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

Alan Roberts, September 26 2012

SUPPLEMENT 003 : Assessment of a Sony BRC-H900

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.

Initial tests were made on a demonstration sample of the Sony BRC-H900 HDTV camera (serial number 400029) and subsequently on anther camera (serial number 400056). It is unconventional in that it is physically mounted in a remote pan/tilt unit for full remote control. It has three CMOS sensors (nominal ½" size, 8mm) but the pixel count is rather confusing (see the test section). It has an integral lens, 14:1 zoom, F/1.9, and it is not possible to attach wide- or tele-converters. It appears to be very similar to the PMW-EX1, apart from having much-simplified menus.

The camera is controlled from a small keyboard with joystick for pan/tilt/zoom, or from a conventional-looking hand-held remote control. It can also be controlled by a data system, RS232 and RS422. There are 16 data stores for settings of pan/tilt/zoom, but only 6 of these are available from the handset.

There is no viewfinder.

Connectivity is simple; there are BNC connectors for SDI/HDSDI output, composite SD, and HD/SD sync input. Analogue SD output is also available via a conventional mini DIN 4-pin S-Video connector, and via a D-sub 15-pin connector. The camera can also be controlled via RS232. There is a slot for an expansion card, such as a multiple SDI/HDSDI outputs.

Power consumption is about 29 watts at 12 volts, from a separate power supply, which more closely resembles consumer equipment than broadcast. The complete camera weighs 5 kg, and is approximately 200x260x240mm.

Sensitivity is claimed to be 4 lux for 50% video signal level at F/1.9 and, presumably, maximum gain. Noise level is claimed to be -50dB on the component luma channel output.

The camera resolution was adequate but not particularly sharp. according to EBU Tech.3335, and the results establish that the camera belongs in Tier 2J for some applications. See the test section for the reasons for this statement.

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Many of the menu items have little or no effect on image quality. Those that have significant effect are highlighted. The full set of menu items is given for completeness. In boxes with a range of numeric settings, e.g. -99~+99, the values indicate the range, and zero means no alteration to factory setting, not zero effect, and no scales are given in the manuals. For each item, the factory setting is underlined. "Pref" (preferred) settings are in the last column, where appropriate, for normal video shooting and for film-look shooting. Where no preferred value is given, either the factory setting is best, or the setting does not have great effect on image quality. In some instances, it is possible to alter the menus such that they produce more meaningful numbers. Menus are nested: items in italics in the listing are headings leading to a further nested menu. The menu structure is very simple and does not allow much image manipulation. Also, control is not easy since it involves using the joystick to enter and modify menu items.

The camera can be set to 1080i/25 and 1080i/29.97, or 720p/50 and 720p/59.94, by setting DIP switches on the base. These switches are interrogated only at power-up, and are normally concealed by the pan/tilt mounting. A small slide-switch on the connection panel will set the SDI output to HD or SD, again this is interrogated only at power-up.

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.

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.

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1 Menus and settings

EXPOSURE Menu

Item	*Range*	*description*	*Pref*
Mode	Full auto, Manual, Shutter Pri, Iris Pri, Backlight, Spot light	Only relevant items below will be available	Manual
Gain	-3, 0, 1, 2, …, 23 ,24dB		
Speed	1/50, 1/100, 1/120, 1/125, 1/250, 1.500, 1/1000, 1/2000, 1/4000, 1/8000	1/60 instead of 1/50 when at 59.94Hz	
Iris	F/1.9, 2.2, 2.4, 2.6, … ,15, 16	¼ stops	
AE speed	Low, Med, High	Auto exposure	
AE level	-1, -0.5, 0, +0.5, +1		
AGC	On, Off		
AGC limit	3, 6, 9, 12, 18dB	Limits AGC gain range	9
AGC point	F/5.6, F/4, F/2.8	Aperture at which AGC starts	F/2.8
Auto shutter	On, Off		
Shutter limit	1/100, 1/125, 1/250, 1/500	Shortest shutter in auto	
Shutter point	F/5.6, F/8, F/11, F/16	[1]	F/8

COLOR Menu

Item	*Range*	*description*	*Pref*
White balance	Auto, Indoor[2], Outdoor, One push, Manual	Only relevant items below will be available	
Speed	1, 2, 3, 4, 5		
Offset	-7 ~ 0 ~ +7	- for blue, + for red	
R gain, B gain	-128 ~ 0 ~ 127	Manual colour tweak	
Matrix	Off, On		On
Select	Std, High sat, Fl light	No information on these	Std
Level	-7 ~ 0 ~ +7	Saturation control	
Phase	-99 ~ 0 +99	Tint	
R-G	-99 ~ 0 +99	Roll your own matrix, dangerous to try and difficult to get right, best left alone unless you're an expert	
R-B	-99 ~ 0 +99		
G-R	-99 ~ 0 +99		
G-B	-99 ~ 0 +99		
B-R	-99 ~ 0 +99		
B-G	-99 ~ 0 +99		

DETAIL menu

Item	*Range*	*description*	*Pref*
Setting	On, Off	Only relevant items below will be available	
Level	-99 ~ 0 ~ +99		-30 to +11[3]
Frequency	-99 ~ 0 ~ +99		+99
Crsipening	-99 ~ 0 ~ +99	Avoids adding noise	-99
H/V ratio	-99 ~ 0 ~ +99	- = more H, + = more V	0
White limiter	-99 ~ 0 ~ +99	Overshoot limit	-99
Black limit	-99 ~ 0 ~ +99	Undershoot limit	-99
VDTL creation	NAM, Y, G, G+R	NAM = greater of R and G	Y
Knee apt level	-99 ~ 0 ~ +99	Sharpen above gamma knee	

COLOR DETAIL menu

[1] Beware of closing the iris too far, iris diffraction will start softening the picture at about F/8.
[2] Indoor=3200K, Outdoor=5800K
[3] The control runs from -99 to +99. Setting to zero gives probably the best results, but this range should be acceptable provided all the other settings are used as shown, see the test section below.

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Item	*Range*	*description*	*Pref*
Setting	On, Off	Only relevant items below will be available	
Level	-99 ~ 0 ~ +99	Detail enhancement of specific colour range	
Area indication	On, Off	Shows zebra in selected range	
Saturation	-99 ~ 0 ~ +99		
Phase	0, 130 ~ +359º	Select hue range to tweak	
Width	0 ~ 40 ~ 90º	Adjust rage of selected colour	

KNEE menu

Item	*Range*	*description*	*Pref*
Setting	On, Off	Not available if gamma=cine	
Auto knee	On, Off	Auto prevents items below	
Point	50 ~90 ~ 109%		
Slope	-99 ~ 0 ~ +99		
Knee sat level	0 ~ 99	Saturation tweak in knee compression	

GAMMA menu

Item	*Range*	*description*	*Pref*
Select	STD1, STD2, STD3, STD4, Cine1, Cine2, Cine3, Cine4		STD3[4]
Level	-99 ~ 0 ~ +99		0
Black gamma	-99 ~ 0 ~ +99		0
Black	-99 ~ 0 ~ +99		0

FLICKER CANCEL menu

Item	*Range*	*description*	*Pref*
Mode	On, Off	Set shutter to suppress lighting flicker	
Frequency	50Hz, 60Hz		

FOCUS menu

Item	*Range*	*description*	*Pref*
Mode	Auto, Manual		

PAN TILT menu

Item	*Range*	*description*	*Pref*
Limit		Set limits for pan/tilt	
Pan	Off, On		
Left	End, +160º ~ -169º	1º steps	
Right	End, -160º ~ +169º		
Tilt	Off, On		
Up	End, -29º ~ +89º		
Down	End, +89º ~ -29º		
Ramp curve	Mode 1, Mode 2	Mode 1 = faster	

SYSTEM menu

Item	*Range*	*description*	*Pref*
IR receive	On, Off	Enable/Disable the handset	

[4] If these gamma curves are those of other Sony cameras of similar size, which is highly probable, then Std3=ITU709, Std4=BBC0.4; Std1 has lowest slope near black (for low noise and black-crushing); Std2 is somewhere between Std1 and Std3. The Cine curves are not the "Hypergamma" curves of the PDW700, HDWF900R/790 etc. Cine2 is the only curve suited to production without grading, since it clips at 100%. Cine1 is similar but copes with overexposure by extending beyond 100% video level. Cine3 and 4 differently share the contrast range, use these to taste. If using Cine1, 3 or 4, make sure that video will not be clipped in post-production. Or that grading can cope with the over-voltages.

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		controller	
IMG flip	Off, On	Needs power off/on to act	
Pan reverse	Off, On	Change the operating sense of the joystick or remote control	
Tilt reverse	Off, On		
Display info	On, Off	Shows which preset store is being used, etc.	
Sync master	HD, SD	[5]	
H phase	0 ~ 3 ~ 959	Shift relative to input sync	
H phase fine	0 ~ 9	Steps of 0.01347	
Steadyshot	Off, On	Image stabiliser	
Color bar	Off, On		
Tally mode	High, Low, Off	Brightness of front tally lamp	
Version	1.00	Firmware version	

VIDEO OUT menu

Item	***Range***	***description***	***Pref***
HD-RGB/component			
Format	YPbPr, RGB	Analogue output signals	
Add sync	RGB, Off	Analogue only	
Sync type	Trisync, VD	VD = bi-level sync	
SD Video/S-Video			
IMG size	16:9 [letter], 4:3 [crop], 4:3 [squeeze]	Down-conversion	4:3 [squeeze]
Setup	Off, On	7.5% for 59.94 modes	Off

SD-SDI menu

Only for BRBK-HSD2 SD output card

Item	***Range***	***description***	***Pref***
IMG size	16:9 [letter], 4:3 [crop], 4:3 [squeeze]	Down-conversion	4:3 [squeeze]

SD menu

Only for BRBK-SA1 analogue output card

Item	***Range***	***description***	***Pref***
D-sub output 1	YCbCr, RGB		
Add sync	RGB, Off		
D-sub output 2	VBS, Y/C	Composite or S-video	
IMG size	16:9 [letter], 4:3 [crop], 4:3 [squeeze]	Down-conversion	4:3 [squeeze]
Setup	Off, On	7.5% for 59.94 modes	Off

[5] The manual is confusing here, it claims that HD means sync to analogue RGB or component connector, and SD means sync to Video or S-Video connector. I don't understand.

2 Measurement results

2.1 Colour performance

Assessments were made visually, using Colorchecker charts as usual. Performance was generally good, but the skin-tone colours were a little pink, and the blues and reds oversaturated. Setting the matrix R-G value to about -8 should make some improvement, and there will certainly be more improvements to be gained by spending more time on this assessment, probably setting R-G to a negative value as well, and possibly using the colour corrector. The performance appears to be very like that of the EX1. Overall, the performance was quite acceptable.

2.2 Gamma curves

There are 4 normal gamma curves available in the camera, and four Cine curves. For broadcast purposes either Gamma 3 (ITU-709) or 4 (BBC 0.4) is perfectly acceptable. The BBC curve always produces more accurate colour rendition, but the 709 curve is normal for HDTV shooting, so all further tests used Gamma 3 (ITU-709). The knee was not explored, since the camera is unlikely to be used in wide-ranging lighting conditions. Therefore it is not possible to comment on the camera's dynamic range, other than report the noise measurements, see below.

2.3 Resolution

A HDTV zone plate chart was used. This contains six circular patterns that fully explore the spatial frequency performance of the camera, up to 1920x1080 pixels per width and height. There are patterns for grey-scale testing of luma performance, the others are coloured for examining chroma resolution or other colour filtering. Modulation is cosine rather than square wave. Each pattern is a "phase space" map of the possible frequencies that the camera can be expected to deal with, reaching 1920 pixels/picture width (960 cycles) horizontally, and 1080 lines/picture height (540 cycles) vertically.

2.3.1 Resolution, 1080i

Figure 1 shows a single quadrant of one luminance pattern; for this exposure, all the camera detail enhancement controls were set to factory levels (zero) which definitely does not mean no correction, so this is certainly not the native performance of the camera.

There are no null zones, where the wanted lower frequencies mix with aliases produced by spectral folding of the unwanted higher frequencies, alias products. This indicates that the

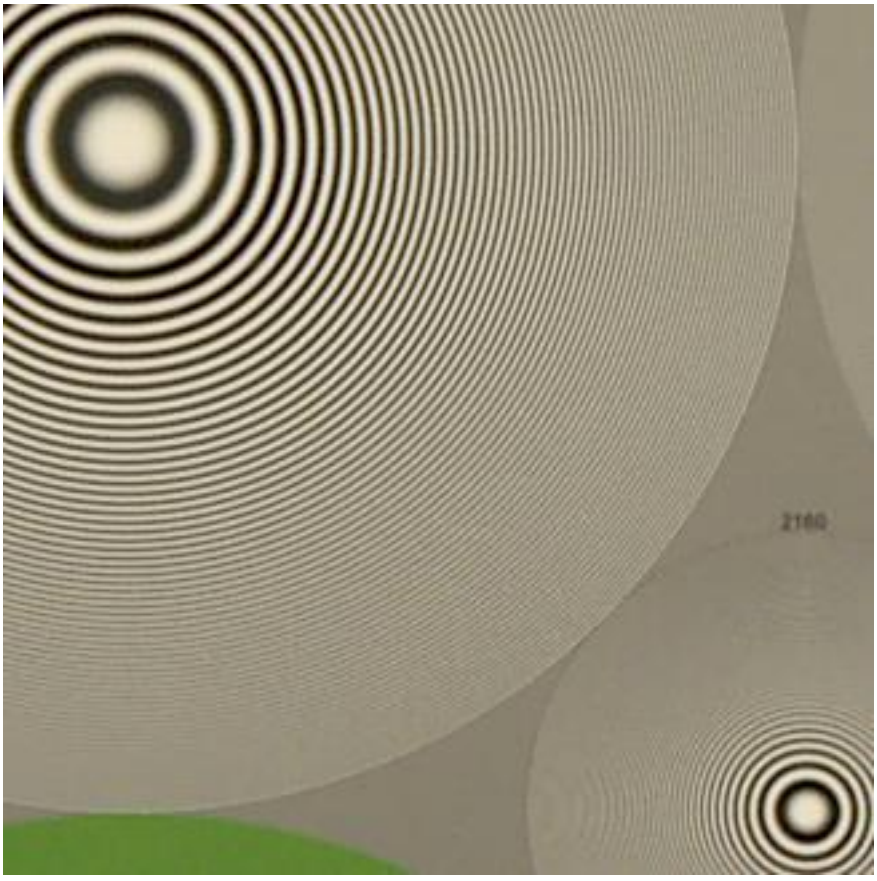

Figure 1 Resolution, 1080i, factory detail

sensors are full 1920x1080 resolution. However, the amplitude of detail at frequencies above about 1280x720 is very low.

In the smaller pattern (bottom-right) which explores double-HDTV resolution, there is some aliasing above 1920x1080, but at quite low levels. This points to the camera probably not having an optical spatial low-pass filter, and that the lens is relatively soft for HDTV.

The specification claims that the sensors are ½" (8mm) size at approximately 3,010,000 photo-sites each, of which only 2,070,000 are effective. The 2 Mega-pixel value agrees with the measurements, but the total count seems extravagant.

2.3.2 Resolution, 720p

Figure 2 shows the result of setting the camera to 720p/50 mode. Detail settings were again left in factory values (zero). There is a complete absence of spatial aliasing within the 1920x1080 space, and the aliasing in the double-frequency pattern is unchanged. This appears to confirm that the lens is rather soft and that there is no optical spatial low-pass filter in the camera.

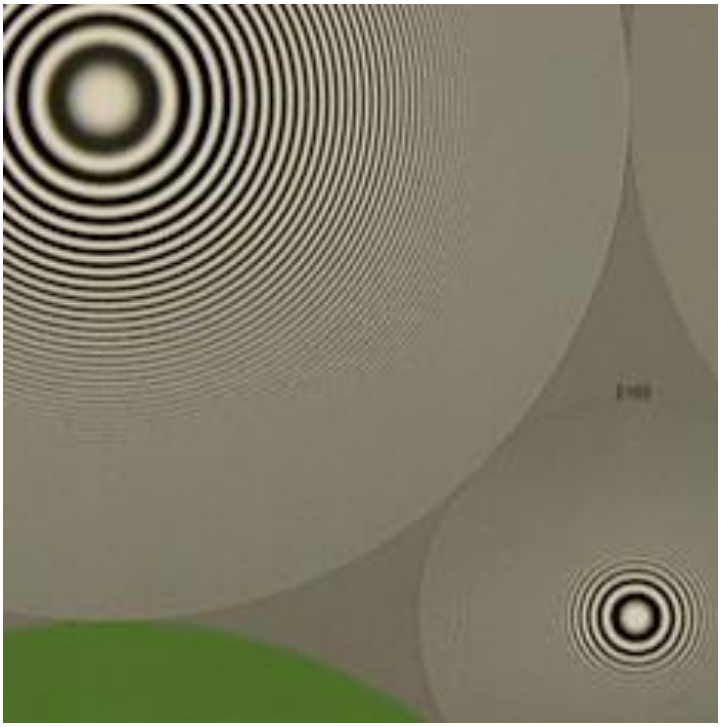

Figure 2 Resolution, 720p, factory detail

2.3.1 Detail enhancement

Attempts were made to improve the apparent sharpness of the 1080i image, with little initial success. Setting detail frequency to +99 (maximum) appeared to have little effect on the achievable detail level. Detail enhancements appeared to affect only frequencies below about 1280x720.

It was only when the controls for 'Crispening' (setting the amplitude of detected detail, below which enhancement will not take place) and the two 'Limit' controls (which limit the amount of under-and over-swing which detail enhancement can cause) were set to very low levels that the detail enhancement started to work on these higher frequencies.

Since the camera is likely to be used in controlled-lighting situations, it is fairly safe to apply some extreme settings which might otherwise cause problems. It was found that by setting 'Frequency' to +99 (maximum), then 'Crispening', 'White limit' and 'Black limit' all to -99 (minimum), the detail 'Level' control properly affected the higher frequencies. It was then found that by setting 'Level' to values

Figure 3 Resolution, 1080i, detail level +11

between -30 and +11 acceptable results could be obtained when the gain was set to 0dB. These settings would certainly not be good at higher gain settings, since video noise would be considerably enhanced.

Figure 3 shows enhancement level +11, Figure 4 shows enhancement level -30, with other controls set as described above.

At +11, the central, lower frequency, area has been brightened considerably, which is an easy identifier for the conventional SDTV over-enhancement producing black lines around objects. Also, there is significantly more noise in this image, since the enhancer is emphasising noise due to the low level of the Crispening control. Therefore, if such a high detail level is to be used, experimenting with the Crispening control is essential to get the best results. It was not possible during the tests to be certain what levels would be acceptable, that depends on the specific usage of the camera. +11 should be regarded as a maximum setting for acceptable pictures, but the potential user should beware that the noise level may make colour-keying operations difficult.

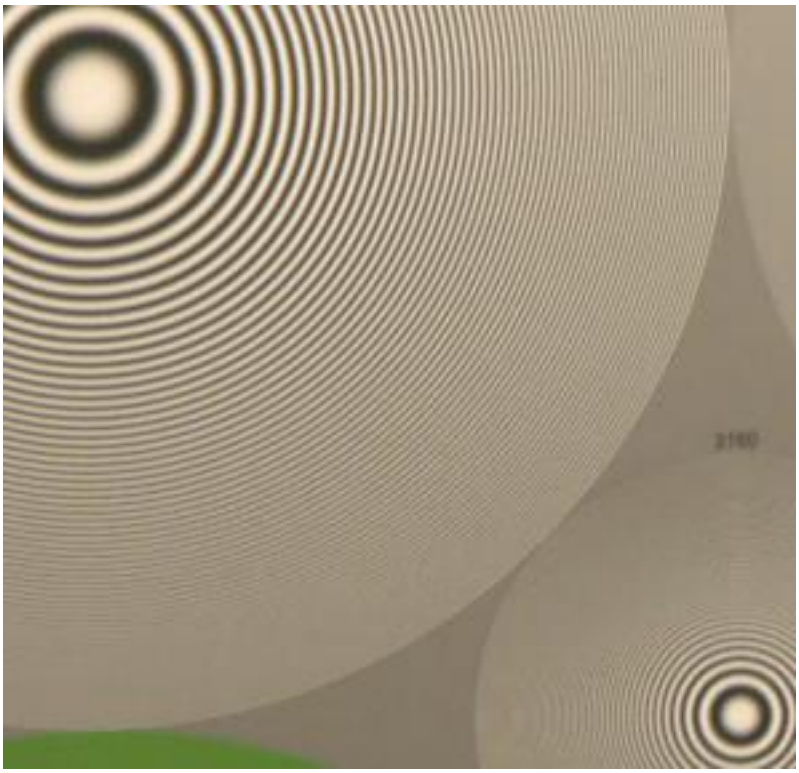

Figure 4 Resolution, 1080i, detail level -30

At -30 (Figure 4), the central area appears to be hardly affected at all, and noise levels are acceptably low. This is misleading, since there is still an enhancement effect going on, it's just that the native resolution of the camera is relatively low, and so this amount of enhancement is essential. Therefore, it should be safe to use a value between -30 and +11 for most purposes.

Figure 5 shows the level of under- and overshooting at these settings on black-white transitions. Careful

Figure 5 Under- and over-shooting (a) +11 (b) -30

adjustment of the White- and Black-limit controls could improve this, but it is probably best to adjust these for specific applications.

The same settings work equally well for 720p, as is shown in Figure 6.

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Clearly, the higher level of enhancement has increased the noise level, but not excessively so. Nevertheless, using such a high level of enhancement could cause problems in applications where colour-keying is to be used, since the colour channels will be rather noisy.

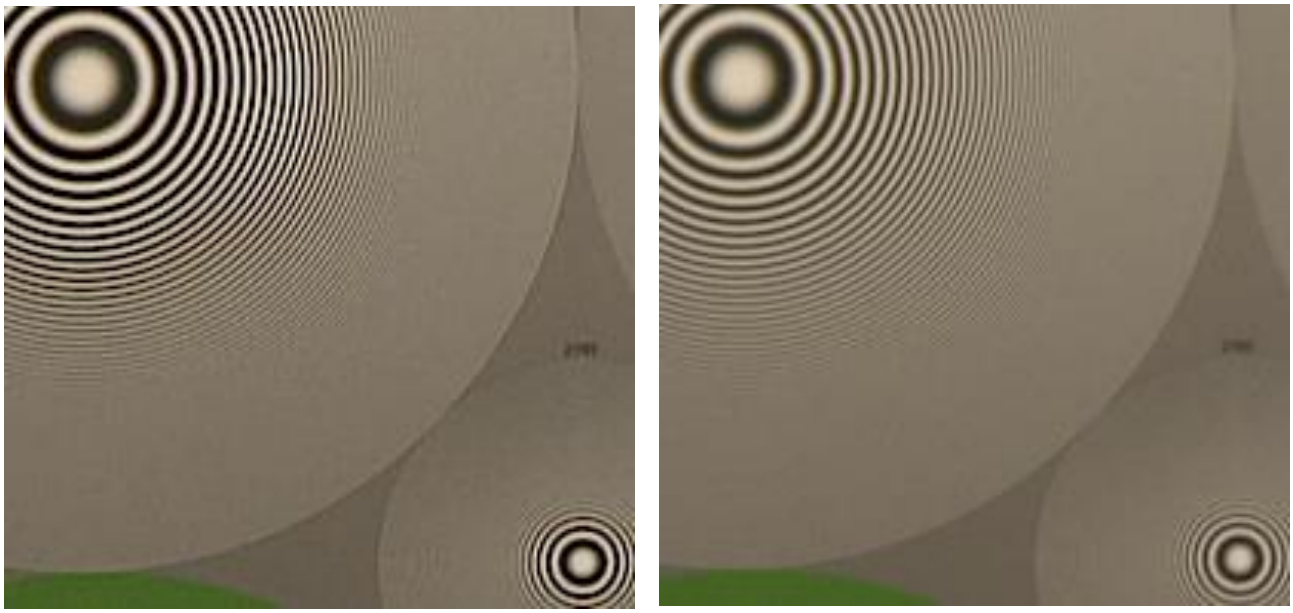

Figure 6 Resolution, 720p (a) detail level +11 **(b) detail level -30**

2.3.1 Resolution, SD 576i

Down-conversion to SD works quite well, which again implies that there is little high-frequency content in the original image. Figure 7 shows this.

Horizontally there is some frequency folding centred on 720 pixels, but there is little first-order aliasing due to the down-conversion itself. There is, however, significant second-order vertical aliasing due to a double-folding of high vertical frequencies. This is not unusual with in-camera down-conversion. Better results would be available using external hardware or software conversion.

Figure 7 Resolution, SD 576i

2.4 Video Sensitivity and Noise Levels

Sensitivity was measured by evenly illuminating a white card at 2000 lux, and setting camera gain to 0dB gain and 1/50 shutter. The lens aperture to produce peak white was F/7.3 at 1080i/25.

The specification claims 4 lux at F/1.9 for 50% video level, presumably at 1/50 shutter and +24dB gain. This converts to 16 lux at 0dB gain, then to about 200 lux at peak white (since 50% video is about 3.5 stops below peak white), and then to about F/6.5 at 2000 lux, all of which agrees well enough with the measurements.

Video noise was measured by recording a defocused white card, uniformly lit, and performing numerical analysis in software. Standard Gamma 3 was used, ITU-709.

The camera was initially set to 0dB gain to determine the typical results from the camera. A high-pass filter was used to remove all horizontal frequencies below about 5% of the nominal maximum of half-sampling frequency. Figure 8 shows the results, noise level in dB plotted versus signal level.

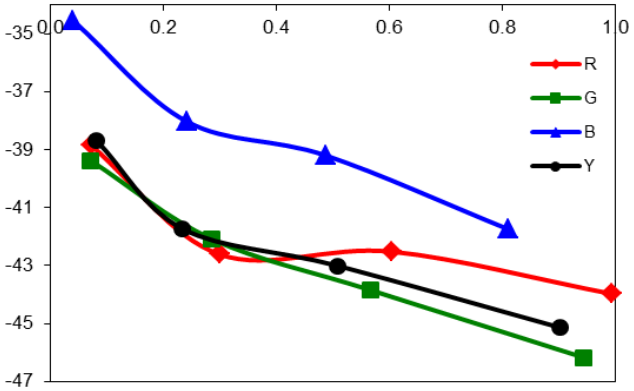

Figure 8 Noise, 1080i, 0dB gain

As expected, the blue channel is noisier than either red or green, because silicon is relatively insensitive to blue. The distribution follows the slope of the gamma curve quite nicely; there should normally be about 14dB more noise near black than near white simply through the greater gain of the gamma-corrector near black.

Nevertheless, the noise result does not closely approach the claim of -50dB; the most likely explanation is that Sony have used a subjective weighting, whereas these measurements do not use weighting.

The noise performance was measured again with the gain set to +24dB, the maximum offered in the camera. The Y channel noise was about 15dB higher than at 0dB, whereas normally it should be expected to be about 12dB higher. This is not unusual, and there may well be some form of noise reduction going on, possibly as simple as the reduced bandwidth of the head-amplifiers when operating at higher gain. The noise was plainly visible in the image, and is probably unacceptable for high-quality HDTV production, a sensible limit of, say, 9dB is probably acceptable.

Noise was not measured in 720p modes.

2.5 Dynamic range

This was not measured specifically. Using the conventional ITU.709 gamma curve, the noise level limits the dynamic range to about 7 to 8 stops. It is possible that up to a further two stops of headroom might be available by using the gamma knee or Cine curves, but for this type of camera and the programme-usage it is likely to be installed for, this is probably not relevant. In any case, it seems unlikely that the total range is greater than 10 stops.

2.6 Shuttering

The camera has three CMOS sensors, and thus is expected to exhibit the effects of a rolling shutter. A motion sequence was recorded, of a small rotary fan. The camera shutter was set to 1/1000 in order to sharpen the images.

Figure 9 is a small part of a frame from that sequence, which clearly show geometric distortions (since the top of the frame is exposed significantly before the bottom); the blade on the right (moving downwards) is wider than that on the left (moving upwards).

Figure 9 Rotating fan, rolling shutter

Nevertheless, the effect is not is not particularly bad.

2.7 Conclusion

Resolution is refreshingly free of spatial aliasing. However, it seems likely that there is no optical spatial filter, and that the lens is rather soft. Thus the images are rather soft, probably too much so for normal

broadcast HDTV production. Detail controls were effective but only after setting some extreme values in the menus. Noise levels are similar to those of other ½" cameras with 3 sensors, as is sensitivity. Operating the camera at high gain produces significantly more noise, probably unacceptably so. The specified noise level of -50dB was not is achieved. Noise distribution is uniform at low gain, but less so at high gain.

Because of the small-format size of the sensor, iris diffraction should start to be visible at about F/8, and the camera has no neutral filters for exposure control, thus it may be difficult to find a satisfactory combination of lens, gain and shutter settings except in fixed-location use.

Performance at 720p is acceptable although not quite ideal. SD performance is adequate.

The camera cannot be straightforwardly assigned to a conventional Tier according to EBU Recommendation 118 because of the limitations in resolution and noise. However, for specific purposes, where lighting and exposure are constant, it should be possible to derive settings which would qualify the performance for level 2J. This does not imply that it has such a Tier level for general use, only that it could be assigned to such a level for some specific usages.