

2-3 Pulldown Explained

by Alan Stewart

Thanks to [Ron Friedman](#)

2-3 Pulldown

An NTSC video image consists of 525 horizontal lines of information. The electron gun scans top to bottom, left to right, odd numbered lines first, then the even numbered lines. Each full scan of even numbered lines, or odd numbered lines constitutes a "field". Each field scan takes 1/60th of a second, therefore a whole frame is scanned each 1/30th of a second. (literally 29.97 frames per second)

Film is generally shot and projected at 24 frames per second (fps), so when film frames are converted to NTSC video, the rate must be modified to play at 29.97 fps. During the telecine process, twelve (12) fields are added to each 24 frames of film (12 fields = 6 frames) so the same images that made up 24 frames of film then comprise 30 frames of video. Video plays at a speed of 29.97 fps so the film actually runs at 23.976 fps when transferred to video.

The Avid Film Composer assumes a 2-3 pull down. That means that the first frame of film is represented by 2 fields of video; the second frame of film is represented by 3 fields of video (1.5 frames); the third frame of film is again represented by two ields and the fourth frame of film is represented by 3 fields, and so on. In the end, what was running at 23.976 fps is running at 29.97 fps.

The first frame of video contains two fields of the 1st (A) frame of film.

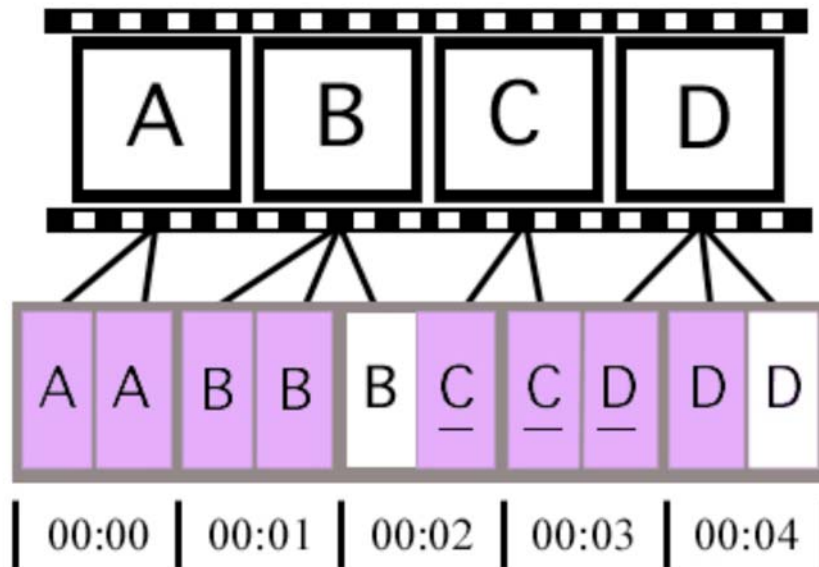
The second frame of video contains two fields of the 2nd (B) frame of film.

The third frame of video contains one field of the 2nd (B) and 3rd (C) frames of film.

The fourth frame of video contains one field of the 3rd (C) and 4th (D) frames of film.


The fifth frame of video contains two fields of the 4th (D) frame of film.

Four Film Frames

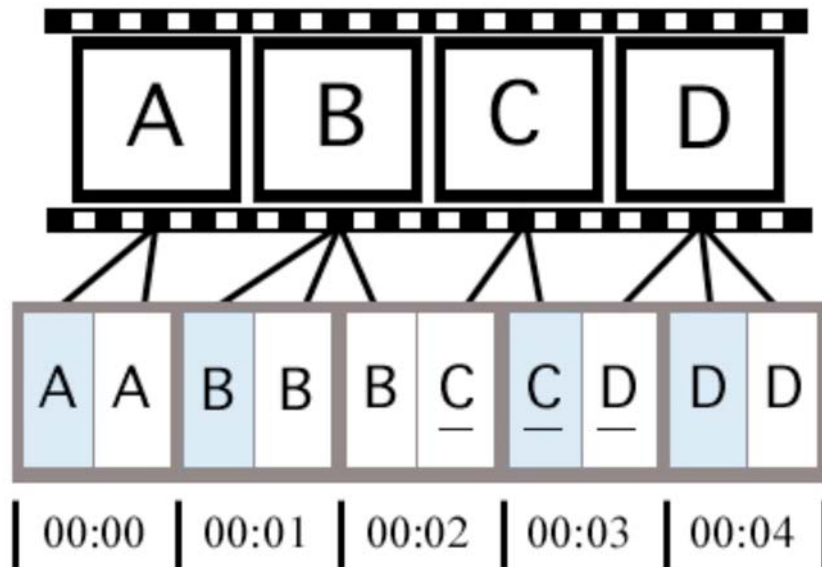


Five Video Frames


(10 video fields)

 = Fields captured in an Avid Meridien 24p project.
These are rejoined in a single progressive frame.

Four Film Frames



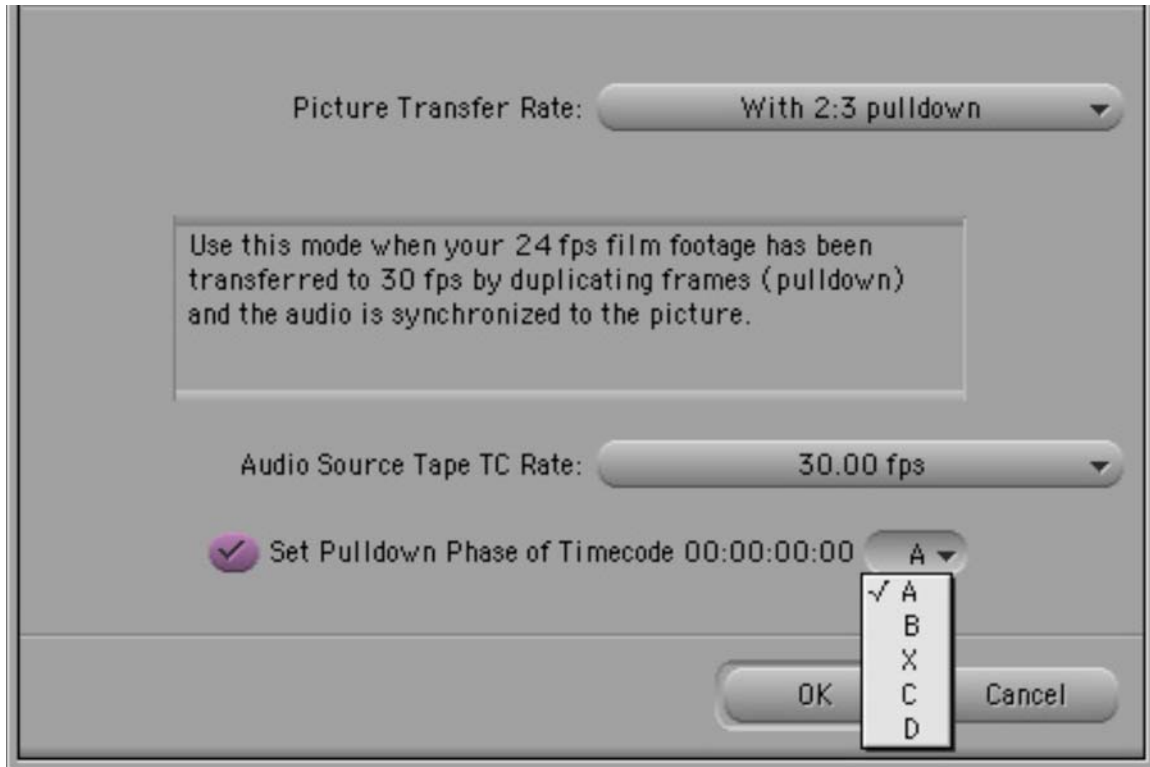
Five Video Frames (10 video fields)

 = Fields captured in a 24fps (single field) NuVista or ABVB project.

The graphics above shows how four frames of film become five frames of video; repeat that process six times and 24 frames of film become 30 frames of video. (technically, 23.976 frames of film become 29.97 frames of video, but it is easier to speak in whole numbers)

The Avid digitizes (records) and plays the film at 24 fps, in a Film Project, so the video has to be stripped of the fields that were added in the tape transfer process. Systems that digitize the 29.97 frames of video produce film Cut Lists by a process called **matchback** where the timecode (from an EDL) is used to locate the nearest real film frame for the negative cutter. Matchback is only accurate + or - one frame. One can choose to work at 30fps on an Avid and matchback for a negative cut, or work at 24 fps and produce a frame accurate negative Cut List. There is a process by which one can import an EDL from a 24 fps film project into a 30 fps project and redigitize the picture at a higher resolution (film projects only capture in single field resolutions).

Pulldown Phase



Avid software always assumes the first frame of a logged clip is an "A" frame unless it is told otherwise. This setting allows the user to work more easily with tapes that do not follow the standard conventions. For example, some telecine sessions or HD down-converts may have "B" frames on 00s and 05s, rather than 01s and 06s which is standard practice. Here one can inform the software that some other frame is on the 00s and 05s, so logging and capture-on-the-fly can be done accurately in a 24p project. If clips are imported from a shot log, this setting will not override the shot log's setting for the pull-in frame. Clips already logged in correctly can be modified using the Modify feature in the Clip menu.

2-3 Pulldown vs. 3-2

It is commonly referred to as 3-2 pulldown; while modern telecine machines can go either way, the norm is 2-3. Therefore, AA BB BC CD DD. If the telecine is set for 3-2, you'll get BB BC CD DD AA, which would require you to change the default pullin before digitizing the clips, because the clips head frames would be "B" rather than "A".

During the telecine process a computer file should be created which indicates the relative timecode, keycode and pullin frames ("A" frames) for each clip to be digitized. Once this file is imported into the Film Composer, clips can be batch digitized without a great deal of data entry on the operators part. You should have the KeyCode numbers displayed on the screen (burned in during the film-to-tape transfer) with an indication of the pulldown frames at the right end of those numbers and a hole punched on an "A" frame at the head of the roll where the digitizing will begin. If your KeyLog files are not accurate, or are missing, you can define and/or log the clips to be digitized individually. If the pulldown frames are not indicated on screen, you must determine which frame is an "A" frame by another method.

How to identify a pulldown frame

Identify a single frame of film (hole punch, a single frame in leader, a speck of dust,...) and scroll field by field through the video watching the time code. (each scroll bar that rolls across the screen indicates a new field, not a new frame)

If the selected frame is represented by only two fields, it is either an "A" or "C" frame. "A" - if the timecode changes after the 2nd field it is an "A" frame. "C" - if the timecode changes after the first field, it is a "C" frame.

If there are three fields representing the selected frame, it is either a "B" or "D" frame. "B" - if the timecode changes after the 2nd field it is a "B" frame. "D" - if the timecode changes after the 1st field it is a "D" frame.

Another slightly confusing consideration: When the pulldown process occurs, it turns out that the video version of the film runs slightly SLOWER than the original film did. This occurs because the film is running at 24 frames per second, but in order to create the right pattern of A-B-C-D on the video tape, which runs at 29.97 frames per second, the film was actually played at 23.976 fps during the telecine (film->tape process). This leads us to dealing with [audio considerations...](#)

Combined Fields

With the NuVista and Enhancement Boards one can select an "e" resolution (i.e., AVR6e) in a single field capture. The "e" board combines the two fields which represent an individual frame of film into one field of captured image. The sequence in a Film Project is A-B-C-D, but with the "e" resolution the image appears more attractive to the eye AND slightly reduces the storage requirements. The "e" board works only with a 640x480 image and is not

compatible with the 720x486 Avid Broadcast Video Board (ABVB).

Avid software versions 6.0.x through 6.1.x use the ABVB and did not offer the option to combine fields. Software versions 6.5.x and later have a software feature which combines fields, much as the Enhancement Board does with the NuVista images. A check-box in the Digitize Settings turns on the Combine Fields option. Combine Fields only works in Film Projects. Single field resolutions in a film project can include either "s" or "m" resolutions (i.e., AVR6s and AVR6m).

There is no need for the "combine fields" option in the Avid Meridien 24p project because the entire frame is captured in a progressive mode so 100% of the image is used and there are no fields as such. See [Avid 24p - The Basics](#) for more details.

Due to the fact that the "C" frame of film is split between two different frames of video, the frame/field count in the timecode burn-in will be blurred, as it contains two different TC addresses for the "C" frame when using Combine Fields.