

SIGNAL[™]

I/O Hardware Guide

Version 5
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Engineering Design

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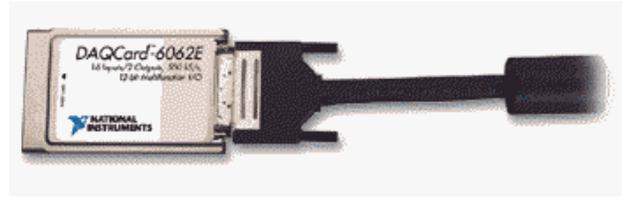
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1. OVERVIEW

Who Should Use This Guide

This guide is intended for use with SIGNAL 5. It describes the capabilities, installation, connection, operation and troubleshooting of analog and digital I/O hardware in SIGNAL 5. Each chapter first describes attributes common to all manufacturers, then individual sections describe manufacturer-specific attributes and requirements. SIGNAL 4 users should install I/O hardware according to the legacy instructions provided in Appendix C, "I/O Hardware Installation", of the *SIGNAL Reference Guide*.

SIGNAL 5 I/O Architecture

SIGNALtm 5 includes built-in support for sound acquisition and playback. The **Experiment Maker 5** module adds capabilities for simultaneous acquisition and playback, digital I/O and precision timing.

SIGNAL I/O involves two components:

- 1) SIGNAL I/O commands, options and menus that configure and control I/O processes
- 2) I/O hardware to perform the I/O processes

SIGNAL I/O commands are described in chapters 9 and 10 of the *SIGNAL Reference Guide*. This guide describes how to manage SIGNAL-supported I/O hardware and accessories – including hardware and driver installation, analog and digital I/O signals, SIGNAL I/O panels, operating hints and troubleshooting.

SIGNAL I/O operates through multiple layers, where each layer communicates with and monitors the layer below it:

- SIGNAL I/O commands configure and control I/O processes at the user level, e.g., setting acquisition duration, sample rate, triggering, etc.
- SIGNAL communicates with the I/O manufacturer's system driver, such as DT-Open Layers™ from Data Translation and NI-DAQ™ from National Instruments, which supports all boards by that manufacturer.
- The system driver communicates with the I/O driver for the installed I/O board.
- The board driver directs the board to perform the I/O process.

Thus when the user issues an I/O command (such as acquisition) for a particular I/O board, SIGNAL issues commands to that manufacturer's system driver, which issues commands to the board's driver, which sends commands to the board to perform the I/O process.

SIGNAL 5 supports four I/O manufacturers or families – Data Translation, National Instruments, Wave-compatible sound cards, and the CAC Dart card introduced with SIGNAL 3. All hardware boards from these manufacturers are supported in SIGNAL 5. I/O hardware from Measurement Computing Corp (formerly Computer Boards Inc) provided with SIGNAL 3 and SIGNAL 4 is supported by CBDisk but not by SIGNAL 5.

Due to its layered architecture, at the SIGNAL command level all I/O boards are operated using the same SIGNAL I/O commands – AC, PL, SET ACRATE, etc. – independent of I/O manufacturer. However, at the board level, individual manufacturers and boards differ in installation, capabilities and troubleshooting.



2. HARDWARE CAPABILITIES

This chapter describes the hardware capabilities of the I/O hardware families supported by SIGNAL 5 and the support for different Windows versions.

Windows Support

Please note that I/O hardware support varies with SIGNAL version, Windows version and I/O card manufacturer. At this time (July 2014), only National Instruments and Wave I/O cards are supported under Windows Vista and later. Windows support is noted in the following and in the "Windows support" section under each manufacturer in the "Installation" chapter below.

General Capabilities

SIGNAL 5 provides these capabilities for all supported I/O hardware:

- Record and play direct-to-RAM up to installed physical memory capacity, or direct-to-disk up to hard disk capacity
- Record and play sound files in either SIGNAL or Wave file format
- Record and play single or multi-channel sound data
- Record for a fixed duration then halt, or indefinitely until halted by the user
- Play a sequence once then halt, or repeatedly and seamlessly until halted by the user
- Continuously monitor recording and playback processes and report data errors to the user

Depending on the capabilities of the installed I/O hardware, SIGNAL 5 can also:

- Adjust recording gain under program control
- Begin recording or playback on receipt of an external trigger signal
- Issue digital trigger signals at the begin and end of recording or playback
- Issue and read digital TTL signals on separate digital ports
- Perform simultaneous acquisition and playback [**Experiment Maker**]
- Perform precision software or hardware timing operations [**Experiment Maker**]

Dart I/O Card

Specific Dart I/O hardware capabilities are:

- Recording and playback of 1 or 2 channels at up to 50 kHz sample rate
- 16-bit resolution on acquisition and playback
- Built-in anti-alias filter on acquisition and playback
- Programmable input gain up to 22.5 dB

SIGNAL 4 and 5 supports the Dart card under Windows XP and earlier. **The Dart card is not supported by any SIGNAL version on Windows Vista and later.**

Data Translation

Specific Data Translation hardware capabilities are:

- Recording up to 8 input channels at up to 1.25 MHz aggregate sample rate
- Playback of 1 or 2 output channels at up to 500 kHz aggregate sample rate
- Simultaneous recording and playback
- Programmable input gain up to factor of 8
- Recording and playback can be initiated by external TTL trigger
- TTL output signal provided for synchronization with external systems

SIGNAL supports current all analog I/O cards manufactured by Data Translation (DT) (800-525-8528, www.datx.com). These include PCI **desktop** cards providing 12-bit and 16-bit resolution at sample rates up to 1.25 MHz, PCMCIA **notebook** cards providing 12-bit resolution at sample rates up to 100 kHz, and the **USB** unit providing 16-bit resolution at sample rates up to 500 kHz. SIGNAL automatically makes the installed card's capabilities available, including maximum sample rate and programmable input gain. **SIGNAL does not support the DT-2821 family of ISA I/O boards used with SIGNAL 3.** SIGNAL has been tested extensively with the 12-bit, 1250 kHz desktop analog I/O card, model DT3010 and the 16-bit, 250 kHz desktop analog I/O card, model DT3016.

SIGNAL 4 and 5 support Data Translation (DT) I/O cards under Windows XP and earlier. **DT I/O cards are not supported by any SIGNAL version under Windows Vista and later at this time.** Please contact Engineering Design for support updates.

National Instruments

Specific National Instruments hardware capabilities are:

- Recording up to 8 input channels at up to 1.5 MHz aggregate sample rate
- Playback of 1-4 channels at up to 1.5 MHz aggregate sample rate
- Simultaneous recording and playback
- Programmable input gain up to 100 (depending on I/O card)
- Recording and playback can be initiated by external TTL trigger
- TTL output signal provided for synchronization with external systems

SIGNAL supports all current analog I/O cards manufactured by National Instruments (NI) (www.ni.com). These include PCI **desktop** cards providing 12-bit and 16-bit resolution at sample rates up to 1.5 MHz, and PCMCIA **notebook** cards providing 12-bit and 16-bit resolution at sample rates up to 500 kHz. SIGNAL supports full card capabilities, including maximum sample rate and programmable input gain. SIGNAL has been tested extensively with the 12-bit, 500 kHz PCMCIA notebook analog I/O card, model DAQCard-6062E and the 16-bit, 1.5 MHz PCI desktop analog I/O card, model PCI-6251.

SIGNAL 4 requires **NI-DAQmx v8 or later** and supports Windows 2000/XP but not Windows Vista/7/8.

SIGNAL 5 requires **NI-DAQmx v9.7 or later** and supports Windows 2000/XP/Vista/7/8.

Wave-Compatible Sound Card

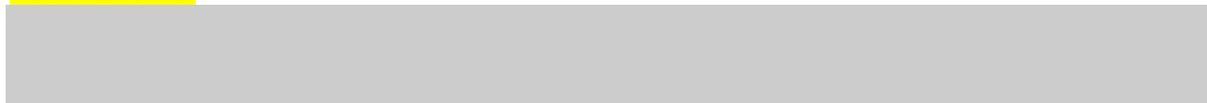
Specific hardware capabilities for typical Wave-compatible sound cards are:

- Recording and playback at 11.025, 22.05, 44.1, 48 and 96 kHz sample rate
- Recording and playback of 1 or 2 channels

SIGNAL supports all Wave-compatible sound cards, built-in desktop and notebook sound chips, and USB sound card units. SIGNAL has been tested extensively with Sound Blaster (SB) PCI-16, SB Audigy PCI, and SB Extigy external USB sound unit.

SIGNAL 4 and 5 support wave-compatible sound cards under Windows XP and earlier.

Wave-compatible sound cards are not supported by any SIGNAL version under Windows Vista and later.



3. INSTALLATION

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This chapter provides installation instructions for I/O drivers and hardware from various manufacturers.

SIGNAL I/O Architecture

An I/O board in Windows is supported by two software layers. These are normally provided by the board manufacturer, but in a few cases (noted below) may be furnished by Engineering Design. The first layer is an **I/O library** or **system driver** which supports all I/O operations for all boards by one manufacturer. Examples are DT-Open Layers™ from Data Translation and NI-DAQ™ from National Instruments. The second layer is a **board driver** which allows the library to communicate with a specific I/O board from that manufacturer. When the user requests an I/O operation (such as acquisition) from an installed I/O board, SIGNAL issues I/O commands to that manufacturer's I/O library, which in turn communicates with the specific board.

Installing a particular I/O board involves the following steps, usually in this order:

1. Install the manufacturer's I/O library or system driver.
2. Install the board driver for the particular I/O board.
3. Install the physical board and configure the board driver for the installed board.

NOTE: Some manufacturers provide one set of support software for all Windows generations, while others provide different software for different Windows generations. **Be**

sure to install the correct I/O software for your operating system! This distinction is pointed out below where appropriate.

Windows Support

I/O hardware support varies with SIGNAL version, Windows version and I/O card manufacturer. The "Windows support" section under each manufacturer provides support details.

Communication Automation Corp (Dart card)

To install your Dart card, perform these steps in the following order:

1. Install the Dart system driver.
2. Install the Dart card.

Windows support

SIGNAL 4 and 5 supports the Dart card under Windows XP and earlier. **The Dart card is not supported by any SIGNAL version on Windows Vista and later.**

Communication Automation Corporation (CAC) provides different support software for Windows 95/98 vs. Windows 2000/XP. **Be sure to follow the instructions for your operating system.**

Installation media

Dart support software may be provided on a disk or via email as a zipped distribution file. In the latter case, unzip the distribution file into an empty directory on your hard disk and substitute this directory wherever the DartDisk disk is referred to below.

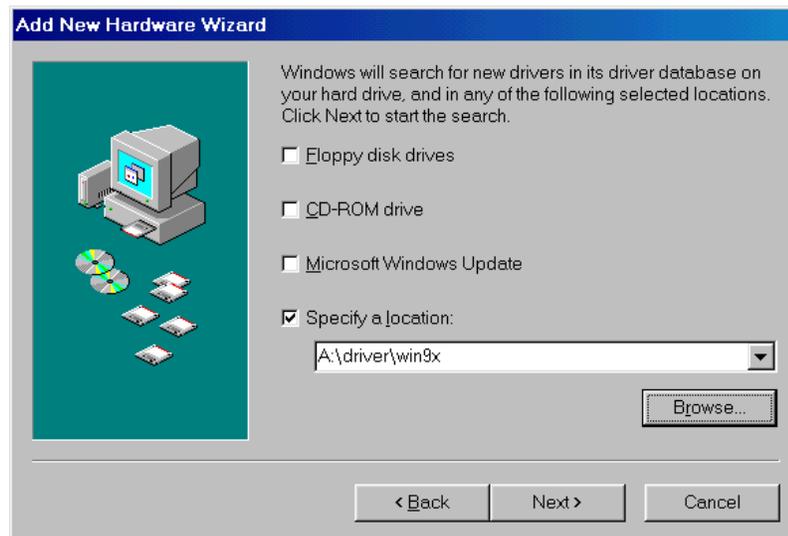
Dart card under Windows 95/98

The Dart card requires different support software for Windows 95/98 vs. Windows 2000/XP. Be sure to follow the instructions for your operating system.

Install Dart software and card

Follow these steps to install the Dart system driver and Dart analog I/O card in Windows 95/98.

1. Exit from SIGNAL if it is running.
2. Be sure the Dart card is removed from the computer.
3. Start Windows 95/98. Insert the DartDisk disk in the drive.
4. Insert the Dart card in the PCMCIA slot. Windows will detect the card and report New Hardware Found.
5. At the Add New Hardware wizard, click Next.
6. At the next screen, select "Search for the best driver for your device" and click Next.
7. At the next screen, select "Specify a location" and deselect all other choices. Click Browse and browse to the \driver\win9x directory on the DartDisk disk. Select that directory and click OK to close the Browse for Folder window, then click Next.



8. The next screen should report the location of the driver information file cacdsp.inf. Click Next to begin installation, then Finish to exit the wizard.



9. Alternately, Windows may report "Please insert the disk labeled CACW95 and click OK." Click OK, then browse to the \driver\win9x directory on the DartDisk disk and click OK to close the browse window. Click OK again to proceed. Windows will install the driver software and exit without further notice.
10. Remove the DartDisk disk and restart the computer.
11. To confirm the installation, see "Confirm installation of Dart software and card" below.

Confirm installation of Dart software and card

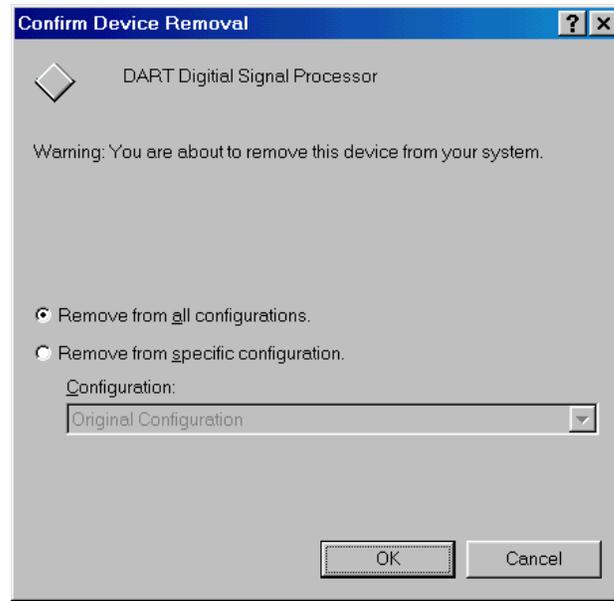
To confirm installation, follow these steps:

1. Open Control Panel | System | Device Manager, open CACDSP, and look for "DART Digital Signal Processor".

Uninstall Dart software and card

Follow these steps to uninstall the Dart system driver and Dart analog I/O card in Windows 95/98.

1. The Dart card must be inserted in the computer to perform the uninstall (otherwise the driver will not be available in Device Manager).
2. Open Control Panel | System | Device Manager, open CACDSP, and select "DART Digital Signal Processor".
3. Click Remove.
4. At Confirm Device Removal, select "Remove from all configurations" and click OK. Driver removal may take a minute or more.



5. When Windows removes the CACDSP entry from Device Manager, the driver has been removed.
6. The above steps remove the system driver but do not delete the driver files. If desired, manually delete the following files from c:\windows\system: cac_cfg.dll, cacdsp.vxd, d32util.dll and the following file from c:\windows\inf\other: "Communication Automation & Control, Inc.cacdsp.inf".

Dart card under Windows 2000/XP

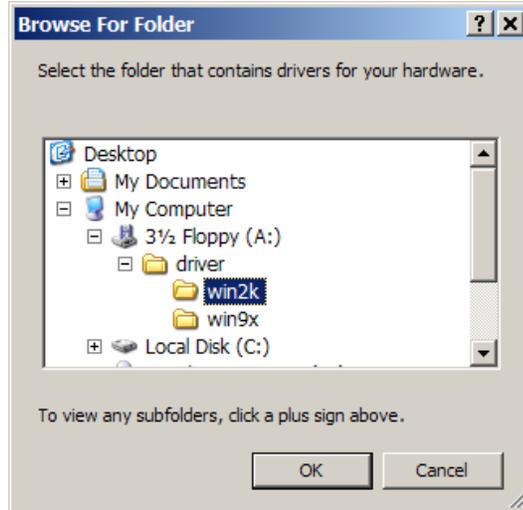
The Dart card requires different support software for Windows 95/98 vs. Windows 2000/XP. Be sure to follow the instructions for your operating system.

Install Dart software and card

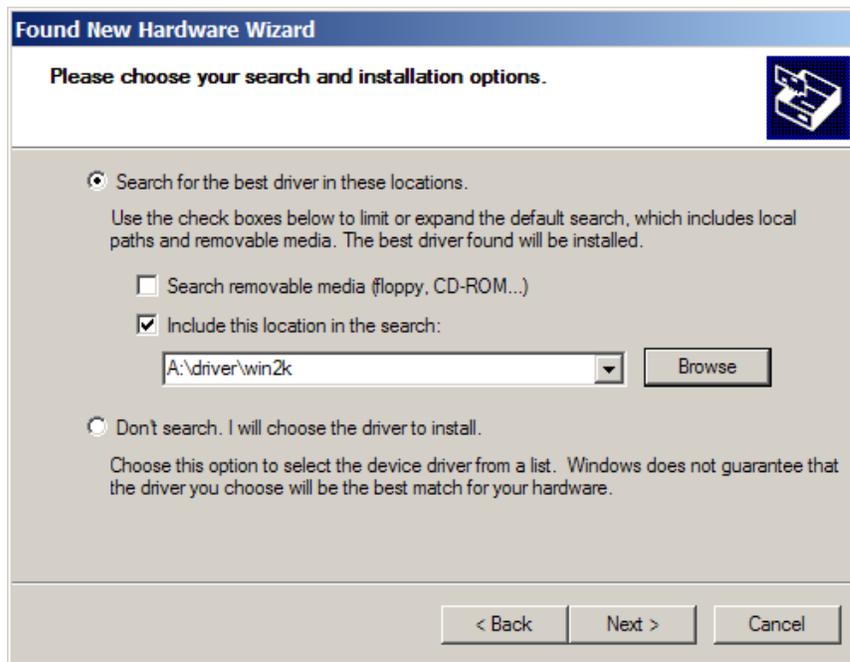
Follow these steps to install the Dart system driver and Dart analog I/O card in Windows 2000/XP.

1. Exit from SIGNAL if it is running.
2. Be sure the Dart card is removed from the computer.
3. Start Windows 2000/XP. Insert the DartDisk disk in the drive.
4. Insert the Dart card in the PCMCIA slot. Windows will detect the card and launch the New Hardware wizard.
5. Select "No, not this time" if Windows offers to connect online to Windows Update.
6. Select "Install from a list or specific location" (**do not select** "Install the software automatically") and click Next.

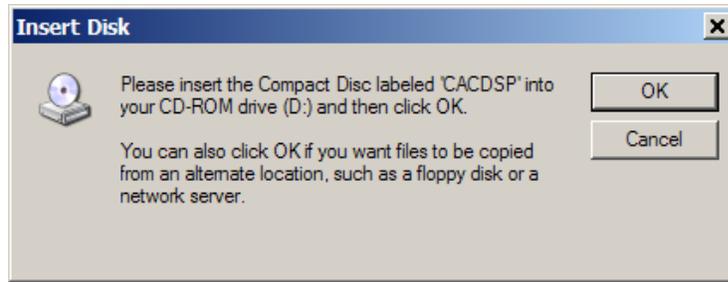
7. At the next screen select "Search for the best driver in these locations" and "Include this location in the search", and deselect all other choices.
8. Click Browse and browse to the \driver\win2k directory on the DartDisk disk. Select that directory and click OK to close the Browse For Folder window.



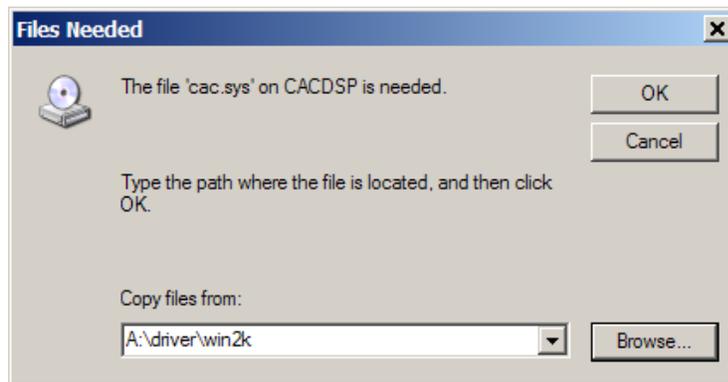
9. Click Next to install Dart system driver files from the DartDisk disk.



10. If you have never installed a Dart on this computer, Windows may present an Insert Disk dialog asking for a "Compact Disc labeled CACDSP", click OK to proceed (the files are on the DartDisk disk). If you have installed a Dart before, the installer will skip this and the following step.



11. At the Files Needed dialog (if presented), click Browse and browse again to the \driver\win2k directory on the DartDisk disk. Select the file cac.sys and click Open, then click OK to copy the file.

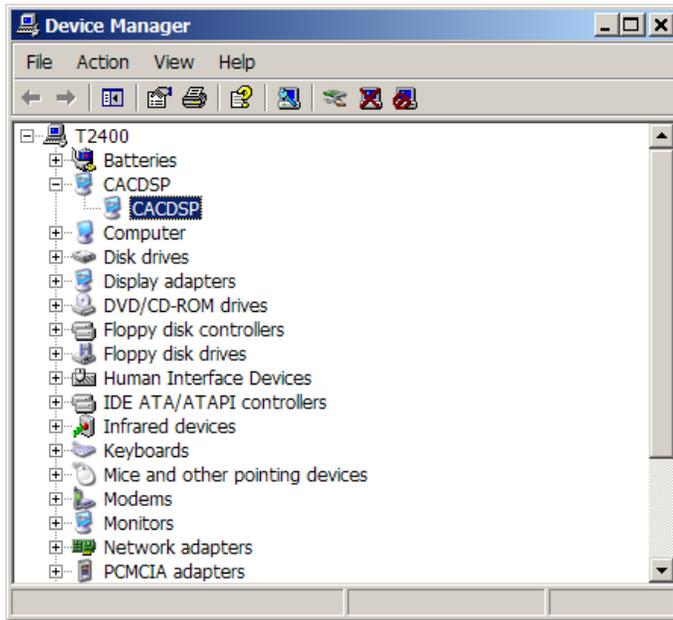


12. Click Finish to exit the wizard.
13. Remove the DartDisk disk and restart the computer.
14. To confirm the installation, see "Confirm installation of Dart software and card" below.

Confirm installation of Dart software and card

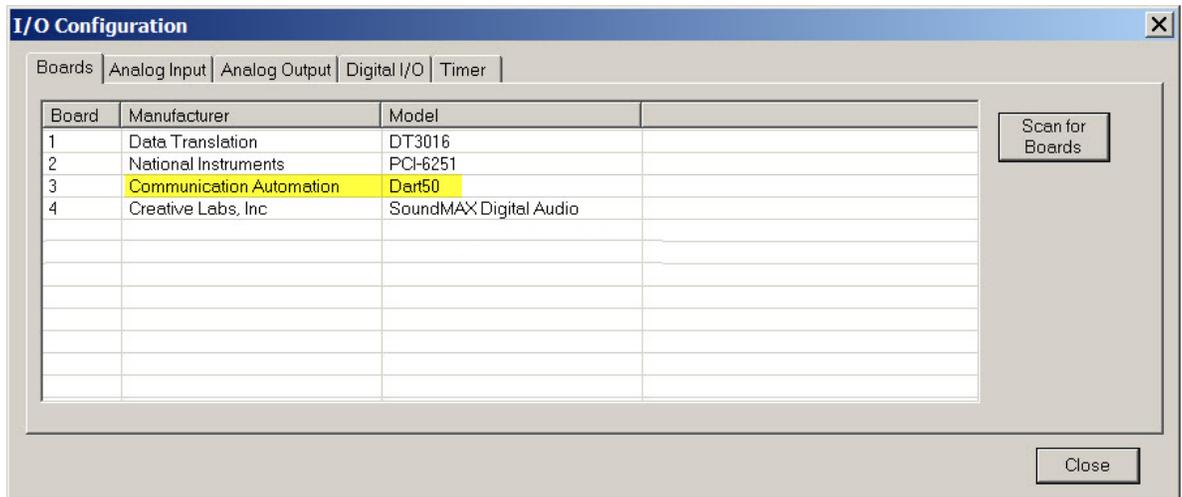
To confirm installation, follow these steps:

1. Open Control Panel | System | Hardware | Device Manager and look for "CACDSP" under CACDSP.



Test I/O card in SIGNAL

1. Launch SIGNAL, select I/O | Configure and confirm the board is recognized:



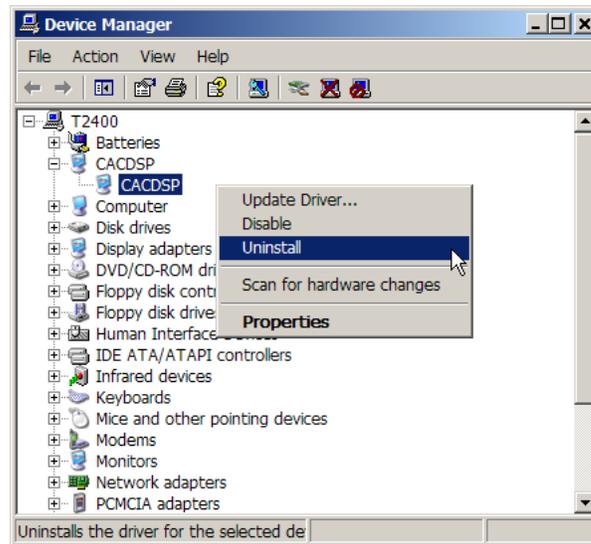
2. Select I/O | Acquire and I/O | Play to test acquisition and playback in SIGNAL.

Uninstall Dart software and card

Follow these steps to uninstall the Dart system driver and Dart analog I/O card in Windows 2000/XP.

1. The Dart card must be inserted in the computer to perform the uninstall (otherwise the driver will not be available in Device Manager).

2. Open Control Panel | System | Hardware | Device Manager and select "CACDSP" under CACDSP, then R-click and select Uninstall from the menu. Click OK to perform the uninstall.



3. Windows will uninstall the Dart system driver. To confirm the uninstallation, note that CACDSP has been removed from Device Manager.
4. The above steps remove the system driver but do not delete the driver files. If desired, manually delete the two files `c:\windows\system32\d32util.dll` and `c:\windows\system32\drivers\cac.sys`.

Connecting signals to the analog I/O card

The Dart card is accessed through the I/O cable provided with the card. See "Analog I/O Connections" in Appendix B, "Hardware Reference" for details.

Data Translation: Overview

IMPORTANT:

Read this section before installing any Data Translation boards!!

Windows support

SIGNAL 4 and 5 support Data Translation (DT) I/O cards under Windows XP and earlier. **DT I/O cards are not supported by any SIGNAL version under Windows Vista and later at this time.** Please contact Engineering Design for support updates.

DT provides separate software support for Windows 95/98 vs. Windows 98/2000/XP. **The SIGNAL 3 (DT2821 family) analog I/O card is not supported on Windows 2000 and later.** This is a limitation of the DT software, not a decision of Engineering Design.

Select the correct DT system driver for your computer according to the following rules:

1. If you wish to operate a DT2821 family analog I/O board, your computer **must** have Windows 95/98 and you **must** install the Windows 95/98 system driver.
2. If your computer has Windows 2000 or XP, install the Windows 98/2000/XP system driver.
3. If your computer has Windows Vista or later, please contact Engineering Design regarding support options.
4. Windows 95/98 and Windows 98/2000/XP drivers are covered in separate sections below.

Installation media for Windows 95/98 vs. 98/2000/XP

DT software support is provided on different installation media for Windows 95/98 vs. 98/2000/XP.

Windows 95/98 support is provided on a disk entitled "DT-Open Layers for Windows 95/98", which is provided by Engineering Design and not available from Data Translation. It can be downloaded from the Support section of the Engineering Design website (www.engdes.com). The disk contains the DT-Open Layers system driver and board drivers for DT2821 family and DT3010 family boards. These are the only DT boards supported by SIGNAL under Windows 95/98. **Note:** the "DT2821 Device Driver" disk included with DT2821 boards does **not** include all necessary support files and is not needed.

Windows 98/2000/XP support is provided by the "OmniCD" from Data Translation, which is included with all Data Translation boards. **SIGNAL requires OmniCD version 6.2.1 or later.**

Installing and uninstalling DT software support

NOTE: If you install one version of DT software support, such as Windows 95/98, then decide to install the other version, **you must completely uninstall one software library before installing the other, or the second library will not function, and future uninstallation may be difficult !!**

Data Translation under Windows 98/2000/XP

IMPORTANT: Read "Data Translation: Overview" above before installing any Data Translation boards!!

Data Translation provides different support software for Windows 95/98 vs. Windows 2000/XP. Be sure to follow the instructions for your operating system.

Installation overview

Installing a Data Translation (DT) board under Windows 98/2000/XP involves two steps:

1. Run the setup program on the OmniCD, which will install the DT-Open Layers Windows 98/2000/XP system driver and I/O board driver.
2. Install and configure the I/O board.

Instructions are provided below for DT3010/3016 boards and the DT9834 USB I/O module. For other boards, see the instructions provided with the board. **In the following, "DT3010" refers to both the DT3010 and DT3016 boards unless otherwise specified.**

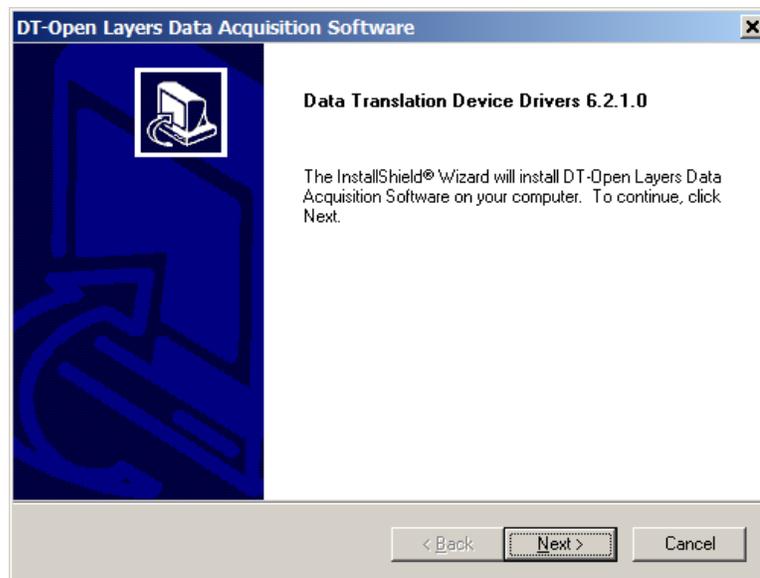
Install DT-Open Layers system driver and board driver

Follow these steps to install the DT-Open Layers Windows 98/2000/XP **system driver** and DT analog I/O **board driver** in Windows 98/2000/XP. Installation is performed by the OmniCD disk, which may be provided either by DT or Engineering Design (ED). If provided by Engineering Design, note the special instructions at steps 2 and 3.

1. Exit from SIGNAL if it is running.
2. Insert the OmniCD installation CD. If the CD doesn't start automatically, click Start|Run and type "d:\launch.exe" (DT CD) or "d:\setup.exe" (ED CD), where d: is the CD drive letter.
3. If you see the following screen, select Install Products. Then do the following. With OmniCD 2.8, select Device Drivers. With OmniCD 2.9, select either DT9834 Device Driver to install the DT9834 I/O unit or Other Device Drivers for all other DT boards.

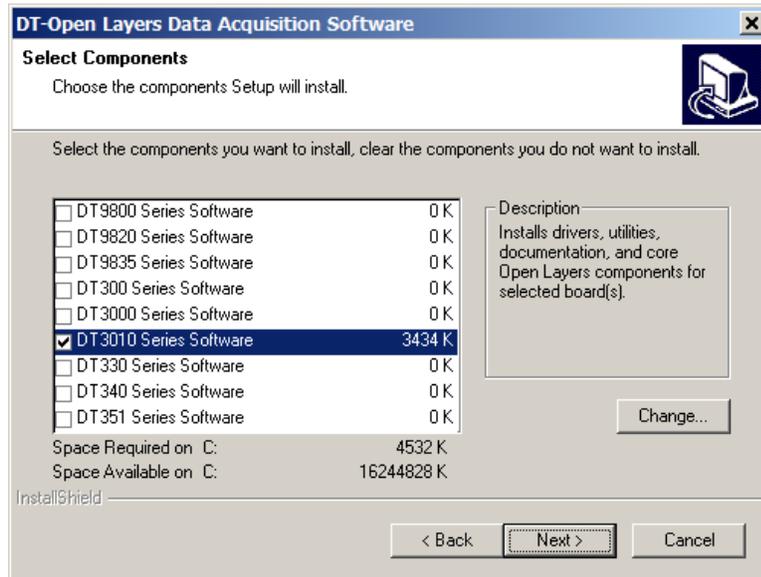


4. If you see following welcome screen, check the driver version. **SIGNAL requires DT-Open Layers version 6.2.1 or later** (this version number is different from the OmniCD version printed on the CD). Click Next.



5. Approve the license agreement.
6. At Choose Destination Location, accept the default folder and click Next.

7. At Select Components or Select Features, select your board family (e.g., "DT3010 Series Software" for DT3010 or DT3016 boards) and click Next.



8. At Select Program Folder, enter a program folder and click Next. The Open Layers system driver and the device driver for your I/O board will be installed. For example, oldaapi32.dll will be copied to c:\windows\system32 and the files dtxxx.inf, dtxxx.sys and possibly dtxxxld.sys (where xxx is the board model) will be copied to c:\windows\system32\drivers.
9. Click Finish to close the installer. If necessary, click Main Menu then Exit to exit the CD browser. Remove the CD.

Install DT3010/3016 I/O boards

Follow these steps to install and configure a DT3010 or DT3016 I/O board:

1. Open the **Getting Started** manual for your board. For example, click Start | Programs | Data Translation | DT3010 Series | DT3010 Getting Started Manual.
2. Open the section "Installing the Board and Loading the Device Driver". **Print this section or copy the document file to another computer**, so you can refer to it with the computer powered off.
3. Power off the computer and unplug the AC power cord.
4. Insert the I/O board in the computer, according to the instructions in "Inserting the DT3010 Series Board into the Computer".
5. Power on the computer. Windows should recognize the board and display the Found New Hardware Wizard.
6. Select "No, not this time" if Windows offers to connect online to Windows Update.

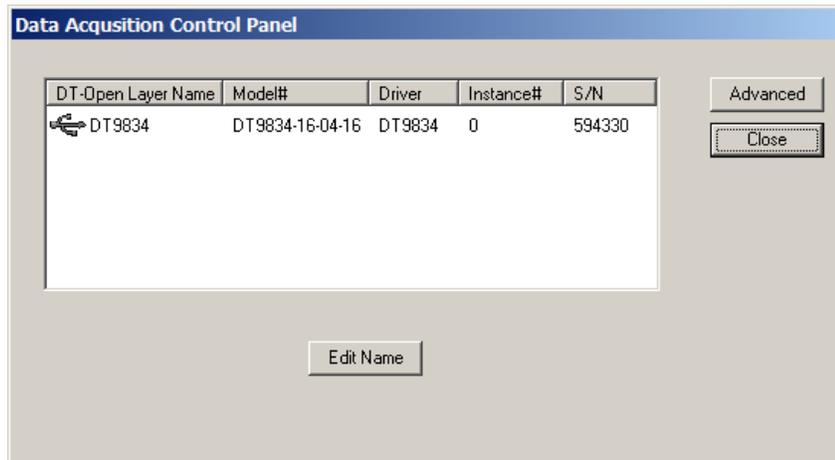
7. Turn to "Loading the Device Driver" under "Installing the Board and Loading the Device Driver" in the Getting Started manual. Skip to the section for your operating system.
Read the following steps before proceeding.
8. **Windows 98:** If Windows launches the Add New Hardware wizard, begin at step 1 in the Getting Started instructions. After the board driver is installed, click Finish to close the installation wizard, then skip to step 8 below. If Windows installs the board automatically without launching the Add New Hardware wizard, go to step 11 below.
9. **Windows 2000:** Begin at step 1 in the Getting Started instructions. After the board driver is installed, click Finish to close the installation wizard, then go to step 11 below.
10. **Windows XP:** Select "Install the software automatically" in the hardware wizard and click Next. If Windows prompts for information, follow the steps under "Loading the Device Driver" in the *Getting Started* manual. Or Windows may install the board without prompts. After the board driver is installed, click Finish to close the installation wizard, then go to step 11 below.
11. Open Windows Control Panel and locate the **Open Layers Control Panel** icon.
12. In the "Loading the Device Driver" section of the *Getting Started* manual, skip to the step "Double-click the Open Layers Control Panel icon" and perform the remaining steps.
Uncheck the box "Handle Overloaded Bus". Do not change the board name or if you must, the **name must begin with "DT3010" or "DT3016"** so SIGNAL can recognize the board.
13. To confirm installation, see "Confirm and troubleshoot I/O card and driver installation" below.

Install DT9834 USB I/O module

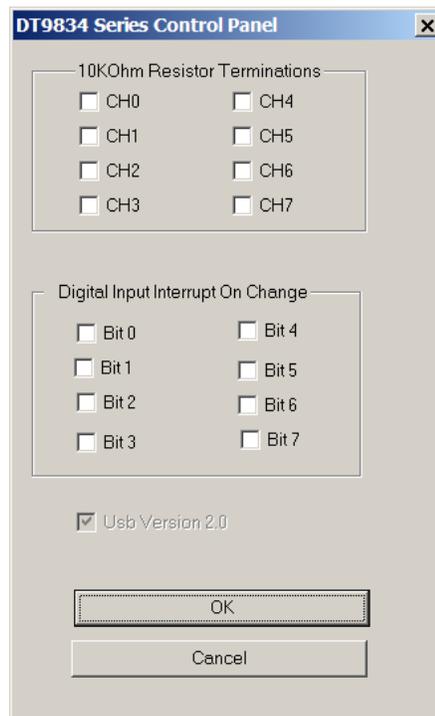
Follow these steps to install and configure a DT9834 I/O module:

1. Click Start | Programs | Data Translation | DT9834 Series | DT9834 Getting Started Manual to open the Getting Started Manual (GSM).
2. Open the section "Setting Up and Installing a DT9834 Series Module".
3. Make sure the I/O module is **not connected** to the computer via the USB cable. Apply power to the I/O module as described in "Applying Power to the Module".
4. Connect the I/O module to the computer as described in "Attaching Modules to the Computer", steps 1-3. The green communication light on the DT9834 should light. The DT9834 has no power light. **Ignore the remaining steps in that section.**
5. Windows should recognize the module and display the Found New Hardware Wizard.
6. Select "No, not this time" if Windows offers to connect online to Windows Update.
7. **Windows XP:** select "Install the software automatically". Windows will install the module. Click Finish to close the wizard. **If the New Hardware wizard starts again, repeat these steps.** Allow the system to reboot if asked.
8. **Windows 98 and 2000:** installation has not been tested.

- Configure the I/O module according to the steps in "Configuring the DT9834 Series Device Driver" in the same section of the GSM, with the following additional instructions.
- At the Data Acquisition Control Panel (step 3 in GSM), you can change the module name via Edit Name, but the **name must begin with "DT9834"** so SIGNAL can recognize the module.



- Following is the DT9834 Series Control Panel (steps 4-7 in GSM):



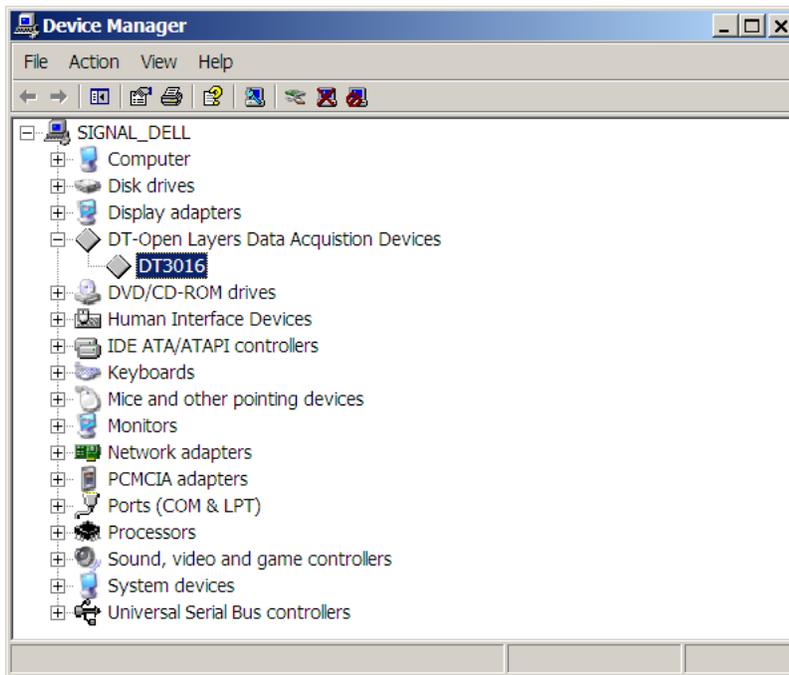
- DT9834 models supplied by Engineering Design normally have single-ended inputs** (model DT9834-16-4-16). In this case, **clear all check boxes** under 10Kohm Resistor Terminations. If your DT9834 has **differential inputs** (model DT9834-16-4-8), check all the 10Kohm Resistor boxes as advised in step 5 of GSM.
- Clear all check boxes** under Digital Input Interrupt On Change (step 6 of GSM).

14. The "USB Version 2.0" box will be checked if the USB bus is version 2.0 or later and unchecked if the bus is 1.0. **Maximum sample rate will be reduced on a USB 1.0 bus.**
15. Click OK to close the DT9834 panel, then Close to close the Data Acquisition panel.
16. To confirm installation, see "Confirm and troubleshoot I/O card and driver installation" below.

Confirm and troubleshoot I/O card and driver installation

To confirm and troubleshoot your installation, follow these steps:

1. DT9834 only – confirm that the unit is communicating with the computer. Connect power supply to DT9834, **then** connect unit to computer. Windows may launch the New Hardware Found wizard, even if already installed (see "Reconnecting the DT9834 module"). Confirm that the green communication light is lit (the unit has no power light).
2. Confirm that the device is present in Device Manager. In Windows 95/98, click Start | Settings | Control Panel | System | Device Manager. In Windows 2000/XP, click Start | Settings | Control Panel | System | Hardware | Device Manager. Open DT-Open Layers Data Acquisition Devices and confirm that your board is present.

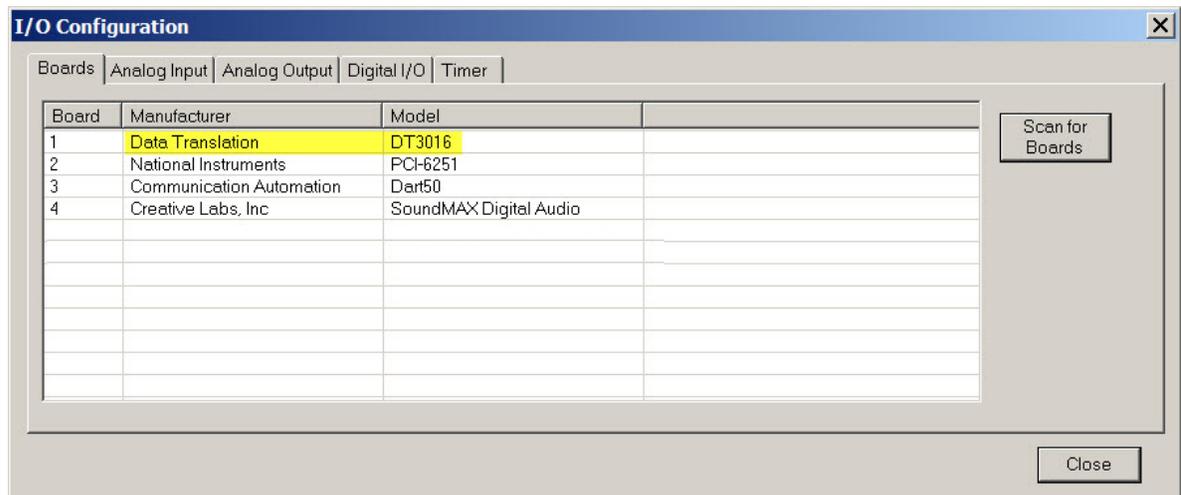


3. Open Control Panel and launch Open Layers Control Panel.
4. If the panel displays the message "No Open Layers boards installed":
 - Power down and remove the device from the computer.
 - Uninstall the DT-Open Layers system driver per "Uninstall DT-Open Layers system driver and DT board driver" below.

- Reinstall the system driver per "Install DT-Open Layers system driver and board driver" and board driver per "Install DT3010/3016 I/O boards" or "Install DT9834 USB I/O module" above.
 - Return to step 1.
5. If the device is present in the control panel, check the board driver configuration:
- For DT3010/3016, follow steps beginning with "Open the Control Panel" under "Loading the Device Driver" under "Installing the Board and Loading the Device Driver" in the DT Getting Started device manual.
 - For DT9834, follow steps in "Configuring the DT9834 Series Device Driver" in DT Getting Started device manual.

Test I/O card in SIGNAL

1. Launch SIGNAL, select I/O | Configure and confirm the board is recognized:



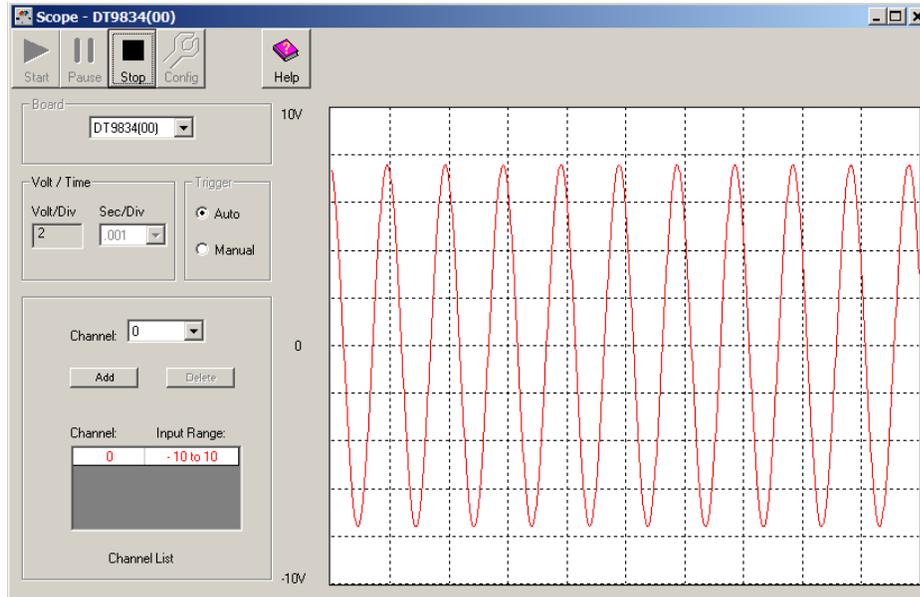
2. Select I/O | Acquire and I/O | Play to test acquisition and playback in SIGNAL.

Confirm DT9834 using test program

The DT OmniCD includes a demo program called Quick Data Acq for testing the DT9834. Follow these steps to install this program and use it to test the DT9834:

1. Install and launch Quick Data Acq as described in "Installing the Quick Data Acq Application" in "Verifying the Operation of a Module" in the DT9834 Getting Started manual.
2. Click Start | Programs | Data Translation, navigate to Quick Data Acq, and launch the program.
3. Select Acquisition | Scope from the menu to display the virtual oscilloscope.

4. Select your module under Board. Set Sec/Div to .001 (1 msec per scope division). Click Config and set Channel Type to Single-Ended (default for Engineering Design-supplied units) or Differential and click OK.
5. Connect a signal source (sine generator or sound source) to the AD Ch0 connector on the DT9834 and click Start to start the display.



6. The waveform generator (Control | Wave Generator) should serve as an output test, but apparently does not work.

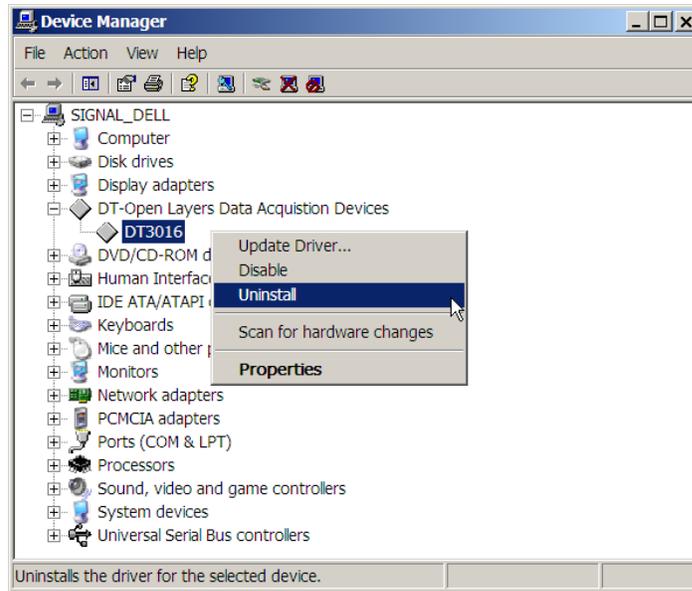
Reconnecting the DT9834 module

When the DT9834 is reconnected to the computer (via the USB) after a disconnection, Windows may launch the Found New Hardware wizard and reinstall the device. Allow Windows to do this, as described in the installation instructions in "Install DT9834 USB I/O module" above. Windows may perform the installation process twice, for unknown reasons.

Uninstall DT-Open Layers system driver and DT board driver

Follow these steps to uninstall the DT board driver.

1. Make sure that the board or I/O module is present in the computer.
2. Click Start | Settings | Control Panel | System | Device Manager in Windows 95/98 or Control Panel | System | Hardware | Device Manager in Windows 2000/XP. Open DT-Open Layers Data Acquisition Devices and select your board.
3. In Windows 98, click Remove, select "Remove from all configurations" and click OK, then Close. In Windows 2000/XP, R-click and select Uninstall.



Follow these steps to uninstall the DT-Open Layers system driver.

1. Click Start | Settings | Control Panel | Add/Remove Programs.
2. Select DT-Open Layers Data Acquisition Software and click Add/Remove or Remove.
3. Restart the computer to complete the uninstallation.

Connecting signals to the analog I/O board

Analog I/O boards from Data Translation can be accessed through a cable and I/O panel available from Engineering Design or a cable and screw panel available from DT. See "Analog I/O Connections" in Appendix B, "Hardware Reference" for details.

National Instruments Overview

To install your National Instruments card, perform these steps in the following order:

1. Uninstall any existing NI-DAQ driver software.
2. Install the NI-DAQmx driver software provided with your NI board.
3. Install your NI board in the computer.
4. Configure your board in the NI-DAQmx driver.

Windows support

Be sure to install the correct version of NI-DAQ for your software, hardware and Windows version !!

Different SIGNAL and Windows versions require different versions of the NI-DAQmx driver.

SIGNAL 4 requires **NI-DAQmx v8 or later** and supports Windows 2000/XP but not Windows Vista/7/8.

SIGNAL 5 requires **NI-DAQmx v9.7 or later** and supports Windows 2000/XP/Vista/7/8.

The standalone I/O program NIDisk may require an earlier NI-DAQ version. See "National Instruments – Legacy Support" below for details.

National Instruments – Current Version

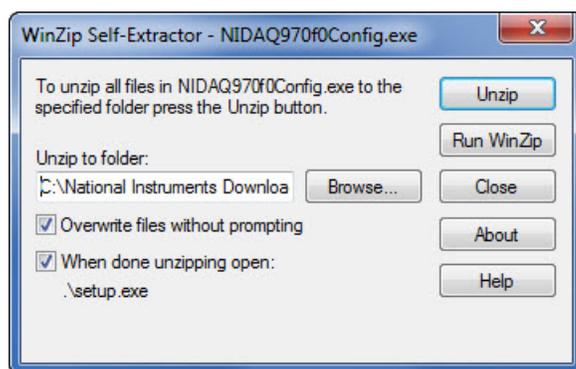
SIGNAL v5.05 and later requires NI-DAQmx driver v9.7 (released 2-25-2013) or later.

Install NI-DAQmx driver

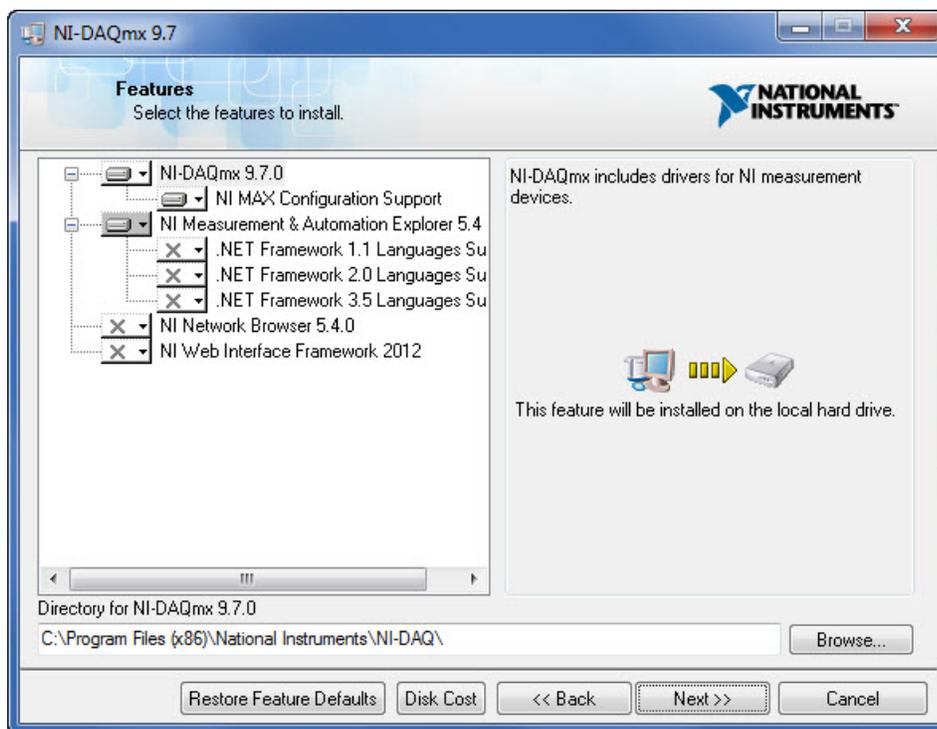
You must uninstall any obsolete NI-DAQ before installing NI-DAQmx!!

These steps will install the NI-DAQmx **configuration runtime** driver, available from the ED website (see below). To install the older NI-DAQ 6.9.2 for legacy support, see "National Instruments – Legacy Support" below.

1. Exit from SIGNAL.
2. If an obsolete version of NI-DAQ is installed, uninstall it using Control Panel | Add or Remove Programs, then restart Windows.
3. Obtain the NI-DAQmx **configuration runtime** driver setup file. This may be on a disc provided with your NI card from Engineering Design, or you can download it from the Support page of the Engineering Design website. The driver setup file for NI-DAQmx v9.7 is **NIDAQ970f0Config.exe**, containing NI-DAQmx v9.7.
4. Run the driver setup file.
5. Click **Unzip** to allow the setup file to unpack into a temp folder. This may take several minutes. **Note the name of the temp folder so you can delete it after the installation, if desired.**



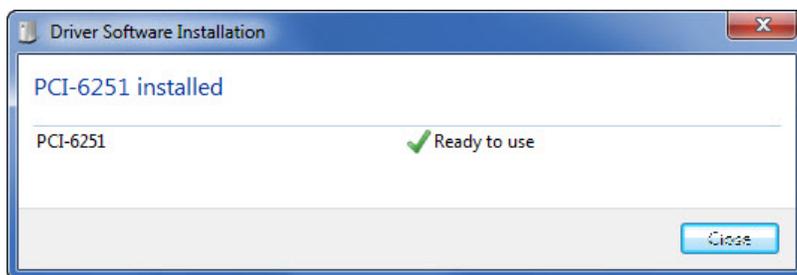
6. Allow the NI-DAQmx installer to install Microsoft .NET if asked.
7. Approve the default destination directory.
8. Select NI-DAQmx, NI MAX Configuration Support and NI Measurement & Automation Explorer (but not its sub-features)



9. Decline "Search for important messages and updates" at this time. SIGNAL prefers the configuration runtime driver without modification.
10. Accept the license agreements and approve installation, which may take 5-10 minutes.
11. After installation completes, restart the system, if requested.
12. Allow the NI Update Service to install critical updates, if offered, and restart the system, if requested.
13. Delete the temporary installation folder created in step 5, if desired.

Install I/O card

1. Shut down the computer.
2. After the computer has **completely powered down**, disconnect the AC power cord.
3. **Caution:** to avoid electrostatic discharge (ESD) damage to your system: 1) never touch the circuit board surface of the I/O card or the computer motherboard. 2) hold the I/O card by the edges or the metal mounting bracket, 3) before inserting the card in the computer, discharge it by grasping its metal mounting bracket with one hand and touching the computer's metal chassis with the other.
4. Inspect the I/O card for damage of any kind.
5. Install the I/O card in the computer.
6. Re-attach the AC power cord and start the computer.
7. Windows Vista and later should recognize and automatically install the card. **Skip the remaining steps in this section.**

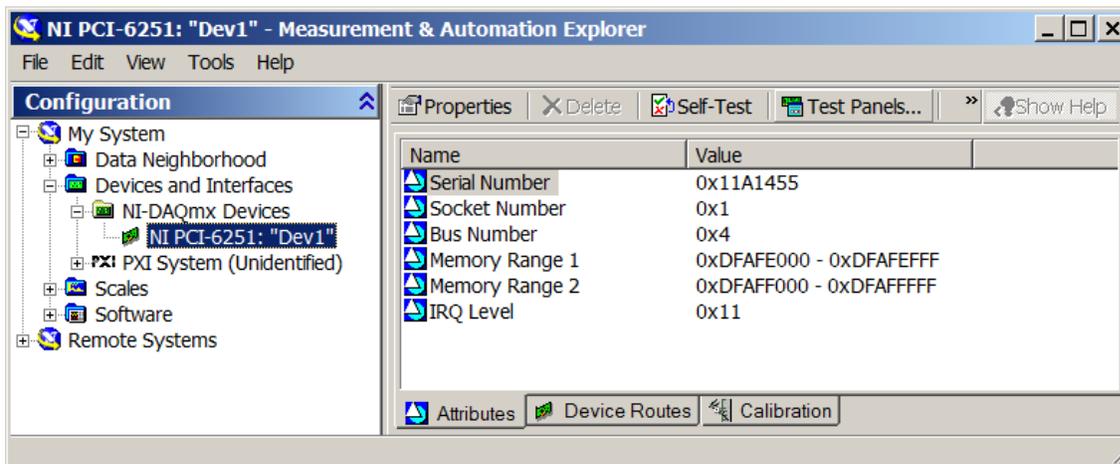


8. On Windows XP, Windows will detect the I/O card and launch the New Hardware wizard. **Follow the remaining steps in this section.**
9. If Windows offers to connect online to Windows Update, select “No, not this time” and click Next.
10. At the next screen, select "Install the software automatically" and click Next.
11. When Windows has finished installing the I/O card, click Finish to close the wizard. Restart the system if requested.

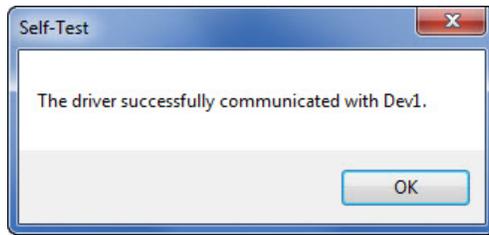
Confirm I/O card installation

Follow these steps to confirm your installation:

1. Start the Measurement & Automation Explorer (NI MAX) from the desktop icon or Programs | National Instruments | NI MAX.
2. In the left browser panel, open all nodes under Devices and Interfaces. Locate your I/O card and select it. **It should be named "Dev1".**



3. Click Self-Test to confirm that your card is communicating with the NI-DAQ driver. MAX should report success, such as

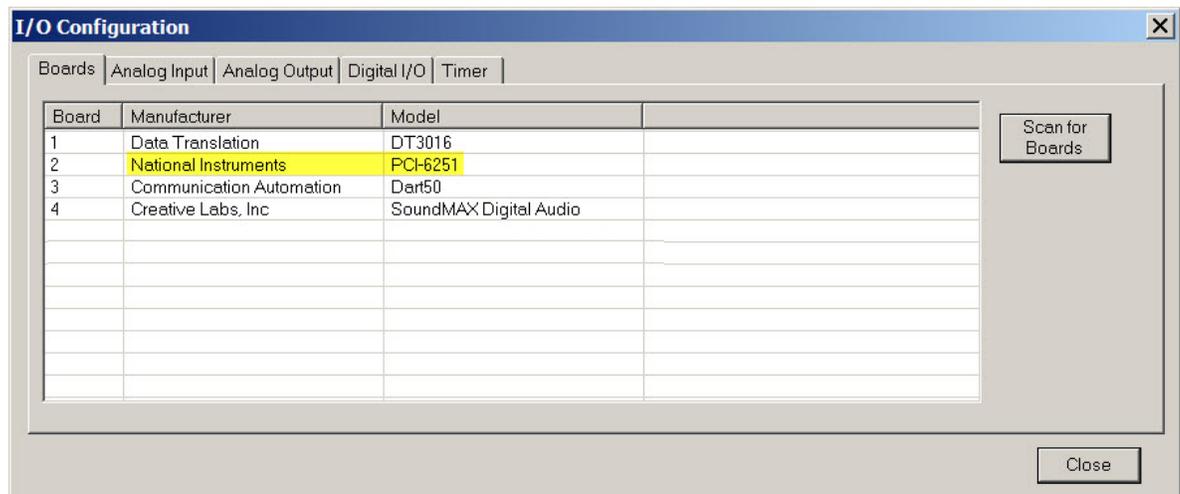


Troubleshoot I/O card installation

1. Run steps 1-2 under "Confirm I/O card installation".
2. If your card is listed in MAX but will not perform I/O, run Self-Test as described above.
3. If the card passes Self-Test but is not recognized by SIGNAL, verify it is named "Dev1", as in the figure above. If not, R-click and rename.
4. If the self-test fails and the device is a PCMCIA card, remove and reinsert it, then return to step 1. Otherwise, reboot the computer and return to step 1.

Test I/O card in SIGNAL

1. Launch SIGNAL, select I/O | Configure and confirm your I/O card is recognized.

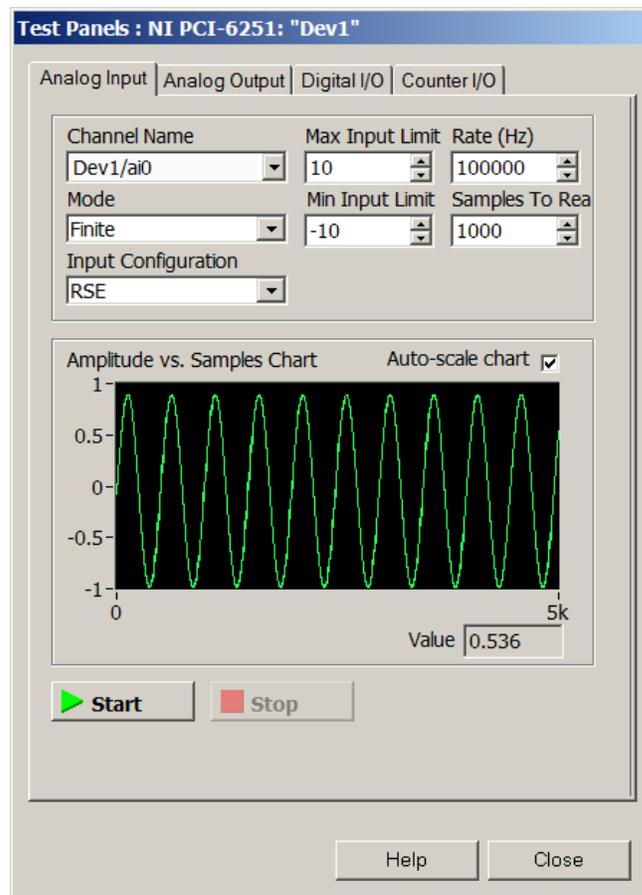


2. Select I/O | Acquire and I/O | Play to test acquisition and playback in SIGNAL.

Test I/O card in Measurement & Automation Explorer (MAX)

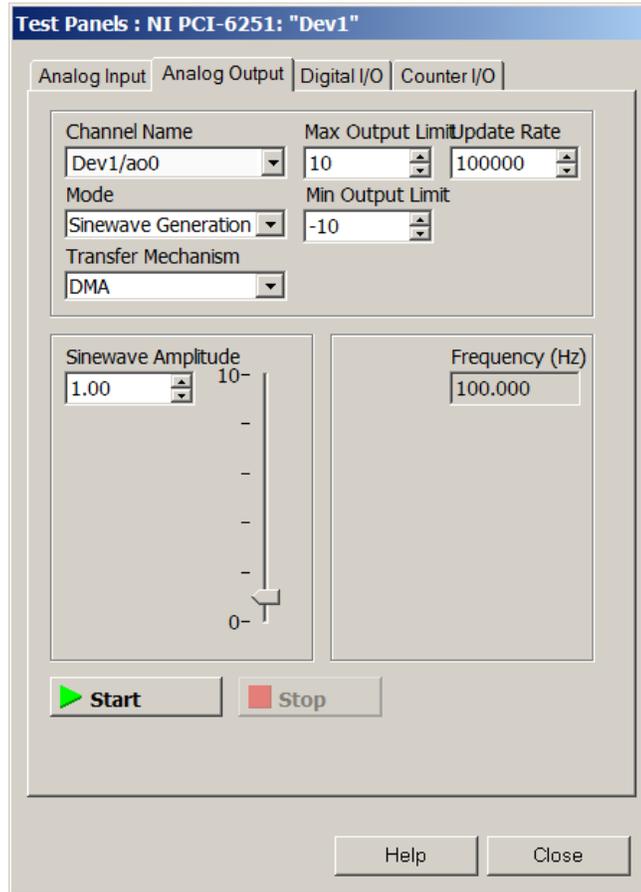
The following steps will test input and output functions on the installed I/O card using NI MAX.

1. An audio signal source, such as an electronic function generator or tape recorder playback, is required for the input test.
2. Connect the test signal to the first input channel on the card, which is channel 1 on the SIGNAL I/O panel or channel 0 on a National I/O panel. See the Operation section below for connection notes. Set the function generator to 1000 Hz, or play an audio signal.
3. Start the Measurement & Automation Explorer (MAX) from the desktop icon or Programs | National Instruments | NI MAX.
4. In the Configuration panel, open Devices and Interfaces and locate and select your I/O card. You should see the display shown under step 2 of "Confirm I/O card installation". Verify the I/O card is labeled "Dev 1".
5. Click the Test Panels button to launch the Test Panel.
6. Select the Analog Input tab and select the settings shown in the figure. Click Start to acquire and display a 10-msec signal segment, and inspect the acquired signal in the graph window. Click Start multiple times to acquire and display new data. To test the card at other sample rates, scale Rate and Samples to Read proportionally, e.g., change Rate to 500000 Hz and Samples to 5000.



7. Connect the first output channel on the card to an oscilloscope or a loudspeaker. **Set the loudspeaker amplifier initially to very low volume** to avoid damaging the loudspeaker or your ears.

8. Select the Analog Output tab and select the settings shown in the figure. Set Transfer Mechanism to DMA if possible, otherwise select Interrupts. The Frequency readout will not update until you click Start. Click Start to begin continuous playback. The card should produce a 100 Hz sine wave (by repetitively outputting 1000 points at 100 kHz sample rate). Monitor the output through the scope or loudspeaker. To test the card at other sample rates, adjust Update Rate, e.g., to 500000 Hz. Frequency will scale proportionally.



9. Click Close, then exit MAX.

Uninstall NI-DAQmx driver and I/O card

Follow these steps to uninstall the NI-DAQ software and I/O card.

1. Click Start | Settings | Control Panel | Add/Remove Programs.
2. Select NI-DAQ Device Document Browser and click Remove.
3. Select National Instruments Software and click Remove.

Connecting signals to the analog I/O board

Analog I/O boards from National Instruments can be accessed through a cable and I/O panel available from Engineering Design or a cable and screw panel available from NI. See "Analog I/O Connections" in Appendix B, "Hardware Reference" for details.

Wave-compatible Sound Card

The support software for a Wave-compatible sound card or sound chip may be supplied with the card or may already be installed in the computer.

1. Install the sound card software as instructed by the manufacturer, if not pre-installed.
2. No card configuration is usually necessary.

Windows support

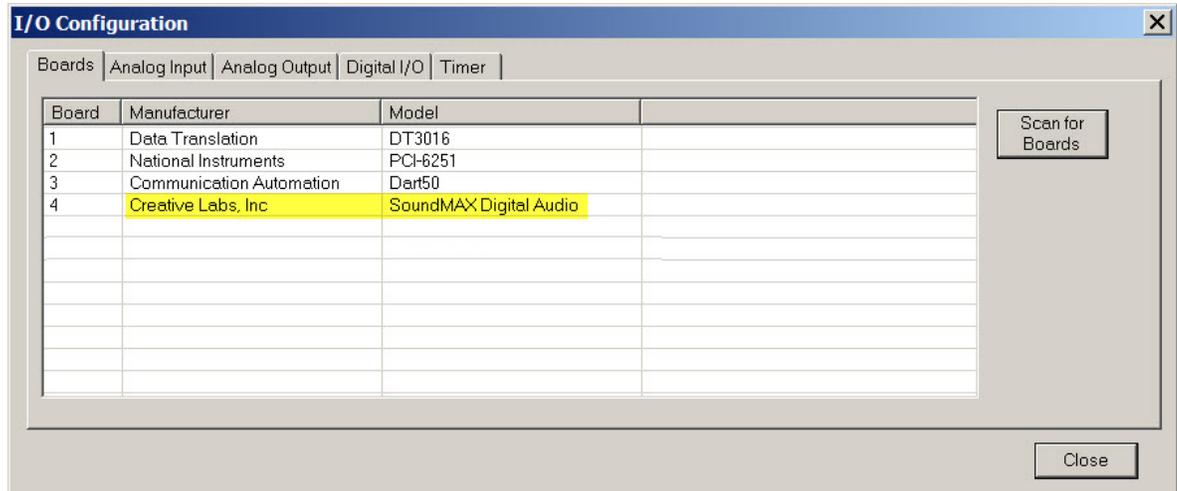
SIGNAL 4 and 5 support wave-compatible sound cards under Windows XP and later.

Installation media

Wave-compatible support software is either provided with the sound card on a CD containing card drivers, or is pre-installed on the computer, as in notebooks and desktops with built-in sound chips.

Test I/O card in SIGNAL

1. Launch SIGNAL, select I/O | Configure and confirm the board is recognized:



2. Select I/O | Acquire and I/O | Play to test acquisition and playback in SIGNAL.



4. ANALOG SIGNAL CONNECTIONS

Overview of I/O Panels

Engineering Design provides I/O cables and/or panels for analog I/O cards from Computer Automation Corporation (Dart card), Data Translation (DT), Measurement Computing Corporation (MCC) and National Instruments (NI). These panels provide the connections used most often with SIGNAL – analog input, analog output, and where applicable, digital lines such as external trigger and I/O activity lines. Signal connections are provided via BNC connectors.

Alternately, Data Translation, Measurement Computing, and National Instruments offer screw terminal panels and cables compatible with their I/O boards, which can be used to construct custom I/O panels.

This appendix describes signal connections to I/O panels provided by Engineering Design and the screw terminal panels provided by I/O board manufacturers.

Single-Ended vs. Differential Connections

Single-Ended vs. Differential Circuits

Analog input signals can be connected to an analog I/O board in either single-ended or differential mode. In **single-ended** mode, the ground reference of the input signal is tied to the ground reference of the digitizer, which measures the voltage difference between the input signal and digitizer ground. In a single-ended connection, the grounds of multiple input channels are implicitly tied together. In **differential** mode, signal ground is isolated from the ground reference of the digitizer, which measures the voltage difference between the two input terminals ("signal" and "ground").

Single-ended mode is the usual choice for digitizing systems, because it provides reliable ground-referencing, which is required with "floating" sources such as tape and CD players.

Differential mode is used for low-noise applications such as instrumentation and studio preamplifiers, but requires careful attention to grounding and shielding, or sources can "float" out of the range of the digitizer or suffer from induced interference.

Analog I/O boards may deliver output signals in single-ended or differential mode, depending on the board, but this does not normally pose grounding issues, because the D/A tracks the ground reference of the load.

I/O Panel Configuration

Analog I/O panels provided by Engineering Design incorporate a hybrid approach. They interface to the I/O board in differential mode and to the user in single-ended mode. This is achieved inside the I/O panel by tying all input grounds together and to the analog ground of the digitizer. This provides some of the noise immunity of a differential connection but allows the user to connect floating sources without concern for ground referencing.

On the other hand, screw terminal panels provided by I/O board manufacturers do not provide any internal ground referencing.

Software Configuration

Depending on the I/O manufacturer, **SIGNAL may operate an I/O board in single-ended or differential mode, and** Engineering Design I/O panels are internally wired to provide the ground referencing required for that operating mode. Thus, for example, all ED I/O panels for NI boards are wired to operate the board in differential mode. **Note** however that if you are not using an Engineering Design I/O panel, **you must provide the necessary analog ground referencing**. See below for details for each manufacturer.

Dart I/O Card

Anti-Alias Filter

The Dart card contains an internal anti-alias filter, so no external filter is needed. See Chapter 10, "Advanced Acquisition and Playback" in the *SIGNAL Reference Guide* for a discussion of anti-alias filters.

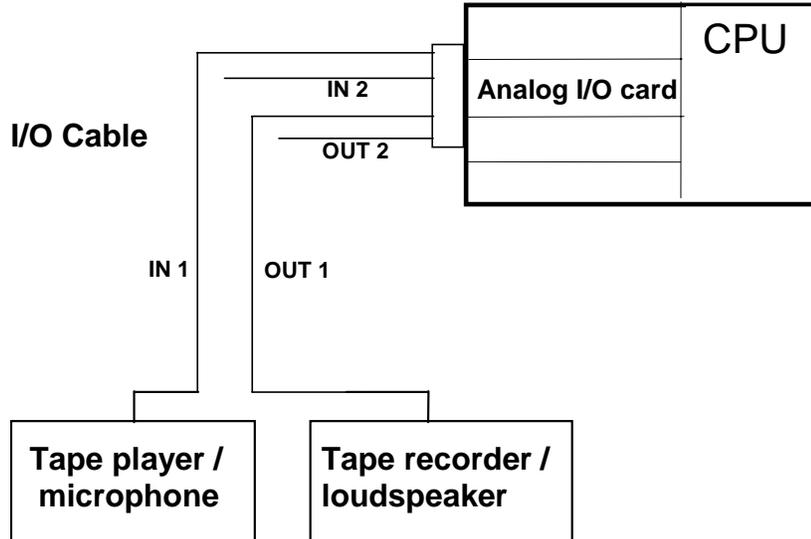
Single-Ended vs. Differential Connection

Dart card inputs and outputs are single-ended. See "Single-Ended vs. Differential Signal Connections" above for discussion.

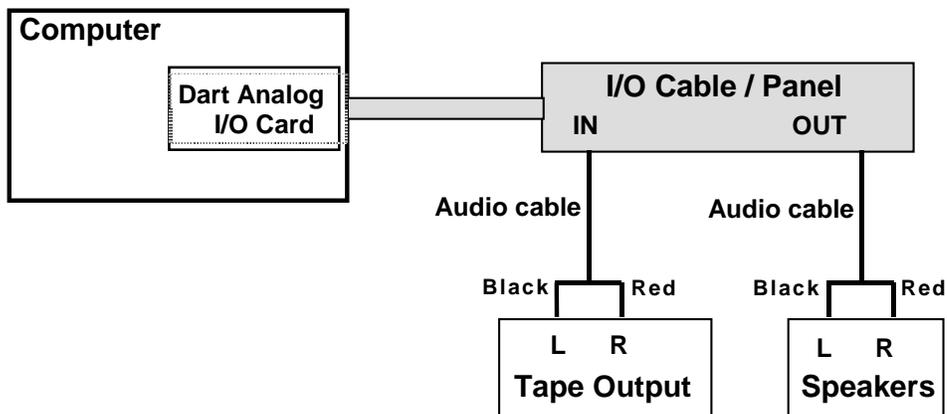
Dart I/O cable

Engineering Design provides an I/O cable for the Dart analog I/O card. This cable comes in two forms:

- 1) The current version consists of a PCMCIA connector which breaks out into four leads terminating in four RCA female connectors, representing In 1, In 2, Out 1, and Out 2.



- 2) An older version consists of a blue plastic enclosure connecting through a short cable to a PCMCIA connector. The enclosure contains two female stereo mini-phone connectors labeled In and Out. Channel 1 appears on the left channel of these jacks and channel 2 appears on the right.



Following are connections instructions for the current model cable:

1. Connect the signal source, which might be a microphone or tape recorder, to Input 1 on the I/O cable. **In ED I/O panels and cables, input and output channels are numbered beginning with 1 (channel 1, 2, 3, etc.).**

2. Connect Output 1 on the I/O cable to a tape recorder or loudspeaker for recording or monitoring.

Data Translation

Anti-Alias Filter

Data Translation boards typically do not include anti-alias filters, so an external anti-alias filter may be necessary to limit the bandwidth of the input signal to avoid sampling artifacts. See Chapter 10, "Advanced Acquisition and Playback" in the *SIGNAL Reference Guide* for a discussion of anti-alias filters.

Single-Ended vs. Differential Connection

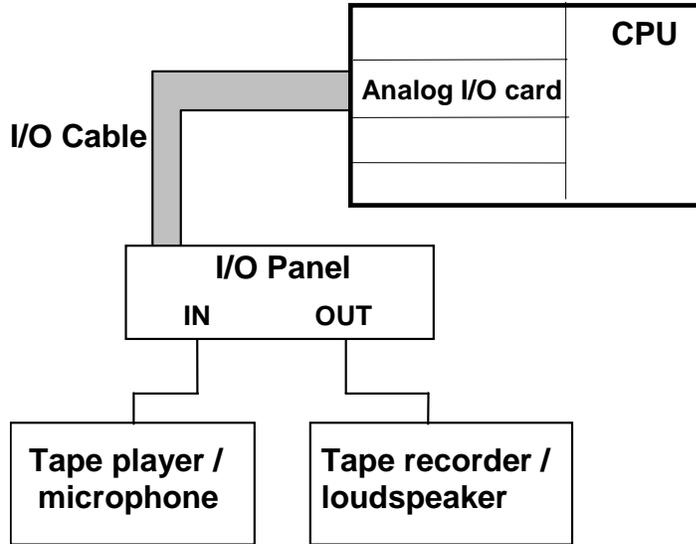
SIGNAL operates all DT boards in differential input mode **except the DT9834, which is operated in single-ended mode**, and must be configured for single-ended mode at the factory. See "Single-Ended vs. Differential Signal Connections" above for discussion.

Engineering Design I/O panel

Engineering Design provides an I/O panel for DT analog I/O boards. **The ED panel is specific to a particular DT board model**, because different models use different pin assignments.

The following diagram shows the connections for one input and one output channel:

1. Connect the signal source, such as a microphone or tape recorder, through an optional anti-alias filter to Input 1 on the I/O panel. **In ED I/O panels, input and output channels are numbered beginning with 1 (channel 1, 2, 3, etc.).**
2. Connect Output 1 on the I/O panel to a tape recorder or loudspeaker for recording or monitoring.
3. Connect the I/O cable between the I/O card and the I/O panel. If the panel has two computer connectors, **typically use the connector associated with pins 1-50**, but see the connector pinout in the I/O card guide for confirmation.



The ED I/O panel may also include connectors for digital TTL signals, such as TRIG IN and TRIG OUT for AC and PL, for interfacing with external systems. These are I/O activity signals, which indicate the duration of acquisition or playback, and trigger signals, to initiate acquisition or playback. See "Output synchronization" and "External trigger" in the *SIGNAL Reference Guide*.

Data Translation I/O panel

DT analog I/O boards can be accessed using screw panels available from DT. **In DT I/O panels and documentation, input and output channels are numbered beginning with 0.** Pin assignments vary with board model – see the board user guide for the correct pinout. **SIGNAL operates the I/O card in differential input mode**, so the user must provide input ground referencing.

The following instructions apply to the DT-740 screw panel. Be sure to consult the DT hardware guide for your panel. **Note that DT panel and board pinout numbering schemes differ.**

For one input channel:

- Connect the "high" side of signal input to Analog Input 00
- Connect signal ground to Analog Input 08/00 Return

For one output channel:

- Connect load "signal" terminal to Analog Output 0+
- Connect load "ground" terminal to Analog Output 0 Return

DT9834 USB I/O Unit

The DT9834 incorporates an integrated I/O panel. **SIGNAL requires the single-ended version of the DT9834**, so connect to the unit in single-ended mode.

For one input channel:

- Connect input channel 1 to AD Ch0

For one output channel:

- Connect load to DAC Ch0

Measurement Computing Corporation

Anti-Alias Filter

Measurement Computing boards typically do not include anti-alias filters, so an external anti-alias filter may be necessary to limit the bandwidth of the input signal to avoid sampling artifacts. See Chapter 10, "Advanced Acquisition and Playback" in the *SIGNAL Reference Guide* for a discussion of anti-alias filters.

Single-Ended vs. Differential Connection

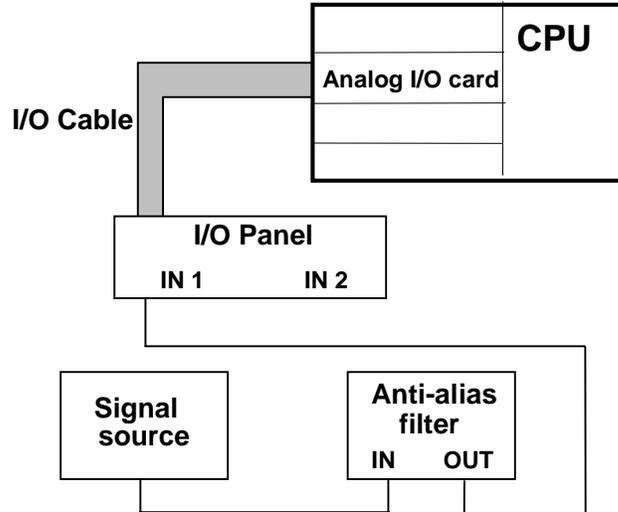
SIGNAL operates MCC boards in single-ended input mode. See "Single-Ended vs. Differential Signal Connections" above for discussion.

Engineering Design I/O panel

Engineering Design provides an I/O panel for Measurement Computing Corporation (MCC) analog I/O boards. **The ED panel is specific to a particular MCC board model**, because different models use different pin assignments.

The following diagram shows the connections for one input channel:

1. Connect the signal source, which might be a microphone or tape recorder, through an optional anti-alias filter to Input 1 on the I/O panel. **In ED I/O panels, input and output channels are numbered beginning with 1 (channel 1, 2, 3, etc.).**
2. Connect the I/O cable between the I/O card and the I/O panel. If the panel has two computer connectors, **typically use the connector associated with pins 1-50**, but see the connector pinout in the I/O card guide for confirmation.



Measurement Computing panel

MCC analog I/O boards can be accessed using screw panels and BNC panels available from MCC. **In MCC I/O panels and documentation, input and output channels are numbered beginning with 0.** Pin assignments vary with each board model – see the user guide for that board for the correct pinout. **SIGNAL operates the I/O card in single-ended input mode** (see the I/O card user guide), so input signals must be connected in single-ended mode.

The following instructions apply to the PC-CARD-DAS16/330 card. Be sure to consult the user guide for your I/O card.

For one input channel:

- Connect the “high” side of signal input to CH0 In
- Connect signal ground to AGND (analog input ground)

For multiple channels, connect additional inputs to CH1 In, CH2 In, etc..

National Instruments

Anti-Alias Filter

National Instruments boards typically do not include anti-alias filters, so an external anti-alias filter may be necessary to limit the bandwidth of the input signal to avoid sampling artifacts. See Chapter 10, "Advanced Acquisition and Playback" in the *SIGNAL Reference Guide* for a discussion of anti-alias filters.

Single-Ended vs. Differential Connections

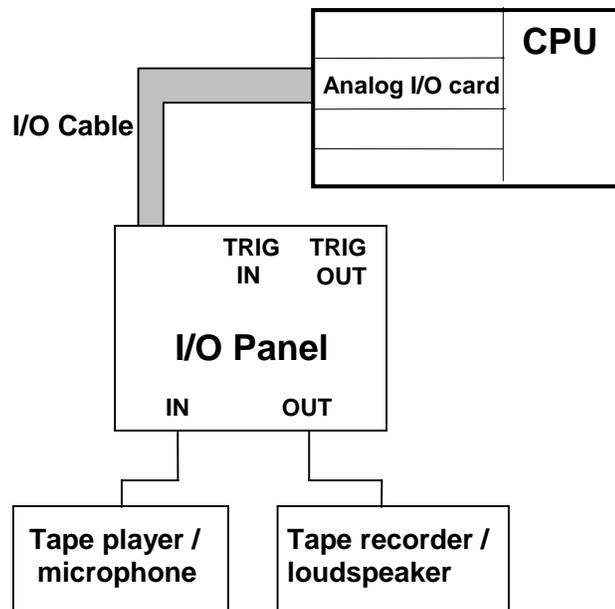
SIGNAL operates NI boards in differential input mode. See "Single-Ended vs. Differential Signal Connections" above for discussion.

Engineering Design I/O panel

Engineering Design provides an I/O panel for National Instruments (NI) analog I/O boards. **The ED panel is specific to a particular NI board model.** To use it with a different model, it must be rewired internally for a different pinout. The ED panel is wired for "**referenced single-ended**" input mode for compatibility with SIGNAL.

The following diagram shows the connections for one input and one output channel:

1. Connect the signal source, which might be a microphone or tape recorder, through an optional anti-alias filter to Input 1 on the I/O panel. **In ED I/O panels, input and output channels are numbered beginning with 1 (channel 1, 2, 3, etc.).**
2. Connect Output 1 on the I/O panel to a tape recorder or loudspeaker for recording or monitoring.
3. Connect the I/O cable between the I/O card and the I/O panel. If the panel has two computer connectors, **typically use the connector associated with pins 1-50**, but see the connector pinout in the I/O card guide for confirmation.



The ED I/O panel may also include connectors for digital TTL interface signals. TRIG OUT provides the output signal IO_ACTIVE, which indicates the duration of acquisition or playback, for synchronization with an external system. TRIG IN receives the external TTL trigger signal EXT_TRIG, to initiate acquisition or playback. See "Output synchronization" and "External trigger" in the *SIGNAL Reference Guide*.

National Instruments I/O panel

NI analog I/O boards can be accessed using screw panels available from NI. **In NI I/O panels and documentation, input and output channels are numbered beginning with 0.** Pinouts vary with each board model – see the user guide for that board for the correct pinout. **SIGNAL operates the I/O card in “referenced single-ended” input mode** (see the I/O card user guide), so input signals must be connected in single-ended mode.

The following instructions apply to the NI-6062E card and associated screw terminal panel. Be sure to consult the NI user guide for your card.

For one input channel:

- Connect the “high” side of signal input to ACH0
- Connect signal ground to AIGND (analog input ground)

For one output channel:

- Connect signal output to DAC0OUT
- Connect signal ground to AOGND (analog output ground)

For multiple channels, connect additional inputs to ACH1, ACH2, etc., and outputs to DAC1OUT, DAC2OUT, etc.

Wave-Compatible Sound Card

Anti-Alias Filter

Sound cards contain internal anti-alias filters, so no external filter is needed. See Chapter 10, "Advanced Acquisition and Playback" in the *SIGNAL Reference Guide* for a discussion of anti-alias filters.

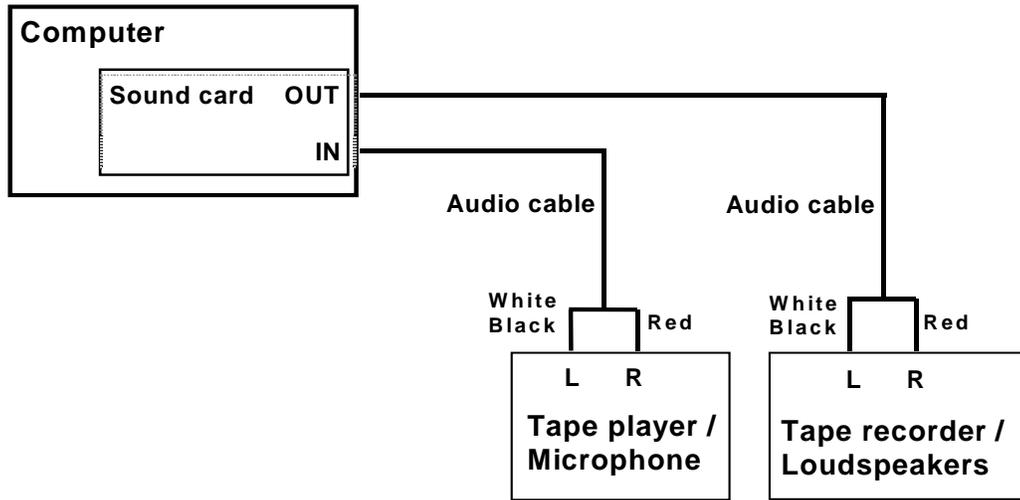
Single-Ended vs. Differential Connection

Sound card inputs and outputs are usually single-ended. See "Single-Ended vs. Differential Signal Connections" above for discussion.

Sound Card cable

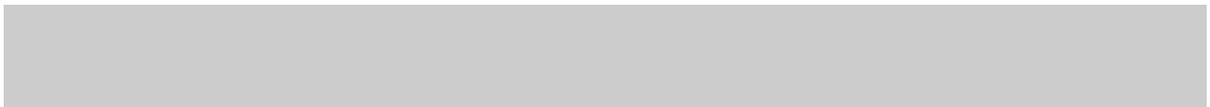
Sound cards usually deliver input and output signals thru stereo mini-phone jacks. One possible cable includes a male stereo mini-phone plug at one end and dual RCA male connectors at the other (for example, Radio Shack 42-2550 or 42-2551). The left channel appears on the white or black RCA connector and the right channel on the red RCA connector.

Signal Connections



Following are connections instructions:

1. Connect the signal source, which might be a microphone or tape recorder, to the left (white or black) connector on the input I/O cable.
2. Connect the left connector of the output I/O cable to a tape recorder or loudspeaker for recording or monitoring.



5. Digital Signal Connections

Triggering SIGNAL from an External System

Overview

External triggering allows the user to initiate SIGNAL acquisition or playback via an external control signal, in order to synchronize the SIGNAL I/O process with an external system. For example, an external system might begin neural data acquisition, collect pre-trigger data for 5 seconds, then trigger SIGNAL to begin playback stimulation. This "hardware" triggering provides very high accuracy, typically on the order of 1 microsecond, which is much more accurate than synchronizing the two systems from the keyboard.

This section describes hardware issues involved in external triggering. Chapter 10, "Advanced Acquisition and Playback" in the *SIGNAL Reference Guide* describes the associated SIGNAL parameters.

Trigger Signals

The **AC_TRIGGER** signal initiates acquisition and the **PL_TRIGGER** signal initiates playback. The trigger signal is a TTL-compatible rising or falling edge. Trigger specs are manufacturer-specific – see below. Always consult the trigger specs of your I/O board and **confirm that the external system can output a compatible trigger signal.**

Trigger Signal Latency

Trigger signal latency is the time delay between the trigger signal and the initiation of the I/O process. Latency is manufacturer-specific but is typically $< 1 \mu\text{sec}$.

Triggering instructions

To perform external triggering:

1. Connect the external trigger signal as described above.

2. Select External trigger in the SIGNAL acquisition or playback Advanced Properties dialog screen, or set the ACTRIG or PLTRIG parameter to EXT.
3. Initiate the I/O process. SIGNAL will prepare the I/O process, for example, by preloading the playback buffers.
4. Acquisition or playback will begin on receipt of the external trigger signal.

Dart I/O Card

Trigger Signals

Not available.

Synchronization Signals

Not available.

Data Translation

NOTE: DT3010/3016 require a digital signal cable between the ED panel or DT screw panel and the I/O board to carry trigger and synchronization signals.

Trigger Signal

The DT3010 and DT3016 require separate trigger signals for acquisition and playback. Trigger signals must be TTL-compatible with a falling edge and a minimum duration of 10 nsec, but **consult the trigger specs of the specific I/O board to confirm this.**

Trigger Signal Latency

DT trigger latency is typically < 1 microsecond.

Trigger Signal Connections

Engineering Design panels have separate AC and PL trigger connectors labeled AC TRIG IN and PL TRIG IN.

If using a DT screw terminal panel, connect the external AC trigger signal to the "External A/D TTL Trigger" pin and the external PL trigger signal to the "External D/A TTL Trigger" pin.

National Instruments

National Instruments (NI) boards under SIGNAL 4 accept a single trigger signal called **IO_TRIGGER**, capable of triggering either acquisition or playback. NI boards under

SIGNAL 5 (July 2007 and later) accept separate AC_TRIGGER and PL_TRIGGER signals. Trigger signals can be rising or falling edge with a minimum duration of 10 nsec.

Trigger Signal

National Instruments (NI) boards typically require a TTL-compatible trigger signal with a minimum duration of 10 nsec. Most NI boards can trigger on either a rising or falling trigger signal, as specified by the **Trigger polarity** parameter in SIGNAL. This is useful because some external systems can provide only one type of polarity. **Be sure to consult the trigger specs of the specific I/O board.**

Trigger Signal Latency

Trigger latency is board-dependent but not CPU-dependent, and is typically < 1 µsec.

Trigger Signal Connections

Engineering Design has produced two generations of the I/O panel for National Instruments boards, which differ only in trigger connectors. Version 4 panels were produced before July 1, 2007 and provide one trigger input and one trigger output connector, shared by AC and PL processes. Version 5 panels were produced after July 1, 2007 and provide 4 trigger connectors for AC and PL processes – AC trigger input, AC trigger output, PL trigger input, and PL trigger output.

SIGNAL 5 supports both panel versions. The **IOPANEL** parameter specifies I/O panel version 4 or 5. If you plan to use the trigger connectors on an NI panel, **you must specify your NI panel version via IOPANEL** so SIGNAL can direct signals appropriately. For example, "set iopanel 4" directs SIGNAL to provide trigger signals for a version 4 panel. IOPANEL defaults to SIGNAL 5 panels.

If using an NI screw terminal panel with SIGNAL 5, connect the external AC trigger signal to pin PFI-0 and the external PL trigger signal to pin PFI-1.

Wave-Compatible Sound Card

Trigger Signals

Not available.

Synchronization Signals

Not available.

Triggering an External System from SIGNAL

Overview

An output trigger or **synchronization signal** allows the user to initiate some process in an external system at the beginning or end of SIGNAL acquisition or playback, in order to synchronize the SIGNAL I/O process with an external system. Synchronization signals can be used to inform the external system of the beginning and the end of an I/O process. For example, the user can start a playback in SIGNAL, then use the synchronization signal to trigger an external neurophysiological data acquisition system. To gather "pre-trigger" data, insert a segment of silence at the beginning of the SIGNAL playback signal.

This section describes hardware issues involved in synchronization signals. Chapter 10, "Advanced Acquisition and Playback" in the *SIGNAL Reference Guide* describes the associated SIGNAL parameters.

Synchronization Signals

Synchronization signals can vary between manufacturers due to board capabilities, but generally, an **AC_ACTIVE** signal indicates acquisition status and a **PL_ACTIVE** signal indicates playback status. These signals are TTL-compatible and they go HIGH at the beginning of the I/O process and LOW at the end of the process, and remain LOW otherwise. For example, the rising edge can synchronize an external system with playback onset, or the HIGH level can be used to enable external data collection.

Note: synchronization signals are issued only when the I/O process has been manually (not externally) triggered.

Synchronization Signal Latency

Synchronization signal latency is the time delay between the beginning of the I/O process and the rising edge of the synchronization signal (and between the end of the I/O process and the sync signal's falling edge). Latency may be approximately 1-20 μ sec, depending on the individual I/O board and CPU speed.

Dart I/O Card

Trigger Signals

Not available.

Synchronization Signals

Not available.

Data Translation

NOTE: DT3010/3016 require a digital signal cable between the ED panel or DT screw panel and the I/O board to carry trigger and synchronization signals.

Synchronization Signals

DT3010 and DT3016 boards provide separate **AC_ACTIVE** and **PL_ACTIVE** signals.

Synchronization Signal Latency

DT synchronization latency is board-dependent and CPU-dependent, but is typically 1-20 μ sec.

Signal Connections

Engineering Design panels have separate **AC_ACTIVE** and **PL_ACTIVE** connectors labeled **AC TRIG OUT** and **PL TRIG OUT**.

If using a DT screw terminal panel, **AC_ACTIVE** and **PL_ACTIVE** are provided at lines 0 and 1, respectively, of the first digital port. This is "Digital I/O Bank A 0" and "Digital I/O Bank A 1", respectively, on the DT3010/3016. On the DT9834 panel, **AC_ACTIVE**, **PL_ACTIVE**, and their ground are provided at pins 20, 21, and 18, respectively, of the Digital In/Out connector. For the DT3010/3016, **AC_ACTIVE** and **PL_ACTIVE** are provided at "Digital I/O Bank A 0" and "Digital I/O Bank A 1", respectively, on the screw terminal panel.

National Instruments

Synchronization Signals

NI boards under SIGNAL 5 (July 2007 and later) provide separate **AC_ACTIVE** and **PL_ACTIVE** signals.

Synchronization Signal Latency

Playback latency before synchronization signal HIGH is about 20 μ sec, depending on CPU speed (measured with a DAQCard-6062E on a Pentium-III/650). Playback latency before synchronization signal LOW varies between 70 and 600 microseconds (measured with a DAQCard-6062E on a Pentium-III/650) on playback. Acquisition latency on the DAQCard-6062E has not been measured but is probably similar.

Latency on the PCI-6251 on a 3 GHz Pentium is probably considerably shorter, but has not been measured.

Signal Connections

Engineering Design panels shipped before July 1, 2007 have one synchronization signal connector labeled TRIG OUT. For SIGNAL 5 compatibility with these panels, set the SIGNAL IOPANEL parameter to 4.

Panels shipped after July 1, 2007 have separate AC and PL synchronization signal connectors. These panels are compatible with SIGNAL 5 with the default IOPANEL setting of 5.

If using an NI screw terminal panel with SIGNAL 5, set IOPANEL to 5. Then AC_ACTIVE (AC Trigger Out) is available at DIO-0 or Port 0/Line 0 and PL_ACTIVE (PL Trigger Out) is available at DIO-1 or Port 0/Line 1.

Engineering Design I/O Panel

The following table shows the assignment of DIO and PFI lines to the trigger and synchronization signal connectors on the Engineering Design NI I/O panel. Not all ED NI I/O panels include these connectors.

<u>Panel Connector</u>	<u>Hardware DIO Port</u>		<u>PFI Pin</u>
Analog I/O triggers			
AC In	Port 1	Bit 0	0
PL In	Port 1	Bit 1	1
AC Out	Port 0	Bit 0	
PL Out	Port 0	Bit 1	

Wave-Compatible Sound Card

Trigger Signals

Not available.

Synchronization Signals

Not available.



6. OPERATING HINTS AND TROUBLESHOOTING

This chapter presents operating hints and troubleshooting guidelines, organized by manufacturer.

General

The following hints apply to all manufacturers.

Disk Fragmentation and Maximum Sample Rate

On older hard disks, fragmentation can degrade the maximum sample rate. Disks can be defragmented by clicking My Computer | Files | Properties | Tools | Defragment Now in Windows 95/98 or My Computer | Local Disk | Properties | Tools | Defragment Now in Windows 2000/XP. This process should be performed with care.

Notebook Power Management

Some notebook computers (such as Toshiba models) optionally reduce processor speed when running from batteries, to conserve battery life. **This can severely reduce the maximum achievable sample rate.** To avoid this, reconfigure the computer's power management program (usually available from the Control Panel) to run at full processor speed on battery power.

As an example, following are steps for reconfiguring a Toshiba Satellite 2250CDT: 1) run Power Saver from the Control Panel (not the Windows-supplied Power Management utility), 2) in the "Running on batteries" section, set the power mode to High Power, 3) click Details, select the Power Save Mode tab, and move the 4 slider controls associated with Processor Speed to Full, 4) click OK.

Running a PCMCIA Card from a Desktop Computer

A PCMCIA card can be run from a desktop computer using a PCMCIA to PCI adapter card. This card costs under \$200 and can allow the card to do "double duty", for example, in a desktop workstation in the lab and in a notebook computer in the field. Contact Engineering Design for the currently recommended adapter.

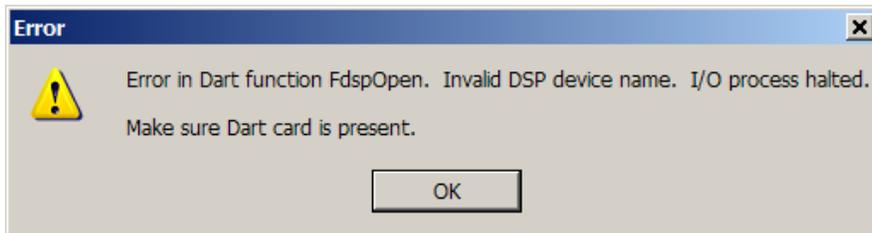
Multiple Analog I/O Boards

If you have installed multiple analog I/O boards, SIGNAL will detect and register them in the SIGNAL I/O environment. An I/O process can be steered to any one of these boards. "Managing Analog I/O Hardware in SIGNAL 5" in Chapter 9, "Acquisition and Playback" in the *SIGNAL Reference Guide* describes I/O board detection and access.

Dart I/O Card

I/O Board Not Present or Disabled

SIGNAL will display the following error message if the I/O board is not present or disabled. Note that removable I/O devices, such as PCMCIA cards and USB units, **may need to be removed and reinserted after the system is restored from Standby**, even when Device Manager reports the device as installed and "working properly". If the I/O device is removable, remove and reinsert it. If the error persists, reboot the computer. If the error still persists, uninstall and reinstall the system driver and board driver for the I/O device.



Minimum and Maximum Duration

Minimum acquisition and playback duration is 0.1 seconds. Maximum acquisition and playback duration is the capacity of the hard disk.

Sample Rate Selection

All Dart cards provide 8 sample rates ranging between a maximum sample rate and (max sample rate)/6. The standard model provides a maximum sample rate of 50 kHz, with the following sample rate choices:

8333, 10000, 12500, 16667, 20000, 25000, 33333, 50000 Hz

Another model provides a maximum sample rate of 44.1 kHz for compatibility with audio CDs, with the following sample rate choices:

7350, 8820, 11025, 14700, 17640, 22050, 29400, 44100 Hz

Another model provides a maximum sample rate of 48 kHz for compatibility with DAT audio, with the following sample rate choices:

8000, 9600, 12000, 16000, 19200, 24000, 32000, 48000 Hz

I/O Errors

Acquisition and playback errors arise when the I/O board cannot convert data, or when SIGNAL cannot store or retrieve data from memory or the hard disk, at the requested sample rate. SIGNAL will issue the following message. Possible causes include performing demanding processes in parallel with SIGNAL, a slow CPU, or a slow hard disk. Remedies are to terminate other processes, defragment the hard disk, increase CPU or disk capabilities, or reduce sample rate. **SIGNAL may also fail if the progress window is moved on the screen during I/O.**

Note: SIGNAL will save data acquired until the error, but use caution because final data blocks may be corrupted.



Data Translation

I/O Board Not Present or Disabled

SIGNAL will display the following error messages if the I/O board is not present or disabled, respectively. Note that removable I/O devices, such as PCMCIA cards and USB units, **may need to be removed and reinserted after the system is restored from Standby**, even when Device Manager reports the device as installed and "working properly". If the I/O device is removable, power off and on again (if appropriate), then remove and reinsert it. If the error persists, reboot the computer. If the error still persists, uninstall and reinstall the system driver and board driver for the I/O device.



Note: the internal processor in the DT9834 USB sound unit can occasionally hang. To perform a hardware reset, disconnect and reconnect the power to the unit.

Minimum and Maximum Duration

Minimum acquisition and playback duration is 0.1 seconds. Maximum acquisition and playback duration is the capacity of the hard disk.

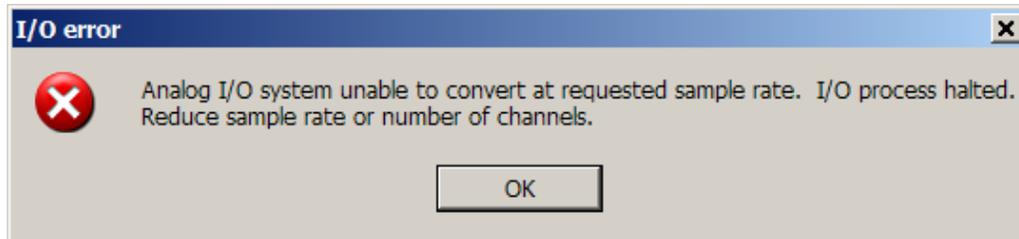
Minimum and Maximum Sample Rate

Minimum sample rate is 100 Hz for acquisition and playback. Maximum sample rate is determined by the analog I/O card. SIGNAL has been tested extensively with the 12-bit, 1250 kHz desktop analog I/O card, model DT3010, and the 16-bit, 250 kHz desktop analog I/O card, model DT3016.

I/O Errors

Acquisition and playback errors occur when the I/O board cannot convert data, or when SIGNAL cannot store or retrieve data from memory or the hard disk, at the requested sample rate. SIGNAL will issue the following message. Possible causes include performing demanding processes in parallel with SIGNAL, a slow CPU, or a slow hard disk. Remedies are to terminate other processes, defragment the hard disk, increase CPU or disk capabilities, or reduce sample rate.

Following is a sample acquisition error message:



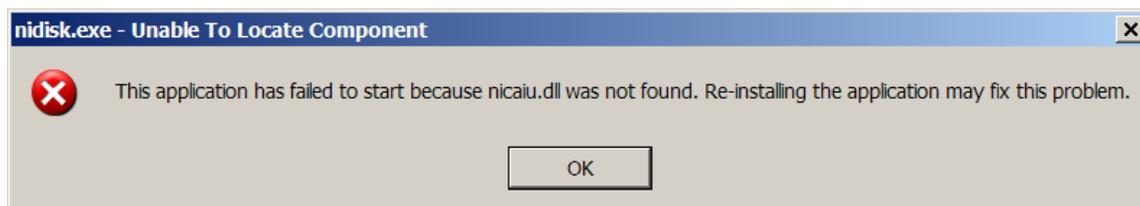
Portability to All Data Translation Analog I/O Cards

SIGNAL operates with all Data Translation analog I/O cards. SIGNAL automatically makes the installed card's capabilities available, including maximum sample rate and programmable input gain.

National Instruments

None or Obsolete NI-DAQ System Driver Installed

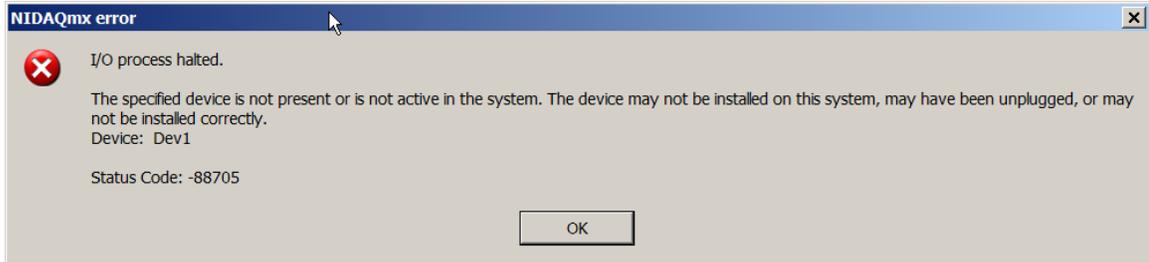
SIGNAL 5 I/O requires NI-DAQmx v8.0 or later. If this version is not installed, SIGNAL will issue a message similar to the following on startup. See the "Installation" chapter in this guide for instructions on downloading and installing the NI-DAQmx system driver.



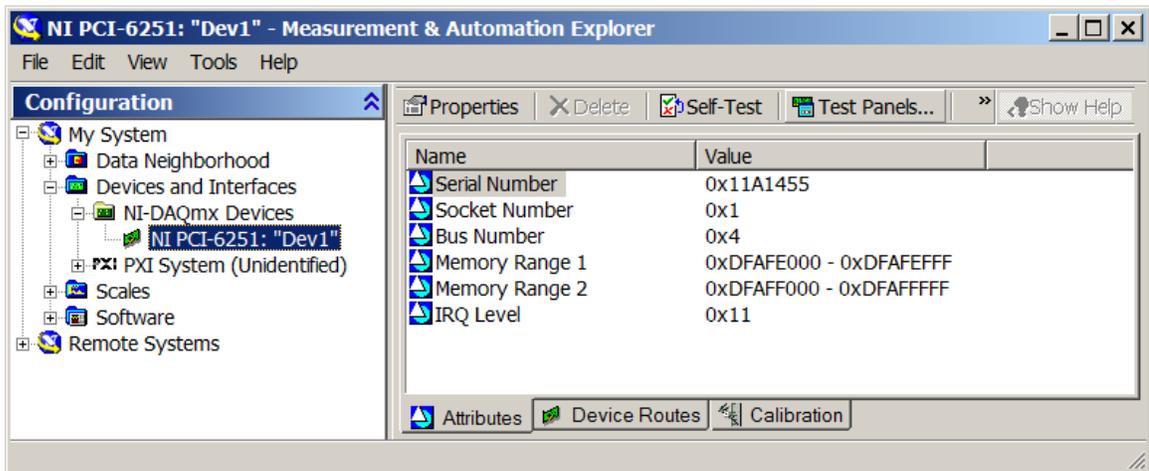
I/O Device Not Recognized or Not Responding

The I/O device not responding can be due to many causes at different system levels, such as board standby state, board initialization, driver initialization, operating system state, and corruption of the board driver or I/O driver. The following sequence of steps descends downward through the system levels, ending with software reinstallation. These should be followed in the order given.

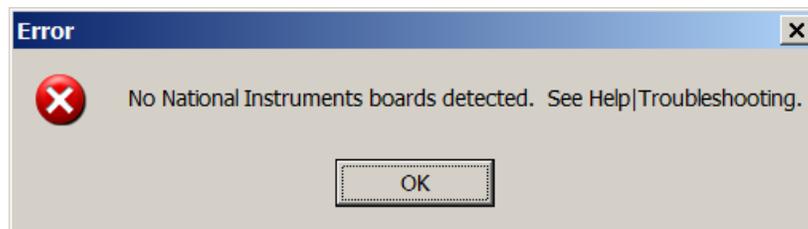
1. If the I/O device is not present or is not named "Dev1", SIGNAL issues the following message:



If the device is not present, install it as described in the "Installation" chapter in this guide. If present, open Measurement & Automation Explorer (MAX) as described under "Confirm and troubleshoot I/O card and driver installation" and verify that the device is named "Dev1" (see figure). If not, R-click and rename.



2. If the I/O device is present but SIGNAL does not recognize it, SIGNAL issues the following message:



Removable I/O devices, such as PCMCIA cards and USB units, usually need to be removed and reinserted after the system is restored from Standby, **even though Device Manager may report the device as installed and "working properly"**. If

the I/O device is removable, remove and reinsert the device. If SIGNAL still does not recognize the device, proceed to step 4.

3. If SIGNAL recognizes the I/O device but will not perform I/O operations, select I/O | Reset on the menu. **Note: this is not currently implemented.** If SIGNAL still will not perform I/O operations, proceed to the next step.
4. If SIGNAL I/O has (or may have) terminated abnormally, SIGNAL may be running as a "phantom" process and preventing SIGNAL I/O processes from operating correctly. To check this in Windows XP, exit SIGNAL, then open Windows Task Manager by hitting Ctrl-Alt-Del, select the Processes tab, and click Image Name to view the task names in alphabetical order. Select each "sigwin.exe" task and click End Process to terminate it. Then launch SIGNAL again. If SIGNAL still will not perform I/O operations, proceed to the next step.
5. Run Measurement & Automation Explorer (MAX) and perform the troubleshooting steps described in "Confirm and troubleshoot I/O card and driver installation" under "National Instruments" in the "Installation" chapter in this guide. If MAX does not recognize the device or reports a problem, proceed to the next step.
6. Reboot the computer, then run MAX again. If MAX still reports a problem, proceed to the next step.
7. Uninstall and reinstall the National Instruments system driver and board driver for the I/O device, as described in the "Installation" chapter in this guide.

Minimum and Maximum Duration

Minimum acquisition and playback duration is 0.1 seconds. Maximum acquisition and playback duration is the capacity of the hard disk.

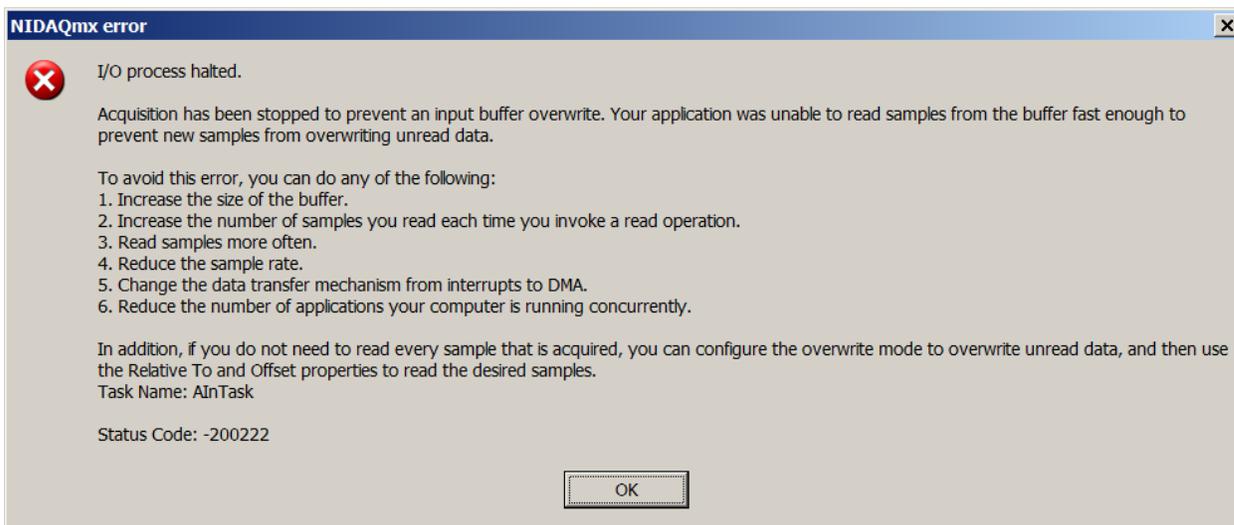
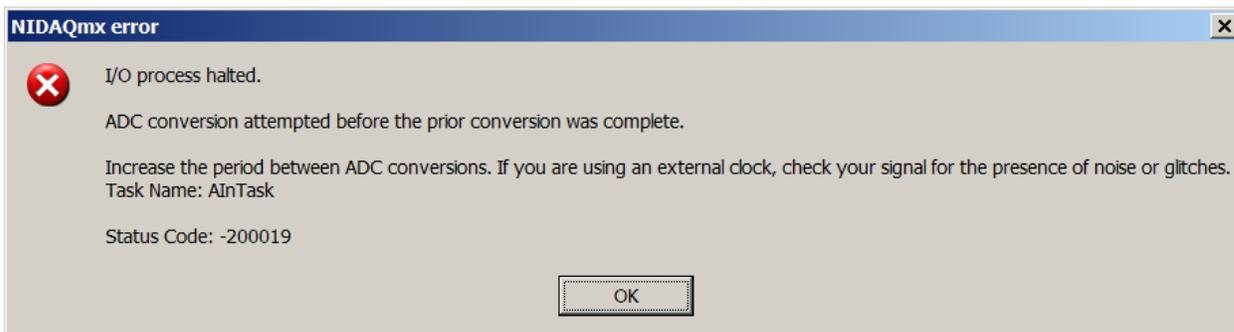
Minimum and Maximum Sample Rate

Minimum sample rate is 100 Hz for acquisition and playback. Maximum sample rate is determined by the analog I/O card. SIGNAL has been tested with a 12-bit, 500 kHz PCMCIA notebook analog I/O card (model DAQCard-6062E) and a 16-bit, 1.5 MHz PCI desktop analog I/O card (model PCI-6251). See "Technical Notes" for more detail.

I/O Errors

Acquisition and playback errors arise when the I/O board cannot convert data, or when SIGNAL cannot store or retrieve data from memory or the hard disk, at the requested sample rate. SIGNAL will issue messages similar to the following. Possible causes include performing demanding processes in parallel with SIGNAL, a slow CPU, or a slow hard disk. Remedies are to terminate other processes, defragment the hard disk, increase CPU or disk capabilities, or reduce sample rate.

Following are two sample acquisition error messages (the verbosity is from the manufacturer, not SIGNAL!):



Portability to All National Instruments Analog I/O Cards

SIGNAL operates with all National Instruments analog I/O cards. SIGNAL automatically makes the installed card's capabilities available, including maximum sample rate and programmable input gain.

Multiple Installed NI I/O Cards

If you have multiple NI I/O cards installed in your computer, the Measurement & Automation Explorer program (MAX) will name them by default "Dev1", "Dev2", etc. Device names are retained when an I/O card is removed from the computer. To rename devices, R-click on the device name in MAX and select Rename.

Wave-Compatible Sound Card

I/O Board Not Present or Disabled

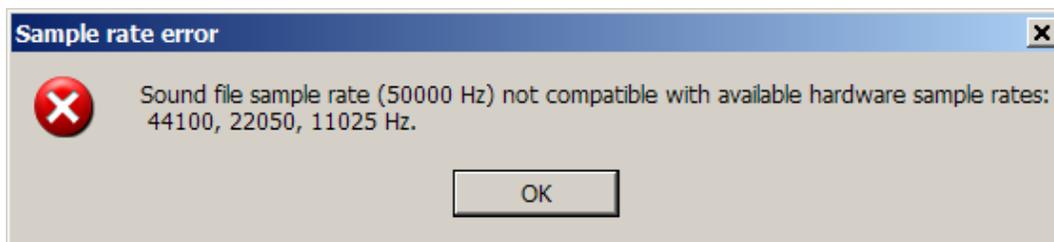
Removable I/O devices, such as PCMCIA cards and USB units, **may need to be removed and reinserted after the system is restored from Standby**, even when Device Manager reports the device as installed and "working properly". If the I/O device is removable, power off and on again (if appropriate), then remove and reinsert it. If the error persists, reboot the computer. If the error still persists, uninstall and reinstall the system driver and board driver for the I/O device.

Multiple Sound Card Devices

If your computer has multiple "sound card" devices (such as a built-in sound chip and external USB sound card unit), SIGNAL will present all devices in the I/O configuration manager (I/O | Configure).

Sample Rate Compatibility

SIGNAL will only play sound files recorded at sample rates compatible with the installed sound card hardware, typically 44100, 22050, and 11025 Hz. SIGNAL will notify the user of sample rate compatibility and abort the playback. Sound files with non-compatible sample rates can be mathematically resampled in SIGNAL.



I/O Errors

Acquisition and playback errors can arise if the I/O process cannot store or retrieve data from the hard disk at the requested sample rate. This can happen when other demanding processes are performed while SIGNAL is running, but this should be rare. The best remedy is to terminate other processes.

7. TECHNICAL NOTES

This chapter presents technical hardware notes, organized by manufacturer.

Dart I/O Card

Technical Specifications for SIGNAL with Dart Analog I/O Card

Following are technical specifications for SIGNAL operating with the 50 kHz Dart PCMCIA analog I/O card. Three sample rate options are available – the standard maximum sample rate of 50 kHz, and optional maximum sample rates of 44.1 kHz and 48 kHz. The upper frequency limit in "Signal bandwidth" applies to a 50 kHz card, and should be scaled accordingly for 44.1 kHz and 48 kHz cards.

Input characteristics

Maximum channels	2
Signal bandwidth	20 Hz - 23 kHz, ± 1.5 dB
Low frequency response	-4 dB at 8 Hz -8 dB at 4 Hz -20 dB at 1 Hz
Programmable gain	0 – 22.5 dB in 1.5 dB steps
Full-scale input level	1.4 Volts typical, 1.5 Volts max
Absolute gain accuracy	± 1.0 dB
Impedance	20 K ohms
DC offset (typical)	3 mV
Noise (re max signal level)	-81 dB
THD	< -90 dB

Output characteristics

Maximum channels	2
Signal bandwidth	5 Hz - 22 kHz, ± 1.5 dB
Full-scale output level	1.4 Volts typical, 1.55 Volts max

Absolute gain accuracy	± 1.0 dB
Impedance	n/s
DC offset (typical)	3 mV
Noise (re max signal level)	n/s
THD	-80 dB

Input/output characteristics

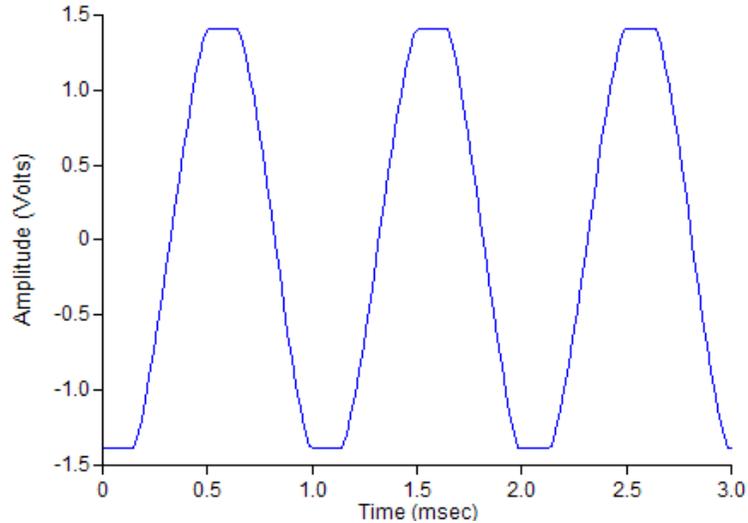
No. sample rates	8
Available sample rates	
7350, 8820, 11025, 14700, 17640, 22050, 29400, 44100 Hz	[44.1 kHz]
8000, 9600, 12000, 16000, 19200, 24000, 32000, 48000 Hz	[48 kHz]
8333, 10000, 12500, 16667, 20000, 25000, 33333, 50000 Hz	[50 kHz]
Absolute (damaging) signal level	± 2.5 Volts
Maximum signal length	Limited by physical disk size
Digitizing resolution	16-bit = 96 dB
Converter type	Delta-sigma 64X
Anti-alias filter	Built-in tracking

n/a = not applicable, n/s = not specified

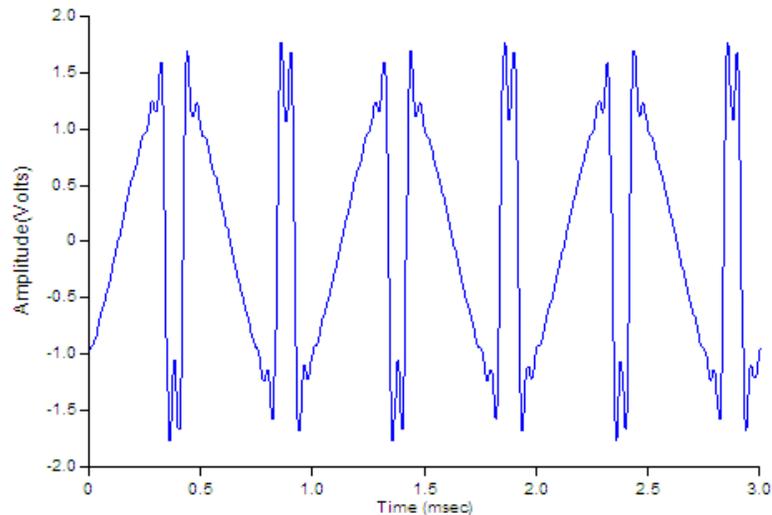
Maximum Input and Output Levels

Full-scale input level is the input voltage which drives the card to its maximum digital value (e.g., 0x7FFF hexadecimal for a positive voltage to a 16-bit card). Conversely, the **full-scale output level** is the output voltage produced when the card processes its maximum digital value. "Technical Specifications" specifies full-scale levels for the Dart.

During acquisition, input voltages beyond the full-scale input level will be truncated or "clipped" by the card. For example, the figure shows a 1.6 Volt peak signal, as digitized by a Dart card with a full-scale input level of 1.4 Volts. All digitized voltages are truncated at ± 1.4 Volts.



During playback, signals beyond the full-scale output level drive the card into a more disastrous form of overload, in which voltages are reflected about the voltage limits. The figure shows the effect of a small overload, in which a 1.6-Volt signal is played through a Dart card with a full-scale output level of 1.55 Volts.



Full-scale input and output levels vary somewhat between individual Dart cards. To avoid accidental overload, SIGNAL assumes the same minimum full-scale level for all cards. Card variation produces input and output gain errors of < 1 dB. If this error is not significant or you are not concerned with absolute sound levels, you can skip the remainder of this discussion.

For example, a Dart card with a nominal full-scale input level of 1.4 Volts and an actual full-scale level of 1.5 Volts will produce a digitized signal whose amplitude is $1.4/1.5 = 93\%$ of the true input level. Thus a 1-Volt peak input signal will be digitized (and displayed in SIGNAL) with a peak level of 0.93 Volts.

Similarly, a Dart card with a nominal full-scale output level of 1.4 Volts and an actual full-scale level of 1.5 Volts will deliver analog output signals whose amplitude is $1.5/1.4 = 107\%$ of their nominal output level. Thus a 1-Volt peak signal (created for example in SIGNAL) would be delivered with a peak level of 1.07 Volts.

Absolute Gain Accuracy

Absolute input gain accuracy expresses the deviation in dB between the digital amplitude level reported by the Dart card and the analog input level presented to the card for digitizing. Similarly, output gain accuracy represents the deviation between the digital signal level presented for playback and the analog output level delivered by the card.

Gain accuracy depends on the manufacturing process and therefore varies slightly between units. Gain accuracy is another way of expressing the variation in full-scale input and output levels discussed in "Maximum Input and Output Levels" above. Dart cards have a specified input and output gain accuracy of ± 1.0 dB. Dart cards are currently shipped with an input gain calibration factor, which can be used to adjust acquired levels when highly accurate absolute input levels are required.

Low-Noise Operation

Low-noise operation is important when acquiring low-level signals. The essential concept is **signal-to-noise ratio** (S/N or SNR), which is the dB ratio of the input signal to the **effective input noise** (EIN) of the Dart card. S/N should be maximized. When a signal's S/N falls below 50-60 dB (depending on source material), the noise component becomes audible to most human subjects.

EIN mathematically expresses the aggregate noise contribution of all internal noise sources, referred to the device input. S/N is the ratio of input signal level to EIN. The principal Dart noise sources are 1) input noise of the programmable gain amplifier and 2) effective noise of the digitizer. Amplifier noise is about 12 μ V-RMS or -98 dB re full-scale (1.4 Volts peak). Digitizer noise is about 2 bits, which translates to -84 dB re full-scale or 60 μ V-RMS. Therefore at 0 dB programmable input gain, EIN will be dominated by digitizer noise, while at gains > 20 dB, EIN will be dominated by amplifier noise. So EIN decreases as programmable gain increases, and **for optimal low-noise operation, use the maximum input gain possible** without saturating (clipping) the input signal.

Following are typical EIN values, measured at 0 dB and 19.5 dB programmable gain. EIN re full-scale represents the card's maximum S/N capability at that gain setting. Nominal full-scale voltage for the Dart is ± 1.4 Volts.

	Gain = 0 dB	Gain = 19.5 dB
EIN (μ Volts-RMS)	60 μ V	12 μ V
EIN (dB re full scale)	-84 dB	-98 dB

Data Translation

Technical Specifications for SIGNAL with DT3010 and DT3016

Following are technical specifications for SIGNAL operating with the DT3010 and DT3016 analog I/O cards.

	<u>DT3010</u>	<u>DT3016</u>
<u>Input characteristics</u>		
Maximum channels	8	8
Minimum sample rate	100 Hz	100 Hz
Maximum sample rate	1250 kHz	250 kHz
Programmable gain	1, 2, 4, 8	1, 2, 4, 8
Impedance	100 M-ohm	100 M-ohm
Noise (re max signal)	n/s	n/s
THD	-71 dB	n/s
<u>Output characteristics</u>		
Maximum channels	2	2
Minimum sample rate	100 Hz	100 Hz
Maximum sample rate	500 kHz	200 kHz
Impedance	n/s	n/s
Noise (re max signal)	n/s	n/s
THD	n/s	n/s
<u>Input/output characteristics</u>		
No. sample rates	> 1000	> 1000
Maximum signal level	± 10 Volts	± 10 Volts
Maximum signal length	Limited by physical disk size	
Digitizing resolution	12-bit = 72 dB	16-bit = 96 dB
Converter type	Linear	Linear
Anti-alias filter	Not included	Not included

n/a = not applicable, n/s = not specified

National Instruments

Technical Specifications for SIGNAL with DAQCard-6062E

Following are technical specifications for SIGNAL operating with the DAQCard-6062E analog I/O card.

Input characteristics

Maximum channels	8
Minimum sample rate	100 Hz
Maximum sample rate	500 kHz
Programmable gain	1, 2, 5, 10, 20, 50, 100
Impedance	100 G-ohm in parallel with 100 pF
Noise (re max signal level)	n/s
THD	n/s

Output characteristics

Maximum channels	2
Minimum sample rate	100 Hz
Maximum sample rate	500 kHz
Impedance	< 0.1 ohm
Noise (re max signal level)	n/s
THD	n/s

Input/output characteristics

No. sample rates	> 1000
Maximum signal level	± 10 Volts
Maximum signal length	Limited by physical disk size
Digitizing resolution	12-bit = 72 dB
Converter type	Linear
Anti-alias filter	Not included
Triggering	Software / external TTL
Trigger latency	< 1 microsec
Synchronization	TTL
Synchronization accuracy	< 1 microsec [w/ special I/O panel]

n/a = not applicable, n/s = not specified

Bandwidth Limitations of PCI-6251

This section discusses the acquisition bandwidth (BW) of the PCI-6251 and the conditions under which that BW can be extended in practice. The NI-specified BW of the 6251 is 1.25 MHz single channel and 1.0 MHz multi-channel.

Acquisition Settling Time

The acquisition BW of a digitizing board is limited by the **settling time** of its input amplifier, which is the time required for the amplifier to register the voltage change between successive input samples to a certain accuracy. Because there is only one input amplifier, successive samples may come from a single channel or consecutive channels in multi-channel mode. If the input signal is $V(t) = A \sin 2\pi ft$, then voltage change is $dV/dt = 2\pi fA \cos 2\pi ft$, whose maximum = $2\pi fA$ Volts/sec. So instantaneous voltage change depends on the product of input amplitude (A) and frequency (f) and will be greatest for a full-scale input signal of maximum (Nyquist) frequency.

Under these worst-case conditions, and for input gains between 1 and 10, NI-specified settling time is 1 usec to 12 bit accuracy and 1.5 usec to 16 bit accuracy. Thus at unity gain (10 Volt range), a 10-Volt input signal at Nyquist frequency requires 1.5 usec to settle to 16-bit accuracy. Smaller signals require less time to settle; for example, a 0.5-Volt input signal acquired at unity gain has only 12 bits to settle and requires closer to 1 usec for a 50% greater BW. NI-specified maximum "small-signal" BW is 1.7 MHz, a settling time of 0.6 usec.

Acquisition Crosstalk

Settling affects multi-channel operation via the voltage difference between successive channels. As total channel BW approaches the board's BW capability, the input amplifier does not have time to settle between successive channel samples, and carries the value from one channel into the next. This artifact is called **crosstalk** and is defined as the ratio of amplitude induced in one channel by a signal in another. Crosstalk is measured by shorting the target channel input, applying a full-scale signal to the previous channel, and measuring leakage into the target channel. NI specifies worst-case crosstalk as -75 dB, but measured performance exceeds that.

The following table summarizes measured crosstalk vs. total bandwidth = (sample rate) * (no. channels), and can be used to limit board operation according to desired accuracy. Measurements were made with 8-channel operation.

<u>Crosstalk level</u>	<u>Bandwidth</u>
-87 dB	1.00 MHz
-65 dB	1.33 MHz
-47 dB	1.43 MHz
-20 dB	1.54 MHz

For example, if the board is operated at 1.33 MHz (e.g., 8 channels at 167 kHz sample rate), crosstalk will be -65 dB, limiting accuracy to about 11 bits, which is acceptable for many biological applications, while at 1.43 MHz (8 channels at 178 kHz), crosstalk is -47 dB.

Wave-Compatible Sound Card

Technical Specifications for SIGNAL with Wave I/O Card

Following are technical specifications for SIGNAL operating with a Sound Blaster SB16-PCI sound card (an older sound card) and an Audigy 2 NX external USB sound card unit (2004).

	SB16-PCI	Audigy 2 NX
Max input channels	2	2
Max output channels	2	2
Digital resolution	16-bit = 96 dB	16-bit = 96 dB
Max signal level	± 100-150 mVolts (approx)	± 3.5 Volts
Programmable input gain	none	none
Sample rates	11.025, 22.05, 44.1 kHz	11.025, 22.05, 44.1 kHz
Max signal length	Limited by physical disk size	Limited by physical disk size
Input signal bandwidth	20 Hz - 20 kHz (approx)	20 - 20 kHz (± 0.5 dB)
Output signal bandwidth	20 Hz - 20 kHz (approx)	5 Hz – 17.5 kHz (± 0.5 dB)
Anti-alias filter	Internal	Internal

Recording

This section discusses recording with sound card devices. Because these devices vary significantly in technical capabilities, limitations, and quality, this discussion may not apply entirely to your device.

Input signals should be connected to the Line In connector, or if quite low level, to the Microphone input.

Setting record level involves ensuring that the input signal is not too low (which reduces the signal-to-noise of the recording) nor too high (which "clips" or distorts the digitized signal).

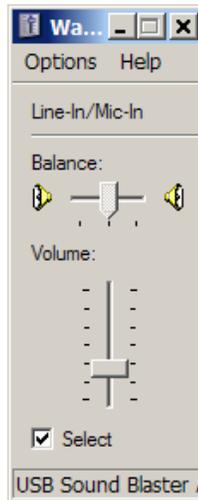
If your input signal is too low for the Line In input (peak levels < 10 mVolts), either amplify it externally or present it to the Mic In connector. Line In circuits on sound cards rarely have programmable gain, unlike A/D boards.

Overloading the input circuit is a common error with sound card recording. This "clips" the input signal (flattening the tops and bottoms of sine waves), which adds significant harmonic distortion. The nominal overload limit for current sound cards (2002 and later) is approximately 3.0 Volts. Older sound cards can clip at much lower levels, such as 150 mV on the SB PCI-16.

It is **strongly recommended** that you determine the clipping level of your sound card in Volts for a particular setting of the Volume Control slider (see below). This requires a

calibrated sine wave source, such as a function generator. Do this once for the sound card, then maintain input levels accordingly. **Digitized signals should always be examined carefully for signs of clipping.**

The Windows **Volume Control (VC) must be configured before recording.** To launch the VC, select Start | Programs | Accessories | Entertainment | Volume Control (Windows XP). A desktop shortcut is recommended for convenience. Select your input device, such as Line In (failing to do this will disable the device!). Set the VC slider. The following position is "unity gain" on many current sound cards, meaning that a 1-Volt signal at the Line In connector will be digitized and then displayed as 1 Volt in SIGNAL (± 0.5 dB). However, the best setting depends on your signal level and the card's overload limit. If your signal is low level, raise the slider to increase digital gain. The SB Extigy for example provides 12 dB of gain between the "unity gain" position shown and the max slider position.



If you are using an external sound card unit, the chassis may have a microphone control which also affects the input level.

Sound card devices normally contain input anti-alias filters which track the sample rate.

Playback

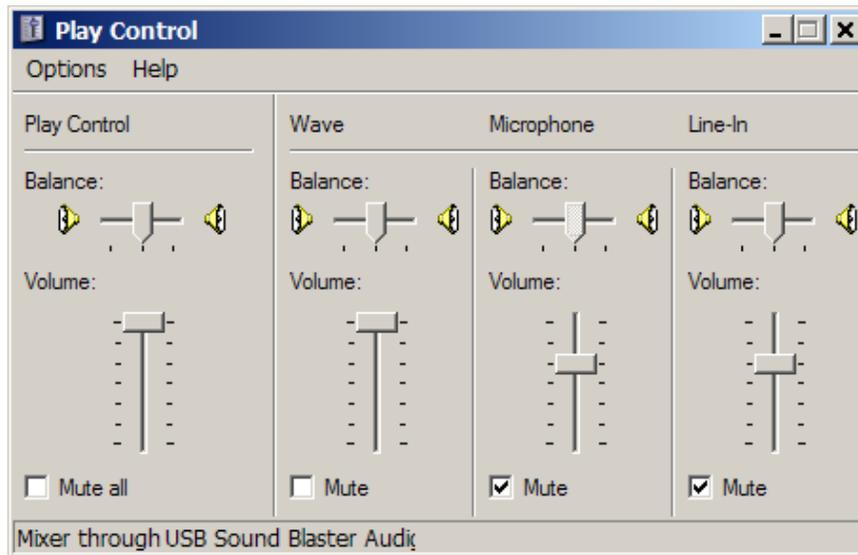
This section discusses playback with sound card devices. Because these devices vary significantly in technical capabilities, limitations, and quality, this discussion may not apply entirely to your device.

Output signals should be connected to the Line Out connector on your sound card or the Headphone connector if Line Out is not included.

Playback level is less critical than recording level with respect to distortion. Because the output level control operations as an attenuator rather than amplifier, if the digital sound file is not distorted, the output signal will not be distorted either.

The Windows **Volume Control (VC) must be configured before playback.** Launch the VC as described above. Select Play Control and Wave devices by **deselecting** the Mute box. Then mute Line In and Microphone (if present) by **selecting** the Mute box, otherwise input signals accidentally connected to these inputs will be mixed with the sound file playback.

Normally, the Play Control and Wave sliders should be set to maximum position (no attenuation), as shown in the figure. At this position, the output level from a digitized 1-Volt signal should be close to 1 Volts, but this depends on the sound card.



If you are using the headphone output on an external sound card unit, the chassis may have a headphone volume control which also affects the output level. This control may be synchronized to the on-screen Play Control slider.

Sound card devices normally contain output anti-alias filters which track the sample rate.

Note that when a one-channel sound file is played through some sound cards, the **output signal is automatically directed to both output channels**. To avoid output on the second channel, either disconnect that channel or play a two-channel file containing silence on the desired channel.