

Slate HD Video Processing

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High Definition (HD) television is the biggest advance in viewing experience since color TV. The innovative Broadcast Pix Slate system produces beautiful live HD content by integrating rich 10-bit HD video with pristine graphics and animations, by manipulating this content with high data rate progressive processing, by supporting an exceptionally wide variety of video formats, and by simultaneously producing both the widescreen 16:9 aspect ratio inherent in HD, and traditional 4:3 video. Cameras and content of both aspect ratios can be used interchangeably.

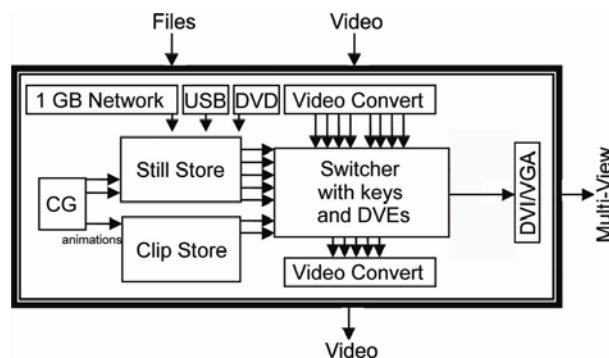
Slate - an Integrated Live Video Production System

Live video production has taken on many elements which when combined help create a final product which can be very compelling for the viewer. This final polished content is the goal of producers today, however, it is not easily achieved. This level of production has meant high cost equipment as well as teams of very skilled operators. The challenges of combining high resolution cameras, video clips and graphics as well as high quality live processing has been a major area of compromise for the producers.

The Broadcast Pix Slate system, an integrated live video production system, combines the elements needed for professional video broadcast production along with high performance, lower cost cameras to make the quality that was achieved only at the high end more commonly available to a much wider range of end-users. Broadcast Pix unlocks the elements needed within the video broadcast, including not just a real-time video production switcher, but also DVE, chromakey, graphic stores, clip and animation players, format and aspect converters, and multi-view monitoring of all elements.

Unlike conventional switchers that accept only video inputs, Slate also accepts files, including QuickTime and MPEG clips as well as graphics and animations. Accepting files greatly streamlines workflow from edit systems, and greatly enhances the ability of a single operator to run a live production system that integrates switcher, graphics and clips.

All these elements are controlled and combined to make a more compelling video presentation for the viewer. This streamlined and simplified production workflow enabled by the unique Slate architecture opens the doors to video producers to enter the world of “Compelling, Cost Effective Video Production” today.



Slate Workstation

Slate Processing Technology

Slate live integrated production systems include multiple workstation PCI hardware assemblies that operate in conjunction with highly developed Broadcast Pix software applications to generate rich live HD production programming. This hardware includes a PCI Switcher Board processor that integrates advanced digital video and mix effects, keys, and graphics with multiple external video sources and internally stored video chips. These clips reach the Slate Switcher Board over a high speed 64-bit PCI bus. Up to 8 cameras and other external sources can be attached directly to the Slate workstation, and up to 32 cameras can be used with an integrated router in larger Slate models. These external inputs are simultaneously integrated in Slate with 14 internal video sources, which are comprised of 7 video and key pairs, 2 channels of clips, and 5 channels of graphics. Slate provides a total of 5 outputs in various combinations of digital and analog formats depending on the specific hardware configuration, and up to 24 outputs in larger Slate models that incorporate a router.

Slate Video I/O

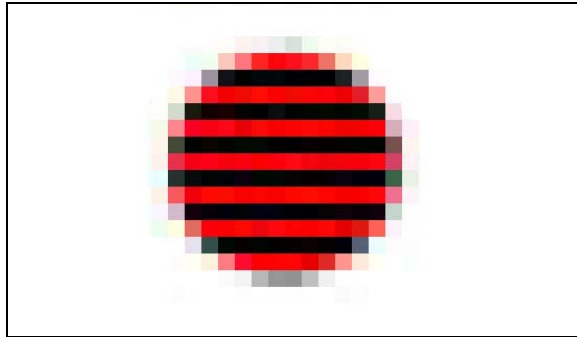
There are three types of input and output boards which are available for the Slate system: HD/SD-SDI, SD-SDI and analog, plus the HD/SD-SDI board has a companion DVI-I board. The two SDI boards each have four SDI input sources and one output. The Analog board also provides 4 inputs and 1 output, each of which can interface CVBS (composite), S-Video, and YPrPb Analog Component formats. The HD I/O PCB adds more flexibility and functionality to Slate with the integration of HD formats including 720p at 59.94, 60 or 50 frames per second (fps) and 1080i, at 29.97, 30 or 25 fps. In addition, the companion DVI-I board provides DVI analog (VGA – R,G,B,HS,VS) and digital signals sources that include VGA, SVGA, XGA, SXGA, UXGA, WXGA and WUXGA formats. Further, HD I/O accepts YPrPb sources via the DVI interface, and can output 1080p via the DVI output and an HDMI cable. The HD I/O cards are unique in the industry as they accept and output multiple video types simultaneously including mixing formats like 720p and 1080i. Slate HD processing provides broadcast quality cross-conversion from HD to SD resolution and visa versa. This advanced video processing and scaling enables the integration of all these formats within the Slate layering engine and final video output.

The elegance of the Slate multi-format system is its ability to combine multiple input formats and provide the wide range of output formats needed in today's productions. Mix Analog, 720p, 1080i, DVI and SD-SDI signals as well as graphic and pre-produced video clips all in real time. The Slate system converts all signals at the input and applies frame synchronizers as needed so that any video signal may be used. This format ambiguous workflow even flows through graphics and clips making your production seamless. Integrate 4x3 and 16x9 sources in the same show and the Slate takes care of all the aspect conversion, as described below. Then for outputs, the Slate will output SDI, HD-SDI, DVI, and analog all at the same time. Even pick multiple HD and SD output types and Slate does all the cross-conversion.

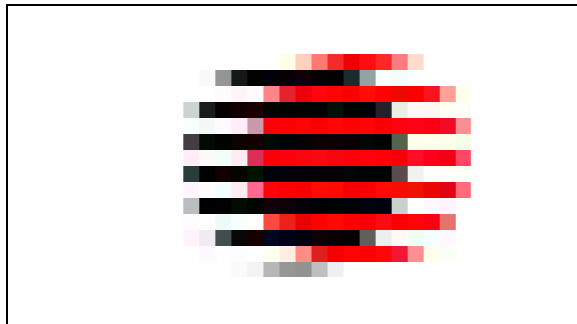
Slate HD Processing

The HD interfaces both interlaced and progressive input formats, but interlaced inputs are de-interlaced to progressive formats prior to applying scaling and format conversion algorithms to convert HD inputs to SD resolution. If interlaced images were used, their inherent field-to-field temporal aspects would create annoying diagonal distortion, edge “jaggies” and glittering artifacts.

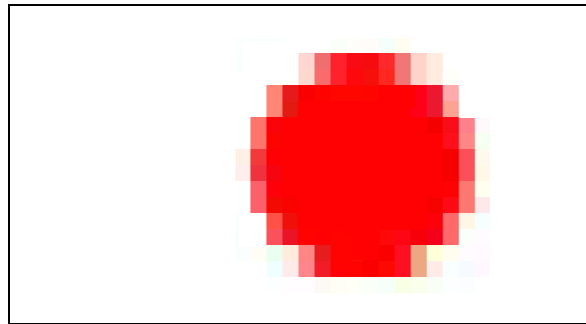
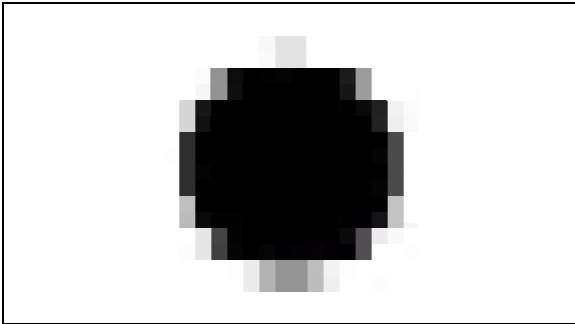
There are several methods in use today to convert interlaced images to progressive formats. These range from simply merging fields together to the use of sophisticated adaptive algorithms that take into account any motion between the fields. Merging fields is an acceptable approach if little or no motion exists between them, but this is unrealistic and the blurry resulting frames in the presence of motion are unacceptable. The image processor devices used in Slate HD processing employ motion adaptive de-interlacing with edge interpolation to generate the progressive outputs at 576p/50 or 480p/59.94.



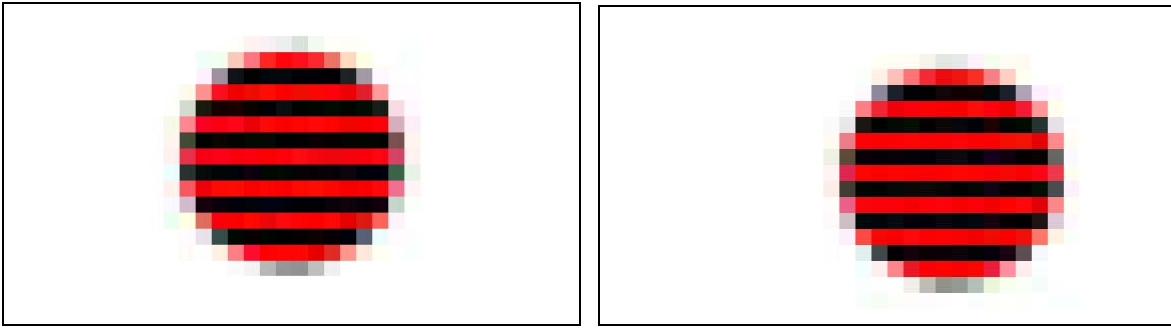
This is what a circle looks like to a video camera. Please note that the odd and even fields on an interlaced image are sampled $1/60^{\text{th}}$ of a second apart: (For clarity, the different fields are illustrated in red and black respectively)



If the circle is moving, the timing difference between the fields shows up as a spatial difference representing the ball's motion over that $1/60$ of a second.



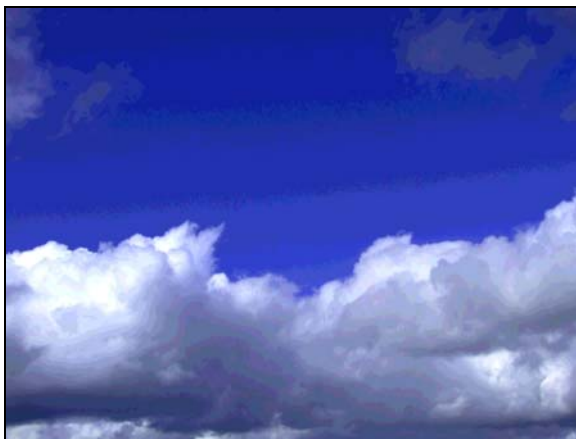
To generate progressive signals and resize images, full frames of video are needed. However, using the interlaced frames would cause ghost images and other picture distortions, so one option is to line-double each field to get complete progressive frames. However, spatial resolution is clearly compromised...



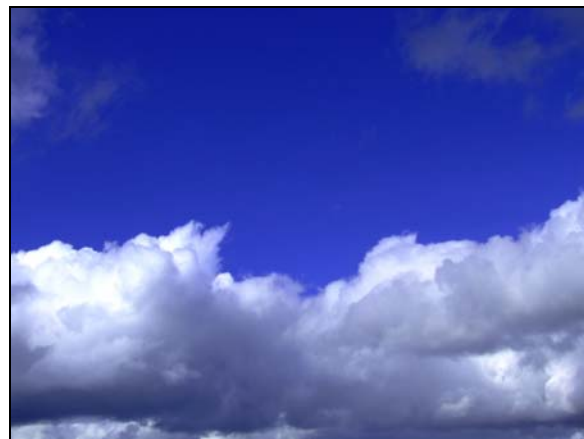
Edge and pattern detection algorithms track the motion in each field to note when objects are shifting. This is used to dynamically reposition the patterns and edges needed to reconstitute a sharp image of the moving object from each field. This results in the highest-quality video for resizing, rescanning and upconversion from interlaced to progressive output. It is used throughout all stages of the Broadcast Pix Slate system processing.

The 576p and 480p formats are directly compatible with the internal signal processing format used in Slate. This format is a progressive 4:4:4 full-bandwidth luminance and chroma component structure that enables very high DVE picture and colorimetry. Slate's progressive format has twice the data rate of conventional SD switchers. Slate actually implements 486p because it processes 486 lines of active video. The reader will find references to 483p, which SMPTE standard 293M describes, but they differ only in the number of active lines defined.

Slate is a 10-bit processor that provides superior image precision and colorimetry quality over 8-bit processing, that often introduces color banding and related distortion. By using 10-bit processing instead of the more standard 8-bit, we increase the dynamic range from 256 levels of color to 1024 – the subtle coloring of the image remains smooth and lustrous at all times.



8-bit images have limited dynamic range. When fades and other effects are introduced, the limited dynamic range manifests itself as banding in the picture. This happens most often with blues because the blue channel only contributes 10% of the luminance signal and thus has the least number of assigned brightness values.



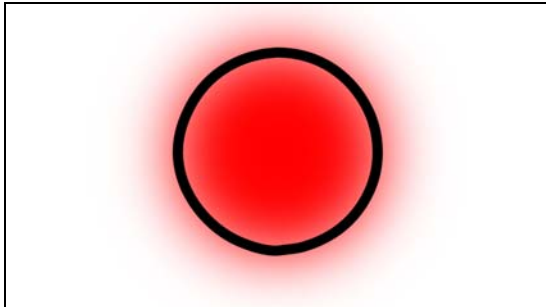
10-bit images have much more dynamic range and can properly reproduce all color gradients, especially blues.

The resulting combined HD and SD production is outputted from Slate as both SD analog and serial digital formats. Further, the HD I/O processor produces exceptional quality up-converted outputs from this result using high performance scaling processors. The HD outputs can be 720p and 1080i formats, including 59.94, 60 and 50 Hz standards.

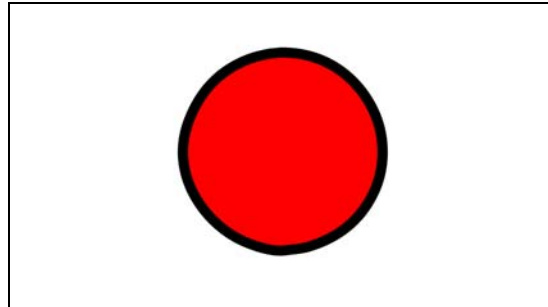
DVI analog and digital outputs, including the same input formats noted above, as well as 1080p, are also output from Slate via a two-channel DVI interface PCB. The DVI outputs are especially suited to large screen projection applications.

Slate Key Processing

The Slate video processing system is capable of processing 6 layers of key signals. The keyed signals are processed using 10-bit 4:4:4 processing. This processing includes advanced keying techniques enabling shaped key processing. This keying capability combined with the 10-bit precision (which is 4 times the precision of 8 bit processing) creates a very rich composite video image.



4:2:2 processing reproduces the color channel at half the sharpness of the brightness (luminance) channel. Colors are fuzzy and appear to 'leak' outside object edges.



4:4:4 processing preserves the sharpness of the color channel.

Slate key processing combines the video layering with chromakey processing which allows for high quality chromakey compositing of images with blue or green screen backgrounds. The slate system can composite up to six chromakey signals on screen simultaneously.

Slate DVE (real-time video scaling) uses 28-bit internal precision and allows for a huge range of compression of a video signal down to infinite compression, as well as enlargement. The video can then be positioned at any location. The compressed video maintains high quality processing and clarity based on the dynamic scaling techniques mentioned previously. The DVE processing is aware of all source material aspect types and will maintain proper aspect on the DVE being processed.

Slate Aspect Conversion

All Slate HD switchers with 2 HD I/O boards installed can produce the program output of a 16:9 show in both 16:9 and 4:3 simultaneously, as shown below. This is ideal for television stations that need to generate both formats, or for anyone producing for multiple versions in different aspect ratios for television, Internet, mobile and projection applications.



16:9 Program Output



Simultaneous 4:3 Program Output

In production today, inputs with both video aspect ratios often need to be combined, including 16:9 and 4:3 video cameras, other sources, clips and graphics. The Slate system combines these elements in real-time into one cohesive production. Slate accomplishes this by allowing each source to have aspect properties assigned to it. The properties include native format (16:9 or 4:3) and then the treatment (scaling or cropping) of the source if the desired output is different than the input. The Slate provides three types of treatments: crop, box, and 14:9. These modes are set on each input independently for external sources. Internal sources (graphics and clips) use a property for each individual clip and graphic. With this technology you may combine almost any aspect and maintain proper proportions for the content without operator intervention during the live production.

Incorporating 4:3 images into 16:9 productions:



The picture on the left is a correctly-proportioned 4:3 image of a familiar figure. The image on the right shows the commonly-encountered effect when 16:9 equipment is unable to aspect-correct mixed image formats stretches them instead. Each person winds up looking too wide.

This is how the Broadcast Pix Slate system handles this situation - It gives the user four choices:



If you really want to stretch the image, that's still an option...



It can 'pillarbox' 4:3 signals so the entire image is visible on the 16:9 screen.



It can expand and crop the image so the entire 16:9 screen is filled with properly-proportioned video.



Or it can do a gentle '14:9' conversion that crops a little and pillarboxes a little to balance image loss and distortion at a minimal level.

Incorporating 16:9 images into 4:3 output:



The picture on the left is a correctly-proportioned 16:9 image of the familiar figure. The image on the right shows the commonly-encountered squeezed effect when a 4:3 version of the program is produced with equipment that can't mix differently-proportioned signals. Everyone winds up looking too thin.

This is how the Broadcast Pix Slate system handles this situation - It gives the user four choices:



If you really want to squeeze the image, that's still an option...



It can 'letterbox' 4:3 signals so the entire image is visible on the 4:3 screen.



It can expand and crop the image so the entire 4:3 screen is filled with properly-proportioned video.



And it can do a gentle '14:9' conversion that crops a little and letterboxes a little to balance image loss and distortion at a minimal level.

Each separate live input, clip and graphic can be processed in a different way.

Slate Processing Delay

The Slate video architecture is very unique in the industry because of its inherent ability to combine so many processing elements with minimal delay. The video delay is very predictable through the Slate system and therefore keeping video and external audio delays in sync is straight-forward. For SD applications there is a 33ms delay for all synchronous sources and 66ms for all asynchronous sources. In the case of HD systems there is 66ms of delay for synchronous sources and 100ms of delay for asynchronous sources. The delay is consistent regardless of the number of keys, clips, aspect correction and video layers composited during the video processing.

Slate Low Latency Presentation Mode

For IMAG (image magnification) or large screen projection applications that require very low latency, Slate allows for minimal system delay in certain configurations. When the slate is interfaced with 720p/59.94 or 720p/50 sources, the Slate HD system can operate in a low latency mode. Low latency is implemented via software control of the image processors. The largest processing delay reduction is realized on the down conversion side because de-interlace of the 720p inputs is not required. Internal genlock timing is also modified as a part of the low latency mode, which results in a small advance in output signal timing from the system with respect to the genlock input timing reference. In Low Latency mode for 720p/59.94 inputs, the total delay is about 57 ms – the equivalent of just under 2 SD frames. For 720p/50 sources, the latency is similarly about 2 frames. Since projectors are typically progressive, these Slate DVI outputs encounter very little additional delay in the projector. In contrast conventional television switchers output an interlaced signal which must then have added delay when converted to progressive in the projector or in a conversion box before it gets to the projector.

Slate Clip and Graphics Stores

The Slate includes a very powerful clip player which enables real time play back of 4 channels of real-time video. The clip player combines 2 channels including key and fill on each player which allows the clips to play not only full screen video but keyed animations in real-time. The clip player supports multiple channels of real-time playback of multiple native formats. Formats include uncompressed SD, QuickTime (.mov encoded in DV, DVCPRO, or H.264/MPEG-4 AVC), and MPEG 2. The slate video clip player also supports audio associated with the formats above as well as wave file support.

Slate clips do not use MPEG compression algorithms - it can distort your picture. As a result, you won't get any of the shimmer or blocky artifacts one sees on satellite, cable, HD-DVD and many HD recording formats.



Uncompressed image.



Compression adds blocky artifacts.

The Slate system includes 10 graphic stores which are combined in 5 key and fill pairs of buffers. These buffers may load images in multiple aspect ratios including 4x3 and 16x9 anamorphic. Graphic types supported are bitmap, png, targa, and tiff. In addition to still images, crawls and rolls are also supported in two of these key and fill pairs. Graphics can be stored in resolution-independent vector mode when used with the integrated character generator.

For more information on the Slate system and Broadcast Pix please visit us at www.broadcastpix.com.