

Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 52 : Tests and Settings on an Ikegami HDS V10 camcorder

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 one-day assessment was made on a sample of the V10 camcorder (serial number AA63081E), a single-standard HDTV camcorder fitted with a Canon HA17x7.6 HD lens. It appears to be made in two versions, one with 1920x1080 CCD sensors, another with 1280x720 CCD sensors. There was no marking on the camera body to identify the version on test, but it operated at 1080-line, 720 options were not available on the tested unit. SD performance was not tested.

Recordings are onto GF PAK modules. Power consumption is rather high, the specification claims 28 watts, but the plate on the camera stated '5.6 amps at 11~17 volts', implying more like 55 watts. The tested camera ran hot to the touch. It is also rather heavy, at 4.5kG.

Physically, it resembles many other camcorders, the familiar Digibeta size and layout, but it has a large lcd side panel with touch-screen controls for menu control. It has the usually BNC connectivity found on such cameras. It also has many features which make it suitable for multi-camera use in studio or location shooting. A full paper manual was available, but there was insufficient time during the test to absorb much of it other than the contents of the menus.

The camera has one filter wheel, carrying neutrals. Colour balancing is performed electronically.

Noise performance was not very good for a camera with 1920x1080 sensors.

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Many menu items have little or no effect on the image. Those that do so are highlighted, default values are bracketed where known. The full menus are given for completeness. Where two values are given {f} denotes film use, {v} video. The photographic speed of the camera is about the same as an equivalent SD camera, sensitivity is claimed as F/11 at 2000 lux, tests did not contradict this. Using conventional gamma and knee settings, about 2 stops of overexposure (about 400%) is possible. Noise level is claimed as 58dB, and the total exposure range is estimated as about 10 stops. However, the camera noise performance does not appear to be so good, measurements were rather disappointing, details are given in the measurements section at the end of this document.

The menus are organised hierarchically, which is indicated by inseting menu items in the following tables. Default values for entries (factory settings) are underlined.

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.

Although the camera does not shoot in progressive or psf modes, settings for a film look (f) have been derived. There are also settings for video (v) and news (n) in the menus. Menu items which affect image quality and require setting are highlighted.

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

1 Menus and settings, touch screen

USER MENU

<i>Item</i>	<i>Range</i>	<i>description</i>	<i>BBC</i>
		Select up to 20 items for the User menu	

USER DATA SELECT

<i>Item</i>	<i>Range</i>	<i>description</i>	<i>BBC</i>
Current Data		Up to 10 sets of User Data	
Data Save			
Data Rename			

META DATA SELECT

<i>Item</i>	<i>Range</i>	<i>description</i>	<i>BBC</i>
Current Data		Up to 5 sets of Meta data	
Rename			
Power On Erase	<u>Off</u> , On	Clears Meta Data on Power Up	
Initialise	Cancel, Ok	Resets all Meta data	
Change Bin Mode	<u>Manu</u> , Sync	Sync makes Bins/Clips from Meta info	
Auto Clip memo	On, <u>Off</u>		

SW ASSIGN

<i>Item</i>	<i>Range</i>	<i>description</i>	<i>BBC</i>
P.Func0	<u>VF DTL</u> Level, Scene File, VF Display Mode, Step Gain, Fine Step Gain, Black Str/Prs, Master ped, Master Black Gamma, Super Knee, Fine DtlL, Audio Ch3 Level, Audio Ch4 Level, No entry		
P.Func1	Retro Loop, Time Lapse, Anime, Pakloop, Hyper Gain +30, Hyper Gain +42, Hyper Gain +54, Hi-light Dtl, Soft DtlL, Skin Dtl, Color Corr, Color Sat, 5600K, Scene 1~Scene 6, Iris_ Corr, Iris++ Corr, Rec Trig, Ret Trg, Thumbnail, R Tally In, G Tally In, No Entry	Default: 1=5600K, 2=Retro Loop, 3=No Entry, 4=No Entry	
P.Func2			
P.Func3			
P.Func Help	<u>On</u> , Off		
Gain Sw (Low)	-3, <u>0</u> , +3, +6, +9, +12, +18, +24, +30dB	1	-3dB
Gain Sw (Mid)	0, +3, <u>+6</u> , +9, +12, +18, +24, +30, +42dB		0dB
Gain Sw (High)	+3, +6, +9, <u>+12</u> , +18, +24, +30, +42, +54dB		+6dB
Handle Sw	<u>Rec/Ret</u> , Zoom, Focus, No entry		
Zoom Speed	1~100		
Focus Speed	1~100		
Ret Sw	<u>Preview/Shot</u> , Ret		
Lens VTR Sw	<u>Rec</u> , No Entry		

VF SETTING

<i>Item</i>	<i>Range</i>	<i>description</i>	<i>BBC</i>
VF Display Mode	Off, <u>1</u> , 2	Amount of stuff shown, 1=markers/TC/variables, 2=everything	
VF Dtl Lvl	1~ <u>20</u> ~100	Level of viewfinder sharpening	
VF MARKER			
Safety Area	<u>Action</u> , Title	Action=90%, Title=80%	
Safety Aspect	16:9, 15:9, 14:9, 13:9, <u>4:3</u>		14:9
Safety Marker	Off, <u>On</u>		
Center Marker	<u>Off</u> , On		
Frame Marker	<u>Off</u> , On		
Frame Aspect	<u>16:9</u> , 15:9, 14:9, 13:9, 4:3		16:9

¹ Noise level is rather high in this camera, so low gain should be used wherever possible.

Side Mask	<u>Off</u> , On	Darkens image outside frame marker	
Marker/Char Lvl	1~ <u>80</u> ~100	Brightness for characters and markers	
Side Mask Lvl	1~ <u>50</u> ~100		
VF ! INDICATOR			
AWB Off	<u>On</u> , Off		
Lens Ext	<u>On</u> , Off		
Manual Knee	<u>On</u> , Off		
Skin Dtl	<u>On</u> , Off		
Shutt/Sup-V	On, <u>Off</u>		
A.Iris Corr	<u>On</u> , Off		
VF Display Sel		Show the lot to help selection	
ZEBRA INDICATOR			
Zebra 1 Detect	30~ <u>100</u> ~109%		
Zebra 1 Ind	On, <u>Off</u>		
Zebra 2 Detect	30~ <u>70</u> ~109%		
Zebra 2 Ind	<u>On</u> , Off		
Focus Value	No Disp, <u>Meter</u> , Feet		
Remote Menu Disp	<u>On</u> , Off	Add V/F items to RMC panel display	
Playback Video	<u>Yes</u> , No	Allows playback video in the V/F	

BIN SETTING

<i>Item</i>	<i>Range</i>	<i>description</i>	<i>BBC</i>
Active Bin		Bin names show in sequence, press SET	
New Bin			
Bin Rename			

CAMERA SETTING

<i>Item</i>	<i>Range</i>	<i>description</i>	<i>BBC</i>
VIDEO ADJUST			
PED			
Master ped	-100~ <u>0</u> ~+100		
R.Ped	-100~ <u>0</u> ~+100		
G.Ped	-100~ <u>0</u> ~+100		
B.Ped	-100~ <u>0</u> ~+100		
Adjust Clr		Resets adjustments to zero	
FLARE			
Flare On/Off	Off, <u>On</u>		
Master Flare	-100~ <u>0</u> ~+100		
R.Flare	-100~ <u>0</u> ~+100		
G.Flare	-100~ <u>0</u> ~+100		
B.Flare	-100~ <u>0</u> ~+100		
Adjust Clr		Resets adjustments to zero	
GAMMA			
Step Gamma	<u>0.45</u> , 0.4, 0.35, Off		0.45
Master Gamma	-100~ <u>0</u> ~+100		
R.Gamma	-100~ <u>0</u> ~+100		
G.Gamma	-100~ <u>0</u> ~+100		
B.Gamma	-100~ <u>0</u> ~+100		
Cine Gamma Mode	<u>Normal</u> , Cine 1, Cine 2	Unusual gamma curves, see measurements section	Normal (v,n), Cine (f)
Adjust Clr		Resets adjustments to zero	
BLACK GAMMA			
Black Gamma On/Off	<u>Off</u> , On		
Master Black Gamma	-100~ <u>0</u> ~+100		
R.Blk Gamma	-100~ <u>0</u> ~+100		
G.Blk Gamma	-100~ <u>0</u> ~+100		
B.Blk Gamma	-100~ <u>0</u> ~+100		
Adjust Clr		Resets adjustments to zero	
KNEE			
Knee On/Off	<u>On</u> , Off		On
Auto Knee On/Off	<u>On</u> , Off		On (n), Off (v,f)

<i>Item</i>	<i>Range</i>	<i>description</i>	<i>BBC</i>
Auto Knee Point	-100~0~+100		
Auto Knee Slope	-100~+0.3~+100		
Manual Knee Point	-100~0~+100		0
Manual Knee Slope	-100~0~+100		0
Super Knee	Low, Mid, High, <u>Off</u>	Retains colour in highlights	
Smooth Knee	<u>Off</u> , Type1, Type2, Type3	Smooths out the join	
Adjust Clr		Resets adjustments to zero	
<i>GAIN</i>			
R.Gain	-100~0~+100		
G.Gain	-100~0~+100		
B.Gain	-100~0~+100		
Adjust Clr		Resets adjustments to zero	
Shockless Step Gain	0.3sec, 0.5, 0.7, 1, 1.5, 2, <u>Off</u>		
<i>WHITE CLIP</i>			
White Clip On/Off	<u>On</u> , <u>Off</u>		
R.White Clip	-100~0~+100		
G.White Clip	-100~0~+100		
B.White Clip	-100~0~+100		
Adjust Clr		Resets adjustments to zero	
<i>DTL ADJUST</i>			
Dtl	<u>On</u> , <u>Off</u>		On
Dtl Lvl	-100~+0.4~+100		0 (v), +15 (n), -21 (f)
Skin Dtl	<u>Off</u> , <u>On</u>		
Auto Hue Detect	<u>On</u> , <u>Off</u>	Skin colour	
Skin Dtl Lvl	-100~0~+100		
Soft Dtl	<u>On</u> , <u>Off</u>		
<i>SOFT DTL ADJUST</i>			
White Sup	-100~0~+100	Positive-going edges	
Black Sup	-100~0~+100	Negative-going edges	
Adjust Clr		Resets adjustments to zero	
Fine Dtl Bal	1~4~8	Negative-going edges	
Hi-Light Dtl	<u>Off</u> , <u>On</u>	Detail in highlights	
Dtl V Filter	<u>On</u> , <u>Off</u>	Vertical detail filter	
Adjust Clr		Resets adjustments to zero	
<i>COLOR ADJUST</i>			
Matrix Sel	<u>Off</u> , 1, 2, 3	Three adjustable matrices	
<i>MATRIX ADJUST</i>			
R-G	-100~0~+100		
R-B	-100~0~+100		
G-R	-100~0~+100		
G-B	-100~0~+100		
B-R	-100~0~+100		
B-G	-100~0~+100		
Color Corr	<u>Off</u> , <u>On</u>		
<i>COLOR CORR ADJ</i>			
R.Sat	-100~0~+100		
R.Hue	-100~0~+100		
Mg.Sat	-100~0~+100		
Mg.Hue	-100~0~+100		
B.Sat	-100~0~+100		
B.Hue	-100~0~+100		
Cy.Sat	-100~0~+100		
Cy.Hue	-100~0~+100		
G.Sat	-100~0~+100		
G.Hue	-100~0~+100		
Yl.Sat	-100~0~+100		
Yl.Hue	-100~0~+100		
Color Sat	<u>Off</u> , <u>On</u>		
Color Sat Lvl	-100~0~+100		

Adjust Clr		Resets adjustments to zero	
<i>Item</i>	<i>Range</i>	<i>description</i>	<i>BBC</i>
ABB/AWB MODE			
AWB With A.Iris	<u>On</u> , Off	Switch off Auto Iris when Black Balancing	
Shockless AWB	Off, 0.3sec, 0.5, 0.7, <u>1</u> , 1.5, 2sec		
Filter AWB Mem	<u>Off</u> , On	Store AWB data for each CC filter setting	
AWB Reference	<u>Off</u> , On	Allows driving the reference point (see Reference Set)	
AWB Detect Area	<u>Wide</u> , Spot	Wide=whole picture, Spot=centre	
Detect Area Marker	<u>Off</u> , On		
Reference Set	<u>AWB</u> , ABB, Cancel	AWB=remember current white as AWB ref, ABB=remember current black as ABB ref	
ABS Mode	<u>Normal</u> , APS, P Only	Normal=correct saw/para, P=Peak Shading, APS=both	
Auto White Shading			
Auto Black Shading			
AUTO IRIS SET			
Iris Set Mode	Off, <u>On</u>		
Iris Level Set	-100~ <u>-40</u> ~+100	Iris aim point	
Peak Ratio Set	-100~ <u>0</u> ~+100	Peak/mean, + for bright, - for dark	
Iris Gain	<u>1</u> ~100	Response sensitivity	
Iris Limit	F22, F20, F18, <u>F16</u>	Don't go below about F/11 for best performance, any lens	F16
Lens Adjust	<u>Off</u> , F2.8, F16	For tweaking lens voltages	
Iris Pattern	<u>0</u> , 1, 2, 3, 4	0=full screen, 1=lower ¾, 2=top ¾, 3=middle, 4=4:3	
LENS SELECT			
File	<u>Off</u> , On	8 lens files	
Number	1~8		
Name		Enter a name	
		Reports name from a 'serial' lens	
Auto Sel	<u>Off</u> , On		
Set Mode	<u>Off</u> , On		
SCENE FILE			
Current Number	<u>Off</u> , 1~8		
Store Scene	1~8		
MONI OUT			
Output Signal	SD SDI, <u>HDS</u> DI, Off		
Playback Video	<u>Yes</u> , No	Allow playback to monitor output	
Char Ind	Off, <u>On</u>	Add V/F stuff to monitor output	
Level	1~ <u>100</u>	Video level of V/F stuff	
Marker Ind (HD)	Off, <u>On</u>	Only in HD mode	
Level	1~ <u>100</u>		
Zebra Ind (HD)	On, <u>Off</u>	Only in HD mode	
Level	1~ <u>80</u> ~100		
SDI OUT			
Output Signal	SD SDI, <u>HDS</u> DI, Off		
Playback Video	<u>Yes</u> , No	Allow playback to SDI/HDSDI	
Char Ind	Off, <u>On</u>		
Level	1~ <u>100</u>		
Marker Ind (HD)	Off, <u>On</u>		
Level	1~ <u>100</u>		
Zebra Ind (HD)	On, <u>Off</u>		
Level	1~ <u>80</u> ~100		
BARS TITLE/MDO			
Display	<u>Off</u> , On	Add title to bars	
Position	Right, <u>Left</u>		
Title		Set the title	
Bars Mode	Normal, <u>Multi</u>	Normal=SMPTE	
OTHERS			
Pwr On AWB Off Clr	<u>Yes</u> , No		

Menu Cursor	<u>Next</u> , Stay	
Access LED	<u>Enable</u> , Disable	

AUDIO SETTING

<i>Item</i>	<i>Range</i>	<i>description</i>	<i>BBC</i>
Front Mic +48V	Off, <u>On</u>		
Front Mic Lvl	<u>-40</u> , -60dBu		
Ch1 Volume	<u>Enable</u> , Disable		
Ch2 Volume	<u>Enable</u> , Disable		
Front Volume	1, 2, 3, 4		
Ch3 AGC	<u>Off</u> , On		
Ch4 AGC	<u>Off</u> , On		
Ch3 Lvl	1~ <u>100</u>		
Ch4 Lvl	1~ <u>100</u>		
Ch1/2 AGC Mode	Stereo, <u>Mono</u>	Stereo locks channel AGCs together	
Ch3/4 AGC Mode	Stereo, <u>Mono</u>	Stereo locks channel AGCs together	
Ch1 Mic LCF	On, <u>Off</u>	Wind cut filter	
Ch2 Mic LCF	On, <u>Off</u>		
Ch3 Mic LCF	On, <u>Off</u>		
Ch4 Mic LCF	On, <u>Off</u>		
Ch1 Mic Limit	On, <u>Off</u>		
Ch2 Mic Limit	On, <u>Off</u>		
Ch3 Mic Limit	On, <u>Off</u>		
Ch4 Mic Limit	On, <u>Off</u>		
Rear Mic1 Lvl	<u>-40</u> , -60dBu		
Rear Mic2 Lvl	<u>-40</u> , -60dBu		
Wireless Mode	<u>Mono</u> , Stereo		
Output Select	<u>Ch1/Ch2</u> , Ch3/Ch4		
Test Tone	<u>With Bars</u> , On, Off		
Moni Mix Mode	<u>Mix</u> , Stereo		
Audio Sampling	<u>24bit</u> , 16bit		

RECORDER SETTING

<i>Item</i>	<i>Range</i>	<i>description</i>	<i>BBC</i>
Rec Source	<u>Camera</u> , Ext SDI	Recording from external SDI is not available on EU models	
REC FORMAT			
HD Video Compression	<u>MPEG2-100</u> , MPEG2-50	100Mb/s=I-frame, 50=Long GoP	
SD Video Compression	MPEG2-50, MPEG2-40, <u>MPEG2-30</u>		
Audio Sampling	16bit, <u>24bit</u>		
Rec Mode	<u>Normal</u> , Retro, T Lapse, Anime, Pak Loop		
RETRO LOOP			
Retro Loop Length	<u>5</u> ~25sec	Video cache	
Retro Tally Blink	<u>On</u> , Off		
TIME LAPSE			
Rec Length	1F~10F		
Interval	hh:mm:ss:ff	Enter values	
During Time	hh:mm:ss:ff	Enter values	
Number Of Times	1~10		
Anime Length	1F~10F	Animation recording, frames	
Pak Loop	5min~Pak remain-1min		
Rec Tally	<u>R Tally</u> , G Tally		
TIME CODE			
DF/NDF	DF, NDF	Relevant only for shooting at 59.94, 29.97, 23.98	
User Bit	User, Date		
User Bit Set			

Auto DPC		Do it	
DPC Effect Check	Ok, Cancel	Check what it's done	
DPC Clear	Ok, Cancel	Reset the stored data	
<i>Item</i>	<i>Range</i>	<i>description</i>	<i>BBC</i>
<i>LENS</i>			
Lens Serial I/F	<u>O</u> n, Off	Allow lens communication with the camera	
Fibre Extension Mode	<u>O</u> n, Off	Allow gunlock with fibre extension	
Camera ID Setup		Enter a name	
<i>FIRMWARE UPDATE</i>			
Firmware Ver.		Show current firmware versions	
Data select		Update firmware from USB device	
Bluetooth Setting			

USB MEMORY

<i>Item</i>	<i>Range</i>	<i>description</i>	<i>BBC</i>
User Data Load		Copy User File from USB	
User Data Save		Copy to USB	
Meta Data Load			
Text File Load			

2 Measurement results

2.1 Colour performance

Assessments were made visually, using Colorchecker charts as usual. Colour performance was acceptable, no issues arose.

2.1.1 Gamma curves

There is no explanation of the gamma curves in the camera, and no sawtooth test signal was found, therefore measurements were taken using standard reflectance cards (Kodak Gray). Each card has a reflectance of 18% on one side, 90% on the other, a ratio of exactly 5:1. Therefore, when exposing to get peak white from the 90% side, the 18% side presents a 20% reflectance which can be compared with the calculated values for standard curves.

For identical illumination and lens settings, the results are shown in Table 1. The ‘Normal’ curve is a close match to the BBC 0.4 law (0.505 for 20% exposure). Cine 1 causes under-exposure by about 0.8 stops, and after compensating for that, the 20% exposure value is 0.459, a reasonable match to the ITU Rec.709 curve (0.434 for 20% exposure). Cine 2 cause under-exposure of about 2.5 stops, and after allowance for that, the 20% exposure value is also 0.459. Clearly, both the Cine curves are actually ITU.709 gamma curves, the only differences being the degree of under-exposure.

	‘18%’	‘90%’
Normal	0.492	0.999
Cine 1	0.376	0.819
Cine 2	0.324	0.706

2.1.2 Gamma knee

The manual knee function is not calibrated in the menus. Measurements showed that setting the knee point to -80 produced a knee break at 100% video level, point 0 set a knee at 95%, and +120 made a break point at about 75%. Without a proper camera test signal it was not easy to derive optimum slope settings, but over-exposure of about 2 stops was found to be possible using the knee, although the default settings result in only about ¼ stop overexposure.

The Super Knee and Smooth Knee functions were superficially tested, they both worked.

2.2 Resolution

A HDTV zone plate chart was used. This contains six circular patterns which 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, and two for chroma channels. 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 shows a single quadrant of one grey-scale pattern; for this exposure, the camera detail enhancement was turned off, so this is the native performance of the camera. There are no visible alias patterns, apart from a faint one centred on 1080 lines (top of the pattern) and another centred on 1920 pixels (right of the pattern). This confirms that the sensors are 1920x1080, and that the optical spatial filtering is perhaps not quite strong enough. The clean horizontal resolution indicates that there is no “precision offset” of the green from red and blue sensors, a common technique to enhance resolution in cameras. This is very encouraging.



Figure 1 resolution, detail off

It is clear that the horizontal resolution is a little better than the vertical, not unusual in an interlaced camera, but it hints that the interlacing process is happening very early in the camera, probably on the CCDs themselves.

There were no alias patterns resulting from frequencies beyond the limits of 1920x1080 video.

2.2.1 Detail enhancement

For a film look (not possible in this camera at 1080-line because it does not appear to support the normal psf format at 1080i), detail can simply be set to -21 (Fig. 2), and the results will be a good match to super-16 film. However, for a 35mm look, a little enhancement would be a good idea, setting level to zero should be acceptable, since setting to zero does not mean no enhancement, only the factory default level.

Since the native resolution is very clean, it is possible to use rather more detail enhancement than usual. Figure 3 shows a setting with detail level +15. Clearly, the outer edge of the chart is a little too sharpened, and the enhancement has generated a faint vertical alias through third-harmonic distortion, but the setting could be good for a “news look”.

However, any more extreme enhancement should be used with care, since it has emphasised the noise somewhat, and since there is no noise slicer control in the menus, there is no way to avoid emphasising noise.

2.3 Noise performance

Measurements were made by exposing the camera to a plain white card, evenly lit, highly defocused. The camera gain was set to 0dB and exposure was set to generate video signals at 4 levels over the signal range. Data files were saved to a data store via HDSDI. Software analysis was then used to convert the files to BMP format, and to measure the rms noise levels in each file, using specialised software. The detail enhancement Level was set to 0, factory default level.

The results are rather odd. In a normal camera, the noise level should be directly related to the slope of the gamma curve, and therefore noise at black should be about 17dB worse than at white. In this camera, noise at black is 4dB better than noise at white. Clearly, there is some odd signal processing taking place in this camera. It is not unusual to have a slight rise in noise near white, perhaps due to shot noise, but that would not normally be greater than 1dB, whereas this camera has noise rising by 2dB near white. One possible cause for the rise near white is electronic noise reduction, reducing noise at lower levels.

The dramatic drop in noise near black can have a number of possible causes, e.g. noise reduction by spatial low-pass filtering, or performing gamma-correction in analogue circuitry before the colour matrix. Since gamma-correction in analogue would have to be performed using parametric amplifiers (where the gain is a

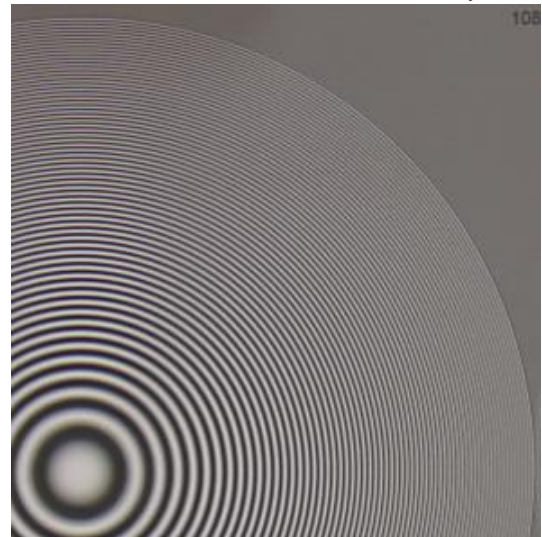


Figure 2 Resolution, detail=-21

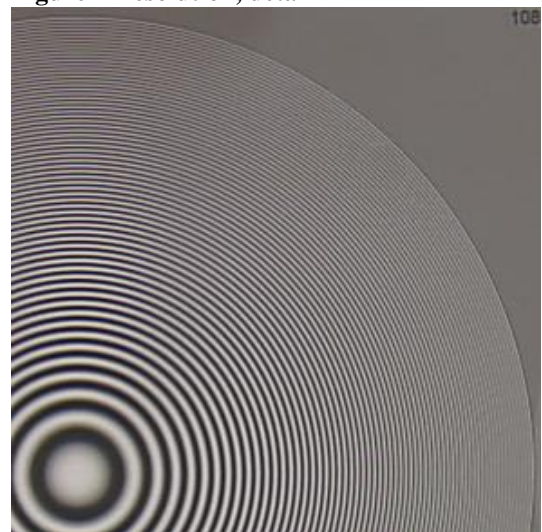


Figure 3 Resolution, detail=+15

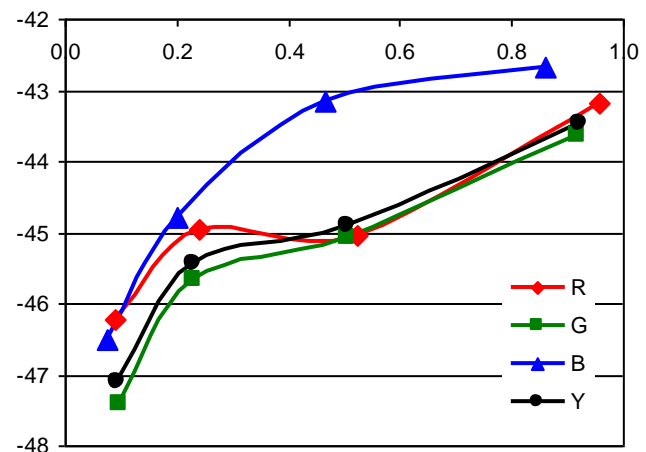


Figure 4 Noise levels

function of the signal level), it is conceivable that such amplifiers have a low gain-bandwidth product, resulting in a significant lowering of resolution as the gain rises near black.

The ITU.709 gamma curve has zero slope (i.e. unity gain) at about mid-grey. Therefore, taking the measured noise value at mid-grey should return the noise value when gamma correction is off (i.e. linear), and this is the normally-quoted value for a camera. In this case, the linear noise is about -45.2dB, which is about 10dB worse than that of the best cameras available for HDTV.

Since the noise performance is relatively poor, it was not investigated any further.

2.4 Conclusion

Resolution at HDTV 1080 is good, but noise performance is poor. Also, it has no progressive mode, which is required by many productions. Also, it is unusually heavy, and runs hot.