DVD-Video Production with DTS Coherent Acoustics Audio

A Practical Guide

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1. Introduction: DTS Coherent Acoustics for High-Impact DVD

DVD producers and viewers know the value of a killer soundtrack. Multichannel surround sound magnifies the impact of almost any presentation. And absolute fidelity of stereo or surround makes a big difference, too.

Connoisseurs also know that DTS provides the highest audio fidelity for DVD-Video. Sophisticated consumers gravitate to titles with DTS. Simply put, DTS can improve the performance of a title in rental and sell-through.

Though DTS audio is recognized as a significant asset, content holders and producers are sometimes hesitant to include it in their title definition, thinking that it may think it might be difficult, expensive, or time consuming. Such fears are unwarranted.

This document has been prepared to provide clear information on available tools and methods of encoding audio to DTS for DVD and for authoring DTS-equipped titles. It includes information about encoding methods, tools, and options for DVD, and provides step-by-step instructions for every available DTS audio encoder and compatible DVD authoring system.

New systems supporting DTS audio are coming to the market continually, and existing tools are regularly updated. For this reason, this document is continuously updated and reprinted periodically. The most current information is always available online at www.dtsonline.com.

1.1. Audio Production and Mixing for DTS DVD

DTS Coherent Acoustics provides audio data compression with extreme fidelity, delivering high-resolution surround sound at the highest audiophile standards. Source audio should be of highest quality when it goes to encoding. DTS can preserve the impact of your surround productions better than other methods of delivery.

A Note on Audio Sample Rate

DTS on DVD-Video supports audio sample rates of 48 and 96 kHz. For a 5.1 music CD, multi-channel audio (without video) can be encoded to DTS at 44.1kHz.

2. Audio Encoding for DTS

Several vendors supply hardware and software tools to convert digital audio from linear PCM to DTS Coherent Acoustics. Encoding services are also available at facilities around the world, including DTS.

In encoding for DVD-Video, there are a few considerations to take into account, and specific parameters to be set, some for compatibility with the DVD-Video specification, other for reasons of title design or the requirements of specific DVD authoring systems.

2.1. Synchronization and Time Code

The most critical considerations in encoding for DVD-Video are those involved with synchronization between sound and picture.

DVD authoring systems vary in the way they ensure synchronization between DTS sound and picture. Some (Scenarist from Sonic Solutions, and the LQ-LQ-VD2000S DVD Authoring System from Panasonic) sync audio and video by matching time stamp data in the DTS audio bit-stream with that of the MPEG video stream. Others ignore embedded time code and simply align the first byte of audio data with the first frame of picture.

Because of these differences, always take care at the encoding stage to make sure that sound and picture will maintain sync when the streams are imported into an authoring system.
2.1.1. DTS Embedded Time Code

The DTS data format provides for embedding timestamp information in every “frame” of 32 audio data bytes. As noted above, not all authoring systems are able to use this information.

Scenarist, from Sonic Solutions, matches audio timecode to video timestamp and automatically trims extraneous data from head and tail. Panasonic’s LQ-VD2000S system does likewise, and actually requires the presence of embedded timecode (.dts padded file) to import DTS audio successfully.

Capture of audio with timecode matching video requires particular conditions, depending to an extent on the encoding system. Hardware-based encoding requires a streaming audio source that has an LTC (longitudinal time code) output. Without a timecode connection, audio cannot be captured accurately.

Software-based encoding systems that are integrated with particular audio workstations, such as Universal Audio’s SmartCode Pro DTS for Digidesign and Steinberg’s DTS Encoder for Nuendo, take timestamp information directly from the source project. As long as timing in the source project matches, the correct timestamp information will be captured in the DTS bit stream.

Software encoders that work with generic digital audio files, such as Minnetonka Audio Software’s SurCode DVD-DTS, take the beginning of the source audio file, either .WAV or .AIFF, as “zero” time. An offset from the start of the file can be specified, but in most cases, it is not possible to capture audio with timecode to match video with these tools.

2.1.2. Audio Data Start and End Point

Some DVD authoring systems (This information is given later on in the article) that support DTS audio do not read the timestamp information from the audio bit stream. To ensure sync between video and audio on these systems, the start of encoded audio data must match the precise frame at which video starts. This can be accomplished either by encoding from the exact start point required, or by trimming the audio bit stream after encoding.

Unless you know for sure that audio will be authored to DVD using a system that recognizes and uses DTS embedded timecode, prepare your encoded audio streams so that the first sample of audio corresponds to the first frame of video...

2.2. Encoding for Compatibility

The DVD-Video specification requires particular source sample rates and output bitrates for DTS audio. Authoring systems that support DTS audio also vary in their requirements for data format and byte order. Options for encoding with and without LFE (low frequency enhancement) channel, attenuation of surround channels, source bit depth, and flagging for alternate formats may also need to be taken into account.

2.2.1. Source Audio Sample Rate

In DVD-Video, all audio uses sample rates of 48 kHz or 96 kHz, not the 44.1 kHz rate familiar to CD mastering engineers (or any multiples of that rate, such as are available in DVD-Audio). Audio for use in DVD-Video should always be prepared at 48 or 96 kHz, regardless of whether it is to be incorporated in DTS, LPCM, or other data formats.

In general, source data for encoding to DTS will be at a sample rate of 48 kHz. The DTS format is capable of supporting source data at 48 or 96 kHz sample rate.

For information about DTS encoding from source material at 96 kHz sample rate, contact DTS directly at:

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Email: proaudioinfo@dtsonline.com
Website: www.dtsonline.com
2.2.2. Bitrate Selection

The DTS encoding algorithm can code audio at a wide range of bitrates, two of which are compatible with the DVD-Video specification. These are **754.5 kbps** (kilobits per second) and **1509.25 kbps**. For use in DVD in DTS format, audio must be coded at one of these two bitrates. For conciseness, we refer to these as 754 and 1509 kbps.

2.2.2.1. 754 vs. 1509 kbps

DTS recommends using the 1509 kbps bitrate, however, DVD bit-budgeting may dictate the use of the lower rate. Successful (and impressive-sounding) DVD titles have been released with DTS audio coded at 754 kbps. Examples would be “Gladiator”, “Saving Private Ryan”, and “U-571”.

Two factors enter into the selection of bitrate for coding on a specific title: overall capacity of the disc and maximum rate of data transfer.

2.2.2.2. Disc Space

DVD discs come in various formats with differing capacities. For practical purposes, these divide into “single-layer” DVD-5 at 4.7G (billions of bytes), and “dual-layer” DVD-9 at 8.5G. Other formats, such as DVD-10, -14, and –17, are simply double-sided combinations of single- and dual-layer discs. For purposes of bit calculations, each side may be considered as a separate disc.

The total number of bits in all elements of the disc (video, audio, still pictures, subtitles, auxiliary ROM content, etc.) must be less than or equal to the total capacity of the target disc format.

2.2.2.3. Transfer rate limitations

DVD content is also constrained by the rate at which data can be transferred from disc. DVD-Video spec defines maximum transfer rate as 10.1 mbps (million bits per second). **Format overheads reduce this to a practical 9.8 Mbps.**

DVD-Video works by reading all video and audio from the disc, then decoding individual audio streams. If multiple audio streams are present, then the data rate of all audio streams, plus that of video, must not exceed the 9.8 mbps maximum.

If subtitle streams are included, these are also part of the total data transfer. However, subtitle streams are usually inconsequential to the total data rate, consisting of simple graphics loaded into memory once for each subtitle.

Alternate video “angles”, if present, are handled differently from multiple audio streams. If alternate angles are used, the total transfer rate remains that of only the main video plus the sum of bitrates of the audio streams.

2.2.3. The LFE Channel

When creating a mix for multichannel surround, you have the option of defining a separate channel for “low frequency enhancement” or LFE. During encoding, this channel (if present) becomes the “point-1” in 5.1. It is intentionally band-limited, with a nominal high-frequency cutoff of 120 Hz.

If there is an active LFE channel in your audio source material, then you must select “LFE” (presented as a checkbox or an alternate action toggle) in the interface of the encoding system.

2.2.4. Surround Channel Attenuation

Encoding systems for DTS include option to attenuate the surround channels by 3dB. This is used when repurposing theatrical release mixes.

Theatrical monitor systems for 5.1 are designed with 3dB less gain in the surround channels than in the front. Home systems have the same gain on all channels. If the same mix is used for home release, then the rear channels must be attenuated.
In encoding for DVD, select the Surround Channel Attenuation option of your encoding system if, and only if, the source surround mix was prepared for theatrical release and has not already been attenuated in transfer.

### 2.2.5. DTS Data File Formats

DTS audio data can be stored in three different data file: Compact (*.cpt), Padded (*.dts), and Wave (.wav). Each of these has its uses. DVD authoring systems vary in their handling of these file formats, but in general:

- Compact (*.cpt) file format is the one most used for DVD authoring.
- Some systems also accept files in the Padded (*.dts) format.
- .wav format files are useful for quality assurance because .wav is a standardized digital audio file format playable on a variety of digital audio systems. .wav format files are not used directly for authoring.

Authoring systems vary in the way they handle these file types, and encoding systems also vary in the way they are specified. The specifics of individual systems are described later in this document.

#### 2.2.5.1. Compact (*.cpt) File Format

Encoding systems for DTS provide a default or option to save files in the Compact format with the file extension “.cpt”. Compact format files are encoded with only audio, timecode, and header information, and are coded in “Motorola” (high-order byte first) byte order.

Not all DVD authoring systems recognize the “.cpt” extension. Depending on the system, you may have to set the list of file types displayed in the Open File dialog to “All Files” in order to see the *.cpt files. In certain cases, you may have rename files to “.dts” in the file system in order to use Compact format files in authoring.

#### 2.2.5.2. Padded (*.dts) File Format

Most of systems for encoding to DTS define the option of Padded (*.dts) file type by selecting this extension when the file is saved. Some systems define this as an option in encoding labeled as “Pad Files with Zeroes”, or similar wording. “Padded” files include extra zeroes in addition to the audio payload and timecode/header information. These files are stored in Motorola byte order.

Most DVD authoring systems are able to use both Padded and Compact file types.

#### 2.2.5.3. .wav File Format

All DTS encoding systems provide option to save in “.wav” format, consisting of padded audio data stored in “Intel” (low-order byte first) byte order. These are identical in format to ordinary audio .wav files, can be handled by standard digital audio application, and can be played in various ways.

This file type is not used directly in DVD authoring, but is often useful for auditioning. Some encoding systems provide an option to generate separate *.wav files automatically for this purpose.

### 2.2.6. Byte Order, Bit Depth, and HDCD Flag

#### 2.2.6.1. Byte Order

By convention, 16-bit DTS data for DVD authoring is stored with the high-order byte first, also known as “Motorola” (Big Endian).

#### 2.2.6.2. 16, 20, and 24-Bit Resolution

DTS-format audio encoders accept source data at resolution of 16, 20, or 24 bits. In most cases, audio encoding system set the “bit depth” of encoding to match that source audio automatically. For systems that have an explicit setting, select the resolution that applies to the source at hand.
2.2.6.3. The HDCD Flag

HDCD (High Definition Compact Disc) is an audio format developed by Pacific Microsonics, now part of Microsoft. A special flag is required in DTS streams to be used in this format, and this option appears in some encoding systems. The setting is never applicable to encoding for DVD authoring, and should always be left in the off position.

2.3. Quality Assurance for Encoding

As in all production, review for quality assurance in audio encoding is essential. There are three kinds of quality assurance review that can be applied in encoding for DTS:

2.3.1. Audition During Encode

Hardware-based encoding systems operate in real time and produce a continuous data stream that can be routed to a standard DTS decoder. DTS manufactures the CAD-4 and CAD-5 Reference Decoders specifically for this purpose. But any DTS-format audio decoder may be used.

Auditioning the output stream in this way verifies the encoding process, but it does not guarantee that the stream is accurately captured and stored. For this reason, audition during encode should not be a substitute for playing back the captured audio file.

Software-based encoding systems do not produce output in real time, and hence cannot provide audition during encoding.

2.3.2. .wav File Playback on Computer

Following encoding, the most immediate way to audition captured data is to play it back from computer. In general, this requires that the data be saved to a file in the *.wav format, rather than the *.cpt or *.dts formats used in authoring. The data “payload” of files in this format, however, should be identical to that of the files imported into the authoring system.

Both hardware and software-based solutions are available for playing back DTS data in *.wav format from a personal computer.

2.3.2.1. Hardware-based Decoding

Currently the Creative Labs Audigy 2ZS has a hardware-based decoder for DTS audio that can be installed directly into a computer, but there are various ways to get a digital audio stream in S/PDIF format. This stream can be routed directly to an external decoder for accurate audition of DTS data.
Software-based encoders for DTS may provide playback of *.wav data in to digital output. Otherwise, virtually any digital audio application can play these files, although the DTS audio data is not decoded in most instances.

When playing DTS data in *.wav format on computer, be careful to set all gain controls and other processing to null. Otherwise, the data will be altered on its way to the digital output, and will not be decodable.

### 2.3.2.2. Software-based Decoding

Two popular audio and video players for PC, WinDVD from InterVideo, Inc. ([http://www.intervideo.com](http://www.intervideo.com)) and PowerDVD from CyberLink ([http://www.gocyberlink.com](http://www.gocyberlink.com)), are available in versions that include software-based decoding for DTS audio. These applications may be used to play DTS audio files in *.wav format, as well as compiled DVD-Video data, directly.

The decoded output of DTS will be reproduced according to the output capabilities of the sound card installed. Cards with stereo output only will reproduce DTS in stereo mixdown. Multichannel cards, increasingly available, can be used to provide full 6-channel output directly from the computer.

Each of these applications, WinDVD and PowerDVD, are available in basic and deluxe versions. The DTS decoding capability is available only in the deluxe version of each program.

### 2.3.3. DVD Format Playback

The other way to audition DTS encoded material for DVD is to prepare it in the form it will be incorporated on a disc as “video object” (*.vob) files or as a complete DVD data set. Such files can be played back in variety of ways, both on computer and on DVD settop players.

There are some important advantages to this approach:

- The actual data file that will be used for authoring is tested, rather than a .wav format file.
- Audio and video sync can be checked, provided that the actual video program is available.
- Prepared as a DVD disc, material can be easily exchanged for checking by different parties at various locations.

Balancing these advantages, the disadvantages are the additional time required to prepare the data, and the need to use a DVD authoring system supporting DTS audio.

For QA of DVD data, it is helpful to have accompanying video program in MPEG-2 form, so that the program can be evaluated in context. If this is not possible, a dummy video stream or a still picture may be substituted.

#### 2.3.3.1. VOB

The files that carry video and audio data on a DVD disc are known as “video object” files, or VOBs. These files are designated .vob. Some DVD authoring systems allow for creation of these files individually, separate from the process of compiling a complete data set for a whole disc.

Some (not all) DVD and multimedia player programs are able to play .vob files with DTS audio directly, outputting the DTS data to external S/PDIF where it can be connected to an external decoder, or decoding in software and feeding stereo or multichannel analog outputs directly.

#### 2.3.3.2. DVD File Set on Computer

DTS audio and MPEG-2 video can also be compiled into a complete DVD data set (a “video_ts” directory) that can be played by software DVD players with hardware digital output or software decoding. Abbreviated versions of a project may be compiled for testing purposes, to save time.

Again, InterVideo WinDVD Platinum and CyberLink Power DVD Deluxe are fully software-based DVD players available with DTS decoding built-in. If using a hardware digital audio output to external...
decoding, be sure to test your hardware-software combination ahead of time, as some may not support output of DTS data.

2.3.3.3. DVD Check Discs

Burning a compiled program to DVD-R/RW disc provides greater flexibility for evaluation, as the resulting disc can be exchanged freely and played back in a variety of settings. With present availability of low-cost DVD burners and media, the primary disadvantage of this approach is the additional time required for disc burning.

Ideally, a DVD data set for encoding QA would be prepared on the same system used for authoring the final product. However, it may be feasible to use lower-cost authoring systems that support DTS to prepare discs for testing. It may also be feasible to incorporate DTS * .wav format files into a disc as DTS audio, as detailed later in this document (“Using Non-Supporting DVD Authoring Systems”) This is not compliant with the DVD specification, however, and discs created in this way should not be distributed generally.

DVD recordable formats are restricted to single-layer programs. For audio checking purposes, longer programs can be divided among more than one disc, but the only way to create a complete check disc of a dual-layer (DVD-9) project is have the disc mastered by a professional replicator.

2.4. Instructions for Encoding DTS Audio for DVD

The principles and consideration of encoding for DTS Coherent Acoustics audio are the same no matter what encoding toolset is used. Specific operations and the configuration of controls, however, vary from system to system. The pages that follow describe the particulars of encoding using the various hardware and software systems currently available on the market.

New systems for encoding in DTS format are coming on the market continually, and existing products are frequently updated. The information in this section is periodically revised to reflect the latest information. For the most recent information visit [http://www.dtsonline.com](http://www.dtsonline.com).

2.4.1. CAE-5 Hardware-Based Encoder

The CAE-5 from DTS combines professional encoding and decoding in hardware-based system. The 2U rack unit receives PCM audio via three or four IEC-958 (AES/EBU) digital audio. LTC (longitudinal time code) input provides timestamp information. This connection is required in order to synchronize audio with video in authoring.
Encoded audio data is output by IEC-958 (AES/EBU) connection to a Windows-based workstation equipped with a digital audio input, where it is captured, trimmed, and saved to a file ready for authoring. The user documentation that comes with the CAE-5 provides details of the configuration required for the capture workstation.

The CAE-5 front panel provides fast selection of preset for bitrate (754 or 1509 kbps) and channel configuration, along with detailed control of all encoding parameters and trigger modes by built-in menus. The unit can also be controlled remotely.

Capture from tape or DAW proceeds under control of the Encoder Remote Panel program running on the capture workstation. This program provides controls to initiate capture, and then to trim the captured audio (if needed) for use in authoring systems that support DTS format audio, but do not recognize timestamp information embedded in the bit stream.

The Job Setup dialog provides for setting of encoding parameters and modes.

The Record/Play dialog controls capture. Having created a project filename and set the encode parameters, preroll the source from a few seconds ahead of desired audio, and click RECORD.

Following capture, use the Play to monitor the captured stream, which may then be saved directly in *.cpt, *.dts, or *.wav formats, for use in DVD authoring systems that recognize DTS embedded timecode.
For other authoring systems, trim the start of audio, using the built-in JOIN utilities, to the precise beginning of audio that matches the timecode of video before saving to file.
2.4.2. CAE-4 Hardware-Based Encoder

The CAE-4, manufactured by DTS, is a real-time hardware-based encoding system. The 1U rack unit receives PCM audio via three IEC-958 (AES/EBU) digital audio connections from digital audio workstation or tape source. An LTC (longitudinal time code) input provides timestamp information. This connection is required for encoding for DVD in order to synchronize audio with video in authoring.

Encoded audio data is output by IEC-958 connection to a Windows-based workstation equipped with a digital audio input, where it is captured, trimmed, and saved to a file ready for authoring. The user documentation that comes with the CAE-4 provides details of the configuration required for the capture workstation.

The CAE-4 front panel provides settings for bitrate (754 or 1509 kbps), LFE on or off, and attenuation of surround channels if required. The front panel TC Trig control must be set ON, and timecode available, in order to capture timestamp information in the DTS bit stream.

Capture from tape or DAW proceeds under control of the “PlayPanel” program running on the capture workstation. This program provides controls to initiate capture, and then to trim the captured audio (if needed) for use in authoring systems that support DTS format audio, but do not recognize timestamp information embedded in the bit stream.

A Setup button in the PlayPanel interface provides for designating the digital audio input to be used in capturing the encoded bit stream.
To encode and capture audio with the PlayPanel program, simply create a project file name, preroll the source from a few seconds ahead of desired audio, and click RECORD.

Following capture, use PlayPanel to check the captured stream, which may then be saved directly in *.cpt, *.dts, or *.wav formats, for use in DVD authoring systems that recognize DTS embedded timecode.

For other authoring systems, trim the start of audio, using the Timecode Edit Position Start field, to the precise beginning of audio that matches the timecode of video before saving to file.
2.4.3. **SurCode DVD-DTS (Minnetonka Audio Software)**

SurCode DVD-DTS from Minnetonka Audio Software is a software encoder that operates on source audio in the form of multiple .wav or AIF files.

Because source audio is provided in a form that lacks timecode information, the encoded output ordinarily does not include timecode information that matches video. For this reason, when encoding audio for video with SurCode, it is necessary to capture with the first sample of audio matching the first frame of video.

To encode with SurCode DVD-DTS, select the source audio sound files (one per channel) that apply and designate the output file type, name and directory. Encoder bitrate, sample rate, and surround channel attenuation options are set in the Encoder Options dialog.

Optionally, you may specify head and tail offsets to the source sound files, to encode only the defined portion of the file. If the source audio files do not begin at the start of video, then an exact offset must be entered here. If video timecode is referenced to 0 hours, it may be possible to encode with embedded timecode to match video, but this would be an unusual case.

Once source audio, encode parameters, and any time offsets are designated, click on the Encode button to initiate processing. The output file is saved automatically in the designated data file type.

SurCode includes a playback function for the destination file, but this operates only with .wav format files, streaming digital output to a designated sound card. Attempting to playback *.cpt or *.dts. files will produce an error message.
2.4.4. SmartCode Pro DTS-DVD (Universal Audio, Inc.)

SmartCode Pro DTS-DVD from Universal Audio’s Kind of Loud division, is a software plug-in that works with most versions of Digidesign digital audio workstations, allowing multichannel mixes to be output directly to DTS-encoded files.

As a plug-in, SmartCode operates on a selected region of a source project. Channels of the source region are assigned to speaker channels according to the order they appear in the project, as shown by the user interface graphic. This order can be changed by the user if need be. Timecode information is embedded in the bit stream according to that of the source region.

Bitrate, LFE channel on/off, and surround channel attenuation options are also set in the program’s UI panel. The output data file type is defined by selecting the Byte Order (Intel for .wav, Motorola for Compact or Padded types) and “Pad Buffers with Zeros” (ON for Padded, OFF for other file types) options. Filename is defined separately, and care should be taken that the file extension matches the file type as defined by these settings (*.wav, *.cpt, or *.dts).

Factory and user-defined presets are available to make setting up and encoding simple. Once the source region, channel mapping, encode parameters, and output file are defined, encoding is initiated by clicking the “process” button.
2.4.5. DTS Encoder for Nuendo (Steinberg Media Technologies)

The DTS Encoder for Nuendo is a plug-in module specific to Steinberg’s Nuendo audio workstation. When installed, it appears as an output option in the system’s “Export/Audio Mixdown” function.

The Nuendo software provides Output Bus configurations for multichannel surround, including 5.1. The selected bus configuration defines the mapping of channels that will be used in encoding. A surround mix can be set up by defining the needed configuration and selecting the project section to be encoded, by adjusting the left and right locators. Timecode information is embedded in the output as defined by the locators.

Having defined the mix, select the command “Export/Audio Mixdown…” from the File menu. In the file and parameter definition dialog that appears, select the “DTS” file type, and define the output filename and directory. This dialog also provides options to save the files as a DTS .wav file type, and a separate option to use the *.cpt file extension. A separate checkbox is provided to create “Monitor” files, which are files of .wav type that are created and imported in Nuendo at the same time as Compact or Padded file types, for convenience in review in Nuendo.

When you click “Save”, another dialog appears with settings for bitrate, LFE channel on/off, and surround channel attenuation. The output file byte order (Intel for .wav, Motorola for Compact or Padded) is also defined here, as is the option of “Pad Buffers with Zeros” (Set ON for Padded, OFF for Compact). Click “OK” to initiate processing.
3. Authoring DVD-Video with DTS Audio

Successful authoring of compatible DVD discs with DTS audio for release to the general market requires four things:

- A DVD authoring system that supports the DTS audio features as defined in the DVD-Video specification,
- Conformance to some simple constraints in the use of DTS-format audio as defined in the same specification,
- Observance of the particulars of the individual system when it comes to handling DTS-format audio data, and
- Provision for quality assurance by system playback, playback of test discs, or both.

When these conditions are met, the actual authoring with DTS audio is generally very simple.

3.1. DVD Spec and Authoring System Considerations

Professional-level DVD authoring systems in use today support the use of DTS-format audio, and an increasing number of systems at lower tiers of the market are adding such support. The particulars of using the currently available systems supporting DTS audio are listed in the next section of this document. This information is updated and maintained online at [http://www.dtsonline.com](http://www.dtsonline.com). Check there for the latest information.

3.1.1. Audio Stream Configuration

DVD-Video provides for multiple alternate audio streams with a single video program. DTS Coherent Acoustics is listed in the DVD-Video specification as an audio format supported for DVD, but to be compliant, program material that includes DTS audio must include at least one stream other than DTS. This stream may be uncompressed linear PCM, or Dolby AC-3.

DTS audio is supported by a large and growing share of players and reproduction systems in the field, but it is still true that not all players and audio systems can play and decode DTS. Commercial titles that include DTS audio usually are authored to default to a non-DTS stream on initial play. The viewer is then given the option of selecting DTS audio from a selection menu. If desired, the disc may be authored to present this option as part of the disc’s startup sequence.

DVD selection menus are also sometimes authored with background sounds or music. The DVD-Video specification does not allow for the use of DTS-format audio underneath a selection menu.

The considerations for authoring with DTS audio that are imposed by the DVD-Video specification, then, are as follows:

- A program using DTS audio must also include at least one stream in uncompressed linear PCM or Dolby AC-3.*
- The default audio stream should be linear PCM or Dolby AC-3.
- DTS-format audio cannot be used as background sound for a DVD menu.

3.1.2. Data File Format

Most DVD authoring systems that support DTS audio accept files in both Compact and Padded format, but some do not recognize the “.cpt” extension directly. Depending on the system, *.cpt files may be recognized by changing the file filter that determines the file types shown in the Open File dialog to “All Files”. Some systems on the market do not recognize the “.cpt” extension at all, and require that the names of the files be changed in order to import them into the authoring system.

The particulars of each available DVD authoring system with regard to file types and file naming are described under the heading for that system in the next section of this document...
3.1.3. Time Code and Synchronization

As discussed previously, not all DVD authoring systems that support DTS audio are capable of recognizing timecode information embedded in the DTS bit stream. The most “universal” way to ensure synchronization of video and audio is to encode so that the first sample of audio matches with the first frame of encoded video.

Because of these variations in system behavior, synchronization is a critical issue in authoring with DTS audio. The next section of this document provides details of behavior of each available authoring system and recommendations for encoding for use on that system.

3.2. Quality Assurance for DTS DVD

In DVD production, careful review of results at each stage is called for to ensure that the final product meets all requirements and rework is minimized.

As with encoding, quality assurance review can be performed from compiled DVD data, either from hard disk or from test disc on DVD-R/RW or mastered disc (necessary for dual-layer DVD-9 discs). The considerations for review in this way are the same as those for encoding.

Most DVD authoring systems provide a means to simulate playback of a DVD project in progress, prior to compilation into a compliant DVD data set. In most cases, these playback simulations do not support DTS audio directly. Playback simulation also does not provide complete assurance that the finished disc will behave as it does in simulation, and all projects should be reviewed from disc before committing to mass replication.

It is often expedient to perform limited test compiles to hard disc and/or DVD-R/RW before building up an entire project. In this way, problems such as audio glitches, data incompatibility, or A/V synchronization issues can be identified early and corrective action taken.

3.3. Instructions for Specific Authoring Systems

Support of DTS audio is a feature characteristic of fully professional DVD authoring systems. Also, an increasing number of systems for industrial, hobbyist and consumer applications are including DTS support in their list of features. The systems listed here are those in use as of this writing that offer support for the DTS audio. There are also a few proprietary authoring systems supporting DTS that are not available to the general market and are not described here.

This list will be updated frequently, with the most recent information always available at www.dtsonline.com.

Professional DVD authoring systems vary in their approach to configuring the many options available in DVD-Video. No attempt is made here to describe the larger process of authoring on each system, but only that portion that is particular to the use of DTS audio.

In general, DTS audio is incorporated into a DVD project by importing it into the list of media assets available to the project, and then combining the DTS asset with video and other audio streams to create an audio/video program (or “video object”) that can be viewed in the final project. Authoring systems vary in the terms they use to apply to these “vobs” (“track” or “movie” are terms used in some systems), but the principles remain the same.
3.3.1. Scenarist (Sonic Solutions)

Sonic Scenarist runs under Windows 2000 or XP Professional, and uses an interface style often seen in professional software development environments. A central “workspace” is surrounded by windows of dedicated function. The size and position of windows can be changed by the user, so that the user’s screen may vary somewhat from the configuration shown here.

3.3.1.1. Authoring Procedure

The central workspace can be switched between various roles, including a “Data Editor” for importing media assets, and a “Track Editor” for the construction of video objects. These two environments are used to bring DTS audio files into the system and to configure video programs that include DTS.

To incorporate DTS audio into a Scenarist project, first switch the main workspace view to Data Editor and import the DTS audio source file or files into the project. Then switch to the Track Editor view and create a new Track (video object) by dragging the principle video stream into the timeline. Audio streams, including DTS can then be added by dragging from the Asset Manager. Following placement of the first audio stream, additional audio streams are defined by using the Audio Track command in the New menu.

Following definition of the video object(s) containing DTS audio, DVD authoring proceeds normally.
3.3.1.2. **Notes for Authoring with Scenarist**

- Scenarist recognizes DTS data files in both Compact (*.cpt) and Padded (*.dts) formats.
- Scenarist recognizes and uses timecode embedded in the DTS bit stream, and will match audio timecode with that of video program, trimming any preceding or following audio automatically.
- When encoding for use with Scenarist, it is common to encode with embedded timecode.
- If audio timecode is not available, the system will synchronize by matching start of audio to start of video. In that case, audio must be encoded with audio start matching the first frame of video.
- Scenarist has no provision for monitoring DTS audio from the authoring environment. QA review with DTS requires compilation of the project into a DVD data set for playback from hard disk and/or a DVD test disc.
- DTS-format audio is supported only in the Professional version of Scenarist. Other versions of the program sold by Sonic Solutions do not support DTS.

3.3.2. **DVD Creator/DVD Fusion (Sonic Solutions)**

DVD Creator and DVD Fusion are authoring programs from Sonic Solutions that run on the Macintosh OS9. (Mac OS X is not supported at this writing). Both programs use an identical interface, and vary only in supported features.

3.3.2.1. **Authoring Procedure**

The Creator/Fusion user interface displays DVD “Titles” (corresponding to a “video object” associated with a DVD “program chain”) and Menus as rectangular objects in a main workspace. These are color-coded to indicate location and role in the DVD disc.

The process of authoring begins with importing media assets into the “Source List” by using the “Import…” command from the Source menu. Media data files can also be imported by drag-and-drop from the Finder.
When a media data file, such as a DTS audio file, is imported into the system from an external source, a dialog appears that lets the user identify the data type. “DTS Audio” appears in this list.

Once the required video and audio data files are added to the Source List, double-click on the image representing the “Track” to be constructed. This opens the “Presentation Editor” window, with a timeline interface. You can then drag video and audio files directly from the Source List into the corresponding timeline, dropping them in the label space at the left end of each track. After placing the first audio stream, new audio “tracks” are created automatically when an audio data asset is dragged into the audio timeline.

### 3.3.2.2. Notes for Authoring with DVD Creator and DVD Fusion

- DVD Creator and DVD Fusion recognize and support DTS data files in Compact format only. The system will accept import of files in Padded (*.dts) form, but these are not compiled correctly in the final product.

- The File Open dialog presented for the “Import…” command by default does not show files with the standard “.cpt” extension for Compact type data files. To see *.cpt files in this view, select “All Files” from the file filter pull-down menu.

- DVD Creator and DVD Fusion do not recognize timecode information embedded in the DTS audio file. Audio files must be encoded with the start of audio data corresponding to the start of video in order to synchronize video with audio.

- DVD Creator and DVD Fusion have no provision for monitoring DTS audio from the authoring environment. QA review with DTS requires compilation of the project into a DVD data set for playback from hard disk and/or a DVD test disc.

- For support of DTS-format audio, DVD Fusion requires the Advanced Authoring Pack (DVD-5072) option. All versions of DVD Creator include support for DTS audio.
3.3.3. DVDMaestro (Spruce Technologies)

DVDMaestro from Spruce Technologies (since acquired by Apple Computer) runs on Windows NT and uses a “workspace” style of interface. Window position can be changed by the user, and the appearance of the screen may vary from that shown below.

3.3.3.1. Authoring Procedure

To import DTS-format audio data and incorporate it into a video object (referred to as “Movie” in DVDMaestro), you may drag-and-drop the source files from the Windows Explorer, or right-click in the “Asset Bin” window and select the file or files to be imported using the File Open dialog.

Once the needed media assets are imported, double-click the icon of a “Movie” in the Project window to open its “timeline” editor. In this view, you can drag the individual assets from the Asset Bin into the respective timelines. In DVDMaestro, the timeline bar representing DTS-format audio data appears in bright orange, making it easy to identify.

DVDMaestro does not use embedded timecode to sync DTS audio with video, nor does it automatically align start of audio with start of video. To align audio (which must be encoded with a start point matching video), after placement in the timeline, drag the bar representing DTS audio to the far left of its timeline, or beyond. When the mouse button is released, the audio will snap into position with the head of audio matching the first frame of video.

3.3.3.2. Notes for Authoring with DVDMaestro

- DVDMaestro recognizes and supports DVD data files in the Compact form only. Files imported as Padded data will not multiplex correctly.
- The File Open dialog presented for the “Import…” command by default does not show files with the standard “.cpt” extension for Compact type data files. To see *.cpt files in this view, select “All Files” from the file filter pull-down menu.
- DVDMaestro does not recognize timecode information embedded in the DTS audio file. Audio files must be encoded with the start of audio data corresponding to the start of video in order to synchronize video with audio.
• Upon placement in the timeline, the head of audio is not automatically matched to the start of video. To align the two streams, simply drag the bar representing DTS audio to the far left of its timeline.

• Spruce Technologies was acquired by Apple Computer in 2001, and DVDMaestro is no longer commercially available. Limited support for existing installations is provided by Apple Computer, Inc.

• DVDMaestro was sold, at different times, with two different hardware decoder cards. Systems equipped with Netstream 2000 card from Sigma Designs are able to preview content from the authoring environment with DTS data streamed to an external decoder via S/PDIF.

• DVDMaestro systems equipped with the Cinemaster card from Quadrant are not able to play DTS audio data. For these systems, QA review with DTS requires compilation of the project into a DVD data set for playback from hard disk and/or a DVD test disc.

3.3.4. LQ-VD2000S DVD Authoring System (Panasonic)

The LQ-VD2000S system from Panasonic (now discontinued) operates in a manner unlike other systems described in this section. Rather than being a stand-alone application that takes encoded video and audio files from external encoding stations, the LQ-VD2000S integrates encoding and authoring such that, ordinarily, video and audio encoding do not proceed until the authoring process is well advanced. Since the system does not encode audio into DTS format directly, DTS audio streams must be imported, which in this system is an unusual action that requires a special procedure.

3.3.4.1. Authoring Procedure

A DVD project in the LQ-VD2000S system is defined in the Project Manager window. This window includes buttons for “Import Video” and “Import Audio” to bring externally-encoded media files into the project.

When the “Import Audio” button is clicked, a separate dialog appears to specify the file or files to be brought into the project. Click on the “Set File” button. This opens a second window that provides for locating the source file (“Ref” button).
Once the source audio file has been identified, the user must define the start timecode, as embedded in the DTS bit stream. Enter the correct timecode for the start of file or start of audio data to be used. Then click “OK”.

The Set File operation may be repeated to define any number of audio streams for import. Once all streams are defined, click “Execute” in the Import Audio dialog. The system will process all listed streams. If any problems with the streams (such as non-matching timecode) are found, the system will display an error message.

3.3.4.2. Notes for Authoring with Panasonic LQ-VD2000S

• The Panasonic LQ-VD2000S system recognizes and support DTS audio data in both Compact (*.cpt) and Padded (*.dts) formats.
• Panasonic LQ-VD2000S requires timecode information embedded in the DTS audio file in order for the audio data file to be imported into the system.
• The LQ-VD2000S system has no provision for monitoring of DTS audio data during authoring. Compilation to hard disc or test DVD is required for quality assurance review.
• For support of DTS-format audio, the LQVD 2000S system requires the Title Movie Software (LQ-VDS130P) option.
• The LQ-VD2000S system is no longer offered by Panasonic, and only limited support is available for existing systems.

3.3.5. DVD Wise (AuthoringWare)

The DVD Wise application from AuthoringWare does not use a timeline interface to build video objects. Instead, the user selects the source file for each video and audio stream directly from the host system. The video object file (*.vob) is then multiplexed and written to disc prior to authoring of navigation functions.

3.3.5.1. Authoring Procedure

The DVD Wise master screen includes a button labeled “V/A Multiplex” that is used to define a video object. When this button is clicked, a dialog appears that has a number of file selection fields.
The topmost field in this dialog defines the main video program, and a compatible MPEG-2 file must be specified here. A series of filename boxes below and to the left of this allow for specifying up to 8 audio streams. Select the “browse” button to the right of each of these fields to define all of the audio tracks that are to accompany the designated video.

Once video and audio files have been specified (along with any subtitle streams), the actual video object file (*.vob) name can be defined. Once this is specified, click on “Create” and wait for completion of multiplexing, then close the dialog by clicking “OK”. Authoring can then be completed using the multiplexed VOB file created.

3.3.5.2. Notes for Authoring with DVD Wise

- DVD Wise supports DTS data files in Compact or Padded format.
- However, the program does not recognize the “.cpt” extension at all. In order to import *.cpt files into the system, the filenames must be changed to *.dts in the Windows Explorer.
- DVD Wise does not recognize timecode information embedded in the DTS audio file. Audio files must be encoded with the start of audio data corresponding to the start of video in order to synchronize video with audio.
- DVD Wise has no provision for monitoring DTS audio from the authoring environment. QA review with DTS requires compilation of the project into a DVD data set for playback from hard disk and/or a DVD test disc.
- DVD Wise provides for identification of audio streams by Language name only (DVD spec provides for multiple streams of the same language, or “no language specified). For this reason, the selection a DTS audio stream may be awkward for the end user.
3.3.6. DVD Junior (AuthoringWare)

As with DVD Wise from the same company, AuthoringWare’s DVD Junior program defines video objects by specifying video and audio source files, then pre-multiplexing these to create a *.vob file.

3.3.6.1. Authoring Procedure

The DVD Junior user interface divides its operations into Authoring and Premastering. To build a video object with DTS audio, click and hold on the button at left labeled “Authoring”, then from the pull-right selections that appear, choose “Title”. This creates a Title object that appears in the field at the right-hand side of the screen.

To define the video and audio files that make up the video object to be created, double-click on the Title object that you just made. This will first present a File Open dialog to specify the main video file. Select the MPEG-2 source file that matches the video program you are creating.

Once the video source file is selected, a second dialog appears with 4 fields for audio source files and 4 for AuthoringWare subtitle files (not covered here). Select the audio files for each audio “stream” that will accompany the video program, plus any subtitle streams that apply.

When you have defined all of the source streams, specify the name for the *.vob file to be created and click “Create” to multiplex audio and video into the VOB file to be used in the final DVD disc. When multiplexing is complete, click “OK” to exit this dialog.

3.3.6.2. Notes for Authoring with DVD Junior

- DVD Junior supports DTS data files in Compact or Padded format.
- However, the program does not recognize the “.cpt” extension at all. In order to import *.cpt files into the system, the filenames must be changed to *.dts in the Windows Explorer.
- DVD Junior does not recognize timecode information embedded in the DTS audio file. Audio files must be encoded with the start of audio data corresponding to the start of video in order to synchronize video with audio.
• DVD Junior has no provision for monitoring DTS audio from the authoring environment. QA review with DTS requires compilation of the project into a DVD data set for playback from hard disk and/or a DVD test disc.

• DVD Junior provides for identification of audio streams by Language name only (DVD spec provides for multiple streams of the same language, or “no language specified). For this reason, the selection a DTS audio stream may be awkward for the end user.

3.3.7. DVD SDK (AuthoringWare)

AuthoringWare also produces a series of software development kits (SDK) that can be used to create DVD authoring applications that support DTS audio for general market or for custom applications. For information, contact AuthoringWare directly.

3.3.8. DVD-lab (MediaChance)

3.3.8.1. Authoring Procedure

DVD-lab from MediaChance uses a workspace-oriented interface with a “project tree”, an asset window in which source files are listed, and a timeline view for defining video and audio streams to be incorporated into a video object.

To define a video object with DTS audio in DVD-lab, you first import the source video and audio streams into the asset window by right-clicking in this window or selecting “Import Asset…” from the File menu.

Once the required streams are imported, select the icon for the appropriate “Movie” (the program’s term for a video presentation object) and then drag the video and audio assets into the corresponding timeline as shown in the main workspace.

3.3.8.2. Notes for Authoring with DVD-lab

• DVD-lab supports DTS data files in Compact or Padded format.
• DVD-lab, however, does not recognize the “.cpt” extension at all. In order to import *.cpt files into the system, the filenames must be changed to *.dts in the Windows Explorer.

• DVD-lab does not recognize timecode information embedded in the DTS audio file. Audio files must be encoded with the start of audio data corresponding to the start of video in order to synchronize video with audio.

• DVD-lab has no provision for monitoring DTS audio from the authoring environment. QA review with DTS requires compilation of the project into a DVD data set for playback from hard disk and/or a DVD test disc.

• The current version of DVD-lab supports only a single audio stream. For this reason, discs authored in DVD-lab with DTS audio are not in technical compliance with the DVD-Video specification, which requires at least one audio stream other than DTS. Such a disc may not play on all DVD Players.

• For this reason, DVD-lab should not be used to prepare commercial releases, but only for vertical applications and testing where the playback situation is controlled.

3.4. Using Non-Supporting DVD Authoring Systems

Some lower-end DVD authoring systems do not support DTS audio as defined by the DVD-Video spec. However, it is possible to use almost any DVD authoring system to make discs with DTS audio presented as linear PCM for testing and controlled vertical applications. Such discs are not compliant with spec, however, and should not be released to distribution.

In .wav format, DTS audio appears as linear 16-bit/48kHz PCM, and can be imported into any authoring program. The authoring system will see this data entirely as LPCM, and will compile it as such in the final disc output. On playback, the audio data will stream from the player’s digital output, and can be decoded externally.

Analog stereo output, however, will sound as white noise. In playing discs of this type publicly, be careful not to connect the analog outputs of the player to active amplifiers and speakers. For this reason, discs authored in this way should never be released to general distribution.

The figure below illustrates the correct hookup to play discs authored in this fashion.

For bit-budgeting, the bit-rate for DTS audio in .WAV file format is that of stereo 16-bit audio at 48 kHz sample rate, or 1.536 mbps, no matter what DTS bit rate is selected.

This type of non-compliant disc can be useful for testing prior to full authoring, and can also be used to good effect in kiosks, presentations, and other environments where playback is controlled.
Appendix: Manufacturer Contact Information

Digital Theater Systems, Inc.
5171 Clareton Dr.
Agoura Hills, California 91301-4523
USA
Telephone: (818) 706-3525 or 800-959-4109
Email: proaudioinfo@dtsonline.com
Web Site: www.dtsonline.com

Minnetonka Audio Software
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Minnetonka, Minnesota 55345
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Universal Audio, Inc.
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