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# AI-7160 Ringing Signal Generator



## User Guide

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Advent Instruments Inc.

Release 1.1a

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## 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.

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## 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.

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# 1. Getting Started

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## 1.1 Introduction

The AI-7160 is a highly flexible programmable ringing signal generator. All of the key operating parameters are adjustable over a wide range of operating conditions, making the unit useful in many compliance testing situations.

The output terminals can be internally configured to support both common mode (Longitudinal) and differential (Metallic) test setups. In addition the digital and analog input/output ports allow for an easy interface to other equipment for inclusion within a complete testing system.

Supplied with the AI-7160 is PC software that runs on the Windows operating system. It provides a high level easy to use graphical interface for controlling and monitoring the unit.

To support integration into test systems the AI-7160 can be controlled directly from its RS-232 communication port. All of the commands and responses needed to use the AI-7160 are fully documented and included with the Windows software or can be downloaded from our web site.

The remainder of this first section provides information on what is included with the AI-7160, basic safety information, AC power connection, and PC connection details.

Section 2 then explains how to use the Windows control software, and finally

Section 3 supplies technical operating information and specifications for the unit.

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## 1.2 Package Contents

Use care when unpacking the AI-7160 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 B: Support ). Keep the shipping materials for the carrier inspection.

The package should contain the following items:

- AI-7160 Ringing Signal Generator
- USB to 9-pin RS-232 adapter
- 9 pin 'straight through' serial cable

- Black/Red Test Leads
- AC Power Cord (plug type dependent on destination country)
- CD-ROM containing application software, DLL drivers, and Setup software
- AI-7160 User Guide
- Calibration Certificate

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

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## 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-7160 or any products connected to it. The AI-7160 is intended for use by qualified personnel who recognize shock hazards and procedures to avoid possible electrical shock. The AI-7160 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.

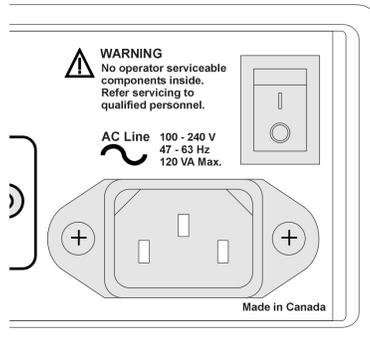
- Insure the AC power source is compatible with the voltage and frequency requirements stated on the rear label of the instrument.
- Do not operate the instrument with the case opened.
- Do not allow any liquid to enter the interior of the instrument.
- Observe all terminal ratings to avoid fire or shock 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.

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## 1.4 Powering on the AI-7160

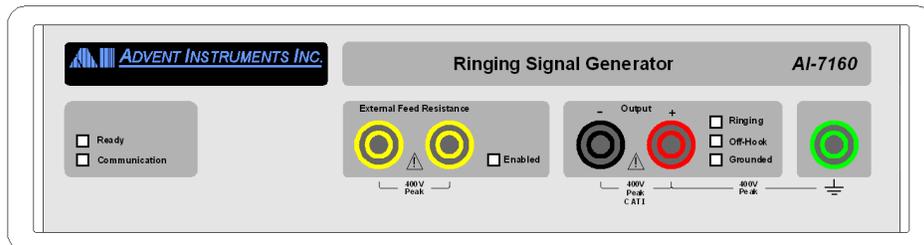
Before powering on the AI-7160 for the first time, disconnect any cables connected to the unit. The unit's power supply automatically adjusts to a wide range of input voltages and frequencies. However please ensure the AC voltage source is within the limits printed on the rear panel.

The power switch for the AI-7160 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.



Connect the AC power cord, ensuring a snug fit to the receptacle. Turn on the power to the AI-7160 by rocking the power switch upward.

All six 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 five indicators ("Communications", "Enabled", "Ringing", "Off-Hook", and "Grounded") 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 flash every 3 seconds. The number of flashes indicates a fault code. If it stays off, the fault is serious and requires that the unit be returned for repair or replacement. In either case, see Appendix A: Error Codes for more information.

## 1.5 Connecting to the PC

The AI-7160 can be connected to the PC by its RS-232 port. There is also a USB jack present on the rear panel, however at this time a USB connection is not supported.

### RS-232

The rear panel 9 pin connector of the AI-7160 is configured as a DCE (Data Communications Equipment) port. As the PC is normally configured as a DTE (Data Terminal Equipment) port, a straight-through cable is required for the connection. Do not use a cross-over cable between the AI-7160 and the PC serial port.

The AI-7160's serial port connector operates at a fixed baud rate of 115,200. The serial line format is fixed at 8 data bits, 1 stop bit, and no parity. 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.

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## 1.6 Next Step

Once the AI-7160 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 supplied Windows control software, which provides a graphical user interface for configuring and controlling the instrument. Or the second approach is controlling the AI-7160 directly by sending commands to its serial port. This approach is favored when implementing automated or semi-automated testing systems.

The next section in this document provides information on how to use the Windows control software.

For detailed information needed to control the AI-7160 directly over its serial port consult the "**AI-7160 Programmers Guide - Direct Control**" documentation available on our website at.

<http://www.adventinstruments.com/Products/AI-7160/Downloads>

# 2. Windows Control Software

## 2.1 Introduction

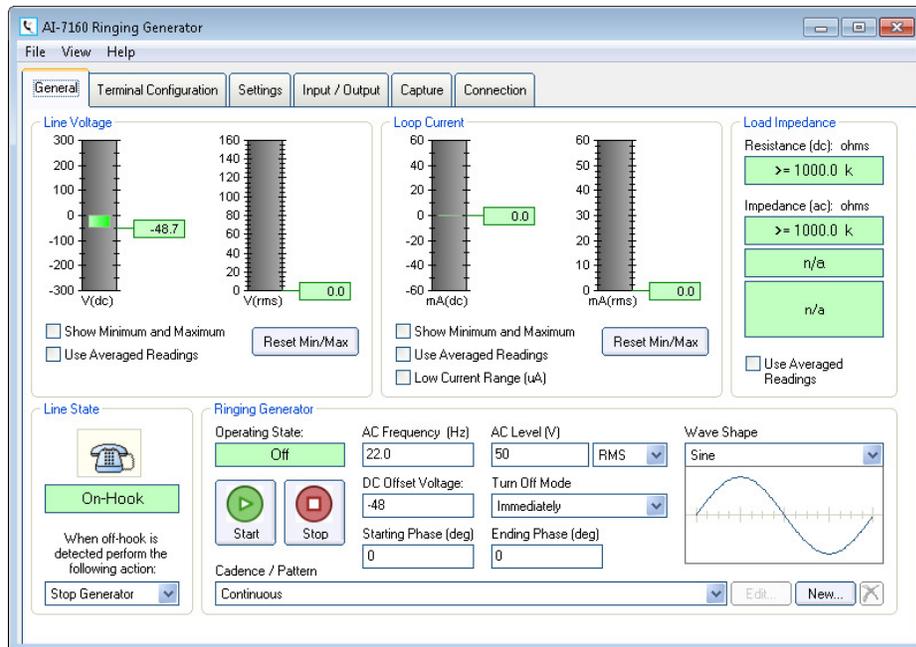
A single file installer for the control software is available for download from our web site at:

<http://www.adventinstruments.com/Products/AI-7160/Downloads>

The software requires that the PC has a serial port available for communication with the AI-7160. If none are directly available on the PC a USB to RS-232 serial converter can be used.

Once the program has been installed and is started it immediately attempts to locate an AI-7160 on any available serial ports. The serial ports enumerated by Windows must be between the range of COM1 to COM20. Serial ports outside this range will not be used by the software.

When the software finds an AI-7160 it resets all of the ringing generator settings to their default values and displays a window similar to the following.

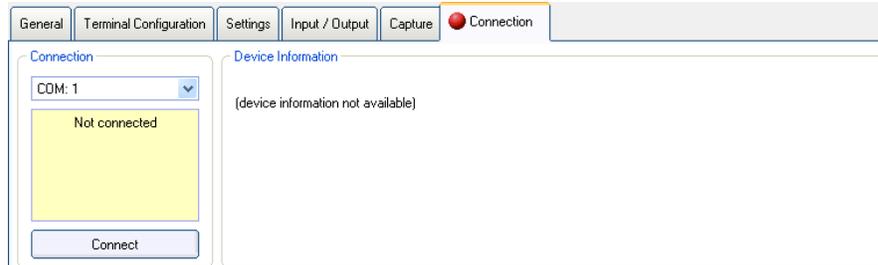


However, if an AI-7160 can not be found when the program starts it is normally because of one of the following conditions:

- i) No physical serial connection exists.

- ii) The serial port is outside the range of COM1 to COM20.
- iii) The serial port is currently used by another application.
- iv) The AI-7160 is not powered on.

The software indicates the failed connection by showing the 'Connection' tab.



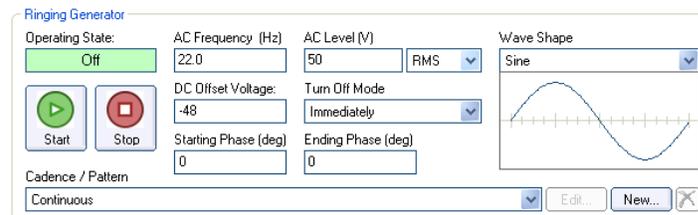
To try again, select the desired serial port from the drop down list and click on the 'Connect' button. If an AI-7160 is found the software then indicates a successful connection state.



## 2.2 Ringing Settings

The software divides all of its functionality into the six different tabs shown near the top of the window, underneath the menu bar. For basic control of the ringing generator ensure the tab labeled 'General' is selected. It shows the primary settings and status for the AI-7160.

The lower portion of the window contains the controls that operate the ringing generator.



Changing any of the basic parameters such as frequency, AC voltage level, and DC offset level is accomplished by simply clicking the mouse inside the text area, entering a new value, and then pressing the 'Enter' key. When the 'Enter' key is pressed the new value is first checked against minimum and maximum limits and then sent to the AI-7160.

While the specified DC offset voltage is always present at the output of the ringing generator, the AC voltage must be enabled by clicking on the 'Start' button. Likewise clicking the 'Stop' button turns off the AC voltage generation.

The operating state of the AC ringing generator is indicated as either:

- i) **Off** – no AC being produced, however the DC offset voltage is present.

- ii) **Active** – AC signal is generated at the specified frequency and level.
- iii) **Muted** – the AC signal is not being generated because an off-hook condition has been detected.
- iv) **Pending off** – the AC signal will be turned off once the ‘ending’ phase angle is reached.
- v) **Active(CLIP)** – The combination of DC offset and AC voltages exceeds the output capability of the AI-7160. A portion of the ringing waveform may be clipped.

The starting and stopping phase angle for the AC signal is controlled by the ‘Starting Phase’ and ‘Ending Phase’ settings respectively. They can range between 0 and 359 degrees. The ‘Turn Off Mode’ setting determines how the AC signal generator is stopped. It operates in one of three different modes. They are:

- i) **Immediately**: The AC generator is immediately stopped at what ever the current wave shape phase angle is.
- ii) **At end phase setting**: The AC generator remains active until the specified ending phase angle is reached.
- iii) **At either 180 or 360 deg.:** The AC generator remains active until either a phase angle of 180 or 360 degrees is reached.

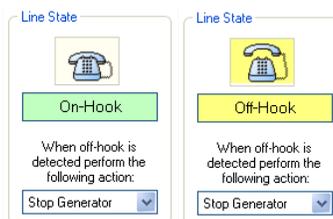
To change the AC signal wave shape select any of the six available options from the drop down list. The possible selections are: sine, square, triangle, and three different forms of trapezoidal wave shapes.

The AI-7160 includes a sophisticated ringing cadence generator. By default the AC signal is continuously generated until turned off; however different cadences can be selected from the drop down list box. For more information on how to change the cadences or create custom cadences see section 2.4.

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## 2.3 Line State Interactions

The AI-7160 continually monitors the voltage being generated as well as the current flow. This is used to determine the line state which can be either on-hook or off-hook, representing the state of connected terminal equipment (TE) device. When TE devices are on-hook they normally present a high impedance to the telephone line and ringing can occur. In the off-hook state they draw DC loop current and present a low impedance.



Normally when the off-hook state is detected the ringing generator is forced to turn off. However the AI-7160 can be configured to take one of three different actions determined by the selection in the drop down list shown in the figure above. These actions are:

- i) **Stop Generator** (default) – turn off the ringing generator as soon as possible based upon its ‘turn off mode’ setting. When the on-hook state is detected the generator does not turn back on.

- ii) **Mute Generator** – Set the AC voltage to zero but continue to run the cadence generator. When the on-hook state is detected un-mute the generator by restoring the AC voltage.
- iii) **No Action** – Maintain the AC voltage during the off-hook state.

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**Note:** With high AC voltages or very demanding loads the AI-7160 may automatically reduce its output level in order to prevent internal damage. This can result in a clipped output waveform.

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The DC loop conditions that determine whether or not the line state is on or off-hook depends on the Off-Hook Detection settings tab. When the ringing generator is not active (no AC voltage), the AI-7160 uses the DC current measurement and source voltage to estimate the off-hook impedance. When the value is lower than threshold in the settings tab the line is considered as Off-Hook.

**Off-Hook Detection**

When ringing is off:

Threshold current for off-hook  
 mA

Amount of time new state must be stable for before change is detected  
 ms

When ringing is active:

DC resistance threshold for off-hook  
 k ohms

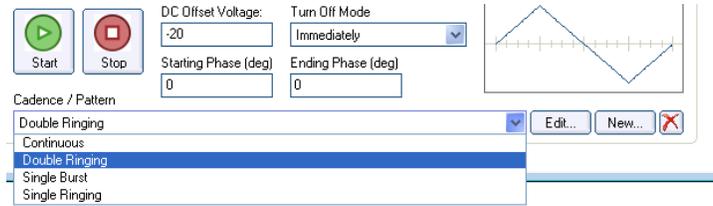
Number of ringing cycles to measure over

Amount of time current and impedance measurements are ignored when ringing is turned on or off  
 ms

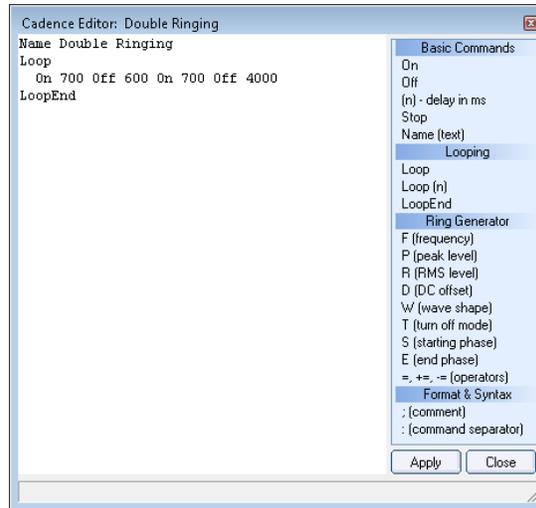
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## 2.4 Ringing Cadences

A very flexible cadence/pattern generator within the AI-7160 provides a wide range of signal generation capabilities. By default, four very basic cadences are available for use. They represent continuous ringing, a single burst of ringing, the standard single ring pattern of 2 seconds on and 4 seconds off, and finally a double ring pattern consisting of two short bursts separated by 4 seconds. The cadence used by the ringing generator is selected from the drop down list shown below.



The three buttons to the right of the drop down list are used to edit/modify the currently selected cadence, create a new cadence, or delete the currently selected cadence. If either the 'Edit' or 'New' buttons are clicked a window similar to the following is displayed.



This window is the AC signal cadence editor. Cadences are created from a very simple scripting language. The above figure shows the default Double Ringing cadence. The first statement provides the name of the cadence as it is displayed in the drop down list. The following statements create a loop which continually turns the ringing on for 700 ms, off for 600 ms, on again for 700 ms, and off for 4000 ms. This pattern repeats until the ring generator is manually stopped or an off-hook condition terminates it.

The right hand side of the editor lists all of the available commands. Clicking on any of the commands provides information on its use in the area at the bottom of the window.

All of the ringing generator settings (such as frequency, voltage, wave shape) can be modified from within a cadence script. The settings can be assigned a new value, incremented by a value, or decremented by a value.

For example, the frequency settings are assigned the letter 'F'. Using the script statement 'F=22' sets the ringing generator frequency to 22 Hz. Alternatively, to increment the frequency by 2 Hz use the statement 'F+=2'.

Loops are created by the combination of the 'Loop' and 'LoopEnd' commands. If the 'Loop' command is followed by an integer value, then the loop repeats the specified number of times. If no value is provided then the loops repeats indefinitely. Loops can also be nested within each other up to a depth of 10. However it is important that the number of 'Loop' statements is matched to the number of 'LoopEnd' statements.

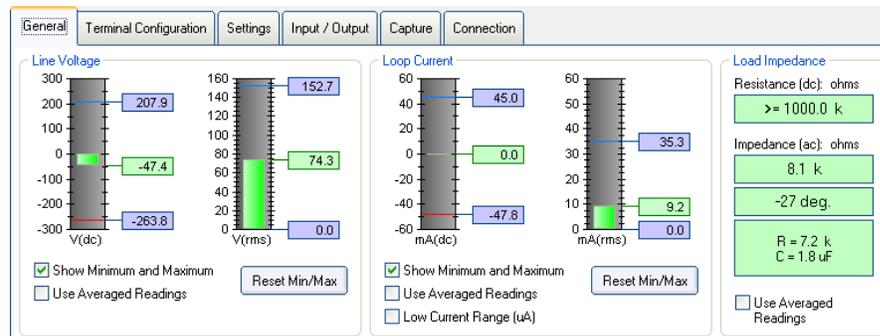
Delays in the script execution occur simply by specifying a time in milliseconds between the limits of 1 to 1,000,000. For example the script 'On 1200 Off' turns on the ringing generator, waits 1200 ms, then turns off the ringing generator.

Execution of the script stops when either the last statement is processed, or the 'Stop' command is used. It is important to note that the ringing generator is not turned off when the script execution ends. If the script does not end with an 'Off' command the generator

remains active until an off-hook condition is detected or the ringing 'Stop' button is pressed.

## 2.5 Measurements

The AI-7160 constantly measures both the voltage and current produced by the ringing generator. The results of these measurements are displayed in the four level meters showing the DC voltage, AC(rms) voltage, DC current, and AC(rms) current. Based on the readings an estimate of any load impedance placed on the output of the ringing generator is calculated. This is displayed to the right of the current meters as a DC resistance and AC impedance. From the magnitude and phase angle of the AC impedance the equivalent resistor/capacitor or resistor/inductor values are calculated.



**Note:** The phase and RLC measurements are only displayed if the ringing waveshape is set to SINE.

The four level meters always show the last measurement made as a numeric value displayed in the light green box. Optionally, the minimum and maximum readings can be displayed as well, each in a light blue box. This feature is turned on or off by clicking the 'Show Minimum and Maximum' check box. To reset the minimum and maximum readings click the button labeled 'Reset Min/Max'.

In situations where the measurement readings experience a high degree of jitter an averaging mode can be enabled. This slows down the rate of updates by first taking an average over a number of measurements. By default, ten measurements are used to compute the average; however, this can be increased.

The current measurement operates in one of two different ranges. A high range (default) consisting of readings between +/- 60 mA, and a low range spanning +/- 1 mA. To toggle the range between high and low click on the 'Low Current Range' check box. The low current range is useful for measuring current draw from terminal equipment devices that present high impedances in the on-hook state.

**Note:** When the low current range is selected the off-hook threshold is set to 0.75 ma t

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**Note:** When the ringing generator is started the current measurement is forced to the high range. Also, the line state detector uses different current thresholds depending on the range selection of the current meter.

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The 'Settings' tab contains controls that are used to modify the operation of the voltage and current measurements.

Measurement Settings:

Minimum amount of time to integrate measurements over  
 ms

Minimum number of ringing cycles to integrate measurements over (when generator is active)

Number of measurements to average over (when averaging is enabled)

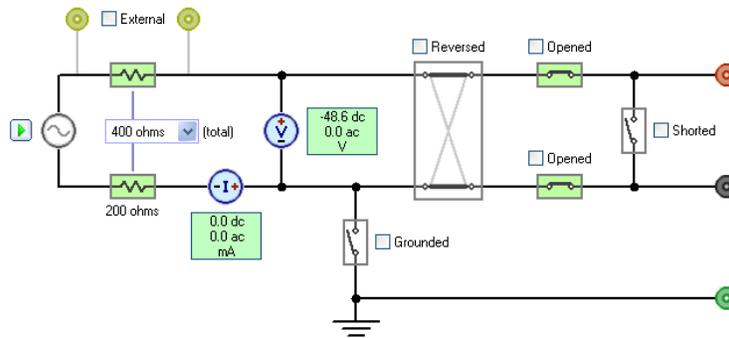
Measurement integration time  
 ms

All voltage and current measurements are calculated by taking a large number of samples over an integration period. The integration period is the duration of a specified number of ringing cycles, bounded by a lower time limit. By default this is 3 ringing cycles and 50 ms. Anytime the ringing frequency changes the integration period is recalculated. By increasing either the minimum number of ringing cycles or minimum integration period the stability of the measurement results are increased, with the trade off being a slower update rate.

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## 2.6 Terminal Configuration

The 'Terminal Configuration' tab is used to view and modify the signal routing between the AI-7160's ringing generator and the front panel connections. A wide range of configurations are possible, easing the setup required when testing to various compliance standards.



Starting at the left hand side of the figure above is the ringing generator. It is responsible for supplying both the DC voltage offset and AC ringing voltage. Clicking on the small green arrow to the left of the generator icon will start and stop the generator respectively.

The output of the generator is passed through two resistances. One is fixed at 200 ohms, while the other is adjustable over a number of selections. The combined resistance is displayed in the drop down list box, and clicking it presents a list of all of the available options. Optionally an externally supplied value can be used by clicking on the check box marked 'External'.

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**Note:** Even if an external impedance is used the fixed 200 ohm resistance is always in series with the output.

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The position of the voltage and current meters contained within the AI-7160 are indicated by the light blue circles, with their latest readings shown in the green boxes.

Following the meters a relay can be engaged to connect the negative end of the ringing generator to earth ground.

Moving left in the signal routing diagram, the connection to the positive and negative output terminals can be reversed in polarity, or each terminal can be individually disconnected, or both terminals can be shorted together. By clicking on the various check boxes the signal path is altered.

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## 2.7 Input & Output Capabilities

The rear panel of the AI-7160 provides a digital I/O connector as well as two BNC connectors for analog I/O. They can be used for monitoring the status of the AI-7160 or for controlling it. The tab marked 'Input / Output' contains the various controls for viewing and modifying the I/O settings of the AI-7160.

The rear panel six pin digital I/O connector supports three outputs labeled 'A', 'B', and 'C'. They are open collector outputs with a weak pull up to +5V.

**Digital**

Output 'A' function  
 Set low

Output 'B' function  
 Set low

Output 'C' function  
 Set low

Input 'A': Ring Generator Control

Start on: neither edge

Stop on: neither edge

Input Pin State: Low

Input 'B': Cadence Control

Start on: neither edge

Stop on: neither edge

Input Pin State: Low

The default setting is for all of the outputs to be forced low. However by clicking on the drop down list, output 'A' can be set to go high when the ringing generator is active (producing an AC signal). Similarly, output 'B' can be set to go high when the AI-7160 detects the line state to be off-hook. And output 'C' can be set to go high when the ringing cadence generator is active.

The two digital inputs labeled 'A' and 'B' accept an external TTL compatible logic level. By default the state of the input signal has no effect on the AI-7160. By changing the settings in the input 'A' drop down lists the ringing generator can be started or stopped when the AI-7160 detects either a rising or falling edge. Likewise, the two drop down lists for input 'B' will start or stop the cadence generator on either a rising or falling edge.

**Analog (BNC)**

Output (maximum output is +/- 3V)  
 Off

Gain: 1.000

BNC output voltage forced to 0.

Input (maximum input is +/- 4V)  
 Off

Gain: 10.000

Voltage at BNC input is ignored.

Note: Negative values of gain can be used to invert the output or input.

The analog I/O are provided on the rear panel with a BNC input and output connectors. The output can produce a voltage between the range of +/- 3 V with a source impedance of 600 ohms. The DC coupled input can accept a voltage between +/- 4 V and presents an input impedance of 100k ohms.

The analog output operates in of five different modes. They are:

- i) **Off** – No signal generated. Output set to zero.

- ii) **Ring Output** – Output represents the DC and AC voltage produced by the ringing generator. The default scaling ratio is 100V to 1V.
- iii) **Ring Wave Shape** – Output represents the ringing wave shape with an output level of +/- 1V<sub>peak</sub>.
- iv) **Voltage Meter** – Output represents the voltage meter readings with a scaling ratio of 100V to 1V.
- v) **Current Meter** – Output represents the current meter readings with a scaling ratio of 50mA to 1V in the high current range and 500uA to 1V in the low current range.

For any of the four modes that produce an output voltage, and additional gain/scaling value between the range of +/-10 can be specified.

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**Note:** At all times the output voltage from the BNC connector is limited to +/- 3V.

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The input BNC connector can be used to supply an arbitrary signal into the AI-7160 and have that signal appear at the output of the ringing generator. This includes both DC and AC components. The voltage applied to the BNC input is multiplied by an adjustable gain setting between the limits of +/-32768 and then sent to the ringing generator for output.

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**Note:** The voltage applied to the BNC input connector must not exceed +/- 4V.

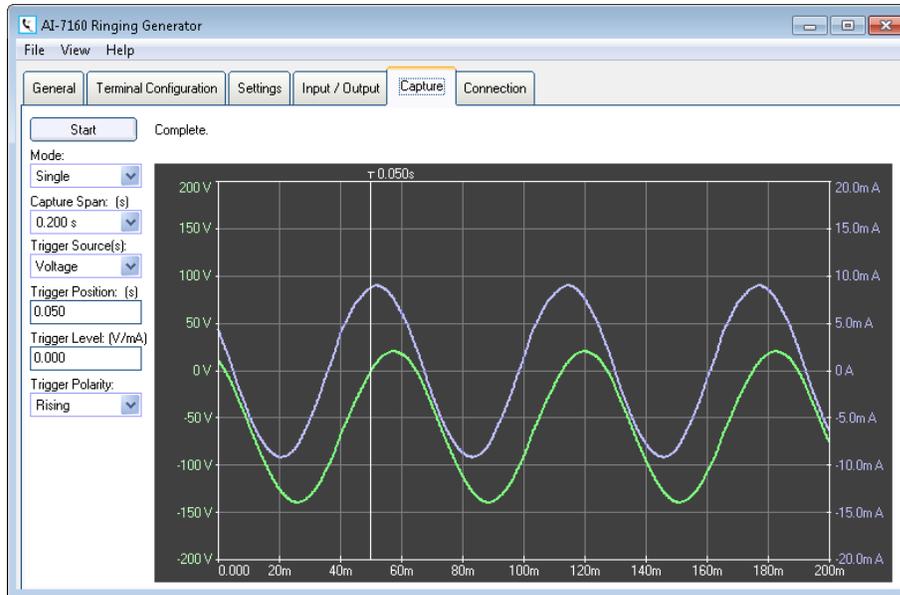
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## 2.8 Waveform Capture & Display

The 'Capture' tab contains a simple collection of controls for viewing the voltage and current waveforms generated by the AI-7160. Sampling at 4 kHz, up to 4000 voltage and current samples can be collected by the AI-7160 and transferred to the PC for display.

Clicking the 'Start' button initiates a capture and transfers the results to the PC. The sampled voltage is displayed in green and uses the left hand scale, while the sample current is displayed in blue and uses the right hand scale.



Similar to an oscilloscope the capture operates in one of two different modes. The default 'Single' mode waits for a trigger, then takes a capture, transfers the data to the PC, and then stops. The 'Normal' mode waits for a trigger, takes a capture, transfers the data to the PC, and then waits again for another trigger. The cycle will continue to repeat for each trigger source as detected.

The capture span can range between the limits of 10 ms to 1000 ms. Shorter time spans results in a quicker capture and screen update rate, while the greater time spans take longer to acquire the data and transfer it to the PC.

One of up to nine trigger sources can be selected. They are:

- **Forced** – Trigger occurs immediately once a capture is started. The AI-7160 effectively does not wait for a trigger.
- **Voltage** – Trigger occurs when the sampled voltage rises above or falls below a specified trigger level.
- **Current** – Trigger occurs when the sampled current rises above or falls below a specified trigger level.
- **Off-Hook** – Trigger occurs when the line state changes from on-hook to off-hook.
- **On-Hook** – Trigger occurs when the line state changes from off-hook to on-hook.
- **Input 'A' rising or falling** – Trigger occurs on a specified change in digital input 'A' logic level.
- **Input 'B' rising or falling** – Trigger occurs on a specified change in digital input 'B' logic level.

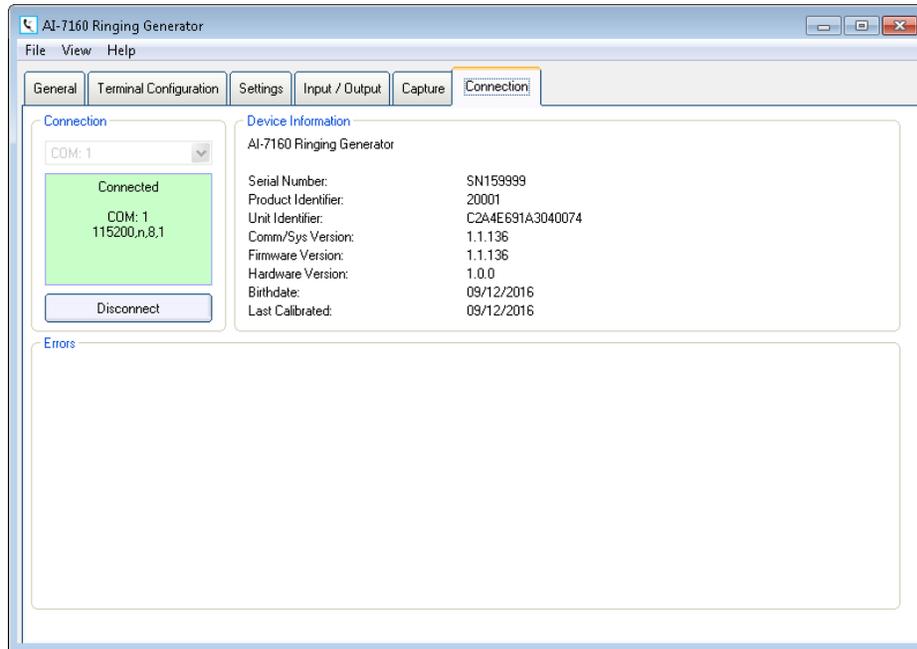
The trigger position time value can be set anywhere between -10 seconds to the time span of the capture. Negative trigger positions mean that the trigger occurs before the first sample captured. If the trigger position is a positive value then a vertical white line on the screen is used to represent its time.

When either the voltage or current trigger is selected the trigger level setting is used as the threshold value when testing for a trigger condition. The units for this setting are in either volts or mA depending on the trigger type. In addition, only for voltage or current

triggers a polarity setting determines if the rising or falling edge is used for the trigger condition.

## 2.9 Device Connection & Errors

The 'Connection' tab displays revision and calibration information for the AI-7160 connected to the PC along with any errors that may have been detected.



To change serial ports first click the 'Disconnect' button to stop all communication with the AI-7160. Then a different serial port in the range of 1 to 20 can be selected from the drop down list. Once selected click the 'Connect' button to initiate a connection to the AI-7160.

## 2.10 Software Updates

Clicking on the 'Help' menu item, followed by 'Check for Updates...' causes the software to query the Advent Instruments web site to determine if the PC software and AI-7160 firmware are the latest versions available.



Newer versions are displayed in the window and they can be downloaded from the website.

<http://www.adventinstruments.com/Products/AI-7160/Downloads>

To update the AI-7160's firmware click the button marked 'Update Firmware'. This opens another window from which the firmware file can be selected. Select the file that was downloaded and click 'Open'. This starts a firmware update process for the connected AI-7160.

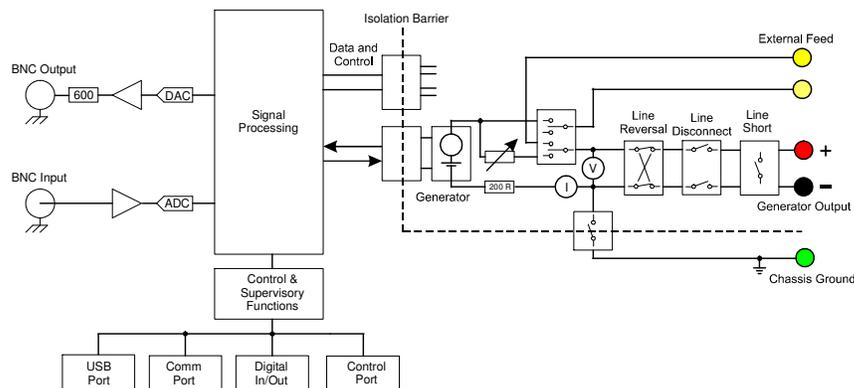
To updated PC software, the new version is installed by double clicking on the file downloaded.

# 3. Technical Overview

## 3.1 Block Diagram

The AI-7160 is designed to be able to generate the high voltage ringing signal as required for many international compliance standards. This signal is typically 150Vrms and is applied to the terminal equipment to ensure the equipment does not draw excessive current in the idle state or on-hook state. In addition the instrument can generate a DC bias to this ringing signal to further test compliance of the terminal to DC voltages up to +/-200 Vdc. The AI-7160 contains all of the circuitry necessary to measure this current and the voltages applied and will calculate the DC resistance and AC impedance in real time.

The following figure shows the major functional blocks of the AI-7160. At its center is the signal processing block responsible for controlling the generator output, the adjustable DC feed resistance and the line state settings. All of the AC signal flow, signal generation, and signal analysis is performed by this block.



The generator circuitry is located on the isolated side of the isolation barrier. It provides a programmable range of DC voltages and low frequency AC signals. In order to accommodate TIA, ETSI and other international standard test setups a programmable feed resistance can be added in series with the generator. If the connected terminal equipment enters the off-hook state, the AI-7160 will provide the loop current dependent on the DC generator voltage setting and the sum of the DC loop resistance and the DC resistance of the device under test. While the AI-7160 output is current limited and protected from voltage transients, it is important not to connect the output terminals to any other voltage source. This may cause unexpected and unbalanced current flows leading to inaccurate AC signal generation and measurements or possible instrument damage. The entire generator block may be left floating with respect to earth ground or ground referenced depending on the state of the grounding relay. Also the output

terminals may be reversed in polarity, shorted or individually disconnected with the use of application software.

The DC feed resistance is software programmable in 32 different values ranging from a minimum value of 200  $\Omega$  to a maximum of 2250  $\Omega$  in series with the generator. The external feed terminals can be used as an alternative to the internal resistance if required.

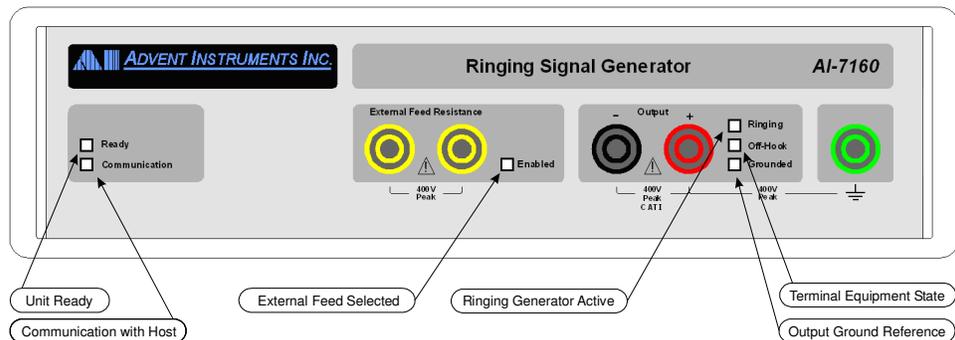
The two BNC connectors present on the rear panel provide a means of monitoring and injecting signals at various points controlled by the application software and described in Section 2.7 Input & Output Capabilities.

## 3.2 Indicators & Connections

The AI-7160 front panel contains six LED indicators to represent the current state of the instrument and 5 IEC61010 insulated banana connectors to connect to the terminal under test.

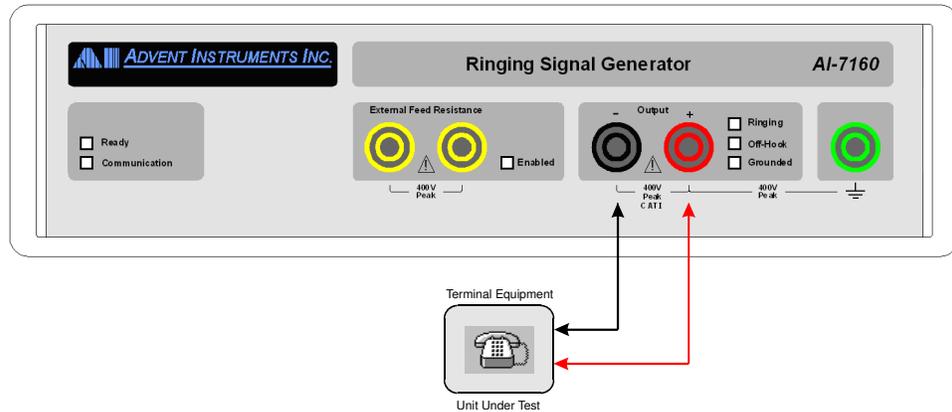
The "Ready" and "Communication" indicators show the status of the unit and communication activity with the PC respectively. Under normal operation the "Ready" indicator should be illuminated. If it is flashing, an internal fault or an excessive telephone interface unbalanced current is detected. While the "Ready" indicator is flashing, the state of the "Ringing" and "Off-Hook" indicators determine the specific fault condition. See Appendix A: 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.



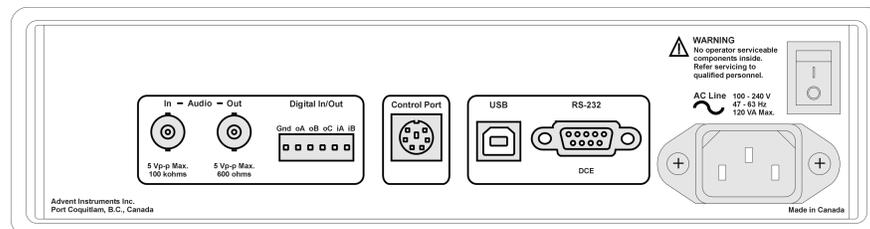
The Ringing indicator will illuminate any time the ringing generator is active. The off-hook indicator is dependant on the state of the terminal equipment that may be connected to the ring generator. If the test requires that the voltage be referenced to ground then the AI-7160 application software allows the instrument to ground reference the output and this state is shown on the Grounded indicator.

The black and red banana connectors are directly connected to the Ringing Signal generator output though the programmable DC feed resistance. In most test configurations these terminals connect to the tip and ring terminals of the device under test. The included banana to alligator clips harness can be used to connect to the unit under test.



The next figure shows the configuration of the AI-7160 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 9 pin RS-232 connector. The USB type B connector is not used at this time. 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-7160 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 remaining pins (1, 4, 6 and 9) have no internal connection.



The two BNC connectors can either monitor various signals internal to the AI-7160 or combine signals with the AI-7160 generator. The BNC input connector is DC coupled and should be driven with a low impedance source. It can accept a maximum peak-to-peak signal of 4 volts and the signal applied can be summed with the Ringing Generator output. The BNC output connector is DC coupled and outputs a maximum of 3 volts peak-to-peak with an output impedance of 600  $\Omega$ . The signal may be set to represent the scaled down version of the Ringing Generator output, the voltage or current measurement or the wave shape.

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-7160. 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  $\Omega$  resistor. All three digital outputs can be set either high or low. An additional software setting permits output A to be set high when the ring generator is active and output B to be high when the terminal is off-hook. Output C can also be set to follow the cadence of the Ring Generator output. The two digital inputs (A, B) have an input impedance of 100 k  $\Omega$ . The maximum input level to detect a logic low is 0.8 volts, while the minimum logic high level is 2.0 volts. The inputs can be configured to start the

Ring Generator or control the cadence on a rising or falling edge of the A and B input respectively.

The 6 pin Control Port connector is designed for powering future peripherals. It uses a standard 6 pin mini-circular DIN connector.

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## 3.4 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.

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## 3.5 Specifications

### Telephone Interface:

#### DC Generation Characteristics:

Loop Voltage	+200 to -200 Volts, $\pm 5\%$ , $\pm 1$ Volts
Loop Current (constant voltage mode)	Load dependent. Current limited to 50 mA peak
DC Feed Resistance	200 $\Omega$ min, (User Selectable, & External)
Off-Hook DC Threshold Current	1 to 20 mA (User Adjustable)

#### Ring Generator:

Amplitude	0 to 160 Vrms, $\pm 0.2$ dB (using sine wave shape & 48V DC offset) Current limited to 50 mA peak
Frequency Tolerance	13 to 70 Hz, $\pm 0.1$ Hz
Frequency Response	13 to 70 Hz, $\pm 0.2$ dB
DC Voltage Offset	0 to 200 Volts, $\pm 5\%$ , $\pm 0.75$ Volts
Noise (20 kHz bandwidth)	< 70 dB down from max output O/C
Source Impedance	Min 200 $\Omega$
Wave shape	Sine, Triangle, Square, or Trapezoidal

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**Note:** The maximum peak output of the combined DC and AC signals is limited to +210 and -290V with respect to the negative output terminal. The application software does not restrict settings that exceed these peak amplitudes to provide flexibility but the resulting waveform may be clipped.

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## Measurements:

### Characteristics:

Line Voltage - DC	$\pm 300$ Volts, $\pm 2\%$ , $\pm 0.5$ Volts
Loop Current - DC	$\pm 60$ mA, $\pm 2\%$ , $\pm 1$ mA
Line Voltage - AC	0 to 160 V rms, $\pm 2\%$ , $\pm 0.5$ Volts
Loop Current - AC	0 to 60 mA rms, $\pm 2\%$ , $\pm 1$ mA
Sample Rate	4 k sample/sec
Voltage & Current Capture	4000 samples

## Input & Output:

### BNC Input:

Unbalanced, DC Coupled	
Input Impedance	100 k $\Omega$ , $\pm 5\%$
Maximum Input Level	4 Vp-p Maximum
Level Accuracy	$\pm 0.2$ dB, 13 Hz to 70 Hz
Frequency Range	13 Hz to 70 Hz
Maximum DC Input Voltage	$\pm 4$ Volts

### BNC Output:

Unbalanced, Ground Referenced	
Output Impedance	600 $\Omega$ , $\pm 3\%$
Maximum Output Level	3 Vp-p Maximum
Level Accuracy	$\pm 0.2$ dB, 13 Hz to 70 Hz
Frequency Range	13 Hz to 70 Hz

### Digital I/O:

Number of Output Pins	3
Output Configuration	Open Collector
Output Maximum Sink Current	25 mA
Output Pull-up Resistance	5.1 k $\Omega$ to +5V
Number of Input Pins	2
Input Impedance	100 k $\Omega$
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	Currently Not Implemented
USB Connector	Standard Type-B
RS-232 Configuration	DCE (Data Communication Equipment)
RS-232 Connector	9 pin D style connector (DE-9)

### 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 $^{\circ}$ C, 80%RH
Storage Temperature Range	-25 to 70 $^{\circ}$ C, 80%RH
Operating Altitude	$\leq 2000$ m

# 4. Firmware Revision Updates

Updates to the AI-7160's firmware are periodically released which may change the operation in one of the following manners:

- Addition of new properties.
- Expanded capability of existing properties.
- Perform fixes to known bugs.

Any time new properties are added or their capabilities expanded all attempts are made to preserve backwards compatibility. This permits the firmware to be upgraded anytime without concern for breaking applications that were developed with older versions of the firmware.

For the most current listing of the AI-7160's firmware's revision history, please see:

<http://www.adventinstruments.com/Products/AI-7160/Support/Firmware%20Revisions>

# Appendix A: Error Codes

The front panel “Ready” indicator shows the state of the AI-7160. Normally it should be illuminated all the time. However, if it flashes or is not illuminated then that indicates an error condition. The various states of the “Ready” indicator are summarized in the following table.

<b>READY Indicator</b>	<b>State</b>	<b>Description</b>
On	Normal operation	No critical errors detected, device operating normally.
Flashing 150 ms on/off	Error condition detected	An error condition has been detected. The state of the “Ringing” and “Off-Hook” indicators determine the type of error.
Blinks a number of times every 3 seconds	Terminal fault detected	A terminal fault was detected that prevents the firmware from continuing normal operation. One to nine blinks are generated by the “Ready” indicator every 3 seconds. The unit must be power cycled to recover.
Off	Power failure, hard fault, or boot loader activated	Either the power supply failed, or the MCU encountered a hard fault, or the firmware boot loader program is active. In all cases, normal communication with the device is not possible.

When an error occurs the “Ringing” and “Off-Hook” indicators can be used to provide more information on the type of error. The following table summaries the possible error conditions.

<b>RINGING</b>	<b>OFF HOOK</b>	<b>Description</b>
Off	Off	Internal software operating system fault.
On	Off	EEPROM memory has been found to be corrupted. The default values for all setting stored in the EEPROM will be used instead.
Flashing	Off	Power supply under voltage. This indicates a possible failure of the internal power supply

If any of these error conditions are encountered please contact technical support for assistance. The unit may have to be returned for repair.

# Appendix B: 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  
                  Fax:        (604) 944-7488  
                  Mail:        Advent Instruments Inc.  
                                  111 - 1515 Broadway Street  
                                  Port Coquitlam, BC, V3C6M2  
                                  Canada
- In Asia:  
                  Tel:        (852) 8108-1338  
                  Fax:        (852) 3909-2338  
                  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