Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 68 : Assessment and settings for Sony PMW-F3

Data for this addendum is taken from a short examination of one production model of the Sony PMW-F3 large-format HDTV camcorder and it's manual. The camera is smaller and lighter than a conventional broadcast size, weighing 2.4kg without lens, approximately 150x190x210mm. The single CMOS sensor is super-35 mm size but the manual gives no clue as to its resolution.

It records onto SxS cards (Express Card 34) via 2 PCMCIA card slots, but only at 8-bit 4:2:0 resolution. In HDTV mode it records MPEG2:

> HDHQ, 35Mb/s variable bit rate
> > 1920x1080 at 59.94i, 50i, 29.97p, 25p, 23.98p
> > 1440x1080 at 59.94p, 50p, 29.97p, 25p, 23.98p
> > 1280x720 at 59.94p, 50p, 29.97p, 25p, 23.98p
> HD SP, 25Mb/s, constant bit rate
> > 1440x1080 at 59.94i, 50i

and in SDTV resolutions using the intra-frame DVCAM coder:

> SD DVCAM, 25Mb/s
> > 720x576 at 50i, 25p
> > 720x480 at 59.94i, 29.97p

The camera can shoot off-speed, both slower and quicker than normal, but only up to the system frame rate:

> HDHQ
> > 1920x1080, 29.97p or 23.97p: 1~30fps
> > 1920x1080, 25p: 1~25fps
> > 1280x720, 59,94p, 29.97, 23.98p: 1~60fps
> > 1280x720, 50p: 1~50 fps

Power consumption is about 18 Watts at 12 V, rising to 24 Watts when using dual link HDSDI output. Although operating at 12V, it does not use conventional full-sized batteries, but the supplied BP-U60 has a nominal capacity of 60 Amp-hours, and there is a conventional 4-pin XLR socket for external power.

The lens mount is standard PL, and has hot connections for the supplied Sony lenses and for the Cooke /I range of lenses. It has a single filter wheel carrying only neutrals, 1/8 and 1/64, colour balancing is entirely electronic. There is an integral monocular viewfinder at the back of the camera, and a fold-out LCD panel to the left. The controls and control features are very similar to those in the EX1 and EX3. There are 8 assignable buttons.

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. The camera is not suited to multi-camera operation since it cannot be remotely controlled, its intended use appears to be in support of high-end film-style cameras such as the Sony F35 or SRW9000. There are video outputs (2xSDI/HDSDI and HDMI, and timecode) plus inputs for genlock and time-code, and audio via SLR connectors.

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.

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

1   Menu settings

CAMERA SET menu   Basic camera settings

Item	range	comments	BBC
Auto Black Bal	Exec		
Gain setup	-3, <u>0</u>, 3, <u>6</u>, 9, <u>12</u>, 15, 18dB	Set gain for each position of the gain switch	[1]
Shutter	<u>Speed</u>, Angle, ECS		
Shutter Speed	<u>1/100</u>	Speed options depend on frame rate	
Shutter Angle	216, <u>180</u>, 172.8, 150, 144, 90, 86.4, 72, 45, 22.5, 11.25	71, 86.4, 144, 150, 172.8 and 216 not available in Slow/Quick mode	
ECS Frequency	<u>60.00</u>	Range depends on frame rate	
SLS Frame	2~8	Number of frames accumulated in Slow Shutter	
Slow Shutter	On, <u>Off</u>	Extreme slow shutter mode	
Frames	2~8		
Color Bar	<u>Multi</u>, 75%, 100%		Multi
Flicker reduce	Auto, On, <u>Off</u>	Supposed to reduce lighting flicker	
Frequency	50, <u>60Hz</u>	Lighting frequency	
Interval Rec	On, <u>Off</u>	Stop-frame recording, see manual for details	
Interval Time	<u>1</u> ~ 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	<u>1</u>, 3, 6, 9	(2, 6, 12 frames in 720p)	
Frame Rec	On, <u>Off</u>		
Number of Frames	<u>1</u>, 3, 6, 9	(2, 6, 12 frames in 720p)	
S&Q Motion	On, <u>Off</u>	Slow and Quick Motion, under/over-cranking	
Frame Rate	1 ~ <u>30</u>	(1~25 in 1080, 1 ~ 50/60 in 720p,)	
Rec Review	<u>3sec</u>, 10sec, Clip	Clip plays back entire clip	
TLCS		Total Level Control System, Iris/Gain/Shutter	
Level	+1, +0.5, <u>0</u>, -0.5, -1	Auto Iris stop override	
Mode	Backlight, <u>Standard</u>, Spotlight		
Speed	-99 ~ <u>50</u> ~ 99	Shifting speed	
AGC	On, <u>Off</u>	Automatic gain control	
AGC Limit	3, 6, 9, <u>12</u>, 18dB	Maximum gain AGC can take	12
AGC Point	F/5.6, F/4, <u>F/2.8</u>	Point at which auto-iris/shutter starts in AGC	F/2.8
Auto Shutter	On, <u>Off</u>		
A.Sht Limit	1/100, 1/150, 1/200, <u>1/250</u>	Set shortest shutter	
A.Sht Point	F/5.6, F/8, F/11, <u>F/16</u>	Point at which iris/shutter starts in Auto Shutter	
Shockless White	Off, 1, <u>2</u>, 3	Speed of white balance response when changed	

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[1] Noise performance is good, 18dB gain may be reasonable for best quality programme-making.

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	
Horizontal Inv	On, Off	For mirror shooting	
Lens IF	Type C, Type A, Off	Type C=Cooke and Sony, A=ARRI	

AUDIO SET menu

Item	range	comments	BBC
Audio Input			
Trim Ch-1	-20 ~ -41 ~ -65dBu	Channel 1 sensitivity, 6dB steps	
Trim Ch-2	-20 ~ -41 ~ -65dBu	Channel 2 sensitivity, 6dB steps	
Limiter	On, Off		
Mic AGC	High, Low	Sensitivity	
AGC Link	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 ~ 4 ~ 7	Alarm volume level	
Beep	On, Off		

VIDEO SET

Item		range	comments	BBC
Input source Select		Camera, i.Link		
SDI/HDMI/ i.Link I/O select	HQ	HDSDI, SDSDI, HD HDMI, SD HDMI i, SD HDMI i & DVCAM		
	SP	HDSDI, SDSDI, HD HDMI & HDV, SD HDMI P & HDV, SD HDMI I & HDV, SD HDMI i & DVCAM		
	DVCAM	SDSDI, SD HDMI i & DVCAM		
SDI/HDMI Out Display		On, Off	Adds viewfinder stuff to the output	
Video Out Display		On, Off	Adds menus and status on A/V outputs	
Down converter		Squeeze, Letterbox, Edge crop		
23.98P Output		59.94 I (2-3 pulldown), 23.98 PsF		
Dual-Link & Gamma select		Off, 1.5G YPbPr422 & Video	3G and S-Log available when options are fitted	
SDI Rec Control		Off, HDSDI remote I/F	Feeds record trigger over SD/HDSDI	

LCD/VF SET

Item	range	comments	BBC
LCD		Side panel controls	
Color	-99 ~ 0 ~ 99		
Contrast	-99 ~ 0 ~ 99		
Brightness	-99 ~ 0 ~ 99		
VF		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 the lcd is folded out	
Peaking		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		

	range	comments	BBC
Aspect Select	4:3, 13:9, 14:9, 15:9, 1.66:1, 1.85:1, 2.35:1, 2.4:1		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%[2]	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[3]	
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		
White Balance Mode	On, Off		
Picture Profile/S-Log	On, Off		
Filter Position	On, Off		
Iris Position	On, Off		
Gain Setting	dB, ISO, Off		
Shutter Setting	On, Off		
Rec Mode	On, Off	Frame Rec, Interval Rec, Slow/Quck	
Video format	On, Off		
5600K CC	On, Off		

TC/UB SET menu

Timecode etc

Item	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 FILE

Item	range	comments	BBC
Information		Lens maker, model, number, version	
Operation			
Display mode	Date&Time, Model name, Lens name		
Recall memory	Exec		
Store memory			
Recall SxS			
Store SxS			
File Name	No offset	16 characters max	
File Source			
Auto Recall	Off, On (name), On (serial number)		
Setting			
Reset Setting	Exec/Cancel		
R Flare	-99~0~99	Set flare compensation	
G Flare	-99~0~99		
B Flare	-99~0~99		
White Offset R	-99~0~99	White balance compensation	
White Offset G	-99~0~99		
White Offset B	-99~0~99		
Shading R H Saw	-99~0~99		
Shading R H Para	-99~0~99		

[2] 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.

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

Shading R V Saw	-99~0~99		
Shading R V Para	-99~0~99		
Shading G H Saw	-99~0~99		
Shading G H Para	-99~0~99		
Shading G V Saw	-99~0~99		
Shading G V Para	-99~0~99		
Shading B H Saw	-99~0~99		
Shading B H Para	-99~0~99		
Shading B V Saw	-99~0~99		
Shading B V Para	-99~0~99		

OTHERS menu

Item	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, ATW Hold, , Rec Review, Rec, Picture Cache, FreezeMix, Expanded Focus, Spotlight, Backlight, IR Remote, Shot Mark1, Shot Mark2, VF Mode, BRT Disp, Histogram, Lens Info, OK Mark	Assign any to buttons 1~8

Factory defaults are:
1=Lens Info, 2=BRT Disp, 3=Histogram, 4=Rec, 5=Rec | |
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			
H Phase HD	-999~0~999	Horizontal fine phase	
H Phase SD	-999~0~999		
Trigger Mode	Internal, Both, External	Controls external recorder via i.Link	
System			
Country	NTSC Area, PAL Area	Sets between 59.94 and 50Hz	PAL Area
HD/SD	HD, SD		
Video Format		Select the recording format	
NTSC Area	HD	HQ 1080/59.94I, HQ 1920/29.97P, HQ 1920/23.98P, HQ 1440/59.94i, HQ 1440/29.97P, HQ 1440/23.98P, SP 1440/59.94i, SP 1440/23.98P,, HQ 1280/59.94P, HQ 1280/29.97P, HQ 1280/23.98P	Actual frame rates are all these numbers/1.001, i.e. 60 means 59.94, 24 means 23.98. This terminology may confuse[4], but it's how it appears in the menu	
	SD	U, DVCAM29,.97P SQ, DVCAM29.97P EC		

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[4] 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.

PAL Area	HD	HQ 1920/50i, HQ 1920/25P, HQ 1440/50i, HQ 1440/25P, SP 1440/50i, HQ 1280/50p, HQ 1280/25p		
	SD	DVCAM50i SQ, DVCAM50i EC, DVCAM25P SQ, DVCAM25P EC		
Clip		nnn_	Set first 4 characters of clip names	
Number Set		0001 ~ 9999	The second set of 4 characters	
Update Slot A/B		Execute, Cancel	Update managerial file on card slot A or B[5]	
Last Clip DEL		Execute, Cancel		
All Clips DEL		Execute, Cancel	Wipe the lot, except clips marked "OK"	
All Clips CPY		Execute, Cancel	Copy card to card	
Format Media			Format card slot A or B	
Media A		Execute, Cancel		
Media B		Execute, Cancel		
Version			Shows current software version	
Version Up		Execute, Cancel	Update camera software from card	

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

item	range	comments	BBC
Profile Name		8 characters, alphanumerics	
Matrix	On, Off		On
Select	Standard, High Sat[6], FL Light, Cinema, F35 709 like		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		
Multi Matrix	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	
Color Detection	Execute, Cancel		
Axis	B, B+, MG-, MG, MG+, R, R+, YL-, YL, YL+, G-, G, G+, CY, CY+, B-		
Hue	-99 ~ 0 ~ 99	Saturation	
Saturation	-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
Level	-99 ~ 0 ~ 99		0
Frequency	-99 ~ 0 ~ 99		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	
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
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	
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		
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		On
Level	-99 ~ 0 ~ 99		+20 (v), 0 (f)
Knee	On, Off	Compress overexposure	Off (f) On(v)
Auto Knee	On, Off	Auto or manual	Off
Point	50 ~ 90 ~109%	Manual knee break point	87
Slope	-99 ~ 0 ~ 99		60[7]
Knee Sat Level	0 ~ 50 ~ 99		
Gamma	-99 ~ 0 ~ 99		

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[6] *High Lit* matrix increases saturation, and could better be described as "vivid". *Cinema* matrix has lower saturation.

[7] 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 if exposure is kept reasonably low.

	Select	Std1 DVW, Std2 x4.5, Std3 x 3.5, Std4 240M, Std5 R709, Std6 x5, Cine1, Cine2, Cine3, Cine4	Std5=ITU709, Std6=BBC 0.4[8]	Std5 {v} Cine2 {f}
Black		-99 ~ 0 ~ 99	No calibration, cap the camera and use waveform monitor or Histogram to set black level	0 {fv} -1 {u}
Black Gamma		-99 ~ 0 ~ 99	Black stretch, use when noise level is low	0[9]
Low Key Sat		-99 ~ 0 ~ 99	Saturation control for dark colours, reduce when noise is high	0[10]
Copy			Copy one profile into another	
PP Data				
	Store	Execute, Cancel	Store profile on SxS card	
	Recall	Execute, Cancel		
Reset			Factory reset this profile	

[8] 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); Std2 is somewhere between Std1 and Std3. The Cine curves are not the "Hypergamma" curves of the PDW700, HDWF900R/790, SRWF9000 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 or 3, make sure that video will not be clipped in post-production. Or that grading can cope with the over-voltages.

[9] *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.

[10] 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 HDSDI output as uncompressed files, for further processing and examination using specialist software. In this section, I shall use the EBU system of designating scanning standards rather than the nomenclature in the camera. Live viewing was done on a 32" Grade 1 HDTV crt monitor and a digital waveform 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 **Std6** *gamma* curve (BBC 0.4). However, since the normal gamma curve for HDTV shooting is that defined in ITU 709, **Std5** is recommended. The yellow and orange patches were a little desaturated and hues shifted towards green, and skin tones a little over-saturated, which is normal for Sony cameras. There was no single colour error large enough to cause a problem. Since there were no "rogue" colours, no further investigation was needed.

For film-like shooting, the CINE matrix and CINE2 gamma make a good combination. Contrast range is good and not unduly compressed; all colours appear a little under-saturated, which is desirable for such shooting. The combination of F35-like matrix and ITU-709 gamma produces considerable oversaturation, when shooting together with the F35 or other Sony film-look cameras, the combination of F35-line matrix and CINE1 or 3 should be acceptable when post-production grading can cope with the nominal overexposure caused by using the coding range above 100%, otherwise CINE2 or 4 should be used.

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. A Sony prime lens was used, 85mm focal PL mount.

1.2.1 1080-line interlace

In HQ mode, the camera records MPEG long-GoP data at up to 35Mb/s. In this mode, the best 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. The camera coding was not tested, since the performance of MPEG coders is well understood, and the high-end use of this camera is likely to involve external video recording.

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.

Figure 1 Zone plate 1080i, factory detail

The result is not free from spatial aliasing, there is both horizontal and vertical visible aliasing. The aliasing, is, unusually, both first and second order, i.e. frequencies are reversed and then reversed again. The first alias appears to be centred on 1920 and 1080, implying that the source is the output standard, while the second aliases are centred on about 1100 pixels and 619 lines, implying that the sensor has dimensions which are related to those numbers, probably 2200x1238. Also, there seems to be
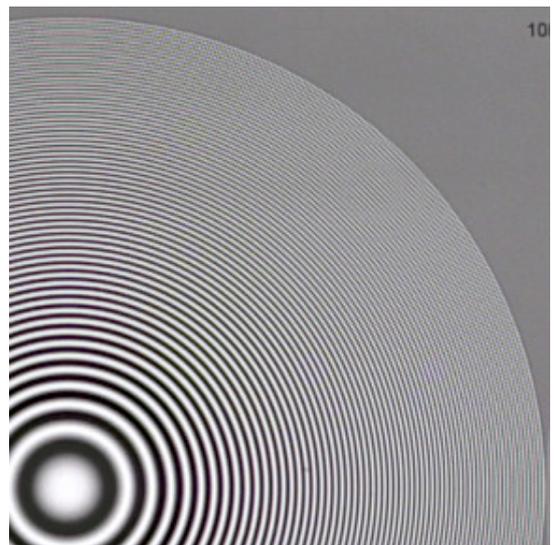
9

either no optical low-pass filter to prevent aliasing, or it is still passing high-frequencies which cannot be supported by the sensor resolution.

Figure 2 shows the patterns for red and green. Clearly, the aliasing in red and green is the same. This, together with the low level of coloured aliasing in the luminance pattern, means that the resolution of red
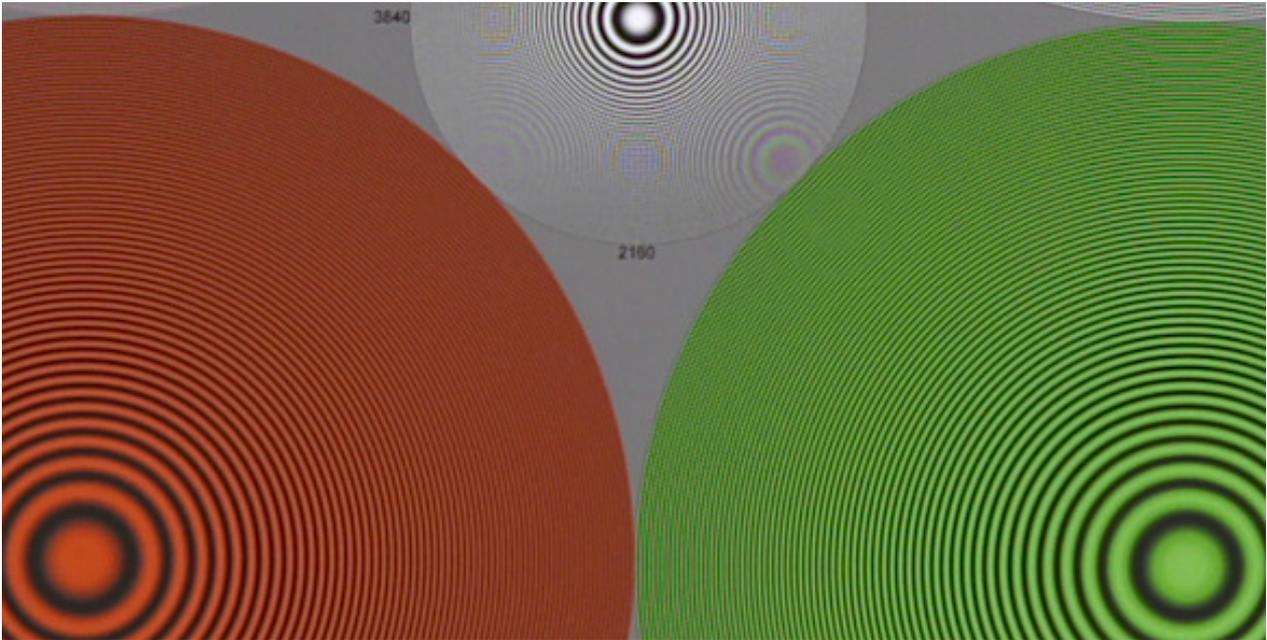

Figure 2 Zone plate, 1080p, red and green

green and blue must be similar or identical, and that the sensor resolution is probably much higher than 2200x1240, but that the down-scaling in the camera, taken with the inevitable filtering due to decoding the Bayer patter, is not good enough. Also, there is significant aliasing in the smaller luminance pattern which explores double the nominal frequency range. This is a good indication that any optical spatial filtering is inadequate, or missing by design.

1.2.2   1080-line HQ, progressive

Figure 3 shows the result for setting progressive, again with factory detail settings.

There appears to be no difference in resolution between progressive and interlace, a sure sign that the native resolution of the camera does not reach the limits of the 1920x1080 format.
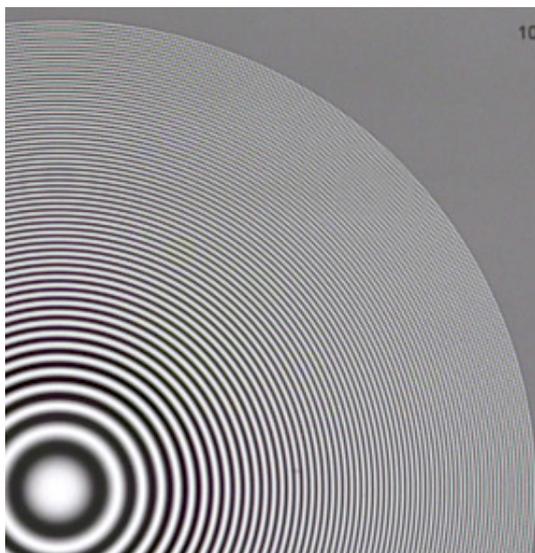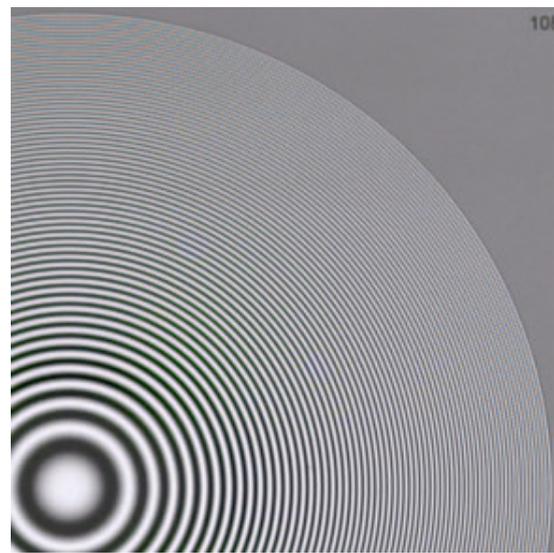

Figure 3 Zone plate 1080P, factory detail

Figure 4 Zone plate, best detail

Interestingly, the Detail Level control appears to be able to subtract detail as well as add it. The factory default level of 0 is a reasonable setting, but at level -25 detail is unaffected, lower settings actually soften the picture. Also, the camera has both Detail and Aperture controls, which permits much greater flexibility than having either alone.

The best setting found by experiment sets Detail Level to 0, Detail Frequency to +99, and Aperture level to +20. *Figure 4* shows the result, aliasing is a little less pronounced.

1.3   Lens performance

Clearly, it would be a mistake to fit lenses to this camera having excessive high-frequency performance, since that would only increase the visibility of the aliases. To see how well the supplied 85mm prime lens performed, images were grabbed at *T*/2.8 (wide open) and *T*/22, at 18mm focal length (close up) and 50mm.

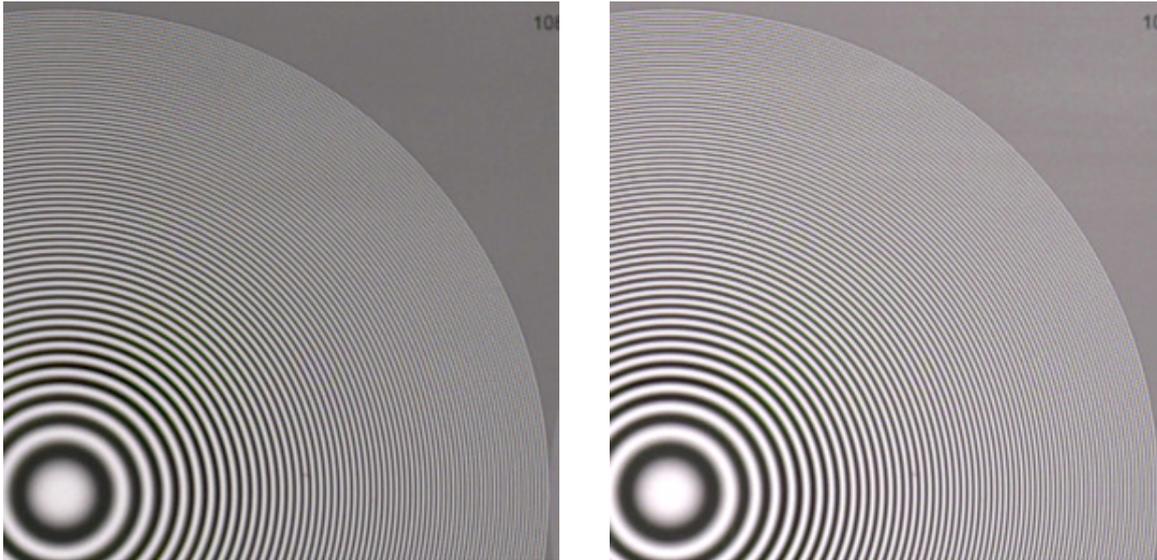**Figure 5 Zone plate, 50mm focal length, (a) T/2.8   (b) T/22**

The lens performance did not appear to change at all over this range, the lens os good, perhaps too good for the camera.

Chromatic aberration levels are acceptable, a maximum colour-fringe width of about 2.5 pixels at 18mm focal length, and *T*/2.8.

1.4   Video noise and sensitivity

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 *Std5* gamma curve (ITU.709) and 0dB gain. 1080P HQ mode was used.

Figure 6 Chromatic aberration

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.

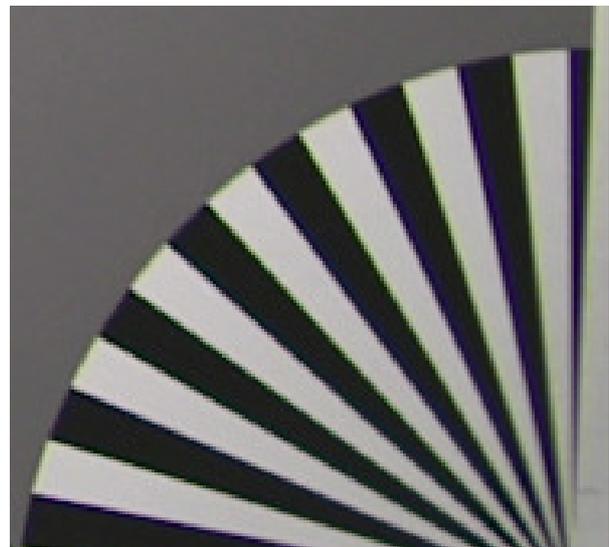*Figure 7a* shows the results, noise levels in dB plotted versus signal level.
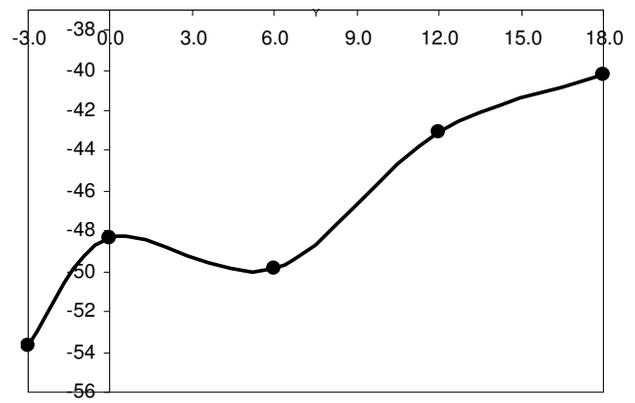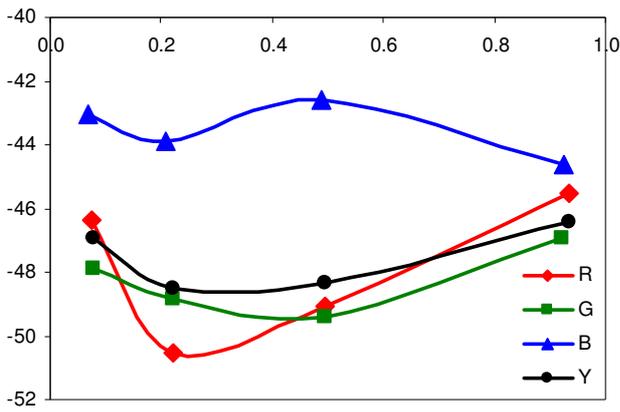
Figure 7 Noise levels (a) at 0dB   **(b) at 50% luma level**

Clearly, the noise levels do not change linearly in accord with the slope of the gamma curve, there being only about 2dB change over the signal range. This probably indicates that there is significant noise reduction being applied in the camera. 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 -48.5dB rather than the claimed -63dB in the specification.

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

Figure 7b shows how the noise changes with camera gain. Noise at 0dB gain does not fit comfortably into the expected linear change of noise level with camera gain, but the discrepancy is only about 2dB and so is probably not significant. Although the camera does not appear to deliver the specified noise levels, the results are perfectly acceptable for most purposes, working at high gains should not be a problem.

Spectrally, the noise appears to be uniformly spread over the frequency range, and has no fixed pattern to it.

Sensitivity was not measured directly. The specification claims it to be T/11 at ISO800, and since ISO800 corresponds to 0dB gain, this means that the sensitivity is very similar to that of a 3-sensor ⅔" sensor, which in turn implies that the pixels are about 5μm square. Given that the sensor is 'super 35mm' size, it must be 24x13.5mm. For the pixels to be 5μm spaced, the sensor width must be about 4800 pixels, making the sensor approximately 4,800x2,700. This fits reasonably well with the estimations in section 1.2.1, and means that the sensor has approximately 12.9 Megapixels, typical of a digital stills camera. It also explains why there is little or no coloured aliasing, and why the red, green and blue signals all have the same resolution and aliasing.