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

Alan Roberts, March 2016

SUPPLEMENT 19: Assessment of a Sony a6300 camera

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.

This is a report on the performance of a Sony a6300 camera, serial number 3370162, provided for testing by Sony. However, it is not a full report, in that there is little or no description of the camera, and no listing of the menu contents.

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All measurements were made on frames captured in the camera onto SD card, and on an external recorder Atomos Shogun. Live viewing was done on a 22” HD LCD television. Clips were ingested into Edius 8.10 and images for this document were extracted as BMP files. In all cases, the project resolution was set to match the clip resolution thus avoiding any scaling.

The camera serial number was 3370162. The lens was a Zeiss Makro Planar 100mm F/2 serial number 15906596. I shall use the EBU system of designating scanning standards (e.g. 25i is what is commonly called 50i).

1. Resolution and aliasing

Measurements were complicated by a peculiar characteristic of the camera; the framing changes with resolution and frame rate settings. Since the tests used a fixed lens, this meant adjusting the camera distance for almost every change of setting. Also, changing the settings of the HDMI output did not always produce the expected effect, it pays to check that what is set is actually happening.

1.1. Resolution for HD

Tests were made at F/5.6. The usual zone plate test chart was framed to fill exactly the width and height of the image. Recording was with standard BT.709 settings.

Fig. 1 shows one quadrant of the luma pattern which reaches the 1920x1080 limits of HD, recorded in-camera and on the external recorder. Resolution does not reach the system limits (at the edge of the larger quadrant) and there is coloured aliasing both vertically and horizontally. There is some diagonal luma aliasing. The levels of aliasing, while not great, are disappointing since the sensor has adequate photo-site numbers for the resolution. This level of aliasing will cause problems in motion-based data compression especially at low bit-rates.

Figure 1 HD resolution
(a) In-camera recording **(b) Atomos Shogun recording**

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The recording was made in 50p mode, and ITU 709 gamma. The horizontal region of clear grey at approximately 820 lines must derive from the down-sampling from the sensor to 1920x1080. It is not clear why this is happening.

Strong aliasing is also clearly seen in the smaller quadrant, which reaches the limits of UHD-1, 3840x2160, which indicates that the down-scaling from 3840x2160 to HD has used a simple algorithm, probably linear or cubic interpolation.

Figure 2 Resolution affected by Detail control
(a) Detail minimum, -7 **(b) Detail maximum, +7**

Fig. 2 shows the effects of detail enhancement. Setting to minimum does not remove the aliasing, although it removes the null zone at ⅔ horizontal resolution (see Fig. 1a) which is normally caused by a mismatch between the gamma of the display and the gamma-correction in the camera. Maximum enhancement is distinctly unpleasant, this level of aliasing will certainly cause problems in low bit-rate compression.

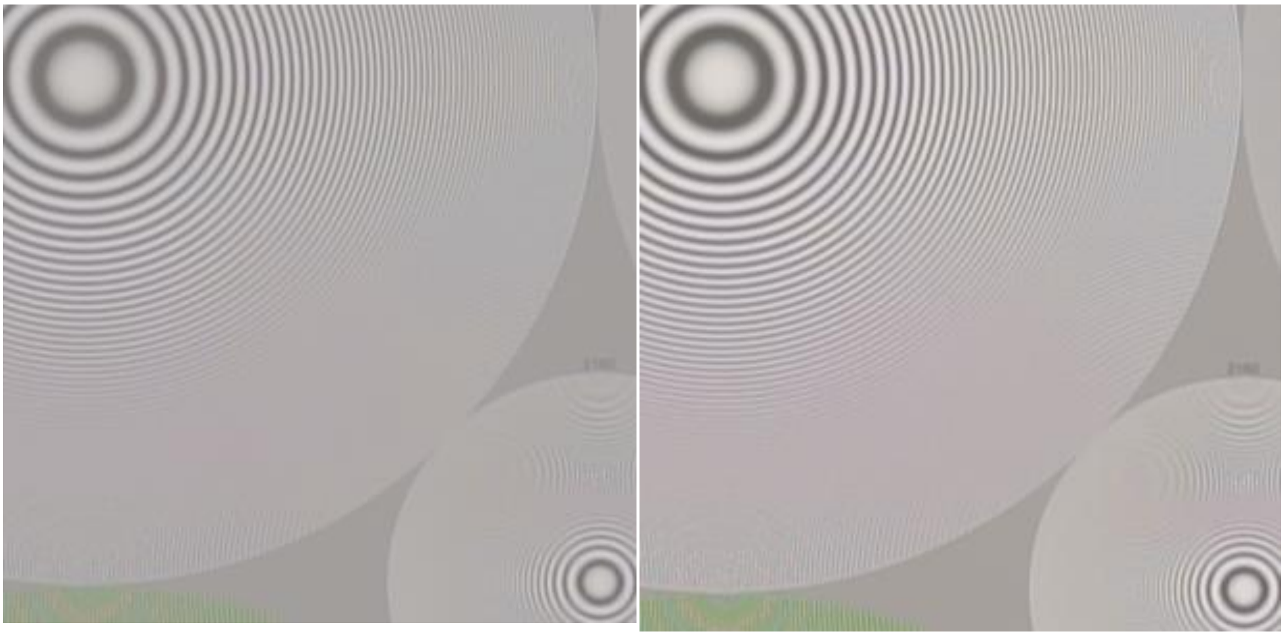

Figure 3 Resolution affected by gamma curves, Detail=0
(a) S-log 3 **(b) S-log 2**

Subjectively, a level of between -2 and -4 ought to be a good compromise, although it will not eliminate the aliasing.

Fig. 3 shows the effects of using the S-log curves, with Detail set to 0 (factory default setting).

Although the alias levels appear to be much lower, the images are far less contrasty due to the nature of the S-log curves, which deliver much ‘flatter’ pictures needing treatment in post-production to make them acceptable. This post-production operation, as well as returning the contrast, will return the aliasing, so this is not a solution.

1.2. Resolution for ‘4k’ (UHD-1 3840x2160)

Normally, the HD zone plate chart would be reframed so that it filled exactly half the frame. However, with the prime lens it was not possible to get far enough away from the chart within the confines of the test room. Therefore it was left fully framed. This means that only the smaller patterns were relevant, and these are less well equalised in the printing process. Nevertheless, they show enough to be revealing.

Exposures were made at F/5.6.

Fig. 4 shows on quadrant of a smaller pattern, reaching 3840x2160. The camera was set to ITU 709 gamma and Detail to zero, factory default. Clearly the camera is resolving detail all the way up to the limits, but this implies that there is probably no optical low-pass filter, and so optical detail at higher frequencies is reaching the sensor and causing more out-of-band aliasing.

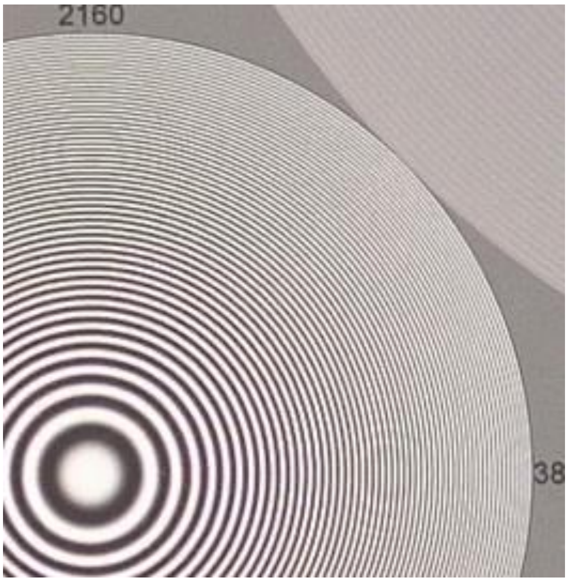

Figure 4 Resolution, UHD

Fig. 5 shows the effect of the Detail control.

Although the minimum setting softens the image, aliasing is still present. The maximum setting is clearly unacceptable because it is heavily emphasising the middle and lower frequencies. Overall, a lower setting, between, say, -3 and -5 might be acceptable, but the level of aliasing remains a problem.

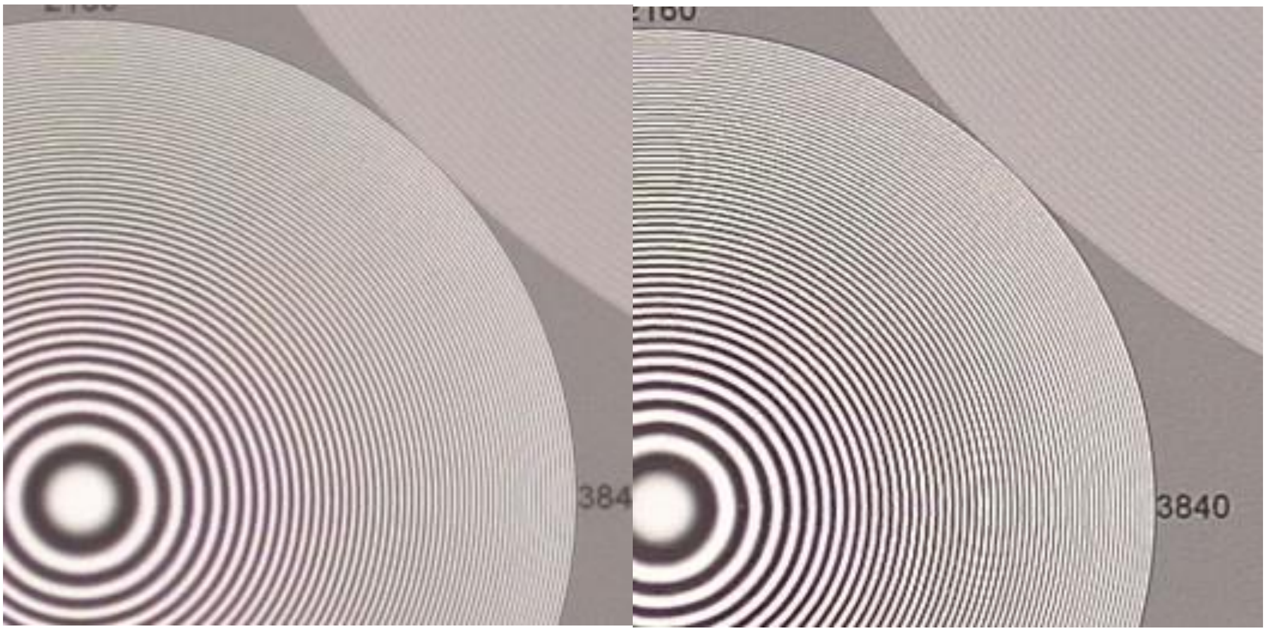

Figure 5 Resolution, UHD
(a) Detail minimum, -7 **(b) Detail maximum, +7**

The effects of the S-log curves on UHD performance are very similar to their effects in HD, flattening the image, softening it, lowering the level of aliases, but with the high probability that post-production operations will reinstate the aliasing along with the resolution.

1.3. Colour performance

A standard Colorchecker chart was exposed, using tungsten illumination. The camera was set to tungsten illumination. The camera has several shooting modes which have great effect on the colour performance; it would be wrong to compare these without including the display system for which each is intended, and there is no reason to expect the colour performance to be affected by these settings, provided the correct post-production operations are done on them.

Fig 6 shows the results for ITU 709 gamma and matrix. There is no difference between HD and UHD performance. Although the orange and yellow patches are a little over-bright, and the red and light skin tone a little over-saturated, the performance is generally good.

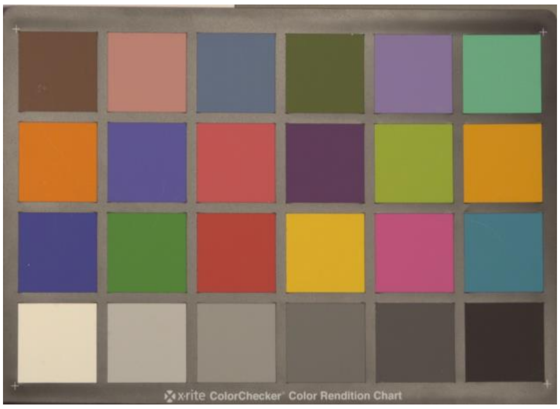

Figure 6 ColourChecker, ITU 709 gamma and matrix

1.4. Gamma curves (opto-electronic transfer characteristic) and Dynamic Range

The Colorchecker chart was exposed with tungsten illumination, using three of the presets. Multiple exposures, using shutter and aperture, provided many exposure levels from which it is possible to extract the curves from the grey scale patches.

Fig. 7a shows the curve for ITU 709 gamma setting, it is a good fit. However, the maths for extracting the data for this curve has revealed that the shutter settings may not be exactly as they should be. The three exposures were at 1/50, 1/1000 and 1/4000, but this resulted in non-monotonic data, estimated corrections to ensure monotonicity show that the 1/1000 and 1/4000 settings could well be nearer 1/2000 and 1/8000. Fig. 7b shows the same curve plotted logarithmically, signal level vs. stops relative to exposure at 18% reflectivity. The curves show a dynamic range of not more than 9 stops.

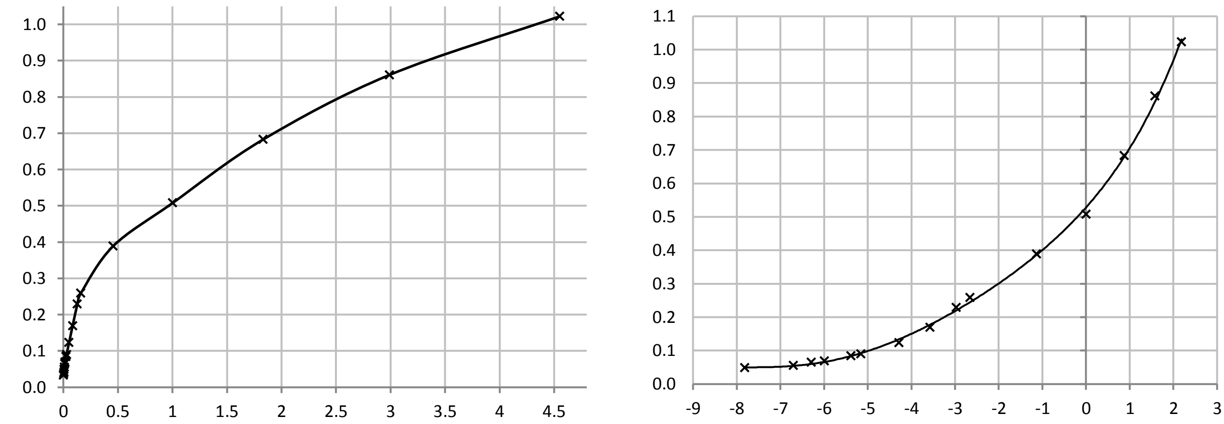

Figure 7 Gamma curve, ITU 709
(a) Linear plot **(b) plot vs stops relative to 18%**

Fig. 8 shows the log plots for S-log3 and S-log 2. The slightly confused areas are where there are several similar measurements due to overlapping exposure ranges. S-log3 appears to capture about 13 to 13.5 stops, S-log2 about 11 to 11.5 stops range. The problems with using these curves is that the recording is only to 8-bit depth, and so there is a significant risk of contours appearing due to the low slope of the curves. S-log2 may well perform better than S-log3 because of this.

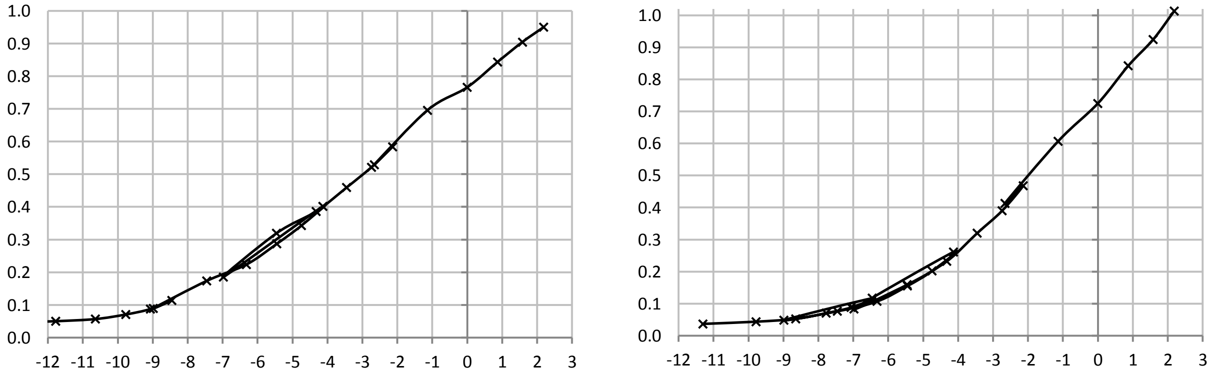

Figure 8 Gamma curves
(a) S-log3 **(b) SD-log2**

1.5. Noise

1.5.1. Noise levels

The camera was exposed to a 6-step grey scale, tungsten illuminated. Multiple exposures were taken to produce measurements exploring the dynamic range at ISO800. The camera was set to UHD mode, and with Noise Reduction switched off.

Conventionally, the noise level is expected to rise as the signal tends towards black. This is because the gamma-correction applies ever–increasing gain towards black. However, photon noise (known as shot noise) increases with signal level. Often these effects cancel out to some degree.

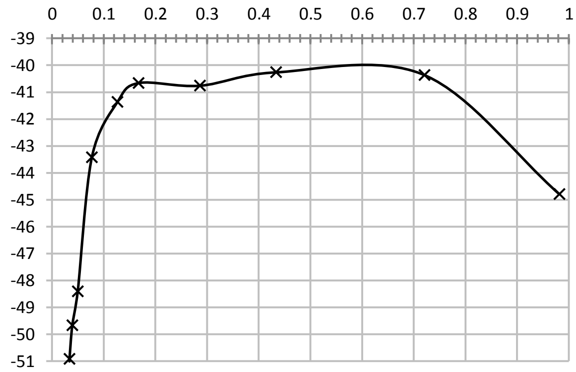

Figure 9 Noise profile, ITU 709 gamma, ISO800

Fig. 9 shows the noise profile for the ITU 709 gamma curve. Here, gamma-corrector noise (rising near black) and photon noise (rising near white) are partially balancing each other. This type of curve is increasingly common in cameras, and is not taken into account in the noise threshold levels set in EBU R.118. Nevertheless, 118 requires the noise level at mid-grey (50% video) to be better than -50dB for UHD. Clearly this criterion has not been met.

Fig. 10 shows noise profiles for S-log3 and S-log2. The shapes are quite different from that for 709, more closely resembling a traditional curve where the noise level is proportional to the slope of the gamma curve. Although the curves look similar, their range is quite different, S-log3 is more noisy than S-log2 near black,

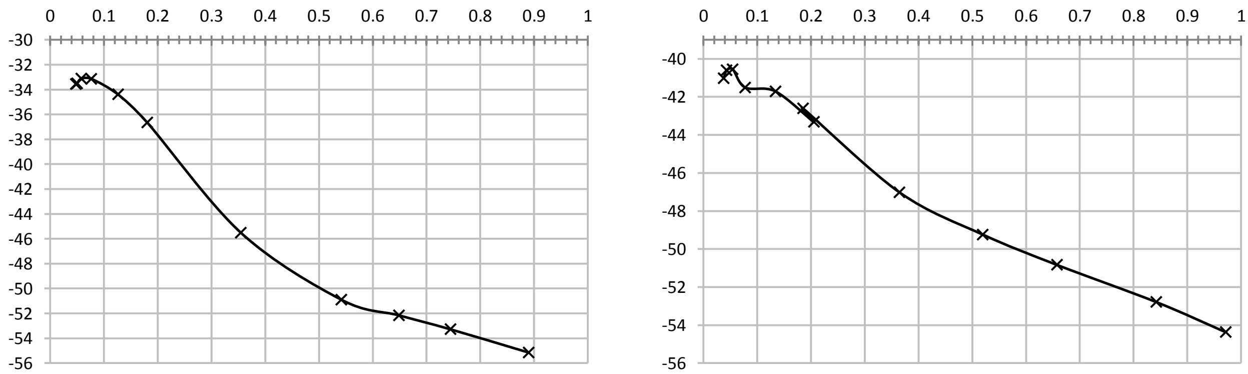

Figure 10 Noise profiles, ISO800
(a) S-log3 **(b) S-log2**

by up to 6dB. In general the S-log2 curve appears to be the better for this camera. However, only the S-log3 curve meets the threshold level of -50dB for UHD, but would require significant post-production work to produce good pictures, which is likely to raise the noise levels.

1.5.2. Noise change with ISO setting

The camera was exposed to a grey card, lit to produce 50% video level, and measurements taken with ISO settings from 100 to 25600. The camera was set to ITU 709 gamma correction. At each setting, the shutter and/or lens aperture was adjusted to keep the signal level to be at or near 50%. Again, Noise Reduction was switched off.

Fig. 11 shows the result. The horizontal axis is marked in dB of gain, with zero corresponding to the reference setting of ISO800; thus ISO100 is -18.062dB, and ISO25600 is +30.1dB. The noise should rise by 3dB for each increase in gain of 6dB (or change of 2 in ISO speed).

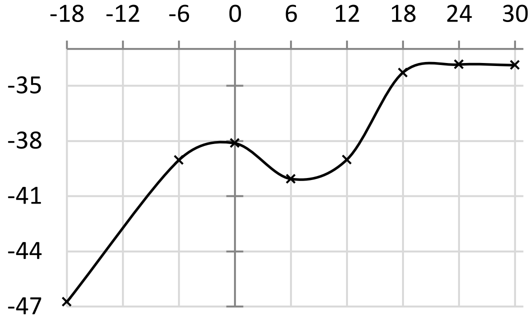

Figure 11 Noise at mid grey, vs gain

The average slope of the line is only 1.6dB per gain-change of 6dB; this plus the dip between ISO 1600 (+6dB) and ISO3200 (+12dB) probably indicates some noise reduction to achieve target noise levels. Note that the UHD target figure of -50dB is never reached, nor is the HD target of -48dB for HD Tier 1, or -44dB for HD Tier 2. It does, however, achieve -42dB (the target for HD Tier SP) at -12dB gain or ISO200.

1.5.3. Noise reduction (NR)

The default setting for Noise Reduction is 'normal', with 'low' and 'off' as options and no other controls. All the measurements above were made with NR switched off. To explore the effect of NR, measurements were made at ISO25600, using four of the six patches in the grey scale.

Fig. 12a shows the results for ITU 709 gamma, noise level versus signal level; the black line is 'normal', green is 'low', red is 'off'. Confusingly, the noise levels are higher when NR is set to low than when it is off. But the differences are only about 1dB at best, so it appears that noise reduction has little or no effect at these noise levels.

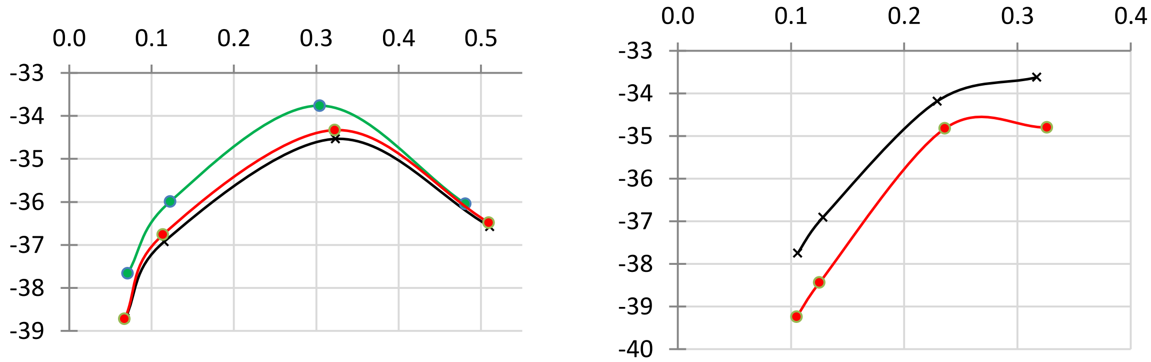

Figure 12 Noise levels with Noise Reduction, red=off, green=low, black=normal
(a) 709 gamma **(b) S-log2**

Fig. 12b shows the result for S-log2. Here the difference is more visible, a clear gain of about 1dB. Given the rather high levels of noise without reduction, it is disappointing that noise reduction seems to be so moderate.

1.6. Sensitivity

In a television camera, sensitivity is normally defined as the lens aperture required to produce 100% peak white from a white card with a reflectance of 90%, lit by 2000 lux. This usually assumes a standard setup condition of either no gamma-correction or a curve which follows the normal equation, i.e. without a knee, and with interlaced scanning using 1/50 exposure interval.

The camera was set to ITU 709 gamma, with the knee point at 105%. At ISO800, the aperture to produce 100% video level from the white side of the card was between F/11 and F/13, say F/12. At ISO200, peak white was reached with F/6.3

1.7. Infra-red response

No camera should respond to infra-red - if we can't see it, neither should a camera. The simplest test for this is to point a conventional remote-control into the lens and press a button. If the camera shows the LED, it is seeing infra-red. There was no response to IR

1.8. Motion portrayal

The sensor is CMOS, which can be read either by scanning or by instantaneous transfer into a readout store. Scanning produces the so-called 'rolling shutter' effect. The simple test for this is to use a small desk fan, and to adjust the clockwise rotation speed such that strobing holds the blades almost stationary. Then, if the sensor is being scanned, the down-ward moving blade will be widened and the upward-moving blade narrowed. The effect is made much more visible by using a short shutter.

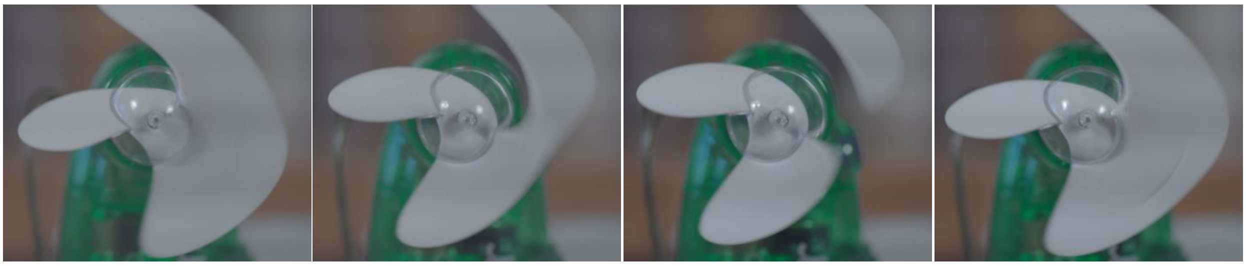

Figure 13 Motion portrayal
(a) HD (b) HD (c) UHD (d) UHD

Fig. 13 shows a series of still frames, using 1/1000 shutter. 13a and b were recorded with the camera set to 1920x1080 HD, 13c and 13d were recorded in UHD. The motion distortion is severe, worse in UHD than in HD. The effect is clearly visible even at 1/50 shutter although the blades are relatively blurred.

2. Conclusion

Testing the camera was made more difficult than expected due to the changes of image size when changing frame rate and output format. It seems that differently-sized parts of the sensor are used for HD and UHD, and for 25 and 30fps shooting. Also, setting the HDMI output did not always produce the expected effect, which has serious implications for the use of external recordings. Since the HDMI output is only 8-bit, there seems to be little advantage in using an external recorder, it only makes life more complex.

The sensor has about 6000x4000 photo-sites, which ought to be enough for good performance even at UHD. The dimensions are 23.5x15.6mm, so the photo-sites are spaced at 3.9µm, meaning that the photo-site area cannot be greater than 15.3µm^2, compared with 5µm and 25µm^2 for a conventional ⅔" camera.

However, the camera fails expectations in several ways. Although the sensor dimensions considerably exceed the requirements of both HD and UHD, the scaling to produce HD and UHD images is unsatisfactory. Resolution at UHD is only adequate, but aliasing is unacceptably high. Similarly, at HD the aliasing is sufficient to cause problems in low bit-rate coding.

The dynamic range is about 9 stops in standard ITU 709 mode (without knee), 11 stops in SD-log2, 13 in S-log3. Thus is unsurprising since the camera uses only 8-bit recording.

Noise levels are consistently higher than acceptable, and noise reduction is too ineffective to improve things adequately. Only at ISO100 or ISO200 could the camera qualify for HD Tier SP, using EBU R.118 requirements.

The sensor is evidently scanned, the so-called 'rolling shutter' effect. Rotating motion is very poor.

This camera is not suitable for use in general broadcasting, apart from Special Purposes where it's physical size or shape makes it uniquely suited to a particular type of shot.