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

Alan Roberts, February 2017

SUPPLEMENT 25: Assessment of a Olympus OM-D E-M1II 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 an Olympus OM-D camera, serial number BAUA00131, marked ‘Sample’. This may be a pre-production model and so the test results may differ from those obtained from a full production model. 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 SDHC card. Live viewing was done on a 22" HD LCD monitor. Clips were ingested into Edius 8.31 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 BAUA00131. The lens was an Olympus M.Zuiko 12~100mmF/4.

The camera has a noise-reduction facility. All tests were done with this set to 'Standard', since this is the condition most likely to be used.

1. Colour performance

A standard ColorChecker chart was exposed, using tungsten illumination. The camera was set to tungsten illumination and 'Picture style' set to several of the many available modes. These can have great effect on the colour performance; it would be wrong to compare these without including the post-processing and display system for which each may be intended, but 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. 1 shows the results. The descriptive names of these modes are quite accurate but the differences between

Figure 1 Colour performance
(a) Natural (b) Vivid (c) Muted (d) Portrait

them are quite subtle, nevertheless my preference is for 'Natural' but the others may have suitable uses. There are no unexpected or significant colour errors, the overall performance is good.

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

The ColorChecker chart was exposed with tungsten illumination, using three only the 'Natural' picture style. Multiple exposures, using shutter and aperture, provided many exposure levels from which it is possible to extract the curves from measurement of the grey scale patches. At the lower end of the exposure range, either 6 or 12dB of gain was added 'in post' to ease measurement, and allowed for in the calculations.

The camera does not appear to offer any control over the gamma curve, and there is clue to which coding rules are used, whether television (ITU. R.709) or graphics (sRGB). However, there is some evidence that 601/709 coding is used (see the following section on Resolution for an explanation), therefore I have assumed 601/709 rules for these calculations.

Fig. 2 shows the curve for the 4K mode (HD is the same).

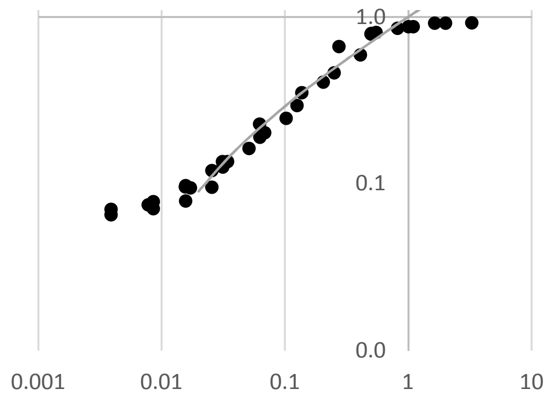

Figure 2 Gamma curve, 4K, Natural mode

The curve is effectively linear in this logarithmic plot over the input range 0.05 to 0.75, with significant curvature at both extremes. There is very little change in signal level at very low exposures: between exposure levels of 0.001 and 0.01 (3.3 photographic stops) the signal changes by only 3 quantum levels in 8-bit video coding, therefore the lower end of the contrast range ought not to be better than 100:1 (6.5 stops) below white level, but the measured patches are visibly different from each other, and so this low end could be acceptable, perhaps to 500:1 below white level. There is curvature near white as well, allowing nearly 2 stops of headroom. Thus the dynamic range is about 11 to 12 stops.

Note that the video signal level never exceeds 0.922, even when overexposed by several stops, and that it never drops below 0.06. Changing the noise reduction settings is unlikely to affect this result.

3. Resolution and aliasing

The camera records in three resolutions: HD (1920x1080, 25P and 50P), 4K (properly called UHD, 3840x2160, 25P) and C4K (more properly called DCI, 4096x2160, 24P). HD recordings can be in a variety of bitrates from 18 to 52Mb/s, 4K is 1902Mb/s and C4K is 237Mb/s.

Image stabilisation was switched off for all these tests.

Fig. 3 shows a captured frame recorded in 4K mode with square pixels. Note that the C4K mode does not make 16:9 pictures, they must be either clipped to 3840 wide (throwing away the edges), or shrunk to 3840 (making the image fill 3840x2025 lines, with black stripes top and bottom).

Figure 3 Zone plate image, 4K (UHD, 3840x2160))

3.1. Resolution for HD

The usual zone plate test chart was framed to fill exactly the width and height of the image. The camera was set to record in all the HD modes, at ISO400 and F/5.6.

Fig. 4 shows one quadrant of the luma pattern which reaches the 1920x1080 limits of HD, recorded using two of the HD recording modes.

There is no significant difference between any of the HD modes, the higher bit-rates are of use in portraying smooth motion rather than greater resolution. There is significant aliasing both horizontally and vertically, rather too much for comfort. Also, the smaller quadrants, which explore the limiting resolution of UHD (4K) under these conditions, show that there is significant image content at beyond the limits of HD, which ought

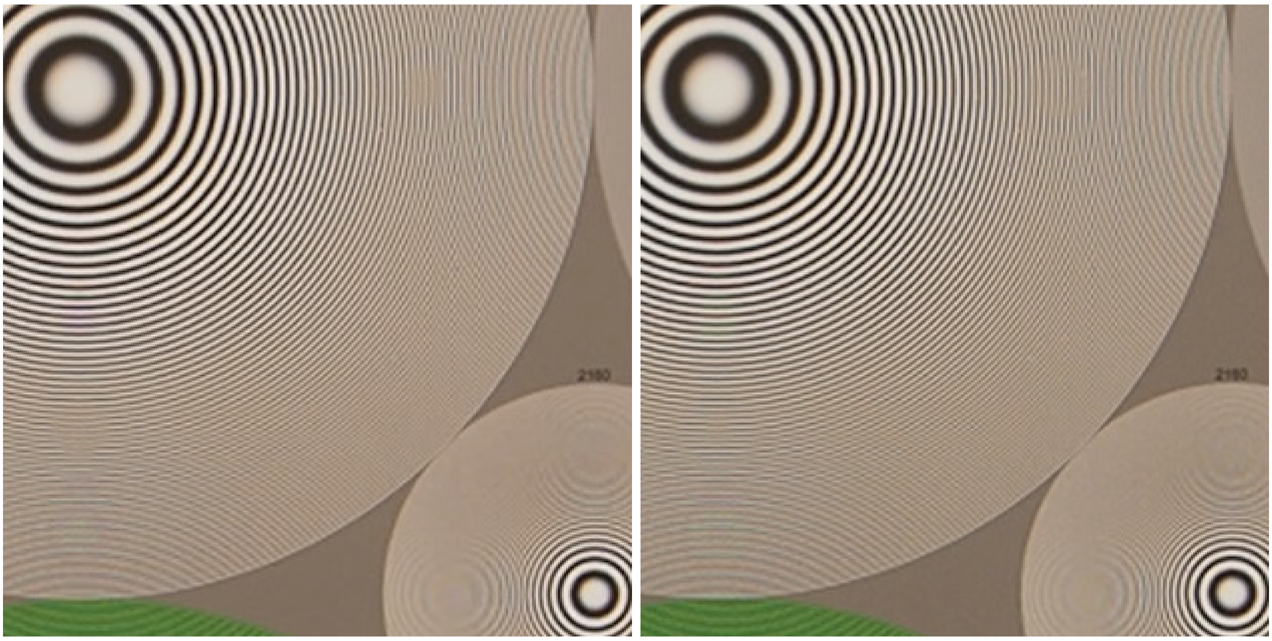

Figure 4 Resolution

(a) FHD N (1920x1080 50P, 18Mb/s) (b) FHD SF (1920x180 50P, 52Mb/s) to have been suppressed in the down-scaling process.

There are null-zones centred on about 67% of the UHD limits (about 2580x1460) which tell something about the pixel dimensions of the sensor patch being used to derive the video image, that it is probably about 5160x2920. This ties in nicely with the sensor being 20.4Mpixels and 4x3 aspect ratio, since the pixel dimensions must be about 5216x3912.

3.2. Resolution for '4k' (UHD 3840x2160)

The HD zone plate chart was reframed so that it filled exactly half the frame height and width. The camera was set to ISO400 and F/5.6.

Fig. 5 shows one quadrant of the luma pattern. The resolution is remarkably good, reaching almost to the limits of UHD with minimal aliasing.

The smaller quadrant, now exploring 8192x4320, shows low levels of aliasing above the limits of 4K, indicating that there is no optical low-pass filter in the camera (or that any such filter is optimised for stills photography rather than for video performance).

Clearly, the lens is well-matched to the camera, and UHD performance is good.

Resolution was not tested at C4K since the results ought to be the same.

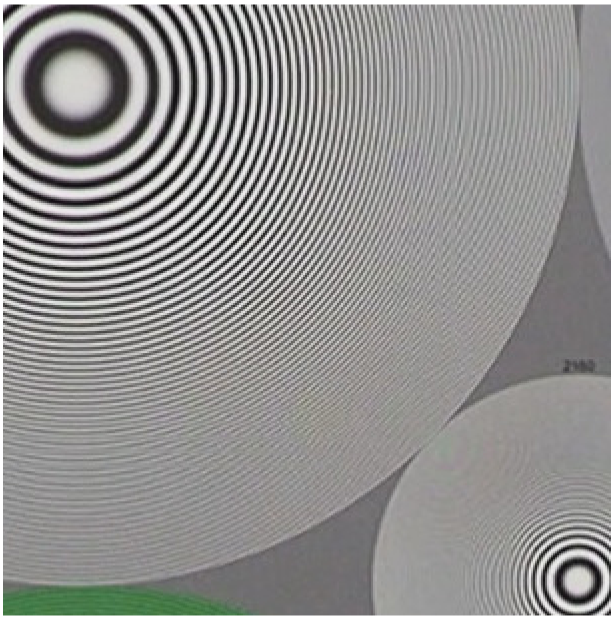

Figure 5 Resolution, 4K (UHD, 3840x2160 25P)

4. Noise

4.1. Noise levels

The exposures of the ColorChecker used in section 2 were used to measure noise levels in the grey scale. Only the 2nd to 5th patches were used to minimise any effects due to uneven illumination of the test chart. The camera was set to 4K, since this is the more promising of the cameras modes. Noise reduction was left in 'Standard' mode.

Fig. 5 shows the noise profile at ISO400.

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 (properly known as shot noise) increases with signal level. In this camera, photon noise clearly dominates near black, and the noise levels are quite low.

At 50% signal level, the noise is at about -50dB, which is the EBU R.118 target level for UHD, so the camera could qualify for UHD use, as far as image performance is concerned.

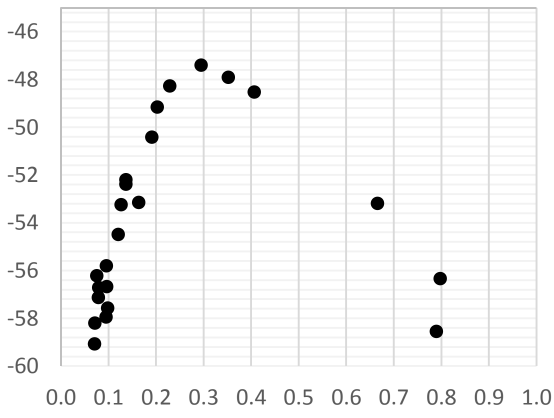

Figure 6 Noise level vs signal level, 4K

Noise levels in HD mode are very similar, but about 1dB worse.

4.2. Noise change with ISO setting

Further exposures to the ColorChecker chart were made at the full range of ISO settings, and measurements made to establish the noise level at exactly 50% video signal level. Monitoring was not sufficiently precise to be able to set the exposure correctly, so interpolation was used between the two patches at which the signal level was just above and just below 50% signal level. Again, noise reduction was left in 'Standard' mode.

Fig. 7 shows the result. The horizontal axis is marked in dB of gain, with zero corresponding to the reference setting of ISO400; thus ISO200 is -6.02dB, and ISO6400 is +24.08dB. The noise should rise by 3dB for each increase in gain of 6dB (or change of 2 in ISO speed), the grey line shows this slope.

The noise level is rather higher than it should be with low ISO settings, by up to 8dB at ISO100. Nevertheless, the target figure of -50dB for UHD is easily met at gain settings of +12dB and below, i.e. ISO settings of 1600 and below.

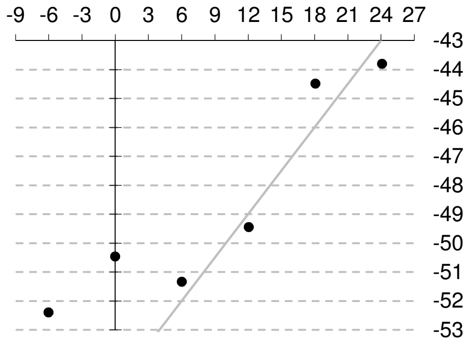

Figure 7 Noise level vs 'speed', 4K

4.3. 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.

However, since the camera does not have such settings, I did not attempt to measure the sensitivity in the conventional way. It seems safe to assume that the ISO settings are accurate.

4.4. 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 even when the camera was overexposed by 4 stops, implying that there is an IR filter in the camera and that IR is not going to be a problem.

4.5. 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.

Fig. 8 shows a still frame, using1/2000 shutter in HD. The effect is exactly the same in 4K.

The motion distortion is significant. The effect is clearly visible even at 1/50 shutter although the blades are quite blurred.


Figure 8 Motion, HD 1/2000 shutter

5. Conclusion

The sensor has about 30.4 megapixels according to the specification, and is approximately 17.3x13mm, the micro 4/3 format. Since the sensor aspect ratio is 4:3, the pixel-counts must be about 5216x3912, and each photo-site must be about 3.2µm square, with an area of about 11 square µm. This compares with the 5µm pixel-size of a conventional ⅔" format HD camera, having an area of 25 square µm. Thus the camera should be 7.11dB less sensitive, about 1.1 stops.

Resolution at HD contains significant aliasing, while there is satisfyingly little when shooting 4K (UHD, 3840x2160). Another major reason for using C4K with care is that it records only at 24P, which is not suitable for 50Hz television.

The dynamic range is 11 to 12 stops.

Noise levels are good. The camera meets the EBU R.118 noise-level target of -50dB for UHD at speeds of 1600 and below. It cannot formally qualify for UHD or for better than Tier 2 HD simply because of the missing features required by EBU R.118 (connectivity, monitoring, sound facilities etc.). In terms of image performance alone, it could qualify for HD and UHD tier 2 even though the missing features will restrict the practical uses of the camera.

The sensor is evidently scanned, the so-called ‘rolling shutter’ effect. Rotating motion is not ideal but is acceptable.