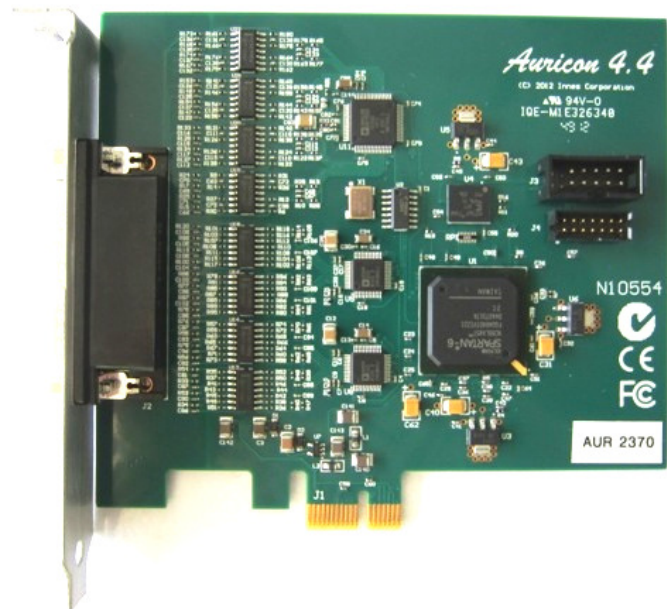# *Auricon 4.4*

Manual

Overview

The Auricon 4.4 is a professional-quality audio input-output card designed in Australia by Innes Corporation. It is supplied with a Windows WDM driver to provide full sound card functionality on Windows XP, Windows Server 2003, Windows Vista, Windows Server 2008, Windows 7, Windows Server 2008 R2, Windows 8 and Server 2012.

The Auricon 4.4 has four stereo inputs and outputs. The inputs and outputs can be reconfigured as separate mono channels, giving eight inputs and outputs. The inputs can be configured for DC or AC coupling.

The card uses 24-bit 192kHz sigma-delta converters which pass data to and from the PC via a single lane PCIe 1.1 interface. An onboard Xilinx Spartan 6 FPGA provides audio buffering, level adjustment and mixing functions as well as the PCIe endpoint. The hardware sampling rate can be set to 48kHz, 96kHz or 192kHz, while the Windows sampling rate converter provides automatic support of all other rates with 32-, 24-,16- or 8-bit PCM data which may be set independently for each input and output channel. All the standard Windows audio APIs are supported, including Wave, DirectSound, DirectShow, MCI and MIDI playback, as are a variety of audio compression modes via the Windows Audio Compression Manager or other software compression systems. The Core Audio API available on Windows Vista and later systems is also fully supported.

Specifications

Operating system: Windows XP, Server 2003, Vista, Server 2008, 7,
Server 2008 R2, 8, Server 2012, including 64-bit versions (x64).
Hardware sampling rate: 48kHz, 96kHz or 192kHz
Hardware resolution: 24 bits
Software sampling rates: 192kHz, 96kHz, 88.2kHz, 64kHz, 48kHz, 44.1kHz, 32kHz, 24kHz, 22.05kHz, 16kHz, 12kHz, 11.025kHz and 8kHz
Software resolution: 32, 24, 16 or 8 bits
Dynamic range: 114dB typical (unweighted)
Input impedance: 20k (balanced)
Output impedance: 40 ohms (balanced)
Maximum signal: +24dBu (34.6Vp-p)
Frequency response: Input – DC to 88kHz (DC coupling)
1Hz to 88kHz (AC coupling)
Output – DC to 88kHz (192kHz hardware sampling rate)

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Electromagnetic Compatibility

WARNING

This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

This product complies with the relevant tested clauses of AS/NZS CISPR 22:2009 +A1:2010 and AS/NZS CISPR 13:2012.

This product complies with the relevant tested clauses of EN55022:2010, EN55013:2013, EN55024:2010, EN61000-3-2:2009 and EN61000-3-3:2013.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

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RoHS

The Auricon 4.4 card is manufactured for compliance with RoHS (reduction of hazardous substances). Certification is available upon request.

Notes Regarding Windows Version Differences

Windows XP and Server 2003 are the only current versions of Windows that provide complete support for "traditional" WDM audio drivers. Windows 8, 7, Vista and corresponding server versions provide limited support for applications using the legacy audio APIs, while adding a new Core Audio API offering greater functionality. The following limitations apply when using the Auricon 4.4 with various versions of Windows.

- Windows 8, 7, Vista and corresponding server versions virtualise the mixer API to each application, providing only a mute and volume control on each input and output. These controls affect only the audio levels going to and from that application. A Windows XP compatibility mode is available in Windows Vista to provide full mixer access to the hardware if needed.

- Peak meters for WDM drivers are only available through the mixer API under Windows XP and Server 2003 (and Windows Vista running in XP-compatibility mode). Windows 8, 7, Vista and corresponding server versions provide an IAudioMeterInformation interface as part of their EndpointVolume API, but this isn't supported on any of the earlier platforms.

- In all versions prior to Windows Vista, Microsoft's sampling rate converter, which is automatically switched in when playing or recording audio streams at sampling rates other than the card's hardware rate, is slightly inaccurate when doing some conversions. The error is typically at most about 0.3%. The most common conversion, that of 44.1kHz to or from 48kHz, is handled correctly, though, as are simple 2:1 ratios.

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Installation

The software package consists of the driver installation file (Auricon44.inf or Auricon44x64.inf), the kernel-mode driver (Auricon44.sys), the configuration DLL (Auricon44Coinstaller32.dll or Auricon44Coinstaller64.dll) and the catalogue file (Auricon44.cat or Auricon44x64.cat).

Switch off the computer and carefully install the Auricon card in any free PCIe slot, observing the normal precautions against static electricity discharge. Then switch the computer back on and boot Windows.

Windows XP, Server 2003, Vista, Server 2008 - Windows will report that new hardware has been found and the New Hardware wizard will start. Insert the driver CD supplied with the card and proceed through the wizard. Allow Windows to search for the driver – do NOT specify a driver location or file name.

Windows 7, 8, Server 2008 R2, Server 2012 – Windows no longer searches removable media for drivers. Open Device Manager, where the Auricon will be listed under Other Devices as a Multimedia Audio Controller. Right-click on it, select *Update Driver Software*, then click on *Browse my computer for driver software* and click on the Browse button to navigate to the driver's location. Click on *Next* to install the driver.

On Windows XP and Server 2003, you may be warned that the driver has not passed Windows Logo testing. Click on *Continue Anyway* to proceed with the installation.

Windows 8, 7, Vista, Server 2012, 2008-R2 and 2008 will recognise Innes Corporation's own digital signature on the driver and invite you to proceed with the installation. If you wish you can tick the box to always accept Innes Corporation drivers.

At the completion of the installation process a loudspeaker symbol should appear in the toolbar at the bottom of the screen. Your Auricon is now fully operational. If the speaker does not appear, it may be necessary to reboot your PC. This typically happens if there has been no sound card previously installed in the PC. Windows XP (prior to Service Pack 1) and Server 2003 by default have the loudspeaker symbol turned off. To enable it, go into **Control Panel**, select **Sounds, Speech and Audio Devices**, then click on **Sounds and Audio Devices**, and finally tick the box marked **Place volume icon in the task bar**.

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Configuration

There are three configuration settings for the Auricon 4.4, these being stereo/mono mode, nominal line level, input topology and input coupling.

The **mode** may be configured as either stereo or mono. In mono mode the number of input and output channels that Windows sees is doubled.

The nominal **line level** can be set to +8dBu, +4dBu or 0dBu. In each case the clipping level is 16dB above the nominal level.

The **input coupling** can be set to either DC or AC (the default is AC). The AC coupling corner frequency is approximately 0.1Hz. Note this is applied after the analogue amplifiers, so a differential DC offset on the inputs can cause premature clipping.

To change the configuration, right-click on the **My Computer** icon on the desktop (or in the Start menu in the case of XP, Server 2003, Vista, Server 2008 and 7), select **Properties**, then click on **Device Manager**. On Windows 8 and Server 2012, open the **Control Panel**, go to **System and Security** and then **System**, and open **Device Manager** from the link in the left hand pane. Open **Sound, video and game controllers**, then right-click on **Auricon 4.4** and select **Properties**. Now click on the **Configuration** tab and select the desired mode, line level and/or topology. Under Windows XP and Server 2003 it may take a minute or so for Windows to reconfigure itself and the screen may flicker during this time. Be patient!

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Operation on Windows 8, 7, Vista and Server 2012, 2008-R2, 2008

The audio subsystem of Windows 8, 7, Vista and corresponding server versions has changed substantially from earlier versions of Windows, although most applications should continue to work without modification. The major differences likely to affect users of the Auricon 4.4 are described below.

Audio Endpoints

Key to the new system is the concept of *audio endpoints*. These are the physical audio sources and destinations, such as microphones, speakers and line connectors.

Previously, an audio capture device would typically have multiple inputs which were combined in a mixer or selector. Under Windows Vista and later, each input is represented by its own device, and Windows itself operates the card's selector to route the chosen source to the A/D converter.

In the case of the Auricon 4.4, each of the physical line inputs is represented by an endpoint device, and as the hardware has separate A/D converters for each one, they can be used simultaneously. There are also virtual endpoint devices for the digital loopback sources, although by default these are disabled. To enable these sources, right-click on the loudspeaker symbol at the bottom right-hand corner of the screen, select Recording Devices, right-click anywhere in the window and select Show Disabled Devices. Now right-click on the desired Wave Out Mix device and select Enable. This source will now appear as one of the available audio recording devices. Note that when an application is recording from a loopback endpoint, the corresponding line input is unavailable, and vice versa.

Windows has a default playback endpoint and a default recording endpoint, which are typically used by applications where the input or output device cannot be explicitly chosen. After the Auricon 4.4 driver is installed, the first channel is set as the default for playback and record but this can be changed by right-clicking on the loudspeaker symbol, selecting Playback Devices or Recording Devices, and then right-clicking on the desired endpoint and selecting *Set as Default Device*. The default device is remembered across reboots and should not need to be set again.

Mixer API

By default, the mixer API is virtualised for each application, providing just a mute and volume control for each endpoint and affecting only the audio going to and from that application. The hardware controls on the card itself are not accessible from the mixer API in this default mode.

For applications that need direct access to the hardware mixer controls, or that need access to the line input monitor controls or peak meter nodes, there are two options. Firstly, if it is a new application being written specifically for Windows Vista or later system, it can be designed to

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use the Core Audio APIs, which include the DeviceTopology API and the EndpointVolume API (which includes the IAudioEndpointVolume and IAudioMeterInformation interfaces). These are documented in the Windows 7 SDK which is available from Microsoft, however note that these APIs don't work with earlier versions of Windows.

Alternatively, applications can be given access to the hardware mixer controls through the mixer API by right-clicking on the application's icon, selecting Properties, clicking on the Compatibility tab and selecting *Run this program in compatibility mode for Windows XP Service Pack 2*. Be aware, though, that in this compatibility mode, the Auricon 4.4 card is represented by a single mixer device with destination lines for each of the individual inputs and outputs, which is slightly different to its behaviour under Windows XP where each input/output pair had its own mixer device. How this will work with any particular application that uses the mixer API can only be determined by experimentation.

Audio Engine

The Windows audio engine runs at a fixed sampling rate and bit depth. By default, the Auricon 4.4 driver sets the sampling rate to the card's hardware rate and the bit depth to 24-bit for all the inputs and outputs. The Windows sampling rate converter is used whenever a different sampling rate or bit depth is requested by applications. The engine bit depth for each endpoint can be changed to 16-bit if required by selecting the endpoint, clicking on Properties, and then clicking on the Advanced tab.

If your applications will be playing or recording at rates higher than 48kHz, you will need to set the card's hardware rate to 96kHz or 192kHz otherwise Windows will down-sample to 48kHz.

Windows Vista / 7 / 8 Mono Recording Bug

Windows Vista / 7 / 8 has a bug which causes mono recording streams to capture only the left channel of the source, rather than mixing the left and right as previous versions did. As a workaround until this is fixed, the driver provides a *Mono Mix* recording endpoint for each of the card's inputs. By default these are disabled, but can be individually enabled as follows.

Right-click on the loudspeaker symbol in the bottom right hand corner of the screen and select **Recording Devices**. Right-click on any of the sources and check **Show Disabled Devices**, which should then reveal two additional sources called **Input 1 Mono Mix** and **Input 2 Mono Mix**. To enable these, right-click on them and select **Enable**. Note that, after enabling, it will still show as *currently unavailable* as these endpoints are multiplexed with the normal stereo inputs and are only activated when opened by a recording application. Also be aware that, for the same reason, the *stereo* and *mono mix* endpoints for the same source can't be used simultaneously.

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The *Mono Mix* endpoints should be used for communications applications such as Skype which open a mono capture stream.

DirectSound and WDM Kernel Streaming

Microsoft's DirectSound and Windows Driver Model (WDM) are designed to work hand in hand to take full advantage of audio card hardware and provide kernel-mode software emulation of features not directly supported. Kernel streaming allows audio data to be passed directly between driver modules resulting in a robust, high performance integrated sound processing system.

With its WDM driver, the Auricon can play MIDI files and audio CDs in addition to Wave files. The kernel mixer allows multiple sounds from the same or different applications to be played simultaneously, while the kernel splitter automatically splits an input source to multiple applications. Sampling rate conversion is automatically inserted if any of the playback or recording streams differ from the card's hardware sampling rate.

WaveRT on Windows 8, 7, Vista and Server 2012, 2008-R2 and 2008

The Auricon 4.4 uses the WaveRT driver model on Windows 8, 7, Vista and corresponding server versions, giving the card's PCI controller and digital signal processor direct access to the audio engine's buffers and position registers. This allows audio transfers to proceed without any driver code involvement, eliminating transitions to and from kernel mode and thus improving efficiency and responsiveness. The card supports both pull mode (the native mode for Windows 7 and 8) and push mode.

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Topology

The Auricon 4.4 topology is shown in the diagrams at the end of this manual.

The playback topology consists of a master output level, mute control and peak meter, and input monitor level and mute controls for each of the line inputs. To these the kernel mixer adds virtual level and mute controls for wave, synthesizer and CD outputs.

The record topology consists of a master input level, mute control and peak meter, and level controls and mutes for the physical input and digital loopback.

The digital loopback allows the output of the card to be digitally mixed back into the input. This function is muted when Windows' Digital Rights Management detects that protected audio is being played, in accordance with Microsoft's specifications. **Note:** Under Windows 8, 7, Vista and corresponding server versions, the loopback endpoint is disabled by default. See the section on Windows 8, 7, Vista and Server 2012, 2008-R2 and 2008 above for instructions on how to enable it.

The range on the input and output master controls is -96dB to +6dB, while the individual line controls range from -96dB to 0dB. Note that, for reasons known only to Microsoft, on Windows 7 and Vista Service Pack 1 the 0dB setting on the playback Master Volume control is 67, while on Windows 8 it is 75.

To access the playback and record mixer controls on Windows XP, Server 2003 and earlier, double-click on the loudspeaker symbol at the bottom right hand corner of the screen. On Windows Vista and later, right-click on the loudspeaker symbol, select Playback Devices or Recording Devices, select the desired endpoint, click on Properties, and then click on the Levels tab.

Extended Bit Depth Audio

Traditionally, PC-based audio capture and playback has been restricted to either 8 bit or 16 bit encoding, with the WAVE_FORMAT_PCM descriptor used to define the audio parameters such as samples per second, bits per sample and number of channels.

With the advent of 24 bit A/D and D/A converters, there was a need to support extended bit depth. To achieve this, Microsoft introduced a new data format descriptor called WAVE_FORMAT_EXTENSIBLE. This provides additional information, including the number of valid bits per sample and support for specifying channel placement in multi-channel streams.

The WAVE_FORMAT_EXTENSIBLE descriptor may be used in place of the normal WAVE_FORMAT_PCM in setting up playback and recording through either the Winmm (wave) API or the DirectSound API. For further information refer to the Microsoft DirectX 8 documentation.

Some audio editing applications, such as Syntrillium's Cooledit 2000 and Adobe Audition, support extended bit depth audio and work well with the Auricon 4.4 using 24 or 32 bit recording.

Hyperthreading and Audio

Some motherboard processors offer hyperthreading, a technology lying midway between single core and fully independent multiple processor cores. A hyperthreaded processor provides parallel execution paths for multiple threads, however there remain some shared resources such as the memory caches and the floating point processor.

For most applications this is fine and results in a substantial improvement in performance for a given processor complexity, however for time-critical audio applications a problem can arise, when a low-priority thread is using a shared resource that the high-priority audio thread requires. Since the processor has no concept of thread priorities, the high-priority thread is blocked until that resource becomes free, resulting in gaps on playback or skipping while recording.

If this proves to be a problem on a hyperthreaded system, the hyperthreading can usually be disabled in one of the BIOS settings. Refer to the motherboard or system documentation for details on how to do this.

Note that this problem does not occur on true multicore processors.

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Connecting the Auricon 4.4 to Unbalanced Inputs and Outputs

Most professional audio equipment, including the Auricon sound card, uses high level balanced audio interconnections. Commercial radio stations in Australia typically use a nominal programme level of +8dBu, while the ABC, SBS and many production houses use +4dBu. In the USA 0dBu is commonly used.
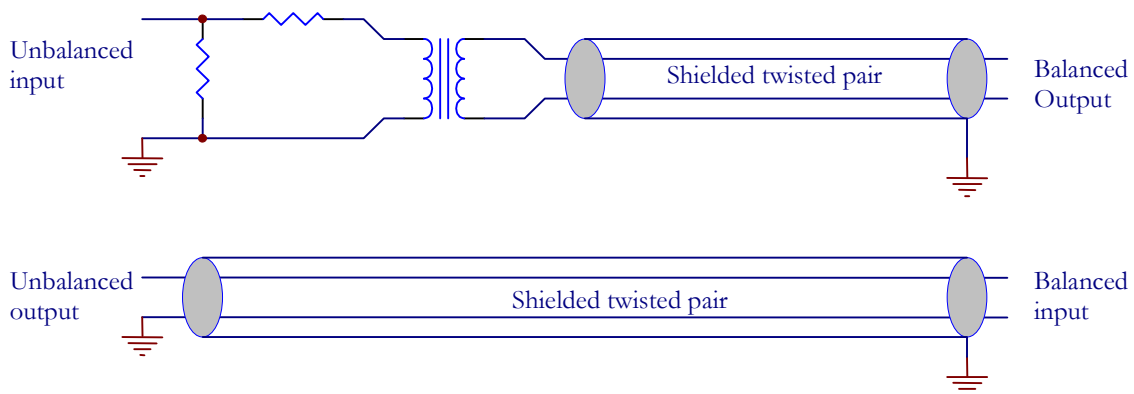
By contrast, domestic audio equipment uses low level unbalanced interconnections, typically at a level of about 100mV rms (about -18dBu). The best way to interconnect between these two systems is with a balancing amplifier. Failing that, it is still possible to achieve an acceptable interconnection, particularly when going from a high level balanced output to a low level unbalanced input.

In the diagram below, the transformer does the balanced to unbalanced conversion and the resistors adjust the level. It is preferable to use a 1:1 transformer and the resistive attenuator rather than a stepdown transformer as this will help minimise capacitive coupling of common mode noise across the transformer windings.

Note that you should **never** ground one side of a balanced output. Doing so will most likely damage the output drivers.

Going the other way from unbalanced to balanced is easy if the signal level is adequate. Simply connect the balanced input across the active and earth of the unbalanced output. In most cases, though, the level at the unbalanced output will be too low so you will need an amplifier. If this is the case it is probably best to do the job properly and use a balancing amplifier.

Finally, note that the shields on the audio cables should only be connected at one end. In the world of balanced audio, the shields are simply that - electrostatic screens - and should not be used for earth returns.

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Functional Description

The balanced audio inputs are buffered, attenuated and filtered prior to being coupled into the A/D converters. From the D/A converters, differential line driver amplifiers provide a maximum output level of +24dBm and also incorporate low pass filtering to attenuate the out-of-band noise produced by the converters.

Digitized audio is passed in serial form between the converters and the Xilinx Spartan 6 FPGA. The FPGA provides circular buffers as short term FIFO storage to cover latency times between PCIe transfers, and also performs the level adjustment and mixing functions. Card-initiated bus mastering is used for audio data transfer through the FPGA's integrated PCIe endpoint.

The converters operate at a sampling rate of 48kHz, 96kHz or 192kHz according to the driver setting.

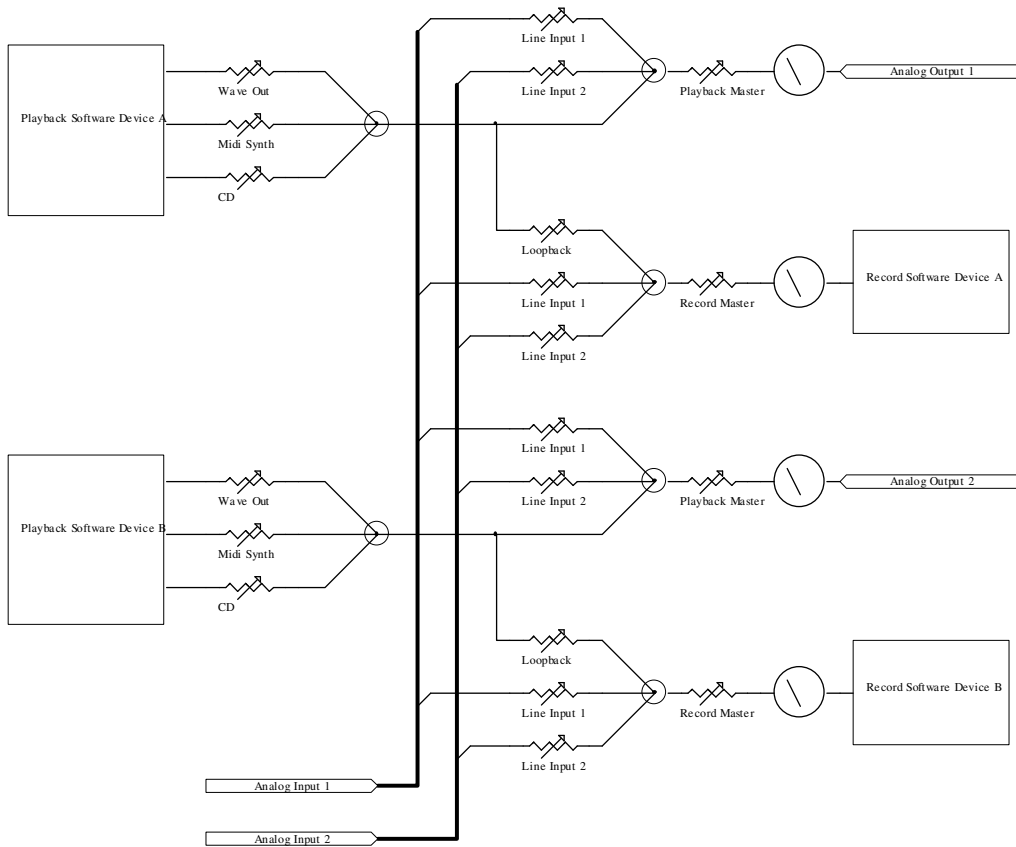The Auricon supports standby and hibernation power management modes.

Auricon 4.4 Pinout

High Density 44-pin Female Connector

Input	Pin	Output	Pin
1 Left +	7	1 Left +	44
1 Left -	22	1 Left -	14
1 Right +	36	1 Right +	29
1 Right -	6	1 Right -	43
2 Left +	35	2 Left +	28
2 Left -	5	2 Left -	42
2 Right +	20	2 Right +	12
2 Right -	34	2 Right -	27
3 Left +	19	3 Left +	11
3 Left -	33	3 Left -	26
3 Right +	3	3 Right +	40
3 Right -	18	3 Right -	10
4 Left +	2	4 Left +	39
4 Left -	17	4 Left -	9
4 Right +	31	4 Right +	24
4 Right -	1	4 Right -	38

Ground: 4, 8, 13, 15, 16, 21, 23, 25, 30, 32, 37, 41

When configured for mono operation, channel A is 1 left, channel B is 1 right, etc.

Auricon 4.4 Topology

Playback Software Device A
Wave Out
Midi Synth
CD

Line Input 1
Line Input 2
Playback Master
Analog Output 1

Loopback
Line Input 1
Record Master
Record Software Device A
Line Input 2

Playback Software Device B
Wave Out
Midi Synth
CD

Line Input 1
Line Input 2
Playback Master
Analog Output 2

Loopback
Line Input 1
Record Master
Record Software Device B
Line Input 2

Analog Input 1
Analog Input 2

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Output Mixing

The Auricon 4.4 presents itself to the operating system as multiple independent wave output devices. Each device can support any number of output streams, courtesy of the Windows Kernel Mixer or Audio Engine.

The topology of each output device is shown below. It consists of the kernel mixer that combines any number of individual waveOut and DirectSound audio streams (applying sampling rate conversion if need be), followed by the "Wave Out" level control. Midi and CD streams are also added at this point. This is then followed by the Auricon mixer (implemented in the on-card FPGA) that adds the input sources (four if configured as stereo and eight if configured as mono), master level control and peakmeter. All level controls include a mute control as well.
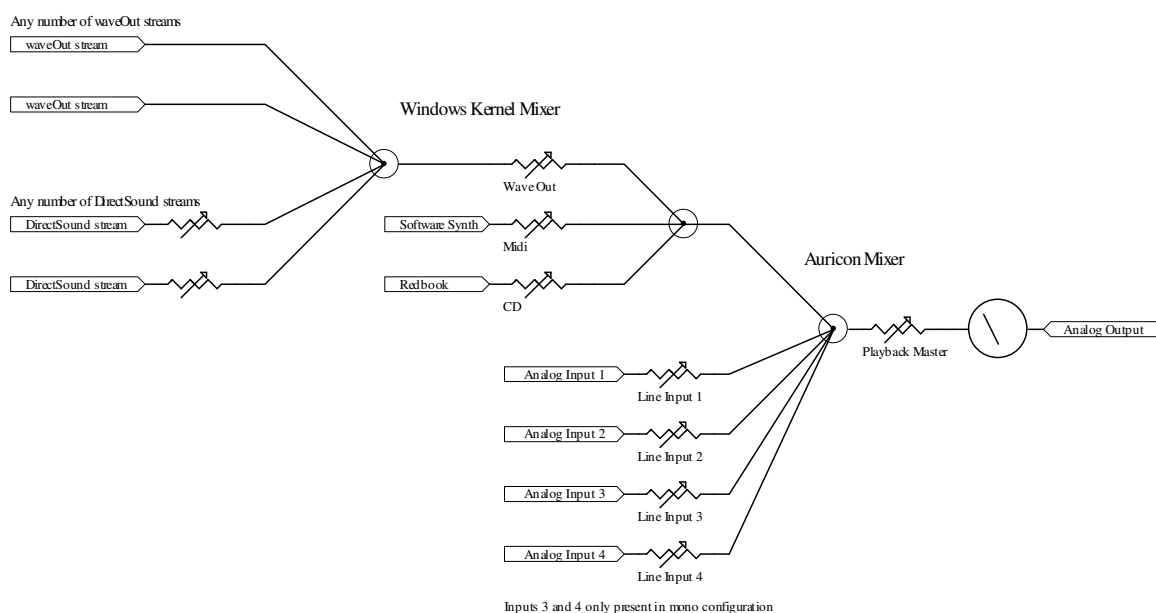
Each waveOut stream is created by opening an instance of the waveOut device. Each DirectSound stream corresponds to a DirectSoundBuffer object. There is no limit to the number of streams that can be opened on each device. Note that with versions of Windows prior to Vista, only DirectSound streams have individual level controls – these are set using the DirectSoundBuffer.SetVolume method. The Windows documentation suggests that waveOutSetVolume should also adjust the level of individual waveOut streams but this doesn't seem to work - instead changing the level of one stream actually changes the setting of the kernel mixer's "Wave Out" fader and thus affects the level of every stream on that device.

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