Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 49 rev.1 : Tests and Settings on a Ikegami MKC-300HD mini-camera

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.

Data for this section is taken from the handbook and a very brief examination of an Ikegami MKC-300HD mini-camera (serial number HA61119E) as part of a group test of HDTV mini-cameras. The model tested was a prototype, production models may vary significantly. The camera is connected via multi-core cable to a separate controller. There are no controls on the camera.

The MKC-300HD is a very small camera (34x34x40mm) and weighs only 100 grammes, but the controller is relatively large and weighs about 2.5kg. The specification claims that it has 3 CMOS sensors (⅓") of 2.07Mpixels, i.e. full 1920x1080. It has a C lens mount, standard amongst mini-cameras. Sensitivity is claimed to be F/10 at 2000lux, which is very high for 1920x1080 cameras with ⅓" sensors. The control unit has both digital outputs (HDSDI and DVI) and analogue, and separate SD outputs of composite, S-video and RGB. There are menus, allowing some image control.

The camera specification says that it will run only at 1080/59.94, but in the menus it was found possible to set it to 1080 or 720 format, at 50Hz and 59.94Hz. At 1080, only interlace is supported.

Power consumption is 60VA, mains only.

There are no controls on the camera itself.

Camera mounting was difficult, there are only two M2 screw holes for fixing. For the tests, it was held onto a tripod head with Velcro cable straps.

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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. The full range of values was not explored in the tests, nor were the default values recorded, therefore only minimal information can be given here. In some cases the range is given in the manual, and is shown here. Where know, or suspected, default values are underlined. The menus closely resemble those of other, full-broadcast, Ikegami cameras; it is suspected that the same digital signal processing is used as in this camera, which explains some of the conclusions in the test section, below.

The control unit has several knobs and buttons for direct control of the camera, such that the menus are needed only for establishing a setup condition. It can then be operated from day to day using only the front panel controls.

1 Menu items

1 VIDEO ADJUST

item	*range*	*comment*	*BBC*
Master pedestal	-5		
Gain offset Red	0	Also via panel knobs	
Gain offset Blue	0		

2 AE MODE Auto exposure

item	*range*	*comment*	*BBC*
Manual shutter	Off		
AE level set	15	Auto exposure aim point	
AE speed	Fast, Middle, Slow		
AE sensitivity	40	Set tightness of AE control	
Peak ratio set	0	+ values for Peak, - values for Average	
Area select	SP narrow, Narrow, Middle, Wide, Full	Set the target image area for auto exposure detection	
AGC max gain	+3, +6, +9, +12, +15, +18dB	Limit auto gain range	
Normal gain setting	-3dB	Set gain when not in Auto Gain	
Auto shutter limit	1/10000	Set maximum shitter speed when in Auto Gain	

3 DTL SET Detail

item	*range*	*comment*	*BBC*
Dtl	On	When Off, disables the panel knob for detail	
Dtl gain	10		
Skin dtl gain	25	Sets the detail level for the panel Detail switch	

4 VIDEO SETTING General controls

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item	*range*	*comment*	*BBC*
Format	1080i/59, 1080i/50, 720p/59, 720p/50		
Aspect	16:9, 4:3		
Analogue output	YPbPr, RGB		

5 AUTO ADJUST

item	*range*	*comment*	*BBC*
Auto black balance	Ready	Execute	

6 SCENE FILE

item	*range*	*comment*	*BBC*
Store scene 1	Ready	Store up to 4 separate files	
Store scene 2	Ready		
Store scene 3	Ready		
Store scene 4	Ready		
Load factory default	Ready	Select Start and press SET switch	
Auto store	On	Automatically save menus in scene file	

7 FOOT SWITCH MODE Remote control

item	*range*	*comment*	*BBC*
Foot switch 1	Freeze, Save still, Scene file, Fluorescein[1], Frip[2], Mirror, Rotate	Set Black foot switch function	
Foot switch 2	Freeze, Save still, Scene file, Fluorescein, Frip, Mirror, Rotate	Set Green foot switch function	
Foot switch 3	Freeze, Save still, Scene file, Fluorescein, Frip, Mirror, Rotate	Set Third foot switch function	
Foot switch 4	Freeze, Save still, Scene file, Fluorescein, Frip, Mirror, Rotate	Set Fourth foot switch function	

8 INVERSE Mirror imaging

item	*range*	*comment*	*BBC*
Horizontal	Off, On	Horizontal/Vertical flip	
Vertical	Off, On		

9 STILL SETTING Remote control

item	*range*	*comment*	*BBC*
Format	JPEG, Bitmap		
JPEG factor	4	Set the compression ratio for JPEG	

10 DATE/TIME ADJUSTMENT Remote control

item	*range*	*comment*	*BBC*
Year			
Month			
Day			
Hour			
Minute			
Adjust		Set values the select Adjust, press START to do it	

11 DVI SETTING Remote control

item	*range*	*comment*	*BBC*
Format	1080i / 1080p		

12 DOWN CONVERTER SETTING Remote control

item	*range*	*comment*	*BBC*
Format	Side cut, Letter box, Squeeze		
Analog output	RGB, YCbCr		

13 MISCELLANEOUS

item	*range*	*comment*	*BBC*
Initialize (ex. Scene)	Ready	Reads factory data except scene file	

[1] Possibly meaning fluorescent illumination, but the manual gives no clue.

[2] Possibly meaning 'flip'. i.e. vertical reverse, but the manual gives no clue.

Media format	Ready	Format USB memory	
Cable length	15m		
Bar mode	Multi		
Center marker	Off		

14 VERSION INFO Sows software versions

item	***range***	***comment***	***BBC***
ROM			
FPGA1			
FPGA2			
FPGA3			
CPLD1			
HEAD			
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.

Since the only camera mountings were a pair of M2 screws, the head was precariously fixed to a tripod head with Velcro cable ties for the tests. This is not a recommended method, nor is it suitable for normal field use.

Figure 1 unconventional camera mount

2.1 Sensitivity

Sensitivity was not measured directly. The specification claims F/10 at 2000lux, equivalent to about 400ASA 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 patch had the usual slight greenish tinge which is common in many cameras but was not particularly bad. Skin tones were good, and no specific colour stood out as being inaccurate apart from the orange and cyan colours being a little desaturated. The overall effect is quite good. Given that there is effectively no control over colour performance, this is quite fortunate, but the camera shows significant response to infra-red illumination which can seriously pollute some colours under some illuminants.

Figure 2 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.

The interlaced capture with detail control switched off shows the native performance of the camera. It is completely free from aliasing, which is quite remarkable in almost any HDTV camera, let alone a mini-camera. However, it is also rather soft, indicating that there is probably a simple optical low pass filter in the camera specifically to eliminate spatial aliasing.

As is usual in small cameras, the detail enhancement is a quite severe, but at level -35 (well below the apparent default setting of zero) the aliases have not been enhanced too much, and the same setting level is valid for interlace and progressive. The default setting is acceptable, if a little artificial, because it enhances horizontal and vertical frequencies but has little effect on diagonal frequencies. Also, it is evident that detail enhancement affects positive-going edges more than negative-going edges, artificially brightening the sharpened image. Also, excessive detail enhancement induces spatial aliases, spoiling the rather nice resolution the camera can make.

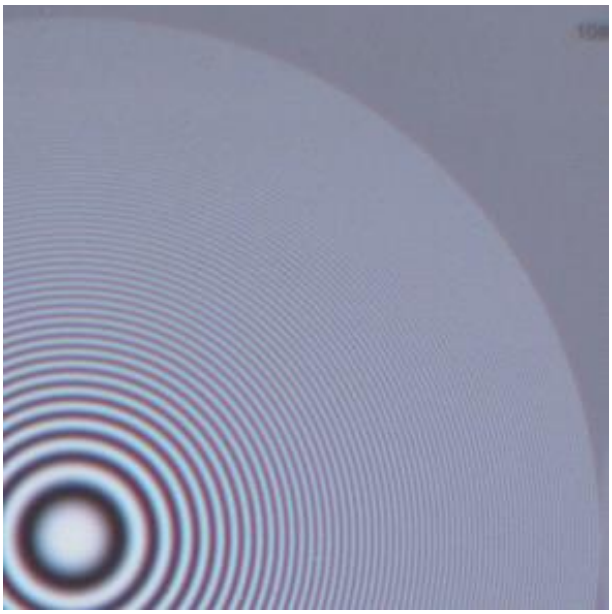
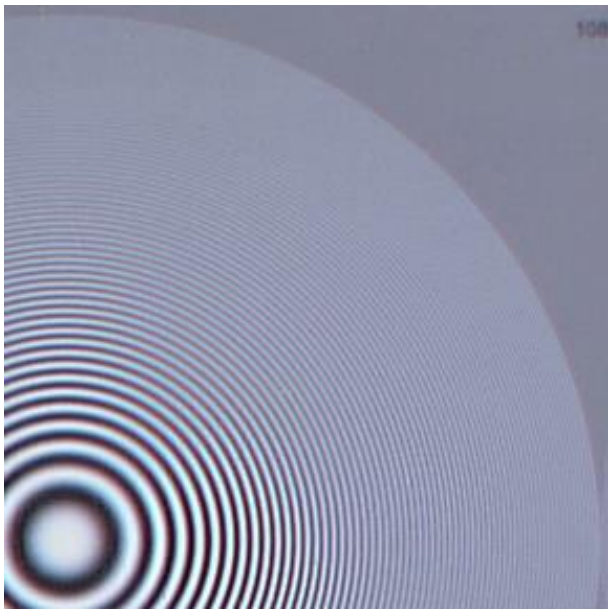


Figure 3 Zone plate, interlaced, detail off



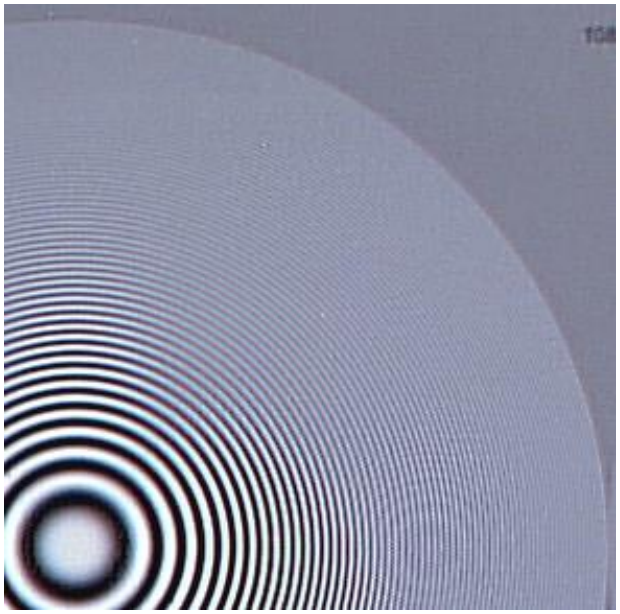


Figure 4 Zone plate (a) detail=-35 **(b) detail=+99 (maximum)**

2.4 Video Noise

The specification claims the luma channel noise level to be -54dB, with gamma and detail switched off.

Measurements were taken on an evenly lit white card, exposed at various levels. Image files were captured via HDSDI as data files, then transcoded to RGB in software before performing a software noise analysis system. 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 rather low value for the blue curve at high signal levels is spurious, and is due to slight clipping of the signal due to accidental overexposure.

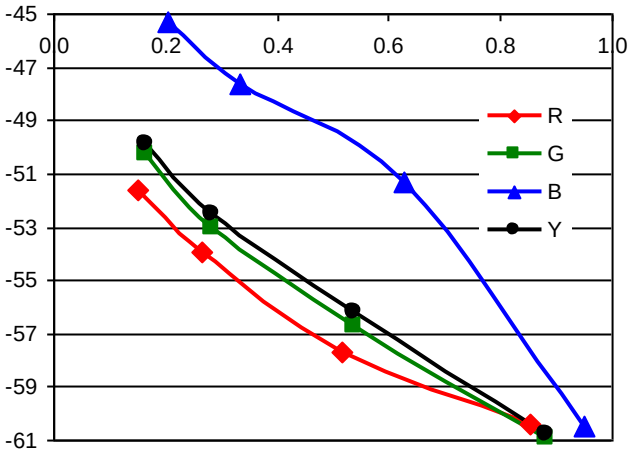


Figure 5 video noise

As expected, the values for blue are worse than for red and green, due to the lower sensitivity of silicon to blue light, this is perfectly normal. The distribution of noise levels 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 near mid-grey). Clearly, the luma noise value at around mid-grey is about -56dB. This figure agrees very well with the specification, and with subjective assessment of the images during the tests. The noise level is unexpectedly low, particularly for a camera with full-resolution sensors at ⅓" image size.

The noise level near black should rise dramatically due to the rapidly rising slope of the gamma curve near black. That it does so indicates that short-cuts have not been made in the video signal processing. It is unusual to find curves which slope as much as these do in small HDTV cameras.

2.5 Infra-red response

The camera responds to infra-red illumination, but not in the normal way. Ordinarily, a camera will respond to an infra-red source by making a monochrome or slightly magenta image, since the infra-red 'light' is passed almost

equally to all channels. However, in this camera, there is little or no response in the red channel, but significant response in blue and green, making a cyan image. This reveals that an infra-red stop filter has been included in the camera, but only in the feed to the red sensor instead of in the light-path to the splitter block. Whether this is deliberate or accidental is not clear.

For this test, a normal, consumer remote control was used, emitting light in the 850-900nm range.

Figure 6 infra-red response

2.6 Rolling shutter

The sensors are CMOS, and therefore have a rolling shutter. This distorts moving edges (making them slope), gives disturbing partially illuminated frames when lit by a stills camera flash, and produces fragmented pictures when the camera is rapidly vibrated.

To demonstrate this, the camera was exposed to a focus test chart, and a white card was vigorously slid back and forth in front of it. In the illustration (one field, shutter off), the white edge is moving to the right, showing the expected 'leaning back' effect of the rolling shutter. The grey fading stripe is due to the integration of light over a full field period, switching the shutter to a short period would sharpen this edge dramatically.

Figure 7 rolling shutter

2.7 Conclusions

The first camera to be tested had many 'stuck pixels', i.e. it showed a fixed, random, pattern of bright pixels when used at high gain. Subsequent testing on a later camera showed no such effect, indicating that it had been due to a faulty sensor and is not endemic to the design.

The camera performs unexpectedly well. It makes no spatial aliases, and the noise level is very low. Although it has a rolling shutter, so does any other CMOS camera. The infra-red response is unusual but not disastrous, and the issue of stuck pixels should not be endemic to the camera model. Mechanically it is rather difficult to use, because of the limited mounting options, and the entire unit can only be mains powered (12V power would make it much more suitable for broadcast use). Nevertheless, it performs remarkably well for a mini-camera.