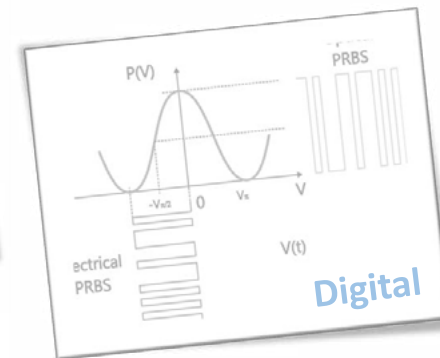
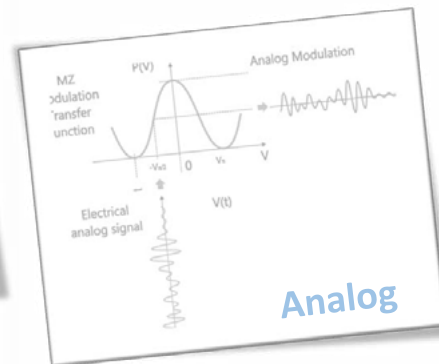
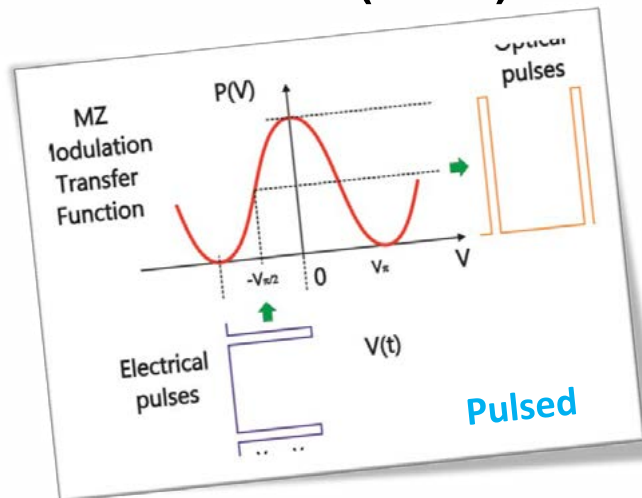


Pulse Application using LiNbO₃ modulators and matching components

Main modulation formats of Mach-Zehnder Modulators (MZM) for Optical Pulse



Pulse Application Using LiNbO₃ modulators and matching components

iXblue Modulation Solution Components

iXBlue Photonics develops and produces:

- Pulsed optical LiNbO₃ modulators showing high extinction ratio and fast rise & fall time,
- high gain and Broadband GaAs MMIC pulsed driver amplifiers,
- Modulator Bias Controller (MBC) to lock the modulator at the minimum transmission.



The Photline NIR-MX & NIR-MPX optical modulators series are dedicated to near infra red high performances pulsed laser applications.

Pulse Application Using LiNbO₃ modulators
and matching components

Pulsed Optical Modulation

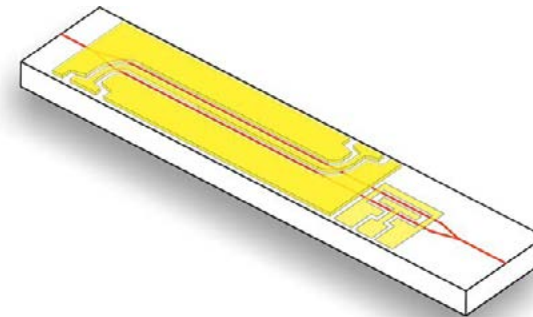
- Applications
 - Fiber lasers
 - Intense laser systems
- Requirements
 - Low loss
 - High extinction ratio
 - Short pulses
- Laser market
 - Rare earth doped pulsed fiber lasers at 1030 nm – 1070 nm Near-Infra-Red (NIR) wavelengths
 - LIDAR (Range-finding, Weather and Pollution monitoring)
 - material processing (Marking Welding Drilling)
- Scientific market
 - Plasma, laser confinement, fusion
 - Large laser systems instruments (Mega-Joule, LULI-CNRS, GSI,...)

Pulse Application Using LiNbO₃ modulators
and matching components

Lithium niobate Mach-Zehnder Modulators for pulsed applications

- High bandwidth up to 40 GHz.
- Rise/fall time as low as 10 ps.
- Chirp free : they do not induce phase distortion of the optical modulated signal.
- Relatively low optical loss (4 dB typ).
- Proven technology: numerous LiNbO₃ modulators are operating in the fiber optics laser systems, worldwide.
- High extinction ratio (larger than 30 dB, up to 40 dB) to ensure no degradation of the SNR in the cascade of optical amplification.
- High optical power handling in Continuous Wave (CW) regime (100 mW) and in pulse regime and up to 7 W peak power for pulses in the ns range (with duty cycle in the range of 1 -100kHz).

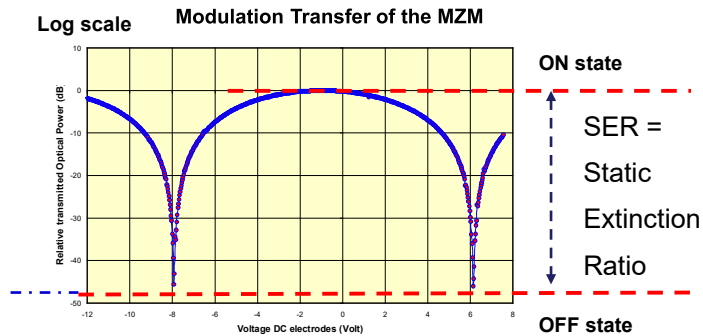
Pulse Application Using LiNbO₃ modulators
and matching components



Extinction Ratio: Modulator Choice

- The **NIR-MX800-LN** is the reference modulator choice for high Extinction Ratio value at short infra red wavelength 780 nm, 795 nm, 850nm.
 - The **NIR-MX-LN** is the best modulator choice for high Extinction Ratio value at near infra red wavelength 1030 nm, 1053 nm, 1060 nm, 1064 nm, 1080 nm.
 - The **MXER-LN** is the best option for high Extinction Ratio in the C-band.
- Bandwidth of 12 GHz, equivalent rise time of 35 ps.
 - Bandwidth of 18 GHz, equivalent rise time of 20 ps.
 - Extinction ratio: > 30 dB, up to > 40 dB.

Pulse Application Using LiNbO₃ modulators and matching components



Photline MBC (Modulator Bias Controller)

- The MBC is a bias controller specially designed to stabilize the operating point of Mach-Zehnder modulators by monitoring the bias voltage applied on the DC port of the device.
- A Mach-Zehnder modulator is illuminated by a CW laser at the optical input port. The pulse signal is applied to the RF electrodes.
- At the output of the MZ modulator, a fiber coupler with a strong imbalance (10:90 or 1:99) allows to detect a small portion of the transmitted light with a monitoring photodiode.
- The signal is amplified and processed in order to control the stability of the operating point.
- Any deviation is compensated by a new value of the electrical bias voltage applied by the feedback loop in order to maintain the operating point at the desired position.

Pulse Application Using LiNbO₃ modulators
and matching components

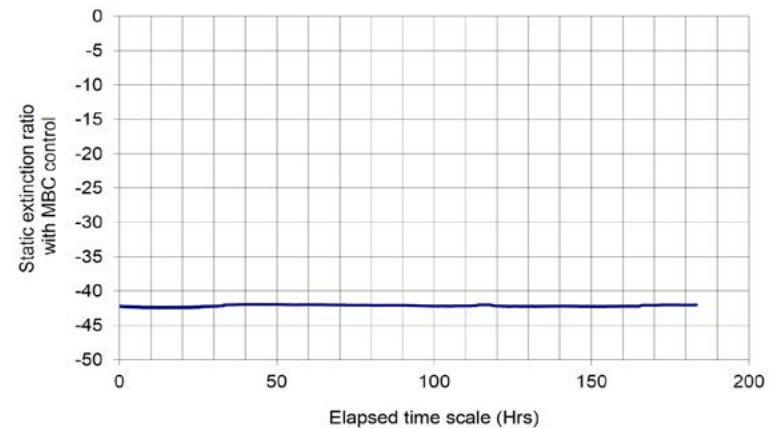
MBC is recommended for
pulsed applications



MBC controllers lock any modulators
at the MIN point of its transfer
function.

Photline MBC controls SER > 40 dB

- The Photline MBC (Modulator Bias Controller) fixes the modulator operating point at the extinction.
- When combined and controlled by the Photline Modulator Bias Controller (MBC), the Photline modulator shows a stable and high extinction ratio
- The modulator stabilized on the OFF state with a SER > 40dB can be monitored with a high stability over time.



Pulse Application Using LiNbO₃ modulators
and matching components

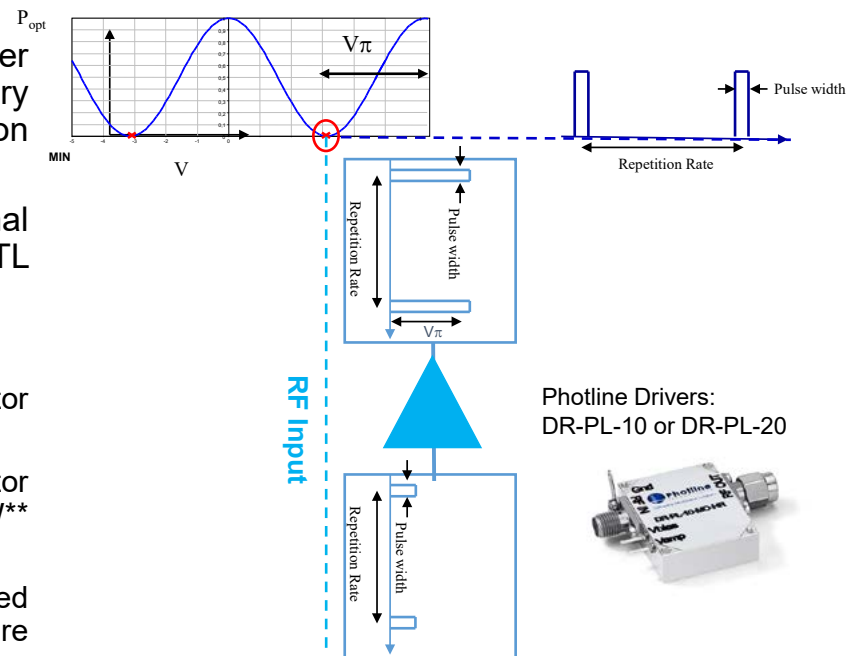
DR-PL: RF driver amplifier

- The Photline **DR-PL** is a driver amplifier dedicated to pulse application, factory optimized to fit with end user repetition rate and pulse width.
- RF Driver boosts the electrical input signal (coming from Pulse generator or TTL signal).
- The Driver is recommended in order:
 - To reach V_{π} amplitude and get modulator ER,
 - To guarantee stabilized input modulator voltage whatever the FRR* and PW** generated from the Pulse generator.
 - To compensate pulse distortion involved by the modulator (and reach very square pulse shape).

Pulse Application Using LiNbO₃ modulators and matching components

*FRR = Frequency Repetition Rate

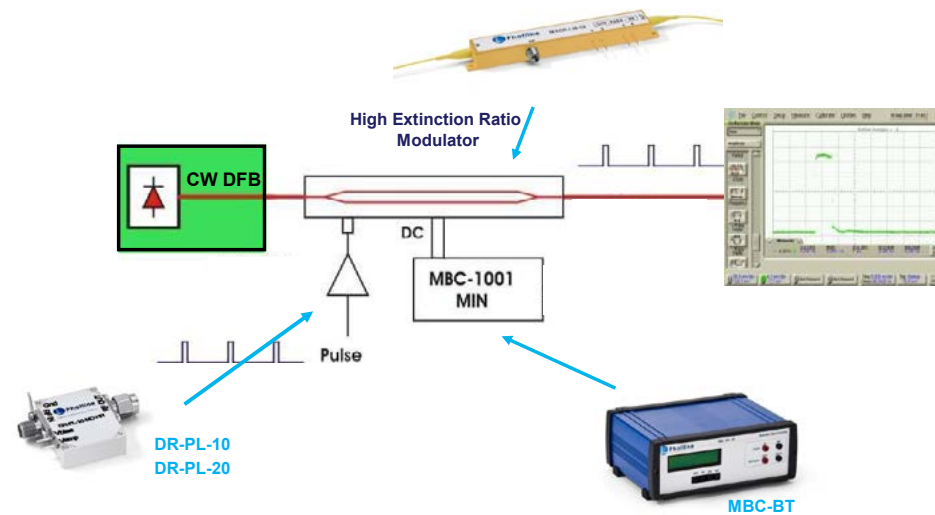
**PW: Pulse Width



Photline Drivers:
DR-PL-10 or DR-PL-20

Pulse Generation – Set-up

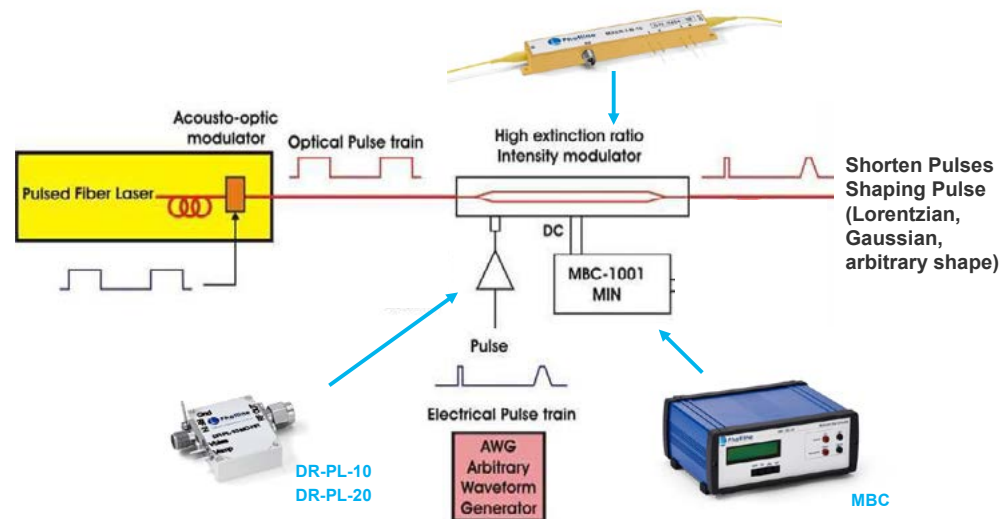
- To generate pulses from an optical continuous wave laser
- To generate low rise / fall time with short pulses
- Application: industrial lasers



Pulse Application Using LiNbO₃ modulators
and matching components

Pulse Shaping – Set-up

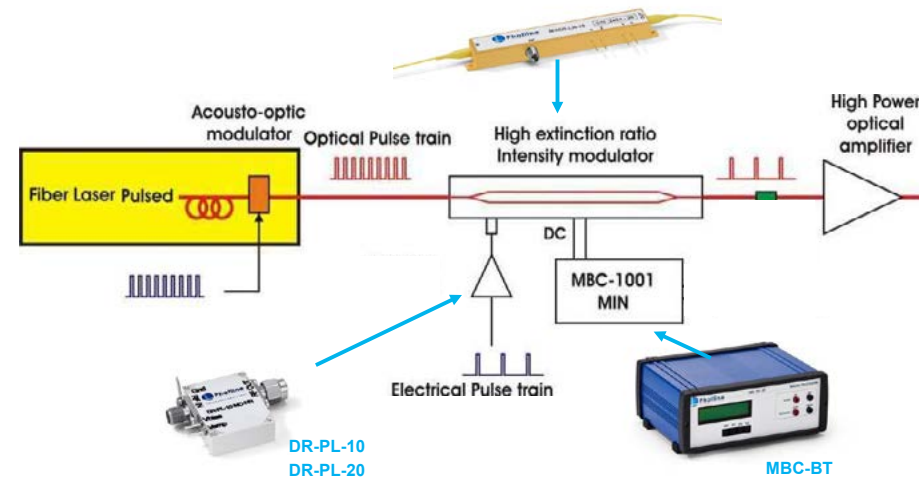
- To shorten pulses from an optical pulse train with low rise / fall times,
- To reshape pulses (Lorentzian, Gaussian, arbitrary shapes) from an optical pulse train,
- Application: industrial lasers



Pulse Application Using LiNbO₃ modulators and matching components

Pulse Picking – Set-up

- To select one pulse among a burst of optical pulses from a pulsed fiber laser
- High extinction ratio required when a cascade of optical amplifier is introduced at the output
- Application: industrial lasers



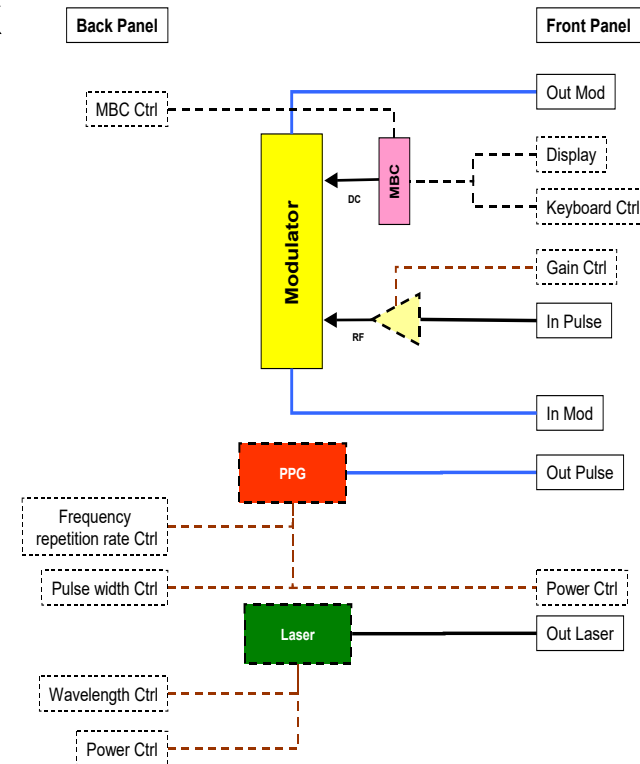
Pulse Application Using LiNbO₃ modulators
and matching components

Turn-key Unit: The Pulse ModBox

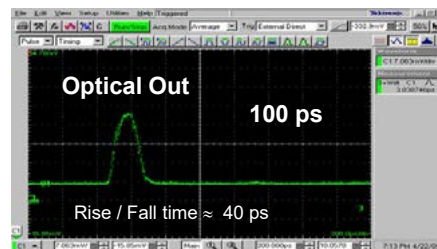
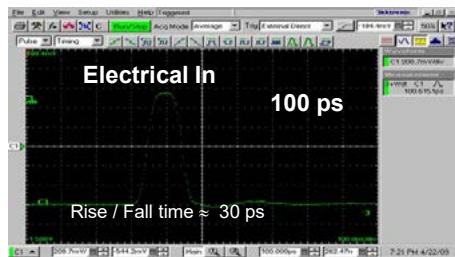
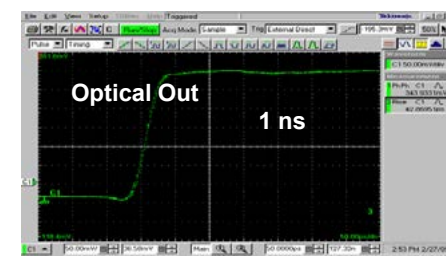
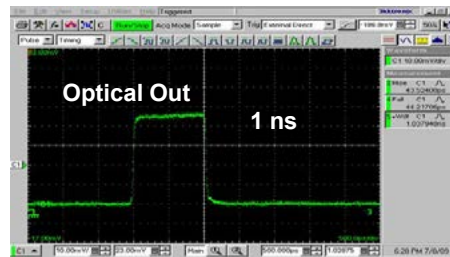
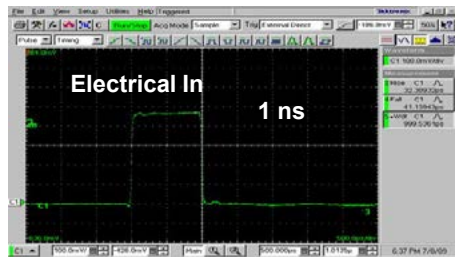
- The Pulse-ModBox integrates at least:
 - 1 × High Extinction Ratio modulator,
 - 1 × Pulse driver,
 - 1 × MBC (Min point).
- Option
 - 790 nm – 2200 nm,
 - Seed Laser,
 - Photodiode,
 - Pulse Generator (Square & Gaussian Shapes),
 - Arbitrary Generator,
 - Optical amplifiers,
 -



Pulse Application Using LiNbO₃ modulators and matching components

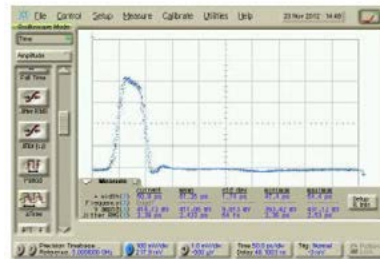


Optical Pulse Waveforms: Down to 100 ps optical pulse width – Square shape

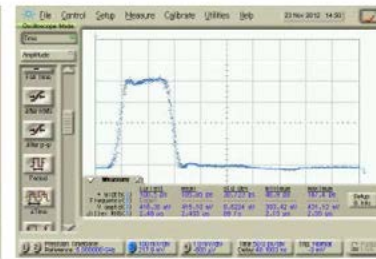


Pulse Application Using LiNbO₃ modulators
and matching components

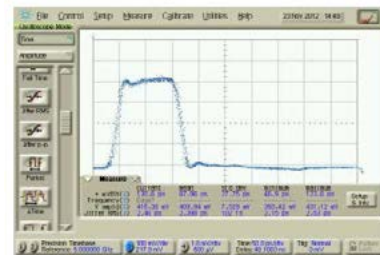
Optical Pulse Waveforms: Down to 50 ps optical pulse width – Square shape



Pulsewidth = 50.9 ps
Jitter rms = 2.39 ps



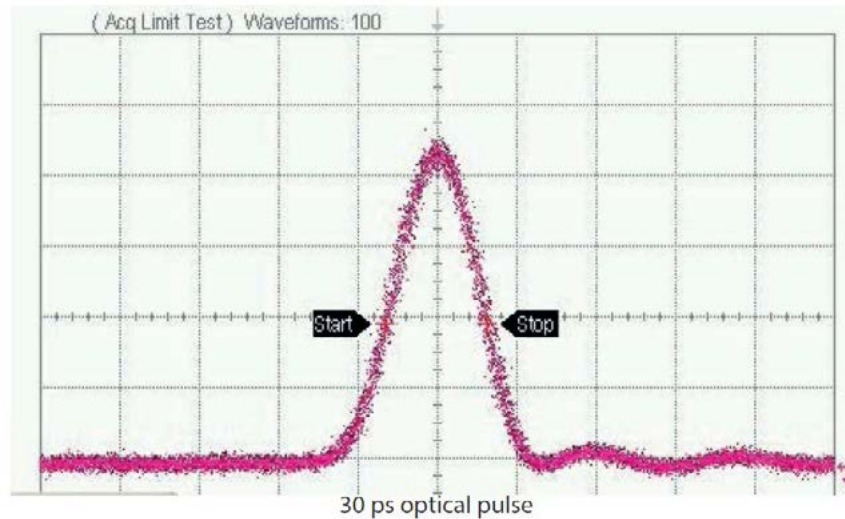
Pulsewidth = 100.5 ps
Jitter rms = 2.49 ps



Pulsewidth = 120.6 ps
Jitter rms = 2.46 ps

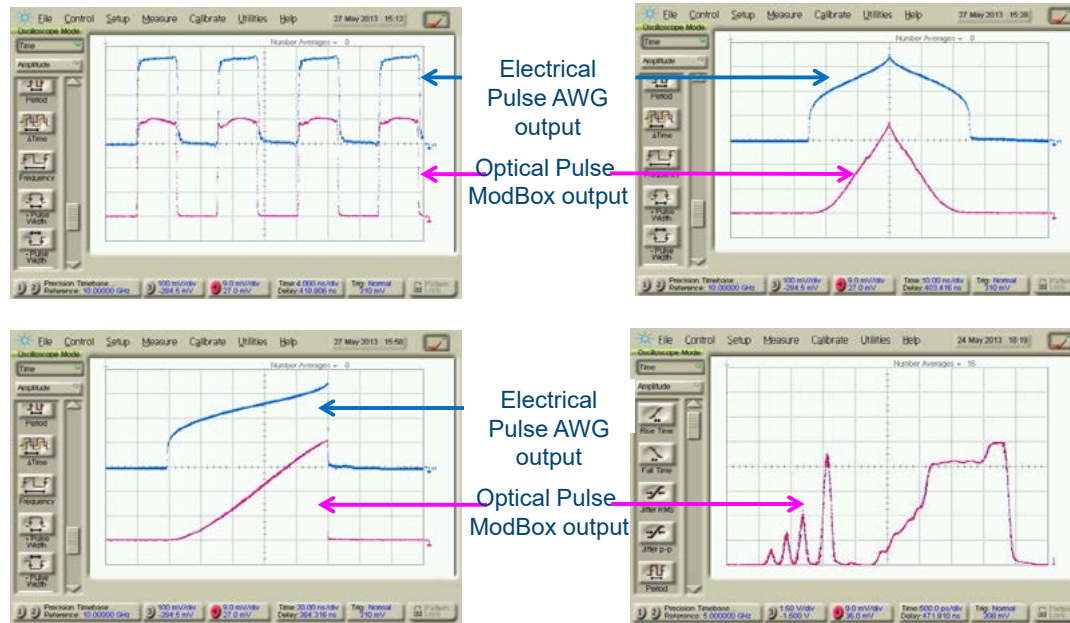
Pulse Application Using LiNbO₃ modulators
and matching components

Optical Pulse Waveforms: Down to 30 ps optical pulse width – Gaussian shape



Pulse Application Using LiNbO₃ modulators
and matching components

Optical Pulse Waveforms: Arbitrary Waveform from 125 ps



Pulse Application Using LiNbO₃ modulators and matching components