White Paper

XF-405

New 4K UHD

Compact Camcorder

February 2nd , 2018

Contents

Abstract

Seven years ago Canon introduced a file-based camcorder – the XF-305 shown below – that was intended to originate full broadcast quality HDTV in a compact and lightweight body. An integrated 20:1 zoom lens, three 1/3-inch CCDs (each having 1920 x 1080 sampling), and 50 Mbps 4:2:2 MPEG-2 recording was central to the high performance. This camcorder continues in popularity today.

The new XF-405 4K UHD camcorder shown to scale versus the established XF-305 HDTV camcorder

While the new XF-405 camcorder is labeled "XF" it is clear that there are distinct differences between the two. The most visible is the overall size difference and the radical difference between the two lenses. The XF-305 uses an 18:1 zoom having three ring control for zoom, focus, and iris – whereas the XF-405 is a 15:1 zoom using a single manual ring that can be switched to control zoom or focus. That lens difference alone separates the two camcorders in terms of those who will use them. In addition, their respective recording codecs are very different. The central design priority of the XF-405 was to achieve a compact and lightweight 4K UHD / HD acquisition system that will support lower-budget documentary, independent filmmaking, event and wedding videography, web-based programming, and run 'n gun broadcast television news. This White Paper will detail the multiple design choices underlying this new camcorder.

1.0 INTRODUCTION

In 2010 Canon introduced the XF-305 digital camcorder for HDTV origination of a range of program genres including broadcast newsgathering. This was a Trisensor system utilizing three 1/3-inch CCDs each having 1920 (H) x 1080 (V) photosites. A few years later the CCD image sensors were replaced by Canon 1/3-inch CMOS sensors. The camcorder embodied an MPEG-2 YCbCr 4:2:2 codec that recorded to two SD memory cards. Seven years later, the XF-305 and its companion XF-300 are still selling briskly.

While HDTV is now widely established worldwide – the transition from SDTV still continues in many regions. HDTV has been with us in the USA for almost 20 years. But, the pace of technological advances in digital motion imaging has accelerated over those years and aspirations of content creators have also grown. Early in the life of HDTV continuing rapid developments in disparate technologies spawned interest in an unceasing quest to elevate television system resolution.

International standardization bodies ultimately produced a long term blueprint for broadcast television – in the form of detailed production standards for 4K UHD and for 8K UHD [1].

Added to these dynamics are the current global developments in 4K UHD television sets with vigorous competition now driving the marketplace to consider acquiring these TVs as a better alternative to HDTV sets. This, on the basis that the internal upscaling offers an excellent way of viewing HDTV program material while new 4K UHD services slowly build-up in the years ahead. That same competition has rapidly driven down the costs of 4K UHD television sets.

4K UHD has acquired a visible global presence over the past few years. While U.S. over the air broadcasting is not yet offering 4K UHD services many broadcasters are quietly experimenting with the production format. Only Korea has launched a 4K UHD broadcast television service (in 2017). Cable operations are also moving cautiously in terms of adoption. But Satellite operations in Europe and the USA are offering early 4K UHD delivery services. The march to 4K UHD is underway.

It is in this context that Canon has introduced the XF-405. In these still early days of 4K UHD it is intended to support cost-effective acquisition in 4K UHD (3840 x 2160) while also facilitating ongoing HD origination according to the standards for 1920 x 1080 and also 1280 x 720.

The XF-405 represents a sharp departure from the Trisensor imaging system of the XF-305. Capitalizing on significant technical developments in large image format single sensor imaging in our now extensive Cinema EOS portfolio this new camcorder utilizes a single one-inch 4K CMOS image sensor developed by Canon. The performance and operational advantages of the tight integration of this sensor to a newly developed one-inch 4K zoom lens will be outlined in detail in this White Paper.

Equally important was the core decision to base 4K UHD and HD image capture squarely upon the globally established MPEG-4 AVC/H.264 compression algorithm. There are a proliferation of 4K UHD camcorders available that utilize more sophisticated codecs to record very high performance and high bit depth digital video for moviemaking and episodic television production. The specific goal of the XF-405, however, is to offer very low-cost and extended duration recording of very good quality 4K UHD to support these early days of the adoption of this digital motion imaging format. The use of MPEG-4 AVC compression within the well-established MP4 container will be outlined in detail in the paper.

2.0 IMAGING SYSTEM

2.1 New 1.0-Inch CMOS 4K Image Sensor

The size and number of image sensors is a pivotal design decision for all digital motion imaging cameras. Canon gave high consideration to this choice when planning the successor to the XF-305. The final decision to employ a single one-inch CMOS image sensor was predicated on the following characteristics deemed important for a 4K UHD camcorder in 2018:

1.1 ***High sensitivity*** – facilitated by the larger photosite size (3.2 x 3.2 micron) of the 1.0-inch image format size

1.2 ***High dynamic range and low noise*** – based upon the larger photosite size that can be accommodated within the 1.0-inch image format size

1.3 ***Shallower depth of field*** – than the established 2/3-inch image format size (and also that of the even smaller 1/2-inch and 1/3-inch formats) – offering a more cinematic look to imagery that has recently proven popular in many broadcast program genres including broadcast News

1.4 ***4K UHD resolution*** – according to the ITU-R BT.2020 production standard of 3840 (H) x 2160 (V)

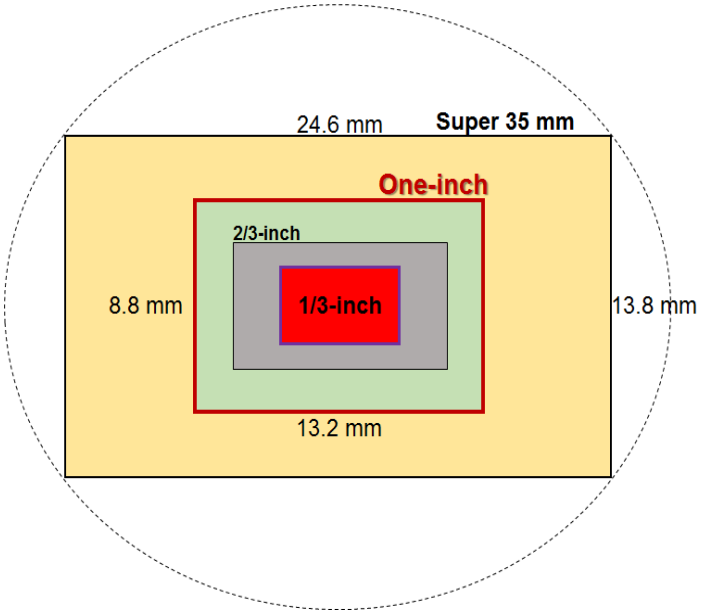


Figure 1 *An overview perspective – a scaled graphic of the active image area of the 1.0-inch image sensor compared to established video image format sizes*

A closer look at the active image area of the 1.0-inch image format is shown in Figure 2 where it is compared to the 1/3-inch image format size of the predecessor XF-305 and also to the well-established 2/3-inch image format size.

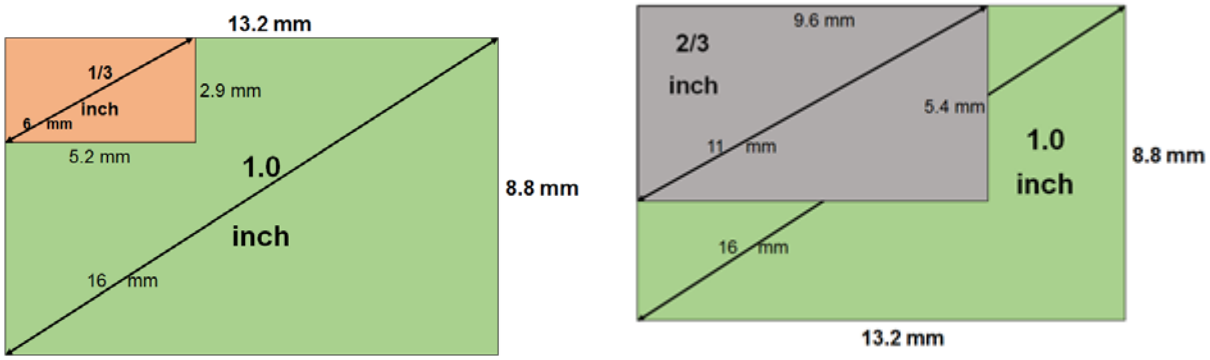


Figure 2 *Scaled graphic showing the active image area and diagonal dimension of the 1.0-inch image sensor compared to those of both the 1/3-inch and 2/3-inch sensors*

The 1.0-inch image sensor has more than 7.5 times the area of the 1/3-inch sensor. At 4K UHD it has a photosite size of 3.2 micron squared versus the 2.7 micron squared of the HDTV 1/3-inch image sensor. The one-inch image sensor has 2.25 times the area of the 2/3-inch image sensor.

Comparative Sensitivity

The distinct advantage of the single large 1.0-inch image sensor can be seen in a comparison of the Minimum Illumination specification of the XF-405 compared to that of the 1/3-inch trisensor XF-305:

XF-405	3840 x 2160 @ 60P	1.7 Lux	[Auto Slow Shutter ON, Shutter 1/30 sec]
XF-305	1920 x 1080 @ 60i	4.7 Lux	Shutter 1/60 sec

Note that the minimum illumination specification for the XF-405 is for the 4K UHD video format at 60 progressive frames per second – which entails a very short exposure period. Yet, it can deliver full Luma signal level at a mere 1.7 Lux of illumination.

In the case of the XF-305 – which is constrained to HDTV origination – it requires 4.7 Lux of scene illumination to deliver full Luma level despite the much greater exposure time associated with 1080-line interlaced video format.

The XF-405 includes infrared imaging when shooting is very dark situations.

2.2 The 1.0-inch 4K Lens

The 15:1 integral zoom lens offers full 4K optical performance and both a wide angle and a generous focal range that will service many program genres. Lens diffraction effects as aperture is stopped down are lessened in the larger image format compared to the smaller 1/3-inch image format of the XF-305.

Focal Range: 8.3mm ------- 124.5 mm
(25.5 mm ---------382.5 mm in 35mm equivalent)

Optical sensitivity: F-2.8 – F-4.5

Number Iris Blades: 9

Image Stabilization: Built-in Shift-IS

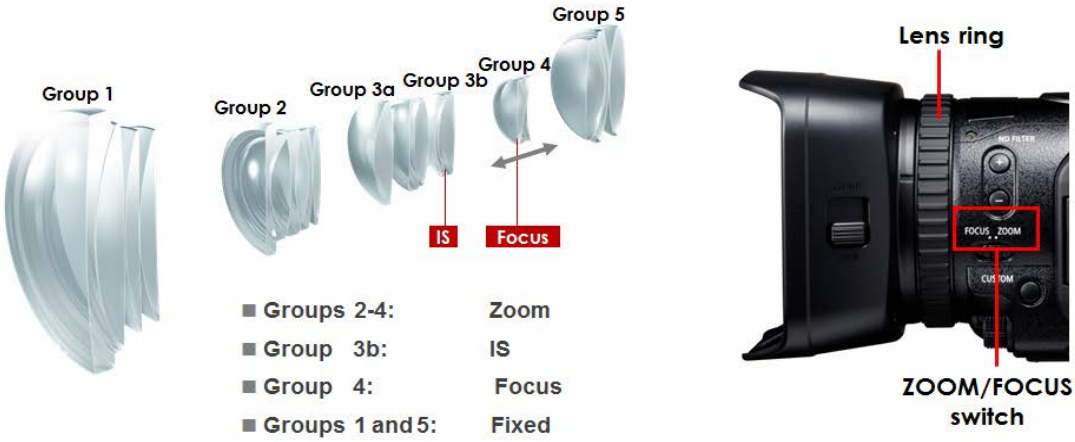


Figure 3 *The 18-element lens that comprises 14 groups – and the Zoom/Focus control ring*

Multiple aspheric elements are included within the lens groups to achieve 4K image quality while correcting various aberrations over the entire zoom range. A three group zooming system helps minimize the size of the lens while also reducing chromatic aberrations over that focal range. A single manual control ring can be assigned to either focus or zoom – this forming part of the strategy to significantly reduce the overall size of the lens. A carefully controlled torque in this ring provides satisfying operational adjustments.

The focal range of the lens can be extended at both extremities by accessory optical adaptors offered by Canon – as shown in Figure 4

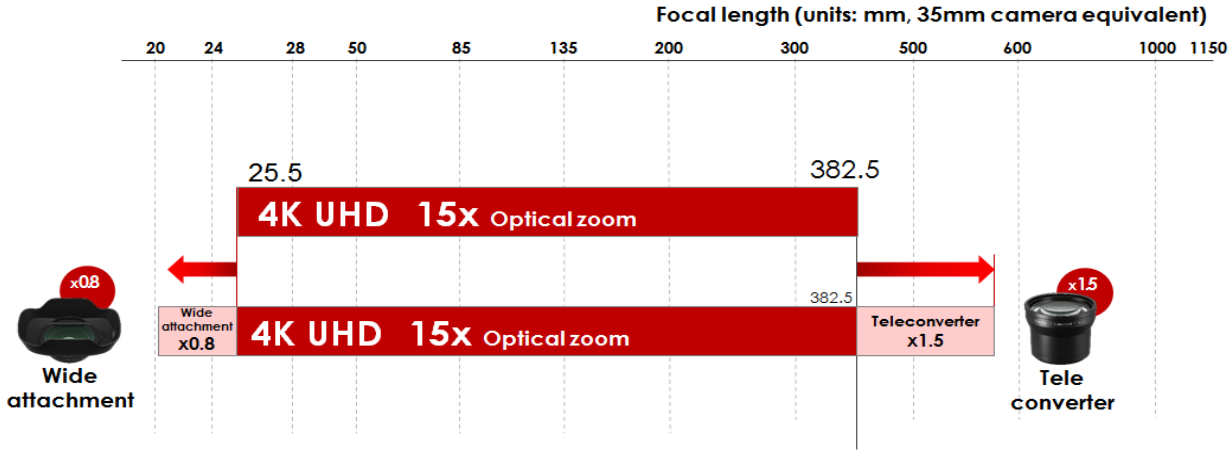
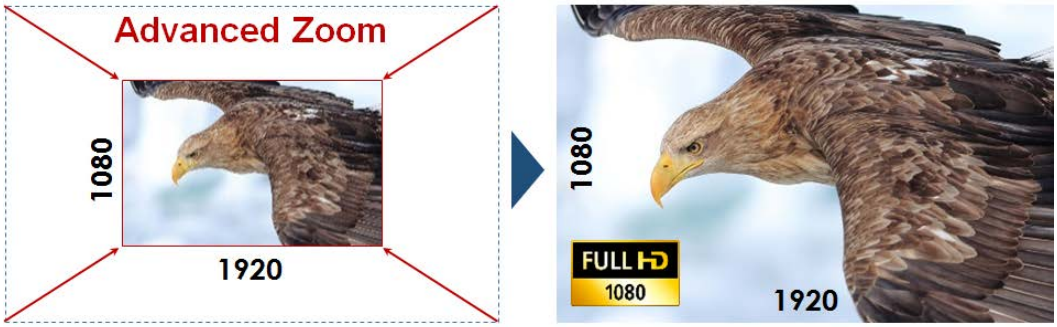


Figure 4 *Showing the focal range of the XF-405 lens (35mm equivalent) – and how it can be further extended at both extremes with accessory optical attachments*

When the XF-405 is set to operate in 1080P HDTV mode the effective focal length can be extended by invoking a 2:1 digital zoom – which is an HD image structure derived from the 4K pixel structure – providing a 765 mm focal range and helping ensure high performance.



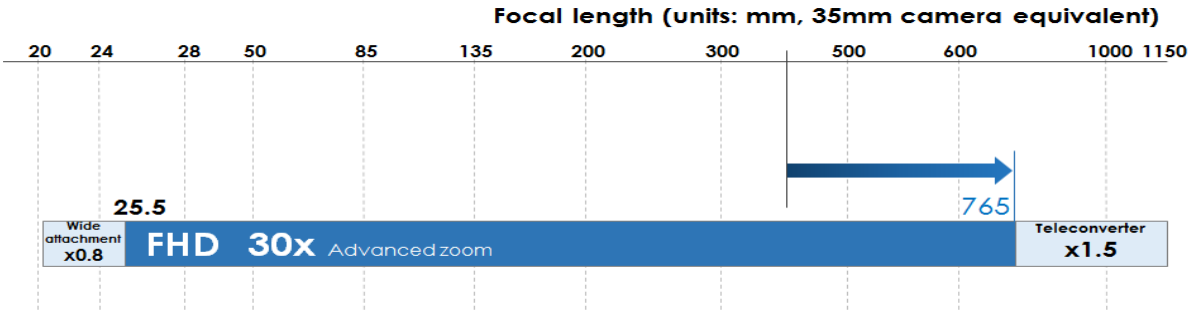


Figure 5 *The effective zoom range can be digitally extended to 30:1 when the XF-405 is directly originating 1080P HDTV*

2.3 ND Filter System

Traditionally, the lower cost professional camcorders do not embody an ND filter. The XF-405, however, offers a selection of three ND filters as well as the CLEAR.

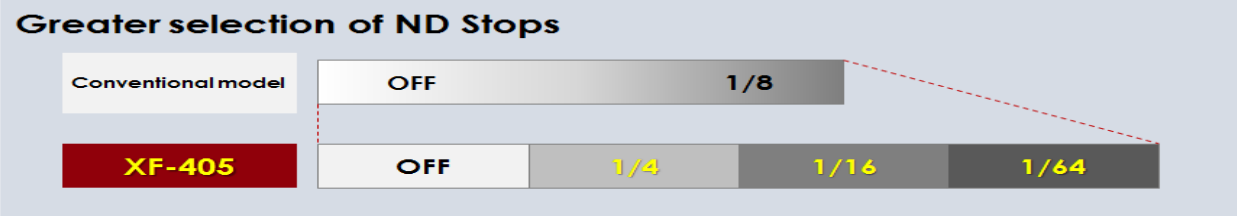


Figure 6 *Outlining the choice of ND filters built into the XF-405*

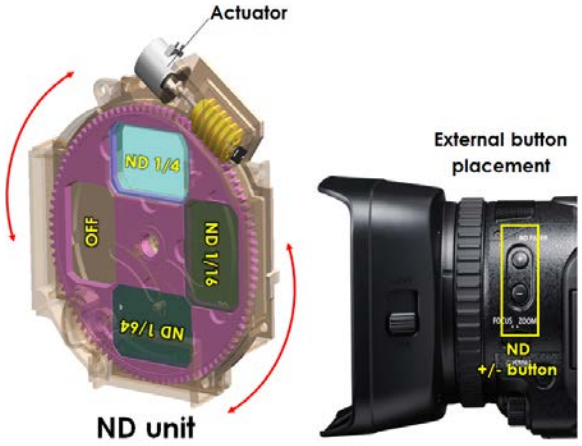


Figure 7 *Showing the internal turret mechanism used to select one of three ND filters*

2.4 Dual Pixel CMOS Auto Focus

Now and then a technology emerges that proves to be a genuine gamechanger. At this juncture the global reputation of Canon's breakthrough technology of Dual Pixel CMOS Auto Focus is well established. The decades-old stigma associated with any form of "auto focus" – especially among cinematographers – has been largely dispelled among those who have had experience with this specific Canon system. This system works – reliably and with high accuracy. It does so because the focus sensing takes place within the image sensor itself – using an innovative phase detection that is inherent within each and every photosite. Each photosite deploys two separate photodiodes which offers two distinct advantages – one, being the phase detection for AF, and the second, enhancement to the effective dynamic range of each photosite [2]. The data from the image sensor is processed using some powerful algorithms to produce a control signal that closes the servo loop around lens focus.

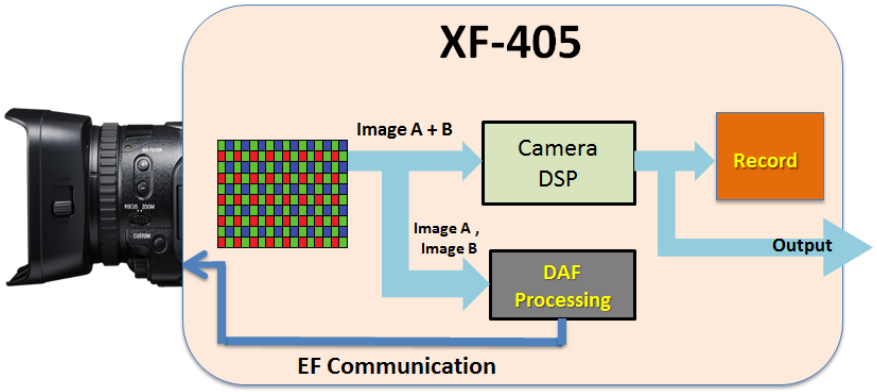


Figure 8 *Showing the basics of the Dual Pixel CMOS Auto Focus control loop*

The operational capabilities of the Dual Pixel CMOS Auto Focus system have been empowered by the 3.5-inch LCD panel that incorporates a capacitive touch capability that supports intuitive operational controls. A smooth rack focus between two subjects within a scene can be implemented by sequentially touching those subjects in the LCD screen.

Figure 9 *The LCD monitor is a capacitive touch screen that supports easy menus selection as well as actuation of operational controls (simulated image)*

The new Dual Pixel CMOS AF system in the XF-405 camera embodies a menu that allows two degrees of freedom in "tuning" the response time – they are "Speed" and "Response". Each has a setting choice of Fast / Normal / Slow. Separately, what is termed the RESPONSE setting is a separate setting of the system that offers a choice in how quickly a focusing action is initiated – thus adding a creative dimension to a rack focus that has been decided between two subjects within the scene.

2.5 Focus Guide

For the cinematographer who prefers traditional creative manual focus operation the dual pixel system can alternatively be switched from the Auto Focus control loop encompassing the lens focus control to an open loop system that utilizes the Dual Pixel CMOS AF data processing to instead transfer precision signaling – shown in Figure 10 – in the camera viewfinder.

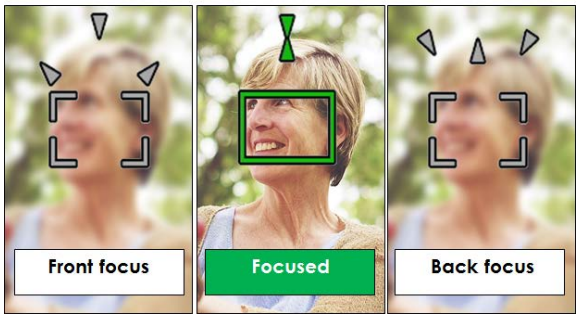


Figure 10 *The viewfinder will signal the desired direction of manual focus and the appearance of the green cursor indicates achievement of an unambiguous precision focus on the chosen subject.*

2.6 Image Stabilization

The Shift-IS technology lends itself well to correcting modest amplitude disturbances and vibrations in longer focal range lenses. In this technology, a lens group is placed near the rear of the lens system and the correcting action entails a horizontal or vertical (or both) physical shifting of that lens group to implement the requisite change in the path of the light rays. The correction is implemented by a combination of optical lens-shift and electronic stabilization. Image rotation and camera movements in the yaw and pitch directions are corrected by a combination of angular velocity detection (using a piezoelectric vibration sensor) and sensor-based movement vector detection.

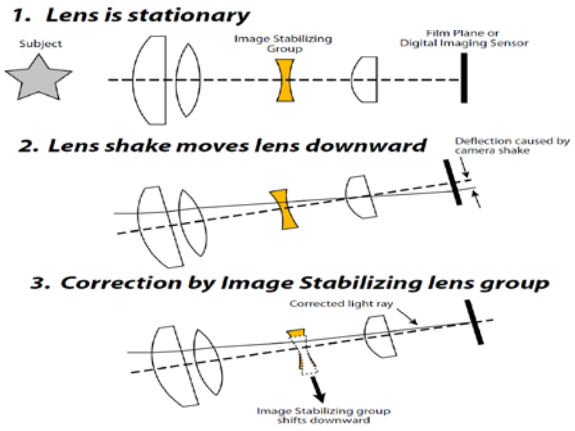


Figure 11 *Showing the principle of the Shift-IS optical correction system*

The correction principle is explained in Figure 11 above, outlining the correcting action of the Shift-Lens when the lens camera system is subjected to a sudden physical disturbance. The system has been designed to implement 5-Axis image stabilization as outlined in Figure 12.

Figure 12 *Showing the five separate axes of image stabilization in the XF-405*

Image stabilization is effective with movement from 0.5Hz to 20Hz (1Hz is one movement cycle per second). This will cope not only with situations from simple camera shake (0.5Hz to 3Hz), but also the engine vibrations encountered when shooting from a moving vehicle or helicopter (10Hz to 20Hz).

3.0 VIDEO IMAGE PROCESSING

Two of the latest generation digital video processors – the DIGIC DV6 – are used to implement advanced video processing of both the 4K UHD video and the Full HD video.

Figure 13 *Two DIGIC DV6 processors to implement all video processing prior to encoding for recording*

In terms of video processing and operational adjustments these two processors implement all of the following:

3.1 Debayering of the data from the 4K image sensor
3.2 Upsampling to 8 megapixel RGB
3.3 Oversampling HD processing
3.4 Linear matrix
3.5 OETF Wide DR (800%) and other selectable options
3.6 Various “Look” settings
3.7 Conversion from high bit depth components to YCrCb @ 8-bit
3.8 MPEG-4 /AVC encoding and formation of MP4 File wrapper

3.9 Dual Pixel CMOS AF
3.10 Focus Guide
3.11 Focus Enabled on-touch panel
3.12 Processing associated with the digital zoom extension of the 1080P HDTV
3.13 Preparation of 3G SDI serial video outputs
3.14 Preparation of HDMI video outputs

3.1 Formulation of the 4K UHD YCrCb 422 Video Component Set

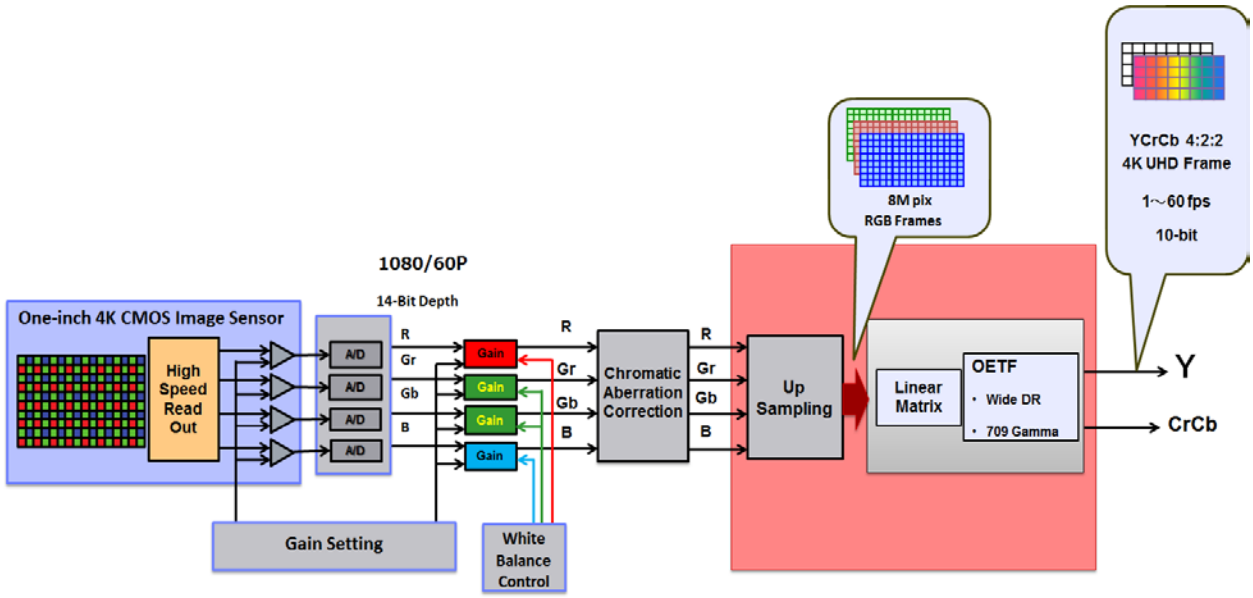


Figure 14 *Showing the video processing system to create the 4K YCbCr 4:2:2 video that is sent to the MPEG-4 AVC/H.264 AVC codec for recording*

3.2 Gain Settings

In normal Gamma	0 – 39dB in 1-dB increments
In Wide DR (800%)	9 – 39 dB in 1-dB increments

3.3 Dynamic Range

The XF-405 offers a choice in OETF. It offers the standardized Rec 709 transfer function for normal HDTV shooting. For the highest dynamic range it employs the "Wide DR" curve shown in Figure 9.

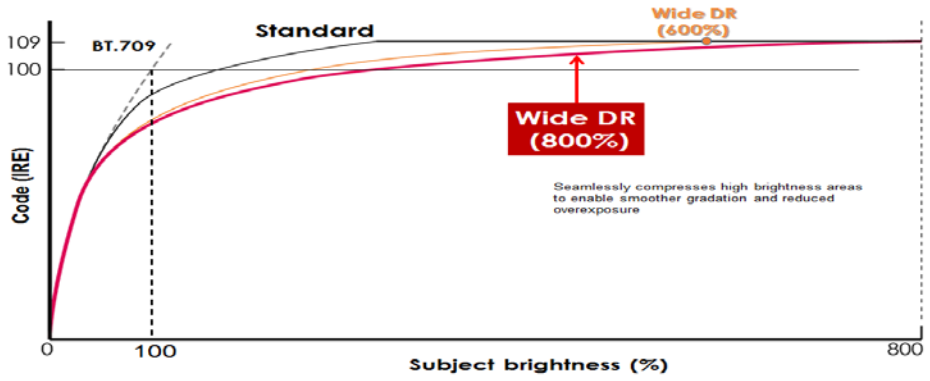


Figure 15 *Showing the various OETF transfer characteristics that can be selected in the XF-405*

4.0 OVERSAMPLING HD PROCESSING

This process begins with deBayer processing to form three 8 Megapixel RGB frames from the 4K / UHD Bayer frame. That deBayer processing moves the first order sideband (from original image sensor sampling) to a higher frequency which in turn opens up spectral space that allows critical pre-filtering prior to a subsequent downsampling back to 2K / HD YCrCb 4:2:2 frames.

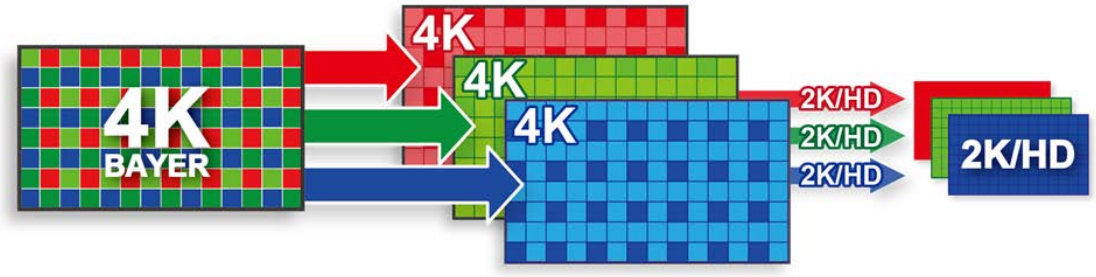


Figure 16 *Showing the principle of the Oversampling HD Processing*

The net result of this sample rate conversion process is to produce three 2K / HD RGB components that have minimum aliasing and a more benign subjective appearance to noise in high ISO settings.

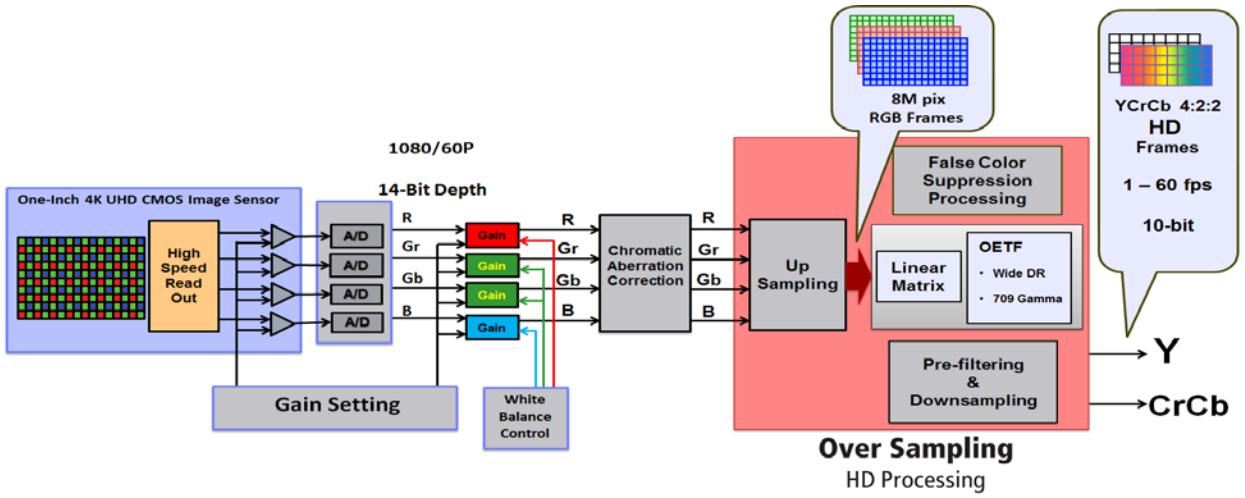


Figure 17 *Formulation of the HD YCrCb 4:2:2 component video set that is sent to the codec*

The three RGB HD components then have a linear matrix applied to them to define the specific color gamut selected for the production. This is followed by application of the camera optoelectronic transfer function (OETF) which digitally maps the high bit rate linear components to a nonlinear set at 10-bit coding. They are then matriced to formulate a set of 10-bit YCbCr 422 components which are sent to the recording codec.

4.1 Conversion to Component Set YCbCr 4:2:0 @ 8-Bit

Within the DIGIC DV6 video processor the four separate video components from the image sensor are converted into an RGB 4:4:4 component video set that are passed through the HD oversampling process described above – and then fully processed at a high bit depth – according to the functions listed in Figure 18.

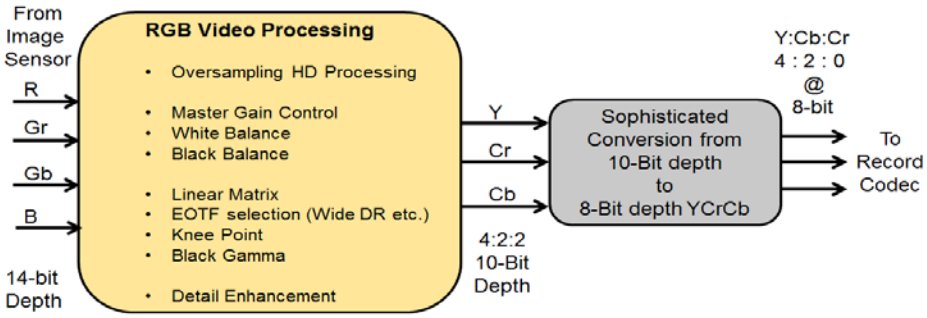


Figure 18 *Within the DIGIC DV6 processor the RGB video components are fully processed and then converted to YCbCr 420 @ 8-bit component set*

It is important to note that all processes on the video component set are at a high bit depth that helps ensure high integrity of the final video image quality. The conversion down to the 8-Bit YCbCr 4:2:0 component set utilizes a sophisticated digital rounding process that protects all of the nuances of that video processing. Proprietary techniques that optimize tonal gradations (especially if the image is originated in Wide DR) are employed in this process. The final result of the Oversampling HD processing and the bit depth conversion is a clean video component set having a remarkably high subjective image quality.

5.0 RECORDING CODEC

5.1 Recording Options in XF-405

The XF-405 placed a high priority on making the capture of 4K UHD program material very affordable:

5.1.1 ***On board Recording*** – of 4K UHD Y:Cr:Cb 4:2:0 @ 8-bit – up to 60 fps

5.1.2 ***On-board Recording*** – of 1080-line HD Y:Cr:Cb 4:2:0 @ 8-bit – up to 120 fps

5.1.3 ***External Recording*** – of 4K UHD up to 60P – via the HDMI connector

5.1.4 ***External recording –*** *of 1080-line HD up to 60P – via the 3G SDI or HDMI connectors*

5.2 Video Compression Codec

The video compression codec used in the XF-405 is a variant of the MPEG-4 international standard. MPEG-4 is a sophisticated compression standard divided into several "Parts". The specific "Part" pertaining to the XF-405 codec is MPEG-4 Part 10 – known as MPEG-4 Advanced Video Coding (AVC).

It is one of the most commonly used formats worldwide for the recording, compression, and distribution of video content. The specific agenda underlying development of the H.264/AVC standard was to provide subjectively excellent video quality at substantially lower bit rates than previous standards – like MPEG-2. Those lower bit rates facilitate very long recording durations on standard lower-cost SD memory cards. This was central to the design strategy for XF-405 which deploys two of these cards.

Technically, MPEG-4 is a powerfully effective compression system having broad flexibilities – embodying the concept of "Profiles" and "Levels" – intended to support specific sets of performance levels and technical capabilities that can be tailored to a very wide range of applications.

The three basic Profiles and their intended applications are identified as the following:

- **Main Profile**: Intended as the mainstream consumer profile for broadcast, packaged media (e.g. Blu Ray), digital cinematography, and storage applications

- **Baseline Profile**: Intended for lower-cost applications with limited computing resources, this profile is for low-latency real-time applications such as videoconferencing and mobile applications

- **Extended Profile**: Intended for IP-based video streaming applications over wireless and wired networks, this profile has relatively high compression capability and some additional strategies for robustness in terms of possible data losses over networks.

Within each of the profiles there are multiple technical strategies relating to the overall compression format. Different Profiles can be combined to formulate a certain level of performance and operational dexterity that can be tailored to different applications. Each of the associated Levels specifies sets of constraints for key compression algorithm parameters. The combination is often referred to as the "Toolkit" of MPEG-4 to structure a specific codec – in terms of application, performance, *and cost*. Figure 18 indicates the combination of the three basic Profiles underlying the codec used in the XF-405.

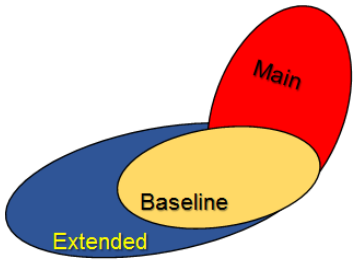


Figure 19 *Showing the combination of MPEG-4 AVC Profiles that are the basis of the high-performance codec in the XF-405/400 camcorders*

TABLE 1 MPEG-4 AVC / H.264 PROFILES and LEVELS

Profiles / Levels	Baseline	Extended	Main	High	High 10	High 422	High 444
8-bit	●	●	●	●	●	●	●
4:2:0	●	●	●	●	●	●	●
10-bit	●	●	●	●	●	●	●
4:2:2	●	●	●	●	●	●	●
4:4:4	●	●	●	●	●	●	●

Green = Yes Red = No

Table 1 summarizes the *basic Levels and Profiles* that Canon selects from in our various camcorders. **NOTE:** *There are many additional levels that are also used within those three Profiles.*

The three Profiles selected to form the basis of the recording codec for the XF-405 are shown shaded in blue in table 1. It is important to note that the standard stipulates that this combination must be 4:2:0 @ 8-bit. This is central to achieving the lower overall recording data rates that support long duration recording.

5.3 Context on the XF-405 Compression Codec

As the standardization development work progressed on MPEG-4 over many years, additional Profiles and Levels were added to support the rapidly increasing sophistication of digital motion imaging systems. Figure 19 is a simplistic summary of those additional Profiles – all of which build on the Main Profile – and it also shows the general approach that Canon has adopted in our deployment of variations of that standard to our overall professional camcorder lineup. Mobilizing elements from all of the Profiles, for example, is the foundation of the very sophisticated Canon codec used in the C700 and C300 Mark II high-end digital cinema camcorders – the codec we term XF-AVC. It should be noted that the specific utilization of the many technical "Tools" within each of these Profiles does define the unique technical nature of the XF-AVC.

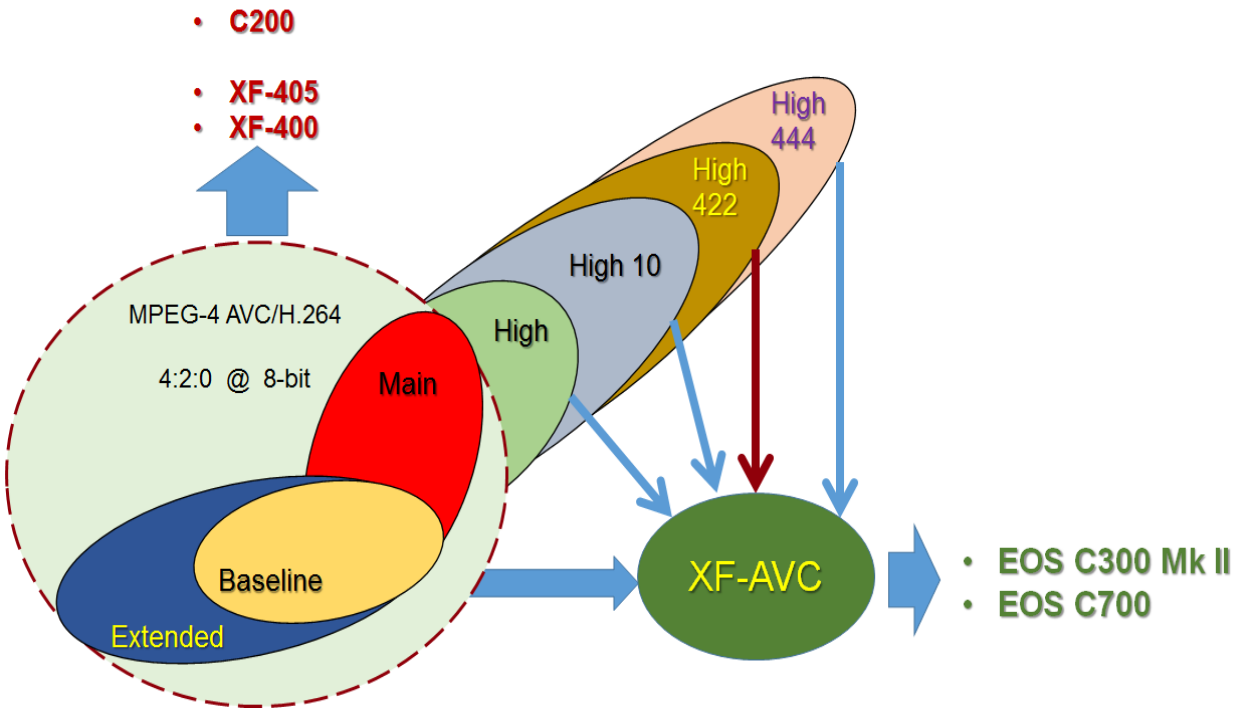


Figure 20 *A simplistic overview of the deployment of variations within the MPEG-4 / H.264 standard to the XF-405 and separately to the Cinema EOS codecs*

5.4 File Structure for Recording in the XF-405

The file structure used in XF-405 is **MP4 –** an abbreviated representation of **MPEG-4 Part 14 –** which is a digital multimedia container format [based on the QuickTime File Format (QTFF) used by .MOV and .QT files] most commonly used to store video and audio. The importance of this container is that it can also store other metadata such as subtitles and still images.

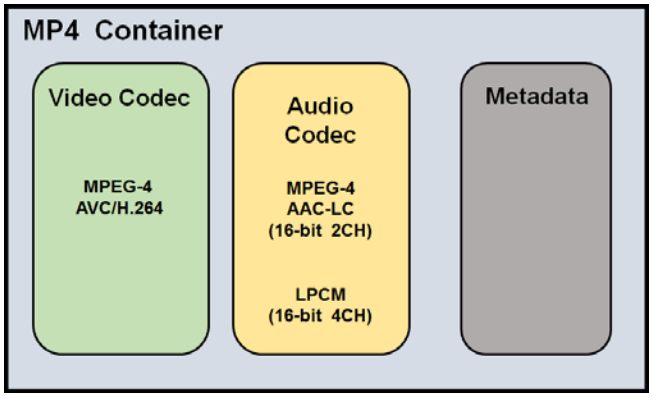


Figure21 *Illustrating the MP4 container used for XF-405 recording – which includes separate compression for audio and video tracks*

Canon chose the MP4 container to enable the XF-405 camcorder to seamlessly integrate into a wide range of usages:

- Movie video, audio, subtitles and images can be merged into a single MP4 file which is available to readily play on various devices.

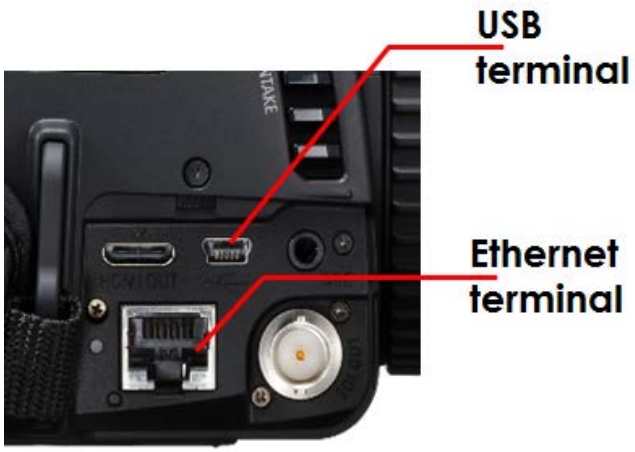


Figure 22 *The Ethernet connector (supports 1000 BASE-T) that allows file transfers by FTP at up to 100 clips; XF-405 records information from GP-ES GPS receiver via the USB connector*

- MP4 media files can be sent to other people via email in a timely manner because the high level of compression produces a small file size
- MP4 allows streaming over the internet. This is expedited by the small file size and low bandwidth

The overall advantage of MP4 is that it can be saved as a single file and is much easier to move, copy, and upload to websites.

5.5 Specific Video Formats Recorded in the XF-405

TABLE 1 XF-405 RECORDING FORMATS

Format	Color Sampling	Bit Rate (Mbps)	Frame Rate (fps)	Compression	Audio MPEG-4 (48 KHz)	File Format
3840 x 2160	4:2:0 @ 8-bit	150	59.94 / 29.97 / 23.98P	MPEG-4 AVC/H.264	AAC-LC 16-bit (2 CH) LCPM 16-bit (4 CH)	MP4
1920 x 1080	4:2:0 @ 8-bit	35 17	59.94 / 29.97 / 23.98P 59.94 / 29.97 / 23.98P	MPEG-4 AVC/H.264	AAC-LC 16-bit (2 CH) LCPM 16-bit (4 CH	MP4
1280 x 720	4:2:0 @ 8-bit	8 4	59.94P 29.97P	MPEG-4 AVC/H.264	AAC-LC 16-bit (2 CH) LCPM 16-bit (4 CH)	MP4

NOTE: A firmware update scheduled for early 2018 will add a further recording option to the XF-405 – using the Canon XF-AVC codec. The performance will be close to that of the present MP4 recording but will have the advantage of the addition of metadata to the files.

Figure 23 *The XF-405 uses two SD memory cards – well-placed for ease of use*

The low bit rates translate into the impressive recording durations summarized below in Table 1.

TABLE 2 XF-405 Recording Durations

Format	SD Card Capacity	Recording Data Rate (Mbps)				
3840 x 2160		150				
1920 x 1080			35	17		
1280 x 720					8	4
	8 GB	5 min	25 min	55 min	120 min	245 min
	16 GB	10 min	55 min	120 min	255 min	515 min
	32 GB	25 min	115 min	245 min	520 min	1045 min
	64 GB	55 min	240 min	495 min	1055 min	2115 min
	128 GB	110 min	485 min	995 min	2120 min	4245 min

5.6 Audio Recording

The on-board 4-channel audio system has independent settings that allow users to set recording levels, input sensitivity, and limiters for each channel. In addition to AAC 2-channel audio, the XF-405 offers support for high-quality linear PCM 4-channel audio (all in MP4).

Figure 24 *XF-405 has flexible audio options – from 2-Ch AAC to the optional 4-Ch LPCM shown here*

6.0 EXTERNAL RECORDING

The XF-405 offers a further recording option by facilitating external recording via the 3G SDI and the HDMI output interfaces. This is a particularly powerful option in the case of the 1080P HD external recording in that the serial video output (from either the 3G SDI or the HDMI port) is a full 10-bit Y:Cb:Cr 4:2:2 at frame rates up to 60P that also has the benefit of the Oversampling HD Processing.

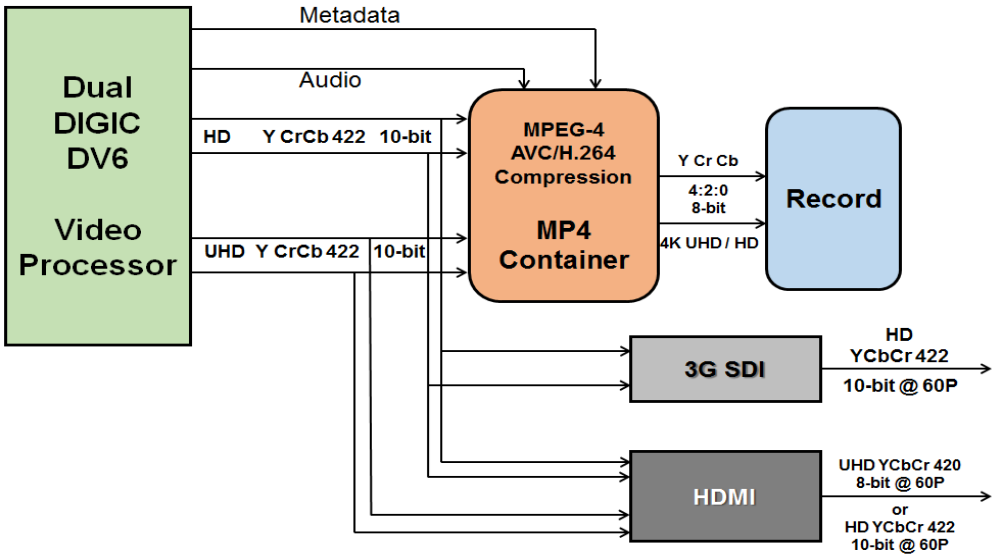


Figure 25 *Outlines the formation of the MP4 format for on-board recording and the external outputs that can be used on external recorder*

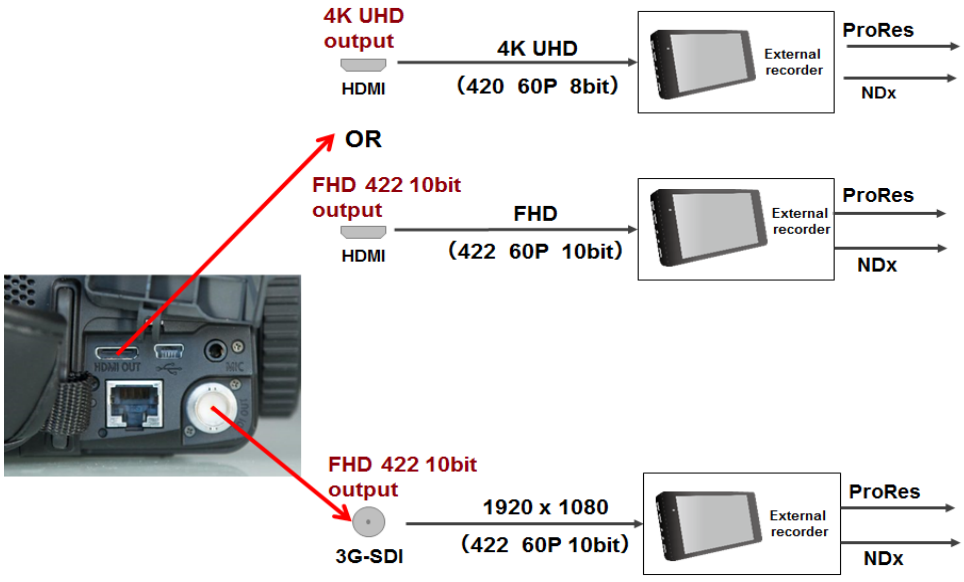


Figure 26 *Showing the two output ports and the video interfaces they provide to external recorders*

7.0 REMOTE VIDEO CONTROL

Remote control of multiple video functions is enabled using the RC-V100 remote control panel. It is important to note that this includes remote control of the lens iris, zoom, and focus. This is especially effective when used for crane shots and other remote operations.

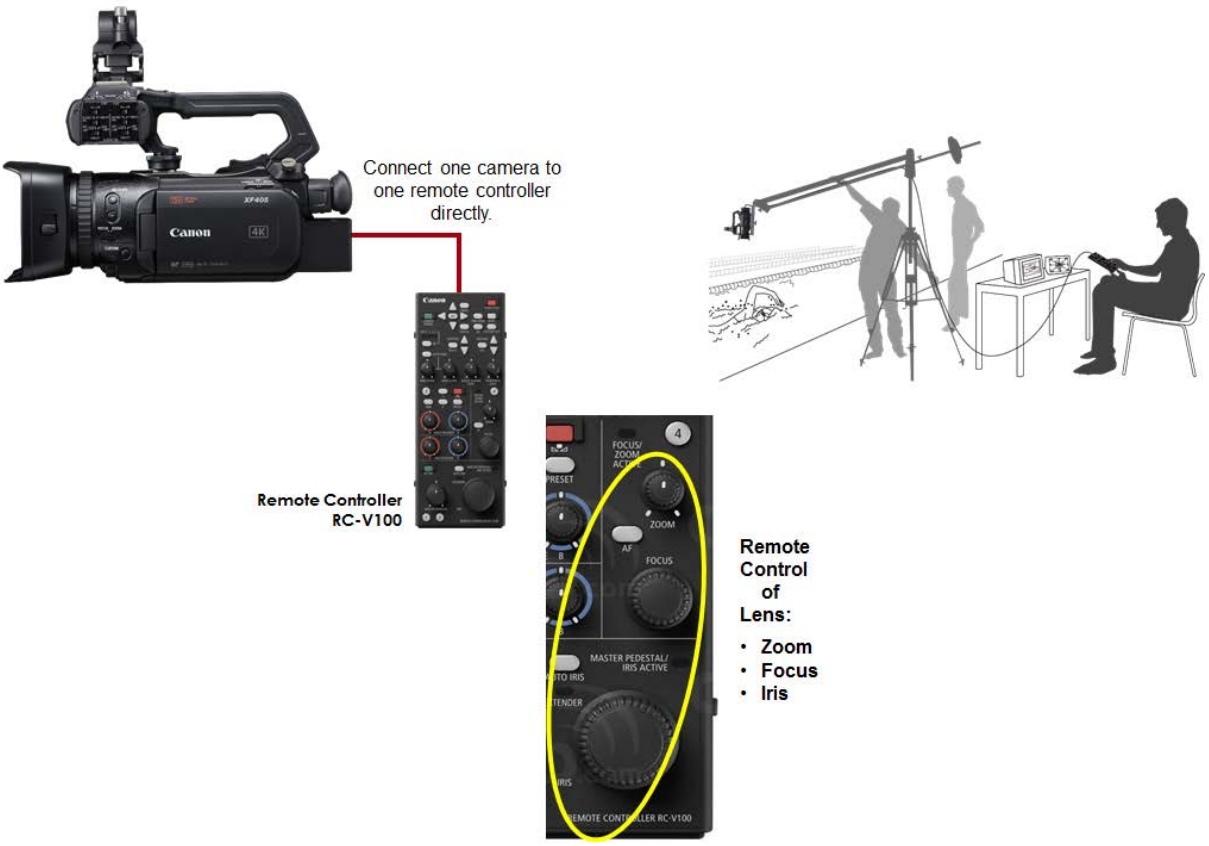


Figure 27 *Canon remote controller RC-V100 connects directly to the XF-405*

8.0 SUMMARY

In this television era where large format imaging has become popular within many program genres, the 1.0-inch image format single-senor camcorder has acquired a rapid ascendancy – now being supported by a number of the major manufacturers. Canon introduced a 4K miniature camcorder the XC-10 in 2015 which utilized MPEG-4 H.264 compression and an MXF wrapper with both 205 and 305 Mbps recording date rates. This was followed a year later with the upgraded XC-15.

The XF-405/400 camcorders offer a compact lightweight video-journalist acquisition system for 4K UHD that is tailored for discrete newsgathering and many documentary applications.

It utilizes a new 1.0-inch CMOS image sensor developed by Canon optimally coupled to an integrated new 15:1 zoom lens that supports an impressive image quality. This is the first 1.0-inch image sensor having Dual Pixel CMOS Auto Focus which significantly empowers high mobility shooting. Two of Canon's DIGIC DV6 digital video processors are used for a variety of innovative image processing functions which enhance the low-noise performance and help elevate the operational sensitivity.

The XF-405 offers almost a half-hour recording duration of 4K UHD @ 60P on a 32GB SD memory card. This supports modest 4K slow motion effects. The on-board 1080P HD recording can be as high as 120P which offers impressive slow motion capabilities.

External recording of both 4K UHD and 1080P HD is also supported via the 3G SDI interface. In the case of the latter the recorded video image quality is very high – being YCrCb 4:2:2 @ 10-bit at frame rates up to 60P.

In addition to the built-in two-channel stereo microphone, the camera has a stereo 3.5mm MIC jack plus twin XLR connections with phantom power on the detachable handle. Four channel recording is supported in LPCM mode, giving additional flexibility for recording ambient sound while carrying out an interview.

9.0 REFERENCES

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[2] 2016 HPA Tech Retreat "*Advances in CMOS Image Sensors and Associated Processing"*

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[3] https://www.cinema5d.com/canon-xf405-review-sample-footage-and-first-impressions/