

TEM1D DOCUMENTATION

Zonge Modeling
Layered-Earth TEM Response
version 2.01

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TEM1D

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Introduction

TEM1D calculates multi-component transient electromagnetic (TEM) responses of an induction loop system on the surface of a layered earth. Source fields are excited by a ramped current step in a large, rectangular transmitter loop placed on the earth's surface. Three-component transient responses are calculated as time-domain voltages in receiver coil antennas placed at arbitrary surface or down-hole locations. TEM1D models may be saved in ASCII files for later editing and reuse. Calculated data may be saved in Zonge-format TEMAVG *.AVG, ZPLOT *.Z files, in AMIRA TEM format *.AMR files, or in files suitable for plotting with Grapher, Surfer or TecPlot.

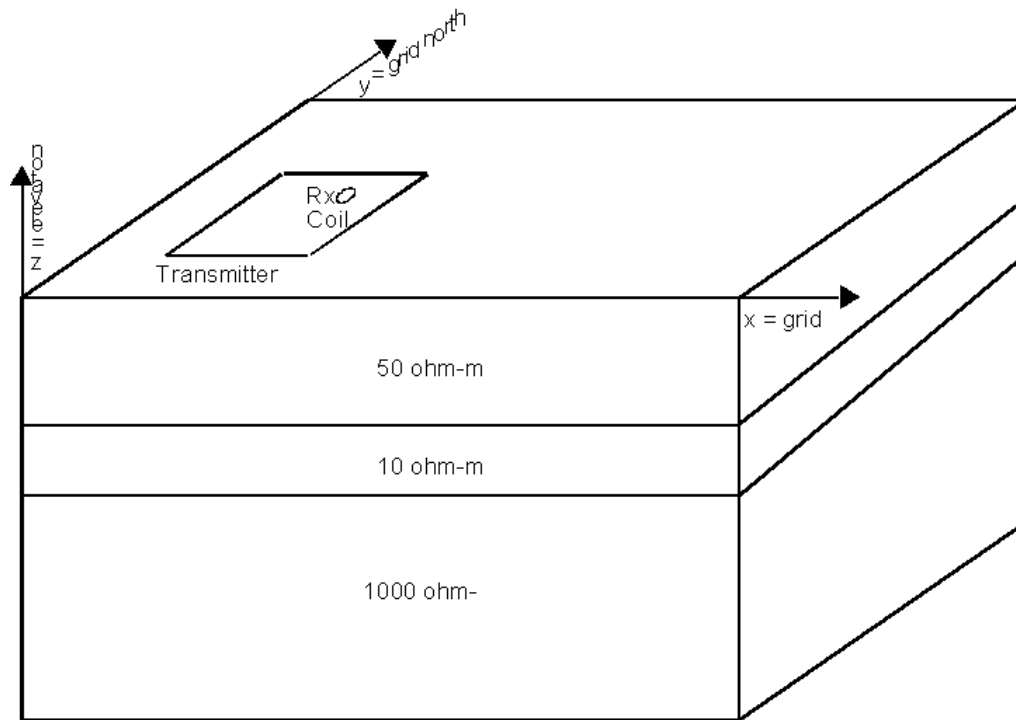


Figure 1: TEM1D models a fixed-loop TEM configuration. Source fields are generated by a horizontal transmitter loop on the surface of a layered earth. Three-component transient responses may be calculated at arbitrary positions on or within a layered-earth model. Up to 256 receiver locations and 32 model layers may be specified. TEM1D uses a right-handed coordinate system with positive x to grid east, positive y to grid north and z positive upward. Azimuths are given in degrees clockwise from grid north.

Installation

Hardware Configuration

TEM1D runs on PC's using MS Windows operating systems configured with High Color (16 bit) color graphics.

Installation Procedure

To install TEM1D, place the distribution disk in a floppy disk drive and log on to that drive. Then type "INSTALL" and press the Enter key. You will see a screen title showing the program's name and version number. Below the title block a set of highlighted fields specify the source drive you are installing TEM1D from, usually floppy drive A: or B:, and the target hard drive letter and path in which TEM1D should be installed. It is usually easier to put TEM1D programs in an existing directory which is already on your computer's MS-DOS path. You can move from field to field in the INSTALL program's screen by pressing the Tab key to move forward and Shift+Tab to move backward. To cycle through disk drive letters, press the space bar or left and right arrow keys. Select drive letters and edit the target path to suit your computer's configuration. When you press F10, INSTALL will verify your edited changes and will extract files from #TEM1D.EXE to your target directory.

After installation, the TEM1D subdirectory should have the following files:

TEM1D program files:

TEM1D.EXE - fixed-Loop TEM layered-earth forward modeling program.
TEM1D_UPDATE.NTS ASCII text file with notes on update changes

Sample data files:

TEM1DEMO.MOD - input file with survey configuration and model parameters.
TEM1DEMO.OBS - calculated data in tabular STEMINV format.
TEM1DEMO.AVG - calculated data in Zonge TEMAVG avg file format
TEM1DEMO.Z - calculated data in Zonge ZPLOT z file format
TEM1DEMO.DAT - calculated data in Tecplot data file format
TEM1DEMO.AMR - calculated data in AMIRA TEM file format (+ chn file)

Program Use

TEM1D may be started from the Windows Run dialog, a screen short cut or by typing "TEM1D" in a Windows MS-DOS box. The initial menu has three choices; **New** to interactively create a model from scratch, **Open** to read model parameters from an existing TEM1D model file, or **Exit** to stop TEM1D.

Choosing **New** brings up a tabbed dialog screen for interactive editing of model parameters grouped into four categories. Model parameters are given default values, which may be edited interactively. The tab labeled **General** includes text fields to hold project and line labels, a free-form description of the model, a choice of length units, and the file name to use for storing model parameters and calculated data. Click on the **OK** button to accept edit changes or click on **Cancel** to abort editing.

Edit Model Parameters

General | Tx | Rx | Layers

Project: TEM 1D Modeling Line: 1

Model Description

TEM1D fixed-loop model with surface and down-hole Rx locations.

3-layer earth with 100 m of 50 ohm-m over 40 m of 10 ohm-m over 1000 ohm-m

Length Units: m Model File Name: TEM1DEMO.IN

OK Cancel

Project = project name, saved in AMIRA TEM files.

Line = line number, used as a coordinate in AMIRA TEM files.

Model Description = three lines of free-form text, saved in TEM1D *.MOD files (Header(2:4)).

Length Units = length units (LengthUnits = m, km, ft or kft).

Model File Name = file name used to save model parameters.
The model-file-name stem also used for calculated data file names.

Selecting the **Tx** tab brings up a dialog screen holding transmitter loop parameters. Click on the **OK** button to accept edit changes or click on **Cancel** to abort editing.

Edit Model Parameters

General Tx Rx Layers

TxID

Tx Center E N

Tx Width E-W N-S

Tx Ramp usec

Tx Freq. hertz

OK Cancel

Tx ID = floating point number used to label the Tx loop stored in *.AVG & *.AMR files.

In fixed-loop surveys, Tx ID is usually an arbitrary loop number.

In separated-loop surveys, Tx ID represents the station number at the center of the loop.

In moving-in-loop surveys, Tx ID is usually ignored. ($-9.9E7 < \text{TxID} < 9.9E8$)

Tx Center = grid east and north coordinates for the center of a rectangular Tx loop aligned with grid coordinates. ($-9.9E7 < \text{TxCX}, \text{TxCY} < 9.9E8$ length units)

Tx Width = grid east-west and north-south width of Tx loop. ($1.0 < \text{TxDX}, \text{TxDY} < 1.0E4$ length units)

Tx Ramp = duration of a linear transmitter turn-off ramp ($1.0E-3 < \text{TxRamp} < 1.0E3$ usec).

Tx Freq. = transmitter repetition rate with 50% duty cycle ($1.0E-3 < \text{TxFreq} < 1.0E3$ hertz).

The **Rx** tab holds model parameters associated with the receiver. Click on the **OK** button to accept edit changes or click on **Cancel** to abort editing.

Edit Model Parameters

General | Tx | **Rx** | Layers

Rx Coil Area: m²

Time Windows (msec)

| | Center | Width |
|----|------------|------------|
| 1 | 0.3050E-01 | 0.1000E-03 |
| 2 | 0.6100E-01 | 0.2000E-03 |
| 3 | 0.9160E-01 | 0.4000E-03 |
| 4 | 0.1221 | 0.5000E-03 |
| 5 | 0.1526 | 0.6000E-03 |
| 6 | 0.1978 | 0.3050E-01 |
| 7 | 0.2590 | 0.3050E-01 |
| 8 | 0.3201 | 0.3050E-01 |
| 9 | 0.3956 | 0.6100E-01 |
| 10 | 0.4873 | 0.6100E-01 |
| 11 | 0.6073 | 0.1220 |
| 12 | 0.7745 | 0.1525 |

Rx Locations

| Station | Easting | Northing | R.L. |
|---------|---------|----------|--------|
| 1.0 | 0.0 | 0.0 | 0.0 |
| 2.0 | 25.0 | 0.0 | 0.0 |
| 3.0 | 50.0 | 0.0 | 0.0 |
| 4.0 | 75.0 | 0.0 | 0.0 |
| 5.0 | 100.0 | 0.0 | 0.0 |
| 6.0 | 50.0 | 50.0 | 0.0 |
| 7.0 | 50.0 | 50.0 | -25.0 |
| 8.0 | 50.0 | 50.0 | -50.0 |
| 9.0 | 50.0 | 50.0 | -75.0 |
| 10.0 | 50.0 | 50.0 | -100.0 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

OK Cancel

Rx Coil Area = effective coil area for all three components ($0.1 < \text{RxArea} < 1.0\text{E}9 \text{ m}^2$).

Time Windows = specify window times in milliseconds from end of Tx ramp ($1 < \text{NTimes} < 64$).

Window Center = center of time window ($1.0\text{E}-4 < \text{WTime} < 1.0\text{E}4 \text{ msec}$).

Window Width = center of time window ($1.0\text{E}-4 < \text{WWidth} < 1.0\text{E}4 \text{ msec}$).

Rx Locations = specify three-component measurement locations ($1 < \text{NRx} < 128$).

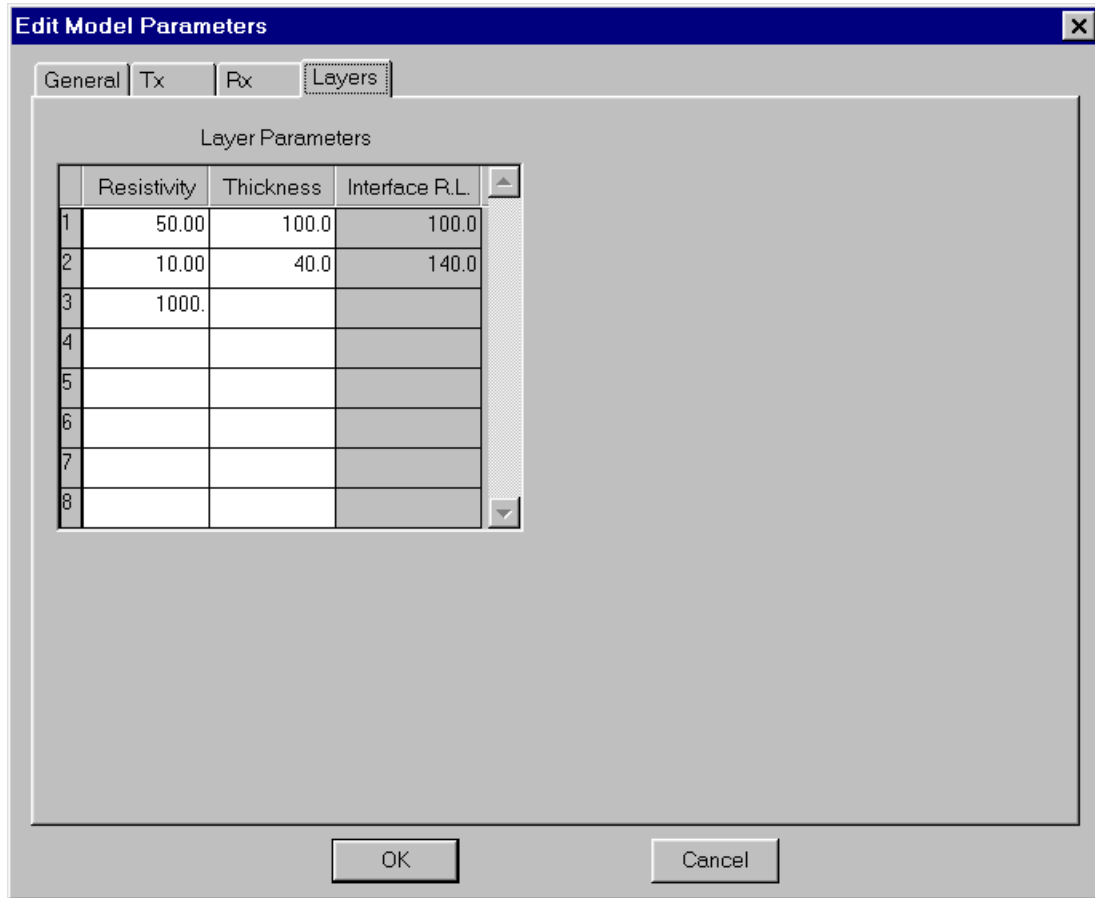
Station Number = arbitrary station number ($-9.9\text{E}7 < \text{SRx} < 9.9\text{E}8$).

Easting = grid east coordinate ($-9.9\text{E}7 < \text{XRx} < 9.9\text{E}8 \text{ length units}$).

Northing = grid north coordinate ($-9.9\text{E}7 < \text{YRx} < 9.9\text{E}8 \text{ length units}$).

R.L. = relative level or elevation, R.L.=0 = surface, R.L.<0 = down-hole ($-9.9\text{E}7 < \text{ZRx} < 0.0$).

Clicking on the Layers tab brings up a dialog for editing model layer parameters. Click on the **OK** button to accept edit changes or click on **Cancel** to abort editing.



The image shows a software dialog box titled "Edit Model Parameters" with a close button (X) in the top right corner. It contains four tabs: "General", "Tx", "Rx", and "Layers", with "Layers" currently selected. The main area of the dialog is titled "Layer Parameters" and contains a table with 8 rows and 3 columns: "Resistivity", "Thickness", and "Interface R.L.". The first two rows are populated with values, while the remaining six rows are empty. The table has a vertical scrollbar on its right side. At the bottom of the dialog are "OK" and "Cancel" buttons.

| | Resistivity | Thickness | Interface R.L. |
|---|-------------|-----------|----------------|
| 1 | 50.00 | 100.0 | 100.0 |
| 2 | 10.00 | 40.0 | 140.0 |
| 3 | 1000. | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 7 | | | |
| 8 | | | |

Layer Parameter = specifies horizontal layer parameters ($1 < N_{\text{Layer}} < 32$).

Resistivity = layer resistivity ($1.0\text{E-}9 < \text{LayerRes} < 1.0\text{E}9$ ohm-m).

Thickness = layer thickness ($0.1 < \text{LayerThk} < 1.0\text{E}9$ length units).

Once model parameters have been set, TEM1D shows a menu with four choices; **File**, **Edit**, **Run Model** or **Exit**.

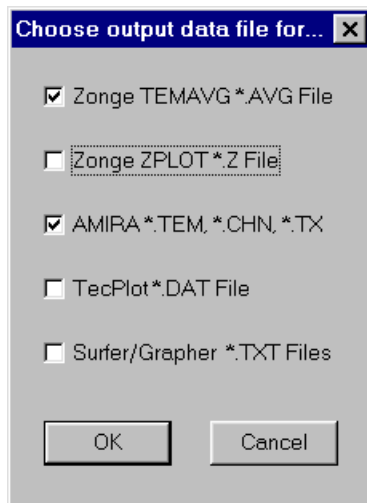
Choosing **File** allows you to create a **New** model, **Open** an existing model, **Save** the current model, use **Save As** to choose a new file name and then save the current model, or to **Exit Menu** to return to the main menu.

Selecting **Edit** brings up the interactive model editing dialog so that you can edit the current model.

Run Model calculates the TEM response for the current set of model parameters.

Choosing **Exit** stops TEM1D.

When **Save** or **Save As** are selected, TEM1D puts model parameters into a *.MOD file. If TEM data have been calculated for the current model, TEM1D will also allow you a choice of output data-file formats, Zonge TEMAVG *.AVG, Zonge ZPLOT *.Z, AMIRA TEM-format *.AMR + *.CHN + *.TX, TecPlot *.DAT, or Surfer/Grapher *.TXT files. File formats are described in appendix A. Output data file formats can be selected by clicking on the appropriate boxes. A check mark indicates that a particular file format will be written.



References

- Anderson, W.L., 1979, Numerical integration of related Hankel transforms of orders 0 and 1 by adaptive digital filtering: *Geophysics*, v44, p1287-1305.
- Anderson, W.L., 1981, Calculation of transient soundings for a central induction loop configuration (Program TCILLOOP): USGS Open-file report 81-1309.
- Knight, J.H. and Raiche, A.P., 1982, Transient electromagnetic calculations using the Gaver-Stehfest inverse Laplace transform method: *Geophysics*, v47, p47-50.
- Raiche, A.P., 1984, The effect of ramp function turn-off on the TEM response of a layered earth: *Exploration Geophysics*, v15, p37-41.
- Raiche, A.P., 1987, Transient electromagnetic field computations for polygonal loops: *Geophysics*, v52, p785-793.
- Raiche, A.P., and Bennett, 1987, Layered-earth models using downhole electromagnetic receivers, *Exploration Geophysics*, v18, p325-329.

Appendix A: TEM1D File Documentation

*.MOD file - survey configuration and model parameters

Partial Listing of STEMDEMO.MOD:

```
&TEM1D
Project='TEM 1D Modeling',Line='1',
Header(1)='From TEM1D v2.00d  Date:03/08/98  Time:12:47',
Header(2)='TEM1D fixed-loop model with surface and down-hole Rxs.',
Header(3)='3-layer earth model',
LengthUnits='m',
NLayer=3,
LayerRES(1)=50.00,LayerTHK(1)=100.0,
LayerRES(2)=10.00,LayerTHK(2)=40.00,
LayerRES(3)=1000.,
TxRamp=70.00,TxFreq=1.000,
TxCX=0.0000,TxCY=0.0000,
TxDX=100.0,TxDY=100.0,
NTimes=30,RxArea=1.0000E+4,
WTime(1)=3.0500E-2,WWidth(1)=1.0000E-4,
. . . . .
NRx=10,
SRx(1)=1.0,XRx(1)=0.0,YRx(1)=0.0,ZRx(1)=0.0,
. . . . .
/
```

Input files use a Fortran namelist format. TEM1D attempts to assign reasonable default values to any parameters which are not included in the namelist block. Default values are bracketed by { } in the following glossary of input-file variables.

TEM1D Fortran Namelist block:

| Variable | Description | Default | Range |
|-------------|---|-------------------|-------------------|
| Project | - project name | {TEM 1D Modeling} | |
| Line | - line number | {1} | (-9.9E7 to 9.9E8) |
| Header() | - descriptive text | { } | |
| LengthUnits | - length units | {m} | (m, km, ft, kft) |
| NLayer | - number of layers in model | {1} | (1 to 32) |
| LayerRes() | - resistivity of each layer (ohm-m) | {100} | (1.0E-9 to 1.0E9) |
| LayerThk() | - thickness of each layer (length units) | { } | (0.1 to 1.0E9) |
| TxCX | - Tx loop center grid east (length units) | {0} | (-9.9E7 to 9.9E8) |
| TxCY | - Tx loop center grid north (length units) | {0} | (-9.9E7 to 9.9E8) |
| TxDX | - Tx loop E-W width (length units) | {100} | (1 to 1.0E4) |
| TxDY | - Tx loop N-S width (length units) | {100} | (1 to 1.0E4) |
| TxRamp | - transmitter turn-off-ramp time (usec) | {50} | (1.0E-3 to 1.0E3) |
| TxFreq | - Tx repetition rate (hertz) | {1} | (1.0E-3 to 1.0E3) |
| NRx | - number of receiver locations | {1} | (1 to 128) |
| RxArea | - effective surface area of Rx coil (m ²) | {1.0E4} | (0.1 to 1.0E9) |
| SRx() | - Rx station number | {0} | (-9.9E7 to 9.9E8) |
| XRx() | - Rx grid east (length units) | {0} | (-9.9E7 to 9.9E8) |
| YRx() | - Rx grid north (length units) | {0} | (-9.9E7 to 9.9E8) |
| ZRx() | - Rx relative elevation (length units) | {0} | (-9.9E7 to 0) |
| NTimes | - number of window times | {30} | (1 to 64) |
| WTime() | - window center times (msec) | {GDP times} | (1.0E-4 to 1.0E4) |
| WWidth() | - window width (msec) | {GDP widths} | (1.0E-4 to 1.0E4) |

TEMAVG-format *.AVG file - averaged TEM data and measurement error estimates

Partial listing of STEMDEMO.AVG file:

```

\ TEM1D v2.00d processed Temldemo.AVG on 03/08/98
$ TEM: Array= Fixed-Loop
$ TEM: TxID=      1.00
$ TEM: TxCX=      0.00 m
$ TEM: TxCY=      0.00 m
$ TEM: TxDX=     100.00 m
$ TEM: TxDY=     100.00 m
$ TEM: TxRamp=    70.00 usec
$ TEM: RxArea= 1.0000E+4 m^2

```

| skp | Tx | Station | Freq | Cmp | Amps | Win | Time | Magnitude | %Mag |
|-----|----|---------|------|-----|------|-----|----------|-------------|------|
| 2 | 1. | 1. | 1. | Hx | 1.00 | 1 | 3.050E-2 | 1.6972E-03 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 2 | 6.100E-2 | -3.0580E-05 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 3 | 9.160E-2 | -3.8452E-04 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 4 | 1.221E-1 | -1.4574E-04 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 5 | 1.526E-1 | -4.7617E-05 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 6 | 1.978E-1 | 1.0197E-04 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 7 | 2.590E-1 | -2.1997E-04 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 8 | 3.201E-1 | -4.4909E-05 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 9 | 3.956E-1 | -4.6320E-05 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 10 | 4.873E-1 | 9.8149E-05 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 11 | 6.073E-1 | 2.5659E-05 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 12 | 7.745E-1 | 2.4446E-06 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 13 | 9.723E-1 | 4.2212E-06 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 14 | 1.215E+0 | -6.7340E-06 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 15 | 1.518E+0 | 1.2804E-05 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 16 | 1.911E+0 | 1.2764E-06 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 17 | 2.426E+0 | -5.7202E-08 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 18 | 3.064E+0 | -2.6947E-07 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 19 | 3.852E+0 | 1.1483E-06 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 20 | 4.838E+0 | -3.8456E-07 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 21 | 6.094E+0 | 2.0280E-08 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 22 | 7.687E+0 | -3.2127E-07 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 23 | 9.659E+0 | 1.9571E-08 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 24 | 1.214E+1 | -1.3788E-08 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 25 | 1.530E+1 | -2.5751E-08 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 26 | 1.925E+1 | -2.1046E-08 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 27 | 2.424E+1 | -1.1518E-08 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 28 | 3.053E+1 | -3.9240E-09 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 29 | 3.842E+1 | 3.8786E-09 | 1.0 |
| 2 | 1. | 1. | 1. | Hx | 1.00 | 30 | 4.838E+1 | -1.1147E-10 | 1.0 |
| 2 | 1. | 2. | 1. | Hx | 1.00 | 1 | 3.050E-2 | 4.0425E+04 | 1.0 |
| 2 | 1. | 2. | 1. | Hx | 1.00 | 2 | 6.100E-2 | 1.0638E+04 | 1.0 |
| 2 | 1. | 2. | 1. | Hx | 1.00 | 3 | 9.160E-2 | 4.3418E+03 | 1.0 |
| 2 | 1. | 2. | 1. | Hx | 1.00 | 4 | 1.221E-1 | 2.2735E+03 | 1.0 |
| 2 | 1. | 2. | 1. | Hx | 1.00 | 5 | 1.526E-1 | 1.3998E+03 | 1.0 |
| . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . |

A TEMAVG-format *.AVG file contains averaged TEM data for discrete times. Field data TEM *.AVG files are produced by the Zonge data processing program TEMAVG, which reads files with repeat readings, averages them and calculates measurement error from variation between repeats. Field data *.AVG files are archived together with GDP-format files (*.RAW) and station location files (*.STN). *.AVG files are used by programs that provide plot files, options for further data processing, modeling and inversion.

Comment lines preceded by a "\", "/", "!" or "" in column 1 may be placed anywhere within *.AVG files. Data processing mode lines preceded by a "\$" in column 1 may also be present. A line holding column labels must precede the numerical data. Column order is not fixed and all columns may not be present in a particular file. Missing values are flagged by a "*". Numerical values are free format with columns separated by spaces or commas.

TEM *.AVG file modes:

```
Array    - survey configuration (In-Loop, Separated-Loop, Fixed-Loop)
TxID     - Tx ID, used as loop center station number in separated loop.
TxCX     - easting of loop center in fixed-loop survey.
TxCY     - northing of loop center in fixed-loop survey.
TxDX     - E-W Tx loop width.
TxDY     - N-S Tx loop width.
TxRamp   - Tx turn-off ramp time.
RxArea   - effective Rx coil surface area.
```

TEM *.AVG file column definitions:

```
Skip      - skip flag, 2 = good data, 1= bad data, 0 = very bad data.
Tx        - Tx ID, used as loop center stn # in separated loop.
Station   - receiver station number in unscaled and unshifted units.
Freq.     - repetition rate frequency (hertz).
Cmp       - measured field component (Hx, Hy or Hz).
Amps      - peak-to-peak square-wave current (amps).
Window    - time window index.
Time      - time window center (msec).
Magnitude - dB/dt magnitude (uV/amp).
%Mag      - relative dB/dt magnitude error (percent).
RampAppRes - ramp-corrected apparent resistivity (ohm-m) (only calculated for in-loop data).
Depth     - diffusion depth = 28*sqrt(resistivity*time) (m) (only calculated for in-loop data).
```

ZPLOT-format *.Z file - TEM profile or pseudosection plotting

TEM *.Z files may contain window magnitude, apparent resistivity or model resistivity data.

```

TEMAVG 7.36 Contour file.
/* 01 Jun 96
$ DATE= 96-06-01
$ ZPLOT: DATA= TIME
Cl Cn Ce Ns Nd Yl   Plot file  1
  0  1  0  3  1  0
TRANSIENT EM SURVEY DATA
Window MAGNITUDE
  values in microV/ampere
  Component: Hz, Rxna: 10000.0
$ CONTOUR= NONE
$ PROFILE= AUTO
$ POST    = NONE
I lxxxxxxxxxYYYYYYYzzzzzzzzzzzz  AAA  ffffffffwww
2    0.00 0.0366 -9.55983e+03      32Hz W 1
2    0.00 0.06712-7.14530e+03      32Hz W 2
2    0.00 0.09764-4.06307e+03      32Hz W 3
2    0.00 0.12815-1.77413e+03      32Hz W 4
2    0.00 0.15867-3.56687e+02      32Hz W 5
2    0.00 0.18919 4.20503e+02      32Hz W 6
2    0.00 0.23438 8.54600e+02      32Hz W 7
2    0.00 0.29555 8.91040e+02      32Hz W 8
2    0.00 0.35667 7.21070e+02      32Hz W 9
2    0.00 0.43215 4.96700e+02      32Hz W10
2    0.00 0.52393 2.99623e+02      32Hz W11
2    0.00 0.64389 1.54230e+02      32Hz W12
2    0.00 0.81105 6.28587e+01      32Hz W13
2    0.00 1.00886 2.35730e+01      32Hz W14
2    0.00 1.25118 7.84533e+00      32Hz W15
2    0.00 1.55483 2.14923e+00      32Hz W16
2    0.00 1.9473  7.98333e-02      32Hz W17
2    0.00 2.46251-1.83467e-01      32Hz W18
2    0.00 3.10054-2.50000e-01      32Hz W19
2    0.00 3.88871-4.03267e-01      32Hz W20
2    0.00 4.87477-3.67400e-01      32Hz W21
2    0.00 6.13034-2.57000e-01      32Hz W22
2    25.00 0.0366 -1.15100e+04      32Hz W 1
2    25.00 0.06712-7.85410e+03      32Hz W 2
2    25.00 0.09764-3.92493e+03      32Hz W 3
2    25.00 0.12815-1.34250e+03      32Hz W 4
2    25.00 0.15867 1.16260e+02      32Hz W 5
2    25.00 0.18919 8.42287e+02      32Hz W 6
:      :      :      :      :      :
:      :      :      :      :      :
9999.0

```

*.Z files are used for storing plot file data in multiple (skp,x,y,z) data blocks. Numerical values are stored in a fixed format, so column position is important. Numerical field widths are indicated by the "lYz" record preceding numerical data. A "lYz" record flags the beginning of a block of numerical (skp,x,y,z) data and a 9999.0 value flags the end of the block. For STEMINV input, the *.Z file must have TEM magnitude data.

Description of lines in sample *.Z file:

\$ ZPLOT: DATA= FLOG - mode line, y-value data type (log(freq))

\$ ASPACE = 60.960m - receiver dipole length

AMTAVG 7.20 - program name and version that generated this file.

CI Cn Ce Ns Nd Yl - labels for integer contour control flags.

CI - label for contour type: 0 = linear

1 = logarithmic

2 = pseudo-log: Pseudo-log contours = positive and negative values are contoured separately, using $\log_{10}(\text{abs}(\text{value}))$, plus a zero contour.

Cn - label for number of contours per interval.

Ce - label for exponent of the contour interval, $\text{interval}=10^{\text{Ce}}$.

Ns - label for number of significant digits when posting values.

Values: -1, 3, 4, 5. (-1 = free format for small values)

Nd - label for the number of digits after the decimal.

Yl - label for vertical axis: 0 = none

1 = log frequency axis

2 = linear frequency axis

3 = linear depth

1 5 0 3 1 1 - integer values for contour control flags.

1 - value of CI => logarithmic contours

5 - value of Cn => 5 contours per "interval"

0 - value of Ce => $\text{interval}=10 \leq \text{Ce}=1$

3 - value of Ns => use 3 significant digits for contouring

1 - value of Nd => plot 1 digit after the decimal

1 - value of Yl => log frequency axis

TEM SURVEY DATA - Data description for this plot file. Two to six lines are available.

values in microV/ampere ZPLOT plots these lines as title annotation.

Component: Hz, Rxna: 10000.0

\$ CONTOUR= NONE - ZPLOT plot control keywords, no contours.

\$ PROFILE= AUTO - plot magnitude profiles.

\$ POST = NONE - do not post data values.

lxxxxxxxYYYYYYYzzzzzzzzzzzz - Header line for the data that follows.

ll - skip flag field:

0 = Skip this line of data.

1 = Omit for contouring, but post the bracketed value.

2 = Use for contouring and post the value (most common).

3 = Label a point or station by plotting a symbol under the X-axis at the X-coordinate.

4 = Use for contouring, post the symbol and not the value. Used for depth plots where interpolated values are used at the bottom of the plot to improve gridding.

5 = Use to set plot limits, do not contour or post. Used for depth plots to set zero depth.

Also used to provide a margin around the data, as for plan maps.

xxxxxxx - x value field, usually unscaled and unshifted station numbers.

YYYYYYY - y value field, for TEM, time window center (msec).

zzzzzzzzzz - z value field, to be plotted at (x,y) when skip flag=1, 2, or 4.

AAA - annotation field, when skip flag=1 or 2, ZPLOT posts any characters in the AAA column instead of plotting the z value. When skip flag=3, ZPLOT plots a symbol below the

x-axis at the x-value according to an integer in column AAA. A zero or positive integer

refers to symbols in TABLE 1 of the PLOT Manual. A negative integer refers to topographic symbols in the CTOPO Manual.

ffffff - repetition rate frequency (hertz).

www - time window number.

9999.0 - marks end of (stn,x,y,z) data block.

AMIRA-TEM-format *.AMR + *.CHN + *.TX files

Partial listing of STEMDEMO.AMR file:

TEM data calculated with TEM1D v2.00d

UNITS:(nV/Am2) CHANNELFILE:Temldemo.CHN INITDELAY:0.0700 CONFIG:FIXEDLOOP F:U

| LOOP | LINE | STN | EAST | NORTH | RL | LSIDE | CUR | RMP | G | FREQ | C | NCH | VPRI | CH1 | CH2 | | |
|-------------------------|------|-----|------|-------|------|-------|------|--------|---|------|---|-----|--------|------------|------------|-----------|-------|
| \ Initial Window Times: | | | | | | | | | | | | | | | 3.0500E-2 | 6.1000E-2 | . . . |
| 1 | 1 | 10 | 0 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | X | 30 | 0.0000 | 1.697E-04 | -3.058E-06 | . . . | |
| 1 | 1 | 10 | 25 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | X | 30 | 0.0000 | 4.043E+03 | 1.064E+03 | . . . | |
| 1 | 1 | 10 | 50 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | X | 30 | 0.0000 | 6.682E+03 | 1.884E+03 | . . . | |
| 1 | 1 | 10 | 75 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | X | 30 | 0.0000 | 7.293E+03 | 2.307E+03 | . . . | |
| 1 | 1 | 10 | 100 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | X | 30 | 0.0000 | 6.228E+03 | 2.319E+03 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -1 | 100 | 1.00 | 0.0700 | A | 1. | X | 30 | 0.0000 | 5.048E+03 | 1.571E+03 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -25 | 100 | 1.00 | 0.0700 | A | 1. | X | 30 | 0.0000 | 1.068E+03 | 6.532E+02 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -50 | 100 | 1.00 | 0.0700 | A | 1. | X | 30 | 0.0000 | -2.531E+03 | -2.865E+02 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -75 | 100 | 1.00 | 0.0700 | A | 1. | X | 30 | 0.0000 | -4.137E+03 | -8.617E+02 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -100 | 100 | 1.00 | 0.0700 | A | 1. | X | 30 | 0.0000 | -3.774E+03 | -8.369E+02 | . . . | |
| 1 | 1 | 10 | 0 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | Y | 30 | 0.0000 | 1.697E-04 | -3.164E-06 | . . . | |
| 1 | 1 | 10 | 25 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | Y | 30 | 0.0000 | 3.147E-04 | -9.629E-06 | . . . | |
| 1 | 1 | 10 | 50 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | Y | 30 | 0.0000 | 2.790E-04 | -2.596E-04 | . . . | |
| 1 | 1 | 10 | 75 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | Y | 30 | 0.0000 | -1.077E-04 | 6.964E-05 | . . . | |
| 1 | 1 | 10 | 100 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | Y | 30 | 0.0000 | -4.943E-05 | -3.067E-05 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -1 | 100 | 1.00 | 0.0700 | A | 1. | Y | 30 | 0.0000 | 5.048E+03 | 1.571E+03 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -25 | 100 | 1.00 | 0.0700 | A | 1. | Y | 30 | 0.0000 | 1.068E+03 | 6.532E+02 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -50 | 100 | 1.00 | 0.0700 | A | 1. | Y | 30 | 0.0000 | -2.531E+03 | -2.865E+02 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -75 | 100 | 1.00 | 0.0700 | A | 1. | Y | 30 | 0.0000 | -4.137E+03 | -8.617E+02 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -100 | 100 | 1.00 | 0.0700 | A | 1. | Y | 30 | 0.0000 | -3.774E+03 | -8.369E+02 | . . . | |
| 1 | 1 | 10 | 0 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | Z | 30 | 0.0000 | 1.503E+04 | 4.845E+03 | . . . | |
| 1 | 1 | 10 | 25 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | Z | 30 | 0.0000 | 1.364E+04 | 4.555E+03 | . . . | |
| 1 | 1 | 10 | 50 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | Z | 30 | 0.0000 | 1.007E+04 | 3.771E+03 | . . . | |
| 1 | 1 | 10 | 75 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | Z | 30 | 0.0000 | 5.772E+03 | 2.707E+03 | . . . | |
| 1 | 1 | 10 | 100 | 0 | 0 | 100 | 1.00 | 0.0700 | A | 1. | Z | 30 | 0.0000 | 2.126E+03 | 1.617E+03 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -1 | 100 | 1.00 | 0.0700 | A | 1. | Z | 30 | 0.0000 | 6.645E+03 | 2.946E+03 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -25 | 100 | 1.00 | 0.0700 | A | 1. | Z | 30 | 0.0000 | 7.990E+03 | 3.649E+03 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -50 | 100 | 1.00 | 0.0700 | A | 1. | Z | 30 | 0.0000 | 7.280E+03 | 3.682E+03 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -75 | 100 | 1.00 | 0.0700 | A | 1. | Z | 30 | 0.0000 | 5.174E+03 | 3.129E+03 | . . . | |
| 1 | 1 | 10 | 50 | 50 | -100 | 100 | 1.00 | 0.0700 | A | 1. | Z | 30 | 0.0000 | 2.677E+03 | 2.295E+03 | . . . | |

AMIRA-TEM-format *.AMR files hold TEM magnitude data in a tabular format. Comment lines preceded by a “\” may be placed anywhere within the file. Apart from comment lines, the first line holds free-format descriptive text. The second line holds keywords and values of constant parameters. The third line holds column labels, followed by numeric data. Numerical values are free format with columns separated by spaces and missing values shown by an “*”. The AMIRA format is quite flexible and constant-value parameters and/or data columns shown in this example may not be present in all AMIRA-format files.

A subset of AMIRA-format keywords:

UNITS - dB/dt magnitude units, in this case nV/Am2.
CHANNELFILE - *.CHN file name holding list of channel (time window) centers in msec.
INITDELAY - delay between top of Tx ramp and time=0 in msec,
 in this case INITDELAY=TxRamp
CONFIG - survey configuration (FIXEDLOOP, INLOOP,
F:U - file type, F:U indicates user defined channel times.

AMIRA-format *.AMR columns:

LOOP - Tx loop ID number, used as loop-center station number in separated-loop
LINE - line number
STN - measurement station number
EAST - measurement grid east (length units)
NORTH - measurement grid north (length units)
RL - measurement relative level, RL=0=surface, RL<0=down-hole
LSIDE - loop width (used for moving-loop)
CUR - Tx current (amps)
RMP - Tx ramp time (msec)
G - Rx gain, A=automatic
FREQ - Tx repetition rate (hertz)
C - component (X=east, Y=north, Z=vertical, A=down-hole-axial)
NCH - number of time channels (time windows)
VPRI - primary voltage (when measured)
CH1 - dB/dt voltage for first channel (time window)
CH2 - dB/dt voltage for second channel (time window)
:
CH30 - dB/dt voltage for last channel (time window)

Partial listing of STEMDEMO.CHN file:

| | |
|--|--------------------------------|
| Zonge GDP delay times w.r.t. end of Tx ramp. | <= free-format text line |
| NUMTIMES:30 | <= number of channel times |
| DELAY | <= column header |
| 3.0500E-2 | <= 1 st time (msec) |
| 6.1000E-2 | <= 2nd time (msec) |
| 9.1600E-2 | |
| : | |
| 48.38 | <= last time (msec) |

Partial listing of 1.TX file:

| | | | |
|-------|-------|-----|---|
| -50.0 | -50.0 | 0.0 | <= grid (east,north,RL) of Tx loop corner 1 |
| 50.0 | -50.0 | 0.0 | <= grid (east,north,RL) of Tx loop corner 2 |
| 50.0 | 50.0 | 0.0 | <= grid (east,north,RL) of Tx loop corner 3 |
| -50.0 | 50.0 | 0.0 | <= grid (east,north,RL) of Tx loop corner 4 |

TecPlot-format *.DAT files

Partial listing of STEMDEMO.DAT file:

```
TITLE="TEM vector data, dB/dt in uV/amp"
VARIABLES = "Stn" "GridE" "GridN" "Elev" "dBx/dt" "dBy/dt" "dBz/dt"
TITLE="Window 1, Time = 3.0500E-02 msec."
ZONE I= 10 F=POINT
  1.0      0.0      0.0      0.0  1.697E-03  1.697E-03  1.503E+05
  2.0     25.0      0.0      0.0  4.043E+04  3.147E-03  1.364E+05
  3.0     50.0      0.0      0.0  6.682E+04  2.790E-03  1.007E+05
  4.0     75.0      0.0      0.0  7.293E+04 -1.077E-03  5.772E+04
  5.0    100.0      0.0      0.0  6.228E+04 -4.943E-04  2.126E+04
  6.0     50.0     50.0     -1.0  5.048E+04  5.048E+04  6.645E+04
  7.0     50.0     50.0    -25.0  1.068E+04  1.068E+04  7.990E+04
  8.0     50.0     50.0   -50.0 -2.531E+04 -2.531E+04  7.280E+04
  9.0     50.0     50.0  -75.0 -4.137E+04 -4.137E+04  5.174E+04
 10.0     50.0     50.0 -100.0 -3.774E+04 -3.774E+04  2.677E+04
TITLE="Window 2, Time = 6.1000E-02 msec."
ZONE I= 10 F=POINT
  1.0      0.0      0.0      0.0 -3.058E-05 -3.164E-05  4.845E+04
  2.0     25.0      0.0      0.0  1.064E+04 -9.629E-05  4.555E+04
  3.0     50.0      0.0      0.0  1.884E+04 -2.596E-03  3.771E+04
  4.0     75.0      0.0      0.0  2.307E+04  6.964E-04  2.707E+04
  5.0    100.0      0.0      0.0  2.319E+04 -3.067E-04  1.617E+04
```

TEM1D writes ASCII TecPlot files using one zone for each window time and singly subscripted data within each zone. The format is suitable for two- or three-dimensional vector or contour plots and time animation. However, plotting stream lines in TecPlot requires IJ or IJK-ordered data, requiring that TEM1D output be gridded from its I-ordered format to a IJ- or IJK-order format on a rectangular grid.

Surfer/Grapher-format *.TXT files

Selecting Surfer/Grapher format produces a set of ASCII files in a comma-delimited spreadsheet format. dBx/dt data are put in a file labeled *Vx.TXT with a format suitable for plotting transients. *Vx.TXT files have a column for each station and a rows for each time window. Similar files are written for dBx/dt and dBz/dt components.

TEM1D also writes a set of files suitable for plan-map plotting of dB/dt data a selected times. Files labeled *.W??.TXT include data for an particular window time with columns of SRx, XRx, YRx, ZRx, dBx/dt, dBy/dt and dBz/dt. There is one row for each Rx locations. *W??.TXT files are also in a comma-delimited spreadsheet format.