

HIGH-SPEED CD ANALYZER

OPERATING MANUAL

Version 2.4

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INTRODUCTION

The Clover Systems CDX Compact Disc Analyzer is an affordable high-speed tool to quantitatively measure the quality of a CD. It will analyze CD-DA, CD-ROM, CD-ROM XA, CD-I, CD-R, Photo-CD, Enhanced CD, and CD-RW discs at 1X, 2X, 4X, 8X, 20X (CAV), or 40X (CAV) speed.

CDX measures disc quality by examining the quantity and severity of CIRC errors generated during playback. It also provides the capability to measure signal parameters related to pit geometry, such as I11, I3, asymmetry, and reflectivity. Together, this information provides a thorough analysis of disc quality. Also see the section titled “INTERPRETING THE RESULTS” on pg. 47.

CDX can also perform various format-checking tests on data discs, and do bit-for-bit data comparison on all types of CD’s.

CDX automatically measures and displays BLER (Block Error Rate), E11, E21, E31, E12, E22, and E32 (uncorrectable errors)¹. Both average values and peak values are displayed for each parameter. For E22 and E32, the TOTAL count is displayed in addition to average and peak. There is also a built in grading system that assigns a quality grade (A-F) based on the results of the test.

A BNC connector on the rear panel provides a buffered HF output for connection to the optional Analog Measurement Module (AMM-1), an oscilloscope, jitter meter, or other measurement equipment.

The CDX software is a Windows program that will run under Windows 2000/XP/Vista. It gathers data from the CDX, and displays the data in the form of charts. It also displays statistics for the whole disc, and prints a summary of the results.

CONVENTIONS

The following document conventions are used throughout this manual:

CAPITAL LETTERS Represent filenames, directory names, or drive letters.

Initial Capitals Represent names of programs, menus, dialog boxes, buttons, and named windows.

Italic Represent menu commands.

¹ See “Why E32 is considered uncorrectable” on Pg. 48

INSTALLATION

The CDX is set up and used just like an ordinary SCSI CD-ROM drive. The drive mounts in a 5¼" drive bay, and the SCSI Host Adapter installs in a PCI slot. The I/O panel installs in an unused expansion slot. To install the external CDX on a laptop PC, see [Laptop Installation](#) on pg. 4.

HARDWARE INSTALLATION

Drive Configuration

First set the SCSI Target ID using the jumpers on the rear panel of the drive. Make sure that no other SCSI device connected to the same host controller has the same ID. The factory setting is 4.

If CDX will be the last device on the SCSI bus, set the termination to ON using the jumpers on the rear panel. Only the last device on the bus should have the termination on, and all others should be OFF. By the "last device", we mean the one at the end of the cable. The factory setting is ON.

To PC Rear Panel

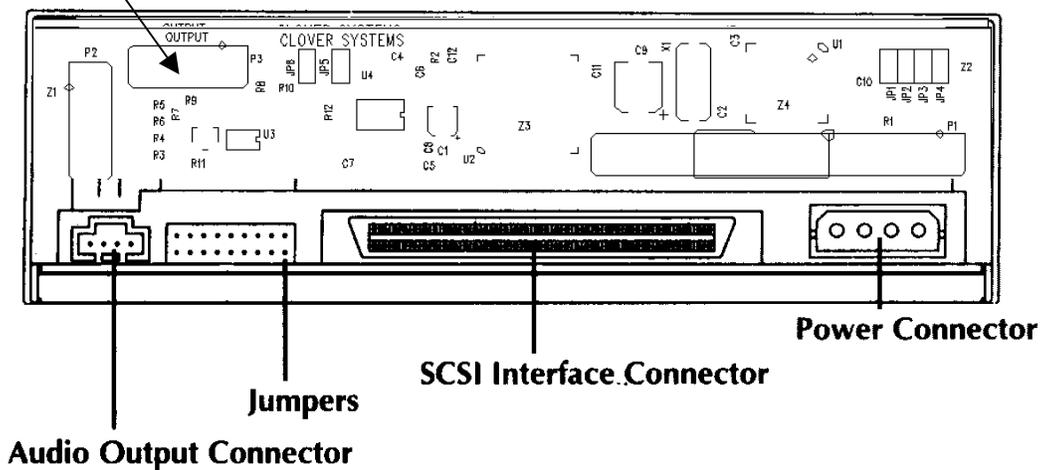


Figure 1- Rear Panel Connections

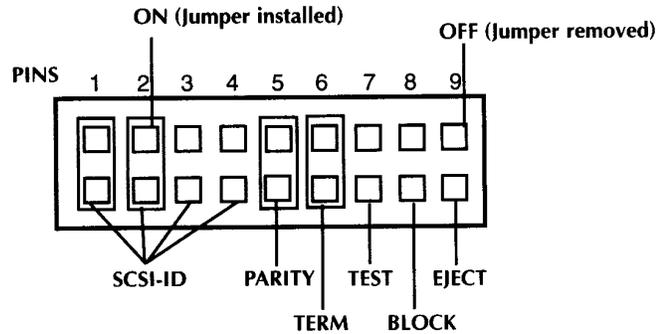


Figure 2 – Jumper Settings

The PARITY jumper **must** be ON.

SCSI Host Adapter Installation

CDX comes with a PCI bus plug & play Ultra Wide SCSI host adapter. The Host Adapter has no jumpers or other settings. It will be configured properly when the driver software is installed.

Inserting the Host Adapter

Find an unused slot of the proper type, and remove the expansion slot cover panel. Align the bus connector on the bottom of the host adapter with the slot, and carefully insert it into the slot. Attach the Host Adapter bracket to the PC chassis with the screw that came from the empty slot cover panel.

Connecting the SCSI Cable

Be sure that the SCSI device that will be at the end of the cable has its termination ON. Insert one end of the cable into the 68-pin connector on the host adapter. Pin 1 on the cable (usually red) is connected to pin 1 on the connector. Connect the other end of the cable to the CDX drive in the same way. If CDX is the only device, be sure that it is connected to the end of the cable, not the middle connector.

Operating System Support

Adaptec 2940UW PCI Host Adapter

Most versions of Windows have built-in support for this adapter. If the installation cannot locate the correct driver, it can be found on the CDX Setup & Qualification CD.

Installing the CDX Drive

CDX installs in a 5/12" half-height drive bay like an ordinary CD-ROM drive. Be sure that circuitry attached to the rear of the drive does not touch anything after it is installed.

I/O Panel Installation

Note: CDX uses one serial port. You must connect the CDX drive to a serial (COM) port for it to work.

The included CDX computer panel provides connectors for both the serial interface and the HF output. The CDX uses one serial communications port. This port can be COM1, COM2, COM3, or COM4. In order to conveniently connect to your computer's COM port, an RS-232 connector is included on the CDX computer panel. Use the included serial cable to connect the CDX panel to your COM port. If you use a cable other than the one supplied, make sure it is wired "straight through", not "null modem". CDX is wired as DCE (Data Communications Equipment).

Install the CDX I/O panel in an open slot. Connect the panel ribbon cable to P3 (labeled "Output") on the rear of the CDX. It is often most convenient to do this before installing the CDX drive in the chassis. Connect the CDX RS-232 connector to your PC's COM port using the provided cable. If your COM port has a 25-pin connector, you will need a 9-pin to 25-pin adapter.

Your COM port will be set to the correct protocol automatically by the CDX program. It is not necessary to change the serial port settings in the Windows Control Panel.

Using a USB port

Many PC's and laptops nowadays do not have RS-232 serial COM ports. These have been replaced by USB ports. If your PC does not have an RS-232 port, you can connect the CDX to a USB port using an RS-232 to USB converter. You will need to install a driver that comes with the converter. You will also need to configure the port in Device Manager to be COM1, 2, 3, or 4.

LAPTOP INSTALLATION

Drive Configuration

First set the SCSI Target ID using the digital switch on the rear panel of the external drive. The Target ID setting is displayed in the window. Increment or decrement the target ID by pressing the small buttons. Make sure that no other SCSI device connected to the same host controller has the same ID. The factory setting is 3.

The external CDX termination is set to ON. Therefore, any other devices connected to the controller should be OFF, and the CDX must be at the end of the chain.

PC Card SCSI Adapter Installation

External CDX comes with a PCMCIA plug & play Ultra SCSI host adapter. The Host Adapter has no jumpers or other settings. It will be configured properly when the driver software is installed.

Install the PC Card Adapter

Install the PC card SCSI adapter according to the supplied instructions, and connect the included SCSI cable to the PC card, and to the external CDX.

Install the Driver

You will need to install a driver from the floppy disk that comes with the PC card adapter. Select Add New Hardware in the Control Panel. Select SCSI Adapter from the list of devices, and Show All Drivers. Click the Have Disk button and insert the floppy disk. Use the Browse button to locate the directory on the floppy disk that corresponds to your operating system.

CDX SOFTWARE INSTALLATION

Once you have the CDX drive installed and running, load the CDX Installation and Qualification CD into the drive. Select *Start / Run* from the Start Menu, and enter “D:SETUP”, where “D” is the drive letter of your CD-ROM drive. Alternatively, you can double-click on SETUP.EXE in Windows Explorer. Then just follow the instructions on the screen. The CDX software requires 10 MB of free disk space to install, and 22 MB of free RAM to run.

A “Clover Systems” folder will be added to the Start | Programs menu and a shortcut is added to your desktop.

ASPI Manager

ASPI Manager (Advanced SCSI Programming Interface) is required for CDX to run. This program will be automatically installed by the setup program. If you have another version of ASPI installed, the installation will overwrite it.

Running CDX with Foreign Language Windows

When running CDX with a foreign language version of Microsoft Windows, you may need to use the command line switch “/W”. This will compensate for the different width of some non-roman characters, and make the main window the correct size. If you do not use this switch, the main window will be initialized to the wrong size.

To start CDX with the “/W” command line switch, do this: After installing the CDX software, delete the shortcut that is created on the desktop. Go to the Clover Systems folder, and create a new shortcut to CDX.EXE on the desktop. Now right-click on the shortcut and select Properties.

In the *Target* edit box, add “/W” (without the quotes) to the end of the target specification. The Target specification should now look like this: “C:\Program Files\Clover Systems\Cdx.exe” /W

Note that the “/W” is outside the quotation marks and there is a space between the closing quote and /W.

Now, when you run CDX from the desktop shortcut, it will size the main window correctly.

ANALOG MEASUREMENT MODULE INSTALLATION

The Analog Measurement Module (AMM-1) is an optional tool to expand the testing capabilities of your CDX. The AMM-1 helps evaluate disc quality by automatically measuring parameters such as reflectivity, Beta, I_3 / I_{top} , I_{11} / I_{top} , and displaying the data in the CDX software. Together with analyzing playback errors, this information provides a thorough analysis of disc quality.

The AMM-1 connects to the HF output of the CDX I/O panel with a coaxial BNC cable, and uses a USB port to communicate with the PC. The DVX software automatically gathers data from the AMM-1 and displays the data as statistics and easy to read charts. Summary of the data, along with the charts can be printed and/or easily saved to disk for future use.



There are two connectors on the AMM-1, one is a BNC connector, the other a USB connector. Connect the USB connector to any available USB port on the PC with the cable provided, and connect the BNC connector to the I/O panel of CDX labeled “HF OUT” with the provided coaxial cable. The AMM-1 is powered by the USB port.

After connection to the USB port, you should receive a “New Hardware Found” message from the operating system, and the AMM-1 driver should install automatically.

DUAL CDX INSTALLATION

Two CDX drives can be installed in one PC and operate simultaneously. You will need two RS-232 serial ports, and one or two PCI slots.

If your PC is fast enough, you can connect both CDX drives to one SCSI controller. However, if your PC will allow both CDX’s to run at maximum speed simultaneously, it may be necessary to use two separate SCSI controllers. To check for proper performance, test a good disc in one drive alone, then see if you get the same results with both drives testing at once. When connected to a common controller, each CDX must be set to a unique Target ID

The CDX at the end of the cable must have the termination jumper installed (see above). Any additional drives on the same cable must have their termination jumper removed.

Installing the Software

To run two CDX’s simultaneously, two instances of the program are run at the same time. The first instance is the normal CDX software. The other instance is a program named CDX2 that must be installed by selecting “Dual Drive Installation” during the installation process. This will install the additional CDX2 program, plus a shortcut that will launch both CDX and CDX2.

CDX.EXE will attach to the first CDX (lowest target ID / drive letter), and CDX2 will attach to the other. CDX2 will not find the CDX drive unless two CDX’s are installed.

If you have monitor resolution higher than 800 x 600, you can arrange the two windows on the screen so that you can easily switch back and forth. If your screen resolution is 800 x 600, each instance will fill the screen, but you can easily switch back & forth by clicking the icons in the task bar at the bottom of the screen.

You must setup each instance separately using the *Preferences...* selection in the main menu.

DUAL CDX WITH DUAL AMM-1

If you have two CDX's both with AMM-1 modules, there are some special considerations: CDX and AMM-1 are configured as matched sets. Since the AMM-1 is calibrated to a certain CDX drive, they must not be mixed up. In order to facilitate this, each AMM-1 is programmed with a serial number that matches the CDX serial number. This way, each CDX knows which AMM-1 to talk to.

Since the CDX serial number cannot be read by software, each CDX serial number is stored in the Registry. The CDX software installation will create the correct Registry entry for both CDX and CDX2, but it will be blank, and you must manually enter the CDX serial number: Run the Registry Editor (regedit.exe), and navigate to HKEY_CURRENT_USER / Software / Clover Systems / CDX / Drive. You will see a string value named CDXSerialNo. Double click the name, which will open an edit dialog box. Enter the serial number of your CDX in the “Value Data” box, then click “OK”.

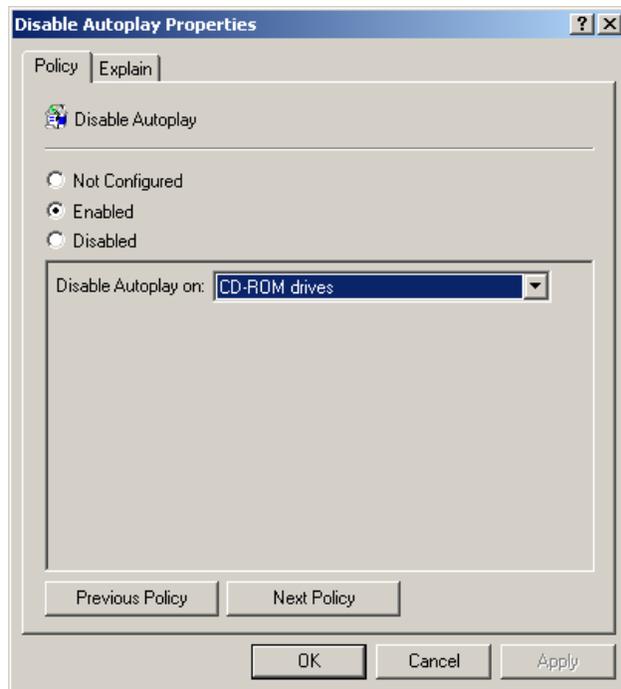
Now do the same for HKEY_CURRENT_USER / Software / Clover Systems / CDX2 / Drive. The serial number of your CDX is printed on a label on the top of the drive.

DRIVE SETTINGS

Note: Failure to set these properly may prevent CDX from working!

Autoplay (Auto Insert Notification) must be disabled in order to prevent other programs from running and conflicting with CDX!

Disabling AutoPlay in Windows 2000



In Windows 2000, the automatic running of programs is called AutoPlay. The CDX installation will automatically disable AutoPlay. If you need to disable AutoPlay manually, select *Run* from the Start Menu. Type GPEDIT.MSC and click OK. Navigate to Computer Configuration \ Administrative Templates \ System. Double-click “Disable Autoplay” in the list box. Select the Enabled radio button, and select CD-ROM Drives in the list. Press OK.

This will prevent programs on a data disc from running. However, you also need to disable the CD Player program, to prevent it from playing an audio disc when inserted. To disable CD Player, Open My Computer, then select the *Tools / Folder Options* menu. Select the File Types tab in the dialog, and select CD Audio Track from the list of Registered File Types. Press the Advanced button, then select the Actions tab.

Click in the list box, but not on “play”. Then press the Set Default button. This will set the default action to “nothing.” If play is set to the default action, it will appear in bold.

Figure 3 - Disable Autoplay

Disabling AutoPlay in Windows XP

The CDX installation will automatically disable Autoplay in Windows XP. If you need to do this manually, run the Registry Editor (regedt32) from the Start | Run menu. Navigate to HKEY_CURRENT_USER \ Software \ Microsoft \ Windows \ CurrentVersion \ Policies \ Explorer, and change the value “NoDriveTypeAutoRun” to B1 hex.

Drive Settings in CDX Software

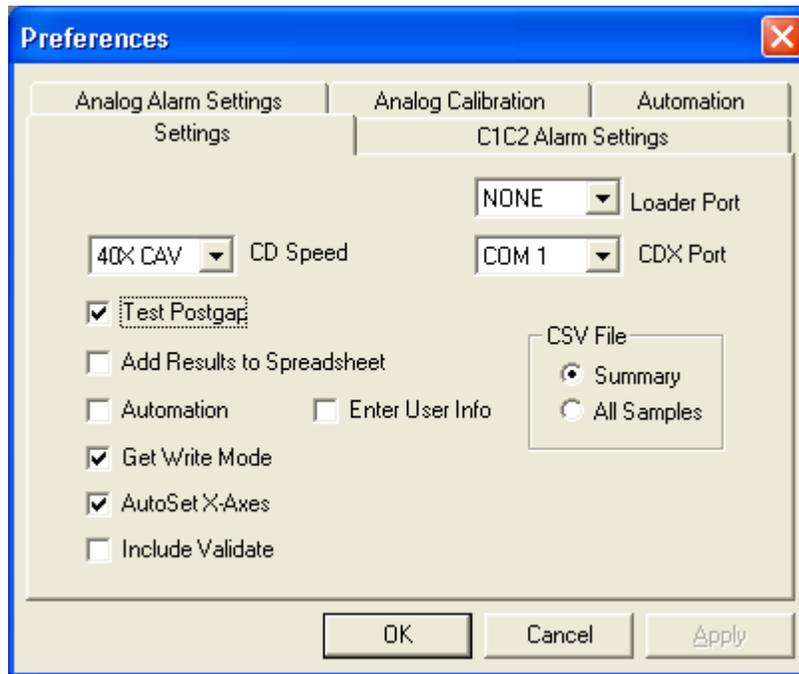


Figure 4 - CDX Drive Settings Sheet

Com Port Setting

Note: CDX uses one serial port. You must connect the CDX drive to a serial (COM) port for it to work.

Open the *Preferences* dialog in the main menu and select the Settings tab. Now set the COM Port(s) you will be using with CDX. Select from the drop-down list, the COM Port that you connected to the CDX drive and click Apply or OK. An easy way to test the operation of the COM Port is to click *Eject!* in the main menu. If the serial interface is working properly, the CDX tray will open / close.

Test Speed

Finally, you can set the speed you want CDX to run at. Select 1, 2, 4, 8, 20, or 40 from the drop-down list. You can change the test speed at any time using this property sheet. Speeds of 1X, 2X, 4X, and 8X are CLV (Constant Linear Velocity), which is the normal playing mode for all CD's. All other speeds are CAV (Constant Angular Velocity), which means that the disc spins at a constant speed. Since the circumference at the outside is twice as large as at the inside, the transfer rate at 24X CAV is 10X at the inside, and 24X at the outside (average 17X). At the 40X setting, the actual speed is 17X at the inside, and 40X at the outside (average 30X).

The Analog tests (only available with AMM-1 installed) run only at 4X speed.

If the Analog Test is selected, the test speed will automatically be set to 4X. No user intervention is required.

Choosing the Best Drive Speed

In general, it is best to test at the fastest speed. However, some types of defects are greatly magnified at higher speed, so you may need to use a slower speed. You can observe this effect by testing the included Qualification Disc 4B. You will see that serious errors like E22 and E32 are much greater at high speed.

On good discs, certain types of errors may be greater at lower speeds. We believe this is because CD-ROM drives are optimized for high speed. At lower speeds, the servo bandwidth is too great for optimum performance.

Furthermore, there are no standards for playing at high-speed. All standards apply to 1X speed only. Some CD's will not play satisfactorily at higher speeds. CD-ROM drives are designed to fall back to a slower speed if they cannot read reliably, and will also re-try up to 10 times before failing. As a result, it is not obvious in normal usage that a disc is not functioning at full speed. You may find discs that do not work at high speed. In this case, lower the test speed until you can get reliable results.

If your application requires a certain throughput (like some games), CDX provides a way to confirm that the disc can play at the required speed.



QUALITY CONTROL BASICS

WHAT IS DISC QUALITY?

We define disc quality as having every disc work in every drive, every time, with a lifetime appropriate to the application. You must decide what level of confidence you need for your application. The higher the cost of failure, the more careful you want to be.

It's Worse Than You Think...

One problem in evaluating disc quality is that discs that appear "good" may not be. All CDs have very powerful error correction built in that hides a multitude of sins. In principle, it is possible to drill a 2mm hole through the disc and still recover every single bit! However, you wouldn't want to rely too heavily on having that disc work reliably. Many people think that just because a disc seems to be readable, it is good. But it actually may be on the verge of failing.

WHY TEST DISCS?

CD Duplicators

You can improve profitability and reduce costly problems in your CD-R duplication business. As a CD duplicator, you are responsible for the quality of your product. Data comparison does not measure disc quality. Just because you can read it doesn't mean it's good. Poor disc quality can cause unreliable operation and short lifetime.

Evaluate and Qualify CD-R Media - All CD-R media are not the same. Compatibility between writer and media is crucial. Find out which type of media works best with your writers. In addition, anyone can make a bad batch of media. Localized defects and dye coating problems are not uncommon. Identify bad batches of media before burning a bunch of bad discs.

Detect Media and Recorder Compatibility Problems - Compatibility between media, writer, and software is necessary to produce good discs. Certain combinations of write strategy, recording speed, and media type can produce poor results. Determining the best media to use with a given recorder (or vice versa) is greatly facilitated by testing disc quality. Identify burners that are failing or about to fail. Discover if the problem is the media or the writer.

Manufacturers

CD manufacturers must test discs to ensure conformance to standards & license agreements. But of course the main goal is customer satisfaction. Many CD replicators have found our products useful for screening discs on the production line to spot problems before many bad discs are made.

Distributors

Distributors can use CD testing as a way to manage quality variations from vendors, and make sure they get what they paid for. Although most replicators produce good quality products, bad discs often slip through. Discs that are made thinner than usual and physical defects such as pit distortion from short manufacturing cycles indicate poor manufacturing techniques and can result in unusable discs. If you are paying for premium discs, you want to be sure the quality measures up. In addition, you can avoid returns and unhappy customers.

Studios & publishers

Avoid problems with mastering - In the majority of glass mastering systems, uncorrectable errors (referred to as E32; see discussion below) automatically abort the mastering session, causing costly delays for both the mastering house and the customer. Most replicators prefer that you be able to demonstrate that your CD-R does not reach this level of error.

Provide confidence in product quality - When problems occur, they can be resolved more quickly and easily if publishers know the quality of their discs and have a way to check them. Also, once a product is in the field, fixing a problem is more difficult and expensive. Publishers can avoid returns and maintain a good reputation by tracking the quality of their discs.

End Users

Critical Applications – If your application has a high cost of failure, you can increase your confidence level by testing the discs.

Archiving – The initial quality of a disc profoundly affects its potential lifetime. A good disc has greater tolerance for the effects of aging than a poor one. If you are archiving either CD-Recordables or replicas, you will want to select the highest quality discs to archive. This is possible only if you have a way of measuring disc quality.

Avoid long access times – As discs degrade, access times increase dramatically.

HOW TO MEASURE DISC QUALITY

Traditionally, many disc producers evaluate the quality of disc copies by comparing the copy with the original. In some cases, this can be useful, but data comparison does not measure disc quality. For instance, a bad disc can still verify. The CD's error correction can make a bad disc work, but it may be about to fail, or may not work on all readers.

The easiest way to measure disc quality, however, is to measure error rates. This technique is effective because any serious problems on the disc will affect error rates. A meaningful quantitative measure of disc quality can be obtained using a desktop disc testing system to measure the quantity and severity of errors. Important information can be gleaned by looking at the size of the errors as well as just the number. BLER (BLock Error Rate) only counts how many errors occurred; it does not tell you anything about how severe those errors were. It is quite possible to have a low BLER, but have some of the errors uncorrectable. CDX measures six different sizes of errors, and graphs them by increasing radius, providing a detail picture of disc quality and defects.

Errors are not necessarily physical features on the disc, but are a measure of how well the total system (disc plus player) works. In fact, all discs generate errors on playback -even the best discs produce thousands of errors. The errors are partly due to the fact that playing a CD is a difficult and complicated process. The width of the pits on a disc is smaller than the wavelength of the light used to detect them, so CD players are operating at the limit of physical laws. Playing a disc is not wholly deterministic, but is rather a statistical process. Therefore, the results will not necessarily be the same each time.

Moreover, the objective (the lens that picks up the laser beam that reads the disc) must stay focused within a range of less than 4 microns while the disc is moving both horizontally and vertically. The pickup must follow the spiral track of pits as it moves to an accuracy of much less than one micron (one millionth of a meter). Several highly tuned and sophisticated servo (control) systems are used



to maintain focus, follow the track, control the spindle speed, and handle timing issues related to reading the data. These servos are very sensitive and work only within a certain range. Thus, some of the errors occur as a result of the narrow tolerances within which the equipment must function.

Two primary features of the disc itself that can cause errors are poor pit geometry and physical defects. Pit geometry refers to the depth, width, length, and wall slope of the physical pits created in the disc. Although CD-R discs do not have pits, the recording process produces areas on the disc that function like pits and are subject to imperfections that cause errors. Physical defects include pinholes, black spots, bubbles, and scratches. Poor pit geometry and physical defects can make it difficult or impossible for the servomechanisms to read the data properly.

A determination can often be made as to whether problems are caused by pit geometry or local defects. A burst of large errors confined to a small part of the disc is most likely caused by some kind of local defect. If many large errors are found over the whole disc (or a large part of it), then the problem is most likely poor pit geometry.

It is extremely difficult to measure pit geometry directly. An easier approach is to play a disc and look at the signals produced by the pickup. By observing the pattern (referred to as an “eye pattern”) created by the playback signal, it is possible to measure features such as pit depth and length. CDX provides a simple way to make pit geometry measurements using an oscilloscope.

MAJOR CAUSES OF DISC FAILURE

The most common cause of disc failure is **scratches and dirt** due to handling.

With molded discs that have not been handled, the most common cause of defects is a **defective master or stamper**. This is true because any defect on the stamper will be faithfully reproduced on every disc.

With CD-Recordables, the most common problem is **incompatibility between the writer and the media**. Often the case is that the recording speed is too high for the type of media being used. Generally, higher recording speeds produce poorer results. This problem usually manifests itself as high error rates across the whole disc. Another common cause of problems is a speck of dust or dirt on the disc (readout) surface when recording. This blocks the recording beam, producing a void, where there are no “pits”. Likewise, bubbles or black spots in the disc substrate can cause the same problem. These type of errors show up as local defects, for example like in fig. 9 on page 28.

QUALITY CLUES

Most problems are traceable to the disc. Often people will encounter a situation where a disc works in one drive, but not another. The tendency is to blame the drive. However, almost certainly it is the disc that is at fault. Since there are no standards for players (other than that they must play a Red Book disc), a disc that is outside the Red Book specs may play on some drives, but not others.

The solution is that all discs must conform to the standards. Discs that are made well within Red Book standards should play on any player.

A disc that behaves erratically is invariably bad. A disc that is outside the Red Book specs (or marginal) will behave in a way that is not predictable. If a disc produces different results each time you test it, that tells you that the disc does not meet Red Book specs.

DISC DUPLICATION TIPS

How to Test Blank Media

Although some things can be measured on a blank disc, none of these things will predict how the disc will work. The recording action is in the dye layer, and the only way to test the dye is to record on it.

We recommend that you record the full disc (74 or 80 minutes) at the speed you wish to use in production. This is important because defects are more common at the outside of the disc. Then do the Error Test to measure the results. Analog pit geometry measurements are especially useful for qualifying new media.

Since the media is generally quite consistent within a batch, it is only necessary to test one or two samples from each batch of new media.

You will also find that the results vary according to the recording speed. Generally, results are worse at the highest speeds. Ideally, you should make full test recordings at several different speeds to discover what is the highest speed that will give satisfactory results.

Hints for Producing Good Discs

- The number one issue is compatibility between the writer and the media. There isn't necessarily a "best" writer or "best" media; some combinations work better than others. The writer's laser power and write strategy must match the type of media used. Both media and writers had evolved over the years, so there are many opportunities for mis-match.
- Use CDX to determine the best type of media for your application. Most major brands will produce good results with modern writers. But anybody can make a bad batch. The media is pretty consistent within a batch, so if there is a manufacturing defect, every disc will be bad. We have gotten bad batches from most major manufacturers. Defects range from stamper defects to bubbles in the plastic, to dirty discs and dye layer coating problems. We have had to change brands several times over the years when a particular brand's process changed. One major advantage of having something like CDX is that you can discover what type of media works best with your writers. You can also discover which is the lowest cost media that gives satisfactory results. The best approach is to try several different types of media in your burners and see which works best.
- Recording speed also makes a big difference. Again, your results will depend on the combination of writer and media, but try each type of media at different speeds to see what works best.
- Discs must be perfectly clean when recording. One of the most common problems is a speck of dust on the disc while recording. The speck will block the recording beam and create a "void", where there are no "pits". This will show up in the test results typically as E22 errors. Since data discs should not have E22 errors, this can be a fatal flaw.

USING CDX

THE MAIN WINDOW

The main window displays information about the disc, a summary of all error rates, charts of each type of CIRC error, and results of all tests. You can print any window by activating it, then clicking the printer icon in the toolbar, or selecting *File / Print* in the menu.

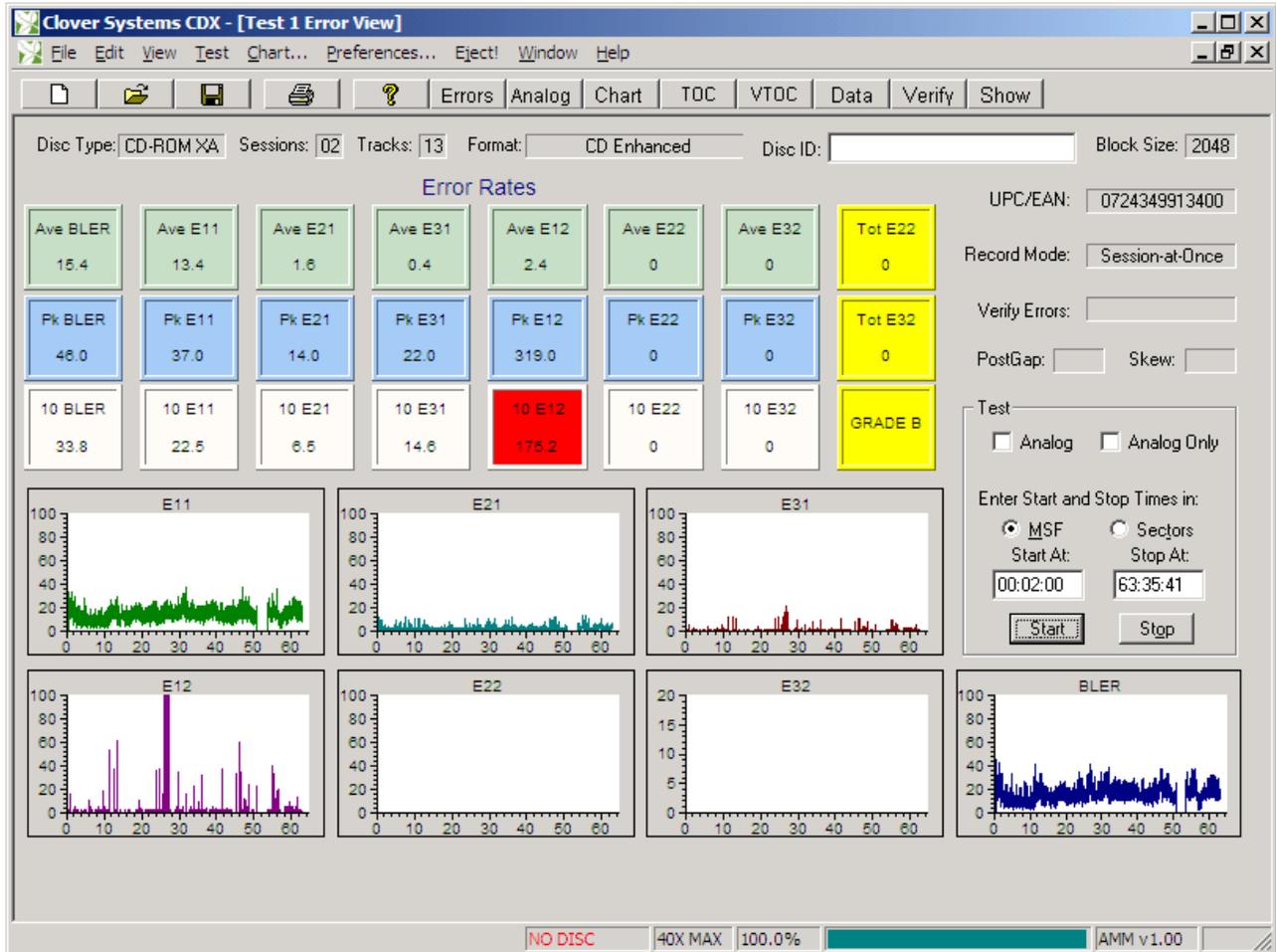


Figure 5 - CDX Main Window

Disc Information

Disc Type

This can be CD-DA, or CD-ROM

Number of Sessions

The number of complete sessions on the disc. Each session consists of a lead-in, program area consisting of up to 99 tracks, and lead-out.

Number of Tracks

The total number of tracks on the disc, including all complete sessions.

Format

The format of the data on the disc. It can be one of the following:

- Audio
- Mode 1 Data
- Mode 2 Data
- Mixed Mode
- Multi-Session
- Enhanced CD
- CD-I

In addition, Mode 1 Data discs and Mode 2 Data discs can be further qualified with the extensions ISO9660, Joliet, HFS, or Rockridge.

Mixed Mode discs have both audio and data tracks. Multi-Session discs are formatted as if they were two separate discs. CD-Enhanced discs have one session with audio tracks, and a second session with data tracks.

Disc ID

The Disc ID edit box in the main window is provided for the user to enter some name, work order, comment, or other means of identifying this disc. The Disc ID will be saved with the test results and printed on the various reports.

Block Size

The number of user bytes in each sector of a data disc. This can vary, depending on the format of the disc. Audio discs have no sectors, so in this case it shows the number of bytes in a subcode frame, which is the same size as a sector on a data disc.

UPC/EAN Code

Universal Product Code; usually implemented as bar code on a package, it can also be encoded into the disc Table of Contents.

Record Mode

The possible modes are: Disc-at-Once, Track-at-Once, Session-at-Once, Fixed Packet, Variable Packet, Not Tested, and Unknown. Disc-at-Once means that the disc was written from start of lead-in to end of lead-out without any write splices. Track-at-Once means that the disc has write splices at the start and end of each track. Session-at-Once means each session is recorded from start of lead-in to end of lead-out without any write splices. Packet mode means the disc was written incrementally, with write splices between each packet. The size of the packets can be variable or fixed. This information is useful for evaluating masters that will be used for duplication or replication. Only Disc-at-Once masters can be made into a glass master for replication. Also, Track-at-Once recording may cause clicks or pops between songs. Incrementally written discs will have write splices between each packet, which can generate many uncorrectable errors. This makes it difficult to evaluate the quality of an incrementally written disc.

This feature will only work for data discs. Audio discs do not use link blocks or track descriptor blocks, and so it is not possible to detect write splices. The write mode will be displayed as "Unknown" for audio discs.



When “Get Write Mode” is turned on in the Options Property Sheet, the write mode of the disc will be displayed in the Disc Info dialog. This feature can be turned off by clearing the checkbox in the Options dialog.

Test Results

The main window shows a summary of all error rates, over-range alarms (Pass / Fail status), and disc Grade.

Error Rates

Error rate data is displayed in two ways: The average and peak values (over the whole disc) are displayed, as well as total E22, and total E32 errors. Each error type is also shown in a graph in the main window.

One-Second and Ten-Second Averaging

When the player is testing, it will send all error parameters to CDX once every second of program time. All data displayed in CDX are one-second averages. Many CD analyzers use one second samples, but the Philips Red Book specification calls for averaging error rates over 10 seconds, so you must be careful in comparing data from different systems. The one-second data will have higher peaks and lower valleys. The 10-second data is smoother because it is averaged over more samples. The average values will be identical for one and ten second data. The CDX main window displays both 1-second and 10-second peak values.

Pass / Fail Indication

If any of these error values goes over a user selectable limit, the indicator will turn red. This provides a simple Pass / Fail indication of test results.

Grade

A letter grade A – D, or F is assigned according to the test results. This provides a simple quantitative result without having to deal with the detailed results. The criteria for the grading systems are explained in the section [Disc Grading System](#) on pg. 26.

Subcode Skew

This shows the results of the Subcode Skew test. The Q-channel subcode on a disc contains time code, called Atime, which is used for rapid locating of specific places. This time code should be identical to the sector address contained in the sector header of a data disc. Any discrepancy between these two values is called Subcode Skew. This type of error can be caused by the recording system. Skew up to ± 7 sectors is allowed, but any skew will adversely affect search times. Positive skew means that Atime is higher than the header address. Negative skew means the Atime is less than the header address. This test applies only to data discs, as audio discs have no sector headers.

Postgap

Shows the results of the Postgap test. The last track on a disc must be followed by a Postgap. The Postgap contains all zeros (or digital silence). A minimum of 150 sectors is required.

Verify

Shows the results of the Verify Disc or Verify File test. This is the total number of bytes that did not compare.

CIRC Test Controls

Start At / Stop At

Sets the start and stop points for the CIRC and Verify tests. This allows you to test only portions of a disc. Default values are the begin and end of the information area. You can enter new values in Minutes, Seconds, and Frames, or Physical Sectors².

Start Button

Starts the CIRC error and / or Analog test.

Stop Button

Stops a test in progress.

MSF Button

Causes the START and STOP points to be displayed and entered in Minutes, Seconds, and Frames.

Sectors Button

Causes the START and STOP points to be displayed and entered in Physical Sectors (see [Logical Blocks and Sectors](#), pg. 17).

Analog Checkbox

Only applicable if the optional AMM-1 Analog Measurement Module is connected. Causes the Analog tests to be automatically performed after the error test. Test speed will be automatically set to 4X.

Analog Only Checkbox

Only applicable if the optional AMM-1 Analog Measurement Module is connected. When checked, only the analog test will be performed, and not the error test.

The Status Bar

The status bar at the bottom of the main window shows the drive status, drive speed, and progress of the current test. The status bar can be viewed or hidden by checking or unchecking *View | Status Bar* in the main menu.

The drive status shows what the CDX drive is doing at all times.

LOGICAL BLOCKS AND SECTORS

Data discs are arranged in sectors, so that the data can be randomly accessed. These sectors are always of a fixed size, but the amount of user data may vary. Also, each sector may contain additional parity bytes for error correction, depending on the mode.

² See “Logical Blocks and Sectors” on pg. 17

Audio discs have no sectors; the data is a continuous stream of music. However, they do have time code that can be correlated to sectors. The size of a subcode frame is the same as the size of a sector on a data disc. Therefore, it is possible to convert between Atime and Sector number.

Physical sector numbers start at the beginning of the disc, and continue to the end. However, the first 150 sectors of a data disc are used for pre-gap, and contain no information. Therefore, the data area begins at physical sector 150, and is called Logical Block 1. Logical Blocks (abbreviated LBA for Logical Block Address) are the same thing as physical sectors; the only difference is that they are numbered beginning at physical sector 150. Whenever we refer to a data disc sector, we mean physical sector unless we say logical block or LBA.

CDX software uses both physical sectors and logical block addresses. When entering START and STOP points, use physical sectors. When viewing disc data, use logical block addresses.

DISPLAYING ADDITIONAL DISC INFORMATION

Table of Contents

This shows the starting time (or physical sector number) for each track, the track length, the track type, copy permit status, and ISRC codes for audio tracks. You can display the Start and Length times in MSF (Minutes, Seconds, Frames) or physical sector number format.

Sn	Tk	Start	Length	Type	Copy	Pre	ISRC
01	01	00:02:00	03:40:65	audio	No	No	USMC19546292
01	02	03:42:65	04:05:00	audio	No	No	USMC19546719
01	03	07:47:65	03:52:47	audio	No	No	USMC19546720
01	04	11:40:37	04:32:00	audio	No	No	USMC19546289
01	05	16:12:37	03:53:08	audio	No	No	USMC19546716
01	06	20:05:45	04:19:52	audio	No	No	USMC19546717
01	07	24:25:22	04:00:15	audio	No	No	USMC19546287
01	08	28:25:37	03:44:48	audio	No	No	USMC19546288
01	09	32:10:10	03:39:40	audio	No	No	USMC19546721
01	10	35:49:50	04:54:45	audio	No	No	USMC19546722
01	11	40:44:20	04:04:30	audio	No	No	USMC19546722
01	12	44:48:50	04:10:02	audio	No	No	USMC19546747
01	13	48:58:52	04:54:57	audio	No	No	USMC19544923

Leadout: 53:53:34

Figure 6 - Table of Contents

ISRC Codes

Clicking the *ISRC* button in the Table of Contents view will get and display the ISRC codes if present. This applies to audio discs and CD Enhanced discs only, as ISRC codes are used to

identify the copyright owner of music selections. This information is not contained in the Table of Contents, but rather within the music selection itself, so CDX must scan each music track to read the codes.

Volume Descriptors

Selecting *Vol Desc* in the View menu will display the disc volume descriptors (Data or CD Enhanced discs only). In addition to the primary volume descriptor, you can display the supplementary volume descriptor if the disc has one.

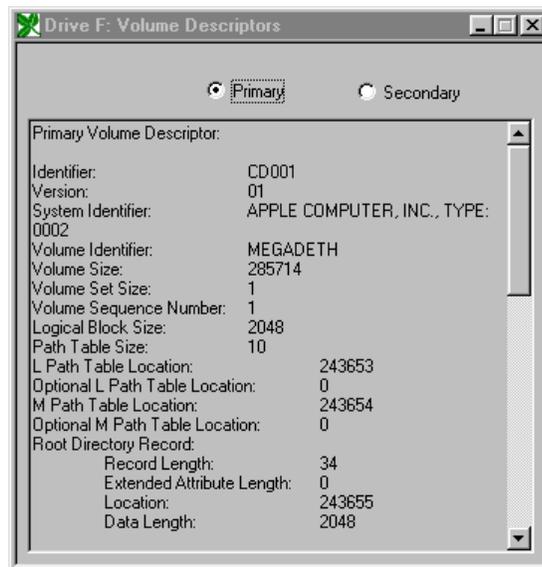


Figure 7 - Disc Info with Volume Descriptor

Summary of Results

View | Summary opens the Summary view. This shows a complete summary of all test results. The summary can be printed by selecting *File | Print* in the main menu, or clicking the print icon in the toolbar.

SETTING OPTIONS

Test Postgap

When checked, the error and analog tests will include the postgap at the end of the program area. This should remain checked, but you can uncheck it to test a disc recorded track-at-once that has link blocks at the end of the postgap.

Add Results to Spreadsheet

When checked, CDX will add a summary of the CIRC test results to the end of the spreadsheet CDTests.wk1. For details, see [Saving Results to a Spreadsheet or Database](#) on pg. 23.

Get Write Mode

When checked, CDX will determine the recording method of a disc when it is loaded (except audio discs).

Auto Set X-Axes

When checked, CDX will automatically set the horizontal axes of all graphs according to the size of the disc. When not checked, the default value for the X axes is 80 minutes. You can change the axis values for all charts, and the settings will be remembered.

Include Validate

When checked, CDX will verify the data on the disc while performing the error test. The program will prompt you for a Clover Signature at the start of the test. It will then attempt to validate this signature during the error test. The results (PASS or FAIL) will be displayed in the "Verify Errors" box in the main view, and also in the Summary view. Before beginning the test, you must create the signature from your master disc that you want to compare against. (See: [CREATING OR VALIDATING A DISC SIGNATURE](#) on pg. 32) In automation mode, you will only be prompted once for the Clover Signature at the beginning of the test. Each subsequent disc will then be validated against this signature. If the validation fails, the disc will be rejected.

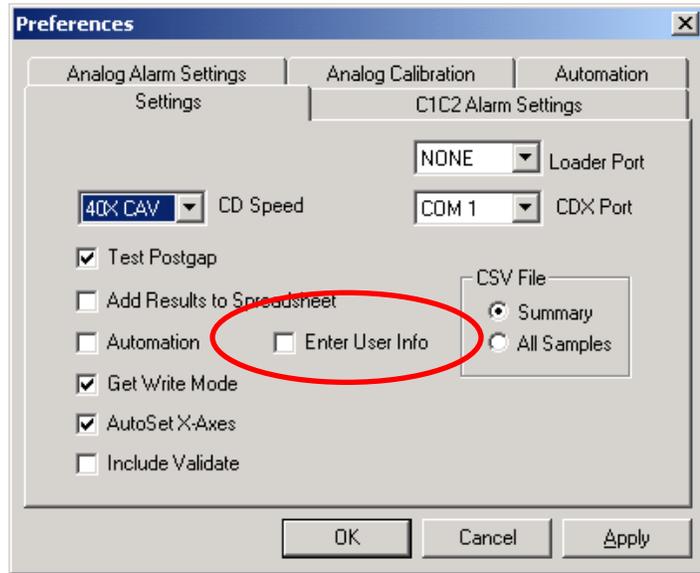


Figure 8 - Enable User Info

Enter User Info

When checked, a dialog will open at the beginning of each test that allows you to enter any information you wish, that will be saved with the test results. See ENTERING USER INFORMATION below.

Automation

In Automation mode, the test is started automatically when a disc is loaded, and the results can be saved automatically without user intervention. This mode is also used with the Autoloader. For details, see [Using the Autoloader](#) on pg. 20

Enable Automation

Automation mode is enabled in the *Automation* property page of the *Preferences* menu.

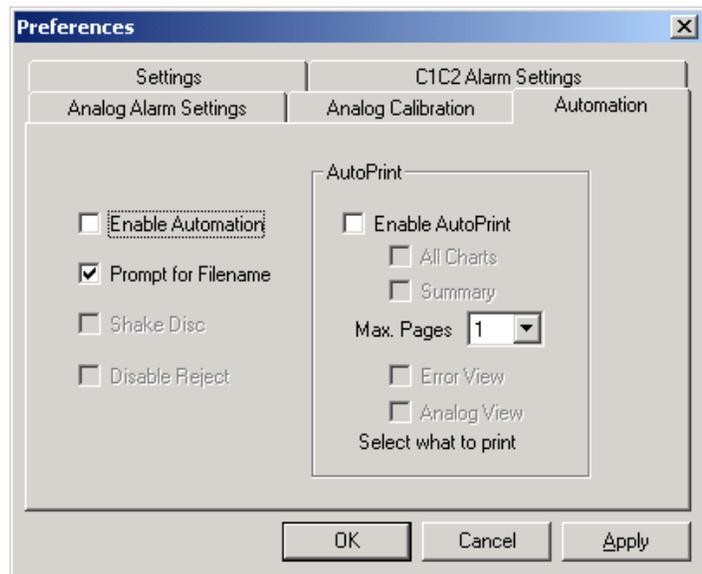


Figure 9 - Automation Settings

Prompt for Filename

When enabled, you will be prompted at the end of the test for a filename for the saved results. When disabled, the file will be saved without user input, with a made-up unique name. If Enter User Info is checked in the Options page, the text in the user information box #1 will be used for the saved filename.

AutoPrint

When enabled, results will automatically be printed at the end of the test. You can select which views you wish to print automatically, including any or all of: All Charts; Summary; Error View; or Analog View. When the Summary view is selected, you can choose to print either one or two pages of the summary. All views can be printed at any time by selecting *File / Print* in the main menu, or pressing the print icon in the toolbar.

Shake Disc

When the Autoloader is attached, you can enable this option, which will cause it to shake the disc when picking from the input stack. Enable this if you have trouble with discs sticking together.

Disable Reject

When enabled, this will prevent the Autoloader from outputting a failed disc to the reject bin. Instead, all discs will be output to the “good” output bin.

Table 1 - AutoSave Rules

Enter User Info Off:	
Prompt for Filename Off	Uses made-up filename
Prompt for Filename On	Prompts for filename with default made-up name
Enter User Info On:	
Prompt for Filename Off	Uses User Info Box #1
Prompt for Filename On	Prompts for filename with default User Info name

With Automation on and the AutoLoader attached, it never prompts for User Info or Filename, and always uses a made-up name.

LOADING THE DISC

Insert a disc in the tray label side up. Press the EJECT button on the front panel, or *Eject!* in the main menu to load the disc. The BUSY light will come on for a few seconds as the drive reads the Table of Contents. The Drive Status display will show “LOAD DISC”. Wait ‘till the light goes out and Drive Status reads “READY”.

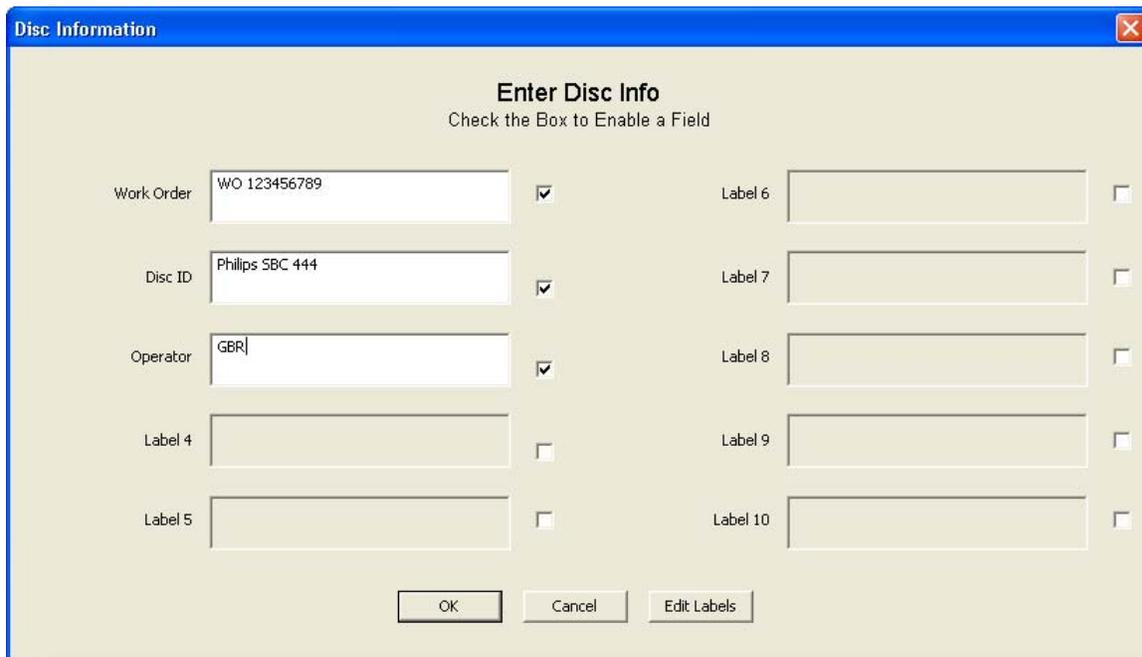
Entering User Information

CDX software v2.3.4 and later now allows you to enter up to 10 fields of user information. This can be things like work order, disc identification, publisher, or anything else you wish. Labels describing each field are user customized.

User Info can be enabled or disabled in the Settings tab of the Preferences dialog. To enable User Info, check the “Enter User Info” checkbox.

When enabled, the User Info dialog will appear whenever a new disc is loaded. To set up the User Info dialog, press the “Edit Labels” button. This will allow you to edit the labels for each field. You will be prompted for a password, to avoid unauthorized modification of the labels. The password is the same one used for entering Alarm Limits. The default password is “Clover” (without the quotes), and is case sensitive. You can change the password by checking the “Change” box in the password dialog. Each label can be up to 64 characters. Use the tab key to advance to the next label. The labels will be permanently saved in the Registry.

To enable the fields you want to use, check the checkbox next to the edit box.



The screenshot shows a dialog box titled "Disc Information" with a subtitle "Enter Disc Info" and the instruction "Check the Box to Enable a Field". It contains ten input fields arranged in two columns. The first column includes "Work Order" (with text "WO 123456789"), "Disc ID" (with text "Phillips SBC 444"), "Operator" (with text "GBR"), "Label 4", and "Label 5". The second column includes "Label 6", "Label 7", "Label 8", "Label 9", and "Label 10". Each field has a small checkbox to its right. The checkboxes for "Work Order", "Disc ID", and "Operator" are checked, while the others are unchecked. At the bottom of the dialog are three buttons: "OK", "Cancel", and "Edit Labels".

Figure 10 - Disc Info Entry Dialog

For each disc, you can enter the appropriate information into each edit box. There is no limit to how many characters you can enter. If the entry goes beyond the end of the box, the text will scroll to the left. You can start a new line by pressing ENTER.

MEASURING ERROR RATES

Setting the Start and Stop Points

The “Start At:” and “Stop At:” edit boxes will default to the first sector with data, and the start of lead-out respectively, so that the whole disc is tested. You can change the start and stop points of the test if you wish to test only a portion of the disc. You can also select whether you want to

display and enter these points in MSF format (Minutes/Seconds/Frames), or Sector numbers. Data discs default to display in Sectors, and audio discs default to display in MSF.

Starting the Test

Click the Start button in the main window, or select *Test / CIRC Errors* in the main menu. The current speed setting for the CDX drive is displayed in the status bar. You can change it using the Options property sheet described above. The test will stop automatically after the specified number of sectors are tested. Progress is displayed in the status bar at the bottom of the window.

If you wish to abort the test before it reaches the end, press Stop. When the test completes, a message box appears with notification that the test has completed.

Saving the Results

The end of test notification prompts the operator to save the results. Selecting YES will save the data; selecting NO will skip the save operation. The data can be saved later on by selecting *File / Save* in the main menu. A dialog box prompts for a filename. You can save the data at any time, even while the test is running. Test data files use the default file extension “.cdx” but you can use another file extension if you wish. You can also enter a comment or identification string in the Disc ID edit box in the main window. This is a text string that is printed on the Summary Printout, and can be used to identify the disc.

Saving Results to a Spreadsheet or Database

The CIRC error test results summary can be saved to a spreadsheet. The feature is enabled by setting the *Append to Spreadsheet* checkbox in the Options tab of the Preferences dialog. When enabled (checked), the summary results of the CIRC test will be appended to the end of an Excel spreadsheet named CDTests.xls. Optionally, you can have it save to a Lotus 1-2-3 spreadsheet. In this case, the results will be saved to CDTests.wk1 instead of CDTests.xls. To do this, start the program with the “/L” command line switch:

Go to the Clover Systems folder, and create a new shortcut to CDX.EXE on the desktop. Now right-click on the shortcut and select Properties.

In the *Target* edit box, add “/L” (without the quotes) to the end of the target specification. The Target specification should now look like this: “C:\Program Files\Clover Systems\Cdx.exe” /L

Note that the “/L” is outside the quotation marks and there is a space between the closing quote and /L. Now, when you run CDX from the desktop shortcut, it will use Lotus spreadsheet format instead of Excel.

Both Excel and Lotus spreadsheet templates are provided with the installation. You can format the spreadsheets any way you want, but they must be named CDTests.xls or CDTests.wk1. They must also be located in the same directory where you store your test results.

In addition, the same summary of results is also appended to a comma-delimited text file named CDTests.txt. The format of the data in CDTests.txt is the same as in CDTests.xls. This text file can then be imported into most database or spreadsheet programs. If the CDTests.txt file does not exist, it will be created in the directory where the binary data is saved.

The results of one test are saved as one row of data. The columns are arranged as follows:

	Contents
--	----------

Column 1	Disc ID
Column 2	File Name
Column 3	Grade
Column 4	Pass / Fail
Column 5	AVE BLER
Column 6	PK BLER
Column 7	10PK BLER
Column 8	AVE E11
Column 9	PK E11
Column 10	10PK E11
Column 11	AVE E21
Column 12	PK E21
Column 13	10PK E21
Column 14	AVE E31
Column 15	PK E31
Column 16	10PK E31
Column 17	AVE E12
Column 18	PK E12
Column 19	10PK E12
Column 20	AVE E22
Column 21	PK E22
Column 22	10PK E22
Column 23	TOT E22
Column 24	AVE E32
Column 25	PK E32
Column 26	10PK E32
Column 27	TOT E32
Column 28	Not Used
Column 29	Not Used
Column 30	Not Used
Column 31	Not Used
Column 32	Not Used
Column 33	Not Used

Column 34	*MIN BETA
Column 35	*AVE BETA
Column 36	*MAX BETA
Column 37	Not Used
Column 38	Not Used
Column 39	Not Used
Column 40	*MIN REF
Column 41	*AVE REF
Column 42	*MAX REF
Column 43	*MIN I_{11} / I_{top}
Column 44	*AVE I_{11} / I_{top}
Column 45	*MAX I_{11} / I_{top}
Column 46	*MIN I_3 / I_{top}
Column 47	*AVE I_3 / I_{top}
Column 48	*MAX I_3 / I_{top}

Figure 11 – Spreadsheet Format

* Only available if Analog Measurement Module installed

Pass/Fail is based on the Alarm settings set by the user. If any parameter goes over the Alarm setting, the result becomes “**Fail**”.

In addition, the same summary of results or the complete test data can be saved to a comma-delimited text file named CDTests.CSV . In the Settings property sheet of the Preferences dialog, you can select either Summary or All Samples in the CSV File group. If you select Summary, a summary of the test results is appended to the CSV file. The format of the data in the text files is the same as in the spreadsheet files.

If you select All Samples, every sample of every parameter will be written to the CSV file. In this case, any previous file contents will be deleted.

These text files can then be imported into most database or spreadsheet programs. If the text file does not exist, it will be created in the directory where the binary data is saved.

You can also export the raw data by using the *Chart...* command in the main menu. See [SingleChart](#) on page 28.

Starting a New Test

To start the test, you only need to load a disc and press “Start”.

Disc Grading System

This feature provides a means of instantly evaluating a disc without looking at the individual data. There are five different grades covering a wide range of performance: A, B, C, D, and F. Here are the criteria used to determine the GRADE. These criteria are somewhat arbitrary, but reflect generally accepted practice in the industry.

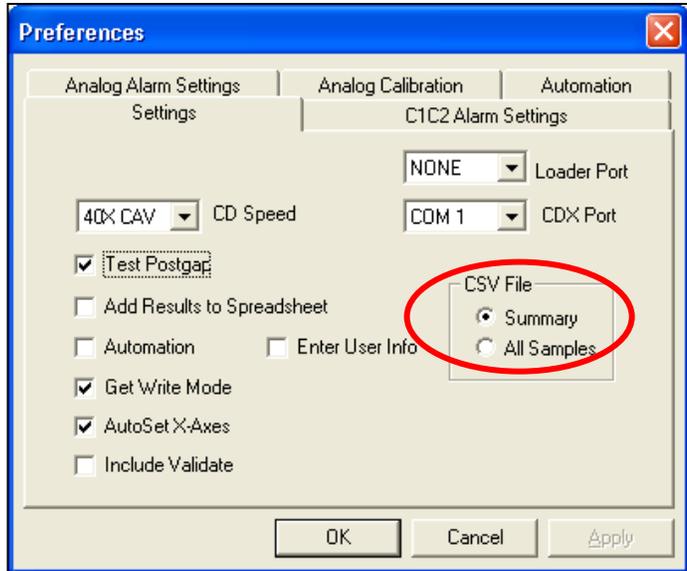


Figure 12 – Export Options

GRADE A = AVE BLER over the whole disc not greater than 5.0
 PK BLER less than 100
 PK E12 less than 400
 NO E22 ERRORS
 NO E32 ERRORS

GRADE B = AVE BLER over the whole disc not greater than 50.0
 NO E22 ERRORS
 NO E32 ERRORS

GRADE C = AVE BLER over the whole disc not greater than 100.0
 NO E32 ERRORS
 * REF less than 60%
 * I_{11}/I_{top} less than 0.6
 * I_3/I_{top} less than 0.3
 * I_3/I_{top} greater than 0.7
 *MAX BETA greater than 15%
 *MIN BETA less than -10%

GRADE D = AVE BLER in all ten second periods is less than 220
 E32 greater than 0 on Audio disc

GRADE F = AVE BLER in any ten second period is greater than 220
 TOT E32 greater than 1000 on Audio disc
 TOT E32 greater than 0 on data disc
 * REF less than 48%
 * I_{11}/I_{top} less than 0.48
 * I_3/I_{top} less than 0.24
 * I_3/I_{top} greater than 0.84
 *MAX BETA greater than 20%
 *MIN BETA less than -15%

* Only available if Analog Measurement Module installed

Generally, a GRADE A disc represents the best possible quality of disc. GRADE B is still an excellent disc, but not quite perfect. GRADES A & B are good discs for any use, including the most demanding CD-ROM uses.

Most CD-ROM publishers do not like to see BLER more than 50 or any E22 or E32 errors. Therefore, GRADES C through F would be unacceptable for these users. However, GRADES C through D are still usable discs. The only grade that is unacceptable is F, since this disc does not meet Red Book specifications. Still, this disc may be usable, and the data fully recoverable.

Uncorrectable errors (E32) may not be a problem on audio discs, since the player's interpolation circuitry will hide these errors. Some players can interpolate over up to eight consecutive bad samples, although the sound quality may be compromised.

Uncorrectable errors do not necessarily make a CD-ROM unusable either. Errors that are uncorrectable in the main CIRC correction stage may still be corrected by the EDC/ECC sector level error correction used on most CD-ROM's. Therefore, the data may still be recoverable, and can still verify if you are comparing to the original. Of course a disc like this has no tolerance for additional degradation, such as scratches and fingerprints, so access time will increase and it will soon fail.

Since there is no Red Book specification for uncorrectable errors (E32), a GRADE D disc is still considered within Red Book specifications. CD-ROM's however, should have no E22 or E32 errors, as made. If the BLER exceeds 220 in any ten-second period, the disc is outside the Red Book specifications. Grade F discs do not meet Red Book specs, and therefore should be rejected.

Depending on your own requirements, you will have to decide where to draw the line as far as what you are willing to consider necessary and sufficient performance. Also please see the section [INTERPRETING THE RESULTS](#) on pg.47.Setting Pass / Fail Criteria

It is possible to set limits for each parameter measured. If the value for any parameter exceeds this limit, then the corresponding indicator in the main window will turn red, indicating an over-range condition. In addition, any parameters which went over it's limit will be printed in red and will be rejected by the autoloader when installed. This feature allows you to create your own "Pass/Fail" criteria.

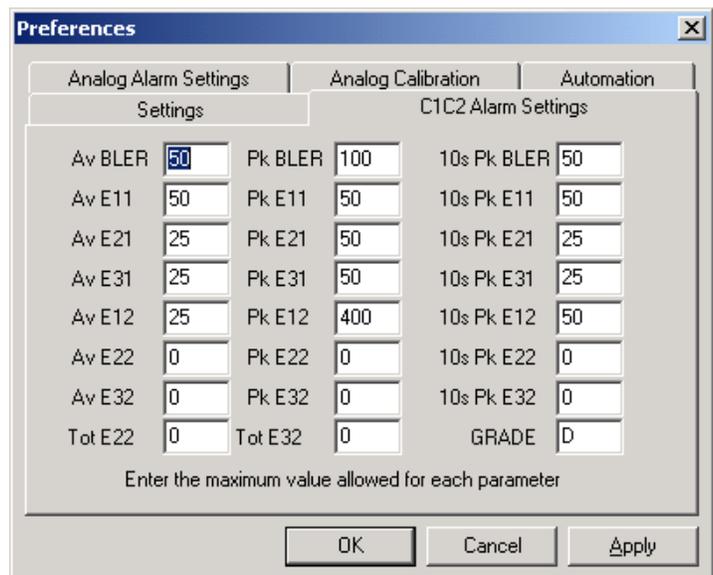


Figure 13 - Alarm Settings

To set these limits, select *Preferences* in the main menu. Now select the *Alarm Settings* tab. After making changes, press *Apply* or *OK*. The Alarm Settings are password protected to avoid inadvertent changes. Enter your password and click "OK". The default password is "Clover". The

password is case sensitive. This property sheet will allow you to enter values for each parameter. Average value limits can be entered with one decimal digit. Peak values, however, must be integers. Note that the value you enter is the maximum allowed, so that the value must be larger than this number to generate an alarm. All alarm settings are permanently saved when you click OK.

How Good is Good Enough?

Each user must decide what criteria to use for pass/fail. The higher the cost of failure, the more critical you want to be. Start with the factory defaults, then as you get more experience, you may wish to fine-tune the settings.

Changing the Alarm Settings Password

To change the password, first enter the current password, and then set the *Change* checkbox, and press “OK”. You will now be prompted to enter a new password. After pressing OK again, you will be prompted to confirm the new password. If the two entries match, the password will be changed to the new entry.

Note: The default password is “Clover”. The password is case sensitive, so you must type it exactly as shown (without the quotes). If you change the password, then forget what it is, you must call the factory for instructions to recover it.

MAKING CHARTS

There are two types of charts: Single Chart, and All Chart. The Single Chart displays any or all error types in one graph. The All Chart displays individual charts of each parameter for one player. On charts with multiple parameters, the individual traces will be color-coded. If you have a color printer, they will be printed in color.

Main Window Charts

The charts in the main window always display all error data. You can change the axes by double-clicking on the axis. This will open a dialog that allows you to change the axis. When Auto Set X-Axes is enabled in Preferences... then the X-axis will be set automatically according to the length of the disc. Each chart can be customized; see [Modifying the Charts](#) on pg. 30.

Single Charts

To graph one or more CIRC errors in a single chart, select *Chart* in the main menu, or the Chart button in the toolbar. A dialog box will appear which allows you to select which error types you wish to display. Check the boxes of the errors you want to display then click OK. To print the chart, select *File | Print* in the main menu or click the printer icon in the toolbar.

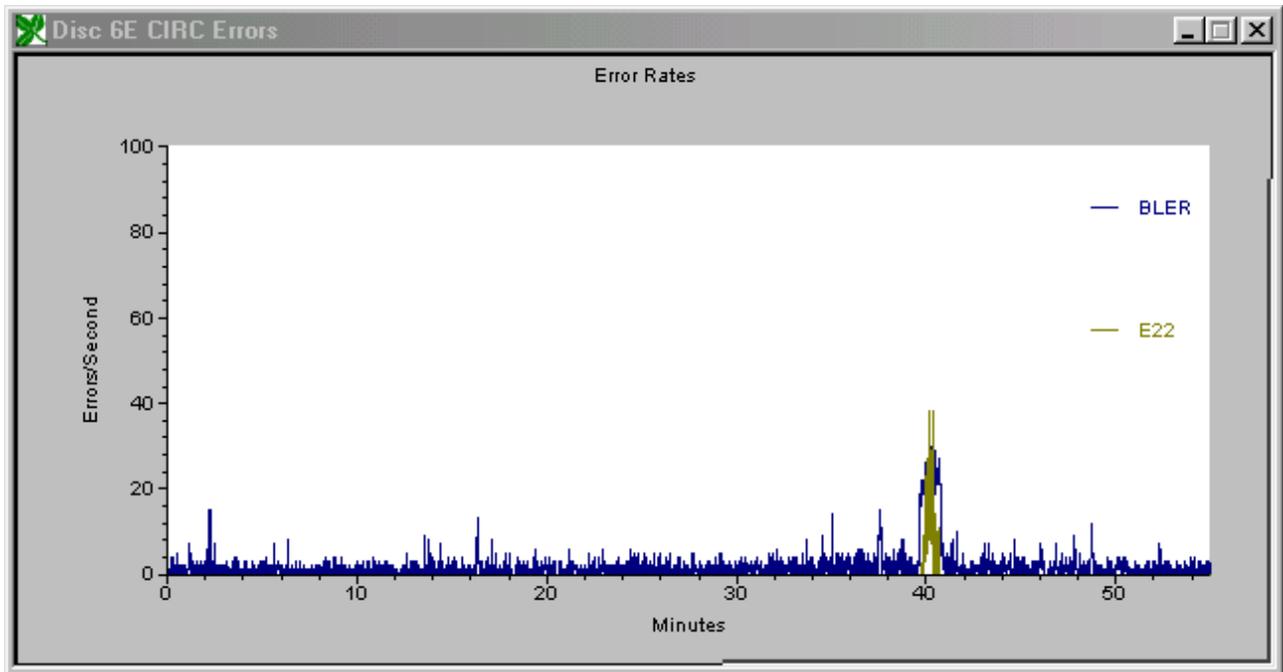


Figure 14 - Sample Single Chart

The Single Chart graphs have some useful features: You can modify both the horizontal and vertical axes to zoom in on detail. You can superimpose two or more error types to see how they are correlated. These charts can be sized, and printed at any size. All objects in the chart can be customized by double-clicking on the object. Double-clicking the line plot will open a dialog that allows you to change various line attributes, and also display the data in tabular form. The resulting data table can be copied and pasted to another application, such as a spreadsheet or database program.

Print All Charts

This menu selection prints a page of eight individual charts of each parameter, similar to that displayed in the main window. This group of charts allows you to print graphs of all results on one page of paper, plus it provides a means of printing all parameters at once with different vertical scales. The vertical and horizontal scale can be individually set for each chart by setting the charts in the main window. The printed charts will use the same settings as for the main window charts.

#	X	Y
7	0.12	1
8	0.13	2
9	0.15	0
10	0.17	0
11	0.18	0
12	0.2	0
13	0.22	2
14	0.23	0
15	0.25	1
16	0.27	0
17	0.28	1
18	0.3	0
19	0.32	2
20	0.33	0

Figure 15 - Data Table

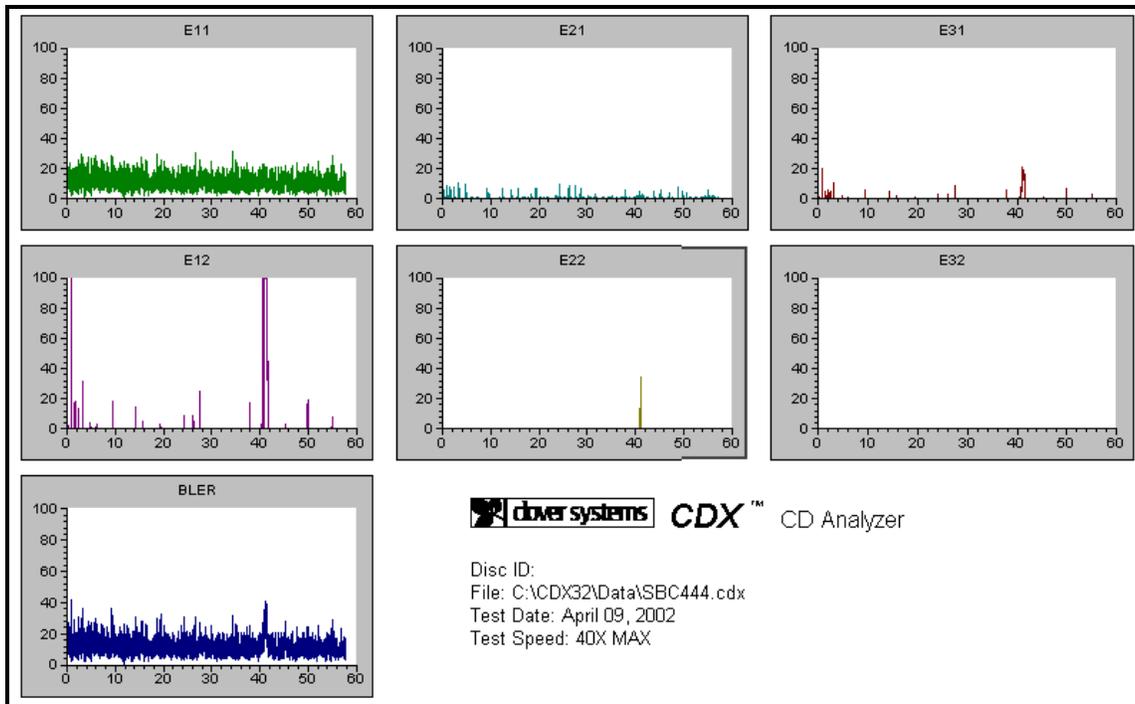


Figure 16 - Sample All Chart

Modifying the Charts

The graphs can be modified to suit your needs. You can change both the horizontal and vertical axes to fit the data. You can also change the line styles and colors, labels, and titles.

Changing the Axes

Double-click on the axis you want to modify. A dialog will appear that allows you to set both the minimum and maximum values for the range of that axis. You can also set the number of major and minor tick marks. If you make the range of the axis really large, be sure to adjust the space between tick marks accordingly. Otherwise you may generate an axis labeled with hundreds of tick marks! You can also apply grid lines to the chart with this dialog. The axis settings are saved for all charts, so that the next time you run CDX, it will start up with the axes set the way you left them.

Changing the Line Style & Color

Double-click on a data plot to open the “Plot Parameters” dialog. Selecting “Line Attributes” will allow you to adjust the color, style, and width of each data plot.

Other Chart Customization

All text, legends, background, etc. of the charts can be modified to fully customize your charts. Double-click on the object you wish to edit.

LOADING IN SAVED DATA

Test data that has been previously saved can be loaded back in to display and print. Select *File / Open* from the main menu. Enter the name of the file you want to load, or select from the list. The loaded data will overwrite any current data for that Drive. After loading a data file, you can make charts, print a summary, etc. just as if you had just completed the test.

You can also double-click on a CDX data file (with extension “.cdx”) to open it. If the CDX program is not already running, it will automatically start. When the CDX program is first run, it will set the file type “.cdx” to automatically open in the CDX program. However, if some other application has already set the “.cdx” file type to use a different application, the setting will NOT be changed. Therefore, if this feature does not work, you can use the *View / Folder Options...* menu and *File Types* tab in Windows Explorer to change the default application for file type “.cdx”.

The four “Most Recently Used” files will appear in the *File* menu. Selecting one of these will open the file.

VERIFYING DATA

Disc to Disc

Data Verification allows you to compare the data on a CD to another CD or a disc image on your hard disk. This is useful to make sure that you have recorded the correct thing, or to verify that the recording system is working correctly.

You can compare two discs, or compare a disc to an image file on your hard disk. To compare two discs, you must of course, have two CD-ROM drives installed. To compare two audio discs, both drives must be capable of audio extraction. Some CD-ROM drives will not read audio discs reliably (“reading” is not the same as “playing”). If you do not have two CD-ROM drives installed, you can compare a disc to a disc image on your hard disk, or use the [Clover Signature](#) feature described on page 32.

In the *Test / Verify Data...* dialog, select the drives you want to use. The Copy must be a CDX drive. Master can be any CD-ROM drive or an image file. All installed CD-ROM drives will appear in the drop-down list box.

Click START to start the test. You can abort the test at any time by clicking STOP in the Verify Data dialog. The current sector and number of bad bytes detected are displayed as the test progresses.

All sectors that fail to verify are listed in the window on the right. Double click on any sector in the list to view that sector’s data.

The verify test will begin and end at the START and STOP points entered in the main window. These default to the begin and end of the program area when you insert the disc, but you can change them to any values you wish, in either MSF format or physical sectors.

Disc to Image

If you choose Image as the Master, the program prompts you for a file to compare to. The default file extension is “.img.” As with Verify CD, you press START to start the comparison, and can abort by pressing STOP. The current sector and number of bad bytes are displayed.

Verify with Offset

Ordinarily, the verify test requires that the two discs are identical. However, there are some cases where there is an offset between the two discs. To accommodate this, you can enter a value in the “Copy Offset” edit box in the Verify dialog. The offset affects only the CDX drive (copy). The offset can be positive or negative. A positive offset means that the copy drive starts at a later sector, whereas a negative offset means that the copy drive starts at an earlier sector. The offset can be

entered in MSF format or physical sectors, depending on the setting of the “MSF” and “Sectors” radio buttons in the main view.

Disc copying programs do not always make an exact copy of a disc. They may change the mode, the starting point, or other factors that do not necessarily affect the data. In these cases, the master and copy will not be identical, and therefore will not verify. To pass this test, the copy must be identical to the master. If you wish to compare the data on such discs, you can use a file compare utility. There are many available for free on the internet, or use the DOS command “FC”. At the DOS prompt, type `fc /?` for instructions.

Verifying Audio Discs

CDX can do bit-for-bit comparison of two audio discs. The Master drive must also be capable of bit-accurate high-speed audio extraction for this to work. Most modern drives can do this, but not all. Many older drives will not work well. In addition, different models of drives read the data differently. Since audio discs have no sector headers, it is somewhat arbitrary as to where the data starts. The Table of Contents specifies the start of a track to 1/75th of a second, but not to the byte. Therefore, different drives will start at different places. CDX will automatically synchronize the two drives so the data is in sync. The offset (in bytes) is displayed. If the two drives cannot be synchronized, an error message is displayed. If you cannot get Disc to Disc verify to work, make a disc image, or use the Clover Signature feature.

CREATING OR VALIDATING A DISC SIGNATURE

Bit-for-bit verification between two discs confirms that the two discs are identical. CDX includes a way to validate a copy of a disc when you don’t have the original. This is accomplished by generating a “Clover Signature” based on the original disc data. This number is a 160-bit “Secure Hash Algorithm” that is guaranteed to be unique, based on the contents of the disc. Additionally, it is “secure” in that it is impossible to deduce the contents of the disc based on the number.

This scheme has many uses: You can verify that a disc is an exact duplicate of the original, without having the original. You can validate a disc or copy as authentic, and confirm that the contents have not been tampered with. A Clover Signature can be generated from the original disc, then e-mailed or otherwise transferred to anyone who needs to validate the disc or a copy. You can also use this feature instead of performing a Disc-to-Disc compare. Verifying the Clover Signature is also faster than comparing two discs.

To generate a Clover Signature, select *Test / Signature / Create* in the main menu. Press Start in the dialog box to start the process. You can abort the process by pressing Stop. After the data on the disc has been processed, the Clover Number will appear in the edit box. It is a 160-bit binary number, represented by 20 hex digits. The number will be saved with the test data if you select *File / Save* in the menu, or toolbar. You can also select the number using the mouse, and press Ctl-C to copy it to the clipboard. You can then paste it into another document to mail or save.

To validate a disc, select *Test / Signature / Validate* in the main menu. Type the Clover Signature into the edit box, or paste it from another document. If you have a .cdx test data file with the number saved, it will appear in the edit box after the data has been loaded. Now press Start to validate the disc.

The Signature Verify function can also be performed during the error test. When the Include Validate box in the Settings property page is checked, CDX will verify the data on the disc while performing the error test. The program will prompt you for a Clover Signature at the start of the

test. It will then attempt to validate this signature during the error test. The results (PASS or FAIL) will be displayed in the "Verify Errors" box in the main view, and also in the Summary view. In automation mode, you will only be prompted once for the Clover Signature at the beginning of the first test. Each subsequent disc will then be validated against this signature. If the validation fails, the disc will be rejected.

Validating Audio Discs

Audio discs do not have any sectors; they are a continuous stream of audio data. Since there are no sector headers with addresses, the only way for the drive can locate to a particular spot is by using the subcode. As there are no standards for locating on an audio discs, different models of drives will interpret the start of a track in different ways. Therefore, a signature made on one model drive may not match one made on a different model drive. To use this feature on audio discs, you must use the same model drive for creation and validation.

Clover Signature vs. MD5

Another data validation scheme known as MD5 is commonly used to verify files. The Clover Signature uses an algorithm devised by the National Institute of Standards and Technology, called SHA-1. SHA-1 is more secure and can accommodate larger files (up to 2^{64} bits) compared to MD5. MD5 produces a 128 bit result; SHA-1 produces a 160 bit result. Additionally, MD5 is not secure; with MD5, it is possible to change the data and still generate the same result.

FORMAT TESTS

ISO9660

Test | Check Format | ISO9660 will check the logical formatting of a CD-ROM disc. It checks the System Identifiers, Volume Identifiers, Directory Identifiers, and Path Tables for correct formatting and illegal characters.

Subcode Skew

Test | Check Format | Subcode starts the Subcode Skew test. The Q-channel subcode on a disc contains time code, called Atime (short for Absolute Time), which is used for rapid locating of specific places. This time code should be identical to the sector address contained in the sector header of a data disc. Any discrepancy between these two values is called Subcode Skew. This type of error can be caused by the recording system. Skew up to ± 7 sectors is allowed, but any skew will adversely affect search times. Positive skew means that Atime is higher than the header address. Negative skew means the Atime is less than the header address.

Post Gap

Test | Check Format | Postgap starts the Postgap test. The last track on a disc must be followed by a Postgap. The Postgap contains all zeros (or digital silence). A minimum of 150 sectors is required.

DISPLAYING DISC DATA

View | Data | Disc displays sector data on a disc. The current LBA (Logical Block Address) is displayed. You can type a new LBA into the edit box, or use the PREV and NEXT buttons to select a different sector. Press ENTER after typing a new LBA. Use the scroll bar to scroll through the



data. All 2352 bytes in a sector are displayed in hexadecimal on the left side, and as ASCII text on the right side of the window. You can print the sector data by pressing *File | Print* in the main menu, or using the print icon in the toolbar.

Audio discs do not have sectors, so this window displays the section of the data stream corresponding to an Atime frame. In this case, the logical block number you enter is the frame number from the beginning of the first track.

Data disc sector data is displayed as “raw” data; that is, with the sector header and parity bytes included. The first 12 bytes of every sector are a SYNC pattern that is used to locate the start of the header. It is identical on every sector header, and consists of zero, followed by 10 FF hex bytes, followed by zero. The next four bytes are the sector header. This consists of 3 bytes of address, and one mode byte. The address bytes are encoded in MSF format: Minutes, Seconds, and Frames. Note that these bytes are encoded as Binary Coded Decimal, not binary. In this example, the header address is 0 minutes, 2 seconds, 16 frames, which is logical block 16.

The mode byte can be 0, 1, or 2, and determines the size of the user data:

Mode 0: 2048 user data bytes which are all zero, + 288 auxiliary bytes which are all zero.

Mode 1: 2048 bytes user data, plus 288 bytes EDC and ECC error correction code. This is the ordinary CD-ROM mode, which provides error detection and correction beyond the CIRC error correction.

Mode 2: 2336 bytes user data; no EDC or ECC code. Typically used for multi-media; has increased user data, but no additional error correction.

Please note that the sector number you enter in the View Data window is a **Logical Block Address (LBA)**³, whereas the sector numbers displayed in the Table of Contents (Disc Info) and Start and Stop in the main window, are **Physical Sector Addresses**. The numbering of physical sector addresses starts at the beginning of the program area, whereas the Logical Block Address starts at the beginning of the user data area. The difference is due to the length of the Pre Gap. To convert a physical address to a logical address, subtract the value shown in the Start box in the main window (should be 150). So, the first sector of user data is typically physical sector 150, which would be logical block address 0.

On CD-ROM's, the first 16 sectors (0-15) are reserved for system use, so the volume descriptor is at Logical Block Address 16, which would be physical sector 166.

³ See “Logical Blocks and Sectors” on pg. 17

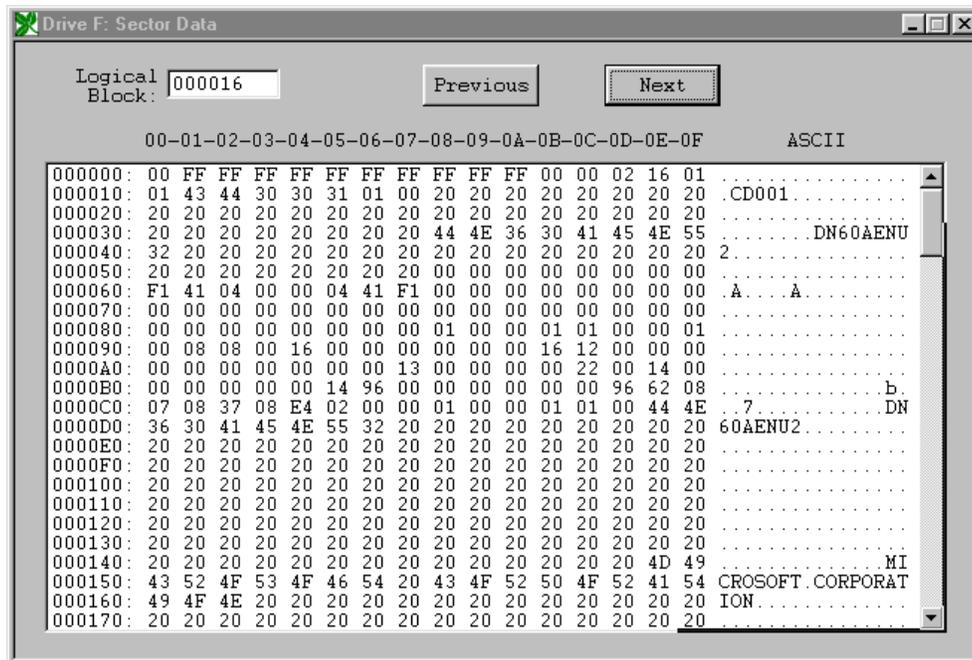


Figure 17 - Sector Data on Disc

View Data / File displays sector data in an image file on your hard disk. It works the same way as described above, except that you select an image file to read from. Image files are saved with all sync, sector header, and parity bytes, so they look the same as on the disc.

CREATING A DISC IMAGE

File / Create Image in the main menu prompts for a file name. The default extension is “.iso”, but you can use other file extensions if you wish.

Click **START** to start saving the file. You can abort the operation by pressing **CANCEL**. The disc is read at the speed set in the *Preferences | Drive Settings* menu, so setting the speed to maximum will speed up the operation.

The disc image files preserve all sector header and error correction bytes, not just the user data.

PRINTING

All CDX windows can be printed. Select the view you want to print, and then *File | Print* or *File | Print Preview*. Or click on the printer icon in the toolbar. Whichever window is currently active is the one that will be printed. For example:

Printing a Summary

You can print a summary of the test results on the printer by selecting *View | Summary*, then *File | Print*. The printed summary consists of the results of all tests that were performed. The same information displayed in the main window (peak and average values for each error type, plus total E22, and total E32 errors) as well as the current date and time, and the filename. If you want the summary printout to have a filename, which can be used to identify the disc, you must save the data first. If you print the summary before saving the data, there will of course be no filename. Any parameters which exceeded the Alarm Limits will be printed in red.

You can also print the main window on the printer, which provides a graphic summary. Just select the main view, and then select *File | Print* in the main menu.

Figure 18 - Sample Summary Printout



CDX v2.3

Summary of Results

Page No. 1

Date: January 16, 2007

File: Z:\CDXv2_1\CDX Data\Test1.cdx

Disc ID:

Disc Type: CD-DA

Test Speed: 4X

Sessions: 1

Tracks: 24

Total Disc Length: 59:40:18

Record Mode: Unknown

Test Date: January 15, 2007 16:08

UPC/EAN: 0042281412523

Format: Audio

Sector Size: 2352

CIRC Test Results:

Av BLER = 12.9	Pk BLER = 47	10Pk BLER = 38
Av E11 = 12.1	Pk E11 = 33	10Pk E11 = 20
Av E21 = 0.3	Pk E21 = 20	10Pk E21 = 6
Av E31 = 0.5	Pk E31 = 26	10Pk E31 = 21
Av E12 = 5.6	Pk E12 = 344	10Pk E12 = 327
Av E22 = 0.3	Pk E22 = 87	10Pk E22 = 44
Av E32 = 0.0	Pk E32 = 13	10Pk E32 = 2
Tot E22 = 1126	Tot E32 = 16	
Grade = D		

Analog Test Results:

Min. Ref = 68.8%	Ave. Ref = 71.1%	Max. Ref = 73.2%
Min. I11 = 0.62	Ave. I11 = 0.62	Max. I11 = 0.62
Min. I3 = 0.33	Ave. I3 = 0.39	Max. I3 = 0.50
Min. Beta = 7.0%	Ave. Beta = 8.2%	Max. Beta = 10.1%

CIRC Test * FAILED *****

- 10Pk E12 Over Limit
- Av E22 Over Limit
- Pk E22 Over Limit
- 10Pk E22 Over Limit
- Pk E32 Over Limit
- 10Pk E32 Over Limit
- Tot E22 Over Limit
- Tot E32 Over Limit

Analog Test *** PASSED ***

Data Verification Results: Not Performed

ISO9660 Format Results: Not Performed

Printing the Charts

Display the chart you wish to print, then select *File | Print* in the main menu.

A dialog box allows you to set the size and location on the paper of the chart. Please note that if you select “Actual Size” for the chart, the size of the printed chart will be dependent on the size of the window on your desktop. In this case, the chart will be printed at the size and shape it appears on the monitor.

You can also print all the charts on one page of paper using the *Chart | Print All Charts* item in the main menu. This command will print all the charts on one page, with date, Disc ID, Filename, and test speed. It will print in landscape mode and fill the page. The chart axes used will be the same as set in the main window.

CONTROLLING THE DRIVE

The CDX works just like an ordinary CD-ROM drive. Place the disc in the loading tray label side up. Use the EJECT button on the right side of the front panel to open and close the tray. You can also play audio discs using the >/>> button on the front panel, or Microsoft CD Player, which comes with Windows. CDX is supplied with Roxio CD Creator, which can be installed from the included CD.

USING THE AUTOLOADER

Provisions have been made to enable automation of disc testing. An optional disc loader can be interfaced to the CDX, and controlled by the software. One or two CDX's can be installed in the Autoloader, and operate simultaneously.

In Automation mode, no user intervention is required. This feature can be enabled or disabled using the *Automation* property page in the *Preferences* menu. To enable Automation, check the Enable Automation box and select OK. When the test is completed, the data is automatically saved to a binary file using an automatically generated file name of the form xxxxxx.cdx, where xxxxxx are unique letters and numbers generated by the operating system.

A summary of results is always appended to the spreadsheet CDTests.xls and CDTests.txt when in Automation mode. Discs that do not pass the PASS/FAIL criteria are unloaded to a separate bin from the good discs.

Installation

Connect a monitor, keyboard, mouse, and printer to the system. Monitor and printer are not included with the system, and must be user-supplied. You can also connect the system to a network, using the built-in Ethernet connection. All software is already factory installed, and the system has been calibrated.

Setup

For Automation Settings, see [Automation Mode](#) on pg. 20.

Loading the discs

Load the discs to be tested into bins 1 and 2. Initially, discs will be loaded into the CDX from bin 1, and output to the output bin. When bin 1 runs out, discs will be loaded from bin 2, and output to bin 1. In this way, you can test up to 250 discs unattended.



Starting the test

To run CDX in fully automatic mode, select *Preferences...* from the main menu. In the *Options* property sheet, check the Automation checkbox.

To start the testing, select Test | Error Test in the main menu, or place a disc in the CDX tray, and close the tray, or press START to start the test.

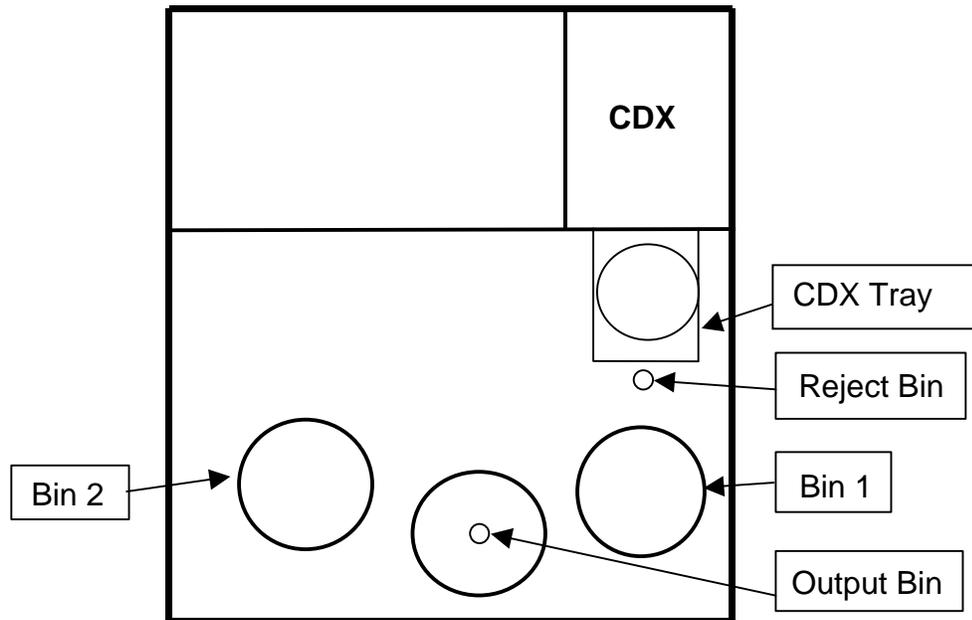


Figure 19 – AutoLoader Layout

MEASURING PIT GEOMETRY – THE KEY TO INTERCHANGABILITY

Unfortunately, error rates do not tell the whole story of disc quality. Measuring error rates is useful because any serious problems will be reflected in higher error rates, and it is easy to do. But when it becomes necessary to establish the cause of high error rates, or compatibility with different players, you must look at the pit geometry.

The primary goal of disc quality is to make sure that a disc will work in every drive, every time. The key to making this happen is proper pit geometry.

In order to play the disc, the player must follow the track and stay in focus as the disc turns and wobbles up and down. This is accomplished using servo signals that are derived from the way the laser beam bounces back from the disc. Generation of the proper servo signals is wholly dependent on the size and shape of the pits.

There are specifications for pit length, depth, and width, but you would need an electron or atomic force microscope to measure them! Pit geometry can be measured indirectly by looking at signals like I_{11} , I_3 , push-pull, and asymmetry.

Disc performance can only be measured by playing the disc. Unfortunately, when you measure discs by playing them back, you are measuring the performance of the player as well as the disc! As a result, it is quite possible for discs that measure good to have problems playing on certain players. Similarly, discs that measure badly may work fine on other players, and even measure differently on other analyzers. Different players are variously sensitive to different parameters such as asymmetry and tracking.

If a disc is found that won't play or gives poor results, yet plays on another player OK, there is almost certainly something wrong with that disc. Compatibility with all players can best be assured by making sure that the pit geometry is close to optimum.

Pit geometry can be measured by looking at the HF signal coming from the pickup (also see [INTERPRETING THE RESULTS](#) Pg. 47).

Analog Measurement Module

The Analog Measurement Module is an optional tool to make signal measurements related to pit geometry. The AMM helps evaluate disc quality by automatically measuring parameters such as reflectivity, I_3 / I_{top} , I_{11} / I_{top} , and asymmetry / beta and displaying the data in the CDX software. Together with analyzing playback errors, this information provides a thorough analysis of disc quality.

The AMM connects to the HF output of the CDX I/O panel with a coaxial BNC cable, and uses a USB port to communicate with the PC. The CDX software automatically gathers data from the AMM and displays the data as statistics and easy to read charts. Summary of the data, along with the charts can be printed and/or saved to disk for future use.

Setting Analog Alarms

Under the Analog Alarms tab of the *Preferences* menu you will be able to set the individual alarms for each analog parameter.

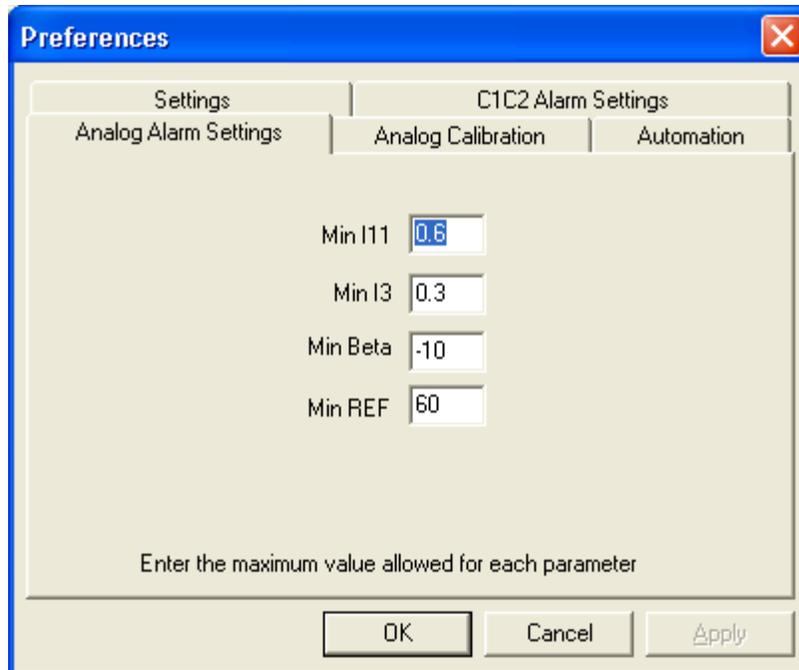


Figure 20 – Analog Alarms Setting

Analog Calibration

Your CDX analog measurements have been calibrated at the factory, using a Philips Test CD BH-1 and 5B.3. If you purchased CDX with a PC or AutoLoader, the calibration constants have already been entered into the software, and you needn't do anything further. If you are installing CDX in your own PC, you will need to enter the calibration constants into the software.

The required numbers are written on the CDX Final Test sheet that is included in the back of this manual. Select *Preferences...* from the main menu, and select the *Analog Calibration* tab. Enter the values from the test form in the corresponding edit boxes, then press OK (see figure below).

The default password is “Clover”. The password is case sensitive.

Because the results can be affected by the PC (power supply voltage, etc.), it may be necessary to re-calibrate your AMM. This can be accomplished using the test discs provided. The correct values for all parameters are printed in the back of this manual, so you can calibrate the system by testing these discs and adjusting the offset in the Analog Calibration property sheet. It is not necessary to adjust the gain settings.

You can also calibrate the system using test discs available from Philips or others. Philips test discs are available directly from Philips at <http://www.licensing.philips.com/>. If you have discs calibrated to some other standard such as Datarius, AudioDev, etc. you can use these discs as well.

It is best to use test discs with more than one measurement value, so that you know that the results are accurate over a wide range. Philips test discs supply several values over a wide range. These are the discs used for factory calibration.

If you have discs with multiple known values, you can set the gain of each parameter by comparing the difference of the measured values to the difference of the known values. For instance, if you

have two discs with known values for Beta, such as +10 and -3, and your measured results show +8 and -2, you can then change the Beta gain by a factor $(10 + 3) / (8 + 2) = 1.3$. In this example, you would multiply the current Beta gain by 1.3 to obtain the new gain setting.

After setting the gain, you can adjust the offset. If the new gain setting produces results of +13 and 0, then you must subtract 3 from the current offset setting.

NOTE – Please note that analog measurements are very sensitive, and differences of only a fraction of a percent are noticeable.

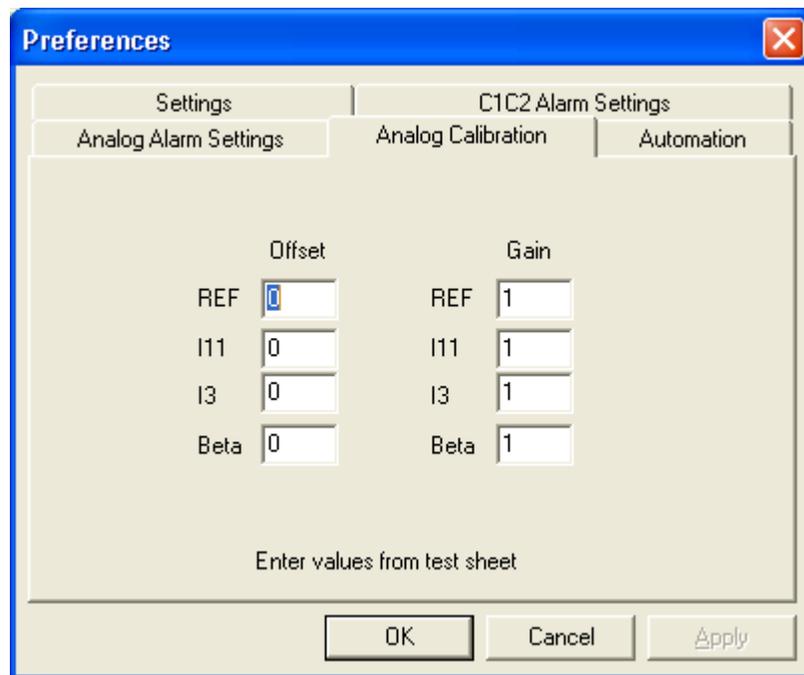


Figure 21 – Analog Calibration

Making Analog Measurements with the Analog Measurement Module

When the Analog Measurement Module is plugged in, you will have the option to select Analog as one of the test options. This test can be done simultaneously with error checking, so if Analog is checked, the analog parameters will be tested while the test is running.

NOTE - Measuring analog parameters must be done at constant linear velocity. The fastest speed that the drive will play CLV is 4x. Therefore, the analog tests are limited to those speeds.

The test speed will automatically be set to the appropriate CLV speed when the test starts, and returned to the default speed when finished, so there is no need to set the speed.

You can view the analog test results by selecting the Analog button in the toolbar.

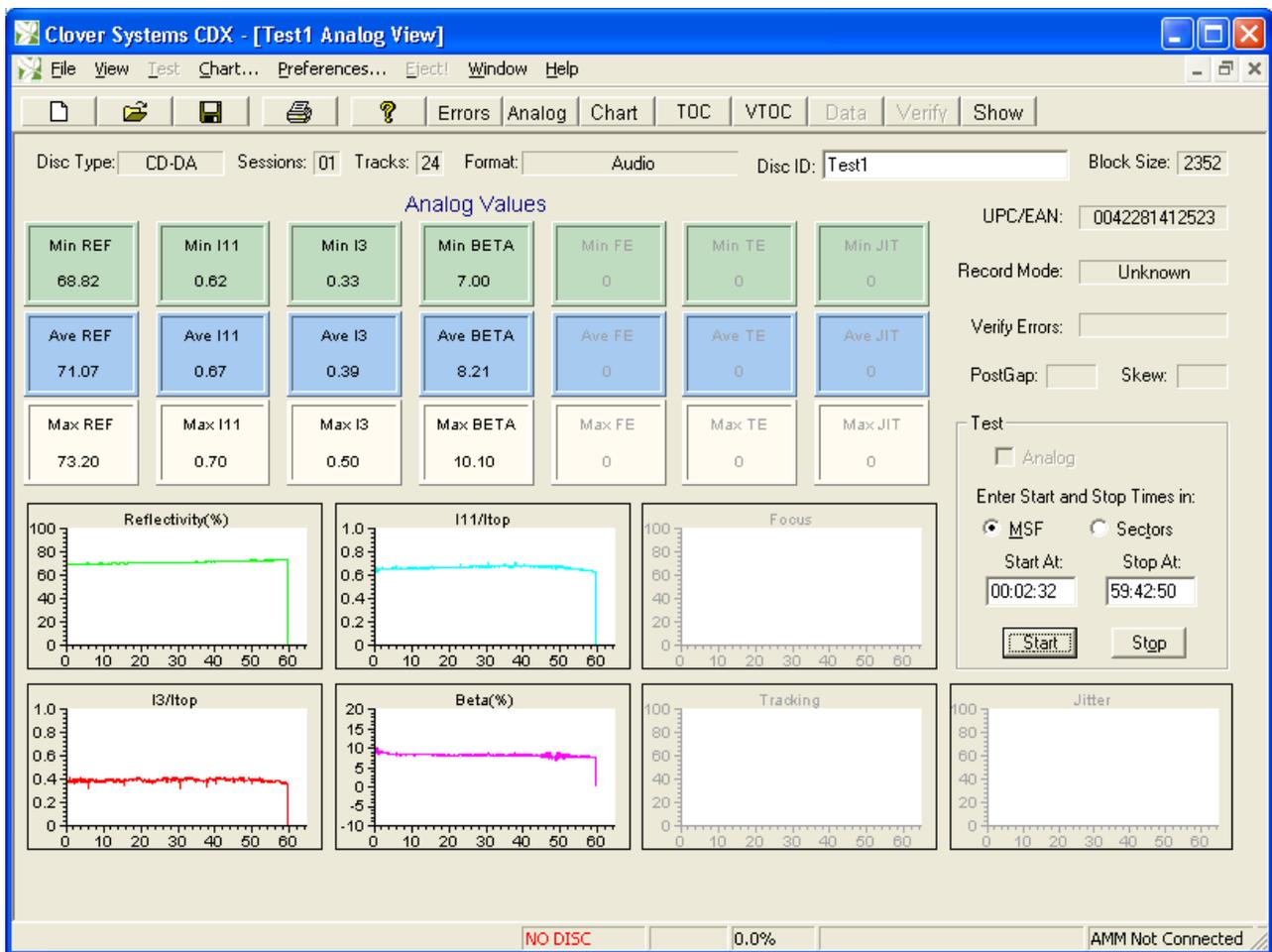


Figure 22 - Analog View with AMM

Components of the HF Signal

The HF (High Frequency) signal coming from the pickup represents the light intensity of the beam reflected back from the disc surface. A higher voltage represents greater light intensity, and a lower voltage represents less light. The signal is rapidly changing between light and dark as the beam passes over the pits. When the beam is over a pit, the light intensity is reduced. When the beam is between pits (over “land”), the light intensity is higher. Data is encoded in the transitions between pits and lands.

The eight-to-fourteen (EFM) modulation scheme used produces just nine different possible lengths of pits and lands. Therefore, the resulting HF consists of square waves of nine different durations. The signal appears sinusoidal on the ‘scope because of the limited frequency response of the optics. The “eye pattern” displayed on the oscilloscope is a superposition of many sweeps, each consisting of up to nine different lengths. Each of the nine pit/land lengths are exact multiples of one fundamental length, called 1T. The nine possible lengths of pits and lands are 3T, 4T, 5T, 6T, 7T, 8T, 9T, 10T, and 11T. The waveforms generated by these pits & lands are called I3, I4, I5, I6, I7, I8, I9, I10, and I11 respectively. I3 represents the shortest pit / land, and I11 represents the longest pit or land. Generally, we only need to look and the longest and shortest pits to get a good picture of pit geometry.

Using The Oscilloscope

Pit geometry measurements can also be made using an oscilloscope if you do not have the Analog Measurement Module.

Setting up the Oscilloscope

Any oscilloscope will work for making HF measurements. An analog scope is best, because you don't see and "eye pattern" on a digital 'scope. The HF signal only requires a bandwidth of about 5 MHz.

Connect the CDX rear panel BNC connector to the oscilloscope with a BNC to BNC cable. Set the input coupling of the channel you are connected to DC. Set the vertical sensitivity to 0.5 volts per division. Set the horizontal sweep speed to $0.5\mu\text{S}$ per division. Set the trigger source to be the input channel you are connected to. With the CDX playing at 1X speed, adjust the trigger level to get the clearest image.

Measuring I_{top}

I_{top} (see fig. 13) is the maximum light intensity reflected from the disc. Therefore, it is related to the laser power and disc reflectivity. In order to make signal measurements that are independent of laser power and reflectivity, I_{11} and I_3 measurements are generally expressed as a fraction of I_{top} . A_{top} in the picture on page 45 is the same as what we are calling I_{top} .

Measure the voltage of the top of the HF eye pattern relative to zero volts. Make sure you are measuring relative to zero volts rather than the level it is at when not playing. The HF output not be at exactly zero volts when not playing.

Measuring I_{11}

I_{11} is the largest component in the HF eye pattern. Measure the peak-to-peak value of the pattern (A_{11} in the picture), and divide by I_{top} . Example: $I_{\text{top}} = 3 \text{ v}$, $A_{11} = 2 \text{ v p-p}$, $I_{11} = A_{11}/I_{\text{top}} = 0.66$. The minimum allowed I_{11} value is 0.60.

Measuring I_3

I_3 is the smallest component in the HF eye pattern. If there is high asymmetry on the disc, it may be a little difficult to pick out. Measure the peak-to-peak voltage of this component (A_3 in the picture) and divide by I_{top} . Example: $I_{\text{top}} = 3 \text{ v}$, $A_3 = 1 \text{ v p-p}$, $I_3 = A_3/I_{\text{top}} = 0.33$. The smallest allowed value for I_3 is 0.30.

NOTE - All pit geometry measurements using the oscilloscope must be made at 1X speed.

Measuring Asymmetry

Asymmetry is a measure of the ratio of pit to "land" (the space between the pits) in the track. The EFM modulation scheme causes the total amount of pit to be the same as the total amount of land. However, mastering and molding (or "burning") considerations can cause them to become unequal. For instance, overexposure of the pits during mastering causes them to be longer than normal, causing some negative asymmetry. Generally, some overexposure is desirable because it increases the signal-to-noise ratio and pit wall steepness.

The formula for measuring the asymmetry according to Figure 1 is



$$\left(\frac{A_D}{A_{11}} - \frac{1}{2} \right) \cdot 100 = \text{Percent asymmetry}$$

AD is measured from the bottom of the HF eye pattern to the “center” of the eye pattern. This point is where the rising and falling edges cross, approximately in the center of the I3 waveform. The maximum allowed asymmetry is -15% to +5%. -5% to -10% is considered optimum.

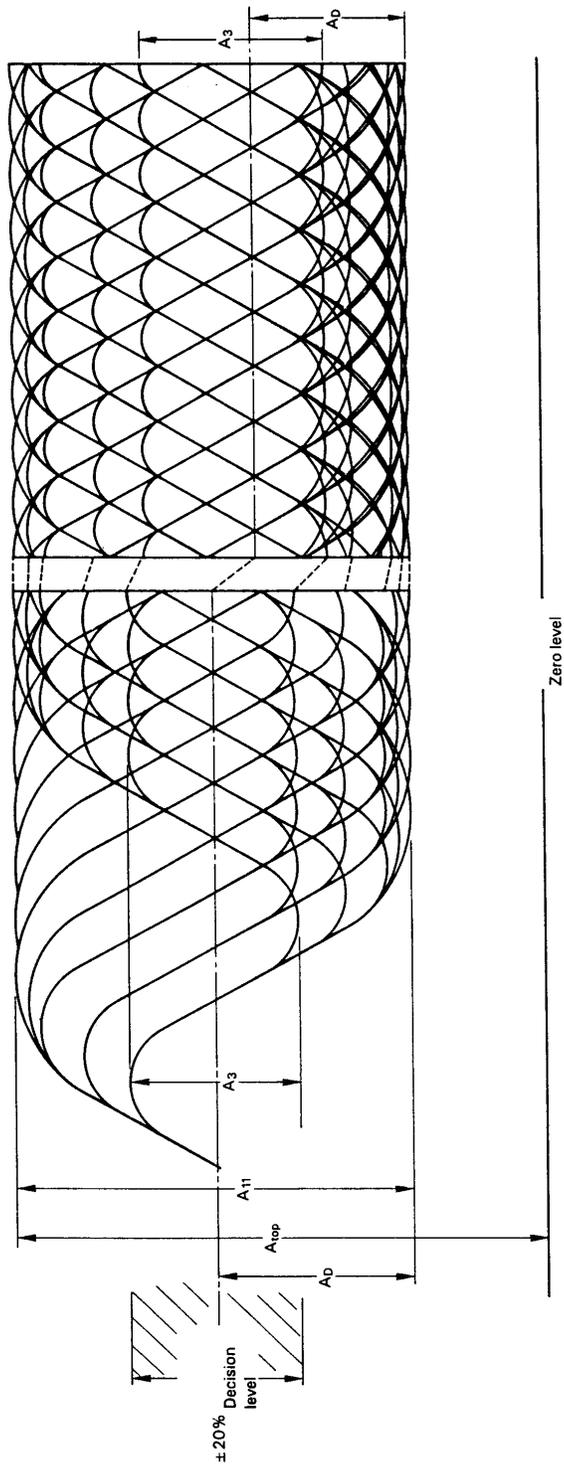


Figure 23 - HF Eye Pattern

Measuring Beta

Beta is a measurement similar to Asymmetry that is easier to make. Also, since beta is directly related to the writing power in a CD-R writer, this measurement is used by CD writers to optimize their writing power.

Unlike the other measurements, the 'scope must be set to AC coupling for this measurement. Now when observing the HF eye pattern, it will center itself around 0 volts. If we call A1 the distance that the waveform reaches above 0 volts, and A2 the distance that the waveform extends below 0 volts, then

$$\beta = \frac{A_1 + A_2}{A_{11}}$$

Where A11 is the peak-to-peak value of the waveform as shown in Fig. 10. Note that since A2 is a negative number, the result can be positive or negative. The range of allowable β is 0 to +8% (0 - 0.08) with an optimum value of +4%. Since CD writers try to set the laser power to produce +4% beta, the results of this test can reveal an inability of the writer to optimize the laser power, due to malfunction or incompatible media.

Measuring Jitter

You can get an idea of the amount of jitter on a disc by measuring the horizontal width of the transitions in the eye pattern. This is normally expressed in nanoseconds. Jitter of ± 115 ns will cause errors. Keep in mind that the oscilloscope measurement will give you (approximately) a peak-to-peak measurement, whereas jitter is normally expressed as one standard deviation. You can also connect the HF output to a jitter analyzer designed to accept an HF input.

Measuring Reflectivity

Since Itop is proportional to the disc's reflectivity, you can measure the reflectivity of a disc by comparing Itop with that of a reference disc of known reflectivity. On CD-Recordable discs, Itop will measure a little lower than it's true value, since the pre-groove will diffract the light and reduce the true intensity. That is, the reflectivity along the track on a CD-R is lower than between the tracks. The minimum allowable reflectivity is 65%.

INTERPRETING THE RESULTS

INTERPRETING ERROR RATES

Any serious disc defects will cause an increase in the error rates. Therefore, measuring the number and severity of errors gives a good indication of disc quality. High error rates are generally caused by local physical defects or poor pit geometry.

Although in some sense any disc that plays without uncorrectable errors is “perfect,” there are other considerations. For one thing, we may wish to know how close is it to getting uncorrectable errors. Obviously, a disc with very low error rates has more tolerance for dirt, scratches, and aging before it will produce an uncorrectable error. Other discs, although they may not produce uncorrectable errors, may be on the verge of doing so. In addition, older first generation players may produce many uncorrectable errors on such a disc because they use a less effective error correction algorithm than newer players do. Because the time code used to search to a location does not have CIRC error correction, CD-ROM access times can rise dramatically with error rates, even though the data is fully recoverable.

A CD could not work without a highly effective error detection and correction scheme. Because the pits on the CD are so small, it is impossible to read the disc without errors. Keep in mind that the width of the pits is less than the wavelength of light used to read them! Therefore, it is the error detection and correction codes that really make the CD feasible. The error detection and correction code used on CD's is known as Cross Interleave Reed-Solomon Code (CIRC).

How CIRC Error Correction Works

This scheme uses two principles to achieve a remarkable ability to detect and correct errors. The first is redundancy. This means that extra information is added, which gives you an extra chance to read it. For instance, if all data were recorded twice, you would have twice as good a chance of recovering the correct data. The CIRC has a redundancy of about 25%; that is, it adds about 25% additional data. This extra data is not just a repeat of the data, but is cleverly used to record information about the original data, which provides the ability to deduce what the missing information must have been.

The other principle used is interleaving. This means that the data is distributed over a relatively large physical area. If the data were recorded sequentially, a small defect could easily wipe out an entire word. With CIRC, the bits are interleaved before recording, and de-interleaved on playback. What happens is that the bits of individual words are mixed up and distributed over many words. Now, to completely obliterate a single byte, you have to wipe out a large area. Using this scheme, local defects destroy only small parts of many words, and there is always enough left of each sample to reconstruct it. To completely wipe out a data block would require a hole in the disc of about 2 mm in diameter.

The CIRC error correction used in CD players uses two stages of error correction called C1 and C2, with de-interleaving of the data between the stages. The error correction chip in this unit can correct two bad symbols per block in the first stage and up to four bad symbols per block in the second stage.



Types of Errors

Therefore, the error type E11 means one bad symbol was corrected in the C1 stage. E21 means two bad symbols were corrected in the C1 stage. E31 means that there were three or more bad symbols at the C1 stage. This block is uncorrectable at the C1 stage, and is passed to the C2 stage. Because of the de-interleaving of the data between the stages, those three (or more) bad symbols are now in separate blocks, and so can be corrected by the C2 stage. Because of the interleaving, one uncorrectable symbol at the C1 stage can be turned into as much as 28 bad symbols at the C2 stage. This is why E12 is typically much larger than E31.

E12 means one bad symbol was corrected in the C2 stage and E22 means two bad symbols were corrected in the C2 stage. E32 means that there were three or more bad symbols in one block at the C2 stage, and therefore this error is not correctable.

BLER (Block Error Rate) is defined as the number of data blocks per second that contain detectable errors, at the input of the C1 decoder. This is the most general measurement of the quality of a disc. The “Red Book” specification (IEC 908) calls for a maximum BLER of 220 per second averaged over ten seconds. Discs with higher BLER are likely to produce uncorrectable errors. Nowadays, the best discs have average BLER below 10. A low BLER shows that the system as a whole is performing well, and the pit geometry is good.

However, BLER only tells you how many errors were generated per second, it doesn't tell you anything about the severity of those errors. Therefore, it is important to look at all the different *types* of errors generated. Just because a disc has a low BLER, doesn't mean the disc is good. For instance, it is quite possible for a disc to have a low BLER, but have many uncorrectable errors due to local defects. The smaller errors that are correctable in the C1 decoder are considered random errors. Larger errors like E22 and E32 are considered burst errors and are generally caused by local defects. As you might imagine, the sequence E11, E21, E31, E12, E22, E32 represents errors of increasing severity.

Why E32 is Considered Uncorrectable

Although it is possible under some circumstances to correct up to four bad symbols at the second stage, not all players can do this. Until recently, most players could only correct two bad symbols at the C2 stage. For these players, E32 would be uncorrectable. In order to have a high probability of a disc working in any drive, we consider E32 an uncorrectable error, even though some drives may be able to correct it.

This is also the rationale for not allowing E22 or E32 errors on a CD-ROM. The earliest generation of CD players could only correct one bad symbol at the C2 stage. As a result, an E22 error (two bad symbols at the second stage) would be uncorrectable on these drives. In order to have the highest confidence in a data disc, it should have no E22 or E32 errors. Also, keep in mind that this requirement is for new discs, as made. Obviously, the quality will degrade with use and age. Making discs with E22 or E32 errors does not leave adequate margin for future degradation. This is not an onerous requirement, because with modern equipment, there is no reason to make discs with E22 or E32 errors.

Summary of Error Names

For CD's, each count of:

E11 means there was one bad byte in a data frame at the C1 stage, which was corrected.

E21 means there were two bad bytes in a data frame at the C1 stage, which were corrected.

E31 means there was three or more bad bytes in a data frame at the C1 stage, which were not corrected.

E12 means there was one bad byte in a data frame at the C2 stage, which was corrected.

E22 means there were two bad bytes in a data frame at the C2 stage, which were corrected.

E32 means there were three or more bad bytes in a data frame at the C2 stage, which were not corrected.

BLER is the total number of errors encountered at the C1 stage (=E11 + E21 + E31)

AVE values displayed are the averages over the whole of the disc that has been tested.

PK values displayed are the largest one-second samples encountered over the whole of the disc that has been tested.

10PK values are the largest 10-second samples encountered over the whole of the disc that has been tested.

CD Errors are reported for each one second of program time. Since there are 7350 data frames per second, the maximum number of errors per second is 7350.

Errors Are Not 'Things'

Please remember that an error on a disc is not a physical thing. It is a manifestation of how well the total system (disc + player) is working. The disc itself does not have an error rate; *playing* the disc *produces* errors.

Ideally, what you want is a disc that will play back on ALL players with a low error rate. Unfortunately, there are no standards for players, only for the discs. Therefore, each type of player will give different results.

How to Interpret the Error Charts

The charts on page 30 show an example of a disc that has low overall error rates, but with a localized defect. This is a good example of why BLER by itself is not a good indicator of disc quality. The average BLER on this disc was only 1.5, with a peak of 30, but there were 541 E22 errors at around 41 minutes. Here's an example of a disc that is defective throughout, not just at one location:

E11 errors are the smallest errors, and are essentially random. High E11 error rates can be caused by excessive jitter, or low signal-to noise ratio. E21 errors represent slightly larger defects like dust or small scratches. E31 are again larger defects that cannot be corrected at the first stage of error correction (C1), and are de-interleaved and passed to the second stage (C2). De-interleaving of the data turns one E31 error burst into as many smaller errors. Each E31 error can produce as many as 28 E12 errors. It is not possible to predict how many E12 errors will be generated for each E31



error unless you know the exact location of the bad bits. This de-interleaving explains why E12 peaks can reach many times higher than the other errors.

E22 and E32 errors are caused by fairly large defects, or mis-tracking.

INTERPRETING HF SIGNALS

I₁₁

This is a measure of overall signal strength. Too small of a signal makes it difficult to decode. I₁₁ is primarily affected by pit depth and width. As a rule, bigger I₁₁ is better, and will generally produce lower error rates. Optimum I₁₁ is about 0.67 on molded discs.

I₃

Represents the shortest pits and lands, and is the highest frequency part of the signal. I₃ is always smaller than I₁₁ because the smallest pits are at the limit of resolution of the optics. Pits that are too small can cause low I₃. Lower writing speed (higher capacity discs) will make the pits shorter, and I₃ lower. Again, larger I₃ is better, up to a point. Minimum allowed is 0.30, and maximum is 0.60.

Asym & Beta

Asymmetry and Beta are two different ways of measuring the same thing. They are a measure of the relative amount of pit and land. Zero asymmetry (or beta) means that the amount of land is the same as the amount of pit. Then they are not the same, this causes distortion of the signal that makes it hard to decode.

Although they measure the same thing, Asymmetry and Beta have opposite signs. So negative asymmetry is the same as positive beta. CDX with AMM-1 measures Beta, so we use that convention.

This measurement is useful because it is a function of the writing power of the laser during glass mastering (or writing a CD-R). Higher laser power produces more positive beta. Some positive beta is desirable, with optimum of +5% to +10%. The maximum allowed is -5% to +15% for molded discs, and -10% to +15% for CD-R. Beta must not vary by more than 2% over the disc. CD-Recordable discs with low I₃ and negative beta are often found to give unreliable results.

Reflectivity

Reflectivity is a function of the metal reflective layer, and on recordable discs, the absorption of the dye layer that is the active recording medium. The reflectivity of aluminum is about 80%, so this is usually the maximum possible. Some light is absorbed by the plastic substrate, so typical values for good molded discs are around 75%. Reflectivity of CD-R discs is usually lower, and the minimum allowed is 65%. Low reflectivity is a common problem with CD-R, which causes lower signal strength, making the signal harder to decode.

CDX QUALIFICATION DISCS

IMPORTANT: Do not lose these discs! They allow you to determine if your CDX is working properly.

Supplied with your unit are two discs: A “good” disc, and a disc with known defects. Both discs are provided with measured results from your CDX before it left the factory. To confirm that your system is operating properly, test both discs and compare the results with the results we have provided. If the results are significantly different, there may be a problem with the system. Obviously, dirt, dust, and scratches will affect your results, so you should be careful to avoid damaging these discs. The factory results for Disc 4B are at 1X speed, and the Setup & Qualification Disc is tested at 40X.

The Setup & Qualification Disc is an ordinary CD-R disc that is known to have very low error rates. Playing this disc will confirm that the unit is capable of generating low error rates. Many subtle problems with the player can be detected using this disc.

The other disc supplied is test disc 4B. This disc has built-in defects that can be used to confirm that the error detection circuitry is working properly. In addition to providing known errors, it tests the player under maximum stress.

On disc 4B, certain results may not be perfectly repeatable because the disc stresses the player to its limits. For instance, the number of E32 errors generated by the black spots may vary. This is because these errors are “soft errors.” That is, they are caused by disturbance to the player’s servo systems, rather than loss of data. Each time the disc is played, the disturbance is slightly different, and the results cannot be predicted.

For example, when the readout beam encounters the black spot, focus, track following, and clock recovery servo signals disappear. After the beam has passed the black spot and the signal is restored, the pickup is out of focus, off track, and the bit clock is at the wrong frequency. This causes many additional errors to be generated in an unpredictable way.

Test results for disc 4B are provided in the form of graphs for the whole disc. You can compare your results with the charts. These quick tests confirm that the system is capable of producing low error rates on a good disc, and can also play a disc with large defects.

Please note that some error rates may be higher at faster speeds, and others will be higher at lower speeds. In general, error rates on good discs will be about the same at higher speeds as at the slowest speed. Small errors such as E11 & E21 will not be affected much. Burst errors, on the other hand, will be greatly affected. Most burst errors (E22 & E32) are caused by disturbances to the servo systems, rather than missing data. This effect is greatly magnified at high speed.



MAINTENANCE AND SERVICE

Ordinarily, there are no adjustments or maintenance required. If you need repairs, send the CDX to us. Call us for help in diagnosing the problem, and to get a return authorization and shipping instructions.

Please save the original shipping carton and packing materials in case you need to ship it for any reason. If you are unable to save the original shipping materials, you must wrap the CDX in at least 3" of bubble-pak or foam rubber before shipping.

Service Contacts:

Tel: +1 949.582.8010

Fax: +1 949.340.7146

Email: service@cloversystems.com

Web: <http://www.cloversystems.com>

Serial Port Troubleshooting

If the drive runs, but you get no error data, most likely the trouble is the serial port communications. Error data is transferred over the serial port, and therefore CDX must be connected to a serial COM port. An easy way to test the serial port connection is to select *Eject!* In the main menu. This command is also transmitted through the serial port, and can only work if the serial port is connected and working. Please note that this test only proves that the PC is sending and CDX is receiving; it does not test the reverse path.

1. Is the CDX I/O panel & cable connected?
 - The cable connects to P3 (labeled "Output") on the rear of the CDX drive.
 - The plug is polarized, and can only be plugged in one way.
2. Is the serial cable connected?
 - The CDX I/O panel must be connected to a serial port with the cable supplied.
 - If you use a different cable, it must be wired "straight through"; not "null modem."
 - Sometimes the serial ports of the PC are mislabeled. Try to confirm that the port labeled "COM1" really is COM 1.
3. Is the correct serial port selected in the SETUP dialog?
 - You must tell the program which COM port you are using with CDX.
 - Select SETUP in the main menu, and select the proper COM port from the drop-down list box.
4. Is the serial port enabled in the PC's BIOS?
 - Most BIOS's allow an on-board serial port to be disabled. Check the "Integrated Peripherals" page of the BIOS setup.
5. Do you get any error messages?
 - If CDX commands to the serial port fail, you will get an error message: "Transmit Command Error." This means that the PC's serial port is not functioning. If you don't get any message, the problem must be in the settings or connection.
6. Is there a conflict with other hardware?
 - Check the COM port in the Device Manager to make sure it is working, and there are no hardware conflicts.

7. Is there a conflict with other software?
 - Is there any other software running that may be trying to use the serial port?
8. Are you using the correct CDX I/O panel?
 - Newer CDX's are wired differently than earlier ones. Early units have the ribbon cable soldered to the DB-9 connector, whereas the current version uses an IDC connector, and is not soldered. The two types are NOT interchangeable!

Note: The serial port communication parameters are set automatically by the CDX software. There is no need to change any COM port settings. The actual settings are:

Baud Rate:	38400
Data Bits:	8
Stop Bits:	1
Parity:	Mark
Handshaking:	None

Please note that these settings will NOT appear in the Device Manager Port Settings! Therefore, there is no way to confirm these settings.

Registry Settings

The CDX installation sets registry entries for proper operation. If for some reason you need to set these manually, the settings are:

WinNT/2000/XP/Vista

```
[HKEY_LOCAL_MACHINE\System\CurrentControlSet\Services\ASPI32]
"ErrorControl" = dword:00000001
"Start" = dword:00000001
"Type" = dword:00000001
[HKEY_LOCAL_MACHINE\System\CurrentControlSet\Services\ASPI32\Parameters]
"Exclude Miniports" = ""
[HKEY_CURRENT_USER \ Software \ Microsoft \ Windows \ CurrentVersion \ Policies \ Explorer] "NoDriveTypeAutoRun" = REG_DWORD: 0xB1
```

DRIVE SPECIFICATIONS

Power Supply

DC +12V ±10% - 2.0A Max.

DC +5V ±5% - 1.7A Max.

Ave. power consumption: 22 W

Cable: 68-pin flat ribbon cable. Maximum length = 48 in.

Dimensions: 5.78" x 1.64" x 7.95"

Weight: 1.0 kg

Host Interface



Type: Ultra SCSI Wide

Transfer: Rate: 40 MB/sec

Inquiry String: CLOVER CDX CD ANALYZER

Environmental

Mounting: Horizontal ± 15 degrees

Operating Temperature: 5 – 40 degrees Celsius

Operating Humidity: 20 – 80% non-condensing

MTBF: 100,000 hours

Tray Loading: 30,000 cycles

Read Speed CD (all types)

Minimum: 1X CLV

Maximum: 17.3 – 40.1X CAV

Safety and EMC Standards

USA	UL	UL60950
	FDA	21 CFR 1040.10. 1.40.11
	FCC	Part 15B-Class B
Canada	C-UL	CSA 22.2 No. 60950
	IC	ICES-003 Class B
Europe	CE	EN60950
		EN60825-1
		EN55024
		EN50022 Class B
Taiwan	BSMI	CNS13438 Class B
Korea	MIC	
Australia	C-Tick	EN55022 Class B

DRIVE ERROR CODES

If the CDX drive is unable to complete a command, it may display an error code and message. The error code has three parts: The digit is the Sense Code. The next two digits are the Additional Sense Code (ASC), and the last two digits are the Additional Sense Code Qualifier (ASCQ).

EXAMPLE: Error 30000
Sense Code = 3 (Medium Error)
Additional Sense Code = 00
Additional Sense Code Qualifier = 00

The Sense Code is described in the error message. The ASC and ASCQ provide additional details to pinpoint the cause of the problem. If ASC = 00 and ASCQ = 00, it means that the cause of the problem cannot be determined. The example error code means that the disc is unreadable for unknown reasons.

The following table lists the additional sense codes and additional sense code qualifiers.

Sense Code (ASC) and Additional Sense Code Qualifier (ASCQ) Descriptions

For Sense Key RECOVERED ERROR (1):

ASC	ASCQ	Description
18	03	RECOVERED DATA WITH CIRC
18	04	RECOVERED DATA WITH L-EC

For Sense Key NOT READY (2):

ASC	ASCQ	Description
04	00	LOGICAL UNIT NOT READY, CAUSE NOT REPORTABLE
3A	00	MEDIUM NOT PRESENT
57	00	UNABLE TO RECOVER TABLE-OF-CONTENTS
53	00	MEDIA LOAD/IEJECT FAILED
04	01	LOGICAL UNIT IS IN PROGRESS OF BECOMING READY (TABLE-OF-CONTENTS READ IN PROGRESS)

For Sense Key MEDIUM ERROR (3):

ASC	ASCQ	Description
03	00	NO SEEK COMPLETE
02	80	SERVO SEEK ERROR
02	81	SYNC ERROR

02	82	HEADER ERROR
02	83	TARGET NOT MET
11	05	L-EC <i>UNCORRECTABLE</i> ERROR (L-EC CODES PRESENT AND L-EC ON)
11	06	CIRC UNRECOVERED ERROR (LEG UNAVAILABLE OR OFF)
00	14	AUDIO PLAY OPERATION STOPPED DUE TO ERROR

For Sense Key *HARDWARE ERROR* (4).

ASC	ASCQ	Description

08	00	LOGICAL UNIT COMMUNICATION FAILURE
09	01	TRACKING SERVO FAILURE
40	00	DIAGNOSTIC FAILURE ON COMPONENT O (INTERNAL BUS FAILURE)
44	00	INTERNAL TARGET FAILURE
47	00	SCSI PARITY ERROR
09	02	FOCUS SERVO FAILURE
09	03	SPINDLE SERVO FAILURE
B6	00	MEDIA LOAD MECHANISM FAILED

For Sense Key *ILLEGAL REQUEST* (5):

ASC	ASCQ	Description

20	00	INVALID COMMAND OPERATION CODE
21	00	LOGICAL BLOCK ADDRESS OUT OF RANGE
24	00	INVALID FIELD IN CDB
25	00	LOGICAL UNIT NOT SUPPORTED
26	00	INVALID FIELD IN PARAMETER LIST
39	00	SAVING PARAMETERS NOT SUPPORTED
53	02	MEDIUM REMOVAL PREVENT
81	00	LOGICAL UNIT IS RESERVED
63	00	END OF USER AREA ENCOUNTERED ON THIS TRACK
64	00	ILLEGAL MODE FOR THIS TRACK
85	00	AUDIO ADDRESS NOT VALID
BF	00	BUFFER OVERFLOW

For Sense Key *UNIT ATTENTION* (6):

ASC	ASCQ	Description

28	00	NOT READY TO READY TRANSITION
29	00	POWER ON, RESET OR BUS DEVICE RESET OCCURRED

2A 01 MODE PARAMETER CHANGED

For Sense Key ABORTED COMMAND (B):

ASC	ASCQ	Description
2C	00	COMMAND SEQUENCE ERROR
43	00	MESSAGE ERROR
45	00	SELECT/RESELECT FAILURE
48	00	INITIATOR DETECTED ERROR MESSAGE RECEIVED
49	00	INVALID MESSAGE ERROR
4E	00	OVERLAPPED COMMAND ATTEMPTED
5A	01	OPERATOR MEDIUM REMOVAL REQUEST
B9	00	AUDIO PLAY OPERATION ABORTED

GLOSSARY

- A**Time** (*Absolute Time*) Timecode encoded in the subchannel of a CD in the form of playing time at 1X in minutes, seconds, and frames from beginning of the program area.**
- ATIP** (*Absolute Time In Pregroove*) Same as ATime but encoded in the pregroove and used by a writer to locate position on an unrecorded disc.
- BLER** (**Block Error Rate**) The total number of errors encountered at the C1 stage (=E11 + E21 + E31)
- CAV** (*Constant Angular Velocity*) The disc rotates at a fixed RPM. This results in a variable data rate, as the discs are recorded with CLV. Data rate is higher at the outside of the disc.
- CD-DA** (*CD-Digital Audio*) Audio disc using 16 bit linear streaming data to represent each digital sample of two audio channels. CD-DA discs do not have sectors.
- CD-R** (*CD-Recordable*) Write once-read many disc specified by the Orange Book Part II. It uses a molded in pre-groove to guide the laser during recording. The laser makes marks in the dye polymer layer by heating.
- CD-ROM** (*CD-Read Only Memory*) Data discs made according to the Philips/Sony Yellow Book. This term is often used to signify a molded disc as opposed to a CD-R disc.
- CD-ROM XA** (*CD-ROM eXtended Architecture*) A data disc that includes a subheader to support various modes of interleaving audio, graphics, video and computer data using CD-ROM XA Mode 2/Form 1 and CD-ROM XA Mode 2/Form 2 sectors. Error correction capability depends on the mode and form of the data.
- CD-RW** (*CD-ReWritable*) Re-Writable disc made according to Orange Book Part III that can be recorded, erased, or overwritten. Uses a pre-groove like CD-R, but recording

mechanism is phase change. Heat from the laser changes the medium from crystalline to amorphous structure, which has lower reflectivity. CD-RW reflectivity is much lower than CD-R, so not all drives can read these discs.

- CIRC** (*Cross Interleave Reed-Solomon Code*) A method of error detection and correction employing parity bytes together with interleaving. Interleaving distributes the data over a relatively large area of the disc, so that one large defect becomes many small defects after de-interleaving. C1 is the first stage of error correction, followed by de-interleave and C2 the correction stage.
- CLV** (*Constant Linear Velocity*) The scanning speed of the laser over the pits is constant. All CD's and DVD's are formatted this way. This requires higher rotational speed at the inside of the disc, and lower speed at the outer tracks. This produces a constant data rate.
- DAO** (**Disc At Once**) Recording method where the entire disc contents are recorded in one continuous operation. Molded discs are always recorded using this method.
- E11** One bad byte in a data frame at the C1 stage, which was corrected (CD Only).
- E21** Two bad bytes in a data frame at the C1 stage, which were corrected (CD Only).
- E31** Three or more bad bytes in a data frame at the C1 stage, which were not corrected (CD Only).
- E12** One bad byte in a data frame at the C2 stage, which was corrected (CD Only).
- E22** Two bad bytes in a data frame at the C2 stage, which were corrected (CD Only).
- E32** Three or more bad bytes in a data frame at the C2 stage, which were not corrected (CD Only).
- EDC / ECC** (*Error Detection Code / Error Correction Code*) Additional error correction data that is added to data CD's, providing an additional layer of error correction in addition to CIRC.
- ECC Block** On a DVD disc, this refers to one Reed-Solomon Product code error correction block. 1 ECC block = 16 sectors = 32768 user bytes.
- EFM** (*Eight-to-Fourteen Modulation*) Modulation scheme used by CD's; converts eight data bits to fourteen channel bits prior to recording.
- EYE PATTERN** The HF signal from the pickup as displayed on an oscilloscope.
- GB** (Gigabyte) 1 GB equals 1024 megabytes. Often, 1 GB is defined as 1000 megabytes. Usage varies.
- GRADE** Letter A, B, C, D, F indicating disc quality, assigned based on the test results. There are no standards for assigning letter grades.
- HF** (*High Frequency*) This refers to the signal from the pickup's light detector that corresponds to the pits and lands on the disc.
- ISO9660** Data format specification for data discs.
- ISRC** (**I**nternational **S**tandard **R**ecording **C**ode)
- Jitter** Variation in the detected lengths of the pits and lands upon playback.
- kB** (Kilobyte), 1 kB equals 1024 bytes.

Land	The area of the disc that is not pits.
LBA	(<i>Logical Block Address</i>) Address of a sector on a data disc. Sectors are numbered consecutively starting with 0 at the beginning of the data area.
Lead-In	Area at the beginning (inside) of a disc containing the Table of Contents (TOC).
Lead-Out	Buffer area following the Program Area used in case the player reads past the end of the track.
Multisession	Each session is like a complete disc, with lead-in, program area, and lead-out, so a multi-session disc is like two or more discs spliced together. http://www.msscience.com/gloss.html - TOP
PI Bytes	Number of bad bytes encountered in all rows of 1 ECC block (DVD only).
PI8	Number of rows in 8 ECC blocks that had errors detected by inner parity (DVD only). Sometimes called PIE or PIE8
PIF	Number of rows that were uncorrectable by inner parity in 1 ECC block (DVD only).
PO Bytes	Number of bad bytes encountered in all columns of 1 ECC block (DVD only).
PO8	Number of columns in 8 ECC blocks that had errors detected by outer parity (DVD only).
POF	Number of columns that were uncorrectable by outer parity in 1 ECC block (DVD only).
Pit	Information is recorded as a series of pits and lands. Pits appear darker than land on playback. Viewed from the readout side, pits are actually bumps. A transition between pit and land (or land and pit) is a one, and everything else is a zero.
Post-Gap	Two second area at the end of a CD program area or Mode change, encoded as null data or audio silence.
Pre-Gap	Two second first part of a CD program area or track, normally encoded as null data or audio silence.
Red Book	Proprietary Philips/Sony specification (red cover) for CD-Audio, subsequently published as IEC 908.
Reed-Solomon Code	Byte-structured parity format used for error detection and correction on optical and magnetic media.
Reflectivity	The percentage of light that is reflected from the disc surface.
SAO	(<i>Session At Once</i>) Recording method where one complete session of a multi-session disc is recorded in one continuous operation.
Sector	Fixed size unit of data on a data disc. Starts with a sector header containing the sector address.
SHA-1	(<i>Secure Hash Algorithm –1</i>) Derives a 160 bit word based on a block of data, which can be up to 2^{64} bits. This word is unique to this data set; changing any bit (or combination of bits) will change the result.
Skew	(Subcode Skew) The difference between a sector address contained in a sector header, and the Atime contained in the subcode.

- Subcode** Ninety-eight-bit codes used in the CD format. P and Q codes contain flag and control information. Timecode (Atime) is encoded in the Q channel. Codes R,S,T,U,V,W may be used for CD+G or other specialized applications.
- Table of Contents (TOC)** Lists number of CD tracks, their starting locations, total length of data on the disc, and identification of type of disc. The TOC is placed in Q-subcode in the lead-in area of a CD disc.
- TAO** (*Track At Once*) Recording method where one track is recorded. Lead-in and lead-out are added later.
- UPC/EAN** (*Universal Product Code / European Article Numbering*) A code identifying a consumer product. Usually appears as a bar code on the package, and can be encoded into a CD.
- UNCR** Total number of uncorrectable ECC blocks for the whole disc (DVD only).
- Volume Descriptor** Up to four sectors containing information describing the disc information.
- Write Mode** sMethod used to record a recordable disc: Can be TAO (track-at-once), SAO (session-at-once), or DAO (disc-at-once).

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TEST REPORTS