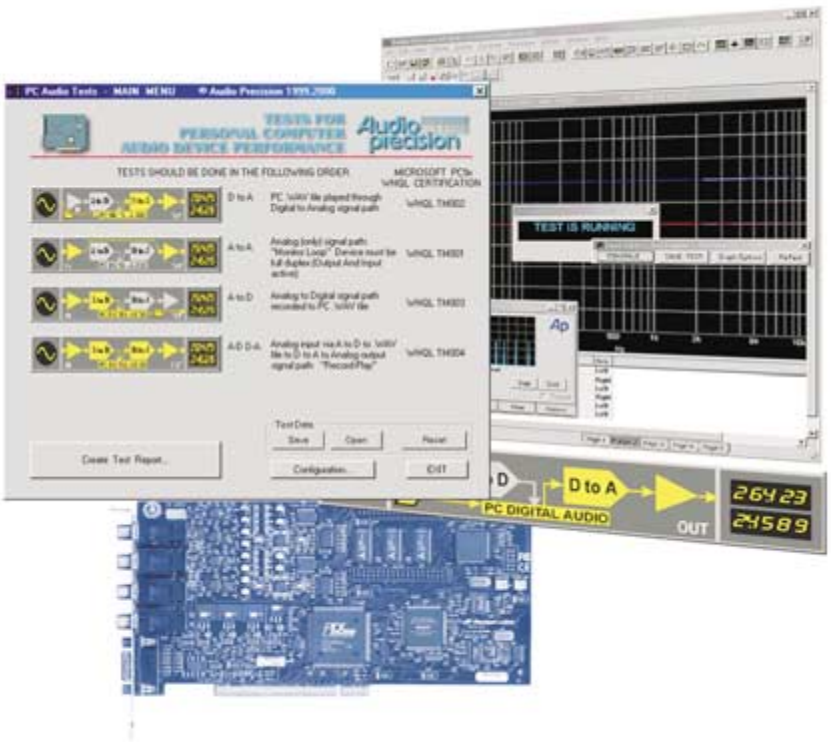
PC Audio Device Performance Tests

Audio Precision Application Note #4

PC Audio Device Performance Tests



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PC Audio Device Performance Tests

Introduction

The PC Sound Card

PC sound cards come in many variations with different feature sets, input and output characteristics, software drivers and bus connections. The most common cards include as a minimum stereo inputs, stereo outputs and wavetable synthesis for game sounds; specialized cards may offer digital inputs and outputs, multiple channel capability, MIDI control or other additional features.

Most currently available cards offer stereo *digital recording* and *digital playback* capability, which are the specific features PC Audio Device Performance Tests (or *PC Audio Tests*) is designed to measure and test. Such a card will have these functional components:

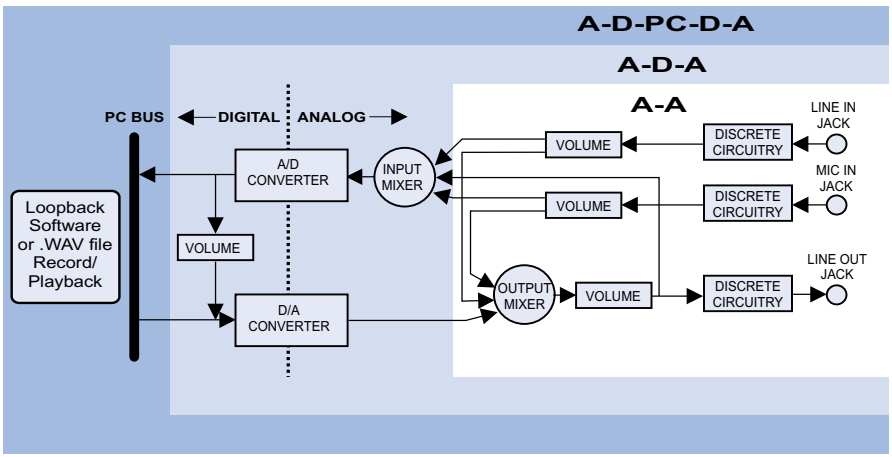


Figure 1 Block Diagram of a Typical Sound Card, with A-A, A-D-A & A-D-PC-D-A signal paths shown.

The input and output of the card are conventional analog audio signals, which are converted into digital data in the card's analog-to-digital converter (ADC) for storage in the computer's memory and as a .wav file on disk. Conversely, a file containing

digitized audio can be recovered from memory and converted back to an analog signal in the card's digital-to-analog converter (DAC).

Software Control of Sound Card Functions

PC sound cards provide software-accessible mechanisms to select signals and adjust and mix volume levels both before the ADC and after the DAC; additionally, they may offer some level control in the digital domain, along with optional tone control, reverberation, surround simulation and other effects by means of digital signal processing (DSP).

Microsoft provides software utilities for volume and mixing control and to record and play audio .wav files with its Windows operating systems. Other specialized sound recording, editing and mixing programs, often with greatly expanded feature sets, are available to control these functions as well.

For a more detailed examination of PC sound cards, see **Appendix B: PC Sound Cards and Audio Devices** (page 137). Check the **Glossary** (page 165) for explanation of unfamiliar terms and concepts.

Figure 2 Typical Third-Party Mixer

PC Audio Device Performance Tests

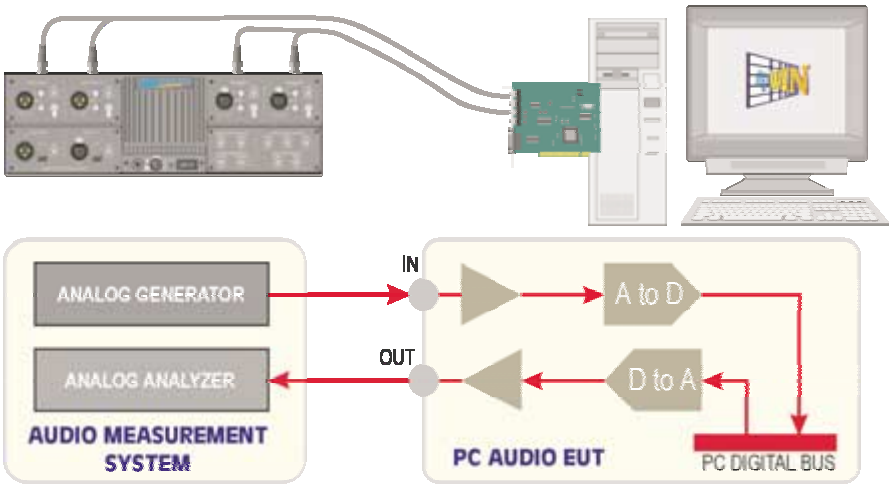


Figure 3 PC Audio Device Performance Tests

Audio Precision's PC Audio Device Performance Tests is a complete set of tests and procedures for measuring the performance of the digital recording and playback functions of a PC sound card or other computer sound device. The sound card must be connected to an Audio Precision System Two and installed in the computer running APWIN.

Accurate test and measurement of a PC sound card can be challenging for several reasons:

- The digital input and output of a sound card consist of data on the host computer's bus, not always easily accessible.
- The digital test stimulus to the card must come from a .wav file created with the proper test characteristics.
- Sound cards vary in their analog input and output levels and impedances
- Sound cards vary in the way they implement software control of their features.

Audio Precision's System Two and APWIN software provide carefully generated test stimuli and powerful analysis, with direct read

and write access to the host computer's data files. To these existing capabilities PC Audio Tests brings new tests, utilities and .wav files especially created for sound card evaluation, all run from within a user-friendly APWIN Basic procedure. The companion program PC LevelCheck further extends APWIN's reach to include direct real-time access to the digital audio signal in the computer's memory.

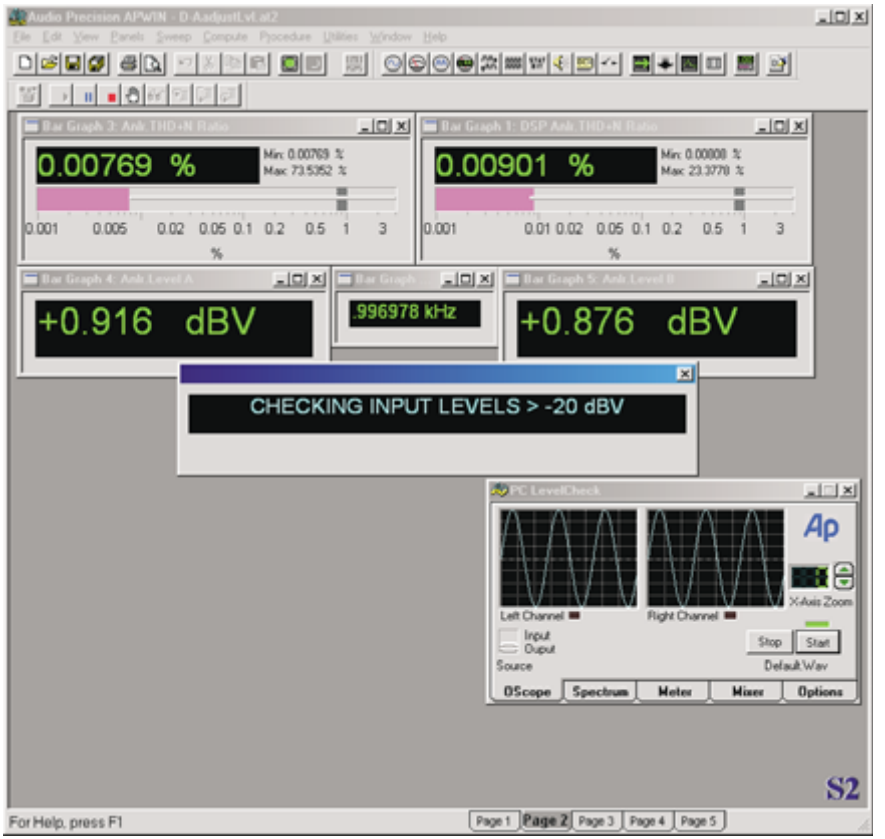


Figure 4 PC Audio Device Performance Tests

PC Audio Tests measures sound card levels, distortion and noise, dynamic range and frequency response in both the analog and digital domains. The tests in PC Audio Tests are designed to produce specific measurements required either to satisfy a standard, such as Microsoft WHQL pc99, AES6, AES17, or a custom specification. See **Appendix C: Standards** (page 145) for more information about these standards.

PC Audio Device Performance Tests is distributed on CD-ROM with this Application Note.

Getting Started

This section will guide you though software installation and hardware connection and prepare you to make tess using PC Audio Tests.

System Requirements

Figure 5 System Requirements

- Measurement instrument:
  Audio Precision System Two Dual Domain (SYS-2322A)
  –OR–
  System Two Cascade Dual Domain (SYS-2522A) in System Two Compatibility Mode

- A personal computer running APWIN Version 2.0 or later under Microsoft Windows 95 or later.

- Equipment Under Test (EUT):
  A PC sound card (or other sound device configured to emulate a

PC sound card) connected to the bus of the PC that is running APWIN. The sound card must have the proper software drivers installed and be correctly configured to the computer operating system.

Connections

For the sake of clarity, a generic consumer-type sound card will be assumed to be the EUT for the testing process that follows. This type of card represents the vast majority of such devices on the market today. If the card you wish to test has different input and output connections and characteristics, refer to **Appendix B: PC Sound Cards and Audio Devices** (page 137) for interface information. The testing process remains the same.

An ordinary sound card usually has two stereo input connections and one stereo output connection using three 3.5 mm tip-ring-sleeve (TRS) jacks (often called *stereo mini jacks*) labeled MIC IN, LINE IN, and LINE OUT. Some cards may have additional connections, perhaps powered for speakers or headphones; some add rear-channel capability and other features.

Due to space limitations on the card, the inputs and outputs are often not labeled by name but may have little icons stamped into the metal panel, or color-coded jacks. Check with your card's documentation if you are not sure about the jack designations.

Also note that the nominal levels and impedances may vary considerably by sound card manufacturer and model. Make no assumptions; calibrate your tests to each card you measure, as performed in the **SET REFERENCE LEVEL** section of each test.

Unbalanced interconnections often degrade analog audio performance by adding hum, buzz, radio-frequency interference or other spurious signals into the audio. Connecting a heavy grounding strap between the analyzer and the EUT will often produce dramatic improvements in measured system noise.

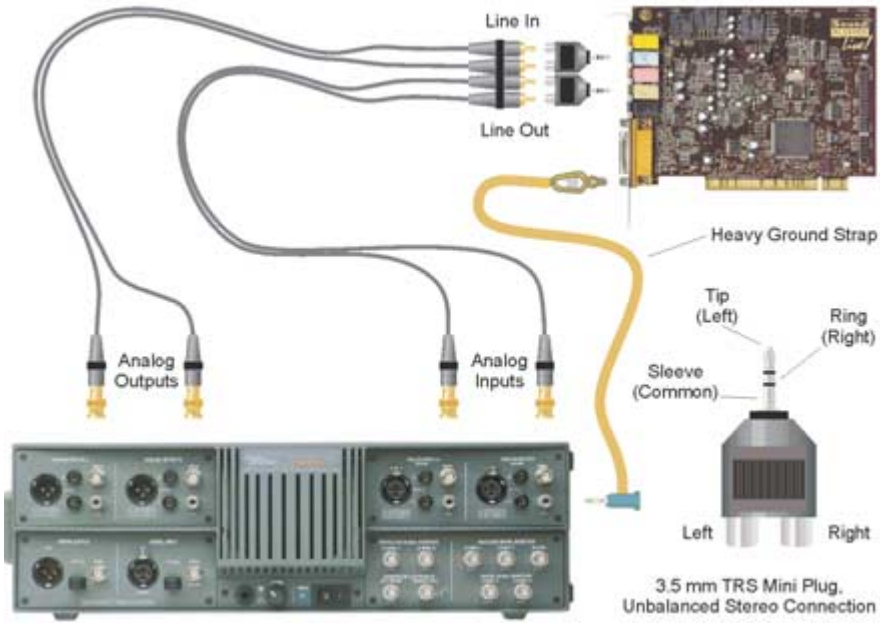


Figure 6 Connecting a PC sound card to System Two for testing

Figure 6 shows basic line-level input and output connections between the EUT and System Two, with an added grounding strap.

There are many strong fields in and around computer equipment that can magnetically or electrostatically couple interfering signals into audio circuits as well. Use well-shielded connection cables, keep them short and route them away from sources of interference, such as data buses, unshielded digital circuits, fans, power supplies, and especially CRT computer monitors.

Installing PC Audio Device Performance Tests

PC Audio Device Performance Tests is distributed from the Audio Precision Web site and on CD-ROM.

To download the installation files from the Web, go to http://www.audioprecision.com, click the **SOFTWARE** button and scroll the list for the latest version of PC Audio Device Performance Tests. Follow the instructions to download and expand the files.

- If you are using Microsoft Internet Explorer, you will have the option of running InstallShield from the Web site or saving the installation file to disk. If you run the program, InstallShield will install PC Audio Tests on your computer over the net.

- If you save the file to disk (the only option with Netscape Navigator), the installation file will be saved in the folder you designate. To launch InstallShield, go to that folder and double-click on Setup.exe

- If you are installing from the CD-ROM, place it in your computer's drive. If your CD-ROM drive is set to automatically run, InstallShield will immediately launch. If not, go to **My Computer** and click on the icon for the CD-ROM drive. When the drive window opens, double-click on Setup.exe to launch InstallShield.

Simply follow the prompts in InstallShield. You can accept all the default choices, or you can designate your own folders and file locations.

When PC Audio Device Performance Tests is installed, you have the options of viewing the Readme file and immediately launching PC Audio Device Performance Tests in APWIN.

For a listing of folders created and files installed, see **Appendix D: File Descriptions** (page 147).

Running the Tests

Launching PC Audio Tests

PC Audio Tests is an APWIN Basic procedure, using APWIN to operate System Two in testing the EUT. First, connect the EUT to System Two following the directions given in **Connections**, above. We strongly recommend adding the heavy grounding cable described earlier as well.

APWIN, PC Audio Tests and PC LevelCheck running together are heavy users of system resources under Microsoft Windows. If your computer seems slow while using PC Audio Tests, close any unnecessary applications that may be running.

Turn on System Two and launch APWIN.

Apply power to System Two and launch APWIN by double-clicking the APWIN icon. (If you have associated *.apb files with APWIN, you can simply go to the \PcAudioTests folder and double-click the file PcAudioTest.apb to launch APWIN and load the procedure.)

If you have System Two Cascade, remember to run APWIN in System Two Compatibility Mode.

Re-size the APWIN window to about 2/3 the size of your desktop. This will allow you to easily switch to Volume Control, Sound Recorder and Media Player windows if you are running PC Audio Tests in Manual Mode. *See* **Test Modes** (page 24).

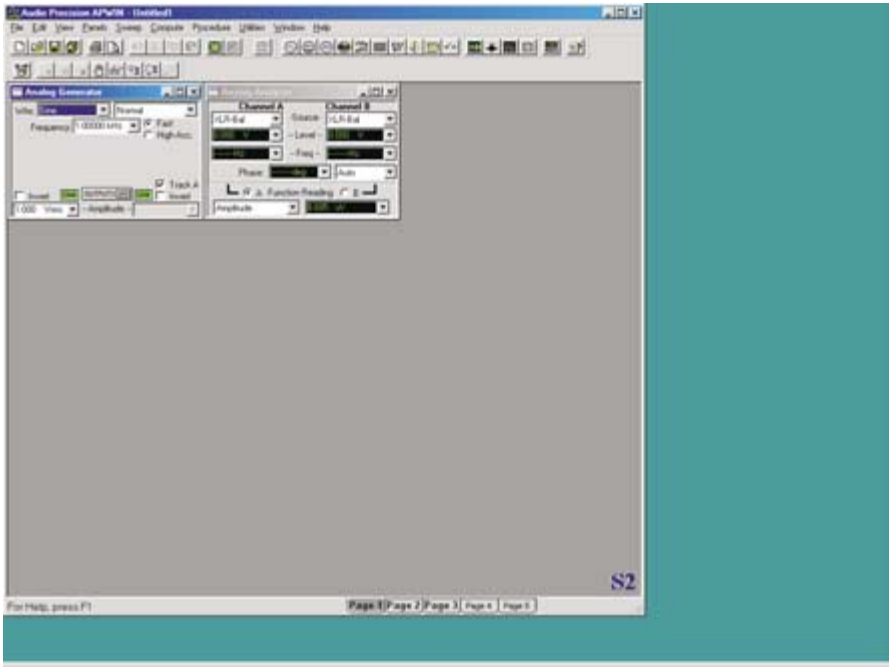


Figure 7 APWIN at 2/3 Desktop width

To load the procedure, select **File > Open > Procedure** from the APWIN menu bar. Browse to the folder where the files were installed (the default is C:\Apwin\PcAudioTests\) and open PcSoundTest.apb. Then select **Procedure > Run** from the APWIN menu bar.

> *You can create a Quick Launch icon in APWIN to bring up PC Audio Tests in one click. See **Quick Launch** in the APWIN users manual.*

PC Audio Tests will present you with the Main Menu.

The Main Menu

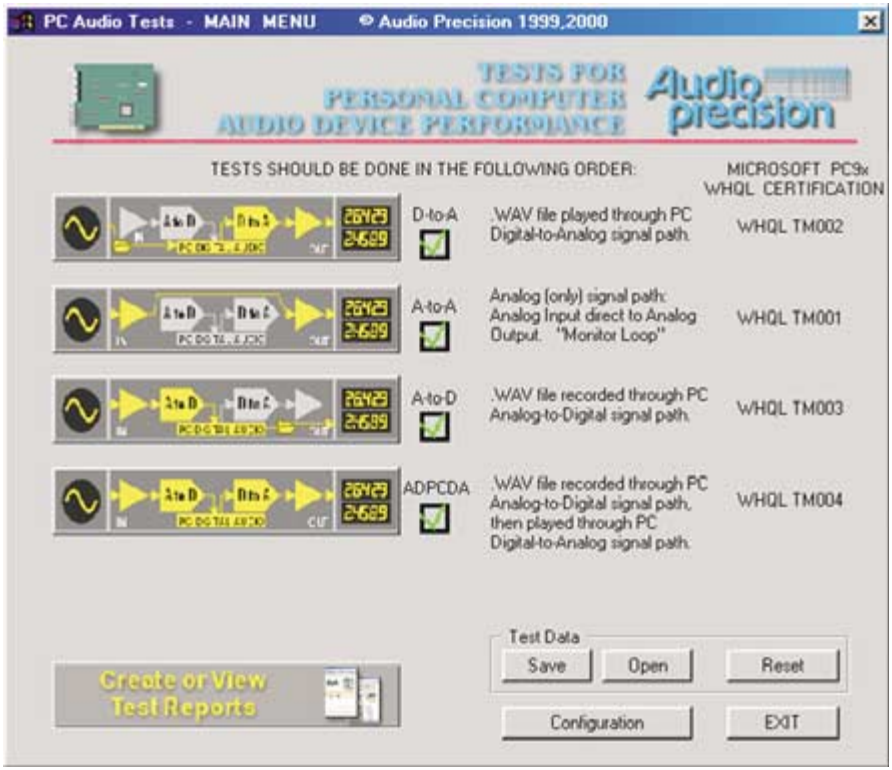


Figure 8 The Main Menu

The Main Menu is the central hub from which to start all the tests, access the Configuration panels, save or open Test Data Files or create a Test Report.

If this is the first time the program has been run, or if you need to change previous settings, click the **Configuration** button. See **Appendix A: Setting Preferences in Configuration** (page 127). The default configuration settings will be correct for most situations. They are initially set to:

Input	Unbalanced
Output	Unbalanced
Sample Rate	44.1 kHz
Test Mode	Automatic

From the main menu you can proceed to any of the four groups of tests or to the Test Report panel. A green check mark will appear next to each test group button on the Main Menu to indicate completion of that group of tests. A yellow check mark indicates that all the data in memory for that group of tests have been retrieved from a saved test data file. A grey check mark indicates that some of the tests within that group have not been completed, or that some of the data have been retrieved from a saved file. See **Saving, Retrieving and Resetting Test Data**, below.

Since the results from some tests are used as the basis for subsequent measurements, the tests should be performed in the order listed:

- **D-to-A**
  Digital-to-Analog, playing a .wav file through the EUT.
- **A-to-A**
  Analog-to-Analog, monitoring the EUT input at the output.
- **A-to-D**
  Analog-to-Digital, recording a .wav file with the EUT.
- **ADPCDA**
  Analog-to-Digital-to-PC-to-Digital-to-Analog, first recording a .wav file with the EUT and then playing back the same file.

All four of the test group panels have a similar appearance, with large buttons on the left to initiate various tests, and text boxes on the right to display results. A green check mark will appear next to each test button on the panel to indicate completion of that test. A yellow check mark indicates that the data in memory for that test have been retrieved from a saved test data file. On each panel you also have the option of reviewing the frequency and phase response graph (which is

initially displayed at the completion of the frequency test) and of saving the graph data with comments. See **Saving, Retrieving and Resetting Test Data**, below.

To begin a group of tests, click the appropriate button on the Main Menu.

Saving, Retrieving and Resetting Test Data

The results for all the tests remain in memory until you exit PC Audio Tests. You can save the results as a Test Data file with the default name New.dat by clicking **Save** in the Test Data area of the Main Menu. By default, these files are saved in the \Reports folder or other folder you have specified in Configuration. The results stored in a Test Data file can be retrieved by PC Audio Tests and can also be accessed by other programs.

To retrieve the information in a Test Data file, click **Open**. This launches a browser window where you can select the file you wish to retrieve. When you open a Test Data file, your configuration information and all of the test results currently in memory are replaced by the retrieved data.

Clicking the **Reset** button retrieves the file Reset.dat from the folder \PcAudioTests. **Reset** sets all the test results to default (or to whatever values you may have saved in the Reset.dat file), but does not change your configuration information.

Frequency response graphs will be re-created from the data retrieved in a *.dat file, but the graph information can also be saved separately as either a *.ada or *.at2 file (choose your preference on the Configuration: Data panel) by clicking **Save Test** in the graph options box available via the **View Response Graph** button.

Test Reports

The test results in memory can be also exported in several different document formats as optional Test Reports, which can be generated at any time during the procedure by clicking **Create Test Report**. See **Creating Test Reports** (page 123).

What the tests do

There are four groups of tests in PC Audio Tests, and each group makes four sets of measurements in similar categories. Although there are clear differences between the tests, there are many common points in the four categories that can be examined here.

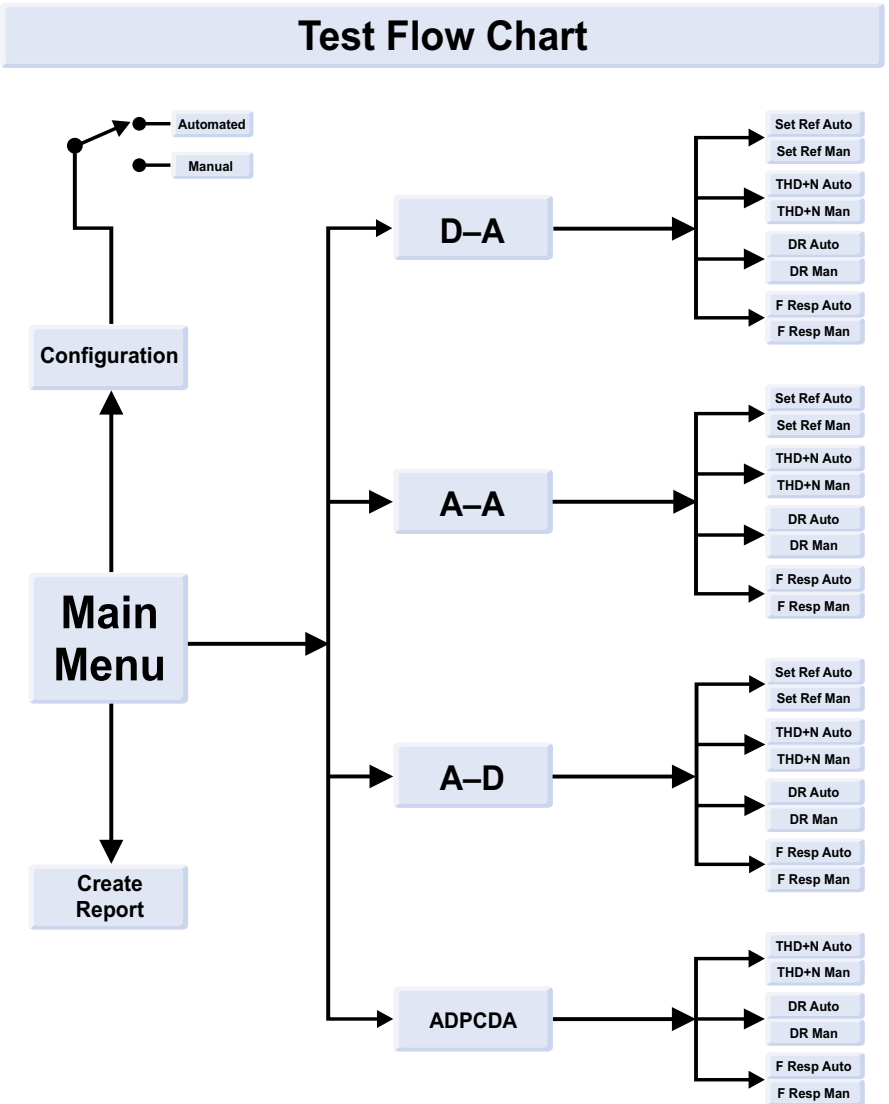


Figure 9 PC Audio Tests Test Modules

Set Reference Level

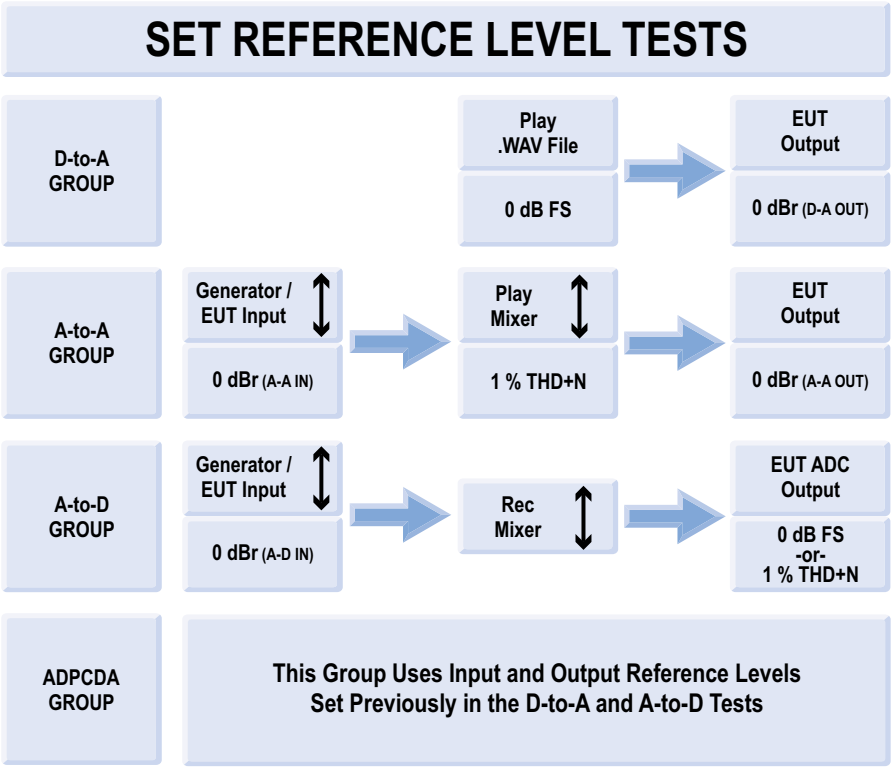
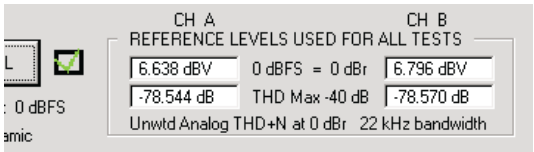


Figure 10 Set Reference Level Tests

Sound cards have a wide range of input and output levels and software mixer implementations, and the first test in each group calibrates PC Audio Tests and System Two to your particular sound device for the signal path of interest (D-to-A, A-to-A, A-to-D, or ADPCDA).

Figure 11 Typical Level Reference Settings



On each panel the reference level determined is listed in dBr. *dBr* means *dB relative to a reference,* ***r,*** a temporary, user-defined or

test-defined reference. In PC Audio Tests, the values set as reference for dBr can have different values within different tests.

> *The* decibel *(dB) is widely used in audio measurements, and it must always be referenced to a value.* dBV*, for example, is the shorthand for decibels referenced to 1 volt root mean square (rms).* dB FS *is a decibel audio measurement for digital audio, and the reference "FS" stands for "Full Scale." A full scale digital signal (0 dB FS) is the rms value of a sine wave whose positive peak just reaches full scale, represented by the maximum value in the coding scheme. See* ***Appendix G: Glossary*** *(page 165) for more information.*

AES17 requires that full scale references must exhibit a THD+N content of less than 1 % (equivalent to –40 dBr). If THD+N exceeds this amount, the full scale reference must be set to a lower value. On the D-to-A, A-to-A, and A-to-D test panels, PC Audio Tests displays the THD+N reading (unweighted, referenced to 0 dBr, 22 kHz bandwidth) in the **REFERENCE LEVEL** area so you can monitor this parameter. If this result exceeds –40 dB (or, if stated as a percentage, 1 % distortion) the measurement is beyond the specification in the AES17 standard and must be performed again with a lower stimulus level.

> *Once reference levels are set, it is essential that no level changes be made to the test setup, whether in hardware or in software. Distortion, noise and dynamic range measurements are all made based on these references and the tests will not return correct results if level changes have been made in APWIN or in the Record or Playback Mixer controlling the EUT. If you inadvertently change signal level, you must return to the D-to-A, A-to-A and A-to-D panels and reset the reference levels.*

Total Harmonic Distortion plus Noise (THD+N)

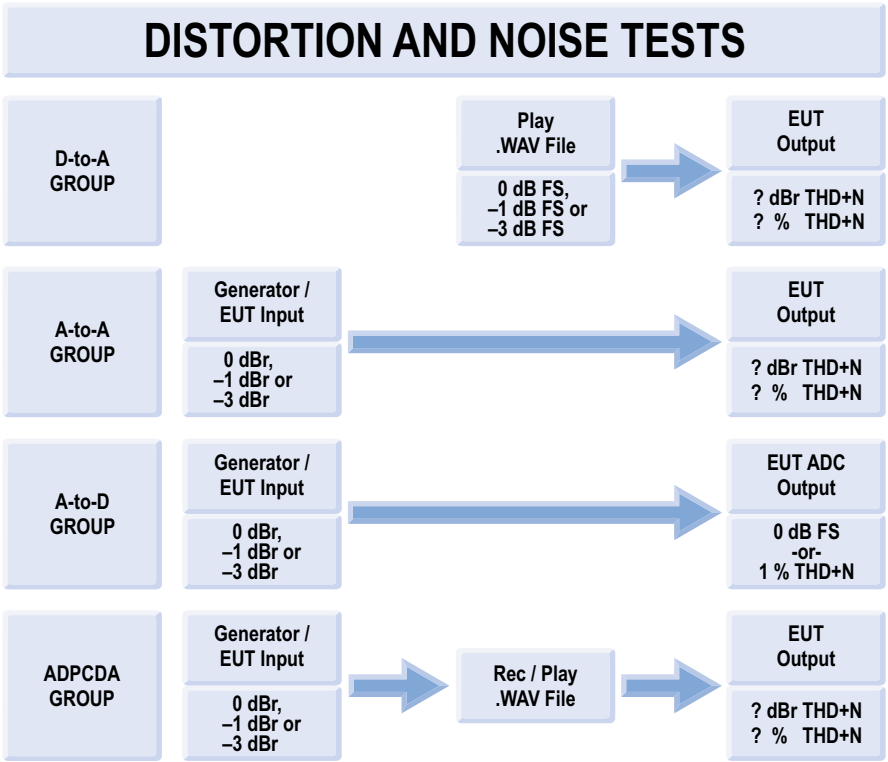


Figure 12 Distortion and Noise Tests

This test measures the total harmonic distortion and noise (THD+N) found in the EUT under the test conditions in each group of tests.

There are four slight variations in the testing methods commonly used to measure THD+N in PC digital audio devices, each using a different stimulus level. In all four methods, the EUT is stimulated by a tone of approximately 1000 Hz (AES17 specifies 997 Hz); the tone is then removed in the analyzing system; and the residual signal (which contains both noise and the harmonics) is measured.

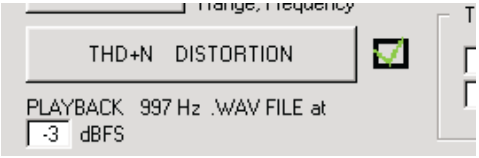
> *When a periodic input signal is resonant with the sample rate, the sampling instants of the converter will repeatedly sample at the same points on the signal. 997 Hz is specified for testing because it is not resonant with the standard sampling*

frequencies and as a consequence exercises all the possible states of the converter.

The first variation simply subjects the EUT to 997 Hz at 0 dB FS, the maximum level of the digital signal. In a well-engineered device this stimulus would not produce significantly more distortion that tones somewhat lower in amplitude, but in many practical devices 0 dB FS is right at the edge of maximum performance, and lower amplitudes must be used to return reasonable distortion test results.

With this in mind, the AES17 standard sets the amplitude of the stimulus signal at –1 dB FS, while the Microsoft WHQL standard recommends an even lower –3 dB FS.

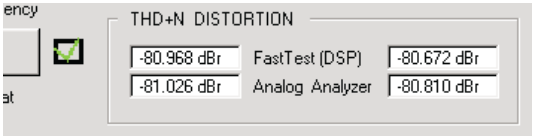
Figure 13 THD+N Stimulus Level



PC Audio Tests makes these three stimulus options available and adds a fourth, –6 dB FS, as well; you can select any of these four levels (or accept the default, WHQL at –3 dB FS) on the Configuration > System Two panel. The level selected is shown on the each test panel in the display window below the THD+N button. See **Appendix A: Setting Preferences in Configuration** (page 127).

In addition to the four different stimulus levels, PC Audio Tests also measures THD+N in two completely different ways, using the System Two DSP program called *FAST*TEST and the System Two Analog Analyzer. Both of these methods are highly accurate, both are valid ways of evaluating THD+N, but they each return slightly different results.

Figure 14 Typical THD+N Readings



The upper pair of boxes in the **DISTORTION** area of each test panel show the THD+N results as measured by *FAST*TEST, which uses FFT analysis of the signal. The lower pair of boxes display the THD+N results as measured by the Analog Analyzer, which uses the

conventional combination of a band-limited level measurement following a narrow notch filter tuned to the frequency of the stimulus. See **Appendix F: Distortion Analysis Techniques** (page 159) for a more detailed comparison of these methods.

The A-to-D test group only uses FASTTEST for THD+N measurements because the signal to be analyzed is only available in the digital domain.

Dynamic Range

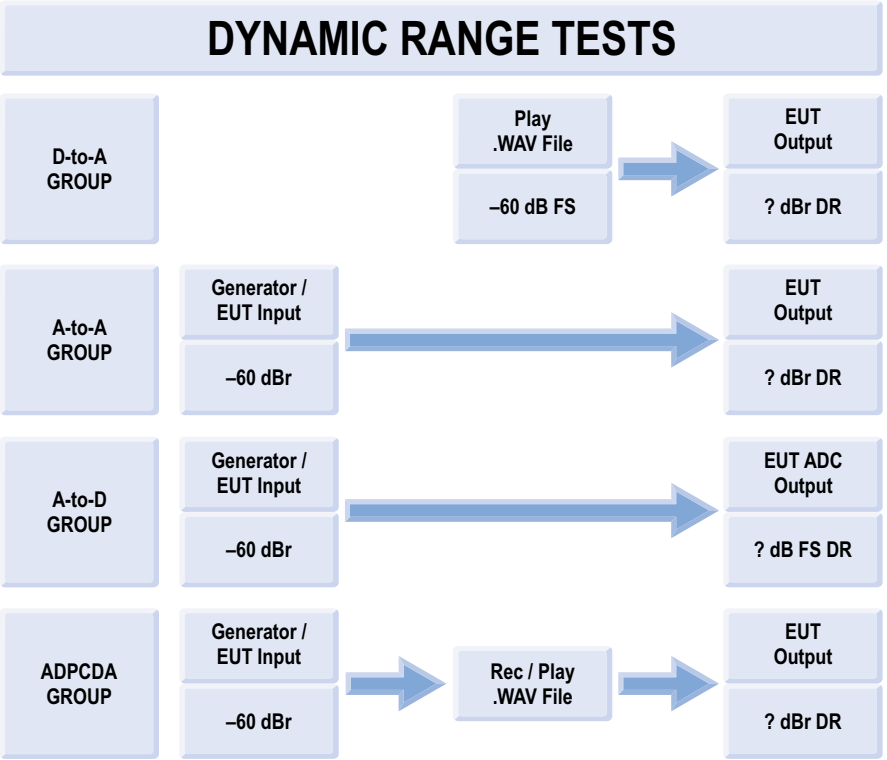


Figure 15 Dynamic Range Tests

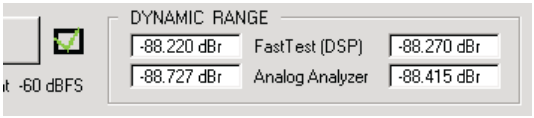
Dynamic range is the difference between the maximum amplitude of a device and its noise level. Since the maximum level in our EUT is 0 dB FS, the noise floor in dB FS gives us a dynamic range figure.

In analog devices, the noise figure is usually determined by simply measuring (after a low-pass filter) the output of the device with no signal applied. Digital devices, however, normally mute the output of the D-to-A converter when no signal is applied, giving an unrealistic noise figure without much relevance to noise under ordinary operating conditions.

The most useful noise measurement for digital devices, then, is made in the presence of a signal. The tests provided in PC Audio Tests use a 997 Hz tone at a very low (–60 dB FS) level to keep distortion

products immeasurably low. This tone keeps the converter "open" so that converter noise is apparent. The tone is then notched out in a manner similar to a THD+N analysis.

Figure 16 Typical Dynamic Range Readings



As in the THD+N test, PC Audio Tests uses both the *FAST*TEST (DSP) FFT technique and the conventional analog notch filter technique to produce two slightly different views of the noise signal and therefore two slightly different dynamic range figures.

For consistency, PC Audio Tests uses this technique even in tests that do not include the D-to-A converters in the signal path.

Frequency Response

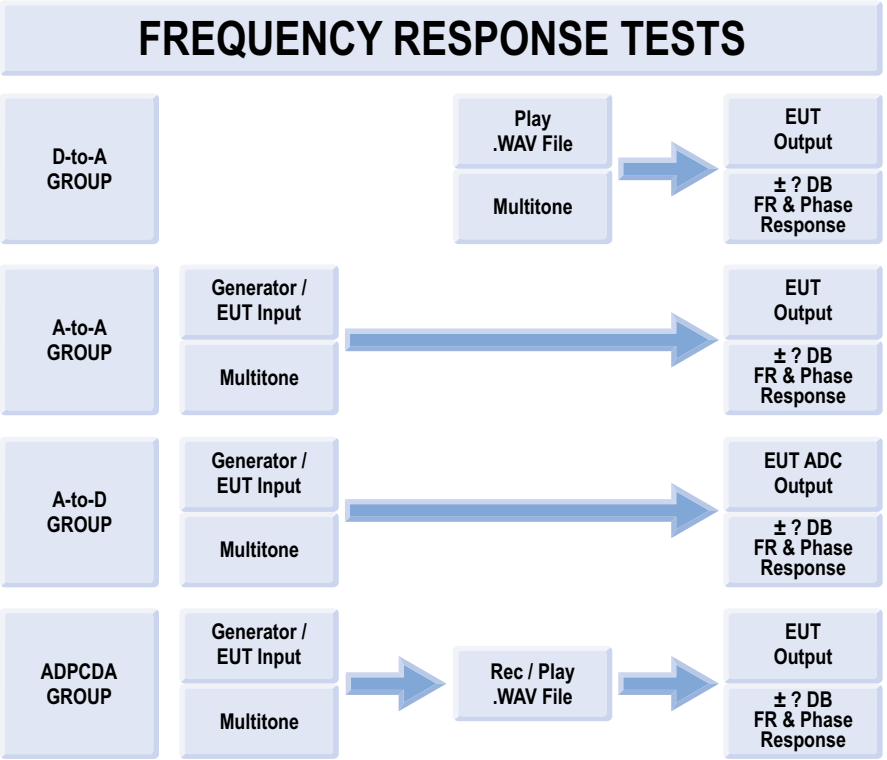


Figure 17 Frequency Response Tests

For frequency response testing, PC Audio Tests performs a *multitone* test (in all cases except one: see the note below) rather than making a conventional frequency sweep. The multitone test uses as a stimulus a .wav file that plays back 31 frequencies simultaneously. Each frequency is centered on one of the ISO 1/3-octave frequencies, spanning the range from 16 Hz to 20 kHz. This method generates results identical to a 1/3-octave step-frequency sweep.

> *In the A-to-A monitor loop test, real-time 1/3-octave step-frequency sweeps are possible. The A-to-A test panel offers this option by clicking the* ***Analog step sweep*** *option button. An analog sweep test is much easier to modify for custom sweep designs than a multitone test, and this option is provided for that purpose.*

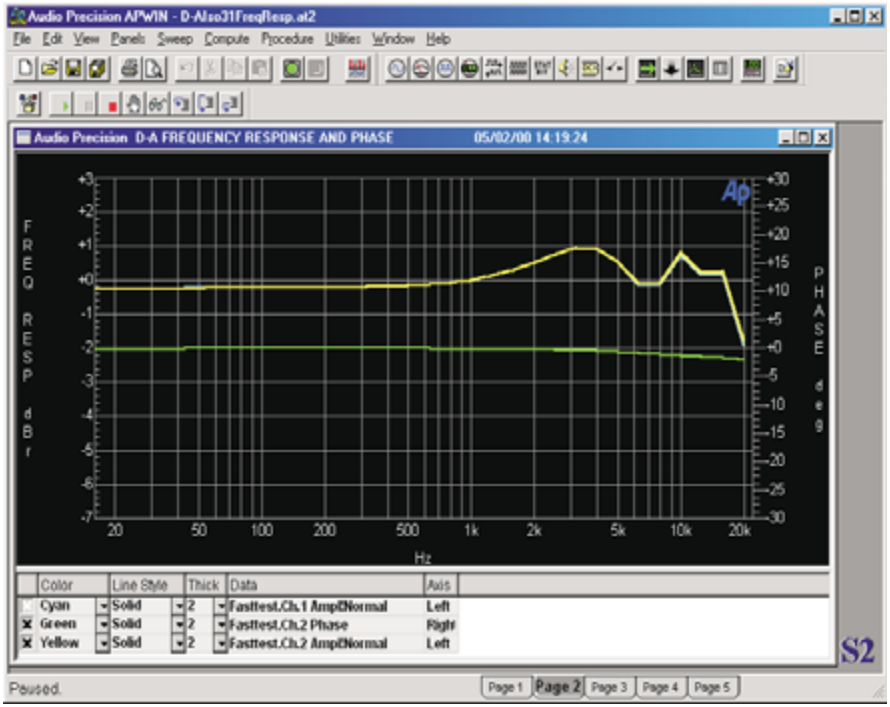
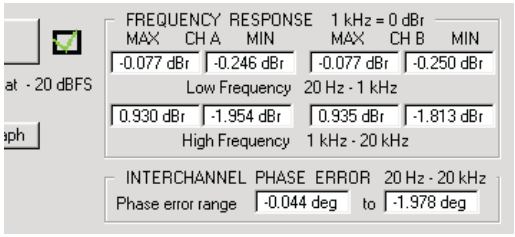


Figure 18 Typical Frequency Response Graph

A line is drawn through the resulting response points to give a graphic representation of frequency response. This response is graphed and also displayed in the **FREQUENCY RESPONSE** and **INTERCHANNEL PHASE** boxes.

Figure 19 Typical Frequency Response Readings



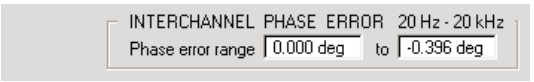
The left group of boxes, as in other areas of the D-to-A MEASUREMENTS panel, show Channel A measurements, while the right group show Channel B. Minima and maxima are shown for each channel in a low-frequency range, 20 Hz to 1 kHz, and also in a

high-frequency range, 1 kHz to 20 kHz. The response values are displayed in dBr units. But notice:

> *0 dBr is re-defined **for the frequency response test only** as the **response test value at 1 kHz.** This gives us the conventional view of response curve data, relative to 1 kHz.*

Interchannel Phase

Figure 20 Typical Interchannel Phase Readings



While the frequency response test is being made, PC Audio Tests also measures the relative phase angle between the channels A and B across the audible spectrum. A graph of this information is shown as a third trace on the response graph, with the maximum deviations displayed in degrees of angle in the two **INTERCHANNEL PHASE** boxes on this panel.

Test Modes

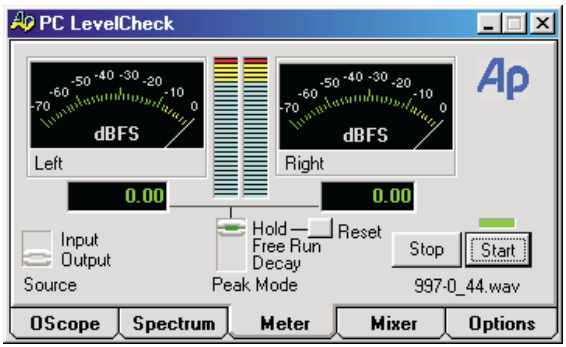
PC Audio Tests has two modes of testing: Automated Mode and Manual Mode. The default condition at installation is Automated Mode. See **Appendix A: Configuration** (page 127) to change modes.

- Automated Mode (which uses PC LevelCheck to automate most functions) is the fastest and easiest way to get test results with PC Audio Tests. See **PC LevelCheck**, next.

- Manual Mode is provided as an alternate solution for situations (due to the wide variations in PC sound card characteristics and control mapping) in which PC LevelCheck will not be able to access certain sound card controls.
  In this case PC LevelCheck will still monitor digital signal levels, but you are guided by screen prompts to make mixer adjustments, .wav file selections and initiate recording and playback manually, steps normally automated by PC LevelCheck.
  Manual Mode performs the same tests and generates the same results as Automated Mode.

PC LevelCheck

Figure 21 PC LevelCheck (shown in Meter mode)



PC LevelCheck is a separate program that is tightly integrated with PC Audio Tests and makes sound card testing easy with these key functions:

- PC LevelCheck accesses, measures and displays the embedded audio in the .wav-file-format PCM signal in the sound card's digital audio signal path.
- PC LevelCheck controls level and muting functions in the volume control mixer and records and plays audio .wav files, under direction the direction of PC Audio Tests.

PC LevelCheck can also be used as a stand-alone program that you may find useful for monitoring audio within your PC. See **Appendix E: PC LevelCheck** (page 149).

Automated Mode Testing

If you have selected Automated Mode (the initial default setting) for your test, you are ready to proceed. Go to **D-to-A Tests** (page 33).

Manual Mode Testing

To use Manual Mode, select the **Manual** option under **Test Mode** on the **EUT** tabbed **Configuration** panel. Instructions on that panel will then provide you with a reminder of Mixer and Media Player settings. See **Appendix A: Configuration** (page 127) to change modes.

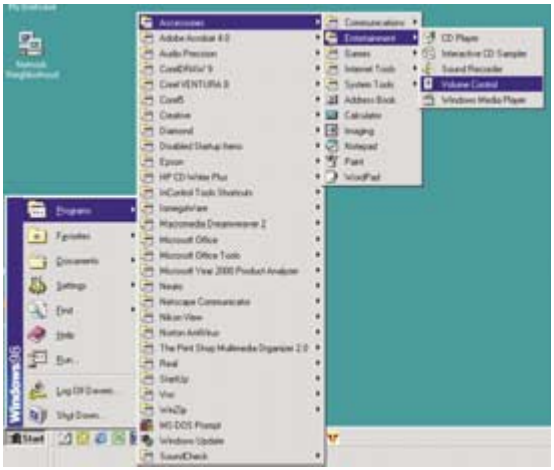
If you have selected Manual Mode for your test, you must launch and set up Volume Control (the Windows mixer), Sound Recorder and Windows Media Player. When you have done this, you can begin the tests. Go to **D-to-A Tests** (page 33).

Launching and configuring multimedia applications

The following instructions for Manual Mode describe the use of standard Windows 98 multimedia interfaces. If you use other Windows controllers or proprietary sound card software, your commands and displays will be different. Be sure all your settings (such as mutes, centered panning, etc.) match the settings recommended below.

Windows Volume Control Mixer Settings

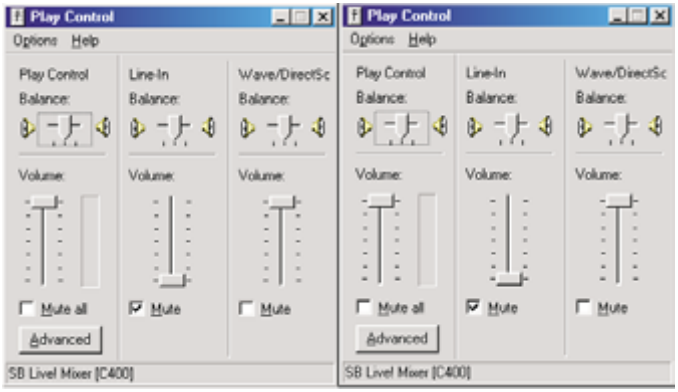
Figure 22 Typical Path to Windows Multimedia Accessories



First open Volume Control (Windows mixer). Click the **Start** button and point to **Programs > Accessories > Entertainment** and click **Volume Control**.

Now repeat the same process to launch Volume Control a second time. Drag the second Windows mixer off the first Windows mixer window.

Figure 23 Windows Volume Control Mixer, launched twice

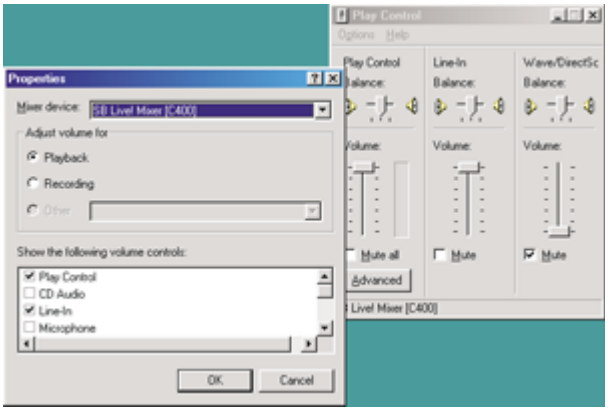


Note: depending on your sound card driver, your playback Mixer may have a different appearance and features.

On one mixer window, click **Options** and then **Properties**. In the box labeled **Adjust volume for** select **Playback**. Then in the list box labeled **Show the following volume controls:** select **Play**

Control, **Line-In** (or **Aux**) and **Wave**. Make sure all other playback volume controls are NOT selected. This is your Play Control mixer. Click **OK** to view the mixer.

Figure 24 Windows Volume Control Mixer, Playback Properties

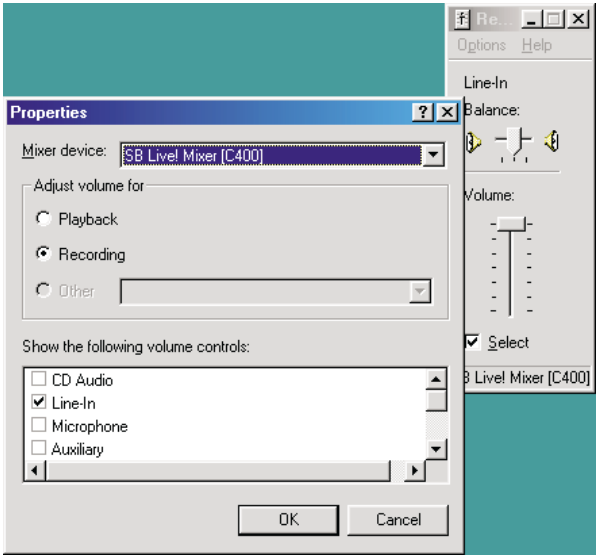


In the second mixer window, click **Options** and then **Properties**. In the box labeled **Adjust volume for** select **Recording**. Then in the list box labeled **Show the following volume controls:** select **Line-In** (or **Aux**). Make sure all other recording volume controls are NOT selected. This is your Record Control mixer. Click **OK** to view the mixer.

On the playback mixer, set the Master or Play Control volume slider to its maximum, and the Wave volume slider to its maximum. Be sure that the Wave channel and the Master Play Control (often labeled "Mute All") channels are NOT muted. Mute all other playback channels. (Line-in should be the only other visible playback channel. Mute it for now.)

If there is no button labeled Advanced on the playback mixer, click **Options > Advanced Controls**. Then click the **Advanced** button and check the Advanced Controls window to be sure that all effects, tone controls, EQ and so on are disabled. Click **Close** to close the Advanced Controls window.

Figure 25 Windows Volume Control Mixer, Recording Properties



On the record mixer, select the **Line In** channel (it should be the only channel visible and should already be selected) and set the Line In volume slider to maximum.

On both mixers, check that the balance or pan sliders are centered or disabled.

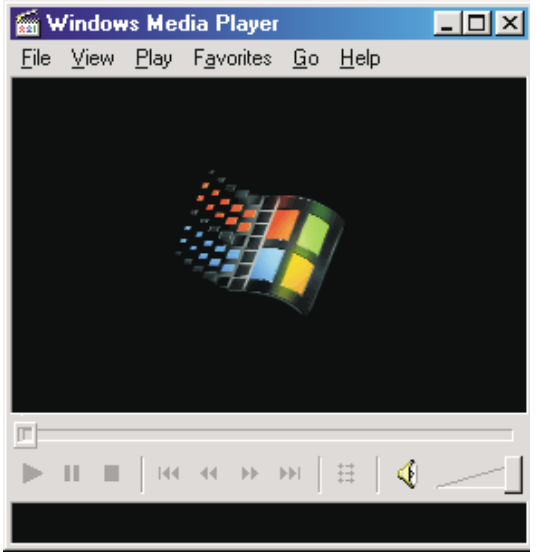
Leave the mixers open and drag them to the edge of your screen for convenient adjustments later in the tests.

Windows Media Player Settings

Windows Media Player will play a number of media files, including .wav audio files. It is particularly useful in running D-to-A tests in manual mode because of the "Repeat Forever" option that allows endless looping of a playback file. Open Windows Media Player. Click the **Start** button and point to **Programs > Accessories > Entertainment** and click **Windows Media Player**. Under **Options**, set **Auto Repeat** or **Repeat Forever**.

Leave Media Player open so you can load, play and stop .wav files during your tests. Drag the window to the edge of your screen.

Figure 26 Windows Media Player



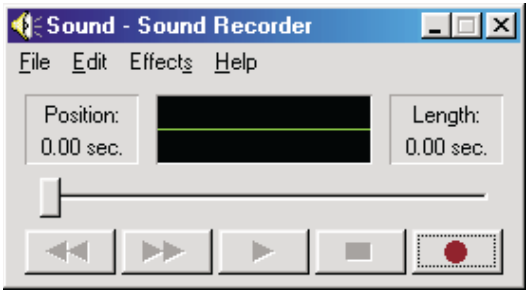
Windows Sound Recorder Settings

Open Windows Sound Recorder. Click the **Start** button and point to **Programs > Accessories > Entertainment** and click **Sound Recorder**. Under **File**, click **Save As** and browse to the folder where you want to save your test recordings, usually C:\Apwin\PC Sound Card Tests\. Choose a name for your test file (usually A.wav) and enter it in the File Name box.

In the Format area, click **Change…**. In the **Name** box, choose **CD Quality** to select **PCM, 44,100 Hz 16 Bit, Stereo, 172KB/s.**

Leave Sound Recorder open so you can record .wav files during your tests. Drag the window to the edge of your screen.

Figure 27 Windows Sound Recorder



Here are a few tips on using Sound Recording with PC Audio Tests:

- Although far from an accurate graphical display, the waveform window in Sound Recorder can be handy to determine if there is signal being recorded, or if the signal is badly distorted.
- Remember to save your .wav file each time you stop recording. PC Audio Tests regularly erases the A.wav test files to be assured of current data, and if you forget to save the file after each recording pass you may see a "File not found" error message.
- You only need to record a few seconds for each test. PC Audio Tests only takes data from near the beginning of the .wav file (after a short period of time to allow the recording to stabilize).

D-to-A Tests

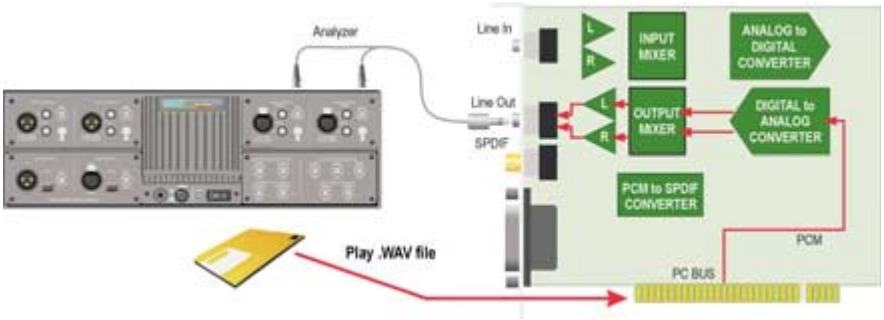


Figure 28 PC Audio Tests: the D-to-A Test Group

What the D-to-A tests do

See **What the tests do** (page 14) in the **Introduction** for an overview of the common functions of all the test groups.

The D-to-A group of tests measures the characteristics of the EUT's digital-to-analog conversion of .wav test files, and of the analog output circuitry of the device. These D-to-A tests satisfy Microsoft WHQL standard TM002.

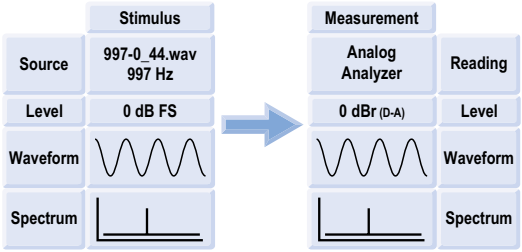
Using the D-to-A tests you will measure the analog output level of the EUT when playing a 0 dB FS digital signal and set that level as a reference. Then you will measure total harmonic distortion plus noise (THD+N), dynamic range and frequency response for the digital-to-analog functions of the EUT.

The D-to-A Reference Level setting must be performed before the other tests in this group, since these results are considered in subsequent calculations.

D-to-A Reference Level

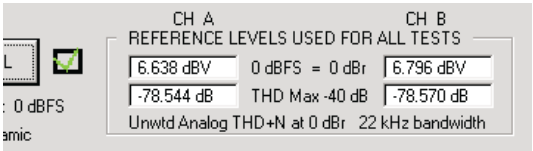
As discussed in **What the tests do** (page 14) in the **Introduction**, this test calibrates PC Audio Tests and System Two to your particular sound device for the D-to-A signal path.

Figure 29 Setting D-to-A Reference Level



First PC Audio Tests plays a 0 dB FS .wav file, and then the output levels of the EUT are measured. Once found, these levels are entered in APWIN as 0 dBr reference values for the line output of each channel. Since a 0 dB FS digital signal was used to generate these results, 0 dBr (D-A) = 0 dB FS.

Figure 30 D-to-A Reference Level Readings

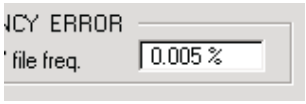


In the example shown, channel A has a result of 0.876 dBV, while channel B shows 0.835 dBV. This is the analog output level at the line output jack that results from playback of a full level 0 dB FS .wav file. These become the 0 dBr (D-A) reference output levels for all further tests that involve line output of a .wav file playback.

D-to-A Sampling Frequency Error

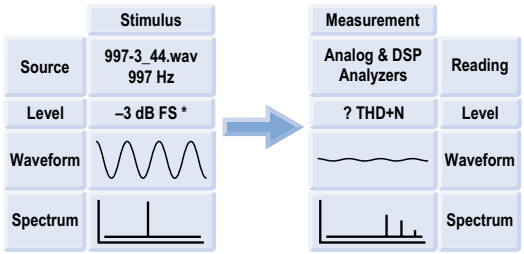
This measurement is actually made during the **SET D-A REFERENCE LEVEL** test, even though the result is displayed at the bottom of the panel. PC Audio Tests measures the frequency of the converted signal from the .wav file, which is known to be 997 Hz. Any variation is due to sampling frequency error in the EUT D-to-A converter, and the percentage of error is displayed here.

Figure 31 D-to-A Sampling Frequency Error Reading



D-to-A THD+N Distortion and Noise

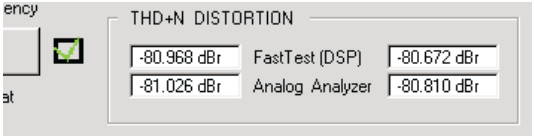
Figure 32 D-to-A THD+N Test



As discussed in **What the tests do** (page 14) in the **Introduction**, this test measures the total harmonic distortion and noise (THD+N) found in the EUT D-to-A signal path under test conditions.

** The stimulus level of –3 dB FS shown in the diagram is an option, one of four stimulus levels available for THD+N testing in setting up PC Audio Tests. See **Appendix A: Configuration** (page 127). The level chosen is displayed on-screen in the small box below the THD+N DISTORTION button.*

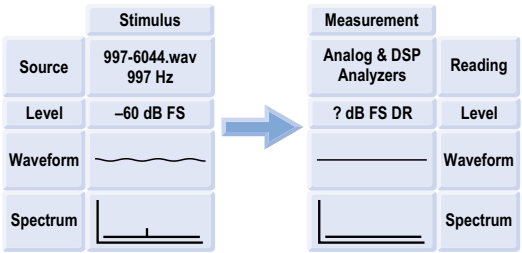
Figure 33 D-to-A THD+N Readings



The upper pair of DISTORTION boxes show the THD+N results for the *FAST*TEST DSP technique, and the lower pair of boxes show the results from the Analog Distortion Analyzer. In the example shown the readings are between –84 dBr and –85 dBr. Notice the slight variations in the readings between the two methods. See **Appendix F: THD+N Techniques** (page 159).

D-to-A Dynamic Range

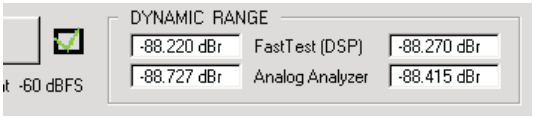
Figure 34 D-to-A Dynamic Range Test



As discussed in **What the tests do** (page 14) in the **Introduction**, this test measures the dynamic range of the EUT D-to-A signal path under test conditions, using a –60 dB FS stimulus.

A level of precisely –60 dB FS is not possible in a 16-bit digital system. The exact level used in this test is –59.94 dB FS.

Figure 35 D-to-A Dynamic Range Readings

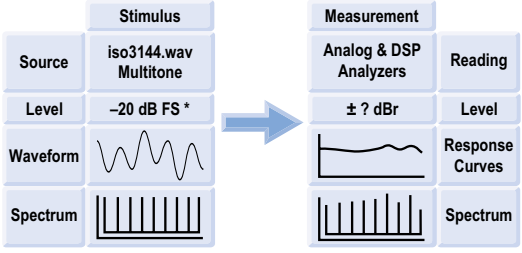


PC Audio Tests uses both the *FAST*TEST (DSP) FFT technique and the traditional analog notch filter technique to produce two slightly different views of the noise signal and therefore two slightly different dynamic range figures.

D-to-A Frequency Response

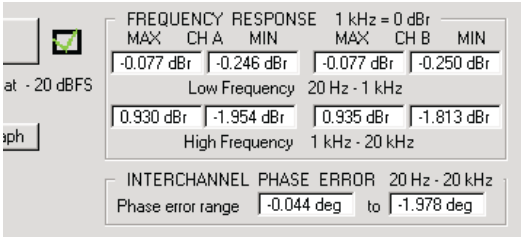
As discussed in **What the tests do** (page 14) in the **Introduction**, this test measures the frequency response through the EUT D-to-A signal path under test conditions.

Figure 36 D-to-A Frequency Response Test



While the response curve graph is on the screen, you have access to the APWIN graph options panel. The maximum and minimum response data are also reported in the FREQUENCY RESPONSE boxes on the test panel.

Figure 37 D-to-A Frequency Response and Interchannel Phase Readings



D-to-A Interchannel Phase

While the frequency response test is being made, PC Audio Tests also measures the relative phase angle between the channels A and B across the audible spectrum. A graph of this information is shown as a third trace on the response graph, with the maximum deviations displayed in degrees of angle in the two **INTERCHANNEL PHASE** boxes on this panel.

Running D-to-A Tests in AUTOMATED MODE

We recommend that you run your tests in Automated Mode (using PC LevelCheck) whenever possible. If PC LevelCheck cannot control your sound device driver software, you must use Manual Mode. See **Test Modes** (page 24).

*If you choose not to use Automated Mode, you can skip this section and go directly to **Running D-to-A Tests in Manual Mode** (page 43).*

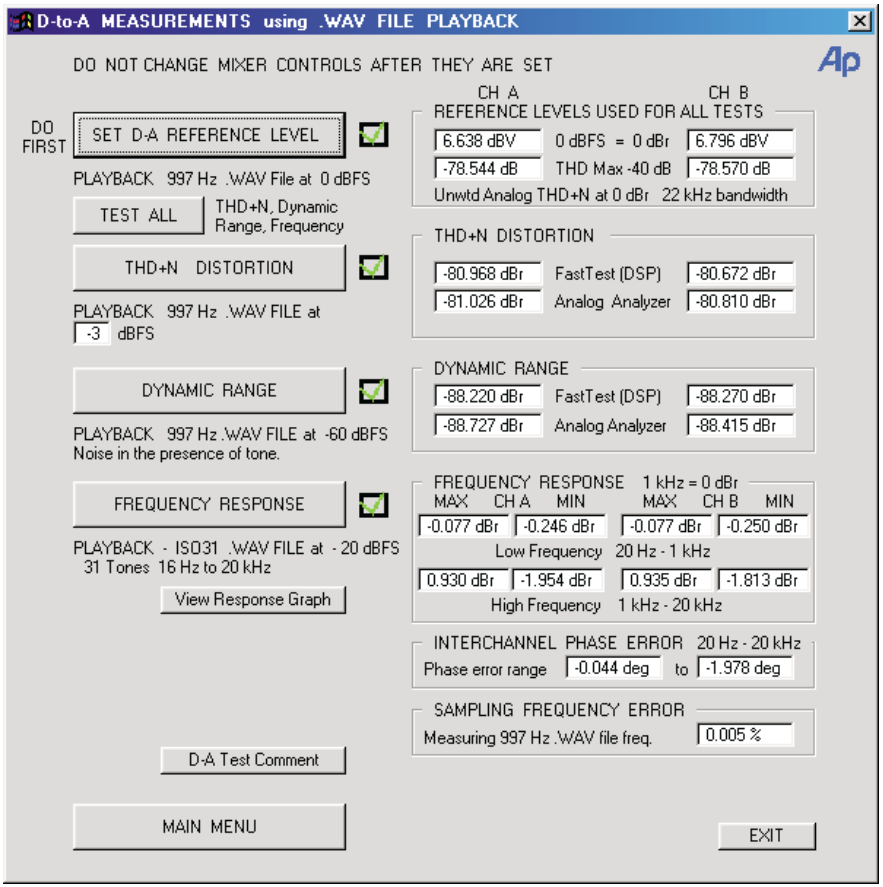


Figure 38 D-to-A Measurements Panel

Click the **D-to-A** button on the Main Menu to begin the test series. The D-to-A MEASUREMENTS test panel will appear.

SET D-A REFERENCE LEVEL

Set D-to-A Reference Level: Automated Mode

Click the **SET D-A REFERENCE LEVEL** button. In Automated Mode the test will proceed on its own, calling PC LevelCheck, adjusting volume levels, playing the .wav file and displaying its progress as it runs, then returning to the D-to-A MEASUREMENTS panel.

Figure 39 D-to-A Reference Level Readings

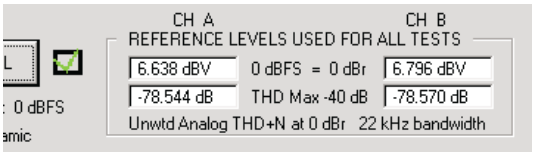
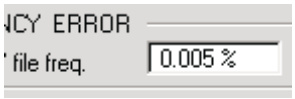


Figure 40 D-to-A Sampling Frequency Error Reading



Notice that the four display boxes to the right of the **SET D-A REFERENCE LEVEL** button now show test results, as does the **Sampling Frequency Error** box at the bottom of the panel.

When this test has been successfully completed, a green check mark appears to the right of the **SET D-A REFERENCE LEVEL** button.

TEST ALL

Test All

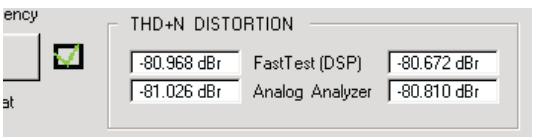
The **TEST ALL** button runs all of the next three tests in succession.

THD+N DISTORTION

D-to-A THD+N Distortion: Automated Mode

To begin the test, click the **THD+N Distortion** button. In Automated Mode the test will proceed on its own, displaying its progress as it runs and quickly returning you to the D-to-A MEASUREMENTS panel. The four display boxes to the right of the **THD+N DISTORTION** button now show test results.

Figure 41 D-to-A THD+N Readings



If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

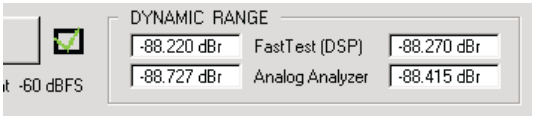
When this test has been successfully completed, a green check mark appears to the right of the **THD+N DISTORTION** button.

DYNAMIC RANGE

D-to-A Dynamic Range: Automated Mode

To run the test, click the **DYNAMIC RANGE** button. In Automated Mode the test will proceed on its own, displaying its progress as it runs and quickly returning you to the D-to-A MEASUREMENTS panel. The four display boxes to the right of the **DYNAMIC RANGE** button now show test results.

Figure 42 D-to-A Dynamic Range Readings



If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

When this test has been successfully completed, a green check mark appears to the right of the **DYNAMIC RANGE** button.

FREQUENCY RESPONSE

D-to-A Frequency Response: Automated Mode

Click the **FREQUENCY RESPONSE** button to begin the test.

As the test is running, you will see an APWIN graph of frequency and phase response rendered on your screen. If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

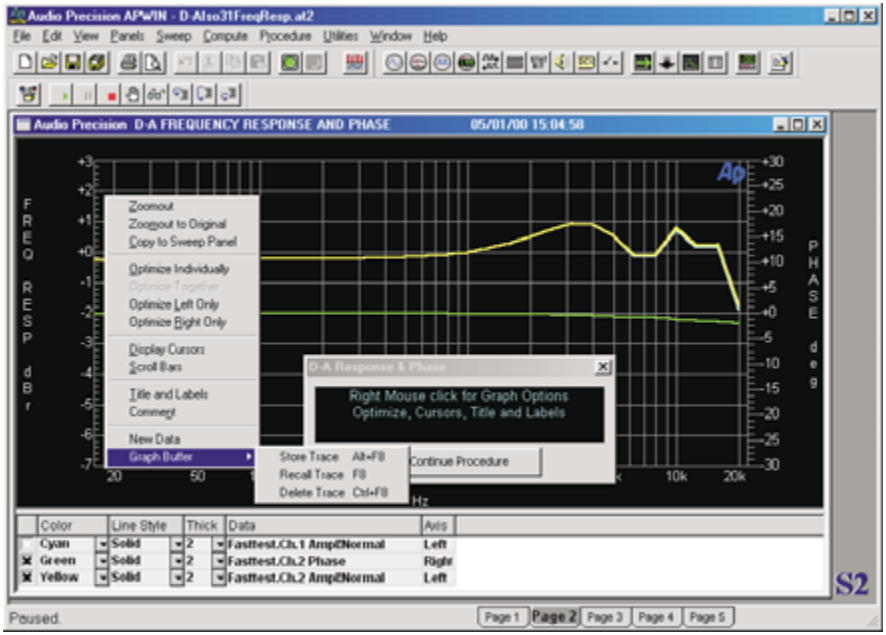
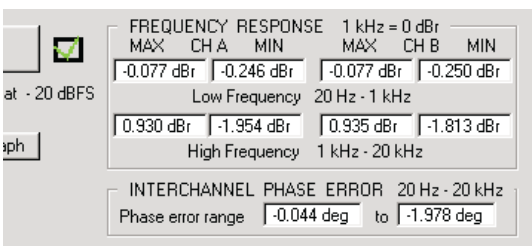


Figure 43 D-to-A Frequency Response Graph Windows with graph options shown

The prompt that appears on the graph gives you access to the APWIN Graph Menu (right click on the graph) for viewing and formatting options. When you are through viewing the graph, click **Continue Procedure.** PC Audio Tests computes the maximum and minimum deviations for both frequency response and phase response and then returns you to the D-to-A MEASUREMENTS panel.

Notice that the **FREQUENCY RESPONSE** and **INTERCHANNEL PHASE** display boxes now contain the computed maximum and minimum values.

Figure 44 D-to-A Frequency Response and Interchannel Phase Readings



When this test has been successfully completed, a green check mark appears to the right of the **FREQUENCY RESPONSE** button.

View Response Graph

View Response Graph

Once the Frequency Response test has been performed, you may return to view the response curve again by clicking **View Response Graph**. This dialog box will appear:

*Figure 45 Graph **Save Test–Set Panels** Window*

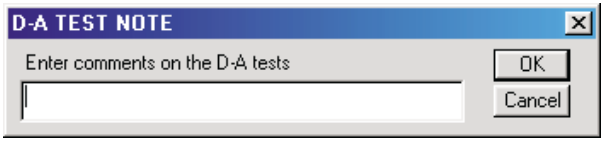
Click **Save Test** to save the graph data as an .ada or .at2 file (an option selectable on the Configuration: Data panel). See **Appendix A: Setting Preferences in Configuration** (page 127). The **Graph, Panel Setup** button calls up a prompt and access to the APWIN Graph Menu (right click on the graph) for graph viewing and formatting options. Click **CONTINUE** to return to the test panel.

D-A Test Comment

D-to-A Test Report Comments

All test data is stored in memory for later retrieval for an optional report. If you would like to add a short comment to the D-to-A section of the test report, click the **D-A Test Comment** button.

Figure 46 D-to-A Test Report Comments



This completes the D-to-A testing of your PC sound device. You may generate a report now by returning to the Main Menu and clicking **Create Test Report**, or you can go to the next set of tests and generate your report later. See **Creating Test Reports** (page 123).

If you leave the program at this point but return later to perform more tests, you must reset your D-to-A reference level See **Set D-to-A Reference Level: Automated Mode** (page 39). Subsequent tests require the results of this test as reference values.

Running D-to-A Tests in MANUAL MODE

We recommend that you run your tests in Automated Mode (using PC LevelCheck) whenever possible. If PC LevelCheck cannot control your sound device driver software, you must use Manual Mode. See **Test Modes** (page 24).

*If you can use Automated Mode, you should skip this section and go directly to **Running D-to-A Tests in Automated Mode** (page 38).*

You will need Windows Volume Control mixer and Windows Media Player on your desktop to run D-to-A tests in Manual Mode. Follow the instructions below:

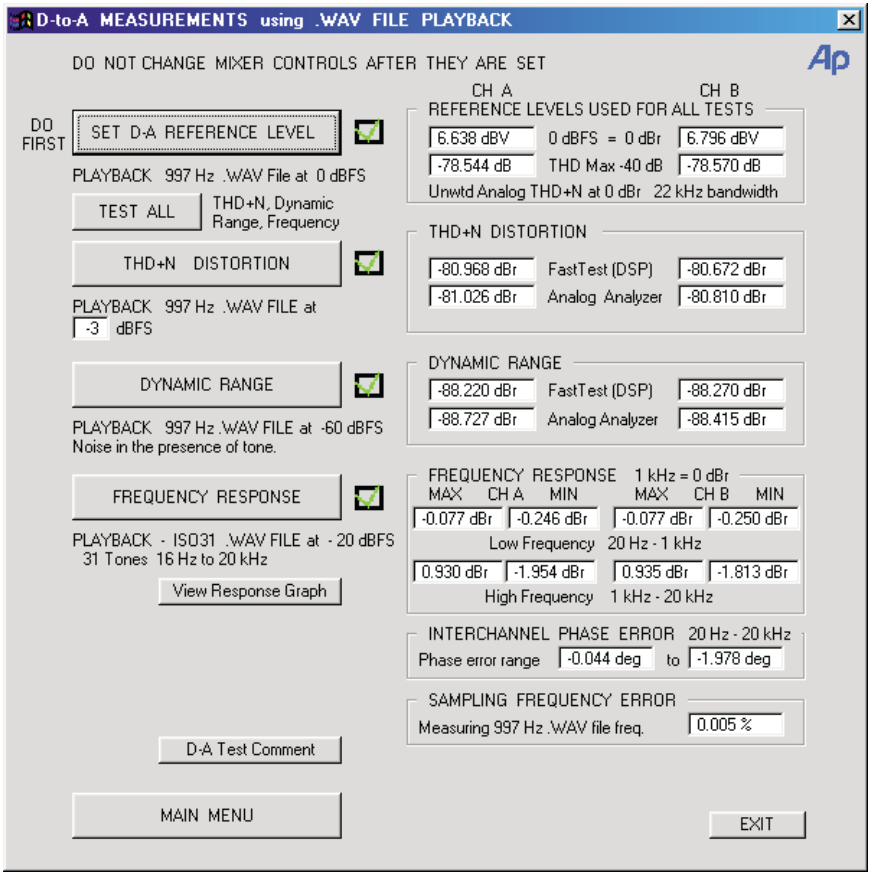


Figure 47 D-to-A Measurements Panel

Click the **D-to-A** button on the Main Menu to begin the test series. The D-to-A MEASUREMENTS test panel will appear.

SET D-A REFERENCE LEVEL

Set D-to-A Reference Level: Manual Mode

You must have Windows Volume Control playback mixer and Windows Media Player on screen.

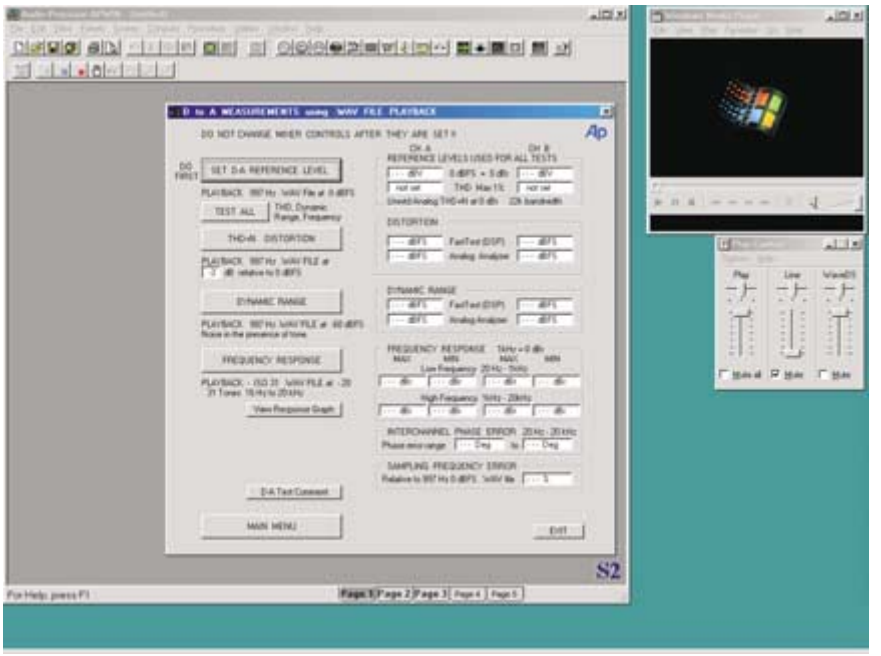


Figure 48 Desktop Setup for D-to-A Manual Mode Testing

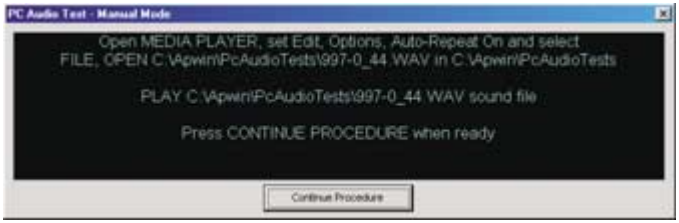
First you will check mixer settings, and then load and play a reference .wav file. System Two will measure the analog output level and set 0 dBr in APWIN to that level. Since a 0 dB FS digital signal was used to generate these results, 0 dBr (D-A) = 0 dB FS.

Click the **SET D-A REFERENCE LEVEL** button. The following prompt will appear:

Figure 49 D-to-A Reference Level Playback Mixer Settings Prompt

Follow the instructions on the prompt to check all your mixer settings. When you have verified the settings, click **Continue Procedure** to see the next prompt.

Figure 50 D-to-A Reference Level Media Player Settings Prompt



The second prompt instructs you to load a file into Media Player and guides you to the file location.

Choose the .wav file that is appropriate for your test from these selections:

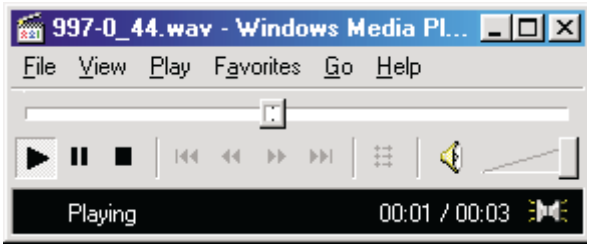
File Name	Reference Level	Sample Rate
997-0_44.wav	0 dB FS	44.1 kHz
997-0_48.wav	0 dB FS	48 kHz

When you use the **Browse** button to look for the file, it will be easier if you set the **Files of type:** selection in the browser window to **Audio Files.**

Be sure **Auto Repeat** / **Repeat forever** are still set as options in Media Player. When the file is loaded it should begin to play. If the file does not play automatically, click the ▶ play arrow. Check again to see

that the Media Player mute is not set, and that the volume slider is set at maximum.

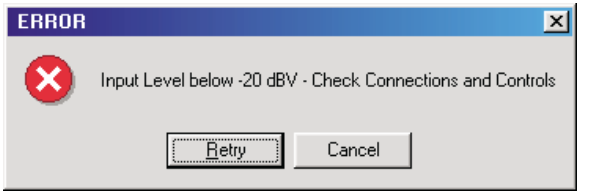
Figure 51 Windows Media Player



With Media Player is playing back the .wav file click **Continue Procedure** to move on. At the completion of the test, you may want to click the ■ stop button on Media Player to interrupt playback of the .wav file.

Display boxes will advise you of progress as the test proceeds. If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

Figure 52 D-to-A Measurements Low Level Error Warning



When the test is complete you will return to the D-to-A MEASUREMENTS panel.

Figure 53 D-to-A Reference Level Readings

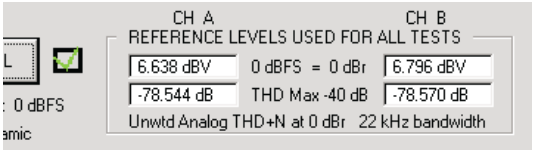
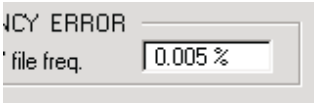


Figure 54 D-to-A Sampling Frequency Error Reading



Notice that the four display boxes to the right of the **SET D-A REFERENCE LEVEL** button now show test results, as does the **Sampling Frequency Error** box at the bottom of the panel.

TEST ALL

Test All

The **TEST ALL** button runs all of the next three tests in succession.

THD+N DISTORTION

D-to-A THD+N Distortion: Manual Mode

Be sure you have your playback mixer and Windows Media Player on screen. To begin the test, click the **THD+N Distortion** button. The following prompt will appear:

Figure 55 D-to-A THD+N Media Player Settings Prompt

This prompt instructs you to load a new file into Media Player and shows the path to the correct folder. The .wav file appropriate for your test is indicated on the prompt, and is chosen from these selections:

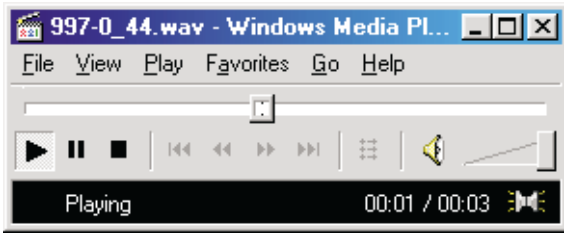
File Name	Stimulus Level	Sample Rate
997-0_44.wav	0 dB FS	44.1 kHz
997-0_48.wav	0 dB FS	48 kHz
997-1_44.wav	-1 dB FS	44.1 kHz
997-1_48.wav	-1 dB FS	48 kHz
997-3_44.wav	-3 dB FS	44.1 kHz
997-3_48.wav	-3 dB FS	48 kHz
997-6_44.wav	-6 dB FS	44.1 kHz
997-6_48.wav	-6 dB FS	48 kHz

When you use the **Browse** button to look for the file, it will be easier if you set the **Files of type:** selection in the browser window to **Audio Files.**

Be sure **Auto Repeat** / **Repeat Forever** are still set as Options. When the file is loaded it should begin to play. If the file does not play

automatically, click the ▶ play arrow. Check again to see that the Media Player ◀ mute is not set, and that the volume slider is set at maximum.

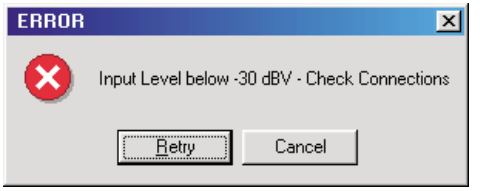
Figure 56 Windows Media Player



With Media Player is playing back the .wav file click **Continue Procedure** to move on. At the completion of the test, you may want to click the ■ stop button on Media Player to interrupt playback of the .wav file.

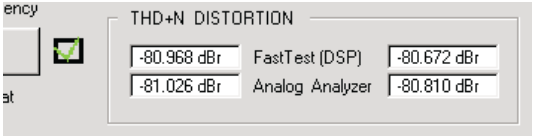
Display boxes will advise you of progress as the test proceeds. If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

Figure 57 Low Input Level Warning



The test will quickly run to completion and return you to the D-to-A MEASUREMENTS panel.

Figure 58 D-to-A THD+N Readings



You will notice that the four display boxes to the right of the **THD+N DISTORTION** button now show test results. The two upper boxes show the THD+N results for the *FAST*TEST DSP technique, and the two lower boxes show the results from the Analog Distortion Analyzer.

When this test has been successfully completed, a green check mark appears to the right of the **THD+N DISTORTION** button.

DYNAMIC RANGE

D-to-A Dynamic Range: Manual Mode

Be sure you have your playback mixer and Windows Media Player on screen. To run the test, click the **DYNAMIC RANGE** button. The following prompt will appear:

Figure 59 D-to-A Dynamic Range Media Player Settings Prompt

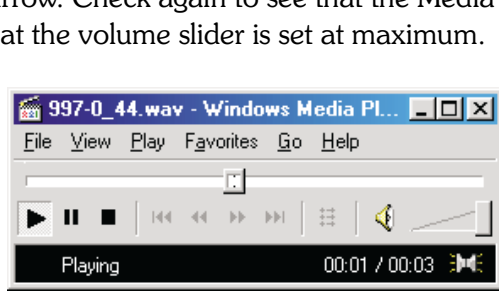
This prompt instructs you to load a new file into Media Player and shows the path to the correct folder. The .wav file appropriate for your test is indicated on the prompt, and is chosen from these selections:

File Name	Level	Sample Rate
997-6044.wav	-60 dB FS	44.1 kHz
997-6048.wav	-60 dB FS	48 kHz

When you use the **Browse** button to look for the file, it will be easier if you set the **Files of type:** selection in the browser window to **Audio Files.**

Be sure **Auto Repeat** / **Repeat forever** are still set as options. When the file is loaded it should begin to play. If the file does not play automatically, click the ▶ play arrow. Check again to see that the Media Player ◀ mute is not set, and that the volume slider is set at maximum.

Figure 60 Windows Media Player



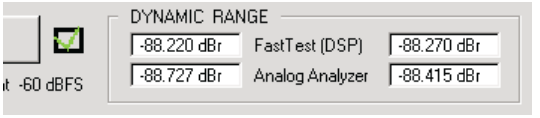
With Media Player is playing back the .wav file click **Continue Procedure** to move on. At the completion of the test, you may want

to click the ■ stop button on Media Player to interrupt playback of the .wav file.

Display boxes will advise you of progress as the test proceeds. If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

When the test is complete you will return to the D-to-A MEASUREMENTS panel.

Figure 61 D-to-A Dynamic Range Readings



You will notice that the four display boxes to the right of the **DYNAMIC RANGE** button now show test results.

When this test has been successfully completed, a green check mark appears to the right of the **DYNAMIC RANGE** button.

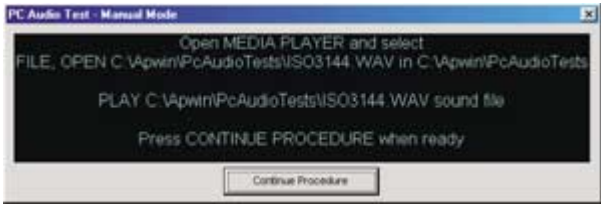
FREQUENCY RESPONSE

D-to-A Frequency Response: Manual Mode

The last test on this panel is the frequency response test.

Be sure you have your playback mixer and Windows Media Player on screen. Click the **FREQUENCY RESPONSE** button to begin the test. The following prompt will appear:

Figure 62 D-to-A Frequency Response Media Player Settings Prompt



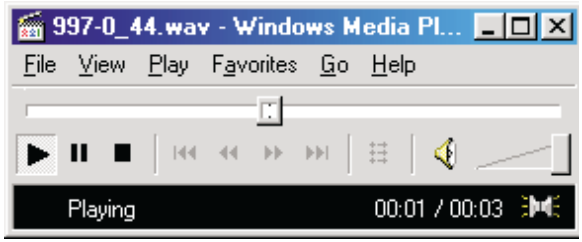
This prompt instructs you to load a new file into Media Player and shows the path to the correct folder. The .wav file appropriate for your test is indicated on the prompt, and is chosen from these selections:

File Name	Multitone Level *	Sample Rate
iso3144.wav	-20 dB FS	44.1 kHz
iso3148.wav	-20 dB FS	48 kHz

When you use the **Browse** button to look for the file, it will be easier if you set the **Files of type:** selection in the browser window to **Audio Files.**

Be sure **Auto Repeat** / **Repeat Forever** are still set as options. When the file is loaded it should begin to play. If the file does not play automatically, click the ▶ play arrow. Check again to see that the Media Player ◀ mute is not set, and that the volume slider is set at maximum.

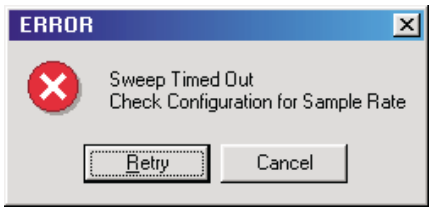
Figure 63 Windows Media Player



When Media Player is playing back the wave file, click **Continue Procedure** to move on.

As the test is running, you will see an APWIN graph of frequency and phase response rendered on your screen. If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

Figure 64 Sweep Timed Out Error Warning



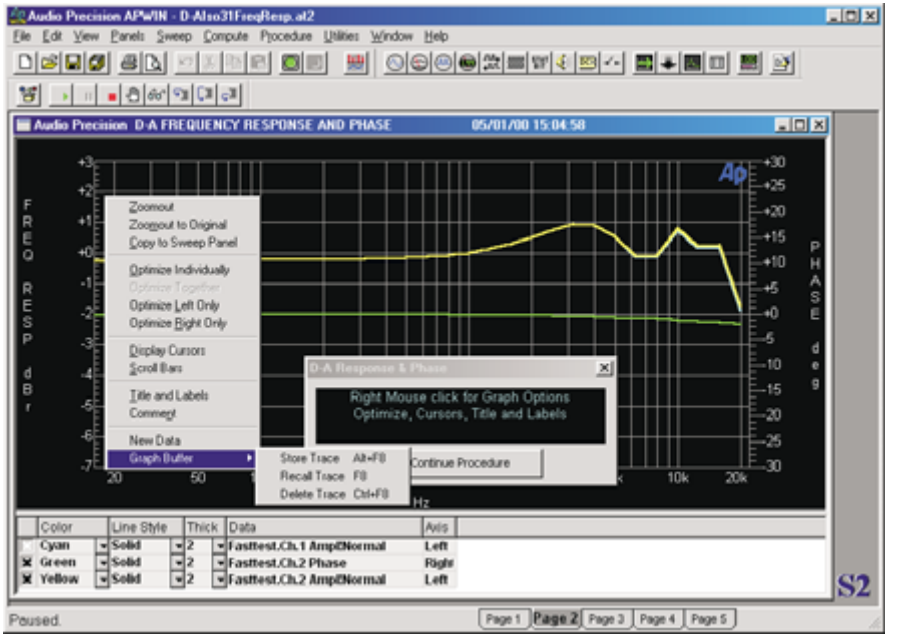
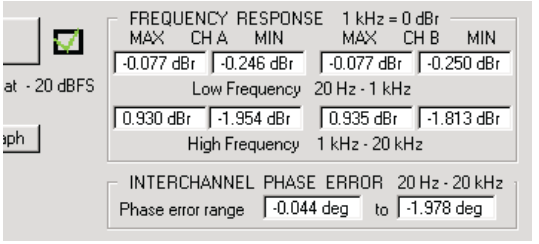


Figure 65 D-to-A Frequency Response Graph Windows

The prompt that appears on the graph gives you access to the APWIN Graph Menu (right click on the graph) for viewing and formatting options. When you are through viewing the graph, click **Continue Procedure**. PC Audio Tests computes the maximum and minimum deviations for both frequency response and phase response and then returns you to the D-to-A MEASUREMENTS panel.

Notice that the **FREQUENCY RESPONSE** and **INTERCHANNEL PHASE** display boxes now contain measurements.

Figure 66 D-to-A Frequency Response and Interchannel Phase Readings



When this test has been successfully completed, a green check mark appears to the right of the **FREQUENCY RESPONSE** button.

View Response Graph

View Response Graph

Once the Frequency Response test has been performed, you may return to view the response curve again by clicking **View Response Graph**. This dialog box will appear:

*Figure 67 Graph **Save Test– Set Panels** Window*

Click **Save Test** to save the graph data as an .ada or .at2 file (an option selectable on the Configuration: Data panel). See **Appendix A: Setting Preferences in Configuration** (page 127). The **Graph, Panel Setup** button calls up a prompt and access to the APWIN Graph Menu (right click on the graph) for graph viewing and formatting options. Click **CONTINUE** to return to the test panel.

D-A Test Comment

D-to-A Test Report Comments

All test data is stored in memory for later retrieval for an optional report. If you would like to add a short comment to the D-to-A section of the test report, click the **D-A Test Comment** button.

Figure 68 D-to-A Test Report Comments

This completes the D-to-A testing of your PC sound device. You may generate a report now by returning to the Main Menu and clicking **Create Test Report**, or you can go to the next set of tests and generate your report later. See **Creating Test Reports** (page 123).

If you leave the program at this point but return later to perform more tests, you must reset your D-to-A reference level. See **Set D-to-A Reference Level: Manual Mode** (page 44). Subsequent tests require the results of this test as reference values.

A-to-A Tests

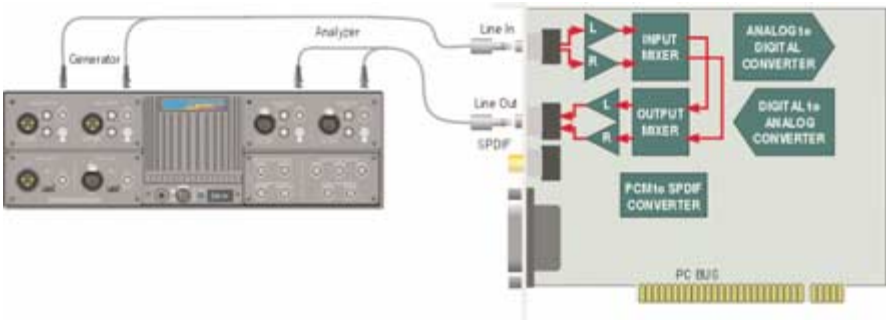


Figure 69 PC Audio Tests: the A-to-A Test Group

What the A-to-A tests do

See **What the tests do** (page 14) in the **Introduction** for an overview of the common functions of all the test groups.

The A-to-A group of tests measures the characteristics of the EUT's analog input and output circuitry, in a configuration sometimes called *analog loop* or *monitor loop*. These A-to-A tests satisfy Microsoft WHQL standard TM001.

First, you will set the internal analog input level to produce just under 1% distortion at the EUT's analog output and set that as a reference. Then you will measure total harmonic distortion plus noise (THD+N), dynamic range and frequency response for the analog-to-analog functions of the EUT.

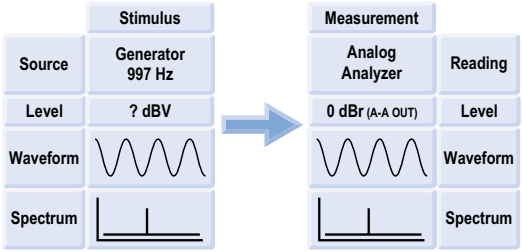
The A-to-A Reference Level setting must be performed before the other tests in this group, since these results are considered in subsequent calculations.

Also, it is helpful if you have set the reference levels in the D-to-A group of tests before you attempt to perform the A-to-A tests here.

A-to-A Reference Level

As discussed in **What the tests do** (page 14) in the **Introduction**, this test calibrates PC Audio Tests and System Two to your particular sound device for the A-to-A signal path.

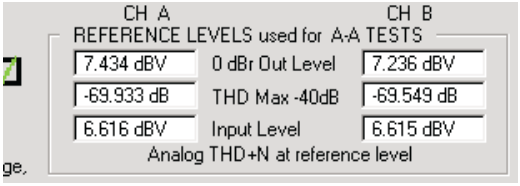
Figure 70 Setting A-to-A Reference Level



PC Audio Tests sets a test level for the System Two analog generator, initially using the same value measured for the EUT's analog output 0 dBr (D-A), determined in the D-to-A set of tests. If that value has not been set, you should return to that panel and reset the D-to-A reference level. In the absence of this information, PC Audio Tests initially sets the generator to +6 dBV (2 V rms) for unbalanced operation, or +20 dBV (10 V rms) for balanced operation.

While monitoring the EUT's output, PC Audio Tests adjusts the Line-In slider on the Record Mixer until the maximum level that renders an output with less than 1% THD+N is determined. When this point is found, the output levels are set as output 0 dBr (A-A) references, and the input levels and THD+N under these conditions are entered in the boxes in the A-to-A panel.

Figure 71 A-to-A Reference Level Readings

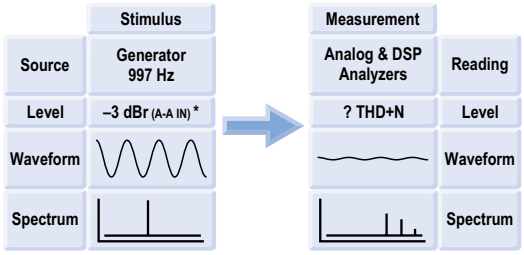


In the example shown, the top pair of boxes show channel A having a 0 dBr reference level of 3.327 dBV, while channel B shows 3.366 dBV. This is the analog output level at the line output jack, at a level just below the point that produces 1% distortion in the analog loop. The actual distortion measured at these levels is shown in the next pair of boxes. The input level required to create these conditions is show in the lowest pair of boxes. The 0 dBr (A-A) output levels become

the references for the THD+N and Dynamic Range tests on this panel, and a second option for the initial analog input level estimate for the A-to-D reference level test.

A-to-A THD+N Distortion and Noise

Figure 72 A-to-A THD+N Test



As discussed in **What the tests do** (page 14) in the **Introduction**, this test measures the total harmonic distortion and noise (THD+N) found in the EUT A-to-A signal path under test conditions.

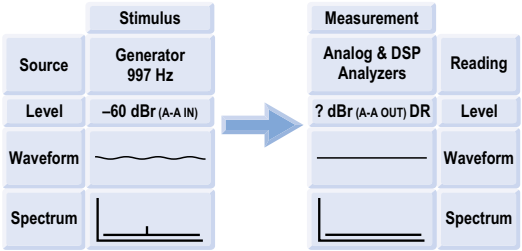
** The stimulus level of –3 dB FS shown in the diagram is an option, one of four stimulus levels available for THD+N testing in setting up PC Audio Tests. See **Appendix A: Configuration** (page 127). The level chosen is displayed on-screen in the small box below the THD+N DISTORTION button.*

Figure 73 A-to-A THD+N Readings

The upper pair of boxes show the THD+N results for the *FAST*TEST DSP technique, and the lower pair of boxes show the results from the Analog Distortion Analyzer. In the example shown the readings are between –85 dBr and –87 dBr. Notice the slight variations in the readings.

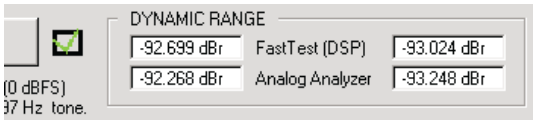
A-to-A Dynamic Range

Figure 74 A-to-A Dynamic Range Test



As discussed in **What the tests do** (page 14) in the **Introduction**, this test measures the dynamic range of the EUT A-to-A signal path under test conditions, using a –60 dB FS stimulus.

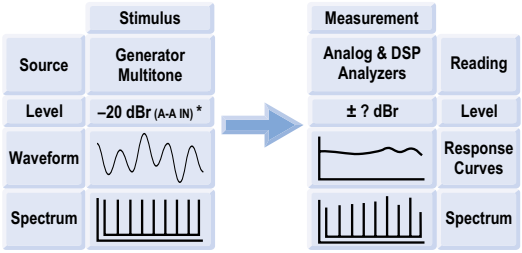
Figure 75 A-to-A Dynamic Range Readings



PC Audio Tests uses both the *FAST*TEST (DSP) FFT technique and the traditional analog notch filter technique to produce two slightly different views of the noise signal and therefore two slightly different dynamic range figures.

A-to-A Frequency Response

Figure 76 A-to-A Frequency Response Test

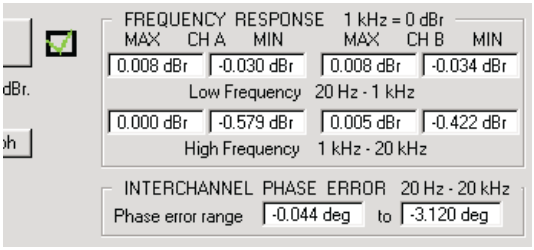


As discussed in **What the tests do** (page 14) in the **Introduction**, this test measures the frequency response through the EUT A-to-A signal path under test conditions.

While the response curve graph is on the screen, you have access to the APWIN graph options panel. The maximum and minimum

response data are also reported in the FREQUENCY RESPONSE boxes on the test panel.

Figure 77 A-to-A Frequency Response and Interchannel Phase Readings



A-to-A Interchannel Phase

While the frequency response test is being made, PC Audio Tests also measures the relative phase angle between the channels A and B across the audible spectrum. A graph of this information is shown as a third trace on the response graph, with the maximum deviations displayed in degrees of angle in the two **INTERCHANNEL PHASE** boxes on this panel.

Running A-to-A Tests in AUTOMATED MODE

We recommend that you run your tests in Automated Mode (using PC LevelCheck) whenever possible. If PC LevelCheck cannot control your sound device driver software, you must use Manual Mode. See **Test Modes** (page 24).

*If you choose not to use Automated Mode, you can skip this section and go directly to **Running A-to-A Tests in Manual Mode** (page 66).*

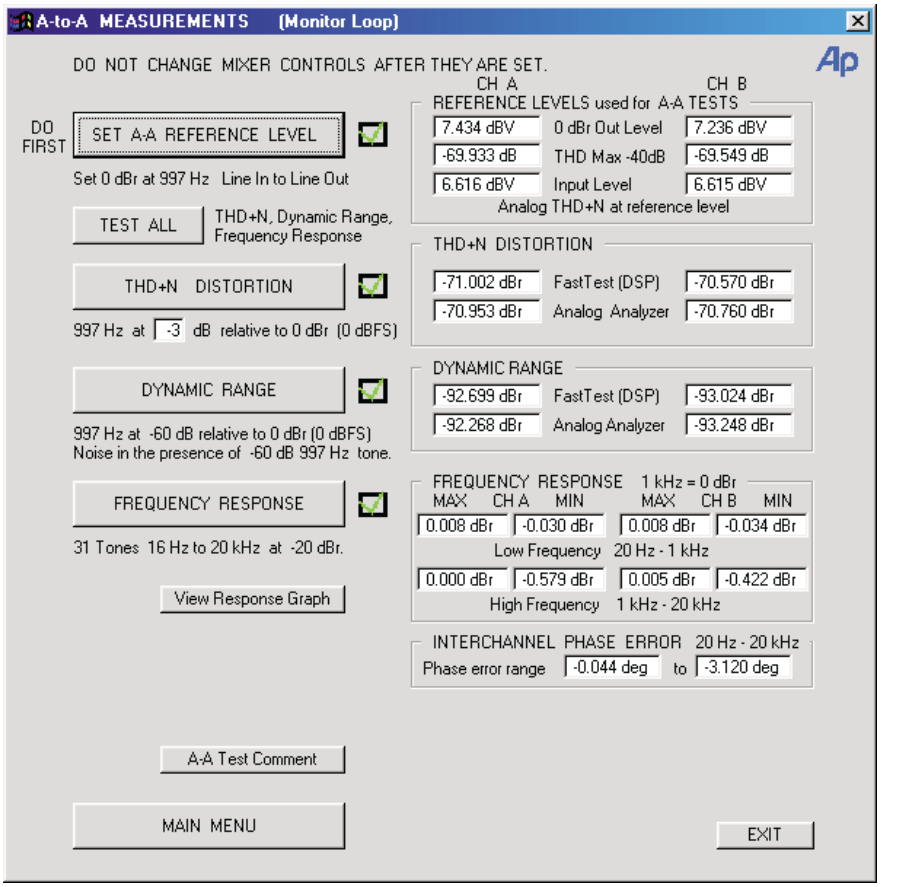


Figure 78 A-to-A Measurements Panel

Click the **A-to-A** button on the Main Menu to begin the test series. The A-to-A MEASUREMENTS test panel will appear.

SET AA REFERENCE LEVEL

Set A-to-A Reference Level: Automated Mode

Click the **SET A-A REFERENCE LEVEL** button.

A prompt will appear to inform you of the source and value of the initial reference level setting for the A-to-A tests. At this time you have the option of changing the generator reference level by moving the bar graph slider. Click **Continue Procedure** to accept or change the initial reference level setting.

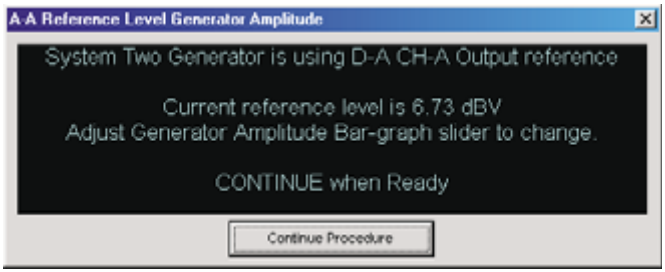


Figure 79 Initial A-to-A Reference Level Setting

In Automated Mode the test will proceed on its own, calling PC LevelCheck, adjusting volume levels and displaying its progress as it runs, then returning to the A-to-A MEASUREMENTS panel.

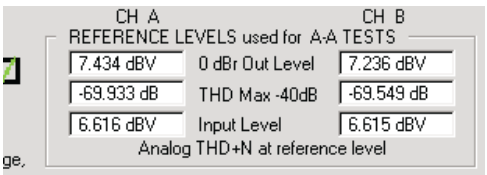


Figure 80 A-to-A Reference Level Readings

The six display boxes to the right of the **SET A-A REFERENCE LEVEL** button now show test results.

When this test has been successfully completed, a green check mark appears to the right of the **SET A-A REFERENCE LEVEL** button.

TEST ALL

Test All

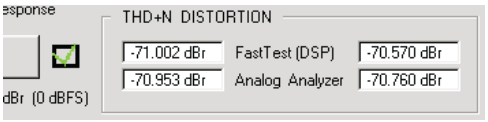
The **TEST ALL** button runs all of the next three tests in succession.

THD+N DISTORTION

A-to-A THD+N Distortion: Automated Mode

To begin the test, click the **THD+N DISTORTION** button. In both Automated Mode and Manual Mode, the test will proceed on its own, displaying its progress as it runs and quickly returning you to the A-to-A MEASUREMENTS panel. The four display boxes to the right of the **THD+N DISTORTION** button now show test results.

Figure 81 A-to-A THD+N Readings



If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

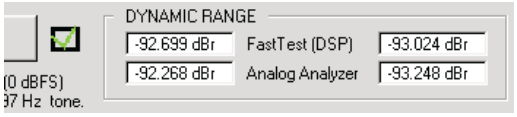
When this test has been successfully completed, a green check mark appears to the right of the **THD+N DISTORTION** button.

DYNAMIC RANGE

A-to-A Dynamic Range: Automated Mode

To run the test, click the **DYNAMIC RANGE** button. In both Automated Mode and Manual Mode the test will proceed on its own, displaying its progress as it runs and quickly returning you to the A-to-A MEASUREMENTS panel. The four display boxes to the right of the **DYNAMIC RANGE** button now show test results.

Figure 82 A-to-A Dynamic Range Readings



If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

When this test has been successfully completed, a green check mark appears to the right of the **DYNAMIC RANGE** button.

FREQUENCY RESPONSE

A-to-A Frequency Response: Automated Mode

Click the **FREQUENCY RESPONSE** button to begin the test.

As the test is running, you will see an APWIN graph of frequency and phase response rendered on your screen. If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

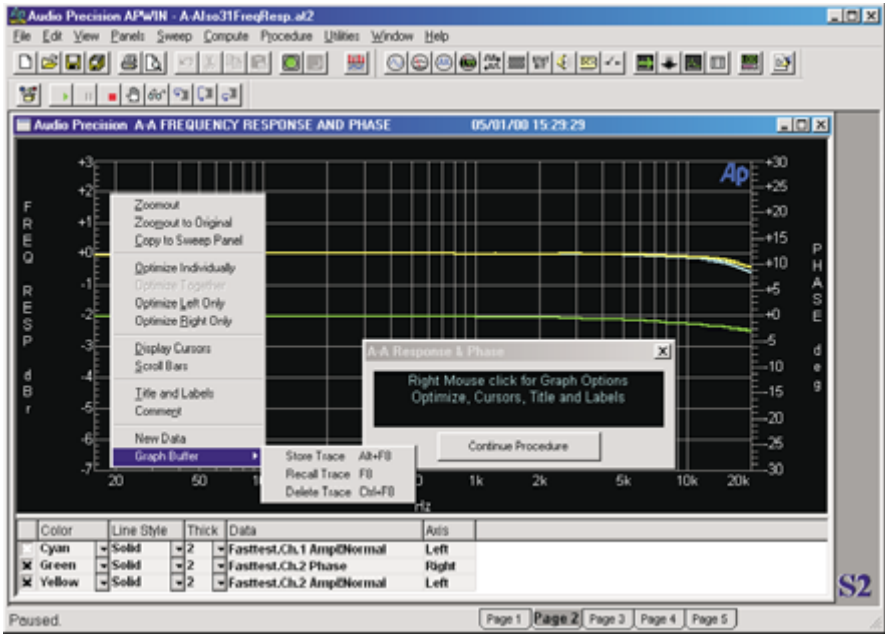
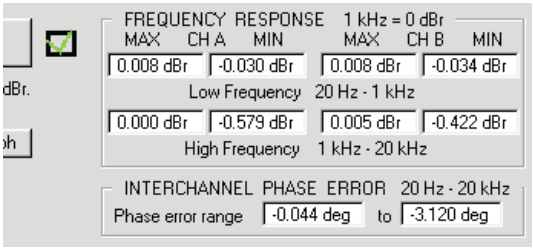


Figure 83 A-to-A Frequency Response Graph Windows with graph options shown

The prompt that appears on the graph gives you access to the APWIN Graph Menu (right click on the graph) for viewing and formatting options. When you are through viewing the graph, click **Continue Procedure**. PC Audio Tests computes the maximum and minimum deviations for both frequency response and phase response and then returns you to the A-to-A MEASUREMENTS panel.

Notice that the **FREQUENCY RESPONSE** and **INTERCHANNEL PHASE** display boxes now contain measurements.

Figure 84 A-to-A Frequency Response and Interchannel Phase Readings



When this test has been successfully completed, a green check mark appears to the right of the **FREQUENCY RESPONSE** button.

View Response Graph

View Response Graph

Once the Frequency Response test has been performed, you may return to view the response curve again by clicking **View Response Graph**. This dialog box will appear:

*Figure 85 Graph **Save Test–Set Panels** Window*

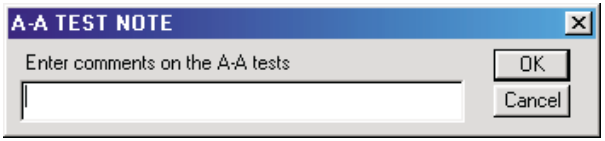
Click **Save Test** to save the graph data as an .ada or .at2 file (an option selectable on the Configuration: Data panel). See **Appendix A: Setting Preferences in Configuration** (page 127). The **Graph, Panel Setup** button calls up a prompt and access to the APWIN Graph Menu (right click on the graph) for graph viewing and formatting options. Click **CONTINUE** to return to the test panel.

A-A Test Comment

A-to-A Test Report Comments

All test data is stored in memory for later retrieval for an optional report. If you would like to add a short comment to the A-to-A section of the test report, click the **A-to-A Test Report Comments** button.

Figure 86 A-to-A Test Report Comments



This completes the A-to-A testing of your PC sound device. You may generate a report now by returning to the Main Menu and clicking

Create Test Report, or you can go to the next set of tests and generate your report later. See **Creating Test Reports** (page 123).

If you leave the program at this point but return later to perform more tests, you must reset your A-to-A reference level See **Set A-to-A Reference Level: Automated Mode** (page 61). Subsequent tests require the results of this test as reference values.

Running A-to-A Tests in MANUAL MODE

We recommend that you run your tests in Automated Mode (using PC LevelCheck) whenever possible. If PC LevelCheck cannot control your sound device driver software, you must use Manual Mode. See **Test Modes** (page 24).

*If you can use Automated Mode, you should skip this section and go directly to **Running A-to-A Tests in Automated Mode** (page 60).*

You will need Windows Volume Control mixer on your desktop to run A-to-A tests in Manual Mode. Follow the instructions below:

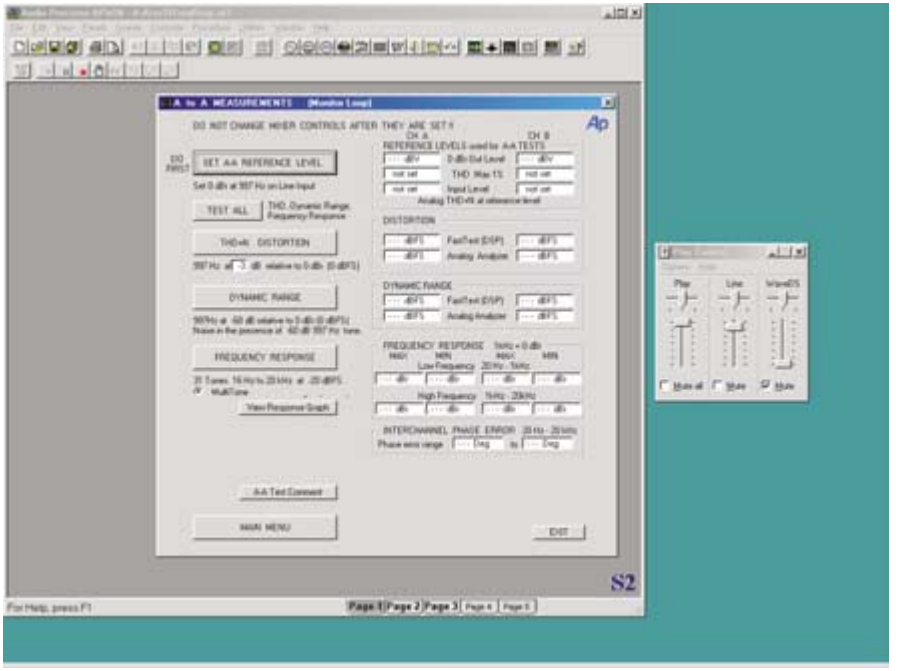


Figure 87 Desktop Setup for A-to-A Manual Mode Testing

Click the **A-to-A** button on the Main Menu to begin the test series. The A-to-A MEASUREMENTS test panel will appear.

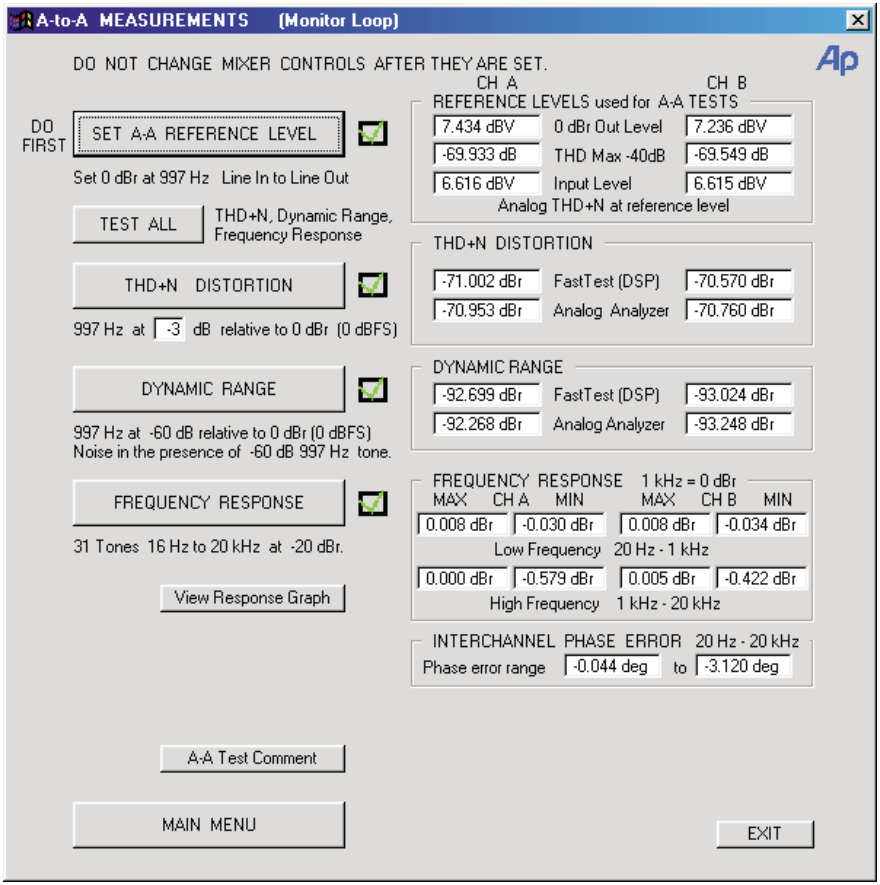


Figure 88 A-to-A Measurements Panel

SET AA REFERENCE LEVEL

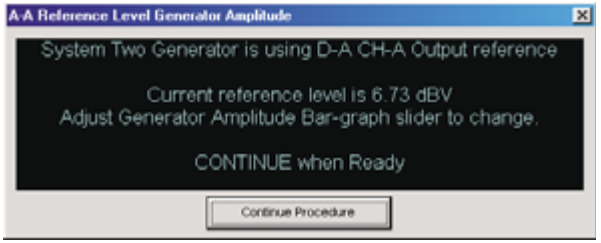
Set A-to-A Reference Level: Manual Mode

You must have Windows Volume Control playback mixer on screen. First you will check your mixer settings, and then apply a 997 Hz tone the line inputs of the EUT. While observing the THD+N bar graph that APWIN is displaying, you will adjust first the mixer level and then the generator level to find the 1% distortion point. The measured output level under this condition is defined as a new 0 dBr (A-A) reference.

Click the **SET A-A REFERENCE LEVEL** button.

A prompt will appear to inform you of the source and value of the initial reference level setting for the A-to-A tests. At this time you have the option of changing the generator reference level by moving the bar graph slider.

Figure 89 Initial A-to-A Reference Level Setting

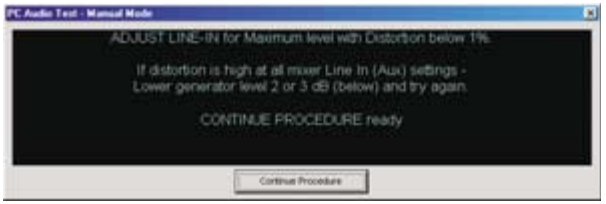


Click **Continue Procedure** to accept or change the initial reference level setting. The following prompt will appear:

Figure 90 A-to-A Reference Level Playback Mixer Settings Prompt

Follow the instructions on the prompt to check all your mixer settings. When you have verified the settings, click **Continue Procedure** to see the next prompt.

Figure 91 A-to-A Reference Level Line-In Adjustment Prompt



The second prompt instructs you to adjust the mixer Line In fader to find the maximum distortion reading below 1% distortion. Software mixer faders often provide rather coarse level control, which shows up here as large jumps between distortion readings. If this is the case, find the first reading below 1% distortion and then adjust the **Gen Ampl A**

Bar Graph fader in APWIN to precisely locate the maximum below 1%. Move this bar graph control with the mouse pointer to adjust the generator. For very fine adjustment use the left and right arrow buttons on the keyboard.

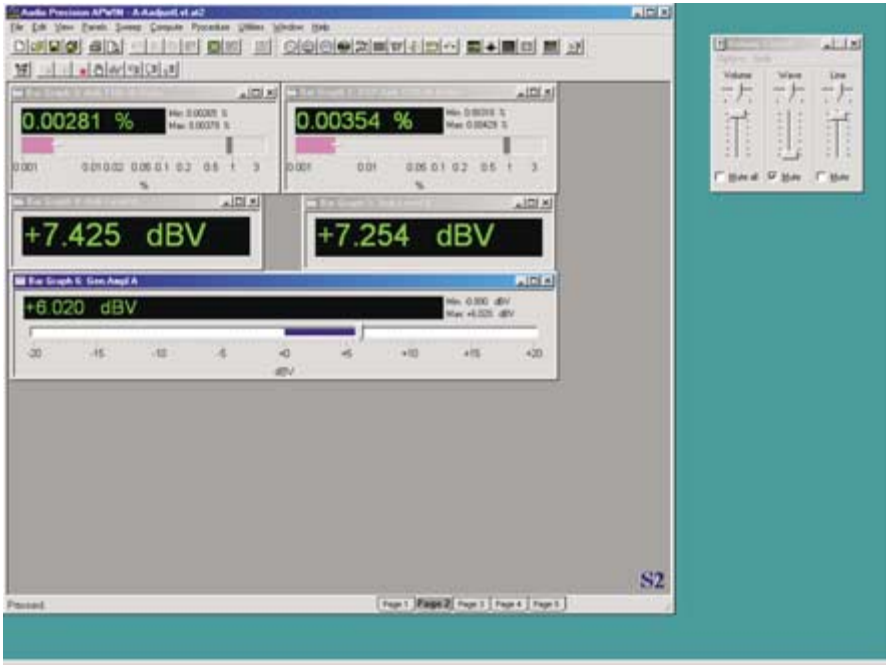


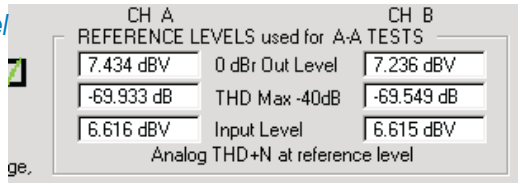
Figure 92 Adjusting Playback Mixer and Generator Levels

If distortion is over 1% at all settings of the mixer fader, the generator level is overloading the input stages of the sound card. Reduce the generator fader by 2 or 3 dB and run through the process again until you locate maximum mixer fader level and maximum generator level under 1% THD+N.

Click **Continue Procedure** to move on.

Display boxes will advise you of progress as the test proceeds. If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

Figure 93 A-to-A Reference Level Readings



When the test is complete you will return to the A-to-A panel. Notice that the six display boxes to the right of the **SET A-A REFERENCE LEVEL** button now show test results.

When this test has been successfully completed, a green check mark appears to the right of the **SET A-A REFERENCE LEVEL** button.

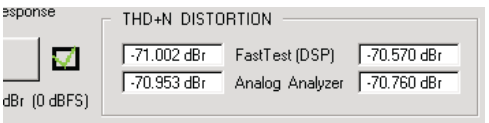
Test All

The **TEST ALL** button runs all of the next three tests in succession.

A-to-A THD+N Distortion: Manual Mode

To begin the test, click the **THD+N DISTORTION** button. In both Automated Mode and Manual Mode, the test will proceed on its own, displaying its progress as it runs and quickly returning you to the A-to-A MEASUREMENTS panel. The four display boxes to the right of the **THD+N DISTORTION** button now show test results.

Figure 94 A-to-A THD+N Readings



If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

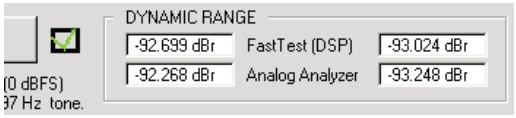
When this test has been successfully completed, a green check mark appears to the right of the **THD+N DISTORTION** button.

DYNAMIC RANGE

A-to-A Dynamic Range: Manual Mode

To run the test, click the **DYNAMIC RANGE** button. In both Automated Mode and Manual Mode the test will proceed on its own, displaying its progress as it runs and quickly returning you to the A-to-A MEASUREMENTS panel. The four display boxes to the right of the **DYNAMIC RANGE** button now show test results.

Figure 95 A-to-A Dynamic Range Readings



If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

When this test has been successfully completed, a green check mark appears to the right of the **DYNAMIC RANGE** button.

FREQUENCY RESPONSE

A-to-A Frequency Response: Manual Mode

Click the **FREQUENCY RESPONSE** button to begin the test.

As the test is running, you will see an APWIN graph of frequency and phase response rendered on your screen. If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

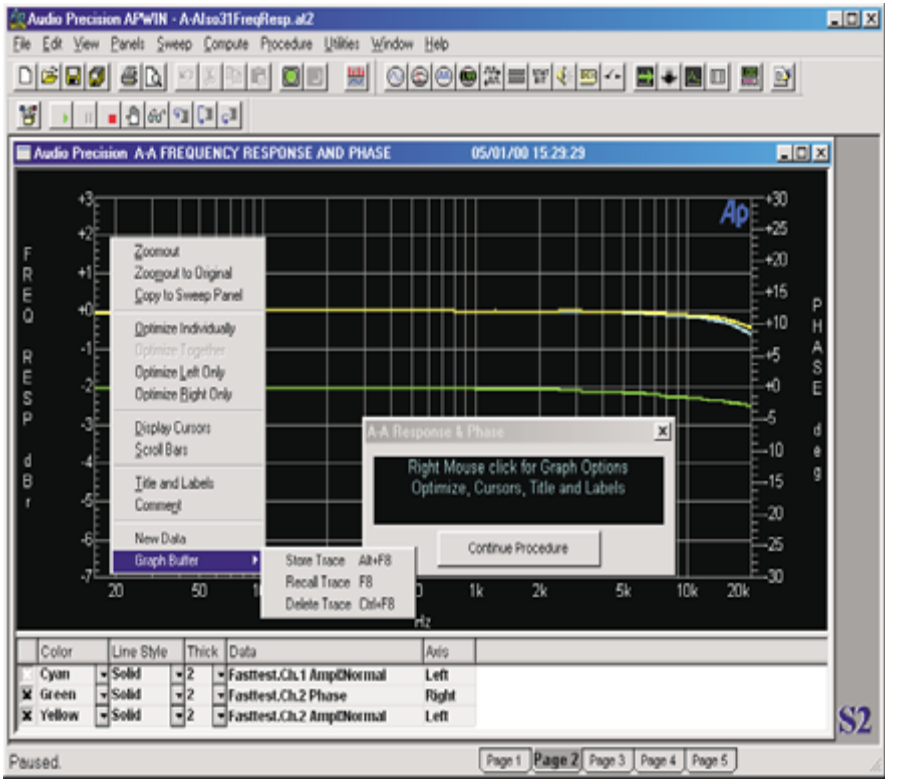
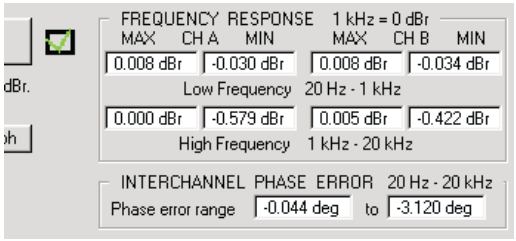


Figure 96 A-to-A Frequency Response Graph Windows with graph options shown

The prompt that appears on the graph gives you access to the APWIN Graph Menu (right click on the graph) for viewing and formatting options. When you are through viewing the graph, click **Continue Procedure**. PC Audio Tests computes the maximum and minimum deviations for both frequency response and phase response and then returns you to the A-to-A MEASUREMENTS panel.

Notice that the **FREQUENCY RESPONSE** and **INTERCHANNEL PHASE** display boxes now contain measurements.

Figure 97 A-to-A Frequency Response and Interchannel Phase Readings



When this test has been successfully completed, a green check mark appears to the right of the **FREQUENCY RESPONSE** button.

View Response Graph

View Response Graph

Once the Frequency Response test has been performed, you may return to view the response curve again by clicking **View Response Graph**. This dialog box will appear:

*Figure 98 Graph **Save Test– Set Panels** Window*

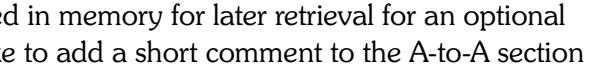
Click **Save Test** to save the graph data as an .ada or .at2 file (an option selectable on the Data Configuration panel). *See* **Appendix A: Setting Preferences in Configuration** (page 127). The **Graph, Panel Setup** button calls up a prompt and access to the APWIN Graph Menu (right click on the graph) for graph viewing and formatting options. Click **CONTINUE** to return to the test panel.

A-A Test Comment

A-to-A Test Report Comments

All test data is stored in memory for later retrieval for an optional report. If you would like to add a short comment to the A-to-A section of the test report, click the A-to-A Test Report Comments button.

Figure 99 A-to-A Test Report Comments



This completes the A-to-A testing of your PC sound device. You may generate a report now by returning to the Main Menu and clicking

Create Test Report, or you can go to the next set of tests and generate your report later. See **Creating Test Reports** (page 123).

If you leave the program at this point but return later to perform more tests, you must reset your A-to-A reference level. See **Set A-to-A Reference Level: Manual Mode** (page 67). Subsequent tests require the results of this test as reference values.

A-to-D Tests

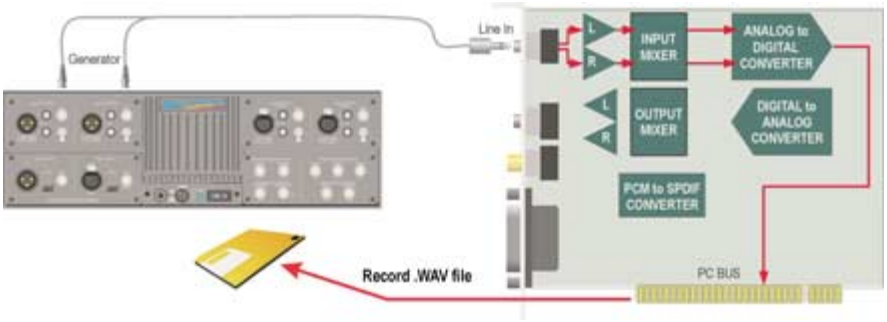


Figure 100 PC Audio Tests: the A-to-D Test Group

What the A-to-D tests do

See **What the tests do** (page 14) in the **Introduction** for an overview of the common functions of all the test groups.

The A-to-D set of tests measures the characteristics of the EUT's analog-to-digital conversion of an audio input signal to a .wav file, and of the analog input circuitry of the device. These A-to-D tests satisfy Microsoft WHQL standard TM003.

Using the A-to-D tests you will measure the input level required to record a 0 dB FS digital signal (or, alternately, the input level required to record a digital signal just below the threshold of 1 % THD+N), and you will set that level as a reference. Then you will measure total harmonic distortion plus noise (THD+N), dynamic range and frequency response for the analog-to-digital functions of the EUT.

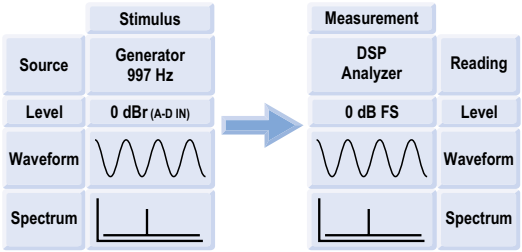
The A-to-D Reference Level setting must be performed before the other tests in this group, since these results are considered in subsequent calculations.

Also, it is helpful if you have set the reference levels in the D-to-A or A-to-A group of tests before you attempt to perform the A-to-D tests here.

A-to-D Reference Level

As discussed in **What the tests do** (page 14) in the **Introduction**, this test calibrates PC Audio Tests and System Two to your particular sound device for the A-to-D signal path.

Figure 101 Setting A-to-D Reference Level



PC Audio Tests sets a test level for the System Two analog generator, initially using the same value measured for the EUT's analog output 0 dBr (D-A), determined in the D-to-A set of tests. If that value has not been set, PC Audio Tests then looks for the input reference level set in A-to-A, 0 dBr (A-A IN). In the absence of this information, PC Audio Tests initially sets the generator to +6 dBV (2 V rms) for unbalanced operation, or +20 dBV (10 V rms) for balanced operation.

While monitoring the digital signal at the output of the EUT's ADC, the Line-In fader on the Record Mixer is adjusted to determine the maximum recording level.

If the EUT does not have a peak limiter in the input circuit, the maximum recording level should produce a 0 dB FS digital signal. When this point is found, the digital signal is sent to System Two for measurement and the results are entered on the A-to-D panel.

However, many sound cards *do* employ peak limiting in the input circuitry to prevent digital clipping. In these cases, it will be impossible to attain 0 dB FS, since the limiter will clamp the input signal at some point below this level. This lower point becomes the effective maximum recording level, even though 0 dB FS is not reached.

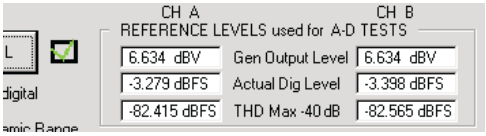
If 0 dB FS cannot be attained with increasing input levels, PC Audio Tests assumes the presence of a peak limiter and uses a second methodology to determine maximum recording level, as follows:

- The digital signal at the output of the EUT's ADC is monitored for distortion as the Line-In slider on the Record Mixer is adjusted to find the maximum level just below the point that produces 1 % THD+N.
- If there is no setting of the Line-In slider that produces less than 1 % THD+N, the slider is set to one step above its lowest extreme. Then the generator level is dropped in 0.5 dB steps until the distortion measured falls below 1 %.
- The Line-In slider and then the generator are now adjusted upward in small increments to find the maximum level just below the point that produces 1 % THD+N.
- When this level is determined, the digital signal is sent to System Two for measurement and the results are entered on the A-to-D panel. It is often the case that the maximum digital level before distortion falls below 0 dB FS by several dB.

A device with an input stage that lacks the capability to fully drive the ADC (in other words, that clips before the ADC reaches maximum) will exhibit symptoms similar to a device with an input stage peak limiter.

*System Two acquires digital test data for measurement via the APIB connection between System Two and the computer mounting the EUT. This data must be in the form of an Audio Precision *.aas wave file. To facilitate this, the digital signal from the EUT's ADC is first saved as a conventional .wav file and is then converted to an *.aas file before the data are sent to System Two for measurement by the Digital Analyzer and FAST*TEST*. Throughout this process, the data remain in the digital domain and are unchanged from the original acquisition.*

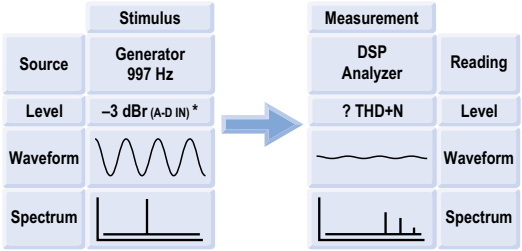
Figure 102 A-to-D Reference Level Settings



In the example shown, the top pair of boxes show channels A and B having a 0 dBr reference level of 6.269 dBV. This is the generator output level (effectively, the EUT line input level), set just below the point that produces 0 dB FS or 1 % distortion in the digital signal at the output of the sound card's ADC. The actual digital level produced (–0.536 dB FS and –0.695 dB FS in this illustration) and the distortion measured under these conditions are shown in the next two pairs of boxes. These 0 dBr (A-D) input levels become the references for the THD+N and Dynamic Range tests on this panel, and also for the analog input levels in the ADPCDA test group.

A-to-D THD+N Distortion and Noise

Figure 103 A-to-D THD+N Test



As discussed in **What the tests do** (page 14) in the **Introduction**, this test measures the total harmonic distortion and noise (THD+N) found in the EUT A-to-D signal path under test conditions.

** The stimulus level of –3 dB FS shown in the diagram is an option, one of four stimulus levels available for THD+N testing in setting up PC Audio Tests. See **Appendix A: Configuration** (page 127). The level chosen is displayed on-screen in the small box below the THD+N DISTORTION button.*

Figure 104 A-to-D THD+N Readings

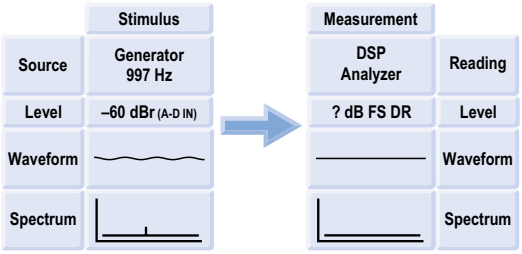
Since the signal being measured in the A-to-D test is acquired at the output of the sound card's ADC, it is in the digital domain and can be measured directly in System Two with the *FAST*TEST DSP program, using FFT analysis of the signal. With no analog output, the System Two analog analyzer is not used in A-to-D tests.

*FAST*TEST measurements are always unweighted measurements.

See **Appendix F: Audio Precision Analysis Techniques** (page 159) for a more detailed discussion of FFT THD+N measurements.

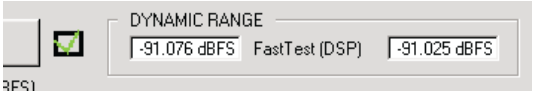
A-to-D Dynamic Range

Figure 105 A-to-D Dynamic Range Test



As discussed in **What the tests do** (page 14) in the **Introduction**, this test measures the dynamic range of the EUT A-to-D signal path under test conditions, using a –60 dB FS stimulus.

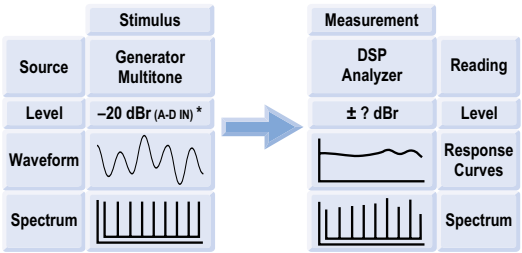
Figure 106 A-to-D Dynamic Range Readings



Since the signal being measured in the A-to-D tests is in the digital domain, PC Audio Tests uses only the *FAST*TEST (DSP) FFT technique for dynamic range measurement.

A-to-D Frequency Response

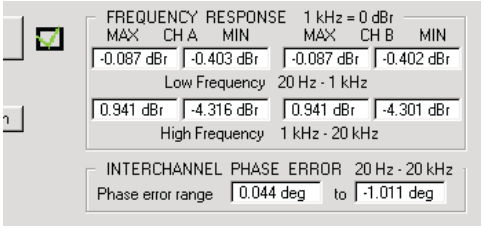
Figure 107 A-to-D Frequency Response Test



As discussed in **What the tests do** (page 14) in the **Introduction**, this test measures the frequency response through the EUT A-to-D signal path under test conditions.

While the response curve graph is on the screen, you have access to the APWIN graph options panel. The maximum and minimum response data are also reported in the **FREQUENCY RESPONSE** boxes on the test panel.

Figure 108 A-to-D Frequency Response and Interchannel Phase Readings



A-to-D Interchannel Phase

While the frequency response test is being made, PC Audio Tests also measures the relative phase angle between the channels A and B across the audible spectrum. A graph of this information is shown as a third trace on the response graph, with the maximum deviations displayed in degrees of angle in the two **INTERCHANNEL PHASE** boxes on this panel.

Running A-to-D Tests in AUTOMATED MODE

We recommend that you run your tests in Automated Mode (using PC LevelCheck) whenever possible. If PC LevelCheck cannot control your sound device driver software, you must use Manual Mode. See **Test Modes** (page 24).

*If you choose not to use Automated Mode, you can skip this section and go directly to **Running A-to-D Tests in Manual Mode** (page 91).*

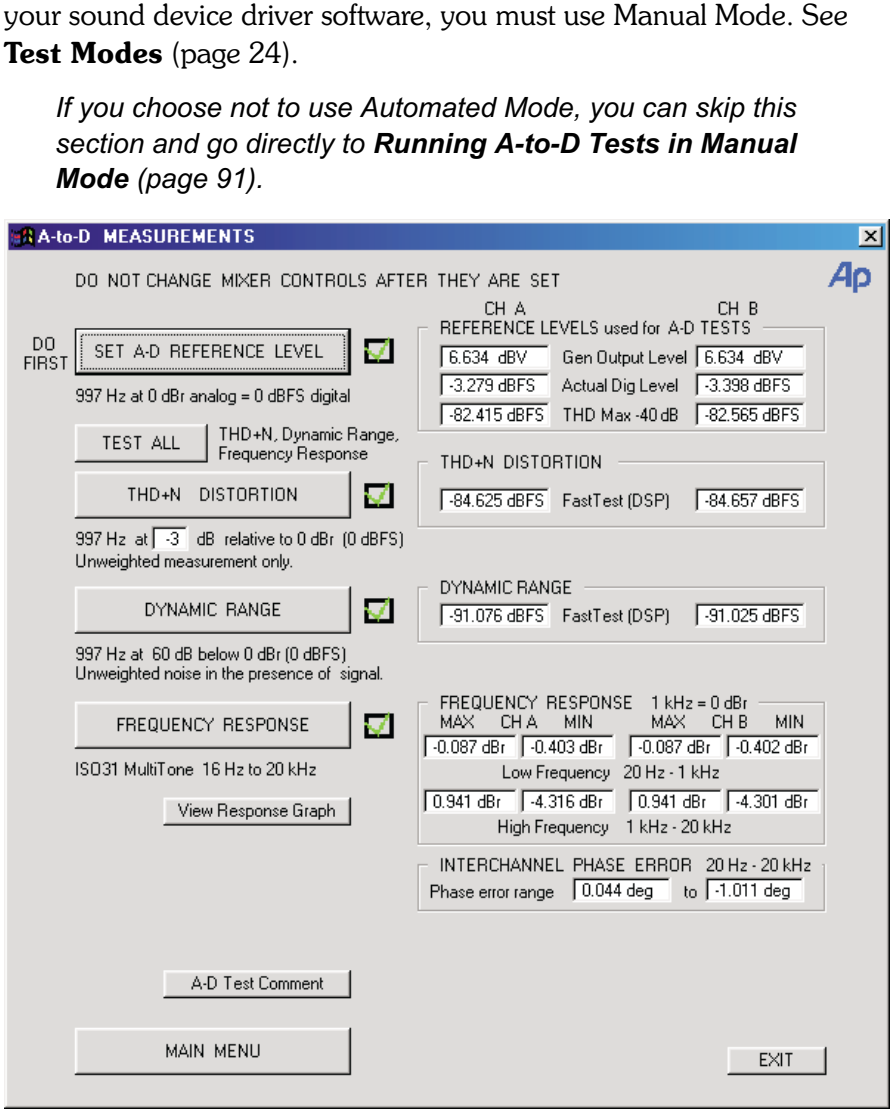


Figure 109 A-to-D Measurements Panel

Click the **A-to-D** button on the Main Menu to begin the test series. The A-to-D MEASUREMENTS test panel will appear.

SET A-D REFERENCE LEVEL

Set A-to-D Reference Level: Automated Mode

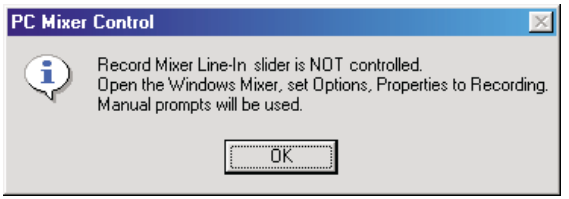
Click the **SET A-D REFERENCE LEVEL** button.

Before continuing, PC Audio Tests checks to see if previous level references have been set, informs you of which reference, if any, is to be used as an initial setting for this test, and displays the actual value of the reference level. You have the option of manually adjusting the generator level, as well. Click **Continue Procedure** to accept the references.

Figure 110 Initial Level Reference Message

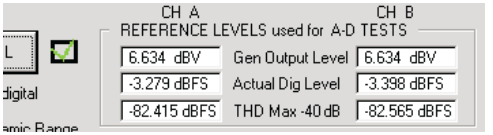
*If the following message appears, skip to **Automated Mode with Manual Record Adjustments** (page 83).*

Figure 111 PC Mixer Control Caution



If the PC Mixer Control caution message does not appear, simply click **Contine Procedure** and the test will proceed on its own, calling PC LevelCheck, adjusting volume levels, recording and converting test files, displaying its progress as it runs, and then returning to the A-to-D MEASUREMENTS panel.

Figure 112 A-to-D Reference Level Readings



The six display boxes to the right of the **SET A-D REFERENCE LEVEL** button now show test results.

When this test has been successfully completed, a green check mark appears to the right of the **SET A-D REFERENCE LEVEL** button.

Automated Mode with Manual Record Adjustments

Figure 113 PC Mixer Control Caution

If the above message appears, PC LevelCheck cannot control the Recording Mixer in your sound card driver software. You must launch Windows Volume Control for manual level adjustments.

Unlike the previous test groups, Automated Mode Reference Level setting in A-to-D may require some manual adjustments due to driver control mapping incompatibilities. This results in a "semi-automated mode" that uses PC LevelCheck for file recording and playback functions but requires manual record level adjustments. Instructions for setting A-to-D levels in semi-automated mode follow. If Automated Mode works fully on your sound card, you can skip this section and go right on to ***Test All*** *(page 86).*

Launching Windows Recording Mixer

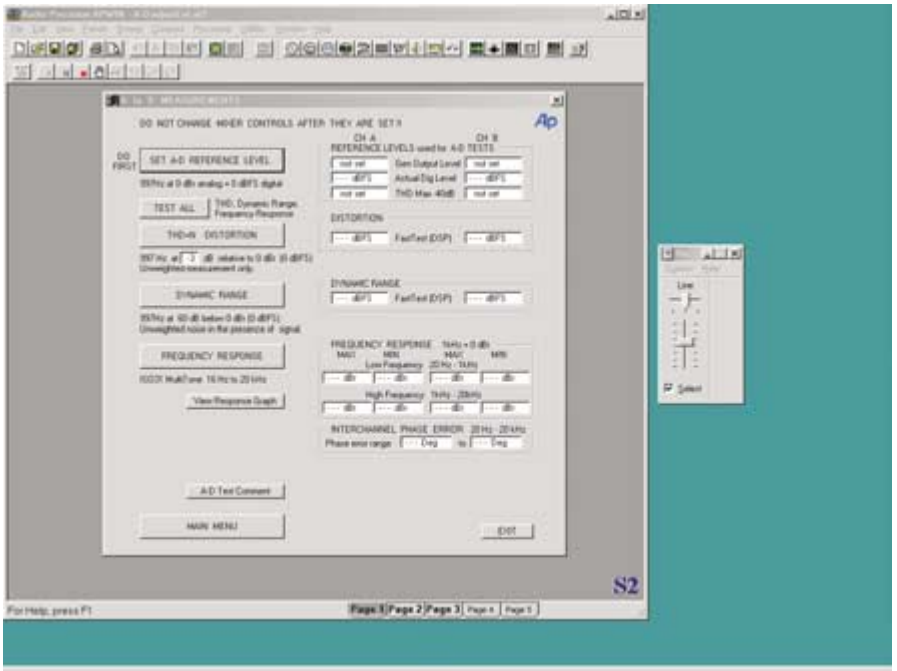
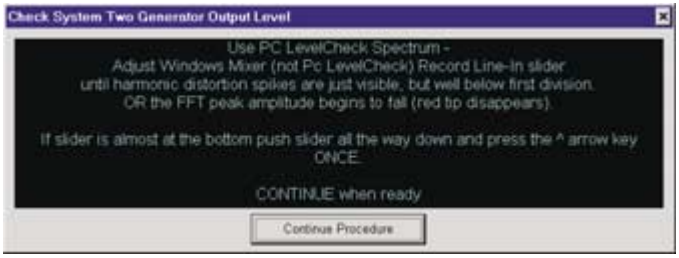


Figure 114 Desktop Setup for A-to-D Automated Mode Testing with Recording Volume Control

Launch Windows Volume Control, go to **Options**, then **Properties** and select **Recording**. Then select **Line-In** (sometimes called **Aux**) as your Recording Volume Control. Leave the volume control on the desktop where you can make adjustments during the tests. If you have not already done so, you should size APWIN to about 2/3 of your screen width so you can easily view your Record Volume Control. See **Test Modes: Launching and configuring multimedia applications** (page 26) for more information.

With Windows Recording Volume Control on the screen, click **OK** on the Record Mixer Control prompt button. The following prompt will appear, as will PC LevelCheck:

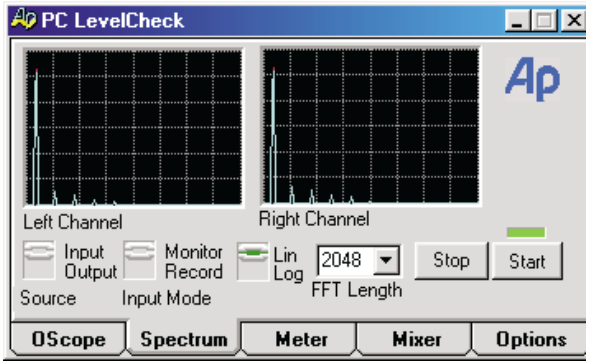
Figure 115 A-to-D Reference Level 1st Distortion Check Prompt



As prompted, reduce the fader setting on the Record Volume Control while monitoring the spectrum analyzer display on PC LevelCheck. Reduce the level until the harmonic spikes are visible but well below the first graticule marking on the PC LevelCheck display *and* the tip of the fundamental spike remains at peak level (indicated by the red tip on the spike).

The up and down arrows on your keyboard will give you finer control of the Record Volume Control slider.

Figure 116 PC LevelCheck Spectrum Display Showing Harmonic Spikes



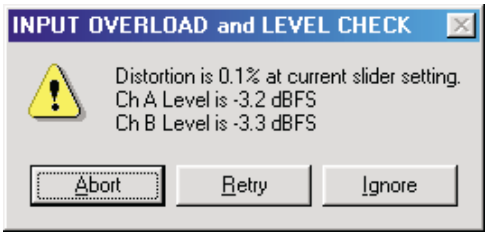
In some situations no setting of the Recording Volume Control will reduce the harmonics sufficiently while maintaining peak amplitude (red tip on the fundamental peak). Leave the slider at the best compromise setting. If the slider is very near the bottom of its range, reset it as follows: reduce the slider setting to absolute minimum, using the down arrow key to be certain the slider is all the way down. Now raise the slider one step by pressing the up arrow key just one time.

Click **Continue Procedure**.

If PC Audio Tests measures distortion greater than 1 %, the generator level is incremented downward in 0.5 dB steps until the distortion falls below 1 %. At this point (or, if distortion was initially less

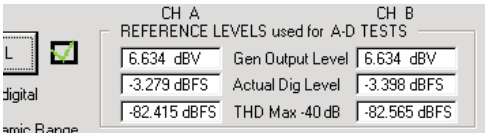
than 1 %) PC Audio Tests converts the data for analysis. If the results are within the acceptable range, you will be returned to the A-to-D MEASUREMENTS panel. If the results lie outside the range, the following message will appear:

Figure 117 Input Overload and Level Check Message



If the distortion and level results do not fall within the target area (THD+N less than 1 %) or otherwise meet your criteria, click **Retry**, reset the Recording Mixer Line-In slider, the generator level, or both, and continue through the cycle until the results satisfy your criteria. At the end of any cycle, you can click **Ignore** to accept the results, even if they fall outside of the target range. You will then be returned to the A-to-D MEASUREMENTS panel.

Figure 118 A-to-D Reference Level Readings



The six display boxes to the right of the **SET A-D REFERENCE LEVEL** button now show test results. The 0 dBr reference at the conclusion of this test is now 0 dBr (A-D IN), and can have a different value than 0 dBr (A-A IN).

When this test has been successfully completed, a green check mark appears to the right of the **SET A-D REFERENCE LEVEL** button.

Test All

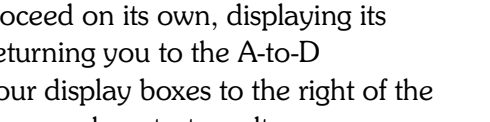
The **TEST ALL** button runs all of the next three tests in succession.

THD+N DISTORTION

A-to-D THD+N Distortion: Automated Mode

To begin the test, click the **THD+N DISTORTION** button. In Automated Mode the test will proceed on its own, displaying its progress as it runs and quickly returning you to the A-to-D MEASUREMENTS panel. The four display boxes to the right of the **THD+N DISTORTION** button now show test results.

Figure 119 A-to-D THD+N Readings



If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

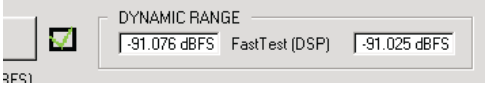
When this test has been successfully completed, a green check mark appears to the right of the **THD+N DISTORTION** button.

DYNAMIC RANGE

A-to-D Dynamic Range: Automated Mode

To run the test, click the **DYNAMIC RANGE** button. In Automated Mode the test will proceed on its own, displaying its progress as it runs and quickly returning you to the A-to-D MEASUREMENTS panel. The four display boxes to the right of the **DYNAMIC RANGE** button now show test results.

Figure 120 A-to-D Dynamic Range Readings



If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

When this test has been successfully completed, a green check mark appears to the right of the **DYNAMIC RANGE** button.

FREQUENCY RESPONSE

A-to-D Frequency Response: Automated Mode

Click the **FREQUENCY RESPONSE** button to begin the test.

As the test is running, you will see an APWIN graph of frequency and phase response rendered on your screen. If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

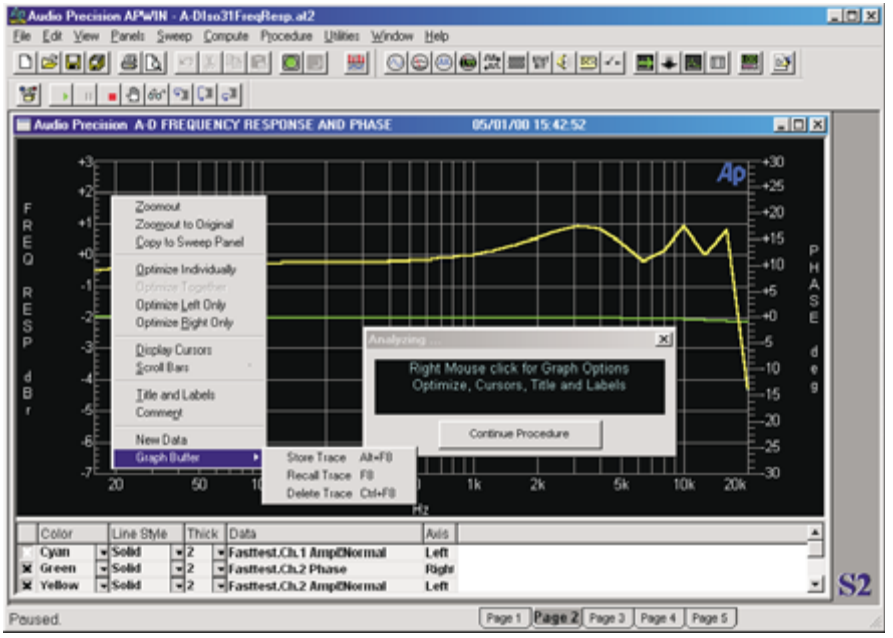
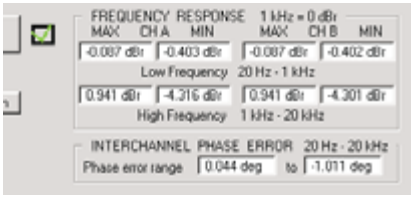


Figure 121 A-to-D Frequency Response Graph Windows with graph options shown

The prompt that appears on the graph gives you access to the APWIN Graph Menu (right click on the graph) for viewing and formatting options. When you are through viewing the graph, click **Continue Procedure**. PC Audio Tests computes the maximum and minimum deviations for both frequency response and phase response and then returns you to the A-to-D MEASUREMENTS panel.

Notice that the **FREQUENCY RESPONSE** and **INTERCHANNEL PHASE** display boxes now contain measurements.

Figure 122 A-to-D Frequency Response and Interchannel Phase Readings



When this test has been successfully completed, a green check mark appears to the right of the **FREQUENCY RESPONSE** button.

View Response Graph

View Response Graph

Once the Frequency Response test has been performed, you may return to view the response curve again by clicking **View Response Graph**. This dialog box will appear:

*Figure 123 Graph **Save Test–Set Panels** Window*

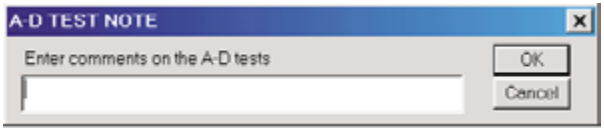
Click **Save Test** to save the graph data as an .ada or .at2 file (an option selectable on the Configuration: Data panel). See **Appendix A: Setting Preferences in Configuration** (page 127). The **Graph, Panel Setup** button calls up a prompt and access to the APWIN Graph Menu (right click on the graph) for graph viewing and formatting options. Click **CONTINUE** to return to the test panel.

A-D Test Comment

A-to-D Test Report Comments

All test data is stored in memory for later retrieval for an optional report. If you would like to add a short comment to the A-to-D section of the test report, click the **A-to-D Test Report Comments** button.

Figure 124 A-to-D Test Report Comments



This completes the A-to-D testing of your PC sound device. You may generate a report now by returning to the Main Menu and clicking

Create Test Report, or you can go to the next set of tests and generate your report later. See **Creating Test Reports** (page 123).

If you leave the program at this point but return later to perform more tests, you must reset your A-to-D reference level (See **Set A-to-D Reference Level: Automated Mode** (page 82). Subsequent tests require the results of this test as reference values.

Running A-to-D Tests in MANUAL MODE

We recommend that you run your tests in Automated Mode (using PC LevelCheck) whenever possible. If PC LevelCheck cannot control your sound device driver software, you must use Manual Mode. See **Test Modes** (page 24).

*If you can use Automated Mode, you should skip this section and go directly to **Running A-to-D Tests in Automated Mode** (page 81).*

You will need Windows Volume Control mixer and Windows Sound Recorder on your desktop to run A-to-D tests in Manual Mode. Follow the instructions below:

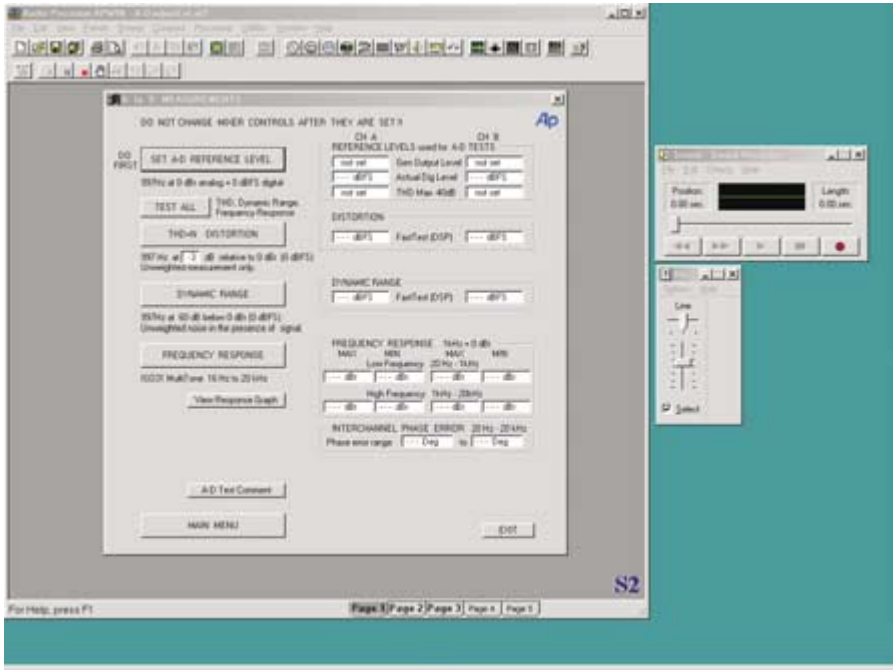


Figure 125 Desktop Setup for A-to-D Manual Mode Testing

Click the **A-to-D** button on the Main Menu to begin the test series. The A-to-D MEASUREMENTS test panel will appear.

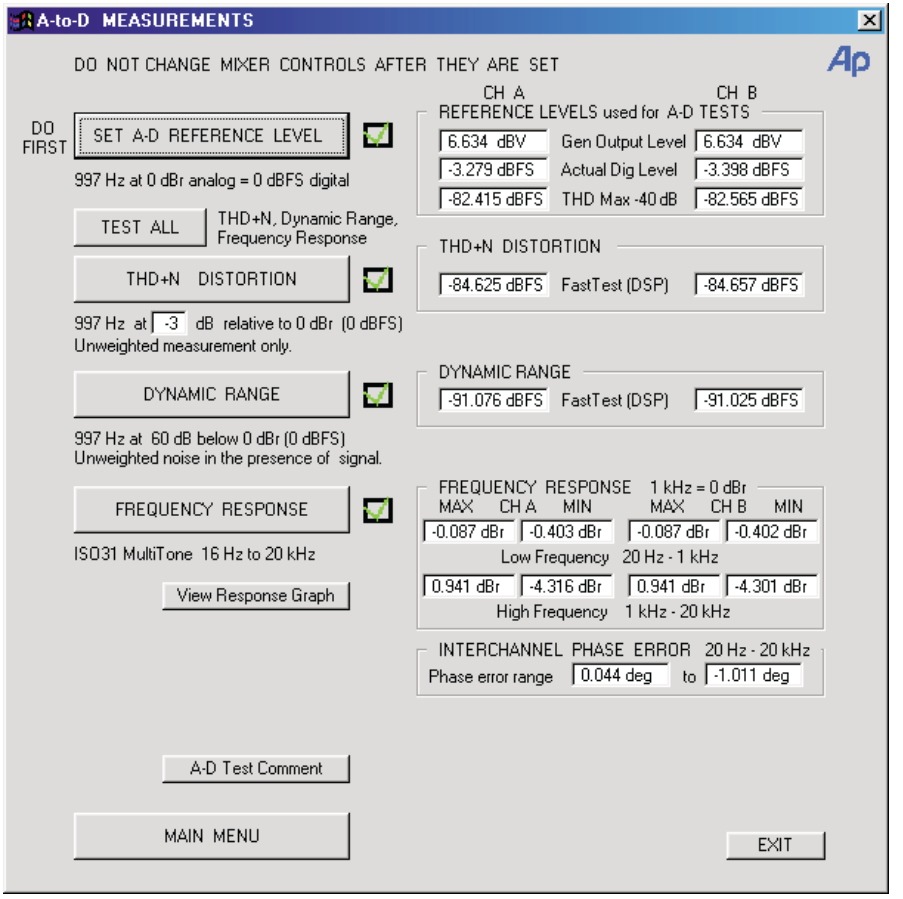


Figure 126 A-to-D Measurements Panel

SET A-D REFERENCE LEVEL

Set A-to-D Reference Level: Manual Mode

First you will configure Sound Recorder, and then check mixer settings. A 997 Hz tone will be applied to the input of the sound card at an initial level of 0 dBr (D-A). You will begin a reiterative testing cycle, the goal of which is to ascertain what input level settings result in recording a .wav file that has a digital signal level of 0 dB FS; or alternately, a file that has a digital signal level at the maximum level with less than 1 % THD+N. During each iteration you will adjust the Recording Mixer Line-In slider or the generator level up or down, then you will record the signal to a .wav file. PC Audio Tests will convert the file for analysis by System Two, which will then report the level and

THD+N for your consideration. You will repeat this process until your results satisfy your criteria.

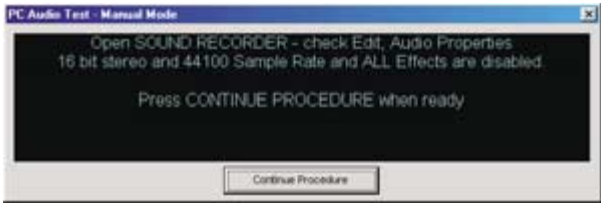
Click the **SET A-D REFERENCE LEVEL** button.

Before continuing, PC Audio Tests checks to see if previous level references have been set. If a reference message appears, you can choose to accept the current settings or stop and reset the references.

Figure 127 A-to-D Initial Level References Message

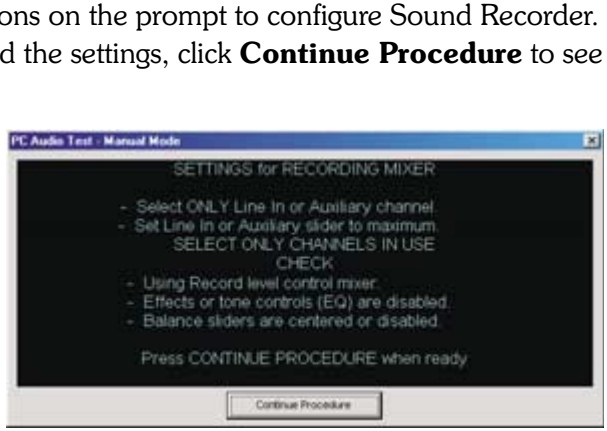
If you do not need to reset the previous references, click **No**. The following prompt will appear:

Figure 128 A-to-D Reference Level Sound Recorder Settings Prompt



Follow the instructions on the prompt to configure Sound Recorder. When you have verified the settings, click **Continue Procedure** to see the next prompt.

Figure 129 A-to-D Reference Level Recording Mixer Settings Prompt



Follow the instructions on the prompt to check all your mixer settings. When you have verified the settings, click **Continue Procedure**. The following prompt will appear:

Figure 130 A-to-D Reference Level Start Recorder Prompt

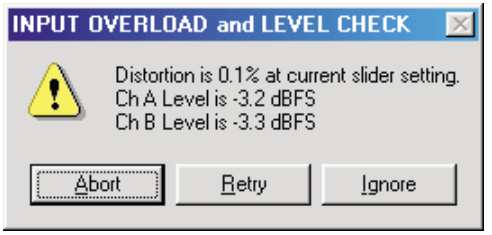
As prompted, start Sound Recorder. Let it record for about three seconds. Click **Continue Procedure** to see the next prompt.

Figure 131 A-to-D Reference Level Save File Prompt

Stop Sound Recorder and save the file as prompted, in the correct folder with the name A.wav. As you save, be sure Sound Recorder is correctly configured for CD-Quality, 44.1 kHz 16-bit. Click **Continue Procedure** to see the next prompt.

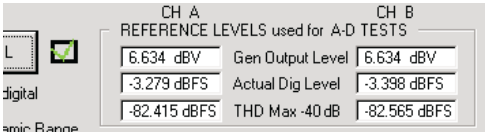
At this point PC Audio Tests takes over and converts the data for analysis. If the results are within the acceptable range, you will be returned to the A-to-D MEASUREMENTS panel. If the results lie outside the range, the following message will appear:

Figure 132 Input Overload and Level Check Message



If the distortion and level results do not fall within the target area (THD+N less than 1 %) or otherwise meet your criteria, click **Retry**, reset the Recording Mixer Line-In slider, the generator level, or both, and continue through the cycle until the results satisfy your criteria. At the end of any cycle, you can click **Ignore** to accept the results, even if they fall outside of the target range. You will then be returned to the A-to-D MEASUREMENTS panel.

Figure 133 A-to-D Reference Level Readings



The six display boxes to the right of the **SET A-D REFERENCE LEVEL** button now show test results. The 0 dBr reference at the conclusion of this test is now 0 dBr (A-D IN), and can have a different value than 0 dBr (A-A IN).

When this test has been successfully completed, a green check mark appears to the right of the **SET A-D REFERENCE LEVEL** button.

TEST ALL

Test All

The **TEST ALL** button runs all of the next three tests in succession.

THD+N DISTORTION

A-to-D THD+N Distortion: Manual Mode

Be sure you have Windows Sound Recorder on screen. To begin the test, click the **THD+N Distortion** button. The following prompt will appear:

Figure 134 A-to-D THD+N Start Recorder Prompt

As prompted, start Sound Recorder. System Two will apply a 997 Hz tone at 0, –1, –3 or –6 dBr (selected in **Configuration,** Page 130) to the EUT inputs. Let it record for about 3 seconds. Click **Continue Procedure** to see the next prompt.

Figure 135 A-to-D THD+N Save File Prompt

Save the file as prompted, in the correct folder with the name A.wav. As you save, be sure Sound Recorder is correctly configured for CD-Quality, 44.1 kHz 16-bit.

Click **Continue Procedure**. At this point PC Audio Tests takes over, converts and analyzes the data via FFT and returns you to the A-to-D MEASUREMENTS panel.

Figure 136 A-to-D THD+N Readings

DYNAMIC RANGE

A-to-D Dynamic Range: Manual Mode

Be sure you have Windows Sound Recorder on screen. To begin the test, click the **Dynamic Range** button. The following prompt will appear:

Figure 137 A-to-D Dynamic Range Start Recorder Prompt

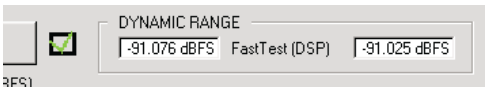
As prompted, start Sound Recorder. System Two will apply a 997 Hz tone at –60 dBr to the EUT inputs. Let it record for about 3 seconds. Click **Continue Procedure** to see the next prompt.

Figure 138 A-to-D Dynamic Range Save File Prompt

Save the file as prompted, in the correct folder with the name A.wav. As you save, be sure Sound Recorder is correctly configured for CD-Quality, 44.1 kHz 16-bit. Click **Continue Procedure** to see the next prompt.

At this point PC Audio Tests takes over, converts analyzes the data via FFT and returns you to the A-to-D MEASUREMENTS panel.

Figure 139 A-to-D Dynamic Range Readings



FREQUENCY RESPONSE

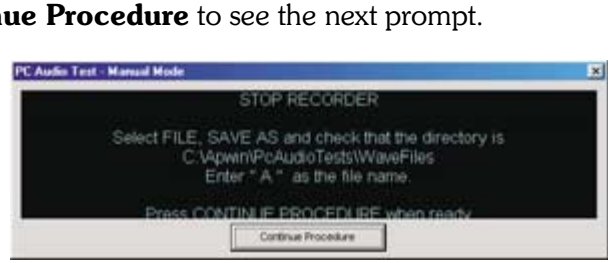
A-to-D Frequency Response: Manual Mode

Be sure you have Windows Sound Recorder on screen. Click the **FREQUENCY RESPONSE** button to begin the test. The following prompt will appear:

Figure 140 A-to-D Frequency Response Start Recorder Prompt

As prompted, start Sound Recorder. System Two will apply an ISO 1/3 octave multitone signal to the EUT inputs. Let it record for about 3 seconds. Click **Continue Procedure** to see the next prompt.

Figure 141 A-to-D Frequency Response Save File Prompt



Save the file as prompted, in the correct folder with the name A.wav. As you save, be sure Sound Recorder is correctly configured for CD-Quality, 44.1 kHz 16-bit. Click **Continue Procedure** to see the next prompt.

As the test is running, you will see an APWIN graph of frequency and phase response rendered on your screen. When the test is completed, a small prompt box appears with these options:

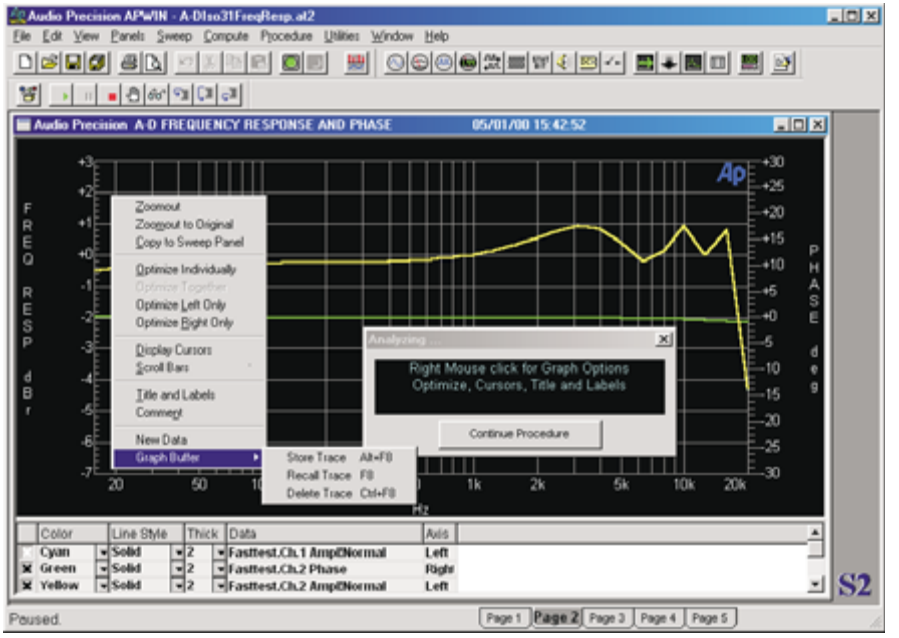
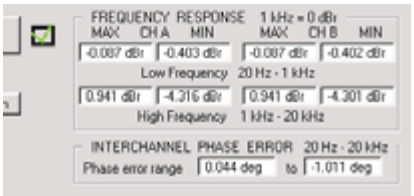


Figure 142 A-to-D Frequency Response Graph Windows with graph options shown

The prompt that appears on the graph gives you access to the APWIN Graph Menu (right click on the graph) for viewing and formatting options. When you are through viewing the graph, click **Continue Procedure**. PC Audio Tests computes the maximum and minimum deviations for both frequency response and phase response and then returns you to the A-to-D MEASUREMENTS panel.

Notice that the **FREQUENCY RESPONSE** and **INTERCHANNEL PHASE** display boxes now contain measurements.

Figure 143 A-to-D Frequency Response and Interchannel Phase Readings



When this test has been successfully completed, a green check mark appears to the right of the **FREQUENCY RESPONSE** button.

View Response Graph

View Response Graph

Once the Frequency Response test has been performed, you may return to view the response curve again by clicking **View Response Graph**. This dialog box will appear:

*Figure 144 Graph **Save Test–Set Panels** Window*

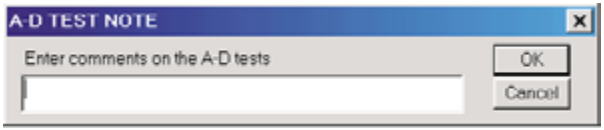
Click **Save Test** to save the graph data as an .ada or .at2 file (an option selectable on the Data Configuration panel). See **Appendix A: Setting Preferences in Configuration** (page 127). The **Graph, Panel Setup** button calls up a prompt and access to the APWIN Graph Menu (right click on the graph) for graph viewing and formatting options. Click **CONTINUE** to return to the test panel.

A-D Test Comment

A-to-D Test Report Comments

All test data is stored in memory for later retrieval for an optional report. If you would like to add a short comment to the A-to-D section of the test report, click the **A-D Test Comment** button.

Figure 145 A-to-D Test Report Comments



This completes the A-to-D testing of your PC sound device. You may generate a report now by returning to the Main Menu and clicking **Create Test Report**, or you can go to the next set of tests and generate your report later. See **Creating Test Reports**, (page 123).

If you leave the program at this point but return later to perform more tests, you must reset your A-to-D reference level. See **Set A-to-D Reference Level: Manual Mode** (page 92). Subsequent tests require the results of this test as reference values.

ADPCDA Tests

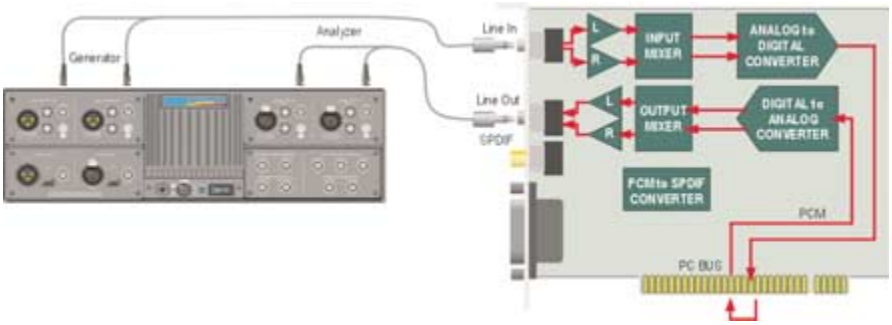


Figure 146 PC Audio Tests: the ADPCDA Test Group

What the ADPCDA tests do

See **What the tests do** (page 14) in the **Introduction** for an overview of the common functions of all the test groups.

The ADPCDA group of tests evaluates the performance of the EUT's entire record/playback path, measuring the characteristics of the analog-to-digital conversion of an audio input signal, the digital-to-analog conversion of .wav files, and of the analog input and output circuitry of the device. These tests satisfy Microsoft WHQL standard TM004.

Using the ADPCDA tests you will apply generator tones to the analog inputs of the EUT, record .wav files, play back the same files and measure the total harmonic distortion plus noise (THD+N), dynamic range and frequency response of the signals at the analog outputs of the EUT.

ADPCDA Reference Level

The ADPCDA test does not set new reference levels but instead uses the levels set in D-to-A for the 0 dBr output reference level, and

the levels set in A-to-D for 0 dBr input reference level. You must set D-to-A and A-to-D references before performing the ADPCDA group of tests.

ADPCDA THD+N Distortion

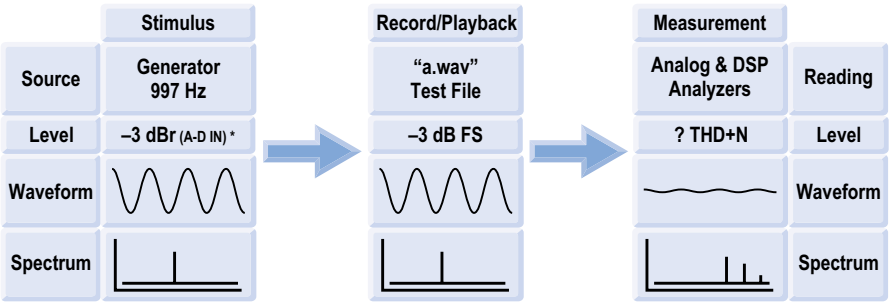
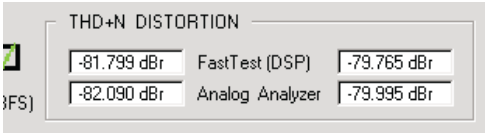


Figure 147 ADPCDA THD+N Test

As discussed in **What the tests do** (page 14) in the **Introduction**, this test measures the total harmonic distortion and noise (THD+N) found in the EUT ADPCDA signal path under test conditions.

** The stimulus level of –3 dB FS shown in the diagram is an option, one of four stimulus levels available for THD+N testing in setting up PC Audio Tests. See **Appendix A: Configuration** (page 127). The level chosen is displayed on-screen in the small box below the THD+N DISTORTION button.*

Figure 148 ADPCDA THD+N Readings



The upper pair of DISTORTION boxes show the THD+N results for the *FAST*TEST DSP technique, and the lower pair of boxes show the results from the Analog Distortion Analyzer. In the example shown the readings are between –78 dBr and –80 dBr. Notice the slight variations in the readings between the two methods.

ADPCDA Dynamic Range

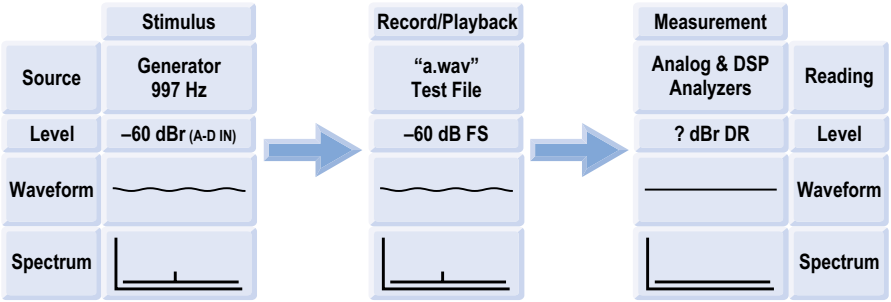


Figure 149 ADPCDA Dynamic Range Test

As discussed in **What the tests do** (page14) in the **Introduction**, this test measures the dynamic range of the EUT ADPCDA signal path under test conditions, using a –60 dB FS stimulus.

Figure 150 ADPCDA Dynamic Range Readings

PC Audio Tests uses both the *FAST*TEST (DSP) FFT technique and the traditional analog notch filter technique to produce two slightly different views of the noise signal and therefore two slightly different dynamic range figures.

ADPCDA Frequency Response

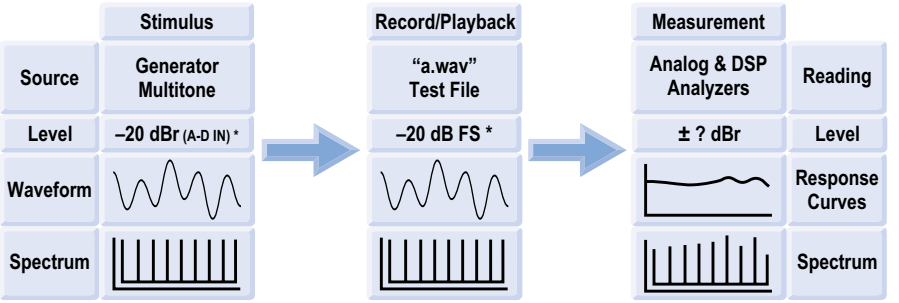
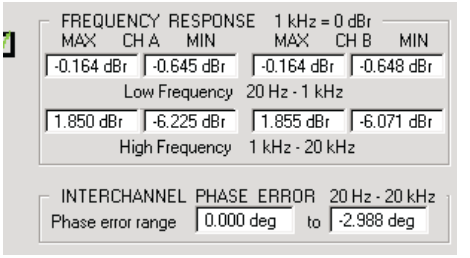


Figure 151 ADPCDA Frequency Response Test

As discussed in **What the tests do** (page 14) in the **Introduction**, this test measures the frequency response through the EUT ADPCDA signal path under test conditions.

While the response curve graph is on the screen, you have access to the APWIN graph options panel. The maximum and minimum response data are also reported in the FREQUENCY RESPONSE boxes on the test panel.

Figure 152 ADPCDA Frequency Response and Interchannel Phase Readings



ADPCDA Interchannel Phase

While the frequency response test is being made, PC Audio Tests also measures the relative phase angle between the channels A and B across the audible spectrum. A graph of this information is shown as a third trace on the response graph, with the maximum deviations displayed in degrees of angle in the two **INTERCHANNEL PHASE** boxes on this panel.

Running ADPCDA Tests in AUTOMATED MODE

We recommend that you run your tests in Automated Mode (using PC LevelCheck) whenever possible. If PC LevelCheck cannot control your sound device driver software, you must use Manual Mode. See **Test Modes** (page 24).

*If you choose not to use Automated Mode, you can skip this section and go directly to **Running ADPCDA Tests in Manual Mode** (page 111).*

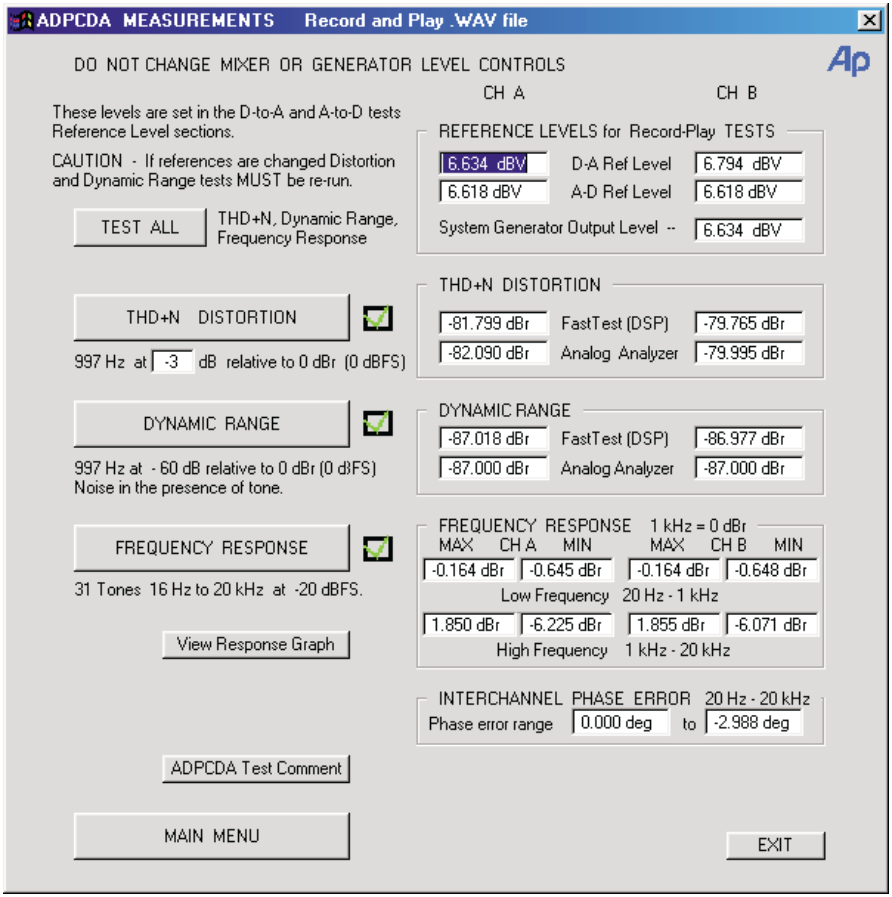


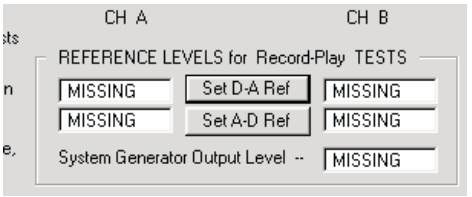
Figure 153 ADPCDA Measurements Panel

Click the **ADPCDA** button on the Main Menu to begin the test series. The ADPCDA MEASUREMENTS test panel will appear.

Set ADPCDA Reference Level: Automated Mode

The ADPCDA group of tests takes its input and output reference levels from previous tests. If you have completed D-A SET REFERENCE LEVEL and A-D SET REFERENCE LEVEL, you will see the results of those settings in the ADPCDA reference levels windows. If not, the windows will contain the word "MISSING."

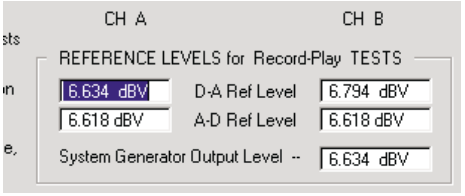
Figure 154 ADPCDA Reference Level Settings "MISSING"

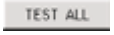


The ADPCDA group of tests cannot proceed without this data. If some or all of your settings are missing, you can either return to the Main Menu and perform the missing tests, or you can click the **Set D-A Ref** button or the **Set A-D Ref** button, as needed. PC Audio Tests will go directly to the tests and set the levels for you.

> *If you are in the middle of a continuing testing procedure and you reset reference levels, you may have to repeat some tests. If the new reference levels are not* exactly *the same as previous results, the other tests in that group will need to be repeated. If the green check marks remain after resetting reference levels, then the values were indeed precisely the same, and the results of the other tests in the group remain valid.*

Figure 155 ADPCDA Reference Levels





Test All

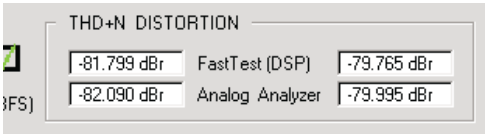
The **TEST ALL** button runs all of the next three tests in succession.

THD+N DISTORTION

ADPCDA THD+N Distortion: Automated Mode

To begin the test, click the **THD+N DISTORTION** button. In Automated Mode the test will proceed on its own, displaying its progress as it runs and quickly returning you to the ADPCDA MEASUREMENTS panel. The four display boxes to the right of the **THD+N DISTORTION** button now show test results.

Figure 156 ADPCDA THD+N Readings



If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

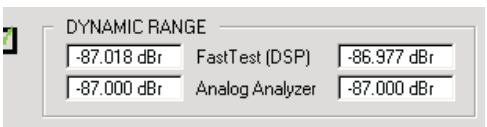
When this test has been successfully completed, a green check mark appears to the right of the **THD+N DISTORTION** button.

DYNAMIC RANGE

ADPCDA Dynamic Range: Automated Mode

To run the test, click the **DYNAMIC RANGE** button. In Automated Mode the test will proceed on its own, displaying its progress as it runs and quickly returning you to the ADPCDA MEASUREMENTS panel. The four display boxes to the right of the **DYNAMIC RANGE** button now show test results.

Figure 157 ADPCDA Dynamic Range Readings



If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

When this test has been successfully completed, a green check mark appears to the right of the **DYNAMIC RANGE** button.

FREQUENCY RESPONSE

ADPCDA Frequency Response: Automated Mode

Click the **FREQUENCY RESPONSE** button to begin the test.

As the test is running, you will see an APWIN graph of frequency and phase response rendered on your screen. If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

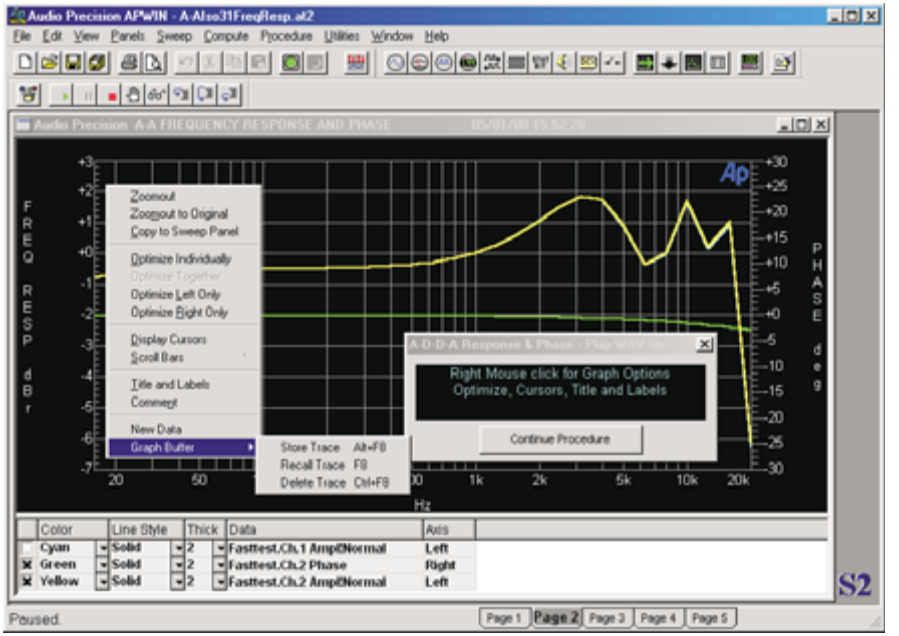
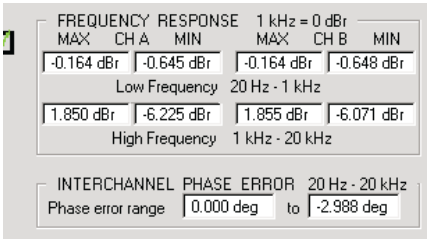


Figure 158 ADPCDA Frequency Response Graph Windows with graph options shown

The prompt that appears on the graph gives you access to the APWIN Graph Menu (right click on the graph) for viewing and formatting options. When you are through viewing the graph, click **Continue Procedure**. PC Audio Tests computes the maximum and minimum deviations for both frequency response and phase response and then returns you to the ADPCDA MEASUREMENTS panel.

Notice that the **FREQUENCY RESPONSE** and **INTERCHANNEL PHASE** display boxes now contain measurements.

Figure 159 ADPCDA Frequency Response and Interchannel Phase Readings



When this test has been successfully completed, a green check mark appears to the right of the **FREQUENCY RESPONSE** button.

View Response Graph

View Response Graph

Once the Frequency Response test has been performed, you may return to view the response curve again by clicking **View Response Graph**. This dialog box will appear:

*Figure 160 Graph **Save Test– Set Panels** Window*

Click **Save Test** to save the graph data as an .ada or .at2 file (an option selectable on the Configuration: Data panel). See **Appendix A: Setting Preferences in Configuration** (page 127)**.** The **Graph, Panel Setup** button calls up a prompt and access to the APWIN Graph Menu (right click on the graph) for graph viewing and formatting options. Click **CONTINUE** to return to the test panel.

AD-PC-DA Test Comment

ADPCDA Test Report Comments

All test data is stored in memory for later retrieval for an optional report. If you would like to add a short comment to the ADPCDA section of the test report, click the **ADPCDA Test Report Comments** button.

Figure 161 ADPCDA Test Report Comments

This completes the ADPCDA testing of your PC sound device. You may generate a report now by returning to the Main Menu and clicking

Create Test Report, or you can make your report later. See **Creating Test Reports**, (page 123).

Running ADPCDA Tests in MANUAL MODE

We recommend that you run your tests in Automated Mode (using PC LevelCheck) whenever possible. If PC LevelCheck cannot control your sound device driver software, you must use Manual Mode. See **Test Modes** (page 24).

*If you can use Automated Mode, you should skip this section and go directly to **Running ADPCDA Tests in Automated Mode** (page 105).*

You will need both the Recording and Playback Windows Volume Controls and Windows Sound Recorder on your desktop to run ADPCDA tests in Manual Mode. Follow the instructions below:

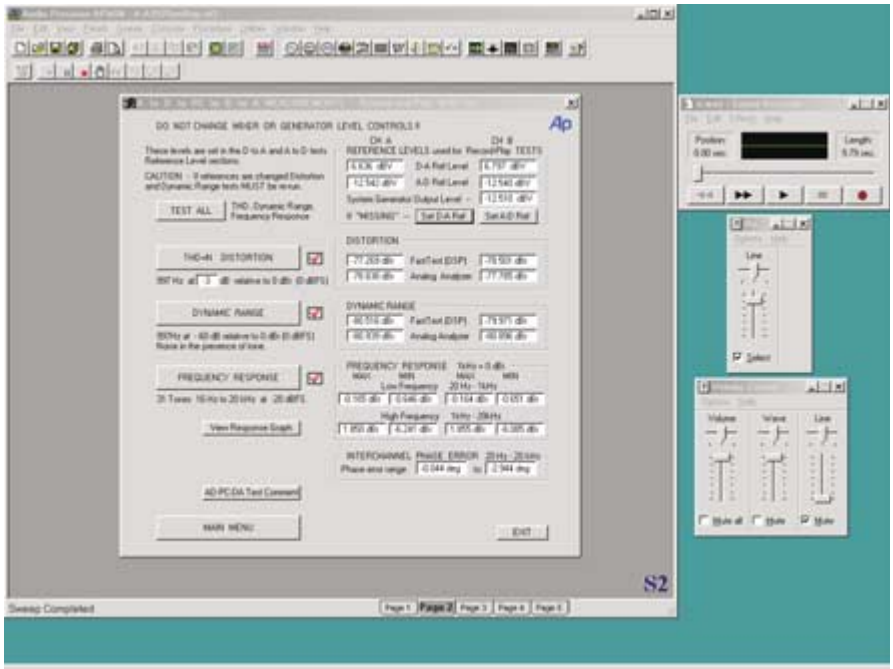


Figure 162 Desktop Setup for ADPCDA Manual Mode Testing

Click the **ADPCDA** button on the Main Menu to begin the test series. The ADPCDA MEASUREMENTS test panel will appear.

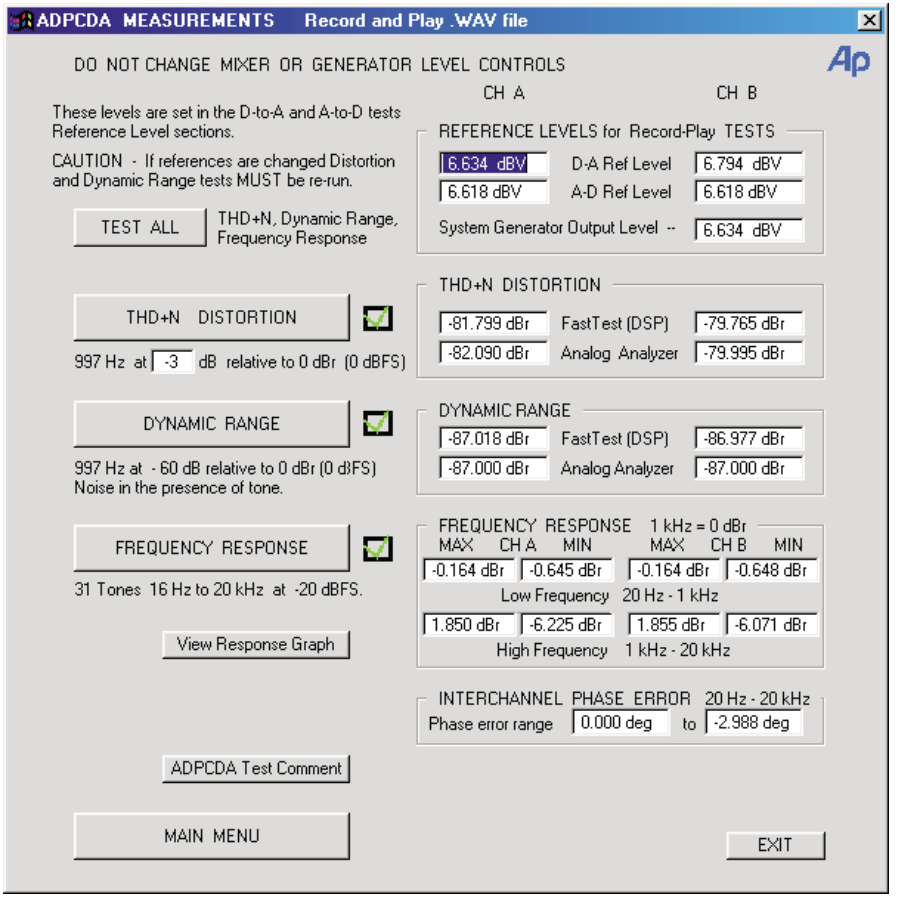
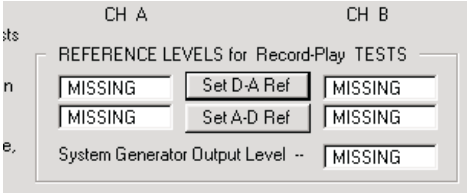


Figure 163 ADPCDA Measurements Panel

Set ADPCDA Reference Level: Manual Mode

The ADPCDA group of tests takes its input and output reference levels from previous tests. If you have completed D-A SET REFERENCE LEVEL and A-D SET REFERENCE LEVEL, you will see the results of those settings in the ADPCDA reference levels windows. If not, the windows will contain the word "MISSING."

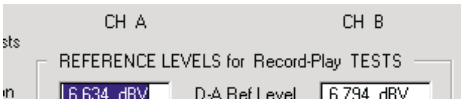
Figure 164 ADPCDA Reference Level Settings "MISSING"



The ADPCDA group of tests cannot proceed without this data. If some or all of your settings are missing, you can either return to the Main Menu and perform the missing tests, or you can click the **Set D-A Ref** button or the **Set A-D Ref** button, as needed. PC Audio Tests will go directly to the tests and set the levels for you.

If you are in the middle of a continuing testing procedure and you reset reference levels, you may have to repeat some tests. If the new reference levels are not exactly *the same as previous results, the other tests in that group will need to be repeated. If the green check marks remain after resetting reference levels, then the values were indeed precisely the same, and the results of the other tests in the group remain valid.*

Figure 165 ADPCDA Reference Level Settings



TEST ALL

Test All

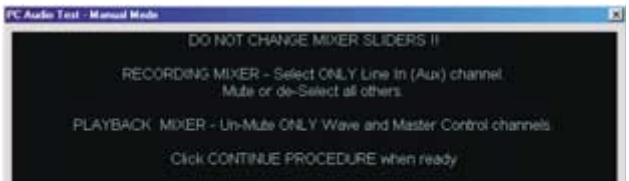
The **TEST ALL** button runs all of the next three tests in succession.

THD+N DISTORTION

ADPCDA THD+N Distortion: Manual Mode

Be sure you have Windows Recording and Playback Mixers and Windows Sound Recorder, on screen. To begin the test, click the **THD+N DISTORTION** button. The following prompt will appear:

Figure 166 ADPCDA THD+N Mixer Settings Prompt



Be sure your mixers are set up properly, with the Line-In slider on the Recording Mixer selected, and the Master Volume and Wave sliders on the Playback Mixer unmuted. All other sliders should be muted. Do not change the level setting of any slider.

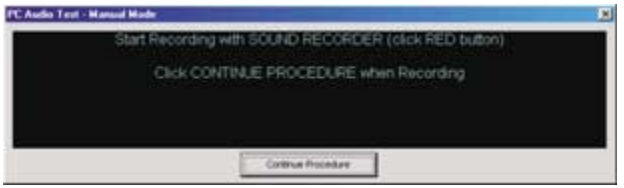
Click **Continue Procedure** to see the next prompt.

Figure 167 ADPCDA THD+N Sound Recorder Settings Prompt

Follow the instructions on the prompts to initialize Sound Recorder by saving a properly formatted file as A.wav.

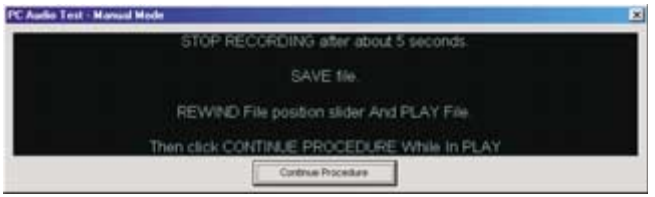
Click **Continue Procedure** to see the next prompt.

Figure 168 ADPCDA THD+N Start Sound Recorder Prompt



As prompted, start recording a file in Sound Recorder by clicking the ● red recording button. System Two will apply a 997 Hz tone at the selected stimulus level to the EUT inputs. Click **Continue Procedure** to see the next prompt.

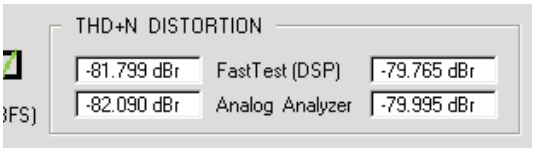
Figure 169 ADPCDA THD+N Save File Prompt



The recording should continue for about 5 seconds. Click the ■ stop button on Sound Recorder and then save the file. Rewind the file position slider (either by clicking the ◂◂ left double-arrow or by dragging the slider to the extreme left). Click the ▸ play arrow, and then click **Continue Procedure** while the file is playing.

Display boxes will advise you of progress as the test proceeds. The test will quickly run to completion and return you to the ADPCDA MEASUREMENTS panel. You may want to click the ■ stop button on Sound Recorder to interrupt playback of the .wav file.

Figure 170 ADPCDA THD+N Readings



You will notice that the four display boxes to the right of the **THD+N DISTORTION** button now show test results. The two upper boxes show the THD+N results for the *FAST*TEST DSP technique, and the two lower boxes show the results from the Analog Distortion Analyzer.

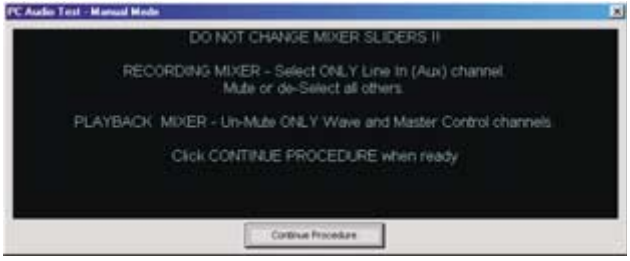
When this test has been successfully completed, a green check mark appears to the right of the **THD+N DISTORTION** button.

DYNAMIC RANGE

ADPCDA Dynamic Range: Manual Mode

Be sure you have Windows Recording and Playback Mixers and Windows Sound Recorder, on screen. To begin the test, click the **DYNAMIC RANGE** button. The following prompt will appear:

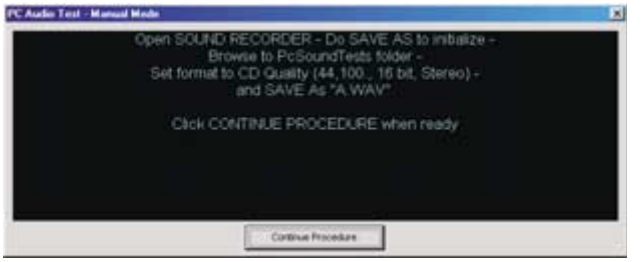
Figure 171 ADPCDA Dynamic Range Mixer Settings Prompt



Be sure your mixers are set up properly, with the Line-In slider on the Recording Mixer selected, and the Master Volume and Wave sliders on the Playback Mixer unmuted. All other sliders should be muted. Do not change the level setting of any slider.

Click **Continue Procedure** to see the next prompt.

Figure 172 ADPCDA Dynamic Range Sound Recorder Settings Prompt



Follow the instructions on the prompts to initialize Sound Recorder by saving a properly formatted file as A.wav.

Click **Continue Procedure** to see the next prompt.

Figure 173 ADPCDA Dynamic Range Start Sound Recorder Prompt

As prompted, start recording a file in Sound Recorder by clicking the ● red recording button. System Two will apply a 997 Hz tone at –60 dBr to the EUT inputs. Click **Continue Procedure** to see the next prompt.

Figure 174 ADPCDA Dynamic Range Save File Prompt

The recording should continue for about 5 seconds. Click the ■ stop button on Sound Recorder and then save the file. Rewind the file position slider (either by clicking the ◀◀ left double-arrow or by dragging the slider to the extreme left). Click the ▶ play arrow, and then click **Continue Procedure** while the file is playing.

Display boxes will advise you of progress as the test proceeds. The test will quickly run to completion and return you to the ADPCDA MEASUREMENTS panel. You may want to click the ■ stop button on Sound Recorder to interrupt playback of the .wav file.

Figure 175 ADPCDA Dynamic Range Readings

You will notice that the four display boxes to the right of the **DYNAMIC RANGE** button now show test results. The two upper boxes show the Dynamic Range results for the *FAST*TEST DSP technique, and the two lower boxes show the results from the Analog Distortion Analyzer.

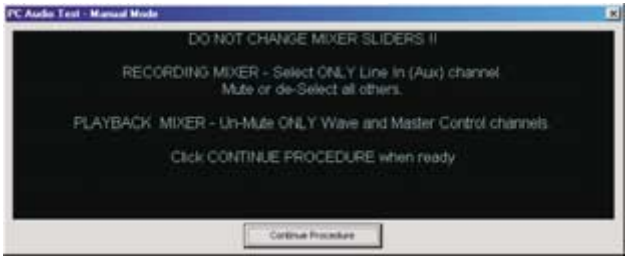
When this test has been successfully completed, a green check mark appears to the right of the **DYNAMIC RANGE** button.

FREQUENCY RESPONSE

ADPCDA Frequency Response: Manual Mode

Be sure you have Windows Recording and Playback Mixers and Windows Sound Recorder, on screen. To begin the test, click the **FREQUENCY RESPONSE** button. The following prompt will appear:

Figure 176 ADPCDA Frequency Response Mixer Settings Prompt



Be sure your mixers are set up properly, with the Line-In slider on the Recording Mixer selected, and the Master Volume and Wave sliders on the Playback Mixer unmuted. All other sliders should be muted. Do not change the level setting of any slider.

Click **Continue Procedure** to see the next prompt.

Figure 177 ADPCDA Frequency Response Sound Recorder Settings Prompt

Follow the instructions on the prompts to initialize Sound Recorder by saving a properly formatted file as A.wav.

Click **Continue Procedure** to see the next prompt.

Figure 178 ADPCDA Frequency Response Start Sound Recorder Prompt

As prompted, start recording a file in Sound Recorder by clicking the ● red recording button. System Two will apply a multitone signal to the EUT inputs. Click **Continue Procedure** to see the next prompt.

Figure 179 ADPCDA Frequency Response Save File Prompt

The recording should continue for about 5 seconds. Click the ■ stop button on Sound Recorder and then save the file. Rewind the file position slider (either by clicking the ◀◀ left double-arrow or by dragging the slider to the extreme left). Click the ▶ play arrow, and then click **Continue Procedure** while the file is playing.

Display boxes will advise you of progress as the test proceeds. The test will quickly run to completion and return you to the ADPCDA

MEASUREMENTS panel. You may want to click the ■ stop button on Sound Recorder to interrupt playback of the .wav file.

As the test is running, you will see an APWIN graph of frequency and phase response rendered on your screen. If PC Audio Tests encounters a problem, an error warning appears to suggest that you check connections and configuration and retry.

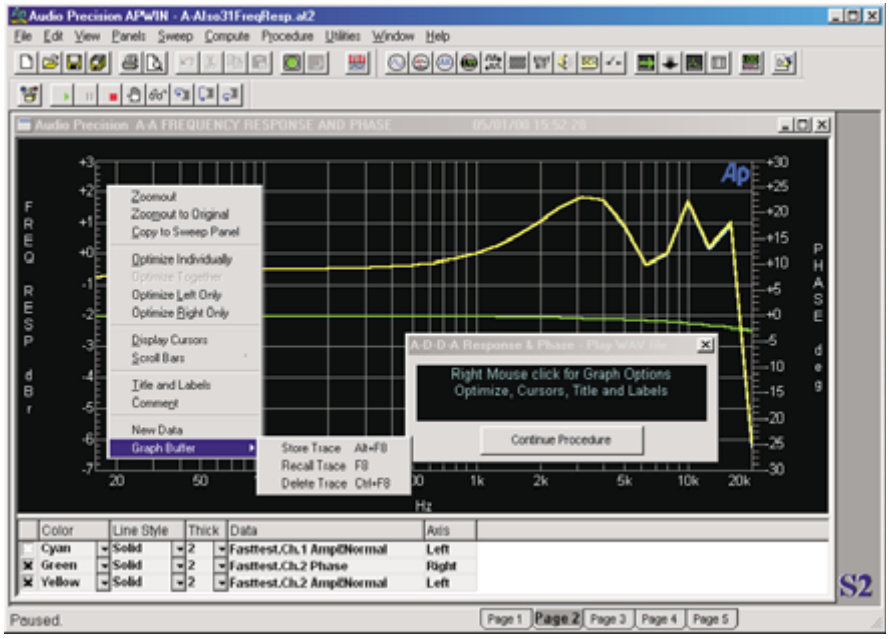
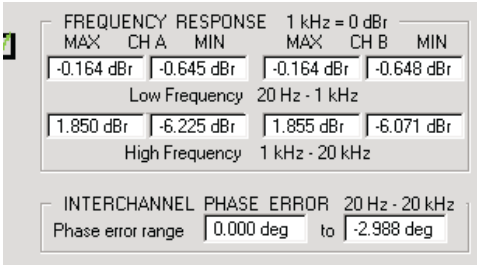


Figure 180 ADPCDA Frequency Response Graph Windows with graph options shown

The prompt that appears on the graph gives you access to the APWIN Graph Menu (right click on the graph) for viewing and formatting options. When you are through viewing the graph, click **Continue Procedure**. PC Audio Tests computes the maximum and minimum deviations for both frequency response and phase response and then returns you to the ADPCDA MEASUREMENTS panel.

Notice that the **FREQUENCY RESPONSE** and **INTERCHANNEL PHASE** display boxes now contain measurements.

Figure 181 ADPCDA Frequency Response and Interchannel Phase Readings



When this test has been successfully completed, a green check mark appears to the right of the **FREQUENCY RESPONSE** button.

View Response Graph

View Response Graph

Once the Frequency Response test has been performed, you may return to view the response curve again by clicking **View Response Graph**. This dialog box will appear:

*Figure 182 Graph **Save Test–Set Panels** Window*

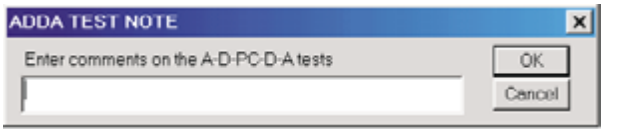
Click **Save Test** to save the graph data as an .ada or .at2 file (an option selectable on the Configuration: Data panel). See **Appendix A: Setting Preferences in Configuration** (page 127)**.** The **Graph, Panel Setup** button calls up a prompt and access to the APWIN Graph Menu (right click on the graph) for graph viewing and formatting options. Click **CONTINUE** to return to the test panel.

AD-PC-DA Test Comment

ADPCDA Test Report Comments

All test data is stored in memory for later retrieval for an optional report. If you would like to add a short comment to the ADPCDA section of the test report, click the **ADPCDA Test Report Comments** button.

Figure 183 ADPCDA Test Report Comments



This completes the ADPCDA testing of your PC sound device. You may generate a report now by returning to the Main Menu and clicking **Create Test Report**, or you can go to the next set of tests and generate your report later. See **Creating Test Reports**, (page 123).

Creating Test Reports

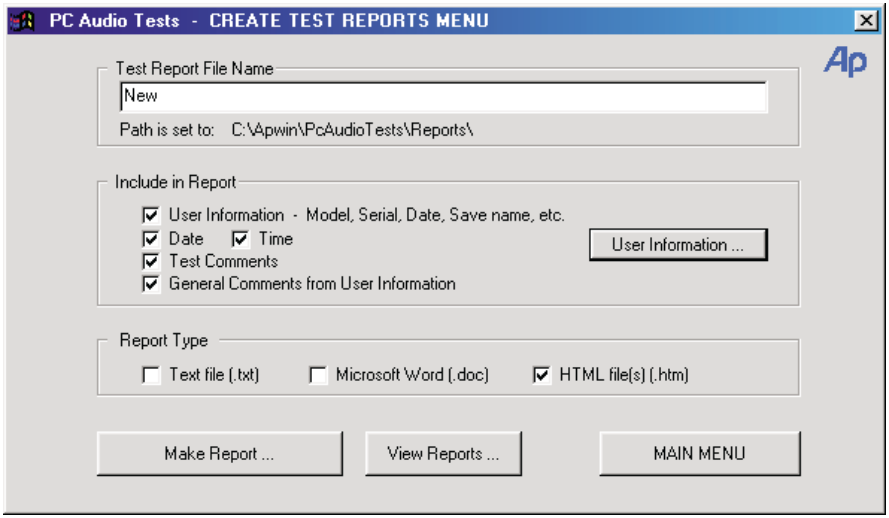


Figure 184 Create Report Panel

As you perform each test, the test results are stored in the computer's memory. You can create a report with the information in these results at any time during the procedure.

Saving Test Reports

On the Main Menu panel, click **Create Test Report**. At the top of the Test Report panel you can select a name for the report file. The default name is New.*, and the file extension is determined by the report type you select.

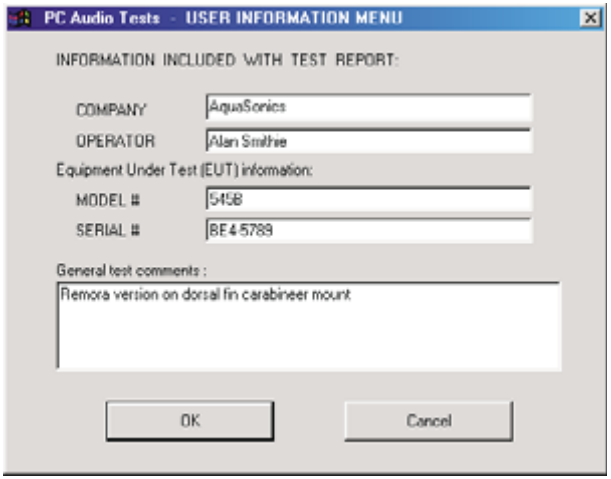
The path to the report folder is shown. You can change the report folder path in the **Configuration: Data** panel (page 132).

In the second box you can select which test results to report. Tests that have been completed are already checked. Simply check or uncheck the boxes to select the results you would like to have included in your report.

You can also choose what additional information you would like to include in your report. Check the box next to the information listed.

You can enter your name, company, the model and serial number of the EUT and whatever comments you may have and include this information in the test report if you wish. Click **User Information** to enter or edit this information.

Figure 185 Test Report User Information Panel



Test Reports can be always be saved as a text file or as a set of linked HTML files, as selected by the check box in the **Report Type** area of the panel. If you have Microsoft Word 97 or later on your computer, you also can save the files as a Word document.

In the Report Type box, simply click **Text file (.txt)**, **Microsoft Word (.doc)** or **HTML file(s) (.htm)** to select the file format you prefer.

When you are finished setting your preferences for a Test Report, click **OK**. PC Audio Tests will generate a report and save it in the format(s) you have specified.

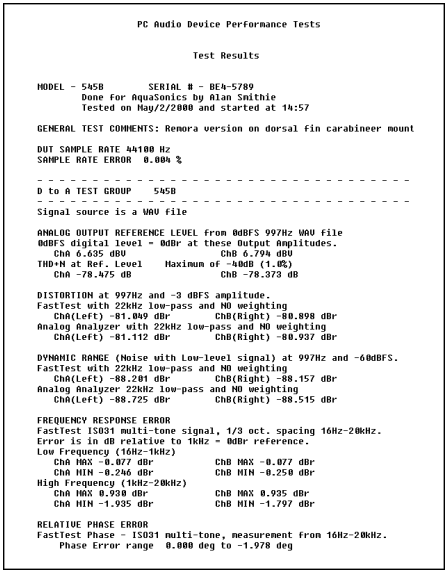
Viewing and Printing Test Reports

To view the files you have created, click **View Report**. This will bring up a browser window listing the all the files in the Reports folder. Select the file you would like to view and click **Open**. The application associated with the file type (typically Notepad, Internet Explorer, Netscape Navigator or Microsoft Word) will launch and display your report.

You can print the report from within any of these programs.

You may also open the report files later in a text editor, in Microsoft Word or in an HTML browser, as appropriate, to view or print your files. The files will be in the folder you specified, with the names you chose.

Word document and HTML reports also provide frequency response graphs.



```
                    PC Audio Device Performance Tests

                              Test Results

MODEL - 545B        SERIAL # - BE4-5789
        Done for AquaSonics by Alan Smithie
        Tested on May/2/2000 and started at 14:57

GENERAL TEST COMMENTS: Remora version on dorsal fin carabineer mount

DUT SAMPLE RATE 44100 Hz
SAMPLE RATE ERROR  0.00% %

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
D to A TEST GROUP   545B
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
Signal source is a WAV file

ANALOG OUTPUT REFERENCE LEVEL from 0dBFS 997Hz WAV file
0dBFS digital level = 0dBr at these Output Amplitudes.
   ChA 6.635 dBV                    ChB 6.794 dBV
THD+N at Ref. Level    Maximum of -40dB (1.0%)
   ChA -78.475 dB                   ChB -78.373 dB

DISTORTION at 997Hz and -3 dBFS amplitude.
FastTest with 22kHz low-pass and NO weighting
   ChA(Left) -81.049 dBr        ChB(Right) -80.898 dBr
Analog Analyzer with 22kHz low-pass and NO weighting
   ChA(Left) -81.112 dBr        ChB(Right) -80.937 dBr

DYNAMIC RANGE (Noise with Low-level signal) at 997Hz and -60dBFS.
FastTest with 22kHz low-pass and NO weighting
   ChA(Left) -88.201 dBr        ChB(Right) -88.157 dBr
Analog Analyzer 22kHz low-pass and NO weighting
   ChA(Left) -88.725 dBr        ChB(Right) -88.515 dBr

FREQUENCY RESPONSE ERROR
FastTest ISO31 multi-tone signal, 1/3 oct. spacing 16Hz-20kHz.
Error is in dB relative to 1kHz = 0dBr reference.
Low Frequency (16Hz-1kHz)
   ChA MAX -0.077 dBr           ChB MAX -0.077 dBr
   ChA MIN -0.246 dBr           ChB MIN -0.250 dBr
High Frequency (1kHz-20kHz)
   ChA MAX 0.930 dBr            ChB MAX 0.935 dBr
   ChA MIN -1.935 dBr           ChB MIN -1.797 dBr

RELATIVE PHASE ERROR
FastTest Phase - ISO31 multi-tone, measurement from 16Hz-20kHz.
    Phase Error range  0.000 deg to -1.978 deg
```

Figure 186 Report in text format

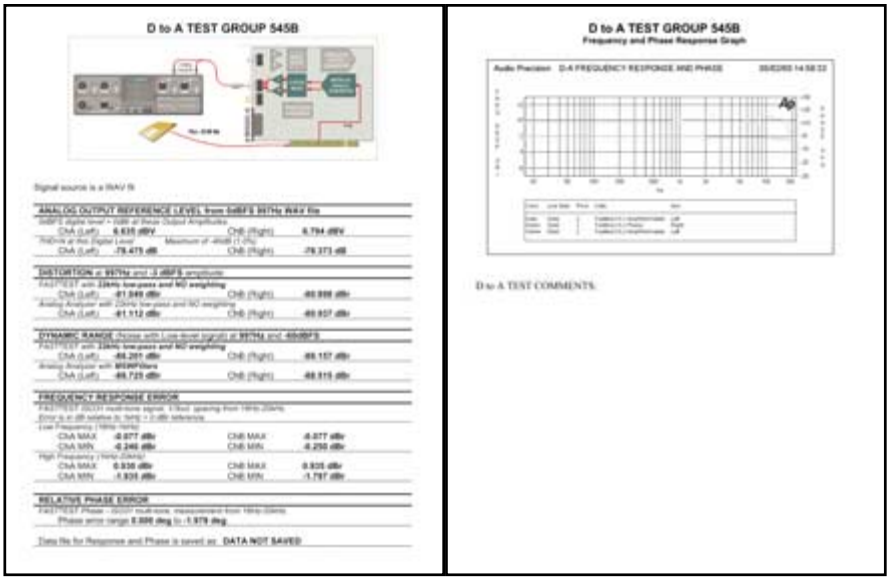


Figure 187 Report in MS Word format

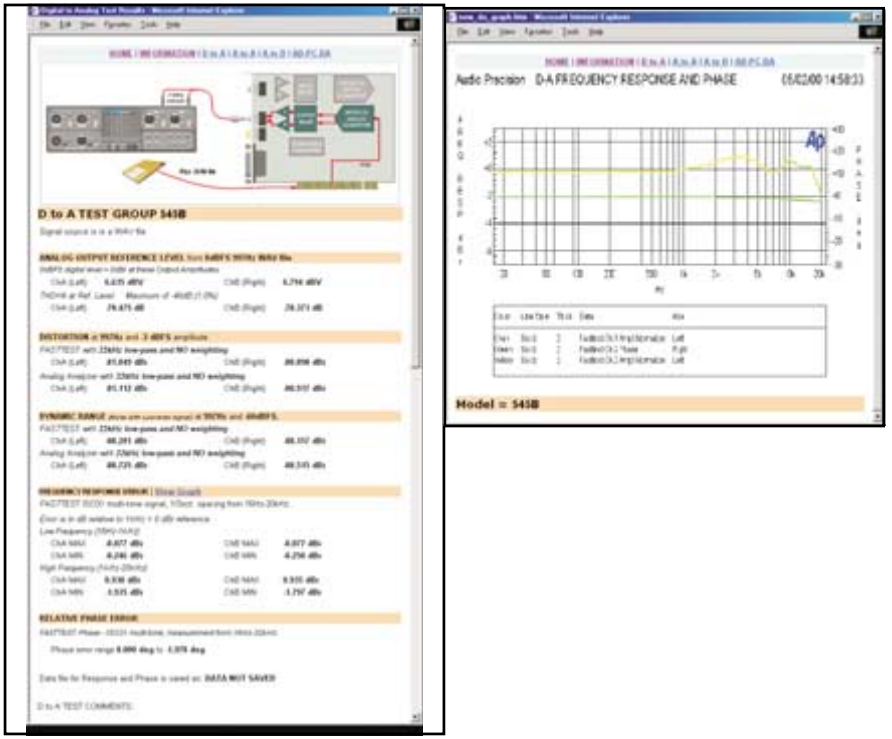


Figure 188 Report in HTML format

Appendix A

Setting Preferences in Configuration

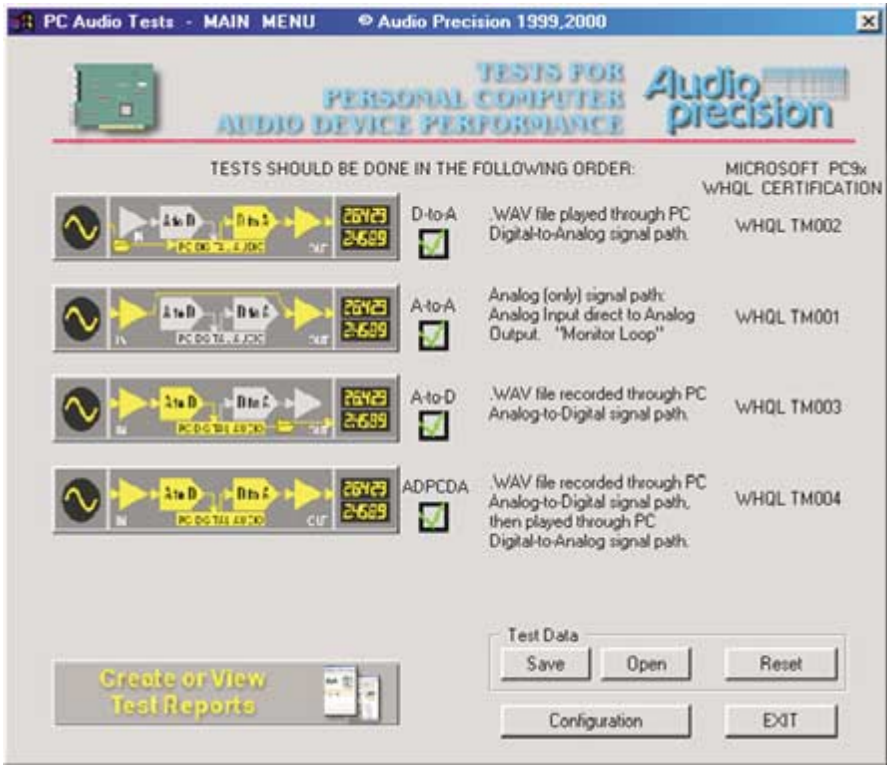


Figure 189 The Main Menu

If this is the first time the program has been run, or if you need to change previous settings, you will need to configure the system before you perform any tests. Click the **Configuration** button at the bottom of the Main Menu to select the first of five tabbed configuration panels that allow you to set your preferences for the test.

Configuration Panel 1: Connections

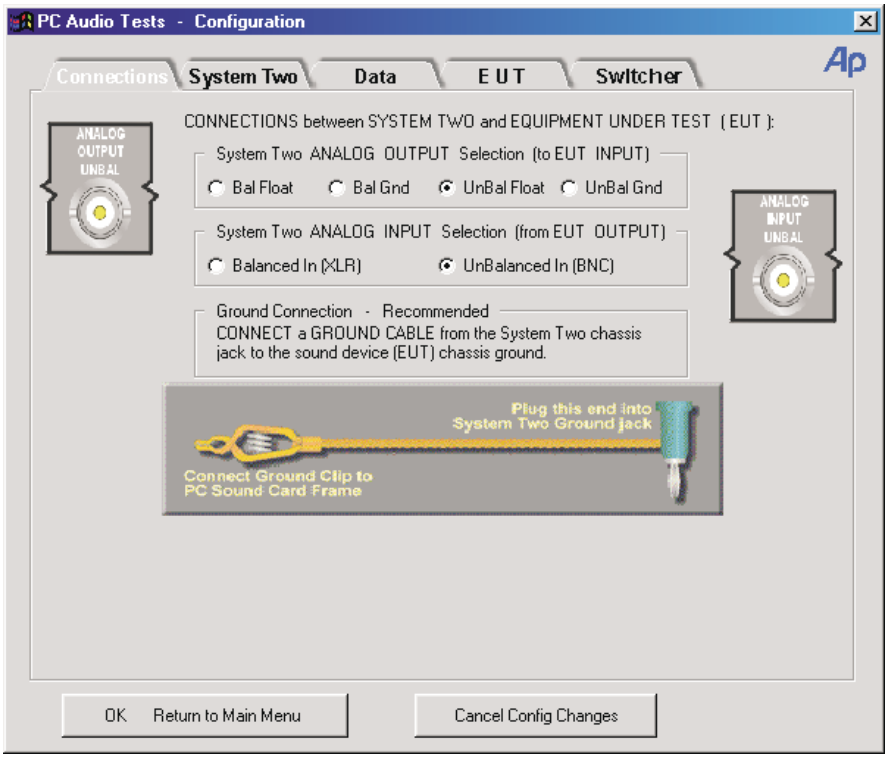


Figure 190 Configuration Panel, Connections Tab, unbalanced to unbalanced

The Connections panel allows you to inform System Two of your interface decisions. Two sets of option buttons allow you to set the input and output configuration of System Two, while additional text and graphics provide a refresher course in PC sound card connections. Select the connections you have chosen by clicking on the appropriate option button. Default selections for System Two are **UnBal Float** for output and **UnBalanced In (BNC)** for input.

As you make your selections graphics will appear to guide you in making the proper connections between System Two and the EUT.

Configuration Panel 2: System Two

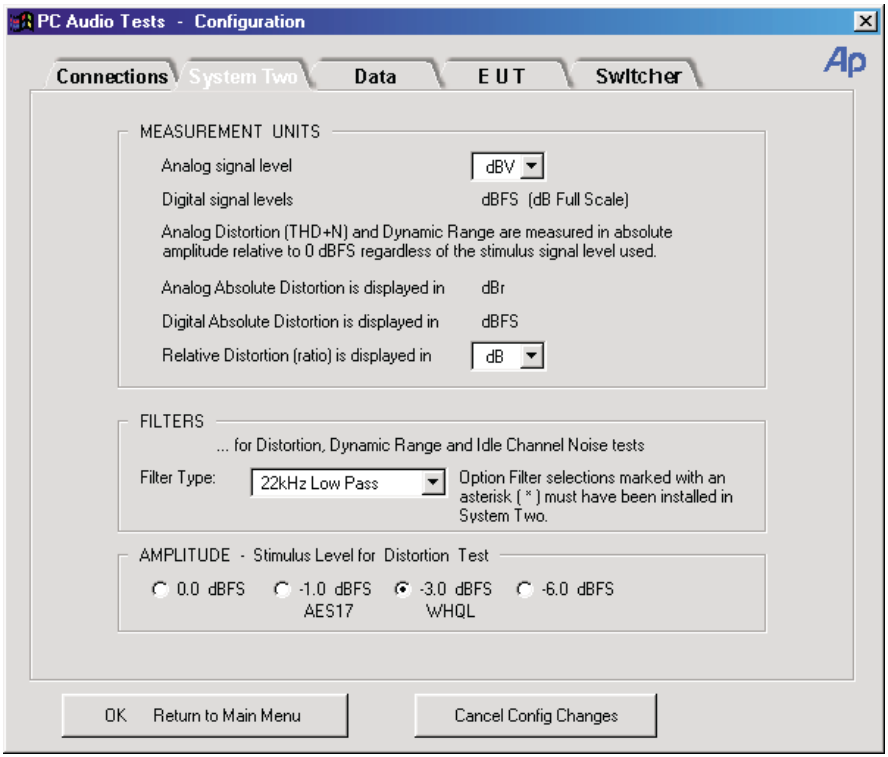


Figure 191 Configuration Panel, System Two Tab

Selecting Units

In the first box on this page you can select your choice of units of measurement for analog signal levels and for distortion ratio. Units of measurement for other parameters are not user-selectable, but are displayed on this panel for your information.

Measurement:	User-selectable:	Units available:
Analog signals	Yes, 3 choices	dBV, V rms, dBu
Digital signals	No, fixed	dB FS

Measurement:	User-selectable:	Units available:
Analog distortion test, dynamic range test, idle channel noise test values	No, fixed	dBr (referenced to 0 dB FS)
Digital distortion test, dynamic range test, idle channel noise test values	No, fixed	dB FS
Distortion expressed as ratio or relative distortion	Yes, 2 choices	dB, %

Table 2 Units of Measurement Selection

The decibel (dB) is widely used in audio measurements, always referenced to a particular value. dBV, for example, is the shorthand for decibels referenced to 1 volt rms. dB FS is a decibel audio measurement for digital audio, and the reference "FS" stands for "Full Scale." A full scale digital signal (0 dB FS) is the rms value of a sine wave whose positive peak just reaches full scale, represented by the maximum value in the coding scheme. See the Glossary for more information.

dBr means dB relative to a temporary, user-defined or test-defined reference. In PC Audio Tests, the values set as reference for dBr have different values within different tests.

Selecting Filters

The next box allows you to select one of a series of filters (or no filter) within System Two for distortion, dynamic range and idle channel noise tests. The 22 kHz low-pass filter is standard in all System Twos; other filters marked with an asterisk (*) are optional and must be installed in a filter slot in System Two to function when selected.

We recommend using some filtering (at least the 22 kHz low-pass filter) for all tests.

Setting Distortion Test Stimulus Level

Distortion tests may be performed at any level, with different levels producing different test results. The third area on this panel allow you

to select one of four different stimuli levels for your distortion test: 0 dB FS, –1 dB FS (in accord with the AES17 specification), –3 dB FS (satisfying Microsoft's WHQL specification) or –6 dB FS. The default setting is the WHQL –3 dB FS stimulus level.

The result of a distortion test at any of these four levels is always expressed as the absolute THD+N signal amplitude in dB FS (or dBr, with 0 dBr set to equal 0 dB FS).

Distortion test results are usually reported as the ratio (in dB or per cent) between the amplitude of the stimulus signal and the distortion products. The WHQL standard specifies the reporting of amplitude of distortion products in dB FS units, regardless of the stimulus amplitude. When expressed in dB, these results correspond to the more conventional means of distortion ratio measurement only when the stimulus is 0 dB FS.

Configuration Panel 3: Data

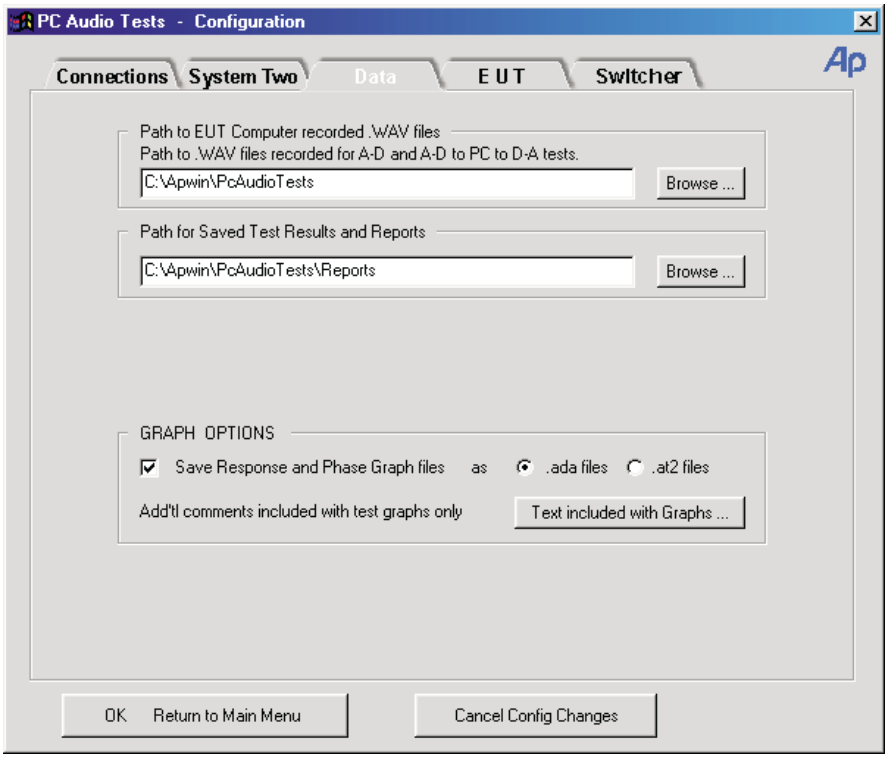


Figure 192 Configuration Panel, Data Tab

Setting file paths

At the top of this panel are two boxes for entering data path information. First set the path locating the output files of the EUT. This is the folder where the computer will store the .wav files the sound card creates when you run A-to-D tests. There is a default file path set in the dialog box, and you can choose that path, edit it or browse for another path.

Saving .wav files created during a test allows subsequent re-analysis of A-to-D and ADPCDA test data.

The second box on the panel lets you set the path to the folder where PC Audio Tests will store test result files and reports. Once again, you can accept the default or choose a different path.

Graph options

When PC Audio Tests displays a graph, you have the option of saving the graph data. Click **Save Response and Phase Graph files** if you want to save this data. If you select this option, you can choose whether to save the information as an AP *.ada data file or *.at2 test file.

You may also elect to save a comment with the graph data files. Click **Text included with Graphs** to exercise this option.

Configuration Panel 4: EUT

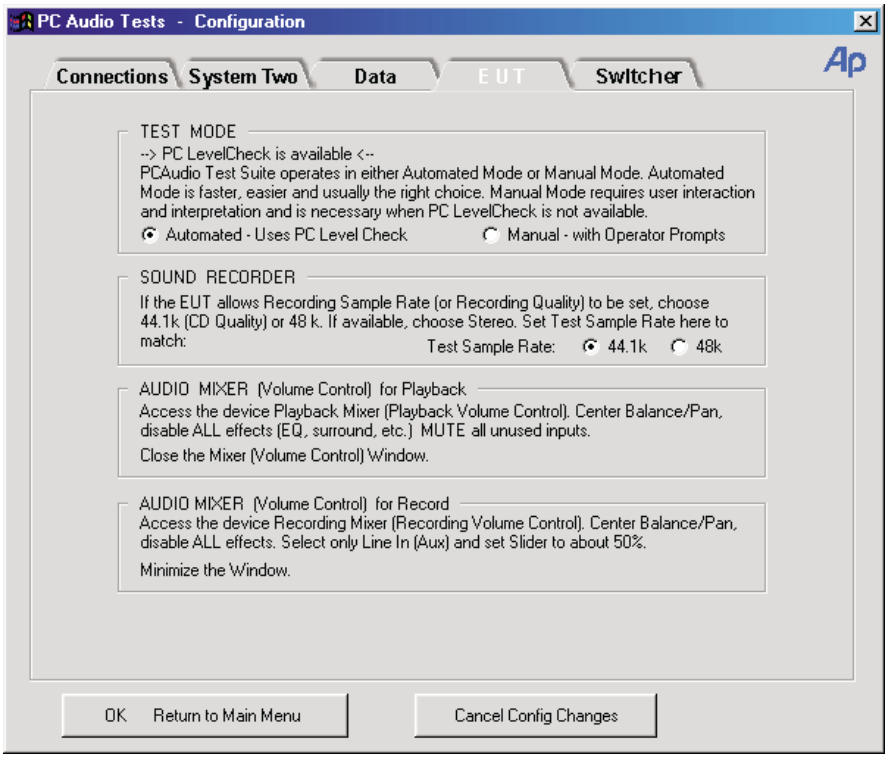
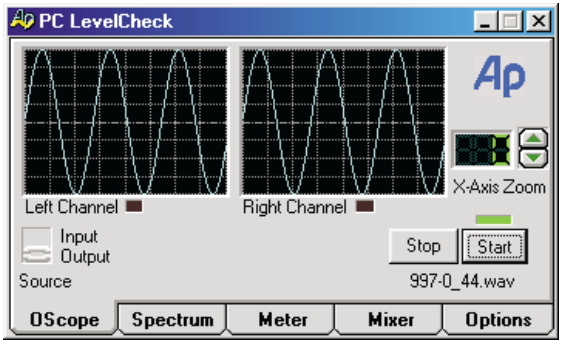


Figure 193 Configuration Panel, EUT Tab, Automated Mode

On this page you have the option of selecting the Test Mode for PC Audio Tests. In most cases you will want to run PC Audio Tests in the Automated Mode, which is the default selection.

Figure 194 PC LevelCheck in OScope Mode



Automated Mode uses the companion program PC LevelCheck to automatically regulate input and output levels, adjust the mixer and make other settings. This is by far the easiest and fastest way to perform tests on a sound card and should be your first choice. However, sound cards vary greatly in their characteristics and there are some that cannot be properly controlled by PC LevelCheck. In these cases, or in situations which for some other reason require manual interaction, you have the option of disabling PC LevelCheck and running PC Audio Tests in Manual Mode using prompts to guide you through the tests.

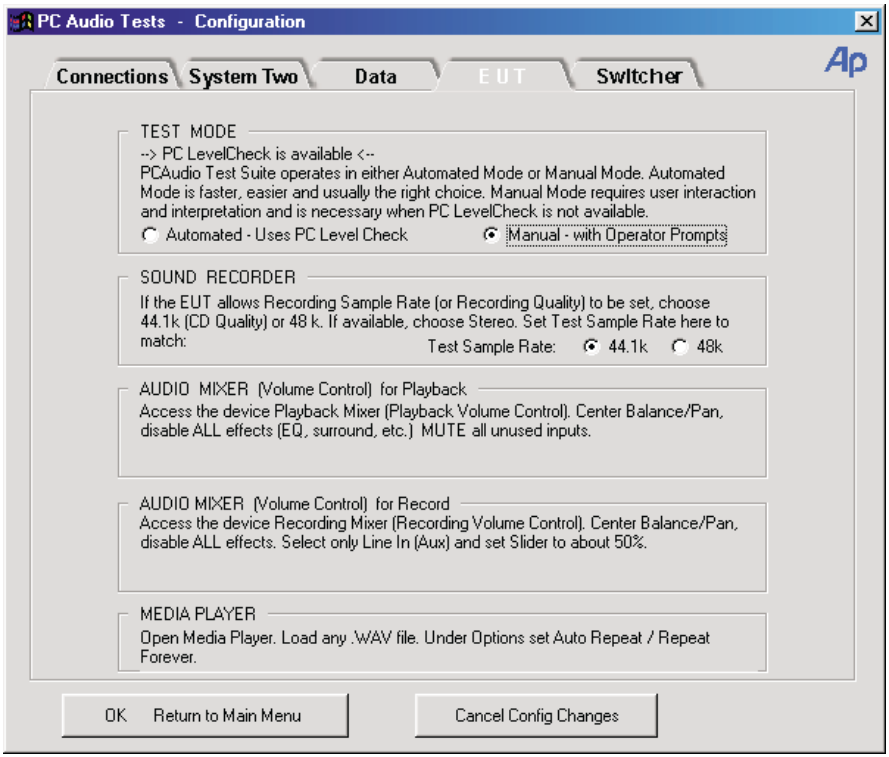


Figure 195 Configuration Panel, EUT Tab, Manual Mode

If you select Manual Mode, new text will appears on the page with instructions for proper configuration for Manual Mode. Manual Mode requires much more user interaction and interpretation of test results than Automated Mode.

See **TEST MODES** page 24.

Configuration Panel 5: Switcher

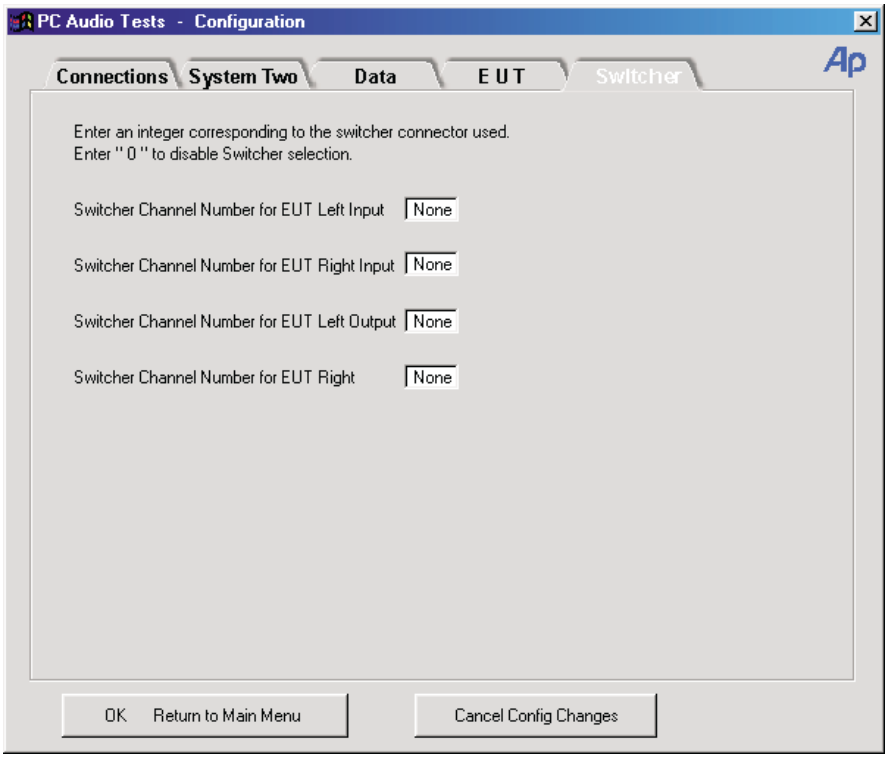


Figure 196 Configuration Panel, Switcher Tab

If you are using an Audio Precision Switcher (series SWR-2122 or earlier) with this procedure, you can go to the Switcher panel to set the channels.

This completes the configuration process. Click **OK** to return to the **Main Menu** and begin the tests.

Appendix B

PC Sound Cards and Audio Devices

Sound cards and other audio devices for use as part of a PC system vary widely in their purposes, features and characteristics. PC Audio Tests is designed to measure only the digital recording and playback functions of PC sound cards and audio devices. Other functions, such as sound synthesis and MIDI control, are beyond the scope of this manual and will not be discussed in this appendix.

A Typical PC Sound Card

A typical inexpensive PC sound card has, among other features, the capability to record and play .wav file format 16-bit PCM stereo digital audio at a 44.1 kHz sample rate. These cards also offers mono file capability, lower sampling rates and 8-bit word length as options. Analog connections are invariably unbalanced circuits with maximum levels of +6 dBV (2 V rms) or often much less, provided on 3.5 mm mini phone jacks.

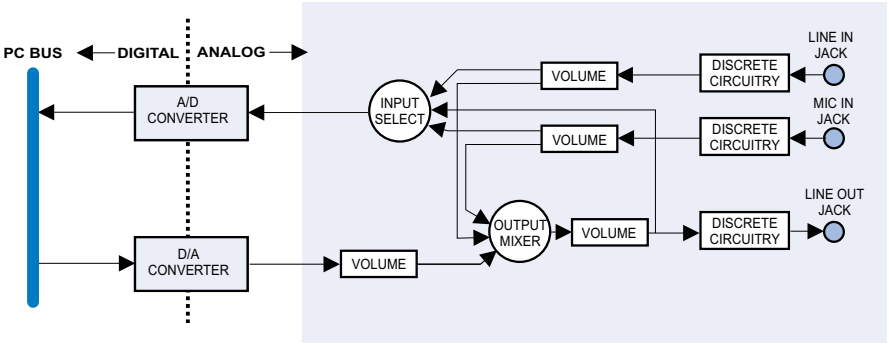


Figure 197 Typical PC Sound Card Block Diagram

Designed for the mass market, such a PC sound card is often referred to as a "consumer" sound card, as opposed to the "professional" or "semi-pro" sound cards designed for specialized markets.

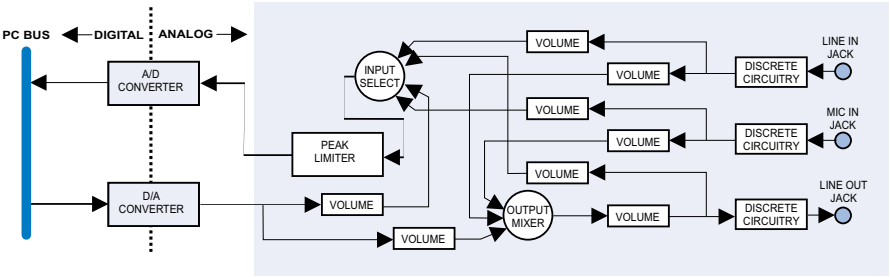


Figure 198 PC Sound Card Block Diagram. This variation offers independent record control paths and a peak limiter.

Recording path

The recording signal path for a sound card includes a stereo input stage with relatively high input impedances in the 10 kΩ to 100 kΩ range, with a maximum input level sensitivity that can vary from as low as –25 dBV to perhaps +6 dBV. The sound card driver software provides a recording mixer to select and adjust analog inputs to the ADC. Volume control changes from the mixer are accomplished in the analog domain in discrete and often rather coarse steps. Gain, commonly 30 dB, can be added to the Mic In channel by selecting the "Mic Boost" option. The recording mixer typically will allow only one input channel to be selected at a time. Cards so configured cannot mix several input signals for recording.

In some sound cards the analog signal is applied to the input of the ADC linearly, allowing extreme signal excursions the possibility of exceeding the maximum input level of the ADC. In other cases, the signal is routed through a peak limiter to prevent digital clipping. While protecting the unwary user from severe distortion, this can complicate measurement by making it difficult to determine the precise input level necessary to produce 0 dB FS.

When the presence of a peak limiter makes direct measurement of the onset of digital clipping impossible, PC Audio Tests with PC LevelCheck uses another method to closely estimate the input level required for 0 dB FS, as follows:

A low-level (-25 dBV) 997 Hz sine wave is applied to the input of the sound card and PC LevelCheck reads the digital code created by

the ADC in response. This digital data corresponds to an embedded audio level that can be expressed in units of dB FS. With this baseline, the generator level required to produce 0 dB FS can be estimated and applied to the input of the sound card.

Nonlinearities in the sound card can throw off this estimate, so PC LevelCheck next increments the estimated input level up and down in an attempt to locate the threshold of 1% distortion at the output of the ADC. The largest applied input signal that produces just less than 1% distortion is then defined as 0 dBr.

In the first case, measuring a sound card with no limiter, 0 dBr = 0 dB FS. In measuring a card with a limiter, 0 dBr = < 1 % THD+N, which will be close to but not exactly 0 dB FS, depending upon the behavior of the limiter.

Playback path

The playback signal path for a sound card includes a stereo output stage with relatively low output impedances in the 100 Ω range. Outputs that are designed to drive headphones have even lower impedances. Analog output levels for a 0 dB FS signal are typically between –1 dBV and +6 dBV; for outputs that are also designed to power speakers, the circuits will have higher current capabilities and levels as high as +12 dBV. The sound card driver software provides a playback mixer to adjust and mute analog outputs from the DAC. Volume control changes from the mixer are accomplished in the analog domain in discrete, coarse steps.

Sound Card Driver Software

With the exception of occasional configuration switches or jumpers, the functions of PC sound cards are entirely controlled by driver software.

Although setting levels, selecting sources and recording and playing .wav files through a PC sound card can be done in many different applications, for test and measurement purposes it is often simplest to use the software provided with Microsoft Windows: Windows Volume Control, Windows Sound Recorder and Windows Media Player.

See **Test Modes** (page 24) in **Running the Tests** for details on setting up Windows Volume Control, Sound Recorder and Media Player for use with PC Audio Tests.

Sound card configuration options can be set from a number of software locations via a number of paths, including:

- Start > Settings > Control Panel > Multimedia > Audio
- Start > Settings > Control Panel > System > Device Manager > Sound, Video and Game Controllers > *your sound card here*
- Start > Programs > Accessories > Entertainment > Sound recorder > Edit > Audio Properties
- Start > Programs > Accessories > Entertainment > Sound recorder > Save As > Change…
- Start > Programs > Accessories > Entertainment > Media Player > View > Options
- Start > Programs > Accessories > Entertainment > Volume Control > Options > Properties
- Start > Programs > Accessories > Entertainment > Volume Control > Options >
- Advanced Controls > Advanced…

Audio Connections

The consumer market sound card usually has three audio jacks on the back panel: Line In, Mic In and Line Out; some also have Aux In, Speaker Out or Surround jacks, and MIDI and game port connections. There are also usually internal connections on Molex headers to the PC Compact Disc drive, the PC speaker circuit and sometimes the PC telephone audio device (TAD).

PC Audio Tests uses only the Line Out connector and the Line In connectors. On a typical sound card, these are invariably 3.5 mm stereo jacks, and should be connected to System Two as shown:

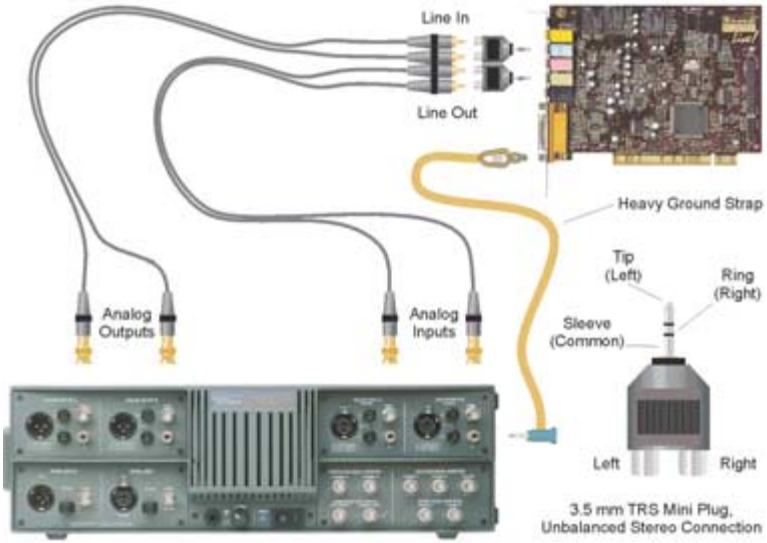


Figure 199 Consumer Market PC Sound Card Connections

"Professional" PC Sound Cards

A smaller percentage of sound cards are designed for specialized markets: specifically, the professional audio and broadcast industries, and semi-professional "project studio" environments. Although these cards offer more features, superior performance and better interfaces, in general the testing methods using PC Audio Tests are identical, with the interface connections being the primary difference.

As always, there is great variance in features and implementation, but pro sound cards may offer:

- Full duplex operation (simultaneous file record and playback capability)
- Sampling rate of 48 kHz
- Greater resolution and signal to noise ratio, with digital word length of 20 or 24 bits.
- Pro-type analog interfaces, with high-level, balanced connections

- Superior analog circuitry, ADCs and DACs.

All of the above features are fully compatible with PC Audio Tests. Other added features need a little more discussion:

- Multitrack capability (more than the standard left and right stereo tracks).
- Higher sampling rates, such as 88.2 kHz or 96 kHz.
- Direct digital interfaces, such as S/PDIF, ADAT optical or AES3

Multitrack capability

Pro audio cards may be able to record and play on more than just the two standard (left and right) stereo channels, either by using two or more physical cards (linked for synchronization) or by installing multiple sound devices on a single physical sound card.

Multitrack sound cards come with proprietary software that allows simultaneous use of more than two channels. PC Audio Tests, PC LevelCheck, Windows Sound Recorder, Windows Media Player and, for that matter, System Two are all two-channel devices. But Microsoft Windows does support use of more than one sound card, and using a multitrack card in Windows you will find channels 3–4, 5–6, etc. as additional audio devices at:

- Start > Settings > Control Panel > System > Device Manager > Sound, Video and Game Controllers > *your sound card here*

To use the higher-numbered channels, select the device driver for the additional pair. Then move the interconnection cables between System Two and the sound card to the correct jacks. To test all the channels on a multitrack sound card with PC Audio Tests, you must move through the channels two at a time by reconfiguring your software drivers and repatching your analog connections. See **Appendix E: PC Level Check** (page 149).

Audio Precision Series SWR-2122 Switchers can be controlled from PC Audio Tests to perform automatic analog signal routing for multitrack use.

Higher Sampling Rates

For 48 kHz sampling rate, simply check the 48 kHz option on the EUT Configuration panel in PC Audio Tests. In Manual Mode, be sure to choose 48 kHz .wav files for playback, and set Sound Recorder to create 48 kHz .wav files (or make the comparable setting on your own recorder software).

Sample rates above 48 kHz require System Two Cascade and are not supported by this version of PC Audio Tests. You can certainly test such sound cards with System Two Cascade, but not using this particular procedure. Future releases may address this capability.

Digital Interfaces

Direct digital interfaces are not supported by this version of PC Audio Tests but will be in a subsequent release.

Connections for Professional Sound Cards

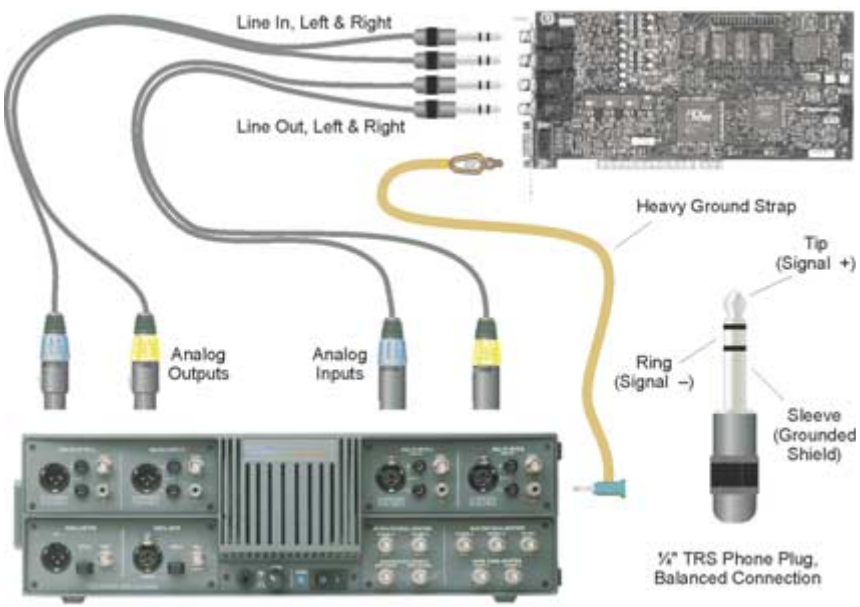


Figure 200 Professional Market PC Sound Card Connections

Appendix C

Standards

Three industry documents are particularly applicable to PC sound devices and are referred to in PC Audio Tests: the Audio Engineering Society's AES6id information document, the AES17 standard and WHQL pc99 from Microsoft Corporation's Windows Hardware Quality Labs (WHQL).

AES6id, AES17 and AES3

The AES6id is subtitled *"AES information document for digital audio—Personal computer audio quality measurements."* AES6id focuses on the measurement of audio quality specifications in a PC environment. Each specification listed has a definition and an example measurement technique. Also included is a detailed description of example test setups to measure each specification.

> *As of this printing,* ***AES6id is a DRAFT****, which may be changed and must not be used as a standard.*

The AES17 standard is subtitled *"AES standard method for digital audio engineering—Measurement of digital audio equipment."* AES17 defines the terms and conditions of testing digital audio equipment and then specifies a number of methods for measuring the characteristics of the equipment under test.

AES3, subtitled *"AES recommended practice for digital audio engineering—Serial transmission format for two-channel linearly represented digital audio data"* may also be of interest.

Copies of AES3, AES6id and AES17can be obtained from

- The Audio Engineering Society, Inc.
  60 East 42nd Street
  New York, New York 10165-2560, USA
- Tel: +1-212-661-8528

- Fax: +1-212-682-0477
- http://www.aes.org

or *e*-mail at:

- hq@aes.org

Microsoft WHQL pc99

WHQL pc99 is subtitled *"Audio Quality Test Methods."* For more information, contact Microsoft Corporation Windows Hardware Quality Labs at

- http://www.microsoft.com/HWTEST/default.asp
- http://www.microsoft.com/HWTEST/sysdocsPC98/

or email WHQL Tech Support (audio) at

- acthelp@microsoft.com

Appendix D

File Listings and Descriptions

InstallShield creates the following folders and files when installing PC Audio Tests:

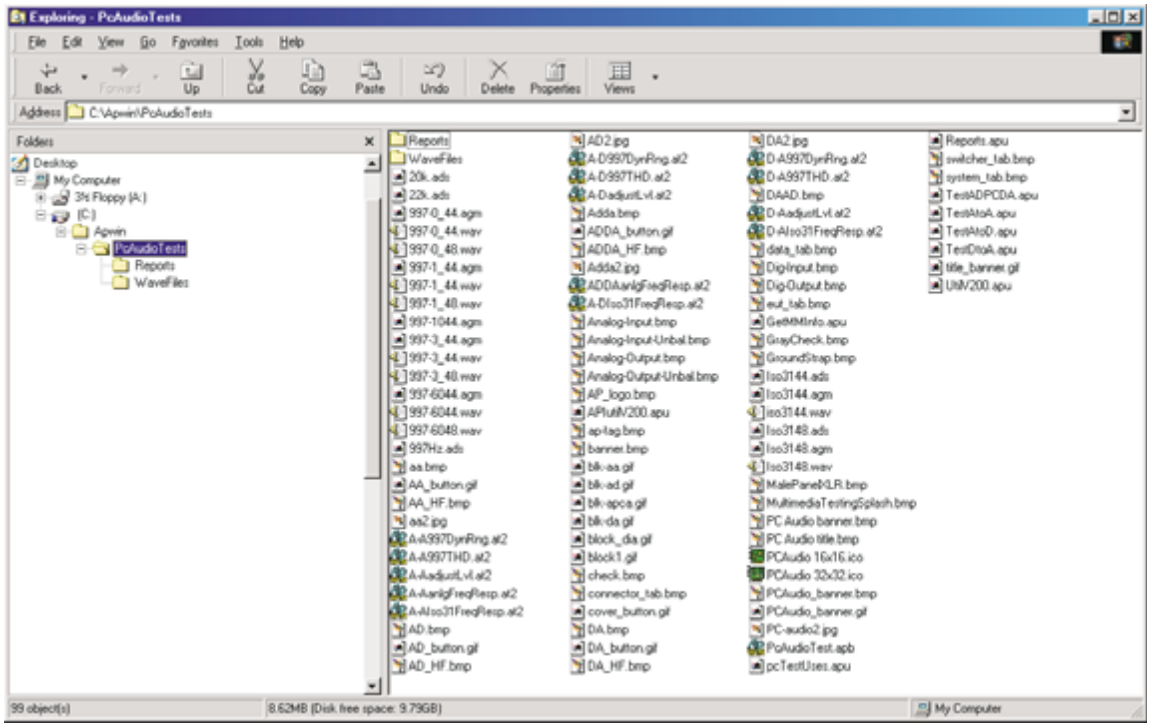


Figure 201 PC Audio Tests Installed Files

The following file types are used by PC Audio Tests:

APWIN Basic macros	*.apb
APWIN Basic macros (supplemental uses)	*.apu
System Two test files	*.at2

System Two data files	*.ada
Sweep data files	*.ads
Generator wave stereo files	*.ags
Generator wave mono files	*.agm
Images	*.bmp, *.jpg
Text files	*.txt
MS Word documents	*.doc
MS-DOS batch file	*.bat

.wav File Names:

997-0_44.wav	997 Hz sine wave at 0 dB FS, 44.1 kHz sampling rate
997-1_44.wav	997 Hz sine wave at -1 dB FS, 44.1 kHz sampling rate
997-3_44.wav	997 Hz sine wave at -3 dB FS, 44.1 kHz sampling rate
997-0_48.wav	997 Hz sine wave at 0 dB FS, 48 kHz sampling rate
997-1_48.wav	997 Hz sine wave at -1 dB FS, 48 kHz sampling rate
997-3_48.wav	997 Hz sine wave at -3 dB FS, 48 kHz sampling rate
997-6044.wav	997 Hz sine wave at -60 dB FS, 44.1 kHz sampling rate
997-6048.wav	997 Hz sine wave at -60 dB FS, 48 kHz sampling rate
iso3144.wav	Multitone, 31 ISO tones 1/3 octave intervals, at -3 dB FS, 44.1 kHz sampling rate
iso3148.wav	Multitone, 31 ISO tones 1/3 octave intervals, at -3 dB FS, 48 kHz sampling rate
dig_0_44.wav	Digital zero at 44.1 kHz sampling rate
dig_0_48.wav	Digital zero at 48 kHz sampling rate

Appendix E

PC LevelCheck

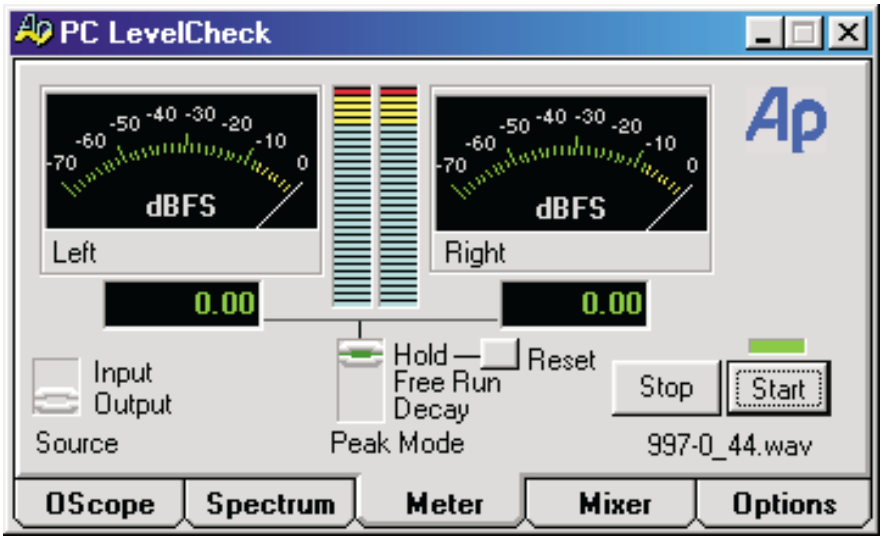


Figure 202 PC LevelCheck

PC LevelCheck (or *LevelCheck*) is a software PCM .wav file level meter and monitor. LevelCheck is an OLE automation server and can be controlled by APWIN Basic or run as a stand-alone application.

As a stand-alone program, LevelCheck can monitor the digital audio signal in your computer's sound card, displaying the level, waveform and spectra of the audio in the card. Additionally, PC LevelCheck has the ability to control the record and playback mixers, and to record and play .wav files. When used in conjunction with APWIN and the PC Audio Tests procedure, it provides features useful for automated PC sound card audio analysis.

PC LevelCheck has five tabbed display panels. The first three, labeled **OScope**, **Spectrum**, and **Meter** are signal displays. **Mixer** offers mixer level control and mutes, and **Options** provides .wav file record and playback controls and other options.

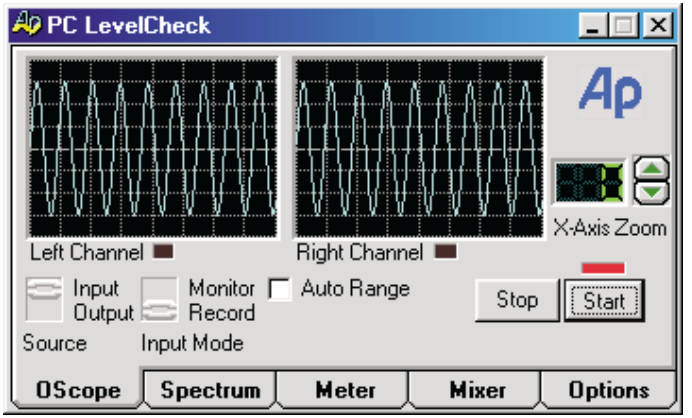
Common Controls

Source, Input Mode, Start and Stop are common controls in PC LevelCheck that appear on several of the display panels and affect the overall operation of the program.

Source: Input / Output

The **Source** switch box appears on the three signal display panels and offers two choices: **Input** and **Output**. Drag the switch up or down to change sources. With **Input** selected as the source, PC LevelCheck monitors the input signal to the sound card after it has been digitized in the card's analog-to-digital converter (ADC) and allows the option of recording the signal as a .wav file; **Output** selects the .wav file playback function of the sound card. When **Output** is selected, the name of the .wav file chosen for playback is displayed beneath the **Stop** and **Start** buttons.

Figure 203 Recording a 3 kHz sine wave to a .wav file in OScope mode



Input Mode

With **Input** selected, an additional switch labeled **Input Mode** is visible on the three signal display panels. **Input Mode** allows you to select whether LevelCheck merely monitors the incoming signal or to direct the program to actually record a .wav file. Drag the switch up or down to select **Monitor** or **Record** modes.

When **Input Mode** switch is set to **Record**, a Save Wave File window appears so you can choose the name and the folder for the file you are about to record.

Stop and Start

The OScope, Spectrum and Meter panels each have a **Stop** and **Start** button.

On any of these three panels, when **Source** is set to **Input** and **Input Mode** is set to **Monitor,** click the **Start** button to acquire, process and display the audio embedded in the digital signal, moments after conversion from the analog inputs. During input signal monitoring the indicator bar above the **Start** button will be green. Click the **Stop** button to end acquisition.

With the **Source** switch is set to **Input** and the **Input Mode** switch is set to **Record**, the **Start** button now begins recording a .wav file. During recording the indicator bar above the **Start** button will be lighted red. **Stop** ends the recording.

When the **Source** switch is set to **Output**, clicking **Start** begins playback of the selected .wav file. (Playback files are selected on the **Options** panel.) During playback the indicator bar above the **Start** button will be green. Click **Stop** to end the file playback.

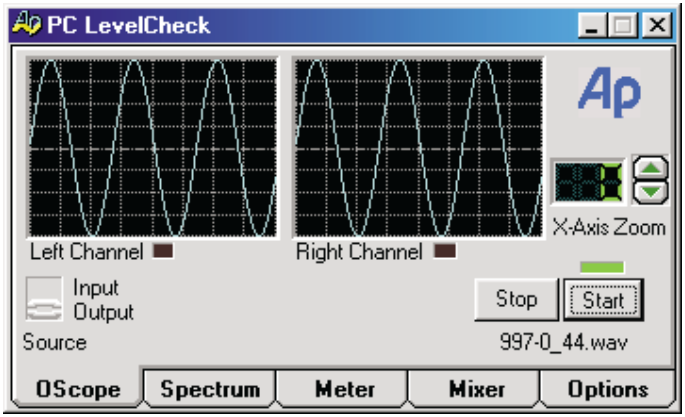
*Both **Source** nor **Input Mode** switches are unavailable while PC LevelCheck is actually acquiring or playing a signal. If these switches appear dimmed and will not drag, click the **Stop** button and retry.*

Control Panels

PC LevelCheck has five tabbed control panels. The first three, labeled OScope, Spectrum, and Meter are primarily signal displays. Mixer offers mixer volume controls and mutes, and Options provides .wav file record and playback controls and other options.

OScope

Figure 204 Playing back a 1 kHz .wav file in OScope mode



The first panel simulates a dual-trace oscilloscope view of the signal, with a default horizontal axis of about 3 milliseconds (showing about 3 cycles of a 1 kHz waveform) and a vertical axis of 0 dB FS.

The **X-Axis Zoom** switch allows you to scroll through a number of uncalibrated horizontal axis settings to adjust the simulated oscilloscope view.

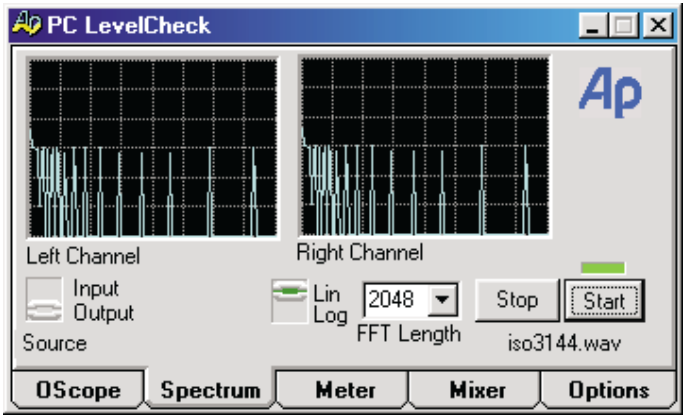
Click **Auto Range** to view small signals at full vertical scale. With **Auto Range** enabled, the actual range of the vertical axis is displayed below the check box. Even though the **Auto Range** check box is only shown on the **OScope** panel, its setting affects the readings displayed on the **Spectrum** panel as well.

Below each oscilloscope screen is a small peak level indicator, which lights red when the signal in that channel exceeds 0 dB FS.

> *In **Auto Range** with no input signal (or a very small input signal) applied to the sound card, any offset of the OScope trace indicates a DC offset at the input to the ADC.*

Spectrum

Figure 205 Playing back an ISO 1/3 octave .wav file in Spectrum mode



The second panel is a display of a dual channel spectrum analyzer. Drag the **Lin** / **Log** switch up or down to alternate horizontal axis display modes. In **Lin** mode the horizontal axis is set to a linear frequency scale with a range of 0 Hz to ½ the sampling frequency. In **Log** mode the horizontal axis is set to a logarithmic frequency scale with the same range, DC to Nyquist.

The graticule line below the top of the display represents the maximum level, 0 dB FS. When **Auto Range** is selected on the **OScope** panel, the vertical axis on the spectrum displayed is scaled by the same factor.

The spectrum analysis is performed digitally using fast Fourier transform (FFT) techniques. The length of the acquired FFT sample is selectable in the **FFT Length** box. Longer FFT lengths such as 1024 or 2048 give greater resolution, while shorter sample lengths offer faster measurement.

Meter

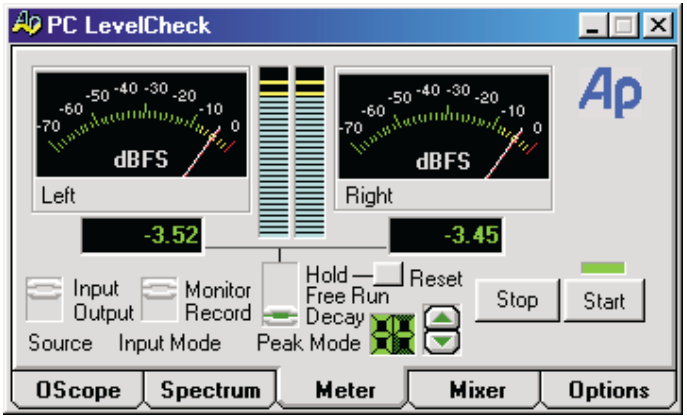


Figure 206 Monitoring a noise signal in Meter mode

The third panel represents a stereo peak level meter with both needle and bar graph displays. Full scale is 0 dB FS.

Display windows below the meters show the peak amplitude reached by the digital signal, referenced to 0 dB FS.

The Meter panel adds a **Peak Mode** switch to control the numerical readout in the display windows.

When **Peak Mode** is set to **Hold**, the windows display and hold the last maximum peak level acquired until the **Reset** button is clicked.

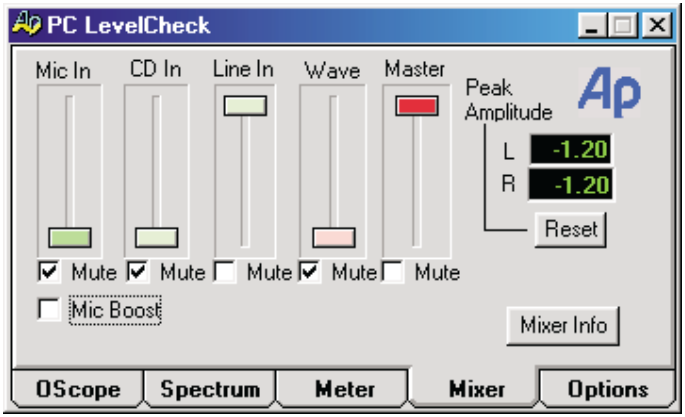
Free Run disables the **Hold** function, and the numerical displays will continuously update the peak level values as they are acquired.

Decay is a compromise between these two. The numerical display windows are updated periodically, and you can select a wide range of periods between updates by scrolling the settings that appear in the adjacent window. Lower numbers result in more frequent updates; higher numbers set longer periods between updates.

Click **Reset** to clear the peak memory for these windows.

Mixer

Figure 207
Mixer settings



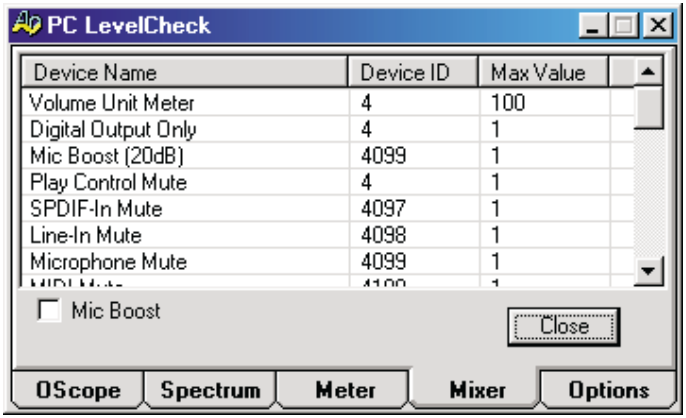
The Mixer panel gives easy access to the Windows Mixer Control application programming interface (API) providing a **Master** control and volume control sliders for **Mic In**, **CD In**, **Line In**, and **Wave**. Each channel can be muted by clicking the **Mute** check box below the slider. The controls on this mixer should parallel the operation of the native sound card mixer.

Click **Mic Boost** to add 30 dB of gain to the **Mic In** channel for microphone level inputs.

The information in the Meter panel **Peak Amplitude** windows is repeated here, as is the **Reset** button.

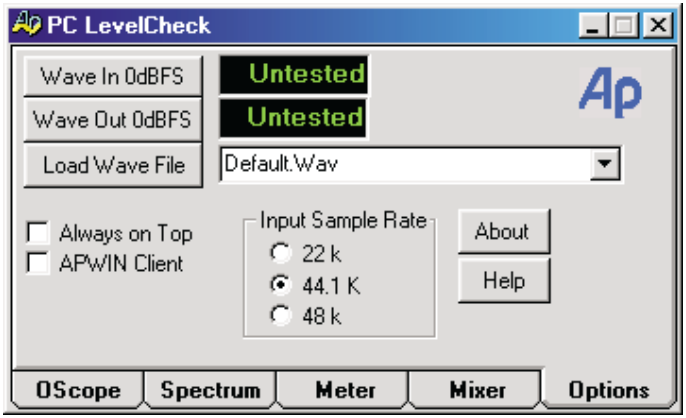
All of the parameters of the mixer panel are accessible via OLE. Click **Mixer Info** to view a mixer property sheet, which shows the sound card driver's available control names, the associated Windows control I.D., and the maximum value for each control.

Figure 208
Mixer Info view



Options

Figure 209
Options Panel



The Options panel offers a number of miscellaneous functions.

The top two buttons in the upper left corner cause PC LevelCheck to calibrate the sound card's input and output analog levels to a 0 dB FS reference in recording and playing back .wav files. To do this, however, you must be running APWIN on the computer and be connected to System Two.

> *These calibration buttons are designed for use when PC LevelCheck is **not** being used with the PC Audio Tests procedure.*

First select the **APWIN Client** box near the bottom of the panel. This establishes an OLE Automation relationship between the programs, with APWIN as the OLE server and PC LevelCheck as the

client. Be sure that System Two is connected properly to your sound card, and that the System Two inputs and outputs are correctly configured.

When all this is ready, click **Wave In 0 dB FS** to perform the input calibration. PC LevelCheck will measure the input level required to produce 0 dB FS in the sound card's ADC, and will enter that level both in the window next to the button and in the **References: dBr** window in the APWIN Analog Generator panel.

Next, click **Wave Out 0 dB FS** to perform the output calibration. PC LevelCheck will measure the output levels produced by the sound card when a 0 dB FS .wav file is played, and will enter that level both in the window next to the button and in the **References: dBr A** and **dBr B** boxes in the APWIN Analog Analyzer panel.

Wave In and **Wave Out** do not set stereo references within PC LevelCheck but use the left channel only.

When LevelCheck is launched the file Default.wav is set as the playback file. Click **Load Wave File** to choose an alternate .wav file for playback. The **Open Wave File** dialog box will appear.

Click **Always on Top** to keep the PC LevelCheck window in the foreground on your computer screen.

In the **Input Sample Rate** box, click **22 k**, **44.1 k** (the default) or **48 k** to set the sampling rate in the sound card ADC.

File listing

InstallShield creates the following folders and files when i8nstalling PC LevelCheck:

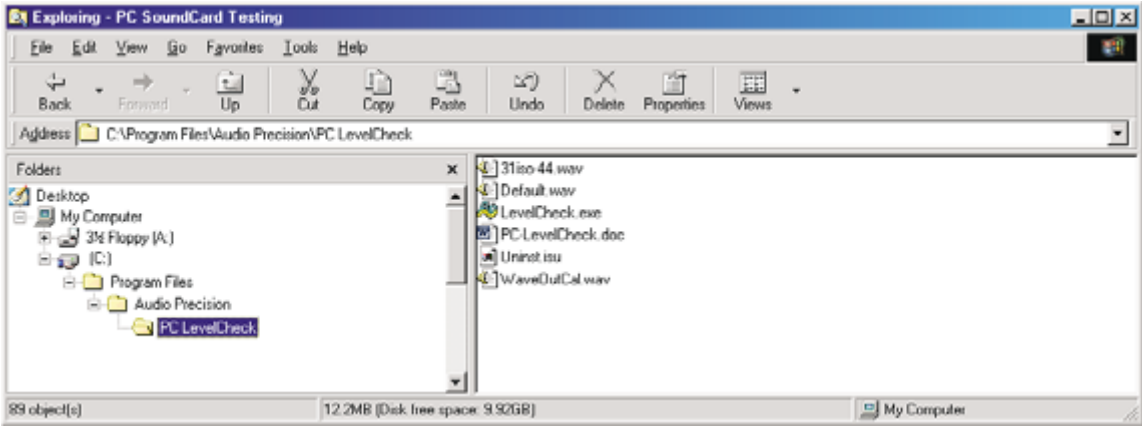


Figure 210 PC LevelCheck Installed Files

Appendix F

Distortion Analysis Techniques Compared

Distortion measurements for audio signals can be made using conventional analog analysis techniques or by converting the signal into its digital representation by means of a precision ADC, then applying DSP analysis techniques.

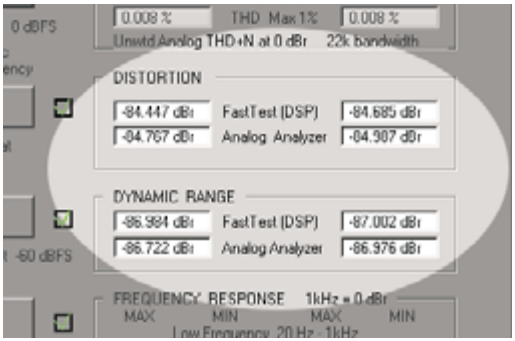


Figure 211 FASTTEST FFT and Analog Analyzer THD+N results

The Audio Precision System Two Dual Domain can operate in both the analog and digital domains, and PC Audio Tests brings this capability to bear to make distortion measurements using both analog and digital techniques. The results of these two methods are slightly different, with the DSP technique sometimes reporting more distortion and noise, sometime less. Why is this?

There are several reasons, all related to subtle differences in the methods applied. Let's look closely at what's going on.

Conventional THD+N Measurement

For clarity we will look at distortion analysis with only one stimulus tone, although in practice swept tones (using analog analysis) or multiple tones (using DSP analysis) can also be used.

Conventional THD+N methods apply a very pure (very low distortion) sine wave to the input of the EUT at the frequency and level of interest.

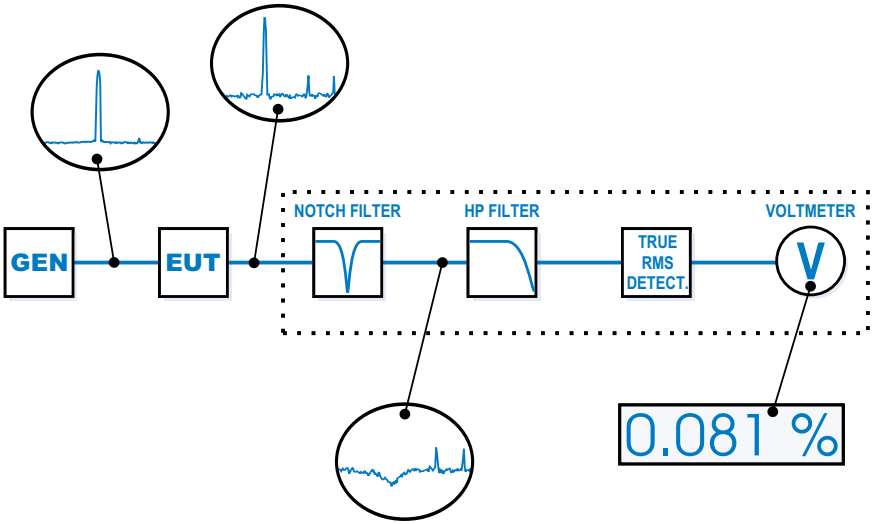


Figure 212 Block Diagram: Conventional THD+N Analysis

In the analyzer, this fundamental is first removed from the output of the EUT by means of a very narrow, very deep notch filter tuned to the stimulus frequency. Then the signal is usually band-limited to reject out-of-band signals. For PC Audio Tests applications we recommend the 22 kHz low-pass filter as a minimum. Option filters, if used, are applied next. After this filtering the remaining signal is measured with a root-mean-square (rms) voltmeter. The result is expressed as a ratio to the amplitude of the fundamental, in decibels or in percent.

DSP THD+N Measurement

In this example we will consider the EUT to be an analog device, stimulated with a pure tone as in the previous measurement.

For DSP analysis, the signal from the EUT is first sampled by a precision ADC and brought into the digital domain. Both the sampling rate and the resolution (word length) of this conversion can have an effect on the distortion analysis. For the THD+N tests in PC Audio Tests, the System Two 20-bit ADC is set to a sampling rate of 48 kHz.

The converted signal is analyzed mathematically using the fast Fourier transform (FFT) technique. FFT analysis by its nature effectively band-limits the signal without applying a physical filter—the

signal acquired will extend in frequency only to the Nyquist frequency (one-half the sampling frequency). This band-limiting acts like a very steep "brick wall" filter at the Nyquist frequency. The low-frequency end of the spectrum, however, is unlimited—flat right to DC (within the performance limits of the analog input circuitry, of course).

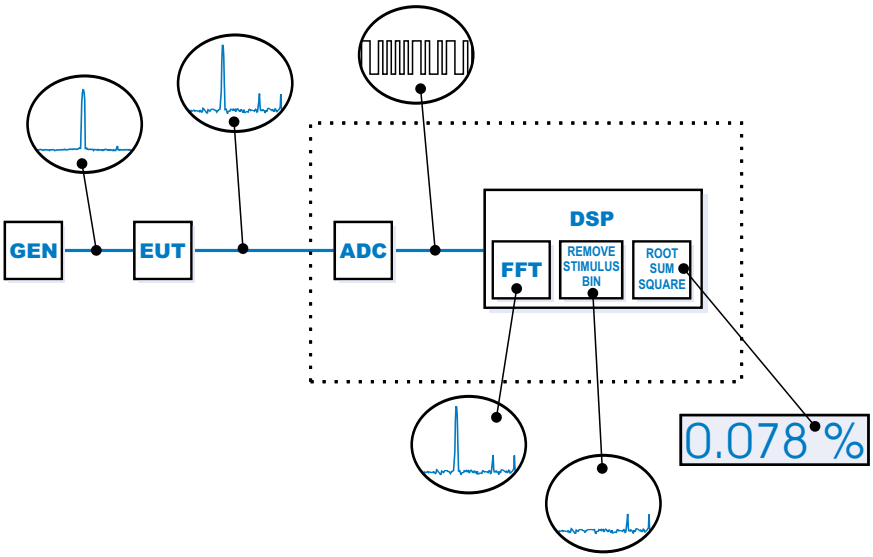


Figure 213 Block Diagram: DSP THD+N Analysis

In FFT analysis the spectrum is divided into *bins,* all of equal frequency width. The number of bins is equal to one-half the number of samples acquired in the record. The width of the each bin is equal to the Nyquist frequency divided by the number of bins. When using PC Audio Tests (System Two sample rate set at 48 kHz, number of samples 8192), the bin width is 5.86 Hz.

For an FFT THD+N measurement, the bin centered on the stimulus frequency is removed from consideration, a process analogous to using a notch filter. The remaining signal is measured by performing a root-sum-square (rss) computation on the data, and a THD+N measurement results.

Different Questions Produce Different Answers

As you can see, the two methods are similar but not exactly the same. Most of the differences in measurements result from the different shapes of the response curves of the physical filters in the analog analyzer and the effective filtering in DSP. Look at these curves, with the analog THD+N filter response overlaid on the effective FFT response:

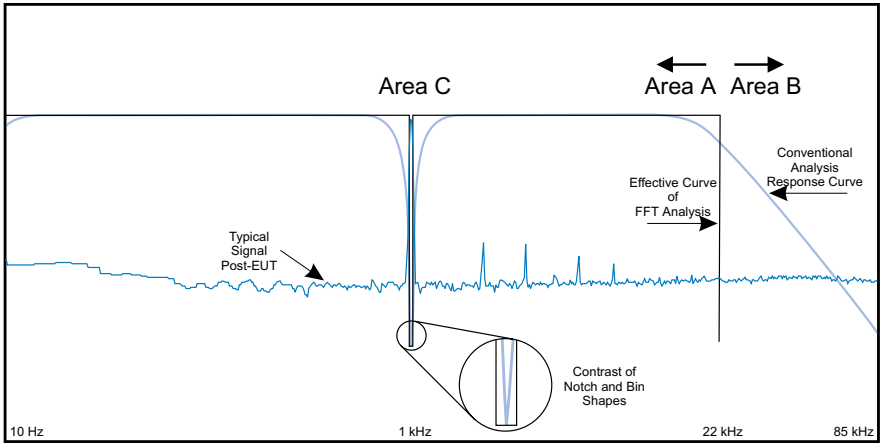


Figure 214 Effective Response Curves of Conventional and DSP THD+N Analysis Compared

At the high end of the spectrum the two filter slopes cross. Below the crossing (Area A) the analog filter offers more attenuation; above the crossing (Area B) no signal at all is being measured by the DSP technique. The analog filter, however, can pass signal (reduced, but still measurable) up to 80 kHz and above. If the signal has a great deal of energy in the range above 20 kHz, the analog analyzer will return a higher THD+N reading.

Near the stimulus frequency a similar phenomenon takes place at Area C. The broader shoulders and steep but finite slope of the analog notch offer more rejection around the stimulus than the extremely narrow FFT bin with its vertical sides.

However, as the magnifying circle at the bottom of the illustration shows, the analog notch, at its extreme, is even narrower than the 5.86 Hz-wide FFT bin.

It may be hard to imagine such a small difference having much meaningful effect, but modulation noise can have strong components near the modulating tone. Depending on the distance of the sidebands from the fundamental, in some cases the analog notch technique may read more THD+N while in other situations the FFT technique will measure more.

Another source of difference between analog and DSP THD+N analysis can be traced to the ADC used in converting the analog signal into the digital domain for measurement. At low input levels near the limit of the resolution of the ADC, quantization error will add distortion (or noise, if the signal is dithered) and increase the THD+N measured by the DSP technique.

However, since the PC sound card analog output signals measured in PC Audio Tests are the result of 16-bit digital-to-analog conversion in the sound card, the noise in the signal will always be above the distortion and noise floor of the higher-resolution 20-bit ADC used in System Two for DSP analysis of analog signals. In this case the DSP conversion for analysis can be considered entirely transparent.

What's the final result of all of this? The numbers you get from applying these two THD+N methods will always be slightly different, depending on the characteristics of the signals being measured. Each set of results is accurate, though, and each represents a valid means of measuring the signal.

Appendix G

Glossary

ADC—see **analog-to-digital converter**.

AES3 interface—a digital interface standard for professional audio equipment interconnection, defined in the AES3 standard. Formerly known as the *AES/EBU interface*. The digital signal carried in the AES3 interface is partially compatible with the digital signal carried on the S/PDIF interface.

AES—the Audio Engineering Society, with headquarters in New York City.

analog audio, analog signal—a representation of an audio signal as a continuously variable quantity. An analog audio signal is usually an electrical voltage varying in analogy to the sound waves it represents.

analog-to-digital converter—a device for converting an analog input signal into a series of digital values representing the instantaneous amplitude of the signal at regular sampling intervals. Abbreviated ADC. See **digital recording or processing**.

analog-to-digital—abbreviated A-to-D, A/D, A-D and so on. See **digital recording or processing** and **analog-to-digital converter.**

balanced—a term referring to an audio transmission line in which the signal is applied differentially between two conductors, each of which has equal impedances to a common reference or ground. A balanced line is usually constructed with three conductors: an internal twisted pair of wires, one carrying signal "+" or HIGH, the other carrying signal "–" or LOW. These are surrounded by a third conductor in the form of a braided or foil shield, which is connected to the common or ground terminal at one or both ends of the cable. Used with properly engineered equipment, balanced lines are superior in performance to unbalanced connections, yielding better rejection of common-mode interference caused by electrostatic and

electromagnetic fields. Additionally, since the audio in a balanced circuit is isolated from the ground conductor, ground-current-induced noise is much more easily dealt with. Also called a *symmetrical line*. See **ground**, **unbalanced**.

bandpass filter—a filter that passes a specific frequency band (called the *passband*) essentially without attenuation while attenuating frequencies both below and above the specified band.

bit depth—see **word length**.

bits of resolution—the number of bits of the binary word by which signals are represented in a digital recording or transmission system. Each bit adds approximately 6 dB to the theoretical dynamic range available. Thus, a 16-bit digital system is capable of approximately 96 dB dynamic range, etc.

bus—in electricity and electronics, a conductor common to three or more circuits. In computers, the data bus is a set of conductors that carry common data between three or more subunits of the computer.

clipping—the action of a system in flattening and squaring off signal peaks when driven with a signal whose peak amplitude is beyond its linear signal-handling capability.

crest factor—the ratio of a signal's peak amplitude to its rms amplitude.

DAC—see **digital-to-analog converter**.

dB—abbreviation for decibel, a ratio unit for expressing signal amplitudes. If the amplitudes are expressed in voltage, dB = 20 log10 (V1/V2). If the amplitudes are expressed in power, dB = 10 log10 (P1/P2). Two important points to remember:
1. The dB, mimicking our hearing, is not a linear unit but a measurement on a logarithmic scale.
2. decibels are relative units of measure, having no meaning in an absolute sense. A dB must always be referenced to something to have meaning. You can speak of a "4 dB change" or a "60 dB signal-to-noise ratio" because these are both relative statements, but describe a signal level as 39 dB means nothing. All absolute measurements expressed as decibels must have an indication of reference, such as dBu, dBV, dBr and so on. See **dBu**, **dBV**, **dBr**.

dB FS—decibels referenced to digital Full Scale (FS), where 0 dB FS is the rms value of a sine wave whose positive peak just reaches positive full scale.
For everyday use, 0 dB FS can be considered to be the maximum digital amplitude available within a system. However, it should be noted that because 0 dB FS has been defined for a sine wave, waveforms with lower crest factors can exceed 0 dB FS by as much as 3.01 dB before incurring digital clipping. See **crest factor** and **digital clipping**.

dBm—decibels relative to a reference value of 1 milliwatt. dBm is a power unit and requires knowledge of power levels (voltage and current, or voltage and impedance, or current and impedance) rather than merely voltage. This term has historically been associated with a measurement of audio levels in "professional" use, but it is rarely correctly applied and should not be used except in certain very specific circumstances. As a unit of power, the voltage value of a dBm will vary with the circuit impedance.
Use the term *dBu* instead. See **dBu**.

dBr—decibels relative to an arbitrary reference value, **r**. The reference value must be stated for this to be a meaningful unit. The dBr can be a handy shortcut during tests, allowing you, for example, to measure a specific voltage and note it as your reference, 0 dBr; and then to express further measurements in dBr relative to this level.

dBu—decibels relative to a signal level of 0.7746 V rms. dBu now is the common term for analog audio amplitude in "professional" audio interfaces and circuits. 0 dBu (0.7746 V rms) equals 0 dBm, but *only* in a 600 ohm load impedance. Unless you are clearly interested in measuring power in a circuit of known impedance, use dBu, not dBm. See **dBm**.

dBV— decibels relative to a signal level of 1 volt rms. dBV now is the common term for analog audio levels in "consumer" audio interfaces and circuits. 0 dBV equals +2.218 dBu.

digital overflow—see **digital clipping**.

digital recording or processing—a technique in which the original signal is periodically sampled and the amplitude value at each

sampling instant is converted into a number represented by a binary word.

digital-to-analog— Abbreviated D-to-A, D/A, D-A and so on. See **digital recording or processing** and **digital-to-analog converter.**

digital-to-analog converter—a device that converts a stream of digital numbers, each representing the amplitude of a signal at a particular sampling time, into a corresponding analog signal. Abbreviated DAC.

DSP—digital signal processing.

DUT—device under test. An alternate form for EUT. See **EUT**.

dynamic range—the difference, usually expressed in dB, between the highest and lowest amplitude portions of a signal, or between the highest amplitude signal that a device can linearly handle and the noise level of the device.

EUT—a common abbreviation in the test and measurement field for "equipment under test."

FFT—fast Fourier transform, a technique to compute the amplitude versus frequency and phase versus frequency information from a set of amplitude versus time samples of a signal.

ground loop—an inadvertent signal path formed when interconnecting the chassis of two or more pieces of equipment, each possessing a safety ground. Ground loops can cause hum-related interference.

ISO—International Organization for Standards, the largest of the many international groups for technical and industrial cooperation. The ISO is based in Geneva, Switzerland.

line level—a relatively high amplitude range suitable for transmission of audio signals. Line level is typically in the 0 dBu to +8 dBu range.

one-third octave—a bandwidth of 1/3 octave, or a frequency ratio of 1.2599:1. Three successive frequency changes by this ratio result in a total frequency change of 2:1 (one octave). Moderately narrow bandpass filters are often set at a bandwidth of 1/3 octave;

frequency response measurement techniques that use spot frequencies (such as real-time spectrum analysis or multitone tests) often use frequencies centered at 1/3 octave distances.

pulse code modulation—a form of data transmission in which amplitude samples of an analog signal are represented by digital numbers. Abbreviated PCM. Almost all digital audio schemes use PCM.

resolution—the smallest change in a measured parameter to which a measurement instrument can respond.

rms—see **root mean square**.

root mean square—the preferred form of ac signal detection that measures amplitude in terms of its equivalent power content, regardless of signal waveshape. Abbreviated rms.

sample frequency, sample rate—the frequency at which the signal is sampled in a digital system. The sample rate must exceed twice the highest analog frequency to be converted. Commonly used sample rates are 48 kHz, 44.1 kHz, and 32 kHz.

signal-to-noise ratio—the difference in level between a reference output signal (typically at the normal or maximum operating level of the device) and the device output with no signal applied. Signal-to-noise ratio is normally stated in dB. The device input conditions for the noise measurement must be specified, such as "input short circuited" or with a specific value of resistance connected at the device input instead of a signal.

S/PDIF—Sony / Philips Digital Interface; a digital interface for consumer audio equipment. Sometimes also referred to as the EIAJ interface. The S/PDIF is similar to the professional AES3 interface, but is normally an unbalanced coaxial signal of lower amplitude. Most of the status byte definitions are different between S/PDIF and AES3.

THD+N—total harmonic distortion plus noise. Measured by attenuating the fundamental signal with a narrow-band notch filter, then measuring the remaining signal which consists of harmonics of various order, wide-band noise, and possibly interfering signals. This is the common harmonic distortion method implemented in most analyzers.

third octave—*see* **one-third octave**.

unbalanced—an audio connection in which the desired signal is present as a voltage with respect to ground or common, rather than as a differential signal across a pair of balanced conductors.

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