

# Product Information

## Complex Impedance Data Fit *zfit.m*

### APPLICATIONS:

- Loudspeaker Measurement
- Thiele-Small Parameter Calculation

### FEATURES:

- 8 Different Impedance Models
- M-file runs in Matlab
- Simple Excel or text file input
- MS Excel output
- Simple to Use Graphical User Interface

## OVERVIEW

*Zfit is a Matlab™ program for fitting complex loudspeaker electrical impedance data. Data is fit to a user selected lumped-parameter equivalent circuit model. Eight different electrical impedance models are available. All models incorporate the conventional parallel R-L-C motional impedance. Input to the program is via an MS Excel or simple delimited ASCII file (e.g., \*.txt, \*.csv, etc.) containing the measured magnitude and phase impedance data. Added volume, added mass, known SPL sensitivity, and expected T-S parameter methods (initial values) are all supported. The program requires the Matlab™ Optimization Toolbox V4.2 (R2009a), or later.*

## Description

It has become standard industry practice to fit measured loudspeaker electrical impedance data, usually magnitude and phase, to a model in order to determine the Thiele-Small parameters. The motional impedance is always the standard  $C_{MS}$ ,  $M_{MS}$ ,  $R_{MS}$  2<sup>nd</sup> order single-degree-of-freedom system. The differences are typically only in the electrical (blocked) impedance. Although a loudspeaker driver can be quite non-linear, particularly in the large-signal domain, the data fit is a linear Least Mean Squares fit to the complex data for small signals. Zfit was created to perform this data fit. The measured impedance data can be in an Excel or a delimited ASCII file. Added volume, added mass, known SPL sensitivity or known initial parameter methods are all

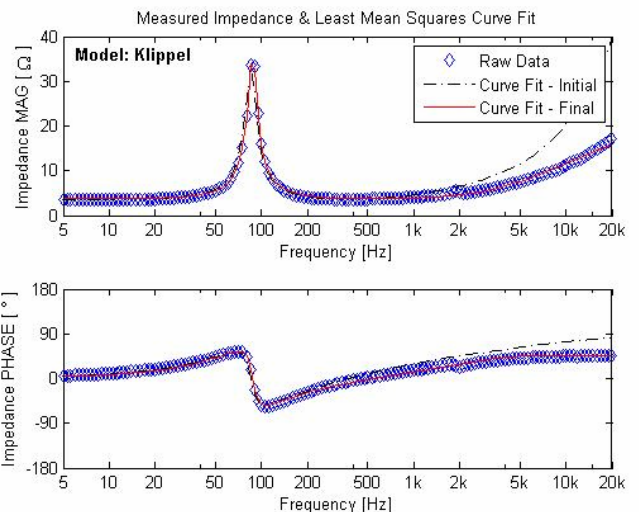


Fig. 1 Measured data and LMS fit to the selected model.

supported. Eight different user-selectable electrical impedance models — three incorporating a semi-inductance — are available. An example fit is shown in Fig. 1. The curve fit results (frequency, magnitude, phase, and T-S parameters) are saved in an Excel worksheet with the name of the model used. Therefore, multiple fits of the same data using different models may be appended to the original data file as new worksheets. The different models shown in Fig. 2 are supported by zfit.m. Afterwards, there is an option to try a new model, load new data, or exit. Note that this m-file requires the Optimization Toolbox V4.2 (R2009a), or later.



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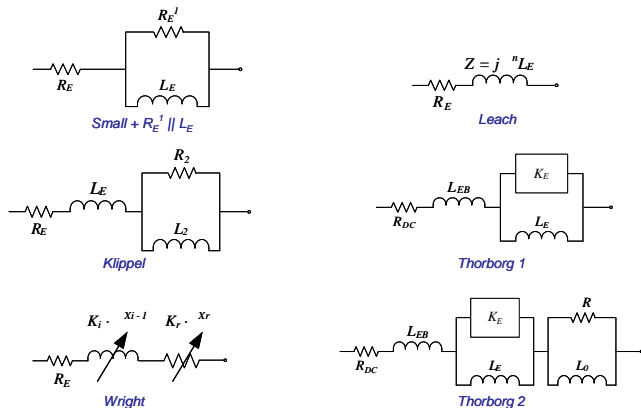


Fig. 2 Supported loudspeaker electrical impedance models

For input data in MS Excel, the name of the worksheet must be 'Zfit Data'. The DC resistance, if measured, should correspond to  $f = 0$  Hz. This value, although used in the calculations, is truncated from the semi-log display. The Added Mass, Added Volume, or SPL data (scalar) is used to determine the initial values for the fit. Alternatively, the initial values if known, e.g., from a spec sheet for a known make and model, can also appear in the 4th row or column. If so, the initial values must be in the following format:

$$R_E [\Omega] \quad L_E [mH] \quad Bl [T \cdot m] \quad M_{MS} [g] \quad R_{MS} [Ns/m] \quad C_{MS} [mm/N]$$

For the SPL method, the half-space sensitivity must be in dB SPL re: 2.83V at 1m. The added volume or added mass value must be in liters or grams, respectively. The test method used is inferred from the data file format. The physical constants (temperature, barometric pressure, reference impedance) are loaded at startup from the text file 'ZfitStart.txt', and may be modified by the user to suit local conditions.

## Thiele-Small Parameters

4" Polypropylene Driver

Model: Klippel

Re	3.71 $\Omega$	Diameter	10.2998 cm
Zmax	36.34 $\Omega$	Sd	83.3 cm <sup>2</sup>
fs	87.22 Hz	Vas	2.28 liters
Zmin	3.75 $\Omega$ at 550.25 Hz	Qms	7.527
		Qes	0.857
Cms	0.2345 mm/N	Qts	0.769
Mms	14.2 grams	$\eta_D$	0.17 %
Rms	1.034 N·s/m	2 $\pi$ Sensitivity	87.7 dB SPL at 1m re: 1W into 8 $\Omega$
Bl	5.81 T·m	fs/Qes	102
Le	0.05767 mH	Optimum System:	Ported
R2	9.552 $\Omega$		
L2	0.141 mH		

Mean Square Error: 0.0024

Iterations: 37

Fig. 3 Thiele-Small Parameters from data fitting.

After the Initial Fit plot, pressing ENTER allows the user to see the LMS fit. Pressing ENTER again continues to a display of the Thiele-Small parameters. The final display of the resulting parameters is shown in Fig. 3.

The user is prompted to enter a text string comment and then to save the results to an Excel file. The curve fit magnitude, phase, and parameters are saved in a worksheet with the name of the model used. Therefore, multiple fits of the same data using different models may be appended to the original data file as new worksheets. Afterwards, there is an option to try a new model, load new data, or exit.

## Technical Specifications

### Matlab Version:

7.8.0.347 (R2009a), or later.

**NOTE:** This m-file requires the Optimization Toolbox V4.2 (R2009a), or later.

### The following m-files are included in the package:

AUTOSCALE, KLIPPEL, KLIPPELERROR, LEACH, LEACHERROR, LOGFAUTOSCALE, REFORM, SMALL, SMALLERROR, SMALLLE, SMALLLEERROR, SMALLLERE1, SMALLLERE1ERROR, THORBORG1, THORBORG1ERROR, THORBORG2, THORBORG2ERROR, TSPS, WRIGHT, WRIGHTERROR.

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