

Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 26: Panasonic AG-HPX500

Data for this section is taken from a short examination of a production model of the Panasonic HPX500E camcorder. This is a HDTV camcorder, physically similar to the standard Digibeta, with three $\frac{2}{3}$ " CCD's. The manual gives no clue as to the sensor resolutions but tests indicate that they are probably 960x540 with precision offset both horizontally and vertically. It records HDTV using the DVCPHD algorithm onto P2 flash cards (1080i, 1080psf, 720p), SDTV using any of the DVCP50 or DVCP or DV algorithms also onto P2 cards (480i, 480psf, 480psfa* or 576i, 576psf, 576psfa). It can also shoot "off-speed" when recording 720p, but only at spot speeds, it is not continuously variable as is the Varicam AJ-HDC27F. Effectively, it is a "big brother" to the HVX200.

The camera is relatively light and consumes only 22 watts. It has a standard B4 lens mount and separate viewfinder, with side LCD panel, and seems aimed at the low-end broadcast/professional market rather than consumer or full broadcast.

It has the usual internal menus for setting the performance, not as complex as in the 720-line Varicam or the 1080-line HDX or HPX cameras, but enough to control most of the important features. It is not suited to multi-camera operation. It has analogue-only video outputs via a multi-pin connector, and digital-only via BNC connectors at both HD and SD, and digits via IEEE1394 Firewire. This puts the camera firmly in the professional/broadcast market.

The same assessment procedure was used as for other HD cameras, partly attempting to get a good "film-look", and the settings reflect that. It is useful to think of the camera, when used in this way, to be mimicking a film camera and telecine, with "best light" transfer to tape, with about 10 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. The recommended settings allow about 1.3 stops of over-exposure and one of under-exposure relative to normal operation.

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The assessment of this camcorder was aimed mostly at discovering what it could do, rather than deriving a preferred setting, results are given in Section 2. The controls are not as flexible as for full “broadcast” cameras, so it may or may not be possible to derive a specific “film-look” for it. However, there is sufficient flexibility to achieve much of what is desirable in “film-look” settings. Photographic “speed” is about 640ASA.

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, e.g. -99~99, the values indicate the range, and zero means no alteration to factory setting, not zero effect, and no scales are given. For each item, the factory setting is given if it is known, and the range offered by the camera under test. “BBC” settings are in the last column, where appropriate. The following table shows the menu settings when the camera is in “Camera” mode, these affect picture performance; other menus are included for completeness. Values that are underlined are the factory default settings. The menus share some features with the Varicam, in that Scene Files store a great deal of information, permitting widely different settings to be stored.

BBC-preferred values are given for SD operation, for 1080 interlaced and psf, and for 720 film and sport (where sport covers all uses that are not intended to look like film). Items that have an important affect on picture appearance are highlighted. Some items are valid only for tape- or P2-operation, all items are flagged. It is unfortunate that the colour bars that the camera generates are only 100/0/75/0 (i.e. EBU) rather than the much more useful SMPTE bars that are ubiquitous in HDTV.

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

1 Menus and Settings

SCENE FILE screen

Item	Range	Description	BBC	
			v	f
Load/Save/Init		Access to the scene files		
Operation Type	Video,Film	In Video, shutters are in 1/n, frame rate depends on Format. In Film, shutters are in degrees, variable frame rate etc		
Frame Rate	<u>Default</u> ,12,18,209,22,24,26,30,32,36,48,50	Frame rates for 720p shooting. 60 replaces 50 only when set to 59.94Hz		
Synchro Scan	(Video) <u>1/50</u> ~1/249.8 (Film) 10~ <u>180</u> ~350deg	Select with Jog wheel. 1/50 replaced with 1/60 or 1/30 or 1/24 depending on frame rate.		
Detail Level	-7~ <u>0</u> ~+7	Collective detail level, -7=no sharpening	0	-2 ¹
V Detail Level	-7~ <u>0</u> ~+7		+4 ²	0
Detail Coring	-2~ <u>0</u> ~+7	Noise threshold	+4	0
Chroma Level	-7~ <u>0</u> ~+7	Saturation	0	
Chroma Phase	-7~ <u>0</u> ~+7	Hue	0	
Color Temp Ach	-7~ <u>0</u> ~+7	Fine tweak white balance in store A		
Color Temp Bch	-7~ <u>0</u> ~+7	And in B		
Master Ped	-127~ <u>0</u> ~+127	Black level		
A. Iris Level	-10~ <u>0</u> ~+10			
News Gamma	On, <u>Off</u>			

¹ Not specifically tested by recording frames, but it produced a subjectively “cleaner” image for a filmic look.

² The value for vertical detail is the maximum recommended for the camera under any circumstances, and is included because it produces uniform resolution in horizontal and vertical directions. With lower settings, e.g. the default level of zero, the pictures are more restful and filmic, with less interlace twitter on an interlaced display.

Gamma ³	HD Norm,Low,SD Norm,High,B,Press, Cinelike_D,Cinelike_V	HD Norm=ITU709, Low compresses contrast, High expands, B.Press crushes shadows, D for film neg, V for film reversal	HD Norm	Cine like_D
Knee	Low,Mid,High	Point, Low=80%, Mid=90%, High=100%, disabled in Cine gammas	Mid	
Matrix	<u>Norm1</u> ,Norm2,Fluo, Cine-like	Norm2 for higher saturation	Norm 1	Cine - like
Skin Tone Dtl	On, <u>Off</u>	No other controls		Off
V Detail Freq	<u>Thin</u> ,Mid,Thick	A good description ⁴		Thin
Name Edit		Enter/Edit the scene name		

CAMERA SETUP screen

Item	Range	Description	BBC
Aspect Conv	Side-crop,Letter box, Squeeze	Aspect ratio conversion for SD output	Squeeze
Setup	0%, <u>7.5%</u> A	Only for 480i camera output, not for recording	

DUBBING MODE MENU

Item	Range	Description	BBC
Mid Gain	0,3, <u>6</u> ,9,12dB	Gain in MID position	
High Gain	0,3,6,9, <u>12</u> dB	Gain in HIGH position	
W.Bal.Preset	3.2,5/6K	Colour temperature stored in PRST position of the White Bal switch	
User Main	RecCheck,Spotlight, Backlight, Blackfade, Whitefade,	Assign the Main User switch	
User 1	Gain18dB,TextMemo,SlotSel, <u>ShotMark</u> ,Le	User 1 switch	
User 2	vMeter, Marker,LcdRev	User 2 switch	

RECORDING SETUP screen

Item	Range	Description	BBC
Rec Format	(59.94) 1080i/60i,1080i/30p,1080i/24p,1080i/24pa,720p/60,720p/30,720p.24,720 p.30pn,720p/24pn,480i/60i,480i/30p,480i/240,480i/24pa	24p=2:3 pulldown, 24pa=2:3:3:2 pulldown, 'pn' records only new frames	1080i/50i
480i/576i Rec Mode	(50) <u>DVCP</u> ro50/DVCPDV	Pro50=4:2; ProDV=4:1:1 at 576/50, 4:1:1 at 480/60	
Rec Function	<u>Normal</u> , Interval, OneShot,Loop		
One Shot Time	<u>1E</u> ,2F,4F,8F,16F,1S	Duration	
Interval Time	<u>2F</u> ,4F,8F,16F,1s,2s,4s, 10s,30s,1m,5m,10m	Time between shots	
Start Delay		Set delay before starting One Shot or Interval	
PreRec Mode	On, <u>Off</u>	3 seconds HD, 7 seconds SD ⁵	
TC Mode	<u>DF</u> ,NDF	DF used in 24p,24pa,24pn regardless of this setting ⁶	NDF
TC In UB Regen	On, <u>Off</u>	On records User Bits from the TC source, Off gets them from the menu	
UB Mode	User,Time,Date,TCG, <u>FrmRate</u>		

AUDIO SETUP screen

Item	Range	Description	BBC
Front VR Ch1	Front,Rear,All, <u>Off</u>	What the front audio level Ch1 control does	
Front VR Ch2	Front,Rear,All, <u>Off</u>	What the front audio level Ch2 control does	
Mic Lowcut Ch1	On, <u>Off</u>	Bass cut	

³ Gamma measurements have been borrowed from the HVX200 assessment. 'HD norm' is approximately ITU709, 'High' is close to BBC 0.4.

⁴ 'Thin' makes more interlace twitter. This is really only a problem for those watching HDTV on CRT's, a diminishing minority, but it can be disturbing during the editing process.

⁵ Video cache.

⁶ Use of DF TC in these rates implies that the rate is actually 23.98 and not 24Hz.

Mic Lowcut Ch2	On,Off	Bass cut	
Mic Lowcut Ch3	On,Off	Bass cut	
Mic Lowcut Ch4	On,Off	Bass cut	
Limiter Ch1	On,Off	Limiter	
Limiter Ch2	On,Off	Limiter	
Limiter Ch3	On,Off	Limiter	
Limiter Ch4	On,Off	Limiter	
Audio Level Ch3	On,Off	On=agc, Off enables Ch3 control	
Audio Level Ch4	On,Off	On=agc, Off enables Ch4 control	
25M Rec Ch Sel	2ch,4ch	DVCPro/DV formats, 2ch 16bit/48k vs 4ch 12bit/32k	
Test Tone	Off,Normal,Always, ChSel	Add tone to bars: Normal=if Audio In Ch1 set to Front, ChSel=if Audio In switch Ch1 or 2 set to Front	
F.Mic Power 1	On,Off	Phantom power	
F.Mic Power 2	On,Off		
R.Mic Power	On,Off		
F.Mic Ch1 Level	-40,-50,-60dB		
F.Mic Ch2 Level	-40,-50,-60dB		
R.Mic Ch3 Level	-40,-50,-60dB		
R.Mic Ch3 Level	-40,-50,-60dB		
Headroom	18,20dB		
Monitor Mode	Live,Recording	Speaker/headphone, recorded has a delay	

OUTPUT SEL screen

Item	Range	Description	BBC
Cmpnt/SDI Sel	(59,94) 720p,1080i,480i	Output to the multi-pin D and BNC connector	
	(50) 720p,1080i,576i		
SDI Metadata	On,Off	Puts metadata on the video output	
SDI EDH	On,Off	????	
TC Video Synchro	TC In,Video	Video outputs delayed TC on the video	

DISPLAY SETUP screen

Item	Range	Description	BBC	
			v	f
Zebra Detect	50,55,60,65,70,75,80,85, 90,95,100,105%	Zebra pattern leans to the left	80	65
Marker	On,Off			
Safety Zone	Off,90%,4:3			
Date/Time	Off,Time,Date, Time&Date	Displayed on video output, not recorded		
Level Meter	On,Off	Audio level bars		
Zoom	On,Off	Runs 00~99		
Card/Batt	On,Off	"Remaining" indicators		
P2Card Remain	Total,OneCard	How much is left on one or all cards		
Other Display	Off,Partial,All	What to show		
Lcd Backlight	High,Normal			
Lcd Set		Brightness, Contrast, Saturation controls		
Self Shoot	Normal,Mirror	Reverses picture on LCD for self-shooting		
Downcon Mode	Side-crop,Letter-box, Squeeze	Down-conversion display		
Display Aspect	Auto,4:3	In 4:3, 16:9 pictures are letter boxed		
Menu Back	On,Off	Changes picture transparency to menus		

BATTERY SETUP screen

Item	Range	Description	BBC
Ext DC In Sel	AC Adapter,Battery	Choice of external power	
Battery Select	Propac14,Trimpac14,Hytron50,Hytron140,Diconic90, Diconic140,NP-L7,Endura7,Endura10,Endura-D, PagL95,BP-GL65/95,Nicd14,TypeA,TypeB	That seems to be enough choice	
Battery Mode	Auto,Manual	Auto will choose automatically from Propac14, Trimpac14, Hytron50, Hytron140,Diconic90, Diconic140,NP-L7,Endura7, Endura10,Endura-D, PagL95,BP-GL65/95	
Propac14 Near		Set "Near End" voltage for Propac14 battery	
Trimpac14 Near			
Hytron50 Near			

Hytron140 Near			
Diconic90 Near			
Diconic140 Near			
NP-L7 Near			
Endura7 Near			
Endura10 Near			
Endura-D, Near			
PagL95 Near			
BP-GL65/95 Near			
Nicd14 Near			
TypeA Full		Set unknown battery "Full" level	
Type A Near		Set unknown battery "Near End" level	
Type A End		Set unknown battery "End" level	
TypeB Full			
Type B Near			
Type B End			
Near End Cancel		Select whether to cancel battery near end warning or not	

CARD FUNCTIONS screen

Item	Range	Description	BBC
Scene File	Read,Write		
User File	Read,Write		
SD Card Format	Exec		

LENS SETUP screen

Item	Range	Description	BBC
Shading Select	<u>Default</u> ,User1,User2, User3,Off	Default is a standard setting	
Shading (User)	Yes	Do it, set shading parameters	
CAC Property	Yes	Shows current chromatic/astigmatic aberration data	
CAC Data Read	Yes	Loads data from SD card	
CAC Data Delete	Yes	Delete data in the camera	
CAC Data Init	Yes	Factory default settings	
Iris Adj	<u>Off</u>	Auto iris control	

OTHER FUNCTIONS screen

Item	Range	Description	BBC
User File	Off,Load,Save,Initial	Load/save, reset user storage area	
1394 Control	<u>Off</u> ,Ext,Both,Chain	Control of external 1394 device by Camera Start/Stop	
1394 Cmd Sel	<u>RecP</u> ,Stop	Start/Stop action, Record/Pause or Record/Stop	
PC Mode	<u>1394 Device</u> ,1394 Host	P2 plays or records via 1394	
Access LED	OffL/OffR/Off, SlotL/OnR/Off, LcdL/OffR/On, BothL/OnR/Off	Which access LED's work, L is the side with the P2 cards slots	
Alarm	<u>On</u> ,Off	Audible alarms	
Save led	Save,P2Card	Save lamp ON in SAVE, or blinks as P2 card warning	
Clock Set		Set the clocks	
Time Zone	-12.00~+9.00~+13.00	+9.00 is for Japan, can also set +12/45	0
Language	English,Japanese,Chinese		
GL Select	SDI,Composite, Component	Genlock source	
GL Phase	On, <u>Off</u>	90-line shift to compensate for the down-converter delay	
H Phase	-511~0~+511		
System Freq	59.94,50	An extremely fundamental control	50

VF! LED screen

Item	Range	Description	BBC
Gan	w/o <u>0dB</u> ,Off	Not 0dB	
White	Pre, <u>Off</u>	Not Preset	
Shutter	<u>On</u> ,Off		
Filter	NG,No1,w/oNo1, <u>Off</u>	Filter position	
Extender	<u>On</u> ,Off		

2 Measurement results

Colour reproduction was assessed visually with Macbeth Color-Checker charts. There were no nasty surprises; performance was quite good, mostly only small saturation errors.

2.1 Transfer characteristic (gamma-correction)

The HPX500 has no built-in test signal generator. This sets it apart from most professional and broadcast cameras since there was no direct way to examine the gamma and knee functions. However, the many similarities between it and the HVX200 lend support to borrowing measurements made on that camcorder. For the HVX200, gamma-correction measurements were made using multiple exposures of a Macbeth Color-Checker chart and extracting the data sample by sample. The equations for the *HDnorm* curve were found to be acceptably close to the ITU.709 curve commonly used for HDTV. The Knee causes the curve to break at signal levels of 80% (Low), 90% (Mid), 100% (High) and then extend to an exposure limit of 2.5 (250%) before clipping occurs at about 107%. The *High* (Black Stretched) gamma-correction curve was found to be a good match to the BBC 0.4 law. Both these curves are acceptable for normal use, the IUT709 curve (HD norm) gives slightly less noise and slightly less good colour-matching than does the BBC curve (High).

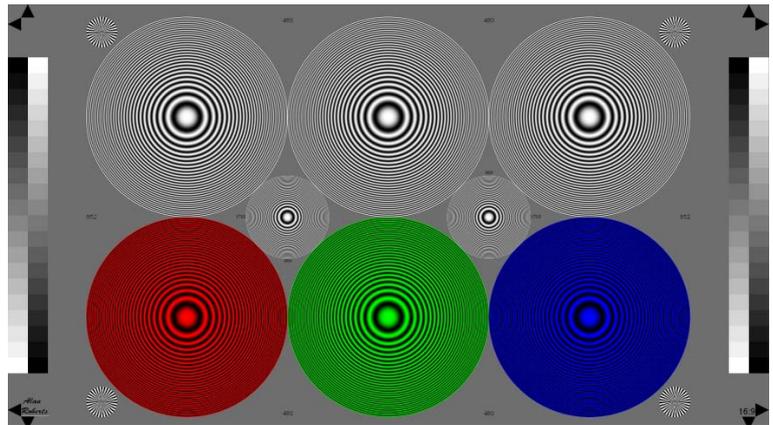


Figure 1, zone plate test chart (480-line video version illustrated)

2.2 Resolution and Detail

Resolution was assessed using a zone plate test chart (Figure 1). It comprises 6 major and 2 minor patterns. The major patterns form a map of the frequency space of 1920x1080 HDTV, while the minor patterns reach double those limits, to check for the presence of out-of-band effects.

2.2.1 Resolution, 1080i

The camera specification makes no mention of the sensor pixel dimensions, only that they are $2^{2/3}$ size.

Figure 2 shows one quadrant of a main pattern, reaching the nominal limits of 1920 and 1080. There is aliasing both horizontally and vertically, with null zones (where the wanted and unwanted frequencies meet to cancel at 960 horizontally and 540 vertically). This shows that the sensors are 960x540. However, the nulls are not deep, resolution survives beyond them, which suggests that “precision offset” (the displacement of green from red and blue) is being used both horizontally and

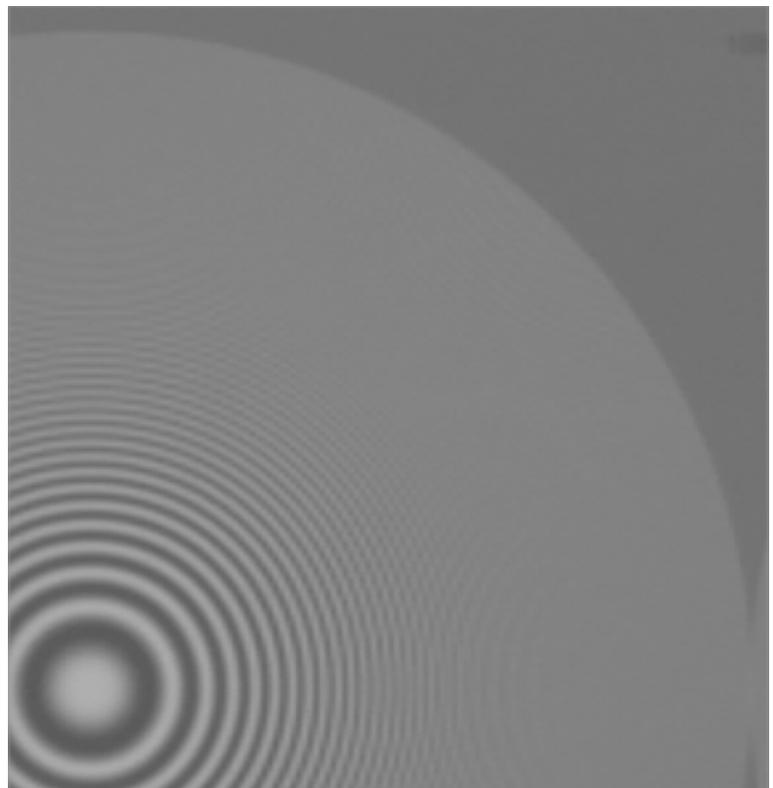


Figure 2, resolution, 1080i

vertically. The result is to increase the usable resolution in both dimensions, at the expense of a loss of some diagonal resolution. Note that there is a faint diagonal alias at the edge of the pattern, this confirms the diagnosis.

The aliasing is not pronounced, confirming that there is a “quarter wave” (bi-refringent crystal) filter in the optical system to suppress spatial frequencies beyond the capabilities of the sensors. Clearly, this is a compromise, but the results are acceptable in “real” pictures.

2.2.2 Detail enhancement, 1080i

Figure 3 shows the result of detail enhancement (Level=0, Vertical=+4), the maximum values recommended for any use.

The wanted resolution is now more clear, and the unwanted aliasing has not been significantly worsened. However, interlace twitter is more visible on an interlaced display, and a lower level of detail is recommended for a more filmic look. However, this setting would be perfectly adequate for most video-style shooting.

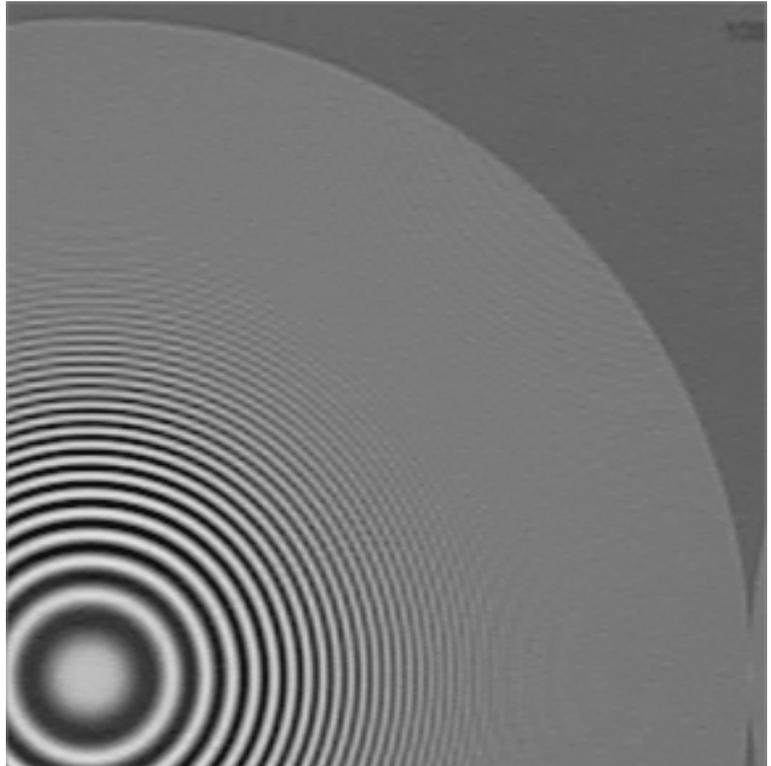


Figure 3, 1080i, detail enhancement

2.2.3 Detail enhancement, 720p

Down-conversion, in any camera, is an issue. While up-conversion is relatively easy to perform, down-conversion must involve the rejection of those frequencies too high to be supported by the lower standard, and this involves the use of fairly large filters. It is unreasonable to expect such hardware in a small camera. Nevertheless, many cameras claim to deliver video at standards other than their originating standard, and so the user may be tempted to use them. Figure 4 shows the performance at 720p, with the same detail settings.

It is interesting to see that there is a little less horizontal and vertical detail here, proof that there is actually more than 1280x720 content in the 1080i image. The down-conversion is clean because there is only a little energy in these higher frequencies so they are easier to suppress in the conversion.

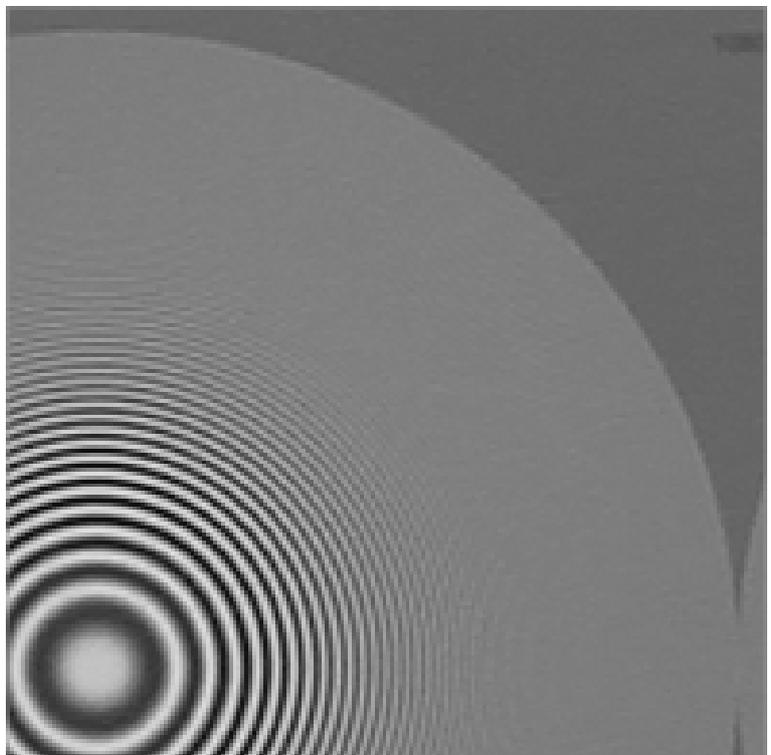


Figure 4, 720p detail enhancement

2.2.4 Detail enhancement, 576i

While the use of an HDTV camera to produce SDTV pictures is becoming less likely, the performance at SD indicates how well the signal processing has been done. Figure 5 shows the results for 576i.

The vertical filtering is better than is the horizontal; high frequencies are almost completely suppressed, with the cut-off at about 440 lines/picture height. This leaves enough vertical resolution to cause interlace twitter, but not excessively so.

Horizontally, there is a null zone (grey patch) at 375 pixels/picture width. This is where aliased frequencies are beating with the wanted frequencies. Wanted detail extends to about 470 pixels/picture width, which is about as good as can be achieved considering the presence of aliases in the original HDTV pictures. These limits might be acceptable for 480i (NTSC), they are a little low for 576i.

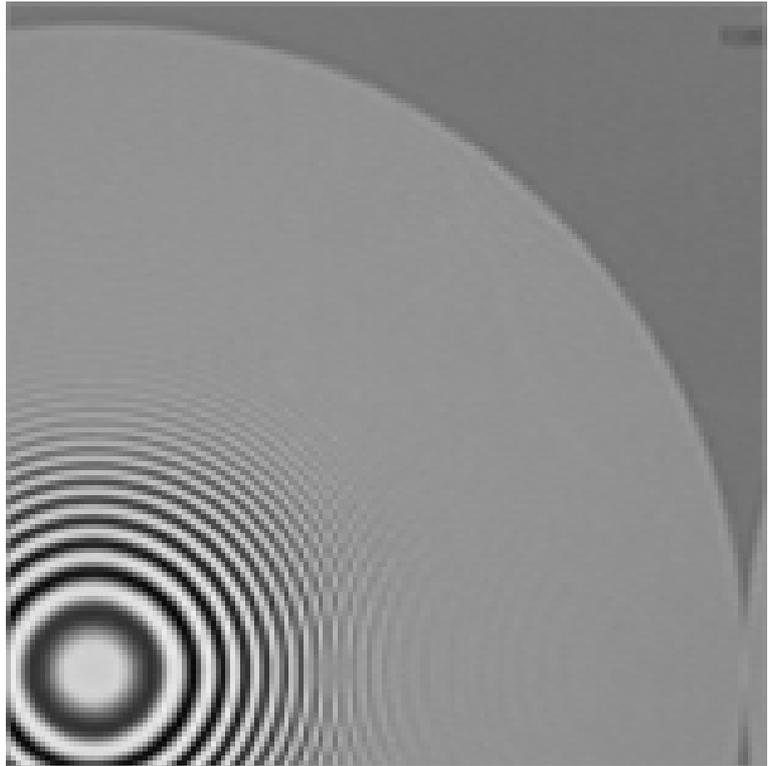


Figure 5, 576i detail enhancement

While not up to the standard of a genuine SDTV camera, these images are not as bad as they might be.

2.3 Video noise at 1080i

Noise was assessed by recording individual frames of a white card, evenly illuminated, at several exposure levels. The levels were chosen to represent shadows (around 10%), skin tones in drama (25% and 50%), and near white (90%, avoiding the compression caused by the knee). The frames were then high-pass filtered and analysed in software. Measurements were made only at 1080i, at +6dB gain, and with the high level of detail enhancement. The data in the table allows for the gain offset, so this is the performance to be expected at 0dB gain. Noise would be a little lower with less detail enhancement.

Level	Noise
8.8%	45.5dB
21.5%	48.3dB
46.2%	50.9dB
81.9%	51.0dB

Although not quite hitting the specified noise level of 54dB, it is not far short, and there could be combinations of the detail enhancement controls at which it does meet the specification. Even so, the noise performance was subjectively quite good.

Only subjective assessments were made at 720p and 576i, which confirmed these figures. Noise does not appear to be a problem.

2.4 Conclusion

The camera performs well, within its limits. With only 960x540 sensors, it is never going to deliver full 1080-line resolution, but what it does deliver is relatively clean. Down-conversion to 720p is surprisingly good, but the SD pictures at 576i were rather soft but did not carry an excessive amount of spatial aliasing.