Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 47 : Tests and Settings on a Panasonic AG-HCK10G and HMR10 mini-camcorder

Data for this section is taken from the handbook and a very brief examination of a Panasonic 'POV' (Point of View) mini-camera and recorder as part of a group test of HDTV mini-cameras. It comprises a camera head with integral lens (F/1.8, 4.0 to 48mm) and separate controller/recorder, recording on to SD or SDHC memory card.

The camera is small (53.5x56x123.8mm); the controller is 96x52.6x133mm and weighs about 580 grammes excluding the battery. The specification claims that the camera has 3 MOS sensors (1/4.1") but gives no indication of the pixel count. However, the specification claims that there are 'approximately 2,510,000 effective pixels', but it is not clear whether this refers to the sensors individually or collectively. Neither sensitivity nor noise levels are quoted. There are two versions, suffixed P and E, the only differences between the models appears to be the factory default settings relating to video format and system frequency.

The controller has HDSDI input (for recording from an external source) and digital outputs via SD and HDMI. There are fairly comprehensive menus, allowing a considerable degree of image control.

It has a significant range of operating formats, including native formats in which genuinely progressive video is recorded at the camera rate, with raising the delivery rate to 50 or 59.94 by pull-down algorithms:

- 1080i/50, 59.94
- 1080psf/25, 29.97
- 1080p/23.976 (native)
- 720p/50, 59.94
- 720p/23.976, 25 (native)

Power consumption is 1.75 Amps at 7.3V 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. The menu structure closely resembles those of consumer camcorders, particularly the HMC41, which seems to have a very similar specification to this camcorder. It seems likely that the derived menu values for this camcorder, where relevant, will work equally well in the HMC41. Menu control is by buttons rather than touch-screen.

This listing of the menus and contents is complete, but this should not be used as an excuse for not reading the manuals. Items in italics are relevant only to recording from the HDSDI input.

1   Menu items

MAIN MENU

Select a submenu

Camera Setup	
Recording setup	
TC/UB setup	
AV out setup	
Display setup	
Card functions	
Meta data	
Play setup	
Thumbnail setup	
Operation	
Other functions	

CAMERA SETUP

item	range	comment	BBC
Synchro scan	1/n~1/250	Adjustable shutter, n=image rate. Defaults to different values for different recording rates	
Detail level	-7~0~+7	Overall detail enhancement level	-2
V detail level	-7~0~+7	Separate vertical detail control	+4
Detail coring	-7~0~+7	Set to avoid enhancing noise	0
Chroma level	-7~0~+7		0
Chroma phase	-7~0~+7		0
Color temp	-7~0~+7		
Master ped	-15~0~+15		
A. iris level	-10~0~+10		
DRS	Off, 1, 2, 3	Dynamic Range Stretcher, stretches blacks and compresses whites	Off
Gamma	HDnorm, Low, SDnorm, High, B.press, Cine-likeD, Cine-likeV	HDnorm looks like ITU709, SDnorm is DVX100 curve, High is like BBC 0.4, Cine-like D for low contrast, V for high contrast	HD norm
Knee	Auto, Low, Mid, High	Sets knee point, Low=80%, Mid=90%, High=100%. Not available in Cine gammas or DRS operation	
Matrix	Norm1, Norm2, Fluo, Cine-like	Norm1 for sun or halogen, Norma2 for more saturation	Norm1
Skin tone dtl	On, Off	No other controls for skin tone	Off
O.I.S.	On, Off	Optical image stabiliser, not tested, but should work	
Iris	Auto1, Auto2, Manual	Auto1 tweaks iris/gain/shutter, Auto2 tweaks iris/gain	Auto2
Focus	Auto, Manual		
D.Zoom	Off, x2, x5, x10	Digital zoom, avoid	Off

RECORDING SETUP

item		range	comment	BBC
Rec format	59.94Hz	PH1080/60i, PH1080/30P, PH1080/24P, PH720/60P, PH720/30P, PH720/24P, HA1080/60i, HG1080/60i, HE1080/60i	24P is native recording at 23.976Hz. Only conventional video formats are accepted as HDSDI sources[1]	PH
	50Hz	PH1080/50i, PH1080/25P, PH720/50P, PH720/25P, HA1080/50i, HG1080/50i, HE1080/50i		
Prerec mode		On, Off	3 second video cache	
Auto rec		Off, Typ1, Type2, Type3	Recording control via HDSDI input. Type1=LTC, Type2=S-VITC, Type3 for non-Panasonic cameras[2]	
Time stamp		On, Off	Adds time and date on video	
Mic ALC		On, Off	Microphone auto gain control	
Int SG		On, Off	Colour bars	

TC/UB SETUP

<div align="right">Time code</div>

item	range	comment	BBC
TC mode	DF, NDF	Drop frame is available only for formats at 59.94Hz system frequency	
TCG	Free run, Rec run		
SDI regen	*On, Off*	*HDSDI recording only, uses S-LTC from input*	
TC preset	Yes, No	Start frame at 0 or multiple of 4, goes wrong for 59.94Hz system frequency	
UB preset	Yes, No		

AV OUT SETUP

<div align="right">General controls</div>

item	range	comment	BBC
SDI out	On, Downcon, Off	Downcon sends SD in the relevant format	
HDMI out sel	Auto, Fix	Auto detects display resolution	
SDI EDH	On, Off	Error Detection Handling, added to SD-SDI output	
SDI EE sel	Normal, Through	Normal adds screen info, Through doesn't	
Downcon mode	Side crop, Letter box, Squeeze	SD-SDI output mode	
HP mode	Live, Recording	Headphone feed, recorded will be delayed	

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[1] All recording modes are variable bit rate (VBR) AVC-HD (MPEG-4). PH records at 21Mb/s, HA is 17Mb/s, HG 13Mb/s, HE 6Mb/s. PH mode is close to broadcast quality.

[2] The manual contains a table for selecting which mode to use when recording from various Panasonic HD cameras.

DISPLAY SETUP

item	range	comment	BBC
Zebra	Off, 105, 100, 95, 90, 85, 80, 75, 70, 65, 60, 55, 50%	Zebra level	
Safety zone	90%, 4:3, Off		
Focus bar	On, Off	Focus assist indicator bar	
Rec counter	Total, Clip	Clip resets to zero for each recording	
Output OSD	On, Off	Enables all on-screen info on the LCD	
Date/time	Time, Date, Time & date, Off	What shows on the LCD	
Level meter	On, Off	Audio level meters	
Zoom & focus	On, Off		
Card & battery	On, Off		
Other display	On, Off	All the other stuff	
LCD backlight	Low, Normal, High		
LCD DTL	On, Off	LCD sharpening	
LCD set		Adjust LCD brightness, contrast, saturation	

CARD FUNCTIONS

SD/SDHC card stuff

item	range	comment	BBC
Card format	Yes, No	Formats the card	
Card status	Yes, No	Shows the card status	
Clip property	Yes, No	Shows info about the selected clip	

META DATA

item	range	comment	BBC
Card read	Yes, No	Loads metadata from the card to the recorder	
Record	On, Off	Records metadata with video	
User clip name	Type1, Type2	Type2 adds Count value to the clip name	
Clip count reset	Yes, No	Reset clip Count to 1	
Meta data prop	Yes, No	Show metadata from the recorder	
Meta initial set	Yes, No	Resets all metadata	

PLAY SETUP

item		range	comment	BBC
PB format	59.94Hz	1080/60i(30p), 1080/24p, 720/60p(30p), 720/24p	Set the playback format. The default value will be the detected recording format	
	50Hz	1080/50i(25p), 720/50p(25p)		
Repeat play		On, Off	Loop ,playback	
Resume play		On, Off	Allows pausing inside a clip	
Skip mode		Clip, Clip & index	Move to start of clip, or to start of clip or index	

THUMBNAIL SETUP

item		range	comment	BBC
Thumbnail mode		All, Same format, Marker, Index	Select which clips to show	
Indicator		On, Off		
Data display		TC, UB, Time, Date, Date & time	What shows in the display time area	
Date format	HMR10P	Y-M-D, M-D-Y, D-M,Y		
	HMR10E	Y-M-D, M-D-Y, D-M-Y		

OPERATION

item	range	comment	BBC
Delete	All clips, Select, No	In Select, press Shift/Exec to collect clips, then Yes to delete them	
Index	Yes, No	Yes adds or deletes a clip index	
Clip protect	Yes, No	Write protection for clips	

OTHER FUNCTIONS

item		range	comment	BBC
User		Inh, Rec check, Spotlight, Backlight, ATW lock, LCD DTL, LCD reverse, Index, Shot mark, Last clip, Counter	User switch. Rec check plays clip last 2 seconds.	
Clock set			Set date and time	
Time zone			World time zones	
Power save		On, Off	Turns power off after 5 minutes inactive except when there's no card inserted or in playback or on external power	
System freq	HMR10E: 59.94, 50Hz		Turn power off and back on the make the change	
	HMR10P: 59.94, 50Hz			

System info		Displays version number	
Menu init		Execute, does a factory reset	
Operation		Displays recorder total power-on time	
LCD operation		Displays recorder LCD total power-on time	
Camera operation		Displays camera total power-on time	

2 Measurement results

All measurements were made using the HDMI output, externally converted to HDSDI. 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 1 lux illumination with +34dB gain and slow-speed shutter set to ½ second, F/1.8. This translates to 1253 lux at 0dB gain, 1/50 second exposure, F/1.8, which approximates to F/2.5 at 2000 lux, about 50ASA.

2.2 Colour performance

Using a Colorchecker chart, the colour performance was judged to be quite acceptable with the standard **HDnorm** curve, which is assumed to be ITU.709. 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 more accurate with either the **High** curve which may well be the BBC 0.4 curve, but performance was quite acceptable with the HD-default ITU709 curve. The **Cine** curves were not explored, but can be expected to do what is claimed in the menus.

Figure 1 Macbeth chart

Unfortunately, the camera shows significant response to infra-red illumination, which is common in non-broadcast cameras.

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 control unit via HDMI converted to HDSDI.

In 1080 interlaced mode, 1920x1080i/25 in EBU parlance, there are visible null zones centred at 1420 pixels and 800 lines, although the level of aliasing is not excessive, even when detail enhancement is added (Level -2, Vertical level +4). There is some diagonal aliasing, but not excessively so.

The specification is coy about sensor resolution, stating only that there are 2,510,000 'effective pixels'. Assuming that the pixel arrays have equal horizontal and vertical spacing, each must then be about 1220x686 pixels. If the green sensor is spatially offset from both red and blue by half a pixel, horizontally and vertically, the resulting resolution ought to be increased by a factor of $\sqrt{2}$, giving limits of 1725x970. Looking at the horizontal extreme of Fig. 1, faint aliases can be seen, centred on a null zone outside the pattern, centred at about 2030 pixels, further proof that the sensors are not 1920x1080, and that some form of offset has been used. Nevertheless, performance is quite good, the level of aliases is very reasonable for a mini-camera.

Figure 2 Zone plate, interlace, detail=-2, vertical=+4

To check this conclusion, a recording was made of a zone plate with +18dB gain, to see if the resolution is compromised by the extra gain. There appears to be some horizontal resolution loss, but not by a dramatic amount. Vertical resolution has not been changed.
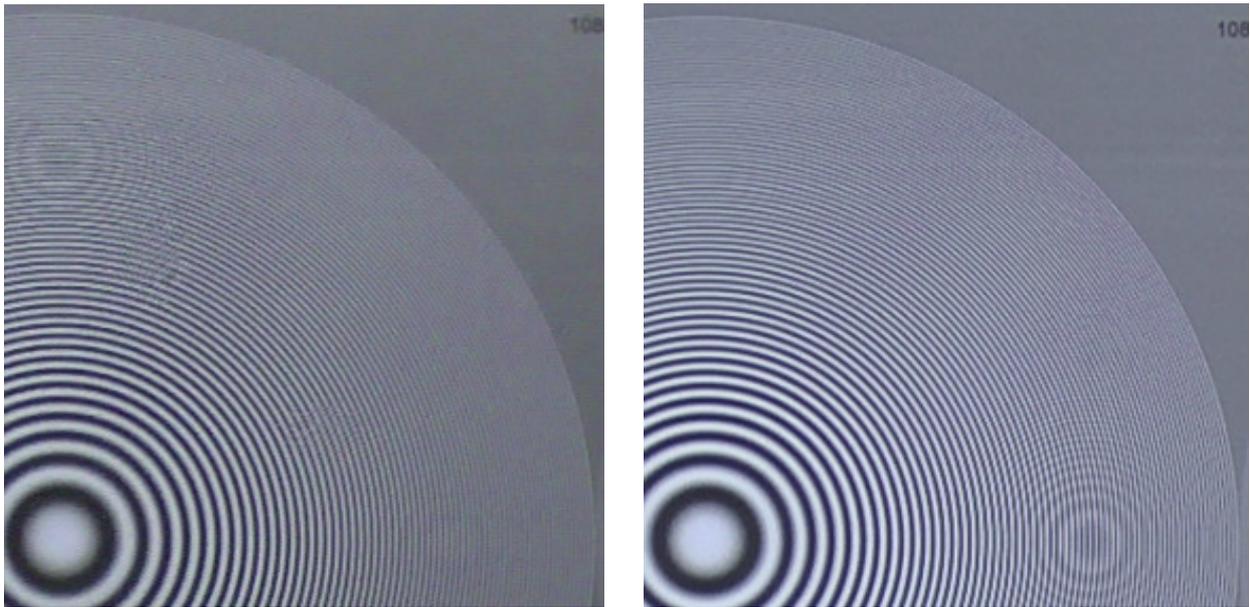

Figure 3 Zone plate (a) interlaced, +18dB   **(b) 1080 progressive**

Performance in psf (1080 progressive images) is very similar to that for interlace, confirming that the sensors are not full resolution, since there only a little extra vertical resolution is revealed.

2.4   Video Noise

The specification makes no mention of noise levels for the camera.

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 +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, so the graph is representative the camera performance at normal 0dB gain setting.

As expected, blue is considerably more noisy, because silicon is much less sensitive to blue than red. The distribution of noise level versus signal level should, ideally, follow the slope of the gamma curve (ITU709 in this case). Noise levels near black should rise significantly, and the curves

Figure 4 Camera noise

shown are as expected for a camera with gamma-correction done in the digital domain, and without any image processing to gain a noise advantage at the expense of resolution. This also helps to explain the good colour rendition.
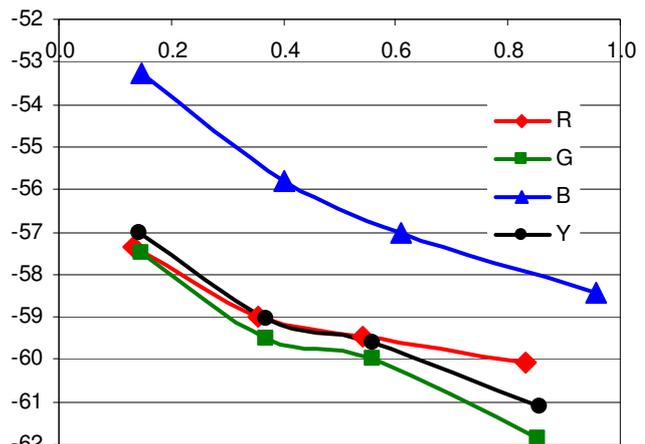
The values at about mid-grey are representative of the performance in linear mode (since the slope of the ITU-709 curve is unity at about mid-grey). Clearly, the noise values are about -59.5dB for the luma signal, while blue noise is about -56.5dB. These figures agree with subjective assessment of the images, and are

7

extraordinarily good for any HDTV camera, let alone a small one. Considering that the sensors are only 1/4.1" size (about 4mm diagonal), this is an exceptional performance.

2.5   Rolling shutter

The camera has 3 MOS sensors, and can therefore be expected to have a rolling shutter through the scanning process. To establish whether this is so, the camera was exposed to a focus test chart, with a white card vigorously slid back and forth in front of it. Fig. 5 confirms the rolling shutter, since the moving edge (going left to right) has a definite slope. The blurring of the edge is due to the actual exposure time (shutter interval), 1/50 second.
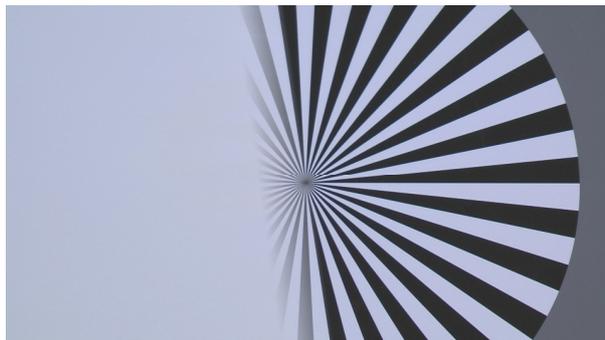

Figure 5 Rolling shutter

Thus the camera can be expected to make moving edges lean away from the motion, flash exposure to cause part-field/frame illumination, and for pictures shot when the camera is vibrating to appear to have been shot through a jelly. This is the price to be paid for having CMOS sensors.

2.6   Conclusion

The camera performs well in all aspects except the recording format. AVC-HD is not approved for broadcast (although AVC-I is), but at the highest rate of 21Mb/s the performance quality should not fall far short of broadcast standards. Noise performance is exceptionally good, although the sensitivity is rather low, indeed, these two facts are inextricably interlinked. Unfortunately, it is responsive to infra-red illumination.