

Pulse Duration Detector

Digital Twin Specification

Twin Code:	DF-PDUR01
Twin Name:	Pulse Duration Detector
Category:	Detector
Type:	Function-Based
Version:	1.0
Package:	Platform
Last Updated:	2026-03-20

Description

This Digital Twin functions as a temporal pulse diagnostic tool. It analyzes a pulsed electromagnetic field and reports the pulse duration by finding the full width at half maximum (FWHM) of the instantaneous irradiance as a function of time. By default, it evaluates the pulse at a single point in the lateral plane (x, y) , but can be configured to analyze the temporal width of the field amplitude rather than the irradiance. It is an essential tool for characterizing ultrashort pulses in applications such as nonlinear optics, ultrafast spectroscopy, and laser material processing.

Model Parameters

The Pulse Duration Detector has no primary design parameters. Its behavior is modified through the configuration of its underlying Add-ons:

- **Position of Evaluation** (x, y) : The lateral coordinates (in the detector plane) where the temporal pulse shape is evaluated. Access this via the *Pulse Evaluation (Point)* Add-on.
- **Percentage Value** (Range: 0–100, default: 50): Defines the percentage of the maximum used for the width calculation. The default value of 50 calculates the Full Width at Half Maximum (FWHM). Changing this value calculates the Full Width at **X%** Maximum (FWX%M). Access this via the *Lateral Extent via Full Width x% Maximum* Add-on.

Simulation Model

The detector computes the instantaneous irradiance from the electric and magnetic fields $\mathbf{E}(\boldsymbol{\rho}, t)$ and $\mathbf{H}(\boldsymbol{\rho}, t)$ at the specified evaluation point $\boldsymbol{\rho} = (x, y)$ in the detector plane. The instantaneous irradiance is given by the magnitude of the Poynting vector:

$$I(\boldsymbol{\rho}, t) = |\mathbf{S}(\boldsymbol{\rho}, t)| = |\mathbf{E}(\boldsymbol{\rho}, t) \times \mathbf{H}(\boldsymbol{\rho}, t)|. \quad (1)$$

From this temporal signal $I(t)$ at the fixed position $\boldsymbol{\rho}$, the detector identifies the maximum value I_{\max} and then determines the two time points t_1 and t_2 (with $t_1 < t_2$) where $I(t)$ falls to a specified percentage p of its maximum:

$$I(t_1) = I(t_2) = \frac{p}{100} \cdot I_{\max}. \quad (2)$$

The reported pulse duration τ is the full width between these points:

$$\tau = t_2 - t_1. \quad (3)$$

By default, $p = 50$, yielding the standard Full Width at Half Maximum (FWHM). The evaluation occurs at a single point in the lateral plane as defined by the user.

Key Physical Principle: Instantaneous Irradiance

The instantaneous irradiance—the magnitude of the Poynting vector—represents the instantaneous energy flux density of the electromagnetic field. For an optical pulse, its temporal profile directly relates to the pulse’s coherence and its interaction with matter. The FWHM of this profile is the most common and practical metric for pulse duration, critical for understanding phenomena like multi-photon absorption or material ablation thresholds.

Typical Application Scenarios

1. **Ultrafast Laser Characterization:** Measuring the output pulse duration from a mode-locked laser or amplifier system to ensure it meets specifications.
2. **Laser Material Processing:** Determining the pulse width incident on a workpiece, as it directly influences the heat-affected zone and ablation quality.
3. **Dispersion Analysis:** Diagnosing the temporal broadening of pulses after passing through lenses, prisms, or other transmissive optics.
4. **Optical Communication Systems:** Analyzing pulse broadening in waveguides or free-space links to estimate data transmission rates.

Software Usage

After adding the detector to your system, use it in your optical setup by:

1. Double-click the detector to open its properties. Navigate to the **Add-ons** tab.
2. To change the evaluation point from the default (often the center of the detector plane), select the **Pulse Evaluation (Point)** Add-on and edit the **Position of Evaluation** parameters (x, y).
3. To change the width percentage from the default 50% (FWHM), select the **Lateral Extent via Full Width x% Maximum** Add-on and change the **Percentage Value** parameter.
4. To detect the FWHM of the electric field amplitude $|E(t)|$ instead of the instantaneous irradiance, change the order of Add-ons. Move the **Lateral Extent via Full Width x% Maximum** Add-on so it is directly behind the **Pulse Evaluation (Point)** Add-on (before any other mathematical operations).

Important notes:

- This detector evaluates the pulse at a single lateral point. For spatial profile information of a pulsed beam, use a **Field Monitor** in combination with a harmonic fields set analysis.
- The detector relies on the temporal sampling of the field provided by the source. Ensure your source (e.g., a Pulsed Gaussian Beam twin) has sufficient temporal resolution to accurately represent the pulse you wish to measure.

Author:	LightTrans International GmbH
Contact:	support@lighttrans.com
Keywords:	pulse, duration, FWHM, ultrafast, temporal, detector, irradiance, time-domain, laser, width, Poynting vector
Related Twins:	DF-PDTE01, DF-PENG01, DF-IFLX01, DF-IIRR01, DF-PDFR01