AI-7280

Central Office Line Simulator

User Guide

Advent Instruments Inc.

Release 1.0h

Safety Symbols and Terms

When the ⚠ symbol is present on an instrument it indicates that the operators should refer to the User Guide for more information.

When the ⏚ symbol is present it indicates a terminal that is connected to the functional ground of the instrument.

When the symbol is present it indicates that the surface may be hot. Avoid contact with the surface of the instrument to avoid burns.

When the symbol is present near a screw it should be connected to a safety earth ground using a wire recommended in the User Guide.

Installation Categories

Advent Instruments products are designed for use and to measure electrical signals that are rated Measurement Category I as described in the International Electrotechnical Commission (IEC) Standard IEC 606064. The equipment measurement terminals are not designed to be directly connected to the mains voltage or a voltage source with high transient over-voltages.

Contents

1. Getting Started

1.1 Introduction

The AI-7280 is a highly flexible central office line simulator using a software programmable FXS port. It is designed primarily for the testing and verification of terminal equipment, including standard telephones, Caller ID devices, SMS (Short Message Service) capable equipment, and any device using an analog Tip/Ring interface circuit.

Supplying a standard RJ-11 telephone jack, the AI-7280 provides a programmable DC feeding circuit, operating in either a constant current or constant voltage mode. Both the line voltage and loop current are adjustable, including line polarity and slew rate control. An on-board ringing generator provides a range of programmable level, frequency, phase, and wave shape settings. All of the signal generation and analysis is performed by a programmable DSP, allowing for future firmware upgrades. The AI-7280 can generate up to four simultaneous tones including FSK (frequency shift keyed), AM (amplitude modulation), DTMF (dual tone multi-frequency), and MF (multi-frequency) signaling tones. In applications requiring signal analysis, the AI-7280 measures RMS level, DC level, frequency, and THD+N (total harmonic distortion plus noise) with a wide selection of adjustable filters. In addition it detects DTMF digits and decodes Bell 202 or V.23 FSK signals for Caller ID and SMS applications.

These capabilities along with the TRsSim software allow the AI-7280 to be used in a wide range of testing applications. Examples of this include:

- Caller ID compliance testing:
    - Telecordia (Bellcore)
    - TIA (Telecommunications Industry Association)
    - ETSI (European Telecommunications Standards Institute)
    - BT (British Telecom)
    - CCA (Cable Communications Association)
- Short Message Service (SMS) testing:
    - ETSI ES 201 912 - Protocol 1
    - ETSI ES 201 912 - Protocol 2
- General Terminal Equipment testing:
    - DTMF & Pulse Dialing Analysis
    - Line Flashing Timing

- Network Tone Detection

Control of the AI-7280 is accomplished by the use of a PC. It supports both a full speed USB 2.0 interface and a legacy RS-232 communications port. Depending on the application, one of three methods can be used to control and operate the AI-7280.

The first is using the supplied TRsSim application software. This PC application operates under the Windows OS and provides a high-level graphical user interface. In its' base form the TRsSim software can generate various ringing patterns and network tones. Additionally, standard Telecordia, ETSI, and DTMF based Caller ID messages can be sent to a TE under test. Other features include level, frequency, THD+N, and sweep measurements along with a flexible scripting language. As an optional component, the TRsSim software supports SM-SC (short message service center) emulation to either the ETSI protocol 1 or protocol 2 standard.

The second method of control for the AI-7280 is via the supplied Windows DLL or .NET assembly. Designed for users wishing to create their own programs or to incorporate the AI-7280 into an existing testing system, the DLL provides a collection of functions giving access to all of its signal generation and analysis features. It supports either a USB or RS-232 connection to the AI-7280, and can be accessed from virtually any Windows 32-bit development environment. This includes Visual C++, Visual Basic, Lab View, or Visual Studio 2008, among others. An included demonstration program allows users the ability to examine and exercise each of the functions. This provides a simplified method for learning the capabilities of the DLL or .NET functions.

Finally, the third method of controlling the AI-7280 is by direct communication. Any device with a RS-232 communications port can send commands directly to the AI-7280. These commands can be used to generate ringing, network tones, FSK, DTMF, or return various measurements of level, frequency, line voltage, and loop current. For devices that support a USB host, various drivers for Windows, Linux, and Apple OS-X are available. These drivers can be used to control the AI-7280 by using the same command set as that used via the RS-232 port. Operating at a lower level than the DLL, this method of control provides both the most flexibility and the most independence of computing platform choice.

Note: A lower cost version of the AI-7280 is available which does not include the ability to operate the TRsSim PC software. It is meant for applications using either the DLL or direct control methods exclusively which do not require the high-level graphical interface. Its ordering part number is: AI-7280/DLL

1.2 Package Contents

Use care when unpacking the AI-7280 to avoid damage to the instrument and the packing materials. Retain the packing materials in case the unit is to be transported in the future.

Please inspect the shipping container and the contents for any damage. If visible damage is present, contact your local sales representative or Advent Instruments directly (see Appendix C: Support). Keep the shipping materials for the carrier inspection.

The package should contain the following items:

- AI-7280 Central Office Line Simulator

- Full speed USB cable

- Telephone Cord with RJ-11 Connectors

- AC Power Cord (plug type dependent on destination country)

- USB Flash drive with TRsSim software, DLL drivers, and Setup software

- AI-7280 User Guide Manual

- TRsSim User Guide Manual (*)

- Software License Key for TRsSim Application (*)

- Calibration Certificate

If any of the above items are missing, contact your local sales representative or Advent Instruments directly (see Appendix C: Support) for replacement.

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*   Note, the AI-7280/DLL does not include these two items.

# 1.3 Important Safeguards and Safety Precautions

Please read all instructions and save them for future use. Observe the following precautions to avoid injury and prevent damage to the AI-7280 or any products connected to it. The AI-7280 is intended for use by qualified personnel who recognize shock hazards and procedures to avoid possible electrical shock. The AI-7280 is designed for use with electrical signals that are rated Measurement Category I as described in IEC Standard 60664. All connectors and I/O are intended for connection to Category I sources unless otherwise described in the manual.

- Ensure the AC power source is compatible with the voltage and frequency requirements stated on the rear label of the instrument.

- Do not operate the instrument with the case opened.

- Do not allow any liquid to enter the interior of the instrument.

- Observe all terminal ratings to avoid fire or shock hazards.

- Avoid exposed terminals. Do not touch exposed connections when power is present.

- Caution To reduce the risk of fire use only a No 26 AWG or larger telecommunications line cord

- The instrument is intended for use in an indoor laboratory environment with an altitude not to exceed 2000m. (Pollution Degree 2)

- Do not operate with suspected failures. If damaged is suspected, do not continue to operate the instruments until inspected by qualified service personnel.

- To clean the instrument, disconnect it from the power supply, and then wipe down the exterior with a cloth dampened with a mixture of mild detergent and water. After the instrument is completely dry, the power supply may be re-connected.

- Refer servicing to a trained personal only.

1.4 Powering on the AI-7280

Before powering on the AI-7280 for the first time, disconnect any cables connected to the unit. The unit's power supply automatically adjusts to a wide range of input voltages and frequencies. However please ensure the AC voltage source is within the limits printed on the rear panel.

The power switch for the AI-7280 is located on the rear panel just above the AC power receptacle. Make sure it is turned off prior to connecting the AC power cord and ensure the mains supply is properly earth grounded.

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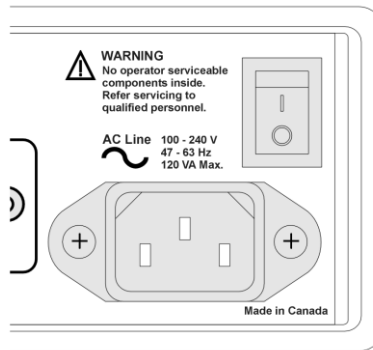
Connect the AC power cord, ensuring a snug fit to the receptacle. Turn on the power to the AI-7280 by rocking the power switch upward.

All four front panel indicators should briefly illuminate for approximately 1 second in duration. Following this the "Ready" indicator should turn on and stay on. The other three indicators ("Communications", "Ringing", and "Off-Hook") should remain off. Once the "Ready" indicator is solidly on, the unit is ready for use.
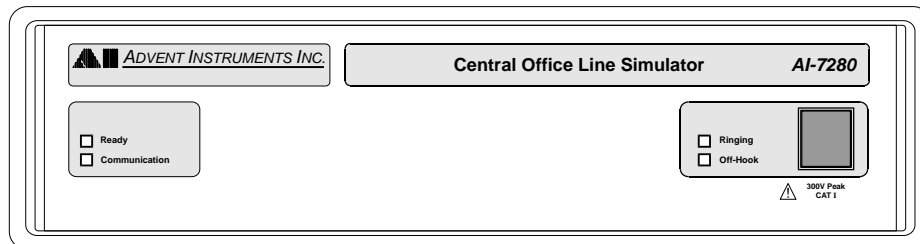
A number of checks are performed during the power up cycle. If a fault is detected, the "Ready" indicator will either flash or be off. If it stays off, the fault is serious and requires that the unit be returned for repair or replacement. In either case, see Appendix B: Error Codes for more information.

1.5 Connecting to the PC

The AI-7280 can be connected to the PC by either its RS-232 port or USB 2.0 compliant full speed (12 Mbit/second) port. Both connectors are present on the rear panel of the unit.

If using the TRsSim software or the Windows DLL to control the AI-7280, the USB connection is preferred because of the higher data rate. It incurs less latency when sending commands and data to the AI-7280. However, either connection method will operate with the TRsSim software or the Windows DLL.

USB Driver

The proper drivers must be installed before a USB connection can be established between the AI-7280 and the PC. The WHQL USB driver files are automatically installed with the TRsSim application and no further steps should be required.

If the end use does not require the TRsSim application then it is also possible to install the driver manually.

For detailed step-by-step instructions on installing the driver, see Appendix A: USB Driver Installation. The following is a summary of the installation procedure described in the Appendix.

1. Download the USB driver installation package from our website or from the CD-ROM.

2. Double click on the self extracting installer. This normally requires using the **administrator** privileges in Windows 7 and Win 10

3. The installer will decompress the files and prompt you through the steps to install the driver files.

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

RS-232

The rear panel 9 pin connector of the AI-7280 is configured as a DCE (Data Communications Equipment) port. As the PC is normally configured as a DTE (Data Terminal Equipment) port, a straight-though cable is required for the connection. Do not use a cross-over cable between the AI-7280 and the PC serial port.

The AI-7280's RS-232 data transmissions are fixed at 8 data bits with 1 stop bit and no parity. The baud rate is adjustable from a default (at power up) setting of 9600 bps to a maximum of 115200 bps. If a break signal is detected by the AI-7280, it will reset its baud rate to 9600 bps. Only three signals are required for communication. These are Tx Data, Rx Data, and Ground. The Request-to-Send (RTS) and Clear-To-Send (CTS) signals have no effect on communication. On the AI-7280's 9 pin RS-232 connector, the Data-Terminal-Ready (DTR) pin is directly wired to the Data-Set-Ready (DSR) pin. As such, if the PC asserts DTR, it can read back that DSR is asserted as well.

1.6 Where to go from Here

Once the AI-7280 has been powered up and connected to the PC, the next step is determined by the end user application. This is generally either using the TRsSim software to provide a graphical user interface for controlling the unit and performing tests, or developing custom control software with the DLL, .NET or direct control methods.

TRsSim Software:

See Section 2:
For an overview

DLL, .NET or Direct Control

See Section 3:
For an overview

Technical Overview: Section 4

Provides technical information on the AI-7280 including block diagrams and specifications.

Firmware Updates: Section 5

Procedures on how to update the AI-7280 internal firmware to the latest version.
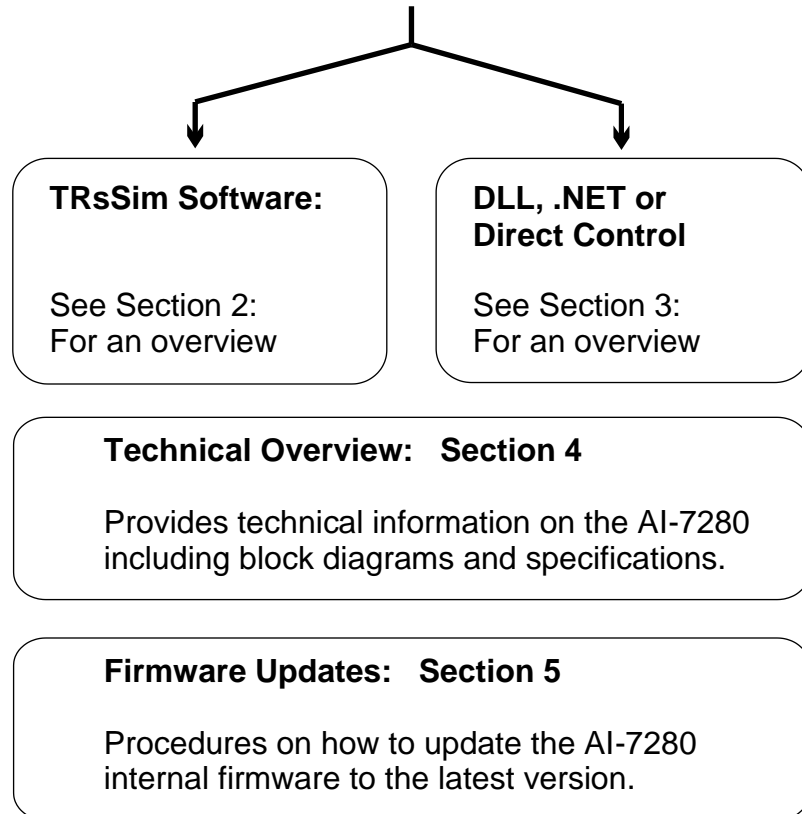
2. TRsSim Software

2.1 Introduction

The TRsSim software provides a high-level graphical user interface to the AI-7280. Operating under the Windows OS (Windows 10 / 11), it controls the AI-7280 via either a USB or RS-232 serial connection. Functioning in one of two different modes, it emulates the major functions of a PSTN (Public Switch Telephone Network) or acts as a flexible signal generator and analyzer.

In the PSTN mode, it emulates a central office telephone line by generating ringing signals, network tones, Caller ID signals, and optionally SMS (Short Message Service) signals. Additionally, the software provides analysis on DTMF or pulse dialing activity performed by the connected terminal equipment.
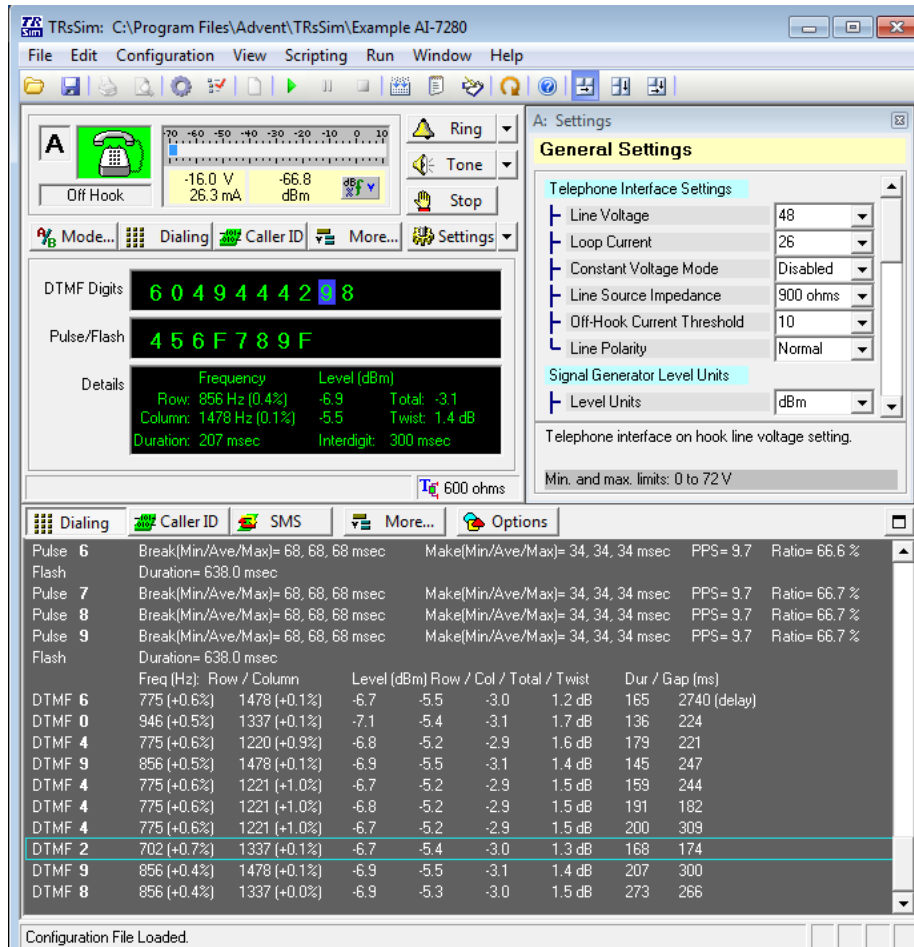
The TRsSim software supports a variety of testing functions. Its ringing generation is programmable over wide range of level, frequency, and cadences. Network tones such as dial, stutter dial, ring back, and busy are predefined, and user defined tones can include arbitrary levels and frequencies or be composed of DTMF and MF tones. Supported MF tones include both the ITU Q.320 and Q.441 variants.

Caller ID functionality includes both the FSK and DTMF formats. The FSK based Caller ID follows either the applicable Telecordia (Bellcore) or ETSI standards. Predefined signaling types support the nominal conditionals in both the on-hook and off-hook cases. The common message and parameter types for both the Telecordia (Bellcore) and ETSI standards are supported. As an option, the Caller ID capabilities of the TRsSim can be expanded. The Advanced Caller ID option (p/n. AI-ET003) enables the TRsSim software to support the Japanese NTT FSK Caller ID standard. In addition, it provides more flexibility in how the Caller ID message is sent along with the composition of the message.

Also, as an optional component (p/n: AI-ET001), the TRsSim software may also support SM-SC (short message service center) emulation. Short Message Service (SMS) is the ability to send and receive text messages between various devices. Terminal equipment which supports SMS uses the PSTN to establish a voice path with a Short Message Service Center (SM-SC). Once a connection between the TE and SM-SC is made, text messages are sent or received. The TRsSim software emulates a SM-SC for TE testing purposes. It can either receive calls from the TE for submission of text messages, or call the TE for delivery of text messages.
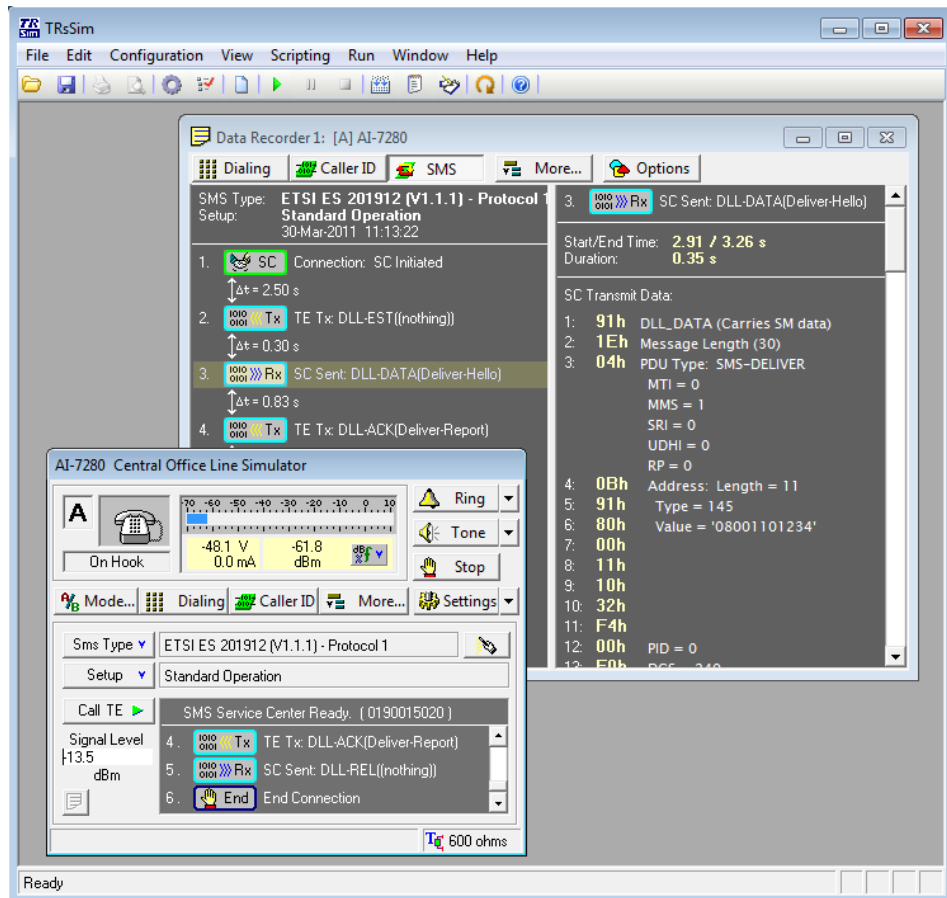
The SM-SC option supports both the ETSI ES 201 912 protocol 1 or protocol 2 standard. Designed as a testing tool, the software allows complete control over the DLL (data link layer) and TL (transfer layer) messages for exception condition testing.

In the second mode of operation, the TRsSim software can act as a flexible signal generator and analyzer. This includes generating various tones of arbitrary level and frequency, DTMF tones, MF tones, FSK signals, or ringing signals. Measurements include RMS level, frequency, THD+N, DTMF level & frequency, and DTMF THD+N. In addition, it supports various parameter sweeps and a flexible scripting language for automating complex testing conditions.
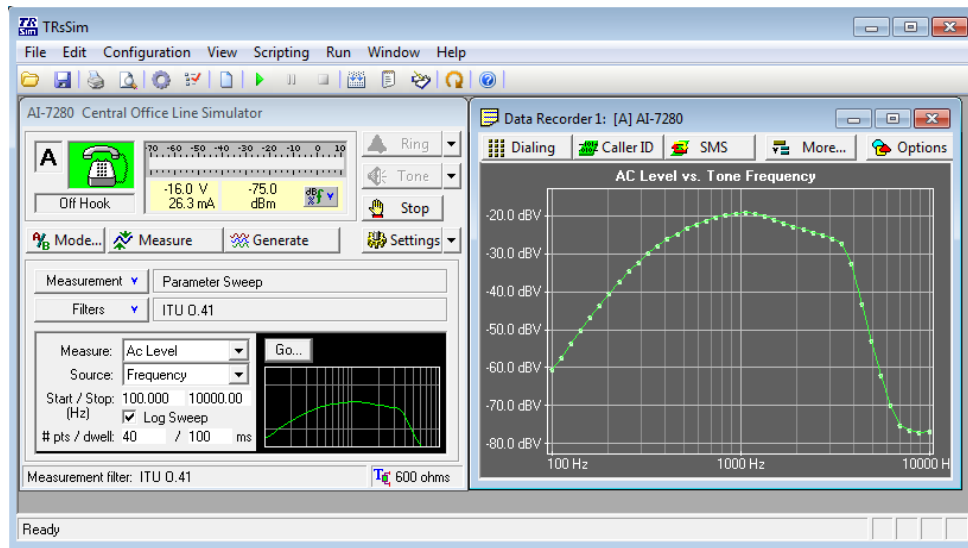
2.2 Software Features

The following tables list the features and capabilities of the TRsSim software. As the TRsSim software supports both the AI-7280 Central Office Line Simulator and the AI-80 Caller ID Generator, some capabilities may not be present on both hardware platforms.

Basic PSTN Features:

Description	AI-80 Restrictions	AI-7280 Restrictions
Generate programmable tones adjustable frequency, level, pattern, up to 4 tones	only 2 tones available, no simultaneous noise	-
Generate DTMF tones adjustable level, twist, freq. offset, on/off time	-	-

Generate MF tones
  adjustable level, freq. offset, on/off time
  ITU Q.320, Q.441, and user define tone tables
	-	-

Generate FSK signals (separate from Caller ID) adjustable mark/space level and frequency, baud rate	-	-
Generate broadband white noise	-	-

adjustable level		
Programmable ringing generator 　adjustable frequency, level, pattern, waveshape, 　and DC offset voltage	wave shape not available, fixed DC offset voltage	-
Generate Telecordia based FSK Caller ID 　Type I (on-hook) signaling 　　Send data after 1st ring 　　Send data after OSI 　Type II (off-hook) signaling 　　Send CAS, wait for ACK, send data 　Message types supported 　　Single/Multiple Message with Visual Msg Waiting 　Parameter types supported 　　Date/time, calling number, number absence, 　　calling name, name absence, visual waiting	-	-
Generate ETSI based FSK Caller ID 　Type I (on-hook) signaling 　　Send data after 1st ring 　　RP-AS before data (with and without ringing) 　　DT-AS before data (with and without ringing) 　　Line reversal, DT-AS before data (with and without ring) 　Type II (off-hook) signaling 　　Send CAS, wait for ACK, send data 　Message types supported 　　Call Setup, Visual Msg Waiting 　Parameter types supported 　　Date/time, calling number, number absence, 　　calling name, name absence, visual waiting	-	-
Generate DTMF based Caller ID 　Type I (on-hook signaling) 　　Send data before ringing 　　RP-AS before data with subsequent ringing 　　Line reversal before data with subsequent ringing 　　Line reversal, wait off-hook, send data 　Type II (off-hook signaling) 　　Send data 　Message structure 　　Up to 4 fields with programmable start code 　　programmable stop code 　　maximum of 64 DTMF digits	-	-
Telephone Interface: Line Voltage & Loop Current	48V fixed line voltage, loop current either 26 or 45 mA. Fixed constant current mode.	Voltage from 0 to 72 V, Current from 5 to 72 mA. E702 option Voltage from 0 to 105 V, Current from 5 to 105 mA. Selectable constant voltage or constant current mode..
Telephone Interface: Adjustable Off-Hook Threshold Current	not available	5 to 15 mA
Telephone Interface: Impedance	600/900 Ω and optional complex	600/900 Ω TBR-21, and optional complex
Telephone Interface: Balance Impedance	not available	600/900 Ω TBR-21, and optional complex
Measure wide band signal level & frequency 　Level units of either dBm (600 Ω), dBV, or mVrms	frequency measurement	-

Description	AI-80 Restrictions	AI-7280 Restrictions
	not available	

Selectable AC Filters
  LPF, HPF, LFP+HPF, Band pass, notch , dual notch
  DTMF LPF, DTMF HPF, C-message weighted
	not available	-

Measure DTMF
  Low and high group level
  Low and high group frequency
  Total and twist level
  Duration and inter-digit time
	timing measurement not available	-

Measure signal THD+N and DTMF THD+N	not available	-

Measure pulse dialing
  Make time (min, max, average)
  Break time (min, max, average)
  Ratio and PPS (pulses per second)
	-	-

Measure line flash timing	-	-
Adjustable DTMF digit limits	-	-
Adjustable pulse dialing & flash timing limits	-	-

Measure Type II (off-hook) Caller ID ACK digit
  Digit code
  Low and high group level
  Low and high group frequency
  Total and twist level
	-	-

Measure DC line voltage and loop current	not available	-
Monitor telephone line signals on BNC output connector	only if I/O module is installed	-
Inject signals onto the telephone line with the BNC input	only if I/O module is installed	-
Monitor telephone line signals with the built-in speaker	-	not available

SM-SC Emulation Option:

Support for the SM Service Center Emulation is an optional component (p/n: AI-ET001) to the TRsSim software. It allows for testing of a SMS capable TE to either the ETSI ES 201 912 protocol 1 or protocol 2 standard.

Description	AI-80 Restrictions	AI-7280 Restrictions

Supports ETSI ES 201 912 standard
  Protocol 1 DLL and TL layers
  Protocol 2 DLL and TL layers
	-	-

Supports the following protocol 1 PDU types
  SMS-DELIVER
  SMS-DELIVER-REPORT
  SMS-SUBMIT
  SMS-SUBMIT-REPORT
  SMS-STATUS-REPORT
	-	-

Supports the following protocol 2 TL messages
  SMS-SUBMIT
  SMS-DELIVER
  SMS-STATUS-REP
  SMS-SUBMIT-REP
  SMS-DELIVER-REP
  SMS-TE-STATUS
  SMS-TE-CAPABILITY
	-	-

Adjustable sending FSK parameters
  Mark/space tone level
  Mark/space tone frequency
  Baud rate
	-	-

Programmable PSTN connection delay and network tone	-	-
Programmable FSK reception limits, frame timing	-	-
Separate SM-SC numbers for TE submit or TE delivery	-	-

Pre-programmed setups for ETSI ES 201 912
  Protocol 1, Annex A
    1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.10
    2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10
	-	-

Protocol 2, Annex B 1.3.1, 1.3.2, 1.3.3, 1.3.4, 1.3.5, 1.3.6, 1.3.7, 1.3.9		
Create stand alone AI-80 test program using current setup for production environment	-	-

2.3 For More Information

Detailed information on the operation of the TRsSim software for the AI-7280 can be found in the "**PSTN Emulation - User Guide**" document. It shows how to install and setup the software along with more complete instructions on its use. This document is normally included with the AI-7280 package and may also be downloaded from our web site at:

> http://www.adventinstruments.com

Along with software updates, the web site also contains the latest versions of any relevant documentation.
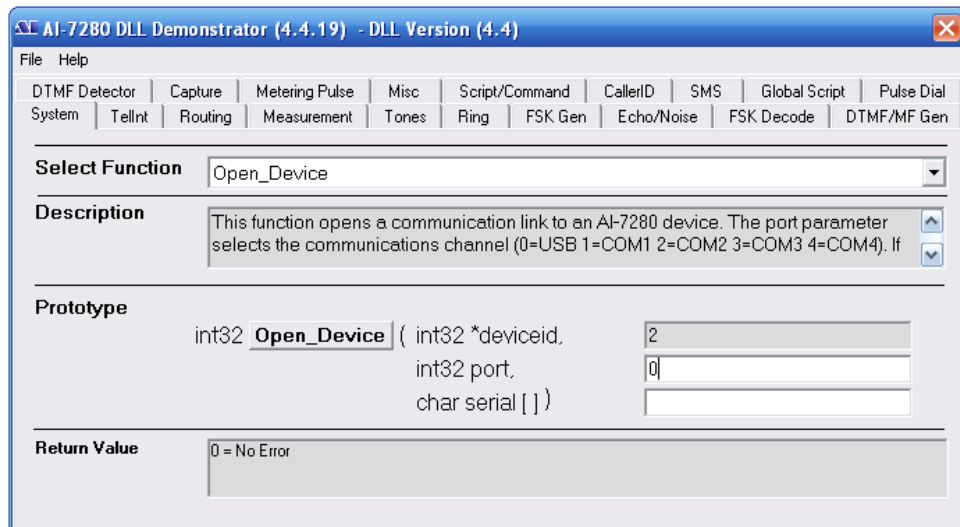
For technical support regarding the AI-7280 or the TRsSim software, please contact us in any of the manners listed in Appendix C: Support.

3. User Programming

3.1 Windows 32 Bit DLL

In situations where a PC graphical user interface is not required, or very specific test sequences are required, using the Windows DLL may be a better approach than the TRsSim software. The DLL provides a collection of function calls supplying a wide degree of control over the AI-7280's operation. This allows the AI-7280 to be integrated into custom test systems or used for custom applications. The DLL can be accessed from virtually any Windows 32 bit development environment.

For use as a demonstration tool, the supplied "AI-7280 DLL Demonstrator" software provides a simplified means for understanding the requirements and operation of each of the DLL function calls.

For detailed information on the DLL and its functions, consult the "**AI-7280 Programmers Guide - Windows DLL**" documentation. The latest version of the DLL and its documentation are made available on our web site, located at:

http://www.adventinstruments.com

For technical support regarding the AI-7280 or the DLL software, please contact us in any of the manners listed in Appendix C: Support .

3.2 Windows .NET Assembly

The aiDevices framework represents the second-generation Application Programming Interface (API) for automating and controlling Advent Instruments hardware products from a .Net programming environment. Unlike simple C-style drivers, this set of assemblies exposes a feature rich network of objects which enable application developers to write fine-tuned applications without sacrificing code clarity or flexibility.

At its core, aiDevices exposes a set of classes which communicate with and control the features of Advent Instruments' hardware products. Each of these classes contains interfaces to:

- Parametrically control instrument settings such as telephone interface physical characteristics.

- Measure signal levels, frequencies, voltages, currents.

- Generate and detect common signals with excellent timing accuracy from high level signal objects. (DTMF, CallerID, FSK ,MF, CAS/DTAS, AM, OSI, Flash, Pulse Dialing, Ringing, etc)

- Make recordings and store the information in arrays or .wav file format

For detailed information on the .NET Assembly and its functions, consult the **"aiDevices Framework - Programmers Guide**" documentation.

The latest version of the .NET Assembly and its documentation are made available on our web site, located at:

> http://www.adventinstruments.com

For technical support regarding the AI-7280 or the .NET Assembly, please contact us in any of the manners listed in Appendix C: Support.

3.3 Direct Control

The AI-7280 can be controlled from any device that contains a RS-232 serial port. By sending simple ASCII character commands, all of the low level functionality of the AI-7280 is accessible. While using this method of control provides the most flexibility, it is generally more complex than using the DLL. The DLL provides a layer of abstraction that simplifies many tasks. However for applications where the DLL can not be used (non-Windows PC), or where the DLL can not perform the specific task, this form of communication and control may be the best option.

It is possible to use the AI-7280's USB port for direct control; however, the correct USB drivers are required for this to function correctly. Currently drivers are available for Windows, Linux, and Apple OS-X operating systems. Please contact technical support (see Appendix C: Support) if you wish to use the available USB drivers.

For detailed information on the command structure, consult the "**AI-7280 Programmers Guide - Direct Control**" documentation on our website.

> http://www.adventinstruments.com

4. Technical Overview

4.1 Block Diagrams

The AI-7280 contains all of the circuitry necessary to simulate a single central office analog telephone line or FXO. It provides the DC feeding voltage and current required to operate terminal equipment along with AC signal generation and measurement capabilities.

The following figure shows the major functional blocks of the AI-7280. At its center is the signal processing block responsible for controlling the telephone interface's DC and AC characteristics. All of the AC signal flow, signal generation, and signal analysis is performed by this block. In addition, it manages the DC line settings and ringing generator.

The DC feeding circuitry provides a programmable range of line voltages and loop currents. If the connected terminal equipment enters the off-hook state, it operates in either a constant current mode or constant voltage mode. While its output current is limited and protected from voltage transients, it is important not to connect the tip/ring leads to any other voltage source. This may cause unexpected and unbalanced current flows leading to inaccurate AC signal generation and measurements.
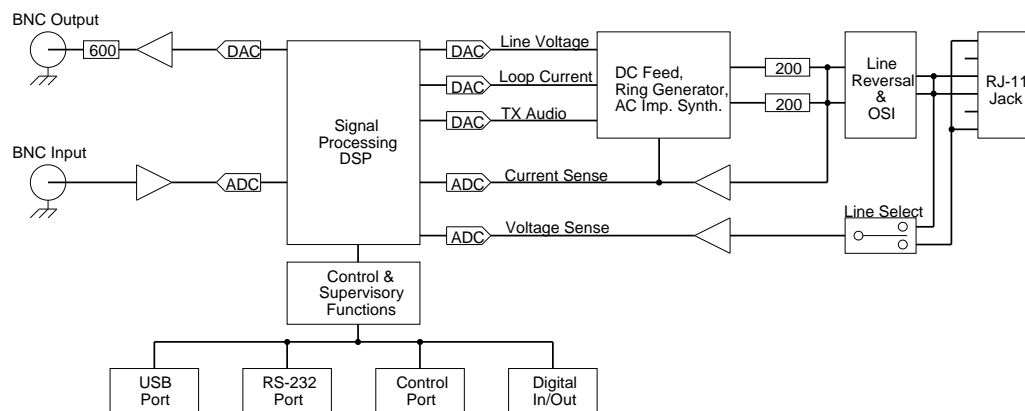

The DC output impedance is fixed at 200 Ω for each of the tip and ring leads, while the AC output impedance can be selected from 3 standard values (600 Ω, 900 Ω, TBR-21 Complex). An optional 4th impedance can be factory installed at the time of ordering.

The DC feeding voltage, ringing generator output, and AC signals are applied to the inner two conductors of the RJ-11 connector. All of the voltage measurements are made from these inner two conductors. However, it is possible to switch the voltage measurement point to the outer two conductors on the six-conductor jack. This becomes useful if line lengths are inserted between the AI-7280 and any terminal equipment. In this case the

outer pair of the RJ-11 connector can be used to sense the voltage directly at the terminal equipment.

The two BNC connectors present on the rear panel provide a means of monitoring and injecting signals at various points. More details regarding the AC signal flow is shown in the following figure.

As the figure indicates, all of the signals routed to the tip/ring leads originate from one of two points. They are the tone & signal generators and the BNC input connector. The signal generators are capable of producing simple tones, FSK modulated data, DTMF, MF, broadband white noise, playback of captured waveforms, or various combinations. The sum of all the generators is passed through a variable gain stage and summed with the BNC input signal. Optionally, varying degrees of echo can be applied to the signal before it is sent to the telephone interface forming the transmit signal.
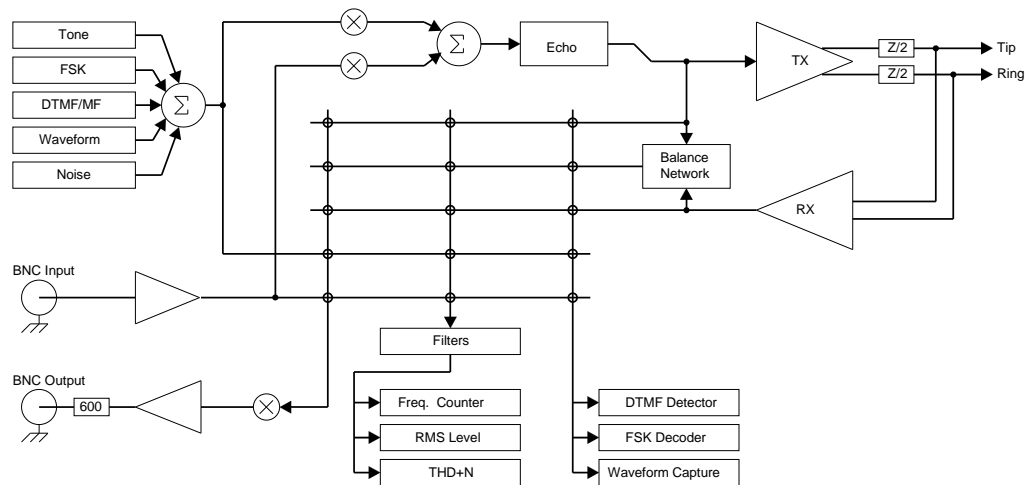
The AI-7280 has three primary signal "sinks". They are a signal measurement meter, signal analyzer, and the BNC output connector.

The measurement meter can provide continuously updated readings of the RMS level, frequency, and THD+N. Prior to making any measurements, it can apply any one of a large number of filters. These include adjustable low pass, high pass, band pass, and notch filters.

The signal analyzer performs three different tasks. They are detecting DTMF digits, decoding Bell 202 or V.23 FSK modulated data, and capturing short AC signal waveforms. The DTMF detector can capture up to 32 digits and measure the row/column signal level and frequency. Additionally, it records the digit start and stop times. The FSK decoder converts a Bell 202 or V.23 modulated signal into a mark/space bit pattern, which is then reduced into 8 bit bytes. Up to 4095 bytes can be stored by the AI-7280 at any given moment. Finally, the waveform capture can record signals for later playback or uploading to the PC for further analysis.

The signal source for the measurement meter, analyzer, and BNC output is selected from one of five different signal points. They are either the generator output, telephone interface TX signal, telephone interface RX signal, BNC input signal, and the telephone interface RX hybrid output signal.

The RX hybrid output signal is generated from a balance network which attempts to cancel the TX signal by simulating the source impedance of the telephone interface and the expected load impedance of any connected terminal equipment. This provides a

means of measuring or monitoring signals that are generated by only the terminal equipment, and not the AI-7280.

4.2 Indicators & Connections

The AI-7280 front panel is quite simple and only contains four LED indicators and the telephone interface RJ-11 jack.

The two left side indicators "Ready" and "Communication" show the status of the unit and communication activity respectively. Under normal operation the "Ready" indicator should be illuminated. If it is flashing, an internal fault or an excessive telephone interface unbalanced current is detected. When the "Ready" indicator is flashing, the state of the "Ringing" and "Off-Hook" indicators determine the specific fault condition. See Appendix B: Error Codes for information describing the fault conditions and possible solutions.

The communication indicator briefly flashes anytime data is either sent to the PC or received from the PC. Data transferred on either the USB or RS-232 causes the indicator to flash.
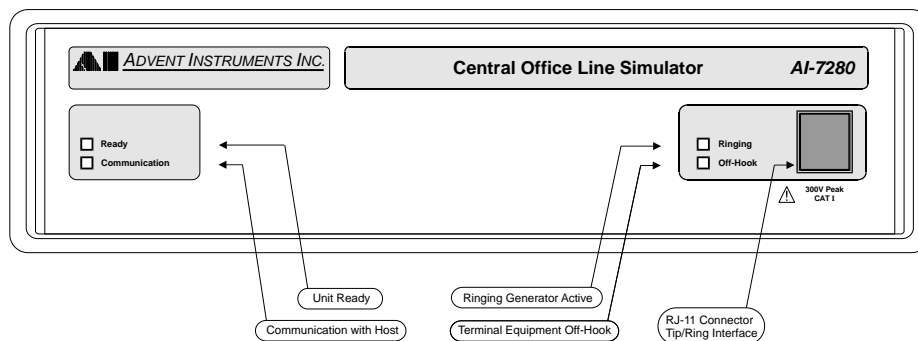

When the "Ready" indicator is illuminated (no fault condition), then the two right side LED's show when the AI-7280 has activated the ringing generator or when the connected terminal equipment is off-hook respectively. The AI-7280 considers any connected terminal equipment to be off-hook once the loop current drawn has exceeded a programmable threshold. If the ringing generator is active and the terminal equipment goes off-hook, the "Ringing" indicator may continue to be illuminated. The AI-7280 will automatically ring trip if sufficient loop current is drawn while ringing is active. However, even though the ring generator is no longer producing any signal, the "Ringing" LED will continue to be on until the controlling PC software turns off the ringing generator.

The RJ-11 jack on the front panel provides access to the tip/ring leads. Four conductors are used in this connector. The center two conductors represent the tip and ring signals and provide the DC feeding voltage, ringing voltage, and AC signal generation. The outer two conductors are not normally used; however, the AI-7280 can measure AC and DC voltages from the two outer conductors instead of the inner two conductors. This functionality finds use if artificial line lengths are inserted between the AI-7280 and the terminal equipment. In such a situation the outer two leads can be used to monitor the signal level at the terminal equipment, if the appropriate connections are made as shown in the following figure.
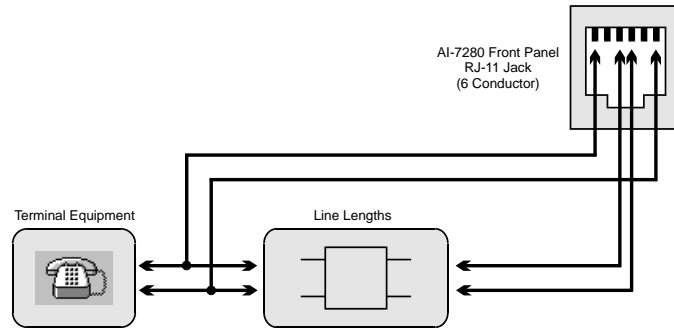
The next figure shows the configuration of the AI-7280 rear panel. In addition to the AC power receptacle and switch, it holds a number of other connectors.

The connection to the PC (or any other host) is made via either the USB type B connector or the 9 pin RS-232 connector. It is possible to transfer data to the AI-7280 over both the USB and RS-232 ports simultaneously. However, the TRsSim software and Windows DLL are configured to only use one of the two ports. The 9 pin RS-232 connector is configured as a DCE (Data Communications Equipment). As such no cross over cable is required when making a connection to a standard PC serial port. A minimum of three wires are required to make a serial connection. They are TX Data (pin 2), RX Data (pin 3), and Ground (pin 5). The AI-7280 can monitor the PC's RTS (pin 7) signal and control the state of the CTS (pin 8) signal, but does not use them to communicate. The DSR (pin 6) and DTR (pin 4) connections are internally tied together. The remaining pins (1 and 9) have no internal connection.
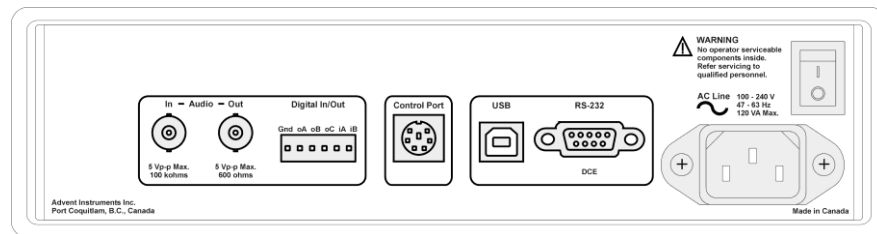
The two BNC connectors can either monitor various signals internal to the AI-7280 or inject signals into the AI-7280. The BNC input connector is AC coupled and withstands a maximum DC voltage of 55 volts. It can accept a maximum peak-to-peak signal of 5 volts with an AC input impedance of 100 k Ω. The BNC output connector is DC coupled and outputs a maximum of 5 volts peak-to-peak with an output impedance of 600 Ω.

To the right of the BNC connectors is a 6-pin terminal block. This connector provides 3 general purpose digital outputs and 2 general purpose digital inputs. The sixth pin provides a ground connection to the AI-7280. The three digital outputs (A, B, C) are in an open collector configuration. They can each sink up to 25 mA and are pulled high to +5 volts with a 5.1 k Ω resistor. All three digital outputs can be set either high or low. An additional setting permits output A to mirror the hook state of the terminal equipment and output B to mirror the bit pattern decoded by the FSK demodulator. The two digital inputs (A, B) have an input impedance of 100 k Ω. The maximum input level to detect a logic low is 0.8 volts, while the minimum logic high level is 2.0 volts.

The 6 pin Control Port connector is designed for control and communication with future peripherals, or other AI-7280 units. It uses a standard 6 pin mini-circular DIN connector.

4.3 Factory Installed Hardware Options

The AI-7280 can be ordered from the factory with optional hardware configurations to suit specific customer requirements.

AI-E701 Additional Line Impedance

This hardware option adds a fourth line impedance to the three standard line impedances (600 ohm, 900 ohm, TBR-21). Common impedance values that may be chosen are:

- 82 ohm + (600 ohm || 68 nF) (TBR-38 "a")

- 220 ohm + (1800 ohm || 150 nF) (TBR-38 "c")

- 220 ohm + (820 ohm || 115 nF) (German Zr)

- 370 ohm + (620 ohm || 310 nF)

- 1200 ohm

(Others values are available by request.)

AI-E702 Extended Line Feed

This hardware option expands the ability of the AI-7280 Line interface to produce 105 V DC when on hook and up to a 105 mA loop current when taken off hook. This option also increases the maximum DC current that can me measured by the instrument to 120 mA.

These features are especially useful when testing compliance of products to international standards that have the expanded DC range requirements

4.4 Extended Product Support and Warranty

AI-K001 Additional One Year Warranty
The standard product support and warranty period for the instruments is one year. This option increases the parts and labor warranty period for another year to a total of two years from date of purchase on the instrument.

AI-K003 Additional Three Year Warranty
The standard product support and warranty period for the instruments is one year. This option increases the parts and labor warranty period for another three years to a total of four years from date of purchase on the instrument.

4.5 Specifications

Telephone Interface:

DC Characteristics:

Line Voltage	0 to 72 Volts, ±5%, ± 400 µVolts
	or
	0 to 105 Volts, ±5%, ± 400 µVolts with optional AI-E702 Extended Line Feed option
Loop Current (constant current mode)	5 to 72 mA, ±5%, ± 200 µA
	or
	5 to 105 mA, ±5%, ± 200 µA with optional AI-E702 Extended Line Feed option
Loop Current (constant voltage mode)	Load dependent. Current limited to a minimum of 80 mA.with standard output and 110mA with optional AI-E702 Extended Line Feed option.
DC Feed Resistance	2 x 200 Ω
Off-Hook Threshold Current	5 to 15 mA (User Adjustable)

Ring Generator:

Amplitude	0 to 80 Vrms, ±0.2 dB (using sine wave shape & 48V DC offset)
Frequency	10 to 100 Hz, ±0.02%
DC Voltage Offset	0 to 72 Volts, ±5%, ± 400 µVolts
Source Impedance	Maximum 420 Ω Capable to drive 5 REN loads
Wave shape	Sine, Triangle, Square, or User Defined

AC Characteristics:

Signal Generator Frequency	20 Hz to 18 kHz, +/- 0.02%
Signal Generator Amplitude	0 to 4 Vrms (un-terminated), ± 0.2 dB from 50 Hz to 10 kHz
Signal Generator Modes	Single, FSK, AM, DTMF, MF
Signal Generator Wave Shapes	Sine, Triangle, Square, User Defined
Source Impedance	600 Ω ±2%
	900 Ω ±2%
	TBR-21 Complex, ±3% (Optional 4th Complex impedance installed at factory)
Balance Impedances	600 Ω 900 Ω TBR-21 Complex, (Optional 4th impedance)

Measurements:

DC Characteristics:

Line Voltage	0 to ±195 Volts, ±5%, ± 200 µVolts
Loop Current	0 to 95 mA, ±5%, ± 200 µA
	0 to 120 mA, ±5%, ± 200 µA with optional AI-E702 Extended Line Feed option
Sample Rate	1 k sample/sec
Voltage & Current Capture	8191 samples (8.191 seconds)

AC Characteristics:

RMS Level	0 to 4 Vrms, ± 0.2 dB from 10 Hz to 10 kHz
Frequency Range	10 to 18 kHz
Selectable Filters	LPF, HPF, Band pass, notch, DTMF, C-Message, ITU O.41
DTMF Measurement	Level: 0 to 4 Vrms, ± 0.2 dB Frequency: ± 1 Hz
FSK Decoder	Bell 202 or V.23 capable

Waveform Capture   Sample Rate: 20 or 40 k sample/sec
                                        Record Length: 5.6 or 11.2 seconds

Input & Output:

BNC Input:
Unbalanced, AC Coupled

Input Impedance	100 k Ω , $\pm$ 5%
Maximum Input Level	5 Vp-p Maximum
Level Accuracy	$\pm$ 0.2 dB, 50 Hz to 10 kHz
Frequency Range	10 Hz to 18 kHz
Maximum DC Input Voltage	$\pm$ 55 Volts

BNC Output:
Unbalanced, Ground Referenced

Output Impedance	600 Ω, $\pm$ 3%
Maximum Output Level	5 Vp-p Maximum
Level Accuracy	$\pm$ 0.2 dB, 50 Hz to 10 kHz
Frequency Range	10 Hz to 18 kHz

Digital I/O:

Number of Output Pins	3 (Can mirror hook state and FSK decoder output status)
Output Configuration	Open Collector
Output Maximum Sink Current	25 mA
Output Pull-up Resistance	5.1 k Ω
Number of Input Pins	2
Input Impedance	100 k Ω
Maximum Low Level Input	0.8 Volts (for logic 0) Maximum
Minimum High Level Input	2.0 Volts (for logic 1) Minimum

General:

Host Communication:

USB Port	Version 2.0, Full Speed (12 Mbit/s)
USB Connector	Standard Type-B
RS-232 Configuration	DCE (Data Communication Equipment)
RS-232 Connector	9 pin D style connector

AC Line:

Voltage	100 to 240 Vrms, 120 VA max
Frequency	47 to 63 Hz

Physical:

|	
Dimensions	Width: 10" (26 cm)
	Height: 3.3" (8.5 cm)
	Depth: 10.6" (27 cm)
Weight	Approximately 5 lbs (2.3 kg)
Operating Temperature Range	5 to 40 ºC, 80%RH
Storage Temperature Range	-25 to 70 ºC, 80%RH
Operating Altitude	$\leq$ 2000 m

5. Firmware Updates

The AI Firmware Update program provides a simple means of updating all of the system files stored in the AI-7280's internal flash memory. The software can be used to upgrade the system files to the latest version and correct device specific problems if the AI-7280's flash memory becomes corrupted.

The program is available from the included CD or from our web site at:

http://www.adventinstruments.com

Once the AI Firmware Update software is installed on a PC, connect the AI-7280 to one of COM ports. Power the AI-7280 on and start the firmware update software. The software will ask if it should query our website for latest updates. It is recommended to click yes to ensure the latest firmware is utilized.
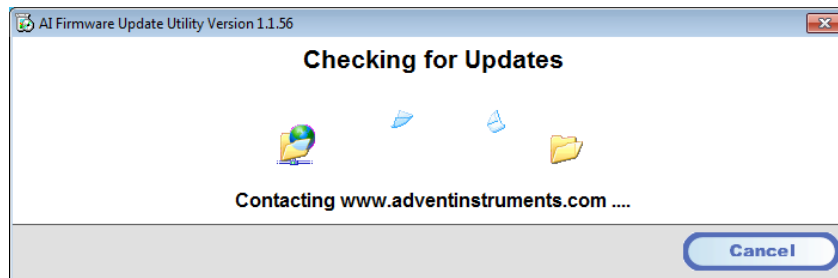

Once the update, if available, is downloaded the software checks for all compatible devices connected to the PC.
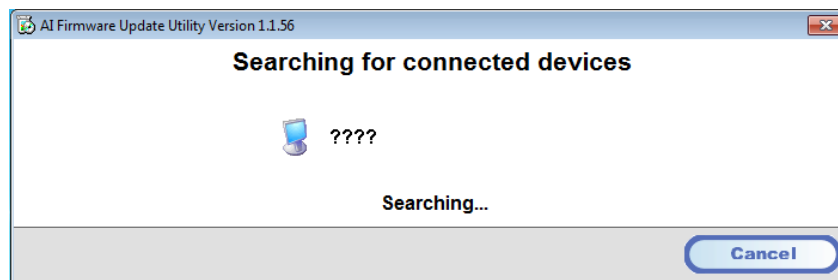

Once this is complete a window appears (as shown below) displaying all the connected devices. For each device, its current firmware revision is shown along with the newest

versions that may be installed. An older version of the firmware may be installed by clicking on the right most firmware selection icon.
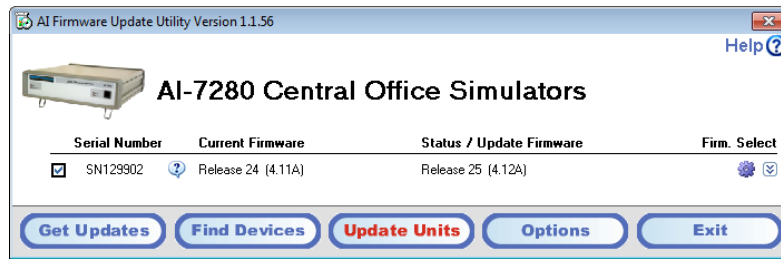

The check box to the left determine which devices are to be updated. By ensuring it is checked and clicking on the **Update Units** button, the process of installing the selected firmware begins.

Note: It is important NOT to shut off the power during the update process as this may permanently corrupt the memory of the device.
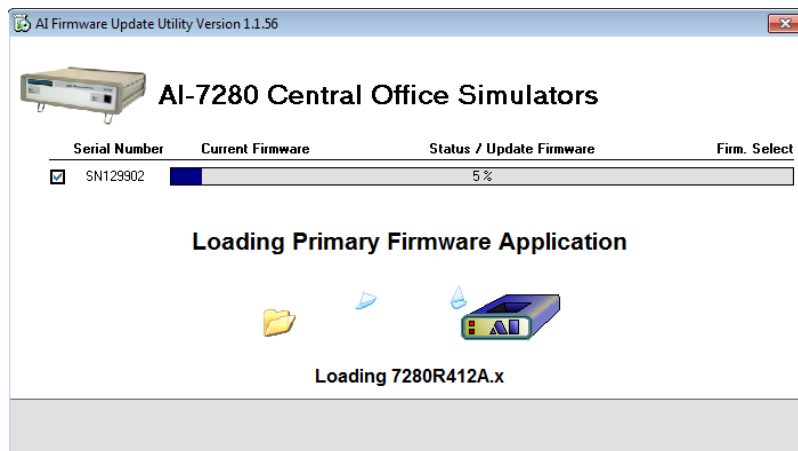
Once the update process is complete and no errors were detected, a green icon is shown to the left of the device information. If the update could not be completed due to errors, a message providing information on the error is displayed. Please contact us for assistance in resolving the error.
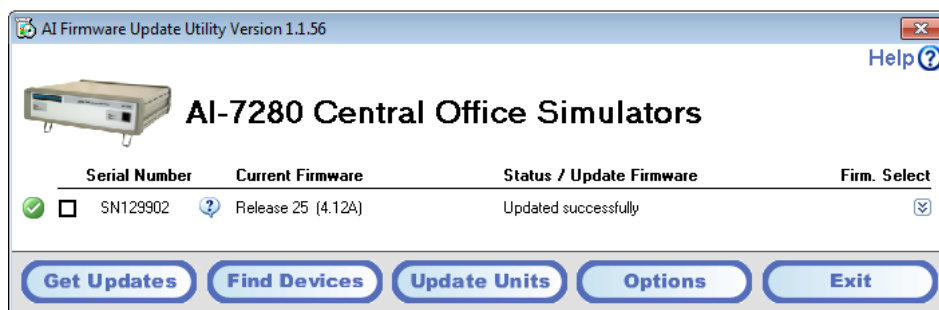
# Appendix A: USB Driver Installation

The WHQL certified driver files are automatically installed along with the TRsSim application and the following procedure should only be required if the end application will not use the TRsSim software.

The drivers may be installed manually by using the add remove hardware wizard or via the self extracting installer package. The following figures show the step-by-step procedure for installing the USB drivers with this installer package.

1. Download the USB installer Package

The USB installer package can be downloaded from our website at the following page

http://www.adventinstruments.com/Downloads/ or copied from the original format provided with the instrument.
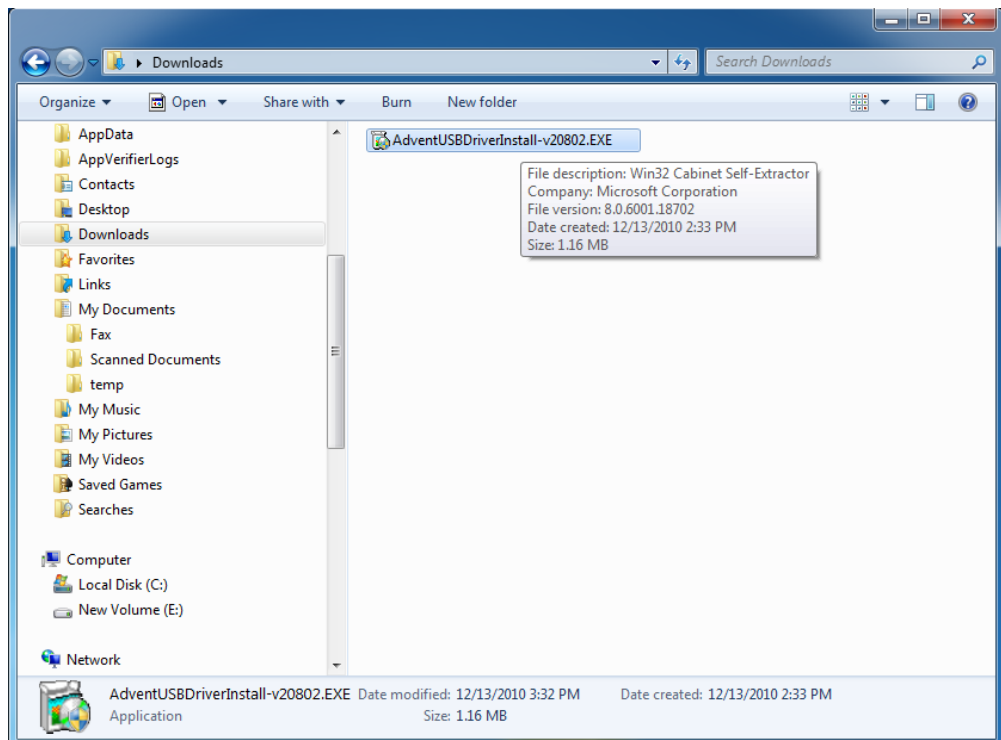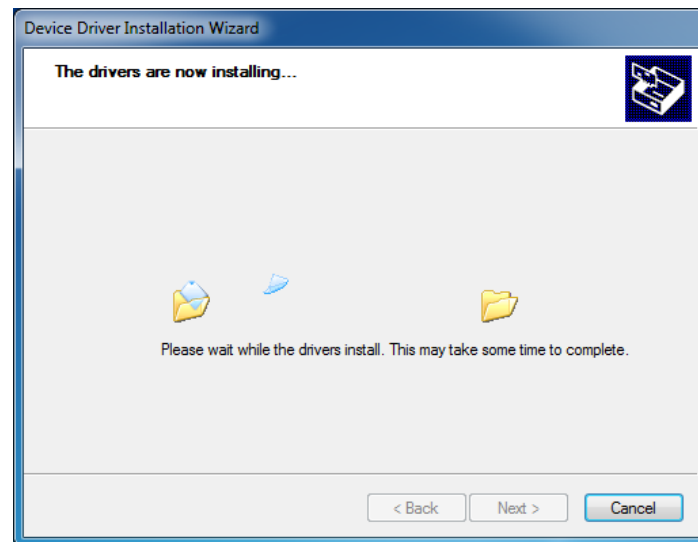
2. Run the USB installer Package

Once the file is located on the target computer double click on the file to start the self extraction and the following window will be displayed.
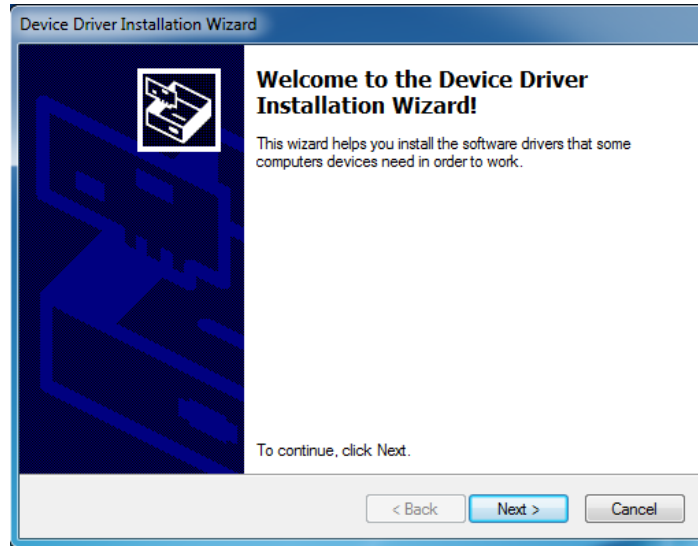

3. Click on the Next button to install the driver files

Windows will now copy the driver files from the installer package to the target computer.

4.   Confirm the Driver installed correctly

Once Windows has completed the installation of the driver files the following window will display the results. Confirm that there are two ✔ marks beside both of the listed driver names.
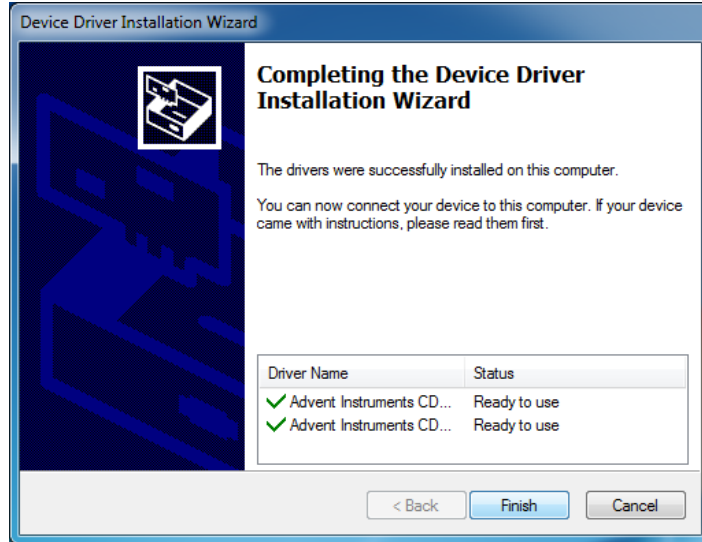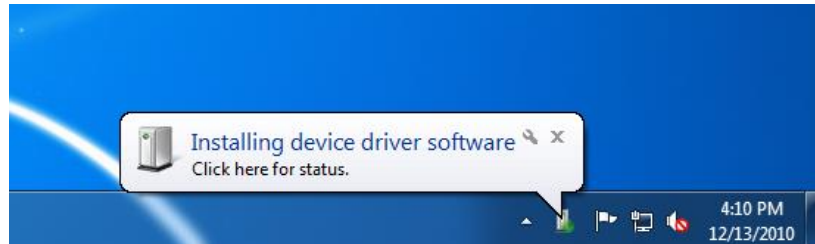

**5.   Click on the Finish button to exit the installer**

The driver is now installed and you may connect the instrument to the PC via a USB cable.

6.   Connect the Instrument to the PC via the USB cable

The following brief popup bubble will appear indicating Windows has detected the new instrument.

Then a short time later the following popup will appear and the instrument is recognized by Windows and the PC.
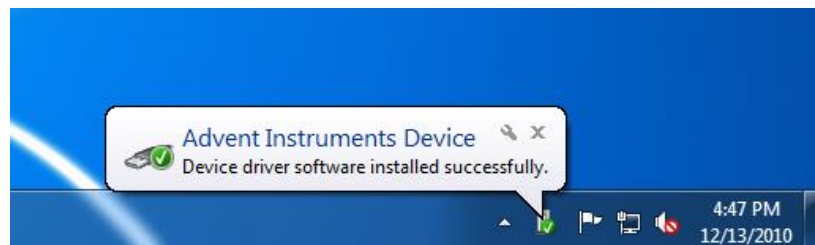
Appendix B: Error Codes

Various AI-7280 error conditions may be detected at power on or during operation. If such a condition is detected, the "Ready" indicator starts to flash from its normally solid on state. The type of error detected is determined by examining the state of the "Ringing" and "Off-Hook" indicators. The following table lists the various error conditions.

READY Indicator	RINGING Indicator	OFF-HOOK Indicator	Description / Corrective Measure	Error Code
Flashing	On	On	**Excessive Line Unbalance:** An excessive amount of unbalanced current has been drawn from the telephone interface. A protection mechanism engages to prevent any damage. Once the problem is corrected the unit will return to normal operation, however the error code remains displayed until cleared by the host.	1102 (set) 900 (clear)
Flashing	On	Flashing	**RAM Test Failure:** Upon power on a check of the system RAM is performed. This error code indicates that one or more data bytes did not pass the check. As this represents a hardware fault, the only corrective action is to return the unit for repair.	1004
Flashing	Off	Off	**Flash Memory Corruption No Program File:** The primary DSP application program is missing from the flash memory or is corrupted. Use the Ai7280Setup.exe program to restore the flash memory contents.	n/a
Flashing	Flashing	Flashing	**Flash Memory Corruption No Startup Script File:** The startup script file is missing from the flash memory or is corrupted. Use the Ai7280Setup.exe program to restore the flash memory contents.	1003
Flashing	Flashing	On	**Flash Memory Corruption No Reset Script File:** The reset script file is missing from the flash memory or is corrupted. Use the Ai7280Setup.exe program to restore the flash memory contents.	1100
Flashing	Flashing	Off	**Flash Memory Corruption Missing Unit ID Code:** The unit ID code stored in the flash memory is either missing or is corrupted. If the Ai7280Setup.exe program has been used at least once after the last calibration, execute it again. It should be able to restore the missing data. If not, please contact technical support for assistance.	1001

| Flashing | Off | Flashing | **Flash Memory Corruption** **Can Not Load Calibration:** Either the calibration factors or the calibration script is missing from the flash memory or is corrupted. If the Ai7280Setup.exe program has been used at least once after the last calibration, execute it again. It should be able to restore the missing data. If not, please contact technical support for assistance. | 1002 |
| Very Fast Flashing | Very Fast Flashing | Very Fast Flashing | **Program Stack Fault** The AI-7280 software has encountered a software stack fault. This error prevents the AI-7280 from responding to any commands and effectively freezes the system. The power must be turned off and on in order to restore normal operation. Please contact technical support if this error occurs. It represents a software problem and should be corrected. | n/a |

The following error code is a special case in which the "Ready" indicator is not flashing, but rather off. It can only occur when the AI-7280 is powered on.

READY Indicator	RINGING Indicator	OFF-HOOK Indicator	Description / Corrective Measure	Error Code
Off	On	Off	**Flash Memory Corruption** **Failure to execute program:** The primary DSP application program could not be started. This may indicate a corrupted file within the flash memory, or a hardware fault. Use the Ai7280Setup.exe program to restore the flash memory contents. If this fails to work, please contact technical support for assistance.	n/a

Appendix C: Support

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

- Email: Technical Questions:

  techsupport@adventinstruments.com

  Sales Inquires:

  sales@adventinstruments.com

- In North America:

  Tel: (604) 944-4298

  Mail: Advent Instruments Inc.

  111 - 1515 Broadway Street

  Port Coquitlam, BC, V3C6M2

  Canada

- In Asia:

  Tel: (852) 8108-1338

  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

RoHS Self-Declaration

Advent Instruments Inc., hereby declares that products listed below conform to the European Union's Restriction of Use of Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive2002/95/EC.

The RoHS Directive restricts the use of certain substances including lead, mercury, cadmium, hexavalent chromium and certain halogenated flame retardants such as PBB and PBDE in electrical and electronic equipment.

Advent Instruments products will have less than the RoHS limits stated below for the six restricted use substances.

Restricted Substance List:

Substance	Maximum Limit (Weight)
Cadmium (Cd)	100 ppm
Lead (Pb)	1000 ppm
Mercury (Hg)	1000 ppm
Hexavalent Chromium (Cr6+)	1000 ppm
Polybrominated Biphenyls (PBB)	1000 ppm
Polybrominated Diphenyl Ethers (PBDE)	1000 ppm

Product list:

Model	Description
AI-5120	Line Monitor
AI-5620	Terminal Equipment Simulator
AI-7280	Central Office Line Simulator

_____
David Stenner   Date: Jan 21, 2007
Advent Instrument Inc.