

Wideband line/cable fitter



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1 Introduction

This device is used for generating data for the Wideband line/cable model “WB m-phase” device. The fitting technique are related material on the wideband line/cable model can be found in described in [1]-[6].

In the following text, “Wideband Line/Cable fitter” is abbreviated by WB Fitter and “Wideband line/cable” is denoted by WE model.

A line or cable can be characterized with its propagation function (\mathbf{H}) and characteristic admittance (\mathbf{Y}_c) which are both frequency dependent square matrices of order equal to the number of conductors. The WB fitter generates a frequency dependent line or cable model by approximating \mathbf{H} and \mathbf{Y}_c with transfer functions in state space forms. Note that, the fitting precision and numerical stability characteristics in time-domain may depend on several factors such as range of frequency, number of samples per decade, conditioning, number of conductors, electromagnetic properties of dielectrics, configuration of conductors and finally the accuracy of input data, i.e., per unit length electrical parameters generated by the Line/Cable Data modules. The fitting of \mathbf{Y}_c is straightforward and does not require user intervention. The fitting of \mathbf{H} is complex particularly for cables, due to the existence of multiple delays associated with propagation modes. Although the default fitting parameters and options handle most of the cases, user intervention may become necessary in some cases.

The WB fitter encapsulates state-of-the-art techniques to generate a robust and accurate model. It is based on the Universal Line Model (ULM) methodology [1] by using the implementation outlined in [2]. It uses the Frequency Dependent Cable Model (FDCM) option for multi-conductor coaxial cables [3] and DC correction [4]. The fitting algorithm used is the well-known vector fitting algorithm [5] with or without the application of a correction term [2], but in a completely vectorized form to avoid frequency loops for fast fitting. The delays are computed using Bode’s formula [6] and optimized to minimize the fitting error using a search algorithm. Time delays have a significant impact on the fitting error of modal propagation functions.

2 Parameters

This device accepts model data file from the “Line Data” or “Cable Data” functions.

The procedure is shown in the following figure when using the “Line Data” device (see Lines library). The “Wideband line/cable fitter” uses the input file “line90.lyz” to generate the model file “line90.mod” that is used by the actual “Wideband line/cable” model.

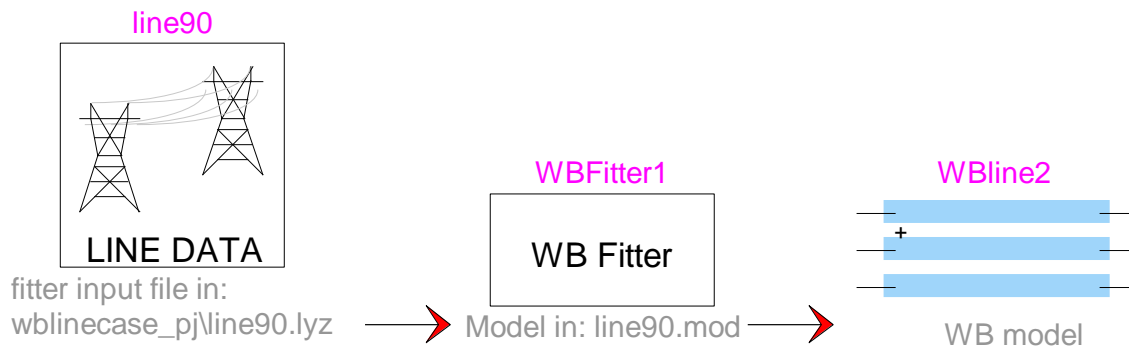


Figure 1 Wideband fitter usage for generating model data

The parameters are:

- **Fitting convergence tolerance:** tolerance used for fitting error.
- **Passivity test:** The WB Fitter includes a test for passivity verification of the generated WB model using frequency sweep technique. Passivity violations may lead to numerical instabilities in time-domain simulations with the WB model. In most cases the model is passive but if there exist passivity violations due to fitting errors, the user can vary fitting parameters to render the model passive. Perturbating the model by reducing the fitting error (**Fitting convergence tolerance**), adjusting the frequency band or number of frequency samples in Line Data or Cable Data devices, enabling/disabling grouping (**Apply grouping in propagation matrix fitting**) and turning on/off **DC correction**, can help to establish passivity. It should be noted that the source of passivity violations may also be due to the input data generated by Line Data or Cable Data modules. In this case, it is unlikely that perturbating the fitting parameters will allow to establish passivity.
- **Cable model correction:** In coaxial cables with several conductors, the conventional fitting approach [1] may cause unbalanced modal contributions in phase domain fitting with high ratio residue pole pairs having opposite signs from different modal groups. This amplifies the integration errors in time domain resulting in numerical instability. In this case, it is recommended to choose the **Cable model correction** option [3], also called FDCM. In FDCM, modal contributions in phase domain are fitted individually and high ratio residue pole pairs with opposite signs are avoided. Since the fitting is performed directly in phase domain and per modal contribution, more poles are required compared to the conventional approach to maintain similar precision. Modal contributions of repetitive eigenvalues are grouped in FDCM to obtain smooth functions to fit. The fitter switches to the FDCM option when selected and when the residue pole ratio (**Residue/Pole threshold for correction**) is above the specified threshold, which is by default 1000.
- **Residue/Pole threshold for correction:** for **Cable model correction** (see above).
- **DC correction:** The line/cable model in HVDC simulations needs to be precise at DC frequencies (frequencies close to DC). However, extending the fitting band to cover frequencies very close to DC (e.g. below 0.01 Hz) stiffens the fitting. A simple yet very efficient DC correction feature is given in [4]. When the DC correction option is selected by the user, the fitter partitions the frequency band to relax fitting and finds a correction term for DC frequencies afterwards. The application of DC correction also helps maintaining passivity. When the DC Correction option is selected, it is recommended to set the lower frequency limit to 0.001 Hz or below (in Line Data and Cable Data devices) for generating fitter data.
If the DC solution in time-domain steady-state conditions is oscillating, then this option may allow obtaining more accurate results.
- **Apply grouping in propagation matrix fitting:** When the ULM [1] methodology is used, the propagation function matrix is fitted in two stages. First stage is the identification of

poles and delays through modal decomposition. By default, propagation modes having identical or almost identical delays are grouped. In some cases, disabling grouping may improve/correct the stability of the model. Second stage is the identification of residues directly in phase domain by using the poles and delays from all modal groups in every entry of the propagation function.

3 References

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