

# Colorimetric and Resolution requirements of cameras

Alan Roberts

## **ADDENDUM 64 rev.3 : Tests and Settings on a Sony PMW500**

Data for this section is taken from a brief examination of a prototype camcorder, and a subsequent test on a production model of the PMW500. Since no manual was available nor even a specification, for the initial tests, the initial testing was more rigorous than normal. The production camera has slight changes in the menu contents, but the performance appears to be near enough identical to that of the prototype.

The camera bears striking similarity to the PMW350 and 320, and is very similar to the PDW700, having very similar menu structure and contents.

This is a 1080-line camcorder, of typical broadcast size but with much lower power consumption, about 29W. It runs at the normal television rates of 50Hz or 59.94Hz, 1080-line interlaced or psf, and 720p. It also runs at the film-related 23.978Hz rate. It has 3 1920x1080 CCD sensors, a neutral density filter wheel but no colour temperature filter wheel.

It records full 1920x1080 images with 4:2:2 colour sub-sampling at 50Mb/s (MPEG-2), and at lower rates with lower resolution. It also records at 720p and SD. Recording is onto Sony SxS cards which fit into two computer PCMCIA Express slots in the camera. The compression system was not tested, but is already well known and understood. There is no HDMI on this camera.

The camera has many internal menus for setting the performance, such that it can then be used without external controls. It is not ideally suited to multi-camera operation, although it can be controlled remotely. A standard feature is a 15-second picture cache, but there is only one filter wheel (neutral density filters), colour temperature compensation is achieved by electronic gain-changing.

The menu settings result from one brief measurement session, attempting to get good settings for drama or wildlife (film-style, with full colour grading), and for live/as-live shooting (no grading), and the settings reflect that. In the reported settings, the camera captures up to 300% overexposure (about 1.5 stops, using the full video range 109%) and is mimicking a film camera and telecine, with “best light” transfer to tape (totalling about 11 stops of tonal range). The range of controls is similar to those in the HDW range of HDCAM camcorders, and so it should be possible to make it mimic negative or positive film, with resolution tailored to 35mm or 16mm, to taste. Assuming that a grading operation will be used in post-production, the settings give the colourist the same range of options as with film. Detail enhancement produced some spatial aliasing, but the Aperture compensation produced a much smoother image with complete freedom from aliasing. For use in Sport or Light Entertainment, it would probably be beneficial to switch off the Black Gamma, and to set Detail On, with Detail Level to -5 (0, factory setting, causes visible aliasing).

This revision contains settings for SD shooting, intended for operations where significant grading is not available, and for News use.

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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. For each item, the factory setting is given where known, and the range offered. “BBC” recommended settings are in the last column, where appropriate. Factory settings, where known, are underlined. Value ranges shown as -99 ~ 99 may differ in practice, as a result of settings in lower menus.

The data files are used in “layers”, Factory, Service, Preset, User. The effect of a numeric data value in the user menus is the sum of all values for that item in all these layers. Only those in the Factory layer are absolute, thus it is vital to have all layers correctly set when entering new values, if the setup is to be copied from camera to camera. The range of values available in some items may not be those quoted in the camera manual, this is due to settings in the Factory layer which must not be altered.

There are settings for:

- Film {film} where a long-contrast film look is wanted and post-production grading is inevitable
- Video {video} where a more conventional video look is appropriate and grading is used
- Ungraded {HDu} for live/as-live shooting in HD where grading is not possible
- Ungraded {SDu} for live/as-live shooting in SD where grading is not possible
- News {news} for News shooting to match existing SD practices in BBC News

... in cases where the variants are not specified, then the most appropriate settings should be used, e.g. if only {film} and {video} are specified, then News should use the video settings.

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.

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 contents

### TOP MENU

OPERATION	Settings for the most common controls
PAINT	Settings that normally need lab facilities to control properly
MAINTENANCE	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 FORMAT

<i>item</i>		<i>range</i>	<i>comment</i>	<i>BBC</i>	
UDF		UDF, FAT	Video data file format		
HD/SD		<u>HD</u> , SD	SD needs CBK-MD01 camera module		
HD system line		1080, 720	Pretty obvious		
System frequency	PAL area	1080	50i, 25p	Lots of options	
		720	50p, 25p		
		SD	50i, 25p		
	NTS area	1080	59.94i, 29.97psf, 23.98psf		
		720	59.94i, 29.97psf, 23.98psf		
		SD	59.4i, 29.97p		
Rec format	UDF	1080/720	HD422 50, HD420 HQ	Affects bit-rates as well as format <sup>1</sup>	
		SD	IMX 50, DVCAM		
	FAT	1080	<u>HQ 1920</u> , HQ 1440, SP 1440		HD 422
		720	HQ 1280		
		SD	DVCAM		
Aspect Ratio (SD)		16:9, 4:3			
Audio Length (IMX)		24, <u>16 bit</u>			
Country		NTSC(J), NTSC, PAL	Affects available settings elsewhere		

#### OPERATION FORMAT MEDIA

Card formatting

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Media (A)	Execute, Cancel	Formats the SxS cards	
Media (B)	Execute, Cancel		

#### OPERATION INPUT/OUTPUT

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Output	<u>HD</u> , SD	For UDF mode only	
Output & i.Link	<u>HD&amp;HDV</u> , SD&HDV, SD&DV	Set the outputs on the HD and Firewire/i.Link connectors	
23.98 Output	<u>PsF</u> , Pull down	Nice to see choices like these	
Source select	<u>Camera</u> , i.Link	Signal input source, only for FAT mode	
i.Link I/O	Enable, <u>Disable</u>		
SDI output	<u>On</u> , Off	Saves power	
SDI out super	On, <u>Off</u>	Adds screen text to outputs for monitoring	
Video out super	On, <u>Off</u>		
Down converter	Crop, Letter, <u>Squeeze</u>		
Wide ID	<u>Through</u> , Auto	Adds wide-screen ID flag to SD output	
Wide mode	<u>Auto</u> , 16:9	SD input, use signal flag for aspect ratio or not	
Setup remove	<u>7.5</u> , 0%	SD input, NTSC area, deals with NTSC setup	

#### OPERATION SUPER IMPOSE

Characters and markers on outputs

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Super (VF display)	<u>On</u> , Off		
Super (menu)	<u>On</u> , Off		

<sup>1</sup> HQ mode records MPEG-2 MP@HL, 35Mb/s variable bit rate. SP records MPEG-2 MP@H-14, 25Mb/s CBR. SD records DVCAM, 25Mb/s. HD422 is 50Mb/s 422 10-bit MPEG2.

Super (timecode)	On, <u>Off</u>		
Super (marker)	On, <u>Off</u>		

### OPERATION LCD

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
LCD color	-99~0~+99	LCD saturation	
LCD marker & zebra	On, <u>Off</u>		

### OPERATION REC FUNCTION

Recording stuff

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Slow & Quick	On, <u>Off</u>	Off-speed operation, disables the cache store	
Frame rate	1080 NTSC area	1~30	Available only when Slow & Quick is on. Off-speed shooting
	1080,PAL area	1~25~30	
	720 NTSC area	1~30~60	
	720 PAL area	4~25~60	
Clip continuous rec	On, <u>Off</u>		
Picture cache rec	On, <u>Off</u>	Disables Slow & Quick, Interval Rec, Frame rec	
P. cache rec time	0~2, 2-4, 4-6, 6-8, 8-10, 10-12, 12-14, 13-15sec		
Interval rec	On, <u>Off</u>	Disables Slow & Quick, Cache, and Frame rec	
Frame rec	On, <u>Off</u>	Disables Slow & Quick, Cache, and Interval rec	
Number of frames	720	1, 3, 6, 12 frames	Frames to be recorded in Interval rec or Frame rec
	Not 720	1, 3, 6, 9 frames	
Interval time	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 30, 40, 50sec, 1min, 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 30, 40, 50min, 1 hour, 2, 3, 4, 6, 12, 24 hour	Set interval between recordings	
Pre-lighting	<u>Off</u> , 2, 5, 10sec	Turns camera light on before recording	

### OPERATION ASSIGNABLE SW

Set the user switches

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
0	<u>Off</u> , Marker, ATW hold, Picture cache, Freeze mix, Focus Mag, Zebra, Shot mark 1, Shot mark 2, OK mark	Focus mag is a handy v/f magnifier for checking focus	
1	<u>Off</u> , Front mic, Marker, Last clip delete, ATW, ATW hold, <u>EZ mode</u> , Turbo gain, Rec review, Rec, Picture cache, Freeze mix, Spotlight, Backlight, EVF mode, BRT disp, Histogram, Lens info, Zoom tele/wide, Zoom wide/tele, Manual focus assist, Focus mag, Zebra, Lens ret, Return video, Shot mark 1, Shot mark 2, OK mark, Color temp Sw 3200K, Color temp Sw 4300K, Color temp SW 5600K, Color temp SW 6300K, Electrical CC, CC5600K, Clip continuous rec		
2	<u>Off</u> , Front mic, Marker, Picture cache, Zebra, Digital extender		
3	(Same list as for Switch 1)		
4			
5			
RET	<u>Off</u> , Lens ret, return video, rec review, Shot mark 1, Shot mark 2, OK mark, Focus mag		
C. temp			
Zoom speed	0~20~99	If Sw4 or 5 is set to Zoom, specifies zoom speed	

### OPERATION VF SETTING

The viewfinder

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Color	-99~0~+99	Saturation	
Peaking type	<u>Normal</u> , Color, Both	Color adds false colour to sharp edges	
Peaking frequency	<u>Normal</u> , High		
Peaking color	<u>White</u> , Red, Yellow, Blue	False colour peaking	
Peaking level	-99~0~+99		
Color peaking level	Low, <u>Mid</u> , High		

### OPERATION MARKER

Items in the viewfinder

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Setting	On, <u>Off</u>	All markers	
Center marker	1, 2, 3, 4, <u>Off</u>	What sort of marker	
Center H position	-40~0~+40		

Center V position	-40~0~+40		
Safety zone	On, Off		
Safety area	80, 90, 92.5, 95%		
Aspect marker	Line, Mask, Off	Line shows the box, Mask darkens the picture outside it	
Aspect select	15:9, 14:9, 13:9, 4:3, 1.66, 1.85, 2.35, 2.4		14:9
Aspect mask	0, 10, 20, 30, 40, 50, 60, 70, 80, 90%		
User box	On, Off		
User box width	40~500~999		
User box height	70~500~999		
User box H position	-479~0~+479		
User box V position	-464~0~+464		
Guide frame	On, Off		Frame outline

#### OPERATION GAIN SWITCH

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Gain low	-3, 0, 3, 6, 9, 12, 18, 24, 30, 36, 42dB		-3
Gain mid	-3, 0, 3, 6, 9, 12, 18, 24, 30, 36, 42dB		0
Gain high	-3, 0, 3, 6, 9, 12, 18, 24, 30, 36, 42dB		+6
Gain turbo	-3, 0, 3, 6, 9, 12, 18, 24, 30, 36, 42dB		+12
Shockless gain	On, Off		

#### OPERATION TLCS

Total Level Control system

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Mode	Backlight, Standard, Spotlight	Auto-exposure compensation	
Speed	-99~0~+99	Tracking speed	
AGC	On, Off	Auto gain control	
AGC limit	3, 6, 9, 12, 18dB	Max gain AGC will go to	
AGC point	F5.6, F4, F2.8	Ideal aperture AGC will aim for	
Auto shutter	On, Off		
Auto shutter limit	1/100, 1/150, 1/200, 1/250	Limit auto shutter will go to	
Auto shutter point	F5.6, F8, F11, F16	Ideal aperture auto shutter will aim for	F8 <sup>2</sup>

#### OPERATION ZEBRA

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Zebra select	1, 2, Both		
Zebra 1 level	50~70~107%		70 <sup>3</sup>
Zebra aperture level	1~10~20%	Zebra width	
Zebra 2 level	52~100~109%		100

#### OPERATION DISPLAY ON/OFF

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Video warning levels	On, Off	High/low video level warnings	
Focus position	On, Off		
Zoom position	On, Off		
Audio level meter	On, Off		
Timecode	On, Off		
Battery remain	On, Off		
Media remain	On, Off		
TLCS mode	On, Off		
Focus mode	On, Off		
White balance mode	On, Off		
Filter position	On, Off		
Iris position	On, Off		
Gain setting	On, Off		
Shutter setting	On, Off		
Color temp	On, Off		
Video format	On, Off		
System line	On, Off		
Rec mode	On, Off		
Extender	On, Off		
WRR RF level	On, Off		

<sup>2</sup> Beyond F/8, resolution will start to fall through iris diffraction. This is normal for 2/3" sensors.

<sup>3</sup> Set lowish to encourage mild underexposure for film-type shooting. Set it a little higher for normal video work.

Clip number (PB)	<u>On</u> , Off		
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### OPERATION! LED

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Gain	<u>On</u> , Off		
Shutter	<u>On</u> , Off		
White preset	<u>On</u> , Off		
ATW run	<u>On</u> , Off		
Extender	<u>On</u> , Off		
Iris override	<u>On</u> , Off		

### OPERATION AUTO IRIS

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Iris override	On, <u>Off</u>		
Iris speed	-99~ <u>0</u> ~+99		
Clip high light	On, <u>Off</u>		
Iris window	<u>1</u> , 2, 3, 4, 5, 6, Var	Select the window shape	
Iris window indication	On, <u>Off</u>		

### OPERATION WHITE SETTING

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
White switch <B>	<u>Memory</u> , ATW	Set the B position of the White Balance switch	
Shockless white	Off, <u>1</u> , 2, 3	Off=instant, 3 is slow	
ATW speed	1, 2, <u>3</u> , 4, 5	Reaction speed when B=ATW, 1=fast, 5=slow	
AWB fixed area	On, <u>Off</u>	On=25% width x height, Off=70% w x h	
Filter white memory	On, <u>Off</u>	On holds separate white balance for each filter position	

### OPERATION OFFSET WHITE

Modifications to white balance

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Offset white <A>	On, <u>Off</u>		
Warm cool <A>		Display of colour temperature, only approximate	
Warm cool balance <A>	-99~ <u>0</u> ~+99		
Offset white <B>	On, <u>Off</u>		
Warm cool <B>		Display of colour temperature, only approximate	
Warm cool balance <B>	-99~ <u>0</u> ~+99		

### OPERATION SHUTTER

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Shutter select	<u>Second</u> , Degree	Show shutter time as...	
Slow shutter	On, <u>Off</u>		
SLS frames	2, 3, 4, 5, 6, 7, 8, 16 frames	Accumulation period	

### OPERATION 18 TIME ZONE

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Zone	-12.00~ <u>00.00</u> ~+14.00	UTC/GMT offset in 30 minute steps	

### OPERATION 19 Clip

White balance stores

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Auto naming		Only for UDF mode	
Title prefix		Text input, alphanumerics	
Number set	0001~9999	Initial part of clip name	
Update	Media A, Media B	Updates the management files, press Exec to do it	

## PAINT

### PAINT SWITCH STATUS

main controls

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Gamma	<u>On</u> , Off		On
Black gamma	<u>On</u> , <u>Off</u> <sup>4</sup>		Off <sup>4</sup>
Matrix	<u>On</u> , Off		On

<sup>4</sup> Black stretch is ok for digging detail from the shadows, but only if the noise level is low enough, use with care.

Knee	<u>On</u> , Off		On
White clip	<u>On</u> , Off		{film} Off {video, HDu, SDu, news} On
Detail	<u>On</u> , Off		On
Aperture	<u>On</u> , Off		On
Flare	<u>On</u> , Off		
Test saw	On, <u>Off</u>	Analogue sawtooth	

### PAINT WHITE

colour temperatures stored by the WHITE A/B switch

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Color temp <A>	Display temp K	Shows current white balance in A, default 3200K	
Color temp bal <A>	-99~0~+99	Fine control	
R gain <A>	-99~0~+99	Tweaking these changes the colour temperature setting	
B gain <A>	-99~0~+99		
Color temp <B>	Display temp K	Shows current white balance in B, default 3200K	
Color temp bal <B>	-99~0~+99	Fine control	
R gain <B>	-99~0~+99	Tweaking these changes the colour temperature setting	
B gain <B>	-99~0~+99		

### PAINT BLACK

master black settings

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Master black	-99~0~+99		
R black	-99~0~+99		
B black	-99~0~+99		

### PAINT FLARE

Flare control

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Flare	<u>On</u> , Off		
Master flare	-99~0~+99		
R flare	-99~0~+99		
G flare	-99~0~+99		
B flare	-99~0~+99		

### PAINT GAMMA

main gamma controls

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Gamma	<u>On</u> , Off	All curve bending	On
Master gamma	0.35~0.45~0.9	These controls have huge range, use with care	0.45
R gamma	-99~0~+99		0
G gamma	-99~0~+99		0
B gamma	-99~0~+99		0
Gamma select	STD	1 ~ <u>5</u> ~ 6	{film} HG <sup>6</sup> {video, HDu, news} STD 5 {SDu} STD 6
	HG	1~4	
Gamma category	<u>STD</u> , HG		

### PAINT BLACK GAMMA

independent slope at black

<i>Item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Black gamma	On, <u>Off</u>		On <sup>7</sup>
Gamma level	-99~0~+99	Raises ITU709 slope to about 7.5x	28 {news} -50 <sup>8</sup>
Range	Low/ L.mid/ H.mid/ <u>High</u>	Low=to 3.6%, L.Mid=to 7.2%, H.mid=to 14.4%, High=to 28.8%	H.mid

<sup>5</sup> Standard gammas: 1=DVW camcorder-like; 2=4.5 slope at black, not sure what curve this is; 3=3.5 slope at black, ENG contrasty style; 4=SMPTE240M, MUSE 1125 spec; 5=ITU709; 6=BBC 0.4 law.

<sup>6</sup> Hypergammas as in other Sonys, good for film look: 1 compresses 325% headroom down to 100%; 2 compresses 460% down to 100%; 3 compresses 325% down to 109%; 4 compresses 460% down to 109%. Use 1 and 3 for low contrast scenes, 2 and 4 for high contrast scenes. Use 1 and 2 for shooting without grading, use 3 and 4 for shooting with a full grade.

<sup>7</sup> Black gamma is useful for lifting shadows, but adds noise in blacks. Use only with low gain (e.g. 6dB or less) and with noise suppression On.

<sup>8</sup> BBC News likes to use this to compress shadows, automatically obtaining a black level in the pictures.

<b>PAINT KNEE</b>			highlight compression
<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Knee	<u>On</u> , Off		{film} Off {video} On {news} On
Knee point	50~ <u>95</u> ~109%	One soft bend	{film} 75% {video} 85% {news} 95%
Knee slope	-99~ <u>0</u> ~+99	Affects segment slope, slightly curved	{film} -23 <sup>9</sup> {video} -35 <sup>10</sup> {news} +30
Knee saturation	<u>On</u> , Off		On <sup>11</sup> {news} Off <sup>12</sup>
Knee saturation level	-99~ <u>0</u> ~+99		0

<b>PAINT WHITE CLIP</b>			highlight clipping
<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
White clip	<u>On</u> , Off		{film, video} Off <sup>13</sup> {news, HDu, SDu} On
White clip level	NTSC area PAL area	90.0~ <u>108.0</u> ~109.0% 90.0~ <u>105.0</u> ~109.0%	102% <sup>14</sup>

#### PAINT DETAIL (HD MODE)

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Detail	<u>On</u> , Off	All DETAIL compensation	{film, video, HDu, SDu} On {news} Off
Level	-99~ <u>0</u> ~+99	Overall level	-5 <sup>15</sup>
H/V ratio	-99~ <u>0</u> ~+99	Changes mix of horizontal and vertical sharpening	0
Crispening	-99~ <u>0</u> ~+99	Signal level range that gets crispened	
Level depend	<u>On</u> , Off	Detail level dependency	
Level depend level	-99~ <u>0</u> ~+99	Detail level range affected	
Frequency	-99~ <u>0</u> ~+99	Frequency of detail compensation	+99
Knee aperture	<u>On</u> , Off	Extra detail above knee point	Off
Knee aperture level	-99~ <u>0</u> ~+99		
Limit	-99~ <u>0</u> ~+99		
White limit	-99~ <u>0</u> ~+99	Detail +ve excursion limit	
Black limit	-99~ <u>0</u> ~+99	Detail -ve excursion limit	
V-BLK limit	-99~ <u>0</u> ~+99		
V detail creation	NAM, G, <u>R+G</u> , Y	Source for edge detection	

#### PAINT DETAIL (SD MODE)

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Detail	<u>On</u> , Off	All DETAIL compensation	On
Level	-99~ <u>0</u> ~+99	Overall level	-30 <sup>16</sup>
H/V ratio	-99~ <u>0</u> ~+99	Changes mix of horizontal and vertical sharpening	-97

<sup>9</sup> Knee settings are designed to capture 250% overexposure (1.5 stops, the measured limit of the camera under test when using standard gamma curves) into 109% coding range, and assumes that a full colour grade will be used, with no clipping during capture. Other settings would be needed for other uses.

<sup>10</sup> This knee setting will capture about 1.5 stops of overexposure without serious white crushing. This is probably as much as any news cameraman would tolerate, but still works well.

<sup>11</sup> Knee saturation helps to keep colours looking right when they're compressed in the knee.

<sup>12</sup> Keep knee saturation off unless the scene contains bright colours which become overexposed as a result of the high knee point.

<sup>13</sup> This allows video to go up to 109%, post-production operations must not clip this during ingest, the extra coding range is useful for capturing overexposure and allows grading to do better than otherwise.

<sup>14</sup> 102% is safe and should not excite 'illegal colours' alarms in the normal production workflow for analogue television transmission.

<sup>15</sup> This is a reasonable setting for Detail enhancement, but it causes some spatial aliasing, see test section below.

<sup>16</sup> This is a good setting for Detail enhancement, higher levels cause some spatial aliasing, see test section below.

Crispensing	-99~0~+99	Signal level range that gets crispened	0
Level depend	On, Off	Detail level dependency	0
Level depend level	-99~0~+99	Detail level range affected	0
Frequency	-99~0~+99	Frequency of detail compensation	+50
Knee aperture	On, Off	Extra detail above knee point	On
Knee aperture level	-99~0~+99		0
Limit	-99~0~+99		0
White limit	-99~0~+99	Detail +ve excursion limit	0
Black limit	-99~0~+99	Detail -ve excursion limit	0
V-BLK limit	-99~0~+99		
V detail creation	NAM, G, R+G, Y	Source for edge detection	
Corss color	-99~0~+99		

#### PAINT APERTURE

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Aperture	On, Off	Separate APERTURE correction	On
Level	-99~0~+99	Overall level	25 <sup>17</sup>

#### PAINT SKIN DETAIL

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Skin detail	On, Off	All skin detail on/off	Off
Area detection		Press rotary encoder to detect skin colour	
Area indication	On, Off	Zebra display of target area	
Level	-99~0~+99	Detail level	
Saturation	-99~0~+99	Saturation change	
Hue	0~359	Hue change	
Width	0~40~359	Target hue angle width	

#### PAINT MATRIX

camera matrix

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Matrix	On, Off	All matrices	On
Preset matrix	On, Off	Standard matrices	On
Preset select	1 ~ 2 ~6	SMPTE240, ITU709, SMPTE-WIDE, NTSC, EBU, ITU601	2
User matrix	On, Off	Roll your own matrix	Off
User Matrix R-G	-99~0~+99		
User Matrix R-B	-99~0~+99		
User Matrix G-R	-99~0~+99		
User Matrix G-B	-99~0~+99		
User Matrix B-R	-99~0~+99		
User Matrix B-G	-99~0~+99		

#### PAINT MULTI MATRIX

multi-linear matrix, for advanced knob twiddlers only

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Multi matrix	On, Off	Roll your own multi-segment matrix	Off
Area indication	On, Off	Use zebra to show active region	
Color detection	Exec	Press rotary encoder to select current area	
Axis	B, B+, Mg-, Mg, Mg+, R, R+, Yl-, Yl, Yl+, G-, G, G+, Cy, Cy+, B-	16 hue angle zones	
Hue	-99~0~+99	Adjustment	
Saturation	-99~0~+99	Adjustment	

#### PAINT V MODULATION

white vertical sawtooth lens shading correction

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
V modulation	On, Off		
Master V modulation	-99~0~+99	Collective control	
R V modulation	-99~0~+99		
G V modulation	-99~0~+99		
B V modulation	-99~0~+99		

#### PAINT LOW KEY SATURATION

extra saturation control for dark bits

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Low key saturation	On, Off		Off <sup>18</sup>

<sup>17</sup> Aperture correction looked much more smooth and resulted in sharper pictures with fewer problems.

<sup>18</sup> Low key saturation can be useful when the noise level is low enough, use with care because it will worsen chroma noise, which might not be visible during the shoot.

Level	-99~0~+99	Collective control	
Range	Low, L.mid, H.mid, <u>High</u>	Same ranges as for Black Gamma	

### PAINT 17 NOISE SUPPRESS

Reduces hf noise

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Noise suppress	<u>On</u> , Off		On <sup>19</sup>

## MAINTENANCE

### MAINTENANCE WHITE SHADING

lens corrections

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Channel select	<u>Red</u> , Green, Blue	Select channel, lower items change	
R/G/B white H saw	-99~0~+99		
R/G/B white H para	-99~0~+99		
R/G/B white V saw	-99~0~+99		
R/G/B white V para	-99~0~+99		
White saw/para	<u>On</u> , Off	All on/off	On

### MAINTENANCE 02 BLACK SHADING

lens corrections

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Channel select	<u>Red</u> , Green, Blue	Select channel, lower items change	
R/G/B black H saw	-99~0~+99		
R/G/B black H para	-99~0~+99		
R/G/B black V saw	-99~0~+99		
R/G/B black V para	-99~0~+99		
Master black	-99~0~+99	All on/off	On
Master gain (TMP)	-3dB to 42dB	Gain changes, only for this operation	

### MAINTENANCE BATTERY

voltage parameters, sets warning levels

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Info Before end	<u>5</u> , 10, 15, ... 95, 100%	Change these only if you really know what you're doing	
Info End	<u>0</u> , 1, 2, 3, 4, 5%		
Sony Before end	<u>11.5V</u> ~17.0V		
Sony End	<u>11.0V</u> ~11.5V		
Other Before end	11.5V~ <u>11.8V</u> ~17.0V		
Other End	<u>11.0V</u> ~14.0V		
DC in Before end	11.5V~ <u>11.8V</u> ~17.0V		
DC in End	<u>11.0</u> ~14.0V		
Detected battery	Display only		
Type detection	<u>Auto</u> / Other		Auto allows auto detection of battery type
Segment no.10	11.0V~ <u>17.0V</u>	These settings are for when "Other" is selected. Each voltage is the value at which the numbered segment in the battery level indicator turns off	
Segment no.9	11.0V~ <u>16.0V</u> ~17.0V		
Segment no.8	11.0V~ <u>15.0V</u> ~17.0V		
Segment no.7	11.0V~ <u>14.0V</u> ~17.0V		
Segment no.6	11.0V~ <u>13.5V</u> ~17.0V		
Segment no.5	11.0V~ <u>13.0V</u> ~17.0V		
Segment no.4	11.0V~ <u>12.5V</u> ~17.0V		
Segment no.3	11.0V~ <u>12.0V</u> ~17.0V		
Segment no.2	11.0V~ <u>11.5V</u> ~17.0V		
Segment no.1	<u>11.0V</u> ~17.0V		

### MAINTENANCE AUDIO

Boring stuff starts here

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Front mic select	Mono/ <u>Stereo</u>		
Audio ch3/4 mode	Ch1/2, <u>Switch</u>	Which source routes through to ch3 and 4	
Rear XLR auto	<u>On</u> , Off	Auto signal detection for XLRs	
Front mic ch1 ref	-70, -60, <u>-50</u> , -40, -30dB		
Front mic ch2 ref	-70, -60, <u>-50</u> , -40, -30dB		
Rear mic ch1 ref	-70, -60, -50, -40, -30dB		
Rear mic ch2 ref	-70, -60, -50, -40, -30dB		
Line input ref	<u>+4</u> , 0, -3, EBUL		
Min alarm volume	<u>Off</u> , Set	Minimum volume for alarm, off=almost inaudible, set=just audible	

<sup>19</sup> Beware, noise suppression is effective in reducing noise, but can lose detail, see the test section below.

Speaker attenuate	<u>Off</u> , 3, 6, 9, 12dB	Speaker volume control, doesn't affect headphones	
Headphone out	<u>Mono</u> , Stereo		
Reference level	<u>-20</u> , -18, -16, -12dB, EBUL	1kHz tone level	
Reference out	<u>0</u> , +4, -2dB, EBUL		
Ch1&2 agc mode	<u>Mono</u> , Stereo	Channels 1/2 as two monos or stereo pair	
Ch3&4 agc mode	<u>Mono</u> , Stereo		
Agc spec	<u>-6</u> , -9, -12, -15, -17dB	AGC saturation level	
Limiter mode	<u>Off</u> , -6, -9, -12, -15, -17dB	Limiter level for manual control	
Output limiter	On, <u>Off</u>		
Ch1 wind filter	On, <u>Off</u>		
Ch2 wind filter	On, <u>Off</u>		
Ch3 wind filter	On, <u>Off</u>		
Ch4 wind filter	On, <u>Off</u>		
Audio SG (1kHz)	On, <u>Off</u> , Auto	On=1kHz on bars, Auto=1kHz when ch1 audio select switch (inside) is on Auto	
Mic ch1 level	Side1, <u>Front</u> , Front+Side1	Front=controlled by mic level control on front of camera, and so on	
Mic ch2 level	Side2, <u>Front</u> , Front+Side2		
Rear1/WRR level	Side1, <u>Front</u> , Front+Side1		
Rear2/WRR level	Side2, <u>Front</u> , Front+Side2		
Audio ch3 level	Side3, <u>Front</u> , Front+Side3		
Audio ch4 level	Side4, <u>Front</u> , Front+Side4		

#### MAINTENANCE WRR SETTING

Wireless radio mic

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
WRR Valid ch sel	<u>All</u> , Ch1	Enables both channels or just ch1	
WRR ch select	<u>Tx1</u> , Tx2		
WRR delay comp	On, <u>Off</u>	On delays sound by about 8mS	
TX		Displays selected transmitter number	
TX audio peak		Displays whether signal is limiting	
TX input level	Mic, Line	Displays whether channel is mic or line level	
TX att level			
TX LCF freq		Low cut filter	
TX system delay	<u>Auto</u> , 0~8ms		

#### MAINTENANCE TIMECODE

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
TC out	<u>Auto</u> , Generator		
DF/NDF	<u>DE</u> , NDF	Drop frame, only in NTSC-land	
LTC UBIT	<u>Fix</u> , Time	Fix=you set data, Time=records time	
Counter display	<u>Counter</u> , Duration		

#### MAINTENANCE ESSENCE MARK

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Ret shot mark 1	On, <u>Off</u>	Shot marking on card, see operations manual for details	
Ret shot mark 2	On, <u>Off</u>		
Index pic pos	<u>0</u> ~10 sec		
Find mode	<u>Clip</u> , Rec start		

#### MAINTENANCE CAMERA CONFIG

General stuff

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Rec tally blink	On, <u>Off</u>	Blinks tally at end of battery or disc	
Rec review	3, 10sec, <u>Clip</u>	Clip=show all the latest clip	
HDSDI remote i/f	<u>Off</u> , Chara, G-tally, R-tally	Control of remote recorder via HDSDI	
Color bars select	<u>Arib</u> , 100%, 75%, SMPTE	ARIB bars are actually better than SMPTE	Arib <sup>20</sup>
RM common memory	On, <u>Off</u>	Memory sharing for remote control box	
RM rec start	<u>RM</u> , Cam, Para	Record enable from remote control box	

#### MAINTENANCE PRESET WHITE

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Color temp <P>	1500~ <u>3200</u> ~50000K	White balance in Preset White	
C temp balance <P>	-99~ <u>0</u> ~+99	Fine control of preset white	
R gain <P>	-99~ <u>0</u> ~+99		
B gain <P>	-99~ <u>0</u> ~+99		

<sup>20</sup> SMPTE colour bars are the accepted standard form HDTV production, but ARIB are more useful, the PLUGE (black-setting) bars are at -2%, +2%, 4%, while SMPTE's are at -4%, +4%. Saturation check is still in blue, versus the grey horizontal bar.

AWB enable <P>	On, <u>Off</u>	Allows Preset to store an auto white balance	
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#### MAINTENANCE WHITE FILTER

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
ND filter C temp	On, <u>Off</u>	Allows a separate colour temperature setting for each ND filter position <b>BEWARE.</b> <sup>21</sup>	
ND flt C temp <1>	3200, 4300, 5600, 6300K		
ND flt C temp <2-4>	3200,4300, 5600, 6300K		
Electrical CC <A>	3200, 4300, 5600, 6300K	Electrical equivalent of colour temperature filters. Select ... in C and D to remove them	
Electrical CC <B>	3200, 4300, 5600, 6300K		
Electrical CC <C>	3200, 4300, 5600, 6300K, ...		
Electrical CC <D>	3200, 4300, 5600, 6300K, ...		

#### MAINTENANCE DCC ADJUST

Dynamic Contrast Control

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
DCC function select	<u>DCC</u> , Fix	DCC is like auto knee, Fix uses values below	
DCC dynamic range	400, 450, 500, 550, 600%	Exposure value the curve reaches in DCC <sup>22</sup>	
DCC point	-99~0~+99	Minimum knee point	
DCC gain	-99~0~+99		
DCC delay time	-99~0~+99	Reaction speed	
DCC peak filter	-99~0~+99	Sensitivity to peak exposure	

#### MAINTENANCE AUTO IRIS 2

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Iris window	1, 2, 3, 4, 5, 6, Var	Size of iris window, Var=variable below	
Iris window ind	On, <u>Off</u>	Frame marker for window	
Iris level	-99~0~+99	Target value	
Iris APL ratio	-99~0~+99	Ratio of peak to mean in detection	
Iris var width	40~500~999	Frame width in Variable	
Iris var height	70~500~999	Frame height in Variable	
Iris var H position	-470~0~+479	Centring	
Iris var V position	-464~0~+464		
Iris speed	-99~0~+99		
Clip high light	On, <u>Off</u>	Ignores brightest areas	

#### MAINTENANCE GENLOCK

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Genlock	On, <u>Off</u>		
H phase (HD)	-999~0~+999	Horizontal phase, HD	
H phase (SD)	-999~0~+999	Horizontal phase, SD	
Reference	Internal, Genlock	Display which genlock source is in use	

#### MAINTENANCE ND COMP

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
ND offset adjust	On, <u>Off</u>	Allows separate colour balance for each filter position	
Clear ND adjust	Exec		

#### MAINTENANCE LENS

Auto back focus

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Auto FB adjust	Exec	Works only with supported lenses	

#### MAINTENANCE AUTO SHADING

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Auto black shading	Exec	Start automatic black shading tweak	
Reset black shad	Exec	Clear ND filter compensations	
Master gain (tmp)	-6dB~42dB	Temporary gain for this adjustment	

#### MAINTENANCE APR

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
APR (SLS)	Exec	Suppress duff pixels in Slow Shutter	
APR preset	Exec		

#### MAINTENANCE TRIGGER MODE

<sup>21</sup> **BEWARE.** Use this feature **ONLY** if you intend to use only preset white balance. It applies a considerable offset to any white balancing you do.

<sup>22</sup> Note that DCC seems to use the full exposure range of the camera, while setting manual knee only extends up to about 250%.

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
i.Link trigger mode	Internal, <u>Both</u> , External	For recording to SxS, or i.Link (Firewire) device	

#### MAINTENANCE CLOCK SET

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Date/Time		Set current date and time	
12H/24H	12, <u>24H</u>		
Date mode	<u>YYMMDD</u> , MMDDYY, DDMMYY		

#### MAINTENANCE LANGUAGE

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Language	<u>English</u> , Chinese	Messages language	

#### MAINTENANCE HOURS METER

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Hours (sys)		Displays cumulative hours, cannot be reset	
Hours (reset)		Displays cumulative hours since last reset	
Reset	Exec		

#### MAINTENANCE VERSION

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Version		Displays firmware version	
Version up	Exec	Updates the firmware from SxS card	

## FILE

#### FILE ALL

None of this affects pictures or sound

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Display mode	<u>Date &amp; Time</u> , Model name	What appears in the file list	
All file load	Exec	All file stores everything	
All file save	Exec		
File ID	Exec	Up to 16 characters, description	
All preset	Exec	Return to Preset values	
Store all preset	Exec	Store current settings as preset	
Clear all preset	Exec	Clear to factory settings	
3 sec clr preset	On, <u>Off</u>	Allows Menu Cancel switch to clear presets	

#### FILE SCENE

less dangerous memory stick stuff

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
1		Up to 5 files in camera, 100 on a stick. Deals with Paint, shutter and white balance. Goes into sub-menu to do the load/save.	
2			
3			
4			
5			
Standard		Returns to standard setting	
Display mode	<u>Date &amp; Time</u> , Model name	What appears in the file list	
Scene recall mem	Exec	Brings up secondary menus to save/load scene files from internal memory	
Scene store mem	Exec		
Scene recall SxS	Exec	Brings up secondary menus to save/load scene files from SxS card	
Scene store SxS	Exec		
File ID		16 characters file name	

#### FILE REFERENCE

less dangerous memory stick stuff

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Reference store	Exec	Save REF file in from memory stick into camera	
Reference clear	Exec	Reset REF file to factory settings	
Reference load	Exec	Read REF file from memory stick	
Reference save	Exec	Save Ref file to memory stick	
File ID		16 characters file name	
Scene white data	On, <u>Off</u>	Allow/disallow white data in scene file	

#### FILE LENS FILE

<i>item</i>	<i>range</i>	<i>comment</i>	<i>BBC</i>
Display mode	<u>Date &amp; Time</u> , Model name	What appears in the file list	
Lens recall mem	Exec	Brings up secondary menus, load/save files to	

Lens store mem	Exec	internal memory	
Lens recall SxS	Exec	Brings up secondary menus, load/save files to SxS card	
Lens store SxS	Exec		
File ID		16 characters file name	
Source		Shows memory number of last loaded lens file	
Lens no offset	Exec	Clear the lens file	
Lens auto recall	<u>Off</u> , On, S.no	Enables auto loading of lens file, if lens can talk to the camera to identify itself	
Serial number		Display only	
Lens ID	Exec	Name of connected lens, if it can talk to the camera	
L. manufacturer	Exec	Manufacturer	
M V modulation	-99~0~+99	Vertical sawtooth lens compensation	
Lens center H	-40~0~40	Compensates horizontal position of lens centremarker And vertical	
Lens center V	-40~0~40		
Lens R flare	-99~0~+99		
Lens G flare	-99~0~+99		
Lens B flare	-99~0~+99		
Lens W-R ofst	-99~0~+99	White balance compensation	
Lens W-B ofst	-99~0~+99		
Shading ch select	<u>Red</u> , Green, Blue	Select channel	
L R/G/B H saw	-99~0~+99		
L R/G/B H para	-99~0~+99		
L R/G/B V saw	-99~0~+99		
L R/G/B V para	-99~0~+99		

## 2 Measurement results

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. This report is a combination of results obtained from a prototype and production models of the camera. Where measurements have been repeated for confirmation, the differences will be pointed out.

### 2.1 Sensitivity

Sensitivity was not measured directly on the prototype. The specification of the production model claims values for 2000lux illumination of a 89.9% reflectance card, F/11 at 59.94Hz, F/12 at 50Hz. On test, the production model was exposed to a 90% white card (the white side of a Kodak Gray card) with 216 lux illumination. In order to achieve 100% signal level with the ITU.709 gamma curve, the lens was set to F/2.4 and closed by about ¼ stop. Correcting for the illuminance level, the aperture for 2000 lux should then be F/8.5 and closed by about ¼ stop, i.e. about F/9.5. This is close enough to the specification value.

### 2.2 Colour performance, Gamma curves, Exposure range

Using a Colorchecker chart, the colour performance was judged to be very good with the standard ITU709 gamma curve. The yellow had the usual slight greenish tinge which is common in many cameras, but not unusually so. Skin tones were very good, and no specific colour stood out as being inaccurate. The picture did not seem to be as highly saturated as in other Sony cameras, and consequently was rather more acceptable. Clearly, the camera section is the same as the PMW350, and so conclusions about it should be the same.

The other gamma curves were not investigated since they are all copies of curves which have already been tested in other cameras.



Figure 1 Macbeth Colorchecker

Although the camera menus hint that 600% overexposure can be coped with by the Hypergamma curves, it was not possible to get such high levels by using the conventional gamma curves. The maximum overexposure which could be dealt with that way was about 1.5 stops, about 300%. The gamma settings in the menu reflect that. It is assumed that the Hypergamma curves really do cope with more overexposure.

The camera shows no response to infra-red illumination.

### 2.3 Resolution and aliasing, 1080-line

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 camera via HDSDI.

In 1080-interlaced mode, 1920x1080i/25 in EBU parlance, there are no visible null zones or aliases, the same as the PMW350. Resolution is well maintained horizontally and vertically, and there is clearly an optical spatial low pass filter to prevent aliasing. Vertical resolution falls cleanly, resulting from the interpolation process needed to generate interlace from a progressive sensor. Clearly, the sensors are full 1920x1080.

Since the resolution is quite clean, it is possible to use some detail enhancement to sharpen the pictures a little. Excessive levels of enhancement cause artificial brightening of the image due to asymmetric enhancements (separate control of positive- and negative-going edge gain is missing in this camera, although there are settings to limit the excursions, which isn't quite the same thing), and can cause null zones to appear where the enhancement is effectively adding a separate gamma correction as a function of frequency.

Detail settings were derived which sharpen the picture without suffering from such problems, detail level -5, aperture level +25. Normally, the Aperture function is a correction for the mathematically precise falling of resolution with frequency, as a result of the sensor sampling process, and a reasonably high level actually

does correct for this droop quite well. The Detail control is best thought of as an artistic control, because it is highly customisable and therefore quite difficult to get right. In this combination, the results work very well together.

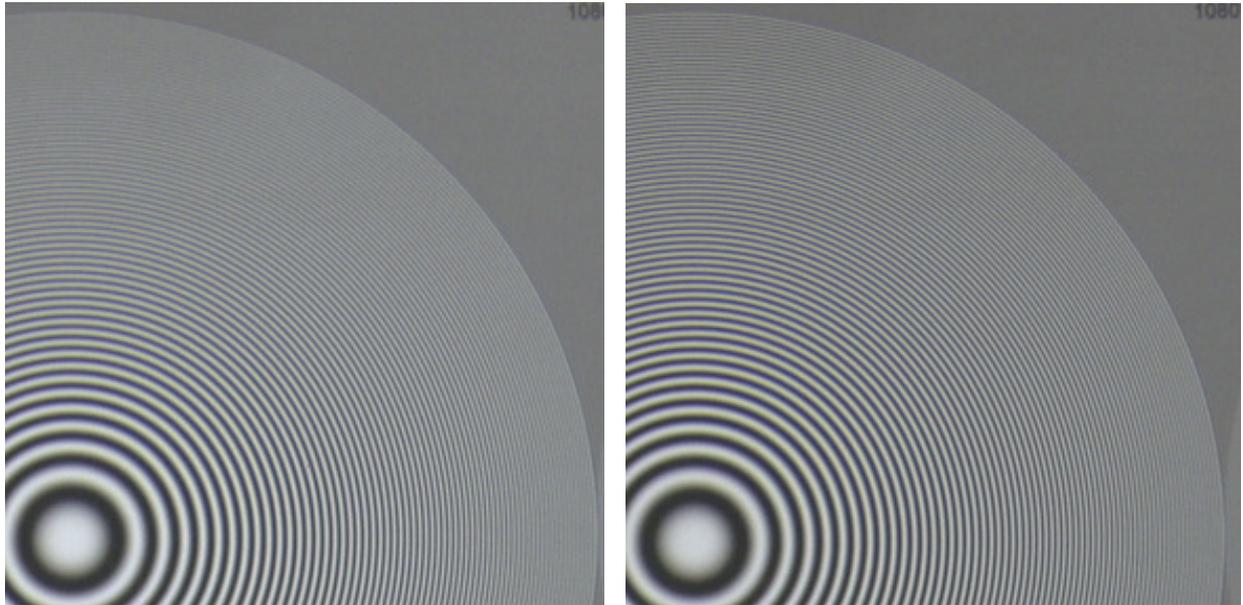


Figure 2 Resolution, detail off (a) 1080 interlaced (b) 1080 progressive

## 2.4 Resolution, 720-line

Performance at 720p was tested using the same zone plate chart, at the same framing, thus the 1280x720 image should not resolve more than the central 2/3 of the resolution pattern by both width and height. Again, detail enhancement was turned off for this test.

There is little or no evidence of aliasing from the higher horizontal frequencies, clearly the down-sampling has been done rather well. The coloured vertical aliasing is a puzzle, and the level of it is rather disturbing.

## 2.5 Resolution, SD 576-line

The prototype camera had been fitted with the CBK-MD02 option for SD recording and playback, but the production model wasn't. Therefore, although measurements had been done on the prototype camera, it was not possible to confirm them on the production model. However, there is no reason to suppose that there would be any difference.

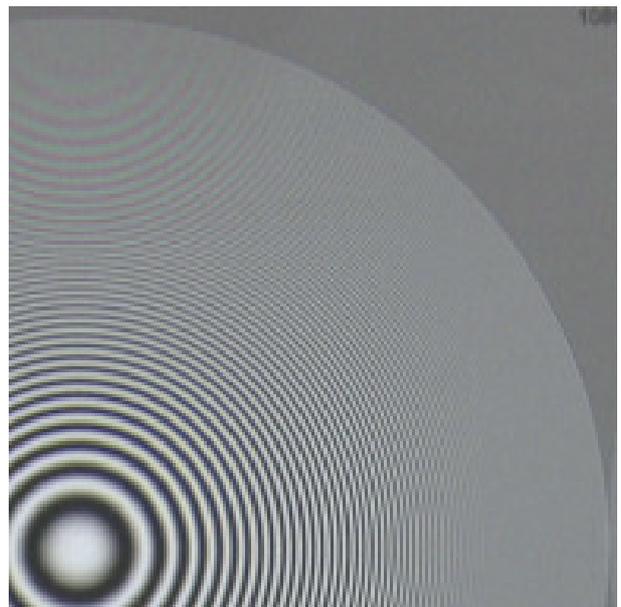


Figure 3 Resolution, 720p, detail off

Performance at SDTV was tested in the same way, thus only a small central portion of the chart should be preserved, approximately 37% by 53%. This test was made with the down-converter detail enhancer set to factory values. Clearly, the horizontal down-scaling from 1920 to 720 pixels has been done quite well, there is little or no aliasing visible except near the 720 extinction frequency, which is normal. But, vertically, there is a clear aliasing visible. Vertical frequency content appears to have been re-sampled twice, since the centre of the alias pattern has been moved from 1080 to 540-lines, using a filter which does not adequately reject the higher frequencies.

Since the alias content from the higher frequencies is being presented as lower frequencies, they cannot subsequently be rejected by any normal processing, and the factor setting for SD detail enhancement emphasises this content significantly, and unacceptably.

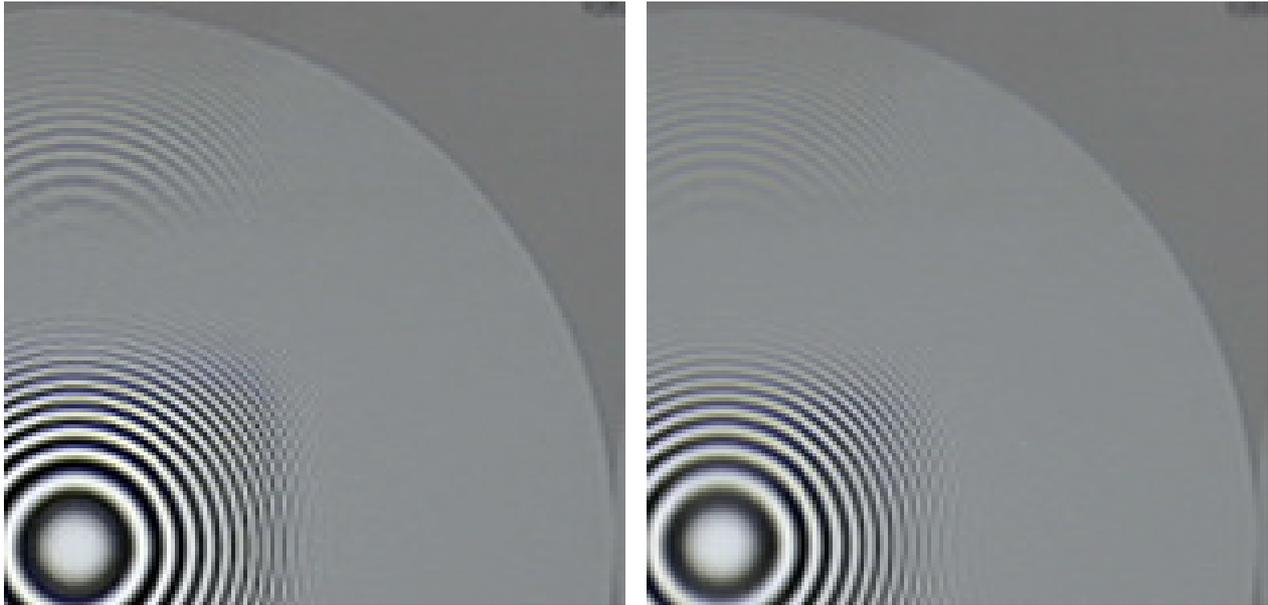


Figure 4 Resolution, 576i (a) factory detail

(b) optimised detail

The optimised settings for down-conversion considerably improve the appearance of the aliasing, but cannot eliminate them altogether.

While the SD performance is adequate, it is not as good as is possible with sufficiently complex down-conversion re-sampling filters.

Note that, for shooting in SD mode, the camera needs to have an option card, CBK-MD01, installed (or enabled). The camera can be set in HD mode (such that the SDI output is SD), and yet record SD, which does not produce the best results. For best SD performance, the camera must be set to SD such that the SDI output is SD.

## 2.6 Video Noise

The specification for the PMW500 claims that video noise level is -54dB, or -59dB with noise suppression switched on.

Measurements were taken on an evenly lit white card, exposed at various levels. Image files were captured via HDSDI as data files, then trans-coded and decoded in software before performing a software noise analysis. 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 6dB compensation has been applied to the results, such that the graph is representative of the camera performance at normal 0dB gain setting.

Fig.5 shows the noise levels when the camera is set to 0dB gain, and noise suppression switched off. Unusually, the level drops near black. In theory, the noise level should rise in direct proportion to the slope of the gamma curve, and thus should be about 13dB higher near black than near white. One possible cause for this effect is gamma-correction done in the linear domain, before the ADCs, but that seems unlikely in this camera, alternately, there may be some noise

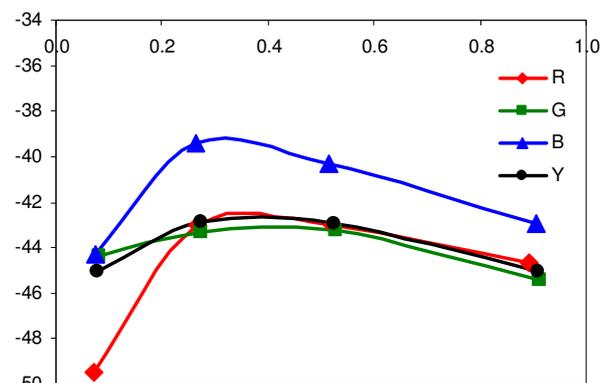


Figure 5 Noise at 0dB, unsuppressed

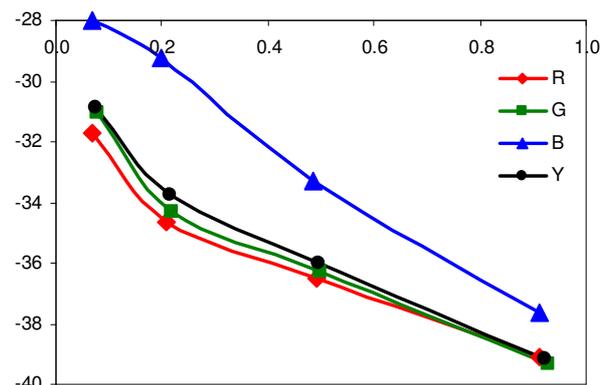


Figure 6 Noise at +12dB, unsuppressed

suppression going on, of which the user is normally unaware.

As expected, blue is consistently 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).

When the gain was switched to +12dB, the results was much more as expected, Fig.6. Note that the noise at mid-grey (50% video level) is about -36dB at +12dB gain, while the equivalent noise level at 0dB gain is 44dB, only 8dB lower. Thus, video noise is not directly related to camera gain setting, which again could be evidence of some unreported noise suppression in the camera.

Fig. 7 shows the noise levels at +12dB camera gain, when noise suppression is switched on. Apart from the blue signal, noise is reduced by about 3.5dB, less near white, more near black. The price to be paid for this reduction of noise levels is a little softening of the picture. Less noise reduction takes place at lower camera gains.

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).

Noise at SD (Fig.8, measured in the prototype) is very low level, -58dB at mid-grey, and the shape of the curves has changed, presumably the result of the spatial filtering and re-sampling involved in the down-conversion process.

The noise suppression is effective, but has lost some resolution, and has left a rather plastic appearance to noise in the plain area. There are also some noise spikes which have escaped the noise suppressor, which has probably become confused by the zone plate signal itself. Nevertheless, noise suppression is worth having provided the resolution loss can be tolerated.

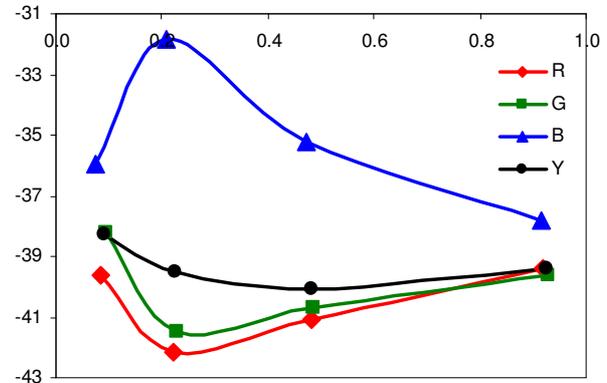


Figure 7 Noise at +12dB gain, suppression on

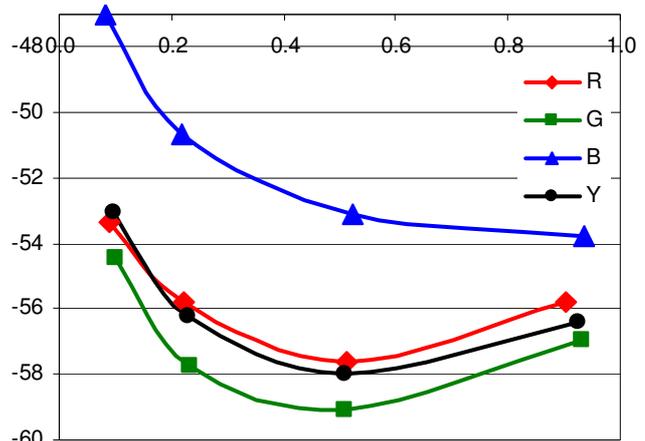


Figure 8 Noise, SD, suppression on (prototype)

## 2.7 Conclusion

The camera performs well in all aspects. The best recording format is considered to be acceptable for top quality broadcast HDTV (50Mb/s is considered to be the minimum acceptable rate for MPEG-2). SD performance is not quite as good as it could be, but is quite adequate for most purposes. 720p performance is a little confusing, it is not as good as it should be. Noise performance is ambiguous.