FEMTOCHROME®
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FR-103XL AUTOCORRELATOR

Specifications:

* Pulsewidth Resolution: < 1fs
* Minimum Pulsewidth: ~ 4fs
* Maximum Pulsewidth: ~100ps '
* Scan Range: > 195ps '
* Sensitivity: $[P_{av}P_{pk}]_{min}=10^{-6}W^2$ "
* Wavelength Range: 410nm-10µm
* Interferometric/Background-free
* Crosscorrelation Option
* Fiber Coupled/ Free Space
* Low Rep Rate Option (> 4Hz)
* Computer Data Acqusition Option

" $10^{-7}W^2$ w/**HS** version. w/ PMT [550-1700nm]

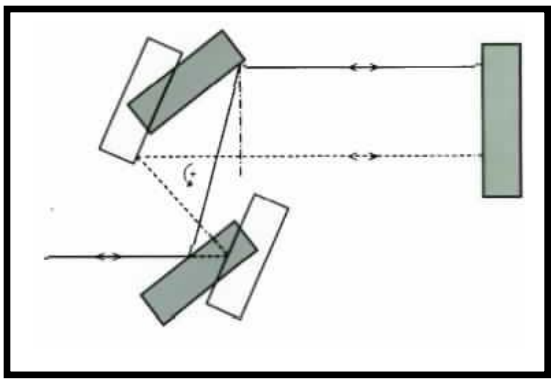
The **FR-103XL** is a dispersion-free, 'real-time' NL crystal autocorrelator for the measurement of temporal width of ultrashort laser pulses. Offering unsurpassed sensitivity, resolution and dynamic range, it is easy to operate. The **FR-103XL** is perfectly suited for the monitoring of low power lasers as common in optical communications, as well as ultrashort (fs/ps) pulses from any mode-locked laser over a wide spectral range.

DISPERSION-FREE, HIGH RESOLUTION

Dispersion is negligible in the **FR-103XL** for pulsewidths down to ~5fs. Using high reflective metallic-coated optics [the only transmissive element is an ultrathin (<1um) pellicle beamsplitter], an unprecedented resolution approaching 1fs [limited only by the NL crystal thickness] is attained.

ROTATING PARALLEL (//) MIRROR ASSEMBLY

Rapid scan, periodic optical delay is introduced by means of a parallel (//) mirror assembly.* This unique mechanism results in uniform and error-free delay generation. Large delays are easily generated, with dispersion-free interferometric resolution.

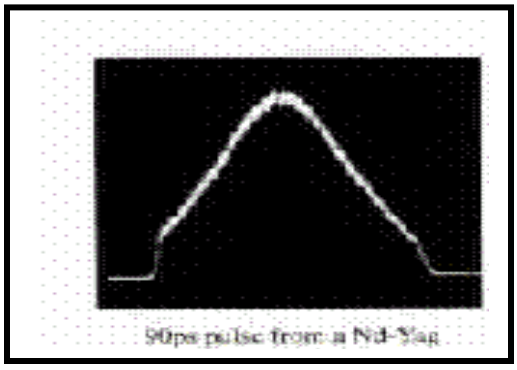


WIDE SCAN RANGE/LINEARITY

The delay generated by the // mirror assembly is an exact sinusoidal function of time. The entire scan range occurring within small angles, linear approximation is excellent. [The error in the measured FWHM autocorrelation is <0.5%, even for a pulwidth as long as 100ps]. Optical delay generation is uniform, devoid of errors (position uncertainty) that can be encountered in other delay methods. Furthermore, the autocorrelation delay axis becomes precisely linear by numerical application of the exact sine transformation.

The theoretical calibration factor (CF) of the **FR-103XL** is not prone to a change since the uniform rotation rate of the // mirrors is crystal locked. Additionally, a micrometer featured on the fixed arm of the Michelson Interferometer set-up allows the user to experimentally check and verify the CF.

With its high resolution and wide scan range, the **FR-103XL** is ideally suited for simultaneously monitoring fsec pulses and satellite pulses that may occur separated from the main pulse by many psecs. The wide scan range is also useful to observe crosscorrelations with adjacent pulses in >10GHz optical telecommunications signals. Extinction ratios in the pulse wings are readily measured.



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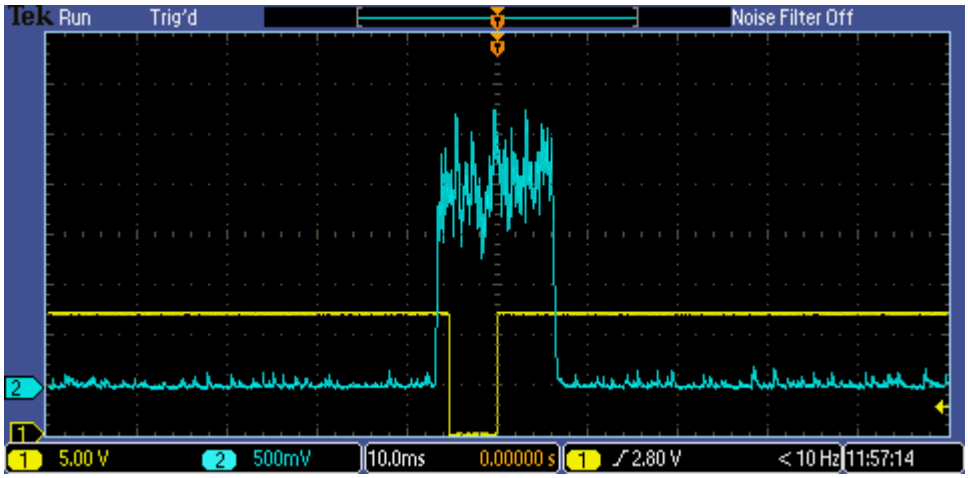
* Z.A.Yasa and N.M.Amer, Optics Commun., V36, 406 (1981)

HIGH SENSITIVITY & DYNAMIC RANGE

The unmatched sensitivity of the **FR-103XL** is demonstrated by its noise equivalent signal level of $[P_{av}P_{pk}]_{min} = 10^{-7}W^{2}$ *. This is further augmented by a dynamic range of ~10^{4}.



Autocorrelation of a ~ 1mW **cw** input at 1552nm ($P_{av}P_{pk}=10^{-6}W^{2}$) as observed with the **FR-103XL**. Signal Avg. = 4

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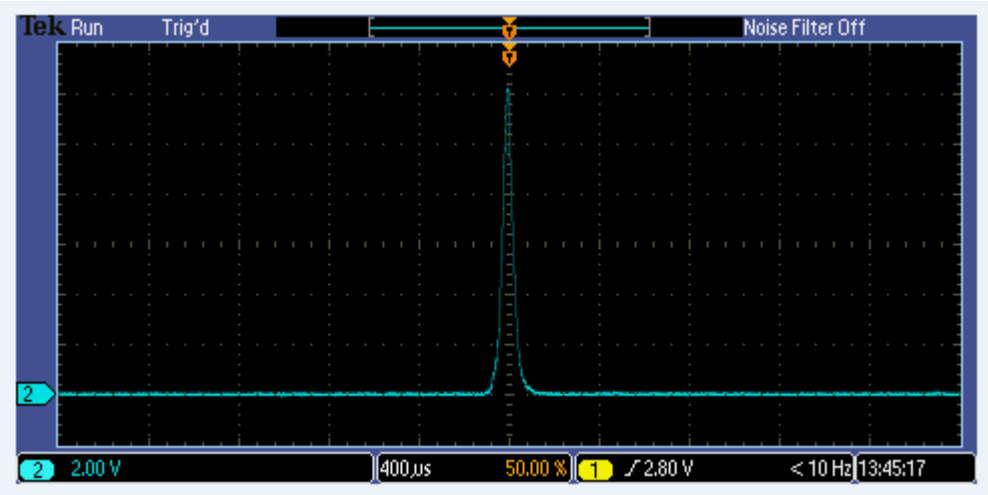
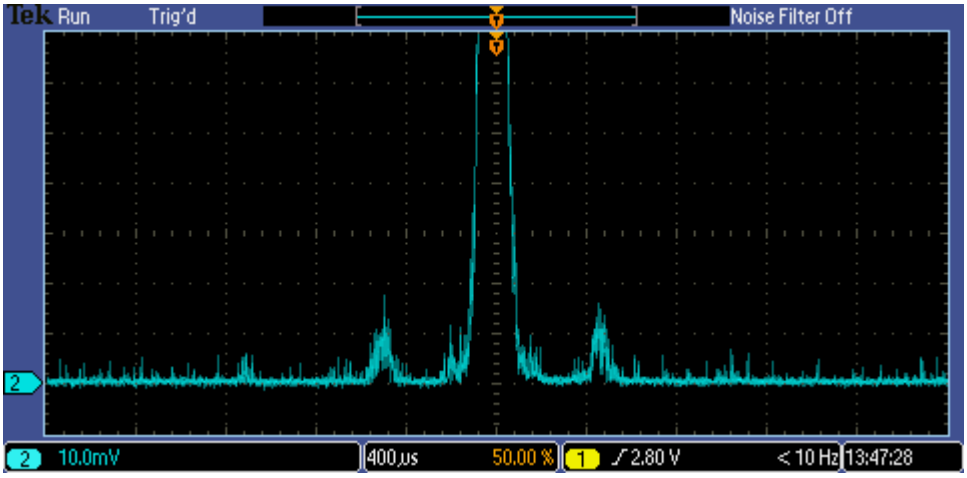
* Over the wavelength range of 550-1700nm, and PMT operation w/ 1ps integration time and a NL crystal thickness of 1mm. Sensitivity is $10^{-8}W^{2}$ w/**HS** version.

These remarkable figures render the **FR-103XL** unique for the measurement of weak satellite pulses which is commonly encountered with modelocked lasers.



Commercial fiber laser (1552nm) pulse [500fs/ 1mW avg. power], measured by the **FR-103XL**.



A weak satellite pulse, separated from the main pulse by ~ 7 ps appears when the **same** trace is expanded vertically. No signal averaging.

WAVELENGTH RANGES (/BBO/KDP/IR/xxxx)

Three optimal **NL crystals** provide operation to ~ 5000nm. The standard unit comes with one NL crystal, customer specified:

/BBO → 410-600nm
/KDP → 510-1100nm
/IR → 850-5000nm.

These NL crystals accept **vertically** polarized input beams, they are BBAR coated and fundamental blocking filters are provided for their operational range. For long term reliability, a desiccators is provided to protect the crystal when not in use. The standard NL crystal thickness is customer specified (0.1mm/0.3mm/1mm), with attention to the trade-off between resolution (thinner NL crystal) and sensitivity (thicker NL crystal).
Typically, a 0.3mm crystal thickness can be considered sufficient for pulsewidths down to ~30fs. With shorter pulses, a thinner crystal is necessary. For sub 10fs pulsewidths, a custom (<25µm) NL crystal thickness will need to be specified.

Two types of ultrathin pellicle **beamsplitters** are used with the **FR-103XL**, one (VS) which covers the entire wavelength range, and the second (IR) optimized for >700nm operation. When working with wavelengths < 700nm, the (VS) beamsplitter needs to be used. For wavelengths > 700nm, (IR) beamsplitter is preferable.

/xxxx PD modules for extended IR wavelengths

The photomultiplier (PMT) in the standard **FR-103XL** covers the 410-1800nm operation. This range can be extended in the IR, by plug-in photodiode (PD) modules (/xxxx) which mount in front of the PMT enclosure. The PD module selections are:

/1300 → 1300-2200nm
/2200 → 2200-3400nm
/3000 → 3000-5000nm

Sensitivity is greatly reduced when operating with these PD modules since they lack the gain as provided by a PMT. Typically, a minimum of ~ 5mW avg. power is needed for a subpicosecond modelocked pulse, over the wavelengths covered by these modules.

OPTIONS:

CROSSCORRELATION (/CC)

The **FR-103XL** has a built-in auxiliary port for crosscorrelation of two spatially separate synchronized beams. A fiber adapter can be installed also at the CC port [/FA(CC)].

INTERFEROMETRIC OPERATION (/IO)

Standard (Michelson Interferometer) configuration of **FR-103XL** utilizes non-collinear (background-free) SHGmethod.* Optionally, it can be converted to provide collinear (interferometric) SHG. Using the highest resolution setting (<1fs) of its integration-time switch, fringe resolved autocorrelation is obtained. [This setting is of lowest gain, for which higher input power levels may be necessary].

FIBER ADAPTER OPTION (/FA)

An optional gimbal mount with a collimator is installed over the variable input aperture of the **FR-103XL**, for easy connection of fiber-coupled beams. Factory aligned, repeated connections with no need for realignment is facilitated. The /FA is easily removable for a free-space input beam. Its standard adapter is FC [FC/PC or FC/APC]. For operation at 1550nm, a PM-DSF patchcord can be attached to the /FA. The collimator of the /FA is focus adjustable to obtain good collimation if necessary to be used over a significantly wide wavelength range. A $\lambda/2$ plate holder is also provided within the /FA assembly, for the user to install one for their wavelength of operation, if needed for polarization control.

The /FA option can also be applied to the CC port [/FA(CC)].

LOW REP RATE OPTION (/LRR)

The rotation rate of the // mirrors is phase-locked to the repetition rate (submultiple) of the input beam. With a linear phase modulation superimposed on the rotation rate, autocorrelation traces are readily accumulated (~ 15secs) and **continuously monitored** for any rep rate (> 4Hz) laser.

This mode is particularly useful for < 100Hz rep. rate pulses..

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* E.P.Ippen, C.V.Shank and A.Dienes, APL, V.21, p.348(1972)

(HS) VERSION

When this version **(HS)** is selected, two modes of operation are available:

1. Uniform rotation (as in the standard **FR-103XL)**, but with a refresh rate typically ~2Hz.
2. Controlled movement such that the // mirrors sharply slow down (4 selectable speeds) over the range within which the pulses from the two arms of the Michelson Interferometer overlap. The // mirror assembly speeds up outside this range, to come back for a repetition of the cycle.

Whereas the standard **FR-103XL** (w/o LRR) provides 'real-time' autocorrelation typically for > 100kHz lasers, this version [**FR-103XL(HS)]** renders the unit suitable for 'real-time' autocorrelation of lasers with any rep rate > 100Hz. This is particularly useful for kHz amplified lasers.

With /CDA installed, the **FR-103XL(HS)/CDA** operates with any rep rate of input pulses >4Hz, under PC control. Higher sensitivity is also attained in this version, with longer integration times available.

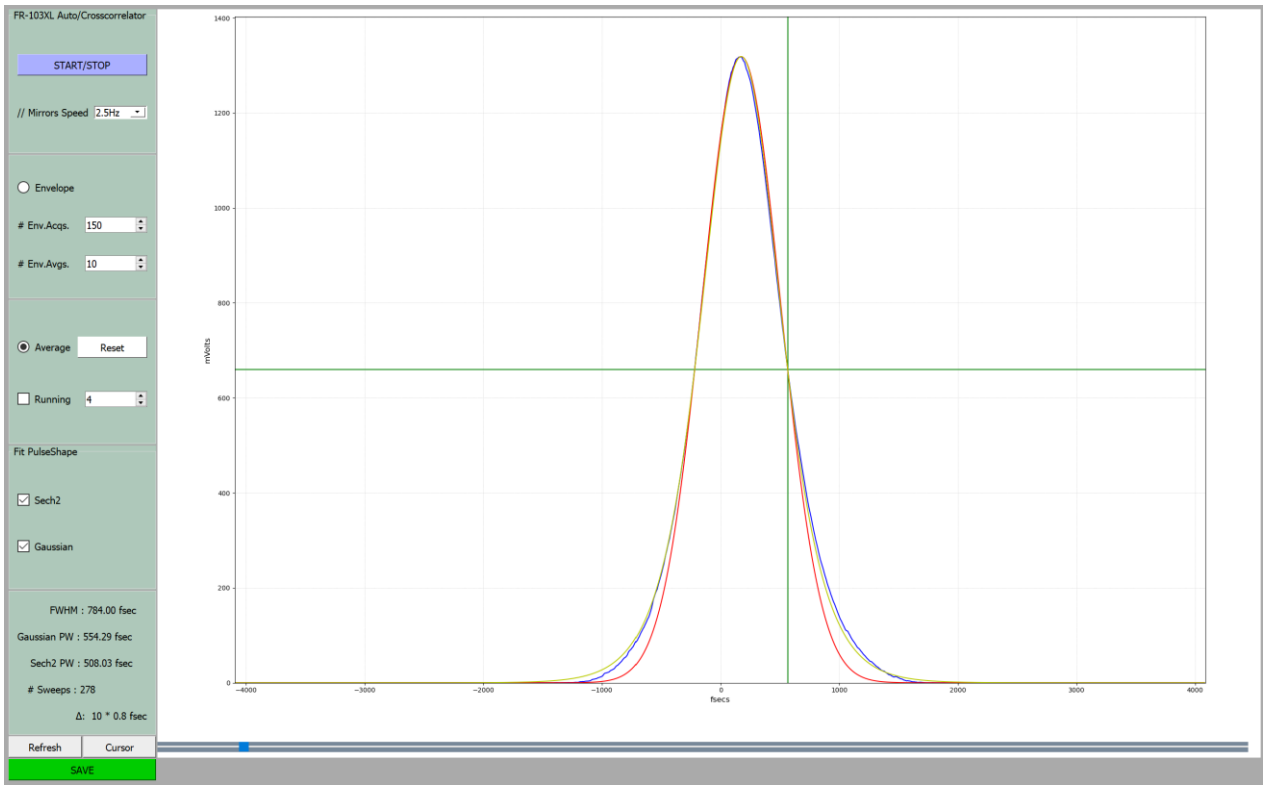
COMPUTER DATA ACQUISITION OPTION (CDA)

A data acquisition board is installed in the **FR-103XL**/CDA, providing an interface (USB) with any PC w/ Windows OS. With its associated software, traces are displayed, analyzed [averaged and/or curve-fit with typical pulseshapes] or saved.

As shown in below typical screen capture of the /CDA display, the signal trace (blue) can be fitted with Sech^2(yellow) or Gaussian (red) pulseshapes with corresponding pulsewidths readout.

A cursor can be set at one half-max (HM) of the trace (green vertical line).

The zoom button (blue) at the bottom of the screen is used to expand (compress) the display range.



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* Computer Data Acquisition Option
* (HS)High Sensitivity Version ('real-time' autocorrelation for any input rep rate >100Hz)

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