Canon

WHITE PAPER

EOS C300 / EOS C500

CINEMA EOS FOR 2K AND HD ORIGINATION

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CINEMA EOS

Cinema EOS for 2K and HD Origination

Introduction

Canon began a rollout of a family of Cinema EOS cameras in the Fall of 2011. The EOS C300 made its debut in November 2011 as an HD-only camera that captured digital HD in-camera to Compact Flash cards. It employed an innovative new Super 35mm 4K image sensor to originate that HD. The EOS C500 followed in 2012 as a digital cine camera having a far broader capability in the digital image formats it originated. It delivers a choice of 4K, 2K, or HD uncompressed files for external recording. It is intended for very high-end origination of movies or television production. Finally, the EOS C100 flanks the family – at the lower-budget end – it too, being an HD-only camera.

This paper is intended to focus on the important differences between the EOS C500 and the EOS C300 – purely in the context of HD or 2K digital origination. The 4K capabilities of the C500 will be addressed in a separate paper.

Imaging Section of EOS C500 and EOS C300

These two cameras share identical imaging sections – in terms of deployment of the Super 35mm 4K CMOS image sensor specially developed by Canon for digital motion imaging. Accordingly, the two cameras share in common the exceptional high sensitivity , wide dynamic range, and high picture sharpness produced by this image sensor.

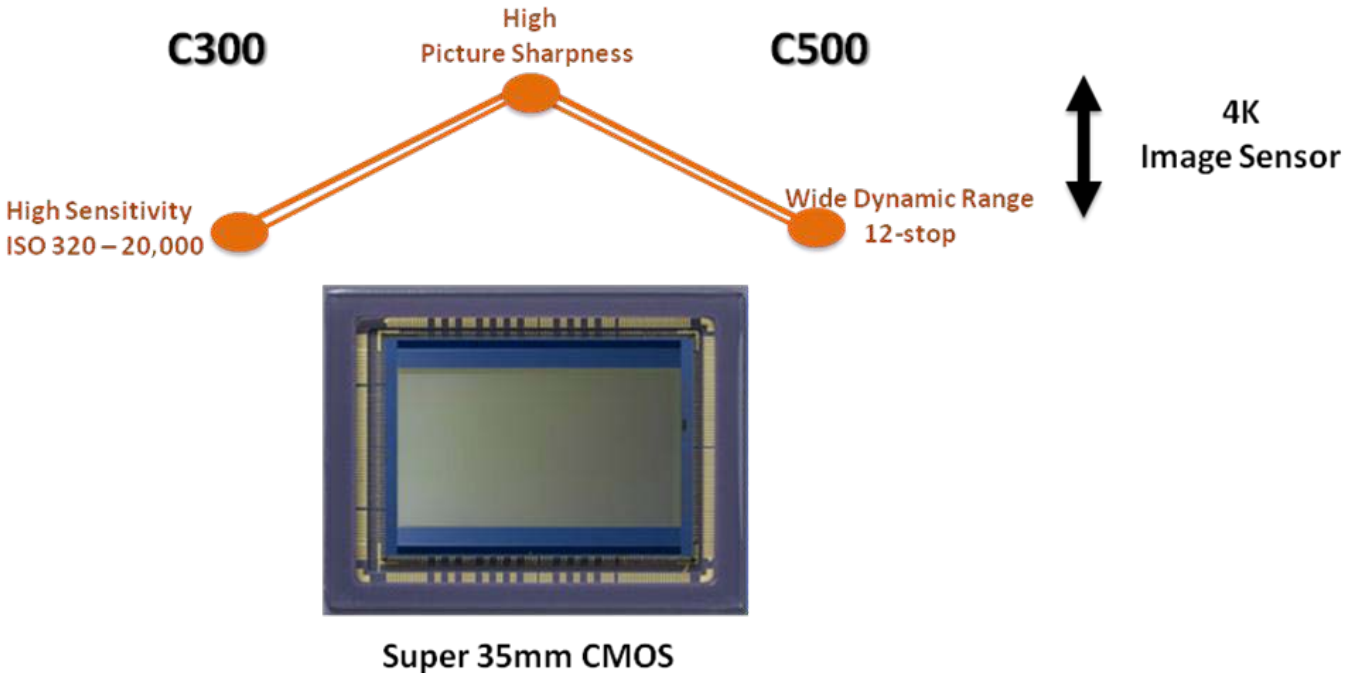

Figure 1 *The same 4K CMOS image sensor is used in both the C500 and the C300 digital cine cameras*

Most large-format single-sensor cameras employs the Bayer CFA (color filter array) to encode the RGB color information. Typically, the RAW outputs from these cameras constitute a single output signal which is subsequently debayered to structure the three separate RGB video components. This process entails some degree of reconstruction errors depending upon the sophistication of the debayering algorithm. The EOS C500 and C300 cameras also employ the classic Bayer CFA – but we deploy an alternative strategy to the construction of the separate HD / 2K RGB frames as described in Reference [1]. No demosaicing processes whatever are employed.

Within the 4K CMOS image sensor there is an innovative readout mechanism that directly reads out four 2K video components in parallel. They are R, Gr, Gb, and B (each at 1920 x 1080 or, in the case of the C500, they can be selected as 2048 x 1080 depending upon the particular choice of "2K"). Because of the nature of the Bayer pattern the two green components Gr and Gb are spatially offset with respect to each other. When they are summed to form the final 2K Green component the traditional first order horizontal and vertical sidebands cancel which eliminate a major source of aliasing. As a consequence the optical low pass filter can be better optimized for an unusually high green MTF. For more information on how this works please see Reference [2].

The Sensitometric characteristics of the two cameras are identical as described in Table 1 and are more fully described in Reference [3].

Table 1

Sensitometric Controls	Sensitometric Controls in EOS C500 and EOS C300	
	EOS C500	EOS C300
Image Format Size	Super 35mm 26.2 x 13.8 mm (29.6 mm dia.) 6.4um	Super 35mm 24.6 x 13.8 mm (28.2 mm dia.) 6.4um
ND Filters	Electrical Control • Clear • 2-stops • 4-stops • 6-stops	• Clear • 2-stops • 4-stops • 6-stops
Video Shutter Modes:		
• Shutter Speed Range	1/60 – 1/2000 in 1/4 or 1/3 stops	1/60 – 1/2000 in 1/4 or 1/3 stops
• Shutter Angle Settings	360 – 11.25 degrees in 12 steps	360 – 11.25 degrees in 12 steps
• Clear Scan Range	59.94 – 250.70 Hz	59.94 – 250.70 Hz
• Slow Shutter Speed	1/4, 1/8, 1/15, 1/30	1/4, 1/8, 1/15, 1/30
Master Gain	-6 to +30db in 9 Steps ISO 320 to ISO 20,000	-6 to +30db in 9 Steps ISO 320 to ISO 20,000
Color Temp (Degrees Kelvin)	2000 to 15,000 (100K Intervals)	2000 to 15,000 (100K Intervals)

In-Camera Recording in the EOS C500 and C300

Both camera employ identical in-camera recording capabilities. They both deploy an MPEG-2 codec to do this recording.

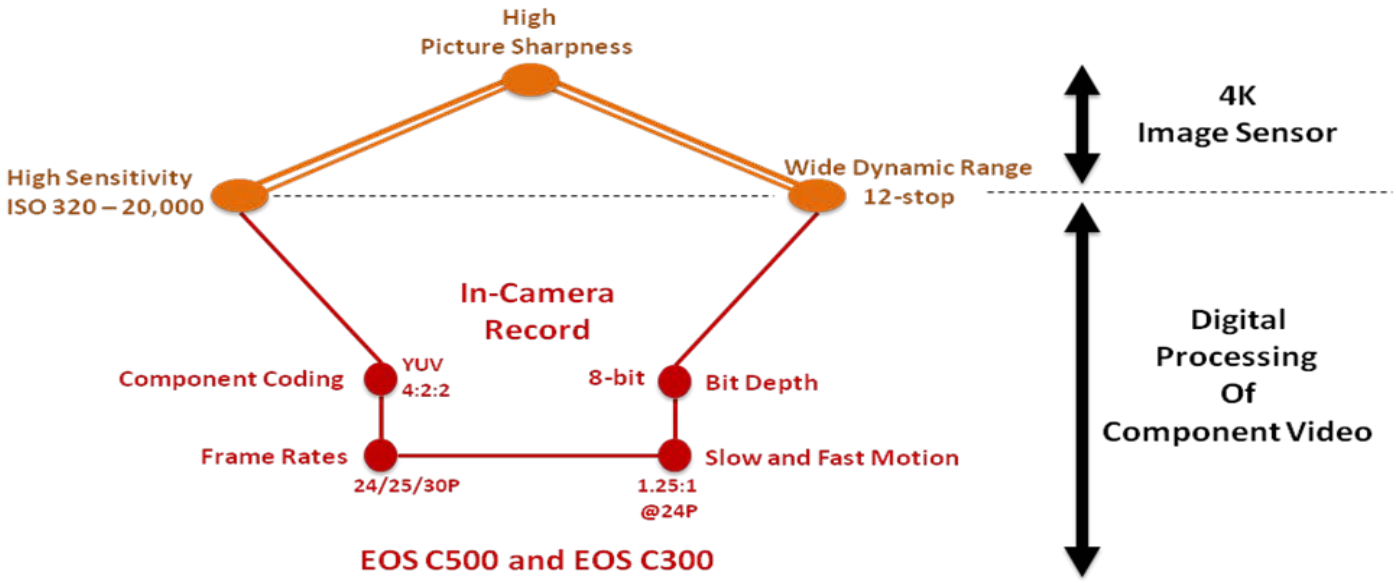

Figure 3 *Summarizing the salient features of the in-camera recording within the C500 and C300*

More specific details of the in-camera recording are summarized in table 2. It will be noted that both are "worldcams" in that they originate and record all of the internationally standardized digital HD formats. In the case of the C300 this recording can constitute the primary program capture. In the case of C500 it is used as an HD proxy of the separately and externally recorded uncompressed 4K/2K/HD material – for use in the offline editing process.

Table 2

EOS C300
In-Camera Recording

Video Formats and Picture Capture Rates	C300 HD	
	1920 x 1080 4:2:2 8-bit	1280 x 720 4:2:2 8-bit
INTERLACE 59.94i 50.0i	•	
PROGRESSIVE 23.97P 24.0P 25.0P 29.97P	• • • •	• • • •
50.0P 59.94P		• •

EOS 500
In-Camera recording

Video Formats and Picture Capture Rates	C500 HD
	1920 x 1080 4:2:2 @ 50 Mbps MPEG-2 @ 8-bits
INTERLACE 59.94i 50.0i	• •
PROGRESSIVE 23.97P 24.0P 25.0P 29.97P	• • • •
50.0P 59.94P	

EOS C500 as High performance 2K or HD Acquisition System

Where the C300 is intended as a compact camcorder with on board MPEG-2 recording, the C500 is intended to originate considerably higher performance 2K or HD digital component video which is then captured on a broad choice of world renowned external digital recorders. Comparing Figure 4 with the previous Figure 3 will reveal the significant elevation in the 2K/HD performance of the C500.

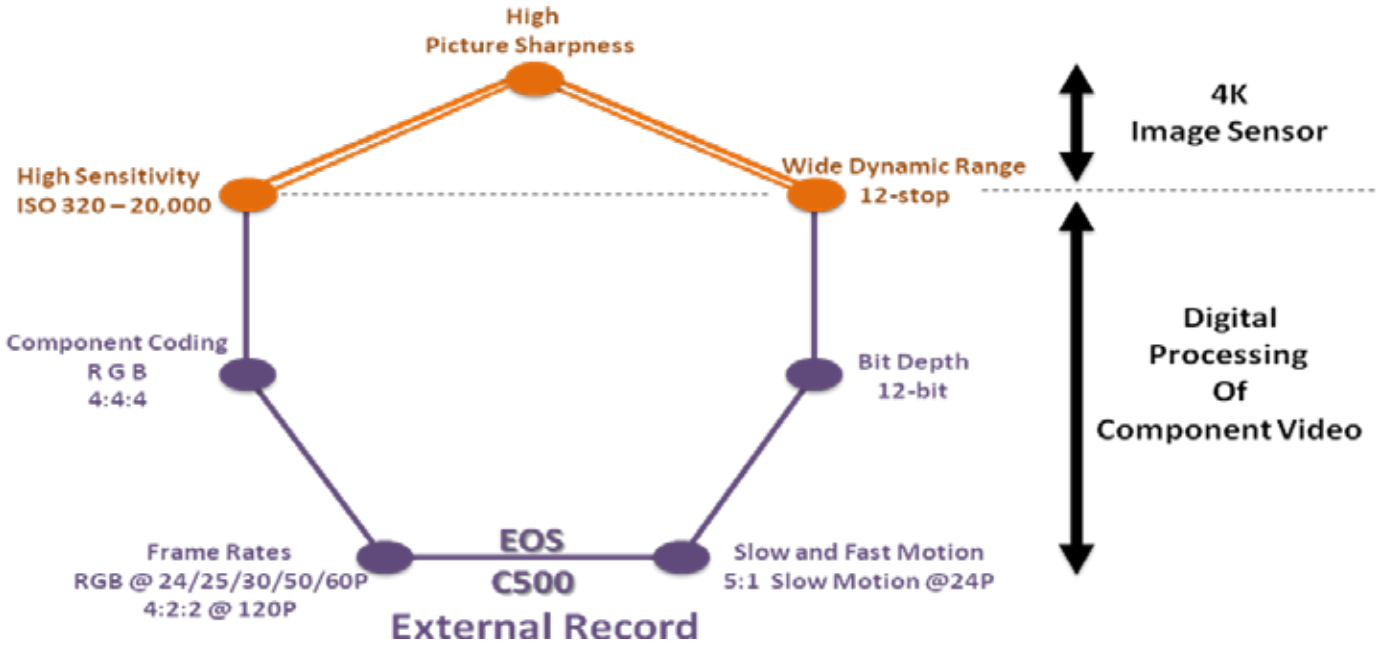

Figure 4 *Summarizing the salient specifications within the C500 processing that sharply distinguish it from the C300*

What is Unique about the 2K or HD Video Components in EOS C500

There is a distinct benefit to structuring the RGB video components in the manner described – in terms of delivering unprecedented overall image quality in the 2K / HD RAW output:

1. Full and equal bandwidth RGB 4:4:4 video components

2. Selectable as 12-bit or 10-bit RGB components

3. Because no debayering process is required – *any form of reconstruction errors and associated aliasing artifacts are totally avoided*

4. No compression is applied to these RAW signals

5. The direct readout of the four separate video components: R Gr Gb B as a 4 : 4 : 4 : 4 set of 1920 x 1080 (or 2048 x 1080) is followed by the digital summation of the two green components Gr and Gb – to produce the *"Super Green"* that has been one of the striking differentiators of the C300, C100, and C500 cameras. That special Green video has (a) enhanced dynamic range, (b) higher resolution, and (c) virtually zero aliasing – see Ref [2].

6. RGB 444 at 12-bit is available at all international standard frame rates up to 60P. If desired, this can be switched to 10-bit.

7. If higher frame rates than 60P are sought – the EOS C500 can be switched from 12-bit RGB 4:4:4 to 10-bit YUV 4:2:2 and this component set can be originated as high as 120 progressive fps (selectable in 2-frame steps from 62 to 120 fps as shown in Table 4).

8. Canon Log [4] is applied to each of the RGB components which are then delivered as 12-bit RAW components for recording.

9. To restore a linear light representation from Canon-Log in postproduction a conversion to linear space should be in accordance with the mathematics shown in Reference [4]

External Recording of 2K or HD

The EOS C500 delivers these RAW RGB video components to an external recorder via a standardized 3G SDI serial interface**.** A single 3G SDI interface will support all progressive frame rates up to 29.97P. Two such interfaces will support RGB components up to 59.94P. Table 3 summarizes the primary characteristics of the component video that can be delivered to the external recorders. Note that the C500 only originates progressive frame rates in contrast to the C300 (the C500 in-camera interlaced formats are derived from the progressive)

Table 3

Video Formats and Picture Capture Rates	HD 1920 x 1080 RGB 4:4:4 10 / 12-bit	2K 2048 x 1080 RGB 4:4:4 10 / 12-bit
INTERLACE		
59.94i		
50.0i		
PROGRESSIVE		
23.97P	●	●
24.0P	●	●
25.0P	●	●
29.97P	●	●
50.0P	●	●
59.94P	●	●

EOS C500 2K / HD Slow and Fast Motion Recording

In addition to the standardized frame rates shown in Table 3, the C500 can be switched into a variable frame rate mode which supports slow motion playback from the recorders, or alternatively, motion that has been speeded up for special effects. Table 4 summarizes the modes of operation that are supported.

Table 4

		60 Hz Modes	50Hz Modes	Increments
2K	RGB 444 *12-bit*	1 – 30fps 32 – 60fps *Playback:* *• 60Hz* *• 24.00*	1 – 25fps 25 – 50fps	1 fps steps 2 fps steps
	YCC 422 *10-bit*	1 – 60fps 62 – 120fps	1 –50fps 52 – 100fps	1 fps steps 2 fps steps

Summary

The C500 is different to other large-format single-sensor digital cinematography cameras. It directly originates from a 4K Bayer CFA Super35mm image sensor three full bandwidth RGB 2K or HD video components that are exceptionally clean of artifacts. Combined with the exceptional sensitivity of the camera and its 12-bit depth and 12-stop exposure latitude – this is 2K / HD at its very best. The summation of the two green components endows the final matriced Luma with unusually high sharpness and freedom from aliasing across the 2K passband. This, in turn, allows any downstream image enhancement to be dispensed with – further contributing to the cleanliness of the imagery and providing a natural sharpness that is especially valuable to the reproduction of human facial close-ups.

References

[1] Canon White Paper: *"New Super 35mm CMOS Sensor for Cine Motion Imaging"*

[2] Canon White Paper: *"RGB Resolution Considerations in a New CMOS Image Sensor for Cine Motion Imaging".*

[3] Canon White Paper: *"Sensitometric Characteristics of the EOS C300 Digital Cine Camera"*

[4] Canon White Paper: *"Canon-Log Cine Optoelectronic Transfer Function"*

All of these listed White Papers can be found on the Canon website via the following URL:

http://www.learn.usa.canon.com/resources/artices/2012/cinemaeos_white_papers.shtml