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THORLABS

UTM-1500 - April 12, 2019

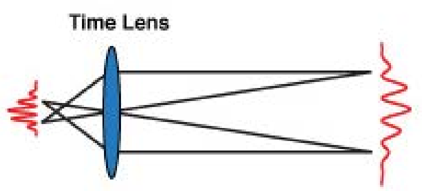
Item # UTM-1500 was discontinued on April 12, 2019. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

PICOLUZ ULTRAFAST TEMPORAL MAGNIFIER

- ▶ **Measures fs Waveforms Using Novel Time Lens Technology**
- ▶ **Single-Shot Sampling of Non-Repetitive Signals with Bandwidth >1 THz**
- ▶ **High-Speed Performance Monitoring Rates ≥ 1 Tb/s**

PicoLuz

A Strategic Partner of THORLABS



UTM-1500

Hide Overview

OVERVIEW

Features

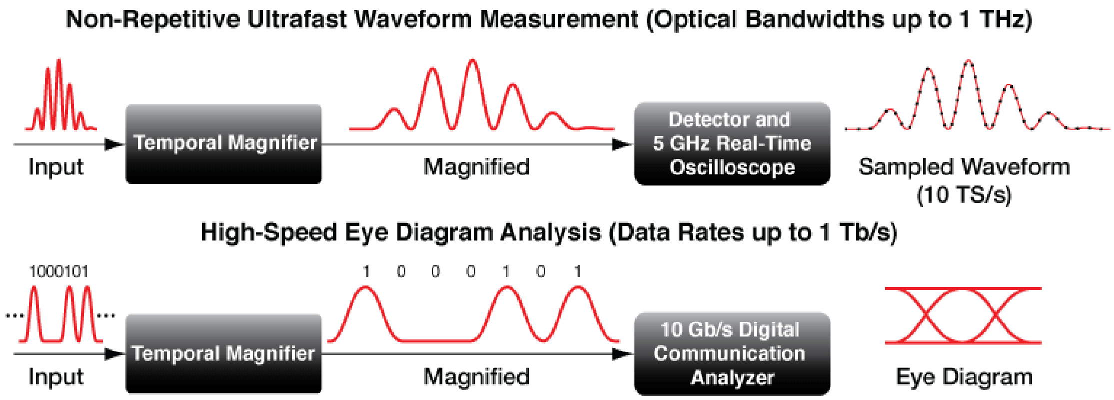
- Long Record Length (Typically >100 ps)
- Magnification Factor: >500
- Temporal Resolution as low as 300 fs
- Fast Update Rates: >100 MHz
- Easy to Install and Operate

Applications

- Stretch or Magnify Optical Waveforms in Time
- Measure Sub-Picosecond Temporal Features Using GHz-Bandwidth Detectors and Oscilloscopes
- Characterize Long and Complex Ultrafast Waveforms with Hundreds of Temporal Features
- Characterize Non-Repetitive Optical Signals and Single Ultrafast Events with BW > 1 THz
- Generate Digital Data Eye Diagrams at Rates as High as 1 Tb/s

The ultrafast temporal magnifier features new time lens technology based on the nonlinear optical process of four-wave mixing. The system is designed to stretch, or magnify, ultrafast optical waveforms in time without distorting their temporal profile. Using the magnifier, long (>100 ps) ultrafast waveforms with hundreds of sub-picosecond temporal features can be measured using GHz-bandwidth optical detectors and standard oscilloscopes.

The system can be used in two ways as depicted in the diagram below. For measuring repetitive ultrafast waveforms or high-speed digital communication signals, the magnifier will be placed between the fast signal and a sampling oscilloscope or a digital communication analyzer. Digital eye diagrams up to 1 Tb/s can be generated in this configuration. The magnifier can also be paired with real-time oscilloscopes or digitization circuits in order to generate rapidly updated snapshots of a non-repetitive ultrafast waveform (single shot sampling). For more details, please see the *Technology* and *Single Shot Sampling* Tabs.



The ultrafast temporal magnifier is sold with an external pump source (a femtosecond fiber laser) and the requried electronics to synchronize the pump repetition rate with the signal repetition rate. A list of components may be found in the *Components* tab. Please contact Tech Support for assistance.

Hide Specs

SPECS

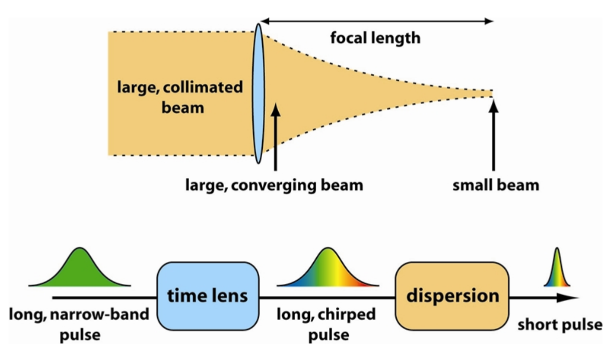
Specifications	
Temporal Resolution (δt)[1]	0.3 - 1 ps, Depending on Desired Record Length
Record Length (T)[2]	30 - 500 ps, Depending on Desired Resolution, Magnification Factor, and Update Rate
Number of Detectable Temporal Features per Waveform (N = T/δt)	100 (for Best Resolution) to 500 (for Best Record Length)
Magnification Factor (M)[1,2,3]	40 - 500
Update Rate (f_R)[2]	50 MHz, 100 MHz, or 250 MHz
Signal Wavelength[4]	C-Band

1. The magnifier output should be detected with a temporal resolution better than the product Mδt.
2. The magnification factor (M), record length (T), and update rate (f_R) are tied together by the following relationship: $MTf_R < 1$.
3. More than one magnfication factor can be provided upon request, which can then be switched by the user.
4. Other signal wavelengths are available upon request.

Hide Technology

TECHNOLOGY

Time Lens Technology

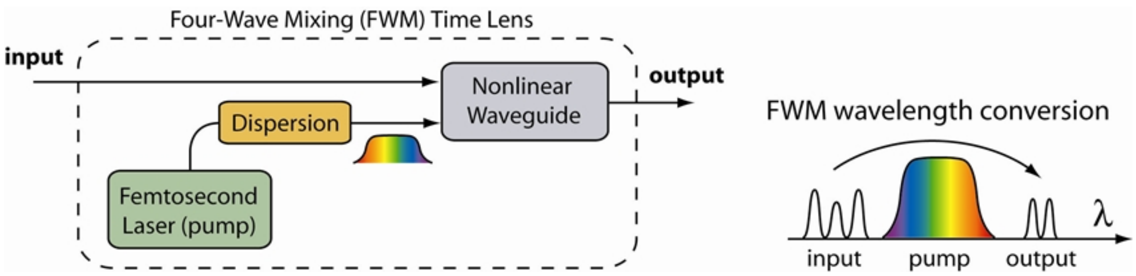


The time lens technology is based on the general concept of space-time duality, which draws a parallel between the dispersion of pulses and the diffraction of beams. The duality can be used for designing a variety of temporal imaging systems that can process optical waveforms in the time domain. The key element in such systems is a temporal analog for the spatial lens, which is called a time lens. The figure to the right shows this concept by comparing beam focusing using a lens to pulse compression using a time lens.

A time lens can be realized by imparting a temporally quadratic phase to an input signal. We use the four-wave mixing (FWM) process in nonlinear optical waveguides to realize a time lens. In addition to its ultrafast nature, this approach has several key advantages over other techniques for realizing a time lens. The FWM-based time lens can be implemented using dispersion-engineered waveguide devices, such as nonlinear fibers and silicon waveguides. Therefore, broadband processing can be achieved in any wavelength region where the waveguide material is transparent and a zero-GVD point can be reached. The guided-wave nature of this method is also crucial for applications, where fully guided systems are desired for their stability and compactness.

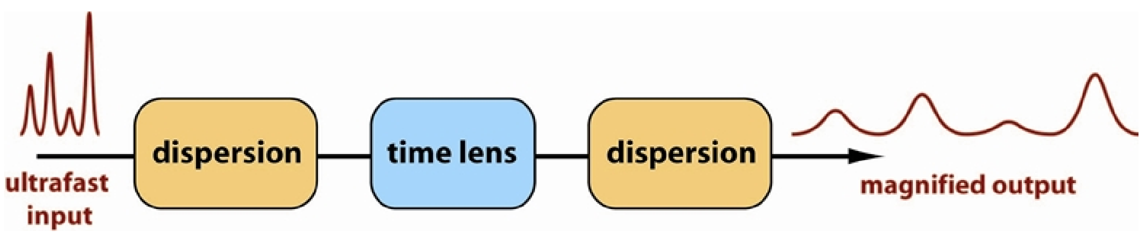
Four-Wave Mixing Time Lens

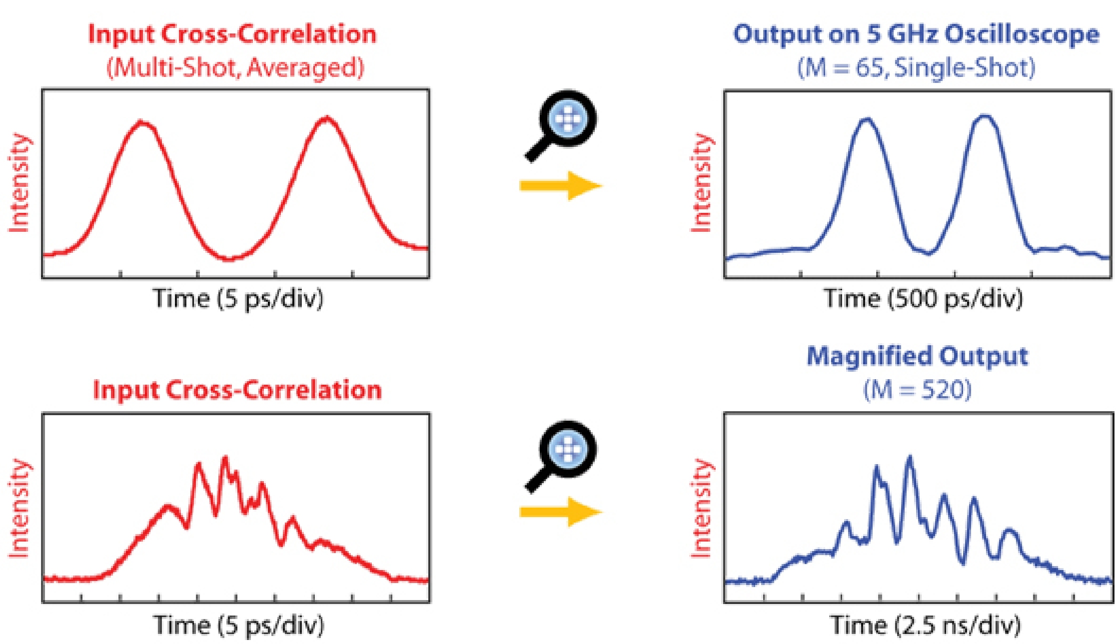
There are several methods for realizing a time lens. Picoluz's temporal magnifier uses the time lens technology based on four-wave mixing in nonlinear waveguides. As shown in the diagram below, a femtosecond pulse is linearly chirped and is mixed with the incoming signal via four-wave mixing wavelength conversion. The mixing process converts the wavelength of the signal, but it also transfers a quadratic phase shift to it, which creates the time lens effect. This technology enables broadband time lens-based systems built on fully guided and stable platforms.



Temporal Magnification

One of the simplest forms of temporal imaging is to magnify an optical waveform in the time domain similarly to the way a lens magnifies an image. Implementing this functionality is possible by utilizing a time lens system in conjunction with appropriately designed dispersive paths. Temporal magnification generates a stretched version of an ultrafast input waveform without changing its temporal profile, which enables a low-bandwidth measurement system to directly sample the high-speed input without the need for any post-processing or retrieval algorithms [Opt. Lett. **33**, 1047-1049 (2008), Opt. Express **17**, 4324-4329 (2009), Opt. Express **18**, 14262-14269 (2010)]. The magnification factor (M) can be changed by adjusting the output dispersion. More than one magnification factor can be provided upon request, which can then be switched by the user. Measurements below show temporal magnification with two different factors: M = 65 and M = 520.





Hide Single Shot Sampling

SINGLE SHOT SAMPLING

Single Shot vs. Multi Shot Sampling

The conventional technique for sampling ultrafast optical waveforms entails using a short optical pulse and a nonlinear gating device to perform a cross-correlation measurement between the pulse and the signal under test as shown in Figure 1. This approach to signal sampling is fundamentally limited to equivalent time sampling and can only be used to detect repetitive optical waveforms or to generate binary data eye diagrams. In contrast, the temporal magnifier system generates stretched snapshots of the input waveform that are updated at the repetition rate of the pump source (typically tens of MHz).

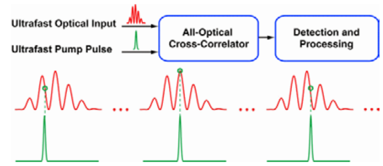


Figure 1. Equivalent-Time (Multi-Shot) Sampling

When the magnifier is paired with a real-time sampling device, the stretched snapshots of the input waveform can be individually detected and analyzed, enabling the measurement of non-repetitive waveforms. In this case, the sampling rate of the system will be the magnification factor (M) multiplied by the real-time sampling rate of the oscilloscope as shown in Figure 2. For example, when a temporal magnification system with M = 200 is used with a 20 GS/s oscilloscope, the waveform is sampled at a 4 TS/s sampling rate.

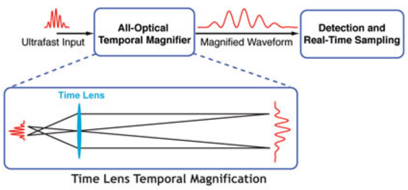


Figure 2. Single-Shot Sampling Using Temporal Imaging

The measurement in Figure 3 shows the single-shot capability of the magnifier system by characterizing a non-repetitive optical waveform. The input waveform consists of two pulses that are separated by a fixed 2.1 ps delay, but their amplitude is modulated with a 15 MHz sinusoidal signal. The plot shows 11 consecutive snapshots of the waveform captured using a 250X temporal magnifier on a 4 GHz real-time oscilloscope. The snapshots are updated every 4 ns, which is fast enough to show the rapid amplitude modulation of the input waveform.

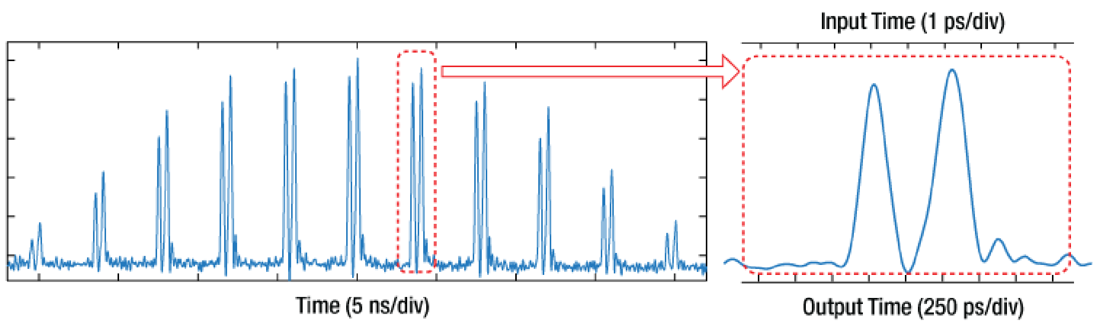


Figure 3. Non-Repetitive Signal Sampling

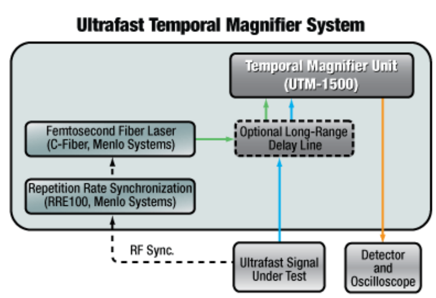
Hide Components

COMPONENTS

The ultrafast temporal magnifier is sold with an external pump source (a femtosecond fiber laser) and the requried electronics to synchronize the pump repetition rate with the signal repetition rate. Please contact Tech Support for assistance.

System Components

- Temporal Magnifier Module
- C-Fiber Femtosecond Laser and Synchronization Electronics
- Long-Range Adjustable Fiber-to-Fiber Delay Line (Optional)



The temporal magnifier system includes synchronization electronics that allow for synchronizing the repetition rate of the pump laser to that of the signal under test. In a synchronized state, adjusting the relative delay between the input waveform and the pump pulse scans the time lens viewing window with respect to the input waveform. The temporal magnifier unit (UTM-1500) includes an integrated delay line with continuous scan range of 160 ps, which is sufficient for applications involving high-repetition-rate signals (>10 GHz). In addition, the temporal magnifier kit features an optional fiber-to-fiber long-range delay line for continuously adjustable delay up to 4 ns, which is applicable for signals with repetition rates lower than 10 GHz.

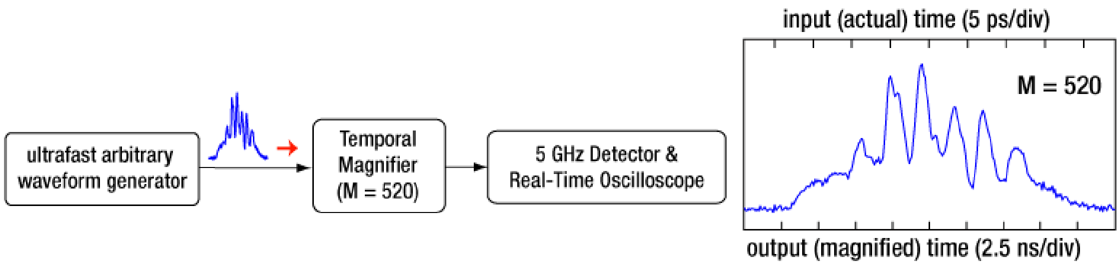
Synchronization between the pump and the input signal repetition rates is not required in applications where the signal repetition period is shorter than the magnifier record length and real-time sampling is performed. In most other applications, synchronization should be achieved between the pump and signal repetition rates.

Hide Application

APPLICATION

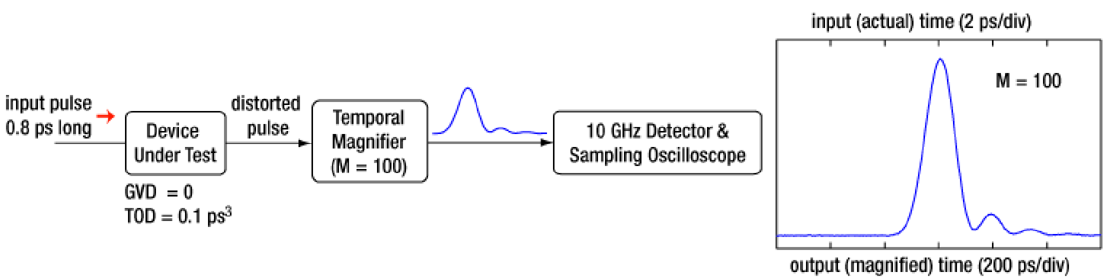
Arbitrary Waveform Characterization

The temporal magnifier stretches the input waveform within its viewing window (record length) and allows direct sampling of the waveform without the need for post processing or retrieval algorithms. As a result, very complex ultrafast waveforms with hundreds of temporal features can be imaged and detected on standard detectors and oscilloscopes. In this experiment, we generate a 40-ps long waveform from an arbitrary waveform generator. The magnifier is configured with a 520X magnification factor allowing the waveform to be detected on a 5-GHz oscilloscope [Opt. Express **17**, 4324-4329 (2009)].



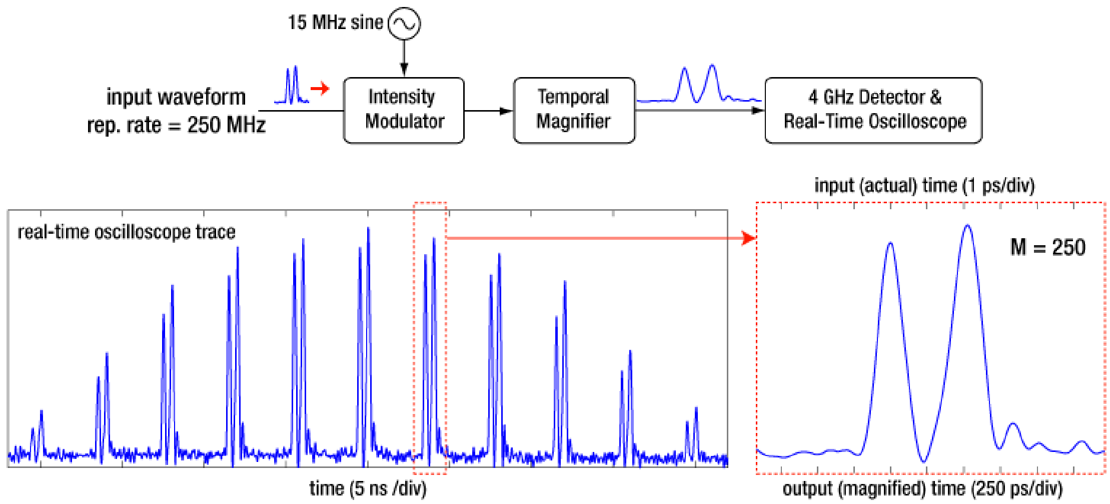
Pulse Distortion Characterization

This experiment shows how the magnifier can be used to detect small distortions caused by the third-order dispersion in a zero-dispersion device (or communication link). We send a 0.8 ps pulse into the device under test with negligible GVD and TOD ˜ 0.1 ps^3. The resulting pulse is asymmetrically distorted and the magnifier (with a 100X stretching factor) enables the characterization of this pulse using a 10 GHz oscilloscope.



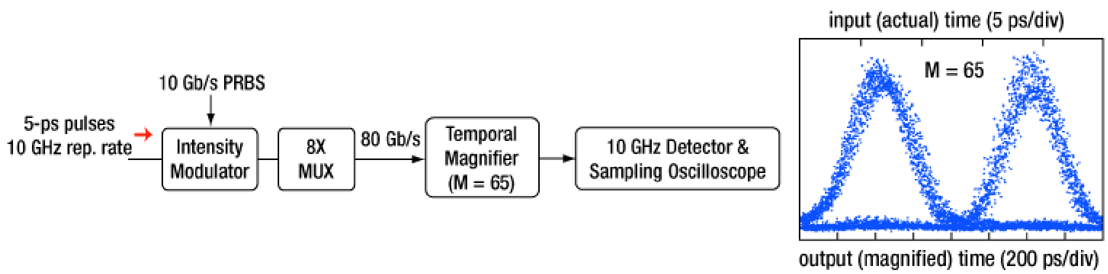
Non-Repetitive Waveform Characterization (Single-Shot Sampling)

This experiment demonstrates the single-shot capability of the temporal magnifier system. A simple waveform consisting of two pulses that are separated by 2.1 ps is generated from a mode-locked laser operating at 250 MHz repetition rate. The amplitude of the signal is modulated using a modulator driven by a 15 MHz sine wave. The magnifier in configured with a 250X magnification factor and it uses a pump source at 250 MHz repetition rate that is synchronized with the signal repetition rate. The magnifier output is sampled on a 4 GHz (20 GigaSample/second) real-time oscilloscope and a trace showing 11 consecutive snap-shots of the input waveform is plotted below. As seen in this example, the time lens image of the input waveform is updated at the repetition rate of the pump laser used in the magnifier system (250 MHz in this example).



High-Speed Eye Diagram Measurement

The temporal resolution of the magnifier allows for data eye diagram measurements up to 1Tb/s. In this experiment, we generate an 80 Gb/s RZ data stream (data rate limited by the signal source pulse width) and we utilize a magnifier with a 65X magnification factor to measure the data eye diagram using a 10 GHz oscilloscope. The magnifier in this experiment uses a femtosecond fiber laser at 50 MHz repetition rate as the pump source. This repetition rate is synchronized with the 10 GHz RF signal that generates the data stream [Opt. Express **17**, 4324-4329 (2009)].



Hide Part Numbers

Part Number	Description	Price	Availability
UTM-1500	Ultrafast Temporal Magnifier	$0.00	Lead Time