Colorimetric and Resolution requirements of cameras

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ADDENDUM 44 rev 1: Tests and Settings on a Toshiba IK-HR1 mini-camera

Data for this section is taken from the handbook and a very brief examination of Toshiba IK-HR1S and IK-HR1D mini-cameras as part of a group test of HDTV mini-cameras. The cameras are self-contained, there is no separate control unit, all controls are on the camera.

The cameras are small (44x44x78mm) and weigh only 146 grammes. The specification states that they have a single CMOS sensor of 2.1Megapixels, which must be Bayer-patterned and is probably 1920x1080 pixel count. The lens mount is the mini-cam standard C mount. Sensitivity is claimed to be F/4 at 2000lux, which is typical of single-sensor 1920x1080 cameras with ⅓" sensor. The HR1S has only HSDSDI output, the HR1D has only DVI output which also carries analogue outputs as VGA. There are menus, allowing some rudimentary image control, which have great similarity to those in the IK-HD1 mini-camera.

Power consumption is 3.5 watts at 12V DC for the HR1S, 4.2 watts for the HR1D.

Tests were made only on the HR1S, since the DVI output of the HR1D is difficult to use in a broadcast environment. However, the HR1D does provide output at 1080p/59.94, and so could be useful under special circumstances. The differences between the cameras are small, and the measurement results should apply equally to both cameras. Differences between them are noted in the menus.

Unfortunately, the cameras show significant response to infra-red illumination.

This revision corrects minor errors which do not affect the measurements or conclusions.

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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.

Auto Black balance can be carried out directly from a button on the camera, and the output format (1080/720, 50/59.94) is set by slide switches on the HR1S. The output format is set differently on the HR1D, which runs only at 59.94Hz: hold down the DATA UP button while powering up to select 1080p, hold down the DATA DOWN button while powering up to select 1080i. This can also be done from menu 6 OPTION. Note that the HR1D really can output 1080p/59.94, and not psf.

There are 5 scene files, selectable directly from the buttons. All other camera control is via the menus, the contents of which form the scene file.

1 Menu items

1 SHUTTER

item	*range*	*comment*	*BBC*
Mode	Auto, Manual, SS	Auto links shutter to iris and gain.	
Manual	HR1S: Off, 1/100, 1/125, 1/250, 1/500, 1/1000, 1/2000, 1/4000	Manual:	
	HR1D: Off, 1/100, 1/125, 1/250, 1/500, 1/1000, 1/2000, 1/4000, 1/8000, 1/16000, 1/32000		
SS	HR1S 1080: Off, 15/1125~1123/1125	Synchro-scan: set shutter in line increments	
	HR1S 720: Off, 10/750~748/750		
	HR1D: Off, 2/1125~1123/1125		
Level	-100~0~+100	Auto: set average video aim level	
Peak/ave	00:10~05:05~10:00	Auto:	
Speed	1~10~20	Auto: response speed	
Area	Preset A, Preset B, Preset C, Preset D, Preset E	Auto: A=full frame, B=diamond, C=small rectangle, D=mid column, E=bottom row	

2 GAIN

item	*range*	*comment*	*BBC*
Mode	Manual, Off	Off=fixed gain, 0dB	
Manual	HR1S: 0~18dB	Manual: fix in 1dB steps	
	HR1D: 0~12dB		

3 WHT BAL White balance

item	*range*	*comment*	*BBC*
Mode	AWB, ATW, Manual		
R paint	-10~0~+10	AWB: Red offset	
B paint	-10~0~+10	AWB: Blue offset	
C. temp	3200, 5600K	AWB: Only two settings, equivalent to optical filter	
Area	Preset A, Preset B, Preset C, Preset D, Preset E	AWB: Active area, as for shutter	
R paint	-10~0~+10	ATW: Red offset	
B paint	-10~0~+10	ATW: Blue offset	
R gain	-100~0~+100	Manual: Red gain	
B gain	-100~0~+100	Manual: Blue gain	
C. temp	3200, 5600K	Manual: colour temperature	

4 PROCESS General controls

item	*range*	*comment*	*BBC*
Gamma on/off	On, Off		On
Gamma	-10~0~+10	No clue in the manual as to what the numbers mean	0
DTL gain	-7~0~+7	Ditto	-3
DTL B.freq	High, Normal, Low	Boost frequency	High
M. ped	-128~0~+127		

5 MATRIX

item	*range*	*comment*	*BBC*
Matrix	On, Off		On[1]
R Hue/Gain	-15~0~+15 / -15~0~+15	Simplified version of colour correction or multi-matrix. Separate control for hue and gain in each 60 degree sector	8, 0
G Hue/Gain	-15~0~+15 / -15~0~+15		0, 0
B Hue/Gain	-15~0~+15 / -15~0~+15		9, 0
Ye Hue/Gain	-15~0~+15 / -15~0~+15		15, 0
Cy Hue/Gain	-15~0~+15 / -15~0~+15		0, 0
Mg Hue/Gain	-15~0~+15 / -15~0~+15		15, 0

[1] This is the only way to adjust colouring.

6 OPTION

item	*range*	*comment*	*BBC*
Monitor	PC, TV	HR1D only	
I/P mode	1080p, 1080i	HR1D only	
Baud rate	9600, 19200bps	Control data rate	

To do a factory reset, select a scene file using the FILE button, press DISP is necessary to disable colour bars, press MENU UP and MENU DOWN together for at least a second.

2 Measurement results

Measurements were made with a Fujinon lens, TF4DA-8, 4mm wide angle. All measurements were made using the HDSDI output from the HR1S; the HR1D was not specifically tested, but the results and observations should apply equally to both cameras. 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/4 at 2000lux (59.94Hz), equivalent to about 100ASA with 0dB gain.

2.2 Colour performance

Using a Colorchecker chart, the colour performance was judged to be unacceptable. The skin tone has a distinct pink hue, while red, pink and magenta are all desaturated. The yellow is distinctly green and the oranges desaturated.

After some experiments with the matrix settings, some improvements were forthcoming, but not enough to produce satisfactory pictures. It would be quite difficult to correct the colouring even in a full grading operation.

Figure 1 Macbeth chart (a) native performance (b) with matrix settings

The camera shows significant response to infra-red illumination which can seriously pollute some colours under some illuminants.

2.3 Resolution and aliasing

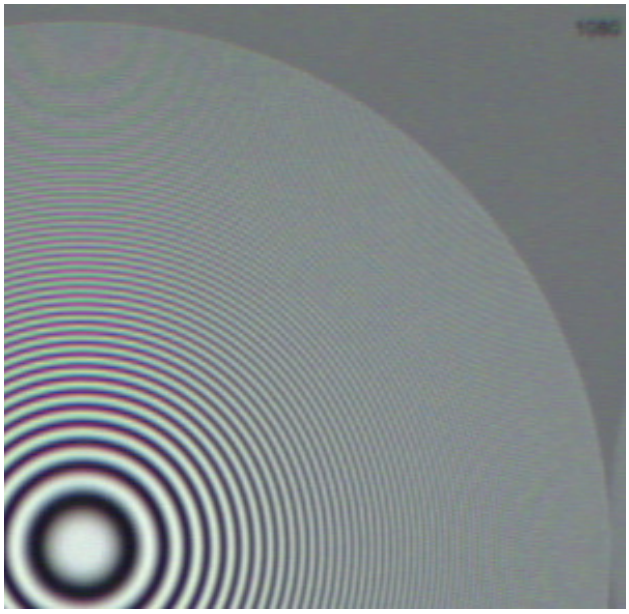
All testing was done with a circular zone plate test chart having 6 sinusoidally modulated patterns. The six patterns explore luminance and chroma channels on the top row, RGB channels on the bottom row, the samples shown here are each only one quadrant of the luminance (grey scale) pattern. Images were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

The camera was not tested in 720p, only in 1080i.

Both horizontal and vertical aliasing are clearly present, and coloured. There is also some diagonal aliasing. These are very good indicators that the camera has a single sensor, with Bayer filter patterning, and that the sensor pixel-count is 1920x1080. The clean resolution limits area about 1280x720, all frequencies beyond these limits are spectrally folded and become coloured aliases. The strength of the aliases is normal for cameras with Bayer single sensors of inadequate resolution.

Clearly, there is no optical filter to prevent high-frequencies from reaching the sensors.

Detail enhancement is a little severe, but at level -3 the aliases have not been enhanced too much. The camera actually performs better with low levels of detail enhancement, zero is acceptable but negative values better still. Level -7 is equal to no detail enhancement. Higher, positive levels greatly enhance the aliasing.



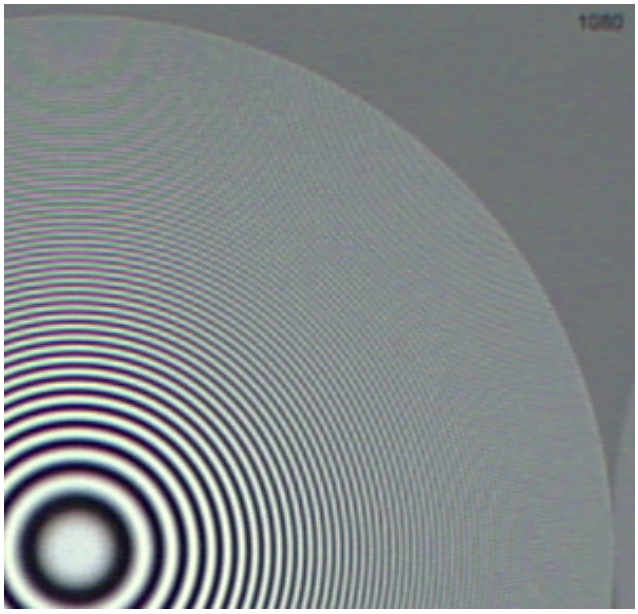


Figure 2 Zone plate (a) no detail (=-7) **(b) detail=-3**

2.4 Video Noise

The specification claims the luma channel noise level to be -54dB, 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 unweighted noise level in dB versus video signal level.

In order to make the measurements more certain, the camera gain was set to +18dB, and the results modified by 18dB 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, and the graph is representative of the camera performance at normal 0dB gain setting. The blue curve has no value at high luma level because the source data was accidentally clipped by slight overexposure. The rise in noise near white level is due to shot noise in the electronics and is unavoidable in small sensors with small pixels.

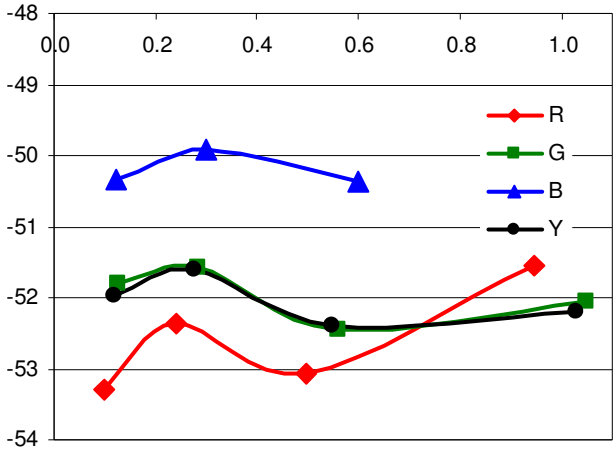


Figure 3 Video noise levels

The distribution of noise level versus signal level should, ideally, follow the slope of the gamma curve (presumably ITU709 in this case), and the values at about mid-grey are then representative of the performance in linear mode (since the slope of the ITU-709 curve is unity at mid-grey). Clearly, the luma noise value at mid-grey is about -52dB, and is admirably close to the specified level. This figure agrees well with subjective assessment of the images. It is not unusual for measurements of HD cameras to differ significantly from the specification claims, and the closeness of this measurement to the specification is quite refreshing.

The noise levels near black should, ideally, rise as the slope of the gamma curve rises. That does not happen in this camera, and is a possible indication that gamma-correction is done in the analogue signals before other processing, and with amplifiers of limited gain-bandwidth product. This is a sensible economy, and contributes towards the rather odd colour performance.

2.5 Conclusions

The camera is tiny, and needs no control unit. However, although the noise level is nice and low, the colour performance is poor and the resolution significantly limited by the single-sensor. The level of aliasing is high and could cause problems in motion-dependant compression such as MPEG2 and MPEG4.