

Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 27 rev.1: Menu settings for

Panasonic P2 AJ-HPX3000

This document is a report of the results of tests that are the precursor of those described in the EBU technical document Tech3335. It is not an endorsement of the product.

A brief assessment was made on a production sample of the AJ-HPX3000 (serial number 17TKA0067), a HDTV camcorder with a Canon HA18x7.6 HD lens. It is very similar in form and function to the HPX2100 and HDX900, sharing many features and having a very similar menu set.

The camera has full 1920x1080 sensors (CCD) and operates at the 1080-line HDTV standards, at both 29.97 and 25Hz. It can also be switched between interlace (50i, 59.94i) and progressive (25psf, 29.97psf, and 23.98psf in both 2:3 and 2:3:3:2 pull-down) modes, but not to 720-line HDTV. It can generate a “film look” in the camera, and has specific “film-look” gamma curves that incorporate many of the contrast handling features of earlier cameras, making it a great deal easier to set up.

The recording system is either the conventional DVCProHD format (8-bits, 1440x1080, 6.7:1 compression at 29.97Hz, 6.3:1 at 25Hz) or the newer AVC-Intra (10-bits, full resolution, H.264, I-frame only) onto solid-state P2 cards (5-cage slots in the camera). It does not have variable-speed capability. Sensitivity is specified as F/10 at 2000lux, power consumption 44 watts, weight 4.5kg without lens or viewfinder.

It is a little larger than the HDX900, being wider to accommodate the P2 cards instead of the tape mechanism, and has HDSDI output. It has many internal menus for setting the performance, such that it can then be used without external controls. It is not ideally suited to multi-camera operation (being a camcorder) but has enough features to make multi use possible. Monitoring and connectivity have been improved over previous Panasonic models; it will genlock to either analogue HD Y or analogue composite (PAL or NTSC as appropriate); there are two video outputs, one switchable between HDSDI, SDI (appropriate down-conversion), and composite (PAL or NTSC), the other between HDSDI and HD analogue Y for monitoring; it has a IEEE1394 (Firewire) output that will feed and control an external recorder. It has a LCD side-panel, useful for menu setting etc.

There is an 8-second video cache memory. Using this, it is possible to record up to 8 seconds of events that occurred before pressing “Record”. The same circuitry is also used to provide a “slow-shutter” in which adjacent frames are summed to produce smeared pictures and reduced noise (or extra gain). The camera section has 14-bit ADC’s that deliver better noise performance than in earlier models.

In this setup, the gamma correction and knee are adjusted to capture almost 2 stops of overload, and 1 stop of underexposure, to mimic film performance.

This revision contains amended settings for both detail enhancement and colour matrix, resulting from field experience, and a second test session (serial number J8TK0012) joint with the HPX2700 and HPX3700. Encouragingly, the settings for each of these three cameras work well with the others, resulting from the use of a common signal processing system across the range of cameras.

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Many menu items have little or no effect on the image. Those that do so are highlighted. The full menus are given for completeness. Where three values are given {f} denotes film use, {v} video and {w} wildlife. The film mode uses the “Filmlike1” gamma curve, which very closely resembles the best that can be done with a conventional gamma curve and knee, but with a nice smooth join; there seems no point in ignoring this curve since Panasonic have clearly put much effort into its design, and it works well. The photographic speed of the camera is unchanged using this curve (“Filmlike2” is a similar curve but copes with about a stop less of overload and reduces the photographic “speed” by about a stop, also the manual knee controls have no effect in this mode so it is not possible to customise it; “Filmlike3” further reduces the exposure range and lowers the photographic “speed” of the camera by about one stop more; both these modes should produce better noise performance and thus may well be the best option for film-like work). The camera also has the “Film-Rec” curve of the Varicam. The video mode uses conventional gamma and knee settings to achieve similar results but with more contrast compression in highlights. Both modes can cope with about 1.7 stops of overexposure (about 350% measured); the video mode (with optimal knee settings) has a slightly more pronounced change of slope in the knee but the difference is marginal. The wildlife mode uses the Film-Rec gamma. The exposure range is about 11 stops.

The shutter can be set to HALF (i.e. 180°), which avoids the problem of having to work out what it should be from the field/frame rate.

Line Mix mode appears in the manual, but not in the menus. In cameras that have this function it is the equivalent of EVS in other cameras. Switched on in 25p mode, Line Mix reduces the vertical resolution to the same as 50i, thus minimising most interlace twitter artefacts although the effect is not great. I am not sure whether this camera has it or not.

Digital Super Gain is implemented by reducing the frame rate. This gives “free” gain without noise, provided the smeared pictures and lowered frame rate is acceptable.

When shooting at 59.94 field/29.97 frame rates, drop-frame time code is always used.

Viewfinder and monitoring outputs can both have markers, individually set.

The camera “Gain” switch stores many camera settings, allowing the user to set completely different conditions selectable by that switch. However, most users will want only different gain, the menu contents given here are appropriate for the range of gains quoted, it is for the user to decide which gain settings are appropriate and to set the other conditions accordingly. Beware that the recommended settings were derived during a short laboratory test of the camera; better settings may well be found once the camera goes into general use.

DRS (Dynamic Range Stretching) appears to be a fully automatic knee and gamma control, untested here, but could be useful when there’s no time to derive best settings.

Switching the camera into SD mode (but still using the HD lens), it produces acceptable pictures with a reasonably low level of spatial aliasing. I have given evidence for this in the final section of this document.

Factory settings are underlined. Clearly, the digital processing owes much to the design of the HDX900, the menu structure is very similar, and many of the settings for the HDX900 have the same effect in this camera. Values are given for Video (v), Film look (f), and Wildlife (w). These settings include rather more detail enhancement than usual, because the camera’s basic resolution is clean enough to sustain it.

This should not be used as a substitute for reading the manual.

This revision contains amended settings for both detail enhancement and colour matrix, resulting from field experience, and a second test session joint with the HPX2700 and HPX3000 where it was evident that they all share the same signal processing since settings for each work well in the others.

1 Menus and settings

SYSTEM SETTING

System mode		Main video standard setting			
Item	Range	description	BBC		
			v	f	w
System Mode	1080-59.94i, 1080-50i, 480-59.94, 576-50i	Any change requires a power-off/on cycle to take effect. Different defaults for E/P models	1080-50i		
Rec Signal	<u>Cam</u> , Video, 1394, SDI	Picture source: CAM=camera, Video=genlock source			
Camera Mode	50i, 25p (60i, 30P, 24P, 24PA)	24PA not available in AVC-Intra ¹ , switches between 50 and 60Hz sets according to mode	50i	25p	25p
Aspect	16:9, 4:3	Only applies to SD recording			
Scan reverse	<u>Off</u> , On	For lenses that invert the picture			
VF Type	SD, <u>HD</u>				
Rec Mode	<u>AVC-I100</u> , AVC-I50, DVCProHD, DVCPro50	DVCPro50 only for SD	AVC-I 100		
Setup	0%, <u>7.5%</u>	Only for SD 480			
PC Mode Select	USB dev, <u>USB host</u>	For connection to USB hard-drive ² : Host=camera control, Dev=PC control			
PC Mode	On, <u>Off</u>	Enables remote (PC) control			

Option mode

General options

Item	Range	description	BBC
Rec Tally	<u>Red</u> , Green, Char	Record indicator, Char puts REC in the v/f	
Access LED	Off, Slot side, LCD side, Both	Enables the P2-card activity LED's	
P.Off GPS Data	Hold, <u>Clear</u>	Holds GPS data while power off	
SDI Metadata	<u>On</u> , Off	Embed UMID data into HDSDI	
SDI EDH	<u>On</u> , Off	Embed error signals into HDSDI	
Save Switch (Aud out)	<u>Off</u> , On	Disables audio out when in power "Save"	
Save Switch (lcd)	<u>Off</u> , On	Disables LCD when in power "Save"	
Auto Rec	<u>Off</u> , Type 1, Type 2	Start/Stop marks derived from LTC (1) or VITC (2)	

Rec function

Specialist recording functions

Item	Range	description	BBC
Interval rec mode	On, One shot, <u>Off</u>	Uses 8-second store	
Interval rec hold	On, <u>Off</u>	On keeps the settings through power Off	
Rec time	<u>00s01f</u> ~59s29f	Frames to be grabbed, frames are 24 for 25fps, 23 for 24p	
Pause time	00h00m00s01f~ <u>00h04m59s29f</u> 29f~23h59m59s29f	Time between grabs	
Total take time	<u>None</u> ~5day	None=continuous	
Total rec time	00m00s01f~99m59s29f, Over 100min, <u>None</u>	Report, not control	
Audio rec	On, <u>Off</u>	Sound capture during interval recording	
Start delay	<u>0sec</u> ~10sec	Delay to start interval grabs	
Pre Rec Mode	Off, <u>On</u>	Cache pre-recording	
Pre Rec Time	1s~ <u>8s</u>	Length of video cache	
Loop Rec Mode	<u>Off</u> , On		
Rec Start	<u>Normal</u> , All	All allows recording to start even during playback except in Interval Rec mode	
P.On Rec Slot Sel	<u>Hold</u> , Slot 1	Which P2 slot to use on power-up	

¹ 24PA is actually 23.98Hz, with "advance pull-down", 2:3:3:2

² The camera can be used as a hard-drive source for the editor, to move clip files, controlled either from the camera or the computer.

Output sel

Signals on the displays

Item	Range	description	BBC
Output Item	TC,Status, <u>Menu only</u>	Puts metadata onto video outputs	
Monitor Out	<u>VBS</u> ,VF,Y	Composite/viewfinder or Y, on camera right	
Monitor Out Chara	On, <u>Off</u>	Adds characters on monitoring output	
LCD Mon Char	<u>On</u> ,Off	And LCD	
VF Mode	Cam, <u>Mem</u>	Mem=EE, Cam always shows the camera	
Thumbnail Out	<u>Off</u> ,On	Puts thumbnails on monitor video outputs	

Downcon setting

Down conversion

Item	Range	description	BBC
Downcon mode	Sqeez,Lt-box,S-crop	Handling the 3 16:9	
Detail	<u>On</u> ,Off	HD fed to the converter has detail settings at HD as well, this turns off the SD tweaks	
H.dtl level	0~ <u>8</u> ~31	Horizontal detail	
V.dtl level	0~ <u>4</u> ~31	Vertical detail	
Dtl coring	0~ <u>1</u> ~15	Noise slicer level	
H.dtl freq	1~ <u>3</u> ~5	Peak: 2.5,3,3.5,4,4.5MHz	
2D lpf	On, <u>Off</u>	Reduces diagonal resolution, cross-colour in composite video	
Setup	0%, <u>7.5</u> %	Only for 480/59.94	

LCD monitor

Simple controls

Item	Range	description	BBC
Brightness	-7~ <u>0</u> ~+7		
Color Level	-7~ <u>0</u> ~+7		
Contrast	-7~ <u>0</u> ~+7		
Backlight	<u>Normal</u> ,High		
Self Shoot	<u>Mirror</u> ,Normal		
Aspect conv	<u>Squeeze</u> ,Lt-box	The LCD panel is 4:3	

Genlock

Item	Range	description	BBC
Genlock	<u>Int</u> ,Ext	Genlock source	
GL.Phase	<u>HDSDI</u> ,Composit	Which output is locked ³	
H.Phase Coarse	-100~ <u>0</u> ~100	Coarse H timing	
H.Phase Fine	-100~ <u>0</u> ~100	Fine H timing	

1394 Settings

Firewire controls

Item	Range	description	BBC
1394 Speed	S100,S200, <u>S400</u>	Firewire speed, Mb/s	
1394 In Ch	0~63, <u>Auto</u>	Assign channel number	
1394 Out Ch	0~63, <u>Auto</u>	Assign channel number	
1394 Control	Off, <u>Both</u>	External recorder, Both servos external to camera controls	
1394 Cmd Sel	<u>Rec P</u> , Stop	External recorder, Stop or hold on RecPause	

PAINT MENUS**RB Gain Control**

Colour balancing

Item	Range	description	BBC
R Gain AWB Pre	-200~ <u>0</u> ~200	Red gain in switch Preset balance	
B Gain AWB Pre	-200~ <u>0</u> ~200	Blue gain in switch Preset balance	
R Gain AWB A	-200~ <u>0</u> ~200	Red gain in switch A balance	
B Gain AWB A	-200~ <u>0</u> ~200	Red gain in switch A balance	
R Gain AWB B	-200~ <u>0</u> ~200	Red gain in switch B balance	
B Gain AWB B	-200~ <u>0</u> ~200	Red gain in switch B balance	

³ The SD output has about 90-line delay relative to HD output. This control determines which output is actually locked to the genlock source.

AWB A Gain Offset	On, <u>Off</u>	On adds A values above after rebalance in A	
AWB B Gain Offset	On, <u>Off</u>	On adds B values above after rebalance in B	

RGB Black Control

More colour balancing

Item	Range	description	BBC
Master Ped	-200~ <u>15</u> ~200	Master black level, 15's a bit high, 6 is better	6
R Pedestal	-100~ <u>0</u> ~100	Red ped, reports value from remote control	
G Pedestal	-100~ <u>0</u> ~100	Green	
B Pedestal	-100~ <u>0</u> ~100	Blue	
Pedestal Offset	On, <u>Off</u>	On enables these values	
R Flare	-100~ <u>0</u> ~100	Red flare correction	
G Flare	-100~ <u>0</u> ~100	Green	
B Flare	-100~ <u>0</u> ~100	Blue	

Matrix (User preset) A,B

Colour matrix, user settings

Item	Range	description	BBC
Matrix Table	<u>A</u> ,B	Two user tweakable matrices	
Matrix R-G	-63~ <u>31</u> ~63	Settings for matrix A or B	31
Matrix R-B	-63~ <u>4</u> ~63		-8
Matrix G-R	-63~ <u>1</u> ~63		-1
Matrix G-B	-63~ <u>4</u> ~63		4
Matrix B-R	-63~ <u>1</u> ~63		1
Matrix B-G	-63~ <u>1</u> ~63		-1
L Matrix Table	<u>Off</u> ,A,B		Select matrix in Low
M Matrix Table	<u>Off</u> ,A,B	Mid	A
H Matrix Table	<u>Off</u> ,A,B	High gain setting	A

Color Correction

rather dangerous territory

Item	Range	description	BBC	
R (Sat/Phase)	-63~ <u>0</u> ~63	Adjusts colour in 45 degree segments, tweaks saturation and hue. This is rather dangerous, but can be very useful for special effects. Generally, you should avoid this unless you have good test kit, including comprehensive colour test charts.		
R-Mg (Sat/Phase)	-63~ <u>0</u> ~63			
Mg (Sat/Phase)	-63~ <u>0</u> ~63			
Mg-B (Sat/Phase)	-63~ <u>0</u> ~63			
B (Sat/Phase)	-63~ <u>0</u> ~63			
B-Cy (Sat/Phase)	-63~ <u>0</u> ~63			
Cy (Sat/Phase)	-63~ <u>0</u> ~63			
Cy-G (Sat/Phase)	-63~ <u>0</u> ~63			
G (Sat/Phase)	-63~ <u>0</u> ~63			
G-Yl (Sat/Phase)	-63~ <u>0</u> ~63			
Yl (Sat/Phase)	-63~ <u>0</u> ~63			Sat +63 Phase +60
Yl-R (Sat/Phase)	-63~ <u>0</u> ~63			
Color Correct	<u>Off</u> ,On			On

Low Setting

Low Level Gain switch position

Item	Range	description	BBC		
			v	f	w
Master Gain	-3, <u>0</u> ~30dB	dB settings, 3dB steps	-3	-3	-3
H Dtl Level	0~ <u>10</u> ~63		10	8	6
V Dtl Level	0~ <u>15</u> ~31		15	12	8
Dtl Coring	0~ <u>1</u> ~15		2		
H Dtl Freq	0~ <u>18</u> ~31		31		
Level Dep	0~ <u>1</u> ~5	Low luma zone, no correction	1		
Gamma	0.35~ <u>0.45</u> ~0.75	0.01 steps	0.45		
Black Gamma	-3~ <u>Off</u> ~+3	No other controls	1		
Matrix Table	<u>A</u> ,B, <u>Off</u>	User preset matrices	A		
Color Corr.	On, <u>Off</u>	12 segment adjust, see above	On		

Mid Setting

Mid Level Gain switch position

Item	Range	description	BBC		
			v	f	w

Master Gain	-3~ <u>6</u> ~30dB	dB settings, 3dB steps	0	0	0
H Dtl Lev	0~ <u>8</u> ~63		8	6	5
V Dtl Lev	0~ <u>12</u> ~63		12	8	6
Dtl Coring	0~ <u>2</u> ~15		2		
H Dtl Freq	0~ <u>18</u> ~31		31		
Level Dep	0, <u>1</u> ~5	Low luma zone, no correction	1		
Gamma	0.35~ <u>0.45</u> ~0.75	0.01 steps	0.45		
Black Gamma	-3~ <u>Off</u> ~+3		1		
Matrix Table	<u>A</u> ,B,Off	User preset matrices	A		
Color Correct	On, <u>Off</u>	12 segment adjust, see above	On		

High Setting

High Level Gain switch position

Item	Range	description	BBC		
			v	f	w
Master Gain	-3~ <u>12</u> ~30dB	dB settings, 3dB steps	6	6	6
H Dtl Lev	0~ <u>6</u> ~63		6	5	4
V Dtl Lev	0~ <u>10</u> ~63		8	7	6
Dtl Coring	0~ <u>3</u> ~15		3		
H Dtl Freq	0~ <u>18</u> ~31		31		
Level Dep	0~ <u>3</u> ~5	Low-luma zone, no correction	4		
Gamma	0.35~ <u>0.55</u> ~0.75	0.01 steps	0.45		
Black Str	-3~ <u>Off</u> ~+3		0		
Matrix Table	<u>A</u> ,B, <u>Off</u>	User preset matrices	A		
Color Correct	On, <u>Off</u>	12 segment adjust, see above	On		

Additional Dtl

Detail, extra controls

Item	Range	description	BBC
Knee Ape Lvl	Off,1, <u>2</u> ~5	Correction in knee compressed zone	3
Dtl Gain +	-31~ <u>0</u> ~31	correction, +ve going edges	0
Dtl Gain -	-31~ <u>0</u> ~31	correction, -ve going edges	8
Dtl Clip	<u>0</u> ~63	Clip level of detail correction	47
Dtl Source	$(R+G)/2, (G+B)/2, (2G+R+B)/4, (3G+R)/4, R, G$	Doesn't make much difference except when noise level is high	$(R+G)/2$
Master Dtl	-31~ <u>0</u> ~31	Copy of master control	

Skin Tone Dtl

Item	Range	description	BBC
Skin Tone Dtl	<u>Off</u> ,A,B,AB	Select skin tone table, reduces wrinkles	Off
Skin Tone Zebra VF	On, <u>Off</u>	Zebra on skin tone detector	
Skin Tone Table	<u>A</u> ,B	Separate tables of target tones	
Skin Tone Get		Looks for skin tone	
Skin Dtl Coring	0~ <u>5</u> ~7		
Y Max	0~ <u>190</u> ~255	Max luma level for skin	
Y Min	0~ <u>10</u> ~255	Min luma level for skin	
I Center	0~ <u>35</u> ~255	Saturation mean level for skin	
I Width	0~ <u>55</u> ~255	Saturation range for skin	
Q Width	0~ <u>10</u> ~90	Hue mean level for skin	
Q Phase	-180~ <u>0</u> ~179	Hue range for skin	

Cam Main Menu 1, Knee Level

Don't use Auto knee, manual is better

Item	Range	description	BBC
Master Ped	-200~ <u>15</u> ~200	Duplicate entry for pedestal	6
Manual Knee	<u>On</u> ,Off	Valid only if AUTO is off	On
Knee Point	70%~ <u>93</u> ~107%	Manual break point	85
Knee Slope	0~ <u>85</u> ~99	Gain in knee zone, about 2.5 stops overload	99
White Clip	<u>On</u> ,Off		On
White Clip Lvl	90%~ <u>109</u> %		109%
A Knee Point	80%~ <u>93</u> ~107%	Auto knee point	85%
A Knee Level	100~ <u>107</u> ~109		105
A Knee Response	1~ <u>4</u> ~8	Auto knee response speed (low=fast)	4

Chroma level	Off,-99%~ <u>0%</u> ~40%	Saturation change	0
DRS effect depth	<u>1</u> ,2,3	Dynamic Range Stretch, auto-tweaks gamma and knee	1

Gamma

Differentials and colour tweaking

Item	Range	description	BBC		
			v	f	w
Master Gamma	0.35~ <u>0.45</u> ~0.75		0.45		
R Gamma	-15~ <u>0</u> ~15	Set R away from Master	0		
B Gamma	-15~ <u>0</u> ~15	Set B away from Master	0		
Gamma Mode Sel	<u>DFLT</u> ,HD,SD,Filmlike1, Filmlike2,Filmlike3,Film Rec	HD=709, SD=BBC0.4, approximately. Film- Rec is Varicam gamma	HD	Film like1	Film -Rec
Dynamic level	200%,300%,400%, <u>500%</u>	Peak exposure in Film-Rec mode	300		
Black str lvl	<u>0%</u> ~30%	Only in Film-Rec mode	0 ⁴		

Camera Settings

Item	Range	description	BBC		
			v	f	w
Detail	<u>On</u> ,Off	All detail	On	On	Off
2D lpf	<u>On</u> ,Off	Cross-colour reduction in NTSC SD			
High Color	<u>On</u> , <u>Off</u>	Hue/Saturation maintenance at high luma, not available in DRS	On		
Gamma	<u>On</u> ,Off		On		
Test Saw	<u>On</u> , <u>Off</u>				
Flare	<u>On</u> ,Off				
H-F Compe	<u>On</u> ,Off	Wide-band detail enhancement	On		

VF Display

User controls (RC=remote control)

Item	Range	description	BBC		
			v	f	w
Disp Condition	<u>Normal</u> /Hold	Show switch status: Normal=On, Hold when ModeCheck pressed	Normal		
Disp Mode	1,2, <u>3</u>	1=off, 2=some, 3=all	3		
VF Out	<u>Y</u> ,NAM,R,G,B	What you see, NAM=non-additive mix	Y		
VF Dtl	<u>0</u> ~5	5 roughly doubles the HD detail in the v/f			
Zebra 1 detect	0%~ <u>70</u> ~109%	Set for skin tone (BL-TR)	70	65	65
Zebra 2 detect	0~ <u>85</u> ~109%	Set for white (TL-BR)	100%		
Zebra 2	<u>On</u> , <u>Spot</u> ,Off	SPOT works only if Zebra 2>1	Spot		
Low Light Lvl	Off,10%~ <u>35%</u>	Warns at low light level	35%		
RC menu Disp	<u>On</u> ,Off	Shows menus in v/f when RC is connected	Off		
50M indicator	<u>On</u> , <u>Off</u>	SD only, indicates shooting DVCPro50			
Marker/Char Lvl	<u>50%</u> ~100%	Marker/Character brightness	100%		
Synchro scan disp	<u>Sec</u> ,Deg	Seconds or degrees, only for synchro shutter			

VF Marker

Viewfinder stuff

Item	Range	description	BBC
Table	<u>A</u> ,B	Switch between AB, 2 sets of setups set below	
Centre Mark	Off, <u>1</u> ~4	Cross size/type	
Safety Mark	Off,1, <u>2</u>	1=box, 2=corners	
Safety Area	80%~ <u>90</u> ~100%	Size of safety area	
Frame Mark	<u>On</u> , <u>Off</u>	Frame marker	OFF
Frame Sig	<u>4:3</u> ,13:9,14:9,Vista	Vista is 16:8.65	14:9
Frame Lvl	0~ <u>15</u>	Picture level outside frame mark, 15=same	15

VF User Box

More viewfinder stuff

Item	Range	description	BBC
User Box	<u>On</u> , <u>Off</u>	Custom frame	
User Box Width	1~ <u>13</u> ~100	Width, %	

⁴ Some black stretch may help in very high contrast scenes.

User Box Height	1~13~100		
User Box H Pos	-50~0~50		
User Box V Pos	-50~0~50		

VF Indicator 1

And yet more

Item	Range	description	BBC
Extender	<u>On</u> ,Off	Lens extender	
Shutter	<u>On</u> ,Off	Shutter speed display	On
Filter	<u>On</u> ,Off	Filter position	On
White	<u>On</u> ,Off	Show AWB or Preset A/B	
Gain	<u>On</u> ,Off		
Iris	Offs,S+Iris,S	Iris/Super Iris (aperture/auto) display	
Camera ID	<u>Bar</u> ,Off	Show camera ID over bars	
ID Position	UpperR, <u>UpperL</u> , LowerR,LowerL	Placement	
Date/Time	<u>On</u> , <u>Off</u>	Show time/date with camera ID	Off
Zoom Lvl	<u>On</u> ,Off	Focal length	
Color Temp	<u>On</u> ,Off		
System Mode	<u>On</u> ,Off	Camera system speed	
Camera Mode	<u>On</u> ,Off	Selects Dynamic Range Stretcher display	

VF Indicator 2

And still more

Item	Range	description	BBC
CAC	<u>On</u> ,Off	Astigmatism correction ⁵	
Film-Rec mode	<u>On</u> ,Off	Show when in Film-Rec	
P2 Card Remain	Off,One Card,Total	How much is left	
Battery	<u>On</u> ,Off	Voltage	On
Audio Level	<u>On</u> ,Off	Bar-graph meters	On
TC on color bar	<u>On</u> , <u>Off</u>		
TC	<u>Off</u> ,TCG,TCR,TCG/TCR	The usual timecode stuff	
System Info	Off, Always, <u>Normal</u>	Normal=3 second display of problems	
Save LED	<u>Save</u> ,P2 Card	Save warns when in Save mode, P2 warns when card nearly full	
Rec Status	<u>On</u> , <u>Off</u>	Rec indicator in VF	
Proxy Rec	<u>On</u> , <u>Off</u>	Proxy recording to P2 and/or SD card	

Mode Check Ind

What happens when you press Mode Check

Item	Range	description	BBC
Status	<u>On</u> ,Off	Get the status screen	On
!LED	<u>On</u> ,Off	Shows why !LED might be lit	On
Function	<u>On</u> ,Off	Function screen	On
Audio	<u>On</u> ,Off	Audio screen	On
P.On Ind	<u>On</u> ,Off	Get status screen up at power-on	On

! LED

VF warnings

Item	Range	description	BBC
Gain (0dB)	<u>On</u> ,Off		
Gain (-3dB)	<u>On</u> , <u>Off</u>		
DS Gain	<u>On</u> , <u>Off</u>		
Shutter	<u>On</u> ,Off		
White Preset	<u>On</u> , <u>Off</u>		
Extender	<u>On</u> ,Off		
Black Gamma	<u>On</u> , <u>Off</u>		
Matrix	<u>On</u> , <u>Off</u>		
Color Correct	<u>On</u> , <u>Off</u>		
Filter	<u>On</u> , <u>Off</u>		

OPERATION**Camera ID**

3 lines of text

⁵ Astigmatism correction for lenses that have the software to talk to the camera.

Item	Range	description	BBC
ID1		Max 10 characters	
ID2			
ID3			

Shutter Speed

Select which speeds go onto the switch list

Item	Range	description	BBC
Synrho Scan	<u>On</u> ,Off	Speed set by buttons near filter wheel, longest exposure depends on frame rate	
Position 1	<u>On</u> ,Off	ON adds items to list of settings that can be cycled through using the switch below the lens.	
Position 2	<u>On</u> ,Off		
Position 3	<u>On</u> ,Off		
Position 4	<u>On</u> ,Off		
Position 5	<u>On</u> ,Off		
Position 6	<u>On</u> ,Off		

Shutter Select

Item	Range	Factory 59.94	Factory 50	description	BBC
Position 1	(59.94) 1/100,1/120,1/250, 1/500,1/1000,1/2000,HALF (50) 1/60,1/120,1/250,1/500, 1/1000,1/2000,HALF 180,172.8,144,120,90,-,45deg	1/100	1/60	HALF keeps exposure at 180° irrespective of field or frame rate	1/60
Position 2		1/120	1/120		1/120
Position 3		1/250	1/250		1/250
Position 4		1/500	1/500		1/500
Position 5		1/1000	1/1000		1/1000
Position 6		1/2000	1/2000		HALF

User SW

Assign user switches

Item	Range	Factory	description	BBC
User Main Sw	Inh,S.Gain,DS.Gain,S.Iris,I.Over,S.Blk,B.Gamma,Yget, DRS,Assist,C.Temp,Audio Ch1,AudioCh2, RecSw,RetSW,Pre.Rec,SlotSel,PCmode	SlotSel		
User 1 Sw		S.Gain		
User 2 Sw		DS.Gain		

SW Mode

More general stuff

Item	Range	description	BBC
Ret Sw	<u>R.Review</u> ,Cam Ret	Review last few seconds/check Genlock input	R.Review
S.Blk Lvl	<u>-10</u> ,-20,-30	Super black level, not a good idea	
Auto Knee Sw	<u>On</u> ,Off,DRS	Disables Auto Knee switch	Off
Shd,Abb Sw Ctl	<u>On</u> ,Off	Does black shading with black balance if pressed >8seconds	On
Color Bars	<u>SMPTE</u> ,Full,Split,Arib	SMPTE default for P model, Full for E model, daft idea. Arib=multi-format bars	SMPTE
S.Gain Off	<u>L/M/H</u> ,S.Gain	Which switch cancels Super Gain	
DS.Gain Off	<u>L/M/H</u> , <u>DS</u> ,Gain	Which switch cancels Digital Super Gain	
RC Check Sw	<u>R.Review</u> ,Play	Which switch does Rec check	

White Balance Mode

Presets

Item	Range	description	BBC
Filter Inh	<u>On</u> ,Off	Off allows separate balance data to be stored for each filter wheel position	On
Shockless AWB	Off,Fast, <u>Normal</u> , Slow1,Slow2,Slow3	Response speed to white change, 1~20 seconds	
AWB Area	<u>25%</u> ,50%,90%	Central screen target area	
Color Temp Pre	2300K~ <u>3200K</u> ~8000K	AWB set in Preset	3200K
AWB A Temp	2300K~ <u>3200K</u> ~8000K	AWB set in A, reports result of rebalance	3200K
AWB B Temp	2300K~ <u>3200K</u> ~8000K	AWB set in B, reports result of rebalance	3200K

User Sw Gain

Gain trickery

Item	Range	description	BBC
S.Gain 30dB	<u>On</u> ,Off		
S.Gain 36dB	<u>On</u> ,Off		
DS.Gain 6dB	<u>On</u> ,Off	Free gain, sums adjacent frames, blurs	
DS.Gain 10dB	<u>On</u> ,Off		

DS.Gain 12dB	<u>On,Off</u>		
DS.Gain 15dB	<u>On,Off</u>		
DS.Gain 20dB	<u>On,Off</u>		

Lens/Iris

Item	Range	description	BBC
A.Iris Level	0~ <u>45</u> ~100	Auto iris target level, luma	
A.Iris Peak/Ave	0~ <u>30</u> ~100	Ratio, 0=average, 100=peak	
A.Iris Window	<u>Norm1</u> ,Norm2,Centr	1=full frame, 2=not top, centre=spot	
S.Iris Level	0~ <u>80</u> ~100	Super Iris target (backlight compensation)	
Iris Gain	Cam, <u>Lens</u>	Where the iris gain control is	
Irtis Gain Value	1~ <u>10</u> ~20	Value used when set to Cam	

MAIN OPERATION**Battery/P2 Card**

Item	Range	description	BBC
Battery Select	Propac14, Trimpac14, Hytron50, Hytron120, <u>Dionic90</u> , Dionic120, NP-L7, Endura7, Endura10, EnduraD, PagL95, BP-GL65/95, Nicd14, TypeA, TypeB	Set your power source type and all the warnings and meters will read correctly	
Ext DC in select	<u>Ac adpt</u> , Propac14, Trimpac14, Hytron50, Hytron120, Dionic90, Dionic120, NP-L7, Endura7, Endura10, EnduraD, PagL95, BP-GL65/95, Nicd14, TypeA, TypeB		
Batt near end alarm	<u>On,Off</u>	Set near end alarm	
Batt near end cancel	<u>On,Off</u>	Mode check button cancels alarm	
Batt end alarm	<u>On,Off</u>		
Batt remain full	<u>70%</u> , 100%	Indicates full at this level	
Card near end alarm	<u>On,Off</u>	Beep near end of card	
Card near end time	<u>2min</u> , 3min	Time for beep	
Card end alarm	<u>On,Off</u>	Beep at card end	
Card Remain	<u>3min</u> , 5min	Segment size in display	

Battery Setting 1

Decide which batteries exist in the list

Item	Range	description	BBC
Propac14	<u>Auto</u> , Manual (11~ <u>13.8</u> ~15)	Select each battery with * Auto/Manual controls whether you can set the warning level voltage manually. Be sensible with this and you'll never have silly battery warnings	
Trimpac14	<u>Auto</u> , Manual (11~ <u>13.6</u> ~15)		
Hytron50	<u>Auto</u> , Manual (11~ <u>13.2</u> ~15)		
Hytron100	<u>Auto</u> , Manual (11~ <u>13.0</u> ~15)		
Dionic90	<u>Auto</u> , Manual (11~ <u>13.6</u> ~15)		
Dionic160	<u>Auto</u> , Manual (11~ <u>13.1</u> ~15)		
NP-L7	<u>Auto</u> , Manual (11~ <u>12.9</u> ~15)		
Endura7	<u>Auto</u> , Manual (11~ <u>13.2</u> ~15)		
Endura10	<u>Auto</u> , Manual (11~ <u>13.2</u> ~15)		
EnduraD	<u>Auto</u> , Manual (11~ <u>13.2</u> ~15)		
PagL95	<u>Auto</u> , Manual (11~ <u>13.5</u> ~15)		
BP-GL65/95	<u>Auto</u> , Manual (11~ <u>13.6</u> ~15)		

Battery Setting 2

Continued

Item	Range	description	BBC
Nicd14	<u>Auto</u> , Manual (11~ <u>13.2</u> end~ <u>13.8</u> near end~15)		
TypeA	<u>Auto</u> , Manual (11~ <u>12.9</u> end~ <u>13.6</u> near end~ <u>14.6</u> full~17)		
TypeB	<u>Auto</u> , Manual (11~ <u>12.4</u> end~ <u>13.0</u> near end~ <u>15.2</u> full~17)		

Mic/Audio 1

Item	Range	description	BBC
Front VR Ch1	Front, WL, Rear, All, <u>Off</u>	Where the audio control is, Ch1	
Front VR Ch2	Front, WL, Rear, All, <u>Off</u>	Audio control, Ch2	
Mic Lowcut Ch1	Front, Rear, WL, <u>Off</u>	Bass-cut filters, to 200Hz	
Mic Lowcut Ch2	Front, Rear, WL, <u>Off</u>		
Mic Lowcut Ch3	Front, Rear, WL, <u>Off</u>		
Mic Lowcut Ch4	Front, Rear, WL, <u>Off</u>		

Limiter 1	<u>On/Off</u>		
Limiter 2	<u>On/Off</u>		
Audio Level Ch3	<u>On,Off</u>		
Audio Level Ch3	<u>On,Off</u>		
Test Tone	<u>Normal,Always,Off,ChSel</u>		Which channel(s) get test tone

Mic/Audio 2

Item	Range	description	BBC
Front Mic Power	<u>On,Off</u>	Phantom power	
Rear Mic Power	<u>On,Off</u>	Phantom power	
Monitor Select	<u>Stereo,Mix</u>	What's monitored	
Front Mic level	<u>-40,-50dB</u>		
Rear Mic Ch1 Level	<u>-50,-60dB</u>		
Rear Mic Ch2 Level	<u>-50,-60dB</u>		
Rear Line In Level	<u>-3,0,+4dB</u>		
Audio Out level	<u>-2,0,+4dB</u>		
Headroom	<u>18,20dB</u>	Ref level, Factory=(50) 18dB, (59.94) 20dB	18dB
Wireless Warn	<u>On,Off</u>	Warns when radio mic level is poor	

TC/UB

Time code and User Bits

Item	Range	description	BBC
TC Mode	<u>DF,NDF</u>	Always NDF at 50 and 24	NDF
UB Mode	<u>User,Time,Date,Ext,TCG,FrmRate,Regen</u>	User bits data	
VITC UB MODE	<u>User/Ext,Time,Date,TCG,FrmRate,Regen</u>		
TCG Set Hold	<u>On,Off</u>	Store TC when powered down	
First Rec TC	<u>Regen,Preset</u>	How TC is started	
P.Off LCD Display	<u>On,Off</u>	TC display when power OFF	
TC Out	<u>TCG,TCG/TCR</u>		
TC Disp Sel	<u>30F,24F</u>	Base for 59.94 frame count, always 25 at 50	
TC Video Synchro	<u>0,1,2,3</u>	Correction for TC, refer to the manual	
Rec Review Regen	<u>On,Off</u>	On uses recorded TC on replay	

UMID Set/Info

Item	Range	description	BBC
Country		Input your data, displays "No-Info" until you do so	
Organization			
User			
Device Node		ID number of the product	

FILE MENUS**SD Card Read/Write**

Item	Range	description	BBC
R.Select	<u>1~8</u>	File number to read	
Read		load from file	
W.Select	<u>1~8</u>	File number to write	
Write		write to file	
Card Config		Format SD card	
Title Read		load user data	
Title1-8		Title, max 8 characters	

Cam Card R/W Select

Decide what gets saved on the card

Item	Range	description	BBC
System Mode R/W	<u>On,Off</u>	System and Camera Modes	
ID Read/Write	<u>On,Off</u>	On=save cam ID to card	
User Menu Select R/W	<u>On,Off</u>	Load/save Menu items that are/aren't marked	
System Menu R/W	<u>On,Off</u>		
Paint Menu level R/W	<u>On,Off</u>		
Paint Menu Sw R/W	<u>On,Off</u>		

VF Menu R/W	<u>On</u> ,Off		
Operation Menu R/W	<u>On</u> ,Off		
Mainte Menu R/W	<u>On</u> ,Off		
Main Ope Menu R/W	<u>On</u> ,Off		

CAC File Card Read

Lens astigmatism correction

Item	Range	description	BBC
Card read select.	<u>1</u> ~32	Select astigmatism data table	
Read		Read it	
Delete		Delete it	
Title read		Read file name	
Title scroll		Scroll CAC files: press rotate Jog wheel	
01-32		File name, 27 characters max	

File Read Screen

Item	Range	description	BBC
Title.		Shows file name	
Yes		Files are recorded in camera	
No (Cancel)		Or not	
Mem store no	<u>Empty</u> ,1~32	Store number to record to, Empty looks for an empty one	
Title scroll	1~25	Scroll CAC files: press rotate Jog wheel	
01-32		File name, 27 characters max	

Lens File

Item	Range	description	BBC
File No.	<u>1</u> ~8	Lens file number	
Read		Read it	
Write		Write it	
Reset All		Reset lens file data	
Title1-8		Max 12 characters	

Lens File Card R/W

Item	Range	description	BBC
Card File Select	<u>1</u> ~8	8 lens files	
Read			
Write			
Title Read			
Title1-8		Create a title	

Scene

Item	Range	description	BBC
Read User Data.	<u>1</u> ~8	8 lens files	
Scene Sel			
Read			
Write			
Reset		Create a title	
Title1-4			

Initialise**Reset**

Item	Range	description	BBC
Read Factory Data.		Resets User/Scene data	
Write User Data		Save User data in the camera	

MAINTENANCE**System Check**

Item	Range	description	BBC
Color Check	<u>On</u> , <u>Off</u>	Displays RGBY levels	

Lens Adj

Item	Range	description	BBC
F2.8 adj	On, <u>Off</u>		
F16 adj	On, <u>Off</u>		

Black Shading

Item	Range	description	BBC
Correct	<u>On</u> , Off		On
Detection (Dig)		This makes it happen	

White Shading

Item	Range	description	BBC
Correct	<u>On</u> , Off		On
Saw/Para	-255~ <u>0</u> ~255	Values for R/G/B, H/V, Para/Saw	

Lens file Adj

Item	Range	description	BBC
RB Gain Ctrl Reset	On, <u>Off</u>	Resets RG gains and flares	
Lens R Gain Offset	-200~0~200		
Lens B Gain Offset	-200~0~200		
Lens R Flare	0~100		
Lens G Flare	0~100		
Lens B Flare	0~100		

CAC Adj**Astigmatism**

Item	Range	description	BBC
CAC Control	On, <u>Off</u>		
CAC File Delete		Delete file	
CAC File No	1~32	Sele3ct astigmatism data to be deleted	
Title Scroll	1~25	Use Jog wheel	
01~32		Title	

Diagnostic 1

card/software versions, values for production sample camera not recorded

Item	Range	description	BBC
Camssoft Main		Internal flash software version	
Cam Table		Table version	
Pulse FPGA		Font version	
UCIF FPGA			
FM FPGA		Frame memories	
Char FPGE		Characters	
DC FPGA		Down-converters	

Diagnostic 2

Some more

Item	Range	description	BBC
Syscon Soft			
LCD Soft			
P2CS OS			
P2CS AP			
Sh4 CTRL FPGA			
PRC CTRL FPGA			
Sysif FPGA			
SDI in FPGA			
AVC-I SOFT			
AVC-I FPGA			

Hours Meter

Usage record

Item	Range	description	BBC
Operation		10h	
P.On times			

Option		Some more	
Item	Range	description	BBC
Eng Security	On, <u>Off</u>	Turns engineering menus off. DON'T DO THIS unless you're happy to send the camera back to Panasonic to have it turned back on	
Frame Rate UB	<u>Frm Rate</u> ,Menu	FRM Rate sets frame rate into User Bits	
1394 Config	<u>Dflt(000)</u> ,001~255	DVCPPro/DV connection	
1394 Gap Count	0~ <u>40</u> ~63	Interval between data packets	
Audio out delay	Delayed, <u>Through</u>	Speaker/headphone delay to compensate for compression delay	
Fan mode	Off, <u>Auto</u>	Auto recommended unless noise is a problem, remember to turn it to Auto afterwards	
Area Select	NTSC,NTSC J,PAL	SD option	
Area Set		Display of current selection	

2 Measurement results

2.1 Colour performance

Assessments were made visually, using Macbeth charts as usual. Performance was good, there were no surprises. However, the red, yellow and orange patches were somewhat improved using the matrix and colour correction settings in the tables.

2.2 Resolution

A HDTV zone plate chart was used (Figure 1). This contains six circular patterns that fully explore the spatial frequency performance of the camera, up to 1920x1080 pixels per width and height. Three patterns are grey-scale for testing luma performance, three more are coloured for examining chroma resolution or other colour filtering. Modulation is cosine rather than square wave. Each pattern is a “phase space” map of the possible frequencies that the camera can be expected to deal with, reaching 1920 pixels/picture width (960 cycles) horizontally, and 1080 lines/picture height (540 cycles) vertically.

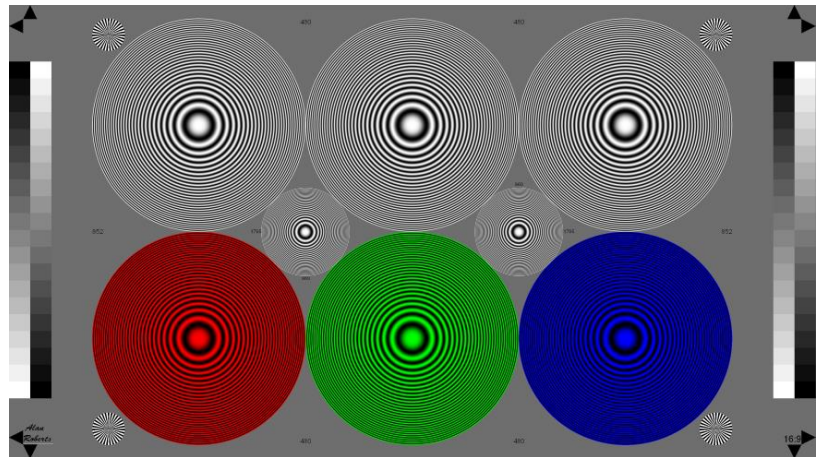


Figure 1, zone plate test chart (480-line video version illustrated)

2.2.1 Resolution, 1080i

Fig.2 shows a single quadrant of one pattern; for this exposure, the camera detail enhancement was turned off, so this is the native performance of the camera. There are clearly no null zones, where the wanted lower frequencies beat with the unwanted alias products, and no aliasing at all. This is good evidence that a “quarter-wave” filter (bi-refringent crystal) has been included in the optical path, and is well suited to the camera resolution.

There was no evidence of aliasing caused by out-of-band frequencies in the minor patterns. Usable resolution up to about 800 lines vertically and 1700 horizontally is clear. Also, there was no evidence through aliasing that “precision offset” (the spatial offsetting of the green sensor from red and blue by exactly $\frac{1}{2}$ pixel spacing to improve luma resolution) is used in this camera.

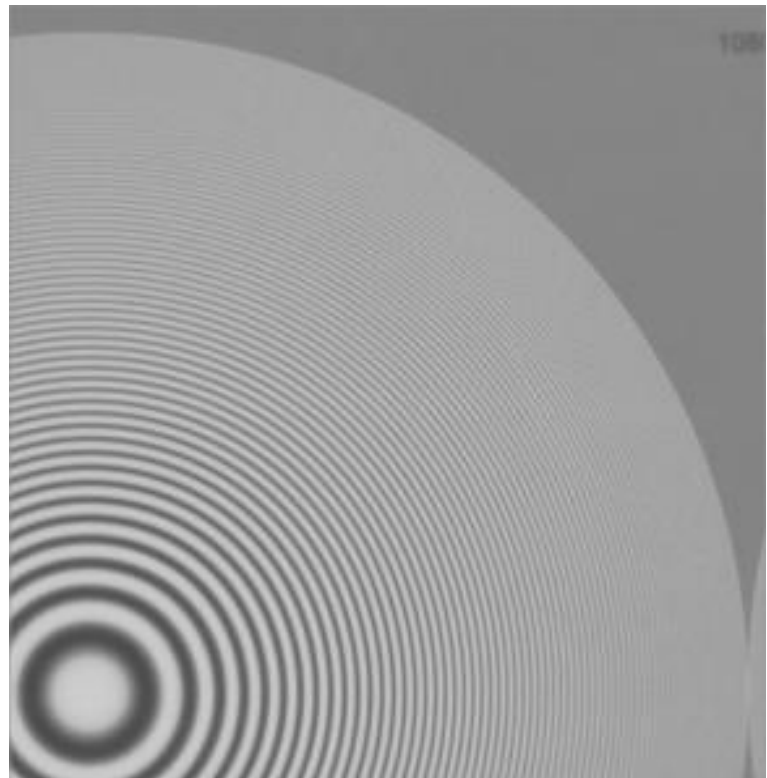


Figure 2, resolution, 1080i, detail off

It is rare to see resolution so clearly as this, which is very encouraging.

2.2.2 Detail enhancement, 1080i, video (v) settings

Figure 3 shows the same quadrant with the Video settings in the menus. Detail enhancement is significant, and the settings were thought to be the highest that could be recommended, lower overall levels may be preferable.

Unusually, detail in the diagonal direction is maintained right to the edge of the pattern, indicating that the modulation transfer function has a high value up to $1/\sqrt{2}$ (over 70%) of the horizontal and vertical frequency limits. This, in itself is rare in any camera.

Even with this high level of detail enhancement, there is no evidence of any spatial aliasing, although the high vertical frequency content caused interlace twitter on an interlaced display. The faint null-centres visible are due to the slight mismatch between the camera gamma curve and that of the display or print.

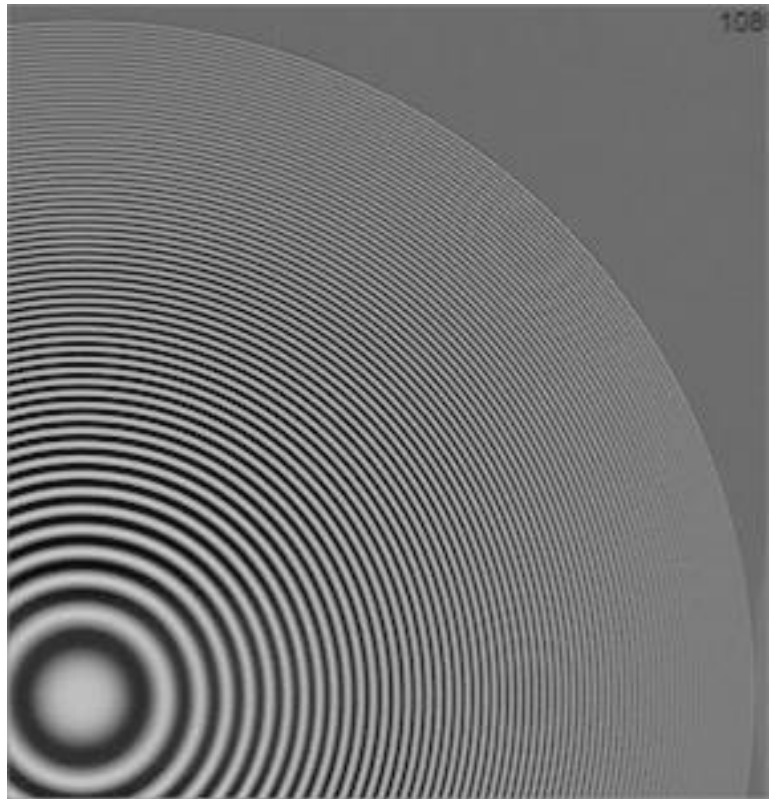


Figure 3, resolution, 1080i, video settings (v), detail on

2.2.3 Resolution, 1080p

Figure 4 shows the result of setting the camera to progressive scanning, and no detail enhancement.

Vertical resolution has improved significantly. This setting is a good resolution match to 35mm negative film scanned at 1080 lines, although the choice of gamma correction is not ideal for that.

Although the “Film-like” gamma curves give a good impression of a film look, the Film-Rec curve is more subtle and has been used to great effect in many BBC productions, and is therefore recommended for getting a film look from this camera.

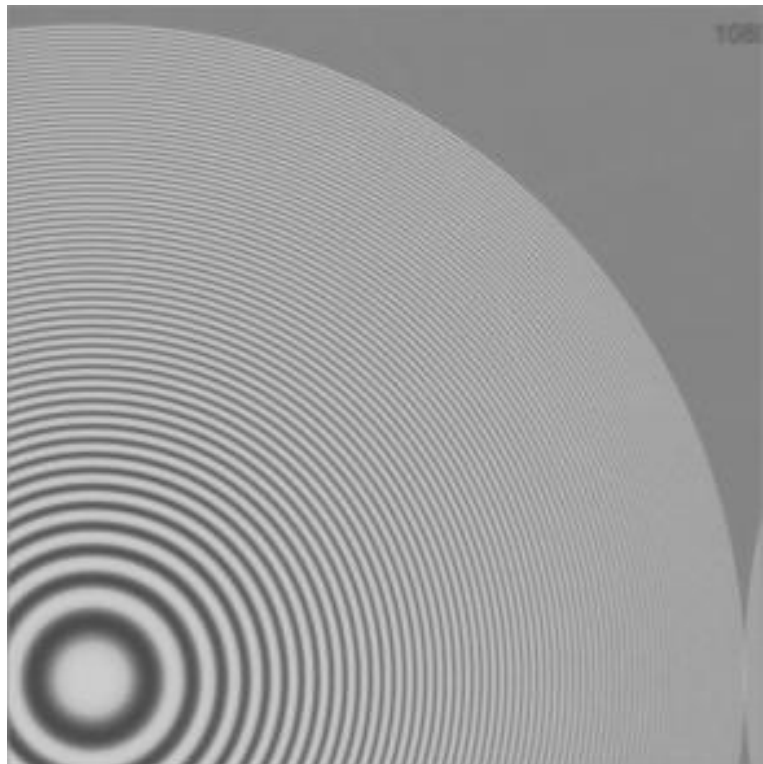


Figure 4, resolution, 1080p, video settings (v), detail off

2.2.4 Detail enhancement, 1080p, video (v) settings

Figure 5 shows what happens with the a little more detail enhancement. Clearly this is a little excessive, since a spatial alias has appeared, and the vertical resolution is clearly maintained up to the 1080-line limit, which causes serious interline twitter on interlaced displays.

This is why a lower setting of vertical detail is recommended for film-look shooting, even though it does not deliver quite the same level of sharpness.

2.2.5 Detail enhancement, 1080p, wildlife (w) settings

Figure 6 shows the results for the lower detail enhancement settings chosen for wildlife shooting. In most cases, wildlife shooting demands minimal detail enhancement. The faint vertical alias seen in Figure 5 has almost gone, and resolution is clean in all directions. This should result in pictures as sharp as the best 35mm negative film.

2.2.6 Detail at SD

Only subjective assessments were made at SD. The performance was acceptable in that there were few aliases from the higher frequencies. The obvious implication is that the camera sensors are scanned progressively, and the down-conversion done from full frames rather than interlaced fields. Even so, I cannot recommend using any HD camera in SD mode when the best quality SD pictures are needed.

2.3 Video Noise Levels

Video noise was measured by recording a white card, uniformly lit, and performing numerical analysis in software. A high-pass filter was used to remove all horizontal frequencies below about 5% of the nominal maximum of half-sampling frequency.

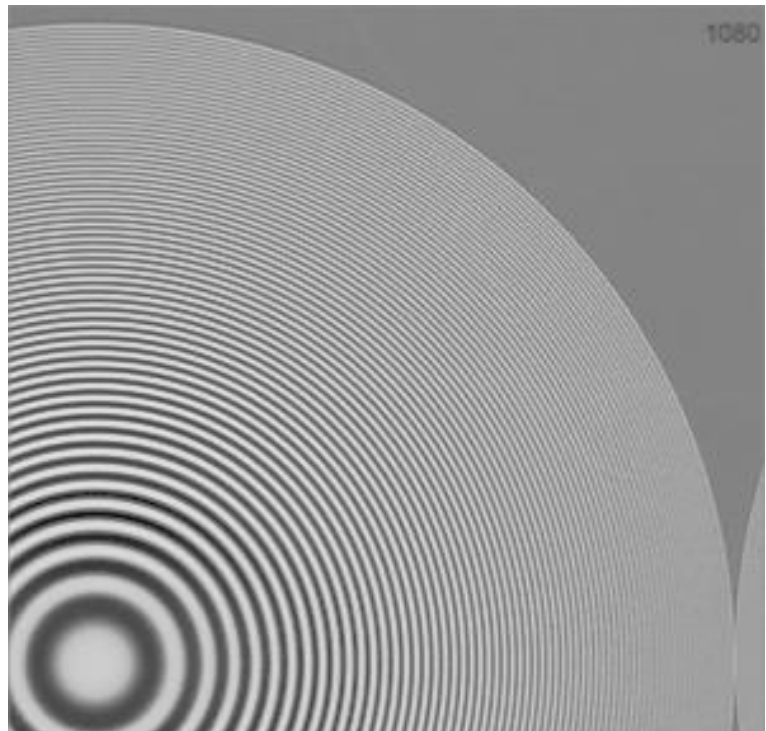


Figure 5, resolution, 1080p, video settings (v), detail on

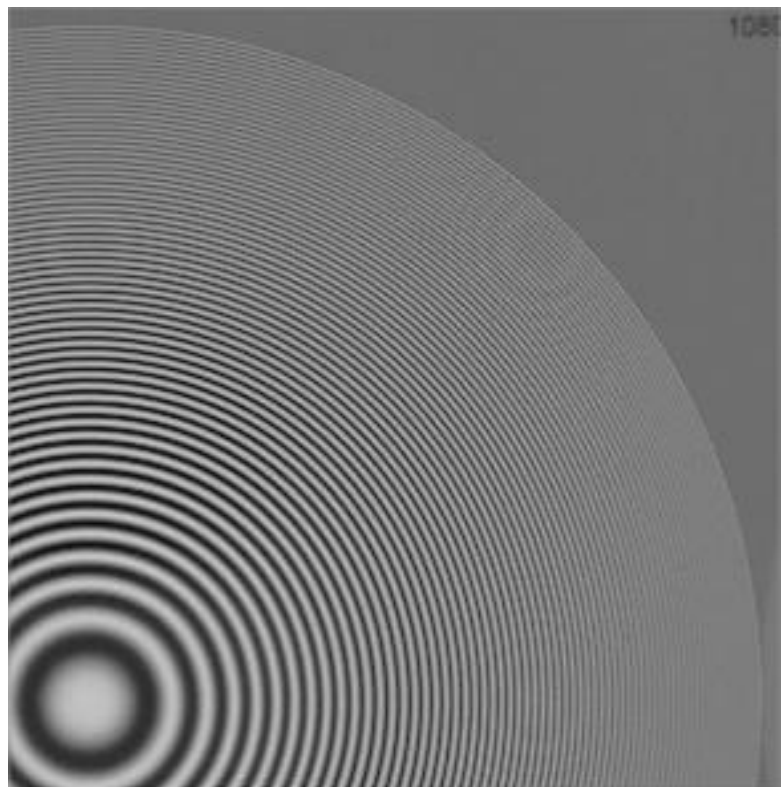


Figure 6, resolution, 1080p, wildlife settings (w), detail on

Two sets of results were obtained, for the video {v} and wildlife {w} settings, representing the extremes of the recommended settings range. Measurements were taken at four points in the grey scale, intended to be near 10%, 25%, 50% and 90%, to see how the noise varies with video level. The values for about 50% indicate performance on shaded skin tones, around 10% shows what happens in shadows, and the highest value is chosen to avoid the effects of the knee in the gamma-correction. I cannot explain the approximately 3dB difference between these sets of results.

Video settings {v}		Wildlife settings {w}	
Level	Noise	Level	Noise
7.8%	-45.2dB	10.8%	-42.3dB
22.1%	-49.1dB	23.9%	46.6dB
46.2%	-49.7dB	47.0%	48.4dB
80.9%	-50.6dB	81.8%	52.1dB

Under normal circumstances, the noise near black should be about 16dB greater than the noise near white, the ratio of the gains near black and white, since the gamma-correction curve amplifies noise differentially depending on level. Any deviation from this form of noise distribution indicates that noise is being limited; in normal use the video compressor would be expected to do this, particularly with 8-bit systems such as DVCPProHD and HDCAM. For these measurements, the HDSDI output of the camera was used, but in 8-bit mode to suit the measurement software, so there is a measurement noise floor at about -54dB. To keep clear of this noise floor, measurements were all taken at +6dB gain, and the results adjusted to indicate the noise levels at 0dB gain.

The results are not surprising; although not achieving the claimed noise level of -54dB, the pictures did not look particularly noisy during the tests. The camera has marked similarities to the HDX900, which has noise levels about 6dB lower. This difference could easily be due solely to the smaller pixel size in this camera (the HDX900 sensors are 1280x720, the HPX3000 sensors are 1920x1080, each pixel being approximately half the area and therefore half the sensitivity, and thus requiring 6dB more gain for the same signal level, which generates 6dB more noise).

2.4 Conclusion

This camera performs well at HD. Resolution is very well maintained and is refreshingly alias-free. Detail enhancement can be used at significantly higher levels than on any previous Panasonic HDTV camcorder without causing visible ringing. It has a good selection of gamma-correction curves, taken from all previous camcorders, with which specific “looks” are fairly easy to achieve. Noise is a little higher than ideal, but within acceptable limits for most purposes, especially if the camera is used at -3dB gain.

Recording of HDTV can use the newer AVC-I coder (MPEG4, H.264, I-frame only), which has full 1920x1080 resolution and 4:2:2 sub-sampling. It was not possible to evaluate this properly during the short time available for these tests. However, it is possible to extrapolate using a few assumptions. I have a “rule of thumb” for video compression systems; MPEG2 (12-frame GoP, variable-bit-rate) uses $\frac{1}{3}$ the data rate of intra-frame compression (e.g. DV, HDCAM, DVCPProHD) for the same level of artefacts, while MPEG4 (12-frame GoP, variable-bit-rate) uses $\frac{1}{4}$. But, the previous HD camcorder formats (HDCAM, DVCPProHD) record only 1440 luma samples whereas AVC-I records the full 1920, a ratio of $1920/1440=4/3$. So, it is quite possible that AVC-I performance produces a similar level of artefacts to that of DVCPProHD at the same data rate. The testing of codecs needs to be done using complex dynamic test sequences and measuring equipment to assess the level of artefacts. This can and should be done at BBC R&D where there is the necessary equipment and expertise.