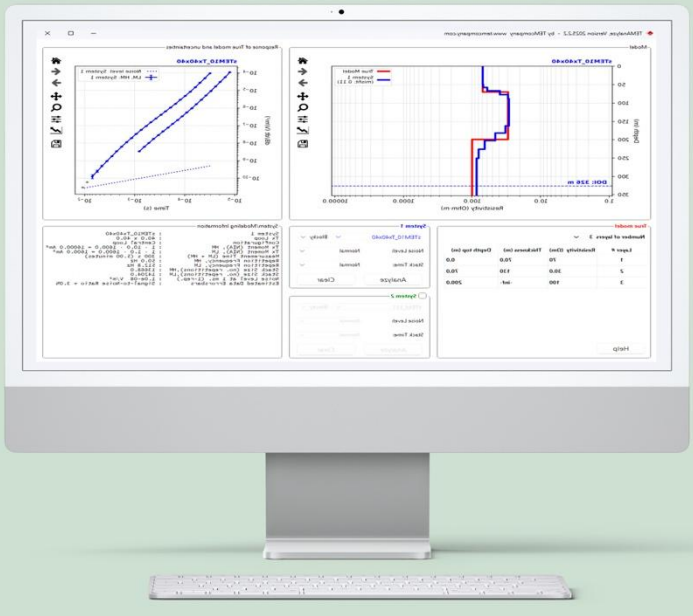
TEMcompany

TEManalyze

HELP MANUAL



Ver.1.

TEManalyze

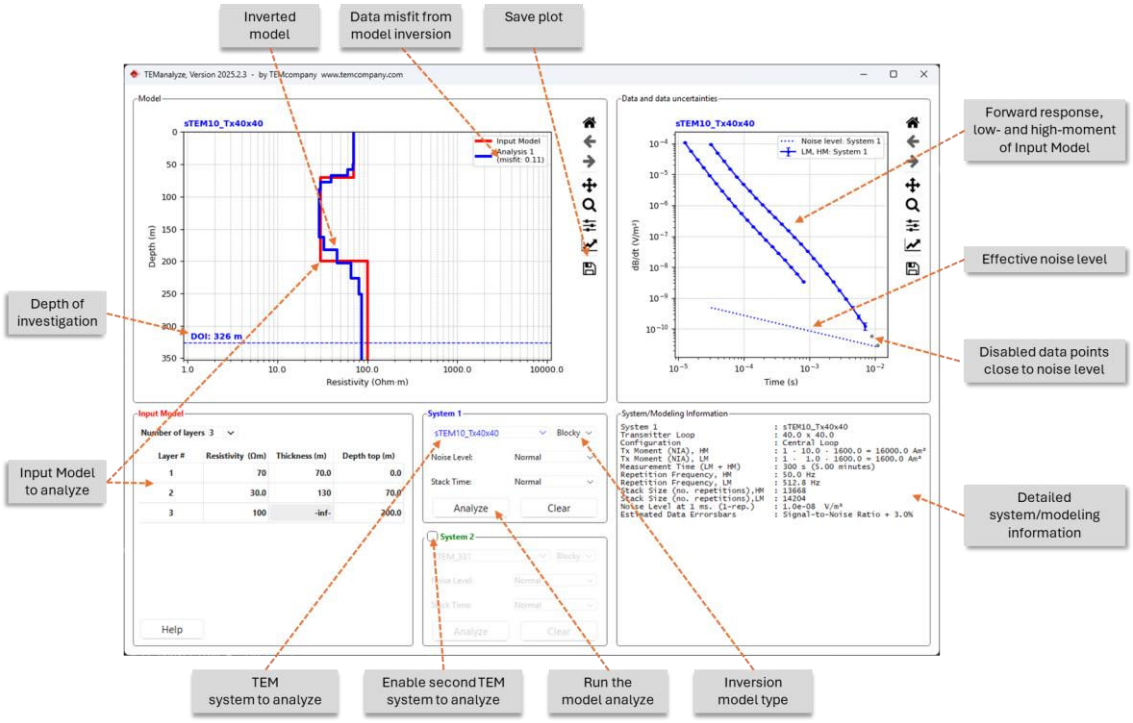
Selecting an appropriate TEM system for a given task can be challenging. Model's resolution and depth of investigation (DOI) not only depend on the system configuration, but also on the background noise level and the subsurface resistivity structure. TEManalyze helps tie all parameters together to provide guidance before going to the site and starting to measure.

With TEManalyze, users can identify the most suitable TEM system and configuration, as well as determine the optimal stacking time. To make the analysis, the user only needs to have some knowledge of the geological model in terms of expected layer resistivities and layer thickness.

1.1 Quick Guide

The figure below shows the program layout with an explanation of the main program features.

1) Type in the resistivity and layer thickness of the expected geological model.
2) Select a TEM system.
3) Select if the inversion should emphasize a Smooth or a Blocky model type.
4) Select Noise Level and Stack Time.
5) Click Analyze – after some seconds, the data for the Input Model and the smooth/blocky model inversion results will be plotted together with the DOI.



Program layout with annotations.

1.2 Terminology

TEManalyze uses a nonlinear optimization algorithm to analyze the model. In geophysics, such an algorithm is called an inversion algorithm. This algorithm considers the following parameters:

- The geological model in terms of the thickness and the resistivity of each layer.
- The TEM system: coil sizes, power, coil separations, signal gating, signal low pass filtering etc.
- "Smoothness" on the variations of the model parameters (also called the regularization).
- The noise level and the stacking time.

Some of these parameters may be difficult to know in advance, but by adjusting, for example, the layer properties or the noise level, it is easy to get an impression of the achievable resolution and its variability.

To limit the number of parameters that can be varied, TEManalyze considers systems in the TEMcompany product family: sTEM, tTEM, TEM2Go. It enables variation of the noise level and the stacking time.

1.3 Modelling details

Noise level and Stacking time

The effective noise level depends on the TEM-system and stacking time and is used to estimate the data uncertainties as well as to decide which data points to be used in the inversion and DOI-calculation.

The *Initial noise level* (before the stacking time is taken into account) is set to:

- Low (1/3 x Normal) : 3.3^{-9} V/m²
- Normal: 1.0^{-8} V/m²
- High (3 x Normal) : 3.0^{-8} V/m²

(noise levels at 1 ms)

The noise level line in the data-plot is the E*ffective noise level*, which takes data stacking into account. The noise level decreases proportionally to $t^{-0.5}$, which is characteristic of random noise in a logarithmic gating scheme.

The stacking time (the measurement time) together with the period time gives the number of measurement repetitions (the *Stack size*). The E*ffective noise level* is calculated as:

$$Effective\ noise\ level = Initial\ noise\ level\ /\ \sqrt{Stack\ size}$$

The stack size is listed in the System/Modeling Information box.

The TEM-systems have the following "*Normal*" *Stack Times*:

sTEM; 20x20, 40x40, 80x80 :	5 min
sTEM profiler:	30 s
tTEM 221, 331, 333, 443:	5 s
TEM2Go :	10 s

The user can select a shorter *Stack Time* (*1/4 x Normal*), which results in a higher *Effective noise level,* or a longer *Stack Time* (*4 x Normal*) which results in lower *Effective noise level*.

Data error bars

Based on the *Effective noise level*, the data uncertainty (error bars) are calculated based on the signal-to-noise ratio and with and a 3 % uniform uncertainty added. Data points with uncertainty exceeding 30% are excluded from the analysis/inversion.

Inversion

The user can select between a smooth model (L2-norm) or a Blocky model (L1-norm) for inversion for the input model forward response.

The inversion compromise:

- The non-excluded forward data and data uncertainties.
- The system setup (loop geometry, transmitter waveform, etc.) of the selected TEM-system.
- 1D multi layered model (30 layers), with vertical constraints, Smooth (L2-norm) or Blocky (L1-norm) model type.
- Inversion output: Resistivity model, DOI, data misfit

The data Misfit of the inversion is displayed in the legend. Misfit <1 is a fit within the data uncertainties. It is possible to type in a Input Model where the forward response can't be fitted with a smooth/blocky model, therefore a warning is displayed if data misfit is >1.5.

Depth of Investigation (DOI)

The displayed DOI is calculated based on the TEM-system, noise level/ data uncertainties, and the smooth/blocky model inversion result.

Inversion/modelling code

The program uses the Lupus TEM inversion code for forward modelling, inversion, and DOI-calculations. The DOI-calculations in Lupus is similar to:
Christiansen, A. V. and Auken, E., A global measure for depth of investigation.
Geophysics, vol. 77, no. 4, 2012, https://doi.org/10.1190/geo2011-0393.1

Advanced Settings

The program default settings are stated in the TEManalyze_settings.json file, located in the program folder (typical, c:\Program Files\TEMcompany\TEManalyze\TEManalyze_settings.json).

Among other, the TEManalyze_settings.json hold setting for:

- "Fwr_NoiseLevel_SingleTransient" : The *Initial noise level*
- "InstrumentType_StackTime" : Stack time (*Normal*) for the Instrument types