K2 AFD Concepts and Operation

How the K2 Media Server Solves SD-to-HD Transition Problems with Regards to Aspect Ratio Conversion (ARC) and Active Format Description (AFD)

Roger Crooks, Product Marketing Manager Grass Valley, a Belden Brand— October 2009

APPLICATION NOTE

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When dealing with both SD and HD content for an SD or HD broadcast channel, there are many technical issues to deal with that were not an issue with SD-only playout. This tech note focuses on how the K2 media server automatically deals with these issues by setting and preserving the correct clip metadata. This includes AFD, which defines the aspect ratio of the signal as it progresses through the workflow; ingest, editing, up/down conversion and playout. The goal of recent SMPTE standards is to preserve the correct description of the signal throughout the process so the consumer sees the picture as the broadcaster meant it to be seen.

Defining the Problem

Problems may arise when broadcasting SD & HD content because:

1. SD Content can be in 4:3 or 16:9

2. HD content is always 16:9

3. A broadcaster must play out an SD or HD channel with all three types of material and must switch seamlessly between them all

4. The aspect ratio of the clip can be changed at various points in the broadcast chain

5. Both set-top boxes and TV sets can crop or scale the picture to various aspect ratios

For the set-top box or the TV to display the most optimal picture, it must have accurate information on the format of the picture it receives. If this information is incorrect, the resulting display will be sub-optimal using less of the screen than desired, often described as a "postage stamp" display. (See Figure 1).

Active Format Description (AFD) & Bar Data

The Active Format Description is a 4-bit code (a0, a1, a2, a3) describing the video picture in terms of the aspect ratio and other characteristics of the active image within the coded frame. The complete set of Active Format Description codes is shown in Appendix A.

Additionally, AFD includes an aspect ratio (AR) bit stored as "b2" which indicates whether the picture is 16:9 (1) or 4:3 (0). The K2 media server records and sets this bit correctly.

Bar Data is 5 bytes of associated data that defines the precise unused areas of active video when the active image does not fill the complete picture area, or where the bars are asymmetrical (such as when the picture is not centered). These cases are rarely used in mainstream broadcast and as such, are not supported in the K2 system.

Aspect Ratio Conversion (ARC)

The K2 media server has many different aspect ratio conversion options as shown in Appendix B. It's critical that the AFD accurately represents the image of the signal as it leaves the server, with or without conversion. If the signal has AFD and it is converted, the AFD code needs to reflect the change.

Wide Screen Signaling (WSS) & Video Index

Outside the US, WSS was sometimes used with SD signals to define the aspect ratio as 16:9 or 4:3. It did not include as much information about the image inside the raster as AFD. WSS is stored on VBI line 20 (NTSC) or line 23 (PAL) luma.

Video Index (stored on VBI line 14 chroma) was defined to add additional information about the display. Together with WSS, it was sometimes used to try to accomplish what AFD does today.

WSS and Video Index are not used for HD material and are replaced with AFD for both SD and HD material.

The K2 media server will pass the WSS and Video Index signals through if the user selects these lines to be stored as uncompressed. If the clip is up-converted, WSS and Video Index are not preserved as they are not defined for HD. As described in this tech note, the K2 media server will correctly set AFD regardless of the WSS and Video Index settings.

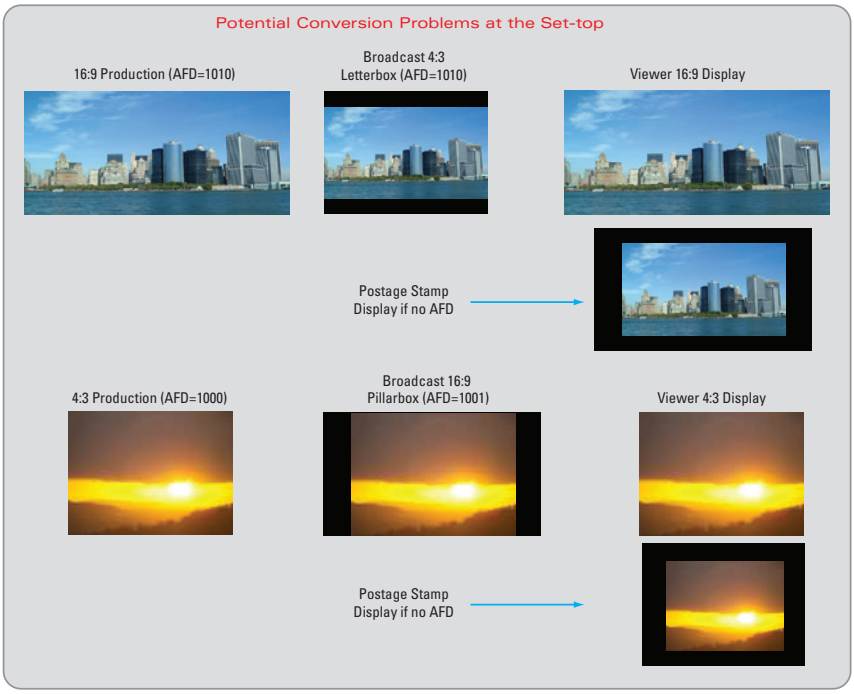


Figure 1 – Examples of displays resulting from no or incorrect AFD information. Consumers complain when only a portion of their video screen is used.

Metadata Throughout the Workflow

Preservation of a clip's metadata is crucial in a file-based workflow. The K2 media server not only preserves metadata throughout the workflow, but also makes it easily available to other application via the protocols. For content on a K2 media server, metadata can be stored in two locations: K2 Movie Properties and K2 Ancillary Data Track.

K2 Movie Properties – Clip metadata is stored in the K2 Movie Properties, which is a database for details of the clip such as length, compression format, marks, etc. It is easiest for applications to access this metadata. K2 media server stores AFD in Movie Properties and uses this data throughout the workflow. Users can check/modify the AFD setting via AppCenter.

K2 Ancillary Data Track – A clip being recorded on a K2 media server has the option of storing an Ancillary Data Track (playout always has an Ancillary Data Track). This is a user option and seldom used for SD clips, but it should always be selected for HD clips. Specifying a K2 Ancillary Data Track will take more storage (approximately equal to four tracks of audio) but will enable AFD and CC/Teletext support for HD.

Ingest – SDI Signals

An SDI video signal stores AFD in the ANC data track (VANC). If AFD is present, its setting two seconds into the file is copied into the K2 Movie Properties (See Figure 2). The ANC data track is copied into the K2 ANC Data track (if selected).

Ingest – File Transfers

For a MXF/GXF file transfer, the AFD is set in this priority order:

- AFD from MXF/GXF metadata is copied to K2 Movie Properties
- If no AFD metadata, AFD from two seconds in on the ANC data track is copied to the K2 Movie Properties
- If neither, no AFD is set
- ARC Property in GXF from pre V3.3 K2 systems is preserved to maintain backward compatibility
- The MXF/GXF ANC data track is copied to K2 ANC data track unchanged

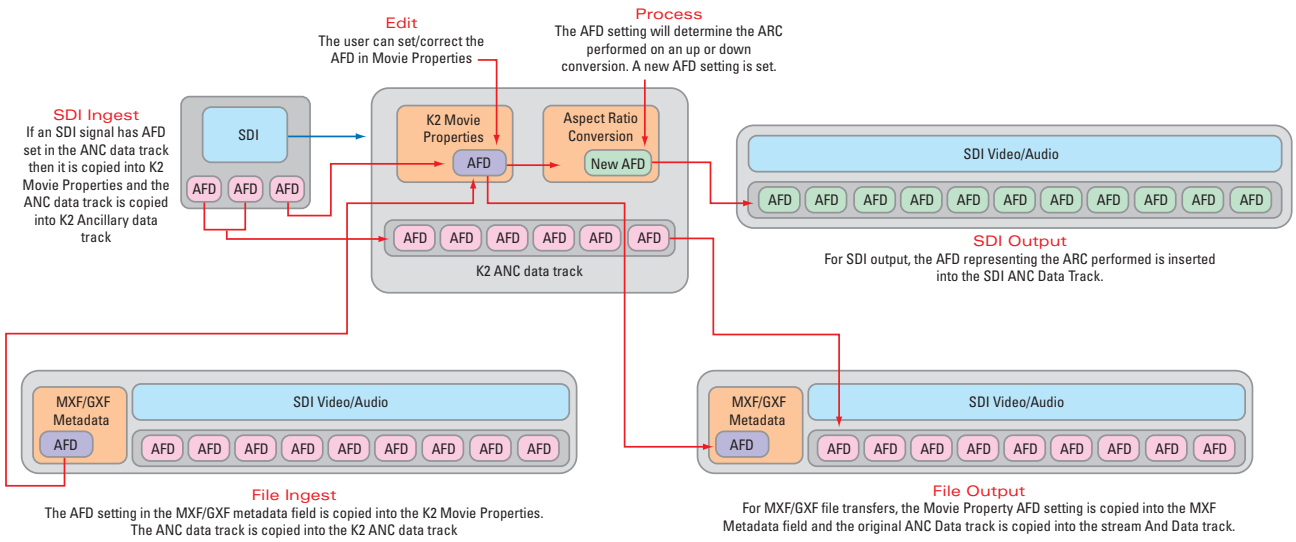


Figure 2 – Example of how AFD is handled when the incoming material contains AFD.

Metadata Throughout the Workflow (Cont.)

Edit

The user can view, add or change AFD information manually through AppCenter or remotely via the K2's protocols – K2.net or AMP. If the user sets or changes AFD, it is changed in the Movie Properties — the original AFD in the Ancillary Data Track remains as it was.

When starting a record, the user can set the format of the input video. This setting is used as the AFD property of the clip being recorded if it does not contain AFD. If the clip contains AFD, the clip's AFD setting will override this user setting.

SD	HD
Undefined	Undefined
Full screen 4:3	Full screen 16:9
Letterbox 16:9	Pillarbox 4:3
Letterbox 14:9	Pillarbox 14:9
Full screen 16:9	Full screen 16:9 with alternate 4:3 center

Figure 3 – AFD setting available when recording video.

Playout

The K2 media server has the built-in ability to process the video on playout, which in a hybrid SD and HD environment can save tremendous cost and time by eliminating specialized equipment downstream.

Up and Down Conversion – A K2 channel can be configured for SD or HD playout. Both SD and HD material can be put on a playout channel's timeline. If the playout channel is configured for HD, then all SD material will be up-converted to HD and visa versa for an SD channel. The K2's up/down conversion capability is a standard feature and its quality is comparable to external conversion equipment.

Cross Conversion – The K2 media server's HD output can be set up for either 720p or 1080i. If an HD channel is set for 1080i, then 720p material will be converted to 1080i and visa versa. The K2 media server performs this conversion in real time at playout.

Aspect Ratio Conversion – The K2 media server has the ability to set any channel to a default ARC, as well as on a clip-by-clip basis. With support for AFD, users will now set the clip's ARC by setting the AFD code as defined in Figure 5. This is an operational change from previous version of K2 software. This ARC setting was used to override the channel's default ARC setting. Now AFD will be used to indicate the aspect ratio of the clip and the ARC performed is determined by the K2 media server. To preserve backward compatibility, if no AFD is set, the ARC setting will operate as before.

K2 Movie ARC settings (see Appendix B):

- Default — use the channel default ARC setting
- Stretch
- Half Bars
- Crop
- Bars

The playout priority for aspect ratio conversion is as follows:

1. AFD as stored or set by the user in the Movie Properties

2. K2 media server's default ARC channel setting

AFD Settings on SDI Output

The AFD code set on output is determined by a variety of conditions and user settings as shown in figure 4. To cover various situations, the user can control how AFD is handled.

The user has three options for AFD control:

- Always Generate: AFD is always generated on the output regardless if the original source contains AFD or not
- When Known Generate: AFD is only generated if the original source contains AFD or AFD is set by the user
- Never Generate: AFD is not generated but will play unchanged from the ancillary data track if present.

Metadata Throughout the Workflow (Cont.)

Input and Settings				Output AFD Value					
AFD Clip Properties	AFD Data Track	ARC Performed	Generate AFD Setting	As set in Movie Property	Derived from Movie Property	As set in Data Track	Derived from Data Track	No AFD	Default AFD
Y	n/a	N	Always or When Known	X					
Y	n/a	Y	Always or When Known		X				
N	Y	N	Always or When Known			X			
N	Y	Y	Always or When Known				X		
N	N	n/a	When Known					X	
N	N	n/a	Always						X
n/a	Y	n/a	Never			X			
n/a	N	n/a	Never					X	

Y = AFD value is set
N = No AFD value is set
n/a = setting does not impact output

Figure 4 – AFD output settings based on inputs and user settings.

AFD Settings on File Output

The AFD code is set in the MXF/GXF output file's metadata and in the Ancillary data track.

- The file metadata setting is determined by the setting in the K2 Movie Properties from the original source or as set by the user
- The file ancillary data is never changed by the K2 media server – it is always the same as the ancillary data track from the original file or source
- Note: it is possible for the Metadata AFD setting to be different from the AFD in the ancillary data track

Examples

Example 1 – SD/HD Newscast

A station simulcasts an HD and SD news channel with exactly the same content. They have archival SD material in standard 4:3 (AFD=1000), 16:9 widescreen (AFD=1010) and 16:9 letterbox (AFD=1010) formats.

All the HD video is 16:9 (AFD=1010), shot in 4:3 protect mode. Archival SD video is used during broadcast and needs to seamlessly switch between HD and SD content.

K2 channel 1 is set to playout SD, 4:3 mode with AFD set to down convert 16:9 HD material to letterbox (AFD=1010).

K2 channel 2 is set to playout HD, 1080i, 16:9 with AFD set to up convert 4:3 content to pillarbox (AFD=1001).

Channel 1: SD — 4:3 — Letterbox set as default

- 4:3 SD Standard: Plays straight through — AFD in the output stream is set to 1001, AR=4:3
- 16:9 SD Widescreen: Displays as letterbox — AFD in the output stream is set to 1010, AR=4:3
- 16:9 SD Letterbox: Displays as letterbox — AFD in the output stream is set to 1010, AR=4:3
- 16:9 HD: Down converted to letterbox — AFD in the output stream is set to 1010, AR = 4:3

Channel 2: HD — 16:9, Pillarbox set as default ARC

- 4:3 SD Standard: Up converted to pillarbox — AFD in the output stream is set to 1001, AR = 16:9
- 16:9 SD Widescreen: Up converted and displays full screen — AFD in the output stream is set to 1010, AR = 16:9
- 16:9 SD Letterbox: Up converted and displays full screen — AFD in the output stream is set to 1010, AR = 16:9
- 16:9 HD: Plays straight through — AFD in the output stream is set to 1010, AR = 16:9

Example 2 – Impact of an incorrect AFD setting

If the AFD setting is missing or set incorrectly, the user may see a “Postage Stamp” display where the display image is shrunk with black bars on the top, bottom and sides.

For example, in Figure 1, in the top example, an HD clip is down converted to SD with a letterbox (AFD=1010). The display device with no AFD information may shrink the letterbox display and add bars to the side giving the “Postage Stamp” effect.

The same results in the bottom example with SD up converted clips.

Example 3 – File Transfers

AFD is also critical when transferring files from one system to another. If AFD exists (either originally or set by the user on the K2 media server) it needs to be preserved when that file is sent to another K2 server, archive or another system. The K2 media server will pass AFD in the MXF or GXF stream as stored or, if no AFD code is set, the K2 media server will set the AFD default code as described in Figure 5.

Supported Conversions Using AFD

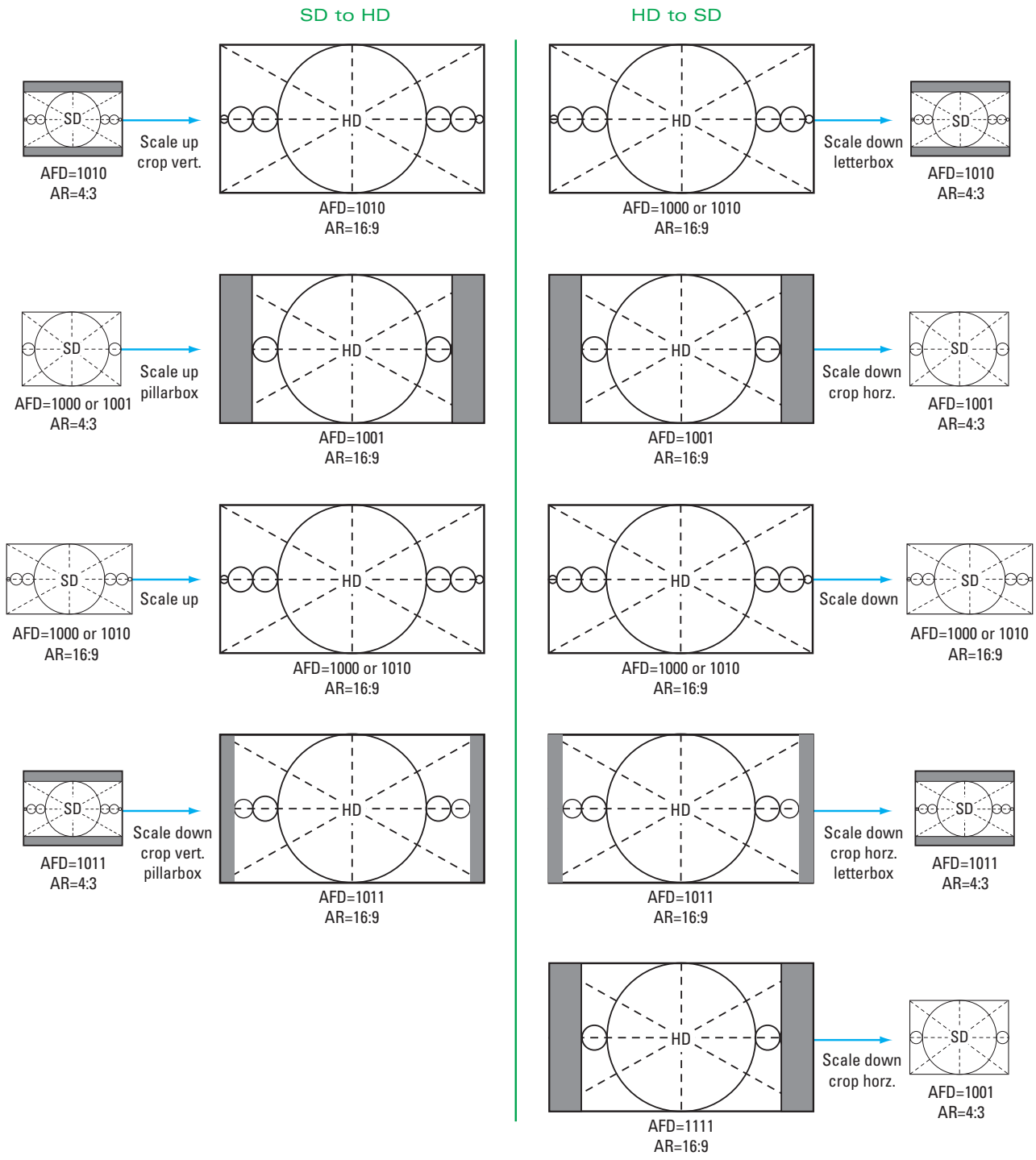


Figure 5 – Supported ARC Conversion using AFD for K2 HD systems.

Note: In several cases above, there are two valid AFD codes indicated. The SMPTE standard (Appendix A) describes this in notes 4 and 5. Based on customer feedback, K2 uses the second value.

Default AFD Settings

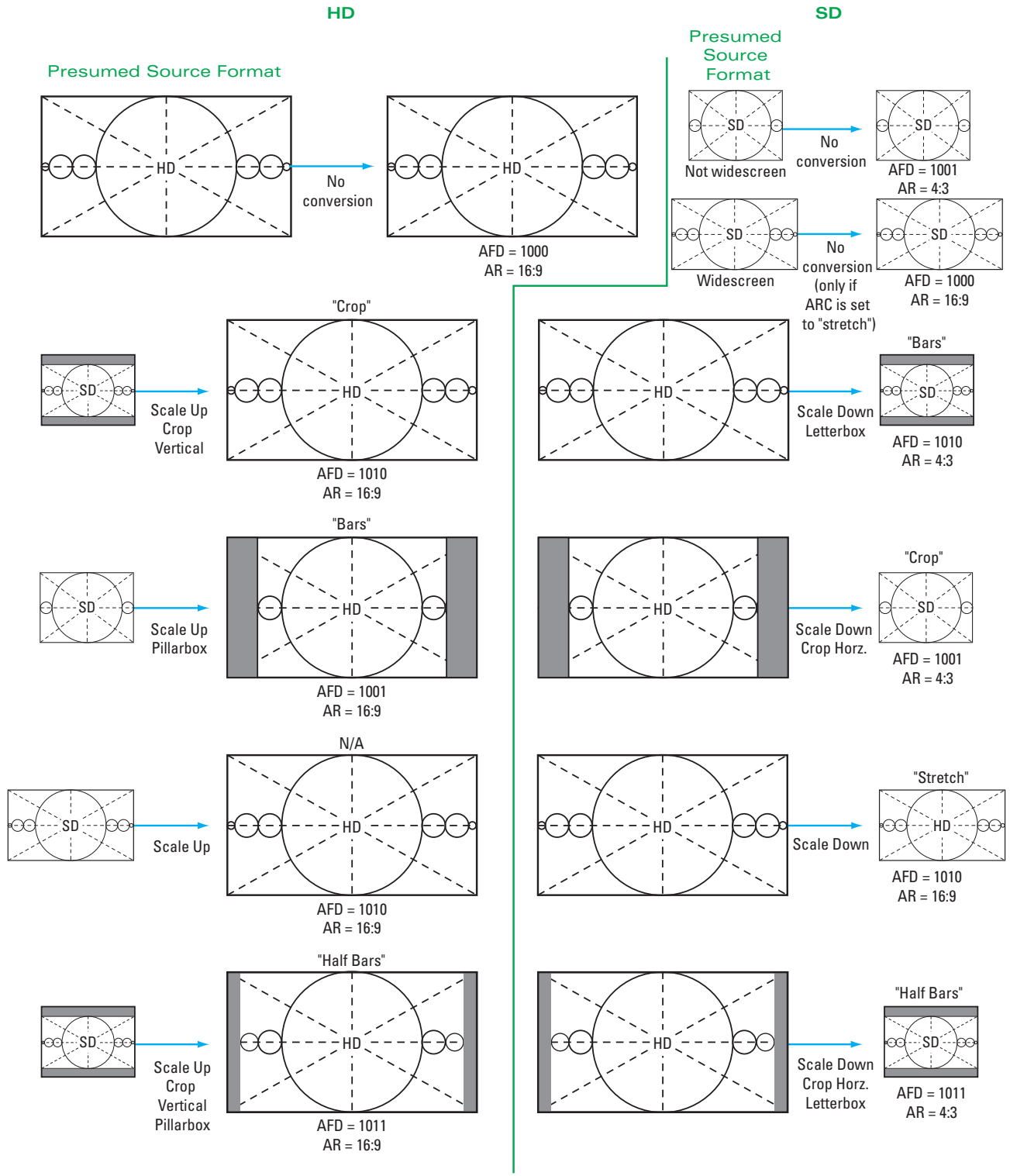


Figure 6 – Default AFD settings. When up/down converting, AFD is set according to this table.

Specifications

Additional Specifications

1. AFD can be defined on a field-by-field or clip basis. The K2 media server supports clip basis. After 2 seconds of recording, the AFD at that field is used for the whole clip (or last frame on a clip shorter than 2 seconds)
2. AFD Bar Data is not supported (rarely used)
3. AFD Aspect Ratio bit is supported (4:3 or 16:9)
4. Supported K2 Media Clients: K2-SD-04, K2-HD-xx, K2 Summit. K2-SDA-22 does not support AFD

Summary

A video server that supports the current SMPTE standards will result in a better looking picture without the extra cost and complexity of downstream equipment. The K2 media server fills this requirement for quality SD and HD broadcasts.

Definitions

Active Image

The Active Image is the portion of the video picture area that is being utilized for program content. In CEA-CEB16 it is defined as the useful image inside the video frame. Active Image excludes letterbox bars and pillarbox bars.

Coded Frame

The Coded Frame is the video frame as coded in a compressed bitstream for emission.

For consistency with ATSC, CEA, ETSI and other standards, the Active Format Description and Bar Data specifications in this document refer to the term Coded Frame. For the purpose of this SMPTE standard, use of the words “Coded Frame” shall be taken to apply also to the active video area defined by the applicable production format standard for the video signal being described by the AFD and Bar Data.

Letterbox

“Letterbox” describes a frame that the active image does not fill vertically, requiring bars without active image information at the top and/or the bottom of the image.

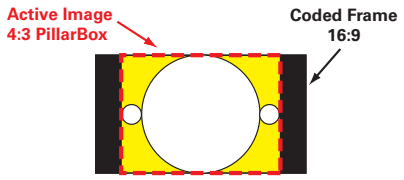


Figure 7 – Active Image vs. Coded Frame

Pillarbox

“Pillarbox” describes a frame that the active image does not fill horizontally, requiring bars without active image information at the left and/or right sides of the image. Some publications, including SMPTE RP 199, refer to pillarbox in a 16:9 display area by the term “sidebar.”

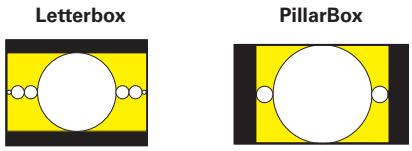


Figure 8 – Two most popular cropping formats

Anamorphic Widescreen

This is a term used to describe a videographic technique utilizing rectangular (wide) pixels to store a widescreen image to standard 4:3 aspect ratio.

SMPTE Standards

SMPTE **2016-1**
Format for Active Format Description and Bar Data

SMPTE **2016-2**
Format for Pan-Scan Information

SMPTE **2016-3**
Vertical Ancillary Data Mapping of Active Format Description and Bar Data

SMPTE **2016-4**
Vertical Ancillary Data Mapping of Pan-Scan Information

SMPTE **2016-5**
KLV Data Coding for Active Format Description, Bar Data and Pan-Scan Information

Appendix A: Active Format Description

Active Format Description codes from SMPTE 2016-1 Specification		
Active Format Description		AFD Code
In a 4:3 coded frame	In a 16:9 coded frame	a3, a2, a1, a0
Undefined (see below)	Undefined (see below)	'0000'
Reserved	Reserved	'0001'
Letterbox 16:9 image, at top of the coded frame (see note 1)	Full frame 16:9 image, the same as the coded frame (see notes 1 and 2)	'0010'
Letterbox 14:9 image, at top of the coded frame (see note 1)	Pillarbox 14:9 image, horizontally centered in the coded frame (see notes 1 and 3)	'0011'
Letterbox image with an aspect ratio greater than 16:9, vertically centered in the coded frame (see note 1)	Letterbox image with an aspect ratio greater than 16:9, vertically centered in the coded frame (see note 1)	'0100'
Reserved	Reserved	'0101'
Reserved	Reserved	'0110'
Reserved	Reserved	'0111'
Full frame 4:3 image, the same as the coded frame	Full frame 16:9 image, the same as the coded frame	'1000'
Full frame 4:3 image, the same as the coded frame (see note 4)	Pillarbox 4:3 image, horizontally centered in the coded frame	'1001'
Letterbox 16:9 image, vertically centered in the coded frame with all image areas protected (see note 5)	Full frame 16:9 image, with all image areas protected (see note 5)	'1010'
Letterbox 14:9 image, vertically centered in the coded frame	Pillarbox 14:9 image, horizontally centered in the coded frame	'1011'
Reserved	Reserved	'1100'
Full frame 4:3 image, with alternative 14:9 center (see note 6)	Pillarbox 4:3 image, with alternative 14:9 center (see note 6)	'1101'
Letterbox 16:9 image, with alternative 14:9 center (see note 6)	Full frame 16:9 image, with alternative 14:9 center (see note 6)	'1110'
Letterbox 16:9 image, with alternative 4:3 center (see note 6)	Full frame 16:9 image, with alternative 4:3 center (see note 6)	'1111'

Notes:

If Bar Data is not present, AFD '0000' indicates that exact information is not available and the active image should be assumed to be the same as the coded frame. AFD '0000,' when accompanied by Bar Data, signals that the active image's aspect ratio is narrower than 16:9, but is not 4:3 or 14:9. As the exact aspect ratio cannot be conveyed by AFD alone, wherever possible AFD '0000' should be accompanied by Bar Data to define the exact vertical or horizontal extent of the active image.

AFD code '0100' signals that the active image aspect ratio is wider than 16:9. As the exact aspect ratio cannot be conveyed by AFD alone, wherever possible AFD '0100' should be accompanied by Bar Data to define the exact vertical extent of the active image.

Bar Data is not supported by the K2 media server as these formats are not commonly used today in broadcast.

1. In determining AFD codes to originate, readers are cautioned that emission systems in some areas of the world may not support some or all of AFD codes '0001' through '0111.'

2. In a 16:9 coded frame, AFD code '0010' represents the same image display as AFD code '1000.' AFD code '1000' is the preferred coding for full-frame 16:9 images. AFD code '0010' is not used in North America.

3. In a 16:9 coded frame, AFD code '0011' represents the same image display as AFD code '1011.' AFD code '1011' is the preferred coding for a horizontally centered 14:9 pillarbox image. AFD code '0011' is not used in North America.

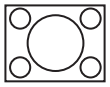
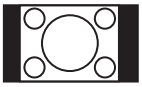
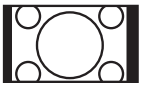
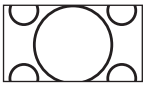
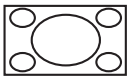
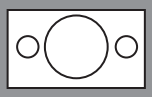
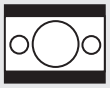
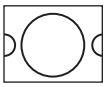
4. In a 4:3 coded frame, AFD code '1001' represents the same image display as AFD code '1000.' AFD code '1000' is the preferred coding for full-frame 4:3 images.

5. AFD code '1010' is intended for use with images that may not fill the frame vertically but where all areas of the image should be displayed (i.e., an image where cropping is not permitted) and which therefore can only be adequately displayed in letterbox format.

6. The "alternative center" image refers to an area of essential picture information. The areas outside this area (shown gray in the illustrations) may optionally be cropped without significant loss to the viewer.

7. Aspect ratio information for the coded frame is not part of the AFD code and it is necessary to code this aspect ratio information separately. The AFD and aspect ratio codes may be transported together as part of a larger data structure.

Appendix B: Aspect Ratio Conversions on HD K2 Server Models

Source Aspect Ratio	Source Image	Conversion Option	Conversion Description	Converted Aspect Ratio	Converted Image
4:3		Bar	The 4:3 aspect ratio is maintained centered on the screen, with black bars filling the left and right portions of the 16:9 display.	16:9	
		Half Bar	The picture aspect ratio is maintained, but the image is slightly enlarged. The top and bottom of the image are slightly cropped, and thin black bars fill the left and right portions of the 16:9 display.	16:9	
		Crop	The picture aspect ratio is maintained, but the image is enlarged so that it horizontally fills the HD display. The top and bottom of the 4:3 SD image are cropped to fit in the 16:9 display.	16:9	
		Stretch	The picture aspect ratio is distorted. The image fills the screen vertically without cropping, and is stretched horizontally to fill the 16:9 display. This conversion upconverts Full Height Anamorphic (FHA) 16:9 SD material.	16:9	
16:9		Bar	The 16:9 aspect ratio is maintained, centered on the screen, with black bars filling the top and bottom portions of the 4:3 display.	4:3	
		Half Bar	The picture aspect ratio is maintained, but the image is slightly enlarged. The left and right sides the image are slightly cropped, and thin black bars fill the top and bottom portions of the 4:3 display.	4:3	
		Crop	The picture aspect ratio is maintained, but the image is enlarged so that it vertically fills the SD display. The left and right sides of the 16:9 HD image are cropped to fit in the 4:3 SD display.	4:3	
		Stretch	The picture aspect ratio is distorted. The image fills the screen horizontally without cropping, and is stretched vertically to fill the 4:3 display. This conversion generates Full Height Anamorphic (FHA) 16:9 SD material.	4:3