

# **AVC-ULTRA**

## Overview

Revision 2.0

February, 2015

**Panasonic**

## Revision History

Revision No.	Description	Date
1.0	Initial release	June 2013
1.1	Typos are fixed in Figure 3 and Figure 4.	February 2014
2.0	Updated the specification on Class 4:4:4	February 2015
	Added the specifications on Class 4K/2K	
	Updated AVC-ULTRA product lineup	
	Updated AVC-ULTRA partnership	

## Introduction

H.264/AVC video codec was adopted by Panasonic in 2007 as "AVC-Intra", the first production format using H.264/AVC for professional applications. Since then, all P2-HD product lines have been equipped as standard with AVC-Intra. AVC-Intra provides excellent picture quality with higher compression efficiency and the potential bit rate saving by AVC-Intra is around 50% over the conventional codec schemes. AVC-Intra employs the Intra-only and frame completed codec scheme suitable for editing. These features have been accepted by the industry and AVC-Intra has been recognized as one of the standard formats for non-linear editing and server systems. Peripheral equipment and a variety of tools supporting AVC-intra have been produced and now more than 45 vendors support AVC-Intra and more than 90 products supporting AVC-Intra are available. Given the situation above, six years behind Panasonic, other major camera manufacturers have started to introduce video codec using H.264/AVC based on the similar concept.

A couple of years after AVC-Intra was introduced to the market, evolutions in network infrastructures and semiconductor technologies has created new innovations in viewing environments of image contents and production workflow. The recent growth of mobile devices has been boosting the performance of public network, improving the network speed by about ten times faster than in the past. This enables customers to review image contents not only by conventional television broadcasting but also by more versatile ways such as using a smart phone or a tablet device. In the image content creation business, a new workflow utilizing IP network transmissions and removing constraints on time and location is going to be feasible. The evolution of semiconductor technologies enables a large scale, high speed, and lower power consumption LSI, allowing the production of rich images with a higher resolution at a lower cost.

Having seen the evolution of these technologies and the environment that has emerged over the past few years as an opportunity to establish a new stage of image production, Panasonic developed the AVC-ULTRA codec family by advancing the use of H.264/AVC technologies accumulated through the development of AVC-Intra.

This paper discusses what AVC-ULTRA will bring to image production, gives an overview of the AVC-ULTRA codec scheme and the technologies supporting AVC-ULTRA implementations.

## What will AVC-ULTRA bring you?

AVC-ULTRA has been developed to provide people who work for image production with the following three core benefits:

- (1) Significantly reducing operational costs in the workflow of image production
- (2) Network-based image acquisition and production by removing constraints on time and location
- (3) Image production environment inspiring the production of creative image content

Figure 1 illustrates the concept of AVC-ULTRA. (1) Operational cost reduction is achieved by AVC-LongG which provides high picture quality with lower bit rate compared to MPEG-2 Long GOP. (2) Network-based workflow is achieved by low bit rate AVC-LongG and AVC-Proxy suitable for data transfer over IP network. (3) AVC-Intra Class 200 and Class 4:4:4 have been developed to meet the requirements for producing creative image content which needs much higher image representation and robustness against manipulation and effects. AVC-Intra has also been enhanced to cover higher frame rates and to specify Class 4K supporting Ultra high definition (4K) image formats.

AVC-ULTRA provides these three features by the unified codec scheme based on H.264/AVC and makes it possible to establish optimum workflow in image production depending on their applications. AVC-ULTRA will expand the business opportunities of vendors and creators who are working towards image content creation.

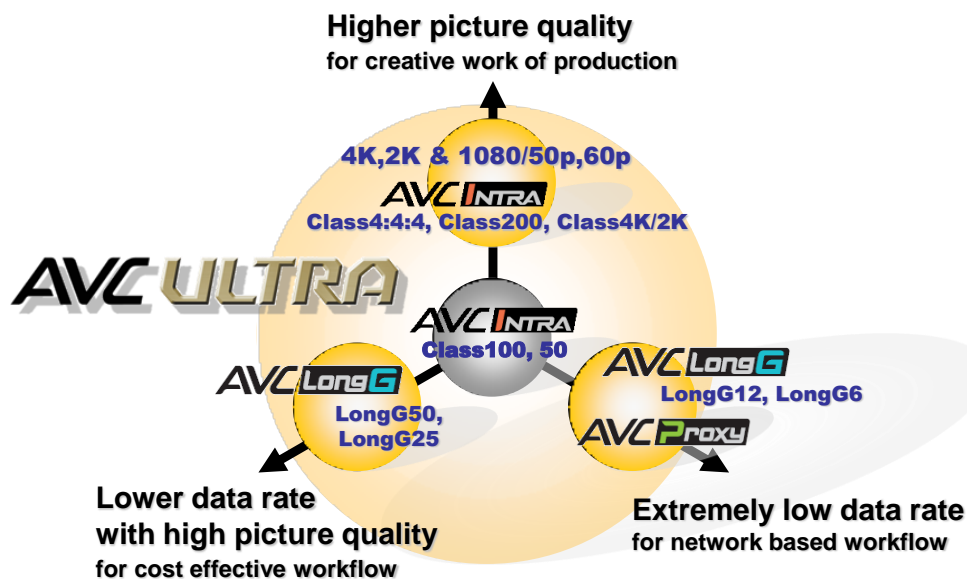


Figure 1 Overview of AVC-ULTRA

## AVC-ULTRA codec family for HD

The AVC-ULTRA codec family complies with the H.264/AVC standard. Figure 2 summarizes the overall specification of the AVC-ULTRA family codec for HD video formats along with approximate compressed bit rates. It should be noted that Figure 2 just describes the scope of the AVC-ULTRA codec for HD and some portions given in Figure 2 may not be implemented in some of actual products.

Figure 3 shows the bit rate for each compression mode in the 1080/59.94i or 1080/29.97p system including the bit rate of an uncompressed image. Bit rate reduction ratios over uncompressed images in 12-bit 4:4:4, 10-bit 4:2:2, and 8-bit 4:2:0 are around 1/5 to 1/10 by AVC-Intra and around 1/25 to 1/125 by AVC-LongG. With regard to file format, AVC-ULTRA supports the industry standard MXF and also supports QuickTime (.mov) for AVC-Proxy and some of AVC-LongG.

Codec	Compression Format						File format	Approximate Video Rate (bps)						
	Class	Color sample	Bit depth	Full resolution	Intra/Long	CBR/VBR		1080			720			1080
								23.98p 24p	25p 29.97p	59.94i 50i	23.98p 24p	25p 29.97p	59.94p 50p	59.94p 50p
<b>AVC Intra</b>	4:4:4	4:4:4	12bit	Yes	Intra	VBR	MXF	180M	220M					440M
	200	4:2:2	10bit	Yes	Intra	CBR	MXF	178M	226M	226M			226M	452M
	100	4:2:2	10bit	Yes	Intra	CBR	MXF	89M	111M	111M	44M	56M	111M	222M
	50	4:2:0	10bit	No	Intra	CBR	MXF			54M			54M	
<b>AVC LongG</b>	G50	4:2:2	10bit	Yes	Long	VBR	MXF	50M	50M	50M			50M	
	G25	4:2:2	10bit	Yes	Long	VBR	MXF	25M	25M	25M			25M	50M
	G12	4:2:0	8bit	Yes	Long	VBR	MXF/mov			12M			12M	24M
	G6	4:2:0	8bit	Yes	Long	VBR	MXF/mov			6M			6M	12M
<b>AVC Proxy</b>	G6	4:2:0	8bit	Yes	Long	VBR	mov	6M						
	SHQ	4:2:0	8bit	No	Long	VBR	mov	3.5M						
	HQ	4:2:0	8bit	No	Long	VBR	mov	1.5M						
	LOW	4:2:0	8bit	No	Long	VBR	mov	800k						

CBR: Constant Bit Rate, VBR: Variable Bit Rate

Figure .2 AVC-ULTRA codec family for HD

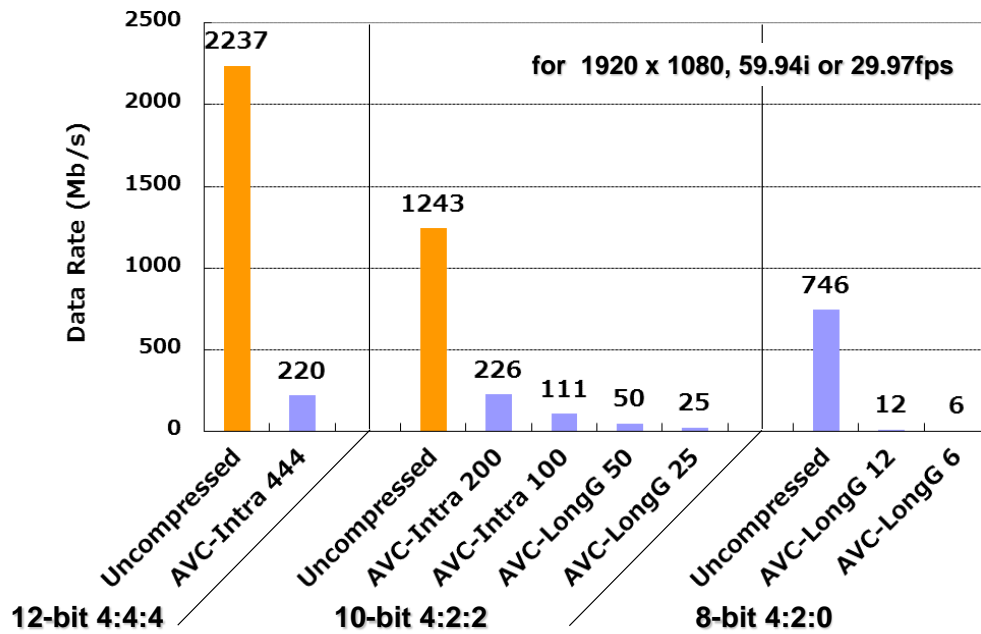


Figure 3 Video data rate of AVC-ULTRA and uncompressed picture for HD

### Low cost operation with AVC-LongG

The growing infrastructure of IP and wireless networks has made it possible for consumers to enjoy a variety of content in a variety of ways, including review content on mobile devices. This leads to the requirement for producing much more contents with economical operational cost. AVC-LongG25 provides high picture quality comparable to AVC-Intra Class100 while the bit rate is reduced by around one quarter. This eventually drives down operational costs in image production. In addition, AVC-LongG50 is also introduced to handle higher quality HD taking advantage of the production infrastructures for SDTV using 50 Mbps.

AVC-LongG employs Long GOP compression utilizing the temporal correlations between pictures and provides higher coding efficiency. Both AVC-LongG50 and LongG25 support full resolution HD with 10-bit 4:2:2 sampling. Stable picture quality and bit rate reduction are well balanced by using VBR (Variable Bit Rate) encoding which optimizes an instantaneous bit rate for each GOP depending on the nature of each picture.

Comparing AVC-LongG25 to MPEG-2 compression adopted by other vendors with a bit rate of 50Mbps and 8-bit 4:2:2 sampling, AVC-LongG25 archives comparable or better picture quality with a 50% bit rate saving over MPEG-2. This saving is due to the use of enhanced codec tools given by H.264/AVC such as precise motion prediction, deblocking

filter, optimized GOP structure, and Context-based Adaptive Binary Arithmetic Coding (CABAC), and the adaptive control technique developed by Panasonic. This technique adaptively allocates amount of bit for each picture with taking the human visual characteristics and minimizing multi-generation degradations into consideration.

Figure 4 shows the storage capacities required for storing materials captured using AVC-LongG25 in comparison with MPEG-2 50Mbps. As shown in Figure 4, AVC-LongG25 can reduce the required storage capacity by one half and it contributes to reduce the investments for a storage system and subsequent operational costs. Figure 5 shows the time required for transferring one minute duration clip over network such as Ethernet, Wi-Fi, and public mobile network. The use of AVC-LongG thus reduces the time required for transferring image materials over IP network by one half and it results in bringing down operational costs relevant to network infrastructures in the site.

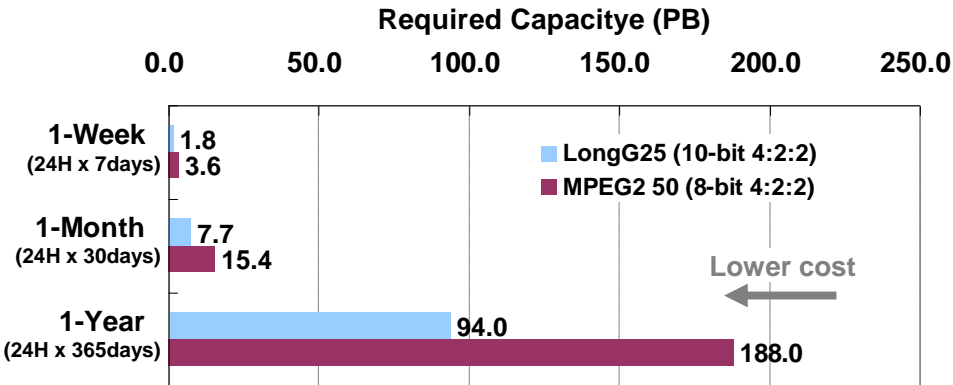


Figure 4 Required storage capacity for HD content

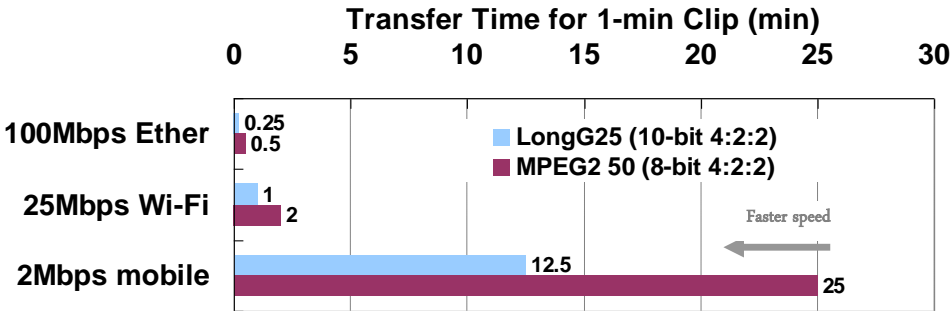


Figure 5 Transfer time of 1-minute HD clip over IP network

There may be a concern that Long GOP would need more computational power and cause an increased load on software processing in editing on a PC compared to Intra-only compression. Figure 6 shows an example of software encoding and decoding speed, where the speed is represented by average time required for processing one frame data in the 1080/59.94i system. The encoding and decoding speeds in LongG25 are almost equal to those in Class100. Especially, decoding process of one frame data is completed within less than one third of one frame period (33.3 ms) and real-time editing handling multiple streams is thus possible. It should be noted that the processing speed given in Figure 6 is based on the measured results using a PC with a Core i7 processor released in 2012 and the evolution of newly developed processors will reduce processing time further year by year.

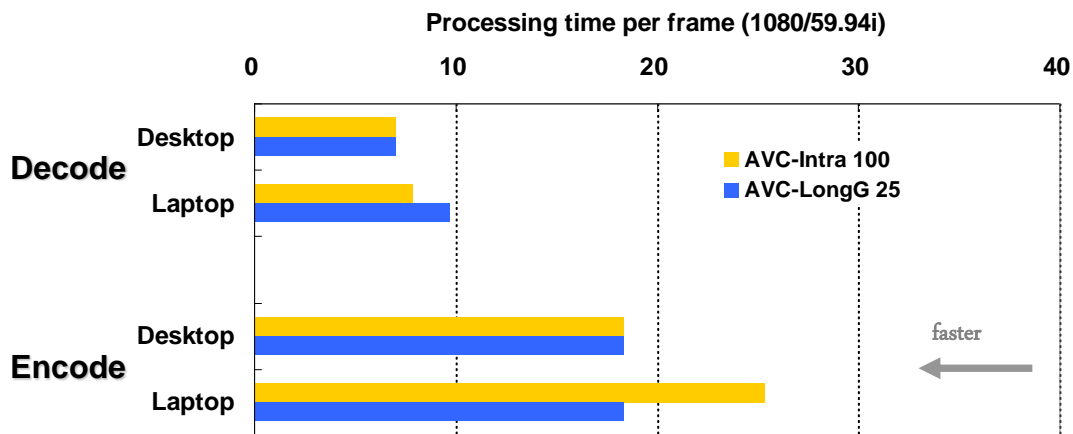


Figure 6 Software codec performance

### MXF file format for AVC-ULTRA

An AVC-LongG stream is encapsulated using MXF OP-1b, which has been standardized as one of the MXF Generalized Operational Patterns. Figure 7 illustrates the essence container structures of OP-1a and OP-1b, where two channels of audio elements are carried and each essence element has a KLV packet structure, which is not depicted. OP-1b as well as OP-1a allows you to wrap video, audio and data essences in a single file. Such a single file including multiplexed essences can be simply transferred over IP network. In the frame-wrapped OP-1a file shown in Figure 7 (a), video and audio data are interleaved on a frame by frame basis and it needs to slice an audio essence into a small piece of audio element. In the OP-1b file for AVC-LongG stream shown in Figure 7 (b), video and audio data are handled as independent essences and are thus interleaved using partitioning in a



specific period, two seconds for example. Such essence data placement in chunk enables fast scanning of audio element in high speed search and easy conversion to other file formats.

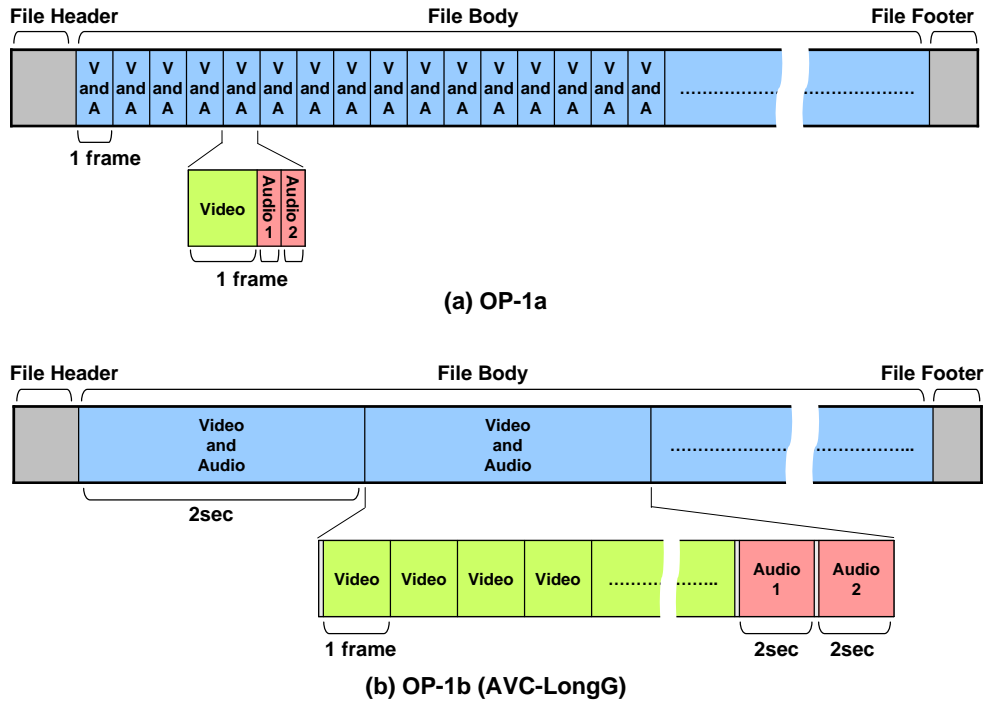


Figure 7 MXF File structure of AVC-LongG OP-1b compared with OP-1a

The file format for AVC-Intra Class 4:4:4 and AVC-Intra Class 4K/2K is also MXF OP-1b. The structure of the OP-1b file for these AVC-Intra codec schemes are the same as that illustrated in Figure 7 (b) and the AVC-Intra streams are encapsulated as the video essence.

### High speed production over the net with AVC-LongG & AVC-Proxy

Although it is expected that fast transfer speed of public mobile network will enable swifter image acquisition and program production by transferring image contents over public network, the current infrastructure would not be enough to transfer an AVC-Intra coded HD material with regard to transfer speed and operational cost. AVC-LongG12, AVC-LongG6, and AVC-Proxy are intended to be used in a networked environment and enable network-based operations by removing constraints on time and location.

AVC-LongG12 and AVC-LongG6 support full HD resolution with 8-bit 4:2:0 sampling. AVC-Proxy employs down sampling for much faster transfer rather than keeping picture

quality. Figure 8 describes the transfer times (in seconds) of one minutes HD material over Wi-Fi and public mobile network where the materials are compressed with LongG12, LongG6 and Proxy HQ. Full HD materials compressed with AVC-LongG12 and LongG6 can be transferred to a remote site in a short period and the materials can be promptly used as primary materials. AVC-proxy enables much faster transfer and is thus suitable for reviewing the content or off-line editing using a mobile device or in a remote place.

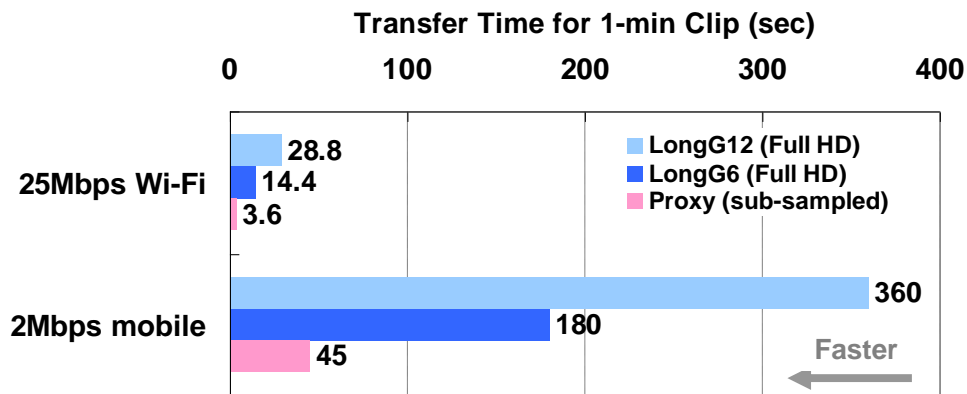


Figure 8 Transfer time of 1-minute HD clip over wireless network

An AVC-Proxy stream is recorded as a .mov file supporting QuickTime. QuickTime is also selectable for AVC-LongG12 and AVC-LongG6 in addition to MXF OP-1b. The support of QuickTime provides direct editing, using mobile devices or existing editing software already supporting QuickTime.

AJ-PX5000 camera recorder, which was released in autumn 2013, is equipped with the ability of recording AVC-Intra or AVC-LongG50/G25 clips along with the simultaneous recording of AVC-LongG6 or AVC-Proxy clips. This feature enables the efficient operation such that 4:2:0 material is generated for network transfer in parallel with 4:2:2 sampling recording using AVC-Intra or LongG50/G25.

### Inspiring creativity with extended AVC-Intra

AVC-Intra, as a family member of AVC-ULTRA codec scheme, has also been extended by adding Class200 and Class 4:4:4. Figure 9 shows the bit rates for Class200 and Class 4:4:4 in the 1080/59.94i and 1080/29.97p systems along with those for HDCAM-SR for reference.

AVC-Intra Class200 doubles the bit rate of Class100 and compresses a 1080/59.94i, 10-bit,4:2:2 sampling image to around 200 Mbps. Class200 provides visually comparable quality to an uncompressed image regardless of the image content and is suitable for high-end image production. The subjective evaluation conducted by EBU (European Broadcasting Union) has summarized the report BPN 098 stating that picture quality through 1<sup>st</sup> generation to 7<sup>th</sup> generation in Class200 is nearly equal to the original. Given high performance in picture quality with about half the bit rate of HDCAM-SR SQ, Class200 allows low cost high-end production with handling high quality material and reducing operational cost.

AVC-Intra Class4:4:4 supports 12-bit 4:4:4 sampling with a bit rate of about 200 Mbps, one quarter that of HDCAM-SR HQ and one half of HDCAM SR SQ. 12-bit 4:4:4 sampling can be used as a master format suitable for any types of image manipulation such as color grading or chroma key as the creators intended.

Class100 has been extended by supporting higher frame rates. AJ-PX5000 provides - 1080/59.94p image acquisition using Class100. Higher frame rate recording to enable capture of beautiful slow motion images has also been supported and VariCam HS released in autumn 2014 provides high speed capturing up to 240fps.

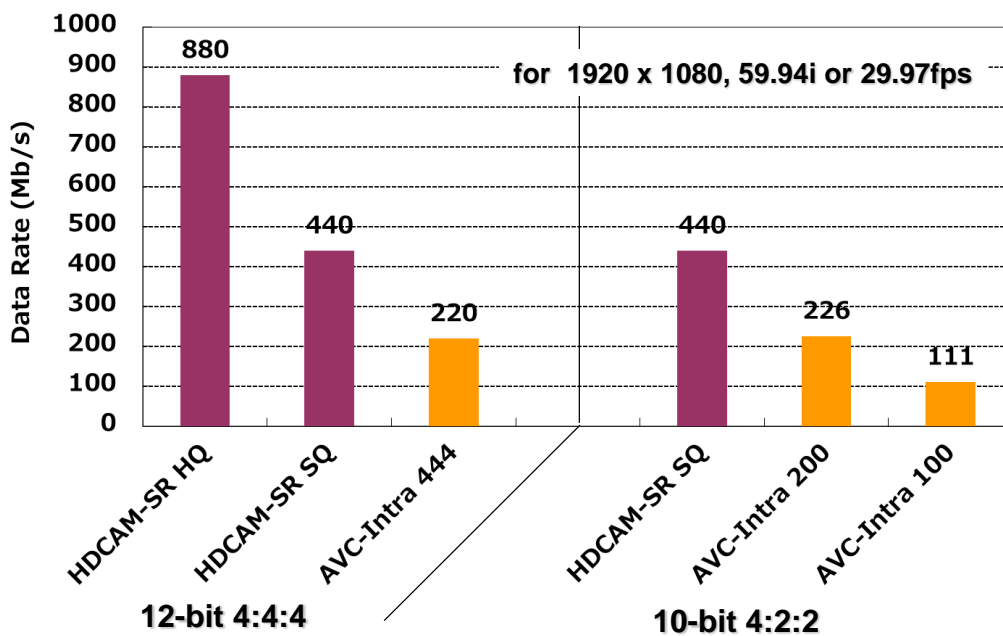


Figure 9 Video data rate of AVC-Intra Class4:4:4, Class200 and Class100

AVC-Intra Class200, Class100, and Class50 employs Intra-only compression scheme and CBR (Constant Bit Rate) encoding where the compression process is completed within each frame and the amount of compressed frame data is kept constant without any dependence of the image content. These features ease editing or manipulation so that specific frames can be simply replaced without processing the entire stream. The two-pass encoding illustrated in Figure 10 functions to make the amount of frame data constant. The encoder analyzes the nature of each video frame while performing pre-encoding and decides the range of encoding parameters in advance. The amount of data for each frame is controlled to be constant by the optimum bit allocation algorithm based on human visual characteristics and multi-generation performance with monitoring the amount of coded data generated by the encoder.

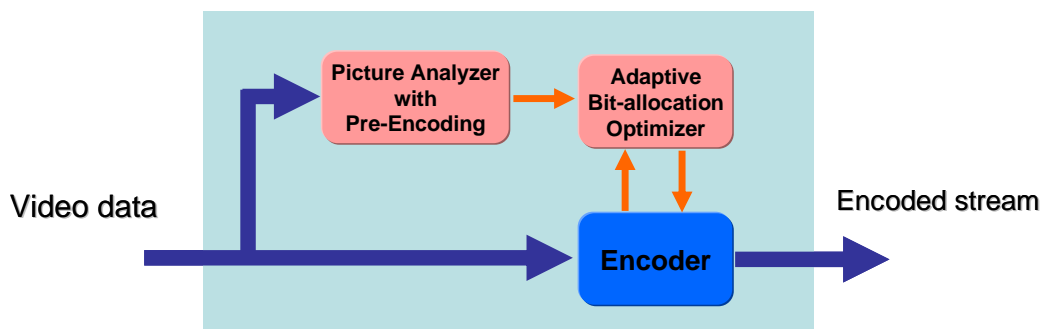



Figure 10 AVC-Intra multi-pass encoder

The addition of Class200 and Class4:4:4 to AVC-Intra, allows high picture quality with revolutionary low operational cost, and enables producing more inspired image contents as creators intended.

## AVC-ULTRA for 4K

In February 2012, Panasonic revealed AVC-ULTRA for 4K at HPA (Hollywood Post Alliance) Tech Retreat and exhibited the 4K image (4096 x 2160 resolution, 4:4:4 sampling, 24fps) compressed to about 400Mbps from the source image of 7.6Gbps. The AVC-ULTRA for 4K received high appreciation as the proposal of the revolutionary codec enabling 4K cinema production with economical operational cost. Image creation using 4K will be expanded to sport programs, live streaming, and broadcasting as well as cinema applications and it is expected that the image acquisition business will expanded accordingly.

Figure 11 summarizes the overall specification of AVC-ULTRA format supporting 4K and 2K. AVC-Intra Class4K supports the resolutions of 4096x2160 for digital cinema and UHD (3840x2160) for television applications. The frame rates to be supported are from 24p for cinema to 60p for high frame rate cinema or television. As to sampling structure, 12-bit 4:4:4 suitable for color grading in post process and 10-bit 4:2:2 for easy handling are supported.

Codec	Compression Format					File format	Approximate Video Rate (bps)					
	Class	Color sample	Bit depth	Intra/Long	CBR/VBR		2048x1080			4096x2160 3840x2160		
							23.98p 24p	25p 29.97p	59.94p 50p	23.98p 24p	25p 29.97p	59.94p 50p
	4K4:4:4	4:4:4	12bit	Intra	VBR	MXF				640M	800M	
	4K4:2:2	4:2:2	10bit	Intra	VBR	MXF				320M	400M	800M
	2K4:4:4	4:4:4	12bit	Intra	VBR	MXF	180M	220M	440M			
	2K4:2:2	4:2:2	10bit	Intra	VBR	MXF	90M	110M	220M			

VBR: Variable Bit Rate

Figure 11 Outline of AVC-ULTRA for 4K/2K

The first product supporting AVC-ULTRA for 4K, VariCam 35 a 4K camera recorder for digital cinema equipped with a newly developed super 35mm CMOS sensor was released in autumn 2014. VariCam 35 provides 4K/UHD high quality recording with AVC-Intra Class4K and supports 2K recording with AVC-Intra Class2K also HD recording with AVC-Intra Class200 and Class100.

## Expanding business opportunities with unified codec

Panasonic has developed a new LSI codec engine to perform a variety of encoding/decoding processes defined in the AVC-ULTRA codec. Figure 12 shows the appearance of the LSI and the photo of the LSI chip. The codec engine supports H.264/AVC profiles for professional applications, "CAVLC 4:4:4 Intra", "High 4:2:2 Intra", "High 10 Intra", and "High 4:2:2", up to Level 5.2 for 4K. This codec engine also has the ability to encode/decode the conventional DVCPRO codec family as well as the newly developed AVC-ULTRA. Incorporating the codec processor chip and high speed memory chips all within a single small package increases reliability and greatly reduces power consumption..

This new codec engine unifies AVC-Intra, AVC-LongG and AVC-Proxy and also supports from HD to 4K formats. An AVC-ULTRA product implementing this engine can support many formats and can be expanded by upgrading. Users can select optimum video

formats and codec schemes depending on their target applications, workflow, and estimated budgets for production and it expands their business opportunity with minimum investments.

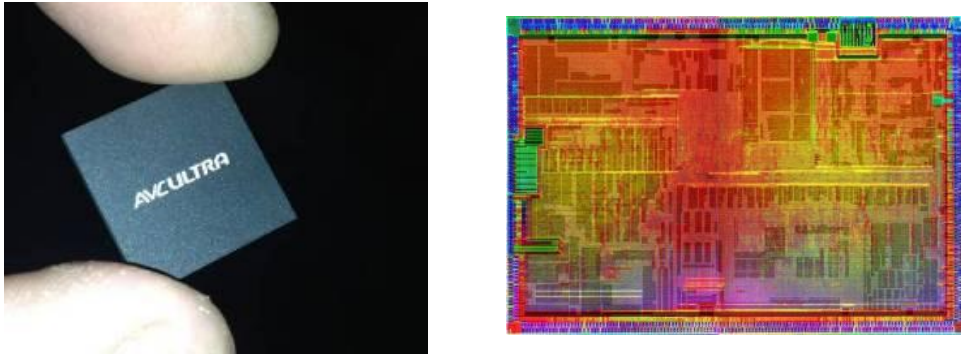


Figure 12 AVC-ULTRA codec engine LSI

### AVC-ULTRA partnership

The first products supporting AVC-Intra Class100 and Class50 were released in 2007. These formats have become one of the standard formats for non-linear editing and server systems and many tools have been released from software vendors. More than 45 vendors including P2 partner companies have provided more than 90 AVC-Intra support products. Figure 13 summarizes AVC-Intra supporting products released from partner vendors as of January 2015. Such AVC-Intra support products enable establishing optimum workflow depending on image production applications.

Brand name	Product name	Brand name	Product name	Brand Name	Product name
Adobe	Premiere Pro CS5 After Effects CS5 Prelude CS6	EVS	Xedio Dispatcher Xedio CleanEdit XT3, XT2+, XS, XTAccess	NewAuto	HIMARAYA 5.0
Amberfin	iCR 6	FilmLight	BaseLight	NL Technology	SAT-AI
Apple	Final Cut Pro 7, X	For-A	Media Concierge LTR-120HS	OpenCube	P2-Soft HD v2.2, ENGSoft v1.2 OpenCube HD/SD XFReader
Assimilate	SCRATCH 6	Grass Valley	EDIUS 4 Aurora 7 K2 Summit, K2 Solo	Quantel	sQ Server Pablo, iQ, eQ, Qube
Autodesk	Smoke 2012, Flame 2012,	Harmonic (Omneon, Rhozet)	Spectrum Media Port 7000 Media Deck Pro Media Carbon	Rimage	Rimage Archiver for P2
Avid	Media Composer 5 NewsCutter 9 Symphony 5 AirSpeed Multi Stream	Harris	Velocity ESX 1.2 NEXIO AMP, Volt QuiC	Sakura Eiki	Prime Edit Prunus NC Prunus Universal Player
Building 4 Media	FORK LIVE ASSIST	Hitachi	PROGRADE	SeaChange	MediaServer 1200
Calibrated Software	Calibrated (Q)	Imagine Products	P2 Log Pro, ShotPutPro	SGO	MISTIKA v6
Cinegy	Cinegy Ingest, Capture Cinegy Air, Player	MainConcept	Codec SDK Reference 2.1	Sobey	E7 v2.5
Dalet	Dalet News Suite Brio	Matrox	X.mio2	SONY	Vegas Pro 12 Xpri NS v5
Dayang	D3 Edit 3.0, ME 1.2	MOG	mx f SPEEDRAIL S1000 mx f SPEEDRAIL F1000	TELESTREAM	FlipFactory 7.1 Vantage, Agility 2G, Episode 6
Digital Rapids	StreamZ /HD, Flux	MXF4MAC	AVC-Intra Codec MXF Import MXF ImEx Suite	TOSHIBA	VIDEOS Neo
Drastic Technologies	MediaReactor KRAYKEN	NEC	Armadia	VITEC ( FOCUS)	ProxSys series
DVFilm	Raylight for Mac Raylight Ultra			Vizrt	Viz Media Engine 5.3
DVS	CLIPSTER 4.5 VENICE				
Evertz	Media Server				

Figure 13 AVC-Intra supported products by 3rd-party vendors

Supporting AVC-ULTRA codec family including AVC-LongG and AVC-Intra Class4K has been expanded with the enhancement of Panasonic camera recorder product line up and the number of AVC-ULTRA partners is now 30 vendors, increased from 22 vendors two years ago. Figure 14 lists AVC-ULTRA partner vendors as of January 2015. It is expected that vendors and products supporting AVC-ULTRA will be increased.

Figure 14 AVC-ULTRA partner companies

### AVC-ULTRA products

AVC-ULTRA started with AVC-Intra Class100 and Class50 in 2007 and these codec have been supported by all P2-HD equipment. The new AVC-LongG and AVC-Intra Class200 additions to the AVC-ULTRA family have been implemented in the products released in Autumn 2013, a new camera recorder AJ-PX5000 and a new recorder AJ-PD500

AVC-ULTRA will be implemented in all future P2-HD products and AJ-PX270 is the first handheld camera recorder equipped with AVC-ULTRA codec. The 4K camera recorder for digital cinema VariCam 35 released in autumn 2014 supports AVC-Intra Class 4K. Figure 15 illustrates the products supporting AVC-ULTRA.

Most AVC-ULTRA supporting products will be equipped as standard with slots for the new microP2 card. A microP2 card has the same high data reliability equal to a P2 card with the use of a built-in RAID system with a transfer speed around twice as fast as that of a P2 card. The size of a microP2 card is the same as a SD card. The microP2 card uses CPS (Content Protection System) so that valuable contents captured is secure and will not be accidentally



leaked. The price range of microP2 cards is around half that of P2 cards, which further reduces operational cost along with economical benefits given by AVC-ULTRA. Furthermore, the new expressP2 card has been released to support master grade 4K recording and high frame rate VFR image recording (up to 240fps) by a new VariCam series product and provides a large capacity of 256GB and fast transfer speed. Figure 16 illustrates the microP2 card and the expressP2 card.

The release of AVC-Ultra equipped camera recorders, recorders, servers and non-linear editing systems, and a variety of tools will lead to establishing flexible workflows depending on applications, reducing operational costs, network-based image acquisition and production by removing constraints on time and location, and image production environment inspiring the production of creative image content. AVC-ULTRA products will expand business opportunities for vendors and creators who are working for image content creation.



Figure 15 AVC-ULTRA products





microP2 card



expressP2 card

Figure 16 microP2 card and expressP2 card