Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 39 rev.1 : Assessment of a Canon 5D DSLR

This document is a report of the results of tests that are the precursor of those described in the EBU technical document Tech3335. It is not an endorsement of the product.

The Canon 5D is a full-size digital single lens reflex camera. Unusually, it also offers HDTV recording. Although there are few of the usual controls that go with video cameras, it was thought worthwhile to check its performance as an HDTV camera. The results were not encouraging.

Initial tests were done on a pre-production model, serial number 0039900173, software version beta 3.6.1.63. This revision contains test results from a production model of the 5D MkII.

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The 5D is a full-size Digital Single Lens Reflex camera, with HDTV recording facilities at 1920x1080. However, monitoring and control of the camera are very different from a conventional video camera, making it rather unsuitable for most video purposes. The prototype camera tested ran only at 29.97 frames/second, NTSC rates. Monitoring was via HDMI, but only from a replay of a recording. During recording, the HDMI output is a 640x480 NTSC feed. This makes it decidedly unsuited to video purposes in Europe.

The camera sensor has approximately 22Mpixels and an aspect ratio of 3:2, so the image dimensions must be about 5760x3840. Since the image size did not change when changing from stills to video, the video feed must be generated from most of the sensor, probably 5760x3240 using a 3:1 down-scaling filter. In theory, this should be a fairly simple conversion.

There appear to be no controls which affect the image, apart from sharpness, and so no menu listing is given here.

1 Resolution

The camera was exposed to a circular zone plate test chart, containing patterns to test luma, R G and B, and chroma channels. Only one quadrant of the luma pattern is shown here.

Figure 1 Resolution, prototype camera

This showed some very worrying aliasing patterns, both luma and coloured, indicating that the down-conversion from 5760x3240 to 1920x1080 is not being done at all well.

The strong coloured aliases top and bottom are not matched horizontally, implying that the down-conversion filter is not square, and the strength of the aliases alone should be a sufficiently strong condemnation of this camera as a contender for any serious HDTV use.

Spatial aliasing is caused by less-than-ideal interpolation, and in still, images may not be a biog problem, because they don't move. However, aliases in moving pictures are much more of a problem because, when the image moves, the aliased frequency content moves in the opposite direction to the image motion, causing a rippling effect on edges. Since motion-sensitive compressors such as MPEG2 and MPEG4 depend on the cleanliness of edges to measure motion, these aliases can cause the compressor to allot undue bit-rate to motion and/or result in excessive compression artefacts. Either way, pictures with aliasing at the levels seen here are not acceptable as HDTV.

Since the alias patterns are highly coloured, there must be some doubt cast on the actual method of filtering. A Bayer-patterned sensor of 5760x3840 should easily be able to reproduce resolution up to 2880x1280, well in excess of the HDTV frequencies presented by this zone plate test chart. The generally accepted opinion of how this camera does the down-scaling, is that it simply omits the outputs of sensor pixels, resulting in a lowering of the sensitivity (because much of the incoming light is ignored).. From the appearance of the zone plate, the down-sampling could even be as simple as selecting only every third sample of each of R G and B from the sensor pattern to result in a Bayer pattern at 1920x1280 (at least, vertically), without any filtering or interpolation at all. A far better method would have been to fully decode the Bayer pattern data at high resolution, and then to down-scale to 1920x1080 using a conventional scaler (i.e. down-converter). But this approach would involve far higher power consumption in the camera, and presumably this is the reason for using such a poor scaling algorithm.

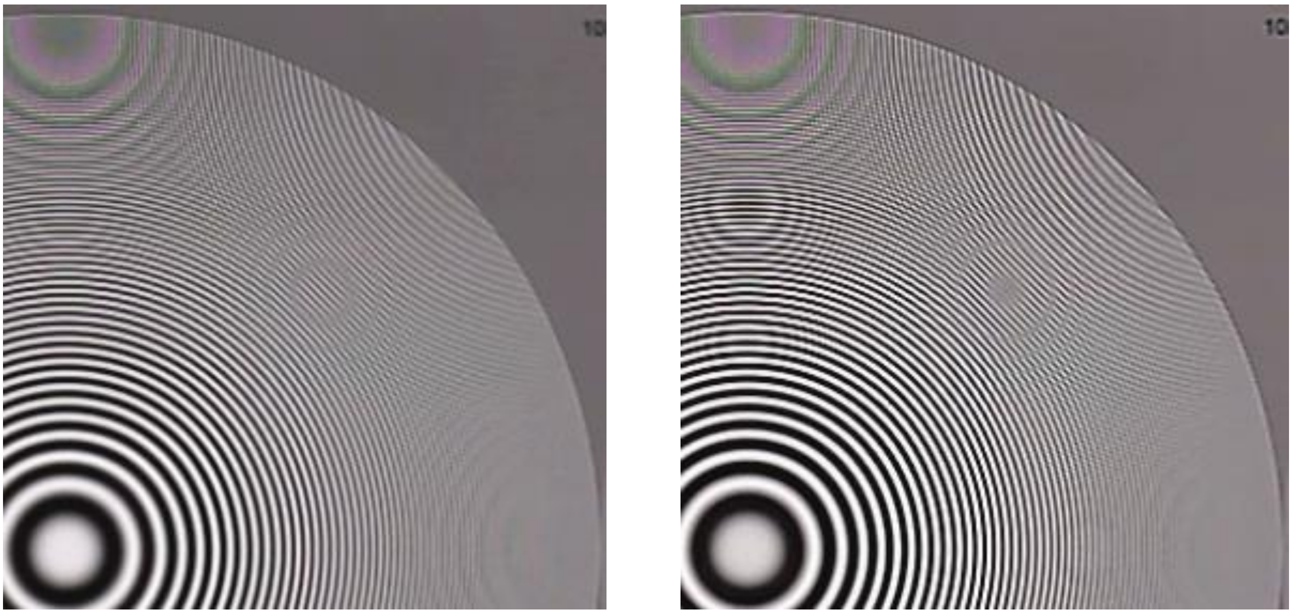

Figure 2 Resolution, production model, (a) sharpness 0 (b) sharpness 7

A production model of the camera, MkII, was subsequently tested, since it has become apparent that some programme-makers are prepared to ignore the poor aliasing performance in exchange for the short depth of field which large format cameras and lenses can deliver. Fig.2 shows the resolution, at 400ISO ‘speed’ setting, with the sharpness parameter at minimum (o) and maximum (7)

Clearly, the sharpness control has little effect on the level of aliasing, but enhances the clean resolution in the range up to about 1280x540. The lower-frequency diagonal aliases are affected by this enhancement, and so it would be wise not to use high levels of enhancement. Fig.3 shows the result with sharpness at level 3, which is about as high as is advisable to use.

The level of aliasing is worrying, but it can be ameliorated by only ever shooting with a short depth of field, and by keeping image motion down such that the aliases don’t move too much. Since the aliases are caused by high frequencies in the scene reaching the lens, they could be reduced by fitting an optical low pass filter in the camera, but that would ruin the stills performance, and so is probably never going to happen.

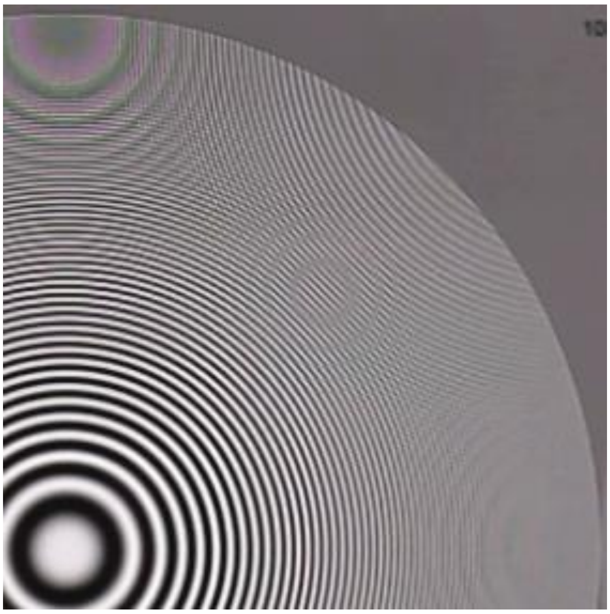

Figure 3 Resolution, sharpness 3

2 Noise measurements

The production camera was exposed to a white card, evenly illuminated. The iris and shutter were used to get approximately 50% video signal level and various ‘speed’ settings. Since photographic speed is directly related to gain, it is easier to show the results as though the camera had a gain control. Thus, a ‘standard’ setting of 0dB has been assumed to correspond to 400ISO, which results in 100ISO being -12dB and 6400ISO being +24dB. There is no guarantee that the photographic speeds are obtained simply using gain in the camera, although it is highly probable. The results show some correlation, but it is not as simple as 6dB noise per factor of 2 in camera speed.

Measurements were made by high-pass filtering the image to remove any shading effects, followed by software analysis. The results in Fig.4a show the clear trend of noise level versus speed, the slope being about 3dB per factor of 2. The ‘zero gain’ setting (400ISO) produces noise at about -52.5dB, a very respectable figure. Even at +18dB (3200ISO) the levels are only about -47dB, which is perfectly acceptable

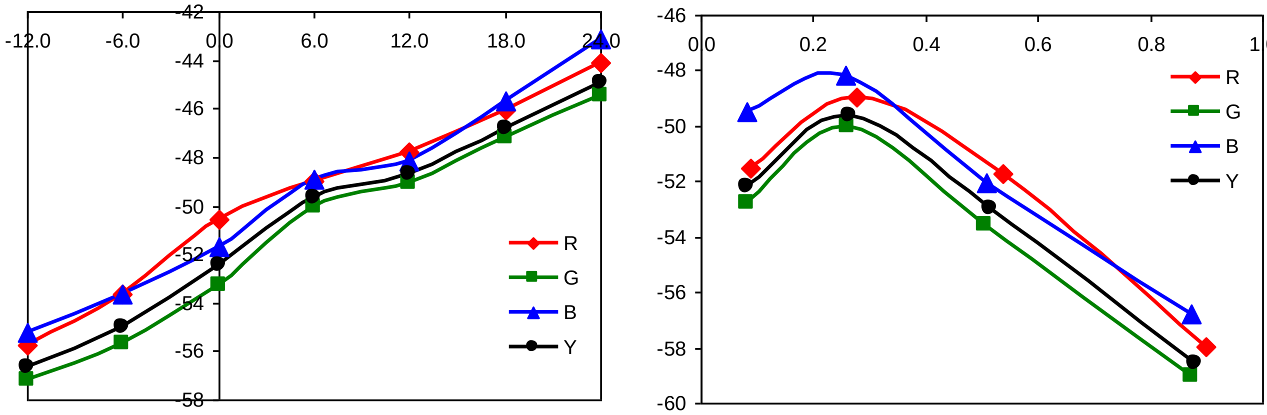

Figure 2 Noise levels, (a) vs speed setting **(b) vs signal level**
for HDTV.

Clearly, video noise is not a problem in this camera.

Fig.4b shows the distribution of noise with video signal level. The rise of noise level as signal level decreases is expected, since the primary cause of noise is the analogue parts of the camera, i.e. the sensor and head amplifiers before the ADCs. The drop in noise levels near black is possibly due to the use of analogue amplifiers with limited gain-bandwidth product to perform gamma-correction, rather than doing it in the digital domain. Nevertheless, the noise performance is quite good by HDTV standards.

3 Conclusion

The camera has very limited controls when in video mode, has poor connectivity, is difficult to monitor accurately, and has a very high level of luma and coloured spatial aliasing. Noise levels are quite good. The only reason for using such a camera in video mode is to obtain short depth of field, and for that use, lenses with large maximum apertures are essential. For most uses, far better pictures are much easer to obtain on normal video cameras.