

Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 42 : tests and Settings on an Iconix HD-RH1 mini-camera

Data for this section is taken from the handbook and a very brief examination of an Iconix HD-RH1 mini-camera as part of a group test of HDTV mini-cameras. It has been in production for some years, and is widely used as a mini-camera in HD productions, but has never before been fully tested as an HDTV camera. This test remedies that situation.

The camera is small (33.5x38x48.8mm) and weighs only 64 grammes, but the controller is relatively large and weighs about 1kg. The specification claims that it has 3 CCD sensors ($\frac{1}{3}$ "") but gives no indication of the pixel count. It has a C lens mount, standard amongst mini-cameras. Sensitivity is claimed to be F/8 at 2000lux, which is typical of camera with $\frac{1}{3}$ " sensors. It has both analogue and digital outputs (HDSDI), and will supply dual-link output for 4:4:4 or 1080 progressive at 50 and 60Hz. It also has DVI output for computer delivery of video. There are fairly comprehensive menus, allowing a considerable degree of image control.

It has a significant range of operating formats, including native progressive as well as low-rate progressive delivered as full-rate:

- 1080i/50, 59.94, 60
- 1080psf/23.976, 24, 25, 29.97, 30
- 1080p/23.976, 24, 25, 29.97, 30, 50, 59.94, 60
- 720p/23.976, 24, 25, 29.97, 30, 50, 59.94, 60
- 720p/23.976n59.94, 24n60, 25n50, 29.97n59.94, 30n60

Power consumption is 30 watts at 12V DC.

There are no controls on the camera itself. Unfortunately, the camera shows significant response to infra-red illumination.

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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 range, and zero means no alteration to factory setting, not zero effect, and no scales are given in the manuals. For each item, the factory setting is underlined where known. “BBC” recommended settings are in the last column, where appropriate. In some instances, it is possible to alter the menus such that they produce more meaningful numbers.

Settings have been derived and are shown in the “BBC” column. Although the camera has all the options for interlaced and progressive shooting, no attempt has been made to derive a ‘film-look’ for it, since the menus do not allow sufficient control over the gamma curve to make it worthwhile.

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.

Measurement results are given in section 2, after the menus.

This listing of the menus and contents is complete, but this should not be used as an excuse for not reading the manuals.

1 Menu items

MAIN MENU

Select a submenu

Gain	
Shutter	
Detail	
Feature	
White balance	
Matrix	
Gamma	
Level/knee	
Video output	
Sync	
Lens	

GAIN

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Mode	<u>Off</u> , Fixed, Var	Off=0dB fixed, Var enables the panel knob	
Fixed gain	0~+15dB		

SHUTTER

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Mode	<u>Off</u> , Fixed, ELC, C-scan, Auto	Off=open shutter, Fixed=Exposure	
Exposure	Open, ...	Various intervals depending on frame rate, Total range is 1/32 to 1/10000	
C-scan	0~100%	'Clear-scan', actual interval depends on frame rate	
Auto level	0~50~100%	Sets the average picture level for Auto to achieve	
Auto area	<u>A</u> , B, C, D, E, F, User	Various patterns for detection, A=full frame	
User area edit		Set a user-defined area for auto detection	

DETAIL

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Focus assist	<u>Off</u> , On	Shows only hf detail against mid grey, nice idea	
Detail mode	Off, <u>On</u>		
Detail level	0~10		+3 ¹

FEATURE

General controls

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Digital NR	<u>Off</u> , On	'Reduces visibility of some noise', interacts with detail level control	
4:3 aspect	Ana, Ltrbox, 4:3	4:3=centre-crop	
Horiz flip	<u>Off</u> , On	Useful for mirror reversal	
Neg. image	<u>Off</u> , On	Inverts everything	
RCP addr		Display only for control address	
Load default		Revert to factory settings	

¹ This is an absolute maximum detail setting to avoid corruption by aliasing. Level zero (off) is better, but some sharpening may add enough detail may improve picture appearance at the expense of aliasing.

WHITE BALANCE

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Mode	<u>AWB</u> , Manual	AWB=balance by pressing button on control panel, Manual enables the knobs	
AWB R paint	-100~0~+100	Red offset from white	
AWB G paint	-100~0~+100	Green offset from white	
AWB area	<u>A</u> , B, C, D, E, F, User	Same pattern selection as for Auto Shutter	
User area edit			
SHD mode	Auto, Man, Off	White shading correction	
SHD auto	Exec		
SHD manual R	-100~0~+100		
SHD manual G	-100~0~+100		
SHD manual B	-100~0~+100		

MATRIX

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Color temp	3200, D4300, <u>D5600</u> , D6500, Flat	Set for various illuminants, equivalent to optical filters (i.e, RGB gain changing)	
Matrix	<u>ITU709</u> , NTSC, EBU, Off		ITU709
User matrix	<u>Off</u> , On	Roll your own extra matrix	Off
R	0 / 0	R-G, R-B	
G	0 / 0	G-R, G-B	
B	0 / 0	B-R, B-G	

GAMMA

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
On/Off	Off, <u>On</u>		On
Table	<u>ITU709</u> , B-law, Cine, User	B-law=BBC 0.4 curve	ITU709 ²
User power	0.35~0.45~0.90		
Blk gamma	<u>Off</u> , On	Extra slope control near black	
BG range	<u>15</u> , 25, 35, 50%	Up to this output level	
BG level	-10~0~+10	-10 crushes black, +10 stretches	
Test ramp	<u>Off</u> , On	Sawtooth test signal	

LEVEL/KNEE

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Master ped	-7~0~+10	IRE offset, i.e. percentage lift	
Red ped	-10~0~+10		
Green ped	-10~0~+10		
Blue ped	-10~0~+10		
Knee mode	<u>Off</u> , On	Not tested	
Knee point	0~100		
Knee slope	0~10		
White clip	<u>Off</u> , On		Off
Wht clip lvl	90~109		
NTSC setup	<u>On</u> , Off	Add 7.5% lift for NTSC analogue output	

VIDEO OUTPUT

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Video format	480i, 576i, 720p, 1080i, 1080p, 1080psf	Change happens when SELECT button pressed	
Rate		Select frame rate, only those suitable for the current format are offered, takes effect on SELECT	
F/P rate mode	<u>1.001</u> , 1	Enables NTSC-related options on front panel control (i.e. 60 light means 59.94 in 1.001)	
F/P 720p carr	<u>On</u> , Off	Enables double rates for 720p (i.e. repeats frames as in 720p24n60, 2:3 pulldown for 24Hz via 60Hz)	
SDI output	SL-422, DL-RGB, DL- YCC, DL-422	Single/dual HDSDI link mode, gets 1080p50 to 60 output, SMPTE 372	
Analog mode	<u>YPbPr</u> , RGB		

² Use Cine gamma for content insertion into a programme with a 'film-look'

SYNC

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Genlock	<u>Off</u> , On	Attempts to sync to whatever's available	
Genlock adj	-4125~ <u>0</u> ~+4125	Adjustment of V-sync in pixels	
Analog sync	Off, All, <u>G/Y</u>	Source signal for analogue syncs	
DVI sync	Pos, <u>Neg</u>	Pos=HDTV, Neg=VESA computer-speak	
Payload ID	<u>On</u> , Off	On HDSDI output, SMPTE325M	

LENS

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Vout 1	0~5V	Set voltage for channel 1 output to lens	
Vout 2	0~5V	And for channel 2	
Motor volt	6~ <u>12V</u>	Voltage for motor-drive channels	
PWM 1	0~100		
PWM 2	0~100		
PWM 3	0~100		
F/P channel	<u>None</u> , Focus, Zoom, Iris	Allows lens motor control directly from the control panel buttons, select which motor here	
F/P drive	<u>Fward</u> / Bkward	Reverses sense of arrow buttons on control panel	

2 Measurement results

Measurements were made with a Fujinon lens, TF4DA-8, 4mm wide angle. All measurements were made using the HDSDI output. Pictures were displayed on a Sony 32" grade 1 CRT monitor, a waveform monitor, and recorded using proprietary software for analysis.

2.1 Sensitivity

Sensitivity was not measured directly. The specification claims F/8 at 2000lux, equivalent to about 200ASA with 0dB gain.

2.2 Colour performance

Using a Colorchecker chart, the colour performance was judged to be quite acceptable with the standard ITU.709 gamma curve. The yellow had a slight greenish tinge which is common in many cameras but not unusually so. Skin tones were good, and no specific colour stood out as being inaccurate. The overall effect is quite good.

Performance would be a little better with either the B-law curve (BBC 0.4) or with a little black stretch to expand the contrast near black, but performance was quite acceptable with the HD-default ITU709 curve.

In the very limited time available for testing, the Cine curve was not explored, but should give a rather less saturated image, capturing rather more contrast for a film look. The actual exposure range was not investigated, for the same reason. Unfortunately, the camera shows significant response to infra-red illumination.

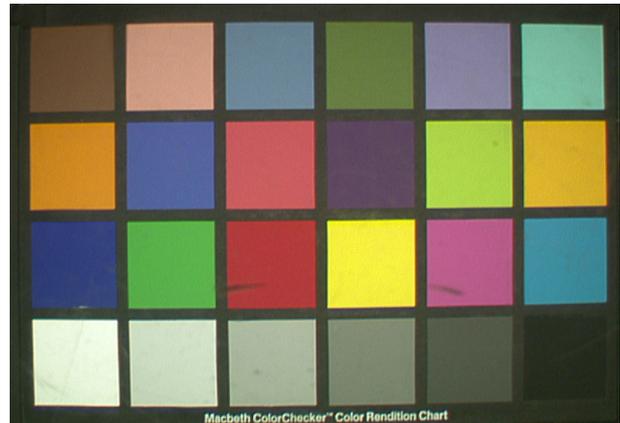


Figure 1, Macbeth chart

2.3 Resolution and aliasing

All testing was done with a circular zone plate test chart having 6 sinusoidally modulated patterns. The six patterns explore luminance and chroma channels on the top row, RGB channels on the bottom row, the samples shown here are each only one quadrant of the luminance (grey scale) pattern. Images were captured uncompressed from the CCU via HDSDI.

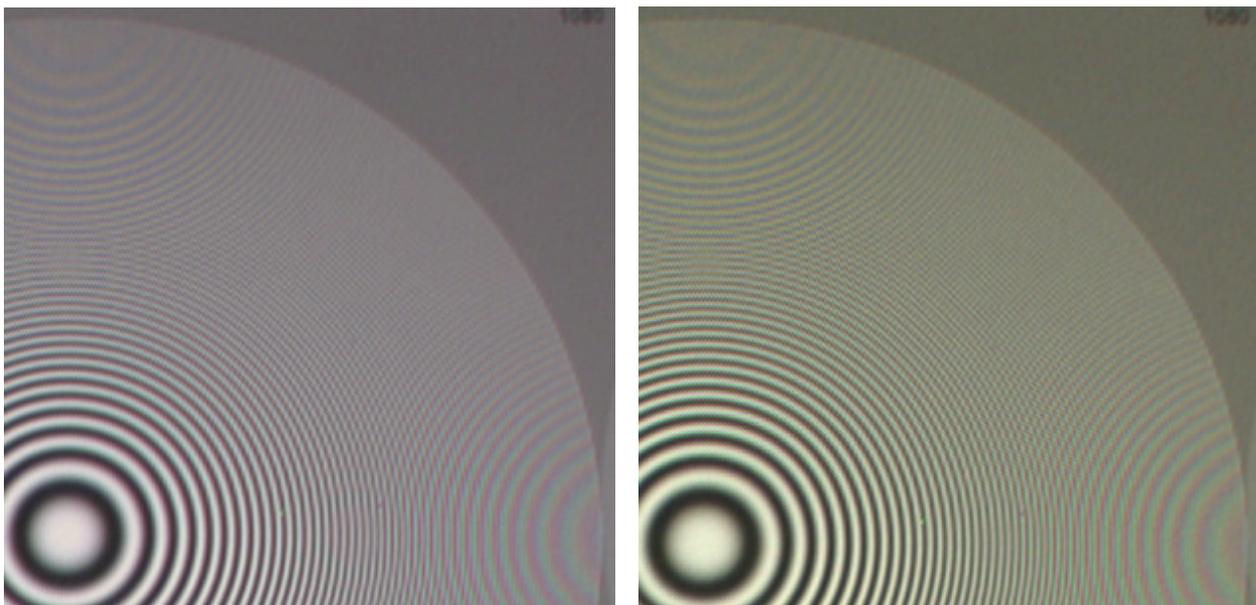


Fig. 2 (a) Zone plate 1080i/25, F/2.2, detail off (b) progressive

In 1080 interlaced mode, 1920x1080i/25 in EBU parlance, both horizontal and vertical aliasing is clearly present. Evidently, there is no optical filter to prevent high-frequencies from reaching the sensors, as would

be expected of a full broadcast camera. But, there is no diagonal aliasing, and this implies that the 3 individual sensors are only 1280x720 resolution, not the full 1920x1080 expected for full HDTV performance, this is a 720p camera. The lack of diagonal aliasing also shows that the sensors are co-sited, there is no precision offset.

Performance at other frame rates should be the same.

With the camera in progressive mode, vertical resolution would normally be rather better, since there is no vertical filtering needed to generate the interlaced signal, but in this case it is only the level of aliases that is increased. Performance at 720p was not tested, but should not differ significantly from that at 1080.

Detail enhancement is a little extreme, but at level +3 the aliases have not been enhanced too much, and the same setting level is valid for 1080i, 1080psf and 720p. But the camera actually performs better with lower levels of detail, zero is acceptable.

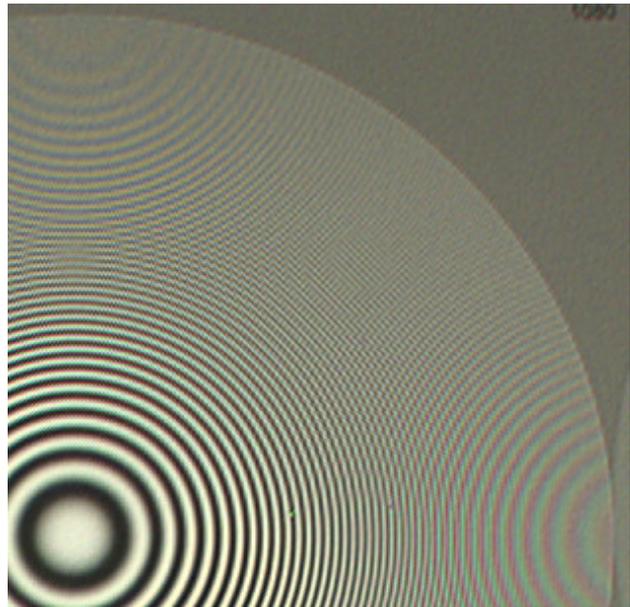


Figure 3 Zone plate, detail level=3

2.4 Video Noise

The specification claims the luma channel noise level to be -52dB, presumably with factory settings (0dB gain).

Measurements were taken on an evenly lit white card, exposed at various levels. Image files were captured via HDSDI as data files, then transcoded and decoded in software before performing a software noise analysis. The plot shows the noise level in dB versus video signal level.

In order to make the measurements more certain, the camera gain was set to +15dB, and the results modified by 15dB to compensate. Also, the measurement files were high-pass filtered to remove any image shading and tilt, and a further 6dB gain applied to avoid any effects due to premature data quantising. So, a further 6dB compensation has been applied to the results, so the graph is representative of the camera performance at normal 0dB gain setting.

As expected, red is less noisy than green (silicon sensors are far more sensitive to red, and so less gain is needed in red), and blue considerably more noisy.

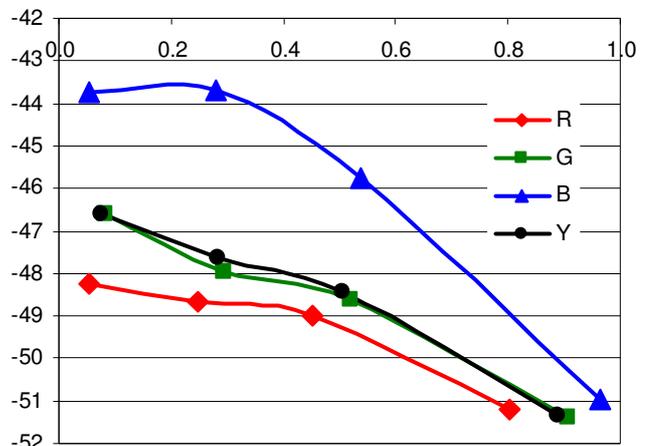


Fig. 4 Camera noise

The distribution of noise level versus signal level should, ideally, follow the slope of the gamma curve (ITU-709 in this case). Noise near black should be significantly higher than measured here by up to 8dB or so, which implies that gamma correction is probably done in analogue, before the matrix, and that some form of noise reduction is going on near black, possibly through limited gain-bandwidth amplifiers (reducing the bandwidth as the gain increases). This would also explain some of the comments about colour performance. This is a valid process provided it doesn't go too far, and in a camera of this type, presents no problem.

The values at a about mid-grey are representative of the performance in linear mode (since the slope of the ITU-709 curve is unity at this value). Clearly, the noise values mid-grey are about -48dB for the luma signal, while blue noise is about -46dB. These figures agree with subjective assessment of the images. It is not unusual for measurements of HD cameras not to agree significantly with the specification claims, and this magnitude of difference is quite unusual. The noise level is unexpectedly low, presumably because the

sensors are only 1280x720, and the pixels are therefore relatively large for the size of the image format (3.75 μ m spacing, 1920x1080 pixels in a $\frac{2}{3}$ " camera are 5 μ m spaced, and so sensitivity or noise performance should be about 5dB worse, which it is).

The camera has a dynamic noise reduction system, which was not tested. It should be capable of providing an improvement of typically 2dB, at the possible expense of a little high-frequency resolution.