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

Alan Roberts, November 2012

SUPPLEMENT 005 : Assessment of a Sony PMW 200 camera

Tests were made on a production model of the Sony PMW-200 HDTV camcorder (serial number 400033) and its manual. Outwardly it appears to be very similar to the PMW EX1, and shares many features with it.

The camera has an integral lens (Fuji, F/1.9, 14:1 5.8~81.2mm) and records onto solid-state storage SxS cards (or other card types via adaptors). The lens has conventional 3-ring control, with manual or automatic operation, but the rings are 'real' in that they directly control the lens and have calibration markings. It has 3 ½" CMOS sensors of 1920x1080 pixels, and therefore should qualify fully as an HDTV camera. Recording HDTV uses MPEG2, 10-bit 4:2:2 1920x1080 at 50Mb/s, 8-bit 4:2:0 1920x1080 at 35Mb/s (with variable bit rate, maximum 35Mb/s), 8-bit 1440x1080 4:2:0 at 35Mb/s (VBR), 8-bit 1280x720 at 35Mb/s VBR, and 8-bit 1440x1080 at 25Mb/s VBR. All the 1080-line modes can be progressive or interlaced at frame rates from 23.976 to 29.97Hz, and 720P up to 60Hz. It can also record in standard SDTV modes, DVCAM. Note that the 50Mb/s mode cannot be used if recording is onto a SDHC card in an adaptor, it must be a proper SxS card (ExpressCard or XQD card via an adaptor) for this mode.

The camera is quite light (about 2.7kg in including battery) and has an integral monocular viewfinder (852x480) and top-handle mounted screen (3½" LCD, 852x480), and seems aimed at the high-end professional and full broadcast markets. It has gen-lock and time-code input and outputs, a WiFi adaptor and remote control socket, so may well be usable in multi-camera shoots. Power consumption is about 12 watts at 14.4 volts.

Variable speed recording is possible, from 1 frame/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 (components and SD-composite via a multi-pin connector which is specific to Sony cameras) and digits via IEEE1394 iLink/Firewire in HDV format, USB-2 for data file transfer, HDMI and 10-bit HDSDI.

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 9.5-stop dynamic range. The recommended settings allow about 2.5 or 1.5 stops of over-exposure relative to normal operation. This is not quite as good as can be achieved in ⅔" cameras, and arises from the difference in pixel size (the pixels here are smaller, so sensitivity is maintained at the expense of highlight handling and video noise) and high sensitivity specifcation.

The 720p mode is very clean and should be the best way to shoot should the camera be expected to produce an SD output.

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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 recommending settings. Virtually all picture control is in the **Profile** menus.

This is not intended as a replacement for reading the manual.

1 Switches and Menu settings

SWITCHES, SOCKETS and BUTTONS

name	place	feature	comment
Headphones	Left	Socket	
White Balance	Left lower front	Push	
Audio inputs	Top right	XLR Sockets	
Play/Pause	Handle panel	Push	
F.Rev	Handle panel	Push	Fast reverse
F.Fwd	Handle panel	Push	Fast forward
Thumbnail	Handle panel	Push	
Stop/Cam	Handle panel	Push	
Prev	Handle panel	Push	Previous
Menu	Handle panel	Push	
Next	Handle panel	Push	
LCD Bright	Handle panel	Push	
Display/Batt Info	Handle panel	Push	
Monitor volume	Handle panel	Push/Push	Up/down buttons
Cancel	Handle panel	Push	
Duration/TC/U-BIT	Handle panel	Push	
Zoom	Handle	Rocker	
Zoom speed	Handle	Switch	Zoom speed/Off
Rec Start/Stop	Handle	Push	
Rec Hold	Handle	Switch	
Focus Ring	Lens	Rotate	Lens
Zoom Ring	Lens	Rotate	
Iris Ring	Lens	Rotate	
Iris	Lens	Switch	
Focus	Lens	Switch	
ND filter	Lens	Switch	
Macro	Lens	Switch	
Focus	Lens	Switch	
Push AF	Lens	Push	
Assign 1 to 5	Left	Push	User buttons
Full Auto	Left	Push	
Picture profile	Left	Push	
Audio In	Left	Switches	Internal/External
Audio Select	Left	Switches	Auto/Manual
Audio Level Ch1-Ch2	Back		
Shutter On/Off	Left	Switch	
Gain	Left	Switch	Manual control/indicator
White Balance	Left	Push	

Menu	Left	Push	
Sel/Set	Left	Jog dial	
Cancel	Left	Push	
SxS Card slot (2 off)	Left	Socket/Push	
USB-2 (data transfer)	Back	Socket	
1394 connector (HDV)	Back	Socket	
Analogue component	Right	Socket	Proprietary format mini-connector
A/V Out	Right	Socket	Another proprietary mini-connector
HDSDI output	Back	BNC Socket	
HDMI output	Back	BNC Socket	
TC I/O	Back	BNC Socket	
Gen-lock I/O	Back	BNC Socket	
External device	Back	Socket	
Rec Review	Right	Push	
Zoom	Right	Rocker	
Expand focus	Right	Push	
Lens remote control	Right front	Socket	
Zoom	Bottom	Switch	
Power	Back	Switch	
DC In	Back	Socket	

CAMERA SET menu

Basic camera settings

Item	range	comments	Pref
Gain setup	-3, 0, 3, 6, 9, 12, 15, 18dB	Set gain for each position of the gain switch	0, 6, 9
Shutter	Speed, Angle, ECS, SLS		
Shutter Speed	1/100	Speed options depend on frame rate	
Shutter Angle	11.25, 22.5, 45, 72, 86.4, 90, 144, 150, 172,8, 180, 216		
ECS Frequency	60.00	Range depends on frame rate	
SLS Frame	2~8	Number of frames accumulated in Slow Shutter	
EX Slow Shutter	On, Off	Extreme slow shutter mode	
Frames	16, 32, 64		
MF Assist	On, Off	Allows fine auto focus control when in Manual	
Color Bars	Camera, Bars		
	Multi, 75%, 100%, SMPTE		SMPTE[1]
Flicker reduce	Auto, On, Off	Supposed to reduce lighting flicker	
Frequency	50, 60Hz	Lighting frequency	
Zoom Speed		Zoom speed for handle zoom control	
High	1 ~ 70 ~ 99	High setting	
Low	1 ~ 30 ~ 99	Low setting	
Remote	1 ~ 50 ~ 99	IR Remote controller setting	
Zoom Transition	Linear, Soft	Zoom start/stop effect	
Interval Rec	On, Off	Stop-frame recording, see manual for details	
Interval Time	1 ~ 10, 15, 20, 30, 40 50 sec, 1 ~ 10, 15, 20, 30, 40, 50 min, 1 ~ 4, 6, 12, 24 hour	1 second to 24 hours	
Number of Frames	1, 3, 6, 9	(2, 6, 12 frames in 720p)	
Frame Rec	On, Off		
Number of Frames	1, 3, 6, 9	(2, 6, 12 frames in 720p)	
Clip Cont. Rec	On, Off	Clip continuous recording	
P. Cache Rec	On, Off	Picture cache recording	
Rec Time	0~2.2~4, 4~6, 6~8, 8~10, 13~15 sec	Defaults to system frame rate	
S&Q Motion	On, Off	Slow and Quick Motion, under/over-cranking	
Frame Rate	1 ~ 60	Defaults to system frame rate	
Rec Review	3sec, 10sec, Clip	Clip plays back entire clip	
TLCS		Total Level Control System, Iris/Gain/Shutter	
Level	+1, +0.5, 0, -0.5, -1	Auto Iris stop override	
Mode	Backlight, Standard, Spotlight		
Speed	-99 ~ 50 ~ 99	Shifting speed	
AGC	On, Off	Automatic gain control	
AGC Limit	3, 6, 9, 12, 18dB	Maximum gain AGC can take	12
AGC Point	F/5.6, F/4, F/2.8	Point at which auto-iris/shutter starts in AGC	F/2.8

[1] SMPTE or Multi bars are acceptable, Multi appears to be ARIB.

Auto Shutter	On, Off		
A.Sht Limit	1/100, 1/150, 1/200, 1/250	Set shortest shutter	
A.Sht Point	F/5.6, F/8, F/11, F/16	Point at which iris/shutter starts in Auto Shutter	F/5.6[2]
Shockless White	Off, 1, 2, 3	Speed of white balance response when changed	
White Switch <B>	ATW, Mem	Assign ATW or Memory to white balance position B	
ATW Speed	1, 2, 3, 4, 5	1=slow, 5=fast	
ATW Mode	Natural, Pure		
Wide Conversion	On, Off	Use with lens Wide Angle adaptor	
Steadyshot	On, Off	Set Off when on a tripod	
Image Inversion	Normal, H inv, V inv, Both		
Auto Black Bal.	Execute, Cancel		

AUDIO SET menu

Item	range	comments	Pref
Audio Input			
Ch 3 Input Source	Internal, External		
Ch 4 Input Source	Internal, External		
Ext Mix Ch1 Ref	-70, -60, -50, -40, -30dB		
Ext Mix Ch2 Ref	-70, -60, -50, -40, -30dB		
Int Mic Level	-12, -6, 0, +6, +12dB		
Limiter Mode	Off, -6, -9, -12, -15, -17dB		
AGC Spec	-6, -9, -12, -15, -17dB		
Ch1&2 AGC Mode	Mono, Stereo		
Ch3&4 AGC Mode	Mono, Stereo, Off		
1kHz Tone	On, Off	Add tone to bars	
Wind Filter Ch-1	On, Off		
Wind Filter Ch-2	On, Off		
Wind Filter Ch-3	On, Off		
Wind Filter Ch-4	On, Off		
Ext Ch Select	Ch1, Ch1/2	Mono/stereo recording	
Audio Output			
Monitor Ch	Ch1/Ch2 (Ch3/Ch4), Ch1+Ch2 (Ch3+Ch4), Ch1 (Ch3), Ch2 (Ch4)	What goes to the speaker and phones	
Output Ch	Ch1/Ch2, Ch3/Ch4	Output pairs	
Alarm Level	0 ~ 4 ~ 7	Alarm volume level	
Beep	On, Off		

VIDEO SET

Item	range	comments	Pref
Input Source Select	Camera, i.Link		
SDI/HDMI.i.Link I/O		Lots of combinations, depending on recording format	
SDI/HDMI Vid Super	On, Off	Outputs menus etc.	
Down Converter	Squeeze, Letterbox, Edge Crop	SD Aspect ratio	Squeeze
23.98P Output	59;.94i (2-3 pulldown), 23.98PsF		
SDI Rec Control	Off, HDSDI Remote I/F		

LCD/VF SET

Item	range	comments	Pref
LCD		Side panel controls	
Color	-99 ~ 0 ~ 99		
Contrast	-99 ~ 0 ~ 99		
Brightness	-99 ~ 0 ~ 99		
EVF		Monocular viewfinder	
Backlight	High, Low		
Mode	Color, B&W		
Contrast	-99 ~ 0 ~ 99		
Brightness	-99 ~ 0 ~ 99		
Power	Auto, On	Auto switches it off when lcd is folded out	

[2] Stopping down beyond F/5.6 can cause visible softening due to iris diffraction. This is normal for this sensor size.

Peaking	On, Off	Artificial sharpening	
Color	White, Red, Yellow, Blue	Show emphasised edges in this colour	
Level	High, Mid, Low		
Marker	On, Off		
Safety Zone	On, Off		
Safety Area	80, 90, 92.5, 95%		
Center Marker	On, Off	Small square corners	
Aspect Marker	Line, Mask, Off		
Aspect Select	4:3, 13:9, 14:9, 15:9, .66:1, 1.85:1, 2.35:1, 2.4:1		14:9
Aspect Mask	90, 80, 70, 60, 50, 40, 30, 20, 10, 0%		
Guide Frame	On, Off	Cross hatch in thirds	
Zebra	On, Off	Exposure metering	
Zebra Select	1, 2, Both		
Zebra 1 Level	50 ~ 70 ~ 107	Zebra 2 is 100%[3]	65 {f} 80{v}
Display On/Off		What appears in the viewfinder	
Video Level Warnings	On, Off	Warns if too dark or bright	
Brightness Display	On, Off	Light meter	
Histogram	On, Off	Brightness level distribution	
Lens Info	Meter, Feet, Off	Depth of field indicator[4]	
Zoom Position	Number, Bar, Off		
Audio Level Meter	On, Off	Audio meters	
Timecode	On, Off		
Battery Remain	On, Off		
Media Remain	On, Off		
TLCS Mode	On, Off		
Steady Shot	On, Off		
Focus Mode	On, Off		
White Balance Mode	On, Off		
Picture Profile	On, Off		
Filter Position	On, Off		
Iris Position	On, Off		
Gain Setting	On, Off		
Shutter Setting	On, Off		
Rec Mode	On, Off	Frame Rec, Interval Rec, Slow/Quck	
Video format	On, Off		
Clip Name	On, Off		
Clip Number (PB)	On, Off		
SDI Rec Control	On, Off		
Wide Conversion	On, Off		

TC/UB SET menu

Timecode etc

Item	range	comments	Pref
Timecode			
Mode	Preset, Regen, Clock	Clock=clock time	
Run	Rec Run, Free Run		
Setting		Set timecode	
Reset	Execute, Cancel	Reset to zeroes	
TC Out	Auto, Generator		
Users Bit			
Mode	Fix, Date	Date=current date	
Setting		Set what you like	
TC Format	DF, NDF	Drop Frame for NTSC speeds	

OTHERS menu

Item	range	comments	Pref

[3] Zebra 2 is always 100%. Use this if the shoot will have no grading. Zebra 1 is best for judging skin tones, set it lower for film-look.

[4] Not sure I believe this from reading the manual, I guess it's actually the focus distance, but I could be wrong.

All Reset		Execute, Cancel	Back to factory settings	
Camera Data			Keep menu settings on SxS card	
Store		Execute, Cancel		
Recall		Execute, Cancel		
Time Zone		UTC-12:00 ~ +13:30	Select local time relative to original setting	
Clock Set			This comes up every time the camera powers up until you set the time/date	
12H/24H		12H, 24H		
Date Mode		YYMMDD, MMDDYY, DDMMYY		
Language		English, Chinese, Japanese	How do you get back if you select a language you can't read? ☺	
Assign Buttons		Off, Zebra, Peaking, Marker, Last Clip Del, ATW, ATW Hold, Rec Review, Rec, Picture Cache, Freeze Mix, Expanded Focus, Spotlight, Backlight, IR Remote, Shot Mark 1, Shot Mark 2, VF Mode, BRT Disp, Histogram, Lens Info, OK Mark, Clip Flag OK, Clip Flag NG, Clip Flag Keep, Clip Continuous Rec, LCD/VF Adjust, Color Bars, One Push Auto-Iris	Assign any to buttons 1~5 Factory defaults are: Button1=Zebra Button 2=Peaking Button 3=Off Button 4=Off Button 5=Off	
Tally		High, Low, Off	Record lamps	
Hours meter			Usage hours meters display	
Hours (Sys)			Elapsed usage hours from new	
Hours (Reset)			Resetable meter	
Reset		Execute, Cancel	Reset Hours (reset) to zero	
IR Remote		On, Off	Enable remote control, sets Off at power up	
Battery Alarm			Set the warning levels	
Low Batt		5, 10, 15, ~ 45, 50%	Level at which "Low Batt" warning happens	
Batt Empty		3 ~ 7%	Empty warning	
DC Low Volt1		11.5 ~ 17V	Alarm levels for DC input	
DC Low Volt2		11.0 ~ 14V		
Battery Info		Displays	Shows type, manufacturer, number of charge cycles, estimated remaining time, voltage etc	
Genlock				
H Phase (HD)		-999~0~999	Horizontal fine phase	
H Phase (SD)		-99~0~99	Horizontal fine phase	
Direct Menu		All, Part, Off	Gives limited access to menus	
Trigger Mode		Internal, Both, External	Controls external recorder via i.Link	
System				
Country		NTSC Area, NTSC (J) Area, PAL Area	Sets between 59.94 and 50Hz, and black setup	PAL Area
UDF/FAT		UDF, FAT		UDF[5]
HD/SD		HD, SD		
Format			Select the recording format	
NTSC (J) Area	UDF	HD422 50/1080/59.94i, HD420 HQ/1080/59;94i, HD422 50/1080/29.97P, HD420 HQ/1080/29;97P, HD420 50/1080/23.98P, HD420 HQ/1080/23.98P, HD422 50/720/59.94P, HD420 HQ/720/23.98P, HD422 50/720/29.97P, HD422 50/720/23.98P, HD420 HQ/720/23.98P, DVCAM69.94 SQ, DVCAM59.94i EC, DVCAM59.97 SQ, DVCAM29.97P EC	SQ=squeeze, EC=edge crop	[6]
	FAT	HQ 1920/59.94i, HQ 1440/59..94i, SP 1440/59.94i, HQ 1920/29.97P, HQ 1440/29.97P, HQ 1920/23.98P, HQ 1440/23.98P, SP 1440/23.98P, HQ 1280/59.94P, HQ 1280/29.97P, HQ 1280/23.98P, DVCAM59.l94i SQ, DVCAM59;.94i EC, DVCAM29.97P SQ, DVCAM29.l97 EC		
PAL Area	UDF	HD422 50/1080/50i, HD420 HQ/1080/50i, HD422 50/1080/25P, HD420 HQ1080/25P, HD422 50/720/50P, HD420 HQ/720/50P, HD422 50/720/25P, DVCAM50i SQ, DVCAM50i EC, DVCAM25P SQ, DVCAM25P EC		
	FAT	HQ 1920/50i, HQ 1440/50i, SP 1440/50i, HQ 1920/25P, HQ 1440/25P,		

[5] EDF isn't available when recording to SDHC card in an adaptor, which means you can't get the 50Mb/s mode.

[6] The EBU's preferred nomenclature is to describe the frame dimensions first, followed by a letter to indicate interlace or progressive, then a right slash and the frame rate. Thus, what is here called HQ 1080/50i would be called, by the EBU, 1920x1080i/25.

	HQ 1280/50P, HQ 1280/25P, DVCAM50i SQ, DVCAM50i EC, DVCAM25P SQ, DVCAM25P EC		
Clip	nnn_	Set first 4 characters of clip names	
Auto Naming	C****, Title, Plan		
Title Prefix		4~46 character name	
Number Set	0001 ~ 9999	The second set of 4 characters	
Update Media	Execute, Cancel	Update managerial file on card slot A or B[7]	
Last Clip DEL	Execute, Cancel		
All Clips DEL	Execute, Cancel	Wipe the lot, except clips marked “OK”	
Filter Clips	OK, NG, KP, None		
Lock All Clips	Execute, Cancel		
Unlock All Clips	Execute, Cancel		
Index Picture Pos	0sec ~ 120sec	Time offset to thumbnail	
Find Mode	Clip, Rec Starr	What happens when you press Prev/Next	
Copy All	Clips, General Files, Clips&General	Copy to SxS card	
Format Media	Execute, Cancel	Format card slot A or B	
Plan.Metadata	Execute, Cancel	Load planning metadata from SxS card	
Load/USB	Load, USB	Load planning metadata from USB	
Properties	Execute, Cancel	Show data	
Clear	Execute, Cancel	Reset data	
Clip Name Disp	Title 1 (ASCII), Title 2 (UTF-8)	Display mode	
Network			
DHCP	Enable, Disable		
IP Address	192.168.1.0	Set when HDCP disabled	
Subnet Mask	255.255.255.0	Set when HDCP disabled	
Default Gateway	0.0.0.0		
User Name	admin		
Password	pmw-200		
Set	Execute, Cancel	Go and do it	
MAC address		Display only	
Net Config Reset	Execute, Cancel		
WiFi			
Scan Networks	Execute, Cancel		
SSID	Reset	Reset network connection name	
Network Type	Infra, Adhoc		
Ch	1 ~ 11	Set when Adhoc	
Authentication	Open, Shared, WPA, WPA2		
Encryption	Disable, WEP	Different options for WPA/WPA2	
WEP Key Index	1, 2, 3, 4		
Input Select	ASCII5, ASCII13, HEX10, HEX26	Different options for TKIP or AES	
Key Network		Set security key	
Set	Execute, Cancel		
WiFi Status		Display	
Wireless Mode	802.11b, 802.11g, 802.11n		
WiFi Enable	Enable, Disable		
Version		Display camera software version	
Version Up	Execute, Cancel	Update, only when SxS card is inserted	
Menu Scroll	Normal, Loop		

[7] If a clip becomes unplayable, updating the managerial file might fix it, or not, it all depends.

PICTURE PROFILES menus, default settings

Camera control

item	range	comments	BBC
PP1			
PP2			
PP3			
PP4			
PP5			
PP6			

PICTURE PROFILES menus, manual settings

Camera control

item	range	comments	BBC
Profile Name		8 characters, alphanumerics	
Matrix	On, Off		On
Select	1, 2, 3, 4, 5, 6	2 for ITU709, 3 for SMPTE wide, 4 for NTSC, 5 or 6 for PAL	2
Level	-99 ~ 0 ~ 99	Saturation	
Phase	-99 ~ 0 ~ 99	Hue	
R-G	-99 ~ 0 ~ 99	Roll your own matrix	
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		
Multi Matrix mode	Multi Matrix, Color Correction		
Multi Matrix	On, Off		
Area Indication	On, Off	Zebra to identify target colour	
Color Detection	Execute, Cancel		
Axis	B, B+, MG-, MG, MG+, R, R+, YL-, YL, YL+, G-, G, G+, CY, CY+, B-	16 colour sectors	
Hue	-99 ~ 0 ~ 99	Tweak the sector contents	
Saturation	-99 ~ 0 ~ 99		
Color Correction	On, Off	Direct control over one colour only	
Area Detection	Execute, Cancel	Detect colour in the centre marker	
Area Indication	On, Off	Zebra1 lights up at the selected colour	
Target Phase	0 ~ 130 ~ 359	Colour phase, degrees	
Target Width	0 ~ 40 ~ 90	Width in degrees	
Level	-99 ~ 0 ~ 99	Saturation	
Phase	-99 ~ 0 ~ 99	Hue shift	
White	On, Off	Manual control over white balances	
Offset <A>	-99 ~ 0 ~ 99	Drive bluish to reddish	
Offset <B>	-99 ~ 0 ~ 99		
Offset <ATW>	-99 ~ 0 ~ 99		
Preset White	2100 ~ 3200 ~ 10000	Nominal colour temperature in 100K steps	
HD Detail	On, Off		On {v}, Off {f}
Level	-99 ~ 0 ~ 99		0 {v}[8]
Frequency	-99 ~ 0 ~ 99		+99
Crispening	-99 ~ 0 ~ 99	Noise suppression	0[9]
H/V ratio	-99 ~ 0 ~ 99	-99=horizontal only, 99=vertical only	0
White Limiter	-99 ~ 0 ~ 99	Limit white overshoots	0
Black Limiter	-99 ~ 0 ~ 99	And black overshoots	0
V DTL Creation	NAM, Y, G, G+R		
Knee APT Level	-99 ~ 0 ~ 99	Sharpen edges that would be lost above the knee	0
SD Detail	On, Off		
Level	-99 ~ 0 ~ 99		
Frequency	-99 ~ 0 ~ 99		
Crispening	-99 ~ 0 ~ 99	Noise suppression	
H/V ratio	-99 ~ 0 ~ 99	-99=horizontal only, 99=vertical only	
White Limiter	-99 ~ 0 ~ 99	Limit white overshoots	
Black Limiter	-99 ~ 0 ~ 99	And black overshoots	

[8] HD detail could be useful for a film look, but use sparingly, it's vicious. Null action is at about -42, so lower values will soften the pictures. -60 looks nice for film.

[9] This may need adjusting if the camera is used at high gains, set the level to avoid sharpening noise.

V DTL Creation	NAM, Y, G, G+R		
Knee APT Level	-99 ~ 0 ~ 99	Sharpen edges that would be lost above the knee	
Skin Tone Detail	On, Off		Off
Level	-99 ~ 0 ~ 99	Selected skin tone detail level	
Area Detection	Execute, Cancel	Detect colour in the centre marker	
Area Indication	On, Off	Zebra1 lights up at the selected colour	
Saturation	-99 ~ 0 ~ 99	Manual skin saturation	
Phase	0 ~ 130 ~ 359	Manual colour phase, degrees	
Width	0 ~ 40 ~ 90	Manual width, degrees	
Aperture	On, Off	Aperture correction	On
Level	-99 ~ 0 ~ 99		0
Knee	On, Off	Compress overexposure	On {v}, Off {f}
Auto Knee	On, Off	Auto or manual	Off
Point	50 ~ 90 ~109%	Manual knee break point	85[10]
Slope	-99 ~ 0 ~ 99		-14
Knee Sat	On, Off		
Knee Sat Level	0 ~ 50 ~ 99		
White Clip	On, Off		Off
Level	90 ~ 105 ~ 109%		
Gamma	-99 ~ 0 ~ 99		
Select	Std1, Std2, Std3, Std4, Std5, Std6, Cine1, Cine2, Cine3, Cine4	Std5=ITU709, STD6 is probably BBC 0.4[11]	Std5 {v}, Cine1 {f}
Black	-99 ~ 0 ~ 99	No calibration: cap the camera and use waveform monitor or Histogram to set black level	
Black Gamma	-99 ~ 0 ~ 99	Black stretch, use when noise level is low	0[12]
Low Key Sat	-99 ~ 0 ~ 99	Saturation control for dark colours, reduce when noise is high	0[13]
Copy		Copy one profile into another	
PP Data			
Store	Execute, Cancel	Save/recall profiels on SxS card	
Recall	Execute, Cancel		
Reset	Execute, Cancel	Factory reset this profile	

[10] Setting level to 85%, slope to -14 gives 1.5 stops headroom, 75% slope +10 gives 2.5 stops.

[11] Descriptions in the manual seem to fit the idea that these curves are directly copied from other cameras, where Std5=ITU709, Std6=BBC0.4; Std1 has lowest slope near black (for low noise and black-crushing) like a consumer camcorder; Std2has decent gain near black (4.5), Std3 looks like SD ENG, Std4 is SMPTE240M (the old analogue HD standard). 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.

[12] *Black stretch* (positive values) should be needed only under exceptional conditions, unless the lower-slope Std gamma curves are used, and will increase the noise level. With negative levels, black-crushing will happen, which may be a solution when operating with high video gain levels.

[13] *Low Key Sat* is useful when video noise levels are high, use a negative amount.

2 Measurements

All measurements were made on frames captured onto a SDHC card using an SxS adaptor, no SxS card was immediately available at the time. Therefore, recordings were made at 35Mb/s rather than the top-end 50Mb/s. I do not expect the test results to be affected by this, except for possible slight differences in noise levels. In this section, I shall use the EBU system of designating scanning standards. Live viewing was done on a 32" Grade 1 HDTV CRT monitor and a digital waveform monitor, via the HDSDI output.

2.1 Colour performance

Colour performance was assessed visually, using ColorChecker charts. The most accurate colour rendering was obtained using matrix 2 (ITU.709) and Std5 gamma curve (also ITI. 709). The yellow and orange patches were a little desaturated and hues shifted towards green, and the reds and pinks a little over-saturated, but otherwise there was no single colour error large enough to cause a problem. Since there were no "rogue" colours, no further investigation was needed.

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 1920x1080

Figure 1 shows the luma resolution when the camera detail enhancement was switched off, the native performance of the camera in 1080 progressive scanning. There is no in-band aliasing, and only low-level aliasing centred on 1920 (horizontal) and 1080 (vertical) visible in the smaller double-frequency pattern. This indicates that the lens is delivering some resolution to the camera at twice HD resolution, and that the optical low-pass filter is not quite removing it. Nevertheless, the performance is good.

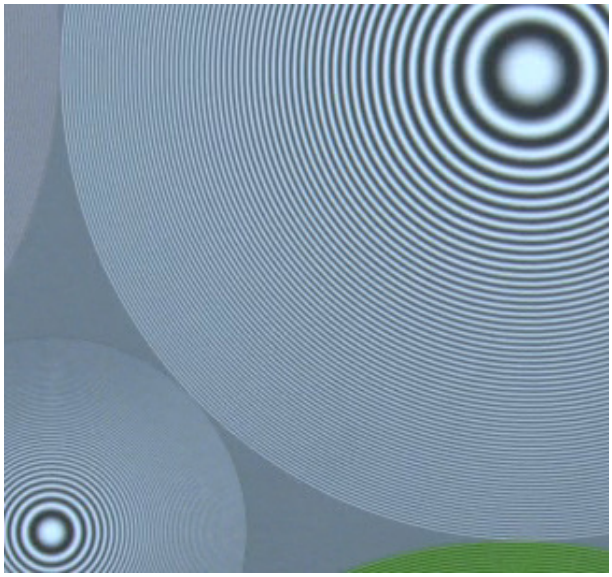

Figure 1 Resolution 1080

It is significant that horizontal and vertical resolutions are identical, since it implies that there is no ITU 709 channel filter preceding the video sampling. Although ITU 709 specifies a filter, it is increasingly unlikely to find one in a camera, which means that the pictures are a little too sharp horizontally, which can cause aliasing.

Figure 2 shows the performance in interlaced mode. Vertical resolution has softened as expected, but nothing else has changed. Resolution is still very good.

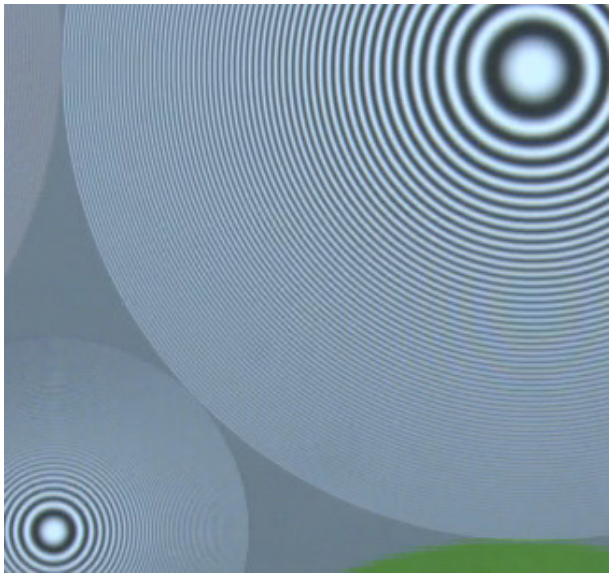

Figure 2 Resolution 1080i

Clearly the sensors are 1920x1080, as stated in the specification. Also, the optical low-pass filter could have been a little more severe, which would have reduced the aliasing at double-HD frequencies, but the advantage would only be slight.

Figure 3 shows the resolution in the 1440x1080 modes.

Oddly, there is a significant increase in vertical aliasing, rather than horizontal. The down-conversion from 1920 to 1440 is very well done, so it is a mystery why the vertical aliasing should suffer in this mode. Clearly there is some odd processing going on in the camera.

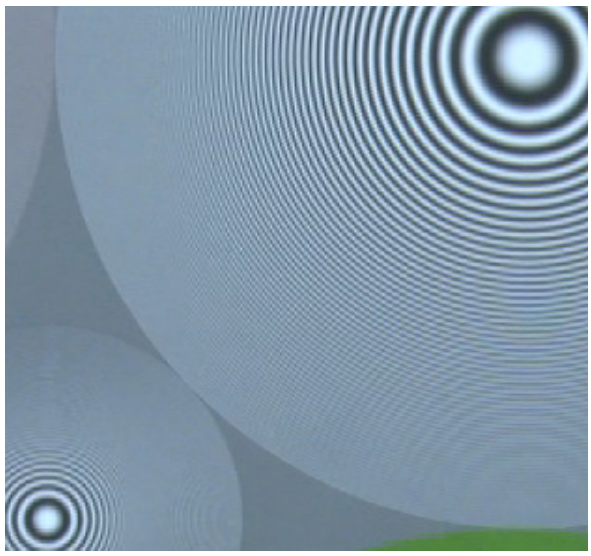

Figure 3 Resolution 1440x1080i

2.2.2 Detail enhancement

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

Unusually, the detail level control allows for detail to be reduced as well as increased. This is a significant benefit, particularly when trying to achieve a specific film look. The level control goes from -99 to +99, with factory default at 0, but experiment showed that it has a null effect when set to about -42. There is also an aperture correction function, which is usually found only on top-end cameras. Aperture correction is an equalisation of the basic fundamental camera frequency response, while detail enhancement is best regarded as a user control. Setting aperture level to zero produced a nice, subtle, effect as it should do.

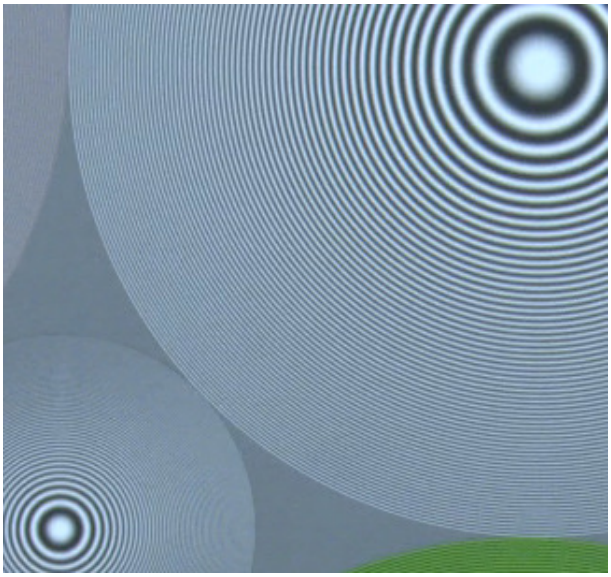

Figure 5 Resolution 1080, aperture correction

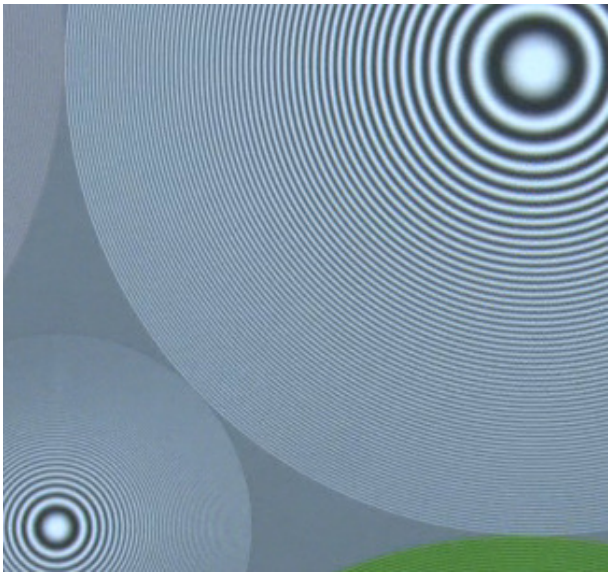

Figure 5 Resolution, 1080, detail and aperture

Figure 4 shows the effect of just aperture correction (level zero) which is recommended for a film look. If the results are still thought to be too sharp, then detail enhancement should be used, with the level control set below -42, even at -99 detail is still visible, but is lowered in level in an acceptable way.

Figure 5 shows the effect of aperture correction and detail enhancement (both at level zero) which is recommended for video-style shooting. Using higher levels of detail causes significant brightening of lower frequencies, and overshoots on high-contrast edges, both of which can be distracting.

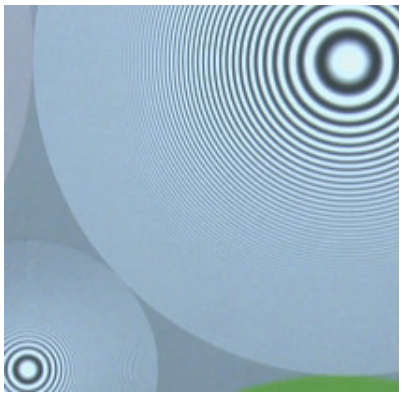

Figure 6 Resolution 720p

2.2.3 1280x720-line

Figure 6 shows the result for 720p shooting, with the video-style detail settings. The down-conversion is very well done; there is virtually no

aliasing from the conversion process.

2.3 Lens aberrations

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

Figure 7 shows the results from one corner of a grab at mid zoom and F/4. There is hardly any displacement of the red/green/blue images, just a small vertical blue/yellow shift which would be invisible on normal pictures. This is good performance for a small camera.

Figure 7 Lens aberrations

2.4 Video noise

Normally, the main source of video noise in a camera is the analogue circuitry of the camera's front end and the sensors themselves. In many cameras (this being no exception) it is impossible to turn off gamma-correction, and so it can be difficult to get accurate measurements.

Video noise levels were measured by capturing exposures of a white card at four video signal levels, with the camera set to Std5 gamma curve and 0dB gain. 1080P HQ mode was used. *Figure 8* shows the result. 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, a range of about 22dB.

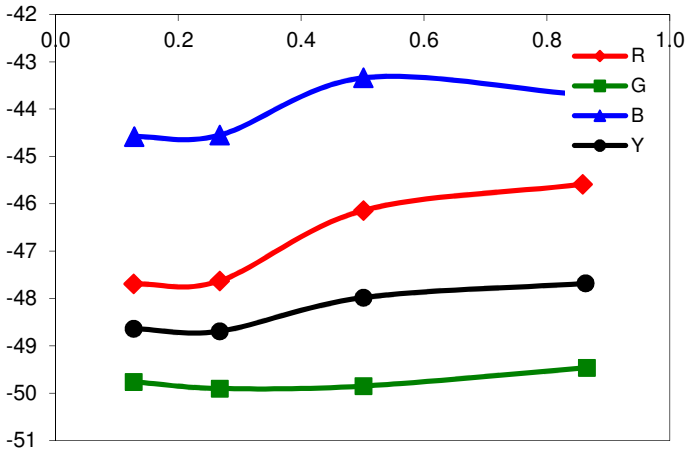

Figure 8 Noise distribution, 0dB gain

Obviously, that is not happening here.

If the internal processing used too small a bit-depth, the noise distribution would be expected to be rather flat, with only a couple of dB or so between values at 10% and 90% video level, and this is what we see here. So, the implication is that the signal processing bit-depth is limited, and causing a noise-floor level below which the noise will not go, even if the analogue noise level falls. To see if this is the case, *Figure 9* shows another measurement made at +18dB gain, where any noise floor effect should be circumvented.

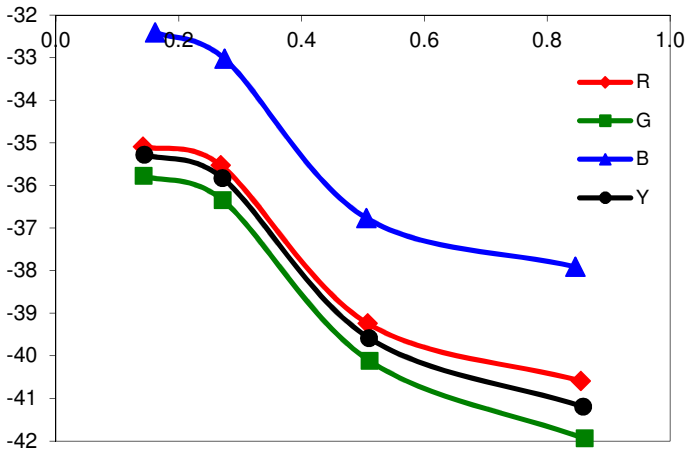

Figure 9 Noise distribution, +18dB gain

The rise in noise as signal level falls is obvious, about 10dB between 15% and 85% video level, more or less as expected according to theory. There are several possible causes for this:

- Noise reduction is 'flattening' the noise distribution,
- Limited processing bit-depth is providing a 'noise floor',
- The ADCs are non-linear or there is some form of pre-gamma before the ADCs.

From these tests, it is impossible to tell which cause is true. The third would show as a reduction in resolution as gain is increased.

Nevetherless, the noise level at 0dB gain is about -48dB, which is quite acceptable for a camera in this category. But lowering the camera gain to -6dB will not produce a substantial change in noise levels.

2.5 Sensitivity and Dynamic Range

The camera was set to 0dB gain, Std5 gamma (ITU 709) with the knee and white-clipper switched off. It was exposed to a Kodak Gray card (white side, reflectance 90%) and lit to 2000 lux tungsten. The iris aperture to achieve 100% video level was a little on the closed side of F/11, say F/11.7. This is very high for a ½" camera and accounts for the rather high noise levels.

The specification claims only a minimum illuminance level of 0.12 lux at 1080/59.94i, F/1.8 and with 64-frame accumulation, which is hardly likely to produce good pictures. So, the camera was set to +18dB gain, iris fully open (F/1.9 at the focal length used) and the lighting level reduced until the Kodak Gray made exactly 50% video level. The illuminance level was then 1.8 lux, which should be regarded as the usable minimum level. This agrees well with the specification claim.

The camera was then reset to 0dB gain and exposed to a ColorChecker chart, and the iris adjusted to get exactly 100% video level. The lens aperture was noted as slightly open from F/8, say F/7.5. The knee was then switched on, point set low (50%) and slope low such that nothing reached white. The iris was then opened until the white patch was just starting to clip. The slope was then adjusted such that this exposure level exactly reached 100%, and the iris aperture noted as a little open from F/4, say F/3.5. This establishes that the over-exposure headroom which the camera can cope with is just over 2 stops, about 500%, or about 8dB.

If we assume that the lowest usable exposure level as that at which wanted detail has the same magnitude as the RMS value of the noise, -48.5dB near black, then the total available dynamic range must be 48.5+8=56.5dB, or 9.4 stops.

2.6 Motion effects

The camera has CMOS sensors and can therefore be expected to show geometrical distortion on moving objects, the 'rolling shutter effect'.

It was exposed to a small electric fan, speed-adjusted to strobe with the television scanning rate. *Figure 10* shows part of one frame, with the shutter set to 1/250 second. The blade on the left (going up) is shrunk in width by about 50% while that on the right (going down) is approximately doubled in width. This indicates that there are no processing tricks in the camera to ameliorate the effect. So 'flash-banding' will a problem as with all CMOS cameras, where stills-camera flashes will illuminate only a part of the field or frame, and intra-frame motion may be disturbing.

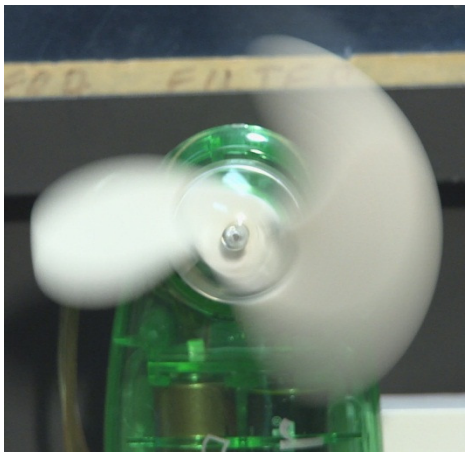

Figure 10 Rolling shutter effect

2.7 Conclusion

The camera should qualify for Tier 2L (Long Form) according to EBU R118, in that it passes all the advisory criteria, although individual broadcasters are free to assign tiering to cameras.

Resolution is good, alias levels are very low, and 720P performance is good.

The dynamic range of 9.4 stops is a little on the low side as a result of the rather high noise levels.

Motion artefacts from the 'rolling shutter' are as expected for a CMOS camera.