EBU - Tech 3335 : Methods of measuring the imaging performance of television cameras for the purposes of characterisation and setting

Alan Roberts, March 2015

SUPPLEMENT 015: Assessment of an ARRI Amira

Tests have been conducted in line with EBU R.118. This document is a report of the results of the tests defined in Tech3335 and is not an endorsement of the product.

Tests were made on an ARRI Amira camera, with ARRI/Zeiss prime lenses.

The camera is unconventional, in television terms. Its controls and layout do not follow the familiar form for stand-alone cameras. It weighs about 4.1kg without lens. There are several software variants of the camera each aimed at a particular market by incorporating extra features under a licence scheme.

The sensor is a single large-format CMOS with the Bayer pattern of photo-sites (3414x2198), super-35mm size (28.2x18.13mm), thus the individual photo-sites must be 8¼µm square, or 68 square microns. By comparison, a conventional 3-chip HD ⅔" camera has pixels 5µm square, 25 square microns. The lens mount can be PL for film-style shooting, video-conventional B4, or EF. For HD recordings, the central 2880x1620 is used, for UHD the central 3200x1800 is used. The viewfinder can show the image from the full sensor, thus mimicking film shooting.

There is a filter wheel with neutral densities, but no colour correction filters. White balancing is done by adjustment of red and blue gains.

Recording is on to CFast 2.0 cards (2 slots), using Apple ProRes (Quick Time). Coding can be 4:2:2 or full 4:4:4, again depending on the options chosen. High-speed recording up to 200fps is possible.

Power supply is from conventional 12V V-lock or Gold-Mount batteries or from external power supply, 10.5 to 34V. Power consumption is typically 50 watts.

There are BNC digital connections for monitoring, return feed or sync input, and two outputs for recording (1.5/3Gb/s). Multi-pin connectors are for external control, power supply, Ethernet and USB devices. There are other connectors for 12V and 24V output, audio in (5-pin XLR channels 1&2, 2x3-pin XLR for channels 3&4) and out (3.5mm headphone jack), viewfinder, and multi-pin lens connectors.

Camera control is menu-driven via a small display on the viewfinder. Navigation is via a jog-wheel and 6 buttons which change function with each menu item, plus a Home and Back button. Other buttons control recording and playback, power on/off, audio levels and so on.

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Many of the menu items have little or no effect on image quality. The full set of menu items is given for completeness, although I cannot guarantee that it is complete or accurate, since the UHD software was still under development at the time of testing. In boxes with a range of numeric settings, the values indicate the range, and no scales are given. Default settings, where known, are underlined. I have not identified 'best' settings, since the factory settings work well. In most menu items, the jog wheel can be used to make selections, or change a numerical value.

This is not intended as a replacement for reading the manual. Information for this section is taken from 'ARRI_AMIRA_User_Manual_SUP_1-1.pdf', supplied by ARRI. Features not mentioned in that document will not appear here.

Controls and buttons

On/Off	Power button, press and hold for 5 seconds to turn off
Rec	Start/stop recording
Lock	Press and hold for 3 seconds to lock/unlock most controls
Neutral density filter	Rotary selector under the lens mount
Audio input level selector, channels 1/2	Rotary switches, 48V/line/mic
Audio input level selector, channels 3 & 4	Rotary switches, 48V/line/mic/AES
Headphone level	Volume control
Operator panel	3 rotary switches
User buttons	4 buttons plus Shift
US switch	User switch
EI switch	Exposure Index, assignable
WB switch	White Balance, assignable
AWB button	Button
Audio function	4-position rotary
Audio set	Jogwheel and button
Audio gains	2 rotary gain controls
Viewfinder peaking (viewfinder top)	Button
Viewfinder exposure tool (viewfinder top)	Button
Viewfinder user buttons (viewfinder top)	2 buttons
Rec (viewfinder top)	Start/stop recording
Viewfinder monitor (viewfinder top)	Button
Play (viewfinder bottom)	Button
Viewfinder panel	8 buttons and jogwheel

In many menu screens, icons will appear to indicate which User Button or other control also changes the settings.

Menu settings

HOME screen

Routing to other menus

Item	**range**	**comments**
I (Info)		Show information
Version info		Software version, serial number, etc
System info		Operating hours, licence, IPs etc
Card A/B info		Card size, number of clips, remaining time
USB info		Card size, free space, numbers of files
Network info		LAN IP, remote URL
Lens data		Status, model, s/n, focal length, focus & iris settings
Export logfiles		
FPS		Set frame rate
Jog	23.976, <u>24</u>, 25, 29.97 … 100	Max value depends on rec mode and licence

Add		Define user frame rate, max 16 values
Delete		Delete a user frame rate
TC		Time code
Edit		Change TC value, use jogwheel, not in Regen mode
Set to time		Set to current system time
Reset		Set to zero
Done		
Options		
Run mode	Rec run, Free run	Free run available only if sensor fps = project fps
Mode	Preset, Regen	Regen uses external TC
Regen source		Display only
Count mode	Non-drop frame, Drop frame	
TC offset		Add/subtract from LTC to compensate for offsets
TC BNC mode	Off, TC in, TC out	Receive/Send TC
Project rate		Link to Recording menu
SHUTTER	5.0~ 356°	Jogwheel to set angle, degrees, also shown as 1/time
Switch unit	Time, Angle	Switch between units, can change the actual value
Add	5 ~ 358°	Add a user shutter angle, only up to 356°
Delete		Delete a user shutter angle
WB	Auto WB, Tungsten, Fluorescent, Daylight	White balance, shows presets
Add	Tungsten, Fluorescent, Daylight, User WB	Jogwheel to select then edit white balance, then CC correction (+/- G)
Rename		Give a name to a white balance setting
Delete		Delete one
LOOK	Rec.709, Commercial, Landscape, LCC, Vibrant, X-2-Alexa	Jogwheel to select Look file. Vibrant and Alexa need extra licences
Set gamma		Needs extra licence
Rec	Log C, Look	Log C is based on Cineon film curve, needs LUT to fix in post. Rec.709 is based on ITU curve, see Tests section below
SDI	Log C, Look	
EVF/Monitor	Log C, Look	
Add		From to the list, from -
USB		… USB device or
Defaults	Rec.709, Commercial, Landscape, LCC, Vibrant, X-2-Alexa	… Camera's defaults list
Delete		Select then delete
Export		Select then export to USB device
Rename		Change the name
Duplicate		Make a copy to edit
Look param[1]		Edit black Slope, Offset, Power, Saturation, Black Gamma, Knee, Saturation (for 6 hues), Gamma
EI settings	160, 200, 250, 320, 400, 500, 640, <u>800</u>, 1000, 1280, 1600, 2000, 32000	Set Exposure Index (ASA/ISO)[2]

Camera menu

Press the jogwheel in HOME menu, routes to other menus

Item	**range**	**comments**
Recording		
Prores codec	422 LT, 422, 422 HQ, 4444	HQ and 4444 need extra licences[3]
Resolution	HD, 2k, UHD	2k = 2048x1152, UHD = 3840x2160 need extra licence
Project settings		
Project rate	23.976p, 24p, 25p, 29.97p, 30p, 48p, 50p, 60p, 50i, 59,94i, 60i	Normal rage of speeds
Next reel count		'Reel number' indentifies a card
Camera index	A ~ Z	Identify the camera
Camera ID prefix		e.g. L or R for 3D shooting
Rec beeper/tally		
Rec beeper	Start, Stop, Start&Stop	
Tally front	Off, On	

[1] This controls colour performance, incorporating virtually all the controls normally found in Gamma, Knee, Saturation and Color Correction in a conventional television camera.

[2] The manual states that 800 ISO is the base setting, but these tests have found that 400 may be a better choice, see the test results for details.

[3] 422 codecs are all 10-bit YCbCr, 4444 is 12-bit RGBKey

Tally rear	Off, On	
Prerecord max duration	0 ~ 20.0sec	Max depends on fps and codec, and needs extra licence. Activate in User Buttons menu
Media		
Erase card A		Press Erase
Erase card B		Press Erase
Delete last clip card A		Select clip with jogwheel, press Confirm
Delete last clip card B		Select clip with jogwheel, press Confirm
Prepare USB medium		Make folders on FAT formatted USB drive
Monitoring		
EVF/monitor		
Surround view	On, Off	Show pixels outside the recorded area
Zoom position	Centred, Eye level	Set area zoomed in the v/f
Exposure tool		
Exp tool selection	Zebra, False color[4]	
Zebra mode	High, Mid, Both	Diagonal stripes, two ranges
Zebra setup		
High zebra level		Set level above which zebra shows
High zebra color		
Mid zebra level		
Mid zebra range		
Mid zebra color		
EVF waveform	Off, On	
EVF waveform size	Small, Large	
Monitor waveform	Off, On	
Monitor waveform size	Small, Large	
Peaking		
Peaking mode	Color, Aperture	Color fills sharp areas, Aperure surrounds them
Peaking level	1 ~ 20	
Peaking offset shift		Adjust peaking threshold vs peaking level
Color		
Settings		
EVF brightness	1 ~ 10	
Monitor brightness	1 ~ 10	
Monitor flip mode	Normal, Flipped, Auto	
EVF overlays		… and very similar menus for Monitoring and SDI
Frame lines	On, Off	Framing help
Centre mark	Off, Small dot, Dot, Cross	
Surround mask	Off, Black line, Color line, Mask 25%, Mask 50%, Mask 75%	Not available on Monitoring and SDI menus
Status info	Off, Overlay, Safe	Safe=outside the image. Not for Monitoring or SDI
Status components	On, Off	Only for EVF
Info 1	On, Off	Above and below the image
Info 2	On, Off	Left and right of the image
Timecode	On, Off	In top-middle of image
Audio	On, Off	Audio levels, right side
Lens data	On, Off	Focus, iris, focal length
Monitor overlays		
SDI		
SDI format	422 1.5G, 422 3G, 444 3G	422 is YCbCr, 444 is RGB
SDI frame rate	23.976, 24, 25, 29,97, 30, 48, 50, 59,94, 60	
SDI scan format	P, Psf, I	I only at 50, 59.94, 60
SDI phase sync	Off, On	
SDI 1 image	Clean, Processed	
SDI 2 image	Clean, Processed	
SDI processing		
Surround view	On, Off	Scales image down to fit
Exposure tool		Same options as Monitoring > Exposure tool
Peaking		Same options as Monitor > Peaking
Overlays		Same options as Monitor > Overlays
Frame lines		

[4] False colours: red=100~99%, yellow=99~97%, pink=56~52%, green=42~38%, blue=4.0~2.5%, purple=2.5~0.0%

Frame line	None, 1.33, 1.66, 1.85, 2.39 Flat	
Add		Maximum 20
Defaults		Select from camera default frames
USB		Get from a USB device
Delete		Select and press Delete
Frame line color		
Frame line intensity		
User rectangles	Off, 1, 2, Both	Roll your own boxes
User rectangle 1/2		Dimensions in 'mille', presumably 1000/W or /H
Width		
Height		
Offset left		
Offset top		
Return in path		Select path for Return input
Color bars	Off, On	SMPTE bars on all outputs
System		
Sensor		
Image sharpness	-5 ~ <u>0</u> ~ +5	See Tests section below
Image detail	-5 ~ <u>0</u> ~ +5	
Image denoising	Off, Normal, Strong	Only available in UHD mode
Genlock	Off, Master, Slave	
Mirror image	V, H, V+H	
Sensor temperature	Normal, High humidity	
Fan mode	Regular, Rec low, Low noise	Speed goes up when data rates above 100Mb/s
Power		
Bat onboard (1) warning		Set warning levels, % only if the battery gives data
Bat onboard (1) warning		
Bat in (2) warning		External power supply warning
Bat unit preference	Volt, %	Bat 1 (onbard) only, % only if the battery gives data
System time + date		Set the time and date
Year	2014	
Month	12	
Day	03	
Hour	12	
Minute	00	
Timezone		Settings not changed here, these values go as metadata
Daylight saving time	Off, On	
Buttons + display		
Display style	Day, Night	
Button brightness	0 ~ 3	
Licensed features		List, add, delete licenses.
	Advanced gives 200fps, ProRes 422HQ, Pre-rec, Log-C, Import/export Look files, edit Look files, AWB, WiFi, Bluetooth monitoring. Premium adds ProRes 444, 2k, 3D LUTs, 3.2k, UHD	
Camera update		See the manual, P.160
Setup		Simple menus to move data about
Save current setup to USB		
Save current setup as default		
Load setup from USB		
Load default setup		
Factory reset		
User buttons	P.134	
User switch	None, Fps, Shutter/Exp Time, Look	
Button EVF 1 and 2 Buttons 1~ 8	Off, EVF zoom, EVF frame lines, EVF zebra/FC, EVF gamma, EVF surround, EVF peaking, EVF exp tool, EVF waveform, Monitor waveform, SDI framelines, SDI zebra/FC, SDI gamma, SDI surround, SDI peaking, SDI exp tool, Select card, Frame line color, Framegrab, Check last clip, Flip monitor, Prerec, Auto iris, Open iris, Close iris, Return in, BT talkback	4 User buttons on camera left, near the Rec button, shift button below to get the other 4

Metadata		Text editing menus for metadata
Production		
Prod company		
Director		
Cinematographer		
Camera operator		
Location		
Scene		
Take		
User info 1		
User info 2		

Three operator switches can be programmed: US, EI and WB. Individual functions can be assigned to each position of each switch. Set the switch to the chosen position, then go to ‘Menu > User buttons’, select ‘User Switch’ then use the jogwheel to select from ‘None, FPS, Shutter, Exp time, Look’. Exit with ‘Home’.

EBU - Tech 3335 : Methods of measuring the imaging performance of television cameras for the purposes of characterisation and setting

Alan Roberts, December 2014

SUPPLEMENT 05: Assessment of an ARRI Amira

Tests were made on an ARRI Amira camera, with ARRI/Zeiss prime lenses.

In HD mode, the camera uses the central 2880x1620 of 3168x2198 effective photo-sites on a sensor of size 28.17x18.13mm. Thus, the viewfinder can show image information from outside the nominal picture. Thus, there is an exact ratio of 3:2 (down-scaling) between the photo-sites and the output pixels, which means that the decoding of the Bayer pattern ought to deliver clean resolution up to 1440x810, with only minimal coloured aliasing outside that range. Since the sensor is 35mm equivalent size, the individual photo-sites must be about 8.25µm square, approximately double the area of those in a conventional ⅔" HDTV camera, which should deliver lower noise levels and/or higher contrast capture range.

In UHD mode, the camera uses the central 3200x1800 to output 3840x2160. Thus there is an exact ratio of 5:6 (up-scaling) between the photo-sites and the output pixels, which means that there ought to be clean resolution up to 1600x900.

All testing was done by recording onto CFast solid-state cards since this is the mode in which the camera is easiest to use and will probably be used. Live monitoring was done on a small camera viewfinder, and on a waveform monitor. The test procedures were as described and recommended by the EBU, in Tech 3335 (http://tech.ebu.ch/docs/tech/tech3335.pdf).

The prime purpose of this test was to establish the performance of the camera when used for broadcast television with the ITU Rec.709 gamma curve. For feature-film production, the LogC curve would normally be used.

ARRI have developed a new algorithm for decoding the Bayer pattern. It is already installed in the Amira and is available as an upgrade for the Alexa.

1 Colour performance

Signals can be recorded in either 444 or 422 sampling in ProRes using the ITU.709 gamma setting or ARRI's proprietary Log-C curve. The 709 setting was used for all the tests.

The curve can be adjusted in much the same way as in a conventional high-end television camera. There are controls for knee (break point and slope), and for black stretch (break point and slope) as well as individual controls for red green and blue. In the default settings, the curve very closely resembles that in the ARRI ALEXA, but is not a true ITU.709 curve as such.

Fig.1 shows a Colorchecker chart captured in this mode; clearly the card's contrast has been reduced, and the colours are all desaturated but of the correct hue.

Figure 1 Colorchecker

2 Opto-electronic transfer function, gamma-correction

A series of exposures of the Colorchecker chart were taken, at several different exposures, and the signal levels of the grey scale were measured each time. The results are all plotted together in Fig. 2, together with the theoretical ITU.709 gamma-correction curve for comparison. The theoretical curve has been adjusted to match the lower part of the camera curve, peak signal level occurs at about 9.6% of peak exposure, which implies that the built-in knee is set to capture over 3 stops of overexposure. Slight deviations from a smooth curve are probably due to my assumption that the chart patches have the manufacturer's specified reflectances rather than the actual values from measurement. Nevertheless, the curve is good enough for this purpose.

Fig. 3 shows the same data plotted with log axes. Here the measurement discrepancies are exaggerated at low exposure and signal levels, but the fit is still good enough as an indication of the gamma curve. Clearly the fit between the data and the official curve is good over much of the midde range, from about 0.2 to 0.5. Deviation at low exposure levels could be due to noise-clipping in the sRGB-coded still files extracted for examination, where negative-going noise peaks could have been clipped off, resulting in a slightly higher signal level. However, close examination of the files has shown no noise clipping, therefor the results can be believed.

While it is easy to set other combinations for the shape of the curve, this default comination performs very well, and allows a good match to the ALEXA. Other settings are probably of less significance, but can be used for special effects.

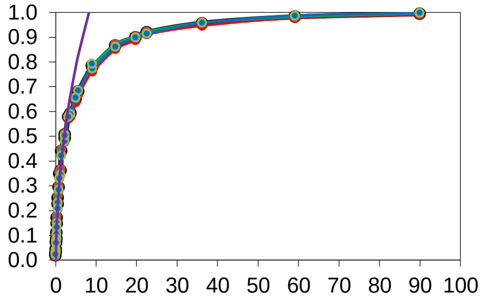

Figure 2 Gamma-correction, signal vs patch reflectance

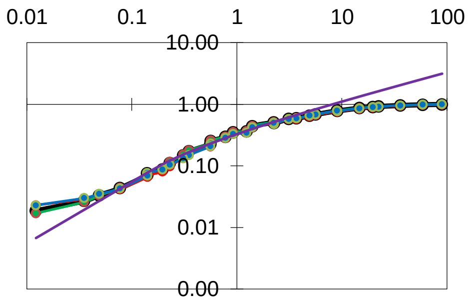

Figure 3 Gamma correction, log axes

3 Exposure range

This is normally calculated as the ratio of the exposure which just causes white clipping to the exposure level below which no details can be seen. The unusual nature of the gamma curve makes assessment almost impossible, since the compression of highlights is highly progressive, never seeming to reach an actual clipping point. Nevertheless, the Colorchecker grey scale used for the measurements of the gamma-correction provided some basis for a dynamic range estimate.

All the measurements of the grey scale produced values which did not clip, either at black or white. So the dynamic range must exceed the dynamic range of the chart (in photographic stops) plus the range of exposure values used to make those measurements. The chart reflectances range from 90.01% to 3.13%, a range of 28.76:1, about 4¾ stops, and the exposures ranged from T2.8 with 1/50 shutter to T22 with 1/200 shutter, an effective range of 10 stops. Thus the dynamic range explored for this test must be at least 14 stops, so the claim of 14 stops seems entirely reasonable, even when using the 'normal' ITU.709 gamma curve.

4 Sensitivity

The normal specification for camera sensitivity is the lens transmission (T) number for which the camera produces exactly 100% luma level from a 90% reflection card lit at 2000 lux. Few manufacturers actually use the T number. A figure of F/8 to F/11 is normal for a ⅔" conventional HDTV camera (see other camera test reports in this series).

Measurement always assumes that either the gamma curve is switched off, or that it is a conventional television gamma curve with no knee to compress tones near white. The Alexa does not allow for such measurements because the gamma curve contains a gentle but long-range knee which compresses over a considerable luma range. However, there is an argument to be made for using the mid-grey performance rather than peak white, since mid-grey is where the important colours such as skin tones will conventionally be placed. The Kodak 'Gray card' provides the solution, and EBU Tech.3335 has been modified to allow this.

The camera was exposed to the 'white' side of a Kodak card which has a specified reflectance of 90%, lit by a tungsten luminaire. The camera was set in HD mode at ISO 400 and T22. The card illumination level was adjusted to get a video signal level of 50%, 3400 lux. Thus 2000 lux should produce this 50% signal level at T16 (¼). In a conventional video camera, the 18% reflectance should produce a mid-grey level when the

90% reflectance produces peak white, and since these reflectances have a ratio of 5:1, it is safe to state that the exposure to produce 100% video level from the 90% card must be 5 times that for 50%, about 2⅓ stops more than the setting to get 50% video. Thus the sensitivity, the aperture to get 100% video level at 2000 lux with ISO400 and if there were no knee in the gamma curve, must be about T8. This corresponds to T/11 at ISO800. Thus the Amira is at least one stop more sensitive than conventional ⅔” HDTV cameras.

5 Video Resolution

Resolution tests were made by exposing the camera to a circular zone plate test chart, containing patterns to test luma, R G and B, and chroma channels.

5.1 Video Resolution, HD

The chart was framed to exactly fill the 1920x1080 image.

Figure 4 Resolution, HD mode, luma

Fig. 4 shows a quadrant of the luma pattern with Sharpness and Detail controls left at factory setting (both zero). Since the sensor performs a 3:2 down-conversion from 2880x1620 to 1920x1080, the normal extinction line joining the maximum horizontal and vertical frequencies only grazes the diagonal limit of the pattern (the null centres are at 2880 horizontally and 1620 vertically). There is some low-level aliasing beyond 1440 horizontally and 810 vertically, but the overall impression is of a clean image even though it does not fully fill the 1920x1080 space. There is a low-level coloured null zone centred at 1440,810, as expected, diagonal response.

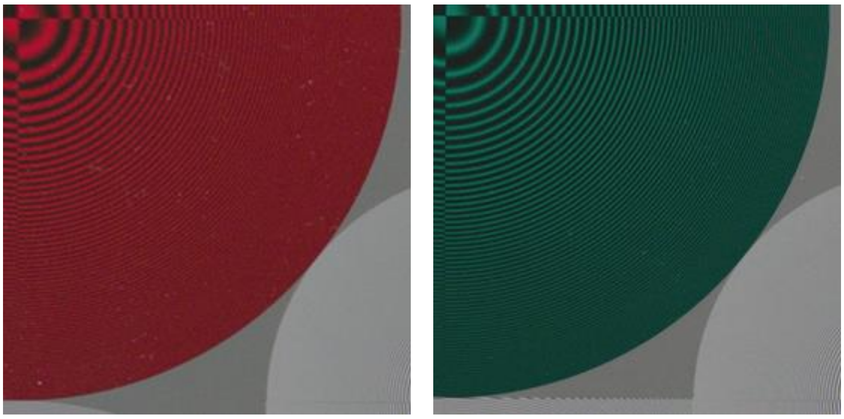

Figure 5 Resolution, HD mode, red and green

Fig. 5 shows the colour resolution, red and green (blue is the same as red).

The red pattern shows more aliasing than does the green, but the level is fairly low. Evidently, the optical low-pass filter does not have a sharp cut, since some aliasing is visible in the double frequency pattern (lower right) but the level is not high enough to cause significant problems in ‘real’ pictures. However, it is clear that the optical filter is more aimed at UHD performance than HD. The overall impression is of good cleanliness, which is quite unusual in a single-sensor camera.

Fig. 6 shows the luma performance with maximum Sharpness and Detail (+5 for both). There is a little more detail both horizontally and vertically, but the coloured aliasing is a little more visible. Clearly, these controls are quite mild and can be used in any configuration.

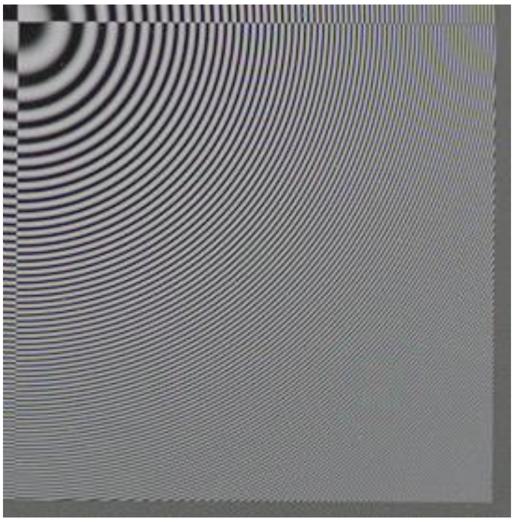

Figure 6 Resolution, HD mode, luma, maximum Sharpness and Detail

5.2 Video Resolution, UHD

Fig. 7 shows the luma resolution in UHD mode (3840x2160). For these tests the zone plate chart was framed to fit exactly half the height and width of the image, thus it now fully explores 3840x2160. The level of coloured aliasing is much higher, and there are null zones centred at 3200 horizontally and 1800 vertically. These are inevitable since the UHD image is formed from an area of the sensor 3200x1800 photo-sites. There are also diagonal aliases, from the same cause.

The image is relatively clean up to 2500x1400, with some coloured aliasing beyond those limits.

Figure 7 Resolution, UHD mode, luma

6 Video Noise

To measure how the noise changes with ‘speed’, the camera was exposed to the white side of a Kodak Gray card. To measure the noise profile (the way noise changes with video signal level at constant camera ‘speed’), it was exposed to a custom-made reflectance chart consisting of 6 large grey patches approximately equally spread from black to white visually. The lighting was made as even as possible with two luminaires, and the lens defocused a little to eliminate any dust or minor blemishes. Since the Bayer pattern decoder affects noise levels, measurements were made with both the old and new algorithm.

6.1 Video Noise, HD

Fig. 8 shows the change of noise with camera ‘speed’, in 4 steps from ISO200 to ISO1600. The horizontal axis is marked in dB; -6.02dB is ISO200, 0dB is 400, +6.02 is 800, +12.04dB is 1600. For each exposure, the aperture was adjusted to get a video level of 50%.

The curves are normally expected to continue upwards as the camera ‘speed’ increases, with a slope of 3dB per change of 6dB in gain. Deviation from this slope is minimal, and the camera just meets the target of -48dB for EBU R.118 Tier 1 at 400ISO.

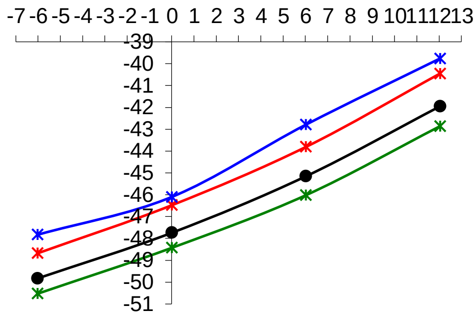

Figure 8 HD Noise versus 'speed (gain, dB)

Fig. 9 shows the noise profile, measured from three exposures of the 6-step grey scale at ISO400. The points have a degree of scatter which is quite normal for this method of measurement, and so only a trend line is plotted, rather than a line through all the points.

There are two sources of noise: electron-noise (‘shot noise’) which rises with signal level, and processing noise caused by the non-linear amplification due to the gamma-correction curve, which falls with signal level. These effects can combine to produce odd noise profiles.

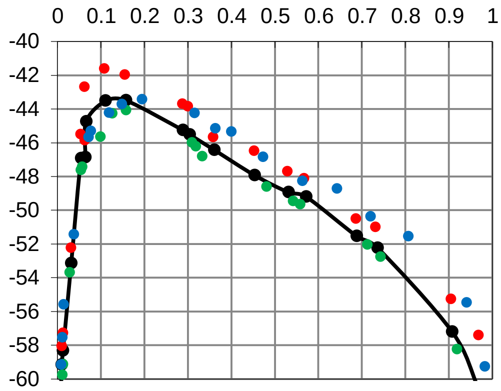

Figure 9 HD Noise profile, ISO400

Thus it can be difficult to determine exactly what is causing the noise, however, in this case the dominant effect is that of rising noise as the level reduces, implying that it comes from the amplification in the gamma-correction. This is perfectly normal and to be expected. The line should normally continue to rise as the signal level falls, since the noise is due in part to analogue noise in the sensor, amplified by the rising gain in the gamma-correction. However, this curve turns and reduces below 15%.

In many cameras this could be due to noise reduction, but the Amira is different. The large dynamic range is achieved by double-reading of the sensor, and so it is likely that this lowering of noise at low video levels is a result of this process. The overall effect is that pictures do not look as noisy as these figures would imply, since we normally judge noise levels near black, where the actual level is about 15dB lower than expected.

Fig. 10 shows signal levels across a single scan line, showing the signal levels near black when amplified by a factor of 4 in software. This establishes that the noise excursions are not going below black and being clipped. In this case, the signal gain has been increased by a factor of 4 so that the effects of quantising in the original recording file can be seen, clearly the signal excursions in the lowest level cover a range of only 4 quantum levels, this the noise figures reported cannot be relied upon.

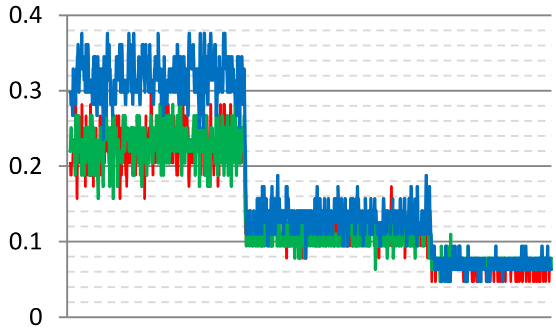

Figure 10 HD Noise waveform, single line

The unusual noise profile has an interesting implication, that the noise level at mid-grey is not truly representative of the overall noise performance. Since the noise near black is usually much higher than at mid-grey, transmission coding is usually most affected near black, but that is not the case here. Investigations are currently being made into ways of improving the interpretation of noise levels, which should result in changes to both EBU Tech.3335 and R.118.

6.2 Video Noise, UHD

Fig. 11 shows the change of noise with ‘speed’. Again, the noise level is plotted versus the effective camera gain. As expected, the noise level rises at approximately 3dB per change of 6dB camera gain. The noise levels are about 1.5 to 2dB higher than in HD mode, presumably because of the increased complexity of the scaling process from 3200x1800 to 3840x2160. The level at ISO400 is about -46dB, while EBU R.118 expects a level of about -50dB for both UHD tiers.

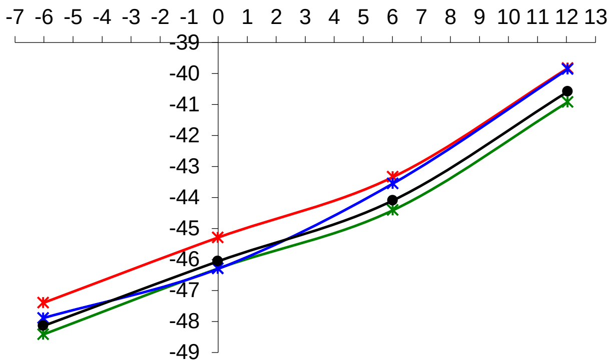

Figure 11 UHD Noise vs ‘speed’

Fig. 12 shows the effect of noise-reduction. There are two settings, ‘Normal’ and ‘High’, only the Normal setting was tested. There is a general advantage of between 1 and 2.5dB, with maximum reduction at low noise levels, which should not have any impact on resolution and is well worth having. Setting to ‘High’ is likely to double this effect, 2 to 5dB advantage, but there could be a loss of spatial of temporal resolution due to the filtering process.

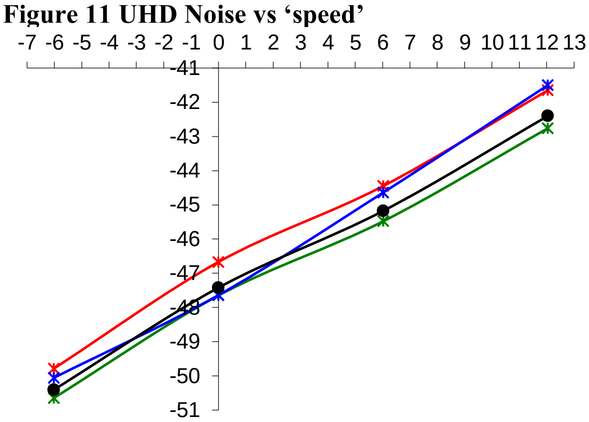

Figure 12 UHD Noise vs 'speed', NR on

If the ‘High’ level of noise reduction is used, the level at ISO 400 ought to be about -49dB, very close to the R.118 specification.

Fig. 13 shows the noise profile at ISO400. Again, the point-scatter is to be expected. The shape is as for HD,

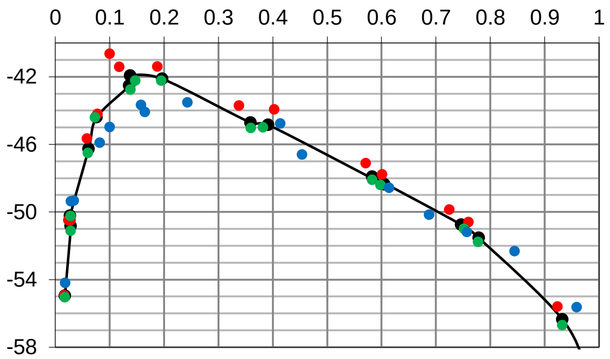

Figure 13 UHD Noise profile, ISO400

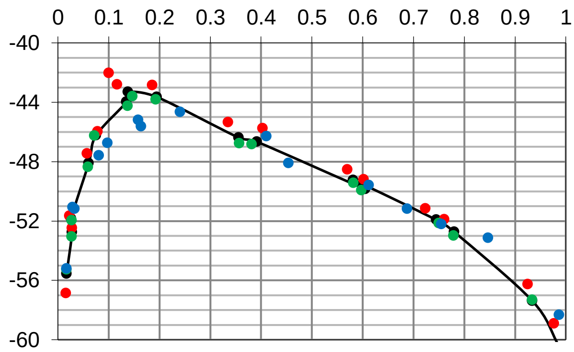

Figure 14 UHD Noise profile, ISO400, NR on

and so can probably be attributed to the sensor double-reading process. Fig. 14 shows the effect of the ‘Normal’ setting of noise-reduction, mid-grey noise is reduced by about 1.8dB to a little below -48dB. Again, using the ‘High’ setting ought to bring about another 1.8dB of improvement and achieve the target level of -50dB for both Tier 1 and Tier 2 in R.118.

7 Motion portrayal, rolling shutter

Since this is a CMOS camera, the image data is most likely read from the sensor by scanning, rather than by taking a very brief, global, reading of the values into a store for later scanning. This process, called ‘rolling shutter’, is the same as scanning in a vacuum tube camera or CRT television set, and can cause severe geometrical distortions when there is significant motion in the image.

My normal test for this is to set up a small fan, rotating at a speed designed to cause strobing of the fan blades. The fan was set such that the total diameter of the blades filled about 50% of the image height.

Fig. 15 shows the fan at high and low exposure levels, with the camera set to HD mode and 1/500 second shutter. There is hardly any change in size of the blades, implying that the sensor is being read very quickly. The result is the same in the UHD mode.

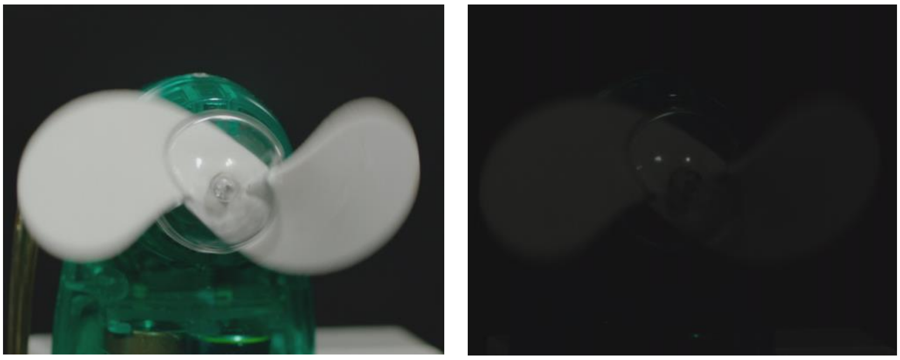

Figure 15 Fan strobing at high and low exposure

The design of the scanning process has largely eliminated rolling-shutter effect in this camera.

8 Infra-red response (IR)

No video camera should respond to IR. The simple test for this is to take a remote control unit and point it into the lens, then start pressing buttons. If the IR LED is seen lit or flashing, then the camera must be responding to IR since all consumer remote controls use LEDs which emit ‘light’ at about 930nm, well beyond the red extreme of the visible range.

The Amira was not specifically tested for IR, partly through forgetting to do it, but mainly because tests on the Alexa showed acceptably low levels of IR response.

9 Conclusion

The camera has good connectivity, allowing full-resolution external monitoring and recording.

The test procedures were as described and recommended by the EBU, in Tech 3335 (http://tech.ebu.ch/docs/tech/tech3335.pdf).

Video performance in HD mode is exceptionally good in terms of resolution and aliasing. There would be no quality advantage to making external recordings via the HDSDI output. The camera achieves the R.118 criteria for HD Tier 1.

UHD resolution performance is less good, being limited to about 3200x1800 (which qualifies it for Tier 2), and there is some coloured aliasing. The noise performance is marginal but can achieve the level for R.118 Tier 2 if noise reduction is used.

The noise profile is not typical of a conventional television camera; the suppression of noise near black has the effect of making the pictures look a rather less noisy than they actually are, which has caused a fresh examination into the nature of video noise and its effects on video coding. This is expected to lead to a change in EBU R.118.

Colour performance is very good.

Motion portrayal is good; the effects of the rolling shutter are nicely suppressed.