Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 33 : Assessment of, and settings for, Panasonic HVX201

Data for this section is taken from a short examination of a production model of the Panasonic HVX201 camcorder. This is a HDTV camcorder, virtually identical to the HVX100, with 3 ⅓" ccds, the manual gives no clue as to the sensor resolutions. It appears to be a slightly simplified version of the HVX200, running only at 50Hz. It records HDTV using the 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), and SDTV onto miniDV. 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.

The camera is relatively light and has an integral lens and viewfinder, with side lcd panel, and seems aimed at the high-end consumer/professional market rather than full broadcast, which would normally demand interchangeable lenses. It has a photographic speed of about 640ASA.

It has the usual internal menus for setting the performance, not as complex as in the 720-line Varicam or the 1080-line HD900 for example, but enough to control most of the important features. It is not suited to multi-camera operation because it cannot be remotely controlled or genlocked. It has analogue-only video outputs (components at both HD and SD via a multi-pin connector) and digits via IEEE1394 Firewire and USB. This alone puts the camera in the consumer/semi-pro market, rather than broadcast, which would normally expect either HDSDI or BNC connectors for analogue.

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.

The settings in this document are virtually identical to those for the HVX200, since the camera performance seems to be near identical.

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The assessment of this camcorder was aimed mostly at confirming that what it could do closely matched the HVX200, 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 effect 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 or ARIB bars that are ubiquitous in HDTV. In the mode column, C=Camera, M=MCR, V=VCR, D=Dub.

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

1 Menus and Settings

CAMERA MENU	
SCENE FILE	Camera operational controls, needs lab work to get the best from these
CAMERA SETUP	Basic camera setup controls
SW MODE	Configuration of switches
AUTO SW	Control of camera automatic features
RECORDING SETUP	Tape and P2 card controls
AV IN/OUT SETUP	Configure audio/video connections
DISPLAY SETUP	Viewfinder and LCD panel settinmgs
CARD FUNCTIONS	P2 flash card controls
OTHER FUNCTIONS	Sundries that don't fit anywhere else
OPTION MENU	Control of IEEE1394 (Firewire) connection

MCR/VCR MENU	
RECORDING SETUP	Timecode, IEEE1394, User bits audio, etc
PLAYBACK FUNCTIONS	Audio matters
AV IN/OUT SETUP	Analogue connection and IEEE1394 settings
DISPLAY SETUP	Viewfinder and LCD panel settings
OTHER FUNCTIONS	Sundries that don't fit anywhere else
OPTION MENU	Control of IEEE1394 (Firewire) connection

DUBBING MODE MENU	
RECORDING SETUP	Timecode, IEEE1394, User bits audio, etc
DUBBING SETUP	Format, pulldown etc

CAMERA MENU

Scene File (1-6)	mode	range	comments		BBC
Operation type (P2, tape)	C	Video/Film	Also sets SynchroScan indicator to time or angle	Video (1080i, SD) Film (1080p, 720p)	
Frame rate (P2)	C	12, 18, 20, 23, 25, 27, 30, 32, 37, 48, 50	Shooting speeds for 720p only		
Synchro scan (P2,tape)	C	1/n~1/249.8	n=frame rate, or degrees for FILMCAM, will not set longer than 1/field or frame		
Detail level (P2,tape)	C	-7~+7	Horizontal and vertical edge detail		0 (1080i) -2 (1080p) +2 (720sport) -4 (720film) 0 (SD)
V Detail level (P2,tape)	C	-7~+7	Vertical edge detail		-2 (1080i) -4 (1080p) +3 (720sport) 0 (720film) -2 (SD)
Detail coring (P2,tape)	C	-2~+7	Noise limiting for detail		+4
Chroma level (P2,tape)	C	-7~+7	Saturation		0
Chroma phase (P2,tape)	C	-7~+7	Hue		0
Color temp (P2,tape)	C	-7~+7	Fine white balance offset		
Master Ped (P2,tape)	C	-15~+15	Master black lift		
A. Iris level (P2,tape)	C	-4~+4	Auto iris gain		
News gamma (P2,tape)	C	On/Off	Adds some extra knee to cope with highlights		Off
Gamma (P2,tape)	C	HDnorm, Low, SDnorm, High, B.press, Cine-likeD, Cine-lineV	HDnorm= ITU709, Low=high contrast (skin press), SDnorm=DVX100, High=black stretch, B.press crushes, CineV=more contrast than CineD		HDnorm (HD), High (SD)
Knee (P2,tape)	C	Auto, Low, Mid, High	Reaches ~ 250%, knee at 80%,90%, 100%		90%[1]
Matrix (P2,tape)	C	Norm1, Norm2, Fluo, Cine-like	Norm1 seems standard, Norm2 could be better called *Vivid*		Norm2/ Norm1
Skin tone detail (P2,tape)	C	On, Off	Reduces skin detail		Off
V Detail freq (P2,tape)	C	Thin, Mid, Thck			Thin
Name edit (P2,tape)	C		Names the selected scene file		
Save/init (P2,tape)	C	Save, Initial	Save changes, or factory reset		

Camera Setup	mode	range	comments	BBC
Aspect conv (P2,tape)	C	Normal, Letter box, Squeeze	Recording format for SD 576-line	

SW Mode	mode	range	comments	BBC
Mid gain (P2,tape)	C	0, 3, 6, 9, 12dB	12dB gain is fairly noisy and visibly soft, probably not acceptable	3dB
High gain (P2,tape)	C	0, 3, 6, 9, 12dB		6dB
ATW (P2,tape)	C	Ach, Bch, Prst, Off	Assign AutoTrackWhite to gain switch	
Handle zoom (P2,tape)	C	L/Off/H, L/M/H, L/OFF/M	Set zoom speed switch settings,	
Iris dial (P2,tape)	C	Down open, Up open	Reverses iris control (when Manual)	
User 1,2,3 (P2,tape)	C	RecCheck, Spotlight, Backlight, Blackfade, Whitefade, ATW, ATWon/off, Gain18dB, FocusRing, IndexMemoP2, SlotSelP2, ShotMarkP2	Assign user switches. 18dB works only with 50Hz operation, and not with slow shutter. P2 options label shots, change slots etc. Default:1=Whitefade, 2=Backlight, 3=Index/Memo	

Auto SW	mode	range	comments	BBC
A.Iris (P2,tape)	C	On, Off	Auto iris	
AGC (P2,tape)	C	6dB, 12dB, Off	Set auto gain maximum	
ATW (P2,tape)	C	On, Off	AutoTrackWhite	
AF (P2,tape)	C	On, Off	AutoFocus, disables Focus/Push Auto	

Recording Setup	mode	range	comments	BBC

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[1] Knee cannot be turned off, a good idea. Set to 90% for productions in which skin tones are vital, to 80% for landscape/wildlife etc., where skin tones are less important.

				BBC
Rec format (P2)	C	<u>1080i/50i</u>, 1080i/250, 720p/50p, 720p/250, 720p/25pn, 576i/50i, 576i,25p	Recording format for P2 card[2].	
Rec format (tape)	C	576i/50i, 576i/250	Tape recording format	
576i rec mode (P2)	C	<u>DVCPro50</u>, DVCPro, DV	Tape compression system	
Rec function (P2)	C	<u>Normal</u>, Interval, One shot, Loop	Non-standard recording functions	
One-shot time (P2)	C	<u>1F</u>, 2F, 4F, 8F, 16F, 1s	Frames or time to record	
Interval time (P2)	C	2F,4F,8F,16F, 1s, 2s, 5s, 10s, 30s, 1m, 5m, 10m	Frames/seconds/minutes	
Prerec mode (P2)	C	On, <u>Off</u>	Memory cache for prerecording	
Rec speed (tape)	CVD	<u>SP</u>, LP	Tape speed	
Audio rec (tape)	CV	32k12bit, <u>48k/16bit</u>	The usual	
Mic alc (P2/tape)	C	<u>On</u>, Off	Auto level control	
Mic gain 1 (P2/tape)	C	<u>-50dB</u>, -60dB	External mic level control	
Mic gain 2 (P2/tape)	C	<u>-50dB</u>, -60dB	External mic level control	
25M rec ch sel (P2)	C	<u>2ch</u>, 4ch	DV/DVCPro25 sound channels	
1394 TC regen (P2/tape)	MV	<u>On</u>, Off	On=TC from 1394, Off=other controls	
TCG (P2/tape)	CMVD	Free run, <u>Rec run</u>	TC runs free or only when tape runs	
First rec TC (tape)	CVD	<u>Regen</u>, Preset	Select TC used at start, Regen reads tape and continues	
TC preset (P2/tape)	CMVD		Set initial TC, when recording 24p, set frame to multiple of 5 for it to make sense	
1394 UB regen (P2/tape)	MV	<u>On</u>, Off	Source of UserBits	
UB mode (P2/tape)	CMVD	User, Time, Date, TCG, <u>FrmRate</u>	FrameRate uses a code, refer to manual	
UB preset (P2/tape)	CMVD		Set info, select User in UB mode	
1394 In preset (P2/tape)	MV	On, <u>Off</u>	Sync TCG to 1394 when TCSet pressed	

Playback Functions	mode	range	comments	BBC
32k audio (tape)	V	<u>ST1</u>, ST2, Mix	Route stereo 1/2 or 3/4 to output when 32k	
Audio out (P2)	MV	<u>Ch1Ch2</u>, Ch1, Ch2, Ch3Ch4, Ch3, Ch4	Channels 3 and 4 available only on P2 recording	
Audio out (tape)				

Dubbing Setup	mode	range	comments	BBC
Format sel	D	<u>1080i/50i</u>, 1080i/50p, 720p/50p, 720p/250, 720p/25pn	Format for playback in dubbing	

AV in/out Setup	mode	range	comments	BBC
Cmpnt out sel (P2)	CM	<u>720p</u>, 1080i, 576i	720p converts only to 1080i	
HP mode (P2,tape)	C	Live, <u>Recording</u>	Headphone feed, use Live for off-speed	
A.dub input (tape)	V	<u>Mic</u>, A.In	Take sound from mics or audio I/O	
1394 out (tape)	V	On, <u>Off</u>	On feeds analogue inputs to 1394, adc	

Display Setup	mode	range	comments	BBC
Zebra detect 1 (P2,tape)	C	50%~105% by 5%	Default <u>80%</u>, left-leaning zebra	
Zebra detect 2 (P2,tape)	C	50%~105% by 5%, Off	Default <u>100%</u>, right-leaning zebra	
Marker (P2,tape)	C	<u>On</u>, Off	Press Zebra button to display markers	
Safety zone (P2,tape)	C	Off, <u>90%</u>, 4:3		
Video out OSD (P2,tape)	C	On, <u>Off</u>	Screen info to video output, beware, it goes to 1394 as well	
Date/Time (P2,tape)	CMV	<u>Off</u>, Time, Date, Time&Date	What to show on screen	
Level meter (P2,tape)	CMV	<u>On</u>, Off	Audio levels on screen	
Zoom, focus (P2,tape)	C	Off, <u>Number</u>, mm/feet, mm/mm	Show real distances (maybe☺)	
Card/Tape, Batt (P2,tape)	CMV	<u>On</u>, Off	Remaining capacity	
Other display (P2,tape)	CMV	Off, <u>Partial</u>, All	Display info depth	
Camera data (P2,tape)	MV	<u>On</u>, Off	Show camera settings on playback	
LCD backlight (P2,tape)	CMV	High, <u>Normal</u>	Brightness	
LCD set (P2,tape)	CMV		Panel, set brightness, contrast, colour	
EVF set (P2,tape)	CMV		V/F, set brightness, contrast, colour	

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[2] The terminology for recording formats is non-standard, but the meaning is clear.

Self shoot (P2,tape)	C	Normal, <u>Mirror</u>	For when panel is forward-facing	
EVF mode (P2,tape)	CMV	On, <u>Auto</u>	Auto switches off V/F when panel is open	
Display aspect (P2,tape)	CMV	<u>Auto</u>, 4:3	Widescreen always appears letterboxed	
EVF color (P2,tape)	CMV	<u>On</u>, Off	For black/white V/F	

Card Functions	**mode**	**range**	**comments**	**BBC**
Scene file (P2)	C	Read, Write	Save up to 4 scene files to P2 card	
User file (P2)	C	Read, Write	Save up to 4 file settings (not Scene) to SD card	
SD card format	C			

Other Functions	**mode**	**range**	**comments**	**BBC**
Remote (P2,tape)	CMV	Vcr1, Vcr2, Off	Remote control access	
1394 control (P2,tape)	C	<u>Off</u>, Ext, Both Chain	Backup via 1394, Ext controls remote deck with Start/Stop, Chain uses remote deck as extra recorder	
1394 cmd sel (P2,tape)	CV	<u>RecP</u>, Stop	Set remote deck to stop or pause	
End search (tape)	CM	<u>Blank</u>, Rec End	Search for unrecorded slot or last recording	
PC mode (P2)	CM	USB device, <u>1394 device</u>, 1394 host	1394 host controls external deck for backup	
Rec lamp (P2,tape)	C	Off, Front, Rear, Both		
Access led (P2)	CM	<u>On</u>, Off	Card access indicator	
Beep sound (P2,tape)	C	On, <u>Off</u>	Warns of card/tape full, no tape, condensation, problem	
Clock set (P2,tape)	CMV		Set clock and calendar. Really, honest, that's what it does	
Time zone (P2,tape)	CMV	-12~+13	Time zone offset from GMT, for foreigners	
Power Save (P2,tape)	C	On, <u>Off</u>	Disables 5-minute inactive shut-down	
User file (P2,tape)	CMV	Load, Save, Initial	Power down/up to activate change	
Hour meter	CV		Shows head hours (5 digits per hour)	
Operation	CM		Shows total power-on time	

Press Disp/Mode Chk button and Menu, then Menu to cancel

Option Menu	**mode**	**range**	**comments**	**BBC**
1394 status (P2,tape)	CMV		**P2**: Format, rate, 50/60, channels, speed, status, video, audio **Tape**: Format, rate, 50/60, channels, speed, mode, Rx, Tx	
1394 config (P2)	CM	<u>Dflt</u>, 1~255	1394 extended menus	

2 Measurement results

The HVX201 has no built-in test signal generator. This alone sets it apart from most professional and broadcast cameras. Thus all measurements had to be made the hard way, using optical test cards and an awful lot of data processing. All monitoring was done live from the camera via the analogue component outputs, using a HDSDI converter.

2.1 Transfer characteristic (gamma-correction)

These measurements are taken directly from measurements of the HVX200. There is nothing about the HVX201 to indicate that different results might be obtained, therefore, only the conclusions are presented here.

HDnorm is a reasonable match to ITU709, but is not perfect. 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%, about 1 1/3 stops) before video clipping occurs at about 107%. *High* (Black Stretched) is a good match to the BBC 0.4 law, which delivers more accurate colour rendition. Contrast range, based on these curves and the measured noise levels, is between 10 and 11 stops, not bad for a camera in this range.

The other variants of the gamma curve were not investigated; the descriptions given in the manual seem to be sufficiently accurate and explicit for the user to make an intelligent choice.

2.2 Resolution and Detail

A zone plate test chart was used, calibrated for 1920x1080 HDTV. It contains 6 circular patterns, each being a phase space of the spatial-frequencies which such a camera should resolve. Analysis was made of one pattern to investigate the frequency responses and the presence of aliases. One quadrant of one pattern is shown here.

With the camera set to 1080, there is little or no detail above 960 horizontally (halfway way from the centre spit to the horizontal edge) or 540 vertically (halfway to the vertical edge). Frequencies beyond these limits are folded, or aliased. Thus, the HVX201 appears to have the same sensors as the HVX200, 960 by 540 pixels; it would be more usual to find sensors, in a 1080-line camera, having 1080 lines rather than only 540. Panasonic use these lower-resolution sensors, presumably, in order to increase sensitivity (since the pixels are bigger, the same 5µm square dimension as is found in ⅔" format HDTV cameras). In the HVX200, the G sensor appears to be offset from R and B by exactly half a pixel, both horizontally and vertically, a process which delivers resolution up to about 25% more than the nominal pixel count. However, the 201 does not appear to have this offset, or perhaps the lens is a little less sharp than on the previously tested HVX200 which seems unlikely.
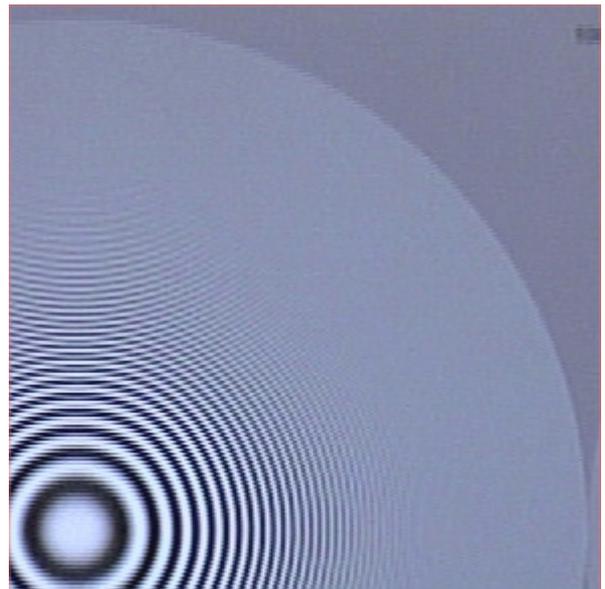
However, the camera is quite well behaved within these limits, in that there do not appear to be any aliases centred on other frequencies, as would be expected if the interpolation process from the 960x540 of the sensors were compromised in any way. There was no significant difference in resolution when the camera was set to 1080p, or to 720p. Since the high-frequency content is quite low, the detail enhancement controls have little effect, the values chosen are, to some extent, arbitrary.

2.2.1 Resolution (576-line)

Down-conversion is rather good. Horizontally, there is some aliasing due to the down-sampling, but vertically there is none at all. This there should be no annoying inter-line "twitter", although the pictures are

a little softer than could be expected. The horizontal aliasing is between "frequencies" of 720 (the horizontal limit for SDTV) and 960, indicating that not all of the higher frequencies are being properly suppressed.

However, the pictures were subjectively rather good. This is rather unusual in any HDTV camera, where the quality of down-conversion is almost always compromised by the over-simplicity of the conversion process when concatenated with the presence of high-amplitude horizontal and vertical frequencies.
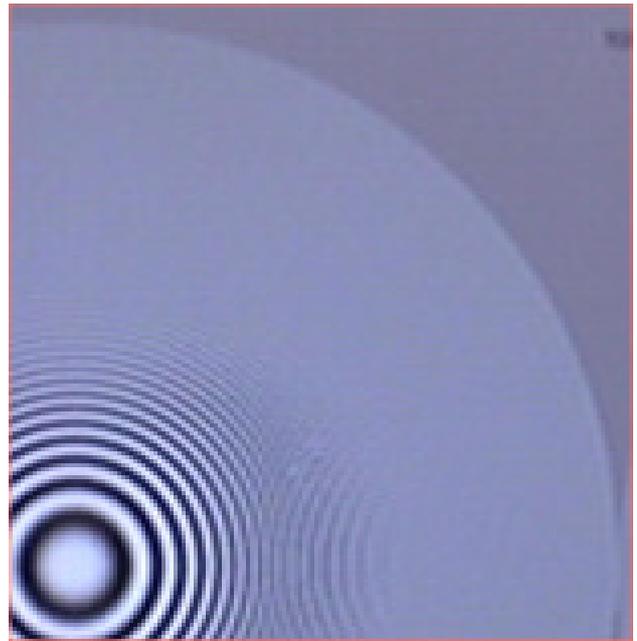
2.2.2 Lens aberrations

The integral lens showed some chromatic aberration.

In this example from the corner of the test chart, there is an offset of between 3 and 4 pixels, not particularly good for an HDTV camera.
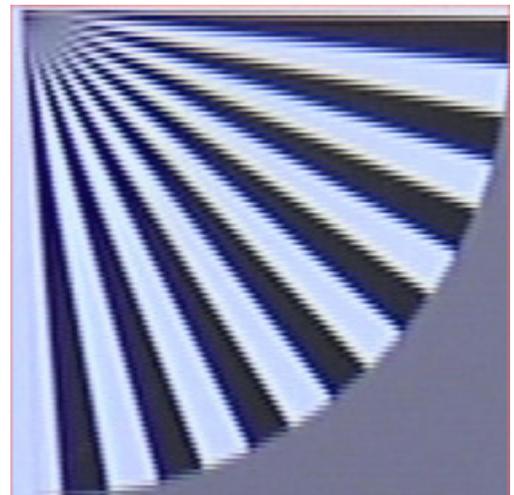
2.3 Noise

No calibrated noise meter was available during the measurement procedure, and the camera specification does not mention noise.

Again, software analysis of frames gives some indication of performance. Measurements were made of full frames at 0dB gain, exposed to a grey card, producing signal levels between 10% and 90%. Noise levels were found to be between -40 and -43dB, not particularly good. These values were confirmed by measuring the noise in the grey patches of a frame-capture of a Macbeth chart.

Intriguingly, there was little difference between the levels of noise at black and white signal levels. Normally, the noise level would be expected to correlate with the slope of the gamma-correction curve, since source noise is differentially amplified by the gamma curve, by typically 10dB more near black than white. There is no apparent correlation in this camera.

There are two possible reasons for this.

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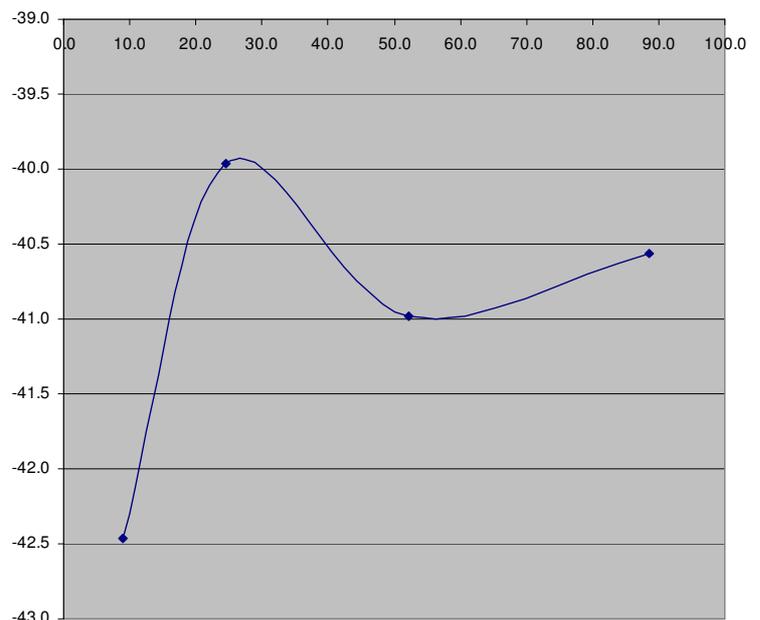
One is the possible use of analogue head amplifiers with limited gain-bandwidth product, such that the bandwidth is lower at low signals levels, reducing the noise. If this trick has been used, it has worked; the particularly low level of noise near black suggests that this is the case.

The other possibility is that the main source of noise is not the analogue circuitry of the camera head, but limited bit-depth video signal processing. The camera monitoring and frame-capture were done from the camera analogue outputs rather than via the recording system, therefore it was expected that the 8-bit limitation of DVCPROHD could be circumvented. However, it seems that the analogue outputs themselves are fed from DACs with 8-bit data, and that the camera processing may be only 10-bit linear and 8-bits in gamma-corrected video.