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

Alan Roberts, June 2014

SUPPLEMENT 014 : Assessment of a JVC GY-HM890 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.

Initial tests were made on a production model of the JVC GY-HM890 HDTV camcorder (serial number 079M0004).

The camera is very similar to the GY-HM850 and shares many features with it. It could well be identical apart from the extra features of the 890 (mainly to do with connectivity for system use). It is also strikingly like the GY-HM600 and 650, but has some improvements, extra features and menu items.

It has a separate lens and was tested with a Fujinon 20:1 F/1.6 zoom lens (4.1 to 82mm, ⅓" bayonet, serial number A19400292 on the model tested). The lens has conventional 3-ring control, with manual or automatic operation, but the rings are all servo-driven and only the zoom ring has proper markings. It has a set of neutral density filters for exposure control. The sensors are 3 ⅓" CMOS of 1920x1080 photo-sites, and although the specification makes no statement about actual pixel dimensions, they are probably 2.5µm square, half the size of those in a ⅔" camera.

Recording is onto two solid-state SDHC or SDXC cards; in MPEG2 4:2:0 (Quick Time or MP4 format), and in MXF and web formats. HQ mode records at up to the expected 35Mb/s VBR, 1920x1080, 1440x1080 and 1280x720 at all the usual frame rates from 23.98Hz to 59.94Hz. It also records in AVCHD in 1920x1080 and 1440x1080 at five bit-rates (EP, LP, SP, HQ and progressive, from 5Mb/s to 28Mb/s). There is another mode, UHQ (H.264) which can record 1920x1080p at 50Mb/s or 35Mb/s; these modes are interesting because they could, potentially, be better than MPEG2 at 50Mb/s and thus suitable for high-end broadcast use. However, this new 50Mb/s mode has not yet been tested by the EBU at the time of writing; this camera provides to means to do so. Only the MPEG2 HQ mode was used for the tests. All recording is 8-bit.

It can also record in standard SDTV modes, Quick Time format, AVC (MPEG4) at 8Mb/s.

Recording can be set to change between cards when one is full, or to record two identical cards as a backup, or simultaneously at different resolutions and bit-rates. In-camera editing can be done by WiFi control or network connection.

The camera is quite light (about 2.75kg in including battery, plus about 1.3kg for the lens) which is typical for a camera of this type. It has an integral monocular colour viewfinder (852x480) and side-mounted 4⅓" LCD screen, and seems aimed at the mid- to high-end professional markets. It has time-code input and output and a remote control socket, so may well be usable in multi-camera shoots. Power consumption is about 21 watts at nominal external 12 volts (4-pin XLR or V-lock battery).

Variable-speed recording is possible, from 2 frames/second up to the nominal frame rate setting (24/25/30 when recording 1080-line, 24/25/30/50/60 when recording 720-line).

There are internal menus for setting the performance, not as complex as in a full broadcast camera, but enough to control many of the important features. There are analogue-only video outputs (SD-composite via BNC for monitoring) and digits via USB-2 for data file transfer, HDMI and HDSDI with 8-bit content. It has 2 XLRs for external audio inputs, although it can record 4 audio channels. It also has Genlock input, and, highly unusually, a SDI/HDSDI input which can be recorded in the camera.

The same assessment procedure was used as for other HD cameras, partly attempting to get a good "film-look", and the settings reflect that. In the search for a "film-look" setting it is normal to think of the camera to be mimicking a film camera and telecine, with "best light" transfer to tape, with about 11 stops of tonal range. Assuming that a grading operation will be used in post-production, the settings attempt to give the colourist the same range of options as with film, achieving about 9 to 11-stop dynamic range. The recommended settings allow about 1 stop of over-exposure relative to normal operation.

This is not unusual for a small camera with ⅓" sensors, but the camera has the unusual feature of selectable sensitivity, which allows for a sensible trade-off between sensitivity, resolution and noise levels.

The 720p mode is very clean, as is the SD mode, it is unusual to be able to say this of any camcorder.

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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, the values indicate the range, and no scales are given. Default settings, where known, are underlined. My recommendations are in the last column, labelled "Pref", where appropriate. Settings are given for:

v Television production
f Film-look television

In the tables, items that have an important effect on picture appearance are highlighted with grey background. Rather than just making assertions about performance, I have included measurement results that illustrate the reasons for the recommended settings. Note that the camera under test had slightly different menu contents from that listed in the printed manual, the listings below refer to the actual camera.

This is not intended as a replacement for reading the manual. Note that since the second camera tested had slightly different menu items, the tables below show the items in that camera rather than those in the manual.

1. Switches and Menu settings

SWITCHES, SOCKETS and BUTTONS

name	place	feature	comment
Front tally lamp	Viewfinder	lamp	
Joystick	Under lens	LRUD/press	User 5~8
Auto White bal	Under lens	Push	User9
Focus auto/manual	Left over LCD	Switch	User 11
Status	Left over LCD	Push	
Cam/Media	Left over LCD	Push	
Full auto	Left over LCD	Switch	
Monitor select	Left back handle	Switch	Audio monitoring
Back tally lamp	Back of handle		
Headphones	Back of handle	3.5mm sockets	
USB	Back of handle	Socket	
Input 1/2	Right front	XLR x 2	
Audio	Right front	Switches	Select 1~4, Mic/line
Rec/hold	Top front	Push/Switch	
Zoom	Top front	Lever	
Fix/Var/Off	Left handle	Switch	Zoom speed
VF Bright	Left front	Rotary	
VF Peaking	Left front	Rotary	
Focus assist	Left front	Push	User 4
OIS	Left front	Push	User 1
Marker	Left front	Push	User 2
Load file	Left front	Push	User 3
Menu/Thumb	Left front	Push	
ND filter	Left front	Lever	
Display	Left front	Push	
Joystick panel	Left front	LRUD/press	UD=Shutter, LR=AE level, Press=shutter etc
Cancel	Left front	Push	
Gain	Left front	Switch	
White balance	Left front	Switch	
Ch12/Ch2 rec level	Left front	Knobs	
Power	Left front	Switch	

Rec start/stop	Left front	Push	User 10
LCD Bright	Under LCD	Push	
LCD Peaking	Under LCD	Push	
Input1/Input2	Under LCD	Switch	Audio AGC
TC Display	Under LCD	Switch	
TC Gene	Under LCD	Switch	
HDSDI/SDI	Back right	BNC	Input
HDSDI/SDI	Back right	BNC	Output
HDSDI/SDI	Back right	BNC	Video out
Genlock	Back right	BNC	Input
TC In	Back right	BNC	
TC Out	Back right	BNC	
Studio	Back right	Multi-pin	For system integration
DC Input	Back right	4-pin XLR	
Remote 1	Back right	Muti-pin	
Audio out	Back right	2xphono	1/3 and 2/4 audio out
Aux input	Right under flap	3.5mm socket	
Remote 2	Right under flap	2.5mm socket	Wired remote control
USB	Right under flap	Socket	Clip management
HDMI	Right under flap	Socket	Video out
SD slot Open	Right	Slide	Open the slots
SD slot select	Right	Push	Toggle slots

CAMERA FUNCTION menu

Basic camera settings

Item	range	comments	Pref
Bars	On, Off	SMPTE	
OIS …	On, Off	Optical Image Stabiliser	
Level	High, Normal		
Flicker Correction	On, Off	E,g, fluorescent lighting	[1]
Flash Band Correction	On, Off	Compensate for rolling shutter	On[2]
Shutter	EEI, Variable, Step	EEI=automatic	
AE Level	-6 ~ 0 ~ +6		
AE Speed	Fast, Middle, Slow		
ALC Limit	24, 18, 12, 6dB		12[3]
Auto Iris Limit (Open)	F5.6. 4, 2.8, 2, 1.6		
Auto Iris Limit (Close)	F16, 11, 8, 5.6		5.6[4]
EEI Limit	4Fstop, 3Fstop, 2Fstop	Auto shutter range	
Smooth Trans	Fast, Middle, Slow, Off	Response speed to auto changes	
FAW	B, A, Preset, None	Full Auto White balance	
Gain L/M/H	+24dB, 21, 18, 15, 12, 9, 6, 3, 0, -3, -6dB	Defaults to L=0, M=6, H=12	0, 6, 12[5]
AE Level Sw	AE level/VRFR, AE level, Disable	What the L/R buttons on cam left do	
Handle Zoom Speed	1 ~ 5 ~ 8		
AF Speed	Fast, Middle, Slow	Auto-focus speed	
AF Assist	Area, Far/Near, Off	How the focus ring controls autofocus	
Remote Func Change	Zoom/Focus, Off	Enables focus when a=zooming by wired remote control	
Lens REC	Intercom, Rec	When the lens REC button does, KA-F790G only	

[1] Flicker correction doesn't work with slow shutter, variable frame rate or 24p.
[2] Flash band correction works well, and should be used for journalism shooting. Doesn't work with shutter on, 24p or variable frame rate, see the manual.
[3] Maximum gain the AGC will go to, setting depends on noise level, which also depends on sensitivity setting.
[4] Iris diffraction softening starts to be visible at F/5.6.
[5] Gives decent noise performance in Standard shooting mode. Extended shooting mode is more sensitive but noisier.

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User Switch Set	Line streaming, Load Picture File, Return Video, Clip Review, OK Mark, Clip Cutter Trig, Backup Trig, Rec, LCD Backlight, Expand Focus, Histogram, Spot Meter, Focus Assist, Marker, Zebra, AWB, White Balance, Preset Zoom1 to Preset Zoom3, Auto Focus, One Push Focus, One Push Iris, OIS, Face Detect, AE Lock, Lolux, Flash Band, Bars, None	Defaults 1=OIS 2=Marker 3=Load File 4=Focus Assist 5=None 6=None 7=Zebra 8=Spot Meter 9=AWB 10=Rec 11=Autofocus	Others Lens Ret=One Push Focus Lolux=30dB, 36dB Clip Review=Last 5 sec, Top 5 sec, Clip Spot Meter=Max&Min, Max, Min, Manual Face Detect=AF&AE, AE AE Lock=AE/WB, AE Preset Zoom Speed=1~64~127, Expand Focus=Lim Time, Mom, Toggle Return Video=Camera>Return, PiP>Return, PiP>Camera, Camera>PiP, Camera<>PiP	
Full Auto	Gain, Iris Control, Shutter, White Balance, ars, Audio		Select what is assigned to full auto Gain=SW Set, ALC Iris Control=Off, Auto Shutter=SW Set, EEI White Balance=SW Set, FAW Bars=Menu Set, Off Audio=SW SET, Auto	

CAMERA PROCESS menu

Item	range	comments	Pref
Detail …	-10 ~ 0 ~ +10	{f}-7, {v}-4, {SD}-4	
Adjust …			
V/H Balance	H+4, H+3, H+2, H+1, Normal, V+1, V+2, V+3, V+4		
H Frequency	High, Middle, Low	{f} High {v} Middle	
V Frequency	High, Middle, Low	[6] {f} High {v} Middle	
Skin Detail …	On, Off		
Level	-1, -2, -3	Skin softening	
Range	-5 ~ 0 ~ +5		
Master Black	-50 ~ -3 ~ +50		
Black Toe …	Stretch, Normal, Compress		
Stretch Level	1, 2, 3, 4, 5	Stretch improves colour performance	
Compress Level	1, 2, 3, 4, 5	Compress improves noise performance	
Knee …	Manual, Auto		Manual
Level	100%, 95, 90, 85	Manual	{f}85 {v}95[7]
Sensitivity	Fast, Middle, Slow	Auto	
White Clip	108%, 100%		108%[8]
Gamma …	Cinema, Standard	{f} Cinema {v} Standard	
Level	-5 ~ 0 ~ +5	+ = black stretch/white crush - = black crush/white stretch	0
WDR	Strong, Natural, Weak, Off	Wide Dynamic Range, another gamma	[9]
White Balance …			
Preset Temp	7500K, 6500, 5600, 4800, 4200, 23200, 3000, 2800K	CCT of Preset White Balance setting	
Alternative Temp	7500K, 6500, 5600, 4800, 4200, 23200, 3000, 2800K	Different CCT for Preset, toggled with White Bal switch. Neat idea.	
AWB Paint	-32 ~ 0 ~ +32 -32 ~ 0 ~ +32	Shift the balance (A or B), redness and blueness	
Clear Paint after AWB	On, Off	Resets Paint values on doing a White Balance	
FAW Paint	-32 ~ 0 ~ +32	Swing R/B gains in Auto White Balance	
Shading	On, Off		
Adjust	-128~0~+128	White shading	

[6] Only active in 1280x720, shame.
[7] Knee is always on, even in Cinema gamma. The slope can't be changed, so headroom is proportional to Level, about 0.5 to 1.5 stops.
[8] Set to 100~103% if the footage is going to be used in analogue SD television. When using 108%, make sure that the client knows you've done so, to make sure he doesn't clip in post-production.
[9] Wide Dynamic Range Strong adds only a bit to the dynamic range, but it redistributes what it captures rather film-like.

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Color Matrix …	Cinema Subdued, Cinema Vivid, Standard, Off	Quite powerful, beware	{f} Cinema Subdued {v}Standard
Adjust	Red, Yellow, Green, Cyan, Blue, Magenta -5 ~ 0 ~ +5	RGB gains in hue sectors, very nice intuitive display	
Color Gain	Off, -50 ~ 0 ~ +15	Saturation	
Reverse Picture	Off, Rotate	H and V reversal	
Shooting Mode	Standard, Extended		Standard[10]
Reset Process	Revert to factory		

TC/UB menu

Item	range	comments	Pref
TC Preset	00:00:00:00	Enter the time code	
UB Mode …	Date, Time, SW Set		
Preset	** ** ** **	Hexadecimal entry, 0~9, A~F	
Drop Frame	Non Drop, Drop	Only in 60/30 fps. ND is fixed in 24p	

LCD/VF menu

Item	range	comments	Pref
Shooting Assist …		General help, all good stuff	
Focus Assist ….	On, Off	Sets VF to mono and adds colour edges	
Type	Accu Focus, Normal	Accu Focus opens the lens to help	
Color	Blue, Green, Red		
Zebra …	1 Pattern, 2 Patterns	Bracketing levels …	
Top 1	Over, 100% ~ 80 ~ 5%	Max level	
Bottom 1	100% ~ 70 ~ 0	Min level	
Top 2	Over, 100% ~ 5%	Max level	
Bottom 2	100% ~ 80 ~ 0	Min level	
Peaking Frequ	High, Middle, Low	What's used in knob/button controls	
Marker Settings …			
Marker …	On, Off		
Grid Marker …	On, Off	3x3 grid	
Aspect Ratio	16:9 + 4:3, 2.35:1 Top, 2.35:1 Centre, 1.85 Top, 1.85 Centre, 16:9, 1.75:1, 1.66:1, 14:9, 13:9, 4:3		
Aspect Marker	Line+Halftone, Halftone, Line, Off	For all but 16:9	
Safety Zone	95%, 93, 90, 88, 80, Off		
Centre Mark	On, Off	Centre cross	
Display Settings …			
Zoom	Number, Bar, Off		
Focus	Feet, Meter, Off		
ND Filter	On+Assist, On, Off	On+Assist blinks the setting if it's appropriate	
Record Format	On, Off		
Media Remain	On, Off		
TC/UB	UB, TC, Off		
Histogram …	On, Off		
Top	5%~80~110	Level for colour change near white	
Bottom	0%~20~105	Level for colour change near black	
Audio Meter	Auto, CH1/2, Off	Not available when Histogram is on	
Battery	Time, Capacity%, Voltage, Off		
Date/Time	On, Off		
Date Style	DMY2, DMY1, MDY2, MDY1, YMD		
Time Style	24 hour, 12 hour		
Shutter	Deg, Sec	Nice to see this choice	
LCD+VF	On, Off		
LCD/VF Display	Wide, Normal	Horizontal overscan	
VF Color	On, Off		
VF Bright	-10 ~ 0 ~ +10		

[10] Changes basic gain by 6dB.

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VF Contrast	-10 ~ 0 ~ +10		
LCD Contrast	-10 ~ 0 ~ +10		
LCD Backlight	Bright, Normal		
LCD Mirror	Mirror, Normal		

A/V SET menu

Item	range	comments	Pref
Video Set …			
HDMI/SDI Out …	HDMI+SDI, SDI, HDMI, Off		
Resolution	1080p, 1080i, 480p, 480i, 576p, 576i	Options change with frame/resolution setting	
HDMI Color	RGB, Auto		
HDMI Enhance	On, Off	Set On when using a PC display	
SDI Rec Trigger	On, Off	Control via SDI	
SD Aspect	Side Cut, Letter, Squeeze	For display on 4:3 monitor	
Display on TV	On, Off		
SD Set Up	7.5%, 0	Only for NTSC-related frame rates	
HDMI Out Character	On, Off	Add menus etc to HDMI	
SDI Out Character	On, Off	Add menus etc to SDI	
Video Out Character	On, Off	Add menus etc to analogue video out	
Genlock Input	SDI, Adapter, BNC		
Genlock Adjust …			
Analog SD H Phase	-28~0~82		
SD-SDI H Phase	-373~0~373		
HD-SDI H Phase	-1024~0~1023		
Return Input	SDI, Adapter, Studio		
Return Aspect	16:9, 4:3		
Audio Set …			
Input 1 Mic Ref	-60dB, -50, -40, -30	Relevant when Input is MIC or MIC+48V	
Input 2 Mic Ref	-62dB, -56, -50, -44, -38		
Aux Gain	+12dB, +6, 0, -6, -12		
CH3/4 Input Level		Disabled when Audio is set to 2CH	
CH1/2 Ref Level	-12dB, -18, -20		
CH3/4 Ref Level	CH1/2 -12dB, CH1/2 -6, CH1/2 Link	Sets relative to CH1/2 setting	
CH1/2 Limiter Mode	Link, Separate		
CH1 Limiter …			
Threshold Level	-17dB, 15, -12, -9, -6, Off		
Attack Time	Fast, Middle, Slow		
Decay Time	Fast, Middle, Slow		
CH2 Limiter …			
Threshold Level	-17dB, 15, -12, -9, -6, Off		
Attack Time	Fast, Middle, Slow		
Decay Time	Fast, Middle, Slow		
CH3/4 Limiter Mode	Link, Separate		
CH3 Limiter …			
Threshold Level	-17dB, 15, -12, -9, -6, Off		
Attack Time	Fast, Middle, Slow		
Decay Time	Fast, Middle, Slow		
CH4 Limiter …			
Threshold Level	-17dB, 15, -12, -9, -6, Off		
Attack Time	Fast, Middle, Slow		
Decay Time	Fast, Middle, Slow		
CH1 Filter	Equalizer, Windcut, Off		
CH2 Filter	Equalizer, Windcut, Off		
CH3 Filter	Equalizer, Windcut, Off		
CH4 Filter	Equalizer, Windcut, Off		
Equalizer	+6dB ~ 0 ~ -6	5-band graphic equaliser, ±6dB	
Output CH	CH3/4, CH1/2, SW Set	What goes to Audio and HDMI	
Monitor	Mix, Stereo	Headphones feed	
Alarm Level	High, Middle, Low, Off		
Test Tone	On, Off	1kHz	

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SYSTEM menu

Item	range	comments	Pref
Record Set …			
Record Format ….			
System	HD, SD, HD+SD, HD+Web, HD (SDI in), SD (SDI in)	To slot A&B	
A Format	QuickTime(MPEG2), MP4(MPEG2), MFX (MPEG2), AVCHD, QuickTime(H.264)	Only AVC in SD	
A Resolution	1920x1080, 1440x1080, 1280x720	Changes to '720x576 or 720x480' in SD	
A Frame & Bit Rate	60p(XHQ), 60i(XHQ), 60i(UHQ), 60p(HQ), 60i(HQ), 60p(SP), 60i(SP), 60i(LP), 60i(EP), 50p(XHQ), 50i(XHQ), 50i(UHQ), 50p(HQ), 50i(HQ), 50p(SP), 50i(SP), 50i(LP), 50i(EP), 30p(XHQ), 30p(UHQ), 30p(HQ), 25p(XHQ), 25p(UHQ), 25p(HQ), 24p(XHQ), 24p(UHQ), 24p(HQ)	Content changes according to HD/SD and Resolution setting 50Mb/s XHQ, 35Mb/s VBR UHQ/HQ, 18.3Mb/2 CBR SP or 25Mb/s for 1080i. AVCHD is 28Mb/2 VBR HQ p, 24Mb/s VBR HQ I, 18Mb/s VBR SP, 9Mb/s VBR LP, 5Mb/s VBR EP	
A Audio	4ch, 2ch	Only 2ch for AVCHD	
B Format	AVCHD, QuickTime(H.264)	For HD+SD, HD+Web	
B Resolution		Content depends on other settings	
B Frame & Bit Rate			
B Audio	4ch, 2ch	Only 2ch for AVCHD	
SD Aspect	16:9, 4:3	Fixed at 16:9 in SD mode	
Rec Mode …	Normal, Pre Rec, Clip Continuous, Frame Rec, Interval Rec, Variable Frame	Options change with frame/Bit rate	
Pre Rec Time	5sec, 10, 15	Cache length	
Rec Frames	1, 3, 6		
Rec Interval	1sec, 2, 5, 10, 30, 1min, 2, 5, 10, 30, 1hour		
Variable Frame Rate		Options depend on Frame/Bit rate setting	
Slot Mode …	Series, Dual, Backup	Allows different modes in the cards, nice	
Backup Rec		Separate control of backup recording	
4GB File Spanning SDXC	On, Off	Max file size (64GB or 4 hours)	
Recording in DCIM Folder	On, Off	Use DCIM structure for QT MOV files	
Time Stamp	On, Off	Burns in Date/Time	
Clip Set …			
Clip Name Prefix		Set first 4 chars of clip name	
Reset Clip Num		Resets to 0001 (0000 in AVCHD)	
Clear Planning Metadata		Erases metadata from FTP server	
Media …			
Format Media		Format either card	
Reset Media		Rescue operation when needed	
Setup File …			
Load File …		Camera settings	
Picture File			
Scene File			
Store File ….			
Picture File			
Scene File			
Delete File …			
Picture File			
Scene File			
Tally Lamp	Internal, Studio		
Front Tally	Rec/Live Streaming, Live Streaming, Rec, Off		

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Rear Tally	Rec/Live Streaming, Live Streaming, Rec, Off		
GPS	On, Off		
Language	English, French …		
Network …	On(SDI Off), On(HDMI Off), Off		
Import Metadata			
Settings ….		All sorts of stuff to do with networks	
System Frequency	60/30/24, 50/25		
Reset All		Factory reset	
Date/Time		Enter settings	
Time Zone	UTC+14:00 ~ UTC ~ UTC-12:00		
System Information …			
Version (Camera)	0102-0028		
Version (Lens)	0105-0037		
Fan Hour	000236H		
Open Source License			

2. Measurements

All measurements were made on frames captured onto a SDHC card. In this section, I shall use the EBU system of designating scanning standards. Live viewing was done on a 24" LCD monitor supplied by JVC and on a 42" consumer grade plasma Panasonic display with 'studio' settings. Waveform monitoring was via a Black Magic Pocket Ultrascope on a PC, using the HDSDI output.

2.1. Colour performance

Colour performance was assessed visually, using ColorChecker charts. The most accurate colour rendering was obtained using the Standard gamma and matrix, as expected. The reds and skin tones were a little bright and oversaturated, but not enough to cause problems. No individual colour was markedly wrong, the pictures looked nice overall. There was no response to near infra-red.

2.2 Resolution and aliasing

All resolution measurements were made with a circular zone plate test chart. This has 6 circular patterns, each exploring the frequency space of the 1920x1080 limits of HDTV. Each pattern has DC (low frequency) at the centre, and reaches 1920 lines/picture width (960 cycles) horizontally and 1080 lines/picture height (540 cycles) vertically. There is a separate pattern to explore each of R G and B, luma (Y'), P_b and P_r. Generally, only one quadrant of each pattern is needed since it fully explores both horizontal and vertical frequency spaces.

2.2.1 1920x1080p

Figure 1 shows the luma resolution when the camera detail enhancement was switched off, the native performance of the camera in 1080 progressive scanning. The lens aperture was about F/2.5, in the centre of the expected best-performance aperture range of the lens. There is no in-band aliasing, and only very low-level aliasing centred on 1920 (horizontal) and 1080 (vertical) visible in the smaller double-frequency pattern. This indicates that the lens is delivering only low-level resolution to the camera at above the limits of HD, and that the optical low-pass filter is removing the residue. The performance is rather good because it is so clean.

Clearly the sensors are 1920x1080, and the optical low-pass filter is well-matched to this resolution with this lens.

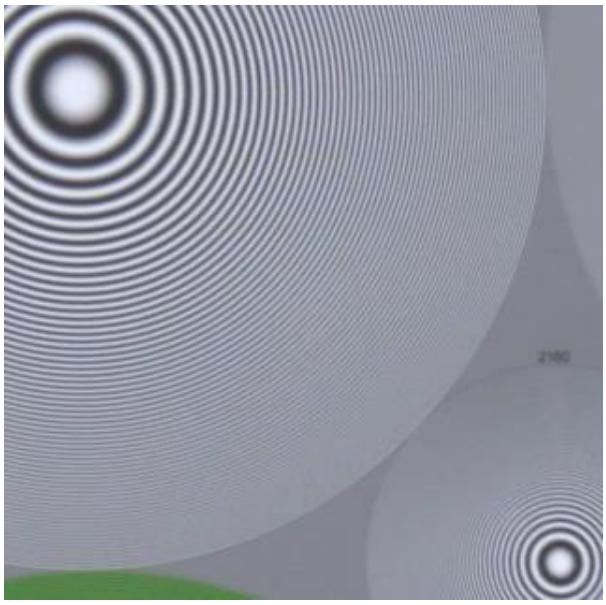

Figure 1 Resolution 1080p, Detail Off

2.2.2 1080p Detail enhancement

The camera hardly needs any enhancement, but it has some controls for detail manipulation, so they were investigated.

The detail level control goes from -10 to +10, with factory default at 0, which does not imply zero effect. Even at -10, some detail enhancement happens. *Figure 2* shows the effect of maximum detail enhancement, which should be avoided at all costs since it over-

Figure 2 Resolution 1080p, Detail +10 (Max)

brightens low frequencies and causes overshoots and ringing on high contrast edges. Setting the detail level control to between -4 and -7 produced much more pleasing pictures, suitable for video- and film-style shooting respectively.

Figure 3 shows the zone plate at zero detail level setting, which shows rather too much brightening at lower frequencies (enhancement of this sort is a hallmark of SDTV and ought not to be necessary in HDTV).

Since the sensors are small, iris diffraction starts to be visible at between F/4 and F/5.6, so the lens should not be stopped down much beyond F/5.6 for the best effect.

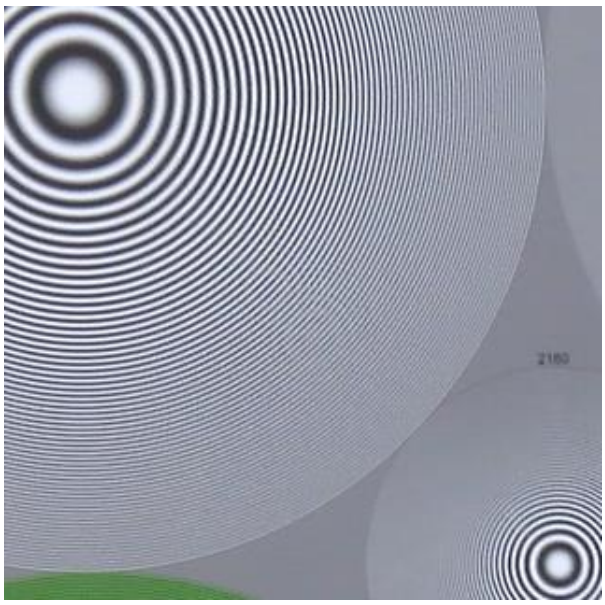

Figure 3 Resolution 1080p, Detail 0 (Mid)

Figure 4 shows the result at F/4.0 and +12dB gain with detail off. Clearly significant resolution is already being lost; F/5.6 should be regarded as the absolute limit for good HDTV production, and even F/4.0 is marginal. Fortunately, the camera has good neutral filters which should be used for exposure control, and has a viewfinder warning to use filters rather than aperture when resolution loss would become noticeable. High gain should be avoided wherever possible.

Figure 4 Resolution 1080p, +12dB F/4.0

There is further resolution loss at +24dB gain (*Figure 5*), to the extent that the pictures can no longer be described as HDTV at all. This loss could be due to a limitation in the gain-bandwidth product of the analogue head amplifiers, together with the effects of dynamic noise-reduction, and is quite normal in all cameras.

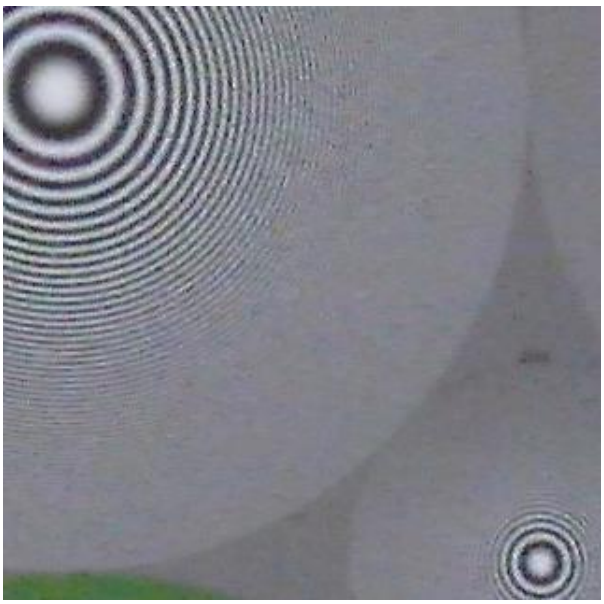

Figure 5 Resolution 1080p, +24dB F/4.0

2.2.3 1920x1080i

Figure 6 shows the resolution at 1080 interlaced, with the detail settings given in the table. The loss of vertical resolution is due to the interlaced scanning process and is quite normal.

Figure 6 Resolution 108i, Detail -4

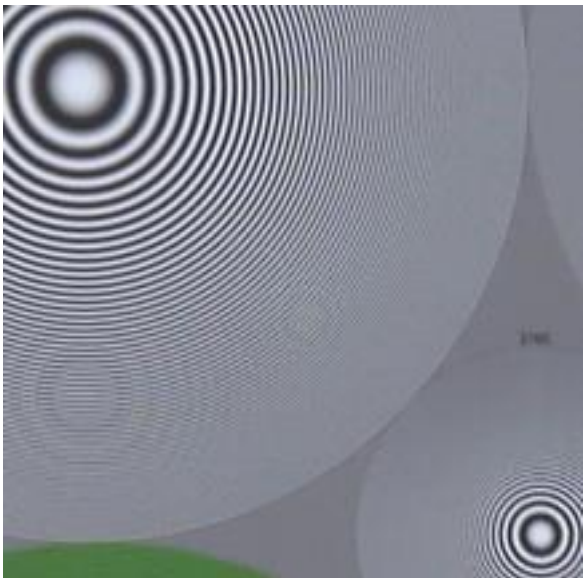

Figure 7 Resolution 720p, Detail -4

2.2.4 1280x720p

Figure 7 shows the result for 720p shooting, with the video-style detail settings. The down-conversion is quite well done; there is some inevitable aliasing centred on 1280 horizontally and 720 vertically, but the level is reasonably low, and the camera can be considered as suitable for 720p shooting providing care is taken not to use excessive detail enhancement.

2.2.5 720x576 SD

The same is true for SD resolution. *Figure 8* shows this.

Frequency content beyond the limits of SDTV are well suppressed. While there are inevitable low-level aliases due to the down conversion process, they are well suppressed provided that the detail enhancement is kept at a low level. Setting the detail level to any level higher than -4 increases the visibility of the aliases, without significantly increasing perceived sharpness.

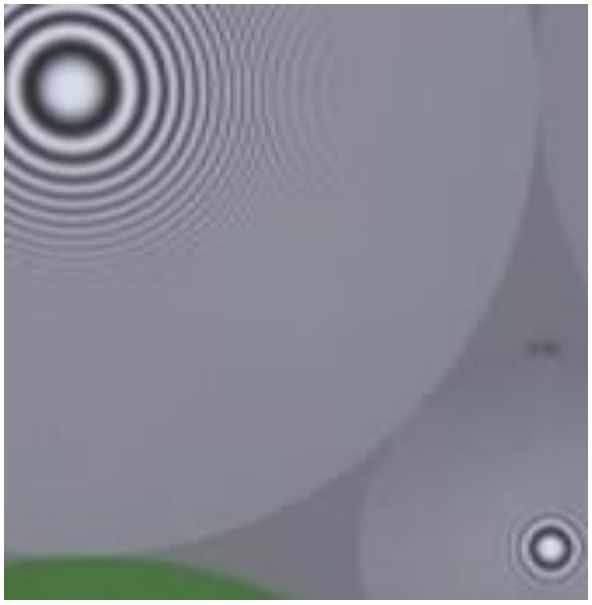

Figure 8 Resolution SD (a) Detail Off **(b) Detail -4**

2.3 Lens aberrations

In small cameras with fixed lenses, it is common to find significant lens aberrations, particularly in the image corners.

Figure 9 shows the results from one corner of a grab at mid zoom and F/2.5, 1080p, with detail off. There is hardly any displacement of the red/green/blue images, just a slight horizontal blue/yellow shift which would be invisible on normal pictures. Clearly, the automatic correction is working well. This is very good performance for a small camera.

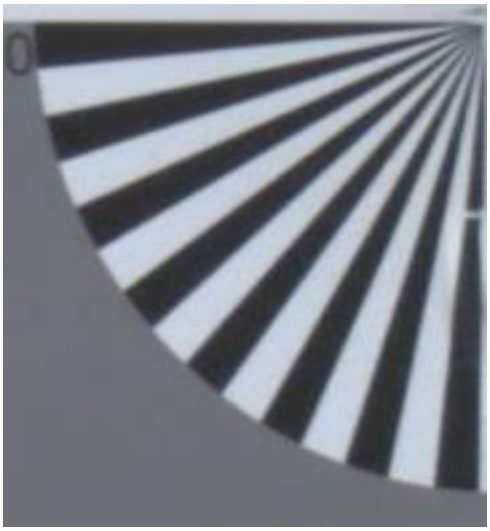

Figure 9 Lens aberration

2.4 Video Sensitivity and Dynamic Range

This camera has an unusual menu item called Shooting Mode: it has two settings, 'Standard' and 'Extended'. The effect of this control is to change the camera basic sensitivity by 6dB which would normally affect noise performance by about 3dB. The gain setting range starts at -6dB in both modes. This allows the user to make some trade-off between sensitivity and noise.

In the Shooting Mode 'Standard' setting, sensitivity at 0dB gain was measured as about F/8.0 for 2000 lux illumination of a 90% reflectance Kodak Gray card to produce 100% video level (with the knee set to 100% and clipping to 108%). In the 'Extended' setting the aperture was about F/12. Note that both these aperture settings are only approximate since aperture reporting in the camera is only in steps of ¼ or ⅓ stop. These are rather high sensitivity values for a camera with ⅓" sensors.

Using factory settings (Gain=0dB, Gamma=Standard, Shooting Mode=Standard, Toe=Off, Knee=100%), the contrast range was measured as 8.05 stops using the grey scale of a Colorchecker chart. The chart has a reflectance range of 90.01/3.13=28.76:1, about 4.84 stops, so adding this to the lens settings for clipping produces the range. At F/3.6 the white patch was just clipped, at F/11 the black patch was just distinguishable from the surround. The Toe setting reduces the range 7.75 when set to 'Compress' (Value=5) while the 'Stretch' setting (Value=5) increases it to 8.75. Setting the Knee to 85% raises the range to 8.8, and the combination of Stretch and Knee raises the range to 10.8.

Setting Shooting Mode to 'Extended', or Gamma to 'Cinema' makes very little difference, both actually reduce the range by up to half a stop.

Setting WDR (Wide Dynamic Range) to 'On' with the best combination of other settings raises the range to between 10.9 and 11 stops, which is rather good for a small-format camera.

Note that the Knee and Toe settings apply equally to both 'Normal' and 'Extended' Shooting Mode, and to both 'Normal' and 'Cinema' Gamma.

2.5 Video Noise

In a larger-format camera, the main source of video noise in a camera is the analogue circuitry of the camera's front end and the sensors themselves. But in smaller format-cameras, electronic shot-noise can dominate. In most cameras it is impossible to turn off gamma-correction to investigate this properly, and so it can be difficult to get accurate measurements. This camera is no exception; measurements were made using Standard gamma.

Video noise levels were measured by capturing defocused exposures of a grey-scale card with six patches, at two exposure levels to cover the dynamic range. The camera was set to 'Standard' gamma curve, 0dB gain, detail off, 1080P HQ mode, MXF format. *Figure 10* shows the results of using Standard and Extended Shooting Mode. It would be unwise to read too much significance into the fine detail of these measurements, noise is difficult to measure accurately.

Normally, the noise level should follow the slope of the camera gamma curve, with at least 10dB difference between the level near white where the gamma slope is about ⅓ and near black where the slope is 4.5, an

extreme range of about 22dB. Also, there should be a general difference of about 3dB between these two sets of curves, due to the gain difference.

Obviously, that is not happening here. There are two probable reasons:

- Shot noise rises with signal level, having a square power curve which counteracts the slope of the square root-type gamma curve. This is a fundamental electronic effect often seen in cameras with small sensors. Normally this effect is secondary to the normal rise in noise towards black.
- The camera has electronic noise reduction permanently in place, which is flattening the noise profile to some extent.

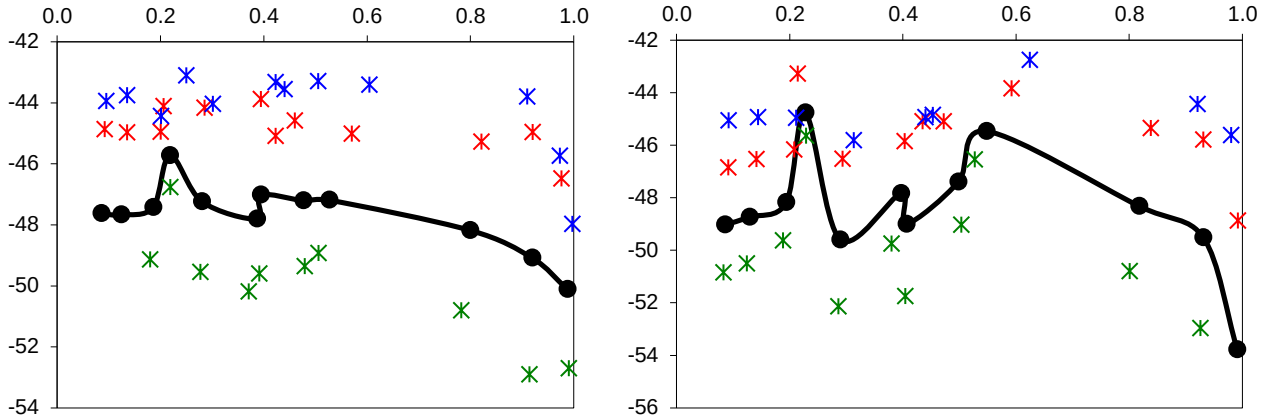

Figure 10 Noise distribution (a) Standard mode (b) Extended mode

It seems likely that shot noise and gamma-correction noise are reasonably well balanced here, since the noise distribution is fairly flat. The sharp drop near peak signal is due to clipping. Taking the luma channel noise levels around mid-grey (50%), the values are both about -48dB although it is not consistent across the distributions. The distribution of noise does not follow the slope of the gamma-correction in either case, all of which is fairly firm evidence for the presence of both shot noise and significant noise reduction in the camera (which has the effect of setting the noise level independent of gain). The visual character does not entirely coincide with these measured results, because the noise near black (where it should be at highest level) is being most heavily reduced. This should have the effect of reducing the resolution or detail near black, which seems to be quite acceptable.

However, noise levels should change with gain level, by 3dB per 6dB of gain. *Figure 11* shows how the noise levels change with gain. The signal level was about 50% for each measurement point.

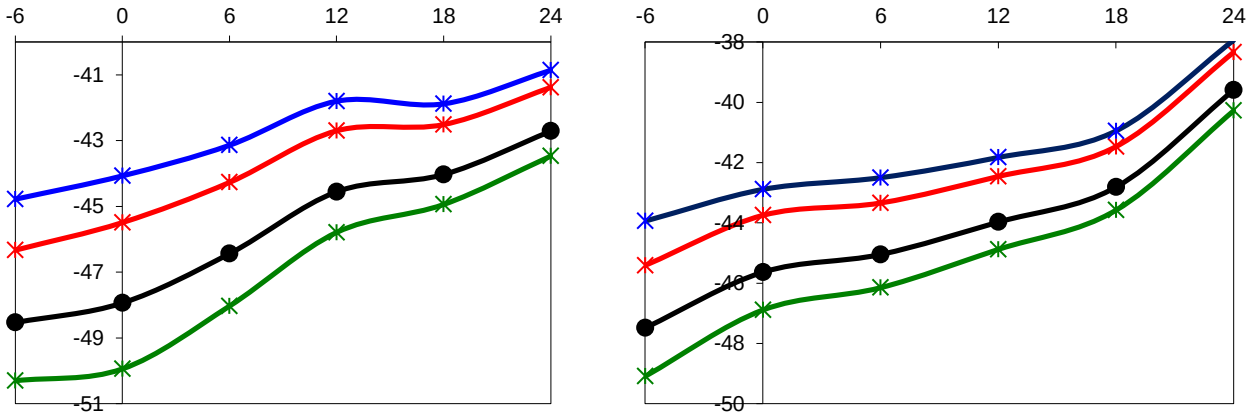

Figure 11 Noise distribution (a) Stadard mode (b) Extended mode

The slope is fairly consistent, 3dB noise per 6dB of gain, which probably indicates that any noise reduction is fairly progressive, increasingly powerful as the gain increases, which is borne out by the resolution loss shown in *Figure 3*.

Nevertheless, the mid-grey (30~60% video level) noise level at 0dB gain is about -48dB in Standard Mode, about -46dB in Extended Mode. These are creditable figures for a camera in this category. Lowering the camera gain setting to -6dB produces a significant change in noise levels which is worth doing because the pictures appear to be subjectively 'cleaner' since the noise reduction does less harm to the resolution..

2.2 Rolling Shutter effects

The camera has CMOS sensors and can therefore be expected to show geometrical distortion on moving objects, the 'rolling shutter effect' since the CMOS is read sequentially, or scanned. It is not inevitable that this should be so, it is perfectly possible to design CMOS sensors with a 'global' shutter in which the entire image is read in one instant, but this is more complex and expensive.

The camera was exposed to a small electric fan, speed-adjusted to strobe with the television scanning rate. *Figure 12* shows part of one frame, with the shutter set to 1/500 second. The blade on the left (going up) is shrunk in width by about 50% while that on the right (going down) is at least doubled in width. This indicates that there are no processing tricks in the camera to ameliorate the effect. So 'flash-banding' ought to be a problem, where stills-camera flashes will illuminate only a part of the field or frame, and intra-frame motion may be disturbing. The effect is the same for both progressive and interlaced scanning.

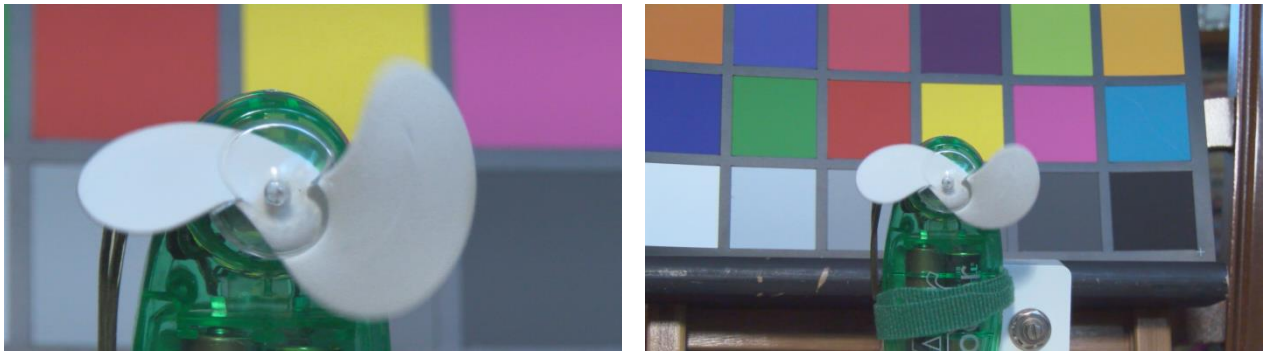

Figure 12 Rolling shutter images, rotating fan, full frames

Both images are full video frames, showing that the distortion is greatest when the motion fills the frame height. Distortion of this magnitude is not unusual, and certainly not excessive.

Flash photography can cause partial over-exposure if the flash exposure is not synchronised with the field/frame scanning process.

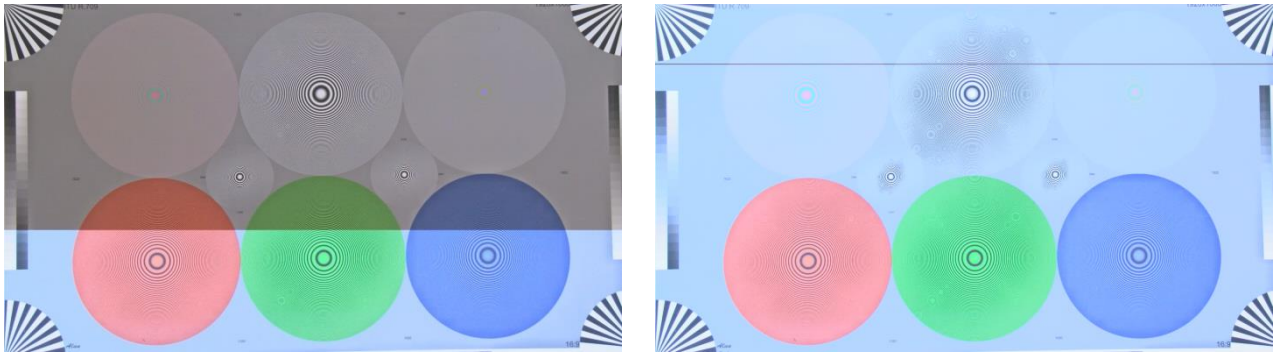

Figure 13 Flash exposure, leading field (a) uncorrected (b) corrected

Figure 13 shows over-exposure from an electronic flash from a stills camera, without and with correction. On the left, the flash has gone off part way down the picture and highly overexposed the lower part of the video image, but on the right, the correction has detected that this has happened and greatly increased the gain in the upper, normally exposed, part of the video field or frame to match the lower, overexposed, part. This works very well, and the sharp line marking the join between the over-exposure and the artificially gain-increased part is not visible in practice since it exists on only one field or frame.

However, if the flash duration is longer than the video image rate, then the flash will spill over into two fields or frames, and the second one is not corrected. *Figure* 14 shows this, where the field in which the flash starts has been corrected, but that in which it ends is not. This effect is not noticeable when viewed at normal video speed, it becomes apparent only when the footage is stepped through, one frame at a time.

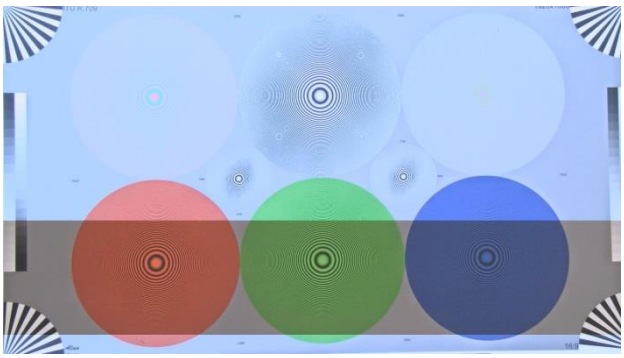

Figure 14 Flash exposure, trailing field

3 Conclusion

The camera appears to qualify easily for EBU R.118 Tier 2J (Journalism). The noise level is acceptable, probably because of noise reduction, but is comfortably inside the target level of -44dB.

It can record up to 1920x1080 50Hz and 59.94Hz progressive with 4-channel audio. It cannot record MPEG2 at 50Mb/s, the highest rate is 35Mb/s VBR. However, it can record AVCHD (MPEG4 at up to 28Mb/s) which might be acceptable for broadcast, subject to testing. It can also record 1920x1080p/50 in H.264 at 50Mb/s which is highly unusual, and should be tested separately.

It can record externally via HDSDI, although only to 8-bit 4:2:2 rather than 10-bit 4:2:2 precision, which means that the coder can be properly tested although that is beyond the scope of these tests.

Resolution is good, alias levels are very low, and both 720P and SD performance is acceptable which is quite unusual in any HD camera.

The total dynamic range of up to about 11 stops is rather good for a camera of this size.

Motion artefacts are as expected for a CMOS camera with a ‘rolling shutter’, but the Flash Band Correction can ameliorate problems from electronic flash photography.