

Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 41 : Tests and Settings on a Sony HSC-300 Studio 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 brief examination of a Sony HSC-300. The camera was an early model, which may or may not represent production models. Superficially, it is similar to the HDC-1500, but has a conventional Triax connection to its CCU, rather than optical fibre. This is a 1080-line studio camera which runs at 50Hz or 59.94Hz interlaced, but does not appear to have a psf option. It also runs at 720p progressive, at both frame rates.

The camera is housed in a conventional small studio-camera shell. It has many internal menus for setting the performance at the camera head, such that it can then be used without external controls. In this report, I shall list only the head controls and not those in the CCU, although the CCU can control most of the camera functions remotely.

It has two conventional filter wheels and a live down-converter to SD, so the camera can be used in mixed environments. The SD performance of the camera was not tested, and should normally be thought of as only for monitoring output, and not for programme use, since an external down-converter will normally deliver a higher quality result.

The menu settings result from one measurement session. In the reported measurements, the camera appears to be able to capture up to about 600% overexposure (about 2.5 stops, using the full video range 109%) and is able to mimic a film camera and telecine reasonably well except for the motion portrayal of psf shooting, with “best light” transfer to tape totalling about 11 stops of tonal range.

The Triax connection carries digital, compressed video data. It proved very difficult to assess the performance of the compression system directly, and there are no clues in the camera or CCU manuals as to how it works. Separate tests have confirmed that performance is acceptable over long lengths of Triax.

The camera is normally used with the HSCU-300 CCU, and can be fitted to either the HDLA1500 or 1506 lens adaptors, or the HDLA1507 adaptor for small lens, and large viewfinder. It can also be controlled remotely via the MSU-900/950 Master Setup Unit, RCP-700/900 Remote Control Panel, or RMB-150/750 Remote Control.

The camera has chromatic aberration correction for ‘serial’ lenses. But it proved to be faulty on test; at one combination of focus, zoom and iris setting, very large errors were introduced by the camera. This is probably only the result of a single erroneous data point in the stored information for the lens, but it rendered the system unusable for these tests.

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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, identified as *v* for video, *f* for film. Although the camera does not have a 1080psf setting for a film look, the *f* settings make sense for shooting 720p when intended to look like film, and will capture the maximum contrast range whether for film-or video-style shooting.

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

TOP MENU

| | |
|---------------------|--|
| USER | Go to daily routine settings, pages that can be customised |
| USER MENU CUSTOMISE | Customise user menu pages |
| ALL | Go to all menu pages |
| OPERATION | Settings for the most common controls |
| PAINT | Settings that normally need lab facilities to control properly |
| MAINENANCE | Camera maintenance, usually best avoided |
| FILE | Load/save reference files etc |
| DIAGNOSIS | Check status of hardware/software |
| SERVICE | Keep out of here if at all possible |

OPERATION MENUS

OPERATION 01 VF DISPLAY

Setting output signals

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|---|---|------------|
| Ex | <u>On</u> , Off | Lens range extender | |
| Zoom | <u>On</u> , <u>Off</u> | | |
| Zoom Disp | <u>Left</u> , <u>Right</u> | | |
| Focus | <u>On</u> , <u>Off</u> | Only when a serial lens is fitted | |
| ND | <u>On</u> , Off | Neutral density wheel | |
| CC | <u>On</u> , Off | Colour temperature wheel | |
| 5600K | <u>On</u> , Off | Daylight open filter white | |
| Iris | <u>On</u> , Off | | |
| White | <u>On</u> , <u>Off</u> | White balance | |
| Gain | <u>On</u> , Off | | |
| Shutt | <u>On</u> , Off | Shutter setting | |
| Batt | <u>On</u> , <u>Off</u> | Battery state | |
| Return | <u>On</u> , Off | Return video | |
| Talk | <u>On</u> , Off | Comms | |
| Messag | <u>All</u> , <u>Wrn</u> , <u>At</u> , Off | Wrn=warnings and higher, At=auto setup and higher | |

OPERATION 02 !INDICATOR

VF warnings

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--|--|------------|
| ND | <u>On</u> , Off <u>1</u> , <u>2</u> , <u>3</u> , <u>4</u> | Whether non-standard setting is reported, and what the standard setting is | |
| CC | <u>On</u> , Off <u>A</u> , <u>B</u> , <u>C</u> , <u>D</u> | | |
| White | <u>On</u> , Off, | White balance, extras with CCU connected. Note that combinations are allowed! | |
| 5600K | <u>On</u> , Off, ... <u>On</u> , <u>Off</u> | 5600 white, extras with CC connected. Normal is Off. | |
| Gain | <u>On</u> , Off, ... <u>L</u> , <u>M</u> , <u>H</u> | | |
| Shutt | <u>On</u> , Off, ... <u>On</u> , <u>Off</u> | | |
| Fan | <u>On</u> , Off <u>Auto1</u> , <u>Auto2</u> , <u>Min</u> , <u>Max</u> | | |
| Ext | <u>On</u> , Off | | |
| Format | <u>On</u> , Off 59.94i, 59.94p, <u>50i</u> , 50p | Normal for the UC model is 59.94i | |

OPERATION 03 VF MARKER

Viewfinder markers

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|--------------|---|--|------------|
| Marker | <u>On</u> , Off <u>White</u> , <u>Black</u> , <u>Dot</u> | | |
| Center | <u>On</u> , <u>Off</u> <u>1</u> , <u>2</u> , <u>3</u> , <u>4</u> | 1=centre cross, 2=cross with hole, 3=centre, 4=centre with hole | |
| Safety zones | <u>On</u> , <u>Off</u> 80, 90, 92.5, 95% | Rectangle | |
| Effect | <u>On</u> , <u>Off</u> | Reports focus assist | |
| Aspect | <u>On</u> , <u>Off</u> 16:9, 15:9, 14:9, 13:9, <u>4:3</u> | | |
| Mask | <u>On</u> , <u>Off</u> 0~12~15 | Darken image outside the mask | |
| Safety | <u>On</u> , <u>Off</u> , (Area) 80, 90, <u>92.5</u> , 95% | Area is added when focus assist is on | |

OPERATION 04 VF DETAIL

Viewfinder sharpening, helps with focusing

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|------------------------------|---|------------|
| VF detail | <u>On</u> , Off 0~25~100% | | |
| Crisp | -99~0~+99 | | |
| Frequency | <u>9M</u> , 14M, 18M | 18M would probably help more, if the VF is decent | |
| FAT mode | <u>On</u> , <u>Off</u> | Thickens sharp edges | |
| Flicker | <u>On</u> , <u>Off</u> | Flickers sharp edges | |
| Area | <u>100</u> , 70, 60, 50, 40% | Limit area of sharpening | |

| | | | |
|--------------|-----------------------------|---------------------------------|--|
| Zoom link | <u>0</u> , 25, 50, 75, 100% | Links detail to zoom setting | |
| Color detail | On, <u>Off</u> | Colours sharp detail edges | |
| | <u>Blue</u> , Red, Yellow | | |
| Peak colour | On, <u>Off</u> | Changes colour of sharpest bits | |
| Chroma level | 100, 50, <u>25</u> , 0% | | |

OPERATION 05 FOCUS ASSIST

Viewfinder assistance for focusing

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|----------------------------------|--|------------|
| Indicator | On, <u>Off</u> , (Effect) | Effect is added when VF Marker menu Effect is On | |
| Mode | <u>Box</u> , B&W, Col | | |
| | <u>Bottom</u> , Left, Top, Right | | |
| Level | 1~3~5 | Set response speed of focus assist | |
| | <u>Quick</u> , Smooth | | |
| Gain | 0~50~99 | And the sensitivity | |
| Offset | 0~50~99 | Manually drive focus assist, see manual for details. | |
| Area marker | On, <u>Off</u> , (Aspect) | Aspect adds when Aspect Safety is on in VF Marker | |
| Size | Small <u>Middle</u> , Large | Set size and position of detection area | |
| Position | Left, <u>Center</u> , Right | | |
| Position H | <u>0</u> ~99 | | |
| Position V | <u>0</u> ~99 | | |

OPERATION 06 ZEBRA

Exposure assistance

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|---------------|-------------------|----------------|------------|
| Zebra | On, <u>Off</u> | | |
| | <u>1</u> , 2, 1&2 | | |
| Zebra 1 level | 50~70~100% | | |
| Width | 0~10~30% | | |
| Zebra 2 | 50~100~109% | | |

OPERATION 07 CURSOR

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|---------------------------|--|------------|
| Cursor | On, <u>Off</u> | Only when large lens adaptor (HDLA) fitted | |
| | <u>White</u> , Black, Off | | |
| Box/Cross | <u>Box</u> , Cross | | |
| H position | 0~50~99 | | |
| V position | 0~50~99 | | |
| Width | 0~50~99 | | |
| Height | 0~50~99 | | |

OPERATION 08 VF OUT

Camera head viewfinder feed

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|---------------|---------------------------------|--|------------|
| VF out | <u>Color</u> , Y, R, G, B | More combinations available when HDLA fitted | |
| Ret mix VF | On, <u>Off</u> | | |
| Mix direction | Main, <u>Ret</u> | | |
| Mix VF mode | <u>Y-mix</u> , Wire(W), Wire(B) | | |
| Mix VF level | 0~80% | | |
| Mix VF scan | <u>16:9</u> , 4:3 | | |

OPERATION 09 SWITCH ASSIGN 1

Custom switches

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-----------------|---|--|------------|
| Gain | -3, 0, 3, 6, 9, 12dB | Factory L=0, M=6, H=12 | -3, 0, 6 |
| Assignable 1 | <u>Off</u> , Return 1 SW, Return 2 SW, Eng, Prod, VF detail, Mix VF, 5600K, Fan max | Slightly different lists for the UC model | |
| Assignable 2 | <u>Off</u> , Return 1 SW, Return 2 SW, Eng, Prod, VF detail, Mix VF, 5600K, Fan max | | |
| Assignable 3 | <u>Off</u> , Return 1 SW, Return 2 SW, Eng, Prod, VF detail, Mix VF, 5600K, Fan max | | |
| Assignable HDLA | <u>Off</u> , Extender, 5600K, Fan max | | |
| Re. rotation | <u>Std</u> , Rvs | Reverses rotation direction of the menu control knob | |

OPERATION 10 SWITCH ASSIGN 2

More about custom switches

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|--------------|---|---|------------|
| Lens VTR S/S | Off, Return 1 SW, <u>Return 2 SW</u> , Eng, Prod | Slightly different lists for the UC model | |
| Front Ret 2 | Off, Return 1 SW, <u>Return 2 SW</u> , Eng, Prod | | |
| Handle SW 1 | Off, <u>Return 1 SW</u> , Return 2 SW, Eng, Prod, Zoom(T) | | |

| | | |
|-------------|---|--|
| Handle SW 2 | Off, Return 1 SW, Return 2 SW, <u>Eng</u> , Prod, Zoom(T) | |
| Zoom speed | 0~ <u>20</u> ~99 | |

OPERATION 11 HEAD SET

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|---------------|---------------------------------|-----------------------------------|------------|
| Intercomm mic | <u>Dynamic</u> , Carbon, Manual | | |
| Level | -60, -40, -20dB -6, -0, +6dB | Fixed gain with Dynamic or Carbon | |
| Power | On, <u>Off</u> | | |
| Unbal | <u>On</u> , Off | | |

OPERATION 12 INTERCOM LEVEL

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|----------------------|----------------|------------|
| Sidetone | Mu, 1~ <u>50</u> ~99 | | |

OPERATION 13 RECEIVE SEL 1

More about comms

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|--------------------------|--------------------------------|----------------|------------|
| Intercomm receive socket | Separate, <u>Mix</u> | | |
| Intercomm | Right, <u>Left</u> , Both, ... | UC model only | |
| End | Right, <u>Left</u> , Both, ... | EC model only | |
| Prod | Right, <u>Left</u> , Both, ... | | |
| Pgm 1 | <u>Right</u> , Left, Both, ... | | |
| Pgm 2 | <u>Right</u> , Left, Both, ... | | |
| Tracker | Right, <u>Left</u> , Both, ... | | |

OPERATION 14 RECEIVE SEL 2

Yet more about comms

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|------------------------|--------------------------------|----------------|------------|
| Tracker receive socket | Separate, <u>Mix</u> | | |
| Intercom | Right, <u>Left</u> , Both, ... | | |
| Talk | Right, <u>Left</u> , Both, ... | | |
| Eng | Right, <u>Left</u> , Both, ... | | |
| Prod | Right, <u>Left</u> , Both, ... | | |
| Pgm 1 | <u>Right</u> , Left, Both, ... | | |
| Pgm 2 | <u>Right</u> , Left, Both, ... | | |

OPERATION 15 RECEIVE SEL 3

Even more about comms

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------------------|--------------------------------|----------------|------------|
| Earphone receive socket | Separate, <u>Mix</u> | | |
| Intercom | Right, <u>Left</u> , Both, ... | UC model only | |
| Eng | Right, <u>Left</u> , Both, ... | EC model only | |
| Prod | <u>Right</u> , Left, Both, ... | | |
| Pgm 1 | <u>Right</u> , Left, Both, ... | | |
| Pgm 2 | <u>Right</u> , Left, Both, ... | | |
| Tracker | Right, <u>Left</u> , Both, ... | | |

OPERATION 16 OPERATOR FILE

Store settings

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|----------------|--------------|-------------------|------------|
| Read (MS-CAM) | | Execute | |
| Write (CAM-MS) | | | |
| Preset | | | |
| File ID | | Max 16 characters | |
| Cam code | | Display only | |
| Date | | | |

OPERATION 17 LENS FILE

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|---------------|--------------------|--|------------|
| File | <u>1</u> ~17 | 17 th only when using a serial lens. Name and F- stop entry only for non-serial lenses | |
| | Name | | |
| | F stop | | |
| Center marker | | To mark the centre of the lens image | |
| H pos | -20~ <u>0</u> ~+20 | | |
| V pos | -20~ <u>0</u> ~+20 | | |
| Store | | Execute | |

PAINT

PAINT 01 SW STATUS

Main controls

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBCv</i> | <i>BBCf</i> |
|-------------|-----------------|----------------|-------------|-------------|
| Flare | <u>On</u> , Off | | On | |
| Gamma | <u>On</u> , Off | | On | |
| Blk gamma | On, <u>Off</u> | | Off | On |
| Knee | <u>On</u> , Off | | On | |
| Wht clip | <u>On</u> , Off | | On | |
| Detail | <u>On</u> , Off | | On | Off |
| Lvl depend | <u>On</u> , Off | | On | |
| Skin dtl | On, <u>Off</u> | | Off | |
| Matrix | On, <u>Off</u> | | On | |

PAINT 02 VIDEO LEVEL

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|-----------------------------------|---|------------|
| White | -99~ <u>0</u> ~+99 | Gain controls for RGB | |
| Flare | -99~ <u>0</u> ~+99 | Black controls for RGB and Master | |
| Gamma | -99~ <u>0</u> ~+99 | Flare controls for RGB | |
| V mod | -99~ <u>0</u> ~+99 | Gamma controls for RGB and Master | |
| Flare | <u>On</u> , Off | Vertical modulation controls for RGB and Master | |
| V mod | <u>On</u> , Off | | |
| D.shad | On, <u>Off</u> | | |
| Test | <u>Off</u> , Saw, 3 step, 10 step | | |

PAINT 03 COLOR TEMP

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|--------------------|------------------------------|-----------------------------|------------|
| White | -99~ <u>0</u> ~+99 | White balance, RGB gains | |
| Auto white balance | | Execute | |
| Color temp | 0~ <u>3200</u> ~65535K | | |
| Balance | -99~ <u>0</u> ~+99 | Blue/Red balance | |
| ATW | On, <u>Off</u> | Auto tracking white balance | |
| Speed | 1~ <u>4</u> ~5 | 5 is fastest | |
| Master | -3, <u>0</u> , 3, 6, 9, 12dB | Gain | |

PAINT 04 GAMMA

Main gamma controls

| TABLE 04: GAMMA | | Main gamma controls | | |
|-----------------|---|---|------------------------------------|---------------------------------|
| item | range | comment | BBCv | BBCf |
| Level | -99~ <u>0</u> ~+99 | | 0 | |
| Coarse | 0.35~ <u>0.45</u> ~0.9 | | 0.45 | |
| Table | <u>Standard</u> , Hyper | Standard: 1=camcorder, 2=4.5 gain, 3=3.5 gain (ENG), 4=SMPTE 240M, 5=ITU709, 6=5 gain, 7=5 gain (ITU709) Hyper: 1=325%~100%, 2=460%~100%, 3=325%~109%, 4=460%~109% | Standard ⁵ ₁ | Hyper ⁴ ₂ |
| | (Standard) 1, 2, 3, 4, 5, 6, 7 (Hyper) 1, 2, 3, <u>4</u> | | | |
| Gamma | <u>On</u> , Off | | On | |
| Test | Off, Saw, 3 step, 10 step | | | |

PAINT 05 BLACK GAMMA

Independent slope at black, Standard gamma only

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBCv</i> | <i>BBCf</i> |
|-------------|-----------------------------------|---------------------------------------|----------------|-------------|
| Level | -99~ <u>0</u> ~+99 | | 0 ³ | |
| Range | Low, L.mid, H.mid, <u>High</u> | Probably 3.5, 7.5, 14.4, 28.8% ranges | H.mid | |
| Test | <u>Off</u> , Saw, 3 step, 10 step | | | |

PAINT 06 SATURATION

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--------------------|----------------|------------|
| Saturation | -99~ <u>0</u> ~+99 | | 0 |
| | On, <u>Off</u> | | Off |
| Low key sat | -99~ <u>0</u> ~+99 | | 0 |

¹ Default gamma should always be ITU709 (Standard 5). Standard 7 should be ok for low noise conditions and ought to work as well as Standard 6 (which is probably the BBC 0.4 law).

² These appear to be the same curves as in the HDWF900R. Hyper 1&3 work well in low contrast scenes, use 2&4 for high contrast scenes, 1&2 do not exceed 100% and so are safe for analogue broadcast, 3&4 use the full coding range to 109% and may need post-production grading.

³ Black gamma is useful when noise levels are low enough, but use of the gamma Standard 7 should obviate the need for it.

| | | |
|------|-----------------------------------|-----|
| | On, <u>Off</u> | Off |
| Test | <u>Off</u> , Saw, 3 step, 10 step | |

PAINT 07 KNEE

Highlight compression

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBCv</i> | <i>BBCf</i> |
|-------------|-------------------|--|-----------------|-------------|
| K point | -99~0~+99 | One soft bend | 0 ⁴ | |
| K slope | -99~0~+99 | Affects segment slope, slightly curved | 5 | |
| Knee | <u>On</u> , Off | | On | |
| Knee max | On, <u>Off</u> | | | |
| Knee sat | <u>On</u> , Off | | On ⁶ | |
| Auto knee | <u>Off</u> , Auto | | Off | |
| Point limit | -99~0~+99 | | | |
| Slope | -99~0~+99 | | | |
| ABS | | Toggles between absolute and relative values | | |

PAINT 08 WHITE CLIP

Highlight clipping

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBCv</i> | <i>BBCf</i> |
|-------------|-----------------|--|-------------|-------------|
| W clip M | -99~0~+99 | Master clipper | 102% | Off |
| | <u>On</u> , Off | | On | |
| ABS | | Toggles between absolute and relative values | | |

PAINT 09 DETAIL 1

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBCv</i> | <i>BBCf</i> |
|--------------|-----------------|--|-------------|------------------|
| Detail | <u>On</u> , Off | All DETAIL compensation | On | |
| Detail level | -99~0~+99 | Overall level | 16 | -19 ⁷ |
| Limiter M | -99~0~+99 | Master | 0 | |
| Limiter wht | -99~0~+99 | | 0 | |
| Limiter blk | -99~0~+99 | | 0 | |
| Crisp | -99~0~+99 | Signal level range that gets crispened | 0 | |
| Lvl dep | -99~0~+99 | Detail level dependency | 0 | |
| | <u>On</u> , Off | | On | |
| ABS | | Toggles between absolute and relative values | | |

PAINT 10 DETAIL 2

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|---------------|----------------|--|------------|
| H/V ratio | -99~0~+99 | | 0 |
| Freq | -99~0~+99 | -99=20MHz, +99=30MHz | +99 |
| Mix ratio | -99~0~+99 | | 0 |
| Knee aperture | -99~0~+99 | | 0 |
| | On, <u>Off</u> | | On |
| ABS | | Toggles between absolute and relative values | |

PAINT 11 SKIN DETAIL

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|------------------------|--|------------|
| Skin dtl | On, <u>Off</u> | All skin detail on/off | Off |
| Skin gate | On, <u>Off</u> , (Mat) | Mat appears when Multi-Matrix Gate is on | |
| Auto hue | | Execute | |
| Phase | 0~359 | Hue in degrees | |
| Width | 0~29~90 | Zone width in degrees | |
| Sat | -99~+89~+99 | | |
| Level | -99~0~+99 | | |
| ABS | | Toggles between absolute and relative values | |

PAINT 12 USER MATRIX

Camera matrix

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--------------|----------------|------------|
| R-G | -99~0~+99 | | |
| R-B | -99~0~+99 | | |

⁴ Setting knee point to +99 is equivalent to 72% video level, ok for film-style, 0 is near 95%.

⁵ Adjust knee slope to taste. The camera can capture about 2.5 stops of overhead, so there's no excuse for clipping highlights in this camera.

⁶ Knee saturation keeps colours correct even when compressed by the knee slope.

⁷ This is a reasonable setting for Detail enhancement, but it cause some spatial aliasing.

| | | | |
|--------|--|-------------------|---------|
| G-R | -99~0~+99 | | |
| G-B | -99~0~+99 | | |
| B-R | -99~0~+99 | | |
| B-G | -99~0~+99 | | |
| Matrix | On, <u>Off</u> | All matrices | On |
| Preset | SMPTE-240M, ITU709, SMPTE-Wide, NTSC, EBU, ITU-601 | Standard matrices | ITU-709 |
| User | On, <u>Off</u> | | Off |
| Multi | On, <u>Off</u> | | Off |

PAINT 13 MULTI MATRIX

Multi-linear matrix, for advanced knob-twiddlers only

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--|-------------------|------------|
| Phase | 0, 23, 45, 68, 90, 113, 135, 158, 180, 203, 225, 248, 270, 293, 315, 338 | | |
| Hue | -99~0~+99 | | |
| Sat | -99~0~+99 | | |
| All clear | | | |
| Matrix | On, <u>Off</u> , (Skin) | | |
| Preset | On, <u>Off</u> SMPTE-240M, ITU709, SMPTE-Wide, NTSC, EBU, ITU-601 | Standard matrices | ITU-709 |
| User | <u>On</u> , Off | | |
| Multi | On, <u>Off</u> | | |

PAINT 14 SHUTTER

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--|---|------------|
| Shutter | On, <u>Off</u> 59.94Hz: 1/100, 1/125, 1.250, 1/500, 1/1000, 1/2000 50Hz: 1/60, 1/125, 1/250, 1/500, 1/1000, 1/2000 | UC model defaults to 1/100 EC model defaults to 1/60 | |
| ECS freq | 59.94Hz: 60~4300Hz 50Hz: 50~4700Hz | | |

PAINT 15 SCENE FILE

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|----------------|--------------|---|------------|
| 1 | | Recall one of the 5 scene files stored in the camera | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| Store | | Execute, move scene files between camera and Memory Stick | |
| Standard | | | |
| Read (ME-CAM) | | | |
| Write (Cam-MS) | | | |
| F id | | 16 character file ID | |
| Can code | | Display only | |
| Date | | | |

MAINTENANCE**MAINTENANCE 01 AUTO SETUP 1**

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|--------------------|-----------------------------------|----------------|------------|
| Auto black | | Execute | |
| Auto white | | | |
| Auto level | | | |
| Auto white shading | | | |
| Auto black shading | | | |
| Test | <u>Off</u> , Saw, 3 step, 10 step | | |

MAINTENANCE 02 WHITE SHADING

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|--------------------|----------------|-----------------------------|------------|
| V saw | -99~0~+99 | Individual controls for RGB | |
| V para | -99~0~+99 | | |
| H saw | -99~0~+99 | | |
| H para | -99~0~+99 | | |
| White | -99~0~+99 | | |
| Auto white shading | Exec | Press Enter | |
| White shading mode | RGB, <u>RB</u> | | |

MAINTENANCE 03 BLACK SHADING

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|--------------------|------------------------------|-----------------------------|------------|
| V saw | -99~ <u>0</u> ~+99 | Individual controls for RGB | |
| V para | -99~ <u>0</u> ~+99 | | |
| H saw | -99~ <u>0</u> ~+99 | | |
| H para | -99~ <u>0</u> ~+99 | | |
| Blk set | -99~ <u>0</u> ~+99 | | |
| Master black | -3, <u>0</u> , 3, 6, 9, 12dB | | |
| Auto black shading | Exec | Press Enter | |

MAINTENANCE 04 OHB MATRIX

Head block correction matrix, steer clear

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--|----------------|------------|
| Phase | <u>0</u> , 23, 45, 68, 90, 113, 135, 158, 180, 203, 225, 248, 270, 293, 315, 338 | | |
| Hue | -99~ <u>0</u> ~+99 | | |
| Sat | -99~ <u>0</u> ~+99 | | |
| All clear | | | |
| OHB matrix | On, <u>Off</u> | | |
| Matrix | On, <u>Off</u> | | On |

MAINTENANCE 05 AUTO IRIS

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--------------------------|---|------------|
| Auto iris | On, <u>Off</u> | | |
| Window | <u>1</u> , 2, 3, 4, 5, 6 | 1=lower 2/3, 2=middle 2/3, 3=H mid 2/3, 4=full, 5=low and mid 2/3, 6=high 2/3 | |
| Override | -99~ <u>0</u> ~+99 | | |
| Iris level | -99~ <u>0</u> ~+99 | | |
| APL ratio | -99~ <u>65</u> ~+99 | | |
| Iris gain | -99~ <u>0</u> ~+99 | | |
| Iris close | On, <u>Off</u> | | |

MAINTENANCE 06 MIC GAIN

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|----------------|-----------------------------|----------------------------------|------------|
| Mic 1 | 20, 30, 40, 50, <u>60dB</u> | Valid only when CCU is connected | |
| Mic 2 | 20, 30, 40, 50, <u>60dB</u> | | |
| Front mic +48v | <u>On</u> , Off | | |

MAINTENANCE 07 UP TALLY

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------------|----------------------|---|------------|
| Tally brightness | 0~ <u>50</u> ~100 | | |
| Number brightness | 0~ <u>50</u> ~100 | | |
| Camera number | 1~96 | | |
| Number display | On, Off, <u>Auto</u> | Auto corresponds with the Up Tally switch on HDLA if attached | |

MAINTENANCE 08 CALL/TALLY

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|-----------------|----------------------------------|------------|
| CCU call | <u>On</u> , Off | Valid only when CCU is connected | |
| Cam call | On, <u>Off</u> | | |

MAINTENANCE 09 OUTPUT FORMAT

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--|--------------------------------|------------|
| Current | | Displays current standard | |
| Active line | 1080 59.94i, 1080 50i, 720 59.95p, 720 50p | Reboot camera to effect change | |

MAINTENANCE 10 DOWN CONVERTER

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|---------------|-----------------------|--|------------|
| Output signal | <u>Main</u> , Ret, VF | Although this can set the main camera output to SD, I do not recommend doing so, this is an HD camera not an SD camera | |
| Setting | Cam, <u>CCU</u> | | |
| SD matrix | <u>On</u> , Off | | |
| Detail | <u>On</u> , Off | | |
| DTL level | -99~ <u>0</u> ~+99 | | |
| H DTL freq | -99~ <u>0</u> ~+99 | | |
| Aspect | <u>SQ</u> , EC | | |

MAINTENANCE 11 TEST OUT

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--|-----------------------------------|------------|
| Output | SD-sync, HD-sync, Prompter 2, <u>VBS</u> | | |
| Pwr save | | Displayed only in Power Save mode | |
| VBS-out | <u>On</u> , <u>Off</u> | | |
| Character | -127~0~~+127 | | |
| Gain | -127~0~~+127 | | |
| Chroma | <u>On</u> , <u>Off</u> | | |
| Setup | | Displayed only when in NTSC mode | |
| HD sync-out | | | |
| V-phase | -127~0~~+127 | | |
| H-phase | -127~0~~+127 | | |

MAINTENANCE 12 SDI OUT

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|-------------------------------------|-----------------------------------|------------|
| Output | Main, VF, Ret, SD-SDI, SDI-prompter | SD-SDI means SD not HD | |
| Pwr save | | Displayed only in Power Save mode | |
| Character | <u>On</u> , <u>Off</u> | Not if Output is VF or Prompter | |
| EMB audio | Mic 1, Mic 2, AES 1, AES 2 | When Output is Main | |
| | PGM 1, PGM 2, ENG, Prod | When Output is not Main | |

MAINTENANCE 13 POWER SAVE

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|----------------|---------------------------------|----------------|------------|
| SDI output | <u>Pwr save</u> , <u>Active</u> | | |
| Down converter | <u>Pwr save</u> , <u>Active</u> | | |
| Prompter | <u>Pwr save</u> , <u>Active</u> | | |

MAINTENANCE 14 TRUNK

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|------------------------|---|------------|
| Trunk | <u>On</u> , <u>Off</u> | Enables remote control at camera or CCU | |

MAINTENANCE 15 GENLOCK

Genlock control when no CCU connected

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|----------------|----------------|------------|
| Reference | | Display only | |
| Genlock | | | |
| Status | | | |
| Format | | | |
| Phase | | | |
| V | -1024~0~~+1023 | | |
| HD H | -1700~0~~+1700 | | |
| SD H | -1024~0~~+1023 | | |

MAINTENANCE 16 DATE

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--------------|------------------|------------|
| Date/time | | yyyy/mm/dd/hh/mm | |

MAINTENANCE 17 BATTERY ALARM

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--------------|----------------|------------|
| Before end | 11.5~17.0V | | |
| End | 11.0~11.5V | | |

MAINTENANCE 18 OTHERS 1

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|------------------|-------------------------------|--|------------|
| Fan mode | Off, Auto 1, Auto 2, Min, Max | Auto 2=slow fan (quiet) | |
| Cam bars | <u>On</u> , <u>Off</u> | Seems to be only full height, no SMPTE | |
| V DTL creation | NAM, G, R+G, <u>Y</u> | | |
| DTL H/V mode | H/V, V only | | |
| Test 2 mode | <u>3 step</u> , 10 step | | |
| White setup mode | AWB, <u>A.LVL</u> | | |
| ALAC | <u>Auto</u> , <u>Off</u> | Automatic lens correction ⁸ | |

MAINTENANCE 19 OTHERS 2

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--------------|----------------|------------|
|-------------|--------------|----------------|------------|

⁸ Chromatic aberration correction, appeared to be faulty in the camera under test, see comments in the Measurements section.

| | | | |
|------------------|---------------------------------------|---|--|
| Date type | Y/m/D, M/D, D/M/Y, D/M, M/D/Y, M/D | Y=year, M=month as numeric, m=month as text, D=day | |
| Filter white mem | On, <u>Off</u> | | |
| F no. disp | <u>Control</u> , Return | Control=camera estimate, Return=lens estimate | |

FILE

FILE 01 OPERATOR FILE

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------------|--------------|-------------------|------------|
| Read (MS-Cam) | | Execute | |
| Write (Cam-MS) | | | |
| Preset | | | |
| Store preset file | | | |
| File ID | | 16 characters max | |
| Can code | | Display only | |
| Date | | | |

FILE 02 SCENE FILE

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|----------------|--------------|---|------------|
| 1 | | Paint data. | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| Store | | Store/read a file in the camera. To store, select the number and execute Store. To read, just select the number | |
| Standard | | | |
| Read (MS-Cam) | | | |
| Write (Cam-MS) | | | |
| File ID | | 16 characters max | |
| Cam code | | Display only | |
| Date | | | |

FILE 03 REFERENCE

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|----------------|--------------|-------------------|------------|
| Store file | | Execute | |
| Standard | | | |
| All preset | | | |
| Read (MS-Cam) | | | |
| Write (Cam-MS) | | | |
| File ID | | 16 characters max | |
| Cam code | | Display only | |
| Date | | | |

FILE 04 LENS FILE

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|---------------|-------------------|--|------------|
| Store file | | Execute | |
| No. | 1~17 | Number 17 available only for serial lenses | |
| Name | | Entry only for non-serial lenses | |
| F no. | F/1.0~F/1.7~F/3.4 | Max aperture | |
| Center marker | | Store centre point of the image | |
| H pos | -20~0~+20 | | |
| V pos | -20~0~+20 | | |
| Store | | Execute | |

FILE 05 OHB FILE

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--------------|--|------------|
| Store file | | Execute, stores data about the optical block | |

FILE 06 FILE CLEAR

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|----------------------|----------------|--|------------|
| Preset operator | | Execute | |
| Reference (all) | | | |
| 10 sec clear | On, <u>Off</u> | Hold control knob in for 10 sec to factory reset | |
| OHB white shad (all) | | Execute | |
| OHB black shad | | | |

| | | | |
|---------------|--|-------------------------|--|
| OHB ND offset | | | |
| OHB matrix | | | |
| M.S. format | | Format the Memory Stick | |

DIAGNOSIS

DIAGNOSIS 01 BOARD STATUS

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--------------|-----------------|------------|
| OHB | OK/NG | Indicators only | |
| DPR | | | |
| CD | | | |
| TX | | | |
| SY | | | |
| PS | | | |

DIAGNOSIS 02 PLD VERSION

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--------------|---------------------------------|------------|
| TG | | Software versions, display only | |
| AT | | | |
| VDAP | | | |
| VSOP | | | |
| ASSIST | | | |
| DEMUX | | | |
| DEMAP | | | |

DIAGNOSIS 03 ROM VERSION

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|--------------|---|------------|
| AT | | Firmware version, not recorded from test camera | |
| PANEL | | Firmware in HDLA | |

DIAGNOSIS 04 SERIAL NO

| <i>item</i> | <i>range</i> | <i>comment</i> | <i>BBC</i> |
|-------------|---------------|----------------|------------|
| Model | HSC-300 | Display only | |
| No. | Serial number | | |

Further menus exist but are accessible only by setting internal switches. They are best left to qualified service personnel.

2 Measurement results

Measurements were made on camera #40002, fitted with a Fujinon lens, 16x6.3. All measurements were made using the HDSDI output, either from the camera head or the CCU. 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/11 at 2000lux, equivalent to about 400ASA with 0dB gain.

2.2 Colour performance, Gamma curves, Exposure range

Using a Colorchecker test chart, the colour performance was judged to be typical of other Sony cameras, with the standard ITU.709 gamma curve (#5 in the menu). Saturation was significantly lower than expected, and judged to be more accurate. Red, yellow, and magenta were all somewhat oversaturated, the yellow had a greenish tinge. Performance was markedly better when using gamma law #6 (believed to be the BBC 0.4 law), because the gain near black is significantly higher. However, performance using the 709 curve was quite acceptable and produced the highest saturation. The 709 curve with higher initial gain is similar to the BBC 0.4 curve.

Performance with the Hyper-gamma curves was not specifically tested, but conclusions should be similar, if not identical to those noted in other cameras, repeated here.

The HG2 and 4 curves have much lower gain slopes across the mid tonal range. Using an 18% reflectance grey-scale chart, the tabulated exposure apertures produce the same 50% video signal levels. This shows that the Hypergamma curves are about 0.5 to 1 stop "slower" than the video curve for skin tones, although peak exposure levels stay the same.

| ITU.709 | F/5.8 |
|---------|-------|
| HG1 | F/4.5 |
| HG2 | F/4 |
| HG3 | F/5.6 |
| HG4 | F/4 |

The exposure headroom for the HSC-300 was measured by setting the gamma curve knee to a low point and slope to reach 100% with the greatest range possible. Then the exposure apertures needed to achieve 100% video level from a white card were measured with knee on and off. With knee off, F/6 was needed, F/2 with knee on. This reveals a range of about 1.5 stops of headroom, 300% to 400%. It seems highly likely that maximum actual exposure (claimed to be 450% in the manual) cannot be dealt with by using conventional gamma curves and knee, that is what the Hypergamma curves are for.

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 both from the CCU and the camera head, in an attempt to discover how well the Triax compression system works.

In 1080/50i mode (interlaced, 1920x1080i/25 in EBU parlance) the vertical resolution rolls off nicely, and there appears to be slightly more horizontal resolution than vertical, which is to be expected. The vertical roll-off is due to the interlaced sampling, the horizontal roll-off is due to the optical filtering in the camera, both are performed well, indicating that the camera has a good optical low-pass filter. There is no evidence of any spatial aliasing, so this camera is admirably suited to shooting at 1920x1080i/25 for live/as-live production.

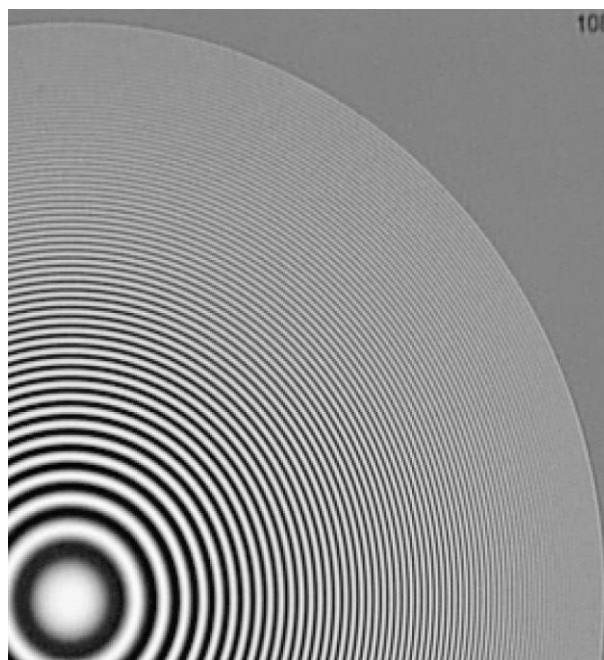


Figure 1 Zone plate 1080/50i, F/2.8 (CCU)

Performance in 1080/59.94i mode should be identical, but was not tested. The lens focal length was 25mm, image distance 1.5m, aperture F/2.8 for this test.

Whilst setting up for this test, a problem with the automatic lens aberration correction was noticed; there was a very large chromatic aberration error in the corners (about 9 pixels). The error could be removed either by switching off the correction, or by changing the lens setting. Moving away from this serendipitous setting greatly improved the image at the vertical edges and in the corners. Clearly there is either a fault in the camera image processing, or a faulty data point in the data table for this lens, probably the latter. Either way, the automatic lens correction was useless for these tests. Fortunately, the lens performed reasonably well without correction, as this 184x189 pixel sample from the top left of the chart shows.

It is fairly clear that chromatic aberration errors attributable to the lens are mostly horizontal and not vertical, which is to be expected, and that the erroneous 'correction' is purely horizontal, and is probably a parabolic horizontal scaling, since the central area is largely unaffected. All further testing was done with the lens correction switched off.

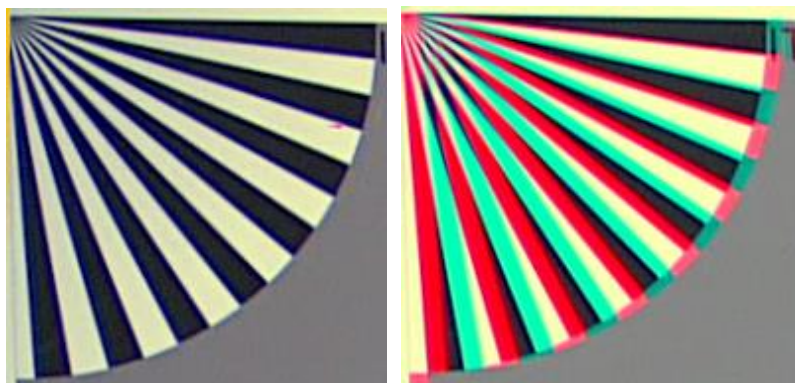


Figure 2 Corner (a) F/2.8

(b) F/5.6

Performance in 720p mode is adequate, but not perfect. It is very rare to find, in any camera, a down-conversion process which adequately eliminates spatial aliasing, and this camera is no exception.

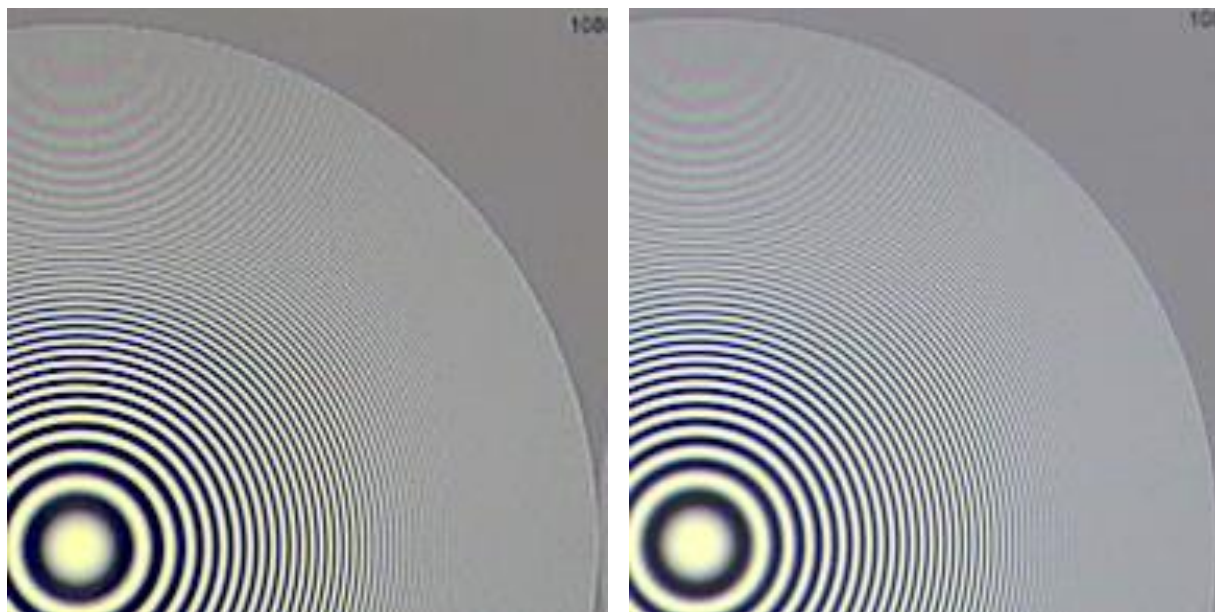


Figure 3 Zone plate 720p, F/2.8 (a) native

(b) detail on

The down-conversion has removed the higher horizontal frequencies well enough, but vertical aliasing is plainly visible, and is heavily coloured. Since spatial aliasing results from a frequency-folding process, it also generates motion-folding, i.e. the aliased (coloured, in this instance) vertical content will move in the opposite direction to the wanted frequencies when the image or camera moves. This can confuse motion-sensitive video compression systems such as all varieties of MPEG, and is to be avoided wherever possible. This camera is only marginally acceptable for shooting in 720p mode.

Spatial aliasing within the area of wanted frequencies at 720-line was removed by optimising the detail enhancement settings, the example shown has detail level set to -19, suitable for film-type work, higher levels will always produce spatial aliases. Clearly, the same settings work well for 1080 shooting, there is no need for separate sets of settings, although higher detail level will produce a more 'crisp' picture at 1080 without generating the spatial aliases seen at 720p.

2.4 Video Noise

The specification claims that the noise level is -55dB, as is typical of claims for all other HDTV cameras.

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 to RGB in software before performing a software noise analysis. The plot shows the noise level in dB versus video signal level in percentage points.

In order to make the measurements more certain, the camera gain was set to +12dB, and the results modified by 12dB 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. 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. The blue line has no point near 'white' because the signal was accidentally clipped for that measurement.

The distribution of noise level versus signal level should, ideally, follow the slope of the gamma curve (ITU709 in this case), and the values at 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 luma noise value at mid-grey is about -45dB, while blue noise is about 8dB higher. These figures agree with subjective assessment of the images. It is not unusual for measurements of HD cameras not to agree with the specification claims, and this magnitude of difference is quite common. The relatively high noise level is probably due to the camera having been set to high sensitivity using fairly high gain head amplifiers. However, it is clear that high gain should not be routinely used in this camera.

2.5 Video Compression

The camera sends video to the CCU over a Triax cable, in a digital compressed form. There is no hint in either the camera or CCU manual as to the bitrates or compression methods used. Maximum cables lengths depend on cable type, between 900 and 1800 metres, this suggests that the data rate used for video is about 150Mb/s, about 10:1 compressed, since the best Triax cable system bandwidth is only about 100MHz.

The CCU manual states that the video delay between camera and CCU is approximately 9 to 12ms, and that the teleprompter feed suffers about 5 frames delay. This implies that inter-frame compression (e.g. MPEG2)

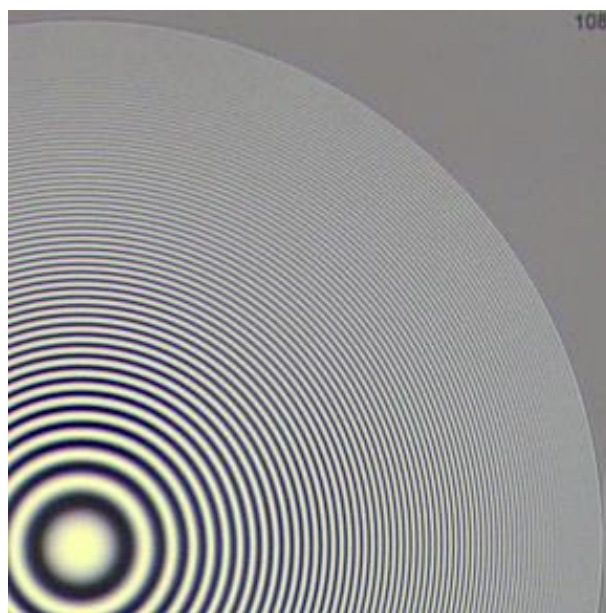


Figure 4 Zone plate, 1080, F/2.8, detail on (CCU)

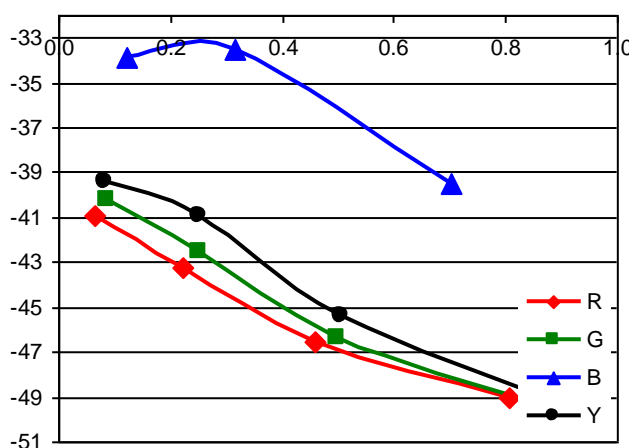


Figure 5 Camera noise

is used for the teleprompter feed, probably at a low bitrate. Also, the viewfinder feed from the CCU has about 1 frame delay, again implying a simpler compression than for the main camera output feed.

The relatively high compression ratio for video, together with the low latency, suggests that the compression uses intra-field (intra-frame for 720p) wavelet technology rather than block-DCT, or a hybrid of the two methods.

To investigate the performance of the compression system, a series of images were grabbed, some of a metronome in front of test cards. Several sequences were grabbed, at varying exposure levels, both from the camera and from the CCU.

Looking at the CCU sequences, there was no apparent loss of information due to motion, as expected. Taking differences between successive frames showed only noise and the motion of the metronome. However, taking differences between images from the camera head and CCU did show some small

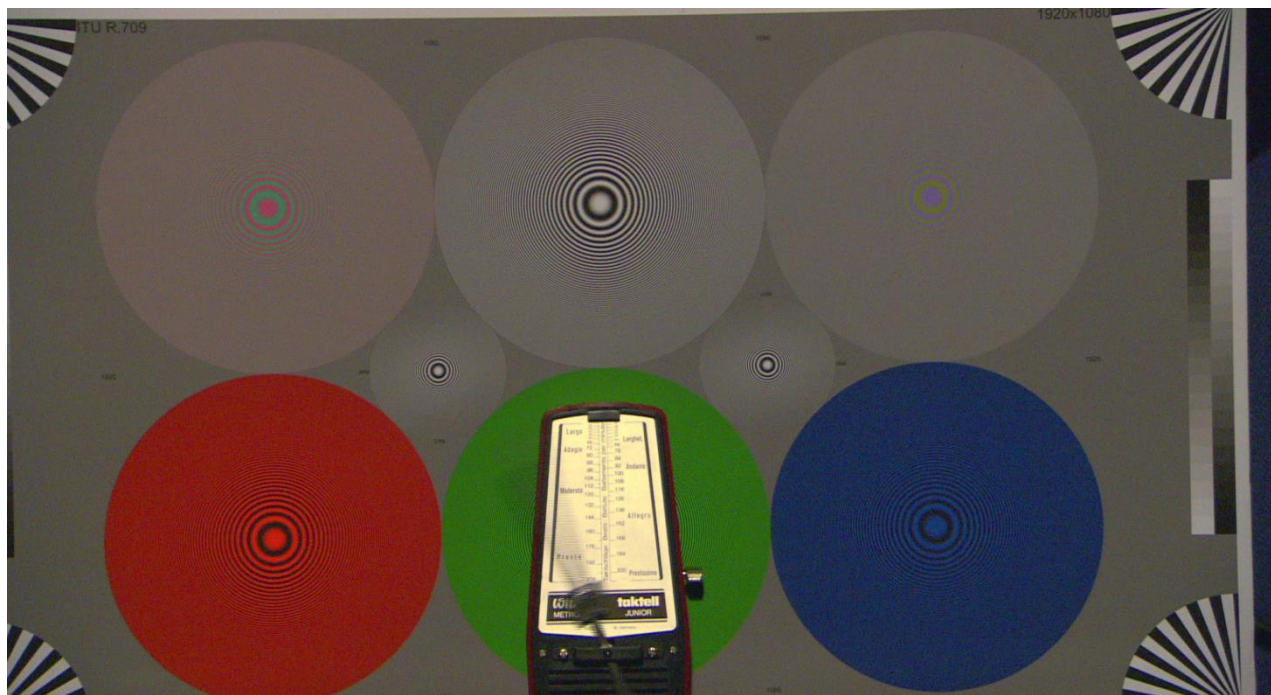


Figure 5 Zone plate with metronome

differences, primarily in diagonal luma resolution, and in horizontal chroma. The illustrations show differences amplified by +12dB, using this formula : –

$$Out = 1/2 + 4(A - B)$$

... where the half-scale offset is applied in order to raise the difference signal to mid-grey for viewing.

In an attempt to quantify the effects of compression, a further series of tests were carried out, measuring the differences as noise signals. Specifically, a sequence of 25 frames (one second) was grabbed simultaneously from the camera head and CCU, with camera gain set to +12dB and recorded uncompressed. From these, a set of difference frames was generated with unity difference gain, using only the camera head frames, taking differences between successive frames. Since there was no camera or image motion apart from the metronome, the difference signal contains only noise and the effects of motion. Noise analysis was performed on the top half of the frame (in which there is no motion), approximately 1 million pixels. A second series of calculations was made, measuring the difference between head and CCU frames at the same instant. The results for the luma (Y') channel are shown in Fig. 6.

At this stage, we are interested only in Y'(t), the upper line, these are the figures for temporal differences between successive frames from the camera head. There is remarkably little variation in values, the typical noise level is around -30.1dB. Since this noise is the sum of noise contributions from two different frames, the noise signals must be uncorrelated, and so the actual noise level for each frame is 3dB better than this

figure (since it is the noise power which is added, not the voltage), around -33.1dB. This figure agrees well enough with the earlier noise measurements once the effect of the +12dB gain is removed, resulting in an average noise level of -45.1dB. Note that there was no high-pass filtering operation in this case, because any shading effects are eliminated in the differencing process.

Thus, the actual noise signal level in each image must be 15.49mV rms because:

For the same sequence of 25 frames, the noise level in the difference signal between the camera head and compressed CCU images is the lower line, identified as $Y(c)$. The average level for this line is -36.5dB, over 6dB better than the inter-frame difference noise level. This can only have resulted from a degree of correlation between the noise content of the camera head signal and that from the CCU, and this means that the compression system is actually delivering the camera luma noise with only small changes.

Fig. 7 shows the same calculations for the chroma channels. Note that the vertical (noise level) scale is much smaller for these plots. The noise content of the differences between the head and CCU are very much closer to those from inter-frame head difference signals, 0.4 and 0.1dB. This can only be due to the camera head and CCU noise signals being almost completely uncorrelated, which, in turn, establishes that the noise in the CCU images must be generated by the compression system rather than the camera head. However, it is clear that the noise level generated by the compression system is affected by and closely follows that of the camera head signals, which is encouraging.

Therefore, it is safe to state that the chroma signals are much more heavily compressed than the luma signal, which is a confirmation of the amplified images in Fig. 8.

Extra compression of chroma is quite normal in video systems, and does not necessarily worsen the pictures significantly. In this case, the balance of compression seems good, and should not significantly affect the delivered image quality.

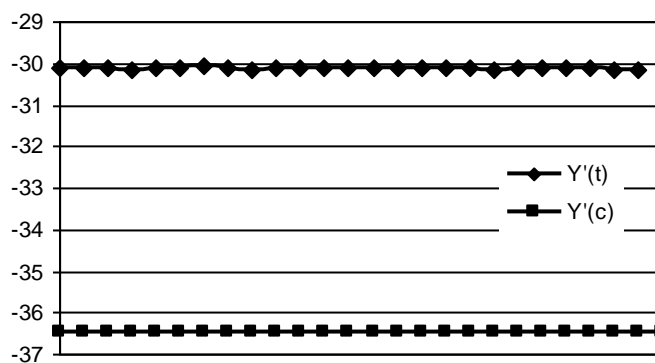


Figure 6 Compression test, luma

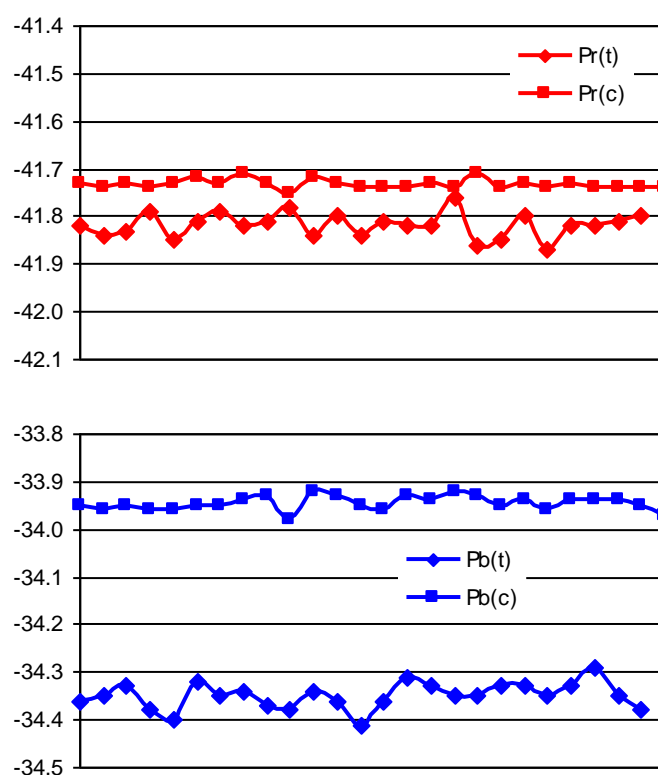


Figure 7 Compression test (a) Pr, (b) Pb

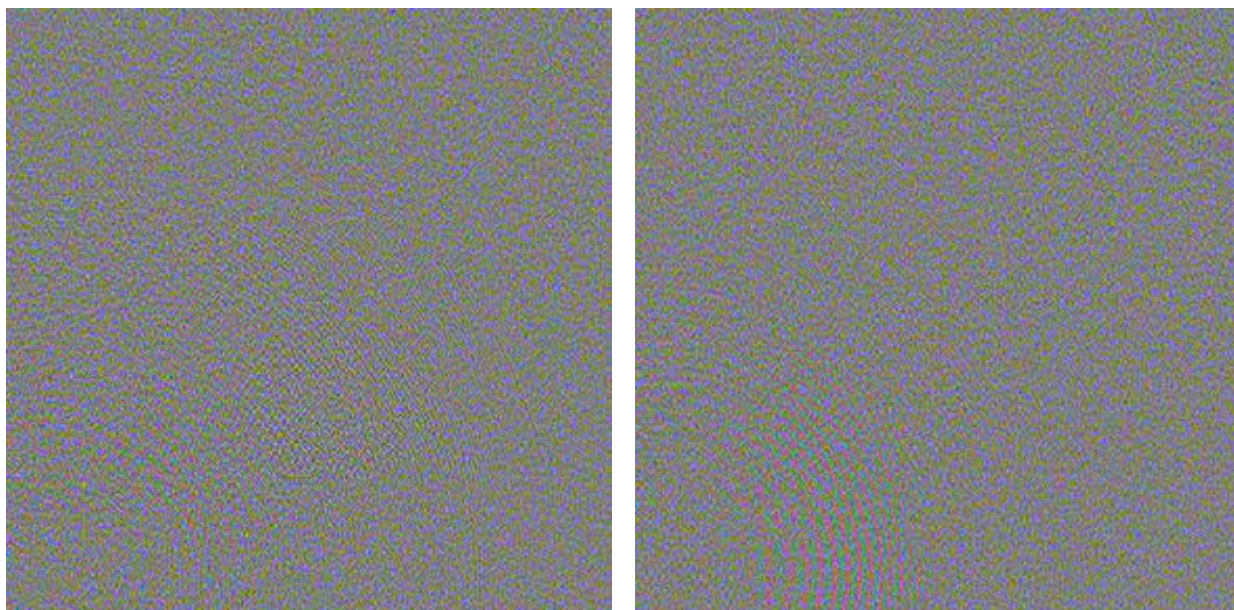


Figure 8 Compression test (a) luma difference

(b) chroma difference