Colorimetric and Resolution requirements of cameras

Alan Roberts

ADDENDUM 54 rev 1 : Tests and Settings on a Sony PMW 320

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 PMW-320. This is a 1080-line camcorder, of typical broadcast size but with much lower power consumption (18W). 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 CMOS sensors and thus should show rolling shutter effects. It is identical to the PMW350 camera, apart from having ½" format sensors rather than the ⅔" of the PMW350. Both cameras have the same digital signal processing as the PDW700, and have almost identical menus and performance.

It records full 1920x1080 images with 4:2:2 colour sub-sampling at 35Mb/s (MPEG-2), and at lower rates with lower resolution. Recording is onto Sony SxS cards which fit into two computer PCMCIA Express slot in the camera. The compression system was not tested, but is already well known and understood.

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).

No specific documentation was available for this camera during the tests, but the menu structure appears to be identical to that for the PMW350, so the menus listed here are those of the 350, with modifications only where specific items were noted to be different. In any revision of this document, the menu details will be checked against proper documentation.

This revision contains settings for ungraded use, and for News shooting to match existing SD practice in BBC News.

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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.

Ther4e 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

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
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 FORMAT

item	*range*	*comment*	*BBC*
HD/SD	HD, SD	SD allowed only when CBK-DV01 is installed	
HD system line	1080, 720	Pretty obvious	
System frequency	1080, not PAL area: 59.94i, 29.97p, 23.98p	Lots of options	
	720, not PAL area: 59.94i, 29.97p, 23.98p		
	SD, not PALarea: 59.94i, 29.97p		
	1080, PAL area: 50i, 25p		
	SD, PAL area: 50p, 25p		
Rec format	1080, 29,97P or 50P: HQ1920, HQ1440	Affects bit-rates as well as format[1]	HQ
	1080, not 29.97P or 50p: HQ1920, HQ1440, SP1440		
	720: HQ1280		
	SD: DVCAM		

OPERATION 02 FORMAT MEDIA Card formatting

item	*range*	*comment*	*BBC*
Media (A)	Execute, Cancel	Formats the cards	
Media (B)	Execute, Cancel		

OPERATION 03 INPUT/OUTPUT

item	*range*	*comment*	*BBC*
Output & i.Link	HD&HDV, SD&HDV, SD&DV, 480p or 576p	Set the outputs on the HD and Firewire/i.Link connectors	
23.98 Output	PsF, Pull down	Nice to see choices like these	
Source select	Camera, i.Link		
i.Link I/O	Enable, Disable		
SDI output	On, Off	Saves power	
HDMI output	On, Off		
SDI/HDMI out super	On, Off	Adds screen text to outputs for monitoring	
Video out super	On, Off		
Down converter	Crop, Letter, Squeeze		
Wide ID	Through, Auto	Adds wide-screen ID flag to SD output	

OPERATION 04 SUPER IMPOSE Characters and markers on outputs

item	*range*	*comment*	*BBC*
Super (VF display)	On, Off		
Super (menu)	On, Off		
Super (timecode)	On, Off		
Super (marker)	On, Off		

OPERATION 05 REC FUNCTION Recording stuff

item	*range*	*comment*	*BBC*

[1] 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.

Slow & Quick	On, Off	Off-speed operation, disables the cache store	
Frame rate	1080, not PAL area: 1~30	Available only when Slow & Quick is on. Off-speed shooting	
	1080, PAL area: 1~25~30		
	720, not PAL area: 1~30~60		
	720, PAL area: 1~25~60		
Picture cache rec	On, Off	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, Off	Disables Slow & Quick, Cache, and Frame rec	
Frame rec	On, Off	Disables Slow & Quick, Cache, and Interval rec	
Number of frames	720, 59.94 or 50: 2, 6, 12 frames	Frames to be recorded in Interval rec or Frame rec	
	720, not 59.94 or 50: 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	Off, 2, 5, 10sec	Turns camera light on before recording	

OPERATION 06 ASSIGNABLE SW Set the user switches

item	*range*	*comment*	*BBC*
0	Off, 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	Off, Front mic, Marker, Last clip delete, ATW, ATW hold, EZ mode, Turbo gain, rev 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, Digital extender		
2	Off, Front mic, Marker, Picture cache, Zebra, Digital extender		
3	(Same list as for Switch 1)		
4			
5			
RET	Off, 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 07 VF SETTING The viewfinder

item	*range*	*comment*	*BBC*
Colour	-99~0~+99	Saturation	
Mode	Color, B&W		
Peaking type	Normal, Color, Both	Color adds false colour to sharp edges	
Peaking frequency	Normal, High		
Peaking color	White, Red, Yellow, Blue	False colour peaking	
Peaking level	Low, Mid, High		
DXF rec tally	Upper, Both	Which tally to use on non-Sony vf	

OPERATION 08 MARKER Items in the viewfinder

item	*range*	*comment*	*BBC*
Setting	On, Off	All markers	
Center marker	1, 2, 3, 4, Off	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, 1/1.85, 1/2.35, 1/2.4		14:9
User box	On, Off		
User box width	400~500~999		
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 09 GAIN SWITCH

item	*range*	*comment*	*BBC*

Gain low	-3, 0, 3, 6, 9, 12, 18, 24, 30dB		-3
Gain mid	-3, 0, 3, 6, 9, 12, 18, 24, 30dB		0
Gain high	-3, 0, 3, 6, 9, 12, 18, 24, 30dB		+6
Gain turbo	-3, 0, 3, 6, 9, 12, 18, 24, 30dB		+12
Shockless gain	On, Off		

OPERATION 10 TLCS Total Level Control system

item	*range*	*comment*	*BBC*
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	F5.6[2]

OPERATION 11 ZEBRA

item	*range*	*comment*	*BBC*
Zebra select	1, 2, Both		
Zebra 1 level	50~70~107%		70[3]
Zebra aperture level	1~10~20%	Zebra width	
Zebra 2 level	52~100~109%		100

OPERATION 12 DISPLAY ON/OFF

item	*range*	*comment*	*BBC*
Video warning levels	On, Off	High/low video level warnings	
Brightness display	On, Off	Numerical video level	
Histogram display	On, Off	Very useful	
Lens info	Off, Meter, Feet		
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		
Clip number (PB)	On, Off		

OPERATION 13 AUTO IRIS

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

OPERATION 14 WHITE SETTING

[2] Beyond F/5.6, resolution will start to fall through iris diffraction. This is normal for ½" sensors.

[3] Set lowish to encourage mild underexposure for film-type shooting. Set it a little higher for normal video work.

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

OPERATION 15 OFFSET WHITE Modifications to white balance

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

OPERATION 16 SHUTTER SELECT

item	*range*	*comment*	*BBC*
Shutter select	Second, Degree	Show shutter time as…	

OPERATION 17 TIME ZONE

item	*range*	*comment*	*BBC*
Zone	-12.00~00.00~+14.00	In 30 minute steps	

OPERATION 18 Clip White balance stores

item	*range*	*comment*	*BBC*
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 01 SWITCH STATUS main controls

item	*range*	*comment*	*BBC*
Gamma	On, Off		On
Black gamma	On, Off		Off[4]
Matrix	On, Off		On
Knee	On, Off		On
White clip	On, Off		{film} Off[5] {video, HDu, SDu, news} On
Detail	On, Off		On
Aperture	On, Off		On
Flare	On, Off		
Test saw	On, Off	Analogue sawtooth	

PAINT 02 WHITE colour temperatures stored by the WHITE A/.B switch

item	*range*	*comment*	*BBC*
Color temp <A>	Display temp K	Shows current white balance in A	
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	
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 03 BLACK master black settings

item	*range*	*comment*	*BBC*
Master black	-99~0~+99		
R black	-99~0~+99		
B black	-99~0~+99		

[4] Black stretch is ok for digging detail from the shadows, but only if the noise level is low enough, use with care.

[5] Set clipping on for live/as-live shooting with no grading.

PAINT 04 FLARE Flare control

item	*range*	*comment*	*BBC*
Flare	On, Off		
Master flare	-99~0~+99		
R flare	-99~0~+99		
G flare	-99~0~+99		
B flare	-99~0~+99		

PAINT 05 GAMMA main gamma controls

item	*range*		*comment*	*BBC*
Gamma	On, 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 ~ 5 ~ 6	4=SMPTE240 (4x), 5=ITU709 (4.5x), 6=BBC (5x)[6]	{video, HDu, news} 5 {SDu} 6
	HG	1~4	Hypergammas for cine-look	{film} HG[7]
Gamma category	STD, HG			

PAINT 06 BLACK GAMMA independent slope at black

Item	*range*	*comment*	*BBC*
Black gamma	On, Off		On[8]
Gamma level	-99~0~+99	Raises ITU709 slope to about 7.5x	28 {news} -50[9]
Range	Low/ L.mid/ H.mid/ High	Low=to 3.6%, L.Mid=to 7.2%, H.mid=to 14.4%, High=to 28.8%	H.mid

PAINT 07 KNEE highlight compression

item	*range*	*comment*	*BBC*
Knee	On, Off		{film} Off {video, HDu, SDu, news} On
Knee point	50~95~109%	One soft bend	{film} 75% {video} 85% {news} 95%
Knee slope	-99~0~+99	Affects segment slope, slightly curved	{film} -23[10] {video} -35[11] {news} +30
Knee saturation	On, Off		On[12]
Knee saturation level	-99~0~+99		0

PAINT 08 WHITE CLIP highlight clipping

item	*range*		*comment*	*BBC*
White clip	On, Off			Off[13]
White clip level	NTSC area	90.0~108.0~109.0%		104%
	PAL area	90.0~105.0~109.0%		

PAINT 09 DETAIL (HD MODE)

[6] 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.

[7] 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.

[8] 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.

[9] BBC News likes to use this to compress shadows, automatically obtaining a black level in the pictures.

[10] 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.

[11] 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.

[12] Knee saturation helps to keep colours looking right when they're compressed in the knee.

[13] 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.

item	*range*	*comment*	*BBC*
Detail	On, Off	All DETAIL compensation	On
Level	-99~0~+99	Overall level	-5[14]
H/V level	-99~0~+99	Changes mix of horizontal and vertical sharpening	0
Crispening	-99~0~+99	Signal level range that gets crispened	
Level depend	On, Off	Detail level dependency	
Level depend level	-99~0~+99	Detail level range affected	
Frequency	-99~0~+99	Frequency of detail compensation	+99
Knee aperture	On, Off	Extra detail above knee point	Off
Knee aperture level	-99~0~+99		
Limit	-99~0~+99		
White limit	-99~0~+99	Detail +ve excursion limit	
Black limit	-99~0~+99	Detail –ve excursion limit	
V detail creation	NAM, G, R+G, Y	Source for edge detection	

PAINT 11 DETAIL (SD MODE)

item	*range*	*comment*	*BBC*
Detail	On, Off	All DETAIL compensation	On
Level	-99~0~+99	Overall level	-30[15]
H/V level	-99~0~+99	Changes mix of horizontal and vertical sharpening	-97
Crispening	-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 detail creation	NAM, G, R+G, Y	Source for edge detection	

PAINT 12 APERTURE

item	*range*	*comment*	*BBC*
Aperture	On, Off	Separate APERTURE correction	On
Level	-99~0~+99	Overall level	25[16]

PAINT 13 SKIN DETAIL

item	*range*	*comment*	*BBC*
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 14 MATRIX camera matrix

item	*range*	*comment*	*BBC*
Matrix	On, Off	All matrices	On
Preset matrix	On, Off	Standard matrices	On
Preset select	1 ~ 2 ~6	1=SMPTE240, 2=ITU709, 3=SMPTE-WIDE, 4=NTSC, 5=EBU(i.e.PAL), 6=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 15 MULTI MATRIX multi-linear matrix, for advanced knob twiddlers only

[14] This is a reasonable setting for Detail enhancement, but it causes some spatial aliasing, see test section below.

[15] This is a good setting for Detail enhancement, higher levels cause some spatial aliasing, see test section below.

[16] Aperture correction looked much more smooth and resulted in sharper pictures with fewer problems.

item	*range*	*comment*	*BBC*
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 16 V MODULATION white vertical sawtooth lens shading correction

item	*range*	*comment*	*BBC*
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 17 LOW KEY SATURATION extra saturation control for dark bits

item	*range*	*comment*	*BBC*
Low key saturation	On, Off		Off[17]
Level	-99~0~+99	Collective control	
Range	Low, L.mid, H.mid, High	Same ranges as for Black Gamma	

PAINT 18 NOISE SUPPRESS Reduces hf noise

item	*range*	*comment*	*BBC*
Noise suppress	On, Off		On[18]

MAINTENANCE

MAINTENANCE 01 WHITE SHADING lens corrections

item	*range*	*comment*	*BBC*
Channel select	Red, 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	On, Off	All on/off	On

MAINTENANCE 02 BLACK SHADING lens corrections

item	*range*	*comment*	*BBC*
Channel select	Red, 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 03 BATTERY voltage parameters, sets warning levels

item	*range*	*comment*	*BBC*
Info Before end	5, 10, 15, … 95, 100%	Change these only if you really know what you're doing	
Info End	0, 1, 2, 3, 4, 5%		
Sony Before end	11.5V~17.0V	Change these only if you really know what you're doing	
Sony End	11.0V~11.5V		
Other Before end	11.5V~11.8V~17.0V		
Other End	11.0V~14.0V		
DC in Before end	11.5V~11.8V~17.0V		
DC in End	11.0~14.0V		
Detected battery	Display only		
Type detection	Auto, Other	Auto allows auto detection of battery type	Auto
Segment no.10	11.0V ~ 17.0V	These settings are for when "Other" is selected. Each	

[17] 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.

[18] Beware, noise suppression is effective in reducing noise, but can lose detail, see the test section below.

Segment no.9	11.0V~16.0V~ 7.0V	voltage is the value at which the numbered segment in the battery level indicator turns off	
Segment no.8	11.0V~15.0V~7.0V		
Segment no.7	11.0V~14.0V 17.0V		
Segment no.6	11.0V~13.5V~17.0V		
Segment no.5	11.0V~13.0V~17.0V		
Segment no.4	11.0V~12.5V~17.0V		
Segment no.3	11.0V~12.0V~17.0V		
Segment no.2	11.0V~11.5V~17.0V		
Segment no.1	11.0V~17.0V		

MAINTENANCE 04 AUDIO Boring stuff starts here

item	***range***	***comment***	***BBC***
Front mic select	Mono, Stereo		
Audio ch3/4 mode	Ch1/2, Switch	Which source routes through to ch3 and 4	
Front mic ch1 ref	-70, -60, -50, -40, -30dB		
Front mic ch2 ref	-70, -60, -50, -40, -30dB		
Rear mic ch1 ref	-70, -60, -50, -40, -30dB		
Rear mic ch2 ref	-70, -60, -50, -40, -30dB		
Line input ref	+4, 0, -3, EBUL		
Min alarm volume	Off, Set	Minimum volume for alarm, off=almost inaudible, set=just audible	
Speaker attenuate	Off, 3, 6, 9, 12dB	Speaker volume control, doesn't affect headphones	
Headphone out	Mono, Stereo		
Reference level	-20, -18, -16, -12dB, EBUL	1kHz tone level	
Reference out	0, +4, -2dB, EBUL		
Ch1&2 agc mode	Mono, Stereo	Channels 1/2 as two monos or stereo pair	
Ch3&4 agc mode	Mono, Stereo		
Agc spec	-6, -9, -12, -15, -17dB	AGC saturation level	
Limiter mode	Off, -6, -9, -12, -15, -17dB	Limiter level for manual control	
Output limiter	On, Off		
Ch1 wind filter	On, Off		
Ch2 wind filter	On, Off		
Ch3 wind filter	On, Off		
Ch4 wind filter	On, Off		
Au sg (1kHz)	On, Off, Auto	On=1kHz on bars, Auto=1kHz when ch1 audio select switch (inside) is on Auto	
Mic ch1 level	Side1, Front, Front+Side1	Front=controlled by mic level control on front of camera, and so on	
Mic ch2 level	Side2, Front, Front+Side2		
Rear1/WRR level	Side1, Front, Front+Side1		
Rear2/WRR level	Side2, Front, Front+Side2		
Audio ch3 level	Side3, Front, Front+Side3		
Audio ch4 level	Side4, Front, Front+Side4		

MAINTENANCE 05 WRR SETTING Wireless radio mic

item	***range***	***comment***	***BBC***
WRR Valid ch sel	All, Ch1	Enables both channels or just ch1	
WRR ch select	Tx1, Tx2		
WRR delay comp	On, Off	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	Auto, 0~8ms		

MAINTENANCE 06 TIMECODE

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

MAINTENANCE 07 ESSENCE MARK

item	***range***	***comment***	***BBC***
Ret shot mark 1	On, Off	Shot marking on card, see operations manual for details	
Ret shot mark 2	On, Off		

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.

MAINTENANCE 08 CAMERA CONFIG General stuff

item	*range*	*comment*	*BBC*
Rec tally blink	On, Off	Blinks tally at end of battery or disc	
Rec review	3, 10sec, Clip	Clip=show all the latest clip	
HDSDI remote i/f	Off, Chara, G-tally, R-tally	Control of remote recorder via HDSDI	
Color bars select	Arib, 100%, 75%	ARIB bars are actually better than SMPTE	Arib[19]
RM common memory	On, Off	Memory sharing for remote control box	
RM rec start	RM, Cam, Para	Record enable from remote control box	
Image invert	On, Off	Vertical mirroring	

MAINTENANCE 09 PRESET WHITE

item	*range*	*comment*	*BBC*
Color temp <P>	1500~3200~50000K	White balance in Preset White	
C temp balance <P>	-99~0~+99	Fine control of preset white	
R gain <P>	-99~0~+99		
B gain <P>	-99~0~+99		
AWB enable <P>	On, Off	Allows Preset to store an auto white balance	

MAINTENANCE 10 WHITE FILTER

item	*range*	*comment*	*BBC*
ND filter c temp	On, Off	Allows a separate colour temperature setting for each ND filter position. BEWARE.[20]	
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 11 DCC ADJUST

item	*range*	*comment*	*BBC*
DCC function select	DCC, Fix	DCC is auto knee, Fix uses values below	
DCC dynamic range	400, 450, 500, 550, 600%	Exposure value the curve reaches in DCC[21]	
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 12 AUTO IRIS 2

item	*range*	*comment*	*BBC*
Iris window	1, 2, 3, 4, 5, 6, Var	Size of iris window, Var=variable below	
Iris window ind	On, Off	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 pos	-470~0~+479	Centring	
Iris var V pos	-464~0~+464		
Iris speed	-99~0~+99		
Clip high light	On, Off	Ignores brightest areas	

MAINTENANCE 13 FLICKER REDUCE

item	*range*	*comment*	*BBC*
Mode	Auto, On, Off	Auto enables it when flicker's detected	
Frequency	60, 50Hz	Select lighting frequency	

MAINTENANCE 14 GENLOCK

item	*range*	*comment*	*BBC*
H phase (HD)	-999~0~+999	Horizontal phase, HD	

[19] 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.

[20] 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.

[21] Note that DCC seems to use the full exposure range of the camera, while setting manual knee only extends up to about 250%.

H phase (SD)	-99~0~+99	Horizontal phase, SD	
Reference	Internal/ Genlock		

MAINTENANCE 15 ND COMP

item	*range*	*comment*	*BBC*
ND offset adjust	On, Off	Allows separate colour balance for each filter position	
Clear ND adjust	Exec		

MAINTENANCE 16 LENS Auto back focus

item	*range*	*comment*	*BBC*
Auto FB adjust	Exec	Works only with supported lenses	

MAINTENANCE 16 AUTO SHADING

item	*range*	*comment*	*BBC*
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 17 TRIGGER MODE

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

MAINTENANCE 17 CLOCK SET

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

MAINTENANCE 18 LANGUAGE

item	*range*	*comment*	*BBC*
Language	English, Chinese		

MAINTENANCE 19 HOURS METER

item	*range*	*comment*	*BBC*
Hours (sys)		Displays cumulative hours, cannot be reset	
Hours (reset)		Displays cumulative hours since last reset	
Reset	Exec		

MAINTENANCE 20 VERSION

item	*range*	*comment*	*BBC*
Version		Displays firmware version	
Version up	Exec	Updates the firmware	

FILE

FILE 01 ALL None of this affects pictures or sound

item	*range*	*comment*	*BBC*
Display mode	Date & Time, 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, Off	Allows Menu Cancel switch to clear presets	

FILE 04 SCENE FILE less dangerous memory stick stuff

item	*range*	*comment*	*BBC*
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	Date & Time, 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		
F.ID		16 characters file name	

FILE 03 REFERENCE less dangerous memory stick stuff

item	***range***	***comment***	***BBC***
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	
F.ID		16 characters file name	
Scene white data	On, Off	Allow/disallow white data in scene file	

FILE 04 LENS FILE

item	***range***	***comment***	***BBC***
Display mode	Date & Time, Model name	What appears in the file list	
Lens recall mem	Exec	Brings up secondary menus, load/save files to internal memory	
Lens store mem	Exec		
Lens recall SxS	Exec	Brings up secondary menus, load/save files to SxS card	
Lens store SxS	Exec		
F.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	Off, On, S.no	Enables auto loading of lens file, if lens can talk to the camera to identify itself	
Lens ID	Exec	Name of connected lens, if it can talk to the camera	
Lens 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	
Lens center V	-40~0~40	And vertical	
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	Red, Green, Blue	Select channel	
Lens R/G/B H saw	-99~0~+99		
Lens R/G/B H para	-99~0~+99		
Lens R/G/B V saw	-99~0~+99		
Lens 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.

2.1 Sensitivity

Sensitivity was not measured directly. The specification claims F/10 at 2000lux for 59.94Hz, F/11 for 50Hz, about ⅔ stop less than the PMW350. Since the light input to ½" sensors is only 50% of that for ⅔" sensors, this must mean that the 320 has rather more analogue gain before the processing, so should be a little more noisy.

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 many other Sony cameras, and consequently was rather more acceptable.

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

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 control unit via HDMI converted to HDSDI. Tests were made at F/2.8, and with focal lengths from 5mm to 20mm, showing no change, with noise suppression switched on, since this is the lilely mode for general use of the camera.

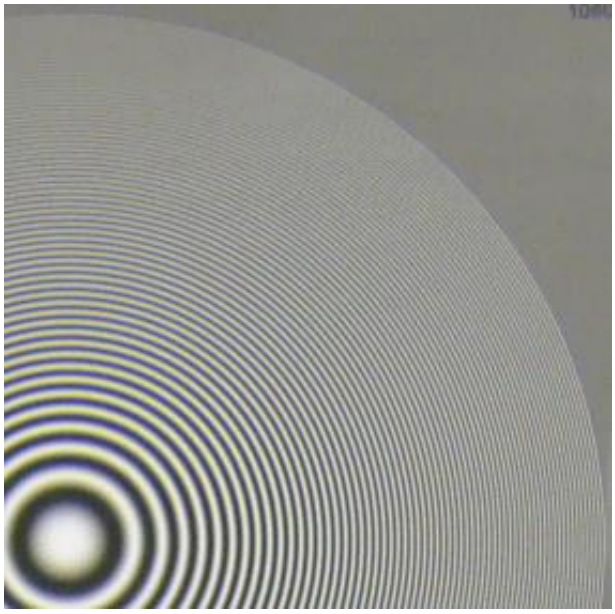

Figure 1 Resolution, 1080 interlaced

In 1080-interlaced mode, 1920x1080i/25 in EBU parlance, there are no visible null zones or aliases. 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.

The similarity in performance with the PMW350 is striking, nothing appears to have been lost by reducing the size of the image sensors, apart from noise (see below). With this in mind, further testing was simplified, only a few examples were recorded for inclusion here

In 1080-progressive mode, there is clearly more vertical resolution, but very slightly less than for the 350. This difference is most probably due to the effect of filtering in the noise suppression system. It is not excessive.

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 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.

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 frequencies, clearly the down-sampling has been done rather well. There is a vertical null zone centred on 630 lines, and a fainter one centred on 960 lines. The one at 960 is due to third harmonic distortion of the sensor's 1080-line vertical resolution (the camera gamma does not exactly match the gamma of the print medium). The one at 630 is due to the same distortion, but this time of the output format's 720-line structure. Neither should be any problem in real use.

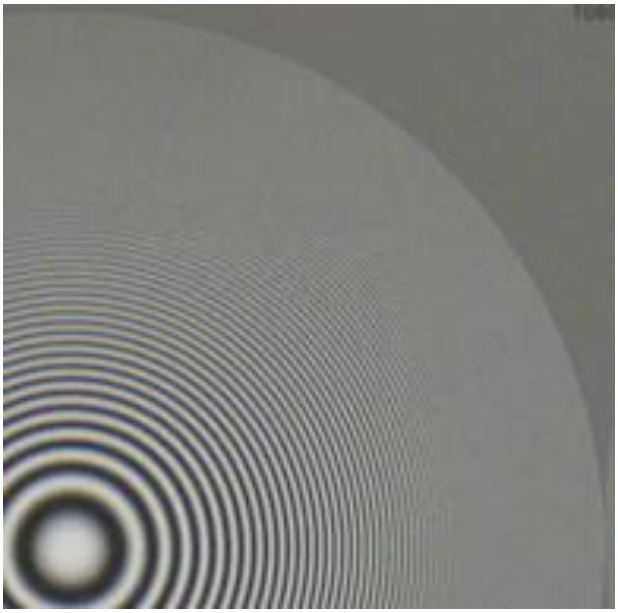

Figure 2 Resolution, 720p

Performance at 720p is good, slightly better than for the PMW350, probably because the 1080 performance of the 320 is not quite as good as that of the 350, but this may be illusory if the difference is due to the effects of the noise suppressor.

2.5 Resolution, SD 576-line

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%.

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 resampled 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.

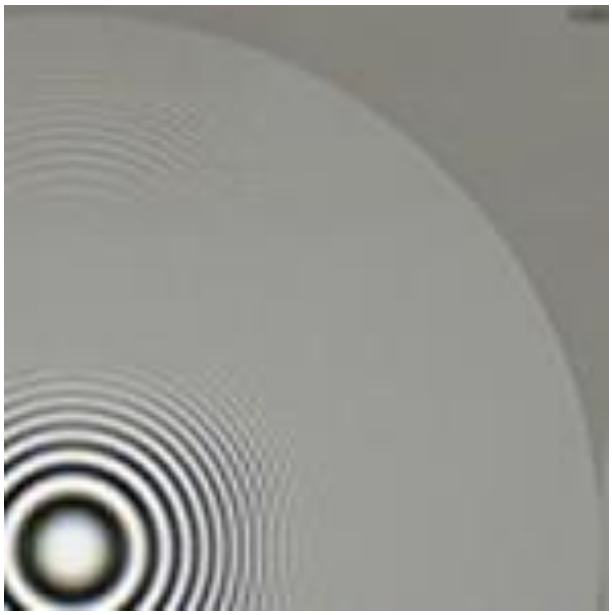

Figure 3 Resolution, SD 576i

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 resampling filters.

2.6 Video Noise

The specification claims that video noise level is -54dB, or -57dB 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 transcoded and decoded in software before performing a software noise analysis. The plot shows the noise level in dB versus video signal level, with noise suppression switched on. Measurements were not made with suppression off, since the noise suppression is known to provide about 6dB improvement and the camera is unlikely to be used without suppression.

In order to make the measurements more certain, the camera gain was set to +9dB, and the results modified by 9dB to compensate. Also, the measurement files were high-pass filtered to remove any image shading and tilt, and a further 6dB gain applied to avoid any effects due to premature data quantising. So, a further 6dB compensation has been applied to the results, so the graph is representative the camera performance at normal 0dB gain setting.

As expected, blue is considerably more noisy, because silicon is much less sensitive to blue than red. The distribution of noise level versus signal level should, ideally, follow the slope of the gamma curve (ITU709 in this case). Noise levels near black should rise significantly, and the curves shown are as expected for a camera with gamma-correction done in the digital domain, and without any image processing to gain a noise advantage at the expense of resolution. However, the rise in noise levels near white are unexpected in a camera with ⅔" sensors. The normal explanation for a rise near white is shot noise, but that should only be relevant in cameras with significantly smaller sensors.

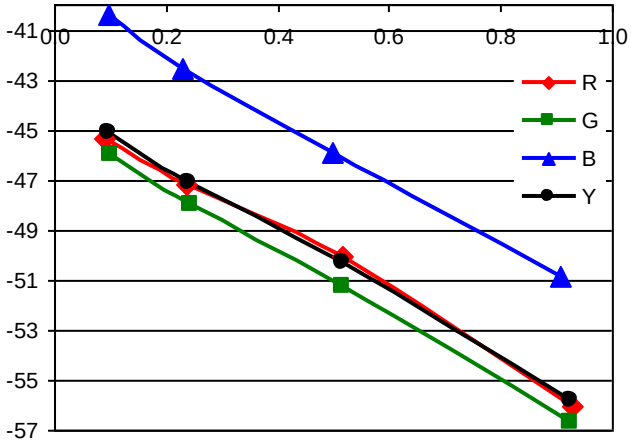

Figure 4 Noise levels, HD, suppression on

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 this value). The luma noise value at mid-grey about -50dB. The effect of noise reduction appears to be near uniform across the signal range, unlike in the PMW350. This is one of the few differences between the two cameras.

The noise suppression is effective, but loses some resolution, and can leave a rather plastic appearance to noise in plain areas. Nevertheless, the noise suppression is effect and worth having.

Noise performance at SD (576i) is significantly better, by 5 to 6dB, noise level is about -56dB at mid-grey. The loss of resolution caused by noise suppression is less relevant at SD resolution.

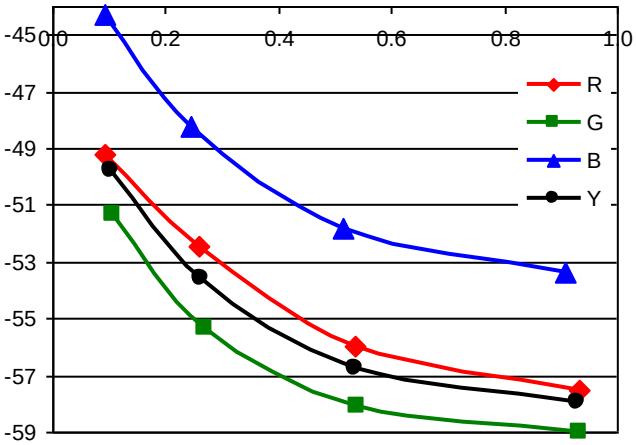

Figure 5 Noise levels, SD, suppression on

2.7 Rolling shutter

The camera has 3 CMOS sensors, and can therefore be expected to have a rolling shutter through the scanning process. Thus the camera can be expected to make moving edges lean away from the motion, flash exposure to cause part-field/frame illumination, and for pictures shot when the camera is vibrating to appear to have been shot through a jelly.

Although the effect was observed in the 320, the example recording here is taken from a test session on a PMW350.

A 6-blade rotating fan was recorded, rotating clockwise, with the camera shutter set to 1/1000. The downward motion of blades on the right is highly expanded, the upward motion of blades on the left is highly compressed. There is no cure for this, it is the price to be paid for having CMOS sensors with rolling shutter. The effect is much less marked when the shutter is set normally, 1/50 second for 50Hz operations, but is still visible.

Figure 6 Rotating fan, rolling shutter at 1/1000

2.8 Conclusion

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