CinemaSource™

Home Theater Video Processors


CinemaSource™

Our current NTSC color video standard is very old. The original B&W portion of the signal was developed during the 1930s when the largest CRT displays were less than 10” in diameter. The engineers involved at the time probably never thought that many years later the country would have thousands of “home theaters” with 100”/120”-size video images using the same basic signal -a signal that has been blown up so large that the “scan lines” that make up the picture are distractingly obvious.

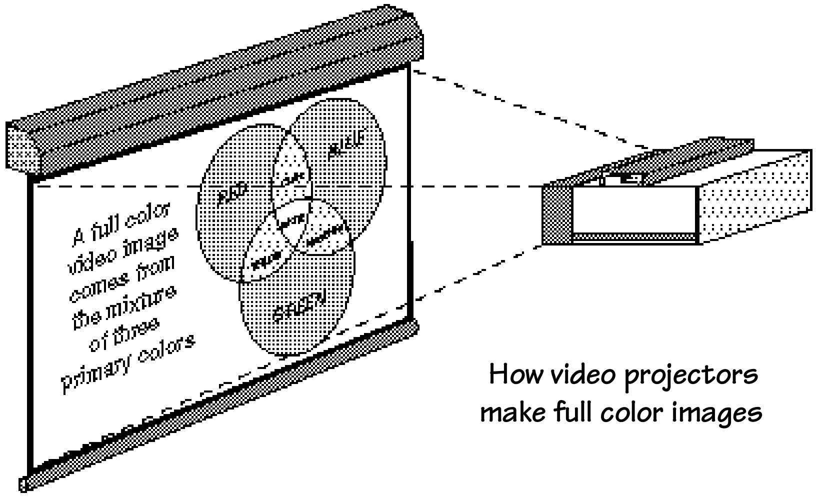
Today, electrical engineering has advanced to a point where it is possible to reduce the visibility of the picture scan lines using sophisticated digital processing techniques. The general term for this process is called line doubling and line quadrupling. It is very popular for high end home theaters because it makes a video image look smooth and film-like. Line doubling/quadrupling is an amazing process, but it requires an investment in two items: a line doubler/quadrupler and a data grade (or graphics grade) projector. Newer units called scalars, which optimize any source for your projector’s optimum scanning rate are beginning to appear on the market.

How A Video Image Is Made

A video image is made by sweeping an electron beam across phosphors (chemicals that glow when electrically excited) and changing the intensity of the beam to “paint the picture with light and dark areas.” If you look closely at the picture on a television set, you will see the scan lines and colored phosphor stripes that make up the image.

The standard video signal in North America is referred to as “NTSC Video” or “Composite Video”. This signal consists of 262.5 horizontal scanning lines per video field, two video fields per video frame (thus 525 lines per frame) and there are 30 video frames scanned per second. The diagram on the next page shows a simplified scanned image with two video fields combining to make one video frame. This is called interlaced scanning.

There are three primary phosphor colors (red, green and blue) used in color video display devices and by combining the excitation of the three different phosphors, a complete spectrum of colors can be reproduced. With a CRT based projection television, the primary colors are projected on top of each other to produce the full spectrum of broadcast colors.



How video projectors make full color images

How Line Doublers/Quadruplers Work

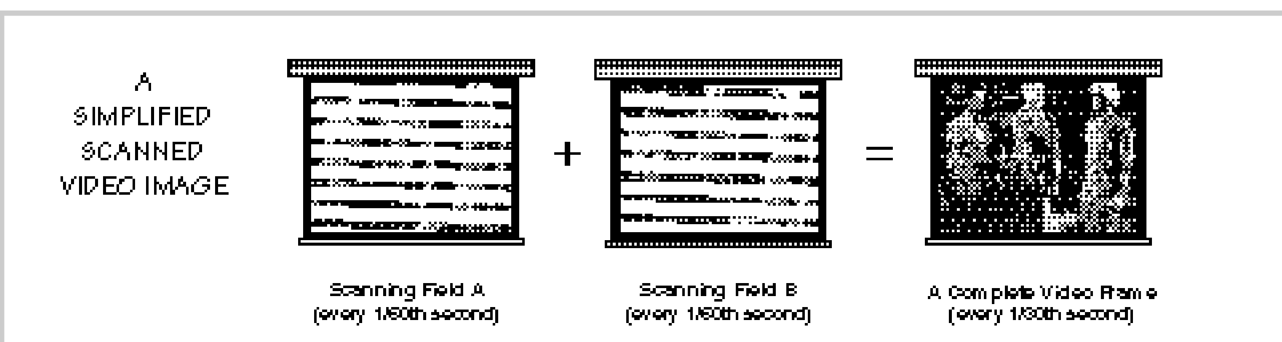
As we mentioned before, the present NTSC 525 line format was developed as a black and white standard in the early 1940s and color was added in 1953. When the standard was originally conceived, the electrical engineers chose 525 lines so that the average viewer *would not see the scan lines* making up the image. They succeeded in this respect, but, as we mentioned, the picture tubes of the time were considerably smaller than what we have today.

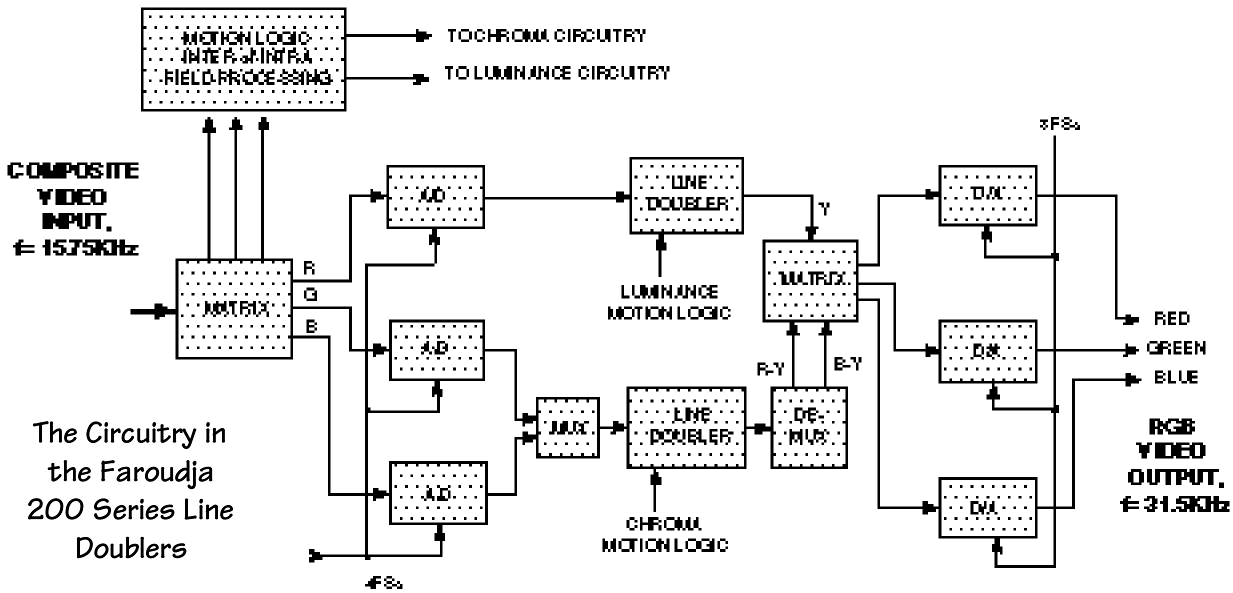
Line doublers are really just signal processors that take an NTSC video signal and convert it into a doubled scan rate video signal. A line doubler allows the display of 525 (instead of 262.5) distinct lines every 1/60th of a second, thus reducing line visibility.

The missing lines are generated two ways. If there is no motion in the picture, the missing lines are generated from the previous field. If there is motion in the picture. the missing line are generated by interpolation the present upper and lower lines.The secret of a well-designed line doubler is the motion detector which allows a choice between the two modes of operation. The line doubler is far from simple. It requires sophisticated digital signal processing algorithms that function in real time to create seamless action with no artifacts.

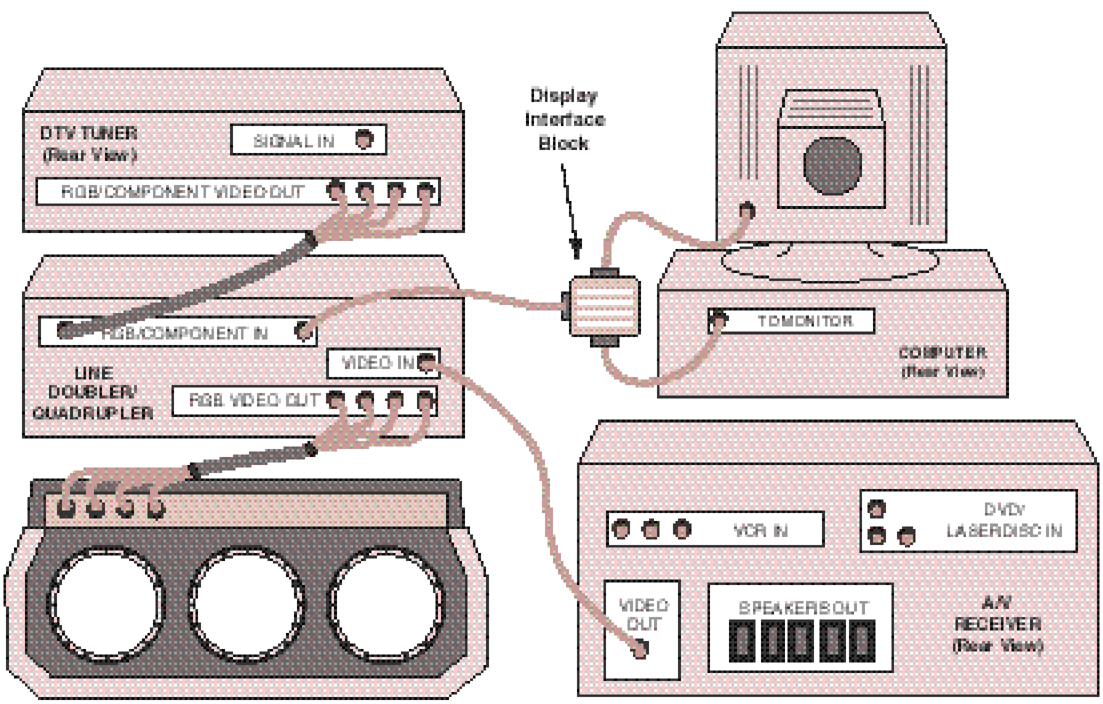
Line Doublers Improve The Picture In Other Ways Too

Elimination of color blurring: Because of the limitations of the human visual system, humans cannot see sharp details in colored images. TV engineers exploited this phenomena when the NTSC standard was being developed. As a result, the NTSC video signal has severe chroma (color) bandwidth restrictions. The result is blurry, smeared colors. This effect is further aggravated by storage media, such as VHS tape, that further degrade the chroma. (ever notice that highly saturated reds always look smeared on VHS tape? This problem results from lack of chroma bandwidth.) A solution is circuitry that uses





The Circuitry in the Faroudja 200 Series Line Doublers



How Video Scanning P rocessors Integr ate Into Typical Home Theaters

After Before

Minimizing Dot Crawl
with accurate Y/C decoding

the sharper B&W transitions in the signal to create a correction signal to sharpen the color transitions.

Eliminating rainbow patterns: Have you ever watched the detail in a hound's tooth sports jacket ripple with colored rainbows as the camera zooms in? If so, you have seen a good example of cross color interference. This annoying artifact is caused by the imperfect separation of the color and the B&W information by the color decoding circuitry.

In the past there was little that could be done about this problem. Today we can use digital adaptive comb filter techniques that don't get fooled by areas in the video image that have fine detail. When the techniques are properly executed, the color rippling caused by cross-color interference can be essentially eliminated.

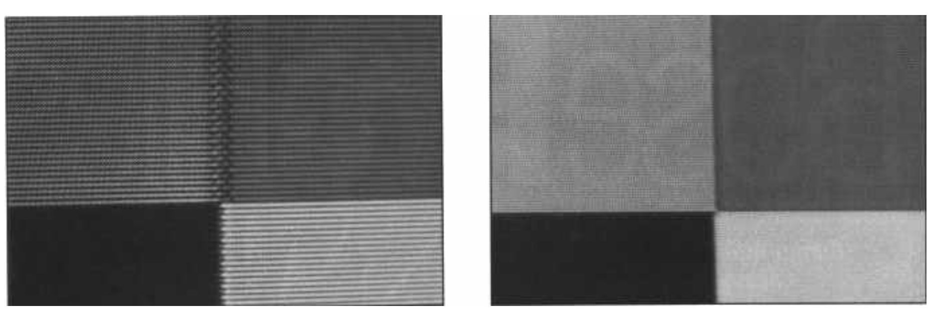
Minimizing dot crawl and hanging dot structure: This phenomena is easily seen when a large stationary colored graphic appears in the video image. It is especially obvious when a color bar test pattern is displayed. Dot crawl is a rapid upward movement of of colored "dots" on vertical transitions in the graphic. The other artifact, hanging dots, lie underneath all the colored horizontal transitions. Engineers refer to both of these phenomena as the artifacts of of cross-luminance interference. They appear from an imperfect color decoding process. Again, we have techniques that that can minimize these effects. Note the absence of dot crawl and hanging dots in the image above when our improved decoder circuitry is used.

It should be noted that these techniques are also being applied to Pal and SECAM video signals. (The NTSC format is used in North America and Japan. PAL is used in most of Europe, Asia and Africa. SECAM is used in France and the countries that comprised the former Soviet Union.)
In particular, the color-transition sharpening circuitry, the digital adaptive comb filtering and other chroma decoding techniques are useful for PAL enhancement. The line doubling technology that produces additional scan lines can be applied to SECAM and PAL displays. In Europe where MAC (Multiple Analog Components) transition schemes are being used, line doubling and some of the signal enhancement methods can also be used to improve the the decoded RGB video signal.

How They Do It

In a line doubler/quadrupler, the processing takes place digitally, so the input analog NTSC video signal is demodulated into red, green and blue signals and then immediately digitized. Then the signal is scan doubled, motion corrected, sharpened, all in the digital domain, and converted back to an analog RGB signal. This signal now scans at 31.5 kHz, twice the NTSC frequency, and is connected to a data grade or graphics grade projector. For quadrupling, four times the NTSC frequency or 63Khz is needed.

Elimination of Dot Crawl and Hanging Dots



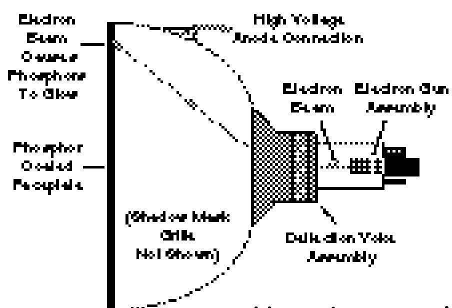
Before Processing After Processing

Understanding Progressive Scanning

Since debuting in the late 1930s, television receivers and the images they display, have evolved continuously and prodigiously. From small, marginally acceptable, B&W affairs television images have morphed into enormous, full color, theater-like displays. And this remarkable change can be attributed to the unrelenting R&D efforts on the parts of hundreds of video technology companies, and individuals, all in pursuit of progress and "competitive advantage". Yet despite the magnitude of this effort, and major advancements in componentry, such as transistors, integrated circuits and microprocessors, some aspects of today's video displays remain firmly rooted in the past. And one of these is the very basic format by which standard video images are created; via interlaced raster scanning techniques.

Raster Scanning 101

Raster scanning is the standard process by which CRT-based display devices create video images. There are other ways to derive images from CRT displays, such as vector-based methods (used in some air traffic control displays and military applications), but by far the most common method used is raster scanning. Raster scanning refers to the method by which video images are actually "assembled" on the face of the CRT. But before we dig into the principals of scanning, let's consider how standard picture tubes actually generate light.



How picture tubes produce light

It starts with a device located deep in the neck of all picture tubes called an electron gun. Electron guns are assemblies that are designed to emit, focus and control streams of electron particles. They are connected to external high voltage power supplies which generate a tremendous potential (27 to 32 Kilovolts) between the electron gun and shadow mask/face plate assemblies. The result is that electrons fly off the cathode surface of the electron gun, and head straight for individual phosphor patches deposited on the face plate. After impact, the phosphors glow, for a brief moment, and then extinguish. The key to making a complete video image with this system is to scan all phosphor patches across the face plate repeatedly. And this is where raster scanning comes into the story.

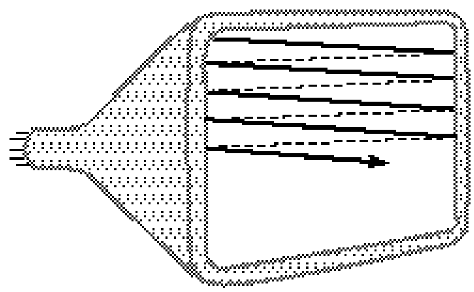
Looking straight at the face of a picture tube, the raster scanning process starts in the upper left hand corner. The electron beam is positioned here, electromagnetically, by the deflection yoke assembly. Scanning starts when the beam is rapidly swept from the left side of the tube over to the right, again, electromagnetically. As it runs across the tube face, the electron beam varies in intensity and causes the phosphors to glow in differing amounts. This first completed sweep becomes one thin slice of a complete video image. Next, the beam is then blanked (turned off) and "flys back" to the left hand side of the tube, and then the whole process begins again. Scan...flyback...scan...flyback... this procedure occurs until the scanning reaches the bottom of the tube and one pass is completed. The electron beam is now blanked again, this time for a longer period, and the vertical section of the deflection yoke lifts the electron beam up to the left-hand top of the tube where the next pass begins.

Now that we have illustrated how one complete pass is completed, let's look at how others are added. This can be accomplished in two ways; either by "interlacing" the scans, or simply writing the entire image at once; "progressively". As it turns out, you have probably seen both methods in use. Interlaced scanning is the technique utilized by all standard television receivers. It is called interlacing because incomplete "A fields" are displayed first and then "B fields" come along and interlace between the lines. The diagram on the next page illustrates this. In case you think this is an odd way to create video images, you're right. But there's a good reason for it, and that is to conserve bandwidth. By using scans that interlace, the resultant television signal is half the size (in frequency) as a progressively scanned one, and in the telecommunications world, bandwidth is scarce. There is only so much bandwidth (frequency spectrum) to go around, so engineers are constantly finding ways to maximize the amount of information they can fit into a allotted frequency slots. In the all-analog world of the 1930s, interlacing was the technique chosen to keep the size of the signal manageable, and as a side benefit, it made the receivers less expensive to produce (more on this later).

Progressive scanning is another way to generate and display video images. Instead of transmitting interlacing A & B fields, a complete video image is transmitted all at once. The computer industry long ago decided that progressive scanning was the technique of choice for them. Since they are not constrained to narrow terrestrial broadcast channels, the computer manufacturers went for maximum image quality. Progressive scanning is a requisite for this.

The Evils of Interlace

Not only does the concept of interlacing video images seem odd, it also produces odd artifacts. The engineers that designed the system long ago were well aware of these artifacts, but weren't bothered because they were considered imperceptible on the small 5 to 9" B&W displays common at the time. And today? Well, we have displays over ten times that size and, as a result, interlacing artifacts can sometimes be seen. For example:



How Raster Scanning Works:
Scan...Flyback...Scan...Flyback...

1) Interline Flicker. Video consists of a rapid series of images or frames displayed one after another. They occur so rapidly that the human visual system integrates them into a continuous moving image. However, if the frequency of frames slows down, you will see the video image flickering, just like in an old B&W movie. This critical "flicker frequency", as measured by countless psychoperceptual studies, occurs somewhere below 50-60 times per second (it depends on the person observing, some people are more perceptible to flicker than others.) Now this is not a problem with larger objects being displayed because both the A and B fields contain sections from the same image. However, if the image is made up of fine horizontal lines, some of the information may not be averaged over different fields. It will show up in specific fields, either all the A fields, or the B fields, and because these are drawn 30 times per second, you are bound to see interline flicker. Engineers sometimes refer to this problem as "venetian blind flutter" because venetian blinds are one of the most common objects demonstrating the phenomena. It occurs when the venetian blind is just at the right size so that each blade of the blind is scanned in the same field. The result is the entire blind pulsates at 30 hz. Our diagram shows how this could happen.

2) Reduction of Vertical Resolution. Another artifact that interlacing brings to us is a reduction in resolution that occurs when fine detailed images move up and down. What happens is that when objects move at exactly the right rate, one video field captures the movement of the object as it scrolls vertically, and the other does not. The effect is to cut the vertical resolution in half because only one field is used to transmit the image. Unfortunately, this often occurs when credits scroll at just the right speed and the result is poor legibility

What can be done, besides just talking about it?

On standard NTSC television receivers, not much. Interlacing, and it's attendant artifacts, are simply a way of life. It's been that way since the beginning of television broadcasting. But don't lose sleep over this, interlacing artifacts are rarely perceptible on smaller displays (under 50 inches or so). They really are more of an academic problem, and only occasionally seen in significantly larger images. But you say you want to build a home theater with a 100" front projected display? Then, there is one device that can help: a line doubler.

Line doublers are signal processing devices that take standard NTSC video, adds some image enhancement, and converts the signal to progressively scanned 31.5Khz video. Because the output of these devices is progressively scanned, the artifacts we illustrated before are not seen. (It is impossible to get a 30 hz flicker in a 60hz progressively scanned image because every single pixel is refreshed at a 60 hz rate.) But note: because the line-doubled output signal is a higher scan rate than NTSC, it must be displayed by a data or graphics-rate display device, typically a front projection monitor. These are more expensive than standard video-grade monitors.

Grand Illusions

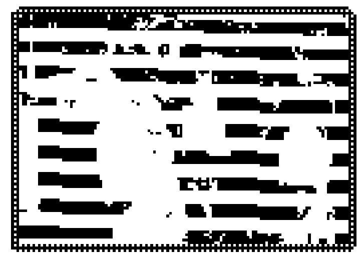
The reason discussions of interlace vs progressive scanning are becoming so common these days is because of the new digital television standard being developed. This new standard, DTV (previously referred to as "HDTV" and "ATV"), is almost certainly going to incorporate both types of scans. You would think with a new, state-of-the-art, digital television standard about to appear, that interlaced scanning as a technique would be relegated to the video history books. However, this is not the case, and there are several reasons for it.

It starts with the Grand Alliance. This consortium of key industry groups, including AT&T, General Instruments, MIT, Philips, Sarnoff Labs, Thompson and Zenith, was allowed by the FCC to combine forces and help define the final digital television standard. Incorporating the desires of the television broadcast industry, the computer industry, and international groups, the Grand Alliance has suggested four main "modes" for the digital television signal format. The chart to the below illustrates the modes suggested as this magazine goes to press (there are already rumors that it may change in the interim). As you can see, three of the modes can be displayed in interlaced form. The lowest resolution mode, 640 x 480, allows four different vertical rates, and one of them is interlaced. The reason for the incorporation of this particular specification is for backward compatibility with existing sets.. This format will be able to be utilized by conventional NTSC television receivers after it is converted from digital to analog composite signal form.

The purpose of the other interlaced scanning mode is more obtuse. Why would one want to compromise the stellar quality of a 1920 x 1080 high resolution mode with antiquated interlacing scanning? The reason is cost. Building interlaced monitors can be significantly cheaper than progressive scanned ones. Interlaced monitors run at slower horizontal scan rates, so deflection circuitry is less expensive and with interlaced monitors, the bandwidth of the video signal channel is less, so video processing and CRT drive boards are less expensive to design and build. And about the artifacts? On smaller displays artifacts are unlikely to be a problem, because they will be minor in nature and difficult to see at high resolutions. So the television broadcast industry has argued that even at the highest resolution mode, the economics of the matter decree that interlacing still has home in digital television displays.

As you may know, the final specifications for DTV are still being worked out. One of the latest conflicts involves the computer industry. Certain vocal representatives are trying to get the Grand Alliance and the FCC to eliminate the inclusion of any of the interlacing formats. Their argument is that of compatibility with the all-digital computer/televisions of the future. Behind the scenes information suggests that cost may be more of an issue. Interlaced images require expensive frame storage RAM to convert the fields into frames and additional memory requirements are not a point relished by the computer industry whose profit margins are razor thin as it is. In any case, they have a valid objection, from their point of view anyway, and it has been officially tossed into the ring with all the other groups involved. We will see what happens, but, we can almost be assured of one thing; interlaced scanning, a primitive technique used almost 60 years ago to trim transmission bandwidth requirements and keep television receiver costs reasonable, continues to exist as a basic technique to create images on CRT-based video displays. It is highly probably that we will still be using it in the all-digital future of television technology.

Interlaced Scanning Field A
(every 1/60th second)

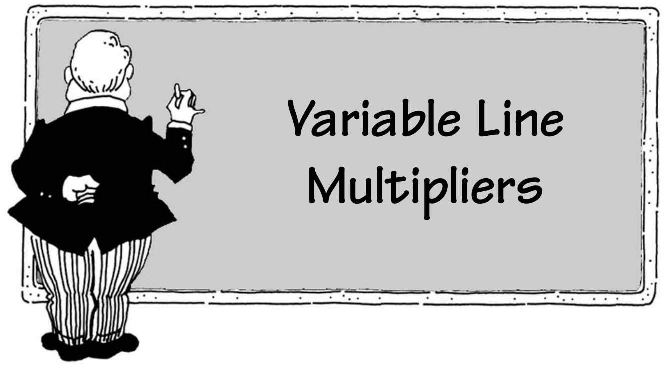


Interlaced Scanning Field B
(every 1/60th second)

Progressive Scanning Frame 1
(every 1/60th second)

Progressive Scanning Frame 2
(every 1/60th second)

Comparison of Interlaced and P rogressive Scanning F rames



Variable Line Multipliers

Traditionally the technique to reduce the visibility of scan lines on large screen CRT-based displays has been to increase the number of horizontal scanning lines via “line doublers”, “line triplers”, and “line quadruplers”. The fundamental operation of these devices is simple: by increasing the number of horizontal scan lines in the image raster, the vertical line structure of the image becomes finer and significantly less visible. However, recent research into video raster smoothing techniques has revealed a superior method. As it turns out, the simple multiplication of a display’s horizontal scanning frequency via integral multiples (2x, 3x, 4x), while easy to do electronically, may produce a less than optimum effect. Too little multiplication still results in some scan line visibility, and too much actually causes scan lines to overlap thereby decreasing vertical resolution. Typically, the optimum scanning frequency, where the scanning lines just blend into each other, is between two integral scanning multiples (2x, 3x, 4x) and requires a “variable line multiplier” to obtain.

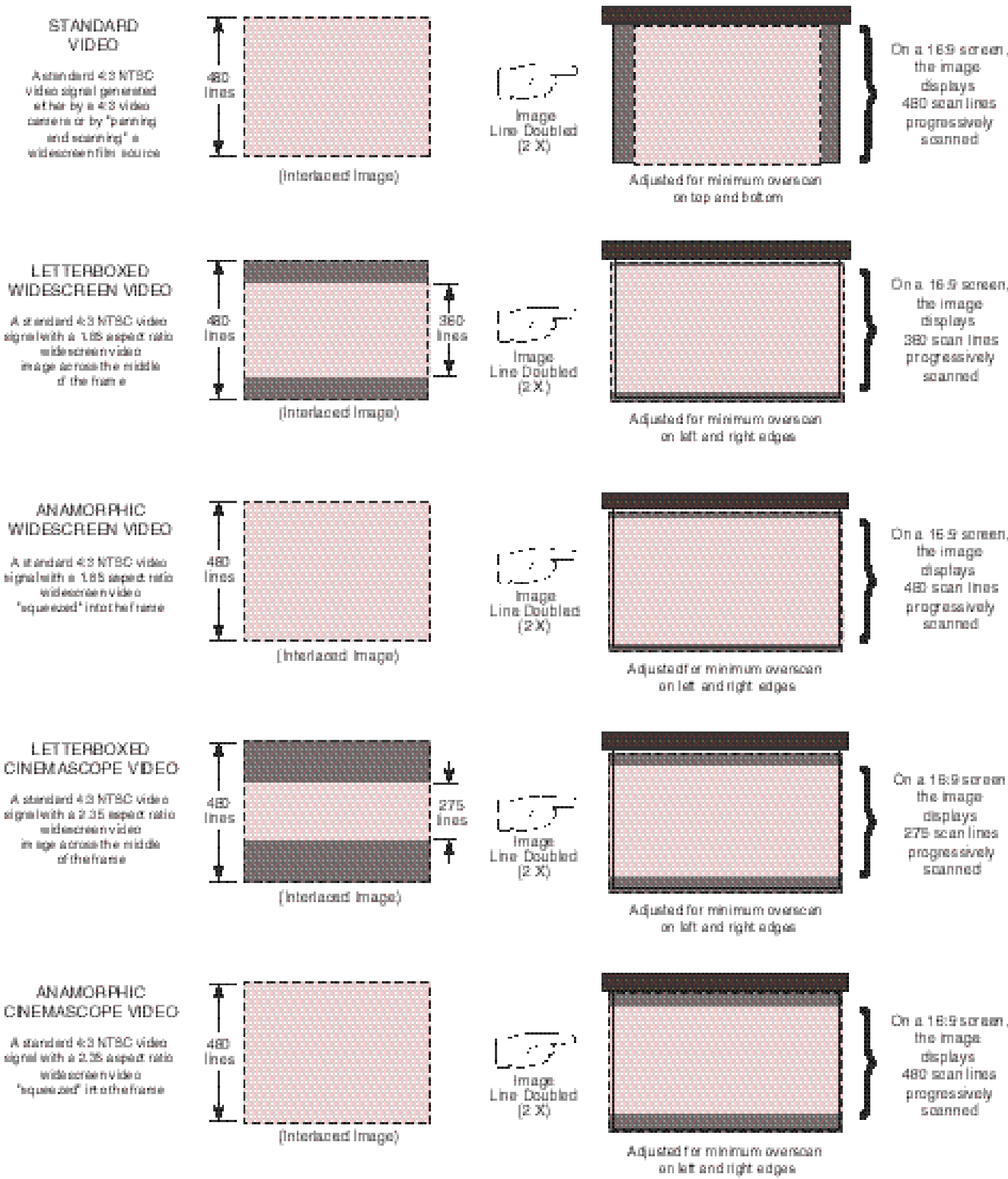
Variable line multipliers are designed so that one can dial-in exactly the right amount of line multiplication so that a video display’s “optimum line density” is achieved. This optimum line density, which is characterized by the size of the projection CRT tubes and the size of the scanning electron beam, is the point where horizontal scan lines just blend into each other to produce a seamless, film-like image. Once a variable line multiplier is programmed properly (during set-up), it automatically calculates the with the correct scanning frequency for different aspect ratio video sources. (if you look at the diagram on the following pages you will see that different video sources have different numbers of scanning lines in the active image of the picture. This means that when you “blow up” that section of the image to fill a screen, a different scanning frequency is necessary to preserve the optimum line density).

Too Few Scanning Lines
(gaps in between lines)

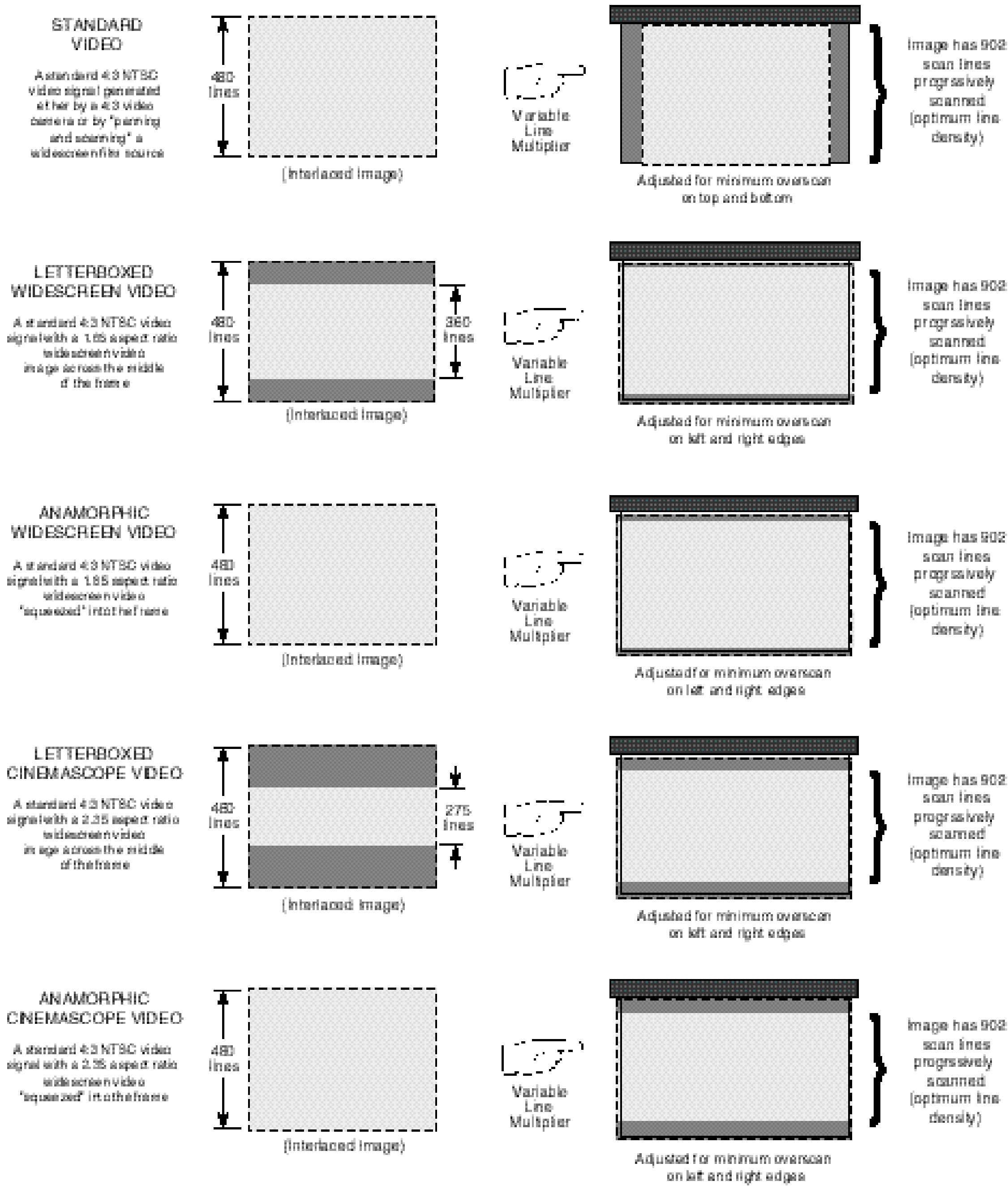
Optimum Scanning Line Density
(scan lines meet each other exactly)

Too Many Scanning Lines
(scan lines overlap)

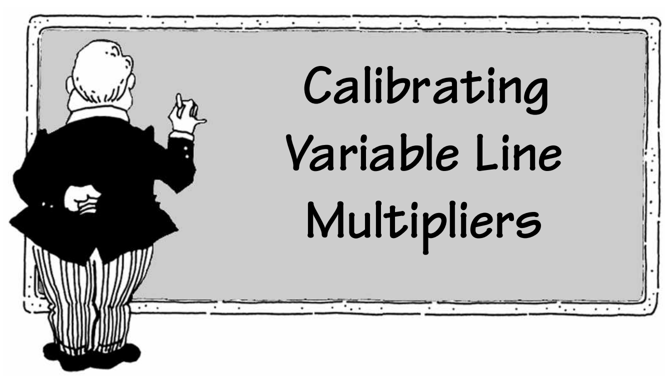
Optimum Line Density Means That The Scan Lines Just Blend Into Each Other



With a standard line doubler, different sources are displayed with different numbers of scan lines



With a variable line multiplier, different sources are displayed with optimum line density



c) Once an image is displayed, use the adjust and select buttons on the remote (see manual) to go to the display setup menu. First, enter the aspect ratio of the screen you are projecting on (4:3 or 16:9). After that, verify that the “Display Lines” reads < 525 >. If not, adjust it till it does (see manual).

This section is from the DWIN’s TranScanner Operating Instructions. It illustrates the procedure followed to find the optimum scanning density of a CRT-based video display

1) Install the Transcanner in the system

a) Connect AC power to the transcanner, connect the RGBS output jacks to a multisync video display device (projection monitor) and connect a video source to one of TranScanner’s video inputs (if you have a laserdisc or DVD disc with a disc you can freeze-frame, use this as the source material).

b) Turn the TranScanner on. If it doesn’t automatically switch to the connected signal source, use the “Source” button on the remote control to cycle to it.

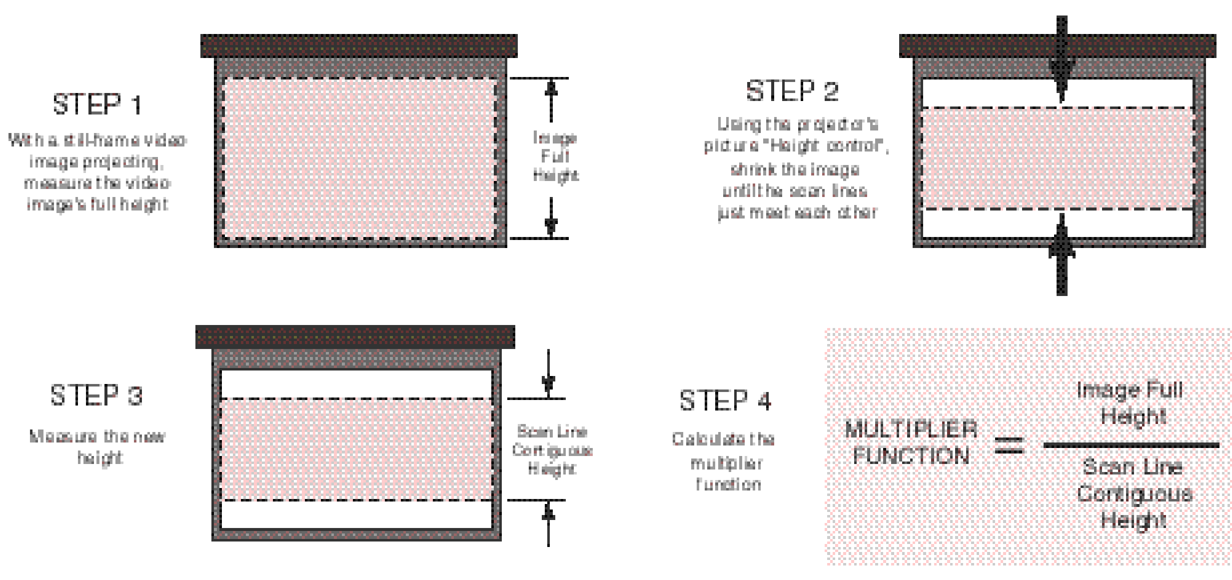
2) Program the Transcanner for “optimum line density”

a) Freeze-frame the video source on a white field test pattern (or a scene with a great deal of white content), then measure the height of the image. (Note: this is not the height of the screen but the actual video image that is projecting on the screen, see our diagram on the next page).

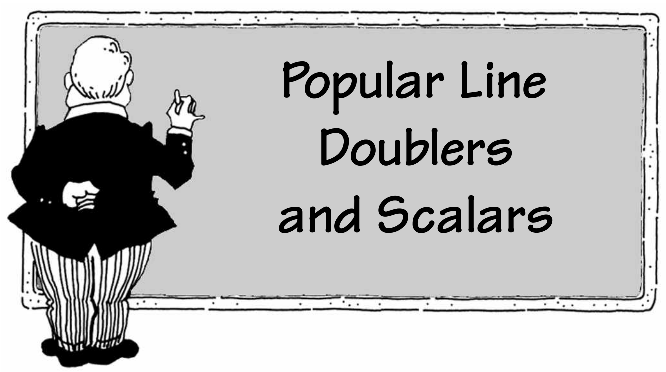
b) While standing close to the screen surface, use the video projector’s “height control” to reduce the picture height until the scan lines just begin to touch each other and produce a seamless image. Measure the height of the resultant image.

c) Calculate the optimum scan line density by dividing the original height by the new height and multiplying by 525 (see diagram on next page).

d) Go to the TranScanner’s display set-up menu and enter the number just calculated in the “Display Lines” field. The TranScanner is now programmed to display the projector’s optimum line density.



Adjusting A Variable Line Multiplier For Optimum Line Density



LINE DOUBLERS:

IEV TurboScan 1500 - Converts 480I to 480P
NEC IPS 4000 - Converts 480I to 480P
DVDO -Converts 480I to 480P
SONY EXB-DS10 -Converts 480I to 480P

QUADRUPLERS:

IEV TurboScan 4000 - Converts 480I to 960P

LINE MULTIPLIERS:

DWIN TranScanner - Converts 480i to 960P in 200Khz increments

SCALARS:

Communications Specialities Deuce -Converts 480I to 480P, 600P, 960P, 1024P
Faroudja DVP-2200- Converts 480I to 480P, 600P
Faroudja DVP-3000- Converts 480I to 480P, 600P, 720P, 960P, 1080i, 1080P
NEC IPS 4000Q - Converts 480I to 480P, 600P, 768P, 960P

COMPUTER/GRAPHICS ADAPTER		RESOLUTION (H/V)	HORIZONTAL FREQUENCY	VERTICAL FREQUENCY
	VGA	640/480 - 640/400	31.5 Khz	60/72 hz
	SVGA	800/600	35.5 Khz	60/72/76 hz
	XGA	1024 x 768	39.4 Khz	60/72/76 hz
	SXGA	1280 x 1024	37.9/48.4/61 Khz	60/72/76 hz