XAVC XAVC S

XAVC™

Specification Overview

Revision 2 Sep. 13th, 2013
First Edition Nov. 1st, 2012

http://www.xavc-info.org/

© 2013 Sony Corporation. All rights reserved.

1) Introduction

The H.264/MPEG-4 Part-10 Advanced Video Coding technology is predominantly being used in HDTV distribution systems, such as Blu-ray, digital broadcasting (terrestrial/cable/satellite), and web browsers. Initial standardization documents date back to year 2003, and it has been extended over the years until 2009 to cover much more than HDTV distribution standards. Today the family of operational levels covers an extremely wide range of compressed image data, starting from several Kilobits per second up to 1.2Gbps, which extreme parameters encompasses 4K, 3D, 14bit sampling, and way over 100 frames per second. Sony was one of the active members of the JVT (Joint Video Team) that completed the standard, and has made significant efforts in establishing the AVCHD format and expanding the levels/profiles of H.264.

The extension of the H.264 standard coincide with rapid developments in high-resolution / high-frame rate imaging technologies (sensors, displays), and in high speed storage technology. A high performance yet efficient compression technology such as H.264 plays a critical role in encoding the vast amount of imaging data generated by modern sensors into a modest file size, so that those images can be recorded on affordable memory cards, and edited/viewed on computers/editing software packages that are readily available.

Figure 1) shows the progress in CMOS imager technology, where Sony has developed and commercialized an imaging sensor with data transfer rates exceeding 30Gbps. It is expected that high resolution, high frame rates, and high bit rate imaging tools will become more common in the coming years. Figure 2) shows the progress of SxS and XQD memory card technology. Note that the latest cards guarantee real-time recording beyond 1Gbps, and the recording capacity has significantly increased over the years. And not just maintaining the same compact form factor but to make the size even smaller.

This document illustrates the attributes and benefits of the XAVC format. It also explains how XAVC fits into the current production workflow, along with well-established compression formats such as MPEG2, MPEG4 SStP, and various camera RAW files.

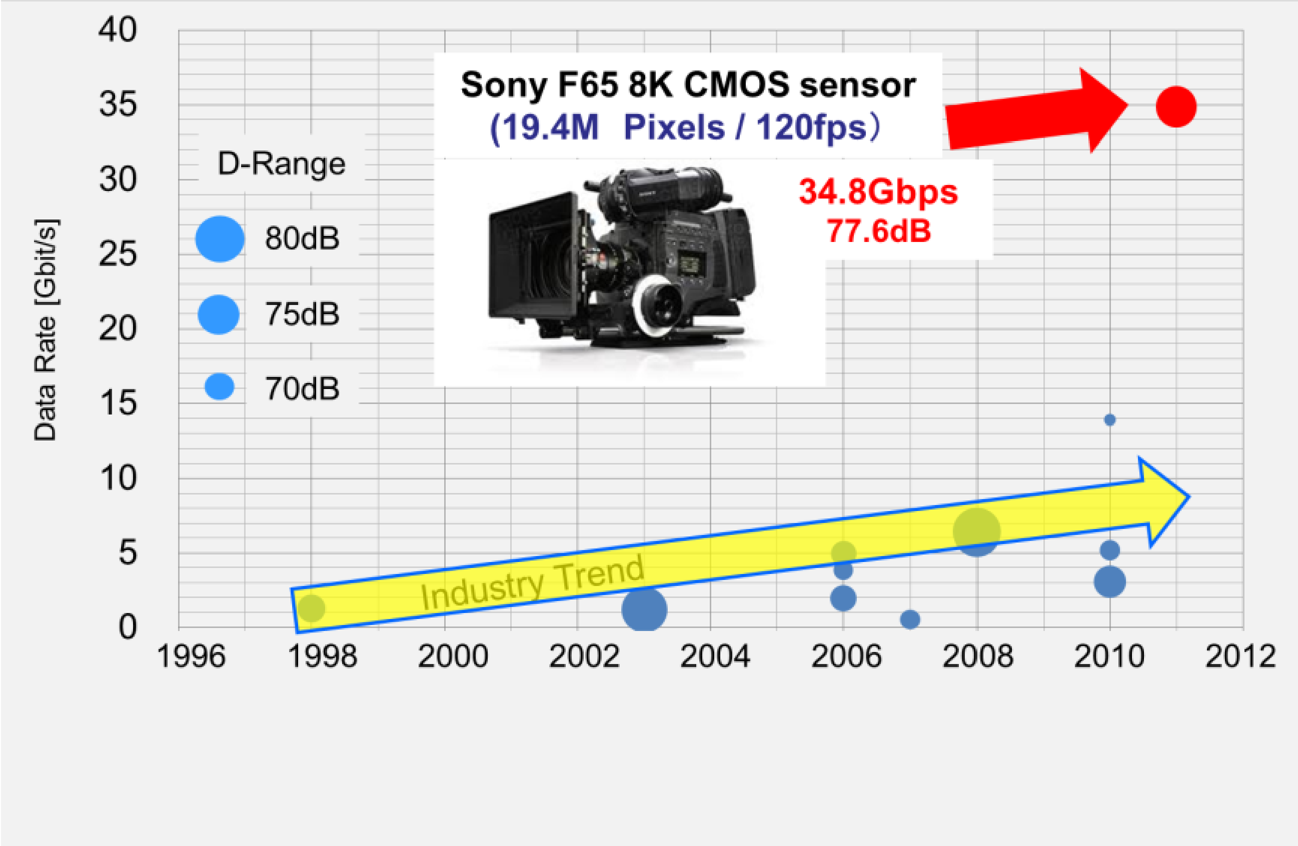

Figure 1) Progress in CMOS technology development

Media	SxS Pro	SxS-1	SxS Pro +	XQD N series	XQD S series
Year of Introduction	2007	2009	2013	2013	2013
Sustained recording data rate	400Mbps	240Mbps	1.3Gbps	-	-
Max. readout speed	1.2Gbps	1.2Gbps	1.6Gbps	1.0Gbps	1.44Gbps
Storage capacity	8GB/16GB(2007) 32GB(2008) 64GB(2011)	32GB(2009) 64GB(2010)	64GB/128GB	32GB/64GB	32GB/64GB
					

Figure 2) Progress of SxS Recording Media Technology

2) The XAVC Format

The Sony XAVC format complies with H.264 level 5.2, which video essence is encapsulated in an industry standard MXF OP-1a wrapper, accompanied by audio and meta-data elements. The primary objective in adopting the XAVC format is to develop a family of professional production tools that can economically handle High-Frame-Rate (HFR) HD and 4K imaging formats. Figure 3) shows the scope of the XAVC format. Please note that this format table describes the global scope of the XAVC format, and actual product implementation may be restricted to a certain portion of this table. On the other hand, this chart excludes any off-speed recording capability (over/under cranking) that some products may offer.

Range	Resolution	Frame Rate	Color	Max Bitrate	Intra / Long
4K	4096x2160 3840x2160	23.98p to 59.94p	4:2:0/8bit to 4:4:4/12bit	960Mbps	Intra Long
HD	2048x1080 1920x1080 1440x1080 1280x720	23.98p to 59.94p 50i/59.94i	4:2:0/8bit to 4:4:4/12bit	440Mbps	Intra Long
Proxy	1920x1080 1280x720 640x360 480x270	23.98p to 59.94p	4:2:0/8bit	28Mbps	Long

Figure 3) XAVC Format overview

In addition, MP4 wrapping format is also introduced and branded as XAVC S to serve the consumer market. This expansion will encourage growth of 4K content in the consumer market.

3) XAVC and 4K

The use of 4K digital motion imaging systems is currently restricted to the domain of digital cinema, where the DCI (Digital Cinema Initiative) theatrical presentation standard is set to 4096 x 2160 @24Fps with compressed JPEG2000 MXF files. As history repeats itself, multiple consumer display manufacturers have started marketing 4K flat panels and

projection systems for home entertainment. Although it may take a few more years for terrestrial 4K broadcasting to begin services, various cable/satellite/network operators and content providers consider 4K as a new business opportunity for content delivery. Current HDTV content can benefit from 4K displays, as the internal up-conversion process will help reduce line and pixel structure effects in large displays or multiple HDTV streams can be displayed simultaneously at full resolution. Today, most digital still cameras, even those built into cell phones boast a native resolution above HDTV. The 4K home panel can serve as a pristine quality digital photo frame.
Due to the wide array of operating points that the XAVC format offers, 4K imaging bandwidth can be reduced to under 100Mbps depending on GOP structure, frame rate, and color sampling. Such efficient selection of operating points is expected to significantly augment the home entertainment experience and applied to certain B2B applications where high resolution imaging is of prime interest.

The active pixel count of most 4K home displays will be restricted to 3840 x 2160, a quadruple of 1920x1080. (Quad HD or QFHD), which is different from the Cinema presentation standard that has 4096 pixels across the image plane. The XAVC format covers both 4096 & 3840 horizontal sampling formats, allowing the XAVC production tools to be used in both cinema and television applications.

The new Sony PMW-F55 camera records 4K XAVC INTRA-frames at operating points between 240Mbps (@24P) to 600Mbps (@60P) within the camera. In order to securely record such high data rate by a cost efficient yet compact media, Sony has newly developed the SxS Pro+ memory card family. The SxS Pro+ memory cards are compatible with all devices that have an SxS card slot, and achieve a sustained recording data rate up to 1.3Gbps. On a single SxS Pro+ 128GB memory card, the PMW-F55 records up to 50 minutes in 4K/24P or approx. 20 minutes in 4K/60P.

4) XAVC , RAW , and ACES workflow

The digital cinema production community is on the way towards standardizing a common set of image parameters that encompasses images created on film, digital cameras, and those generated by computers. ACES (Academy Color Encoding System) is expected to establish a common playing field for images of different origins, offer maximum headroom for image manipulation (color grading), and achieve a consistent appearance across different tool sets and service providers. Sony is an active participant in the ACES initiative, and has created various IDTs (Input Device Transforms) to allow high-end cameras to fit into the ACES workflow. The 16bit half-float bit depth of ACES files achieves the best from high-end camera images and CGI elements, and offers maximum flexibility for color grading in the DI (Digital Intermediate) suite. This is why recent cameras from Sony (F65+SR-R4, PMW-F55+AXS-R5, PMW-F5+AXS-R5) have the ability to record 16 bit linear RAW files via compact on-board recorders.

While the PMW-F5/F55 cameras are recording camera RAW files via the AXS-R5 on-board recorder, the in-camera SxS card slots can simultaneously record XAVC files at HD resolution, which perfectly matches the RAW files in respect to recording In/Out points, audio, timecode, and other metadata including file names. The XAVC files complement the RAW files as editorial files, which allow the editing process to start immediately when the SxS cards are removed from of the cameras.

In order to color grade and edit images derived from camera RAW files, an extra image processing step (typically referred as De-Bayering, or De-mosaicking) is required. Although the camera RAW files offer the maximum creative freedom which is imperative for sophisticated post production work, there can be time/budget constraints. 4K XAVC files can be considered as a cost efficient alternative to camera RAW files. As shown on Figure 4) the 4K XAVC file size is similar to those of HD resolution files that are commonly used today. It is expected that 4K XAVC files will be one of the major driving force in expanding 4K production.

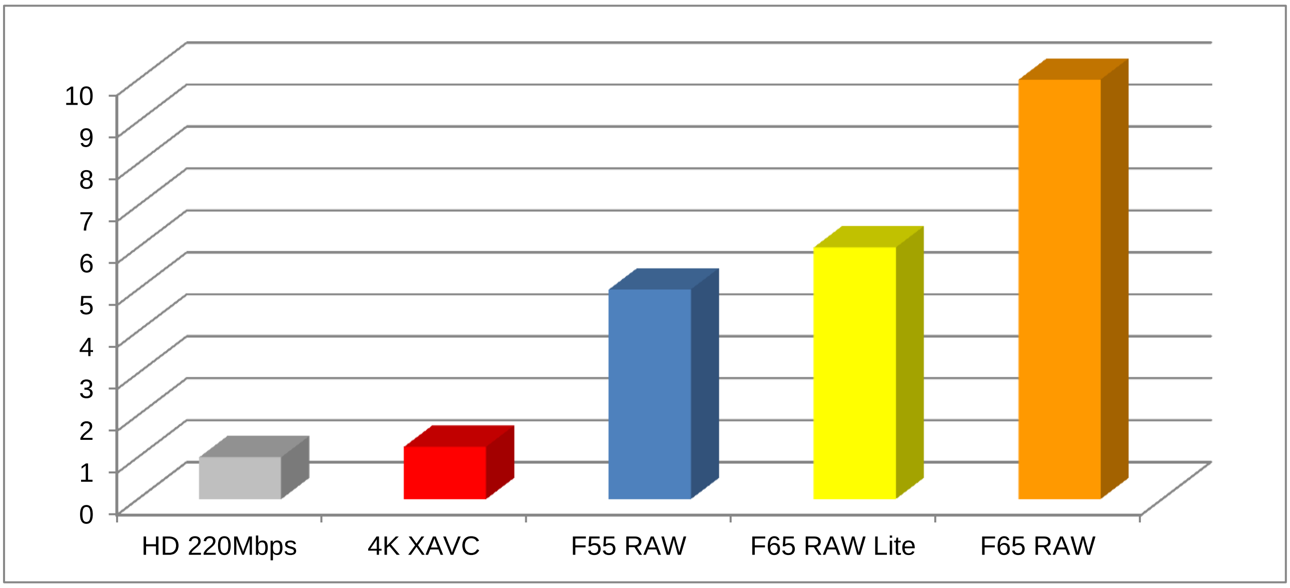

Figure 4) Image file size comparison: Unit Giga Byte / Frame

5) XAVC and HDTV

It is often described that newly developed compression algorithms are more efficient than their predecessors. Although this is true in the sense that a given image quality can be achieved with less amount of image data (or bit rate), the increased complexity of modern coding schemes do demand more computational power, which could be a major challenge when migrating the production infrastructure and associated workflow from one generation to the next. The amount of processing power requirements to decode a certain compressed bit stream is extremely critical when multiple files are simultaneously used in an edit session.

Today, the vast majority of broadcast and reality-TV industry is operating on the MPEG2 HD Long GOP format (50Mbps or 35Mbps) for HDTV production due to its small file size, high picture quality, and economy in computational requirements. From breaking news to reality shows, and prime sports events, the data rate of 35 to 50Mbps is the sweet spot to operate a file based HDTV infrastructure.

Figure 5 shows how different compressed video streams can be decoded on a given computer platform, without resorting to any hardware accelerators or GPU`s. The horizontal scale represents Frames-per-Second, and it is obvious that MPEG2 50Mbps is the fastest (or most efficient) amongst all of the contenders.

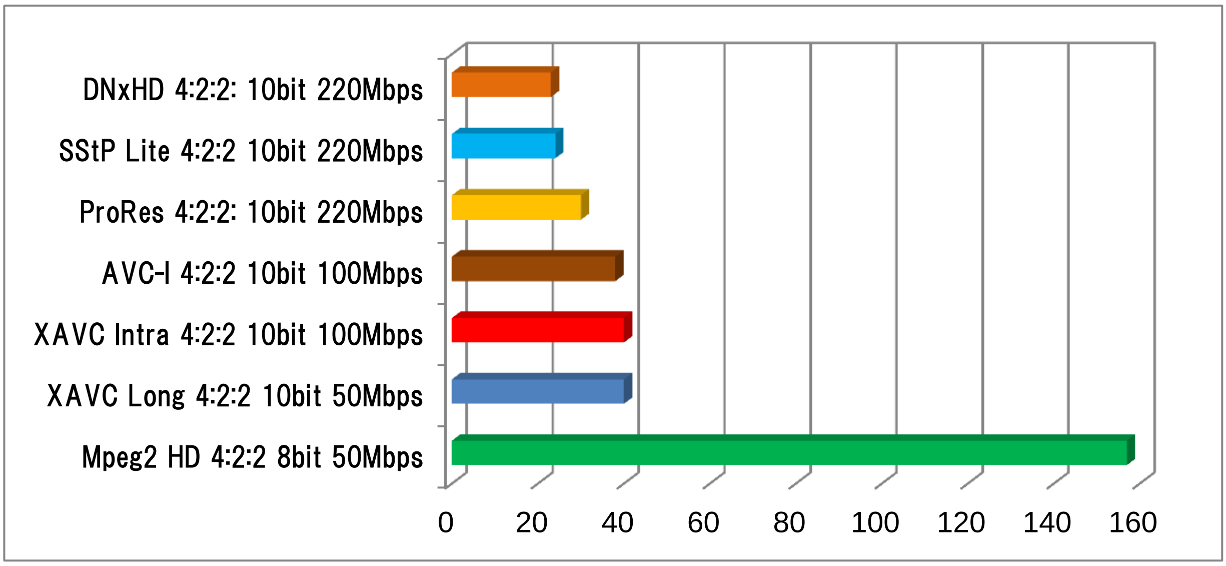

Figure 5) Software decode speed comparison Unit: Frames-per-second

Recently several broadcasters have started showing interest in adopting H.264 format as their main in-house format due to the following reasons.

- Consolidate all program files, from prime time programming to news, into one single codec contained in a common, industry-standard wrapper.
- 10 bit sampling as opposed to 8bit on MPEG-2.
- MPEG-2 50Mbps image quality perceived as not enough to replace current tape formats such as HDCAM.
- Storage space, network bandwidth, and processing power are becoming less of an issue to handle multiple high bit rate streams.

For 50p/60p HDTV operation, XAVC Intra supports up to 440Mbps and can be considered as the mezzanine level format that fills the gap between the mastering quality format (MPEG4 SStP, or HDCAM-SR), and MPEG2 as illustrated in Figure 6.

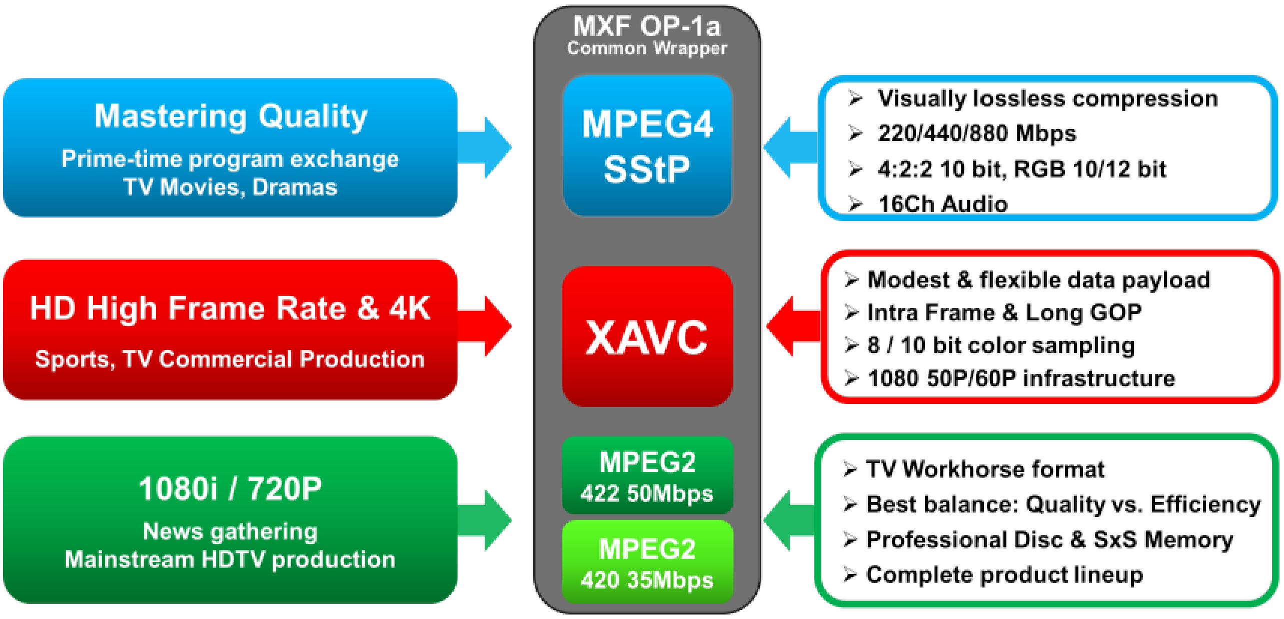

Figure 6) HDTV Compression format overview

XAVC also plays a critical role in enabling a portable camcorder with extreme high-frame rate capability in HDTV resolution. The PMW-F55 records full resolution 1920x1080 10bit 4:2:2 images up to 180 Frames-per-second onto the internal SxS Pro+ memory cards. By filling the two memory card slots with 128GB cards, continuous recoding time is extended to approx. 40 minutes at 180Fps.

Demand for keeping the file size small enough to run through the current 35-50Mbps pipeline, even in the 1080-50p/60p operation workflow will still remain. Utilizing Long GOP is the preferable technique for this demand, which makes file size smaller without affecting the picture quality. As shown in Figure 5 above, decoding performance is quite equivalent between Long GOP 50Mbps and Intra 100Mbps, although more arithmetic is required.

6) XAVC enabling technology

The XAVC format complies with the H.264 format specifications, and Sony has strived to improve the image quality, while maintaining file interoperability with products provided by other manufacturers. Figure 7) shows the XAVC bit stream based on a traditional KLV structure. One key element on this bit stream is the frame-by-frame integration of SPS (Sequence Parameter Set) and PPS (Picture Parameter Set) into the bit stream. This allows the recording device to dynamically optimize the image quality per picture frame, and the optimized image setting value will remain attached to the picture file after editing. It also helps to optimize the image quality during random access playback.

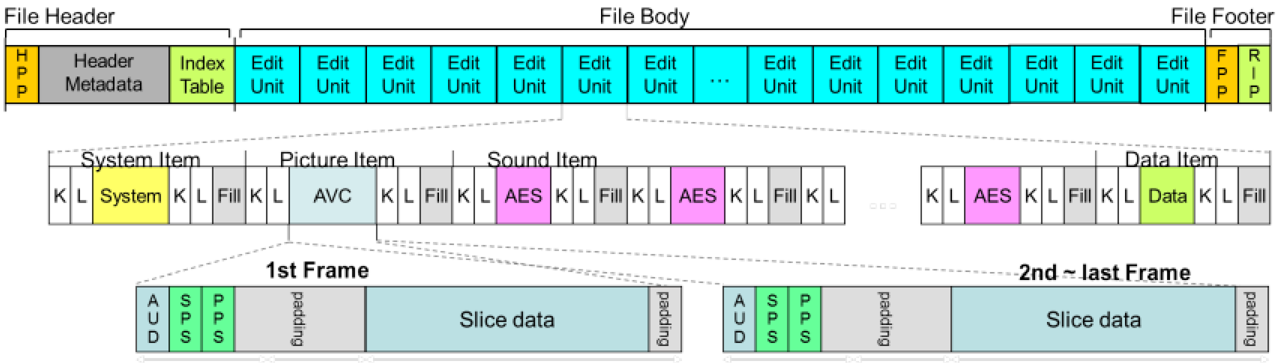

Figure 7): XAVC bit stream structure

The XAVC encoder has a pre-coding mechanism, which helps to make maximum use of data that is allows compression of each image frame or stream. The pre-coding mechanism is integrated into both software and hardware encoders. This two-stage encoding process takes place during high-frame-rate recordings and 4K recordings.

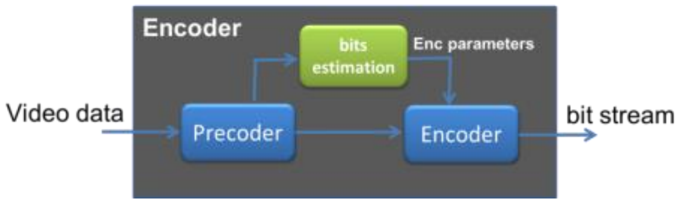

Figure 8) Pre-coding mechanism

Figure 9) XAVC/MPEG2 codec chipset

In order to productize portable camcorders with modest power consumption, Sony has developed a custom hardware chipset that handles the XAVC encoding & decoding process. Moreover, the chipset has the ability to encode/decode MPEG2 as well. The multi codec capability is expected to significantly increase the product life value. It will allow facility/equipment owners to create a service infrastructure that can easily convert between MPEG2 and XAVC. The first product to make full use of this multi codec capability is the

PMW-F5/F55 production camcorder, which handles MPEG4 SStP and RAW in addition to XAVC and MPEG2.

In order to efficiently cope with ever escalating production demands and yet meet the project budget, it is extremely important to select the optimum format and operating point. The XAVC format elevates the creative possibilities to a new level, and offer quality and efficiency at the same time.

7) XAVC supporters

Note: Avid and the Avid logo are trademarks or registered trademark of Avid Technology, Inc. or its subsidiaries in the United States and/or