

SIGNAL PRE-PROCESSING

Delivering the faultlessly clean signals demanded by the digital domain



Signal Pre-processing

In an increasingly digital world, the need for clean video signals has never been greater. Digital signal paths within a facility are capable of passing video information with faultless accuracy. For the best possible results, digital signal paths in turn demand inputs that are as near faultless as possible.

Moreover, digital broadcasting can only achieve the high degree of compression that bandwidth limitations demand if the signal inputs to a digital encoder are as free from noise and artifacts as possible. The answer is efficient, accurate pre-processing of the video signal to remove as many of the unwanted elements as possible, without degrading the signal itself*.

*For further information regarding types of noise and filtering options see page 12

Snell & Wilcox is uniquely qualified to provide the definitive solutions to signal pre-processing needs. As a recognized leader in digital signal processing for many years, the company's research has resulted in many ground-breaking advances and has gained the company numerous awards from around the world.

RollCall™ Control

In the increasingly complex world of digital television, simplicity and ease of control are of paramount concern.

That's why we've developed RollCall, the intelligent control and monitoring system.

RollCall is a powerful solution that meets all your control and monitoring requirements. It offers a range of control strategies, from simple panel control to a sophisticated suite of PC applications.

RollCall provides the operator with an automatic update of a system's status at all times. It also offers monitoring and logging, with the ability to react automatically to events as well as to record these for diagnostic analysis.

RollCall integrates Snell & Wilcox products (stand-alone as well as modular) onto a single network. It is also designed to enable simple interfacing with third party systems.



Prefix CPP100 and CPP200

Compression Pre-processors



Interactive capability enhances accuracy

Prefix's versatility is enhanced by its additional ability to work interactively with suitably equipped compression engines. Details of the incoming video signals such as 3:2 pull-down sequences from telecines and video edit information can be extracted and then passed-on to the compression engine. This information can then be used to 'steer' the compression device by alerting it to forthcoming characteristics of the input signal. Awareness of these characteristics greatly increases the accuracy of the subjective decisions made by the compression engine, thereby improving the overall compression performance at any given bit rate.

This ability to work interactively with the compression engine, or independently from it, combined with its processing power make the Prefix the most powerful and comprehensive system of its kind.

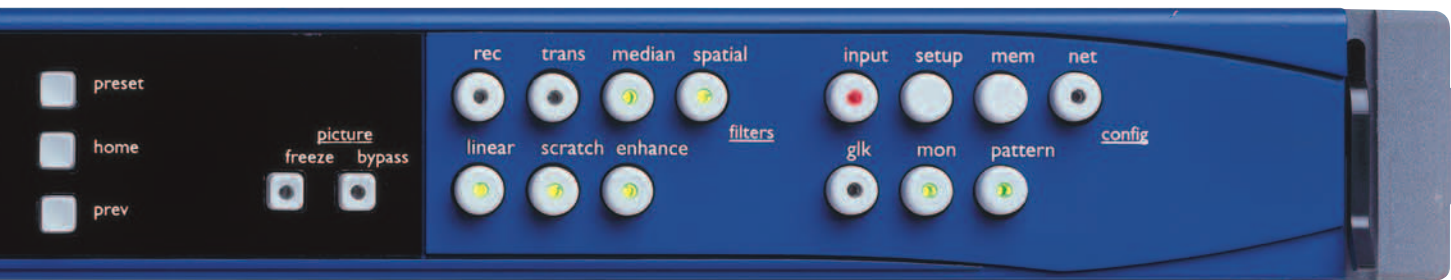
'Prefix' from Snell & Wilcox is the proven solution to the needs of MPEG2 pre-processing. Available with audio insertion capability (CPP200) or without (CPP100), this multi-award winning design will ensure the lowest level of noise in any MPEG2 source signal. The result? Improved picture quality for the viewer, and greatly reduced bandwidth requirement for the broadcaster.

MPEG compression demands extremely high quality inputs if artifacts are to be minimized. A compressor may work well enough on clean signals from a component digital recorder, but real-world signals from analog, composite or film sources can cause serious problems.

MPEG achieves the required data compression by transmitting only the differences between successive pictures. Noise is thus a particular problem in MPEG encoding since it causes changes from one picture to the next that are random - changes that the compressor will try to encode, using up valuable data capacity. With the powerful noise reduction and pre-processing of a Prefix, a compressor can more fully utilize the bandwidth that is available to it. The result is improved quality pictures that require less bandwidth.

Prefix operates in the component 4:2:2 domain and has a number of distinct filters, each 'tuned' to remove a specific type of noise.

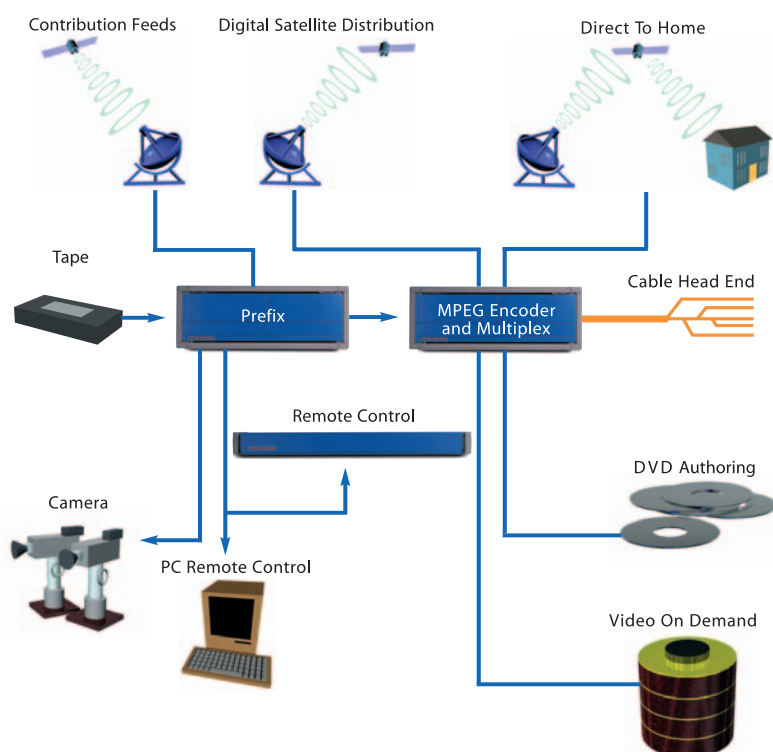
Because of its sub-sampling operation, MPEG cannot transmit some very high frequency information.



Moreover, high frequency aliasing can occur without adequate pre-filtering. Prefix incorporates a range of 3D de-enhancement filters, which allow selective reduction of high frequencies prior to the encoder.

As well as reducing noise, Prefix contains a sophisticated detail enhancer for pictures that have been band limited. The enhancer works to sharpen detail in the picture without introducing the ringing or overshoots normally associated with such enhancement. The level of enhancement can be subjectively selected by the user to suit the bandwidth of the program material, with coring facilities to ensure that low level noise is not enhanced.

Prefix - typical applications



Prefix filter types

- Recursive (motion adaptive temporal filter) reduces noise in stationary areas without loss of horizontal and vertical resolution
- Semi-transversal (on recursive filter output only) – improves performance of recursive filter at scene changes and around moving objects
- Median (adaptive median filter) – effective for elimination of impulse noise such as drop-out
- Spatial (2D median filter) – spatial noise reducer
- Linear filters brickwall low pass filters – provide good band-limiting for MPEG encoders using half resolution processing; ten sets of Gaussian low-pass filters correct materials that have been previously boosted or enhanced; five sets of Gaussian high-pass filters provide variable correction of high level luminance from analog VTRs
- Scratch filter – fully automatic key generation and correction; algorithm can be biased for specific scratch characteristics
- Enhancer – enhance, MPEG de-enhance, decoder matching and video mode (these cannot be used in combination)

Prefix

Essential Picture Conditioning

Prefix CPP100/200 features:

- Essential picture conditioning to improve compression ratios and optimize bandwidth usage in MPEG encoding
- Adaptable for picture source type – film, lowband video, etc
- Full range of noise and artifact reduction filters, including recursive, median, transversal and brick wall to ensure optimal pre-conditioning of any input signal
- Two composite decoder options: standard decoder or advanced multi-phase decoder featuring 'Golden Gate' technology
- Comprehensive signal analysis and noise reduction ensures optimum compression
- Gives significant quality improvements on archive material, especially when the archive source is lowband, or contains dropouts and the like
- 'Steers' the compression engine by supplying 'flagged' information on picture characteristics the encoder can use to improve the efficiency of encoding decisions
- Includes frame synchronization with full horizontal and vertical offset control
- Decoder options allow decoding to be selected to suit the application
- Digital audio embedding and delay (from an analog source - CPP200 only)
- All VITS lines controllable (pass or blank)
- Embedded audio is passed seamlessly through unit
- All digital input formats supported
- Wide range of test patterns



Audio Insertion (CPP200)

In its 2RU high CPP200 form, Prefix can be supplied with an additional audio processor card to provide AES/EBU standard embedding of analog audio inputs into the digital output signal. The same card also provides automatic delay compensation to ensure perfect video/audio sync.

Up to four channels (usually two stereo pairs) are analog-to-digital converted by the audio processor card, and formatted to the AES specification. A phase-locked loop circuit is then used to lock the 48kHz sampling rate of the audio signal to the video output from the pre-processor. Finally, the video and formatted audio are serialized to provide two 270Mbit/sec output signals in accordance with the SMPTE 259M-C Rec.601 specification.

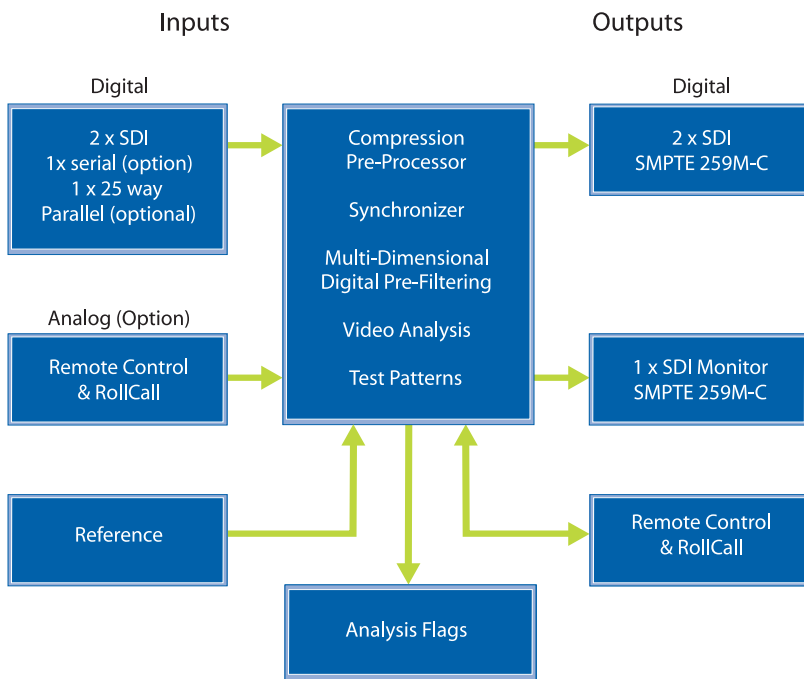
Filter memories

In addition to its user-selectable filter options, Prefix has a pre-set memory of nine combinations of filter operation and level stored in memory to provide optimal pre-processing for common source material conditions:

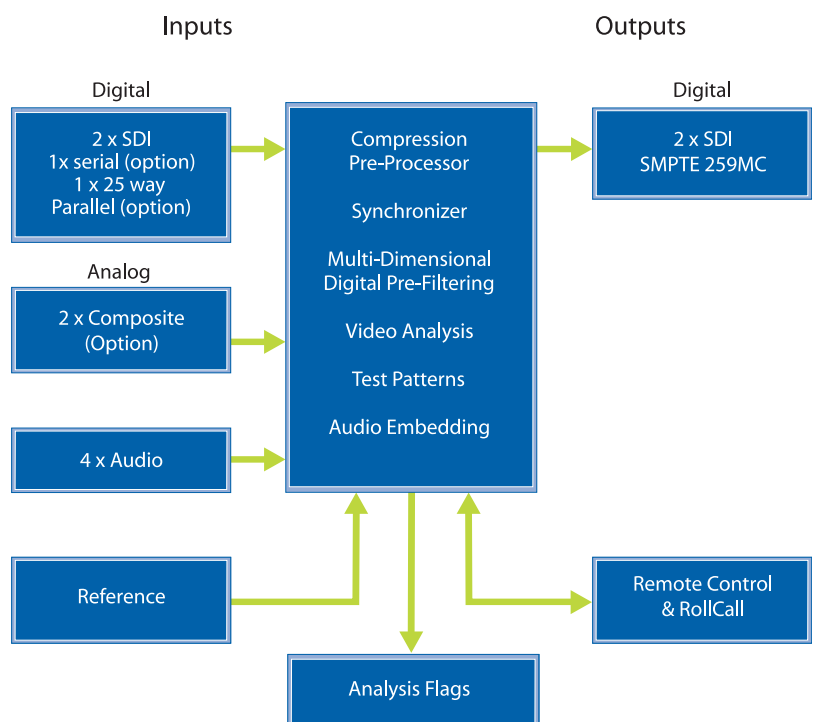
- **Film artifacts**
- **Video artifacts**
- **Film – MPEG bit rate low**
- **Film – MPEG bit rate medium**
- **Film – MPEG bit rate high**
- **Film and video artifacts**
- **Video – MPEG bit rate low**
- **Video – MPEG bit rate medium**
- **Video – MPEG bit rate high**



PREFIX CPP100



PREFIX CPP200



Noise

A Universal Problem

“Noise” is a term used in the general sense to describe any unwanted signal that has become part of the video waveform. For a noise reducer, however, “noise” does not exist in this generalized sense: it has to be categorized according to its nature, and suitable corrective measures devised for each category.

In transmission systems, for example, broadband noise having a true random behavior is frequently encountered, and there are many other types and sources of unwanted signal elements. Poor quality composite decoding can result in problems of residual subcarrier and cross-color, analog VCRs can produce crosstalk. Tape dropout, damaged film and faults in digital links can all add their contributions in the form of impulse noise.

Worse still, noisy signals can bring with them the problems of timebase error - either from VCRs or from the effects of transmission noise on sync pulse edges.

As a consequence, Snell & Wilcox engineers have expended considerable effort to develop new approaches to noise reduction techniques and products.

With the advent of lower cost silicon and dynamic random access memories (DRAM) in particular, new generations of powerful noise reducers are increasingly accessible to the television and related industries. Snell & Wilcox offers a wide range of real-time noise reducer and image enhancer products to choose from depending on the application.

Noise reducers now operate in the digital component domain and provide repeatable and reliable performance.

Sources of Noise

Noise can be broadly categorized into two types, depending on the source: video noise and film-related noise.

Video noise occurs as one of four main types:

1. Electronic Processing Noise: in transmission systems, broadband noise having a true random behavior is encountered.
2. Decoding Artifacts: a picture decoded from a composite source may contain unwanted signals that are a function of the picture structure and processing. Decoding artifacts include residual subcarrier and cross color, the result of poor quality composite decoders.
3. VTR Noise: the main storage medium in broadcast television is tape. This produces several types of noise, including crosstalk from analog VCRs and dropouts as well as general broadband noise. In practice, noisy signals from analog VTRs are often accompanied by timebase errors that result from the VTR's operation, or from transmission noise affecting the sync edges.
4. Digital Errors: faulty digital links can cause unwanted impulse signals caused by bit-dropouts. Low carrier-to-noise levels in FM links can result in impulse noise such as the 'sparkles' often found in satellite signals.

There are two principal sources of noise and artifacts in video from film originated material.

1. Film Structure: can produce background noise over the complete frame. This is a result of the film grain, the individual grains of dye being seen as a background noise pattern. Film makers try to use finer grain, slower speed film stock to overcome the problem; however if 16mm film or large amounts of zoom are used then this effect will still be visible.

2. Film defects: the most common forms of film defects are dirt and scratches. Most post-production houses have extensive film cleaning facilities to remove dirt. However random dirt can appear and can be difficult to deal with.

Scratches are the result of damage to the film emulsion due to poor handling or faulty replay equipment, and are a particularly obvious and thus irritating form of noise.

Noise Reduction Filters and Their Operation

Recursive Filter Recursive filtering is a widely used technique for the reduction of random video noise such as camera and tape noise. Recursive filters reduce noise by averaging successive pictures over a period of time (Figure 1), using delays of exactly one frame to create, in effect, a temporal low-pass filter. Noise can be reduced in stationary areas without loss of spatial (vertical and horizontal) resolution.

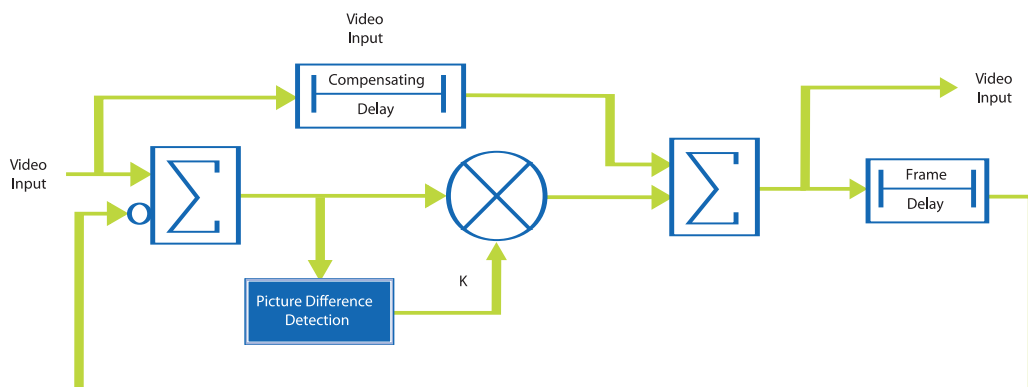
Bitrate Management

To the digital broadcaster, the bandwidth available for transmission is a precious asset. Making the best possible use of this asset requires careful management of the signals being transmitted to ensure the bitrate for any given signal is high enough to ensure good picture quality, but not so high as to be wasteful.

Compression encoders cannot differentiate what is wanted in a signal from what is not: any noise or artifacts in the signal feed will be encoded at the compression stage. Not only does this result in poorer quality pictures for the viewer, it results in a transmission bitrate greater than that needed - often much greater.

Whether the problem is video noise, composite decoding artifacts, unsteadiness, excess enhancement or any other impairment, accurate and appropriate conditioning of the signal prior to compression can provide significant bitrate savings.

Figure 1. Temporal Recursive Filter



Noise

A Universal Problem

Although temporal recursive filters offer considerable levels of noise reduction, sophisticated control logic is necessary to ensure that picture detail is retained at higher noise settings.

In particular, analysis of the noise floor level is necessary to set movement thresholds which allow maximum discrimination between noise and movement. In addition, the recursive filter provides settings for luminance and chrominance, bias and threshold.

Semi-transversal Filter: The semi-transversal is a unique, Snell & Wilcox patented design that operates in conjunction with the recursive filter to increase its effectiveness with moving areas and after scene changes.

Unlike traditional transversal filters in its design, the semi-transversal filter operates by selecting the most appropriate outputs from a chain of picture stores at the output of the recursive filter. An algorithm is used to determine which of the stores contains the highest level of noise-reduced picture.

The Snell & Wilcox semi-transversal filter is able to measure the recurrence of noise and delay the output of the recursive filter by up to three frames. Operating on a pixel-by-pixel basis, the overall level of noise in a typical picture is maintained at a more uniform level and is less dependent on movement. As the semi-transversal filter operates in conjunction with the recursive filter, it cannot be used on its own. Operation of the filter is entirely automatic, requiring no user adjustments or settings to be made.

Median Filter: Median filters are effective at removing impulse noise such as the 'sparkles' often encountered in satellite transmissions. They operate by rank-filtering pixels from an odd number of aperture points around the target pixel to give a median value. The aperture set may utilize the surrounding points from the same field or, more usually, a combination of pixels from the current and adjacent fields or frames (Figure 2). When a pixel is judged to be in error, it is replaced by the median value of its aperture set; pixels judged not to be in error remain unaltered.

The algorithm used is very specific to the areas of the picture that are filtered, and uses both spatial and temporal gradient information to determine whether a pixel has impulse noise characteristics. In operation, the filter automatically detects impulse noise for black, white, long or short (film or dust) drop-outs, and requires only level settings from the user.

Spatial Filter: Spatial filtering involves the use of an aperture comprising adjacent pixels from the same field. Spatial median filters can be very effective at reducing impulse noise resulting from film dust or small drop-outs; they can also be highly effective as Gaussian noise reduction filters.

The spatial filter operates by median filtering a small kernel of adjacent pixels and then comparing the median filtered pixel value with the current pixel. The spatial filter has three level settings used to vary the comparison threshold, and thus, in effect, to set the balance between the level of noise suppression and the preservation of fine detail. Spatial filtering is typically used in conjunction with temporal filter types such as recursive and semi-transversal to boost the overall level of noise reduction.

Figure 2. Spatial and Temporal Median Aperture Set

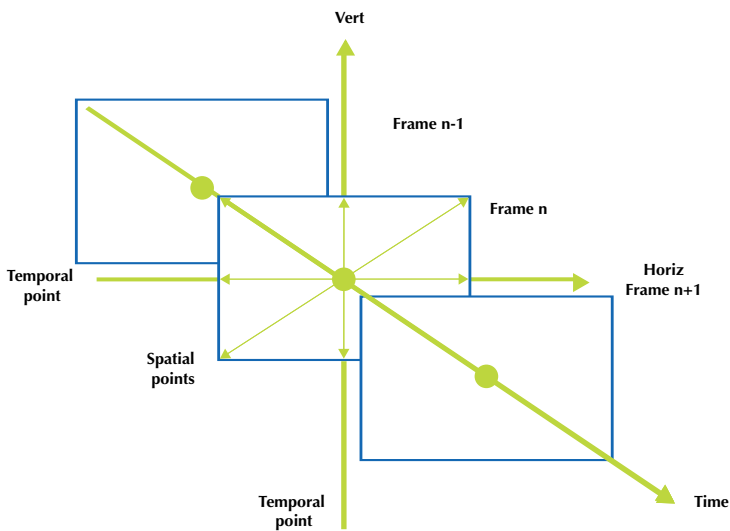
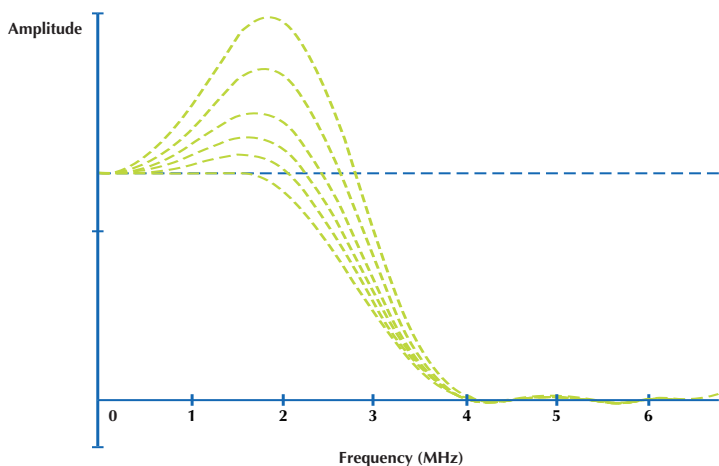


Figure 3. 2.8MHz Brickwall Filter with Available Boost



Brickwall Low-pass: This is a linear filter providing ranges from 4.2 to 2.5MHz, and providing effective band-limiting facilities for MPEG encoders that use half resolution processing. This filter also provides variable peaking or boosting at each of the selected cut-off frequencies (Figure 3). The overall perception of picture sharpness can be raised by boosting prior to brickwall filtering.

The filter provides an additional set of extra low-pass settings where even greater band-limiting is required, with cut-off frequencies from 2.4 to 0.9MHz.

Gaussian Low-pass: Units such as the NRS500 and the CPP range provide ten sets of linear Gaussian low-pass filters. These can be used to attenuate high frequencies to correct material that has been previously enhanced or boosted, and to reduce high frequency noise.

Gaussian High-pass: Five sets of linear Gaussian high-pass filters provide variable correction of high-frequency luminance that may have been attenuated by faulty distribution links or by analog VTR processes.

Scratch Filter: The scratch filter detects and eliminates the effects of film scratches of variable length and contrast, whether they are black, white or both. It does so while ensuring there is no loss of quality in areas of the picture unaffected by scratches. To maximize the benefits of the filter, it is provided with a selection of filter strengths.

Enhancement: Restores the perceived sharpness of an image by adding a correction signal. The correction is derived from information in the incoming signal and is used to sharpen the edges and boost peaks. Careful design ensures that it does so without producing unnaturally sharp results or the artifacts associated with other enhancers. The enhancer has separate controls for mode enhance, luminance, chrominance and coring.

The coring function is a window with an adjustable threshold that can be altered according to the level of noise in the incoming signal. The coring levels can be adjusted according to the quality of the input pictures: the higher the coring level, the less the noise is enhanced.

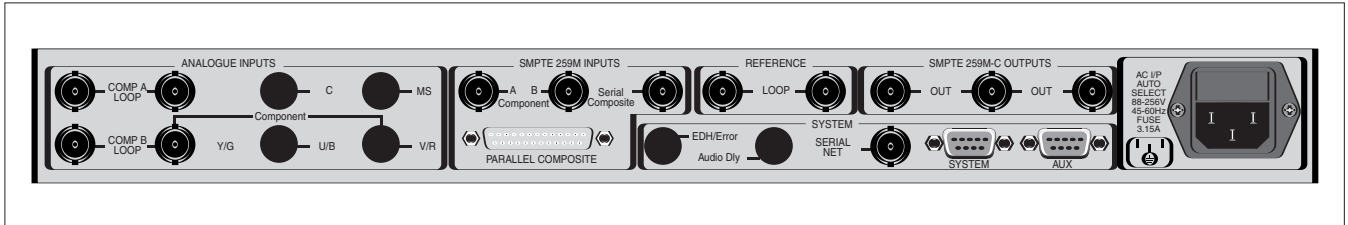
Prefix and NRS500 Filter Combinations for Optimum Solutions-Typical Examples

Application	Recursive	Semi Transversal	Median	Spatial	Linear	Scratch	Enhancer
1 Satellite Noise	Y - Med C - Med Threshold - Auto Bias - 0	On	Level - Med 3	Off	Mode: Off	Off	Off
2 Film Artifacts	Y - Min C - Med Threshold - Auto Bias - 0	On	Level - Med 4	Y - Min C - Med	Mode: Off	Strength - Med Contrast - Low+Med Length - Long Type - Both	Mode: Enhance Y - Min C - Min Y Core - Min C Core - Min
3 Video Artifact	Y - Med C - X Color Threshold - Auto Bias - 0	On	Level - Med 3	Y - Min C - Max	Mode: Off	Off	Off
4 Film & Video Artifacts	Y - Med C - X Color Threshold - Auto Bias - 0	On	Level - Max 5	Y - Med C - Max	Mode: Brickwall Cutoff - 3.2MHz Boost - 0dB	Strength - Med Contrast - Low+Med Length - Long Type - Both	Off

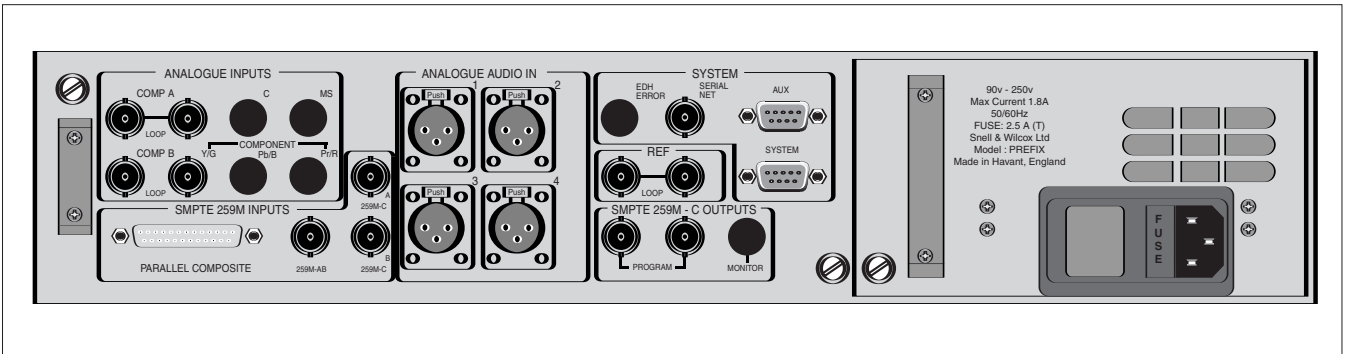
Though designed individually to counteract different types of noises, filters do not have to be used in isolation from each other. In practice, they can be used in combination to provide the optimum solution to the imperfections of real signals.

All filter types in the Snell & Wilcox range of signal pre-processing equipment are provided with a full range of adjustments and settings to ensure the highest level of noise reduction without unnecessary impairment of the picture quality.

Rear panel connections



Prefix CPP100 Compression Pre-processor



Prefix CPP200 Compression Pre-processor with Audio Insertion

Technical Profiles

Prefix CPP100 and CPP200 Compression Pre-processors

Signal Inputs

Composite Loop A: Analog loop-through input, 1V pk to pk, 75 ohm impedance

Input Return Loss: Better than 40dB at 4.43MHz (standard

decoder); better than 35dB at 5.5MHz (advanced multi-phase decoder)

Composite Loop B: Analog loop-through input, 1V pk to pk, 75 ohm impedance

Input Return Loss: Better than 40dB at 4.43MHz (standard

decoder); better than 35dB at 5.5MHz (advanced multi-phase decoder)

Digital Component: SMPTE 259M-C A input SMPTE 259M-C B input

Input Return Loss: Better than 17dB at 270MHz

Reference Loop: Analog loop-through input, 1V pk to pk, 75 ohm impedance

Signal Outputs – CPP100

SMPTE 259M-C 2 x program outputs 1 x monitor output

Output Return Loss Better than 17dB at 270MHz

Signal Outputs – CPP200

SMPTE 259M C 2 x program outputs with embedded AES audio in channel positions 1, 2, 3, 4

Output Return Loss Better than 17dB at 270MHz

Standard Decoder (optional)

Digital Processing: Minimum 10-bit processing throughout

A to D Conversion: Analog composite input is sampled using 10-bit ADC, twice oversampled

Luminance/Chrominance Separation: and digitally filtered/decimated Symmetrical multi-standard adaptive field comb Dual 263H NTSC, PAL-M Dual 312H PAL-I, PAL-N ±100Hz

BLO Operating Range:

Video Gain: ±3dB in 0.1dB steps

Chroma Gain: ±6dB in 0.05dB steps

Black Level: ±20mV, in 2mV steps, manual or automatic tracking

Color Filters: Wide/Medium/Narrow On: Input has a pedestal Off: Input does not have a pedestal

NTSC Hue: ±180° in 1°steps

Picture Position: ±600ns

Decode Mode: Enable or disable Y/C separation

Comb Mode: Non-adaptive, adaptive (default)

Vertical Adaption: Chrominance 'Hanover bars' suppression: On – adaptive vertical filter (default) Off – non-adaptive vertical filter

VITS Individual line controls or group control for blanking/passing of VITS lines; 625 composite format: lines 6 to 22 and 318 to 335, 525 composite format: lines 9 to 20 and 272 to 282

Advanced Multi-phase Decoder (optional)

Digital Processing Minimum 10-bit processing throughout

A to D Conversion Analog composite input is sampled using 10-bit ADC

Composite Formats NTSC, PAL, PAL-M, PAL-N

Video Gain 0 to 117% in 1% steps

Chroma Gain 0 to 200% in 1% steps

NTSC Pedestal Pedestal On/Off

NTSC Hue -180 to +179° in 1° steps

Picture Position -600 to +600ns in 7.4ns steps

Comb Mode

9 x comb modes available

Studio 1, Studio 2, Ldisk, VHS, Still, Simple 1, Simple 2, Line

VITS

Individual line controls or group control for blanking/passing of VITS lines 625 composite: lines 6 to 22 and 319 to 335 525 composite: lines 10 to 20 and 272 to 282

Pre-processor Recursive Filter

Motion adaptive asymmetrical temporal (frame) recursive filter. Three set levels with maximum noise reduction of 12dB Bias adjustment ±3dB in approximately 1dB steps Filter: On/Off Luminance: Off, Min, Med, Max Chrominance: Off, Min, Med, Max Threshold (noise floor): Auto, 1 to 15

Semi-Transversal Filter

Operates on recursive filter output. Reduces absolute levels of noise trails in static revealed/concealed areas, e.g. after scene changes up to 4.7dB. Can only be switched on when recursive filter is selected. Filter: On/Off

Median Filter

Adaptive spatial/temporal median filter Filter: On/Off

Level: Min 1, Min 2, Med 3, Med 4, Max 5, Max 6

Spatial Filter

Spatial 2D median filter Filter: On/Off

Luminance: Off, Min, Med, Max Chrominance: Off, Min, Med, Max

Linear Filter	18 sets of linear 15-tap low pass brickwall digital filters 6 sets of linear 15-tap extra low pass brickwall digital filters 6 sets of peaking value for each cut-off frequency 10 sets of Gaussian low-pass filters (no peaking) 5 sets of Gaussian high-pass filters	Decoder Match	Non-adaptive symmetrical vertical temporal filter utilizing ± 1 field contributions. Aperture adjusted to complementary match decoder comb structure - line comb, field comb, other	Key Window	Allows split screen facilities to monitor effects of digital filtering applied to the key area only Select: Off, H-split, V-split, Box, User, H-repeat User: user-defined key window coordinates X1, Y1, X2, Y2 Invert: inversion of selected key window Border: selects the border shade around the key window: Off, Black, White
Brickwall Low Pass Cut-off	Full bandwidth, 4.2 to 2.5MHz (-6dB) in 0.1MHz steps	Synchronizer	Genlock Input/Reference/Off Status: Input Lock/Reference Lock Horizontal Offset: 0 to 1H in 37ns steps Vertical Offset: 0 to 624H (625 line standards) 0 to 524H (525 line standards)	Event Logging	Enables the user to monitor events using RollCall™ PC log reviewer
Brickwall Extra Low-pass Cut-off	2.4 to 0.9MHz (-6dB) in 0.3MHz steps (no boost)			Pattern	Internal test patterns: Black, EBU bars, Y ramp, UV sweep, UV sweep, Bowtie, Full bars
Boost	None, 1, 2, 3, 4.5, 6dB			On Fail	This sets the default for the unit when the input signal fails: SDI B, Video (comp. input), Freeze (SDI input), Message, any of the test patterns
Gaussian Low-pass	-4 to -40dB in 4dB steps	VITS	All On, All Off, Select individual lines Individual line controls or group control for blanking/passing of VBIS lines Advanced Multi-phase Decoder 625 Standard: 6 to 22 and 319 to 335 525 Standard: 10 to 20 and 272 to 282 Standard Decoder 625 Standard 6 to 22 and 318 to 335 525 Standard 9 to 22 and 272 to 282	Panel Display	RollCall™ "shoebox" panel display information: Normal, Recursive, Median, Spatial, Enhancer, Linear, EDH Check, Network, Auto-loop
Gaussian High-pass	1, 2, 3, 4.5, 6dB			On-screen Display (not available with CPP200)	Using monitor output: None, System, Filters, Decoder
Scratch Filter	Filters of different strengths for vertical scratches of variable contrast, type and length Filter: On/Off Strength: Min, Med, Max Contrast: Low, Med, High Length: Any, Long Type: Black, White, Both			Memory Store	User-defined memory, slots 1 to 8
Enhancer Modes	Off, Enhance, MPEG De-enhance, Decoder Mode, Video Mode			Memory Recall (User)	User-defined memories 1 to 8,
Enhance	Spatial 2D enhancer utilizing separately derived, non-linear and linear edge detection and compression Luminance: Off, Min, Med, Max Chrominance: Off, Min, Med, Max Luminance Coring: Off, Min, Med, Max Chrominance Coring: Off, Min, Med, Max	Embedded V flag Style (525 line only)	OVD Optional Video Data (1 to 9/264 to 272) OBD Optional Blanking Data (1 to 19/264 to 282) ABD Additional Blanking Data (20/22) Lines 1 to 22/264 to 282 not filtered (V flag as OBD)	Memory Recall (Preset)	Recall preset or factory set memories
		8-bit Rounding	10-bit to 8-bit rounding using truncation error feedback	Memory Set Name	Set memory name (user-defined) 1 to 8; 10 characters of ASCII character set
MPEG De-enhance	Non-adaptive symmetrical vertical temporal filter utilizing ± 1 field contributions Luminance: Off, Min, Med, Max Chrominance: Off, Min, Med, Max	EDH	Input error detection and handling Status: None, Ok, Errors AP/FF: individual or linked reset EDH insertion on two Program outputs		

Technical Profiles

Audio Processor (CPP200 only)		Communications	
Analog Audio In	4 x channels XLR analog audio inputs; 10kOhm impedance, balanced	Serial Net	Proprietary Snell & Wilcox interface multi-drop
Reference Level	Nominal input level +4dBu	RollCall BNC System	via BNC T network 9-pin D-type, RS422 slave
A to D Conversion	18-bit resolution, 64 times oversampled	Communication Auxiliary	9-pin D-type, RS422 master
Input Headroom	Adjustable, nominally +18dB	Power	
Frequency Range	20Hz to 20kHz, ±1dB	Input Voltage	90 to 250V, 50/60Hz, 1.2A
Total Harmonic Distortion	Less than 0.015% at 1kHz	Consumption	100VA maximum
Signal to Noise Ratio	Better than 100dB, 20Hz to 20kHz	Mains Fuse Rating	2.5A(T)
Input Dynamic Range	106dB	Mechanical – CPP100	
Phase Difference Between Channels	Less than 1° at 1kHz	Temperature Rating	0 to 30°C operating
Cross-talk	Less than 75dB at 15kHz	Cooling	Filtered axial fan; front-to-rear air flow
Channel Level Difference	Less than 0.5dB	Case Type	1RU rack mounting
Digital Audio Sample Rate	48k samples/s	Dimensions	483 x 535 x 45mm (w x d x h)
Serial Digital	Pair of 32 bit synchronous	Mechanical – CPP200	
Format	serial channels	Temperature Rating	0 to 40°C operating
Delay Adjustment	-1, 0, 1 to 10 fields in 0.25 field steps	Cooling	Filtered axial fan; front to rear air flow
Audio Level Adjustment	Mute, -95.5 to +31.5dB in 0.5dB steps	Case Type	2RU rack mounting
Test Tone	Individually selectable on channels 1 to 4, digitally generated at +4dBu level	Dimensions	483 x 495 x 89mm (w x d x h)
AES Group	Group 0, 1, 2, 3		
SMPTE 259M-C Outputs	2 x program outputs with embedded AES audio in channel positions 1 to 4		
Output Return Loss	Better than 17dB at 270MHz		

Company policy is one of continuous product improvement. Specifications are therefore subject to change without notice.

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