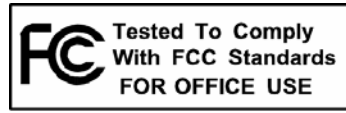


<sup>TM</sup>  
**INDIGO 10x**

<sup>TM</sup>  
**INDIGO DJx**

# Owner's Manual Version 1.0 for Windows XP and Vista



## Important Safety Instructions



**WARNING:** *Listening to audio at high volumes over headphones can cause hearing damage. Please be careful to limit the volume level of your Indigo ExpressCard while listening through headphones.*

1. **Read Instructions** — Be sure to read all of the safety and operating instructions before operating this product.
2. **Retain Instructions** — The safety instructions and owner's manual should be retained for future reference.
3. **Heed Warnings** — All warnings on your Echo product and in the Owner's Manual should be followed.
4. **Follow Instructions** — All operating and use instructions should be followed.
5. **Moisture** — Water and moisture are detrimental to the continued good health of your Echo product. Do not install or operate your Echo product near sources of water or moisture such as sinks, damp basements, leaky roofs, etc.
6. **Heat** — Your Echo product should be situated away from sources of heat such as heaters or radiators.
7. **Servicing** — Do not attempt to service this unit yourself, as opening the case will damage your Indigo ExpressCard and void your warranty. All servicing should be referred to qualified service personnel.
8. **Damage Requiring Service** — Undock this unit and refer it to a qualified service technician when any of the following occur:
  - a) Objects have fallen or liquid has spilled into the unit
  - b) The product has been exposed to rain or water
  - c) The product stops operating normally
  - d) The product has been dropped or damaged in any way

Registering your product online at <http://www.echoaudio.com/support/register.php> allows us to register key information so that we may handle problems faster and inform you of advance information on upgrades and other news. Thank you in advance for registering. We hope you enjoy your Echo product.

## Limited Warranty

Echo Digital Audio Corporation warrants this product, when purchased at an Authorized Echo Dealer in the United States of America or directly from Echo, to be free of defects in materials and manufacturing workmanship for a period of one year from the date of original purchase. During the warranty period Echo shall, at its option, either repair or replace any product that proves to be defective upon inspection by Echo. Final determination of warranty coverage lies solely with Echo. Echo reserves the right to update any unit returned for repair, and reserves the right to change or improve the design of the product at any time without notice.

This is your sole warranty. Echo does not authorize any third party, including any dealer or sales representative, to assume any liability on behalf of Echo or to make any warranty for Echo.

Service and repairs of Echo products are to be performed only at the factory (see below) unless otherwise authorized in advance by the Echo Service Department. Unauthorized service, repair or modification will void this warranty.

### **To obtain factory service:**

Contact Echo Digital Audio Corporation at (805) 684-4593, 9AM to 4PM Monday through Friday (Pacific Time). If necessary, you will be given a return authorization number. Products returned without an RA number will be refused. Echo may, at its option, require proof of the original date of purchase in the form of a dated copy of the original authorized dealer's invoice or sales receipt. Pack the product in its original shipping carton and attach a description of the problem along with your name and a phone number where Echo can contact you if necessary. Ship the product insured and freight prepaid to:

**Echo Digital Audio Corporation  
6450 Via Real  
Carpinteria, CA 93013**

## **DISCLAIMER AND LIMITATION OF WARRANTY**

Echo makes no other warranties, express, implied, or otherwise, regarding Echo products, and specifically disclaims any warranty for merchantability or fitness for a particular purpose. The exclusion of implied warranties is not permitted in some states and the exclusions specified herein may not apply to you. This warranty provides you with specific legal rights. There may be other rights that you have which vary from state to state.

In no event will Echo be liable for any lost profits, or for any consequential, direct or indirect damages, however caused and on any theory of liability, arising from this warranty and sale.

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Carpinteria, CA 93013

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## Introduction

Thank you for choosing Echo Digital Audio. We think you'll find your Echo Indigo ExpressCard to be an extremely flexible, high-performance audio tool for your notebook.

## Box Contents

When you opened the box, you should have found the following:

- An Indigo IOx or Indigo DJx ExpressCard
- A mini CD-ROM containing:
  - Windows XP and Vista drivers (including a PDF User's Guide)
- Quick Start guide
- A six foot audio connection cable
- Spacer for 54 mm ExpressCard slots. (This should only be used if your IOx or DJx does not fit firmly into your notebook's ExpressCard slot.)

## System Requirements

In order to enjoy your Indigo ExpressCard on a Windows-based notebook, you'll need the following:

- A notebook computer running Windows XP or Vista (32-bit or 64-bit) with a 34 mm or 54 mm ExpressCard slot
- A minimum 128Mb of RAM (256Mb highly recommended)
- Peripheral audio equipment such as headphones, studio monitors, microphones, musical instruments, etc.

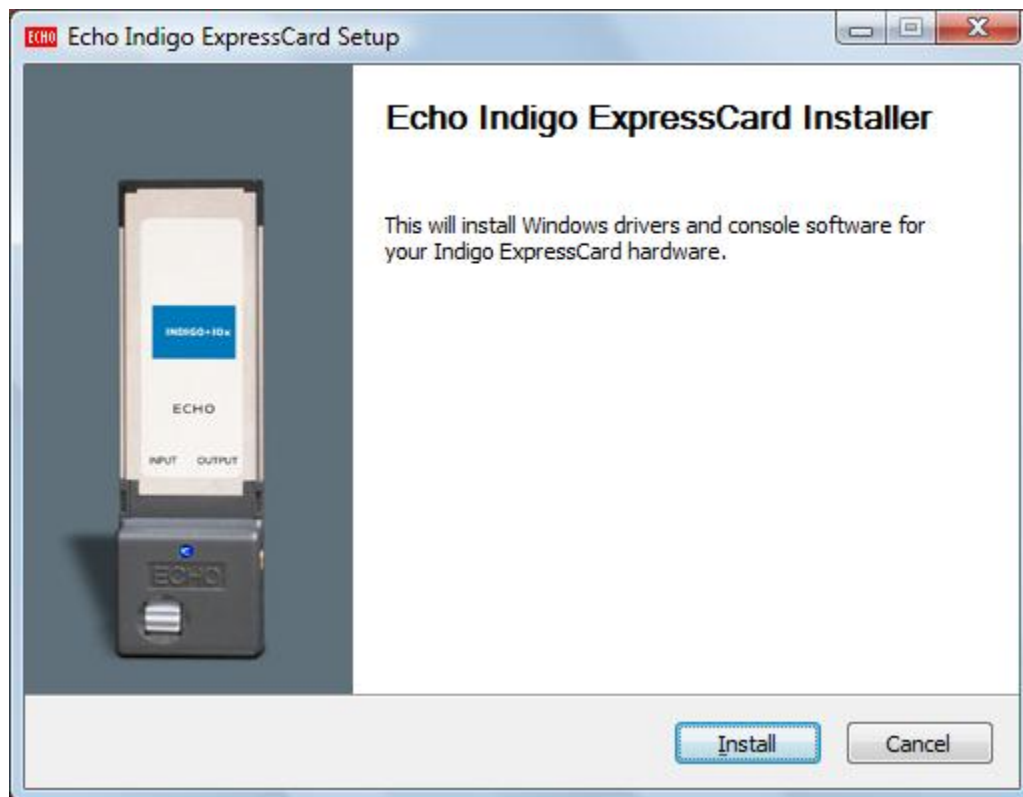
# Installation

Complete installation consists of installing the Windows driver onto your system, installing the ExpressCard and, if necessary, installing professional audio software.

## *Driver Installation for Windows XP and Vista*

Before you can use your Indigo ExpressCard in your notebook computer, you will need to install the driver.

To install the driver, just insert the Echo Indigo ExpressCard CD-ROM into your notebook. The Main Install Window should automatically appear. If it does not, go to My Computer and double-click on your CD-Rom drive. Now, select “Setup” and follow the on-screen directions.



## *Driver Versions and Windows Support*

Driver 7.5 and higher supports the following versions of Windows:

- Windows XP
- Windows XP Professional x64 Edition
- Windows Server 2003
- Windows Server 2003 x64 Edition
- Windows Vista
- Windows Vista 64-bit Edition

Driver 8.3 (for WaveRT) and higher supports the following versions of Windows:

- Windows Vista
- Windows Vista 64-bit Edition

All Echo drivers and driver updates can be found at:

[www.echoaudio.com/Downloads/Drivers.php](http://www.echoaudio.com/Downloads/Drivers.php)

Or on our archived driver page:

[www.echoaudio.com/Downloads/Archived\\_Drivers.php](http://www.echoaudio.com/Downloads/Archived_Drivers.php).

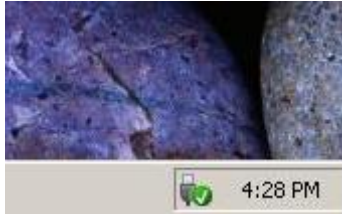
## *Hardware Installation*

Once the driver is installed, turn off your computer. Insert your Indigo ExpressCard into your notebook. Simply insert the card into any available ExpressCard slot. It will work in either the 34 mm or 54 mm ExpressCard slot. If you find your Indigo ExpressCard is loose in the 54 mm slot, you may use the enclosed spacer. Now turn your computer on.

Windows should detect that you have installed new hardware. In Windows XP, when the “Found New Hardware Wizard” dialogue box appears, click on “No, not this time.” Then “Install the software automatically.” For Windows XP, you will need to confirm that you want to install the driver. To do this click on “Continue Anyway.”

In Windows Vista, the hardware is recognized and installed silently.

Once the hardware is installed, a small “Safely Remove Hardware” icon will appear in the system “tray” (usually on the lower right-hand side of the screen). This icon looks slightly different in Windows XP. In addition, the blue power indicator on your Indigo ExpressCard will light up.



The “Safely Remove Hardware” icon

***If you want to remove the card with your computer turned on, the card must first be disabled.*** To do this, double-click on the “Safely Remove Hardware” icon in the tray. Select “Stop” from the dialogue box and then “OK” to confirm. You will get a message when it is safe to remove it. Failure to disable the card before removing it could potentially damage the card or the computer.

You should have received a 6-foot cable with RCA and 1/4" connectors with your Indigo ExpressCard. Now would be a good time to use this cable to connect your Indigo ExpressCard to your other audio gear. If you have an Indigo DJx you can also connect a set of headphones if you like. The inputs and outputs are clearly marked on the face of your Indigo ExpressCard.

## *Windows Default Audio Playback Device*

Your Indigo ExpressCard will automatically be set up as the default audio playback device in Windows XP. To confirm or change this, you need to access the “Sounds and Audio Devices” control panel. The following examples are for the Echo Indigo IOx, but apply to the Indigo DJx as well.

Simply select “Start/Control Panel” and open the “Sounds and Audio Devices” control panel. Then, select the “Audio” tab. If you just installed the hardware, you should see “Indigo IOx 1-2 Virtual Out” as the default playback device:



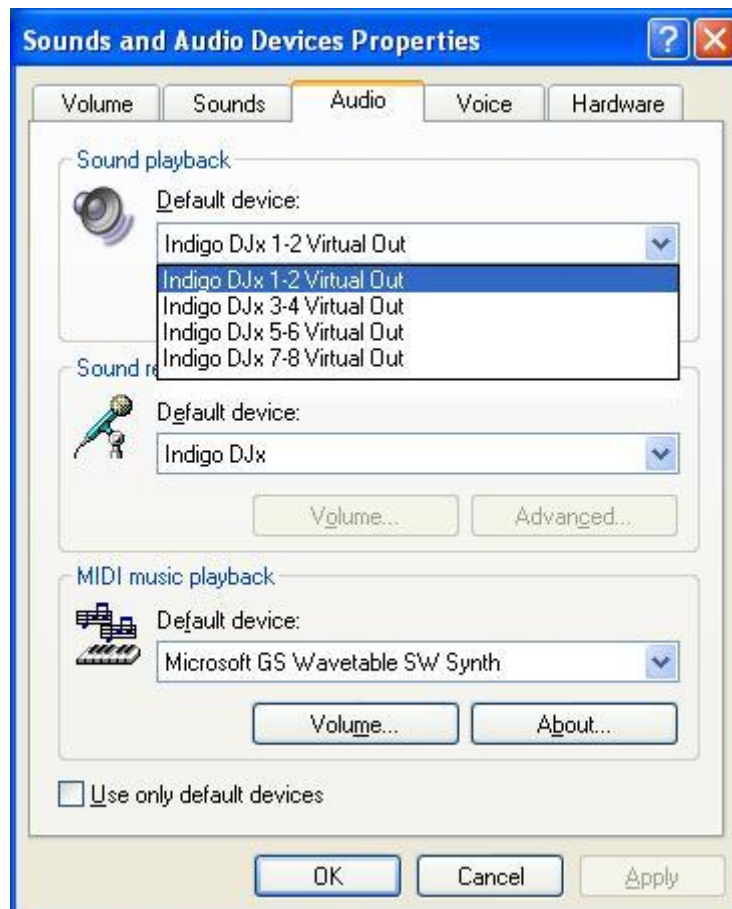
If you aren't hearing any audio out of your Indigo ExpressCard, you can use this control panel to make sure that your Indigo ExpressCard is selected as your default playback device.

In Windows Vista, this dialogue box has changed. It is now simply labeled “Sound” and can be accessed from the control panel. The default sound device has a green check mark next to it. To change this, right-click on the desired default output and choose “Set as Default Device.” Virtual outputs 1-2 are set as the default device for an Indigo DJx in the illustration below:



## Professional Audio Software

To audio software, the Indigo ExpressCard appears as a group of stereo wave devices. You can view the list of these devices either from within your audio software or from the Windows control panel.



You'll find these same input and output options available when using your audio recording/editing software with the devices assignable on a per-track basis. See your software owner's manual for details on how to make these device assignments.

**NOTE: Some audio software applications require an input device, so we have provided a “dummy” input the Indigo DJx. You will not be able to record with the Indigo DJx. If you do try to record from the dummy input, you will record silence.**

This completes the hardware and software installation for your Indigo ExpressCard.

## Virtual Outputs

Most audio cards with a pair of analog outputs will appear to software as having just that, a single pair of outputs. When one application appropriates the card for its use, all other software is “locked-out” from using the card at the same time.

Quite often, musicians find it useful to play back from multiple applications simultaneously. A good example would be playing back digital audio while at the same time using a software synthesizer for MIDI. Another example would be using multi-track editing software. Before multiple tracks can be played back on a stereo device, they must be mixed down within the software to the two output tracks. This takes up extra CPU cycles that might otherwise be dedicated to software effects or some other task.

Your Indigo ExpressCard gets around this by combining the use of “virtual” outputs with its “multi-client” drivers. Indigo IOx and Indigo DJx appear to software as if they have eight separate outputs. These are mixed together with the on-board DSP to produce the actual or “physical” outputs that connect to external equipment without any CPU intervention. Any virtual output can be sent to any actual output along with any combination of other virtual outputs. The levels and routing of the virtual outputs are fully controllable with the Console, which is described later in this manual.

An example of this would be using Tascam’s GigaStudio with Cakewalk’s SONAR. GigaStudio could be set up to play back through the Indigo ExpressCard’s outputs 7 & 8. SONAR, which combines MIDI sequencing with digital playback, could then play back its MIDI output through GigaStudio while using the Indigo ExpressCard’s outputs 1 through 6 for six separate tracks of digital output.

This gives your Indigo ExpressCard most of the advantages of products with eight separate analog outputs, without the added expense of the extra converters or having to use an external mixer to mix the outputs down to a final pair of stereo outputs.

## Console4

A “virtual control surface” application called Console4 is included with the Indigo ExpressCard driver. The Console allows you to control the audio playback functions of your Echo Indigo ExpressCard, and it brings these controls to a single easy-to-use location.

If you’re curious, the name “Console4” means that this is Echo’s fourth-generation design for a software console.

### *Running the Console*

Once you have run the installer, you will find a shortcut on your desktop for the Echo Console. Double-click on this to launch. Alternatively, you can find the console under your Start menu under the group “Echo Digital Audio.”

### *The System Tray Icon*

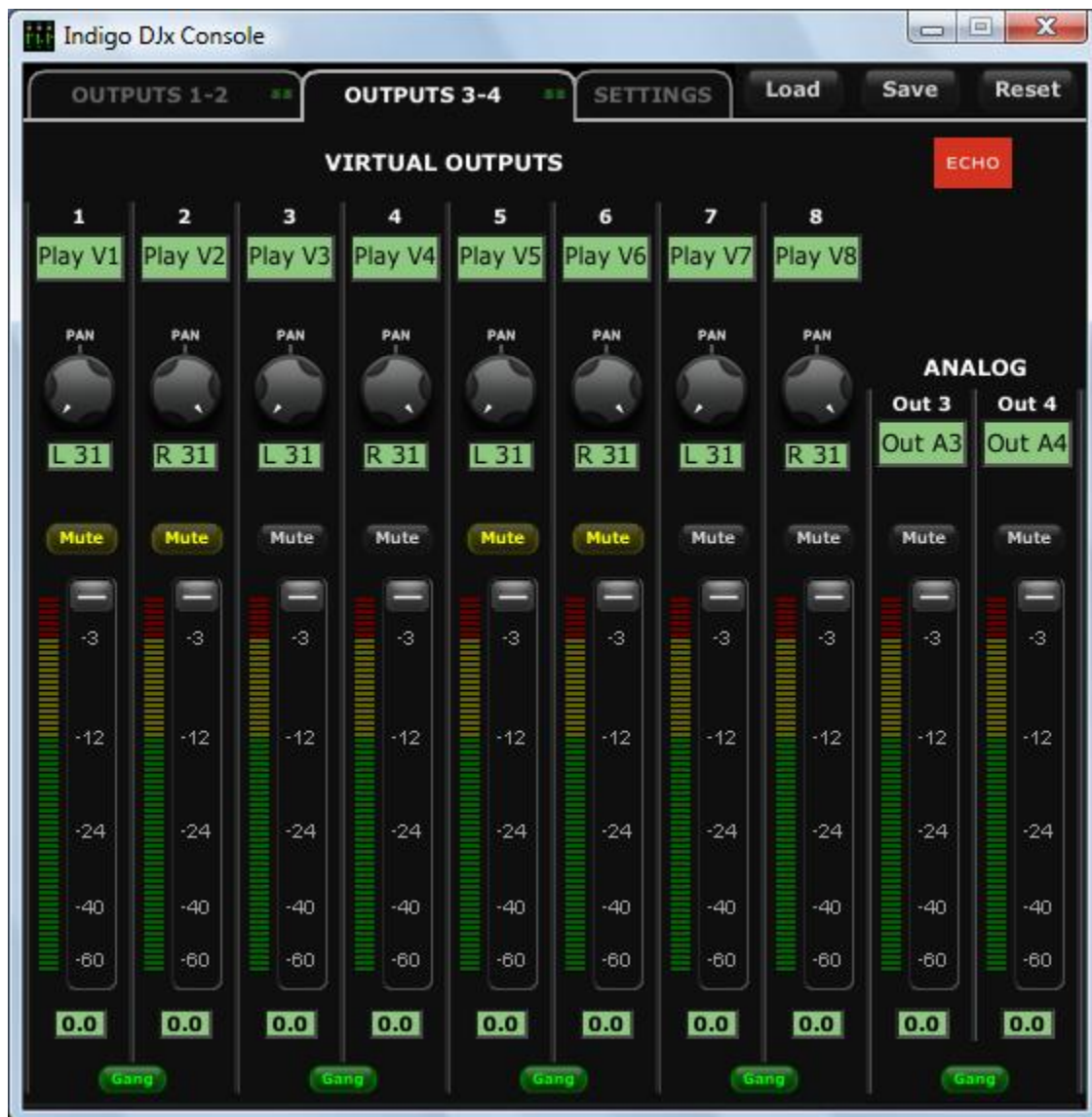
When you open the console, you will see an icon added to the system tray (see figure below). Clicking the left mouse button on the tray icon will bring the console window to the foreground if it is minimized. If you are running more than one Echo product, it will bring all the console windows to the foreground.

Clicking the right mouse button on the tray icon will display a pop-up menu that will let you select individual console windows, show or hide all of the console windows, or arrange the console windows in the middle of your monitor.



## Console Window

The basic metaphor for the console interface is a digital mixing board, and it works in terms of **output busses**. An output bus is a stereo pair of outputs on your hardware. For example, analog outputs 1 and 2 are an output bus. The console window allows you to control what is mixed and sent to that output bus. With the Indigo IOx you will also be able to control input monitoring.



## *Bus Select (Indigo DJx Only)*

To select an output bus, click on either the “Outputs 1-2” tab or the “Outputs 3-4” tab at the top of the Console. (See figure above.) Clicking on an output bus tab simply selects the settings that are displayed. In the figure above “Outputs 3-4” is the active bus. This means all parameters such as volume, pan, and mute apply to the audio coming out Analog Outputs 3 and 4 of your Indigo DJx.

## *Master Output Bus Control*

The master bus control is the area on the right side of the Console. The figure above shows the Indigo DJx Console. The Master Output bus is labeled “Analog: Out 3 – Out 4.” This indicates you are currently controlling everything mixed to analog outputs 3 and 4. The Indigo IOx only has controls for Analog Outputs 1 and 2.

The *mute buttons* and *faders* affect everything being mixed to this bus. Holding down the Ctrl key and clicking on a fader will set that fader to 0 dB, and clicking on the readout below the fader will allow you to enter a numerical value for the fader setting. You can also select or deselect all the mute buttons by Ctrl-clicking on one of them.

The *gang button*, below the fader readout, sets the gang mode. If you are in gang mode, the mute buttons will work together for the left and right channels; for example, clicking the mute on one channel activates the mute button on the other channel. In addition, ganging ties the faders together so they will maintain their relative placement with regard to each other.

## Analog Inputs (Indigo IOx Only) and Virtual Outputs

The controls for the analog inputs are on the left side of the Console and are labeled “Analog: In A1 – In A2”. There is one strip, or *input monitor*, corresponding to each of Indigo IOx’s two physical analog inputs. The controls for the virtual outputs are in the middle of the Console and are labeled “Virtual Outputs: Play V1 – V2,” etc. The green labels below each numbered input and output can be edited to your liking and saved in a console session (see discussion below.)



At the top of the analog inputs are two pan knobs that pan the input channel between the two channels of the output bus. Holding down the Ctrl key and clicking on a pan slider will set the knob to the center position. Note that this does not affect your recording. Below the pan knob is the monitor mute. This controls whether or not you want this input channel to be mixed directly out to the currently selected output bus. Again, this does not affect recording. However, if you leave the mutes off and your software is capable of direct monitoring, you are likely to hear a phasing effect in your main outputs. This phasing effect is not recorded either. This is followed by the monitor fader, which controls the input monitor level. Like the pan and mute controls, this does not affect your record level. Also, clicking on the readout below the fader will allow you to numerically enter a fader setting.

The analog inputs also have gang buttons, and their operation is the same as the gang button for the master outputs except that when the gang button is engaged, the pan knobs will mirror each other when turned.

The virtual outputs are used to control the level of audio being played by an application. The Indigo ExpressCard Console has multiple playback strips – one for each virtual output. Each playback strip allows you to pan, mute and change the level of the audio signal that is being sent to your Indigo ExpressCard’s physical outputs. The controls operate in the same way as the analog input controls described above. Each virtual output can be mixed in any combination to your Indigo ExpressCard’s analog outputs.

### *Adjusting Playback Volume*

Output volume adjustments are made in the digital domain. When you lower a volume fader below 0dB, you are actually decreasing the number of available bits, thereby taking away from the potential dynamic range of the system. Therefore, we suggest that whenever possible you leave the output faders set to 0dB, and perform any necessary attenuation with the volume knob on your Indigo ExpressCard or with an external mixer. When the playback volume controls are set to 0dB and the input signal approaches the maximum pre-clipping level, you can achieve the full 24-bit dynamic range of the system.

## *Console Sessions*

The Indigo ExpressCard console supports saving and loading the state of the Indigo ExpressCard to a file, called a “session”.

Sessions are stored in your documents folder in a sub-folder named after the device. For example, Indigo IOx sessions are stored in a folder named “Indigo IOx sessions”.

To save or load a session, click on the “Load” or “Save” button at the top of the Console window. You can also use Ctrl-s to save or quick save (if you already have a session loaded) and Ctrl-o to load.

To restore the device to its default state, click the “Reset” button.

The “Gang” buttons, the “Core Audio sample rate” buttons, the “Locked” sample rate button (in Windows XP only), the “Sync wave devices” button and “GSIF buffer size” do not reset.

The “Locked” sample rate button, the “Sync wave devices” button and “GSIF buffer size” do not save.

The console will remember the last folder used to save or load a session.

## Console Settings Tab

Clicking the Settings tab at the top of the Console gives you a dialog box for changing console settings. On the “Settings” tab, you will see four control groups: “Sample rate,” Core Audio sample rate,” “Sync wave devices” and “GSIF buffer size.”



## *Locking the Sample Rate in Windows XP*

Locking the sample rate can be very important, since Windows will frequently try to set the hardware to the highest supported sample rate. Then, Windows sample rate converts between that rate and the rate at which you are playing or recording. For instance, you may be trying to play at 44.1 kHz, but Windows sets the hardware to 96 kHz and converts between the two. This is undesirable because you may be trying to do a digital transfer at a specific rate. In addition, sample rate conversion will reduce your audio quality and consume a great deal of CPU power. Locking the sample rate forces Windows to only use the hardware at the locked rate. In general, we recommend you set the sample rate first in your audio application. Then, lock that same rate within the console. Locking the sample rate is not really necessary for applications that do not use the legacy wave/MME interface (such as SONAR, Cubase, etc.).

## *Core Audio Sample Rate in Windows Vista*

In Windows Vista, the Console displays the current sample rate in the “Sample rate” control group as set by your audio software. In the figure above, the sample rate readout is “48 kHz.”

You can also select the sample rate used by Vista Core Audio by clicking on one of the sample rate buttons in the “Core Audio sample rate” control group. You will see the buttons briefly turn red as Vista resets the sample rate. After you change the Core Audio Sample Rate, you may need to go into your Sound panel and reset your default audio device. The sample rate you have just set will not actually appear in the “Sample rate” control group until an audio application begins to play or record.

**Note: Setting the sample rate using the “Core Audio sample rate” control group does not affect ASIO.**

## *Core Audio*

Core Audio is the name for Windows Vista's new audio system.

You can set the sample rate and format used by Core Audio in Vista's Sound control panel. If you open the Sound control panel, you should see one or more playback and recording devices for your Echo hardware.

For Echo hardware, each of these playback and recording devices share a common physical audio clock – in other words, if you have your analog outputs set for 48 kHz, your digital or headphone outputs are also running at 48 kHz.

However, Core Audio does not recognize this configuration. Therefore, rather than setting the Core Audio sample rate from the Sound control panel, you should set the Core Audio sample rate from the Echo Console.

Be aware that setting the Core Audio sample rate from the Console will cause the current playback and recording devices to be removed and new ones created in their place; this ensures that the sample rate is consistent. The downside is that this will stop any applications that are currently playing or recording. We therefore recommend that you only change the Core Audio sample rate when you are not playing or recording.

If you set your audio software to play or record at a different format or sample rate than that specified for the Core Audio sample rate, Windows Vista will automatically perform format conversion.

Note that none of this applies to audio software that uses ASIO. Setting the Core Audio sample rate has no effect on the sample rates available to or used by ASIO.

## *ASIO and Windows Vista*

The ASIO driver now supports Windows Vista's multimedia thread scheduler (also known as MMCSS). The practical result of this is more reliable, lower latency performance.

The ASIO driver will automatically use the new scheduler. Should you wish to not use the new scheduler, you can disable it by opening the ASIO control panel for the driver. There you will see two new settings:

- Use Vista multimedia priority boost: If this box is checked, the ASIO driver will use the new scheduler.
- Lower Vista window manager primary: If this box is checked, the ASIO driver will instruct Vista to prioritize audio over drawing windows on the screen.

### *Synchronize Wave Devices*

This is mainly for developers who are using tools like Visual Basic or Delphi and want the inputs and outputs to be totally independent. Unless you have a good reason to turn it off, you should leave this switch on. Also, if you are running multiple applications on one card and you can't get it to work, try un-checking this box.

### *GSIF*

This window allows you to set the latency of GigaStudio in terms of samples. Select the value here that provides the best tradeoff between performance and reliability. These settings have no effect on any applications other than GigaStudio.

Note: GSIF is not currently supported in Windows XP Professional x64 Edition or Vista 64. Keep checking our homepage [www.echoaudio.com](http://www.echoaudio.com) for updates.

### *About*

This displays the console version and driver version numbers and a link to our homepage. You can copy the driver version information to your clipboard by clicking on "Copy to clipboard". You can then paste it into an e-mail if you need to communicate with our customer service.

## *Hot Keys*

There are a number of hot keys that can be used to control the console when it is the active window:

Ctrl-s saves or quick-saves the current session

Ctrl-o loads a session

Ctrl-click a fader to set to 0 dB

Ctrl-click a pan slider to set to center

Ctrl-click on a mute button to select all or deselect all

You can click on the numerical readout below each fader on the console and enter a value. Pressing the Tab key lets you step between each fader readout.

Left-click on the tray icon to restore Console(s) if minimized. Right-click on the tray icon for other options.

## Listening to Your Indigo ExpressCard

Your Indigo ExpressCard was designed for use with high-end headphones.

The **Indigo DJx** has two output jacks and provides four independent channels for playback. The volume knob sets the volume for the jack labeled “PHONES (1-2)”. It is located farthest from the volume knob. The line out jack, labeled “(3-4) LINE”, provides a line-level stereo output that is not affected by the volume knob. You can set the volume for the line out jack via the console.

For the **Indigo IOx**, the jack farthest from the volume knob is the stereo output. The volume for the output is set with the volume knob. The jack closest to the volume knob is the line-level stereo input, which is set to a fixed nominal gain of  $-10$  dB.

**Note: You will need to use a preamp to record mic level signals on the Indigo IOx input.**

The headphone output on your Indigo DJx or IOx can also be used as a line-level output; depending on what you connect to, you may need to adjust the volume knob to an appropriate level.

We hope that you enjoy your Echo Indigo ExpressCard!



***WARNING: Listening to audio at high volumes over headphones can cause hearing damage. Please be careful to limit the volume level of your Indigo ExpressCard while listening through headphones.***

## Registration

Registering your Indigo ExpressCard with Echo allows us to register key information so that we may handle problems faster and inform you of advance information on upgrades and other news. Thanks in advance for registering. We hope you enjoy your Echo product.

You can register via our web site - just go to:

<http://www.echoaudio.com/register.html>.

## Contacting Echo Customer Service

If you experience any trouble with your Echo hardware please go to the support area of our website at: [www.echoaudio.com](http://www.echoaudio.com), and check out the tutorials & troubleshooting FAQ's we have there. If you can't find a solution to your problem there, you may email technical support with your problem. Our technical support staff will respond to you as quickly as possible. The best way to get the help you need is by giving us plenty of detailed information about your computer system, your audio software and the problem you are having.

We do ask you to please read through this manual and the support area of our website before contacting us.

Thank you for buying an Echo product!

## **Appendix A: Multi-client Audio FAQ**

### **Q: What is “Multi-client audio”?**

Multi-client audio is a feature that lets you use different virtual outputs on your Indigo ExpressCard with different applications at the same time. This way you can use several different audio applications with just one Echo card. Otherwise, you would have to use a different audio device for each audio application.

For example, suppose you own both Steinberg’s Cubase (multitrack audio) and Native Instrument’s Absynth (software synthesizer). You can now set Cubase to play out through outputs 1 through 6, and set Absynth to play out through outputs 7 and 8. In previous Echo card drivers, you had to choose between one software program and the other.

### **Q: So what's the catch?**

The catch is this: all the apps using the Echo card at the same time must be set at the same sample rate. This is a limitation of the hardware.

Say that you didn't follow this rule in the previous example. Say that you initially had Cubase and Absynth set up for 44.1 kHz- so far, so good. Then you load a song into Cubase that is set up for 48 kHz. Cubase will change the sample rate of the hardware. Unfortunately, this means that Absynth is now also coming out at 48 kHz, so all the sounds played out of Absynth will sound higher in pitch.

If you're planning to use multi-client audio, the best thing you can do is to sit down and plan it out. Make a chart of each virtual output on your Indigo ExpressCard and write down what application is going to use what virtual output. Go through all the applications you plan to use this way, set them all up for the same sample rate, and set up their inputs and outputs correctly.

You should also turn off your system sounds. Most system sounds tend to be at 11 kHz or 22 kHz. Imagine that you're recording the best guitar solo of your life and someone clicks on something on the screen. The 22 kHz system sound will play out of an unused output and drop the sample rate of the whole system to 22, ruining your take.

If you really want system sounds, use your notebook's internal sound card and play them through that. Set the preferred device in the Multimedia control panel to the notebook's internal sound device and check "Use preferred devices only."

**Q: What are the rules that I should follow if I want to use multiple audio applications at the same time?**

- Set all your applications to the same sample rate. (You can also use the "sample rate lock" feature in the Console to help with this.)
- Turn off your system sounds.
- Figure out ahead of time, which inputs and outputs each application is going to use. Inputs and outputs cannot be shared between applications.

# Appendix B: An Introduction to Digital Recording

## Converting Sound into Numbers

In a digital recording system, sound is represented as a series of numbers, with each number representing the voltage, or amplitude, of a sound wave at a particular moment in time. The numbers are generated by an *analog-to-digital converter*, or ADC, which converts the signal from an analog audio source (such as a guitar or a microphone) connected to its input into numbers. The ADC reads the input signal several thousand times a second, and outputs a number based on the input that is read. This number is called a *sample*. The number of samples taken per second is called the *sample rate*.

On playback, the process happens in reverse: The series of numbers is played back through a *digital-to-analog converter*, or DAC, which converts the numbers back into an analog signal. This signal can then be sent to an amplifier and speakers for listening.

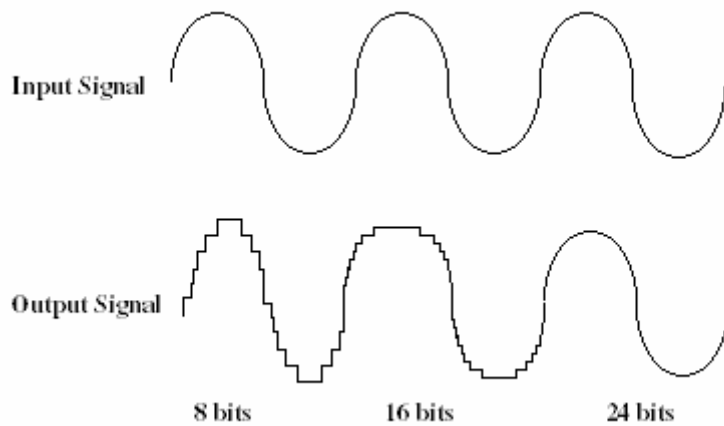
In computers, *binary numbers* are used to store the values that make up the samples. Only two characters, 1 and 0, are used. The value of a character depends on its place in the number, just as in the familiar decimal system. Here are a few binary/decimal equivalents:

<u>BINARY</u>	<u>DECIMAL</u>
0000000000000000	0
0000000000000001	1
0000000000000011	3
0000000000000111	7
0000000000001111	15
0000000000011111	31
1111111111111111	65,535

*Figure A. Binary numbers and their decimal equivalents*

Each digit in the number is called a *bit*. The binary numbers expressed in Figure A are sixteen bits long, and have a maximum value of 65,535. The more bits that are used to store the sampled value, the more closely it will represent the source signal. In a 16-bit system, there are 65,535 possible

combinations of zeroes and ones, so 65,535 different voltages can be digitally represented. (see Figure A above).



*Figure B. The more bits there are available, the more accurate the representation of the signal and the greater the dynamic range.*

Your Echo card's analog inputs use 24-bit ADCs, which means that the incoming signal can be represented by any of over 16 million possible values. The output DACs are also 24-bit; again, over 16 million values are possible. Your Echo card processes signals internally with 24-bit resolution to insure that there is no degradation to the audio signal as it is processed through the system.

The number of bits available also determines the potential dynamic range of the device. Moving a binary number one space to the left multiplies the value by two, so each additional bit doubles the number of possible values that may be represented. Each doubling of the number of values provides 6dB of additional dynamic range (see decibel section below). So, a 24-bit system can theoretically provide 144dB of dynamic range (6dB times 24 bits = 144dB) versus a 16-bit system with a maximum dynamic range of only 96 dB.

Also important to the quality of a digital recording is the frequency with which the samples are stored, called the sample rate. In order for a waveform to be faithfully digitized, it must be sampled at a minimum of twice the highest frequency to be stored. Failure to sample frequently enough results in a kind of distortion called aliasing. (If you like technical issues, do some research on The Nyquist Theorem which explains why this

happens). In addition to aliasing, sampling too slowly will result in reduced high frequency reproduction. Your Echo card allows you to sample sound at up to 96,000 times per second.

Once the waveform has been transformed into digital bits, it must be stored. When sampling in stereo at 96kHz using a 24-bit word size, the system has to accommodate 4,608,000 bits per second. In the past, storing this vast amount of data was problematic. Today, computer-based digital recording systems record the data directly to the computer's hard disk. Today's hard disks are capable of storing large amounts of data, though the performance of hard drives can vary substantially. The speed and size of your hard drive will be a major determining factor in how many tracks of audio you will be able to simultaneously record and playback.

## **Decibels**

Audio signal levels are generally expressed in units called "decibels" which are abbreviated as "dB". This is a "logarithmic" scale where each doubling of signal level is represented by an increase of 6dB. Therefore a signal of 6dB is twice as big as a 0dB signal and a signal of 12dB is four times as big as a 0dB signal.

Since digital audio signals are represented by binary data, each bit of audio information represents 6dB. A 16-bit number can represent a total range of 96dB and a 24-bit number can represent a total range of 144dB (6 times the number of bits). It's much easier to say that one signal is 72dB less than another instead of saying it is 1/4096 the size of the other one. It also more accurately represents the way we hear sounds, since the smaller signal in the above example will still be audible and not appear to be only 1/4096 as loud when we listen to it.

Just as there are different types of degrees used to represent temperature (Fahrenheit, Celsius, etc), there are different types of decibels used to represent the level of analog audio signals. The most common are dBu and dBV decibels. Both of these represent voltage levels and still double for every increase of 6dB. It is only the reference point, or 0dB level that is different. A 0dBV signal has a voltage level of 1.0 volts. A 0dBu signal has a voltage level of .775 volts. Since .775 is approximately 2dB less than 1.0,

converting dBV levels into dBu levels is as simple as subtracting 2dB (2.21 to be exact).

Signals are also occasionally represented with units of dBm. This is an older unit that measures power instead of voltage levels with 0dBm representing 1 milliwatt. Earlier tube-based audio equipment used standardized input and output impedances of 600 ohms, so a 0dBm signal was produced with a voltage of .775 volts. Since most of today's equipment uses impedances other than 600 ohms, it is more useful to represent signals by voltages rather than power and the dBu unit was introduced. A signal level of 0dBu is identical to a level of 0dBm.

Digital signals, after they are recorded, no longer directly represent any physical quantity such as voltage or power and 0dB is generally used to represent a "full-scale" or maximum signal level. All other signal levels are lower and are expressed as negative decibels. Most meters on digital equipment have 0dB at the top and range downward from there. A signal that is 30dB below full scale would simply be referred to as a -30dB signal.

## **Dynamic Range**

Dynamic range represents the difference between the maximum signal that can be recorded and the "noise floor", or level of noise with no signal present. A system with a high dynamic range will be quieter than one with a lower dynamic range. Dynamic range is a very important specification, and your echo card uses converters that have very high dynamic range.

Theoretically, a 24-bit system has a dynamic range of 144dB and a 16-bit system has a dynamic range of 96dB. Two questions immediately come to mind:

- 1) Why doesn't my Echo card have a dynamic range of 144 dB?
- 2) For mastering 16-bit CDs with a dynamic range of 96dB, isn't anything more than 96dB just overkill?

First, today's analog-to-digital converters typically produce a full-scale input voltage with an input of +7dBu. If they were to have 144dB of dynamic range, they would have to be capable of resolving signals as small as -137 dBu (7dBu - 144dBu) or approximately 10 nano-volts. That's 10 *one-billionths* of a volt! Transistors and resistors produce noise in this range just

by having electrons moving around due to heat. Even if the converters could be perfectly designed to read these levels, the low noise requirements of the surrounding circuitry such as power supplies and amplifiers would be so stringent that they would either be impossible or too expensive to build.

In answering the second question, consider the fact that music is often compressed or amplified after it is recorded, and that some headroom is necessary when recording to avoid clipping. The only way that 96dB would be adequate is if all music were recorded so that the peaks were just under full-scale and no compressing or amplification was going to be applied after recording. Any time recorded music is amplified, so is the noise at the low end. Your Echo card has enough dynamic range to allow sufficient headroom and post-processing to be applied while still keeping the noise either off the CD completely or down as far as possible.