Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 59 : Tests and Settings on a Thomson/GV LDK3000

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 short assessment was made on a sample of the LDK3000, a multi-standard HDTV camera, tested with a Canon HJ17ex7.6B HD lens.

Physically, it resembles many other system cameras, the familiar digibeta size and layout. It has 3 ⅔" CMOS sensors, good connectivity, and operates at 1080-, 720- and SDTV standards. Much of the content of this document is taken directly from the manual.

Power consumption is 40 watts and it weighs 5.3kg, both typical for a system camera. However, the power management and cooling system keep the camera cool to the touch, and acceptably quiet acoustically. The camera has both neutral and colour-temperature filter wheels. The camera is connected to its CCU via conventional Triax cable.

The LDK3000 operates at 1080i and 720p resolutions, at 50 and 59.94Hz. The menu structure and contents are both very similar to those of the LDK8000/4000, with only a few items missing (e.g. noise reduction), indicating that similar processing is used throughout.

Sensitivity is claimed to be F/9 for 2000 lux illumination at 90% reflectance, a little lower than is normal for system cameras. Noise level is claimed to be -56dB.

Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 59 : Tests and Settings on a Thomson/GV LDK3000

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. Noise level is claimed as 60dB, and the total exposure range is estimated as about 11 stops. However, the camera noise performance does not appear to be that good, measurements were rather disappointing, details are given in the measurements section at the end of this document.

Recommended settings are given for normal video use.

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 simplicity, the camera was tested without the CCU, the menus listed below are those obtainable at the camera head.

The menus are hierarchical, sub-menus are indicated by insetting items. For each item, the range of offered values is given, and the factory default value (where known) is underlined.

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

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.

1 MENUS AND ~~S~~SETTINGS

VIEWFINDER MENU

Item	*Range*	*description*	*BBC*
VF monitoring	Y, R, G, B, -G		
VF detail			
VF detail	Off, On, Boost		
Level	0~50~99		
Focus assist	On, Off	Makes sharp edges crawl	
Zebra			
Zebra	On, Off		
Zebra mode	Level, Band	Level lights up above level, Band for ±2.5%	
Zebra level (%)	0~90~117		
Zebra contrast	0~15~99		
Center cross	On, Off		
QoS bar	On, Off	Show quality of wireless mic channels	
Focus ind	On, Off	0=close, 99=infinity	
Iris ind	On, Off		
Zoom ind	On, Off	0=wide, 99=tele	
Box downright	Off, Fltr, QoS	What shows bottom right	
Safe area	On, Off	80% box	
Safe area type	16:9, 15:9, 14:9, 4:3		
Marker	On, Off		
Marker type	15:9, 14:9, 4:3		
Marker style	Dot, Shad, Both	Dot-dotted, Shad=shaded	
Marker shading	Shad, Black	Shad=transparent	
Ind white	0~70~99	Character brightness	
Ind black	0~30~99	Character background	
Display	On, Time	On=always on, Time=goes off	
Menu time	3~10~30	Time to going off	
Rotary speed	1~5~10	Rotary encoder sensitivity	
Notch ext	On, Off	Notch filter	
Ext aspect ratio	16:9, 4:3	Aspect ratio for external signal in VF	

LENS MENU

Item	*Range*	*description*	*BBC*
Lens type	Std, WA	Affects white shading compensation	
Auto iris	On, Off		
Peak/Average	0~64~99		
Auto iris set point	0~35~99		
Mom iris set point	0~50~99		
RE iris comp	On, Off	Range extender iris compensation	
Auto iris const			
Auto iris gain	5~10	Speed, 5=slow	
Ext iris	On, Off	Range extender auto iris	
Ext iris const			
Gain speed	1~5~20		
Exp time speed	1~4~20		
Min iris	F5.6, F8, F11, F16		F8[1]
Max iris	F1.4, F2, F2.8, F4, F5.6		[2]
Min gain (dB)	-6~0		
Max gain (dB)	0~+15		
Zoom/Focus	Loc, Rem	Local control when SuperXpander installed	
Lens i/f	Analog, Digital	Type of lens interface	
Lens i/f state	OK, Not OK	Display only, status of digital lens interface	

[1] Iris diffraction starts at about F/8 in ⅔" cameras.
[2] HD lenses are generally good wide open, it is safe to use them wide open.

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.

VIDEO MENU

Item	*Range*	*description*	*BBC*
Colour temp			
Colour filter	0~50~99	Value of auto white balance	
Col temp level	2500~3200~20000		
Detail			
Detail	On, Off		On[3]
Level	0~30~99	Enhancement level	26
Source select	R+G, R, G, Y		
MORE			
Vert detail	0~50~99		29
Coarse/fine	0~5~99	Set coarseness, 0=very fine	99
Level	0~30~99		30
Level dep	0~40~99	Low signal level for detail to start	40
Noise slicer	0~10~99		10
Soft detail			
Soft detail	On, Off	Avoid over-correction of contrasty edges	
Level	0~70~99		
Knee detail	1, 2, 3, 4, Off	Edges in the knee	
Skin			
Skin	Off, 1, 2, 1+2	Skin-tone softening	
Auto skin	On, Off		
View	On, Off		
Skin 1 level	0~50~99		
Skin 2 level	0~50~99		
MORE			
Width 1 red	0~50~99	Hue range	
Width 1 blue	0~50~99		
Color 1 red	0~50~99	Signal gain	
Color 1 blue	0~50~99		
Width 2 red	0~50~99		
Width 2 blue	0~50~99		
Color 2 red	0~50~99		
Color 2 blue	0~50~99		
Flare			
Flare	On, Off		
Red	0~10~99		
Green	0~15~99		
Blue	0~25~99		
Black			
Black stretch	0~50~99		
Master	0~50~99		
MORE			
Red	0~50~99		
Green	0~50~99		
Blue	0~50~99		
Master	0~50~99		
Gain			
Red	0~50~99		
Green	0~50~99		
Blue	0~50~99		
Range	3dB, 6dB		
Master gain (dB)	-6~+12	In steps of 0.5 dB	
Knee			
Knee	Off, Var, Auto		Var[4]
Knee type	Y, NAM	NAM=highest of RGB	NAM[5]

[3] Detail values are those derived for the LDK6000, they

[4] Knee function is good, and can cope with 2 stops, which the camera can easily handle.

[5] Using non-additive mix here makes sure that no individual RGB channel is arbitrarily clipped, preventing highly saturated colours from clipping.

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.

Item	*Range*	*description*	*BBC*
Slope M	0~50~99		90[6]
Point M	0~60~99		17
MORE			
Knee limit	0~99		99
Auto point	0~30		
Auto ref	0~30~99		
Gamma			
Curve	BBC0.4, BBC0.5, BBC0.6, ARD, 6xARD, RAI, CCIR, 709-J, 709_S	Standard gamma curves	CCIR[7]
Preset	1, 2, Lin, Var	1=normal, 2=low gamma	
Master	0~76~99		
Red	0~76~99		
Green	0~76~99		
Blue	0~76~99		
Matrix			
Matrix	EBU, Skin, B/W, RAI, BBC, 1:1, CoolFl, Var1, Var2, XGL	XGL=Asian/Sony matrix	BBC[8]
Saturation	0~50~99		
R>G	0~50~99		
G>R	0~50~99		
R>B	0~50~99		
B>R	0~50~99		
G>B	0~50~99		
B>G	0~50~99		
Mat/gam	G/M, M/G		M/G[9]
White limiter			
White limit	Off, On		
Master	0~80~99		
Shading			
White shading	Off, On		
H saw red	0~50~99		
H saw green	0~50~99		
H saw blue	0~50~99		
V saw red	0~50~99		
V saw green	0~50~99		
V saw blue	0~50~99		
H par red	0~99		
H par green	0~99		
H par blue	0~99		
V par red	0~99		
V par green	0~99		
V par blue	0~99		
Freeze	Off, On	Holds current image	
Noise reduction	Off, 1, 2, 3, 4	1=light reduction, 4=strong	

INSTALL MENU

Item	*Range*	*description*	*BBC*
Video mode	1080i/50, 1080i/59.94, 720p/50, 720p/59.94	Video mode, depends on version	
Disable camera	Off, On	Locks camera user panel	
Intercom			

[6] Detail values taken from LDK6000 recommendation. Knee point is 65%, slope extends 2 stops.
[7] Gamma is very confusing. The CCIR ceased to exist many years ago, and never defined any gamma curves. The CCIR cuirve is possibly the ITU.709 curve, see measurements section.
[8] Matrix is also very confusing. Neither the BBC nor the EBU has ever calculated a matrix for this camera, and presumably, neither has RAI. The exact matrices used here are therefore unknown, and very difficult to measure. The BBC matrix performs well.
[9] 'Gamma before matrix' is colorimetrically wrong, although it usually delivers slightly better noise performance. Thomson's advice to use matrix before gamma when attempting to match performance to other cameras, is right, that's how other cameras are made.

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.

Side tone level	0~50~99		
Item	***Range***	***description***	***BBC***
Cam mic	Off, Switch, Track, Prod	Switch gives control to cam back panel	
Cam mic gain	0, 40dB		
Cam mic power	Off, On	+12V power to camera mic socket	
Prod volume	Front, Rear	Which volume control to use	
Cam prod	Off, Left, Right, Both	Which can it goes to	
Cam eng	Off, Left, Right, Both		
Cam prog	Off, Left, Right, Both		
Audio			
Audio gain mode	Loc, Ext	Ext=CCU control	
Audio 1 level	-22, -28, -34, -40, -46, -52, -58, -64dB		
Audio 1 hpf	Off, On		
Audio 2 level	-22, -28, -34, -40, -46, -52, -58, -64dB		
Audio 2 hpf	Off, On		
Tally			
Tally lock	Off, On	Locks some controls when tally's on	
Exposure			
Lighting	-10~0~+10	Fine correction for ac lighting	
Clean scan			
Cl scan mode	Extended, Normal	Extended turns off mechanical shutter	
Value	50Hz 50.8~125.0Hz 60Hz 61.0~150.0Hz	Tweak to eliminate lighting strobing, also shows in msec	
Units	Hz, mSec	Change 'value' to time	
Gain preset			
Gain – (dB)	-6dB, -3dB	Gain switch, low setting	-3dB
Gain + (dB)	3dB, 6dB, 9dB		0dB
Gain ++ (dB)	6dB, 9dB, 12dB		6dB
Auto white			
AWB speed	0~4~99	Auto white balance	
AWB gain	0~10~99		
PCI id	0~1~8	set ID for external PC operation	
Main text insert	Auto, On, Off	Adds text to video at OCP/MCP	
HD-SDI (B) video	Main, VF	What comes out of B connector	
Buttons			
Filter pos4	ND1/64, Star 4P	Depends on what's in the wheel	
Sw 1	Call, Ext 1, Ext 2	Ext=select external video to VF	
Sw 1 control	Mom, Alt	Alt=toggling	
Sw 2	EIris, Foc ast, Ext 1, Ext 2	EIris=Extended auto iris	
Sw 2 control	Mom, Alt	Alt=toggling	
VTR start	Prod, Eng, Zoom, Ext 1, Ext 2		
VTR st control	Mom, Alt	Alt=toggling	
VTR lens	Prod, Eng, Zoom, Ext 1, Ext 2		
VTR l control	Mom, Alt	Alt=toggling	
Ret lens	Zoom, Ext, Foc ast		
Ret control	Mom, Alt	Alt=toggling	
Ret 2 switch	Zoom, Ext		
Ret 2 control	Mom, Alt	Alt=toggling	
2" VF option	None, Disab		

FILES MENU

Item	***Range***	***description***	***BBC***
Store scene file			
File select	Scam1~4	Scam a writes scene files to camera or card	
Store		Execute	
Recall scene file			
File select	Standard, Scam1~4	Scam reads scene files from camera or card	
Store		Execute	
Store oper file			

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.

File select	Ocam1~4	Ocam writes operator to camera and card	
Store		Execute	

SECURITY MENU

Item	***Range***	***description***	***BBC***
Installed level	User 0, User 1, User 2, User 3	Select user level	
PIN code	(0000)	Enter 4 digit code to enter S level	
Customer files			
Store cust scene		Exec to store current setting to scene file	
Cust scene attrib	R/W, R		
Store cust oper		Exec to store current settings to operator file	
Green button			
Standard	Fact, Cust	Type of file to recall when pressing the Green button	
Scene file	Yes, No	Recall scene file with Green button	
Operator file	Yes, No	Recall operator file with Green button	
Factory defaults		Exec, all reset to factory	

DIAGNOSTICS MENU

Item	***Range***	***description***	***BBC***
Communication			
BS connected	Yes, No	Show base station status	
C2IP panels	0~99		
Cam config	Invalid, 3000	Show camera type	
Camera ID		Show camera ID code	
Camera number	0~99	Camera number on the network	
Adaptor type	Triax	Show type of camera connection	
Adaptor number	LDK5630		
Front power	OK, NotOK		
Y carrier	OK, NotOK		
Cam, 12NC		Last 4 digits of camera 12NC	
Cam version		Show camera version	
Cam status	0~99	Show camera status	
Cam temp			
Head temp C	-55~+128	Show head temperature in ºC	
Head temp F	-67~+262	and in ºF	
Adaptor temp C	-55~+128	Lens adaptor	
Adaptor temp F	-67~+262		
Adaptor fan (V)		Fan voltage	
PCB status			
Board	DVP, SyncM, PPG, PPGsb, SeDa, LSP, RCB, PrePr, FSP, DaCam, FrDri, DacOu, FwDri, Front	Select a board to get info on	
Board PID		Show product id	
Board 12NC		Show last 4 digits of 12NC code	
Board status	0~99	Show hardware status	
Boot sw ver	0~99	Show software version	
FPGA ver	0~99	Show FPGA version	
Firmw 12NC		Show last 4 digits of 12NC code	
Firmw status	0~99	Show firmware status	
Firmw version	0~99	Show firmware version	
Softw 12NC		Show last 4 digits of 12NC code	
Softw status	0~99	Software status	
Softw version	0~99	Software version	
System status			
System	Unknown, HD-LC, Illegal	More displays	
Camera	Unknown, HD-LC, Illegal		
Head HW	Unknown, HD-LC, Illegal		
Adaptor	Unknown, HD-LC, Illegal		
Base station	Unknown, HD-LC, Illegal		

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.

SERVICE MENU

Item	***Range***	***description***	***BBC***
Test signal			
Test signal	Off, On		
Test input	DacO, DVP	Select injection point	
Test select	SawT, Step	Inject at DVP	
Test select	SawT, Bars	Inject at DAC O	
Calibrations			
3200K			
3200K	Off, On	Run calibration procedure	
3200K preset	Fact, Cust	Select test mode for calibration	
Black calib			
Black calib	Off, Running	Start auto black calibration	
Status	Unknown, OK, Error, Needed Warming up, Busy, Ready, Failed, Aborted		
Cal temp (C)	55 <actual>	Set the calibration temprature	
Act temp (C)	-128~0~+128	Show actual temperature during calibration	

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.

2 Measurement results

All visual tests and measurements were made using a Sony 32" crt HD monitor and digital waveform monitor. Analytical measurements were made by capturing HDSDI, and subsequent software analysis.

2.1 Colour performance, gamma, matrix and headroom

2.1.1 Gamma and headroom

The selection of gamma-correction curves, while extensive, has no adequate descriptions. Also, one item in the offered list refers to a long defunct organisation (CCIR) which was never known to have defined any gamma correction curve. Therefore, several of the gamma curves were measured accurately using software analysis.

The 'BBC 0.4' law has a slope at black (gain) of 5.0, and 20% exposure produces a signal value of 50.1%, whereas the mathematical curve should produce 50.5%. This is a very accurate BBC curve.

The 'CCIR' curve has a slope at black of 4.5, and 20% exposure produces 43.4% signal, both values are exactly those of the ITU.R BT-709 curve universally adopted for HDTV.

'ITU-S' has black slope of 3.25, and 20% exposure produces 46.1%, and so should produce reasonably accurate colour reproduction (because the 20% value is quite high) with poor shadow performance but improved noise levels, because the slope near black is low.

'ITU-J' has black slope of 3.7, and 20% exposure produces 42.9% signal, so colour rendering will be more saturated and noise levels a little higher.

The other curves were not investigated, but, given the accuracy of the BBC and ITU curves, the RAI and ARD curves are expected to be accurate as well.

2.1.2 Colour matrix

The menus offer the choice of processing order, performing gamma-correction before or after the matrix. 'Matrix-before-gamma' results in more accurate colorimetry and more consistent results, but 'gamma-before-matrix' can deliver slightly lower noise levels.

However, the list of matrices is as confusing as is the list of gamma-correction curves. The 'correct' matrix for any camera must be calculated for that camera and the television system for which it is to operate within, since its primary function is to approximate the channel responsivity curves (RGB) to approximate to the colour-matching functions of the display primaries for the selected display system (HDTV, ITU.709 for this camera). Therefore, there should be little or no need for any choice of matrix. Unless each of the organisations listed in the choice of matrices has actually calculated a matrix for this specific camera, the matrices can only be approximations, calculated for other, unknown cameras. Thus, all the matrices are suspect.

It is extremely difficult to measure the matrix in a camera by any direct means, the only possibility is to check the colour performance using test colours, so visual assessments were made using Colorchecker charts. Colour performance was generally good.

The 'EBU' matrix produced higher saturation and slightly blue skin tones. The 'Skin' matrix desaturated the oranges but was no more accurate for skin tones. The 'BBC' matrix produced lower saturation, although the yellow patch was slightly shifted towards green. On the basis of these tests, it is difficult to recommend one matrix over any other, although the BBC matrix was subjectively a little more pleasing.

2.2 Resolution

A HDTV zone plate chart was used. This contains six circular patterns that fully explore the spatial frequency performance of the camera, up to 1920x1080 pixels per width and height. There are patterns for grey-scale, RGB and 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. For

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.

each measurement, only one quadrant of the luma channel is used, although the other patterns were examined during the tests, and showed nothing untoward.

2.2.1 Resolution 1080 interlaced

Measurements were taken with detail enhancement turned off.

There are no visible alias patterns, even at the exact edges of the pattern. The clean way in which resolution falls to the edges of the pattern confirms that the sensors are full resolution, and that there is an optical low-pass filter designed for 1920x1080 use. The clean resolution also indicates that there is probably no "precision offset" of the green from red and blue sensors, a common technique to enhance resolution in cameras. This is very encouraging

The horizontal resolution droops gracefully to 1920, while the vertical resolution is rather soft as a result of the inevitable line-pairing involved in interlaced scanning. Vertical resolution is clean, and in this grabbed frame, extends to about 830 lines, all resolution above 540 lines contributes to interlace twitter on an interlaced display (e.g. CRT), and is recoverable as resolution in frames only in the absence of motion.

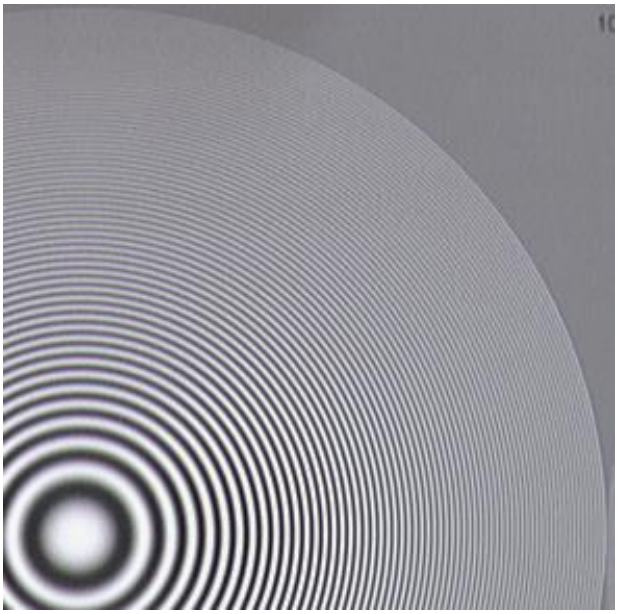

Figure 1 Resolution, 1080i, detail off

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

2.2.2 Resolution 720p

Figure 2 shows the camera performance at 1280x720, with detail switched off.

There are no disturbing horizontal aliases, the down-sampling from 1920 to 1280 is very clean. There is a faint alias visible, resulting from frequency-folding at 1280, hinting that the down-sampling filter does not have zero response at 1280, but the results are actually very good.

Vertically, there are clearly visible coloured aliases resulting from the 1080-line structure of the sensors. This is typical of 1080-line cameras, few if any of which actually perform well at 720p. However, the level of aliases is acceptably low, and there are no other indications of aliasing.

Performance at 720-line is adequate, but not good.

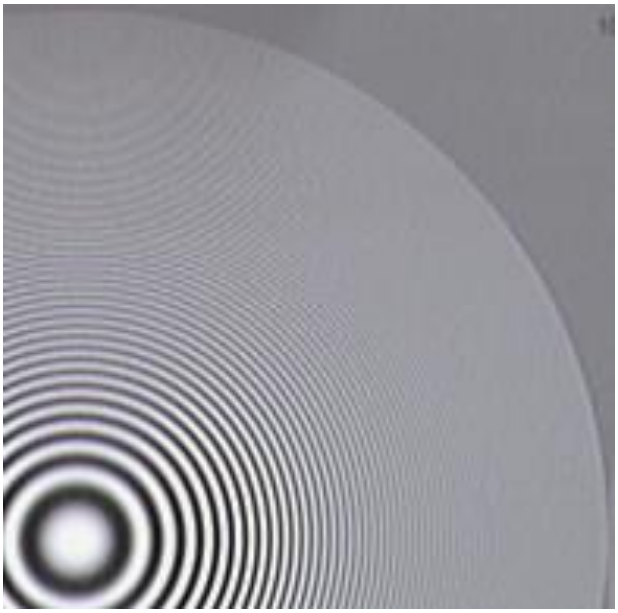

Figure 2 Resolution, 720p, detail off

2.2.3 Detail enhancement

Figure 3 (a) shows 1080-line performance with detail switched on, and factory settings. Performance is not very good.

Since the LDK3000 has menus which are strikingly similar to those of the LDK8000, the same detail enhancement settings found for that camera can be used, and the performance slightly better, as can be seen in Figure 3 (b).

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.

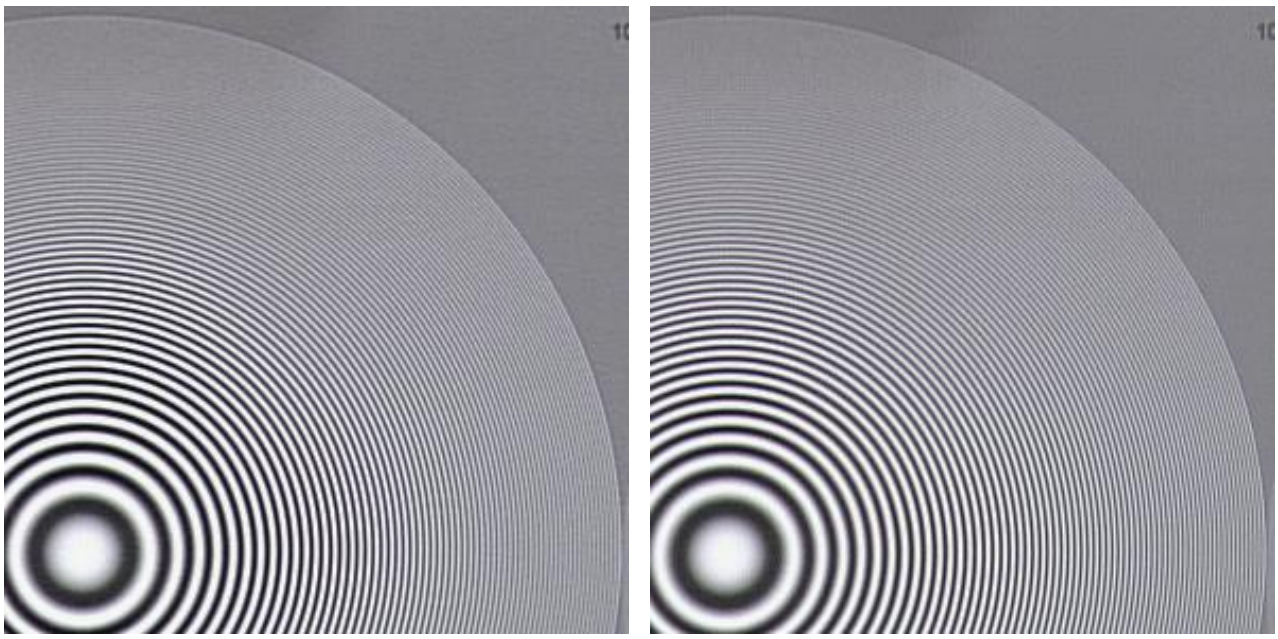

Figure 3 Resolution, detail on (a) factory (b) as LDK8000

2.3 Noise performance

The camera specification claims that noise level is -56dB, presumably with gamma-correction switched off, and distribution weighted.

Measurements were made by exposing the camera to a plain white card, evenly lit, highly defocused to eliminate any marks. Gamma-correction was switched on (CCIR) because this is the mode for normal use, gain was set to +6dB and exposure set to generate video signals at 4 levels over the signal range. Data files were saved either 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. Compensation for the 6dB gain was included in the processing. Detail settings were as recommended in the menus.

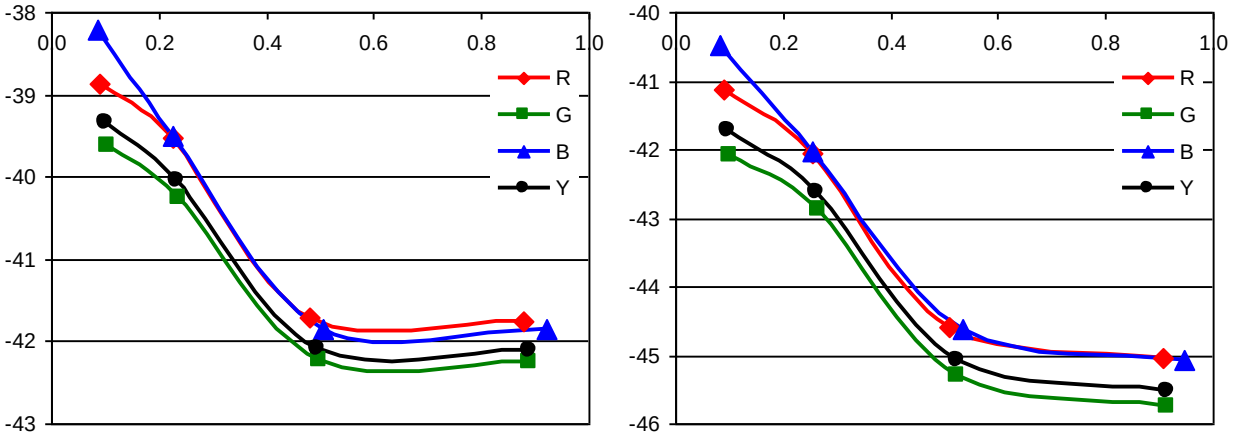

Figure 4 Noise levels, (a) 1080i (b) 720p

The shape of the curves is generally as expected. Normally, noise level should be directly proportional to the slope of the gamma-correction curve, least at white, most at black, with about 17dB between them. Reassuringly, these curves look normal.

The noise level at about mid-grey is representative of the camera performance with gamma-correction switched off. For 1080i, this is about -42dB, while for 720p it is about -45dB. The lower noise at 720p is due to the lower bandwidth of 720p video, and to the effects of the down-scaling filter in the down-conversion process. Noise levels are a little high for a camera with ⅔" sensors, but not especially so.

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.

2.4 Conclusion

Several menu items are confusingly misnamed, and wrongly used. However, the performance is not compromised by this.

Resolution at HDTV 1080 is good. There are significant aliases in the pictures at 720p which probably render the camera not suitable for 720p use in broadcast environments.

Noise performance is only adequate, it not as good as the specification claims.

Colour performance was good, but could probably be improved by installing a colour matrix calculated for the camera, and eliminating all the preset matrices.

Since the camera has CMOS sensors, it should exhibit the normal effects of rolling shutters, distortion on moving edges and patterns. This was not investigated directly because the effects are well known.

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.