Colorimetric and Resolution requirements of cameras

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ADDENDUM 55 : Tests and Settings on a Ikegami HDK-79EXIII

Data for this section is taken from parts of the handbook and examination of a production model (serial number AA44623E) of the Ikegami HDK-79. It is a conventional system camera, with separate control unit (Triax or fibre connected) and viewfinder. Variants of the camera exist, operating at 50Hz or 59.94Hz, 1080i or 720p. The unit under test had 3 ⅔" CCD sensors of 1920x1080 pixel dimensions, and operated at 1080/50 interlaced. The choice of scanning system is a factory option. Output from the CCU is via HDSDI, and SDI for down-converted for SDTV, however it can be operated from 12 volts as a stand-alone camera.

The camera head weighs about 4.5kg and has a standard B4 lens mount with F/1.4 optical block, and consumes about 28 watts at 12 volts. The specification claims sensitivity of F/10 for 1080i/59.94, presumably about F/11 for the 50Hz variant, which is normal for this image size and resolution. It appears to be very similar to other full-resolution system cameras in the broadcast range.

It has two conventional filter wheel with neutrals and colour correction filters.

There are internal menus for setting the performance. Although the camera can operate without the CCU, the menus are available only via the CCU.

For the test procedures a Canon HJ17ex7.6B lens was used.

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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 nominal 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 where known, "BBC" settings are in the last column, where appropriate, and the reasons for the values are given in footnotes throughout the tables where necessary.

Where menus are hierarchical (i.e. one menu item opens another menu page), the items are inset.

"BBC" setting values are given for use in conventional video mode, since the camera does not have system options for progressive.

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.

For the tests, only as paper version of the manual was available, which was probably only a photo-copy. In order to write this document, only a photo-copy of that photo-copy was available, with very low contrast. Thus there could well be errors in my interpretation of the menu contents.

Menu items which affect the picture quality, and need attention, are highlighted in the menu tables.

The results of tests are given after the menu settings.

1 MENU TABLES

CCU-790A MENU

Routes to other menus

Bars title	
HDTV DC UC cont	
Ret video format	
Information	
Others	

BARS TITLE ENTRY

item	*range*	*comment*	*BBC*
Display	Off, On		
Title edit		Enter text shown over bars	
Position			

HDTV DC UC CONT

item	*range*	*comment*	*BBC*
HDTV Cont 1/2			
Output format	[1]		
2-3 format	Type A, Type B, Type C, Type D	Only for 59.94Hz versions. Various algorithms for temporal shifting and filtering to get from 23.98 to 59.94	
Var frame	1~60[2]	Not tested	
Sync cont	Off, HD-90H, SD+90H, SD+90H CL, FD, HF FD-90H, SD FD+90H, SD+120H, SD+120H CL, SD FD+120H, HD-90H CL	Output is in sync with HD or SD syncs, or shifted by lines, or delayed by a field or frame etc.	
HD out H phase	-1375~0~+1375		
HD out V phase	-563~0~+563		
SD out V phase	-750~0~+750		
HDTV Cont 2/2			
NR & still mode	Off, NR[3], After image[4], Still, Half still		
NR effect	0~128	Controls frame-averaging in noise reduction	
Frame accum ratio	0~128		
HV slim dtl type	H only, V only, H+V		
V slim dtl freq	A, B, C, D	A=lowest frequency. D=highest, not a big range though	
HDSDI phase	-128~0~+128		
Motion detect	Music, Drama, Still, Off, Sports	Controls some form of frame processing, not tested	
Down conv cont (1/3)		Only when DOWNCON A module is installed	
Out format	Normal, 2-3 pulldown, Var frame	2-3 pull down is only for 59.94 version	
2-3 pulldown	Type A, Type B, Type C, Type D	Only for 59.94Hz versions. Various algorithms for temporal shifting and filtering to get from 23.98 to 59.94	
Var frame	1~60	Not tested	
Aspect dscrm pls	Off, On	Aspect ratio flag on lines 16 and 279, 59.94Hz	
10 field id sig	Off, On		
Screen mode	4:3, 16:9, Letter		
Letter box mode	16:9, 14:9, 13:9		
H filter	Narrow, Normal, Wide		
V filter	Narrow, Normal, Wide, Spuier		
Motion detect	Music, Drama, Still, Off, Sports	Controls some form of frame processing, not tested	
Down conv cont (2/3)		Only when DOWNCON A module is installed	
SC phase fine	-100~0~+100		
H phase	-100~0~+100		
Comb type	Off, Enc only, Enc+D1	Comb filtering, Enc=coded output, D1=SDI	
Comb gain	0~100		

[1] Options for format depend on camera version. The tested version operated only at 1080i/50.
[2] Variable frame rate seems to be aimed at 59.94Hz versions, not tested here.
[3] Noise reduction, not tested here.
[4] Appears to be frame-averaging, to reduce noise and increase sensitivity, not tested here.

item	*range*	*comment*	*BBC*
HV slim dtl type	H only, V only, H+V		
V slim dtl freq	A, B, C, D	A=low, D=high, but not very high	
Analogue out	RGB, YCbCr		
Sync	Off, G only, RGB, Y only		
Phase adj dl	-128~0~+128		
Phase adj wfm pm	-128~0~+128		
Down conv cont (3/3)		Only when DOWNCON A module is installed	
Pm out	Ana, D1	Analogue or SDI output	
Wfm out	Ana, D1		
Up conv cont (1/2)		Available only when UPCON A module is installed	
Screen mode	4:3, 16:9, Letter		
Letter box mode	16:9, 14:9, 13:9		
Motion detect	Music, Drama, Still, Off, Sports	Controls some form of frame processing, not tested	
Edge cancel	On, Off	Disables detail enhancement when SD is input	
H level	0~128~150		
V level	0~128~150		
Out sel	Mono, Color		
Up conv cont (2/2)		Available only when UPCON A module is installed	
Dtl	Off, On		
H gain	-127~0~+128		
V gain	-127~0~+128		
H coring	0~255		
V coring	0~255		
H boost freq	8M, 10M, 12M, 14M, 16M, 18M		

RET VIDEO FORMAT

item	*range*	*comment*	*BBC*
Menu enable	Off, On	Permit selection of return video format	
Ret1 video format	HDTV, SDTV	Select HDSDI or SDSDI for return video	
Ret2 video format	HDTV, SDTV		
Ret3 video format	HDTV, SDTV		
Ret4 video format	HDTV, SDTV		

INFORMATION

item	*range*	*comment*	*BBC*
MPU module sw		Shows DIP switch settings, PULSE&MPU MULTI module	
ROM version		Shows control ROM version	

OTHERS

item	*range*	*comment*	*BBC*
Head menu	Off, On	Allows all menu items controlled form the head	
HDTV bars type	ARIB, 100%, 75%, SMPTE, User		
ARIB bars type	A75, A100, A+1	White levels	
SMPTE bars type 1	75%, 100%, +1, -1		
SMPTE bars type 2	0%, +Q		

All normal camera controls are performed only at the CCU.

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. The lens was a Canon HJ17ex7.6B.

2.1 Gamma and Headroom range

The camera has only one gamma curve, and three settings for it, 0.4, 0.45, 0.5. Using 'Kodak Gray' cards to explore the curves, 20% exposure in the 0.4 curve was found to cause exactly 50% signal level, and is thus likely to be close to the BBC 0.4 law. 20% exposure in the 0.45 curve caused 45% signal level, slightly higher than in the ITU-709 curve, but close enough to be useful. Colour performance with the 0.45 gamma curve was visually judged to be good.

Setting the Knee Point to +100 and Slope to -50 produced a curve with a knee point at 0.58v (83%), reaching 109% at 2 stops overexposure. Setting Knee Point to 0 causes the curve to change at 0.66v (94%).

2.2 Resolution

Resolution was tested using a test card of circular zone plate patterns, calculated for 1920x1080 standard. 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.

2.2.1 Resolution at 1080-line

The camera does not have a progressive mode at 1080-line.

With detail enhancement switched off, the results for 1080-line interlace are very encouraging. Horizontal resolution droops gracefully towards the edge of the pattern, as it should do, due to the effect of the optical horizontal low-pass filter, and there is no spatial aliasing. This confirms that a proper optical low-pass filter has been fitted in the optical assembly.

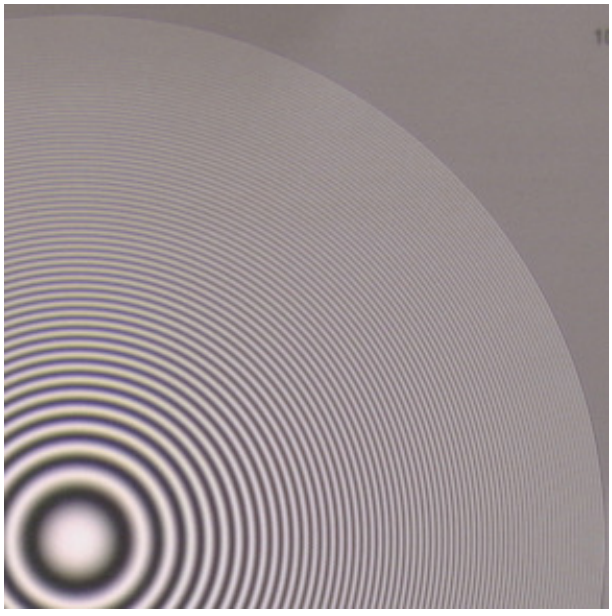
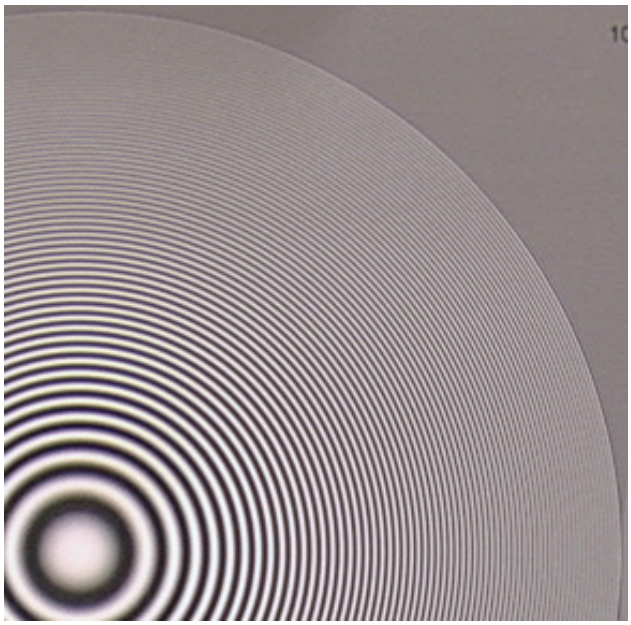


Figure 1 Resolution, 1080i, detail off

Vertical resolution also falls, but this time due to the line-pairing implicit in interlaced scanning. There are no horizontal null zones or alias patterns visible, and no visible vertical aliases. This performance is very good, and allows the user to apply detail enhancement without risk of causing visible aliasing effects.

Clearly, the factory settings for detail enhancement are rather aggressive, raising horizontal spatial aliasing, and visibly increasing the low-frequency contrast considerably.

Setting 'soft' detail reduces the aliasing centred at 1920, but raises a 'null zone' centred at about 1250 pixels, due to induced harmonic distortion. Setting 'slim' detail instead raises the resolution levels near 1920 acceptably, but still leaves the null zone. This is to be expected, since the peak frequency of the enhancement has been raised. The combination of 'slim' and 'soft' is quite good, improving the higher frequency content without unduly raising the low-frequency contrast. This combination should not cause problems in video compression.



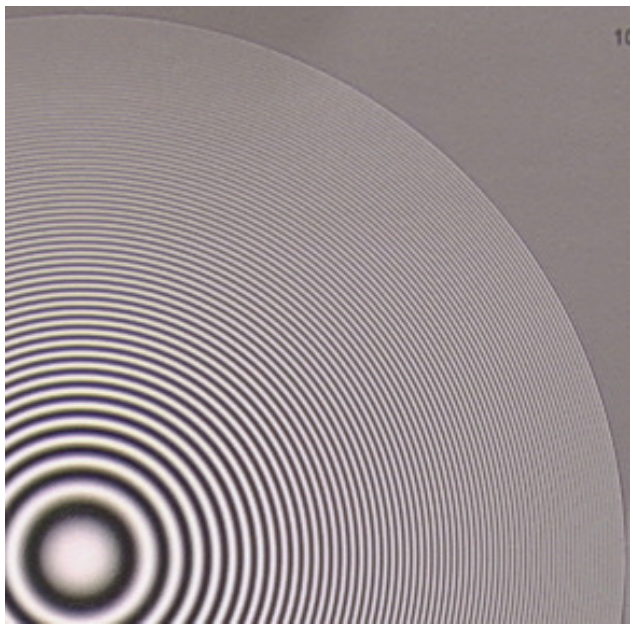


Figure 2 Resolution, (a) factory detail **(b) soft detail**

Figure 3 Resolution (a) slim detail **(b) slim + soft detail**

2.2.2 Resolution at SD (576i)

The camera does not have a SDTV mode as such, but there is a continuous feed of SD images from the CCU.

The horizontal resolution is nicely alias-free, which is a good sign, a reassurance that reasonably good filtering has been used in the down-scaling. However, there is significant vertical aliasing, a double folding of the higher frequencies, centred on 576 lines vertically. This is evidence that the SD output is down-converted from interlaced fields at 1080i, rather than from the full 1080 image. The vertical down-scaling filter probably takes input from more than one field (one-field interpolation would cause the aliasing to centre on 540 lines), but does not have enough filter coefficients to do the job properly.

Aliasing such as this is almost inevitable in any camera 1080-line camera when down-converting to SDTV, since the down-conversion filters used are rarely adequate. However, the level here is unusually high. The down-converter detail settings were not altered from the factory values for this example, and it was not possible to find any combination of detail control settings which improved the picture, so the search was abandoned.

Clearly, the SD output should be used only for monitoring, it is not good enough for use as a programme output.

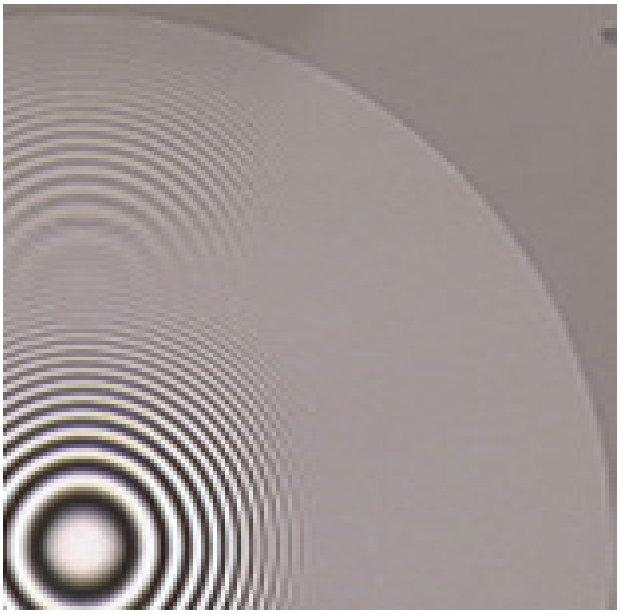


Figure 4 Resolution, SD downconversion

2.3 Noise

Noise was measured by exposing the camera to an evenly illuminated white card, and exposure adjusted to get 4 luma values between 10% and 100%. Noise reduction set to default values, and video gain was set to +6dB, with correction in the software analysis. Thus the results are representative of normal conditions in the camera.

The grabbed frames were processed with a high-pass filter to remove any residual shading effects. Vignetting was avoided by adjusting the lighting level such that the extremes of the aperture range were not used.

The plot of measured noise versus signal level for 1080i shows that noise in the middle range (where the slope of the gamma curve is unity) is at about -44.5dB, which is only adequate. This was confirmed by direct observation during the tests, both off-screen and on the waveform monitor. Blue channel noise is a little higher than for red or green; this is because silicon is less sensitive to blue than red, and is perfectly normal.

The general shapes of the curves are, however, not as expected. Since the primary source of noise is the analogue circuitry of the sensors and pre-amplifiers, and this noise is non-linearly amplified by the gamma-corrector, the noise level should be directly proportional to the slope of the gamma curve. This means that noise should rise smoothly towards black level, and noise at black should be up to 17dB higher level than at white.

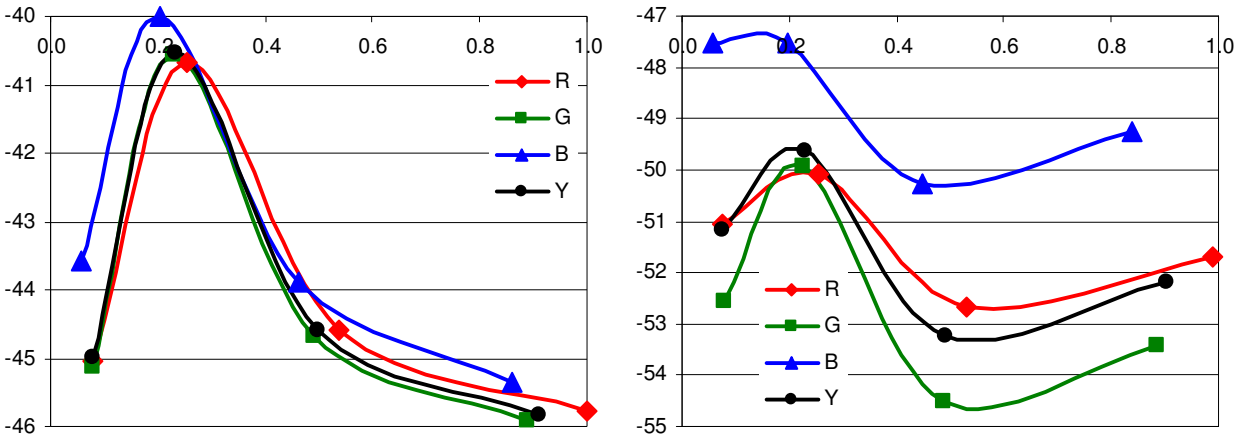


Figure 5 Noise (a) 1080i **(b) SD 576i**

The sharp fall in noise near black is highly unusual. It could be due to gamma-correction, or pre-gamma correction, being performed on analogue signals rather than digital, in amplifiers with limited gain-bandwidth products. This would cause a loss in resolution at low levels, as the gain increases near black, together with a reduction of noise levels. The sharp fall in noise levels could also be caused by active noise reduction, which was left in factory settings. The cause remains unknown.

Noise at SDTV is about 9dB lower than for 1080i, a remarkable improvement. This is probably due to the very good down-scaling filter used for horizontal scaling; a 'perfect' filter should reduce the noise level by

about 8.5dB [20*log(720/1920)], almost exactly the value found. Clearly, the nature of the noise has also been changed somewhat, although the sharp drop near black is still there.

2.5 Conclusion

The HDK-79 performs quite well, but has an odd noise characteristic. Noise levels are very similar to those in other HDTV system cameras. The SD performance is poor, but not abnormally so for cameras with full-resolution HD sensors.