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

Alan Roberts, June 2016

SUPPLEMENT 21: Assessment of a Sony FCB-EV7100 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 tests carried out on a Sony mini-camera, FCB-EV7100, serial number 301515. The single sensor is Bayer-patterned CMOS, 2.14 Mpixel and 1/2.8" format, so the individual photo-sites must be about 2.95µm square, yielding an area about 35% of that of a conventional ⅔" camera. It has an integral 10:1 zoom lens (3.8~38mm) F/1.8 although it ramps severely at the telephoto end. Minimum focus distance is 10mm at the wide end, 800mm at the long end.

Being a mini-camera, it has no controls, no viewfinder, and only miniature single-in-line connections. For the purpose of these tests, it was fitted with an external adaptor, to convert from the LVDS signals to 8-bit HDSDI via a single BNC socket. The electronics of this adaptor was exposed on the back plate.

Control is by custom software via serial data using Visca protocol, a Windows version was used for the tests.

The camera body is 46x49x78mm, and weighs 210 grams, although the addition of the LVDS to BNC converter containing some electronics and the connectors extends the length to 105mm. Power consumption is 3.4 to 3.7 watts from 6~12volts DC.

The camera performed reasonably well under test. Tests were made according to EBU Tech.3335, and the results establish that the camera belongs in HD Tier SP.

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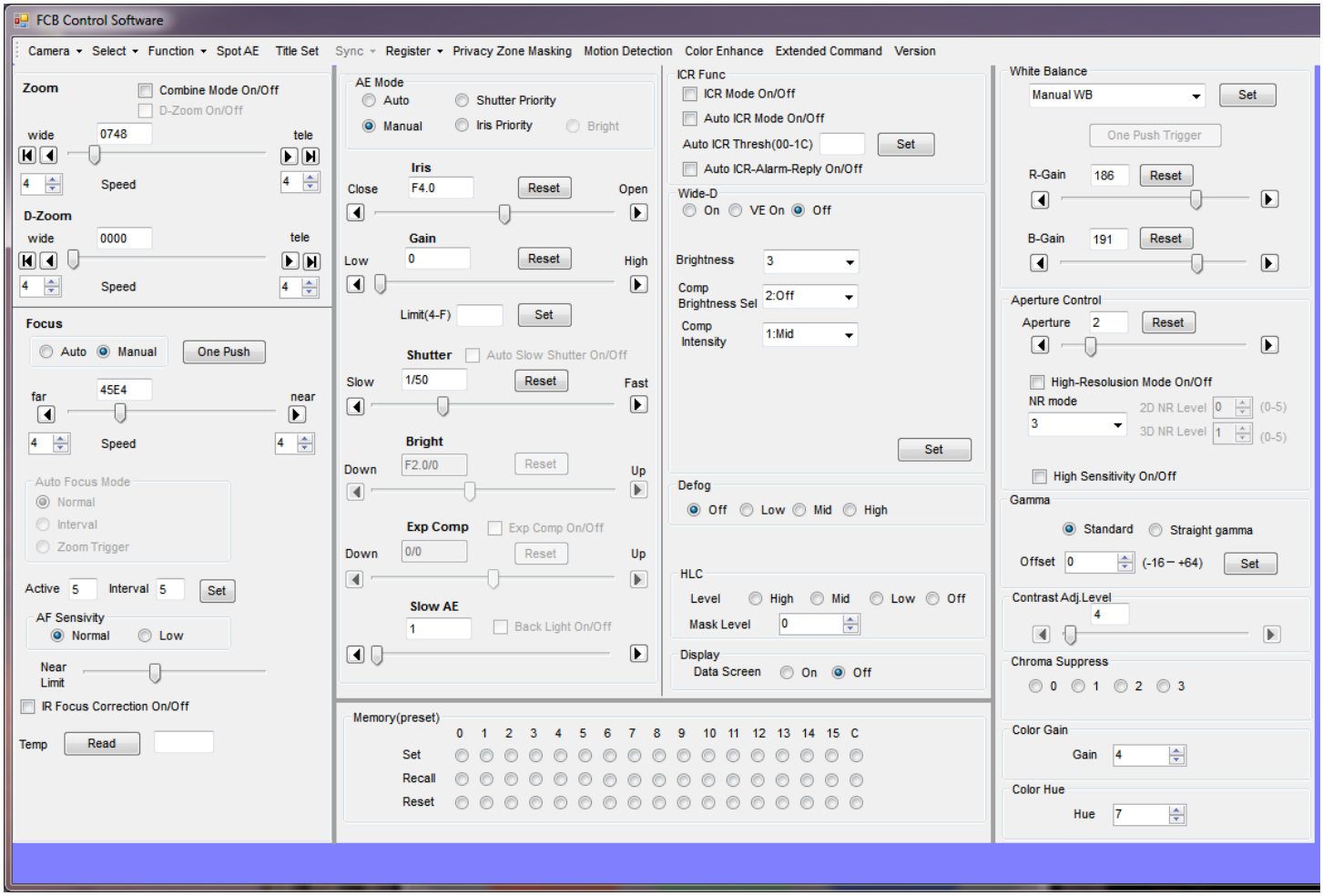
My preferred settings are only starting points, recommendations. They should not be used rigidly, they are starting points for further exploration. However, they do return acceptable image performance. Items that significantly affect picture quality are highlit, and my preferences given. Default values, where known, are underlined.

Measurement results are given in section 2, after the menus. Measurements were made according to the procedures set out in EBU Tech.3335.

This listing of the menus and contents is complete, but this should not be used as an excuse for not reading the manuals.



The tabs across the top allow for setting the serial data port, camera selection, various functions which don't affect picture performance, and three items offering control over motion detection, colour enhancement and some command extensions. These items are not listed in the menu contents below, and were not specifically tested in the normal course of testing.

There are 16 presets available.

1. Menu contents

Item	Range	Description	Rec
Zoom			
Combine mode	On, Off	Combines digital zoom into one control	Off
D-Zoom	On, Off	Digital zoom produces very soft pictures	Off
Indicator	Hex display	Zoom position	
Buttons		Full wide, Full tele, creep wide/tele with speed control	
D-Zoom			
Indicator	Hex display	Zoom position	
Buttons		Full wide, Full tele, creep wide/tele with speed control	
Focus			
	Auto, Manual, One Push		
Indicator	Hex display		
Buttons		Far, near with speed control	
Auto Focus Mode	Normal, Internal, Zoom Trigger		
Active		Set time in seconds	
Interval		Set time in seconds	
Set			
AF Sensitivity	Normal, Low		
IR Focus Correction	On, Off		
Temp		Indicates sensor temperature	
Read	display		
AE Mode	Auto, Manual, Shutter Priority, Iris Priority, Bright	Enables relevant items below	
Iris			
Indicator	F/1.8 ~ F/9.6	Half F stops	
Buttons		Open, Close	
Gain			
Indicator	0 ~ 28	Indicates numbers, appears to be 3dB steps	0~21
Buttons		High, Low	
Limit			
Shutter			
Auto Slow Shutter	On, Off	Slow shutter goes below the image rate	
Indicator	1/1 ~ 1/10000	Related to image rate, 16 values, 22 if Slow enabled	
Buttons		Slow, Fast	
Bright		Combines iris and gain	
Indicator		25 steps, 07~11 = F/9.6~F/1.8 gain = 0, 12~1F = iris F/1.8 gain = 0~28	
Buttons		Up, Down	
Exp Comp		Compensation in Auto	
	On, Off		
Indicator	-7 ~ 0 ~ +7	1.5dB steps	
Buttons		Up, Down	
Slow AE		Compensation in Auto	
Back Light	On, Off		
Indicator	01 ~ 30	Response speed, 01=1 second, 30=10 minutes	
Buttons		Up, Down	
		Infra-Red cut filter	

ICR Func			
ICR Mode	On, Off	Picture is mono when IR filter is out, full Auto exposure control	
Auto ICR Mode	On, Off		
Auto ICR Thresh		Set light level at which filter changes setting	
Auto ICR-Alarm-Reply	On, Off		
Wide-D	On, VE On, Off	Wide Dynamic Range, differential gain/shutter setting for relevant parts of the picture. VE = Visibility Enhancer, reduces contrast. [1]	
Brightness	0 ~ 3 ~ 6	0= dark, 6=bright	
Comp Brightness Set	0 Darker, 1 Dark, 2 Standard, 3 Bright	Which brightness range to affect	
Comp Intensity	0 Low, 1 Mid, 2 High	How hard to work	
Defog	Off, Low, Med, High		
HLC			
Level	High, Mid, Low, Off		
Mask level			
Display Data Screen	On, Off		
White Balance	Auto, ATW, Indoor, Outdoor, One Push WB, Manual WB, Outdoor Auto, Sodium Vapour Auto, Sodium Vapour, Sodium Vapour Lamp Outdoor Auto	Enables relevant items below	
One-Push Trigger			
R-Gain			
Indicator	0 ~ 255		
Buttons			
B-Gain			
Indicator	0 ~ 255		
Buttons			
Aperture Control			
Aperture	0 ~ 8 ~16		2~4
Buttons			
High Resolusion (sic) Mode	On, Off	Step edge enhancement, nasty but could be useful	
NR Mode		Not explained in the manual	
High Sensitivity	On, Off	Adds 12dB gain, and noise	Off
Gamma			
	Standard, Straight gamma		Standard
Offset	-16 ~ 0 ~ +64	Black level, presumably quantum levels	0
Contrast Adj Level			
Indicator	0 ~ 255	Not explained in the manual, not tested	
Buttons			
Chroma Suppress	0, 1, 2, 3	Reduces chroma in low-light	
Colour Gain			
Gain	0 ~ 4 ~ E	Not explained in the manual, not tested	
Colour Hue			

[1] Wide-D did not appear to do anything when tested.

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Hue	0 ~ 7 ~ E	Not explained in the manual, not tested	

2. Measurements

All measurements were made on frames captured onto a CFast card in a Convergent Design nanoFlash recorder, at 50Mb/s MPEG Long GoP. Live viewing was done on a 50" Panasonic 4k television (TX50DX750). Clips were ingested into Edius 8.20 and images for this document were extracted as BMP files.

2.1. Colour performance

A standard Colorchecker chart was exposed, using tungsten illumination. The camera was allowed to auto-white balance, but produced a significant pink hue, so all further testing was done using manual or preset white balance settings.

Fig.1 shows the performance with gain setting '4', which presumably means 6dB, the default setting. Colour performance showed no problems.

There was no response to infra-red, with the IR cut filter in place. Without it, the pictures are monochrome, and the camera is about 2 stops more sensitive.

Figure 1 Colorchecker

2.2. Gamma curve and Dynamic Range

The Colorchecker chart was exposed with tungsten illumination, at F/4.0 and using the shutter to control exposure level. The gamma curve was extracted using measured levels for the grey scale patches.

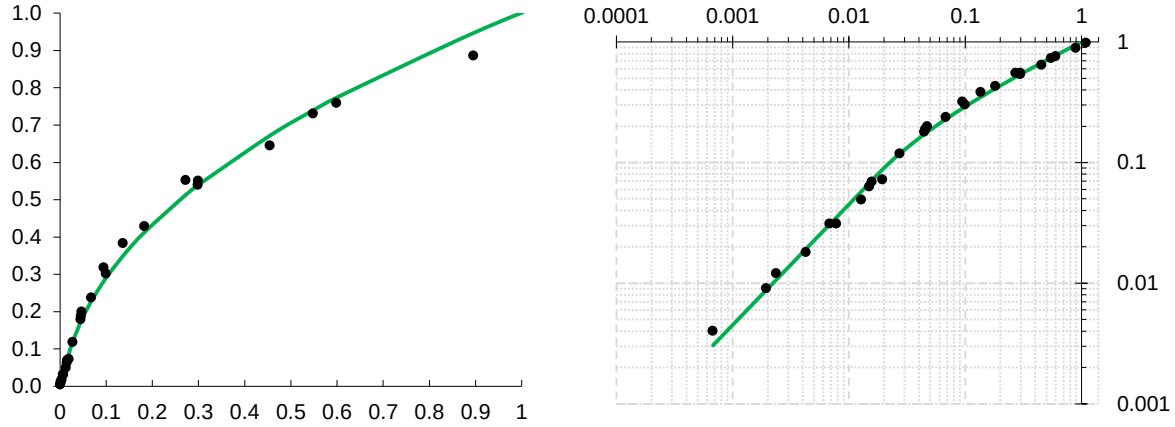

Figure 2 Gamma curve a: linear scales **b: logarithmic scales**

Fig. 2a shows the curve. The black points are measurements, the green line is a theoretical ITU.709 curve. During this analysis, it became clear that the luma signal is clipped at 100%, and that values below 0.02 (2%) have no chroma signal, presumably to reduce chroma noise. The measurements are a reasonable match to ITU.709, and there is a little evidence that there is a knee in the curve, but only to extend the dynamic range by about half a stop. The dynamic range is about 1000:1, 10 stops.

Fig. 2b shows the same data replotted with logarithmic axes.

The 'Wide-D' function, which should deal with highly contrasty scenes by selective contrast compression, did not appear to be working on test.

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2.3. Resolution and aliasing

Tests were made at F/4.8 and at mid-zoom, with the usual zone-plate test chart. If the camera is focussed to less than about 400mm distance, the image is quite dramatically barrel-distorted.

Fig. 3 shows the zone plate at close-up and F/4.8, the distortion is clear. Fig. 4a shows a quadrant of the luma pattern from this image. Fig. 4b shows the same quadrant at the same distance but at F/9.6. Clearly, iris diffraction is limiting the resolution, the effect starts at between F/6.3 and F/8, which should be set as a limit for practical use.

Figure 3 Zone plate, wide-angle

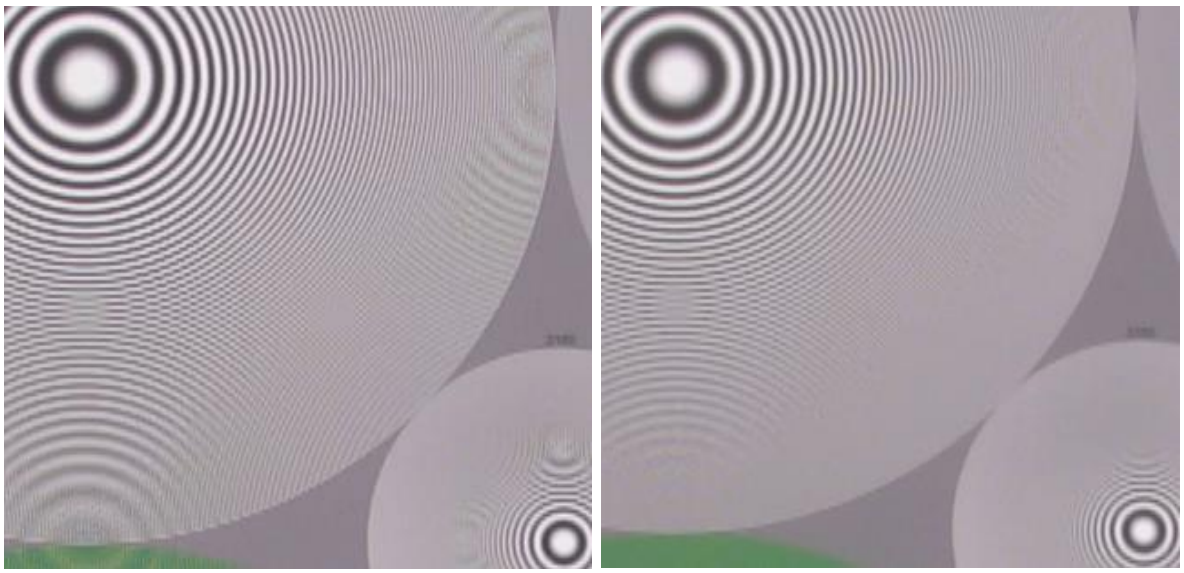

Figure 4 Zone plate quadrant a: F/4.8 **b: F/9.6**

At F/4.8, the modulation is extinguished above about 1660 horizontally, and is highly polluted vertically above 540. This is fairly normal for an interlaced signal, but the level of aliasing is very high. Diagonal resolution is reduced to about 74% which is normal for a Bayer-patterned single sensor with photo-site dimensions equalling the system image dimensions.

At the long end of the lens, pincushion distortion happens, Fig.5, although it is not as bad as the wide-end barrel distortion.

Figure 5 Zone plate, telephoto

2.3.1. Aperture

The effect of the aperture control was investigated at F/4.0, where the lens is sharpest. The Aperture control has a scale, 0 ~ 15. Results are shown in Fig.6.

The control is powerful. Even at mild settings, it raises the alias levels dramatically, and at the highest setting the aliases are much stronger than the wanted signal. A level of 2~4 seems optimal.

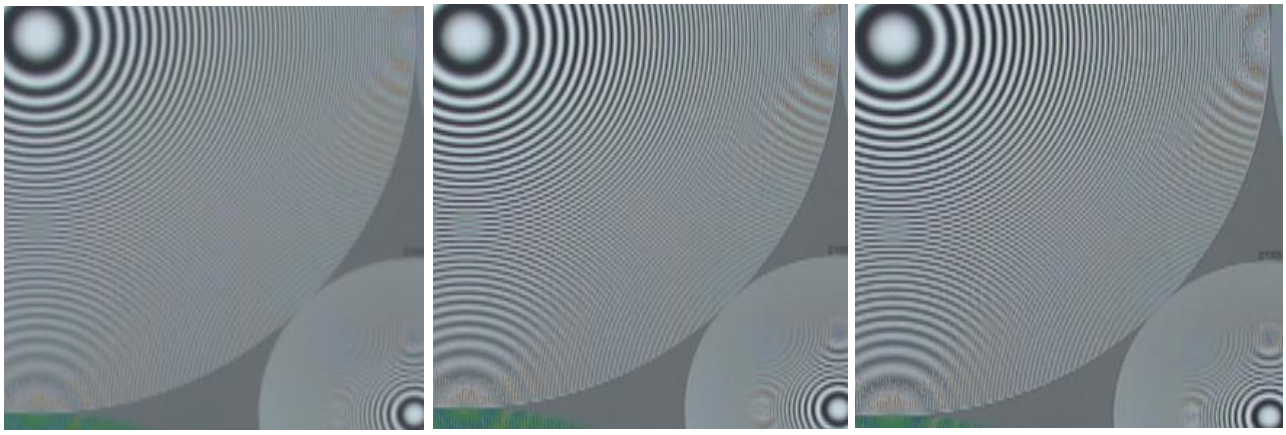

Figure 6 Zone plate a: aperture = 0 b: aperture = 4 c: aperture = 8

Figure 6 Zone plate d: aperture 12 e: aperture 15 f: aperture 2

2.4. Noise

The multiple exposures of the Colorchecker used in section 2.2 were also used to determine the noise profile, noise level versus signal level. Fig.7 shows the profile, the black spots are measurements and their apparently wide distribution is not unusual for measurements made on small parts of the picture, although this spread is rather large. The green trend line shows that noise levels change little with signal level, which is unusual.

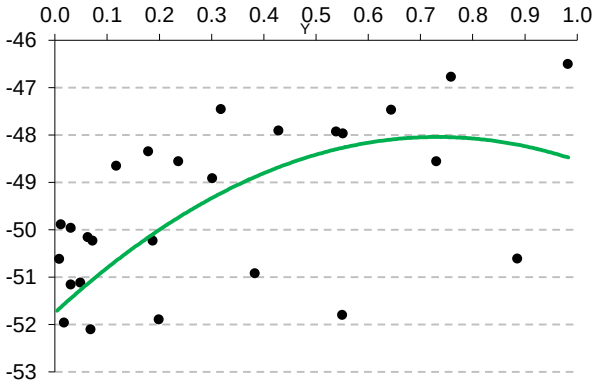

Figure 7 Noise profile, gain=4 (6dB)

Conventionally, the noise level would be expected to rise near black since the differential gain applied by gamma correction affects the noise level, but here it drops dramatically. There are several possible reasons, but it is hardly worth exploring these since the user has no control over the noise profile. The noise level at 50% video is about -48dB which is the qualifying level for EBU R.118 HD Tier 1. However, since the noise level falls from this level towards black, the pictures look much less noisy than these figures imply. This alone cannot qualify the camera for such a high tier because of other limitations.

Next, the camera was exposed to a pair of Kodak Gray cards, showing 90% white and 18% grey sides together. Exposure was adjusted to achieve 50% luma level from the grey card over the full range of gain settings. Exposure was controlled using the shutter and iris.

Fig. 8 shows the result. The trend is normally a rise of 3dB in noise level per 6dB of signal gain, and this is approximately achieved if the gain settings (numbers) are measured in steps of 1.5dB. Using gain settings higher than 21 (30dB) should be avoided if possible.

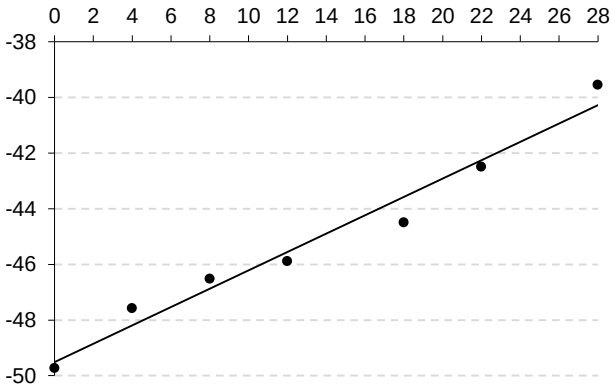

Figure 8 Noise versus gain setting

2.5. Sensitivity

In a television camera, sensitivity is normally defined as the lens aperture required to produce 100% peak signal 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 most sensible approach is to use the Kodak Gray cards. The white side has a reflectance of 90% (the grey side has a reflectance of 18% which is 20% relative to the white side). At a gain setting of 0 (0dB), 100% exposure was achieved at F/2.3. At gain = 4, 100% video occurred at F/3.8, which is consistent. Thus the camera's sensitivity is F/2.3, and is very low compared with a conventional ⅔" camera which normally measures at about F/11. Taking the relative sizes of the photo-sites as a guide, we should expect a linear ratio of 5^2:2.95^2 or 25:8.7, i.e 2.87:1 which is about 1.52 stops, so we should expect this camera's sensitivity to be about F/6.3, so it is about 2 stops less sensitive than expected. It seems likely that the full dynamic range of the sensor is being use here, rather than about 2 stops less than the full range for a ⅔" camera, indicating that there is no headroom which could benefit from the use of a knee in the gamma curve.

2.6. Vignetting (white uniformity) and Ramping

The lens performance was investigated, using a white card – evenly lit. The camera was set to each end of the zoom range, and to three aperture settings. The results are in Table 1, measurements of normal video level, i.e. after gamma-correction. The results for 'centre' take the centre of the card at F/1.8, with the lens at the full wide end of the zoom range as a reference. The results for 'corners' are the average for the four extreme corners of the card, each relative to the centre level at that setting. Thus the 'centre' column describes lens ramping, while the 'corners' column describes white uniformity.

Zoom	Aperture	Gamma-corrected video		Stops down	
		Centre	Corners	Centre	Corners
Wide	F/1.8	100%	76%	0.00	0.79
Wide	F/4.0	96%	85%	0.12	0.47
Wide	F/9.6	90%	86%	0.31	0.45
Tele	F/1.8	59%	83%	1.53	0.55
Tele	F/4.0	92%	90%	0.25	0.31
Tele	F/9.6	86%	94%	0.44	0.19

The two right-most columns convert the gamma-corrected video levels to photographic stops, via the camera's gamma curve.

So, uniformity in the corners is ¾ stop down when close-up and wide, otherwise about half a stop down. Ramping (light-level loss in the centre) is about 1½ stops at F/9.6, another reason for not closing the lens down this far.

2.7. 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 rotation speed such that strobing holds the blades almost stationary. Then, if the sensor is

being scanned, the down-ward moving blade (right-hand) will be widened and the upward-moving blade narrowed. The effect is made much more visible by using a short shutter.

Fig. 9 shows a still frame, using 1/1000 shutter. The blades are distorted, but acceptably so. With more normal shutter durations, the effect is much less pronounced.

Figure 9 Rotating fan, 1/1000 shutter

2.8. Conclusion

The sensor qualifies the camera only for Tier SP. Its performance is not particularly good, it is relatively insensitive and resolution could be better, although the lens performs quite well for such a short focal length. Motion portrayal is as good as can be expected for a camera with rolling shutter.

The control software is not particularly intuitive, and the control buttons are small. This is relevant in a situation where control is on a computer screen and picture monitoring is on a separate display, it is easy to miss a button. Also, in the controls which have both a slider and left/right buttons, I found that the state of the control was not indicated correctly unless only the slider was used, pressing the left/right buttons changed the camera setting but the fact was not indicated in the control surface. This could be highly confusing to the uninitiated operator.

Noise levels satisfy the requirements for Tier SP of R.118 (i.e. better than -42dB), through intelligent image processing. Dynamic range is as expected, about 10 stops.

Infra-red response is zero when the IR filter is in use.

Overall, the camera qualifies for R.118 Tier SP.