

Double Slit

Digital Twin Specification

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| Twin Code: | CF-DOSL01 |
| Twin Name: | Double Slit |
| Category: | Component |
| Type: | Function-Based |
| Version: | 1.0 |
| Package: | Platform |
| Last Updated: | 2026-03-20 |

Description

The Double Slit component models an opaque screen containing two narrow rectangular slits that are infinitely long in the y -direction. It introduces a transmission function with two slits, modifying an incident electromagnetic field by multiplication. This twin is essential for simulating Young's double-slit experiment, studying interference patterns, and investigating the transition from near-field to far-field diffraction.

The component can be used with any incident field (plane wave, Gaussian beam, etc.) and produces the characteristic interference pattern that depends on the slit separation, slit width, and wavelength. An optional smooth-edge apodization reduces numerical artifacts from sharp edges.

Simulation Model

The transmission function $T(\rho)$ at the aperture plane ($z = 0$) is defined as:

$$T(x) = \text{rect}\left(\frac{x - d/2}{w}\right) + \text{rect}\left(\frac{x + d/2}{w}\right),$$

where d is the center-to-center slit distance and w is the slit width. The function $\text{rect}(u)$ equals 1 for $|u| \leq 1/2$ and 0 otherwise. Since the slits are infinitely long in the y -direction, the transmission function depends only on x .

The field after the component is given by:

$$\mathbf{E}_{\text{out}}(x, y) = T(x) \cdot \mathbf{E}_{\text{in}}(x, y).$$

Key Physical Principle

The double slit produces an interference pattern in the far field (Fraunhofer regime) that is the product of the single-slit diffraction pattern and the interference pattern from two point sources:

$$I(\theta) \propto \text{sinc}^2\left(\frac{\pi w \sin \theta}{\lambda}\right) \cdot \cos^2\left(\frac{\pi d \sin \theta}{\lambda}\right),$$

where θ is the observation angle. The first factor governs the envelope of the pattern, while the second gives the rapid oscillations.

When smooth edges are enabled, the sharp rect function is replaced by a super-Gaussian or error-function profile to reduce high-frequency components in the Fourier spectrum, which helps avoid aliasing in numerical propagation.

Model Parameters

Design parameters:

- **Slit Distance d :** Center-to-center separation between the two slits. Unit: μm or mm.
- **Slit Width w :** Width of each slit (assumed identical). Unit: μm or mm.
- **Absolute Edge σ :** Defines the edge width for smooth-edge apodization. A value of 0 gives ideal rectangular slits; positive values introduce a smooth transition over a distance σ at each edge.

Typical Application Scenarios

1. **Young's double-slit experiment:** Classic demonstration of wave nature of light; used in educational settings and to calibrate optical setups.
2. **Interferometric sensing:** Small changes in slit separation or refractive index between slits can be detected via fringe shifts, enabling displacement or pressure sensors.
3. **Optical coherence tomography (OCT):** Double-slit configurations can be used to generate structured illumination for extended depth-of-field imaging.
4. **Beam shaping and mode conversion:** By selecting appropriate slit dimensions, one can generate specific intensity distributions (e.g., two-beam interference for structured light).

Software Usage

After adding the Double Slit twin from the Digital Twin Hub to your VirtualLab Fusion document, follow these steps:

1. **Position the component:** Place the double slit at the desired plane in your optical system (e.g., after a source and before a detector or propagation distance).
2. **Set parameters:** Adjust the slit distance and width according to your experiment. Enable smooth edges if you need to avoid ringing artifacts in the propagated field.
3. **Connect input and output:** The component automatically applies the transmission function to the incoming field and outputs the modified field.
4. **Observe results:** Insert a Field Monitor detector immediately after the double slit to view the near-field pattern, or place it at a distance to examine the evolution into the far-field interference pattern. Use the Parameter Run feature to sweep the detector position along z and visualize the transition from Fresnel to Fraunhofer diffraction.

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| Related Twins: | CF-APER01, CF-APGS01, CF-KNED01 |