Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 53 : Tests and Settings on a Panasonic AG-HPX371

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.

Data for this document is taken from a short examination of a production model of the Panasonic AG-HPX371 camcorder (serial number #FOTEA0073), using the supplied lens (Fuji XT17x4.5). This is a HDTV camcorder, almost identical to the Panasonic HPX301. It has 3 ⅓" CMOS sensors, each 1920x1080. The manual makes no claims for noise levels. It records HDTV using the AVC-I or DVCProHD algorithm onto P2 flash cards (1080i, 1080psf, 720p), SDTV using any of the DVCPro50 or DVCPro or DV algorithms onto P2 cards (576i, 576psf, 576psfa). It can also shoot "off-speed" when recording 720p onto P2 cards, but only at spot speeds, it is not continuously variable as is the Varicam AJ-HDC27F. There are 2 P2 card slots.

Perhaps most significantly, the camera has electronic correction for chromatic aberration in the lens. Since cameras with ⅓" sensors suffer iris diffraction starting at about F/4, lens performance appears to deteriorate dramatically at F/5,6 and smaller apertures, this correction facility seems to eliminate much of the chromatic problems, leaving only the gradual softening as the lens is stopped down. Subjectively, this appears to move the onset of diffraction limiting by about 1 stop, and to make further stopping-down less objectionable. However, the lens must be on the list of known lenses in the menus for this to work. The camera is not sensitive to infra-red light.

The camera is light (5kg including lens), has a side lcd panel, and seems potentially aimed at the high-end consumer/professional market and full broadcast, which would normally demand interchangeable lenses. It has the useful Panasonic YGET luma metering facility, waveform monitoring, and a pre-recording facility (3 seconds for HDTV, 7 for SDTV).

It has the same range of external switches and controls as a full broadcast camcorder, plus internal menus for setting the performance, although not as complex as in the 720-line Varicam or the HPX2000/3000 range for example, but enough to control most of the important features. It has genlock and remote control but is no better suited to multi-camera operation than any other professional camcorder. It has two SDI video outputs (at HD or SD) and 1394 (Firewire), plus an analogue monitoring output. This puts the camera into the professional or broadcast market, subject to video performance.

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 (250%) and one of under-exposure relative to normal operation.

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The assessment of this camcorder was aimed mostly at establishing whether it could perform to broadcast standards, since the sensors are rather small. However, it was possible to derive settings which make sense for both video- and film-type shooting. Measurement results are given in Section 2. The controls are not as flexible as for full "broadcast" cameras, so it was not possible to customise it as much as other cameras, but the performance seemed adequate with the settings available. There is sufficient flexibility to achieve much of what is desirable in "film-look" settings. The sensitivity is specified in the manual as F/11 for 2000 lux illumination of a 90% reflectance card, but this was not measured during the tests.

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. -7~7, 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 underlined if it is known, and the range offered by the camera under test. "BBC" settings are in the last column, where appropriate. Differences from the HPX301 are small.

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 effect on picture appearance are highlighted. It is unfortunate that the colour bars that the camera generates are only 100/0/75/0 (i.e. EBU) in 50Hz modes, rather than the much more useful SMPTE or ARIB bars that are ubiquitous in HDTV. However SMPTE bars are available if the camera is set to 59.94Hz modes.

Settings are only starting points, recommendations. They should not be used rigidly, they are starting points for further exploration. However, they do return acceptable image performance.

Two preferred settings are given, for video (v) and film-like (f).

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

1   Menus and Settings

MAIN MENU	
SCENE FILE	Camera operational controls, needs lab work to get the best from these
SYSTEM SETUP	Basic camera setup controls
SW MODE	Configuration of switches
RECORDING SETUP	P2 card controls
AUDIO SETUP	Configure audio connections
OUTPUT SEL	
DISPLAY SETUP	
BATTERY SETUP	
CARD FUNCTIONS	P2 flash card controls
LENS SETUP	
OTHER FUNCTIONS	
DIAGNOSTIC	
OPTION MENU	

SCENE FILE 1-6   Main video standard setting, defaults are for Scene-file 1

Item		Range	description	BBC	
				v	f
Load/Save/Init		Exec	Get/save/clear scene file		
VFR		On, Off	Enable variable frame rate (720p only)		
Frame Rate	50Hz	12,15,18,20,21,22,23,24,25,26,27,28, 30,32,34,37,42,48, 50	Frame rate at 720p. Not available at SD or 1080		

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	60Hz	12,15,18,20,21,22,24,25,26,27,28,30, 32,34,36,40,44,48,54, 60			
Synchro Scan		Display only	Shows synchro shutter speed		
Detail Level		-7~ 0 ~+7	Collective detail	-2	-4
V Detail Level		-7~ 0 ~+7	Vertical detail	0	
Detail Coring		-7~ +5 ~+7		+5	
Chroma Level		-7~ 0 ~+7	Saturation	-2	-4
Chroma Phase		-7~ 0 ~+7	Hue	0	
Color Temp Ach		-7~ 0 ~+7	Fine colour adjustment to A channel balance		
Color Temp Bch		-7~ 0 ~+7	B channel		
Master Ped		-100~ +15 ~+100		+3	
A.Iris Level		-10~ 0 ~+10	Auto iris target level		
DRS Effect		1,2, 3	Soft knee function, compresses highlights	3	
Gamma		HD norm, Low, SD norm, High, B. Press, Cine-like D, Cine-like V	HDnorm=ITU709, Low=eng, SD norm=DVX100, High=BBC0.4, Cine-likeD=film neg, Cine-likeV=finished film	HD norm	Cine-like D
Knee		High, Mid,Low	High starts at 100%, Mid at 90%, Low at 80%	Mid	
Matrix		Norm1, Norm2, Fluo, Cine-like	Norm2 raises saturation	Norm1	Cine-like
Skin Tone Dtl		On, Off	On reduces skin tone detail	Off	
V Detail Freq		Thin, Mid,Thick	Fine to coarse detail	Thin	
Name Edit			Name the file		

SYSTEM SETUP   General options

Item		Range	description	BBC	
				v	f
System Mode	50Hz	1080-50i, 720-50p, 576-50i	Turn off power to effect the change. Not available in USB Device mode		
	60Hz	1080-59.94, 720-50.94, 480-59.94i			
Rec Signal		Camera, 1394	Select recording via 1394 input		
Rec Format	1080-50i	AVC-I100/50i, AVC-I100/25pn, AVC-I50/50i, AVC-I50/25pn, DVCPROHD/50i	i=interlaced, p=progressive, pn=progressive native (i.e. frames not split into fields as psf)	AVC-I100	
	720-50p	AVC-I100/50p, AVC-I100/25pn, AVC-I50/50p, AVC-I50/25pn, DVCPROHD/50p, DVCPROHD/25pn			
	576-50i	DVCPRO50/50i, DVCPRO/50i, DV/50i			
	1080-59.94i	AVC-I100/60i, AVC-I100/30pn,AVC-I100/24pn, AVC-50/60i, AVC-I50/30pn, AVC-I50/24pn, DVCPROHD/60i			
	720-59.94p	AVC-I100/60p, AVC-I100/30pn, AVC-I100/24pn, AVC-I50/60p, AVC-I50/30pn, AVC-I/50/24pn, DVCPROHD/60p, DVCPROHD/30pn, DVCPROHD/24pn			
	480-59.94i	DVCPRO50/60i, DVCPRO/60i, DV/60i			
Camera Mode	50Hz	50i, 25p	pa=2:3:3:2 pulldown	50i	25p
	60Hz	60i, 30p, 24p, 24pa		60i	24pa
Scan Reverse		On, Off	Useful for film lenses and adaptors		
Aspect Conv		Side Crop, Letter Box, Squeeze	Available only when shooting SD (576 or 480)		
Setup		0%, 7.5% A	Relevant only for SD 480		
PC Mode Select		USB Host, USB Device	Camera acts as host or device		
PC Mode		On, Off	Allows direct connection to a computer		

SW MODE   Set the external switches

Item	Range	description	BBC	
			v	f
Low Gain	-3, 0, 3, 6, 9, 12dB		-3	
Mid Gain	-3, 0, 3, 6 ,9, 12dB		+3	
High Gain	-3, 0, 3, 6, 9, 12dB		+9	
ATW	Bch, Off	Sets Auto Tracking White to B channel		
ATW Type	1, 2	1=normal, 2=limited tracking range		

W.Bal.Preset	3.2K, 5.6K	Set PRST white balance colour	
User Main	Rec Review, Spotlight, Backlight, ATW, ATWlock, Gain:24dB, Yget, DRS, TextMemo, SlotSel, ShotMark, MagA.Lvl, PreRec, PCmode, Wfm, FBC	Yget=luma meter	
User 1			
User 2			
Ret Sw	Rec Review, Text Memo, Shot Mark, Inhibit	Lens Ret switch	
WFM	Wave, Vector, Wave/Vect	Waveform or vectorscope display, Wave/Vect toggles them	
Auto Knee Sw	On, Off, DRS		

RECORDING SETUP

Item	Range	description	BBC
Rec Function	Normal, Interval, OneShot, Loop	Clever shooting modes, not always available, see manual page 39	
One Shot Time	1frm, 2frm, 4frm, 16frm, 1s		
Interval Time	2frm, 4frm, 8frm, 16frm, 1s, 2s, 5s, 10, 30s, 1min, 5min, 10min		
Start Delay	On, Off	Delays start of Interval/OneShot by 1 sec	
PreRec Mode	On, Off	3 second pre rec in HD, 7 sec in SD	
TC Mode	DF, NDF	Not displayed in 50Hz modes	
UB Mode	User,Time,Date,Ext,TCG, Frm.Rate	Set user bits, Frm.Rate is useful for off-speed shooting	
One Clip Rec	On, Clip		
Start Text Memo	On, Off	Adds text memo to each clip, in Normal recording	

AUDIO SETUP

Item	Range	description	BBC
Front VR Ch1	Front, W.L., Rear, All, Off	Enable front audio level control, chan 1	
Front VR Ch2	Front, W.L., Rear, All, Off	Enable front audio level control, chan 2	
Mic LowCut Ch1	Front, W.L., Rear, Off		
Mic LowCut Ch2	Front, W.L., Rear, Off	Low-cut filter passes roughly 200Hz~10kHz	
Mic LowCut Ch3	Front, W.L., Rear, Off		
Mic LowCut Ch4	Front, W.L., Rear, Off		
Limiter 1	On, Off	Audio limiters, ignored if Auto is set	
Limiter 2	On, Off		
Auto Level Ch3	On, Off	Off fixes sound level	
Auto Level Ch4	On, Off		
25M Rec Ch Sel	2ch, 4ch	SD sound, 2ch/48k/16b or 4ch/32k/12b	
Test Tone	Normal, Always, Chsel, Off	Normal=tone on bars when Ch1=front	
F.Mic Power	On, Off	Phantom power	
R.Mic Power	On, Off	Phantom power	
Monitor Sel	Stereo, Mix	Sound to audio out and phones/speaker	
F.Mic Level	-40, -50, -60dB		
R.Mic Ch1 Level	-50, -60dB		
R.Mic Ch2 Level	-50, -60dB		
Headroom	18dB, -20dB		
Wireless Warn	On, Off	Warning of poor radio mic signal	
Wireless Type	Single, Dual	Mono/stereo	
1394 Audio Out	Ch1/Ch2, Ch3/Ch4	Only in SD 576 or 480	

OUTPUT SEL

Simple controls

Item	Range	description	BBC
SDI Select	Auto, 1080i, 576i(480i)	Auto outputs what's shot, 1080i up-converts 720p, 576(480) always down-converts	
SDI Metadata	On, Off	Adds UMID to SDI	
SDI EDH	On, Off	Adds EDH to SD SDI	
Downcon Mode	SideCrop, LetterBox, Squeeze		
Video Output Char	On, Off	Adds characters	
Video Out Zebra	On, Off		

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| TC Out | TCG, TCG/TCR | Time code from cam or cam/recording | |
| TC Video Synchro | TC In, Video Out | Delays TC to match video out | |

DISPLAY SETUP

Item	Range	description	BBC	
			v	f
EVF Peak Level	-7~ 0 ~+7	Viewfinder peaking		
EVF Peak Freq	High, Low	Frequency		
EVF Setting		Set brightness and contrast		
EVF B.Light	High, Normal, Low	Backlight level		
EVF Color	On, Off	Off sets monochrome viewfinder		
Zebra1 Detect	50%~ 70% ~109%		75	65
Zebra2 Detect	50%~ 85% ~109%		100	85
Zebra2	On, Spot, Off			
Marker	On, Off	Centre cross marker		
Safety Zone	90%, 4:3,13:9,14:9,Off		14:9	
Focus Bar	On, Off	Bargraph focus display		
LCD Setting		Set saturation, brightness, contrast		
Self Shoot	Normal, Mirror	Lateral inversion of lcd		
LCD Bakclight	High, Normal, Off			
Sync Scan Disp	Sec, Deg			
Date/Time	Time, Date, Time&Date, Off	Set time/date displays		
Level Meter	On, Off	Audio levels		
Zoom	On, Off			
Card/Batt	On, Off	Capacity and charge		
P2card Remain	Total, One-card	Show remaining card capacity		
Other Display	Partial, All, Off			
Menu Back	On, Off	Lowers background transparency		
Rec Counter	Total, Clip	Continuous or clip duration shown		

BATTERT SETUP

Item	Range	description	BBC
EXT DC In Sel	AC Adapter, Battery		
Battery Select	ProPac14, Trimpac14, Hytron50, Hytron140, Dionic90, Dionic160, NP-L7, Endura7, Endura10, Endura-D, PagL95, BP-GL65/95, NiCd14, TypeA, TypeB		
Battery Mode	Auto, Manual		
ProPac14 Near	11.0~ 13.5 ~15.0V	Set Near End voltage	
TrimPac14 Near	11.0~ 13.4 ~15.0V		
Hytron14 Near	11.0~ 13.4 ~15.0V		
Hytron140 Near	11.0~ 13.1 ~15.0V		
Dionic90 Near	11.0~ 13.7 ~15.0V		
Dionic160 Near	11.0~ 13.3 ~15.0V		
NP-L7 Near	11.0~ 13.6 ~15.0V		
Endura7 Near	11.0~ 13.4 ~15.0V		
Endura-D Near	11.0~ 13.4 ~15.0V		
Pag L95 Near	11.0~ 13.8 ~15.0V		
BP-GL65/95 Near	11.0~ 13.4 ~15.0V		
NiCd14 Near	11.0~ 13.5 ~15.0V		
NiCd14 End	11.0~ 13.1 ~15.0V		
Type A Full	11.0~ 15.7 ~17.0V		
Type A Near	11.0~ 13.7 ~15.0V		
Type A End	11.0~ 13.3 ~15.0V		
Type B Full	11.0~ 15.7 ~17.0V		
Type B Near	11.0~ 13.7 ~15.0V		
Type B End	11.0~ 13.3 ~15.0V		
Near End Cancel	On, Off	Press Disp/ModeChk to cancel warning	

CARD FUNCTIONS

Item	Range	description	BBC
Scene File	File Select, Read, Write, Title Reload	Read/Write Scene files to SD card	
User File	File Select, Read, Write, Title Reload	Read/Write User files to SD card	
SD Card Format			

LENS SETUP

Item	Range	description	BBC
Shading Select	Default, User1, User2, User3, Off		
Shading (User)		Select/Set settings 1~3	
CAC	On, Off	Chromatic aberration correction	On
CAC Property		Show current file number and data	
CAC Card Read	Exec	Loads file from SD card	
CAC File Delete		Show list of files, select to delete	
CAC File Init	Exec	Return to factory settings	
Iris Adjust	F2.8, F16	Forcibly set iris	

OTHER FUNCTIONS

Item	Range	description	BBC
User File	Load, Save, Initial	Move user files around, doesn't affect scene files	
1394 Control	Ext, Both, Chain, Off	Controls external 1394 recorder	
1394 Cmd Sel	Rec_P, Stop	How external recording s stopped	
Access LED	On, Off	P2 card slot access light	
Alarm	High, Low, Off	Alarm volume	
Clock Setting		Set the clock	
Time Zone	-12:00~ 0.00 ~+13:00		
GL Phase	HD SDI, Composite	Set which output is synchronised	
H Phase	-512~ 0 ~+511	Fine tune locking	
Menu Init	Exec	Factory reset all menus and files	

DIAGNOSTIC   Reports status and version numbers

Item	Range		description	BBC
Version	Version		Values not recorded from the camera tested	
	Cam Soft			
	Syscon Soft			
	P2CS BL2-1			
	P2CS BL2-2			
	P2CS KR			
	P2CS AP			
	VUP			
	VUP FS			
	CAM1 FPGA			
	CAM2 FPGA			
	CAM3 FPGA			
	DM FPGA			
Model Name	AG-HPX301E			
Serial No.	FOTEA0073			
Operation				

OPTION MENU   Check on 1394 status, press Disp/ModeChk then Menu

Item	Range	description	BBC
1394 Status		Shows format, transfer rate, field rate, channels, speed etc	
1394 Config	Defl, 1-255	Opens a configuration menu, use Default normally	

2   Measurements

All measurements were made at BBC R&D, using a Sony 32" crt Grade 1 HDTV monitor and a digital waveform monitor. Frame files were grabbed via HDSDI for software analysis. Importing recordings into editing software is unreliable because the decoding and transcoding is not fully specified.

2.1 Gamma and Headroom range

Like the HPX301, the HPX371 does not have an in-built test signal (sawtooth). Since the 371 is clearly almost identical to the 301, no measurements were made of the gamma curves, they are assumed to be those of the 301.

The *HDnorm* curve is essentially that of ITU.709. When the knee is set to *High*, there is no contrast compression below 100% signal level. The *Cine-likeD* curve shows the degree of overexposure that the camera can handle, about 250%, 1.3 stops. The other curves were not investigated in detail, but it seems that the *High* gamma curve is probably the BBC 0.4 curve, providing the most accurate colour reproduction, while *B.Press* and *Cine-likeV* both compress low levels rather excessively.

The exposure range is limited by the headroom (250%) and the noise level. The camera specification makes no claim for video signal-to-noise ratio.

2.2 Colour performance

Having assumed that the *HDnorm* gamma curve is the IUT709 curve, visual assessments confirmed that the colour performance is the same as for the 301. Pictures were judged to be over-saturated, a more accurate colour reproduction resulted with the camera's Chroma Level control (saturation) set to -3 or -4. This also reduced the video noise a little. The most accurate colour reproduction was with the *High* gamma curve, believed to be the BBC 0.4 law. The recommended values (-2 for video, -4 for film) are only starting points, and it is always preferable to use the chroma control than to play with matrix values.

The *Norm2* matrix over-saturates even more, while the Cine-line matrix under-saturates nicely.

2.3 Noise

Noise was measured by exposing the camera to an illuminated white card, and exposure adjusted to get 4 luma values between 10% and 100%. The grabbed frames were processed with a high-pass filter to remove shading effects from uneven illumination. Vignetting was avoided by adjusting the lighting level such that the extremes of the aperture range were not used.

Figure 1 Noise levels

The plot of measured noise versus luma signal level shows that noise in the middle range is at about -45dB, which is adequate but a little disappointing. The curves are very similar to those for the 301, and show the expected rise in noise level as the signal level reduces, due to the increasing gain of the gamma-correction process. Since sensor and head-amplifier noise is amplified differently by the gamma-correction, the noise level should be proportional to the slope of the gamma curve, and should have a range of about 17dB between 2% and 100% video level.

The noise levels are not excessive. It is inevitable that noise should be higher with the small size of the photo-sites in the sensors (place on 2.5μm centres compared with 5μm for a ⅔" camera), shot noise in particular is to be expected (causing a rise in noise levels near white). The basic sensitivity of this ⅓" camera should be about 2 stops less than that of a ⅔" camera, or 12dB more noisy, depending on exactly how the signals are converted to digits. The performance of the HPX371 is not surprising, and means that the exposure range is about 10 stops, maybe a little more.
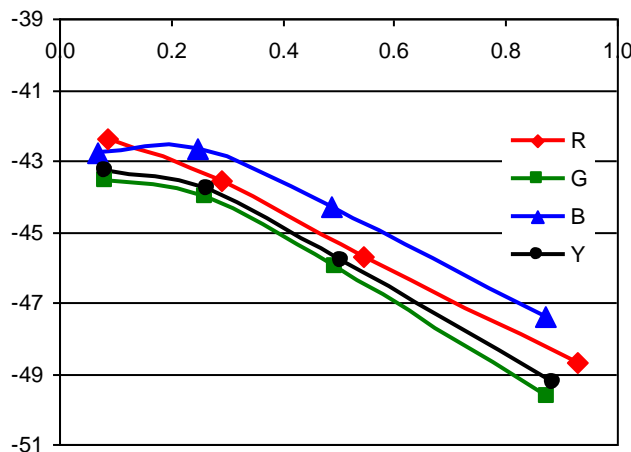
The Noise Coring control appeared to have little effect, typically 1.5dB improvement between setting -7 and +7.

2.4 Resolution

Resolution was tested using a test card of circular zone plates. The zone plate presents a spatial map of all the frequencies the camera should have to deal with, dc and low frequencies in the middle of each pattern, rising to the Nyquist limits horizontally and vertically. The test chart has sinusoidal modulation to avoid sampling problems, and has patterns for luminance, chrominance, R G and B. Only the luminance pattern is presented here, the other patterns revealed no surprises.

With factory settings, the result for progressive 1080 is good, there is no aliasing, and resolution nicely reaches the Nyquist limits at a low level, indicating either that there is proper optical filtering in the camera, or that the lens is providing the limit. The lens aperture was F/2.8, usually optimum for an HDTV lens.

Interlace also provided no surprises, with considerable (but correct) vertical softening due to the interlaced

Figure 2 Resolution, 1080p factory detail

scanning. Exploring the *detail enhancement*, it became apparent that the range of control is offset, -7 being no enhancement, +7 lots. The central, factory set, level of 0 did not produce the best pictures, values of -2 and -4 were much more acceptable for video- and film-type shooting.

The setting of -4 goes with the use of *Cine-likeD* gamma curve for a film-type look. The pictures are completely clear of aliasing, which should make for efficient video coding.

2.4.1 Resolution at 720p

The camera can be used in 720p mode, which is the only way to get access to "off-speed" shooting.

There is clear aliasing in the picture, both horizontally and vertically. This is inevitable in any camera, since the conversion to 720p is a standards-conversion, which cannot be done satisfactorily in any camera at an economic price. Resolution is clean up to about 1280 by 540, with vertical aliasing dominating above 720. The aliasing with a null-centre at 1080 (vertically) and 1920 (horizontally) is evidence that there is probably only horizontal optical filtering in the camera, the strong vertical alias would be suppressed if there were vertical filtering as well.

The performance is not bad, and is probably acceptable if the need is to shoot off-speed, but for shooting on-speed, it would be better to shoot at 1080 and down-convert externally as part of the post-production operation unless the motive for using 720p is to improve motion capture.
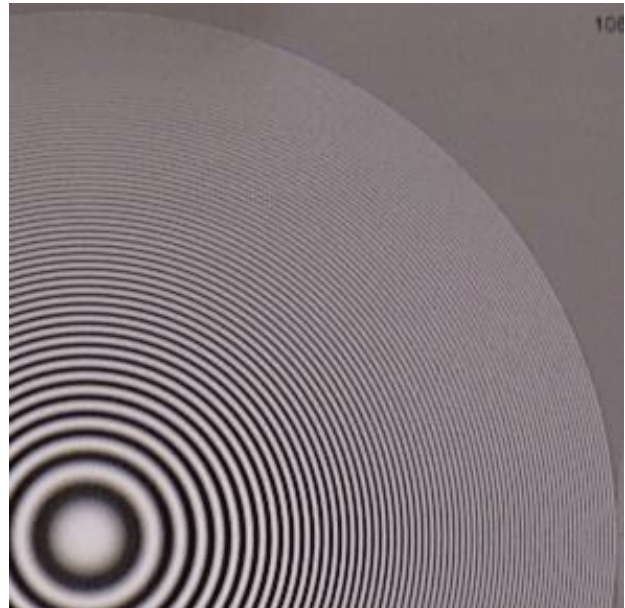
2.4.2 Resolution at 576i

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Figure 4 Resolution, 576i

Down-conversion to standard-definition produced more aliasing. The original aliasing with null-centres at 1080 and 1920 are still present (they could hardly be absent since they are generated in the sensors themselves). The down-conversion to SD appears to be significantly better than in the HPX301, but the level of aliasing is still rather high. In order to result in SD material, it still seems better to shoot 1080p and down-convert externally.

2.5 Iris Diffraction and Chromatic Aberration

In a 1080-line HDTV camera with ⅓" sensors, the iris diffraction limit is about F/4; stopping the lens down beyond that aperture softens the picture and introduces chromatic aberration effects. In a ⅔" camera the limit is about F/5.6 and so softening is visible from F/8. Panasonic have introduced a neat trick in this camera (and some others), whereby a video scaler is driven by data from the lens, to correct chromatic aberration. It cannot correct the loss of sharpness, but correcting the coloured fringing should improve matters considerably. The lens supplied with the camera was tested, a Fujinon ⅓" format T17x4.5BRM-K14. Frames were grabbed at 1080p, with the lens set to 12mm and 40mm focal length, at F/8 and F/1.6.
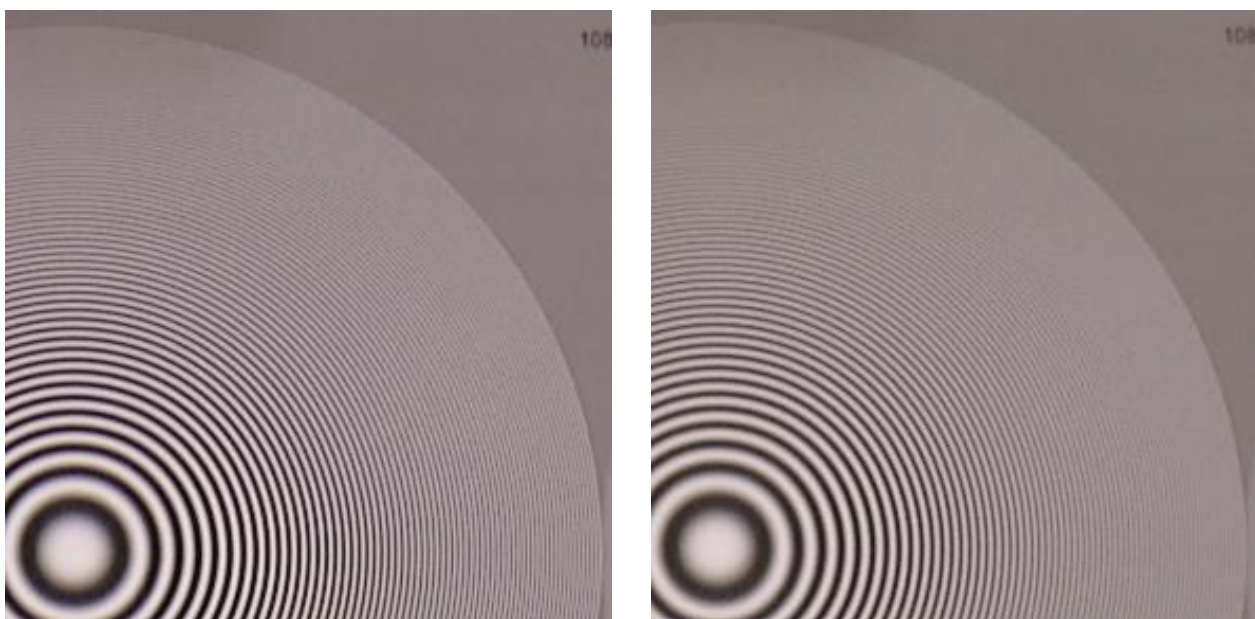

Figure 5 Resolution 12mm a) F/1.6   **b) F/8**

Clearly, the resolution is good at F/1.6, but considerable resolution has been lost by stopping the lens down; at F/8, the camera barely makes enough resolution for 720p.

Chromatic aberrations are worst in the corners, in this case bottom left. However, the camera's correction system appears to be working well, since the star pattern is only soft, there is very little actual chromatic aberration. The correction works only horizontally, but at the level of aberration present in the lens this appears to be perfectly adequate. The performance of this lens and camera is significantly better than that of the previously tested HPX301.

Bear in mind that these illustrations are cropped sections of the image, only about 190x190 pixels. The aberrations are not severe, and the correction has not fully worked, but there is a major improvement.
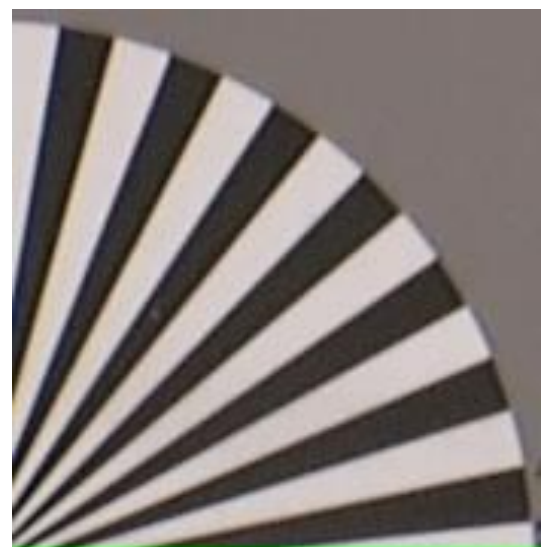
2.5 Conclusion

Figure 6 Chromatic aberration, F/8

The HPX371 performs a little better than does the HPX301, particularly relating to lens aberrations. The noise levels are very similar, but the 371 exhibits noise distribution which is easier to explain. In all other respects, it appears to be almost identical to the 301.