Tip/Ring Signal Simulator

Telephone Line Monitor

User Guide & Reference Manual

(Applies to AI-5120)

Advent Instruments Inc.

Release 2.00a - September 2009

Printed in Canada

Advent Instruments Inc.
111 - 1515 Broadway Street
Port Coquitlam, BC, V3C6M2
Canada

Internet: techsupport@adventinst.com
sales@adventinst.com

Web Site: http://www.adventinstruments.com

Telephone: (604) 944-4298
Fax: (604) 944-7488

Contents

1. Introduction 1

2. Installation & Setup 3

2.1 System Requirements 3
2.2 Software Installation 3
2.3 USB Driver Installation 4
2.4 First Time Setup 5
2.5 Using a RS-232 Connection 7
2.6 Technical Support 8

3. Getting Started 10

3.1 Overview of TRsSim 10
3.1.1 Saving Data and Settings 11
3.1.2 Scripting Capability 12
3.1.3 Remote Control 12
3.2 Using the AI-5120 12
Optional Waveform Analysis Component (AI-ET003) 13
3.3 Initial Settings 14

4. Basic Operation 17

4.1 Main Control Panel 17
4.1.1 Line Status Display 19
4.1.2 Detected Event Display 20
4.2 Data Recorder Introduction 23
4.2.1 Docked Window Mode 23
4.2.2 Waveform Views and Event Reports 24
4.3 Detectable Events 27
4.4 Event Warnings 31
4.5 Exporting & Logging Events 33
4.6 Saving & Loading Program Data 34

5. Data Recorder Window 36

5.1 Event Listing 37
5.2 Viewing Waveforms 39
5.2.1 Navigation 40
5.2.2 Event Markers & Timing 42
5.2.3 Cursors 43
5.2.4 FFT Viewing Modes 44
5.2.5 Waveform Management 45
5.2.6 Analysis & Measurements 50
5.3 Caller ID Summary Report 51
5.4 Event Searching 52
5.4.1 Defining Event Search Criteria 52
5.4.2 Displaying Search Results 55

6. Waveform Analysis Option 58

6.1 FSK Analysis 59
6.1.1 Viewing FSK Decoder Output 59
6.1.2 Physical Layer Analysis 60
6.1.3 Data Layer Analysis 62
6.2 DTMF Analysis 62
6.3 CAS/DTAS Analysis 64
6.4 Tone Analysis 65
6.5 Analysis Settings 66
6.6 Waveform Operations 68
6.6.1 Waveform Filtering & Transforms 68
6.6.2 Waveform RMS & Envelope 69
6.7 Measurements 70

7. Program Settings 72

7.1 General Settings 72
7.1.1 Threshold Voltage Settings 73
7.1.2 BNC Monitor Settings 73
7.1.3 Speaker Jack Settings 74
7.1.4 Waveform Recoding Settings 74
7.1.5 Event & Waveform Data 75
7.1.6 Digital Output Settings 75
7.1.7 Miscellaneous Settings 75
7.2 Level Meter & Filter Settings 75
7.3 Event Detection 76
7.4 Pulse Dialing Limits 77
7.5 FSK Detection Settings 78
7.6 Tone Detection Settings 79
7.7 Event Warning Limits 82

8. Additional Information 83

8.1 Hardware Setup 83
8.2 Enabling Optional Features 85

Appendix A: USB Driver Installation 86

Appendix B: Glossary of Terms 89

1. Introduction

The TRsSim software in conjunction with the AI-5120 provides a wide range of telephone line monitoring capabilities. By sensing the voltage present on the telephone line the AI-5120 detects and measures ringing, DTMF & pulse dialing, FSK (Bell 202 and V.23) signals, line polarity reversals, and open switching intervals (OSI). This allows the TRsSim software to become a valuable tool in analyzing and debugging Caller ID and SMS (Short Message Service) data transmission. Like an oscilloscope, the AI-5120 can capture and display waveforms showing the various signals present on the telephone line. However, unlike an oscilloscope, it automatically triggers on events specific to telephony. These include on-hook or off-hook transitions, line flashes, pulse dialing, line polarity reversal, DTMF digit detection CAS/DTAS tone detection, and FSK message detection.

This document contains information on the installation, setup, and use of the TRsSim software with the AI-5120. Consult the following sections for more detailed information on various program aspects.

- **Installation & Setup** on page 3 provides instructions for installing the software, minimum PC requirements, and setting up the hardware.
- **Getting Started** on page 10 introduces the TRsSim software and provides an overview of its operation when used with the AI-5120.
- **Basic Operation** on page 17 describes general aspects on how to use the TRsSim software to detect events and view captured data and waveforms. It describes how the main control panel operates along with how to access the various program functions.
- **Data Recorder Window** on page 36 provides more detailed information on how the data recorder window is used to display and analyze the events captured..
- **Waveform Analysis Option** on page 58 describes the capabilities of the waveform analysis optional software component. It performs a more detailed analysis on FSK, DTMF, and CAS/DTAS waveforms and extracts additional measurements to those returned by the AI-5120.

- **Program Settings** on page 72 explains in detail the effect of various program settings. These settings control what events are detected, limits imposed on event detection, FSK detection requirements, network tone definitions, and event warning limits.
- **Additional Information** on page 83 describes how to configure TRsSim for connecting to various devices and enabling optional components.

2. Installation & Setup

This section provides information on how to install the TRsSim software and configure it for use with the AI-5120 Telephone Line Monitor. If any problems are encountered please see the Technical Support section on how we can be contacted to provide assistance.

2.1 System Requirements

Computer/Processor:	PC with Pentium 4 (2 GHz) or greater
Memory:	512 MB of RAM
Display:	SVGA or greater
Operating System:	Microsoft 2000, XP, Vista

While the AI-5120 can be connected to the PC via either USB or RS-232, it is strongly recommend that USB be used. Due to the large amounts of waveform data transferred to the PC, a RS-232 connection dramatically slows down the system response and may cause the AI-5120 to flush captured data due to excessively long data transfer times.

All waveforms collected by the TRsSim software are stored in temporary files on the PC. These files can become very large if many waveforms are recorded. As such, the PC's processor speed and memory size have a significant impact on the responsiveness of the TRsSim software.

It may be possible to use the TRsSim software with different PC configurations containing less RAM, lower resolution display, and different operating systems than stated above. Under most conditions it is likely that the software will operate correctly; however being outside our testing environment we can not ensure that system resource limitations do not occur.

2.2 Software Installation

If installing the software from the supplied CD, insert the CD in your PC's CD-ROM drive. Automatically your default browser software should display a screen showing the various products from Advent Instruments. Click the mouse on the AI-5120 device. This displays a new screen listing various software applications and documents. Click the mouse on the **TRsSim - Telephone Line Monitor** item. This executes the software's

setup program. Follow the instructions displayed on the screen to complete the remainder of the installation.

If the CD does not auto start, click the **Start** button on the Windows Task Bar. Choose **Run**, then type 'D:\index.htm' in the **Open** textbox and click **OK**. If the PC's CD-ROM is not mapped to driver letter 'D', then substitute the appropriate drive letter.

Alternatively, the software can be downloaded from our web site at

http://www.adventinstruments.com

as a single file executable. To install the software simply run the single file executable and follow the instructions presented.

At this point the TRsSim application is installed but in order to connect via USB the installation of the USB driver described in the following section must be completed.

Software updates are made available on our web site for download. The TRsSim software can be configured to periodically check for a newer version. If one is available, a message is displayed and you may download the latest files. When executing the TRsSim software for the first time, you will be asked if periodic update checks should be enabled.

2.3 USB Driver Installation

The proper drivers must be installed before a USB connection can be established with the AI-5120. The driver files needed are included with the TRsSim software in addition to being located on the supplied CD. If a serial RS-232 connection is used with the AI-7280 then the USB driver installation is not required.

Note: For detailed, step-by-step, instructions on installing the driver, see: Appendix A: USB Driver Installation on page 86.

In summary the installation of the the AI-5120 USB drivers follow these steps:

1. Ensure sufficient operating system rights are available to install device drivers. This normally requires using the **administrator** account.
2. Power up the AI-5120 by connecting the supplied AC power adapter.
3. Connect the AI-5120 to the PC using a USB cable.
4. The windows operating system should indicate that it has found a new device and is requesting a location for the proper driver. Specify that the driver is located in the **drivers**\ subdirectory of the TRsSim software If the default directory was used during the software installation, this will be:

   C:\Program Files\Advent\TRsSim\Drivers

5. A message should be displayed indicating the successful installation of the driver.

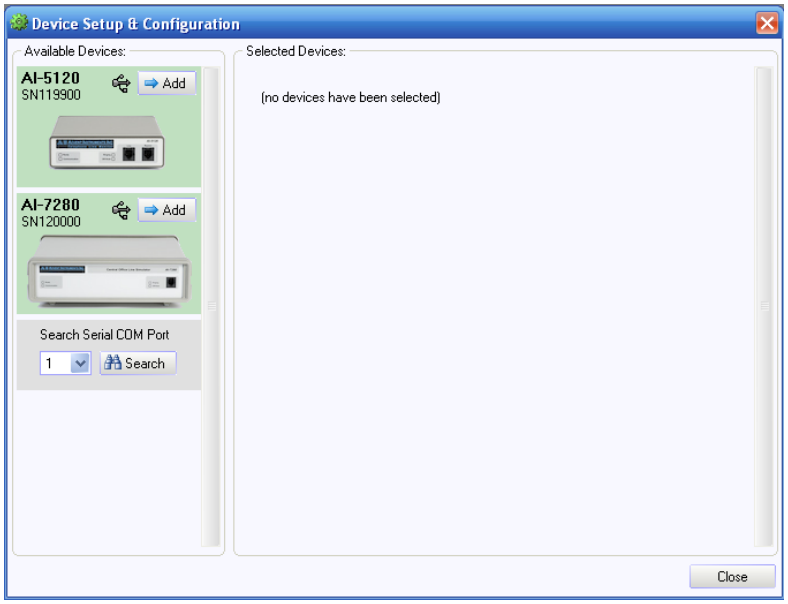
2.4 First Time Setup

After completing the software installation you can execute the TRsSim program. By default the installation process adds an entry to 'Programs' menu under the folder **Advent Instruments**. Selecting the **Tip-Ring Signal Simulator** entry in this folder starts the program.

As the TRsSim software may function with various hardware devices (AI-5120, AI-5620, AI-80), it needs to be told to search for an AI-5120 Telephone Line Monitor. Shortly after starting the program, the the following window is shown.

Click the **Demonstration Mode** button if you do not have any hardware connected to the PC and would like to evaluate the software. This bypasses the hardware setup and continues the process of loading the remaining software. By running in demonstration mode the software is unable to control any connected hardware; however the various software features and general user interface can be explored.

If an AI-5120 is connected to the PC, click the **Configure and Setup Hardware** button. TRsSim will then display the device setup window. This window is divided into two columns. The left column lists all devices that are currently connected to the PC and are available for use. The right column lists all the devices that TRsSim is currently connected to. Initially the right column will be empty.



The above figure shows that two devices, an AI-5120 and AI-7280 are available to TRsSim. Select the desired device and add it to the list of selected devices, by clicking the **Add** button

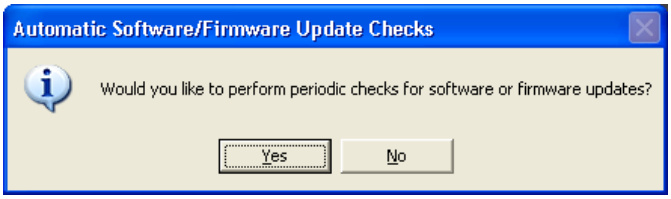
Note that the TRsSim software supports up to four devices simultaneously. Only devices connected via USB are automatically displayed in the left column. To find devices connected on a serial COM port, click the **Search** button.

Once the **Add** button is clicked, the TRsSim software attempts to establish communications with the AI-5120. A software key will have to be entered the first time it connects to the selected device. The key is included with the documentation provided with the AI-5120. It is composed of the numbers 0 to 9, and the capital letters A to Z (with the exception of the letter 'O'). The letter 'O' is not used in the key so to avoid confusion with the number zero. The software key is linked to the serial number of the AI-5120. This allows the installation of the TRsSim software on multiple PC's, however only when the hardware device with the matching serial number is connected are all the software features available. After entering the software key, click the **OK** button.

The TRsSim software remembers the software key for each AI-5120 connected. As such, it will not have to be entered again.

Once a connection is established with the AI-5120, the TRsSim software will ask if you wish to enable periodic checks for updated versions of both the TRsSim software and the AI-5120 firmware. If you do not wish to enable this feature, click **N**o. If **Yes** is clicked, an immediate check is made for updates and additional Check will be made once every 30 days upon program startup. This update feature and the interval of the update checks can also be changed from the **Preferences** window.

Note, the TRsSim software can only check for updates if it is permitted access to the internet by the PC and firewall software if installed.

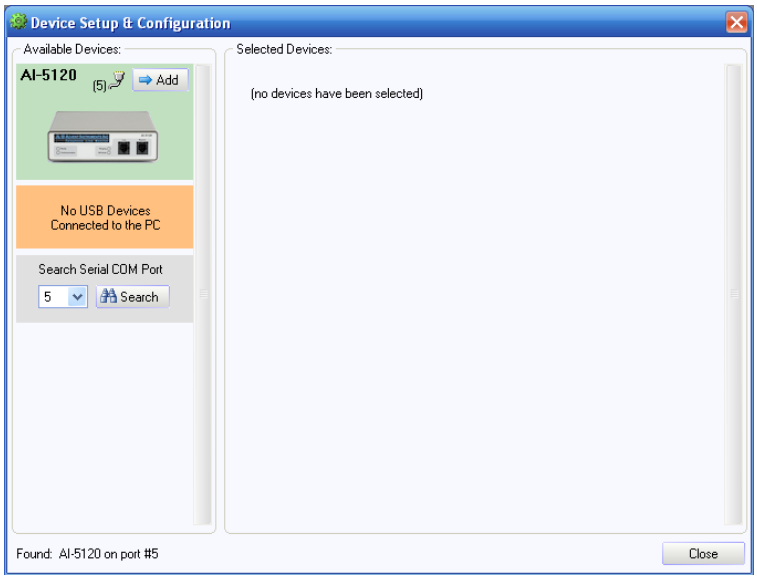


At this point the AI-5120 is ready to perform actions or monitor the telephone line. See Section 4. Basic Operation on page 17 for an for an overview of the TRsSim software and using it with the AI-5120.

2.5 Using a RS-232 Connection

While the AI-5120 supports either a serial RS-232 or USB connection to the PC, it is strongly recommended to only use a USB connection. As RS-232 data transfer rates are much slower, the AI-5120 may be required to delete captured data if it can not transfer it to the PC before its internal buffers overflow. If a RS-232 connection is required, then all waveform recording from the AC coupled channel should be turned off. This minimizes the amount of data to be transferred and prevents the AI-5120 from losing captured data.

In order to find the AI-5120 the COM port must be specified from the pull down menu and then the search button pressed. The following window is displayed when the AI-5120 is located.



A software key will have to be entered the first time it connects to the selected device. The key is included with the documentation provided with the AI-5120. It is composed of the numbers 0 to 9, and letters A to Z (with the exception of the letter 'O'). The letter 'O' is not used in the key so to avoid confusion with the number zero. The software key is linked to the serial number of the AI-5120. This allows the installation of the TRsSim software on multiple PC's, however only when the hardware device with the matching serial number is connected are the software features available.

After entering the software key, click **OK**. The TRsSim software remembers the software key for each AI-5120 connected. As such, it will not have to be entered again.

Following a short initialization process, the software displays the main control panel from which various program features are accessed. At this point the AI-5120 is ready to detect events and record waveforms. See the section Getting Started on page 10 for an overview of the TRsSim software and the AI-5120.

2.6 Technical Support

For assistance in program installation, hardware setup, or general technical questions, please contact us in any of the following methods.

- **Email**:
  techsupport@adventinst.com

- **In North America**:
  Tel (604) 944-4298
  Fax (604) 944-7488
  Mail Advent Instruments Inc.
  111 - 1515 Broadway St.
  Port Coquitlam, BC, V3C6M2
  Canada

- **In Asia**:
  Tel (852) 8108-1338
  Fax (852) 2900 9338
  Mail Advent Instruments (Asia) Ltd.
  Unit 42, 18/F., Block D,
  Wah Lok Industrial Centre, Phase II,
  31 / 35 Shan Mei Street,
  Fotan, Shatin, New Territories, Hong Kong

Product updates providing new features and bug fixes are made available on our web site at:

www.adventinstruments.com

If unexpected results or any program errors are detected, please contact us in any of the above manners. In order to help us resolve encountered problems, it is recommended that all of the TRsSim settings and collected data are saved to a file. This is accomplished by selecting the **File** menu followed by the **Save as Configuration File** command. If you can email us this file as well as a description of the problem, it greatly helps our ability re-create similar operating conditions.

3. Getting Started

This section introduces the TRsSim software and provides an overview of its operation when used with the AI-5120.

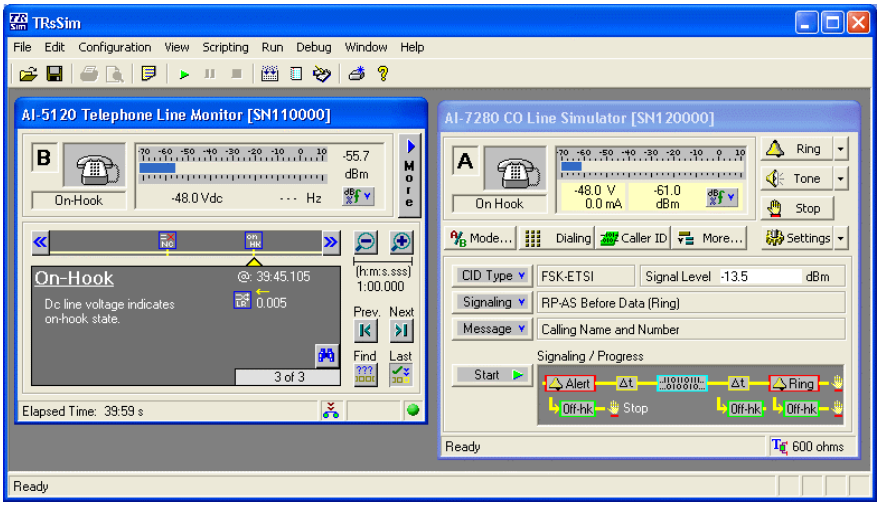
The topics included in this section are:

- **Overview of TRsSim** on page 10.
- **Using the AI-5120** on page 12.
- **Initial Settings** on page 14.

3.1 Overview of TRsSim

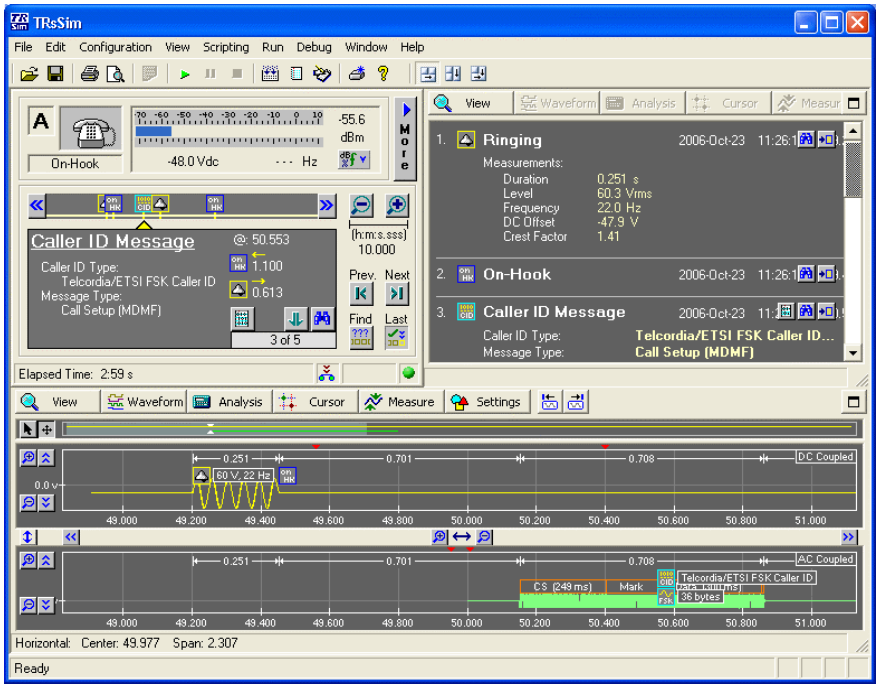
The TRsSim software can connect to and control multiple devices at the same time. While normally only a single AI-5120 is used at any time, it is possible to connect additional devices such as another AI-5120, an AI-7280 Central Office Line Simulator, or an AI-80 Caller ID Generator.

Each device controlled by the TRsSim software is represented by a separate 'control panel' window. In the example shown below, the TRsSim software controls two different devices. The left window represents the AI-5120 while the right window represents an AI-7280 Central Office Line Simulator. Each 'control panel' has separate controls and displays specific to the type of device it is connected to.



For each device, additional windows may be opened to either adjust settings, or display captured data.

When only a single AI-5120 is connected the TRsSim software it, by default, enables the 'Docked Window Mode'. This display mode automatically opens two Data Recorder windows used to display information on all events and/or waveforms recorded by the AI-5120. All three windows are sized to maximize the space available. The following figure shows an example of the 'Docked Window Mode'.



In the above figure, the AI-5120 has detected ringing followed by a FSK Caller ID transmission. The top right window lists each event detected, while the bottom window displays the recorded waveforms. As additional events are detected by the AI-5120, the listing of events is automatically updated and any new recorded waveforms are displayed.

Three buttons located on the top tool bar determine which window is given priority when maximizing its size. The first two buttons maximize either the waveform view or the event list view respectively; while the last button maximizes which ever of the two windows the mouse is currently over.

The 'Docked Window Mode' is best used with large display sizes (1280 by 1024 pixels) and with relatively newer and faster PC's. As constantly updating the event and waveform display can be processor intensive, older and slower PC's operate better with only a single Data Recorder window opened. To disable this display mode, select the **Window** menu followed by the **Docked Window Mode** command. This toggles the setting between enabled and disabled. Note that the TRsSim software remembers the above settings when the program is subsequently executed.

3.1.1 Saving Data and Settings

The TRsSim software uses two different types of files for storing or reading data. These file types are called 'Configuration Files' and 'Data Recorder Files'. A configuration file contains the entire state of the TRsSim software. This includes all program settings and all data recorded for all connected devices. As such, when loading a configuration file, all of the program's settings are overwritten with those read from the file.

The Data Recorder files are different in that they only contain the data captured by all devices. For the AI-5120, this means that the Data Recorder files hold the information

about every event detected and all waveforms recorded. They will not contain any information on the program's settings. As such, when loading Data Recorder files, the current settings in the TRsSim software are not changed. Only the event and waveform data is updated to match that contained in the file.

Configuration files have capabilities not available with Data Recorder files. They are:

- Store the data and settings only from specific devices
- Password protect the file contents
- Place requirements on which devices must be connected to the PC
- Embed text notes, possibly to describe the file contents or purpose
- Embed a script program to automate tasks, which may be started upon file load
- Allow file load only between a range of dates

All of the above settings are accessed by selecting the **File** menu, followed by the **Configuration File Settings** command.

3.1.2 Scripting Capability

A scripting capability is included with the TRsSim software which can be used to automate repetitive tasks. The scripts can access any device connected and change its settings or read data collected by the device. All the script settings and programs are saved as part of the configuration file, or can be saved in a separate 'Script Project' file that only contains information related to the scripting capability of TRsSim.

Descriptions of the scripting language are outside the scope of this document. For more information, please see the appropriate document or on-line help file.

3.1.3 Remote Control

The TRsSim software can be controlled from another application. Using a TCP/IP connection, an application located on the same or a different computer may setup a link over which the TRsSim software can respond to commands. Once a link is established, commands can be issued to returns event or waveform data. By default, the TRsSim software will not accept any TCP/IP connection requests until enabled. These settings can be changed by selecting the **Configuration** menu followed by the **Options** command. Located in the TCP/IP tab are various settings controlling the TCP/IP connection. These include specifying acceptable IP addresses and a port number.

For more information on using these features, see the 'Remote Control' on-line help file. An example program called 'TRsSimRC.exe' is included in the same directory as TRsSim (normally c:\program files\advent\trssim). A DLL is also provided that abstracts the details of setting up a TCP/IP connection with TRsSim. Information on its use is provided in the file 'trsrmt_V100.zip'.

3.2 Using the AI-5120

Operating under control of the TRsSim software, the AI-5120 is configured as an event recorder. This means it continually monitors the telephone line for events such as on-hook or off-hook transitions, line flashes, pulse dialing, line polarity reversals, DTMF digit detection; CAS/DTAS tone detection, and FSK message detection. Once an event is detected, any applicable measurements are made and the signal waveforms may be

recorded. This information is then transferred to the PC where the TRsSim software is used to view and analyze the data.

The front panel of the AI-5120 provides two RJ-11 jacks and four status indicators. A telephone line can be connected to either RJ-11 jack, as they are configured in parallel to each other. The impedance presented by the AI-5120 to the telephone line is over 10 Mohms. As such it has little to no effect on any signals present on the telephone line. As a line monitor, the AI-5120 can not go off-hook (seize the line), or generate tones. It only listens. Two of the front panel indicators show if ringing or an off-hook condition is detected, while the other two indicate internal processor status and communication status with the PC.

The rear panel of the AI-5120 supplies a USB and a RS-232 connector used for communication with a PC. Also on the rear panel, are a BNC audio output connector and 3 mm mono audio jack. These can be used to route monitored audio signals to other equipment, or an external speaker/headphone. Both the BNC output connector and mono audio jack have adjustable output gain and can be enabled or disabled. They are controlled from the General Settings window (see the section: General Settings on page 72)

Optional Waveform Analysis Component (AI-ET003)

Once the AI-5120 detects an event of interest, it attempts to perform various measurements. These include ringing frequency, level and duration, DTMF frequency, level, and duration, FSK level and message contents. In addition to reporting the event to the TRsSim software, it records a waveform on either the AC or DC coupled channels which is then transferred to the TRsSim software for display. Because the AI-5120 must operate on a real time basis, it lacks the ability to perform advanced signal analysis and measurement extraction. However, the 'Waveform Analysis' component to the TRsSim software is designed to perform this function. It is an option to the software and may or may not be enabled based on the software key entered when first connecting to the AI-5120.

Note, to check if the Waveform Analysis option is enabled, select the **Configuration** menu following by the **Hardware Setup** command. The displayed window shows the status of all connected devices along with what optional software components are enabled.

If the Waveform Analysis component is enabled, it can examine the waveforms downloaded from the AI-5120 and attempt to extract additional measurements. Some of the events such as network tone detection and AC signal analysis require the Waveform Analysis option in order to operate. They analyze the downloaded waveforms for tones conforming to the specified templates. The following list summarizes the functions provided by this optional software component:

- Annotate FSK bits and bytes. When displaying an FSK signal, the decoder output is overlaid showing the position and value of each detected bit and byte value.
- Analyze FSK signals and extract the number of channel seizure, mark and mark out bits. Report mark/space frequency and level. Report presence of interfering signals. Report signal drop-outs detected during channel seizure. Display spectral content present during the mark signal.
- Analyze DTMF signals and extract distortion level, identify strongest interfering signal, check for transients, measure rise and fall time, verify compliance to

TIA-470.230-C or ETSI ES 201 235-3 distortion limits. Display spectral content present during the DTMF digit.

- Analyze CAS/DTAS signals and extract tone levels and frequencies, determine tone duration, measure distortion, check for preceding SAS tone and extract frequency, level, and timing. Display spectral content present during CAS/DTAS signal.
- Detect and analyze signals matching network tone templates. These templates define frequencies, level range, and duration range. If a waveform contains a signal matching any of the defined templates, the analysis extracts the level and frequency of each tone. Common templates include those for dial tone, ring back tone, and busy tone.
- Perform general tone analysis. Any waveform can be analyzed for tones in the range of 200 Hz to 7000 Hz. The frequency, level, duration, and possibly distortion are measured for every tone detected. If a sequence of tones in ascending or descending frequency is detected, then a Frequency Sweep event reports each frequency along with absolute and relative level readings.
- Waveform filtering and analysis. Any waveform can have 1 of 9 programmable filters applied and its RMS level profile or envelope displayed.
- Waveform measurements. Measurements such as frequency, peak-to-peak, maximum, minimum, mean, RMS, cyclic mean, and cyclic RMS can be performed on any displayed waveform.

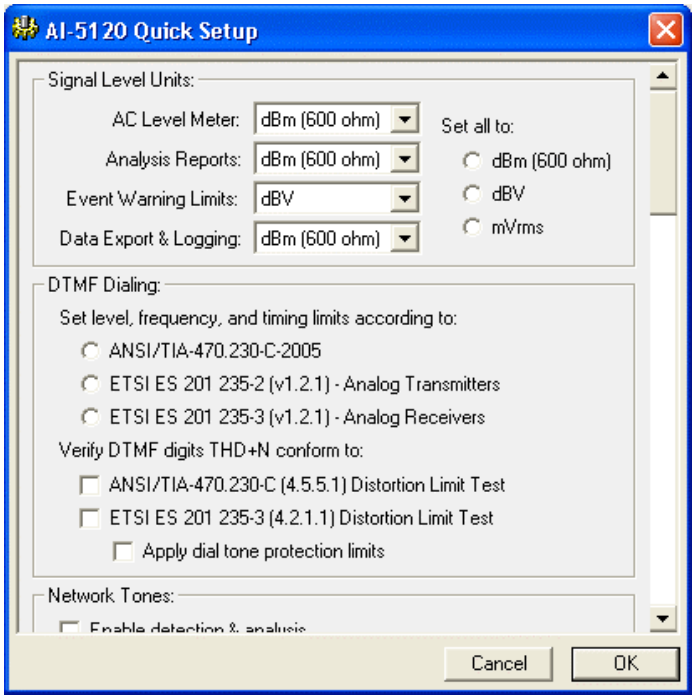
Note, when the Waveform Analysis option is required to perform various functions described in this document, the icon displayed in the left margin will be present.

For more information on the Waveform Analysis option, please see the section: Waveform Analysis Option on page 58.

3.3 Initial Settings

Once the TRsSim software starts up and connects to the AI-5120 it is ready to begin listening for events. Initially the 'Control Panel' window for the AI-5120 indicates that it is active and that no events have been detected.

A large number of settings can be modified in order to customize how the TRsSim software and AI-5120 behaves and operates. These are all access by first clicking the **More** button, which displays a list of options to choose from. However a number of the most common settings have been combined in a single window in order to simplify the program's configuration. By clicking the **Quick Setup** button shown above, the following window is displayed.



Six categories of common settings are displayed in the Quick Setup window. They are:

- Signal Level Units: The units of signal level may be independently set between different portions of the TRsSim software. Any of the three different unit types (dBm, dBV, and mVrms) can be specified by changing the drop-down lists.
- DTMF Dialing: Limits can be placed upon detected DTMF digits based on either the TIA-470.230-C or ETSI ES 201 235 standards. If any digits fall outside the pre-defined limits, they will be flagged with warnings. In addition, if the Waveform Analysis option is enabled, DTMF digits can be analyzed for compliance to distortion and spurious signal limits.
- Network Tones: If the Waveform Analysis option is enabled, detection and analysis of defined network tone templates can be enabled. In addition, pre-defined tone templates may be loaded by selecting them from the drop-down list.
- General AC Signal Analysis: The AI-5120 can be configured to look for the presence of a specific tone frequency and level. The settings in this category define the minimum signal level needed and the desired frequency. If '(any)' is selected for the frequency, then all signals meeting the minimum level are detected. If enabled, the optional Waveform Analysis component attempts to measure the frequency, level, duration, and possibly distortion in all waveforms recorded. If the Frequency Sweep event is enabled, then ascending or descending tones are grouped together and displayed with absolute and relative level measurements.
- Events and Waveforms: The amount of time an event or waveform is kept can be specified by this setting. Once the age of the event or waveform exceeds the specified time period, it is deleted. If a setting of 'Never' is chosen then events and waveforms are not deleted regardless of their age. The maximum number of

events and waveforms that can be stored is dependent on the PC's memory and hard drive capacity.

- Settings: Enabling the check box saves all of the current settings to a file and automatically loads them every time the TRsSim software is restarted.

To apply any of the above settings, click the **OK** button. If the **Cancel** button is clicked, then all changes made to any of the settings are ignored.

4. Basic Operation

This section provides details on the common and basic features of the TRsSim software when used with the AI-5120 Telephone Line Monitor. It is a good starting point for understanding how the user interface works along with performing basic operations.

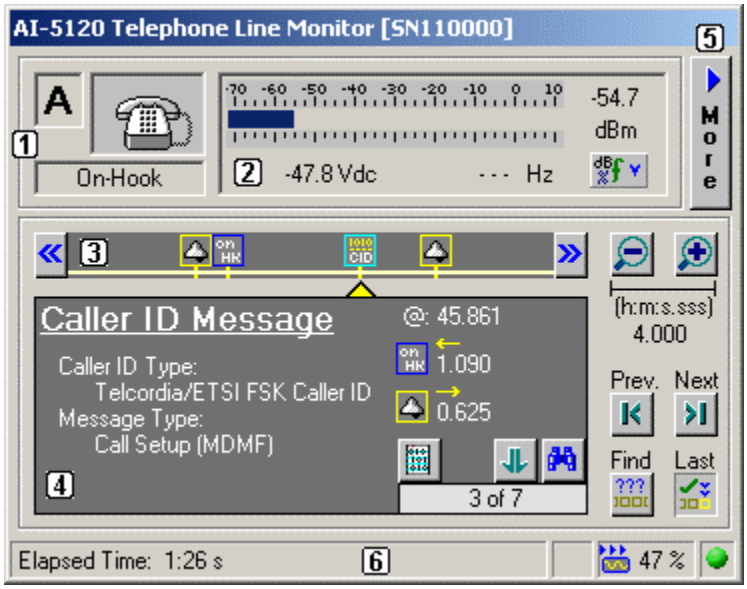
For more information on the various program capabilities and settings, consult one of the following topics:

- **Main Control Panel** on page 17.
- **Data Recorder Introduction** on page 23
- **Detectable Events** on page 27.
- **Event Warnings** on page 31.
- **Exporting & Logging Events** on page 33.
- **Saving & Loading Program Data** on page 34.

4.1 Main Control Panel

The graphical representation of the AI-5120 is the main control panel. The TRsSim software can connect with more than one AI-5120, and each one is displayed in a separate control panel window. From this window, the current telephone line status is shown as well as the DC voltage and AC signal readings. In addition, any detected events are displayed, including their measurement details. From the control panel all of the settings for the AI-5120 are accessed, as well as viewing event data and waveforms.

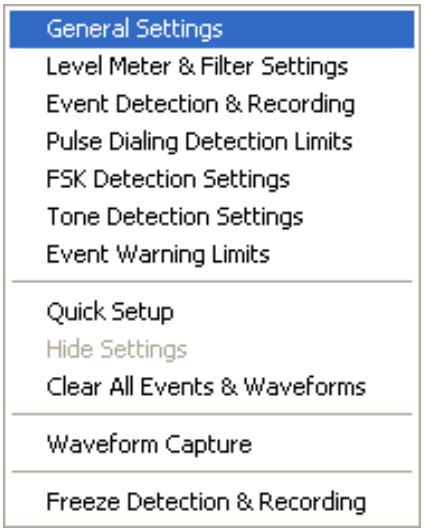
The figure below shows an example of the main control panel.



The top portion of the window (indicated by the numbers '1' and '2') shows the current line status along with the current AC signal and DC voltage measurements. In the example above the current line status is on-hook with a line voltage of -47.8 Volts. The wideband AC signal level is negligible at a reading of approximately -55 dBm. The large letter 'A' represents the device identifier. Since the TRsSim software supports multiple devices simultaneously (for example, two AI-5120's), each device is assigned a unique device identifier. To add or remove other devices, see the section: Hardware Setup on page 83.

The bottom portion of the window (indicated by numbers '3' and '4') displays the detected events along a time line, including summary information for one of the events. In the example above, the time line is viewing a 4 second span showing a Caller ID message transmission. Both the time span and time position are adjustable by clicking on the zoom in/out and right/left arrow buttons respectively. The selected event is the detection of a Caller ID FSK message. The Caller ID type of message is displayed along with time intervals to prior and following events.

Clicking the mouse on the **More** button (indicated by '5') displays the following menu of selections.



From these menu options, various program settings can be viewed and modified. For more detailed information on all of the program settings, see the section: General Settings on page 83.

The status bar at the bottom of the control panel ('6') normally shows the elapsed time that the AI-5120 has been listening for events. Other messages are temporarily displayed if changes to the settings are made. On the right side of the status bar are icons representing waveform recording, waveform data transfer, and event detection status. The right most icon represents either a green light or red light. Green indicates that the event detection and waveform recording is active, while red means that the no further events will be detected or waveforms recorded. To toggle the event detection and recording state, click the icon with the mouse.

Note that after loading a configuration file, event detection and recording is turned off. This allows examination of the data stored in the file without new events or waveforms overwriting the loaded data.

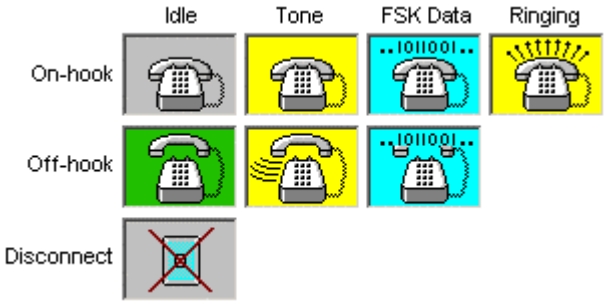
Normally the AI-5120 only records a waveform once an event has been detected. However at times it is convenient to manually initiate a waveform recording. This can be accomplished by clicking on the record icon shown in the status bar.

The icon changes once waveform recording has started. Once a recording is in progress, clicking the icon extends the recording time (default time extension is five seconds).

While the control panel shows the basic or summary data for detected events, further event information and waveform display is provided by the Data Recorder windows.

4.1.1 Line Status Display

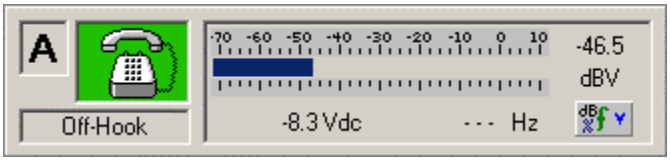
The line status section of the main control panel is continually updated with information regarding the telephone line state and signal level. A number of different icons are used to represent the line state, as shown in the figure below.



The distinction between on-hook, off-hook, and disconnect states is made solely on the basis of measured DC line voltage. While the threshold settings are adjustable (General Settings section on page 72) by default a line voltage above 20 indicates on-hook. If the line voltage falls below 18 volts, the off-hook state is reached. Finally falling below 2 volts indicates the disconnected state. In either of the on-hook or off-hook states, the **Tone** icon is displayed when the AC signal level exceeds 50 mVrms (-26 dBV). Or, if FSK data is detected the **FSK Data** icon is displayed. Ringing, while only applicable

when on-hook, is detected when the AC voltage present on the telephone line exceeds approximately 35 Vrms. Under this condition the **Ringing** icon is shown.

The signal level meter on the top right side of the main control panel displays the AC RMS level, frequency, and DC voltage present on the telephone line. In the example figure below, the AI-5120 reports an off-hook state with the DC line voltage at -8.3 volts.

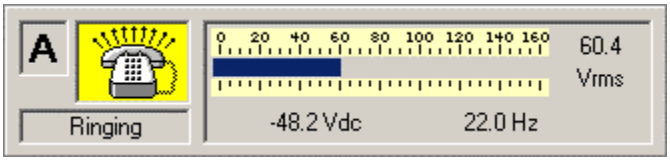


At low signal levels, no frequency measurement is returned. Only when the signal level exceeds 50 mVrms (-26 dBV) is a frequency reading displayed. The default signal level unit of dBm can be changed to either dBV, mVrms, dBr, or % by clicking on the units button just underneath the level reading.

The bar graph scale reflects the current unit settings, except for the units of mVrms. In that case the bar graph is calibrated to dBV. The dBr and % units are relative to a defined reference level. The reference level can be set to the current level reading by choosing the **Set Ref.** menu selection. As an alternative, it can be specified in Vrms from within the **Level Meter & Filter Settings** window.

The **Measure THD+N** selection enables a distortion plus noise measurement mode. In this mode the AI-5120 displays the distortion plus noise reading in units of dB. Filters, such as low pass, high pass, band pass, notch, or C-message, can be enabled from within the **Level Meter & Filter Settings** window.

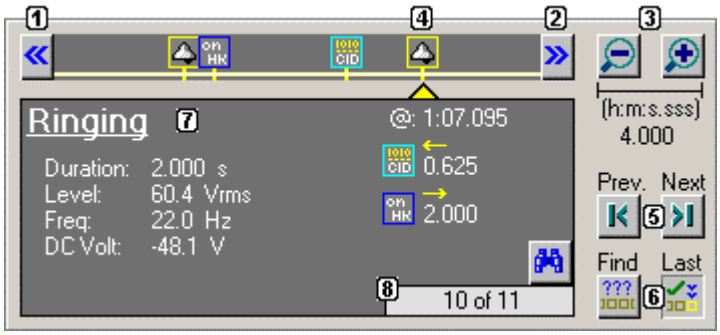
If ringing is detected, the level meter display changes to a linear scale showing the ringing level in units of Vrms. In addition, the ringing DC offset voltage and frequency are displayed.



The units of level measurement during ringing are fixed at Vrms.

4.1.2 Detected Event Display

The lower portion of the main control panel provides information on the detected events. This includes showing a time line of events and more detailed information on a single selected event. The following figure shows an example.



Four events are displayed on the time line. They are: ring start, on-hook (end of ringing), Caller ID message, and finally ring start again. Each type of event (i.e. ring start, DTMF, Caller ID) is represented graphically by an icon. The buttons indicated by numbers (1) and (2) are used to pan the time line left or right. Clicking on the left button pans the time line to show earlier events, while the right button pans to show later events. If the mouse button is held down and mouse moved either left or right, the panning speed changes in proportion to the mouse movement.

The span of the time line is controlled by two buttons (3). Clicking them either zooms in or out the time line. In the figure above the current time span is 4.000 seconds. The span can be changed from a minimum value of 0.010 seconds to 1000 hours by using the two buttons.

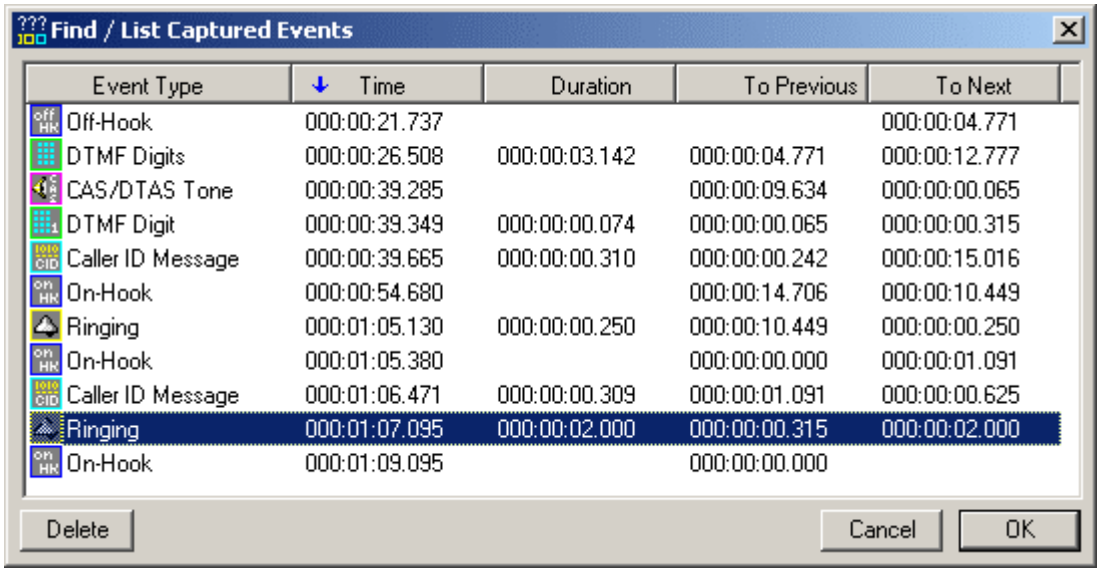
The area below the time line displays the details for a single selected event (7). In the figure above, the selected event (4) is the start of ringing, as indicated by the yellow triangle below the icon in the time line. For all events, the time stamp of the event, time to prior event, and time to next event are shown along the right side. To the left are any event details. In the case of ringing, the duration, level, frequency, and DC voltage offset measurements are displayed.

The selected event can be changed by either clicking on the **Next** and **Previous** buttons (5), or clicking the mouse on the icon shown in the time line. The event number and total event count are shown in the bottom right corner (8). The example ringing event is the 10th out of a total of 11 detected events.

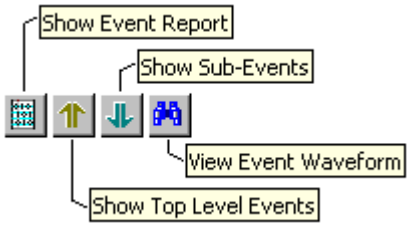
If the button marked **Last** (6) is depressed (default setting), then once a new event is detected it automatically becomes the selected event and its details are displayed. This setting can be toggled on and off by clicking the mouse on the button.

The **Find** button (6) shows a listing of all captured events. In addition to listing the events, the time stamp, duration, time to next event, and time to previous event is included. The currently selected event is automatically highlighted in the list. To view a different event, simply select it in the list and click the **OK** button. Events can also be deleted from this window by selecting one or more with the mouse and clicking the **Delete** button.

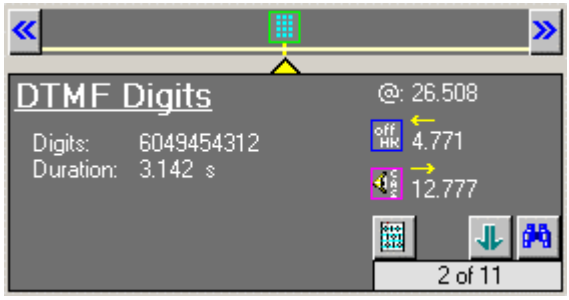
To simplify the task of finding specific events, the list can be sorted on any of the five columns by clicking the mouse on the desired column header. By default, the events are sorted by ascending time.



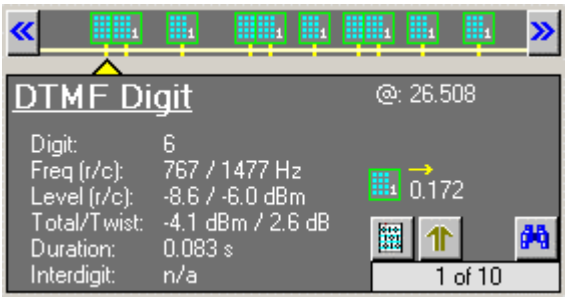
Displayed just above the event counter (8), are up to four different buttons. These are used to either show more information collected about the selected event, or show any child or parent events. The following figure shows the different buttons and indicates their function.



Depending on the selected event, not all of the buttons may be visible. The two outside buttons are used to display either the event waveform or event details in a Data Recorder window. The two inner buttons navigate the event hierarchy. Some events may be composed of sub-events. An example of this is DTMF dialing. The following figure shows an event of DTMF dialing. The details indicate that the digits "6049454312" were dialed with a total duration of 3.142 seconds.



To gain more information on each digit, click the down arrow (show sub events). This shows the sub-events, which for this event are the details on each digit dialed. The following figure shows the 10 digits dialed on the time line. The first digit "6" is automatically selected and its measurements are displayed. The event counter indicates that the selected event is the first of 10 sub-events.



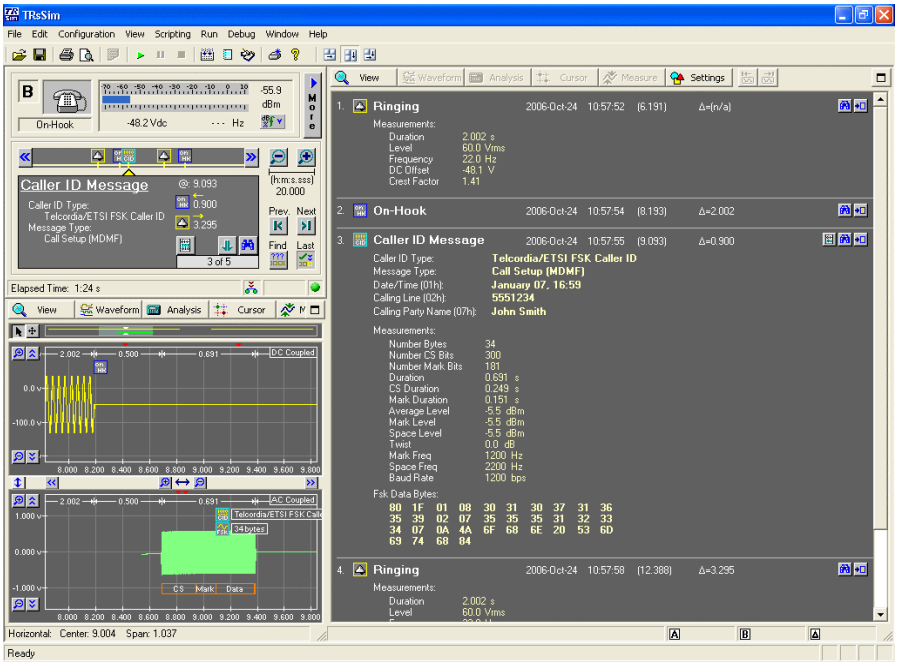
To return to the top level events, simply click the up arrow.

4.2 Data Recorder Introduction

The Data Recorder windows are used for displaying all recorded waveforms and event reports. This section only provides an introduction on how these windows can be used. For more detailed information please see Data Recorder Window on page 36.

4.2.1 Docked Window Mode

If only a single device (AI-5120) is connected to the TRsSim, it automatically opens two Data Recorder windows in what is termed 'Docked Window Mode'. An example is shown in the following figure.



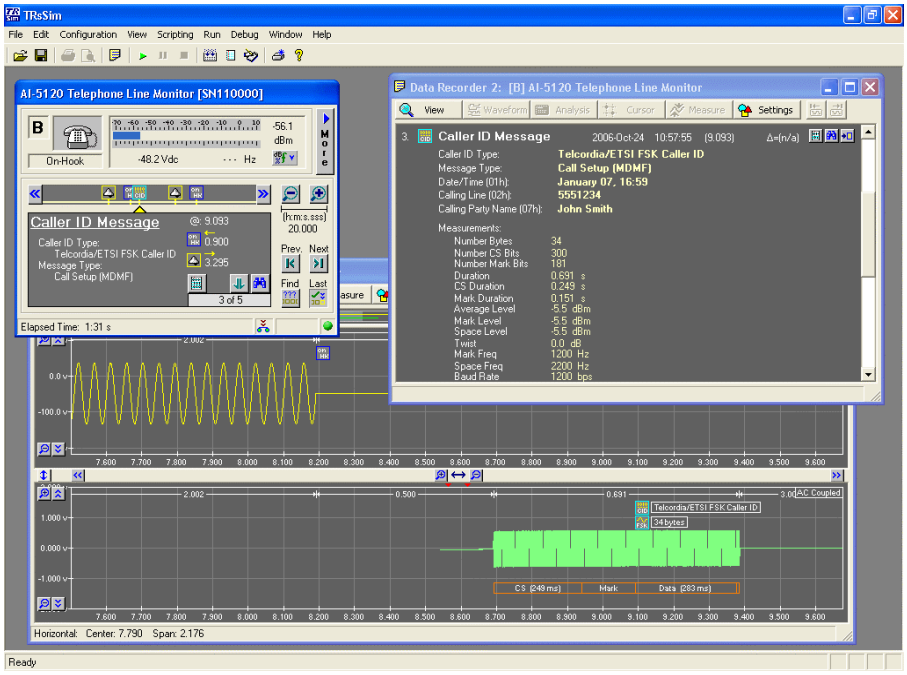
The windows are maximized to fill all of the desktop space provide by the TRsSim application. By using the view buttons located on the tool bar either the two windows can be increased in size at the expense of the other window.

Normally the window to the right lists the events as they are detected, while the bottom left window displays the waveforms recorded. As new events or waveforms are

captured, the displays are automatically updated. Either of the two windows may be further increased in size by clicking the 'maximize' button located at the top right corner.

The 'Docked Window Mode' works best when the monitor screen size is quite large (1200 by 1024 pixels or greater) and with a relatively new PC's (Pentium 4, 2 GHz or greater). With older PC's, the 'Docked Window Mode' may make the system run at a slower rate due to the processing time required to constantly update the event list and waveform display. This display mode is toggled on and off by selecting the **Window** menu, followed by the **Docked Window Mode** command.

If the 'Docked Window Mode' is turned off, the Data Recorder windows appear as normal resizable windows with the standard controls. Up to four windows may be opened at any given moment.



In either mode, the Data Recorder windows operate in the same manner. They are used to either display waveforms or event reports.

4.2.2 Waveform Views and Event Reports

The Data Recorder windows can display either event data or waveforms in a variety of manners. To change the display, click the **View** button at the top left corner of the window and make a selection from the popup menu shown.

The possible waveform display modes are:

- **AC Coupled Channel waveforms:** Shows the waveform(s) recorded only on the AC coupled channel. The AC coupled channel is sampled at approximately 20,000 samples per second with a range of +/- 5.5 Volts. Signals such as DTMF, FSK, CAS/DTAS, and network tones are normally viewed with the AC coupled channel waveforms.
- **DC Coupled Channel waveforms:** Shows the waveform(s) recorded only on the DC coupled channel. The DC coupled channel is sampled at approximately 1,200 samples per second with a range of +/- 300 Volts.

Line state changes such as ringing, line flash, pulse dialing, OSI are normally viewed with the DC coupled channel waveforms.

- **Both AC and DC Coupled waveforms:** Shows both channels in a split display. The DC coupled waveforms are shown in the top half and the AC coupled waveforms using the bottom portion of the window. The 'split' position between the two waveforms is adjustable by clicking and dragging the icon at the far left side of the split bar.
- **FFT of AC Coupled waveform:** Displays an FFT of the AC coupled channel waveform. The data points for the FFT are taken from the waveform at the center of the AC coupled waveform display.
- **FFT of DC Coupled waveform:** Displays an FFT of the DC coupled channel waveform. The data points for the FFT are taken from the waveform at the center of the DC coupled waveform display.
- **AC Coupled Channel with FFT:** Splits the window into a top and bottom half with the top half showing the AC coupled waveform and the bottom half showing the FFT of the same waveform.

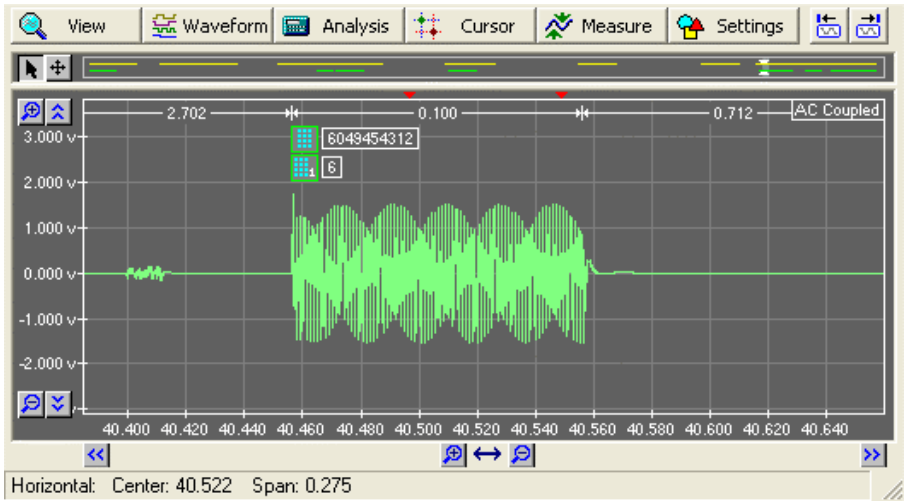
In addition to the above waveform display modes, the following general event reports can be viewed:

- **Event List Report:** Lists events detected. Filters may be applied to only show specific events, events with warnings, or events without warnings. In addition, events can be listed with or without measurement data. Only the first 500 events that pass the filter settings are shown. For more details, see the section Event Listing on page 37.
- **Caller ID Summary Report:** Displays a time line of all FSK Caller ID transmissions detected. Each FSK Caller ID transmission can be selected and its details displayed. For more details, see the section Caller ID Summary Report on page 51.
- **Search Results Report:** The results of any of the defined search criteria are displayed. Search criteria can be created to scan for specific combinations of events with timing and measurement limits. For more details, see the section Event Searching on page 52.

Finally, certain events can display detailed information in a report format. Those events are Caller ID, SMS, FSK, and DTMF Dialing. These are not selected from the **View** popup menu, but rather by clicking on the report icon shown in the main control panel.

When events are displayed on the main control panel or in the Data Recorder window reports, a small "View Event Waveform" button may be displayed.

Clicking this button causes the Data Record window to switch to a waveform display mode and display the waveform captured. The previous topic showed an example of a DTMF dialing event, where the details of digit '6' were examined. By clicking on the "View Event Waveform" button, the following waveform is displayed.



Waveforms are display on a graph using time for the horizontal axis and voltage for the vertical axis. In this example, the DTMF digit starts at approximately 40.46 seconds with a duration of 100 ms. Event icons and timing markers above the waveform indicate the type of event along with timing relationships to other events. Both of these graphical tools may be turned off by using the **View** button menu.

Different methods can be used to move or change graph scaling. They are:

- Clicking the mouse on the pan and scale buttons. The four left/right and up/down arrow buttons pan the graph in the horizontal or vertical directions respectively. To change the graphing scale, use the four zoom in/out buttons. Click the mouse (and hold) until the desired scale or position change is achieved.
- Hold the CTRL key and right click the mouse anywhere on the waveform and then drag the mouse. This pans the waveform in either axis with the zoom or scale factor unchanged.
- Click and hold the left mouse button on the graph to draw a rectangle representing the desired time and voltage range. Once the mouse button is released, the waveform is zoomed to the new position.

It is important to note that event waveforms may not be continuous. Waveform recording is only performed by the AI-5120 when the event is detected. If no events are detected for a period of time, then no waveforms are recorded. This is why waveforms do not continue indefinitely. Also some events only cause waveform recording on a single channel. For example, by default DC related events such a on-hook, off-hook, line reversal, pulse dialing do not record any waveforms from the AC coupled channel. Only the DC coupled channel is recorded. To override this mode of operation, change the 'Record AC channel on DC' setting to 'on' (see the section General Settings on page 72).

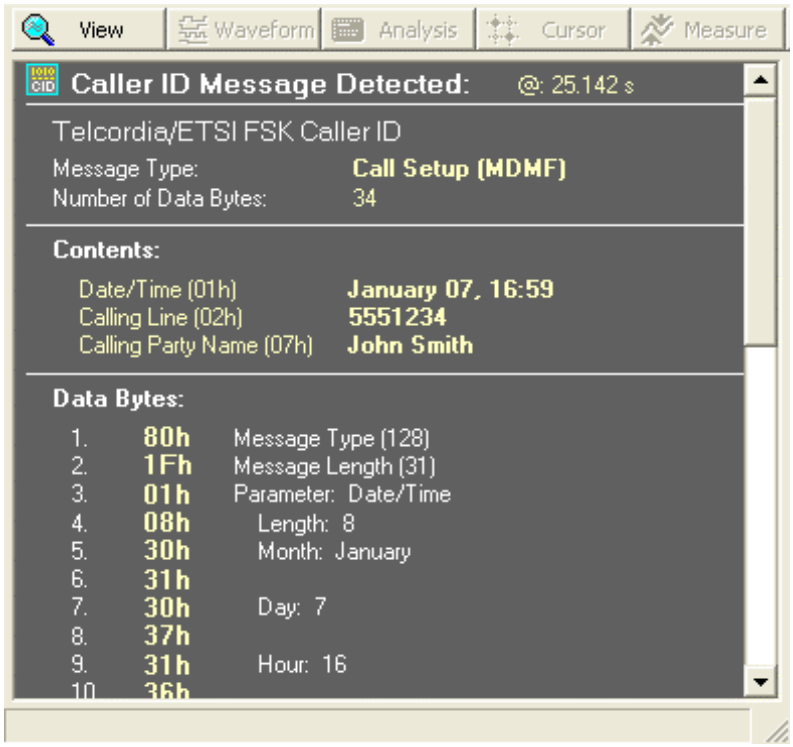
A waveform 'Navigation Bar' is shown at the top of the waveform display. It graphically displays the length and location of all waveforms recorded. The yellow lines represent DC coupled channel waveforms, while the green lines underneath represent the AC coupled channel waveforms.

The time span currently displayed is drawn as a lightly shaded grey area on the navigation bar. By clicking and dragging the mouse on the shaded area, the waveform view is panned either earlier or later in time.

For more information on how to use the waveform view and navigation bar, see the section: Data Recorder Window on page 36.

In addition to displaying waveforms, the Data Recorder window can display event reports. These provide additional details on events not shown on the main control panel. Clicking on the 'Show Event Report' button displays the event report.

The button is visible on the main control panel for DTMF, Caller ID, and SMS events. The following figure shows an example of the event report for a Caller ID message.



It provides more detailed information than possible on the main control panel. In the above example the contents of the Caller ID message along with the FSK byte values are displayed.

For additional information on modifying waveforms, generating analysis reports, playing back waveforms, making cursor and other measurements, see the section: Data Recorder Window on page 36.

Note, the **Analysis** and **Measurements** menus are only available if the optional Waveform Analysis component is enabled. For more information, please see the section: Waveform Analysis Option on page 58.

4.3 Detectable Events

The TRsSim software and AI-5120 detects up to 24 different event types. With each event, DC or AC coupled waveforms may be recorded. For some event types (such as on-hook and off-hook), only the DC coupled channel is recorded (by default). This is because the AC coupled channel provides no additional information. In the **General Settings** window, this setting may be modified to allow recording of the AC coupled

channel when DC related events are detected. The measurements taken by the AI-5120 depend on the type of event. For some events, no measurements are made, since none are applicable. An example of this is off-hook. Only the time stamp of the event is recorded.

Events may be ignored by the AI-5120 if they are not required, in addition, waveform recording may be enabled or disabled for any of the events. These settings can be viewed and modified from the **Event Detection & Recording** settings window.

Some of the events have their measurements compared against 'warning' limits. If the event measurements fall outside the limits, the event is identified by the following icon:

The measurements warning limits can be viewed or modified in the **Event Warning Limits** window.

The following list describes the different event types detected by the AI-5120.

Going Off-Hook: This event timestamps the point in time when the AI-5120 determines the telephone line has entered the off-hook state. This occurs either when the absolute DC telephone line voltages falls below the "Off Hook DC Threshold" (default value 18 volts), or when the absolute DC voltage goes above the "Disconnect DC Threshold" (default 2 volts). The threshold voltages can be modified from the **General Settings** window. If the DC line voltage enters the off-hook range for only a very brief time (less than 15 ms), no off-hook event is reported.

Going On-Hook: If the absolute DC line voltage exceeds the "On Hook DC Threshold" (default 20 volts) setting, then an on-hook event is recorded. The threshold voltage can be modified from the **General Settings** window. If the DC line voltage enters the on-hook range for only a very brief time (less than 15 ms), no on-hook event is reported. Note that if ringing stops and the DC voltage is above the threshold voltage, an on-hook event is recorded.

Line Flash: The line flash event is derived from the on-hook and off-hook events. If the two events occur within a specified time window (default 200 ms to 1000 ms), then a line flash event is displayed. The only measurement taken is the duration of the flash time. The timing limits can be changed from the **Event Detection & Recording** settings window.

 The line flash duration is checked against 'warning' limits.

Line Reversal: A line reversal event occurs when the DC line voltage changes sign (positive to negative, or negative to positive) and the absolute line voltage is greater than the "Disconnect DC Threshold" setting (default 2 volts). Note that ringing is not considered a line reversal.

Disconnect State: The disconnect state indicates that the absolute DC line voltage has fallen below the "Disconnect DC Threshold" setting (default 2 volts). This event normally indicates that the DC feeding voltage has been removed from the telephone line, which may occur during an OSI (open switching interval). The threshold voltage can be modified from the **General Settings** window. Note that by default, the Disconnect event is disabled and not shown.

Open Switching Interval (OSI): The OSI event indicates a brief period of time in which the absolute DC line voltage fell below the "Disconnect DC Threshold" and then returned back to either the on-hook or off-hook voltage levels. The default time window is from 100 to 1000 ms, which can be changed from the **Event Detection & Recording** settings window. The only measurement taken is the OSI duration.

The OSI duration is checked against 'warning' limits.

Extension-in-use Check: The extension-in-use check is a brief period in time where the DC line voltage increases to the on-hook state, and then returns to the off-hook state shortly after a CAS/DTAS tone. This may occur as part of Type II (off-hook) Caller ID transmission. Normally the duration of the on-hook interval is in the range of 5 to 8 ms, which can be changed from the **Event Detection & Recording** settings window. The only measurement taken is the duration.

Ringing (start of): This event marks the start of ringing. Ringing is defined as the presence of an AC signal on the telephone line exceeding 35 Volts RMS. During ringing the frequency, AC voltage, crest factor, and DC offset voltage measurements are recorded, provided the ring duration is long enough for a stable reading. The end of ringing is marked by either a on-hook or off-hook event.

The ringing duration, frequency, level, and DC offset voltage measurements are checked against 'warning' limits.

Pulse Dialing Digit: The pulse dialing event is derived from a series of on-hook and off-hook events. Only if the break and make times meet the limits specified in the **Pulse Dialing Limits** settings window, is the pulse dialing event shown. It should be noted that the break and make times are determined by measuring the voltage present on the telephone line. This may result in slightly different measurements than if the loop current is used to determine the break and make times.

DTMF Dialing Digit: Marks the start time of a single DTMF digit. The AI-5120 measures the level and frequency for both the row and column tones, along with duration and inter-digit delay. If the Waveform Analysis option is enabled, additional distortion, rise time, and transient measurements can be performed on the DTMF digit.

The DTMF digit duration, frequency error, level, twist, and inter-digit delay measurements are checked against 'warning' limits.

DTMF Dialing String: This event is derived from multiple DTMF digit events. If less than a 5 second gap exists between DTMF digits, they are combined into a single DTMF string event. If the Waveform Analysis option is enabled, additional distortion, rise time, and transient measurements can be performed on each DTMF digit.

The DTMF digit duration, frequency error, level, twist, and inter-digit delay measurements are checked against 'warning' limits.

Caller ID FSK Message: The Caller ID event indicates that a FSK message conforming to the ETSI, Telecordia, or NTT standards was detected. Limits and requirements for detecting FSK messages is specified in the **FSK Detection Settings** window. Once a Caller ID message is detected, it is analyzed for its message type and parameter contents. If the Waveform Analysis option is enabled, additional measurements are made. These include mark/space frequency and level, baud rate, channel seizure and mark periods, interfering signal checks, and signal drop-out check.

The FSK signal level measurement is checked against 'warning' limits.

SMS FSK Message: This event is shown if an ETSI protocol 1 or protocol 2 SMS FSK message is detected. Limits and requirements for detecting FSK messages is specified in the **FSK Detection Settings** window. The received data bytes are analyzed for the DLL message type and possibly the transfer layer (TL) message type. If the Waveform Analysis option is enabled, additional measurements can be made. These include mark/space frequency and level, baud rate, channel seizure and mark periods, interfering signal checks, and signal drop-out check.

The FSK signal level measurement is checked against 'warning' limits.

FSK Message: While normally a sub-event of the Caller ID and SMS events, this icon may be displayed if FSK data bytes are detected but the content does not conform to either a known Caller ID or SMS message structure. No message analysis is performed; however, the collected data byte values can be viewed. If the Waveform Analysis option is enabled, additional measurements can be made. These include mark/space frequency and level, baud rate, channel seizure and mark periods, interfering signal checks, and signal drop-out check.

The FSK signal level measurement is checked against 'warning' limits.

CAS/DTAS Tone: Marks the detection of a CAS or DTAS tone. This signal is comprised of two tones at 2130 Hz and 2750 Hz that are present for a duration between approximately 80 to 100 ms. If the Waveform Analysis option is enabled, the duration, tone level, and tone frequency measurements are extracted from the captured waveform.

The CAS/DTAS duration, frequency error, level, and twist measurements are checked against 'warning' limits.

Network Tone Detection: If the Waveform Analysis option is enabled, network tone templates can be specified using the **Tone Detection Settings** window. If a waveform is analyzed that conforms to any of the defined tone templates, a Network Tone event is displayed. Common usage for this event is the detection of dial tone, ring back, and busy tone.

Tone Sequence: A tone sequence is a series of network tone events. Using the **Tone Detection Settings** window, a sequence of network tones can be defined, that if detected cause this event to be displayed. Note that the Waveform Analysis option must be enabled for the detection of this event.

AC Level/Freq: The AI-5120 can monitor the telephone line for a specific signal level and/or frequency. If either (or both) the signal level or frequency meet the defined limits for the specified time duration, this event is triggered. By default the event is disabled; however, it can be enabled from the **Event Detection & Recording** settings window. If the Waveform Analysis option is enabled, the frequency, level, duration, and possibly the THD+N reading is extracted from any recorded waveforms.

AC Frequency Sweep: If enabled, this event is displayed when a series of AC Level/Freq events are detected containing a single frequency tone that is either increasing or decreasing in frequency. The Waveform Analysis option must be enabled for detection of this event. By default this event is disabled; however, it can be enabled from the **Event Detection & Recording** settings window.

DC Line Voltage: Similar to the AC Signal Level event, the AI-5120 can monitor the DC coupled channel line voltage. If the voltage maintains a specified range for a specified minimum amount of time, the DC Line Voltage event is triggered. By default this event is disabled.

Digital Input A: This event is displayed when a change is detected in the logic level of the AI-5120's rear panel digit input A connector. Normally this event is disabled; however, it can be enabled from the **Event Detection & Recording** settings window. From the settings window the trigger edge is selected as well as which waveform channel should be recorded (if any).

Digital Input B: Functions in the same manner as Digital Input A, except it is for the AI-5120's rear panel digit input B connector.

Forced Waveform Recording: Via the Waveform Recorder window, the user may manually initiate a recording of both the AC and DC coupled channels. This event marks the time position when the recording was initiated.

4.4 Event Warnings

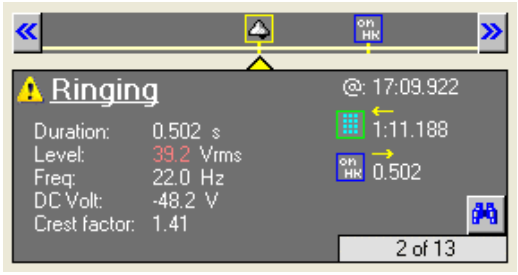
Event warnings are a mechanism notifying users that some aspect or measurement of an event has fallen outside defined limits. This provides a convenient method for sifting through large numbers of captured events looking for those few events that may indicate problem conditions.

Warnings can arise from two possible sources. They are:

- One or more of the measurements associated with an event as fallen outside a valid range defined in **Event Warning Limits** window. This window is used to define valid measurement ranges for various events. Once an event is detected, its measurements are compared against the defined limits. If outside the defined range, a warning is tagged to the event. The limits specified in the Event Warnings Limits window may be changed at any time, and any changes forces a re-check of all events captured.

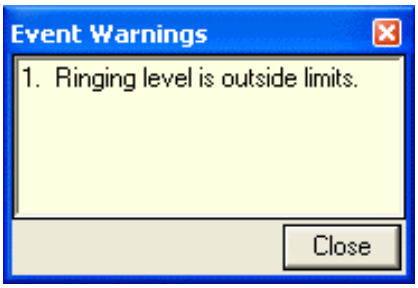
- Events that trigger an analysis of the waveform once downloaded may have warnings issued if the analysis results indicate unusual characteristics in the event. For example, signal drop-outs in FSK Caller ID or SMS data cause warnings to be issued. Note that in order for these types of warnings to be displayed, the optional Waveform Analysis software component must be enabled.

As an example, the following figure shows a captured ringing event that triggered a warning. The ringing level was measured at 39.2 Vrms, which is below a defined minimum limit of 40 Vrms.

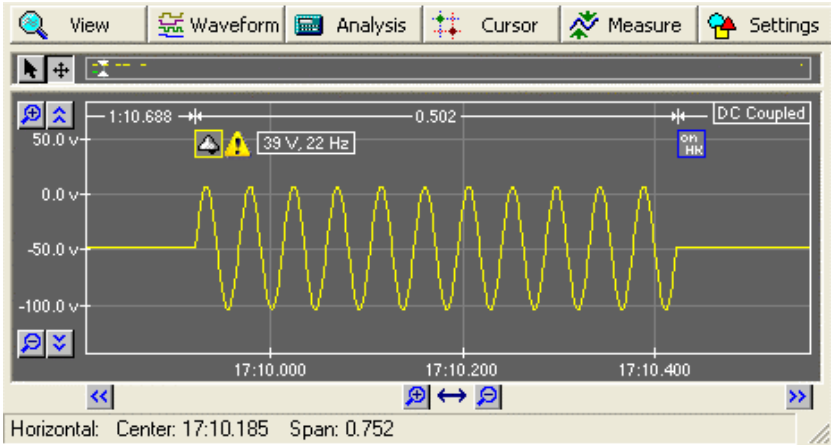


Events that have warnings, display a 'warning' icon to the left of the event name in the control panel. In addition, any measurements that caused the warning are highlighted in a red color.

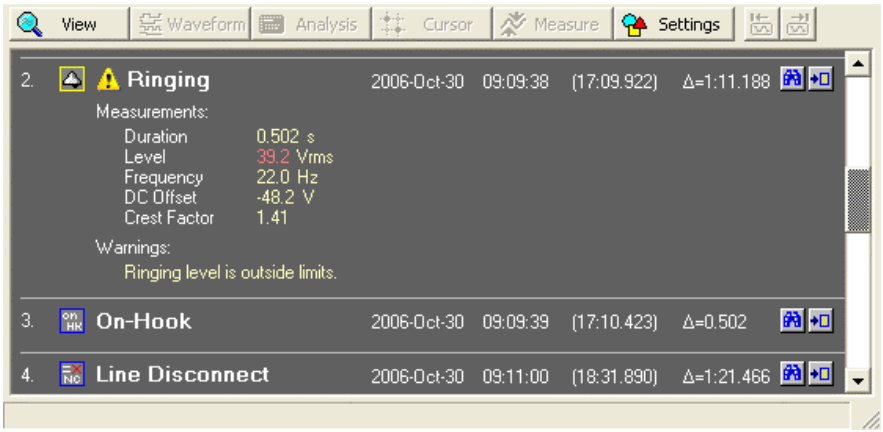
Moving the mouse over the warning displays the number of warnings detected. Clicking the mouse on the warning icon causes a window to appear listing all of the warnings associated with the event.



Events that have warnings are also flagged in the Data Recorder window. Using the above example of the ringing event, when the captured ringing waveform is viewed, the event icon is followed by the warning icon.



The ringing event is also flagged in the event listing. Any warning messages associated with an event are displayed beneath the measurement values.



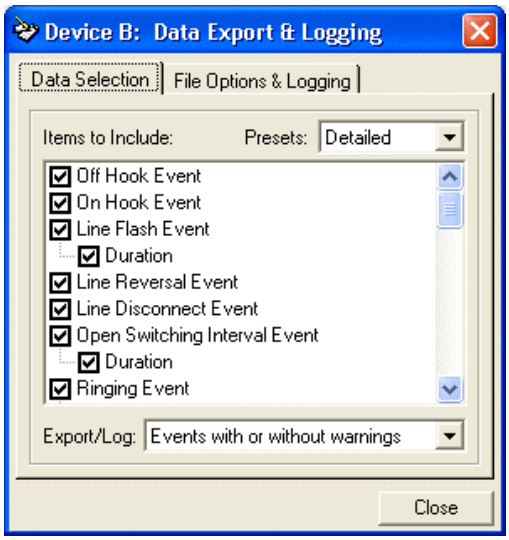
The Event List display in the Data Recorder window can be configured to only display events with warnings, or ignore all events with warnings. The event list filter controls are accessed by clicking the **Settings** button, followed by the **General Settings** command.

The same type of filter can be applied when logging event data to a file or exporting event data. See the following section for more information on event logging or data exporting.

4.5 Exporting & Logging Events

The TRsSim software can export all of the recorded events to a text file, or log it to a text file as the events are detected. By default the data logging function is disabled. If a large number of events have been captured, a filter can be applied to only export or log events of interest.

The settings window for the event export and logging is shown by selecting the **Export & Data Log Settings** command from the **File** menu. The following figure shows the window.



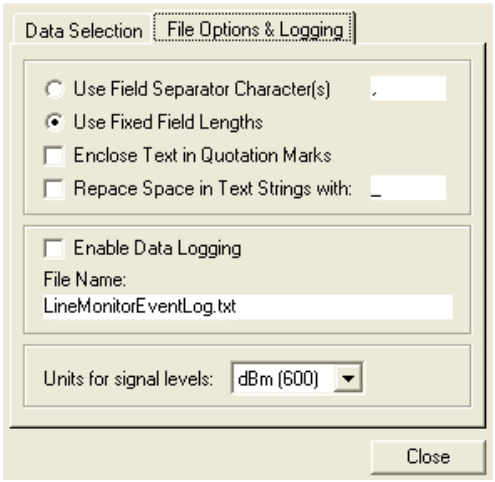
The first of two tabs sets the event filter. Any event listed with a checkmark beside the name is exported and logged (if logging is enabled). In addition, some events have the option to export/log measurement or analysis data if the appropriate box is checked. The

last four items in the filter allow the inclusion of the event count field, event time stamp, time to the previous exported or logged event, and event warning messages.

The drop-down list box at the top right corner of the window is used to quickly select either a summary or detailed filter mode. The summary mode only allows the more significant events to pass the filter, while the detailed mode allows all events with all measurements to pass the filter.

The second tab marked File Options & Logging provides options as to how the export or log file is formatted. This includes if field separators are used, and if so, what character(s) to use.

Logging is enabled or disabled by clicking the **Enable Data Logging** check box. If the data logging file name does not include an absolute path (i.e. start with drive letter or network path), the file is stored in the \log\ subdirectory of the TRsSim software.



Note that if logging is enabled, the detected event is written to the log file only after a time delay of approximately 30 seconds.

4.6 Saving & Loading Program Data

All of the event data and program settings can be saved to a configuration file. This file contains the complete state of the TRsSim software. A configuration file can be loaded into the TRsSim software at a later time for further analysis or display. Use the **Open Configuration File** or **Save as Configuration File** menu commands to load and save the files respectively.

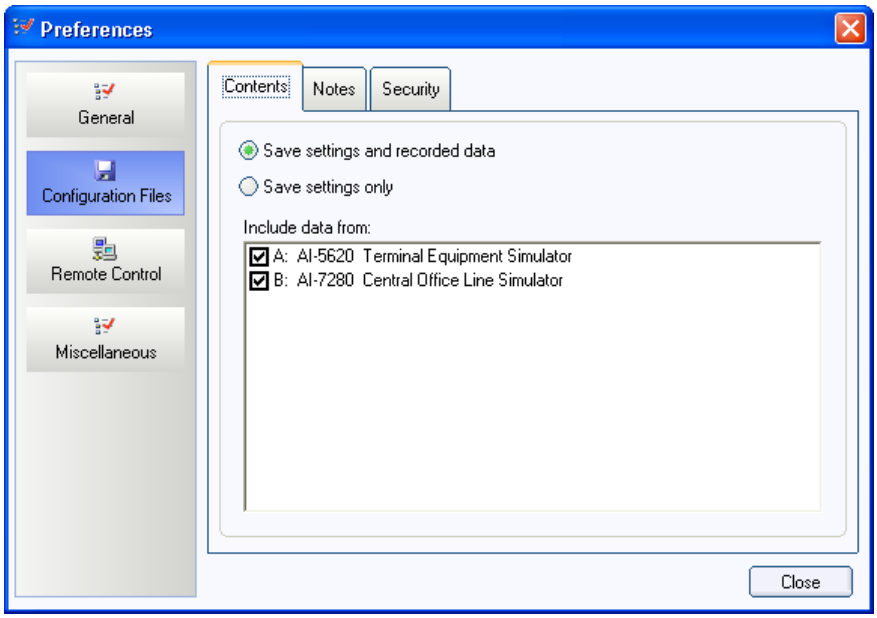
If only the events and waveforms are to be saved to a file (not the settings), use the Data Recorder file type. The **Save as Data Recorder File** menu command creates a file that stores only the captured event data. None of the program settings are stored within this type of file. This allows loading of the file without overwriting any of the program settings.

Loading a configuration file erases all prior events, waveforms, and program settings. In addition the AI-5120 stops event detection once a configuration file is loaded. This prevents any detected events to conflict with the events loaded from the file. To resume event detection at the same timestamp the configuration was saved, click the **More** button followed by the **Resume Detection & Recording** command.

A configuration file may be customized in the following manners:

- Store the data and settings from only specific devices
- Store only devices settings
- Password protect the file contents
- Place requirements on which devices must be connected in order to load the file
- Place restrictions on changing certain settings after loading the file
- Embed text notes, possibly to describe the file contents or purpose
- Allow file load only between a range of dates

To change any of the above settings, display the Preferences window by clicking on the 'Configuration' menu, followed by the 'Preferences' command.



5. Data Recorder Window

The Data Recorder window provides a means for viewing waveforms and event measurement details. While the main control panel gives some information on the detected events, it does not show the recorded waveforms.

If the 'Docked Window Mode' is enabled, then two Data Recorder windows are always opened. These windows remain visible at all times and no additional windows can be opened. By default the two windows will show a listing of detected events and the AC coupled and DC coupled waveforms recorded.

In cases where the 'Docked Window Mode' is turned off, three different methods can be used to open a Data Recorder window. They are:

- Select the **Data Recorder** command from the **View** menu. This opens a new window. By default, the new window shows a list of all the events detected. A maximum of four windows can be opened at any given moment.
- Click on the  (show waveform) icon from the main control panel. This opens a new window (if none are opened) and shows the captured waveforms for the selected event. If a Data Recorder window is already open, then its current view changes to show the waveform.
- Click on the  (show report) icon from the main control panel. This opens a new window (if none are opened) and shows a detailed report of the event. If a Data Recorder window is already open, then its current view changes to show the event data.

When used with the AI-5120, the Data Recorder window displays either event related reports or recorded waveforms. The event reports can be either an event listing, FSK Caller ID summary report, event search results, or detailed measurements for a single event. When displaying waveforms, the Data Recorder window shows either the AC coupled channel, DC coupled channel, or both simultaneously. In addition, it can show a FFT (Fast Fourier Transform) of either channel. This provides a representation of a waveform's spectral content.

Clicking the **View** button, located in the top left corner of the Data Recorder window, shows the following menu.

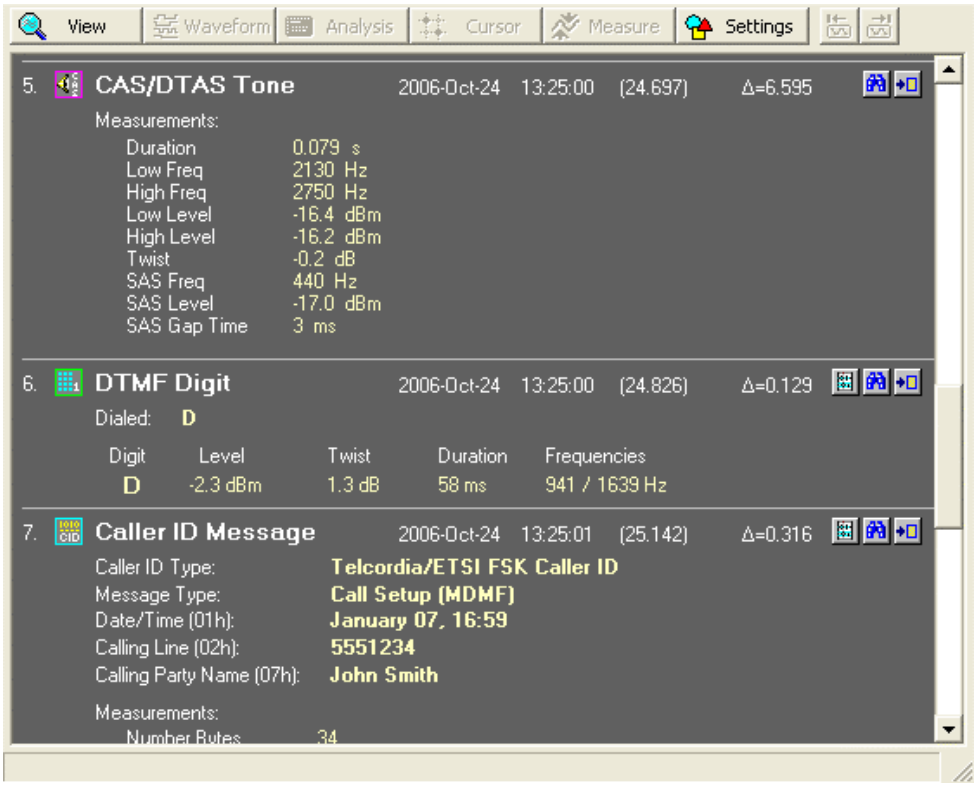
The first six selections represent the various waveform views, while the following three display the event related reports. To change views, simply select the desired menu item.

5.1 Event Listing

The Event List view is the default selection when opening a Data Recorder window. It provides a listing of each event along with any measurement data collected.

The example figure below shows three events representing a Type II (off-hook) Caller ID transmission. The events are a CAS/DTAS tone, followed by the ACK signal (DTMF 'D'), which is then followed by FSK data containing the Caller ID message.

As more events are detected over time, the scroll bar at the right is used to view either prior events or later events. By default, the 'Snap to Last Event in List' setting is enabled. This causes the event list to always show the last event in the list when a new one is detected. The setting can be toggled on and off from the **View** menu.

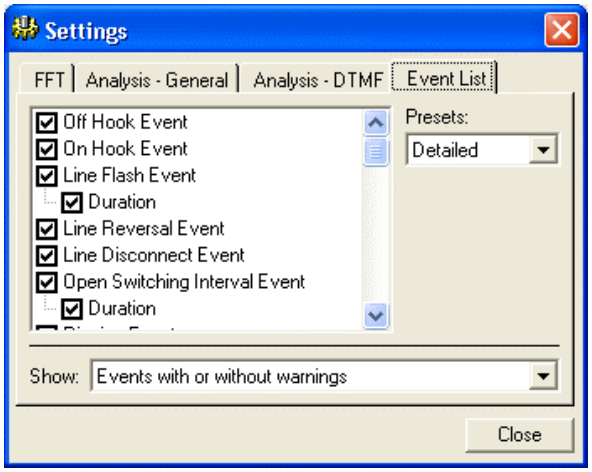


For each event listed, the event name and timing information is shown on the first line. Two time stamps are displayed. The first is the PC date and time when the event was detected. This is followed by the time (in hours:minutes:seconds format) from when the AI-5210 started listening for events. This time stamp is displayed to the right of the PC date/time enclose in '(' ')' brackets. Finally, the last value shown is the difference in event detection time between the current event and the prior event. For the example above, the start of the DTMF digit 'D' occurred 0.129 seconds after the start of the CAS/DTAS tone.

To the right side of the window, one to three buttons may be displayed for each event.

Clicking the mouse on the **Show Report** button changes the Data Recorder window view showing a detailed report for that event. This button is only visible for DTMF, Caller ID, SMS, and FSK events. Clicking the **Show Waveform** button causes the Data Recorder window to show the captured waveform associated with the detected event. This button is only visible if a waveform has been recorded for the event. Finally, clicking the last button causes the main control panel to select the event.

In situations where it is convenient to only display certain events, or limit the amount of details shown, an event list filter can be applied. Clicking the **Settings** button on the Data Recorder window and selecting the **General Settings** command displays the following window. The **Event List** tab is used to control which events and measurements are displayed.



Only the events that have a check mark beside their name are shown in the Event List. In addition, the inclusion of event measurements may be enabled or disabled by clicking on the appropriate check box.

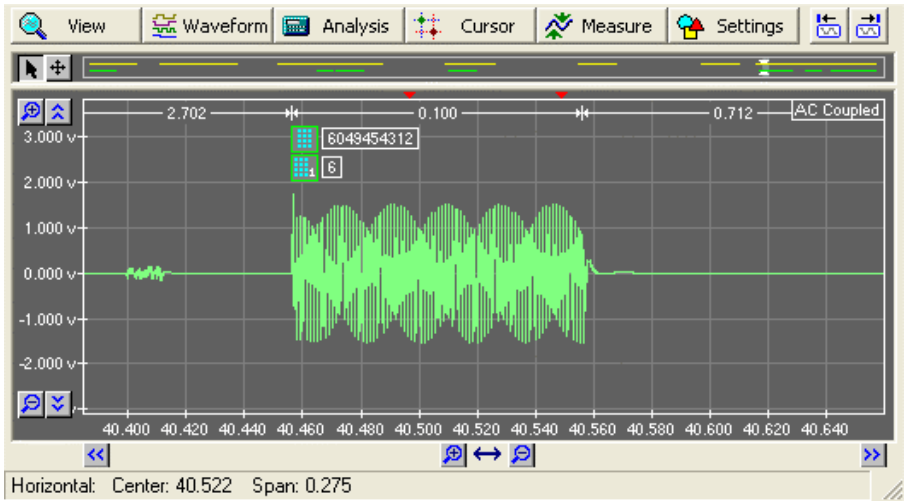
The drop-down list at the right side of the window is used to select from predefined filter settings. The **Detailed** selection shows all events and all event information, while the **Summary** selection only shows the more significant events with limited details.

5.2 Viewing Waveforms

One of the primary purposes of the Data Recorder window is to view captured waveforms. Depending on the type of event, voltage waveforms from either the AC coupled channel, DC coupled channel, or both may be captured by the AI-5120. These waveforms are viewed and manipulated from the Data Recorder window.

All of the waveform settings and functions are controlled through a tool bar displayed at the top of the window. Clicking any of the buttons displays a menu from which further choices can be made.

The following figure shows the waveform from a DTMF dialed digit '6'. The upper right corner of the graph denotes that the waveform was recorded from the AC coupled channel. By default, event icons are displayed marking the time stamp of the event relative to the waveform. In addition, timing markers at the top of the graph provide an indication of the time between events and the duration of events. Both of these graphical aids can be enabled or disabled from the **View** menu.



The horizontal scale is in units of time and formatted as "hours:minutes:seconds" with a resolution down to 1 ms. For both the AC coupled and DC coupled waveforms, the vertical scale is always in units of volts. However for FFT results, the vertical scale may be changed to dBm or dBV. Various parameters affecting the calculation and display of FFT graphs can be viewed or modified by clicking the **Settings** button and selecting the **General Settings** command.

The following sections provide information on manipulating waveform scale or position, changing viewing modes, using cursors, and other waveform functions.

5.2.1 Navigation

As a large number of waveforms may be collected, it becomes important to be able to isolate the region of interest. The Data Recorder window can display waveforms spanning a range of 10 ms up to 1000 hours. As waveforms are only recorded when events are detected, the displayed graph may contain regions of time in which no data exists. The simplest method to view a waveform is to select the event in the main control panel, and then click the **Show Waveform** button. This causes the Data Recorder window to show the waveform associated with the event.

Various different methods can be used to change the position and scale of a displayed waveform. They are:

- Using the pan/zoom buttons
- Using the mouse to pan and zoom
- Using the navigation bar at the top of the window
- Using the next/previous waveform buttons

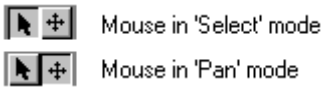
Using the Pan/Zoom Buttons

Eight different buttons pan and zoom the waveform in both the time and voltage axis. The buttons with arrows are used to pan the waveform, while the small magnifying glass buttons are used to change either the vertical or horizontal scale. All of the buttons auto-repeat if the mouse click is held down for more than one second.

The distance the panning buttons shift the graph depends on the mouse position relative to the button. For example if the pan left button is clicked and held the graph begins to show more data to the left (earlier in time) in small steps. However by holding the mouse button down and moving the mouse to the left, the step size increases. If the mouse is moved to the right of the button, the graph begins to pan in the opposite direction. All of the four panning buttons operate in a similar manner.

Using the Mouse to Pan and Zoom

When viewing waveforms, the mouse operates in one of two modes. They are 'Select' mode and 'Pan' mode. Clicking on the two buttons at the top left corner of the window changes this mode. As an alternative, double clicking the mouse on any portion of the waveform display (except where a waveform is drawn) toggles the mouse mode between 'Select' and 'Pan'.

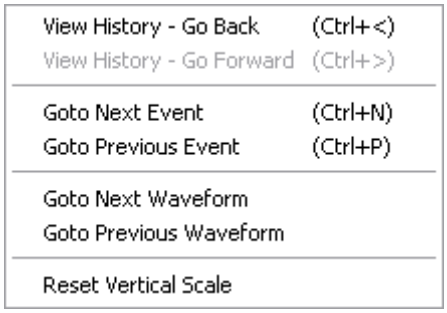


When operating in the select mode, a 'zoom box' can be drawn to zoom into a small region of interest. This is done by clicking the mouse on either the top left or bottom right region of interest and then dragging it to the opposing corner. Once the mouse button is released, the scale and position of the graph is changed to reflect the position of the rectangle that was drawn.

In the pan mode, clicking the left mouse button and dragging the mouse pans the waveform display in the same direction as the mouse. If the mouse is dragged off the waveform display area, the waveform automatically scrolls in the same direction.

In either mouse mode, holding down the CTRL key and the right mouse button also pans the waveform display.

If the right mouse button is clicked (without the CTRL key), the following pop-up menu is displayed.

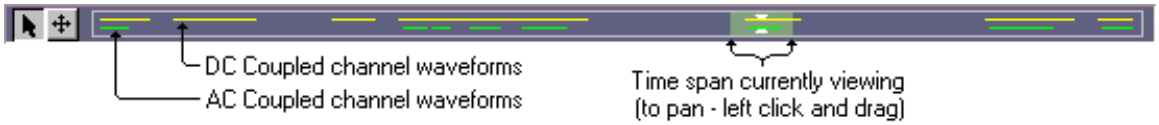


The first two menu commands causes the display to go back (or forward) though previous view settings. Each time the waveform display is panned or scaled, its position is remember. By using the 'Go Back' and 'Go Forward' commands, the viewing position history can be traversed.

The next four selections move the waveform display to either the next or previous event or waveform. Finally the last selection will reset the vertical scale and position of the waveform display to a voltage range sufficient enough to view the current waveform(s).

Using the Navigation Bar

The navigation bar shown at the top of the window displays the relative time position of all waveforms recorded. The top yellow lines indicate DC coupled channel waveforms, while the bottom green lines represent the AC coupled channel waveforms. Normally only a small time span of all the recorded waveforms is viewed at any given moment. This time span is represented by the lightly shaded area on the navigation bar.



To pan the waveform display either earlier or later in time, left click the mouse on the lightly shaded area in the navigation bar. By holding and dragging the mouse, the display can be moved to any recorded waveform. This provides a rapid means to pan over a very large time frame.

A second method to use the navigation bar is to hover the mouse on top of any waveform. A small pop-up window shows the waveform the mouse is currently over. Clicking the mouse left mouse button then changes the time position and span time to match that of the waveform.

The third way the navigation bar can be used is by right clicking the mouse anywhere on the navigation bar and dragging it right or left. This also pans the waveform display (just as left clicking the mouse), but only over a limited time span (10 times current span). This is useful when viewing a very small time span and wishing to pan either left or right quickly. By using the right mouse click, the panning is limited to a reasonable range based on the current span instead of panning over the complete span of all waveforms.

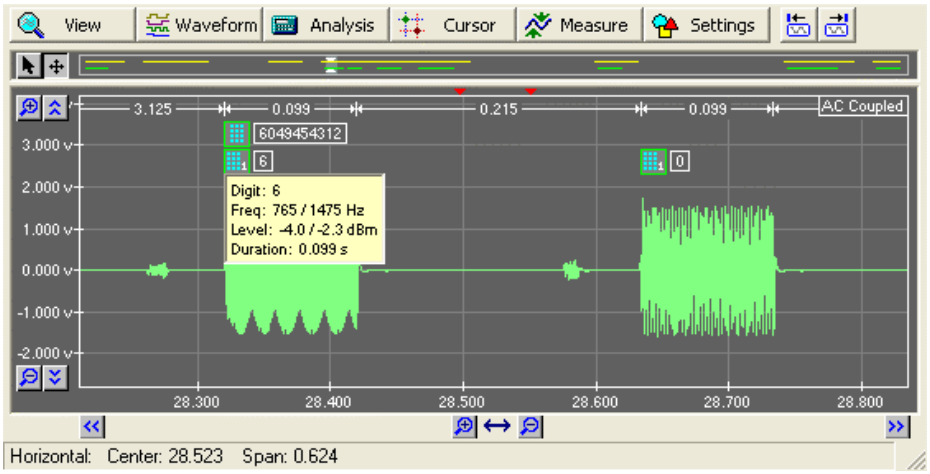
Using the Next/Previous Buttons

The last method to change the position of the waveform display is by using the 'Next/Previous' waveform buttons. These two buttons located at the top of Data Recorder window cause the display to shift to either the previous or next recorded waveforms. If only AC coupled channel waveforms are displayed, then the DC coupled channel waveforms are ignored. Likewise if only DC coupled channel waveforms are displayed, the AC coupled channel waveforms are ignored.

5.2.2 Event Markers & Timing

By default the waveform graphs also show the time position of any detected events. These are marked on the graph by various icons. Each event type is represented by a different icon. The figure below displays the event icons for DTMF dialing. The top most icon represents the DTMF dialing string of 10 digits, while the ones below it represent the individual digits. Holding the mouse over the icons causes measurement data to be displayed (if any exists). In the case of the DTMF digit below, the frequency,

level, and duration measurements are shown. For some events (DTMF, Caller ID, SMS, FSK, CAS/DTAS) clicking on the event icon changes the display to report mode showing more details of the event.

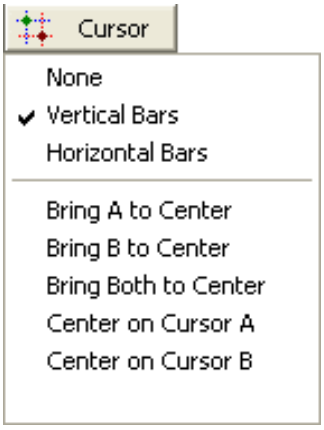


In addition to the event icons, timing lines are drawn at the very top of the graph. These timing lines correspond to the start time of events and the duration of events. In the example above, the timing lines display the duration of the two DTMF digits as well as their inter-digit time.

Both the event icons and timing lines may be toggled on and off by clicking the **View** button following by the appropriate menu command.

5.2.3 Cursors

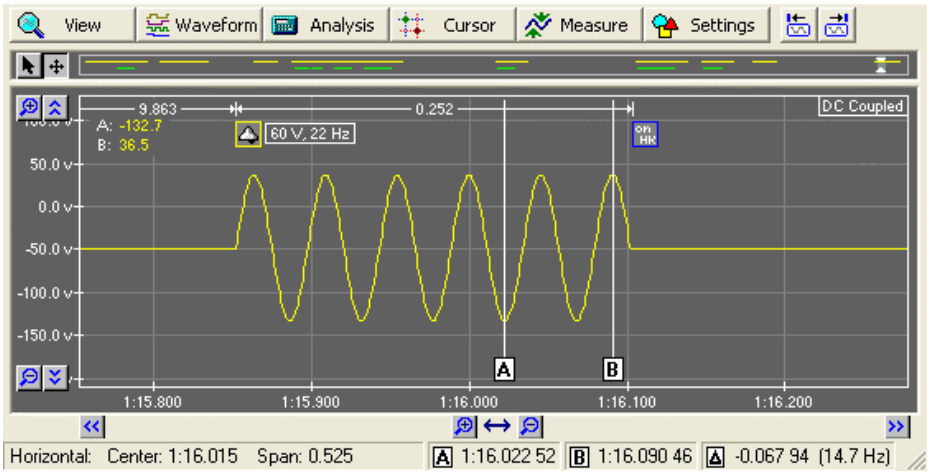
Cursors can be used to make various measurements on any displayed waveforms. All of the cursor functions are accessed by clicking the **Cursor** button. This displays the following list of menu selections.



Cursors can operate in either a horizontal or vertical mode. To change modes, simply click the **Cursor** button and select the desired mode. In either mode, two cursors (labeled 'A' and 'B') are made available for measurements.

The status bar at the bottom of the Data Recorder window displays the position of cursor A and B as either time (vertical), or voltage (horizontal). In addition, the difference between the two cursors (A minus B) is marked by the delta symbol.

To move the cursor, click the mouse on the box surrounding the letter 'A' or letter 'B' and drag. Once the desired position is reached, release the mouse button.



If vertical cursors are enabled, the point at which the cursor intersects the waveform is displayed in the top left corner of the graph. In the example figure above, cursor A measures a waveform voltage of -132.7 volts, while cursor B measures 36.5 volts.

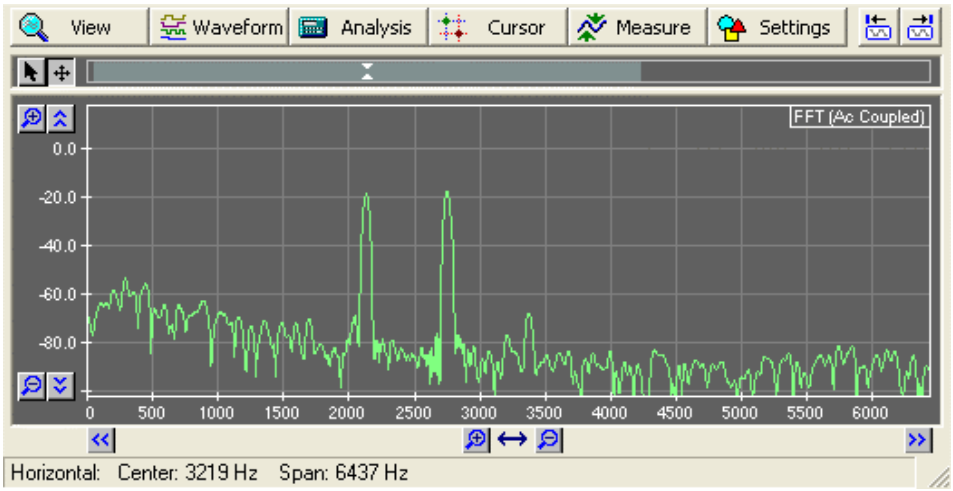
When displaying both AC coupled waveforms and DC coupled waveforms together, the vertical cursors track each other, keeping cursor A and B in both graphs at the same time position.

5.2.4 FFT Viewing Modes

In addition to showing waveforms in a time domain view, the spectral content of any waveform can be displayed. One of three different FFT display modes is selected by clicking the **View** button. The FFT display modes are:

- FFT of DC coupled channel waveform
- FFT of AC coupled channel waveform
- Split mode showing time domain and FFT of AC coupled channel waveform

The graph displays the magnitude of the FFT on the vertical scale versus the frequency along the horizontal scale. To change the FFT magnitude units, display the **General Settings** window and choose the FFT tab. The possible choices include volts, dBV, and dBm. In addition, the number of points used in the FFT calculation may be changed. As the number of points used is lowered, the frequency resolution decreases. However the minimum waveform time required is also reduced. Two small red triangles at the top of either the AC coupled or DC coupled waveform graphs represent the time span used to calculate the FFT. As the number of FFT points is reduced, these triangles move closer together.



The third type of FFT view (AC Coupled Channel with FFT) is different in that it splits the display into two regions. The top region shows the AC coupled channel waveform, while the bottom region shows the FFT of the waveform. The shaded area in the middle of the waveform graph represents the time span taken for the FFT calculation. As the waveform is panned either left or right, the FFT display is automatically updated.

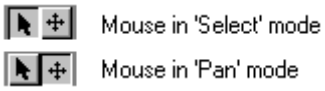
In this split display, the horizontal pan and zoom buttons are used to control both the top waveform graph and the bottom FFT graph, though not at the same time. The buttons modify the horizontal settings for the last graph selected. To change which graph is selected, click the left mouse button anywhere on the graph.

5.2.5 Waveform Management

The **Waveform** menu performs a number of different waveform functions. These include changing how the waveform is displayed, waveform playback, waveform export, and importing waveforms. To display the menu, click the **Waveform** button.

If more than one waveform is shown on the graph, some of the waveform menu functions may be disabled. This is because the Data Recorder needs to know which of the multiple waveforms displayed does the menu function apply to. Waveforms can be selected by clicking the mouse at any point on the waveform. Once selected the waveform is displayed in a white color. To select more than one waveform, hold down the keyboard CTRL button and click the desired waveforms. To de-select all waveforms click the mouse anywhere on the graph, except on a waveform.

Note that to select waveforms, the mouse must be 'Select' mode and not 'Pan' mode.



Playback

Choosing the playback command allows the selected waveform(s) to be played though either the PC's standard playback device (usually a sound card), AI-5120 speaker/BNC output, or possibly other devices. The playback command displays the Waveform Playback window. The first time the window is displayed, a playback device must be selected. Clicking the **Playback Using** button shows a list of possible playback devices. In the example figure below, the devices include the PC sound card, AI-5120 speaker output, AI-5120 BNC output, and AI-7280 Central Office Line Simulator. The AI-7280 selection only appears if it is connected to the TRsSim software. It can be used to play the recorded signal back onto a telephone line.

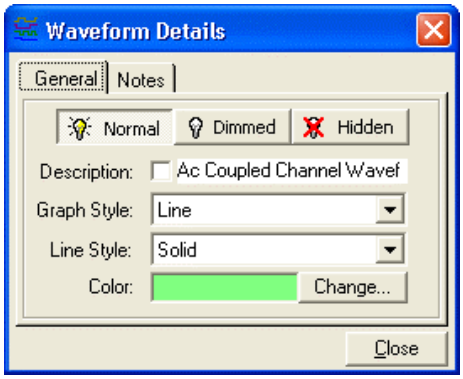
After selecting the playback device, the waveform is loaded into the device. Once finished, click the play button (green triangle) to start playback.

If more than one waveform is selected then the playback output is the sum of all waveforms. The timing relationship between multiple waveforms is preserved. For example if two waveforms each with a duration of 1 second are separated by 3 seconds, the total playback time will be 5 seconds, with 3 seconds of silence between the two waveforms.

Note that only the AC coupled waveforms may use the waveform playback function.

Details

To change the display characteristics of a waveform or to add notes, select the **Details** command after clicking the **Waveform** button. Only one waveform must be visible or selected for this command to be enabled. The command displays the Waveform Details window, as shown in the following figure. The first of two tabs marked **General** controls the display characteristics of the waveform. This includes settings to change the brightness of the waveform (or hide it), waveform description, graph/line style, and waveform color.



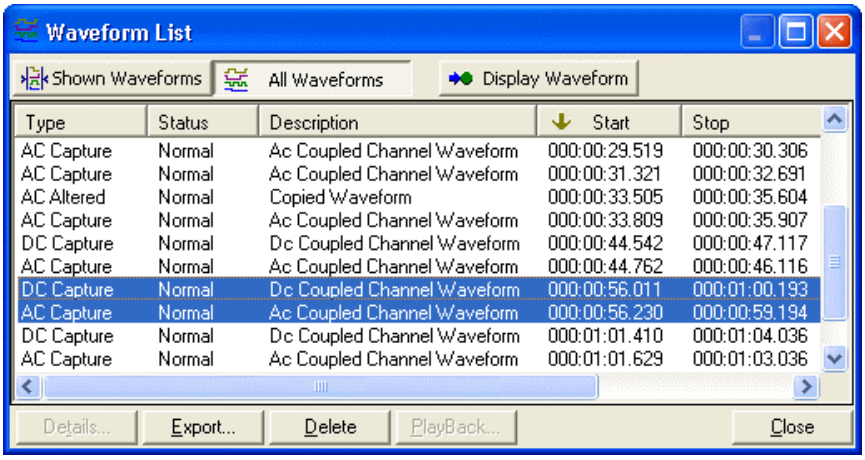
To add waveform notes, click the tab marked **Notes**. This displays a text area to enter notes linked to the selected waveform. Notes for any selected waveform are viewed by clicking the **Show Notes** command from under the **Waveform** menu.

If the waveform description is enabled, it is displayed at the bottom of the graph in the same color as the waveform. In addition, the presence of waveform notes is indicated by a small square box just to the left of the waveform description.

View List

The **View List** command shows a window listing either the currently displayed waveforms or all of the waveforms recorded. In addition, it shows the waveform type,

status, description, start time, stop time, duration, and sample rate. The list can be sorted on any column simply by clicking the mouse on the column heading.



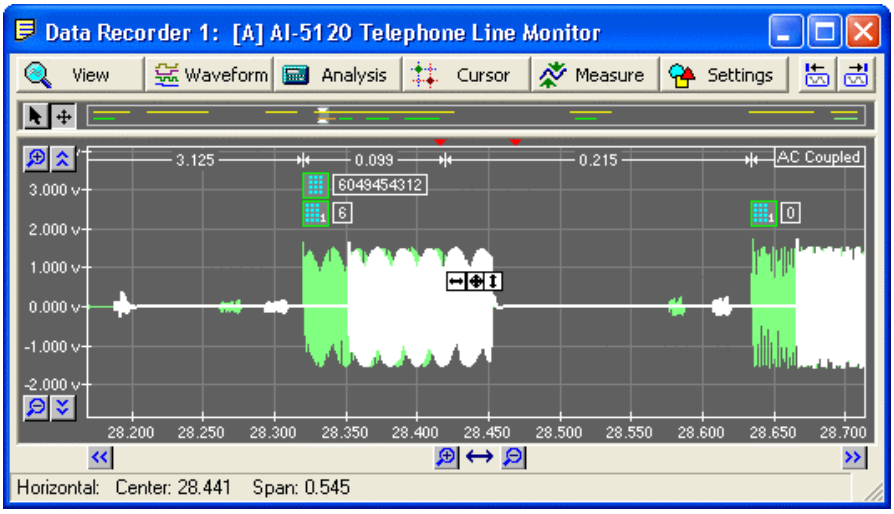
The two buttons at the top of the window, labeled **Shown Waveforms** and **All Waveforms** toggle between listing only the currently visible waveforms or all of the recorded waveforms. By selecting a waveform in the list, it can be displayed on the Data Recorder window by clicking the **Display Waveform** button. In addition, the buttons at the bottom of the window may be used to alter the selected waveform details, export the waveform(s), delete the waveform(s), or playback the waveform(s).

Send To

The **Send To** command can be used to send a copy of the waveform to another connected device. For example, if an AI-7280 Central Office Line Simulator was connected to the TRsSim software, the selected waveform could be transferred to the AI-7280. This allows the AI-7280 to playback the waveform from its telephone line port.

Copy & Float

Any of the recorded waveforms may be copied by selecting the waveform (if more than one is displayed) and clicking on the **Copy & Float** command. This makes a copy of the selected waveform and freezes its horizontal position on the display. As the graph is panned either left or right, the copied waveform does not change its screen position. This allows it to 'float' in time.

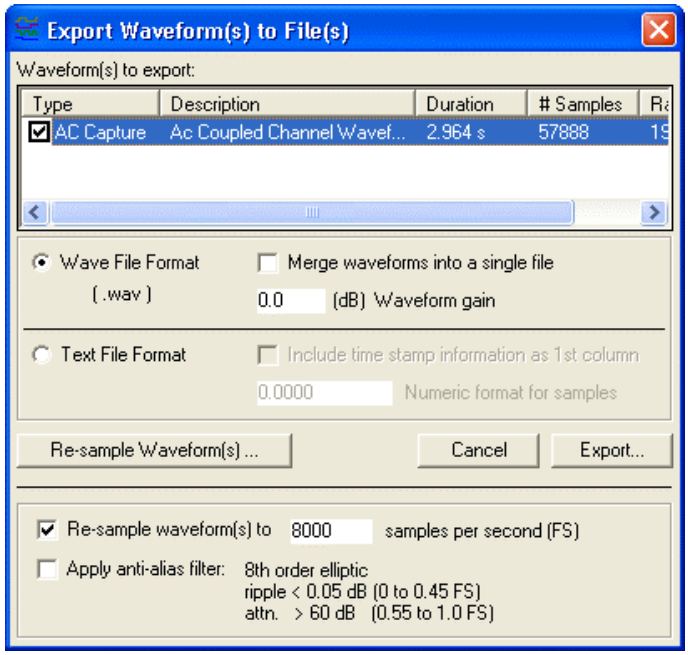


After panning the display to the desired horizontal position for the copied waveform, select the **Lock Position** command from the **Waveform** menu. This locks the copied waveform's time position on the graph. It now pans just like all the other waveforms shown.

The three directional controls shown at the center of the window can be used to shift the position of the 'floating' waveform. Click the mouse on either of the three controls and drag the waveform to the desired position. The left most control only allows the waveform to slide left or right, thus maintaining its correct vertical position (voltage offset). The right most control does the opposite by allowing a change in vertical position (voltage offset) while keeping the same horizontal position. Finally clicking the middle control allows the waveform to be dragged in both directions at the same time.

Export

Any of the recorded waveforms may be exported to a file in either a wave file format (.wav) or text file format. Clicking the **Export** command from the waveform menu (or from the **Waveform List** window) displays the following window. All of the selected waveforms are shown in the list including information on the duration, number of samples, and sample rate.



If the wave file format is selected, the resulting file is formatted as a 16 bit wave file containing a single channel. Multiple waveforms may be either merged into a single file or separate files created for each waveform. If the waveforms are merged, the timing relationship between the waveforms is preserved. Any gaps between waveforms is replaced with silence (zero codes). The scaling factor used to convert AC coupled waveforms results in +/-5 volt range translating into wave file codes of -32768 to +32767. Optionally gain or loss to the scale factor can be specified by entering the amount in the text box provided.

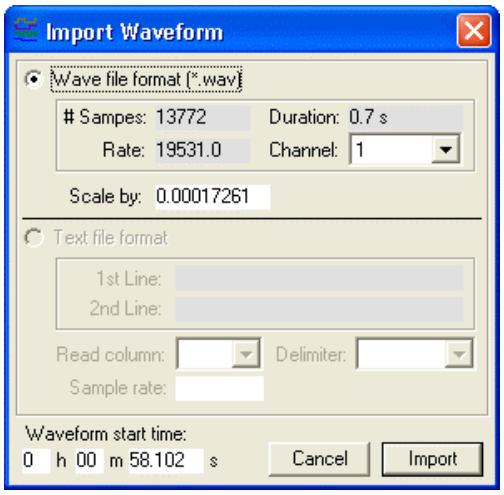
The text file format is simply a listing of all the waveform's sample points. Each sample point is separated by a carriage return and line feed character. Optionally, the time of each sample may be included in the file. The colon character ':' is used as the field separator. If multiple files are selected, multiple text files are generated. Each with a number appended to the file name. The number starts at one for the first file and increments with each additional file exported.

If the **Re-Sample Waveform(s)** button is pressed, the window expands to show additional controls. These settings allow the sample rate of the waveforms to be converted before writing the wave or text files.

Import

The Data Recorder window can import waveforms and display them by selecting the **Import** command. After selecting the file to import it is read and a determination of its format is made. Following this the Import Waveform window is displayed.

For wave file formats, the window shows the number of waveform samples, sample rate, and duration. If more than one channel is present, the channel to import is selected from the drop-down list box labeled **Channel**. The scaling factor is assumed to be the same as used by the Data Recorder when exporting waveforms. This is the value used to convert the 16 bit waveform samples to volts.



If a text file is read, an attempt is made to extract the column containing the waveform samples, delimiter character, and sample rate. These may by changed if incorrect by entering a new value for the field.

For either the wave file format or text file format, the time position at which to insert the waveform must be specified. This time position represents the first sample of the imported file and is by default the exact midpoint of the currently displayed span. To change this time, click the mouse in either the hour, minute, or second fields and enter a new value. Finally to complete the waveform import process, click the **Import** button.

Note that imported waveforms are sample rate converted to match the native rates used by the AI-5120. For the AC coupled channel this is approximately 20,000 samples per second, and for the DC coupled channel it is approximately 1200 samples per second.

5.2.6 Analysis & Measurements

The **Analysis** and **Measure** buttons shown at the top of the Data Recorder window are part of an optional software component that can perform various waveform analysis and measurements. Unless the component is enabled, the menu selections are disabled. To check if the option is present, see the section: Hardware Setup on page 83.

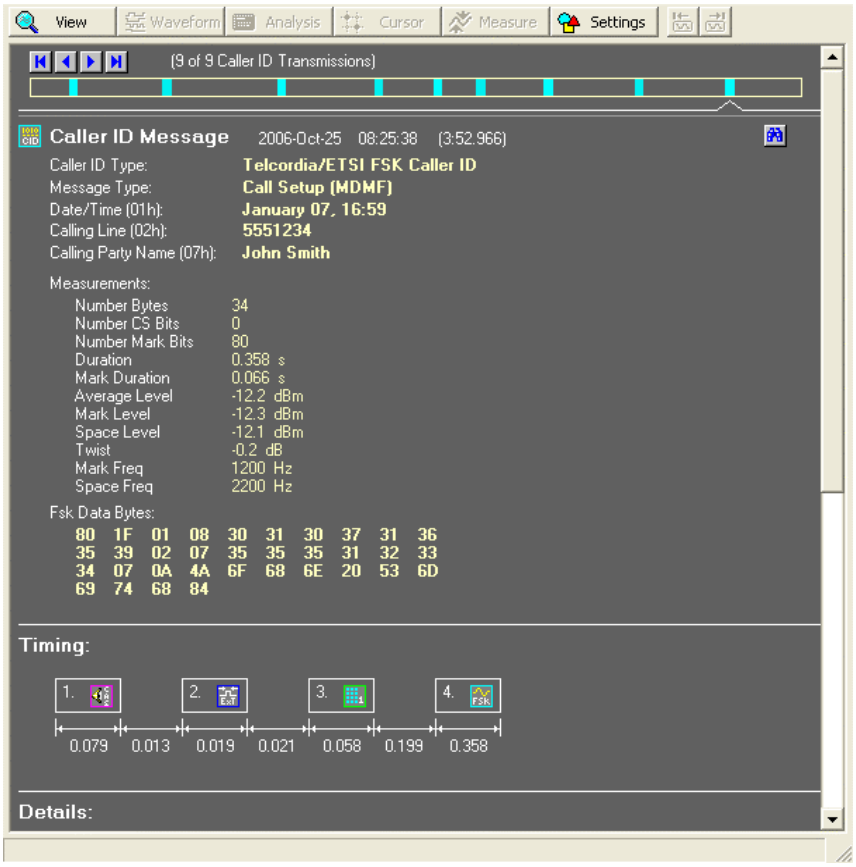
For more information on the waveform analysis and measurement functions, see the section: Waveform Analysis Option on page 58.

5.3 Caller ID Summary Report

The Caller ID Summary report scans all of the FSK Caller ID events detected and summarizes information on each FSK Caller ID transmission. To show this report, click the **View** button and then select the **Caller ID Summary** command.

An example of this report is shown in the following figure. The top of the display shows a time line representation of all the Caller ID transmissions detected. Each Caller ID event is shown as a light blue box with its position on the time line indicating relative timing relationship to the other Caller ID transmissions.

To select different Caller ID transmissions, click the mouse on either its representation on the time line (light blue rectangle), or click on one of the four navigation buttons in the top left corner. The buttons (from left to right) select the first, previous, next, and last Caller ID transmission detected.



Below the displayed header is a summary of the selected Caller ID transmission consisting of three sections. The first section lists details on the Caller ID message contents as well as FSK waveform measurements and a listing of the decoded data bytes.

Note that if the Waveform Analysis option is not enabled, many of the measurements displayed above are not available.

The second section in the summary shows the timing between any events that make up the Caller ID transmission. In the example shown above, the Type II (on-hook) Caller ID transmission started with a CAS/DTAS tone, to which the TE (Terminal Equipment) following with an Extension-in-Use check 13 ms later. Following this was a DTMF ACK signal with a duration of 58 ms. Finally 199ms after the DTMF ACK signal, the FSK message was sent.

The third section shown for every Caller ID transmission lists all the events, and any applicable measurements, that were part of the Caller ID transmission.

To the right side of each event listed, up to three buttons may be displayed.

Depending on the buttons display, clicking on them will either display the waveform associated with the event, display more information about the event, or select that event in the main control panel.

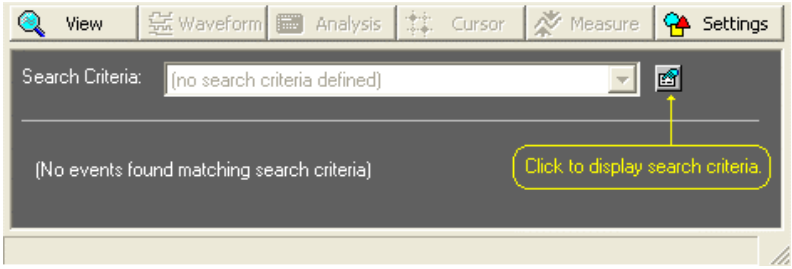
5.4 Event Searching

In situations where the AI-5120 has collected a large number of events, it can be a difficult task to find the occurrence of specific conditions. This may include events with unexpected measurements, or invalid sequences of events, or combinations of both.

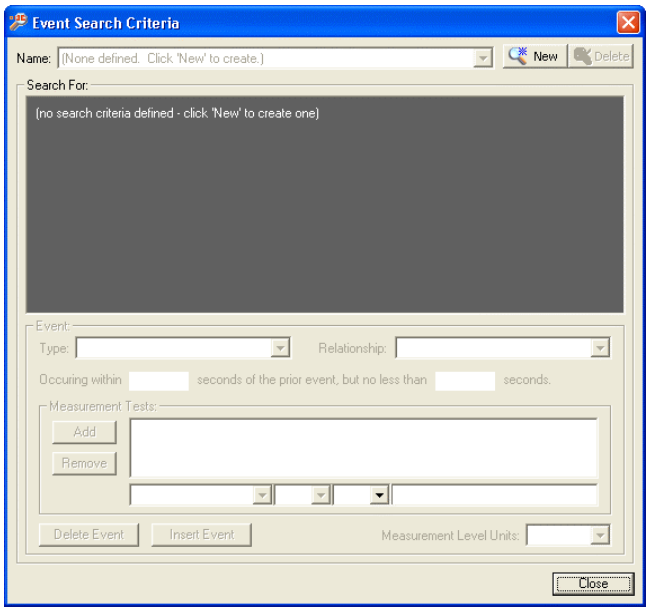
The Data Recorder window can be configured to scan for events that match a defined search criteria. Once search criteria are defined, a check for any matches can be initiated by clicking the **View** button and selecting **Search Results**.

5.4.1 Defining Event Search Criteria

Before any event searches can be made, the search criteria must be defined. This is done by opening the 'Event Search Criteria' window. To do this, click the **Settings** button followed by the **Event Search Criteria** command. As an alternative, when displaying the search results, click the button that is shown to the right of the 'Search Criteria' drop down list.



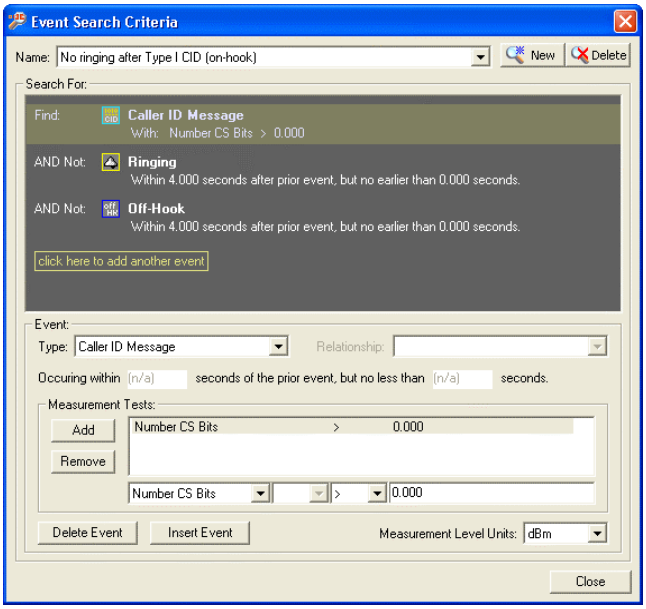
Many different search criteria can be defined, as each one is identified by a name given to it when created. When the search criteria window is first displayed, there are no criteria defined. As such, the first step is to click the **New** button in order to create a new search criteria. A window appears requesting a unique name for the criteria. Once a name is entered and the **OK** button clicked, a search criteria can be defined.



The following figure shows an example of a search criteria named 'No Ringing after Type I CID (on-hook)'. It defines a criteria that looks for Type I (on-hook) Caller ID that did not follow with ringing or the line state going off hook.

Search criteria are composed of a list of events that have logical relationships defined between them. In addition to logical relationships, timing restrictions can be placed between events as well. The events themselves may be defined with measurement criteria. In this example, the search criteria is as follows:

> *Find a Caller ID event that has greater than zero channel seizure bits (Type I – on hook CID) and then ensure no ringing event occurs within 4 seconds or no off-hook event occurs within 4 seconds.*



In the Event Search Criteria window, events are listed in the top half of the window. If there are no events, then click the text labeled 'click here to add another event' to add an event. When an event is selected, it is highlighted by a lighter background color. To select different events, simply click the mouse on any event in the list.

The bottom half of the window is used to specify the logical and timing relationships for the selected event along with any measurement requirements. As shown in the example above, the first event (Caller ID Message) has no logical or timing relationships. It does however, require that the number of channel seizure bits measured is greater than 0. Such a condition indicates that the Caller ID message is Type I (on-hook), since Type II (off-hook) messages do not send channel seizure bits. If multiple measurement requirements are placed on an event, they must all evaluate to 'true' in order for the event to evaluate as 'true'. Measurement requirements can be added or removed by clicking the **Add** and **Remove** buttons.

Note that some measurements may not be available if the Waveform Analysis option is not enabled. This is because the measurement is not made by the AI-5120, but rather it is derived from an analysis of the recorded waveform.

The second and third events in this example are Ringing and Off-hook. Both events are specified with an 'And Not' logical relationship and a timing requirement of 0 to 4 seconds from the Caller ID event.

There are four different logical relationships that can be used to define search criteria. The combination of event requirements, logical relationships, and timing creates a logical expression that must evaluate to true in order for the condition to be met. Note that the logical expression is evaluated from the top event to the bottom event with equal precedence between relationship operators.

The four event relationships that can be used are:

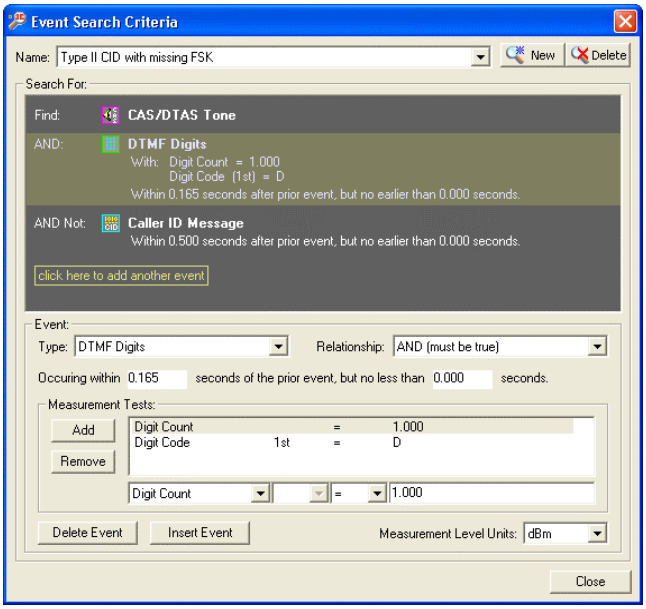
- AND: The logical expression is true if: a) the expression formed by all prior events evaluates to true, and b) the current event must be present, and c) the current event must meet any measurement requirements defined, and d) the timing between the current event and last usable event must be within limits.
- OR: The logical expression is true if: a) the expression formed by all prior events evaluates to true, or b) the current event is present and any measurement requirements are met. Note that timing limits do not apply when the OR relationship is used.
- AND NOT: The logical expression is true if: a) the expression formed by all prior events evaluates to true, and b) the current event is not present within the timing limits, or c) the current event is present within the timing limits but does not meet all the measurement requirements.
- XOR: The logical expression is true if either (but not both) conditions occur: a) the expression formed by all prior events evaluates to true, b) the current event must be present, and the current event must meet any measurement requirements defined, and the timing between the current event and last usable event must be within limits.

Note that when a prior event in the list uses the AND NOT operator, that prior event can not be used for checking timing limits against the currently selected event. This is because the prior event may not be present in the first place, so no timing data exists. As such, for events that follow an AND NOT event, any timing limits refer to the last event which does not use the AND NOT relationship. This is why in the example above, the timing limit for the 3rd event (off-hook) refers back to the first event (Caller ID), and not the 2nd event (ringing).

As a second example to creating search criteria, the next figure shows the events and settings required to find what should have been a Type II (off-hook) Caller ID transmission in which the FSK data was not sent. The logical expression for this search would be as follows:

Find a CAS/DTAS event that is followed by a DTMF ACK (D) within 165 ms and then ensure no Caller ID event is found within 500 ms of the DTMF ACK.

To create these criteria, three events are used. The first event is a CAS/DTAS tone. No measurement requirements are placed on this event. The second event is a DTMF digit event with the logical relationship of AND to the CAS/DTAS tone. This requires both events to be present. Two measurement requirements are placed on the DTMF event. The first is a digit count of 1 (only a single DTMF digit), and the second is that the digit code is 'D' representing the ACK signal. The third event is Caller ID message with the AND NOT relationship.

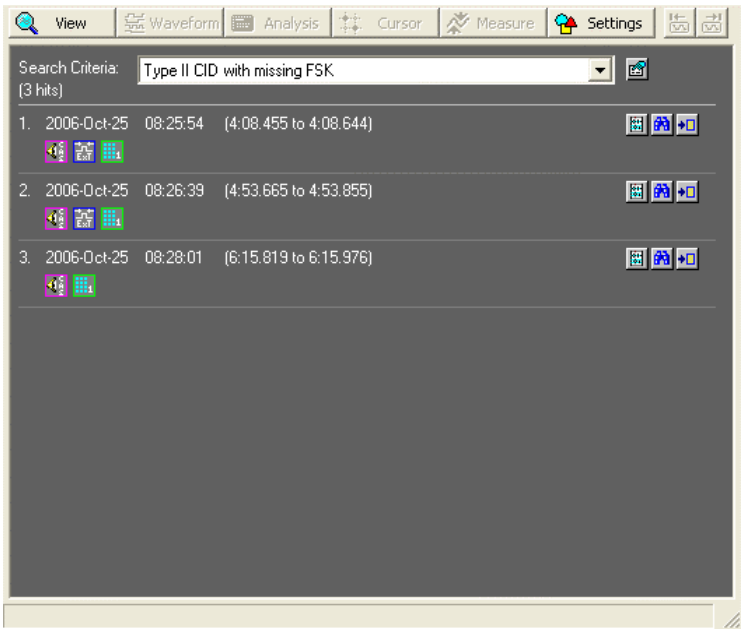


The logical expression created by this search criteria is evaluated true, if: a) CAS/DTAS event is found, and b) single DTMF digit 'D' is detected within 165 ms of the CAS/DTAS, and c) no Caller ID message event is found within 500 ms of the DTMF digit event.

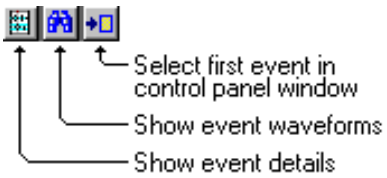
5.4.2 Displaying Search Results

Once one or more search criteria have been defined, the search results report can be viewed by clicking the **View** menu followed by **Search Results**.

The drop-down list box shown at the top of the display contains all of the search criteria defined. By selecting one of them, the results of the search are listed. Using the example criteria defined in the previous section, three 'hits' were found. As shown in the following figure, each occurrence in the list shows the time range that contained the required event pattern and all the events detected within that time range.



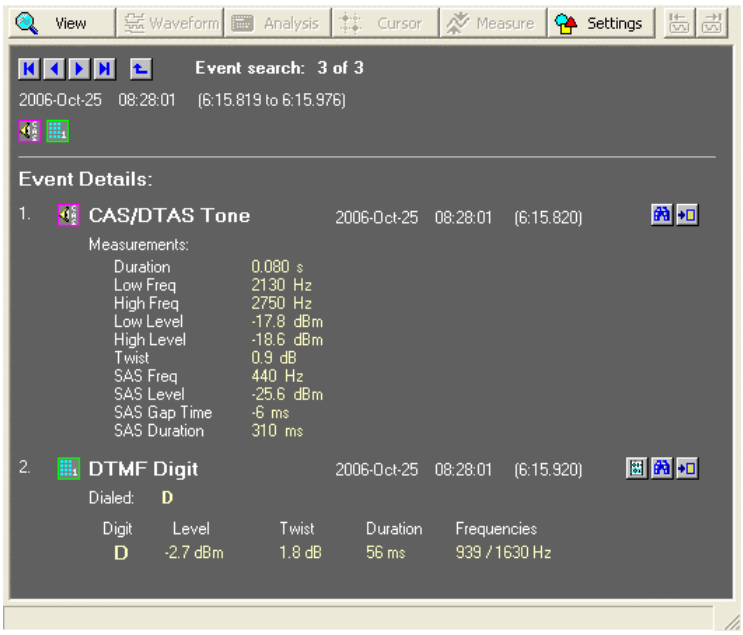
The three buttons shown at left side of each search hit perform the following action when left clicked with the mouse.



The left most button changes the display to show more detailed information on each event that is present in the time range representing the search 'hit'. Clicking the button changes the window to display as the following figure shows. The top of the display shows the same summary information as the prior list. However, below this the details of each event are shown.

In the top left corner of the display are four buttons used to select any one of the three search 'hits'. Their function from left to right are: show first occurrence, show previous occurrence, show next occurrence, and show last occurrence.

The fifth button causes the display to return to the summary listing.

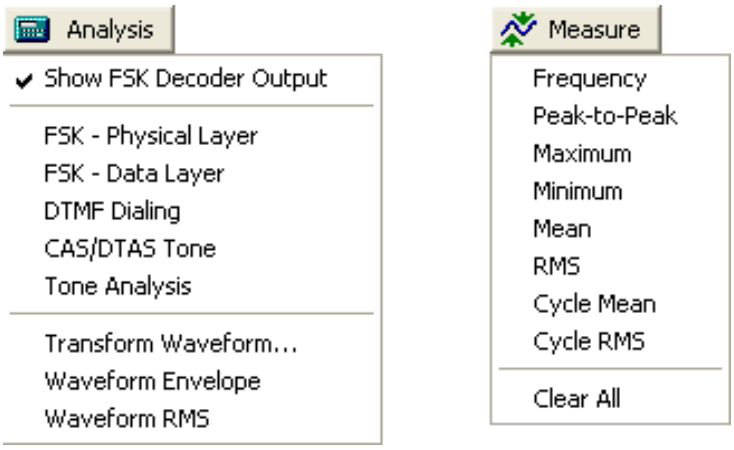

View
Waveform
Analysis
Cursor
Measure
Settings
Event search: 3 of 3
2006-Oct-25 08:28:01 (6:15.819 to 6:15.976)
Event Details:
1. CAS/DTAS Tone 2006-Oct-25 08:28:01 (6:15.820)
Measurements:
Duration 0.080 s
Low Freq 2130 Hz
High Freq 2750 Hz
Low Level -17.8 dBm
High Level -18.6 dBm
Twist 0.9 dB
SAS Freq 440 Hz
SAS Level -25.6 dBm
SAS Gap Time -6 ms
SAS Duration 310 ms
2. DTMF Digit 2006-Oct-25 08:28:01 (6:15.920)
Dialed: D
Digit Level Twist Duration Frequencies
D -2.7 dBm 1.8 dB 56 ms 939 / 1630 Hz

6. Waveform Analysis Option

This optional component to the TRsSim software provides additional analysis and measurement tools. They perform a more in-depth examination of recorded FSK, DTMF, and CAS/DTAS waveforms as well as the ability to apply general purpose filtering and waveform adjustments. The measurement tools add a simple method to determine waveform characteristics such as frequency, min/max, mean, and RMS level.

The ability to detect and analyze network tones and tone sequence events requires the Waveform Analysis option be enabled. This is because the AI-5120 lacks the ability to completely process and extract measurements on these events on a real time basis. As such, once waveforms are downloaded from the AI-5120, the ensuing analysis determines if a valid tone was detected and determines its freq, level, and duration characteristics.

Integrated into the Data Recorder window, the optional features can be accessed from the **Analysis** and **Measure** buttons. Clicking either of them presents a menu showing the available waveform analysis functions and measurements.



The **Analysis** menu selections include the ability to annotate FSK waveforms with the bit and byte values, and perform an analysis on any recorded waveforms looking for specific signals. These include FSK modulated signals containing Caller ID or SMS messages, DTMF dialing, CAS/DTAS signals, or a general tone analysis that attempts to look for tones matching any predefined templates or sequences. Additionally, a selected waveform can have various filters applied or its RMS level profile and envelope displayed.

The **Measurement** menu lists eight possible measurements that are applied to any displayed waveform. Any combination of the eight different measurements can be active at any given time.

Note that the Waveform Analysis component automatically executes when specific events are detected. The analysis provides additional measurement results that are displayed with the event in either the main control panel, or one of the event list displays.

Controls that determine which events trigger an automatic analysis can be found in the **General Settings** window. See the section: General Settings on page 72 for more information.

6.1 FSK Analysis

The FSK analysis functions provide three main features. They are:

- **Viewing FSK Decoder Output**: If enabled, the bit and byte values encoded within the FSK message and the binary FSK decoder output are displayed underneath the waveform.
- **Physical Layer Analysis**: Any selected waveform can be subjected to an analysis that searches for FSK data bytes as well as performing various signal measurements.
- **Data Layer Analysis**: Similar to the Caller ID and SMS analysis performed on the detected events, this analysis can be extended to any recorded or imported waveform.

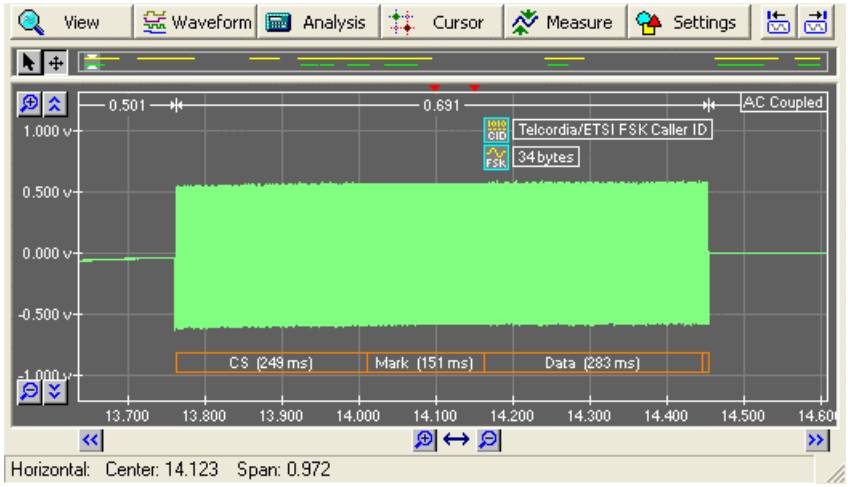
The following sections provide more information regarding the use and operation of the FSK analysis features.

6.1.1 Viewing FSK Decoder Output

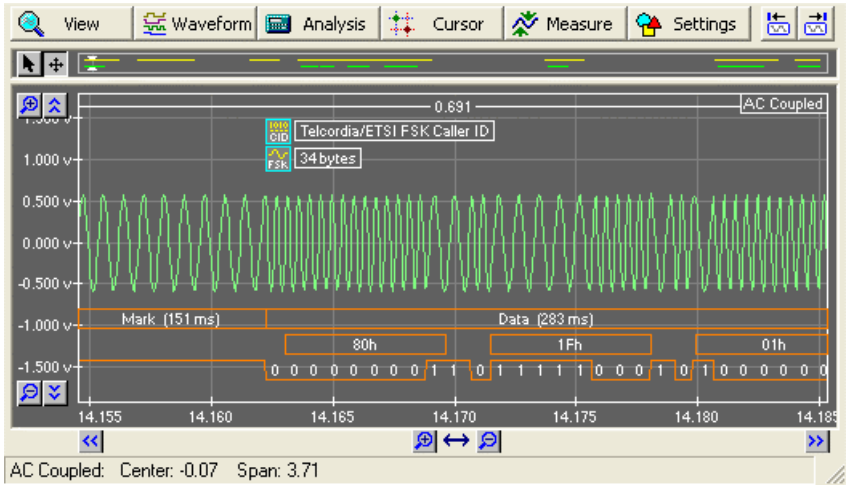
For any waveforms that have been analyzed for FSK signals, the output of the FSK decoder may be displayed underneath the waveform. The decoder converts the waveform into a logical 1/0 signal and decodes the signal into bits and bytes. Bytes are assumed to be encoded from LSB (least significant bit) to MSB (most significant bit). All LSB's must be preceded by a single start bit (space or logical zero), and all MSB's must be followed by at least one stop bit (mark or logical one).

The FSK decoder display is toggled on or off by selecting the **Show FSK Decoder Output** command from the **Analysis** menu.

In the figure below, the FSK decoder only shows the channel seizure, mark, and data periods for a Caller ID message. This is because the waveform is too "zoomed out" to show the bit and bytes value.



Zooming into the FSK waveform expands the display of the FSK decoder output to include the data bytes and data bits. The next figure shows the first two bytes of the Caller ID message. The byte values 80h and 1Fh are surrounded by a rectangle with its width representing the start time and stop time of the byte. If any byte values signify an ASCII printable character, it is shown (enclosed in single quotation marks) after its hexadecimal value. Underneath the byte values are the decoded bits from the FSK message. The bits are shown for each data byte, including start and stop bits.



By default, if Caller ID, SMS, or other FSK events are detected by the AI-5120 the FSK decoder output is automatically generated once the recorded waveform data has been transferred to the PC. As processing the waveform data can take a significant amount of time on older PC's and slow down the software's responsiveness, the automatic analysis may be disabled. This parameter is located in the **General Settings** window, under the **Waveform Recording** category. The **Automatic FSK Decode** parameter may be turned on or off by clicking on the drop-down list and choosing a new setting.

6.1.2 Physical Layer Analysis

The FSK physical layer analysis performs an in-depth measurement of any selected waveform. The waveform is searched for FSK messages, and if found, the bit and byte values are decoded. In addition, various measurements of the signal characteristics such as mark/space level and frequency are made.

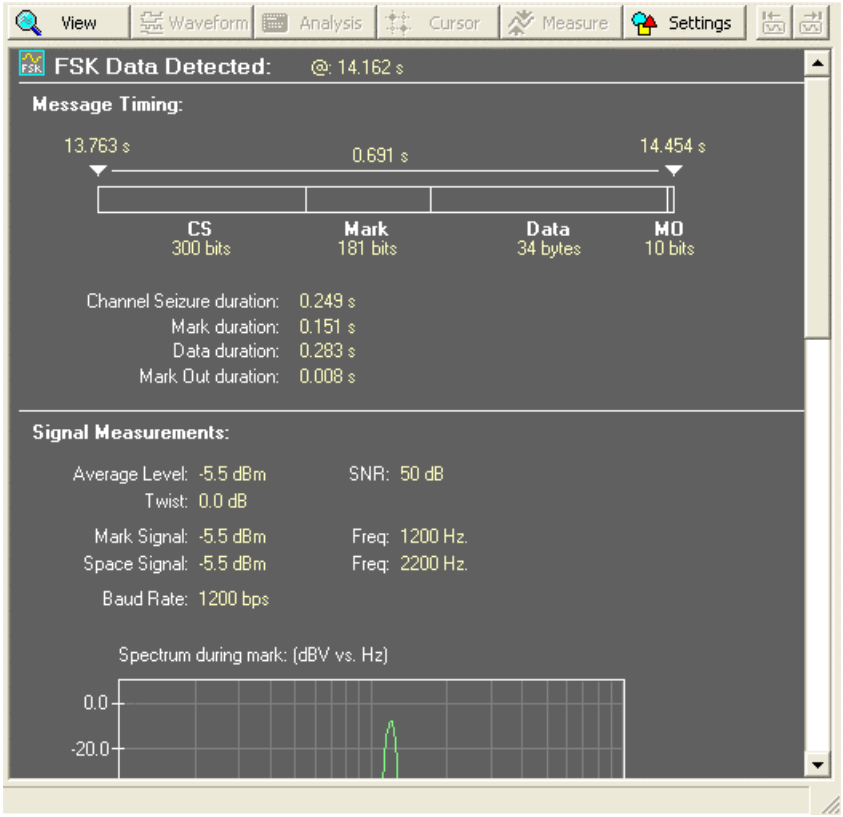
To perform the analysis ensure only one waveform is visible within the Data Recorder window, or select the desired waveform by clicking on it. Then click the **Analyze** button followed by the **FSK - Physical Layer** selection. Once the analysis has completed, a report is generated with the results.

For each FSK message detected, the report shows three sections. The first provides information on the message timing. This includes the duration and number of bits/bytes for channel seizure, mark, data, and mark out. Mark out is defined as any mark bits sent following the last data byte (normally the checksum).

The second section in the report shows the FSK signal measurements. The measurements include readings for the average level, mark level, mark frequency, space level, space frequency, signal to noise ratio, and baud rate. A graph shows the results of a FFT taken during the mark time. This provides information about any interfering signals that may be present during the FSK message.

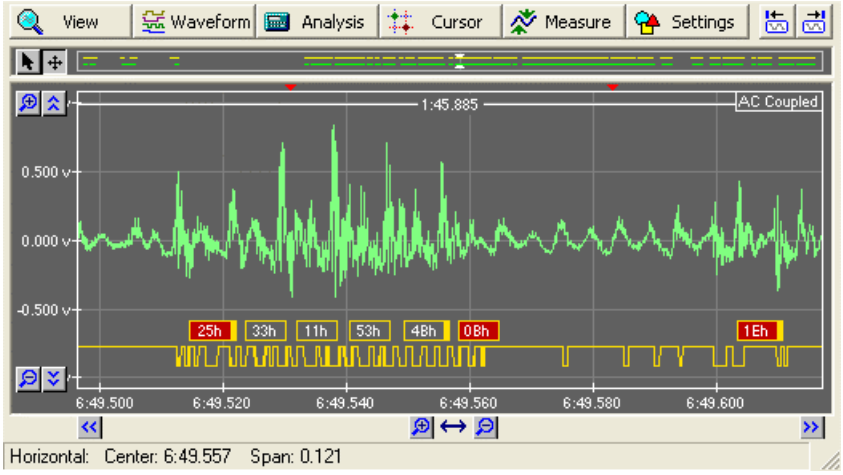
Finally, the third section of the report lists the values of all data bytes detected.

The figure below shows an example FSK analysis of a waveform containing a Caller ID message.



Note that depending on the message bit pattern, some measurements may not be possible. For example, if an insufficient number of consecutive zero bits are contained within the message, an accurate space frequency and space level measurement can not be made.

If after running the physical layer analysis, a valid FSK signal could not be found, a message is displayed with the option to show the output of the FSK decoder anyway. If 'Yes' is selected, the FSK decoder output is displayed underneath the waveform. The following figure shows the result of running a FSK analysis on a short segment of speech.



The FSK decoder waveform at the bottom of the display shows either a high (mark) or low (space) state. Any bytes detected are shown just above the decoder output. Bytes that are displayed with a red background color indicate that at some time during the byte,

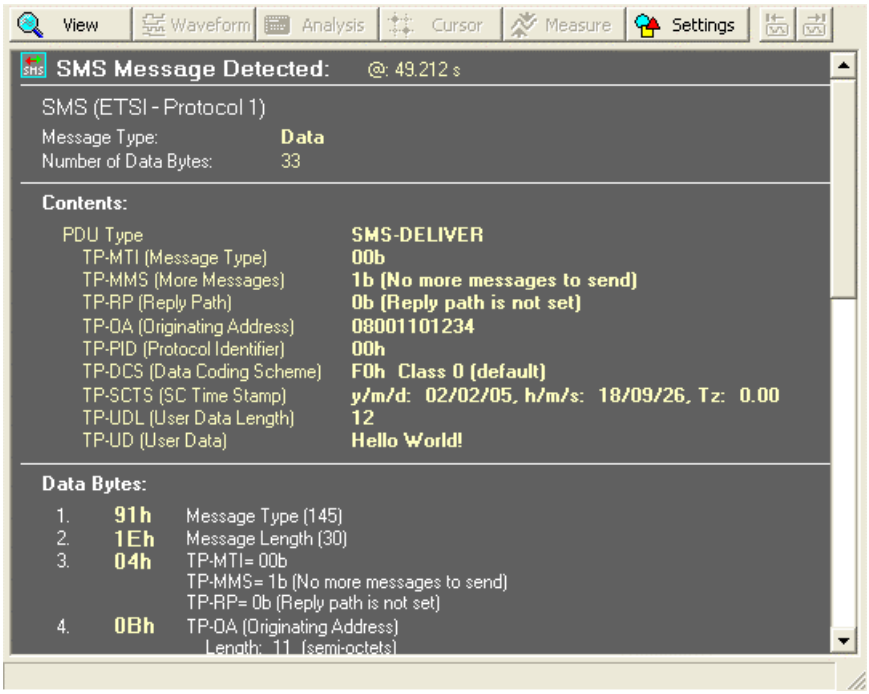
the FSK signal level dropped below the minimum threshold. Also, bytes detected with a framing error (stop bit is not mark), are shown with a yellow rectangle above where the expected mark bit should have been.

6.1.3 Data Layer Analysis

The FSK Data Layer analysis provides information on the content and structure of Caller ID or ETSI protocol 1/2 SMS messages.

To perform the analysis ensure only one waveform is visible within the Data Recorder window, or select the desired waveform by clicking on it. Then click the **Analyze** button followed by the **FSK - Data Layer** selection. Once the analysis has completed, a report displaying the results are shown.

The following example figure shows the contents of a ETSI protocol 1 SMS-DELIVER message. All of the fields contained in the message are listed as well as their contents. In addition each data byte in the FSK message is listed with a description.



The results of the data layer report contain the same information as detected Caller ID or SMS events. The only significant difference when performing the **FSK - Data Layer** analysis is that the source of the data can be any waveform. This includes waveforms recorded by the AI-5120 when FSK events are detected, or waveforms imported from files.

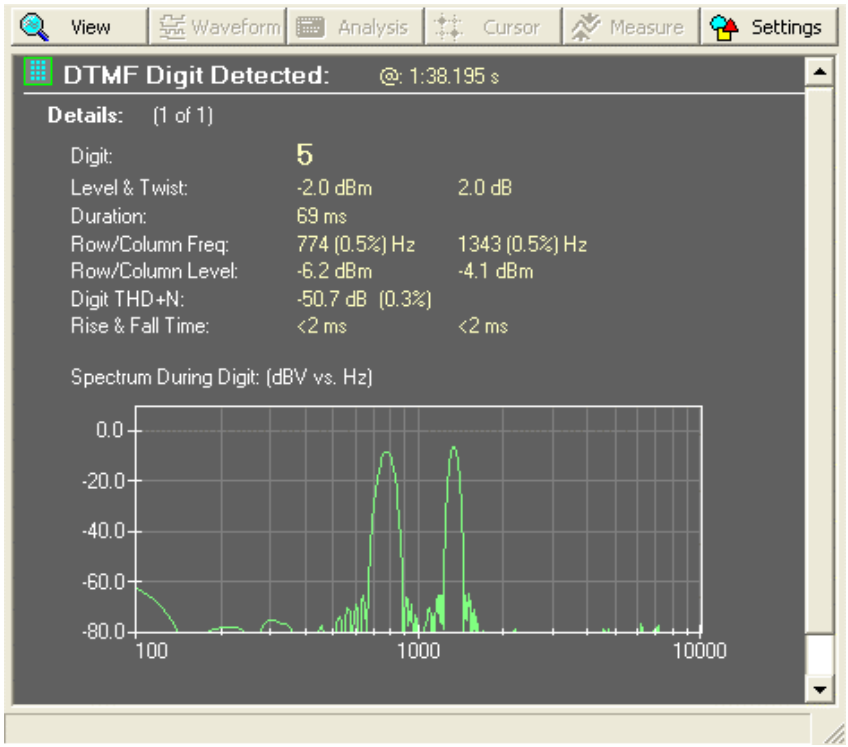
6.2 DTMF Analysis

The DTMF analysis function scans a selected waveform looking for DTMF dialed digits. If any digits are found, various measurements such a frequency, level, timing, rise/fall time, and distortion are made.

To perform the analysis ensure only one waveform is visible within the Data Recorder window, or select the desired waveform by clicking on it. Then click the **Analyze** button followed by the **DTMF Dialing** selection. Once the analysis has completed, a report is generated with the results.

If more than one digit is detected, the top section of the report includes a summary of all DTMF digits. The summary lists the level, twist, frequency error, and duration of all the detected digits. Following the summary is a more detailed analysis for each of the digits.

The example figure below shows the results presented for the single DTMF digit '5'. The report lists the measurements taken along with displaying a graph of the digit's spectral components and optionally a graph of the RMS/envelope level profiles. To view the RMS/envelope level profiles, click the 'Display DTMF level profile and envelope' box displayed in 'Analysis – DTMF' tab of the Settings window.



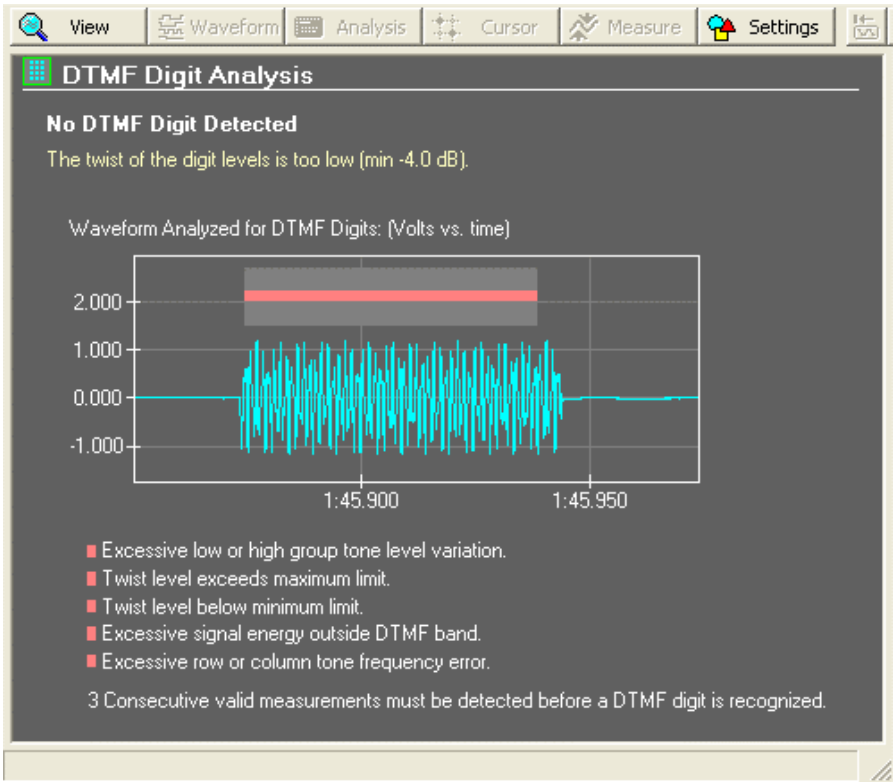
If any signal measurements are found to be outside the specified DTMF dialing limits, warnings are displayed in the report.

At times is may be useful to know why some signals that appear to be DTMF digits are not detected. If the analyzed waveform contains no DTMF digits, then a different report is shown that may provide information as to why. The following figure shows an example of a DTMF digit with a twist level outside of the specified detection limits. The report shows the waveform analyzed with additional information indicating why the digit was rejected. Five different checks are performed on the waveform, they include:

- Excessive low or high group tone variation
- Twist beyond maximum limit
- Twist beyond minimum limit
- Excessive signal energy outside DTMF band
- Excessive row or column tone frequency error

The result of each of the five checks is shown above the waveform as rectangular blocks. If a block is marked in a red color, then the check has failed. The example figure shows that for the entire duration, the twist level was below the minimum limit.

In order for a DTMF digit to be detected all of the checks must pass for at least three measurement cycles. This corresponds to approximately 30 ms.



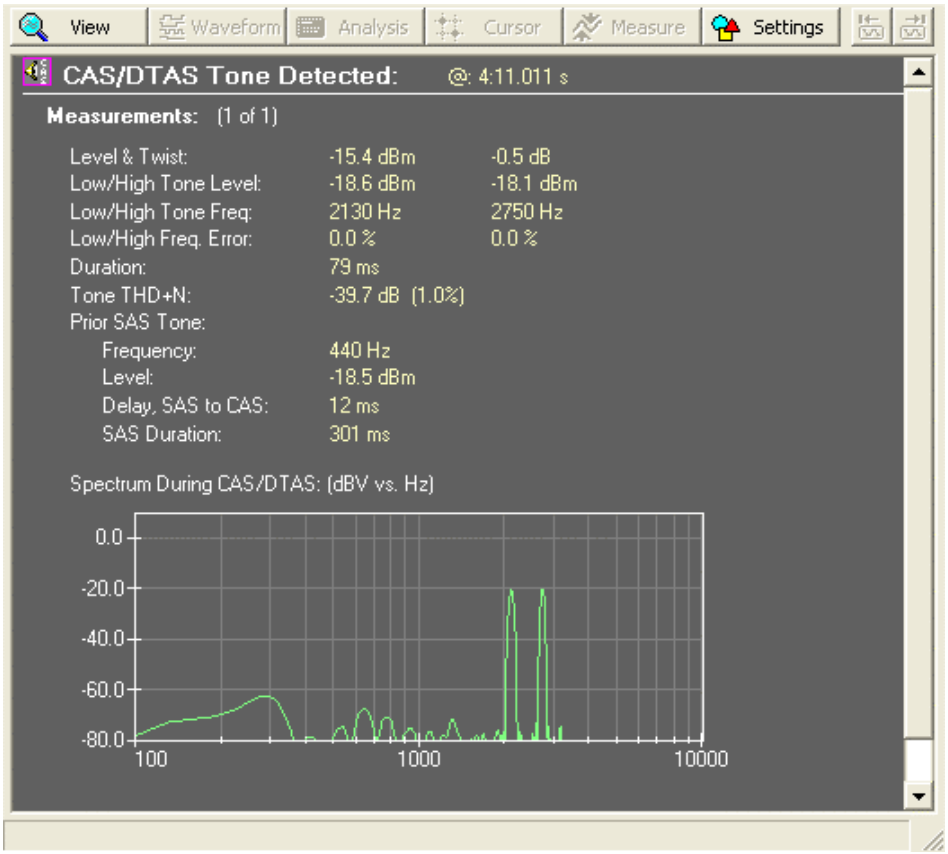
In some cases, it may be useful to only analyze a portion of a waveform for DTMF digits. This can be done from the Data Recorder settings window. Click the **Settings** button and select the **Analysis-General** tab. The selection shown in the drop-down box marked 'Range of waveform analysis' can be either: Entire Waveform, Visible Portion, or Between Cursors. Also, in the **Analysis – DTMF** tab, automatic distortion tests complying with the TIA-470 and ETSI ES 201 235 standards may be enabled. If the tests find excessive distortion or strong signal interference, warning messages are displayed.

6.3 CAS/DTAS Analysis

While the AI-5120 can detect CAS/DTAS signals, it is unable to extract measurements such as frequency and level. As such, an analysis is automatically executed once the recorded waveform data has been transferred from the AI-5120 to the PC.

To perform a manually initiated analysis for CAS/DTAS signals, ensure only one waveform is visible within the Data Recorder window, or select the desired waveform by clicking on it. Then click the **Analyze** button followed by the **CAS/DTAS Tone** selection. Once the analysis has completed, a report is generated with the results.

The following figure shows an example of the CAS/DTAS analysis report. It indicates that a single CAS/DTAS tone was detected in the waveform and lists the tone levels and frequencies.



If a SAS (subscriber alerting signal) was detected prior to the CAS/DTAS tone, the analysis attempts to extract its frequency and level. In the example above, a SAS tone was detected with a duration of 301 ms and ending just 12 ms before the CAS/DTAS tone started.

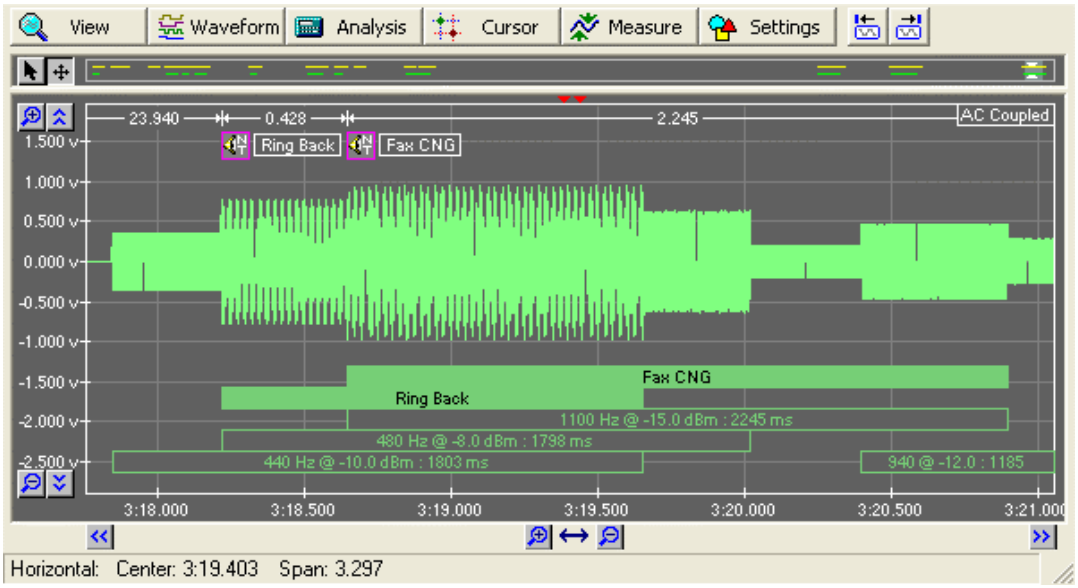
6.4 Tone Analysis

The tone analysis function scans a waveform looking for single frequency tones that remain consistent in level for their active duration. If it finds what looks like a 'tone', it attempts to extract the frequency, level, duration, and possibly distortion measurements. Even if tones overlap in time, the analysis can isolate them provided they are in the frequency range of 200 to 7200 Hz and are present for at least 75 ms.

This analysis function is initiated automatically if the AI-5120 detects a signal that may appear to match one of the define network tone templates or tone sequences. Once the waveform has been transferred to the PC, the tone analysis determines if in fact a defined tone template or tone sequence was detected. Once a valid tone is detected, the frequency, level, and timing parameters are extracted.

In addition to the automatic operation, a tone analysis can be initiated manually on any waveform recorded by the AI-5120, or any imported waveform. To perform the analysis ensure only one waveform is visible within the Data Recorder window, or select the desired waveform by clicking on it. Then click the **Analyze** button followed by the **Tone Analysis** selection. Any tones found by the analysis are displayed underneath the waveform.

The following figure shows an example of the tone analysis. The waveform analyzed contained a ring back tone overlaid with a fax CNG tone. Both the ring back tone and CNG tone were included in the tone templates and detected as separate events.



The analysis detected four separate tones in the waveform. The duration of each tone is representing by the rectangles shown underneath the waveform. Within each rectangle are the measurement results for the tone detected. In the case of the above example, the two ring back tones (440 Hz and 480 Hz) started slightly before the fax CNG tone (1100 Hz). Note that the two components to the ring back tone did not start at the same time. The 440 Hz component started before the 480 Hz (and ended sooner as well). In addition, before the end of the fax CNG tone, a 940 Hz tone was detected.

Since both the ring back and fax CNG tones were included in the defined tone templates, their duration is represented by the solid green rectangles that have the tone name displayed in the middle.

For information on how tone templates and tone sequences are defined, see the section: Program Settings on page 72.

6.5 Analysis Settings

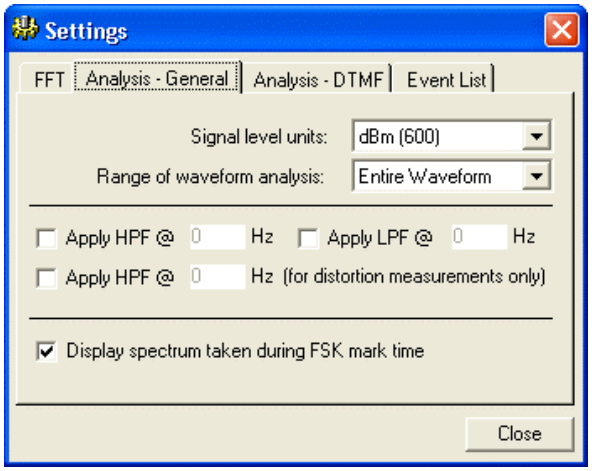
A number of settings are used in controlling the analysis of waveforms. To view or modify these parameters, click the **Settings** button at the top of the Data Recorder window and then select the **General Settings** command. This displays a window containing four tabs near the top. The two marked 'Analysis – General' and 'Analysis – DTMF' contain the applicable settings.

The controls shown on the 'Analysis – General' tab affect all the different analysis types (FSK, DTMF, CAS, tone) unless otherwise mentioned.

The drop-down list box at the top of the window determines what units are used for presenting signal level measurements. Possible selections include dBm (600 ohms), dBV, and mVrms. The default units are dBm (600 ohms).

The next setting controls the waveform range when performing any analysis. By default the entire waveform is analyzed; however, this may be restricted to either the visible

portion of the waveform (what is shown in the Data Recorded window), or the portion between the two vertical cursors.



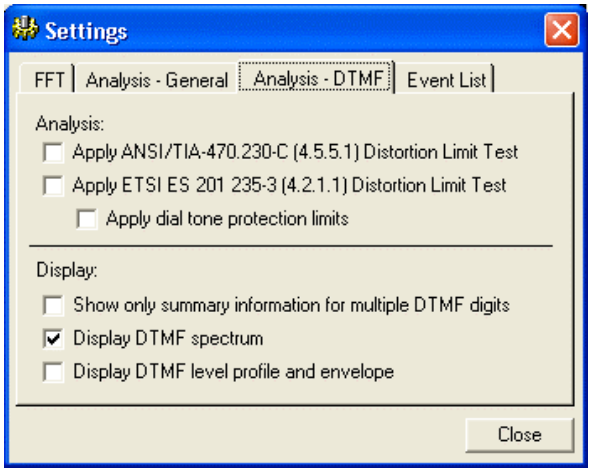
The next group of controls are used to enable optional low and high pass filters. If the corresponding check box is marked, a 4th order Butterworth low and/or high pass filter may be applied to the waveform before any analysis is performed. The corner frequencies of both filters are programmable between the range of 50 to 5000 Hz for the high pass filter and 100 to 10000 Hz for the low pass filter.

An additional 4th order Butterworth high pass filter may be enabled only when distortion measurements are made. This setting should be enabled when long settling times from DC voltage transients are disturbing the THD+N measurement results. The high pass filter can reject any low frequency signals and more importantly any DC offset voltage before the THD+N measurement is made.

The last setting only applies to the FSK signal analysis, and determines if the FFT taken during the mark time should be shown in the report display.

The controls shown on the 'Analysis – DTMF' tab only affect the DTMF dialing analysis.

The first three settings can be used to enable a distortion test for any DTMF digit detected by the waveform analysis. Descriptions of the test limits can be found in the TIA-470.230-C and ETSI ES 201 235-3 documents. While using different limits and test procedures, they both verify the signal during the DTMF digit does not contain excessive distortion or interfering noise/tone components.



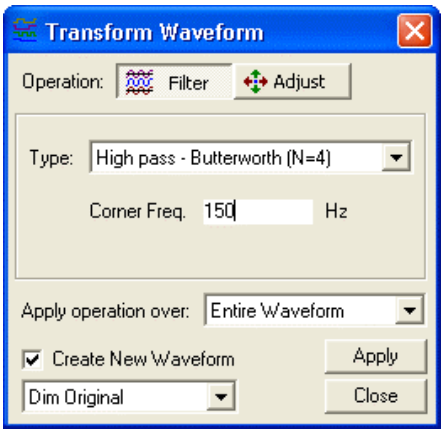
The last three settings affect how the analysis data is displayed for the DTMF reports. The first setting, if enabled, limits the report to only summary information, while the following two enable or disable the display of the DTMF spectrum and level profile.

6.6 Waveform Operations

A number of generic operations may be perform on any of the waveforms displayed in the Data Recorder window. This includes applying filters, adjusting their gain, DC offset, or time position. In addition, RMS level profiles and min/max signal envelopes can be computed and displayed for any waveform.

6.6.1 Waveform Filtering & Transforms

To modify a waveform, ensure that only it is visible within the Data Recorder window, or selected the desired waveform by clicking on it. Then click the **Analysis** button followed by the **Transform Waveform** selection. This displays the following window.



Two different types of operations may be performed. They are either filtering or adjusting the gain, offset, and time position of the selected waveform. The two buttons at the top of the window select the desired mode.

If filtering is selected, simply choose the filter type from the drop-down list. Some filters have programmable corner or center frequencies. These include the low pass, high pass, band pass, and notch filter selections. In those cases enter the desired corner or center frequency in the text box provided.

For either type of operation (filter or adjustment), the operation is normally applied over the entire waveform. However this can be changed to just the visible portion of the waveform or the portion of the waveform located between the vertical cursors.

If the **Create New Waveform** box is checked, then a new waveform is created rather than modifying the original waveform. The original waveform can be left in the normal state, dimmed, or it can be hidden. The last selection in the drop-down list deletes the original waveform once the operation is complete.

The waveform adjustment controls are shown in the above figure. For the selected waveform the following operations may be applied.

- **Gain Adjustment**: The waveform amplitude may be increased or decreased by specifying a gain value. If the **dB** box is checked, then the gain is to be specified in dB.
- **Offset Adjustment**: Entering a non-zero value offsets every sample of the waveform by that amount. This can be used to shift a waveform higher or lower in voltage. If the Remove DC box is checked, the mean value of the waveform is first subtracted from every sample point before any offset is applied.
- **Time Shift**: These settings allow the waveform (or portion of it) be shifted in time. The dropdown list selects how the time shift is specified. Possible selections include incrementing or decrementing the time of each sample point by a fixed amount. Another option is to directly specify the waveform start time. The last option is to offset the waveform by the time difference between cursors A and B.
- **Window Function**: One of four standard windowing functions may be applied to the waveform, if selected, from the drop-down list.

As with the waveform filtering, the adjustment operations may be applied over all or only a portion of the selected waveform.

6.6.2 Waveform RMS & Envelope

The RMS level profile of any waveform, or the min/max envelope for any waveform, can be generated by clicking the **Analysis** button followed by the **Waveform Envelope** or **Waveform RMS** commands.

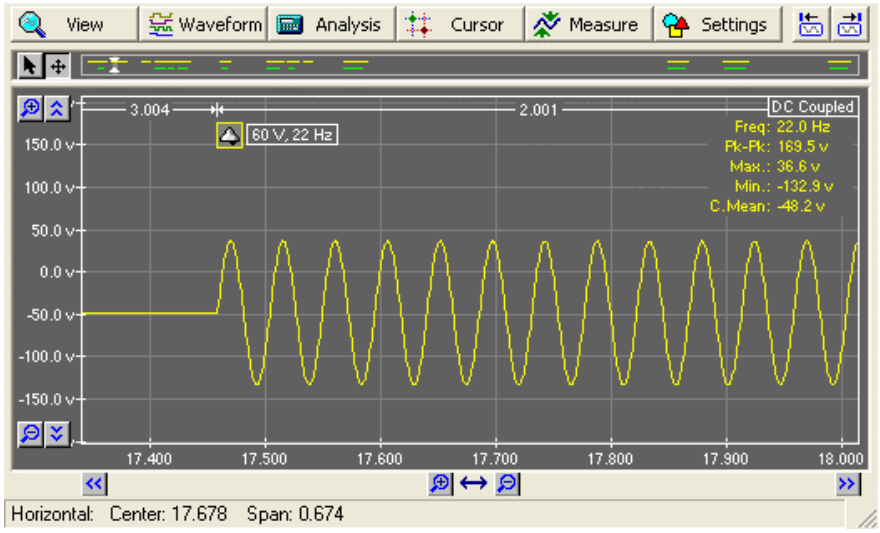
The envelope function creates two waveforms that represent the maximum envelope and minimum envelope of the original waveform. These waveforms can be measured and modified just like any recorded waveform.

The waveform RMS function generates a single waveform representing a smoothed RMS level of the original waveform. This can be useful in examining level variations in DTMF or FSK signals.

6.7 Measurements

Up to eight different signal measurements may be computed on any displayed waveform. They are toggled on and off by clicking the **Measure** button followed by the desired measurement. If the measurement name shows a check mark beside it, then it is currently active. All measurements may be turned off by selecting the **Clear All** command.

The figure below shows an example of measurements made on a ringing signal. The enabled measurements are frequency, peak-to-peak, maximum, minimum, and cycle mean. Measurements are displayed in the upper right hand corner of the Data Recorder window. Their color matches the waveform color in case more than one waveform is visible.



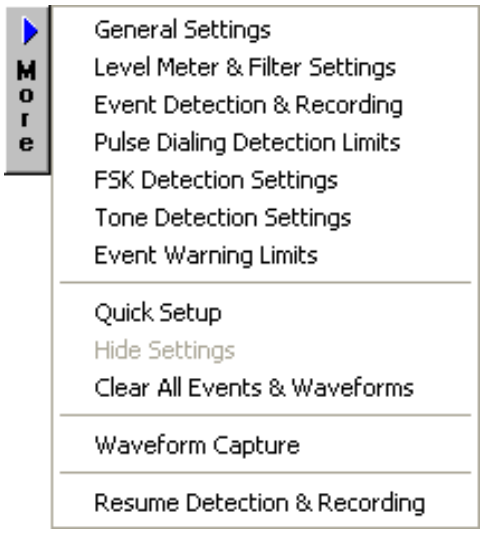
When the Data Recorder window shows large time spans, the measurement functions may not be accurate. This is because when greatly zoomed out, the measurement functions only operate on a subset of the all the waveform's data points. When this occurs the character '*' is displayed following the measurement value. For accurate measurements the time span should be reduced until the '*' character is no longer shown.

The measurements available are:

- **Frequency**: Measures the frequency of a periodic signal over the displayed range of the waveform. If the displayed waveform's period is not constant over the displayed waveform, an accurate frequency measurement can not be made.
- **Peak-to-Peak**: Returns the voltage difference between the highest displayed sample to the lowest displayed sample.
- **Maximum**: Returns the voltage of the highest displayed sample point.
- **Minimum**: Returns the voltage of the lowest displayed sample point.
- **Mean**: Returns the average of all sample points displayed.
- **RMS**: Returns the square root of the mean of the squared display sample points.
- **Cycle Mean**: Calculates the average of all sample points over a single period of the displayed waveform.
- **Cycle RMS**: Calculates the RMS (root, mean, squared) of all samples points over a single period of the displayed waveform.

7. Program Settings

This section provides more information on the various program settings. These settings are grouped into seven categories and are accessed by clicking the **More** button on the main control panel. This displays a pop-up menu from which the desired category is chosen.



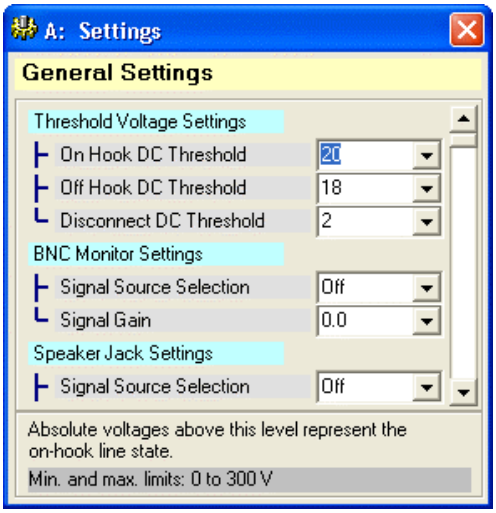
Selecting one of the first seven menu items opens a window containing the settings. For more detailed information on the various program settings, consult one of the following topics:

- **General Settings** on page 72.
- **Level Meter & Filter Settings** on page 75.
- **Event Detection** on page 76.
- **Pulse Dialing Limits** on page 77.
- **FSK Detection Settings** on page 78.
- **Tone Detection Settings** on page 79.
- **Event Warning Limits** on page 82

7.1 General Settings

The General Settings window provides access to various parameters controlling the AI-5120's operation. To display this window, click the mouse on the **More** button (located

on the main control panel) and select **General Settings** from the pop-up menu. Shown is a window similar to the following figure.



The various parameters are grouped into different categories. To modify any of the settings, simply click the mouse on the text box to the right of the parameter name and enter or select the new setting value. Displayed at the bottom of the window is additional information regarding the selected parameter along with minimum/maximum limits (if applicable). As only a few of the parameters are visible at any one time, use the scroll bar on the right side to slide the list either up or down.

7.1.1 Threshold Voltage Settings

The three parameters in this category set the voltage thresholds used in determining the telephone line state. The AI-5120 continually monitors the telephone line voltage and checks if changes in the voltage require a change in the displayed line state.

- **On Hook DC Threshold**: If the absolute line voltage exceeds this value, then the telephone line is deemed to be in the on-hook state.
- **Off Hook DC Threshold**: If the absolute line voltage falls below this value, but not below the Disconnect threshold voltage, then the telephone line is deemed to be in the off-hook state.
- **Disconnect DC Threshold**: If the absolute line voltage falls below this value, the telephone line is deemed to be in the disconnected state.

It is important that the threshold voltages listed be in descending order. That is the on-hook threshold must be greater than the off-hook threshold. Likewise, the off-hook threshold voltage must be greater than the disconnect threshold value.

7.1.2 BNC Monitor Settings

These two parameters control the rear panel BNC output connector of the AI-5120. It can be used to monitor the AC signals present on the telephone line. The output impedance of the BNC connector is 600 ohms with a maximum output level of approximately 5 Volts peak to peak.

- **Signal Source Selection**: Sets the signal source for the BNC output connector as either off (default), telephone line, or filtered. The difference between the telephone line and filtered selections is that choosing the filtered setting passes the AC coupled signal from the telephone line

through a programmable filter prior to output. The filter selection is made from the **Lever Meter & Filter** settings window.

- **Signal Gain**: Sets any gain (or loss) applied to the AC signal prior to output from the BNC connector. The range of gain is from -40 dB to +40 dB.

7.1.3 Speaker Jack Settings

Similar in function to the BNC monitor settings, these two parameters control the AI-5120 rear panel 3 mm mono speaker jack connector. This connector can be used to listen to the audio signals on the telephone line via either a speaker or headphone.

- **Signal Source Selection**: Sets the signal source for the speaker jack connector as either off (default), telephone line, or filtered. The difference between the telephone line and filtered selections is that choosing the filtered setting passes the AC coupled signal from the telephone line through a programmable filter prior to output. The filter selection is made from the **Lever Meter & Filter** settings window.
- **Signal Gain**: Sets any gain (or loss) applied to the AC signal prior to output from the speaker jack connector. The range of gain is from -40 dB to +40 dB.

7.1.4 Waveform Recoding Settings

The parameters in this category effect waveform recording when events are detected by the AI-5120.

- **AC Signal Capture Post Event**: Sets the amount of time recording continues after the event has been detected. For some events like DTMF or FSK, the time delay is referenced from the end of the digit or FSK, not from when it was detected. This setting applies to the AC coupled channel only.
- **DC Signal Capture Post Event**: Determines how long after an event is detected the recording of the DC coupled channel will continue.
- **Automatic FSK Decoding**: This setting can only be enabled if the Waveform Analysis option is present. If enabled, the TRsSim software automatically performs an analysis of the FSK message once it has been recorded. The analysis allows the message bit and byte values to be displayed on the Data Recorder waveform window.
- **Automatic DTMF Analysis**: This setting can only be enabled if the Waveform Analysis option is present. If enabled, the TRsSim software automatically performs a DTMF dialing analysis once the waveform has been recorded by the AI-5120.
- **Automatic CAS Analysis**: This setting can only be enabled if the Waveform Analysis option is present. If enabled, the TRsSim software automatically performs a CAS/DTAS tone analysis once the waveaform has been recorded by the AI-5120.
- **Record AC Channel on DC**: If enabled, then the AC coupled channel is recorded any time the DC coupled channel is recorded. For some DC related events, such as on-hook, off-hook, line reversal, the AC coupled channel is not recorded. However this setting can force the recording of the AC coupled channel.

7.1.5 Event & Waveform Data

The TRsSim software can be configured to delete events and waveforms after a specified time period has elapsed. The default setting is 'never', which means that events or waveforms are never automatically deleted. However if the AI-5120 is operating for long periods of time, it may be desirable to set a time limit for the captured data.

- **Time to Flush Captured Data**: Sets the amount of time to hold detected events and recorded waveforms before deleting them from memory or temporary storage files. This delay time can be set from 15 minutes to 1 week, or the default selection of 'never'.

7.1.6 Digital Output Settings

The operation of the three AI-5120 rear panel digital outputs is controlled by the following parameters. The digital outputs are an open collector configuration with an approximately 5 kohm pull up resistor to +5 volts.

- **Output A Function**: Sets the state of output A as either fixed low (default), fixed high, or mirror the state of the FSK decoder. If set to mirror the state of the FSK decoder, the output is logic high when either no signal is detected or mark bits are detected. For space bits the output is driven low.
- **Output B Function**: Sets the state of output B as either fixed low (default), fixed high, or mirror the ring detector state. If set to mirror the ring detector, the output goes to logic high when ringing is detected.
- **Output C Function**: Sets the state of output C as either fixed low (default), fixed high, or mirror the hook detector state. If set to mirror the hook detector state, the output goes to logic high when the line changes to the off-hook state.

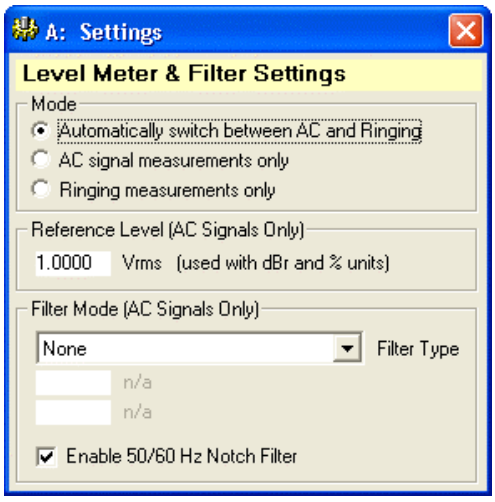
7.1.7 Miscellaneous Settings

The only setting in this group determines if the AI-5120 is to resume event detection and waveform recording after a configuration file is loaded. By default, loading a configuration will stop all event detection and waveform recording.

- **Resume Upon Config File Load**: If set to yes, then once a configuration file is loaded the AI-5120 resumes detection of events and recording of waveforms. The default setting is no.

7.2 Level Meter & Filter Settings

The Level Meter & Filter Settings window controls the operation of the main control panel level meter. In addition, it determines if optional filters are applied to the AC signal path. To display the window, click the mouse on the **More** button (located on the main control panel) and then select **Level Meter & Filter Settings** from the pop-up menu. This shows the following window.



The level meter shown on the main control panel shows either AC signal measurements or ringing measurements. Normally the mode changes automatically when the AI-5120 detects ringing. The **Mode** selection shown in the above figure can be used for fix the measurements to either AC signal or ringing.

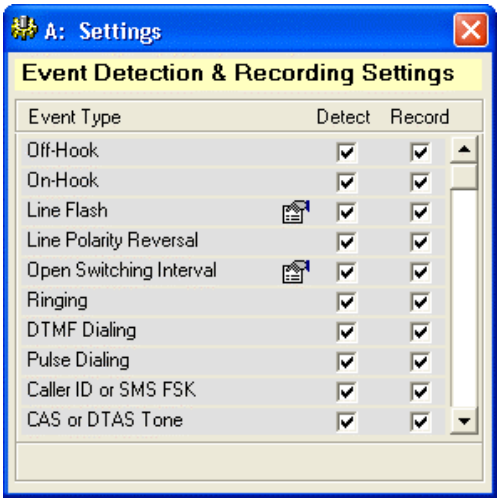
The **Reference Level** text box shows the AC signal reference level used in the calculation with dBr or % units. This is only applicable if the main control panel level units are selected as either 'dBr' or '%'. To specify a new reference level, simply enter a value into the text box.

Various filters may be applied prior to measuring the AC signal frequency and level shown on the control panel's meter. To select a filter, simply click on the drop-down list box shown in the figure above. One of nine different filter configurations can be chosen. This includes low pass, high pass, band pass, notch filters, DTMF band splitting filters, and a c-message weighted filter. Some of the filters have one or two adjustable corner/center frequencies. If they are selected, the corner or notch frequency must be entered in the appropriate text box. If any of these filters are enabled, they only effect the measurements displayed on the main control panel, and the signals present at the BNC output and speaker jack connectors. The filter setting has no effect on the AC coupled waveform recording.

The last filter option is a 50/60 Hz notch filter. This is used to minimize the effect of power supply hum noise and is enabled by default. Unlike the above filter setting, the notch filter applies to all AC coupled signals within the AI-5120. As such, any recorded waveforms will be subjected to this filter, if enabled.

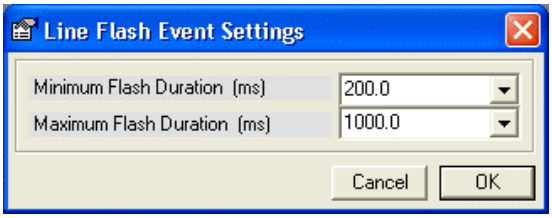
7.3 Event Detection

The Event Detection & Recording Settings window is used to select which events are detected by the AI-5120. Additionally, for some events, detection limits can be viewed and modified. To display the window, click the mouse on the **More** button (located on the main control panel) and then select **Event Detection & Recording** from the pop-up menu. This shows the following window.



Events will be detected and time stamped by the AI-5120 if a checkmark is present in the **Detect** column. The **Record** column indicates if any waveforms should be recorded once the event is detected. If an event is not enabled for detection, then it can not be enabled for recording.

 Some events, such as Line Flash, display a **properties** icon to the right of the event name. The icon means that additional settings are available that may effect event detection. Clicking the mouse on the icon displays a new window showing any properties of the event that can be modified. For example, clicking on the Line Flash properties icon displays the following window.

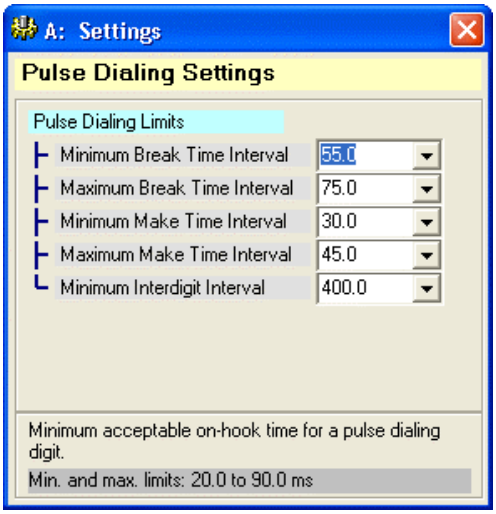


The Line Flash event has two additional settings. These set the minimum and maximum detectable flash time. Only line flashes with durations between these limits are detected by the AI-5120.

Note that the Network Tone, and AC Frequency Sweep events can not be enabled unless the Waveform Analysis option is present. This is because these events are generated by the results from analyzing waveforms transferred from the AI-5120.

7.4 Pulse Dialing Limits

The Pulse Dialing Limits window is used to specify the detection limits for any pulse dialed digit. To display the window, click the mouse on the **More** button (located on the main control panel) and then select **Pulse Dialing Limits** from the pop-up menu. This shows the following figure.

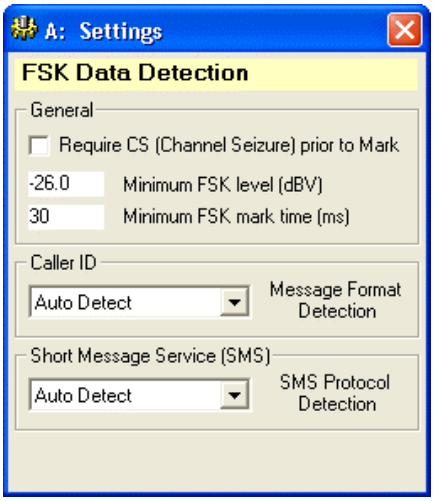


The minimum and maximum break time limits define the range of time the telephone line must be in the on-hook state. The make time range then defines the amount of time required between the on-hook pulses. The number of pulses determines the dialed digit (from 1 to 10, 10 representing digit zero).

It should be noted that the break and make times are calculated by measuring the voltage present on the telephone line. This may cause slightly different readings than if the loop current is used to determine the timing.

7.5 FSK Detection Settings

The FSK Detection Settings window controls the operation of the FSK decoder and any subsequent message analysis. To display the window, click the mouse on the **More** button (located on the main control panel) and then select **FSK Detection Settings** from the pop-up menu. This shows the following figure.



The three settings grouped in the **General** category apply to all FSK messages. If the "Require CS" setting is checked, then all FSK message require a channel seizure signal to be present prior to the mark signal. Channel seizure is defined as an alternating one/zero bit pattern with a duration of at least 50 ms (60 bits).

The following two text boxes control the minimum FSK signal level needed for detection as well as the minimum mark signal time prior to the data bytes. The minimum FSK level is defined in units of dBV and can range from -40 dBV to +10 dBV. For the mark time, its limit can be set to any value in the range of 25 ms to 100 ms.

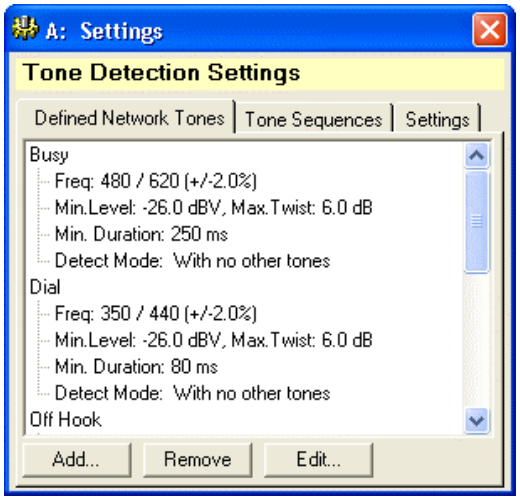
For Caller ID messages, by default the AI-5120 automatically determines the message format as either conforming to the Telecordia/ETSI standard or to the Japanese NTT standard. If required, it can be fixed to only detect one of the two formats by clicking the mouse on the dropdown list box.

Similar for SMS, by default the AI-5120 automatically determines the protocol as either ETSI protocol 1 or ETSI protocol 2. However it can be forced to interpret all SMS messages in one of the two possible formats.

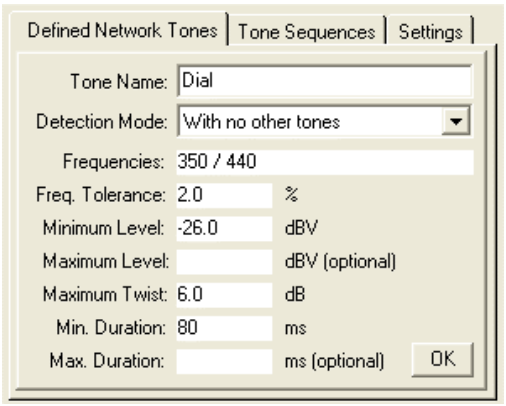
7.6 Tone Detection Settings

The Tone Detection Settings window is used to define network tone templates and tone sequences. Note that the Waveform Analysis option is required for the detection of network tone templates and tone sequences. The detection of the Network Tone and Tone Sequence events only occurs once a waveform has been transferred by the AI-5120 to the PC and analyzed.

To display the window, click the mouse on the **More** button (located on the main control panel) and then select **Tone Detection Settings** from the pop-up menu. This shows the following window.



The first of the three tabs is used to define network tone templates. These templates define the basic characteristics of a tone that the AI-5120 is trying to detect. Normally the window shows a listing of all the tone templates defined and their settings. To add a new tone template or remove one, click the **Add** or **Remove** button respectively. If the Add button is clicked, a message is displayed requesting the name for the new tone template. Entering a unique name and clicking **OK** changes the window to display the following.



Clicking the **Edit** button also changes the window to display the figure above.

With the above window settings, all of the characteristics for the selected tone template can be modified. Two of the fields, maximum level and maximum duration, are optional. If no maximum limit is desired, leave these two fields blank.

The detection mode determines how the tone is to be treated in the presence of other tones. The three possible settings are:

- **With no other tones**: No other tones may be present at the same time as this tone, otherwise the tone will not be detected. This is the most restrictive setting in that no other tones can be present at the same time.
- **With only defined tones**: No undefined tones may be present at the same time as this tone, otherwise the tone will not be detected. This setting allows other tones to be present, but only if the tones are identified as matching a tone template.
- **With any other tones**: This tone will be detected regardless of what other tones are detected at the same time. This is the least restrictive detection mode.

The frequency text box must contain the frequencies that make up the network tone template. Up to five different frequencies may be defined and must all be in the range of 200 to 5000 Hz. Two different 'separators' may be used to list the frequency. The first is using the '/' character. By using this character to separate frequencies, it means that the frequencies must occur at the same time. For example, a frequency list of:

350 / 440

means that both a frequency of 350 Hz and 440 Hz must be present at the same time in order for the template to match. The second type of separator character is '>'. It is used to denote frequencies that are separated in time. For example, the frequency list of:

950 > 1400 > 1800

means that a signal must consist of three tones of 950 Hz, 1400 Hz, and 1800 Hz in succession in order for the template to match. It is possible to combine the two different separators. For example, the frequency list of:

350 / 440 > 480 / 620

means that a signal must contain frequencies of 350 Hz and 440 Hz at the same time, which is then followed by 480 Hz and 620 Hz at the same time in order for the template to match. Note that the '/' separator has precedence over the '>' operator.

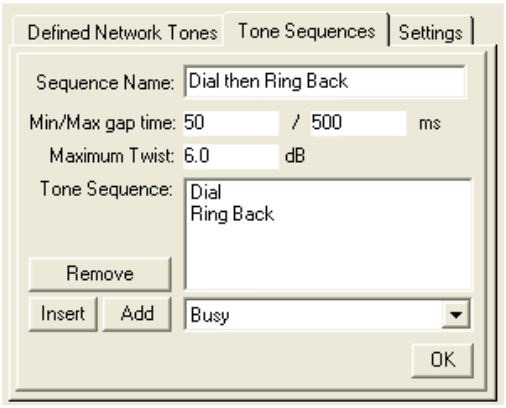
Using the '>' separator provides a simple means to define a tone sequence. In situations requiring the detection of a more complex sequence, special 'tone sequence templates' can be defined. These offer more flexibility in creating complex conditions. They are discussed later in this section.

In addition to the frequency list, a frequency tolerance, minimum level, maximum twist, and minimum duration complete the settings for a tone template. Note that the twist limit is only applicable if more than one frequency is specified.

Clicking the **OK** button modifies the tone template and returns to the list view.

In addition to network tone templates, the Tone Detection Settings window is used to define tone sequences. A tone sequence is simply a combination of network tones with specific timing requirements. The sequence allows defining which network tones must occur and in what order.

Tone sequences are created, deleted, and edited by clicking on the second tab. Similar to the tone templates, a list of sequences are shown, of which one can be selected. Adding or deleting a sequence is accomplished by clicking the **Add** or **Remove** button respectively. Creating a new sequence or editing an existing sequence changes the window to show the following settings:



The minimum and maximum gap time settings define the acceptable range between detected network tones. The gap time limits may be negative as well as positive. A negative value means that overlap between network tones is allowed. For example, a minimum gap time of -100 ms allows a subsequent tone to start 100 ms before the current tone has ended.

The maximum twist setting limits the largest difference in tone levels before the tones are ignored.

The lower half of the window is used to create a list of network tones that define the sequence. This is accomplished by selecting a network tone template from the drop down list and clicking either the **Insert** or **Add** buttons. The **Insert** button adds the tone above the one selected in the list, while the **Add** button adds the tone to the end of the list. To remove a tone from the list, select it with the mouse and click the **Remove** button.

Once the tone sequence edits are finished, clicking the **OK** button returns to the list of defined sequences.

The third tab in the Tone Detection Settings window contains a number of detection settings.

The first two settings affect all tone templates that use the '>' frequency separator. The 'Maximum gap time' and 'Maximum tone twist' settings limit the maximum time between frequencies and the maximum difference in signal level. Note that for tone templates using the '>' separator, the minimum gap time is fixed at 0 ms.

The following three settings affect all tone templates. The first 'Out-of-band level ratio' setting determines the minimum difference in level between the AI-5120 band splitting filters before a network tone can be detected. The second 'Max level variation' sets an

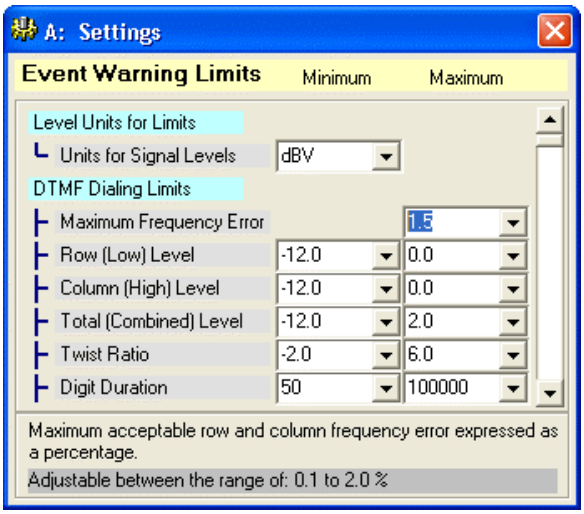
upper bound on the level fluctuation of each frequency. Finally the third setting defines a level ratio which below the strongest frequency where all other frequencies are ignored.

7.7 Event Warning Limits

The Event Warning Limits window is used to define minimum and/or maximum limits for various event measurements. When events are detected the measurement results are compared against the limits defined in this window. If one or more of the measurements falls outside the valid range, the event is tagged with a warning.

Events with warnings are displayed with a 'warning' icon in both the main control panel window, and the Data Recorder window event list view.

To display the limits window, click the mouse on the **More** button (located on the main control panel) and then select **Event Warning Limits** from the pop-up menu. This shows the following figure.



The first setting determines the unit system used to define all event limits that relate to signal levels. This may be either dBm (default), dBV, or mVrms.

Two columns are used to set the minimum and maximum value for a particular event measurement. Note that some measurements may only have a minimum limit or a maximum limits.

To change any of the limits, click the mouse in the text box to the right of the measurements name and enter a new value. The scroll bar on the right side of the window is used to show limits that extend below the last visible one.

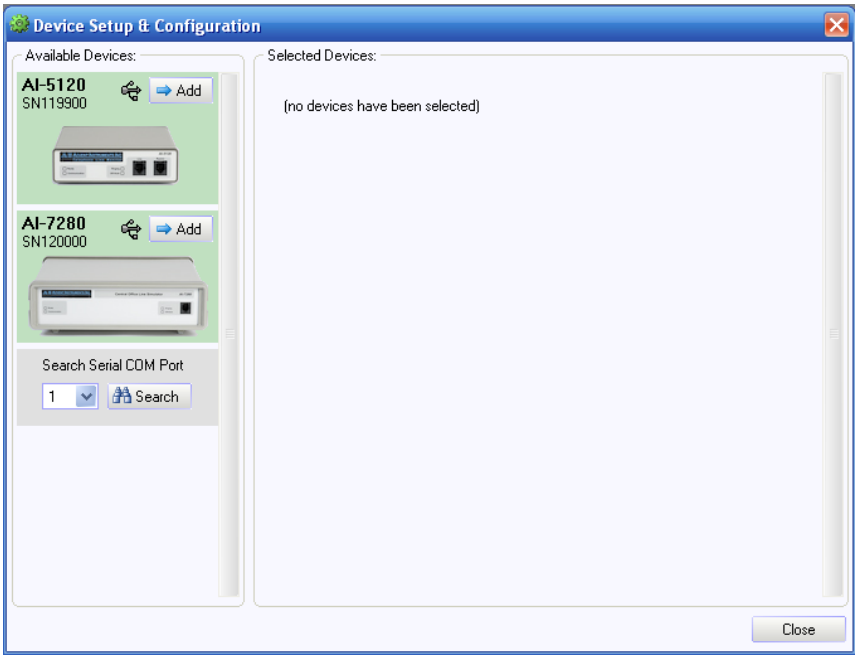
Note, for the line flash duration limit and the OSI duration limit, it is important the warning limits be inside the detection range. For both of these events, the detection range is set in the Event Detection & Recording setting window. If the warning limits fall outside the detection bounds, then a warning can never be issued since the detected event is always within the warning limits.

8. Additional Information

8.1 Hardware Setup

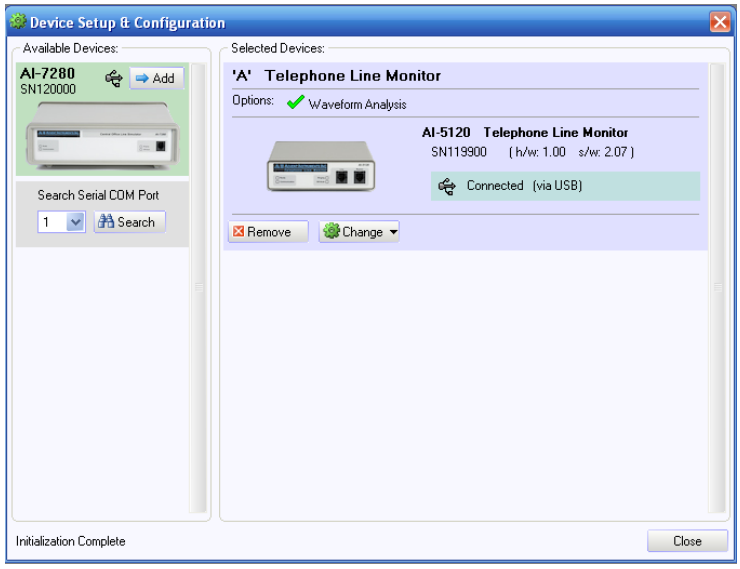
The Device Setup & Configuration window is used to display the current state of the AI-5120's or other Advent products connection to the PC. Selecting the **Configuration** menu followed by **Hardware Setup** command shows this window.

As shown below, the window is divided vertically into a listing of available devices (left side) and the selected devices (right side).



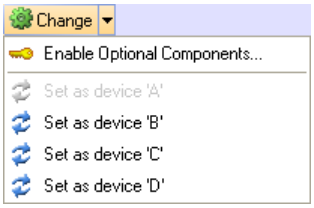
Available devices connected via USB are automatically displayed. However for devices connected via a RS-232 serial port, they must be discovered manually by clicking the **Search** button.

The TRsSim software supports up to four simultaneously connected devices. To add available devices, simply click the **Add** button for the desired device. As devices are added, each is assigned a device letter from A to D. This letter is used to identify each device for scripting purposes.



To remove a selected device, simply click the device's **Remove** button.

Clicking the **Change** button displays a menu of options for enabling optional components or changing the letter assigned to the device.



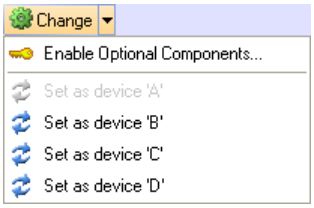
For each selected device, the window displays the device model & name, serial number, firmware and hardware versions, connection status, and what options (if any) are enabled.

When exiting the TRsSim software, it remembers which devices it was connected to. Thus when re-starting the program it attempts to connect with the same devices. If a device is missing or can not be found the Device Setup & Configuration window indicates that no connection was established with the device. Clicking on the **Connect** button attempts to find the unit again, while clicking on the button with the information icon displays why the attempt to find and connect to the unit failed.

8.2 Enabling Optional Features

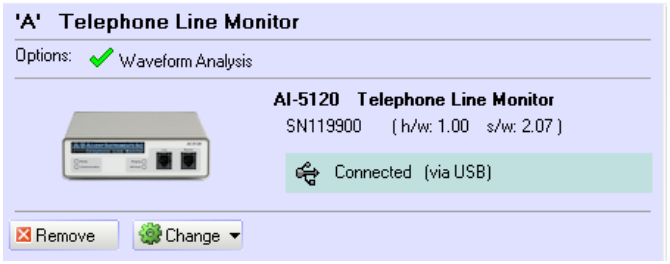
Depending on the connected device, various optional components may be available. The TRsSim software uses license keys for enabling these functions. Each key is linked to a specific device (ie. AI-5120, AI-7280) and may not be available if a different device is connected to TRsSim.

To enable optional components for a device, open the Device Setup & Configuration window by clicking on the **Configuration** menu followed by **Device Setup** command. Then click the **Change** button which displays the following menu.



Selecting the **Enable Optional Components** menu item then shows the following window. Enter the license key provided in this window to enable the optional components.

Once the new key has been entered the window closes and the Device Setup & Configuration window displays any changes to the optional components.



Options that are enabled are listed with a green check mark, while options not enabled are shown with a red 'X'.

Appendix A: USB Driver Installation

The following figures show the step by step procedure for installing the AI-5120 USB drivers. These drivers are required in order to use the USB connection to the AI-5120. The figures are taken from the Windows XP operating system.

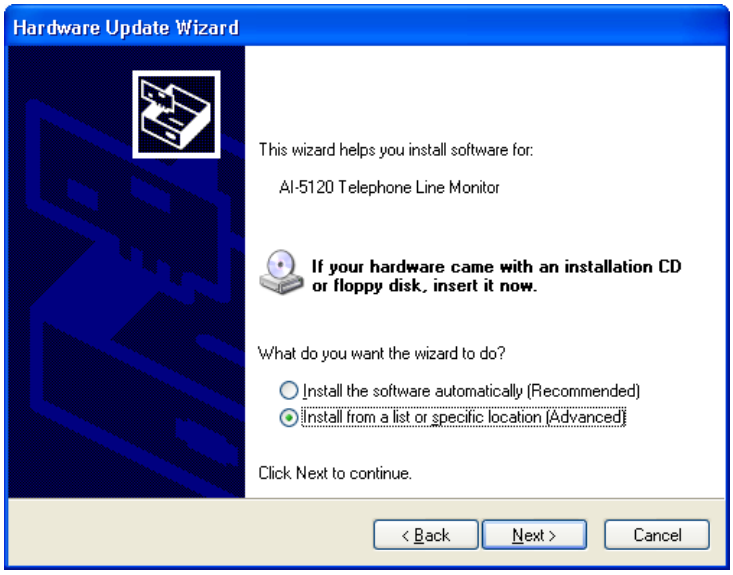
1. Connect AI-5120 to PC with USB cable

With the AI-5120 powered by the supplied AC adapter, connect a USB cable from the PC to the AI-5120. The windows operating system will detect the presence of the AI-5120 and display a message as follows:

As the USB drivers are not installed, Windows starts the new hardware wizard to guide you through the installation process.

2. Select "No, not at this time", and click "Next"

The Windows operating system needs to know how it should locate the driver files for the AI-5120. The correct selection is to specify the location for the driver files.



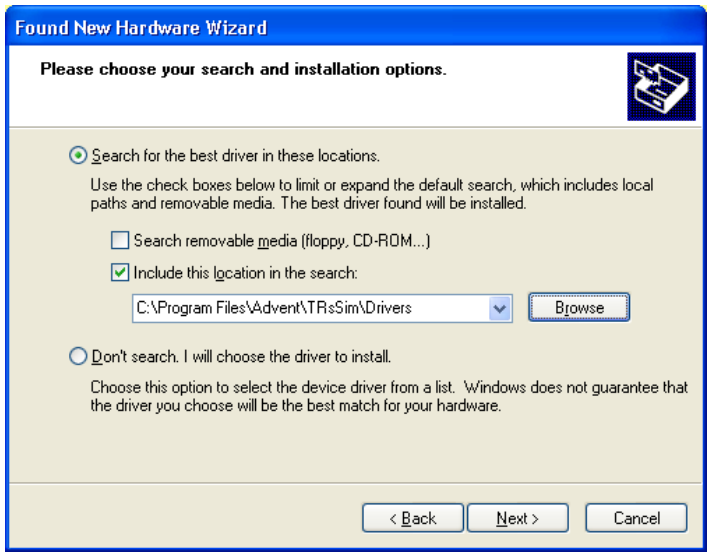
3. Select "Install from a list or specific location" and click "Next"

The path to the driver files is supplied in the following window. Click the **Browse** button, which opens a window for selecting directories. The directory to select is the \drivers\ subdirectory within the TRsSim software program files. By default the drivers will be copied to the following folder when TRsSim is installed:

C:\Program Files\Advent\TRsSim\Drivers

As an alternative, the drivers are also located on the supplied CD under the following folder:

<CD Drive>:\UsbDriver



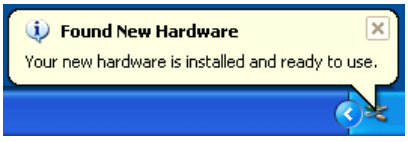
4. Select "Specify a location" and click "Next"

The installation process may take a few moments. During this time, a window similar to the following will be shown.

Once the installation is complete, the AI-7280 will be ready for use. The name for the USB driver is "FTDI FT8U2XX Device" so that when viewing the Control Panel's 'Device Manager' window, the AI-7280 is indicated by the "FTDI FT8U2XX Device" driver name.

5. Click "Finish"

A brief popup bubble, as shown below, indicates that the USB driver has been correctly installed and the AI-5120 is ready for use.



Appendix B: Glossary of Terms

ACK Tone

Acknowledgement signal sent by the TE in response to detecting a DT-AS or CAS tone. The signal is usually a DTMF digit 'D' or 'A'.

Bell 202

An FSK modulation standard that uses 1200 Hz for the mark tone frequency and 2200 Hz for the space tone frequency. The baud rate used is 1200 bits per second.

CAS Tone

CPE Alerting Signal. See DT-AS.

Channel Seizure

A FSK modulated alternating zero/one bit pattern that may be sent prior to any data bytes.

Checksum

For the purposes of Caller ID or SMS DLL, the checksum is a byte value sent after the message data. It represents the two's complement sum of all the message byte values. The checksum is used for error detection.

dBm

Unit of signal power level. Calculated as 10 times the base 10 logarithm of the ratio of the signals power relative to 0.001 Watt. For example, 1 mW = 0 dBm, 100 mW = 20 dBm. For most telephone applications, signal levels expressed in dBm are expressed with a 600 ohm terminating impedance. This fixes the relationship between dBm and dBV as 0 dBm = -2.218 dBV, or 0 dBV = 2.218 dBm.

dBV

Unit of signal voltage level. Calculated as 20 times the base 10 logarithm of the signal's voltage. For example, 1 Vrms = 0 dBV, 0.1 Vrms = -20 dBV.

DLL

Data Link Layer: A layer in the SMS protocol stack above the physical layer, but below the TL layer. Used to transport TL messages between SME's.

DT-AS

Dual Tone Alerting Signal: A signal composed of two tones (2130 Hz & 2750 Hz) used to alert the TE of an incoming Caller ID data transmission. Also referred to a CAS tone.

DTMF

Dual Tone Multi-Frequency: A signal comprised of two tones used for dialing or other signaling purposes. Eight different frequencies represented by a 4x4 matrix are used for the two tones.

Flash

Telephone Line Flash: An action by a TE in which it momentarily goes on-hook, then returns to the off-hook state. The on-hook duration is usually in the range of 100 ms to 1000 ms.

FSK

Frequency Shift Keying: A method of signal modulation for data transmission. For Caller ID and SMS applications, a tone's frequency is shifted between two values representing either a mark or space bit.

MDMF

Multiple Data Message Format: A structure used to convey FSK modulated data of up to 255 bytes in length. Most commonly used for Caller ID applications or for sending SMS DLL messages.

MF

Multi-Frequency: A method used to convey signaling information over telephone networks. Uses signals comprised of two, or possible more, tones from a standardized list of frequencies.

Off-Hook

A state in which a TE draws loop current from the tip/ring interface. Denotes that the device is in use or active.

On-Hook

A state in which a TE does not draw any loop current from the tip/ring interface. Denotes that the device is idle or in-active.

OSI

Open Switching Interval: An interval of time in which the central office disconnects the DC feed voltage from the TE. Can be used as a method of informing a TE of an

incoming Caller ID message, or simply generated as an artifact by the central office when various resources are being connected/disconnected from the telephone line.

PDU

Protocol Data Unit: For the purposes the ETSI Protocol 1 SMS, the PDU is a data structure used to convey information. These PDU's are the Transfer Layer (TL) messages and take the form of one of six different types. They are: SMS-DELIVER, SMS-DELIVER-REPORT, SMS-SUBMIT, SMS-SUBMIT-REPORT, SMS-STATUS-REPORT, and SMS-COMMAND.

pps

Pulses per Second: A measurement of pulse dialing which expresses the rate of dialing pulses. A dialing pulse is a short interval of time in which the TE goes on-hook and then returns to the off-hook state. The most common pulse rate in use is 10 pps; however various PSTN's may require faster or slower rates for dialing.

PSTN

Public Switched Telephone Network: A network of devices allowing a TE to establish a connection to another device for the purposes of passing voice band signals.

RP-AS

Ring Pulse Alerting Signal: A short ringing burst that is used to alert the TE of an incoming Caller ID data transmission.

SAS

Subscriber Alerting Signal: A signal used as part of the call waiting service alerting the subscriber of an incoming call. Also may be used during a Type II Caller ID transmission by preceding the CAS signal.

SDMF

Single Data Message Format: A data structure that may be used to send Type I Caller ID data consisting of date/time and calling number information. See also MDMF.

SM

Short Message: Information sent between SME's using the Short Message Service (SMS)

SME

Short Message Entity: A device having the capability to send or receive short messages (SM). Can be either a SM-TE or SM-SC.

SMS

Short Message Service: A service used to send short messages (SM) to and from SME's.

SM-SC

Short Message Service Center: A functional unit that receives or sends short messages to a SM-TE.

SM-TE

Short Message Terminal Equipment: A terminal equipment device that is capable of sending or receiving short messages to or from a SM-SC.

Start Bit

For Caller ID and SMS applications, every 8 bit data byte transmitted via a FSK modulated signal is preceded with a single start bit. The start bit is always represented with the space tone.

Stop Bit

For Caller ID and SMS applications, every 8 bit data byte transmitted via a FSK modulated signal is followed with at least one stop bit. The stop bit is always represented with the mark tone.

TE

Terminal Equipment: A device connected to the telephone network. Also commonly referred to as a CPE (Customer Premise Equipment).

THD+N

Total Harmonic Distortion plus Noise: A measurement normally expressed as a ratio of the signal's harmonic distortion level plus noise to the total signal level.

TL

Transfer Layer: A layer in the SMS protocol stack providing a service to the SMS application layer. The transfer layer messages convey short message data or status information between SME's.

TPDU

Transfer Protocol Data Unit. See ETSI TS 100 901 section 9 for PDU structure as it relates to SMS applications.

Twist

Commonly refers to the ratio in signal level between the row and column tones of DTMF, or the mark and space tones of FSK. The ratio is normally expressed in decibels (dB). In the case of DTMF, positive twist indicates that the column signal level is greater than the row signal level. For FSK the most common convention is that positive twist indicates that the mark signal level is higher than the space level.

Type I

Caller ID data transmission occurring while the TE is in the on-hook state.

Type II

Caller ID data transmission occurring while the TE is in the off-hook state.

V.23

An FSK modulation standard that uses 1300 Hz for the mark tone frequency and 2100 Hz for the space tone frequency. The baud rate used is 1200 bits per second.