Teranex White Paper

Overview

In the past, broadcast facilities were oriented around an analog composite signal path. Although the facility may have had several different types of tape machines, cameras, etc, each of these could be interconnected without the use of conversion equipment.

In the transition from standard definition (SD) to DTV, many broadcasters are faced with a need for managing a hybrid SD/HD facility. In today's economy, the concept of converting an entire facility and all of the associated workflows to HD is not a practical business plan. This makes implementing a highly integrated SD/HD processing infrastructure mandatory.

Building a hybrid facility will likely require the source material be converted to a new, internal video production format. This means any analog sources must be converted to serial digital (SDI) and all SDI signals must either be up-, down-, or cross-converted to the newly selected internal format.

In addition to the issues of the video and audio conversion, the hybrid infrastructure introduces an entirely new level of audio and ancillary data handling requirements. In the analog and SD environments, audio tended to be fairly basic, consisting of a stereo pair, and ancillary data tended to be in the vertical blanking interval or its digital equivalent.

In the new hybrid environment, audio has grown to include multi-channel audio, compressed audio and Dolby-E encoded audio, while ancillary data elements now go beyond the traditional VBI space to include things like EIA-708 closed caption, timecode, and video indexing, such as active format description (AFD), WSS and RP186 flags.

A number of challenges face broadcasters attempting to implement and operate an SD/HD processing infrastructure in which digital video, audio and metadata elements seamlessly interoperate. Addressing these challenges is now critical because of the analog shutoff and the public's increased DTV awareness.

Format Conversion

A fundamental challenge in any facility transitioning to an SD/HD infrastructure is the requirement to transparently handle multiple signal formats. In addition to handling existing video signals, such as analog composite or SD-SDI, a broadcast facility will be required to handle at least one of the new HD formats, including 720p or 1080i.

Most hybrid facilities will be based on a single, internal format. This means that all material that is not in the native format, whether it is received from outside the facility or ingested internally, will need to be format converted.

An important consideration in choosing a format converter is the de-interlacing technique used in converting between the various formats. In addition, if International program interchange is involved, the ability to perform frame-rate conversion is another important consideration.

De-interlacing

Most SD and HD video sources used in broadcast applications are interlaced images. In an interlaced format only half of the information in each frame is transmitted at a given time. A progressive format, on the other hand, transmits the entire frame at one time.

In order to perform format conversion on an interlaced video signal, for example from 480i or 1080i sources, it is required that the image first be de-interlaced to create a progressive image. Once the image is in the progressive domain, it is then possible to scale it to the desired output resolution without creating unwanted image artifacts. This interlaced-to-progressive conversion is the most important step in the format conversion process and determines the overall quality of the output video signal.

De-interlacing Techniques

If the objects in the video image are not moving, it is easy to de-interlace the image. The two fields can be ‘weaved together’ to form a complete frame. However, if there is motion in the image, the two source fields that make up the complete frame will contain slightly different information because of the temporal offset of the interlaced fields. This means that the two fields cannot be simply weaved together without causing artifacts. A more sophisticated process must be used.

The simplest approach to avoid these artifacts is to ignore the even fields. This is called a non-motion adaptive approach. In this method, when the two fields are processed, data from the even fields are completely ignored. The video-processing circuitry recreates or “interpolates,” the missing lines by averaging pixels from above and below. While there are no combing artifacts, image quality is compromised because half of the resolution has been discarded.

A more advanced de-interlacing technique is a frame-based, motion-adaptive algorithm. By default, these format converters use the same techniques described in the non-motion adaptive approach above. However, by using a simple motion detection system, the converter can determine when no movement has occurred in the image. If nothing in the image is moving, the converter combines the two fields directly. With this method, still images will have full vertical resolution, but as soon as there is any motion, half of the data is discarded and the resolution drops by half.

The most advanced de-interlacing technique available is a true pixel-based motion-adaptive approach. With this technique, motion is identified at the pixel level rather than the frame level. While it is mathematically impossible to avoid discarding pixels in motion during de-interlacing, the method is designed to discard only the pixels that would cause combing artifacts. Everything else is displayed with full resolution.

Pixel-based, motion-adaptive de-interlacing avoids artifacts in moving objects and preserves full resolution of non-moving portions of the screen even if neighboring pixels are in motion.

Poor De-interlacing | Pixel-based Motion Adaptive De-interlacing

Diagonal Filtering

To recover some of the detail lost in the areas of motion, Pixel-Based Motion Adaptive processing implements a multi-directional diagonal filter that reconstructs some of the lost data at the edges of moving objects, filtering out any “jaggies.” This operation is called “second-stage” diagonal interpolation because it’s performed after the de-interlacing, which is the first stage of processing.

No Diagonal Filtering | With Diagonal Filtering

Frame Synchronization

In a hybrid facility there is a high probability that you will need to work with signals that come from outside of the facility or from internal workflows that are not integrated with the main system. In these cases, a frame synchronizer must be used to align video signals with the internal facility reference. The frame synchronizer has a source input for the incoming un-timed signal and a reference input to which the facility reference is applied. The device delays the source feed signal by storing the image information in memory. The reference signal determines the time at which the device begins to output the video. By synchronizing all signals to the same reference, the signals can now be switched together (i.e. mixed, dissolved, etc.) without timing errors.

Aspect Ratio Conversion

Aspect ratio conversion is another factor that must be addressed in the hybrid facility. Standard definition material can exist in either 4:3 or 16:9 aspect ratio while high definition material is primarily in a 16:9 aspect ratio. It is important to remember that aspect ratio refers to the ratio of an image‘s width to its height. It is not related to image size.

The video industry generally expresses aspect ratios as whole numbers such as 4:3 or 16:9. Thus an image with an aspect ratio of 4:3 means that the image is 4 units wide by 3 units high. The value of the units is completely arbitrary.

The technical issues of aspect ratio conversion are not very complex. The process does not require any information to be created; rather it is simply a process of cropping, stretching or squeezing the image.

This manipulation does, however present a number of creative issues in how an image is resized and reshaped to change its aspect ratio.

Up-conversion: Common Top & Bottom

If a 4:3 image is up-converted without any aspect ratio changes it is referred to as Common Top and Bottom. The top and bottom edges of the image match the top and bottom edges of the display device. This creates a pillarbox, as shown in Figure 1, or an image with black curtains on either side.

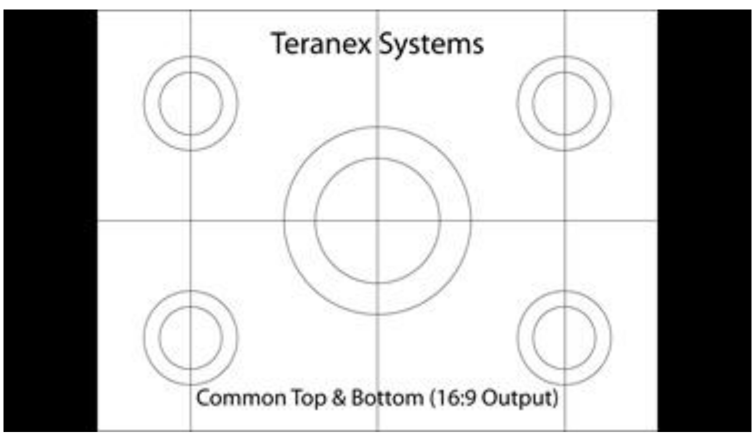

Figure 1: Common Top & Bottom

Up-conversion: Anamorphic

If the 4:3 image is stretched to fill the 16:9 output display, we refer to the aspect ratio mode as Anamorphic, as shown in Figure 2. This mode is usually intended for material that was captured with an anamorphic lens, as it will horizontally stretch the compressed source material to compensate for the effects of the anamorphic lens. If the Anamorphic mode is used with standard

4:3 material, the result is a horizontal distortion of the geometry of the image (e.g. circles are stretched and become ovals).

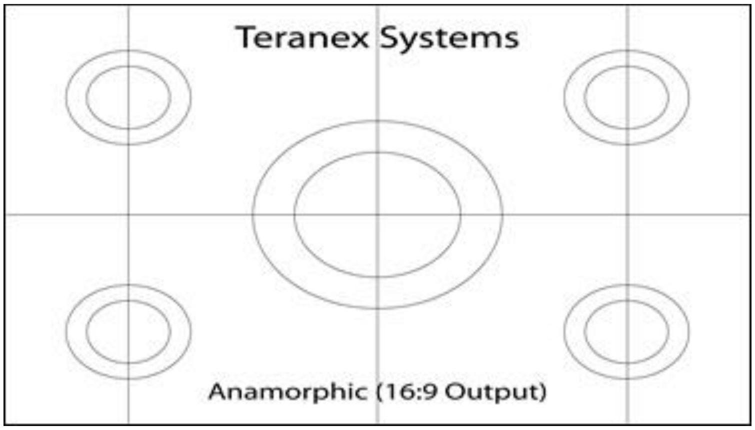

Figure 2: Anamorphic

Up-conversion: Common Sides

As was seen above, if the 4:3 image is stretched horizontally to fill the 16:9 display, the result is a distortion of the geometry of the image. In order to correct this and continue to fill the output display, the image must be stretched vertically as well as horizontally. This yields the ‘correct’ 16:9 geometry, but causes approximately 33% of the original input information to be lost from the top and bottom of the image. We refer to this mode as “Common Sides or “Common Left & Right” and can be seen in Figure 3.

The loss of the information in the vertical domain, in addition to its creative issues, does present a technical one as well. By cropping the lines, less vertical information is made available to the interpolation process. This will effectively lower the overall resolution of the output image.

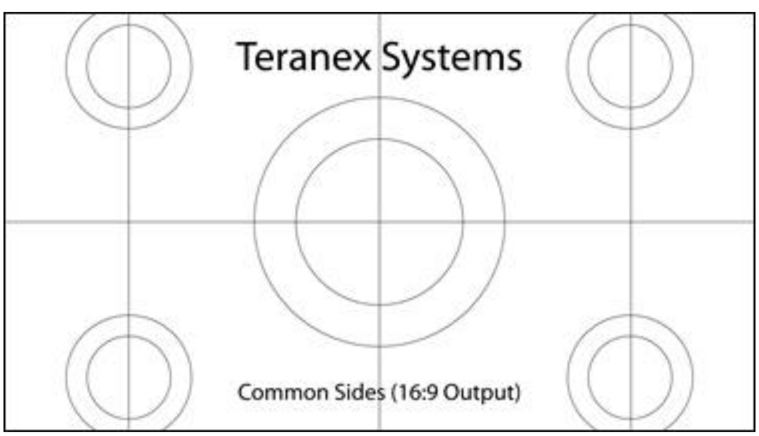

Figure 3: Common Sides

Up-conversion: 14:9
Another aspect ratio, 14:9, has become known as the compromise format. This format is generally shown with a correct geometry. It also requires both a horizontal and vertical stretch of the image. The horizontal stretch being 14 units, as opposed to 16, will result in small bars (pillarbox) on either side of the image. The vertical stretch needed to maintain geometry is only 15%, rather than 33%, and thus results in less information being cropped, as shown in Figure 4. Like the 16:9 format above, the 14:9 format will also have an effect on the overall vertical resolution.

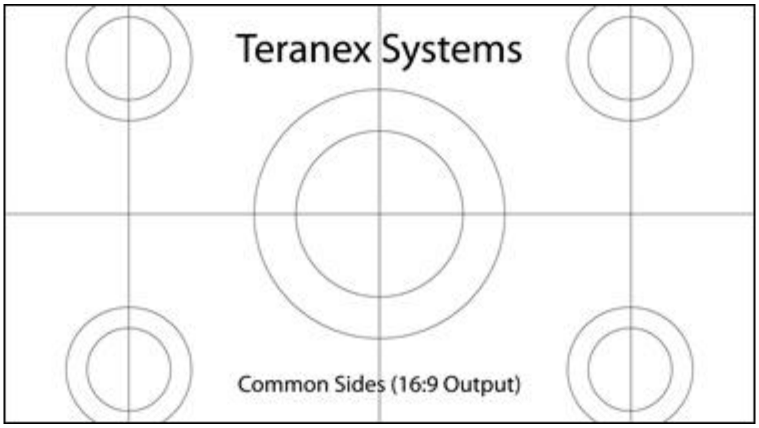

Figure 4: 14:9 Common Sides

Up-conversion: Flexview
The creative problem associated with aspect ratio conversions is one that has plagued broadcasters since the start of the DTV transition. A compromise between the pillarbox method and the anamorphic or common sides methods, was needed.

One compromise for this issue is the Flexview aspect ratio, introduced by Teranex. The Flexview aspect ratio utilizes a non-linear anamorphic function. It performs the aspect ratio conversion by leaving the picture information in the center of the image relatively undisturbed and by applying progressively more ‘stretch’ to the image as it gets closer to the left and right edges. This process, while largely done in the horizontal domain, also has a small vertical component to help maintain correct geometry.

The basic premise of Flexview is that most of the important content in a scene (the material that your eye is drawn to) is in the center of the image and the information on the edges is generally less important. Flexview leaves the center portion undisturbed and stretches the image most aggressively around the edges where there is less important material.

The examples on the next page show a comparison of an up-conversion of the same frame of video utilizing the Common Top & Bottom aspect ratio (as shown in Figure 5), the Common Sides aspect ratio (as shown in Figure 6), the Anamorphic aspect ratio (as shown in Figure 7) and the Flexview aspect ratio (as shown in Figure 8).

Figure 5: Common Top & Bottom

Figure 6: Common Sides

Figure 7: Anamorphic

Figure 8: Flexview

Down-conversion: Common Sides

If a 16:9 image is down-converted without any aspect ratio changes, we refer to the aspect ratio conversion mode as Common Sides. The left and right edges of the image will match the left and right edges of the display device. This creates a letterbox, as shown in Figure 9, or an image with black bars on the top & bottom.

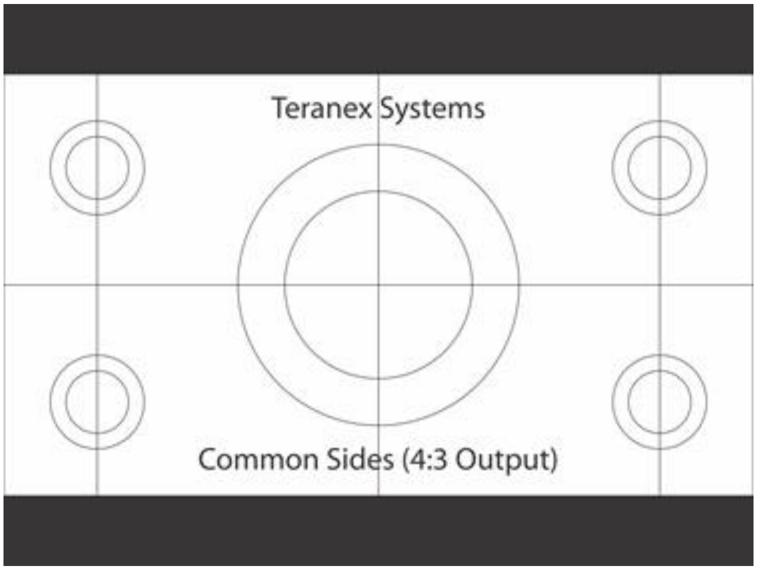

Figure 9: Common Sides

Down-conversion: Anamorphic

If the 16:9 image is squeezed to fill the 4:3 output display, we refer to the aspect ratio mode as Anamorphic, as shown in Figure 10. When the Anamorphic mode is used, the result is a horizontal distortion to the geometry of the image (circles are squeezed to become ovals).

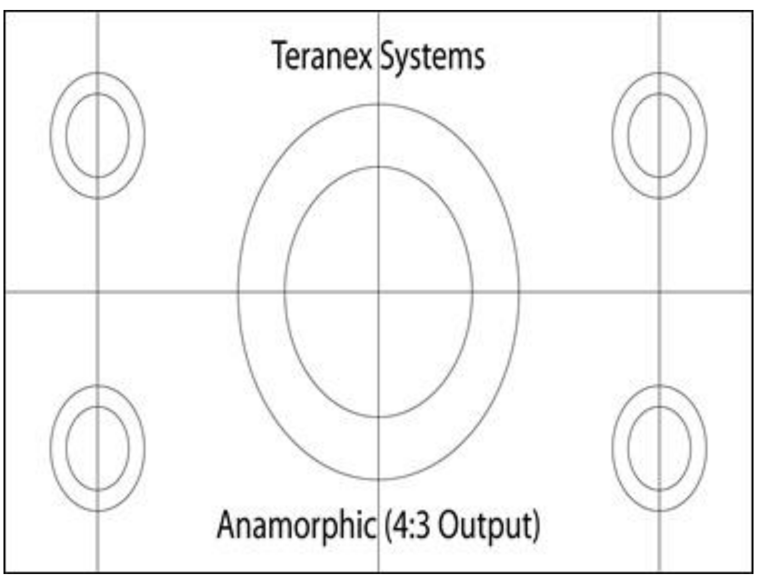

Figure 10: Anamorphic

Down-conversion: Common Top & Bottom

As was seen above, if the 16:9 image is squeezed horizontally to fill the 4:3 display it results in a distortion of the geometry of the image. In order to eliminate the distortion, the image must be cropped horizontally. This will result in ‘correct’ geometry, but will cause information on the left and right side of the input image to be lost. This mode is referred to as "Common Top & Bottom," as shown in Figure 11.

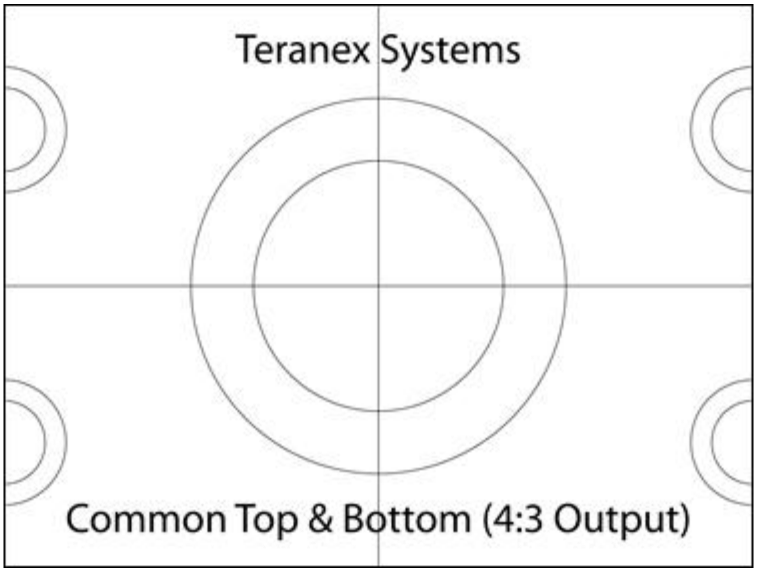

Figure 8: Common Top & Bottom

The use of a high quality de-interlacing process is very important in the format conversion process. Since a format converter must create picture information in the resampling it is critical that the maximum amount of vertical detail be recovered from the input signal. The Teranex VC100, with its motion adaptive de-interlacing process and diagonal filtering, can recover the full vertical detail of the input signal even in areas of motion.

Aspect ratio conversion is another area that will impact both the engineering and the creative side of a broadcast facility. From an engineering standpoint one must ensure that the format converter can address aspect ratio conversion. There may be a decision as to whether the facility should switch to 16:9 for all programming new and old. This decision would lead to changes in equipment such as cameras, and the redesign of sets. From a creative side there is the issue of how to fill the new widescreen displays, what percentage of cropping or distortion will be acceptable.