Spirent Communications — Inspired Innovation

## User Guide

# DLS 5500 xDSL Custom Noise Generator

February 2008

P/N 71-004027 Rev A

## Spirent Communications, Inc.

26750 Agoura Road
Calabasas, CA
91302 USA




## Limited Warranty

Spirent Communications, Inc. ("Spirent") warrants that its Products will conform to the description on the face of order, that it will convey good title thereto, and that the Product will be delivered free from any lawful security interest or other lien or encumbrance.

Spirent further warrants to Customer that hardware which it supplies and the tangible media on which it supplies software will be free from significant defects in materials and workmanship for a period of twelve (12) months, except as otherwise noted, from the date of delivery (the "Hardware Warranty Period"), under normal use and conditions.

To the extent the Product is or contains software ("Software"), Spirent also warrants that, if properly used by Customer in accordance with the Software License Agreement, the Software which it supplies will operate in material conformity with the specifications supplied by Spirent for such Software for a period of ninety (90) days from the date of delivery (the "Software Warranty Period"). The "Product Warranty Period" shall mean the Hardware Warranty Period or the Software Warranty Period, as applicable. Spirent does not warrant that the functions contained in the Software will meet a specific requirement or that the operation will be uninterrupted or error free. Spirent shall have no warranty obligations whatsoever with respect to any Software which has been modified in any manner by Customer or any third party.

Defective Products and Software under warranty shall be, at Spirent's discretion, repaired or replaced or a credit issued to Customer's account for an amount equal to the price paid for such Product provided that: (a) such Product is returned to Spirent after first obtaining a return authorization number and shipping instructions, freight prepaid, to Spirent's location in the United States; (b) Customer provides a written explanation of the defect or Software failure claimed by Customer; and (c) the claimed defect actually exists and was not caused by neglect, accident, misuse, improper installation, improper repair, fire, flood, lightning, power surges, earthquake, or alteration. Spirent will ship repaired Products to Customer, freight prepaid, based on reasonable best efforts after the receipt of defective Products. Except as otherwise stated, any claim on account of defective materials or for any other cause whatsoever will conclusively be deemed waived by Customer unless written notice thereof is given to Spirent within the Warranty Period. Spirent reserves the right to change the warranty and service policy set forth above at any time, after reasonable notice and without liability to Customer.

TO THE EXTENT PERMITTED BY APPLICABLE LAW, ALL IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY, NONINFRINGEMENT AND FITNESS FOR A PARTICULAR PURPOSE, ARE HEREBY EXCLUDED, AND THE LIABILITY OF SPIRENT, IF ANY, FOR DAMAGE RELATING TO ANY ALLEGEDLY DEFECTIVE PRODUCT SHALL BE LIMITED TO THE ACTUAL PRICE PAID BY THE CUSTOMER FOR SUCH PRODUCT. THE PROVISIONS SET FORTH ABOVE STATE SPIRENT'S ENTIRE RESPONSIBILITY AND CUSTOMER'S SOLE AND EXCLUSIVE REMEDY WITH RESPECT TO ANY BREACH OF ANY WARRANTY.

# Contents

# About this Guide

## In About this Guide...

# Introduction

This *DLS 5500 xDSL Custom Noise Generator User Guide* describes the DLS 5500 xDSL Custom Noise Generator chassis and operating software. The noise generator is designed for use in physical testing of ANSI, ETSI, ITU-T, DSL Forum, HomePNA and EFM xDSL network access equipment, and it is generally referred to as the *DLS 5500* in this document. General information is also provided on system administration functions, testing procedures, and diagnostics. Additional user documentation is available.

# User Documentation

DLS 5500 user documentation is available in PDF format. PDF documents support product installation, provide important system reference information, and support DLS 5500 users.

Customers can view and download the following manuals from the Spirent Communications Customer Service Center (CSC) website: http://support.spirentcom.com.

- DLS 41x Series Operating Manuals
- DLS 400 Series Operating Manuals
- DLS 3000 Series Operating Manuals
- DLS 5000 Series Operating Manuals
- DLS 6000 Series Operating Manuals
- DLS 8000 Series Operating Manuals

# Hardware Handling/Cleaning Practices

The DLS 5500 contains electronic components that are sensitive to Electrostatic Discharge (ESD) damage. To prevent premature component failure or latent product damage, it is crucial that you handle this equipment following industry standard ESD handling practices. Refer to *Appendix D, "ESD Requirements,"* for further information.

To clean the DLS 5500, unplug the AC power cord from the facility power or inlet at the back of the DLS 5500. Use a lint-free damp cloth for cleaning the exterior of the DLS 5500 only.

# Protecting Your Investment

Spirent Communications is committed to providing the highest quality products and customer support possible. An annual calibration is required to ensure that your DLS 5500 unit is operating properly.

Spirent Communications offers two cost-effective optional service programs, an extended warranty and a three-year calibration agreement. Each of these programs is designed to improve the ease and efficiency of servicing Spirent Communications test equipment.

## Extended Warranty

Spirent Communications' Extended Warranty gives two years in addition to the original one-year manufacturer's warranty. Under the warranty agreement, Spirent Communications repairs any covered product that needs service during the warranty period. At the time of repair, any required firm ware and/or software upgrades are installed free of charge and if required as part of the repair, the unit receives a complete calibration. Spirent Communications also provides return shipment of any unit covered under warranty at Spirent Communications' cost.

The Extended Warranty provides:

- Extension of the original one-year limited warranty by two years (thus, a total warranty coverage of three years)
- Required firmware and software upgrades installed free at time of repair
- If required because of a repair, free calibration due to repair during the coverage period
- Prepaid, return shipment of repaired products worldwide.

Spirent Communications' Extended Warranty can be purchased at any time up until the expiration of the original one-year manufacturer's warranty.

## Three-Year Calibration Agreement

Spirent Communications' three-year calibration agreement gives the opportunity to invest in a yearly calibration for three years at a significant cost saving, ensuring optimum product performance.

Specific Spirent Communications products are shipped with a National Institute of Standards and Technology (N.I.S.T.) traceable calibration that expires one year from the original ship date. With ISO-9000 and other manufacturer specific metrology requirements, timely calibrations become critical to your operations. Spirent Communications sends out an e-mail reminder when the next calibration is due. A report containing all calibration data is shipped with the product.

The Spirent Communications' three-year calibration agreement provides:

- Three yearly N.I.S.T traceable calibrations (one per year)
- Notification from Spirent Communications when calibration is due
- Calibration data report
- Prepaid return shipment of calibrated unit worldwide.

The Spirent Communications' three-year calibration agreement may be purchased at any time.

Please contact Spirent Communications Customer Service for more information on these programs.

# How to Contact Us

To obtain technical support for any Spirent Communications product, please contact our Support Services department using any of the following methods:

## Americas

E-mail: support@spirent.com
Web: http://support.spirentcom.com
Toll Free: +1 800-SPIRENT (+1 800-774-7368) (US and Canada)
Phone: +1 818-676-2616
Fax: +1 818-880-9154
Hours: Monday through Friday, 05:30 to 18:00, Pacific Time

## Europe, Africa, Middle East

E-mail: support@spirent.com
Web: http://support.spirentcom.com
Phone: +33 (0) 1 61 37 22 70
Fax: +33 (0) 1 61 37 22 51
Hours: Monday through Thursday, 09:00 to 18:00, Friday, 09:00 to 17:00, Paris Time

## Asia Pacific

E-mail: supportchina@spirent.com
Web: http://support.spirentcom.com
Phone: 400 810 9529 (mainland China only)
Phone: +86 400 810 9529 (outside China)
Fax: +86 10 8233 0022
Hours: Monday through Friday, 09:00 to 18:00, Beijing Time

The latest versions of user manuals, application notes, and software and firmware updates are available on the Spirent Communications Customer Service Center website at http://support.spirentcom.com.

Information about Spirent Communications and its products and services can be found on the main company websites at http://www.spirentcom.com and http://www.spirentcom.com.cn (China).

## Company Address

Spirent Communications, Inc.
26750 Agoura Road
Calabasas, CA 91302

Chapter 1
# Introduction

**In this chapter. . .**

# Spirent's Involvement in Noise Generation

Spirent Access Emulation Division (AE) has been in the wireline simulation business for over 20 years. Since the days of the S2, Spirent Communications has designed many new simulators both to customers' specifications and to conform to an ever-growing range of industry standards. By introducing the DLS 100 in 1985, we believe that we sold the world's first truly wideband wireline simulator with the capability to successfully simulate attenuation, characteristic impedance, and delay.

In association with wireline simulation, Spirent Access Emulation has also developed products that can effectively simulate the impairments found on real cable. Crosstalk, white noise, RF Ingress (RFI), and impulse noise are but a few of many impairments generated to meet requirements of ANSI, ETSI, ITU-T, DSL Forum and Japanese standards.

The need for simulated impairments in xDSL network access equipment testing has grown in terms of both bandwidth requirements and noise shapes definitions. It became necessary to quickly generate not only standards-based noise shapes for conformance testing, but arbitrary defined shapes for performance testing of new customer xDSL products. The DLS 5500 xDSL Custom Noise Generator assists customers in designing and testing products that exceed these standards.

# Overview of the DLS 5500 xDSL Custom Noise Generator

The DLS 5500 (*Figure 1-1*) allows you to apply standards-based noise shapes (DLS 5Bxx Noise Libraries) or customer generated noise shapes to your test circuit. The noise generator is designed for use in physical testing of ANSI, ETSI, ITU-T, DSL Forum, HomePNA and EFM xDSL network access equipment. The DLS 5500 has a bandwidth of 30 MHz.

**Figure 1-1.** DLS 5500 xDSL Custom Noise Generator

The DLS 5500 has four noise output ports, all on the back panel. DLS 5200 and DLS 5204 platforms can be upgraded to a DLS 5500. Several upgrade options are available, please contact Spirent Communications on pricing.

# DLS 5500 Noise Configuration

Mechanically, the DLS 5500 noise generator consists of a rack-mountable PC chassis (2U high), keyboard, and mouse (monitor optional), custom Arbitrary Waveform Generator (AWG) module, control software, and sample noise library (s/w).

Electrically, the DLS 5500 is equipped with a 90 to 264 VAC, 50 to 60 Hz power supply (auto-ranging) or 100-120/220-240 VAC (±10%), 60/50 Hz power supply (switchable).

The DLS 5500 is configured as follows:

- Computer
  - CD-ROM/DVD drive
  - 512 MB RAM (minimum)
  - RS232 and parallel printer port
  - IEE-488 cable (IEE-488 interface card sold separately)
- DLS 5500 (4 channel) Arbitrary Waveform Generator (AWG) and Storage
  - 16 M sample word per channel, each with 14-bit DAC
  - Spirent-defined, up to 100 MHz or fixed sample rate per channel
  - Software controlled
  - BNC connector for:
    - 4 Noise Outputs designed to drive a 50 Ω load
    - Sync In
- Included software:
  - Win2000™ Operating System
  - DLS 1100 Software
  - DLS 5500 Software
  - License Manager software
  - DLS 5B07 Sample VDSL Noise Files

The DLS 5B07 Sample VDSL Noise Files includes a set of noise profiles that can be used immediately and/or serve as an example of how noise files are defined. Included in these profiles are ETSI VDSL sample profiles (reflecting the Dec. 2000 TS 101270 VDSL Standard) and ANSI VDSL sample profiles (reflecting the Dec. 2000 VDSL T1E1.4/2000-360 (v 009 R.3) Trial Use Standard).

The DLS 5500 does not perform noise injection directly to the wireline. It must be introduced to the test circuit by means of a connection to any one of the following Spirent products:

- DLS 400 Series Wireline Simulators equipped with DLS 5A00, DLS 5A01, DLS 5A01H Noise Impairment Module(s) or DLS 5401D xDSL Differential Mode Noise Injection Circuit
- DLS 5101 or DLS 5103 Noise Impairment Generators
- DLS 5402DC xDSL Differential & Common Mode Noise Injection System
- DLS 5403D Differential Mode VDSL Japanese Noise Injector
- DLS 5404 Differential Mode Noise Injector
- DLS 8100 or DLS 8200 VDSL Wireline Simulators
- DLS 5406 Japanese VDSL Noise Injector
- Other noise injector products as they become available.

# Test Setup

The building blocks of this test set-up are:

- A test loop, being either a real cable or a cable simulator
- A noise generator such as the DLS 5500 that generates a mixture of random noise
- An “adding” element (noise injection network) to inject the impairment noise into the test loop
- A balanced high impedance differential voltage probe connected with level detectors such as a spectrum analyzer or a true RMS volt meter.

The DLS 5500 creates noise profiles that must meet many noise characteristics to enable a realistic imitation of (spectrally polluted) operational access networks. Noise is:

- Frequency dependent
- Dependent on the length of the test loop, since FEXT coupling functions between wire pairs are length dependent
- Usually different for downstream and upstream performance tests (depending on the application)

A noise profile is a Power Spectral Density (PSD) description of the crosstalk noise as it is observed at the receiver of the xDSL modem under test (near the point of injection), so you use a different noise profile for each measurement.

The signal and noise levels are to be probed with a well-balanced differential voltage probe. From this voltage, the following levels can be extracted:

- Probing an RMS-voltage $U_{rms}$ [V] in this system over the full signal band means a *power level* into resistance $R_V$ of P [dBm] that equals:

  $P = 10 \times \log_{10} (U_{rms}^2 / R_V \times 1000)$ [dBm]

- Probing an RMS-voltage $U_{rms}$ [V] in this system within a small frequency band of $\Delta f$ (in Hertz) means a *power spectral density level* of P [dBm/Hz] into resistance $R_V$ within that filtered band that equals:

  $P = 10 \times \log_{10} (U_{rms}^2 / R_V \times 1000 / \Delta f)$ [dBm/Hz]

The bandwidth $\Delta f$ has to represent the noise bandwidth of the filter, and not the –3dB bandwidth, otherwise the PSD level is inaccurate.

The following equation is derived from the equation above:

dBm/Hz = dBm - 10 log (Resolution Bandwidth of spectrum analyzer)

*Figure 1-2* shows examples of typical test setups using the DLS 5500.

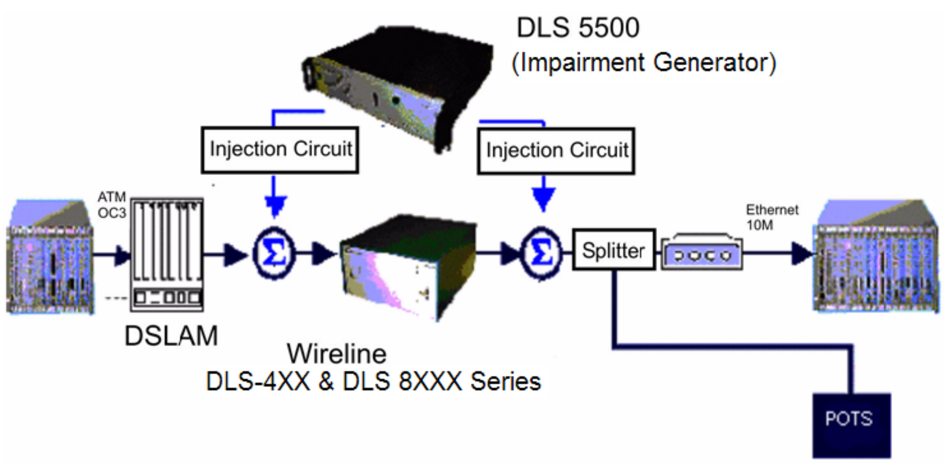



**Figure 1-2.** Example Test System Setups

Using these test setups enables you to be certain that the device under test (DUT) passes standards-based testing. The AE simulators and DLS 5500 noise generator together make the most comprehensive and accurate test bed available for xDSL impairment and wireline simulation. For more information on the compatible AE simulators, see *"User Documentation" on page 8*.

# DLS 5500 Noise Shapes

The DLS 5500 combines PC architecture, custom Arbitrary Waveform Generator (AWG) module(s) and Spirent control software to both synthesize and generate noise. This combination of hardware and software results in an impairment generator that generate precision noise for testing of xDSL network access equipment. With the DLS 5500, you can generate noise that is a realistic replica of the spectral pollution induced in a wire pair of a real network access cable.

The DLS 5500 software implements the following two independent noise sources:

- A *crosstalk noise* source to generate a replica of the noise that originates from xDSL transmission equipment (disturbers) that make use of other wire pairs in the same cable. The spectrum of crosstalk noise is dominantly continuous in nature.
- An optional[1] RFI *ingress noise* source to generate a replica of the noise that originates from (broadcast) radio stations outside the cable. The spectrum of ingress noise is dominantly discrete in nature.

In addition, the DLS 5500 supports:

- Impulse noise a short surge of electrical, magnetic, or electromagnetic energy.
- Time domain noise profiles such as impulsive type and Spirent supplied noise types for synchronization requirements based on TCM-ISDN signalling.
- Custom noise file capability is included with the standard DLS 5C20 license. This feature allows you to calculate and save this noise file. When the custom file is re-selected, the file no longer requires the calculation process which can shorten testing time when running extended tests. These files are saved with the *.cst* file extension.
- Combiner functionality, allowing you to combine various frequency domain or time domain impairments.

You control and calculate types of noise independently from each other and then generate them together. *Figure 1-3 on page 19* illustrates an example of simultaneously generated crosstalk and RFI ingress noise. You observe the combination with a spectrum analyzer at the output of the impairment generator. The discrete RFI tones in the spectrum represent the ingress noise, while the continuous part of the spectrum re-presents the crosstalk noise.

1. Purchase of the DLS 5B36 “RFI Tone Generator License” is required to activate this feature. Please contact your sales representative for further information.

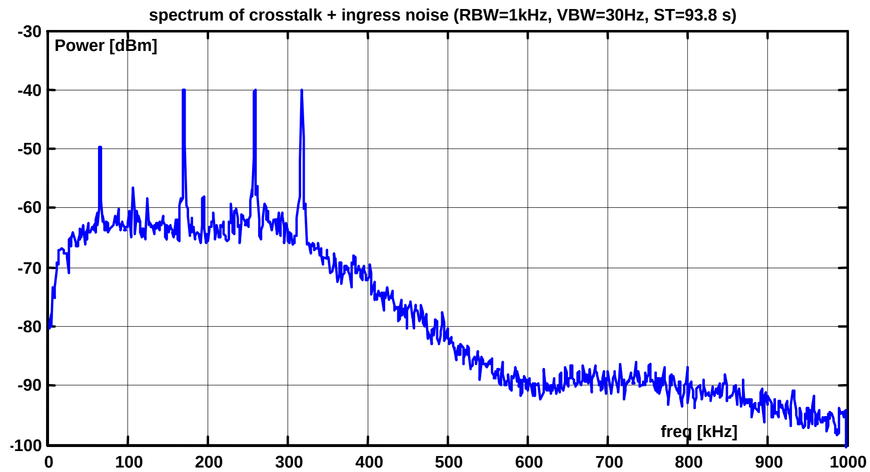



**Figure 1-3.** Example of Combination of Crosstalk and Ingress Noise

The major advantage of this software-based noise generator is that you can define the main characteristics of the noise. First, the software reads a noise profile from an ASCII-file that specifies the relevant characteristics in terms of PSD levels, frequencies, and modulation depth. You then select the relevant profiles from a set of pre-defined files and the software synthesizes the noise. Finally, the software loads the noise data into the hardware and the hardware generates the customized noise profile.

The size of the PSD description in the crosstalk noise profile is only limited by AWG memory and the output power of the noise generator. The ingress noise profile can specify up to 30 discrete AM RFI tones.

For more information about:

- Programming the DLS 5500, see *Chapter 3, "DLS 5500 Software."*
- Creating custom noise files, see *Chapter 5, "Crosstalk Noise Profiles,"* and *Chapter 6, "Ingress Noise Profiles (Optional)."*

# Where to Start

You should read *Chapter 2, "Getting Started,"* thoroughly before powering up a DLS 5500 xDSL Custom Noise Generator. The remainder of this manual contains information about the control, specifications, performance and warranty of the DLS 5500.

We recommend you use our software to configure and control the noise generator. However, we detail common and device specific message sets that can be sent to the noise generator through the Ethernet port, in *Chapter 8, "Remote Control Programming."*

Some features covered in this manual may not be available with the specific hardware and software configuration on your noise generator. Contact a Spirent Communications sales representative to discuss upgrading your DLS 5500 system.

If you have any questions after reading this manual, please contact a member of the Customer Service team. See *"How to Contact Us" on page 10*.

Chapter 2

# Getting Started

**In this chapter. . .**

# Receiving and Unpacking the Unit

This noise generator has been shipped in a reinforced shipping container. Please retain this container in case you need to ship the noise generator to another location or for repair.

The DLS 5500 is a 2U rack mountable instrument, which can be mounted in a standard 19-inch equipment rack. Rack mounting hardware is included with the unit.

Items supplied:

- Front panel door key
- One (1) Y cable
- One pair of ferrite clamps
- PS/2 mouse and keyboard
- Pre-installed, licensed DLS 5500 Software
- Optional licensed software (Noise Files). Contact Spirent for available noise files and optional upgrades
- One (1) AC power cord
- Four (4) BNC cables

**Note:** The standard DLS 5500 package does not include a monitor. If required, Spirent Communications can supply a monitor as a package option. This monitor should be a CRT or LCD type with a minimum display screen of 15 inches.

Confirm that you have received all the items on the list and report any discrepancies to Spirent Communications. See also *"Returning the DLS 5500"* in the next section.

# Returning the DLS 5500

**Note:** An RMA number is mandatory and must be obtained from a Spirent Communications Customer Service center prior to shipping the unit (see *"How to Contact Us"* for details on how to contact the nearest Customer Service center).

**To return the DLS 5500:**

1. Prepare the unit for shipment: turn the power off, disconnect all cables (including the power cable) and pack the unit in its original cartons. Do not place any cables or accessories directly against the front panel as this may scratch the surface of the unit.
2. Mark all shipments with labels indicating that the contents are fragile.
3. Ensure that the Return Material Authorization (RMA) number is shown on the outside of the package(s) if you are sending a unit back to the factory.

# Front Panel Components and Connections

The DLS 5500 has a locking front panel door, behind which are the Power and Reset switches and the hard drive LEDS. The front panel is used to connect an optional keyboard, turn on the power, reset the unit, or insert floppy disks or CD/DVDs. *Figure 2-1* shows the key components of the front panel (including those behind the locking door).

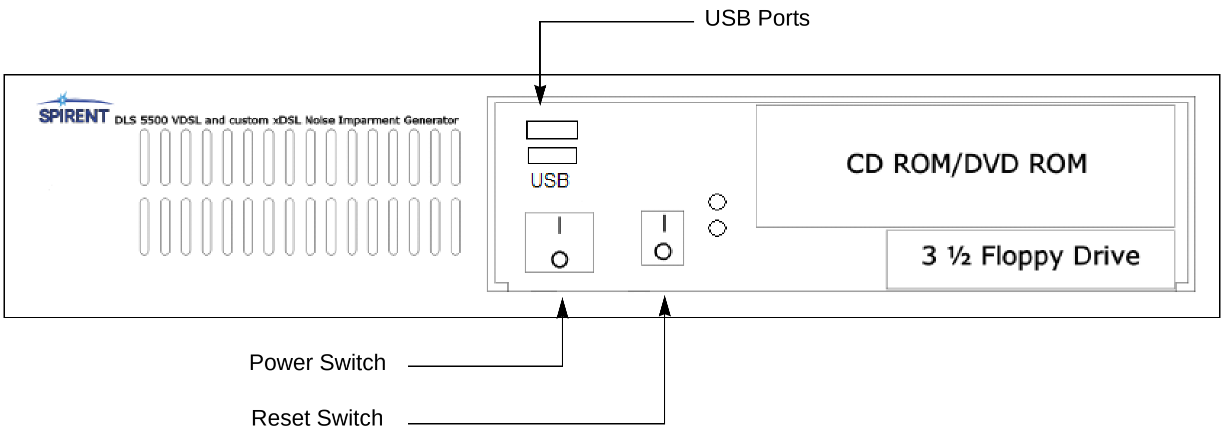



**Figure 2-1.** DLS 5500 Front Panel

The DLS 5500 front panel components are as follows:

- Optional keyboard connector (not used for the supplied keyboard. PS/2 keyboards are connected via "Y" Cable on rear panel)
- USB ports. These can be used for a keyboard or for memory devices.
- Power switch
- Reset button
- CD ROM/DVD ROM and 3.5 floppy drive

## Accessing the Power Switch, Reset Button, and Drives

The power switch, reset button, and drives are located behind the locking front panel door. Ensure you have completed all back panel connections before opening the locking front panel door and turning on the power. The key is supplied with the unit.

# Back Panel Components and Connections

The back panel (see *Figure 2-2 on page 24*) is used to connect a mouse, keyboard, and monitor as well as to connect to the test circuit for both communication (optional remote control of test system components) and noise generation purposes.

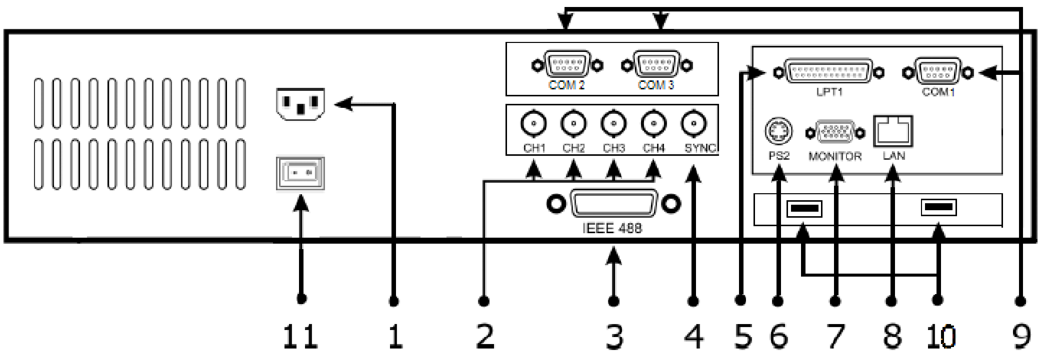



**Figure 2-2.** DLS 5500 Back Panel

The DLS 5500 back panel components (see numbered callouts in *Figure 2-2*) are as follows:

**1** AC power input

**2** Noise outputs

**3** IEEE 488 Connector (optional). To remotely control external devices

**4** Sync In connector

**5** LPT 1 (Printer port)

**6** PS/2 port. To connect mouse, and/or computer keyboard (adaptor required for both).

**7** Monitor connector

**8** LAN connector. Ethernet port, which allows remote control of the DLS 5500 by another computer.

**9** COM 1, COM 2, and COM 3 connectors. To remotely control wireline simulators or noise injection units.

**10** USB ports

**11** Power switch

## Connecting to Power

**To connect to power:**

1. Connect the power input (on the DLS 5500 back panel) to an AC line, with 90–264 VAC, 50 to 60 Hz (auto-ranging) or 100–120/220–240 VAC (±10%), 60/50 Hz (switchable).
2. Verify the power supply type on your unit, and if it is switchable, set it to the appropriate voltage setting.

**Note:** Always ground the external insertion circuit to the same ground circuit/power bar as the DLS 5500.

Please see *Appendix C, "Safety Information and Instructions"* for more details.

## Introducing Noise to the Test System

For noise injection purposes, connect the DLS 5500 to one or more of the following test system components:

- The BNC 50 Ω External Noise Input of DLS 400 Series Wireline Simulators (back of unit) equipped with DLS 5A00, DLS 5A01, DLS 5A01H Noise Impairment Module(s) or DLS 5401D xDSL Differential Mode Noise Injection Circuit
- The BNC 50 Ω External Noise Input of the DLS 5101 or DLS 5103 Noise Impairment Generators
- One of the four (4) BNC 50 Ω Noise Inputs of the DLS 5402DC xDSL Differential and Common Mode xDSL Noise Injector
- The BNC 50 Ω Noise Input of the DLS 5403D Differential Mode Japanese Noise Injector
- The BNC 50 Ω Noise Inputs of the DLS 5406 Noise Injector Unit
- The BNC 50 Ω noise inputs of the DLS 5404 Noise Injection Unit.
- The BNC 50 Ω External Noise Input of the DLS 8100 or DLS 8200 VDSL Wireline Simulators (back of unit)
- The RJ-45 switched ports used for external noise injection. They are located on the front of some wireline simulator models.
- Other noise injector products as they become available.

## Connecting the Mouse, Keyboard and Monitor

**To connect the mouse, keyboard, and monitor:**

1. Attach the PC compatible mouse, keyboard, and monitor to the appropriate (labeled) inputs at the back of the unit. Turn on the monitor.

**Note:** A “Y” cable is supplied with the unit to allow the supplied PS/2 compatible keyboard and mouse to share the same port.

2. Optionally, instead of attaching a keyboard to the back panel PS/2 port, attach a keyboard and mouse to the USB ports located at the front of the unit.
3. Ensure the mouse and keyboard are plugged in before turning on the power.

## Controlling and Configuring Units in the Test System

The DLS 5500 software is factory installed on the DLS 5500. It allows you to select, customize, and load noise files for noise injection in to the test system. However, you can also control the unit remotely by means of the Ethernet interface (using Spirent software or custom software message sets) from another computer on the local area network.

If you are developing custom control software, *Chapter 8, "Remote Control Programming,"* discusses the accepted commands to configure the DLS 5500 unit.

**Note:** Spirent Communications warrants the DLS 5500 and associated software. Spirent Communications however, does not warrant non-Spirent application software that may be run on DLS 5500 units. Applications installed on the DLS 5500 units without prior approval from Spirent Communications voids all warranties associated with this product.

From the DLS 5500, the software communicates within the test system with three possible types of connections: IEEE 488, serial, and/or Ethernet.

## Installing the Software

Software packages are factory installed on this unit. Should you ever need to re-install the software, use the steps below.

**To install the software:**

1. Insert a software installation CD/DVD in the computer CD/DVD drive.
   The Installation Wizard starts.
2. Follow the instructions on the Wizard's series of dialog boxes.
3. Repeat this procedure for each CD.

## IEEE 488 Port (GPIB) Connections

The IEEE 488 portion of the control software Spirent Communications supplies only works with a National™ IEEE 488 interface card.

**Note:** Customer removal of this card will void the warranty.

If necessary, install the National™ IEEE 488 interface card in the computer. For information on how to install the card, please refer to the *National Instruments GPIB Card and Software Installation* document, which comes with the card.

**To make an IEEE 488 (GPIB) connection:**

1. Connect the IEEE 488 cable to the IEEE 488 connector located on the rear panel(s) of the AE units.
2. Connect the other end of the IEEE 488 cable to the IEEE 488 interface card in the DLS 5500 unit.

## Serial Port (RS-232) Connections

Use one of the serial ports (COM 1, COM 2, or COM3) to control the noise injector (DLS 5405 or later models). See the noise injector operating manual for detailed procedures.

## Local Area Network Connections

**To make LAN connections:**

**1** Optionally, connect the Ethernet cable to the LAN port when connecting the computer to a local area network.

**2** Set the IP address according to the instructions in the sections beginning on *page 28*.

This enables the DLS 5500 unit to be controlled remotely via the LAN.

A shortcut icon should appear on your desktop when you have finished the installation. However, if you do not see the icon, you can find the program executable file in the default installation folder: **C:/Program Files/Spirent Communications**.

**3** Right-click on the file name to create a shortcut on your desktop.

## Connecting the Ferrite Clamp

To ensure EMC compliance, attach the enclosed ferrite clamp to the Ethernet port cable, close to the unit.

# IP Address Setup

The DLS 5500 unit can be used as a stand-alone PC or as part of a network configuration.

## DLS 5500 in a Stand-Alone System

When you operate the DLS 5500 unit as a non-networked stand-alone system (default configuration), use the settings provided in this section to ensure maximum performance.

For maximum performance the PC's TCP/IP properties should be set to obtain a static IP address as shown.

**To obtain a static IP address:**

1. Select **Control Panel** > **Network** > **Configuration**.
2. Select **TCP/IP** from the list.
3. Click on **Properties**.
4. Select the **IP Address** tab.
5. Click the **Specify an IP address** button.

**Note:** In the following steps, the specified IP Address and Subnet Mask field entries should only be used when the computer is not connected to a network.

6. In the *IP Address* field, enter the following:
   192.168.0.1
7. In the *Subnet Mask* field, enter the following:
   255.255.255.0

## DLS 5500 as part of a Network

When you connect the DLS 5500 computer to a network, the settings in *Step 6* and *Step 7* above must be changed, either to obtain a dynamic IP address or to an assigned static IP address. Your Network Administrator can tell you which settings to use.

**To specify IP addresses statically:**

1. Select **Control Panel** > **Network** > **Configuration**.
2. Select **TCP/IP** from the list.
3. Click on **Properties**.
4. Select the **IP Address** tab.
5. Click the **Specify an IP address** button.
6. In the *IP Address* field, enter the value as specified by your Network Administrator.
7. In the *Subnet Mask* field, enter the value as specified by your Network Administrator.

**To obtain IP addresses dynamically:**

1. Select **Control Panel** > **Network** > **Configuration**.
2. Select **TCP/IP** from the list.
3. Click on **Properties**.
4. Select the **IP Address** tab.
5. Click the **Obtain an IP address automatically** button.

# TCM-ISDN Noise Injection Setup

*Figure 2-3* shows the detailed hardware setup for proper TCM-ISDN noise injection for ADSL2+ Japan. This configuration requires a 400-Hz signal from the DLS 5A02 NCS clock decoder into the Clock Sync input of the DLS 5500 custom noise generator.

The diagram shows a DLS 5404 being used as a differential-mode high-impedance noise injection circuit, applying generated noise from the DLS 5500 onto the simulated Wireline.

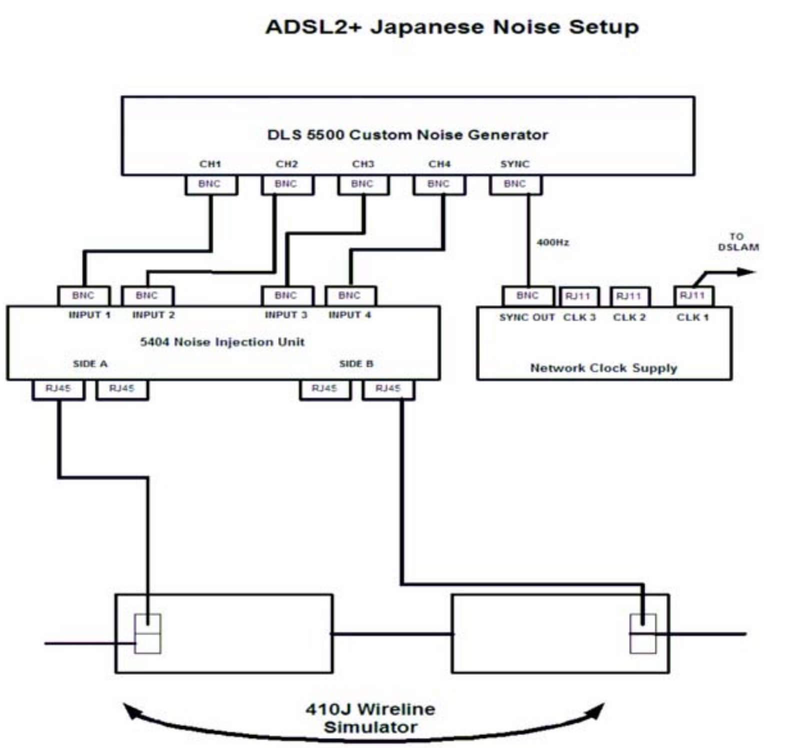



**Figure 2-3.** ADSL2+ Japanese Synchronization Setup

Chapter 3

# DLS 5500 Software

In this chapter. . .

# Introduction

This chapter explains the DLS 5500 Control Application, which ships with the DLS 5500. For information on developing your own script-based control software, see *Chapter 8, "Remote Control Programming."*

The DLS 5500 Control Application uses a Graphical User Interface (GUI) to provide you with an easy, intuitive method of configuring the various properties of the generated noise.

The DLS 5500 can simulate the combined spectral pollution from hundreds of arbitrary xDSL transmission systems that use the same multi-wire telephony cable.

For more information about the noise shape configurations see:

- *Chapter 5, "Crosstalk Noise Profiles"*
- *Chapter 6, "Ingress Noise Profiles (Optional)"*
- *Chapter 7, "Time Domain Noise Profiles"*

# Overview of the DLS 5500 Software Features

The DLS 5500 Control Application calculates a noise sample from the noise profiles that you select. The noise sample is downloaded to the DLS 5500. The DLS 5500 outputs the noise sample without further signal processing.

- A *Noise Profile* is a description of the characteristics of the noise, such as the power spectral density (PSD) of crosstalk noise or the radio frequency interference (RFI) tones of ingress noise.
- A *Noise Sample* is a sequence of numbers representing the noise profile in the time domain. Noise samples exist in the internal memory of the software, and are not made available as a separate entity.

The software implements the following features:

- Importing a *Crosstalk Noise Profile* from a file that specifies the PSD of crosstalk noise in a human readable ASCII table format.
- Importing an *Ingress Noise Profile* from a file that specifies the RFI tones of ingress noise in a human readable ASCII table format.
- Importing a Time Domain Profile from a file that specifies amplitude levels vs. time.
- Choosing the settings of the noise generator. These correspond to fundamental parameters of the Noise Sample, such as the length of the Noise Sample.
- Various amplification settings to control and fine-tune the level of the total output noise.
- Calculating a noise sample from an active noise profile.

  When the DLS 5500 Control Application calculates the noise sample, an iterative algorithm is called to synthesize crosstalk noise that can also meet the requirement for a crest factor of greater than 5. Recent standards, including the ETSI-SDSL standard, require a crest factor equal to or greater 5, and tight constraints on the amplitude distribution of the crosstalk noise.

- Downloading the synthesized noise sample to the DLS 5500 and activating its output.
- Displaying a graphic representation of the requested spectrum, and the one that will be generated (in case the output signal is amplified to compensate for the attenuation in the noise injection network).
- Display of the key properties (power, crest factor, and so on) of the synthesized noise sample.
- A graphic representation of the characteristics of the generated noise, both in the time-domain and in the frequency-domain. This includes the spectral density and the distribution function of the noise.

**Note:** When ETSI-compliant crosstalk noise (crest factor >5) is combined with ingress noise (for example, a single RFI tone at very high level), the crest factor of this combined noise may be lower than the crest factor of crosstalk noise. Therefore, always deactivate the ingress noise when checking ETSI compliance of the crosstalk noise.

# Quick Start - Generating a Noise Sample

This procedure provides you with the basics to quickly select one or more noise profiles and generate a noise sample from them. For detailed descriptions of DLS 5500 software fields see *“Work Space Region” on page 37*.

**To configure and generate a noise sample for the DLS 5500:**

1. If it is not already running, launch the DLS 5500 application from **Start** > **Programs** > **Spirent Communications** > **DLS 5500** > **DLS 5500**.
2. From the DLS 5500 Control Application main window, use the browsing tree at the left to locate the desired noise file(s).
3. Click on the file names to load the files into the workspace.
4. Make any required Control Application settings (for example, Calibration Impedance).
5. Choose the **Target Channel** from the Noise Calculation workspace and select the **SampleNumber** required.
6. Click the **Calculate** button.
7. Click **Generate** to load the calculated sample into the Noise Generator and start signal output on the previously selected target channel.
8. Use the **Channel 1, ..., Channel 4** buttons on the top screen of the DLS 5500 Control Application to control the individual Channel output.
9. To exit DLS 5500, select **File** > **Exit**.

# Launching the DLS 5500 Control Application

**To launch the DLS 5500 Control Application:**

1 Select **Start** > **Programs** > **Spirent Communications** > **DLS 5500** > **DLS 5500**.
The main window appears.

2 To exit the DLS 5500 Control Application, select **File** > **Exit**.

# Licenses

**To view installed license packages:**

1 Select **System** > **License Management**
The *DLS5500 License Management* dialog box appears (*Figure 3-1 on page 35*).

2 Click the **Display Licenses** button.
The *License Information* window appears.
For each license installed, the *License Information* window displays the product name, platform type, identification, expiration date, and key.

**Note:** You can also access this window without starting the DLS 5500 Control Application. Select **Start** > **Programs** > **Spirent Communications** > **DLS 5500** > **License Info**.

**Warning:** Licensed noise files supplied by Spirent Communications must not be moved in the directory structure. A licensing failure will occur if any of the ***.enc** (encrypted) file types are moved.

# License Management

The license management dialog (*Figure 3-1*) displays the MAC address of the DLS 5500 chassis. The MAC address is required by Spirent Communications to create new noise file licenses.

Click the **Display Licenses** button to see a list of currently loaded licensed packages for this DLS 5500.

Click the **Add Licenses** button to add additional noise licenses.


**Figure 3-1.** License Management Dialog Box

**Warning:** Do not install a second NIC card into the DLS 5500 chassis. This will cause a problem, and your noise file licenses will no longer be valid.

# Control Application Window Layout

The DLS 5500 Control Application window is divided into five regions, as shown in *Figure 3-2*:

**1** Work Space

**2** Combined Noise

**3** Noise Calculation

**4** Noise Output

**5** File browsing tree

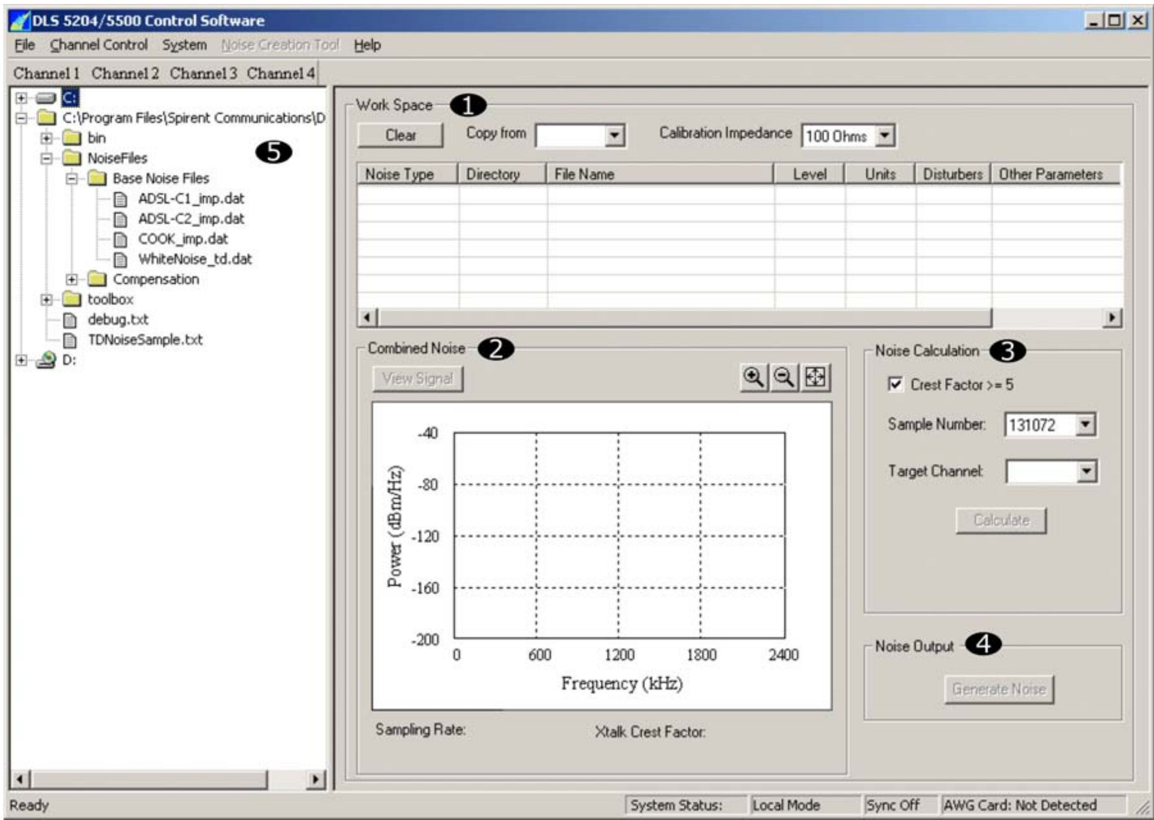



**Figure 3-2.** DLS 5500 Control Window

## Work Space Region

The *Work Space* region (*Figure 3-3*) allows you to combine various noise profiles available in the DLS 5500 hardware. The table shown within the Work Space is referred to as the *combiner window.* This term is used extensively throughout this chapter.

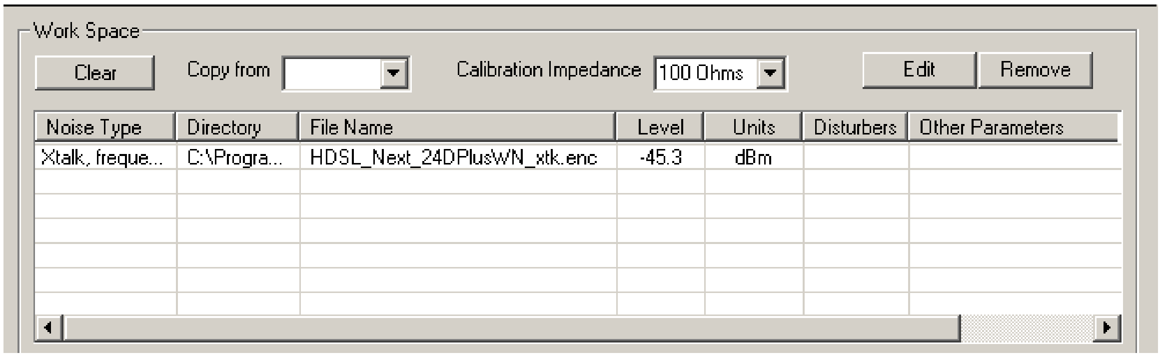



**Figure 3-3.** Combiner Window

Up to seven different noise profiles can be combined in the combiner window if a 5C20 license is installed. The combined profiles can be generated onto a single channel output. The combiner window displays the noise file properties described in *Table 3-1*.

**Table 3-1.** Combiner Window Table Description

| Column | Description |
|---|---|
| Noise Type | Identifies the file type as a frequency OR time domain file type |
| Directory | File location |
| File Name | Shows the noise file name and extension |
| Level | Shows the reference power level of the selected noise. This level is also known as the 0 dB reference level calculated by Spirent across a specific calibration impedance. |
| Units | Shows the units of measurement for the level field |
| Disturbers | Shows the number of disturbers for specific files that use this method of specifying level. ANSI specifies some of its crosstalk files related to the quantity of disturbers within a binder group. Note: If the file does not use this method, the field is grayed out. |
| Other Parameters | Displays specific file properties for information purposes only. ETSI complex load impedance file types will be displayed in this field as CLIC (Complex Load Impedance Compensation). |

**Notes:**
- The DLS 5500 cannot combine time domain noise (_td) files with any other type of noise files, such as (_xtk), (_td), (_rfi) or (_imp).

- X-Talk files can be combined with other xtalk files (_xtk) and with RFI files (_rfi).
- Impulse files (_imp) cannot be combined with any other type of noise files (_xtk), (_td), (_rfi) or (_imp).
- Time domain files only allow one (_td) file to be loaded onto one channel at a time.

## Clear Button

Click this button to delete listed noise profiles from the combiner window

## Copy from Drop-Down List

To apply a previously loaded channel to another channel, select the channel in the *Copy from* drop-down list (*Figure 3-4*). The noise profile from the selected channel will be loaded into the combiner window.


**Figure 3-4.** Copy From Drop-Down List

## Calibration Impedance Drop-Down List

Noise files are calibrated and measured using different load impedance values, which are outlined in the various xDSL standards. To identify which calibration impedance should be selected, refer to the relevant xDSL standard.

The DLS 5500 allows you to select one of three calibration impedance values using the *Calibration Impedance* drop-down list (*Figure 3-5*):

- 100 Ohms
- 35 Ohms
- ETSI Load


**Figure 3-5.** Calibration Impedance Drop-Down List

**Note:** The DLS 5500 allows just one calibration impedance value to be specified per channel. ETSI complex impedance noise files can only be combined with other ETSI complex impedance noise types.

ETSI complex impedance noise types are identified and displayed in the *Other Parameters* field of the DLS 5500 combiner window with the acronym CLIC (Complex Load Impedance Compensation).

## Edit Button

Click **Edit** (*Figure 3-6*) to modify various parameters of the currently selected noise file.


**Figure 3-6.** Edit button

You can edit noise levels or disturber quantity either by double-clicking on the appropriate row of the combiner window or by selecting a table entry and clicking the **Edit** button.

When you click the **Edit** button, the *Noise Attribute Editing* window appears (*Figure 3-8 on page 40*).

## Remove Button

Click **Remove** (*Figure 3-7*) to remove the currently selected noise profile from the combiner window.


**Figure 3-7.** Remove button

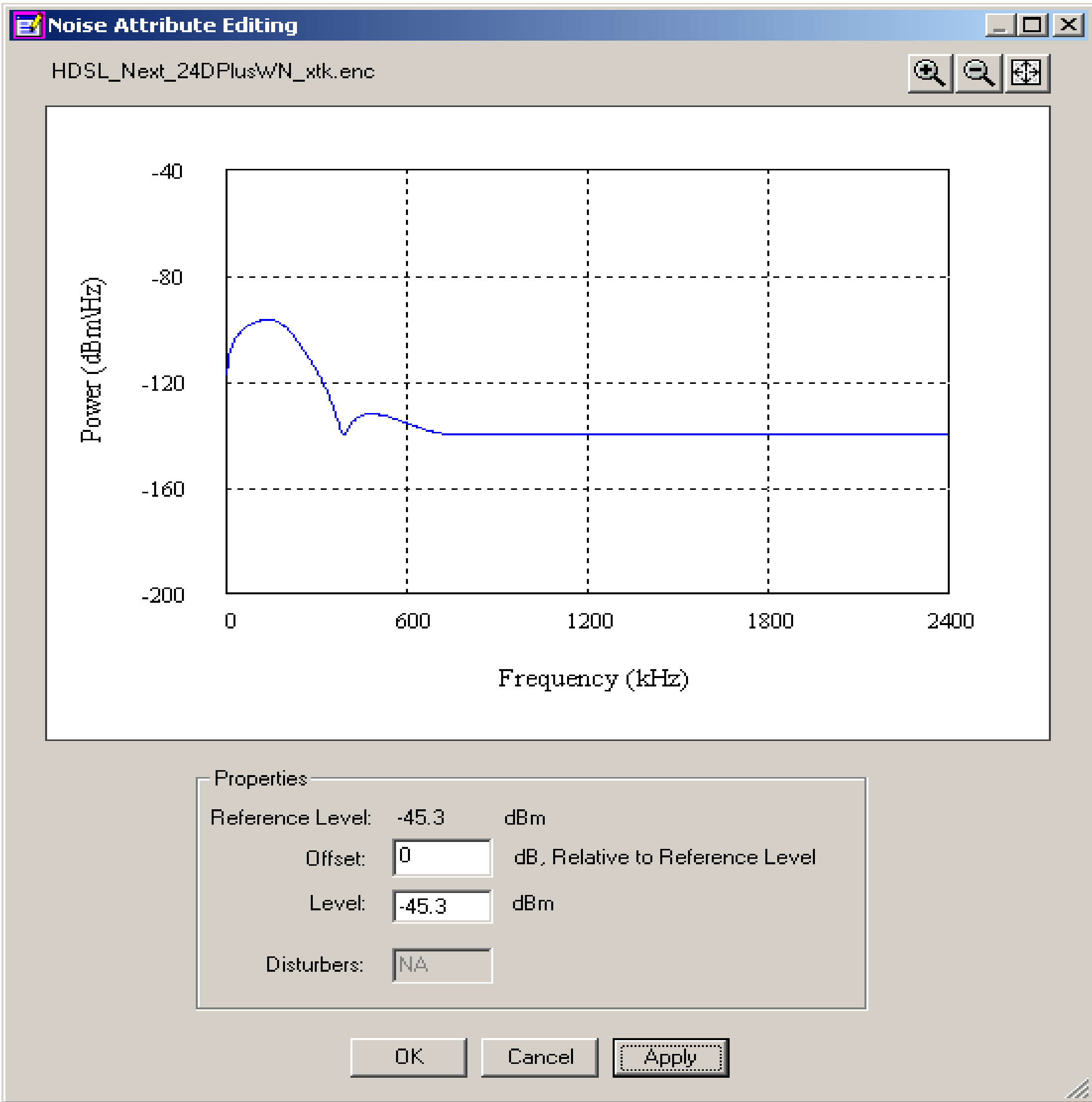



**Figure 3-8.** Noise Attribute Editing window

The *Properties* pane, shown in *Figure 3-8*, has the following controls:

- Reference Level: the value displayed identifies the calculated power level for a specified noise file and is considered to be the 0 dB reference level using a specified load as calculated by Spirent.
- Offset dB Relative to Reference Level: enter the level (in dB) for the specified noise in the text box and click **Apply**. Placing a value in this field changes the total power based on the specified reference level of the noise file.

- Level: This field identifies the reference power level of the noise selected. This value is also known as the 0 dB reference level calculated by Spirent across a specified calibration impedance. Enter a new level for the specified noise in the text box and select **Apply**.
- Disturbers: NA (grayed out)

## Combined Noise Region

The *Combined Noise* region (*Figure 3-9*) provides a visual indicator of the noise characteristics for the noise files listed in the combiner window. The combined noise parameters are only visible after a *Target Channel* has been selected (see *“Target Channel” on page 45*), followed by clicking **Calculate** in the *Noise Calculation* region (see *“Calculate” on page 45*).

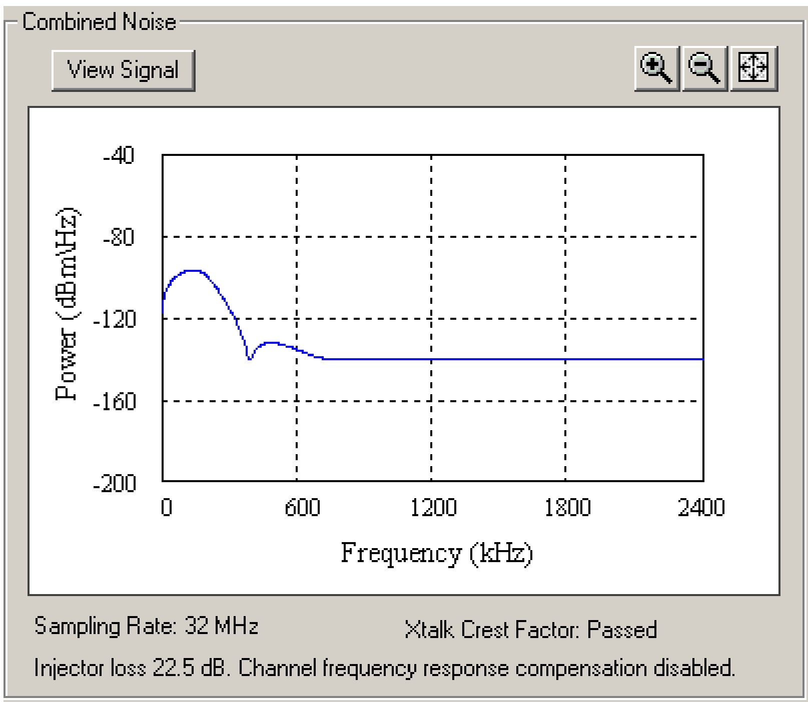



**Figure 3-9.** Combined Noise Region

The areas of the *Combined Noise* region are explained in the following sections.

### View Signal

Click **View Signal** to produce a plot that shows various characteristics of the Noise Sample, as it is downloaded onto the DLS 5500 noise card. Types of plots include the ones shown in *Figure 3-10*, *Figure 3-11*, and *Figure 3-12 on page 42*.

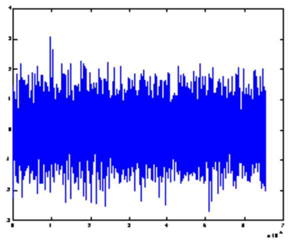


**Figure 3-10.** Noise Sample in the Time-domain

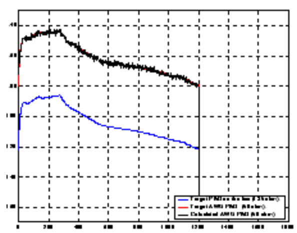


**Figure 3-11.** Spectrum of the Noise Sample

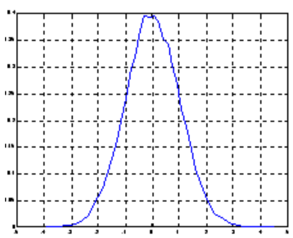


**Figure 3-12.** Amplitude Distribution Function of the Sample

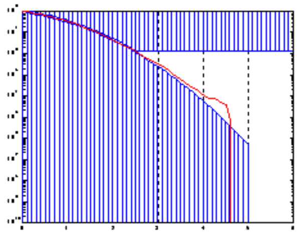


**Figure 3-13.** Cumulative Amplitude Distribution Function of Generated Crosstalk Noise Sample

### Sampling Rate

This value is fixed and is determined by the file type being used. This value is displayed as 12.5 MHz, 32 MHz, or 100 MHz.

### Crosstalk Crest Factor

When the crest factor is equal to or greater than 5, the word “passed” displays to indicate this condition.

## Noise Calculation Region

The *Noise Calculation* region is shown in *Figure 3-14*.

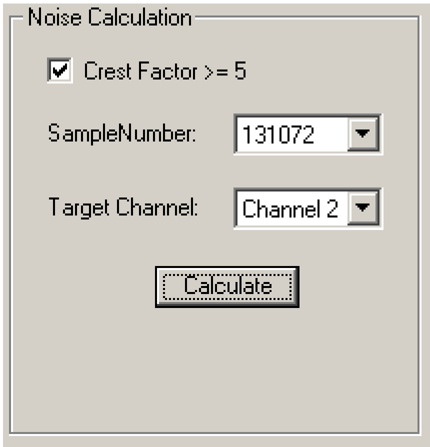



**Figure 3-14.** Noise Calculation Region

The controls in this region are explained in the following sections.

### Crest Factor Greater Than or Equal to 5 Checkbox

Check the **Crest Factor >=5** checkbox to ensure that generated noise samples have amplitude distribution compliant with the 2nd-generation ETSI xDSL standards (such as SDSL).

ETSI has specified this amplitude distribution by means of a tight mask, to give meaning to concepts like “near Gaussian” and “crest factor above CF=5”. This compliance is achieved using an iterative algorithm for calculating the noise sample.

*Figure 3-15 on page 44* and *Figure 3-16 on page 44* show how the cumulative distribution function may be different between an ETSI and non-ETSI compliant noise sources. To be ETSI compliant, the cumulative distribution function must fit completely between the two limits of the mask.

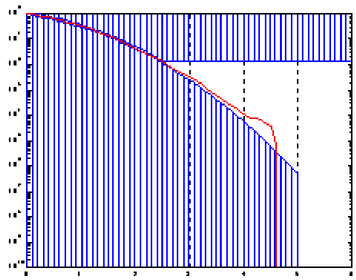


**Figure 3-15.** Cumulative Distribution Function of a Noise Sample that is not ETSI Compliant

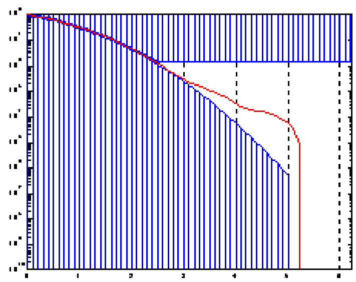


**Figure 3-16.** Cumulative Distribution Function of an ETSI Compliant Noise Sample (crest factor CF>5)

## Sample Number Drop-Down List

*Figure 3-17* shows the *Sample Number* drop-down list. Click the down arrow and set the number of points in the noise sample.


**Figure 3-17.** Sample Number Drop-Down List

T(s) seconds= N (samples)/Fs (Sample Rate).

Fs (Sample Rate) can be changed in the Header information of a noise file (refer to *"Header Information Details" on page 85* and *"Sampling Rate" on page 43*). The Fs options are 12.5 MHz, 32 MHz, and 100 MHz.

N (Samples) refers to the sample number that you select.

The N(Samples) and Fs(Sample Rate) determine the total time it takes to replay or repeat the file playback.

### Target Channel

*Figure 3-18* shows the *Target Channel* drop-down list. Click the down arrow to select the generator channel for noise output.


**Figure 3-18.** Target Channel Drop-Down List

### Calculate

*Figure 3-19* shows the Calculate button. Click the **Calculate** button to recalculate the noise sample from the noise profiles and settings in the combiner window.

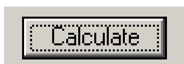



**Figure 3-19.** Calculate Button

## Noise Output

*Figure 3-20* shows the *Noise Output* region. Click the **Generate Noise** button to send the current Noise Sample to the AWG card, and tell the hardware to start the generation of the output signal to the *Target Channel* you selected in the *Noise Calculation* region. You use this button in conjunction with the Channel 1-4 buttons located in the top left of the DLS 5500 Control Application to start or stop the actual generation of the noise signal.

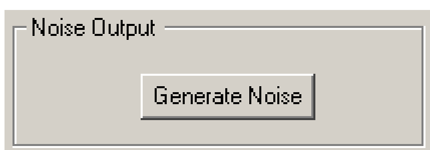



**Figure 3-20.** Noise Output Button

# Channel Specific Settings

The Channel 1 through Channel 4 buttons at the top left of the Control Application window are shown in *Figure 3-21*.

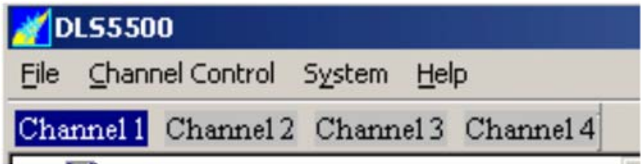



**Figure 3-21.** Channel Buttons

## Channel Buttons 1-4

Clicking a Channel button provides status information for that channel and also displays the current noise type/file settings (*Figure 3-22*). Highlighted channel buttons represent active (ON) channels, and non-highlighted buttons represent inactive (OFF) channels. Selecting any of these channels displays the channel-specific parameters as explained in the following sections.

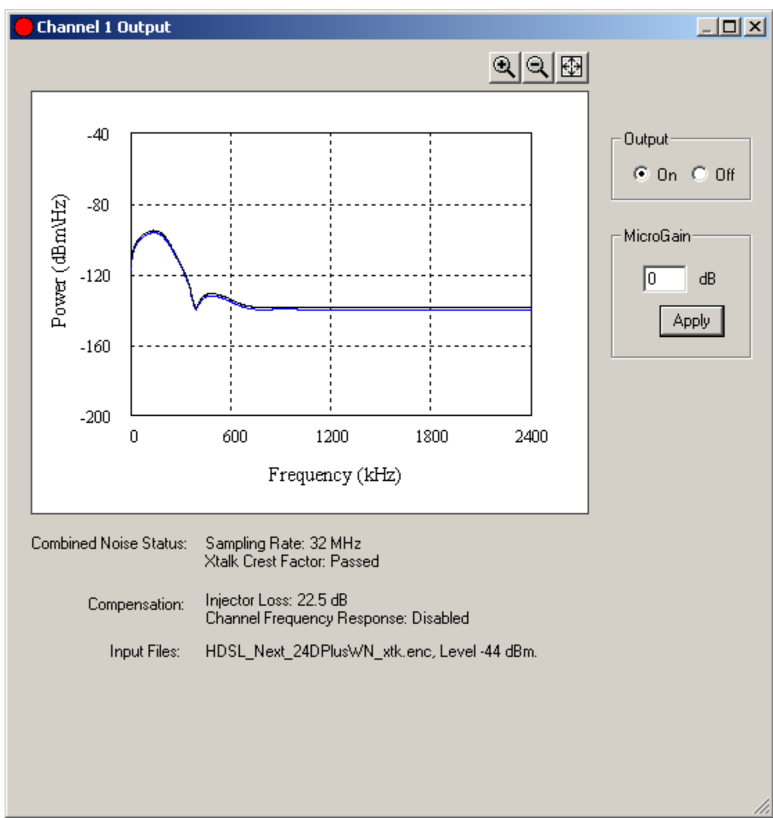



**Figure 3-22.** Channel Output Window

### Output On/Off

Click the **Off** radio button to stop the generation of the output signal by the DLS 5500 noise card. Click the **On** radio button to resume the output.

### MicroGain

The *MicroGain* field allows you to enter small power level changes without requiring a recalculation of the Noise Sample. This allows you to make power level changes with virtually no delay.

The *MicroGain* field increases or decreases the aggregate output power level, and is used for Time Domain or Frequency Domain Crosstalk or RFI files. Time Domain based noise types have a range of -7 dB to 7 dB. Frequency based noise PSDs have a range of -3 dB to 9 dB.

If you need to change the power level by an amount that exceeds the MicroGain range, edit the *Level* or *Offset* in the *Noise Attribute Editing* window (see *Figure 3-8 on page 40*), then recalculate and regenerate the output.

**Example**

Frequency Domain noise “X” has been calculated and is presently on the CH1 output. The *MicroGain* field is increased from -3 dB to 9 dB (this can be achieved with no time delay delta between power levels). If, for example, you now want to increase the overall power level by 10 dB, enter 10 dB in the *Level* field, then click **Calculate** (see *Figure 3-14 on page 43*). When you click **Generate Noise** (see *Figure 3-20 on page 45*), the newly calculated noise file will have a slight time delay when output to CH1. You can now vary the output power level using the *MicroGain* field between -3 dB and 9 dB with no delay between specified levels. This same process applies for_td.dat file types. Impulse noise types are not supported with MicroGain functionality.

### Spectral Monitor Area (Graph)

The display within the channel output window allows you to monitor the following spectra of the noise shape you are fine tuning.

- The blue line indicates the desired spectrum, as specified in the Noise Profile.
- The black line denotes the spectrum of the actual Noise Sample as it has been downloaded into the DLS 5500 hardware. This is a calculated spectrum, but it is based on the actual Noise Sample. The black curve provides a realistic prediction of how the output signal will look when examined with a real spectrum analyzer.

When selecting Time Domain profiles, the displayed graph is based on an Amplitude vs. Time grid.

# Save Custom

The *Save Custom* feature allows you save the calculated noise sample for later use. Recalling this noise sample eliminates the need to perform a time-consuming calculation.

User-defined custom noise files can be time based *_td or frequency based *_xtk noise types. When you have created a custom noise file, provide a descriptive name. Save the file with a _cst extension.

**To save a custom noise file:**

1. Define your profiles, then calculate the noise sample.
2. Select **File** > **Save Custom** (*Figure 3-23*).

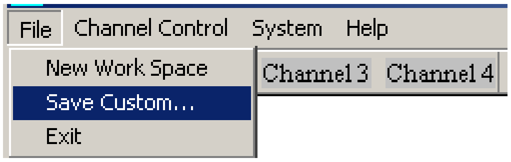



**Figure 3-23.** Save Custom command

3. Enter the desired descriptive text when the following prompt appears: *Input your Noise Information* (see *Figure 3-24*).
4. Click **OK**.

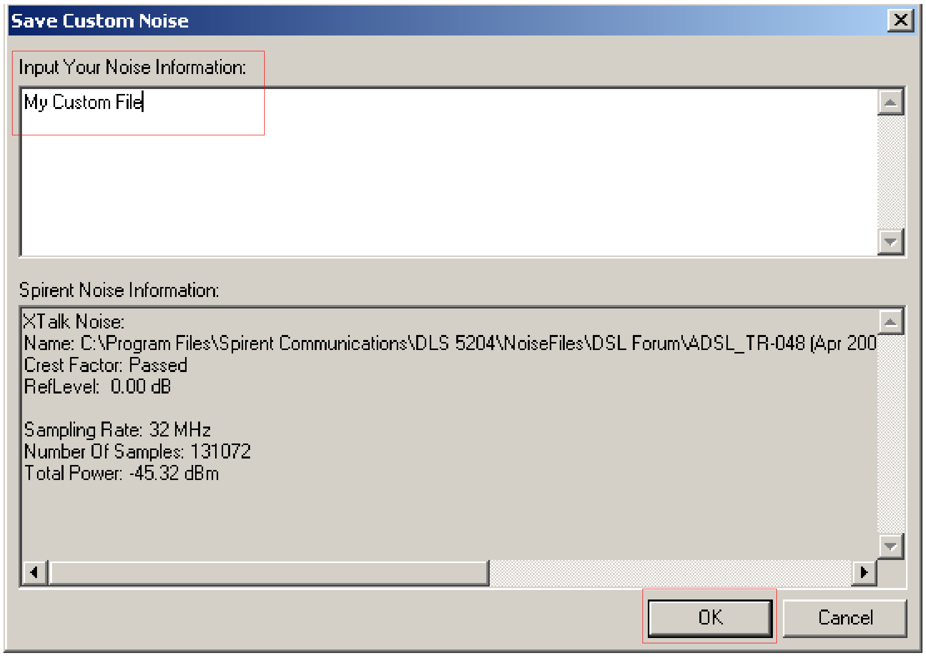



**Figure 3-24.** Save Custom Noise Dialog Box

5 When the Save As dialog appears, choose the file name and location.

The file is saved with an extension _cst.enc, which identifies it as a custom noise file.

**Note:** Because *-cst files are generated in the time domain, the DLS 5500 Control Application does not display custom generated files.

# Sync

Select **System** > **Sync** to test TCM-ISDN signalling commonly used in Japan. Use this command to synchronize CH1-4 outputs. Time Domain _td noise files are required for proper simulation of this signalling.

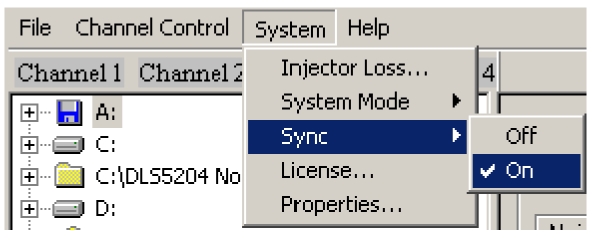



**Figure 3-25.** Sync command

**Note:** If you require this ClockSync feature for TCM ISDN transmission, contact your local Spirent sales representative for pricing.

# System Mode

Select **System** > **System Mode** to choose the mode. System mode can be selected to be Local or Remote (see *Figure 3-26*). Remote mode allows the DLS 5500 to be controlled from a remote computer. For a detailed explanation of remote control, see *Chapter 8, “Remote Control Programming.”*

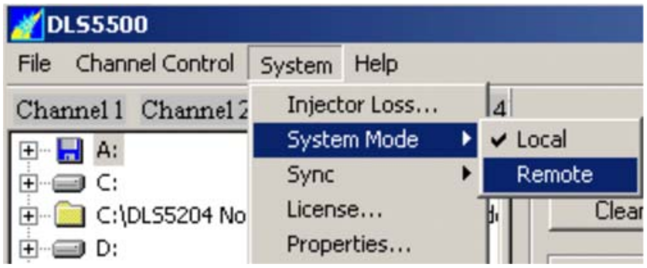



**Figure 3-26.** System Mode command

**Note:** The DLS 5500 must be in remote mode before sending remote commands to it.

# Double Session Remote Control

You can use the DLS 5500 as two independent remotely controlled noise generators by using the *Double Session Remote* feature.

Double session mode splits the control software into two sections, one controlling Channels 1 and 2, the other controlling Channels 3 and 4.

**To enter the dual remote control session mode:**

1. Select **System** > **Properties** from the Control Application menu bar.
   The *System Properties* dialog box opens (*Figure 3-27 on page 51*).
2. Select the **Double Session** radio button.
3. If necessary, edit:
   - the *Remote Port* field (which controls Channels 1 and 2)
   - the *Remote Port (2nd Instance)* field (which controls Channels 3 and 4).

   Valid port numbers range from 1024 to 65535.
4. Click **OK**.
5. Select **System** > **System mode** > **Remote**.
   A second instance of the DLS 5500 Control Application will start and initialize in remote mode. Each will have control over a pair of channels (*Figure 3-28 on page 51*).

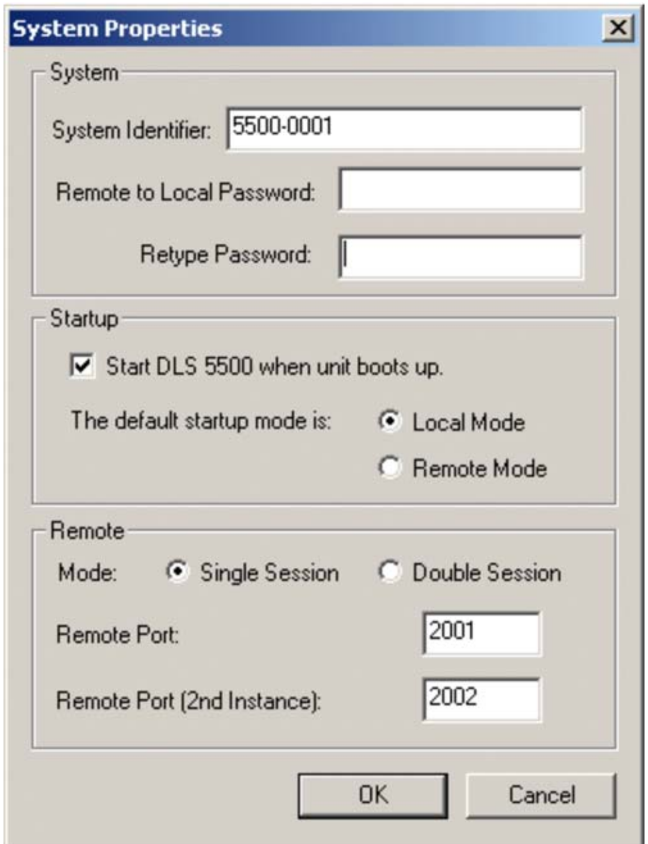
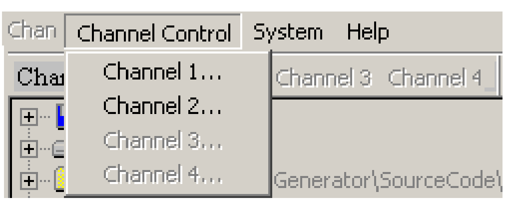
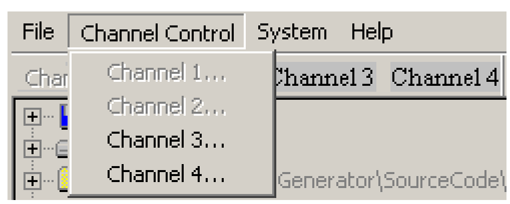



**Figure 3-27.** System Properties Dialog Box




Instance one (Channels 1 & 2)




Instance two (Channels 3 & 4)

**Figure 3-28.** Dual Remote Control Sessions

**To switch back into local mode:**

1. Go to the main session (the session controlling Channels 1 and 2)
   The main session can be identified by verifying that the *Channel 1* and *Channel 2* menu names are grayed out on the menu bar.
2. Select **System** > **System Mode** > **Local** from the menu bar.
   You will be prompted to confirm, since this will cause the second session to terminate.

The following limitations should be considered when running in a dual remote control mode:

- *Clock Sync* used for TCM-ISDN signalling cannot be set on a per channel basis. If Clock Sync is enabled, then all channels are enabled.
- Using the *DISABLE_REMOTE* command will not work when using the dual remote sessions, because the DLS 5500 does not run one local and one remote DLS 5500 Control Application.

# Password Protection

Password protection can be used to prevent inadvertently exiting remote mode.

**To use password protection:**

1. Select **System** > **System Properties** from the Control Application menu bar.
   The *System Properties* dialog box opens.
2. Enter a password in the *Remote to Local Password* field.
3. Retype the password in the *Retype Password* field.
   This password will now be required to exit Remote Mode.
4. If you forget your password, edit the “DLS5204Value.dat” file, and remove the “RemotePassword: xxxxxxx” line.

# DLS 5500 Boot Mode

**To set up the DLS 5500 to boot up in local or remote mode:**

1. Select **System** > **System Properties** from the Control Application menu bar.
   The *System Properties* dialog box opens.
2. Select the **Start DLS 5204 / DLS 5500 When unit boots up** checkbox.
3. Select the **Local Mode or Remote Mode** radio button.

# Injector Loss Dialog Box

The DLS 5500 can be used with a variety of noise injectors. Each noise injector model has its own set of electrical characteristics, for example:

- Injector loss
- Frequency response
- Bandwidth.

The *Injector Loss* dialog box is used to adjust for some of these characteristics.

To define the signal loss caused by the external signal injection unit, see *"Noise Injector Types" on page 53*. For information on controlling micro interrupts (on some injector models) see *"Micro Interrupts" on page 55*. For exceptionally accurate results, frequency compensation can be applied to each channel, see *"Compensation" on page 56*.

Verify that the bandwidth of the noise injector you plan to use is compatible with the xDLS mode you are testing.

## Noise Injector Types

There are two types of Spirent noise injectors:

- Passive (fixed-range) injectors
- Controllable (multiple-range) injectors.

Fixed-range noise injectors, such as the DLS 5404, do not require a control connection. They have a fixed insertion loss, which is specified in the *Injection Loss* dialog box. See *"Using Passive Injectors" on page 55* for details.

Multi-range noise injectors use an RS-232 connection between the DLS 5500 and the noise injector to control range selection. The insertion loss is adjusted automatically by the DLS 5500 Control Application.

Multiple-range noise injectors allow the noise to be injected at a number of selectable power levels. For example, the DLS 5406 has a low-noise-floor range with lower power, and a high-power range with a higher noise-floor.

These ranges have different injector loss values for each range. When communications are established with multi-range noise injector, the Control Application adjusts to the correct injection range and corresponding injection loss.

## Using Controllable Injectors

**To control an injector:**

**1** Select **System** > **Injector Loss** from the menu bar in the Control Application main window.

The the *Injector Loss* dialog box opens (*Figure 3-29*).

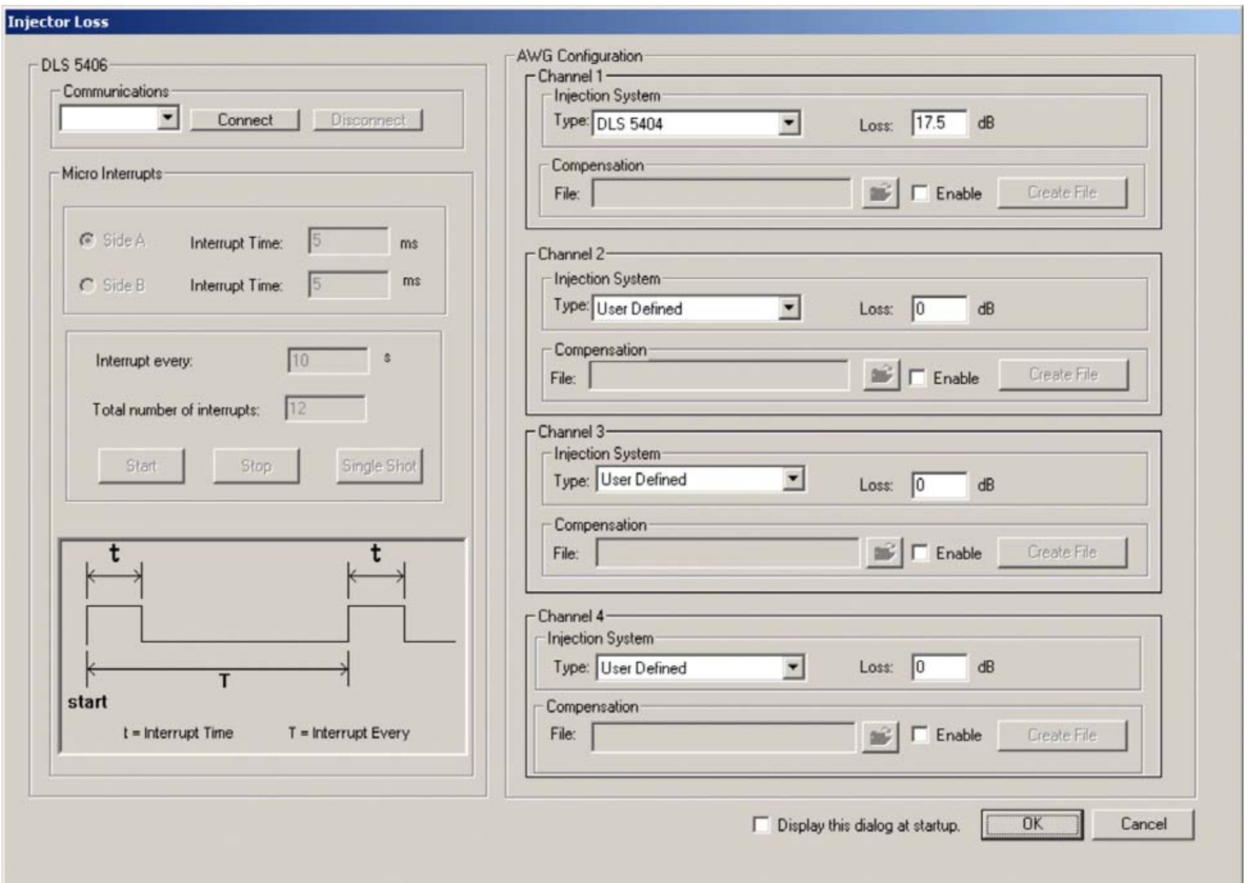



**Figure 3-29.** Injector Loss Dialog Box

**2** Choose a serial port from the *Communications* drop-down list.

The Communications drop-down list contains all serial ports that were available to Windows when the Control Application was started, but were not used by any other Windows program.

**3** Click the **Connect** button.

If the connection is successful, the Control Application sets the DLS 5500 to default values and enables the controls in the *Micro Interrupts* section of the window. The *Injection System* fields will be set to DLS 5406 or DLS 5404, and the *Loss* fields for each channel will be disabled.

The DLS 5406 injector handles noise inputs in pairs: Channels 1 and 2 are handled as one pair, and Channels 3 and 4 as another pair.

For example, when the power level on Channel 1 is changed from low to high, Channel 2 also switches from low to high. The Control Application automatically recalculates and regenerates the noise output to Channel 2 to compensate, but Channel 2 turns off briefly during the range change.

Some controllable injectors offer auxiliary functions. For example, the DLS 5406 or DLS 5404 generates micro interrupts.

## Micro Interrupts

Micro interrupts cause a very short interruption in the end-to-end continuity of a wireline. Some testing standards require the application of repeated micro interruptions within a specified amount of time. A micro interrupt can be specified to last 1 – 60,000 ms.

The noise injector is updated with new micro interrupt parameters whenever you press **Enter** or move from one field to another.

The *Side A* and *Side B* radio buttons select the noise injector (output) side at which the micro interrupt will take place.

To start the micro interrupt sequence, click the **Start** button. The first micro interrupt is generated immediately, and then periodically at the frequency specified in the *Interrupt every* field. The total number of micro interrupts is specified in the *Total number of interrupts* field.

**Note:** The *Interrupt Time* field must be shorter than the *Interrupt every* field.

When the Start button is clicked, the DLS 5500 Control Application verifies that the micro interrupt values entered are valid, and that the *Interrupt Time* field is shorter than the *Interrupt every* field.

## Using Passive Injectors

**To adjust the injection loss:**

**1** Select **System** > **Injector Loss**.
The *Injector Loss* dialog box opens (*Figure 3-29 on page 54*).

**For each channel:**

**2** Select the injector type from the drop-down list.
If the injector model you are using is not listed in the drop-down list, select **User Defined**, then enter a value in the **Loss** field. Refer to the relevant injector's operation manual for its injector loss value.

**3** Repeat *Step 2* for each Channel.

**Note:** If you select a Spirent injector in the Injection System *Type* field, then manually enter a value in the *Loss* field, the Control Application automatically selects *User Defined* in the Injection System *Type* field.

## Compensation

The Channel Frequency Response Compensation (CFRC) feature corrects for minor performance differences between the DLS 5500 outputs and the noise injection unit, and between small channel-to-channel performance differences on each injection channel. The use of compensation is optional.

**To use compensation:**

1. Select the **Enable** checkbox associated with a channel.
   Compensation is turned on for that channel.
2. If a compensation file already exists, load it using the browse icon next to the *File* field.
3. To produce a new compensation file, click the **Create File** button, then follow the instructions provided by the wizard.
   The wizard uses a Spirent-supplied reference file, which it compares to the results measured by an Agilent 4395A spectrum analyzer at the outputs of the noise injection unit. The results are used to generate the compensation file for a specific noise injection unit on a specific channel.

# Combining Several Noise Files with NCD Files

An .ncd file describes the combining of several noise files, each with a specified power level.The .ncd files can be used to recall a specific combination of up to six _xtk files and one _RFI file.

To create an .ncd file, use a text editor such as Notepad and type out a combining specification, then save it with an .ncd extension.

Four file format options are illustrated below.

For frequency domain noise files like *_xtk* or *_rfi***,** these file types must contain file headings such as:

$name

$offset

$disturber

If a file type contains both the "*$offset*" and "*$disturber*" heading within the same .ncd file the last heading will overwrite the previous value since both offset and disturber quantity values are directly related to each other.

Example: Xtalk and RFI noise files

```
$name<C:\Program Files\Spirent Communications\DLS 5204\
   NoiseFiles\DSL Forum\ADSL_TR-048 (Apr 2002)\8-1-
   1_White_Noise_Impairment\Downstream_At_ATU-R\
   White_Noise_xtk.enc>
```

```
$offset<20 dB>

$name<DLS5B17\1.0\NoiseFiles\DSL Forum\ADSL_TR-048 (Apr
  2002)\8-1-2_24_HDSL_Impairment\Downstream_At_ATU-R\
  HDSL_Next_24DPlusWN_xtk.enc>
$disturber<24>
```

Example: Time Domain noise files

```
$name<C:\Program Files\Spirent Communications\DLS 5204\
  NoiseFiles\DSL Forum\ADSL_TR-048 (Apr 2002)\8-8-
  1_Impulse_Tests\ Downstream_At_ATU-R\
  HDSL_Next_20DPlusWN_td.enc>
$offset<-2 dB>
```

Example: Time Domain noise files with Impulse noise

```
$name<C:\Program Files\Spirent Communications\DLS 5204\
  NoiseFiles\DSL Forum\ADSL_TR-048 (Apr 2002)\8-8-
  1_Impulse_Tests\Downstream_At_ATU-R\
  HDSL_Next_20DPlusWN_td.enc>
$offset<-2 dB>

$name<C:\Program Files\Spirent Communications\DLS 5204\
  NoiseFiles\Base Noise Files\ADSL-C1_imp.dat>
$level<100 mV>
$ impulse repeat number <15 >
```

Example: Impulse noise only

```
$name<C:\Program Files\Spirent Communications\DLS 5204\
  NoiseFiles\Base Noise Files\ADSL-C1_imp.dat>
$level<50 mV>
$impulse rate<50 pps>
$impulse repeat number<15 >
```

**Note:** When selecting Xtalk and RFI noise types, Impulse and Time Domain noise must not be combined. An error message will appear if you attempt to combine these different noise types.

# Display Remote Commands

The DLS 5500 allows you to display status of remote control commands sent to the noise generator (see *Figure 3-30*). These commands can be used to monitor the sequence of commands being sent to the unit. This window is only available when the DLS 5500 is in “Remote” mode.

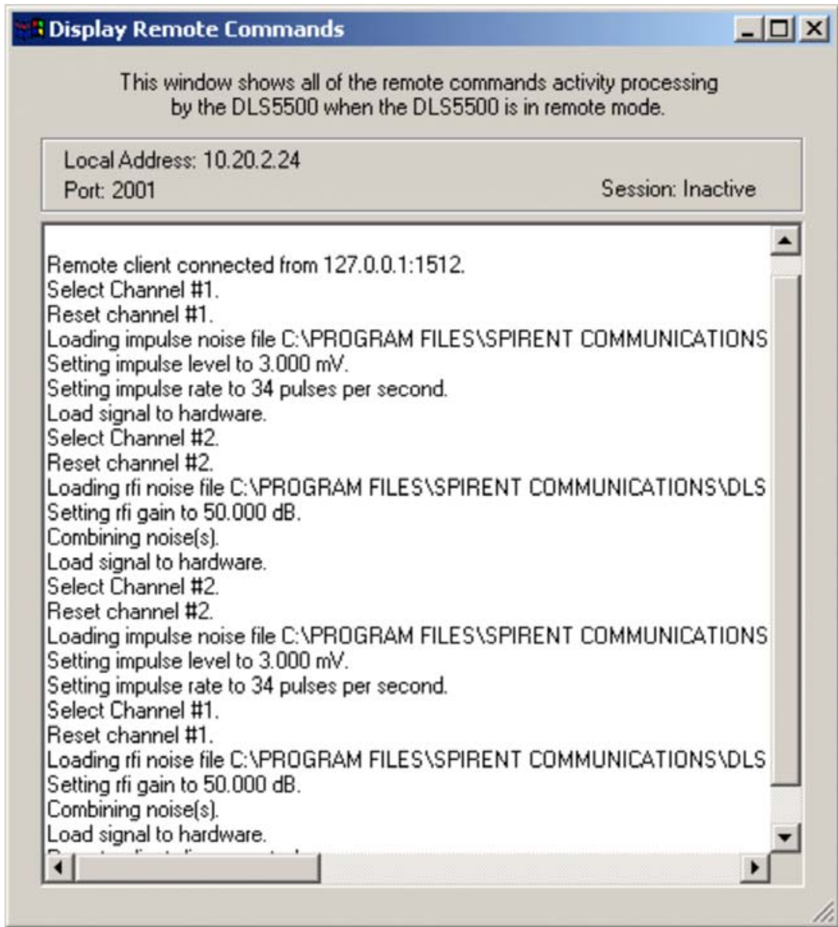



**Figure 3-30.** Display Remote Commands Window

**Note:** The deprecated/unsupported commands that are no longer working will still be displayed in the Remote Commands windows but will not set the hardware or output the files.

Chapter 4

# Reference Tests

**In this chapter. . .**

# Introduction

For the purpose of acceptance, functional checks, and/or calibration of the DLS 5500, a reference noise profile is provided. You can verify the correct functioning of the noise generator by comparing the reference response of the noise generator to this reference stimulus.

# Reference Response, in Terms of Narrow Band Signal Power

*Figure 4-2* shows the narrow band signal power (NBSP), into 50 Ω, as it can be observed from the screen of spectrum analyzer at various resolution bandwidths. The wider the resolution bandwidth, the higher the observed NBSP. The noise outside the 300-800 kHz band is caused by a mixture of:

- the output noise of the Spirent Noise Card
- the spurious response of the spectrum analyzer
- the receiver noise of the spectrum analyzer.

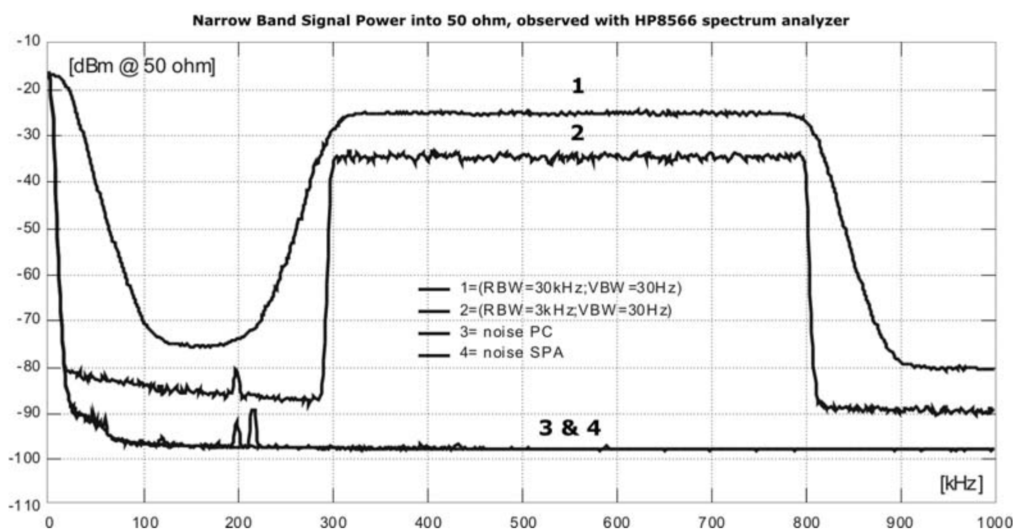



**Figure 4-1.** Narrow Band Signal Power of the Generated Noise

# Reference Response, in Terms of Spectral Density

Extracting the power spectral density (PSD) from the observed narrow band signal power (NBSP) by dividing it with the resolution bandwidth of the spectrum analyzer gives you no more than a rough estimate of power spectral density. Errors of a few dB are to be expected, which is a principal uncertainty for most spectrum analyzers when measuring noise.

This is caused because many spectrum analyzers use:

- –3dB bandwidth of the band filters as resolution bandwidth (which is different from the noise bandwidth that should be used for NBSP measurements)
- analog line to log conversion, to increase their dynamic range
- a peak detector to sense the narrow band level.

The above restrictions of spectrum analyzers give no real restriction when measuring harmonic signals, but troubles measurements when the full resolution band is ‘filled’ with spectral components. The random noise, generated by the DLS 5500, is an example of such a signal.

To perform a reliable PSD measurement, for calibrating the DLS 5500, an additional *true* RMS Volt meter is required (or *true* dBm meter). A *true* RMS meter uses a real square and root approach to find the RMS value of the signal, such as an analog multiplier (for squaring) or a thermocouple (for power measuring). Check if your equipment is a *true* RMS meter and not an instrument using a peak detector that displays peak values as pseudo-RMS values. The *true* RMS meter must be capable of handling the full frequency range from 100 kHz (or lower) up to 1 MHz (or higher).

*Figure 4-2* shows a modified version of the NBSP. The level is shifted downward to facilitate that the aggregate power from 200 to 900 kHz exactly equals the value that has been reported by the true RMS meter (–10.5 dBm in this example, caused by 0.5 dB error in the output amplifier of the Spirent Noise Card). This curve can be considered an accurate representation of the power spectral density of the output noise from this setup.

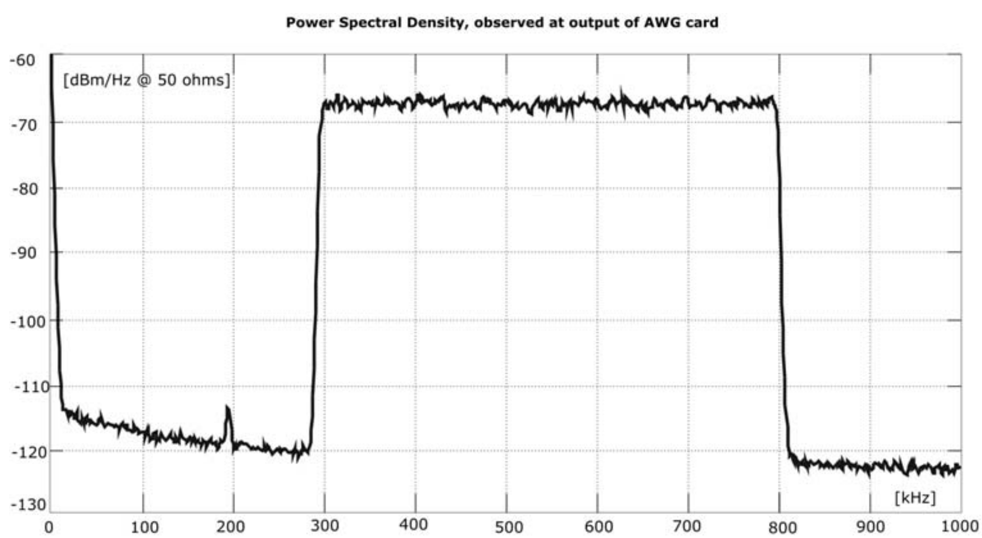



**Figure 4-2.** Spectral Density of the Generated Noise

SPIRENT
Communications

Chapter 5
# Crosstalk Noise Profiles

**In this chapter. . .**

# Introduction

A noise profile is a Power Spectral Density (PSD) description of the crosstalk noise as it is observed at the receiver of the xDSL modem under test (near the point of injection). It is generated and applied as follows:

- The DLS 5500 reads a file carrying a noise profile that describes what kind of noise has to be generated (this is in ASCII/ frequency vs. power)
- The DLS 5500 synthesizes and generates the noise PSD and applies it, via a noise injection mechanism, onto the wireline or simulated wireline near the receiver of xDSL modem under test.
- If required, the DLS 5500 can generate noise at a higher level in order to compensate for the insertion loss of the noise injection network.

In older xDSL standards (for example, ISDN & HDSL), PSDs were few and relatively generic. This was done to simplify testing and had the consequence of not being very representative of real access network conditions.

Today, with the advent of automated test set-ups and higher precision test equipment, xDSL Standard's organizations now define noise PSDs that include changing test loop length and type as well as changing bitrate or transmission direction for the xDSL modem under test. The result is a more realistic set of noise shapes, as a set that sometimes numbers in the thousands of shapes.

Therefore, to simplify xDSL testing, noise profiles are stored in separated files so the DLS 5500 can load a dedicated or specific noise profile for each required test. Spirent Communications has developed noise libraries for most xDSL test requirements.

As an example of noise PSD development, the following section describes the way ETSI defines noise profiles, provides some sample noise profiles for SDSL, and provides the associated DLS 5500 file format of these noise profiles.

# Defining Noise Profiles Using Building Blocks

The profile of the crosstalk noise defined in current ETSI xDSL standards varies with the length of the test loop. The rationale behind this is that the FEXT coupling function between the wire pairs in a real cable is length dependent, and this can have a significant impact on the crosstalk noise when upstream and downstream signals of xDSL modems do not use the same frequency band.

*Figure 5-1 on page 65* shows how various ETSI standards compose the crosstalk noise from isolated building blocks, and is used for impairment testing in downstream as well as in upstream direction.

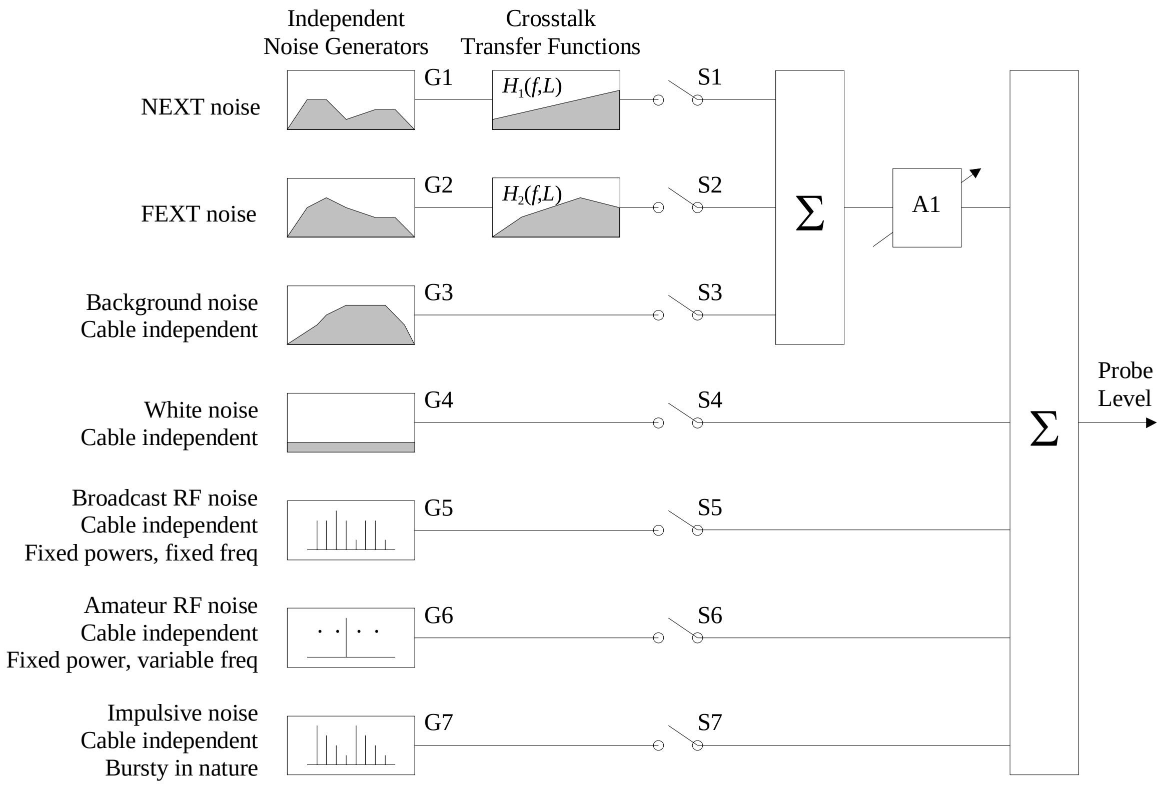



**Figure 5-1.** ETSI Functional Description of Crosstalk Noise Calculations

- Generator G1 is an equivalent noise source that represents the combined equivalent disturbance of a mixture of impairing xDSL systems, located at the *receiver* side of the xDSL modem under test. Its noise spectrum is defined in the appropriated ETSI standards, and may vary with the bitrate of the xDSL modem under test.
- Generator G2 is similar to G1, but represents the combined equivalent disturbance at the *transmitter* side of the xDSL modem under test.
- Generator G3 represents background noise, (if any). For now, ETSI currently sets background noise to zero.
- Generator G4 represents white noise. To generate white noise, test equipment must be designed with an extremely low-noise floor (generally at –140 dBm/Hz or lower).
- The transfer function $H_1(f,L)$ models the length and frequency dependency of the NEXT crosstalk coupling. The transfer function is dependent of the loop-set number and changes *slightly* with the length of the test loop, and is well defined in ETSI xDSL standards.
- The transfer function $H_2(f,L)$ models the length and frequency dependency of the FEXT crosstalk coupling. The transfer function is dependent of the loop-set number

and changes *significantly* with the length of the test loop, and is well defined in ETSI xDSL standards.

The transfer functions $H_1$(f,L) and $H_2$(f,L) are defined in *Table 5-1* for calculating the NEXT and FEXT coupling functions.

**Table 5-1.** Definition of the Crosstalk Transfer Functions

| |
|---|
| $H_1(f, L) = K_{xn} \times (f/f_0)^{0.75} \times 1 - \lvert sT(f, L)\rvert 4\ )$<br>$H_2(f, L) = K_{xf} \times (f/f_0) \times (L/L0)\ ) \times \lvert s_T(f, L)\rvert$ |
| $K_{xn} = 10^{(-50/20)} \approx 0.0032$, $f_0 = 1$ MHz<br>$K_{xf} = 10^{(-45/20)} \approx 0.0056$,$L_0 = 1$ km<br>$s_{T0}(f, L)$ = test loop transfer function |

Because the signals or transfer functions of the individual building blocks change when the test conditions are altered, the output noise of the impairment generator changes as well. This occurs when changing:

- from upstream testing to downstream testing
- the test loop
- the test loop length
- the bit-rate of the xDSL modem under test
- the environmental scenario from noise model “A” to “B” or “C”, etc.

# Definitions of Alien, Self, and Full Noise

Noise generators G1 and G2 represent the combined equivalent disturbance of a mixture of impairing xDSL systems. Usually, the xDSL modem under test is one of them. When changing the bit-rate of the xDSL modem under test, its transmission spectrum may change as well. In the ETSI noise scenarios, it is assumed that such a modem is deployed in a cable, connected to similar systems. So the crosstalk noise may change as well when the bit-rate of the xDSL modem under test changes. To cope with this in a convenient way, ETSI xDSL standards identified the following crosstalk components:

- **Alien noise:** is the combined equivalent disturbance caused by modems that are different from the xDSL modem under test. For instance, using ADSL and HDSL disturbers when testing SDSL. Recent ETSI xDSL standards define the Alien noise by means of a simple table, describing their PSD.
- **Self noise:** is the combined equivalent disturbance caused by modems that are equal to the xDSL modem under test. For instance, using SDSL disturbers when testing

SDSL, at the same bit-rate of the SDSL modem under test. If Self noise behavior conforms the nominal PSD values specified in the standard, it can be calculated in advance; if not, it has to be measured from the xDSL modem under test.

- **Full noise:** is the combined equivalent disturbance from both Alien and Self-disturbers. This is the noise that must be used when defining generator “G1” and “G2” in *Figure 5-2 on page 68*.

Combining Alien and Self noise into Full noise is *not* a linear power sum of all individual disturbers, since only one disturber can occupy the worst-case wire pair (from a crosstalk coupling point of view). Therefore a *weighted* power sum is specified in recent ETSI xDSL standards.

When Self noise has to be evaluated by measuring the PSD of the modem under test, then a noise profile library cannot provide the Full noise in advance. It must be restricted to Alien noise only, and the you must convert it into Full noise before performance testing can start.

# Description of the Noise Profile File Format

The ASCII format to describe a noise profile is very simple. It consists of a number of lines, each containing two numbers separated by spaces or tabs. In this way, two columns are formed. The first column describes a number of frequency values (in Hz); the second column contains the corresponding value for the power spectral density. This second column (the PSD) may be expressed in either dBm/Hz or in V/sqrt(Hz). The DLS 5500 distinguishes between the two by the *sign* of the numbers in the second column. If these numbers are negative, they are interpreted as amounts of dBm/Hz; if they are positive, they are interpreted as amounts of V/sqrt(Hz).

Optionally, the file may contain a line of which the frequency value is negative. This tells the DLS 5500 to interpret the second number on this line as the reference impedance. If this negative symbol is not in the *Frequency* column, the noise file will not generate.

An example of a frequency vs. power is shown in *Table 5-2*.

**Table 5-2.** Example of Noise Profile in ASCII Formats

| Frequency (Hz) | Power (dBm/Hz) |
|---|---|
| 999 | -140 |
| 1e6 | -140 |
| 1.00001e6 | -70 |
| 4e6 | -70 |
| 5.0000e6 | -140 |
| -1 | 50 |

The DLS 5500 interpolates between the values provided in the noise profile ASCII file. By default, the interpolation scheme is based on 'linear frequency, linear dB.' See *Figure 5-2* for a picture of the noise profile corresponding to the data in *Table 5-2 on page 67*.

You can create custom noise files using several formats, which include .txt editors (Notepad) or Microsoft® Excel® and so on. The file format outlined in *Table 5-2 on page 67* must be saved as an **_xtk.dat** extension, similarly for RFI ingress these file types would be saved as **_rfi.dat** extensions. These files can be saved in any directory specified, and can be recalled using the DLS 5500 software.

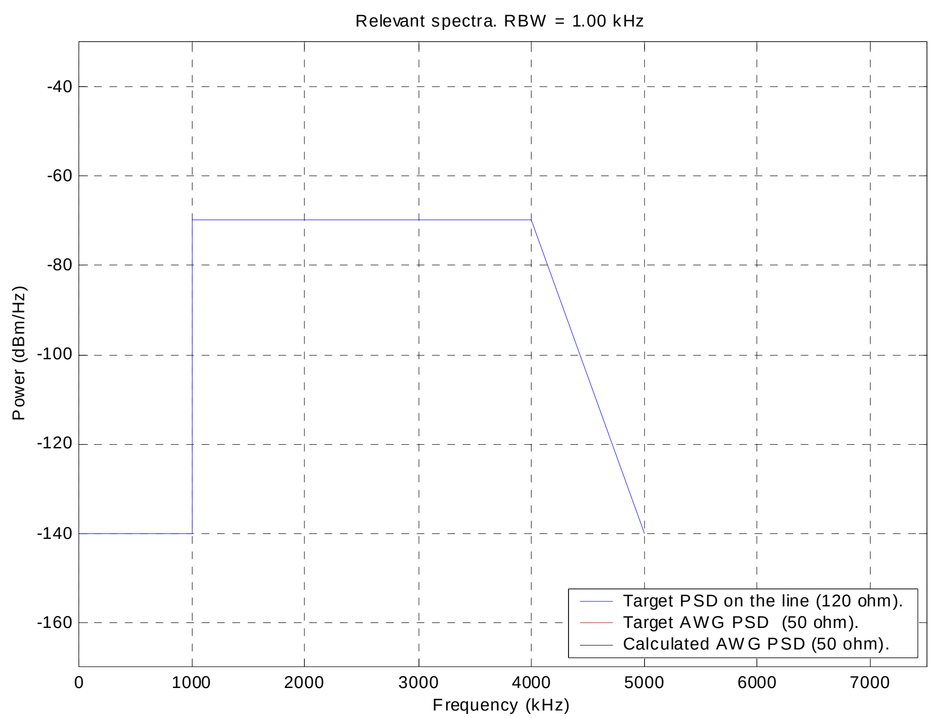



**Figure 5-2.** Sample PSD Calculated Profile from *Table 5-2 on page 67*

Chapter 6

# Ingress Noise Profiles (Optional)

**In this chapter. . .**

# Introduction

An ingress noise profile is an RFI-tone description of the ingress noise, as observed at the receiver of the xDSL modem under test (near the point of injection). The Spirent RFI technology within the impairment generator synthesizes this ingress noise according to the associated profile. The profile is used as follows:

- DLS 5500 software reads a file carrying an ingress noise profile that describes the ingress noise to be generated. Two file formats are presently available. These formats can be purchased as optional licenses. The DLS 5B14 and DLS 5B36 are the two available license options. The DLS 5B36 is an updated version from Spirent and supersedes the DLS 5B14. *"DLS 5B36 RFI Modulation Method" on page 77* identifies the DLS 5B36 modulation method.
- DLS 5500 software synthesizes the requested noise in such a way that the ingress noise at the receiver under test meets the requirements according to the ingress noise profile. If required, the software algorithms can synthesize ingress noise at a higher level to compensate for the insertion loss of the noise generator.
- Hardware of the impairment generator generates the synthesized noise, and its output noise is injected into the cable near the receiver of xDSL modem under test.
  - DLS 5500 reads a file carrying a noise profile that describes what kind of noise has to be generated (this is in ASCII / frequency vs. power)
  - DLS 5500 synthesizes and generates the noise PSD and applies it via a noise injection mechanism onto the wireline or simulated wireline near the receiver of xDSL modem under test.
  - If required, the DLS 5500 can generate noise at a higher level in order to compensate for the insertion loss of the noise injection circuit.

Different xDSL standards use different RFI-tone descriptions. To simplify xDSL testing, ingress noise profiles can be stored in separate files, so that for each test the DLS 5500 can select and load a dedicated ingress noise profile from a library with ingress profiles. You define noise profiles as explained in the following sections.

# Definition of the RFI Tones in Ingress Noise

The ingress noise generated by the DLS 5500 software is a superimposition of a number of random modulated carriers (AM). The total voltage $U(t)$ of this noise is defined as:

$$U(t) = \sum_k U_k \times cos(2\pi \cdot f_k \times t + \varphi_k) \times (1+m \times \alpha_k(t))$$

The individual components of the ingress noise voltage $U(t)$ are defined as follows:

$\boldsymbol{U_k}$

The voltage $U_k$ of each individual carrier is specified as a *parameter* in the ingress noise profile by means of a power level $P_k$ (dBm) into a resistive load of R. Note that spectrum analyzers will detect levels that are slightly higher then the values of the individual carriers when their resolution bandwidth is set to 10 kHz or more, since they will detect the modulation power as well.

$\boldsymbol{f_k}$

The frequency $f_k$ of each individual carrier is specified as a *parameter* in the ingress noise profile.

$\boldsymbol{\varphi_k}$

The phase offset $\varphi_k$ of each individual carrier is a random value that is uncorrelated with the phase offset of each other carrier in the ingress noise signal.

**m**

The modulation depth *m* of each individually modulated carrier is specified as a *parameter* in the ingress noise profile. This value is a RMS-modulation depth; the modulation index equals the peak levels of the modulation signal $m \times \alpha_k(t)$.

$\boldsymbol{\alpha_k(t)}$

The normalized modulation noise $\alpha_k(t)$ of each individually modulated carrier is random and Gaussian distributed in nature, has an RMS value of $\alpha_{rms}=1$, has a crest factor of 2 to 5 or more, and is uncorrelated with the modulation noise of each other modulated carrier in the ingress noise signal.

$\boldsymbol{\Delta b}$

The modulation width $\Delta b$ of each modulated carrier is specified as a *parameter* in the ingress noise profile. This is equivalent to creating $\alpha_k(t)$ from white noise, filtered by a low-pass filter having its cut-off frequency at $\Delta b/2$ and having a rectangular filter shape. This modulation width represents the *double sided* modulation band used by AM broadcast stations.

# Description of the RFI Noise Profile File Format

The ASCII format to describe an ingress noise profile is very simple. It consists of a number of lines, each containing four numbers separated by spaces or tabs (see *Table 6-1*).

**Table 6-1.** Ingress Noise Profile ASCII Format

| Frequency (Hz) | Power | Modulation Width | Modulation Depth |
|---|---|---|---|
| <freq.1> | <power.1> | <width.1> | <depth.1> |
| <freq.2> | <power.2> | <width.2> | <depth.2> |
| ... | ... | ... | ... |
| <freq.N> | <power.N> | <width.N> | <depth.N> |

The columns in *Table 6-1 on page 71* are explained here.

- **Frequency (Hz)**. Describes the frequencies (in Hz) of the individual carriers.
- **Power**. Contains the corresponding value for the power of this carrier (without the modulation power) into a resistive load $R_N$ (the reference impedance). These values may be expressed in either dBm or in Volts. The DLS 5500 software distinguishes between the two by the *sign* of the numbers in the second column. If these numbers are *negative*, they are interpreted in dBm into resistance $R_N$; if they are *positive*, they are interpreted in Volts. $R_N$=135Ω by default, but can be modified in the ingress noise profile as well (see below).
- **Modulation Width**. Contains the (double-sided) modulation width Δb of each carrier, in Hz. This can be regarded as twice the bandwidth of a (random) base band signal that is used to AM modulate the carrier frequency. It means that the actual bandwidth of the modulation noise will be half this value.
- **Modulation Depth**. Contains the modulation depth *m* of each carrier, as specified in the previous paragraph.

**Note:** The above file format can be used for a DLS 5B36 licensed system with some slight differences. The *Power* column is always interpreted in dBm, the *Modulation Depth* column can only contain either a .31 or 0 value. If you select .31, the modulated signal will appear as having left and right side bands of 10 tones as displayed in the above example. If 0 is used, the single center tone frequency will be generated with no side bands.

Optionally, the file may contain a line of which the *Frequency* value is –1. The software will interpret the second number on this line as the reference impedance $R_N$, for defining power values of the RFI tones. This special line may occur anywhere in the file, but there must be at most one such line. The software uses these values to calculate the appropriate signal in the time domain that corresponds to the prescribed characteristics. For $R_N$, use only the following values: 50, 100, 135 or 150.

An example of an ingress noise profile is provided in *Table 6-2*.

**Table 6-2.** Example of an Ingress Noise Profile in ASCII Format

| Frequency (Hz) | Power (dBm or V) | Width (Hz) | Depth (m) |
|---|---|---|---|
| 100e3 | -40 | 9e3 | 0.32 |
| 300e3 | -90 | 18e3 | 0.20 |
| 500e3 | -90 | 9e3 | 0.20 |
| 750e3 | -90 | 9e3 | 0.32 |
| -1 | 50 | 0 | 0 |

The number of RFI tones that can be specified in an ingress noise profile is limited by AWG memory and the output power of the noise generator. In practice, there are a few restrictions:

- The modulation bands of different carriers cannot overlap in frequency, and
- The frequency resolution Δf is restricted by the sample frequency Fs and sample length N of the noise sample, and equals Δf=Fs/N. These numbers are controlled by the AWG setting.

When reading ingress noise profiles from the DLS 5500 Control Application, the software, by default, filters all files with the extension ***_rfi.dat.** This default can be overridden, but it does help distinguish between crosstalk and ingress noise profiles.

# Accuracy Limits of the AWG

The Spirent Access Emulation Arbitrary Waveform Generator (AWG) has been implemented with a wide dynamic range by using an output amplifier with a discrete number of gain factors. These gain factors are switchable and under control of the DLS 5500 software.

The hardware accuracy of these gain factors set a limit to the overall accuracy of the output level of the impairment generator. The DLS 5500 software does not compensate for these *systematic* hardware errors of the output levels, since it would require a (manual) calibration of each gain factor by a level detector with a much higher accuracy.

# Reference Ingress Noise Profile

The reference tests assume that the crosstalk noise generation is deactivated, that the output levels are measured with an accurate true power meter (or true RMS-meter), and that their spectra are monitored with a spectrum analyzer. See *Table 6-3*.

**Table 6-3.** Reference Ingress Noise Profiles for Functional Checks

| Profile | Frequency (Hz) | Power (dBm or V) | Width (Hz) | Depth (m) |
|---|---|---|---|---|
| Ingress ref Profile A1 | 300e3 | -10 | 0 | 0 |
| | -1 | 50 | 0 | 0 |
| Ingress ref Profile A2 | 300e3 | -70 | 100e3 | 1000 |
| | -1 | 50 | 0 | 0 |

**Table 6-3.** Reference Ingress Noise Profiles for Functional Checks (continued)

| Profile | Frequency (Hz) | Power (dBm or V) | Width (Hz) | Depth (m) |
|---|---|---|---|---|
| Ingress ref Profile A3 | 300e3 | -10 | 100e3 | 1 |
| | -1 | 50 | 0 | 0 |
| Ingress ref Profile A4 | 300e3 | -10 | 10e3 | 1 |
| | -1 | 50 | 0 | 0 |

The test should verify that the true power meter observe for each reference profile the associated output powers, and that the spectrum analyzer monitors the associated spectral width. The accuracy should be within the combined accuracy of the AWG card and the true power meter (for example, within 0.5 dB). *Figure 6-1* to *Figure 6-4 on page 77* illustrate the spectral shapes that can be observed when the signal is fed to a spectrum analyzer.

Ingress reference Profile A1 (*Figure 6-1*) generates a single unmodulated carrier of -10 dBm at 300 kHz. The true RMS-meter should display the same -10 dBm. If this not the case, you should first compensate for this *systematic* error of the setup by adjusting the amplifier gain of the source settings.

See *Figure 6-1* for what spectrum can be observed at the output of the AWG – Profile A1, unmodulated carrier of -10 dBm.

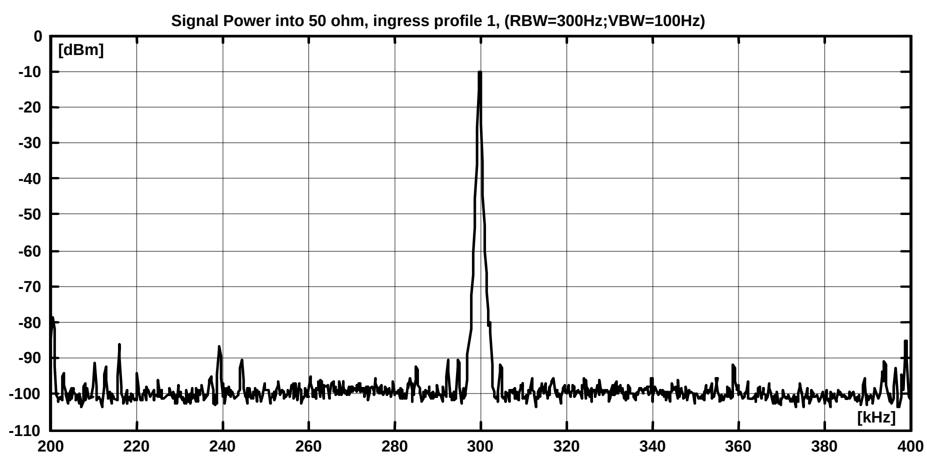



**Figure 6-1.** Measured Spectrum of the Reference Ingress Noise (A1) (Aggregate power into 50Ω P = -10 dBm = 0.1 mW)

Ingress reference Profile A2 (*Figure 6-2*) generates a single modulated carrier at the same frequency, but with suppressed carrier level. The carrier suppression is deep enough to enable that the aggregate power of this signal is dominated by the power of the modulation. Since the modulation depth is 1000 times the carrier level, and the carrier is suppressed by a factor of 1000 (or 60 dB), the modulation power in profile A2 is the same as the carrier power in profile A1.

See *Figure 6-2* for the spectrum that can be observed at the output of the AWG – Profile A2, suppressed by 60 dB, Modulation depth of m=1000, and Modulation width of Δb=100 kHz.

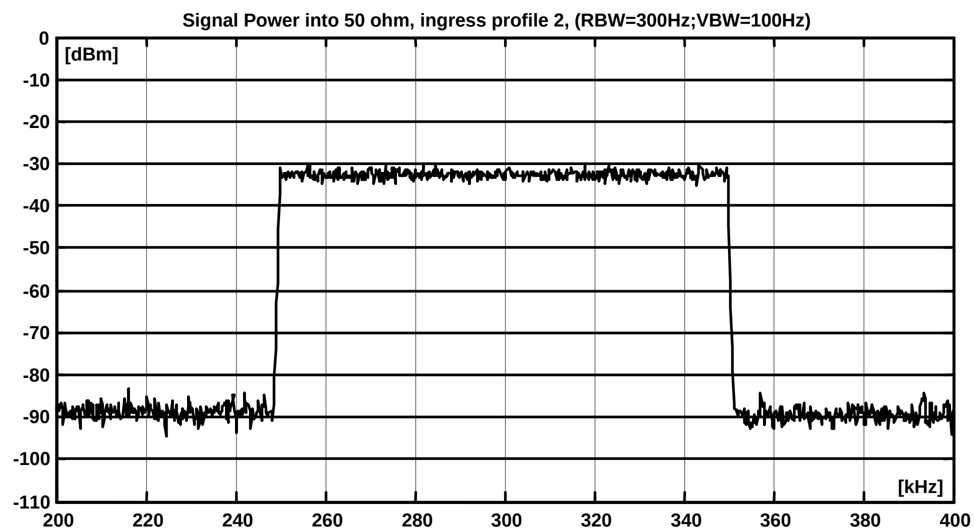



**Figure 6-2.** Measured Spectrum of the Reference Ingress Noise (A2) (Aggregate power into 50Ω P = -10 dBm = 0.1 mW)

Ingress reference Profile A3 (see *Figure 6-3*) generates a single modulated carrier at the same frequency as profile A1. Both the carrier power, as well as the modulation power, are equal now, so that the aggregate power doubles (+3.01 dB), compared to the aggregate power of profile A1.

See *Figure 6-3* for the spectrum that can be observed at the output of the AWG – Profile A3, modulated carrier of -10 dBm, modulation depth of m=1, and modulation width of Δb=100 kHz.

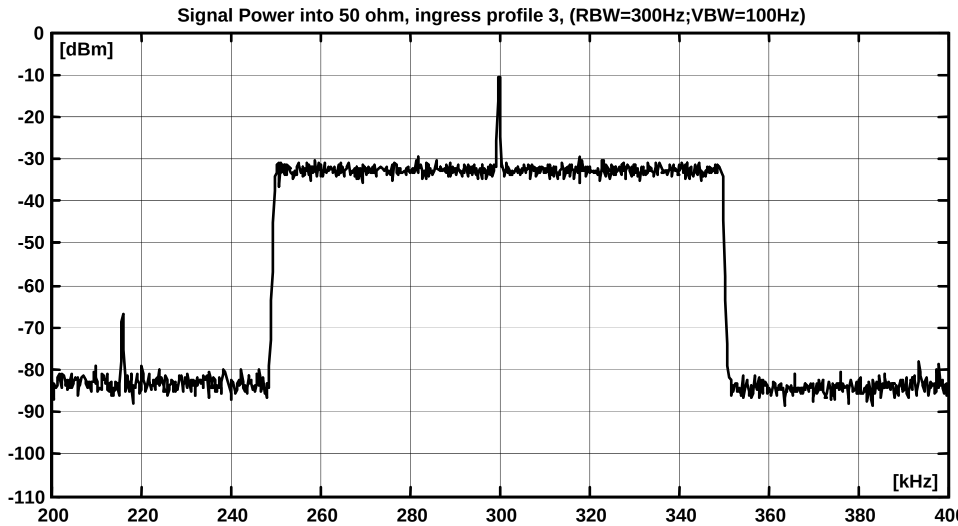



**Figure 6-3.** Measured Spectrum of the Reference Ingress Noise (A3) (Aggregate power into 50Ω P = -6.99 dBm = 0.2 mW)

Ingress reference Profile A4 (*Figure 6-4*) generates a single modulated carrier at the same frequency as profile A3 but at reduced modulation width. Since the modulation depth is unchanged, compared to profile A3, the aggregate power of profile A4 equals the aggregate power of profile A3. The *spectral* levels of the side bands, however, increase with 10 dB, which can easily be verified by means of a spectrum analyzer.

See *Figure 6-4* for the spectrum that can be observed at the output of the AWG – Profile A4, modulated carrier of -10 dBm, modulation depth of m=1, and modulation width of 10 kHz.

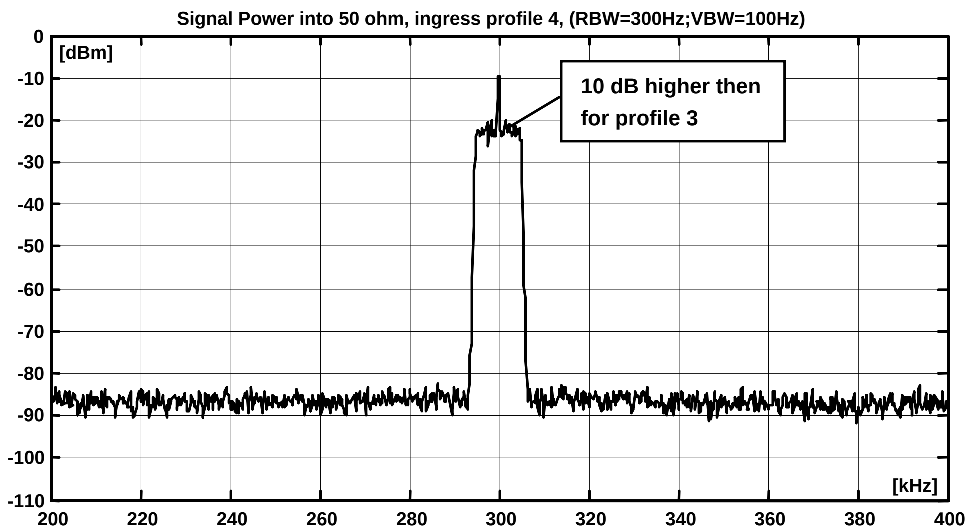



**Figure 6-4.** Measured Spectrum of the Reference Ingress Noise (A4) (Aggregate power into 50Ω P = -6.99 dBm = 0.2 mW)

# DLS 5B36 RFI Modulation Method

A revised RFI impairment method has been introduced for the DLS 5500 noise generator that is now available under the DLS 5B36 license. This RFI modulation is described according to ETSI guidelines in *TD 23R1 from ETSI TM6 September 20 to October 3 2003*, (file name 033t23r1.pdf) titled “Text Proposal for RFI Testing.”

Previous RFI noise injection had a non-zero modulation index specified. This will now be a fixed modulation index as required by the new ETSI proposal. Files which previously had a modulation of zero (that are intended to be a single tone) will be a single tone.

**Note:** The DLS 5500 noise generator allows both RFI licenses to coexist on the same noise generator. In situations where both RFI licenses are present the default modulation method will be DLS 5B36. To test using DLS 5B14 modulation, remove the DLS 5B36 from the license file directory. Please consult with Spirent Communications about this process (see *“How to Contact Us” on page 10*).

*Figure 6-5* displays the frequency representation of the observed signal when using this new method.

## Practical Modulation (Left And Right Sidebands, With 10 Lines Total)

In the actual noise spectra, there are 10 additional lines, symmetrical around the main AM carrier, all 10 with an amplitude of .1 or 20dB below the main carrier. The total power added to the main carrier by the side lobes would be 10%, or a 0.41 power increase.

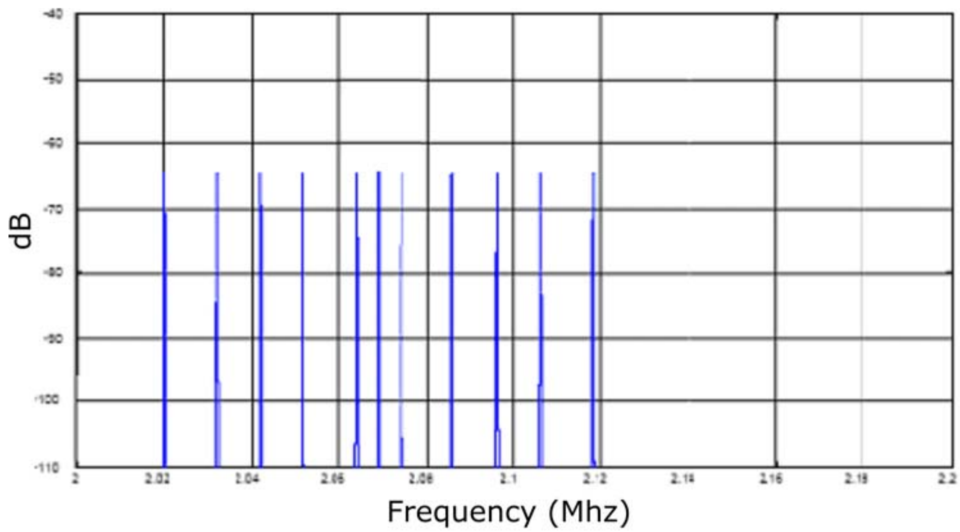



**Figure 6-5.** Example of Five-band RFI Tone Modulation

The amplitude envelope of the composite AM signal for this 5-tone based signal shown in *Figure 6-5* is displayed in *Figure 6-6 on page 79*. The tones are around .5 kHz, 1.5 kHz, 2.5 kHz, 3.5 kHz and 4.5 kHz. The frequencies are multiples of the repetition rate of the noise generator. However, the tones received some offset in frequency to make their frequencies odd multiples and mutually prime.

*Figure 6-6* shows the envelope of the amplitude of a carrier, with the modulation modeled with six aligned cosines, each with an amplitude of 20% of the carrier, or with 10 lines in the AM sidebands.

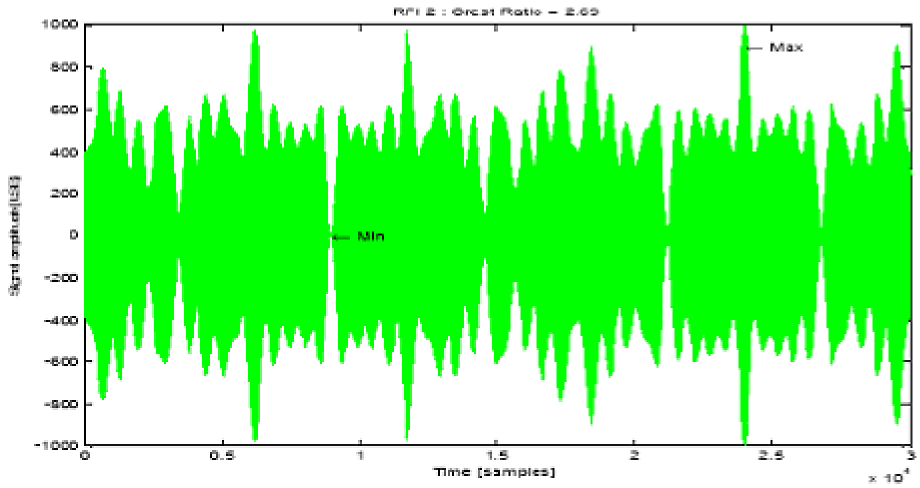



**Figure 6-6.** Carrier Envelope

The file format for this modulation method is displayed in *Figure 6-7 on page 80* and contains two parts. The file format must contain a *Header Information* area followed by a *Data Points* area. The *Data Points* must be comprised of two columns of data. The first column specifies the center frequency in (Hz) and the second column should display the required tone power in (dBm).

The *Header Information* contains several lines of text which can be modified if required.

Two parameters cannot be modified: $dist<ref> and $data<begin>. These parameters are for future use and must remain unchanged as shown in the file format in *Figure 6-7 on page 80*.

`$name<NewFormat_rfi>`

- This parameter can be changed to identify the name of the file _xtk must remain within the file name for proper operation

  `$standard< TS 101 388>`

- This parameter can be changed to identify a specific standard.

`$ver<1.1.1>`

- This parameter can be changed to identify a version number.

`$clk<32 MHz>or $clk<100MHz>`

- This parameter identifies the sampling frequency of the noise generator. Two options are available 32 or 100MHz. This parameter identifies the sampling frequency used by the noise generator when outputting the RFI noise file.

$depth<0>

- This parameter identifies the modulation method used. Two options are available 0 or .31, if you select .31, the modulated signal will appear as having left and right side bands of 10 tones as displayed in the above example. If 0 is selected the single center tone frequency will be generated with no side bands.

$clic<>

- Two available options exist: 135 Ω or 100 Ω. Select the value based on the ETSI calibration impedance required. The format should be:

  $clic<ETSI135Ohm.clc> or $clic<ETSI100Ohm.clc>.

In the *Data Points* area of the file format, specify the center frequency of interest in the first column (Hz), and the associated power level in (dBm) in the second column. The minimum start frequency is 6KHz and the maximum end frequency cannot exceed 30MHz. The *Data Points* area must contain all frequency values in ascending order. All RFI noise files must contain a -1 in the *Frequency* column followed by the reference impedance within the power column.

For custom RFI noise files made using the DLS 5B14 licensing method, the second column power values must be verified and converted to dBm. The DLS 5B36 assumes the second column to be in dBm.

## Sample File RFI Modulation Method

The following example (*Figure 6-7*) illustrates the use of the RFI modulation method using the DLS 5B36 License.

```
$name<NewFormat_rfi>
$standard<TS 101 388>
$ver<1.1.1>
$clk<32 MHz>
$depth<0>
$clic<>
$dist<ref>
$data<begin>
```

Header Information

```
500000      0.1
600000      -10
1000000     -20
-1          100
```

Data Points

**Figure 6-7.** Use of RFI Modulation Method Using the DLS 5B36 License

Chapter 7
# Time Domain Noise Profiles

**In this chapter. . .**

# Introduction

The DLS 5500 is capable of taking in user-generated time-domain files and reproducing them. This chapter provides relative information on the file format and an example to assist in describing this feature.

# Principles of Operation

The system works by repeatedly playing back a number of data samples at a specific rate. These samples are read out of RAM memory kept inside the DLS 5500. You must first put the data samples into memory and then generate the specified noise type. The data samples are converted into voltages by a Digital to Analog Converter (DAC) inside the DLS 5500 at the rate specified by the sample rate (specified within the header information of the file). This is normally 12, 32, or 100 Megasamples per second (Msps). The output changes every time a new sample is converted by the DAC. The DAC is a 14-bit device, which accepts numbers from 0 to 16383. Half scale (8191.5) corresponds to 0 V out of the DAC, and out of the BNC connector at the back of the DLS 5500.

In practice, for noise files with Gaussian amplitude distributions, we recommend a minimum of 2 Megasamples before the output repeats. To create large file types, a good ASCII text editor such as Textpad can be used.

Other text editors may be used instead. Textpad is not included with the DLS 5500. Applications such as Microsoft® Excel® have a limitation of 65536 rows, which does not allow the file to achieve a Gaussian crest factor higher than 5.

If you use pre-recorded files created by Spirent, you will not need to make samples into files. Select the appropriate file from the DLS 5500 Control Application and generate the specified noise type.

You must create time domain noise files. Save these files with a .txt or .prn extension. Once you have selected and generated this file from the DLS 5500 Control Application, a new file will be created with an extension, _td.dat, which represents the time domain file format which can be read by the DLS 5500.

These are some of the functions you can control:

- Number of samples in the file
- Sample rate
- External synchronization
- Power output
- Relative amplitude for each sample
- Which of the 4 Channels to use

You have limited control over:

- Output scaling

You cannot directly control:

- Type of triggering of the sample file. Once started, the triggering is continuous and the file continues until stopped.
- Alternating sample rates
- Alternating between files during playback
- File structure

# Description of the Time Domain Profile File Format

The file structure consists of a header and a main body. The main body of the file must be a number of lines that corresponds to successive data samples. One line corresponds to one data sample. The lines are numeric. Prepare this portion of the file in ASCII format. The *header information* and *relative amplitude* file format requirements is provided below. *Figure 7-3 on page 85* details the corresponding graph to the ASCII data shown in *Figure 7-1*.

$name<filename_td.dat>

$ver<1.0>

$freq<32.000E6 Hz>

$level<-30.0 dB>

$compensation<None>

$power value<-45.00 dBm>

$res<16bit>

$data<begin>

Header Information Details

**Figure 7-1.** Header Portion of File

8192
11326
13984
15759
16383
15759
13984
11326
8192
5057
2399
624
0
624
2399
5057

Relative Amplitude for Each Sample

**Figure 7-2.** Relative Amplitude Portion of File

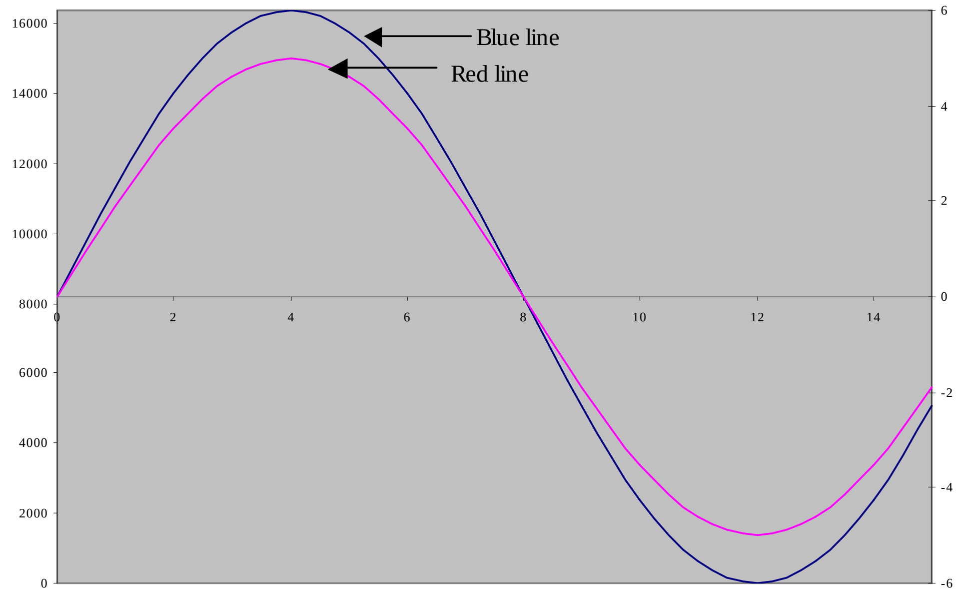



**Figure 7-3.** 5500 Time Domain File Example

## Header Information Details

**$name**<filename_td.dat> Enter a descriptive name in the *filename* field. The _td.dat extension is required.

**$ver**<1.0> is the version number of the file created and can be changed.

**$freq**<32.000E6 Hz> is the sampling rate used by the 5500 to generate the time domain profile. The sampling frequency options are 32.000E6 Hz, 12.500E6 Hz, or 100.000E6 Hz.

**$level**<-30.0 dB> The RMS value of the samples is required to calculate the attenuator levels set by the DLS 5500 (for large data files this is the same as the standard deviation of the data). This in turn controls output power. Output power is based on a 50 Ω load.

The level needed in the file header is calculated (in dBm) from the formula:

51.28 + Power - 20*log(RMS)

where *Power* is the required power output in dBm and *RMS* is the RMS value of all the numbers in the body of the file.

**$compensation**<None> presently defined as “None” for future development by Spirent.

**$power value**<-45.00 dBm> This value does not affect the power of the signal. The value in this field will be displayed by the DLS 5500 Control Application when the file is being generated. You can leave this field blank, or put in a value of meaning for reference purposes.

**$res**<16bit> presently defined as “16bit” for future development by Spirent.

**$data**<begin> presently defined as “begin” The main body of the file **must** start on the line after this header information.

## Relative Amplitude for Each Sample

Each line of the body of the file must be a decimal number between 0 and 16383. A value of 0 means that the DAC will output -5 V, and a value of 16383 means that the DAC outputs a voltage of +5 V. For telecommunications purposes, the average (mean) value of the data samples should be 8191.5 ±20.

For instance, you could create a simple file with values of a sine wave. The example in *Figure 7-2 on page 84* and *Figure 7-3 on page 85* is a theoretical example of one that has 16 samples to create the sine wave. A value is required on each row of the time domain file main body.

The blue line, plotted on the scale at the left hand side of the graph (*Figure 7-3 on page 85*) represents the data needed by the body of the file, and the red scale, plotted on the scale at the right hand side of the graph, is the corresponding output in Volts. Once started, this plays the 16 amplitude levels and repeats to create a sine wave. If no attenuation is set, this gives a sine wave from the BNC channel output of the DLS 5500 with peak values of ±5 Volts as shown on the right-hand scale.

# Number of Samples In the File

In practice, for noise files with Gaussian amplitude distributions, we recommend a minimum number of samples of 2 Meg before the output repeats.

As an example, suppose we use a 32-MHz sampling rate and 2^21 (=2097152) data samples. This means that after the file reaches the end of its 2097152 samples, it will start again and repeat the same set of data values. The time taken to cycle once through all the samples is (2^21)/ (32.0E+6) = 0.065536 seconds. This is a rate of 15.26 times per second. The subsequent spectrum cannot contain frequencies lower than 15.26 Hz. It can have frequencies at harmonics of 15.26 Hz all the way up to half the clock rate.

## Maximum Memory Size

Each channel can record and play back a maximum of 16 Megasamples

## External Synchronization

This BNC sync input on the back panel of the DLS 5500 is used to synchronize playback to an external signal. In particular, in Japan, it can be used to synchronize noise playback to TCM-ISDN. This input expects to see a 0 to 5 V digital signal, and uses the positive edge. As presently configured, the sync input needs 98 positive edges before it causes a trigger in the DLS 5500. During replay of the data samples the trigger samples back to the beginning of the file, so that play back continues at the beginning of the file again.

In order for the external sync to work, the *Clock Sync* must be set to *ON*. To do this, click the **Clock Sync** button in the DLS 5500 Control Application, and set **External Sync** to **ON**. This condition of *Clock Sync* (*ON* or *OFF*) is remembered by the instrument even if you power down. If you do not want to use external synchronization, you must turn it off or make sure that no synchronizing pulses appear at the sync input. If using the unit remotely, it is wise to send a sync *OFF* command before reading in any new data file.

# Output Scaling And Injector Loss

Normally, the unit is used with an external injector circuit that performs two main functions:

- to condition the signal so that it is balanced
- to provide a high-impedance or current output from the injector, so that when the injector is attached to the line it does not significantly affect the modem signal already on the line.

Normally, the injector circuit has a signal loss through it .For instructions on how to measure the loss of an injector, see *“Command: M_INJECTOR_LOSS” on page 97*. This value of injector loss for each channel is set from the front panel according to the actual loss of the injector attached to each channel. This is done using the *Injector Loss* field on the DLS 5500 Control Application.

When the injector loss has been set for a particular channel, the DLS 5500 automatically sets a gain equal to the channel injector loss for that channel, and the signal is correspondingly higher at the BNC back panel connectors of the DLS 5500.

The graphical representation do not display the entire _td file from start to finish of the file format.

## Maximum Level and Overload Conditions

There are several ways in which you can accidentally overload the output. Normally the DLS 5500 warns you if this happens.

- If the .td file contains values outside the range of 0 to 16383, the software rejects the whole file and generates an error message.
- You might indirectly overload the channel by specifying inappropriate IL and Level settings. For example, the following data set:
  8192
  8505
  8771
  8948
  9011
  8948
  8771
  8505
  8192
  7878
  7612
  7435
  7372

7435
7612
7878
has an RMS value of 579.23. If the Level in the file header is set to 15 dB, and the IL of the injector is 0, the above data set will not overload the DLS 5500. If, however, the IL is set to 19.3 dB, the above data set will overload the DLS 5500. In this case the DLS 5500 will not process the file.

## Calculation of RMS

As noted before, the RMS value is the same as the standard deviation of the file. It is calculated according to the following formula:

$$rms := \sqrt{\frac{1}{N} \cdot \sum_{n=0}^{N-1} \left(A_n - mean(A)\right)^2}$$

where *A* is the amplitude of the samples.

## Converting to dBm from Volts

The output from the DLS 5500 is specified as power output in dBm into a 50 Ω load. 0 dBm corresponds to 1 mW. This means that 0 dBm provides 0.2236 Volts of output across the 50 Ω load. You can convert voltages to dBm for the output of the DLS 5500 by using the following formula:

Output in dBm = 20*log(V/0.2236)

where *V* is the RMS voltage across the 50 Ω load.

## File Generation

The most convenient way of generating a large digest of samples is with some type of mathematical software. Output the data to an ASCII text file with a .prn or .txt file extension.

Some software applications generate values in the range of +1 to -1, with 0 as the mean value. This needs to be converted to a 0 to 16383 range with 8191.5 as the mean value.

## Text File Editor

You can use any ASCII text editor that does not add extra characters, and can handle the number of lines in the file. For this reason, we recommend you avoid:

- Microsoft Excel (not long enough)
- Notepad (not long enough)

- Wordpad.exe (slow, output may be incorrect)
- Word processors in general.

## Total File Length

The body of the data file can be almost any length from a few samples to maximum length. The maximum length of the body of the file is 16 Mbytes (2^24) bytes. The minimum recommended length depends on the nature of the amplitude variations (or probability distribution function, pdf) of the file that you have calculated, but for Gaussian noise should not be less than 2 Mbytes, and preferably 4.

Chapter 8

# Remote Control Programming

**In this chapter. . .**

# Developing a Remote Controller

Programming the DLS 5500 means, in this context, controlling it from a separate application running on the same, or a remote, machine by using TCP/IP to transport messages that follow the DLS 5500 inter-process communications protocol. Such an application can be thought of as a *remote controller.*

You may use any programming language to develop a remote controller as long as it permits you to “talk” TCP/IP. Indeed, you may develop the remote controller for any operating system and/or host machine. The essential requirement is that you adhere to the messaging protocol defined for the DLS 5500.

The DLS 5500 runs on Windows® 98 or Windows® 2000, which typically employs Intel® x86 processors. These processors use little-endian formatting for data. The remote control software inside the DLS 5500 does not perform host-to-network byte-order translation of the data it sends, so generally the remote controller must accommodate for this, in both sending and receiving, if its host processor uses big-endian data. However, since the message contents, as seen, consist of byte-sized ASCII character sequences (non-zero terminated strings), this is not a concern in the present case; their sequence should remain the same regardless.

With the above in mind, this chapter defines the messaging required to effect remote control operation of the two DLS 5500 units.

# Inter-Process Communications

## Providing a System Identifier

A system name can be used to identify a specific noise generator. This name can then be retrieved remotely using the *M_SYSTEM_ID* command (see *“System and Network Commands” on page 99*).

**To name a specific DLS 5500 noise generator:**

1. Select **System** > **Properties** from the menu bar.
   The System Properties dialog box appears.
2. Enter a name in the *System Identifier* field.
   The name can be up to 30 characters long.
3. Click **OK** to close the dialog box.

## Establishing a Connection

Remote control applications need to employ a *client socket*, and initiate a TCP/IP connection request to the targeted DLS 5500 unit before they can start exchanging inter-process messages.

Operationally, the first step is to enable remote control access at the DLS 5500 unit. This causes the unit to begin listening for a remote connection request for the DLS 5500 on ports ranging from 1024 to 65535. For instructions on enabling remote access on the DLS 5500, see *"System Mode" on page 50*.

At this point, the remote controller can try to connect. Once the connection is established, the *listener socket* in the DLS 5500 control window(s) ignores any further connection requests until the current connection is ended. If remote control access is disabled, either at the DLS 5500 unit, or by a command from the remote controller, while the connection is established, the listener ignores connection requests following the termination of the connection, but it does not close the connection. Re-enabling of remote control access must always be done at the DLS 5500 unit itself.

## DLS 5500 Messaging Format

The format of an inter-process message that conforms to the DLS 5500 convention is a *case-sensitive* byte sequence of the form:

```
!STX: <message body> ;ETX!
```

where the *message body* is described below. !STX: is the *message start token*, and ;ETX! is the *message end token*.

Every byte in the DLS 5500 inter-process message set is a printable, 8-bit ASCII character. New versions of the DLS 5500 utilize condensed command structures to enhance usability.

Messages sent by a remote controller that do not follow the protocol format are dropped by the DLS 5500, and no feedback is provided to the sender. It is up to the remote control application developers to ensure that the messages being sent are grammatically correct.

## Message Body Specifications

There are four types of remote control messages used in the DLS 5500:

- SET(*parameter ID*):VAL(*value*)
- GET(*parameter ID*)
- REPLY(*parameter ID*):VAL(*value*)
- TRAP(*parameter ID*):VAL(*value*)

With the exception of the GET message, the messages have VAL appended as a suffix, which delimits a parameter value accompanying the message.

To see how these fit with the general scheme, consider these examples:

```
!STX:SET(M_ENABLE_OUTPUT):VAL(OUTPUT_1:ON OUTPUT_2:OFF);ETX!
!STX:GET(M_SELECTED_OUTPUT);ETX!
!STX:REPLY(M_SELECTED_OUTPUT):VAL(OUTPUT_1);ETX!
!STX:TRAP(ERROR):VAL(BAD_PARAMETER_ID);ETX!
```

Each of these messages is the exact character sequence expected for that remote control operation. Refer to *Table 8-1 on page 95* for a comprehensive enumeration of the messages and their associated parameter identifiers and values.

Every byte in the DLS 5500 interprocess message set is a printable, 8-bit ASCII character.

## Functional Details

A remote controller emulates local control at the DLS 5500 unit; hence, operation of the DLS 5500 under remote control would nominally proceed as shown here.

**To operate the DLS 5500 under remote control:**

1. Manually enable remote control at the DLS 5500 unit.
2. Launch your remote controller application, and connect to the unit using TCP/IP, port range 1024-65535.
3. Send the messages of interest (see *"Typical Message Sequences" on page 94*), and watch for the replies.
4. When your application is ready to relinquish remote control, it need only disconnect.
5. Your application should not issue a SET(DISABLE_REMOTE) message unless it will prevent subsequent access to the DLS 5500 remote control capabilities for all remote controllers. There is no way to remotely re-enable remote control.

Output-specific commands are applied to the most recently selected output. It is therefore a good idea to select the output via a remote control message as the first step. The messages that follow apply to the selected output.

**For a specific output:**

1. Load a noise file.
2. Set all the necessary parameters.
3. Generate the sample.
4. Load the output.
5. Return to *Step 1* for each output to be deployed.
6. Enable the output, or outputs, as desired.

## Typical Message Sequences

A sequence of messages between a remote controller, and a DLS 5500 unit is tabulated in *Table 8-1 on page 95*. Note that the shortened description of the message, excluding the start and end tokens is used. Some cells in the table are connection management events, not messages.

Time flows downward, from the top to the bottom of the table (*Table 8-1 on page 95*).

**Table 8-1.** Typical Message Sequences

| From the Remote Controller | At/From the DLS 5500 |
|---|---|
| | Enable remote control. Start listening on port range 1024-65535 |
| Connect to the unit, port range 1024 to 65535 | |
| | Connection succeeded. Stop listening |
| SET(M_SELECT_OUTPUT):VAL(OUTPUT_1) | |
| | SET(REPORT):VAL(CMD_SUCCEEDED) |
| SET(M_LOAD_FILE):VAL(*filepath string*) | |
| | SET(REPORT):VAL(CMD_SUCCEEDED) |
| SET(M_NOISE_GAIN):VAL(*gain string*) | |
| | SET(REPORT):VAL(CMD_SUCCEEDED) |
| SET(M_CREST_FACTOR):VAL(*value string*) | |
| | SET(REPORT):VAL(CMD_SUCCEEDED) |
| SET(M_NUMBER_SAMPLES):VAL(*integer string*) | |
| | SET(REPORT):VAL(CMD_SUCCEEDED) |
| SET(M_GENERATE_SAMPLE) | |
| | SET(REPORT):VAL(CMD_SUCCEEDED) |
| SET(M_LOAD_OUTPUT) | |
| | SET(REPORT):VAL(CMD_SUCCEEDED) |
| SET(M_ENABLE_OUTPUT):VAL(OUTPUT_1:ON OUTPUT_2:OFF OUTPUT_4:ON) | |
| | SET(REPORT):VAL(CMD_SUCCEEDED) |
| | Disable remote control. No immediate effect |
| . . . | |
| SET(M_ENABLE_OUTPUT):VAL(OUTPUT_1:OFF OUTPUT_2:OFF OUTPUT_4:OFF) | |

**Table 8-1.** Typical Message Sequences (continued)

| From the Remote Controller | At/From the DLS 5500 |
|---|---|
| | TRAP(ERROR):VAL(CMD_OVERFLOW) |
| Disconnect | |
| | Disconnection event recognized |
| Attempt re-connection | |
| | Connection denied/immediately closed. Remote control not enabled |
| . . . | |
| | Remote control enabled. Accept first connection request on port 1024 - 65535 |
| Connect to the unit, port range 1024 - 65535 | |
| | Connection succeeded. Stop listening |

. . .

## Using Telnet Client

The remote commands can be sent by means of a Telnet client. Both character-mode input and line-mode input are accepted. It is recommended that the Telnet client be configured in line mode.

# Remote Commands

## Injector Remote Commands

The commands listed in this section are relayed by the DLS 5500 to the noise injector (for example the DLS 5406).

**Note:** It is possible to put the system into a seemingly non-responsive state if very large numbers of micro interrupts and/or very long micro interrupts are used, since control will only be returned once the micro interrupt test is complete.

Scripts are responsible for managing connection states. If a script connects to the injector, and that script will be re-run, the script must disconnect as its last instruction. Use the M_INJ_DISCONNECT command for this purpose.

## Non-Controllable Injector Commands

### Command:M_INJECTOR_LOSS

Description: Set and get channel injector loss. Use only for non-controllable injectors or an error will be generated.

Parameters: Channel name and injector loss value, or injector name.

Telnet example:

```
!STX:SET(M_INJECTOR_LOSS):VAL(OUTPUT_1:DLS 5402DC);ETX!
!STX:SET(M_INJECTOR_LOSS):VAL(OUTPUT_1:22.5);ETX!
```

## Controllable Injector Commands

### Command:M_INJ_CONNECT

Function:Connect to DLS 5406

Parameter: Serial port number

Range: 1 to 31

Telnet example:

```
!STX: SET(M_INJ_CONNECT):VAL(1);ETX!
```

If the serial port is out of range, the return will be:

```
'VALUE_IS_OUT_OF_RANGE'
```

If the serial port cannot be opened, the return will be:

```
'M_INJ_PORT_UNAVAILABLE'
```

### Command:M_INJ_DISCONNECT

Function:Disconnect from DLS 5406.

Parameter: none

Telnet example:

```
!STX: SET(M_INJ_DISCONNECT); ETX!
```

## Micro Interrupt Control Commands

### Command:M_INJ_CHAN1_INTERRUPT_LENGTH

Function:Set Side A Micro Interrupt length

Parameter: Channel 1 micro interrupt length in mS.

Range: 1 - 60000

Telnet example:

```
!STX:SET(M_INJ_CHAN1_INTERRUPT_LENGTH):VAL(1);ETX!
```

If the value is not in range, the return will be:

`‘VALUE_IS_OUT_RANGE’`

### Command:M_INJ_CHAN2_INTERRUPT_LENGTH

Function:Set Side B Micro Interrupt length:
Parameter: Channel 2 micro interrupt length in mS.
Range: 1 - 60000
Telnet example:

```
!STX: SET(M_INJ_CHAN2_INTERRUPT_LENGTH):VAL(1);ETX!
```

If the value is not in range 1 - 60000, the return will be:

`‘VALUE_IS_OUT_RANGE’`

### Command:M_INJ_INTERRUPT_EVERY

Function:Set the Repetition Rate for Micro Interrupts
Parameter: Repeat rate in seconds
Range: 1 - 60000
Telnet example:

```
!STX: SET(M_INJ_INTERRUPT_EVERY):VAL(1); ETX!
```

### Command:M_INJ_INTERRUPT_SIDE

Function:Set the side at which Micro Interrupts are generated.
Parameter: Side index
Range: 1 = Side A, 2 = Side B
Telnet example:

```
!STX: SET(M_INJ_INTERRUPT_SIDE):VAL(1); ETX!
```

### Command:M_INJ_INTERRUPT_TOTAL

Function:Set the total number of Micro Interrupts
Parameter: Total number of micro interrupts
Range: 1 - 60000
Telnet example:
Sending the command by using Telnet:

```
!STX: SET M_INJ_INTERRUPT_TOTAL):VAL(10); ETX!
```

### Command:M_INJ_INTERRUPT_TRIGGER_SINGLE

Function:Trigger Single Micro Interrupt:
Parameter: none
Telnet example:

```
!STX: SET(M_INJ_INTERRUPT_TRIGGER_SINGLE); ETX!
```

### Command:M_INJ_INTERRUPT_TRIGGER_START

Function:Start automatically generated micro interrupt triggering
Parameter: none
Telnet example:

```
!STX: SET(M_INJ_INTERRUPT_TRIGGER_START); ETX!
```

## System and Network Commands

### Command:M_SOFTWARE_VERSION

Description: Get software version.
Telnet example:

```
!STX:GET(M_SOFTWARE_VERSION);ETX!
```

### Command:M_INSTALLED_LICENSE

Description: Get installed license
A string contains all licensed product names that have DLS 5500 as the platform type, such as DLS5C20_Key, DLS5B13, DLS5B17, and so on.
Telnet example:

```
!STX:GET(M_INSTALLED_LICENSE);ETX!
```

### Command:M_INSTALLED_PACKAGES

Function:Returns a list of all installed noise packages, with the package version.
Parameter: None
Telnet example:
Sending

```
!STX:GET(M_INSTALLED_PACKAGES);ETX!
```

Receiving:

```
!STX:SET(REPORT):VAL(DLS 5B11 v1.0; DLS 5B13 v1.1; );ETX!
```

If no noise packages are installed, the control software returns the following message:

```
!STX:TRAP(ERROR):VAL(NO_INSTALLED_PACKAGES);ETX!
```

### Command:M_MAC_ADDRESS

Description: Get MAC address.
Telnet example:

```
!STX:GET(M_MAC_ADDRESS);ETX!
```

### Command:M_NETWORK_NAME

Description: Get network name.
Telnet example:

```
!STX:GET(M_NETWORK_NAME);ETX!
```

### Command:M_SYSTEM_ID

Description: Retrieves the identification tag that was set in the DLS 5500 Control Application.

Telnet example:

```
!STX:GET(M_SYSTEM_ID);ETX!
```

## Channel/Output Commands

### Command:M_SELECTED_OUTPUT

Description: Queries which output is currently selected, and to which subsequent commands will apply.

Telnet example:

```
!STX:GET(M_SELECTED_OUTPUT);ETX!
```

### Command:M_FILE_NAMES

Description: Get channel file name(s).

Parameter:A string that may contain more than one name if number of noises combined.

Format:1. name1; 2. name2;

Telnet example:

```
!STX:GET(M_FILE_NAMES):VAL(OUTPUT_1);ETX!
```

### Command:M_OUTPUT_LEVEL

Description: Get channel output level

Parameter:A string that contains noise file name and level at 100 Ω calibration impedance. For example:

1. ETSI-A_xtk.dat level –49.9 dBm.
2. DSL_Next_24D_xtk.dat level -43 dBm, at 100 Ω calibration impedance.

Telnet example:

```
!STX:GET(M_OUTPUT_LEVEL):VAL(OUTPUT_1);ETX!
```

### Command:M_OUTPUT_CFRC

Description: Get CFRC file and status for the requested channel.

Parameter:A string that contains CFRC status and file name. For example:

'Channel 1 CFRC enabled, file name: C:\5402_chan1.cfr'.

Telnet example:

```
!STX:GET(M_OUTPUT_CFRC):VAL(OUTPUT_1);ETX!
```

### Command:M_SELECT_OUTPUT

Description: Selects the current channel (output) to operate on. Selects the output to which subsequent commands will apply.

*Valid selector strings:*

“OUTPUT_1”, through “OUTPUT_4”

Telnet example:

```
!STX:SET(M_SELECT_OUTPUT):VAL(OUTPUT_3);ETX!
```

### Command:M_LOAD_FILE

Description: Loads a noise file of types impulse, xtalk, rfi, time domain, and custom noise.

*RFI, XTalk, Time domain:*

The absolute path and file name, or in the form of “PACKAGE\VERSION\Noise-Files\…\FILE”

*Impulse*: The absolute path and file name.

*Custom noise:*The absolute path and file name. The file name must end with “_cst.enc”.

Telnet examples:

```
!STX:SET(M_LOAD_FILE):VAL(C:\Program Files\Spirent Communica-
tions\DLS 5500\NoiseFiles\DSL Forum\ADSL_TR-048 (Apr 2002)\8-1-
2_24_HDSL_Impairment\Downstream_At_ATU-
R\HDSL_Next_24DPlusWN_xtk.enc);ETX!
```

```
!STX:SET(M_LOAD_FILE):VAL(DLS5B17\1.0\NoiseFiles\DSL
Forum\ADSL_TR-048 (Apr 2002)\8-1-
2_24_HDSL_Impairment\Downstream_At_ATU-
R\HDSL_Next_24DPlusWN_xtk.enc);ETX!
```

```
!STX:SET(M_LOAD_FILE):VAL(C:\Program Files\Spirent Communica-
tions\DLS 5500\NoiseFiles\Base Noise Files\ADSL-C1_imp.dat);ETX!
```

### Command:M_GENERATE_SAMPLE

Description: Constructs and combines the noise shape before output. Starts generating the noise sample.

Telnet example:

```
!STX:SET(M_GENERATE_SAMPLE);ETX!
```

### Command:M_LOAD_OUTPUT

Description: Loads the output with the combined noise file to the current selected channel.

Telnet example:

```
!STX:SET(M_LOAD_OUTPUT);ETX!
```

### Command:M_NOISE_GAIN

Description: Sets the gain of the last loaded noise. In the case of impulse noise, the gain is based from a starting level of 0 mV.

*Xtalk, and RFI:*

A number in the range of -72.25 to +72.25

*Time domain:*A number in the range of -7.0 to +7.0

*Impulse:* A number in the range of 0.0 to 100.0

Telnet example:

```
!STX:SET(M_NOISE_GAIN):VAL(22);ETX!
```

### Command:M_CREST_FACTOR

Description: Enables or disables crest factor for xtalk noise.

*Value string:*“ON”, “OFF”

Telnet example:

```
!STX:SET(M_CREST_FACTOR):VAL(ON);ETX!
```

### Command:M_NUMBER_SAMPLES

Description: Sets the number of samples to use for frequency domain noises.

*Valid Values:*Powers of 2, ranging from 32768 to 2097152

Telnet example:

```
!STX:SET(M_NUMBER_SAMPLES):VAL(32768);ETX!
```

### Command:M_TD_WHITENOISE

Description: Enables or disables time domain white noise.

*Value string:*“ON”, “OFF”.

Telnet example:

```
!STX:SET(M_TD_WHITENOISE):VAL(ON);ETX!
```

### Command:M_IMPULSE_RATE

Description: Sets the number of pulses per second for impulse noise when not used with time domain noise.

*Value string:* 1 - 100 pps (pulses per second)

Range: 1 - 100

Telnet example:

```
!STX:SET(M_IMPULSE_RATE):VAL(30);ETX!
```

### Command:M_RESET_CHANNEL

Description: Clears the loaded files in the workspace and stops output on the current selected channel. It is recommended that this command be used after selecting a channel.

Telnet example:

```
!STX:SET(M_RESET_CHANNEL);ETX!
```

### Command:M_ENABLE_OUTPUT

Description: Enables or disables the output(s) identified by the value selectors. More than one selector may be specified, and they must be separated by white spaces.

*Valid* “OUTPUT_1:ON” … ”OUTPUT_4:ON” to

*selectors:*“OUTPUT_1:OFF” … “OUTPUT_4:OFF”

*Valid status:* ON, OFF

Telnet example:

```
!STX:SET(M_ENABLE_OUTPUT):VAL(OUTPUT_1:OFF OUTPUT_2:ON);ETX!
```

### Command:DISABLE_REMOTE

Description: Disables remote control and terminates the connection.

Telnet example:

```
!STX:SET(DISABLE_REMOTE);ETX!
```

### Command:M_EXTSYNC

Description: Enables or disables the external sync out BNC connector for Japanese transmission synchronization

*Value string:*”ON”,”OFF”

Telnet example:

```
!STX:SET(M_EXTSYNC):VAL(OFF);ETX!
```

### Command:M_NOISE_GAINEX

Description: Extended command to set the gain of the a loaded noise. In the case of impulse noise, the gain is based from a starting level of 0 mV.

The parameter is in the form of index_or_filename:level. Index's start from 0.

*Xtalk, and RFI*:

A number in the range of -72.25 to +72.25

*Time domain:*A number in the range of -7.0 to +7.0

*Impulse:*A number in the range of 0.0 to 100.0

Telnet example:

```
!STX:SET(M_NOISE_GAINEX):VAL(0:10);ETX!
!STX:SET(M_NOISE_GAINEX):VAL(White_Noise_xtk.enc:10);ETX!
```

### Command:M_MICRO_GAIN

Description: Adjusts the power level of the noise being currently outputted.

*dB value range:*

*For frequency domain noises:* -3.0 to +9.0.

*For time domain noise:* -7.0 to +7.0.

Telnet example:

```
!STX:SET(M_MICRO_GAIN):VAL(4.2);ETX!
```

#### Command:M_SAVE_CUSTOM_FILE

Description: Saves a noise to disk. The path and file name of the noise. The file name must end with "_cst.enc".

Telnet example:

```
!STX:SET(M_SAVE_CUSTOM_FILE):VAL(C:\MyCustomFile_cst.enc);ETX!
```

#### Command:M_INFO_CUSTOMNOISE

Description: Sets the user defined description for saved files. Use a string with a maximum of 256 characters.

Telnet example:

```
!STX:SET(M_INFO_CUSTOMNOISE):VAL(This is my custom file);ETX!
```

#### Command:M_CFRC_ENABLE

Description: Enable channel frequency response calibration Channel name, CFRC state (ON/OFF) and CFRC file name.

Telnet example:

```
!STX:SET(M_CFRC_ENABLE):VAL(OUTPUT_1:ON:C:\TestChan1.cfr);ETX!
!STX:SET(M_CFRC_ENABLE):VAL(OUTPUT_1:OFF);ETX!
```

#### Command:M_NOISE_DISTURBER

Description: Set noise disturber file index (start from 0) or file name and disturber value.

Telnet example:

```
!STX:SET(M_NOISE_DISTURBER):VAL(0:10);ETX!
!STX:SET(M_NOISE_DISTURBER):VAL(ETSI-A_xtk.enc:10);ETX!
```

## Noise Burst Commands

The Noise Burst is a remote-only feature of the DLS 5500 software version 2.1 and higher. This feature allows precision timing control of the noise generator output.

### How it works

The Noise Burst feature uses an internal timer to turn on and off the output of the loaded and running noise generator.

The Noise Burst feature generates single bursts of programmable duration using a trigger command. The Noise Burst Test lets you repeat bursts a specified number of times at a specified interval after an optional programmable delay.

## How to Use it

The general command sequence for using the Noise Burst feature is shown in this section. The new commands are shown in bold. See *“Commands” on page 106* for details on these commands, and see *“Example Sequence for Noise Burst Test” on page 107* and *“Example Sequence for Single Noise Burst” on page 108*.

**To use the noise burst feature:**

1. Select the output channel (M_SELECT_OUTPUT)
2. Reset the channel (M_RESET_CHANNEL)
3. Load the file (M_LOAD_FILE)
4. Set the gain (M_NOISE_GAIN)
5. Generate the sample (M_GENERATE_SAMPLE)
6. Load the output buffer but do not turn on the output (**M_LOAD_OUTPUT_BUFFER**)
7. Specify the burst duration in milliseconds (**M_NOISEBURST_DURATION**)

**To generate single bursts:**

8. Trigger the burst (**M_NOISEBURST_TRIGGER**)

OR

**To generate repeated bursts:**

9. Specify an optional delay (in seconds) before the first burst (**M_NOISEBURST_DELAY**)
10. Specify the number of bursts to generate (**M_NOISEBURST_REPEATS**)
11. Specify the interval (in seconds) between burst triggers (**M_NOISEBURST_INTERVAL**)
12. Start bursts (**M_NOISEBURST_STARTTEST**)

**Note:** If you need to stop the burst test before it is finished, use **M_NOISEBURST_STOPTEST**.

## Commands

### Command: M_LOAD_OUTPUT_BUFFER

Description: Loads the output buffer of the noise generator without turning on the output. This is used after you generate the sample, and replaces the M_LOAD_OUTPUT command that is used in regular (non-burst-noise) applications.

Telnet example:

```
!STX:SET(M_LOAD_OUTPUT_BUFFER);ETX!
```

### Command: M_NOISEBURST_DURATION

Description: Sets the duration of the noise burst in milliseconds.

**Important:** Although the command will accept steps of 1 ms, the measured results actually showed increments of 10 ms. The value is rounded to the next largest multiple. In other words, entering 10 ms will give 10 ms duration; entering 11 ms will give 20 ms duration.

Range: 10 to 10000 ms

Telnet example:

```
!STX:SET(M_NOISEBURST_DURATION):VAL(50);ETX!
```

### Command: M_NOISEBURST_TRIGGER

Description: Generates a single noise burst with the programmed duration.

Telnet example:

```
!STX:SET(M_NOISEBURST_TRIGGER);ETX!
```

### Command: M_NOISEBURST_REPEATS

Description: Sets the number of times to repeat noise bursts when the test is started.

Range: 1 to 60000 bursts

Telnet example:

```
!STX:SET(M_NOISEBURST_REPEATS):VAL(5000);ETX!
```

### Command: M_NOISEBURST_INTERVAL

Description: Sets the interval between bursts in seconds.

**Important:** The interval between bursts refers to how often the burst is triggered, and does not account for the duration of the burst. You need to ensure that the interval is greater than the burst duration.

Range: 1 to 300 seconds in 1 second steps

Telnet example:

```
!STX:SET(M_NOISEBURST_INTERVAL):VAL(1);ETX!
```

### Command: M_NOISEBURST_DELAY

Description: Sets the delay between receiving the M_NOISEBURST_STARTTEST command and the first burst. Subsequent bursts are generated at the interval specified by M_NOISEBURST_INTERVAL.

Range: 1 to 10 seconds in 1 second steps

Telnet example:

```
!STX:SET(M_NOISEBURST_DELAY):VAL(2);ETX!
```

### Command: M_NOISEBURST_STARTTEST

Description: Starts the Noise Burst test. This will cause the programmed number of noise bursts to be generated at the programmed interval, after the programmed delay.

Telnet example:

```
!STX:SET(M_NOISEBURST_STARTTEST);ETX!
```

### Command: M_NOISEBURST_STOPTEST

Description: Stops the Noise Burst test. This is useful for stopping the test if you have accidentally programmed an extremely long time span.

Telnet example:

```
!STX:SET(M_NOISEBURST_STOPTEST);ETX!
```

## Example Sequence for Noise Burst Test

**Note:** You need to replace <noise file name> and <noise level> in the respective commands with values appropriate for your noise generator.

```
!STX:SET(M_SELECT_OUTPUT):VAL(OUTPUT_1);ETX!
 !STX:SET(M_RESET_CHANNEL);ETX!
 !STX:SET(M_LOAD_FILE):VAL(<noise file name>);ETX!
 !STX:SET(M_NOISE_GAIN):VAL(<noise level>);ETX!
 !STX:SET(M_GENERATE_SAMPLE);ETX!
 !STX:SET(M_LOAD_OUTPUT_BUFFER);ETX!
 !STX:SET(M_NOISEBURST_DURATION):VAL(50);ETX!
 !STX:SET(M_NOISEBURST_REPEATS):VAL(50);ETX!
 !STX:SET(M_NOISEBURST_INTERVAL):VAL(2);ETX!
 !STX:SET(M_NOISEBURST_STARTTEST);ETX!
```

### Example Sequence for Single Noise Burst

**Note:** You need to replace <noise file name> and <noise level> in the respective commands with values appropriate for your noise generator.

```
!STX:SET(M_SELECT_OUTPUT):VAL(OUTPUT_1);ETX!
!STX:SET(M_RESET_CHANNEL);ETX!
!STX:SET(M_LOAD_FILE):VAL(<noise file name>);ETX!
!STX:SET(M_NOISE_GAIN):VAL(<noise level>);ETX!
!STX:SET(M_GENERATE_SAMPLE);ETX!
!STX:SET(M_LOAD_OUTPUT_BUFFER);ETX!
!STX:SET(M_NOISEBURST_DURATION):VAL(50);ETX!
!STX:SET(M_NOISEBURST_TRIGGER);ETX!
```

**Notes:**

- The timer used for bursts is not synchronized with the generation of impulses from the noise generator.
- Bursts can be used only on one channel at a time. If attempting to generate bursts on multiple channels, unpredictable results will occur.
- Although the duration command will accept steps of 1 ms, the measured results actually showed increments of 10 ms. The value is rounded to the next largest multiple. In other words, entering 10 ms will give 10 ms duration; entering 11 ms will give 20 ms duration.
- The interval between bursts refers to how often the burst is triggered, and does not account for the duration of the burst. You need to ensure that the interval is greater than the burst duration.

## Deprecated Commands

Deprecated commands are commands that are no longer supported. If your previous scripts use any of the commands in this section, remove them and substitute with the suggested replacements.

**Warning:** Deprecated commands may still be accepted through the software GUI and may return successful results through the *Display Remote Commands* window, but they may produce unpredictable behavior.

#### Command: M_COPY_CHANNEL*

Description: Copies the contents of the source channel to the workspace and selects the destination as the channel on which to output.

**Note:** *This command has been deprecated in version 1.0. User must load noises onto each channel as required.

### Command: M_IMPULSE_LEVEL*

Description: Sets the level of the selected impulse noise.
*Valid values:* “0” to “100” Telnet

**Note:** *This command has been deprecated in version 1.0. Use:M_NOISE_GAIN

### Command:M_LOAD_XTALK_FILE *

Description: Loads a xtalk noise file (license permitting). Filepath is fully qualified or “DLS5B17\1.0\NoiseFiles\…\…\file name”.

**Note:** *This command has been deprecated in version 1.0. Use:M_LOAD_FILE

Telnet example:

```
!STX:SET(M_LOAD_XTALK_FILE):VAL(filepath string);ETX!
```

### Command:M_LOAD_RFI_FILE *

Description: Loads a time RFI noise file (License permitting). Filepath is fully qualified or “DLS5B17\1.0\NoiseFiles\…\…\filename”.

**Note:** *This command has been deprecated in version 1.0. Use: M_LOAD_FILE.

Telnet example:

```
!STX:SET(M_LOAD_RFI_FILE):VAL(filepath string);ETX!
```

### Command:M_RFI_GAIN *

Description: Sets the gain for rfi noise. The dB value is relative to Reference Level.
*Typical values:*
-72.25 to 72.25

**Note:** *This command has been deprecated in version 1.0. Use: M_NOISE_GAIN.

Telnet example:

```
!STX:SET(M_RFI_GAIN):VAL(gain string);ETX!
```

### Command:M_XTALK_GAIN *

Description: Sets the gain for xtalk noise. The dB value is relative to Reference Level.
*Typical values*:
-72.25” to 72.25

**Note:** *This command has been deprecated in version 1.0. Use: M_NOISE_GAIN.

Telnet example:

```
!STX:SET(M_XTALK_GAIN):VAL(gain string);ETX!
```

### Command:M_XTALK_MUTE *

Description: Enables or disables the use of xtalk noise files.
*Value string*: “ON”, “OFF”

**Note:** *This command has been deprecated in version 1.0. It will return successful regardless of the parameter.

Telnet example:

```
!STX:SET(M_XTALK_MUTE):VAL(value string);ETX;
```

### Command:M_RFI_MUTE *

Description: Enables or disables the use of RFI noise files (license permitting).

*Value string:*"ON", "OFF".

**Note:** *This command has been deprecated in version 1.0. It will return successful regardless of the parameter.

Telnet example:

```
!STX:SET(M_RFI_MUTE):VAL(value string);ETX!
```

### Command:M_TD_NOISE_GAIN *

Description: Sets the gain for time domain noise. The dB value is relative to Reference Level.

*Valid Values:*"-7" to "7"

**Note:** *This command has been deprecated in version 1.0. Use:M_NOISE_GAIN.

Telnet example:

```
!STX:SET(M_TD_NOISE_GAIN):VAL(gain string);ETX!
```

### Command:M_IMPULSE_TYPE *

Description: Selects the type of impulse file to load. Valid type string: ADSL-C1, ADSL-C2.

**Note:** *This command has been deprecated in version 1.0. Use: M_LOAD_FILE.

Telnet example:

```
!STX:SET(M_IMPULSE_TYPE):VAL(type string);ETX!
```

### Command:M_IMPULSE_MUTE *

Description: Enables or disables the use of impulse noise files.

*Value string:* "ON", "OFF"

**Note:** *This command has been deprecated in version 1.0. It will return successful regardless of the parameter.

Telnet example:

```
!STX:SET(M_IMPULSE_MUTE):VAL(value string);ETX!
```

### Command:M_LOAD_TD_FILE *

Description: Loads a time domain noise file. Filepath is fully qualified or "DLS5B17\1.0\NoiseFiles\….file name".

**Note:** *This command has been deprecated in version 1.0. Use: M_LOAD_FILE.

Telnet example:

```
!STX:SET(M_LOAD_TD_FILE):VAL(filepath string);ETX!
```

### Command:M_TD_NOISE_MUTE *

Description: Enables or disables the use of time domain noise files.

*Value string:*"ON", "OFF".

**Note:** *This command has been deprecated in version 1.0. It will return successful regardless of the parameter.

Telnet example:

```
!STX:SET(M_TD_NOISE_MUTE):VAL(value string);ETX!
```

### Command:M_LOAD_CUSTOM_FILE *

Description: Loads a custom noise file. The file name must end with "_cst.enc".

**Note:** *This command has been deprecated in version 1.0. Use: M_LOAD_FILE.

Telnet example:

```
!STX:SET (M_LOAD_CUSTOM_FILE): VAL (C:\file path_CST.ENC);ETX!
```

## Report Strings

### Report: CMD_SUCCEEDED

Description: The message has been accepted for processing.

### Report: CHANNEL_x_SELECTED

Description: The selected output is channel x where x is 1,2,3 or 4.

### Report: LEVEL_TOO_HIGH

Description: Power level of combined crosstalk exceeds maximum output power level.

### Report: PACKAGE_MANAGER_ERROR

Description: Package manager error: "Load file" not executed.

### Report: CREST_FACTOR_UNATTAINED

Description: The resulting crest factor is less than 5.

### Report: SET_XTALK_GAIN_BLOCKED

Description: Attempted to set crosstalk gain while crosstalk is muted.

### Report: SET_RFI_GAINED_BLOCKED

Description: Attempted to set RFI gain while XTalk muted, or RFI has not been licensed.

### Report: RFI_INVALID_LICENSE

Description: Invalid license for RFI.

### Report: LICENSE_SERVER_LOST

Description: Connection to License Server was lost.

### Report: M_INJ_UNSUPPORTED_HARDWARE

Description: Equipment connected to the serial port has returned an identifier string indicating that it is not a DLS 5406.

### Report: M_INJ_PORT_UNAVAILABLE

Description: The script has attempted to connect to the DLS 5406 using a serial port that cannot be opened. Possible causes for this error are that the serial port does not exist or it is already opened.

## Error Strings

### Error: FAILURE

Description: Unspecified error.

### Error: BAD_PARAMETER_ID

Description: Invalid task or parameter identifier in message.

### Error: BUSY

Description: Busy operating on a previous command.

### Error: CMD_OVERFLOW

Description: A command has been sent after DLS 5500 remote control access has been disabled. The first command sent after disabling is accepted and queued. If a second command is then sent, an overflow will occur. The first command is not processed until remote control is re-enabled.

OR

The previously sent command has not completed before the next command is sent.

### Error: PROCESS_FAILURE

Description: Unspecified error.

### Error: FILE_ACCESS_ERROR

Description: File does not exist.

### Error: UNABLE_TO_APPLY_XTALK_NOT_SELECTED

Description: Xtalk mute on, but no other Xtalk message such as the following has been received by the DLS 5500:

M_LOAD_XTALK_FILE

M_XTALK_GAIN

M_CREST_FACTOR

### Error: UNABLE_TO_APPLY_RFI_NOT_SELECTED

Description: RFI mute is on, but no other RFI message such as the following has been received by the DLS 5500:

M_LOAD_RFI_FILE

M_RFI_GAIN

### Error: UNABLE_TO_APPLY_TIME_DOMAIN_NOT_SELECTED

Description: Time Domain mute is on, but no other Time Domain message such as the following has been received by the DLS 5500:

M_LOAD_TD_FILE

M_TD_NOISE_GAIN

### Error: VALUE_IS_OUT_OF_RANGE

Description: Value is out of valid range.

### Error: CHANNEL_NOT_SELECTED

Description: Output channel was not be selected.

### Error: SELECT_CHANNEL_NOT_EXIST

Description: A channel parameter other than 1 through 4 has been used. For example, the *output selector* parameter in the following command must be between 1 and 4:

“SET(M_SELECT_OUTPUT):VAL(output selector)”

### Error: LOAD_OUTPUT_ERROR

Description: Failure to load the hardware output channel.

### Error: INVALID_PACKAGE_LICENSE

Description: Invalid License.

### Error: UNABLE_TO_APPLY_IMPULSE_NOT_SELECTED

Description: Impulse is mute on, but no other Impulse message such as the following has been received by the DLS 5500:

SET(M_NOISE_GAIN):VAL(level string)

SET(M_IMPULSE_REPEAT_NUM):VAL(integer string)

SET(M_IMPULSE_TYPE):VAL(type string)

### Error: FAILURE_TIME_DOMAIN_OR_IMPULSE_SELECTED

Description: Impulse or Time Domain is Mute off, and an Xtalk, RFI or related message has been received by the DLS 5500.

### Error: FAILURE_XTALK_OR_RFI_SELECTED

Description: Xtalk or RFI is Mute off, an Impulse or Time Domain or related message has been received by the DLS 5500.

### Error: FAILURE_BOTH_XTALK_AND_RFI_NOT_SELECTED

Description: Both Xtalk and RFI are Muted On, sample generation attempted.

### Error: FAILURE_OUTPUT_SIGNAL_TOO_HIGH

Description: The output signal in dB is higher than maximum allowed value, but attempt made to export sample to arbitrary wave generator card.

### Error: FAILURE_TD_NOISE_NOT_COMPATIBLE_WITH_IMPULSE

Description: Attempt to combine Time Domain with Impulse, but the sample frequency is different.

### Error: HARDWARE_FAILURE

Description: Disable output channel failed.

### Error: FAILURE_BASE_OF_POWER_IS_NOT_TWO

Description: An invalid value used for a power-of-two parameter. Valid values are powers of 2 ranging between 32768 and 2097152.

### Error: MICROGAIN_IS_NOT_ADJUSTABLE

Description: A noise profile must be loaded to the hardware before the microgain can be adjusted.

### Error: UNABLE_TO_APPLY_IMPULSE_RATE

Description: A time domain noise type has been selected for which rate pps values cannot be set.

### Error: UNABLE_TO_APPLY_IMPULSE_NOT_SELECTED

Description: A noise type has been selected that is not compatible with impulse noise.

### Error: VALUE_IS_OUT_RANGE

Description: Impulse parameter was not between 1 and 100 pps (rate).

### Error: FAILURE_SAVE_CUSTOM_NOISE

Description: Custom noise file save sequence is incorrect.

### Error: CUSTOMNOISE_NOT_SELECTED

Description: Custom noise not enable or selected.

### Error: FAILURE_LOAD_CUSTOM_NOISE

Description: File path or file name is not recognized.
File may not end with "_CST.ENC".

### Error: 5C20_LICENSE REQUIRED

Description: Required license is not loaded or enabled.

### Error: FAILURE_OTHER_NOISE_SELECTED

Description: Other noise types are currently in use or selected.

### Error: IMPULSE_TYPE_WRONG

Description: Incorrect impulse noise type was selected.

### Error: FAILURE_CANNOT_SET_WHITENOISE

Description: TD white noise cannot be set because sampling frequency is incompatible.

### Error: FAILURE_FILE_LIMIT_EXCEEDED

Description: The maximum number of one or more file types has been exceeded.
The maximum number of files according to type is as follows:
Xtalk:6

RFI: 1
Impulse:1
Time Domain:1
Custom:1

### Error: UNABLE_TO_COMBINE_WITH_OTHER_NOISE_TYPE

Description: Attempt to load a file with a different type of noise.
For example, xtalk with impulse.

### Error: FAILURE_FILE_ALREADY_LOADED

Description: This file has already been loaded.

### Error: FAILURE_COMPLEX_LOAD_NOT_COMPATIBLE

Description: This file does not have the same complex load impedance compensation as the previously loaded file.

### Error: FAILURE_FILE_NOT_LOADED

Description: Attempt to perform an operation requiring a loaded file (such as setting the noise gain) when no file has been loaded.

### Error: FAILURE_INVALID_INDEX

Description: The index position is invalid relative to the extended noise gain command.

### Error: FAILURE_GAIN_NOT_ADJUSTABLE

Description: Attempt to adjust gain for a file with a fixed gain, for example a custom noise profile.

### Error: UNABLE_TO_APPLY_DISTURBER_NOT_AVAILABLE

Description: Disturbers cannot be set for the selected noise file.

### Error: CHANNEL_NOT_ACCESSIBLE

Description: Attempt to invoke a command which would access a channel in another remote instance.

### Error: UNABLE_TO_COMPLY_IN_DOUBLE_SESSION_MODE

Description: The command affects both remote instances and therefore cannot be completed.
For example, a remote instance requests a return to local mode.

### Error: FAILURE_LOAD_NOISE_COMMAND_FILE

Description: A command in the noise command file contains an error that prevents it from successfully loading.

### Error: FAILURE_NOT_CUSTOMER_SAVED_FILE

Description: The file is not a customer saved file (ending with "_cst.enc").

### Error: FAILURE_LOADING_CFRC_FILE

Description: The CFRC file is unable to load.

### Error: INCORRECT_CFRC_FILE_FOR_CHANNEL

Description: The CRFC file is meant for a different channel.

### Error: INCORRECT_NOISE_INJECTOR

Description: The CFRC file is meant for use with a different noise injector type.

## Sample Remote Control Script

```
###################### Start 5500 SCRIPT ####################
Select channel 1
!STX:SET(M_SELECT_OUTPUT):VAL(OUTPUT_1);ETX!

Reset the current selected channel
!STX:SET(M_RESET_CHANNEL);ETX!

Load 24 HDSL Next & White noise
!STX:SET(M_LOAD_FILE):VAL(DLS 5B18\v1.0\NoiseFiles\DSL
Forum\ADSL_TR-048 (Apr 2007)\8-1-
2_24_HDSL_Impairment\HDSL_Next_24D_xtk.enc);ETX!
!STX:SET(M_LOAD_FILE):VAL(DLS 5B18\v1.0\NoiseFiles\DSL
Forum\ADSL_TR-048 (Apr 2007)\8-1-
2_24_HDSL_Impairment\White_Noise_xtk.enc);ETX!

Set the reference level to +10 dBm for both files
!STX:SET(M_NOISE_GAINEX):VAL(0:10);ETX!
!STX:SET(M_NOISE_GAINEX):VAL(1:10);ETX!

Enable crest factor > 5
!STX:SET(M_CREST_FACTOR):VAL(ON);ETX!
```

```
Set the number of samples to 262144
!STX:SET(M_NUMBER_SAMPLES):VAL(262144);ETX!

Generate the new noise.
!STX:SET(M_GENERATE_SAMPLE);ETX!

Output noise on the current selected channel.
!STX:SET(M_LOAD_OUTPUT);ETX!

Increase noise power level by 2.5dB (5C20 license required).
"!STX:SET(M_MICRO_GAIN):VAL(2.5);ETX!"

####################### END 5500 SCRIPT ####################
```

Appendix A

# Specifications

**In this appendix . . .**

# Standards

The DLS 5500 simulates the noise requirements as currently defined by ETSI, ANSI, ITU and DSL Forum. Updates will be provided by Spirent Communications Access Emulation as the standards progress. Other xDSL noise file CD/DVDs are available for purchase for these products. Please contact your local sales representative for details.

Spirent Communications Access Emulation reserves the right to offer additional and different noise profiles in the future as separately packaged offerings, compatible with the DLS 5500.

# System Specifications

- Main Processing and Storage minimum configuration:
  - Pentium® processor PC, with a minimum of 512 Mbyte RAM, hard disk drive with Windows operating system pre-installed, 3.5-inch 1.44 Mbyte floppy drive, and CD/DVD drives.
- Arbitrary Waveform Generator and Storage
- Pre-installed software:
  - Windows XP
  - DLS 5500 Software
  - VDSL Noise Profiles – 26 samples included
  - License Manager software

# Mechanical and Environmental Specifications

The DLS 5500 mechanical and environmental specifications are shown in *Table A-1*.

**Table A-1.** DLS 5500 Mechanical and Environmental Specifications

| Item | Description |
|---|---|
| **Rear Connectors** | |
| Noise | BNC Connectors (4 outputs) |
| Control | RS232 standard, with an optional National Instruments GPIB-PCII/ZZA interface card |
| Interface | Ethernet (remote control not supported on DLS 5500) |
| Printer | Standard PC printer connector |

**Table A-1.** DLS 5500 Mechanical and Environmental Specifications (continued)

| Item | Description |
|---|---|
| Mouse | Standard mouse connector |
| Monitor | Standard VGA connector |
| Power | World wide standard (universal power supply) |
| Sync I | BNC connector |
| **Spirent Communications Supplied** | |
| PC compatible 101 QWERTY keyboard | |
| PC compatible mouse | |
| **User Supplied or Spirent Communications Options** | |
| PC compatible color VGA compatible monitor (SVGA and XVGA supported) | |
| PC compatible printer | |
| **Dimensions** | 2U Rack mounted unit |
| | 19 in. x 3.5 in. x 17.7 in. |
| | 49.5 cm x 8.9 cm x 45 cm (H x W x D) |
| **Net Weight** | 12 kg |
| **Environmental** | |
| Operating Temperature | 10°C to 40°C (50°F to 104°F) |
| Storage Temperature | -4ºF to 158ºF (-20ºC to +70ºC). |
| Relative Humidity | 10 to 95% RH non-condensing |

# Electrical Specifications

The DLS 5500 mechanical specifications are shown in *Table A-2*.

**Table A-2.** DLS 5500 Electrical Specifications

| Item | Description |
|---|---|
| Rated Input Voltage | Switchable: 90-132 VAC 60 Hz and 207-264 VAC 50 Hz. |
| | Autoranging: 100-240VAC (±10%), 50/60 Hz. |
| Rated Power Consumption | 300 VA max |
| Line fuses | There are no user-replaceable fuses in the DLS 5500 |

**Note:** All new DLS 5500 units come with an auto-switching power supply that does not require user intervention when powering up the unit. Units that have been upgraded from DLS 5204 to DLS 5500 may require user intervention to change the switch setting on the rear of the unit to either 115 VAC or 230 VAC (depending on the input power).

# DLS 5500 Technology

The DLS 5500 is a PC-based, 4-channel, l Arbitrary Waveform Generator with deep (32 MB per channel) memory. Each generator uses a 14-bit DAC for excellent dynamic range. Designed for the testing of xDSL modems and DSLAMs, the DLS 5500 generates impairments such as Crosstalk Noise, White Noise, RFI tones, and Crosstalk Noise (PSD and time domain). In addition, the DLS 5500 has the hardware capability to generate many impulses, including C1 and C2 impulses from ANSI T1.413 and the Cook Pulse. The technology is summarized in *Table A-3*.

**Table A-3.** DLS 5500 Technology

| Item | Description |
|---|---|
| Crest Factor | Greater than 5 in ETSI compliant mode using memory of 0.5 MegaWords or less. By using a longer memory, truly Gaussian distribution and crest factor greater than 5 can also be generated. |
| Execution Memory | 32 MB (16 Megasamples) for each channel |
| Maximum Output | ±10V (20 V p-p) unloaded, ±5 V (10 V p-p) into 50 Ω |
| Maximum RMS Output | + 13 dBm into 50 Ω with a crest factor of 5 |

**Table A-3.** DLS 5500 Technology (continued)

| Item | Description |
| --- | --- |
| Output Impedance | 50 Ω single-ended channels |
| Channel Noise Floor | Less than -140 dBm/Hz |
| Spurious Response | Any spurious noise spike is less than -143.5 dBm/Hz, in a 4 Khz channel |
| Frequency Range | 4 KHz to 30 MHz for differential mode noise |
| Channel Dynamic Range | 100 dB (one single sine wave) |
| Effective Dynamic Range | Greater than 50 dB from peak to lowest power in the impairment profile within the dynamic range of the instrument for any impairment with crest factor of 5 |
| Accuracy of PSD Profile | Less than 0.5 dB mean absolute error (MAE) for all profiles |
| Accuracy of PSD Level | The DLS 5500 is calibrated to be within 0.5 dB mean error (ME) for all profiles, as measured using an HP 4395A Spectrum Analyzer. |
| DLS 5500 (Rack mountable) | 3.50 in. (89mm) x 19.00 in. (482mm) x 17.7 in. (450mm) [H x W x D]<br>26 lb (12 kg) |

# Spirent Communications Options

- IEEE 488: ACC-GPPCINT
- DLS 5Bxx Noise Impairment Libraries

SPIRENT
Communications

Appendix B

# Measuring Injection Loss

**To measure the actual insertion loss of a specific noise generator injection unit:**

1 Generate several signals within the required xDSL frequency band using a frequency generator.

2 Capture the signals using a spectrum analyzer.

3 Connect the Noise Injection Circuit as shown in *Figure B-1* and apply a fixed load to the output of the circuit with a Balun to match the load impedance.

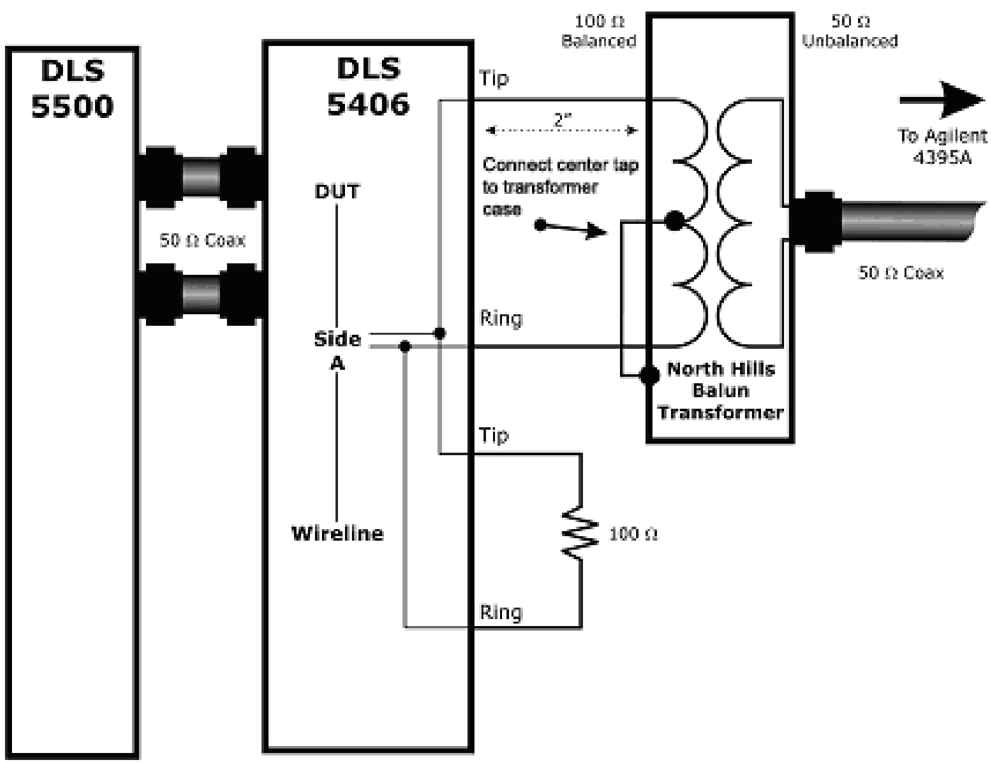



**Figure B-1.** Calculating Gain/Injector Attenuation

4 Take a new capture of the signals with the spectrum analyzer.

The idea is to have a substantial output power of the AWG (above 5 dBm), which should then be attenuated by an external attenuator. This has two advantages:

- The final desired signal can be created with maximum accuracy, without, for example, the influence of background noise in the hardware of the noise generator.
- By *decreasing* the external attenuation, the power of the noise signal on the line can be smoothly increased during a performance test.

Appendix C
# Safety Information and Instructions

**In this appendix . . .**

# Safety Information

## Protective Grounding (Earthing)

This unit consists of an exposed metal chassis that must connect directly to a ground (earth) by means of a protective grounding conductor in the power cord. The symbol used to indicate a protective grounding conductor terminal in the equipment is shown in *“Symbols” on page 130*.

## Before Operating the Unit

- Inspect the equipment for any signs of damage, and read this manual thoroughly.
- Become familiar with all safety symbols and instructions in this manual to ensure that the equipment is used and maintained safely.

**Warning:** To avoid risk of injury or death, ALWAYS observe the following precautions before operating the unit:

- Use only a power supply cord with a protective grounding terminal.
- Connect the power supply cord only to a power outlet equipped with a protective earth contact. Never connect to an extension cord that is not equipped with this feature.
- Do not wilfully interrupt the protective earth connection.

**Caution:** When lifting or moving the unit, do not touch the cooling fan, which is located at the back of the unit. Lift the unit by using the handles on the front.

## Power Supply Requirements

The unit can operate from any single phase AC power source that supplies between 100 VAC and 240 VAC (±10%) at a frequency range of 50 Hz to 60 Hz.

**Warning:** To avoid electrical shock, do not operate the equipment if it shows any sign of damage to any portion of its exterior surface, such as the outer casting or panels.

## Main Fuse Type

The fuse type used is specified in *Appendix A, “Specifications.”*

## Connections to a Power Supply

In accordance with international safety standards, the unit uses a three-wire power supply cord. When connected to an appropriate AC power receptacle, this cord grounds the equipment chassis.

**Note:** When connecting the AC power cable input into the back of the DLS 5500, please ensure that the AC power cable is positioned so that it is not difficult to remove and so that there are no obstructions present that would prevent its removal.

## Operating Environment

To prevent potential fire or shock hazard, do not expose the equipment to any source of excessive moisture.

## Class of Equipment

The unit consists of an exposed metal chassis that is connected directly to earth via the power supply cord. In accordance with HARMONIZED EUROPEAN STANDARD EN 61010-1:1993, it is classified as Safety Class I equipment.

**Warning:** This is a class A product. This product may cause radio interference. In this case you may be required to take adequate measures to mitigate this problem in a domestic environment.

# Safety Instructions

The following safety instructions must be observed whenever the unit is operated, serviced or repaired. Failing to comply with any of these instructions or with any precaution or warning contained in the Operating Manual is in direct violation of the standards of design, manufacture and intended use of the equipment.

Spirent Communications assumes no liability for the customer's failure to comply with any of these requirements.

## Before Operating the Unit

- Inspect the equipment for any signs of damage, and read the User Guide (this document) thoroughly.
- Install the equipment as specified in the relevant section of this manual.
- Ensure that the equipment and any devices or cords connected to it are properly grounded.

## Operating the Unit

- Do not operate the equipment when its covers or panels have been removed.
- Do not interrupt the protective grounding connection. Any such action can lead to a potential shock hazard that could result in serious personal injury.

- Do not operate equipment if an interruption to the protective grounding is suspected. Ensure that the instrument remains inoperative.
- Use only the type of fuse specified.
- Do not use repaired fuses and avoid any situation that could short circuit the fuse.
- Unless absolutely necessary, do not attempt to adjust or perform any maintenance or repair procedure when the equipment is opened and connected to a power source at the same time. Any such procedure should only be performed by qualified service professional.
- Do not attempt any adjustment, maintenance or repair procedure to the equipment if first aid is not accessible.
- Disconnect the power supply cord from the equipment before adding or removing any components.
- Operating the equipment in the presence of flammable gases or fumes is extremely hazardous.
- Do not perform any operating or maintenance procedure that is not described in this User Guide.
- Some of the equipment's capacitors may be charged even when the equipment is not connected the power source.

## Cleaning the Unit

To clean the DLS 5500, unplug the AC power cord from the facility power or inlet at the back of the DLS 5500. Use a lint-free damp cloth for cleaning the exterior only of the DLS 5500.

## Symbols

The meanings of the symbols that may appear on the DLS 5500 are provided in *Figure C-1 on page 131*.

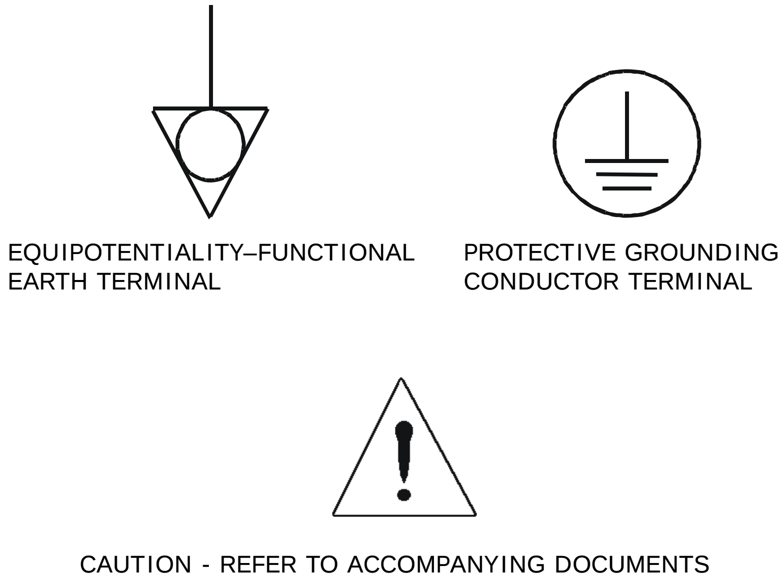



**Figure C-1.** DLS 5500 Symbols

Appendix D

# ESD Requirements

Spirent Communications manufactures and sells products that require industry standard precautions to protect against damage from electrostatic discharge (ESD). This document explains the proper process for handling and storing electrostatic discharge sensitive (ESDS) devices, assemblies, and equipment.

The requirements presented in this document comply with the EIA Standard, *ANSI/ESD S20.20-1999: Development of an Electrostatic Discharge Control Program*, and apply to anyone who handles equipment that is sensitive to electrostatic discharge. Such equipment includes, but it not limited to:

- All electronic assemblies manufactured by Spirent Communications
- Discrete and integrated circuit semiconductors
- Hybrid microcircuits
- Thin film passive devices
- Memory modules

**Caution:** Failure to comply with the requirements explained in this document poses risks to the performance of ESDS devices, as well as to your investment in the equipment.

## General Equipment Handling

Whenever you handle a piece of ESDS equipment, you must be properly grounded to avoid harming the equipment. Also, when transporting the equipment, it must be packaged properly. Follow the requirements below to help ensure equipment protection.

- Wrist straps must be worn by any person handling the equipment to provide normal grounding.
- The use of foot straps is encouraged to supplement normal grounding. If foot straps are used exclusively, two straps (one on each foot) should be used. Note that foot straps are only applicable in environments that use ESD flooring and/or floor mats.
- Hold ESDS equipment by the edges only; do not touch the electronic components or gold connectors.
- When transporting equipment between ESD protected work areas, the equipment must be contained in ESD protective packaging. Equipment that is received in ESD

protective packaging must be opened either by a person who is properly grounded or at an ESD protected workstation.

- Any racks or carts used for the temporary storage or transport of ESDS equipment must be grounded either by drag chains or through direct connection to earth ground. Loose parts that are not protected by ESD-safe packaging must not be transported on carts.

## Workstation Preparation

The ideal setup for working with ESDS equipment is a workstation designed specifically for that purpose. *Figure D-1* illustrates an ESD protected workstation. Please follow the requirements listed below to prepare a proper ESD protected workstation.

- The ESD Ground must be the equipment earth ground. Equipment earth ground is the electrical ground (green) wire at the receptacles.
- An ESD protected workstation consists of a table or workbench with a static dissipative surface or mat that is connected to earth ground. A resistor in the grounding wire is optional, providing that surface resistance to ground is $\geq 10^5$ to $\leq 10^9\ \Omega$.
- The workstation must provide for the connection of a wrist strap. The wrist strap must contain a current limiting resistor with a value from ≥ 250K Ω to ≤ 10M Ω.
- ESD protective flooring or floor mats are required when floor-grounding devices (foot straps/footwear) are used or when it is necessary to move in between ESD protected workstations when handling ESDS equipment.

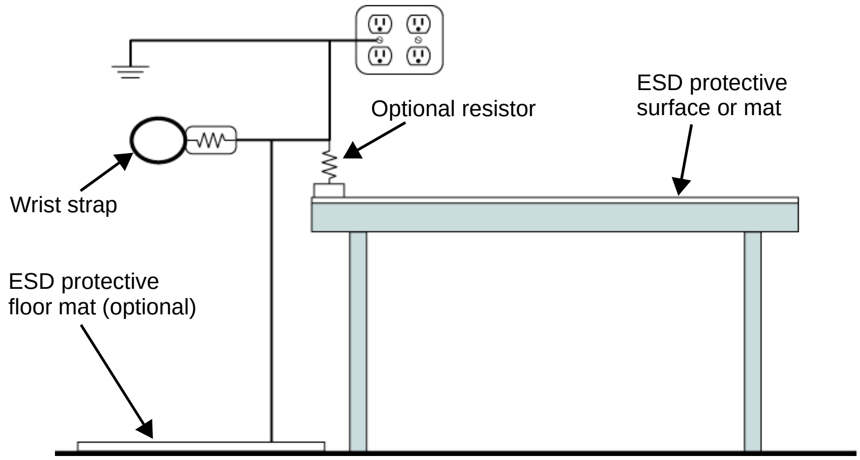



**Figure D-1.** ESD Protected Workstation

**Note:** The equipment needed for proper grounding is available in ESD service kits, such as the ESD Field Service Kit available from Spirent Communications (P/N 170-1800). Additional information on ESD can be found on the following website: http://www.esda.org/aboutesd.html