

# HOW DO 24 FILM FRAMES EQUAL 30 VIDEO FRAMES? - OR - MORE THAN YOU EVER WANTED TO KNOW ABOUT FIELDS AND FRAMES!

Written by: Pam Malouf, A.C.E.

The purpose of this article is to provide (as simply as possible) a clear and comprehensive explanation of video fields and frames and how 24 fps film frames (and digital systems) relate to them. If that goal is accomplished, this will explain why a film project cannot properly digitize as a video project, why an online will not *precisely* match a cut negative or digital output, and more.

## Let's talk about fields -

United States, 60 cycle (Hz) electricity pulses 60 times every second. The pioneers of television and video technology had to create a signal that could pulse 60 times each second. Video was created - 30 frames per second with two fields per frame - hence, 60 "pulses" per second. NTSC color video standard calls for 525 lines of information scanned at a rate of 30 frames per second, hence, each field scans 262.5 horizontal lines. Some people refer to the two fields of a video frame as being "interlaced." They are also referred to as "odd and even" fields, or "field one and field two".

Diagram 1.

4 FILM FRAMES	10 VIDEO FIELDS	5 VIDEO FRAMES
A	A F1	A 1
	A F2	
B	B F1	B 2
	B F2	
C	B F1	C 3
	C F2	
D	C F1	D 4
	D F2	
D	D F1	D 5
	D F2	

In **Diagram 1**, these fields are indicated by F1 and F2. It doesn't matter what image is on a video field - the important point is that **video must be respected as it's own medium requiring two fields (one odd, one even) per frame**. Not a half a field from one frame and a half a field from another - **each video frame must have it's own two fields!**

Well, it'd be really perfect if **film** were 30 fps but it's not!

### 3 - 2 PULL DOWN

This created a problem - how to get 24 frames to equal 30! Even though a **video frame must have two fields**, each field *can* have a different image! So, it works like this: 2 video fields for the first film frame, 3 video fields for the second film frame, 2 for the third, 3 for the fourth and so on - 2,3,2,3. This is referred to as the "Three-two pull down" (side note on

this at end of article).

## DIAGRAM 1 -

The first column shows four film frames. The next column shows how that equates (gets translated) to 10 video fields. The next column shows how that equates into 5 video frames.

**WE CAN'T SEE THOSE REPEATING FIELDS?**

24 film frames per second are translated into 60 video fields per second. **The totality of what material we see in one second remains the same.** 1/60th of a second is invisible to the naked eye. *Everything* we've *ever* watched on tape or TV - that was shot on film - does indeed have an extra field for every other frame.

**HOW DIGITAL SYSTEMS DIGITIZE AND SAVE SPACE**

Now that we've established that there are two to three *video* fields per *film* frame, let's analyze 24 frame capture (digitizing). Guess what? Another Techno wizard said "if each of the two fields of a video frame is the same image visually, let's digitize just one field and that will save hard drive storage space! We can then duplicate the fields during play back." Great idea. This is also the root of all *digital skipping* problems. But before we get into that, let's get back to how systems digitize.

The digital systems all work with one field only for digitizing. Avid takes the first video field and digitizes that. Lightworks takes the second field and digitizes that.

Now, look at Diagram 2. Because only one field is digitized, you'll see that the third (Avid) or fourth (Lightworks) frame becomes a duplicate. The digital systems ignore, and do not digitize this frame. In other words, they throw this extra video frame out. This allows for true 24 frame capture and film editing - which, of course, is wonderful.

Diagram 2 How 5 Video frames are digitized as four film frames:

4 FILM FRAMES	5 VIDEO FRAMES		DIGITIZED FRAMES		PLAY BACK
			Avid - field one	Lightworks - field two	
<b>A</b>	field one	A	1 A	1 A	A
	field two	A			A
<b>B</b>	field one	B	2 B	2 B	B
	field two	B			B
<b>C</b>	field one	B	3 B	3 C	B
	field two	C			Avid throws out this frame
<b>D</b>	field one	C	4 C	4 D	C
	field two	D			Lightworks throws out this
<b>D</b>	field one	D	5 D	5 D	D
	field two	D			D

When you **play back** your cut or make an output (in a 24 fps project), the digital system recreates the extra fields based on the 3-2 pull down formula (Diagram 2, column 5). **The digital system takes frame one of your cut and immediately starts the 2-3-2-3 field configuration.** This is *exactly* what happens when your cut negative is put on a Telecine machine starting with frame one. The great thing about this is, that if you are cutting negative, your digital output will precisely match a Telecine transfer of your cut negative.

**MAKING SURE YOUR DIGITAL OUTPUT PRECISELY MATCHES YOUR CUT NEGATIVE!**

As editors, we must be aware that *if you abort a final assembly (digital output) in the middle of a reel or act, and then do a pick up on your digital system, you have re-started the 2-3-2-3 configuration and therefore you may not match your cut negative by one to two fields.* Abort and pick-up more than once, and you could be out of sync by several frames! For example, you may have aborted at the end of a two field edit, where the next cut would have started with a three field edit. The 2-3-2-3 configuration will be restarted at the pickup point and that next frame coming in on your output will come in with two fields only. But when your negative gets transferred, that frame will be a three field edit - because the 2-3-2-3 configuration will not have been interrupted.

Bottom line? *When you are doing your final digital output, you should not make any pickups in your assembly.* If you have to stop and make a change, then you should start the output over starting with frame one of your cut (reel or act) so that the 2-3-2-3 configuration *remains constant* throughout the entire reel or act. This will assure that your cut negative tape transfer will precisely match your digital output. You could try and do a pick up on a two field edit, but the decks are not guaranteed to be field accurate. By the way, because of this, it's best to *start your assembly based on a time code* rather than manually setting the 3/4" deck.

**WHY DO 24 FPS FILM DAILIES STUTTER WHEN DIGITIZED AS A 30 FPS VIDEO PROJECT?**

Let's say you're cutting a show that isn't going to cut negative because they are shooting it partially on film and partially on video tape. So, you load it as a 30 fps video project and notice that your digitized film dailies stutter upon playback. **Sorry** - but there is nothing you can do about it!

**DIAGRAM 3 -**

Diagram 3 24 FPS FILM DAILIES DIGITIZED AS 30 FPS PROJECT

	VIDEO FIELDS FROM FILM SOURCE	(USING FIELD ONE)	DIGITIZED FIELDS	PLAYBACK IN VIDEO PROJECT
field one	A	1	1 A	A
field two	A			A
field one	B	2	2 B	B
field two	B			B
field one	B	3	3 B	B
field two	C			B
field one	C	4	4 C	C
field two	D			C
field one	D	5	5 D	D
field two	D			D

Playback in a 30fps video project verses a 24fps film project is different. Notice above that each field is played back twice, whereas playback in a film project uses the 3-2 pulldown field configuration.

When you digitize as a **30 frame video project**, the digitizing and playback process changes! One field of **each** video frame is digitized and each field is played **twice** during playback. The 3-2 field configuration does not take place during playback in a video project. Hence, the stutter effect for 24 frame film digitized into a video project. (We humans *can* see that extra field when it's out of proper sequence!) Perhaps it goes without saying, but, **original 30 fps video dailies** digitize and playback accurately in a 30 fps project.

The only solution for us editors who need to cut 24 frame film in a 30 frame project, would be to digitize it at, for example, level 75, where they digitize both fields. (Not really practical on a hard drive storage level.)

Or, if you must mix tape and film dailies, you might experiment loading it all as a 24 frame *film* project - stuttering video dailies may

look less offensive than stuttering film dailies. Perhaps someday, the electronic editing systems will have an option to digitize both fields (besides broadcast quality which uses double the storage space.)

## **WHY AN ONLINE (TAPE TO TAPE) WILL NEVER PRECISELY MATCH YOUR 24 fps OUTPUT OR CUT NEGATIVE TRANSFER**

Here's where the fact that *each video frame must always have its own two fields* comes into play most obviously. (Because there is not an even ratio of film to video frames, the cut film and corresponding video edit points do not line up evenly.) A video edit in the EDL might be slightly longer or shorter than the corresponding film edit.

Look at Diagram 1 for a moment. Let's say you have a 2 frame cut (frames A & B) that you want to online. It will never, ever online as 2 ½ video frames. That's not possible - no more than having a 3 perf film frame in the middle of a reel of 4 perf cut negative. Therefore, the online will be either 3 video frames (6 fields) or 2 video frames (4 fields). Your online will be one field longer or shorter than your cut. Put another way, with a ratio of 24 film frames to 30 video frames, *a 6 frame film edit corresponds exactly to a 7 ½ frame video edit*. However, video edits cannot include partial frames (less than two fields,) so the video edit must be 7 or 8 frames long.

Based on durations and time codes, the digital systems add or subtract a video frame to match as closely as possible the film cut list. Therefore, your video online will never be more than 3 fields out of sync with your cut negative. (Only! Ha!) So if you ended a cut on a close-up of a dead man - and that actor opened his eyes on the very next frame - that frame could end up in the movie if you online your show!

Meanwhile, (not to depress you,) the **audio is correcting itself independently of the video** because the audio edits are usually occurring at different points (due to split edits and overlaps). Unfortunately, this means the picture and audio can be out of sync for a video edit, although by no more than a frame. To quote the Avid user manual - "this effect is the natural result of the sync disruption caused when 24 fps is converted to 30 fps."

### ***What can be done about these discrepancies in my online verses cut negative?***

If your producers want to cut negative, the most accurate and cost efficient way to go, is to make a digital output (without pickups - as previously mentioned) - do not online. Give the output to your negative cutters and sound editors. When the negative is cut, it will precisely match your output.

If you must online a film show you must be aware that at any point - a cut you made may be up to 1 ½ frames longer or shorter. So, plan to view the final online and look for critical edits that may have changed. You can then correct them in an online bay. Also, there will be some cuts that go in and out of sync with your video - there is nothing you can do about this except warn your sound editors! (Unfortunately, if the dailies were already a frame or so out of sync, and then the online adds another frame - this can sometimes be quite noticeable.)

-----

If your head isn't spinning with technical information and you care to read more, below are a few side notes.

### ***SIDE NOTES:***

***An odd field must always cut to an even field*** or you have Color Framing problems - a color shift or bump occurs. Because of this you'll find that if you call around town, every Video House is either field one or field two dominate. This means that all video edits made, in any bay in that video house, should always occur on the same field. Keep this in mind if you see an unexplained color bump on your online master.

***THE NAME "3-2 Pull Down"*** - (the A-B-C-D // 2-3-2-3 sequencing) - *originally started with a 3 field (3-2-3-2)* but the technicians soon discovered that starting with a 2 field was better, but they never changed the name!

***The "3-2 Pull Down"*** field configuration - A-B-C-D // 2-3-2-3 sequencing - (which is how 24fps film is transferred to 30 fps video tape,) is based on **four** film frames equaling **five** video frames. Then the A-B-C-D sequence restarts.

Therefore:

A = 2 fields

And  
C = 2 fields  
**BUT ...**

**A**  **C**

*So, if you're trying to do a 24 frame capture from a digital output tape* or any tape that originated from film and it stutters - that's because you started on a random or 3 field frame. Keep re-trying until you start on the first field of an A frame and it will digitize properly.

*Video is really 29.97 frames per second* because NTSC standard television operates at 59.94 Hz, therefore *24 fps film is actually transferred in Telecine at 23.976* frames per second - this allows the film frames to divide evenly into 29.97. (The sound is also slowed down by .01%.) Upon playback, the digital systems speed them up to play at a true 24 frames per second. Fine. The repercussions to us as film editors occur only if you need to output audio that will be transferred to 35mm mag and expected to play in sync with a projected film print. (There is a procedure for doing this but it is not an aspect *this* article will go into.)

*For further details about time codes* and how they relate to 59.94 Hz verses 60 Hz, please read "To Drop or Not to Drop."

Pam Malouf started as an assistant film editor in 1976. After a few years in Post Production management in the early 80's, she began cutting film & tape promos and trailers. Since 1985 she has been editing television series and TV movies. Besides film, Pam has edited on the Montage, Laser Edit, Ediflex tape, Ediflex Digital and the Avid. She has cut shows using non-drop and drop frame time code, that both onlined and/or cut negative.