1 IN connector on the rear panel of the secondary unit. Install a BNC cable from the SYNC 2 OUT connector shown in Figure 1-3 on the rear panel of the primary unit to the SYNC 2 IN connector on the rear panel of the secondary unit. The TTL digital signal on these connectors are used to provide synchronization of the digital signal processing between two 4500 units that are configured in a 4 branch diversity test setup.

> **NOTE:** The SYNC 1(2) OUT signals must not be connected to each other to avoid permanent damage to the output driver circuitry.

Configuration of the Local Oscillator (LO)

> **NOTE:** The configuration of the LOs described below is a simple and cost effective approach for providing each channel of the 4500 with its required LO. However there are also several other LO configuration that may be suitable for your test setup.
>
> A LO (Local Oscillator) signal must be present at the LO IN for that channel to operate. The LO is used by the channel's down converter to translate the RF input signal to an internal IF signal, and by the channel's up converter to translate the IF signal back to a RF output signal. Refer to Section 7.0. Technical Specifications for the required LO frequency and level.

1. For each 4500, install a short cable from the N type connector labeled "CHANNEL 1 LO OUT" to the "CHANNEL 1 LO IN" connector on the front panel of the TAS 4500 shown in Figure 1-7.

2. For each 4500, install a short cable from the N type connector labeled "CHANNEL 2 LO OUT" to the "CHANNEL 2 LO IN" connector on the front panel of the 4500.

Interconnect of the RF Transmit and Receive Signals

> **NOTE:** An attenuator is required if the transmit power is greater than the specified input signal level range of the 4500 (-10 dBm is the nominal; see technical specifications for limits). The loss required by the RF attenuator depends on the transmitter's output power. A 6 watt (38 dBm) transmitter with a 50 dB attenuator would present the power splitter with -12 dBm (38 dBm - 50 dB).

1. Install a cable from the antenna jack of the RF transmitter to the input of a 50 ohm 1 to 4 power splitter. The power splitter is needed to split the transmit signal to drive the four channel inputs of this dual TAS 4500 setup.

2. Install a cable from one of the four splitter outputs to the N type connector on the front panel of the primary TAS 4500 labeled "CHANNEL 1 RF IN".

3. Install a cable from the second of the four splitter outputs to the N type connector on the front panel labeled "CHANNEL 2 RF IN" on the primary unit.

4. Then install a cable from the third splitter output to the N type connector on the front panel of the secondary TAS 4500 labeled "CHANNEL 1 RF IN".

5. Now install a cable from the last of the four splitter outputs to the N type connector on the front panel labeled "CHANNEL 2 RF IN" on the secondary unit.

6. On the primary 4500 install a cable from the output of the N type connector labeled "CHANNEL 1 RF OUT" to the 1st input of the 4 branch diversity receiver.

7. Repeat step 6 for the other 4500 channel outputs and receiver inputs.

Configuration of the Test System Control Interfaces

The TAS 4500 4 Branch Diversity Test System is controlled by TASKIT/4500 Diversity software that executes on an IBM compatible PC. In the test system the Primary 4500 functions as a RS-232 to IEEE-488 interface converter. The PC interfaces to the Primary 4500 with a RS-232 cable. The PC controls the secondary 4500 over the IEEE-488 interface with the interface conversion capability of the primary 4500 as shown in Figure 1-8.

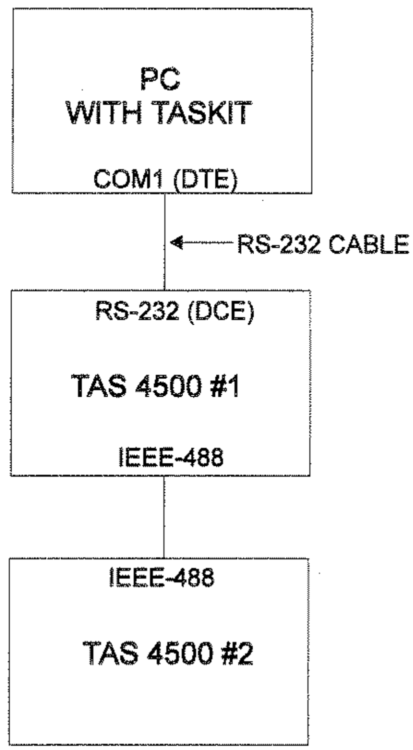

Figure 1-8. 4 Branch Diversity Test System Control Setup

The following is a list of helpful tips that should be considered when using TASKIT/4500 Diversity to control the TAS 4500 4 Branch Diversity Test System.

1. The remote protocol configuration for both 4500 units must be setup to match the selections in the COMMUNICATIONS OPTIONS menu of TASKIT. The remote protocol is configured from the CONFIG menu on the front panel of the 4500. Typical selections are as follows:

INSTRUMENT	PROTOCOL	GPIB ADDRESS	RS-232 DATA FORMAT
Primary 4500	RS-232 CR/LF (carriage return/line feed)	-	4800 bits/sec 7 bit data, odd parity 1 stop bit
Secondary 4500	GPIB	05	-

2. Each instrument must be in remote control mode to allow control by the TASKIT software. Verify that the remote LED located at the lower right-hand corner of the front panel is on, thus indicating that the unit is in remote operation. If the unit is not in remote mode press the remote button to light the remote LED.

3. Do not take the TAS 4500 units out of remote control mode once TASKIT has established communication with the test system. If the 4500 is changed out of remote mode to local mode and then back to remote mode it will be placed into a state that is not compatible with the control requirements of the TASKIT software..This will result in improper operation of the test system.

4. Refer to Section 3.5. for more information on correlation.

1.3.7. 8 Branch Diversity Test Setup

TAS 4500 units can be configured in a group of four units to support an 8 branch test application. When configured properly this setup provides 8 independent (uncorrelated) channels of Rayleigh modulation. Programmable correlation is restricted and is available only between the channels within a 4500 unit. The correlation between pairs that span more than one 4500 unit cannot be programmed but are nominally uncorrelated to each other.

In the 8 branch diversity configuration a RF transmitter is connected to the 8 channel (branch) inputs provided by the four 4500 units with an 1 to 8 power splitter as shown in Figure 1-9. Each one of the outputs from these channels provide the input signal to one of the 8 available ports of a 8 branch diversity receiver.

Control of the 8 branch diversity test configuration is provided by TASKIT/4500 software or from the front panel of the 4500. The typical configuration requirements for providing TASKIT control are provided below.

The following operations are required for the proper installation of an 8 branch diversity test setup:

1. Configuration of the Local Oscillator (LO)
2. Interconnect of the RF transmit and receive signals
3. Configuration of the test system control interfaces
4. Selection of the channel correlation type parameter

See the information that follows for details.

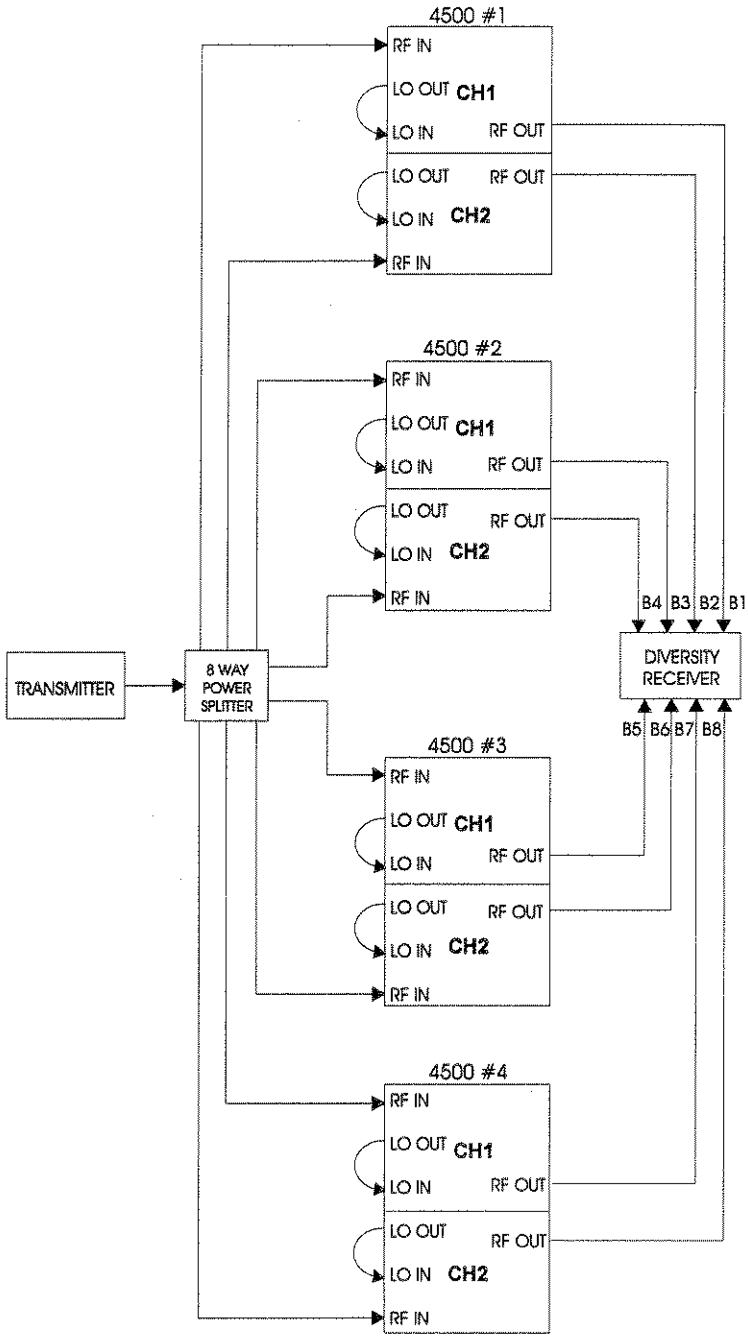

Figure 1-9. 8 Branch Diversity Configuration

Configuration of the Local Oscillator (LO)

NOTE: The configuration of the LOs described below is a simple and cost effective approach for providing each channel of the 4500 with its required LO. However there are also several other LO configuration that may be suitable for your test setup.

An LO (Local Oscillator) signal must be present at the LO IN for that channel to operate. The LO is used by the channel's down converter to translate the RF input signal to an internal IF signal, and by the channel's up converter to translate the IF signal back to a RF output signal. Refer to Section 7.0. Technical Specifications for the required LO frequency and level

1. For each 4500, install a short cable from the N type connector labeled "CHANNEL 1 LO OUT" to the "CHANNEL 1 LO IN" connector on the front panel of the TAS 4500 shown in Figure 1-9.

2. For each 4500, install a short cable from the N type connector labeled "CHANNEL 2 LO OUT" to the "CHANNEL 2 LO IN" connector on the front panel of the 4500.

Interconnect of the RF Transmit and Receive Signals

NOTE: An attenuator is required if the transmit power is greater than the specified input signal level range of the 4500 (-10 dBm is the nominal; see technical specifications for limits). The loss required by the RF attenuator depends on the transmitter's output power. A 6 watt (38 dBm) transmitter with a 50 dB attenuator would present the power splitter with -12 dBm (38 dBm - 50 dB).

1. Install a cable from the antenna jack of the RF transmitter to the input of a 50 ohm 1 to 8 power splitter. The power splitter is needed to split the transmit signal to drive the eight channel inputs of this four TAS 4500 setup.

2. Install a cable from one of the eight splitter outputs to the N type connector on the front panel of the primary TAS 4500 labeled "CHANNEL 1 RF IN".

3. Install a cable from the second of the eight splitter outputs to the N type connector on the front panel labeled "CHANNEL 2 RF IN" on the primary unit.

4. Repeat steps 2-3 for the six remaining splitter outputs and 4500 channel inputs.

5. On the 1st 4500 install a cable from the output of the N type connector labeled "CHANNEL 1 RF OUT" to the 1st input of the 8 branch diversity receiver.

6. Repeat step 5 for the other 4500 channel outputs and receiver inputs.

Configuration of the Test System Control Interfaces

The TAS 4500 8 Branch Diversity Test System is controlled by TASKIT/4500 software that executes on an IBM compatible PC. Two control setups are possible for the 8 Branch Diversity Test System. In the first setup, depicted in Figure 1-10, the PC is required to have four COM (serial communications) ports to interface to the four 4500 units. Each COM port connects to one of the four 4500 units via a RS-232 cable.

In the second setup, depicted in Figure 1-11, the PC interfaces to one of the TAS 4500s with a RS-232 cable. The PC then controls the three remaining 4500 units over the IEEE-488 interface with the interface conversion capability of the TAS 4500.

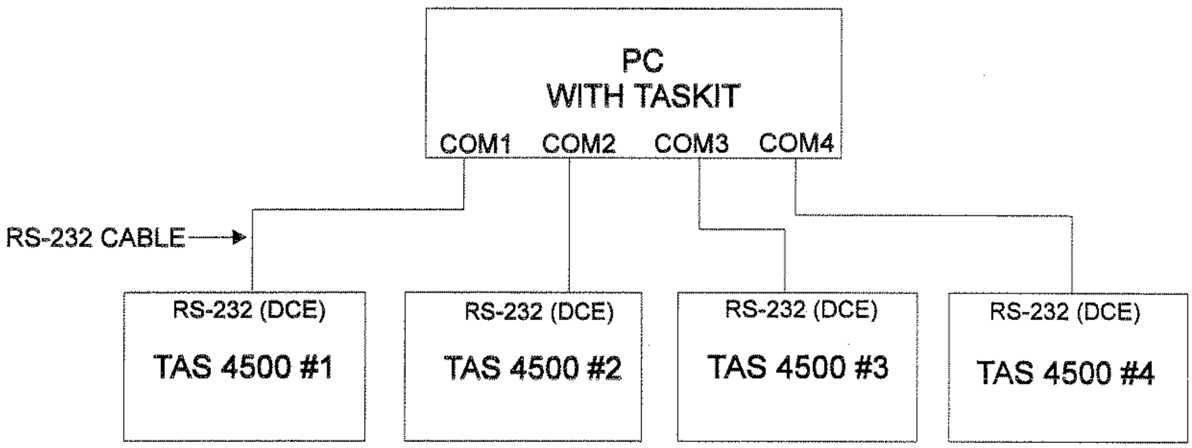

Figure 1-10. 8 Branch Diversity Test System Control Setup with 4 COM Ports

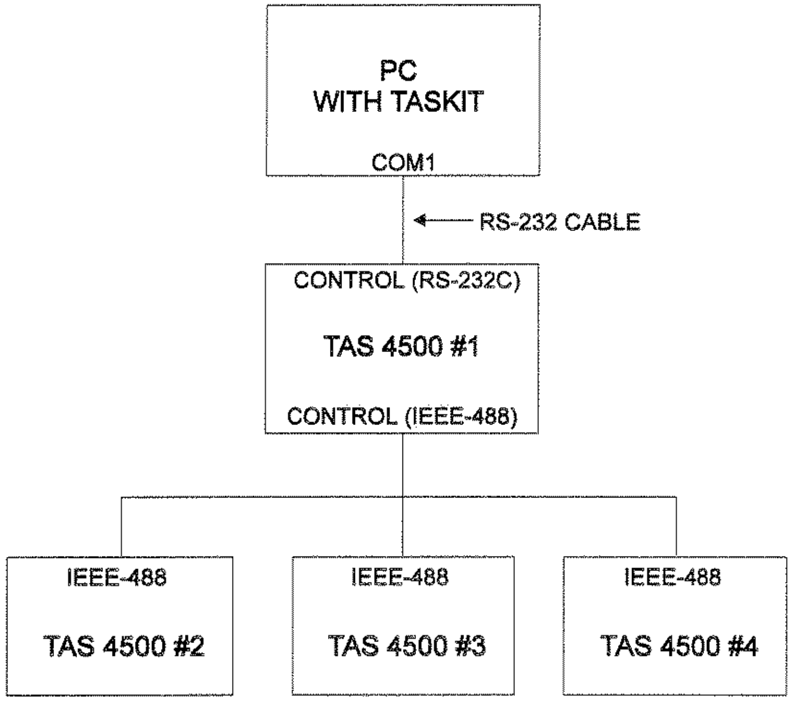

Figure 1-11. 8 Branch Diversity Test System Control Setup with a IEEE-488 control

The following is a list of helpful tips that should be considered when using TASKIT/4500 to control the TAS 4500 8 Branch Diversity Test System.

1. Four instances of TASKIT must be executed. The remote protocol configuration for the instruments must be setup to match the selections in the COMMUNICATIONS OPTIONS menu of each instance of TASKIT. The remote protocol is configured from the CONFIG menu on the front panel of 4500.

Typical selections for the control setup for each TAS 4500 shown in Figure 1-10 are as follows:

INSTRUMENT	PROTOCOL	RS-232 DATA FORMAT
TAS 4500 # 1-4	RS-232 CR/LF (carriage return/line feed)	4800 bits/sec 7 bit data, odd parity 1 stop bit

Typical selection for the control setup for each TAS 4500 shown in Figure 1-11 are as follows:

INSTRUMENT	PROTOCOL	GPIB ADDRESS	RS-232 DATA FORMAT
TAS 4500 #1	RS-232 CR/LF (carriage return/line feed)	-	4800 bits/sec 7 bit data, odd parity 1 stop bit
TAS 4500 #2	GPIB	05	-
TAS 4500 #3	GPIB	06	-
TAS 4500 #4	GPIB	07	-

2. Each instrument must be in remote control mode to allow control by the TASKIT software. Verify that the remote LED located at the lower right-hand corner of the front panel is on, thus indicating that the unit is in remote operation. If the unit is not in remote mode press the remote button to light the remote LED.

3. Refer to Section 3.5. for more information on correlation.

Selection of the Channel Correlation Type Parameter

The TAS 4500 can be controlled from the front panel or the remote control interface in an 8 branch diversity application. It is required that the CHANNEL CORR (CNFG:CHCORR) parameter be set as follows:

INSTRUMENT	CHANNEL CORRELATION
1st 4500	TYPE2
2nd 4500	TYPE3
3rd 4500	TYPE4
4th 4500	TYPE5

See section 2.4. of this manual for more information on the selection of the channel correlation type from the front panel.

1.4. Feature Release History

The following information provides a summary of the feature releases of the 4500 that have occurred since the initial Version 1.00 release.

Version 1.10

- Implementation of the "Path Model" parameter was changed to eliminate the requirement for the primary and secondary 4500 units, that form a 4 channel 12 path configuration, to directly communicate with each other. As a result the rear panel AUX port (9 pin D-sub connector) is no longer used. No menus or remote commands were added or changed.

Version 1.11

- Implementation of path delay was changed to correct the intermittent improper operation at a delay setting of 70 nsec. No menus or remote commands were added or changed.

Version 2.00

- Support of the 4500 FLEX was added including a new, more flexible RF front end, additional internal local oscillators, and 6 MHz bandwidth.
- GSM Rician fading was added to the available selections for modulation type on path 1 only.
- The capability to edit the modulation parameters (including the effective velocity) without causing the path to be momentarily disabled was added.

Version 2.10

- A wideband 15 MHz channel option was made available with 1 nsec relative delay resolution over a range of 100μs.
- The Channel Paths Correlation (CNFG:CPCORR) parameter was eliminated from the menus and remote command set. Paths within a channel will always be uncorrelated.
- The Path Model parameter (MODEL) was replaced in the menus and remote command set (CNFG:PMODL) with the Channel Correlation parameter (CHANNEL CORR) parameter and remote command (CNFG:CHCORR).
- The Configuration Options (CNFG:OPT) parameter was eliminated from the remote command set. It has been superseded by the Configuration System (CNFG:SYS) parameter which offers a superset of the information previously reported by the Configuration Options parameter.
- Two new factory installed options are now available that add support for 4 branch diversity and/or 8 branch diversity test applications. The 4 branch

diversity feature provides comprehensive control of the correlation factor (coefficient) between paths in up to four channels (branches). This test configuration uses two 4500 units (a primary unit provides channels 1 and 2, while a secondary unit provides channel 3 and 4) along with TASKIT/4500 Diversity software to provide up to six programmable correlation coefficients. An 8 branch diversity test setup requires four 4500 units to provide 8 independent (uncorrelated) channels of Rayleigh modulation. Programmable correlation is restricted for an 8 branch configuration and is available only between the channels within a 4500 unit. The correlation between pairs that span more than one 4500 unit cannot be programmed but are nominally uncorrelated to each other.

Version 2.20

- The Correlation Algorithm parameter was added in the system configuration menu (CONFIG\SYSTEM) and remote command set (CNFG:CORRAL). The path correlation can now be programmed as Envelope or as Component. Envelope correlation is between the envelope of the Rayleigh faded signals at the output of the associated channels. While Component defines the correlation between the In-Phase components of the associated Rayleigh faded signals in addition to the correlation between the Quadarature components.

Version 2.21

- The method used to decorrelate Channel 1 Path 1 and Channel 2 Path 4 from each other was modified. The new method correspond to that used to decorrelate all other paths.

Version 3.00

- The capability to accommodate up to 12 independent transmission paths in a single TAS 4500 was added.
- A wideband 15 MHz channel option was made available with 1 nsec relative delay resolution over a range of 100μs.
- A PCMCIA System Software Interface was added to facilitate firmware upgrades to the TAS 4500 while in the field.
- The ability to select between two different Rayleigh power spectrum shapes was added.
- The syntax of the remote commands pertaining to the Path parameters was modified.
- The Channel Paths Correlation (CNFG:CPCORR) parameter was eliminated from the menus and remote command set. Paths within a channel will always be uncorrelated.

- The Configuration Options (CNFG:OPT) parameter was eliminated from the remote command set. It has been superseded by the Configuration System (CNFG:SYS) parameter which offers a superset of the information previously reported by the Configuration Options parameter.
- The Delay Units Parameter (CNFG:DLYU) was eliminated from the front panel menus. The units will always be µsec.
- The Path Model parameter (MODEL) was replaced in the menus and remote commands set (CNFG:PMODL) with the Channel Correlation parameter (CHANNEL CORR) and remote command (CNFG:CHCORR).

Version 3.10

- The 4 Branch Diversity and 8 Branch Diversity test setups can now support 6 paths per branch.
- A 200 to 400 MHz LO option was added to support carrier frequencies of 60 to 260 MHz and 340 to 540 MHz.
- Type 2 Output Attenuator was made available. The Type 2 output attenuator supports a 0 to 80.0 dB attenuation range in 0.5 dB step size over a frequency range of 25 MHz to 2500 MHz.
- Rayleigh Fading with Frequency Shift was added to the available selections for modulation type on TAS 4500 units that are equipped with a Type 3 or later DSP module.
- The Correlation Algorithm parameter was added in the system configuration menu (CONFIG\SYSTEM) and remote command set (CNFG:CORRAL). The path correlation can now be programmed as Envelope or as Component. Envelope correlation is between the envelope of the Rayleigh faded signals at the output of the associated channels. While Component defines the correlation between the In-Phase components of the associated Rayleigh faded signals in addition to the correlation between the Quadrature components.

Version 3.11

- The method used to decorrelate Channel 1 Path 1 and Channel 2 Path 1 from each other was modified. The new method correspond to that used to decorrelate all other paths.

Version 4.00

- The Emulation Mode parameter was added to the remote command set (CNFG:EMULM). MODE1 is the static mode, while MODE2 is a dynamic mode. MODE2 allows the Dynamic Parameter Emulation Mode available through TASKIT.

- To support the MODE2 emulation mode the PATHS remote command set was added. This command set supports changes that effect all paths within one TAS 4500.
- The following remote commands were created to support dynamic emulation mode: PATHS:D, HALT, LOOP, RANGE, RUN, STEP, S and CHi_Pj:D.
- A user selectable Fading Repetition Rate was added to the system configuration menu (CONFIG\SYSTEM) and remote command set (PATHS:FADREP). Three nominal rates are available, 20 minutes, 27 seconds and 24 hours.
- A user selectable Fading Emulation Method was added to the system configuration menu (CONFIG\SYSTEM) and remote command set (CONFIG:FADEM). Two fading emulation methods are available; Jakes and filtered noise.
- A user selectable Fading Power Spectrum was added to the channel\path\modulation menu. Four spectrums are available when in filtered noise emulation method: classical 6 dB, flat, classical 3 dB and rounded. Two spectrums are available when in Jakes emulation method: classical 6 dB and flat.
- An optional Extended Relative Path Delay feature is now available. The maximum delay range is now 1.6 ms for a 6 MHz bandwidth IF module and 0.8 ms for a 15 MHz bandwidth IF module.
- External from 4500 setting was added to the LO Mode menu. This new setting is used when an LO signal from another 4500 channel is being used to drive the set channel.

Version 4.10

- Nakagami Fading, with programmable M value and angle of arrival, and Rician Fading, with programmable K factor and LOS arrival angle, were added to the available selections for modulation type on TAS 4500 units that are equipped with a Type 5 or later DSP module.
- The RF Carrier Range was expanded to cover carrier frequencies ranging from 25 MHz to 3.0 GHz while providing more consistent RF output levels and insertion loss through the TAS 4500.
- A 940 to 2860 MHz LO option was added to support the carrier frequency range of 800 MHz to 3.0 GHz. This option supersedes the LO1 and LO2 options.
- A Type 3 Output Attenuator will support 0 to 95.5 dB of attenuation in 0.5 dB steps while covering the entire RF Carrier Range of 25 MHz to 3.0 GHz. Note that the attenuator is specified over the range of 25 MHz to 2.7 GHz.

- The resolution of the programmable correlation for 2, 4, and 8 Branch Diversity applications has increased from 1 digit to 2 digits. This requires the use of the new ECORR command.
- New calibration capability has been added to improve the performance of the Input Reference Level and Peak Measurement functions across the entire RF Carrier Range. The range of the Input Reference Level for both 15 MHz and 6 MHz systems has been adjusted to a standard +5 to -30 dB range
- A new option has been added to the system configuration menu (CONFIG\SYSTEM) and remote command set (CNFG:REF) to allow user selection of either an internal or external 10 MHz reference for the signal processing modules in the TAS 4500.
- Dynamic Parameter Emulation Mode (MODE2) and the associated PATHS: D, RANGE, S and CHi_Pj:D remote commands were amended to provide up to 512 programmable states through the associated TASKIT control interface and to allow the use of Nakagami and Rician Fading within MODE2.
- An Insertion Loss Estimation Feature is added and is only available through the TASKIT control interface.
- A Filter Bypass (FLEX4-FBP) option was added. This extends the frequency range of operation to 25-3000 MHz when purchasing the Enhanced Front End option. Below 800 MHz the enhanced feed-through suppression is automatically bypassed..

Version 4.20

- A 26 MHz IF bandwidth option was added. This includes support for a 26 MHz RF module and an EFX-26 enhanced RF front end option.

Version 4.30

- An RF Channel Bypass(FLEX4-CBP) option was added. This permits the bypass of both the RF Front End and the IF signal processing circuitry of the TAS 4500. When used in this mode, the unit will pass RF IN directly to RF OUT with minimal insertion loss.
- Added the ability to put the TAS 4500 into REMOTE operation over the GPIB control interface

2.0. LOCAL OPERATION

2.1. Overview

The TAS 4500 RF Channel Emulator can be operated either locally from the instrument's front panel, or remotely using either the instrument's RS-232 or GPIB control interfaces. For remote control, a computer or terminal is required to pass commands to the TAS 4500. Remote operation proves to be most effective when you need to perform automatic or repeated test scripts.

This section of the manual will describe the local operation of the TAS 4500. Section 4.0. "Remote Operation" describes the TAS 4500's remote command protocols and commands.

A Remote Operation Mode LED indicates the current mode of operation. The LED is located on the lower right-hand corner of the TAS 4500's front panel, and is accompanied by a **REMOTE** operation mode key. This key toggles the mode of operation from local to remote. When lit, the LED indicates that the TAS 4500 is in remote mode. When operating the TAS 4500 from the front panel, be sure the Remote LED is off, thus indicating the unit is in Local Operation Mode.

2.2. Getting Started

This section explains step by step how to perform local control of some of the basic features of the TAS 4500. It is intended to familiarize the user with the local control through two examples. For more information on each menu and control key, refer to Section 2.3. "Menu Overview".

The first example guides the user through a series of simple local control operations to perform a parameter file recall. The second example shows the user how to change certain system parameters and then how to save the parameter configuration as a user defined file for later use.

2.2.1. Recalling Predefined Test Configurations

The TAS 4500 provides a set of predefined test configurations for many industry standards such as IS-54 (TDMA), IS-95 (CDMA), and GSM. These configurations are stored in ROM and can be recalled as often as needed. For detailed information on these files see Section 8.1 "Standard Test Profiles".

A predefined factory default file can be recalled. The default file sets the following parameters:

Default Values												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	**1**						**2**					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	900.00						900.00					
RF Channel	enabled						enabled					
Path	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Status	on	off	off	off	off	off	on	off	off	off	off	off
Relative Delay (µs)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Modulation Type	none	none	none	none	none	none	none	none	none	none	none	none
Doppler Freq. (Hz)	41.7	41.7	41.7	41.7	41.7	41.7	41.7	41.7	41.7	41.7	41.7	41.7
Velocity (km/h)	50	50	50	50	50	50	50	50	50	50	50	50
Fading Power Spectrum	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*
Phase Shift (deg)	0	0	0	0	0	0	0	0	0	0	0	0
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Relative Loss (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal STD (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	0	0	0	0

* Fading Power Spectrum = Classical (6dB)

By recalling any one of the predefined parameter configurations, the TAS 4500 can be configured for testing within seconds. Wireless communication devices can then be tested according to these specified standards. These predefined configurations can be easily recalled from the front panel by following the steps described below:

1. Select the File Recall menu by first pressing the **File Menu Tree** key on the front panel. The File Recall submenu selection will appear on the right hand side of the front panel display as shown below:

```
FILE
File Save↵              File Recall↵
```

2. Move the blinking cursor to the File Recall submenu selection by pressing the **Menu Navigation Right Arrow** key. Once on this field, press the **Enter** key to descend into the submenu shown below:

```
RECALL FILE: file0↵
Press Enter to recall file
```

3. Change the configuration file parameter to the desired selection ("IS55-56_1" in this example) using the **Value +** or **Value -** key. You can experiment with changing the parameter value using these keys before proceeding to the next step. Here "IS55-56_1" is chosen as the desired parameter configuration file.

```
RECALL FILE: IS55-56_1↵
Press Enter to recall file
```

4. Execute the recall by pressing the **Enter** key. The front panel will display:

```
RECALL FILE: IS55-56_1↵
Recalling setup...
```

Then:

```
RECALL FILE: IS55-56_1↵
Setup recalled - Esc to continue
```

Indicating a successful configuration recall from the IS55-56_1 file.

If the TAS 4500 had not been equipped with the necessary hardware required for the desired configuration the following message would have been displayed:

```
RECALL FILE: IS55-56_1↵
Insufficient hardware configuration<ESC>
```

5. Press the **Escape** key to return to the File Recall menu:

```
FILE
File Save↵          File Recall↵
```

The TAS 4500 is now configured with the TAS defined IS55-56_1 parameter values.

2.2.2. Defining and Saving Custom Test Configurations

In addition to predefined parameter configuration files, the TAS 4500 can save up to five (file 0 to file 4) user defined configurations. These user defined (SAVE) configuration files can also be recalled in the same manner as described in Section 2.2.1, "Recalling Predefined Test Setups".

Defining a custom test setup can easily be done by first recalling the predefined configuration that is most similar to the desired setup, and then modifying those parameters that are different from the desired configuration.

After all the modifications have been made, the existing setup can be saved to one of the user files: file0, file1, file2, file3, or file4. This modified setup can then be recalled as described in Section 2.2.1.

> **WARNING:** Any previous configuration in the user-defined file will be overwritten by the existing setup upon a save operation to the file.
> The following is an example of defining and saving a user defined parameter configuration that is based on the factory default configuration:

1. Recall the "**default**" configuration using the method described in the previous section, "Recalling Predefined Test Configurations."

2. Select the Channel 1 Path Status Menu by first pressing the **Channel 1 Menu Tree** key and then using **Menu Navigation Up** and **Down Arrow** keys to arrive at the menu shown below. Once this menu is displayed, use the **Menu Navigation Right** and **Left Arrow** keys to position the blinking cursor on the Path 2 status field.

```
CHANNEL1                                         ⇕
PATH 1:on↵      PATH 2:off      PATH 3:off
```

3. Change the Path 2 status parameter to **on** by pressing the **Value +** key:

```
CHANNEL1                                         ⇕
PATH 1:on↵      PATH 2:on↵      PATH 3:off
```

4. Once the status parameter is changed to on, the Path 2 Characteristics Submenu can be accessed by pressing the **Enter** key. The top line of this submenu is shown below:

```
CHANNEL1\PATH2                                   ⇩
DELAY:_    0.000µs       MODULATION:none
```

5. Change the value of the Path 2 Delay from 0.000 μsec to 10.000 μsec as follows:

First, using the **Cursor Navigation Left Arrow** key position the blinking cursor on the Path 2 Delay parameter's tens digit as shown below. Then use the **Value +** key to change the value of this digit from a 0 to a 1. The Path 2 Delay will now be set to 10.000 μsec as shown in the following display:

```
CHANNEL1\PATH2                                ⇩
DELAY:  10.000µs      MODULATION:none
```

Practice changing the Path 2 Delay parameter to other values using the Cursor Navigation keys and the Value keys before moving on to the next step.

6. To save this new custom configuration to a user file, first select the File Save menu by pressing the **FILE Menu Tree** key. The File Save submenu selection will appear on the left hand side of the display as shown below:

```
FILE
File Save↵            File Recall↵
```

7. If this field is not already selected, move the blinking cursor to the File Save submenu using the **Menu Navigation Left** and **Right Arrow** keys. Once this field is selected, press the **Enter** key to descend into the submenu shown below:

```
SAVE FILE: file0↵
Press Enter to save file
```

8. Select the user file that you want to save the current configuration to by using the **Value +** or **Value -** key. Remember that the previous configuration of the file will be overwritten. For this example, this configuration will be saved to file 1:

```
SAVE FILE: file1↵
Press Enter to save file
```

9. Execute the save operation by pressing the **Enter** key. The front panel will now display:

```

Setup saved - Esc to continue
```

10. Press the **Escape** key again to return to the File menu:

```
FILE
File Save↵            File Recall↵
```

This custom parameter configuration is now saved to file 1 and can be recalled in the same manner as any other predefined configuration. The parameters saved to a user-defined file, and which can subsequently be recalled are listed below:

Systems Configuration:
- Velocity Units
- Emulation Method
- Nominal Fading Repetition
- Correlation Algorithm
- 10 MHz Reference

Channel 1 & 2:
- Carrier Frequency
- LO Status
- LO Frequency
- Input Reference Level
- Output Attenuator
- RF Channel Status

Channel 1 & 2 Paths 1-6:
- Status
- Delay
- Loss
- Modulation
- Doppler Frequency
- Velocity
- Fading Power Spectrum
- Phase Shift
- Shift Frequency
- Log-Normal Status
- Log-Normal Standard Deviation
- Log-Normal Rate
- Path Correlation (Channel 2 only)

WARNING: The following parameters are not saved as part of a user-defined file:
- Remote Protocol Parameters
- Channel Correlation Type

2.3. Menu Overview

The TAS 4500 provides a convenient and easy to use hierarchical menu structure that gives easy access to all of its functions. This section will give you instructions on navigating through the TAS 4500 menu structure using the keys on the front panel. You will also find specific information about the different menus which appear in the TAS 4500 LCD display.

2.3.1. Menu Summary

There are five menu tree groups in the TAS 4500; CHANNEL 1, CHANNEL 2, MEASURE, CONFIG, and FILE. Each of these menus is represented by a key and active menu indicator LED on the instrument's front panel. For example, to access the CONFIG menu tree, press the CONFIG key. The indicator LED next to the key will light to indicate the current menu group. These menu trees organize the TAS 4500's functionality so that you can find the instrument's features easily. Once you become familiar with the TAS 4500's menu structure, you will find it easy to use.

CHANNEL 1 Main Menu

The **CHANNEL 1** menu group controls the simulated unidirectional RF channel that consists of either three or six independently programmable transmission paths. This menu group allows I/O parameters such as carrier frequency, LO frequency, and input reference level, as well as RF channel parameters such as the number of paths in the channel model, relative path delay, fast and slow fading, frequency shift, phase shift, and relative path attenuation to be viewed and controlled. The menu screens contained in the Channel 1 menu group are shown below. Note that the RF Channel bypass menu will only be visible if the TAS 4500 has been equipped with this option (FLEX4-CBP).

```
CHANNEL1                           [ENABLED]    ⇩
RF CHANNEL:bypassed↵    (Enter To Select)
```

```
CHANNEL1                                        ⇩
CARRIER: 900.000MHz  LO:internal manual↵
```

```
CHANNEL1
⇳INPUT REFERENCE LEVEL:-10.0dBm
```

```
CHANNEL1
⇳OUTPUT ATTENUATOR:  0.0 dB
```

```
CHANNEL1                                        ⇕
PATH 1:on↵      PATH 2:on↵      PATH 3:on↵
```

```
CHANNEL1                                        ⇧
PATH 4:on↵      PATH 5:on↵      PATH 6:on↵
```

CHANNEL1\LO Submenu

```
CHANNEL1\LO
LO FREQ:1040.0MHz
```

CHANNEL1\PATH1 Submenu

(Paths 2-6 submenus not shown, as they are identical to Path 1)

```
CHANNEL1\PATH1                                  ⇩
DELAY: 125.110µs      MODULATION:rayleigh↵
```

```
CHANNEL1\PATH1                                  ⇧
LOSS:25.0dB                  LOG NORMAL:on↵
```

CHANNEL1\PATH1\RAYLEIGH Submenu

```
CHANNEL1\PATH1\RAYLEIGH                         ⇩
VELOCITY:     60.0ft/s    DOPPLER:  54.9Hz
```

```
CHANNEL1\PATH1\RAYLEIGH                         ⇧
FADING POWER SPECTRUM: classical (6 dB)
```

CHANNEL1\PATH1\FREQUENCY SHIFT Submenu

```
CHANNEL1\PATH1\FREQ SHIFT
VELOCITY:     60.0ft/s    DOPPLER:  54.9Hz
```

CHANNEL1\PATH1\PHASE Submenu

```
CHANNEL1\PATH1\PHASE
ANGLE:   5.0deg
```

CHANNEL1\PATH1\GSM_RICIAN Submenu

```
CHANNEL1\PATH1\GSM_RICIAN                    ⇩
VELOCITY:     60.0ft/s   DOPPLER:   54.9Hz
```

```
CHANNEL1\PATH1\GSM_RICIAN                    ⇧
FADING POWER SPECTRUM: classical (6 dB)
```

CHANNEL1\PATH1\RICIAN Submenu

```
CHANNEL1\PATH1\RICIAN                        ⇩
VELOCITY:     60.0ft/s   DOPPLER:   54.9Hz
```

```
CHANNEL1\PATH1\RICIAN                        ⇳
LOS ARRIVAL ANGLE: 45.0deg [100.0Hz]
```

```
CHANNEL1\PATH1\RICIAN                        ⇳
K FACTOR: 12.0dB
```

```
CHANNEL1\PATH1\RICIAN                        ⇧
FADING POWER SPECTRUM: classical (6 dB)
```

CHANNEL1\PATH1\NAKAGAMI Submenu

```
CHANNEL1\PATH1\NAKAGAMI                      ⇩
VELOCITY:     60.0ft/s   DOPPLER:   54.9Hz
```

```
CHANNEL1\PATH1\NAKAGAMI                      ⇳
ANGLE OF ARRIVAL: 45.0deg [100.0Hz]
```

```
CHANNEL1\PATH1\NAKAGAMI                      ⇳
M VALUE: 25
```

```
CHANNEL1\PATH1\NAKAGAMI                      ⇧
FADING POWER SPECTRUM: classical (6 dB)
```

CHANNEL1\PATH1\RAYLEIGH WITH FREQUENCY SHIFT Submenu

NOTE: Menu present only when Emulation Method = Jakes

```
CHANNEL1\PATH1\RAYLEIGH WITH FREQ SHIFT⇩
VELOCITY:    60.0ft/s   DOPPLER:  54.9Hz
```

```
CHANNEL1\PATH1\RAYLEIGH WITH FREQ SHIFT⇳
SHIFT FREQ:  24.9Hz
```

```
CHANNEL1\PATH1\RAYLEIGH WITH FREQ SHIFT⇧
FADING POWER SPECTRUM: classical (6 dB)
```

CHANNEL1\PATH1\ LOG NORMAL Submenu

```
CHANNEL1\PATH1\LOG NORMAL
LOG NORMAL RATE:10.105Hz          STD: 0dB
```

CHANNEL 2 Main Menu

The **CHANNEL 2** menu group controls the simulated unidirectional RF channel that consists of either three or six independently programmable transmission paths for TAS 4500's equipped with two RF channels. This menu group allows I/O parameters such as carrier frequency, LO frequency, and input reference level, as well as RF channel parameters such as the number of paths in the channel model, relative path delay, fast and slow fading, frequency shift, phase shift, and relative path attenuation to be viewed and controlled. The menu screens contained in the Channel 2 menu group are shown below. Note that the RF Channel bypass menu will only be visible if the TAS 4500 has been equipped with this option (FLEX4-CBP).

```
CHANNEL2                       [ENABLED]   ⇩
RF CHANNEL:bypassed↵    (Enter To Select)
```

```
CHANNEL2                                   ⇩
CARRIER: 900.000MHz  LO:internal manual↵
```

```
CHANNEL2
⇳INPUT REFERENCE LEVEL: -10.0dBm
```

```
CHANNEL2
⇳OUTPUT ATTENUATOR: 0dB
```

```
CHANNEL2                                         ⇕
PATH 1:on↵       PATH 2:on↵       PATH 3:on↵
```

```
CHANNEL2                                         ⇧
PATH 4:on↵       PATH 5:on↵       PATH 6:on↵
```

CHANNEL2\LO Submenu

```
CHANNEL2\LO
LO FREQ:1040.0MHz
```

CHANNEL2\PATH1 Submenu

(Paths 2-6 submenus not shown, as they are identical to Path 1)

```
CHANNEL2\PATH1                                   ⇩
DELAY: 125.110µs      MODULATION:phase↵
```

```
CHANNEL2\PATH1                                   ⇧
LOSS:25.0dB                LOG NORMAL:on↵
```

CHANNEL2\PATH1\RAYLEIGH Submenu

```
CHANNEL2\PATH1\RAYLEIGH                          ⇩
VELOCITY:     60.0ft/s    DOPPLER:   54.9Hz
```

```
CHANNEL2\PATH1\RAYLEIGH                          ⇕
CH1-CH2 PATH 1 CORRELATION: 0.52
```

```
CHANNEL2\PATH1\RAYLEIGH                          ⇧
FADING POWER SPECTRUM: classical (6 dB)
```

CHANNEL2\PATH1\FREQUENCY SHIFT Submenu

```
CHANNEL2\PATH1\FREQ SHIFT
VELOCITY:     60.0ft/s    DOPPLER:   54.9Hz
```

CHANNEL2\PATH1\PHASE Submenu

```
CHANNEL2\PATH1\PHASE
ANGLE:  5.0deg
```

CHANNEL2\PATH1\RICIAN Submenu

```
CHANNEL2\PATH1\RICIAN                         ⇩
VELOCITY:     60.0ft/s   DOPPLER:   54.9Hz
```

```
CHANNEL2\PATH1\RICIAN                         ⇳
LOS ARRIVAL ANGLE: 45.0deg [100.0Hz]
```

```
CHANNEL2\PATH1\RICIAN                         ⇳
K FACTOR: 12.0dB
```

```
CHANNEL2\PATH1\RICIAN                         ⇧
FADING POWER SPECTRUM: classical (6 dB)
```

CHANNEL2\PATH1\NAKAGAMI Submenu

```
CHANNEL2\PATH1\NAKAGAMI                       ⇩
VELOCITY:     60.0ft/s   DOPPLER:   54.9Hz
```

```
CHANNEL2\PATH1\NAKAGAMI                       ⇳
ANGLE OF ARRIVAL: 45.0deg [100.0Hz]
```

```
CHANNEL2\PATH1\NAKAGAMI                       ⇳
M VALUE: 25
```

```
CHANNEL2\PATH1\NAKAGAMI                       ⇧
FADING POWER SPECTRUM: classical (6 dB)
```

CHANNEL2\PATH1\RAYLEIGH WITH FREQUENCY SHIFT Submenu

NOTE: Menu present only when Emulation Method = Jakes

```
CHANNEL2\PATH1\RAYLEIGH WITH FREQ SHIFT⇩
VELOCITY:     60.0ft/s   DOPPLER:   54.9Hz
```

```
CHANNEL2\PATH1\RAYLEIGH WITH FREQ SHIFT⇳
SHIFT FREQ:   24.9Hz
```

```
CHANNEL2\PATH1\RAYLEIGH WITH FREQ SHIFT⇧
FADING POWER SPECTRUM: classical (6 dB)
```

CHANNEL2\PATH1\ LOG NORMAL Submenu

```
CHANNEL2\PATH1\LOG NORMAL
LOG NORMAL RATE:10.105Hz          STD: 0dB
```

MEASURE Main Menu

The **MEASURE** menu group controls the instrument's measurement function. The measure menu allows the measurement of peak signal levels. The measure menu group is as follows:

```
Press Enter to update measurement
SOURCE:ch1 input↵   PEAK LEVEL=- - - . - dBm
```

CONFIG Main Menu

The **CONFIG** menu group allows the configuration of the remote control interface, displays the instrument's software version and diagnostic status, and selects the unit's that the characteristics will be displayed in the path submenus. The CONFIG menu group arrangement is as follows:

```
CONFIG                                    ⇩
Remote Protocol↵    Units↵      System↵
```

```
CONFIG                                    ⇧
Summary↵    Display↵
```

CONFIG\REMOTE PROTOCOL Submenu

```
CONFIG\REMOTE PROTOCOL
PROTOCOL: crlf↵
```

CONFIG\REMOTE PROTOCOL\CRLF Submenu

```
CONFIG\REMOTE PROTOCOL\CRLF               ⇩
BAUD RATE: 1200
```

```
CONFIG\REMOTE PROTOCOL\CRLF               ⇧
DATA: 7       PARITY: odd       STOP: 1
```

CONFIG\REMOTE PROTOCOL\ACKNAK Submenu

```
CONFIG\REMOTE PROTOCOL\ACKNAK                  ⇩
BAUD RATE: 4800      ADDRESS: 11
```

```
CONFIG\REMOTE PROTOCOL\ACKNAK                  ⇧
DATA: 7        PARITY: odd       STOP: 1
```

CONFIG\REMOTE PROTOCOL\GPIB Submenu

```
CONFIG\REMOTE PROTOCOL\GPIB
ADDRESS:  30
```

CONFIG\UNITS Submenu

```
CONFIG\UNITS
VELOCITY UNITS:ft/S
```

CONFIG\SYSTEM Submenu

```
CONFIG\SYSTEM               [ TYPE1 ]         ⇩
CHANNEL CORR:type1↵        (ENTER TO SELECT)
```

```
CONFIG\SYSTEM                                 ⇳
EMULATION METHOD: jakes
```

```
CONFIG\SYSTEM                                 ⇳
CORRELATION ALGORITHM: envelope
```

```
CONFIG\SYSTEM                                 ⇧
10MHz REFERENCE: internal
```

CONFIG\SYSTEM\FILTERED NOISE Submenu

```
CONFIG\SYSTEM\FILTERED NOISE
NOMINAL FADING REPETITION RATE: 20 min
```

CONFIG\SUMMARY Submenu

```
CONFIG\SUMMARY                                 ⇩
STATUS:ok   FW VER:4.10    DSP VER:4.10       _
```

```
CONFIG\SUMMARY                                 ⇳
RF RANGE CH1:  25-3000 CH2:  25-3000 MHz_
```

```
CONFIG\SUMMARY                                 ⇳
RF ATTEN CH1: 95.5/0.5dB CH2: 80/0.1dB           _
```

```
CONFIG\SUMMARY                                 ⇳
RF FILTER CH1:INSTALLED CH2:INSTALLED          _
```

```
CONFIG\SUMMARY                                 ⇳
LO CH1: 800-1100MHz  CH2:1800-2500MHz          _
```

```
CONFIG\SUMMARY                                 ⇳
IF BANDWIDTH:15MHz DELAY: 100µsec/1nsec _
```

```
CONFIG\SUMMARY                                 ⇳
DYNAMIC EMULATION MODE: INSTALLED              _
```

```
CONFIG\SUMMARY                                 ⇧
ESYS:000000000121122222401245l662123           _
```

CONFIG\DISPLAY Submenu

```
CONFIG\DISPLAY
LCD CONTRAST: 3
```

FILE Main Menu

The **FILE** menu group allows you to load both user and TAS defined parameter profiles and to save user define parameter configurations. The FILE menu group is as follows.

```
FILE
File Save↵              File Recall↵
```

SAVE FILE Submenu

```
SAVE FILE: file1↵
Press Enter to save file
```

RECALL FILE Submenu

```
RECALL FILE: IS55-56_1↵
Press Enter to recall file
```

2.3.2. Control Key Summary

This section describes the set of keys used to navigate through the TAS 4500 menus.

Menu Group Select Keys
The menu tree select keys are: CHANNEL 1, CHANNEL 2, MEASURE, FILE and CONFIG. Pressing any one of these five keys will select that menu group and return to the menu screen previously displayed the last time this menu tree was active. By pressing a menu tree key for the currently selected submenu group, you can return back to the top of the menu tree.

To illustrate this function, when the CHANNEL 1 key is pressed while in one of the path submenus, as in the example below, you will exit the submenu and the front panel will display the path status screen:

Current screen...

```
CHANNEL1\PATH1\PHASE
ANGLE: _5.0deg
```

Press CHANNEL1 key...

```
CHANNEL1                                        ⇳
PATH 1:on↵      PATH 2:on↵      PATH 3:on↵
```

Menu trees are configured in a hierarchical nature, each with associated levels of submenus. To indicate a submenu is present, a carriage return symbol is displayed at the right side of a menu parameter. The top line of the LCD is used to display status information related to the current menu tree. The current menu path is displayed in the upper left corner of the LCD to facilitate menu navigation. Each time a submenu is entered, the name of the submenu is added to the current path.

A screen above/below prompt is also used to indicate the presence of additional screens above and/or below the current screen in the selected menu. This directional arrow character is displayed in the last position on the top line of the LCD.

Menu Navigation Up & Down Arrow Keys
To move between screens of the same menu, the Menu Navigation Up & Down Arrow keys are used. They are located together with the Menu Navigation Left & Right Arrow keys as a group under the left hand side of the front panel display.

For example, if the user is on the first screen of the Channel 1 menu, and the Menu Navigation Down Arrow key is pressed, the next (second) line of the Channel 1 menu will be displayed. In the example below, note how the screen above/below prompt changes to indicate that additional screens are now located above and below the second screen of the Channel 1 menu.

Current screen...

```
CHANNEL1                                    ⇩
CARRIER: 960.000MHz  LO:internal manual↵
```

Press Menu Navigation Down Arrow key...

```
CHANNEL1
⇳INPUT REFERENCE LEVEL:-10.0dBm
```

Menu Navigation Left & Right Arrow Keys
The Menu Navigation Left and Right Arrow Keys move the cursor between parameter fields of the same menu screen. They are located together with the Menu Navigation Up & Down Arrow keys as a group under the left hand side of the front panel display. The following example illustrates how to change the active field from DELAY to MODULATION:

Current field...

```
CHANNEL2\PATH1                              ⇩
DELAY: 125.110µs     MODULATION:phase↵
```

Press Menu Navigation Right Arrow key...

```
CHANNEL2\PATH1                              ⇩
DELAY: 125.110µs     MODULATION:phase↵
```

Enter & Escape Keys

The Enter and Escape keys have two main functions. Their first function is to allow entry and exit from submenus. When the blinking cursor is positioned under this carriage return symbol ↵, the associated submenu can be accessed by pressing the Enter key as in the example shown below:

Current screen...

```
CHANNEL1                                         ⇳
PATH 1:on↵     PATH 2:on↵     PATH 3:on↵
```

Press Enter key...

```
CHANNEL1\PATH1                                   ⇩
DELAY: 125.110µs     MODULATION:phase↵
```

Pressing the Escape key exits the submenu. An example is shown below.

Current screen...

```
CHANNEL1\PATH1                                   ⇩
DELAY: 125.110µs     MODULATION:phase↵
```

Press Escape key...

```
CHANNEL1                                         ⇳
PATH 1:on↵     PATH 2:on↵     PATH 3:on↵
```

The secondary function of the Enter and Escape keys is to execute instrument functions and clear errors. In screens that allow the user to execute a particular action, the display indicates the instrument function performed by pressing the Enter key as shown in the example below:

```
SAVE FILE: file1↵
Press Enter to save file
```

If an error occurs after executing an instrument function, the Escape key will clear the error screen. After being prompted of the error shown in the screen below, pressing the Escape key clears the error condition and returns control to the previous screen.

```
Error:Input Signal Out of Range
```

Cursor Left & Right Arrow Keys

The Cursor Left and Right Arrow Keys move the cursor between digits within a parameter field. The following example shows how to move from the hundred's to the ten's of nanoseconds digit:

Current digit...

```
CHANNEL2\PATH1                              ⇩
DELAY: 125.970µs      MODULATION:phase↵
```

Press Cursor Right Arrow key...

```
CHANNEL2\PATH1                              ⇩
DELAY: 125.970µs      MODULATION:phase↵
```

Value + & - Keys

The Value + and - keys are used to modify the value of the parameter field that is currently active. The Value + key increments the value of the field while the Value - key decrements the value of the field. An example is shown below:

Current value...

```
CHANNEL2\PATH1                              ⇩
DELAY: 125.970µs      MODULATION:phase↵
```

Press Value + key...

```
CHANNEL2\PATH1                              ⇩
DELAY: 125.980µs      MODULATION:phase↵
```

2.4. Setting System Configuration Parameters

This section contains information on system configuration parameters. It is assumed that the user is familiar with the basic local operations of the TAS 4500. If you are not familiar with the local control of the TAS 4500, please read Sections 2.2. "Getting Started" and 2.3. "Menu Overview" before referring to this section.

The menu location, definition and range of the system configuration parameters are listed in the following sections.

2.4.1. Selecting the Channel Correlation

The user can configure the TAS 4500 to be used in a standalone or dual-unit configuration by setting the CHANNEL CORRelation parameter in the CONFIG Menu Tree. A standalone TAS 4500 (TYPE1), equipped with two RF channels, can emulate up to six independent paths on each channel. For tests that require a greater number of channels or paths, two TAS 4500s can be used in conjunction to form a dual-unit configuration with up to 24 uncorrelated paths. In applications requiring two units, the user must configure one TAS 4500 as the primary instrument (TYPE2) and the other as the secondary instrument (TYPE3). Eight channel applications add a 3rd and 4th unit configured to TYPE4 and TYPE5 respectively.

The Value + and - keys are used to select the desired Channel Correlation and once the desired type is selected the Enter key is used to activate the selection. The status field on the top line of the display indicates the currently activated type.

```
CONFIG\SYSTEM                      [TYPE1]       ⇩
CHANNEL CORR: type1↵          (Enter to Select)
```

PATH MODEL

Definition
Sets the channel correlation of the TAS 4500.

Value Range
type1, type2, type3, type4, type5

2.4.2. Selecting the Fading Emulation Method

The user can select the method used to emulate multipath fading. In the Jakes method the I/Q modulation signals consist of a summation of individual tones. In the filtered noise method the I/Q modulation signals consist of a filtered noise spectrum. See the Section 3. Reference for a detailed description of these methods.

```
CONFIG\SYSTEM                                       ⇕
EMULATION METHOD: jakes
```

EMULATION METHOD

Definition
Selects the emulation method for multipath fading

Value Range
jakes, filtered noise

2.4.3. Selecting the Nominal Fading Repetition Rate

When the Emulation Method is set to filtered noise, the user can select between three rates at which the fading repeats. The fading repetition rate is fixed for the Jakes Emulation Method. The nominal time of the rates are 20 minutes, 27 seconds and 24 hours. The exact duration of the fading sequence depends on the specific Doppler frequency and can be calculated using the equations stated in Section 3. Reference.

```
CONFIG\SYSTEM\FILTERED NOISE
NOMINAL FADING REPETITION RATE: 20 min
```

NOMINAL FADING REPETITION RATE

Definition
Selects the nominal fading repetition rate for filtered noise multipath fading

Value Range
20 min, 27 sec, 24 hrs

2.4.4. Selecting the Correlation Algorithm

The user can select the correlation algorithm used to specify the correlation between Rayleigh faded paths. Envelope correlation is between the Rayleigh faded signals at the output of the associated channels. While component correlation defines the correlation between the In-Phase components of the associated Rayleigh faded signals in addition to the correlation between the Quadarature components.

```
CONFIG\SYSTEM                                   ⇧
CORRELATION ALGORITHM: envelope
```

CORRELATION ALGORITHM

Definition
Selects the correlation algorithm used for path correlation.

Value Range
envelope, component

2.4.5. Viewing the System Summary

The TAS 4500 Summary submenu in the CONFIG Menu Tree contains system status information such as the control processor and DSP processor firmware version, and current operating status. Information pertaining to which RF, LO and IF modules are present in the system is also given. The RF ATTEN submenu gives the RF attenuator range and resolution. The IF DELAY submenu gives the delay range and resolution. The ESYS command string is also reported. The ESYS command is described in Section 4. Remote Operation. The eight screens found in the Summary submenu are "read-only" and do not contain any user programmable parameters.

```
CONFIG\SUMMARY                                  ⇩
STATUS:ok   FW VER:4.30    DSP VER:4.10 _
```

```
CONFIG\SUMMARY                                  ⇳
RF RANGE CH1:  25-2500 CH2:  25-2500 MHz
```

```
CONFIG\SUMMARY                                  ⇳
RF ATTEN CH1: 95.5/0.5dB CH2: 80/0.1dB   _
```

```
CONFIG\SUMMARY                                  ⇳
RF FILTER CH1:INSTALLED CH2:INSTALLED  _
```

```
CONFIG\SUMMARY                                  ⇳
LO CH1: 800-1100MHz  CH2:1800-2500MHz  _
```

```
CONFIG\SUMMARY                                  ⇳
IF BANDWIDTH:15MHz DELAY: 100µsec/1nsec_
```

```
CONFIG\SUMMARY                                  ⇳
DYNAMIC EMULATION MODE: INSTALLED      _
```

```
CONFIG\SUMMARY                                  ⇧
ESYS:000000000121122222401245166212 3  _
```

2.4.6. Setting the Display Format for Vehicle Velocity Parameters

The user can specify the format that the vehicle velocity parameter is displayed in by configuring the Unit's parameter in the Units submenu found in the CONFIG Menu Tree.

NOTE: The Velocity Units parameter cannot be configured using remote commands.

The Velocity Units parameter indicates the format for the vehicle velocity parameter found in the Path submenus. The vehicle velocity parameter combined with the carrier frequency parameter sets the Doppler frequency for path characteristics such as Rayleigh fading.

```
CONFIG\UNITS
VELOCITY UNITS:ft/s
```

VELOCITY UNITS

Definition
Sets the format for displaying the vehicle velocity parameter.

Value Range
ft/s, mi/h, m/s, km/h

2.4.7. Setting the Contrast Parameter for the LCD Display

The user can vary the contrast of the LCD on the front panel of the TAS 4500 by adjusting the LCD CONTRAST parameter in the Display submenu of the CONFIG Menu Tree. Increasing the index for this parameter increases the amount of contrast.

```
CONFIG\DISPLAY                              ⇩
LCD CONTRAST: 3
```

LCD CONTRAST

Definition
Adjusts the amount of contrast for the LCD on the front panel of the TAS 4500.

Value Range
0-10

2.4.8. Selecting the 10 MHz Reference Source

The TAS 4500 requires a 10 MHz sinusoidal reference signal to synchronize the internal signal processing functions of the unit. The user can elect to use either the internally generated 10 MHz reference or to provide their own external source via the BNC connector labeled EXT REF I/O available on the rear panel (See Section 1.2.2 Rear Panel Description to locate BNC connector). This parameter must be set to match the chosen mode of operation. Refer to Section 7 Technical Specifications for the requirements on the external source.

```
CONFIG\SYSTEM                                ⇩
10MHz REFERENCE: internal
```

10MHz REFERENCE

Definition
Selects either internal or external 10 MHz reference source.

Value Range
INT, EXT

It is important to note that the external signal source must be connected to the TAS 4500 and must have the proper frequency and power settings prior to toggling this parameter. If the signal is not present or is detected to be out of the specified power or frequency range, the TAS 4500 will respond with the following message on the front panel:

```
E064 - External reference not detected
Returning to internal mode           [ESC]
```

Only when the signal present is determined to meet the specification will the unit proceed and allow for an external source to be used.

NOTE: The TAS 4500 generates a very high quality internal source, and it is not recommended that an external source be used unless the user has a specific reason for doing so.

2.5. Setting Channel I/O

This section contains information on setting channel I/O parameters. It is assumed that the user is familiar with the basic local operations of the TAS 4500. If you are not familiar with the local control of the TAS 4500, please read Sections 2.2. "Getting Started" and 2.3. "Menu Overview" before referring to this section.

The menu location, definition and range of the channel I/O parameters are listed in the following sections.

2.5.1. Setting Manual Input Reference Level

The user can manually adjust the gain applied to the RF signal present at the input of each RF channel by setting the Input Reference Level parameter found in the Channel 1 and Channel 2 Menu Trees. The input reference level is calibrated to the power level of a sine wave. The actual input reference level set will depend upon the RF frequency and signal waveform. The input reference level for each channel is configured independently and overrides any automatic range operation that had been previously performed.

A red OVERLOAD LED is associated with each RF channel and is located under the left hand side of the display. These two LEDs should be monitored to be sure the signal applied at the RF Channel input is within the specified range. When lit, the LED indicates the RF input signal has peak levels above the permitted range and will be clipped by the instruments input circuitry. If an overload condition occurs, the input reference level parameter should be increased and/or the input signal level should be reduced.

```
CHANNEL1
⇕INPUT REFERENCE LEVEL:-10.0dBm
```

```
CHANNEL2
⇕INPUT REFERENCE LEVEL:-10.0dBm
```

INPUT REFERENCE LEVEL

Definition
Sets the gain applied to the input of the selected RF Channel.

Value Range
5.0 to -30.0 dBm for both 6 MHz and 15 MHz bandwidth IF Module

Manual configuration of the Input Reference Level is recommended for applications with wideband or noise-like transmit signals. This will provide the most accurate and repeatable setting for the Input Reference Level parameter. The following procedure illustrates how to manually set the Input Reference Level parameter for the transmit signal present at either RF input of the TAS 4500.

1. Begin by setting the desired channel's Input Reference Level to its maximum value of +5.0 dBm.
2. Check the overload LED for the RF channel being configured. If the overload LED is already illuminated, the input level to the TAS 4500 is too high and must be lowered using an appropriate external attenuator.
3. Otherwise, monitor the overload LED and step the Input Reference Level down in 1 dB steps until the LED is illuminated.
4. If the minimum Input Reference Level of -30.0 dBm is reached before the LED becomes illuminated, the transmit signal level may be too low to optimize the dynamic range of the input level circuitry.

NOTE: Under many circumstances the TAS 4500 will continue to provide accurate emulation characteristics for signals less than the minimum Input Reference Level. However, it should be noted that for each dB that the input signal is less than the minimum Input Reference Level the optional dynamic range of the transmission channel will be reduced by an equal amount. To achieve the maximum dynamic range with very low transmit levels an external amplifier may be required.

5. After reaching the overload condition, step the Input Reference Level up by 3 dB. This creates approximately 3 dB headroom for the input circuitry of the TAS 4500 and helps to insure that the peaks of the transmit signal will not be clipped.

2.5.2. Performing Automatic Input Level Range

Two front panel RANGE keys, one for each RF channel, are dedicated to the automatic input level range function. They are located below the left side of the front panel display and each key has an associated red LED. When the TAS 4500 performs an automatic level range it adjusts the input signal peak level to maximize the dynamic range of the instrument. To perform an input level range, press the RANGE key that corresponds to the desired channel.

For example, if the Channel 1 RANGE key is pressed, the following message is displayed on the instrument's front panel.

```
Performing Channel 1 Auto Range...
```

If the autorange is successful, the corresponding Input Reference Level parameter is changed to reflect the amount of gain applied by the range algorithm. If the RF signal is out of range, the user is prompted with the following message.

```
Error:Input Signal Out of Range
```

2.5.3. Setting the Output Attenuator

The 4500 FLEX can be equipped with an optional RF output attenuator. This programmable attenuator can be used to precisely set the RF OUT level of the transmission channel. When this feature is present in the instrument, the menu shown below will be displayed.

```
CHANNEL1                                    ⇕
OUTPUT ATTENUATOR: 80.0 dB
```

```
CHANNEL2                                    ⇕
OUTPUT ATTENUATOR: 80.0 dB
```

OUTPUT ATTENUATOR (OPTIONAL)

Definition
Sets the amount of loss provided by an RF attenuator for the selected RF channel.

Value Range
0.0 to 80.0 dB, in 0.1 dB steps with 800 to 2500 MHz (Type 1) Attenuator

0.0 to 95.5 dB, in 0.5 dB steps with 25 to 3000 MHz (Type 3) Attenuator

2.5.4. Setting the RF Channel Bypass

The 4500 FLEX can be equipped with optional RF switches. These switches can be used to bypass the TAS 4500 RF Front End and IF Signal Processing components. When in bypass mode, the TAS 4500 passes RF IN directly to RF OUT avoiding the insertion loss inherent in the RF channel emulation path of the unit. When the bypass option is present in the instrument, the menu shown below will be displayed.

```
CHANNEL1                          [ENABLED]    ⇩
RF CHANNEL:bypassed↵    (Enter To Select)
```

```
CHANNEL2                          [ENABLED]    ⇩
RF CHANNEL:bypassed↵    (Enter To Select)
```

The RF CHANNEL parameter can be toggled between the enabled and bypassed options. However, the Enter key must be pressed in order for the Bypass mode to be changed in the instrument. The bracketed text in the upper right hand corner of the display indicates the current active state of the unit as either [BYPASSED] or [ENABLED]. The menus shown below indicate that the unit is currently in Bypassed mode:

```
CHANNEL1                          [BYPASSED]
RF CHANNEL:enabled↵    (Enter To Select)
```

```
CHANNEL2                          [BYPASSED]
RF CHANNEL:enabled↵    (Enter To Select)
```

The menu tree for the selected channel cannot be accessed while the RF Channel is bypassed. Pressing the Enter key with the enabled option visible as in the menus shown above will enable the Channel and allow access to the entire menu tree.

RF CHANNEL BYPASS (OPTIONAL)

Definition
Allows the TAS 4500 RF Channel to be either enabled or bypassed.

Value Range
bypassed, enabled

2.5.5. Setting the Carrier Frequency

The user must set the carrier frequency of the RF input signal for Channel 1 and Channel 2. The CARRIER parameter is used by the TAS 4500 in determining the Doppler frequency for path characteristics, and for setting the internal local oscillator frequency when the LO mode is set to "internal auto". For more details on the interdependence of the carrier frequency parameter and the local oscillator mode, refer to Section 2.5.6. "Setting the Local Oscillator Mode".

```
CHANNEL1                                         ⇩
CARRIER: 960.000MHz  LO:internal manual↲
```

```
CHANNEL2                                         ⇩
CARRIER: 960.000MHz  LO:internal manual↲
```

CARRIER

Definition
Sets the carrier frequency for the selected RF channel.

Value Range
Depends on the specific RF options installed. See technical specifications for details.

2.5.6. Setting the Local Oscillator Mode

The TAS 4500 requires a local oscillator (LO) to down convert the user's RF input signal to an IF signal. A LO input is provided for each channel on the front panel via N-type connectors. The LO source can be supplied by an optional internal LO or a user-supplied external RF synthesizer.

When equipped with an optional internal LO, the user must choose the applicable Local Oscillator Mode for Channel 1 and Channel 2. The LO Mode determines how the frequency of the LO will be configured. In "internal auto" mode, the LO will automatically configure itself to optimally track the CARRIER frequency parameter. Please note that setting the LO Mode to "internal auto" will restrict the available range of the carrier frequency to those supported by the internal LOs.

In "internal manual" mode, the LO frequency will be manually set in the LO submenu. Refer to Section 2.5.6 "Setting the Local Oscillator Frequency" for explicit details on manually setting the LO frequency.

If the LO mode is set to "external", the internal LO is switched off, and the TAS 4500 expects an external signal generator to be the source of the LO signal to allow the necessary down conversion of the RF signal. Refer to Section 7.0. Technical Specifications for the required LO frequency and level.

If the LO mode is set to "ext. from 4500", the internal LO is switched off. The TAS 4500 expects an external LO signal from another 4500 channel to be the source of the LO signal to allow the necessary down conversion of the RF signal. This setting is designed for applications where a single internal LO signal from the TAS 4500 is used to supply the LO signal for several channels. Verify, in Section 7.0. Technical Specifications, that the required LO level for each channel is being met.

```
CHANNEL1                                    ⇩
CARRIER: 960.000MHz  LO:internal manual↵
```

```
CHANNEL2                                    ⇩
CARRIER: 960.000MHz  LO:internal manual↵
```

LO

Definition
Sets the local oscillator mode.

Value Range
internal auto, internal manual, external, ext. from 4500

2.5.7. Setting the Local Oscillator Frequency

For most applications, the LO Mode is set to "internal auto" and the internal synthesizers are automatically programmed to provide the correct frequency required for the TAS 4500's up/down conversion of the RF input signal. But when the LO mode is set to "internal manual", the user must set the frequency of the on-board synthesizer using the LO FREQ parameter located in the LO submenu of the Channel 1 and Channel 2 Menu Trees. The capability to manually set the LO frequency proves most useful when the internal synthesizers are being used for a testing application other than supplying the signal required for the 4500's up/down conversion.

```
CHANNEL1\LO
LO FREQ: 956.6MHz
```

```
CHANNEL2\LO
LO FREQ: 956.6MHz
```

LO FREQ

Definition
Sets the local oscillator frequency in internal manual mode.

Value Range
Valid range of internal synthesizer

2.6. Setting Path Characteristics

This section contains information on setting parameters to define the path characteristics. It is assumed that the user is familiar with the basic local operations of the TAS 4500. If you are not familiar with the local control of the TAS 4500, please read Sections 2.2. "Getting Started" and 2.3. "Menu Overview" before referring to this section.

The menu location, definition and range of the parameters for the path characteristics are listed in the following sections.

2.6.1. Setting Path On/Off Status

Each RF channel of the TAS 4500 models up to six independent transmission paths. The paths can be turned on or off on an individual basis in the Path Status menu located in the Channel 1 and Channel 2 Menu Trees. When enabled, the user is permitted access to the active path's submenu which contains the path specific propagation characteristics.

```
CHANNEL1                                            ⇳
PATH 1:on↵     PATH 2:on↵     PATH 3:off
```

```
CHANNEL1                                            ⇧
PATH 4:off     PATH 5:off     PATH 6:off
```

```
CHANNEL2                                            ⇳
PATH 1:on↵     PATH 2:on↵     PATH 3:off
```

```
CHANNEL2                                            ⇧
PATH 4:off     PATH 5:off     PATH 6:off
```

PATH x

Definition
Sets status of the path selected for the selected RF channel.

Value Range
on, off

2.6.2. Setting Relative Path Delay

The user can independently program the relative path delay on each of the instrument's transmission paths. Note that the DELAY parameter does not represent an absolute time delay through the path.

Although only the Channel1\Path1 Delay parameter menu screen is shown below, there is a distinct DELAY parameter for each of the available transmission paths.

```
CHANNEL1\PATH1                                  ⇩
DELAY: 125.110µs      MODULATION:phase↵
```

DELAY (CH1&2 Paths 1-6)

Definition
Sets value of relative delay parameter for the selected path.

Value Range
Depends on the specific IF module and options installed. See Section 7 Technical Specifications for details.

2.6.3. Setting Path Modulation

The user can independently program the path modulation on each of the instrument's transmission paths.

If "Rayleigh", "Frequency Shift", "GSM_Rician", "Rician", "Nakagami", or "Rayleigh with Frequency Shift" modulation is selected, additional submenus can be accessed to set the Doppler frequency and fading power spectrum. Refer to Section 2.6.4. "Setting Vehicle Velocity and Doppler Frequency" and Section 2.6.5. "Setting Fading Power Spectrum Shape" for additional details.

If "Phase" modulation is selected, a submenu can be accessed to set the amount of phase shift desired. Refer to Section 2.6.7 "Setting Relative Phase Modulation Angle" for additional details on this type of modulation.

If "Rayleigh with Frequency Shift" modulation is selected, a submenu can be accessed to set the "Shift Frequency". Refer to Section 2.6.8 "Setting Shift Frequency for Rayleigh with Frequency Shift" for additional details on this type of modulation.

If "Rician" modulation is selected, two additional submenus are available for setting the Line Of Site Arrival Angle and the K factor. Refer to Section 2.6.9 "Setting LOS Arrival Angle and Rician K Factor" for additional details on this type of modulation.

If "Nakagami" modulation is selected, two additional submenus are available for setting the Angle of Arrival and the M value. Refer to Section 2.6.10 "Setting Angle of Arrival and Nakagami M value" for additional details on this type of modulation.

Although only the Channel1\Path1 Modulation parameter menu screen is shown below, there is a distinct MODULATION parameter for each of the available transmission paths.

```
CHANNEL1\PATH1                                    ⇩
DELAY: 125.110µs        MODULATION:phase↵
```

MODULATION (CH1&2 Paths 1-6)

Definition
Sets the modulation type for the selected path.

Value Range
none, rayleigh, rician, nakagami, freq shift, phase, GSM_rician (CH1 Path 1 only), FShift_ray

2.6.4. Setting Vehicle Velocity and Doppler Frequency

The user can program either the desired vehicle velocity or Doppler frequency on each of the instrument's transmission paths. Note that the vehicle velocity and Doppler frequency are *dependent* parameters, and modifying one affects the other. This parameter pair is used to define characteristics of Rayleigh, Rician, Nakagami, Frequency Shift, GSM_Rician and Rayleigh with Frequency Shift modulation.

When the Emulation Mode is set to Jakes, the vehicle velocity or Doppler frequency can be programmed independently in each of the instrument's transmission paths. When in Filtered Noise Emulation mode, there is one System Doppler frequency for all paths in the system. Paths set to Rayleigh, Rician, Nakagami, or GSM_Rician must be equal to the System Doppler Frequency. All Frequency Shifted paths must be less then or equal to the System Doppler frequency. Also, Rayleigh with Frequency Shift is not available when in Filtered Noise Emulation Mode.

Although only the Channel1\Path1\ Vehicle Velocity and Doppler Frequency menu screens are shown below, there is a distinct VELOCITY and DOPPLER parameter pair for each of the available transmission paths.

```
CHANNEL1\PATH1\RAYLEIGH                         ⇩
VELOCITY:     60.0ft/s   DOPPLER:   54.9Hz
```

```
CHANNEL1\PATH1\RICIAN                           ⇩
VELOCITY:     60.0ft/s   DOPPLER:   54.9Hz
```

```
CHANNEL1\PATH1\NAKAGAMI                         ⇩
VELOCITY:     60.0ft/s   DOPPLER:   54.9Hz
```

```
CHANNEL1\PATH1\FREQ SHIFT                       ⇩
VELOCITY:     60.0ft/s   DOPPLER:   54.9Hz
```

```
CHANNEL1\PATH1\GSM_RICIAN                       ⇩
VELOCITY:     60.0ft/s   DOPPLER:   54.9Hz
```

```
CHANNEL1\PATH1\RAYLEIGH WITH FREQ SHIFT⇩
VELOCITY:     60.0ft/s   DOPPLER:   54.9Hz
```

VELOCITY (CH1&2 Paths 1-6)

Definition

Sets the velocity of the mobile terminal, and along with the programmed carrier frequency, determines the Doppler frequency for the selected path.

Value Range

Range determined by limit of ±1.0 Hz to ±740.0 Hz and the carrier frequency according to the following equation:

$$Freq_{Doppler} = \frac{Velocity_{mobile} \times Freq_{carrier}}{C}$$

where C = Speed of Light (3×10^8 m/s)

DOPPLER (CH1&2 Paths 1-6)

Definition

Sets the Doppler frequency, and along with the programmed carrier frequency, determines the velocity of the mobile terminal for the selected path.

Value Range

±1.0 Hz to ±740.0 Hz, in 0.1 Hz steps

2.6.5. Selecting the Fading Power Spectrum Shape

The user can select the shape of the fading power spectrum when the Modulation is set to Rayleigh, Rician, Nakagami, GSM_Rician, or Rayleigh with Frequency Shift. The classical (6 dB) power spectrum is the common Rayleigh definition which adheres to the specifications outlined in the IS55/56 and IS97/98 test standards. The flat power spectrum has been determined to be representative of the multipath propagation effects experienced in some indoor applications. The classical (3 dB) and rounded power spectrums are additional spectrum shapes defined in the GSM specifications.

Although only the Channel1\Path1\ Fading Power Spectrum menu screens are shown below, there is a distinct Fading Power Spectrum parameter for each of the available transmission paths.

```
CHANNEL1\PATH1\RAYLEIGH                 ⇧
FADING POWER SPECTRUM: classical (6 dB)
```

```
CHANNEL1\PATH1\RICIAN                   ⇧
FADING POWER SPECTRUM: classical (6 dB)
```

```
CHANNEL1\PATH1\NAKAGAMI                 ⇧
FADING POWER SPECTRUM: classical (6 dB)
```

```
CHANNEL1\PATH1\GSM_RICIAN               ⇧
FADING POWER SPECTRUM: classical (6 dB)
```

```
CHANNEL1\PATH1\RAYLEIGH WITH FREQ SHIFT⇧
FADING POWER SPECTRUM: classical (6 dB)
```

FADING POWER SPECTRUM

Definition
Selects the shape of the fading power spectrum

Value Range
classical (6 dB), classical (3 dB), flat, rounded

2.6.6. Setting Rayleigh Fading Correlation

The user can independently program the path correlation coefficient between each of the pairs of like-numbered paths in Channel 1 and Channel 2. The Rayleigh fading correlation coefficients are accessed in the Rayleigh modulation submenu in the Channel 2 Paths 1-6 submenus.

Although only the Channel 2\Path 1 Correlation parameter menu screen is shown below, there is a distinct CORRELATION parameter for CH2 Paths 2-6 as well.

```
CHANNEL2\PATH1\RAYLEIGH                 ⇳
CH1-CH2 PATH 1 CORRELATION: 0.52
```

CORRELATION (CH2 Paths 1-6)

Definition
Sets the correlation coefficient of selected path pair. This parameter is only valid when Rayleigh modulation is selected on each of the paths that make up the pair.

Value Range
0.00 to 1.00, in 0.01 steps

2.6.7. Setting Relative Phase Modulation Angle

When Phase is the selected modulation type, the user can independently program the relative phase modulation angle for each of the instrument's transmission paths using the ANGLE parameter. It is important to note that the phase modulation angle parameter only applies when phase modulation is selected on the selected path.

Although only the Channel1\Path1 Phase Angle menu screen is shown below, there is a distinct ANGLE parameter for each of the available transmission paths.

```
CHANNEL1\PATH1\PHASE                    ⇧
ANGLE:   5.0deg
```

ANGLE (CH1&2 Paths 1-6)

Definition
Sets the relative phase shift of the selected path. This parameter is only valid when the desired path has phase modulation selected.

Value Range
0.0 to 360.0, in 0.1 degree steps

2.6.8. Setting Shift Frequency for Rayleigh with Frequency Shift

When Rayleigh with Frequency Shift is the selected modulation type, the user can independently program the Shift Frequency for each of the instrument's Rayleigh faded transmission paths using the Shift FREQuency parameter. It is important to note that this modulation type is available only when Jakes is selected as the Emulation Method and the Shift FREQuency parameter only applies when this modulation type is selected on the path.

Although only the Channel1\Path1 menu screen is shown below, there is a distinct Shift FREQuency parameter for each of the available transmission paths.

```
CHANNEL1\PATH1\RAYLEIGH WITH FREQ SHIFT⇕
SHIFT FREQ:  24.9Hz
```

SHIFT FREQ (CH1&2 Paths 1-6)

Definition
Sets the shift frequency of the selected Rayleigh faded path. This parameter is only valid when the desired path has Rayleigh with Frequency Shift modulation selected.

Value Range
-240.0 Hz to +240.0 Hz, in 0.1 Hz steps

2.6.9. Setting LOS Arrival Angle and Rician K Factor

When Rician is the selected modulation type, the user can independently program the LOS (line of site) arrival angle and the K factor for each of the instrument's Rician modulated transmission paths using the LOS ARRIVAL ANGLE and K FACTOR parameters respectively.

Although only the Channel1\Path1 menu screen is shown below, there are distinct LOS ARRIVAL ANGLE parameters for each of the available transmission paths.

```
CHANNEL1\PATH1\RICIAN                     ⇳
LOS ARRIVAL ANGLE: 45.0deg [100.0Hz]
```

LOS ARRIVAL ANGLE (CH1&2 Paths 1-6)

Definition
Sets the arrival angle of the direct line of site component for the selected Rician modulated path. Notice that while both the LOS arrival angle and the corresponding Doppler frequency are displayed, only the arrival angle can be modified from the front panel.

Value Range
0.0 to 360.0, in 0.1 degree steps

Although only the Channel1\Path1 menu screen is shown below, there are distinct K FACTOR parameters for each of the available transmission paths.

```
CHANNEL1\PATH1\RICIAN                     ⇳
K FACTOR: 12.0dB
```

K FACTOR (CH1&2 Paths 1-6)

Definition
Sets the power ratio between the direct line of site component and the faded component of the selected Rician modulated path.

Value Range
-30 to 30, in .1 dB steps

2.6.10. Setting Angle of Arrival and Nakagami M Value

When Nakagami is the selected modulation type, the user can independently program the angle of arrival and the M value for each of the instrument's Nakagami modulated transmission paths using the ANGLE OF ARRIVAL and M VALUE parameters respectively.

Although only the Channel1\Path1 menu screen is shown below, there are distinct ANGLE OF ARRIVAL parameters for each of the available transmission paths.

```
CHANNEL1\PATH1\NAKAGAMI                         ⇕
ANGLE OF ARRIVAL: 45.0deg [100.0Hz]
```

ANGLE OF ARRIVAL (CH1&2 Paths 1-6)

Definition
Sets the angle of arrival of the direct line of site component for the selected Nakagami modulated path. Notice that while both the angle of arrival and the corresponding Doppler frequency are displayed, only the angle of arrival can be modified from the front panel.

Value Range
0.0 to 360.0, in 0.1 degree steps

Although only the Channel1\Path1 menu screen is shown below, there are distinct M VALUE parameters for each of the available transmission paths.

```
CHANNEL1\PATH1\NAKAGAMI                         ⇕
M VALUE: 25
```

M VALUE (CH1&2 Paths 1-6)

Definition
Sets the ratio of direct signal components to multi-path faded signal components for the selected Nakagami modulated path.

Value Range
1, 3, 5, 10, 15, 25, and 100

2.6.11. Setting Relative Path Loss

The user can independently program the relative path loss on each of the instrument's transmission paths using the LOSS parameter found in each of the path submenus. Note that the LOSS parameter does not indicate an absolute level difference from input to output.

The Relative Path Loss and Log-Normal Standard Deviation parameters are *dependent* parameters. Please refer to Section 2.6.11 "Setting Log-Normal Parameters" for further details on the inter-relationship of the valid ranges for these two parameters. When an invalid combination of path loss and log-normal standard deviation is set a [LN-UNCAL] prompt is displayed in the upper right-hand corner of the screen shown below. This indicates the current log-normal settings are un-calibrated, resulting in less than a two sigma variation of the path power level.

Although only the Channel1\Path1 Path Loss menu screen is shown below, there is a distinct LOSS parameter for each of the available transmission paths.

```
CHANNEL1\PATH1                              ⇧
LOSS:25.0dB                 LOG NORMAL:on↵
```

LOSS (CH1&2 Paths 1-6)

Definition
Sets the relative path loss of the selected path.

Value Range
Depends on the specific IF module and options installed. See Section 7 Technical Specifications for details.

2.6.12. Setting Log-Normal Parameters

When log-normal fading is enabled, the user can independently program the log-normal standard deviation (sigma) and log-normal rate for each of the instrument's transmission paths.

Before programming the log-normal parameters, it is important to understand the interrelationship of the path LOSS and LOG NORMAL STD parameters. To attain a minimum of two sigma amplitude variation for the log-normal standard deviation parameter on the desired path the following upper and lower bound requirements must be met:

1. Two times the LOG NORMAL STD value plus the path LOSS value is upper bounded by a total of 50 dB.
2. The path LOSS value minus two times the LOG NORMAL STD value is lower bounded by 0 dB.

As an example with LOG NORMAL STD set to 12 dB, a two sigma amplitude variation can be achieved with path LOSS set to 25 dB.

If the path loss and the standard deviation parameters are programmed in such a way that a 2 sigma variation cannot be met a [LN-UNCAL] prompt is displayed on the instrument's screen to indicate the current settings are un-calibrated. When the [LN-UNCAL] message is displayed, the amplitude variation, induced by log-normal fading, will remain symmetrical around the mean power level but will be limited by the minimum distance of the current loss setting to either 0 or 50 dB.

For example, with the log-normal standard deviation set to 10 dB and the path loss set to 16 dB, the maximum amplitude variations will be constrained by ±16 dB. Since 16 dB < 20 dB (2 x 10 dB), a two sigma amplitude variation cannot be achieved and the [LN-CAL] message would be displayed.

Although only the Channel1\Path1 log-normal status menu screen is shown below, there is a distinct LOG NORMAL STATUS parameter for each of the available transmission paths.

```
CHANNEL1\PATH1                                        ⇧
LOSS:25.0dB                    LOG NORMAL:on↵
```

LOG NORMAL STATUS (CH1&2 Paths 1-6)

Definition
Toggles log-normal fading either on or off for the selected path.

Value Range
on, off

Although only the Channel1\Path1\LogNormal log-normal standard deviation menu screen is shown below, there is a distinct LOG NORMAL STD parameter for each of the available transmission paths.

```
CHANNEL1\PATH1\LOG NORMAL
LOG NORMAL RATE:10.105Hz    STD: 0dB
```

LOG NORMAL STD (CH1&2 Paths 1-6)

Definition
Sets the standard deviation for log-normal fading for the selected path.

Value Range
0 to 12 dB, in 1 dB steps

Although only the Channel1\Path1\LogNormal log-normal rate menu screen is shown below, there is a distinct LOG NORMAL RATE parameter for each of the available transmission paths.

```
CHANNEL1\PATH1\LOG NORMAL
LOG NORMAL RATE:10.105Hz    STD: 0dB
```

LOG NORMAL RATE (CH1&2 Paths 1-6)

Definition
Sets the log-normal fading rate for the selected path.

Value Range
0.000 to 20.000 Hz, in 0.001 Hz steps

2.7. Dynamic Emulation Mode

The Dynamic Emulation Mode allows the user to dynamically simulate changing transmission mediums. This feature is only available through TASKIT/4500 with the TAS 4500 in REMOTE mode. Dynamic Emulation is not available on all TAS 4500's, see Section 7 Technical Specifications for details. The TAS 4500 will not respond to any key press except the REMOTE button. When the TAS 4500 is in the Dynamic Emulation Mode the following screen in displayed:

```
--- DYNAMIC EMULATION MODE SELECTED ---
```

When TASKIT/4500 switches out of Dynamic Channel Emulation mode or if the TAS 4500 is taken out of REMOTE the following screen is displayed

```
 TERMINATING DYNAMIC EMULATION. . .
```

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3.0. Reference

3.1. Overview

This section of the operations manual provides reference information that describes the features provided in the TAS 4500 FLEX RF Channel Emulator. This information is grouped into the following sections:

Front and Rear Panel Interfaces
This includes all connectors, indicators, and input/output ports on the front and rear panels of the TAS 4500.

Parameter Description
This includes all of the parameters of the TAS 4500. These parameters are divided into system configuration, input/output, and path characteristics.

Dynamic Parameter Emulation
This section describes the Dynamic Parameter Emulation mode available through TASKIT/4500. The Dynamic Parameter Emulation Mode allows the user to cascade multiple static parameter "states" to emulate a dynamic propagation environment.

3.2. Front and Rear Panel Interfaces

The front panel contains the display, overload and menu group LEDs, and RF and LO input/output N-type connectors. The rear panel contains the remote control interfaces (IEEE-488 and RS-232), auxiliary (AUX) port, clock/synch input/output connectors, power entry module, and fan vent area.

3.2.1. Front Panel Displays and Interfaces

On the front right hand side of the TAS 4500 (Figure 3-1) is the display, menu group LEDs, remote LED, and the overload LEDs. On the left hand side of the front panel are the channel RF I/O and LO I/O N-type connectors.

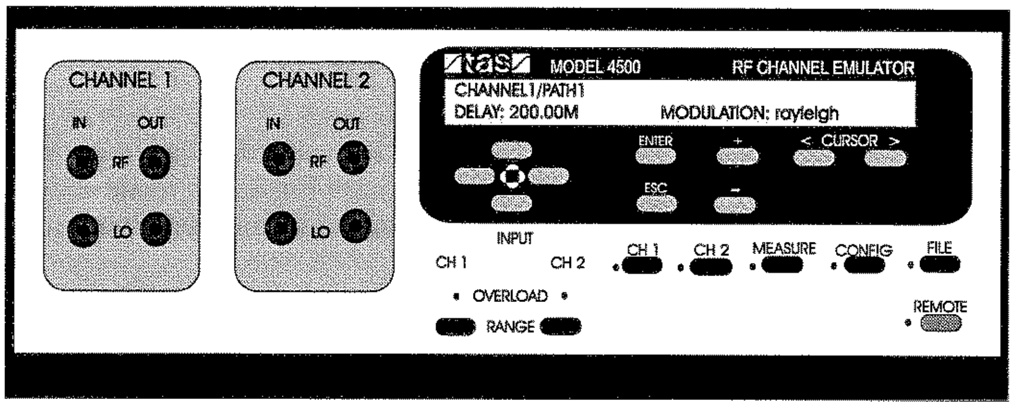

Figure 3-1. TAS 4500 Front Panel

Display

The TAS 4500 has an eighty character display on the front panel. The display will show the active menu tree. All parameters for the system, input/output, and path characteristics are visible from the front panel display. Error messages are also displayed here.

Menu Group LEDs

There are five menu group LEDs on the TAS 4500 front panel. The lit LED corresponds to the active menu tree on the display. The five menu groups are as follows:

CHANNEL 1 (CH 1) - Indicates the control of parameters for Channel 1 input/output and path characteristics when lit.

CHANNEL 2 (CH 2) - Indicates the control of parameters for Channel 2 input/output and path characteristics when lit.

MEASURE - Provides a peak level measurement of the channel input when lit.

CONFIGURATION (CONFIG) - Indicates the control of system configuration parameters when lit.

FILE - Indicates the control of file save and recall when lit.

Remote LED

The remote LED is located in the lower right hand corner of the TAS 4500 front panel. The remote LED functions as follows:

REMOTE - Indicates that the TAS 4500 is under remote control when lit.

Overload LEDs

Under the RANGE heading on the front panel are two overload LEDs one each for Channel 1 and 2. When lit, these LEDs indicate an overload condition on the specified channel; the input signal level must be decreased since it is outside the dynamic range of the TAS 4500 internal processing. The signal level seen by the TAS 4500 can be reduced by increasing the input reference level parameter or by lowering the absolute level of the signal input to the TAS 4500.

When performing an autorange, the overload LED will light momentarily, indicating that the TAS 4500 is optimizing the signal level.

RF Input/Output N-Connectors

There are two N-type connectors per channel located on the upper left hand side of the TAS 4500 front panel for RF input and output. The transmit signal must be provided by the user to the RF IN connector. The received signal will be present at the RF OUT connector.

LO Input/Output Connectors

There are two N-type connectors per channel located on the lower left half side of the TAS 4500 front panel for LO (Local Oscillator) input and output. A LO signal must be present at the LO IN for that channel to operate.

3.2.2. Rear Panel Interfaces

Figure 3-2 shows the rear panel of a standard 4500.

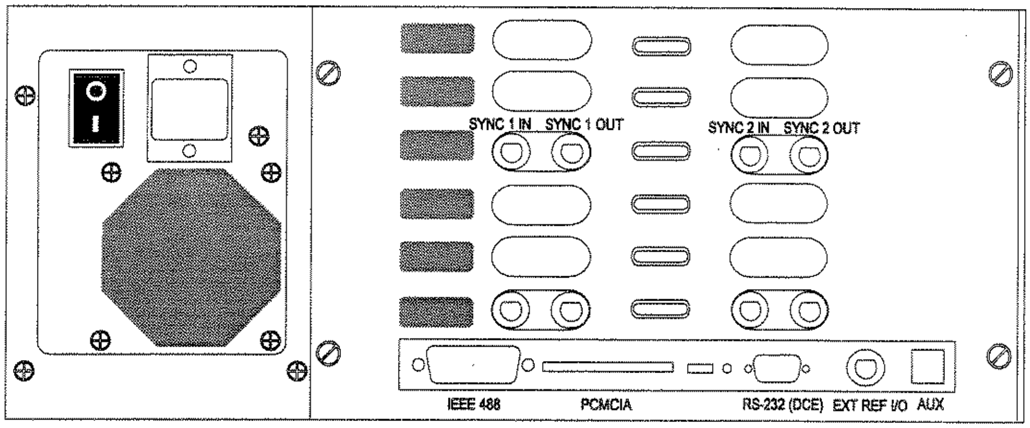

Figure 3-2. Rear Panel of the TAS 4500

PCMCIA Software Card Interface

The system software for the TAS 4500 is resident on a PCMCIA memory card which plugs into the PCMCIA System Software Interface on the lower portion of the instrument's rear panel. This PCMCIA card makes it easy to upgrade to the latest firmware version.

IEEE-488 Remote Control Port

The CONTROL (IEEE-488) port is a 24 pin IEEE-488 receptacle which supports the IEEE-488 (GPIB) protocol. This port must be connected to an IEEE-488 controller to control the TAS 4500 via IEEE-488. This connection may be either direct or via multi-point bus which contains other IEEE-488 controlled equipment.

The IEEE-488 controller can be a generic PC with an embedded IEEE-488 control card installed, a IEEE-488 computer, an RS-232 to IEEE-488 converter, or some other IEEE-488 controller.

RS-232 (DCE) Remote Control Port

The CONTROL (DTE) port is a 9 pin female D-sub connector which supports RS-232C. The control port is wired as a Data Communications Equipment (DCE). All RS-232C remote control of the TAS 4500 must be done via this port. An RS-232C terminal or a PC (IBM compatible) can control the TAS 4500 through this port via a regular RS-232 cable. It is important to note that a null modem cable is not required. Two protocols are supported in RS-232 control mode, ACK/NAK (ACKnowledge/Negative AcKnowledge), and CR/LF (Carriage Return/Line Feed). Both of these protocols are explained in full detail in Section 4.0. "Remote Operation" of this manual.

AUX Port

The AUX (auxiliary) port is a RJ-45 connector that is currently not used.

SYNC 1(2) IN(OUT) Connectors

The SYNC 1(2) input(output) connectors shown in Figure 3-2 are BNC type connectors. The TTL digital signal on this connector is used to provide synchronization of the digital signal processing between two 4500 units that are configured in a 4 branch diversity test setup.

EXTernal REFerence I/O Connector

The External Reference Input/Output connector is a BNC type connector that provides a 10 MHz sine wave reference signal as an output when the TAS 4500 is using its own internal reference. This connector can also accept an externally supplied 10 MHz sine wave reference signal which can be used to drive the internal signal processing circuitry of the TAS 4500.

AC Power Receptacle

The AC power receptacle is located on the upper left corner of the rear panel. The TAS 4500 has an autosensing AC voltage that operates over the range stated in Section 7.0. Technical Specifications. This receptacle also contains the fuses for the unit. If it becomes necessary to change the fuses, the proper procedure for performing the operation is described below:

1. Remove the power cord and slide the fuse holder out of the power entry module.

2. Replace the fuse(s) with the appropriate type (see Section 7.0. Technical Specifications).

3. Reinsert the fuse holder into the power entry module.

Fan Vent Areas

The rear panel of the TAS 4500 contains two fan vent areas. One vent area is below the AC power receptacle, the other to the left of this vent. The area behind these vents should be unobstructed for proper air flow to cool the TAS 4500.

3.3. System Configuration Parameters

In this section, parameters for the system configuration will be discussed. The system configuration parameters consist of the Unit parameters, System parameters, and the Remote Protocol parameters.

In this section, the different vehicle velocity formats will be explained along with how to convert between the various formats. The types of channel correlation available and their setup requirements will be listed. Also, the fading configuration choices will be discussed. Finally, the remote protocol formats will be reviewed.

3.3.1. Vehicle Velocity Parameter Formats

The TAS 4500 can be configured to display the vehicle velocity in four different data formats. The data formats are only selectable from the TAS 4500 front panel under the CONFIG/UNITS menu. Refer to Section 2.4. "Setting the Display Format for Vehicle Velocity Parameters" for more details on configuring this parameter.

The vehicle velocity is the speed at which the mobile receiver is moving relative to the transmitter in a straight path. The vehicle velocity data formats are: kilometers per hour (km/h), meters per second (m/s), miles per hour (mi/h) and feet per second (f/s).

3.3.2. Channel Correlation

The TAS 4500 can be either used as a standalone instrument or in conjunction with other 4500 units in a multiple-instrument configuration. A single standalone TAS 4500 can provide up to two RF channels each with six transmission paths. For applications that require 4 channels, or up to 24 paths, two units can be used to provide an expanded test system. The TAS 4500 can be expanded up to a 4 unit test system that supports 8 channels, or up to 48 paths. When properly configured, the Channel Correlation parameter provides fading characteristics that are independent, or uncorrelated between the transmission paths of a multiple-instrument configuration.

For standalone instrument configurations the Channel Correlation parameter located in the CONFIG/SYSTEM submenu should be set to its default value: Type1. When two units are to be used in a single test system, the primary unit should be set to Type2 and the secondary unit should be set to Type3. When a third 4500 unit is included in a single test system, it should be set to Type4, and a fourth unit should be set to Type5. These settings configure multiple instruments to provide uncorrelated fading statistics across the transmission paths of all channels in the test system. Refer to Section 2.4. Selecting the Channel

Correlation for further details on changing this parameter. Also please see Section 3.5. for more information concerning correlation.

3.3.3. Emulation Method

The TAS 4500 allows the user to select the emulation method used to generate Rayleigh fading (also referred to as fast fading). Rayleigh fading is generated using an I/Q modulator shown in Figure 3-5. The I/Q signals are modulated with two independent and identically distributed band limited Gaussian signals. The two emulation methods supported are Jakes method and the filtered noise method.

Jakes emulation method generates the I/Q modulation waveforms from a weighted sum of sinusoids. Advantages of the Jakes method are:

- Perfectly band limited signal due to the sinusoidal nature of the I/Q modulation waveform generation.
- Permits the use of multiple Rayleigh and Rician Doppler frequencies within one system.
- An excellent approximation of Rayleigh fading.

The filtered noise emulation method generates the I/Q modulation waveforms from two band limited Gaussian pseudo random noise sources. These noise sources provide the ability to control the spectral shape of the faded signal. Advantages of the filtered noise method are:

- Permits spectral shaping of the faded signal to emulate various environmental conditions.
- Allows for a controllable fading repetition rate.

For further details on setting this parameter see Section 2.4. Selecting the Fading Emulation Method.

3.3.4. Fading Repetition Rate

The TAS 4500 allows the user to select the nominal period of the pseudo random filtered noise sources. This period corresponds with the time it takes for the pseudo random Rayleigh power distribution to repeat. There are three repetition rates available. The nominal period for these rates are: 20 minutes, 27 seconds, and 24 hours. The formula to compute the repetition rate for some system configuration is as follows:

$$T_{repeat} = \frac{(T_{fundamental})}{(40 * F_{system\ Doppler})}$$

where

$T_{fundamental}$ $= 2^{22}$ for RATE1 (20 minutes)
2^{17} for RATE2 (27 seconds)
2^{28} for RATE3 (24 hours)

$F_{system\ Doppler}$ = current Rayleigh or Rician Doppler frequency setting

The nominal repetition rates stated above were each computed based on typical test setup Doppler frequencies. For further details on setting this parameter see Section 2.4. Selecting the Nominal Fading Repetition Rate.

3.3.5. Correlation Coefficient Algorithm

The TAS 4500 allows the user to select the correlation algorithm used to specify the correlation between Rayleigh faded paths. Envelope correlation is between the Rayleigh faded signals at the output of the associated channels. While component defines the correlation between the In-Phase components of the associated Rayleigh faded signals in addition to the correlation between the Quadarature components.

The Correlation Algorithm parameter can be found in the CONFIG\SYSTEM submenu. For further details on setting this parameter see Section 2.4. Selecting the Correlation Algorithm.

3.3.6. Remote Protocol Formats

The following remote protocol formats are available under the CONFIG/REMOTE PROTOCOL menu from the TAS 4500 front panel: ACK/NAK (ACKnowledge/Negative AcKnowledge), CR/LF (Carriage Return/Line Feed), and GPIB. ACK/NAK and CR/LF are used with the RS-232C remote control port; GPIB is for the IEEE-488 port. These protocols are explained in full detail in Section 4.0. "Remote Operation" of this manual.

3.3.7. 10 MHz Reference Source

NOTE: The TAS 4500 generates a very high quality internal source, and it is not recommended that an external source be used unless the user has a specific reason for doing so.

The TAS 4500 requires a 10 MHz sinusoidal reference signal to synchronize the internal signal processing functions of the unit. The user can select either the internally generated 10 MHz reference or they can provide their own external source via the BNC connector labeled EXT REF I/O available on the rear panel. Refer to Section 7.0. Technical Specifications for the requirements on the external source.

It is important to note that the external signal source must be connected to the TAS 4500 and must have the proper frequency and power settings prior to changing the source selection. If the signal is not present or is detected to be out of the specified power or frequency range, the TAS 4500 will not allow use of an external source. Only when the signal present is determined to meet the specifications will the unit proceed and allow for an external source to be chosen.

The 10 MHz Reference parameter can be found in the CONFIG\SYSTEM submenu. For further details on setting this parameter see Section 2.4.8 Setting the 10 MHz Reference Source.

NOTE: When the TAS 4500 is set to produce its own internal reference, there will be a 10 MHz sinusoidal output present on the BNC connector.

3.4. Input and Output Parameters

In this section the input/output parameters consisting of the control of both the carrier and local oscillator frequencies, the local oscillator mode, input reference level, and MEASURE function will be discussed. The carrier frequency is the first parameter that must be set for a channel to operate properly. The local oscillator must be set to ensure proper down conversion of the RF signal. The programmable input reference level parameter allows the TAS 4500 to function over a range of input levels. The MEASURE function provides a peak level measurement of the input channel signal.

3.4.1. Carrier Frequency

The carrier frequency parameter is set by the user to the RF input signal frequency. The carrier frequency is set independently for each channel, in a two channel unit. The two channels need not have the same carrier frequency. The carrier frequency must be set to ensure proper calculation of the fading parameters for the channel. Refer to Section 7.0. Technical Specifications for the carrier frequency range supported by your model 4500.

3.4.2. Local Oscillator Mode

A local oscillator signal is required for each channel of the 4500 to down convert the RF input signal for IF signal processing, and then to up convert the processed IF signal back to the original RF frequency. The 4500 can be equipped with internal local oscillators eliminating the need for an external signal source. The local oscillator has four possible modes, Internal Auto, Internal Manual, External and External from 4500. When equipped with two local oscillators, these modes are independently available for each channel.

The Internal Auto mode activates the internal synthesizer. In this mode the internal synthesizer is automatically set to the frequency offset required to down/up convert the carrier frequency. When in Internal Auto mode, the 4500 restricts the carrier frequency range that can be programmed to reflect only those frequencies that can be supported by the internal synthesizer. The carrier frequency will not be allowed outside of this range, and an error message will be displayed on the TAS 4500 front panel if an out-of-range value is selected. The local oscillator mode must be changed to External if a carrier frequency is required that resides outside the range supported by the internal local oscillators.

The Internal Manual mode activates the internal synthesizer and the frequency is controlled by the user. In this mode, the range of the carrier frequency is not limited by the internal synthesizer range. This allows the user the flexibility to manually program the frequency of the local oscillator for use in other lab applications. Special care must be taken when manually programming the local oscillator to down convert the RF input signal to the IF signal required by the 4500. The synthesizer's frequency must be chosen to provide the proper frequency offset from the desired carrier frequency. Refer to Section 2.4. Viewing the System Summary for information on determining how your 4500 is equipped and Section 7.0. Technical Specifications for the required LO frequency and level.

The External local oscillator mode disables the internal synthesizer if installed. When this mode is selected, an externally-generated local oscillator signal must be provided by the user. The local oscillator must be set to provide the required frequency offset from the carrier frequency for proper down conversion of the RF input signal. Refer to Section 2.4. Viewing the System Summary for information on determining how your 4500 is equipped and Section 7.0. Technical Specifications for the required LO frequency and level.

The fourth mode, External from 4500 should be set when a LO signal is being supplied from another channel of a 4500. The LO signal can be from the other channel in the same unit or from a different 4500 unit. The internal LOs in a 4500 can be set either above or below the carrier frequency in order to maximize their range of coverage. In External from 4500 mode, the channel relies on the carrier frequency set in the channel to correctly determine the location of the LO signal, either above or below the carrier. The 4500 will automatically compensate for any inversion that takes place in the up/down converter due to the LO frequency.

3.4.3. Local Oscillator Frequency

The local oscillator frequency must be provided to the LO IN connector on the TAS 4500 front panel for each channel in use. The signal can be provided by either an internal local oscillator (if equipped) or an external signal source. In either case, the local oscillator is used to down convert the RF input signal to an acceptable IF frequency for signal processing. The local oscillator must be set to provide the required frequency offset from the carrier frequency for proper down conversion of the RF input signal. Refer to Section 7.0. Technical Specifications for the required LO frequency and level.

3.4.4. Input Reference Level & Automatic Input Level Range

The input reference level parameter allows the level of the RF input signal to be programmed in 0.1 dBm steps over a range defined in Section 7.0. Technical Specifications for your system. Using this parameter, the input level circuitry adds a fixed amount of gain to adjust the peak level of RF input signal for optimal performance of the TAS 4500. Note that the input power setting corresponds to the optimum performance for a sine wave at 900 MHz, which has a peak-to-average ratio of 3 dB. If the peak-to-average ratio of the RF input waveform is not 3 dB, the power level of the input signal will not directly match that of the optimal input level setting. To maximize the performance of the TAS 4500, the input level parameter should be used to make the peak level as large as possible *without* overloading the channel. If the input reference level parameter is set too low, or the RF input signal is too large, the overload LED for the corresponding channel will light. The input reference level setting should be increased or the RF signal reduced, until the LED goes off.

The amount of input gain placed on the down converted signal can be optimized by the Automatic Input Range. Selecting the RANGE button on the TAS 4500 front panel will initiate an automatic input range. The input gain will be increased until the signal level overloads the TAS 4500 internal processing, and then the input gain will be decreased approximately 2 - 4 dB. It is recommended that the automatic input range be used each time a new input signal is presented to the TAS 4500.

Manual configuration of the Input Reference Level is recommended for applications with wideband or noise-like transmit signals. This will provide the most accurate and repeatable setting for the Input Reference Level parameter. The following procedure illustrates how to manually set the Input Reference Level parameter for the transmit signal present at either RF input of the TAS 4500.

1. Begin by setting the desired channel's Input Reference Level to its maximum value. Refer to Section 7.0. Technical Specifications for the maximum value for your system configuration.
2. Check the overload LED for the RF channel being configured. If the overload LED is already illuminated, the input level to the TAS 4500 is too high and must be lowered using an appropriate external attenuator.
3. Otherwise, monitor the overload LED and step the Input Reference Level down in 1 dB steps until the LED is illuminated.
4. If the minimum Input Reference Level, refer to Section 7.0. Technical Specifications, is reached before the LED becomes illuminated, the transmit signal level may be too low to optimize the dynamic range of the input level circuitry.

> **NOTE:** Under many circumstances the TAS 4500 will continue to provide accurate emulation characteristics for signals less than the minimum Input Reference Level. However, it should be noted that for each dB that the input signal is less than the minimum Input Reference Level the optional dynamic range of the transmission channel will be reduced by an equal amount. To achieve the maximum dynamic range with very low transmit levels an external amplifier may be required.

5. After reaching the overload condition, step the Input Reference Level up by 3 dB. This creates approximately 3 dB headroom for the input circuitry of the TAS 4500 and helps to insure that the peaks of the transmit signal will not be clipped.

3.4.5. Output Attenuator (Optional)

The TAS 4500 can be equipped with an RF output attenuator on a per channel basis. This output attenuator can be used to precisely set the output level of the RF channel over a wide range of levels. Refer to Section 7.0. Technical Specifications for the attenuator options that are available. The functionality of the Output Attenuator differs from that of Path Loss when multiple paths in a channel are enabled simultaneously. When multiple paths are used, the Path Loss settings are programmed on a per path basis to set the level of one path relative to another within the same channel.

The purpose of the Output Attenuator is to adjust the level of the composite channel after the paths have been summed together at the output of the emulation channel. Since this programmable attenuator is placed after the final up conversion it affects all signals, desired and spurious, equally. By doing so, the margin, or ratio between the desired carrier signal and any parasitic signals introduced by the up conversion is held constant regardless of the amount of loss introduced by the RF attenuator. This feature is especially important in order to maintain the channel's spectral purity when using a large amount of attenuation.

3.4.6. LO Feed-through and RF Image Suppression (Optional)

The TAS 4500 can be equipped with a bandpass filter at the RF output used to suppress the LO feed-through and RF image signals present from the signal up conversion. This feature is available on a per channel basis. Refer to Section 7.0. Technical Specifications for the suppression options that are available. The filter will suppress the RF image signal, 280 MHz away from the desired output, and the LO feed-through signal, 140 MHz away from the desired output. This feature is especially important when the users receiver is not capable of filtering out of band RF signals.

3.4.7. RF Channel Bypass (Optional)

The TAS 4500 can be equipped with RF switches which are used to bypass the RF Front End and IF Signal Processing functions of the TAS 4500. The switches provide a direct signal path from RF IN to RF OUT to avoid the inherent insertion loss of the RF emulation channel. This feature is designed primarily for use in an automated test scenario where the fading emulation capability of the TAS 4500 is not required in all tests. In this case, the RF Channel may be bypassed during those tests which do not require fading emulation to avoid the insertion loss of the emulator.

3.4.8. MEASURE Feature

The MEASURE feature on the TAS 4500 front panel provides a peak level measurement of the input signal, at either channel. The same circuits that provide the Automatic Input Range also control the peak level measurement.

NOTE: During the peak level MEASURE function, the signal level will be automatically adjusted by the TAS 4500.

To determine the signal level, the TAS 4500 adjusts the input gain level until a peak overload occurs; from this point an estimated peak level may be determined. The input signal is sampled to determine if a peak overload occurred. If an overload condition cannot be reached, an out of range message will be returned.

3.5. Path Characteristic Parameters

In this section, the theory and implementation associated with the TAS 4500's emulation of the path characteristics will be discussed. A block diagram of the TAS 4500 is shown in Figure 3-3. Using these blocks, parameters for the following path characteristics can be simulated in the TAS 4500:

- Relative Path Delay
- Path Modulation: Rayleigh, Frequency Shift, Phase Shift, GSM_Rician, Rician, Nakagami, and Rayleigh Fading with Frequency Shift
- Relative Path Loss
- Log-Normal Fading

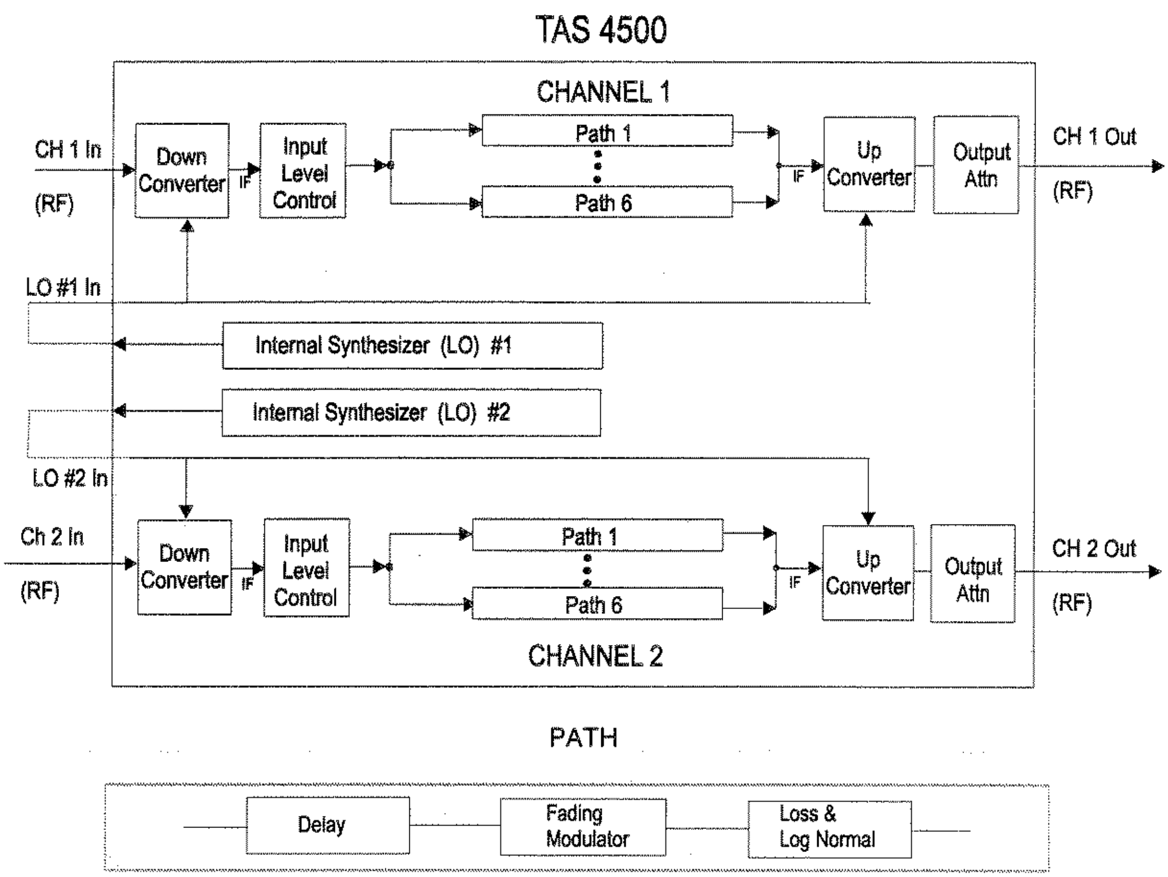

Figure 3-3. TAS 4500 Block Diagram

3.5.1. Path On/Off Status

Each channel in the TAS 4500 is comprised of three or six individual paths. Each path is capable of simulating all of the characteristics listed in Section 3.3. except GSM_Rician which is only available on path 1. Each of the paths may be independently turned on or off. For a signal to pass through the channel, at least one of the available paths must be turned on. The Path On/Off status is controlled in the CHANNEL submenu.

3.5.2. Relative Path Delay

Relative path delay is a phenomenon where individual signal paths from the transmitter to the receiver arrive at different times. An example of this is shown in Figure 3-4 between Paths (A) and (C). Path (C) will arrive at the receiver (the automobile) a finite time after signal Path (A). The net effect of the arrival time difference is to spread the signal in time. In a digital system this will cause received symbols to overlap resulting in inter-symbol interference.

The amount of relative path delay varies with terrain and application. In an indoor application, delays could be in the 10's of nanoseconds (ns), where 10 ns is about 10 feet. In outdoor applications, delays of 10 microseconds (μs) or less are typical (1 μs is about 1000 feet). Delays greater than 50 μs are rare in cellular environments. Consult the Section 7.0. Technical Specifications for the resolution and range of the relative path delay offered in your model TAS 4500

The relative path delay is implemented in the TAS 4500 by digital delay devices. Path clocks in the TAS 4500 are synchronized so that an accurate delay between paths is possible. The synchronization includes paths within a single channel, paths between two channels and paths between two TAS 4500's (when connected in the 12 path model).

3.5.3. Relative Path Loss

Relative path loss is a phenomenon where individual signal paths arriving at the receiver are at different absolute power levels. The difference in power levels between paths is caused by the physical obstructions in the signal path. Referring to Paths (A) and (C) in Figure 3-4, Path (C) will arrive at a lower power level then Path (A). This occurs since some amount of the power in signal Path (C) is lost when it reflects off the truck. Signal strength will also vary due to the distance the signal travels. The loss of signal strength should follow the $1/d^2$ law, where d is the distance between the transmitter and the receiver. In the actual cellular environment the loss is much worse, (between $1/d^3$ to $1/d^6$), due mainly to variations in the terrain.

The TAS 4500 is capable of path losses that far exceed any testing specs, most of which do not call for relative path losses to be greater than 20 dB. If a large amount of loss is needed on the entire channel, the internal Output Attenuator should be used.

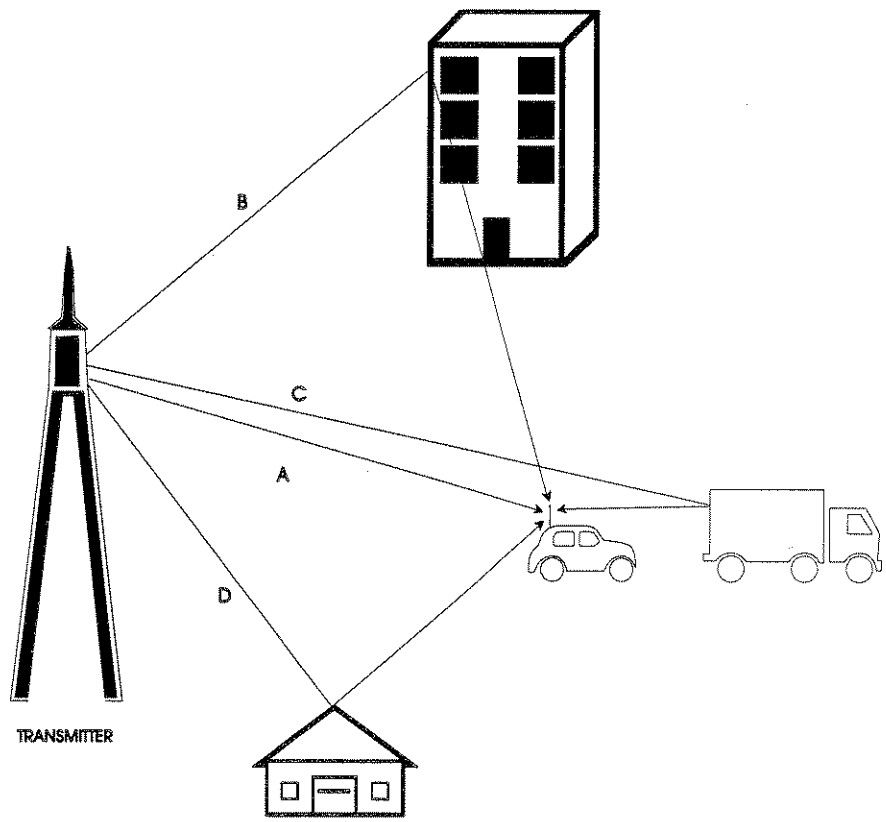

Figure 3-4. Transmitter to Receiver Signal Diagram

3.5.4. Path Modulation Type

Several different modulation types are supported by the TAS 4500 including Rayleigh fading, static frequency (Doppler) shift, static phase shift, GSM_Rician, Rician, Nakagami and Rayleigh Fading with Frequency Shift. All five of these modulation types are implemented using the same functional hardware block in the TAS 4500. There is one modulator per path in the TAS 4500.

The fading modulator hardware block consists of a 90° phase split filter, an in-phase and quadrature-phase modulator, and a summer as shown in Figure 3-5. The IF signal is phase split to produce an I and Q signal. The individual I and Q signals are then modulated with the selected type of modulation waveform. Finally, the I and Q signals are summed together.

The modulation waveforms are produced digitally. Therefore, all of the selectable modulation types can be generated using the same hardware.

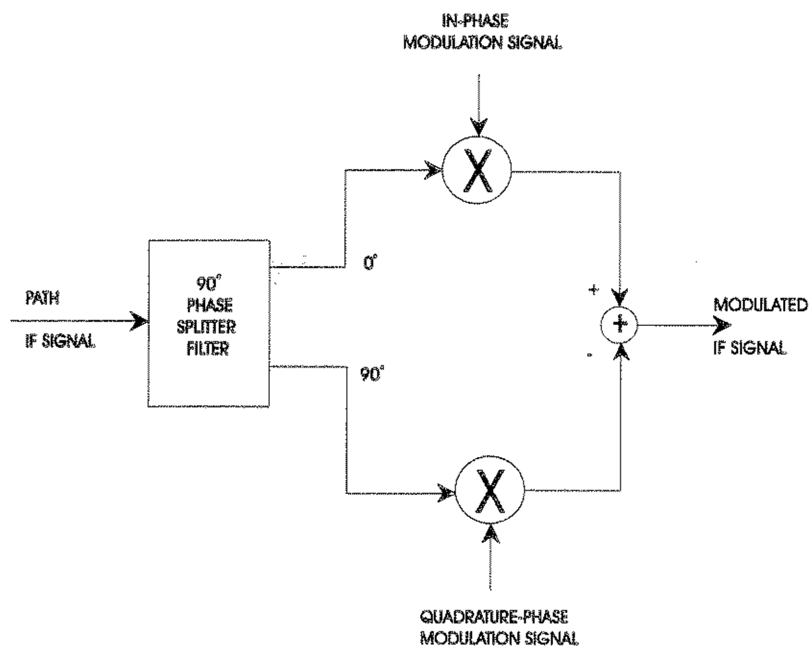

Figure 3-5. Path Modulator Block Diagram

3.5.5. Rayleigh Modulation

Rayleigh modulation is commonly referred to as fast fading. A Rayleigh modulated signal is caused by scattering from man-made and natural obstacles such as buildings and trees in the local geographical area (within a few hundred wavelengths of the receiver). It is formed by a large number of these scattered (reflected) signals combining at the receiver. Each of these signals has a random phase and amplitude at the receiver due to the reflections and difference in distance traveled.

The phenomenon that creates Rayleigh fading can be easily illustrated using a simple two path example. At the receiver the two paths can be of any amplitude and phase. If the two paths are of the same amplitude, and their phase is 180° apart, there will be total destructive interference and there will be no resultant signal. If the two signal paths are 0° apart in phase there will be constructive interference and the signal envelope will be 3 dB larger than the individual path's amplitudes.

The signals rarely combine to greater than 10 dB above the individual path's power. The deep fades (destructive interference) would range from just a few dB to fades of greater than 50 dB. The spacing and amplitude of the fades are a function of the carrier frequency. At 900 MHz the deep fades will occur at the mobile every few centimeters apart.

The fades and peaks of the signal envelope follow a Rayleigh distribution. This causes the signal strength to fluctuate rapidly between slightly higher levels to deep fades of greater than 50 dB. Figure 3-6 shows an example of the Rayleigh faded signal versus time. Rayleigh fading is called fast fading since the fluctuations are so rapid, as compared to log-normal or slow fading.

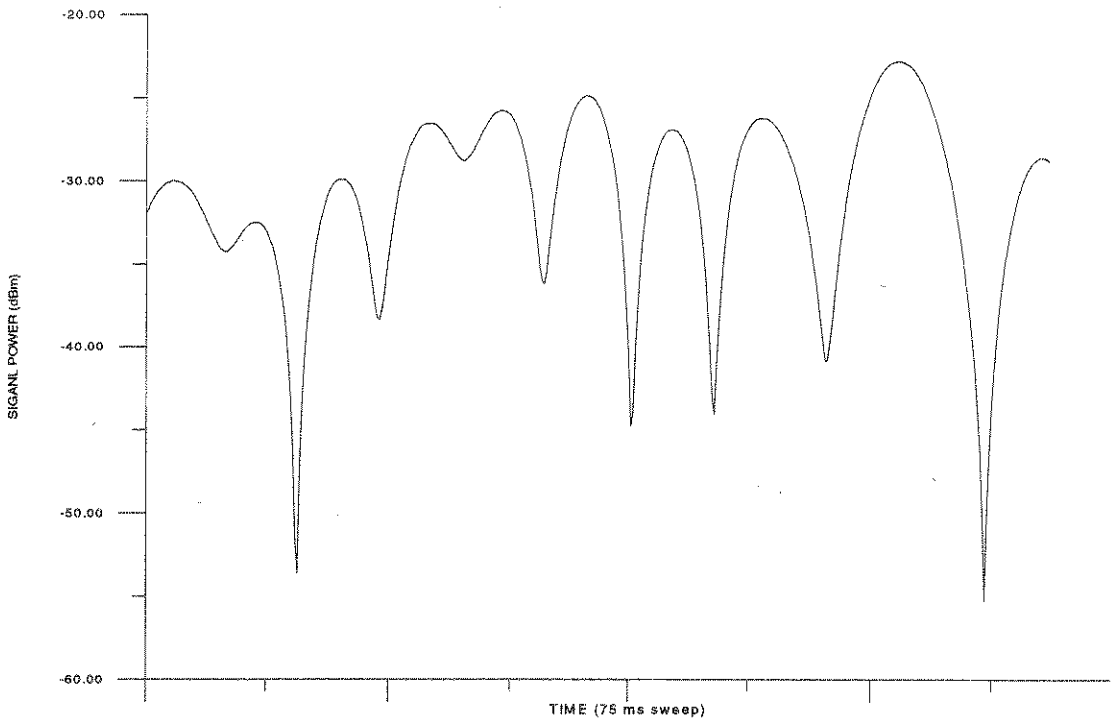

Figure 3-6. Rayleigh Faded Signal vs. Time
Doppler Freq. = 100 Hz
Center Freq. = 900 MHz
Span = 0 Hz
RBW = 100 kHz
Sweep Time = 75 msec

The Rayleigh distribution is generated using an I/Q modulator. The I/Q signals are modulated with two Gaussian distributed signals. Since Rayleigh fading occurs when there is relative movement between the transmitter and receiver, the signal is subjected to a Doppler shift (frequency shift). As a result the spectrum of Rayleigh fading is limited to plus or minus the Doppler frequency (which is a function of the vehicle velocity) assuming that there is an equal probability that the signal is received with an arrival angle anywhere within the range from 0 to 360 degrees. The theoretical power spectral density of a Rayleigh faded signal is shown in Figure 3-7. Also shown, in Figure 3-8, is the measured power spectral density from a TAS 4500.

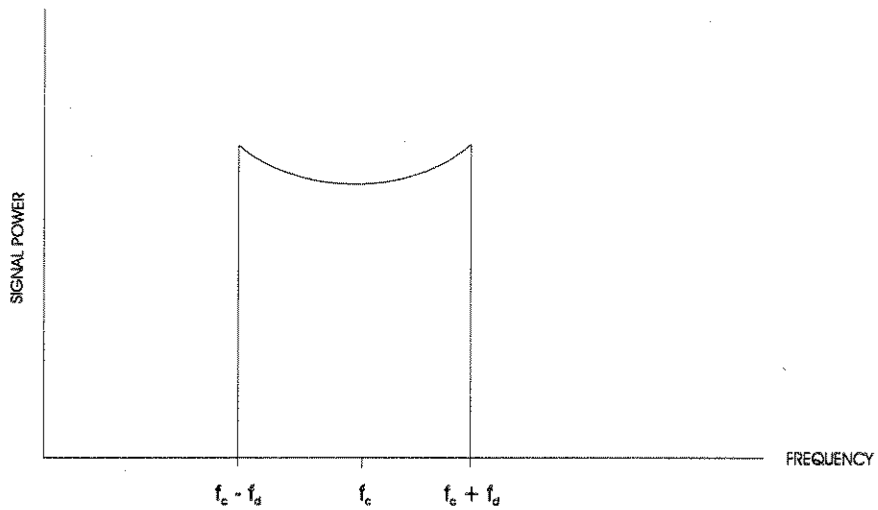

Figure 3-7. Theoretical Rayleigh Power Spectral Density

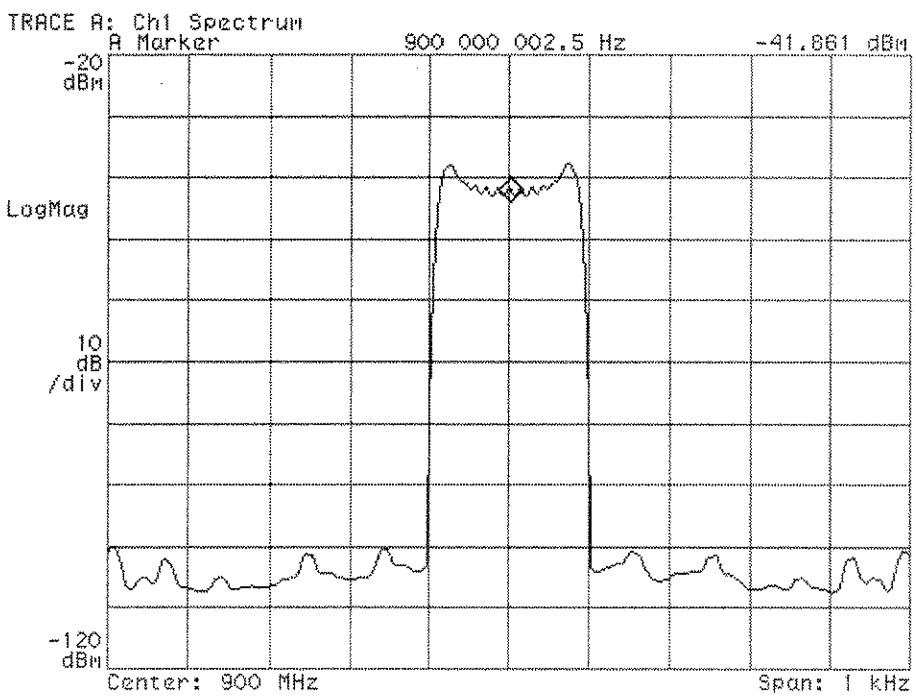

Figure 3-8. Measured Rayleigh Power Spectral Density
Doppler Freq. = 80 Hz
Center Freq. = 900 MHz
Span = 1 kHz
RBW = 10 Hz
Sweep Time 30 sec
Emulation Method = Jakes

To evaluate the performance of Rayleigh fading implemented in the TAS 4500, it must be compared to a defined standard to ensure consistent performance. A set of standard performance criteria can be found in the EIA/TIA IS-55 and IS-56 documents. The primary performance criteria that are used to evaluate Rayleigh fading are the Cumulative Probability Distribution Function (CPDF) and the Level Crossing Rate (LCR). IS-55 states that an unmodulated carrier with Rayleigh fading should meet the following performance:

1. The measured Rayleigh (CPDF) should match the calculated CPDF using the following criterion:

   a) The measured CPDF of power shall be within ±1 dB of the calculated CPDF from +10 dB above the mean power to 20 dB below the mean power.

   b) The measured CPDF of power shall be within ±5 dB of the calculated CPDF from 20 dB to 30 dB below the mean power.

2. The measured LCR should match the calculated LCR, and not deviate more than ±10% of the simulated vehicle speed over a range of 3 dB above the mean power level to 30 dB below the mean power level.

The theoretical and measured CPDF are shown in Figure 3-9. This plot is the probability of a signal level being less then the mean level. The LCR plots, shown in Figure 3-10, are the number of crossings per second versus the signal power. In both of these plots the signal power is relative to the mean. The CPDF and LCR were taken with an 80 Hz Doppler frequency. Both of these plots show that the measured performance of the TAS 4500 well exceeds the IS-55 standards for Rayleigh fading.

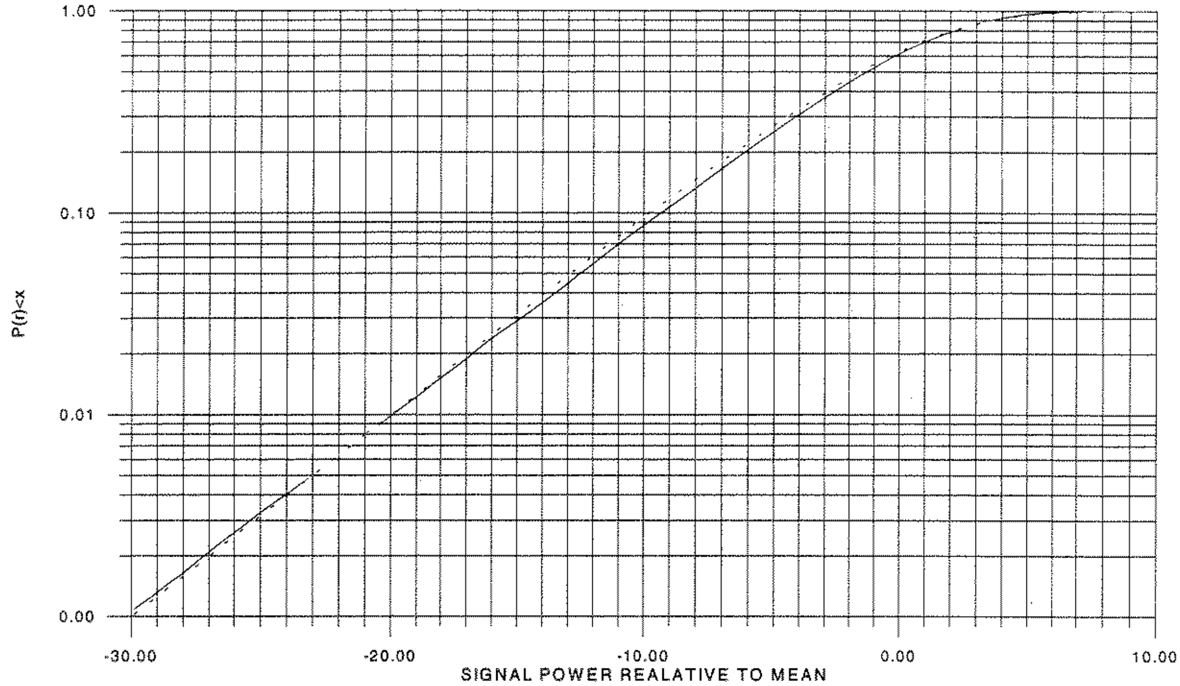

Figure 3-9. Measured vs. Theoretical CPDF
______ Measured
_ _ _ _ _ Theoretical

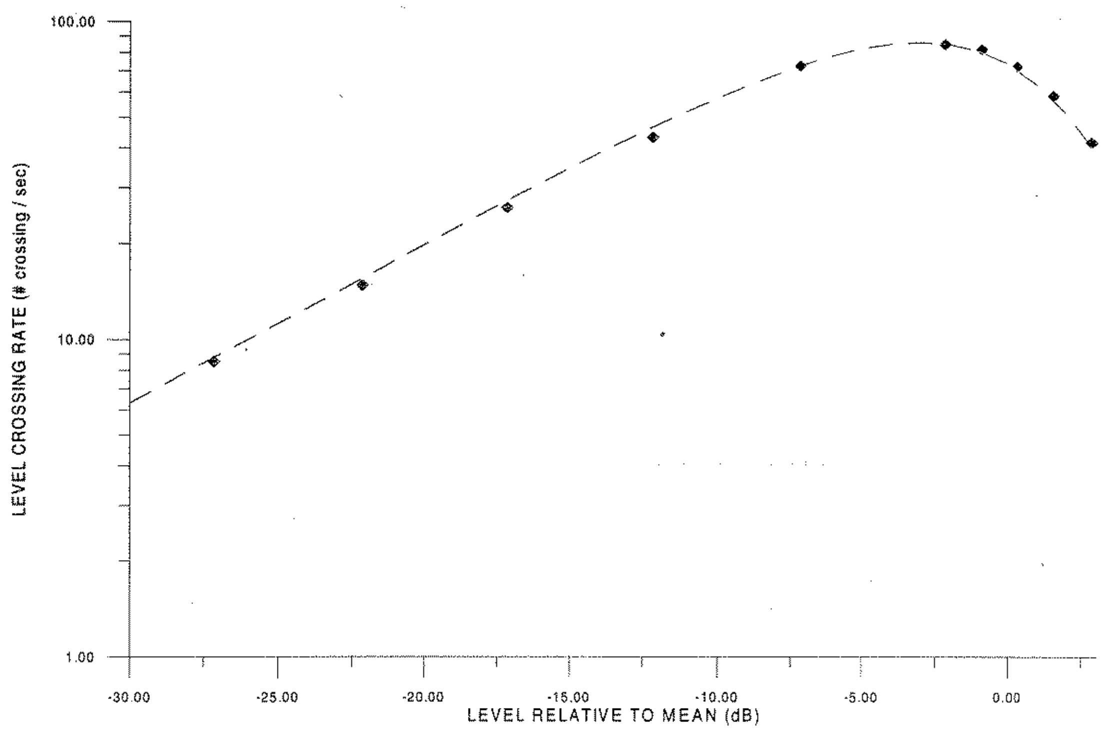

Figure 3-10. Measured vs. Theoretical LCR
♦ ♦ ♦ ♦ Measured
_ _ _ _ _ Theoretical

3.5.6. Fading Power Spectrum

The TAS 4500 allows the user to select the shape of the power spectrum produced by multipath fading. The four possible spectrum shapes that can be set are shown in Figure 3-11. The first shape, Classical 6 dB, adheres to the spectral requirements detailed in the IS55/56 (TDMA North American Dual-Mode Cellular) and IS97/98 (CDMA North American Dual Model Cellular) test specifications for Rayleigh fading conditions. The Flat spectrum shape has been determined to be representative of the multi-path propagation effects experienced in some indoor applications. The Classical 3 dB and Rounded spectrum shapes are defined in the CODIT specification.

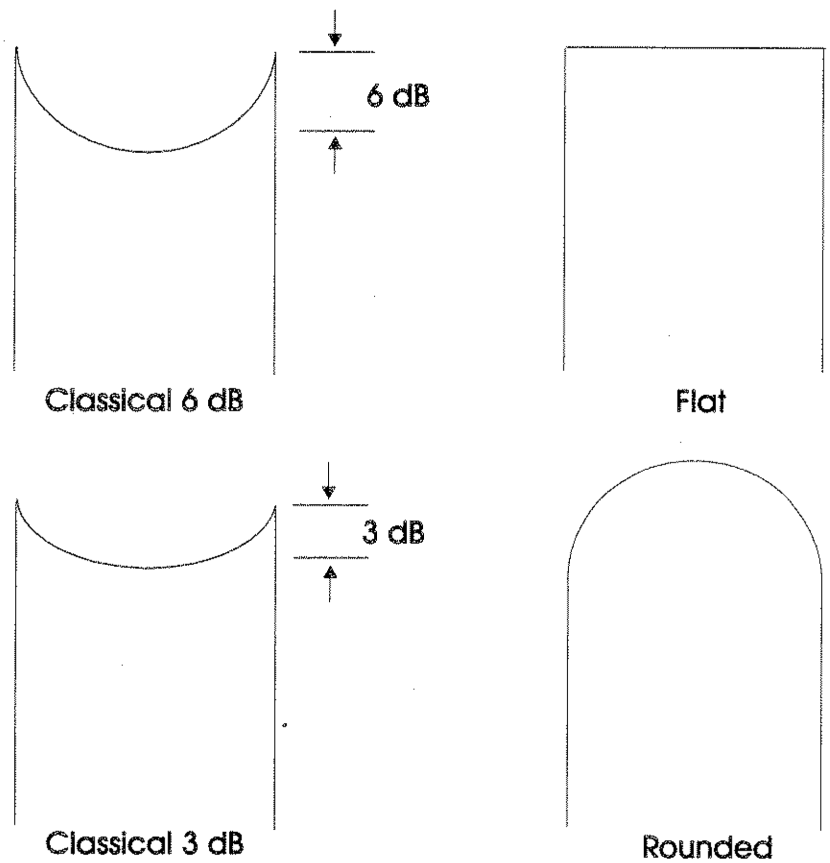

Figure 3-11. Fading Power Spectrum Shape

The Classical 6 dB and Flat shapes are available when in Jakes Emulation Mode and are set remotely using the Rayleigh Power Spectrum parameter (CONFIG:RAYPS). All four shapes are available when in filtered noise Emulation Mode and are set remotely using the Fading Environment Type parameter (CHi_Pj:FADET). The fading power spectrum is set locally in the path/modulation submenu. For further details on setting this parameter see Section 2.4.2 Selecting the Rayleigh Power Spectrum Shape.

3.5.7. Correlation Between Rayleigh-faded Paths in Different Channels

The test channel for diversity applications requires programmable correlation between Rayleigh faded paths in different branches (channels). Each channel of the 4500 represents a branch of a diversity test channel. As a result one 4500 unit supports dual diversity test applications, two 4500 units support either triple or quadruple diversity applications, and four 4500 units support eight branch diversity applications. The TAS 4500 allows the user to program the correlation factor (coefficient) between two Rayleigh faded paths in different channels. The correlation factor is a measure of the similarity between the two paths' output waveforms. Diversity receiver schemes often use the lack of perfect correlation between multipath signals to help resolve the original transmit signal.

The amplitude characteristics of a path using Rayleigh modulation can be described as a random variable with a Rayleigh distribution. For example if CH1 is the random variable that represents the amplitude characteristics of Channel 1 Path 1, and CH2 is the random variable that represents the amplitude characteristics of Channel 2 Path 4, the correlation coefficient, r , that defines the relationship between Channel 1 and Channel 2 is given below:

$$r = \frac{C_{P1P4}}{\sigma_{P1}\sigma_{P4}}$$

where C_{CH1CH2} is the covariance, and σ_{CH1} and σ_{CH2} are the standard deviations of CH1 and CH2. A correlation factor of 1.00 between Path 1 and Path 4 means that the two paths fade in harmony with each other. While a correlation factor of 0.00 indicates the paths fade independently. Correlation factors that fall between the extremes of 0.00 and 1.00, describe the degree of the relationship between the output signal amplitudes of the two paths at any instant in time.

The correlation factor between liked numbered paths in Channel 1 and Channel 2 can be programmed from 0.00 to 1.00 in 0.01 steps as described in Section 2.6. Setting Rayleigh Fading Correlation. A correlation factor of 1.00 between a given pair of paths means that the two paths fade in harmony with each other. While a correlation factor of 0.00 indicates the paths fade independently. Correlation factors that fall between the extremes of 0.00 and 1.00, describe the degree of the relationship between the output signal amplitudes of the two paths at any instant in time.

Phase Offset related to Diversity Applications

Phase misalignment between correlated signals may introduce measurement errors. Many diversity receivers compensate for phase offset but some types of receivers or measurement techniques may not do this compensation.

Two common causes of phase offset are:

- Non-symmetrical measurement setups
- Small propagation delay differences between channels

If the test setup is not symmetric (balanced) such as in the case where the signals being measured pass through different length cables, a phase offset (shift) will be created. At 1.8 GHz, the wavelength is only 16.67 cm, so that a small difference is cable length has a significant effect on the phase. This phase offset may prevent some measurement techniques from obtaining consistent and accurate measurement results.

A phase offset is also caused by a difference in propagation delay between the channels (branches). The propagation delay between channels of the 4500 FLEX may not be identical. The resulting phase shift may prevent some measurement techniques from obtaining consistent and accurate results.

One method for compensating for phase offset before performing correlation measurements is a follows:

1. Set correlation between channels to 1.00.

2. Observe the down converted signals using two channels of a storage oscilloscope.

3. If channel 1 signal is not aligned with channel 2 signal, adjust the Path Delay within each channel in the TAS 4500 FLEX until they are aligned on the oscilloscope.

Correlation Coefficient Algorithm

The TAS 4500 allows the user to set the algorithm used to determine the correlation coefficient. The correlation algorithm can set in two modes, envelope and component. Figure 3.12 shows a TAS 4500 providing the inputs to a 2 branch diversity receiver. Inside the diversity receiver the signals are quadrature demodulated. With the correlation algorithm set to envelope, the correlation coefficient is a measure of the correlation between the signals at points A and B in the diversity receiver. This is the standard definition of correlation, and is the default setting for the TAS 4500. When the correlation algorithm is set to component, the correlation coefficient is a measure of the correlation between signals at points A_I and B_I in addition to the correlation between points A_Q and B_Q. In this setting the correlation coefficient defines the correlation between the In-Phase components of the associated Rayleigh faded signals in addition to the correlation between the Quadarature components.

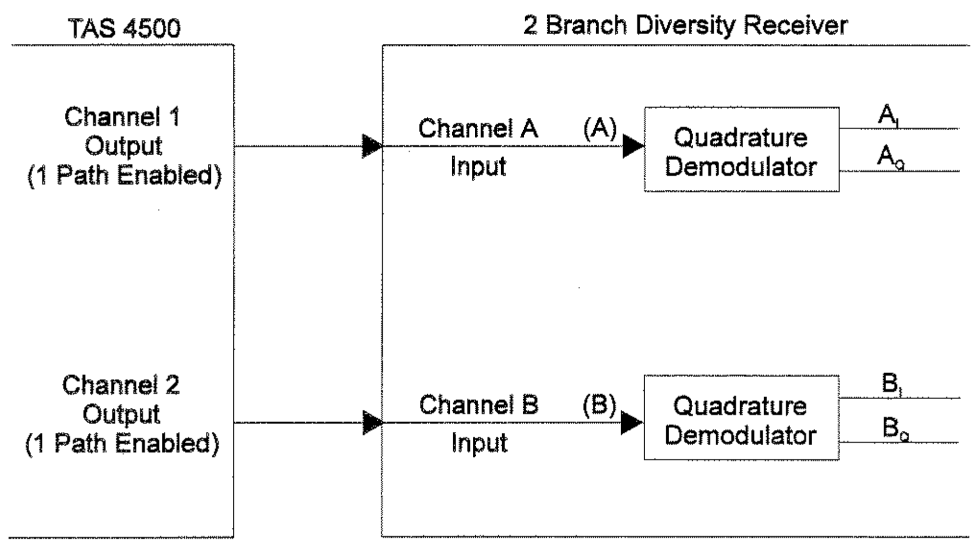

Figure 3-12. 2 Branch Diversity Receiver with Demodulator

3.5.8. Path Correlation for 2 Branch Diversity Test Applications

The correlation factor between liked numbered paths in Channel 1 and Channel 2 can be programmed from 0.00 to 1.00 in 0.01 steps. This can be done from the front panel as described in Section 2.6. or with the remote control command set as described in Section 5.3.

The following is a list of helpful tips that should be considered when using the 4500 in a 2 branch diversity test application.

1. The CHANNEL CORR (CNFG:CHCORR) parameter must be set to TYPE1.

2. The correlation factor (coefficient) is programmable between specific pairs of paths; one path in channel 1 and one path in channel 2 as follows:

   Path 1 in channel 1 to Path 1 in channel 2
   Path 2 in channel 1 to Path 2 in channel 2
   Path 3 in channel 1 to Path 3 in channel 2
   Path 4 in channel 1 to Path 4 in channel 2 (if installed)
   Path 5 in channel 1 to Path 5 in channel 2 (if installed)
   Path 6 in channel 1 to Path 6 in channel 2 (if installed)

   Paths should be enabled as a pair as defined above, a path from channel 1 and the associated path from channel 2. **Path loss and path delay for each path in a pair should be set to equivalent values.** For example, if path 1 is enabled in channel 1 with a path loss of 6 dB and a delay of 5 microseconds and path 2 is enabled with a path loss of 8 dB and a delay of 9 microseconds then paths 1 and 2 should be enabled in channel 2 with the same path loss and delay settings as paths 1 and 2 of channel 1.

3. All active (enabled) paths in channel 1 and in channel 2 must be programmed to Rayleigh modulation with the Doppler frequency set to the same value. Programmable correlation is undefined for other modulation types.

4. The input reference level, and the output attenuation should be set to equivalent levels to align the average output power from both channels to be the same. Typically the most convenient method to configure the input reference level is to perform an autorange after the transmit signal is present at the RF IN ports of the TAS 4500.

5. The correlation factor (coefficient) should be programmed to zero (0.00) to disable channel correlation.

It is recommended that you allow the TAS 4500 unit to warm up for at least thirty minutes before beginning any tests.

3.5.9. Path Correlation for 4 Branch Diversity Test Applications

TAS 4500 units that are equipped with the factory installed 4 Branch Diversity feature can provide comprehensive control of the correlation factor (coefficient) between paths in up to four channels. Two 4500 units (a primary unit provides channels 1 and 2, while a secondary unit provides channel 3 and 4) used in conjunction with the TASKIT/Diversity software provide up to six programmable Correlation Coefficients (CC). These coefficients apply to the entire channel (branch) and will affect all the paths that are enabled within the channel. The table below defines the relationship between correlation coefficients and the paths that will be affected. Note, paths 4,5 and 6 are only available if installed into the unit and are not required for 4 branch diversity.

Channel (CH) Output Affected by Correlation Coefficients	Applicable Correlation Coefficients (CC)	Path (P) Correlation Defined By Coefficient(s)
1	$CC_{1,2}$	$(P1)_{CH1}$ to $(P1)_{CH2}$ $(P2)_{CH1}$ to $(P2)_{CH2}$ $(P3)_{CH1}$ to $(P3)_{CH2}$ $(P4)_{CH1}$ to $(P4)_{CH2}$ $(P5)_{CH1}$ to $(P5)_{CH2}$ $(P6)_{CH1}$ to $(P6)_{CH2}$
2	$CC_{1,2}$	$(P1)_{CH1}$ to $(P1)_{CH2}$ $(P2)_{CH1}$ to $(P2)_{CH2}$ $(P3)_{CH1}$ to $(P3)_{CH2}$ $(P4)_{CH1}$ to $(P4)_{CH2}$ $(P5)_{CH1}$ to $(P5)_{CH2}$ $(P6)_{CH1}$ to $(P6)_{CH2}$
3	$CC_{1,3}$, $CC_{2,3}$	$(P1)_{CH1}$ to $(P1)_{CH2}$ to $(P1)_{CH3}$ $(P2)_{CH1}$ to $(P2)_{CH2}$ to $(P2)_{CH3}$ $(P3)_{CH1}$ to $(P3)_{CH2}$ to $(P3)_{CH3}$ $(P4)_{CH1}$ to $(P4)_{CH2}$ to $(P4)_{CH3}$ $(P5)_{CH1}$ to $(P5)_{CH2}$ to $(P5)_{CH3}$ $(P6)_{CH1}$ to $(P6)_{CH2}$ to $(P6)_{CH3}$
4	$CC_{1,4}$, $CC_{2,4}$, $CC_{3,4}$	$(P1)_{CH1}$ to $(P1)_{CH2}$ to $(P1)_{CH3}$ to $(P1)_{CH4}$ $(P2)_{CH1}$ to $(P2)_{CH2}$ to $(P2)_{CH3}$ to $(P2)_{CH4}$ $(P3)_{CH1}$ to $(P3)_{CH2}$ to $(P3)_{CH3}$ to $(P3)_{CH4}$ $(P4)_{CH1}$ to $(P4)_{CH2}$ to $(P4)_{CH3}$ to $(P4)_{CH4}$ $(P5)_{CH1}$ to $(P5)_{CH2}$ to $(P5)_{CH3}$ to $(P5)_{CH4}$ $(P6)_{CH1}$ to $(P6)_{CH2}$ to $(P6)_{CH3}$ to $(P6)_{CH4}$

The Correlation Coefficients (CC) are defined as follows:

$CC_{1,2}$: specifies the amount of correlation between the paths in channel 1 and those in channel 2.

$CC_{1,3}$: specifies the amount of correlation between the paths in channel 1 and those in channel 3.

$CC_{2,3}$: specifies the amount of correlation between the paths in channel 2 and those in channel 3.

$CC_{1,4}$: specifies the amount of correlation between the paths in channel 1 and those in channel 4.

$CC_{2,4}$: specifies the amount of correlation between the paths in channel 2 and those in channel 4.

$CC_{3,4}$: specifies the amount of correlation between the paths in channel 3 and those in channel 4.

To illustrate the effect of the correlation coefficients on the output characteristics of a specific channel consider the following example involving the channel 4 output (2nd channel in the secondary unit). The characteristics of the Rayleigh fading of this output can be influenced by the fading from each of the 12 paths depending on the value of the three coefficients ($CC_{1,4}$, $CC_{2,4}$, $CC_{3,4}$) defined above. As a consequence, the composite Rayleigh modulation for path 1 of channel 4 is formed by scaling and summing the independent modulation from path 1 of channel 4 $(M1)_{CH4}$ with that of path 1 of channel 1 $(M1)_{CH1}$, along with path 1 of channel 2 $(M1)_{CH2}$, and path 1 of channel 3 $(M1)_{CH3}$ as illustrated below:

Output Rayleigh Modulation for Path 1 of Channel 4 = (CH4C_1) * $(M1)_{CH1}$
+ (CH4C_2) * $(M1)_{CH2}$ + (CH4C_3) * $(M1)_{CH3}$ + (CH4C_4) * $(M1)_{CH4}$

Similarly:

Output Rayleigh Modulation for Path 2 of Channel 4 = (CH4C_1) * $(M2)_{CH1}$
+ (CH4C_2) * $(M2)_{CH2}$ + (CH4C_3) * $(M2)_{CH3}$ + (CH4C_4) * $(M2)_{CH4}$

Output Rayleigh Modulation for Path 3 of Channel 4 = (CH4C_1) * $(M3)_{CH1}$
+ (CH4C_2) * $(M3)_{CH2}$ + (CH4C_3) * $(M3)_{CH3}$ + (CH4C_4) * $(M3)_{CH4}$

Output Rayleigh Modulation for Path 4 of Channel 4 = (CH4C_1) * $(M4)_{CH1}$
+ (CH4C_2) * $(M4)_{CH2}$ + (CH4C_3) * $(M4)_{CH3}$ + (CH4C_4) * $(M4)_{CH4}$

Output Rayleigh Modulation for Path 5 of Channel 4 = (CH4C_1) * $(M5)_{CH1}$
+ (CH4C_2) * $(M5)_{CH2}$ + (CH4C_3) * $(M5)_{CH3}$ + (CH4C_4) * $(M5)_{CH4}$

Output Rayleigh Modulation for Path 6 of Channel 4 = (CH4C_1) * $(M6)_{CH1}$
+ (CH4C_2) * $(M6)_{CH2}$ + (CH4C_3) * $(M6)_{CH3}$ + (CH4C_4) * $(M6)_{CH4}$

where:

CH4C_1, CH4C_2, CH4C_3, and CH4C_4 are amplitude scalers whose value are a function of the correlation coefficients

$(M1)_{CH1}$, $(M2)_{CH1}$, ... $(Mx)_{CHy}$ are the Rayleigh independently modulated signals from path x of channel y.

The following is a list of helpful tips that should be considered when using the 4500 in a 4 branch diversity test application.

1. The 4500 test setup must be configured in a manner that is consistent with the installation instructions in Section 1.3 of this manual.

2. Control of the parameters associated with 4 branch diversity is not available from the front panel of the 4500 and is provided only from the remote control interface. TASKIT/Diversity software from TAS is the recommended method for controlling the 4500 for 4 branch diversity applications.

3. The correlation factor (coefficient) is programmable between specific groups of paths as follows:

   - (path 1 in channel 1) to (path 1 in channel 2) to (path 1 in channel 3) to (path 1 in channel 4)
   - (path 2 in channel 1) to (path 2 in channel 2) to (path 2 in channel 3) to (path 2 in channel 4)
   - (path 3 in channel 1) to (path 3 in channel 2) to (path 3 in channel 3) to (path 3 in channel 4)
   - (path 4 in channel 1) to (path 4 in channel 2) to (path 4 in channel 3) to (path 4 in channel 4) (if installed)
   - (path 5 in channel 1) to (path 5 in channel 2) to (path 5 in channel 3) to (path 5 in channel 4) (if installed)
   - (path 6 in channel 1) to (path 6 in channel 2) to (path 6 in channel 3) to (path 6 in channel 4) (if installed)

4. Paths should be enabled as a group as defined above; a path from channel 1 and the associated path in each of the other channels. **Path loss and path delay for each path in a group should be set to equivalent values.** For example, if path 1 is enabled in channel 1 with a path loss of 6 dB and a delay of 5 microseconds then path 1 should be enabled with 6 dB of path loss and a delay of 5 microseconds in all the other channels that are being used.

5. All active (enabled) paths in all channels must be programmed to Rayleigh modulation with the Doppler frequency set to the same value. Programmable correlation is undefined for other modulation types.

6. The input reference level, and the output attenuation should be set to equivalent levels to align the average output power from all channels to be the same. Typically the most convenient method to configure the input reference level is to perform an autorange after the transmit signal is present at the RF IN ports of the TAS 4500.

7. The correlation coefficients for channel 1 to 2, channel 1 to 3, and channel 1 to 4 are all independent parameters and can be programmed over the range from 0.00 to 1.00. The valid programmable range that is available to the channel 2 to 3 correlation coefficient depends on values that have been specified for the channel 1 to 2 correlation coefficient and the channel 1 to 3 coefficient. Similarly the valid programmable range that is available to the channel 2 to 4 correlation coefficient depends on values that have been specified for the channel 1 to 2 correlation coefficient, channel 1 to 3 coefficient, channel 2 to 3 coefficient and the channel 1 to 4 coefficient. Finally, the valid programmable range that is available to the channel 3 to 4 correlation coefficient depends on values that have been specified for all the other correlation coefficients.

8. The correlation factor (coefficient) should be programmed to zero (0.00) to disable channel correlation.

It is recommended that you allow the TAS 4500 unit to warm up for at least thirty minutes before beginning any tests.

3.5.10. Path Correlation for 8 Branch Diversity Test Applications

TAS 4500 units that are equipped with the factory installed 8 Branch Diversity feature can be configured in a group of four units to support an 8 branch test application. When configured properly this setup provides 8 independent (uncorrelated) channels of Rayleigh modulation. Programmable correlation is restricted and is available only between the channels within a 4500 unit. The correlation between pairs that span more than one 4500 unit cannot be programmed but are nominally uncorrelated to each other.

The following is a list of helpful tips that should be considered when using the 4500 in a 8 branch diversity test application.

1. The 4500 test setup must be configured in a manner that is consistent with the installation instructions in Section 1.3 of this manual.

2. The TAS 4500 can be controlled from the front panel or the remote control interface in an 8 branch diversity application. It is required that the CHANNEL CORR (CNFG:CHCORR) parameter be set as follows:

INSTRUMENT	CHANNEL CORRELATION
1st 4500	TYPE2
2nd 4500	TYPE3
3rd 4500	TYPE4
4th 4500	TYPE5

3. Programmable correlation is restricted to channels within the same 4500. The correlation factor (coefficient) is programmable between specific pairs of paths; as follows:

   Path 1 in channel 1 to Path 1 in channel 2
   Path 2 in channel 1 to Path 2 in channel 2
   Path 3 in channel 1 to Path 3 in channel 2
   Path 4 in channel 1 to Path 4 in channel 2 (if installed)
   Path 5 in channel 1 to Path 5 in channel 2 (if installed)
   Path 6 in channel 1 to Path 6 in channel 2 (if installed)

   Path 1 in channel 3 to Path 1 in channel 4
   Path 2 in channel 3 to Path 2 in channel 4
   Path 3 in channel 3 to Path 3 in channel 4
   Path 4 in channel 3 to Path 4 in channel 4 (if installed)
   Path 5 in channel 3 to Path 5 in channel 4 (if installed)
   Path 6 in channel 3 to Path 6 in channel 4 (if installed)

Path 1 in channel 5 to Path 1 in channel 6
Path 2 in channel 5 to Path 2 in channel 6
Path 3 in channel 5 to Path 3 in channel 6
Path 4 in channel 5 to Path 4 in channel 6 (if installed)
Path 5 in channel 5 to Path 5 in channel 6 (if installed)
Path 6 in channel 5 to Path 6 in channel 6 (if installed)

Path 1 in channel 7 to Path 1 in channel 8
Path 2 in channel 7 to Path 2 in channel 8
Path 3 in channel 7 to Path 3 in channel 8
Path 4 in channel 7 to Path 4 in channel 8 (if installed)
Path 5 in channel 7 to Path 5 in channel 8 (if installed)
Path 6 in channel 7 to Path 6 in channel 8 (if installed)

4. Paths should be enabled as a pair within each 4500 unit as defined above. **Path loss and path delay for each path in a pair should be set to equivalent values.** For example, if path 1 is enabled in channel 1 with a path loss of 6 dB and a delay of 5 microseconds and the path 2 is enabled with a path loss of 8 dB and a delay of 9 microseconds then paths 1 and 2 should be enabled in channel 2 with the same path loss and delay settings as paths 1 and 2 of channel 1.

5. The correlation between pairs that span more than one 4500 unit cannot be programmed but are nominally uncorrelated to each other.

6. All active (enabled) paths in each 4500 must be programmed to Rayleigh modulation with the Doppler frequency set to the same value. Correlation is undefined for other modulation types.

7. The input reference level, and the output attenuation should be set to equivalent levels to align the average output power from all channels to be the same. Typically the most convenient method to configure the input reference level is to perform an autorange after the transmit signal is present at the RF IN ports of the TAS 4500.

8. The correlation factor (coefficient) should be programmed to zero (0.00) to disable channel correlation.

9. It is recommended that you allow the TAS 4500 unit to warm up for at least thirty minutes before beginning any tests.

3.5.11. Static Frequency Shift (Static Doppler)

Static frequency shift from the carrier frequency occurs when the distance between the receiver and transmitter is changing. An example of this is when a mobile receiver (car) is driving away from the transmitter. Path (A) in Figure 3-4 will have a static frequency shift due to the movement of the car. The amount of the frequency shift (Doppler frequency) from the carrier is determined by the following formula:

$$Freq_{Doppler} = \frac{Velocity_{mobile} \times Freq_{carrier}}{C}$$

where C = Speed of Light (3×10^8 m/s)

The Doppler frequency can be either positive or negative depending whether the mobile receiver is moving away from or towards the transmitter respectively. The TAS 4500 implements a static frequency shift through the modulator circuit (Figure 3-5).

3.5.12. Static Phase Shift

A static phase shift is a result of the random distance between the transmitter and receiver. This distance is very rarely going to be an integer number of carrier wavelengths; a non-integer value will result in a static phase shift on the signal path. The amount of phase shift can vary between 0 and 360 degrees.

The TAS 4500 implements the static phase shift through the modulator circuit shown in Figure 3-5. Refer to Section 7.0. Technical Specifications for the range of phase shift supported by your TAS 4500.

3.5.13. Rician Fading

Rician fading is formed by the sum of a Rayleigh distributed signal and a Line-Of-Site (LOS or direct path) signal, where the LOS signal is typically subjected to a static frequency shift (static Doppler). A fading environment typically associated with Rician fading is that where one strong direct path reaches the receiver at roughly the same delay as multipath from local scatterers.

The 4500 supports both the general case of Rician fading as well as Rician fading with characteristics per the GSM specification. Version 3.50 of GSM Recommendation 5.05 specifies the angle of arrival of the LOS signal path to be 45°, resulting in a Doppler shift that is 0.7 of the maximum Doppler shift of the Rayleigh distributed signal (classical Doppler spectrum). GSM also specifies that the signal power of Rician fading be split equally between the LOS and multipaths (where the power envelope of the multipaths combine to from a Rayleigh distribution) with no relative delay. A theoretical power spectral density for GSM compliant Rician fading is shown in Figure 3-13 and a measured spectral density is shown in Figure 3-14. GSM specified Rician is emulated by the 4500 when the modulation type for the Path 1 in Channel 1 is set to "GSM_Rician".

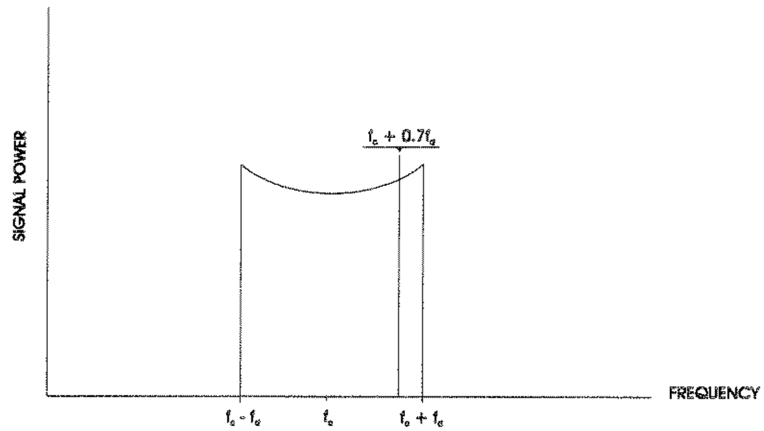

Figure 3-13. Theoretical Power Spectral Density for GSM Rician

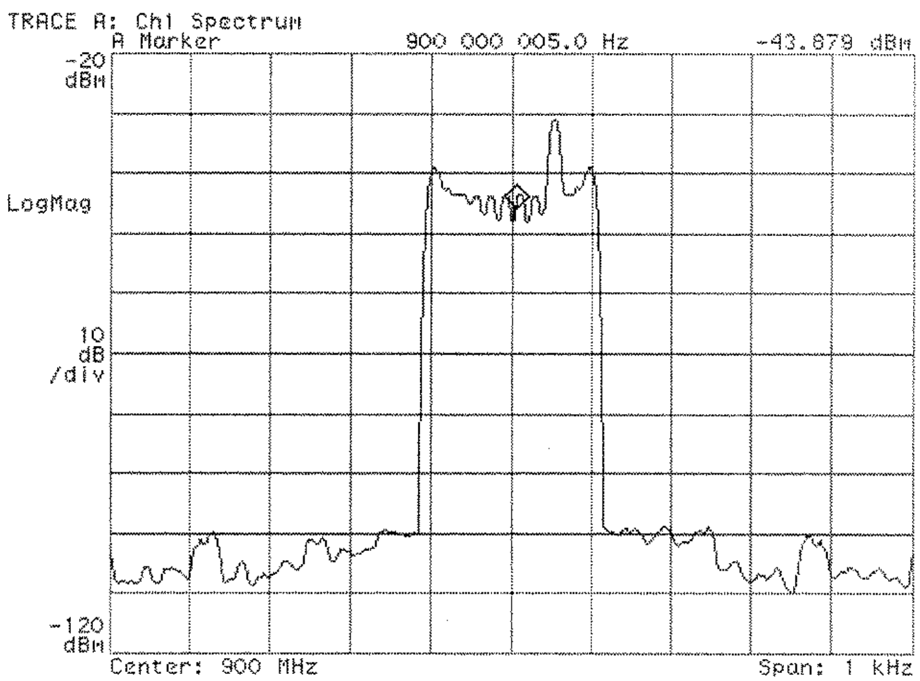

Figure 3-14. Measured GSM Rician Fading Power Spectral Density

Doppler Freq. = 100 Hz
Center Freq. = 900 MHz
Span = 1 kHz
RBW = 10 Hz
Sweep Time = 30 sec.
Emulation Method = Jakes

In the general case of Rician fading the arrival angle of the LOS path at the receiver is programmable, as is the ratio of power between the LOS path and the multipath. The TAS 4500 provides access to both the LOS arrival angle and the LOS path to multipath power ratio, defined as the K factor expressed in dB. Changing the LOS arrival angle will move the relative location of the direct path with respect to the faded spectrum by changing the static Doppler shift of this component. This Doppler shift is set according to the following equation:

$$\text{Doppler}_{\text{direct component}} = \text{Doppler}_{\text{faded component}} \times \text{cosine(LOS arrival angle)}$$

The K factor setting then controls the relative power of the direct path and the multipath and has a valid range of -30dB (faded spectrum will dominate) to +30dB (LOS signal will dominate). The general case of Rician is emulated by the 4500 when the modulation type is set to "Rician."

3.5.14. Rayleigh Fading with Frequency Shift

Rayleigh fading with frequency shift cascades frequency shift modulation with Rayleigh modulation within a single path. This modulation type is only available in Jakes emulation mode. This modulation type allows a channel of the 4500 to generate multiple Rayleigh faded carriers from a single transmit carrier input. For example, consider the case where a transmitter with carrier frequency F_c is input into a 4500 that is equipped with 3 paths per channel. Three different Rayleigh faded carriers will be generated and combined for input into the receiver that is connected to the output of the 4500 channel. The following table provides a general illustration of this feature.

Path	Input Carrier Freq.	Modulation Type	Shift Freq.	Path Output
1	F_c	Rayleigh	none	Rayleigh faded carrier at F_c
2	F_c	Rayleigh with Freq. Shift	F_{s1}	Rayleigh faded carrier at $F_c + F_{s1}$
3	F_c	Rayleigh with Freq. Shift	F_{s2}	Rayleigh faded carrier at $F_c + F_{s2}$

Refer to Section 7.0. Technical Specifications for the range of Rayleigh Doppler and the range of the shift frequency provided by the TAS 4500.

3.5.15. Log-Normal Fading (Active Terrain Emulation™)

Log-Normal fading is the slow variation of the average signal power over time. A plot of signal power versus time for log-normal fading is shown in Figure 3-15. Note that the time scale is much larger than that for Rayleigh fading shown in Figure 3-6. The variation in signal strength at the receiver is due to blockage or absorption of the signal by large-scale variations in the terrain profile and by changes in the nature of the local topography in the path from the transmitter to the receiver. The blockage of the signal is caused by elements in the environment such as hills or a building. This phenomenon is often called shadowing since the receiver is passing through a large "shadow" of an object. An example of this can be seen in Figure 3-16 as the mobile receiver (car) passes in the "shadow" of the building, the signal strength would fade.

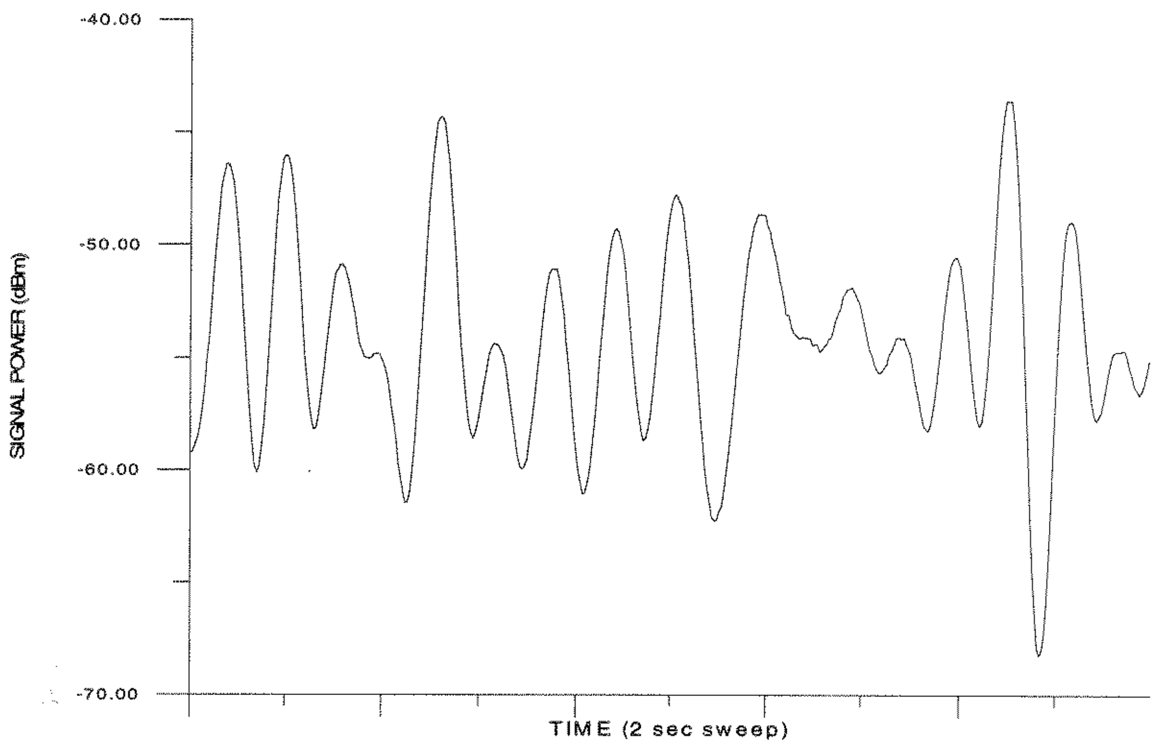

Figure 3-15. Log-Normal Fading vs. Time
Log-Normal Standard Deviation = 10 dB
Log-Normal Rate = 10 Hz
Path Loss = 25 dB
Center Freq. = 900 MHz
Span = 0 Hz
RBW = 100 kHz
Sweep Time = 2 sec.

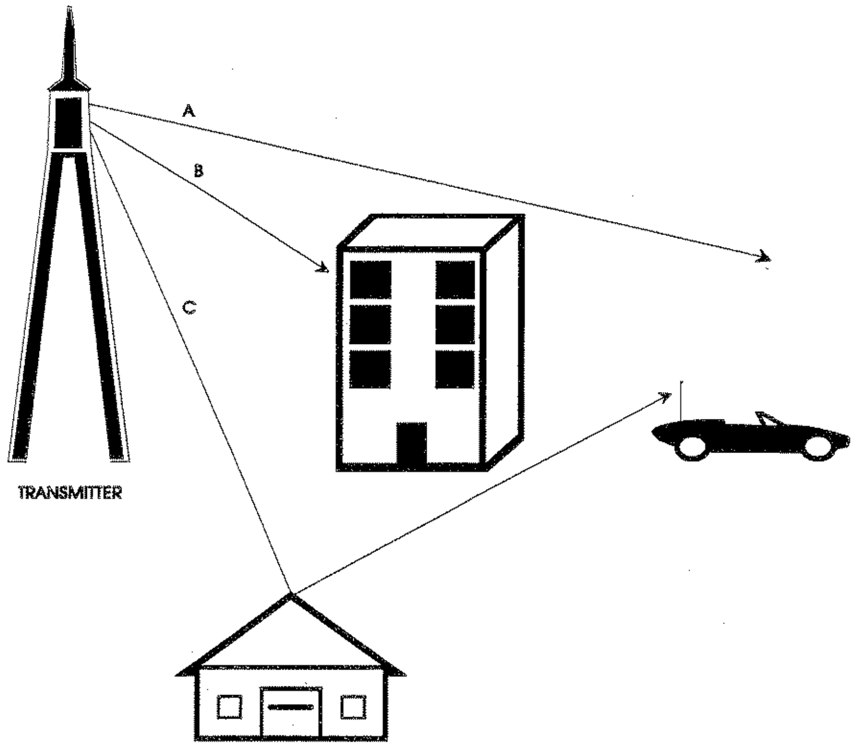

Figure 3-16. Transmitter to Receiver Log-Normal Diagram

This fading has statistical characteristics that are represented by a log-normal distribution of fluctuations in the mean (average) signal power expressed in decibels (dB). The standard deviation of the log-normal distribution is determined by the characteristics of the terrain where the transmitter and receiver are located. For example, a standard deviation of between 6-8 dB is typical for urban areas, while a deviation of 10-12 dB can be observed in rural locations.

The maximum rate of the log-normal fading must also be specified. The rate of log-normal fading is the maximum frequency of the fading spectrum and defines the maximum pace the that mobile will move through the shadow of elements in the terrain. An example can be given of a mobile receiver (car) driving at a fixed speed along a road. If the car is in a rural area behind hills far apart, the log-normal rate would be small since the car is moving through "shadows" at a slow rate. If the car is in an urban area behind rows of buildings, the rate would be larger since the mobile would be passing through "shadows" at a higher rate.

The following relationship holds for log-normal fading:

$$\text{Log Normal Rate (Hz)} = \frac{\text{Mobile Velocity (m / s)}}{\text{Min. Shadow Length (m)}}$$

The log-normal frequency in this equation will be the maximum rate that the mobile will move through "shadows". This corresponds to the maximum frequency of the log-normal fading spectrum that has a span that begins near DC.

As described above log-normal is terrain-induced fading that has statistical properties that are defined by its standard deviation and rate. The ability to program these parameters allows the 4500 to actively emulate a variety of terrain. This capability is called Active Terrain Emulation™ .

Referring to Figure 3-3, the log-normal circuitry follows the modulator circuit. Both the log-normal and path loss are implemented using the same hardware. The hardware consists of a single modulator in the IF signal path. The log-normal modulation signal is formed with a digital synthesis method.

When log-normal fading is enabled, the user can independently program the log-normal standard deviation and log-normal rate for each of the instrument's paths.

Before programming the log-normal parameters, it is important to understand the interrelationship of the path LOSS and LOG NORMAL STD parameters. To attain a minimum of two sigma amplitude variation for the log-normal standard deviation parameter on the desired path the following upper and lower bound requirements must be met:

1. Two times the LOG NORMAL STD value plus the path LOSS value is upper bounded by a total of 50 dB.
2. The path LOSS value minus two times the LOG NORMAL STD value is lower bounded by 0 dB.

As an example with LOG NORMAL STD set to 12 dB, a two sigma amplitude variation can be achieved with path LOSS set to 25 dB.

If the path loss and the standard deviation parameters are programmed in such a way that a 2 sigma variation cannot be met a [LN_UNCAL] prompt is displayed on the instrument's screen to indicate the current settings are un-calibrated. When the [LN_UNCAL] message is displayed, the amplitude variation, induced by log-normal fading, will remain symmetrical around the mean power level but will be limited by the minimum distance of the current loss setting to either 0 or 50 dB.

For example, with the log-normal standard deviation set to 10 dB and the path loss set to 16 dB, the maximum amplitude variations will be constrained by ± 16 dB. Since 16 dB < 20 dB (2 x 10dB = 20dB), a two sigma amplitude variation cannot be achieved and the [LN_UNCAL] message would be displayed.

3.5.16. Suzuki Fading

Suzuki fading is the superposition of Rayleigh fading and log-normal fading. Log-normal is the variation in the mean (average) received signal power as the receiver moves from place to place within a given area. This is caused by large-scale variations in the terrain profile along the path to the transmitter and by changes in the nature of the local topography. Log-normal is often termed "slow fading." Superimposed on this slow fading are the rapid and severe variations in the received signal strength caused by multipath propagation in the immediate vicinity of the receiver. This is Rayleigh fading which is caused by scattering from man-made and natural obstacles such as buildings and trees in the local geographical area (within a few hundred wavelengths of the receiver). Rayleigh fading is commonly called "fast fading".

The TAS 4500 is easily configured to generate Suzuki fading by setting the characteristics of a specific path to Rayleigh modulation and enabling log-normal fading with the desired standard deviation and rate.

3.5.17. Nakagami Fading

Nakagami fading describes the time domain characteristics of the envelope power of a faded signal. There are two controllable parameters associated with this fading type, the direct path angle of arrival and the M value. The Probability Density Function of the envelope of the Nakagami faded signal is controlled by the M value. The Nakagami M value provides a means of differentiating the typical fading environments by providing a relative measure of how 'direct' the received paths are.

The programmable M value describes the fading condition as the ratio of the direct signal component to multi-path faded signal components. The discrete range of M values supported in the TAS 4500 offer a progression from a Rayleigh faded distribution (M=1) to a single direct path (M=100) which approaches a pure frequency shifted component. The values between these two limits (M=3, 5, 10, 15, and 25) describe an environment where both a direct path and a multi-path are present, where the M value defines a relative power ratio of the direct path to faded path components. One reference which describes various fading environments in terms of multiple Nakagami paths is the UMTS Code Division Testbed (the propagation model to be used for CODIT).

The programmable angle of arrival will then change the position of the direct path relative to the multi-path component. This is accomplished by scaling the static Doppler shift of the direct path appropriately. This Doppler shift is set according to the following equation:

$$\text{Doppler}_{\text{direct component}} = \text{Doppler}_{\text{faded component}} \times \text{cosine(angle of arrival)}$$

3.6 Dynamic Parameter Emulation Mode with Power Delay Profiles

The Dynamic Emulation Mode allows the user to cascade multiple static parameter "states" to emulate a dynamic propagation environment. Each "state" is defined by the modulation type, modulation setting, path loss and delay for each path in the system. Each "state" is active for a user specified time before stepping to the next "state" in the environment. The user has the ability to run through the states once, to loop through the states indefinitely, or to single step from one state to the next.

For each "state" a nominal Power versus Delay Profile (PDP) graph is displayed. The PDP displays the power of each path as a function of the delay of the path. The powerful Dynamic Emulation Mode can be used in many applications, such as adaptive antenna array and Rake receiver testing, and "playback" of measured propagation data This mode is only available through TASKIT/Dynamic.

3.6.1 State Settings

The Dynamic Parameter Emulation mode allows up to 512 individual states to be configured. For each state the TAS 4500 must be given:

- State duration
- Number of active paths
- State Doppler frequency
- Relative path loss for each path
- Relative delay for each path
- Modulation type for each path
- Modulation setting for each path (i.e. phase shift, Doppler frequency, angle of arrival)

In this mode the emulation method is set to filtered noise, therefore Rayleigh with frequency offset is not available as a modulation type. All other modulation types are available in this mode.

Each state has a "state" Doppler frequency. All paths with multipath fading enabled will have their Doppler set to the "state" Doppler. During the transition from one state to the next each path is individually disabled for a brief duration. For this reason, it is recommended that the user use at least two paths in every state while using the dynamic parameter emulation feature.

An Arrival Angle parameter is available within Dynamic Parameter Emulation Mode for paths within each state with frequency shift, Rician, or Nakagami modulation selected. Using the arrival angle, the Doppler for any frequency shifted component will be set automatically. The equation for the frequency shifted Doppler frequency is:

$$\text{Doppler}_{\text{frequency shift}} = \text{Doppler}_{\text{state}} \times \text{cosine(arrival angle)}$$

Refer to Section 7.0. Technical Specifications for ranges and resolutions for the active parameters while in Dynamic Parameter Emulation Mode.

3.6.2 The Power Delay Profile

For each state, a Power Delay Profile will be displayed. Power Delay Profiles are often used to characterize received signals for adaptive antenna array systems and Rake receiver systems. In this plot, the nominal path signal strength in dB is displayed versus the relative path delay setting. Both channels are displayed on a single graph.

The following is the example of a Power Delay Profile plot that approximates a hilly urban area with 6 paths.

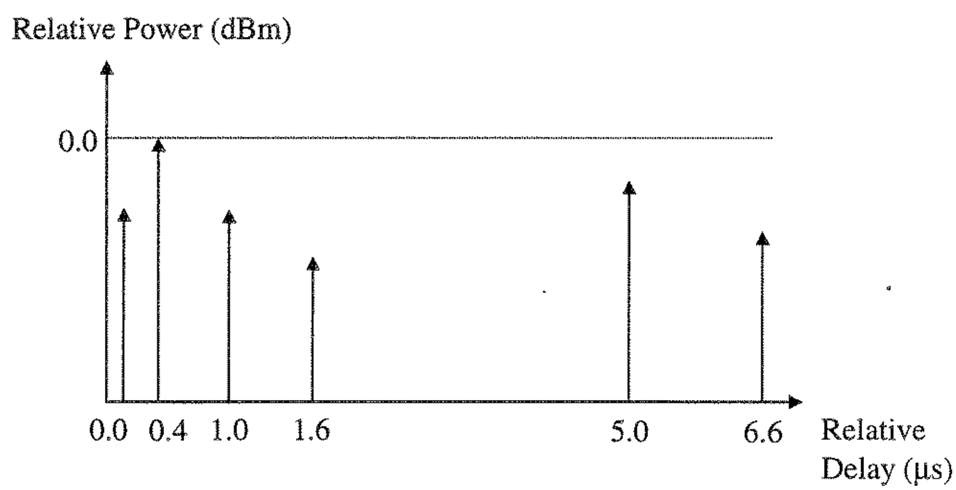

Figure 3-17. Power Delay Profile Example

3.7. Insertion Loss Estimation

The TAS 4500 has been equipped with an insertion loss estimation capability which can be accessed only through the TASKIT control interface. This feature is designed to provide the user with an insertion loss estimate from the RF input of the instrument to the RF output. This feature is not designed to be an absolute power measurement tool, but rather a reasonable estimate of the insertion loss in the TAS 4500. It is assumed that the contributions of all paths are orthogonal to one another ignoring the possible effects of constructive or destructive interference between paths with relative phase or delay offsets.

4.0. Remote Operation

4.1. Overview

A computer or terminal can control the TAS 4500 by issuing commands through the GPIB or RS-232C remote control port. The TAS 4500 supports three control link protocols:

- RS-232 CR/LF
- RS-232 ACK/NAK
- GPIB

CR/LF (carriage return/line feed) is a simple command-line protocol, and allows you to control TAS 4500 from a dumb terminal or a computer. In addition to being easiest to implement, the CR/LF protocol provides a convenient way to practice using the 4500 command set.

ACK/NAK is a more sophisticated serial control protocol that includes error-checking and command retransmission.

GPIB (General Purpose Instrumentation Bus) is the industry-standard parallel-bus instrument control protocol.

4.2. Remote Control Features

TAS 4500 commands are arranged in functional groups. The following brief descriptions outline the function of each TAS 4500 command group. For a complete description, refer to Section 5.0. Command Reference.

- The CHAN1/CHAN2 command groups are used to setup parameters common to a transmission channel.
- The CNFG command group is used to setup system configuration parameters.
- The FILE command group is used to save and recall standard and user-defined files.
- The MEAS command group is used to make measurements on transmission channel.
- The CH1_P*x*/CH2_P*x* command groups are used to setup parameters common to a transmission path.

4.3. Configuring the TAS 4500 for Remote Control

Before you can control TAS 4500 from a remote terminal or computer, you must first set the remote control configuration. The remote configuration can be set only from the TAS 4500 front panel. To set the remote control configuration, you must perform the following steps:

1. Verify the remote LED located at the lower right-hand corner of the front panel is off, thus indicating that the unit is in local operation mode.
2. Select the **CONFIG** menu tree.
3. Enter the **Remote Protocol** submenu.
4. Select the desired protocol (**gpib**, **crlf**, or **acknak**).
5. Enter the submenu of the specified protocol and set the protocol specific options.
6. Use the key next to the remote LED to select remote operation mode.

For example, to configure TAS 4500 for RS-232 CR/LF control, select REMOTE PROTOCOL: **crlf**, and press ENTER to select the **crlf** submenu. Next, set the BAUD RATE, DATA, PARITY, and STOP parameters for the CR/LF protocol. Figure 4-1 shows the screens used to configure the remote protocol parameters.

```
CONFIG\REMOTE PROTOCOL
PROTOCOL: crlf↵
```

```
CONFIG\REMOTE PROTOCOL\CRLF                    ⇩
BAUD RATE: 1200
```

```
CONFIG\REMOTE PROTOCOL\CRLF                    ⇧
DATA: 7         PARITY: odd         STOP: 1
```

Figure 4-1. Menu Screens to Configure Remote Protocol Parameters

For more information on the TAS 4500 CONFIG menu tree, see Section 2.0. Local Operation. For detailed information on each of the TAS 4500 link control protocols, see the "Remote Control Protocol" information in this section.

4.4. TAS 4500 Command Protocol

4.4.1. Command Types

TAS 4500 supports three distinct types of commands. These command types are SET commands, REPORT commands, and EXECUTE commands.

SET commands simply assign a value to a TAS 4500 configuration parameter. If TAS 4500 receives a SET command without a parameter value, it returns the current setting of the parameter.

REPORT commands return a value. For example, the CNFG command that returns the version number of the firmware is a REPORT command.

EXECUTE commands instruct TAS 4500 to perform an operation. For example, the GPIB command that disables the front control panel is an EXECUTE command. EXECUTE commands do not return a value.

4.4.2. Command Sequence

To execute a TAS 4500 command, a controller must execute a simple three-step sequence:

1. Check for any pending command response. TAS 4500 does not execute a new command if the result from a previous command has not been read.

2. Send the command to the TAS 4500.

3. Read the command response from the TAS 4500.

4.4.3. Command Messages

A TAS 4500 command message consists of one or more command frames. A command frame consists of a command group name and one or more commands. A slash precedes and follows each command frame. A colon follows the command group name, and a comma follows each command name except the last command. TAS 4500 ignores white space within the command frame and characters are not case sensitive. The command frame has the following syntax:

/command group: command1, command2, ..., commandn/

All of the commands within a command frame must belong to the same command group. An example of a command group is CH1_P1:

/CH1_P1: MOD=FS, DOPP=100/

The above command sets the following Channel 1 Path 1 parameters:

- SET Channel 1 Path1 modulation to frequency shift
- SET Channel 1 Path1 Doppler frequency to +10 Hz.

NOTE: All of the commands in the previous example are SET commands.

An example of a REPORT command is:

/CNFG:MODL/

This command instructs the instrument to report its model number. The response would be:

/CNFG:MODL=4500/

If TAS 4500 receives a SET command without a parameter value, it returns the current value of the parameter. For example, the following message tells TAS 4500 to return the value of the PATH1 modulation parameter:

/CH1_P1: MOD/

The TAS 4500 would respond with the following message:

/CH1_P1: MOD=FS/

An example of an EXECUTE command is:

/FILE: FRCL/

This command tells TAS 4500 to EXECUTE a file recall.

A command message can contain more than one command frame. For example, the following command message tells TAS 4500 to EXECUTE diagnostics, SET the RESPONSE mode to TERSE, and REPORT the current value of the Doppler frequency for Path 1:

/CNFG:DIAG, RESP=TERSE/CH1_P1:DOPP/

A single slash separates the CNFG command group from the CH1_P1 command group.

4.4.4. Response Format

TAS 4500 provides an explicit response to each command message that it receives. A command message can be one of three types:

- Command Completion message
- Value message
- Error message

Command Completion Message

TAS 4500 returns a command completion message in response to a SET command or EXECUTE command. The command completion message is:

/C/

Parameter Value Readback

TAS 4500 returns a value message in response to a REPORT command. The form of the value message is:

/command group: command=value/

For example, if the controller sends the message

/CH1_P2: MOD/

TAS 4500 might respond with

/CH1_P2: MOD=RAYL/

This response indicates that Rayleigh modulation is selected for Channel 1 Path 2.

Error Message Format

TAS 4500 returns an error message when it detects a problem with command syntax, or when it detects an internal processing error. The form of the error message is:

/command group: Exxx/

where *xxx* is the error number.

Response to a Multiple-Command Message

TAS 4500 returns only one response for each command message that it receives. If the command message contains multiple commands, TAS 4500 responds to the last command in the message. If one of the commands in a multiple command message results in an error, TAS 4500 ceases processing the command message and reports the error.

Terse Responses

If the PROTOCOL RESPONSE MODE is **terse**, TAS 4500 does not include the slashes, command group name, or parameter name in the response. The following command transactions illustrate the format of terse responses.

Command: /CNFG: MODL/

Response: 4500

4.5. Transmission Layer Protocols

TAS 4500 provides three remote control protocol options: RS-232 CR/LF, RS-232 ACK/NAK, and GPIB. The command syntax remains the same, regardless of the remote protocol. The remote control protocol determines only the method by which TAS 4500 receives commands and provides responses.

4.5.1. RS-232C CR/LF Protocol

The TAS 4500 RS-232 CR/LF is the simplest remote control protocol. You can use this protocol to control TAS 4500 from a data terminal or a computer. The RS-232 CR/LF protocol does not perform error checking, so you should not use this protocol unless the control terminal or computer is co-located with the TAS 4500.

TAS 4500 provides a **>** prompt when it is ready to receive a command. To enter a command, simply type the command, then press CARRIAGE RETURN. TAS 4500 executes the command and provides a response. After TAS 4500 provides the response, it sends another **>** prompt to indicate that it is again ready to receive a command.

4.5.2. ACK/NAK Protocol

The TAS 4500 ACK/NAK protocol supports RS-232 multipoint communication between a controller and one or more TAS devices. ACK/NAK also detects command transmission errors, and provides for retransmission of corrupted commands.

The controller initiates all ACK/NAK protocol transactions. To effect a command transaction with TAS 4500, the controller must perform the following operations:

- Poll the TAS 4500 for a pending response.
- Send the command to TAS 4500.
- Poll TAS 4500 for the command response.

The following example illustrates a command transaction between a controller and TAS 4500.

First, the controller polls for any pending response. This ensures that the TAS 4500 response buffer is empty so that TAS 4500 can process the next command.
[addr]p<ENQ>

The TAS 4500 response buffer is empty, so it responds:

[addr]<EOT>

Next, the controller sends the command to TAS 4500:

[addr]s<ENQ><SOH><STX>/CNFG: CHCORR=TYPE1/<ETX>[checksum]

TAS 4500 receives the command, does not detect any errors, and responds:

[addr]<ACK>

The controller then polls for the response to the command:

[addr]p<ENQ>

TAS 4500 has finished executing the command, so it responds:

[addr]<SOH><STX>/C/<ETX>[checksum]

NOTE: [addr] is the device address. The address can be any decimal number from 0 to 99. If the address is less than 10, the controller must left-pad the address with a space.

[checksum] is the message checksum. The message checksum is a three-digit decimal number. [checksum] is the two's complement of the module 256 sum of all characters from the first address character through the <ETX> character. For example, if the checksum is 201, then the block checksum should be 055 (256-201).

<ENQ> is the ASCII INQUIRE control character.

<EOT> is the ASCII END OF TRANSMISSION control character.

<SOH> is the ASCII START OF HEADER control character.

<STX> is the ASCII START OF TEXT control character.

<ETX> is the ASCII END OF TEXT control character.

Polling the TAS 4500 for a Response

When TAS 4500 receives a command from the controller, it executes the command and prepares a response. The controller must poll TAS 4500 to receive this response. The poll sequence is:

[addr]p<ENQ>

The poll message results in one of the following:

- TAS 4500 does not respond.
- TAS 4500 has no response waiting.

  `[addr]<EOT>`
- TAS 4500 provides a response.

  `[addr]<SOH><STX>[response]<ETX>[checksum]`

TAS 4500 does not respond to a poll if one of the following conditions exists:

- The TAS 4500 configuration is not proper. For example, TAS 4500 does not respond if its ACK/NAK address does not match the address contained in the poll message.
- TAS 4500 is currently processing a command.
- The poll message has been corrupted by an error.
- TAS 4500 AC power is off.

If the controller does not receive a response from TAS 4500, it should poll again. TAS 4500 responds with [addr]<EOT> if it has no response pending.

Sending Commands to the TAS 4500

To send a command to TAS 4500, the controller must assemble and send a SELECT message. The format of the SELECT message is shown below.

[addr]s<ENQ><SOH><STX>[command]<ETX>[checksum]

The select message yields one of three possible results:

- TAS 4500 does not respond to the message.
- TAS 4500 detects an error in the message:

  [addr]<NAK>
- TAS 4500 receives the message and does not detect any errors:

  [addr]<ACK>

TAS 4500 does not respond to the SELECT message if one of the following conditions exists:

- The TAS 4500 address does not match the address contained in the SELECT message.
- TAS 4500 AC power is off.

TAS 4500 responds with a negative acknowledgment (NAK) if it detects a transmission error in the SELECT message (bad checksum), or if the message is too long (greater than 512 characters). If TAS 4500 detects a transmission error in the message, the controller should send the message again.

Receiving Responses from the TAS 4500

TAS 4500 provides a command response when it is polled by the controller. If the controller detects a transmission error in the TAS 4500 response, it should perform the following steps:

- Poll TAS 4500 until TAS 4500 responds with [addr]<EOT>.
- Send the message again.
- Poll TAS 4500 again for the response.

4.5.3. GPIB Protocol

The TAS 4500 GPIB protocol supports a parallel bus control architecture in which TAS 4500 is one of the devices being controlled. The controller must meet all GPIB electrical and mechanical specifications.

The controller initiates all GPIB protocol transactions. In order to communicate with TAS 4500, a GPIB controller must perform the following operations:

- Poll TAS 4500 for a pending response.
- Send the message to TAS 4500.
- Poll TAS 4500 for the command response.

TAS 4500 provides a GPIB status byte to indicate its current state. Possible states include:

- IDLE - 02H
- BUSY - 01H
- READY TO RESPOND (RTR) - 04H or 44H

IDLE indicates that TAS 4500 does not have a message to send and is ready to accept a command.

BUSY indicates that TAS 4500 is currently processing a command. TAS 4500 does not accept a new command until it has finished processing the current command and has provided the response to the controller.

READY TO RESPOND (RTR) indicates that TAS 4500 currently has a message to send to the controller. TAS 4500 is always Ready to Respond when it finishes processing a command.

When TAS 4500 is ready to respond, it activates the service request line (SRQ), and sets the RTR status to 44 hex. After the controller conducts the serial poll, SRQ goes inactive, and TAS 4500 sets the RTR status to 04 hex.

Figure 4-2 shows a flowchart for a typical bus controller sequence.

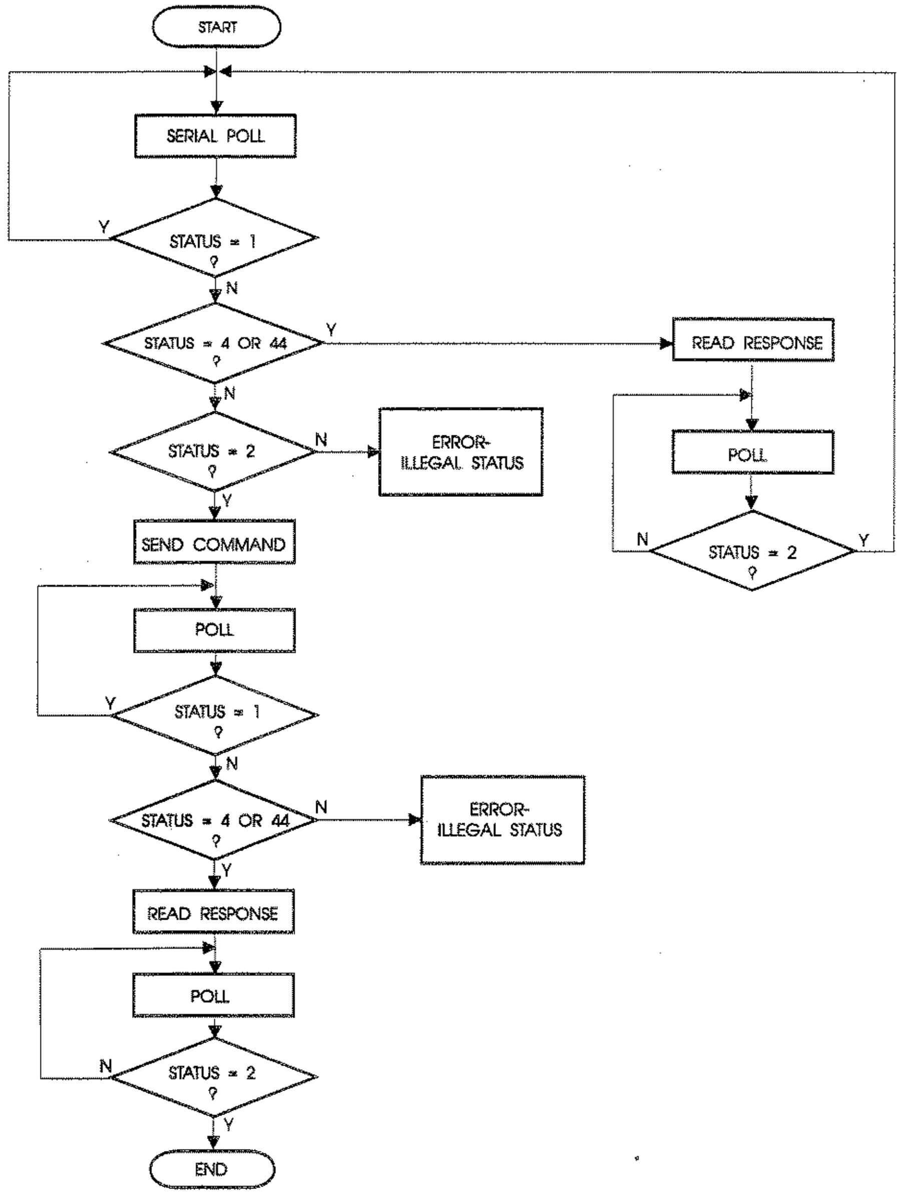

Figure 4-2. GPIB Controller Sequence

Polling for a Response

The controller must conduct a serial poll to receive a command response from TAS 4500. The following example shows the typical GPIB sequence required to achieve a serial poll of TAS 4500. Your actual bus sequence may be different:

a. ATN active

b. UNT - (UNTalk)

c. UNL - (UNListen)

d. SPE - (Serial Poll Enable)

e. MTA - (TAS 4500 My Talk Address)

f. Controller programmed to listen

g. ATN inactive

h. TAS 4500 sends status

i. ATN active

j. SPD - (Serial Poll Disable)

k. UNT - (UNTalk)

Always conduct a serial poll before sending a command to TAS 4500. If TAS 4500 has a pending message to send, it does not accept a new command.

Sending Commands to the TAS 4500

The following example shows the typical GPIB sequence required to send a command to TAS 4500. Your actual bus sequence may be different.

a. ATN active

b. UNT - (UNTalk)

c. UNL - (UNListen)

d. MLA - (TAS 4500 My Listen Address)

e. Controller programmed to talk

f. ATN inactive

g. Controller sends command to TAS 4500 and asserts EOI with last command character

h. ATN active

i. UNL - (UNListen)

Command strings must not be terminated with CARRIAGE RETURN or CARRIAGE RETURN+LINE FEED. The controller must signal the end of a command message by asserting EOI (end of interrupt) while it sends the last character of the message.

Some commands require several seconds of TAS 4500 processing time. While TAS 4500 completes most commands in less than 100 msec., some commands may require up to 3 seconds. The controller should conduct serial polls until the TAS 4500 status is RTR.

Receiving Responses from the TAS 4500

The following example shows the typical GPIB sequence required to receive a command from TAS 4500. Your actual bus sequence may be different.

a. ATN active

b. UNT - (UNTalk)

c. UNL - (UNListen)

d. MTA - (TAS 4500 My Talk Address)

e. Controller programmed to listen

f. ATN inactive

g. TAS 4500 sends data to controller

h. Controller reasserts control when EOI goes active

i. ATN active

j. UNT - (UNTalk)

TAS 4500 does not terminate its response message with a CARRIAGE RETURN or CARRIAGE RETURN+LINE FEED. TAS 4500 signals the end of a response message by raising EOI while it sends the last character of the response.

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5.0. Command Reference

This section is designed to help those who are already familiar with the TAS 4500 command set to easily find and use commands. The TAS 4500 Parameter Reference provides a complete description of each command group and all commands within each group.

The user should be thoroughly familiar with Section 4.0. "Remote Operation", before attempting to use the TAS 4500 remote commands. The "Remote Operation" section provides the details of the TAS 4500 command message format and syntax.

5.1. Conventions to Specify Commands

The TAS 4500 commands are divided into three types: SET, REPORT, and EXECUTE. In the Command Summary, these three types are indicated in the column type.

SET commands are issued to the TAS 4500 in the format:

/command group:parameter=setting/

The TAS 4500 will respond to a legal SET command with the response:

/C/

REPORT commands require the format:

/command group:name/

The TAS 4500 will provide the requested information as:

/command group:name=response/

where *response* can be more than one value separated by commas. All SET commands respond like REPORT commands if "*=setting*" is left out. The returned value is the current setting of the parameter.

EXECUTE commands require the format:

/command group:command/

If the command is successful, the TAS 4500 will respond with:

/C/

5.2. Command Summary

Channel 1 or Channel 2 **CHAN1:** or **CHAN2:**

Name	Description	Data Range	Type
CBP	RF Channel Bypass	ON,OFF	SET
FC	Set Channel Carrier Frequency	25000 to 3000000[1] (25.000MHz to 3000.000MHz)	SET
ILEVEL	Set Channel Input Level	50 to -300 (5.0 to -30.0 dBm)	SET
LOSEL	Select Local Oscillator Control	EXT, AUTO, MANU, EX4500	SET
LOFRQ	Set LO Frequency In Manual Mode 200 MHz LO Option 800 MHz LO Option 1800 MHz LO Option 940 MHz to 2860 MHz LO Option	 20000 to 40000 (200.00 MHz to 400.00 MHz) 80000 to 110000 (800.00 MHz to 1100.00 MHz) 180000 to 250000 (1800.00 MHz to 2500.00 MHz) 94000 to 286000 (940.00 MHz to 2860.00 MHz)	SET
OUTATTEN	Set output attenuator loss (Optional) 800 to 2500 MHz Attenuator (Type1) 25 to 3000 MHz Attenuator (Type3)	 0 to 800 (0.0 to 80.0 dB) 0 to 955 (0.0 to 95.5 dB)	SET
RANGE	Perform Automatic Input Range	None	EXEC

File Save & Recall **FILE:**

Name	Description	Data Range	Type
FNAM	Set File Name	(see Note [2])	SET
FRCL	Recall File With Current Name (See FNAM)	None	EXEC
FSAV	Save File To Current Name	None	EXEC

Measure **MEAS:**

Name	Description	Data Range	Type
SEL	Select Measurement Source	SIGN1, SIGN2 (Channel 1 or Channel 2 input)	SET
VALUE	Take A Measurement and Report Result Value	None	RPT

---

[1] Manufacturing calibration and test frequency range extends only to 2.7 GHz

[2] FNAM options are the read/write files: file0, file1, file2, file3, file4, and the read-only files IS55-56_1, IS55-56_2, IS55-56_3, CDMA_1, CDMA_2, CDMA_3, CDMA_4, CDMA_5, HT100_1, HT100_2, TU50_1, TU50_2, EQ50, EQ100, RA100_1, RA100_2, RA250_1, RA250_2 and FDEFAULT

System Configuration **CNFG:**

Name	Description	Data Range	Type
CHCORR	Sets the Channel Correlation	TYPE1, TYPE2, TYPE3, TYPE4, TYPE5, TYPE6, TYPE7	SET
CH1A_1	Channel 1 (2) Correlation Scaler 1	0 to FFFF (two's compliment hexadecimal)	SET
CH1A_2	Channel 1 (2) Correlation Scaler 2	0 to FFFF (two's compliment hexadecimal)	SET
CH3B_1	Channel 3 Correlation Scaler 1	0 to FFFF (two's compliment hexadecimal)	SET
CH3B_2	Channel 3 Correlation Scaler 2	0 to FFFF (two's compliment hexadecimal)	SET
CH3B_3	Channel 3 Correlation Scaler 3	0 to FFFF (two's compliment hexadecimal)	SET
CH4C_1	Channel 4 Correlation Scaler 1	0 to FFFF (two's compliment hexadecimal)	SET
CH4C_2	Channel 4 Correlation Scaler 2	0 to FFFF (two's compliment hexadecimal)	SET
CH4C_3	Channel 4 Correlation Scaler 3	0 to FFFF (two's compliment hexadecimal)	SET
CH4C_4	Channel 4 Correlation Scaler 4	0 to FFFF (two's compliment hexadecimal)	SET
CORRAL	Sets the Correlation Algorithm	TYPE1 (envelope) TYPE2 (component)	SET
DIAG	Perform Diagnostics	None	EXEC
DSP1	Report DSP1 Version Number	None	RPT
DSP2	Report DSP2 Version Number	None	RPT
DSP_EXE	Starts Execution of Suspended DSP Operations	None	EXEC
DSP_INIT	Initialize Digital Signal Processor Operations	None	EXEC
DSP_STOP	Stops (Suspends) Execution of DSP Operations	None	EXEC
EMULM	Emulation Mode	MODE1 (static), MODE2 (dynamic)	SET
ESYS	Report Extended System Configuration	None	RPT
FADEM	Fading Emulation Method	TYPE1 (Jakes Method) TYPE2 (Filtered Noise Method)	SET
LOC	Enable Local Control (Enter Local)	None	EXEC
MODL	Report System Model Number	None	RPT
RAYPS	Sets the shape of the Rayleigh Power Spectrum (only available in Jakes emulation mode)	TYPE1 (classical 6 dB) TYPE2 (flat)	SET
REF	Selects Internal/External 10 MHz reference	INT, EXT	SET
REM	Enable Remote Control (Enter Remote)	None	EXEC
RESP	Sets the remote response format	VERBOSE, TERSE	EXEC
SCV	Report System Controller Version Number	None	RPT
STAT	Report Last Error Status (Diagnostics Status)	None	RPT
SYS	Report System Configuration	None	RPT

Control All Paths **PATHS:**

Name	Description	Data Range	Type
D[3]	Set state machine data (Doppler and duration) for state n	"n;Doppler;duration" where: n = 1 to 512 Doppler = -7400 to -10,10 to 7400 (-740.0 to -1.0, 1.0 to 740.0 Hz) duration = 1 to 32765 (0.1 sec to 3276.5 sec)	SET
FADREP	Set nominal Fading Repetition Rate (only available for filtered noise emulation mode)	RATE1 (20 minutes) RATE2 (27 seconds) RATE3 (24 hours)	SET
HALT[3]	Halts execution of state machine	no data	EXEC
LOOP[3]	Loop execution of state machine over the programmed range of states	ON, OFF	SET
RANGE[3]	Set state machine range of execution	"begin state;end state: where: begin state = 1 to 512 end state = 1 to 512	SET
RUN[3]	Run (begin execution) state machine over programmed range of states	no data	EXEC
STEP[3]	Single step execution of state machine from current state to next state	no data	EXEC
S[3]	Set current state (GOTO) of state machine	1 to 512	SET

Path Correlation **CH2_Pi (i=1 to 6):**

Name	Description	Data Range	Type
CORR	Set Path Correlation Coefficient	0 to 10 (0.0 to 1.0)	SET
ECORR	Set Path Correlation Coefficient	0 to 100 (0.00 to 1.00)	SET

3 Only Available when Emulation Mode set to MODE2 (Dynamic)

Path Control **CH1_Pi, CH2_Pi: (i=1 to 6)**

Name	Description	Data Range	Type
AOA	Rician and Nakagami Angle of Arrival	0 to 3600 (0.0 to 360.0 degrees)	SET
D[3]	Set state machine data (modulation type, Doppler, loss and delay) for state n	"n;mod;mod data 1;mod data 2;loss;delay" where: n = 1 to 512 — mod = 0 to 5 0 - none 1 - Rayleigh 2 - Frequency Shift 3 - Phase 4 - Rician 5 - Nakagami — mod data 1 (for mod=0 or 1) = 0 mod data 1 (for mod=2) = -7400 to -10, 10 to 7400 (-740.0 to -1.0, 1.0 to 740.0 Hz) mod data 1 (for mod=3) = 0 to 3600 (0.0 to 360.0 degrees) mod data 1 (for mod=4 or 5) = -7400 to 7400 (-740.0 to 740.0 Hz) — mod data 2 (for mod=0,1,2. or 3) = 0 mod data 2 (for mod=4) = -300 to 300 (-30.0 to +30.0, K factor) mod data 2 (for mod=5) = 10,30,50,100,150,250,1000 (1,3,5,10,15,25,100, M value) — Loss = 0 to 501 (6 MHz IF module) (0.0 to 50.0 dB; 501 = path off) Loss = 0 to 401 (15 MHz IF module) (0.0 to 40.0 dB; 401 = path off) — delay = 0 to 200000 (6 MHz IF module) (0.0 to 200.000μs/50ns) delay = 0 to 100000 (15 MHz IF module) (0.0 to 100.000μs/25ns)	SET

[3] Only Available when Emulation Mode set to MODE2 (Dynamic)

Path Control **CH1_Pi, CH2_Pi: (i=1 to 6)**

Name	Description	Data Range	Type
DELAY	Set Relative Path Delay 6 MHz bandwidth IF Module with extended delay option 15 MHz bandwidth IF Module with extended delay option 26 MHz bandwidth IF Module with extended delay option	 0 to 200000 (0 to 200.000μs) 0 to 1600000 (0 to 1600.000μs) 0 to 100000 (0 to 100.000μs) 0 to 800000 (0 to 800.000μs) 0 to 66666 (0 to 66.666μs) 0 to 800000 (0 to 533.328μs)	SET
DOPP	Set Path Doppler Frequency	-7400 to -10, 10 to 7400 (-740.0 to -1.0, 1.0 to 740.0 Hz)	SET
FADET	Set fading environment type (only available in Filtered Noise emulation mode)	TYPE1 (classical 6 dB) TYPE2 (flat) TYPE3 (classical 3 dB) TYPE4 (rounded)	SET
FSF	Set Shift Frequency for Rayleigh With Frequency Shift (Jakes emulation mode only)	-2400 to 2400 (-240.0 Hz to 240.0 Hz)	SET
LNCAL	Report Log-normal calibration status	yes, no	RPT
LNRT	Set Path Log-normal rate	0 to 20000 (0 to 20.000 Hz)	SET
LNSTAT	Set Log-normal status	on, off	SET
LNSTD	Set Path Log-normal standard deviation	0 to 12	SET
LOSS	Set Relative Path Loss 6 MHz bandwidth IF Module 15 MHz bandwidth IF Module 26 MHz bandwidth IF Module	 0 to 500 (0 to 50.0 dB) 0 to 400 (0 to 40.0 dB) 0 to 300 (0 to 30.0 dB)	SET
MOD	Set Path Modulation Type	NONE, RAYL, FS, PHAS, RICE[4] , FSRAY, NAK, RICE_K	SET
NM	Set Nakagami M Value	1, 3, 5, 10, 15, 25, 100	SET
PHAS	Set Phase For Phase Modulation	0 to 3600 (0 to 360.0 degrees)	SET
RK	Set Rician K Factor	-300 to 300 (-30 dB to +30 dB)	
STAT	Set Path Status	ON, OFF	SET

[4] RICE corresponds to GSM_Rician which is available on CH1 path 1 only.

5.3. Command Descriptions

All commands summarized in the previous Section 5.2 "Command Summary" will be described in detail in this section.

5.3.1. Channel 1 & Channel 2 Configuration (CHAN1 & CHAN2)

Command Group Format:

/CHAN1:command(s)/ or /CHAN2:command(s)/

Command Group Description:

The CHAN1 and CHAN2 command groups allow the user to configure channel settings of the TAS 4500. The CHAN1 command group controls settings of channel 1 of the TAS 4500 while the CHAN2 command group controls settings of the channel 2 setting if the system is equipped with a second channel.

Commands:

CBP, FC, IGAIN, LOSEL, LOFRQ, OUTATTEN, RANGE

RF Channel Bypass (CBP)

Command Description:

Enable or Bypass the selected RF Channel

Valid Command Data:
Range: ON, OFF

Example:

To bypass Channel 1 of the TAS 4500.

/CHAN1:CBP = ON/

Expected Response:

/C/

Carrier Frequency (FC)

Command Description:

Sets the carrier frequency for the specific channel.

Valid Command Data:

Range: 25000 to 3000000 (25 MHz to 3.0 GHz)

NOTE: Range may vary according to RF options present. Consult Section 7 Technical Specifications of your model 4500 to confirm the valid range supported.

Example:

To set channel 1 carrier frequency to 900 MHz.

/CHAN1:FC=900000/

Expected Response:

/C/

Input Level (ILEVEL)

Command Description:

Sets the input reference level for the specific channel.

Valid Command Data:

Range: 50 to -300 (5.0 dBm to -30.0 dBm)

Example:

To set channel 2 input reference level to -15.0 dBm.

/CHAN2:ILEVEL= -150/

Expected Response:

/C/

Local Oscillator Control Mode (LOSEL)

Command Description:

This command selects the control mode of the local oscillator associated with the channel. AUTO and MANUal are only for systems that are equipped with internal local oscillator(s),

Valid Command Data:

EXT - External LO used. (i.e. Disable internal LO output)

AUTO - Internal LO frequency automatically tracks the carrier frequency

MANU - Internal LO enabled, but the user has to set the frequency manually

EX4500 - External LO from another 4500 channel used.

Example:

To change the channel 2 LO control to auto:

/CHAN2:LOSEL=AUTO/

Expected Response:

/C/

Local Oscillator Frequency (LOFRQ)

Command Description:

If equipped with this option, this command sets the LO frequency when the LO control is in manual mode. If the LO control is not in manual mode, an error will be returned. As different LO options support distinct frequency ranges, be sure to check to see which LO module is present in your system. This can be done by using the /CNFG:SYS/ command described in Section 5.3.2. See Section 3.4. for more details on setting the local oscillator control.

Valid Command Data:

LO 1 option
Range: 80000 to 110000 (800.00 MHz to 1100.00 MHz)

LO 2 option
Range:180000 to 250000 (1800.00 MHz to 2500.00 MHz)

LO 3 option
Range: 20000 to 40000 (200.00 MHz to 400.00 MHz)

LO4 option
Range: 94000 to 286000 (940.00 MHz to 2860.00 MHz)

Example:

To set the channel 1 local oscillator frequency to 940.00 MHz (in manual mode):

/CHAN1:LOFRQ=94000/

Expected Response:

/C/

Programmable Output Attenuator (OUTATTEN)

Command Description:

If equipped with this option, this command allows the amount of loss provided by the output attenuator to be programmed. See Section 3.4. for more information on the output attenuator.

Valid Command Data:

800 to 2500 MHz Attenuator / 0.1 dB step size (Type 1)
0 to 800 (0.0 to 80.0 dB)

25 to 3000 MHz Attenuator / 0.5 dB step size (Type 3)
0 to 955 (0.0 to 95.5 dB)

NOTE: TAS 4500 will round data to the nearest 0.5 dB step.

Example:

To set the output attenuator to 60.0 dB on channel 1:

/CHAN1:OUTATTEN=600/

Expected Response:

/C/

Automatic Input Range (RANGE)

Command Description:

Performs an automatic input range on the channel. If the input to the channel is out of the possible range, an error will be returned to signal a failure of the input range operation. See Section 3.4. for more information on the input range.

Valid Command Data:

None

Example:

To perform an automatic input range on channel 1:

/CHAN1:RANGE/

Expected Response:

If the input range is successful:

/C/

5.3.2. System Configuration (CNFG)

Command Group Format:

/CNFG:command(s)/

Command Group Description:

The CNFG command group allows the user to query, execute and select different system configuration settings.

Commands:

CHCORR, CH1A_1, CH1A_2, CH3B_1, CH3B_2, CH3B_3, CH4C_1, CH4C_2, CH4C_3, CH4C_4, CORRAL, DIAG, DSP1, DSP2, DSP_EXE, DSP_INIT, DSP_STOP, EMULM, ESYS, FADEM, LOC, MODL, OPT, RAYPS, REF, REM, SCV, STAT, SYS

Channel Correlation (CHCORR)

Command Description:

Selects different channel correlation configurations for the system. Under normal single instrument operation (power up system default is TYPE1), this parameter does not need to be changed. TYPE2, TYPE3, TYPE4, and TYPE5 are only used in an 8 branch diversity test configuration. TYPE6 and TYPE7 are only used in a 4 branch configuration for TAS 4500 units that are equipped with the factory installed 4 branch diversity test feature.

Valid Command Data:

TYPE1 - Normal single instrument configuration

TYPE2 - 1st unit in an 8 branch diversity configuration

TYPE3 - 2nd unit in an 8 branch diversity configuration

TYPE4 - 3rd unit in an 8 branch diversity configuration

TYPE5 - 4th unit in an 8 branch diversity configuration

TYPE6 - Primary (1st) unit in a 4 branch diversity configuration

TYPE7 - Secondary (2nd) unit in a 4 branch diversity configuration

Example:

To configure the 4500 as the secondary unit in a dual-instrument configuration:

/CNFG:CHCORR=TYPE3/

Expected Response:

/C/

Channel Correlation Scaler (CH1A_1, CH1A_2, CH3B_1, CH3B_2, CH3B_3, CH4C_1, CH4C_2, CH4C_3, CH4C_4)

Command Description:

Sets the different channel correlation scalers when operating in 4 branch diversity mode. Valid only when CHCORR set to TYPE6 or TYPE7 and are only used in a 4 branch configuration for TAS 4500 units that are equipped with the factory installed 4 branch diversity test feature.

Valid Command Data:

0 to FFFF (two's complement hexadecimal)

Example:

To set the Channel 4 Correlation Scaler 1 in the secondary 4500 unit:

/CNFG:CHC4C_1=7FFF/

Expected Response:

/C/

Correlation Algorithm (CORRAL)

Command Description:

Selects the correlation algorithm used to calculate the correlation coefficient.

Valid Command Data:

TYPE1 (Envelope) - Defines the correlation between the Rayleigh faded signals at the output of the associated channels.

TYPE2 (Component) - Defines the correlation between the In-Phase components of the associated Rayleigh faded signals in addition to the correlation between the Quadrature components.

Example:

To set the correlation algorithm based on the output of associated channels:

/CNFG:CORRAL=TYPE1/

Expected Response:

/C/

System Diagnostics (DIAG)

Command Description:

Performs a self-test and report system diagnostics. If the system encounters and error during the diagnostic, the system error will be returned. For more information on system errors, see Section 6.0. for a listing of the error codes.

Valid Command Data:

None

Example:

To perform a system diagnostic:

/CNFG:DIAG/

Expected Response:

If no error is encountered during the diagnostic:

/C/

Digital Signal Processors Version Numbers (DSP1 & DSP2)

Command Description:

Reports the version numbers of the digital signal processors. Command DSP1 queries the version number of processor 1 while command DSP2 queries the version number of processor 2.

Valid Command Data:

None

Example:

To query the version number of the digital signal processor 2:

/CNFG:DSP2/

Expected Response:

/CNFG:DSP2=4.00/

Execute Suspended Digital Signal Processor Operations (DSP_EXE)

Command Description:

Starts execution of suspended DSP operations for fading, frequency shift, and log-normal modulation that have been stopped (suspended) by the DSP_STOP command. This command should be sent to the primary 4500 unit of a dual-unit 4 branch diversity test system to restart DSP execution. The system controller of a 4 branch diversity test system must include this command in the control sequence for parameters associated with the following commands:

CNFG:CHCORR	CHi_Pj:LNRT
CNFG:FADEM	CHi_Pj:LNSTAT
CHi_Pj:DOPP	CHi_Pj:LNSTD
CHi_Pj:FADET	CHi_Pj:MOD
CHi_Pj:FADREP	CHi_Pj:STAT

where i = 1 to 2; j = 1 to 6

The following is an example of how the DSP_EXE command should be used when setting parameters that are associated with the CHi_Pj commands listed above:

1. The test system controller sends "/CNFG:DSP_STOP/" command to the primary 4500.
2. The test system controller sends any of the above listed CHi_Pj commands to the desired 4500.
3. The test system controller sends "/CNFG:DSP_INIT/" command to both the primary and secondary 4500.
4. The test system controller sends "/CNFG:DSP_EXE/" command to the primary 4500.

NOTE: The DSP_EXE command should only be used for dual-unit 4 branch diversity test systems.

Valid Command Data:

None

Example:

/CNFG:DSP_EXE/

Expected Response:

/C/

Initialize Digital Signal Processor Operations (DSP_INIT)

Command Description:

Initializes DSP operations for fading, frequency shift, and log-normal modulation. This command should be sent to both the primary and secondary 4500 of a dual-unit 4 branch diversity test system to initialize DSP operations. The system controller of a 4 branch diversity test system includes this command in the control sequence for parameters associated with the following commands:

CNFG:CHCORR	CHi_Pj:LNRT
CNFG:FADEM	CHi_Pj:LNSTAT
CHi_Pj:DOPP	CHi_Pj:LNSTD
CHi_Pj:FADET	CHi_Pj:MOD
CHi_Pj:FADREP	CHi_Pj:STAT

where i = 1 to 2; j = 1 to 6

The following is an example of how the DSP_INIT command should be used when setting parameters that are associated with the CHi_Pj commands listed above:

1. The test system controller sends "/CNFG:DSP_STOP/" command to the primary 4500.
2. The test system controller sends any of the above listed CHi_Pj commands to the desired 4500.
3. The test system controller sends "/CNFG:DSP_INIT/" command to both the primary and secondary 4500.
4. The test system controller sends "/CNFG:DSP_EXE/" command to the primary 4500.

NOTE: This command should only be used for dual-unit 4 branch diversity test systems.

Valid Command Data:

None

Example:

/CNFG:DSP_INIT/

Expected Response:

/C/

Stop (Suspend) Digital Signal Processor Operations (DSP_STOP)

Command Description:

Stops (Suspends) execution of DSP operations for fading, frequency shift, and log-normal modulation. This command should be sent to the primary 4500 unit of a dual-unit 4 branch diversity test system to suspend DSP execution. The system controller of a 4 branch diversity test system must include this command in the control sequence for parameters associated with the following commands:

CNFG:CHCORR	CHi_Pj:LNRT
CNFG:FADEM	CHi_Pj:LNSTAT
CHi_Pj:DOPP	CHi_Pj:LNSTD
CHi_Pj:FADET	CHi_Pj:MOD
CHi_Pj:FADREP	CHi_Pj:STAT

where i = 1 to 2; j = 1 to 6

The following is an example of how the DSP_STOP command should be used when setting parameters that are associated with the CHi_Pj commands listed above:

1. The test system controller sends "/CNFG:DSP_STOP/" command to the primary 4500.
2. The test system controller sends any of the above listed CHi_Pj commands to the desired 4500.
3. The test system controller sends "/CNFG:DSP_INIT/" command to both the primary and secondary 4500.
4. The test system controller sends "/CNFG:DSP_EXE/" command to the primary 4500.

NOTE: The DSP_STOP command should only be used for dual-unit 4 branch diversity test systems.

Valid Command Data:

None

Example:

/CNFG:DSP_STOP/

Expected Response:

/C/

Set the Emulation Mode (EMULM)

Command Description:

Sets to emulation mode of the system. MODE1 is for static mode; MODE2 is used in Dynamic Parameter Emulation mode. MODE1 is the standard mode of operation for the TAS 4500. Refer to Section 3.6. Dynamic Parameter Emulation mode for a complete description of MODE2.

Valid Command Data:

MODE1, MODE2

Example:

To set the system in static mode:

/CNFG:EMULM=MODE1/

Expected Response:

/C/

Extended Query of the System Configuration (ESYS)

Command Description:

Extended report of the system's configuration.

Valid Command Data:

The system configuration information is encoded into a 32 digit string. The following list explains each of the digit assignments.

DIGIT	DESCRIPTION	VALUES	
26-31	Digit 26 to digit 31 are reserved for future use	default value = 0	
25	CH 1 RF Channel Bypass	0=Not Installed 1=Installed	
24	CH 2 RF Channel Bypass	0=Not Installed 1=Installed	
23	Insertion Loss Estimate	0=Not Installed 1=Installed	
22	Selectable 10 MHz Reference	0=Not Installed 1=Installed	
21	CH1 RF Carrier Frequency Range	1=800 to 2500 MHz 2=25 to 2500 MHz 3=25 to 3000 MHz 4=800 to 3000 MHz	
20	CH2 RF Carrier Frequency Range	1=800 to 2500 MHz 2=25 to 2500 MHz 3=25 to 3000 MHz 4=800 to 3000 MHz	
19	Dynamic Emulation Capability	0=Not Installed 1=Installed	
18	Doppler Frequency Range	1=-740 to -1, 1 to 740 Hz	
17	Input reference Level Range	1=8 to -32 dBm 2=5 to -35 dBm 3=5 to -30 dBm	
16	Relative Path Loss Range	1=0 to 50 dB 2=0 to 40 dB 3=0 to 40 dB	
15	Relative Delay Resolution	1=10 nsec 2=1 nsec	
14	Relative Delay Range	1=200 µsec 3=800 µsec 5=66.666 µsec	2=100 µsec 4=1600 µsec 6=533.328 µsec
13	IF Channel Bandwidth	1=6 MHz 2=15 MHz 3=26 MHz	
12	DSP Module Type	1=Type 1 DSP FW Version = 1.10 2=Type 2 DSP FW Version = 2.00 3=Type 3 DSP FW Version = 3.00 or 3.20 4=Type 4 DSP FW Version = 4.00 5=Type 5 DSP FW Version = 4.10	

Digit	Description	Values
11	CH1 Tunable RF Filter Type	0=not present 1=Type 1 (800 to 2500 MHz) 2=Type 2 (800 to 3000 MHz/30 MHz) 3=Type 3 (800 to 3000 MHz/35 MHz)
10	CH2 Tunable RF Filter Type	0=not present 1=Type 1 (800 to 2500 MHz) 2=Type 2 (800 to 3000 MHz/30 MHz) 3=Type 3 (800 to 3000 MHz/35 MHz)
9	Number of RF channels	1 or 2
8	Total number of paths	1=3 paths 2=6 paths 3=9 paths 4=12 paths
7	IF Module Type	1=Type 1 (reserved) 2=Type 2 (6 MHz, 10nsec/200μsec) 3=Type 3 (15 MHz, 1nsec/100μsec) 4=Type 4 (15 MHz, 1nsec/800μsec) 5=Type 5 (Universal)
6	Reserved	1
5	CH1 Up/Down Converter Type	0=not present 1=Type 1 (reserved) 2=Type 2 (6 MHz enhanced conversion) 3=Type 3 (6 MHz basic conversion) 4=Type 4 (15 MHz enhanced conversion) 5=Type 5 (15 MHz basic conversion) 6=Type 6 (Universal)
4	CH2 Up/Down Converter Type	0=not present 1=Type 1 (reserved) 2=Type 2 (6 MHz enhanced conversion) 3=Type 3 (6 MHz basic conversion) 4=Type 4 (15 MHz enhanced conversion) 5=Type 5 (15 MHz basic conversion) 6=Type 6 (Universal)
3	CH1 Output Attenuator Type	0=not present 1=Type 1 (0.1 dB step/800 to 2500 MHz) 2=Type 2 (0.5 dB step/25 to 2500 MHz) 3=Type 3 (0.5 dB step/25 to 3000 MHz)
2	CH2 Output Attenuator Type	0=not present 1=Type 1 (0.1 dB step/800 to 2500 MHz) 2=Type 2 (0.5 dB step/25 to 2500 MHz) 3=Type 3 (0.5 dB step/25 to 3000 MHz)
1	CH1 Local Oscillator Type	0=not present 1=Type 1 (reserved) 2=Type 2 (800-1100 MHz) 3=Type 3 (1800-2500 MHz) 4=Type 4 (200-400 MHz) 5=Type 5 (940-2860 MHz) 6-7=reserved
0	CH2 Local Oscillator Type	0=not present 1=Type 1 (reserved) 2=Type 2 (800-1100 MHz) 3=Type 3 (1800-2500 MHz) 4=Type 4 (200-400 MHz) 5=Type 5 (940-2860 MHz) 6-7=reserved

Example:

/CNFG: ESYS/

Expected Response:

/CNFG: ESYS= 00000011111111322225222251661155/

NOTE: Bit 0 is to the right.

This response would indicate the unit was equipped with the following features:

- RF Channel 1 Bypass Installed
- RF Channel 2 Bypass Installed
- Output Power Estimation Installed
- Selectable 10 MHz Reference Installed
- Channel 1 RF Carrier Range : 800 to 2500 MHz
- Channel 2 RF Carrier Range : 800 to 2500 MHz
- Dynamic Emulation Capability Installed
- Doppler Frequency Range of -740 to 740 Hz
- Input Reference Level Range of 5 to -30 dBm
- Relative Path Loss Range of 0 to 40 dB
- Relative Path Delay 100 µsec range / 1nsec resolution
- Fifteen MHz IF Channel bandwidth
- Type 5 DSP Module
- Channel 1 Type 2 (800 to 3000 MHz) Tunable RF Filter present
- Channel 2 Type 2 (800 to 3000 MHz) Tunable RF Filter present
- Two RF channels
- Six total paths
- Universal (Type 5) IF module
- Reserved
- Universal (Type 6) Channel 1 Up/Down Converter Type
- Universal (Type 6) Channel 2 Up/Down Converter Type
- Channel 1 Type 1 Output Attenuator present
- Channel 2 Type 1 Output Attenuator present
- Channel 1 Type 5 LO present (940-2860 MHz)
- Channel 2 Type 5 LO present (940-2860 MHz)

Fading Emulation Method (FADEM)

Command Description:

Sets the Fading Emulation Method used by the system. The Jakes method (TYPE1) uses a discrete set of tones to emulate Rayleigh fading. The Filtered Noise method (TYPE2) uses a band limited noise signal to emulate Rayleigh fading. The default method is Jakes (TYPE1).

Valid Command Data:

TYPE1, TYPE2

Example:

To set the system in Jakes Method:

/CNFG:FADEM=TYPE1/

Expected Response:

/C/

Local Control (LOC)

Command Description:

Puts the system into local (front panel) control mode.

Valid Command Data:

None

Example:

/CNFG:LOC/

Expected Response:

/C/

Query System Model Number (MODL)

Command Description:

Reports the system model number.

Valid Command Data:

None

Example:

/CNFG:MODL/

Expected Response:

/CNFG:MODL=4500/

Rayleigh Power Spectrum (RAYPS)

Command Description:

Selects the shape of the Rayleigh modulation power spectrum.

NOTE: This command only applies when Emulation Method is set to Jakes.

Valid Command Data:

TYPE1 - Classical 6 dB fading power spectrum shape as specified in IS55/56 and IS97/98 standards.

TYPE2 - Flat fading power spectrum shape observed for some indoor propagation models

Example:

To configure the fading power spectrum to have the classical 6 dB shape:

/CNFG:RAYPS=TYPE1/

Expected Response:

/C/

Reference (REF)

Command Description:

Selects either internal or external generation of the 10 MHz system reference signal utilized by the internal signal processing circuitry of the TAS 4500.

Valid Command Data:

INT - Selects internal reference so the TAS 4500 will utilize its own 10 MHz signal source.

EXT - Selects external reference source which requires a 10 MHz sinusoidal source be provided via the EXT REF I/O connector on the rear panel. Refer to Section 7 Technical Specifications for the requirements for the external source.

Example:

To set the reference source to external:

/CNFG:REF=EXT/

Expected Response:

/C/

Remote Control (REM)

Command Description:

Puts the system into remote control mode. Only available when in RS-232 control mode.

Valid Command Data:

None

Example:

/CNFG:REM/

Expected Response:

/C/

Response Format (RESP)

Command Description:

Sets the remote response format to either verbose or terse. If the RESP format is TERSE, TAS 4500 does not include the slashes, command group name, or parameter name in the response. The default value for RESP format is VERBOSE.

Valid Command Data:

VERBOSE: Causes the TAS 4500 to use its usual command response format as shown in the following example.

Command: /CNFG:MODL/

Response: /CNFG:MODL=4500/

TERSE: Causes the TAS 4500 to use the terse command response format shown in the following example:

Command: /CNFG:MODL/

Response: 4500

Example:

To set remote response format to TERSE:

/CNFG:RESP=TERSE/

Expected Response:

/C/

System Controller Version Number (SCV)

Command Description:

Reports the system controller processor firmware version number.

Valid Command Data:

None

Example:

/CNFG:SCV/

Expected Response:

/CNFG:SCV=4.20/

Diagnostics Status (STAT)

Command Description:

Reports the system status or the last diagnostics performed.

Valid Command Data:

None

Example:

/CNFG:STAT/

Expected Response:

/CNFG:STAT=ok/

Query System Configuration (SYS)

Command Description:

Reports the system's configuration. This command is superseded by the ESYS command and should not be used for new applications. See the ESYS command description for more information.

Valid Command Data:

The system configuration information is encoded into a 12 digit string. The following list explains each of the digit assignments.

DIGIT	DESCRIPTION	VALUES
11	CH1 Tunable RF Filter Type	0=not present 1=Type 1 (800 to 2500 MHz) 2=Type 2 (800 to 3000 MHz/30 MHz) 3=Type 3 (800 to 3000 MHz/35 MHz)
10	CH2 Tunable RF Filter Type	0=not present 1=Type 1 (800 to 2500 MHz) 2=Type 2 (800 to 3000 MHz/30 MHz) 3=Type 3 (800 to 3000 MHz/35 MHz)
9	Number of RF channels	1 or 2
8	Total number of paths	1=3 paths 2=6 paths 3=9 paths 4=12 paths
7	IF Module Type	1=Type 1 (reserved) 2=Type 2 (6 MHz, 10nsec/200μsec) 3=Type 3 (15 MHz, 1nsec/100μsec) 4=Type 4 (15 MHz, 1nsec/800μsec) 5=Type 5 (Universal)
6	Reserved	1

DIGIT	DESCRIPTION	VALUES
5	CH1 Up/Down Converter Type	0=not present 1=Type 1 (reserved) 2=Type 2 (6 MHz enhanced conversion) 3=Type 3 (6 MHz basic conversion) 4=Type 4 (15 MHz enhanced conversion) 5=Type 5 (15 MHz basic conversion) 6=Type 6 (Universal)
4	CH2 Up/Down Converter Type	0=not present 1=Type 1 (reserved) 2=Type 2 (6 MHz enhanced conversion) 3=Type 3 (6 MHz basic conversion) 4=Type 4 (15 MHz enhanced conversion) 5=Type 5 (15 MHz basic conversion) 6=Type 6 (Universal)
3	CH1 Output Attenuator Type	0=not present 1=Type 1 (0.1 dB step/800 to 2500 MHz) 2=Type 2 (0.5 dB step/25 to 2500 MHz) 3=Type 3 (0.5 dB step/25 to 3000 MHz)
2	CH2 Output Attenuator Type	0=not present 1=Type 1 (0.1 dB step/800 to 2500 MHz) 2=Type 2 (0.5 dB step/25 to 2500 MHz) 3= Type 3(0.5 dB step/25 to 3000 MHz)
1	CH1 Local Oscillator Type	0=not present 1=Type 1 (reserved) 2=Type 2 (800-1100 MHz) 3=Type 3 (1800-2500 MHz) 4=Type 4 (200-400 MHz) 5=Type 5 (940-2860 MHz) 6-7=reserved
0	CH2 Local Oscillator Type	0=not present 1=Type 1 (reserved) 2=Type 2 (800-1100 MHz) 3=Type 3 (1800-2500 MHz) 4=Type 4 (200-400 MHz) 5=Type 5 (940-2860 MHz) 6-7=reserved

Example:

/CNFG: SYS/

Expected Response:

/CNFG: SYS= 112221221133/

NOTE: Bit 0 is to the right.

This response would indicate the unit was equipped with the following features:

- CH1 Type 1 Tunable RF Filter present
- CH2 Type 1 Tunable RF Filter present
- Two RF channels
- Six total paths
- Type 2 IF Module (6 MHz channel bandwidth, with 10nsec/200µsec delay)
- Reserved
- CH1 Type 2 Up/Down Converter present (6 MHz enhanced)
- CH2 Type 2 Up/Down Converter present (6 MHz enhanced)
- CH1 Type 1 Output Attenuator present
- CH2 Type 1 Output Attenuator present
- CH1 Type 3 LO present (1800-2500 MHz)
- CH2 Type 3 LO present (1800-2500 MHz)

5.3.3. File Save & Recall (FILE)

Command Group Format:

/FILE:command(s)/

Command Group Description:

The FILE command group allows the user to save system configurations to a user file or recall system configurations from a read-only file or predefined user file.

Commands:

FNAM, FRCL, FSAV

File Name (FNAM)

Command Description:

Selects the file name of the file to save to or recall from. For the configurations of the predefined read-only files, see Section 8.1 "Appendix 1: Standard Test Profiles". Note that this command only sets the file name of the file to be used; no actual save or recall action is carried out. To perform a file save or recall the command FSAV and FRCL are used. The FSAV and FRCL commands are described in the following sections.

Valid Command Data:

FDEFAULT	System factory default configuration (read-only)
FILE0-FILE4	User defined files (read/write)

other read-only files:

<u>IS55/56 Test Files</u>
IS55-56_1, IS55-56_2, IS55-56_3

<u>IS97/98 Test Files</u>
CDMA_1, CDMA_2, CDMA_3, CDMA_4, CDMA_5

<u>GSM Test Files</u>
HT100_1, HT100_2, TU50_1, TU50_2, RA100_1, RA100_2, RA250_1, RA250_2, EQ50, EQ100, HT100_12_1, HT100_12_2, TU50_12_1, TU50_12_2

Example:

To set the file name to the system default file:

/FILE:FNAM=FDEFAULT/

Expected Response:

/C/

File Recall (FRCL)

Command Description:

Performs a file recall with current file defined by the command FNAM. See Section 5.3.3. for details on the FNAM command.

> **NOTE:** For the user file0 to file4, they have to be predefined first before they can be recalled. i.e. a configuration has to be saved to the user files before they can be recalled.
> If the default file is recalled, any Dynamic Parameter Emulation data will be cleared.

Valid Command Data:

None

Example:

/FILE:FRCL/

Expected Response:

/C/

File Save (FSAV)

Command Description:

Performs a file save with current file defined by the command FNAM. See Section 5.3.3. for details on the FNAM command.

> **NOTE:** A file save operation can only be done on the user (read/write) files - file0 to file4. Any attempt to save the system configuration to a read-only predefined standard file will result in an error.
> Dynamic Parameter Emulation data can not be saved.

Valid Command Data:

None

Example:

/FILE:FSAV/

Expected Response:

/C/

5.3.4. Measure (MEAS)

Command Group Format:

/MEAS:command(s)/

Command Group Description:

The measure command group allows the user to perform peak level measurements on the input of the channel(s).

Commands:

SEL, VALUE

Select Measurement Source (SEL)

Command Description:

The SEL command lets the user select the source of the measurement to be performed on.

Valid Command Data:

SIGN1 - Channel 1 input

SIGN2 - Channel 2 input

Example:

To set the source of the measurement to the channel 1 input:

/MEAS:SEL=SIGN1/

Expected Response:

/C/

Take Measurement (Value)

Command Description:

Performs a measurement on the source specified by the SEL command and report the value. The SEL command is described in details in the previous Section 5.3.4. Select Measurement Source.

Valid Command Data:

None

Example:

To take a peak level measurement on the channel 2 input.

/MEAS:SEL=SIGN2,VALUE/

Expected Response:

/MEAS:VALUE=-7.9 dBm/

5.3.5. Control of all Paths (PATHS)

Command Group Format:

/PATHS:command(s)/

Command Group Description:

The PATHS command groups allow the user to configure all paths of the unit simultaneously.

Commands:

D, FADREP, HALT, LOOP, RANGE, RUN, STEP, S

Set State Machine Data for System State (D)

Command Description:

Sets the state Doppler and state duration when in Dynamic Emulation Mode (EMULM=MODE2). The first item in this command, "n", sets the state number. "Doppler" sets the Doppler frequency for all paths with Rayleigh or GSM_Rician modulation selected and sets the maximum Doppler for frequency shifted paths. "Duration" sets time that the state is active.

Command Format:

D="n;Doppler;duration"

Valid Command Data:

n = 1 to 512

Doppler = -7400 to -10, 10 to 7400
(-740.0 to -1.0, 1.0 to 740.0 Hz)

Duration = 1 to 32765
(0.1 to 3276.5 seconds)

Example:

To set state 5 to a Doppler frequency of 100 Hz and a duration of 7 seconds:

/PATHS:D=5;1000;70/

Expected Response:

/C/

Fading Repetition Rate (FADREP)

Command Description:

Sets the repetition rate of the fading pattern when using Filtered Noise Emulation Mode. Since the repetition rate is dependent on the Doppler frequency, the times given below are approximate. Equations to calculate the exact repetition rate can be found in Section 3.0. Reference.

Valid Command Data:

RATE1 (20 Minutes)

RATE2 (27 Seconds)

RATE3 (24 Hours)

Example:

To set the Fading Repetition Rate to 24 hours:

/PATHS:FADREP=RATE3/

Expected Response:

/C/

Halt Execution of State Machine (HALT)

Command Description:

Halts the execution of the state machine when in Dynamic Emulation Mode (EMULM=MODE2).

Valid Command Data:

None

Example:

To halt the state machine:

/PATHS:HALT/

Expected Response:

/C/

Loop Execution of State Machine (LOOP)

Command Description:

Loops the execution of the state machine when in Dynamic Emulation Mode (EMULM=MODE2). A continuous loop is set over the states set by the RANGE command.

Valid Command Data:

ON, OFF

Example:

To enable state machine looping:

/PATHS:LOOP=ON/

Expected Response:

/C/

Set Range of Execution of State Machine (RANGE)

Command Description:

Sets the range of states for execution of the state machine when in Dynamic Emulation Mode (EMULM=MODE2).

Command Format:

RANGE= "begin state; end state"

Valid Command Data:

Begin state = 1 to 512

End state = 1 to 512

Example:

To set the range of states to start at state 3 and end at state 8:

/PATHS:RANGE=3;8/

Expected Response:

/C/

Start Run of State Machine (RUN)

Command Description:

Begins the execution of the state machine over the programmed RANGE when in Dynamic Emulation Mode (EMULM=MODE2).

Valid Command Data:

None

Example:

To begin execution of the state machine over the programmed range:

/PATHS:RUN/

Expected Response:

/C/

Step through State Machine (STEP)

Command Description:

Single steps the execution of the state machine when in Dynamic Emulation Mode (EMULM=MODE2). State will step to the next state.

Valid Command Data:

None

Example:

To step to the next state in the state machine:

/PATHS:STEP/

Expected Response:

/C/

Set Current State of State Machine (S)

Command Description:

Sets the current state of the state machine when in Dynamic Emulation Mode (EMULM=MODE2).

Valid Command Data:

1 to 512

Example:

To set the current state of the state machine to 17:

/PATHS:S=17/

Expected Response:

/C/

5.3.6. Path Control (CH1_P1 to CH1_P6, CH2_P1 to CH2_P6)

Command Group Format:

/CH1_Pn:command(s)/ where n=1 to 6 for Channel 1.

/CH2_Pn:command(s)/ where n=1 to 6 for Channel 2.

Command Group Description:

The CH1_Pn and CH2_Pn command groups allow the user to configure each path of the unit separately.

Commands:

D, DELAY, DOPP, FADET, FSF, LNCAL, LNRT, LNSTAT, LNSTD, LOSS, MOD, PHAS, STAT

Set State Machine Data for Individual Path(D)

Command Description:

Sets the state information for an individual path when in Dynamic Emulation Mode (EMULM=MODE2). The first item in this command, "n", sets the state number. "Mod" sets the modulation type for the path; the modulation can be none, Rayleigh, GSM Rician, Rician, Nakagami, frequency shift, or phase shift.

The "modulation data 1" parameter sets the Doppler frequency of a frequency shift tone or line of site component when the modulation type is Frequency Shift, Rician, or Nakagami. It is also used to set the phase shift in degrees for paths with this modulation type selected. This Doppler setting should be distinguished from the state Doppler which is common to all paths.

The "modulation data 2" parameter is used to set the K factor for Rician modulation and the M value for Nakagami modulation. It is unused for all other modulation types.

The relative path loss and relative path delay are also set with this command.

Command Format:

D="n;mod;modulation data 1;modulation data 2;loss;delay"

Valid Command Data:

n = 1 to 512

mod = 0 to 5
0 = none
1 = Rayleigh
2 = Frequency Shift
3 = Phase
4 = Rician
5 = Nakagami

modulation data 1 = 0
for mod = 0 or 1

modulation data 1 = -7400 to -10, 10 to 7400 (-740.0 to -1.0, 1.0 to 740.0 Hz)
for mod = 2

modulation data 1 = -7400 to 7400 (-740.0 to 740.0 Hz)
for mod = 4 or 5

NOTE: The frequency shift, Rician, and Nakagami Doppler settings must be less then or equal to the state Doppler defined in the PATHS:D command.

modulation data 1 = 0 to 3600 (0.0 to 360.0 degrees)
for mod = 3

modulation data 2 = 0
for mod = 0 or 1

modulation data 2 = -300 to 300 (-30 to +30 dB; K factor)
for mod = 4

modulation data 2 = 10, 30, 50, 100, 150, 250, 1000
(1, 3, 5, 10, 15, 25, 100; M value)
for mod = 5

loss = 0 to 501 (0 to 50.0 dB; 501 = path off)
for 6 MHz bandwidth IF module

loss = 0 to 401 (0 to 40.0 dB; 401 = path off)
for 15 MHz bandwidth IF module

delay = 0 to 200000 (0 to 200.000μs - 50ns step size)
for 6 MHz bandwidth IF module

delay = 0 to 100000 (0 to 100.000 μs - 25ns step size)
for 15 MHz bandwidth IF module

Example:

To set channel 1 path 2 state 5 to Rician with a line of site component at a 70 Hz Doppler frequency, a K factor of +10dB, a relative path loss of 13 dB and 100 μs of relative path delay:

/CH1_P2:D=5;4;70;100;130;100000/

Expected Response:

/C/

Relative Delay (DELAY)

Command Description:

Sets the relative delay between paths. The resolution and range of this parameter is dependent on the IF Module type present as detailed below.

Valid Command Data:

For 6 MHz bandwidth IF Module:

Range: 0 to 200000 (0.000 μs to 200.000 μs)
0 to 1600000 (0.000 μs to 1600.000 μs) optional

For 15 MHz bandwidth IF Module:

Range: 0 to 100000 (0.000 μs to 100.000 μs)
0 to 800000 (0.000 μs to 800.000 μs) optional

For 26 MHz bandwidth IF Module:

Range: 0 to 66666 (0.000 μs to 66.666 μs)
0 to 533328 (0.000 μs to 533.328 μs) optional

Example:

To set the relative path delay for Channel 1 Path 3 to 1.000 μs:

/CH1_P3:DELAY=1000/

Expected Response:

/C/

Doppler Frequency (DOPP)

Command Description:

Sets the Doppler frequency for the path to be used for both Doppler shift (frequency shift), Rayleigh, GSM Rician, Rician, Nakagami, and Rayleigh with Frequency Shift. This parameter will only be in effect if the modulation type of the path is set to one of these types. See Section 5.3.5. for information on setting the modulation type of the path.

> **NOTE**: When in filtered noise emulation mode the Doppler frequencies of all Rayleigh, GSM Rician, Rician, and Nakagami paths are set to the same value. This value is the maximum Doppler frequency. All frequency shifted paths must have a Doppler less then or equal to the maximum Doppler frequency.

Valid Command Data:

Range: -7400 to -10, 10 to 7400
(-740.0 to -1.0, 1.0 to 740.0 Hz)

Example:

To set the Doppler frequency of Channel 1 Path 1 to 20.5 Hz:

/CH1_P1:DOPP=205/

Expected Response:

/C/

Fading Power Spectrum / Fading Environment Type (FADET)

Command Description:

Sets the fading power spectrum, also referred to as the fading environment type. This parameter will only be in effect if the emulation mode is set to filtered noise.

Valid Command Data:

TYPE1 - Classical 6 dB fading power spectrum shape as specified in IS55/56 and IS97/98 standards.

TYPE2 - Flat fading power spectrum shape observed for some indoor propagation models.

TYPE3 - Classical 3 dB fading power spectrum shape as specified in the CODIT specification.

TYPE4 - Rounded fading power spectrum shape as specified in the CODIT specification.

Example:

To configure the fading power spectrum to have the classical 6 dB shape:

/CNFG:DAFEM=TYPE1/

Expected Response:

/C/

Shift Frequency for Rayleigh with Frequency Shift (FSF)

Command Description:

Sets the shift frequency for the path to be used for the modulation type of Rayleigh with Frequency Shift. This parameter will only be in effect if the modulation type of the path is set to Rayleigh with Frequency Shift. See Section 5.3.5. for information on setting the modulation type of the path.

> **NOTE**: This command is only available when the Emulation Method is set to Jakes.

Valid Command Data:

Range: -2400 to -2400 (-240.0 Hz to 240.0 Hz)

Example:

To set the shift frequency of Channel 1 Path 1 to 40.5 Hz:

/CH1_P1:FSF=405/

Expected Response:

/C/

Log-Normal Calibration (LNCAL)

Command Description:

Reports whether or not the log-normal standard deviation and path loss are set to allow a minimum of two sigma variation for Log-normal fading on the specified path. See Section 2.6. "Setting Log-Normal Parameters".

Valid Command Data:

yes - $\geq$ 2 sigma deviation

no - < 2 sigma deviation

Example:

To report the status of the Log-normal sigma variation of Channel 1 Path 1:

/CH1_P1:LNCAL/

Expected Response:

/CH1_P1:LNCAL=yes/

Log-Normal Rate (LNRT)

Command Description:

Sets the Log-normal rate of the path.

Valid Command Data:

Range: 0 to 20000 (0.000 Hz to 20.000 Hz)

Example:

To set the Log-normal rate of Channel 1 Path 2 to 0.005 Hz:

/CH1_P2:LNRT=5/

Expected Response:

/C/

Log-Normal Status (LNSTAT)

Command Description:

Sets the Log-normal fading status to on (enable) or off (disable) for the specified path.

Valid Command Data:

on, off

Example:

To turn Log-normal fading on for Channel 1 Path 1:

/CH1_P1:LNSTAT=ON/

Expected Response:

/C/

Log-Normal Standard Deviation (LNSTD)

Command Description:

Sets the Log-normal standard deviation of the path.

Valid Command Data:

Absolute Range: 0 to 12 (0 dB to 12 dB)

Example:

To set the Log-normal standard deviation of Channel 1 Path 2 to 5 dB:

/CH1_P2:LNSTD=5/

Expected Response:

/C/

Relative Path Loss (LOSS)

Command Description:

Sets the relative path loss of the path.

Valid Command Data:

6 MHz Bandwidth IF Module:
Absolute Range: 0 to 500 (0.0 dB to 50.0 dB)

15 MHz Bandwidth IF Module:
Absolute Range: 0 to 400 (0.0 dB to 40.0 dB)

26 MHz Bandwidth IF Module:
Absolute Range: 0 to 300 (0.0 dB to 30.0 dB)

Example:

To set the relative path loss of Channel 1 Path 2 to 0.0 dB:

/CH1_P2:LOSS=0/

Expected Response:

/C/

Path Modulation Type (MOD)

Command Description:

Set the modulation type of the path.

Valid Command Data:

NONE	No modulation
RAYL	Rayleigh fading
FS	Frequency shift (Doppler shift)
PHAS	Phase shift
RICE	GSM Rician (CH1 Path 1 only)
FSRAY	Rayleigh with Frequency Shift
NAK	Nakagami fading with programmable M value and angle of arrival
RICE_K	Rician fading with programmable K factor and LOS arrival angle

NOTE: MOD=FSRAY is only available when the Emulation Method is set to Jakes.

Example:

To sets the modulation type of Channel 1 Path 1 to Rayleigh fading:

/CH1_P1:MOD=RAYL/

Expected Response:

/C/

Nakagami M Value (NM)

Command Description:

Sets the M value for a Nakagami faded signal. This parameter will only be in effect if the modulation type of the path is set to Nakagami. See Section 5.3.5. for information on setting the modulation type of the path. For more details on setting an appropriate M value refer to Section 3.6.17 on the theory of operation for Nakagami fading.

Valid Command Data:

Range: 1, 3, 5, 10, 15, 25, 100

Example:

To set an M value of 3 for Channel 1 Path 2 with Nakagami modulation set:

/CH1_P2:NM=3/

Expected Response:

/C/

Phase Angle (PHAS)

Command Description:

Sets the phase angle of the path for phase shift modulation. This parameter will only be in effect if the modulation type of the path is set to phase shift. See Section 5.3.5. for information on setting the modulation type of the path.

Valid Command Data:

Range: 0 to 3600 (0.0 degrees to 360.0 degrees)

Example:

To set the phase angle of Channel 1 Path 2 to 45.0 degrees:

/CH1_P2:PHAS=450/

Expected Response:

/C/

Rician K Factor (RK)

Command Description:

Sets the K factor for a Rician faded signal. This parameter will only be in effect if the modulation type of the path is set to Rician. See Section 5.3.5. for information on setting the modulation type of the path. For more details on setting an appropriate K factor refer to Section 3.6.13 on the theory of operation for Rician fading.

Sets the path status to on (enable) or off (disable) for the specific path.

Valid Command Data:

Range: -300 to 300 (-30.0 dB to +30.0 dB)

Example:

To set a K factor of +12.0 for Channel 1 Path 2 with Rician modulation set:

/CH1_P2:RK=120/

Expected Response:

/C/

Path Status (STAT)

Command Description:

Sets the path status to on (enable) or off (disable) for the specific path.

Valid Command Data:

ON, OFF

Example:

To turn off Channel 1 Path 2:

/CH1_P2:STAT=OFF/

Expected Response:

/C/

Rayleigh Fading Path Correlation Coefficient (CORR) [CH2_P1 to CH2_P6]

Command Description:

Sets the Rayleigh fading path correlation coefficient between paths. This parameter will only be in effect if the modulation type of both paths to be correlated is in Rayleigh fading. See Section 5.3.5. for information on setting the modulation type of the path.

CH2_P1:CORR controls the correlation between CH1-CH2 Path 1

CH2_P2:CORR controls the correlation between CH1-CH2 Path 2

CH2_P3:CORR controls the correlation between CH1-CH2 Path 3

CH2_P4:CORR controls the correlation between CH1-CH2 Path 4

CH2_P5:CORR controls the correlation between CH1-CH2 Path 5

CH2_P6:CORR controls the correlation between CH1-CH2 Path 6

Valid Command Data:

Range: 0 to 10 (0.0 to 1.0 of correlation coefficient)

Example:

To set the correlation coefficient of Rayleigh faded CH1-CH2 Path 5 to 0.7:

/CH2_P5:CORR=7/

Expected Response:

/C/

Extended Rayleigh Fading Path Correlation Coefficient(ECORR)[CH2_P1 to CH2_P6]

Command Description:

Sets the Rayleigh fading path correlation coefficient between paths. This parameter will only be in effect if the modulation type of both paths to be correlated is in Rayleigh fading. See Section 5.3.5. for information on setting the modulation type of the path.

CH2_P1:ECORR controls the correlation between CH1-CH2 Path 1

CH2_P2:ECORR controls the correlation between CH1-CH2 Path 2

CH2_P3:ECORR controls the correlation between CH1-CH2 Path 3

CH2_P4:ECORR controls the correlation between CH1-CH2 Path 4

CH2_P5:ECORR controls the correlation between CH1-CH2 Path 5

CH2_P6:ECORR controls the correlation between CH1-CH2 Path 6

Valid Command Data:

Range: 0 to 100 (0.00 to 1.00 of correlation coefficient)

Example:

To set the correlation coefficient of Rayleigh faded CH1-CH2 Path 5 to 0.75:

/CH2_P5:ECORR=75/

Expected Response:

/C/

6.0. Error Codes

The TAS 4500 provides error codes to indicate its current state of operation. Error conditions are reported on the front panel and the remote control (GPIB or RS-232) interfaces. For more information on reading error codes, see the CNFG command group in section 5.0. "Remote Commands Reference".

Error Code	Description
000	TAS 4500 OK
001	Command value error
002	Command syntax error
003	Command group syntax error
004	Command failure
005	Undefined command group
006	Undefined command
007	File recall operation failed
008	Reserved
009	Reserved
010	Reserved
011	Database failure
012	Reserved
013	EPROM checksum failed
014	Reserved
015	Reserved
016	Reserved
017	Reserved
018	Reserved
019	Remote Command ignored when in local mode
020-029	Reserved
030	CCB1 DSP1 no response
031	CCB1 DSP2 no response
032	Channel 1 not present
033	Reserved

Error Code	Description
034	Reserved
035	Reserved
036	Reserved
037	Reserved
038	Synthesizer 1 timeout
039	Synthesizer 2 timeout
040-050	Reserved
051	Channel 2 not present
052	Input signal out of range
053	Reserved
054	Reserved
055	Reserved
056	Value of Doppler frequency is out of range for the selected channel correlation type
057-059	Reserved
060	CCB2 DSP1 no response
061	CCB2 DSP2 no response
062-063	Reserved
064	External Reference Signal not detected
065-076	Reserved
077	Insufficient hardware configuration for desired file recall

7.0. Technical Specifications

The specifications are measured under the following channel conditions unless otherwise indicated:

- RF Input Frequency = 900/1800 MHz sinewave
- RF Input Level = -10 dBm nominal (Input Reference Level set 3.0 dB less then input overload)
- Output Attenuator = 0 dB
- LO Input Level = +13 dBm
- LO Input Frequency = RF Input Frequency - 140 MHz
- One Path On, Path Modulation = none, Path Loss = 0 dB, Path Delay = 0 μs

7.1. RF Channel Specifications

RF Input Signal Frequency Range*:	25 to 3000 MHz
RF Bandwidth:	6 MHz, 15 MHz or 26 MHz
Number of Independent RF Channels	1 or 2
RF Input Signal Level	
Minimum	-30 dBm
Nominal	-10 dBm
Maximum	+5 dBm
Damage Level	+20 dBm
Automatic Reference Level Range	0 to -25 dBm
Path Insertion Delay	
RF In to RF Out	4.0 μs maximum
Variation path to path within a channel at band center	10 ns maximum
Group Delay Distortion	
6 MHz Bandwidth System	±50 ns typical ±100 ns maximum
15 or 26 MHz Bandwidth System	±30 ns typical ±70 ns maximum

RF Bandwidth Peak to Peak Amplitude Variation

6 MHz Bandwidth System	
(6 MHz Bandwidth)	1 dB typical
15 MHz Bandwidth System	
(8 MHz Bandwidth)	1 dB typical
(12 MHz Bandwidth)	2 dB typical
(15 MHz Bandwidth)	3 dB typical
26 MHz Bandwidth System	
(26 MHz Bandwidth)	3 dB typical

Path Insertion Loss

Band Center 900 MHz	9 dB typical 13 dB maximum
Band Center 1800 MHz	12 dB typical 16 dB maximum

Insertion Loss Variation (Path to path within a channel)

6 MHz Bandwidth System	<0.2 dB
15 or 26 MHz Bandwidth System	<0.5 dB

Path On/Off Ratio	55 dB minimum

Spurious Emission Levels on RF Out

Nonharmonic within RF Bandwidth	
6 or 15 MHz Bandwidth System	-50 dBc maximum
26 MHz Bandwidth System	-40 dBc maximum
Harmonic within RF Bandwidth	
6 or 15 MHz Bandwidth System	-45 dBc maximum
26 MHz Bandwidth System	-40 dBc maximum
(except $127 \leq f_c \leq 143$ MHz)	-30 dBc typical
Image Feedthrough	= RF OUT level
LO Feedthrough	0 dBm maximum

Physical Interface Characteristics

Impedance	50 ohms
SWR	< 1.5
Connector Type	Type N Female

7.2. RF Channel Options

RF Output Attenuator

ATT1:

Attenuation Range	0 to 80 dB
Resolution	0.1 dB steps
Frequency Range	800 to 2500 MHz
Accuracy	
0 to 10 dB attenuation	±0.5 dB
>10 to 20 dB attenuation	±1.25 dB
>20 to 30 dB attenuation	±1.75 dB
>30 to 45 dB attenuation	±2.5 dB
>45 to 60 dB attenuation	±2.75 dB
>60 to 80 dB attenuation	±4.0 dB
Additional Insertion Loss	
900 MHz	2.5 dB maximum
1800 MHz	2.5 dB maximum

ATT2:

Attenuation Range	0 to 95.5 dB
Resolution	0.5 dB steps
Frequency Range	25 to 3000 MHz
Accuracy (25 to 2700 MHz)	
0 to 19.5 dB attenuation	±1.0 dB
20 to 39.5 dB attenuation	±2.0 dB
40 to 59.5 dB attenuation	±3.0 dB
60 to 79.5 dB attenuation	±4.0 dB
80 to 95.5 dB attenuation	±6.0 dB
Additional Insertion Loss	
900 MHz	2.5 dB maximum
1800 MHz	3.5 dB maximum

RF Image and LO Feedthrough Suppression (EFX Option)

Frequency Range	800 to 3000 MHz
Image Feedthrough on RF Out	-50 dBc maximum
LO Feedthrough on RF Out	-55 dBc maximum
Additional Insertion Loss	4 dB typical, 6 dB maximum
Additional Amp. vs. Freq. Variation	1 dB typical

RF Channel Bypass (CBP Option)

Insertion Loss with Channel Bypassed	1 dB typical

7.3. Channel Characteristics Emulation

Number of Independent Paths per Channel	3 or 6
Path Modulation	None, Rayleigh, Frequency Shift, Phase Shift, GSM Rician, Rayleigh with Frequency Shift, Nakagami, Programmable Rician

Fading Emulation Method

Programmable in 2 modes:	Jakes, Filtered Noise

Fading (Rayleigh) Amplitude Distribution

Deviation from Theoretical CPDF exceeds the following IS-55/56, IS-137/138, and IS-97/98 requirements:

From +10 to -30 dB of mean power level	± 0.5 dB

Level Crossing Rate (LCR) Accuracy exceeds following IS-55/56, IS-137/138, and IS-97/98 requirements:

From +3 to -30 dB of mean power level	< ± 2.5% deviation theoretical LCR curve of the simulated vehicle velocity

Fading Power Spectrum

Emulation Method = Jakes Programmable in 2 modes:	Classical 6 dB, Flat
Emulation Method = Filtered Noise Programmable in 4 modes:	Classical 6 dB, Flat, Classical 3 dB, Rounded

Fading Repetition Interval

Emulation Method = Jakes	
Simulated Doppler frequency ≤ 500 Hz	> 20 minutes
Simulated Doppler frequency > 500 Hz	> 10 minutes
Emulation Method = Filtered Noise	
Programmable in three nominal ranges:	20 minutes, 27 seconds, 24 hours

Correlation Coefficient
(Between Channel 1 and Channel 2 Paths)

Range	0 to 1
Resolution	0.01

Velocity

Range (f_c = 900 MHz)	± 1.2 to ± 885.0 km/hr (± 0.74 to ± 550 mph)
Resolution	0.1 units
Units	m/sec, km/hr, feet/sec, miles/hr

Doppler Frequency (Frequency Shift or Fading)

Range	± 1 to ± 740 Hz
Resolution	0.1 Hz

Relative Phase Between Paths
(Modulation = Phase)

Range	0 to 360 degrees
Resolution	0.1 degrees

Rician K Factor
(Modulation = Rician)

Range	- 30 to + 30 dB
Resolution	0.1 dB

Nakagami M Value
(Modulation = Nakagami)

Values	1, 3, 5, 10, 15, 25, 100

Rayleigh Fading Shift Frequency (Only available when Emulation Method = Jakes)
(Modulation = Rayleigh with Frequency Shift)

Range	- 240 to + 240 Hz
Resolution	0.1 Hz

Relative Path Delay

Range	
6 MHz Bandwidth System	0 to 200 µsec
Extended Delay Option	0 to 1600 µsec
15 MHz Bandwidth System	0 to 100 µsec
Extended Delay Option	0 to 800 µsec
26 MHz Bandwidth System	0 to 66.666 µsec
Extended Delay Option	0 to 533.328µsec
Resolution	1 nsec
Accuracy	
6 or 26 MHz Bandwidth System	± 10 nsec maximum
15 MHz Bandwidth System	± 5 nsec maximum

Relative Path Loss
(measurement performed with Modulation=Rayleigh)

Range	
6 MHz Bandwidth System	0 to 50 dB
15 MHz Bandwidth System	0 to 40 dB
26 MHz Bandwidth System	0 to 30 dB
Resolution	0.1 dB
Accuracy	
6 MHz Bandwidth System	
0 to 30 dB attenuation	±0.3 dB
>30 to 40 dB attenuation	±1.0 dB
>40 to 50 dB attenuation	±3.0 dB
15 MHz Bandwidth System	
0 to 20 dB attenuation	±0.3 dB
>20 to 30 dB attenuation	±1.0 dB
>30 to 40 dB attenuation	±3.0 dB
26 MHz Bandwidth System	
0 to 20 dB attenuation	±0.3 dB
>20 to 30 dB attenuation	±1.0 dB

Log Normal Fading Standard Deviation
(Relative Path Loss = 25 dB)

Range	0 to 12 dB
Resolution	1 dB

Log Normal Fading Rate

Range	0 to 20 Hz
Resolution	0.001 Hz

7.4. Dynamic Parameter Emulation

> **NOTE:** Dynamic Parameter Emulation is available via the remote connection only. The front panel interface is disabled while in Dynamic Parameter Emulation mode. Dynamic Parameter Emulation is not available on 26 MHz bandwidth systems.

Number of States:	1 to 512
State Duration	
Range	0.1 to 3276.7 sec.
Resolution	0.1 sec.
State Transitions	automatic looping, automatic single pass, single step, jump

All other specifications in Section 7.0. are valid with the following exceptions:

Relative Path Delay Resolution	
6 MHz Bandwidth System	50 nsec
15 MHz Bandwidth System	25 nsec
Fading Emulation Method:	Filtered Noise Only
Log Normal Fading:	Not Available

7.5. Local Oscillator (LO) Characteristics

Internal Local Oscillators (optional)
(All specs refer to LO OUT unless noted)

LO Frequency Range	
LO 3 option	200-400 MHz
LO 4 option	940-2860 MHz
Carrier Frequency Range (RF IN)	
LO 3 option	60 - 260, 340-540 MHz
LO 4 option	800-3000 MHz
Frequency Resolution	100 kHz
Frequency Accuracy	2 kHz
Level	+13 dBm typical
Off Level (wideband)	-40 dBm maximum
Phase Noise (1 kHz offset)	
LO 3 or LO 4 option	-75 dBc/Hz
Harmonics	< -10 dBc

External Local Oscillators
(All specs refer to LO IN unless noted)

LO Frequency Range	165-2860 MHz
LO Offset from Carrier Frequency (F_c)	
$F_c \geq 800$ MHz	F_c - 140 MHz
$F_c < 800$ MHz	F_c + 140 MHz
Level	
Nominal	+13 dBm
Minimum	+10 dBm
Maximum	+15 dBm
Damage	+23 dBm
Nominal LO Impedance	50Ω

7.6. General

Power Requirements

Voltage	85-265 VAC (auto sensing)
Frequency	47 - 63 Hz
Fuse Type	8.0 Amp, 250 Volt slo-blo
Number of Fuses	2
Fuse Location	Hot conductor, Neutral conductor

Operating Environment

Temperature	0 to 50 degrees C (32 to 122 degrees F)
Humidity	10% to 90%, noncondensing

Dimensions and Weight

Height	6.9 inches
Width	17.7 inches
Depth	19.9 inches
Weight	45 pounds

Control Interfaces

Interfaces Provided	RS-232 (DCE) and IEEE-488 (GPIB)

Serial Control Port Parameters

Bit Rates	300, 1200, 2400, 4800, 9600
Format	asynchronous
Bits/Char.	7 or 8
Parity	none, odd, even
Stop Bits	1, 1.5, 2

External 10 MHz Reference Requirements

Input Frequency	10.000 MHz
Input Power Level	+5.0 dBm

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8.0. Appendixes

8.1. Appendix 1: Standard Test and Factory Default Profiles

The following sections list the contents of the read-only standard test profile parameters that will be set when a recall is performed. The profile for the factory default is also included for reference purposes. Parameters that are not listed in the profiles will remain the same as before the recall operation.

NOTE: The RF Channel Status (Enabled or Bypassed) is reset to the Enabled state only when the factory default profile is recalled. The standard test profiles lists below do not modify the status of this parameter when recalled.

The list of standard test profiles is divided into three main groups:

1. IS-55/56 and IS-137/138 North American Dual mode (TDMA) cellular test profiles
2. IS-97/IS-98 North American Dual mode spread spectrum (CDMA) cellular test profiles
3. GSM test profiles (6 path and 12 path models)

The order of the profiles listed is as follows:

Default

IS55-56_1, IS55-56_2, IS55-56_3

CDMA_1, CDMA_2, CDMA_3, CDMA_4, CDMA_5

GSM_EQ50, GSM_EQ100

GSM_RA100_1, GSM_RA100_2, GSM_RA250_1, GSM_RA250_2

GSM_HT100_1, GSM_HT100_2

GSM_TU50_1, GSM_TU50_2

GSM_HT100_1_12, GSM_HT100_2_12

GSM_TU50_1_12, GSM_TU50_2_12

For the IS55-56 and CDMA test profiles, Channel 1 of the TAS 4500 is configured as the forward channel (base station-to-mobile link) and Channel 2 of the TAS 4500 is configured as the reverse channel (mobile-to-base station link). The GSM files listed above utilize a six path emulation model except those with a "_12" suffix which refer to a 12 path emulation model.

8.1.1. Default Values

Default Values												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	**1**						**2**					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	900.00						900.00					
RF Channel	enabled						enabled					
Path	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Status	on	off	off	off	off	off	on	off	off	off	off	off
Relative Delay (μs)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Modulation Type	none	none	none	none	none	none	none	none	none	none	none	none
Doppler Freq. (Hz)	41.7	41.7	41.7	41.7	41.7	41.7	41.7	41.7	41.7	41.7	41.7	41.7
Velocity (km/h)	50	50	50	50	50	50	50	50	50	50	50	50
Fading Power Spectrum	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*
Phase Shift (deg)	0	0	0	0	0	0	0	0	0	0	0	0
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Relative Loss (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal STD (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	0	0	0	0

* Fading Power Spectrum = Classical (6dB)

8.1.2. IS55-56 Dual Mode Cellular Test Profiles

The standard test profiles for IS-55 and IS-56 were derived from the EIA/TIA/IS-55 December 1991, and the EIA/TIA/IS-56-A October 1993 specifications. These test profiles are identical to those in the EIA/TIA/IS-137 December 1994, and the EIA/TIA/IS-138 December 1994 specifications. See Section 8.1. for more information.

IS55-56_1												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	881.01						836.01					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	off	off	off	off	on	off	off	off	off	off
Relative Delay (µs)	0.0	41.2	-	-	-	-	0.0	41.2	-	-	-	-
Modulation Type	Rayl.	Rayl.	-	-	-	-	Rayl.	Rayl.	-	-	-	-
Doppler Freq. (Hz)	6.5	6.5	-	-	-	-	6.2	6.2	-	-	-	-
Velocity (km/h)	8	8	-	-	-	-	8	8	-	-	-	-
Fading Power Spectrum	C6*	C6*	-	-	-	-	C6*	C6*	-	-	-	-
Phase Shift (deg)	0	0	-	-	-	-	0	0	-	-	-	-
Rayleigh Fading Shift Freq. (Hz)	0	0	-	-	-	-	0	0	-	-	-	-
Relative Loss (dB)	0	0	-	-	-	-	0	0	-	-	-	-
Log-normal Freq. (Hz)	0	0	-	-	-	-	0	0	-	-	-	-
Log-normal STD (dB)	0	0	-	-	-	-	0	0	-	-	-	-
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	-	-	-	-

* Fading Power Spectrum = Classical (6dB)

IS55-56_2												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	881.01						836.01					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	off	off	off	off	on	on	off	off	off	off
Relative Delay (μs)	0.0	41.2	-	-	-	-	0.0	41.2	-	-	-	-
Modulation Type	Rayl.	Rayl.	-	-	-	-	Rayl.	Rayl.	-	-	-	-
Doppler Freq. (Hz)	40.8	40.8	-	-	-	-	38.7	38.7	-	-	-	-
Velocity (km/h)	50	50	-	-	-	-	50	50	-	-	-	-
Fading Power Spectrum	C6*	C6*	-	-	-	-	C6*	C6*	-	-	-	-
Phase Shift (deg)	0	0	-	-	-	-	0	0	-	-	-	-
Rayleigh Fading Shift Freq. (Hz)	0	0	-	-	-	-	0	0	-	-	-	-
Relative Loss (dB)	0	0	-	-	-	-	0	0	-	-	-	-
Log-normal Freq. (Hz)	0	0	-	-	-	-	0	0	-	-	-	-
Log-normal STD (dB)	0	0	-	-	-	-	0	0	-	-	-	-
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	-	-	-	-

* Fading Power Spectrum = Classical (6dB)

IS55-56_3												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	881.01						836.01					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	off	off	off	off	on	on	off	off	off	off
Relative Delay (μs)	0.0	41.2	-	-	-	-	0.0	41.2	-	-	-	-
Modulation Type	Rayl.	Rayl.	-	-	-	-	Rayl.	Rayl.	-	-	-	-
Doppler Freq. (Hz)	81.6	81.6	-	-	-	-	77.5	77.5	-	-	-	-
Velocity (km/h)	100	100	-	-	-	-	100.1	100.1	-	-	-	-
Fading Power Spectrum	C6*	C6*	-	-	-	-	C6*	C6*	-	-	-	-
Phase Shift (deg)	0	0	-	-	-	-	0	0	-	-	-	-
Rayleigh Fading Shift Freq. (Hz)	0	0	-	-	-	-	0	0	-	-	-	-
Relative Loss (dB)	0	0	-	-	-	-	0	0	-	-	-	-
Log-normal Freq. (Hz)	0	0	-	-	-	-	0	0	-	-	-	-
Log-normal STD (dB)	0	0	-	-	-	-	0	0	-	-	-	-
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	-	-	-	-

* Fading Power Spectrum = Classical (6dB)

8.1.3. IS-97/98 Dual Mode Wideband Spread Spectrum (CDMA) Cellular Test Profiles

The standard test profiles for IS-97 and IS-98 were derived from the EIA/TIA/IS-97 (PN-3120) Ballot Version and EIA/TIA/IS-98 (PN-3121) Ballot Version. The following chart can be used to cross reference the TAS test file name with the IS-97/98 test configuration.

CDMA_1: IS-98 Test 1, IS-97 Test 1
CDMA_2: IS-98 Test 2
CDMA_3: IS-98 Test 3, IS-97 Test 2
CDMA_4: IS-98 Test 4, IS-97 Test 3
CDMA_5: IS-98 Test 5

CDMA_1												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	881.01						836.01					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	off	off	off	off	on	on	off	off	off	off
Relative Delay (µs)	0.0	2.0	-	-	-	-	0.0	2.0	-	-	-	-
Modulation Type	Rayl.	Rayl.	-	-	-	-	Rayl.	Rayl.	-	-	-	-
Doppler Freq. (Hz)	6.5	6.5	-	-	-	-	6.2	6.2	-	-	-	-
Velocity (km/h)	8	8	-	-	-	-	8	8	-	-	-	-
Fading Power Spectrum	C6*	C6*	-	-	-	-	C6*	C6*	-	-	-	-
Phase Shift (deg)	0	0	-	-	-	-	0	0	-	-	-	-
Rayleigh Fading Shift Freq. (Hz)	0	0	-	-	-	-	0	0	-	-	-	-
Relative Loss (dB)	0	0	-	-	-	-	0	0	-	-	-	-
Log-normal Freq. (Hz)	0	0	-	-	-	-	0	0	-	-	-	-
Log-normal STD (dB)	0	0	-	-	-	-	0	0	-	-	-	-
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	-	-	-	-

* Fading Power Spectrum = Classical (6dB)

CDMA_2												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	881.01						836.01					
Path	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Status	on	on	off	off	off	off	on	on	off	off	off	off
Relative Delay (μs)	0.0	2.0	-	-	-	-	0.0	2.0	-	-	-	-
Modulation Type	Rayl.	Rayl.	-	-	-	-	Rayl.	Rayl.	-	-	-	-
Doppler Freq. (Hz)	24.5	24.5	-	-	-	-	23.2	23.2	-	-	-	-
Velocity (km/h)	30	30	-	-	-	-	30	30	-	-	-	-
Fading Power Spectrum	C6*	C6*	-	-	-	-	C6*	C6*	-	-	-	-
Phase Shift (deg)	0	0	-	-	-	-	0	0	-	-	-	-
Rayleigh Fading Shift Freq. (Hz)	0	0	-	-	-	-	0	0	-	-	-	-
Relative Loss (dB)	0	0	-	-	-	-	0	0	-	-	-	-
Log-normal Freq. (Hz)	0	0	-	-	-	-	0	0	-	-	-	-
Log-normal STD (dB)	0	0	-	-	-	-	0	0	-	-	-	-
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	-	-	-	-

* Fading Power Spectrum = Classical (6dB)

CDMA_3												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	881.01						836.01					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	off	off	off	off	off	on	off	off	off	off	off
Relative Delay (µs)	0.0	-	-	-	-	-	0.0	-	-	-	-	-
Modulation Type	Rayl.	-	-	-	-	-	Rayl.	-	-	-	-	-
Doppler Freq. (Hz)	24.5	-	-	-	-	-	23.2	-	-	-	-	-
Velocity (km/h)	30	-	-	-	-	-	30	-	-	-	-	-
Fading Power Spectrum	C6*	-	-	-	-	-	C6*	-	-	-	-	-
Phase Shift (deg)	0	-	-	-	-	-	0	-	-	-	-	-
Rayleigh Fading Shift Freq. (Hz)	0	-	-	-	-	-	0	-	-	-	-	-
Relative Loss (dB)	0	-	-	-	-	-	0	-	-	-	-	-
Log-normal Freq. (Hz)	0	-	-	-	-	-	0	-	-	-	-	-
Log-normal STD (dB)	0	-	-	-	-	-	0	-	-	-	-	-
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	-	-	-	-	-

* Fading Power Spectrum = Classical (6dB)

CDMA_4												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	881.01						836.01					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	on	off	off	off	on	on	on	off	off	off
Relative Delay (μs)	0.0	2.0	14.5	-	-	-	0.0	2.0	14.5	-	-	-
Modulation Type	Rayl.	Rayl.	Rayl.	-	-	-	Rayl.	Rayl.	Rayl.	-	-	-
Doppler Freq. (Hz)	81.6	81.6	81.6	-	-	-	77.5	77.5	77.5	-	-	-
Velocity (km/h)	100	100	100	-	-	-	100.1	100.1	100.1	-	-	-
Fading Power Spectrum	C6*	C6*	C6*	-	-	-	C6*	C6*	C6*	-	-	-
Phase Shift (deg)	0	0	0	-	-	-	0	0	0	-	-	-
Rayleigh Fading Shift Freq. (Hz)	0	0	0	-	-	-	0	0	0	-	-	-
Relative Loss (dB)	0	0	3	-	-	-	0	0	3	-	-	-
Log-normal Freq. (Hz)	0	0	0	-	-	-	0	0	0	-	-	-
Log-normal STD (dB)	0	0	0	-	-	-	0	0	0	-	-	-
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	0	-	-	-

* Fading Power Spectrum = Classical (6dB)

CDMA_5												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	881.01						836.01					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	off	off	off	off	on	on	off	off	off	off
Relative Delay (μs)	0.0	2.0	-	-	-	-	0.0	2.0	-	-	-	-
Modulation Type	none	none	-	-	-	-	none	none	-	-	-	-
Doppler Freq. (Hz)	1.0	1.0	-	-	-	-	1.0	1.0	-	-	-	-
Velocity (km/h)	1.2	1.2	-	-	-	-	1.3	1.3	-	-	-	-
Fading Power Spectrum	C6*	C6*	-	-	-	-	C6*	C6*	-	-	-	-
Phase Shift (deg)	0	0	-	-	-	-	0	0	-	-	-	-
Rayleigh Fading Shift Freq. (Hz)	0	0	-	-	-	-	0	0	-	-	-	-
Relative Loss (dB)	0	0	-	-	-	-	0	0	-	-	-	-
Log-normal Freq. (Hz)	0	0	-	-	-	-	0	0	-	-	-	-
Log-normal STD (dB)	0	0	-	-	-	-	0	0	-	-	-	-
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	-	-	-	-

* Fading Power Spectrum = Classical (6dB)

8.1.4. GSM Test Profiles

All GSM profiles require at least six paths to be present in the TAS 4500. The six paths may be either in a single channel or split between two channels. The tables of parameter settings below assume all six paths are in a single channel. If only three paths per channel are present the parameter settings for CH1 paths 4-6 will be shifted to CH2 paths 1-3. The "Hilly Terrain" and "Typical Urban" profiles have both six and twelve path model test configurations. For the twelve path model configuration six paths must be present in each channel of the TAS 4500. The profiles are configured with carrier frequency of 947.4 MHz.

The following test configurations were derived from GSM Recommendation 05.05 version 3.5.0. The name of each model and its abbreviation is as follows:

6 Path Configurations:

Equalization test @50 km/h	GSM_EQ50
Equalization test @100 km/h	GSM_EQ100
Rural area @ 100 km/h options 1 & 2:	GSM_RA100_1, GSM_RA100_2
Rural area @ 250 km/h options 1 & 2:	GSM_RA250_1, GSM_RA250_2
Hilly terrain @100 km/h options 1 & 2:	GSM_HT100_1, GSM_HT100_2
Typical urban @50 km/h options 1 & 2:	GSM_TU50_1, GSM_TU50_2

12 Path Configurations:

Hilly terrain @100 km/h options 1 & 2:	GSM_HT100_1_12, GSM_HT100_2_12
Typical urban @50 km/h options 1 & 2:	GSM_TU50_1_12, GSM_TU50_2_12

GSM_EQ50												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	**1**						**2**					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	947.4						902.4					
Path	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Status	on	on	on	on	on	on	on	on	on	on	on	on
Relative Delay (μs)	0.0	3.2	6.4	9.6	12.8	16.0	0.0	3.2	6.4	9.6	12.8	16.0
Modulation Type	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.
Doppler Freq. (Hz)	43.9	43.9	43.9	43.9	43.9	43.9	41.8	41.8	41.8	41.8	41.8	41.8
Velocity (km/h)	50	50	50	50	50	50	50	50	50	50	50	50
Fading Power Spectrum	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*
Phase Shift (deg)	0	0	0	0	0	0	0	0	0	0	0	0
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Relative Loss (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal STD (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	0	0	0	0

* Fading Power Spectrum = Classical (6dB)

GSM_EQ100												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	947.4						902.4					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	on	on	on	on	on	on	on	on	on	on
Relative Delay (µs)	0.0	3.2	6.4	9.6	12.8	16.0	0.0	3.2	6.4	9.6	12.8	16.0
Modulation Type	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.
Doppler Freq. (Hz)	87.8	87.8	87.8	87.8	87.8	87.8	83.6	83.6	83.6	83.6	83.6	83.6
Velocity (km/h)	100	100	100	100	100	100	100	100	100	100	100	100
Fading Power Spectrum	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*
Phase Shift (deg)	0	0	0	0	0	0	0	0	0	0	0	0
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Relative Loss (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal STD (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	0	0	0	0

* Fading Power Spectrum = Classical (6dB)

	GSM_RA100_1											
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	947.4						902.4					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	on	on	on	on	off	off	off	off	off	off
Relative Delay (μs)	0.0	0.1	0.2	0.3	0.4	0.5	-	-	-	-	-	-
Modulation Type	Rice	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	-	-	-	-	-	-
Doppler Freq. (Hz)	87.8	87.8	87.8	87.8	87.8	87.8	-	-	-	-	-	-
Velocity (km/h)	100	100	100	100	100	100	-	-	-	-	-	-
Fading Power Spectrum	C6*	C6*	C6*	C6*	C6*	C6*	-	-	-	-	-	-
Phase Shift (deg)	0	0	0	0	0	0	-	-	-	-	-	-
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	0	0	-	-	-	-	-	-
Relative Loss (dB)	0	4	8	12	16	20	-	-	-	-	-	-
Log-normal Freq. (Hz)	0	0	0	0	0	0	-	-	-	-	-	-
Log-normal STD (dB)	0	0	0	0	0	0	-	-	-	-	-	-
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	-	-	-	-	-	-

* Fading Power Spectrum = Classical (6dB)

GSM_RA100_2												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	947.4						902.4					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	on	on	off	off	off	off	off	off	off	off
Relative Delay (µs)	0.0	0.2	0.4	0.6	-	-	-	-	-	-	-	-
Modulation Type	Rice	Rayl.	Rayl.	Rayl.	-	-	-	-	-	-	-	-
Doppler Freq. (Hz)	87.8	87.8	87.8	87.8	-	-	-	-	-	-	-	-
Velocity (km/h)	100	100	100	100	-	-	-	-	-	-	-	-
Fading Power Spectrum	C6*	C6*	C6*	C6*	-	-	-	-	-	-	-	-
Phase Shift (deg)	0	0	0	0	-	-	-	-	-	-	-	-
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	-	-	-	-	-	-	-	-
Relative Loss (dB)	0	2	10	20	-	-	-	-	-	-	-	-
Log-normal Freq. (Hz)	0	0	0	0	-	-	-	-	-	-	-	-
Log-normal STD (dB)	0	0	0	0	-	-	-	-	-	-	-	-
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	-	-	-	-	-	-

* Fading Power Spectrum = Classical (6dB)

GSM_RA250_1												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	947.4						902.4					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	on	on	on	on	off	off	off	off	off	off
Relative Delay (µs)	0.0	0.1	0.2	0.3	0.4	0.5	-	-	-	-	-	-
Modulation Type	Rice	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	-	-	-	-	-	-
Doppler Freq. (Hz)	219.5	219.5	219.5	219.5	219.5	219.5	-	-	-	-	-	-
Velocity (km/h)	250	250	250	250	250	250	-	-	-	-	-	-
Fading Power Spectrum	C6*	C6*	C6*	C6*	C6*	C6*	-	-	-	-	-	-
Phase Shift (deg)	0	0	0	0	0	0	-	-	-	-	-	-
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	0	0	-	-	-	-	-	-
Relative Loss (dB)	0	4	8	12	16	20	-	-	-	-	-	-
Log-normal Freq. (Hz)	0	0	0	0	0	0	-	-	-	-	-	-
Log-normal STD (dB)	0	0	0	0	0	0	-	-	-	-	-	-
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	-	-	-	-	-	-

* Fading Power Spectrum = Classical (6dB)

GSM_RA250_2												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	947.4						902.4					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	on	on	off	off	off	off	off	off	off	off
Relative Delay (μs)	0.0	0.2	0.4	0.6	-	-	-	-	-	-	-	-
Modulation Type	Rice	Rayl.	Rayl.	Rayl.	-	-	-	-	-	-	-	-
Doppler Freq. (Hz)	219.5	219.5	219.5	219.5	-	-	-	-	-	-	-	-
Velocity (km/h)	250	250	250	250	-	-	-	-	-	-	-	-
Fading Power Spectrum	C6*	C6*	C6*	C6*	-	-	-	-	-	-	-	-
Phase Shift (deg)	0	0	0	0	-	-	-	-	-	-	-	-
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	-	-	-	-	-	-	-	-
Relative Loss (dB)	0	2	10	20	-	-	-	-	-	-	-	-
Log-normal Freq. (Hz)	0	0	0	0	-	-	-	-	-	-	-	-
Log-normal STD (dB)	0	0	0	0	-	-	-	-	-	-	-	-
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	-	-	-	-	-	-

* Fading Power Spectrum = Classical (6dB)

GSM_HT100_1												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	**1**						**2**					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	947.4						902.4					
Path	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Status	on	on	on	on	on	on	on	on	on	on	on	on
Relative Delay (μs)	0.0	0.1	0.3	0.5	15	17.2	0.0	0.1	0.3	0.5	15	17.2
Modulation Type	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.
Doppler Freq. (Hz)	87.8	87.8	87.8	87.8	87.8	87.8	83.6	83.6	83.6	83.6	83.6	83.6
Velocity (km/h)	100	100	100	100	100	100	100	100	100	100	100	100
Fading Power Spectrum	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*
Phase Shift (deg)	0	0	0	0	0	0	0	0	0	0	0	0
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Relative Loss (dB)	0	1.5	4.5	7.5	8	17.7	0	1.5	4.5	7.5	8	17.7
Log-normal Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal STD (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	0	0	0	0

* Fading Power Spectrum = Classical (6dB)

GSM_HT100_2												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	**1**						**2**					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	947.4						902.4					
Path	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Status	on	on	on	on	on	on	on	on	on	on	on	on
Relative Delay (μs)	0.0	0.2	0.4	0.6	15	17.2	0.0	0.2	0.4	0.6	15	17.2
Modulation Type	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.
Doppler Freq. (Hz)	87.8	87.8	87.8	87.8	87.8	87.8	83.6	83.6	83.6	83.6	83.6	83.6
Velocity (km/h)	100	100	100	100	100	100	100	100	100	100	100	100
Fading Power Spectrum	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*
Phase Shift (deg)	0	0	0	0	0	0	0	0	0	0	0	0
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Relative Loss (dB)	0	2	4	7	6	12	0	2	4	7	6	12
Log-normal Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal STD (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	0	0	0	0

* Fading Power Spectrum = Classical (6dB)

GSM_TU50_1												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	947.4						902.4					
Path	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Status	on	on	on	on	on	on	on	on	on	on	on	on
Relative Delay (μs)	0.0	0.2	0.5	1.6	2.3	5.0	0.0	0.2	0.5	1.6	2.3	5.0
Modulation Type	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.
Doppler Freq. (Hz)	43.9	43.9	43.9	43.9	43.9	43.9	41.8	41.8	41.8	41.8	41.8	41.8
Velocity (km/h)	50	50	50	50	50	50	50	50	50	50	50	50
Fading Power Spectrum	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*
Phase Shift (deg)	0	0	0	0	0	0	0	0	0	0	0	0
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Relative Loss (dB)	3	0	2	6	8	10	3	0	2	6	8	10
Log-normal Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal STD (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	0	0	0	0

* Fading Power Spectrum = Classical (6dB)

GSM_TU50_2												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	947.4						902.4					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	on	on	on	on	on	on	on	on	on	on
Relative Delay (µs)	0.0	0.2	0.6	1.6	2.4	5.0	0.0	0.2	0.6	1.6	2.4	5.0
Modulation Type	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.
Doppler Freq. (Hz)	43.9	43.9	43.9	43.9	43.9	43.9	41.8	41.8	41.8	41.8	41.8	41.8
Velocity (km/h)	50	50	50	50	50	50	50	50	50	50	50	50
Fading Power Spectrum	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*
Phase Shift (deg)	0	0	0	0	0	0	0	0	0	0	0	0
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Relative Loss (dB)	3	0	2	6	8	10	3	0	2	6	8	10
Log-normal Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal STD (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	0	0	0	0

* Fading Power Spectrum = Classical (6dB)

GSM_HT100_1_12												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	947.4						947.4					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	on	on	on	on	on	on	on	on	on	on
Relative Delay (μs)	0.0	0.1	0.3	0.5	0.7	1.0	1.3	15.0	15.2	15.7	17.2	20.0
Modulation Type	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.
Doppler Freq. (Hz)	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8
Velocity (km/h)	100	100	100	100	100	100	100	100	100	100	100	100
Fading Power Spectrum	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*
Phase Shift (deg)	0	0	0	0	0	0	0	0	0	0	0	0
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Relative Loss (dB)	10	8	6	4	0	0	4	8	9	10	12	14
Log-normal Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal STD (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	0	0	0	0

* Fading Power Spectrum = Classical (6dB)

GSM_HT100_2_12												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	947.4						947.4					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	on	on	on	on	on	on	on	on	on	on
Relative Delay (µs)	0.0	0.2	0.4	0.6	0.8	2.0	2.4	15.0	15.2	15.8	17.2	20.0
Modulation Type	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.
Doppler Freq. (Hz)	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8	87.8
Velocity (km/h)	100	100	100	100	100	100	100	100	100	100	100	100
Fading Power Spectrum	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*
Phase Shift (deg)	0	0	0	0	0	0	0	0	0	0	0	0
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Relative Loss (dB)	10	8	6	4	0	0	4	8	9	10	12	14
Log-normal Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal STD (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	0	0	0	0

* Fading Power Spectrum = Classical (6dB)

GSM_TU50_1_12												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	1						2					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	947.4						947.4					
Path	1	2	3	4	5	6	1	2	3	4	5	6
Status	on	on	on	on	on	on	on	on	on	on	on	on
Relative Delay (µs)	0.0	0.1	0.3	0.5	0.8	1.1	1.3	1.7	2.3	3.1	3.2	5.0
Modulation Type	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.
Doppler Freq. (Hz)	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9
Velocity (km/h)	50	50	50	50	50	50	50	50	50	50	50	50
Fading Power Spectrum	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*
Phase Shift (deg)	0	0	0	0	0	0	0	0	0	0	0	0
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Relative Loss (dB)	4	3	0	2.6	3	5	7	5	6.5	8.6	11	10
Log-normal Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal STD (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	0	0	0	0

* Fading Power Spectrum = Classical (6dB)

GSM_TU50_2_12												
Configuration	Velocity Units = km/h Emulation Method - Jakes Nominal Fading Repetition - 20 minutes Correlation Algorithm - Envelope											
Channel	**1**						**2**					
Input Reference Level	-10.0 dBm						-10.0 dBm					
Output Attenuator	0 dBm						0 dBm					
LO Mode	external						external					
Carrier Freq. (MHz)	947.4						947.4					
Path	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Status	on	on	on	on	on	on	on	on	on	on	on	on
Relative Delay (µs)	0.0	0.2	0.4	0.6	0.8	1.2	1.4	1.8	2.4	3.0	3.2	5.0
Modulation Type	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.	Rayl.
Doppler Freq. (Hz)	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9	43.9
Velocity (km/h)	50	50	50	50	50	50	50	50	50	50	50	50
Fading Power Spectrum	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*	C6*
Phase Shift (deg)	0	0	0	0	0	0	0	0	0	0	0	0
Rayleigh Fading Shift Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Relative Loss (dB)	4	3	0	2	3	5	7	5	6	9	11	10
Log-normal Freq. (Hz)	0	0	0	0	0	0	0	0	0	0	0	0
Log-normal STD (dB)	0	0	0	0	0	0	0	0	0	0	0	0
Ch1-Ch2 Path Correlation	-	-	-	-	-	-	0	0	0	0	0	0

* Fading Power Spectrum = Classical (6dB)

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