An introduction to lightlabsFDS

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The lightlabsFDS mission

To enable engineers and scientists to characterize optical structures quickly, simply, and cost-effectively.

Innovate on three fronts to make this a reality:

- Solve for electromagnetic fields in the frequency domain,
- Run simulations from pre-installed scientific software (Matlab),
- Offload computation to centralized custom-tuned hardware.

Solving electromagnetics in the frequency domain

- lightlabsFDS: Frequency-Domain Solver

- Solves
$$\nabla \times \mu^{-1} \nabla \times E - \omega^2 \epsilon E = -i\omega J. \tag{1}$$
  - Inputs: frequency (ω), structure (μ, ϵ), and excitation (J).
  - Outputs: electromagnetic fields (E, H, D, B).

- *Many* practical advantages over existing time-domain solvers.

Example

Time-domain issues include

- Input: clean excitation at input requires an auxiliary simulation

- Device: approximations required for material dispersion

- Output: overlap integrals must be repeatedly calculated *during* the simulation

- Fundamental problem: trying to use a time-domain solver as a frequency-domain solver.

- Additionally, no method to measure simulation error!

- Allow direct access to frequency-domain data.
- Take care of input and output fields outside of the simulation.
- Material dispersion explicitly defined.
- Simulation error well defined.

- Frequency-domain solver made possible by correct choice of PML and linear algebra algorithm.

- See: Wonseok Shin, Shanhui Fan, "Choice of the perfectly matched layer boundary condition for frequency-domain Maxwell's equations solvers", Journal of Computational Physics (January 2012).

Interface

- No installation required.

```
>>> [E, H] = fds(omega, epsilon, J); % Run FDS.
```