



Frame Accurate Synchronization

(updated November 15, 2003)

Note: Important information about using cheap DVD-R discs is near the end of this tutorial

Overview

There are a number of things that can affect whether your presentation has it's video channels locked exactly to the frame or not. These can include the way that the video was shot in the first place, the way you edit your video, the way you create your DVD discs, and the way you set the synchronizer for controlling them.

Shooting the video

There are many ways to create the video content used in frame accurate video presentations. One of which is to shoot multiple channels of video using multiple cameras. This may sound straight forward, but it is not. It may seem that all you have to do is to bolt (for example) three cameras to a mobile rig, start the cameras, and then move the rig around to shoot 3 matched channels of video. But this by itself does not guarantee a set of frame accurate images.

When you use several independent cameras or camcorders, they each typically have their own internal sync generators. That means that when you turn them on and start shooting, you will end up with multiple channels of video that are not locked at the vertical interval. Why is this important? It's simple. Each camera starts scanning in a frame of video at a random time. If we consider camera one as our reference point, then camera two might randomly power up so it's frames start scanning at exactly the same nanosecond. But they could also start scanning at any time from there to the next vertical interval. This means that camera two might be off from camera one by a pixel, a scan line, a field, or just short of an entire frame. So no matter how accurately you select your starting frame for each channel, when doing the editing or synchronizing, your presentation was shot up to one frame out of sync from channel to channel right from the start.

To ensure that all of your original source videos are shot exactly in sync, you must first make sure that the cameras used to shoot the source material are all locked together. This means that you can't simply bolt several camcorders or cameras to a rig and start shooting. It means that your cameras must be able to genlock to a master reference sync signal, and that all cameras are locked to the vertical interval of your reference signal. The reference could be an external black burst generator, or even one of the cameras (such as camera #1). Only when all the cameras have their video signals locked to each other at the vertical interval will you get a frame accurate recording of multiple images.

Editing the video

If your source material has SMPTE/EBU timecode on it, and your video editing software supports it, this can help greatly in being sure that your editing is done exactly to the frame. It is not always easy to keep track of edits within several channels of video that you are trying to keep synchronized. I'm not aware of any video editing software specifically designed to edit and preview synchronized tracks of video. So it is up to you to keep track of the total number of frames from one key point in the video to the next. If your source video and editor support timecode, you can usually keep track of the different channels by doing some basic math on the timecode, keeping track of exactly how many frames of video there are from edit to edit, or from one point to another within the tracks where you will see the match or not between channels.

There is no simple answer here if you do not have timecode. You will simply have to find frames in your various clips that match, and try to make those frames come out on the same frame number on each of the timelines you create in your editing software.

One thing we do recommend while editing your video clips is to add several seconds of extra material at the end of each track, beyond the end of the video that you plan to play in your presentation. If your video clips fade out to black at the end, simply add several seconds of black after that fade down. Similarly, if the video fades up to white at the end, hold that white for several seconds. Or if you plan to have a logo or other image displayed on the screen in your presentation while the DVD players are rewinding, then make sure that the first frame of your video clip, and several seconds of video at the end of the video clip both contain that exact same image. The reasons for this are explained later.

When you think you have the video edited, there is a simple method for double checking your results. Create a new video timeline and place all of your edited channels of video on it, starting at the same point on the timeline. Use the special effects of the editing software to shrink each of the video clips visually so that all of them fit on the screen at once. Now you have a single channel preview clip that contains all channels. You can play it, pause it, single step through it, and examine it carefully to see if any of the channels are off from each other. You don't have to worry about synchronizing yet, since all clips are merged on the same timeline into a single channel, so must be locked to each other. If at this point you are satisfied that all channels have been shot and edited exactly to the frame, you can move on to making your DVDs of the individual channels.

DVD Authoring

If your video was shot exact to the frame, and edited exactly to the frame, then you should be able to make your DVDs with almost any DVD authoring software and they will retain the exact to the frame relationship between channels. There are a few exceptions. Do not create multiple segments for each channel in your editing software and try to combine those into a single channel in the DVD authoring software. Create each channel as a single complete video clip in your editing software, and then use that clip as the complete source for one track (Title) of the DVD.

Note, the DVD spec calls each complete track of video on a DVD a "Title", while some DVD authoring programs call it a "Track". These are the same thing. There can be multiple Titles (tracks) on a DVD and each one is a separate entity, with it's own frame numbers, chapters, etc... If you are placing multiple video clips onto the same DVD disc, they should be kept on separate Titles. If you wish to have several channels of video be within a single Title, and to use Chapter marks to control where the start and end points are for the synchronizer, do this in the video editing so that all channels are made into one large track. Then add chapter marks in the DVD authoring software to mark the start and end points for each channel.

Our DVD synchronizers ship pre-programmed to start each channel at Chapter 1 of Title 1, and play until they reach Chapter 2. You can always change this programming yourself, but many people prefer to simply use our default programming and not have to reprogram the synchronizer. For this to work you must:

- Make a unique disc for each channel
- Have the video on Title (Track) 1
- Have the video start right at the beginning of the Title (a chapter 1 mark is there by default)
- Place a Chapter 2 mark within the Title, before the end of the Title, at the point where you want playback to end. We suggest it be at least one second, and preferably several seconds before the end of the Title.
- Do not disable Chapter searches on the disc

As a safety measure we also suggest that you make sure your authoring software does not disable frame searches on the disc. Some software, such as DVD Studio Pro does disable frame searching by default and you must manually re-enable it within your project settings (see our "DVD Authoring Tips" tutorial for details). By enabling frame searching you have a fallback method of adjusting the synchronizer if it turns out that you made a mistake in the shooting, editing, or authoring of your channels and the discs need to be offset by one or more frames relative to each other in order to get the channels to be exactly in synch with each other.

One final note on authoring concerning audio. Be aware that no matter how accurately the discs are synchronized, there will always be a tiny bit of difference between the channels. A few pixels difference between the video signals can not be seen, but a tiny offset like that can be heard if you try to use audio tracks from several of the discs at once, and those tracks have sound that is the same. This small offset can cause subtle shifts in tone because of the audio cancelling each other out between the channels, or can sound like a reverb or echo if the offset between channels is larger.

You don't hear this if the audio coming from different discs are different. Only if the same sounds are coming from the different discs. So if you need more than the default stereo sound, and the sounds contain the same content mixed together, then use the 5.1 Dolby sound from a single player. This is not an issue if the sounds coming from the different players are not related, such as music from one player and voices from another. But if you mix the same music into the background of the audio on several channels, and they each come from different players then you will hear audio artifacts.

Synchronizing

Our DVD synchronizers are extremely accurate, perhaps the most accurate method of synchronizing DVD discs available, but they require you to use them correctly in order for them to be frame accurate. Besides shooting the video properly, editing it properly, and creating the discs properly, you must also set up the synchronizer and players properly.

Just like the cameras described in the first section of this tutorial, the players also have their own internal sync generators. If allowed to play by themselves, the video outputs of the players will not be locked at the vertical interval, so no matter what else you do right, the video outputs will be off from each other by as much as one frame. The Pioneer industrial DVD players have a built in genlock that allows them to lock to an external black burst reference. When the players are all locked to a reference like that then the video output of all players are locked at the vertical interval. This is important for frame accurate synchronizing.

Our DVD synchronizers come in two basic versions. With or without a built in black burst generator. To get frame accurate synchronization you must feed a black burst reference to all of the players in your installation. It does not matter if it is our black burst reference, or one that you already have available, but you must use one or the other. Since our black burst generator is built in there is no chance of you losing it while transporting your installation. Also it typically costs less than an external one, so it is often more economical to get our synchronizer that includes the black burst generator.

The black burst reference must match the format of the video on the discs. Use PAL black burst for PAL discs, and NTSC black burst for NTSC discs. Be careful when creating your discs that you do not author a start title on the disc that uses a different video format than the main content of the disc. We have heard of people making PAL discs that for some reason (maybe cheap authoring software?) had an NTSC image used on the Start Title for the disc. The Pioneer players will not allow you to genlock to a PAL black burst and use a disc that has an NTSC Start Title.

Simply connecting the black burst to the players is not enough. You must go into the Advanced Setup menu of the players and set several settings there to enable the genlock. Besides the BAUD rate of the player being set to 9600, which is required for all of our synchronizers, you must also set three settings in that advanced setup menu that directly relate to the external black burst. On the second page of the advanced setup menu is a setting called "Sync Out (During SQ)". Be sure this is set to "OFF". Next is the "Ext Sync" setting. If you have PAL black burst, this must be set to "PAL". If using NTSC black burst, then it must be set to "NTSC". If no black burst is being used, then this must be set to "OFF". Finally there is another setting called "Advanced Sync". This must be set to "OFF".

You are still not done. On the back of the Pioneer players is a switch that has settings for NTSC, PAL, and AUTO. In most cases it is safe to leave this on AUTO. If you are sure that you will always use PAL discs, then you can set it to PAL, and if you are sure you will always use NTSC discs then you can set this to NTSC.

Even with all of these settings, and with the correct black burst connected to the players, it is still possible to not have the players genlock to the black burst. The Pioneer players only lock to external black burst when a disc is not playing. If a disc is already playing when the black burst gets connected, or if the disc is already playing before the black burst generator is powered on, then the Pioneer player will not lock to the black burst and your playback will not be exact to the frame.

When the Pioneer players lock to the external black burst they briefly show a message on the screen that says "Locking To External Sync". When in doubt, after connecting and turning on the black burst, stop all of your players. The synchronizer will cycle them back up to speed in order to play them, but this allows the disc to not be running long enough for the players to lock to the external sync. Another method is to not turn on the players before turning on the black burst generator. Either power the synchronizer/black burst generator and the players up at the same time, or turn on the synchronizer/black burst generator first.

Cheap DVD-R Discs Can Cost Accuracy

We have found several instances where people using low cost DVD-R discs have ended up with installations that can not be accurately synchronized. We only recommend using Pioneer or Apple (which are made by Pioneer) brand DVD-R discs. Cheaper blank discs use cheaper dyes, and can result in higher error rates within the discs. DVD is designed to recover from errors on the discs, but that recovery can cost you a lost frame or two in the video. If the player loses a frame while playing your disc, it can lose track of exactly what frame it was playing and this will cause your otherwise perfectly synchronized discs to no longer match. Why spend thousands of dollars producing an accurate presentation, only to have it lose synchronization because you wanted to save a couple of dollars on cheaper blank discs? Stick with the Pioneer or Apple brand blank DVD-R discs.

Along those same lines, it is possible to also have errors on your discs caused by dust. Especially when the players have been kept in an environment where they may be excess dust in the air. Regularly clean the discs and the players to keep them free of dust.

Summary

We hope this tutorial has made it clear that there are many things involved in creating a frame accurate DVD synchronized presentation. Any one of those things can cause your presentation to lose accuracy. You need to pay attention to all of them. Letting one or more of these things get out of your control can cause your presentation to get out of your control too. Pay attention to all of the details and your presentation can be exact to the frame. Your discs are already made, and you need to program a DVDplay synchronizer to work with them. What do you do? You start by analyzing your discs to see what is possible and what is not.

Be sure to check our web site for updated versions of this and other tutorials.
www.djdesign.com