How to simulate pulsed fiber amplifiers with LAD v3.0

LIEKKI

The Nanoparticle Fiber Company

LAD tutorial

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How LAD v3.0 performs a transient simulation

- When you start a transient simulation, the first step (at t=0) is a regular CW simulation that sets the inversion level from which the real transient calculations will continue. The component properties for this CW calculations are those set in the property line of the component.

- There are some restrictions in setting the simulation time and the time step. The time step should be small enough to properly follow the signals and to avoid large changes in the inversion level (one can easily see instability in the results when the time step is too large and that produces large inversion variation between time steps). In the same time, due to hardware limitation (huge mount of data accumulates), the number of time steps are limited in the current version to 2001. That reduces the maximum total time of the simulation.

- The pulse profile defined for the source is just a coefficient that multiplies the CW value set by the property line (or the spectrum of that source). If you want a different profile than what LAD offers, you may build it in Excel (for instance) and then save it in a text (ASCII) file with tab separated values. The file should contain 2 columns: the first column is the time (in seconds) and the second column is the profile (as a coefficient to multiply the CW value of the source). You may load such files in LAD using the "Load from file" button in "Set time dependence" window.

How to perform a simulation of a pulsed fiber amplifier (I)

Evaluate what is the inversion level just before the pulse will rise. For this you may simulate the setup with the signal source switched off and considering that the pump has a step like evolution (like a switch on process). See what is the inversion level inside the active fiber when the simulation time reaches your pulse period. Usually, if your pulse period is lower than 2kHz for YDFA or 500Hz for (EDFA), the inversion in the fiber reaches the maximum value for the available pump power.

How to perform a simulation of a pulsed fiber amplifier (II)

If the pulse period is below 2kHz or 500Hz (as described above) you have to set the CW value of your signal source to a very low level (this is because this value will set the inversion level just before the pulse will start to rise). You cannot set the CW value to 0 because the pulse shape is a coefficient that multiplies the CW value (see the third item in the first slide). Usually, setting the CW to 1uW would be reasonable for most applications.

If your simulation made in step I indicates that the inversion inside the fiber does not reach the maximum possible with the available pump, then you should mark the inversion level and then run several CW simulations with different signal powers to see what is the signal power level for which you obtain the marked inversion level.

How to perform a simulation of a pulsed fiber amplifier (III)

Next you have to scale (in Excel for instance) the pulse profile data you will load from file into the Time Dependence window of your source. The scaling factor is: x/(y*z) where x=the peak pulse value after scaling (your desired peak power), y=the original peak pulse value (original data you start from), z=the CW value of your source (as you set it after performing step II). Then you load the scaled data into the Time Dependence window of your source.

In addition: when creating the pulse profiles, please make sure that the profile starts with a reasonable low value (below 1uW).

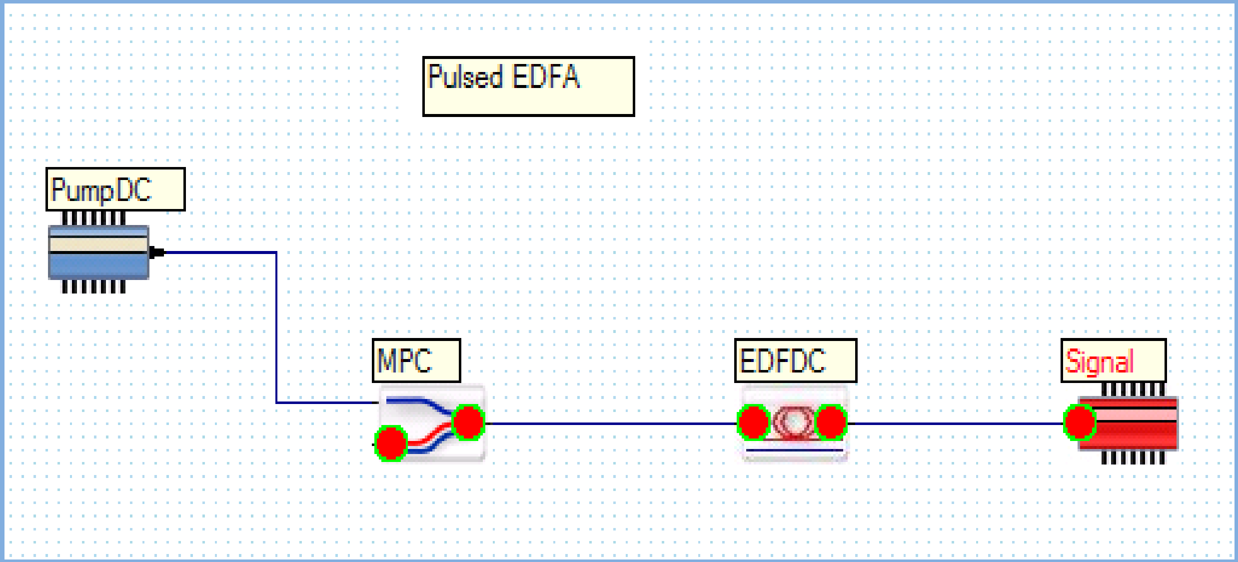
How to perform a simulation of a pulsed fiber amplifier (IV)

Then you may run the transient simulation.

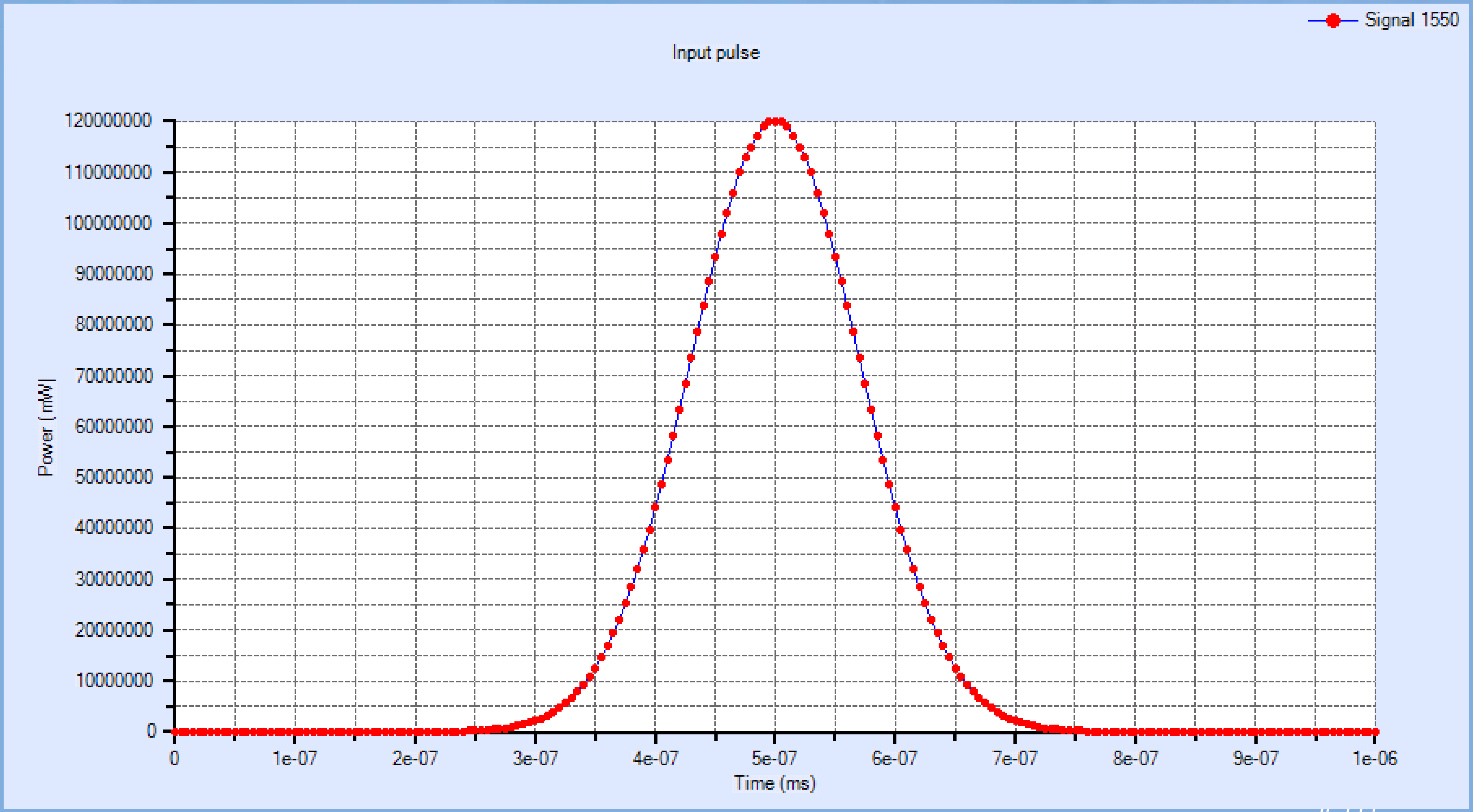
An example:
You have a 1ns pulse you loaded it into the source time dependence as a time evolution from 0 to 4ns. You set the duration of your simulation to 4ns and the time step to 0.01ns. This way you will perform 401 simulation steps.

When displaying the results you may use the linear scale for the y-axis to see the pulse shape as shown by a oscilloscope.

Example: Pulsed EDFA – the set-up



Example: Pulsed EDFA – input pulse



Example: Pulsed EDFA – output pulse