Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 30 rev1: Assessment and settings for Sony PMW-EX1 and EX3

Data for this addendum is taken from a short examination of one production model of the Sony PMW-EX1 HDTV camcorder and its manual and from a brief comparison with the EX3. These are HDTV camcorders (the EX1 with integral lens, EX3 having interchangeable lenses) of similar size to the Z1 but recording only onto solid-state storage. They have 3 ½" cmos sensors of 1920x1080 pixels, and therefore should qualify fully as HDTV cameras. Recording HDTV uses MPEG2, 8-bit, 4:2:0 colour sub-sampled, at 35Mb/s (with variable bit rate, maximum 35Mb/s, 1920x1080 interlaced/progressive, or 1280x720 progressive or at 25Mb/s (with constant bit rate, 1440x1080) onto solid-state SxS cards. There is no SDTV mode available.

The cameras are relatively light (about 2.8kg in including battery) and have an integral viewfinder (3½" lcd), and seems aimed at the high-end professional and full broadcast markets, even though the broadcast market would normally demand an image format larger than ½" and removable lens, and a recording format with higher bit-rate. The EX3 has genlock and time-code inputs, and a remote control socket, so may well be usable in multi-camera shoots.

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). The implications, for production at 25p, of setting the camera to 720p/60 and then recording a variable frame rate, have yet to be established. Perhaps the only problem would be timecode and genlocking.

There are internal menus for setting the performance, not as complex as in a full broadcast camera, but enough to control some of the important features, albeit only in "on/off" states. They are not suited to multi-camera operation since they cannot be remotely controlled. There are analogue-only video outputs (components and SD-composite via a multi-pin connector which are specific to these cameras) and digits via IEEE1394 iLink/Firewire in HDV format, USB-2 for data file transfer, 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. However, it was not possible to fully explore some of the colorimetric features because there was no sawtooth test signal available in the normal menus (a sawtooth is apparently available in the service menu). Since many camera parameters are undefined in the specifications, more measurements than usual were necessary, and the results cannot be guaranteed as explicitly as with more complex cameras. 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, but without achieving the full 10-stop dynamic range. The recommended settings allow about 1.5 stops of over-exposure and one of under-exposure relative to normal operation. This is perhaps 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).

Although there is no standard definition recording mode, the 720p mode is very clean and should be the best way to shoot should the camera be expected to produce an SD output. The quality of this 720p mode is highly unusual in any camcorder.

This revision corrects a typographical error.

Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 30 rev1: Assessment and settings for Sony PMW EX1 and EX3

Data for this is taken from tests on a production model of the Sony HD camcorder, PMW EX1 and a brief comparison with an EX3. They are HDTV camcorders with three full-resolution ½" cmos sensors (1920x1080). Recording of HDTV is MPEG2 (8-bit, 4:2:0 colour sub-sampled, probably 12-frame GoP structure) onto SxS cards in HQ mode at 35Mb/s maximum variable bit rate: 1920x1080i/29.97; 1920x1080i/25; 1920x1080psf/29.97; 1920x1080psf/25; 1920x1080psf/23.98; 1280x720p/59.94; 1280x720p/50; 1280x720p/29.97; 1280x720p/25; 1280x720p/23.98. They can also record in a lower resolution SP mode at 25Mb/s with constant bit rate: 1440x1080i/29.97; 1440x1080i/25. There is no SDTV recording mode, but the analogue outputs can be set to SD for monitoring. This SD monitoring feed is not good enough for programme recording.

The cameras are essentially professional models with some professional features such as having XLR connectors at mic or line level. Resolution is good enough for full HDTV. Minimum exposure is claimed to be F/10 at 2000 lux, about 400ASA.

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). The implications, for production at 25p, of setting the camera to 720p/60 and then recording a variable frame rate, have yet to be established.

There are many internal menus for setting the performance and a reasonable selection of external controls. There are analogue component video outputs, and digits via IEEE1394 Firewire/iLink in HDV format and full 10-bit HDSDI. All measurements were made using the HDSDI output.

The normal assessment procedure for full broadcast cameras could not be used, largely because there was no selectable sawtooth test signal in the normal menus (apparently there is one in the service menu). Therefore, testing had to be done the hard way, via the lens. Recommended settings allowing for a "video-look" and a "film-look" have been derived, although there are some significant compromises that have to be taken into account.

It is useful to think of these cameras, when used with "film-look", to be mimicking a film camera and telecine, with "best light" transfer to tape. Measurement results are given after the settings tables, in order to explain the decisions. At best, the camera can deliver about 11 stops of exposure range, similar to other full HD cameras, but it is easy to set the camera such that exposure range drops to 7 stops or less. In the target market for this camera, a grading operation may well not be used in post-production, so the settings should be used with care. Attempts at a film look are compromised by the 8-bit recording system, 10-bits would do a much better job.

The controls for these cameras are not as flexible as for full "broadcast" cameras and have great commonality with such as the Z1, so more effort was expended in measuring performance than in trying to derive a specific "look". Very small lens apertures (less than F/5.6) soften the picture and produce visible colour-fringing due to diffraction effects in the iris, the included neutral density filters are the better alternative to small apertures when shooting in very bright light.

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. The numbers represent the count of bars in the thermometer presentation from the left, usually 1 to 16 with 8 being the central (default) value. Default settings, where known, are underlined. My recommendations are in the last column, labelled "BBC", 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.

Note that, in each power-switch mode, the menus can be separately customised, adding or removing any menu item from the entire set of menus. Where menu items for the EX1 and EX3 are different, they are marked as such, otherwise the same settings will work in both cameras. There are some small physical differences between the cameras, but hardly enough to differentiate them from a casual viewing.

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

1 Switches and Menu settings

SWITCHES, SOCKETS and BUTTONS, EX1

name	place	feature	comment
Headphones	Right	Socket	
1394 connector (HDV)	Right	Socket	
Analogue component	Right	Socket	Proprietary format mini-connector
A/V Out	Right	Socket	Another proprietary mini-connector
USB-2 (data transfer)	Right	Socket	
Audio inputs	Right	XLR Sockets	
White Balance	Right	Push	
Shutter On/Off	Right	Switch	
Assign 4	Right	Push	
Rec Start/Stop	Right	Push	
Rec Review	Right	Push	
Expand focus	Right	Push	
Zoom	Right	Rocker	
Monitor volume	Handle	Push/Push	Up/down buttons
Thumbnail	Handle	Push	
Play/Pause	Handle	Push	
F.Rev	Handle	Push	Fast reverse
Prev	Handle	Push	Previous
Stop	Handle	Push	
Zoom	Handle	Rocker	
Zoom	Handle	Switch	Zoom speed/Off
Cancel	Handle	Push	
Sel/Set	Handle	Joystick	
F.Fwd	Handle	Push	Fast forward
Next	Handle	Push	
Rec Start/Stop	Handle	Push	
Rec Hold	Handle	Switch	
Shot Transition	Top	Push	Multi-function transition control
LCD B.Light	Top	Switch	
LCD B.Light +/-	Top	Buttons	
TC/U-Bit/Duration	Top	Push	Toggles between timecode and user bits on lcd
Status	Top	Push	
Display/Batt Info	Top	Push	
Bars/Cam	Top	Push	
Focus Ring	Left	Rotate	Lens
Zoom Ring	Left	Rotate	
Iris Ring	Left	Rotate	
Iris	Left	Switch	
Macro	Left	Switch	
Focus	Left	Switch	
Push AF	Left	Push	
ND filter	Left	Switch	
Assign 1 to 3	Left	Push	User buttons
Peaking	Left	Push	
Full Auto	Left	Push	
Zebra	Left	Push	
White Balance	Left	Push	
Gain	Left	Switch	Manual control/indicator

SxS Card slot (2 off)	Left	Socket/Push	
Menu	Back	Push	
Sel/Set	Back	Jog dial	
Cancel	Back	Push	
Picture profile	Back	Push	
Power	Back	Switch	
DC In	Back	Socket	
Audio Level Ch1-Ch2	Back		
Audio Select	Back	Switches	Auto/Manual
Audio In	Back	Switches	Internal/External
HDSDI output	Back	BNC Socket	

SWITCHES, SOCKETS and BUTTONS, EX3

name	place	feature	comment
Headphones	Right	Socket	
DC In	Right	Socket	
Monitor out	Right	Socket	BNC
S-Video	Right	Socket	4-pin, camera-specific
Audio out	Right	Sockets	2 x phono
Analogue component	Right	Socket	Proprietary format mini-connector
USB-2 (data transfer)	Right	Socket	Mini B
Lens mount stopper	Right	Switch	
Audio inputs	Right	Sockets	2 x XLR
Lens Remote	Right	Socket	Lens connector
Monitor volume	Handle	Push/Push	Up/down buttons
Thumbnail	Handle	Push	
Play/Pause	Handle	Push	
F.Rev	Handle	Push	Fast reverse
Prev	Handle	Push	Previous
Stop	Handle	Push	
Zoom	Handle	Rocker	
Zoom	Handle	Switch	Zoom speed/Off
Cancel	Handle	Push	
Sel/Set	Handle	Joystick	
F.Fwd	Handle	Push	Fast forward
Next	Handle	Push	
Rec Hold	Handle	Lever	
Rec Start/Stop	Handle	Push	
1394 connector (HDV)	Back	Socket	
TC In	Back	Socket	BNC, timecode input
TC Out	Back	Socket	BNC, timecode output
SDI Out	Back	Socket	BNC, HDSDI output
Genlock In	Back	Socket	BNC
Remote	Back	Socket	8-pin remote control for RMB750/150
Audio Level Ch1-Ch2	Back		
Audio Select	Back	Switches	Auto/Manual
Audio In	Back	Switches	Internal/External
Assign 4	Front	Push	Under the lens
Shutter	Front	Switch	Under the lens
Wht Balance	Front	Push	Under the lens
Assign 1 to 3	Left	Push	User buttons
S&Q (Slow and Quick)	Left	Dial	Off-speed frame rate
Full Auto	Left	Push	
Bars/Cam	Left	Push	
White Balance	Left	Switch	
Gain	Left	Switch	Manual control/indicator
Cancel	Left	Push	
Sel/Set	Left	Jog dial	
Menu	Left	Push	
Status	Left	Push	
ND filter	Left	Switch	
SxS Card slot (2 off)	Left	Socket/Push	
Picture profile	Left	Push	
Power	Left	Switch	
Shot Transition	Top	Push	Multi-function transition control
TC/U-Bit/Duration	Top	Push	Toggles between timecode and user bits on lcd
Peaking	Viewfinder	Knob	

Contrast	Viewfinder	Knob	
Bright	Viewfinder	Knob	
Mirror Image	Viewfinder	Switch	
Display/Batt Info	Viewfinder	Push	
Zebra	Viewfinder	Push	
Focus Ring	Lens	Rotate	
Zoom Ring	Lens	Rotate	
Iris Ring	Lens	Rotate	
Steady Shot	Lens	Push	
Iris	Lens	Switch	
Macro	Lens	Switch	
Focus	Lens	Switch	
Push AF	Lens	Push	
Rec Start/Stop	Grip	Push	
Release	Grip	Push	Push to allow the grip to rotate
Rec Review	Grip	Push	
Expand focus	Grip	Push	
Zoom	Grip	Rocker	

CAMERA SET menu

Basic camera settings

Item	EX	range	comments	BBC
Auto BLK Balance	3	Exec		
Gain setup		-3, 0, 3, 6, 9, 12, 15, 18dB	Set gain for each position of the gain switch	-3/0/6[1]
Shutter		Speed, Angle, ECS, SLS		
Shutter Speed		1/100	Speed options depend on frame rate	
Shutter Angle		180, 90, 45, 22.5, 11.25		
ECS Frequency		60.02	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		
Shot Transition				
Trans Time		1 ~ 4 ~ 15sec	Transition time	
Trans Speed		1 ~ 5 ~ 10		
Time Speed		Time, Speed		
Trans Curve		Linear, Soft Trans, Soft Stop	Shape of transition curve	
Start Timer		Off, 5, 10, 20sec	Delay to start transition	
Rec Link		Off, Shot-A, Shot-B	Set transition to link to a recording start	
MF Assist		On, Off	Allows fine auto focus control when in Manual	
Color Bar		Multi, 75%, 100%		Multi
Flicker reduce		Auto, On, Off	Supposed to reduce lighting flicker	
Frequency		50, 60Hz	Lighting frequency	
Zoom Speed			Zoom speed for handle zoom control	
High		0 ~ 70 ~ 99	High setting	
Low		0 ~ 30 ~ 99	Low setting	
Remote		0 ~ 50 ~ 99	IR Remote controller setting	
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)	
S&Q Motion		On, Off	Slow and Quick Motion, under/over-cranking	
Frame Rate		1 ~ 30	(1 ~ 60 in 720p modes)	
Rec Review		3sec, 10sec, Clip	Clip plays back entire clip	
Fader				
Fade In		On, Off		
Fade In Type		White, Black		
Fade In Time		1, 2, 3, 5, 10sec		
Fade Out		On, Off		
Fade Out Type		White, Black		
Fade Out Time		1, 2, 3, 5, 10sec		
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
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	
Wide Conversion		On, Off	Use with lens Wide Angle adaptor	
Steadyshot	1	On, Off	Set Off when on a tripod	

[1] Noise performance is not particularly good, therefore it is not sensible to use high gain for best quality programme-making.

[2] Stopping down beyond F/5.6 causes visible softening due to iris diffraction. This is normal fort this lens size.

AUDIO SET menu

Item	EX	range	comments	BBC
Audio Input				
Trim Ch-1		-11 ~ -41 ~ -65dBu	Channel 1 sensitivity, 6dB steps	
Trim Ch-2		-11 ~ -41 ~ -65dBu	Channel 2 sensitivity, 6dB steps	
AGC		Linked, Separate	Separate to get individual control	
1kHz Tone		On, Off	Add tone to bars	
Wind Filter Ch-1		On, Off		
Wind Filter Ch-2		On, Off		
Ext Ch Select		Ch-1, Ch1-/Ch-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 ~ 5 ~ 10	Alarm volume level	
Beep		On, Off		

VIDEO SET

Item	EX	range	comments	BBC
YPbPr/SDI Out		HD, SD, Off	Component/SDI output, SD is not recorded	
YPbPr/SDI Out Display		On, Off	Adds menus and status on component/SDI outputs	
Video Out Display		On, Off	Adds menus and status on A/V outputs	
Setup		On, Off	7.5% lift for NTSC rates, if needed	Off
Down Converter		Squeeze, Letterbox, Edge Crop	SD Aspect ratio	Squeeze
24P System	1	60i, 24psf	Output signal when in HQ1080p/24	

LCD/VF SET

Item	EX	range	comments	BBC
LCD	1		Side panel controls, only on EX1	
Color	1	-99 ~ 0 ~ 99		
Contrast	1	-99 ~ 0 ~ 99		
Brightness	1	-99 ~ 0 ~ 99		
EVF	1		Monocular viewfinder	
Backlight	1	High, Low		
Mode	1	Color, B&W		
Contrast	1	-99 ~ 0 ~ 99		
Brightness	1	-99 ~ 0 ~ 99		
Power	1	Auto, On	Auto switches it off when the lcd is folded out	
VF	3			
Color	3	-99 ~ 0 ~ 99		
Mode	3	Color, B&W		
Peaking			Artificial sharpening	
Color		White, Red, Yellow, Blue	Show emphasised edges in this colour	
Level	1	High, Mid, Low		
Frequency	3	Normal, High		
Marker		On, Off		
Safety Zone		On, Off		
Safety Area		80, 90, 92.5, 95%		
Center Marker		On, Off	Small square corners	
Aspect Marker		On, Off		
Aspect Select		4:3, 13:9, 14:9, 15:9		14:9
Guide Frame		On, Off	Cross hatch in thirds	
Zebra		1, 2, Both	Exposure metering	
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		On, Off	Warns if too dark or bright	

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

Warnings				
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		
Fader Status		On, Off		
Rec Mode		On, Off	Frame Rec, Interval Rec, Slow/Quck	
Video format		On, Off		

TC/UB SET menu

Timecode etc

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

LENS

Item	EX	range	comments	BBC
Auto FB Adj	3	Exec/Cancel		
File	3			
Lens ID	3		ID of the mounted lens (if it's the right type)	
Recall	3		Get lens file	
Store	3		Save lens file	
File ID	3		Set name of lens file	
No Offset	3		Delete settings, factory reset	
Auto Recall	3		Automatically get lens data for known lens	
Flare	3			
R Flare	3	-99~0~99	Set flare compensation	
G Flare	3	-99~0~99		
B Flare	3	-99~0~99		
R Flare EX	3	-99~0~99	Set compensation when using range extender	
G Flare EX	3	-99~0~99		
B Flare EX	3	-99~0~99		
Shading	3			
Channel	3	R, G, B	Which channel to adjust	
M Vmod	3	-99~0~99		
H Saw	3	-99~0~99		
H Para	3	-99~0~99		
V Saw	3	-99~0~99		
V Para	3	-99~0~99		
Shading Channel EX	3	R, G, B	Which channel to adjust, using extender	
M Vmod	3	-99~0~99		
H Saw	3	-99~0~99		
H Para	3	-99~0~99		
V Saw	3	-99~0~99		

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

V Para	3	-99~0~99		

OTHERS menu

Item	EX	range	comments	BBC
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 ~ +14:00	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, Marker, Last Clip DEL, ATW, Rec Review, Rec, FreezeMix, Expanded Focus, Spotlight, Backlight, IR Remote, Shot Mark1, Shot Mark2, Fader, EVF Mode, BRT Disp, Histogram, Lens Info	Assign any to buttons 1~4 Factory defaults are: Button1=Lens Info (DoF) Button 2=BRT Disp (light meter) Button 3=Histogram Button 4=Off	
Tally			Record lamps	
Front		High, Low, Off	Brightness/Off	
Rear		On, Off		
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	3			
24p system	3	60i, 24psf	Genlock source for 24p only	
GL Phase	3	-999~0~999	Horizontal fine phase	
H Advance	3	0H, 90H	0H=o/p matches ref source. 90H=sets HD 90 lines ahead of SD sync, or SD o/p 90 lines behind HD sync.	
Direct Menu		All, Part, Off	Gives limited access to menus	
i.Link I/O		Enable, Disable	IEEE1394, only in SP mode, disables HDSDI	
Trigger Mode		Internal, Both, External	Controls external recorder via i.Link	
Country		NTSC Area, PAL Area	Sets between 59.94 and 50Hz	PAL Area
Video Format			Select the recording format	
NTSC Area		HQ 1080/60i, SP 1080/60i, HQ 1080/30p, HQ 1080/24p, SP 1080/24i, HQ 720/60p, HQ 720/30p, HQ 720/24p	Actual frame rates are all these numbers/1.001, i.e. 60 means 59.94, 24 means 23.98. This terminology may confuse[5], but it's how it appears in the menu	
PAL Area		HQ 1080/50i, SP 1080/50i, HQ 1080/25p, HQ 720/50p, HQ 720/25p		
Clip		nnn_	Set first 4 characters of clip names	
Number Set		0001 ~ 9999	The second set of 4 characters	
Update Media		Execute, Cancel	Update managerial file on card slot A or B[6]	
Last Clip DEL		Execute, Cancel		
All Clips DEL		Execute, Cancel	Wipe the lot, except clips marked "OK"	

[5] 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.

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

Format Media		Execute, Cancel	Format card slot A or B	

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	Standard, High Sat[7], FL Light, Cinema		Standard {v} Cinema {f}
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		
Color Correction	On, Off	Direct control over one colour only	Off
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	
Detail	On, Off		On
Level	-99 ~ 0 ~ 99		0 {v} -5 {f}[8]
Frequency	-99 ~ 0 ~ 99		30
Crispening	-99 ~ 0 ~ 99	Noise suppression	-45
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		Y
Knee APT Level	-99 ~ 0 ~ 99	Sharpen edges that would be lost above the knee	0
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	
Knee	On, Off	Compress overexposure	On
Auto Knee	On, Off	Auto or manual	Off
Point	50 ~ 90 ~109%	Manual knee break point	87
Slope	-99 ~ 0 ~ 99		60[9]
Knee Sat Level	0 ~ 50 ~ 99		
Gamma	-99 ~ 0 ~ 99		

[7] *High Lit* matrix increases saturation, and could better be described as "vivid". *Cinema* matrix has lower saturation.
[8] Setting Level to -5 tones down the limiting resolution somewhat, but this still might be too sharp a good film look. A sensible alternative would be to turn off detail altogether for film shooting. I strongly advise testing this for each shoot.
[9] These *Knee* settings will cope with overexposure up to about 1.5 stops. When using the Std3 or 4 gamma curves for a video look, important colours (e.g. skin) are unaffected by the knee.

Select	Std1, Std2, Std3, Std4, Cine1, Cine2, Cine3, Cine4	STD3=ITU709, STD4 is probably BBC 0.4[10]	Std3 {v} Cine2 {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[11]
Low Key Sat	-99 ~ 0 ~ 99	Saturation control for dark colours, reduce when noise is high	0[12]
Copy		Copy one profile into another	
Reset		Factory reset this profile	

[10] Descriptions in the manual seem to fit the idea that these curves are directly copied from other cameras, where 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.

[11] *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.

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

Measurements

All measurements were made on frames captured via the analogue component outputs of the EX1 and via HDSDI in the EX3. The results shown here are for the EX1 except where specifically noted otherwise. Although not the usual practice for camera tests, the image capture process was far easier to manage, and did not lead to any confusion or misrepresentation of the camera performance. In this section, I shall use the EBU system of designating scanning standards. Live viewing was done on a 36" Grade 1 HDTV crt monitor.

1.1 Colour performance

Colour performance was assessed visually, using Macbeth charts. The most accurate colour rendering was obtained using the **Standard** *matrix* and **Std4** *gamma* curve (BBC 0.4). However, since the normal gamma curve for HDTV shooting is that defined in ITU 709, **Std3** is recommended. The yellow and orange patches were a little desaturated and hues shifted towards green, 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.

1.2 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. There was no substantial difference between the EX1 and EX3.

1.2.1 1080-line HQ interlace

In HQ mode, the camera records MPEG long-GoP data at 35Mb/s, with variable bit rate. In this mode, the recorded format is 1920x1080, with chroma sub-sampling at 4:2:0 thus the chroma signals have resolutions of 960x540. This mode is not usually considered suitable for full broadcast HDTV shooting.

Figure 1 shows the luma resolution when the camera was in factory default settings for detail enhancement. The camera was set to 1080i/25 (known in the menus as 1920x1080/50i). Thus this is an interlaced image.

The result is remarkably free from spatial aliasing, there being only the normal low-level extinctions near the horizontal limit indicating that there is an optical bi-refringent filter limiting the resolution reaching the sensors and that it is passing just a little too much high-frequency content.

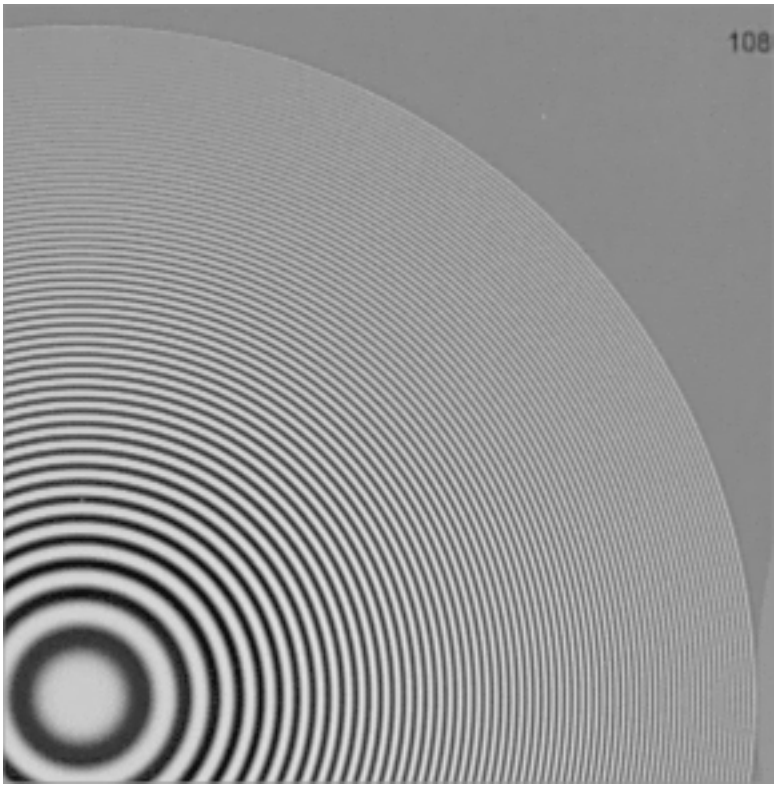

Figure 1 1080i HQ, factory detail settings

Vertically, there is a gradual and clean extinction starting at about 540 and extinguishing completely at about 1000 lines/picture height. This is a little high for interlace and a little low for progressive, probably not a bad compromise.

Figure 2 shows the result of the modified detail enhancement settings for video-look (v). The main difference from factory settings is to swing the horizontal/vertical balance (**H/V ratio**) away from vertical, to reduce interline twitter. There is slightly more horizontal aliasing, i.e. the depth of modulation is a little higher. The overall result was very pleasing to view live.

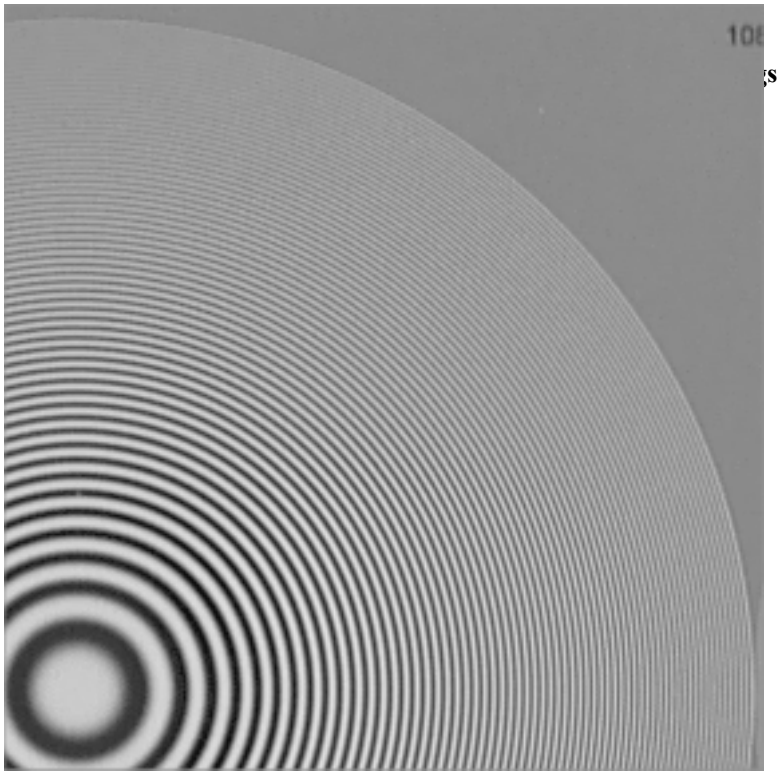

Figure 2 1080i HQ, video detail settings

1.2.2 1080-line HQ, progressive

From the measurements of interlaced resolution, it seemed likely that the camera designers had aimed the performance of the optical filter more towards progressive than interlaced usage.

Figure 3 shows the result for setting progressive, but with the same detail control settings as for interlace.

Horizontal resolution has not changed, there is still light aliasing near 1920, but not enough to cause problems. But vertical resolution has changed significantly, there is now the same depth of modulation at 1080 vertically as there is at 1920 vertically. This level of vertical detail will cause "twittering" when viewed on a classical crt monitor, and may cause some problems in MPEG compression, because high frequency content is not expected to have high amplitudes.

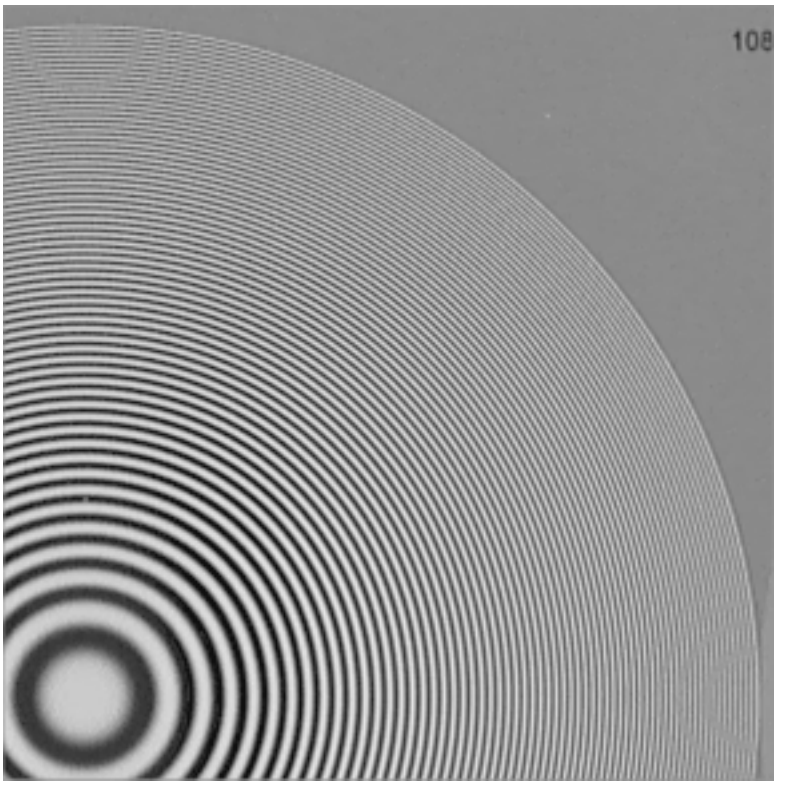

Figure 3 1080p HQ, video detail settings

Also, this level of high-frequency content is unlikely to be desirable for film-type shooting, the pictures may look too sharp. For film-look work, the user has a choice, either to turn off detail altogether, or to turn down the level.

Figure 4 shows the result with detail **level** reduced to -5, quite a small change. Both horizontal and vertical resolution has been lowered in amplitude a little, but more so vertically. This level of resolution should not present any compression problems, and will probably be more acceptable, but the user should not be afraid to turn detail off altogether if the results are still acceptable.

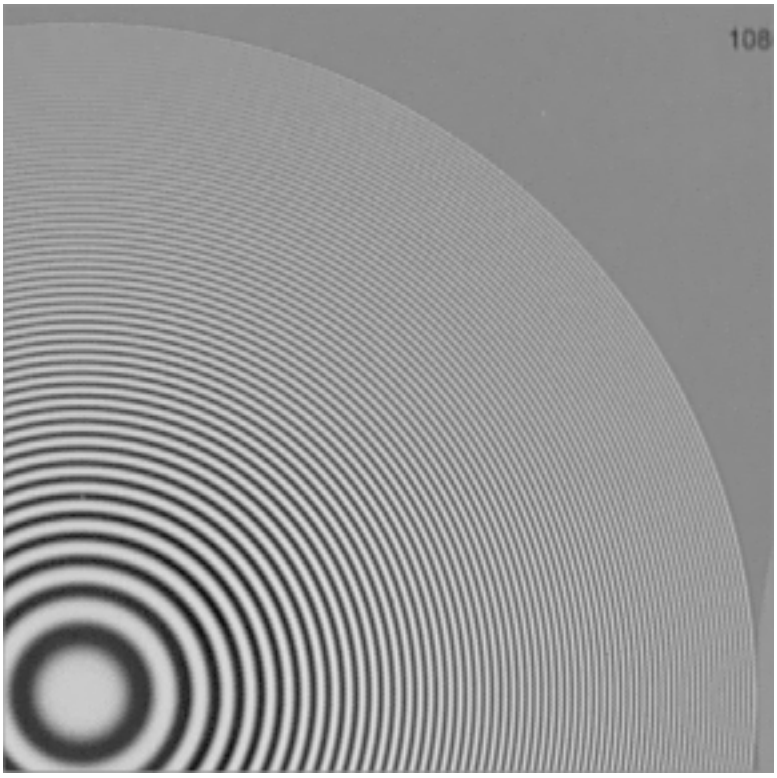

Figure 3 1080p HQ, film detail settings

1.2.3 1080-line SP

The camera can also be set to record in SP mode, at 25Mb/s with constant data rate. However, the resolution in this mode is reduced to 1440x1080 with 4:2:0 chroma sub-sampling. In this mode, the recording closely resembles HDV, and is not a real candidate for full HDTV recording because of the reduced chroma bandwidths. Nevertheless, it could be valid for production with lower requirements in quality.

Figure 5 shows the luma resolution, with detail settings as for video. The resolution now appears to be more circular, the horizontal limit at 1440 being significantly more severe than the smooth reduction of modulation depth in the vertical direction.

Also, there is some light aliasing at 1440, showing the effect of the luma sub-sampling down from 1920. This performance is very similar to that available from the Sony HDCAM range, which records only in a 1440x1080 format.

In this mode, chroma is sub-sampled 4:2:0, thus the chroma channels are only 960x540. This is exactly the same number of chroma pixels recorded in HDCAM, which sub-samples 3:1:1 and therefore delivers chroma signals of 480x1080. Subjectively, this 960x540 square matrix 4:2:0 mode appears to be better than HDCAM's highly asymmetric chroma mode.

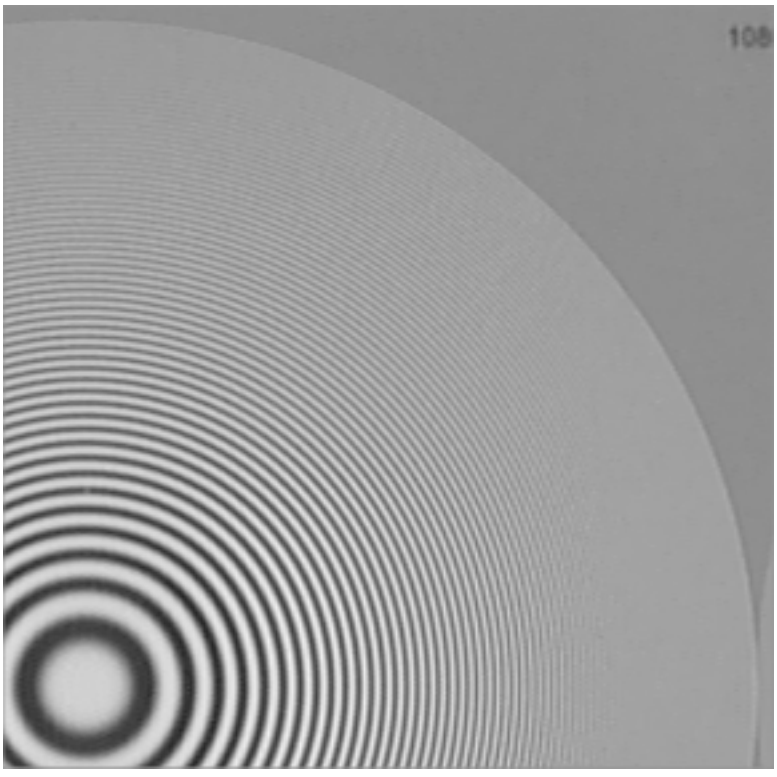

Figure 4 1080i SP, video detail settings

1.2.4 720-line HQ

There is no standard definition recording mode in the EX1. However, it records at 1280x720p in HQ mode (35Mb/s), and this mode is interesting because it represents the best way to get a standard definition picture from the camera. If recordings are made at 1080 interlaced, then the down-converter (external) will have to de-interlace in order to produce the output fields, while recording at 1080 progressive may not give the look the user wants (jerky motion).

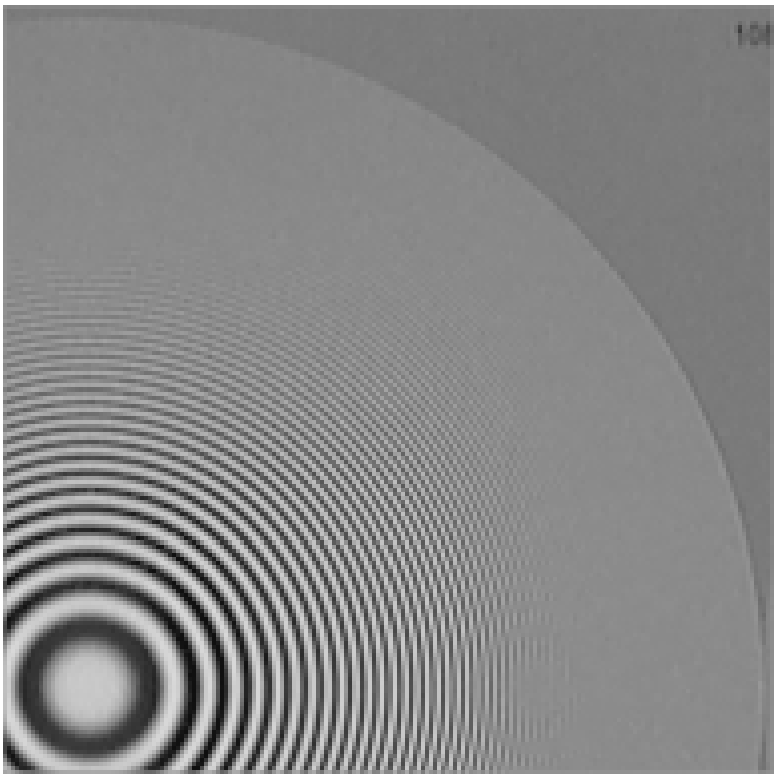

Figure 6 720p HQ, video detail settings

Since the sensors are cmos and are scanned progressively, it could make sense to shoot in 720p with the view to down-conversion to SD, since there would then be no need for de-interlacing, and the down-conversion would have full frames to work with, at the output field rate.

Figure 6 shows the result for 720p shooting, again with the video detail settings.

There is a horizontal null centre at 1280, as expected from the sub-sampling, and a virtually complete extinction beyond 1400, everything between 1280 and 1440 being aliased. Vertically, things are a little better, there is a smooth progression into extinction at 680 and virtually no aliasing. Therefore, the down-conversion appears to be a little asymmetric, but in an acceptable way.

Clearly, a subsequent down-conversion to standard definition from this format should be the best route to take. It is highly unusual to see such good down-conversion in a camcorder.

1.3 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 from the EX1 at mid zoom and about F/4. Clearly, there is a small disparity in red/green, about 2 pixels in horizontally, and about 1 vertically. Similar results exist in the other corners, red being a little to the left, and registration appeared to be correct in the centre, so this is truly a lens distortion.

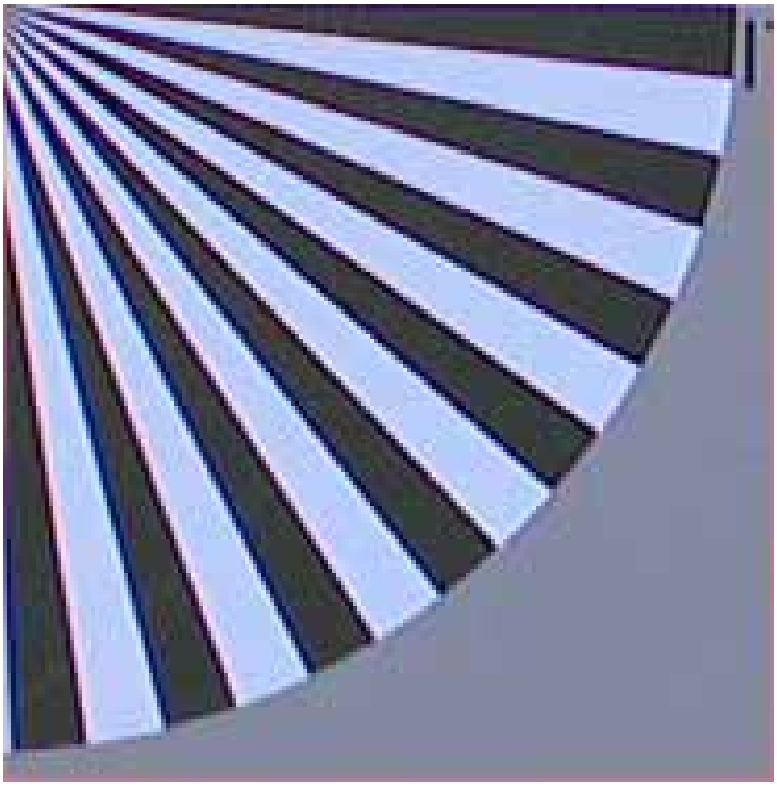

Figure 7 lens aberration, EX1

This is not as good as could be expected

from a top-quality ⅔”B4-mount HDTV zoom lens, but a lot better than most, and certainly better than many other cameras with fixed lenses.

Figure 8 shows the result for the EX3. the performance is very similar, showing that there is little to be gained by using the detachable lens of the EX3

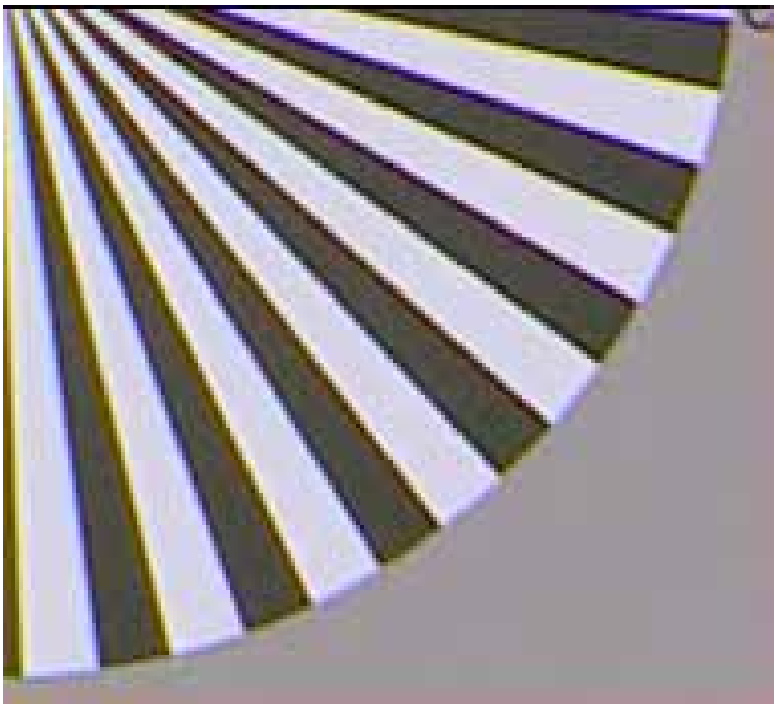

Figure 8 lens aberration, EX3

1.4 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. Therefore it is difficult to get accurate measurements.

Therefore, video noise levels were measured by capturing exposures of a white card at four video signal levels, with the camera set to use *Std3* gamma curve and +6dB gain (a correction factor was built in to the calculations to allow for that). This ensured that the camera was in the condition that might be expected to return worst noise values, and that the noise would not be compromised by the video signal processing. 1080i HQ mode was used.

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.

Figure 8 shows the results, of noise levels in dB plotted versus signal level in percentage, corrected for the 6dB gain, thus this illustrates the noise to be expected at 0dB gain.

Clearly, the noise levels change well in accord with the slope of the gamma curve, there being about 10dB between black and white. This indicates that the camera front end is the prime source of noise, and that the adcs are probably 12- or 14-bit. Since the slope of the gamma curve is unity when the signal level is about 50%, it is also clear that the noise level is only about -44dB rather than the claimed -54dB in the specification.

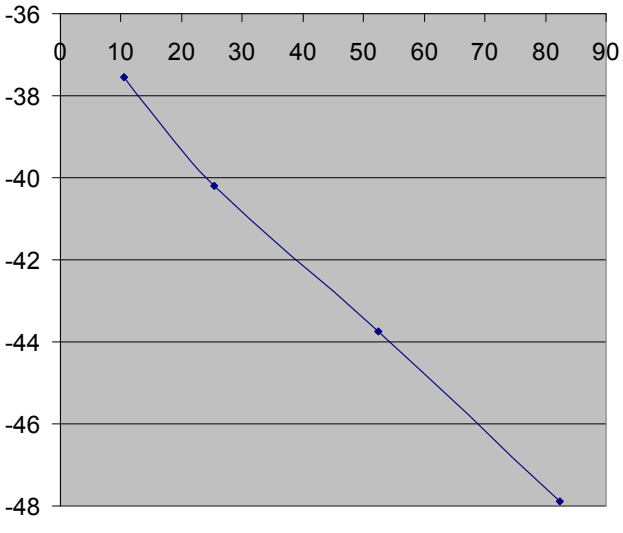

Figure 9 video noise distribution, EX1

Thus, the noise should be about -47dB when at -3dB gain and -38dB when at +6dB gain. It would make sense not to use high gain settings for high-end production.

Noise levels should not be affected by the 8-bit nature of the MPEG recording.

Spectrally, the noise is uniformly spread over the frequency range, and has no fixed pattern to it. Subjectively, it does not appear to be as bad as these figures show, possibly because many cameras do not produce clean images at full resolution. The noise performance of the EX3 was not measured, the other aspects of performance being identical to that of the EX1, there seemed to be no need.