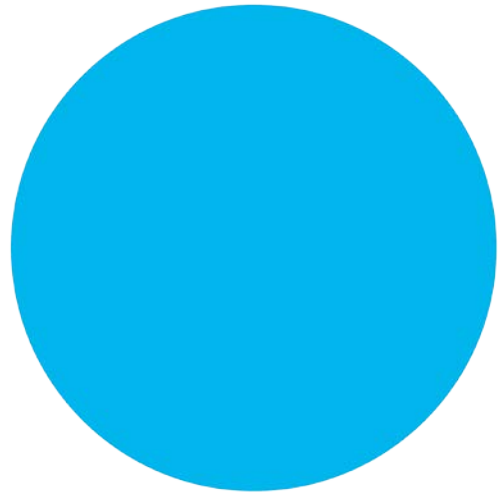




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LiNbO₃ modulators and ModBox for NIR laser applications



1

**iXblue delivers
modulation solution to
fiber laser and high
energetic and powerful
lasers**

iXblue delivers modulation solution to fiber laser and high energetic and powerful lasers



LiNbO₃ Modulators



ModBoxes & System



2

Amplitude Modulators: NIR-MX-LN series

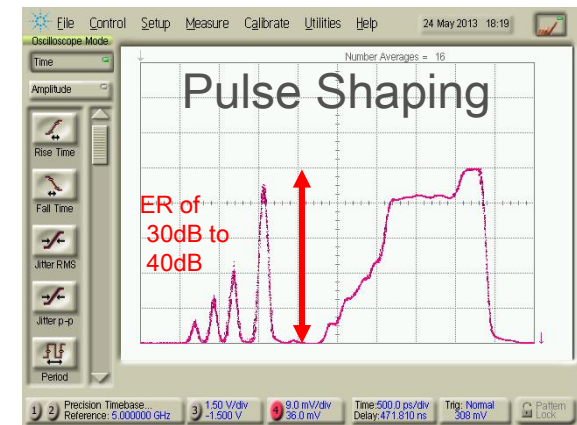
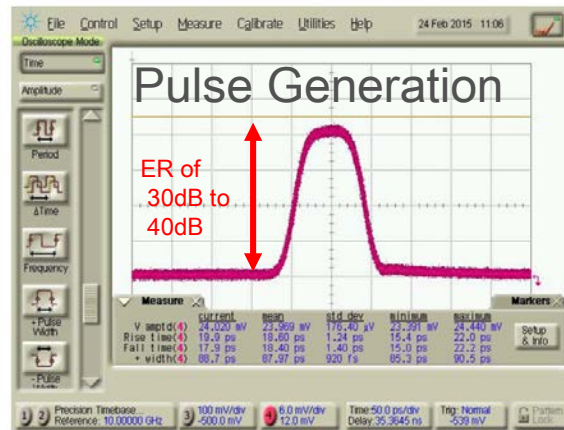
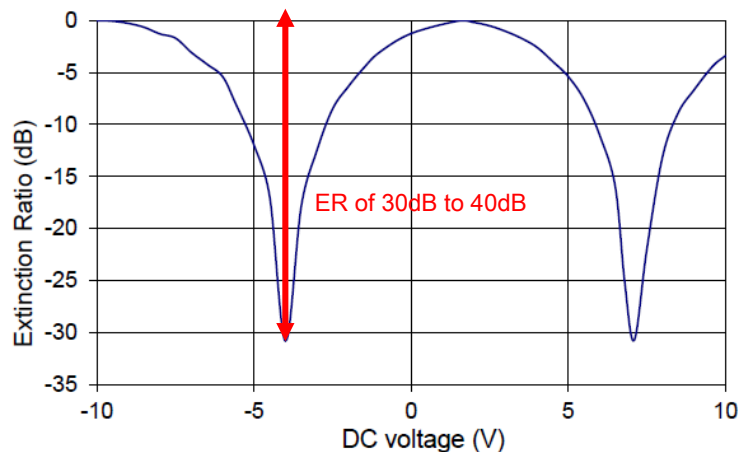
Amplitude Modulators: NIR-MX-LN series

High extinction ratio modulator @1030nm, 1053nm, @1064nm, 1080nm

- Low insertion loss of 3,5 dB typically
- Lower $V_{\pi_{50\text{kHz}}}$ of 3.5 V typically
- Pulse picking / Slicing / Generation / Shaping with 35ps Rise time
- Extinction Ratio up to 40dB



NEW Higher PER > 29 dB typical



Amplitude Modulators: NIR-MX-LN series

NIR-MX-LN series:

- NIR-MX-LN-10
Pulse rise time less than 35ps
- NIR-MX-LN-20
Pulse rise time less than 20ps
- NIR-MX-LN-40
Rise time less than 10ps



NIR-MX-LN series
1000 nm band Intensity Modulator
PHOTLINE MODULATOR



FEATURES

- Superior Extinction ratio: > 30 dB
- X-cut for high stability
- Low drive voltage
- Low insertion loss

APPLICATIONS

- Pulse generation / picking
- Carrier suppression
- Fiber optics sensors
- Pulse applications
- Analog transmission

OPTIONS

- 1550 nm, 1300 nm band versions
- Choice of optical connectors

RELATED EQUIPMENTS

- RF amplifiers
- MBC-DG Automatic Bias Controllers

The Photline NIR-MX-LN series are an intensity modulator especially designed for operation in the 1000 nm wavelength band.

This Mach-Zehnder modulator offers engineers working in the 1000 nm the intrinsic and unparalleled benefits of LiNbO₃ external modulation : high bandwidth, high contrast up to 30 dB and beyond, ease of use. Thanks to iXBlue Technologies proprietary waveguide process, the NIR-MX-LN exhibits a stable behaviour and supports several tens mW of input optical power.

NIR-MX-LN-10 Performance Highlights

Parameter	Min	Typ	Max	Unit
Operating wavelength	980	-	1150	nm
Insertion loss	-	3.5	-	dB
Extinction ratio	-	30	-	dB
Electro-optical bandwidth	-	12	-	GHz
V _{mRF} @ 10 GHz	-	4.5	-	V

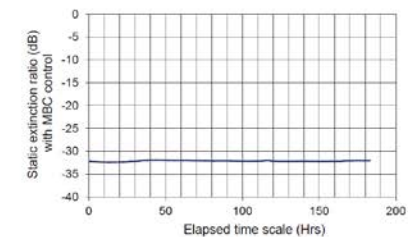
Specifications given at 25 °C, 1060 nm

NIR-MX-LN-20 Performance Highlights

Parameter	Min	Typ	Max	Unit
Operating wavelength	980	-	1150	nm
Insertion loss	-	3.5	-	dB
Extinction ratio	-	30	-	dB
Electro-optical bandwidth	-	12	-	GHz
V _{mRF} @ 20 GHz	-	6	-	V

Specifications given at 25 °C, 1060 nm

Extinction Ratio Response





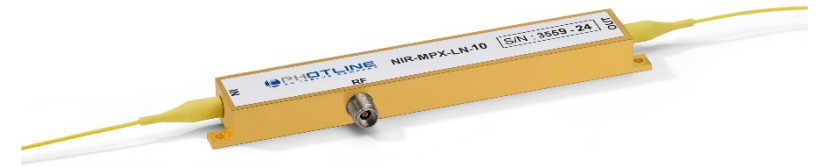
3

Phase modulators: NIR-MPX series

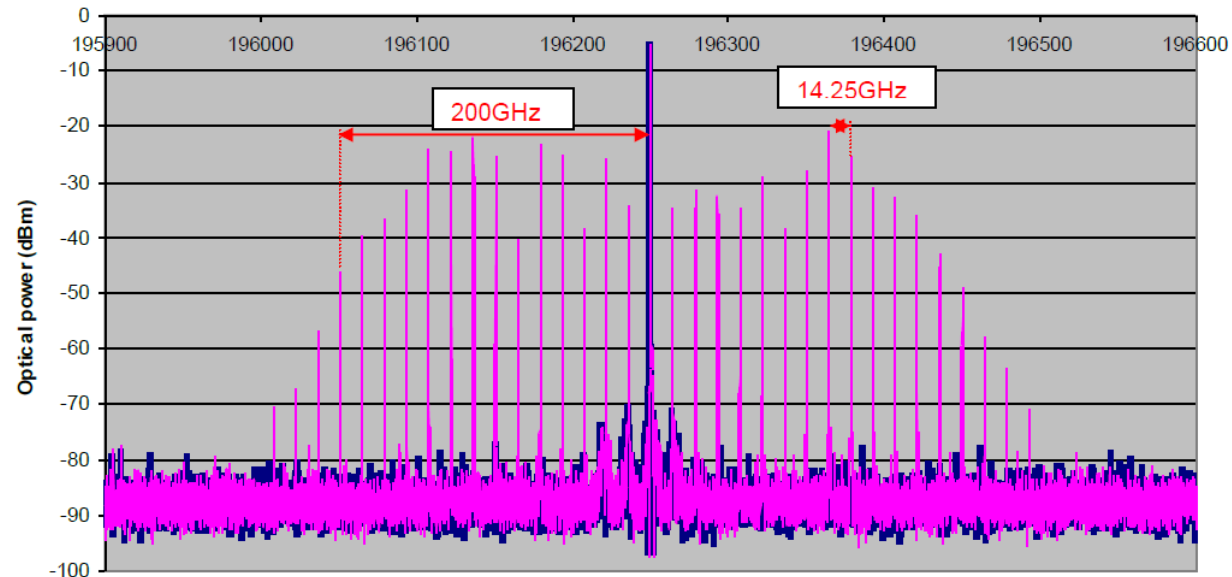
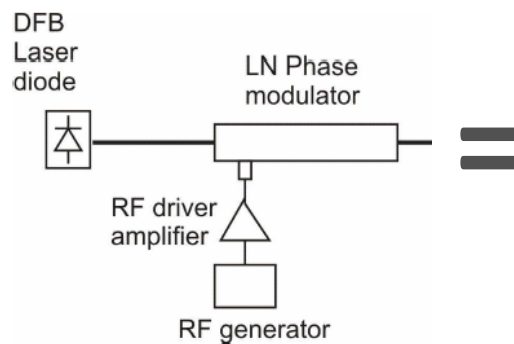
Phase modulators: NIR-MPX series

New NIR Phase:

- @1030nm, @1053nm, @1064nm, @1080nm
- Low insertion loss of 3 dB typicaly
- Lower $V_{\pi_{50\text{kHz}}}$ of 2.5 V typicaly



Higher PER of 29 dB Typ



Phase modulators: NIR-MPX series



NIR-MPX-LN series
1000 nm band Phase Modulators

PHOTLINE MODULATOR

NIR-MX-LN series:

- NIR-MPX-LN-0,1
- NIR-MPX-LN-02
- NIR-MPX-LN-05
- NIR-MPX-LN-10



NIR-MPX-LN-20



FEATURES

- High optical power : 100 mW
- High Bandwidth version > 20 GHz
- High stability
- Low V_{π}
- Low insertion loss

APPLICATIONS

- Interferometric based sensor
- Spectral broadening
- Frequency shifting
- Laser combining
- Pound-Drever-Hall locking (PDH)

OPTIONS

- 20 GHz version
- Hermetic sealing
- 800 nm, 950 nm versions
- High PER
- Lower Insertion Loss < 2.5 dB

RELATED EQUIPMENTS

- Matched RF amplifiers
- NIR-MX-LN intensity modulators

The Photline NIR-MPX series are phase modulators especially designed to operate in the 1000 nm wavelength band. They are available with various modulation bandwidths, from low frequency to 20 GHz and beyond.

Like all iXBlue Near InfraRed (NIR) modulators, the NIR-MPX series use a proton exchanged based waveguide process that confers them an unparalleled stability even when operating at high optical power. The NIR-MPX phase modulators come with high PER and low IL options.

NIR-MPX-LN-0.1 Performance Highlights

Parameter	Min	Typ	Max	Unit
Operating wavelength	980	-	1150	nm
Electro-optical bandwidth	-	150	-	MHz
V_{π} RF @50 kHz	-	2.5	-	V
Insertion loss	-	3	-	dB

Specifications given at 25 °C, 1060 nm

NIR-MPX-LN-02 Performance Highlights

Parameter	Min	Typ	Max	Unit
Operating wavelength	980	-	1150	nm
Electro-optical bandwidth	2	-	-	GHz
V_{π} RF @50 kHz	-	3	-	V
Insertion loss	-	3	-	dB

Specifications given at 25 °C, 1060 nm

NIR-MPX-LN-05 Performance Highlights

Parameter	Min	Typ	Max	Unit
Operating wavelength	980	-	1150	nm
Electro-optical bandwidth	5	-	-	GHz
V_{π} RF @50 kHz	-	4.5	-	V
Insertion loss	-	3	-	dB

Specifications given at 25 °C, 1060 nm

NIR-MPX-LN-10 and NIR-MPX-LN-20 Performance Highlights

Parameter	Min	Typ	Max	Unit
Operating wavelength	980	-	1150	nm
Electro-optical bandwidth	-	12 / 20	-	GHz
V_{π} RF @50 kHz	-	5.5	-	V
Insertion loss	-	3	-	dB

Specifications given at 25 °C, 1060 nm



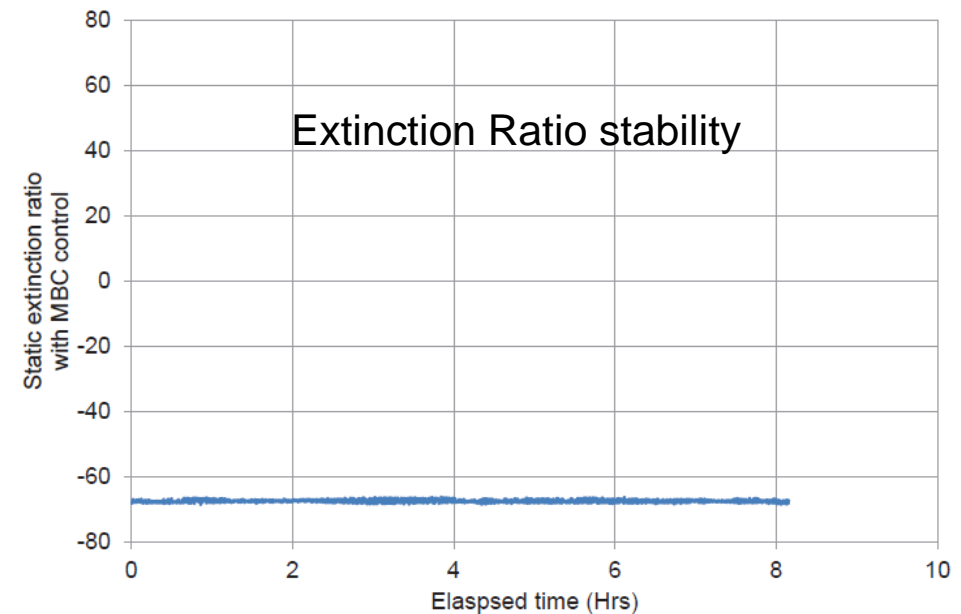
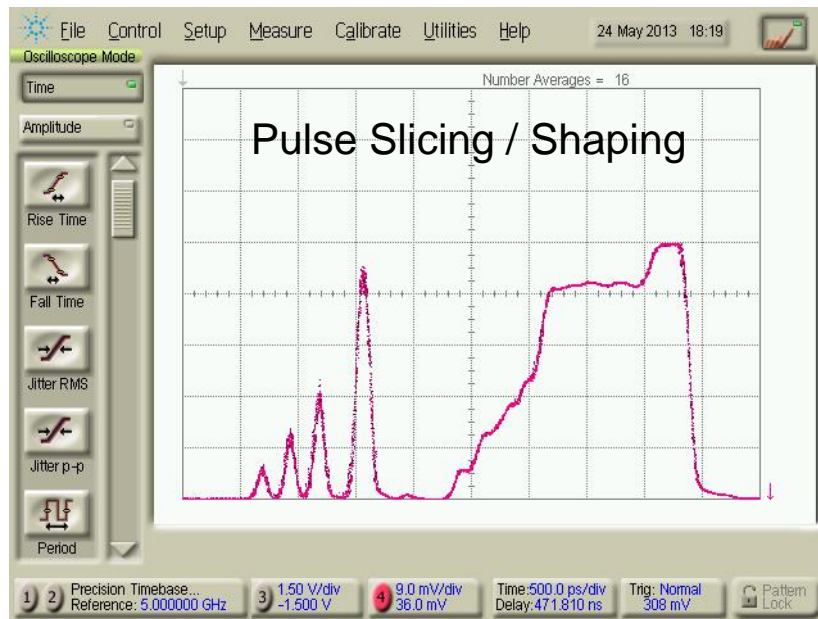
4

ModBox-Pulse-Shaper

ModBox-Pulse-Shaper

The ModBox-PS is Pulse Modulation Unit generating:

- @1030nm, @1053nm, @1064nm, @1080nm
- Arbitrary optical waveform from 125ps pulse width, from single shot to 100 kHz
- High (to 40dB) or extremely high (to 60dB) optical pulse contrast
- AWG of 800 samples per pulse with a jitter of 7ps max value !



ModBox-Pulse-Shaper

- OPCPA
- Main source laser (narrow line width laser)
- @1030nm, 1053nm, @1064nm, 1080nm
- ER@40dB, @60dB
- IL@8dB



The Photline Modbox-Pulse-Shaper is an Optical Modulation Unit to generate short shaped pulses with high extinction ratio at 1030 nm, 1053 nm or 1064 nm. It allows dynamic extinction ratio from 35 dB to above 55 dB with user adjustable pulse duration, repetition rate and temporal pulse shape. One benefit of the Photline Modbox-Pulse-Shaper is to pre-compensate the pulse distortion that occurs in the amplifiers chains that operate in (a highly) saturated regime.

When combined with properly selected high power CW laser, pulsed optical amplifier, and Pulse Broadening ModBox, the Photline Modbox-Pulse-Shaper makes up a complete Front End System that can deliver custom pulses with energy of several uJ.

Photline has accumulated a strong experience in such systems and successfully installed them in many Intense Laser Facilities all over the world.

FEATURES

- Optical waveform flexibility
- Low jitter
- Low rise & fall times
- Very high extinction ratio (35 dB, 55 dB)
- Proven solution

APPLICATIONS

- Inertial confinement fusion
- Interaction of intense light with matter
- Laser plasma interaction
- Laser implosion
- Interaction of ion beam with HP laser

OPTIONS

- Complete Front-End System
- Extinction ratio value
- Choice of electrical pulse generator

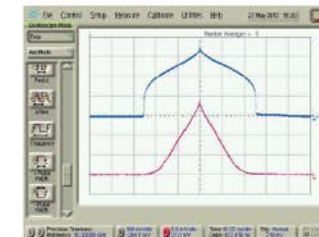
RELATED EQUIPMENTS

- ModBox Spectrum Broadening
- CW high power laser
- Pulsed optical amplifiers

Performance Highlights

Parameter	Min	Typ	Max
Operating wavelength	1030 nm, 1053 nm, 1064 nm		
Pulse contrast	35 dB, or > 55 dB		
Pulse waveform	Arbitrary, user adjustable		
Pulse width	> 125 ps		
Rise / Fall times	< 50 ps		
Jitter	< 10 ps		

Electrical & Optical Pulse Diagrams



Electrical pulse from AWG (blue curve) with corresponding Optical output (pink curve)



5

Front-End Systems

Front-End System – I/II

The system Front-End is generating:

- @1030nm, @1053nm, @1064nm, @1080nm
- Arbitrary optical waveform from 125ps pulse width, from single shot to 100 kHz
- High (to 40dB) or extremely high (to 60dB) optical pulse contrast
- AWG of 800 samples per pulse with a jitter of 7ps max value !
- @1053nm and 1ns pulse: > 800pJ with ER@40dB or > 250pJ with ER@60dB

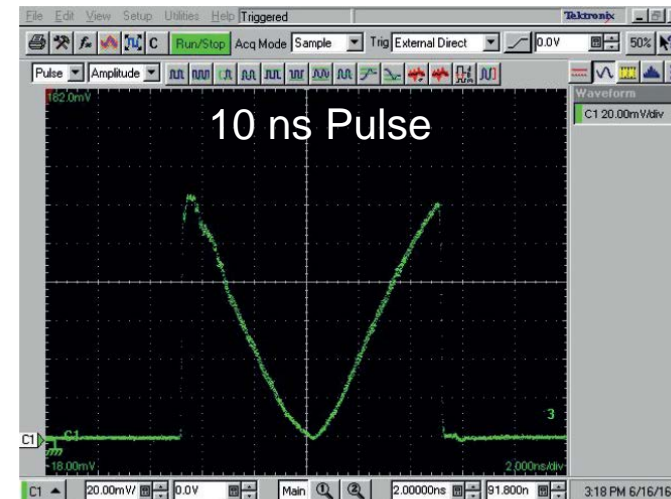
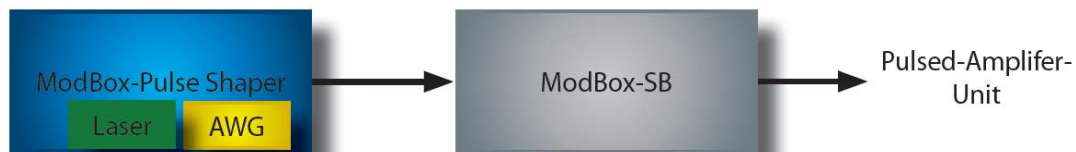
	1030 nm	1053 nm	1064 nm
Pulse contrast	35 dB / 55 dB		
Pulse waveform	Arbitrary, user adjustable		
Pulse width	125 ps to 10 ns		
Energy per pulse: PW = 1 ns & ER = 35 dB	300 pJ	800 pJ	800 pJ
Energy per pulse: PW = 1 ns & ER = 55 dB	100 pJ	250 pJ	250 pJ
RMS jitter	7 ps		



Front-End System – II/II

The system Front-End is generating:

- EXTREMELY low jitter < 7 ps peak to peak
- Arbitrary optical waveform from 100ps pulse width, from single shot to 100 kHz
- High (to 40dB) or extremely high (to 60dB) optical pulse contrast
- AWG of 2 500 samples per pulse !
- @1053nm and 1ns pulse: > 800pJ with ER@40dB or > 250pJ with ER@60dB



Front-End System

- OPCPA
- Main source laser (narrow line width laser)
- @1030nm, 1053nm, @1064nm, 1080nm
- ER@40dB, @60dB
- Pulse Energy >100pJ to 800pJ



The Photline ModBox-FE is a complete front end laser system designed to be used as a seed source in high energy density laser facilities. The system is available at 1030 nm, 1053 nm and 1064 nm , it allows to generate 125 ps to 10 ns, custom shaped optical pulses with high stability and high extinction ratio. The short pulse generation is based on the combination of a high performance continuous laser source combined with a large bandwidth modulation stage based on a high extinction ratio external LiNbO₃ modulator.

An automatic bias control circuitry (MBC) guarantees the extinction ratio stability over time and the optical pulses are carved out thanks to a high resolution Arbitrary Waveform Generator. A multi year collaboration experience with famous intense laser facilities all over the world allows Photline to propose high performance, reliable and easy to use systems perfectly suited to the various applications related with high energy optical pulse generation.

The ModBox-FE can be associated with the Spectral Broadening unit ModBox-SB in order to counter the SBS effects caused by the amplification of a narrow linewidth laser source.

FEATURES

- Optical waveform flexibility
- Low jitter
- Low rise & fall times
- Very high extinction ratio and stability
- Proven solution

APPLICATIONS

- Inertial confinement fusion
- Interaction of intense light with matter
- Laser plasma interaction
- Laser implosion
- Interaction of ion beam with HP laser

OPTIONS

- Extinction ratio choice
- Pulse energy

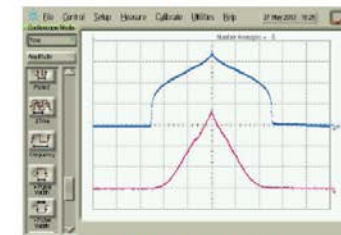
RELATED EQUIPMENTS

- ModBox-SB

Performance Highlights

	1030 nm	1053 nm	1064 nm
Pulse contrast	35 dB / 55 dB		
Pulse waveform	Arbitrary, user adjustable		
Pulse width	125 ps to 10 ns		
Energy per pulse: PW = 1 ns & ER = 35 dB	300 pJ	800 pJ	800 pJ
Energy per pulse: PW = 1 ns & ER = 55 dB	100 pJ	250 pJ	250 pJ
RMS jitter	7 ps		

Electrical & Optical Pulse Diagrams



Electrical pulse from AWG (blue curve) with corresponding Optical output (pink curve)



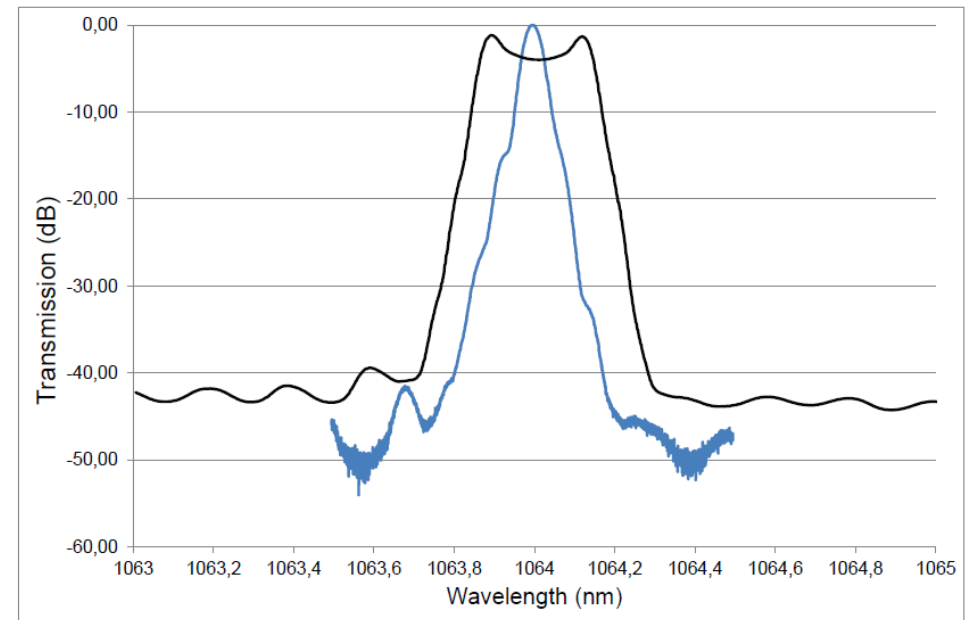
6

ModBox-SB: Spontaneous Brillouin Suppression (SBS) effect Solution

ModBox-SB: Spontaneous Brillouin Suppression effect Solution

2GHz, 14,25GHz and 20GHz side band gap

- @1030nm, @1053nm, @1064nm, @1080nm
- Low Insertion loss of 3 dB
- From 0,2nm to > 1nm broadened spectrum



ModBox-SB: Spontaneous Brillouin Suppression effect Solution

- Main source laser (narrow line width laser)
- @1030nm, 1053nm, @1064nm, 1080nm
- Low IL 3dB
- Pulse Energy >100pJ to 800pJ

iXblue
light.augmented

ModBox-SB-NIR
Near Infra Red Spectral Broadening Unit

PHOTLINE ModBox



FEATURES

- Suppress Stimulated Brillouin Scattering
- Externally triggered
- Low insertion loss

APPLICATIONS

- Inertial confinement fusion
- Interaction of intense light with matter
- Laser plasma interaction
- Laser implosion
- Interaction of ion beam with HP laser

OPTIONS

- Wavelength from 780 nm up to 2 220 nm
- Alternative synthesizer frequencies
- Rack-mount or module version

RELATED EQUIPMENTS

- ModBox Pulse-Shaper
- CW high power laser
- Pulsed amplifiers
- Complete Front-End System

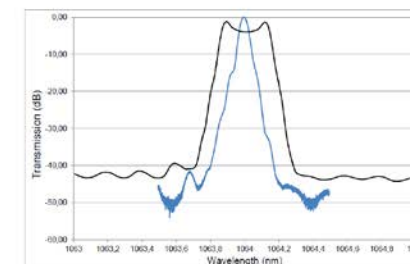
The Spectral Broadening ModBox achieves the broadening of an optical signal by modulating its phase via the mean of a very efficient LiNbO₃ phase modulator. A number of side bands are created over a spectral width that can reach several hundreds GHz.

The spectral broadening of optical signals is a solution to suppress the Stimulated Brillouin Scattering (SBS) caused in optical fibers by high fluxes of highly coherent light. The SBS degrades the signal integrity and prevents the proper transmission through the fiber. Under certain conditions, when amplification occurs for instance, the SBS can lead to the destruction of the fiber and the optical components along or forward the fiber. When the temporal coherence of the signal is destroyed, the SBS power threshold is significantly increased and thus its effects can be eliminated.

Performance Highlights

Parameter	Min	Typ	Max
Operating wavelength	980 nm	1053 nm	1150 nm
Spectral broadening	-	0.3 nm / 1.5 nm	-
RF source frequency	-	2 GHz / 14.25 GHz	-
Insertion loss	-	3 dB	-

Broadened Spectrum



Typical ModBox responses: the blue curve is the optical analyzer impulse response, the black curve is the broadened spectrum.



7

ModBox-DER: ns-Pulse and Pedestal Measurement DER monitoring

ModBox-DER: ns-Pulse and Pedestal Measurement DER monitoring

- @1030nm, 1053nm, @1064nm, 1080nm
- 5ns to 25ns pulse analysis
- DER 10dB \Rightarrow 60dB



The ModBox-DER is the first equipment specially designed to measure the Dynamic Extinction Ratio (DER) of high contrast ns optical pulses in the 1000 nm wavelength band. It measures Extinction Ratios up to more than 50 dB, for pulses as short as 5 ns, from single-shot operation to 10 kHz repetition frequency.

The ModBox-DER uses the French Nuclear Agency technology developed for the monitoring of the MegaJoule laser. It finds applications mostly in ultra-intense laser facilities.

Principle

The high contrast pulse to be characterized is split in two parts: one part is strongly attenuated by a factor which is typically the expected value of the DER; for the second part, most of the pulse is retrieved using a high extinction modulator, leaving only the pedestal. The two parts are then measured with the same high bandwidth - high sensitivity photodetector for which only a few dB of dynamic range are required.

The main advantage of this measurement principle is the "self-calibration": Peak and noise powers of the optical pulse are measured by the same high bandwidth and high sensitivity photodetector.

FEATURES

- 1030 nm, 1053 nm, 1064 nm
- Dynamic Extinction Ratio up to 55 dB

APPLICATIONS

- Inertial confinement fusion
- Interaction of intense light with matter
- Laser Plasma interaction
- Laser implosion

OPTIONS

- Other maximum Extinction Ratio value
- Wavelength

RELATED EQUIPMENTS

- ModBox-Pulse-Shaper
- Front-End System

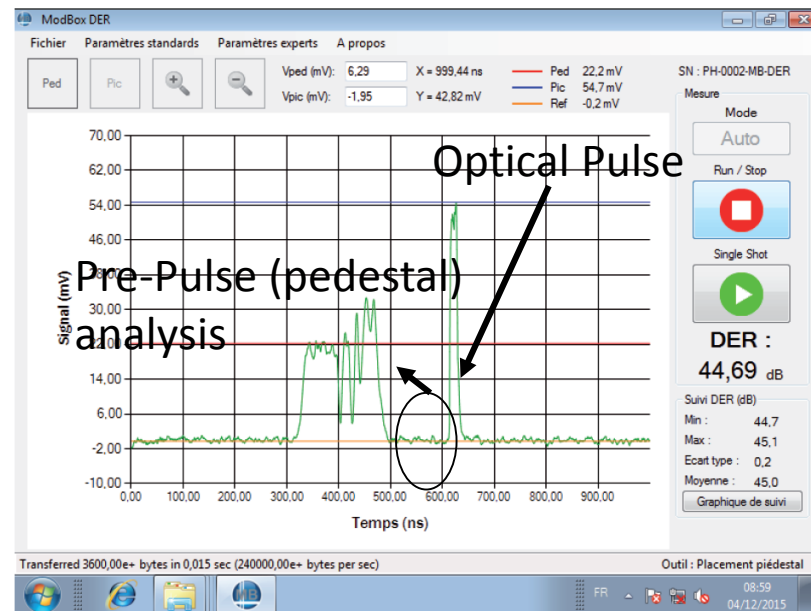
Performances

Parameter	Min	Typ	Max	Unit
Input Signal				
Wavelength	1030 nm, 1053 nm, 1064 nm			-
Signal type	Optical Pulse			
Pulse Width	5	-	25	ns
Pulse Rate	Single shot	-	10	kHz
Pulse amplitude	70	-	450	mW
Optical Characteristics				
DER	Automatic measurement			-
	10	50	55	dB
DER monitoring	-	until 1 week	-	-
Resolution	-	0.6	-	ns
Measuring window	500 n	-	2 m	s
Pulse acquisition rate	-	0.5	-	Hz

ModBox-DER: ns-Pulse and Pedestal Measurement DER monitoring

- @1030nm, @1053nm, @1064nm, @1080nm
- Pulse and Pedestal Measurement DER monitoring
- Very High Dynamic Extinction ratio Measurement from 10dB up to 60dB

Pulse and Pedestal Measurement



DER monitoring

