Optical Instrumentation

WAVESHAPER®

Series A Family of Programmable Optical Processors

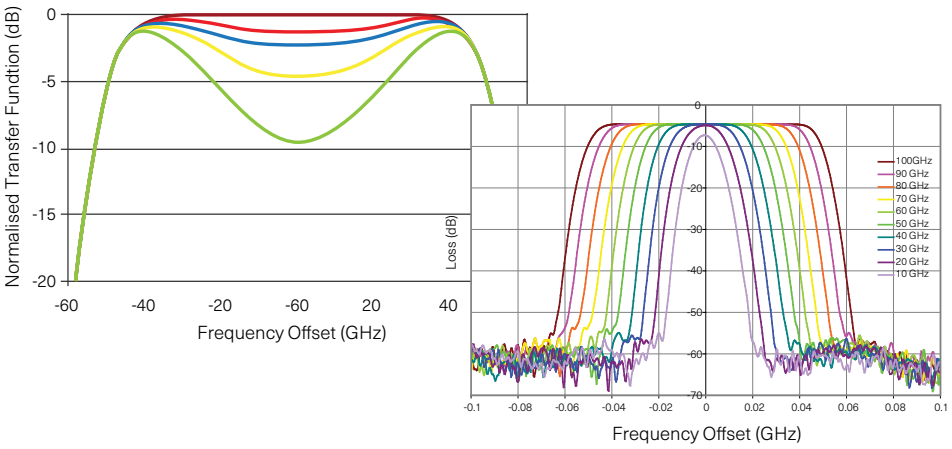
The WaveShaper® Series A Programmable Optical Processors provide a range of programmable optical filtering and switching options for optical R&D and production test applications. With a highly advanced high-resolution, solid-state Liquid Crystal on Silicon (LCoS) optical engine, the WaveShaper family provides extremely fine control of filter characteristics, including center wavelength, bandwidth, shape, dispersion and attenuation. The WaveShaper family is used in a wide variety of applications, including optical communications, pulsed lasers in the medical and material processing area as well as optical sensors.

COHERENT

Applications

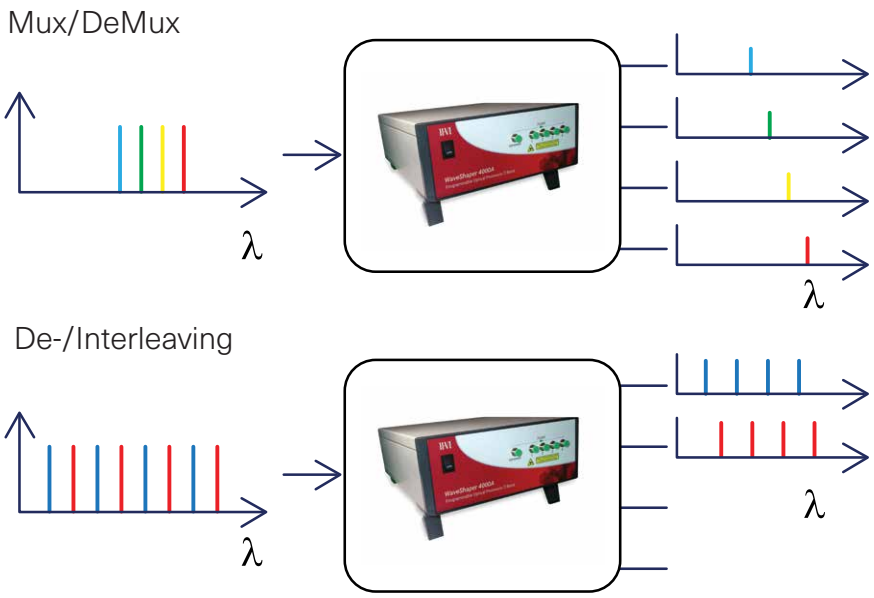
Filtering with arbitrary spectral shapes

Filtering with variable bandwidth and with arbitrary spectral shapes is of importance in system test experiments. For example, the influence of cascading of optical filters on the transmission quality can be investigated by programming the resulting filter shape into the WaveShaper.



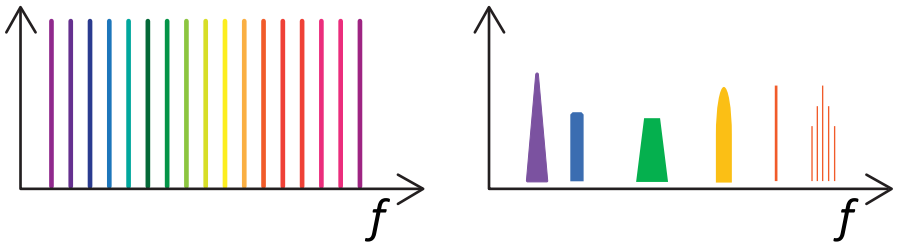
Mux/DeMux and De-/Interleaving

The WaveShaper 4000A can serve as a programmable Multiplexer/Demultiplexer or Interleaver/De-Interleaver. It can incorporate basically any channel spacing, including non-equally spaced channels. It fully supports Flexgrid™, the standard approach to flexible grid network architectures. Since it can operate in both directions, it can be used as a wavelength splitter as well as a combiner.



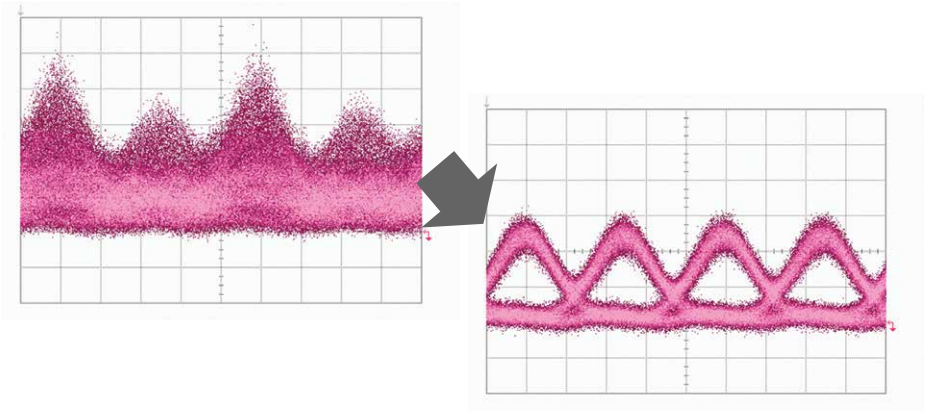
Component and System Loading

Generation of controllable optical combs is key in a variety of module and system test applications. For example, loading an amplifier with a representative power spectrum is required for proper amplifier testing. Similar requirements exist for testing optical systems involving amplified links. The WaveShaper can create individual spectral lines – even with shapes as if they were modulated.



Dispersion Compensation

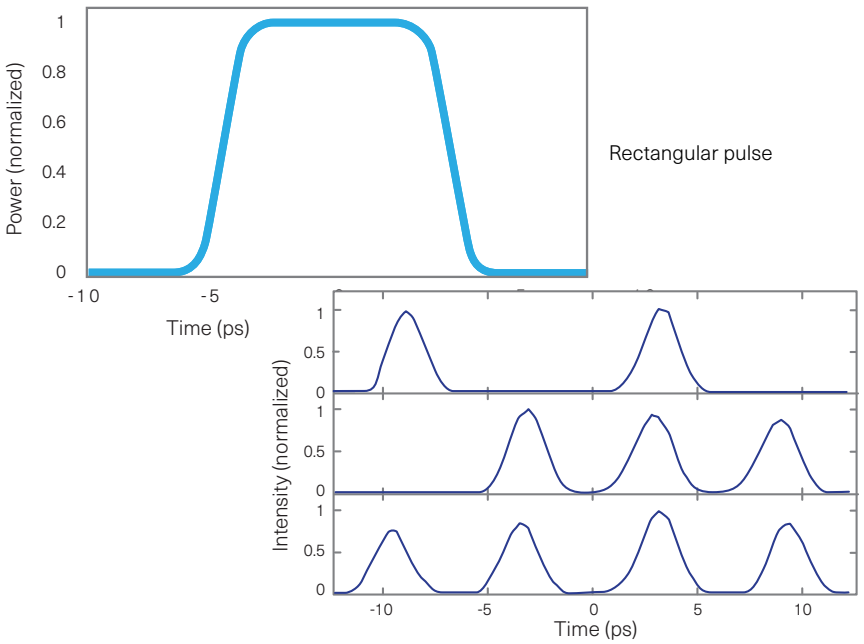
In system testing, verification of dispersion budgets and sensitivity of transmission systems to group delay ripple (and other dispersion imperfections) is of importance. Several members of the WaveShaper family allow setting dispersion values of up to 100 ps/nm (per 50 GHz channel) as well as creating group delay ripple with high spectral frequency.



Laser Pulse Compression, Shaping and Generation

Pulsed Lasers are utilized in a large number of medical, material processing, communications and other applications. Several of these applications require very short optical pulses, for example when athermal ablation is required. The WaveShaper 1000/SP allows dynamic compression of optical pulses and therefore enables stable operation of such laser pulses in the femtosecond regime.

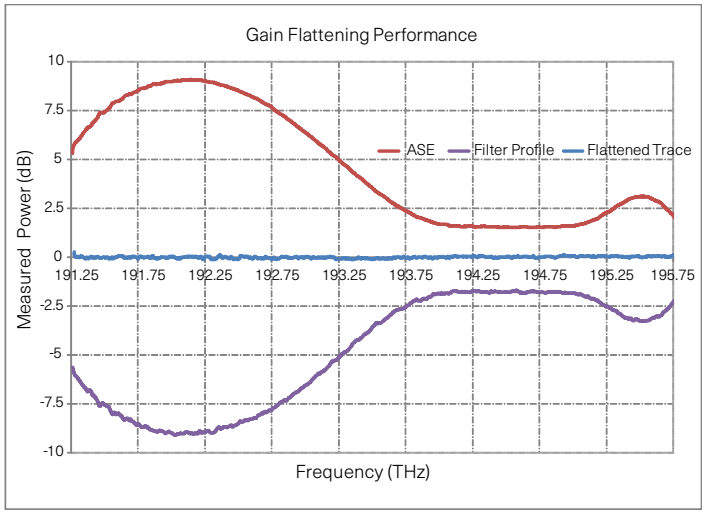
Certain other applications, in particular in the communications area, require specific pulse shapes (like rectangular for example) or particular bit sequences.



Creation of pulse patterns: pulse sequences of 1010, 0111, 1111 have been created from a single input pulse

Gain Equalization

A number of parameters need to be verified in communication test beds including the tolerance of the transmission system to spectral shapes of the gain. The WaveShaper allows creating such gain shapes with very high resolution (down to 0.01 dB attenuation steps), which allows for creation and compensation of such gain shapes.



Power Splitting and Broadcasting

The WaveShaper 4000 and 16000 both have the ability to split an input signal between multiple output ports. Simple structures like wavelength-dependent couplers and splitters (Figure 1) can be created with user defined coupling ratios and frequency dependencies.

Figure 1: Splitter

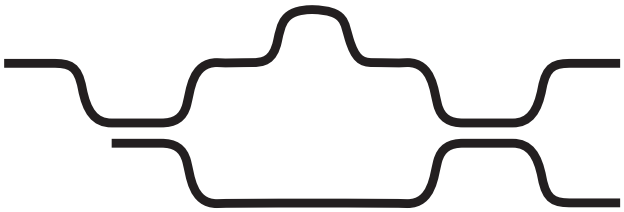


Figure 2: Variable Delay Line Interferometer

Programmable Interferometer

In addition to splitting power, the phase of signals in the different ports can also be adjusted. This allows the user to create, on the fly, more complex structures like delay line interferometers (e.g. DPSK-Demodulator – shown in Figure 2) or DQPSK-Demodulators with a variable, easily-programmable, optical transfer function (Figure 3).

More complex functions, such as the all-optical Discrete Fourier Transform (DFT) filter shown in Figure 4 can also be easily created.

These capabilities can be best described as “just like an Optical FPGA”, where an optical functional element (component) can be created within a fraction of a second just by uploading a definition table. The ability to easily generate complex interferometric structures simplifies many areas of research which require an arbitrary optical transfer function, including the ability to share (or combine) power between multiple ports.

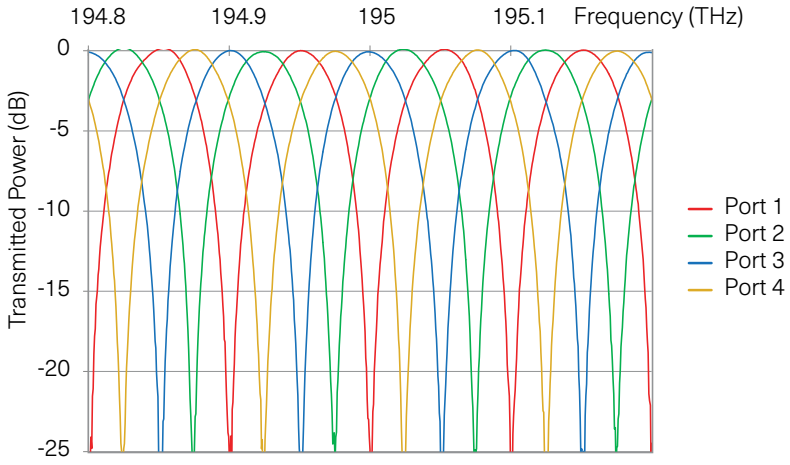


Figure 3: Optical transfer function of a DQPSK demodulator generated in a WaveShaper 4000A using the Fourier processor software

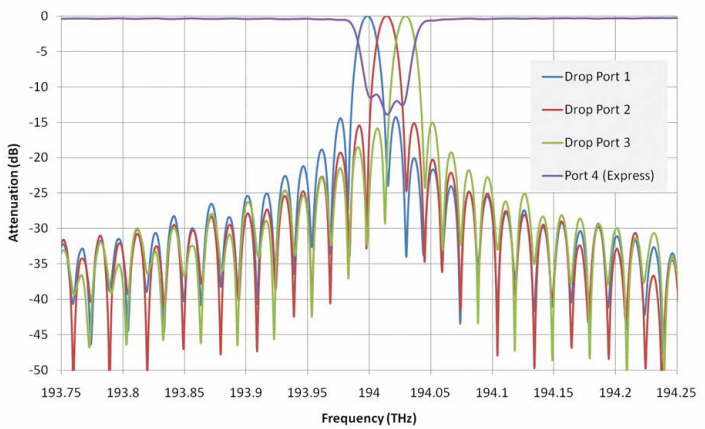
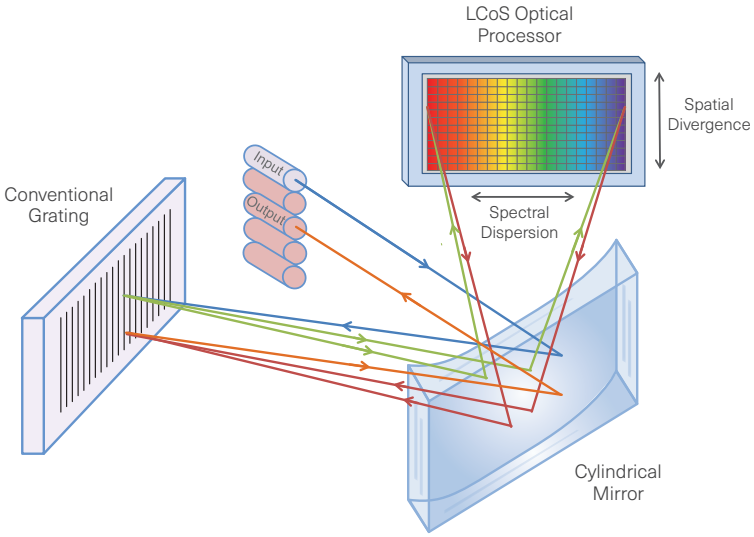


Figure 4: Optical transfer function of an all-optical DFT filter with 15 GHz FSR

Technology - How does it work?

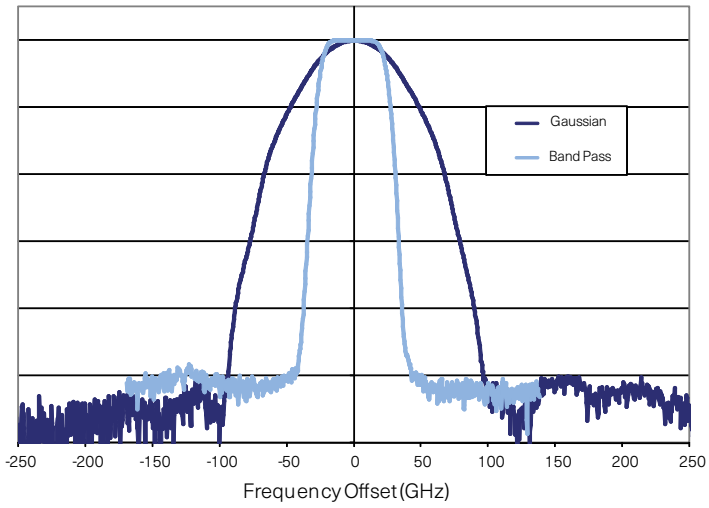
The WaveShaper family is based on advanced Liquid Crystal on Silicon (LCoS) technology. As shown schematically in the figure below, the input signal is dispersed by a conventional grating before its spectral components hit the LCoS optical processor. This LCoS processor consists of a matrix of reflective liquid crystal elements. By applying voltages to these matrix elements, they can add individual phase shifts to the reflected signals which allows beam steering of the signal components hitting the LCoS processor. As the wavelengths are separated on the LCoS chip, the control of each wavelength is independent of all others and can be switched or filtered without interfering with other wavelengths. As a result, the structure offers spectral attenuation, dispersion and optical switching capabilities which are available in the WaveShaper family.



WaveShaper 100A

Tunable Optical Filter

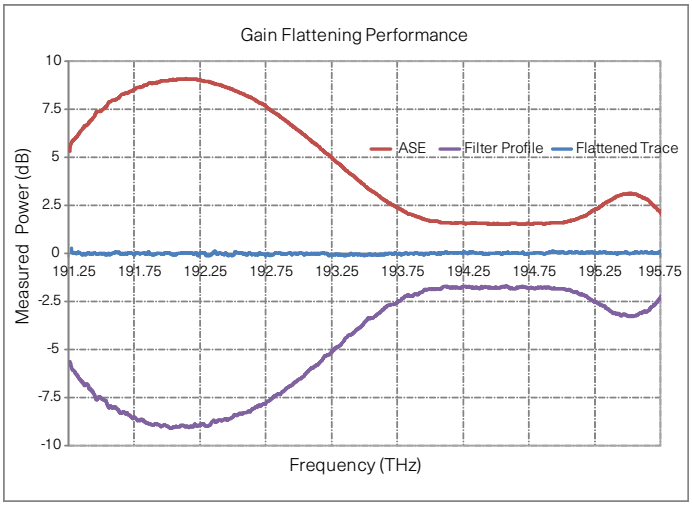
Fully programmable, DWDM tunable optical filter with user-selectable band-pass (flat-top) and Gaussian filter shapes. The filter bandwidth is programmable in 1 GHz increments from 10 GHz up to 1000 GHz, with the center frequency programmable in 1 GHz increments over the whole C- band. Ideal for production test applications.



WaveShaper 500A

Programmable Optical Filter

Optical filter covering the C-band or L-band with arbitrarily programmable attenuation shape. Typical applications include gain equalization, channel selection and channel shaping.



WaveShaper 1000A

Programmable Optical Filter

Supports arbitrary user-generated channel and filter shapes. Depending on the model of the 1000A, the bandwidth can be set from 10 GHz to about 5 THz with 1 GHz increments (L-band version) or from 20 GHz to about 9 THz (S-band and U-band version), also with 1 GHz increments. The required filter shape (both amplitude and phase) can be generated by the user, then loaded into the WaveManager software which translates the user specification into the required optical shape. Band-stop and optical comb filters are also supported as is optical power control over a range of 30 dB for all filter types.

Available for various bands from 1468 nm to 1651 nm

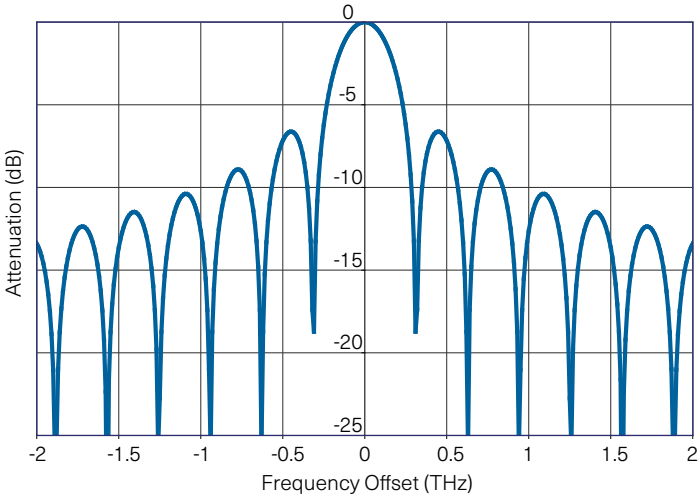
WaveShaper 4000A

Multiport Optical Processor

Extends the capability of the WaveShaper 1000A including the ability to direct different portions of the signal to different output ports with different, arbitrary user-generated channel shapes for each port.

All members of the WaveShaper 4000 family support power splitting, broadcasting and the ability to create programmable interferometers, as described on page 4.

Available for various bands from 1468 nm to 1651 nm



Example filter shapes generated with WaveShaper 1000/4000 programmable optical processor

WaveShaper 1000/SP

Programmable Single Polarization Filter

Polarization maintaining version of the WaveShaper 1000 programmable filter. It transmits and processes the signal which is launched into the slow axis of the input PM fiber. The signal being launched into the fast axis is not transmitted and will be extinguished by more than 20 dB. Covering the entire C-band, the unit allows testing of single-polarization telecommunications components such as lasers and modulators, as well as the creation and shaping of short pulses down to the femtosecond regime in short-pulse fibre lasers.

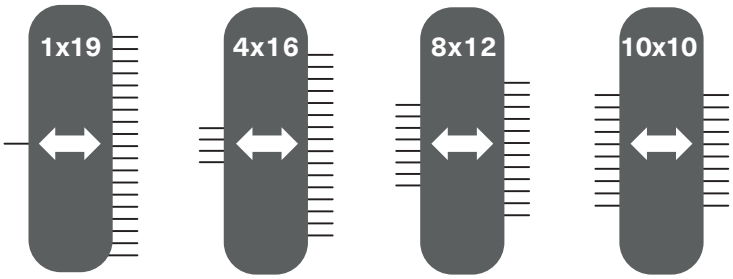
Coherent also offers a WaveShaper 1000/SP operating in the 1 µm wavelength window for pulsed laser applications. For more information, visit www.ii-vi.com/instruments.

WaveShaper 16000A

Reconfigurable Optical Processor

Programmable wavelength-selective MxN optical filter with control of filter shape and phase on each input/output port combination. The instrument has a total number of 20 optical ports. These can be configured by software commands to 1 x 19, 4 x 16, 8 x 12 or 10 x 10. All these port combinations work bi-directional, therefore also 19 x 1, 16 x 4 and 12 x 8 are included.

Covering the entire C-band, the WaveShaper 16000A combines precise control of filter wavelength, bandwidth, shape and phase with the ability to switch and combine multiple signals in an “Add” or “Drop” configuration. The WaveShaper 16000A in a 1x16 configuration also supports power splitting, broadcasting and the ability to create programmable interferometers, as described on page 4.



The WaveShaper 16000A allows arbitrary channel control and switching with high granularity. It has been designed for research and development applications in the advanced optical networking space. It provides key functions which are critical in the areas of elastic and space division multiplexed optical networks as well as software defined optical networking and OFDM.

The WaveShaper 16000 is programmable with user defined filter shapes either through the WaveManager Application Suite which serves as Graphical User Interface (GUI) or through the Application Programming Interface (API).

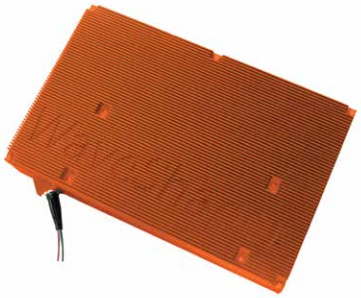
Operating the WaveShaper 16000 in a 4 x 16, 8 x 12 or 10 x 10 configuration is in terms of functionality equivalent to cascading two 1 x N WaveShapers back to back. For example, the 4 x 16 configuration is similar to operating a 4 x 1 WaveShaper and a 1 x 16 WaveShaper back to back. In order to prevent wavelength contention, the signals entering the WaveShaper through the different input ports should not spectrally overlap (one specific wavelength is only used at one input port - other ports receive different wavelengths). Both the GUI and API ensure that only those filter functions are accepted which do not lead to wavelength contention issues.

The programmable and integrated optical functions of the WaveShaper 16000A are highly desirable in next generation optical data center interconnects and high performance computing.

WaveShaper M-Series

For OEM Applications

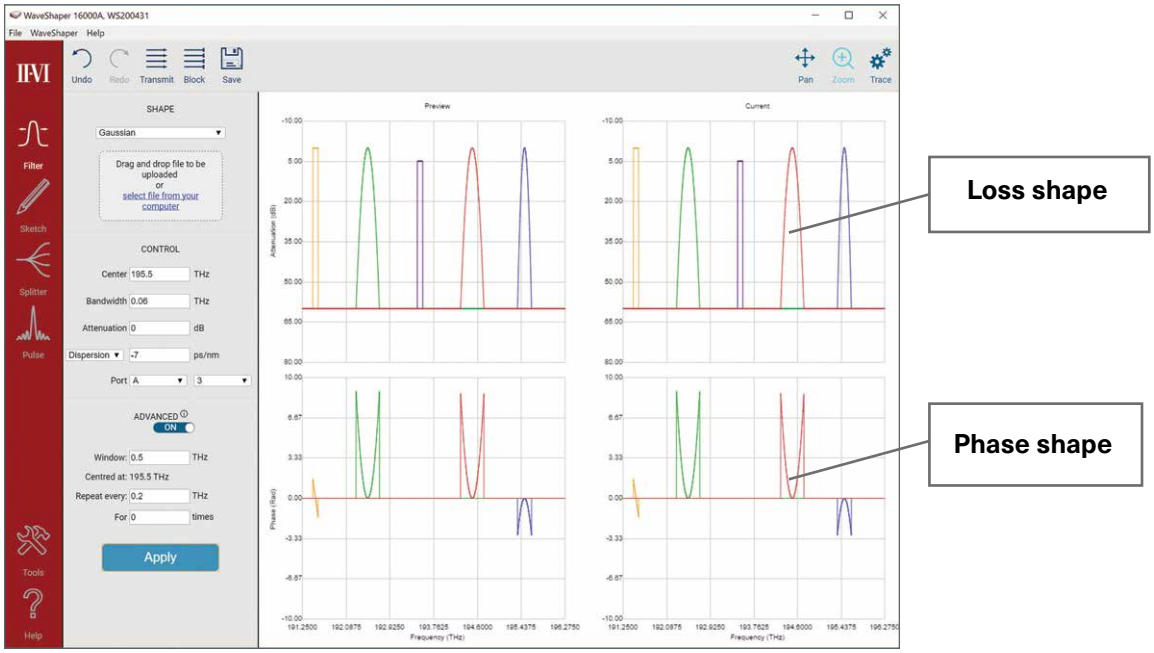
OEM version of the WaveShaper family of programmable optical processors. It is designed for embedding into third party equipment and instrumentation. It provides full WaveShaper functionality but with reduced size. Most of the benchtop WaveShaper models are also available as M-Series module.



Graphical User Interface (GUI)

The WaveShaper A Series instruments are controlled from an external device to select and update the filter shape. Communication with the WaveShaper is via USB or Ethernet interfaces. For the Graphical User Interface (GUI), the A Series WaveShaper supports the following approaches:

- **Integrated Webserver (Ethernet Interface):** The WaveShaper Series A instruments contain an in-built webserver that provides the most flexible approach, as the users client only needs to provide a web browser. No dedicated software or drivers are required. Supported systems include Windows 7 and higher, Linux, OS X, Android, iOS etc. Existing *.wsp and *.ucf files can be used, providing backward compatibility with current filter profiles.
- **WaveShaper App software package (Ethernet Interface):** This package runs on the user's computer and is available for Win 11 systems. It provides the same functionset as operation through the web browser, as well as providing a full device discovery service for networked units.
- **WaveManager 2.7x software package (USB Interface):** WaveShaper A Series instruments are fully backward-compatible with the existing WaveManager 2.7x software. This package runs on the user's computer and is available for Win 7, Win 8.1 and Win 10 systems. It provides the same functionset as operation through the web browser plus it has additional functions supporting power splitting and modeling (which provides a prediction of the real filter curve considering physical limitations). The WaveManager 2.7x software package can be downloaded from www.ii-vi.com/instruments.

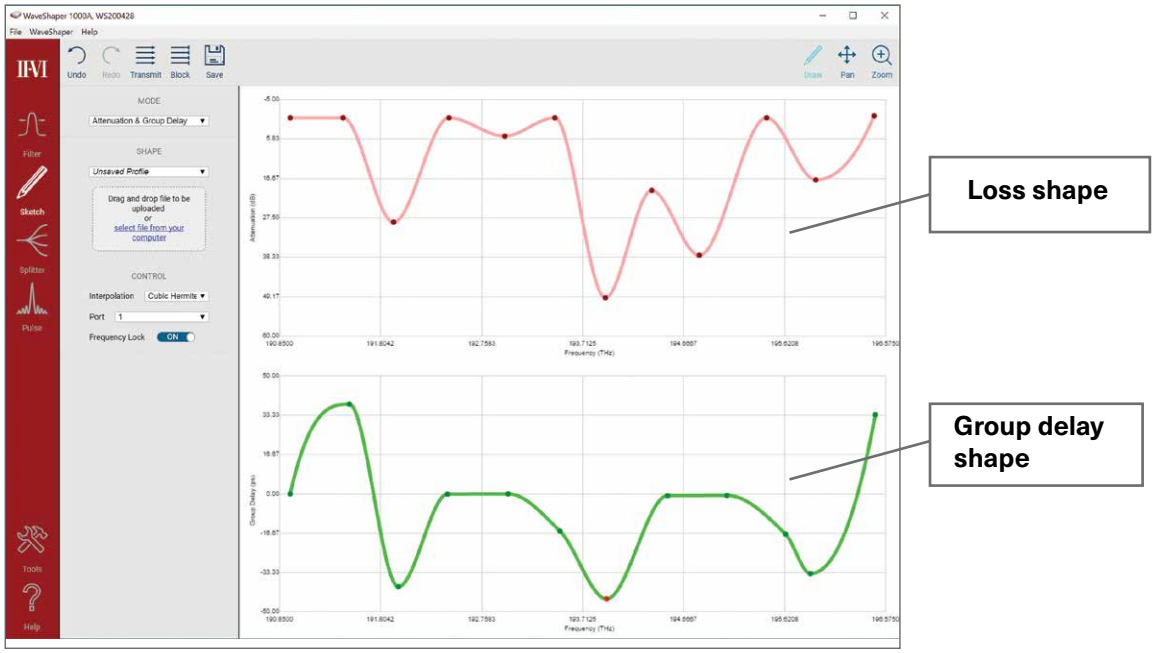


Application Programming Interface (API)

The WaveShaper A Series instruments include a web service API which enables the user to remotely configure the device over an Ethernet connection using HTTP commands from any software programming language. Programming examples are available for LabView, Matlab, Python, Octave, Visual Basic and C#. In addition, a DLL package is available for Windows-based PCs ensuring full backward compatibility ("drop-in replacement") with previous generation WaveShaper units.

WaveSketch

WaveSketch is an exciting capability which enables users of all versions of the WaveShaper 500A, 1000A, 4000A and 16000A to manually create filter shapes using a 'drag and drop' graphical interface. As both the loss and phase (only for 1000A, 4000A and 16000A) of the filter curve are manipulated on screen, the WaveShaper transfer function is updated in real time thus allowing, for example, continuous adjustments to eliminate drift in system test applications. The figure below shows a WaveSketch screenshot in which defined points can be added, deleted or modified as required.



Coherent Knowledgebase

Obtain further application and technical information about the Optical Instrumentation Portfolio including the WaveAnalyzer Family by clicking here: https://ii-vi.com/waveshaper-and-waveanalyzer-knowledgebase

WaveShaper Demonstration on YouTube

Watch product demo at: https://www.youtube.com/@CoherentCorp

WaveShaper Specifications

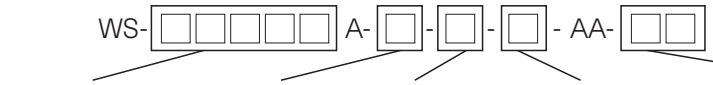
Model		100A	500A	16000A	1000A/SP (1)	500A/L	1000A/L, 4000A/L	1000A/S, 4000A/S	1000A/U (6), 4000A/U (6)
Wavelength Band		C-Band				L-Band		S-Band	U-Band
Optical Ports	Port Configurations	1x1		1x19, 4x16, 8x12, 10x10	1x1		1x1, 1x4		
Filter Control	Operating Frequency Range	191.1 THz to 196.46 THz (1526.0 nm to 1568.7 nm)			191.250 THz to 196.275 THZ (1527.4 nm to 1567.5 nm)	186.2 THz to 191.05 THz (1569.2 nm to 1610.0 nm)		196.2 THz to 204.2 THz (1468.0 nm to 1528.0 nm)	181.55 THz to 190.25 THz (1575.8 nm to 1651.3 nm)
	Filter Bandwidth	10 GHz – 1 THz (0.08 – 8 nm)	10 GHz – 5.36 THz (0.08 – 42.7 nm)		10 GHz - 5 THz (0.08 nm - 40 nm)	10 GHz – 4.85 THz (0.08 – 40.8 nm)		20 GHz - full range (0.16 nm - full range)	
	Filter Shape	Band-pass, Gaussian	Arbitrary						
	Frequency Setting Resolution	±1 GHz (±8 pm)							
	Frequency Setting Accuracy	±2.5 GHz (±20 pm)						± 5 GHz	
	Bandwidth Setting Resolution	±1 GHz (±8 pm)							
	Bandwidth Setting Accuracy	±5 GHz (±40 pm)						± 10 GHz	
	Bandwidth Setting Repeatability	±2.5 GHz (±20 pm)						± 5 GHz	
	Group Delay Control Range	n/a		-25 ps to +25 ps		n/a	-25 ps to +25 ps	-15 ps to +15 ps	
	Attenuation Control Range	n/a	0 to 35 dB						
	Attenuation Setting Resolution	n/a	0.01 dB		0.1 dB	0.01 dB			
	Attenuation Setting Accuracy	n/a	±1.0 dB from 0 to 10 dB, ±10 % from 10 to 30 dB						
	Settling Time	<500 ms							
Loss and Dispersion	Insertion Loss	< 5 dB (2)						< 7 dB (3)	
	Insertion Loss Non-Uniformity	0.7 dB				0.7 dB (4)		1 dB	
	Polarization Dependent Loss (PDL)	0.4 dB			0.5 dB	n/a	0.4 dB	0.8 dB	
	Differential Group Delay (DGD)	< 0.5 ps			n/a	< 0.5 ps			
	Return Loss	>25 dB							
Optical Power (5)	Max Total Input Optical Power	+27 dBm							
	Max Optical Power per 50 GHz channel	+13 dBm							
Environment	Operating Temperature	Bench-top / Rack-mount instrument: 15 to 35°C Module: 15 to 55°C with airflow of min 1 m / sec across top of module							
	Operating Humidity	10 to 90%							
Electrical	Communications Interface	Ethernet (GbE), USB 2.0							
	Power Consumption	<50 VA							
Mechanical	Connector Interface	FC/APC		LC/APC		FC/APC			
	Dimensions, weight	Bench-top: 241 mm x 88 mm x 316 mm, 3.8 kg Module: 220 mm x 140 mm x 37 mm, 0.8 kg							

Notes
(1) Measured on signal in slow axis
(2) Valid for Filter Bandwidth settings of 15 GHz and larger. For Filter Bandwidth settings below 15 GHz an additional loss of up to 2 dB may apply.
(3) Valid for Filter Bandwidth settings of 25 GHz and larger. For Filter Bandwidth settings below 25 GHz an additional loss of up to 2 dB may apply.
(4) Specification is valid over the frequency range of 187.0 to 191.05 THz. From 186.35 to 191.05 THz the insertion loss non-uniformity is 1.0 dB max.
(5) Optical signals with spectral components below 600 nm must be avoided.
(6) Optical specifications are guaranteed up to 1649 nm. Above 1649 nm Specifications are met on a best effort basis.

Configuration Guide

Model	Order Code	Description	Wavelength band	Housing option	Fiber Type	Connector type
WaveShaper 100	WS-00100A-C-S-1-AA-00	Tunable Optical Filter	C	Benchtop	SM	FC/APC
	WS-00100A-C-M-1-AA-00	Tunable Optical Filter	C	Module	SM	FC/APC
	WS-00100A-C-R-1-AA-00	Tunable Optical Filter	C	Rackmount	SM	FC/APC
WaveShaper 500	WS-00500A-C-S-1-AA-00	Programmable Optical Filter	C	Benchtop	SM	FC/APC
	WS-00500A-C-M-1-AA-00	Programmable Optical Filter	C	Module	SM	FC/APC
	WS-00500A-C-R-1-AA-00	Programmable Optical Filter	C	Rackmount	SM	FC/APC
	WS-00500A-L-S-1-AA-00	Programmable Optical Filter	L	Benchtop	SM	FC/APC
WaveShaper 1000	WS-01000A-L-S-1-AA-00	Programmable Optical Filter	L	Benchtop	SM	FC/APC
	WS-01000A-L-M-1-AA-00	Programmable Optical Filter	L	Module	SM	FC/APC
	WS-01000A-S-S-1-AA-00	Programmable Optical Filter	S	Benchtop	SM	FC/APC
	WS-01000A-U-S-1-AA-00	Programmable Optical Filter	U	Benchtop	SM	FC/APC
	WS-01000A-C-S-1-AA-01	Programmable Single Polarization Filter	C	Benchtop	PM	FC/APC
	WS-01000A-C-M-1-AA-01	Programmable Single Polarization Filter	C	Module	PM	FC/APC
WaveShaper 4000	WS-04000A-L-S-1-AA-00	Programmable Optical Processor	L	Benchtop	SM	FC/APC
	WS-04000A-L-M-1-AA-00	Programmable Optical Processor	L	Module	SM	FC/APC
	WS-04000A-S-S-1-AA-00	Programmable Optical Processor	S	Benchtop	SM	FC/APC
	WS-04000A-U-S-1-AA-00	Programmable Optical Processor	U	Benchtop	SM	FC/APC
WaveShaper 16000	WS-16000A-C-S-3-AA-00	Reconfigurable Optical Processor	C	Benchtop	SM	LC/APC
	WS-16000A-C-S-4-AA-00	Reconfigurable Optical Processor	C	Benchtop	SM	LC/UPC
	WS-16000A-C-M-3-AA-00	Reconfigurable Optical Processor	C	Module	SM	LC/APC
	WS-16000A-C-R-3-AA-00	Reconfigurable Optical Processor	C	Rackmount	SM	LC/APC

Order Code Key



Model Number
00100
00500
01000
04000
16000

Wavelength
C: C-band
L: L-band
S: S-band
U: U-band
X: C+L band
Y: 1 µm band

Housing
S: Benchtop
R: Rackmount
M: Module

Connectors
1: FC/APC
2: FC/UPC
3: LC/APC
4: LC/UPC

Options
00: Standard
01: Single Polarization

sales@coherent.com
www.coherent.com

WAVESHAPER® B-SERIES

500B Programmable Optical Filter
1000B Programmable Optical Filter
4000B Programmable Optical Processor
32000B / 32002B Reconfigurable Optical Processor

Full flexibility for Filtering and Switching operations in optical communications

The WaveShaper B-Series family allows arbitrary optical filtering of attenuation and phase (1000B, 4000B and 3200xB only) across the O-Band, the Super C-Band, Super L-Band or the entire C+L band. The 4000B and the 3200xB allow wavelength selective optical switching and in addition the 1000B and the 4000B provide a high resolution mode of operation in which the optical signal passes twice through the grating based monochromator. This high resolution mode ensures narrow channel shapes in combination with steep filter slopes of more than 700 dB/nm. This instrument family is broadly used in Research, Development and Manufacturing applications.

FEATURES

- Product versions available for:
  - O-Band
  - Super C-Band
  - Super L-Band
  - C+L Band
- Arbitrary control of attenuation and phase
- Filter update rate of more than 10 Hz
- High resolution: bandwidth down to 8 GHz (FWHM)
- Power splitting (4000B, 3200xB)
- Webserver included

APPLICATIONS

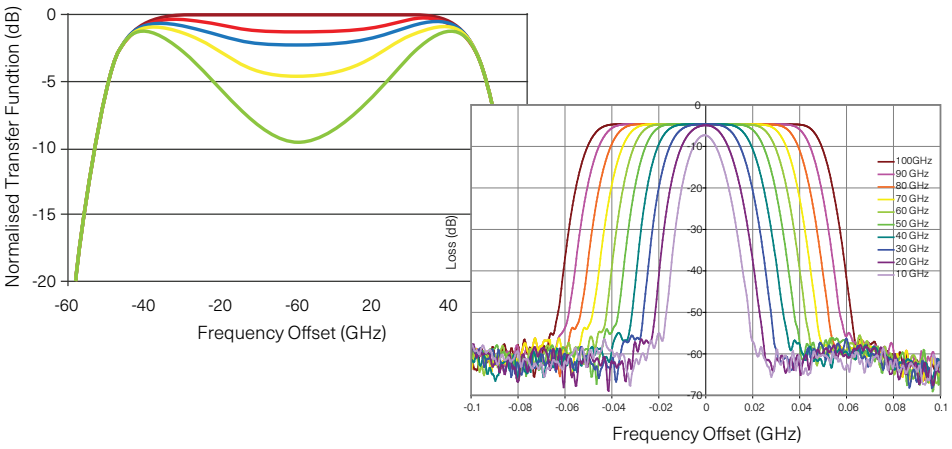
- DWDM System Test
- Network Simulation
- Transceiver test
- Pulse shaping
- Optical comb generation
- Quantum optics

COHERENT

Applications

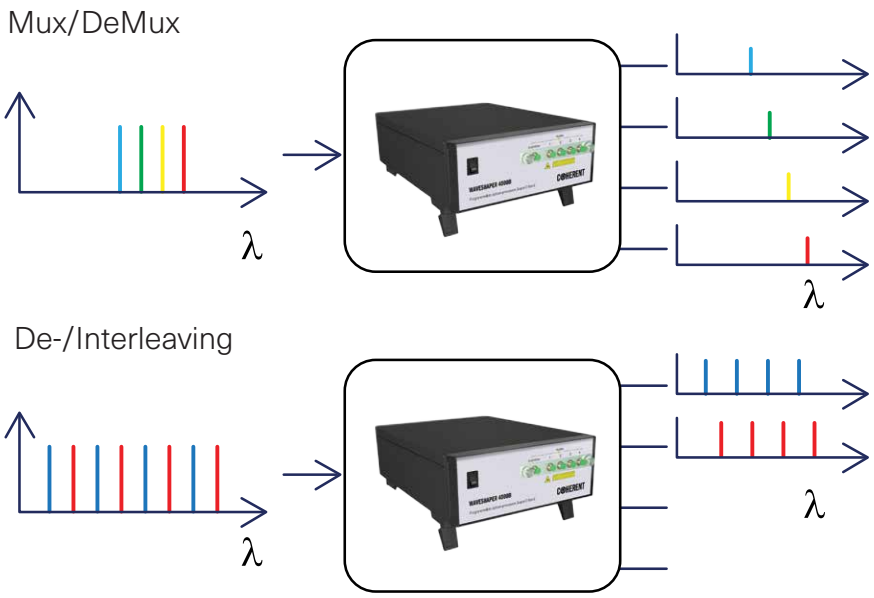
Filtering with arbitrary spectral shapes

Filtering with variable bandwidth and with arbitrary spectral shapes is of importance in system test experiments. For example, the influence of cascading of optical filters on the transmission quality can be investigated by programming the resulting filter shape into the WaveShaper.



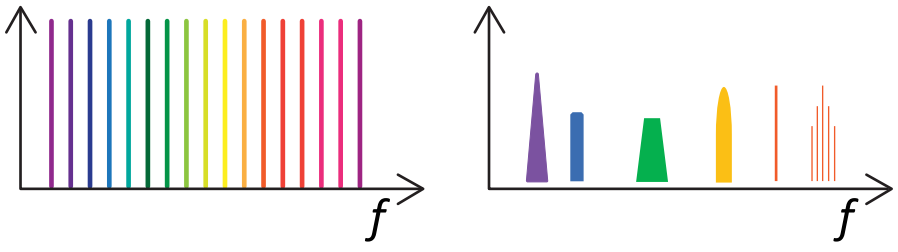
Mux/DeMux and De-/Interleaving

The WaveShaper 4000B can serve as a programmable Multiplexer/Demultiplexer or Interleaver/De-Interleaver. It can incorporate basically any channel spacing, including non-equally spaced channels. It fully supports Flexgrid™, the standard approach to flexible grid network architectures. Since it can operate in both directions, it can be used as a wavelength splitter as well as a combiner.



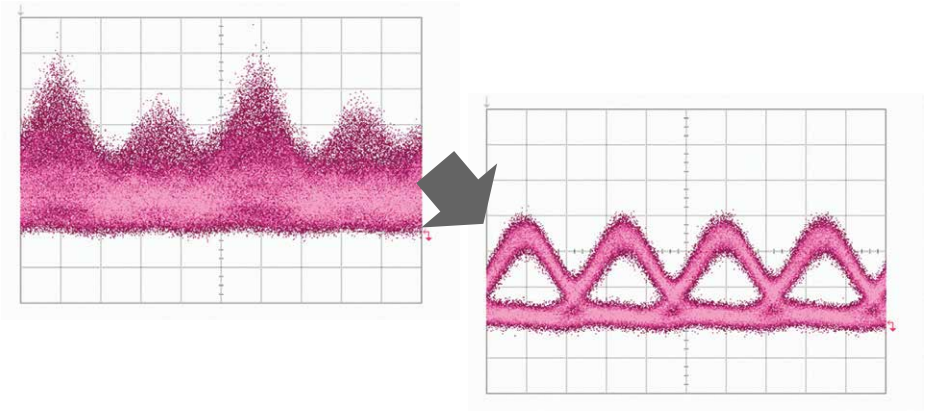
Component and System Loading

Generation of controllable optical combs is key in a variety of module and system test applications. For example, loading an amplifier with a representative power spectrum is required for proper amplifier testing. Similar requirements exist for testing optical systems involving amplified links. The WaveShaper can create individual spectral lines – even with shapes as if they were modulated.



Dispersion Compensation

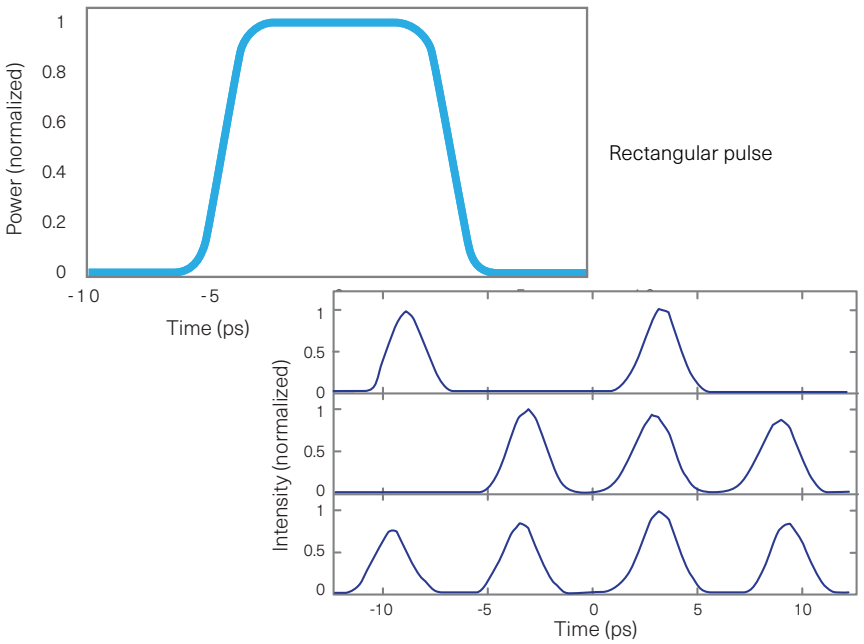
In system testing, verification of dispersion budgets and sensitivity of transmission systems to group delay ripple (and other dispersion imperfections) is of importance. Several members of the WaveShaper family allow setting dispersion values of up to 100 ps/nm (per 50 GHz channel) as well as creating group delay ripple with high spectral frequency.



Laser Pulse Compression, Shaping and Generation

Pulsed Lasers are utilized in a large number of medical, material processing, communications and other applications. Several of these applications require very short optical pulses, for example when athermal ablation is required. Several members of the WaveShaper family allow dynamic spectral shaping of amplitude and phase of optical pulses and therefore enables stable operation of such laser pulses in the femtosecond regime.

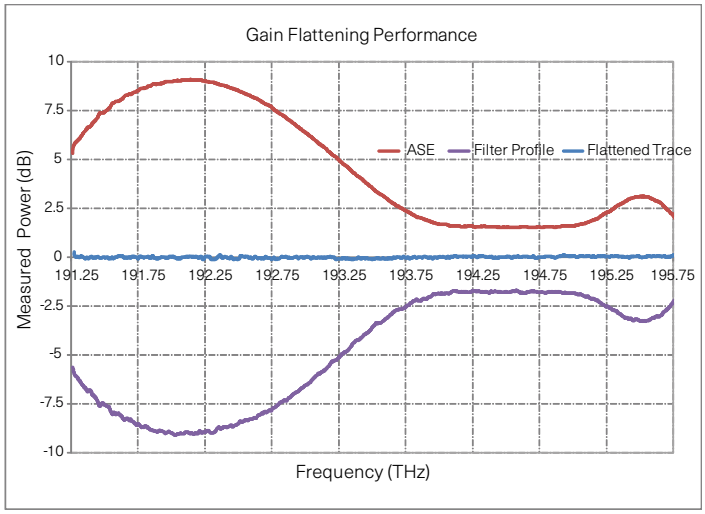
Certain other applications, in particular in the communications area, require specific pulse shapes (like rectangular for example) or particular bit sequences.



Creation of pulse patterns: pulse sequences of 1010, 0111, 1111 have been created from a single input pulse

Gain Equalization

A number of parameters need to be verified in communication test beds including the tolerance of the transmission system to spectral shapes of the gain. The WaveShaper allows creating such gain shapes with very high resolution (down to 0.01 dB attenuation steps), which allows for creation and compensation of such gain shapes.



Power Splitting and Broadcasting

The WaveShaper 4000 and 32000 as well as the 32002 have the ability to split an input signal between multiple output ports. Simple structures like wavelength-dependent couplers and splitters (Figure 1) can be created with user defined coupling ratios and frequency dependencies.

Figure 1: Splitter

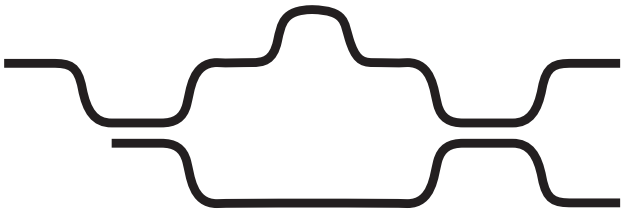


Figure 2: Variable Delay Line Interferometer

Programmable Interferometer

In addition to splitting power, the phase of signals in the different ports can also be adjusted. This allows the user to create, on the fly, more complex structures like delay line interferometers (e.g. DPSK-Demodulator – shown in Figure 2) or DQPSK-Demodulators with a variable, easily-programmable, optical transfer function (Figure 3).

More complex functions, such as the all-optical Discrete Fourier Transform (DFT) filter shown in Figure 4 can also be easily created.

These capabilities can be best described as "just like an Optical FPGA", where an optical functional element (component) can be created within a fraction of a second just by uploading a definition table. The ability to easily generate complex interferometric structures simplifies many areas of research which require an arbitrary optical transfer function, including the ability to share (or combine) power between multiple ports.

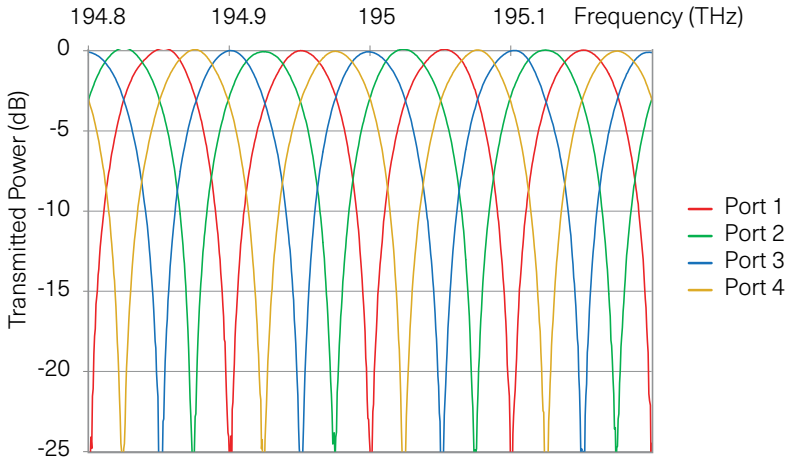


Figure 3: Optical transfer function of a DQPSK demodulator generated in a WaveShaper 4000B using the Fourier processor software

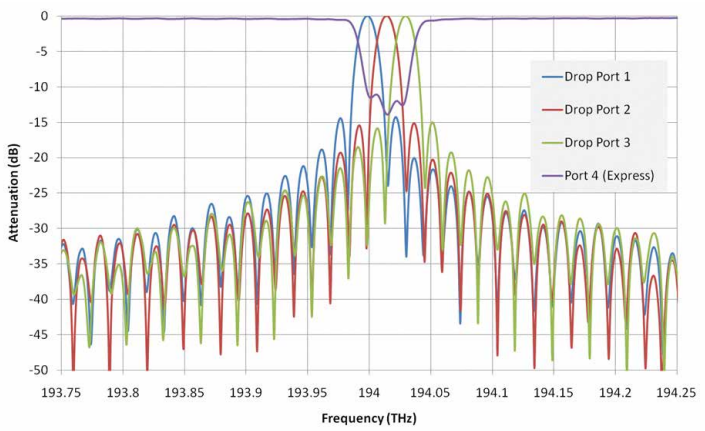
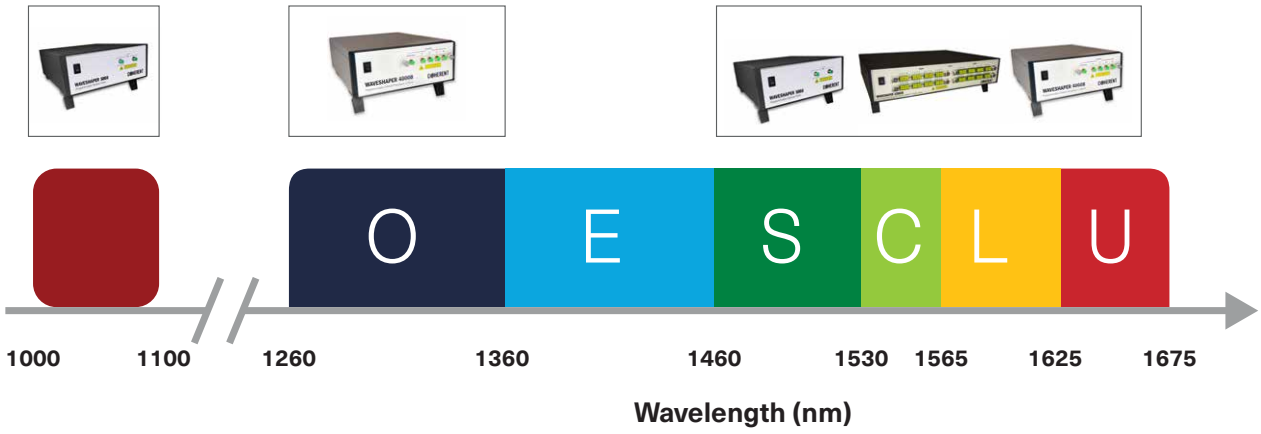


Figure 4: Optical transfer function of an all-optical DFT filter with 15 GHz FSR

A range of WaveShaper models is available covering the wavelength bands of interest in optical communications. In addition to instruments for the C- and the L-band — these bands are already used in many deployed networks — also instruments for the research and development space operating in the O-, S- and U-band are available. In addition a range of instruments developed for laser pulse shaping applications with operational windows in the 1 µm, C- and L-band is available. These are displayed in a separate brochure which is available on https://www.coherent.com/networking/optical-instrumentation.

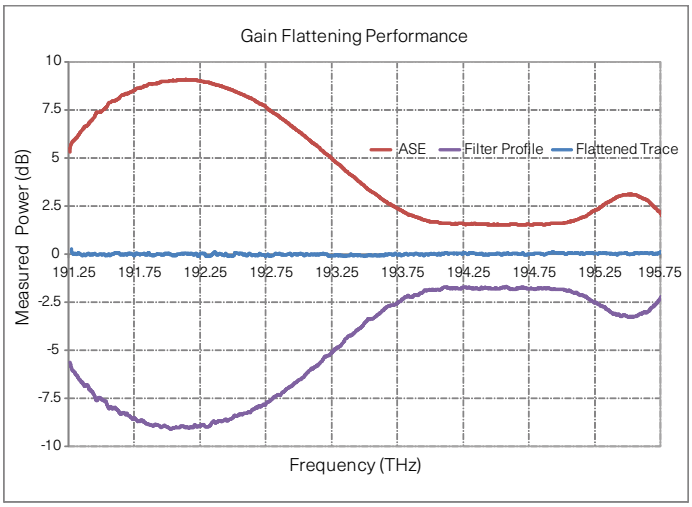
Wavelength Band Coverage by WaveShaper



WaveShaper 500B

Programmable Optical Filter

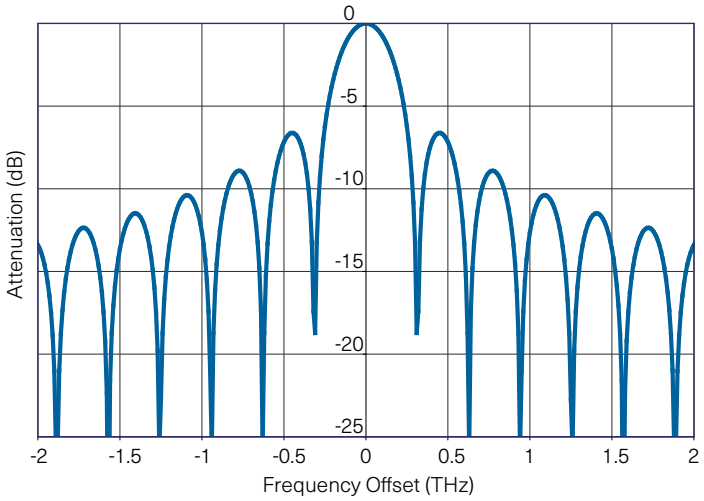
Optical filter covering the Super-C or Super-L band with arbitrarily programmable attenuation shape. Typical applications include gain equalization, channel selection and channel shaping as well as noise level setting in a transceiver test application.



WaveShaper 1000B

Programmable Optical Filter

Supports arbitrary user-generated channel and filter shapes. Depending on the model of the 1000B, the bandwidth can be set from 10 GHz to about 6 THz with 1 GHz increments (Super-C Band version and Super-L Band version) or from 16 GHz to about 11.1 THz (C+L Band version), also with 1 GHz increments. The required filter shape (both amplitude and phase) can be generated by the user, then loaded into the WaveManager software which translates the user specification into the required optical shape. Band-stop and optical comb filters are also supported as is attenuation control over a range of 40 dB for all filter types.



Example filter shapes generated with WaveShaper 1000/4000 programmable optical processor

WaveShaper 4000B

Multiport Optical Processor

Extends the capability of the WaveShaper 1000B including the ability to direct different portions of the signal to different output ports with different, arbitrary user-generated channel shapes for each port.

All members of the WaveShaper 4000 family support power splitting, broadcasting and the ability to create programmable interferometers, as described on page 4.

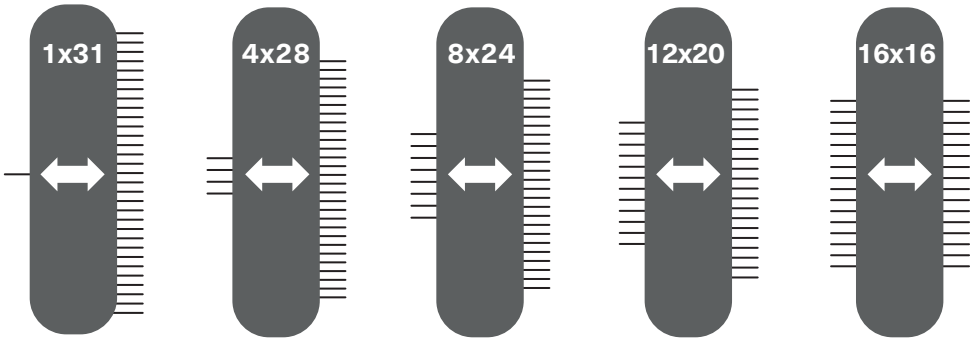
The WaveShaper 1000B and 4000B include a High Resolution mode in which the optical signal is guided twice through the optical filtering engine of the WaveShaper. As a result filter with a minimum bandwidth (FWHM) of 8 GHz and slopes with a steepness of more than 700 dB/nm are available!

WaveShaper 32000B / 32002B

Reconfigurable Optical Processor

Programmable wavelength-selective MxN optical filter with control of filter shape and phase on each input/output port combination. The instrument is available as a one-core unit or as a two-core unit, where a core is a WaveShaper engine. The two-core unit therefore includes the functionality of two separate WaveShaper units. Each core has a total number of 32 ports. These can be configured by software commands to 1 x 31, 4 x 28, 8 x 24, 12 x 20 and 16 x 16.All these port combinations work bi-directional, therefore also 31 x 1, 28 x 4, 24 x 8 and 20 x 12 are included.

Covering either the Super-C band or the Super-C + Super-L band, the WaveShaper 32000B and 32002B combine precise control of filter wavelength, bandwidth, shape and phase with the ability to switch and combine multiple signals in an “Add” or “Drop” configuration. Both WaveShaper units, the 32000B and the 32002B, also support power splitting, broadcasting and the ability to create programmable interferometers, as described on page 4.



The WaveShaper 32000B and 32002B allow arbitrary channel control and switching with high granularity. It has been designed for research and development applications in the advanced optical networking space. It provides key functions which are critical in the areas of elastic and space division multiplexed optical networks as well as software defined optical networking and OFDM.

The WaveShaper 32000B and 32002B are programmable with user defined filter shapes either through the WaveShaper App which serves as Graphical User Interface (GUI) or through the Application Programming Interface (API).

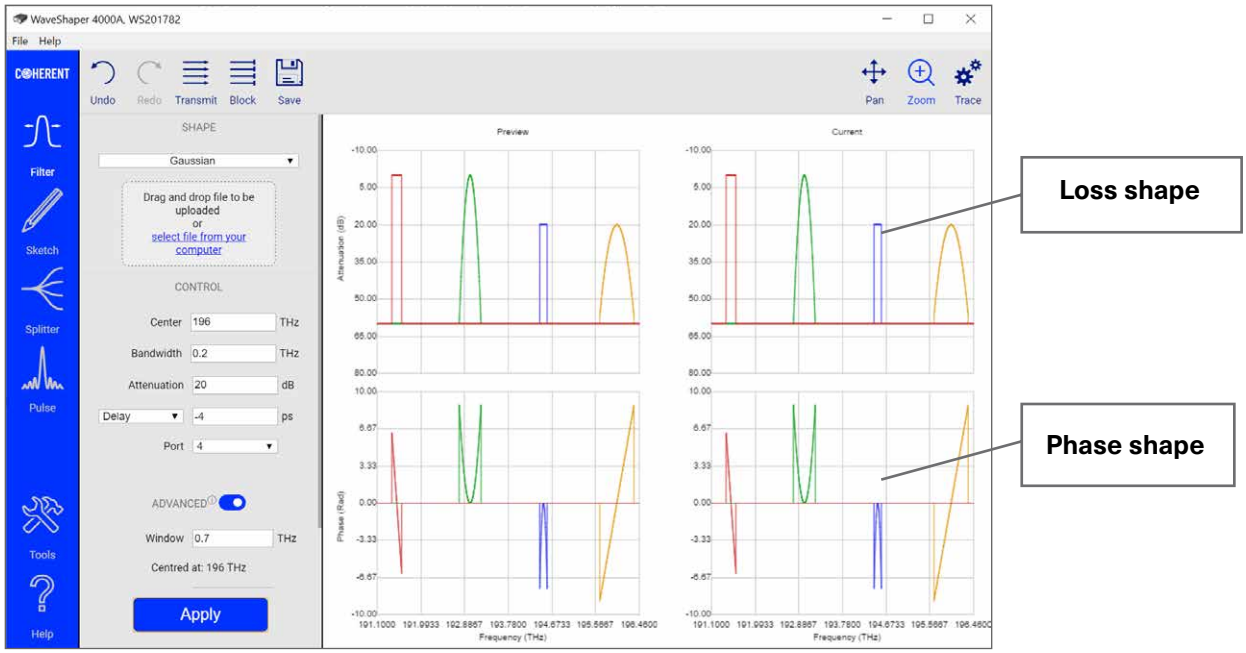
Operating the WaveShaper 32000B and 32002B in a 4 x 28, 8 x 24, 12 x 20 or 16 x 16 configuration is in terms of functionality equivalent to cascading two 1 x N WaveShapers back to back. For example, the 12 x 20 configuration is similar to operating a 12 x 1 WaveShaper and a 1 x 20 WaveShaper back to back. In order to prevent wavelength contention, the signals entering the WaveShaper through the different input ports should not spectrally overlap (one specific wavelength is only used at one input port - other ports receive different wavelengths). Both the GUI and API ensure that only those filter functions are accepted which do not lead to wavelength contention issues.

The programmable and integrated optical functions of the WaveShaper 32000B and 32002B are highly desirable in next generation optical data center interconnects and high performance computing.

Graphical User Interface (GUI)

The WaveShaper B Series instruments are controlled from an external device to select and update the filter shape. Communication with the WaveShaper is via USB or Ethernet interfaces. For the Graphical User Interface (GUI), the B Series WaveShaper supports the following approaches:

- **Integrated Webserver (Ethernet Interface):** The WaveShaper Series B instruments contain an in-built webserver that provides the most flexible approach, as the users client only needs to provide a web browser. No dedicated software or drivers are required. Supported systems include Windows 7 and higher, Linux, OS X, Android, iOS etc. Existing *.wsp and *.ucf files can be used, providing backward compatibility with current filter profiles.
- **WaveShaper App software package (Ethernet Interface):** This package runs on the user's computer and is available for Win 11 systems. It provides the same functionset as operation through the web browser, as well as providing a full device discovery service for networked units. The WaveShaper App package can be downloaded from https://www.coherent.com/networking/optical-instrumentation.

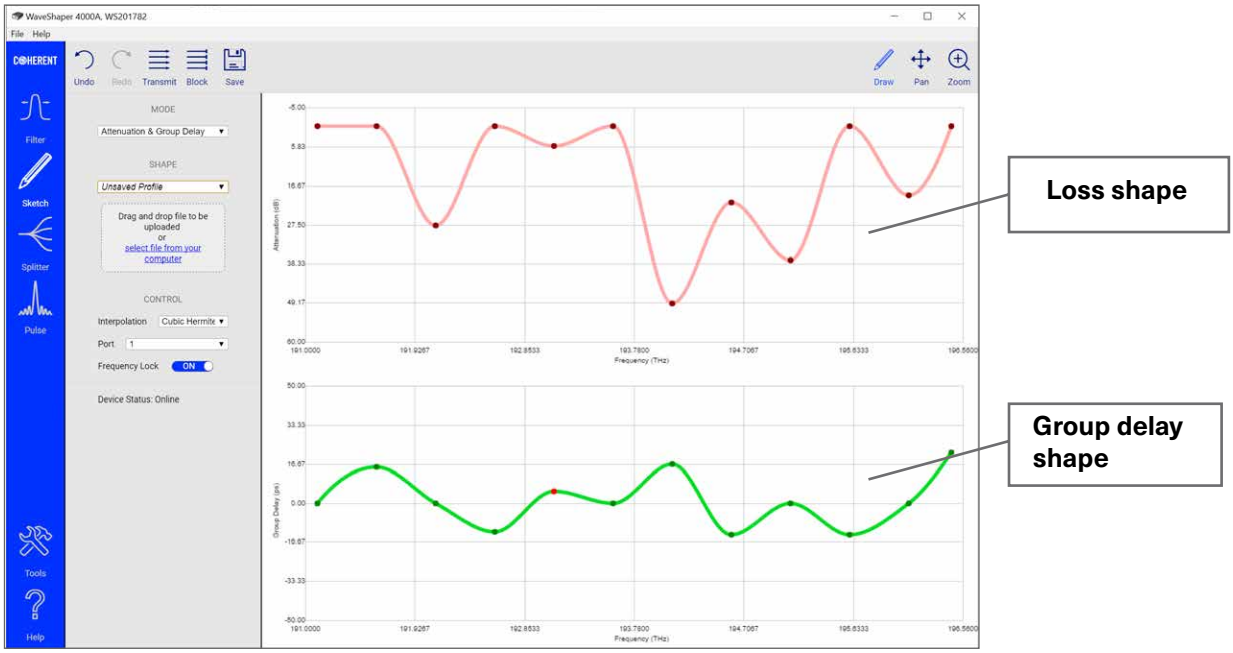


Application Programming Interface (API)

The WaveShaper B Series instruments include a web service API which enables the user to remotely configure the device over an Ethernet connection using HTTP commands from any software programming language. Programming examples are available for LabView, Matlab, Python, Octave, Visual Basic and C#.

WaveSketch

WaveSketch is an exciting capability which enables users of all versions of the WaveShaper 500B, 1000B, 4000B and 32000B / 32002B to manually create filter shapes using a 'drag and drop' graphical interface. As both the loss and phase (only for 1000B, 4000B and 32000B / 32002B) of the filter curve are manipulated on screen, the WaveShaper transfer function is updated in real time thus allowing, for example, continuous adjustments to eliminate drift in system test applications. The figure below shows a WaveSketch screenshot in which defined points can be added, deleted or modified as required.



Coherent Knowledgebase

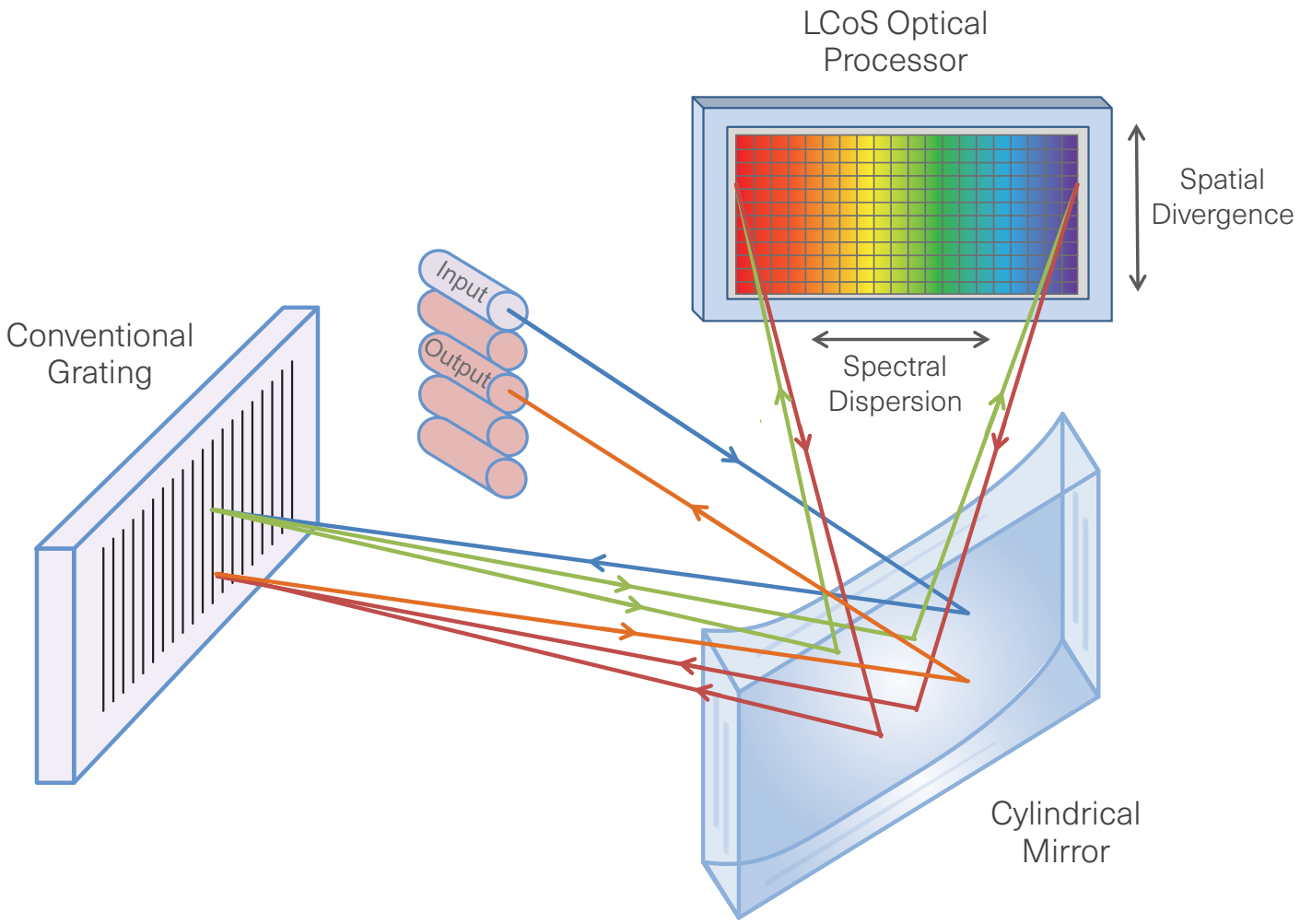
Obtain further application and technical information about the Optical Instrumentation Portfolio including the WaveAnalyzer Family by clicking here: https://www.coherent.com/networking/optical-instrumentation/knowledgebase

WaveShaper Demonstration on YouTube

Watch product demo at: https://www.youtube.com/@CoherentCorp

Technology - How does it work?

The WaveShaper family is based on advanced Liquid Crystal on Silicon (LCoS) technology. As shown schematically in the figure below, the input signal is dispersed by a conventional grating before its spectral components hit the LCoS optical processor. This LCoS processor consists of a matrix of reflective liquid crystal elements. By applying voltages to these matrix elements, they can add individual phase shifts to the reflected signals which allows beam steering of the signal components hitting the LCoS processor. As the wavelengths are separated on the LCoS chip, the control of each wavelength is independent of all others and can be switched or filtered without interfering with other wavelengths. As a result, the structure offers spectral attenuation, dispersion and optical switching capabilities which are available in the WaveShaper family.



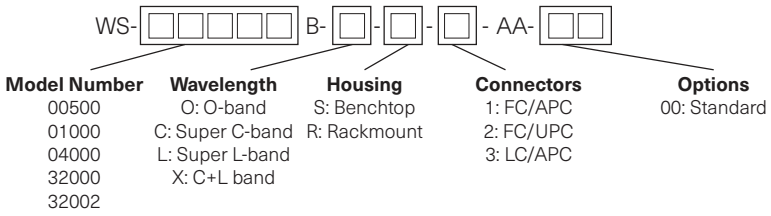
Specifications The device will meet all specifications following a warm-up period of 10 minutes from a temperature within the Operating Temperature range. Specifications may change without notice.

Model (5)		1000B/O	4000B/O	500B/C	1000B/C	4000B/C	1000B/L	4000B/L	1000B/X	4000B/X	32000B/C	32002B/C	32000B/X	32002B/X
Optical Cores		Single										Dual	Single	Dual
Transmission Band		O-band		Super C-band			Super L-band		C+L band		Super-C		Super-C + Super-L	
Optical Ports	Port Configurations	1x1	1x4	1x1		1x4	1x1	1x4	1x1	1x4	1x31, 4x28, 8x24, 12x20, 16x16			
Filter Control	Operating Frequency Range	220.76 THz to 237.20 THz (1264 nm to 1358 nm)		190.55 THz to 196.775 THz (1523.53 nm to 1573.301 nm)			184.25 THz to 190.59 THz (1572.97 nm to 1627.10 nm)		185.85 THz to 197.000 THz (1521.79 nm to 1613.08 nm)		190.65 THz to 196.65 THz (1524.5 nm to 1572.47 nm		184.28 THz to 196.8 THz (1523.4 nm to 1626.8 nm)	
	Filter Bandwidth	30 GHz to full range		10 GHz to full range	10 GHz to full range 8 GHz to full range (1)				18 GHz to full range 14 GHz to full range (1)		10 GHz to full range			
	Filter Shape	Arbitrary Attenuation and Arbitrary Phase		Arbitrary Attenuation	Arbitrary Attenuation and Arbitrary Phase									
	Frequency Setting Resolution	0.1 GHz (0.8 pm)												
	Frequency Setting Accuracy	±10 GHz (± 60 pm)		±1.5 GHz (±12 pm)					±5 GHz (±40 pm)		±1.5 GHz (±12 pm)		±5 GHz (±40 pm)	
	Bandwidth Setting Resolution	0.1 GHz (0.8 pm)												
	Bandwidth Setting Accuracy	±20 GHz		±5 GHz (±40 pm)					±10 GHz (±80 pm)					
	Bandwidth Setting Repeatability	±5 GHz (± 30 pm)		±2.5 GHz (±20 pm)					±5 GHz (±40 pm)					
	Group Delay Control Range	±20 ps		Not Applicable	±25 ps				±15 ps					
	Attenuation Control Range	0 to 40 dB												
	Attenuation Setting Resolution	0.1 dB		0.01 dB										
	Attenuation Setting Accuracy	±1 dB for 0.01 to 10 dB ±10% for 10.01 to 25 dB ±15% for 25.01 to 30 dB												
	Settling Time (Filter update rate)	<0.1 s (>10 Hz)												
Loss and Dispersion	Insertion Loss	8 dB		5 dB (2)	5 dB (2) 10 dB (1,2)				6.5 dB (3) 12 dB (1, 3)		6.0 dB (premium ports) (6) 8.0 dB (standard ports)		6.5 dB (premium ports) (6) 9.0 dB (standard ports)	
	Insertion Loss Non-Uniformity	0.8 dB		0.6 dB					0.8 dB		1.5 dB			
	Polarization Dependent Loss (PDL)	0.6 dB		0.4 dB					0.6 dB		0.8 dB			
	Differential Group Delay (DGD)	0.5 ps		0.6 ps					0.5 ps		0.5 ps			
	Return Loss	30 dB		25 dB					30 dB					
Optical Power (4)	Max Total Input Optical Power	27 dBm												
	Max Optical Power per 50 GHz channel	13 dBm												
Environment	Operating Temperature	10 to 35 °C												
	Operating Humidity	10% to 90% non condensing												
Electrical	Communications Interface	USB 2.0, Ethernet (GbE)												
	Power Consumption	< 50 W									< 60 W			
Mechanical	Connector Interface	FC/APC, FC/UPC									LC/APC			
	Dimensions	241 x 88 x 316 mm^3									241 x 88 x 375.5 mm^3	442 x 88 x 316 mm^3	241 x 88 x 375.5 mm^3	442 x 88 x 316 mm^3
	Weight	3.8 kg									4.5 kg	5 kg	4.5 kg	5 kg

Notes:
(1) Valid for port 1 when selecting “High Resolution” mode
(2) Valid for Filter Bandwidth settings of 15 GHz and larger. For Filter Bandwidth settings below 15 GHz an additional loss of up to 2 dB may apply.
(3) Valid for Filter Bandwidth settings of 25 GHz and larger. For Filter Bandwidth settings below 25 GHz an additional loss of up to 2 dB may apply.
(4) Optical signals with spectral components below 600 nm must be avoided.
(5) Specifications for the WaveShaper 1000B/O, 4000B/O, 32000B and for 32002B are preliminary.
(6) The WaveShaper 32000B and 32002B have at least 10 premium ports which show reduced insertion loss. These will be named in the Certificate of Conformity which comes along with the shipment.

Model	Order Code	Description	Wavelength Band	Housing Type	Fiber Type	# of Cores	Connection Type
WaveShaper 500B	WS-00500B-C-S-1-AA-00	Programmable Optical Filter	Super C	Benchtop	Single-mode	1	FC/APC
	WS-00500B-C-R-1-AA-00	Programmable Optical Filter	Super C	Rackmount	Single-mode	1	FC/APC
WaveShaper 1000B	WS-01000B-O-S-1-AA-00	Programmable Optical Filter	O-band	Benchtop	Single-mode	1	FC/APC
	WS-01000B-O-R-1-AA-00	Programmable Optical Filter	O-band	Rackmount	Single-mode	1	FC/APC
	WS-01000B-C-S-1-AA-00	Programmable Optical Filter	Super C	Benchtop	Single-mode	1	FC/APC
	WS-01000B-C-S-2-AA-00	Programmable Optical Filter	Super C	Benchtop	Single-mode	1	FC/UPC
	WS-01000B-C-R-1-AA-00	Programmable Optical Filter	Super C	Rackmount	Single-mode	1	FC/APC
	WS-01000B-L-S-1-AA-00	Programmable Optical Filter	Super L	Benchtop	Single-mode	1	FC/APC
	WS-01000B-L-S-2-AA-00	Programmable Optical Filter	Super L	Benchtop	Single-mode	1	FC/UPC
	WS-01000B-L-R-1-AA-00	Programmable Optical Filter	Super L	Rackmount	Single-mode	1	FC/APC
	WS-01000B-X-S-1-AA-00	Programmable Optical Filter	C+L	Benchtop	Single-mode	1	FC/APC
	WS-01000B-X-S-2-AA-00	Programmable Optical Filter	C+L	Benchtop	Single-mode	1	FC/UPC
	WS-01000B-X-R-1-AA-00	Programmable Optical Filter	C+L	Rackmount	Single-mode	1	FC/APC
WaveShaper 4000B	WS-04000B-O-S-1-AA-00	Programmable Optical Processor	O-band	Benchtop	Single-mode	1	FC/APC
	WS-04000B-O-R-1-AA-00	Programmable Optical Processor	O-band	Rackmount	Single-mode	1	FC/APC
	WS-04000B-C-S-1-AA-00	Programmable Optical Processor	Super C	Benchtop	Single-mode	1	FC/APC
	WS-04000B-C-S-2-AA-00	Programmable Optical Processor	Super C	Benchtop	Single-mode	1	FC/UPC
	WS-04000B-C-R-1-AA-00	Programmable Optical Processor	Super C	Rackmount	Single-mode	1	FC/APC
	WS-04000B-L-S-1-AA-00	Programmable Optical Processor	Super L	Benchtop	Single-mode	1	FC/APC
	WS-04000B-L-S-2-AA-00	Programmable Optical Processor	Super L	Benchtop	Single-mode	1	FC/UPC
	WS-04000B-L-R-1-AA-00	Programmable Optical Processor	Super L	Rackmount	Single-mode	1	FC/APC
	WS-04000B-X-S-1-AA-00	Programmable Optical Processor	C+L	Benchtop	Single-mode	1	FC/APC
	WS-04000B-X-S-2-AA-00	Programmable Optical Processor	C+L	Benchtop	Single-mode	1	FC/UPC
	WS-04000B-X-R-1-AA-00	Programmable Optical Processor	C+L	Rackmount	Single-mode	1	FC/APC
	WS-04000B-X-R-2-AA-00	Programmable Optical Processor	C+L	Rackmount	Single-mode	1	FC/UPC
WaveShaper 3200xB	WS-32000B-C-S-3-AA-00	Reconfigurable Optical Processor	Super C	Benchtop	Single-mode	1	LC/APC
	WS-32000B-X-S-3-AA-00	Reconfigurable Optical Processor	Super C+ Super L	Benchtop	Single-mode	1	LC/APC
	WS-32002B-C-S-3-AA-00	Reconfigurable Optical Processor	Super C	Benchtop	Single-mode	2	LC/APC
	WS-32002B-C-R-3-AA-00	Reconfigurable Optical Processor	Super C	Rackmount	Single-mode	2	LC/APC
	WS-32002B-X-S-3-AA-00	Reconfigurable Optical Processor	Super C+ Super L	Benchtop	Single-mode	2	LC/APC
	WS-32002B-X-R-3-AA-00	Reconfigurable Optical Processor	Super C+ Super L	Rackmount	Single-mode	2	LC/APC

Order Code Key



Additional Resources

Visit https://www.coherent.com/networking/optical-instrumentation for the latest product information, news and software for the WaveShaper and WaveAnalyzer product families.

Knowledge Base

Obtain further application and technical information about the Optical Instrumentation portfolio by visiting: https://www.coherent.com/networking/optical-instrumentation/knowledgebase

Product Demonstration Videos

Watch product demos at: https://www.youtube.com/@CoherentCorp

sales@coherent.com
www.coherent.com