



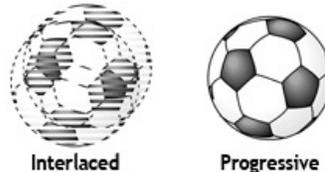
## Frame Rate Conversion Simplified

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### Why So Many Frame Rates?

Motion pictures, whether film or television, are nothing more than a series of rapidly changing still images, or frames. The faster they change the smoother the motion. A long time ago it was determined that 24 frames per second was acceptable for motion, but left a noticeable flicker due to the screen going dark each time a frame was pulled into place. By putting a rotating shutter in the projector to create a flicker rate of 48 frames per second the illusion of a steady moving picture was created. When the NTSC television standard was created a frame rate of 30 frames per second was selected because it was half the electrical line rate of 60Hz. To avoid flicker it was necessary to create an effective frame rate of 60 frames per second, but the technology of the time could not transmit that much information that fast. The solution was to first scan only the odd lines, then the even ones, dividing the picture in half as two interlaced fields. The result of this is a full resolution image if an object is standing still, but two slightly offset versions of the object if it is in motion. When color was added it was necessary to adjust the frame rate slightly to prevent the color information from interfering with the audio carrier in a television broadcast signal. Thus the frame rate for NTSC became 29.97.

In Europe the electrical line rate is 50Hz, so the PAL standard set the frame rate at 25 frames per second, and like America used interlacing to gain a flicker rate of 50 fields per second. Fortunately PAL did not have a problem between color and audio, so PAL still runs at 50 fields per second.



*An example of a soccer ball in motion*

When a committee was formed to set a standard for high definition television they decided not to set one standard, but allow many. The 29.97 interlaced frame rate was preserved for compatibility with existing systems, and even frame rates (30 & 60) were added as well. In addition, progressive rates, where the entire frame is sent together, were added. Thus 29.97 progressive, 30 progressive, 59.94 progressive, and 60 frame progressive were added to the mix. Later the obvious step of adding a high definition standard that matched film was taken and 24 and 23.98 progressive were added. (23.98 has the same offset from 24 as 29.97 has from 30 and was necessary to be compatible with NTSC.) In PAL countries 25 and 50 progressive were added as well. As a result of all this there are at least one dozen possible frame rates in today's high definition video.

### Converting Between Frame Rates

Some conversions are easy. Converting between 24 and 25 just requires speeding up or slowing down the source by 4.16% (Audio may require separate pitch and data-rate conversion). Converting between fractionally adjacent speeds (59.97 to 60) is even easier. Converting a slower frame rate to a faster one requires duplicating frames or fields. People have been transferring film to video for a long time. For NTSC the film is slowed down to 23.98, and then every other film frame is held for one extra field. (see diagram) This is called 3:2 pulldown. Some of the original film frames now begin on the second field of the video frame. This looks fine while being played, and can easily be removed for conversion to 25 frame PAL or 24 fps for DVD compression. However, if this material is edited without attention to keeping a steady 3:2:3:2:3:2 cadence, a clean frame rate conversion becomes nearly impossible.

Recently some computer systems, and tape formats, have chosen to convert 24 to 30 by simply duplicating every fourth frame. This makes editing simpler, and works well for computer formats that can not handle interlaced images, but it results in a noticeable stutter six times every second. Also professional systems that are expecting a 3:2 cadence will not know how to remove the extra frames.

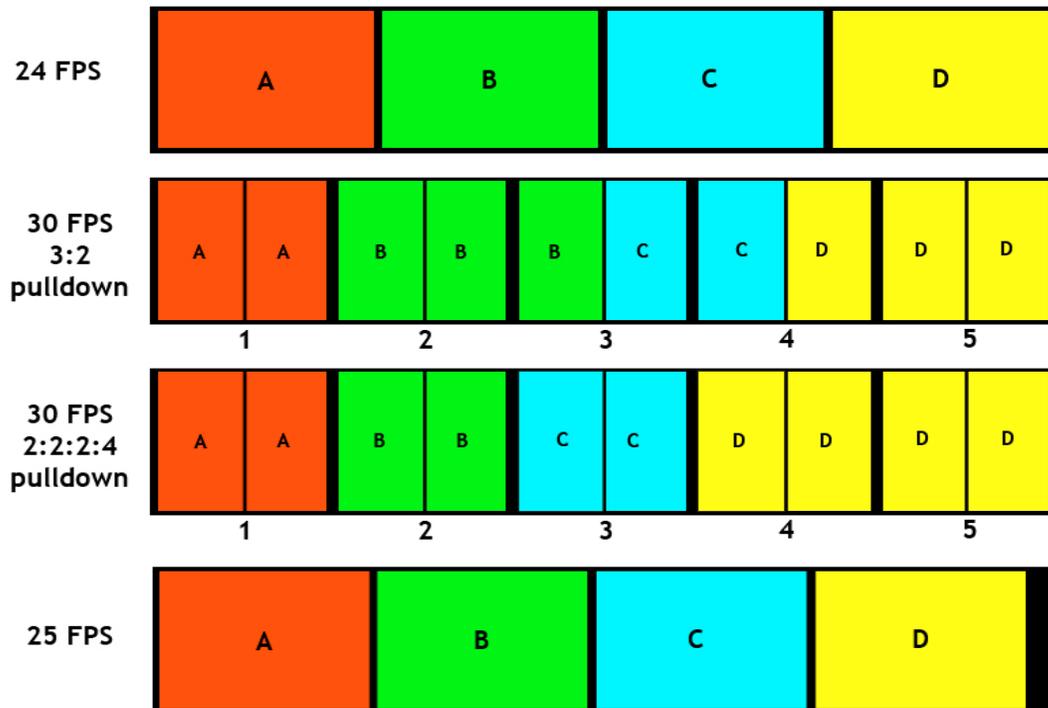


Where conversions become difficult is when an interlaced format is converted to a progressive one, or when large frame rate reductions are needed. When an interlaced format is converted to a similar progressive one (i.e. 30i to 30p) either every other field is discarded, resulting in an image with only half the vertical resolution, or the fields are blended, creating a distorted image (all moving objects will have serrated edges). The only way around this is to interpolate, or create an entirely new image out of the two fields. How well this works depends entirely on the quality of the hardware or software performing the interpolation. When going from a high frame rate to a lower one some frames must be discarded, resulting in choppy motion. The only way around this is to discard all the original frames and create an entirely new sequence using the information in the old ones to estimate where things would have been had it been shot at the new frame rate. This is a very complicated process that takes a lot of computer power and time. Depending on the quality of the software used the results can vary greatly.

### How To Survive In A Multiple Frame Rate World

It is not uncommon for a project to be distributed in multiple frame rates. American television runs at either 29.97i or 59.94p. Europe and many others are 50i, while film is still shown at 24 frames per second. For a project to be easily and inexpensively made available for all of these markets it is important to take the frame rate into account from the beginning. For a universal format nothing beats 23.98psf. With no quality loss and little expense it can convert to any format. However many smaller format HD cameras that claim to record 24p don't. These cameras capture images at 24 frames per second, but the tape records at 60i. If they use a standard conversion format, such as 3:2 pulldown, this is not a problem, as many systems can easily remove the extra fields. But if a non-standard conversion is used it may be difficult, or even impossible to create a satisfactory 24 frame master. Also, if using a 24/60i camera be sure to convert to 24 frames per second (actually 23.98) before editing, or you may end up with an unusable master.

24 frame converted to 30 & 25 frame formats





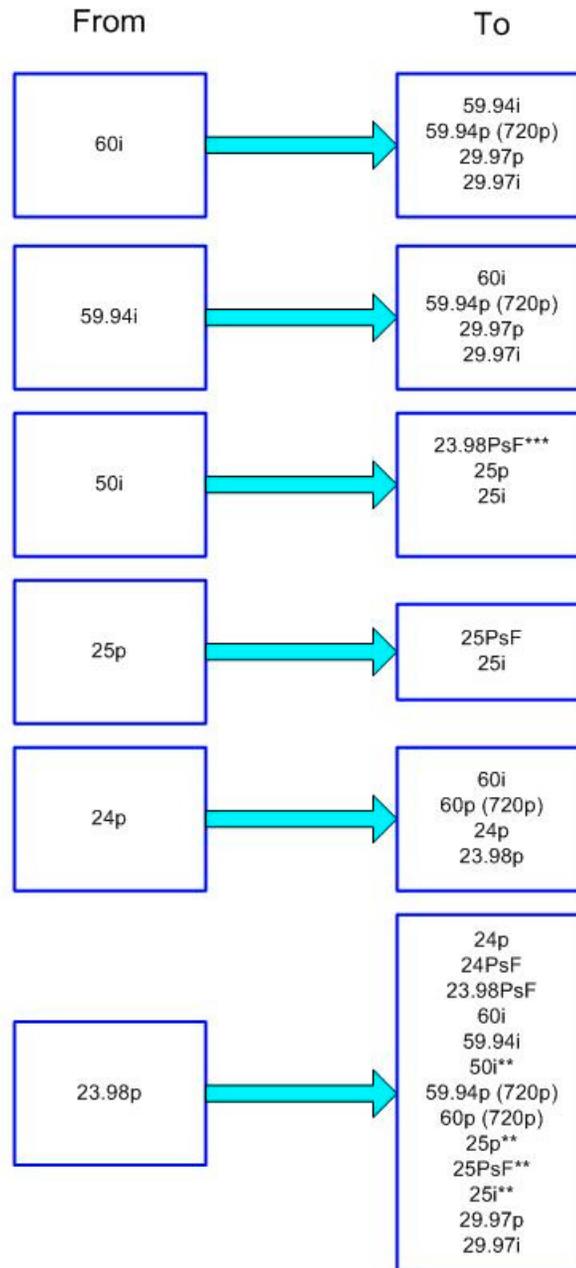
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## ***SIMPLE FRAME RATE CONVERSIONS\**** ***(NOT REQUIRING SPECIAL PROCESSING)***



\*Any frame rate conversion will result in the loss of all Closed Captioning data.

\*\* Conversion is accomplished by playing the material at the new speed. As a result audio may need to be pitch corrected and music will have a slight change in tempo.

\*\*\* Only HDCAM-SR can convert both picture and audio at these rates. Material not originating on HDCAM-SR would have to be dubbed to HDCAM-SR for conversion, or externally converted and pitch corrected.